April/May 2018
UVOST® Investigation Report

Columbus, MT 59019

DEQ Agreement# 418004

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1.0 Introduction

This report documents the laser-induced fluorescence (LIF) ultra-violet optical screening tool (UVOST®) investigation conducted by West Central Environmental Consultants (WCEC) in Columbus, Montana from April 23 to May 2, 2018. WCEC was contracted by the Montana Department of Environmental Quality (MTDEQ) in accordance with the State of Montana Term Contract SPB12-2177V-59 (DEQ Agreement# 418004) to perform a city-wide subsurface investigation using high resolution site characterization (HRSC) technologies to define the extent and magnitude of historic releases at multiple facilities in Columbus, Montana.

Seven petroleum release sites were originally scheduled to be studied under this agreement:

1. Columbus Sports Hut, FID: 48-012653, Release 1095.
2. Former Newman's Downtown Exxon, FID: 48-04005, Release 1781.
3. Former Platinum Motors, FID: 48-04575, Release 4482.
4. Git's Conoco, FID: 48-07859, Release 4012.
5. Montana Rail Link (Former Shell Oil Co.), FID: 48-12059, Release 4036.
6. Montana Rail Link (Former Shortridge Oil Co.), FID: 48-05082, Release 1928.
7. Columbus Farmers Union, FID: 48-03409, Releases 1408, 1659, 3762, and 4915.

The Columbus Sports Hut facility was later removed from this list as requested by the MTDEQ.

1.1 Site Location

The town of Columbus is situated in the Yellowstone River valley of south-central Montana and is the county seat of Stillwater County. Site location maps are included as Figure 1 and an investigation area overview figure is provided as Figure 2. The Public Land Survey System (PLSS) description for the project area is the NW/4 of Section 27 and the NE/4 of Section 28, T2S, R20E. The approximate geographic coordinates are N 45.636130°, W 109.250254°. Township, range, and section information was obtained using the United States Geological Survey (USGS) Columbus East, Montana 1:24,000 Quadrangle. The project area is located within the Countryman Creek-Yellowstone River Hydrologic Unit (5th Code).

Properties within the investigation area consist of mixed-use light industrial and commercial businesses. A Class II railroad administered by Montana Rail Link (MRL) runs east-west through the middle of the investigation area. Right-of-ways controlled by the Montana Department of Transportation (MDT) exist within the Highway 78 and Highway 10E corridors. The town of Columbus maintains right-of-ways in

municipal alleys and streets within the investigation area including Diamond Street, Allen Street, and Clough Avenue.

The majority of the release sites included in this investigation no longer contain active petroleum storage and distribution infrastructure. Only Git's Conoco (FID: 48-07859) and Columbus Farmers Union (FID: 48-03409) currently maintain active petroleum storage and dispensing equipment. The remaining release sites previously dismantled their petroleum distribution systems and either removed the equipment from the property entirely or attempted to abandon any remaining infrastructure in place.

1.2 Geologic/Hydrogeologic Setting

According to the *Geologic Map of the Big Timber 30' x 60' Quadrangle, South-Central Montana* produced by the Montana Bureau of Mines and Geology (MBMG), the investigation area lies on Quaternary alluvial terrace gravels (Qat) derived from the Holocene and Pleistocene [Lopez, 2000]. The younger alluvial terrace gravels (Qat1) range from approximately 10 to 20 feet higher in elevation than the current river bottom and consist primarily of cobbles and pebbles with lesser amounts of sand and silt. These deposits are generally about 10 to 40 feet thick and contain granitic igneous clasts such as gneiss, schist, and quartzite, with minor amounts of limestone and sandstone [Lopez, 2000].

The nearest surface water body is the Yellowstone River located approximately 200 to 1,500 feet to the southwest from the proximal and distal portions of the investigation area, respectively. The anticipated groundwater flow direction is to the southeast paralleling the flow direction of the Yellowstone River. Further evidence for a southeast flow direction is contained in the data from the numerous groundwater monitoring events conducted at the release sites within the central and eastern portions of the investigation area. Local fluctuations in the groundwater flow direction from the southeast to the southwest are likely depending on seasonal variations in groundwater inputs and proximity to the river. Particularly on the western margin of the investigation area at locations nearer to the river, groundwater flow directions have been documented to deviate from the overall southeasterly trend and flow more directly towards the river with a south-southwest orientation.

A review of the available monitoring well logs on the MBMG Groundwater Information Center (GWIC) online data base [GWIC, 2018] and the cumulative groundwater elevation data for the facilities indicates that the depth to groundwater ranges from approximately 8 to 10 feet below ground surface (bgs). Lithologic materials listed on the well logs include a sandy gravel interval beginning at approximately 5 to 9 feet bgs that is overlain by lean clay. The sandy gravel layer is described as being dense to very dense and occasionally exhibits strong petroleum odors and staining.

1.3 Scope of Work

WCEC performed the following tasks to complete the requested scope of work:

- Deployment of a UVOST unit with operator for rapid high-resolution site characterization (HRSC) of the light non-aqueous phase liquid (LNAPL) plume. Dakota Technologies (Dakota) supplied the UVOST equipment housed in a four-wheel drive truck containing a generator to power the UVOST laser and associated computer software, and a rod rack pre-strung with fiber optic cable.

- Deployment of a direct push technology (DPT) rig and operator to advance the UVOST tooling into the subsurface. Dakota provided a GeoProbe model 7822DT track mounted unit capable of pushing 1.5-inch rods with a dampener at the required rate of 0.8 inches per second for UVOST data collection.

- Providing a Data Analyst experienced with UVOST data collection and interpretation methodologies to direct the field investigation.

- Preparation of a summary report containing a comprehensive analysis of the data collected during the UVOST investigation including two-dimensional (2D) and three-dimensional (3D) visualizations.

2.0 Investigation Overview and Daily Project Narratives

2.1 LIF UVOST Technology Overview

LIF technology consists of a direct optical sensing tool that uses laser light to cause polycyclic aromatic hydrocarbons (PAHs) found in petroleum-derived light non-aqueous phase liquids (LNAPL) to fluoresce. An ultra-violet optical screening tool (UVOST) housed in a shock-protected optical compartment (SPOC) attached to the end of a direct-push probe string is delivered into the subsurface at an average rate of approximately 0.8 inches per second. Fiber optic cable pre-strung in the probe rods continuously transmits fluorescence data back to a computer mounted on the probe rig, providing a real time log of fluorescence data points at sub-inch intervals. The OST computer software transforms the fluorescence data into multi-wavelength waveforms that are specific to the types of PAHs present in a particular LNAPL petroleum solvent, such as diesel for example.

Compared with traditional soil boring methods, UVOST is advantageous because the probe string is continuously delivered into the subsurface without interruption for soil sample collection, resulting in increased production (probed feet per day). Decontamination of the probe string between boreholes usually is not required and no drill cuttings or other investigation-derived waste are generated in the data collection process, further increasing efficiency and reducing overall project costs. Additionally, the high resolution data output from UVOST investigations matches the scale of subsurface heterogeneities which influence LNAPL distribution that are often too small for conventional investigation technologies to adequately characterize.

A typical UVOST probe rig can obtain 200 to 500 feet per day depending on soil type and site layout. UVOST boreholes are ideally spaced approximately 30 to 50 feet apart in a measured grid pattern across the investigation area. Valid fluorescence data can be obtained both above and below the saturated zone. UVOST signal responses correlate to free phase and residual LNAPL only. Vapor, adsorbed, and dissolved hydrocarbon phases are invisible to the UVOST system. As a result, an investigation using UVOST technology focuses on the source of site impacts and produces an accurate, detailed depiction of the extent and magnitude of the LNAPL body.

UVOST borehole data logs are generated in real time as the probe string is advanced into the subsurface. The vertical scale of the UVOST data log is depth in feet and the horizontal scale is the intensity of the fluorescence signal given in percent of a calibrated reference, referred to as a reference emitter (RE). The log provides a semi-quantitative representation of the magnitude of LNAPL saturation and reveals the depth and thickness of LNAPL impacted soil. Onsite production of the UVOST logs in real time allows for a flexible and intuitive progression of the field investigation.

An electrical conductivity (EC) probe is advanced in tandem with the UVOST SPOC probe tip. Using a dipole arrangement, the EC probe measures electrical current and voltage as it moves downhole to calculate the conductivity of the surrounding formation in millisiemens per meter (mS/m). In general, higher EC measurements indicate finer grained sediments and lower EC measurements reflect coarser grained, more permeable soil. The EC data is reported alongside the %RE signal response graph on the UVOST logs. This side-by-side visualization of the two datasets results in a more complete understanding of the relationships between lithology and contaminant fate and transport mechanisms.

Further information regarding UVOST technology and its application can be found on the Dakota website: http://www.dakotatechnologies.com/learn-more/intro-to-lif/overview.

2.2 Investigation Overview

Prior to initiation of field activities, WCEC coordinated several underground utility locates which encompassed the entire investigation area both on and off the subject properties including state and municipal right-of-ways and the MRL railway. WCEC and Dakota mobilized to Columbus, Montana on Sunday afternoon, April 22, 2018. Upon arrival to the site on Monday morning, April 23, 2018, WCEC met with representatives of the Columbus sewer/water department and various other utility locators to perform a site walkover for identification and discussion of the underground utilities present in the investigation area. An authorized representative of the MTDEQ from North Wind Portage, Inc. (Portage) mobilized to the site around midday on Monday, April 23, 2018 to assist the field team with the investigation and monitor the overall progress of the data collection effort.

The UVOST investigation commenced on Monday, April 23, 2018, and continued until Wednesday, May 2, 2018, with a two-day break for the weekend. A total of 96 UVOST boreholes were completed during the eight days of the investigation. The UVOST boreholes were assigned a two digit identification number starting at 01 that increased sequentially based on the order in which the boreholes were completed, with the suffix "-LIF" following the number. A field report compiled by Dakota containing a data summary table and copies of all of the UVOST logs generated during the investigation is included as Appendix A. Borehole locations are displayed on Figure 3.

Initially, the UVOST borehole locations were pre-probed to 2 feet bgs using a solid drill rod to prevent damage to the SPOC tip from the hard-packed, gravel/asphalt surface cover. The target completion depth for the UVOST boreholes was 16 feet bgs. Difficult subsurface drilling conditions encountered in the dense sandy gravel/cobble underlying the site impeded advancement of the UVOST probe assembly. The more sensitive components of the UVOST equipment were frequently damaged during the first 2.5 days of the investigation as a result of the difficult drilling conditions. Starting with borehole 32-LIF, a pre-probe pilot hole was installed to the terminal depth of each borehole (16 feet bgs) prior to advancement of the UVOST

probe in an effort to minimize damage to the equipment and prolong the investigation to ensure that the proposed scope of work could be effectively completed.

At the end of each field day, all boreholes were abandoned with bentonite and restored to the original surface condition. UVOST borehole locations were surveyed daily by WCEC using a Trimble Geo7x centimeter grade GPS. WCEC post-processed the daily GPS measurements in the evenings to facilitate the creation of daily site maps that could be reviewed in the morning tailgate meetings. The maximum signal response from each UVOST borehole was incorporated in the daily mapping procedures so that up to date 2D contour maps of UVOST signal response were available to help inform the borehole location selection process.

The average completion depth for the UVOST boreholes was 15.29 feet bgs and the total UVOST drilling footage achieved was 1,468.18 feet. The pre-probe pilot hole footage totaled 1,033 feet. The following sections contain summarized narratives of the field activities completed each day.

2.2.1 Monday, April 23

WCEC and Dakota personnel met with a maintenance crew from MRL in the section house at approximately 10:00. The MRL foreman reviewed the anticipated drilling plan and made arrangements to provide track protection with derails and locked switches as necessary. A permanent lookout was stationed with the drilling crew to monitor train movements. Following a site health and safety plan review and an inspection of the utility locate markings, the first borehole was sited on the south side of the MRL rail yard near a monitoring well (MW-1) associated with the Former Shortridge Oil Co. facility that had previously exhibited in-well LNAPL thicknesses.

Borehole 01-LIF displayed positive indications of LNAPL presence in a low-level fluorescence interval (less than 3.0 %RE) ranging from approximately 11 to 13 feet bgs. An inspection of the drill string after the 01-LIF borehole push provided additional evidence of LNAPL presence with a distinct petroleum odor evident on the drill rods. The field team also observed that the SPOC tip had already been pitted by the dense sandy gravel encountered in the 01-LIF borehole even though this was the first boring completed with this brand new tooling. A malfunction in the communication between the OST software and the EC tooling resulted in no EC data obtained from 01-LIF.

A transect of borings was initiated to the east of 01-LIF with spacing of approximately 40 feet between boreholes. Boreholes 02-LIF through 04-LIF returned responses at similar depths as the 01-LIF boring with fluorescence intervals in these boreholes ranging from approximately 10 to 14 feet bgs. The maximum signal response observed was 9.1 %RE at 12.53 feet bgs in the 02-LIF borehole. Borehole 05-LIF exhibited a “non-detect” response for LNAPL presence and therefor the transect was discontinued to the east. The sapphire

window in the SPOC assembly was cracked during the installation of these first five UVOST boreholes and had to be replaced before proceeding.

After the sapphire window had been replaced, the borehole transect on the south side of the rail yard was continued with the installation of 06-LIF approximately 40 feet west of 01-LIF. Three more boreholes (07-LIF through 09-LIF) were completed in the western advancement of the transect before the MRL lookout advised the drilling team that the investigation needed to wrap up for the day so that time could be allotted for removing the derails and switch locks. The maximum signal response recorded on the west side of the transect was 5.1 %RE in a thin fluorescence spike at 13.09 feet bgs.

At the end of this day of field work, nine UVOST boreholes (01-LIF through 09-LIF) had been advanced with a total drilling footage achieved of 144.36 feet.

2.2.2 Tuesday, April 24

Project personnel assembled at the site at approximately 07:45 to warm up equipment and wait for the MRL lookout to arrive. After waiting several minutes, WCEC mobilized to the MRL section house and found that a new lookout had been assigned to the investigation. Once the new lookout had established the necessary track protection procedures, the investigation continued on the west end of the transect located on the south side of the rail yard. Three boreholes (10-LIF through 12-LIF) were advanced in this transect before it was determined that sufficient data had been obtained on the south side of the rail yard. Track protection was secured on the northern rail lines to enable the investigation to proceed on the north side of the rail yard.

Borehole 13-LIF was advanced on the anticipated western end of the northern rail yard transect, approximately 75 feet north of borehole 12-LIF. Positive indications of LNAPL were observed in the 13-LIF borehole from approximately 12 to 14 feet bgs. The SPOC adapter and coupler were bent during advancement of 13-LIF and a new SPOC and fiber optic cable assembly needed to be re-strung through the probe rods before the investigation could continue.

After the new SPOC and fiber optic cable had been tested and calibrated successfully, the investigation continued to the east on the northern rail line transect with borehole spacing of approximately 40 feet. The next two boreholes in the transect (14-LIF and 15-LIF) encountered refusal before reaching the target depth of 16 feet bgs. The drill rig engine was frequently stalling during these borehole pushes, and a plan was made to perform maintenance on the rig including fuel filter replacement during the lunch break.

After breaking for lunch and performing maintenance on the drill rig, the investigation continued to the east. The next five boreholes in the northern rail line transect (16-LIF through 20-LIF) all exhibited LNAPL

fluorescence intervals of varying thickness ranging from approximately 10 to 14 feet bgs. Borehole 19-LIF displayed the most intense fluorescence response with a maximum signal of 19.7 %RE at 13.63 feet bgs. Borehole 21-LIF appeared to be nearly "non-detect" for LNAPL presence, with several low-level fluorescence responses ranging from approximately 7 to 10 feet bgs. The final borehole in the transect to the east (22-LIF) was offset approximately 60 feet to line up with the LNAPL detections found on the southern rail line transect. Borehole 22-LIF was "non-detect" for LNAPL presence.

The last borehole for this day (23-LIF) was installed on the west end of the northern rail line transect, approximately 40 feet west of 13-LIF. Borehole 23-LIF displayed low-level LNAPL fluorescence in an interval from approximately 12 to 13 feet bgs. At this point it was determined that sufficient data had been obtained within the railyard and plans were made to continue the investigation the following day on MRL lease property to the north of the rail lines.

An inspection of the UVOST tooling after the 23-LIF borehole push revealed that the sapphire window had cracked and there was evidence of possible moisture infiltration into the SPOC. Attempts to remove and replace the sapphire window were unsuccessful due to smearing of the metal around the window port. Prior to renewing the investigation the following day, the UVOST operator would have to replace the damaged SPOC with a new one containing a functioning sapphire window and port.

A total of 14 UVOST boreholes (10-LIF through 23-LIF) were completed on this day for an aggregate drilling footage achieved of 214.40 feet.

2.2.3 Wednesday, April 25

The field investigation team met on the northwest corner of the MRL lease property near the intersection of Pike Avenue (Old U.S. Highway 10) and Pratten Street at approximately 07:45. A transect of boreholes was initiated extending from west to east with borehole spacing of 40 feet starting with 24-LIF. Borehole 24-LIF exhibited intermittent low-level fluorescence spikes from approximately 6 to 11 feet bgs that were near background levels (1 %RE). The sapphire window was scratched after the 24-LIF borehole push and needed to be replaced.

Borehole 25-LIF reached the target depth of 16 feet bgs with a maximum signal response of 4.0 %RE in a thin spike at 6.22 feet bgs. The next two boreholes in the transect (26-LIF and 27-LIF) experienced shallow refusal at approximately 6 and 8 feet bgs respectively. Concrete dust was found on the drill rods indicating that buried concrete rubble was possibly responsible for the probe refusals. Borehole 28-LIF was successfully advanced to the target depth and displayed a low-level fluorescence response from approximately 7.5 to 8 feet bgs that may be indicative of LNAPL. Borehole 29-LIF encountered shallow refusal and borehole 30-LIF was "non-detect" for LNAPL presence.

After the borehole 30-LIF push a small scratch was observed on the outer edge of the sapphire window. The UVOST operator was unable to replace the slightly damaged window due to smearing of the metal around the window port. The decision was made to continue using the compromised window until it was no longer functional at which point the UVOST operator would have to re-string the fiber optic cables through the third SPOC available for the investigation.

The investigation proceeded onto the MRL release facility associated with the Former Shell Oil Co. with the advancement of borehole 31-LIF. 31-LIF displayed a robust LNAPL fluorescence response from approximately 9.5 to 13 feet bgs with a maximum signal of 18.7 %RE at 11.44 feet bgs. Upon retrieval of the SPOC assembly following installation of 31-LIF, fogging was noted in the sapphire window which is an indication of moisture intrusion. Since the sapphire window could not be removed as a result of the smeared metal around the window port, the interior of the SPOC could not be cleaned and dried out, and therefore the SPOC needed to be removed from service to ensure the integrity of the UVOST data collection process. The third SPOC allocated for the investigation would be re-strung through the fiber optic cables following a break for lunch.

An impromptu project meeting was held during the lunch break to discuss options to mitigate ongoing damage to the UVOST tooling. Dakota personnel communicated that the SPOC assemblies cost $1,500 to replace and that two had already been permanently damaged during the first 2.5 days of the investigation. A total of three SPOCs had been allocated for the investigation, meaning that only one functioning SPOC remained. The decision was made to attempt a pre-probe pilot hole prior to advancing the UVOST tooling in an effort to slightly displace the sandy gravel substrate. The goal of the pre-probe boring was to create a sufficient pathway to advance the UVOST tooling without further damage while simultaneously maintaining adequate soil contact to satisfy data quality objectives. A duplicate boring (32-LIF) would be established at the 31-LIF location to enable a comparison of the data obtained from an undisturbed borehole and a pre-probed borehole installation to evaluate the effectiveness of the proposed strategy.

Duplicate borehole 32-LIF was installed approximately 2 feet south of 31-LIF. A butterfly side-by-side plot was generated in the field with the OST software to compare the results from the two duplicate boreholes. Although the magnitude of the maximum signal responses from the two duplicate locations differed substantially (10.2 %RE versus 18.7 %RE), the depth intervals signifying LNAPL impacts were nearly identical in the two boreholes. By necessity, two different fiber optic cable assemblies were used in each of the boreholes and the variability in performance of the two different cable setups can be seen in the output color on the UVOST logs, particularly in the background fluorescence intervals. The fiber optic cable used in borehole 32-LIF had been deployed extensively in previous UVOST investigations and was generally brought along as an emergency backup for the Columbus investigation, whereas the cable used in borehole 31-LIF was essentially brand new. It is possible that some of the irregularities in fluorescence response between the two duplicate boreholes are related to fiber optic cable performance, such as impurities that may have existed in the worn cable used by necessity in 32-LIF, rather than the different methodologies employed during probe advancement (i.e., pre-probing versus undisturbed).

Based on an initial review of the results from the two duplicate locations, it appeared that instigating a pre-probe protocol may provide data of sufficient quality while also prolonging the life of the UVOST equipment to enable the completion of the anticipated scope of work. The investigation continued with the advancement of five boreholes (33-LIF through 37-LIF) east of the 31-LIF/32-LIF duplicate pair in the asphalt covered lumber storage area previously occupied by the Former Shell Oil Co. facility. In general, the majority of the LNAPL fluorescence response encountered in these boreholes was at depths ranging from 8 to 10 feet bgs, with a maximum signal response of 63.7 %RE at 9.01 feet bgs recorded in 34-LIF. Shallow vadose zone fluorescence responses were also observed in 34-LIF and 35-LIF, possibly indicating the presence of a historical source area at these locations. Both boreholes 36-LIF and 37-LIF displayed decreasing signal response intensities and fluorescence interval thicknesses, signifying that the investigation had progressed to near the margins of the LNAPL plume in this area.

A total of 14 UVOST boreholes (24-LIF through 37-LIF) were completed on this field day with a total UVOST drilling footage of 196.55 feet and a total pre-probe drilling footage of 80 feet.

2.2.4 Thursday, April 26

The field team assembled on the south side of Pike Avenue (Old U.S. Highway 10) at approximately 07:45 to initiate a transect of boreholes from west to east in the highway right-of-way. Traffic control measures for working in the right-of-way were established according to the traffic control plan contained in the MDT encroachment permit for the project. The first borehole (38-LIF) was advanced approximately 30 feet northeast of the 31-LIF/32-LIF duplicate pair. Borehole 38-LIF exhibited shallow vadose zone LNAPL responses indicative of a source area location, with a maximum signal of 19.0 %RE at 6.22 feet bgs. Three more borings (39-LIF through 41-LIF) were installed to the east of 38-LIF spaced approximately 40 feet apart. The maximum signal response decreased gradationally as the transect progressed eastward, from 18.0 %RE at 39-LIF to 3.8 %RE at 41-LIF.

The investigation continued on the west side of 38-LIF with the advancement of 42-LIF. Borehole 42-LIF displayed shallow vadose zone LNAPL responses signifying a source area location similar to 38-LIF. A relatively thick interval of fluorescence response greater than 10 %RE was also observed in the 42-LIF borehole extending from approximately 7 to 13 feet bgs. Borehole 43-LIF was installed approximately 40 feet west of 42-LIF and was near “non-detect” levels (1 %RE).

At this point the investigation was directed toward the MRL lease properties south of the rail yard near the Former Shortridge Oil Co. facility. Boreholes 44-LIF through 46-LIF were installed in a north-south line roughly corresponding with the locations of former petroleum above ground storage tanks (ASTs), product piping, and dispenser pumps based on information gathered from historic facility diagrams and the outlines of existing concrete slab structures. Both boreholes 44-LIF and 45-LIF were near “non-detect” levels for

LNAPL response (1 %RE). Borehole 46-LIF was installed inside the footprint of a former pump island dispenser and returned shallow vadose zone responses indicating that this is an LNAPL source area. The maximum response at 46-LIF was 21.2 %RE at 5.95 feet bgs.

Borehole 47-LIF was advanced approximately 40 feet east of 46-LIF and displayed smear zone LNAPL responses at depths ranging from approximately 8 to 12 feet bgs with a maximum signal of 12.3 %RE at 8.22 feet bgs. A post borehole inspection of the drill string revealed that the SPOC sapphire window had loosened during the push which allowed water and sediment to infiltrate the SPOC housing. The SPOC was not damaged beyond repair, but needed to be cleaned and dried before it could be put back into service. A fourth backup SPOC assembly was retrieved by the UVOST operator and the investigation experienced down time while the required components were connected to make this fourth SPOC functional.

After the new SPOC assembly had been tested and calibrated successfully, the investigation continued with two boreholes (48-LIF and 49-LIF) advanced to the east of 47-LIF. Decreasing fluorescence responses were evident in these two boreholes to near "non-detect" levels in 49-LIF. The final borehole for this day (50-LIF) was installed approximately 80 feet west of 46-LIF, near a location designated as a former fuel rack in historic diagrams. Borehole 50-LIF displayed smear zone LNAPL responses from approximately 9 to 13 feet bgs with a maximum signal of 10.0 %RE at 9.70 feet bgs. At this point the UVOST operator indicated that he needed to perform the recharge procedure on the UVOST laser to keep it functioning properly and the investigation ceased for the day.

A total of 13 UVOST boreholes (38-LIF through 50-LIF) were installed on this day for a total UVOST drilling footage of 204.25 feet and a total pre-probe drilling footage of 208 feet.

2.2.5 Friday, April 27

This day began at 08:00 with the advancement of borehole 51-LIF approximately 50 feet west of 50-LIF. Borehole 51-LIF returned responses that were near "non-detect" levels for LNAPL presence. The next two boreholes (52-LIF and 53-LIF) were installed in a short transect line to the north of 50-LIF, in an area that previously contained petroleum underground storage tanks (USTs) according to historic facility diagrams. Borehole 52-LIF displayed a very thick LNAPL fluorescence response starting at approximately 5 feet bgs that extended to the terminal depth of the boring at 16.06 feet bgs, with a maximum signal response of 127.9 %RE noted in a thin spike at 8.60 feet bgs. Borehole 53-LIF also exhibited relatively robust fluorescence responses ranging from approximately 9 to 16 feet bgs, with a maximum signal of 20.4 %RE at 15.26 feet bgs.

Borehole 54-LIF was placed in a line between 52-LIF and 46-LIF to further delineate the source area responses observed at these two locations. 54-LIF exhibited a relatively moderate LNAPL fluorescence response in the smear zone near the anticipated groundwater interface with a maximum signal of 5.3 %RE at

8.80 feet bgs. The next two borings (55-LIF and 56-LIF) were installed on the western and eastern margins of the Former Shortridge Oil Co. facility and both of these locations displayed relatively minor fluorescence responses with a maximum of 6.8 %RE noted in a very thin spike at 7.93 feet bgs in 56-LIF.

The investigation proceeded to the south side of Clough Avenue with the advancement of six boreholes (57-LIF through 62-LIF) in a transect from west to east at a spacing of approximately 40 feet. Maximum fluorescence responses in these downgradient boreholes ranged from 1.4 %RE in 58-LIF to 27.4 %RE in 62-LIF. The final borehole for this day (63-LIF) was sited in an infill location near the Former Shortridge Oil Co. facility source areas approximately 20 feet south of 54-LIF. 63-LIF exhibited low-level LNAPL fluorescence in three discrete zones starting at approximately 5 feet bgs and ending at approximately 13 feet bgs.

A total of 13 UVOST boreholes (51-LIF through 63-LIF) were completed on this day for a total UVOST drilling footage of 204.12 feet and a total pre-probe drilling footage of 208 feet.

2.2.6 Monday, April 30

After taking a two-day break for the weekend, the investigation resumed on Monday, April 30 at 08:00. A transect was initiated in the MDT right-of-way on the north side of Pike Avenue (Old U.S. Highway 10). Traffic control signage was deployed according to the approved traffic control plan prior to advancing the first borehole. Borehole 64-LIF was installed approximately 30 feet south of the pump island dispenser located at the Former Newman's Downtown Exxon facility. 64-LIF displayed LNAPL fluorescence responses from approximately 6.5 to 13 feet bgs, with a maximum signal of 12.3 %RE at 9.62 feet bgs.

A step-out boring (65-LIF) was sited approximately 40 feet west of 64-LIF. Prior to the advancement of 65-LIF, the UVOST operator noted that the depth encoder was not functioning properly. After several minutes of troubleshooting it was determined that leaky voltage was responsible for the malfunctioning depth encoder. A severed ground wire in the drill rig remote display was found to be the source for the voltage leak. The remote display was replaced with a backup and the depth encoder once again began to function as designed. After confirming that all of the components of the UVOST system were operating satisfactorily, borehole 65-LIF was successfully advanced to the target terminal depth. Borehole 65-LIF exhibited two low-level fluorescence responses at 9 and 12.5 feet bgs that may or may not be LNAPL related.

The transect was extended to the east with the installation of six boreholes (66-LIF through 71-LIF) at an approximate spacing of 40 feet. Borehole 66-LIF displayed low-level fluorescence responses in the smear zone and 67-LIF was "non-detect" for LNAPL presence. Borehole 68-LIF was installed south of the Former Platinum Motors facility adjacent to monitoring well JW-04-5. Fluorescence response in 68-LIF was moderate to low-level with a maximum signal of 3.9 %RE at 8.53 feet bgs. As the drill string was being retrieved from

borehole 68-LIF, a strong petroleum odor was noted and a petroleum sheen was evident in the saturated sediments coating the rods.

The pre-probe pilot hole for 69-LIF experienced refusal at approximately 9 feet bgs. A step out boring was attempted approximately 5 feet from the refusal location and ultimately 69-LIF was advanced successfully to the target completion depth (16 feet bgs). Low-level smear zone fluorescence was observed in the 69-LIF boring from approximately 8 to 14 feet bgs. The next two boreholes in the transect (70-LIF and 71-LIF) displayed decreasing fluorescence to near "non-detect" levels in 71-LIF.

Difficult drilling conditions in the sandy gravel substrate damaged four sapphire windows during the installation of the first eight boreholes on this day. The UVOST operator only had one more undamaged sapphire window left following the installation of 71-LIF. Several more windows were put on order and scheduled to be delivered priority overnight for the following day.

The investigation continued with the installation of borehole 72-LIF on the east side of the current lumber store office building at the Former Platinum Motors facility. Borehole 72-LIF contained a maximum signal response of 10.5 %RE at a depth of 8.15 feet bgs which corresponds to the anticipated groundwater interface. Borehole 73-LIF was advanced on the northwest (upgradient) side of the Former Platinum Motors facility and was near "non-detect" fluorescence levels (1 %RE). The next borehole (74-LIF) was placed in an accessible location adjacent to the alley north of the Former Newman's Downtown Exxon facility. 74-LIF also returned responses that were at or near "non-detect" levels. The final borehole for this day (75-LIF) was sited on the east side of the Former Platinum Motors facility. Fluorescence responses in 75-LIF were at or near "non-detect" levels for LNAPL presence with the exception of some low-level surficial detections at approximately 0.5 feet bgs.

A total of 12 UVOST boreholes (64-LIF through 75-LIF) were installed on this day for a total UVOST drilling footage of 185.03 feet and a total pre-probe drilling footage of 201 feet.

2.2.7 Tuesday, May 1

This day began with a planning meeting at 07:30. A series of infill borings were scheduled while utility clearance was pending in downgradient locations. Three infill borings (76-LIF through 78-LIF) were advanced on the north side of Pike Avenue near the Former Newman's Downtown Exxon and Former Platinum Motors facilities. Borehole 76-LIF was installed on the west side of the Former Platinum Motors facility and displayed a maximum signal of 21.4 %RE in a thin spike at 8.24 feet bgs. Borehole 77-LIF was placed to the west of 76-LIF, along the east side of the Former Newman's Downtown Exxon facility. 77-LIF was "non-detect" for LNAPL presence. The final infill borehole (78-LIF) on the north side of Pike Avenue was sited approximately

20 feet west of borehole 68-LIF where petroleum sheen had been noted in the saturated sediments coating the drill rods. 78-LIF returned a maximum signal of 6.2 %RE at 12.56 feet bgs.

The investigation progressed to the south side of Pike Avenue to install more infill borings in the vicinity of the MRL Former Shell Oil Co. facility. Boreholes 79-LIF and 80-LIF displayed diminished responses compared with the more elevated fluorescence observed in source area boreholes 38-LIF and 42-LIF. Borehole 79-LIF contained a maximum signal of 2.6 %RE at 10.94 feet bgs and 80-LIF returned a maximum signal of 11.8 %RE at 8.67 feet bgs.

After a break for lunch the investigation continued on the south side of the MRL rail yard at the Former Shortridge Oil Co. facility. Boreholes 81-LIF and 82-LIF were installed in between the two source areas defined at 52-LIF and 46-LIF. Both 81-LIF and 82-LIF displayed elevated fluorescence response starting at about 8 feet bgs. At this point the drill rig operator noted that the drill hammer was not functioning properly and the investigation stalled while the hammer was re-pressurized. The replacement SPOC sapphire window shipment also had arrived so that any scratched windows could be replaced.

After the drill rig maintenance had been performed, the next borehole (83-LIF) was advanced in the city right-of-way of South Allen Street near monitoring well MW-3. Borehole 83-LIF was near “non-detect” levels for LNAPL presence. The final borehole for this day (84-LIF) was installed approximately 45 feet south of 09-LIF on the west side of the MRL lease parcel adjacent to the Former Shortridge Oil Co. facility. Borehole 84-LIF returned fluorescence responses that were near “non-detect” levels (1 %RE).

A total of nine UVOST boreholes (76-LIF through 84-LIF) were completed on this day for a total UVOST drilling footage of 132.12 feet and a total pre-probe footage of 144 feet.

2.2.8 Wednesday, May 2

The field investigation team assembled at the Columbus Farmers Union facility at 07:45. Utility locate marks were reviewed and the possible layout of current petroleum storage and distribution equipment was discussed. The first borehole (85-LIF) was installed approximately 30 feet south of remediation well SVE-5 in a location that was considered outside the footprint of the existing petroleum product piping infrastructure. Borehole 85-LIF displayed a robust LNAPL fluorescence interval from approximately 10 to 15 feet bgs with a maximum signal of 72.2 %RE at 10.92 feet bgs. A preliminary review of the waveform patterns from 85-LIF indicated a diesel source was responsible for the fluorescence response.

The investigation proceeded in what was considered a downgradient direction to the south and west of the pump island dispensers and UST basin with the installation of four additional boreholes (86-LIF through 89-LIF). All four of these boreholes displayed waveform patterns indicative of diesel similar to 85-LIF. The

maximum signal response decreased in a downgradient direction from 87.9 %RE at 9.93 feet bgs in 86-LIF to 32.3 %RE at 8.04 feet bgs in 89-LIF, the furthest downgradient borehole.

Next a short transect was initiated extending from south to north along the west side of Pratten Street (Highway 78) on the east side of the Columbus Farmers Union facility. Boreholes 90-LIF through 92-LIF exhibited elevated fluorescence intervals ranging from approximately 10 to 15 feet bgs with signal response tending to increase as the transect moved closer to the pump islands. Waveform patterns encountered remained similar with a likely diesel source. The extremely worn pre-probe solid drive point was replaced after the 90-LIF borehole push when a shipment of additional points that had been ordered previously finally arrived. The last borehole installed at the Columbus Farmers Union facility was sited in an anticipated upgradient direction on the north side of the dispenser pump islands. Borehole 93-LIF was “non-detect” for LNAPL presence.

At this point it was determined that sufficient data had been obtained at the Columbus Farmers Union facility and the investigation returned to the area downgradient of the Former Shortridge Oil Co. facility. Three boreholes (94-LIF through 96-LIF) were installed in a west-east transect in the alley south of Clough Avenue. These boreholes were carefully sited to avoid a private sewer line that extends to a lift station west of South Allen Street. These three downgradient boreholes returned mostly “non-detect” fluorescence responses with the exception of a very thin low-level signal response of 1.4 %RE at 7.58 feet bgs in borehole 95-LIF. After completing these boreholes the field team concluded that the extent and magnitude of the LNAPL plume in the vicinity of the MRL rail yard had been sufficiently delineated and the investigation was deemed complete.

A total of 12 UVOST boreholes (85-LIF through 96-LIF) were completed on this day for a total UVOST drilling footage achieved of 187.35 feet and a total pre-probe drilling footage of 192 feet.

3.0 UVOST Data Analysis

3.1 Survey Control

WCEC surveyed the UVOST borehole locations using a Trimble Geo7x centimeter grade GPS. The raw GPS data was post-processed through Trimble Pathfinder Office software using a continuously operating reference station (CORS) located in Billings, Montana (MTEI). Horizontal coordinates were exported to the North American Datum of 1983 (NAD 83) Montana State Plane Coordinate System in units of US Survey Feet. Vertical coordinates were exported to the North American Vertical Datum of 1988 (NAVD 88) in units of US Survey Feet. Topography data was also procured from a light detection and ranging (LiDAR) survey conducted in 2004 under the direction of the United States Army Corps of Engineers (USACE) and the Yellowstone River Conservation District Council (YRCDC) [USACE and YRCDC, 2015].

3.2 Electrical Conductivity

Electrical Conductivity (EC) measurements are collected simultaneously with the UVOST data and are reported in units of millisiemens per meter (mS/m). The EC data provides an indication of grain size and resulting soil textural class with higher values generally corresponding to increasing silt and clay content. Typically, EC values for coarse grained materials (sand/gravel) are less than 80 to 100 mS/m. EC values for fine grained materials (silt/clay) are generally greater than 100 mS/m and can range up to 300 mS/m or more for clays. Similar to resistivity, which is the inverse of conductivity, deflections in the EC log can be interpreted as changes in lithologic sequences. This is particularly effective when additional lines of evidence are applied to the EC data such as historical monitoring well log information, previous soil boring descriptions, and site-specific soil core examination.

Review of the EC logs obtained during the April/May 2018 UVOST investigation indicates that the majority of the native soil responded with EC measurements less than 100 mS/m, which is consistent with the coarse grained nature of the overall sandy gravel soil matrix. EC measurements greater than 100 mS/m were observed in certain situations, generally at shallow depths less than 10 feet bgs which most likely contain more fines than deeper intervals. An extremely low EC zone was noted in several of the UVOST logs at depths ranging from approximately 6 to 10 feet bgs. This low EC zone seemed to be semi-continuous across the investigation area and appeared to contain larger gravel/cobble which presented difficult drilling conditions for the investigation team resulting in decreased push rates and damaged equipment. There was a correlation between the depth of this low EC gravel/cobble zone and the transition from unsaturated to saturated conditions at the groundwater interface. LNAPL related fluorescence was frequently observed in

this low EC zone and it may be a significant factor in LNAPL transport and downgradient migration based on the assumed enhanced permeability of the coarse grained material.

3.3 UVOST Signal Response

3.3.1 UVOST Signal Response Overview

The UVOST system measures fluorescence signal based on a percent response normalized to a calibration reference LNAPL referred to as the Reference Emitter (RE). A cuvette containing the RE fluid is placed over the sapphire window prior to every UVOST log and returns a fluorescence signal of 100 %RE. All of the fluorescence responses obtained in the subsequent borehole are gauged against this single point calibration. Typically, natural soils have a background fluorescence that corresponds to 0.25 to 0.75 %RE. A signal response greater than 1 %RE may indicate the presence of LNAPL. However, various natural materials including calcareous and carbonaceous soils may produce “false positive” results with signal responses as high as 10 to 20 %RE. Further inspection of the fluorescence response, including analysis of waveform patterns, can aid in determining the likely presence of LNAPL especially when the intensity of fluorescence overlaps possible ranges for false positives. Ultimately, confirmation soil and/or groundwater sampling should be considered to provide additional lines of evidence if a more conclusive determination of LNAPL presence or absence at a particular UVOST location is desired.

The intensity of fluorescence response is influenced by the type and quantity of polycyclic aromatic hydrocarbons (PAHs) contained in a particular LNAPL solvent. For example, a response of 5 %RE for gasoline may be equivalent to a 50 %RE signal for diesel because the PAHs solvated in diesel tend to “glow” brighter on the UVOST system. Soil matrix can also affect fluorescence intensity with an approximately 10-fold increase in response for sands/gravels compared to clay.

The UVOST system is a mature technology that has been proven to be an effective screening tool for LNAPL. UVOST does not respond to vapor or dissolved phase constituents and therefore it is focused on the source term LNAPL only. The results are semi-quantitative; assuming the soil matrix, oxygen concentration, and LNAPL type remain constant, it is generally correct to view increases in %RE response as correlating with higher degrees of LNAPL pore saturation. But UVOST results will not necessarily differentiate between mobile and immobile LNAPL and additional lines of evidence will be required to adequately quantify LNAPL flux and potential for recoverability

As the probe is advanced into the subsurface the UVOST system collects a data point at approximately one inch intervals, producing a high-resolution vertical LNAPL profile. In combination with the intensity of the UVOST signal response, the thickness of the LNAPL profile can be utilized to generally ascertain the degree of

impacts on a site-wide basis in a manner that is consistently more reliable than in-well LNAPL thickness measurements, which can be misleading. The precise vertical LNAPL interval data enables estimations of contaminant mass distribution in relation to stratigraphic sequences and hydrologic horizons that are simply not possible with traditional monitoring well data. Analysis of fluorescence intervals can also provide clues for interpreting site lithology. Continuous signal responses with minor fluctuation may suggest a homogenous matrix whereas noisy responses potentially indicate heterogeneous conditions.

3.3.2 Site-Specific UVOST Signal Response

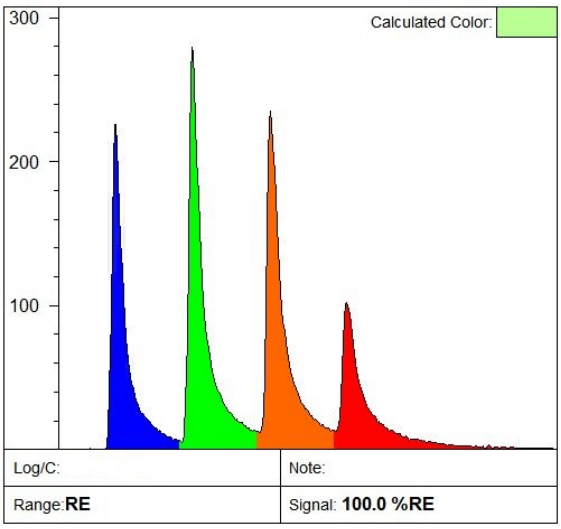
A total of 96 LIF boreholes were advanced during the April/May 2018 UVOST investigation, with 87 boreholes (01-LIF through 84-LIF, and 94-LIF through 96-LIF) completed near the MRL railroad right-of-way and lease properties, and nine boreholes (85-LIF through 93-LIF) completed on the Columbus Farmers Union property. Of the 87 boreholes completed near MRL property, eight boreholes were designated as “non-detect” for LNAPL presence because the maximum signal response was less than 1 %RE (not including false positive fluorescence). Five boreholes experienced shallow refusal. A total of 53 boreholes displayed signal responses greater than 1 %RE but less than 10 %RE, most likely indicating lower levels of LNAPL pore saturation on the margins of LNAPL plume. The remaining 21 boreholes with signal responses greater than 10 %RE represent higher LNAPL pore saturation within the main body of the plume. The maximum signal response recorded was 127.9 %RE at borehole 52-LIF. The average signal response was 28.3 %RE for the 21 boreholes with values greater than 10 %RE. On the Columbus Farmers Union property, UVOST maximum signal responses ranged from 1.4 %RE at 93-LIF to 87.9 %RE at 86-LIF. The average signal response for the eight boreholes (85-LIF through 92-LIF) with values greater than 10 %RE on the Columbus Farmers Union property was 50.9 %RE.

The thickness of LNAPL intervals ranged from a maximum of approximately 14 feet at 38-LIF and 42-LIF to less than 0.1 feet at various locations such as 95-LIF. The majority of the LNAPL response was located at depths greater than 6 feet bgs that correspond to the groundwater interface and saturated smear zone. Significant vadose zone fluorescence responses were encountered at boreholes 34-LIF, 38-LIF, 42-LIF, 46-LIF, and 52-LIF, indicating that these are likely source area locations. Note that any false positive fluorescence was not included in the final data set. Further discussion of false positives can be found in the next section.

4.0 UVOST Waveform Analysis

4.1 Waveform Overview

Waveforms are fluorescence signatures that may be used in an attempt to differentiate LNAPL types, such as gasoline versus diesel. Waveform analysis can also be effective in separating false positives from true LNAPL detections. It is important to note that additional lines of evidence, including co-sampling and careful analysis of soil cores, are required to obtain the maximum benefit of potential diagnostic waveform information. The following discussion is based on a preliminary review of the primary waveform patterns observed at the site. Only generalized assertions are made in this section as to what the different waveform patterns potentially represent. Examples of waveforms for common LNAPL types are included on the last page of the Dakota HRSC UVOST report in Appendix A. Various other waveform patterns for pure PAHs, fuels/oils, weathered gasoline, and false positive substances can be viewed at Dakota's website: http://www.dakotatechnologies.com/learn-more/intro-to-lif/data-interpretation.



100 %RE waveform, RE calibration fluid

The image above is the waveform returned by the RE fluid which is placed on the SPOC sapphire window to calibrate the UVOST system prior to every borehole. The four colored peaks in the waveform (referred to as channels) reflect different PAHs emission wavelengths that are filtered by the UVOST system into four categories: 350 nanometers (blue), 400 nanometers (green), 450 nanometers (orange), and 500 nanometers (red). The shorter wavelength channels on the left side (blue/green) represent smaller PAHs with two to three benzene rings; the middle two channels (green/orange) contain response from intermediate size PAHs with three to four benzene rings; and the rightmost channels (orange/red) correspond to larger PAHs with four or more benzene rings.

The relative contribution of each channel's area to the total waveform area influences the output fill color on the main UVOST log. For example, a waveform with a stronger contribution by the blue channel relative to the other three channels will plot with a bluish color on the UVOST log. In the case of the RE waveform, the calculated color is a pale green that is displayed in a box in the upper right hand corner of the waveform plot window.

On the waveform graph, the y-axis represents the intensity of the fluorescence signal and the x-axis is time. The four waveform channels are sequentially delayed by the UVOST system so that they will plot separately on the graph. The amplitude of each channel corresponds to the maximum energy released by the PAHs following the excitation by the UVOST laser pulse. The time it takes for the excitation energy to dissipate is recorded by the decay curve to the right of the peak. The width of each channel measured along the x-axis at the point where all of the excitation energy has been released is referred to as that channel's "lifetime." In general, longer lifetimes are diagnostic of LNAPL as opposed to false positive substances, which usually have shorter lifetimes and narrower peaks. Other factors that may influence waveform morphology should also be considered including quenching (i.e., shortening) of lifetimes caused by energy transfer from the excited PAHs to the surrounding matrix, larger PAHs, or an oxygen rich environment.

4.2 Waveform Cluster Plots Overview

Cluster plots provide a method for viewing the waveform data in the context of a Cartesian coordinate system. Each individual waveform collected from the UVOST log is represented by a point on that borehole's cluster plot. In this fashion, all of the waveforms from a borehole can be viewed in a single figure allowing intuitive comparisons to be made among potential fluorescence categories. Cluster plots from all of the UVOST boreholes are included as Appendix B.

The x-axis of the graph corresponds to the balance of the four colored channels in the waveform. If the waveform is predominately comprised of the blue and green channels, then the point on the cluster graph will plot on the left side of the x-axis. Alternatively, if the orange and red channels make up the majority of the fluorescence response, the cluster plot point will appear on the right side of the graph. Waveforms with a relatively equivalent contribution from all four channels, or with the two central peaks dominating, will plot somewhere in the middle.

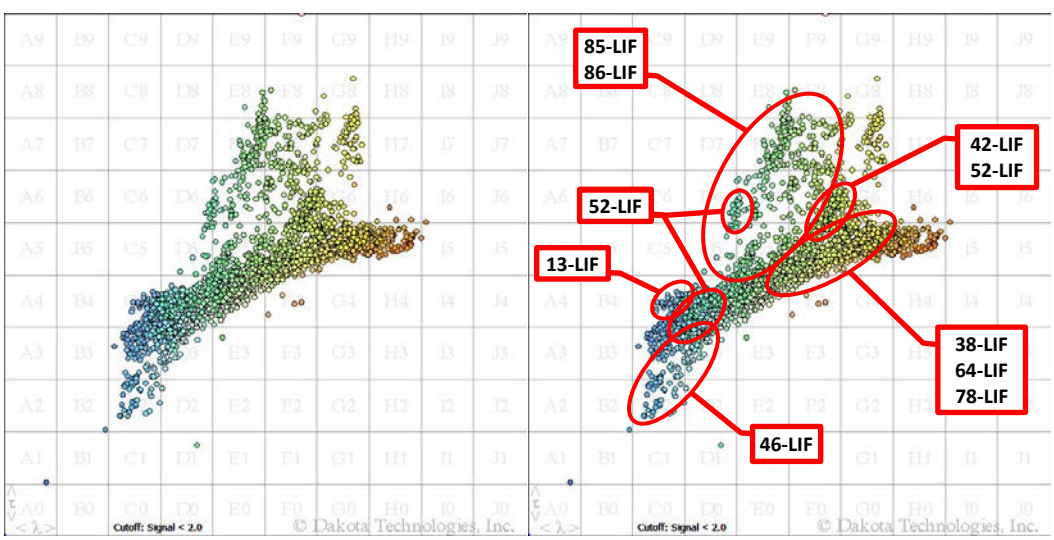
The y-axis relates to fluorescence decay or "lifetimes" of the four waveform channels. In simple terms, the longer the lifetimes are in a given waveform (wide at the base), the higher it will plot on the y-axis in the cluster graph. Waveforms with short lifetimes (narrow at the base) will plot on the lower half of the graph. In an effort to provide the maximum possible spread for common LNAPL types to plot in the graph window, the exact placement of the waveform point on the y-axis is actually dependent upon a ratio of the second, third, and fourth channel's lifetimes divided by the first, not simply the sum of the lifetimes of all four

channels. However, complete comprehension of this subtlety in the y-axis formulation is not required to successfully interpret the plots. It suffices to conceptually view the y-axis as generally correlating with lifetime duration while acknowledging that the software will plot some points higher or lower than others to provide separation between classic LNAPL types based on bench-scale tests.

The color of the points on the cluster plot corresponds to the output color of all four channels on the UVOST log. For example, if the point is colored blue then the waveform for which it represents came from the depth on the UVOST log that also exhibits blue coloring. To further aid in determining the source on the UVOST log for a point cluster, the main callouts from the log with their respective depth intervals are depicted on the upper left corner of the cluster plot. Polygons (for depth ranges) and circles (for discrete depths) with the same coloration as the callout waveform enclose the point clusters included in that callout.

4.3 Site-Specific Waveform Discussion

The cluster plots displayed below represent the cumulative waveforms from all of the UVOST data obtained during the April/May 2018 UVOST investigation. Individual cluster groups from selected locations are highlighted in the graph on the right side of the panel. The characteristics of the waveforms from these selected groups are examined in the following paragraphs. In the discussion below, the cumulative cluster plot has been further grouped into four sections relating to the region of the site where the UVOST data was obtained, starting from the northwest (upgradient) portion of the investigation area and moving southeast (downgradient). A fifth cluster plot section was added for the data collected from the Columbus Farmers Union facility.

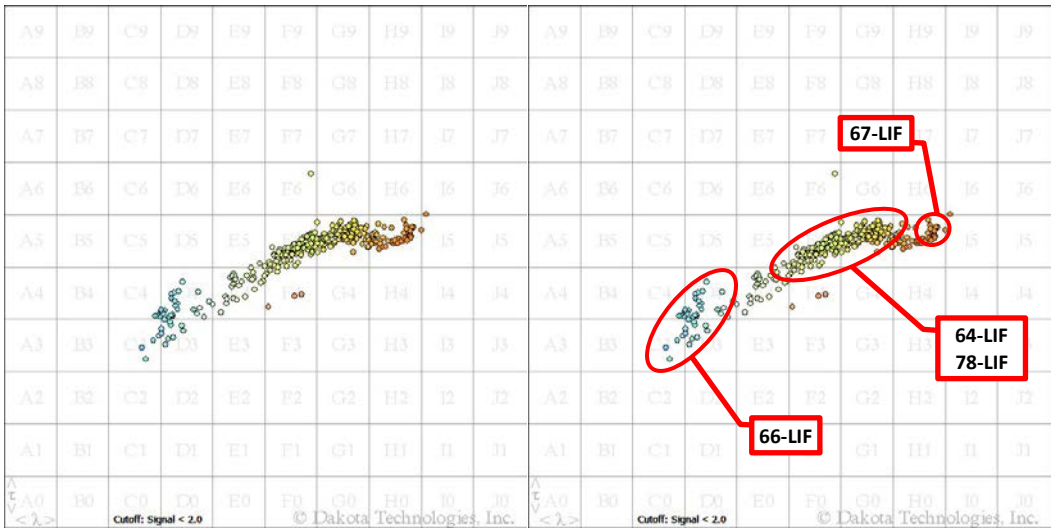


Cluster plot, all waveforms, with selected waveform clusters shown on right.

Note that in the cluster plots a signal cutoff of 2 %RE was utilized to remove background signals from the plot and emphasize potential LNAPL responses only. Natural background fluorescence responses generally plot in cells F5 and G5 on the cluster plot graphs as can be seen in Appendix B. A colored polygon is included on each cluster plot to highlight the location where the selected waveform is plotting on the graph.

4.3.1 North of Pike Avenue (Old U.S. Highway 10) – Boreholes 64-LIF to 78-LIF

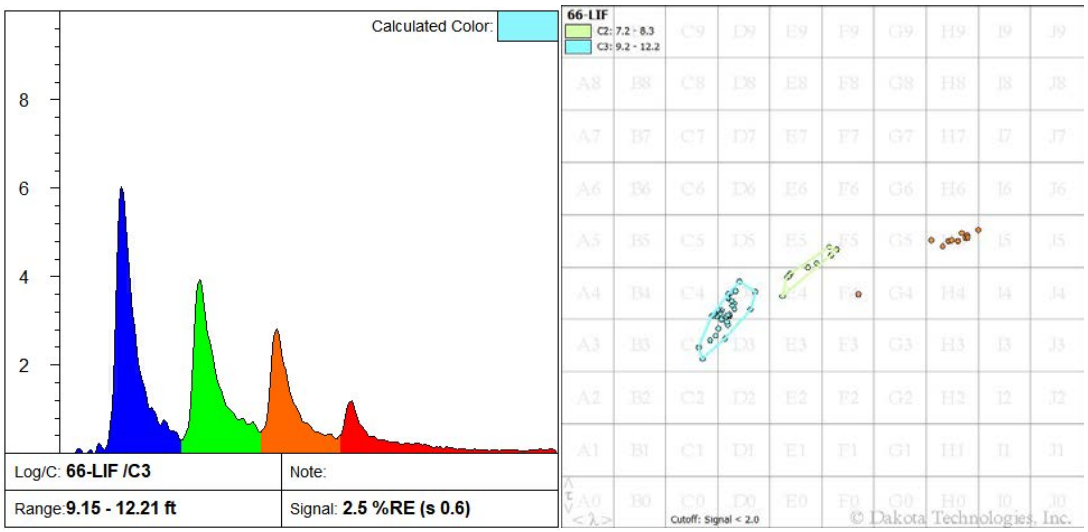
The cluster plot graphs below depict waveforms obtained from boreholes 64-LIF through 78-LIF completed north of Pike Avenue in the vicinity of the Former Newman's Downtown Exxon and Former Platinum Motors facilities.



Cluster plot, 64-LIF to 78-LIF, with selected waveform clusters shown on right.

The waveform points from this area generally plot along a lineal trajectory extending from cell C2 on the left to cell H5 on the right. This type of cluster plot pattern with a continuum of points aligned in a lineal or arc shape is usually indicative of weathering of a single LNAPL type, such as gasoline for example. However if multiple LNAPL types are present, it is possible the difference in waveform patterns observed across the cluster plot continuum could be the result of the presence of distinct LNAPL types, or possibly the mixture of more than one LNAPL type. Additional lines of evidence, such as collocated analytical data, would need to be gathered to confirm the hypothesis that the continuum pattern observed on the cluster plot graph is related to differential weathering of gasoline and not multiple distinct LNAPL types that may or may not be mixed.

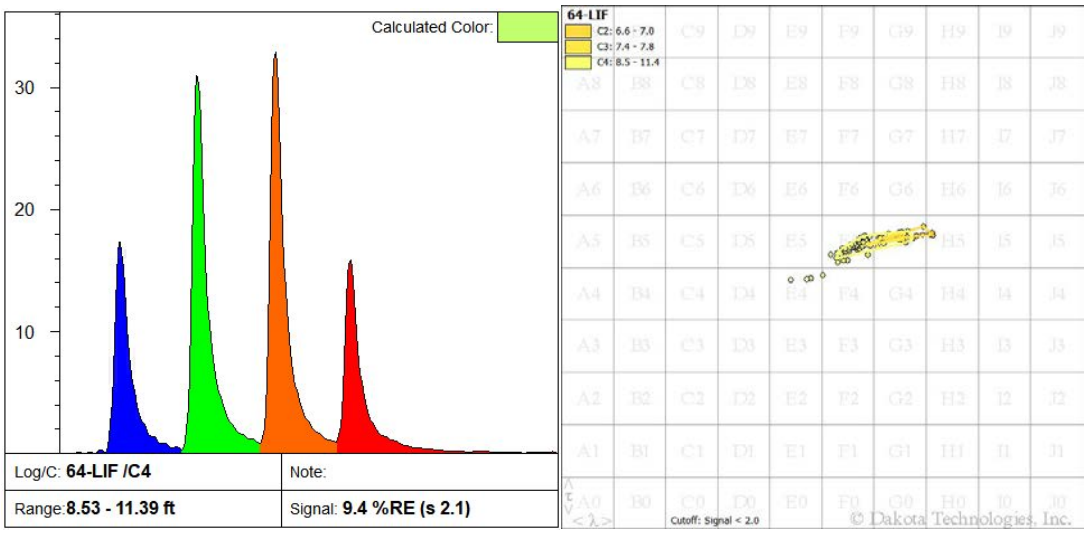
The waveform at the top of the following page was harvested from 66-LIF at a depth range of 9.15 to 12.21 feet bgs. This waveform exhibits a prominent blue channel and a diminished red channel with a resultant log output color that is light blue. The corresponding waveform points plot on the left side of the cluster graph, in columns C/D and rows 3/4.



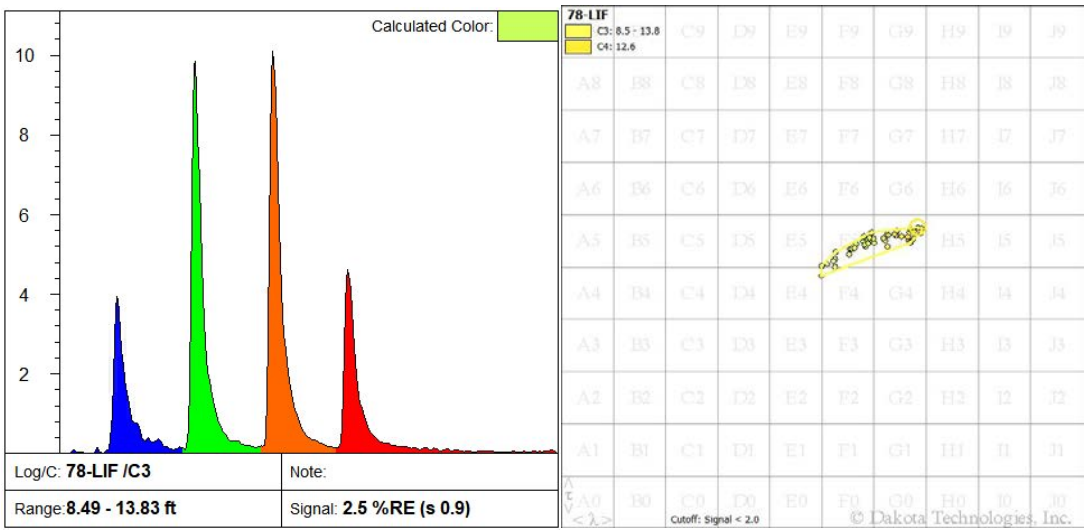
66-LIF waveform (callout 3) and cluster plot.

The 66-LIF waveform is primarily influenced by the blue channel. Waveforms with dominant blue channels may represent LNAPL types containing lighter range PAHs, such as gasoline, kerosene, or jet fuel. Persistence of the blue channel may also indicate that the LNAPL is more intact (i.e., less weathered) since the smaller PAHs responsible for the blue channel are generally more susceptible to weathering processes and biological degradation. Given time and exposure to conditions favorable for weathering, the smaller PAHs will be selectively removed from the matrix and as a result the blue channel can appear diminished in a waveform obtained from a weathered LNAPL.

The following two waveforms collected from 64-LIF and 78-LIF plot near the right side of the cluster plot continuum.



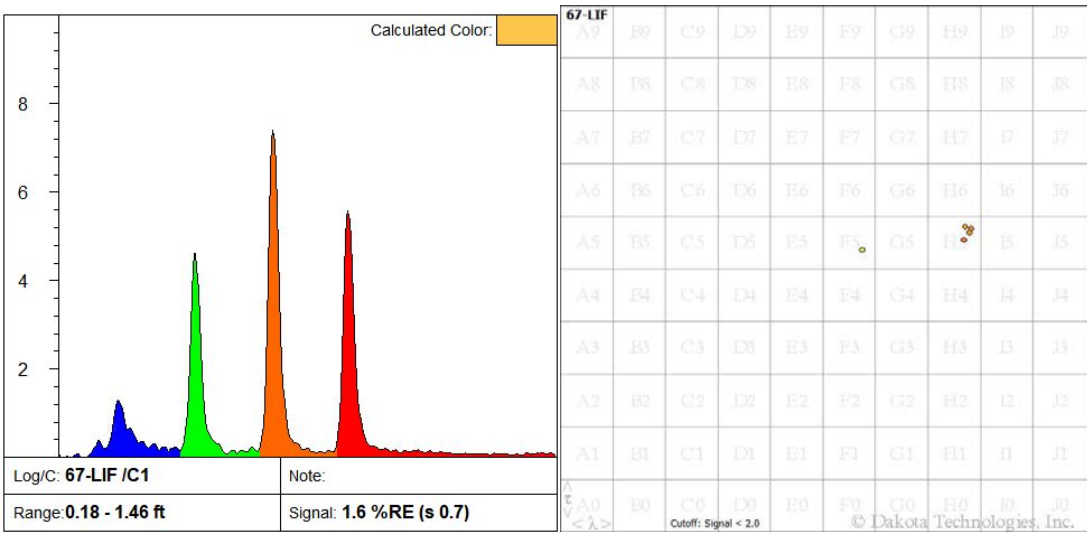
64-LIF waveform and cluster plot.



78-LIF waveform and cluster plot.

The decreasing prominence of the blue channel moving from left to right along the cluster plot continuum may reflect the loss of lighter range PAHs as a result of weathering processes and biologic activity. In this case, the waveforms are described as being "red-shifted", as the persistence of the larger PAHs in the matrix shifts the balance of the four channels from left to right towards the red channel. If the blue waveform colors on the left side of the cluster plot continuum represent intact gasoline, then the light green to yellow waveform colors on the right side may represent a weathered gasoline that has been "red-shifted." Bench scale tests completed by Dakota in which controlled experiments of weathering gasoline caused "red-shifting" of fluorescence from blue to green to yellow along a continuum support this conclusion.

The waveform below was harvested from 67-LIF at a depth range of 0.18 to 1.46 feet bgs.

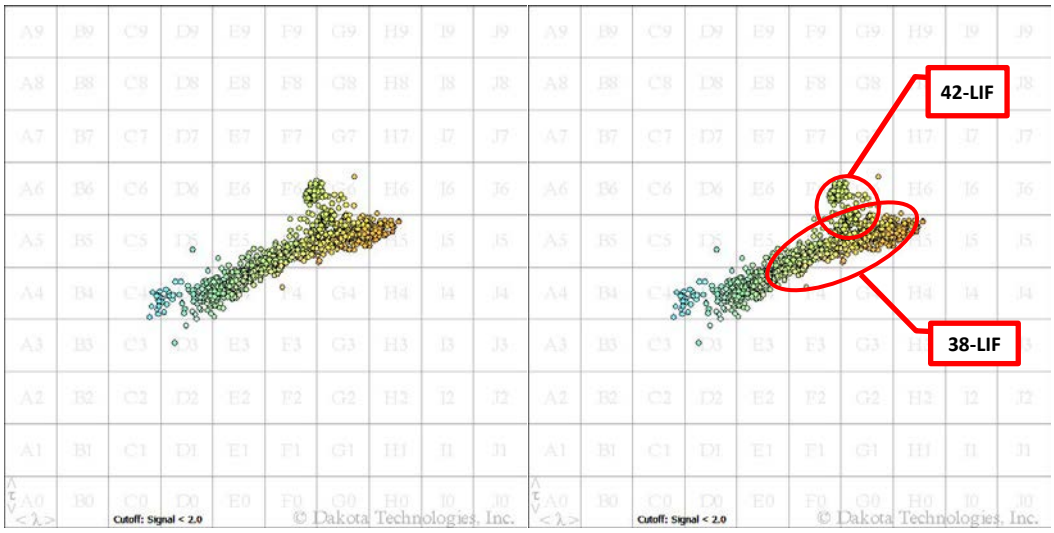


67-LIF waveform and cluster plot.

The maximum signal response for 67-LIF was 3.3 %RE at 0.19 feet bgs. This is greater than the typical threshold value indicating a non-background, LNAPL response (1 %RE). However, since the waveform was obtained from the shallow subsurface underneath a paved roadway (Pike Avenue), it is possible that a false positive material associated with road construction activities, such as asphalt, was responsible for the fluorescence in this zone. Review of the waveform channels reveals short lifetimes with narrow peaks, which are often associated with false positives. On the cluster plot the waveform points for 67-LIF are located in the upper right corner of the point continuum (cell H5), which is not a typical cluster location for the LNAPL encountered at the site. For these reasons, the fluorescence response at 67-LIF was categorized as a false positive response and filtered out of the data set. Consequently 67-LIF was designated as a "non-detect" location.

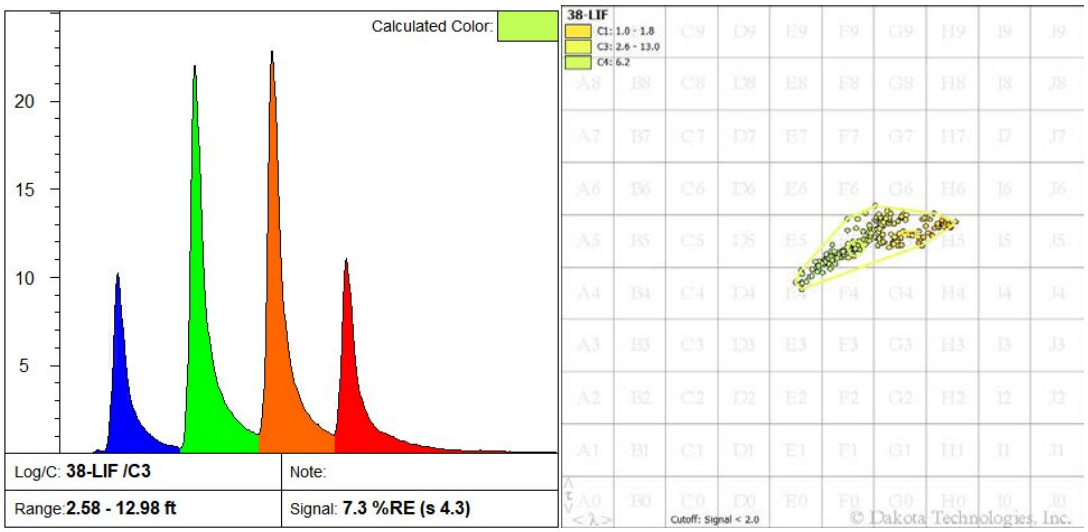
4.3.2 North MRL Lease Property – Boreholes 31-LIF to 43-LIF, 79-LIF, and 80-LIF

The cluster plots displayed at the bottom of this page represent waveforms recorded in boreholes installed on the MRL lease property north of the railroad and south of Pike Avenue. This includes boreholes 31-LIF through 43-LIF, 79-LIF, and 80-LIF. Similar to the cluster plot graphs evaluated in the previous section from boreholes advanced north of Pike Avenue, there is a continuum of points on the north MRL lease property cluster plots that suggests different stages of weathering of a single LNAPL type, such as gasoline. The two highlighted waveform clusters on the right side of the panel came from 38-LIF and 42-LIF. Both of these boreholes contained significant vadose zone fluorescence intervals indicative of proximity to an LNAPL point of origin (i.e., source). The waveform clusters from 38-LIF plot along the weathering continuum line, while the cluster plot points from 42-LIF group slightly higher.



Cluster plot, 31-LIF to 43-LIF, 79-LIF, and 80-LIF, with selected waveform clusters shown on right.

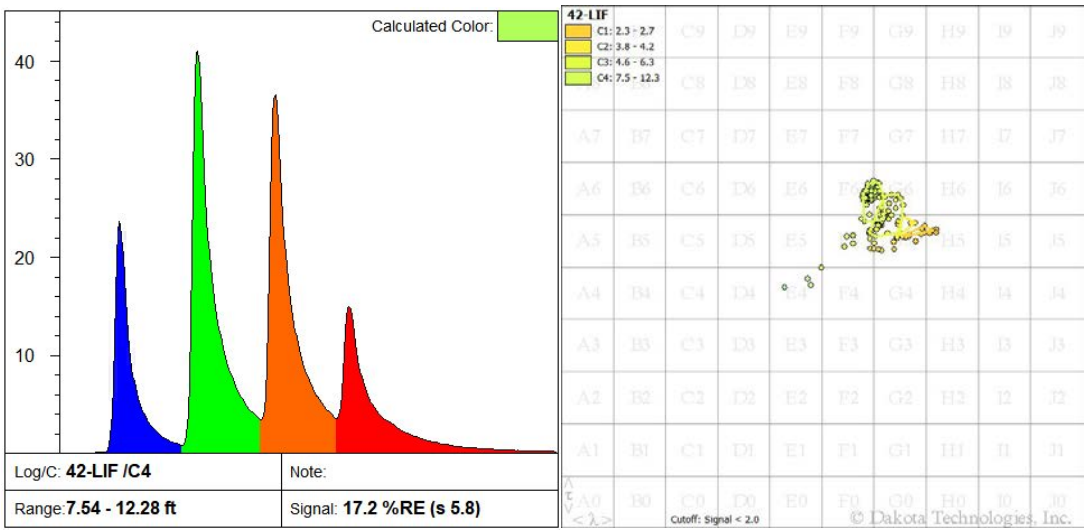
The waveform below was harvested from 38-LIF at a depth interval of 2.58 to 12.98 feet bgs, which essentially covers the entire depth range of fluorescence observed at this location.



38-LIF waveform and cluster plot.

The waveform clusters from 38-LIF plot from the middle to the right of the weathering continuum line, indicating that the LNAPL responsible for the fluorescence may be weathered gasoline. Inspection of the 38-LIF UVOST log supports this conclusion, as the banding in coloration from yellow to green is emblematic of a weathered gasoline response. The yellow fluorescence bands on the 38-LIF UVOST log near the surface potentially represent more degraded gasoline that has been subjected to increased weathering as a result of the elevated oxygen content and biological activity in the shallow subsurface. The waveform cluster points from this yellow fluorescence plot on the far right side of the cluster graph. The green fluorescence bands on the 38-LIF UVOST log may signify a less weathered gasoline response and consequently the waveform clusters plot more near the middle of the weathering continuum.

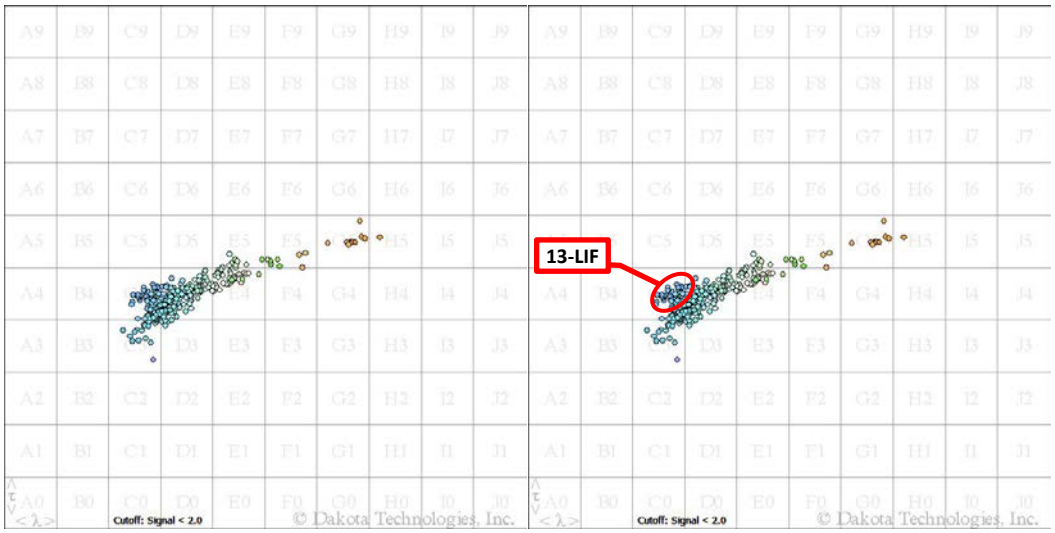
The waveform collected from 42-LIF at 7.54 to 12.28 feet bgs is shown in the panel at the top of the following page. Note that the relative amplitudes of the 42-LIF waveform channels are similar to the 38-LIF waveform, with the central two peaks dominating. However, the 42-LIF waveform displays slightly longer lifetimes in the three right-most channels and as a result the waveform cluster points plot higher on the cluster plot graph, just above the typical trend of the weathering continuum line. Similar to 38-LIF, the waveform pattern and resultant cluster plot from 42-LIF are consistent with a weathered gasoline response, although the subtle deviation from the weathering continuum line evident in the 42-LIF waveform clusters may signify the presence of an LNAPL type with a slightly different chemical composition.



42-LIF waveform and cluster plot.

4.3.3 Middle Rail Line – Boreholes 01-LIF to 23-LIF

The cluster plots below represent waveforms obtained from boreholes 01-LIF through 23-LIF which were installed in the MRL right-of-way. Note that these points also correspond with the weathering continuum line discussed previously, primarily on the intact (left) side of the continuum. The fluorescence encountered in these middle rail line boreholes was relatively deep, approximately 10 to 14 feet bgs, which is 1 to 5 feet below the static water level recorded at the time of the investigation.

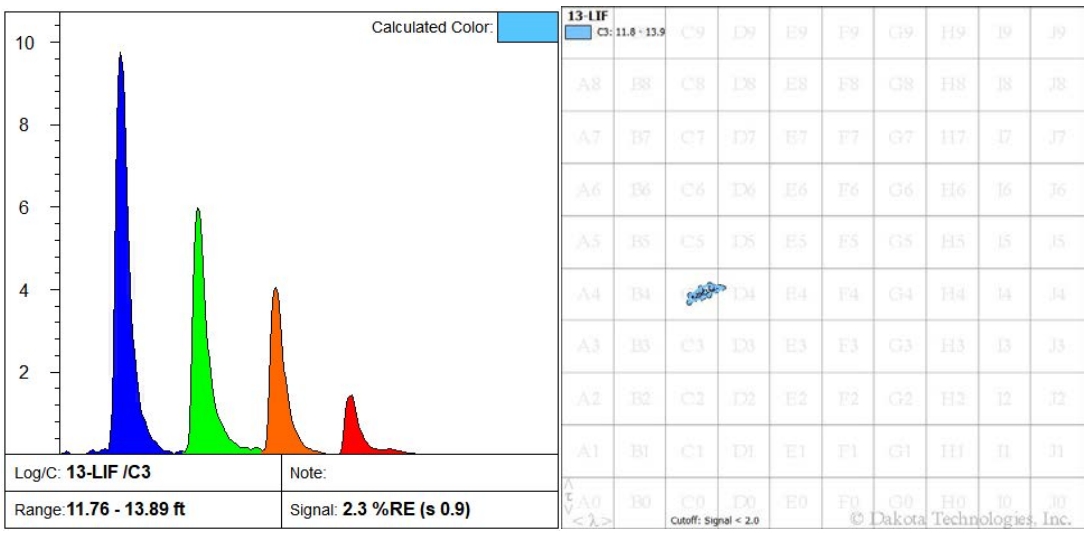


Cluster plot, 01-LIF to 23-LIF, with selected waveform clusters shown on right.

One possible explanation for the relatively intact response at these downgradient locations is that the LNAPL became entrapped at depth during a period of low water levels followed by higher water conditions. Natural

attenuation processes are usually limited in the principally anaerobic environment present at depth within the water column, and as a result the LNAPL retained an intact fluorescence profile.

An example of a waveform obtained from with the MRL right-of-way is represented by 13-LIF in the panel below. This waveform was harvested from a depth of 11.76 to 13.89 feet bgs. The blue channel is dominant in this waveform, and the cluster points plot on the left side of weathering continuum line.

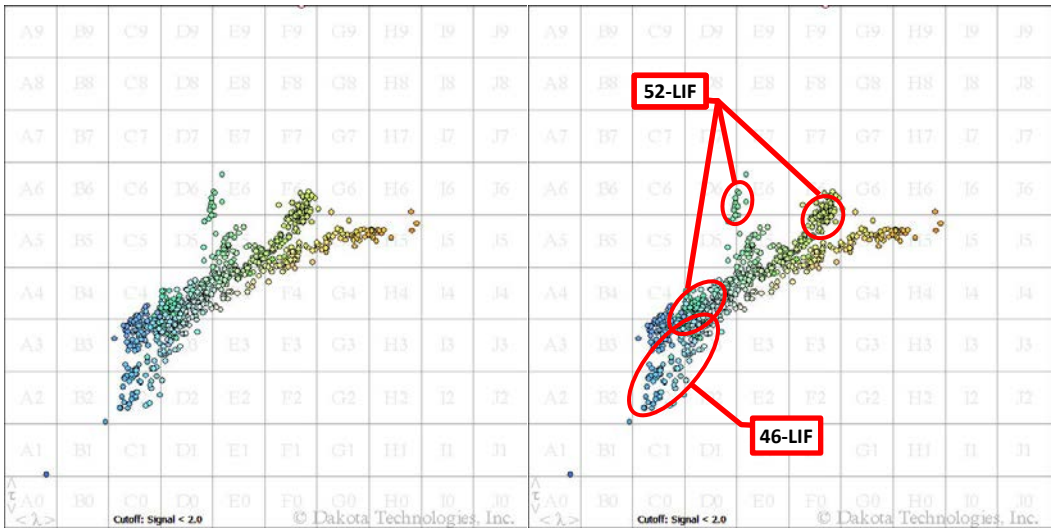


13-LIF waveform and cluster plot.

Note that the 13-LIF waveform channels are relatively narrow with short lifetimes. Short lifetimes may be an indication of a false positive substance that is unrelated to the LNAPL of interest to the UVOST investigation. However, since naturally occurring fluorophores do not produce waveforms that are blue dominant it is a generally accepted practice to view a blue waveform as a positive LNAPL response. In the case of 13-LIF, corroborating evidence for LNAPL presence at this depth is provided by data from adjacent boreholes with similar responses.

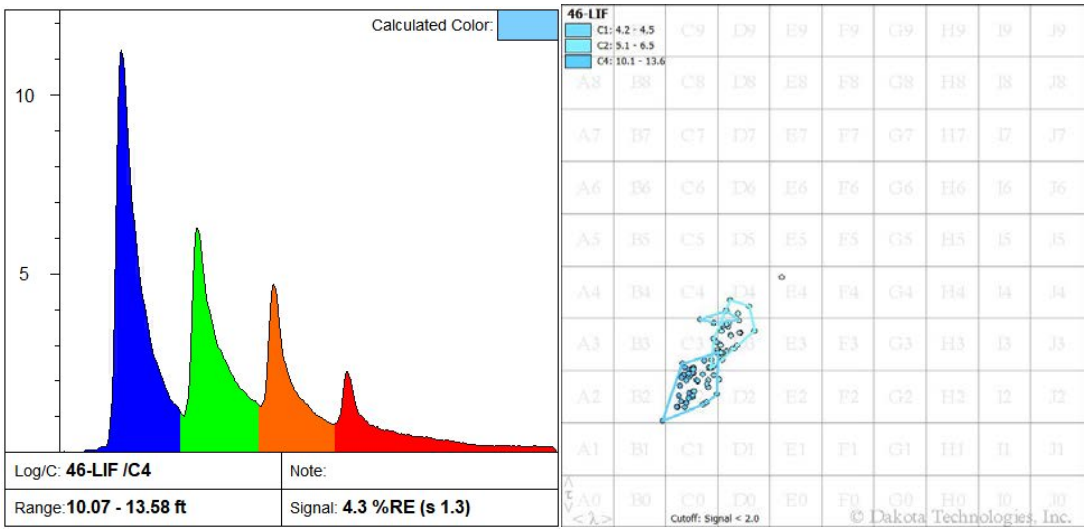
4.3.4 South MRL Lease Property – Boreholes 44-LIF to 63-LIF and 81-LIF to 83-LIF

The cluster plots displayed at the top of the following page represent the waveforms collected on the MRL lease property south of the railroad, in the vicinity of the Former Shortridge Oil Co. facility. This includes boreholes 44-LIF through 63-LIF and 81-LIF through 83-LIF. The typical weathering band continuum line observed at other locations in the investigation area that extends diagonally across the cluster plot graph is also evident in the data obtained south of the railroad. However, there are some deviations in the cluster plots from this linear weathering continuum that suggest there may be some heterogeneity to the LNAPL composition near the Former Shortridge Oil Co. facility.



Cluster plot, 44-LIF to 63-LIF and 81-LIF to 83-LIF, with selected waveform clusters shown on right.

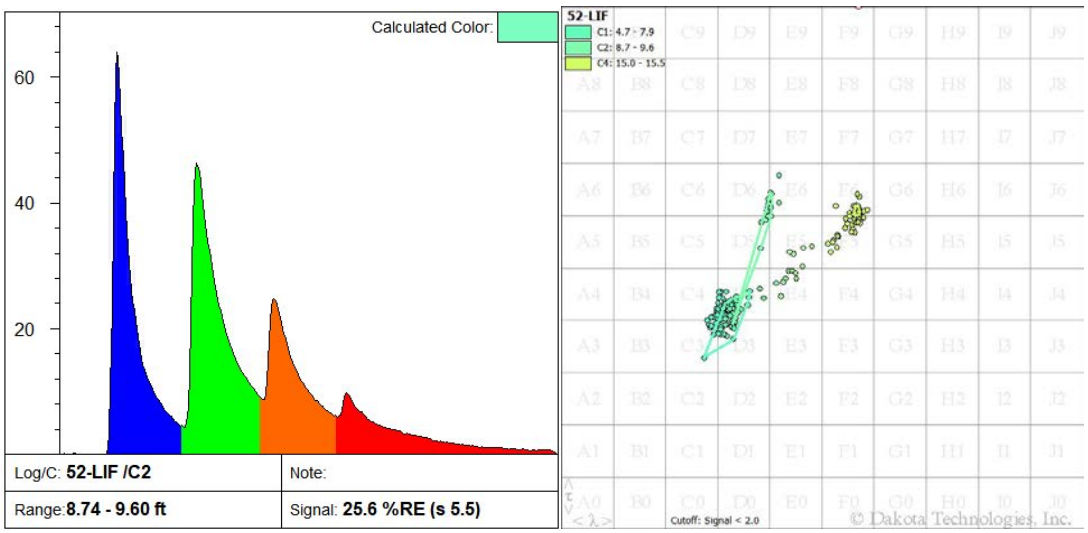
The waveform obtained from borehole 46-LIF at 10.07 to 13.58 feet bgs is shown in the panel below. Borehole 46-LIF was installed near the footprint of a former pump island dispenser concrete pad. Vadose zone fluorescence responses indicative of a source area were recorded in the 46-LIF borehole log starting at approximately 4 feet bgs.



46-LIF waveform (callout 4) and cluster plot.

The 46-LIF waveform contains a prominent blue channel with decreasing amplitude of the three right-most channels in a stair step pattern. The waveform cluster points plot on the intact (left) side of the weathering continuum consistent with a gasoline response.

A waveform and cluster plot from 52-LIF is shown in the panel below. Note that there are three distinct cluster group locations in the 52-LIF borehole, two of which plot higher than the typical location for the weathering band continuum line. The waveform displayed on the left side of the panel was collected from 8.74 to 9.60 feet bgs and corresponds to callout 2, which is the cluster group residing near the boundary between cells D6 and E6. This waveform has much longer lifetimes in the three right-most channels relative to the first, which is characteristic of a diesel waveform. This may signify that there is a diesel component to the LNAPL responsible for the fluorescence observed at 52-LIF.

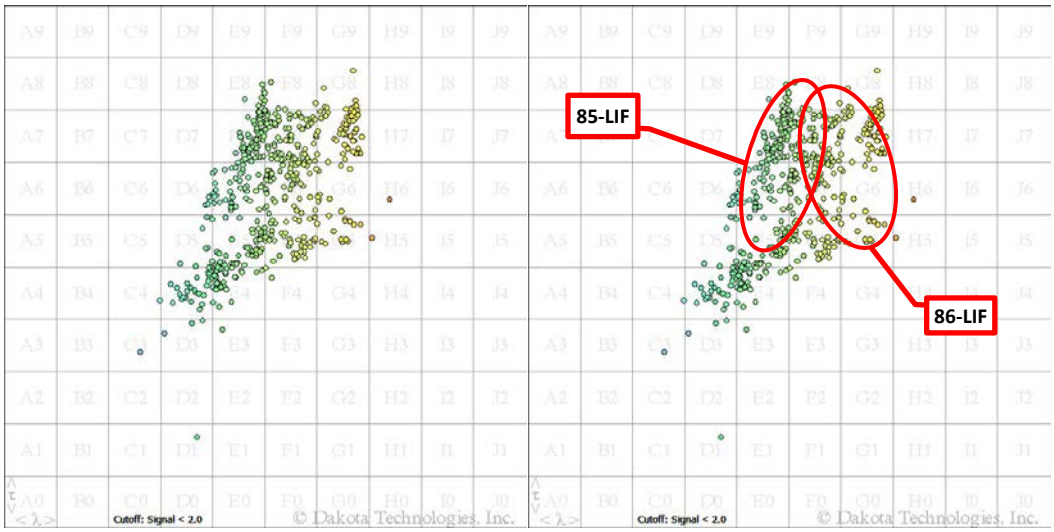


52-LIF waveform and cluster plot.

Borehole 52-LIF was installed near the location of a former UST according to historic site diagrams from the Former Shortridge Oil Co. facility. Vadose zone LNAPL response was observed in the 52-LIF borehole starting at approximately 4.5 feet bgs, indicating that this is likely a source area location. The variety of waveform patterns and resulting cluster plot groups in the 52-LIF borehole provides evidence that there may be more than one LNAPL type present at this location.

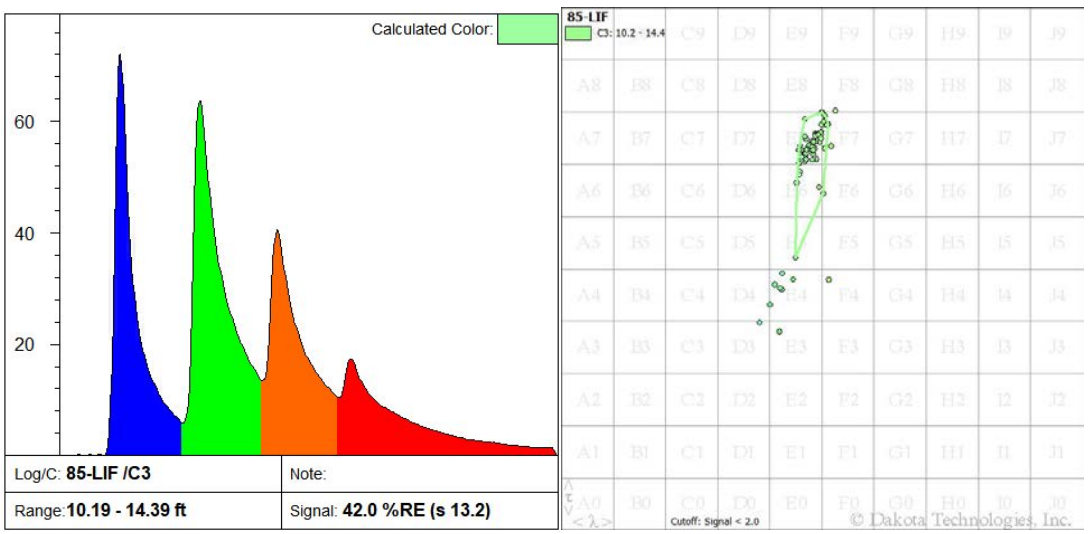
4.3.5 Columbus Farmers Union – Boreholes 85-LIF to 93-LIF

The cluster plot graphs at the top of the following page represent the waveforms collected at the Columbus Farmers Union facility (85-LIF through 93-LIF). A triangular shape is evident in the Columbus Farmers Union cluster plot graphs that differs from the previously discussed linear weathering band continuum presumed to be associated with gasoline. The majority of the cluster groups in the Columbus Farmers Union data plot higher on the graph, and individual borehole cluster plots tend to have more of a vertical orientation to the point grouping than found in the diagonal weathering continuum line.

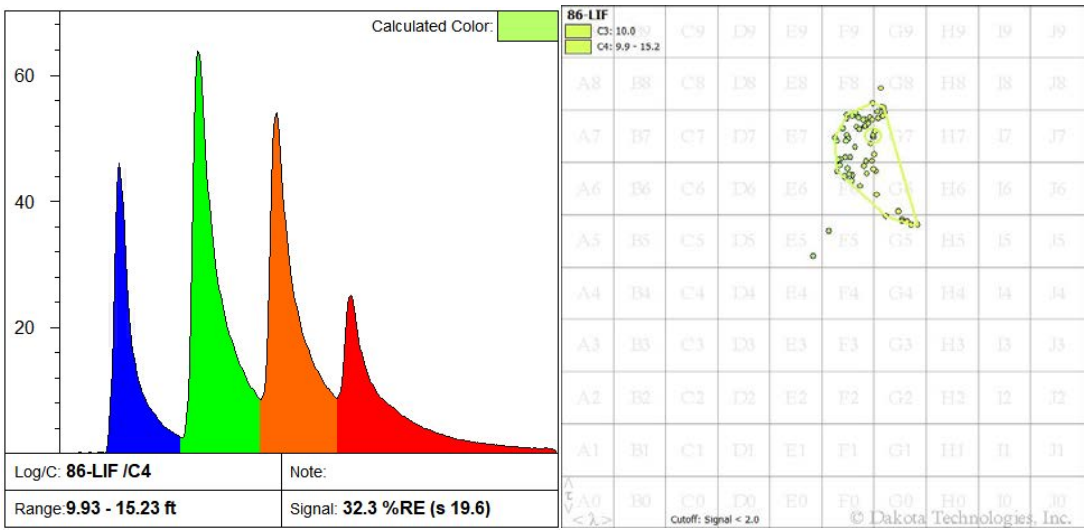


Cluster plot, 85-LIF to 93-LIF, with selected waveform clusters shown on right.

Two example waveforms from the Columbus Farmers Union facility are shown in the panels below. Both of the waveforms from boreholes 85-LIF and 86-LIF exhibit long lifetimes, particularly in the three right-most channels. The waveform clusters plot in the upper middle portion of the cluster diagram and tend to have a vertical orientation in the point spread. The blue channel is slightly diminished in the 86-LIF waveform which shifts its cluster plot points to the right of 85-LIF, from column E to column F.



85-LIF waveform and cluster plot.



86-LIF waveform and cluster plot.

The waveform patterns obtained from the Columbus Farmers Union facility are consistent with a diesel response. The elevated signal responses and relatively monochromatic fluorescence observed are also characteristic of diesel. This correlates with the most recent groundwater analytical results at the facility in which several monitoring wells contained diesel range dissolved phase constituents.

5.0 Integrated Site Visualization

5.1 Integrated Site Visualization Overview

The post-processed GPS survey coordinates were merged with the UVOST data set to create an Integrated Site Visualization (ISV) where the fluorescence responses could be visualized in a geospatial context. This merged data set was then filtered to decrease the density of "non-detect" results to approximately one measurement per foot. In zones of elevated fluorescence response indicating LNAPL, higher signal responses were preferentially retained over lower responses. Favoring maximums in this manner decreases the "noise" which is common in UVOST data collected in heterogeneous substrates that exhibit LNAPL mottling. In practical terms, greater weighting of maximum data points results in the creation of a more continuous plume body than if all of the data were included in the 3D model creation.

The filtered data set was kriged using algorithms developed by C Tech Development Corporation (C Tech) in their Earth Volumetric Studio (Studio) software. High resolution aerial photography was overlaid with the kriged output to provide spatial reference for facility structures and roads. Topographic elevation data for the surrounding area was incorporated via a digital elevation model (DEM) surface derived from a LiDAR survey conducted in 2004 [USACE and YRCDC, 2015]. Select monitoring well locations are displayed to provide reference for dissolved phase data collection points. The following sections review the results of the ISV creation process.

5.2 2D Contour Map of Maximum %RE

Figures 4 and 5 display 2D contours of the UVOST data maximum %RE. 2D contour maps of UVOST data represent the simplification of what is inherently a 3D data set. Only the maximum data point is retained at each borehole location, and this data is kriged relative to each other in a hypothetical flat plane that does not account for the actual elevation where the data point was collected. 2D contour maps are valuable as an introductory step for viewing UVOST data, particularly in the field as the investigation is ongoing. It is important to note that the footprints and relative intensities of 2D and 3D plume depictions will most likely not correspond exactly with each other. The 3D plume depiction is the more comprehensive of the two methods and is the preferable way to ultimately view the data.

The maximum UVOST signal response recorded at each location is listed underneath the borehole symbol on Figures 4 and 5. Boreholes which did not exhibit LNAPL related fluorescence response are labeled with "ND" to signify that they were "non-detect." Refusal locations that failed to reach the target depth are labeled "R"

to signify refusal. Data from the refusal boreholes was not included in the 2D contour map kriging calculations since no data was obtained from the targeted LNAPL interval at these locations.

In Figure 4, the blue coloring on the margin of the plume represents signal responses that are between 1 %RE and 2 %RE. In the center of the plume, the orange and red coloring depicts signal responses greater than 4 %RE. In Figure 5 the contour levels are approximately 10 times greater, with blue representing 10 %RE to 20 %RE and orange/red signifying response above 40 %RE. As can be seen in Figure 4, there is a consistent spatial relationship among the UVOST signal responses, with a relatively clear gradation in fluorescence intensity from the center to the margins of the plume. This suggests that the LNAPL body near the MRL railroad has been adequately bounded by the data collected during the UVOST investigation, with the possible exception of the southeastern edge of the plume where the contour lines in the map are not entirely enclosed. A linear axis for the plume is also evident in the 2D contours shown on Figure 4, with a northwest-southeast orientation. This plume axis generally correlates with the slope of the local surface topography and the anticipated groundwater flow direction to the southeast.

5.3 3D Model Generation

5.3.1 Top View PDFs

Static top view representations of the UVOST data 3D plume near the MRL railroad are included as Figures 6 through 10. The 3D plume is displayed with the following solid color contours: 1 %RE (cyan), 2 %RE (green), 3 %RE (yellow), 4 %RE (orange), and 5 %RE (red). Volume measurements which represent the total volume of LNAPL impacted soil derived from the UVOST 3D data with plume isolevels of 1 %RE up to 5 %RE are provided on the figures. The volume calculations ranged from a maximum of 24,796 cubic yards for the 1 %RE plume shell to 1,563 cubic yards for the 5 %RE plume shell.

5.3.2 3D PDFs

Figures 11 through 14 are interactive 3D PDFs that display perspective and side views of the 3D plume near the MRL railroad with topography and aerial imagery overlaid. Vertical exaggeration of the 3D visualization is five times the horizontal dimension. Left click on the PDF figure with the mouse to activate the 3D content. Instructions for manipulating the 3D PDF viewer with mouse controls are listed in the lower left corner on each figure. A link to an Adobe Acrobat help page is included which details the process to enable playing of 3D content in a PDF document. Go to Edit-->Preferences-->3D & Multimedia and check “Enable playing of 3D content.” After the 3D content has been activated, right click on the figure with the mouse and select “Full Screen Multimedia” to transition to a full screen view if desired. Note that 3D PDFs will not function inside of

a web browser. This report document will need to be downloaded locally to disk for the 3D PDF content to display properly.

The 3D PDF figures are structured in a similar fashion to the 4DIM files described in the following section. The files are organized into four basic categories based on content: isolevel (Figure 11), horizontal slice (Figure 12), easting slice (Figure 13), and northing slice (Figure 14). The isolevel 3D PDF figure shows the LNAPL plume at the minimum threshold value of 1 %RE. The slice figures cut away the plume using slice planes based on the three primary orthogonal angles (horizontal, easting, and northing). The vertical slice planes have been rotated to align parallel with either the plume axis (easting slice, 145 degrees) or the UVOST borehole transects (northing slice, 108 degrees). In contrast to the 4DIM files which have several scenes or "states", the 3D PDFs only contain a single state, and should be considered simplified versions of the 4DIM files. Unlike the 4DIM files, the 3D PDFs do not require external viewer software and can be opened directly out of this document assuming the Adobe Acrobat preferences have been set correctly.

5.3.3 4DIMs

Interactive 3D viewer files, called 4DIMs, can be downloaded from the project website [WCEC, 2018]. Individual links to download the 4DIM files and the 4DIM player are also included in the list of 4DIMs following the figures section. According to C Tech, the term 4DIM stands for Four-Dimensional Interactive Model, referring to its capability to display different states of a 3D visualization over time (the fourth dimension). In order to view the 4DIM files, a 4DIM player must be downloaded and installed on the user's computer. The 4DIM player is offered as a free download by C Tech and only takes a few minutes to install. Once the player has been installed, double click on the 4DIM file and it will automatically open inside the player. Move the slider bar at the top of the screen to step through states in the 4DIM. Use the mouse to pan, rotate, and zoom the 3D model. Select the "Snapshot" button to output image files of the current view on the screen.

There are four 4DIM files posted on the project website depicting the LNAPL plume near the MRL properties. As mentioned previously, the content of the 4DIMs is similar to the 3D PDFs, with additional states included. The UVOST isolevels 4DIM steps through the plume isolevels from 1 %RE to 5 %RE and calculates volumes on the screen for each isolevel. The horizontal slices 4DIM displays cuts through the plume at one foot intervals with a horizontal slice plane starting at 3,581 feet above mean sea level (amsl) and ending at 3,564 feet amsl. The easting and northing slices 4DIMs contain vertical slices that step through the LNAPL plume from west to east and south to north, respectively. Only boreholes within 20 feet of the vertical plane are visible during each slice to emphasize the locations providing data for the current slice view. For the easting slices 4DIM, the slice plane azimuth has been rotated to a bearing of 145 degrees to align with the major axis of the LNAPL plume. In the northing slices 4DIM, the slice plane azimuth was rotated to a bearing of 108 degrees to match the orientation of the majority of the UVOST borehole transects.

6.0 Summary & Discussion

6.1 UVOST Investigation Summary

WCEC and Dakota performed the UVOST investigation in Columbus, MT from April 23 to May 2, 2018. A total of 96 UVOST boreholes were installed during the investigation. Of this total, 87 boreholes (01-LIF through 84-LIF and 94-LIF through 96-LIF) were advanced near the facilities adjacent to the MRL railroad including Former Newman's Downtown Exxon, Former Platinum Motors, MRL (Former Shell Oil Co.), and MRL (Former Shortridge Oil Co.). The remaining 9 boreholes (85-LIF through 93-LIF) were completed at the Columbus Farmers Union facility. The data from the UVOST boreholes completed near the MRL railroad were integrated with GPS survey measurements to generate an ISV of the LNAPL plume at the site.

Very difficult drilling conditions were encountered in the dense sandy gravel substrate underlying the project area. A substantial amount of damage to the most sensitive components of the UVOST tooling occurred during the first 2.5 days of the investigation. Starting with borehole 32-LIF, all UVOST boring locations were pre-probed to the target terminal depth of approximately 16 feet bgs to create a pilot hole for the UVOST probe. This method was successful in minimizing damage to equipment and prolonging the investigation so that the anticipated scope of work could be satisfactorily accomplished. Although data quality objectives did not appear to be significantly diminished by the pre-probing tactic, it should be emphasized that any review of the UVOST data set and associated visualizations needs to consider that the data from 32-LIF through 96-LIF was obtained using a non-standard methodology (i.e., pre-probing).

6.2 Source Zone Determination

LNAPL delineation at petroleum release sites is necessary to develop an adequate conceptual site model (CSM) that can be referenced during future remediation decision making processes. Since LNAPL is the source for dissolved and vapor phase impacts, defining the horizontal and vertical extent of the LNAPL body is paramount to mitigating potential exposure pathways and achieving regulatory compliance objectives. As such, conceptually it is appropriate to classify the entirety of an LNAPL body as the "source" zone at a petroleum release site. However, to more thoroughly evaluate the concept of source areas in the context of release points of origin, it is beneficial to segment the LNAPL body into unsaturated (vadose zone) and saturated (smear zone) fractions.

In an unconfined porous media, LNAPL migration through the vadose zone is primarily vertically downward as a result of gravity. Once the LNAPL plume contacts the groundwater interface in the saturated zone, advection forces provide a mechanism for horizontal LNAPL transport in the direction of decreasing hydraulic

head. LNAPL in the saturated zone can also move vertically upwards and downwards as a result of "smearing" related to seasonal fluctuations in groundwater elevations. In contrast, above the groundwater table in the vadose zone, gravity prevents upward vertical migration and overall the LNAPL plume must migrate downward, with some lateral movement radially outward from the release source. In this case, vadose zone LNAPL detections signify that an LNAPL release point of origin is nearby. This relationship between vadose zone LNAPL detections and release origins forms the principal basis for categorizing "source" areas at individual facility locations in this report, along with additional lines of evidence such as proximity to historic petroleum storage/distribution equipment and the relative intensity of UVOST fluorescence response.

6.3 UVOST Investigation Results

As a result of the data obtained during the April/May 2018 UVOST investigation, the basic geometry of the majority of the LNAPL body near the MRL properties has been defined. Shallow vadose zone LNAPL responses indicative of source areas were recorded at both the Former Shell Oil Co. (34-LIF, 35-LIF, 38-LIF, and 42-LIF) and Former Shortridge Oil Co. (46-LIF and 52-LIF) facilities. It is also likely that an upgradient source exists in an inaccessible location underneath the Former Platinum Motors office building based on the data collected from boreholes 68-LIF through 70-LIF, 72-LIF, 76-LIF, and 78-LIF. Residual LNAPL may still remain near the pump island at the Former Newman's Downtown Exxon facility as evidenced by the data recovered from 64-LIF. The LNAPL plume body extends from these source area zones in a downgradient direction to the southeast along the groundwater interface smear zone present from approximately 8 to 14 feet bgs. Volume calculations derived from the 3D plume depiction of LNAPL impacted soil range from 24,796 cubic yards for the 1 %RE plume shell to 1,563 cubic yards for the 5 %RE plume shell.

Analysis of the UVOST waveforms for boreholes installed near the MRL properties indicates that weathered gasoline may be primarily responsible for the fluorescence observed in the north portion of the investigation area. Fluorescence intervals consistent with a weathered gasoline response were found both north and south of Pike Avenue (Old U.S. Highway 10) in the vicinity of the Former Newman's Downtown Exxon, Former Platinum Motors, and Former Shell Oil Co. facilities. Downgradient of these facilities in the MRL right-of-way, a more intact gasoline response was observed at a greater depth, which may signify submerged LNAPL that has resisted weathering. Moving further downgradient to the Former Shortridge Oil Co. facility, a diversity of fluorescence waveforms encountered suggests that the plume in this area may be composed of a heterogeneous mixture of LNAPL types. Collocated soil samples from discrete locations corresponding with UVOST fluorescence intervals should be obtained to provide analytical data that could potentially bolster or repudiate these suppositions that are based largely on the UVOST dataset alone.

The following sections summarize the results of the UVOST investigation for each individual facility contained in the scope of work (DEQ Agreement# 418004).

6.3.1 Columbus Sports Hut

The Columbus Sports Hut facility (FID: 48-012653, Release 1095) was originally listed in the project planning documents (DEQ Agreement# 418004) as one of the release sites to be evaluated during the Columbus city-wide UVOST investigation. The MTDEQ later removed this facility from the scope of work to be completed. The location of the Columbus Sports Hut facility relative to the other release sites is shown on Figure 2.

6.3.2 Former Newman's Downtown Exxon

Access to the Former Newman's Downtown Exxon facility (FID: 48-04005, Release 1781) was denied by the property owner. As a result, UVOST data could not be obtained from potential source zones within the boundaries of the facility parcel. A total of five UVOST boreholes (64-LIF through 66-LIF, 74-LIF, and 77-LIF) were advanced in public right-of-ways adjacent to the Former Newman's Downtown Exxon parcel. The maximum signal response recorded was 12.3 %RE at 9.62 feet bgs in borehole 64-LIF. The LNAPL fluorescence intervals in 64-LIF ranged from approximately 6.5 to 13 feet bgs, which correlates with the anticipated saturated smear zone. Borehole 64-LIF was installed approximately 30 feet south of the inactive pump island dispensers at the facility, indicating that the LNAPL encountered at 64-LIF may be related to historic operation of the pump dispensers. The waveform patterns observed in 64-LIF are consistent with a weathered gasoline response. The estimated volume of LNAPL impacted soil at the Former Newman's Downtown Exxon facility is approximately 1,000 cubic yards based on the 1 %RE plume shell.

Groundwater samples from monitoring wells installed at the Former Newman's Downtown Exxon facility have recently been below cleanup levels, with total purgeable hydrocarbons (TPH) concentrations ranging from approximately 200 to 800 µg/L [Tetra Tech, 2017], [Table 1]. Since access was not granted for the UVOST investigation team to enter the property, collocated UVOST data could not be obtained at the existing groundwater monitoring well locations. There are no groundwater monitoring wells located south of the pump island dispenser where 64-LIF was installed. Based on this information, it is possible that the current dissolved phase groundwater analytical data set for the Former Newman's Downtown Exxon facility does not adequately represent the LNAPL fluorescence observed at this downgradient location.

6.3.3 Former Platinum Motors

The source area at the Former Platinum Motors facility (FID: 48-04575, Release 4482) is currently inaccessible. The office for the lumber supply store now occupying the building was constructed on top of the former UST basin. A total of 10 UVOST boreholes (67-LIF through 73-LIF, and 75-LIF through 78-LIF) were installed in accessible areas around the Former Platinum Motors facility. The majority of the LNAPL fluorescence intervals were encountered in the saturated smear zone from approximately 8 to 14 feet bgs.

The maximum signal response recorded was 21.4 %RE at 8.24 feet bgs in borehole 76-LIF. The waveform patterns from boreholes completed near the Former Platinum Motors facility are consistent with a weathered gasoline response. The estimated volume of LNAPL impacted soil at the Former Platinum Motors facility is approximately 1,600 cubic yards based on the 1 %RE plume shell.

Groundwater samples from monitoring wells located on the south side of the lumber supply store (JW-04-4 and JW-04-5) have recently exceeded cleanup levels with TPH concentrations ranging from approximately 8,000 to 13,000 µg/L and benzene concentrations ranging from approximately 100 to 200 µg/L [Weston, 2017], [Table 1]. A distinct petroleum odor and sheen was evident on the drill rods retrieved from borehole 68-LIF completed adjacent to JW-04-5. The maximum UVOST signal response recorded in the vicinity of these monitoring wells was 6.2 %RE at 12.56 feet bgs in borehole 78-LIF. While this signal response may be on the lower end of the spectrum of values obtained during the investigation, it is not out of the ordinary for gasoline to respond with very low signal responses (less than 5 %RE) that may correspond with mobile LNAPL and/or high dissolved phase concentrations. The data gap presented by the office building constructed over the former UST basin further complicates analysis of the UVOST data in this area, as boreholes could not be completed in the source zone for comparison with downgradient and peripheral locations.

6.3.4 Git's Conoco

The data from boreholes completed at the release sites adjacent to the Git's Conoco facility (FID: 48-07859, Release 4012) provided evidence that the Git's Conoco release was not a contributor to the commingled LNAPL body in the vicinity of the MRL lease properties and right-of-way. Based on this information, the MTDEQ directed the UVOST investigation team not to install any exploratory boreholes on the Git's Conoco property. Recent groundwater monitoring events at the Git's Conoco facility have shown that groundwater constituent concentrations are currently below detection limits [RTI, 2017a].

6.3.5 Montana Rail Link (Former Shell Oil Co.)

A total of 22 UVOST boreholes (24-LIF through 43-LIF, 79-LIF, and 80-LIF) were installed at the Former Shell Oil Co. facility, not including the boreholes completed in the MRL right-of-way (13-LIF through 23-LIF). The majority of the LNAPL related fluorescence was encountered in the saturated smear zone from approximately 8 to 14 feet bgs. Shallow vadose zone fluorescence indicating proximity to release point of origin was observed in boreholes 34-LIF, 35-LIF, 38-LIF, and 42-LIF. The maximum signal response recorded was 63.7 %RE at 9.01 feet bgs in 34-LIF. The waveform patterns from boreholes completed at the Former Shell Oil Co. facility are generally consistent with a weathered gasoline response. The estimated volume of LNAPL impacted soil at the Former Shell Oil Co. facility is approximately 8,000 cubic yards based on the 1 %RE

plume shell. This volume estimate does not include the portion of the LNAPL plume that extends underneath the MRL right-of-way.

During recent groundwater monitoring events completed at the Former Shell Oil Co. facility, TPH concentrations have ranged from approximately 100 to 9,440 µg/L and benzene concentrations have ranged from approximately 1 to 635 µg/L [Olympus, 2017a], [Table 1]. The highest TPH and benzene groundwater concentrations have been found in samples from monitoring well JW-7, which correlates to the area returning the highest UVOST signal response at 34-LIF installed approximately 25 feet northeast of the well.

The depth to groundwater in JW-7 was measured at 8.94 feet bgs during the UVOST investigation. This represents the highest groundwater elevation recorded at JW-7 in site history based on a review of the cumulative site data [Olympus, 2017a], [Table 1]. Depth to groundwater at JW-7 has typically fluctuated from approximately 10 to 11 feet bgs.

6.3.6 Montana Rail Link (Former Shortridge Oil Co.)

A total of 23 UVOST boreholes (44-LIF through 63-LIF, and 81-LIF through 83-LIF) were installed at the Former Shortridge Oil Co. facility (FID: 48-05082, Release 1928), not including the boreholes completed in the MRL right-of-way (01-LIF through 12-LIF). The majority of the LNAPL related fluorescence was encountered in the saturated smear zone from approximately 8 to 14 feet bgs. Shallow vadose zone fluorescence indicating proximity to release point of origin was observed in boreholes 46-LIF and 52-LIF, which respectively correspond to a former pump island dispenser and UST location based on historic site diagrams. The maximum signal response recorded was 127.9 %RE at 8.60 feet bgs in 52-LIF. The waveform patterns from boreholes completed at the Former Shortridge Oil Co. facility are consistent with a mixture of weathered gasoline and diesel. The estimated volume of LNAPL impacted soil at the Former Shortridge Oil Co. facility is approximately 7,000 cubic yards based on the 1 %RE plume shell. This volume estimate does not include the portion of the LNAPL plume underneath the MRL right-of-way.

During recent groundwater monitoring events completed at the Former Shortridge Oil Co. facility, in-well LNAPL was detected in monitoring wells MW-1 and MW-5 [Olympus, 2017b], [Table 1]. These wells were gauged with an oil/water indicator probe during the UVOST investigation and no measurable quantity of LNAPL was detected. At the time of the UVOST investigation, the depth to water in MW-1 was 9.03 feet bgs and the depth to water in MW-5 was 8.33 feet bgs, which represent the highest recorded groundwater elevations at these locations in site history based on a review of the cumulative site data [Olympus, 2017b], [Table 1]. Depth to groundwater measurements at monitoring wells MW-1 and MW-5 have typically fluctuated from approximately 9.5 to 11.5 feet bgs.

Analysis of the UVOST log for borehole 01-LIF completed adjacent to MW-1 indicates that the LNAPL interval in this area was submerged by approximately 2 feet of groundwater during the UVOST investigation, which may explain the lack of mobile LNAPL in the well. Similarly at monitoring well MW-5, examination of the nearest UVOST log (46-LIF) reveals that the top of the lower LNAPL fluorescence interval from approximately 10 to 14 feet bgs was underneath approximately 2 feet of water. Since there was no mobile LNAPL detected in monitoring well MW-5 during the UVOST investigation, it is possible that the upper fluorescence interval evident in the 46-LIF log from approximately 4 to 7 feet bgs may represent LNAPL exposed above the groundwater table that is below the residual saturation point (i.e., immobile) and therefore the lower fluorescence interval from 10 to 14 feet bgs may be the source for historic LNAPL occurrences in the well. In this case, periods of low groundwater may provide conditions more suitable for increased LNAPL mobility at the site.

It is common to have a direct correlation between lower groundwater conditions and increased LNAPL mobility at petroleum release sites with fluctuating groundwater tables that recurrently submerge and expose LNAPL intervals depending on seasonal variations in groundwater inputs. Lower groundwater tables tend to increase the surface area of the LNAPL/air interface providing more pore space available for LNAPL to inhabit, as opposed to groundwater. Air requires a lower threshold entry pressure than water for LNAPL to enter the pore, meaning that it is easier for LNAPL to displace air than water from a pore. In contrast, higher groundwater tables may submerge LNAPL intervals resulting in entrapped LNAPL that is immobilized by the capillary pressure of the surrounding water-wet pores.

6.3.7 Columbus Farmers Union

A total of nine UVOST boreholes (85-LIF through 93-LIF) were advanced at the Columbus Farmers Union facility (FID: 48-03409, Releases 1408, 1659, 3762, and 4915). LNAPL responses characteristic of diesel were observed in all of the boreholes with the exception of 93-LIF which was near non-detect levels. Residual LNAPL was encountered at a depth corresponding to the saturated smear zone extending from approximately 8 to 16 feet bgs, depending on location. The maximum signal response recorded was 87.9 %RE at 9.93 feet bgs in borehole 86-LIF. Additional UVOST investigation at the Columbus Farmers Union facility will be necessary if complete delineation of the extent and magnitude of the residual LNAPL body is desired.

During recent groundwater monitoring events completed at the Columbus Farmers Union facility, samples from groundwater monitoring wells have contained total extractable hydrocarbons (TEH) concentrations ranging from below detection limits to a maximum of 4,470 µg/L in SVE-5 [RTI, 2017b], [Table 1]. Dissolved phase concentrations appear to be highest during low groundwater conditions although samples from the majority of the well locations have recently been below cleanup levels. Comparison of the cumulative groundwater analytical data with the current UVOST data set indicates that a higher minimum threshold for a

UVOST signal response signifying elevated dissolved phase impacts may be warranted, such as 50 %RE for example. Diesel responds much more robustly on the UVOST system compared with gasoline. It is a recommended best practice to apply additional lines of evidence such as site-specific soil and groundwater analytical data to select the most appropriate minimum threshold representing a significant UVOST signal response.

7.0 References

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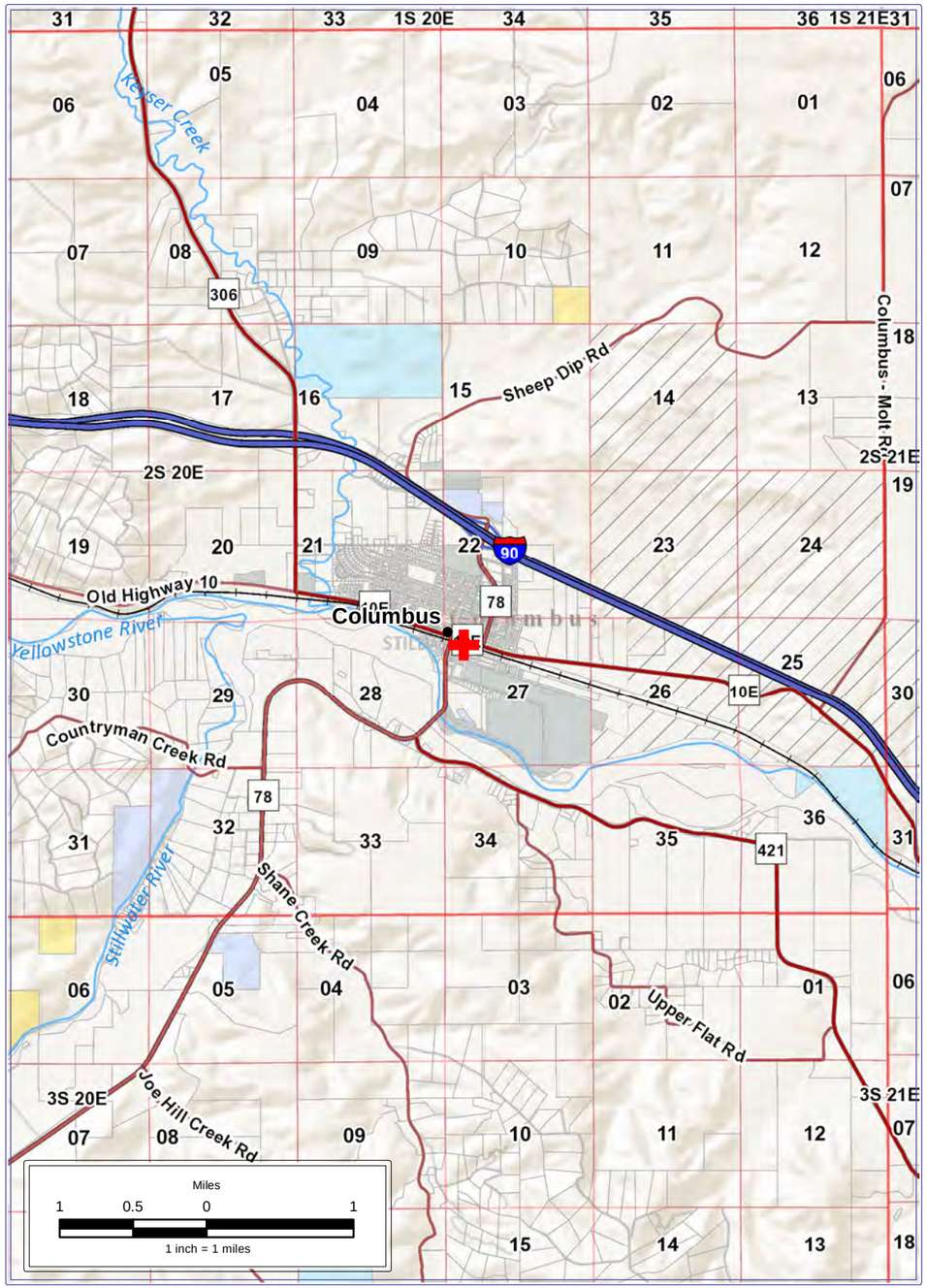


LEGEND

SITE LOCATION

N

Site Location Maps

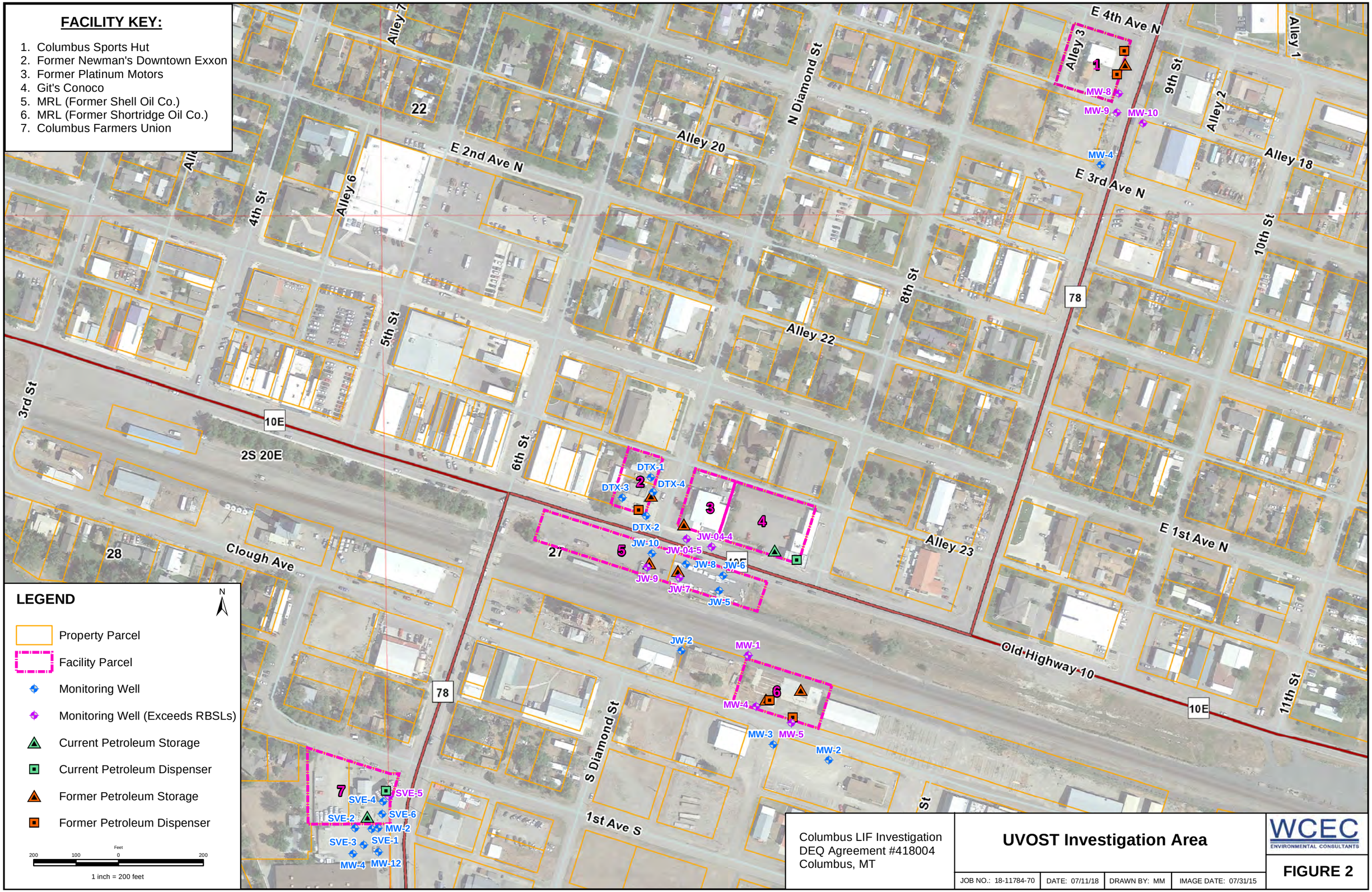
Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT

DRAWN BY: MM
DATE: 03/12/18
SCALE: 1:12,000

PROJECT NUMBER: 18-11784-70
IMAGE SOURCE: ESRI BASEMAPS

WCEC
ENVIRONMENTAL CONSULTANTS

FIGURE 1



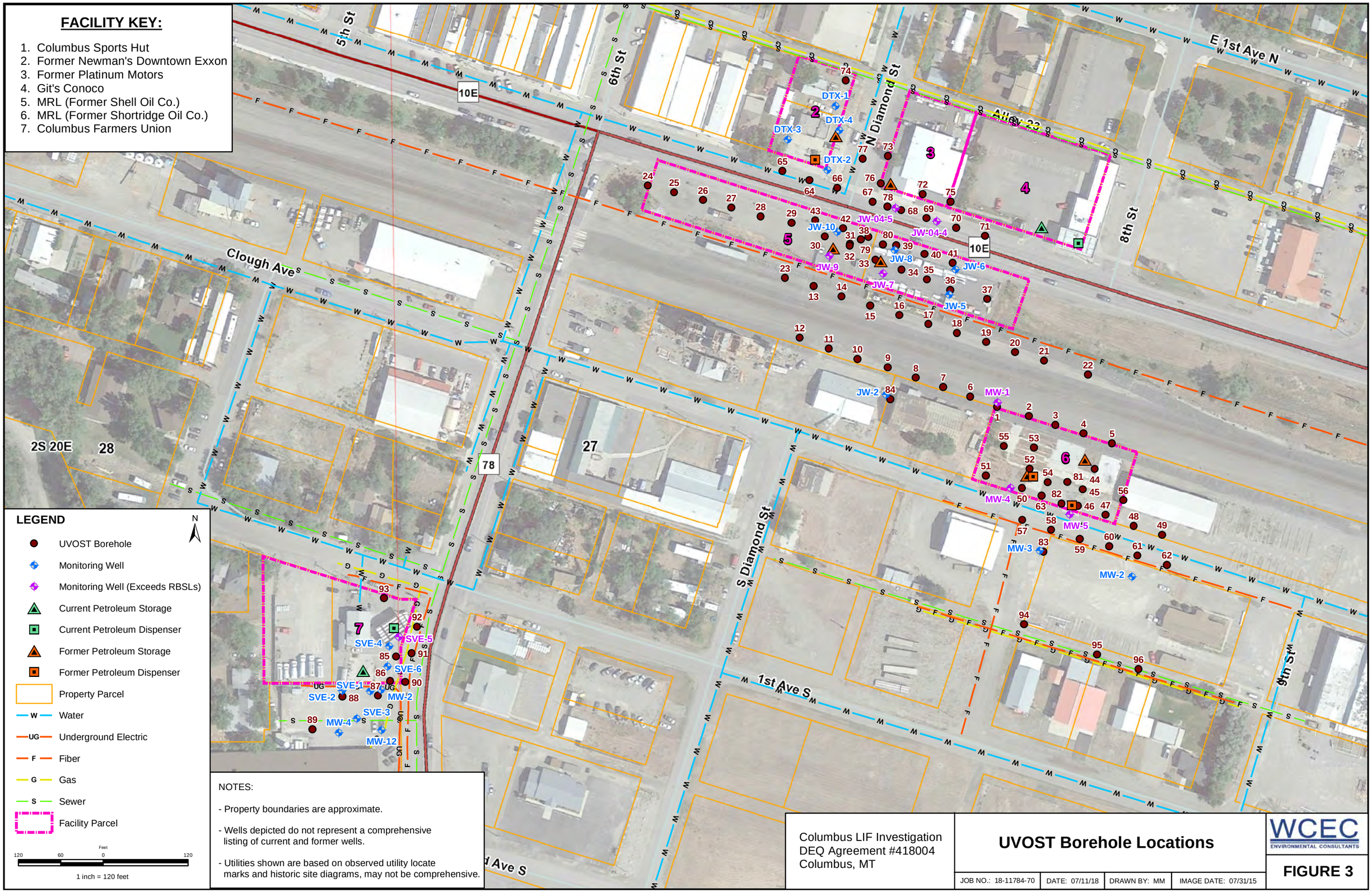
Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT

UVOST Investigation Area

JOB NO.: 18-11784-70 | DATE: 07/11/18 | DRAWN BY: MM | IMAGE DATE: 07/31/15

WCEC ENVIRONMENTAL CONSULTANTS

FIGURE 2



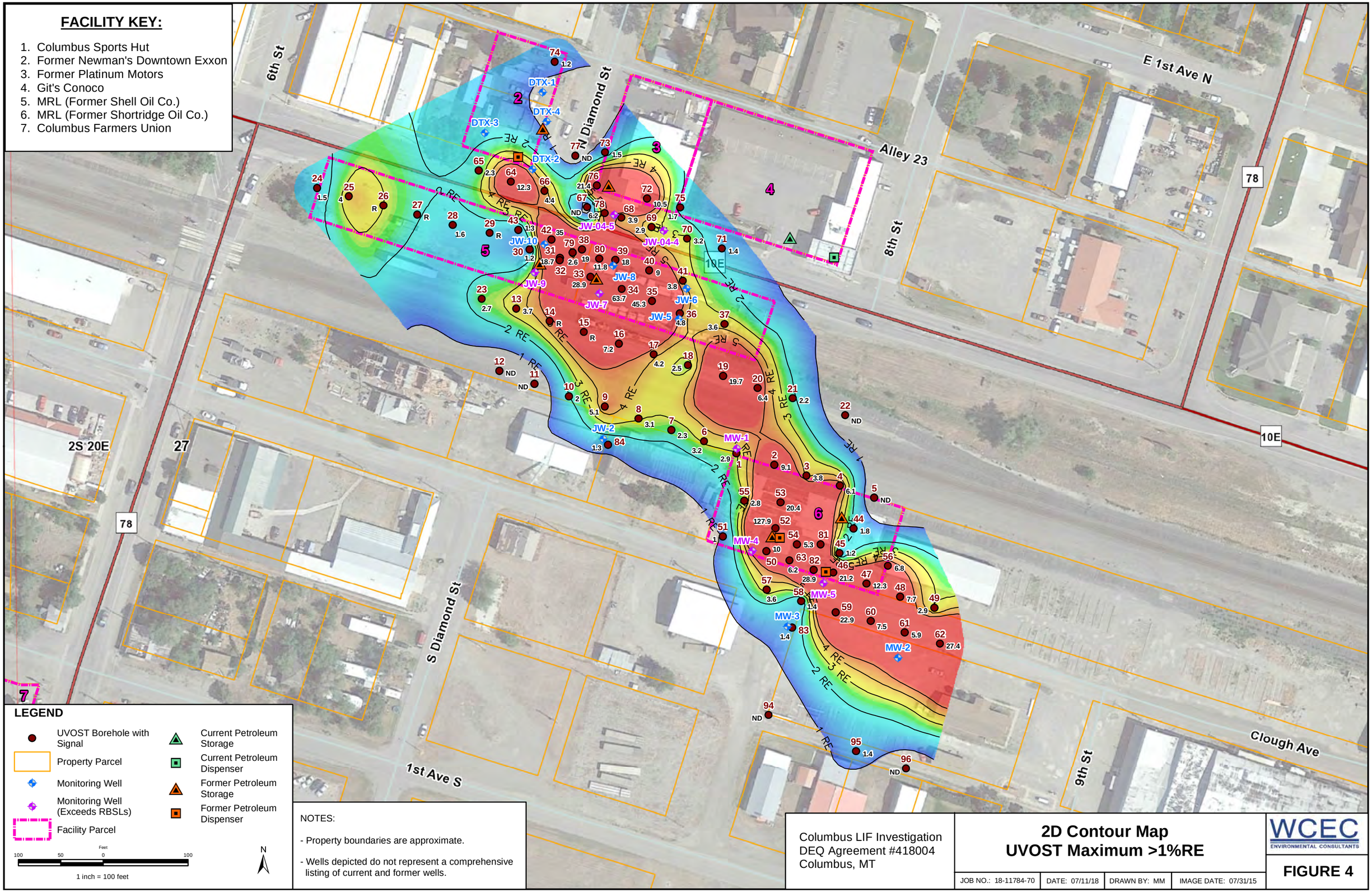
Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT

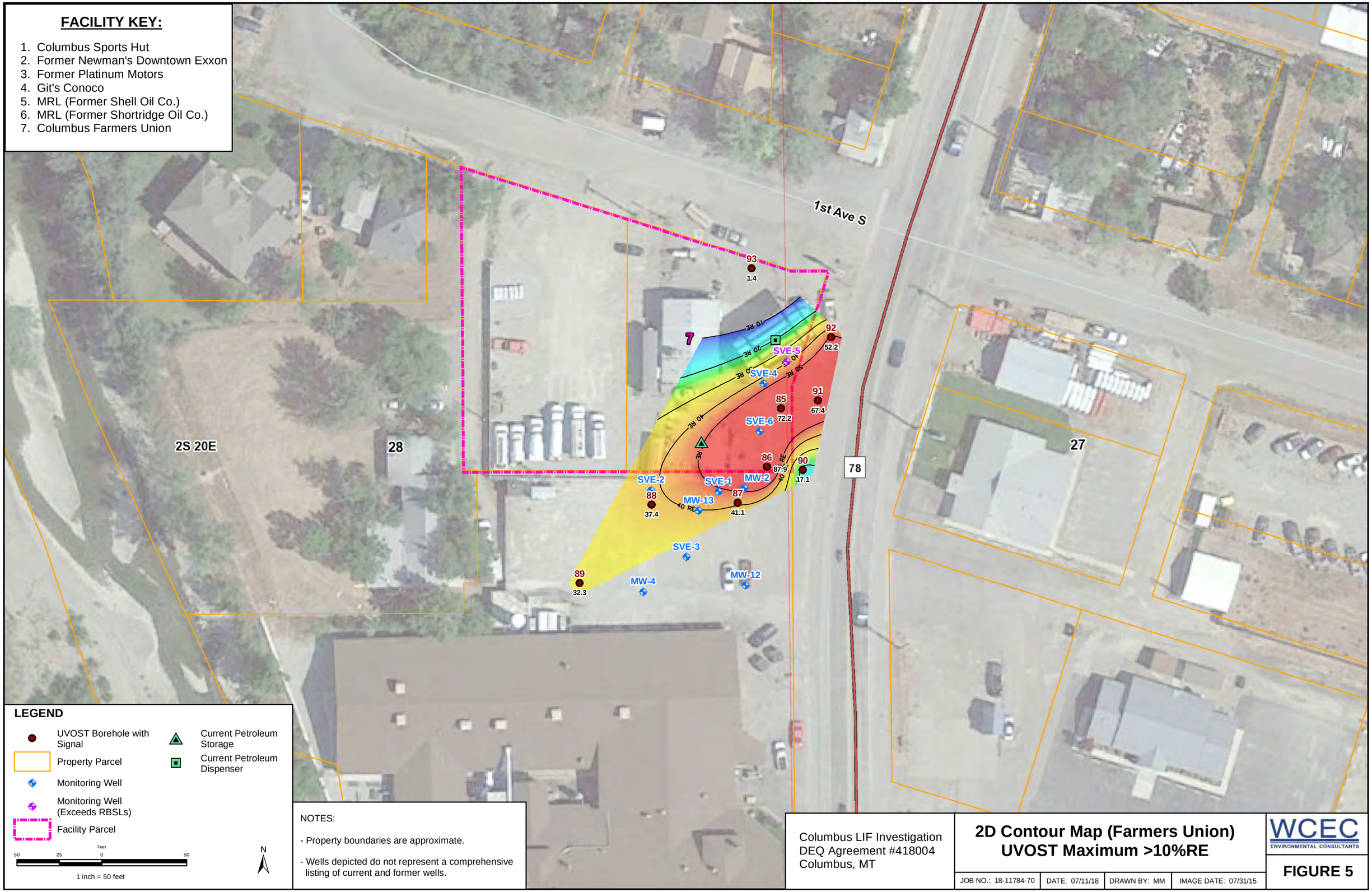
UVOST Borehole Locations

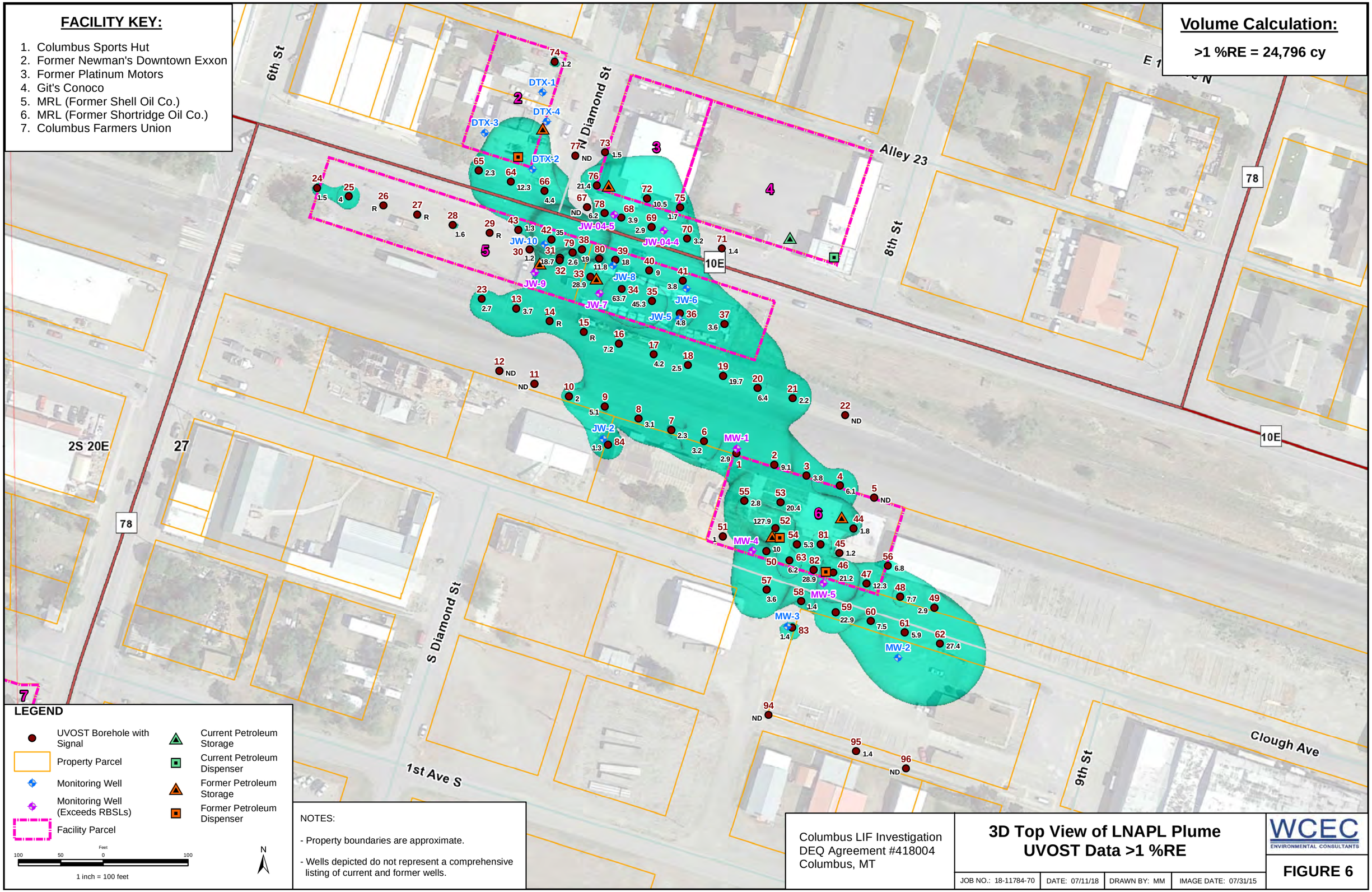
JOB NO.: 18-11784-70	DATE: 07/11/18	DRAWN BY: MM	IMAGE DATE: 07/31/15

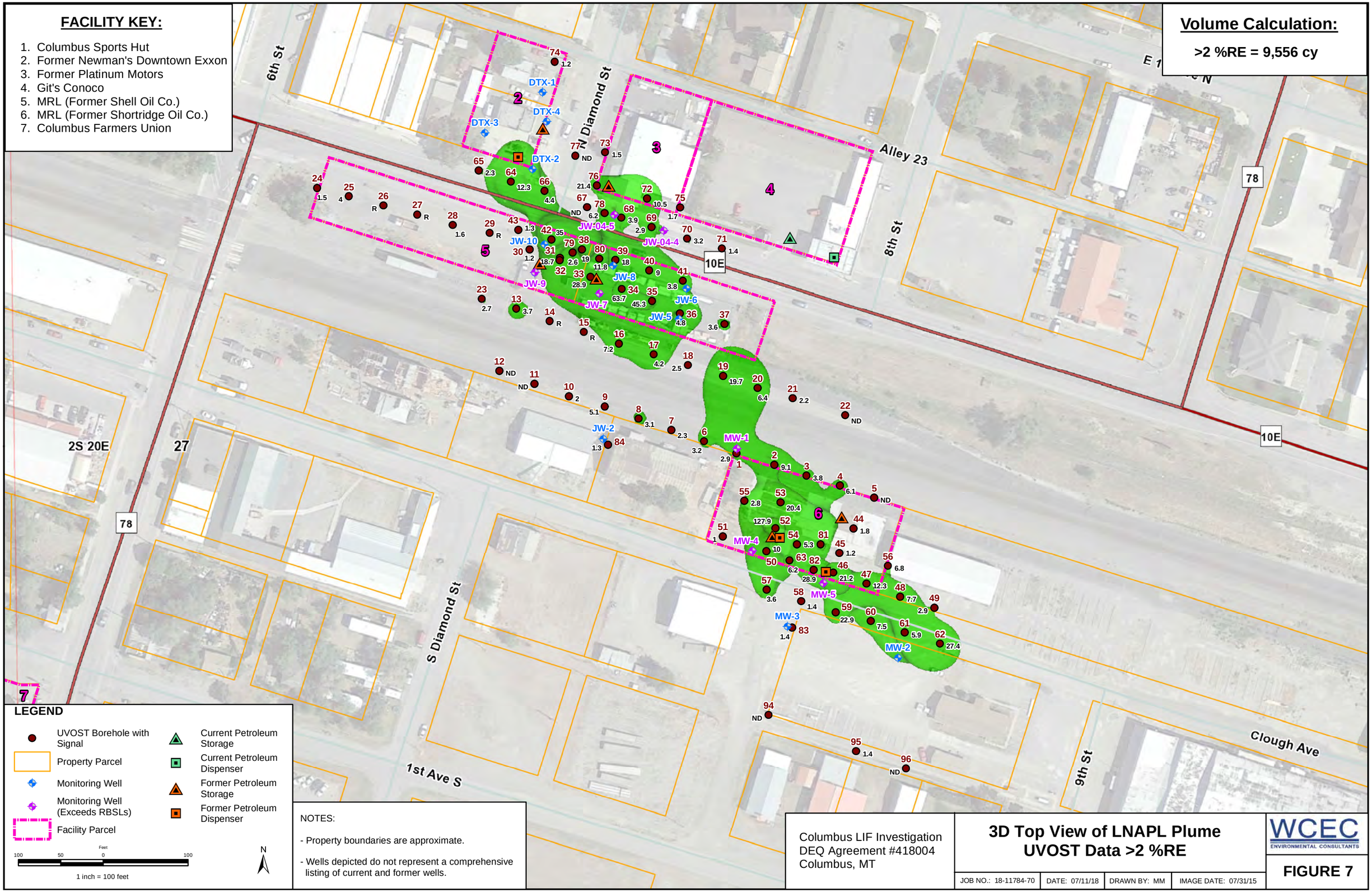
WCEC ENVIRONMENTAL CONSULTANTS

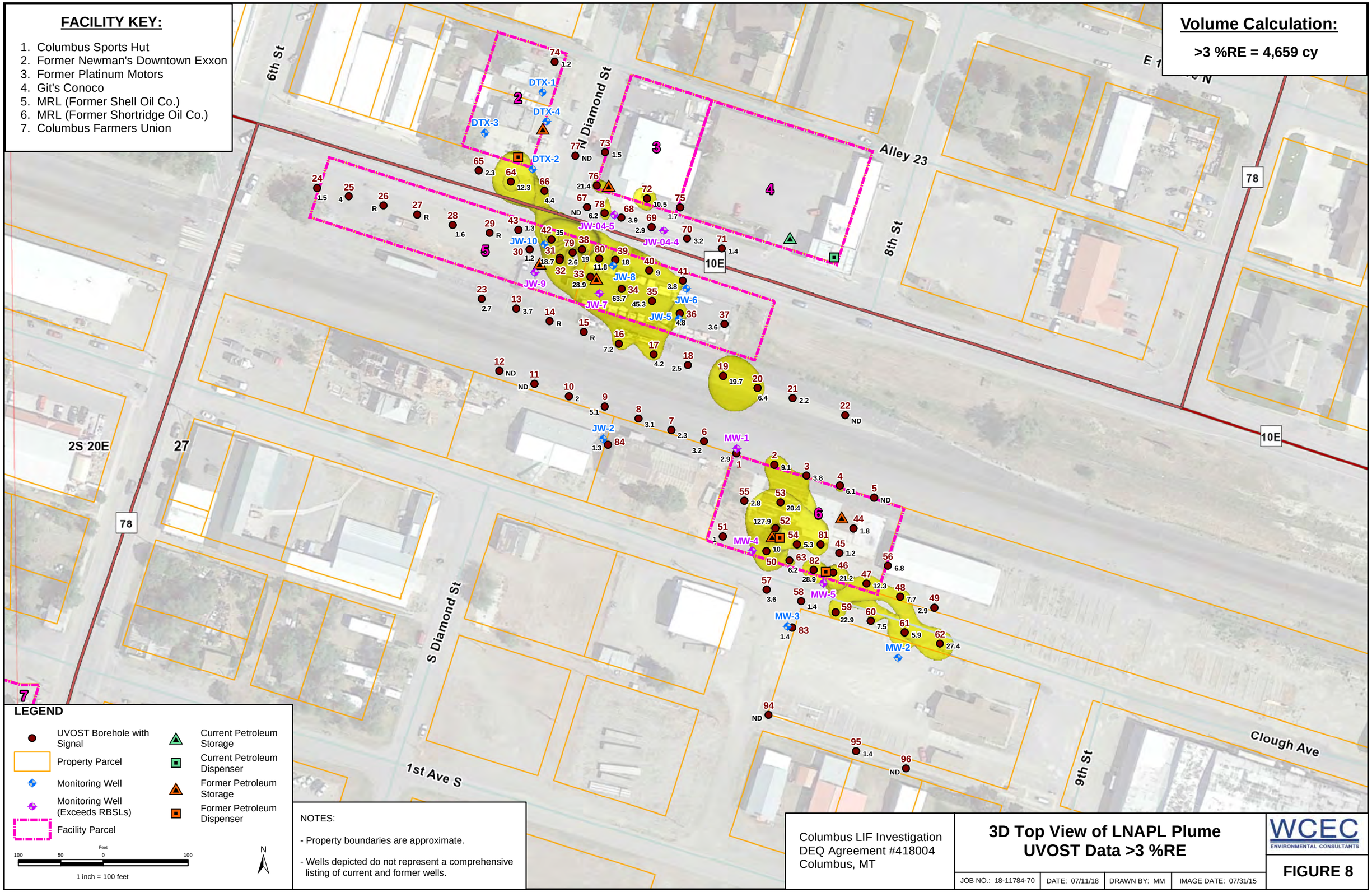
FIGURE 3

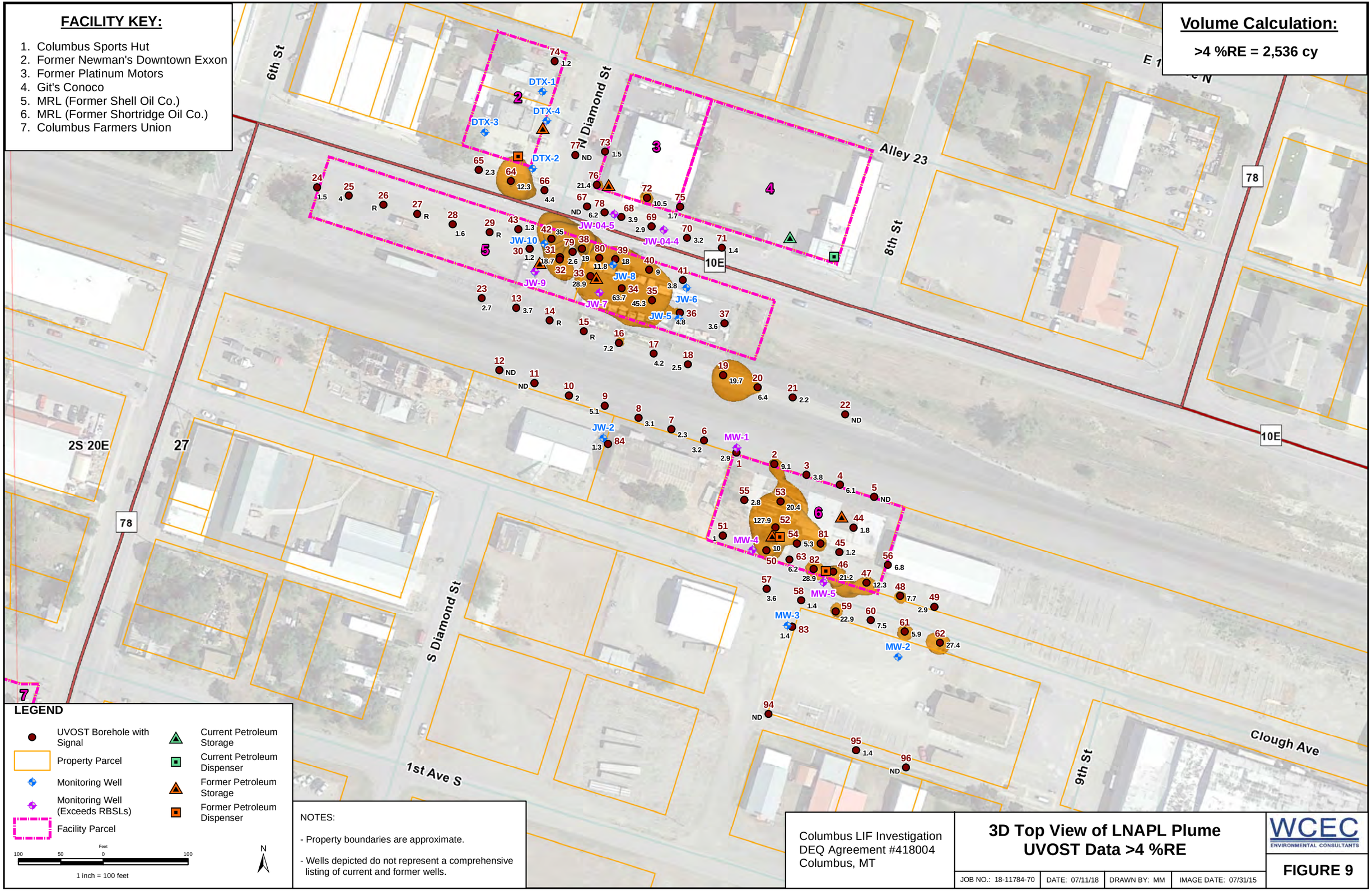

FACILITY KEY:
1. Columbus Sports Hut
2. Former Newman's Downtown Exxon
3. Former Platinum Motors
4. Git's Conoco
5. MRL (Former Shell Oil Co.)
6. MRL (Former Shortridge Oil Co.)
7. Columbus Farmers Union
6th St
N Diamond St
E 1st Ave N
Alley 23
8th St
S Diamond St
1st Ave S
9th St
Clough Ave
2S 20E
27
78
10E
LEGEND
UVOST Borehole with Signal
Property Parcel
Monitoring Well
Monitoring Well (Exceeds RBSLs)
Facility Parcel
Current Petroleum Storage
Current Petroleum Dispenser
Former Petroleum Storage
Former Petroleum Dispenser
Feet
100 50 0 100
1 inch = 100 feet
N
NOTES:
- Property boundaries are approximate.
- Wells depicted do not represent a comprehensive listing of current and former wells.
Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT
2D Contour Map
UVOST Maximum >1%RE
JOB NO.: 18-11784-70
DATE: 07/11/18
DRAWN BY: MM
IMAGE DATE: 07/31/15
WCEC
ENVIRONMENTAL CONSULTANTS
FIGURE 4


FACILITY KEY:
1. Columbus Sports Hut
2. Former Newman's Downtown Exxon
3. Former Platinum Motors
4. Git's Conoco
5. MRL (Former Shell Oil Co.)
6. MRL (Former Shortridge Oil Co.)
7. Columbus Farmers Union
1st Ave S
2S 20E
28
27
78
7
93
1.4
92
52.2
91
67.4
85
72.2
86
87.9
90
17.1
87
41.1
88
37.4
89
32.3
SVE-1
SVE-2
SVE-3
SVE-4
SVE-5
SVE-6
MW-2
MW-4
MW-12
MW-13
10 RE
20 RE
30 RE
40 RE
50 RE
LEGEND
UVOST Borehole with Signal
Property Parcel
Monitoring Well
Monitoring Well (Exceeds RBSLs)
Facility Parcel
Current Petroleum Storage
Current Petroleum Dispenser
Feet
50 25 0 50
1 inch = 50 feet
N
NOTES:
- Property boundaries are approximate.
- Wells depicted do not represent a comprehensive listing of current and former wells.
Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT
2D Contour Map (Farmers Union)
UVOST Maximum >10%RE
JOB NO.: 18-11784-70
DATE: 07/11/18
DRAWN BY: MM
IMAGE DATE: 07/31/15
WCEC
ENVIRONMENTAL CONSULTANTS
FIGURE 5


FACILITY KEY:
1. Columbus Sports Hut
2. Former Newman's Downtown Exxon
3. Former Platinum Motors
4. Git's Conoco
5. MRL (Former Shell Oil Co.)
6. MRL (Former Shortridge Oil Co.)
7. Columbus Farmers Union
Volume Calculation:
>1 %RE = 24,796 cy
6th St
N Diamond St
Alley 23
8th St
10E
78
2S 20E
27
S Diamond St
1st Ave S
9th St
Clough Ave
DTX-1
DTX-2
DTX-3
DTX-4
JW-04-5
JW-04-4
JW-10
JW-9
JW-8
JW-7
JW-6
JW-5
JW-2
MW-1
MW-4
MW-5
MW-3
MW-2
LEGEND
UVOST Borehole with Signal
Property Parcel
Monitoring Well
Monitoring Well (Exceeds RBSLs)
Facility Parcel
Current Petroleum Storage
Current Petroleum Dispenser
Former Petroleum Storage
Former Petroleum Dispenser
Feet
100 50 0 100
1 inch = 100 feet
N
NOTES:
- Property boundaries are approximate.
- Wells depicted do not represent a comprehensive listing of current and former wells.
Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT
3D Top View of LNAPL Plume
UVOST Data >1 %RE
JOB NO.: 18-11784-70
DATE: 07/11/18
DRAWN BY: MM
IMAGE DATE: 07/31/15
WCEC
ENVIRONMENTAL CONSULTANTS
FIGURE 6


FACILITY KEY:
1. Columbus Sports Hut
2. Former Newman's Downtown Exxon
3. Former Platinum Motors
4. Git's Conoco
5. MRL (Former Shell Oil Co.)
6. MRL (Former Shortridge Oil Co.)
7. Columbus Farmers Union
Volume Calculation:
>2 %RE = 9,556 cy
6th St
N Diamond St
Alley 23
8th St
10E
78
2S 20E
27
S Diamond St
1st Ave S
9th St
Clough Ave
DTX-1
DTX-2
DTX-3
DTX-4
JW-04-5
JW-04-4
JW-10
JW-9
JW-8
JW-7
JW-6
JW-5
JW-2
MW-1
MW-2
MW-3
MW-4
MW-5
LEGEND
UVOST Borehole with Signal
Property Parcel
Monitoring Well
Monitoring Well (Exceeds RBSLs)
Facility Parcel
Current Petroleum Storage
Current Petroleum Dispenser
Former Petroleum Storage
Former Petroleum Dispenser
Feet
100 50 0 100
1 inch = 100 feet
N
NOTES:
- Property boundaries are approximate.
- Wells depicted do not represent a comprehensive listing of current and former wells.
Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT
3D Top View of LNAPL Plume
UVOST Data >2 %RE
JOB NO.: 18-11784-70
DATE: 07/11/18
DRAWN BY: MM
IMAGE DATE: 07/31/15
WCEC
ENVIRONMENTAL CONSULTANTS
FIGURE 7


FACILITY KEY:
1. Columbus Sports Hut
2. Former Newman's Downtown Exxon
3. Former Platinum Motors
4. Git's Conoco
5. MRL (Former Shell Oil Co.)
6. MRL (Former Shortridge Oil Co.)
7. Columbus Farmers Union
Volume Calculation:
>3 %RE = 4,659 cy
6th St
N Diamond St
Alley 23
8th St
S Diamond St
1st Ave S
9th St
Clough Ave
2S 20E
27
10E
78
DTX-1
DTX-2
DTX-3
DTX-4
JW-04-5
JW-04-4
JW-10
JW-9
JW-8
JW-7
JW-6
JW-5
JW-2
MW-1
MW-2
MW-3
MW-4
MW-5
LEGEND
UVOST Borehole with Signal
Property Parcel
Monitoring Well
Monitoring Well (Exceeds RBSLs)
Facility Parcel
Current Petroleum Storage
Current Petroleum Dispenser
Former Petroleum Storage
Former Petroleum Dispenser
Feet
100 50 0 100
1 inch = 100 feet
N
NOTES:
- Property boundaries are approximate.
- Wells depicted do not represent a comprehensive listing of current and former wells.
Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT
3D Top View of LNAPL Plume
UVOST Data >3 %RE
JOB NO.: 18-11784-70
DATE: 07/11/18
DRAWN BY: MM
IMAGE DATE: 07/31/15
WCEC
ENVIRONMENTAL CONSULTANTS
FIGURE 8

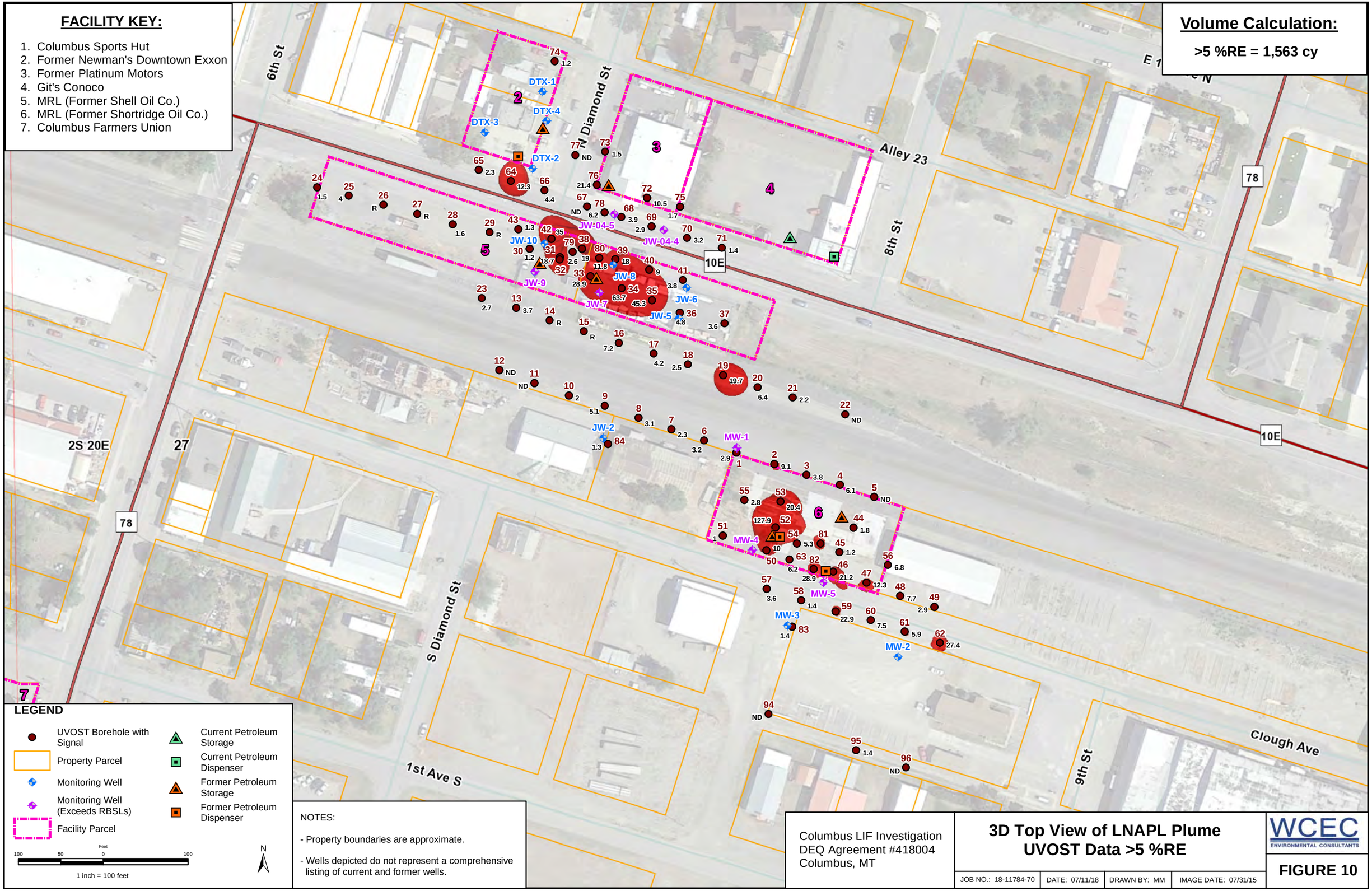

FACILITY KEY:
1. Columbus Sports Hut
2. Former Newman's Downtown Exxon
3. Former Platinum Motors
4. Git's Conoco
5. MRL (Former Shell Oil Co.)
6. MRL (Former Shortridge Oil Co.)
7. Columbus Farmers Union
Volume Calculation:
>4 %RE = 2,536 cy
6th St
N Diamond St
Alley 23
8th St
10E
78
2S 20E
27
S Diamond St
1st Ave S
9th St
Clough Ave
DTX-1
DTX-2
DTX-3
DTX-4
JW-04-5
JW-04-4
JW-10
JW-9
JW-8
JW-7
JW-6
JW-5
JW-2
MW-1
MW-2
MW-3
MW-4
MW-5
LEGEND
UVOST Borehole with Signal
Property Parcel
Monitoring Well
Monitoring Well (Exceeds RBSLs)
Facility Parcel
Current Petroleum Storage
Current Petroleum Dispenser
Former Petroleum Storage
Former Petroleum Dispenser
Feet
100 50 0 100
1 inch = 100 feet
N
NOTES:
- Property boundaries are approximate.
- Wells depicted do not represent a comprehensive listing of current and former wells.
Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT
3D Top View of LNAPL Plume
UVOST Data >4 %RE
JOB NO.: 18-11784-70
DATE: 07/11/18
DRAWN BY: MM
IMAGE DATE: 07/31/15
WCEC
ENVIRONMENTAL CONSULTANTS
FIGURE 9

FACILITY KEY:

1. Columbus Sports Hut
2. Former Newman's Downtown Exxon
3. Former Platinum Motors
4. Git's Conoco
5. MRL (Former Shell Oil Co.)
6. MRL (Former Shortridge Oil Co.)
7. Columbus Farmers Union

Volume Calculation:

>5 %RE = 1,563 cy



NOTES:

- Property boundaries are approximate.
- Wells depicted do not represent a comprehensive listing of current and former wells.

Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT

3D Top View of LNAPL Plume
UVOST Data >5 %RE

JOB NO.: 18-11784-70	DATE: 07/11/18	DRAWN BY: MM	IMAGE DATE: 07/31/15

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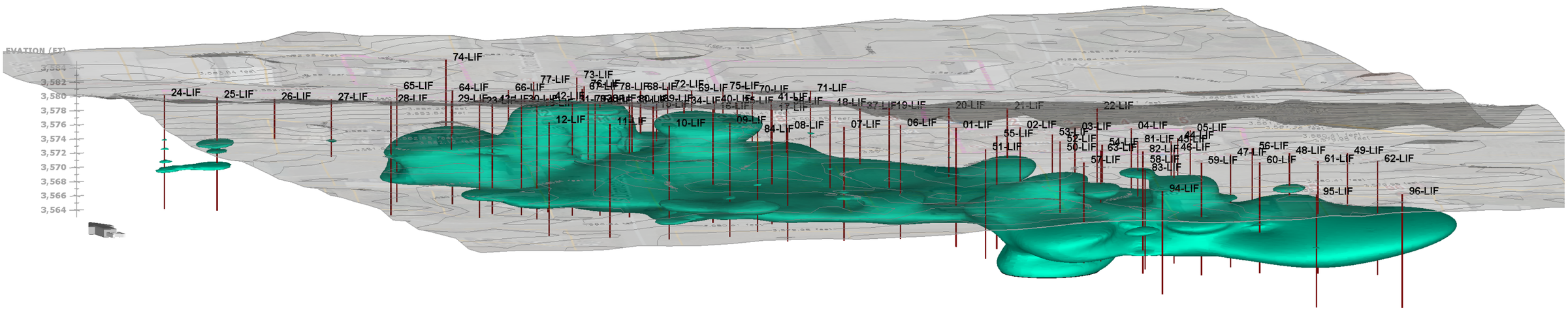
FIGURE 10

3D Visualization of UVOST Signal (%RE)
MTDEQ LIF Investigation
Columbus, MT
Vertical Exaggeration = 5:1

SIGNAL above 1.0 %RE

UVOST Signal Volume = 24,796 cubic yards



SIGNAL %RE

- >5
- 4-5
- 3-4
- 2-3
- 1-2

SIGNAL above 1.0 %RE

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ENVIRONMENTAL CONSULTANTS

May 2018 Integrated Site Visualization (ISV)

3D PDF NOTES: Click screen to activate 3D content.

Mouse controls:
hold left click = rotate
hold right click = zoom (also mouse wheel)
hold left + right click = pan (also Ctrl + left click)
single right click for advanced options, such as full screen

For Adobe help with displaying 3D models, CLICK HERE.

3D PDF Isolevel
UVOST Data >1 %RE

Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT

DRAWN BY: MM
DATE: 06/08/18
SCALE: NA

PROJECT NUMBER: 18-11784-70
IMAGE SOURCE: Google Earth

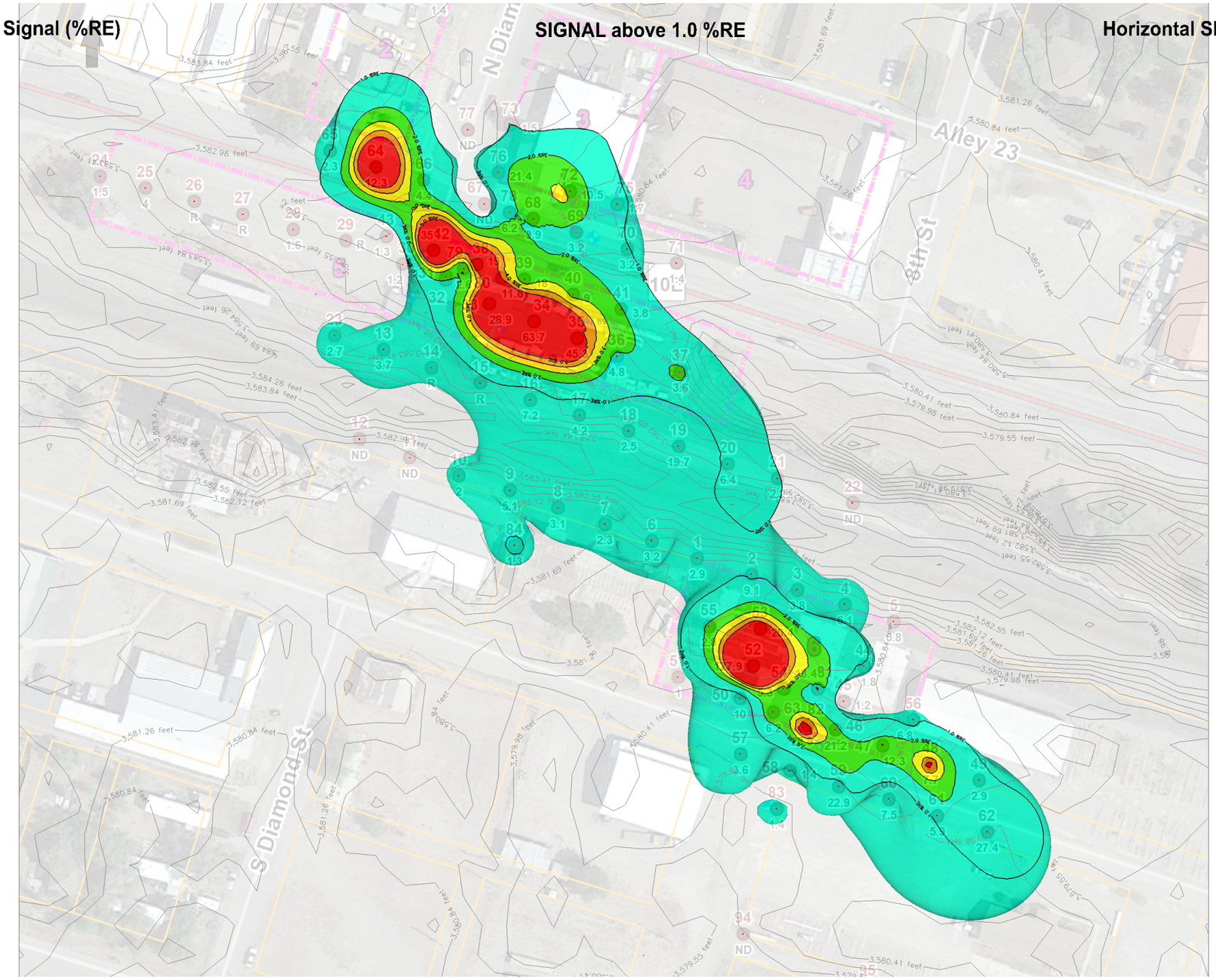
WCEC
ENVIRONMENTAL CONSULTANTS

FIGURE 11

3D Visualization of UVOST Signal (%RE)
MTDEQ LIF Investigation
Columbus, MT
Vertical Exaggeration = 5:1

SIGNAL above 1.0 %RE

Horizontal Slice, Elevation = 3,572.50 feet amsl



SIGNAL %RE

- >5
- 4-5
- 3-4
- 2-3
- 1-2

SIGNAL above 1.0 %RE

WCEC
ENVIRONMENTAL CONSULTANTS

May 2018 Integrated Site Visualization (ISV)

3D PDF NOTES: Click screen to activate 3D content.

Mouse controls:
hold left click = rotate
hold right click = zoom (also mouse wheel)
hold left + right click = pan (also Ctrl + left click)
single right click for advanced options, such as full screen

For Adobe help with displaying 3D models, CLICK HERE.

3D PDF Horizontal Slice
3,572.50 ft amsl

Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT

DRAWN BY: MM
DATE: 06/08/18
SCALE: NA

PROJECT NUMBER: 18-11784-70
IMAGE SOURCE: Google Earth

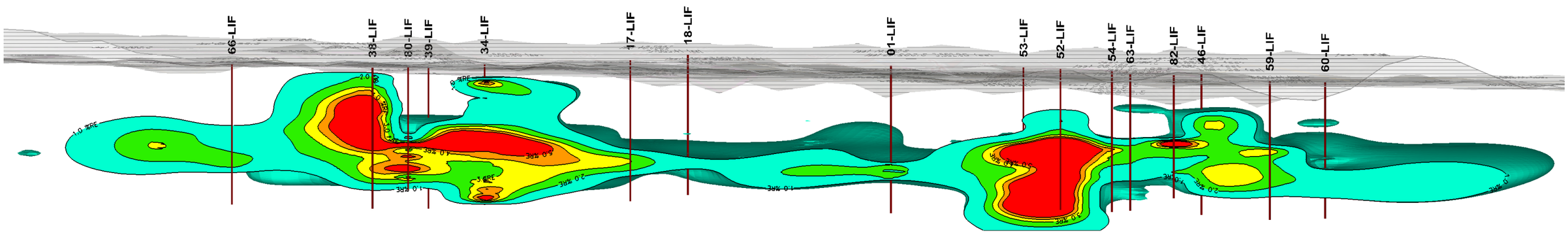
WCEC
ENVIRONMENTAL CONSULTANTS

FIGURE 12

3D Visualization of UVOST Signal (%RE)
MTDEQ LIF Investigation
Columbus, MT
Vertical Exaggeration = 5:1

SIGNAL above 1.0 %RE

Vertical Slice, Easting = 2,032,531.00 feet
Slice azimuth = 145 degrees



SIGNAL %RE

- >5
- 4-5
- 3-4
- 2-3
- 1-2

SIGNAL above 1.0 %RE

WCEC
ENVIRONMENTAL CONSULTANTS

May 2018 Integrated Site Visualization (ISV)

3D PDF NOTES: Click screen to activate 3D content.

Mouse controls:
hold left click = rotate
hold right click = zoom (also mouse wheel)
hold left + right click = pan (also Ctrl + left click)
single right click for advanced options, such as full screen

For Adobe help with displaying 3D models, CLICK HERE.

3D PDF Easting Slice
2,032,531 ft easting

Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT

DRAWN BY: MM
DATE: 06/08/18
SCALE: NA

PROJECT NUMBER: 18-11784-70
IMAGE SOURCE: Google Earth

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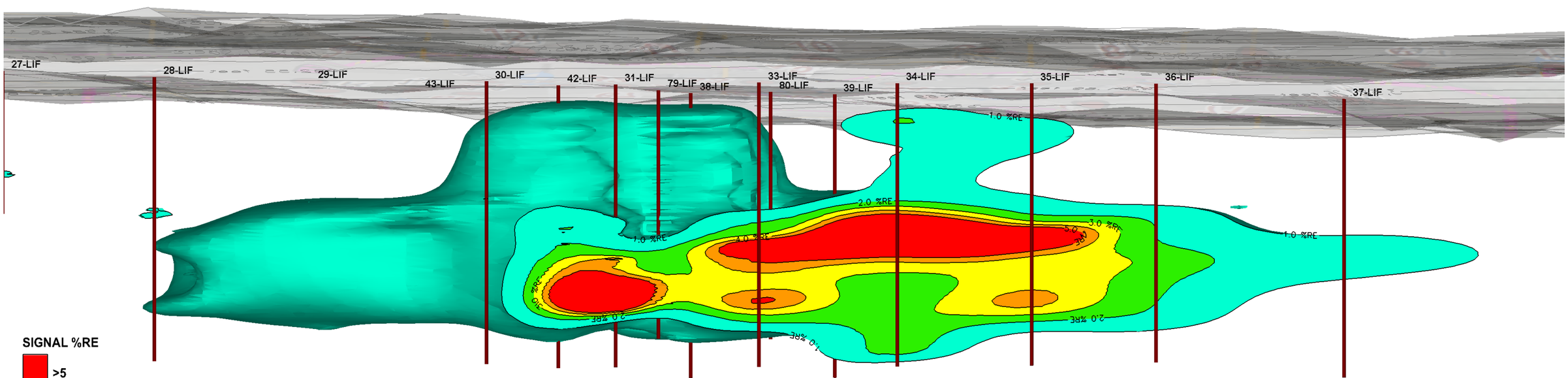
FIGURE 13

3D Visualization of UVOST Signal (%RE)
MTDEQ LIF Investigation
Columbus, MT
Vertical Exaggeration = 5:1

SIGNAL above 1.0 %RE

Vertical Slice, Northing = 505,472.00 feet
Slice azimuth = 108 degrees



SIGNAL %RE

- >5
- 4-5
- 3-4
- 2-3
- 1-2

SIGNAL above 1.0 %RE

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3D PDF Northing Slice
505,472 ft northing

Columbus LIF Investigation
DEQ Agreement #418004
Columbus, MT

DRAWN BY: MM
DATE: 06/08/18
SCALE: NA
PROJECT NUMBER: 18-11784-70
IMAGE SOURCE: Google Earth

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FIGURE 14

List of Tables

Table 1: Groundwater Monitoring Well Data Summary

TABLE 1

Groundwater Monitoring Well Data Summary
Columbus, MT City-Wide UVOST Investigation
DEQ Agreement# 418004

Location	Sample Date	LNAPL (ft)	Depth to Water (ft)	VPH Constituents (µg/L)										EPH Constituents (µg/L)				
				MTBE	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Naph-thalene	C9-C10 Aromatics	C5-C8 Aliphatics	C9-C12 Aliphatics	TPH	EPH Screen	C9-C18 Aliphatics	C19-C36 Aliphatics	C11-C22 Aromatics	TEH
Former Newman's Downtown Exxon [Tetra Tech, 2017]																		
DTX-1																		
	03/19/96	-	8.65	-	**130**	190	580	2,900	-	-	-	-	5,000	-	-	-	-	-
	10/19/00	-	-	<2	<1	<1	<1	<3	<3	<60	<240	<100	<500	-	-	-	-	-
	09/06/02	-	8.86	<2	<1	<1	<1	<3	<3	<20	<150	<150	<300	-	-	-	-	-
	06/29/04	-	8.82	ND	1.5	1.5	11	27	-	36	43	22	107	-	-	-	-	-
	10/25/04	-	9.10	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-	-	-	-
	12/27/11	-	10.07	<0.5	<0.5	<0.5	<0.5	<1.5	<5	<20	<20	<20	20.6	-	-	-	-	-
	10/21/14	-	9.30	<1	<0.5	<0.5	<0.5	<0.5	<1	<20	<20	<20	<20	-	-	-	-	-
	01/06/17	-	9.86	<1	<0.5	<0.5	<0.5	<0.5	1.5	<20	<20	33	231	-	**6,640**	**1,400**	**1,690**	9,930
	06/29/17	-	8.79	<1	<0.5	<0.5	<0.5	<2	<5	<20	<20	<20	<20	<202	-	-	-	-
DTX-2																		
	03/19/96	-	8.65	-	**1,200**	**4,400**	**1,900**	9,900	-	-	-	-	23,000	-	-	-	-	-
	10/19/00	-	-	23	**29**	2	41	75	<2	315	300	<100	1,000	-	-	-	-	-
	09/06/02	-	9.54	free product										free product				
	06/29/04	-	9.25	free product										free product				
	10/25/04	-	9.64	free product										free product				
	12/27/11	-	10.03	free product										free product				
	10/21/14	-	9.58	<1	1.7	2	150	59	13	1,000	325	770	2,110	-	839	<300	607	2,250
	01/06/17	-	9.76	<1	<0.5	1.1	13	<0.75	<2.5	206	143	143	495	-	<306	<306	<306	465
	06/29/17	-	8.54	<1	<0.5	<0.5	70.6	<2	<5	424	167	78	788	-	<202	<202	<202	<605
DTX-3																		
	03/19/96	-	8.92	-	**18**	<1	140	11	-	-	-	-	11,000	-	-	-	-	-
	10/19/00	-	-	<2	<2	<2	<2	<4	<2	1,000	**1,500**	600	3,400	-	-	-	-	-
	09/06/02	-	9.03	<2	<1	26	5	11	<2	180	470	240	1,000	-	-	-	-	-
	06/29/04	-	9.38	ND	1.1	7.5	6.6	9.2	-	382	259	565	980	-	-	-	-	-
	10/25/04	-	9.11	ND	ND	ND	6.7	9.4	-	302	313	484	820	-	-	-	-	-
	12/27/11	-	10.24	<0.5	<0.5	<0.5	4.6	<1.5	<5	150	266	356	701	-	-	-	-	-
	10/21/14	-	9.59	<1	<0.5	<1	<0.5	1.1	<1.5	120	230	122	392	356	-	-	-	-
	01/06/17	-	10.09	<1	<0.5	<0.5	<0.5	2.2	<3	141	338	199	603	594	-	-	-	-
	06/29/17	-	8.93	<1	<0.5	<0.5	<0.5	<2	<5	64	115	38.6	225	277	-	-	-	-
DTX-4																		
	09/06/02	-	8.70	<2	**7**	3	2	9	7	49	<150	<150	<300	-	-	-	-	-
	06/29/04	-	8.60	ND	3.9	3.5	20	47	-	52	64	60	196	-	-	-	-	-
	10/25/04	-	8.89	ND	ND	ND	ND	2.6	-	21	ND	ND	23	-	-	-	-	-
	12/27/11	-	9.81	<0.5	<0.5	<0.5	<0.5	<1.5	<5	<20	<20	<20	<20	-	-	-	-	-
	10/21/14	-	9.02	<1	<0.5	<0.5	<0.5	<0.5	<1	<20	<20	<20	<20	<300	-	-	-	-
	01/06/17	-	9.63	<1	<0.5	<0.5	<0.5	<0.5	<1	<20	<20	<20	<20	<300	-	-	-	-
	06/29/17	-	8.53	<1	<0.5	<0.5	<0.5	<2	<5	<20	<20	<20	<20	<193	-	-	-	-
RBSLs				30	5	1,000	700	10,000	100	1,100	650	1,400			1,400	1,000	1,100	

Bold indicates that the constituent exceeds the MTDEQ Tier 1 RBSL.

(-) Sample was not analyzed for the constituent or data was not available/not applicable.

(ND) Constituent was not detected at a concentration exceeding the method reporting limit.

18-11784-70

TABLE 1 Continued (Page 2 of 4 Pages)

Groundwater Monitoring Well Data Summary
Columbus, MT City-Wide UVOST Investigation
DEQ Agreement# 418004

Location	Sample Date	LNAPL (ft)	Depth to Water (ft)	VPH Constituents (µg/L)										EPH Constituents (µg/L)				
				MTBE	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Naph-thalene	C9-C10 Aromatics	C5-C8 Aliphatics	C9-C12 Aliphatics	TPH	EPH Screen	C9-C18 Aliphatics	C19-C36 Aliphatics	C11-C22 Aromatics	TEH
Former Platinum Motors [Olympus, 2017a], [Weston, 2017]																		
JW-04-4																		
	07/01/04	-	8.89	ND	**605**	130	**1,080**	2,700	-	**5,960**	**11,000**	**4,520**	19,400	-	-	-	-	11
	10/26/04	-	9.25	ND	**535**	122	**913**	1,200	-	**5,490**	**9,000**	**3,840**	15,600	-	ND	ND	0.25	4.4
	03/08/17	-	9.37	<17	**217**	77	**1,060**	1,407	**156**	**5,660**	**2,220**	**6,350**	12,700	8,080	<300	<300	456	3,850
JW-04-5																		
	07/01/04	-	9.22	ND	**398**	**203**	**1,040**	4,660	-	**5,940**	**9,810**	**5,740**	22,400	-	-	-	-	17
	10/26/04	-	9.61	ND	**168**	79	**1,110**	1,390	-	**3,730**	**6,460**	**2,850**	11,800	-	0.43	ND	0.41	18.5
	03/08/17	-	9.71	<20	**154**	69	1,200	1,152	90	**2,290**	**2,250**	**3,900**	8,610	13,800	<300	<300	294	2,280
Montana Rail Link (Former Shell Oil Co.) [Olympus, 2017a]																		
JW-7																		
	08/17/00	-	10.16	<10	**205**	284	317	688	-	**2,630**	-	-	7,450	1,600	<660	<660	<660	-
	05/08/03	0.13	11.32	**574**	**2,940**	**5,690**	**4,080**	**13,800**	**1,230**	**15,500**	**94,900**	**51,100**	146,000	29,200	**7,990**	**1,710**	**2,690**	12,400
	06/30/04	-	9.95	<15	**186**	225	229	436	29	736	**2,390**	580	3,340	1,100	<330	<330	<330	620
	10/26/04	0.10	10.46	<10	**284**	167	285	402	28	848	**1,980**	589	3,490	1,300	<310	<310	<310	510
	09/08/06	-	10.48	**1,160**	**1,830**	**3,240**	**7,180**	**17,600**	**1,600**	**49,600**	**177,000**	**66,500**	324,000	270,000	**257,000**	**<12,800**	**<12,800**	268,000
	06/25/07	-	9.76	**301**	**1,900**	**3,330**	**2,900**	8,670	**623**	**9,510**	**21,700**	**8,130**	56,400	193,000	**147,000**	**14,900**	**20,600**	182,000
	01/17/17	-	11.06	<20	**635**	140	**831**	691	77	**2,270**	**4,430**	**1,960**	9,440	8,820	<300	<300	349	2,900
JW-8																		
	08/17/00	-	9.36	<10	**404**	499	227	1,030	-	**2,780**	-	-	8,830	1,800	<670	<670	<670	-
	05/08/03	-	10.37	**42.3**	**2,980**	**5,000**	**2,570**	9,840	**664**	**5,870**	**44,500**	**15,800**	60,400	412,000	**188,000**	**9,130**	**27,600**	225,000
	06/30/04	-	9.25	<1	**7.8**	5.3	20	63	2.8	68	127	57	288	<330	-	-	-	-
	10/26/04	-	9.66	<1	**144**	44	48	117	6.7	250	**859**	160	1,270	330	-	-	-	-
	09/08/06	-	9.78	**405**	**741**	948	**1,410**	5,560	**512**	**16,200**	**58,400**	**18,100**	102,000	56,500	-	-	-	-
	06/25/07	-	9.10	**328**	**771**	**1,100**	**1,630**	6,360	**658**	**10,800**	**19,100**	**8,110**	48,200	118,000	-	-	-	-
	01/17/17	-	10.43	<1	0.85	0.47	1.4	4	1	48	63	31	128	<300	-	-	-	-
JW-9																		
	08/17/00	-	9.89	<1	2.1	9	3.3	36	-	-	-	-	-	660	-	-	-	-
	05/08/03	-	10.87	**103**	**811**	**4,050**	**1,560**	7,030	**578**	**4,160**	**21,100**	**10,600**	31,800	31,600	**9,200**	**1,670**	**3,310**	14,200
	06/30/04	-	9.90	<2	**11**	33	45	146	14	280	359	238	827	440	-	-	-	-
	10/26/04	-	10.31	<2	**24**	35	58	161	16	342	490	315	1,060	450	-	-	-	-
	09/08/06	-	10.43	**72.9**	**347**	**1,660**	**1,800**	6,630	**<250**	**16,300**	**20,300**	**14,700**	61,800	44,300	-	-	-	-
	06/25/07	-	9.77	**71.2**	**413**	**2,810**	**1,730**	7,920	**570**	**8,900**	**9,620**	**6,920**	38,400	110,000	-	-	-	-
	01/17/17	-	11.02	<10	**52**	111	323	1,350	**118**	**2,260**	**1,800**	**1,940**	6,800	6,640	<300	<300	387	2,560
JW-10																		
	08/17/00	-	9.79	**37**	**22**	3.5	122	461	-	**1,370**	-	-	3,170	610	-	-	-	-
	05/08/03	-	10.59	18.8	**117**	26.1	**936**	1,650	**176**	**1,530**	**4,750**	**4,320**	9,070	5,630	308	497	401	1,210
	06/30/04	-	9.65	<2	**11**	1.5	80	96	11	233	245	250	709	510	-	-	-	-
	10/26/04	-	10.05	<5	**13**	2.8	93	94	14	388	409	343	970	570	-	-	-	-
	09/08/06	-	10.20	16.2	**72.6**	31.3	**831**	904	**152**	**3,060**	**4,470**	**2,630**	12,000	6,430	**1,330**	**1,760**	299	3,390
	06/25/07	-	9.56	14.8	**101**	16.9	**951**	1,490	**148**	**2,920**	**2,170**	**2,040**	9,710	10,600	**1,350**	**5,220**	**2,430**	9,000
	01/17/17	-	10.77	<1	3.7	0.39	5	0.38	1.3	108	131	73	282	1,360	<300	<300	<300	<300
RBSLs				30	5	1,000	700	10,000	100	1,100	650	1,400			1,400	1,000	1,100	

Bold indicates that the constituent exceeds the MTDEQ Tier 1 RBSL.

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TABLE 1 Continued (Page 3 of 4 Pages)

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Montana Rail Link (Former Shortridge Oil Co.) [Olympus, 2017b]																		
MW-1																		
	10/10/94	-	10.98	-	**60**	183	629	2,500	-	-	-	-	-	-	-	-	-	-
	11/23/98	-	10.13	<2	4.9	8.2	ND	ND	-	-	-	-	525	-	-	-	-	<0.5
	06/30/04	-	10.25	ND	1.5	6.5	31	77	-	353	429	357	952	-	0.28	ND	ND	1.7
	10/25/04	0.15	10.81	ND	1	2.5	22	58	-	299	313	275	690	-	-	-	-	0.73
	01/09/17	0.30	11.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-2																		
	10/10/94	-	9.85	-	<1.25	10	30	88	-	-	-	-	-	-	-	-	-	-
	11/23/98	-	9.23	<2	<0.5	<0.5	<0.5	<1	-	-	-	-	<20	-	-	-	-	<0.5
	06/30/04	-	9.37	ND	ND	ND	0.76	2.9	-	22	44	38	88	-	-	-	-	ND
	10/25/04	-	9.74	ND	ND	ND	ND	1	-	ND	ND	ND	19	-	-	-	-	ND
	01/09/17	-	10.31	<1	**<0.5**	<0.5	<0.5	0.44	<1	<20	<20	<20	18	<300	-	-	-	-
MW-3																		
	10/10/94	-	9.32	-	<0.5	<0.5	<0.5	<0.5	-	-	-	-	-	-	-	-	-	-
	11/23/98	-	8.81	<2	<0.5	<0.5	<0.5	<1	-	-	-	-	<20	-	-	-	-	<0.53
	06/30/04	-	8.94	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-	-	-	ND
	10/25/04	-	9.32	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-	-	-	ND
	01/09/17	-	9.92	<1	<0.5	<0.5	<0.5	<0.5	<1	<20	<20	<20	<20	<300	-	-	-	-
MW-4																		
	11/23/98	-	9.18	<100	**428**	ND	ND	ND	-	-	-	-	32,000	-	-	-	-	15
	06/30/04	-	10.34	ND	**195**	99	601	1,440	-	**5,020**	**5,310**	**3,630**	12,000	-	0.63	ND	0.45	9.2
	10/25/04	-	9.80	ND	**71**	42	494	792	-	**4,170**	**4,090**	**3,690**	9,460	-	ND	ND	0.35	6.3
	01/09/17	-	10.35	<10	**11**	20	141	85	18	**2,170**	**1,960**	**1,460**	5,100	10,500	**1,940**	<300	754	5,160
MW-5																		
	11/23/98	-	9.54	<100	**703**	ND	ND	ND	-	-	-	-	41,300	-	-	-	-	21
	06/30/04	0.39	10.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/25/04	0.49	10.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	01/09/17	0.54	11.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RBSLs				30	5	1,000	700	10,000	100	1,100	650	1,400			1,400	1,000	1,100	

Bold indicates that the constituent exceeds the MTDEQ Tier 1 RBSL.

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TABLE 1 Continued (Page 4 of 4 Pages)

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Columbus Farmers Union [RTI, 2017b]																		
MW-2																		
	02/15/17	-	9.85	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	-
	06/15/17	-	7.66	ND	ND	ND	ND	ND	ND	ND	20	21	35	ND	-	-	-	-
MW-4																		
	02/15/17	-	8.76	ND	0.8	ND	7.2	0.68	ND	169	203	112	489	3,700	ND	ND	ND	ND
	06/15/17	-	6.37	ND	ND	ND	12	ND	3	224	253	154	544	2,280	ND	ND	ND	ND
MW-12																		
	02/15/17	-	9.11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	-
	06/15/17	-	6.89	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	-
MW-13																		
	02/15/17	-	9.05	ND	ND	ND	ND	ND	ND	20	54	20	94	2,160	ND	ND	ND	ND
	06/15/17	-	6.74	ND	ND	ND	ND	0.46	1.5	40	42	22	101	1,540	ND	ND	ND	ND
SVE-5																		
	02/15/17	-	10.81	ND	3.8	ND	13	3	ND	298	81	216	878	10,600	**1,940**	471	**1,630**	4,470
	06/15/17	-	8.56	ND	3	ND	9.7	2.1	6.8	305	59	257	790	8,960	658	ND	723	1,750
RBSLs				30	5	1,000	700	10,000	100	1,100	650	1,400			1,400	1,000	1,100	

Bold indicates that the constituent exceeds the MTDEQ Tier 1 RBSL.

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List of 4DIMs (click to download 4DIM player)

4DIM 1: Columbus_UVOST_Isolevels_4DIM.4d (click to download)

4DIM 2: Columbus_UVOST_Horizontal_Slices_4DIM.4d (click to download)

4DIM 3: Columbus_UVOST_Easting_Slices_4DIM.4d (click to download)

4DIM 4: Columbus_UVOST_Northing_Slices_4DIM.4d (click to download)

Appendix A

Dakota Technologies HRSC UVOST Report

High Resolution Site Characterization Report – UVOST®-EC Investigation

Client: WCEC

Project Name: Columbus DEQ Sites

Location: Columbus, MT

Prepared by:

Dakota Technologies Company, LLC

Morris, MN 56267

320-589-4610

5/7/18

Project Number: 138.18

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1.0 UVOST® SYSTEM DESCRIPTION & CALIBRATION

The Ultra-Violet Screening Tool (UVOST®) is a laser induced screening tool specifically designed to detect light-non-aqueous phase liquid (LNAPL) in the subsurface. It is primarily used for mapping petroleum, oils and lubricants (POLs) at fueling areas, railroad sites, pipelines, refineries etc. UVOST® had been in commercial use since 1994. Fluorescence is the emission of photons (light) of a longer wavelength relative to the source emission. The release of these photons can be used to detect small amounts of substance (i.e., polycyclic aromatic hydrocarbons (PAHs)) in a larger matrix (soil). This method of detection has been used in laboratories for decades. With the commercial availability of lasers and optical fibers, this technology can also be applied in-situ in the field to identify the presence of light non-aqueous phase liquids (LNAPL).

The UVOST® system sends laser light (308 nanometer wavelength) through a fiber optic cable strung within probe rods on a direct push drill rig. The light, reflected by a parabolic mirror, then exits through a sapphire window in the side of the probe. As the probe is advanced, the immediately adjacent soil is exposed to the UV laser light. If PAHs (compounds in petroleum oils and lubricants that fluoresce) are present, longer wavelength light is emitted by the PAH compounds. This “signal” light is transmitted through a return fiber, back to the surface to be analyzed. Responses are indicated in real-time on a graph of signal vs. depth. The UVOST® log displays “color mixed” signal logs consisting of contributions from four wavelength channels, and waveforms (“fingerprint” of multi-wavelength) to aid in identification and relative quantity of the compound present.

Prior to every log, the UVOST® system is checked for optical quality by observing the background signal for sources of signal in the fiber, filter, mirror and sapphire window. Also, the reference emitter (a standard, proprietary LNAPL mixture called the “RE”) is placed on the window to determine the qualitative and semi-quantitative properties of the laser system. This is to assure that the RE response has the correct shape and intensity and that the UVOST® system is calibrated to log. Typically, the RE will fall between 10,000 and 11,000 picovolt-seconds (pVs), which is a measure of waveform area. The background can vary from 0.1% to 1%, which is typically an area of approximately 0 to 100 pVs. The relationship between the instrument responses from NAPL in the subsurface and the RE depends on the properties of the NAPL. The calibration of the system is not to a concentration, but to a known fluorescence signature.

2.0 ELECTRICAL CONDUCTIVITY (EC) DESCRIPTION

Electrical Conductivity (EC) data were collected simultaneously with the UVOST® data. EC is a measure of the soil's ability to conduct an electrical current between two dipoles on the UVOST/EC probe. Conductivity is the reciprocal of electrical resistivity and has the units (in our application) of millisiemens per meter (mS/m). Since soil is in the pathway of the charge flow, the grain size can be determined by comparing the EC log to lithology observed in a soil boring. Conductivity readings in the 100s indicate smaller grain (size such as clay). Larger grain size (sand and gravels) are typically in the 10s of mS/m range. Prior to every log, the EC point of the UVOST® probe is checked for proper operation by performing a voltage test with a voltage meter and a conductivity test with a test block.

3.0 DISCUSSION AND COMMENTS

Dakota Technologies Company, LLC (Dakota) completed 96 UVOST® borings on the property over 8-days in April/May 2018. The target depth of the borings was 16 feet, based upon data acquired by WCEC personnel from previous site activities. QA/QC tests were performed prior to the advancement of each boring and passed specifications before any data was collected.

Drilling conditions at this site proved to be quite difficult and damaging to the UVOST equipment. Large cobble present in the subsurface often damaged or bent drilling rods and adapters or broke the sapphire windows on the UVOST tooling. Sapphires are a 9/10 on the Moh's scale of mineral hardness, meaning that it is extremely hard and naturally scratch resistant. Under great pressure, such as the forces exerted on the window during advancement and extraction of the drilling rods through large cobbles, they can shatter/crack. Over the course of the project, these conditions led to damaging: 9 sapphire windows, 2 SPOCS (main probe body), 3 mirrors, 3 connection tubes (starter rod), and 4 adapters (connects SPOC to starter rod).

Typically, UVOST borings are pre-drilled with a solid point to a depth of approximately 2ft to clear any surface debris and ensure a straight boring, at which point they are advanced with the UVOST probe to the desired depth. This method of only pre-probing approximately 2 ft ensures good subsurface contact with the sapphire window, which gives the most accurate data. This method was followed for the first 31 borings that were advanced on this site. At this point much of the previously mentioned equipment damage had occurred, and an alternate method was needed to proceed with the project. With input from WCEC field personnel, it was decided to pre-probe the entire 16-foot boring depth. The pre-probing was done with 1.5-inch rods, like those being used in the UVOST portion of the project, with a 1.75-inch solid point. The SPOC being used in the UVOST portion of this project is 1.625-inches in diameter, which can potentially leave a gap of 0.125-inches between the sapphire window and the subsurface. For this reason, this method is generally not suggested except in extreme conditions. Boring 32-LIF was the first boring advanced with this method and was completed as a duplicate of 31-LIF. The responses seen in the two borings were similar both in the intensity of the responses and depths at which they were found. After discussions with WCEC field personnel, the Portage representative (DEQ surrogate), and the DEQ representative on site, it was determined that the project would continue with this method.

During this investigation, borings were advanced near several different suspected/known leak sites and across multiple properties. For the sake of this report they will be generalized down to MRL (Montana Rail Link), ROW (right of way)/lumberyard, and Farmer's Union Trading Company. The MRL site includes the rail right of way, the adjacent leased properties to the north and south of the tracks, and the street/alley way to the south of the lease properties. The ROW/lumberyard includes all the borings done within E Pike

Avenue, the lumberyard parking lot, and Diamond Street. The Farmer's Union Trading site includes the active station and the parking lot of Montana Silversmith's to the south.

The MRL property and the adjacent lease properties were the largest of the three areas investigated during this project. Borings 1-LIF to 23-LIF were advanced within the railway area of the MRL property. This area required a railway spotter as well as derails and switch locks. Borings 24-LIF to 43-LIF, as well as borings 79-LIF and 80-LIF were advanced in the leased property areas to the north of the railway. These properties are owned by MRL but leased to other businesses such as the Stillwater Building Center. Borings 44-LIF to 65-LIF, 81-LIF to 84-LIF, and 94-LIF to 96-LIF were advanced in the leased properties and roadway/alleyway to the south of the railway. These properties are owned by MRL and leased to other businesses like those found on the north side of the railway. The borings advanced in the roadway/alleyway are on City of Columbus property.

LNAPL was observed in most of the borings advanced in this area of the investigation. The LNAPL found during the advancement of these borings was typically found between 8-13 feet below the surface. Shallower responses in borings 34-LIF, 38-LIF, and 42-LIF started as shallow as 1 foot and were found as deep as 14 feet suggesting a vertical migration of LNAPL though the soil column in this area. In some cases, this can suggest a potential source area but additional lines of evidence such as soil borings, Sanborn maps, and as built data from any old tank systems are needed to be certain.

The ROW/lumberyard area to the north of MRL properties was suspected to have two potential sources based upon reports WCEC personnel obtained prior to beginning this project. Borings 64-LIF to 78-LIF were advanced within this area. This area required an MDT permit to work within the road right of way as well as a traffic control setup.

LNAPL was observed in most of the borings advanced in this area of the investigation. LNAPL found during the advancement of these borings was typically found between 7-13 feet below surface, with the largest response being found at the water table interface (~8 feet). The largest responses in this area were found around the building center office. Based upon the UVOST responses and old report data from WCEC, the potential source in this area may exist underneath the Stillwater Building Center office.

The Farmer's Union Trading Company area was several blocks away from the MRL and ROW/lumberyard sites and formerly had an SVE system operating on site. Borings 85-LIF to 93-LIF were advanced in this area. Despite previously having an operating remediation system, LNAPL was found in all but one of the borings advanced on this site. LNAPL was typically found between 8-15 feet below the surface at this site. Groundwater is thought to travel in a southwesterly direction in this area, yet borings 85-LIF,91-LIF, and 92-

LIF on the northeast area of the site had some of the highest responses. Additional access to the surrounding properties would be required to fully delineate the contamination plume with LIF in this area.

4.0 LIMITATIONS

The analysis and opinions expressed in this report are based upon data obtained from the specific test locations and from other information discussed in this report. Exceptions, if any, are discussed in the accompanying comments section of this report. This report is prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted practices. Reported results shall not be reproduced, except in full, without written approval of Dakota. No warranties, expressed or implied are intended or made.

Appendix A

UVOST® Field Summary Log

UVOST®-EC Field Summary Log

Columbus DEQ Sites 138.18

Columbus, MT

File Log ID	Date / Time	Pre-Probe *(ft)*	Final Depth *(ft)*	Max Signal *(%RE)*	Max Signal Depth *(ft)*	Initial RE Area *(pVs)*	Background Area *(pVs)*	Fluorescence* Top - Bottom
01-LIF	4/23/2018 12:37	3	16.8	3	11.7	10550	0	11.3-13.0
02-LIF	4/23/2018 13:03	3	16.1	9	12.5	10462	34	8.3-13.7
03-LIF	4/23/2018 13:26	3	16.0	4	12.3	9975	22	7.1-8.2, 11.2-13.2
04-LIF	4/23/2018 13:51	3	16.1	6	13.0	11680	30	11.8-13.2
05-LIF	4/23/2018 14:14	3	15.3	1	10.5	12077	41	-
06-LIF	4/23/2018 14:39	3	16.0	3	11.7	11292	43	9.9-10.5, 11.7-13.8
07-LIF	4/23/2018 15:16	3	16.0	2	11.7	11809	51	8.6-9.3, 11.2-13.0
08-LIF	4/23/2018 15:40	3	16.0	3	11.7	11830	42	6.8, 11.4-13.0
09-LIF	4/23/2018 16:05	3	16.0	5	13.1	10728	39	10.1-13.5
10-LIF	4/24/2018 10:00	3	16.0	2	13.5	9518	8	6.4-13.9
11-LIF	4/24/2018 10:24	3	16.0	1	11.7	10739	2	Elevated BKG from 5.3-12.0
12-LIF	4/24/2018 10:48	3	16.0	1	0.1	10328	6	-
13-LIF	4/24/2018 11:28	3	16.1	4	12.7	10589	15	10.4-14.2
14-LIF	4/24/2018 12:26	3	12.4	1	0.0	10439	7	12.1-EOB
15-LIF	4/24/2018 12:51	3	9.5	1	0.2	10621	13	-
16-LIF	4/24/2018 13:30	3	16.1	7	11.4	10239	19	9.9-13.8
17-LIF	4/24/2018 13:51	3	16.1	4	11.5	10440	18	7.1-13.6
18-LIF	4/24/2018 14:16	3	16.0	3	12.0	10343	13	11.1-13.2
19-LIF	4/24/2018 14:35	3	16.0	20	13.6	10934	31	11.3-14.2
20-LIF	4/24/2018 15:04	3	16.0	6	11.7	10594	37	6.9-13.7
21-LIF	4/24/2018 15:27	3	16.0	2	9.3	11017	60	7.0-9.2
22-LIF	4/24/2018 15:55	3	16.0	3	0.0	10318	45	-
23-LIF	4/24/2018 16:34	3	16.1	3	12.9	10901	93	12.2-13.1
24-LIF	4/25/2018 9:24	3	16.0	2	0.1	10501	26	6.1-10.8
25-LIF	4/25/2018 9:51	3	16.0	4	6.2	12168	33	6.2-10.0
26-LIF	4/25/2018 10:17	3	5.6	1	1.7	11663	22	-
27-LIF	4/25/2018 10:32	3	8.1	1	6.0	11680	29	5.5-EOB
28-LIF	4/25/2018 10:56	3	16.1	2	7.9	11357	30	7.2-8.0
29-LIF	4/25/2018 11:19	3	6.9	1	6.8	10407	30	6.3-EOB
30-LIF	4/25/2018 11:36	3	16.0	1	6.7	11424	35	-
31-LIF	4/25/2018 12:38	3	16.0	19	11.4	10796	46	7.4-13.1
32-LIF	4/25/2018 15:10	16	16.2	10	9.3	10102	63	6.5-14.9
33-LIF	4/25/2018 15:37	16	16.1	29	9.2	11074	77	7.5-13.6
34-LIF	4/25/2018 16:05	16	16.1	64	9.0	10502	64	1.5-3.5, 6.9-15.8
35-LIF	4/25/2018 16:49	16	16.0	45	8.6	10673	89	8.5-14.4
36-LIF	4/25/2018 17:11	16	15.8	5	9.9	9862	83	9.0-13.6

UVOST®-EC Field Summary Log

Columbus DEQ Sites 138.18

Columbus, MT

File Log ID	Date / Time	Pre-Probe *(ft)*	Final Depth *(ft)*	Max Signal *(%RE)*	Max Signal Depth *(ft)*	Initial RE Area *(pVs)*	Background Area *(pVs)*	Fluorescence* Top - Bottom
37-LIF	4/25/2018 17:39	16	15.8	4	8.1	11007	89	7.9-10.6
38-LIF	4/26/2018 9:26	16	16.1	19	6.2	11796	73	1.0-13.1
39-LIF	4/26/2018 9:48	16	16.0	18	7.9	11439	65	5.9-13.3
40-LIF	4/26/2018 10:29	16	16.1	9	8.3	11412	73	6.2-12.2
41-LIF	4/26/2018 10:51	16	15.7	4	7.3	10300	70	6.3-8.2
42-LIF	4/26/2018 11:23	16	16.0	35	7.7	11246	74	1.3-14.2
43-LIF	4/26/2018 12:03	16	15.9	2	0.0	10705	53	-
44-LIF	4/26/2018 13:34	16	16.0	3	0.0	11111	49	-
45-LIF	4/26/2018 13:52	14.5	14.0	1	10.5	11687	64	8.4
46-LIF	4/26/2018 14:25	16	16.0	21	6.0	11765	53	4.0-13.8
47-LIF	4/26/2018 14:54	16	15.9	12	8.2	11482	57	7.4-13.3
48-LIF	4/26/2018 16:55	16	15.4	8	7.6	10770	52	6.6-11.9
49-LIF	4/26/2018 17:20	16	15.7	3	8.0	11850	46	8.6-12.4
50-LIF	4/26/2018 17:44	16	15.5	10	9.7	10794	40	9.1-14.3
51-LIF	4/27/2018 9:28	16	15.4	5	0.0	10360	21	13.4
52-LIF	4/27/2018 10:03	16	16.1	128	8.6	11919	0	4.6-EOB
53-LIF	4/27/2018 10:37	16	16.0	20	15.3	11813	10	5.1-EOB
54-LIF	4/27/2018 11:05	16	16.0	5	8.8	11415	15	8.0-12.6
55-LIF	4/27/2018 11:41	16	15.9	3	9.3	10119	9	6.7-12.9
56-LIF	4/27/2018 12:24	16	15.9	7	7.9	11528	25	7.8-8.1
57-LIF	4/27/2018 14:11	16	14.2	4	9.8	9614	19	8.4-13.4
58-LIF	4/27/2018 14:31	16	15.7	1	15.7	10046	29	-
59-LIF	4/27/2018 15:03	16	15.9	23	8.1	10800	25	8.0-13.3
60-LIF	4/27/2018 15:34	16	15.6	8	10.1	11112	21	9.9-12.9
61-LIF	4/27/2018 16:04	16	15.8	6	12.5	11153	23	7.6-13.3
62-LIF	4/27/2018 16:32	16	16.0	27	8.1	11099	20	8.1-12.0
63-LIF	4/27/2018 17:07	16	15.7	6	8.2	10033	29	4.8-13.1
64-LIF	4/30/2018 10:55	16	16.1	12	9.6	12918	38	6.5-13.9
65-LIF	4/30/2018 11:14	16	16.0	4	1.0	11151	34	8.3-13.0
66-LIF	4/30/2018 11:41	16	16.0	4	10.6	10313	28	7.0-12.6
67-LIF	4/30/2018 12:28	16	14.2	3	0.2	12543	39	-
68-LIF	4/30/2018 13:41	16	15.1	4	8.5	78734	26	7.7-13.1
69-LIF	4/30/2018 14:15	16	16.0	3	4.8	11899	18	7.8-13.7
70-LIF	4/30/2018 14:43	16	15.4	3	7.8	12161	19	7.7-12.3
71-LIF	4/30/2018 15:10	16	15.2	1	6.0	11705	24	5.9-6.1
72-LIF	4/30/2018 15:53	16	13.8	11	8.2	11076	13	8.1-12.8

UVOST®-EC Field Summary Log

Columbus DEQ Sites 138.18

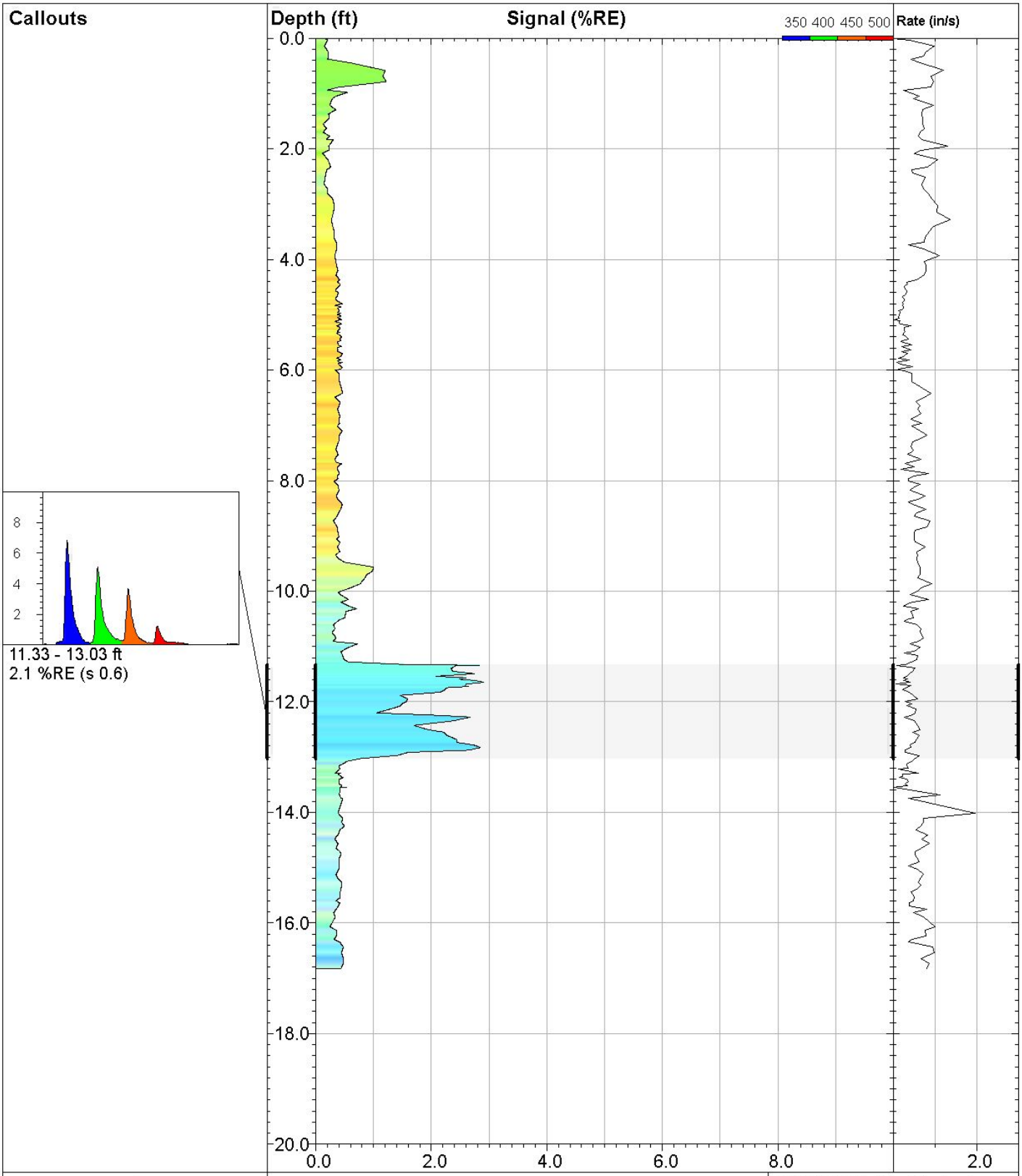
Columbus, MT

File Log ID	Date / Time	Pre-Probe *(ft)*	Final Depth *(ft)*	Max Signal *(%RE)*	Max Signal Depth *(ft)*	Initial RE Area *(pVs)*	Background Area *(pVs)*	Fluorescence* Top - Bottom
73-LIF	4/30/2018 16:25	16	15.5	2	0.0	11032	9	7.5-7.6
74-LIF	4/30/2018 16:50	16	15.8	1	6.7	11084	15	8.1-13.0
75-LIF	4/30/2018 17:26	16	15.9	4	0.4	11204	12	7.9-12.9
76-LIF	5/1/2018 10:31	16	15.7	21	8.2	11109	21	7.8-13.7
77-LIF	5/1/2018 10:59	16	15.4	1	0.1	10600	0	-
78-LIF	5/1/2018 11:36	16	15.4	6	12.6	11070	23	7.4-13.8
79-LIF	5/1/2018 12:23	16	14.1	3	10.9	10706	23	8.3-12.7
80-LIF	5/1/2018 12:57	16	14.0	12	8.7	10699	34	7.5-13.8
81-LIF	5/1/2018 15:05	16	15.4	18	9.0	10937	0	4.2-4.6, 8.8-14.8
82-LIF	5/1/2018 15:31	16	14.0	29	7.8	10344	0	7.5-11.2
83-LIF	5/1/2018 16:40	16	14.0	1	8.3	11107	27	-
84-LIF	5/1/2018 17:14	16	14.1	2	0.7	11255	36	7.4
85-LIF	5/2/2018 10:19	16	16.0	72	10.9	10621	0	9.9-15.0
86-LIF	5/2/2018 10:49	16	16.0	88	9.9	11710	34	9.8-15.6
87-LIF	5/2/2018 11:13	16	15.7	41	9.2	10952	39	8.7-14.8
88-LIF	5/2/2018 11:45	16	14.2	37	12.8	11087	42	8.9-14.2
89-LIF	5/2/2018 12:20	16	15.8	32	8.0	11222	29	7.8-14.2
90-LIF	5/2/2018 13:08	16	16.0	17	9.9	9762	22	9.7-14.9
91-LIF	5/2/2018 13:34	16	15.7	67	10.1	10277	21	9.8-14.8
92-LIF	5/2/2018 13:59	16	15.9	52	10.3	9426	46	9.1-15.1
93-LIF	5/2/2018 14:29	16	15.4	2	0.6	10716	24	7.1
94-LIF	5/2/2018 15:21	16	14.6	4	0.2	9910	18	-
95-LIF	5/2/2018 15:43	16	16.0	1	7.6	10934	19	7.6
96-LIF	5/2/2018 16:03	16	16.0	2	0.1	10812	18	-
		Total Footage	**1468.2**					

* Many low responses were not included in this graph. See Report Discussion Section.

Appendix B

UVOST® Logs at 10% RE



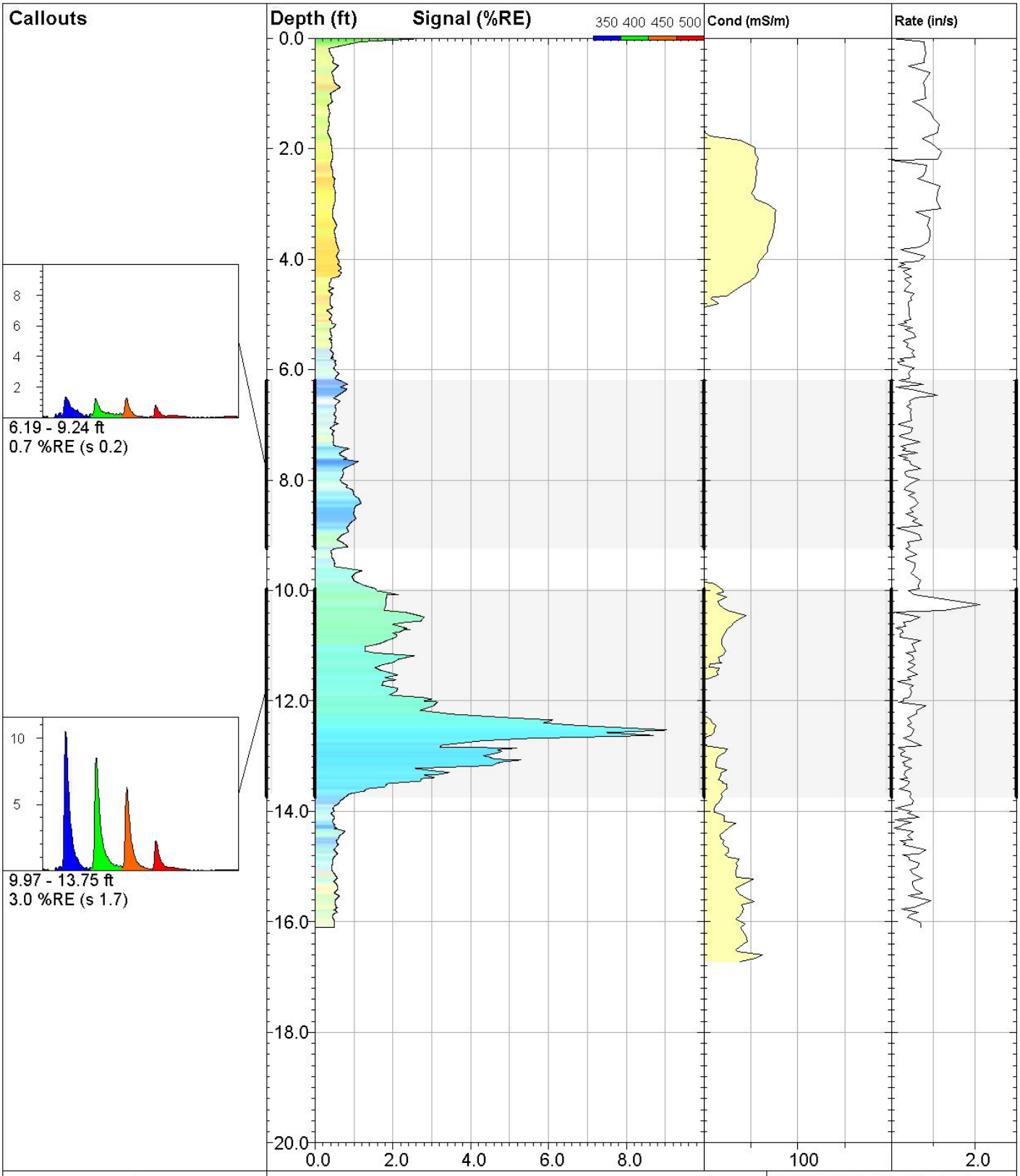
DAKOTA TECHNOLOGIES

www.DakotaTechnologies.com

01-LIF

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.83 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.9 %RE @ 11.65 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 12:37 CDT**



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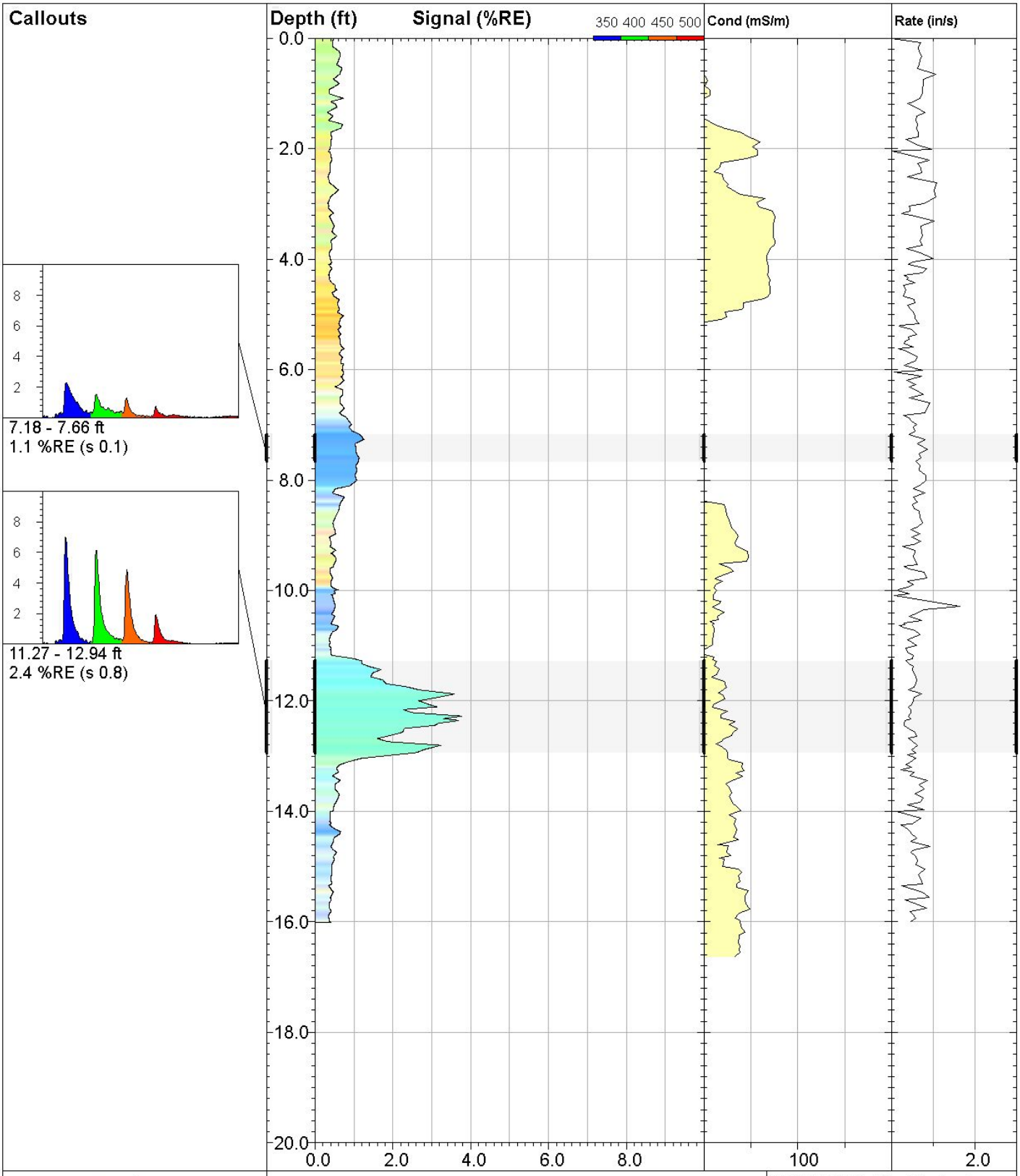
02-LIF

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.10 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **9.1 %RE @ 12.53 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 13:03 CDT**



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03-LIF

UVOST® By Dakota
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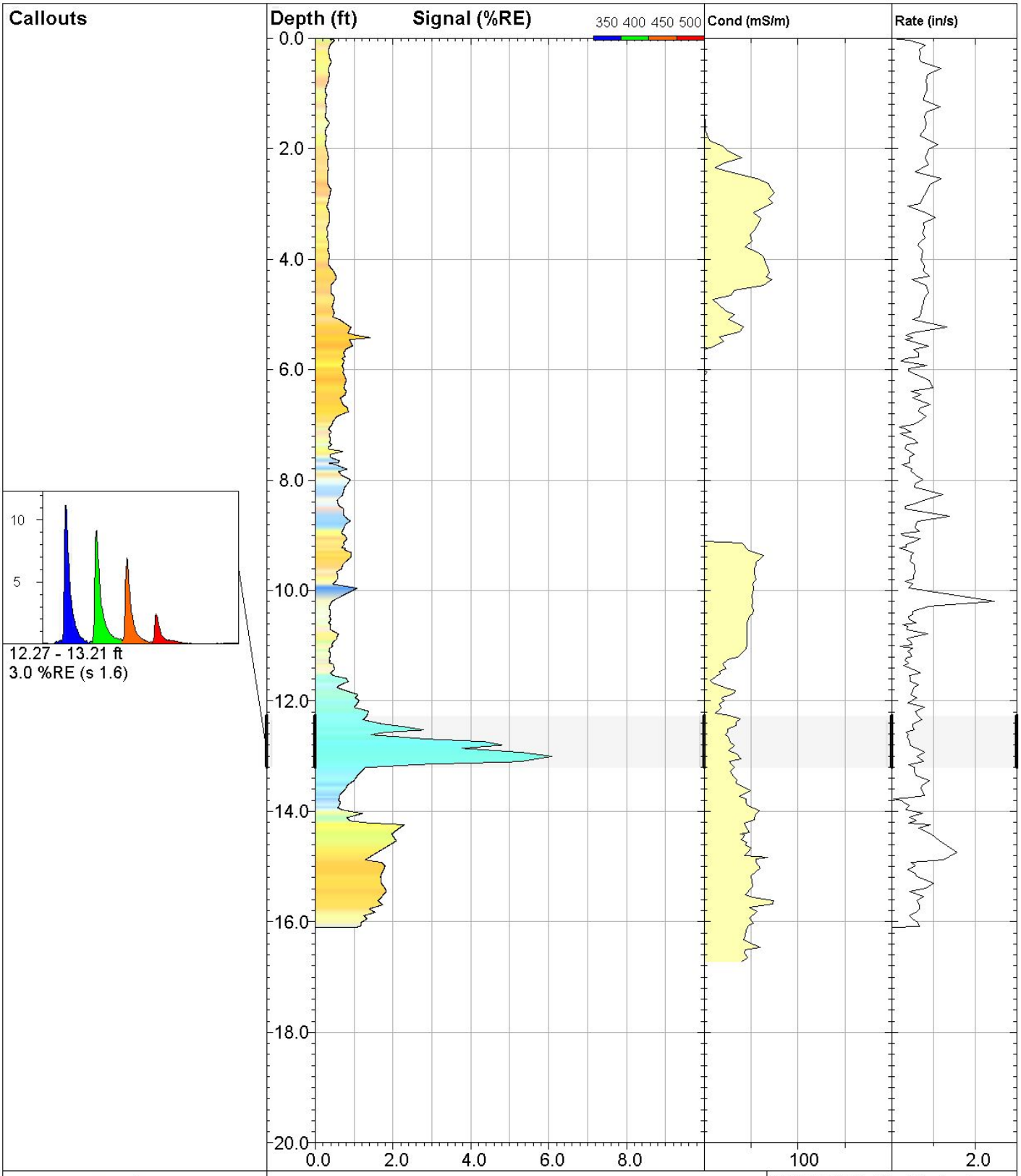
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.8 %RE @ 12.28 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 13:26 CDT**



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04-LIF

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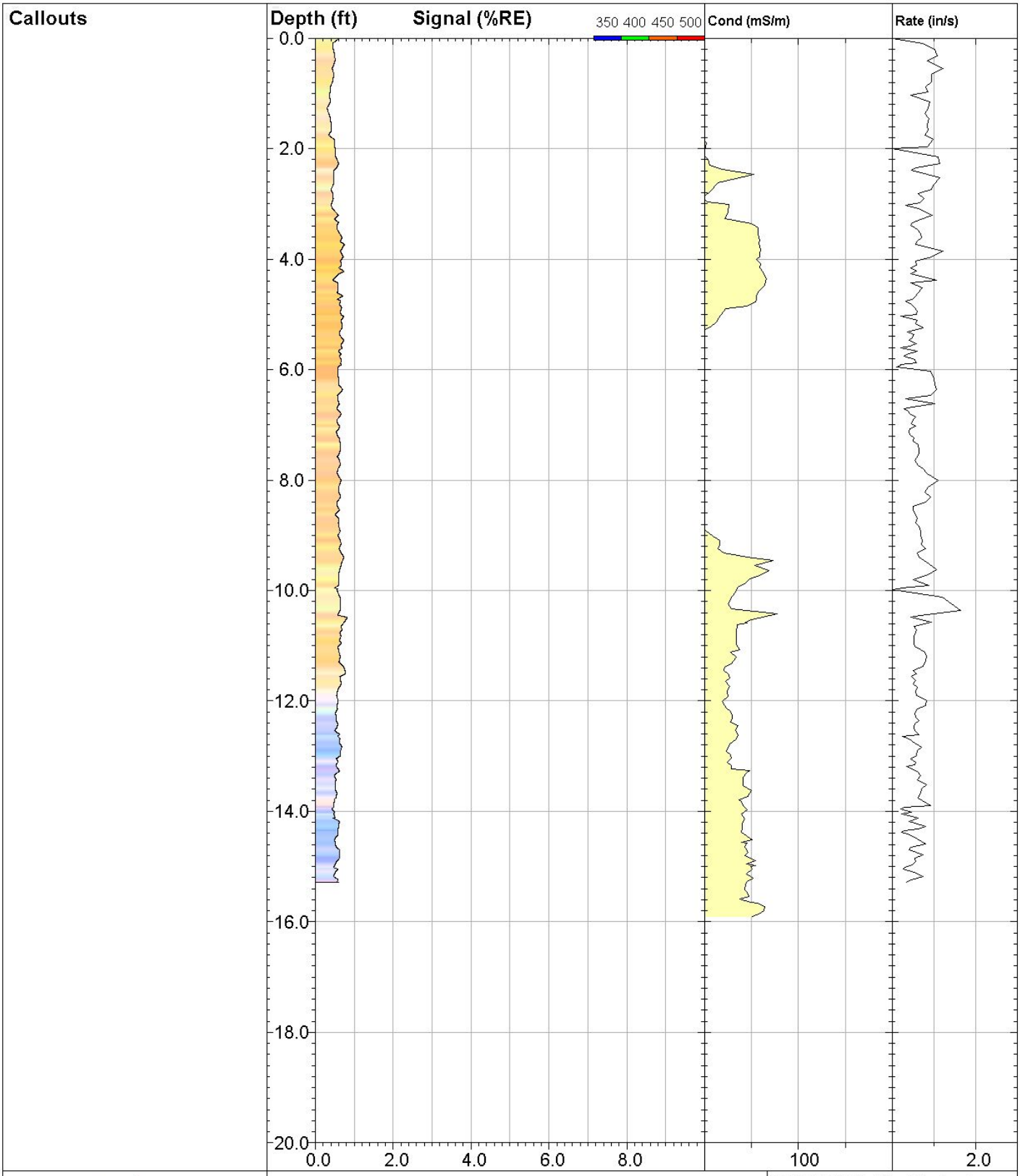
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.10 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.1 %RE @ 13.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 13:51 CDT**



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05-LIF

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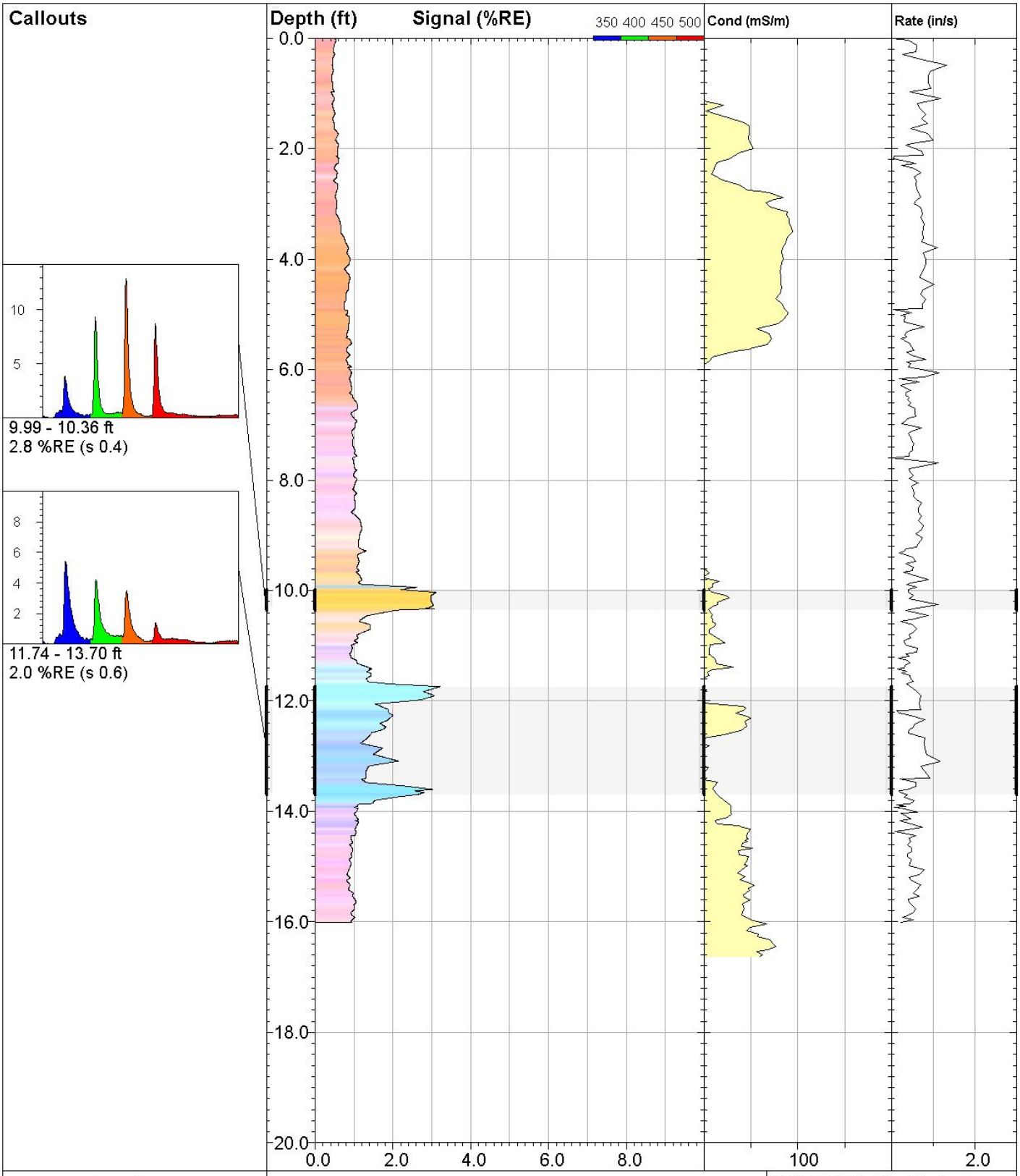
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.29 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **0.8 %RE @ 10.49 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 14:14 CDT**



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06-LIF

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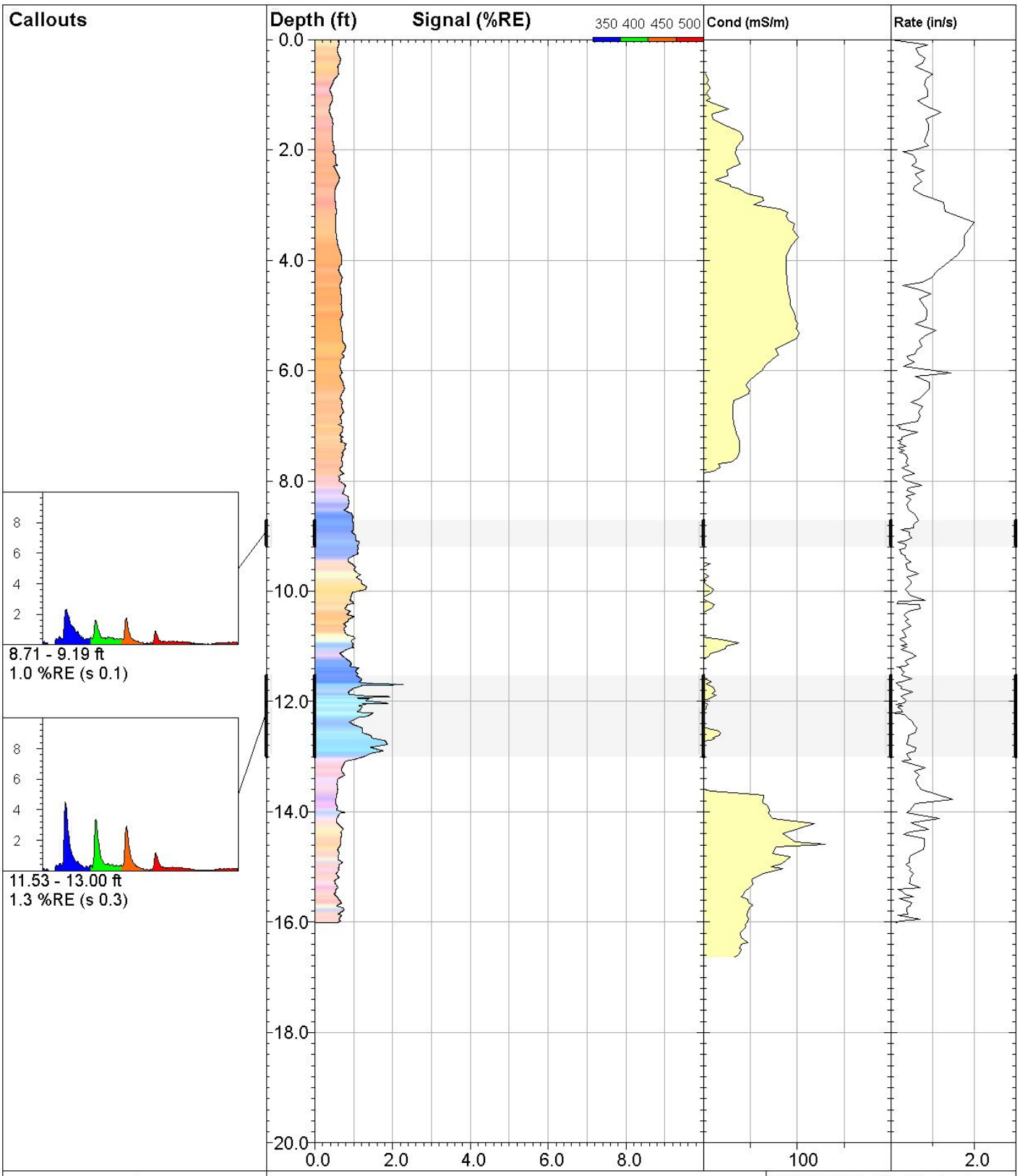
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.2 %RE @ 11.74 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 14:39 CDT**



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07-LIF

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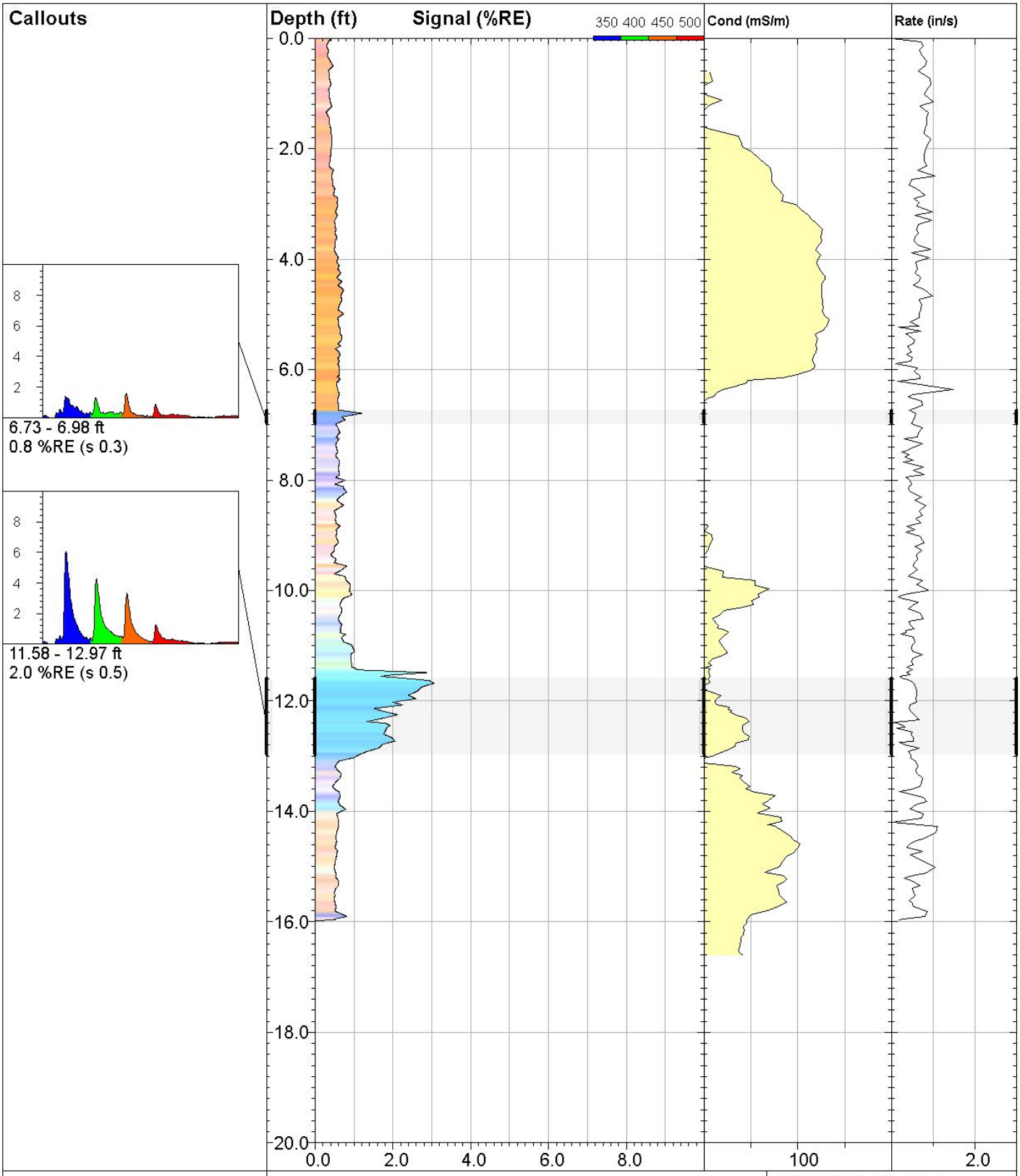
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.3 %RE @ 11.69 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 15:16 CDT**



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08-LIF

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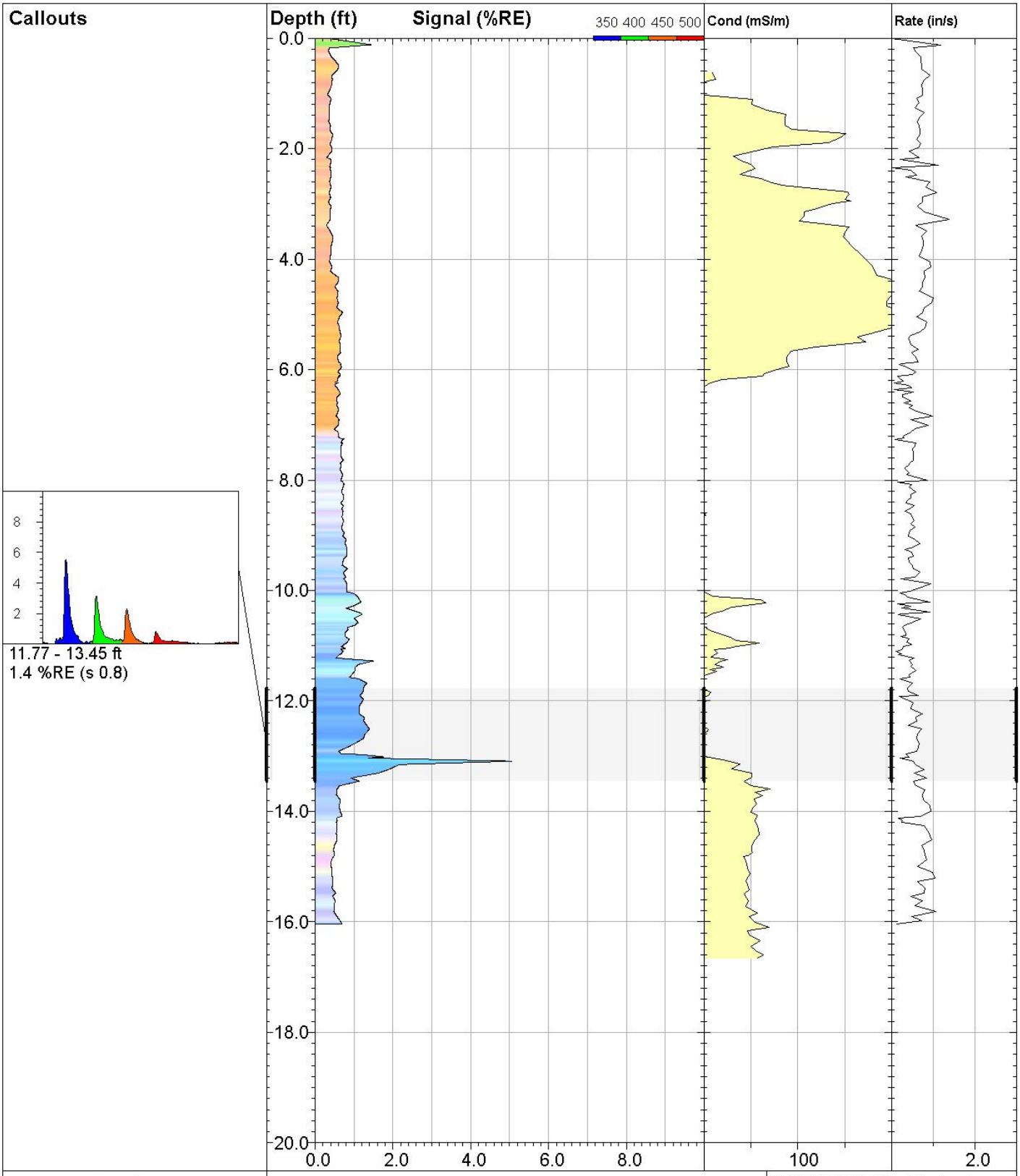
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.97 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.1 %RE @ 11.68 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 15:40 CDT**



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09-LIF

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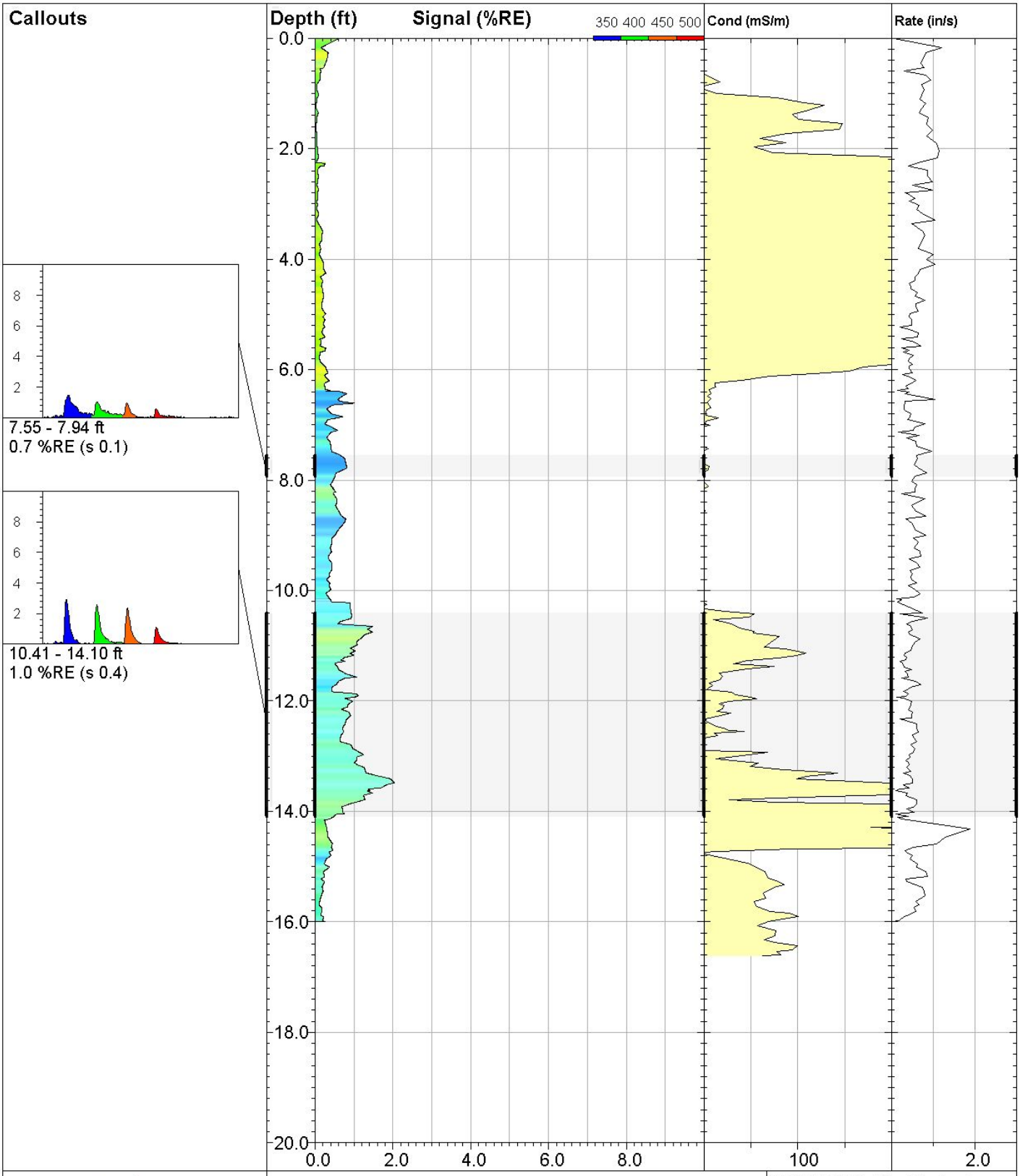
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.1 %RE @ 13.09 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 16:05 CDT**



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10-LIF

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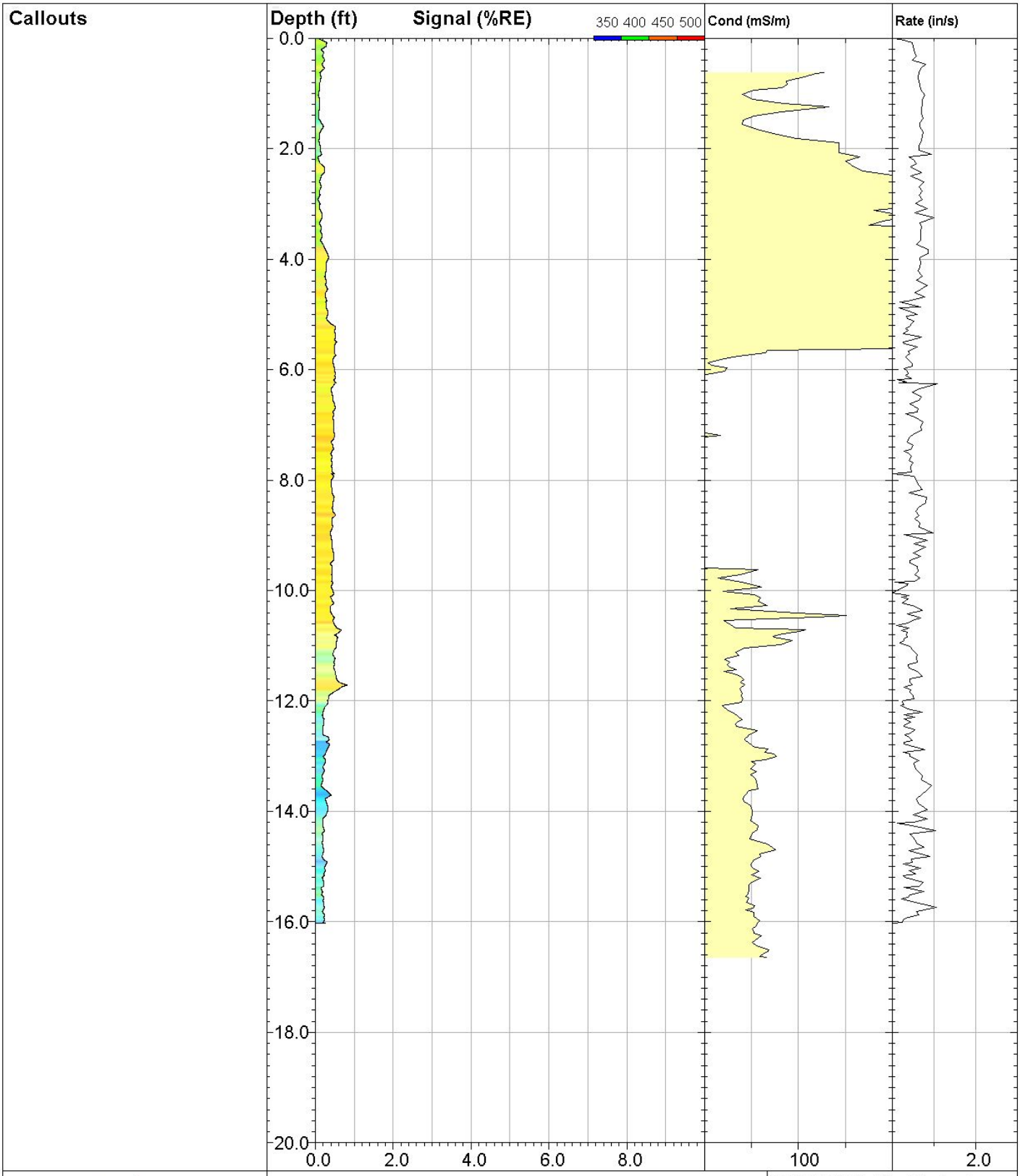
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.0 %RE @ 13.48 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 10:00 CDT**



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11-LIF

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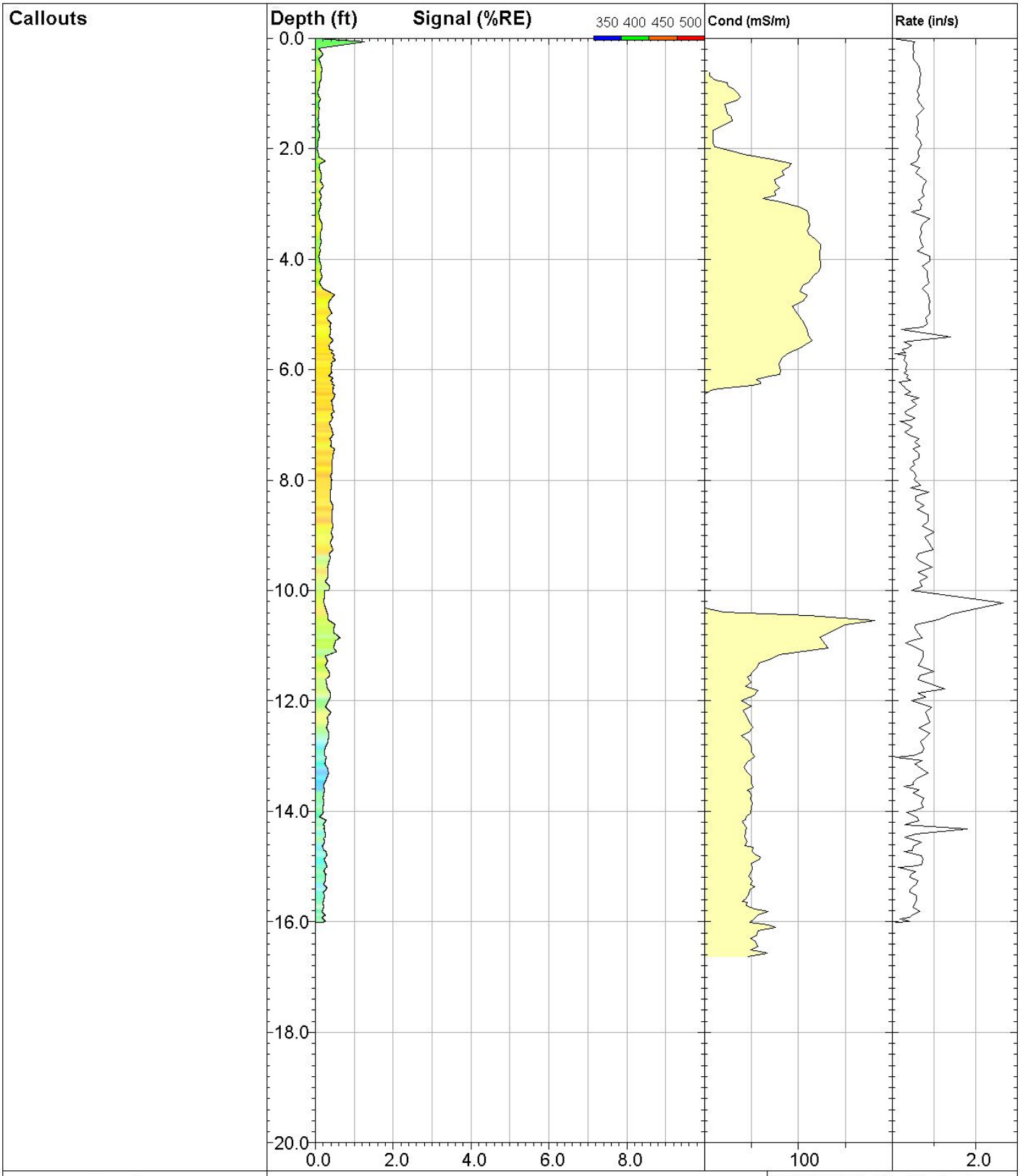
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **0.8 %RE @ 11.71 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 10:24 CDT**



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12-LIF

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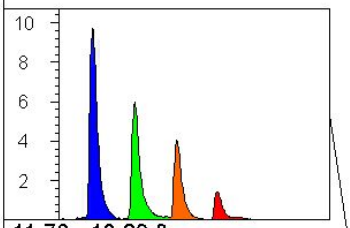
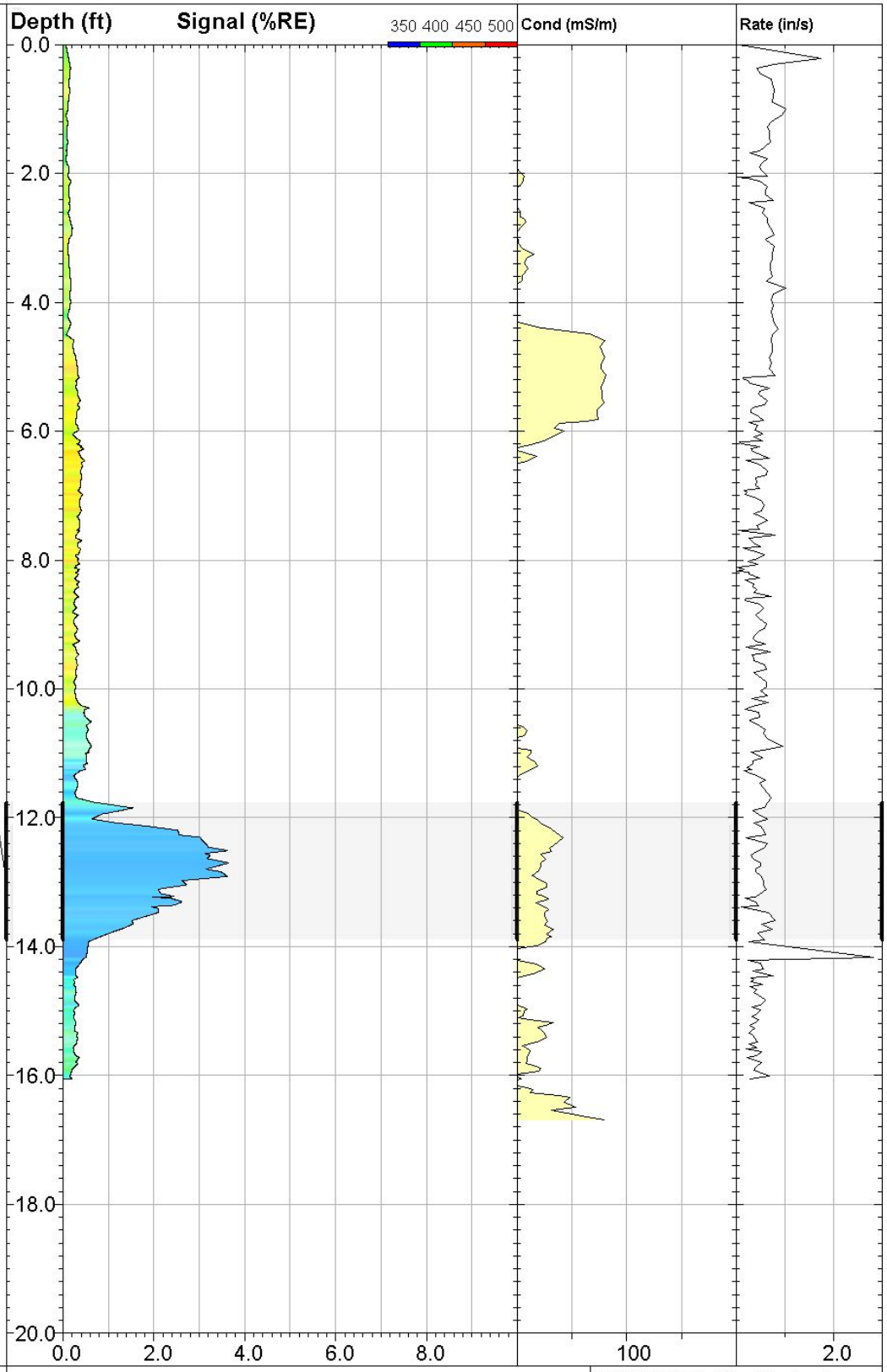
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.3 %RE @ 0.07 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 10:48 CDT**

Callouts



11.76 - 13.89 ft
2.3 %RE (s 0.9)

RESTRING DUE TO BENT MIP TUBE



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13-LIF

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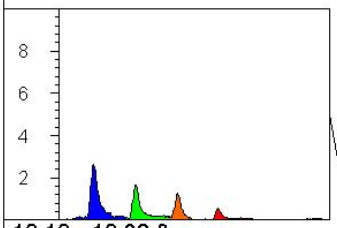
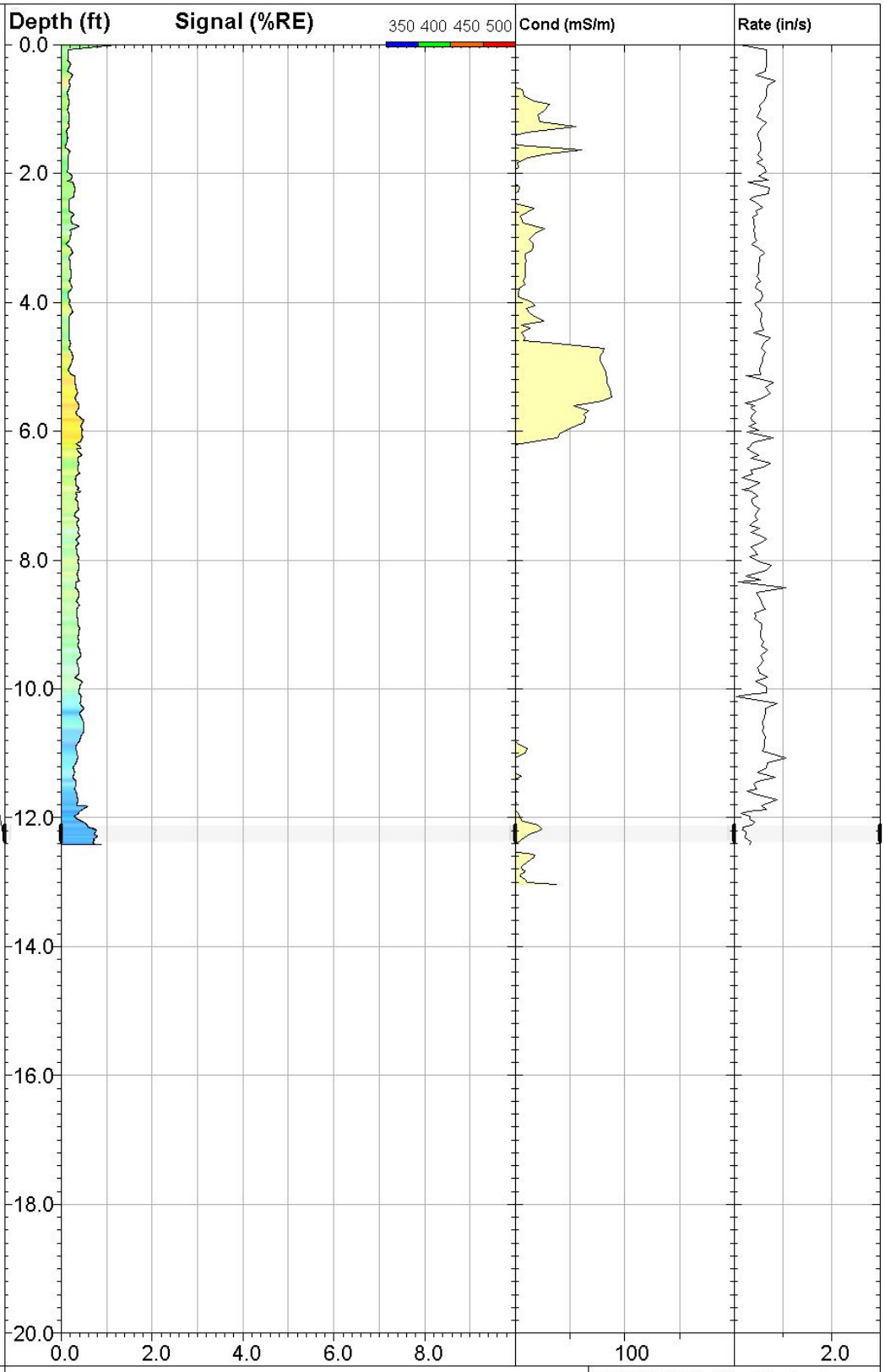
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.06 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.7 %RE @ 12.70 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 11:28 CDT**

Callouts



12.12 - 12.38 ft
0.7 %RE (s 0.1)

REFUSAL AT 12.42FT



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14-LIF

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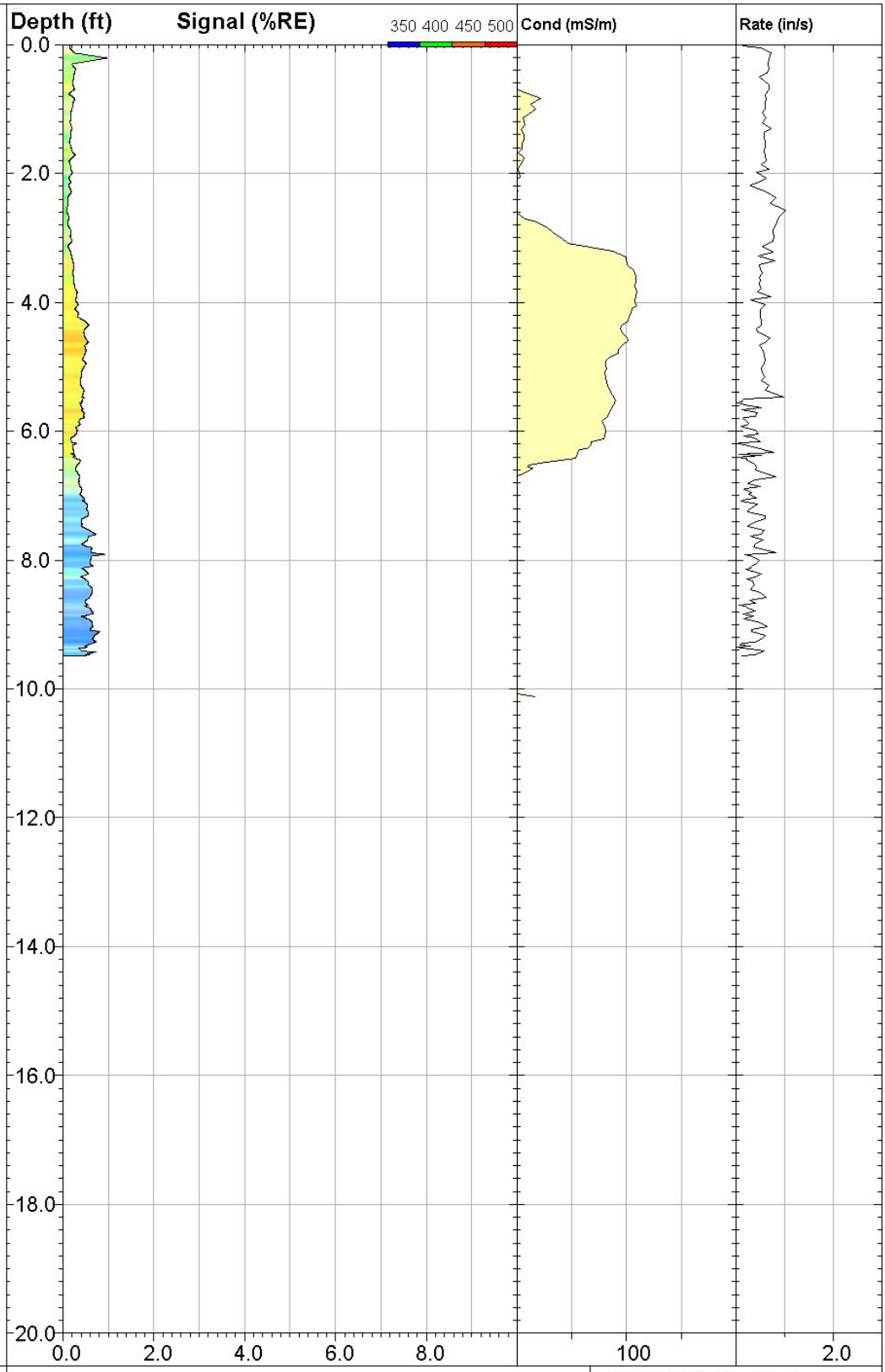
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **12.42 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.2 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 12:26 CDT**

Callouts
REFUSAL AT 9.49FT



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15-LIF

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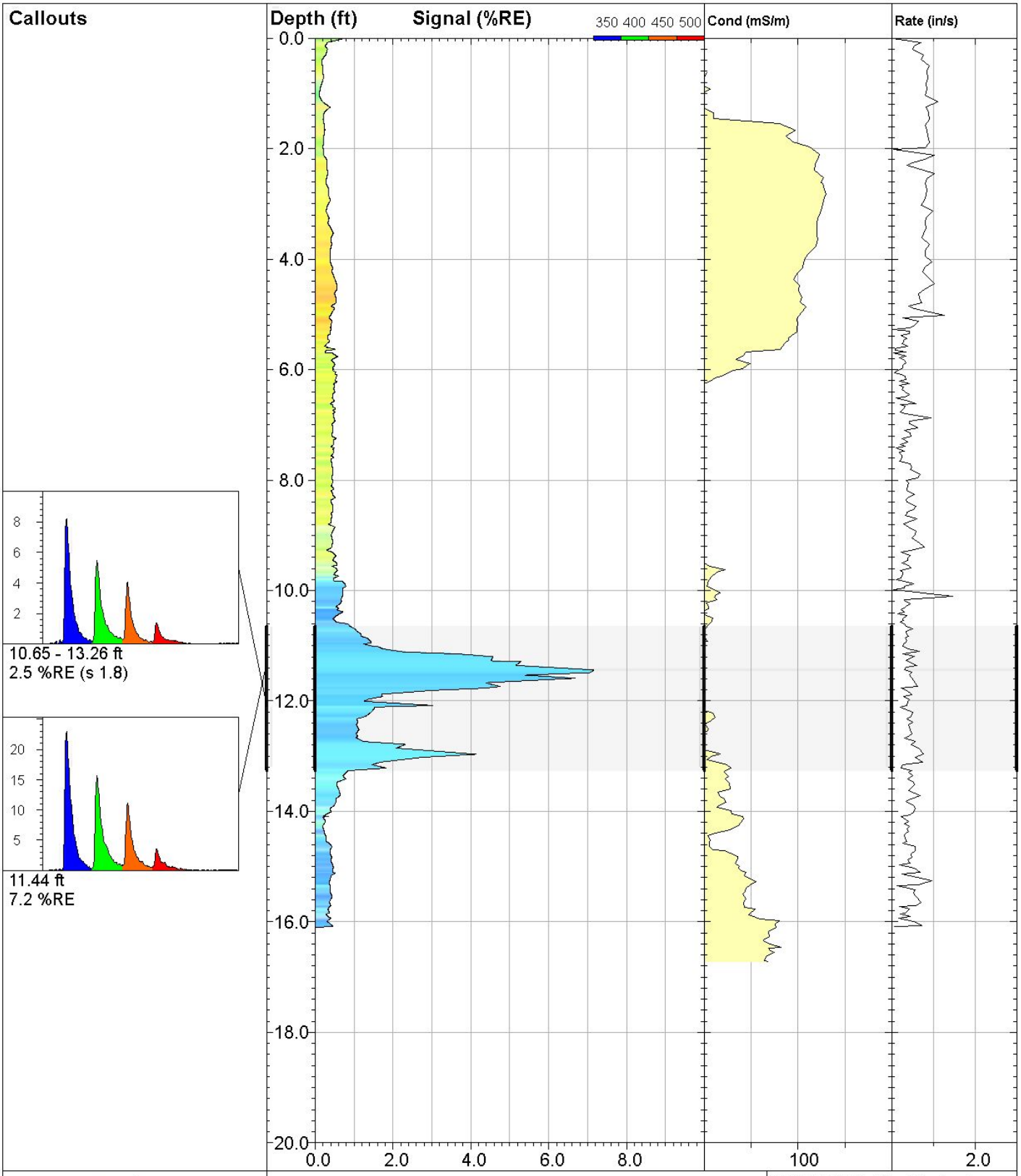
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **9.49 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.0 %RE @ 0.21 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 12:51 CDT**



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16-LIF

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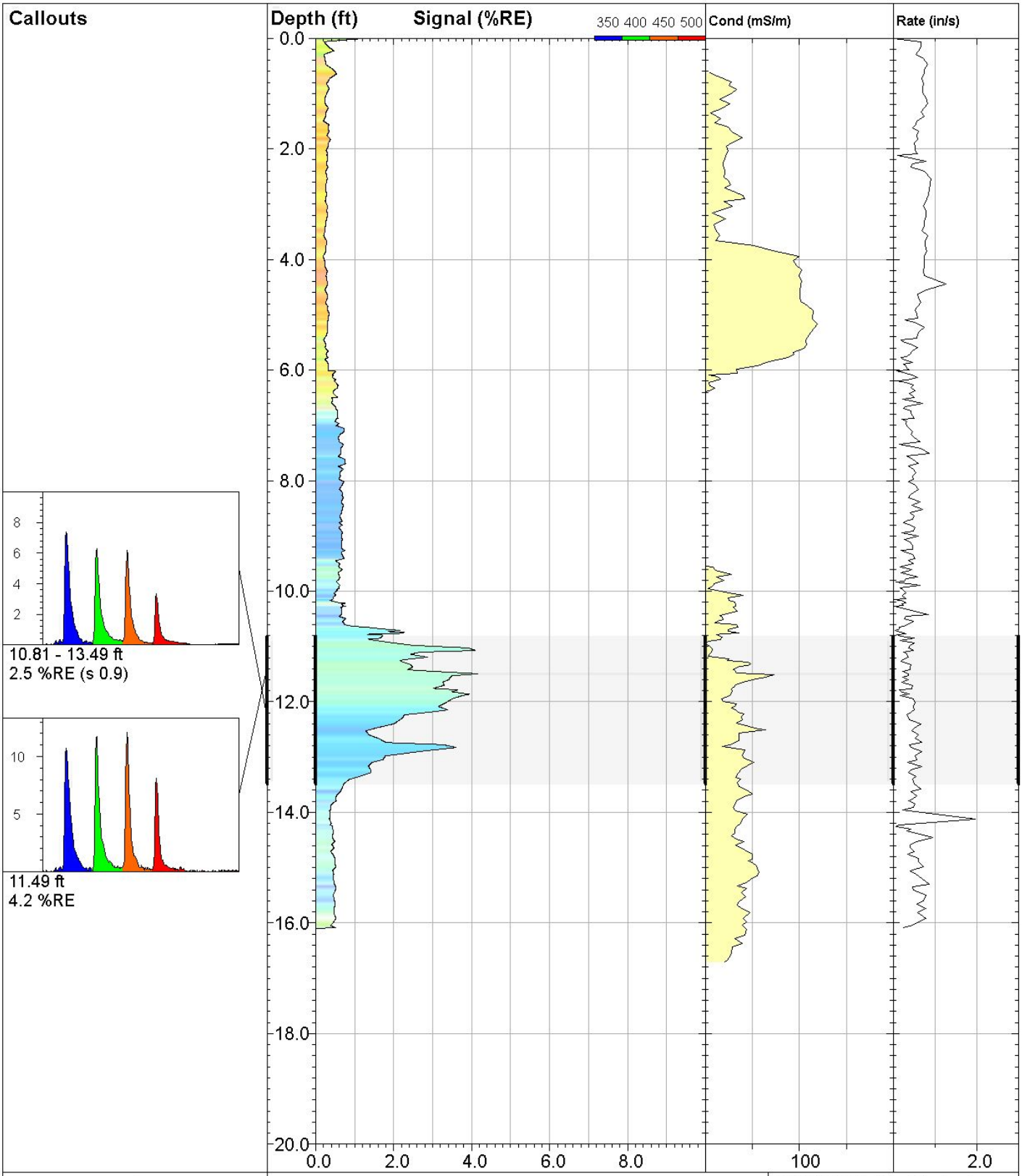
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **7.2 %RE @ 11.44 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 13:30 CDT**



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17-LIF

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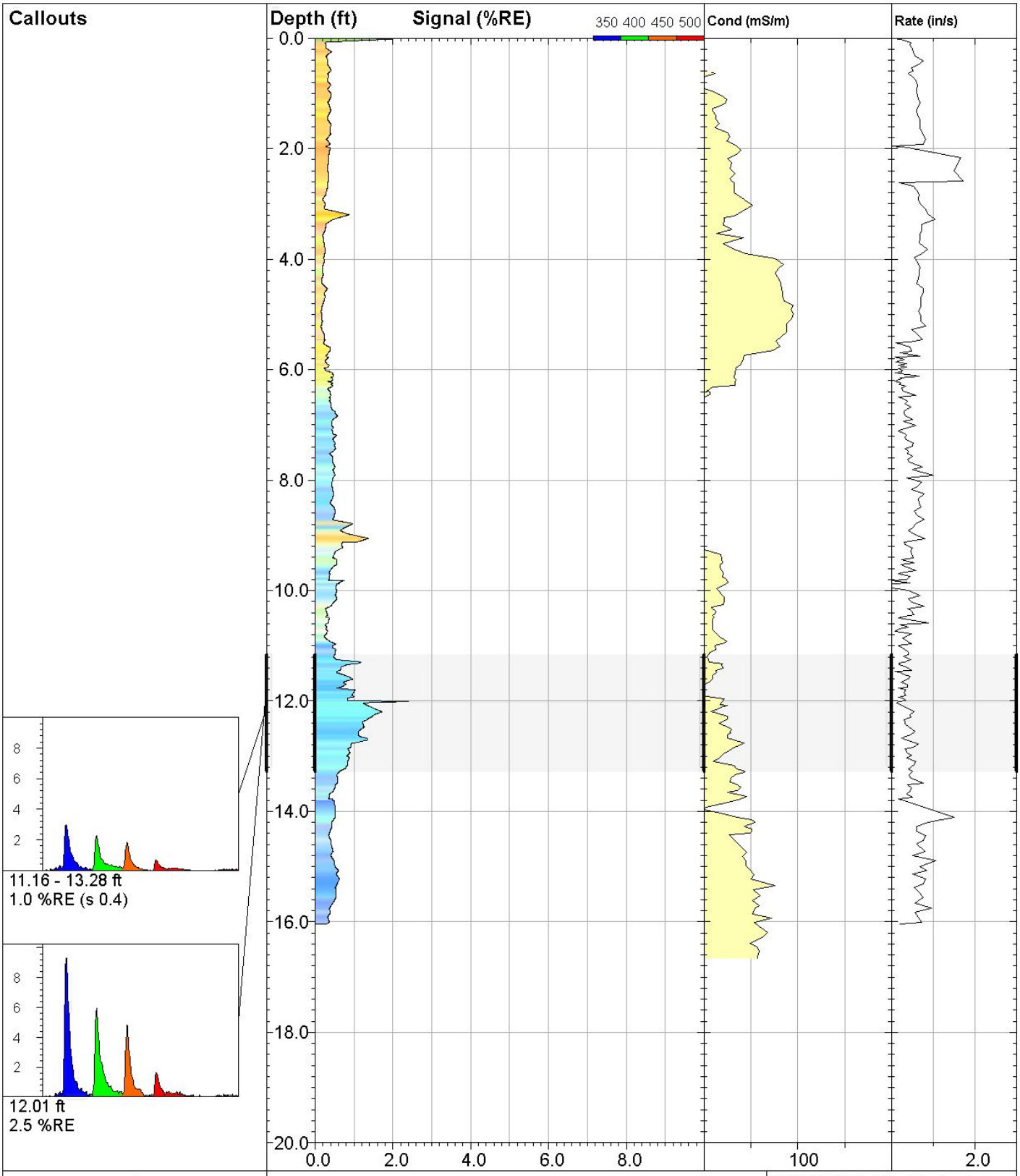
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.2 %RE @ 11.49 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 13:51 CDT**



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18-LIF

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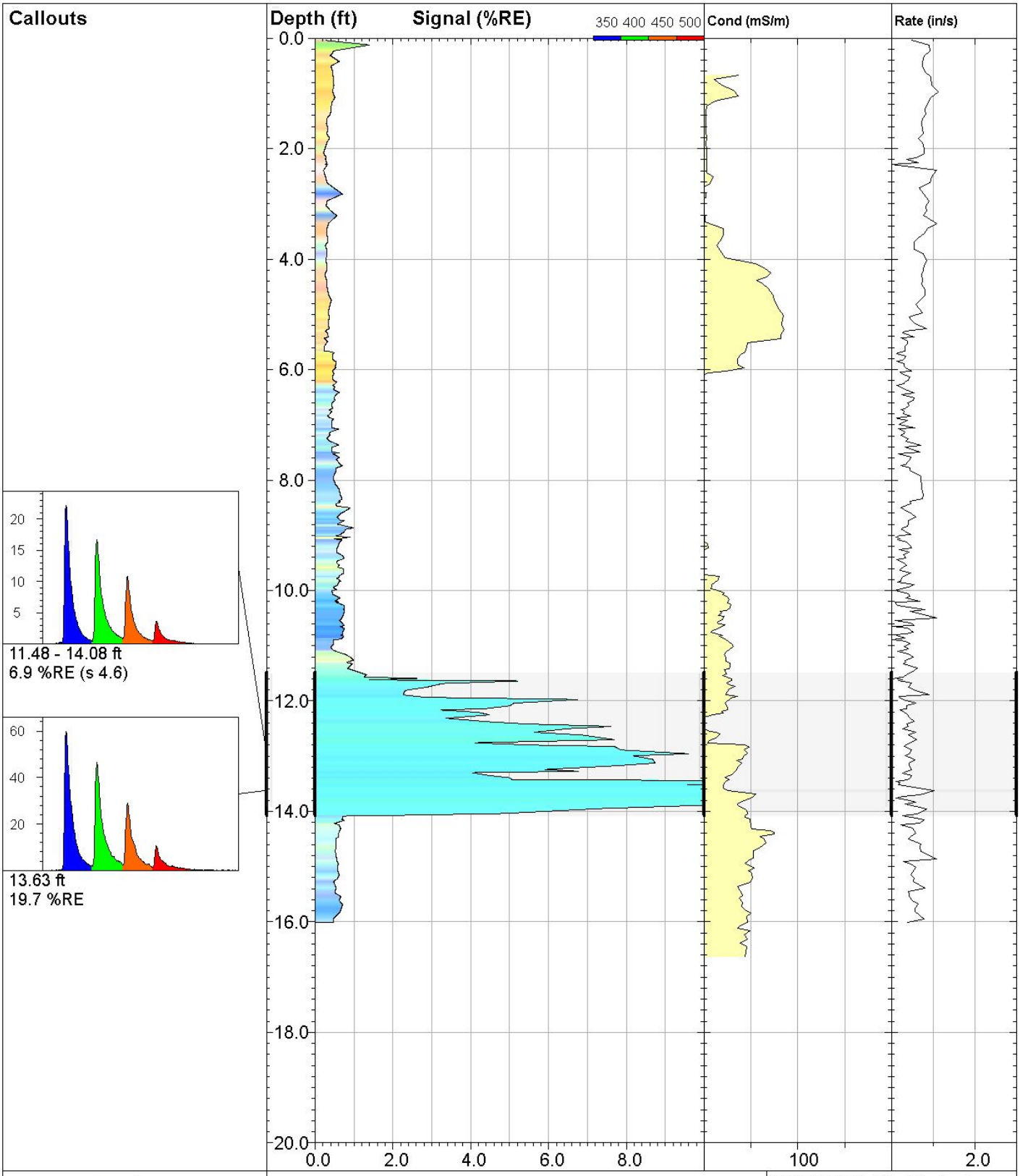
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.5 %RE @ 12.01 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 14:16 CDT**



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19-LIF

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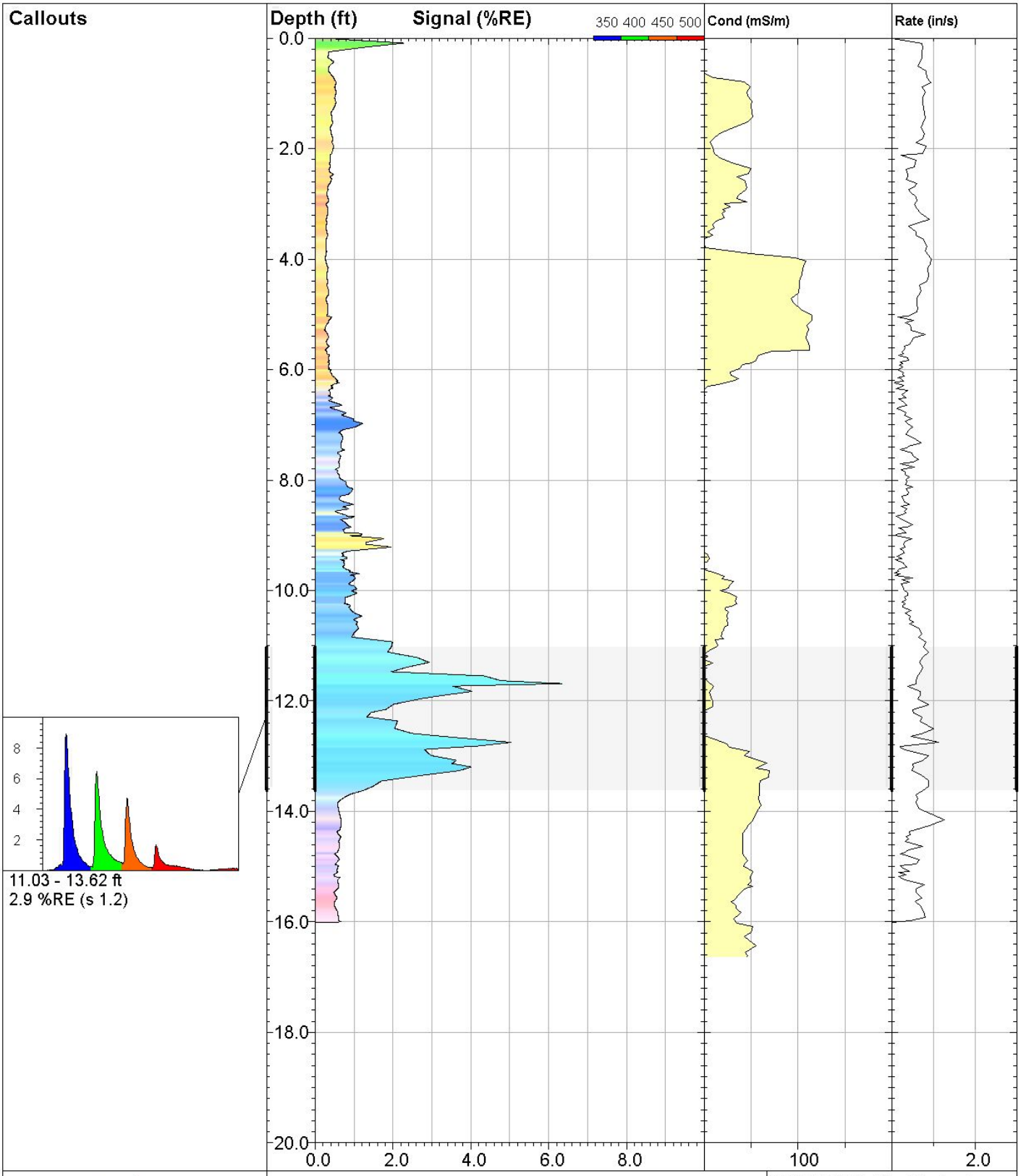
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **19.7 %RE @ 13.63 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 14:35 CDT**



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20-LIF

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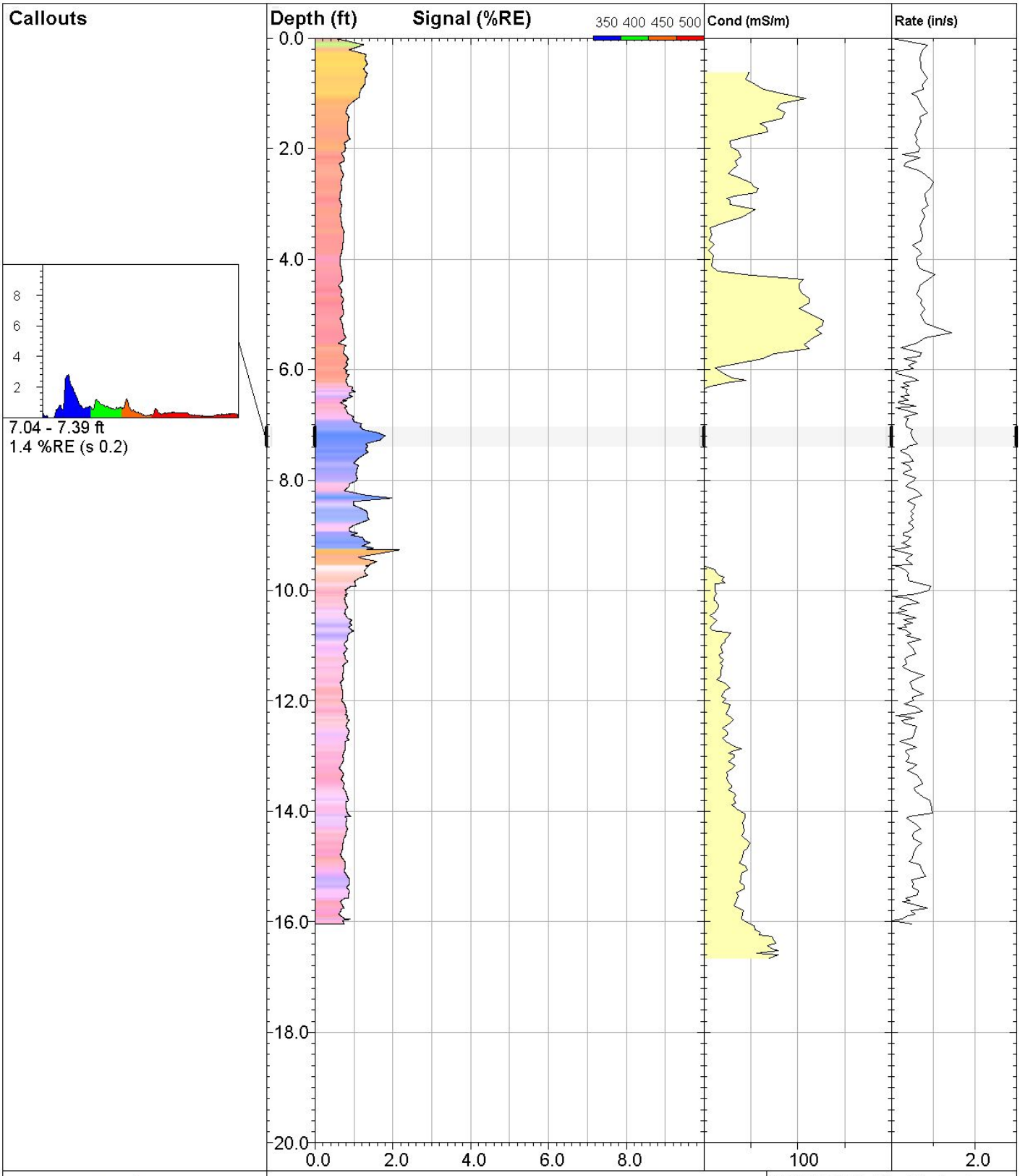
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.4 %RE @ 11.69 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 15:04 CDT**



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21-LIF

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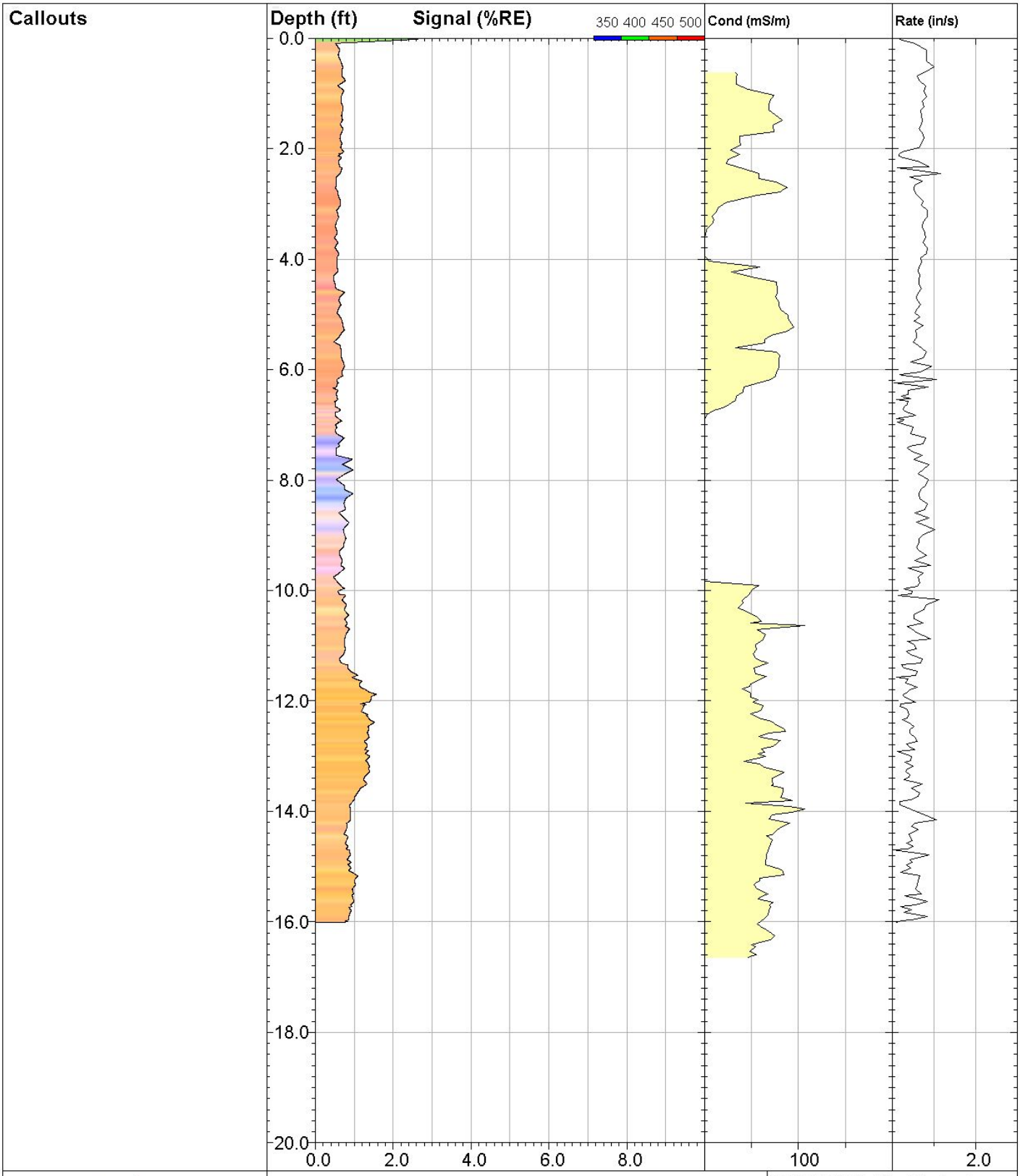
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.03 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 9.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 15:27 CDT**



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22-LIF

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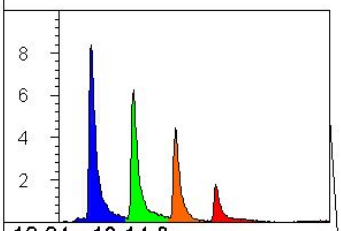
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.7 %RE @ 0.01 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 15:55 CDT**

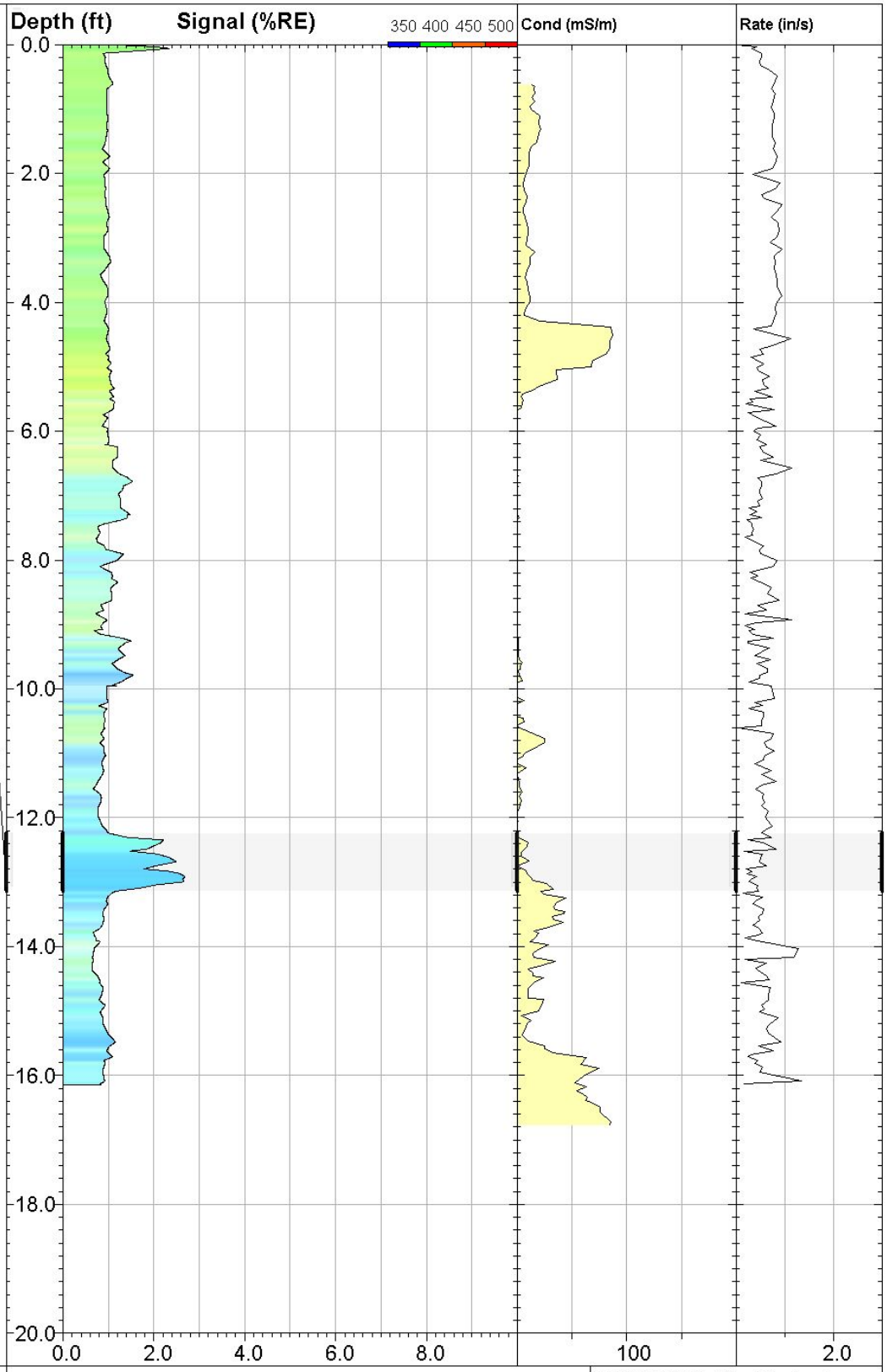
Callouts



12.24 - 13.14 ft
2.0 %RE (s 0.5)

ELEVATED BACKGROUND DUE TO SCRATCH ON WINDOW. WINDOW UNABLE TO BE REMOVED. MELDED TO SPOC WITH THE DIFFICULT DRILLING

CONDITIONS. ENTIRE TOOL STRING WILL BE SWAPPED OUT.



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23-LIF

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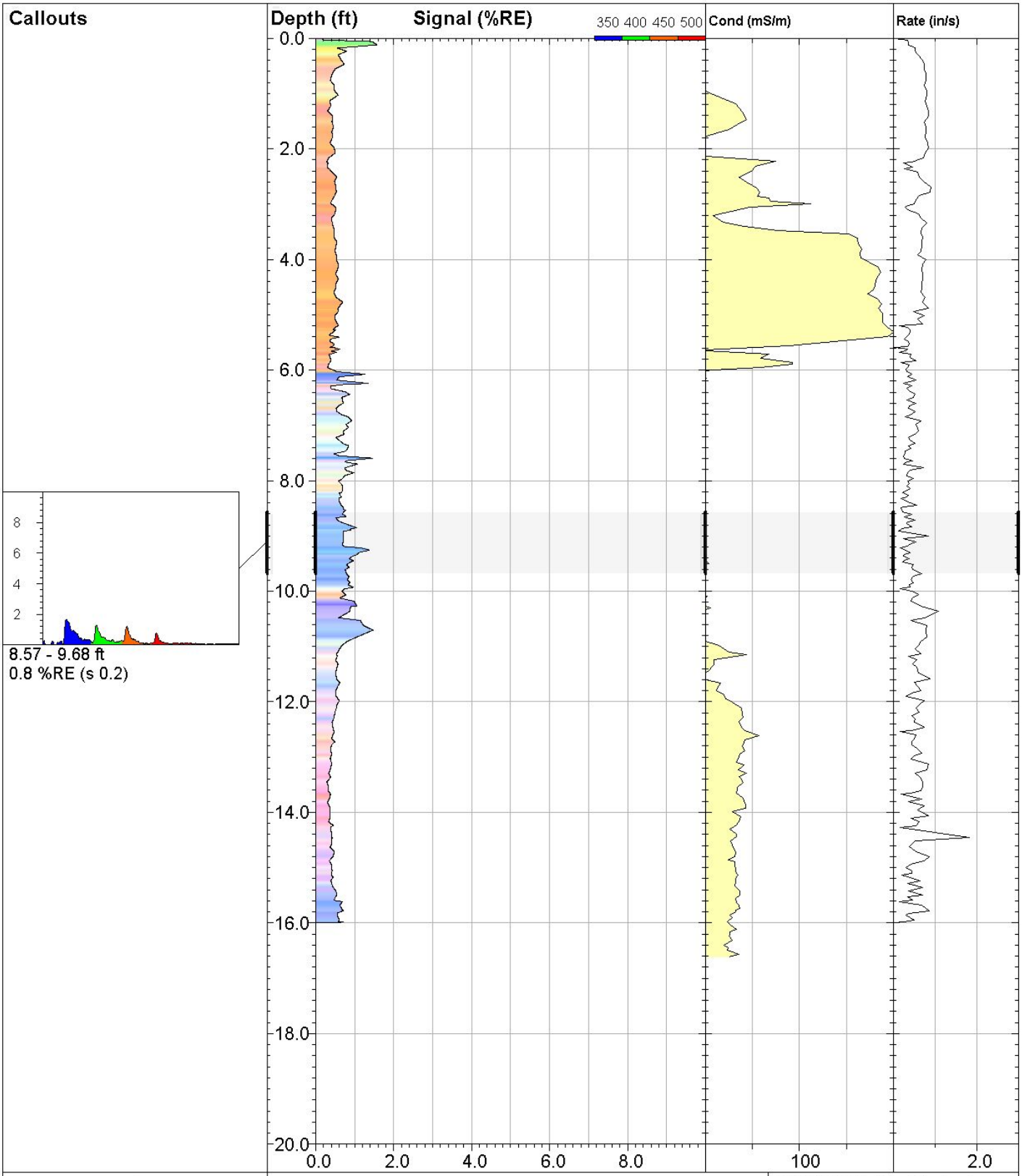
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.14 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.7 %RE @ 12.91 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 16:34 CDT**



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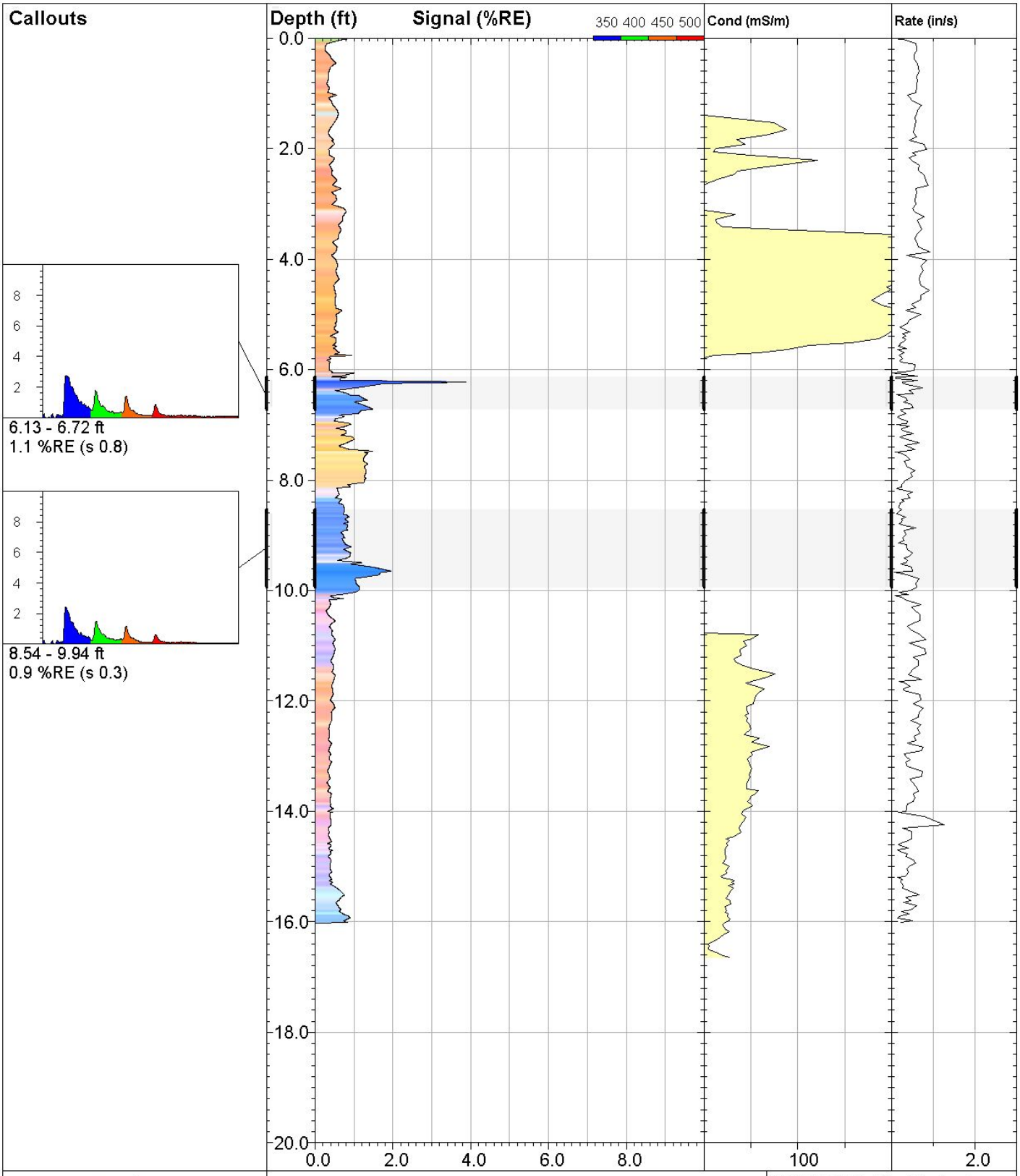
Site:	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **/**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.6 %RE @ 0.12 ft**
Operator / Unit: **/ UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 09:24 CDT**



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25-LIF

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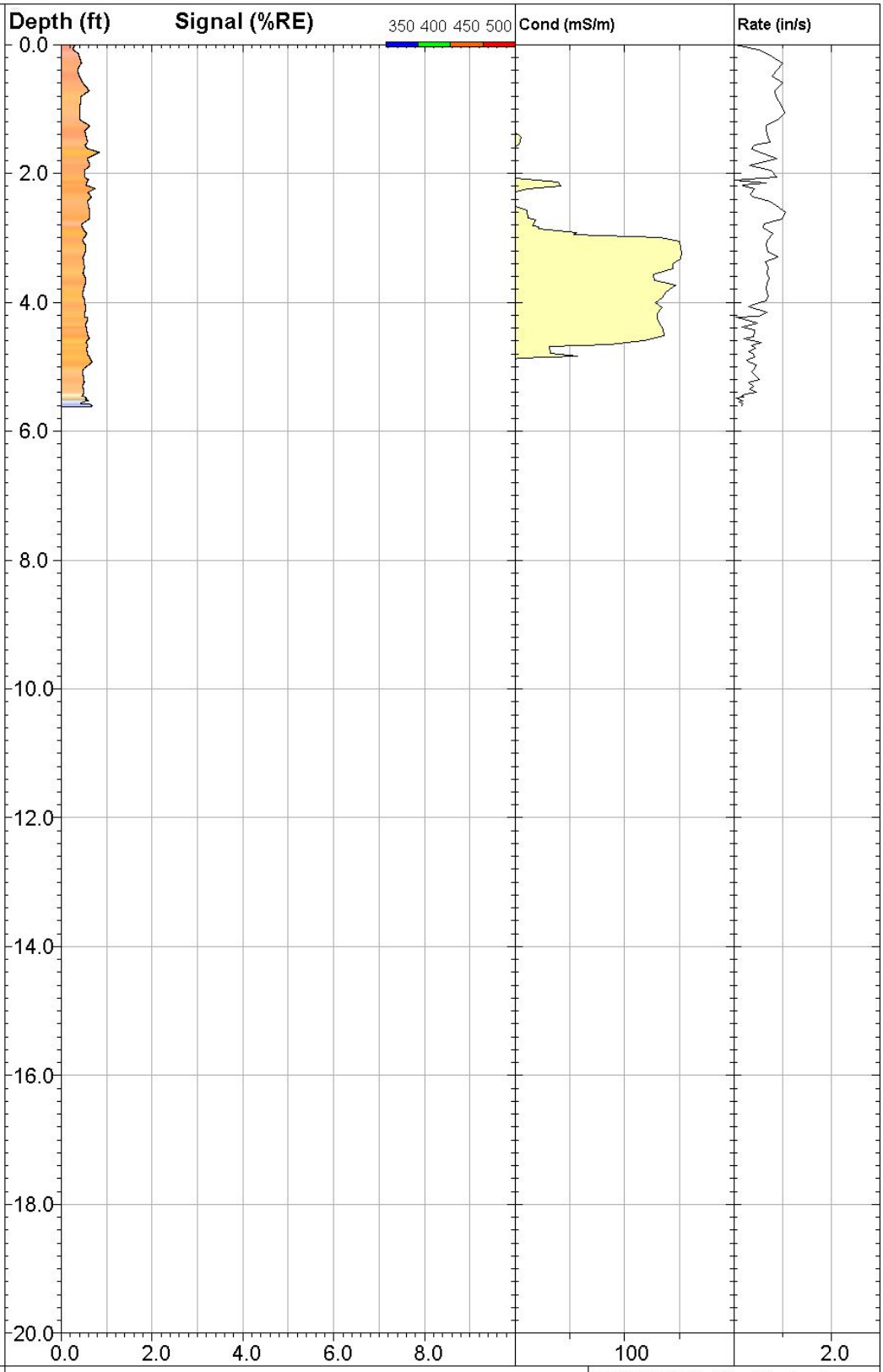
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.0 %RE @ 6.23 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 09:51 CDT**

Callouts
REFUSAL AT 5.62FT



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26-LIF

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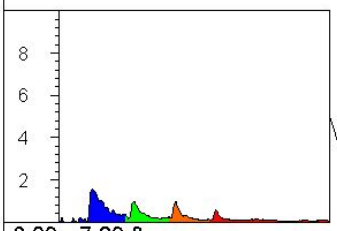
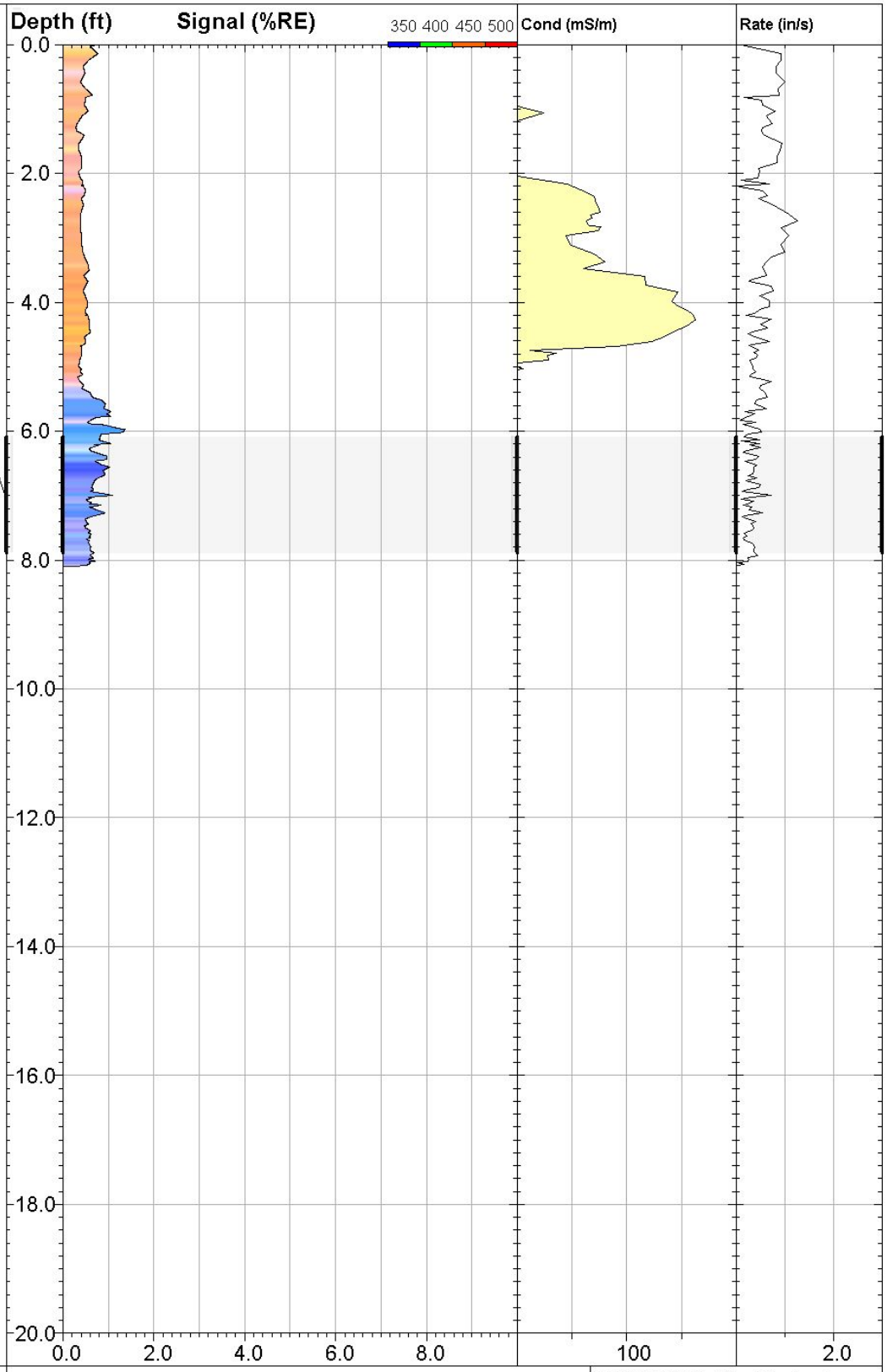
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **5.62 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **0.8 %RE @ 1.68 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 10:17 CDT**

Callouts



6.09 - 7.89 ft
0.7 %RE (s 0.2)

REFUSAL AT 8.09FT



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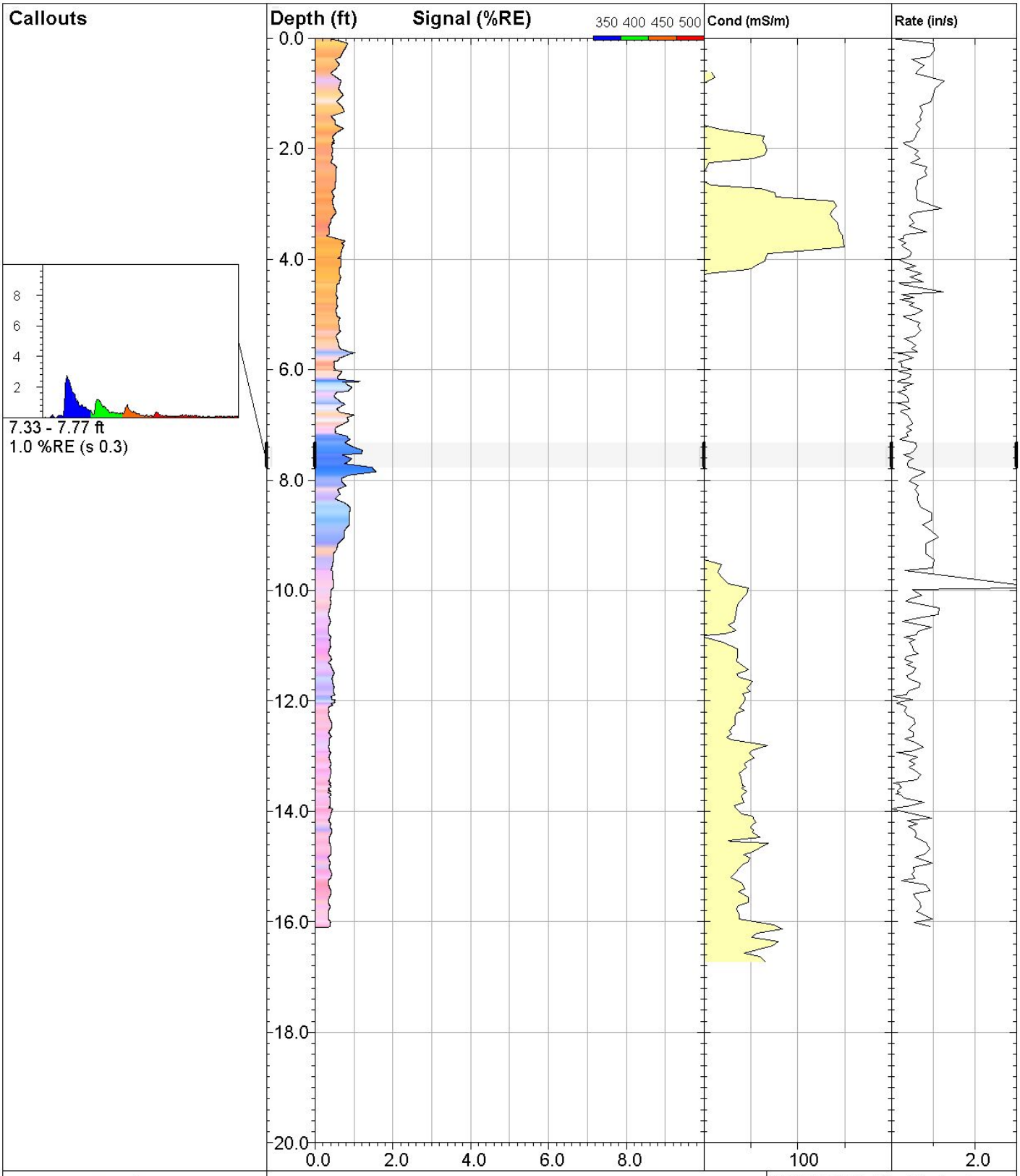
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **8.09 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 5.97 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 10:32 CDT**



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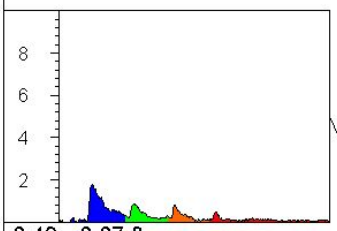
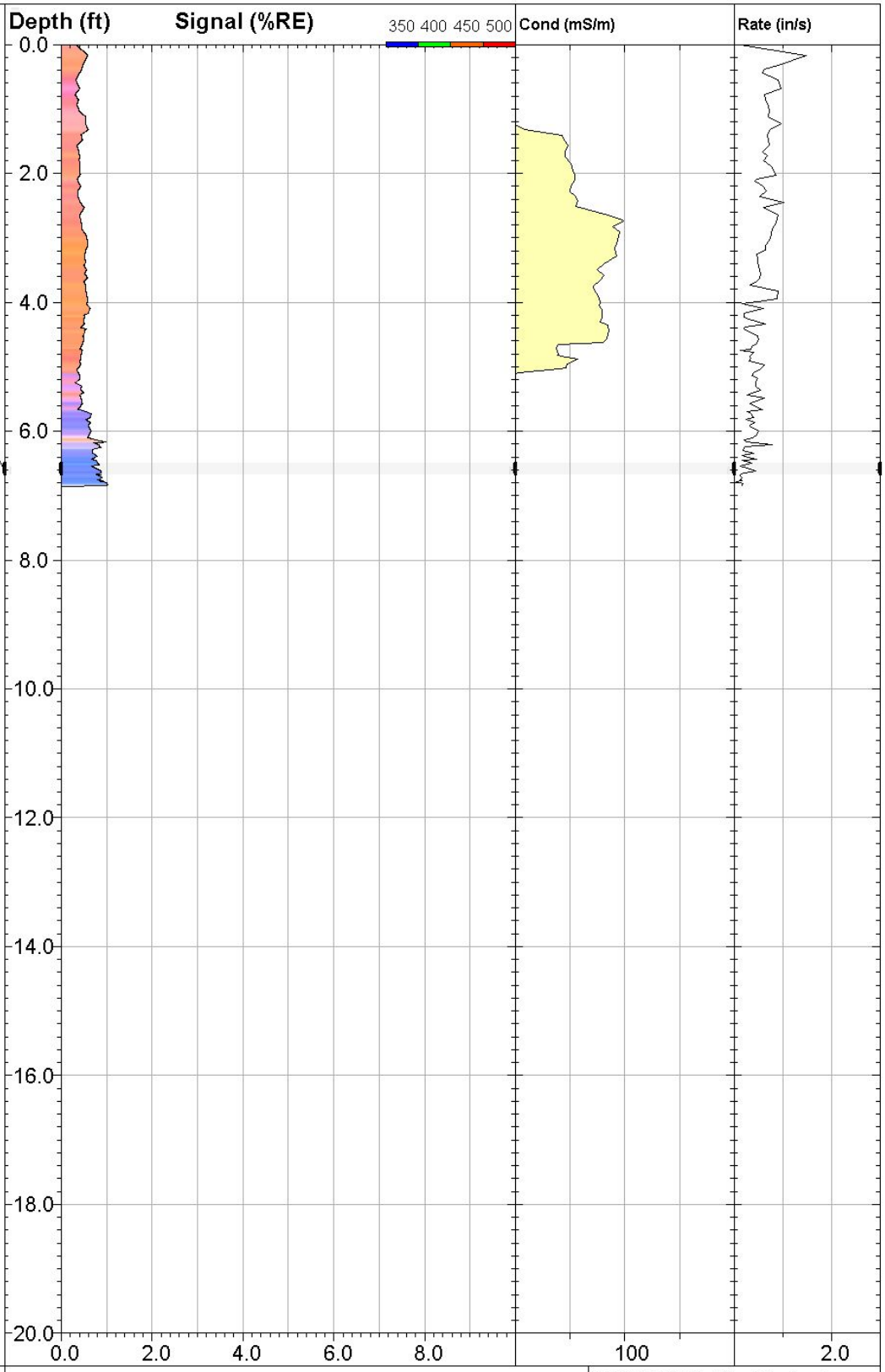
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.6 %RE @ 7.85 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 10:56 CDT**

Callouts



6.49 - 6.67 ft
0.8 %RE (s 0.1)

REFUSAL AT 6.85FT



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29-LIF

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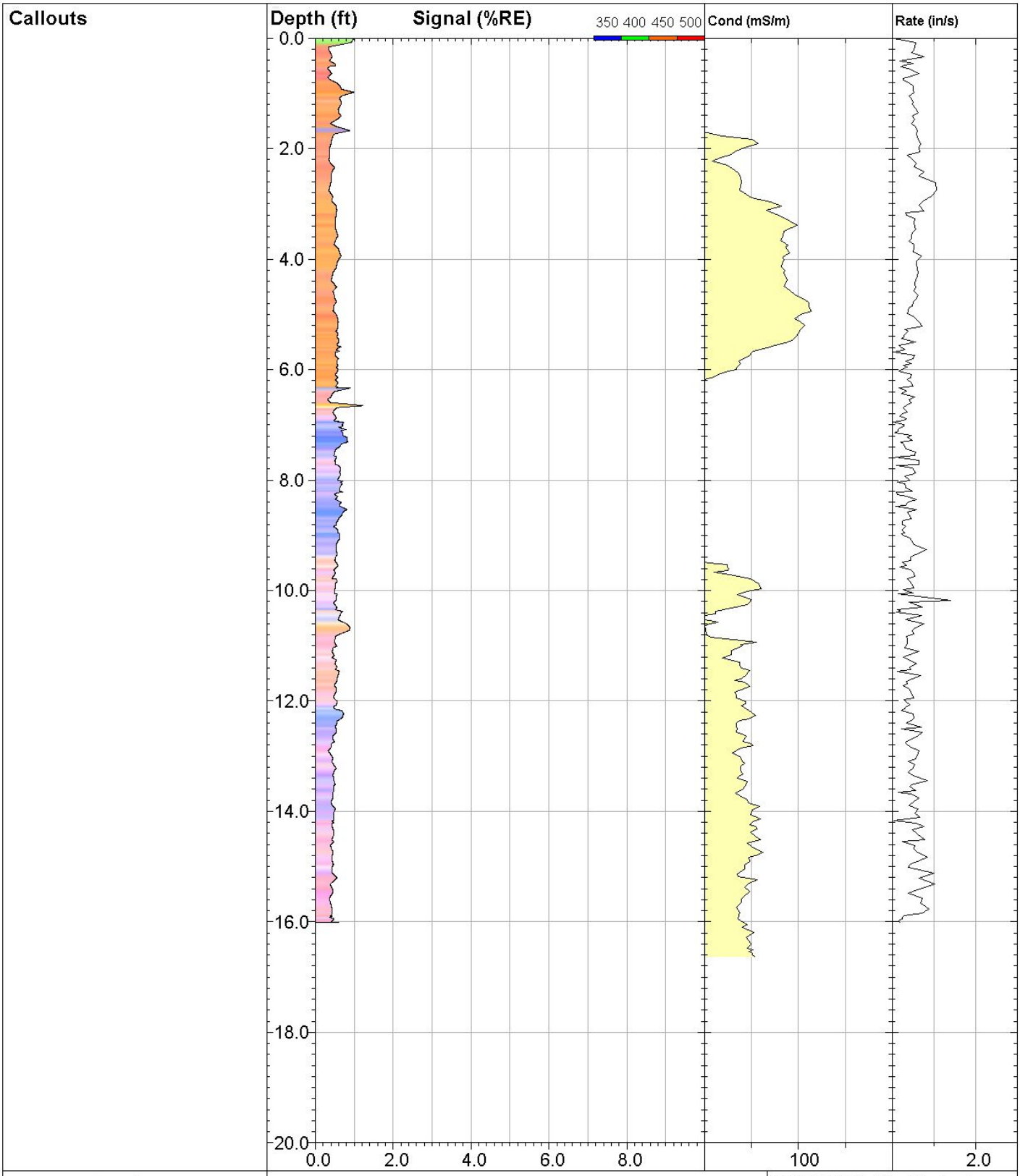
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **6.85 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.0 %RE @ 6.83 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 11:19 CDT**



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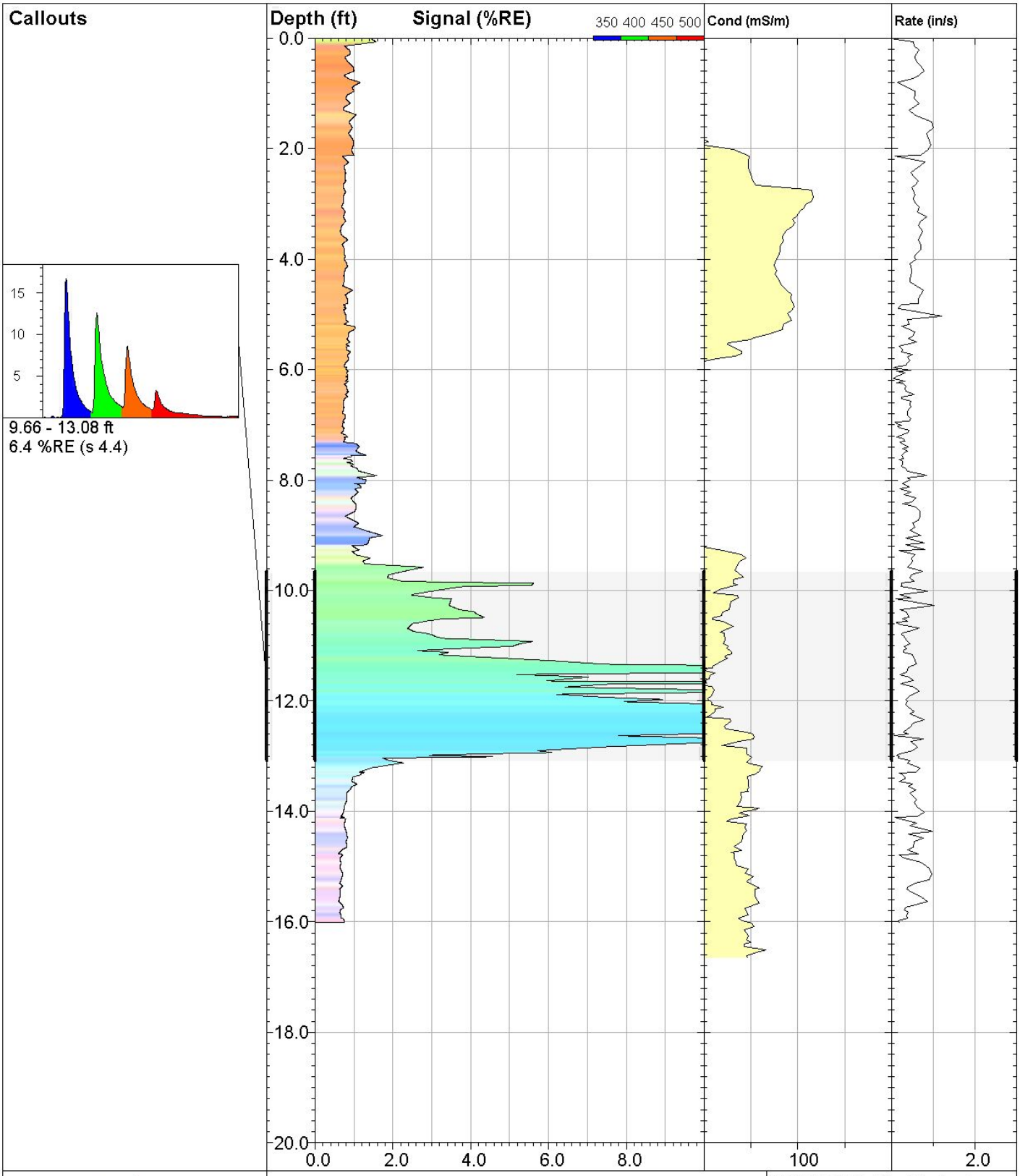
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.2 %RE @ 6.65 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 11:36 CDT**



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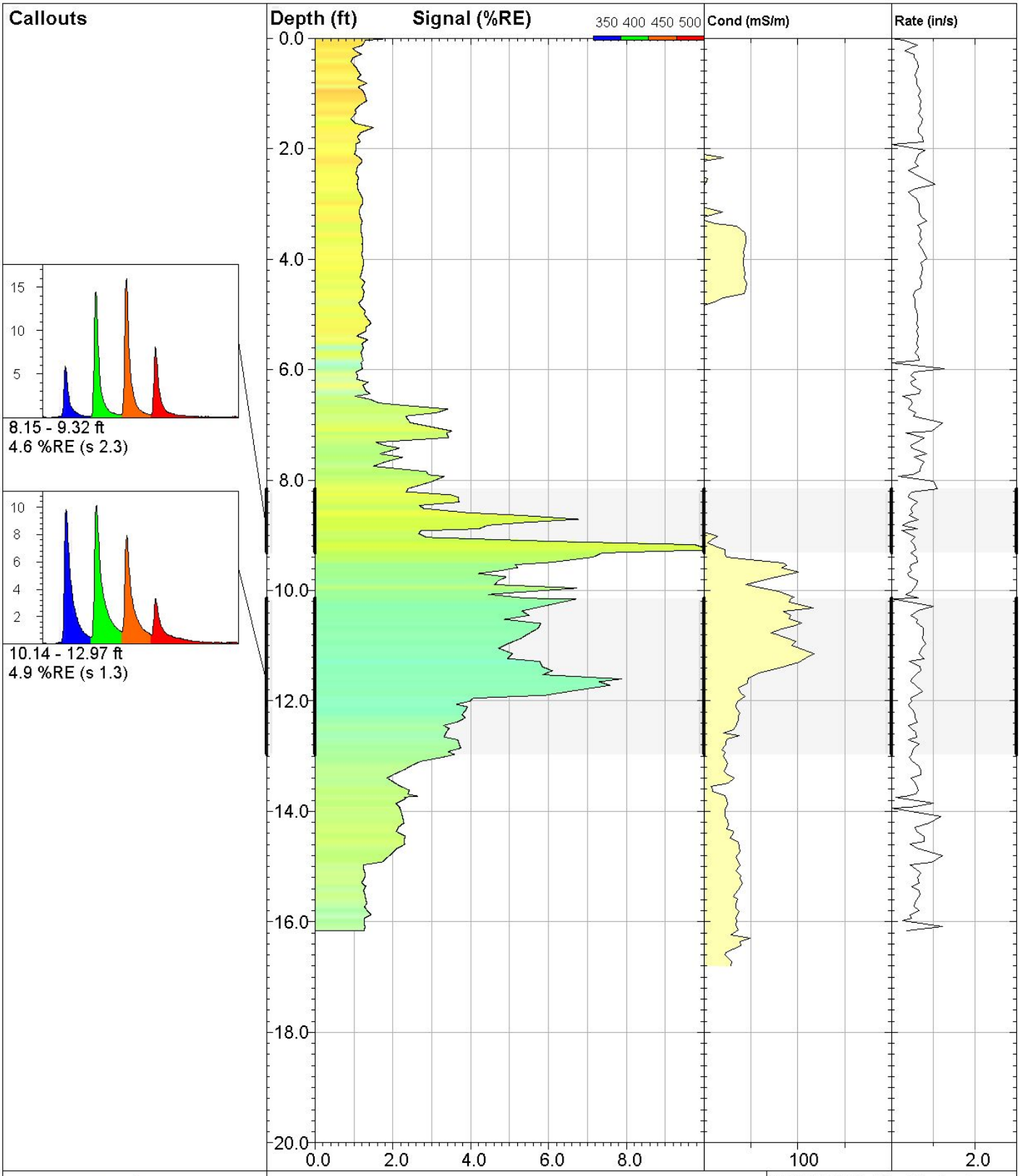
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.7 %RE @ 11.44 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 12:38 CDT**



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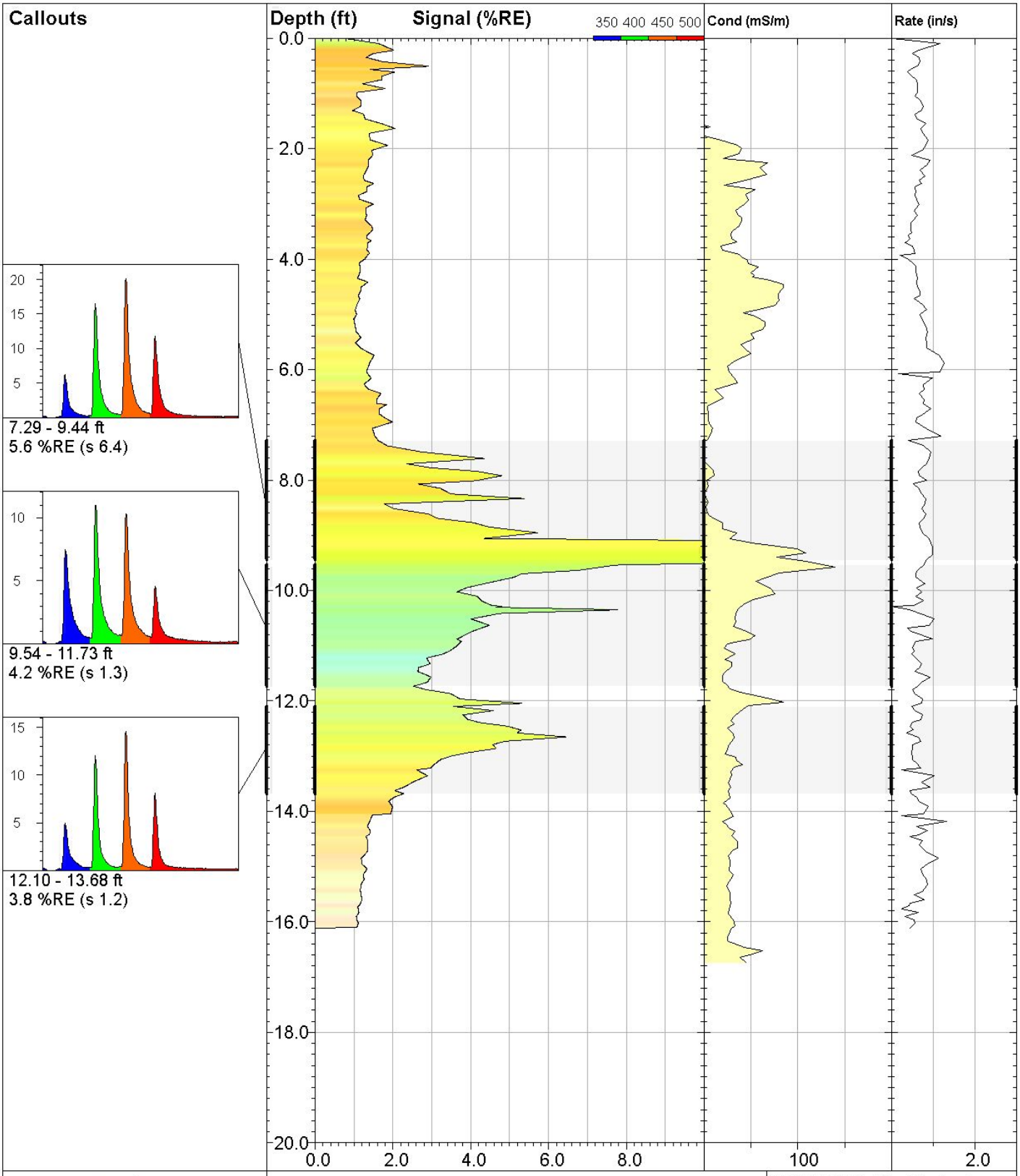
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.16 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **10.2 %RE @ 9.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 15:10 CDT**



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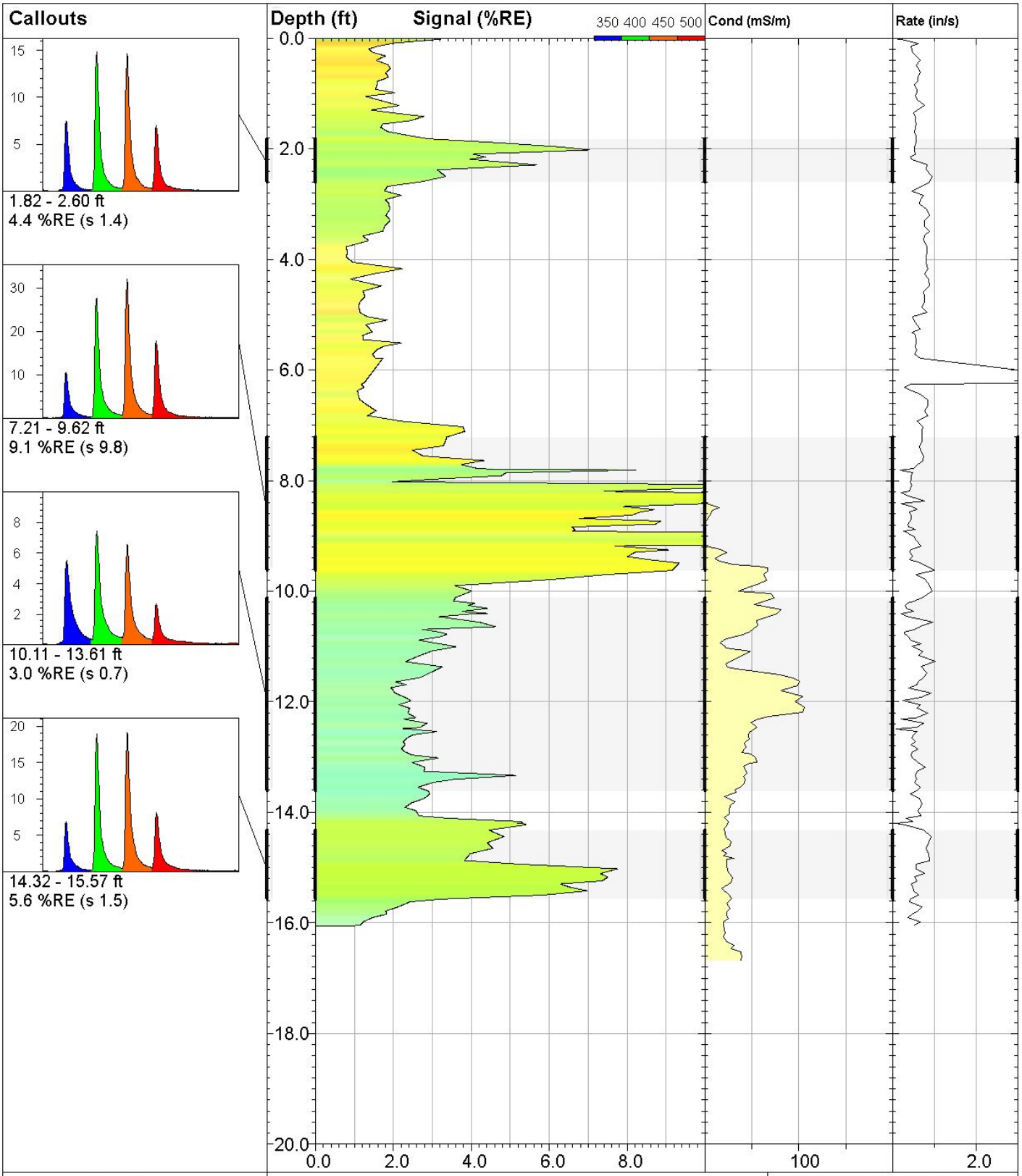
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.11 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **28.9 %RE @ 9.21 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 15:37 CDT**



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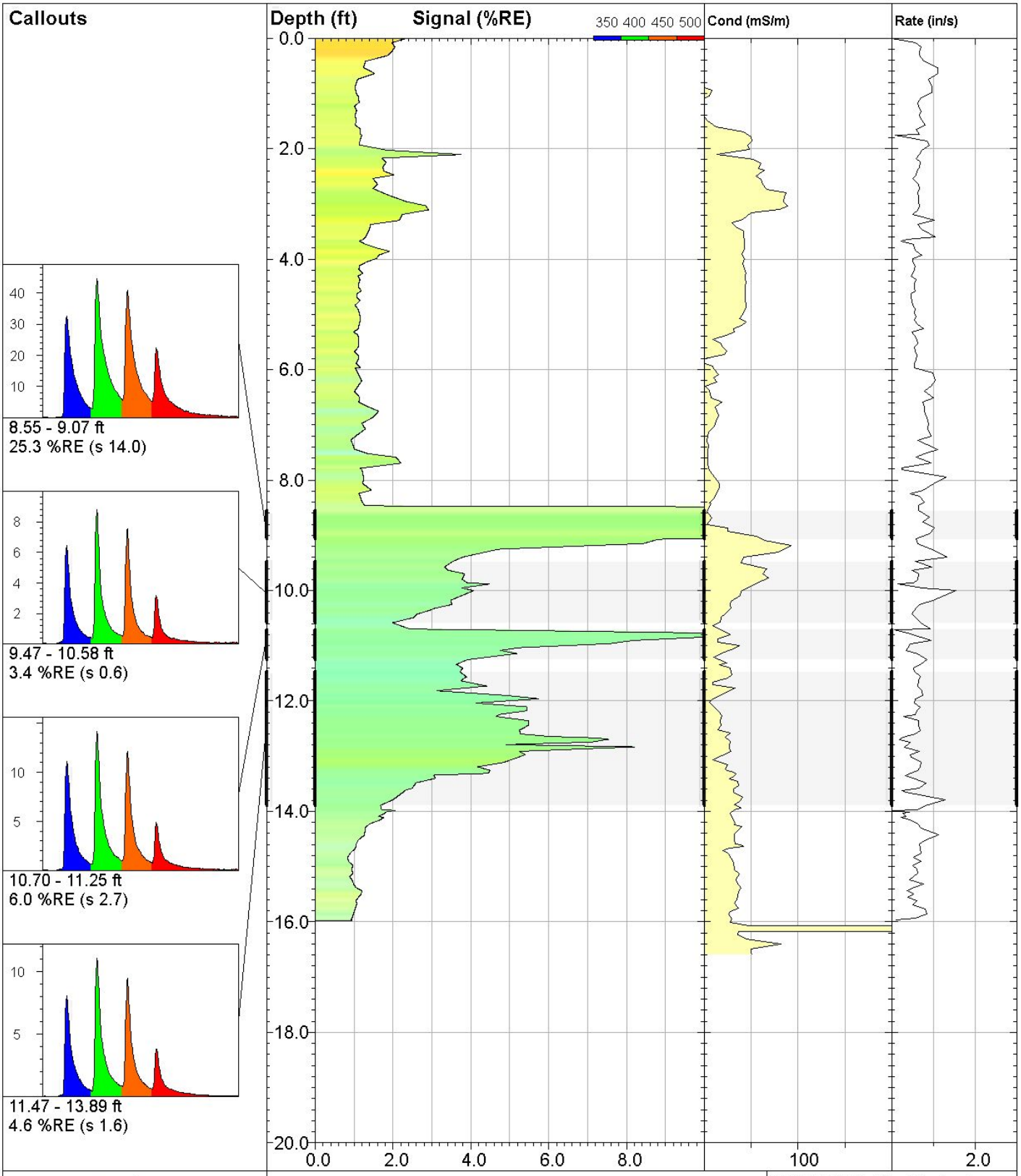
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.05 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **63.7 %RE @ 9.01 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 16:05 CDT**



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35-LIF

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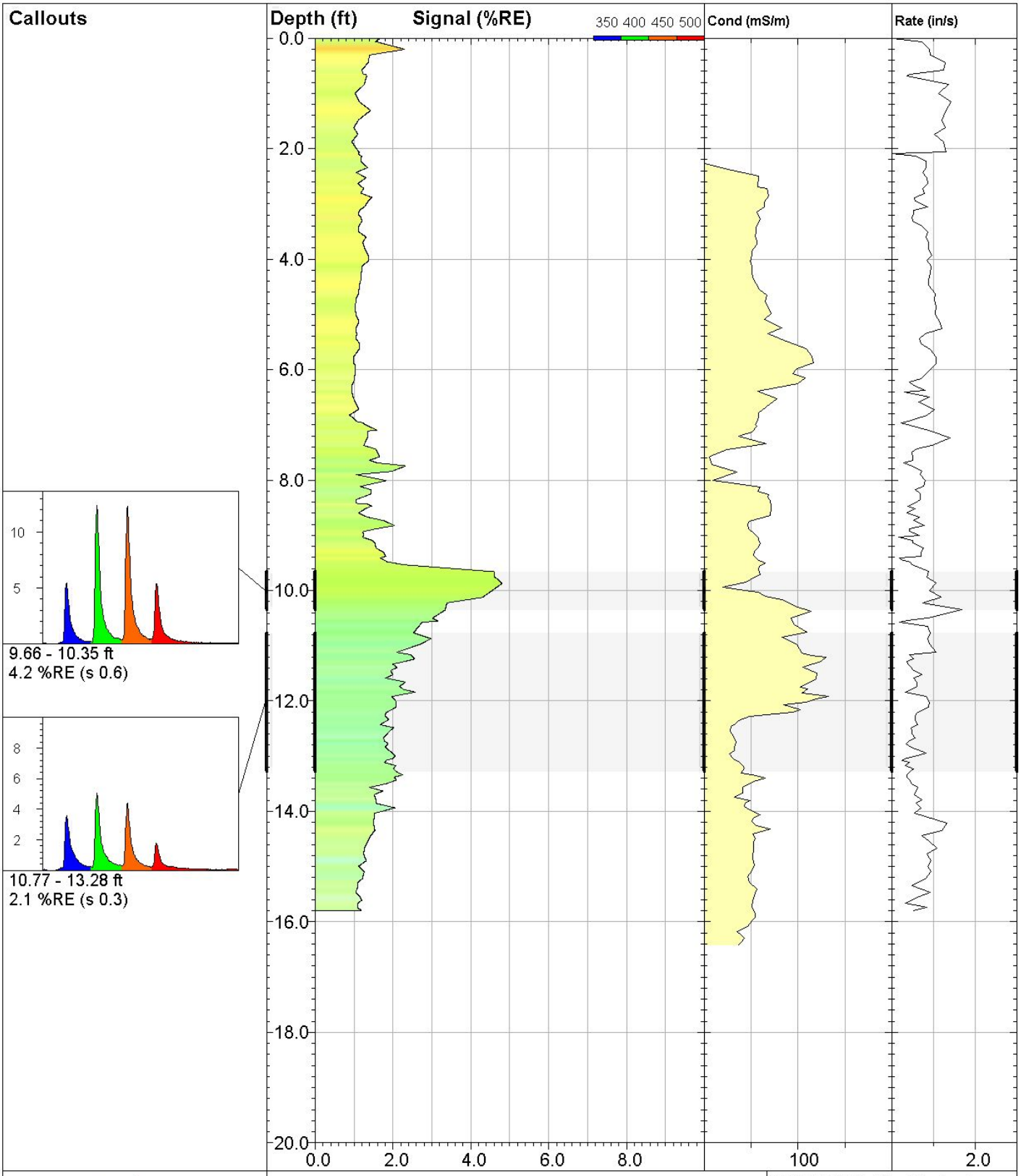
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.97 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **45.3 %RE @ 8.55 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 16:49 CDT**



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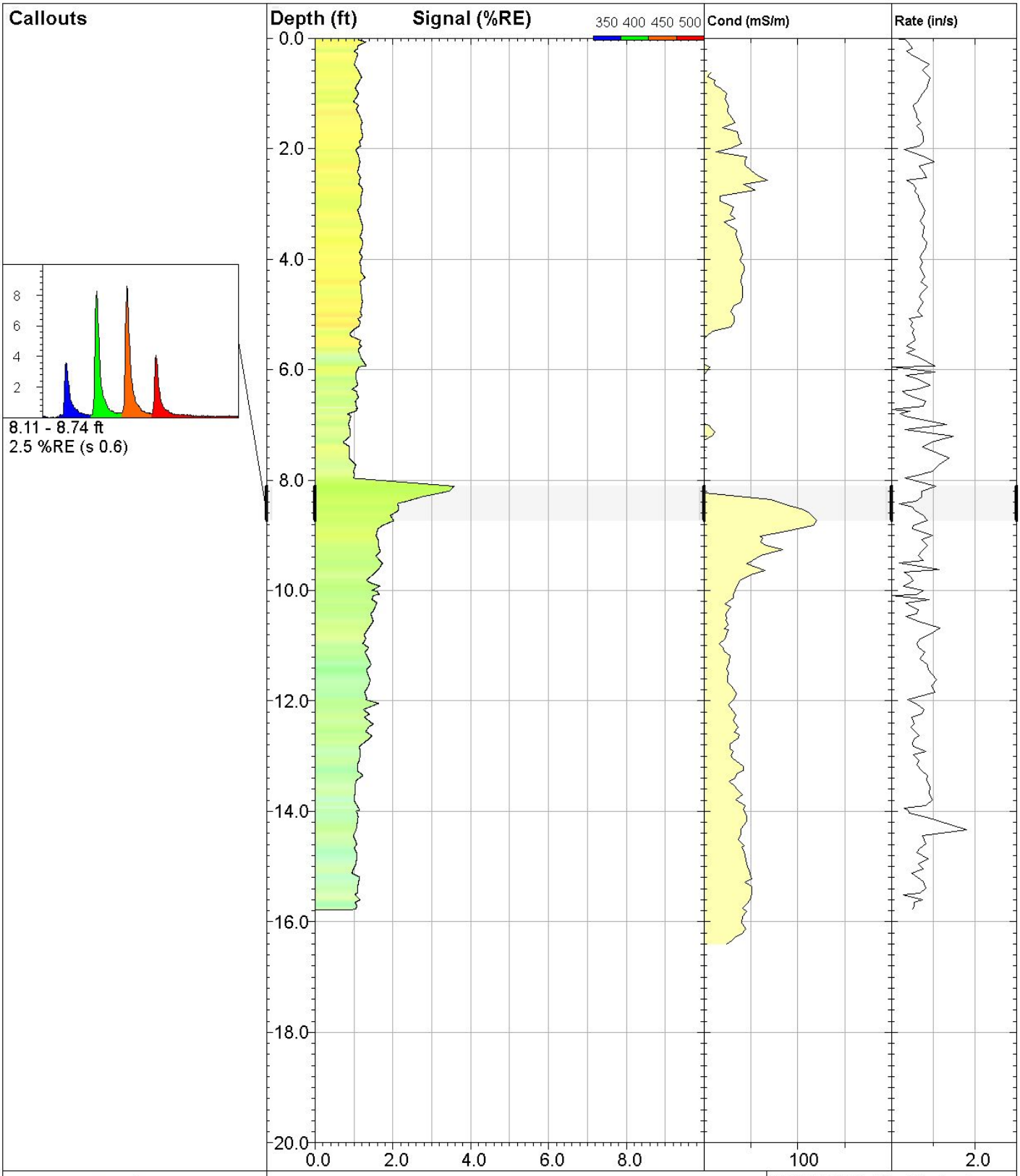
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.80 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.8 %RE @ 9.87 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 17:11 CDT**



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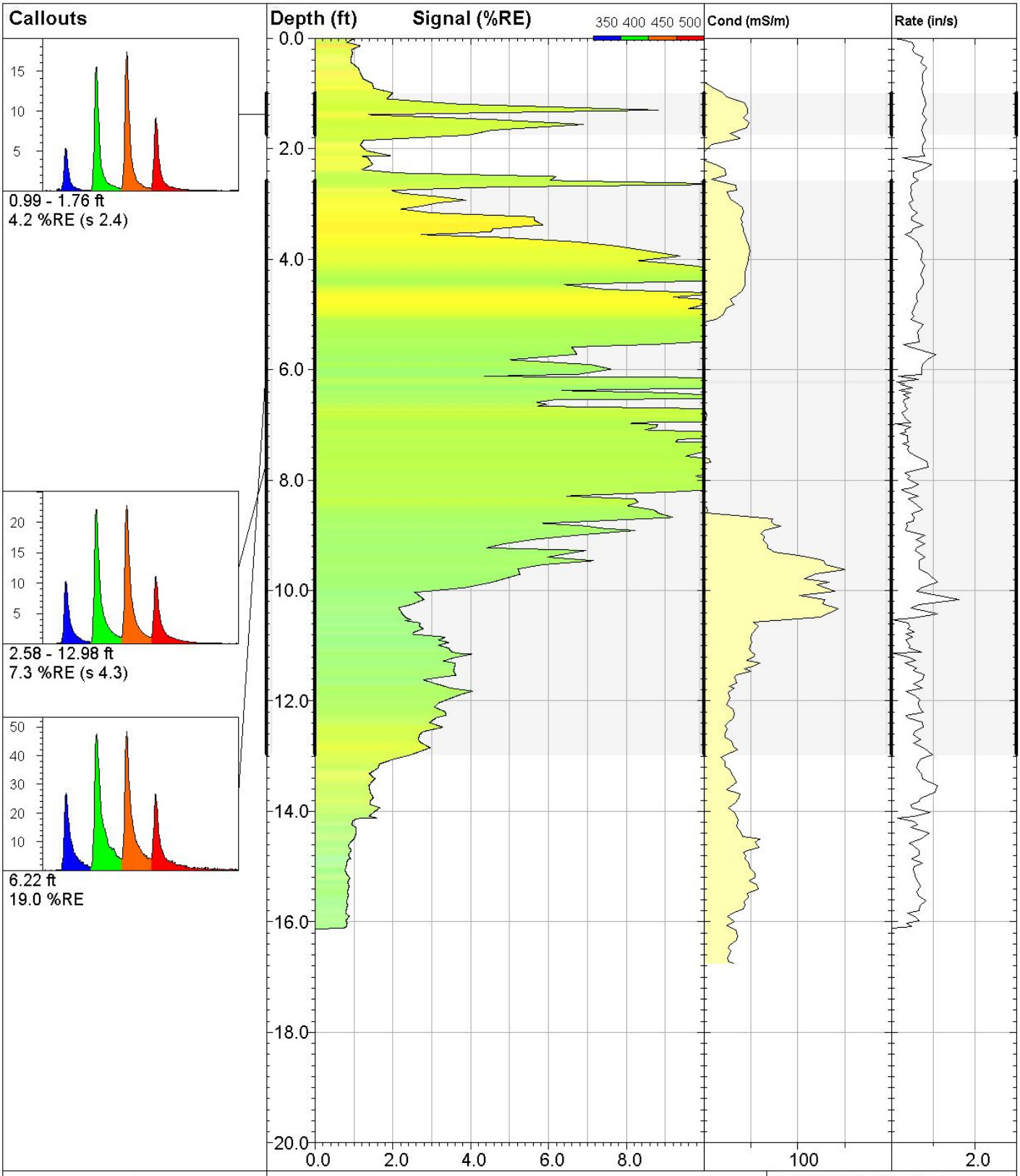
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.78 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.6 %RE @ 8.11 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 17:39 CDT**



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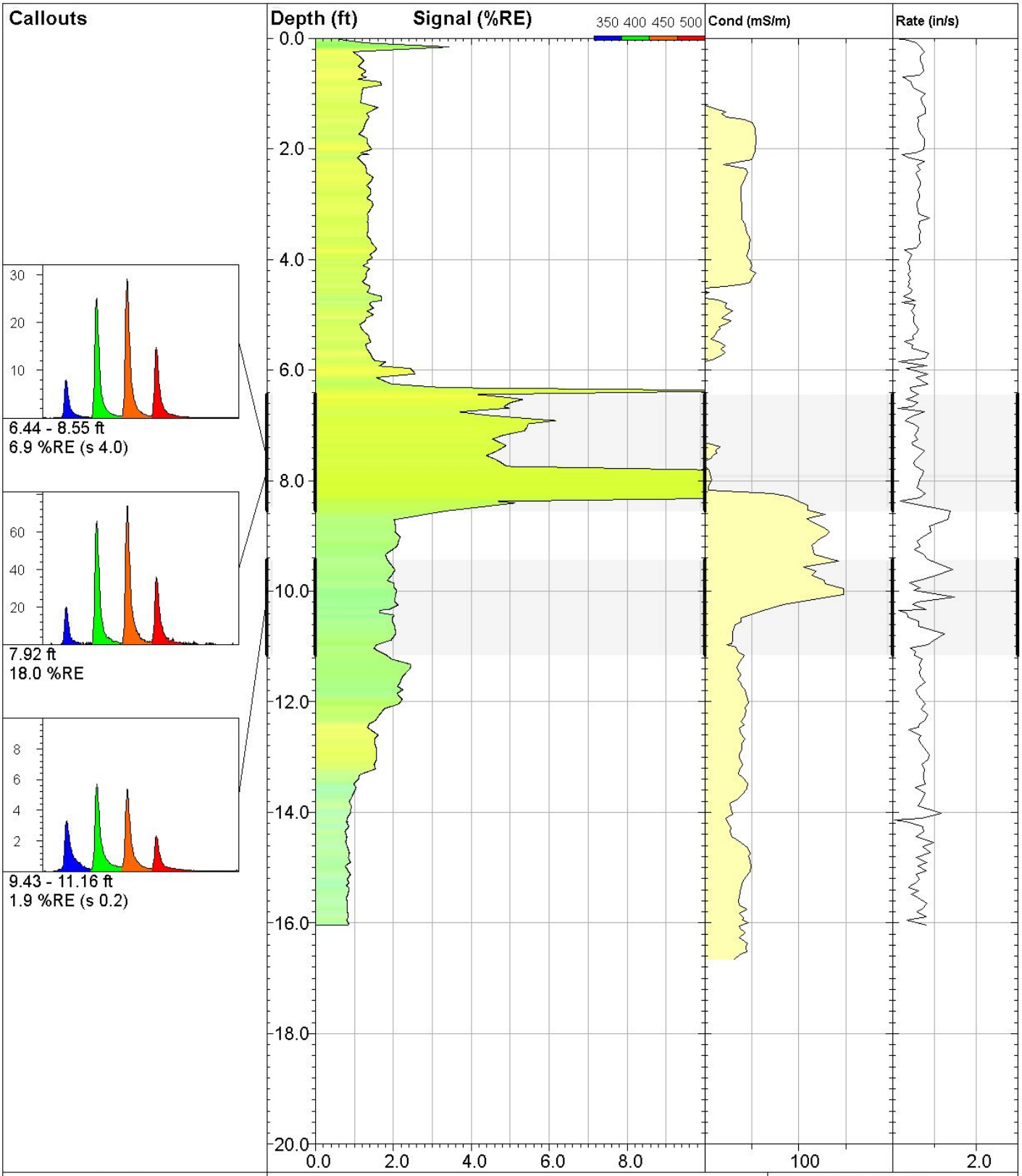
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.12 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **19.0 %RE @ 6.22 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 09:26 CDT**



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39-LIF

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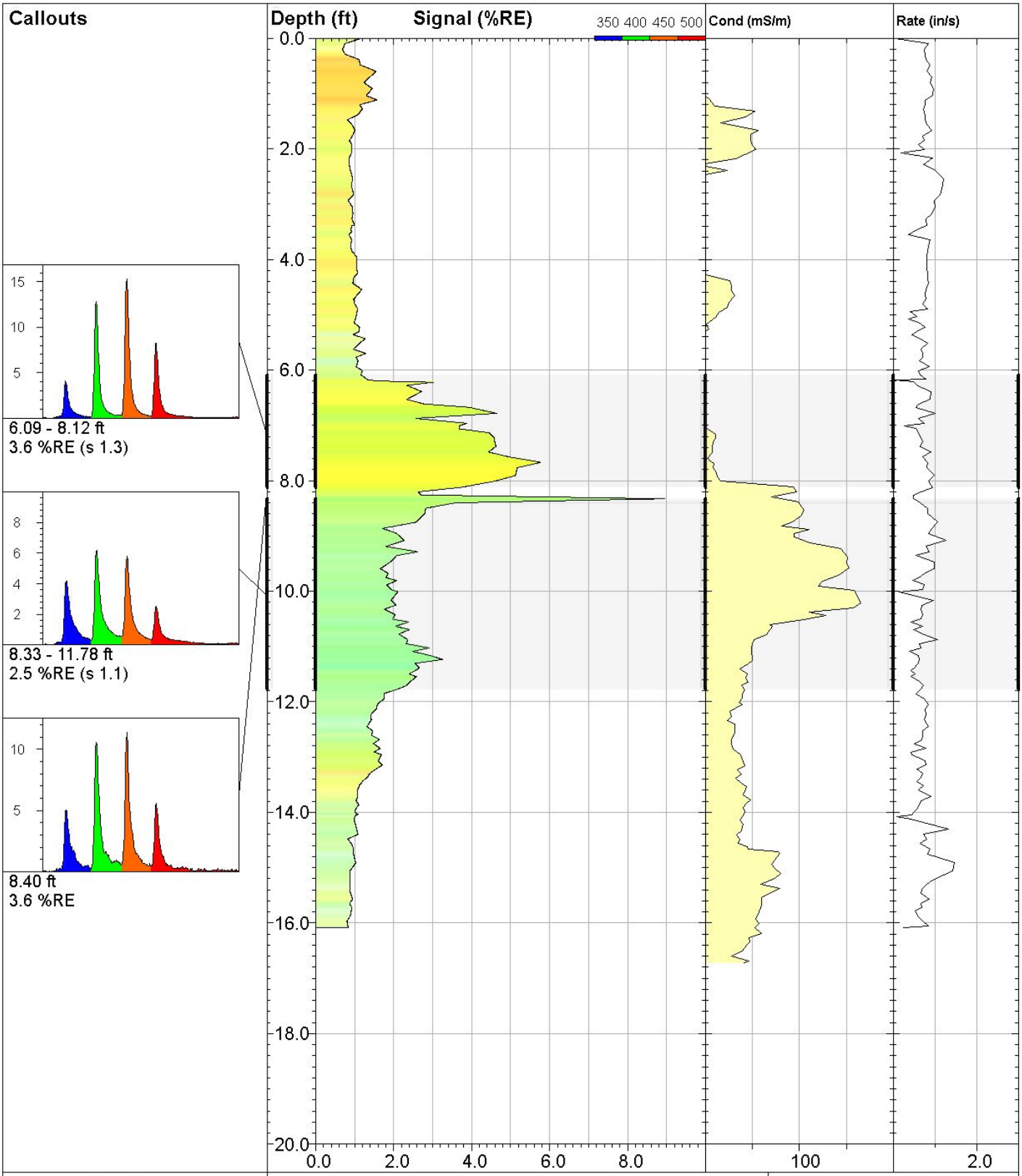
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.0 %RE @ 7.92 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 09:48 CDT**



40-LIF

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Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **9.0 %RE @ 8.33 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 10:29 CDT**

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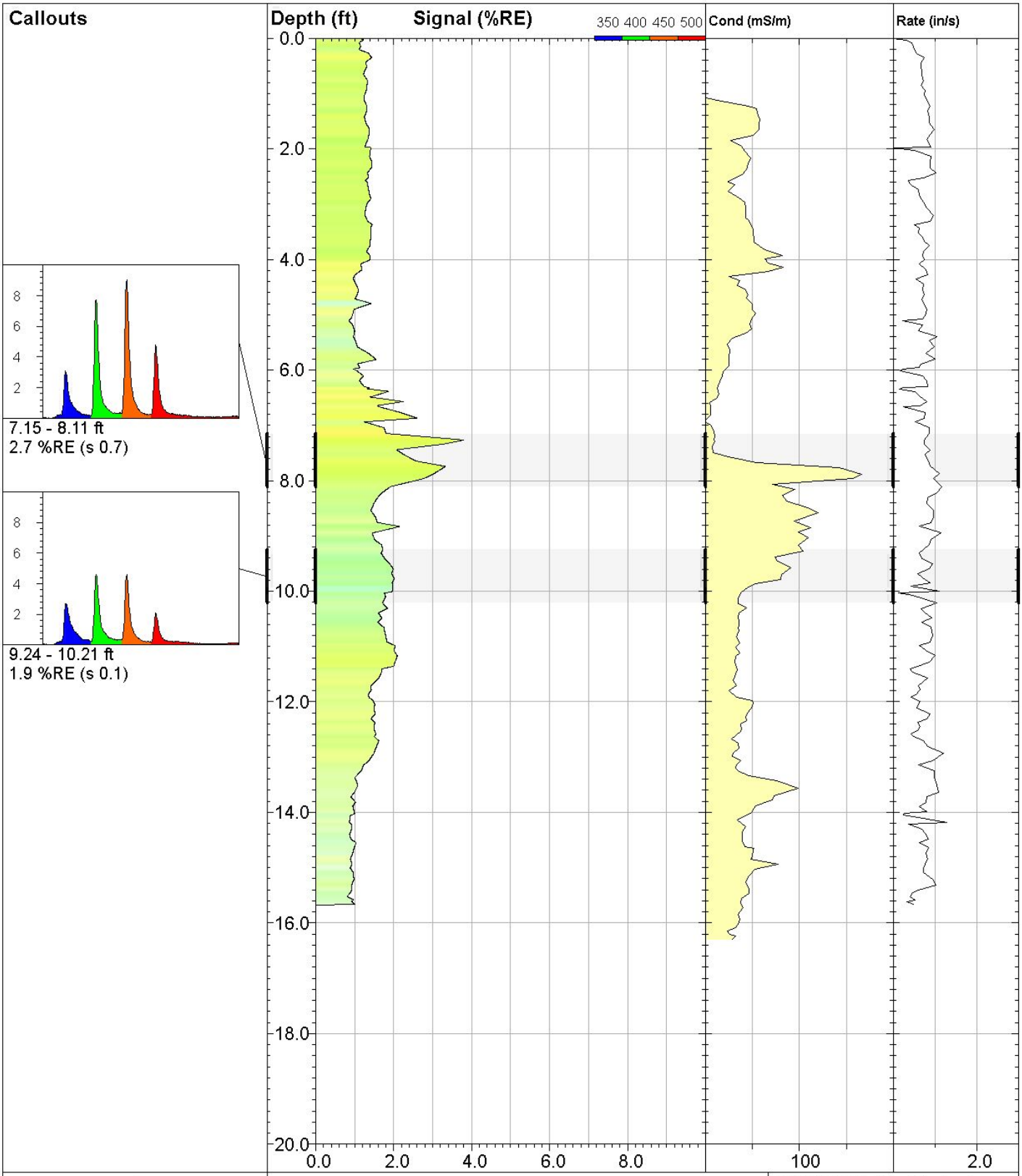

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41-LIF

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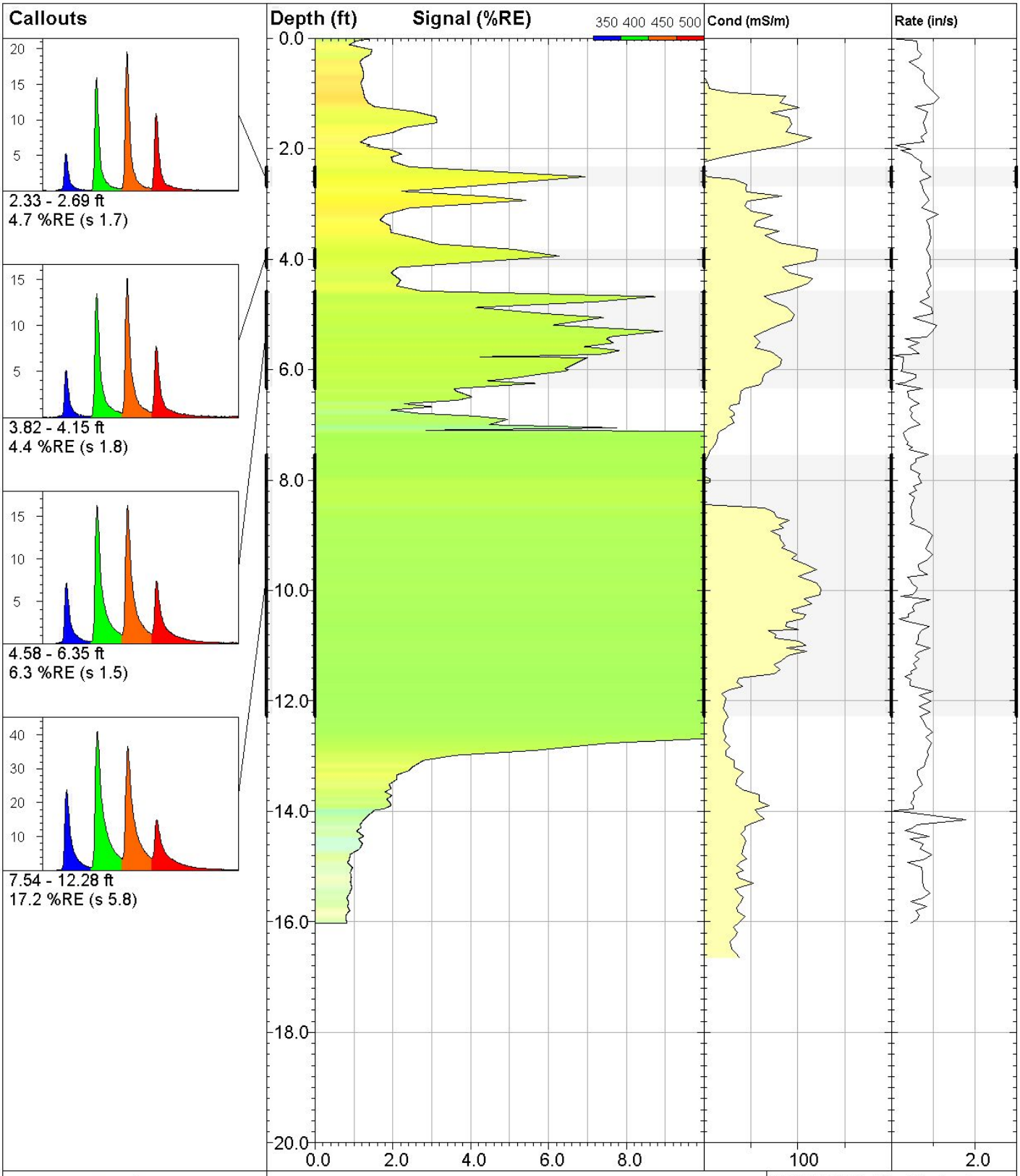
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.67 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.8 %RE @ 7.27 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 10:51 CDT**



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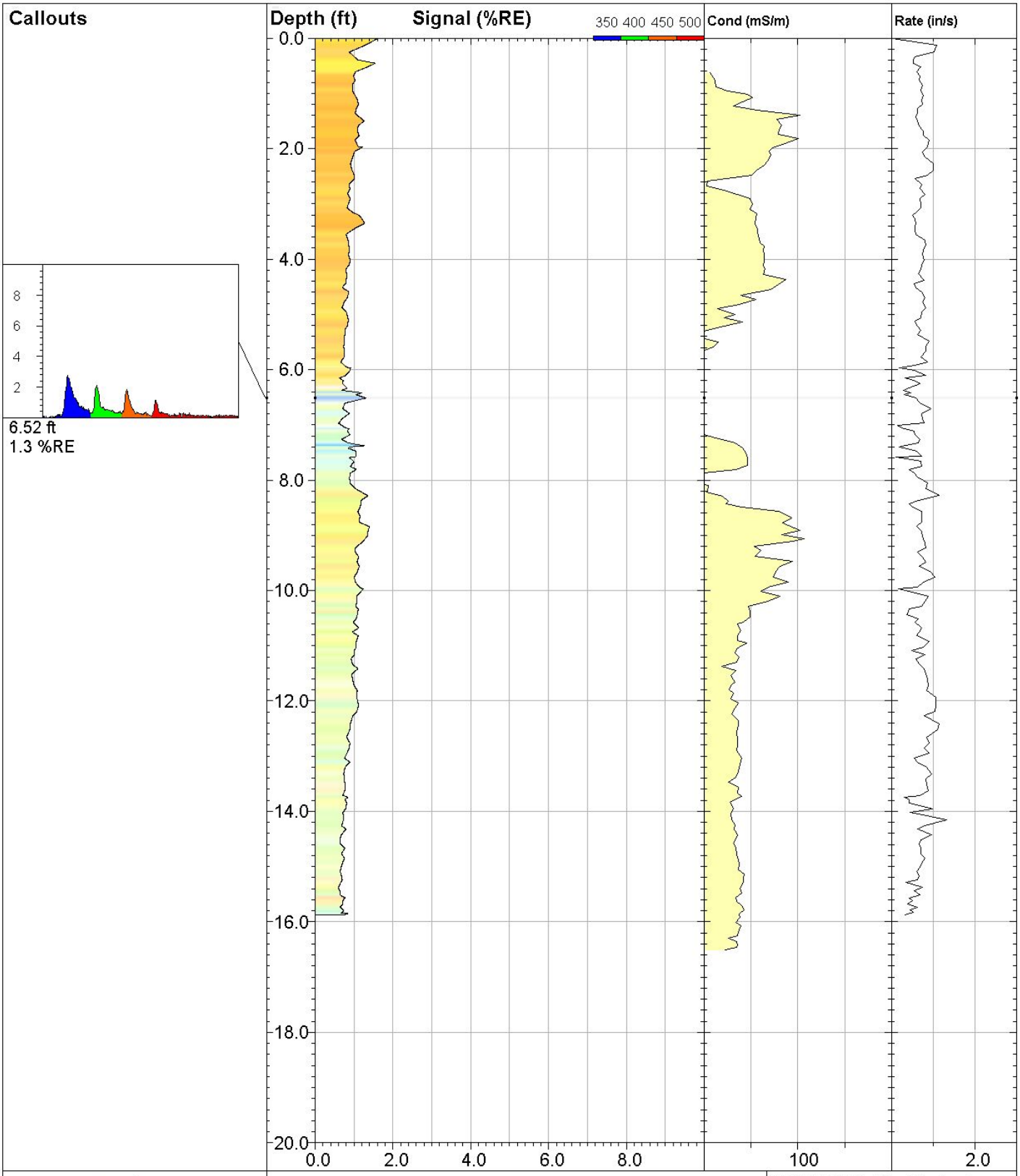
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **35.0 %RE @ 7.68 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 11:23 CDT**



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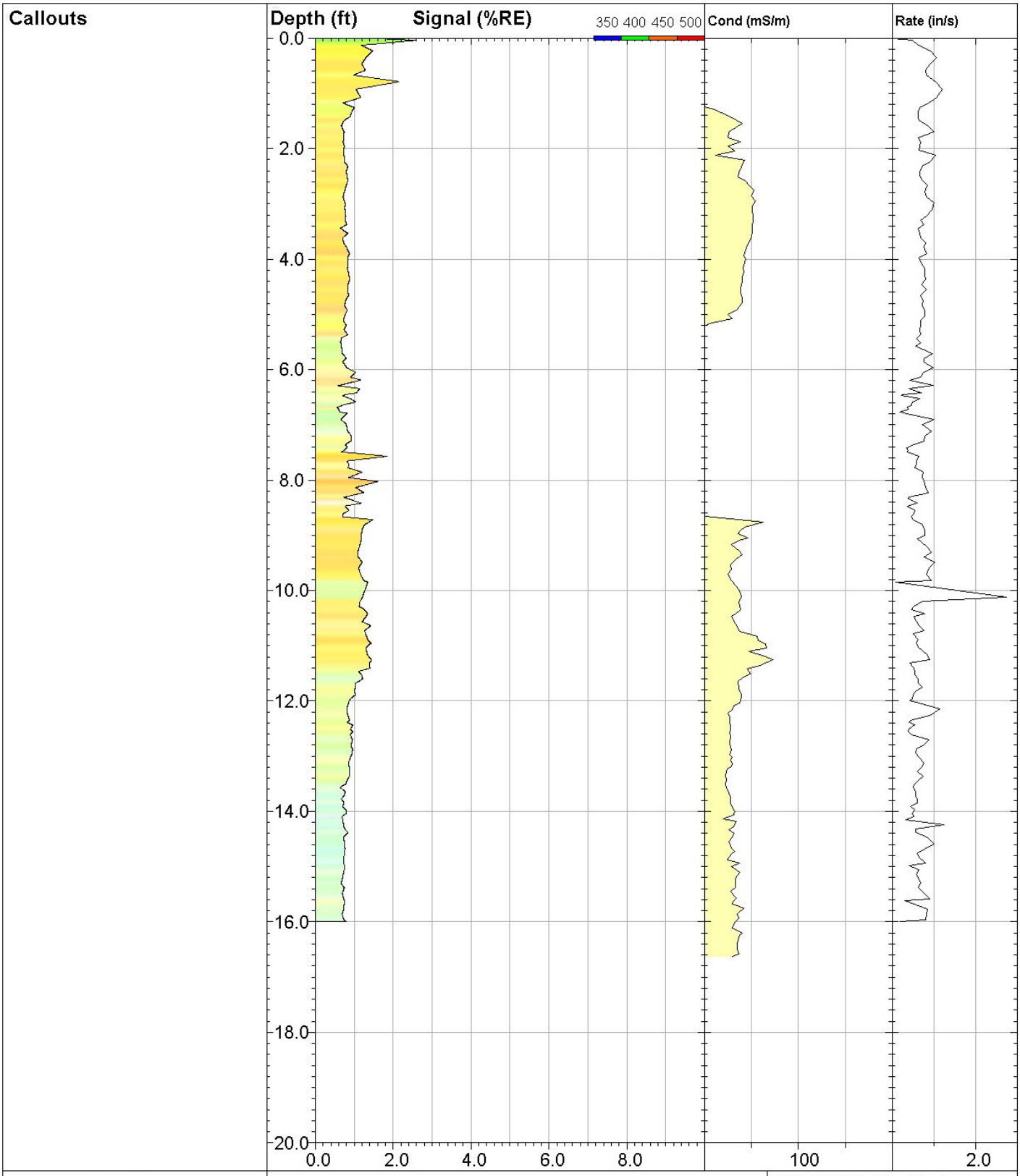
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.88 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.6 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 12:03 CDT**



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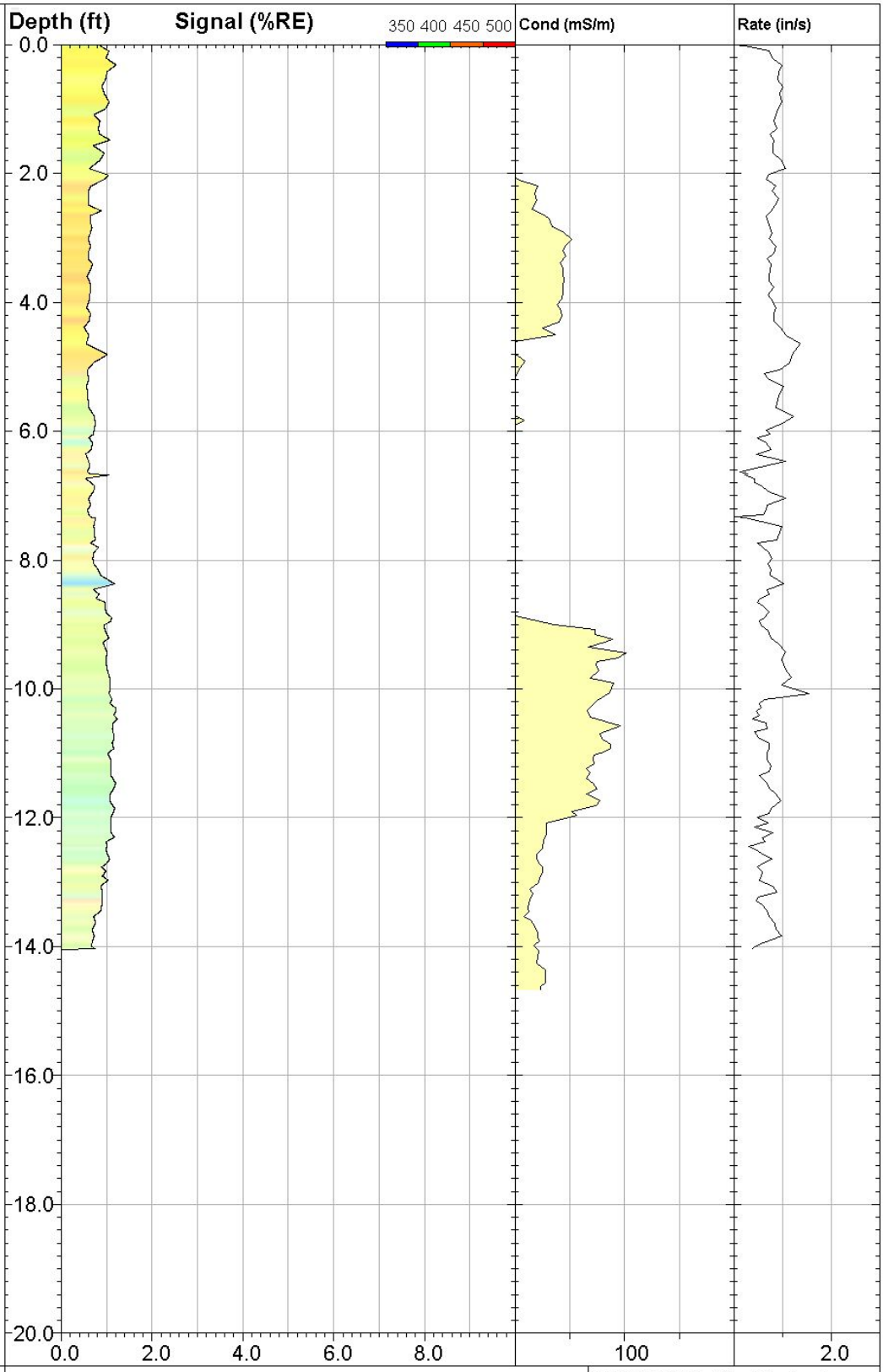
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.6 %RE @ 0.04 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 13:34 CDT**

Callouts
preprobe hit refusal just past 14.5ft



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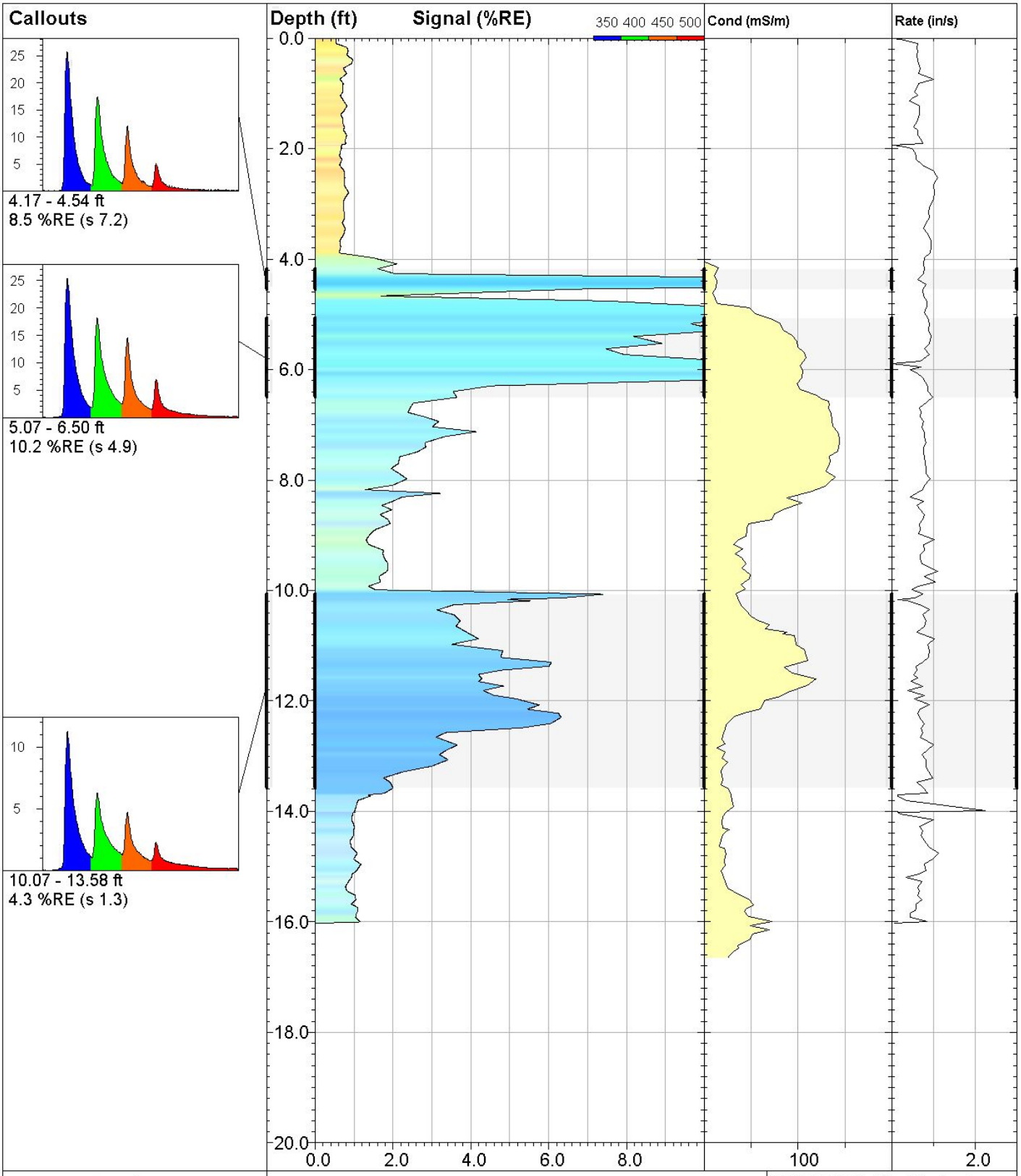
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.2 %RE @ 10.46 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 13:52 CDT**



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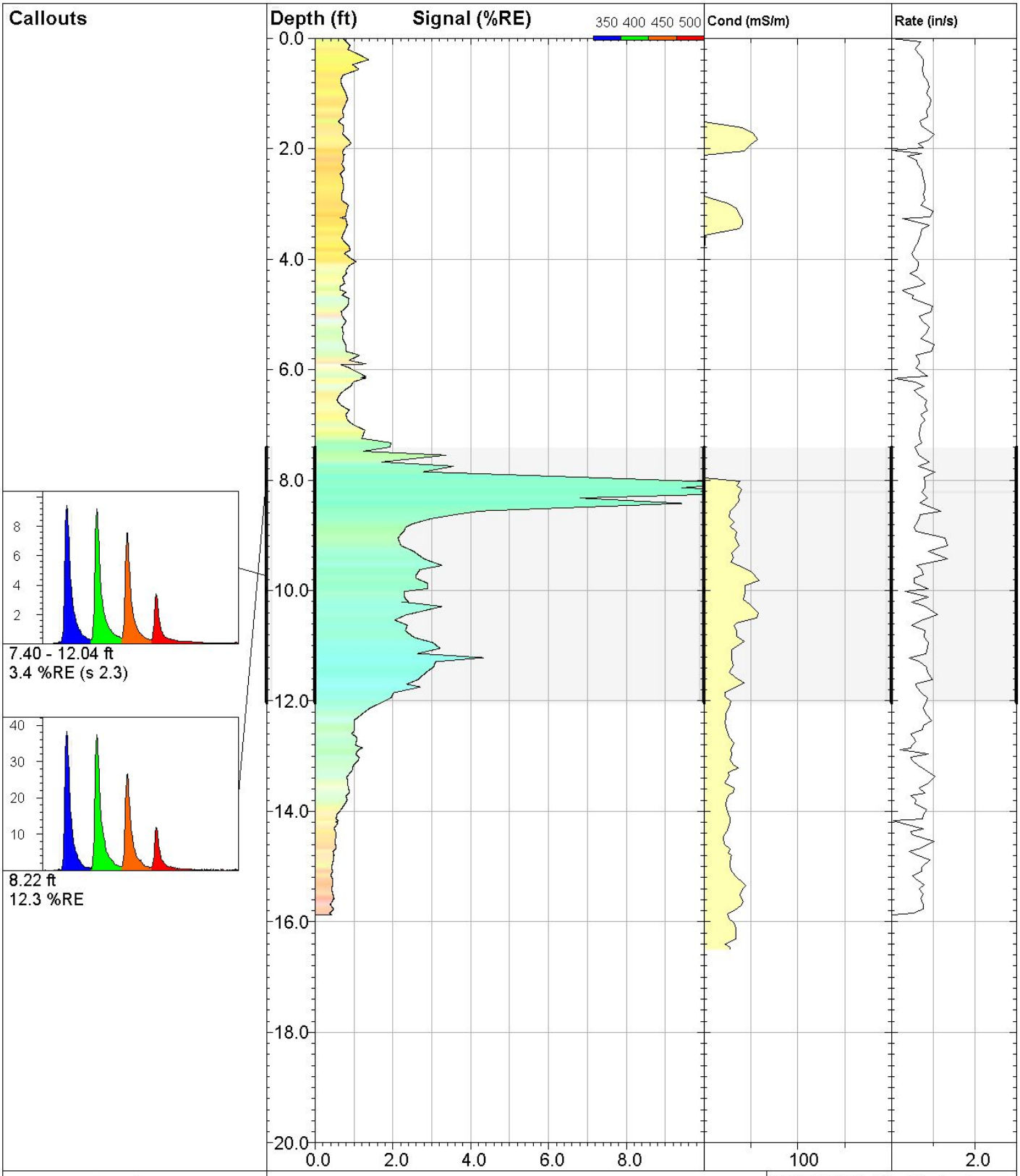
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **21.2 %RE @ 5.95 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 14:25 CDT**



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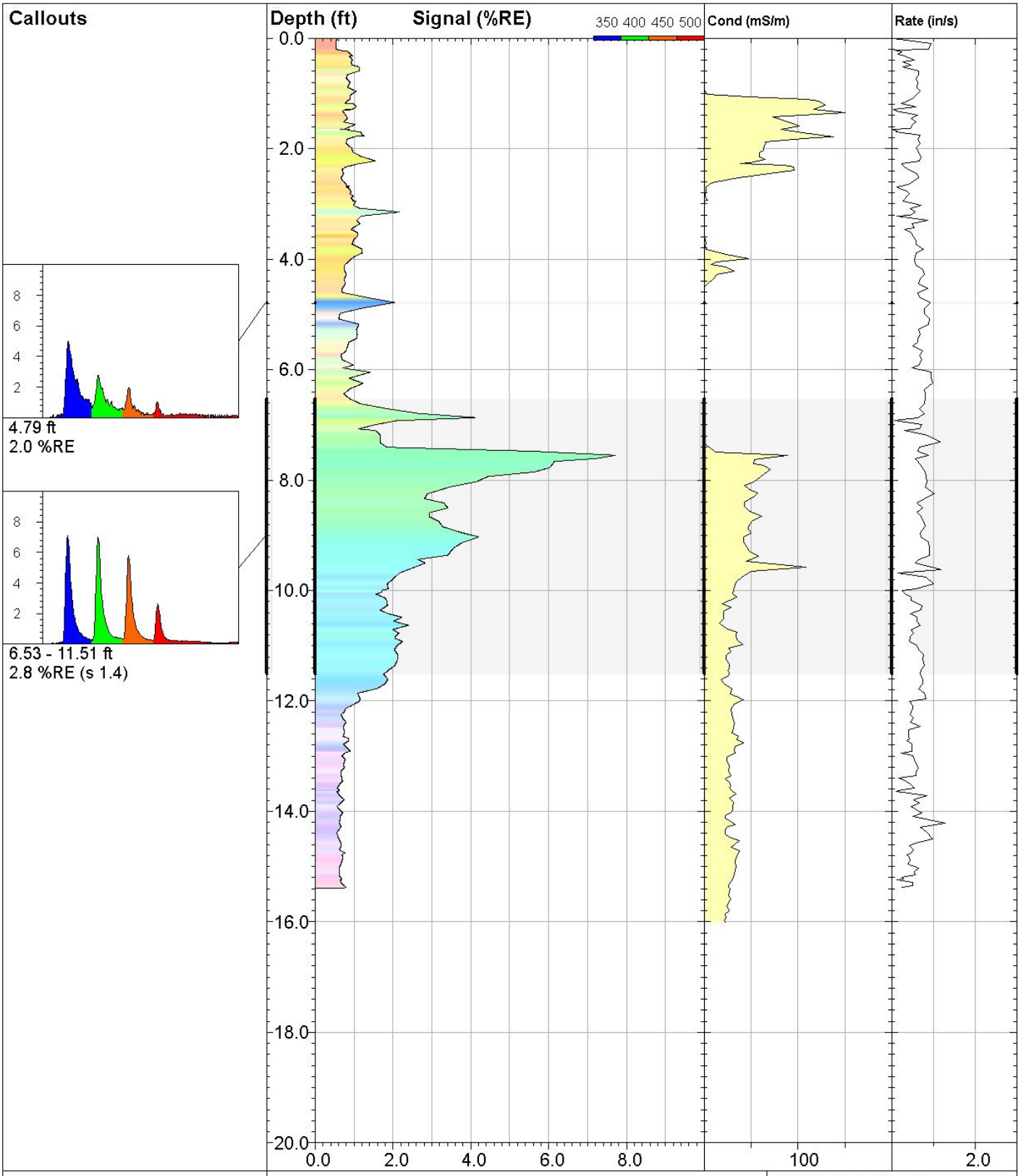
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.87 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.3 %RE @ 8.22 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 14:54 CDT**



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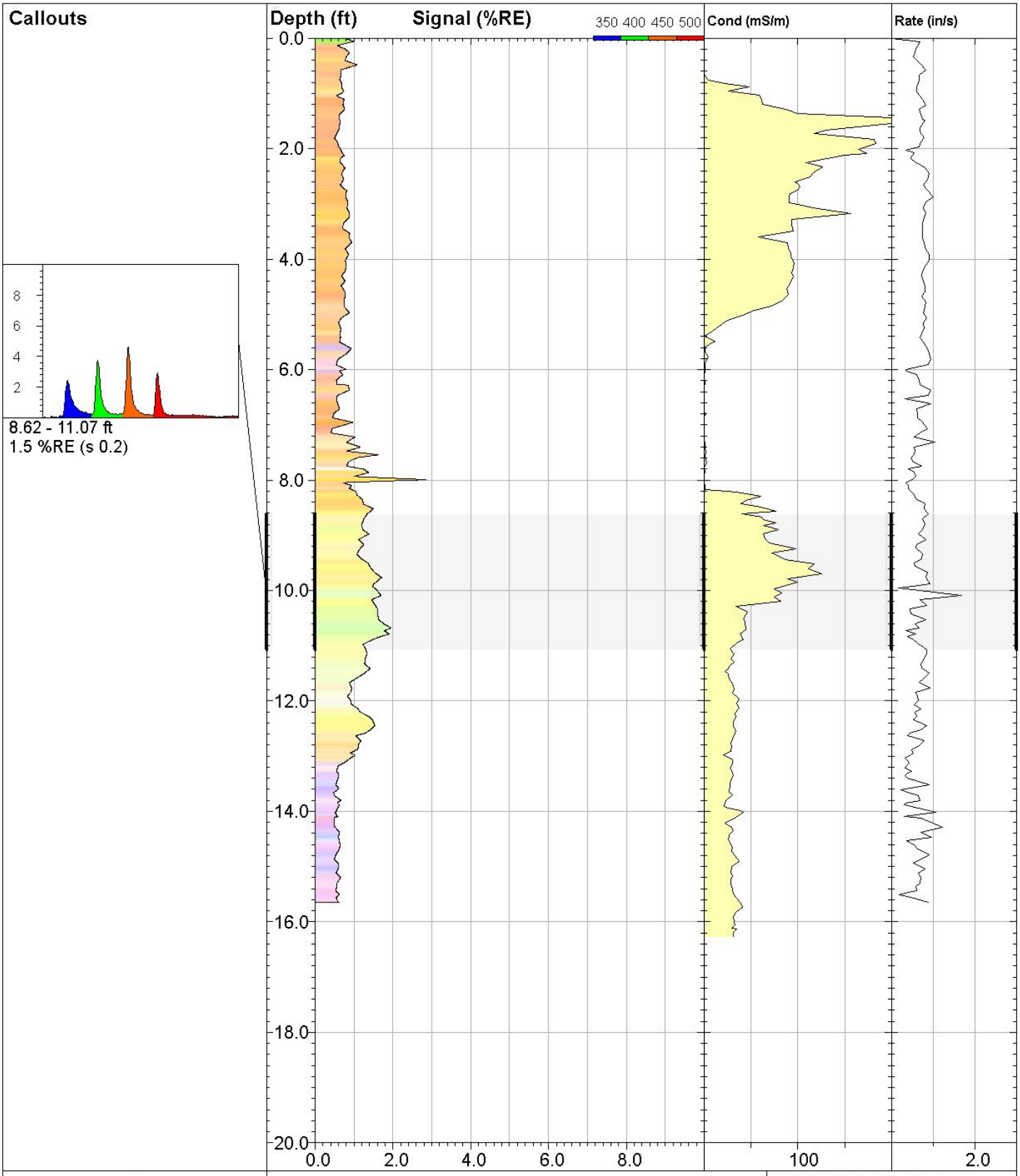
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.39 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **7.7 %RE @ 7.55 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 16:55 CDT**



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49-LIF

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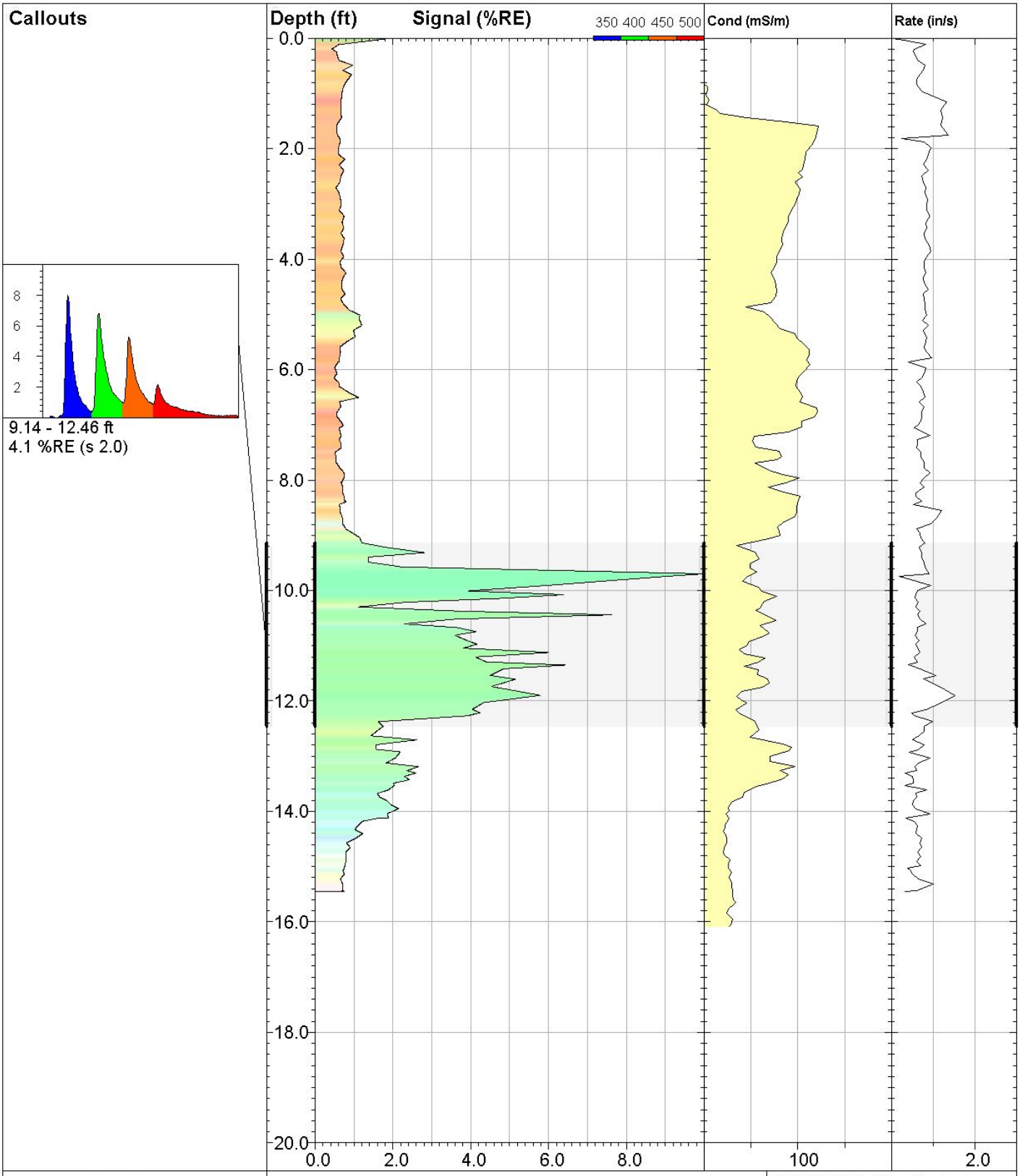
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.65 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.9 %RE @ 7.99 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 17:20 CDT**



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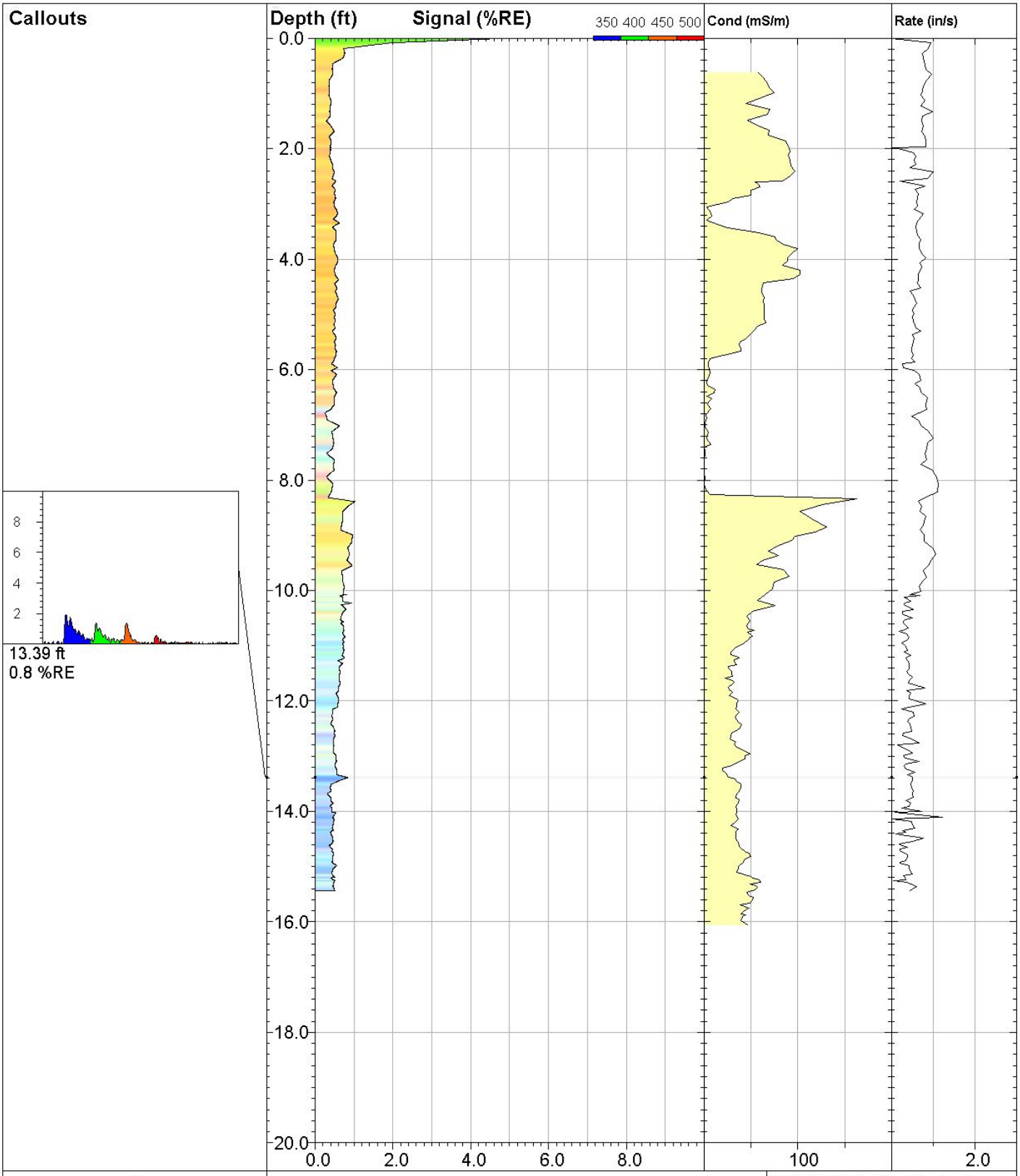
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.46 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **10.0 %RE @ 9.70 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 17:44 CDT**



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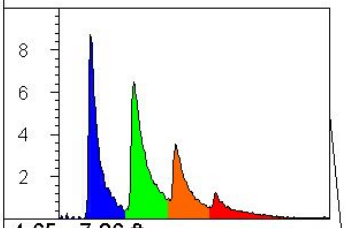
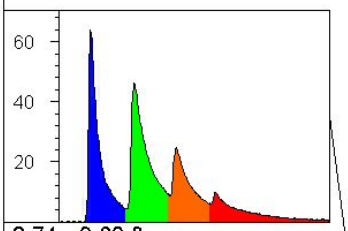
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.43 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.0 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 09:28 CDT**

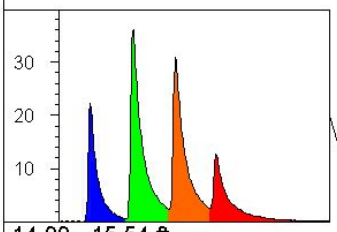
Callouts



4.65 - 7.86 ft
3.0 %RE (s 2.5)

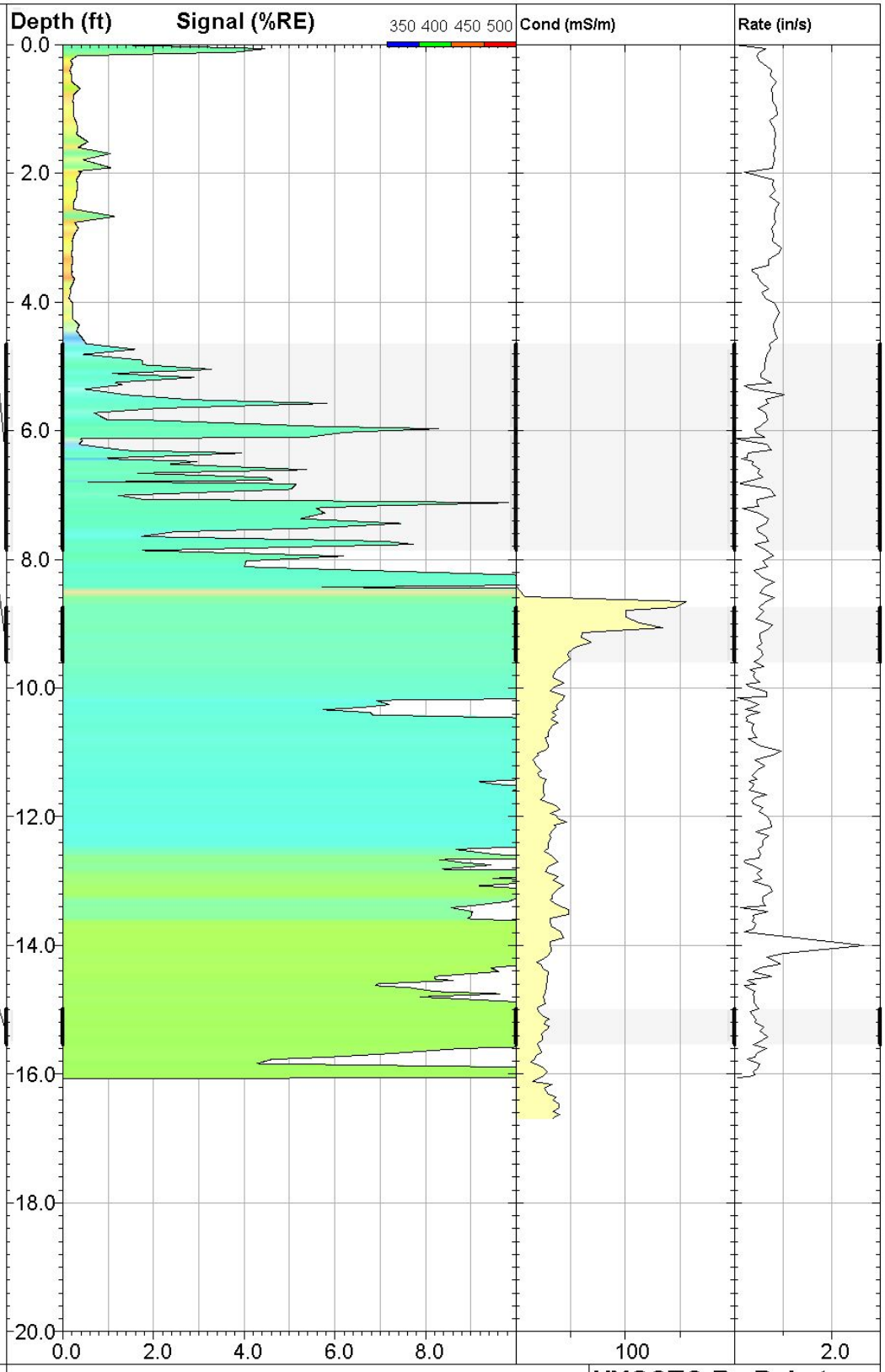


8.74 - 9.60 ft
25.6 %RE (s 5.5)



14.99 - 15.54 ft
13.6 %RE (s 1.2)

BORING REACHED THE END OF PILOT HOLE.



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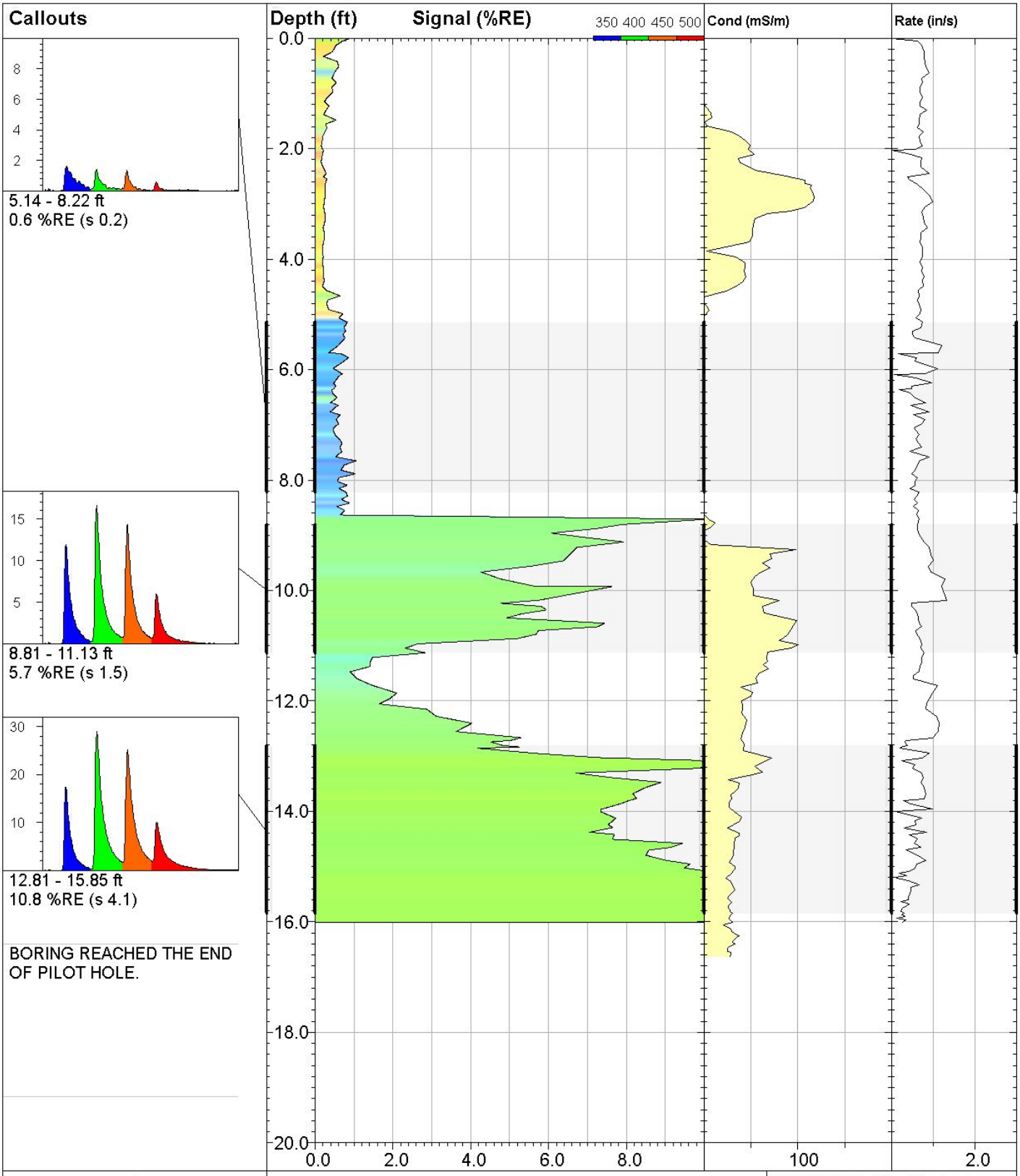
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.06 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **127.9 %RE @ 8.60 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 10:03 CDT**



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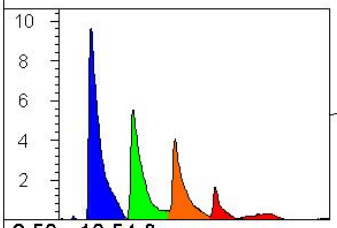
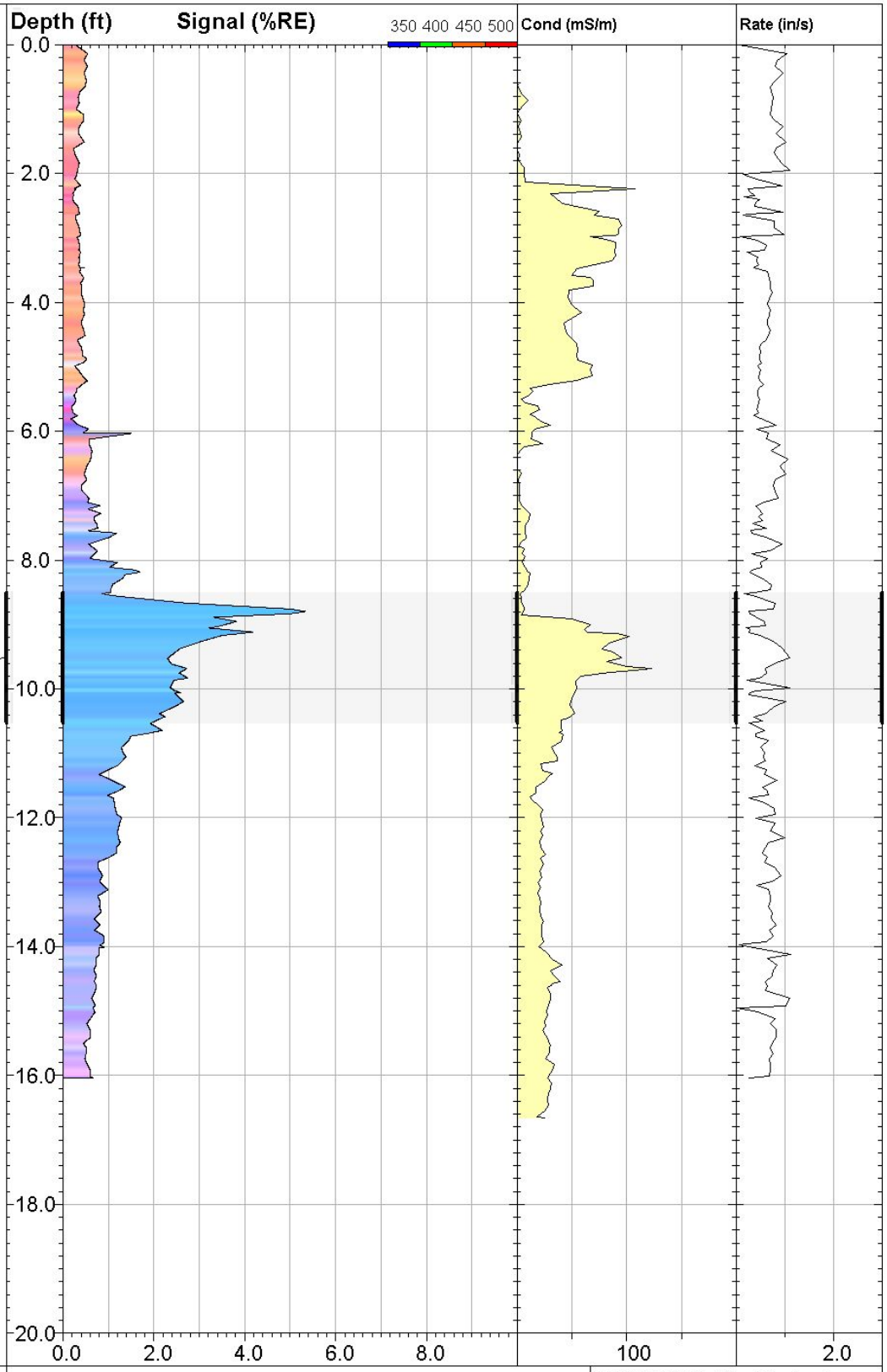
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **20.4 %RE @ 15.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 10:37 CDT**

Callouts



8.50 - 10.54 ft
2.8 %RE (s 1.0)

BORING REACHED THE END OF PILOT HOLE.



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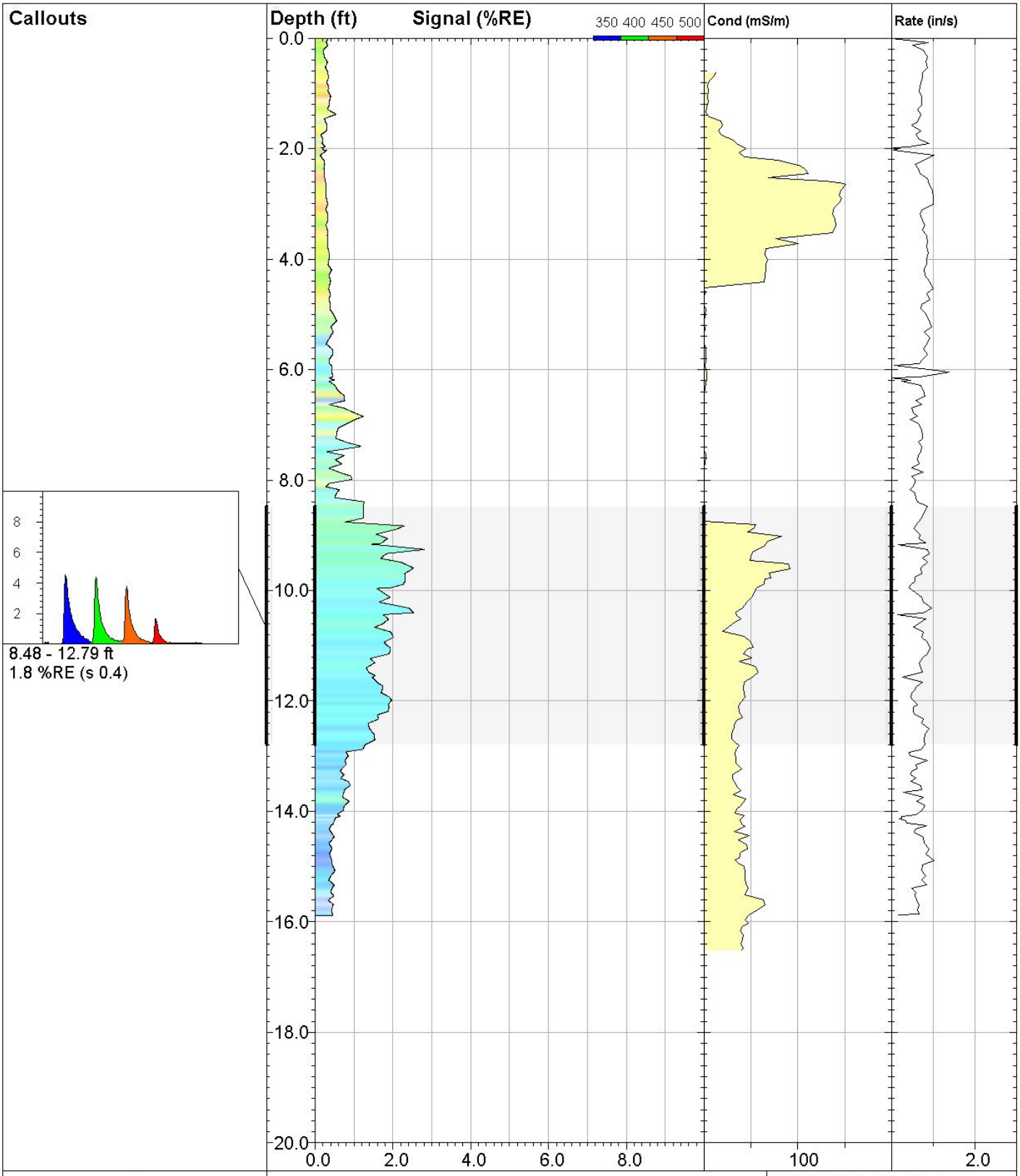
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.3 %RE @ 8.80 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 11:05 CDT**



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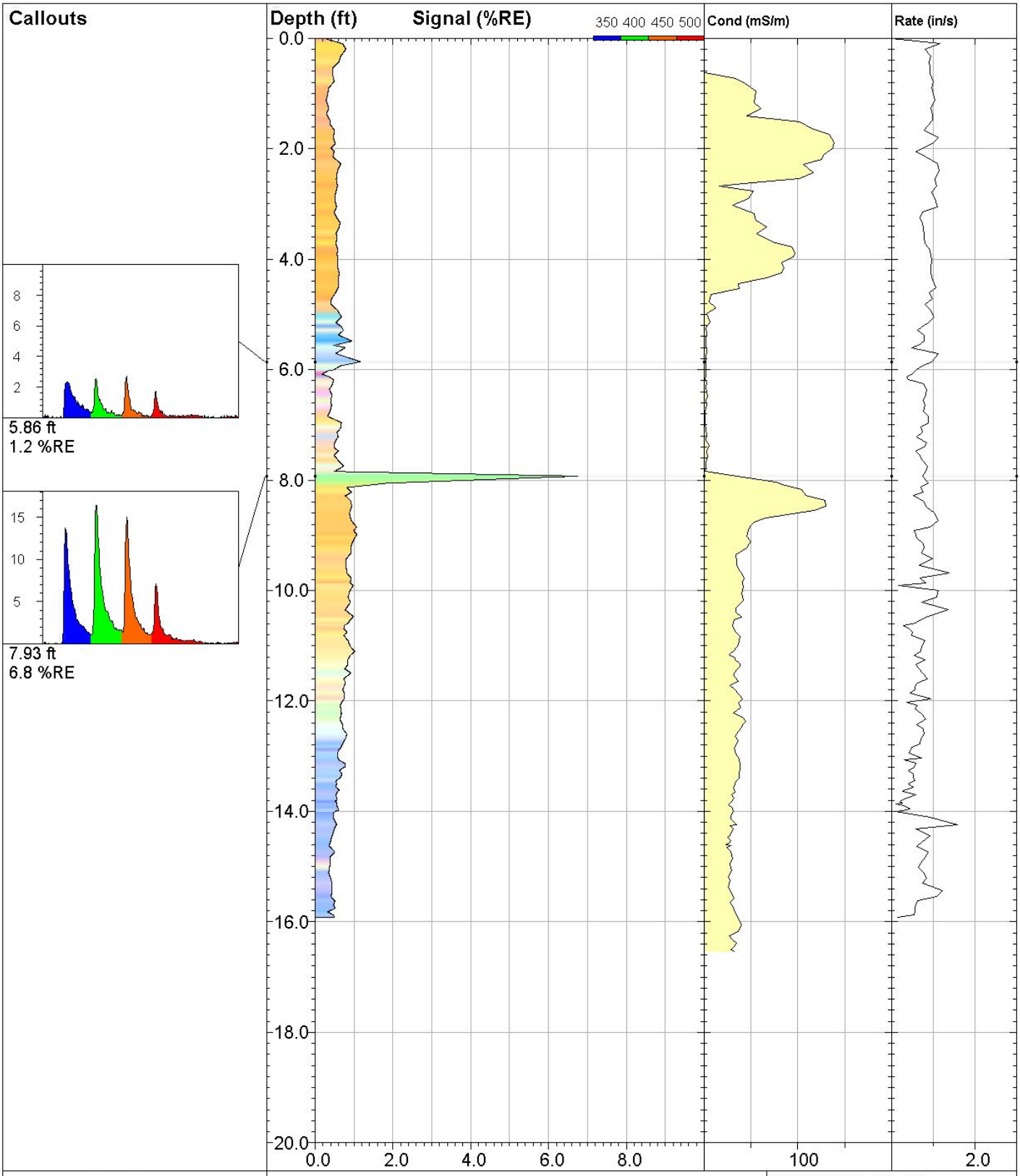
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.89 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.8 %RE @ 9.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 11:41 CDT**



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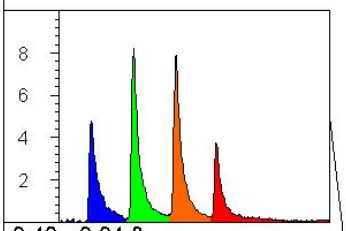
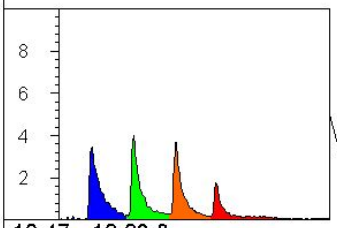
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.92 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.8 %RE @ 7.93 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 12:24 CDT**

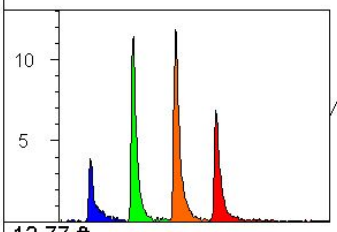
Callouts



9.40 - 9.94 ft
3.1 %RE (s 0.4)

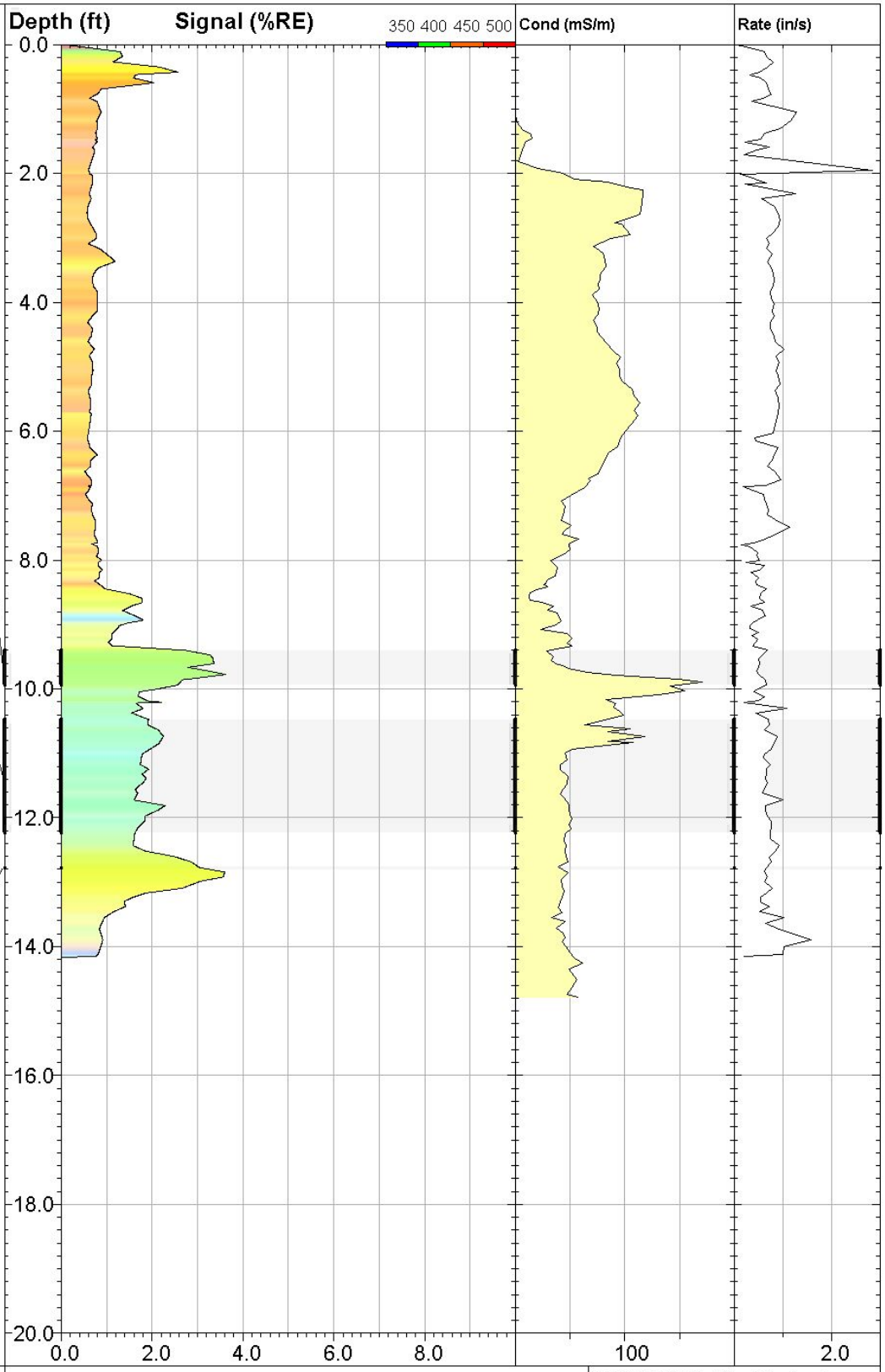


10.47 - 12.23 ft
1.9 %RE (s 0.2)



12.77 ft
3.0 %RE

BORING COMPLETED TO
END OF PREPROBE



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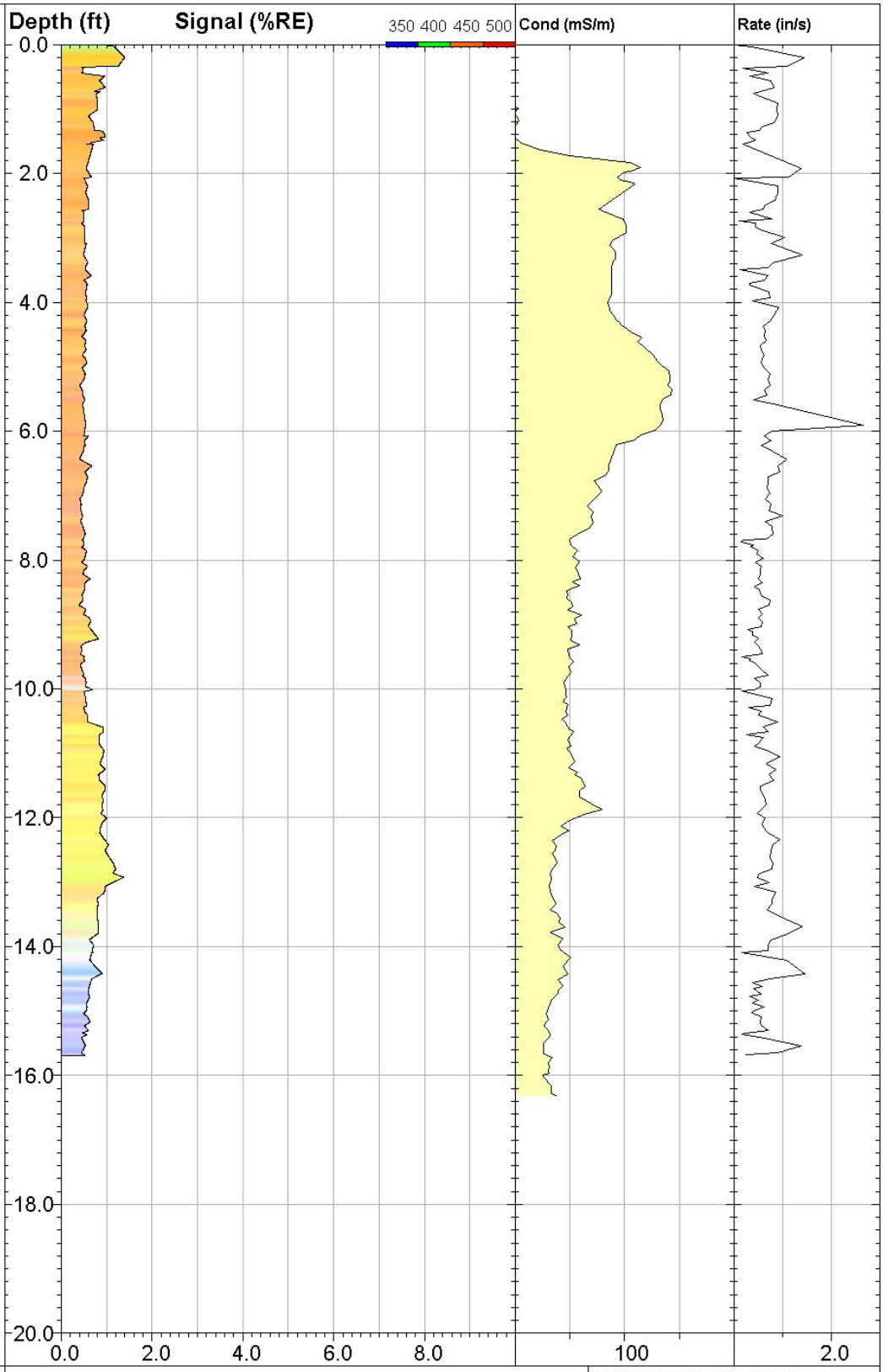
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.16 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.6 %RE @ 9.78 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 14:11 CDT**

Callouts
BORING COMPLETED TO END OF PREPROBE



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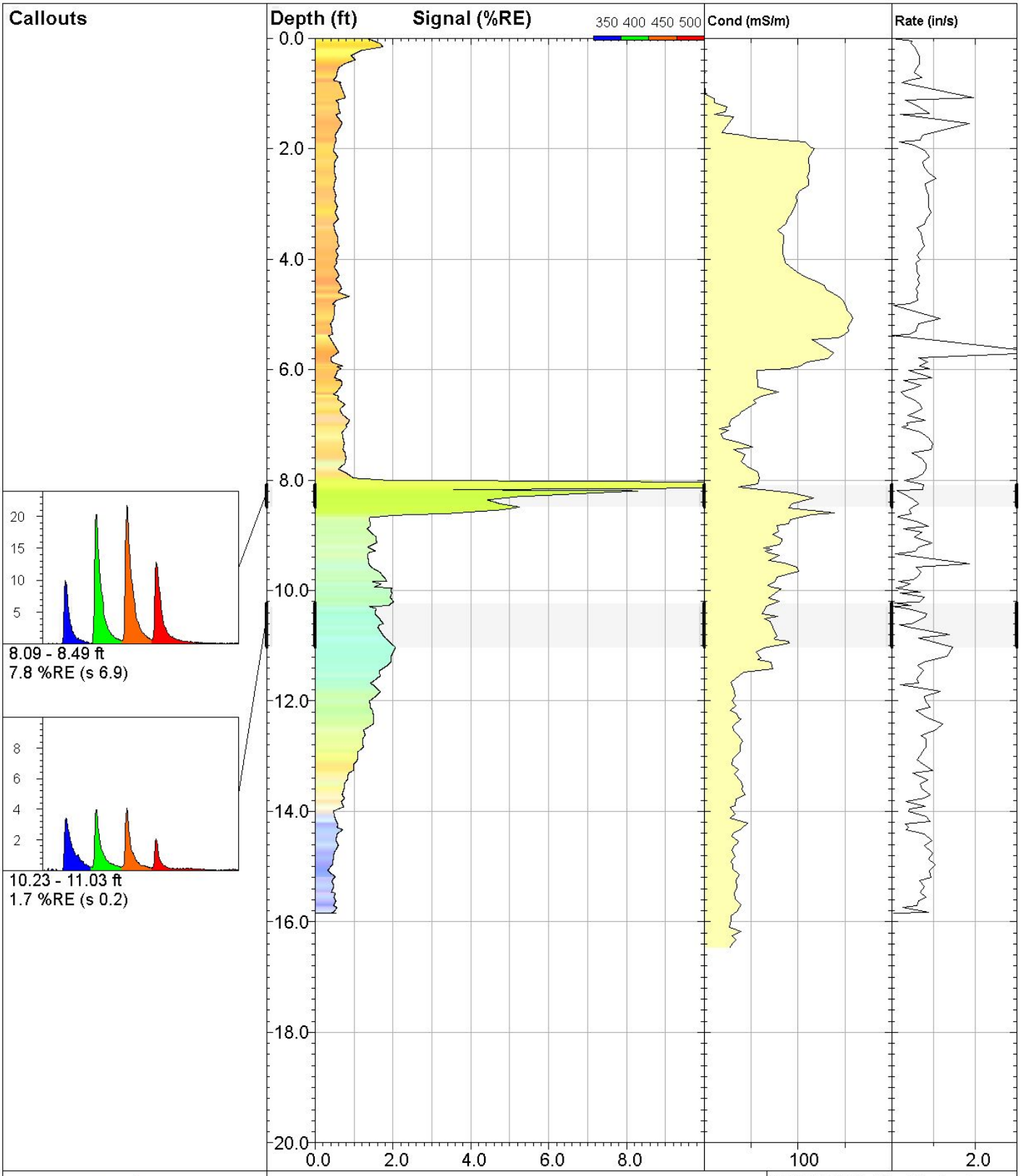
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.70 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 15.70 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 14:31 CDT**



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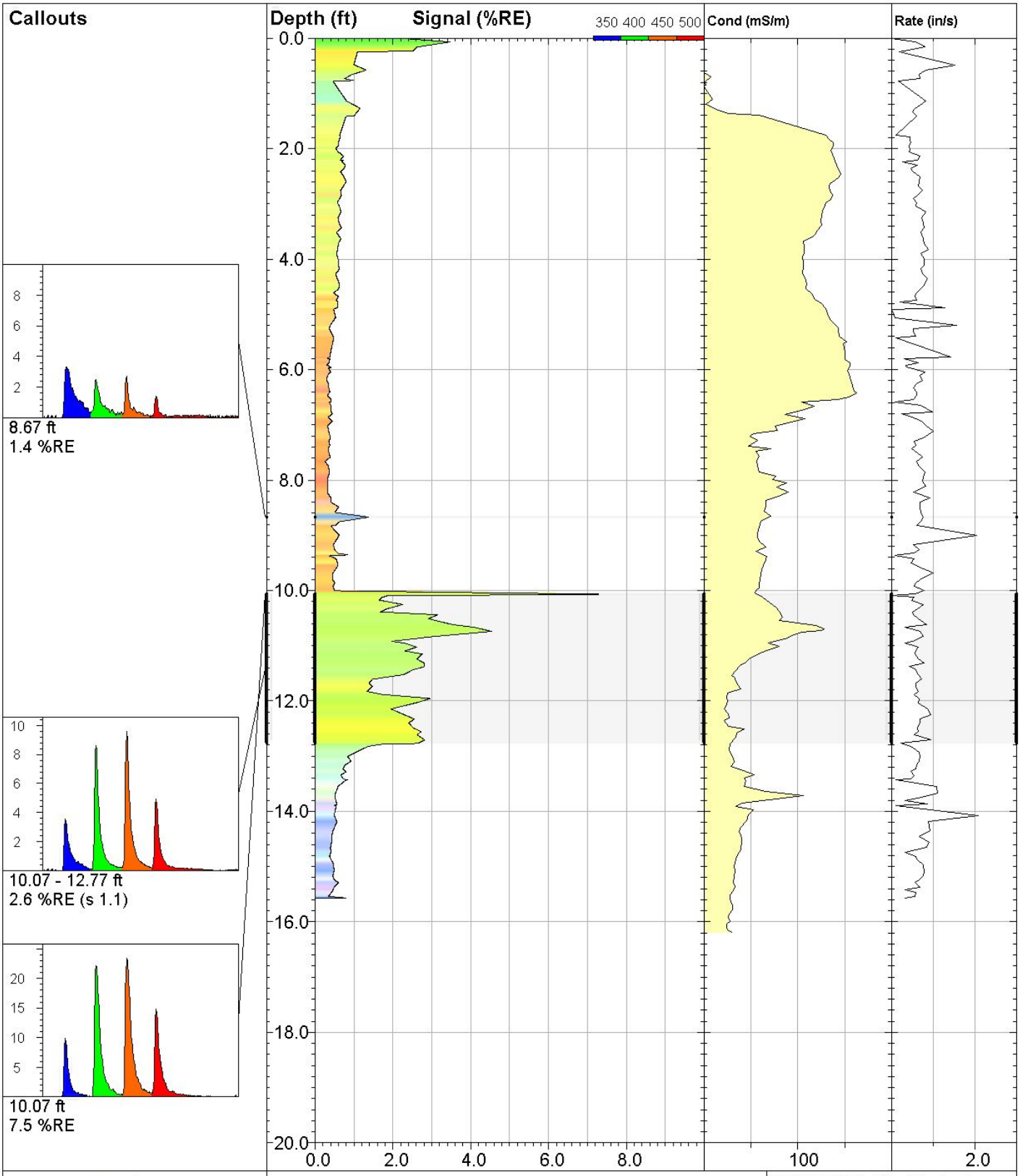
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.85 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **22.9 %RE @ 8.09 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 15:03 CDT**



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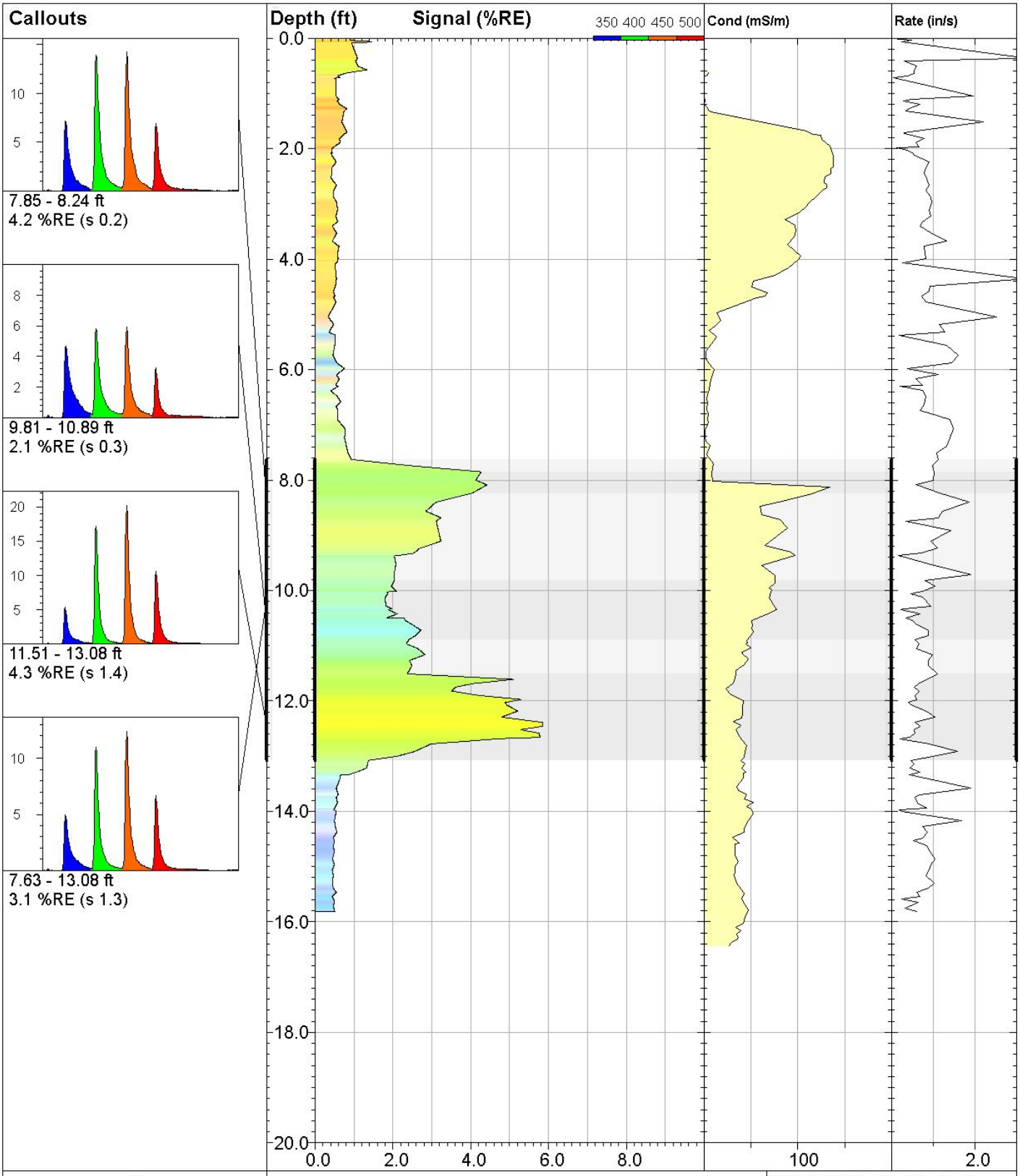
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.57 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **7.5 %RE @ 10.07 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 15:34 CDT**



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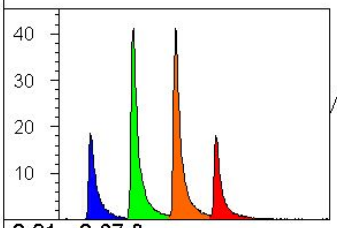
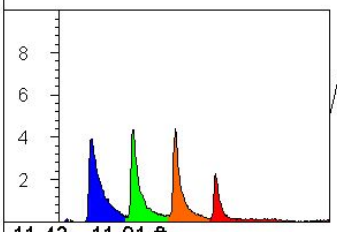
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.82 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.9 %RE @ 12.46 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 16:04 CDT**

Callouts

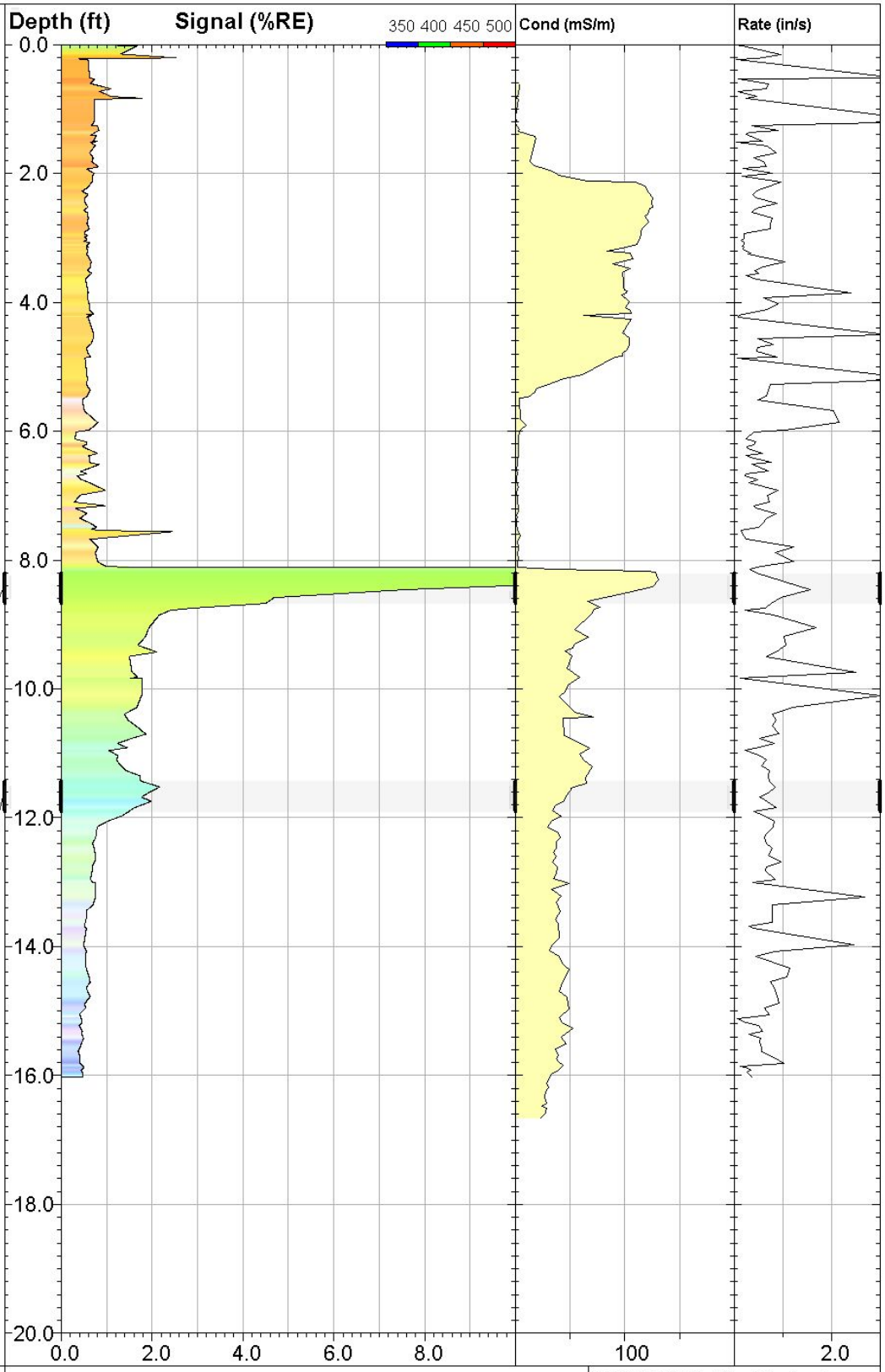


8.21 - 8.67 ft
11.7 %RE (s 8.9)



11.43 - 11.91 ft
1.8 %RE (s 0.2)

SEVERAL VOID SPACES
DURING ADVANCEMENT.
RATE JUMPED



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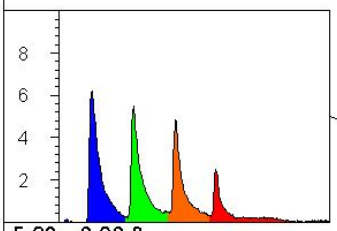
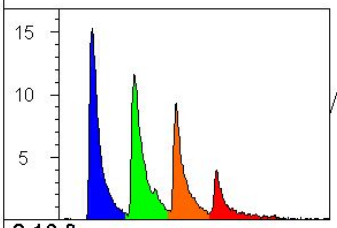
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.03 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **27.4 %RE @ 8.14 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 16:32 CDT**

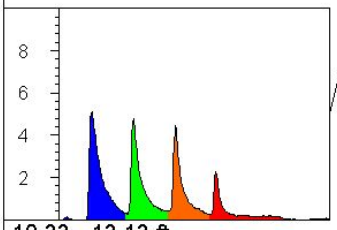
Callouts



5.23 - 6.06 ft
2.7 %RE (s 0.8)

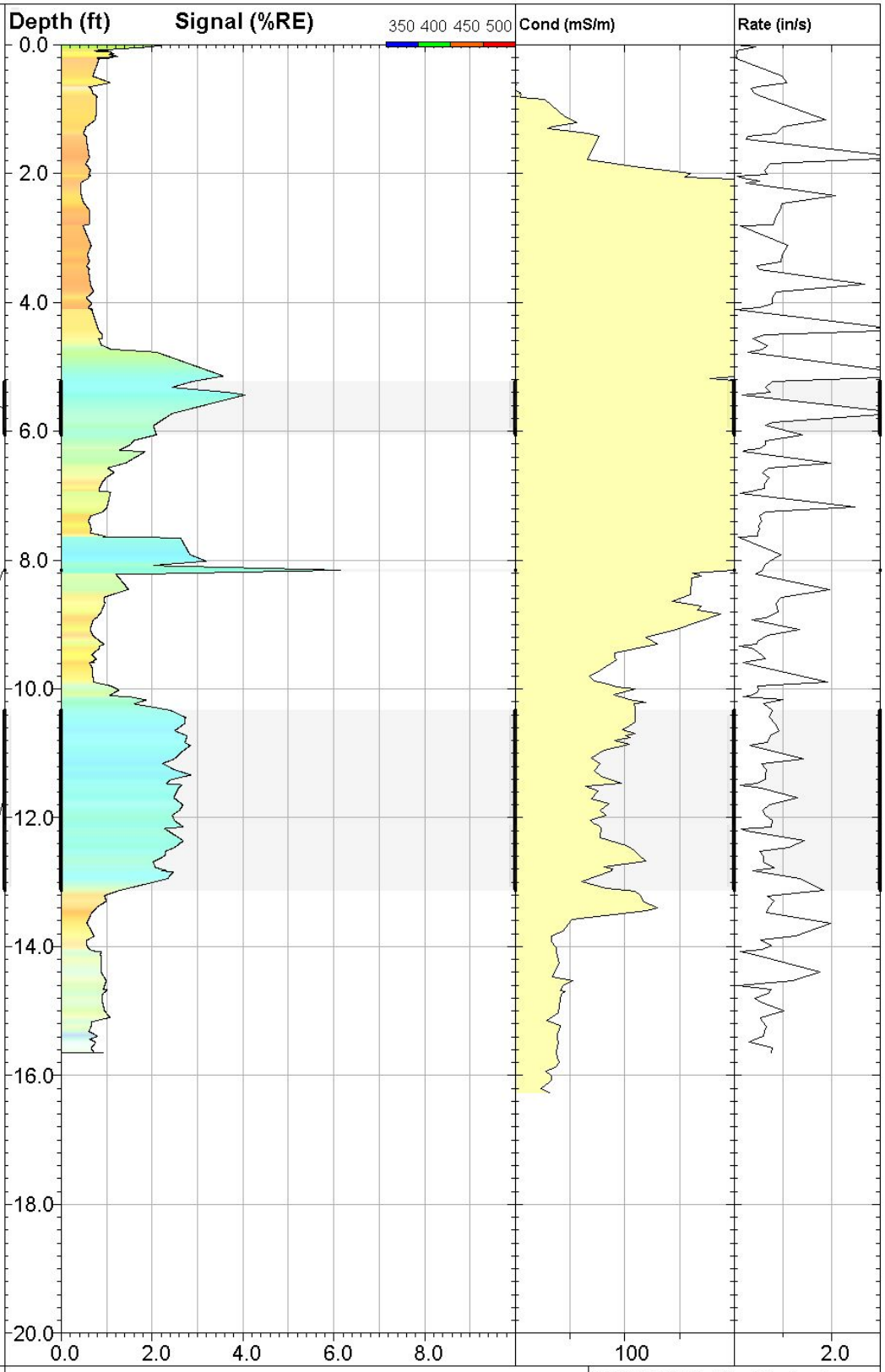


8.16 ft
6.2 %RE



10.33 - 13.13 ft
2.4 %RE (s 0.3)

SEVERAL VOID SPACES
DURING ADVANCEMENT.
RATE JUMPED



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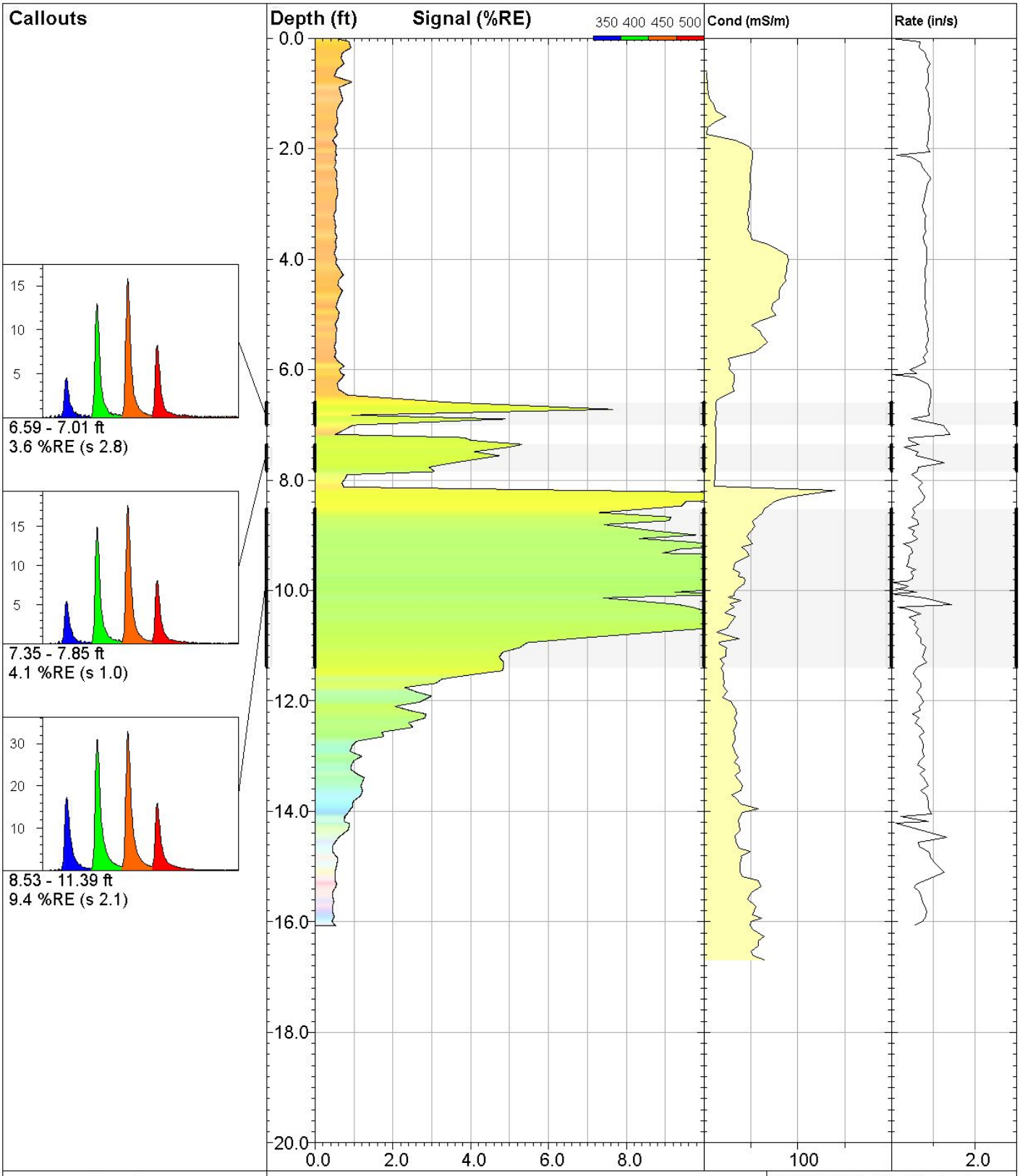
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.65 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.2 %RE @ 8.16 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 17:07 CDT**



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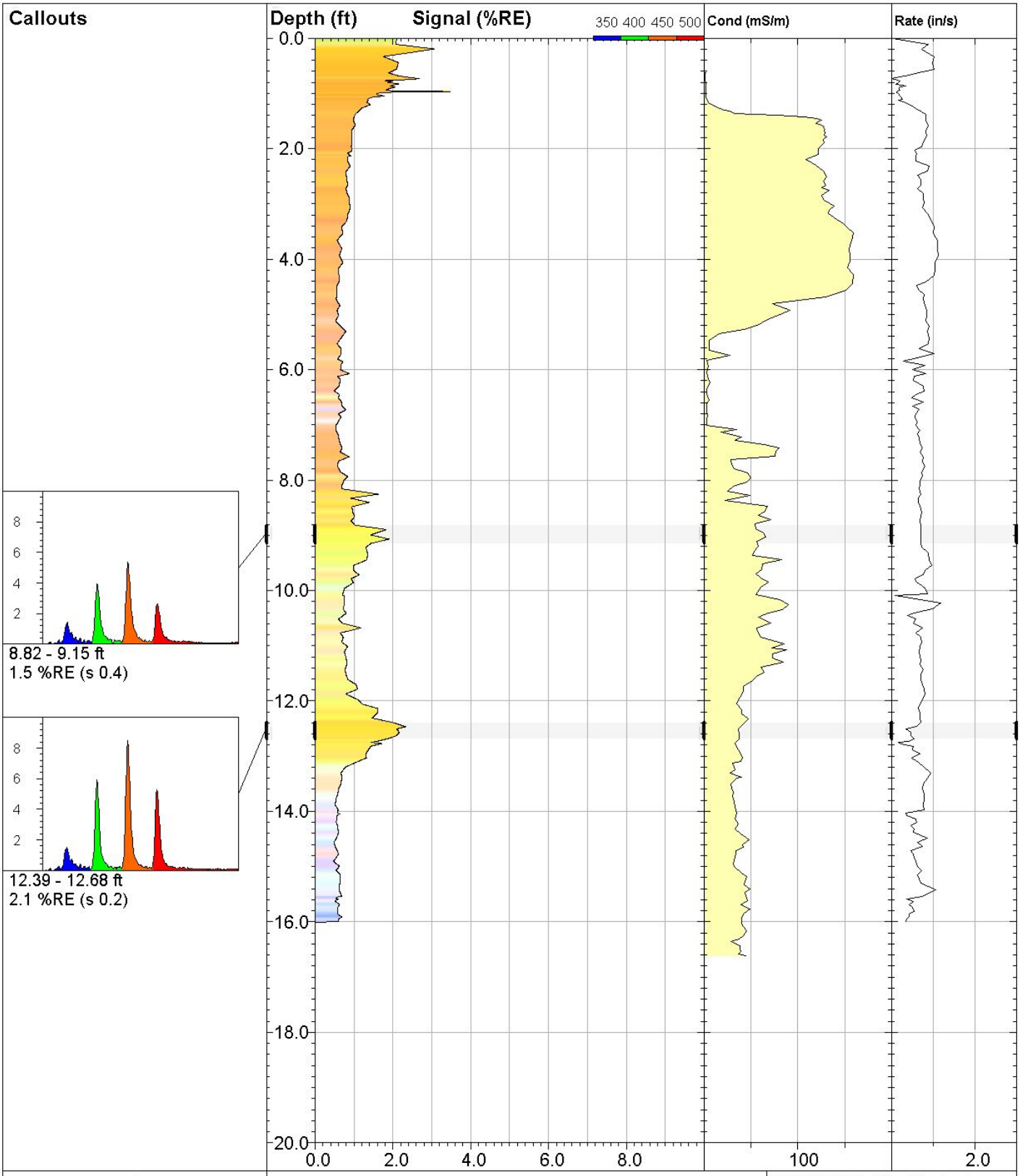
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.07 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.3 %RE @ 9.62 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 10:55 CDT**



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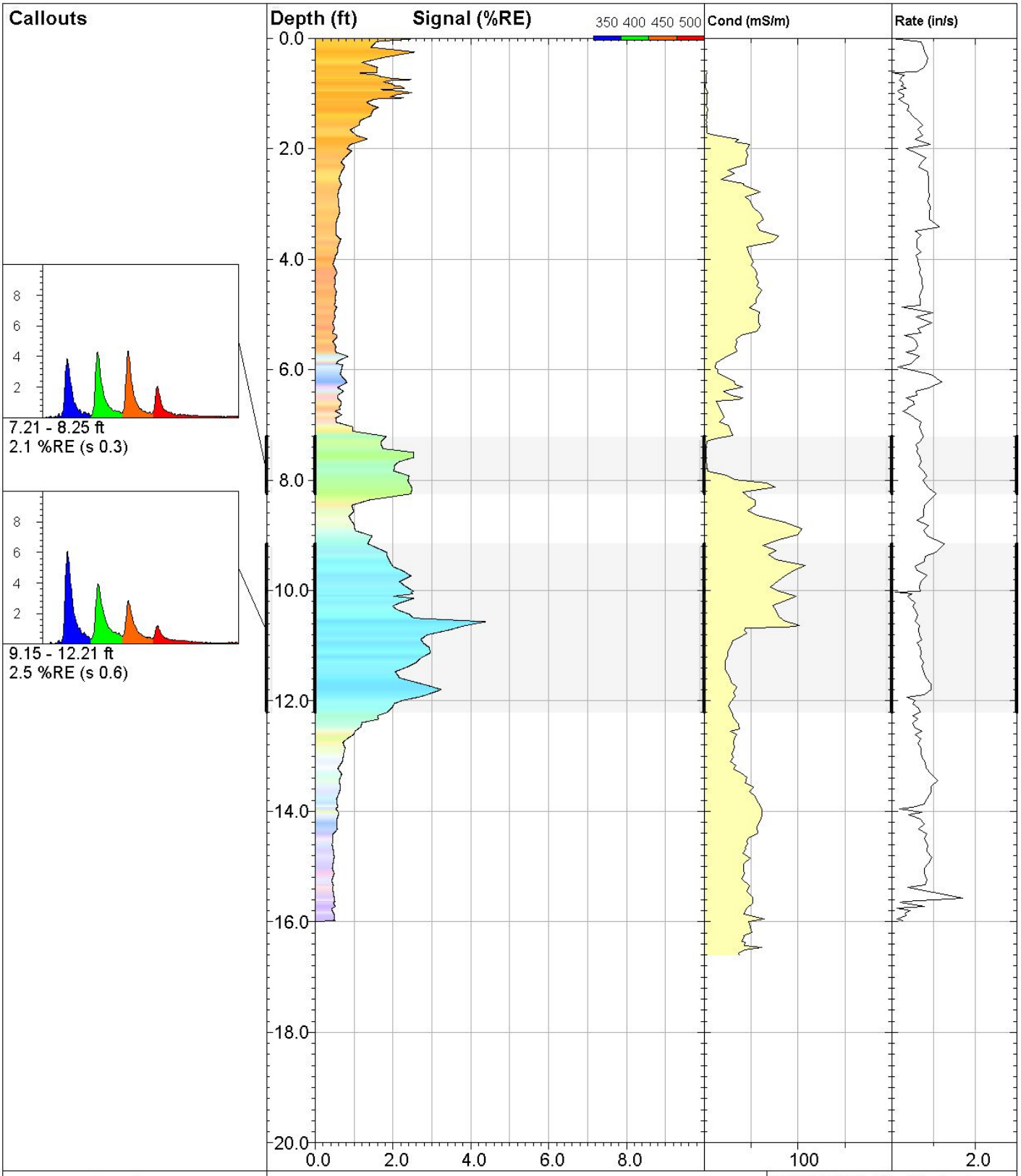
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.5 %RE @ 0.97 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 11:14 CDT**



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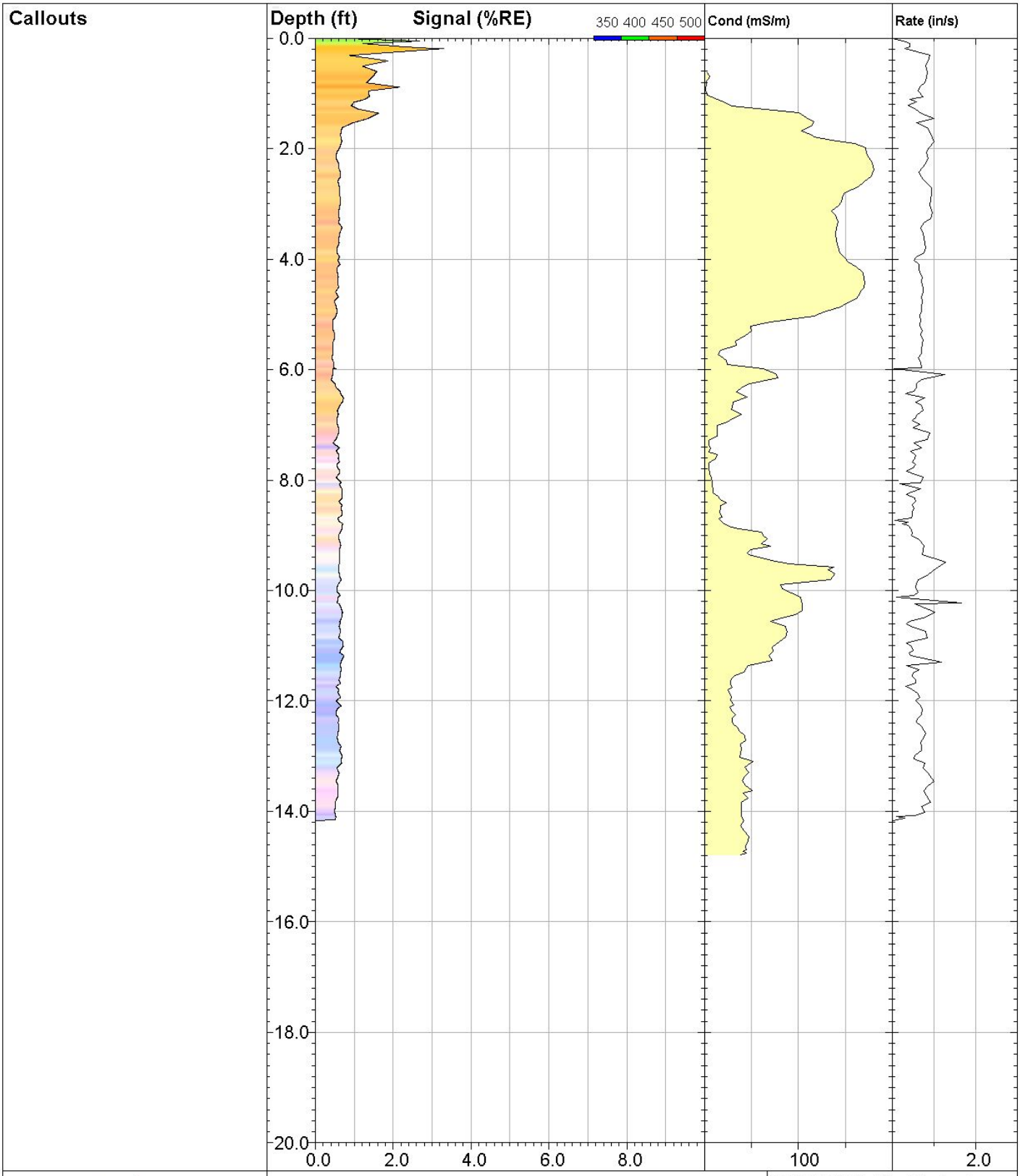
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.4 %RE @ 10.56 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 11:41 CDT**



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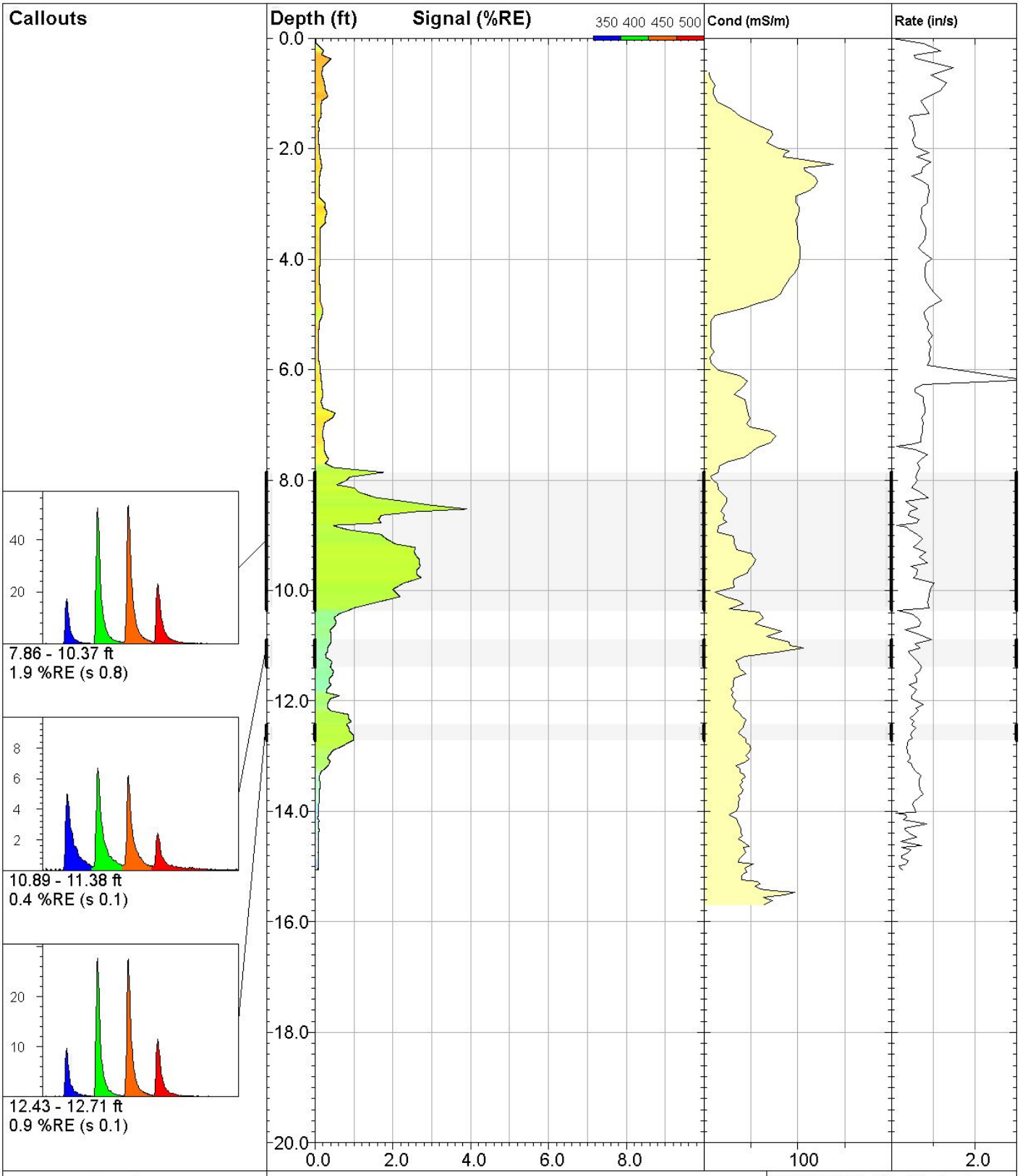
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.16 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.3 %RE @ 0.19 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 12:28 CDT**



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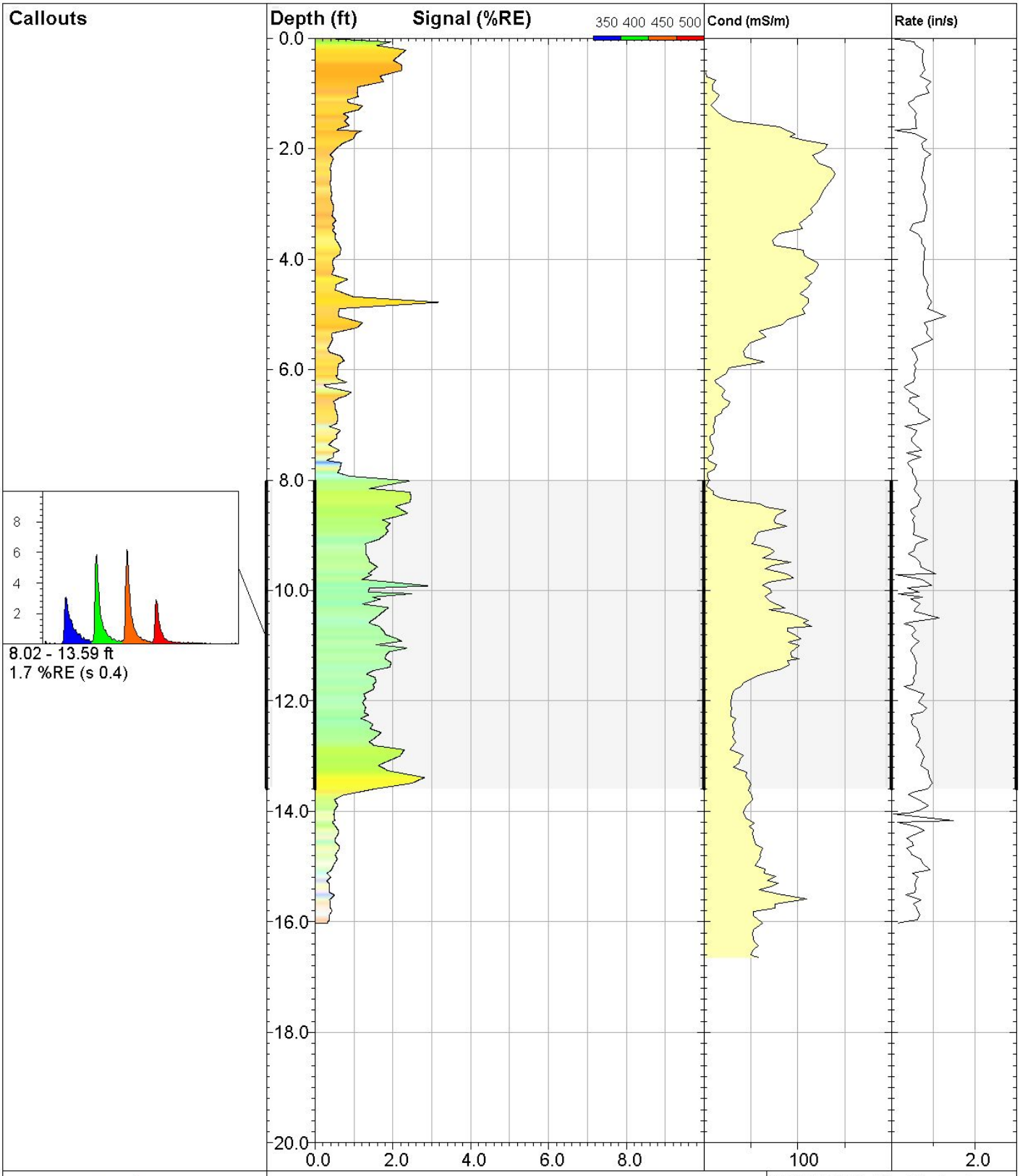
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.06 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.9 %RE @ 8.53 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 13:41 CDT**



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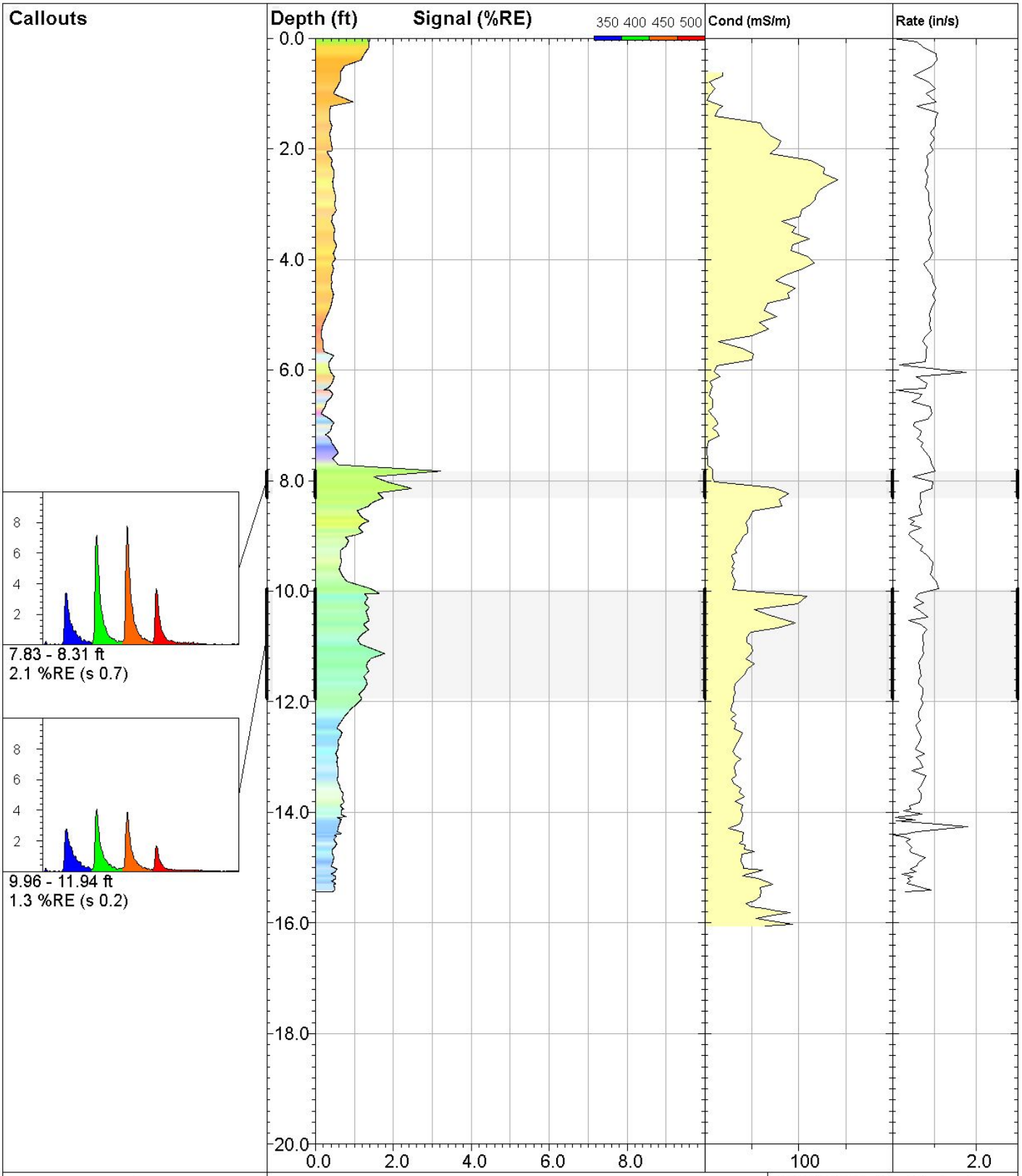
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.2 %RE @ 4.78 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 14:15 CDT**



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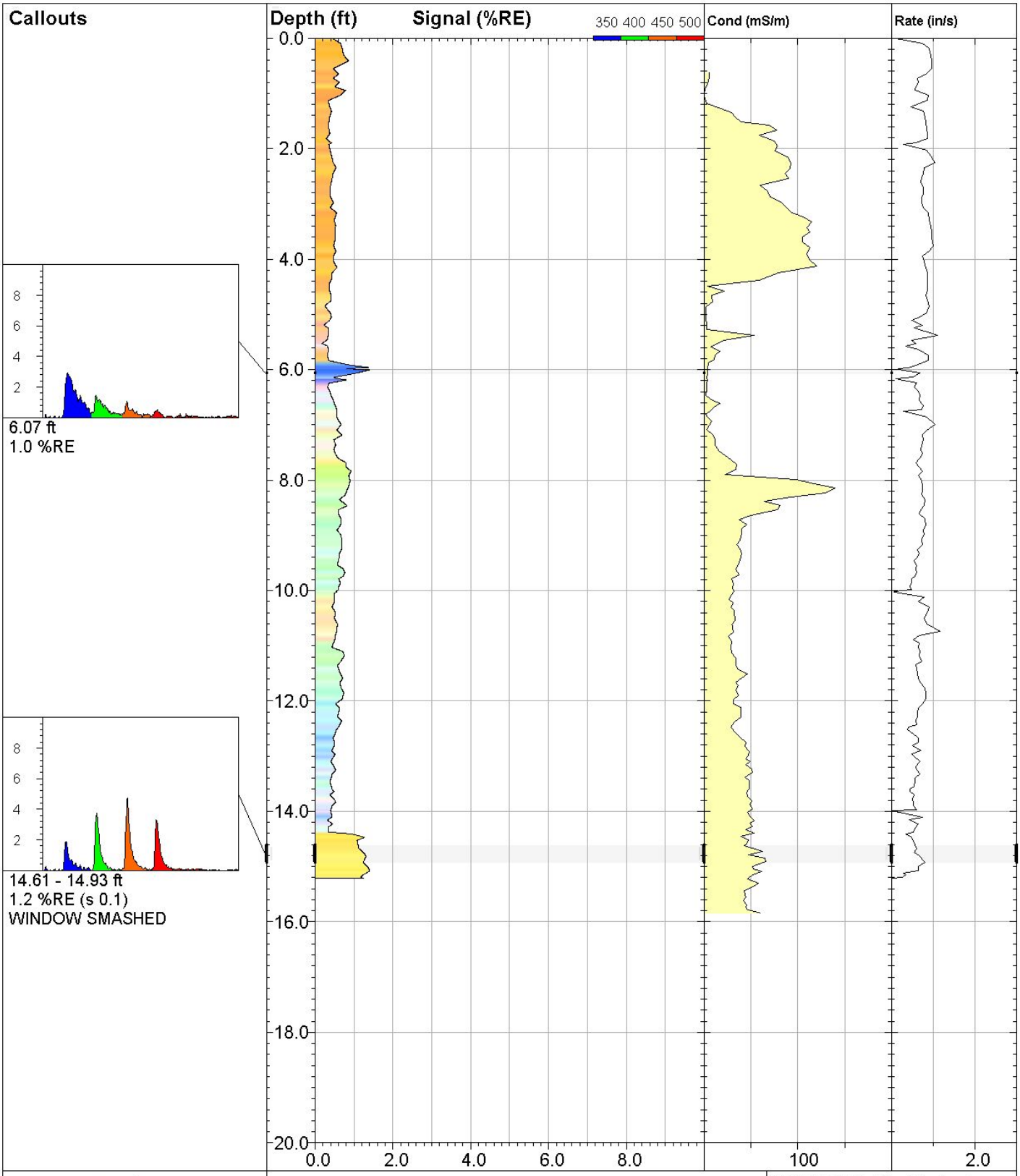
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.44 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.2 %RE @ 7.83 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 14:43 CDT**



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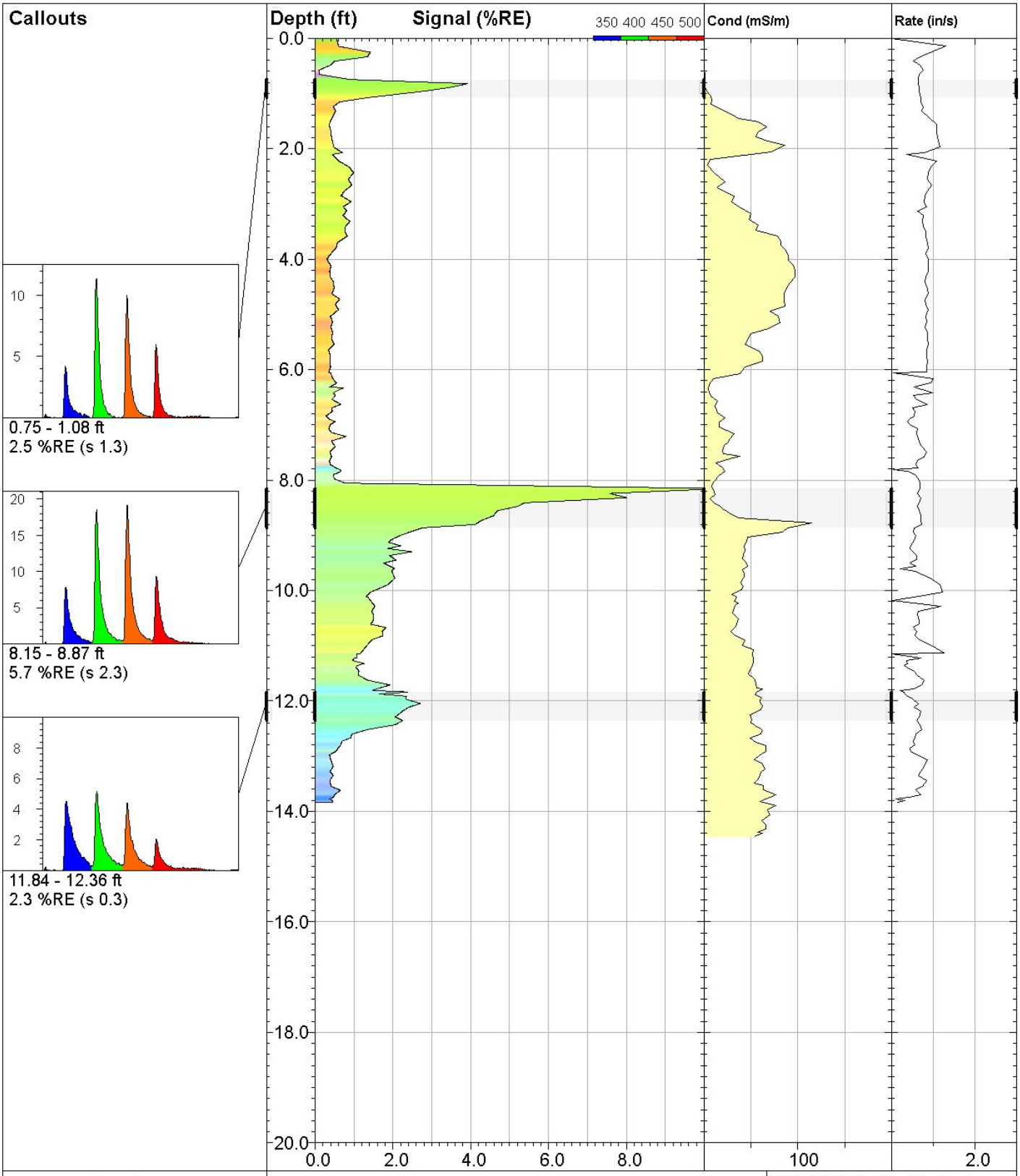
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.22 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 6.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 15:10 CDT**



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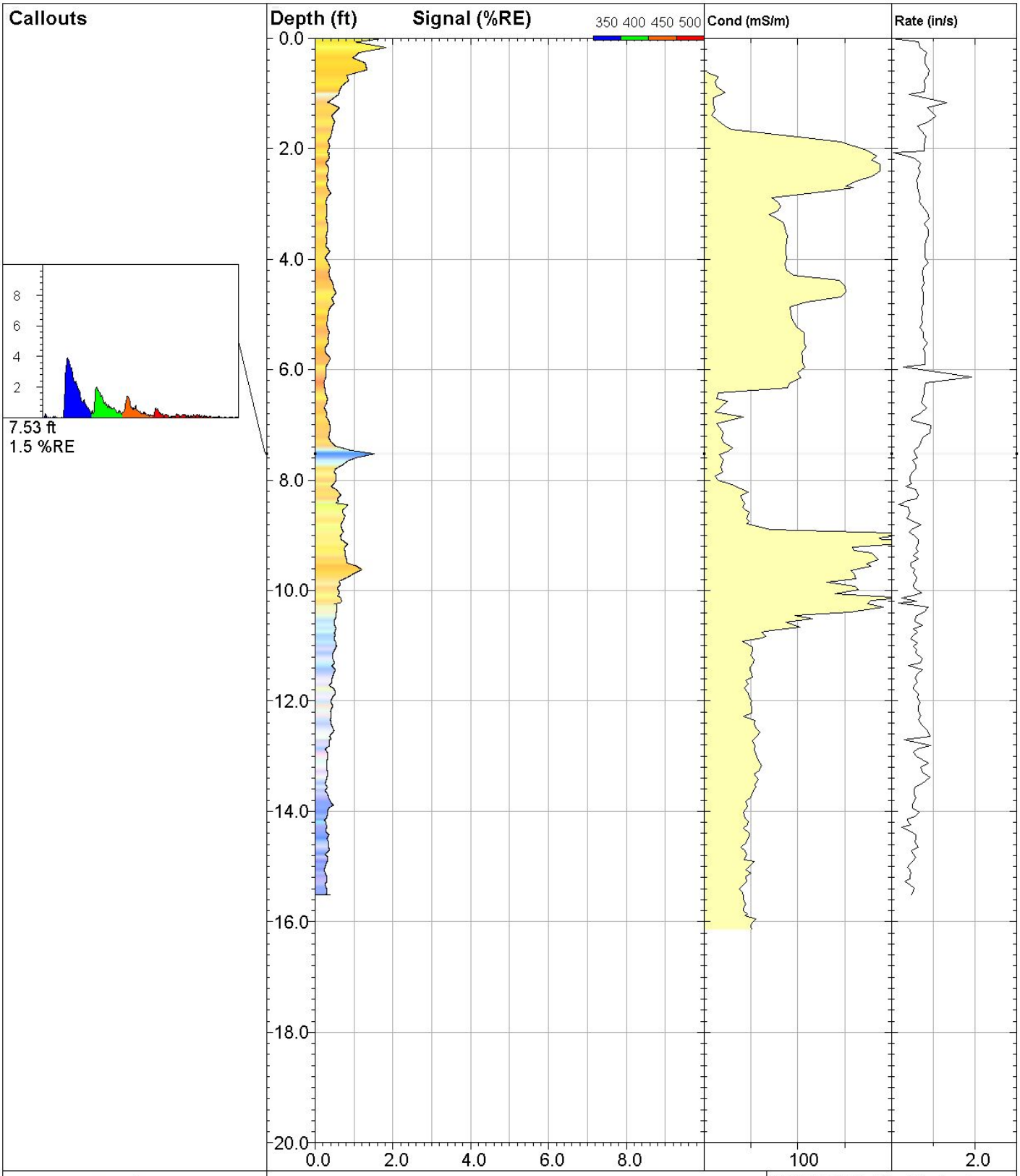
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **13.83 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **10.5 %RE @ 8.15 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 15:53 CDT**



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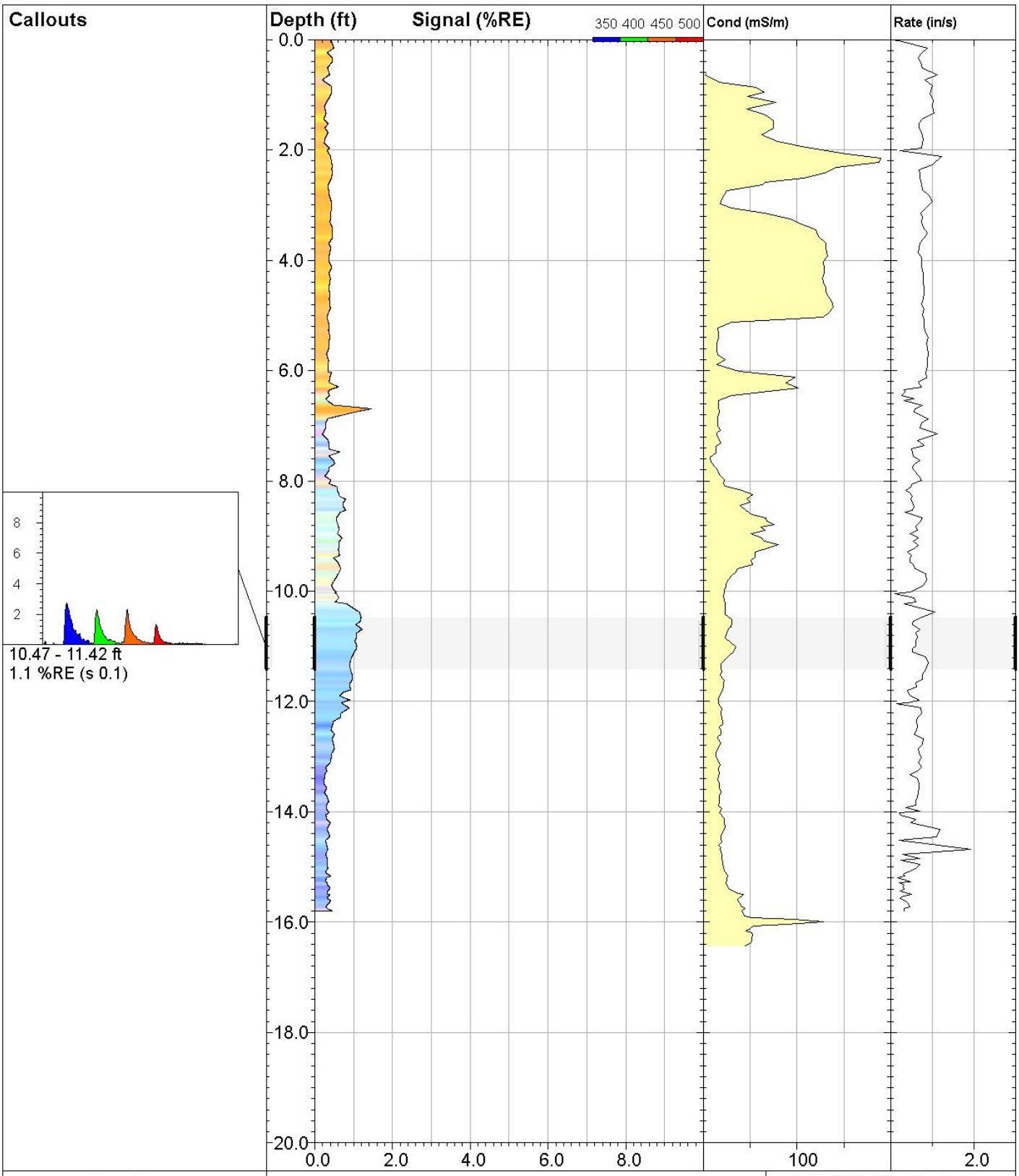
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.51 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.9 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 16:25 CDT**



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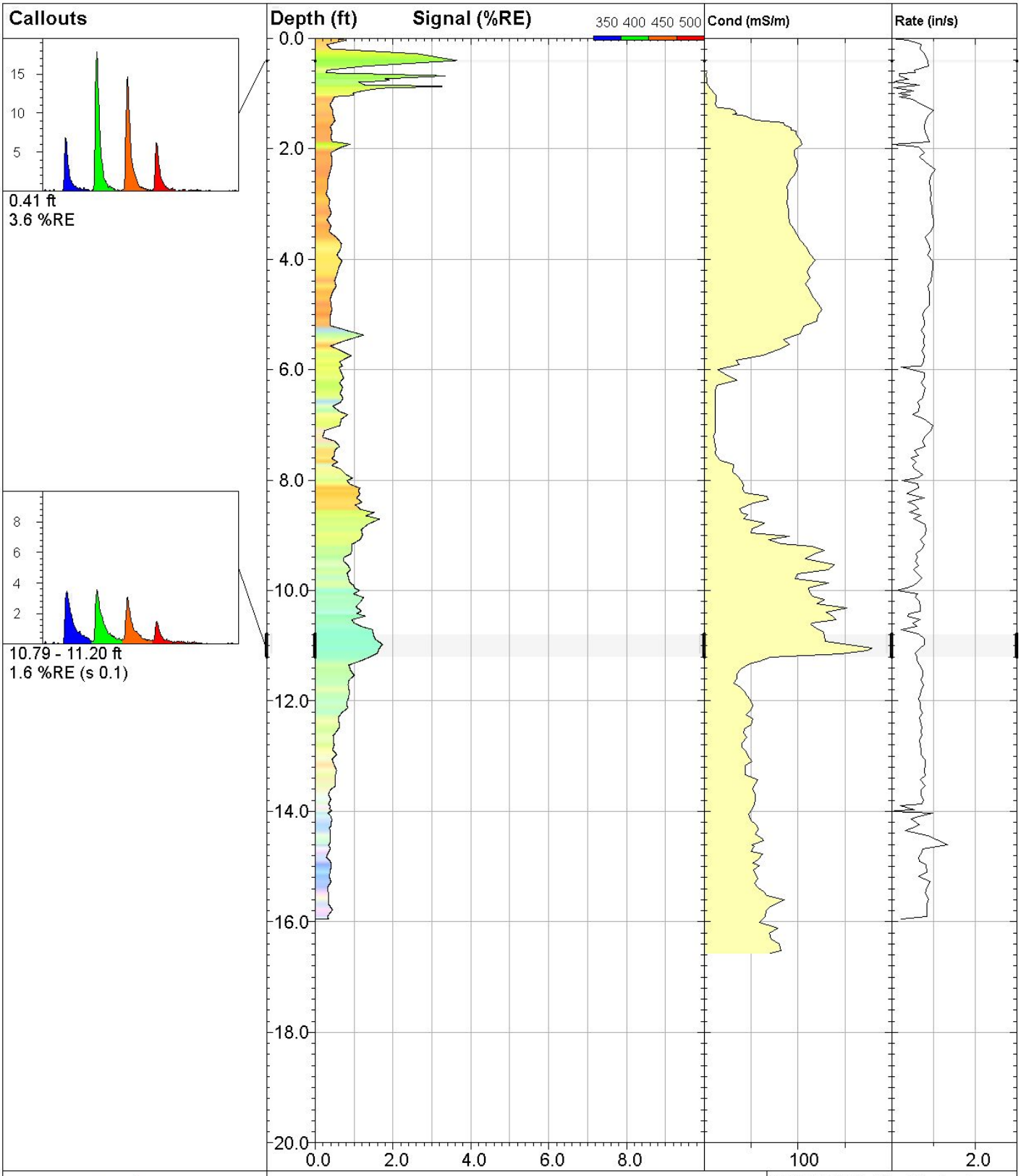
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.80 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 6.69 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 16:50 CDT**



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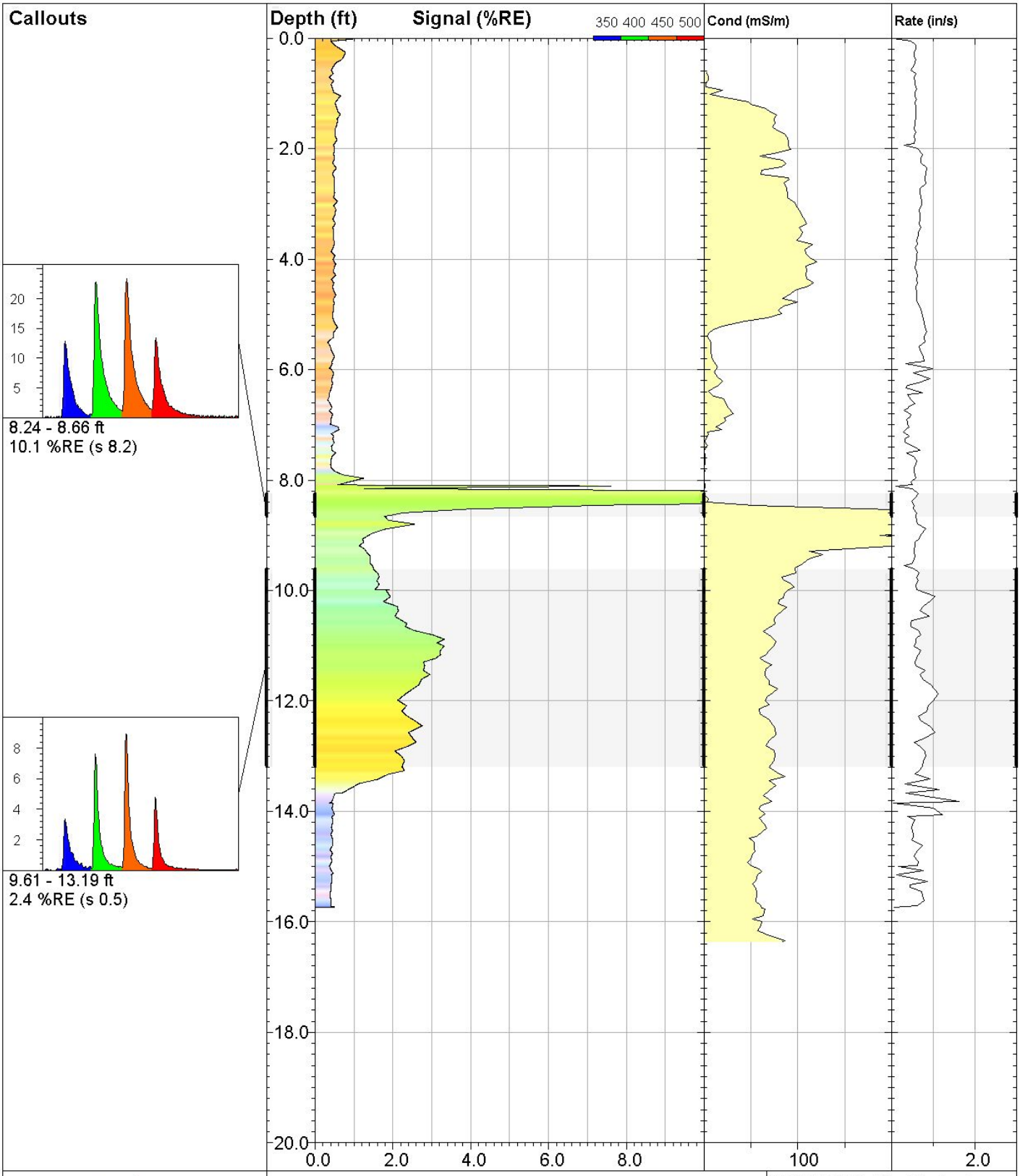
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.94 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.6 %RE @ 0.41 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 17:26 CDT**



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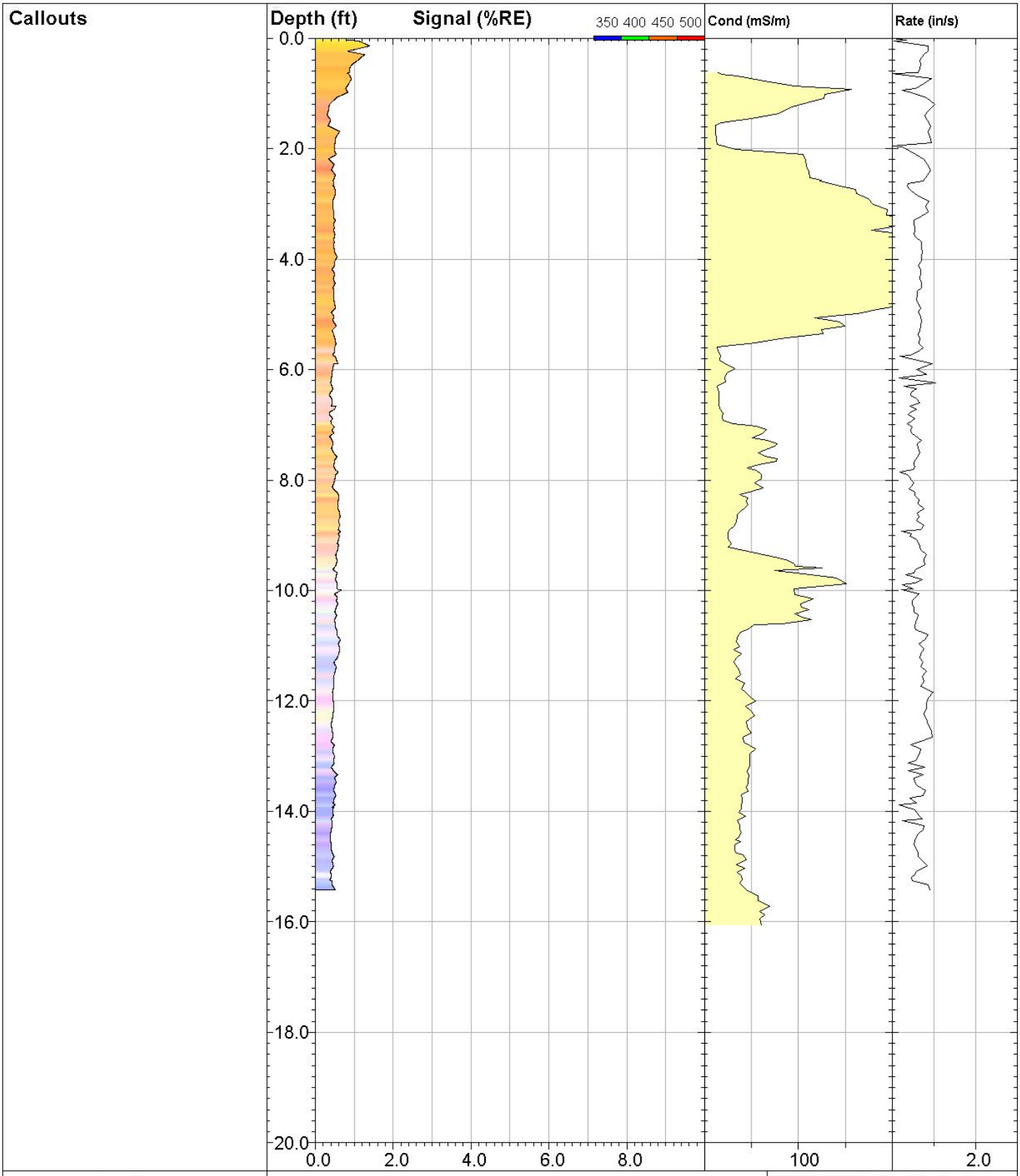
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.74 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **21.4 %RE @ 8.24 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 10:31 CDT**



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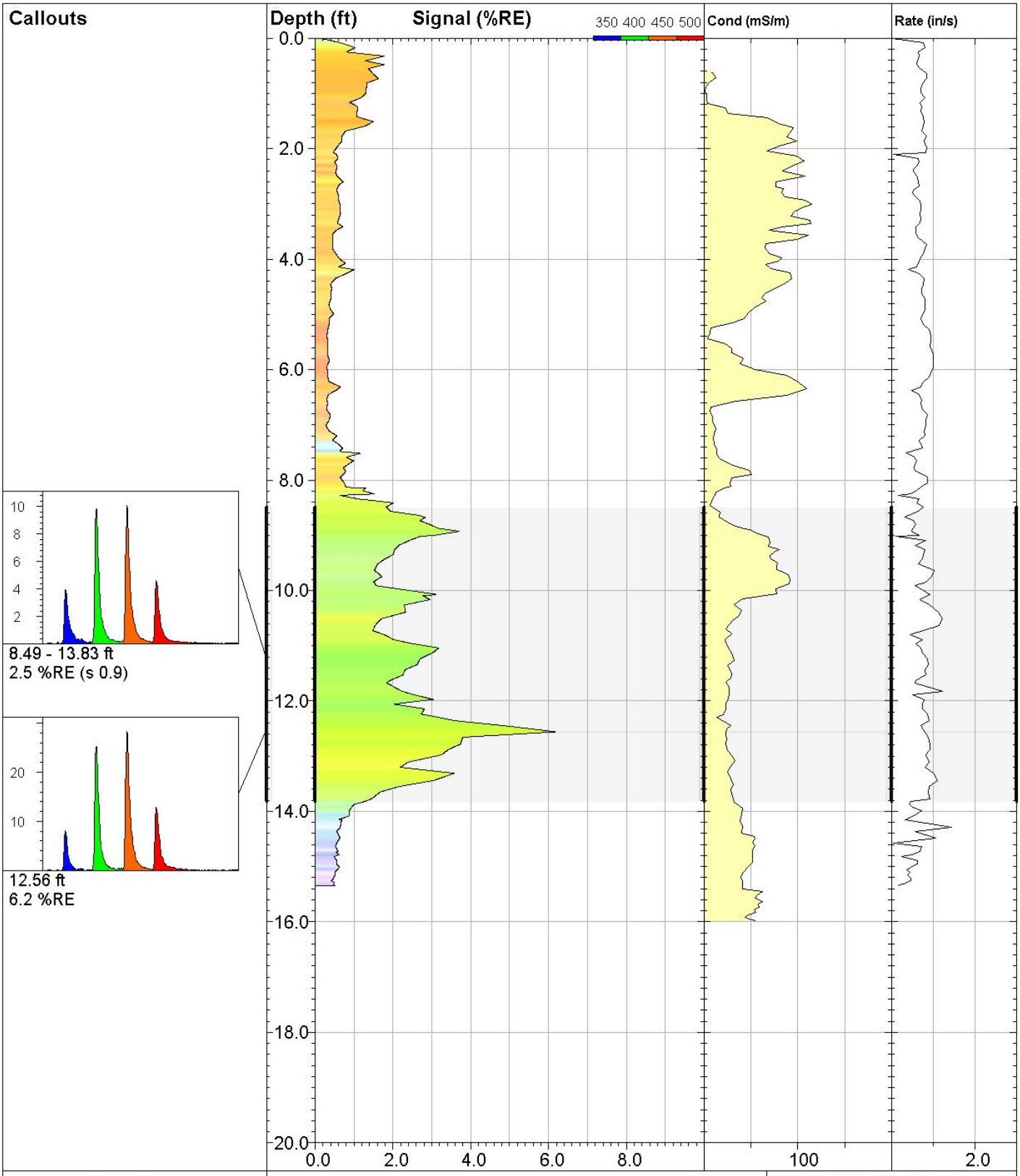
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.43 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 0.14 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 10:59 CDT**



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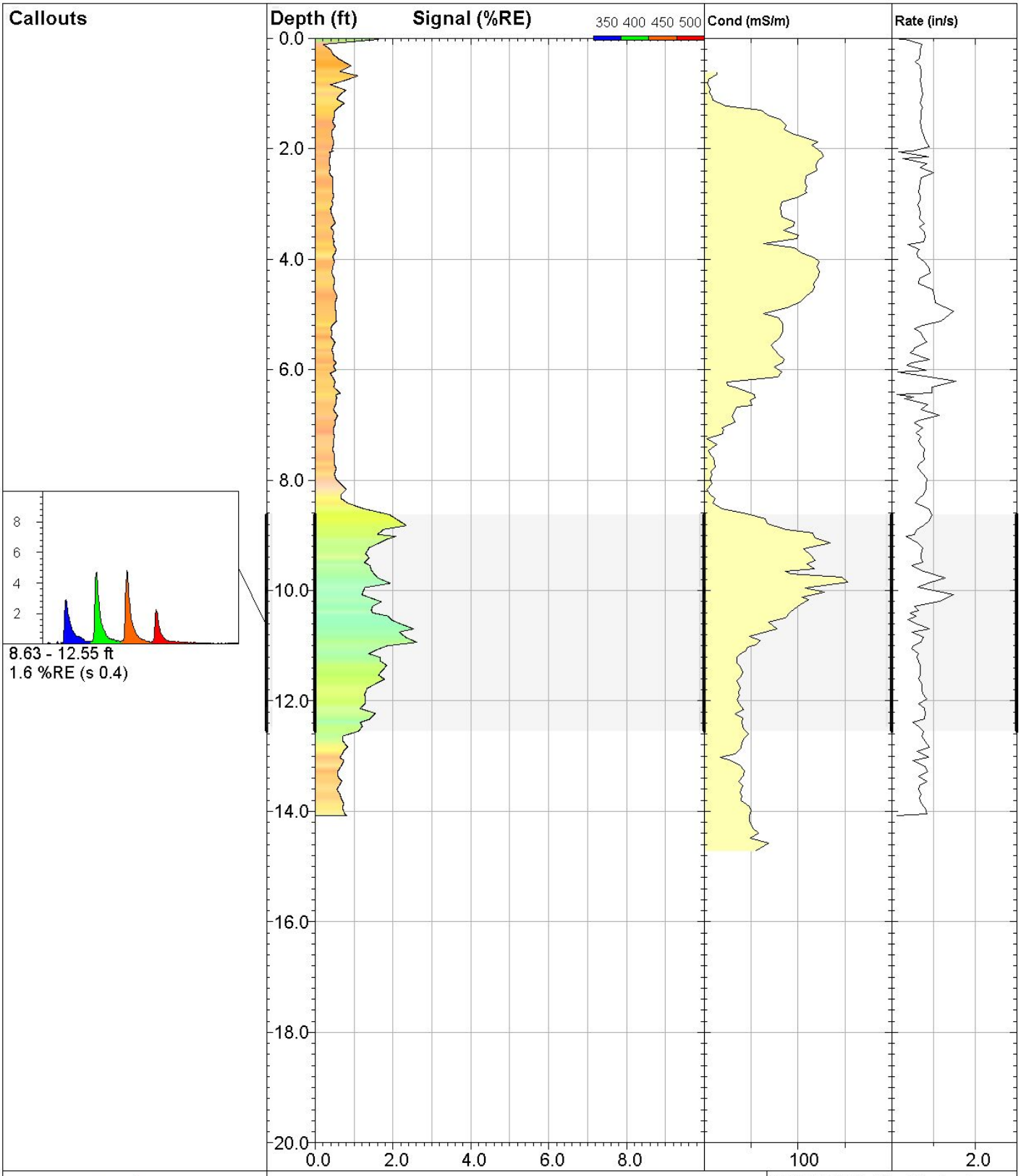
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.35 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.2 %RE @ 12.56 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 11:36 CDT**



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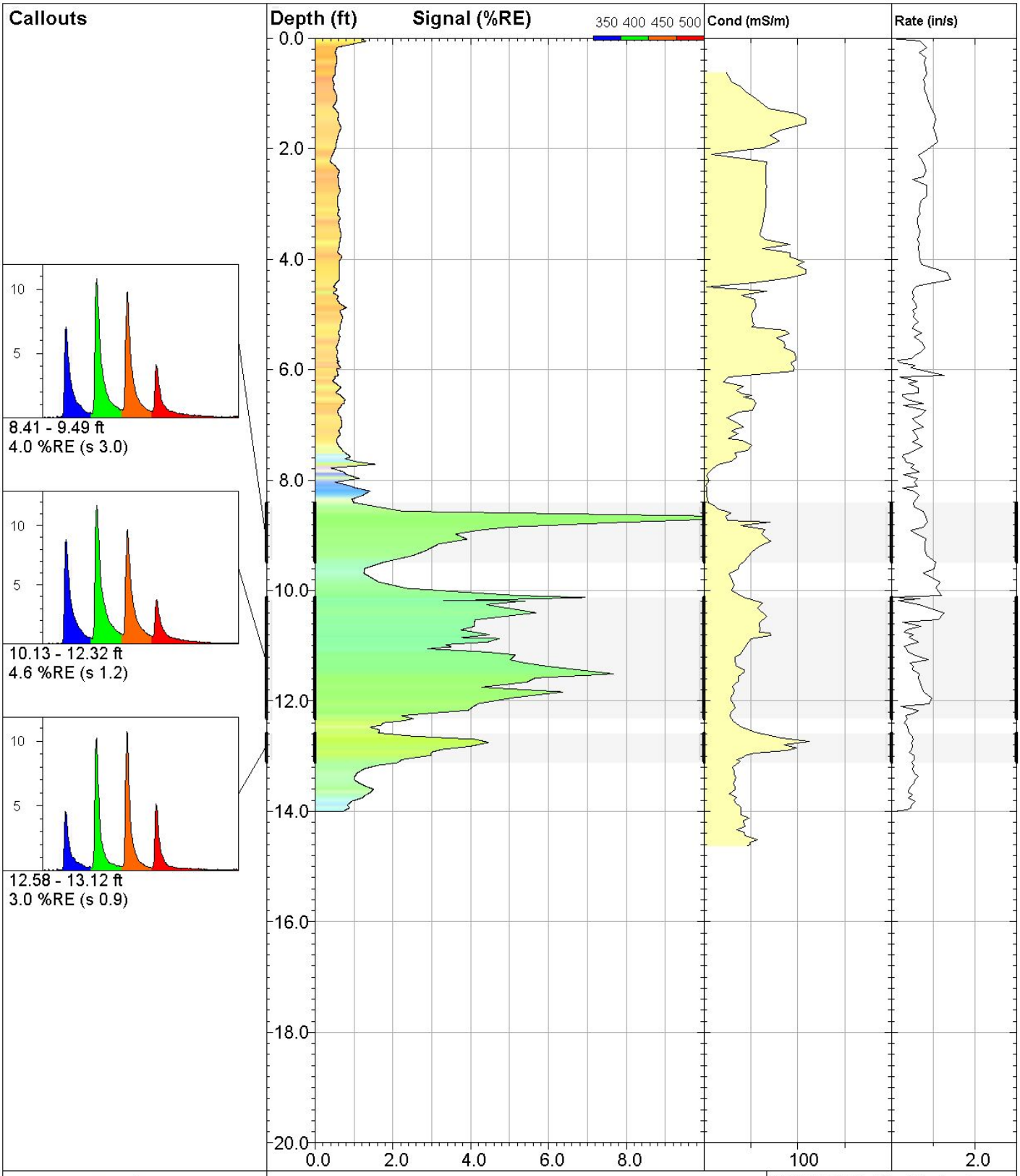
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.08 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.6 %RE @ 10.94 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 12:23 CDT**



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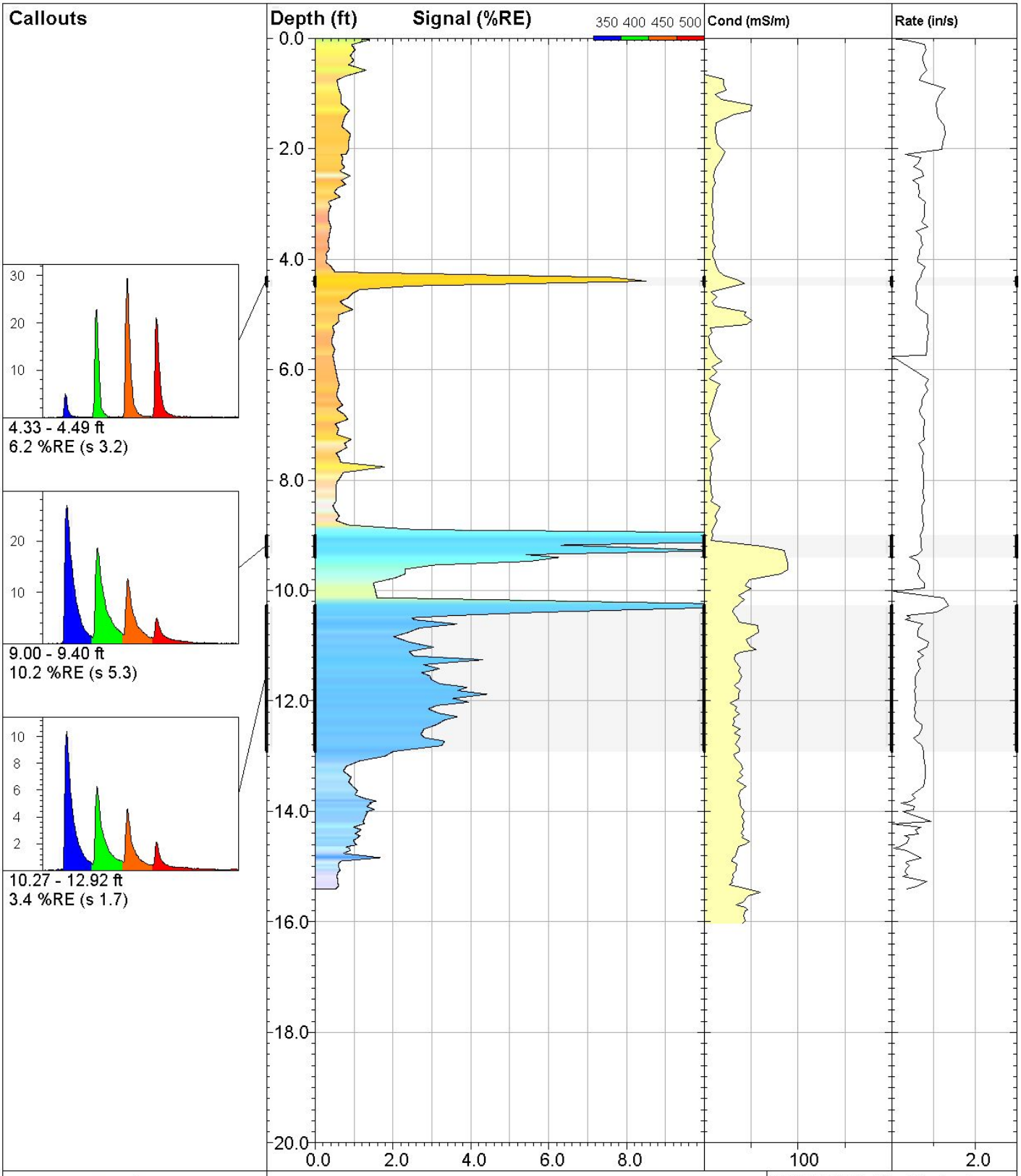
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **11.8 %RE @ 8.67 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 12:57 CDT**



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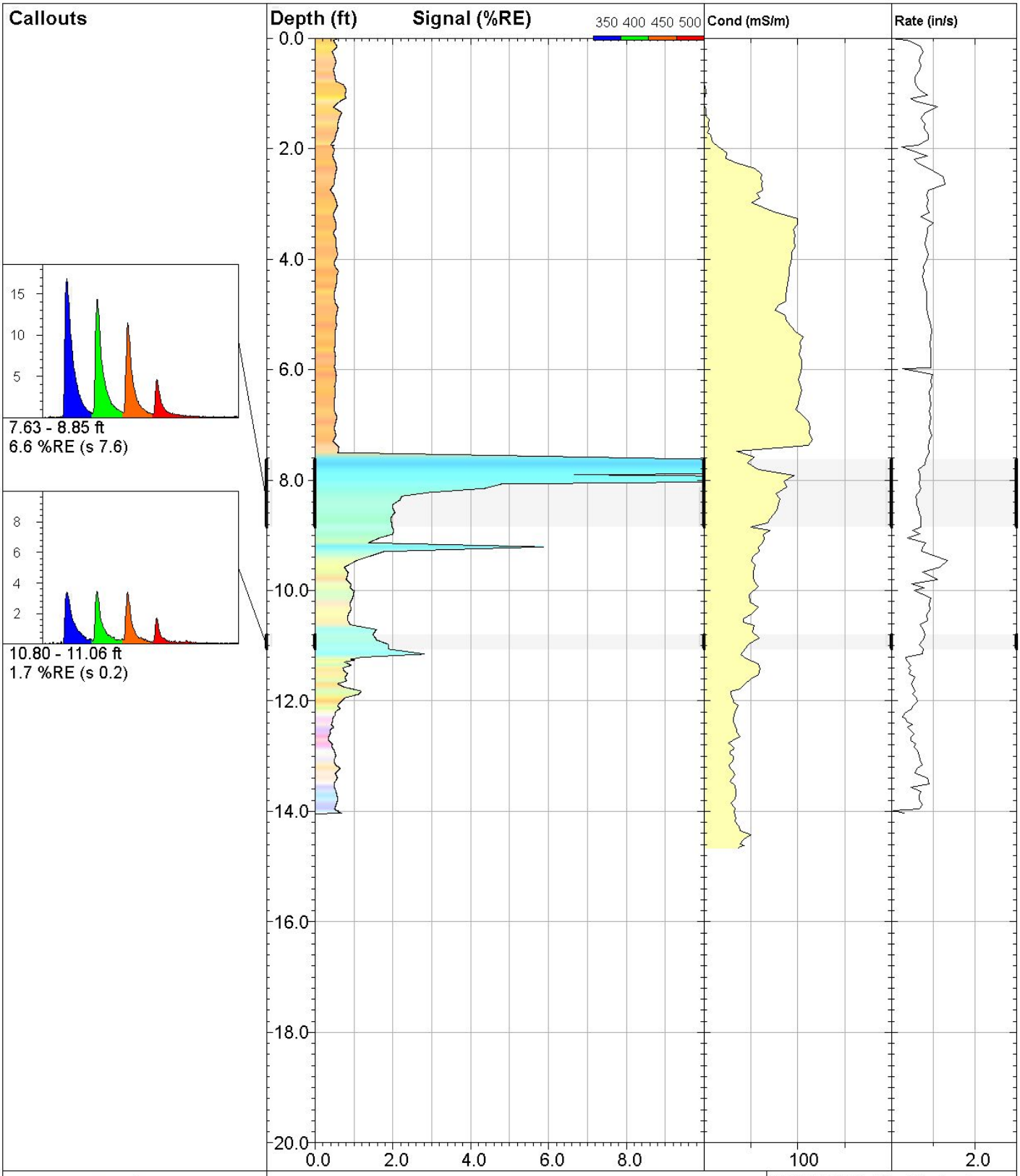
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.40 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.4 %RE @ 9.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 15:05 CDT**



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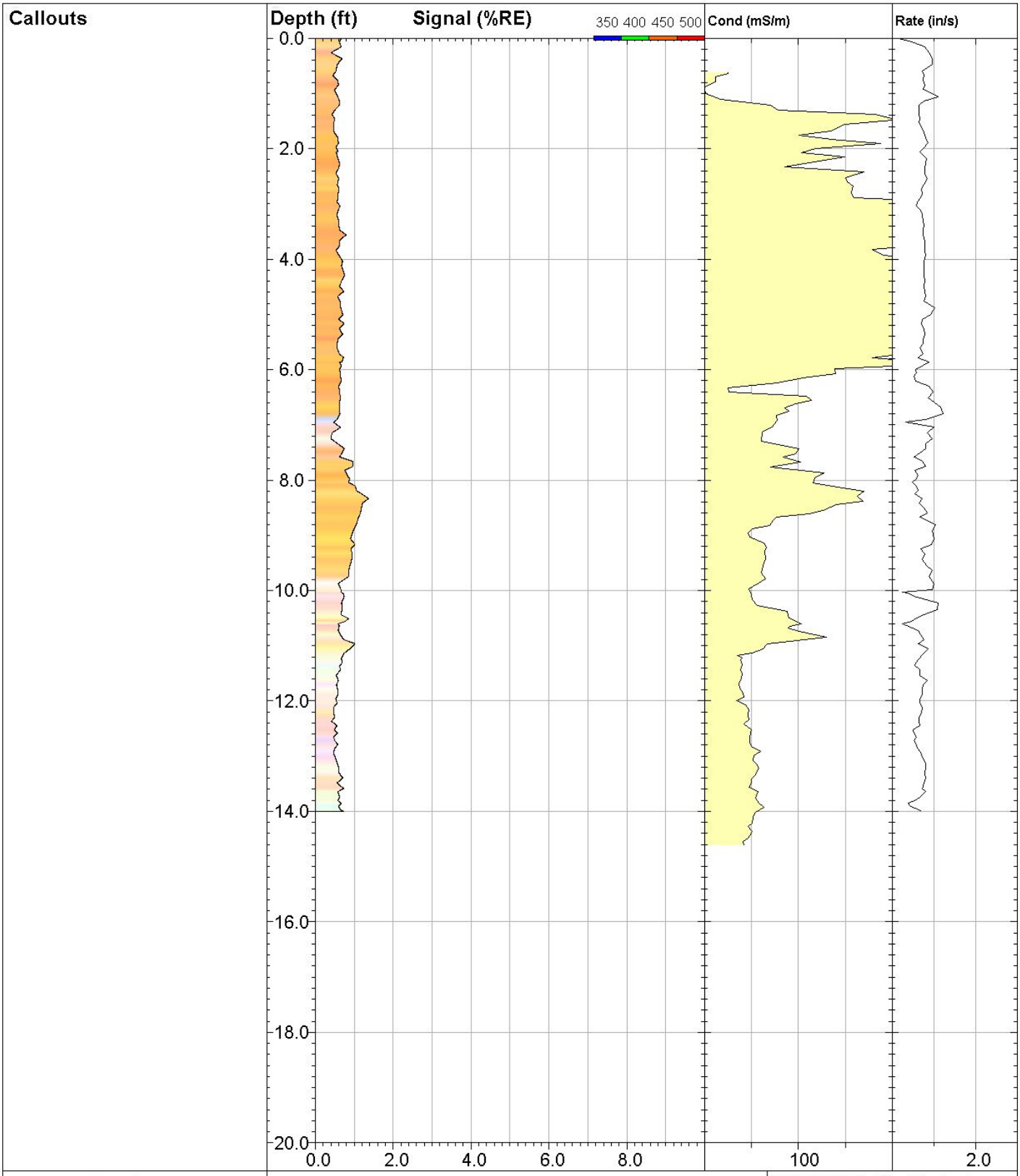
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **28.9 %RE @ 7.81 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 15:31 CDT**



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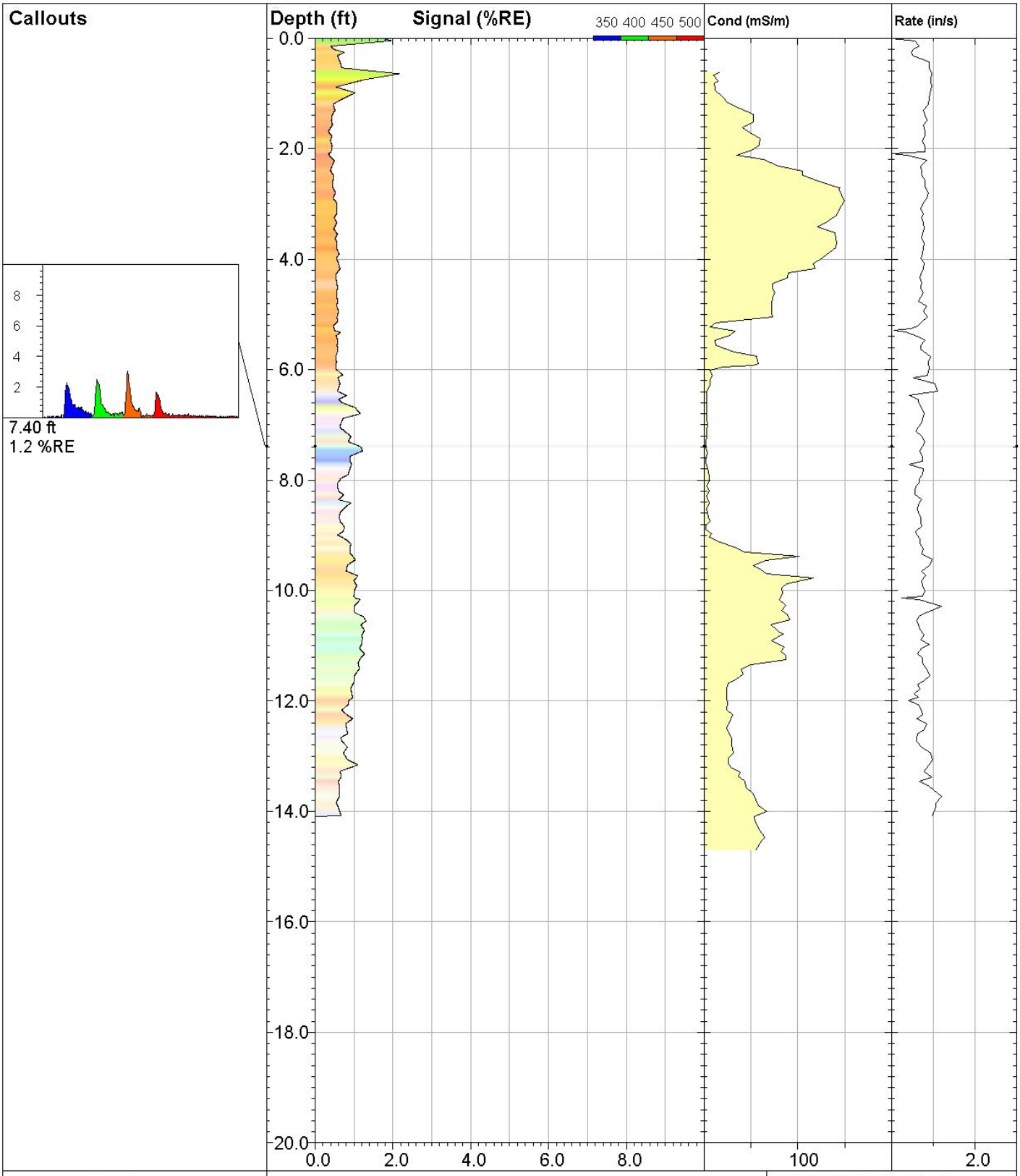
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 8.34 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 16:40 CDT**



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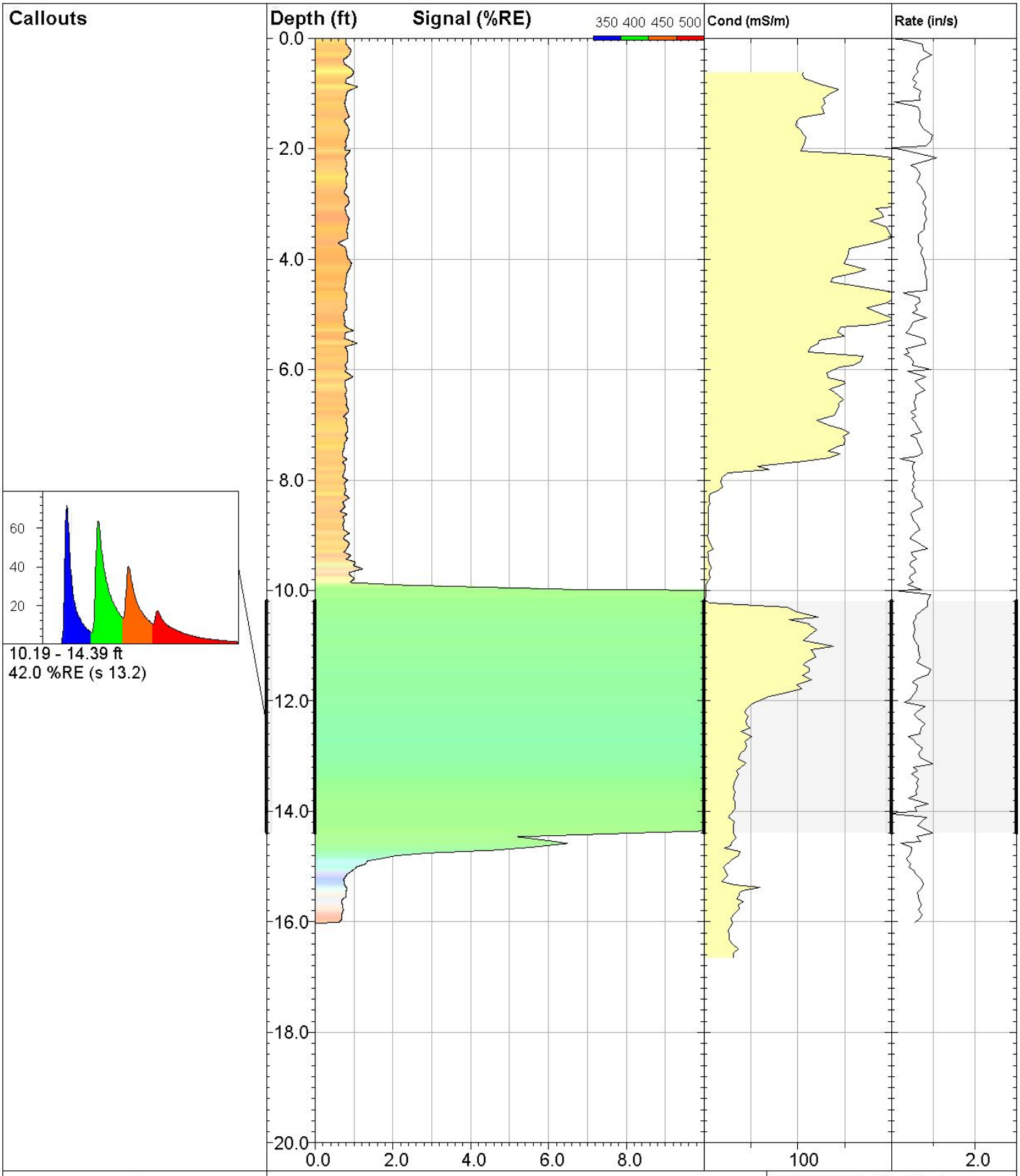
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.08 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 0.65 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 17:14 CDT**



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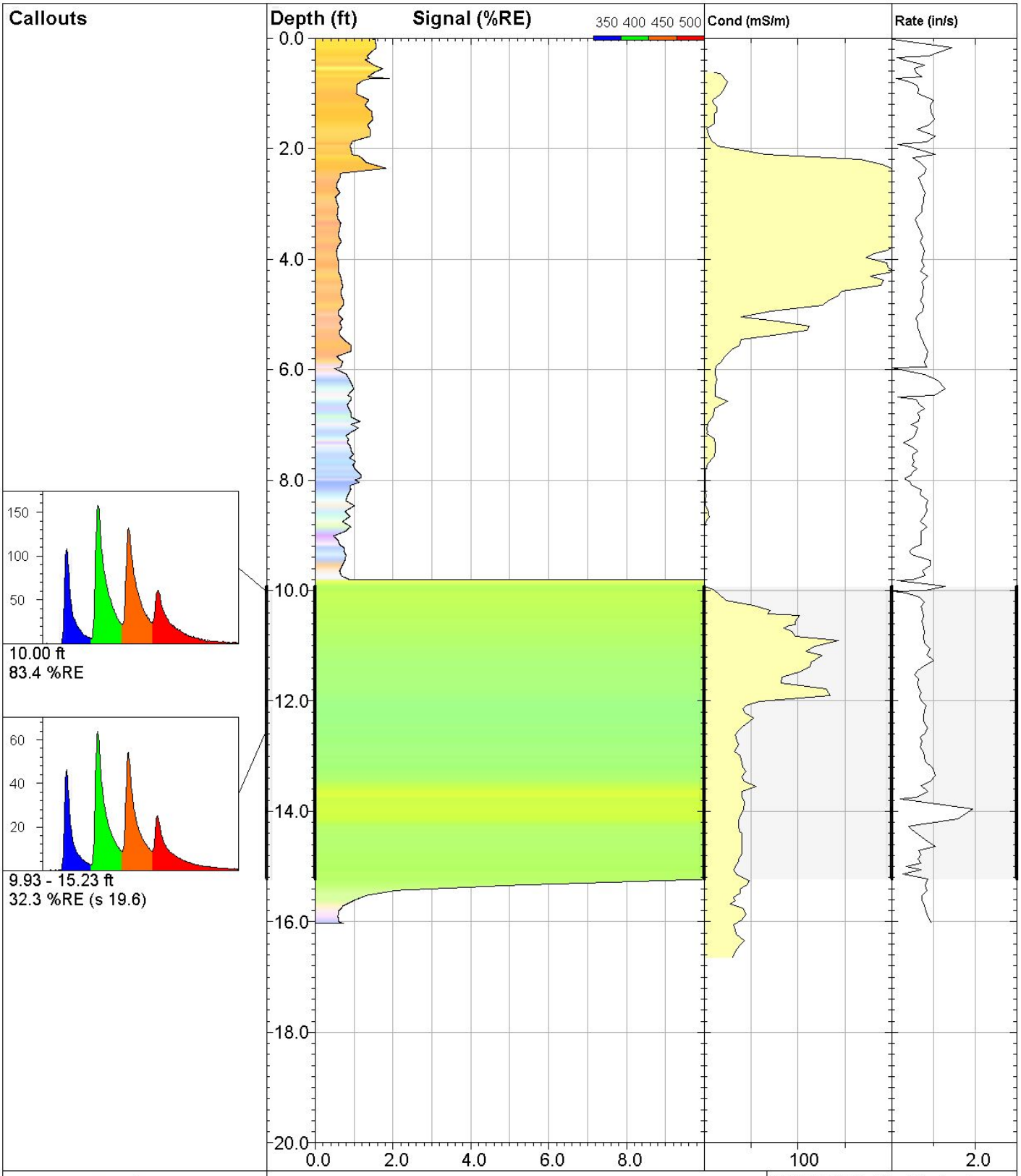
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **72.2 %RE @ 10.92 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 10:19 CDT**



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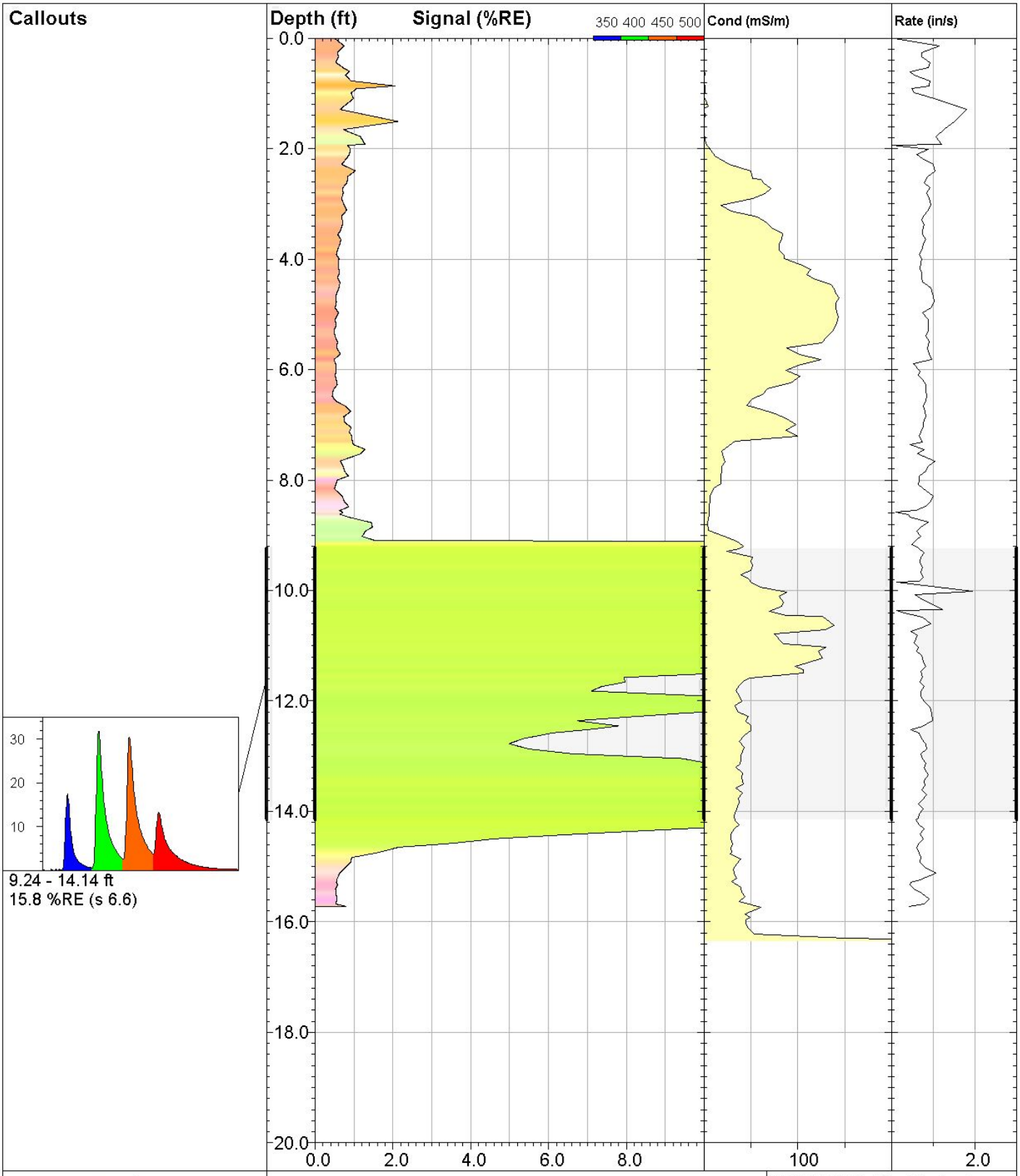
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **87.9 %RE @ 9.93 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 10:49 CDT**



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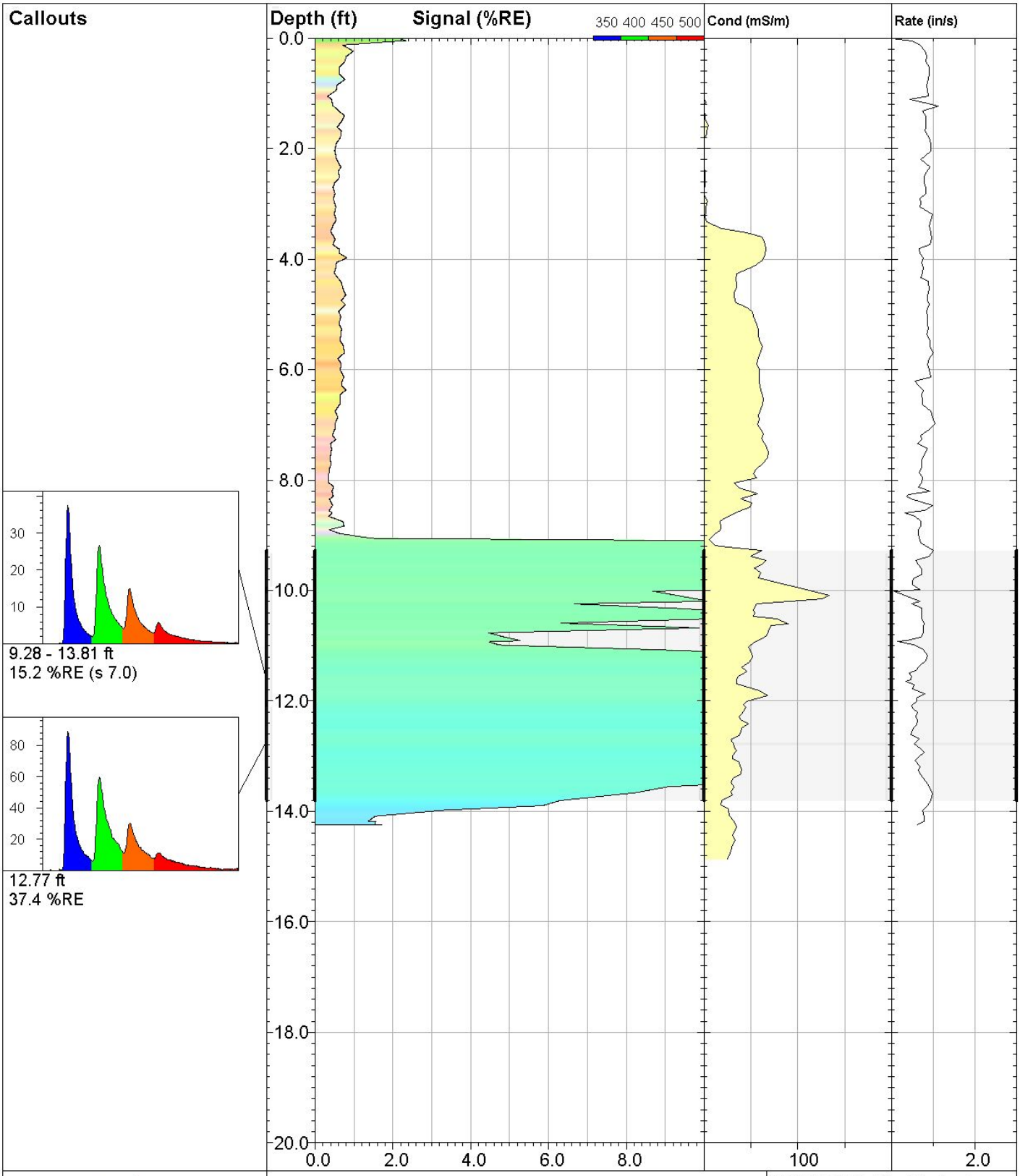
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.73 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **41.1 %RE @ 9.17 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 11:13 CDT**



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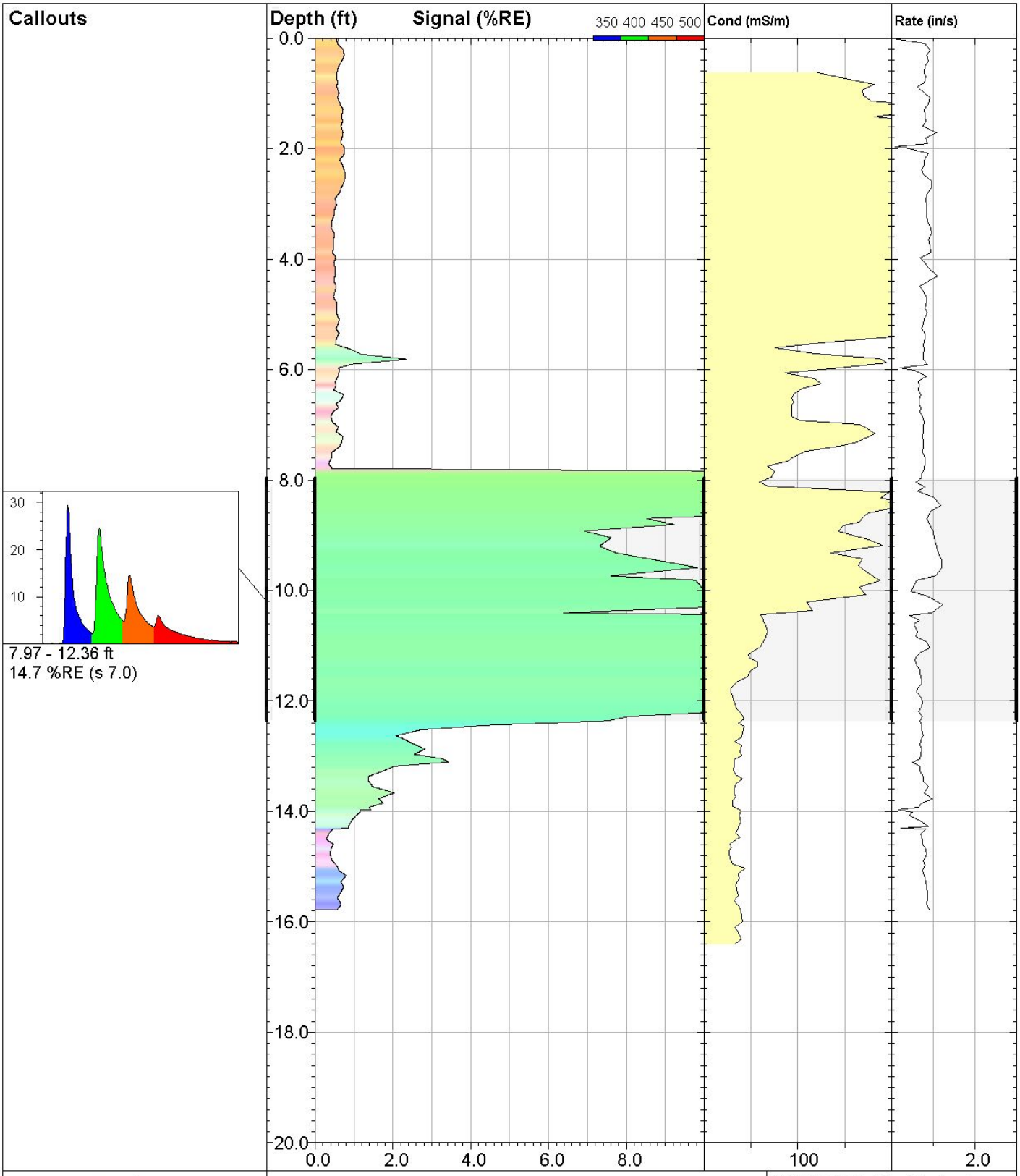
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.24 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **37.4 %RE @ 12.77 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 11:45 CDT**



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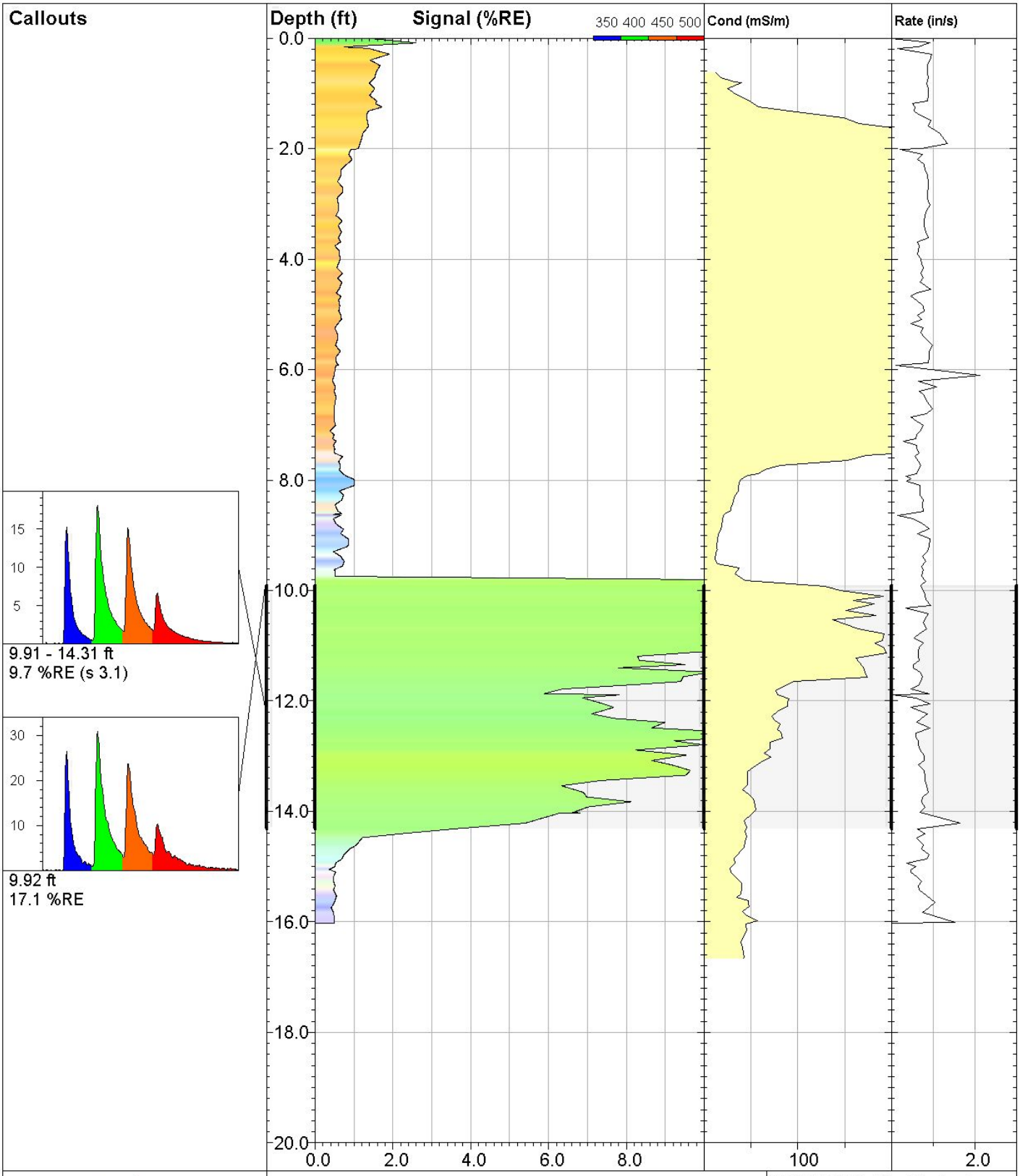
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.78 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **32.3 %RE @ 8.04 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 12:20 CDT**



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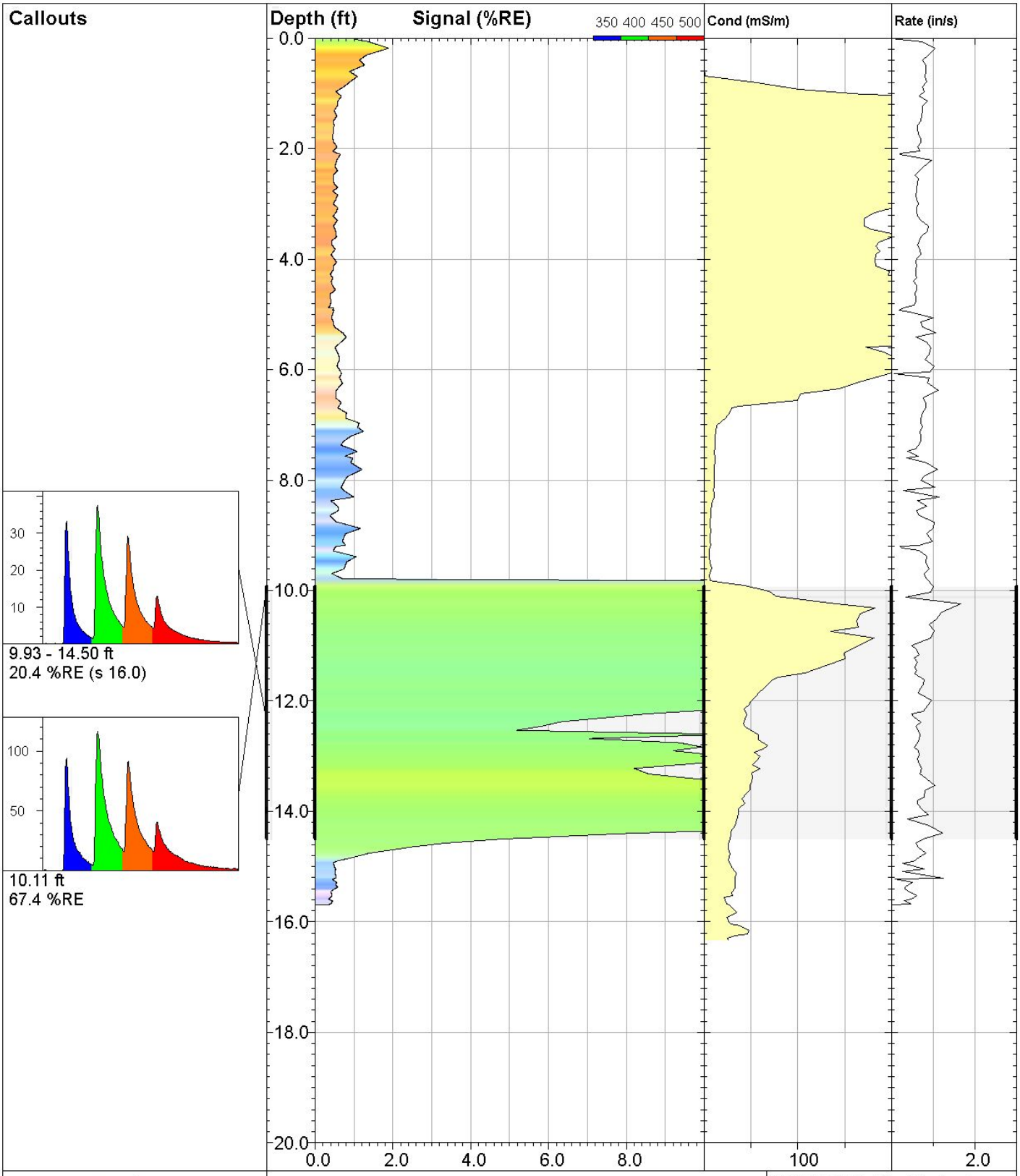
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.03 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **17.1 %RE @ 9.92 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 13:08 CDT**



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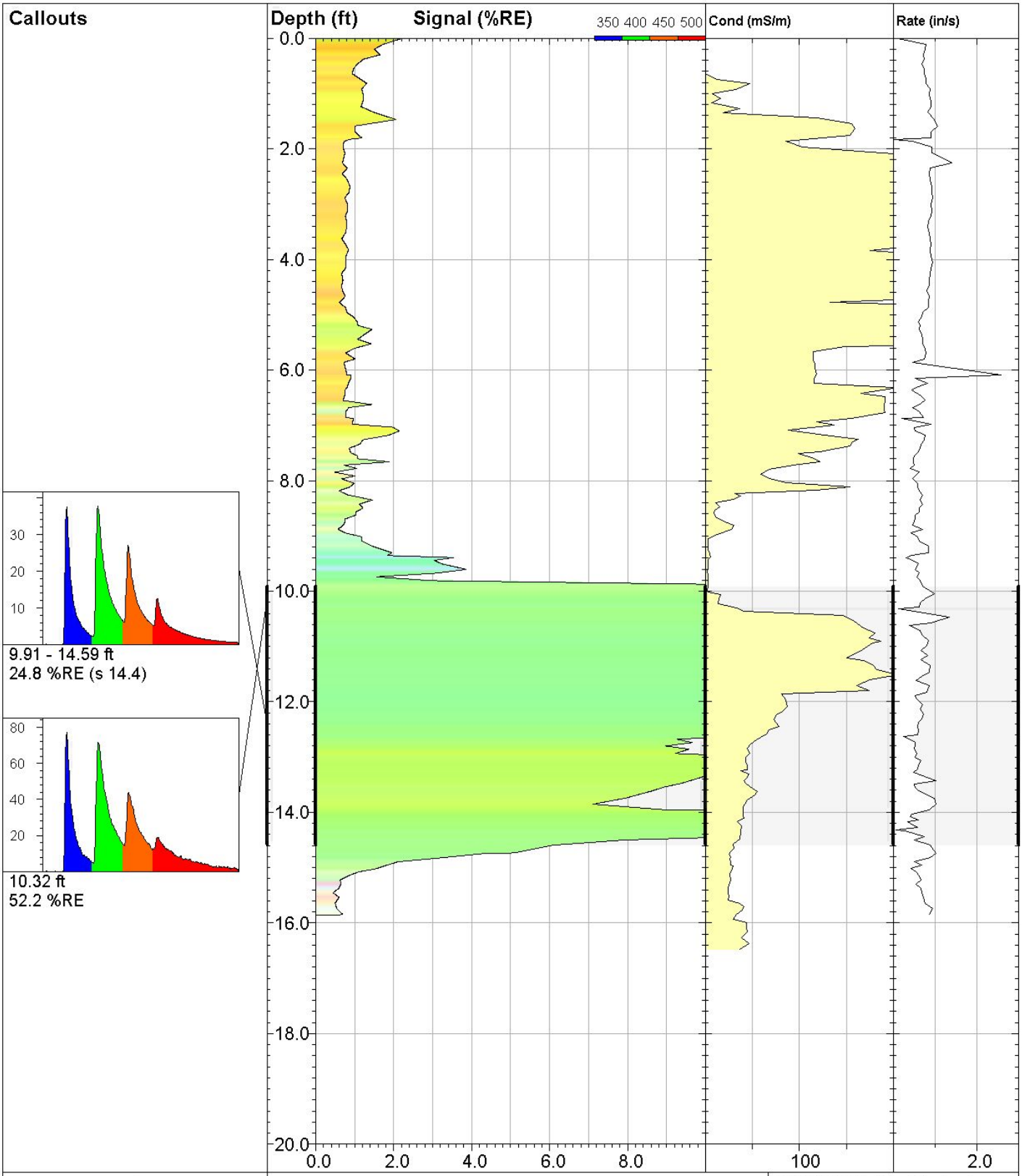
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.69 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **67.4 %RE @ 10.11 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 13:34 CDT**



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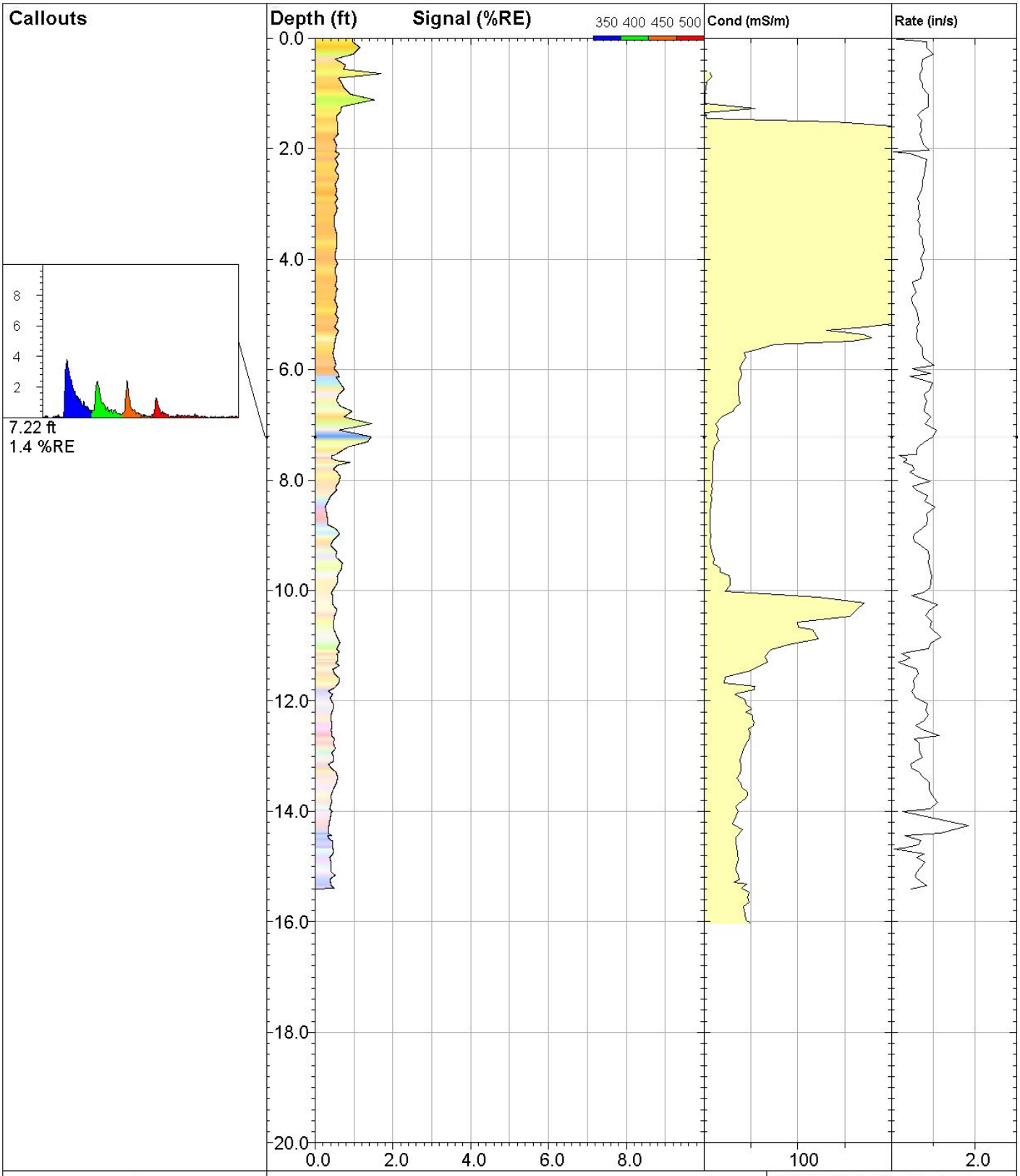
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.86 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **52.2 %RE @ 10.32 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 13:59 CDT**



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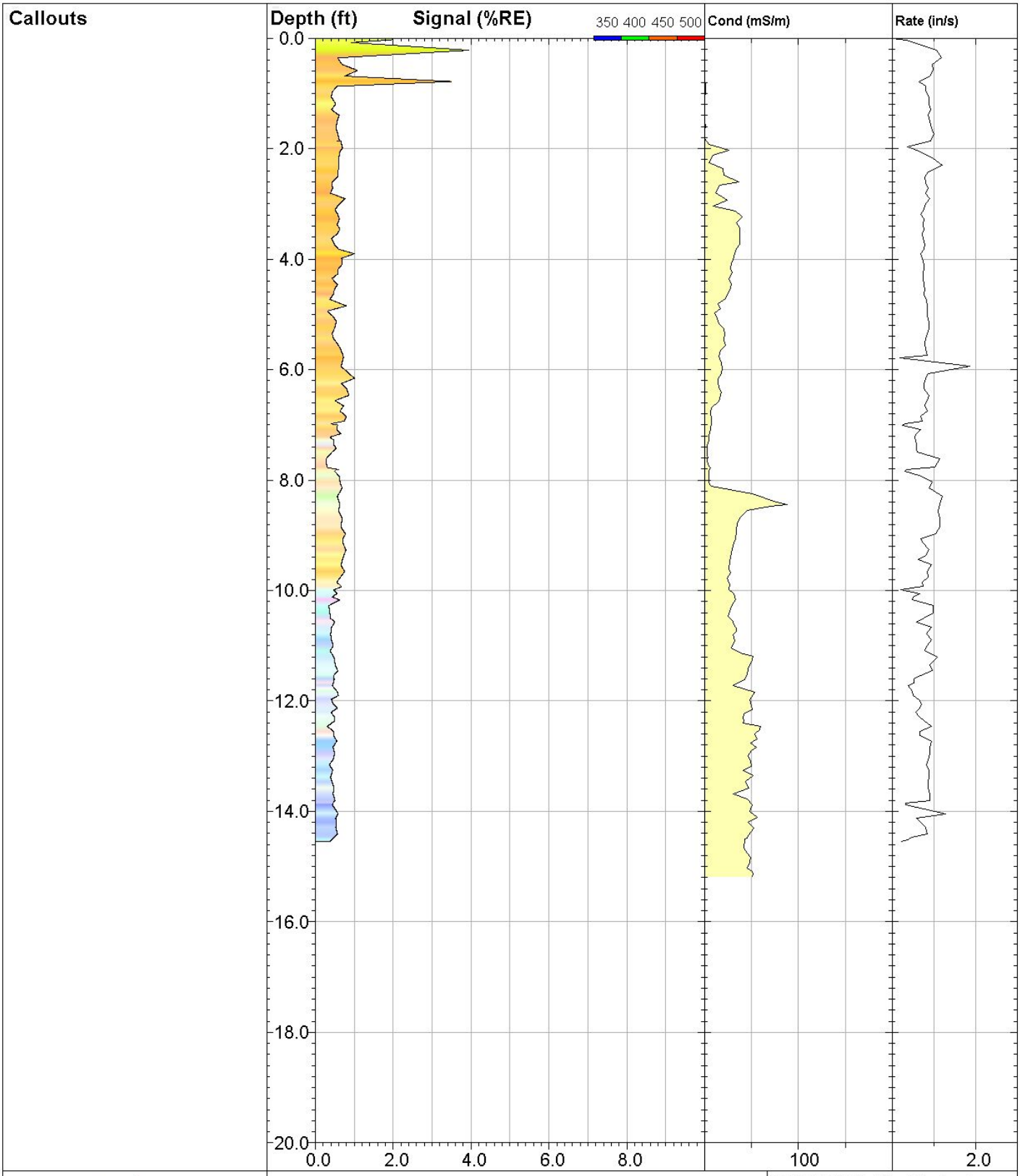
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.40 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.7 %RE @ 0.64 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 14:29 CDT**



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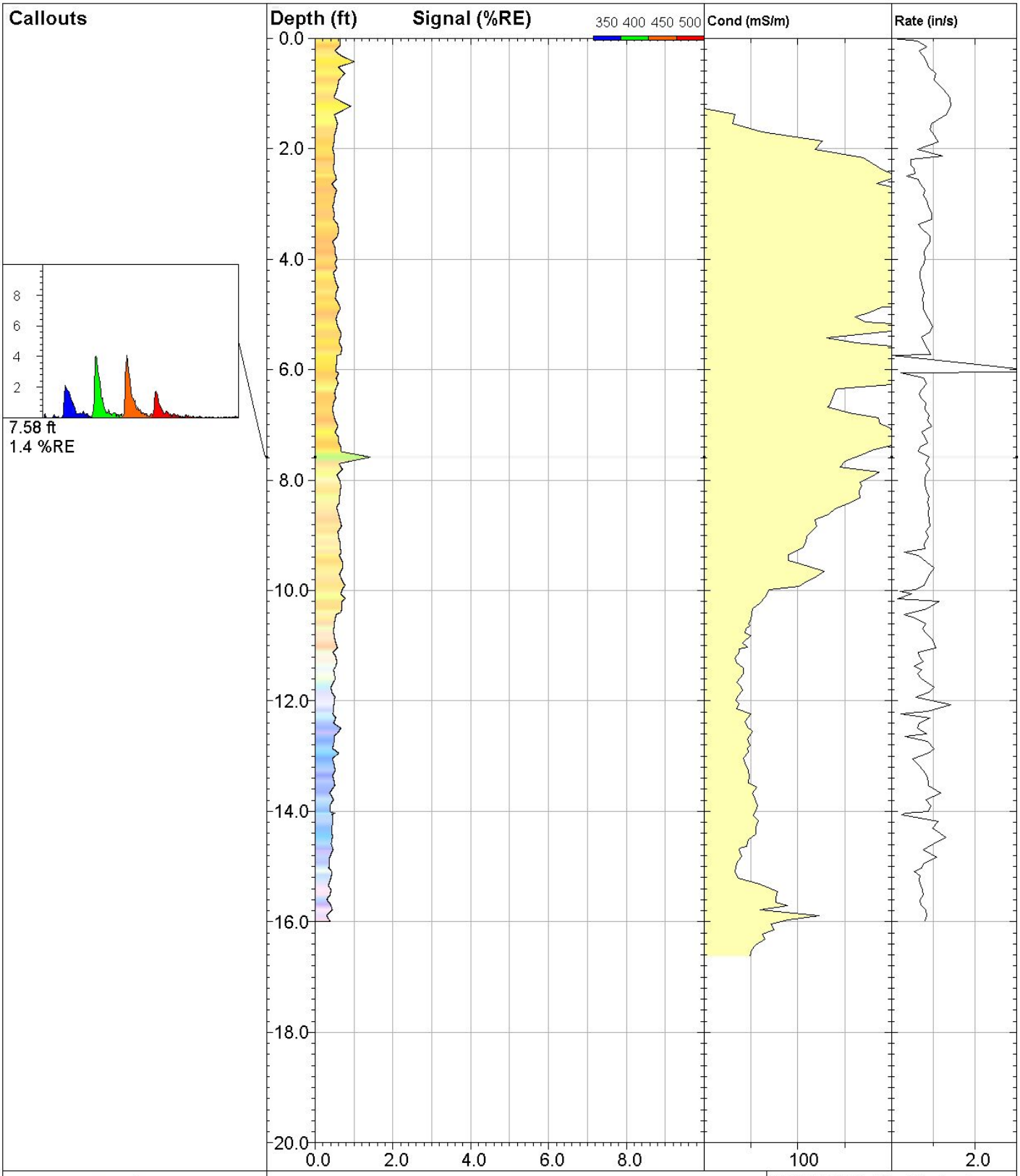
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.55 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.0 %RE @ 0.22 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 15:21 CDT**



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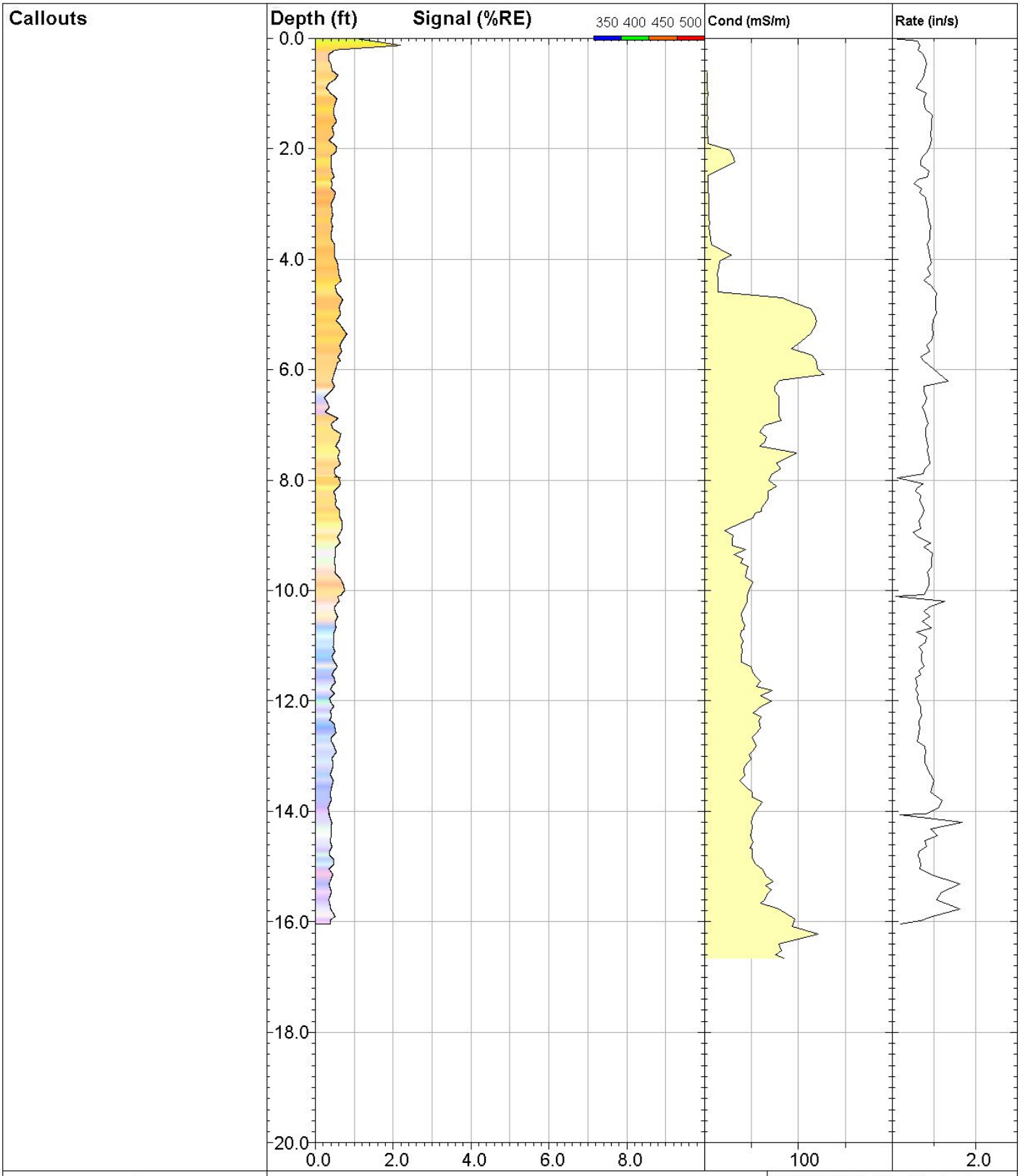
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 7.58 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 15:43 CDT**



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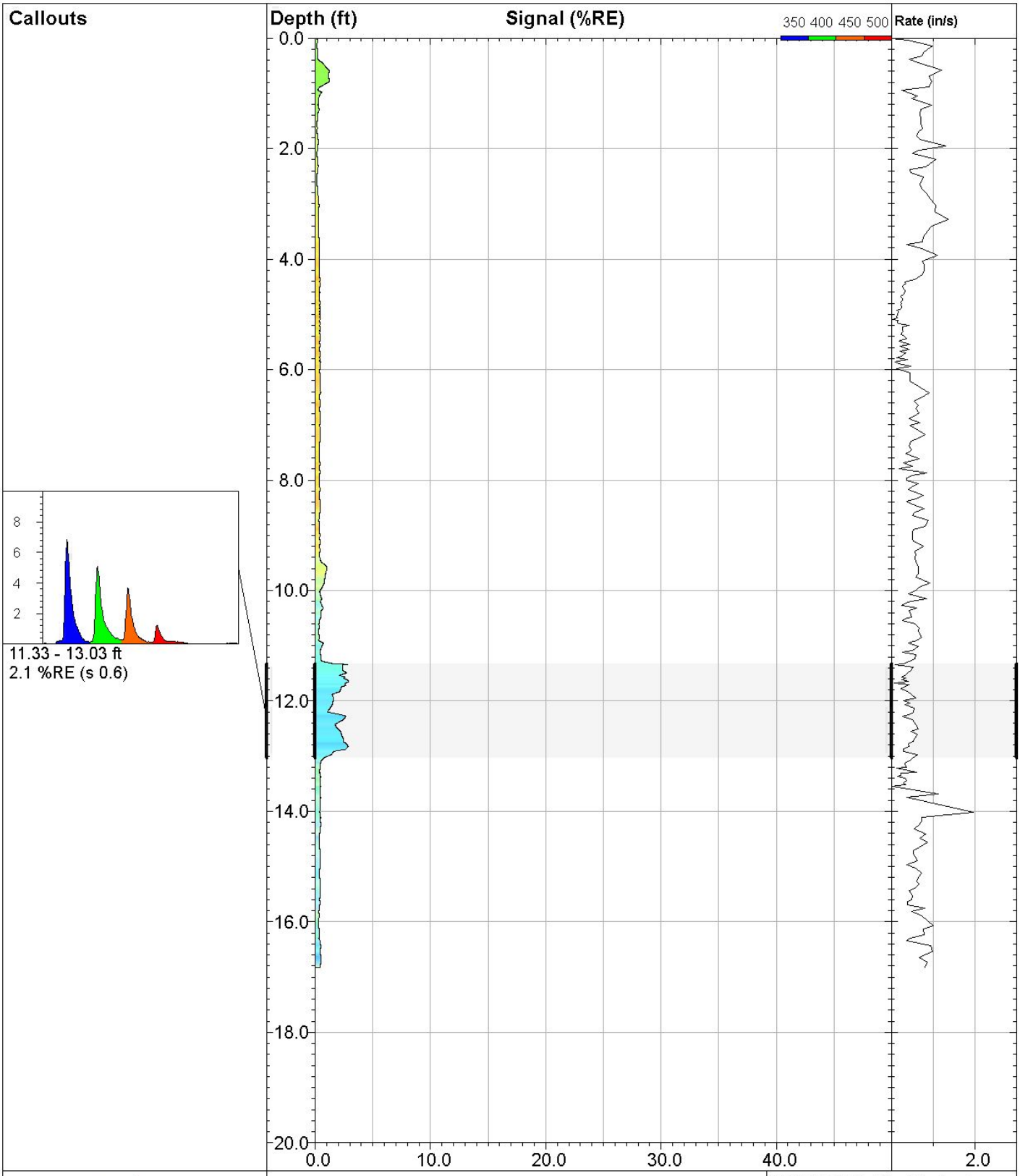
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 0.13 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 16:03 CDT**

Appendix C

UVOST® Logs at 50% RE



01-LIF		**UVOST® By Dakota** www.DakotaTechnologies.com
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.83 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.9 %RE @ 11.65 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 12:37 CDT**

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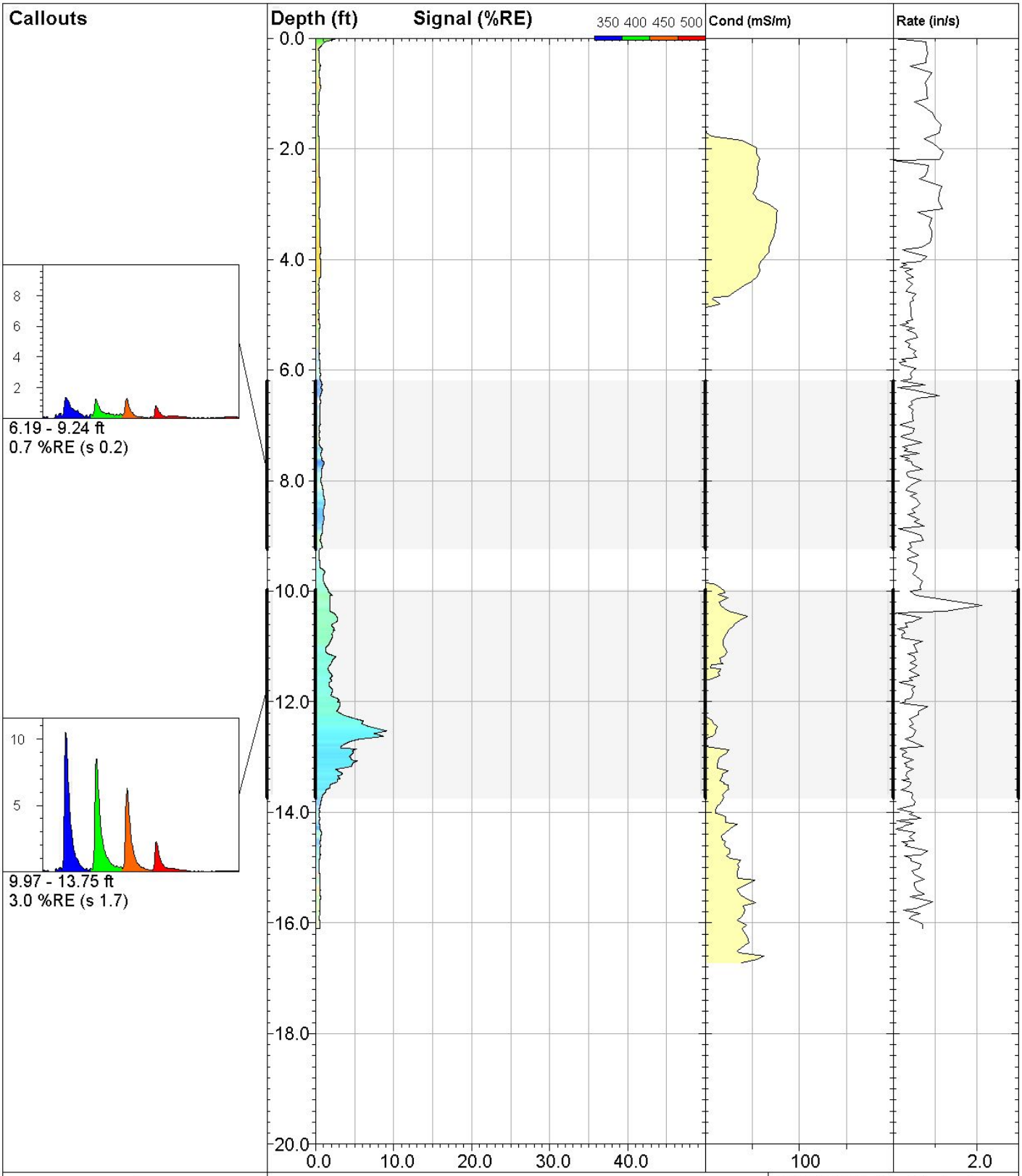

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02-LIF

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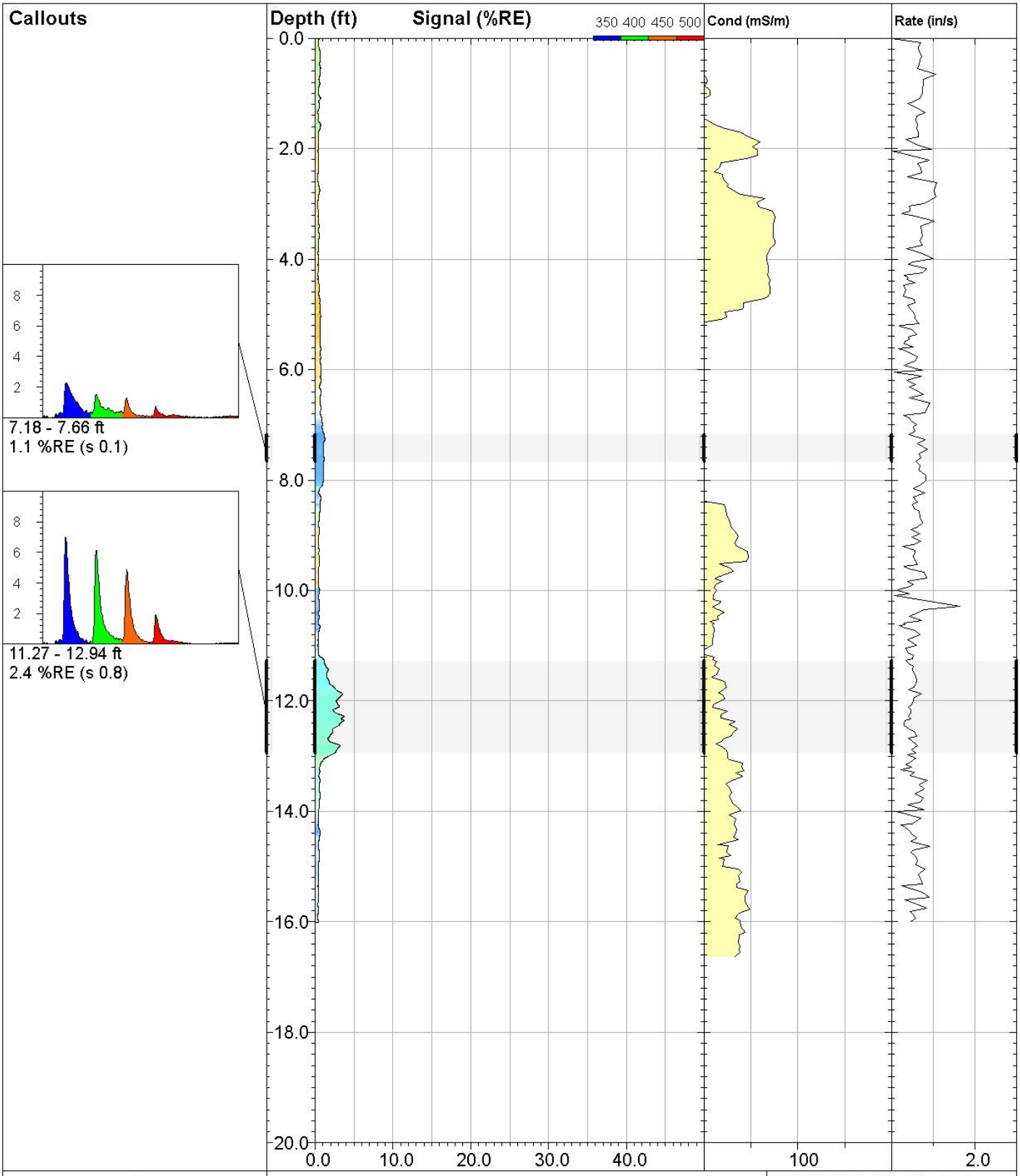
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.10 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **9.1 %RE @ 12.53 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 13:03 CDT**



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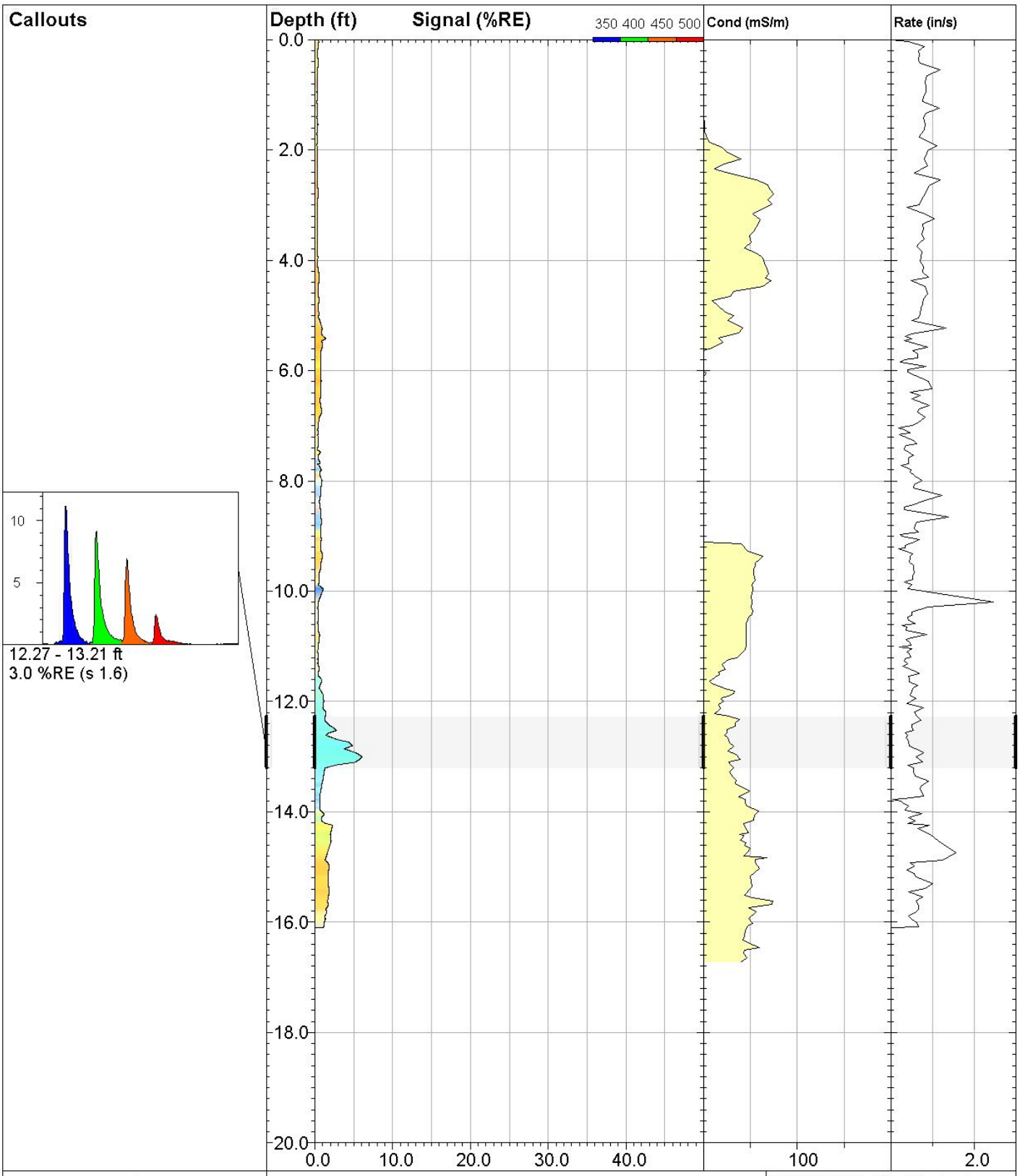
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.8 %RE @ 12.28 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 13:26 CDT**



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04-LIF

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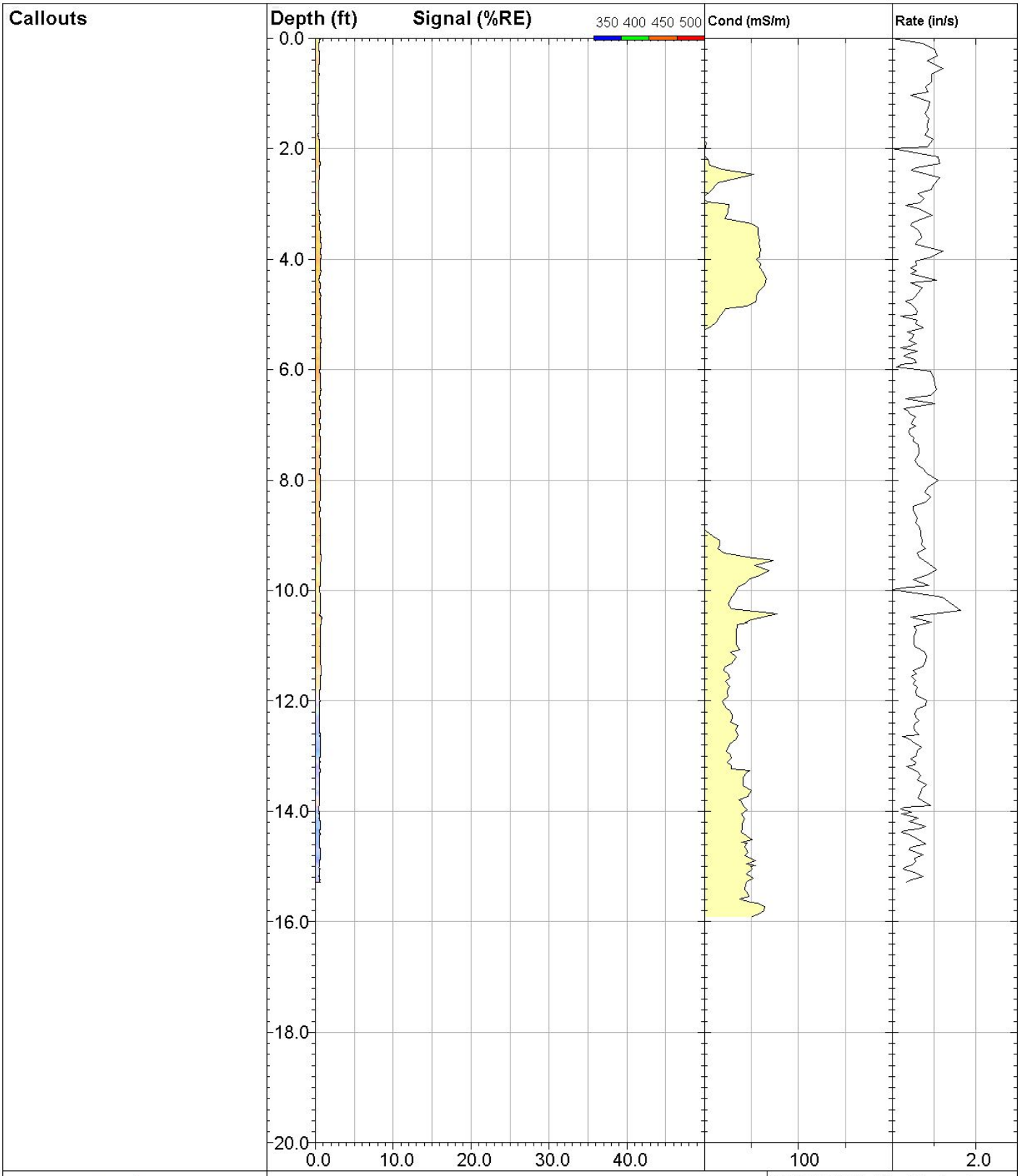
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.10 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.1 %RE @ 13.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 13:51 CDT**



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05-LIF

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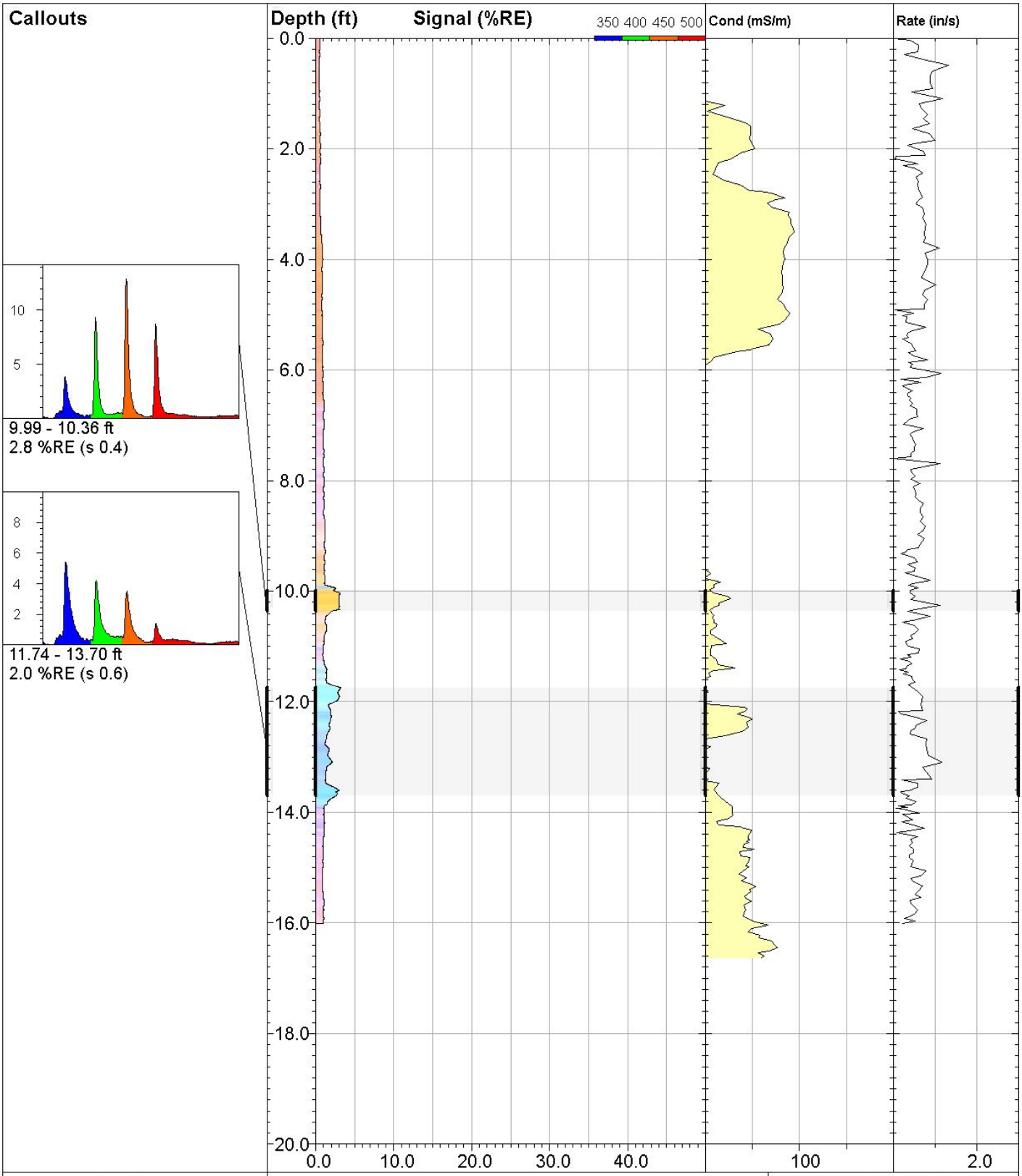
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.29 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **0.8 %RE @ 10.49 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 14:14 CDT**



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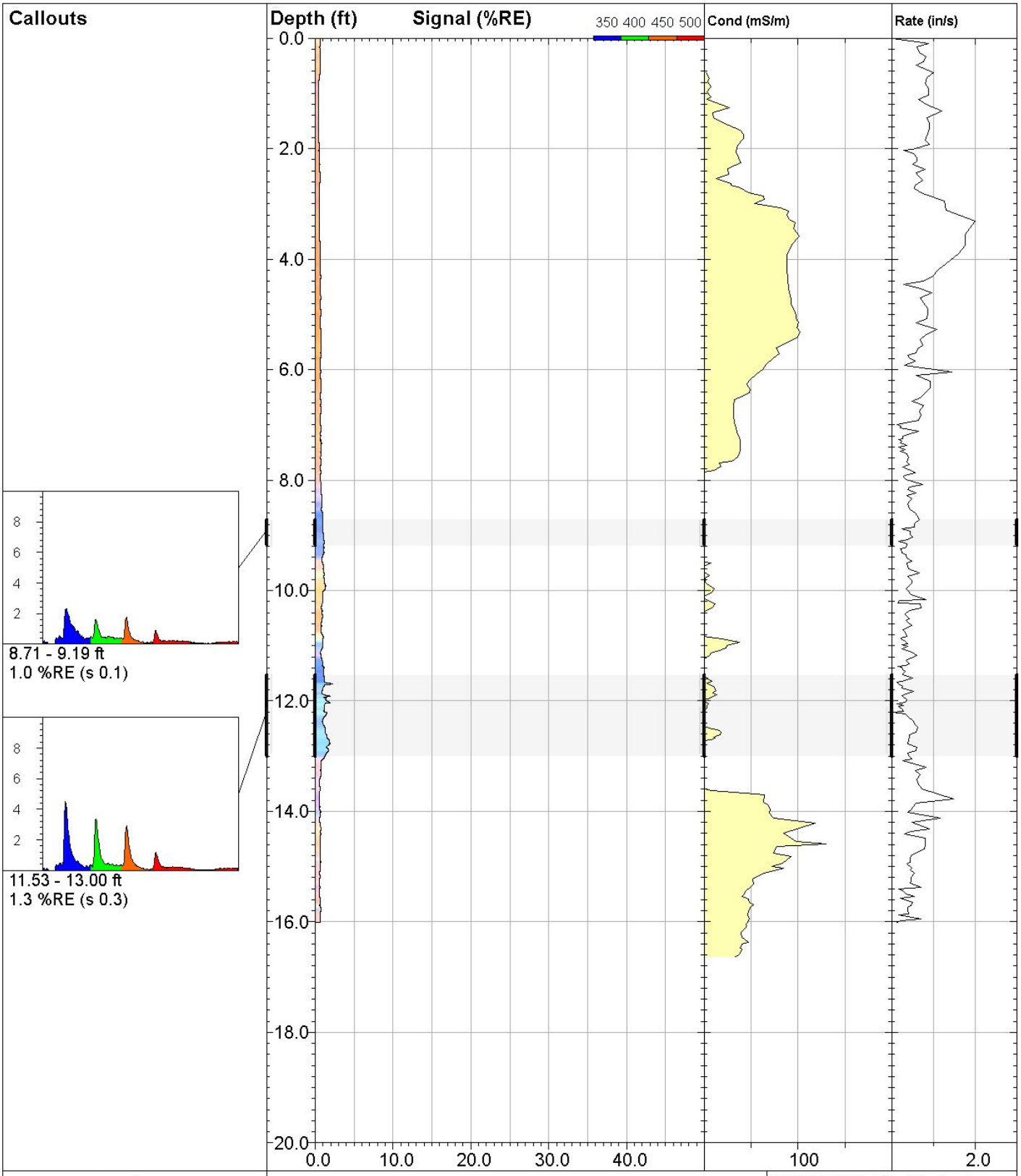
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.2 %RE @ 11.74 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 14:39 CDT**



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07-LIF

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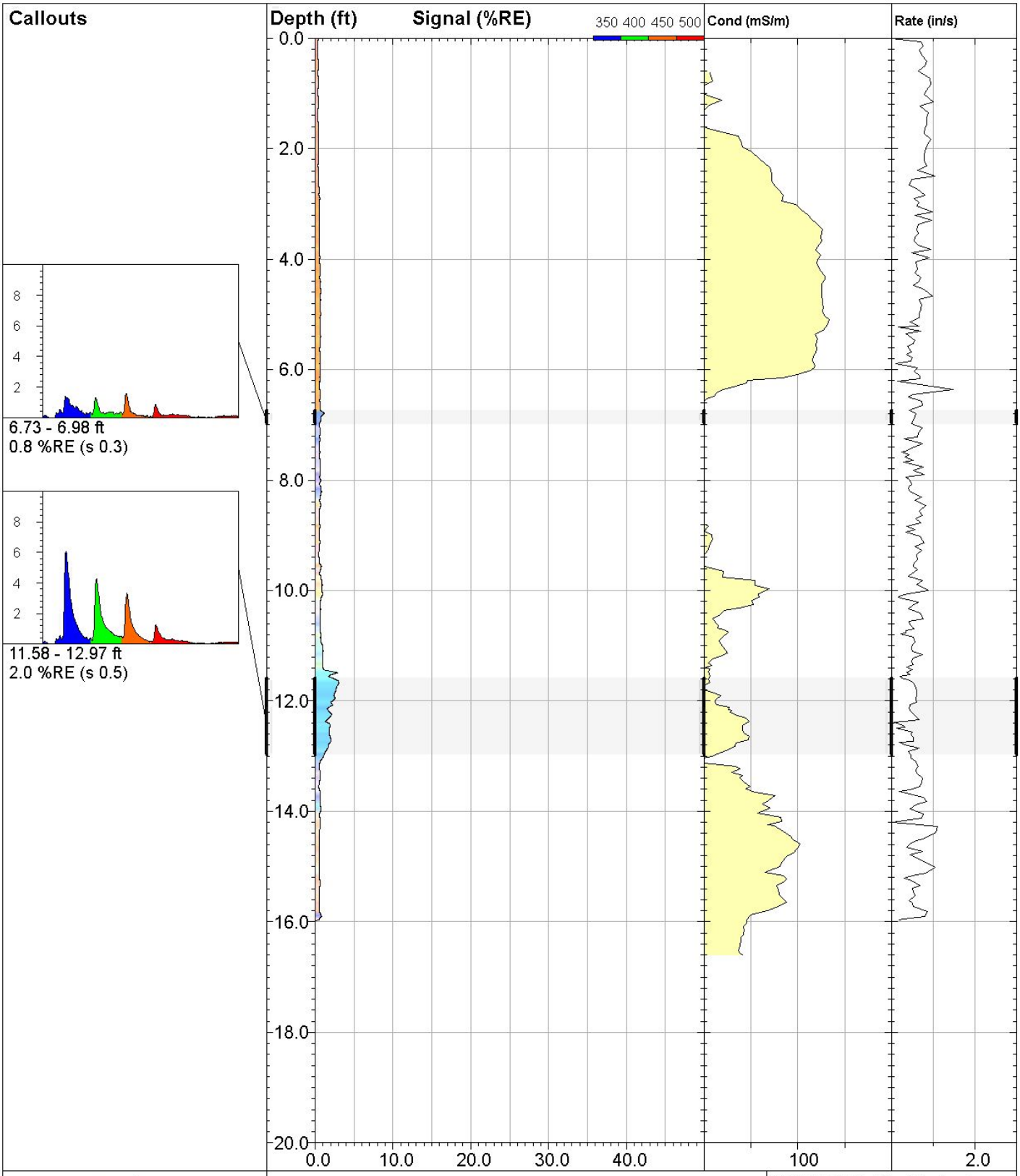
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.3 %RE @ 11.69 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 15:16 CDT**



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08-LIF

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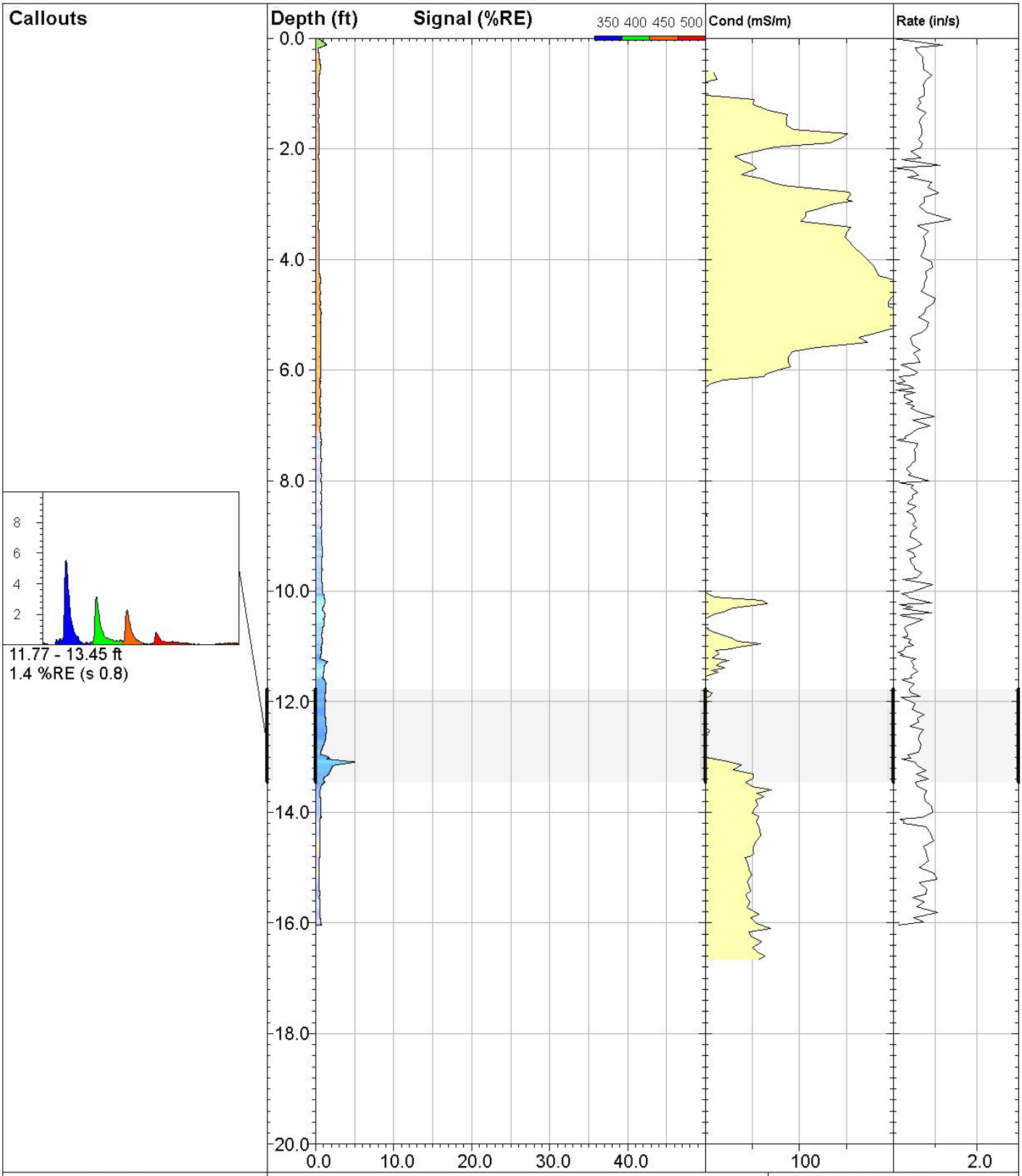
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.97 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.1 %RE @ 11.68 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 15:40 CDT**



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09-LIF

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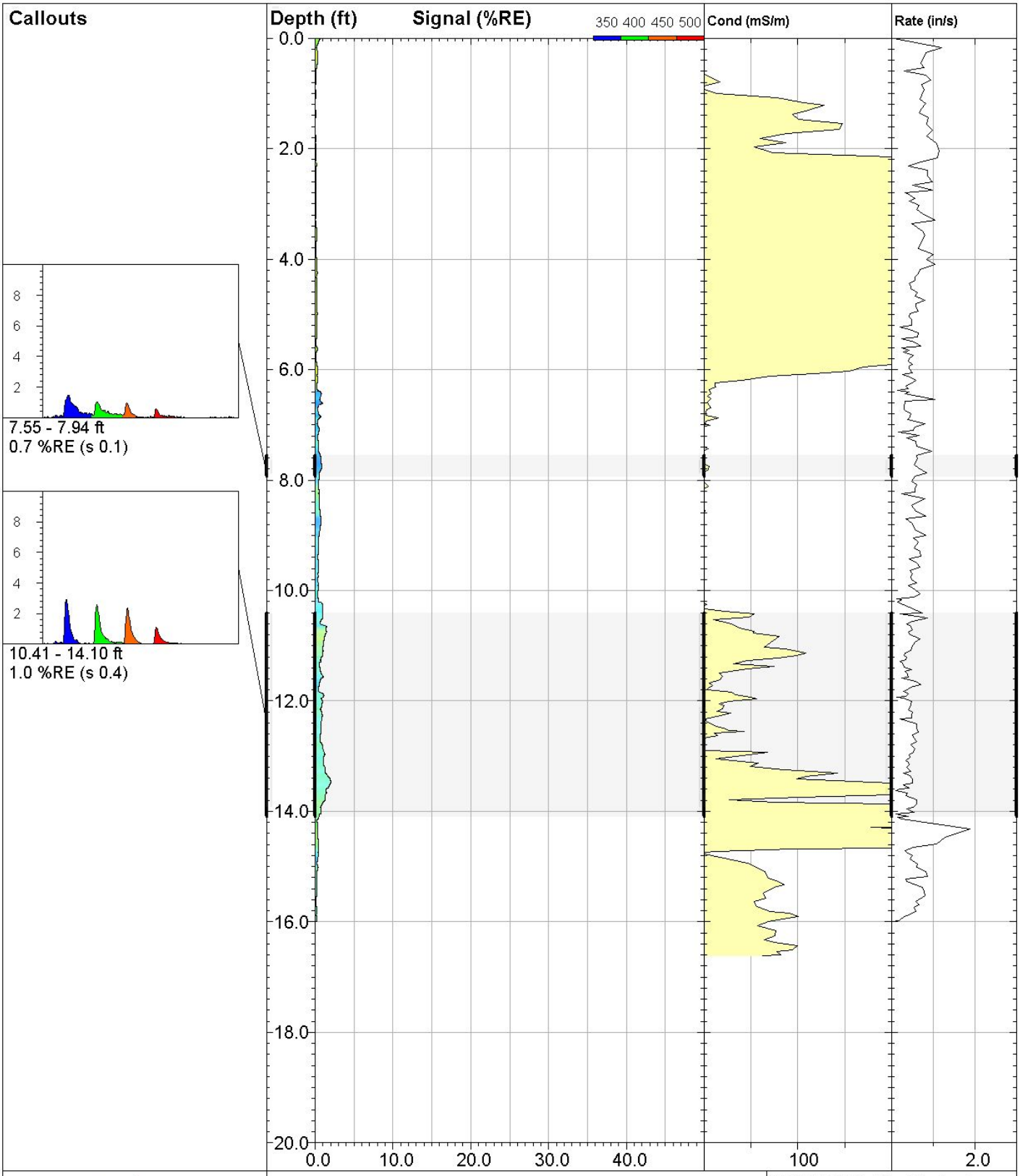
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.1 %RE @ 13.09 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 16:05 CDT**



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10-LIF

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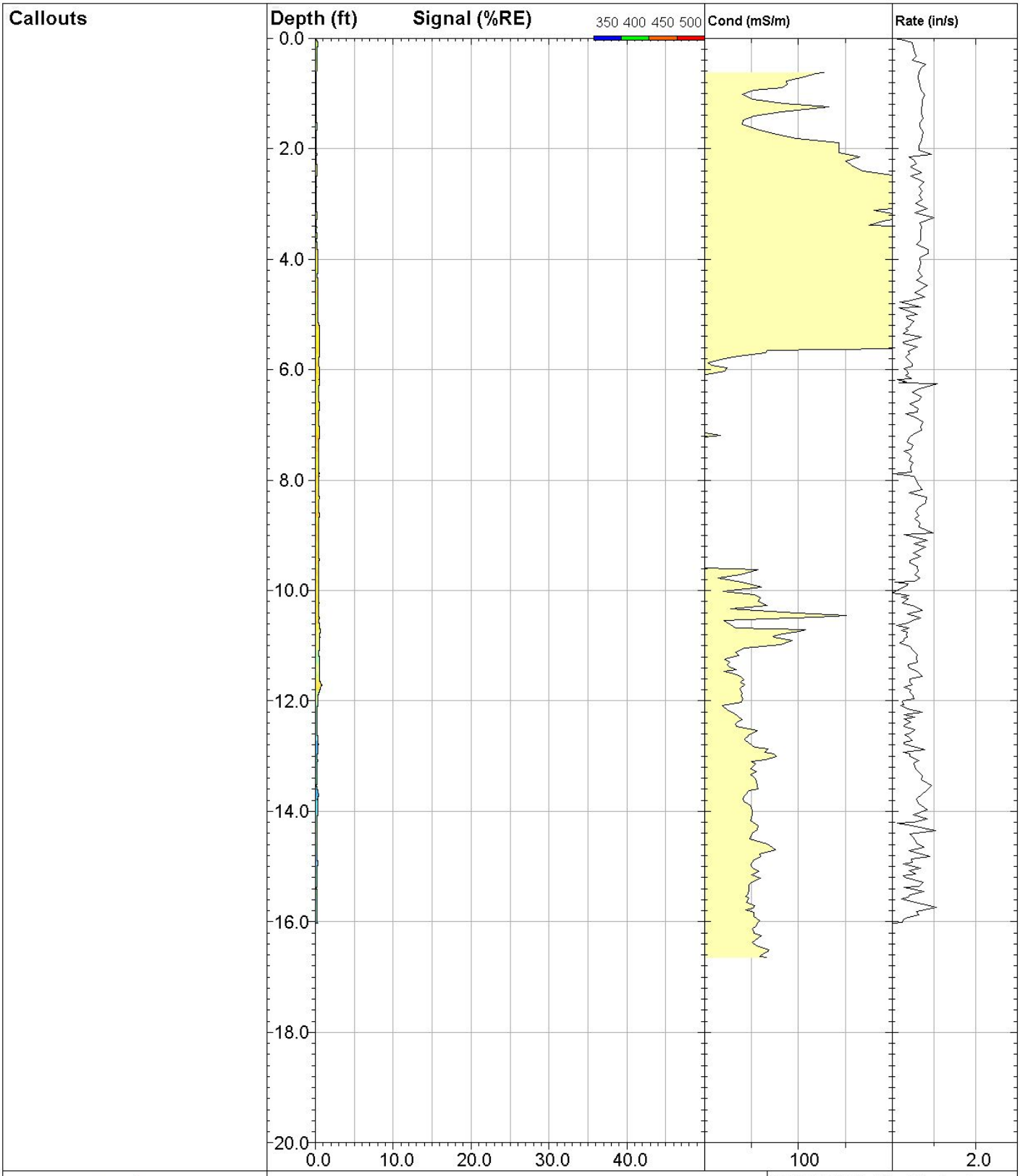
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.0 %RE @ 13.48 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 10:00 CDT**



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11-LIF

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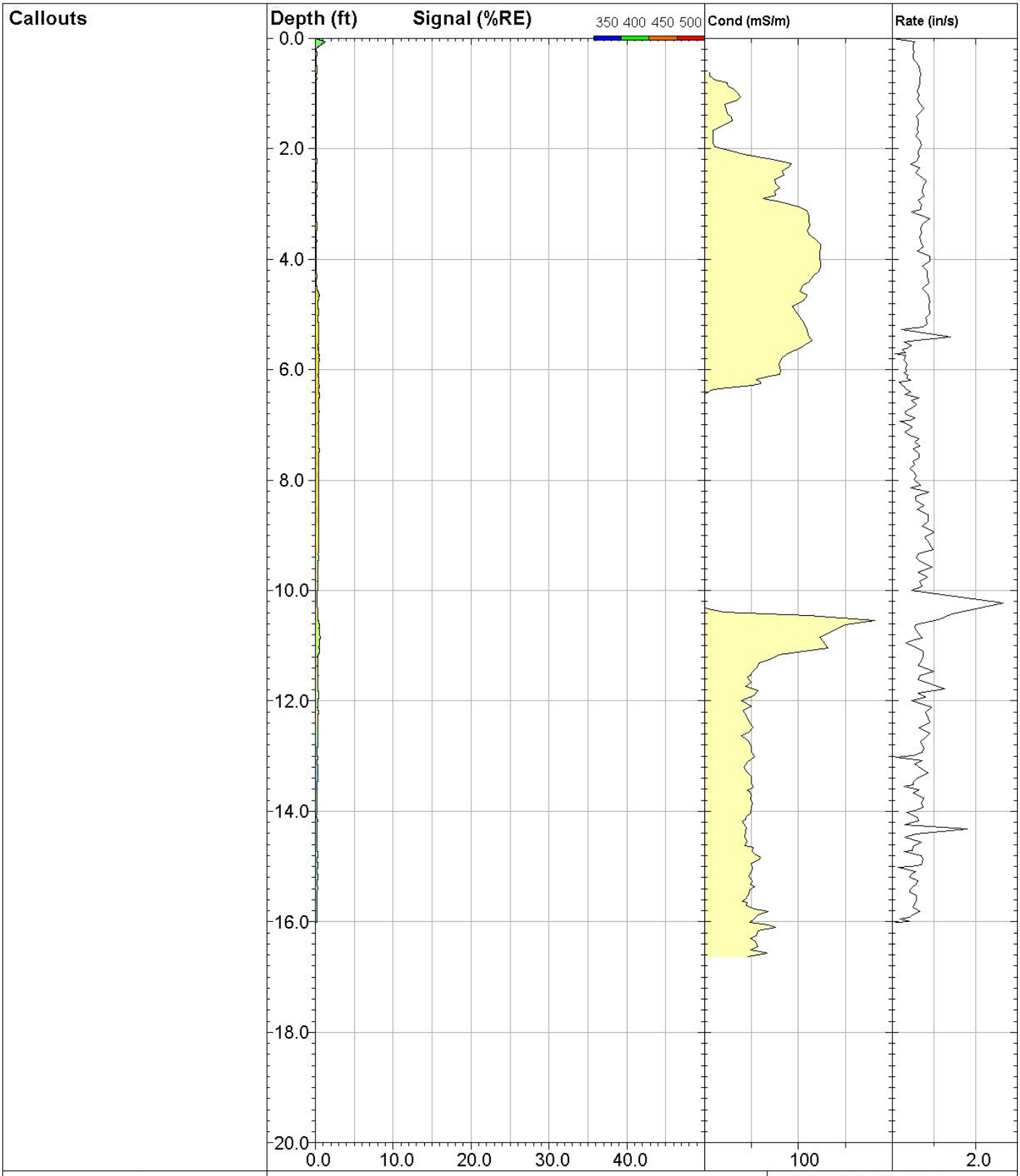
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **0.8 %RE @ 11.71 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 10:24 CDT**



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12-LIF

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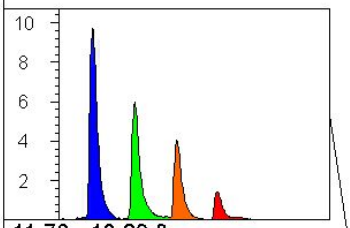
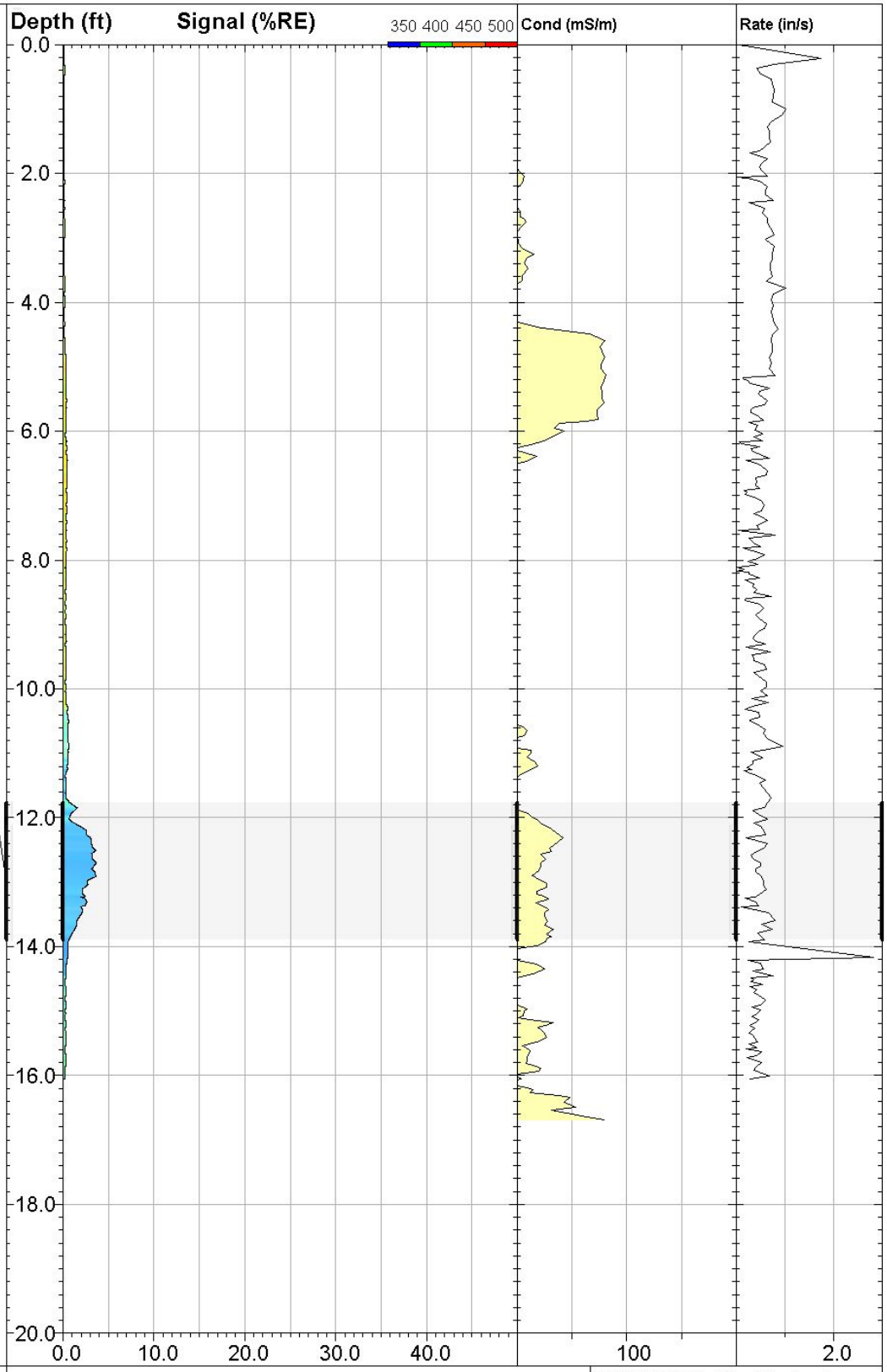
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.3 %RE @ 0.07 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 10:48 CDT**

Callouts



11.76 - 13.89 ft
2.3 %RE (s 0.9)

RESTRING DUE TO BENT MIP TUBE



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13-LIF

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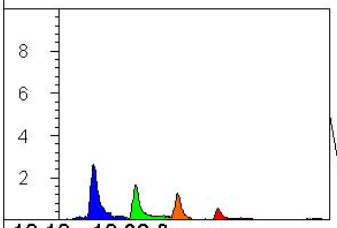
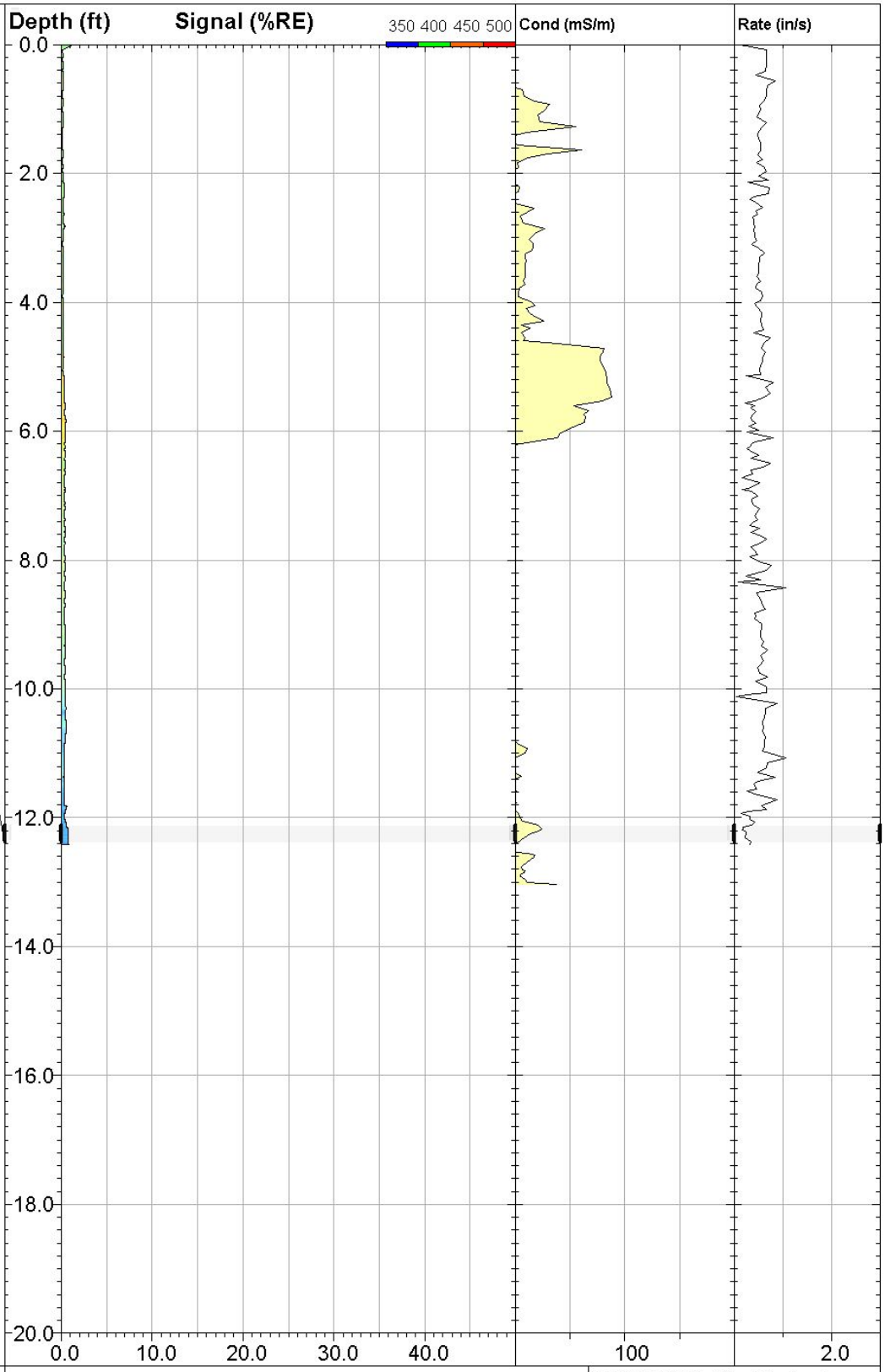
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.06 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.7 %RE @ 12.70 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 11:28 CDT**

Callouts



12.12 - 12.38 ft
0.7 %RE (s 0.1)

REFUSAL AT 12.42FT



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14-LIF

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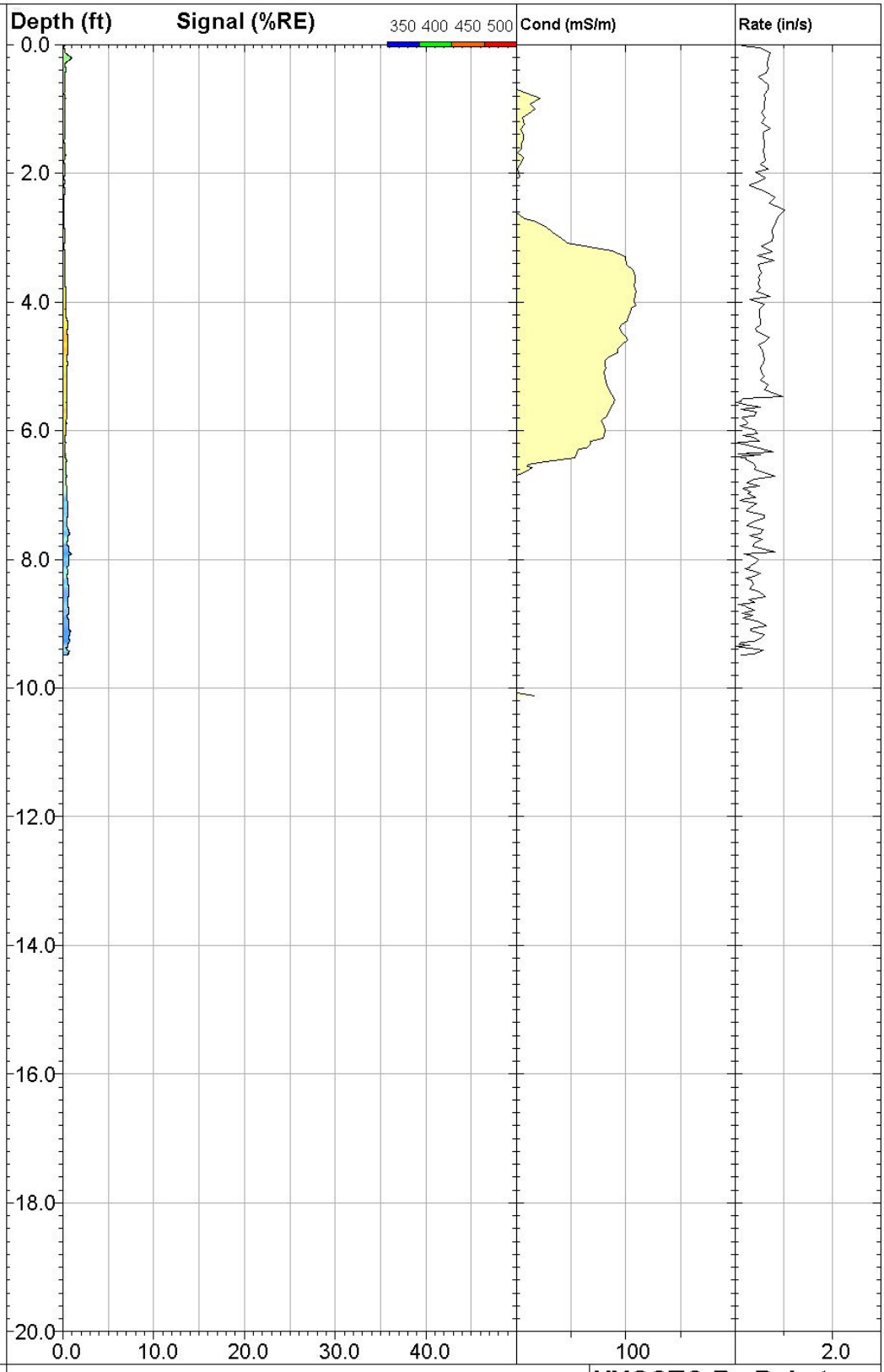
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **12.42 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.2 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 12:26 CDT**

Callouts
REFUSAL AT 9.49FT



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15-LIF

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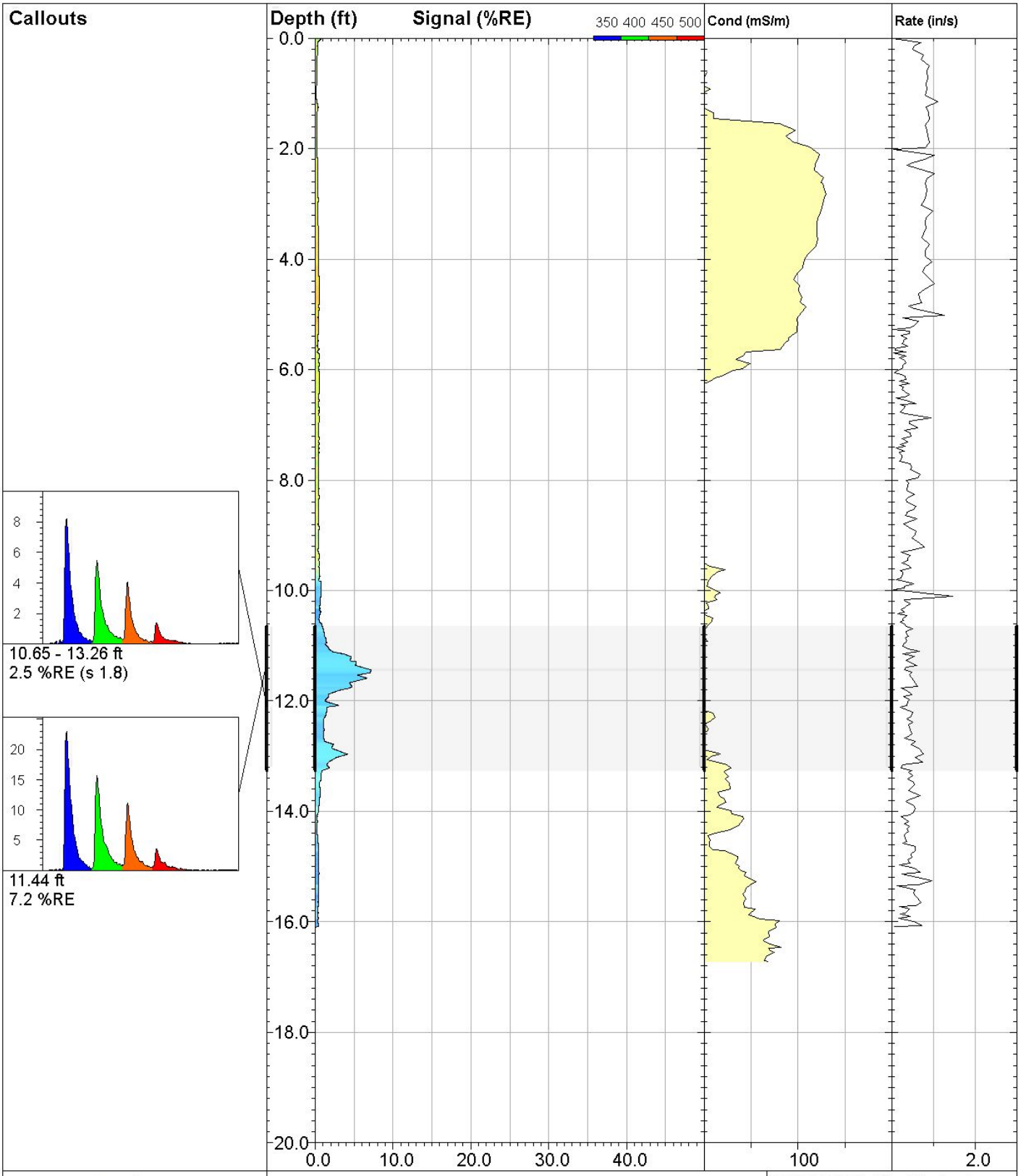
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **9.49 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.0 %RE @ 0.21 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 12:51 CDT**



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16-LIF

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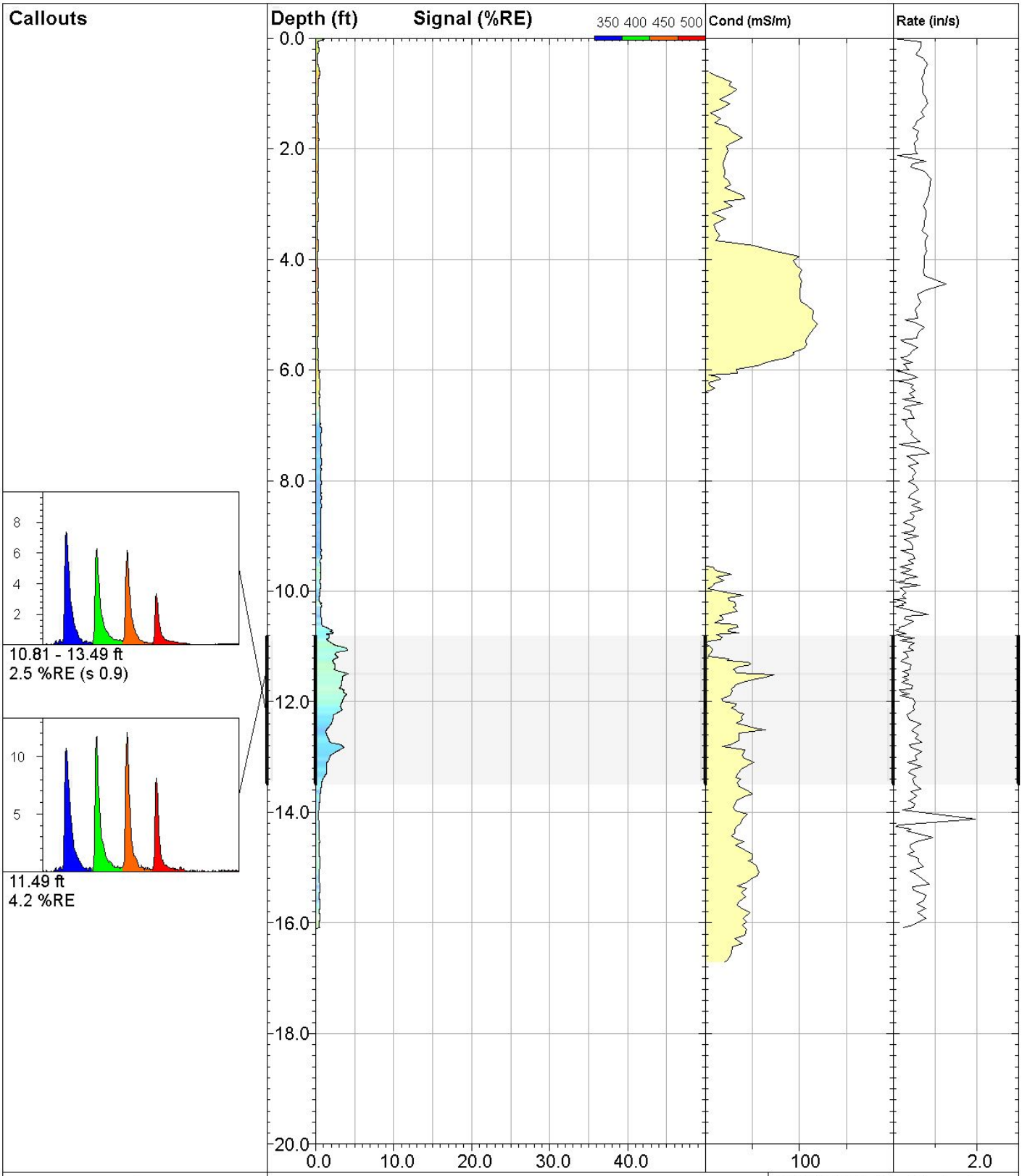
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **7.2 %RE @ 11.44 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 13:30 CDT**



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17-LIF

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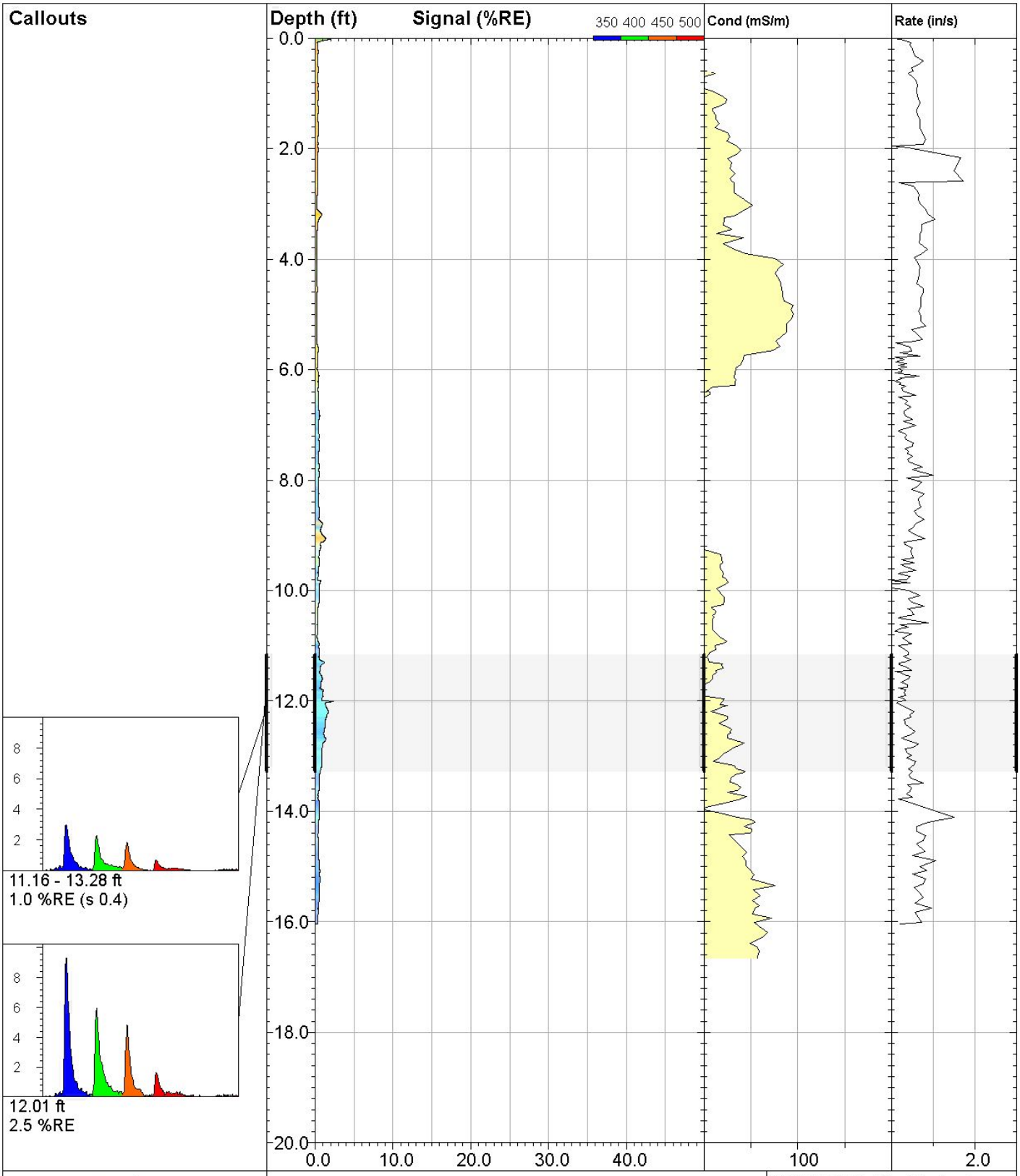
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.2 %RE @ 11.49 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 13:51 CDT**



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18-LIF

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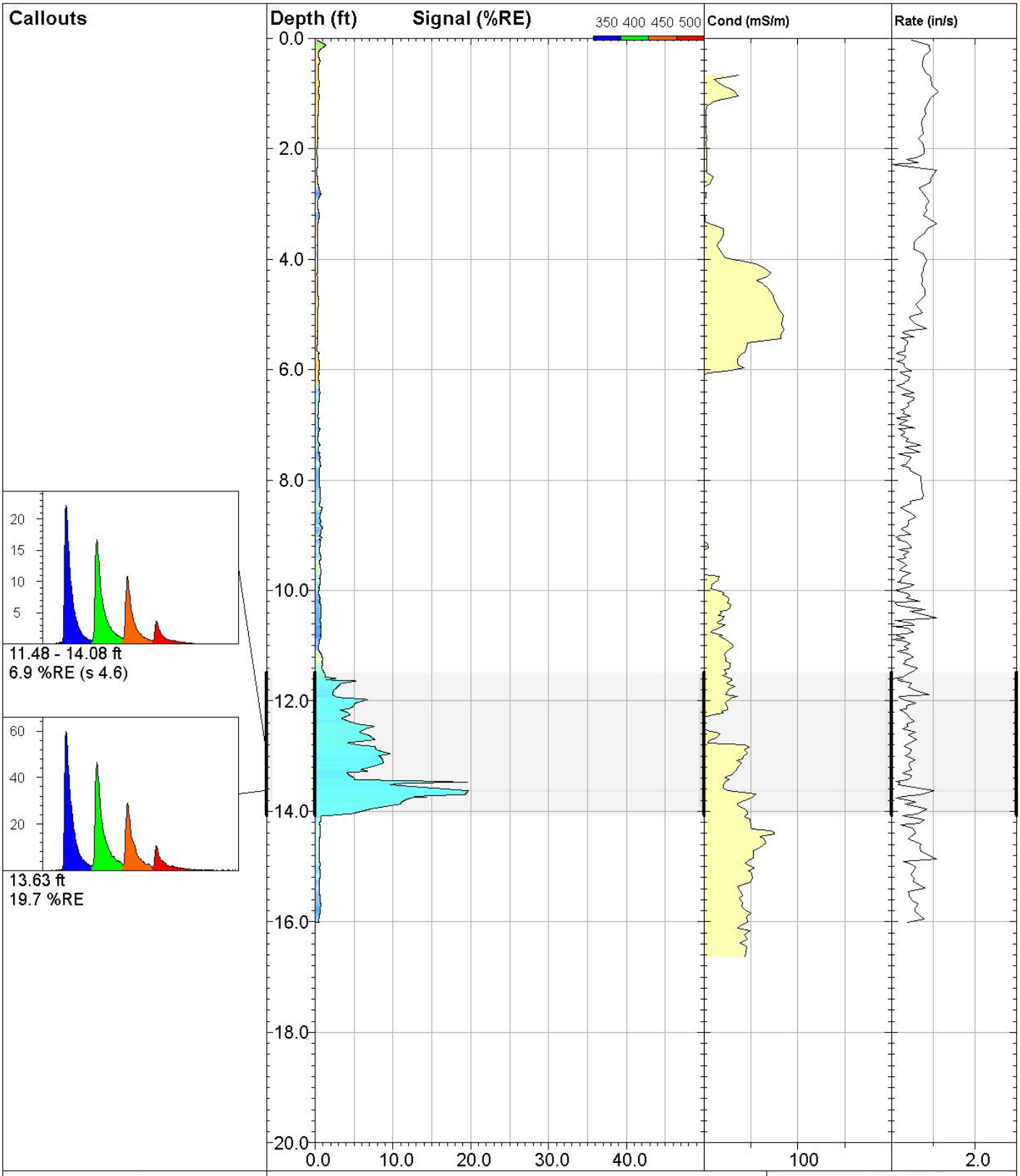
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.5 %RE @ 12.01 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 14:16 CDT**



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19-LIF

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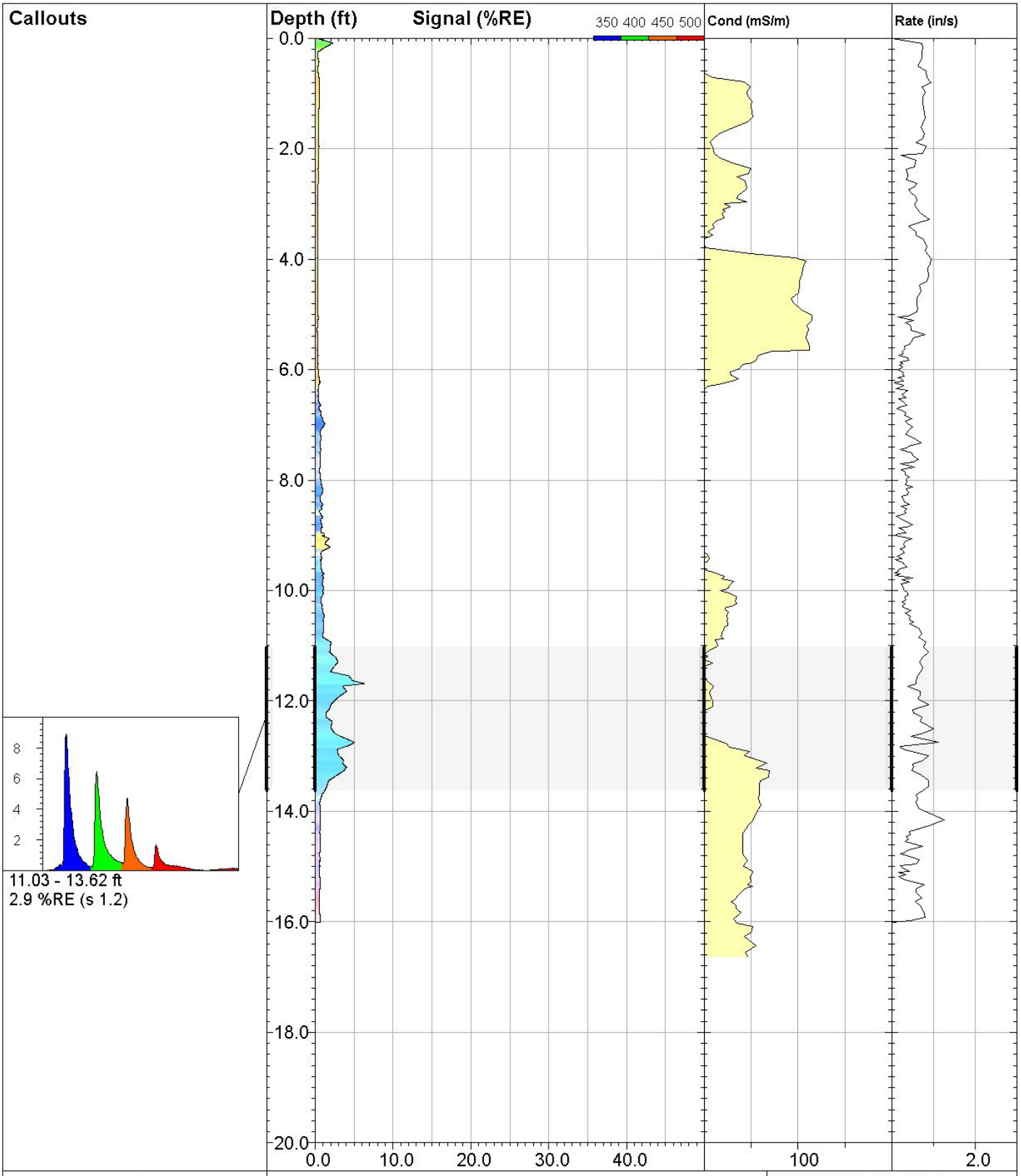
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **19.7 %RE @ 13.63 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 14:35 CDT**



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20-LIF

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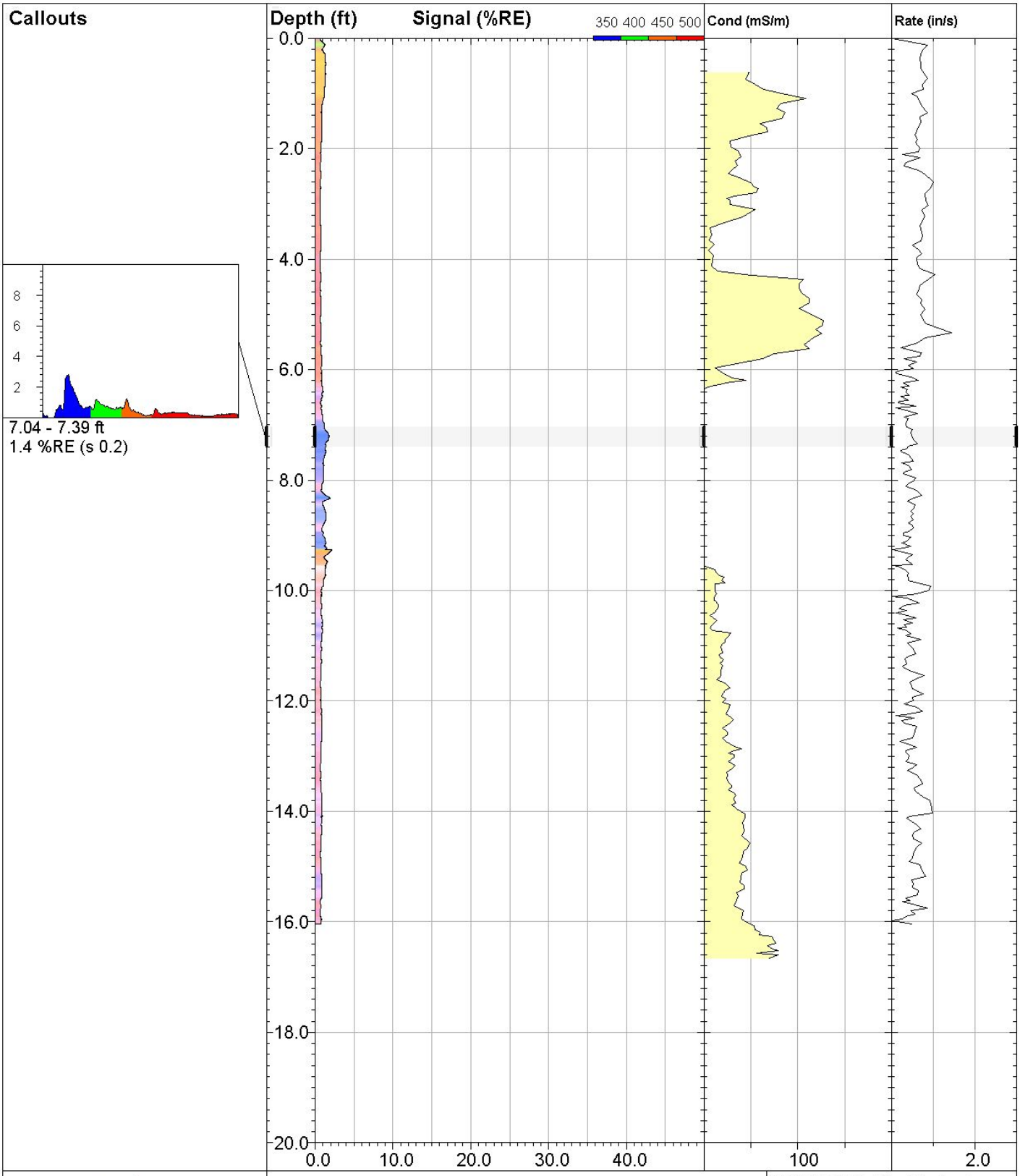
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.4 %RE @ 11.69 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 15:04 CDT**



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21-LIF

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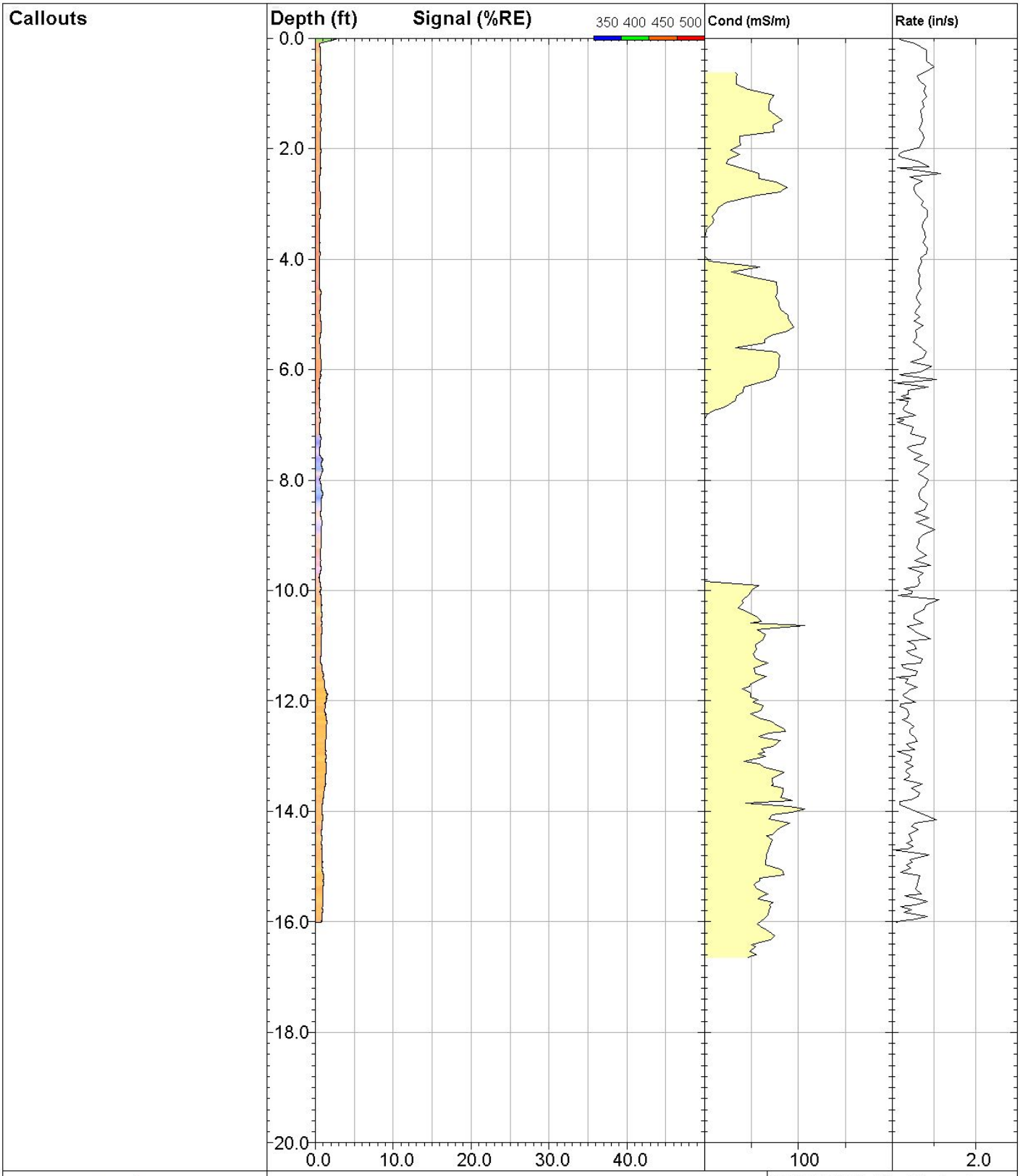
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.03 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 9.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 15:27 CDT**



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22-LIF

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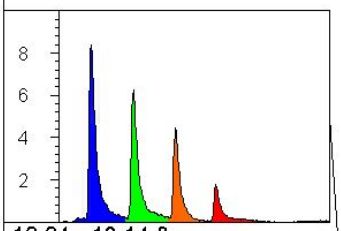
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.7 %RE @ 0.01 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 15:55 CDT**

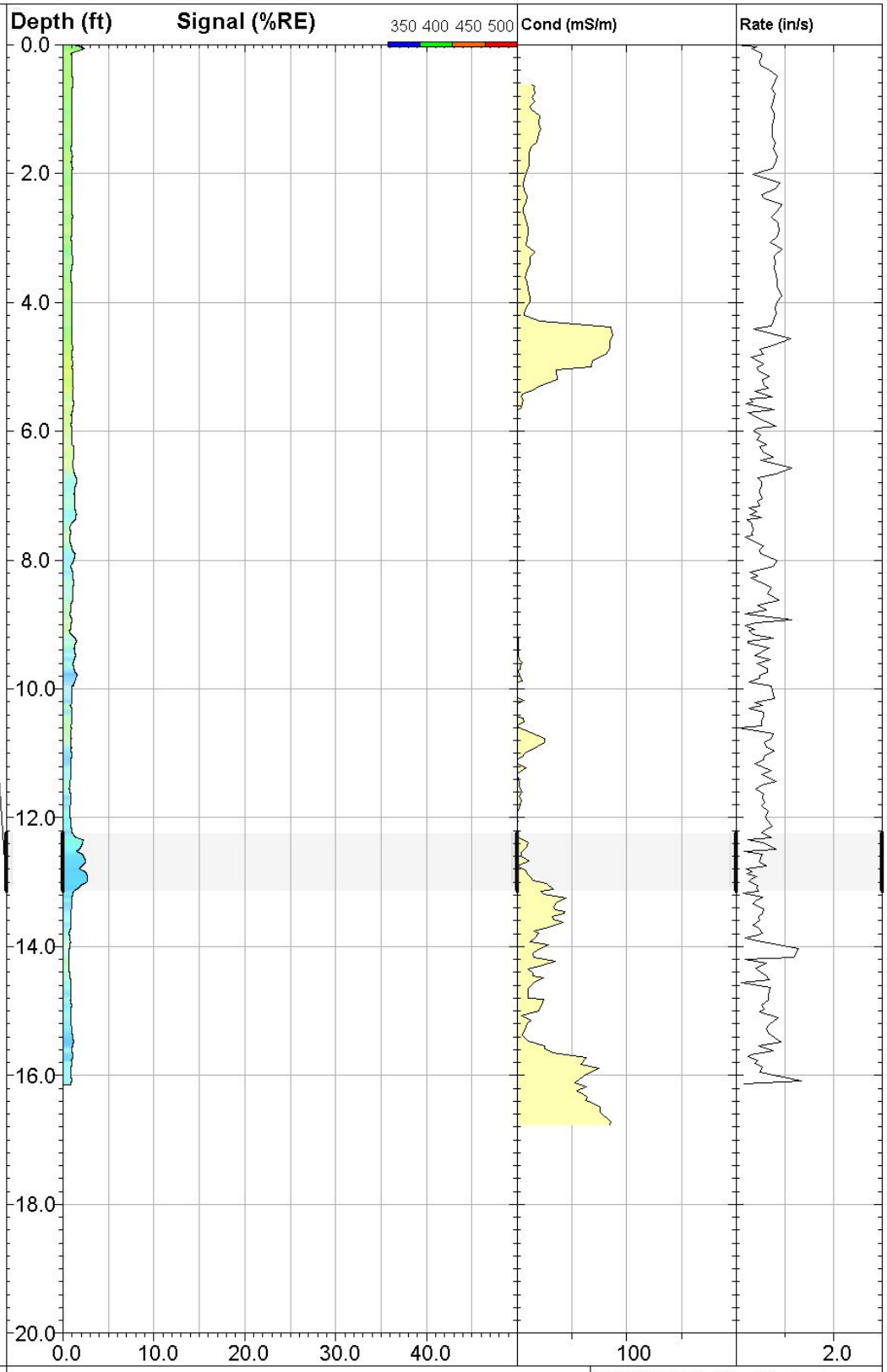
Callouts



12.24 - 13.14 ft
2.0 %RE (s 0.5)

ELEVATED BACKGROUND DUE TO SCRATCH ON WINDOW. WINDOW UNABLE TO BE REMOVED. MELDED TO SPOC WITH THE DIFFICULT DRILLING

CONDITIONS. ENTIRE TOOL STRING WILL BE SWAPPED OUT.



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23-LIF

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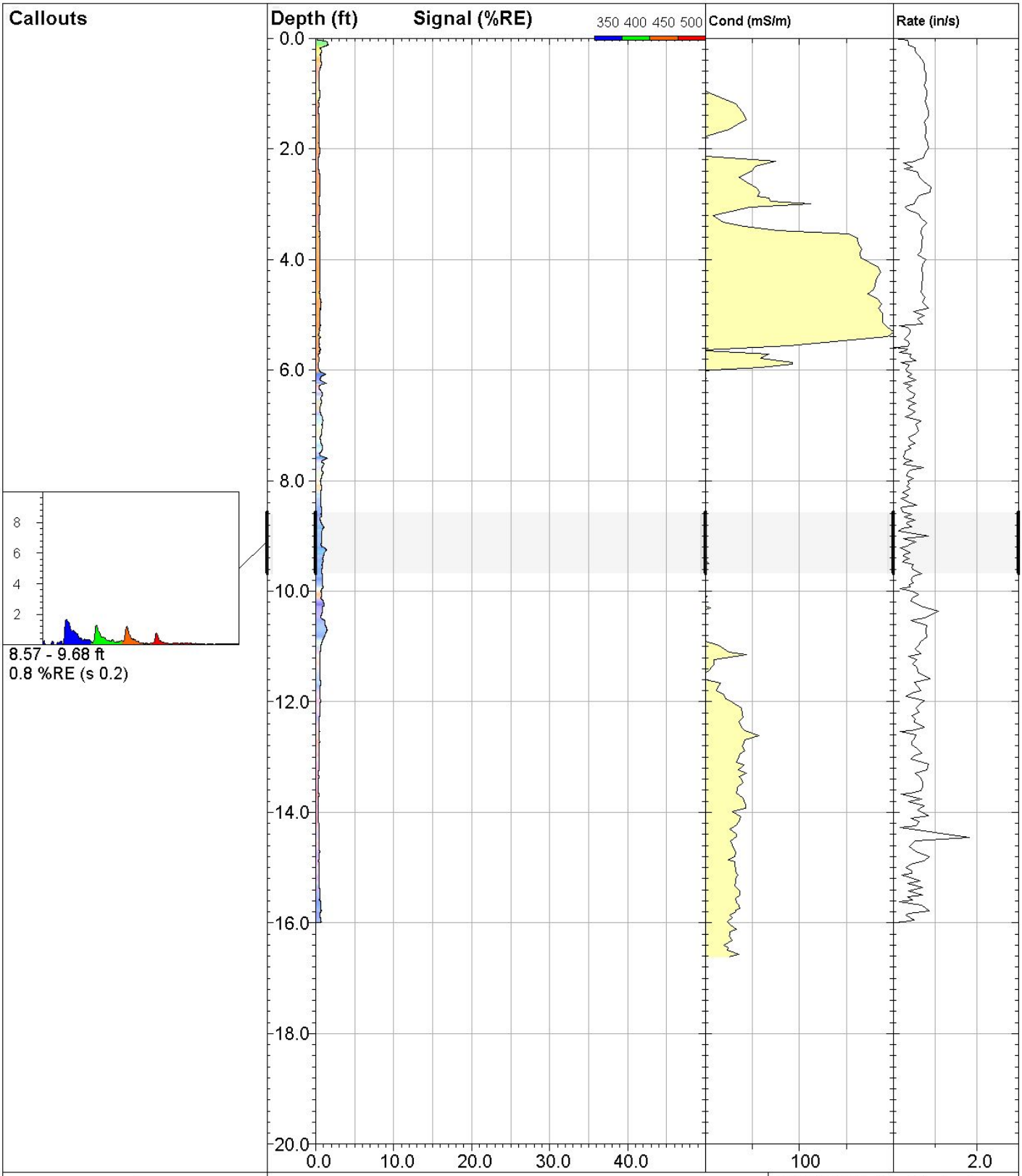
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.14 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.7 %RE @ 12.91 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 16:34 CDT**



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24-LIF

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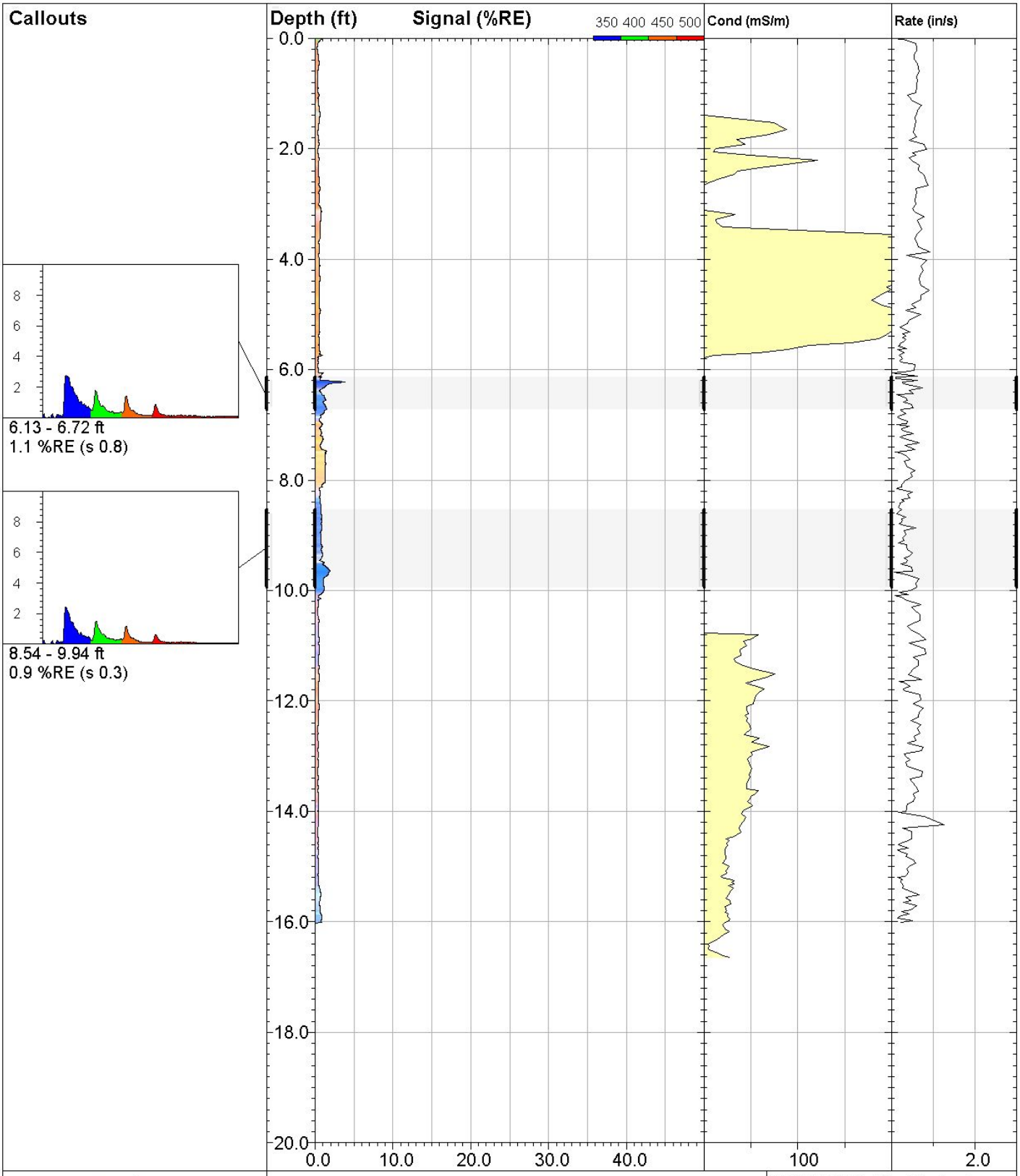
Site:	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **/**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.6 %RE @ 0.12 ft**
Operator / Unit: **/ UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 09:24 CDT**



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25-LIF

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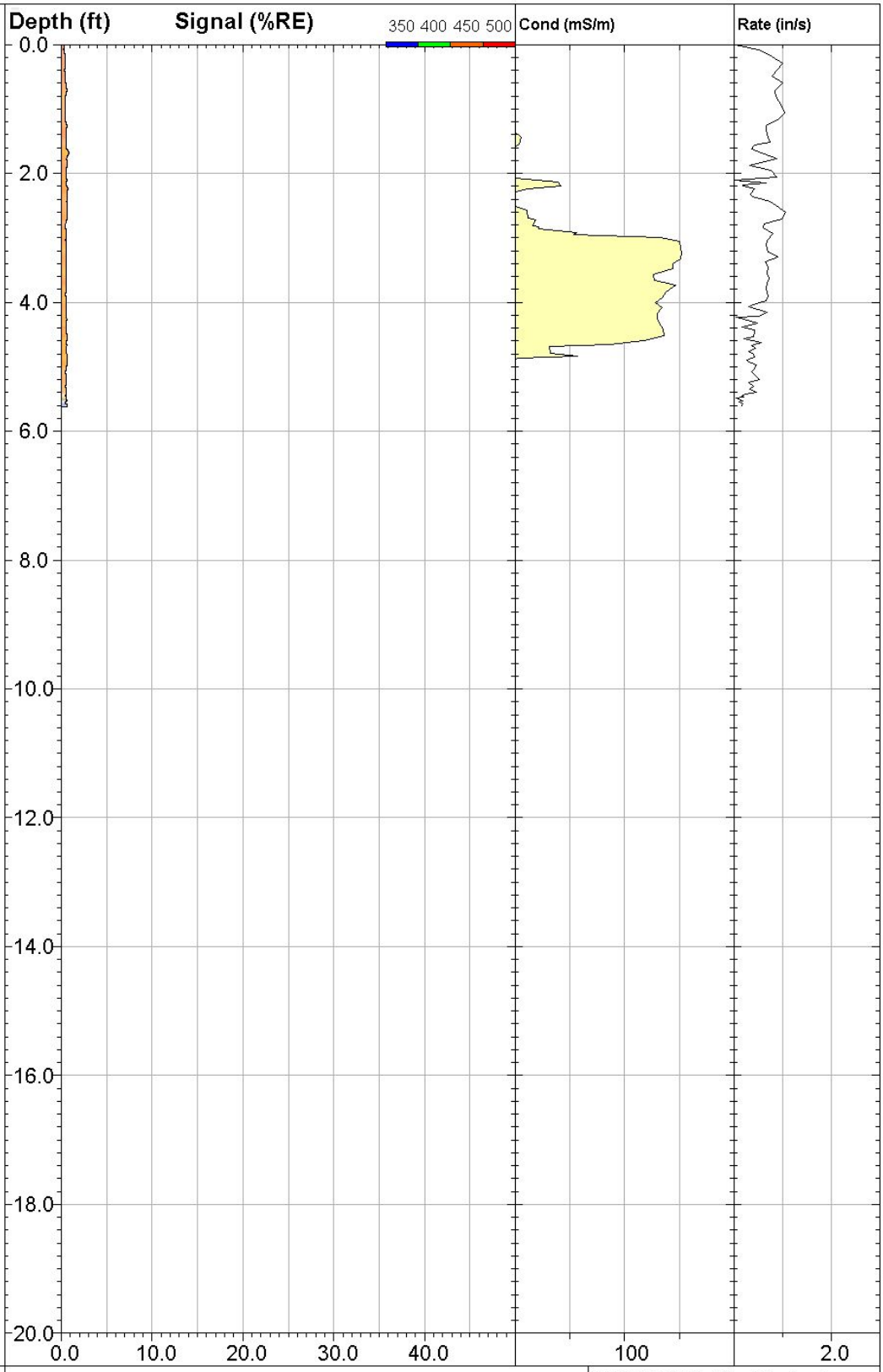
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.0 %RE @ 6.23 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 09:51 CDT**

Callouts
REFUSAL AT 5.62FT



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26-LIF

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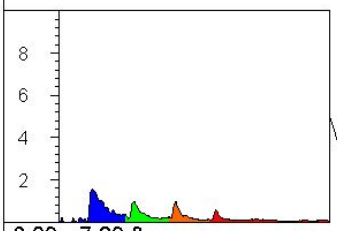
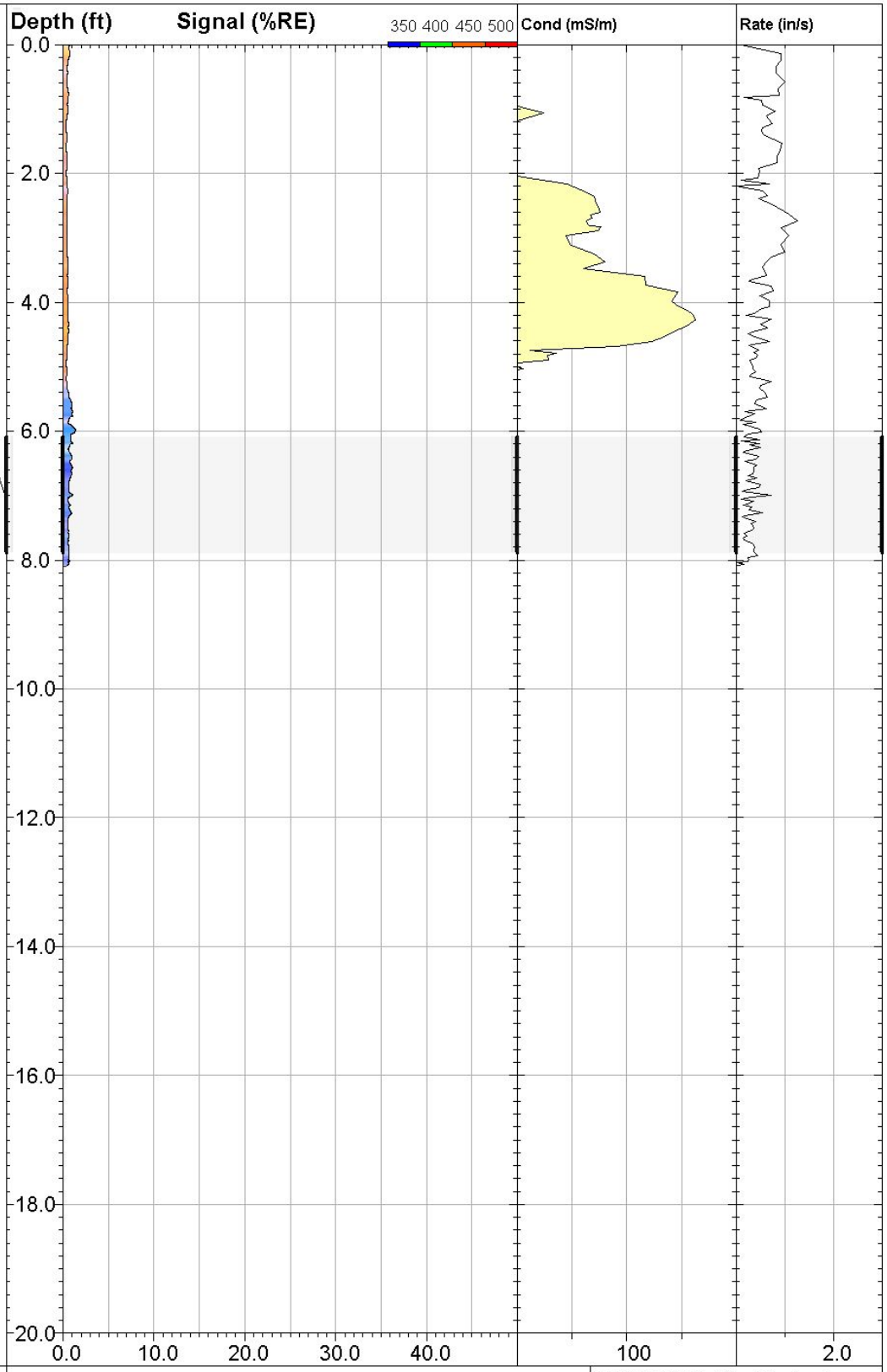
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **5.62 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **0.8 %RE @ 1.68 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 10:17 CDT**

Callouts



6.09 - 7.89 ft
0.7 %RE (s 0.2)

REFUSAL AT 8.09FT



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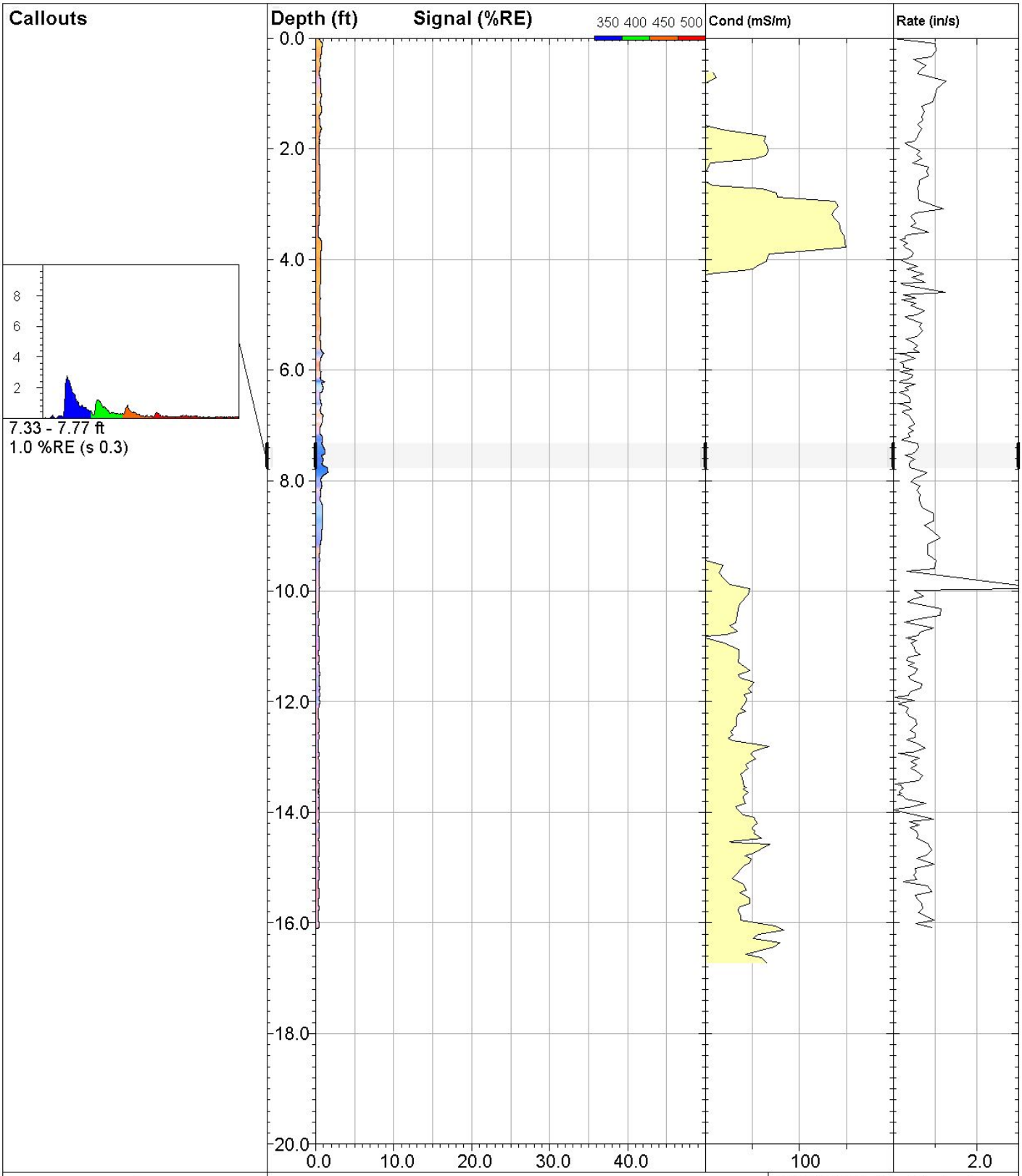
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **8.09 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 5.97 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 10:32 CDT**



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28-LIF

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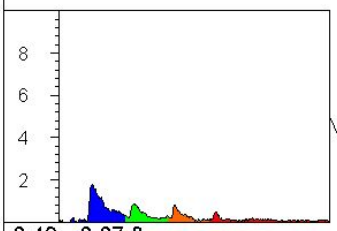
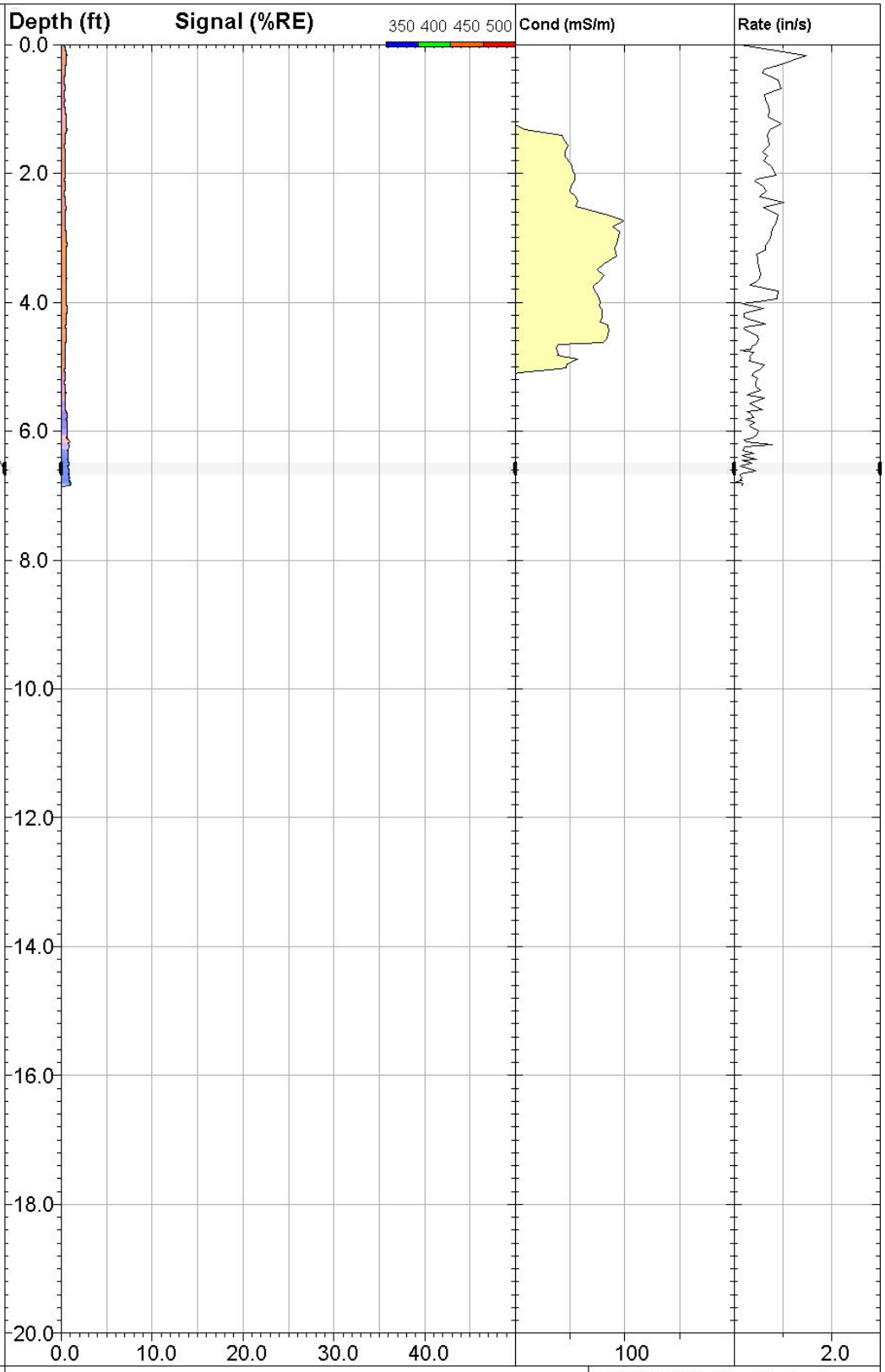
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.6 %RE @ 7.85 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 10:56 CDT**

Callouts



6.49 - 6.67 ft
0.8 %RE (s 0.1)

REFUSAL AT 6.85FT



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29-LIF

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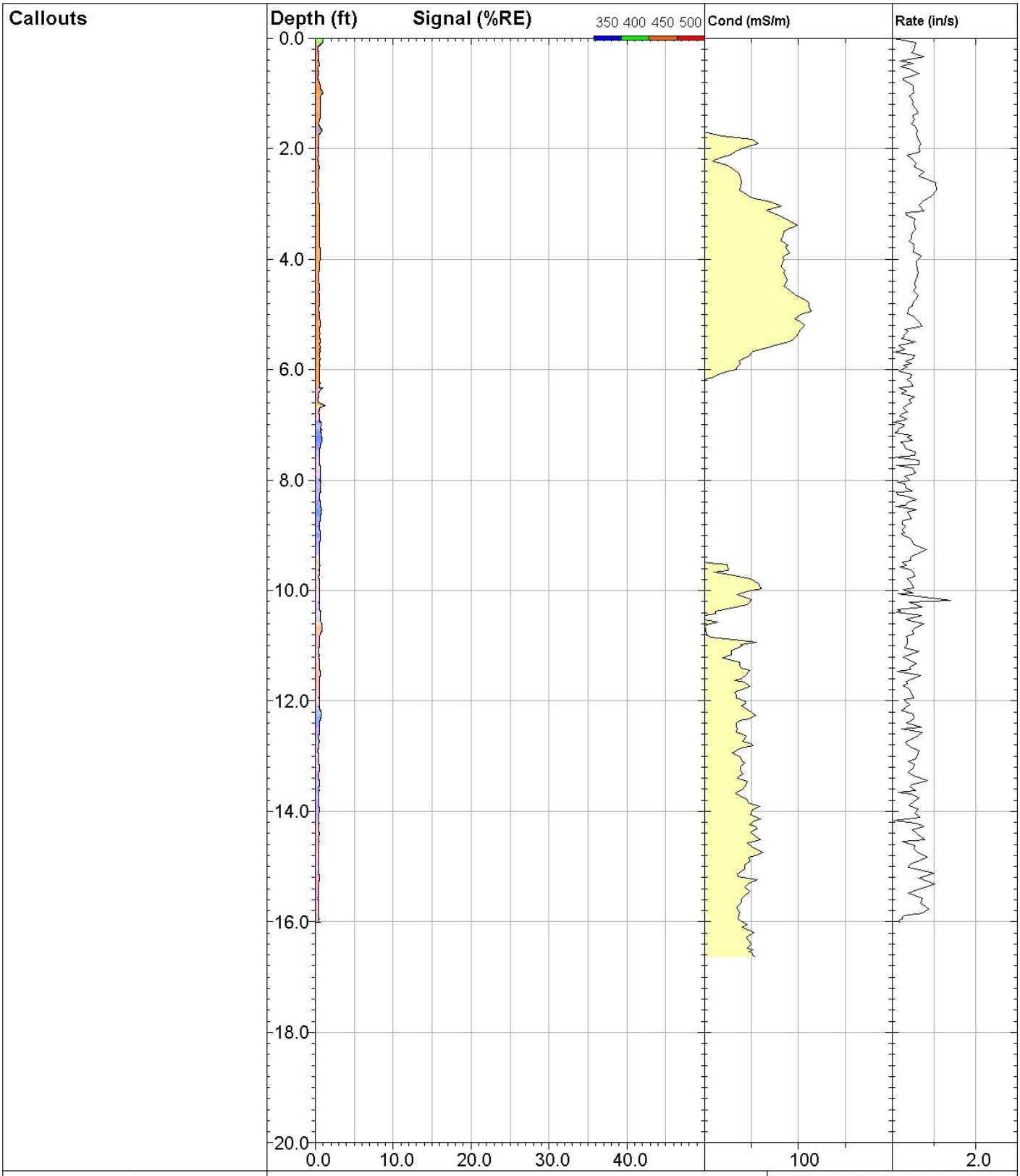
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **6.85 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.0 %RE @ 6.83 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 11:19 CDT**



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30-LIF

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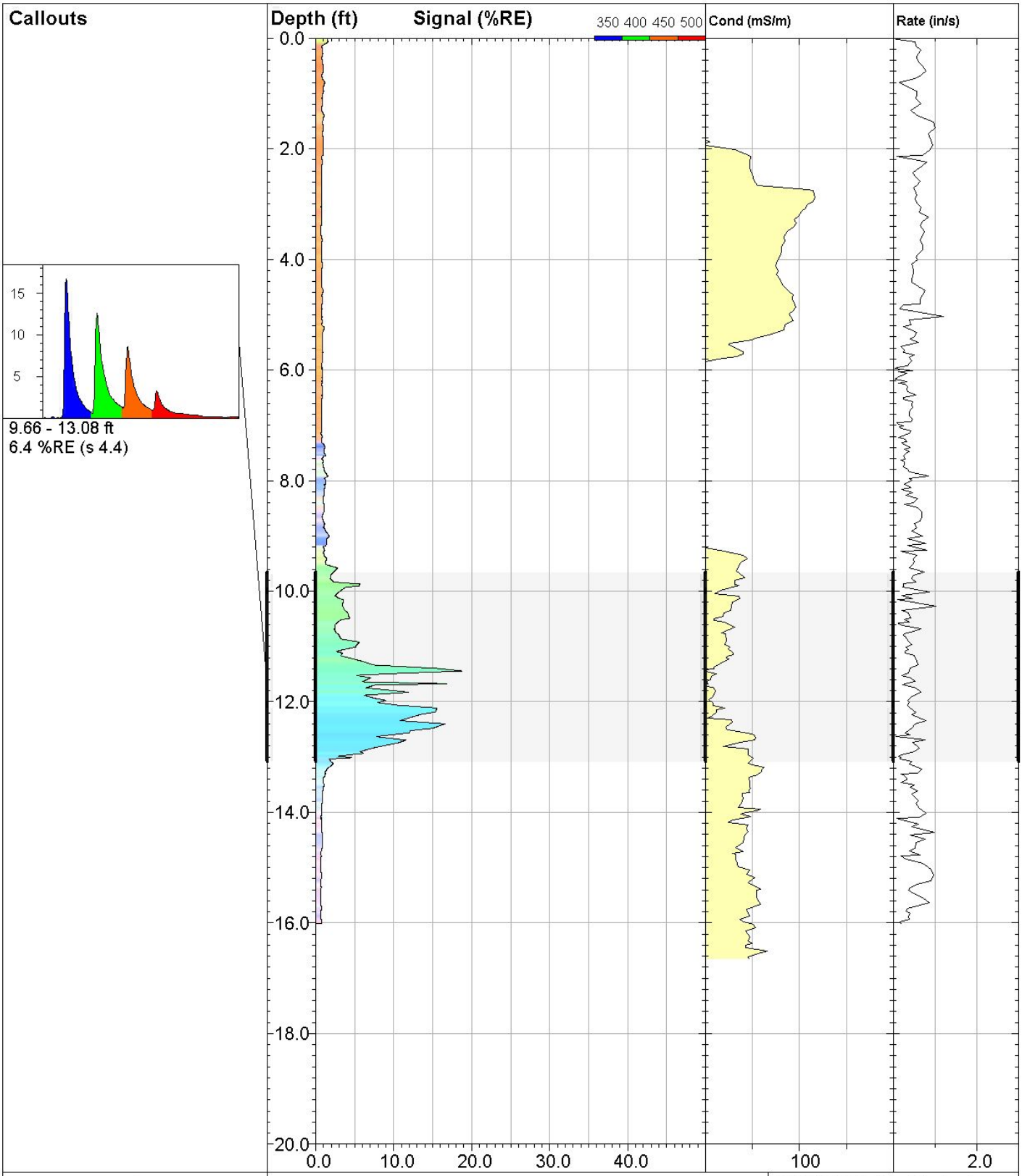
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.2 %RE @ 6.65 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 11:36 CDT**



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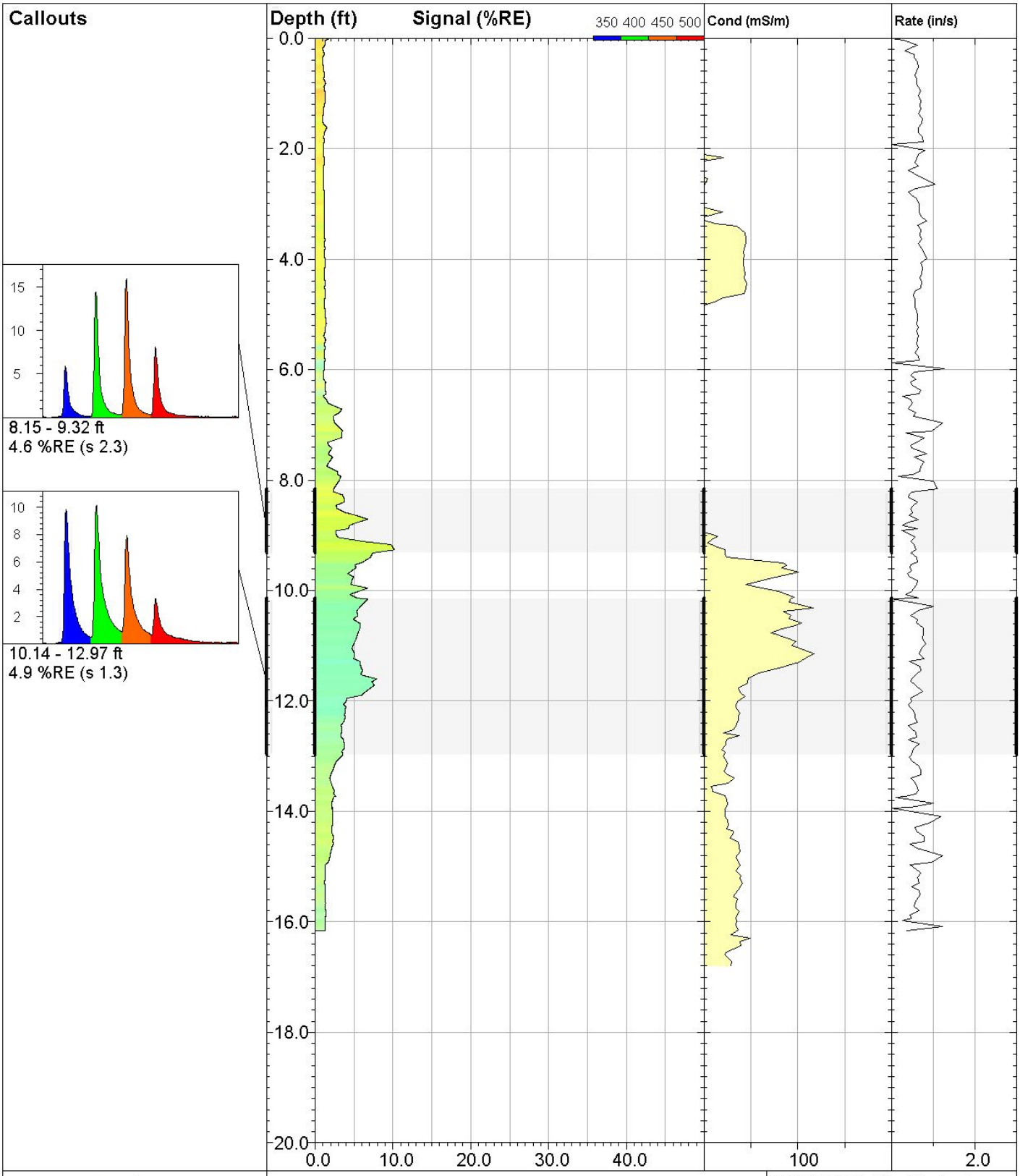
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.7 %RE @ 11.44 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 12:38 CDT**



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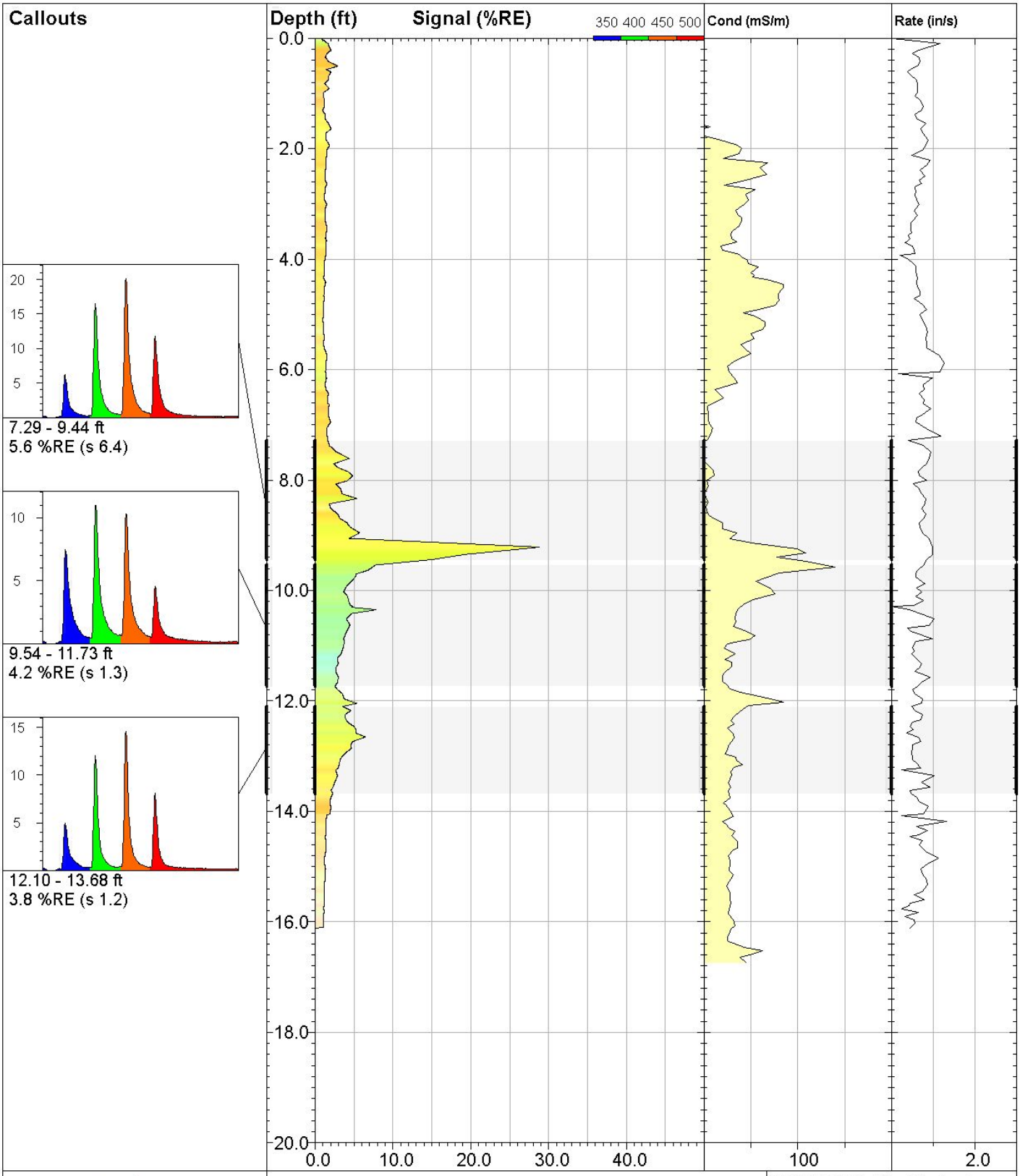
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.16 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **10.2 %RE @ 9.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 15:10 CDT**



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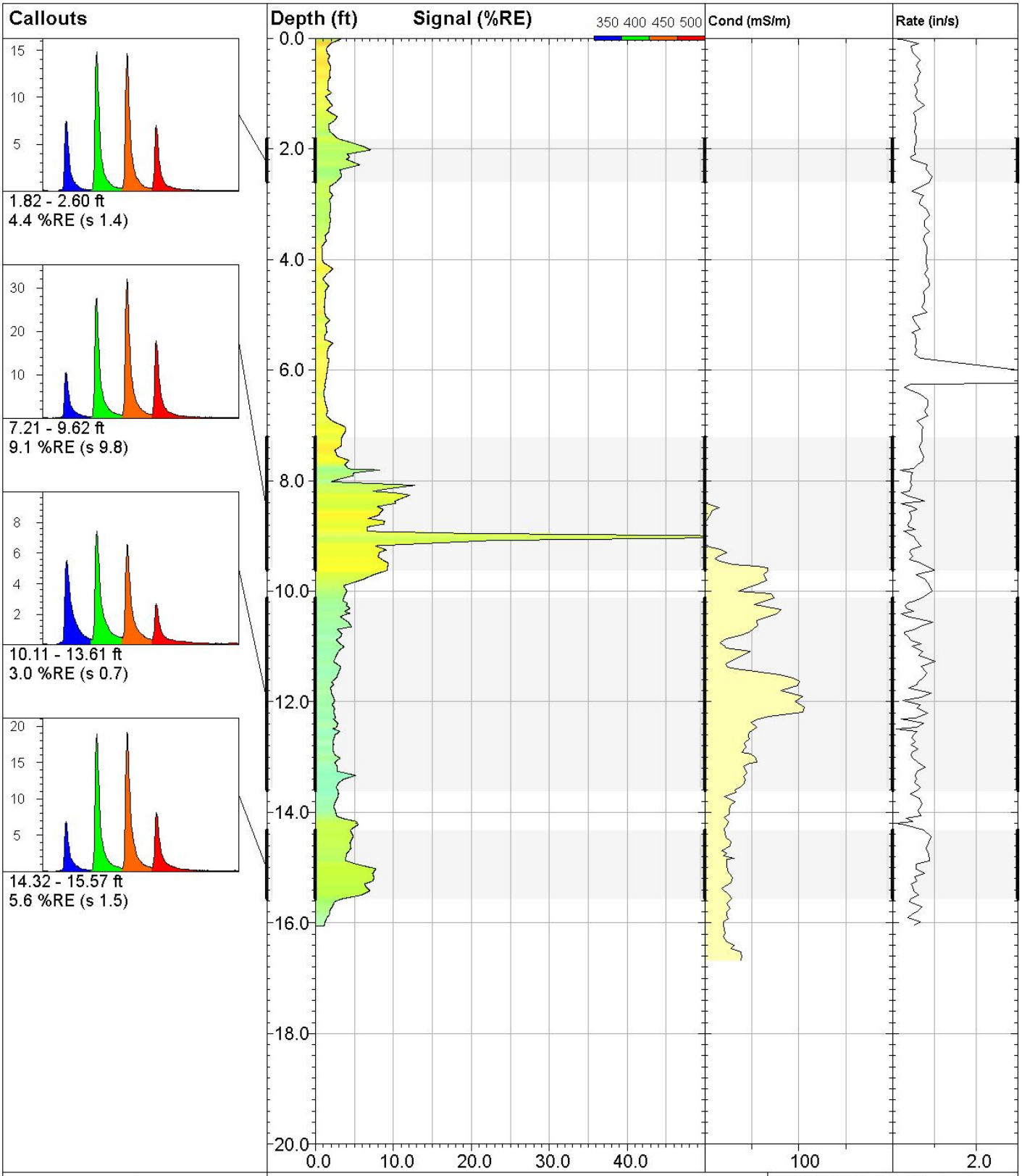
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.11 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **28.9 %RE @ 9.21 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 15:37 CDT**



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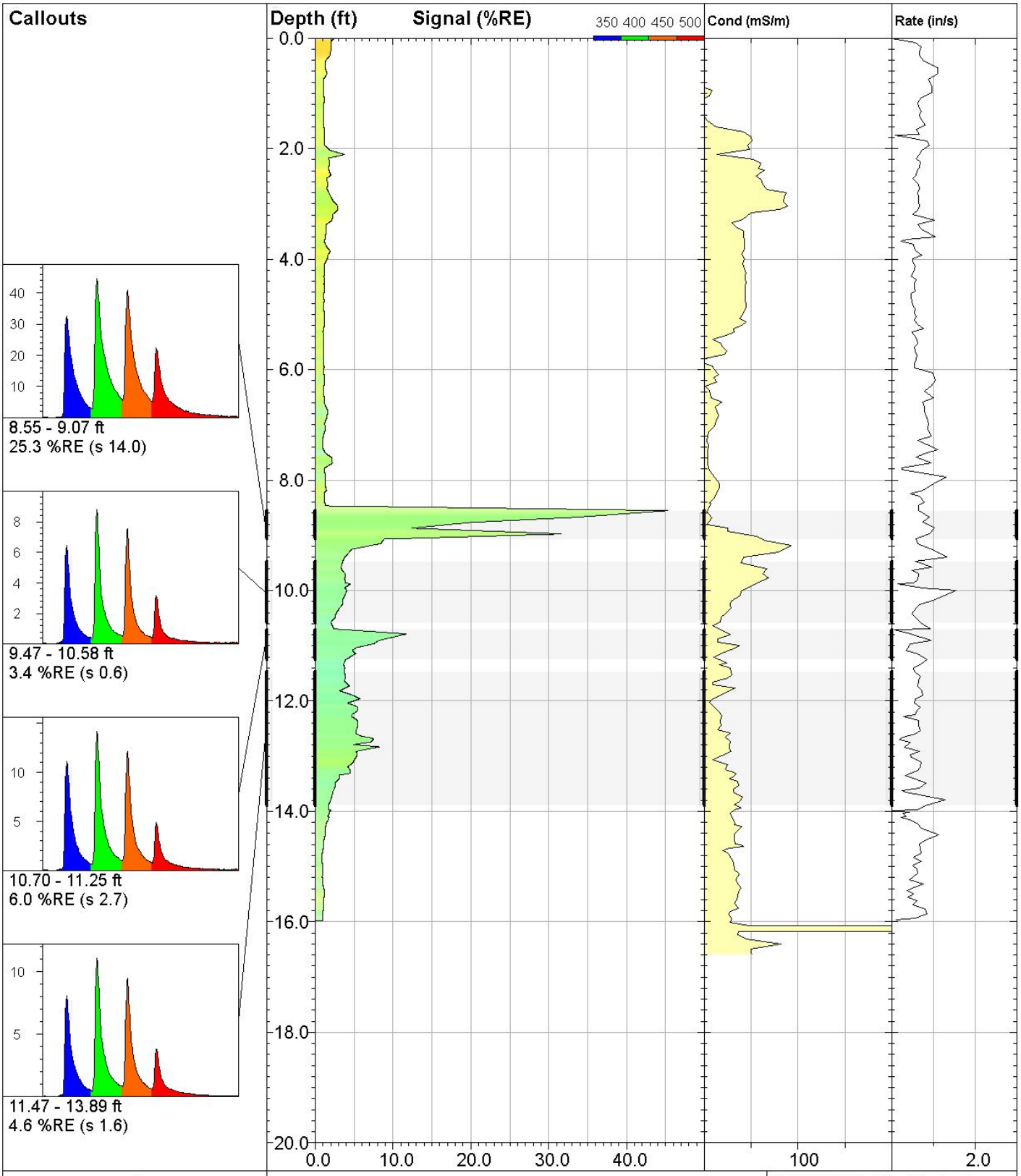
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.05 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **63.7 %RE @ 9.01 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 16:05 CDT**



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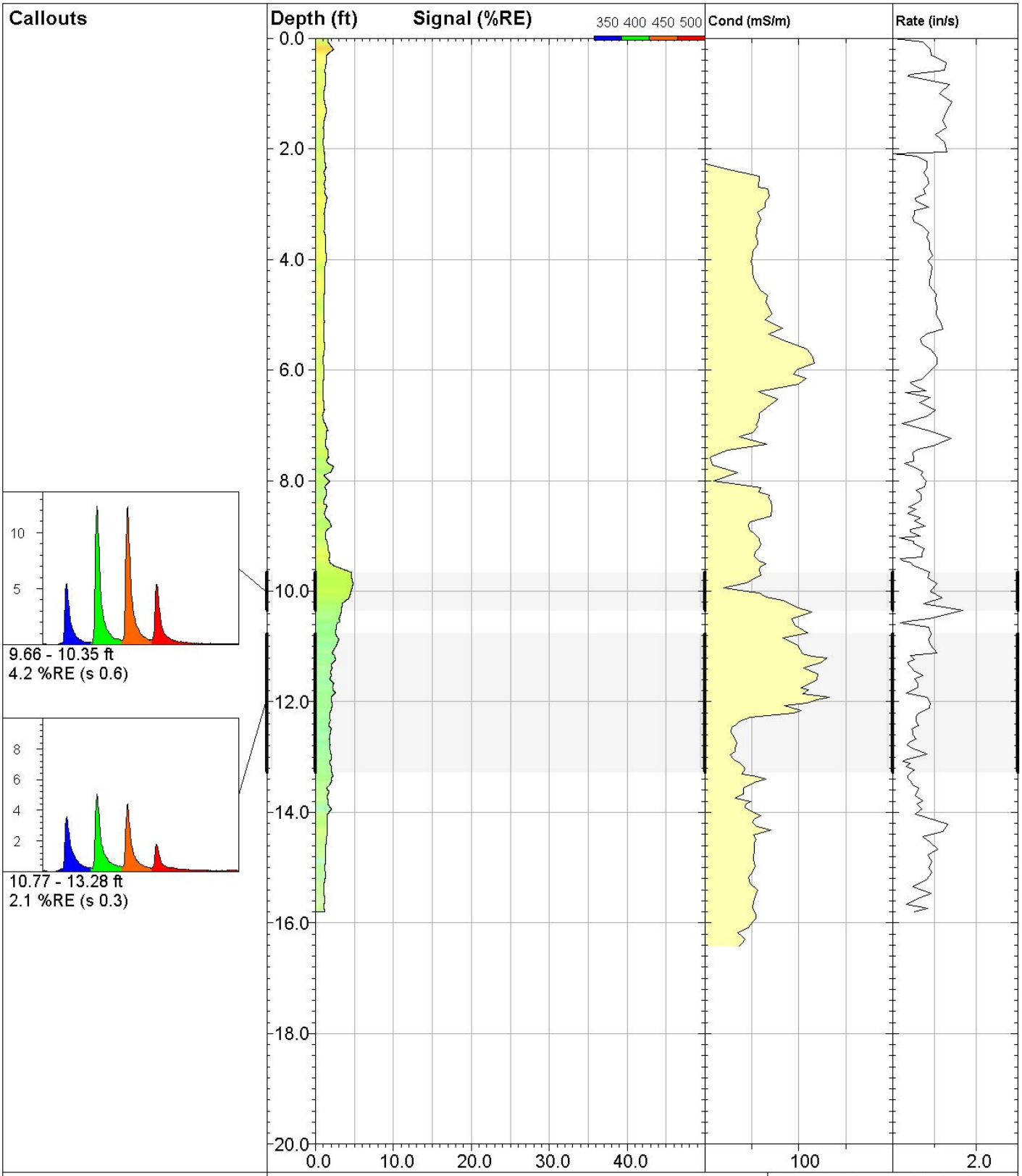
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.97 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **45.3 %RE @ 8.55 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 16:49 CDT**



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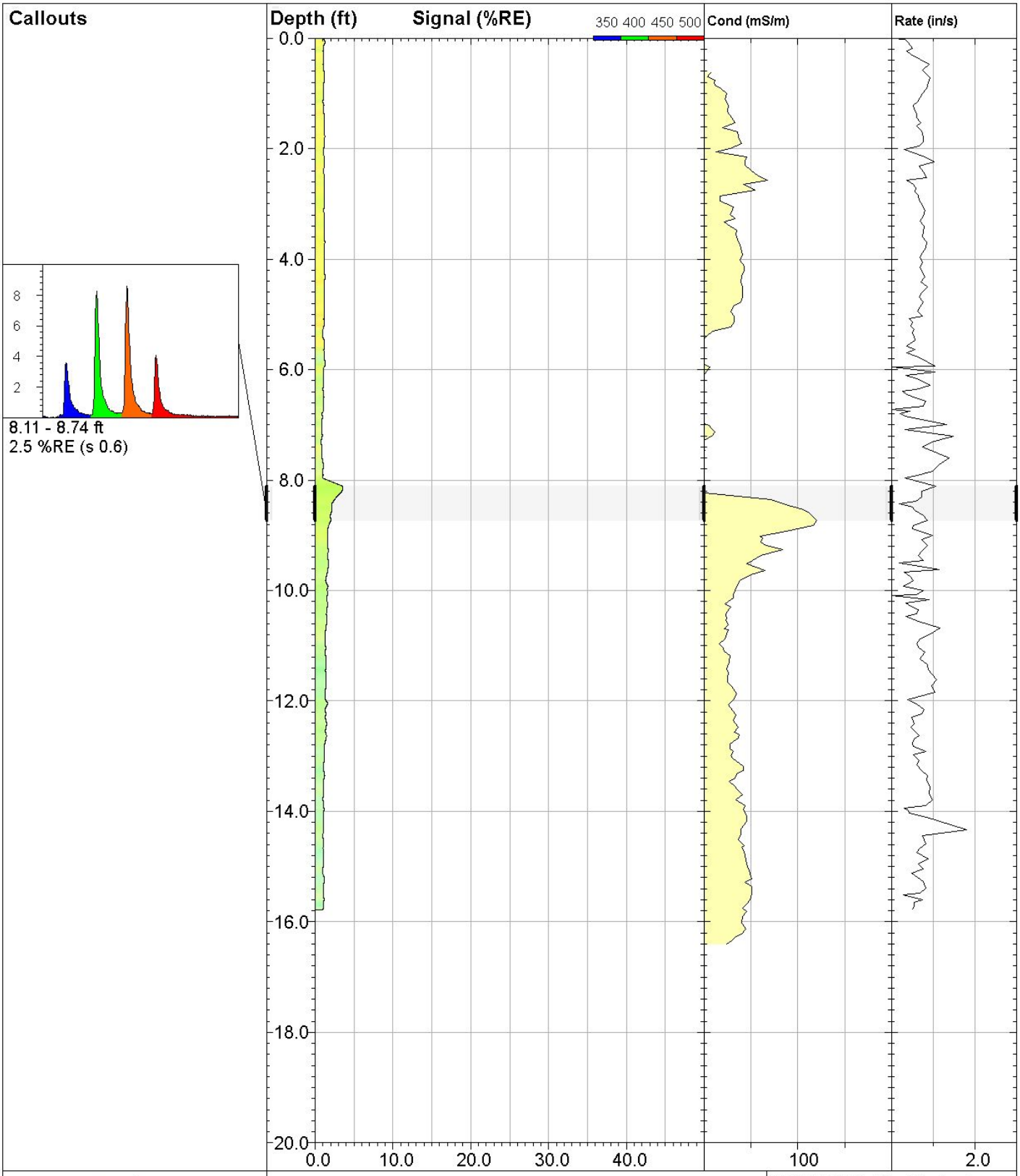
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.80 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.8 %RE @ 9.87 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 17:11 CDT**



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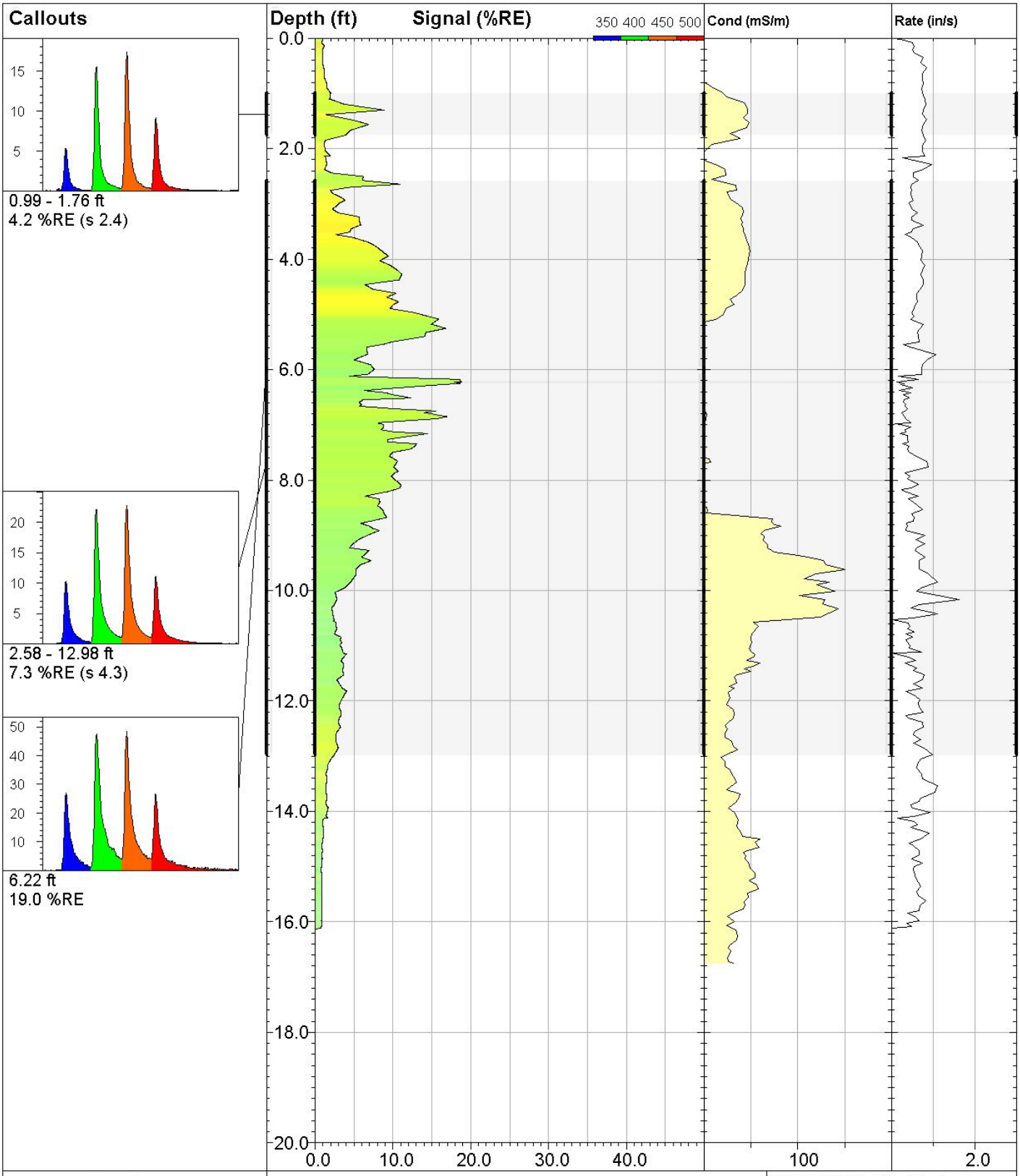
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.78 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.6 %RE @ 8.11 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 17:39 CDT**



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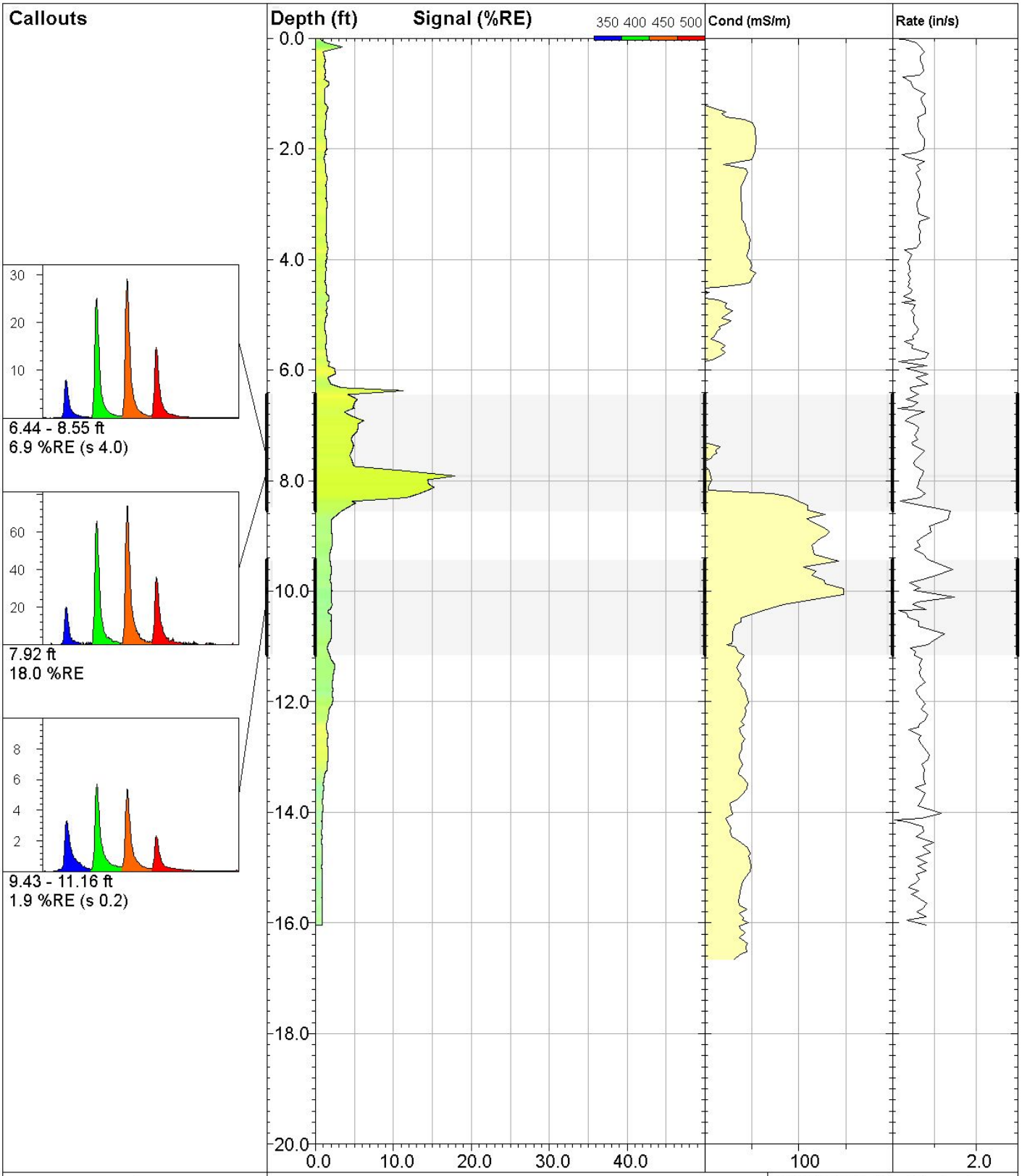
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.12 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **19.0 %RE @ 6.22 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 09:26 CDT**



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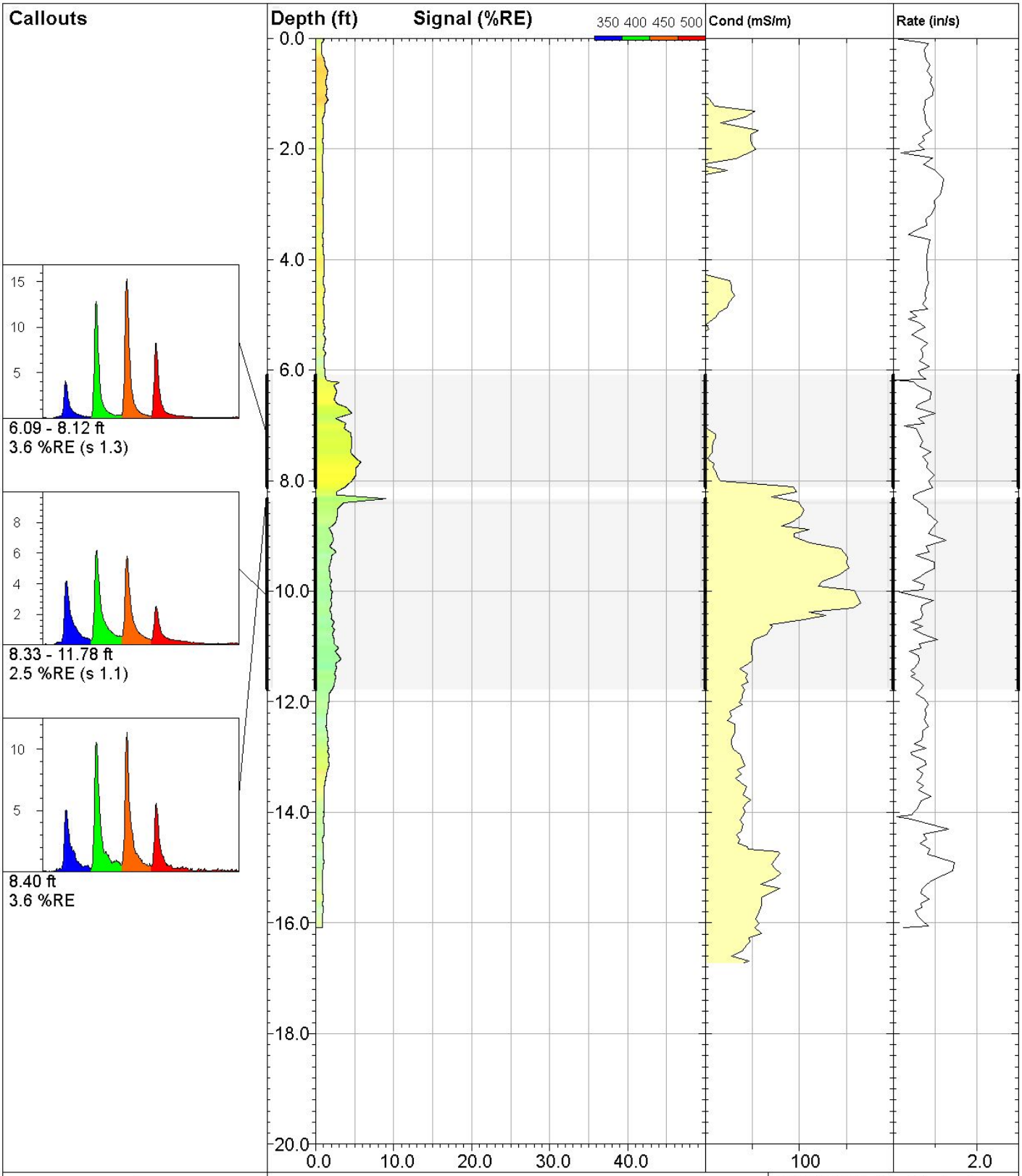
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.0 %RE @ 7.92 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 09:48 CDT**



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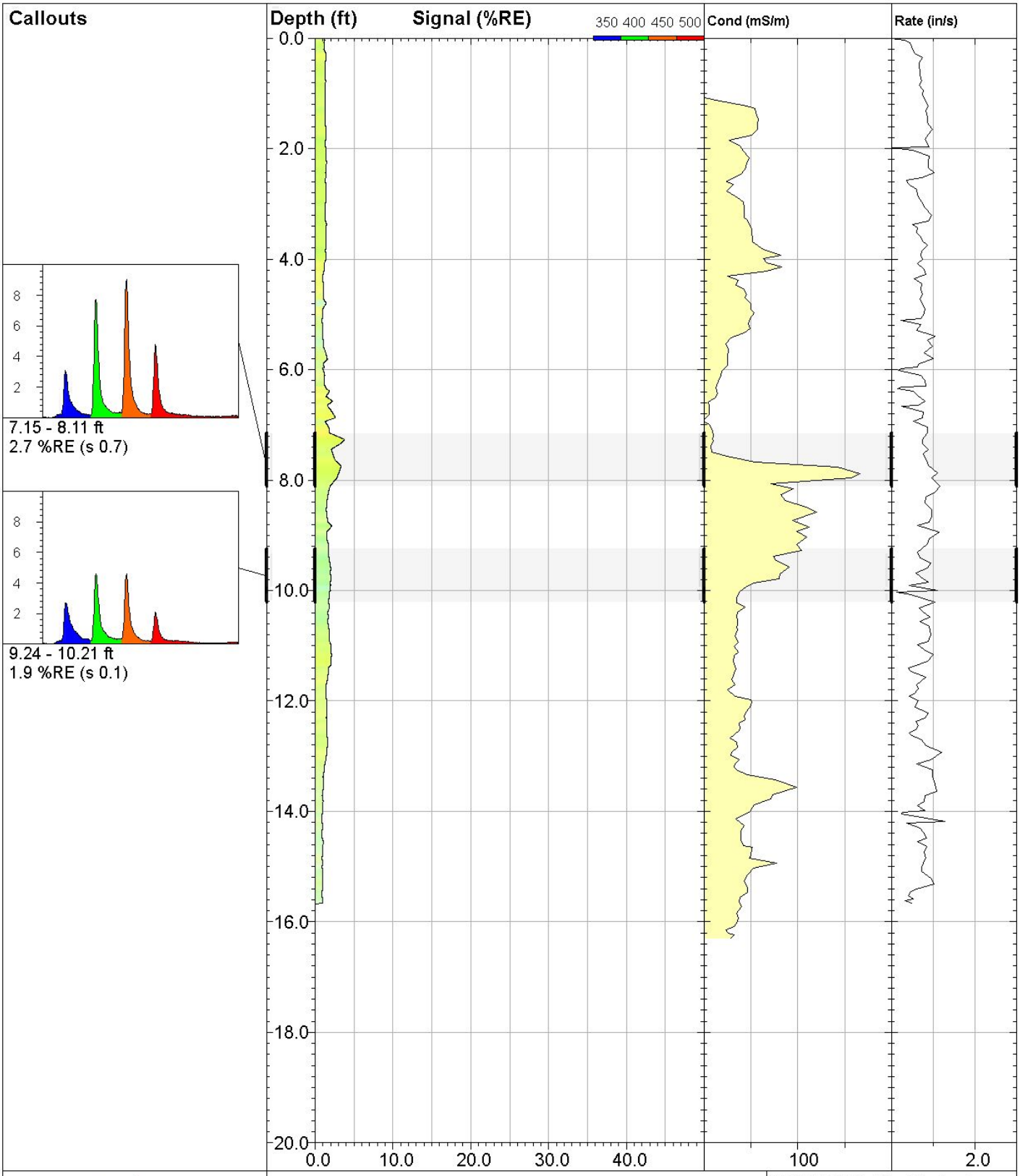
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **9.0 %RE @ 8.33 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 10:29 CDT**



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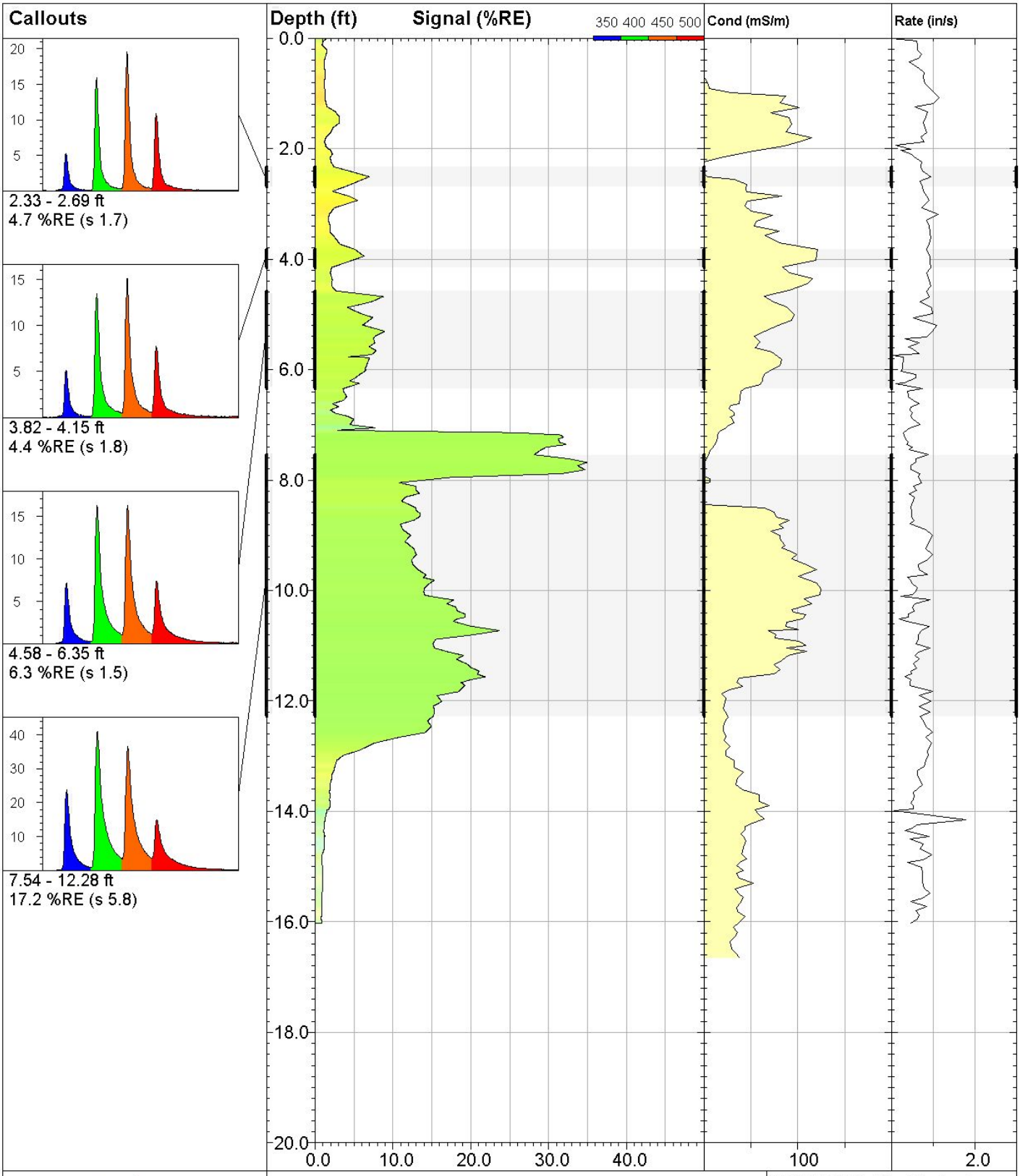
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.67 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.8 %RE @ 7.27 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 10:51 CDT**



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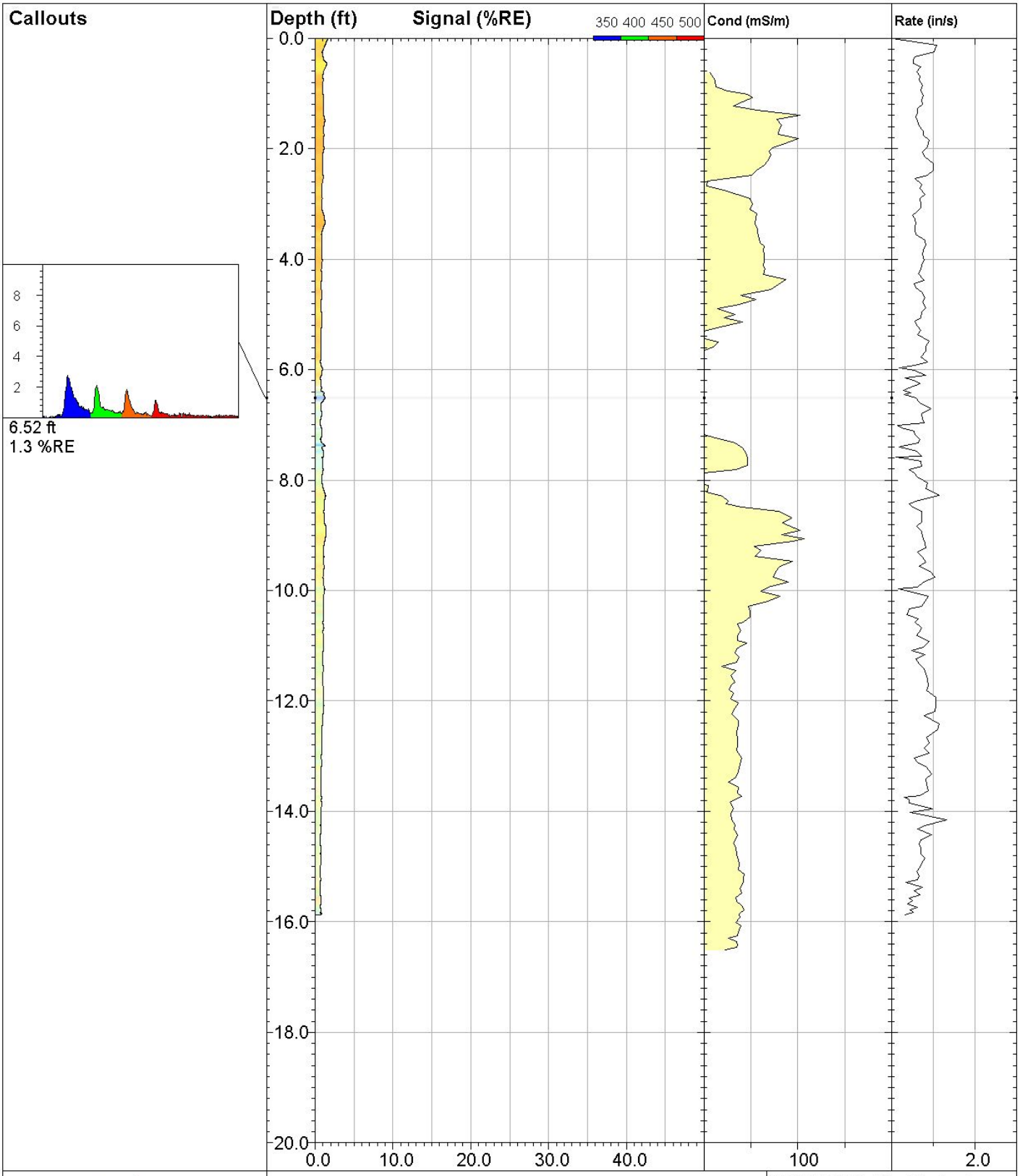
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **35.0 %RE @ 7.68 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 11:23 CDT**



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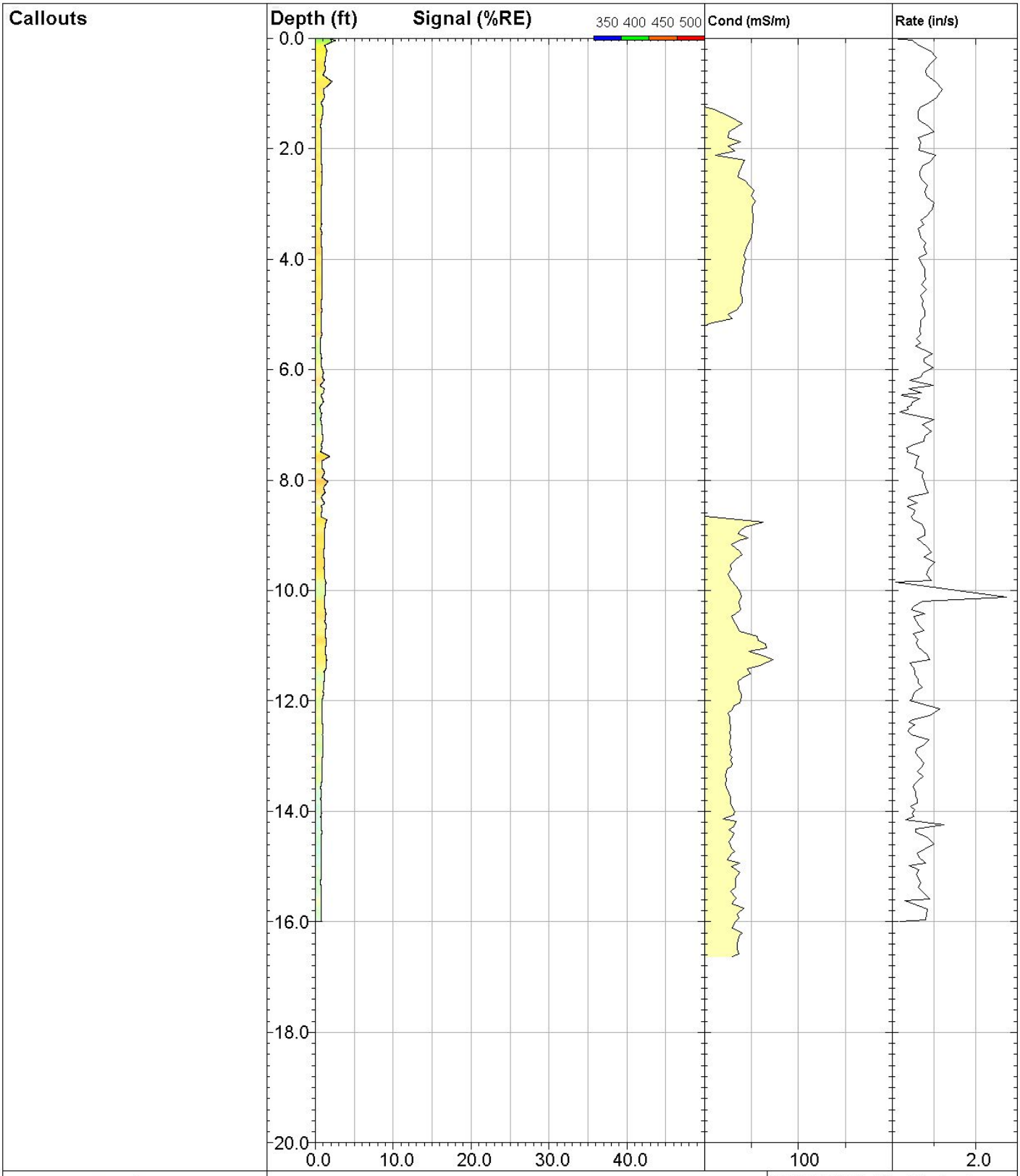
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.88 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.6 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 12:03 CDT**



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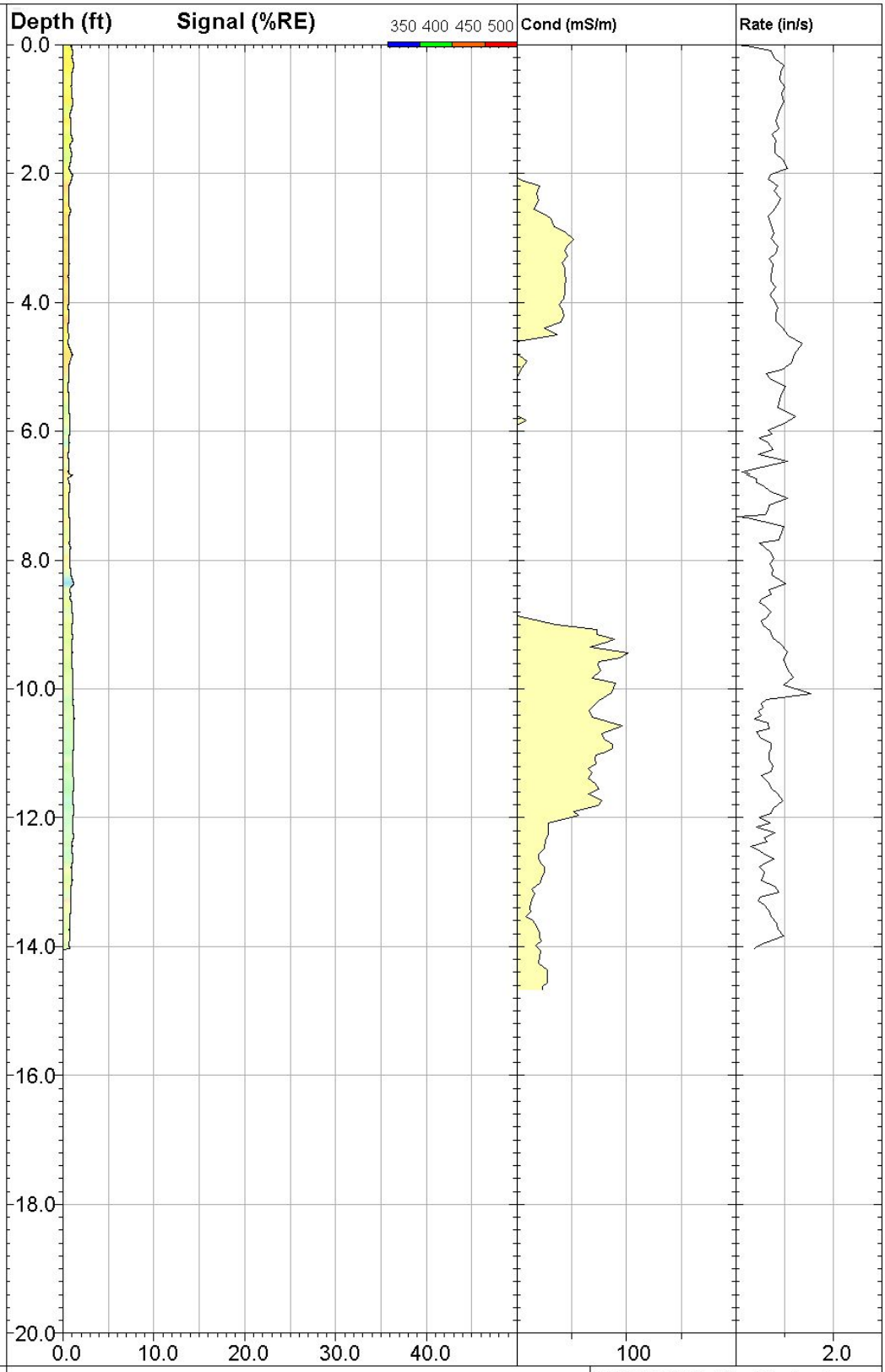
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.6 %RE @ 0.04 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 13:34 CDT**

Callouts
preprobe hit refusal just past 14.5ft



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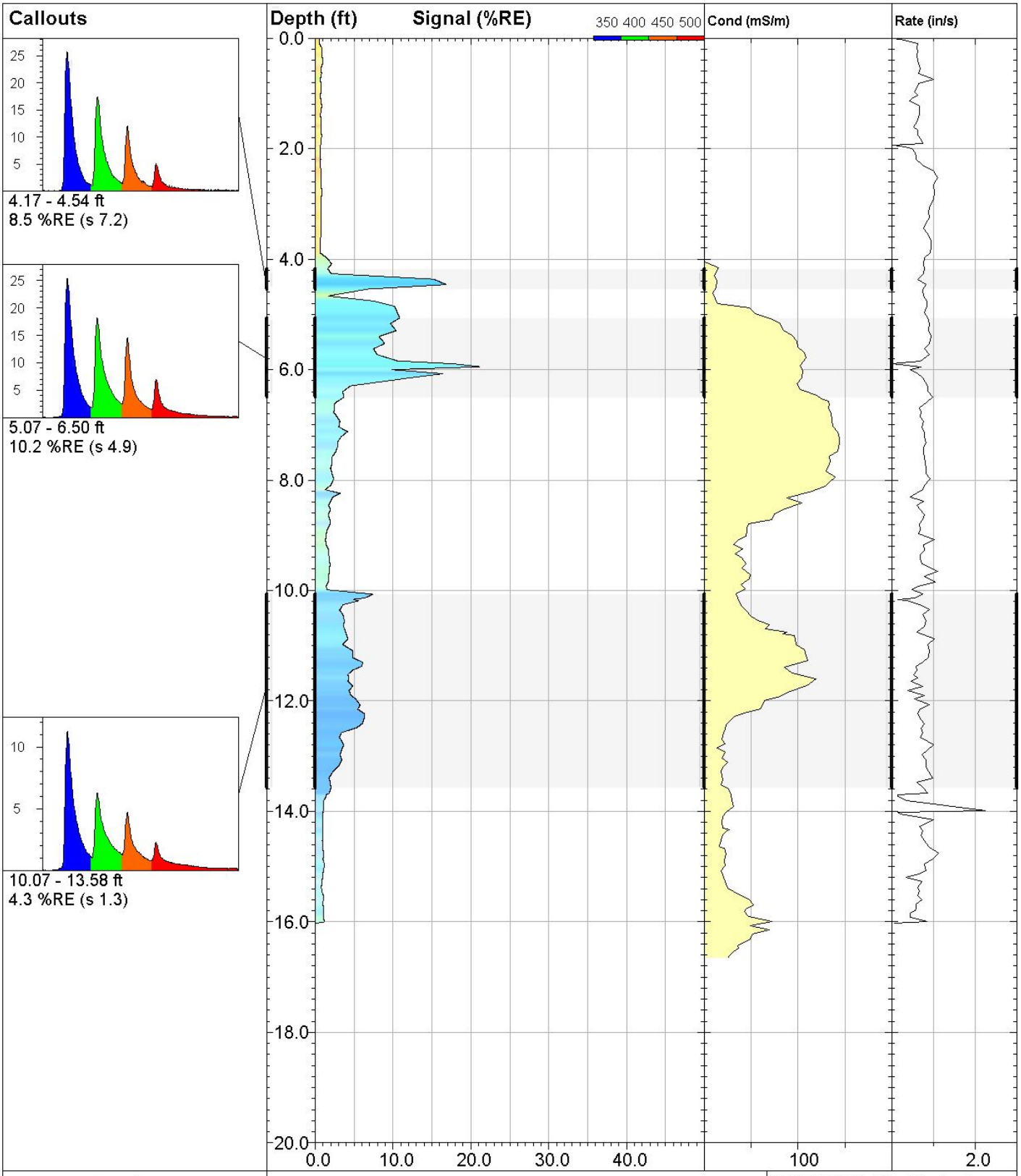
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.2 %RE @ 10.46 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 13:52 CDT**



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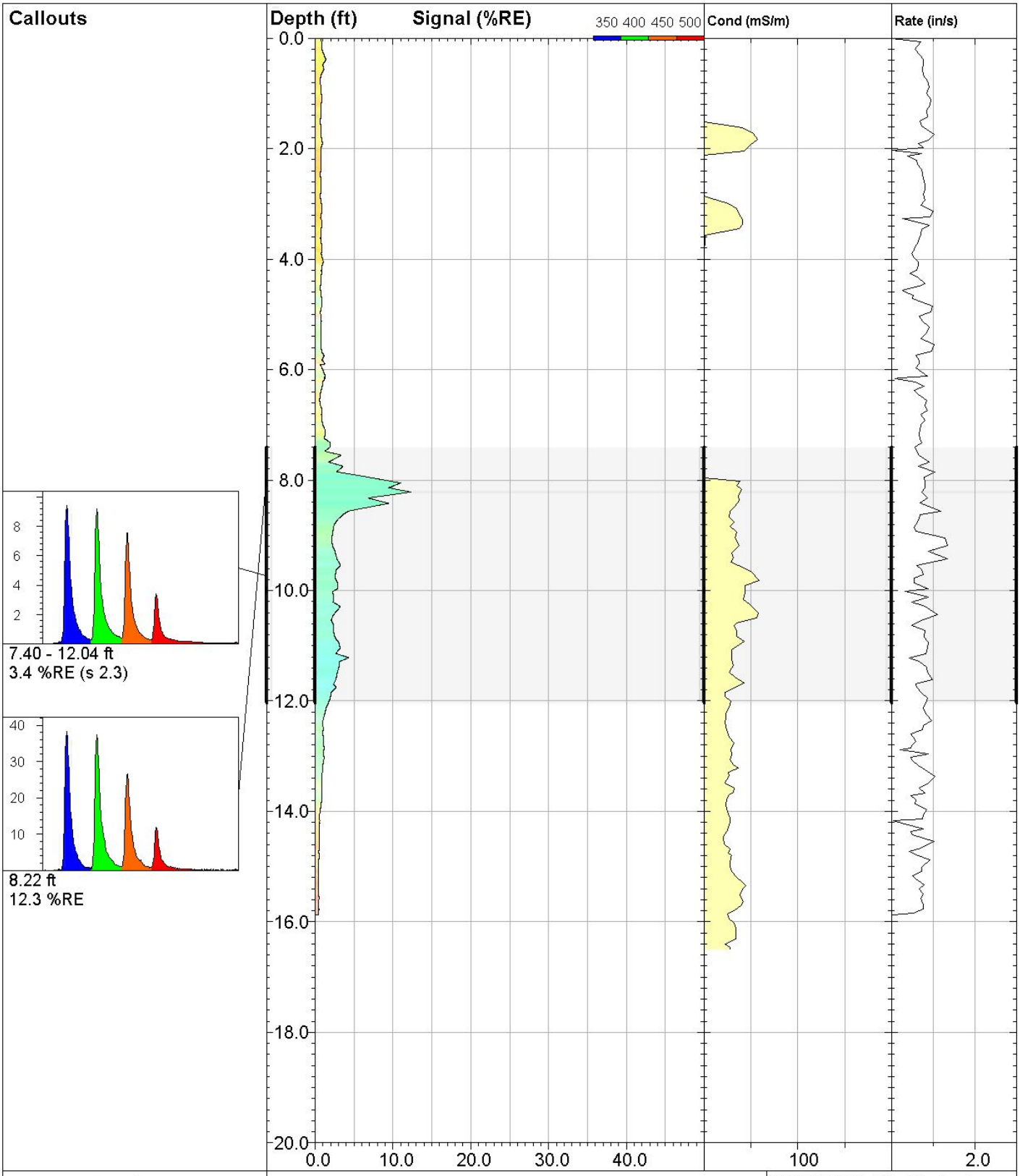
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **21.2 %RE @ 5.95 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 14:25 CDT**



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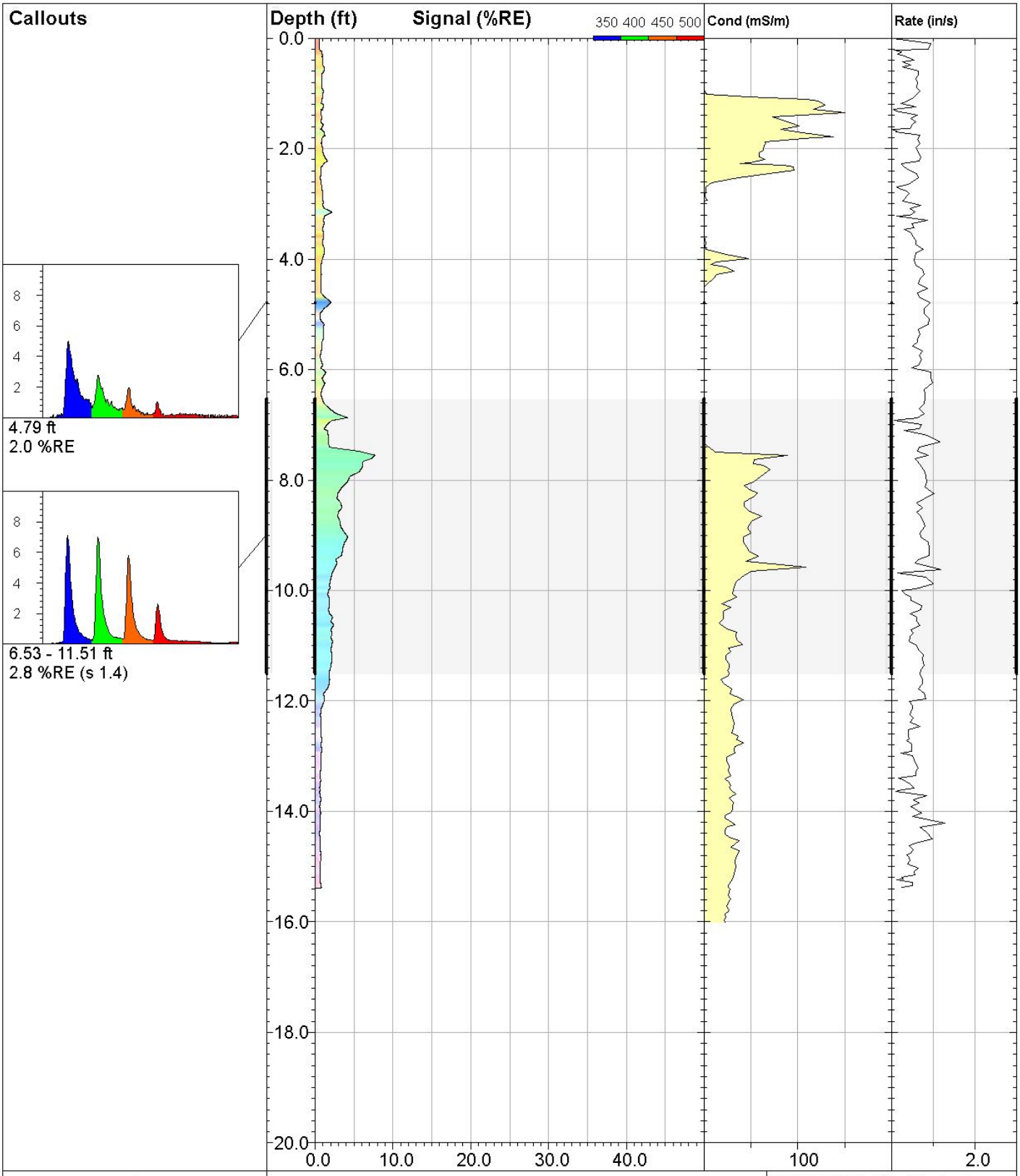
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.87 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.3 %RE @ 8.22 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 14:54 CDT**



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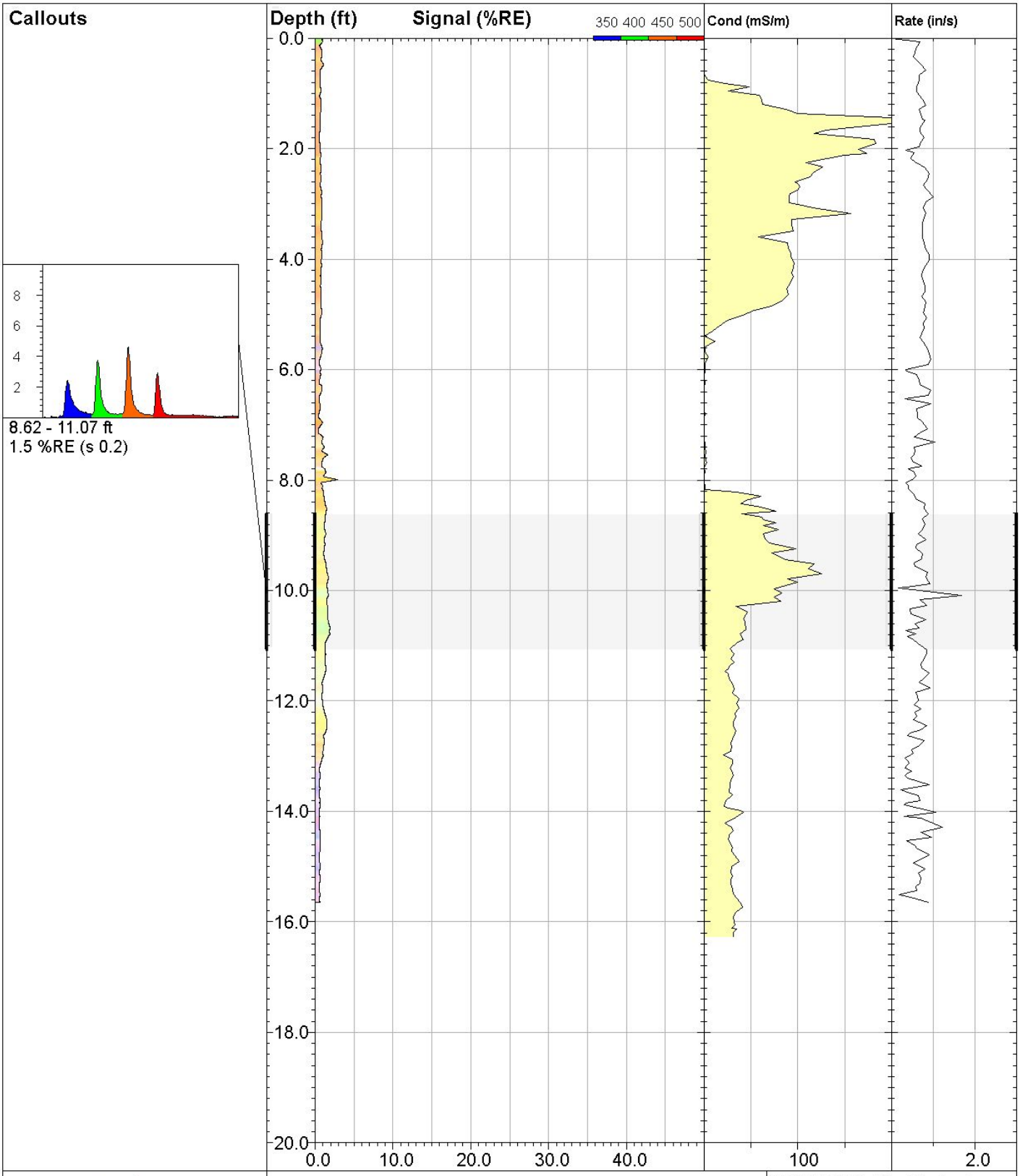
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.39 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **7.7 %RE @ 7.55 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 16:55 CDT**



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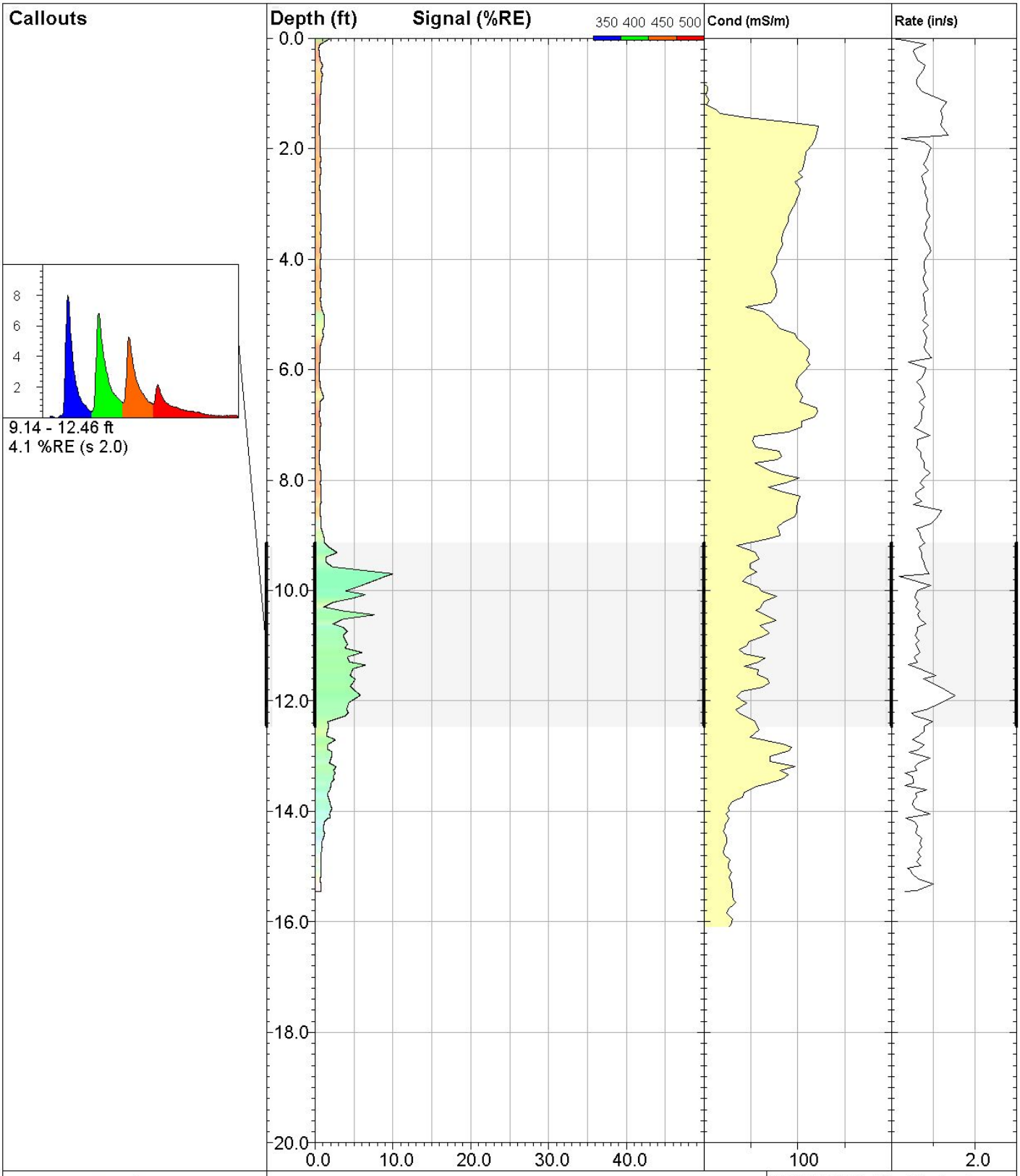
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.65 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.9 %RE @ 7.99 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 17:20 CDT**



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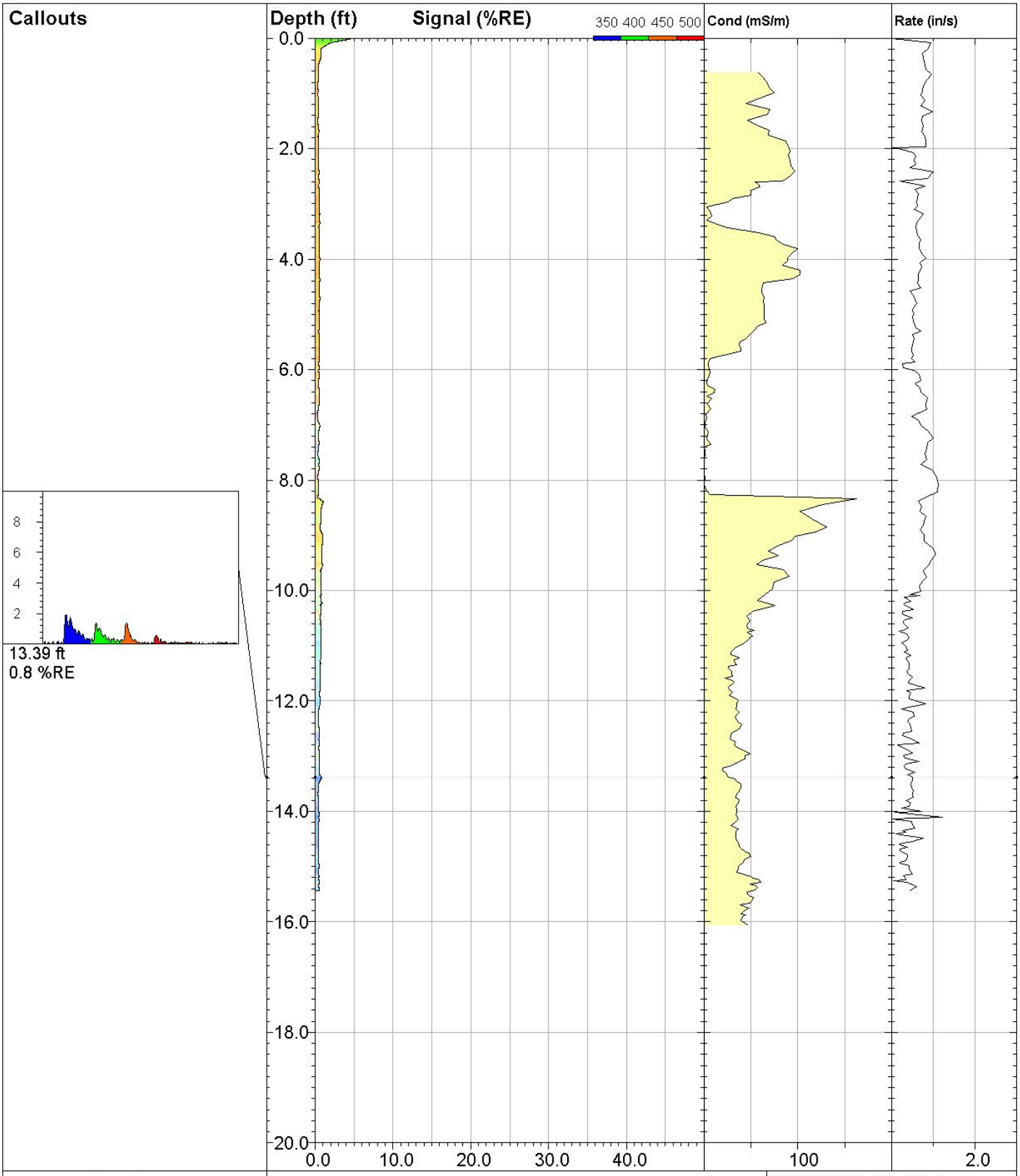
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.46 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **10.0 %RE @ 9.70 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 17:44 CDT**



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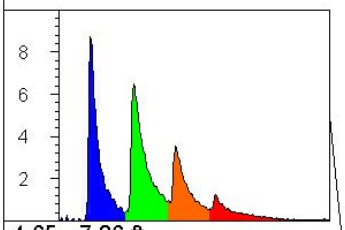
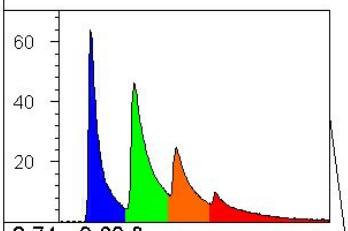
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.43 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.0 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 09:28 CDT**

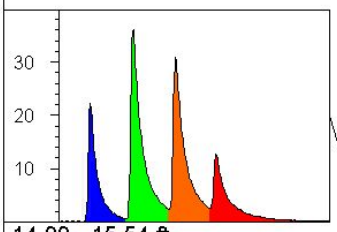
Callouts



4.65 - 7.86 ft
3.0 %RE (s 2.5)

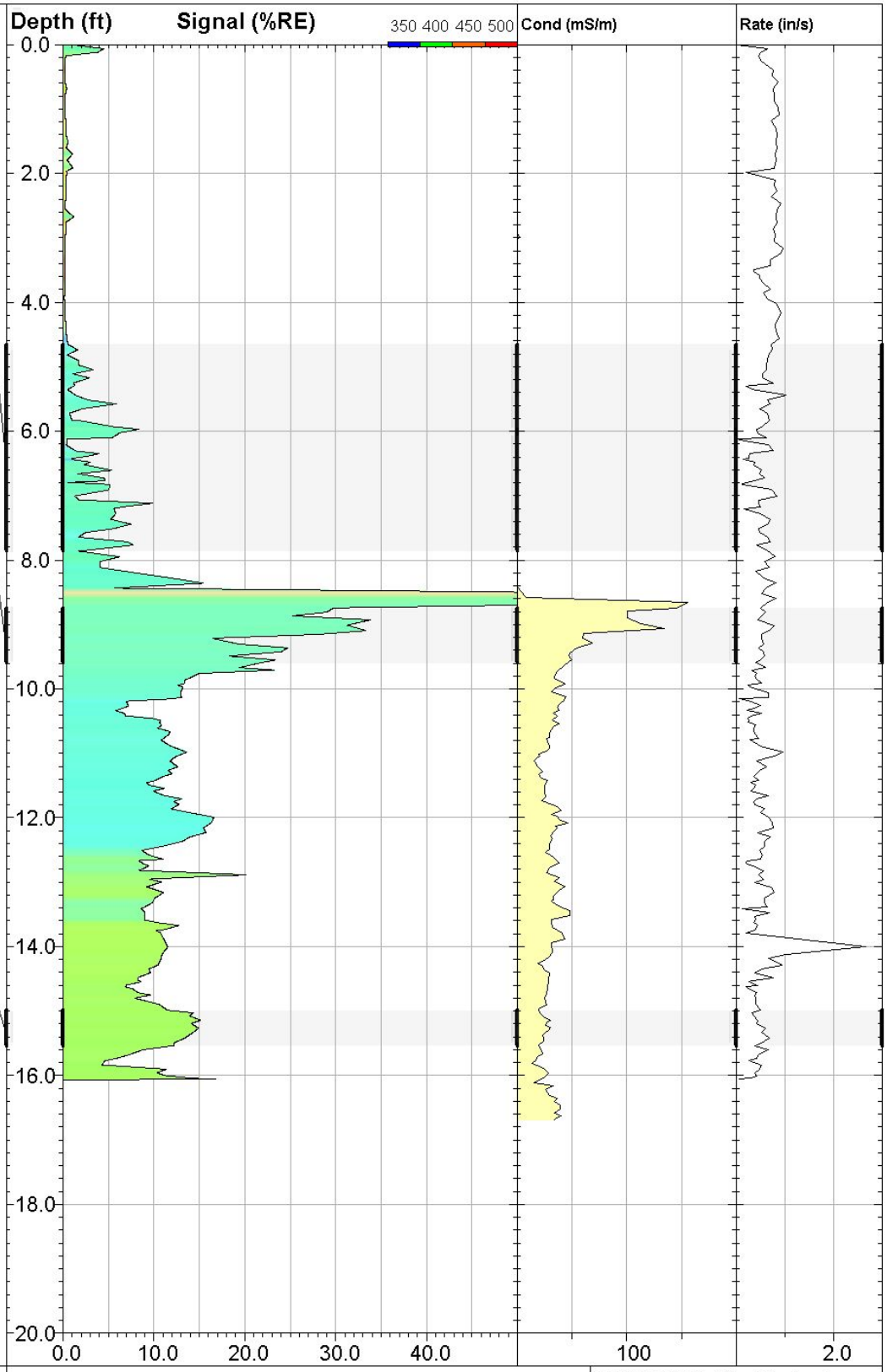


8.74 - 9.60 ft
25.6 %RE (s 5.5)



14.99 - 15.54 ft
13.6 %RE (s 1.2)

BORING REACHED THE END OF PILOT HOLE.



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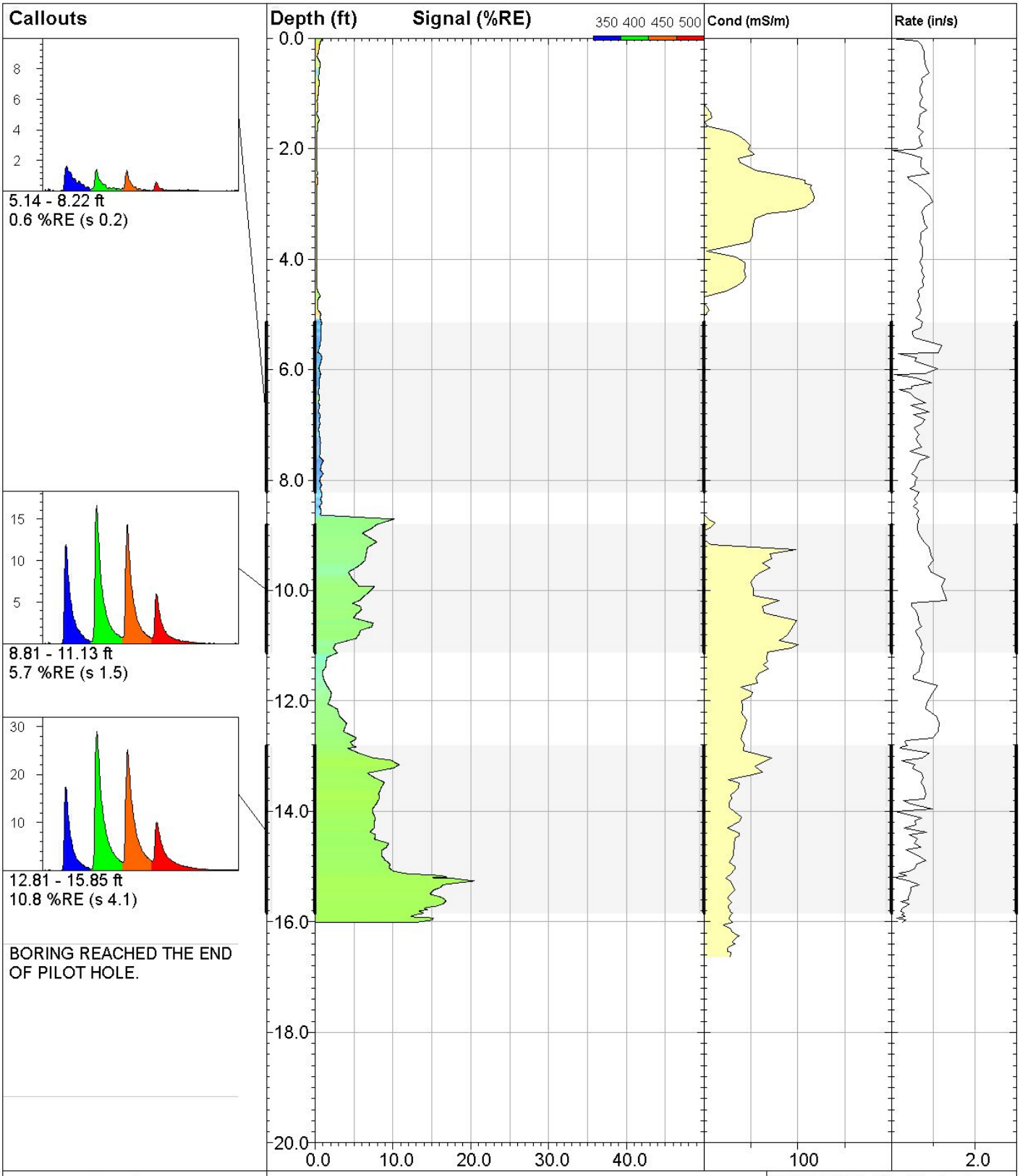
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.06 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **127.9 %RE @ 8.60 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 10:03 CDT**



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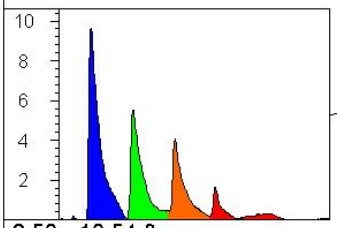
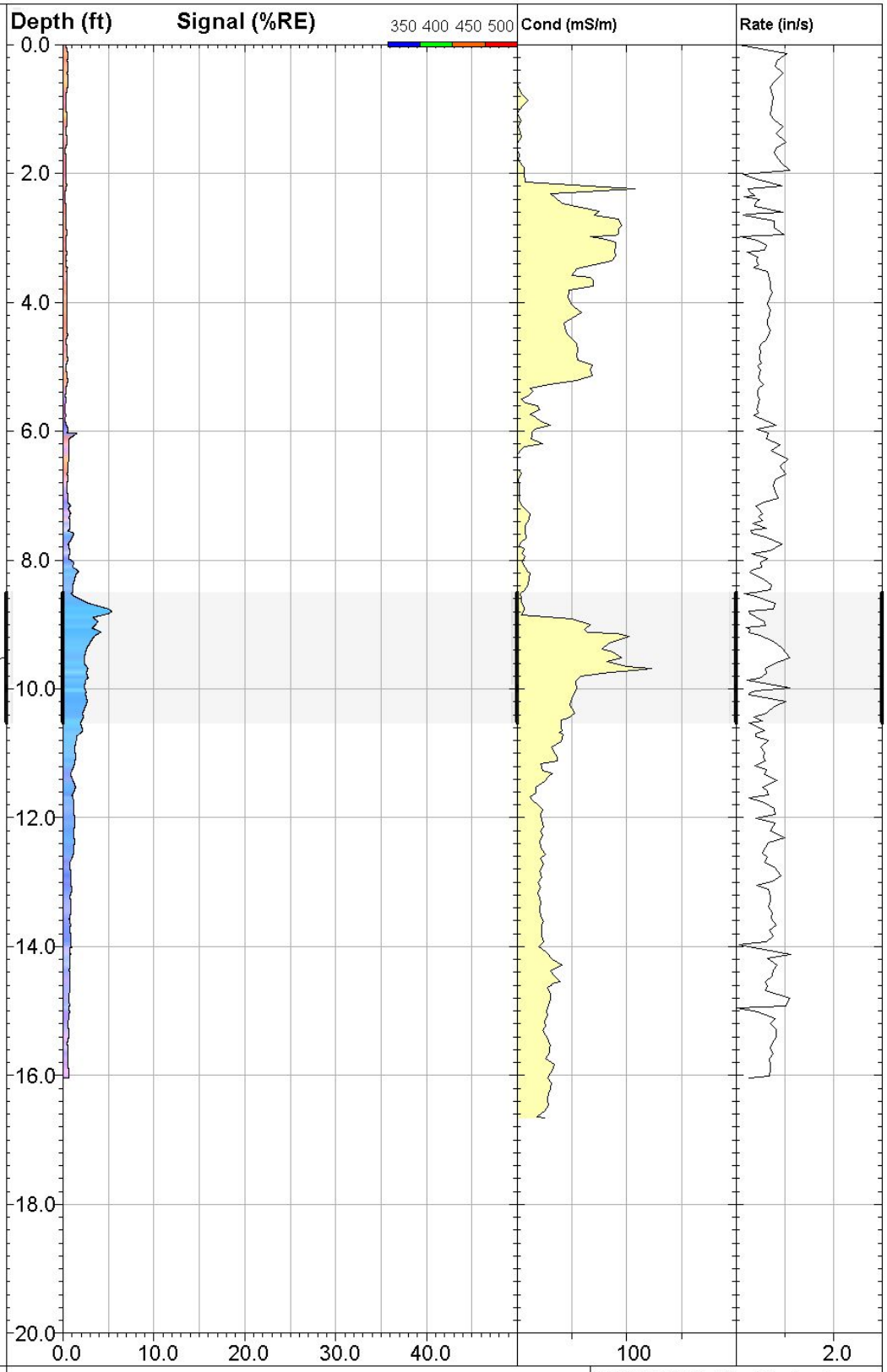
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **20.4 %RE @ 15.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 10:37 CDT**

Callouts



8.50 - 10.54 ft
2.8 %RE (s 1.0)

BORING REACHED THE END OF PILOT HOLE.



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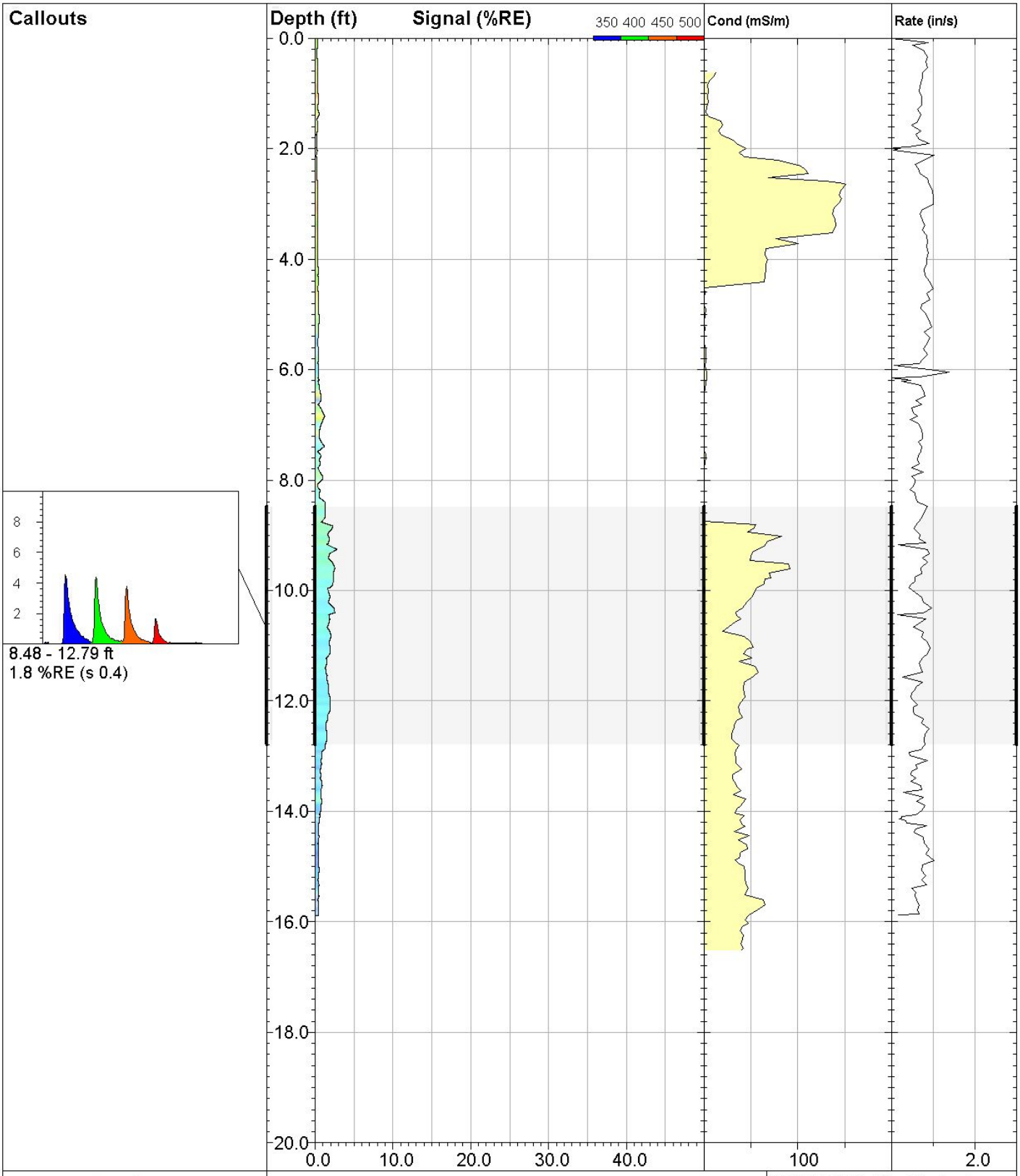
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.3 %RE @ 8.80 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 11:05 CDT**



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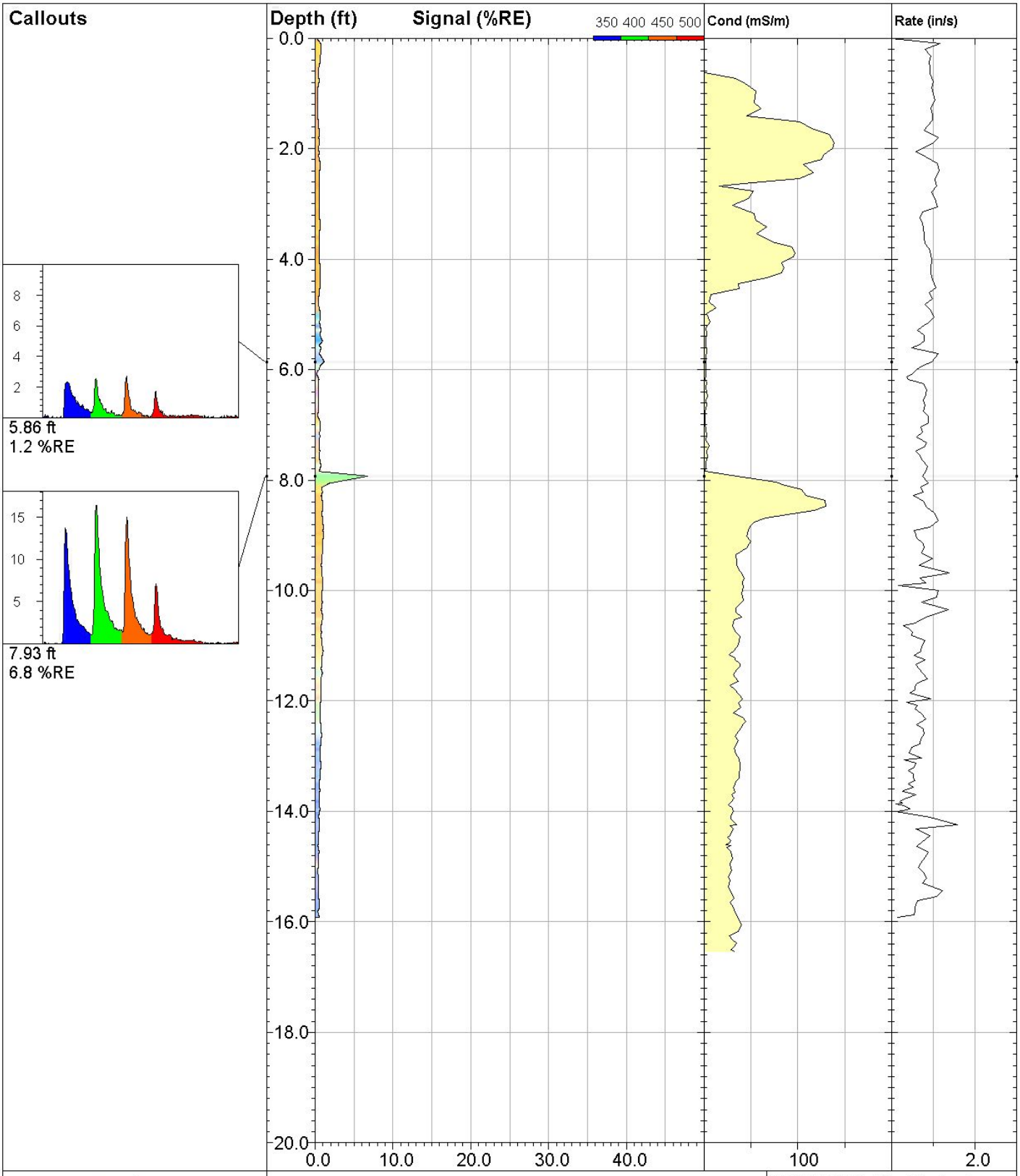
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.89 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.8 %RE @ 9.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 11:41 CDT**



56-LIF		**UVOST® By Dakota** www.DakotaTechnologies.com
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.92 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.8 %RE @ 7.93 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 12:24 CDT**

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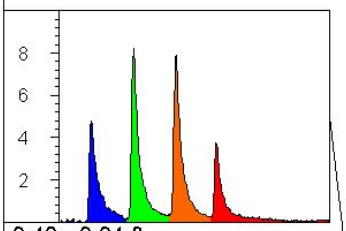
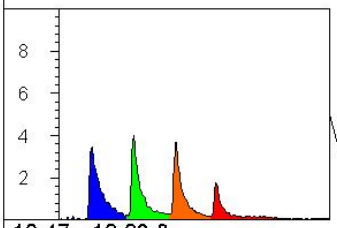
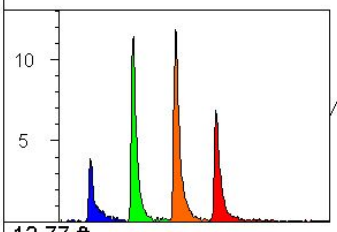
Callouts



9.40 - 9.94 ft
3.1 %RE (s 0.4)

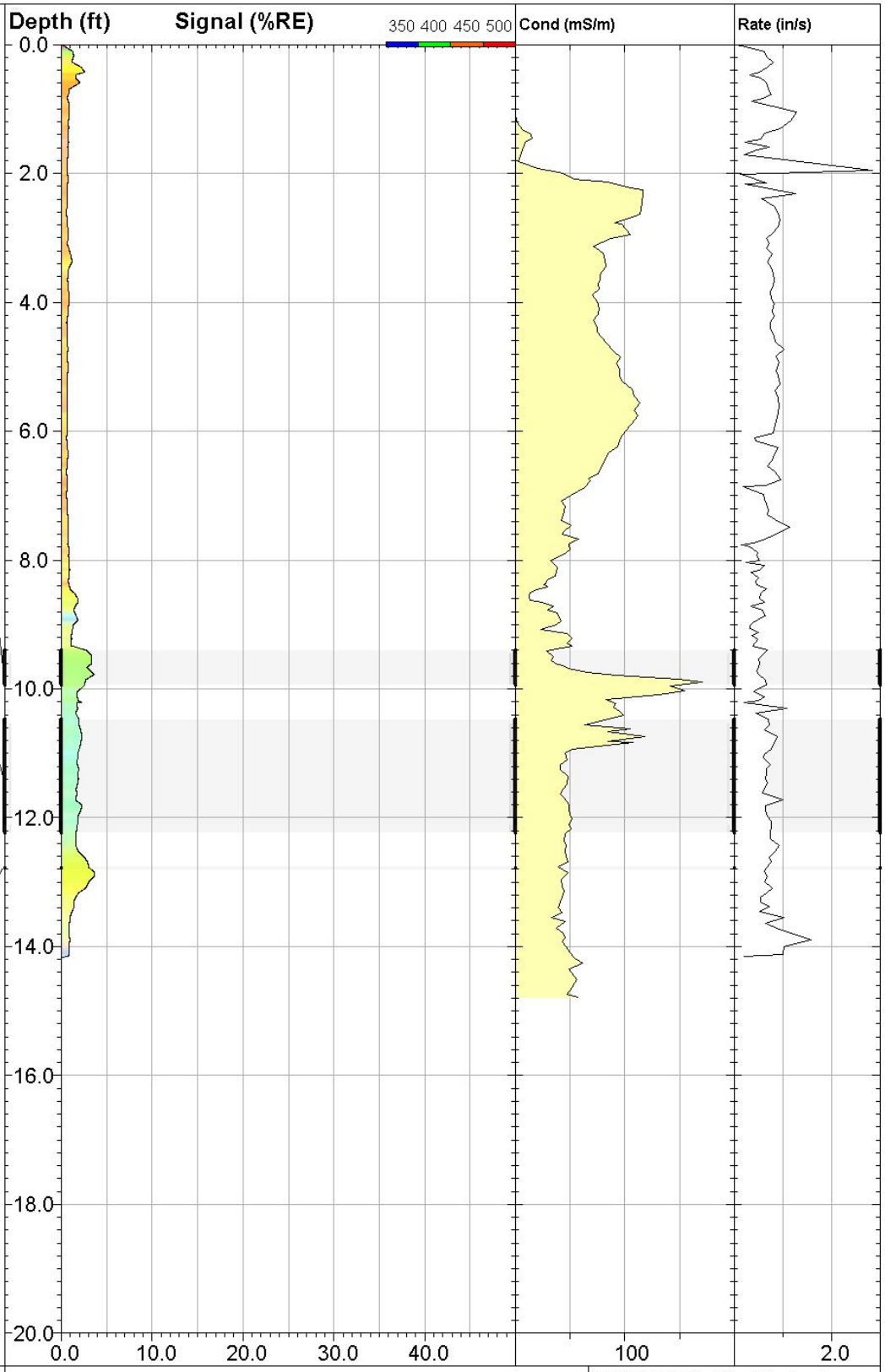


10.47 - 12.23 ft
1.9 %RE (s 0.2)



12.77 ft
3.0 %RE

BORING COMPLETED TO
END OF PREPROBE



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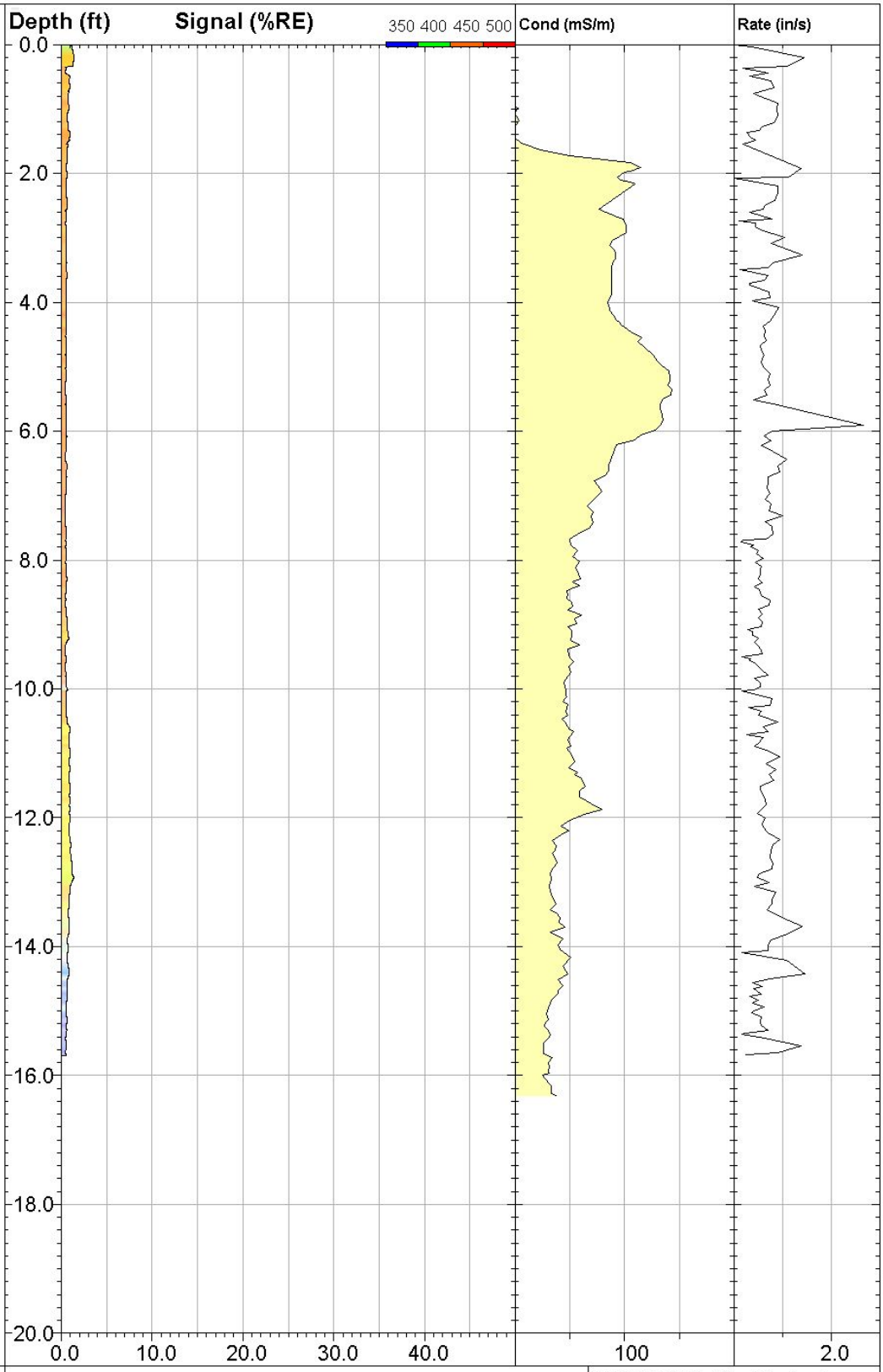
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.16 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.6 %RE @ 9.78 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 14:11 CDT**

Callouts
BORING COMPLETED TO END OF PREPROBE



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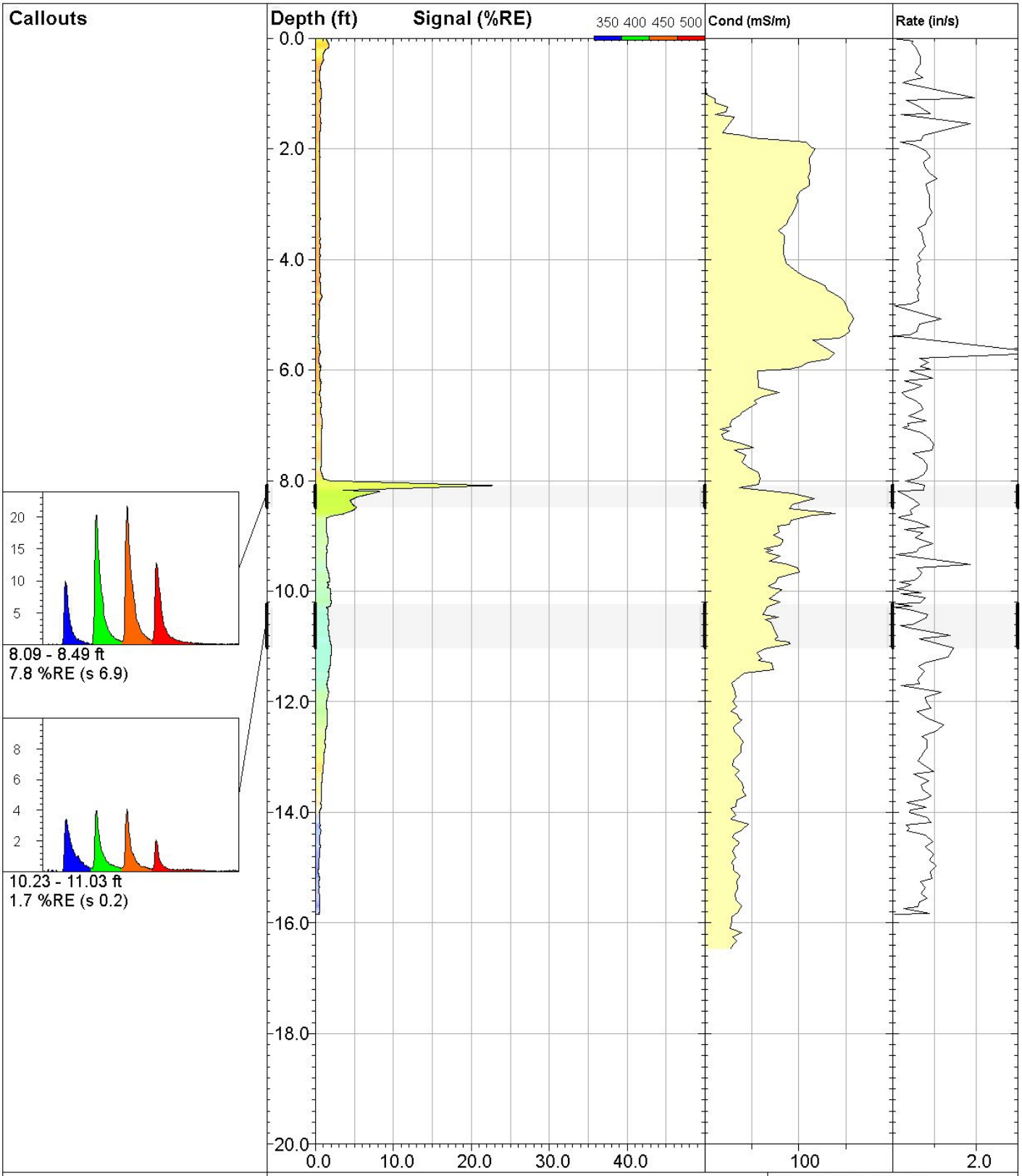
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.70 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 15.70 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 14:31 CDT**



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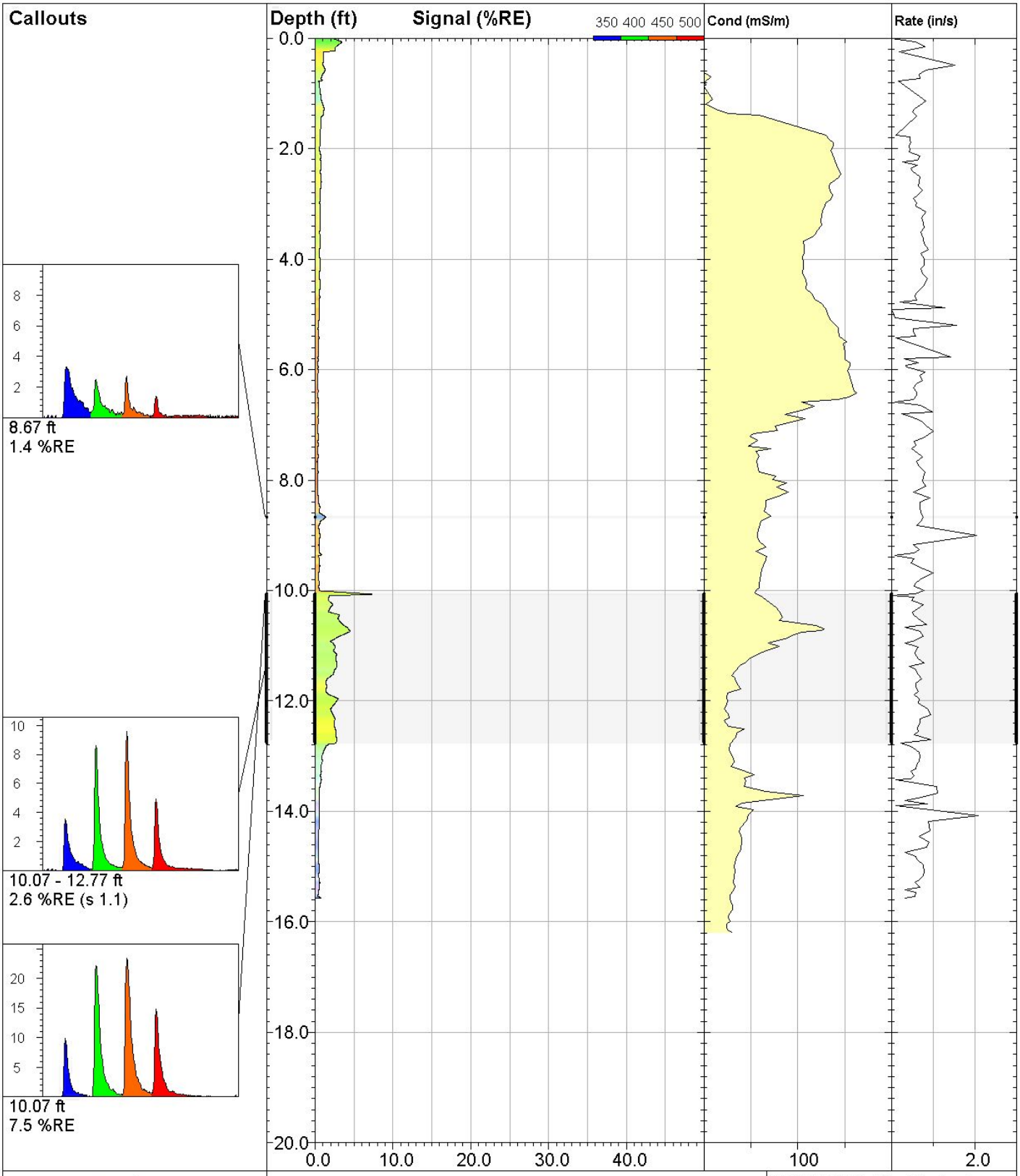
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.85 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **22.9 %RE @ 8.09 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 15:03 CDT**



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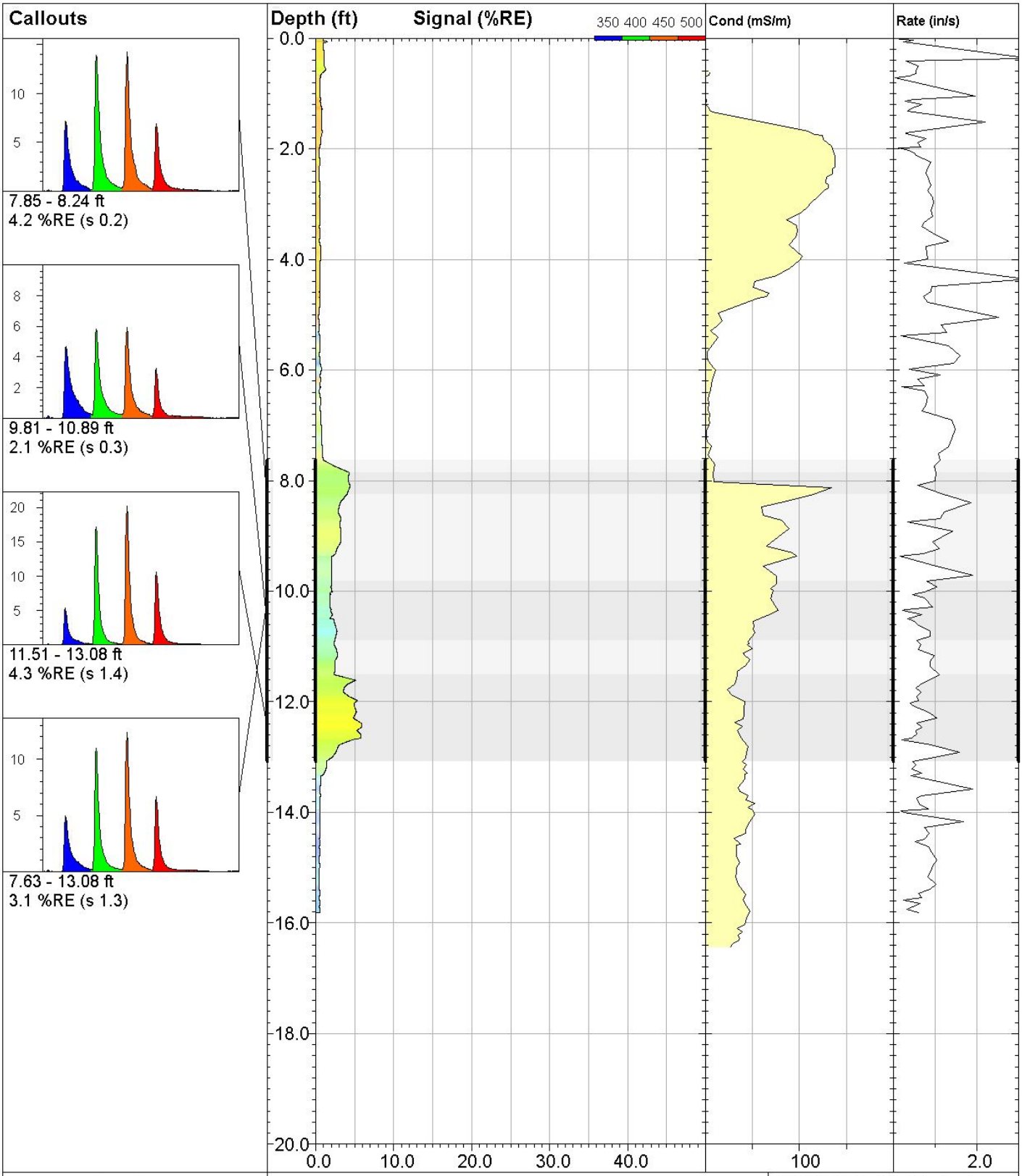
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.57 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **7.5 %RE @ 10.07 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 15:34 CDT**



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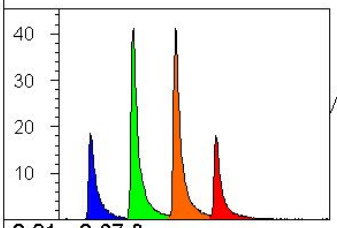
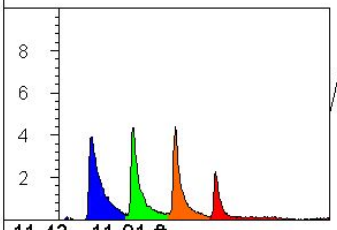
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.82 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.9 %RE @ 12.46 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 16:04 CDT**

Callouts

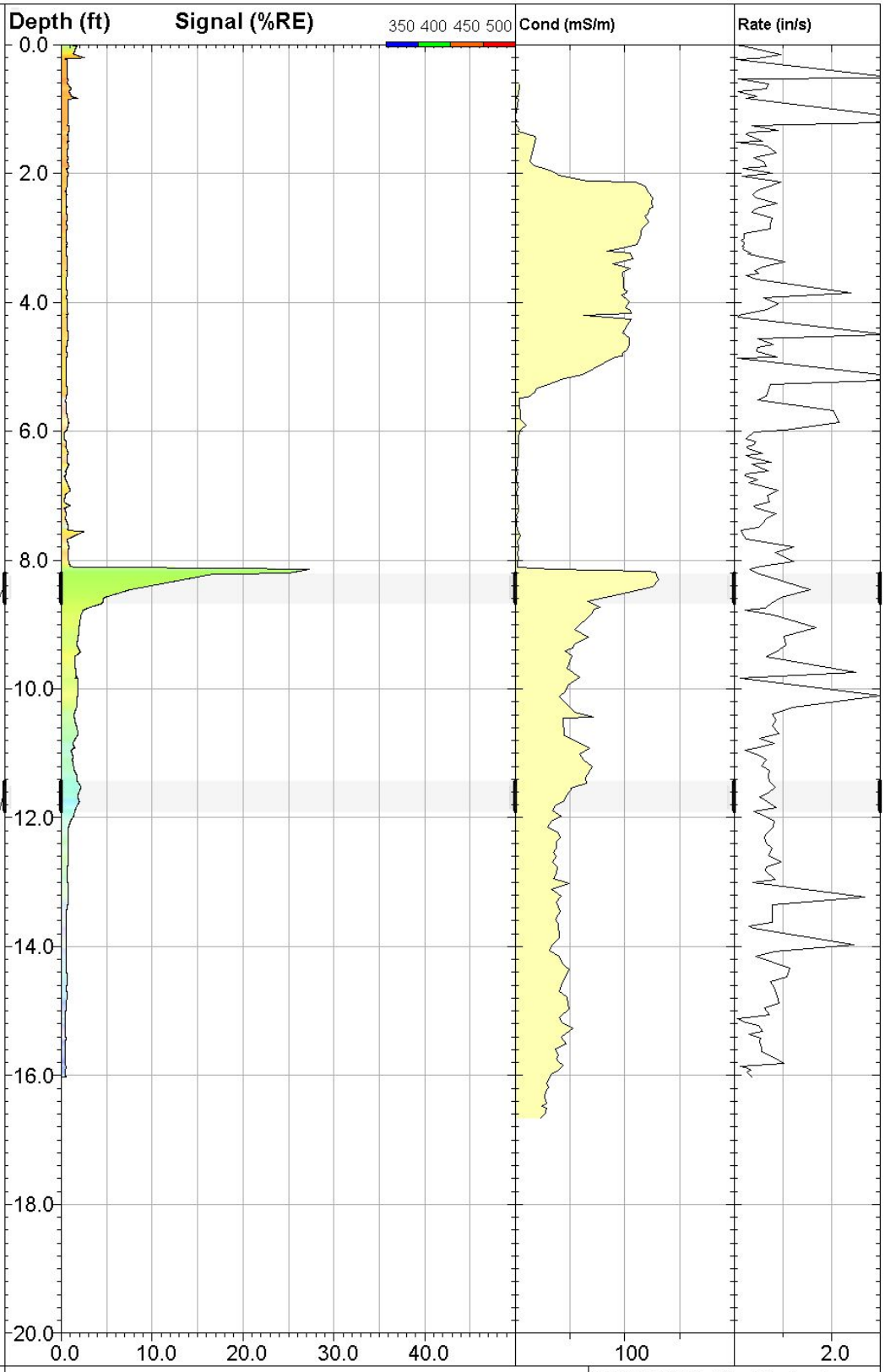


8.21 - 8.67 ft
11.7 %RE (s 8.9)



11.43 - 11.91 ft
1.8 %RE (s 0.2)

SEVERAL VOID SPACES
DURING ADVANCEMENT.
RATE JUMPED



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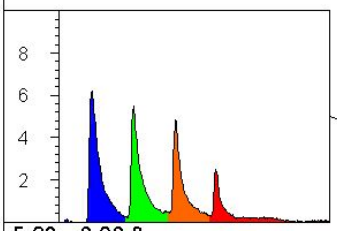
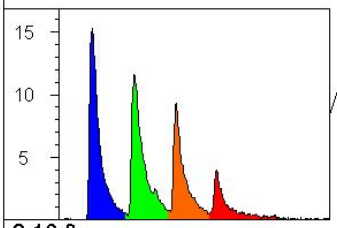
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.03 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **27.4 %RE @ 8.14 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 16:32 CDT**

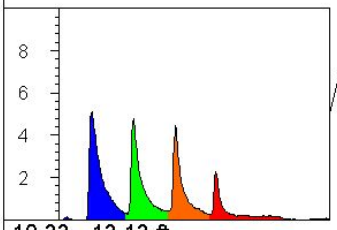
Callouts



5.23 - 6.06 ft
2.7 %RE (s 0.8)

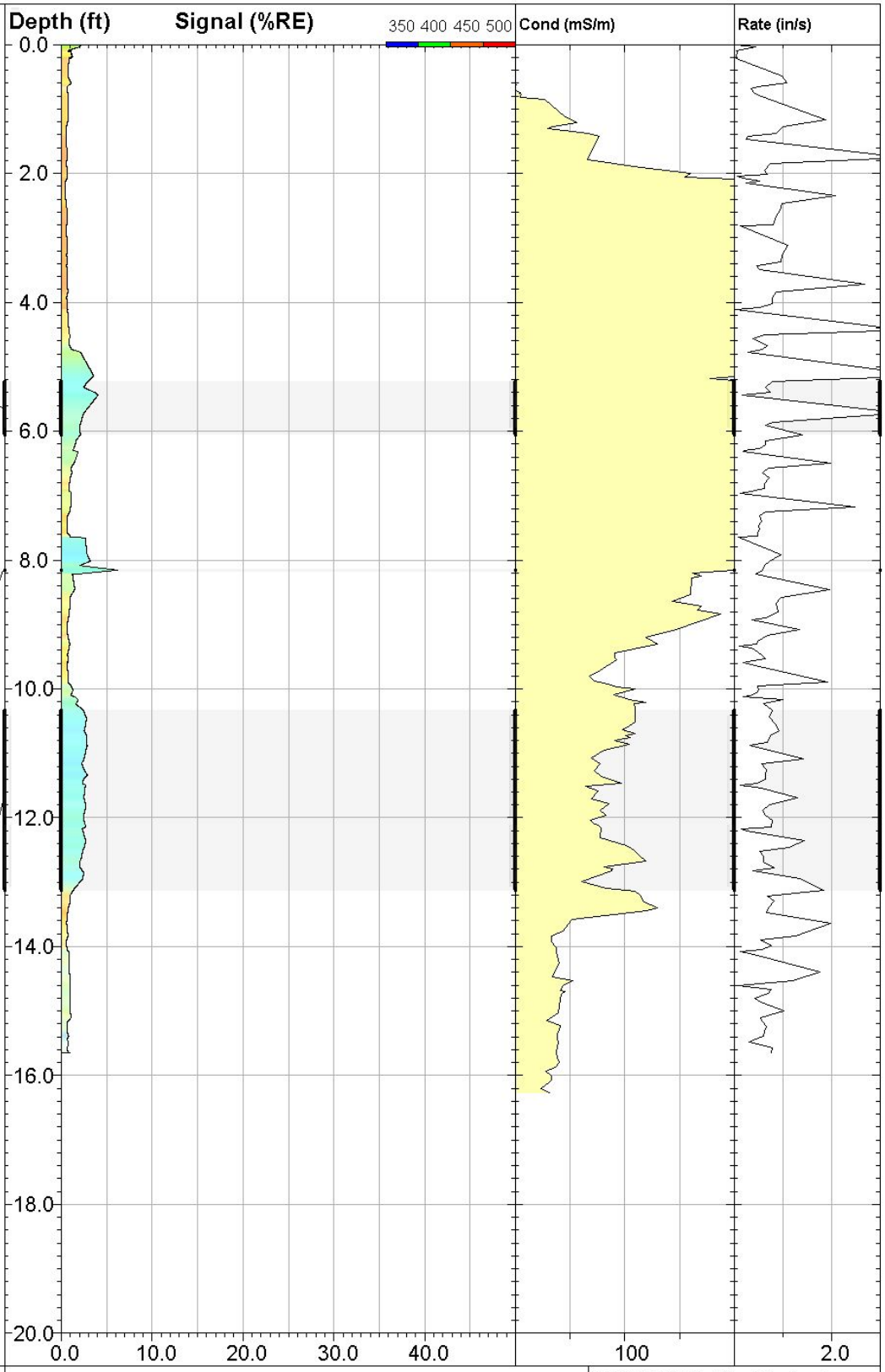


8.16 ft
6.2 %RE



10.33 - 13.13 ft
2.4 %RE (s 0.3)

SEVERAL VOID SPACES
DURING ADVANCEMENT.
RATE JUMPED



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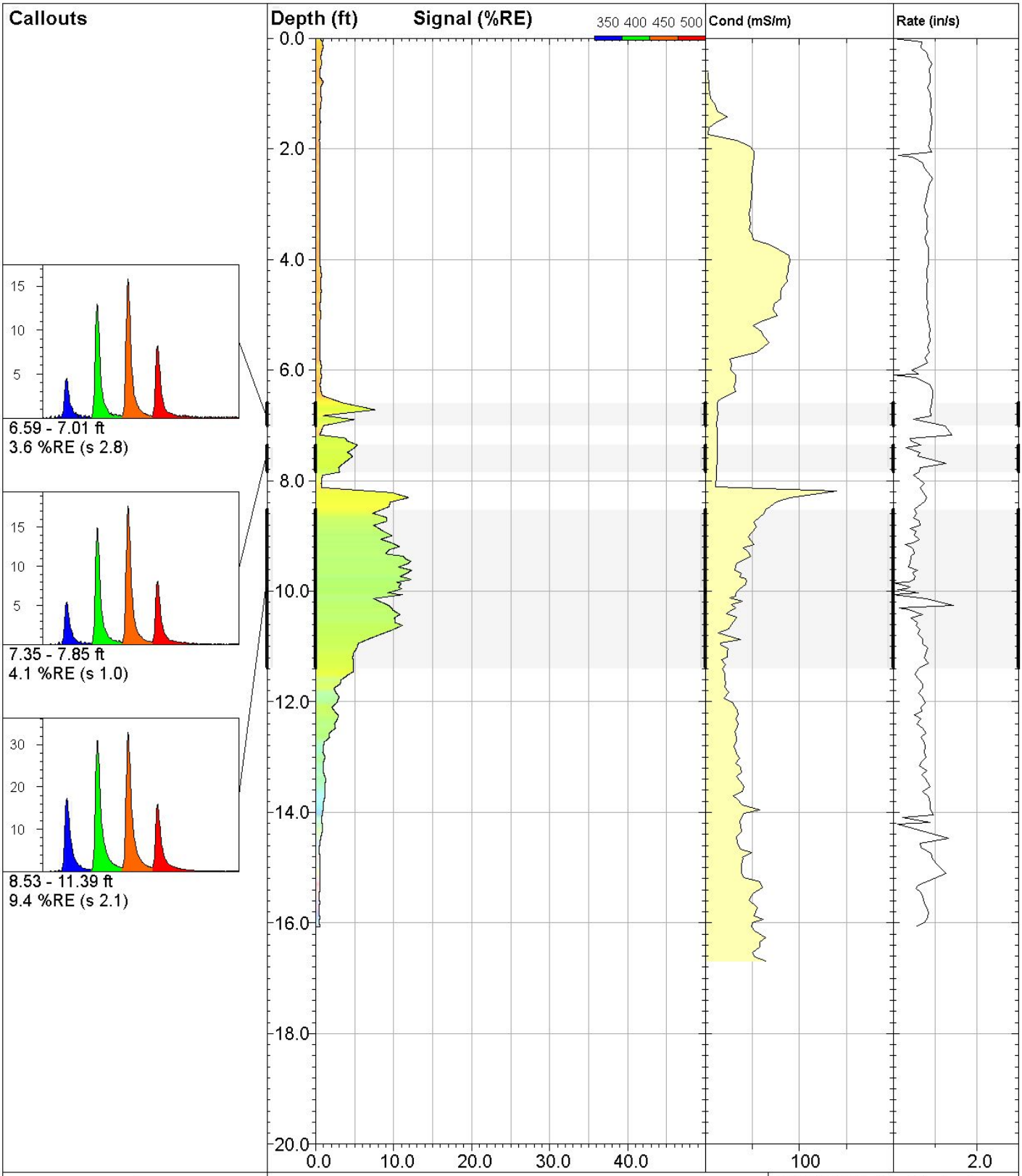
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.65 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.2 %RE @ 8.16 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 17:07 CDT**



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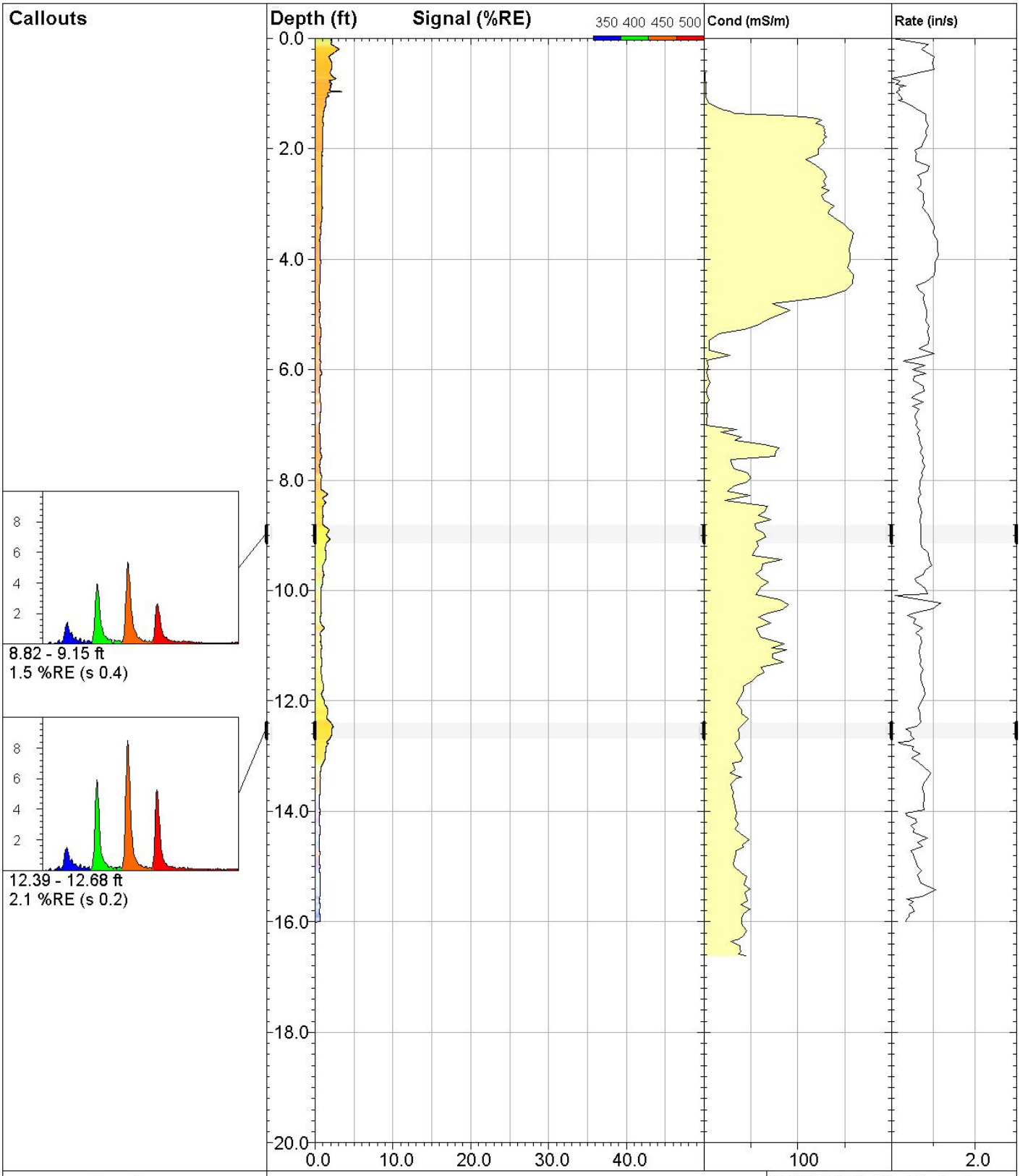
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.07 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.3 %RE @ 9.62 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 10:55 CDT**



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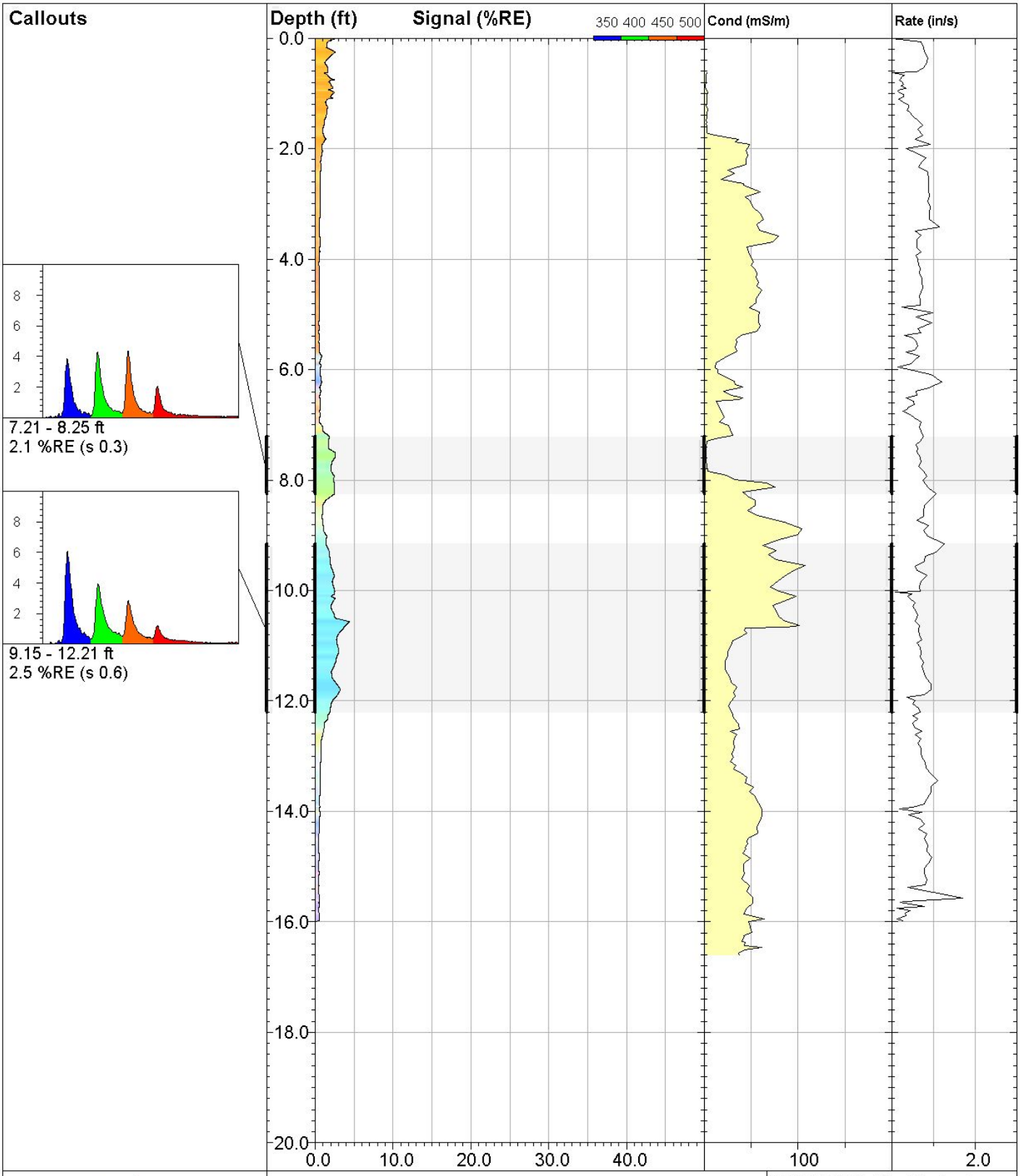
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.5 %RE @ 0.97 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 11:14 CDT**



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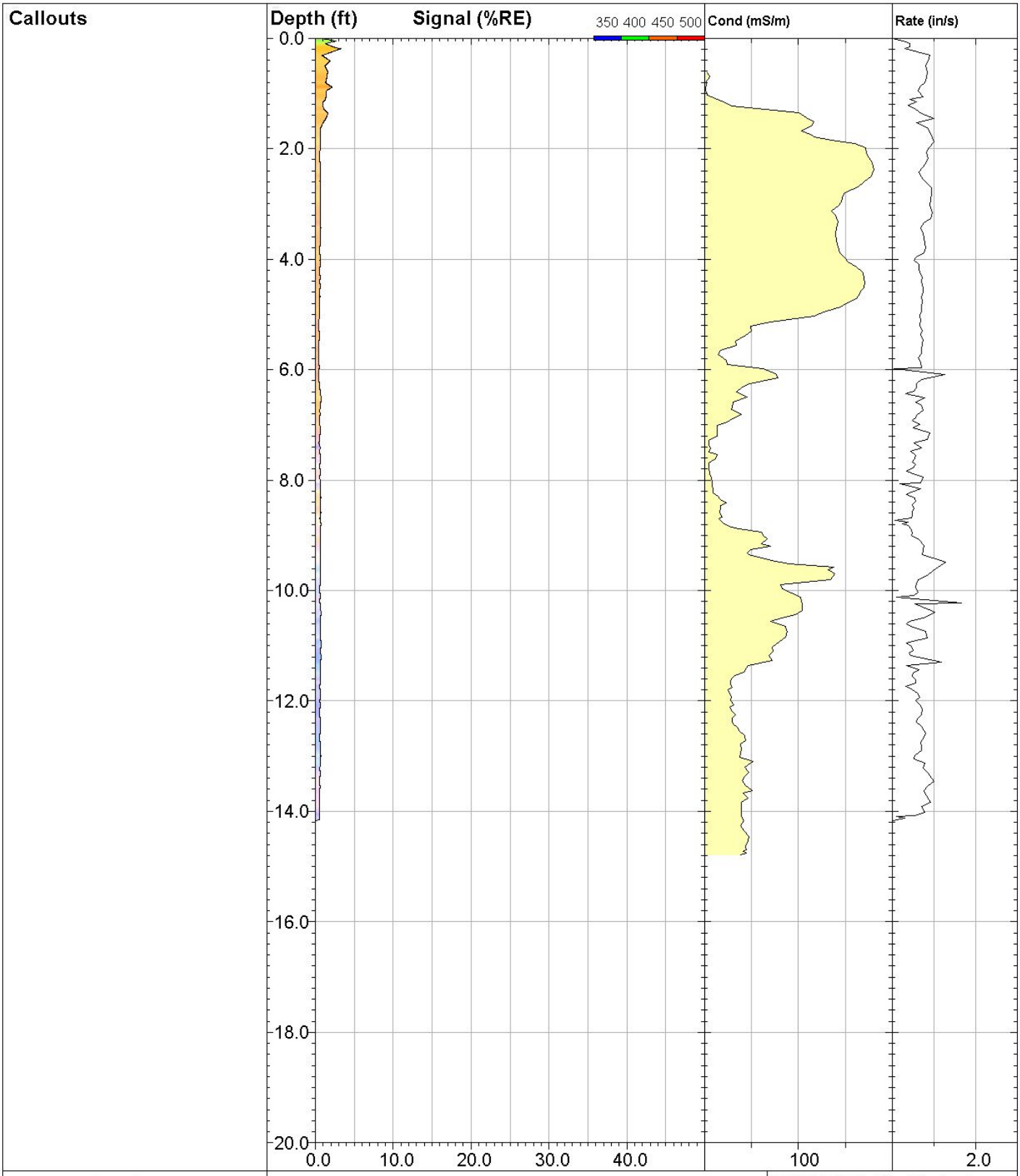
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.4 %RE @ 10.56 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 11:41 CDT**



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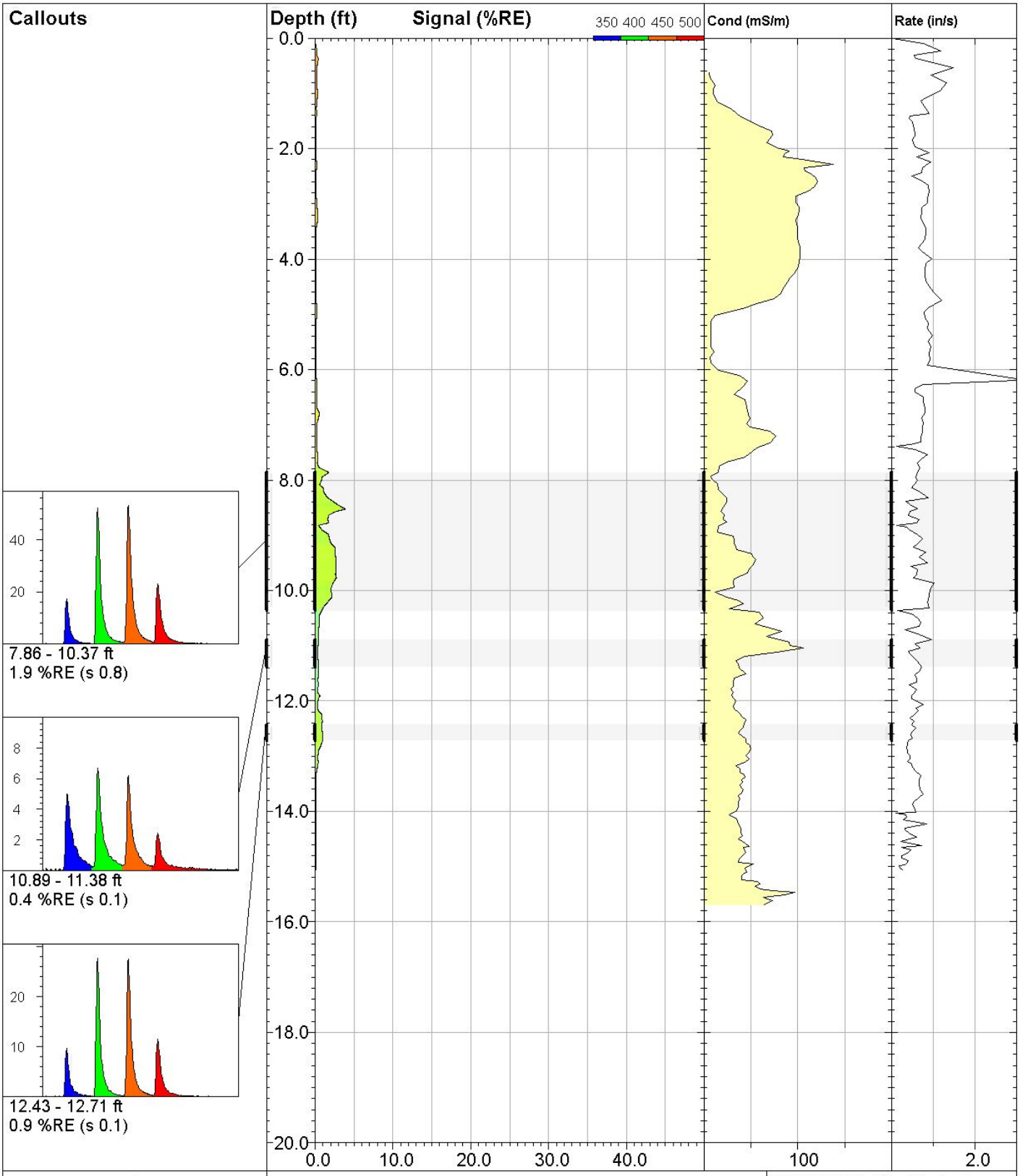
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.16 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.3 %RE @ 0.19 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 12:28 CDT**



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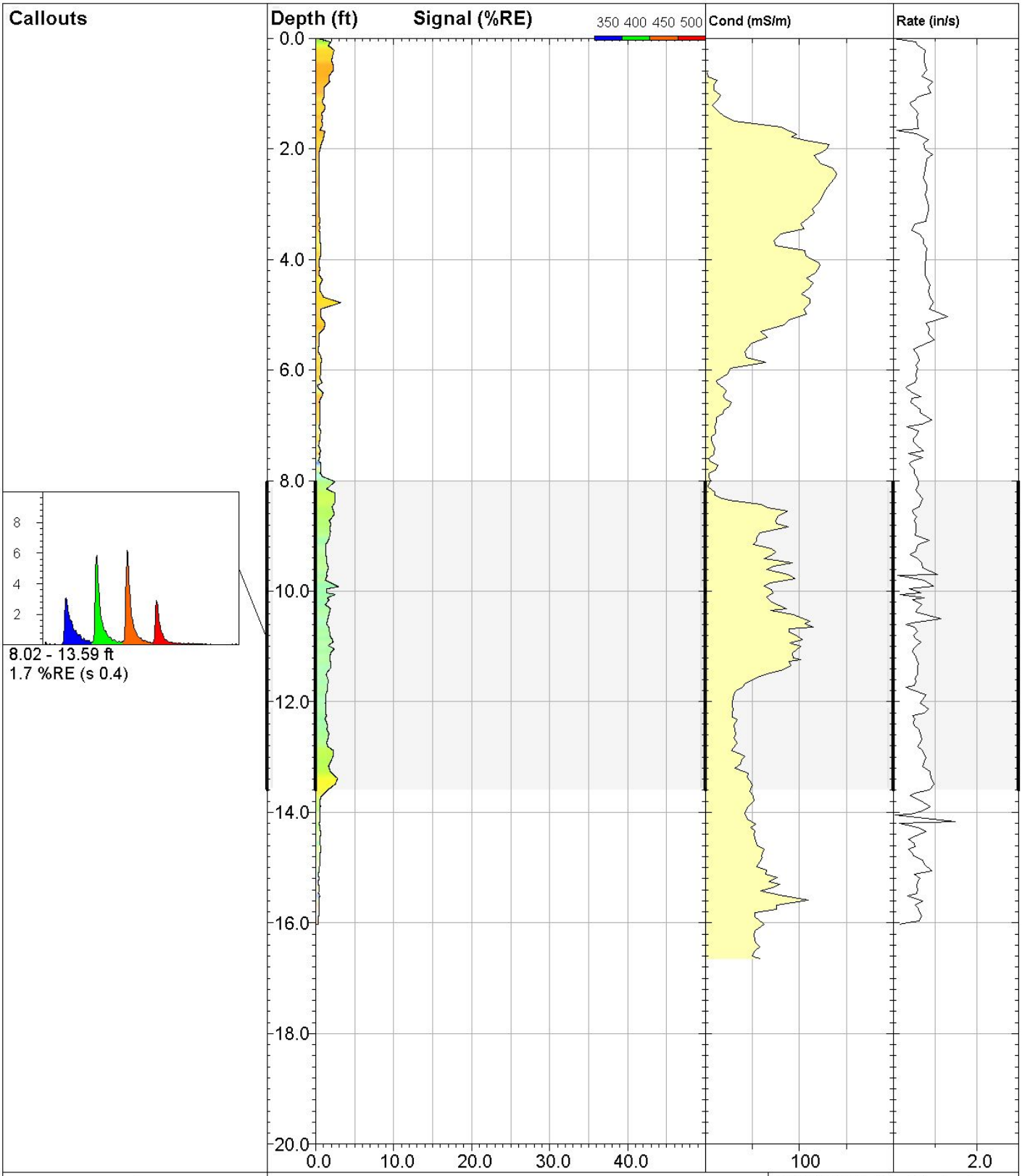
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.06 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.9 %RE @ 8.53 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 13:41 CDT**



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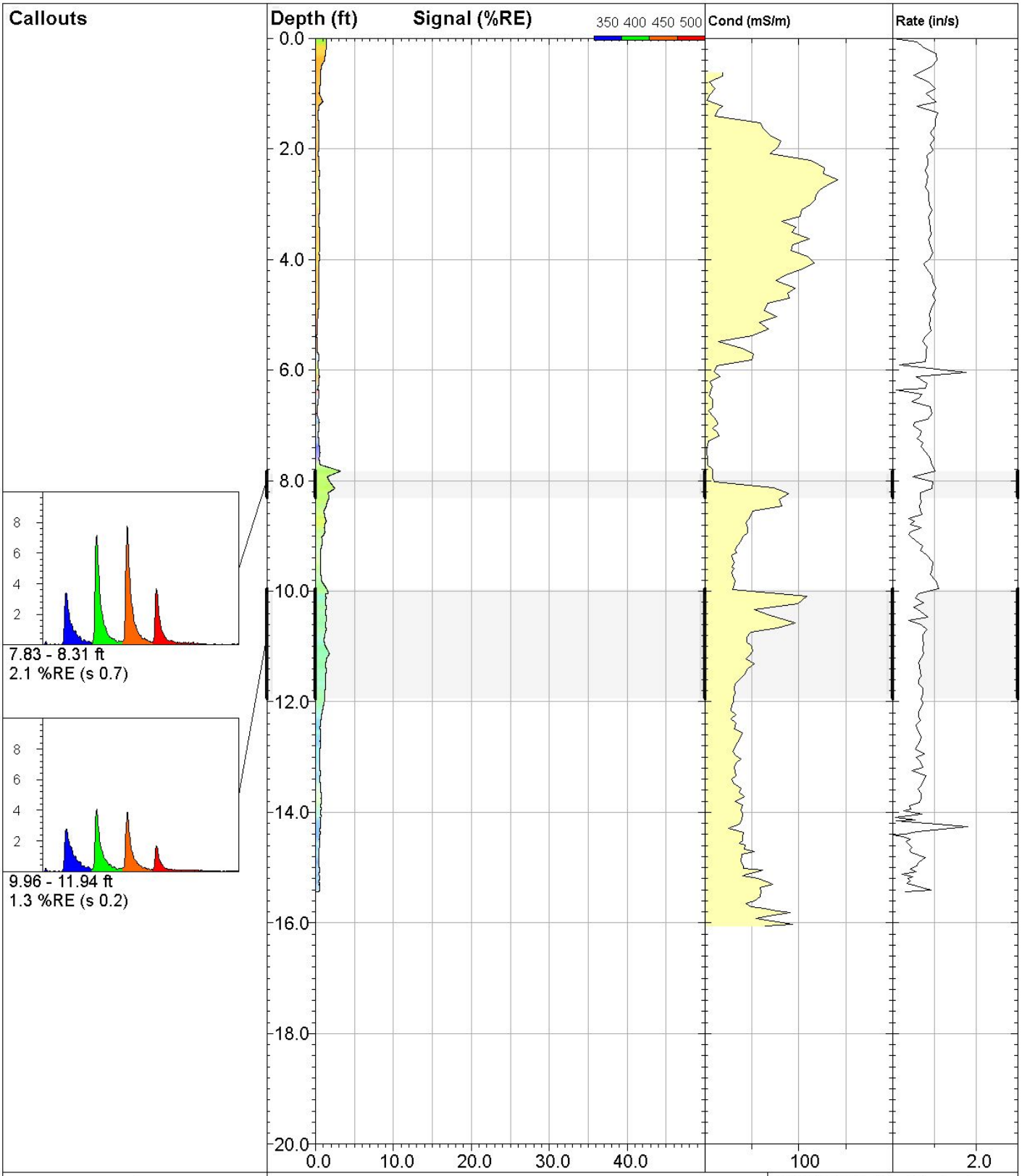
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.2 %RE @ 4.78 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 14:15 CDT**



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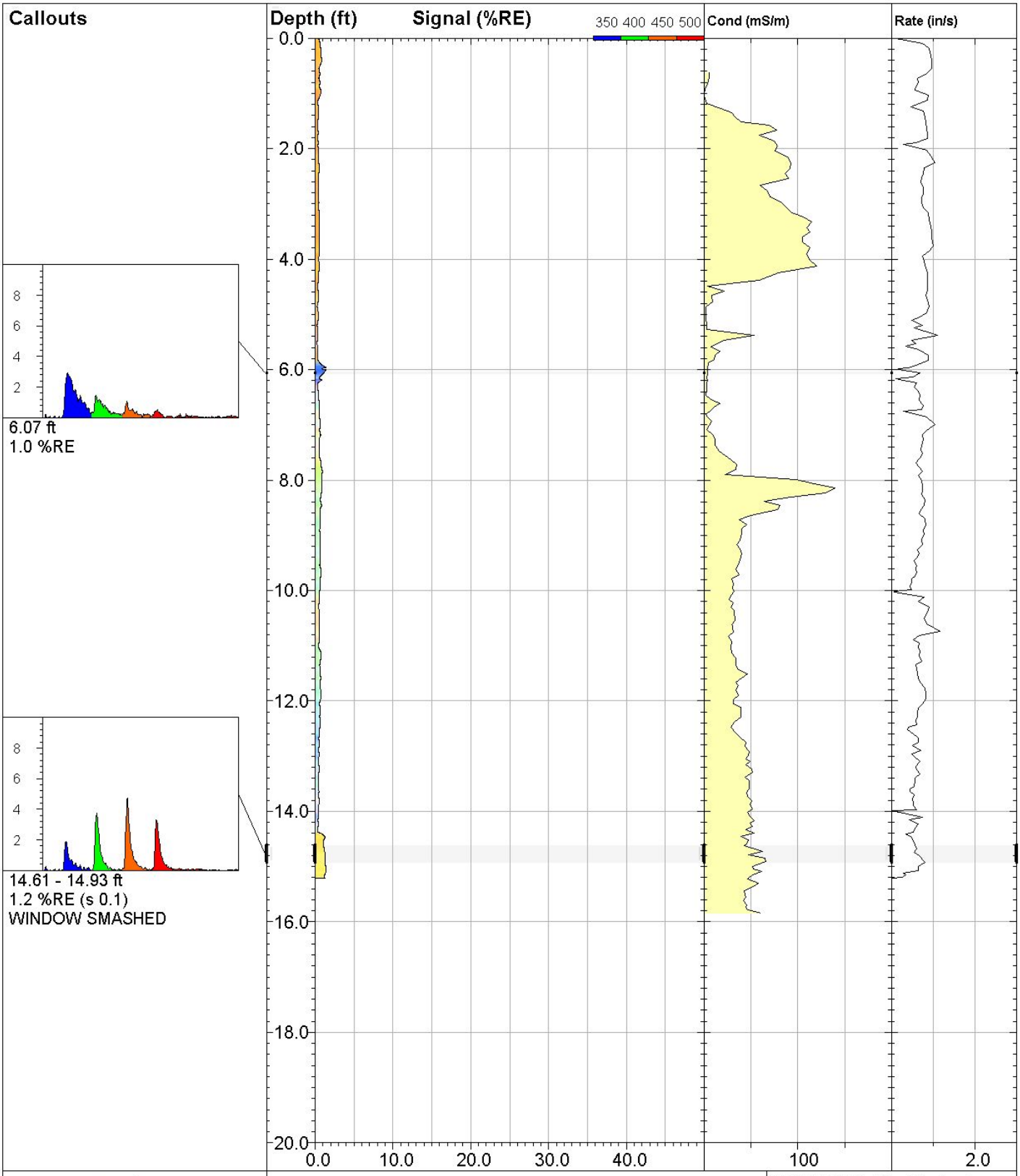
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.44 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.2 %RE @ 7.83 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 14:43 CDT**



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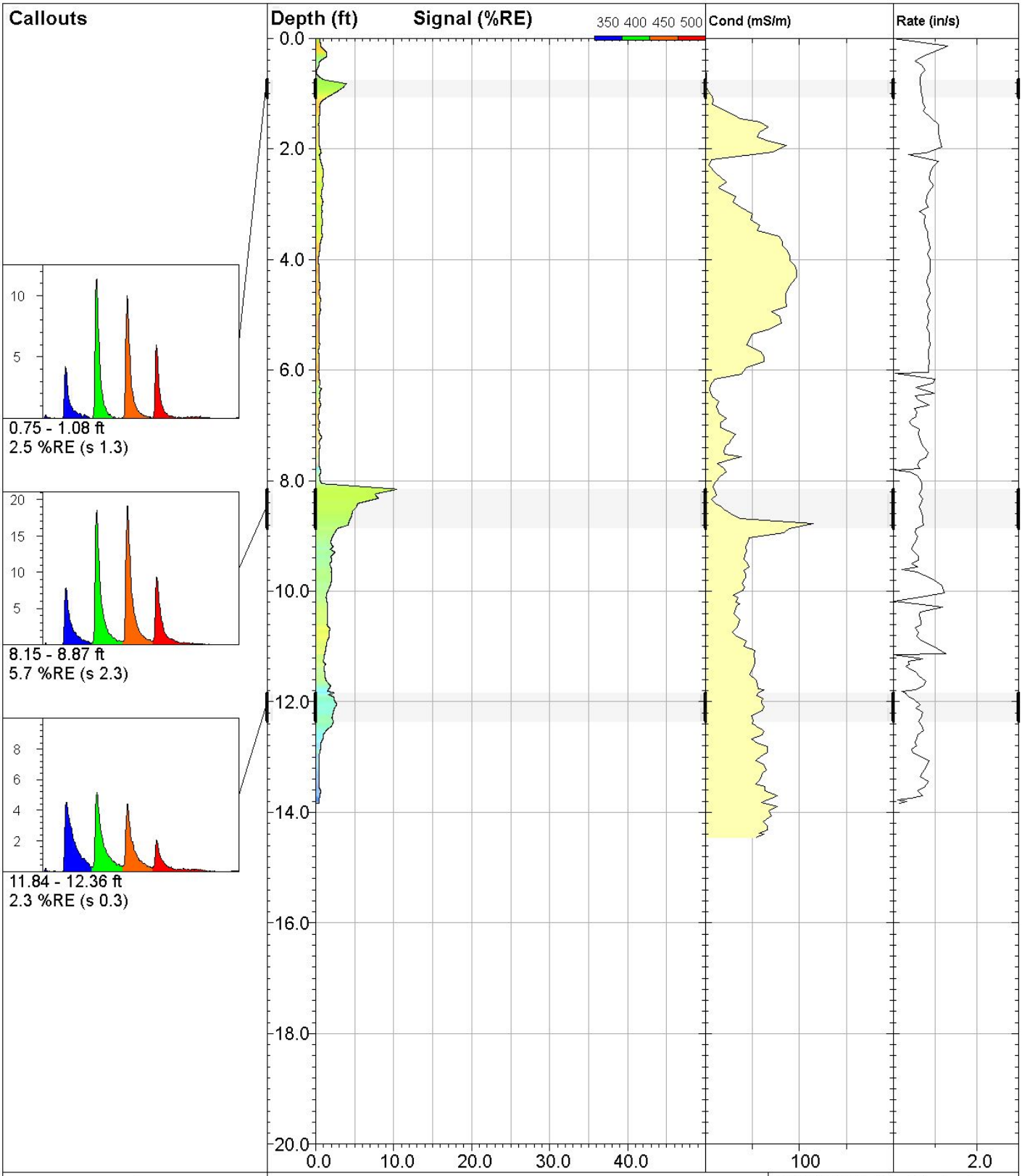
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.22 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 6.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 15:10 CDT**



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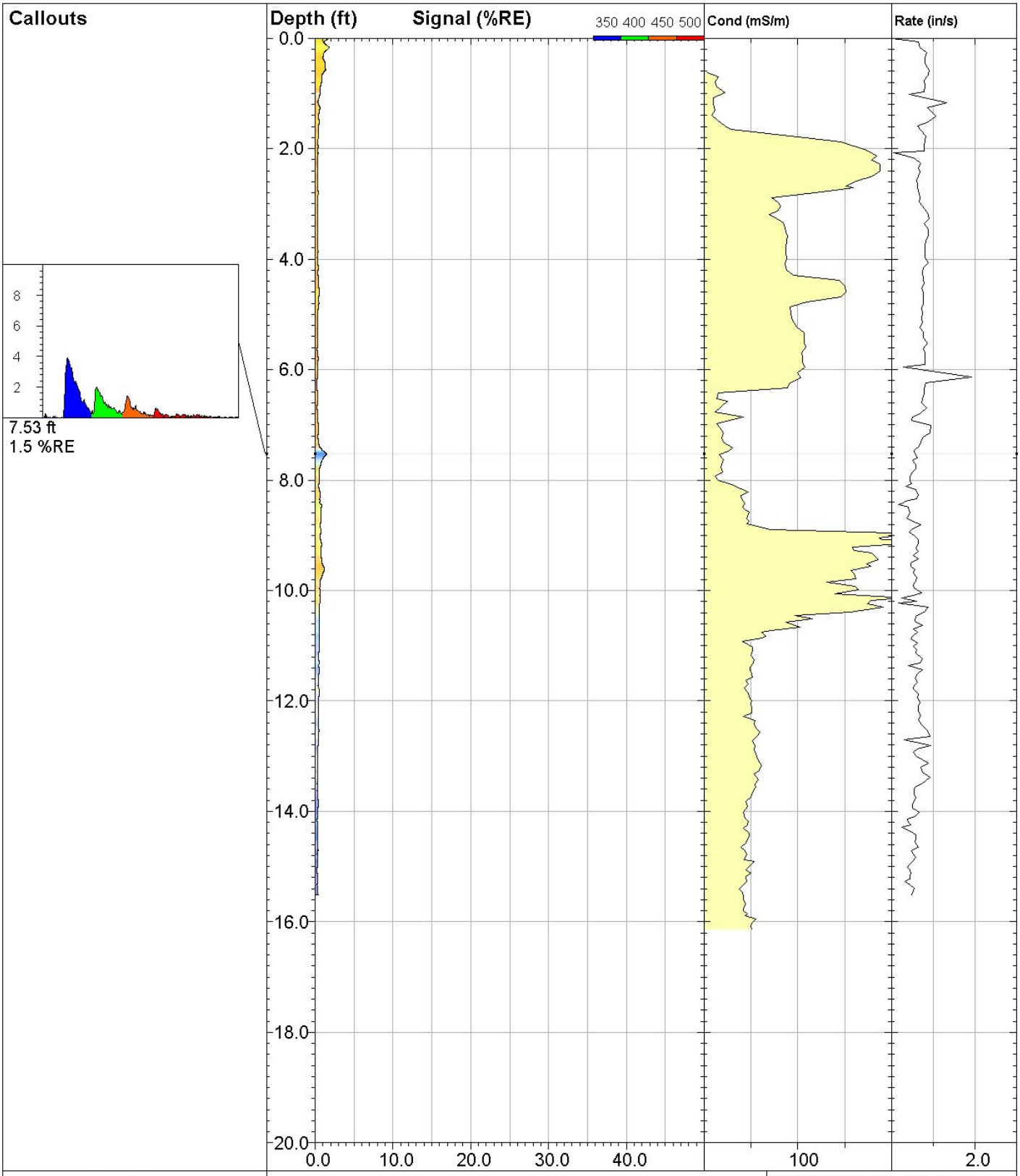
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **13.83 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **10.5 %RE @ 8.15 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 15:53 CDT**



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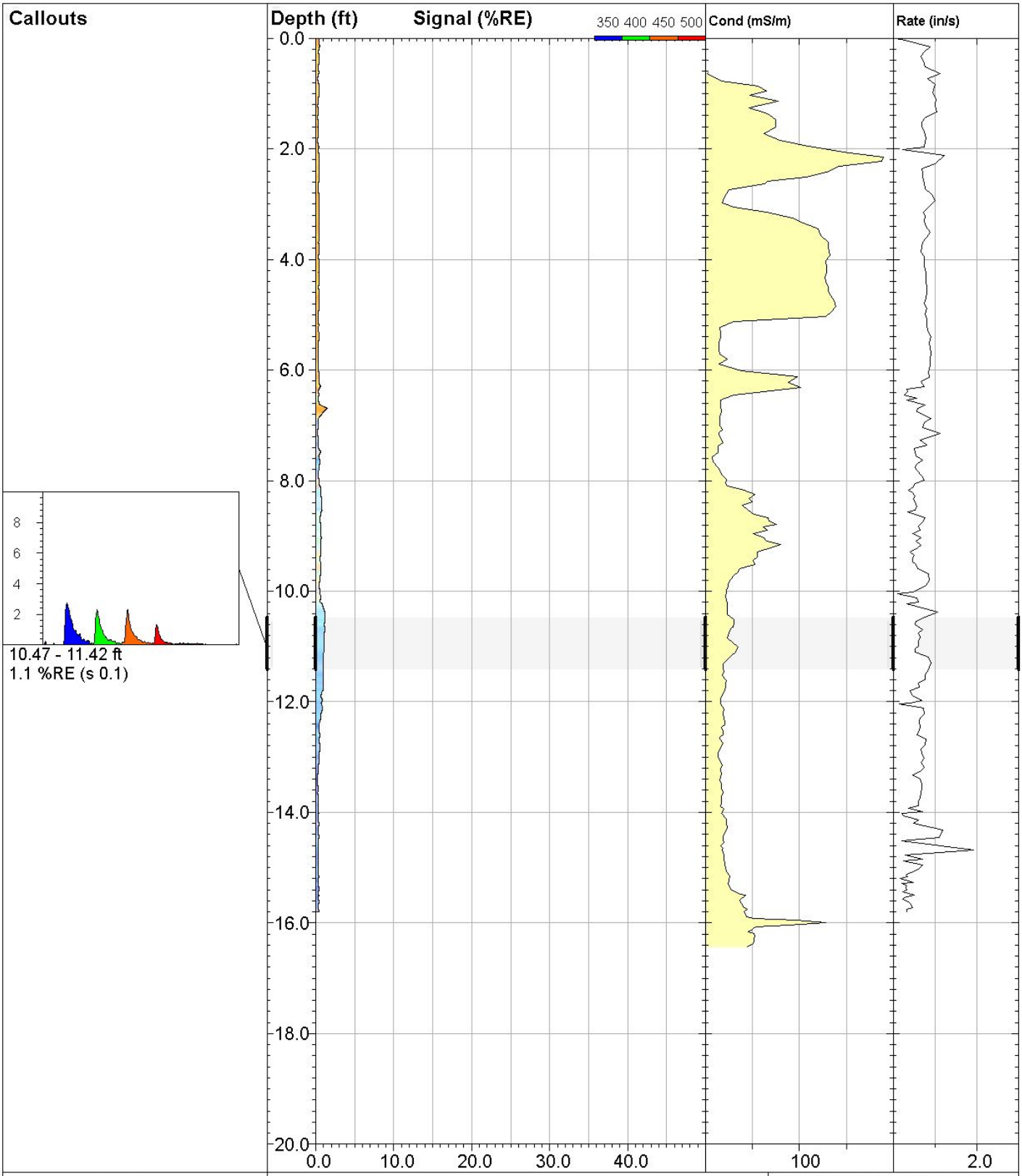
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.51 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.9 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 16:25 CDT**



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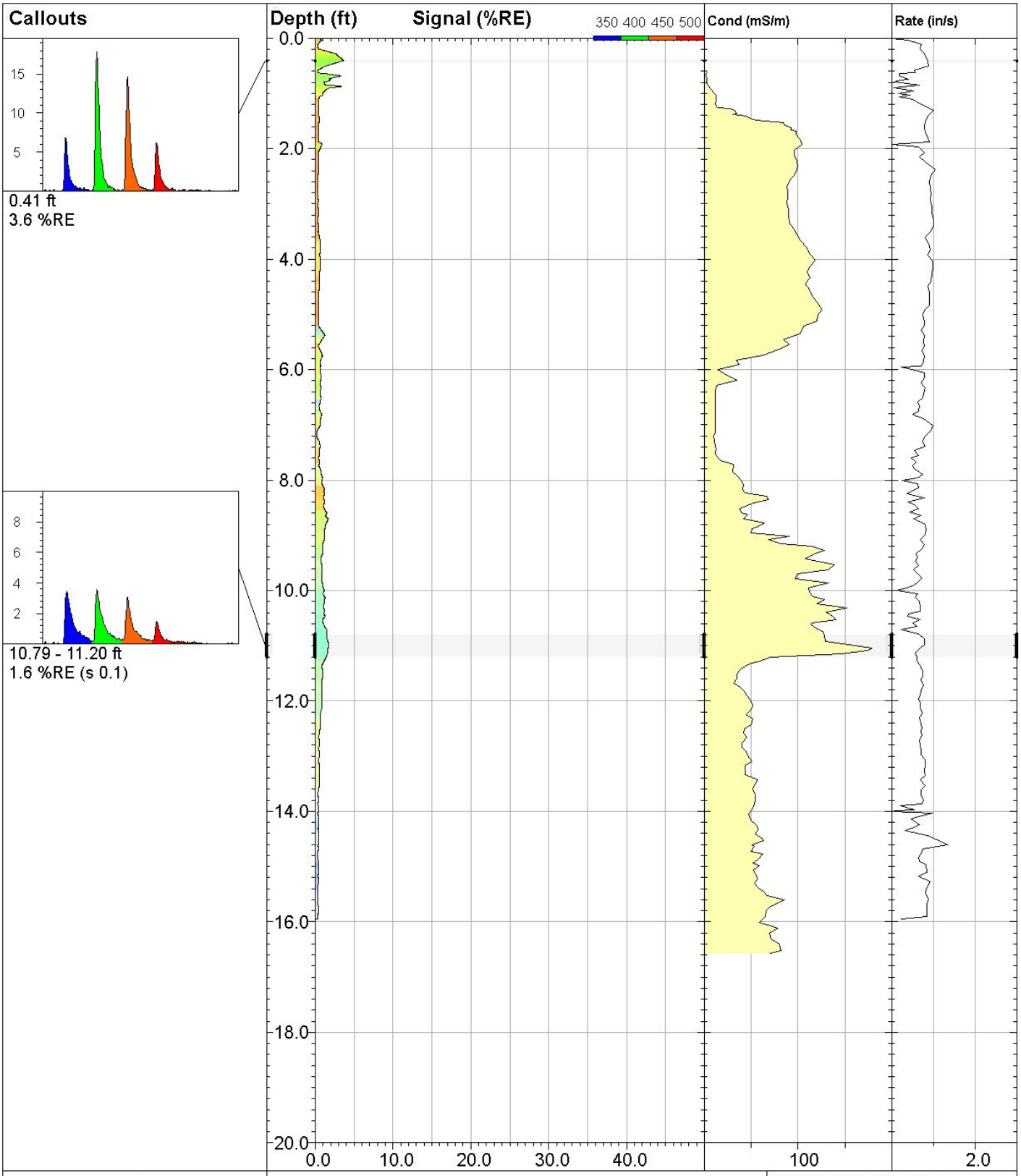
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.80 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 6.69 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 16:50 CDT**



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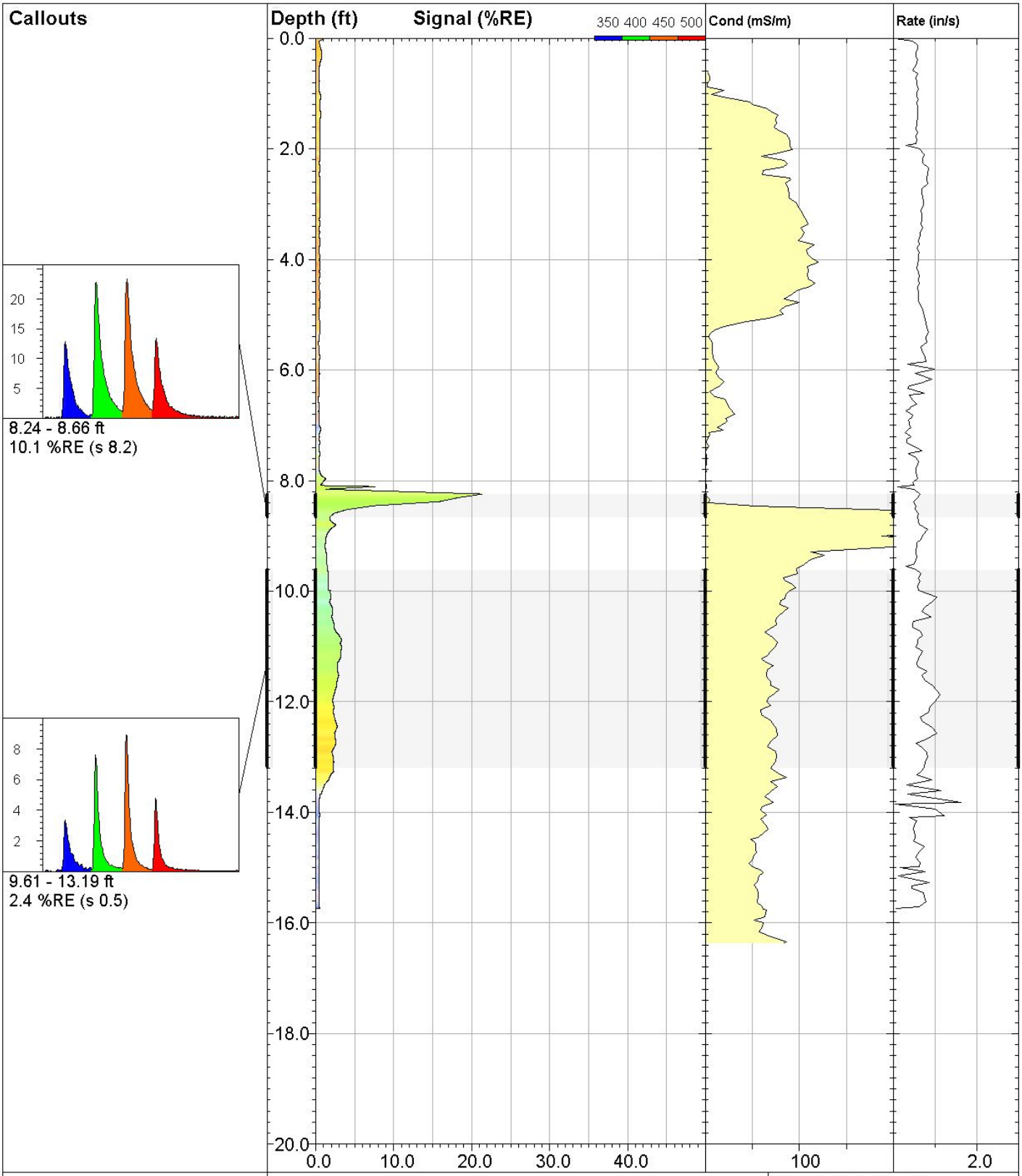
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.94 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.6 %RE @ 0.41 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 17:26 CDT**



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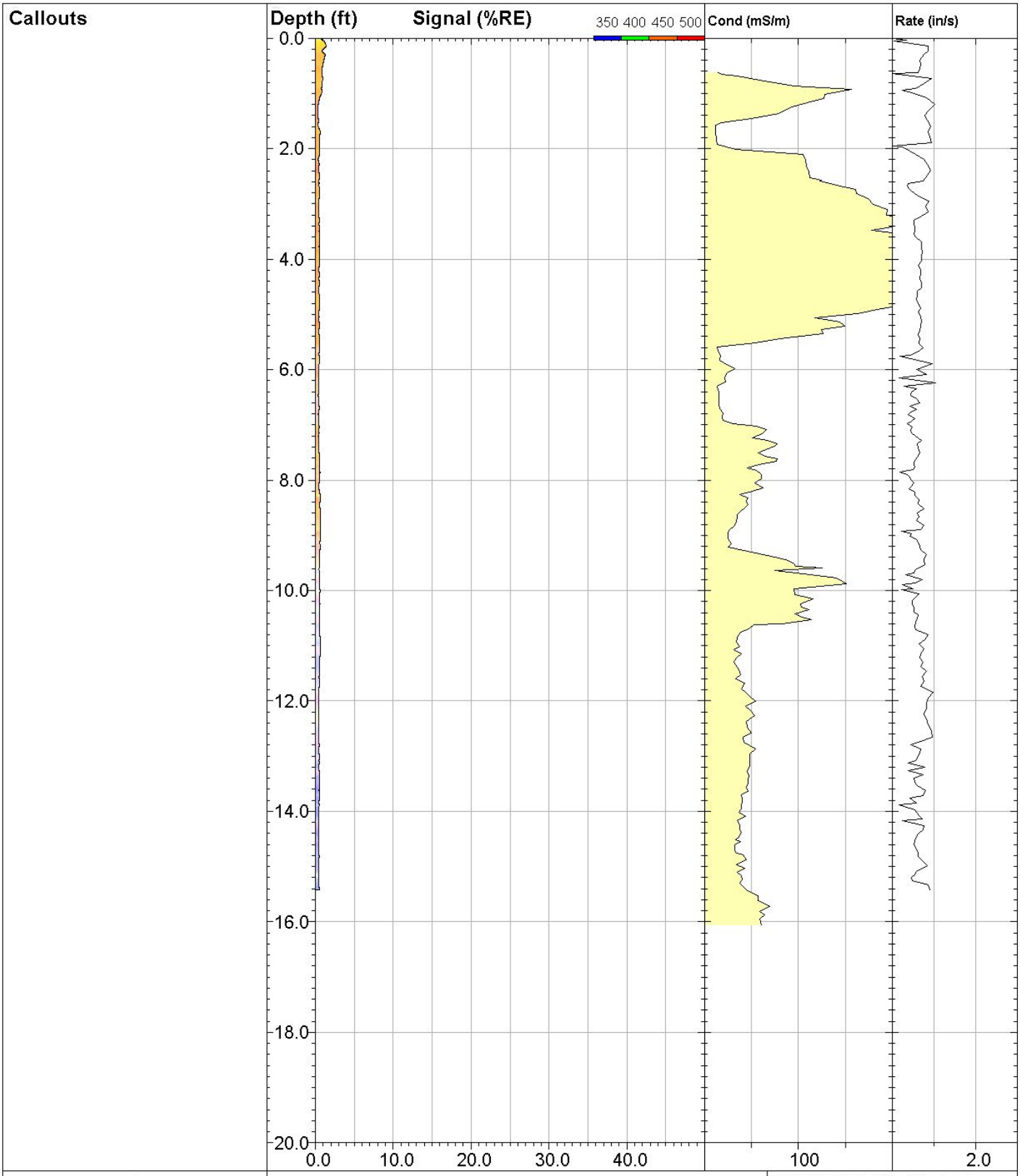
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.74 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **21.4 %RE @ 8.24 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 10:31 CDT**



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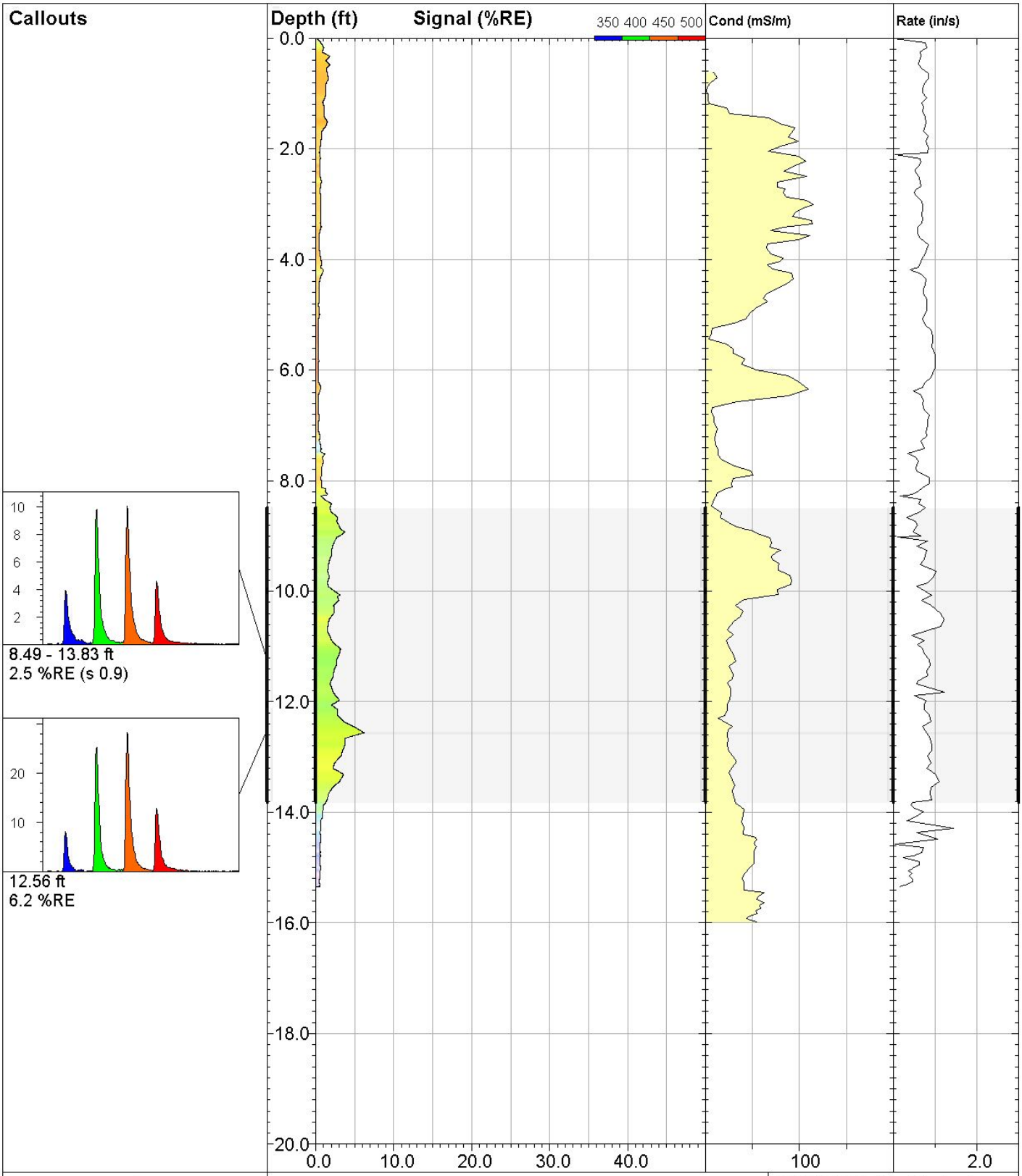
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.43 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 0.14 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 10:59 CDT**



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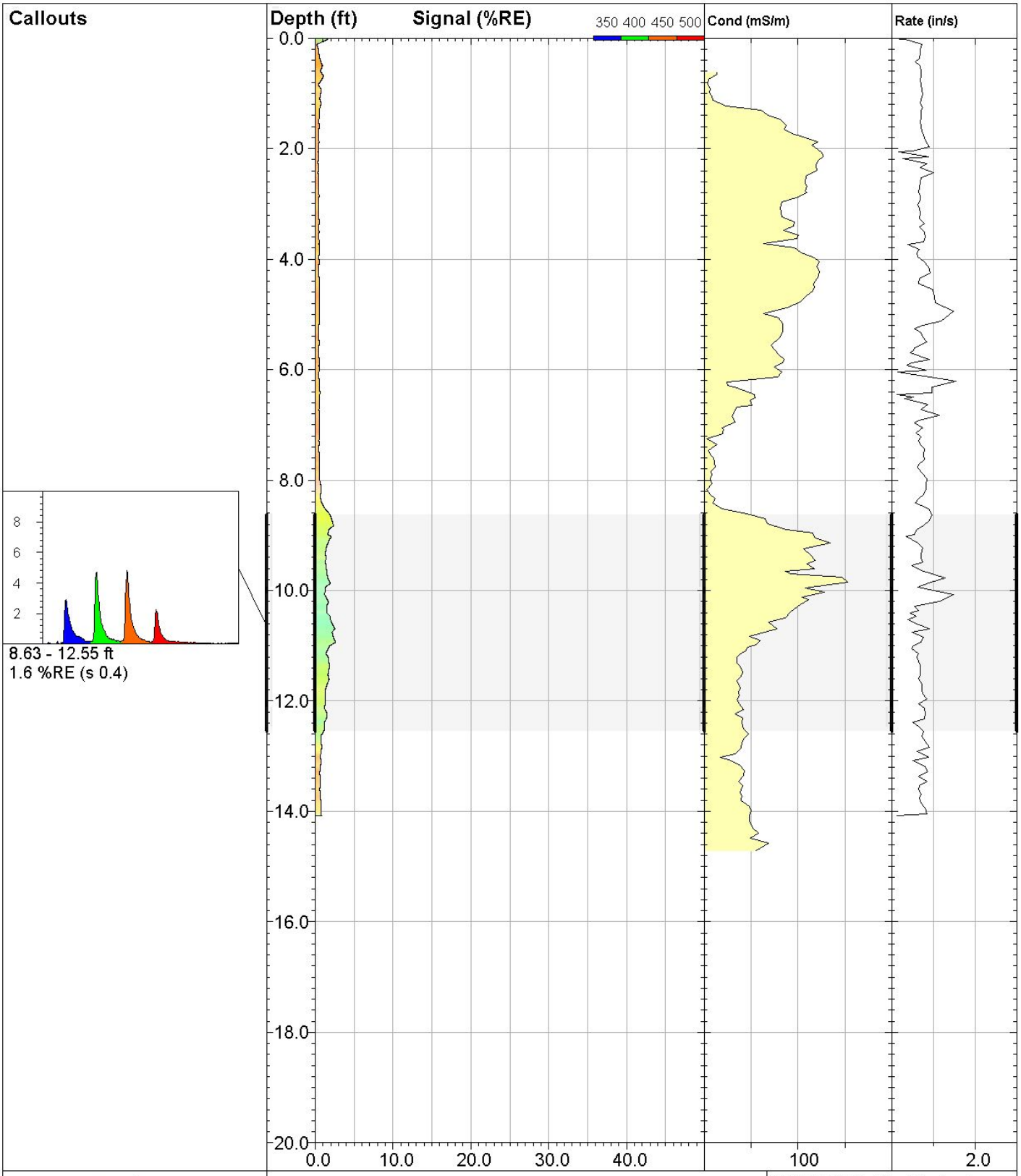
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.35 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.2 %RE @ 12.56 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 11:36 CDT**



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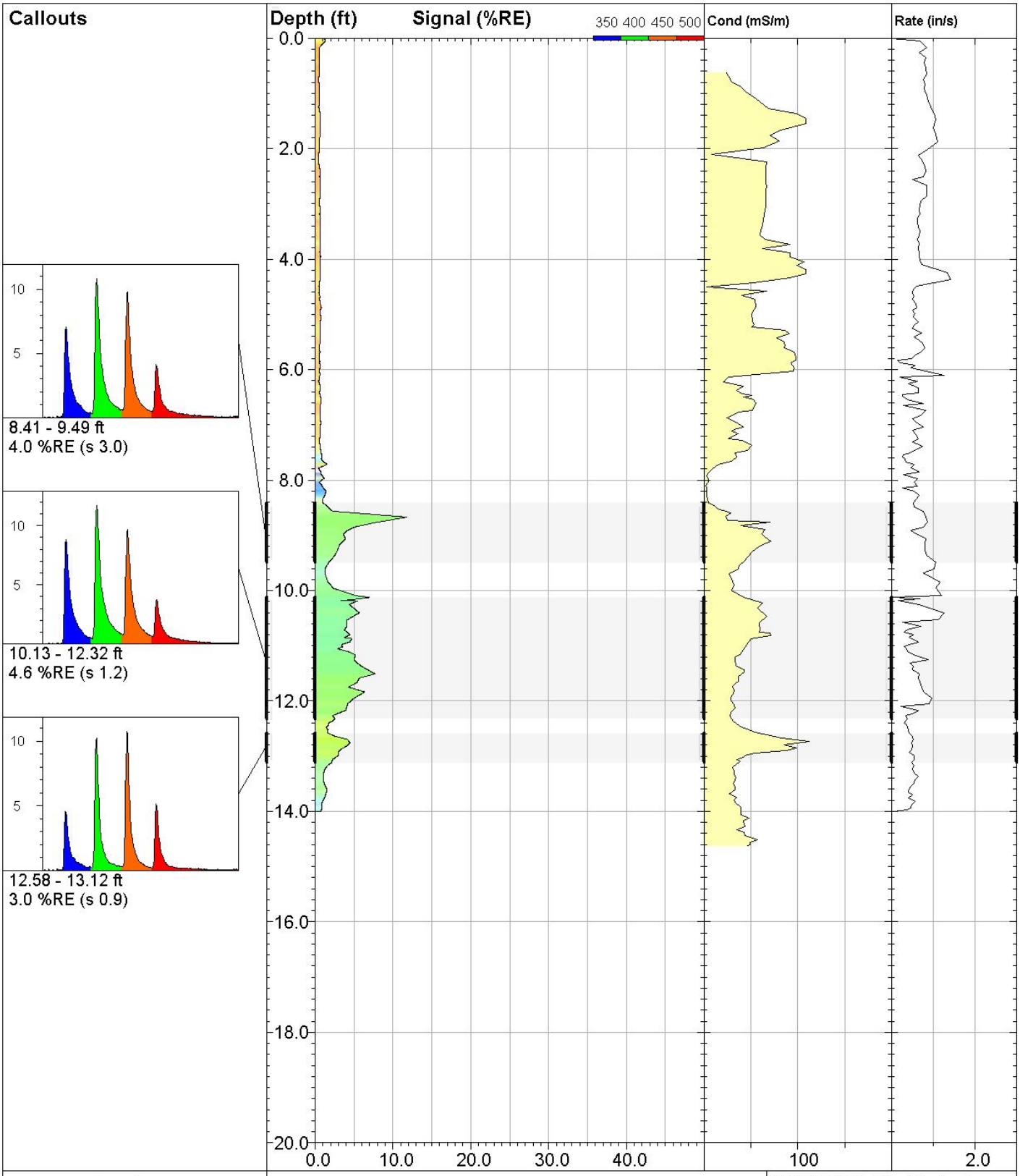
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.08 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.6 %RE @ 10.94 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 12:23 CDT**



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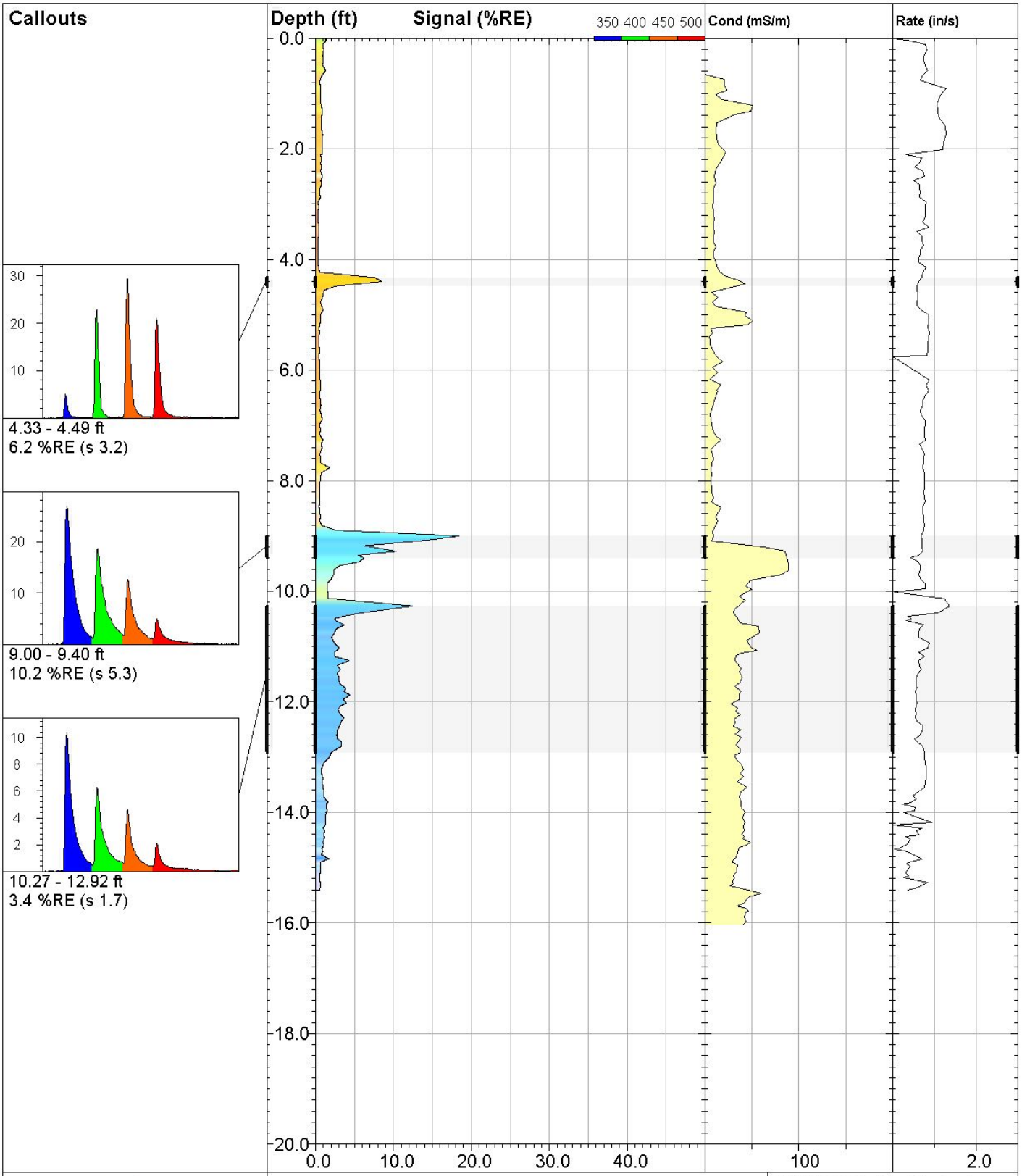
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **11.8 %RE @ 8.67 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 12:57 CDT**



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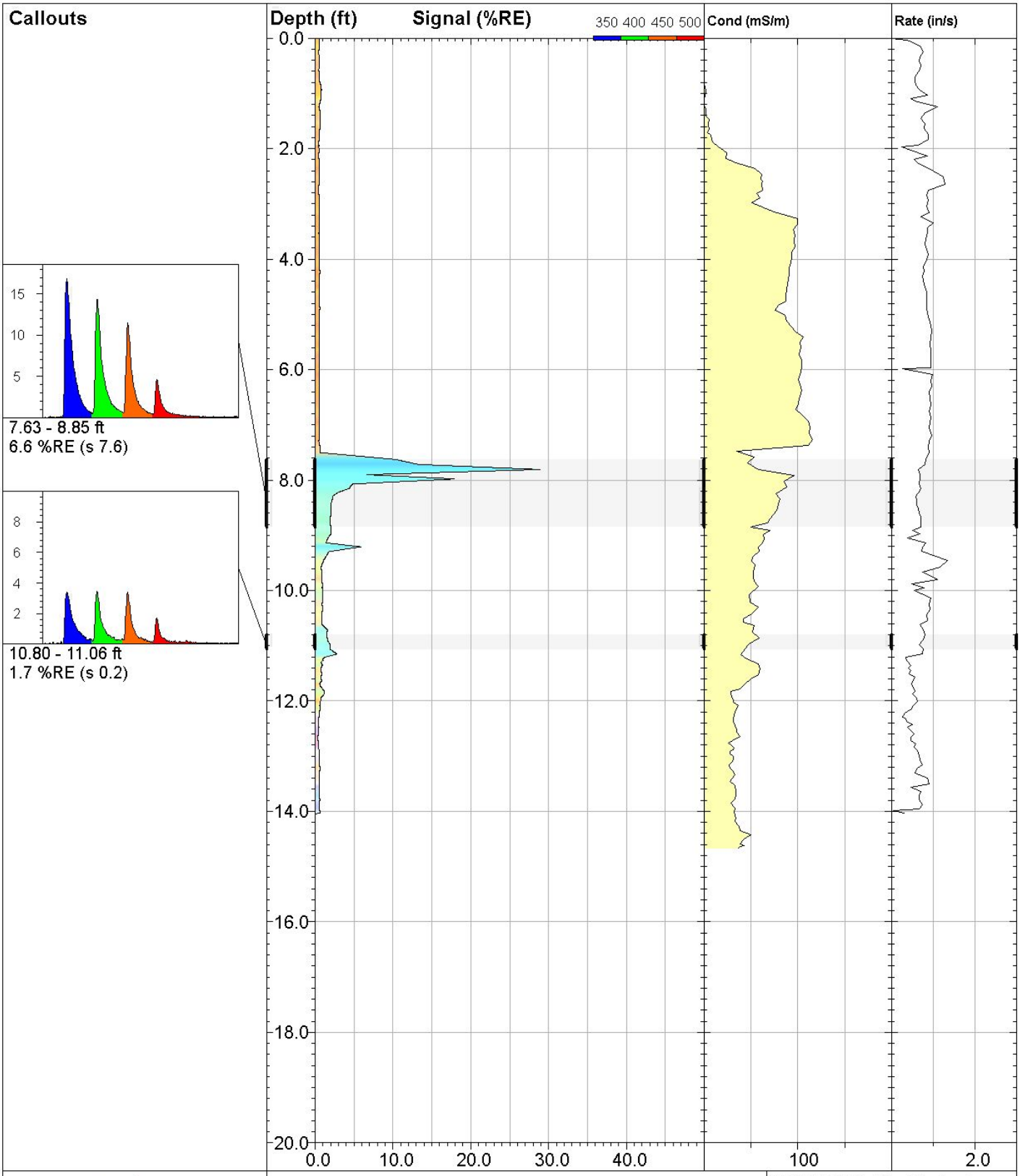
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.40 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.4 %RE @ 9.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 15:05 CDT**



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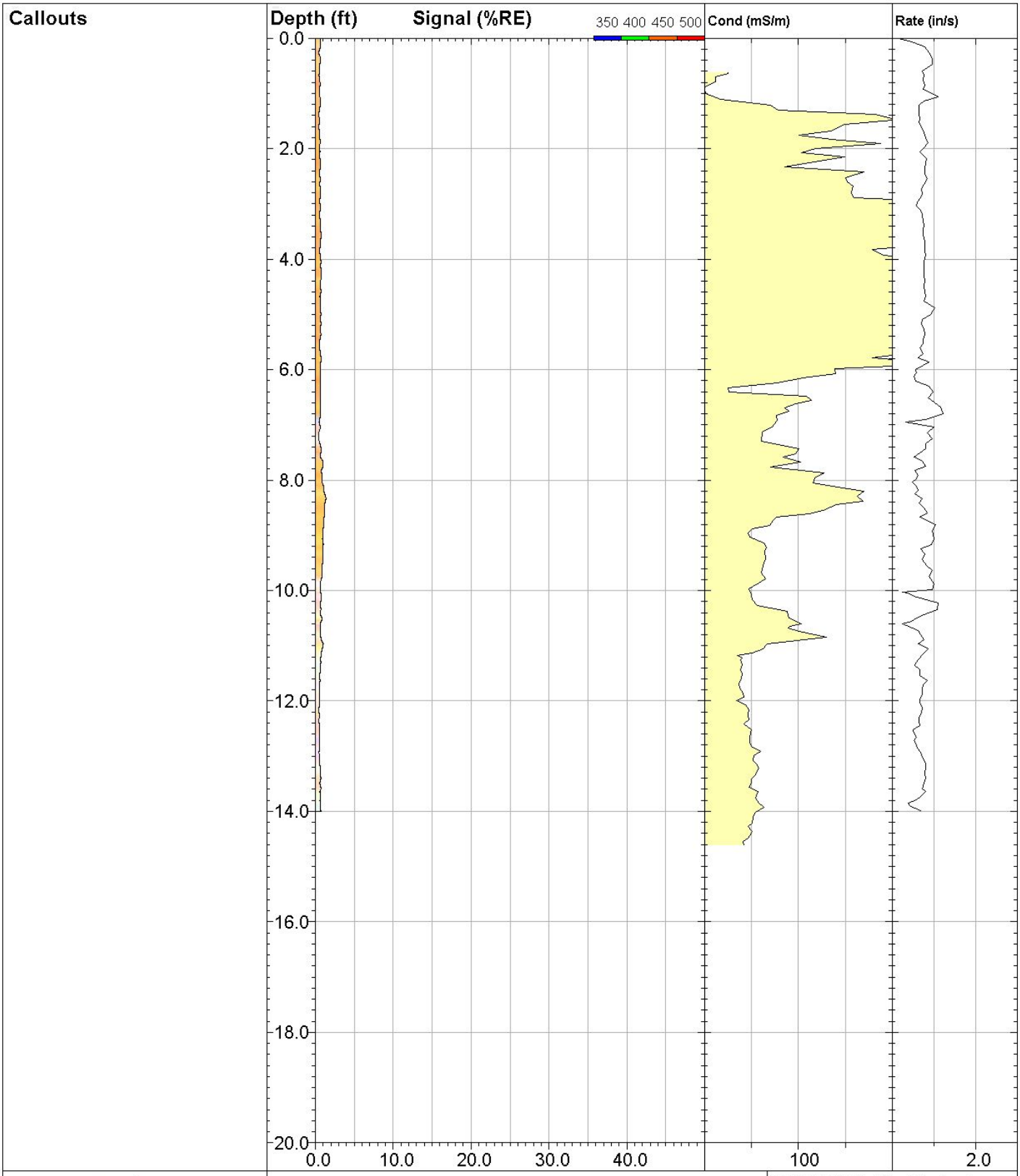
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **28.9 %RE @ 7.81 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 15:31 CDT**



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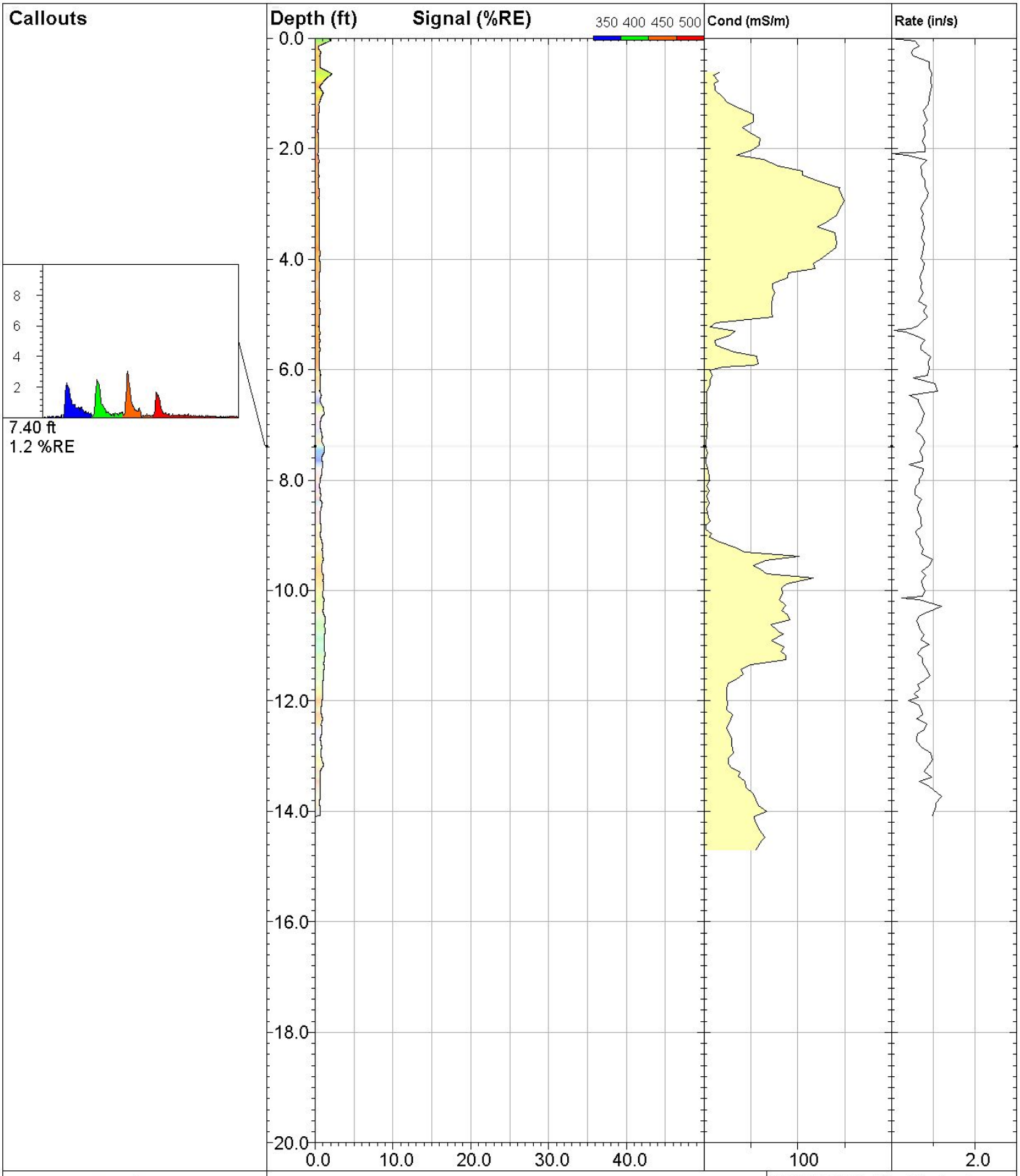
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 8.34 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 16:40 CDT**



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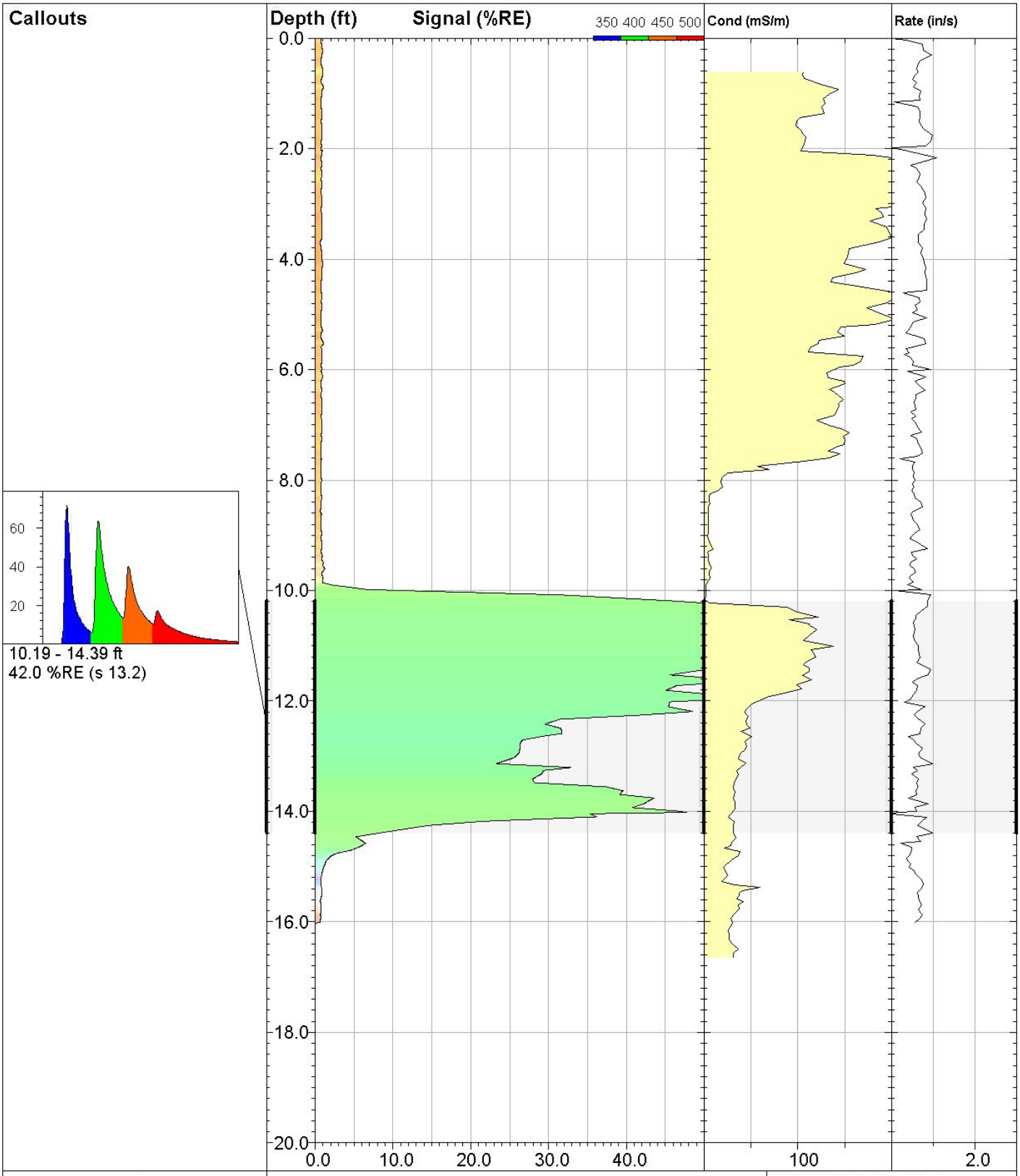
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.08 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 0.65 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 17:14 CDT**



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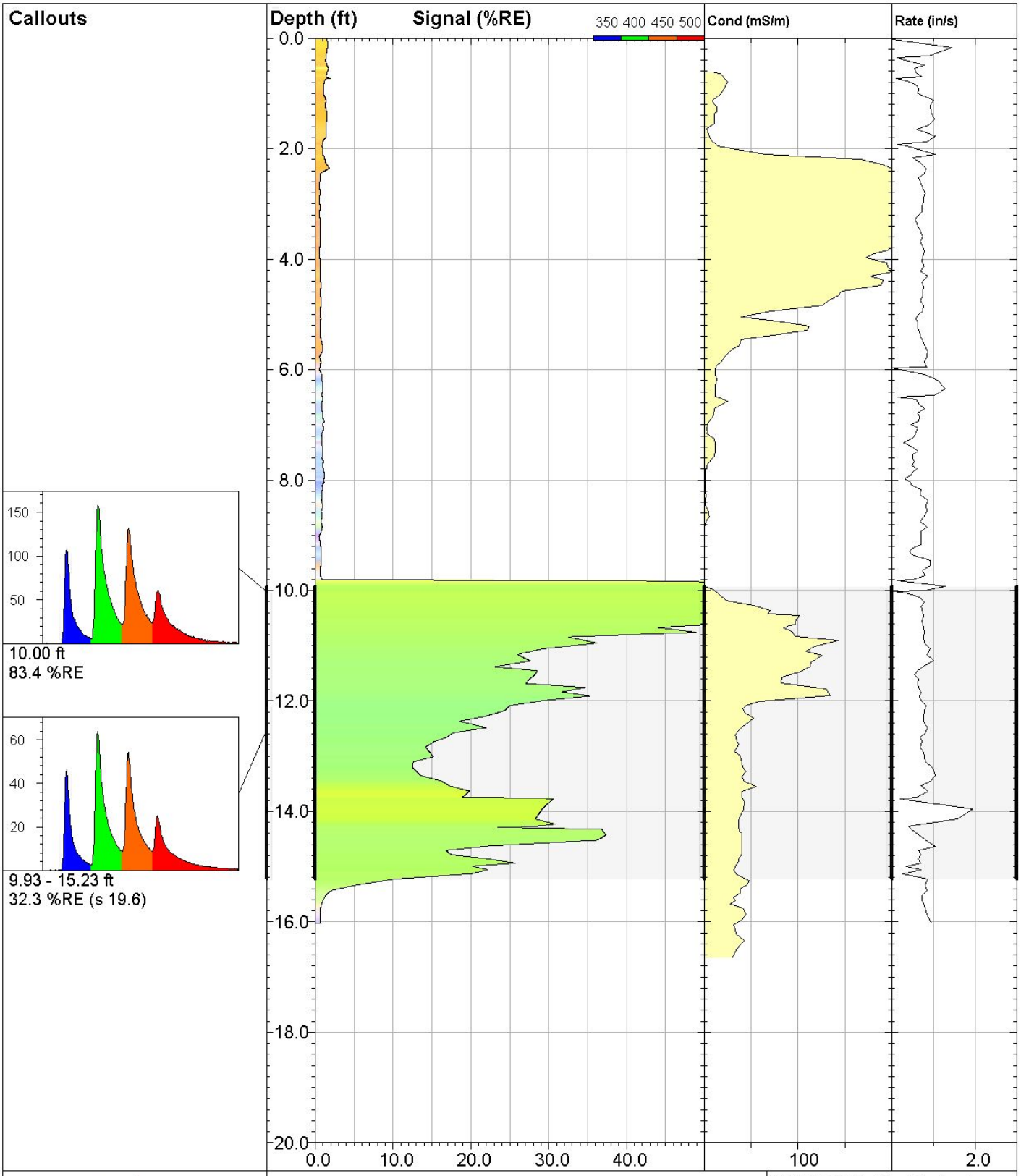
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **72.2 %RE @ 10.92 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 10:19 CDT**



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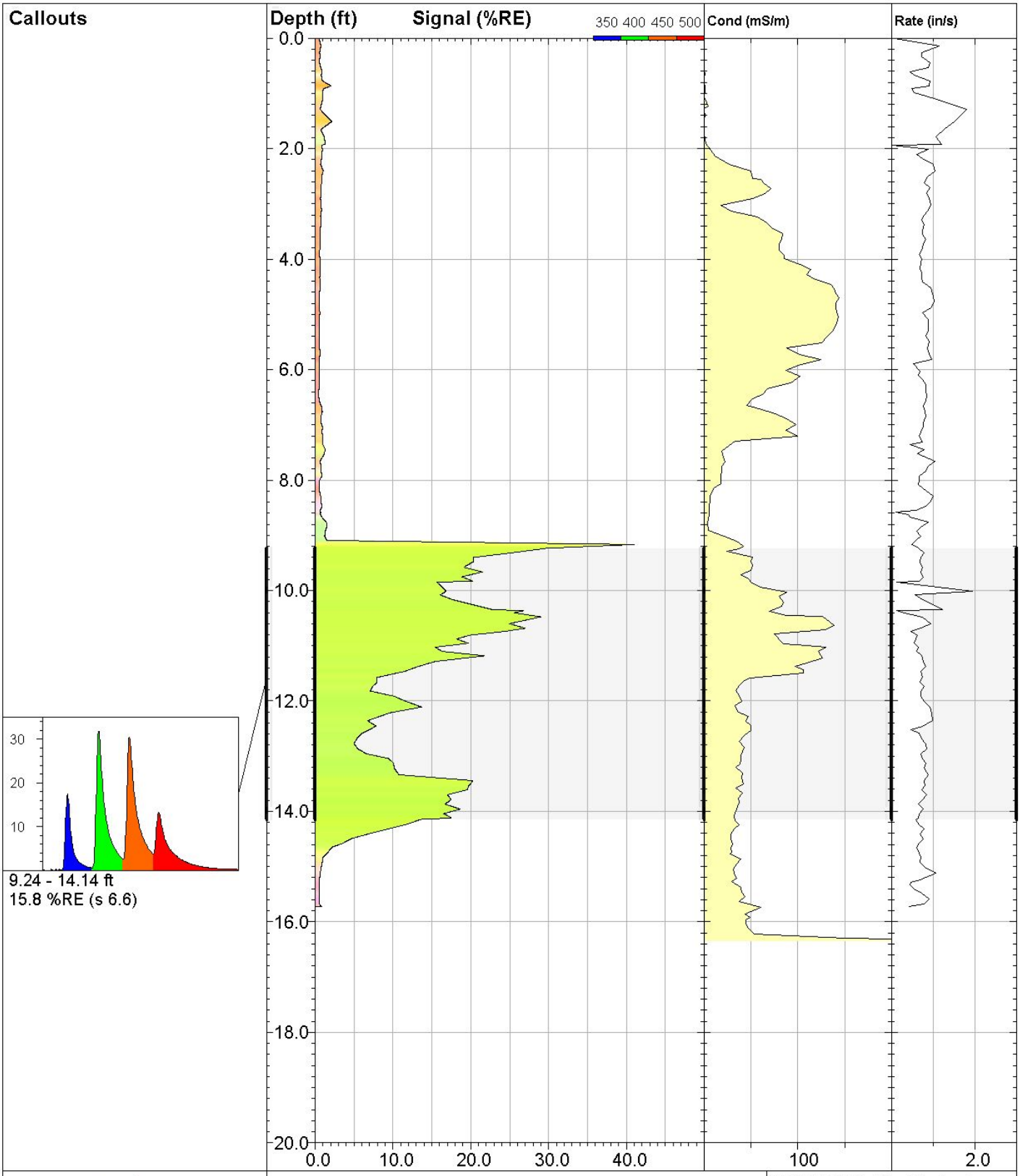
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **87.9 %RE @ 9.93 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 10:49 CDT**



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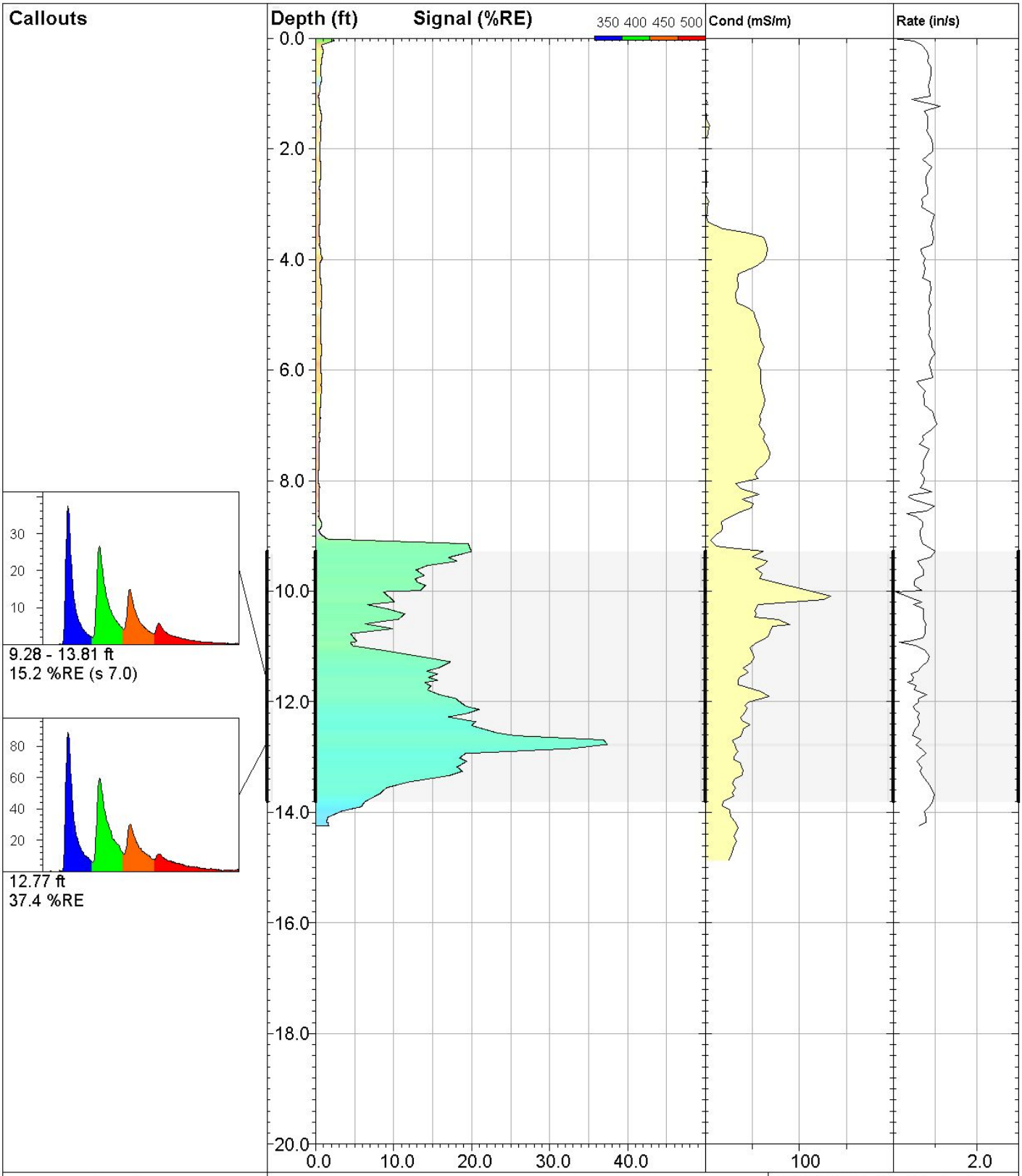
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.73 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **41.1 %RE @ 9.17 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 11:13 CDT**



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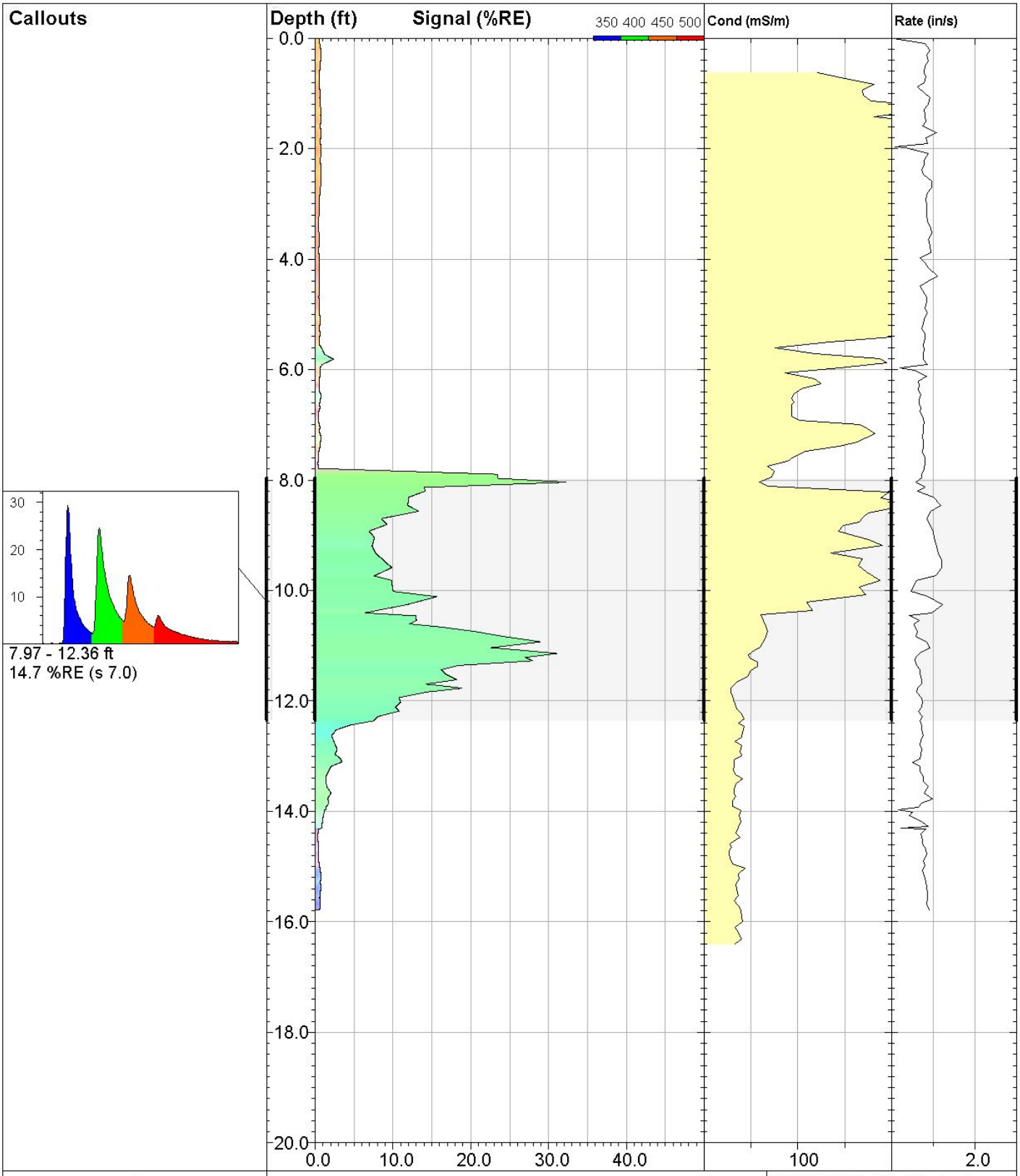
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.24 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **37.4 %RE @ 12.77 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 11:45 CDT**



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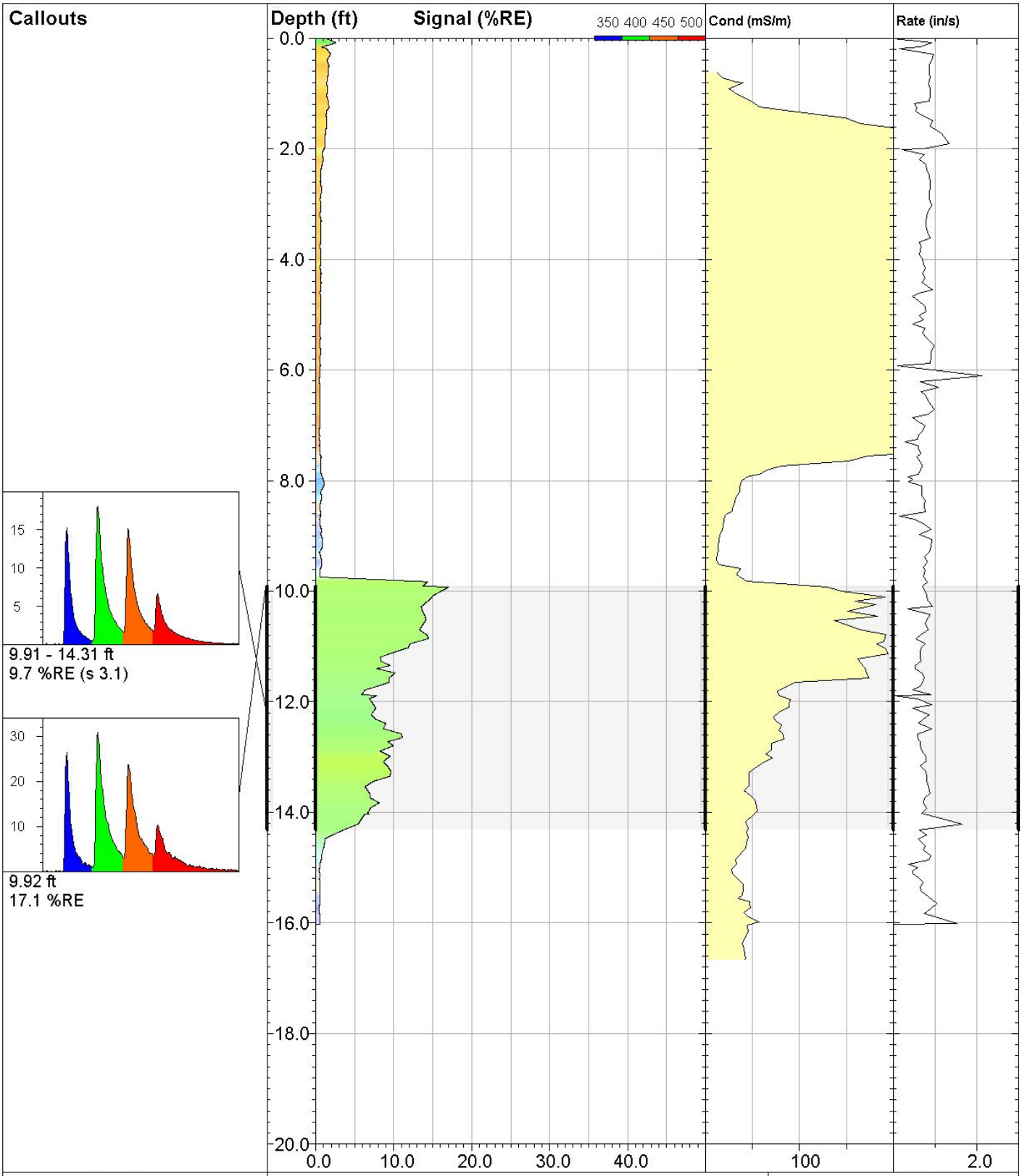
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.78 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **32.3 %RE @ 8.04 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 12:20 CDT**



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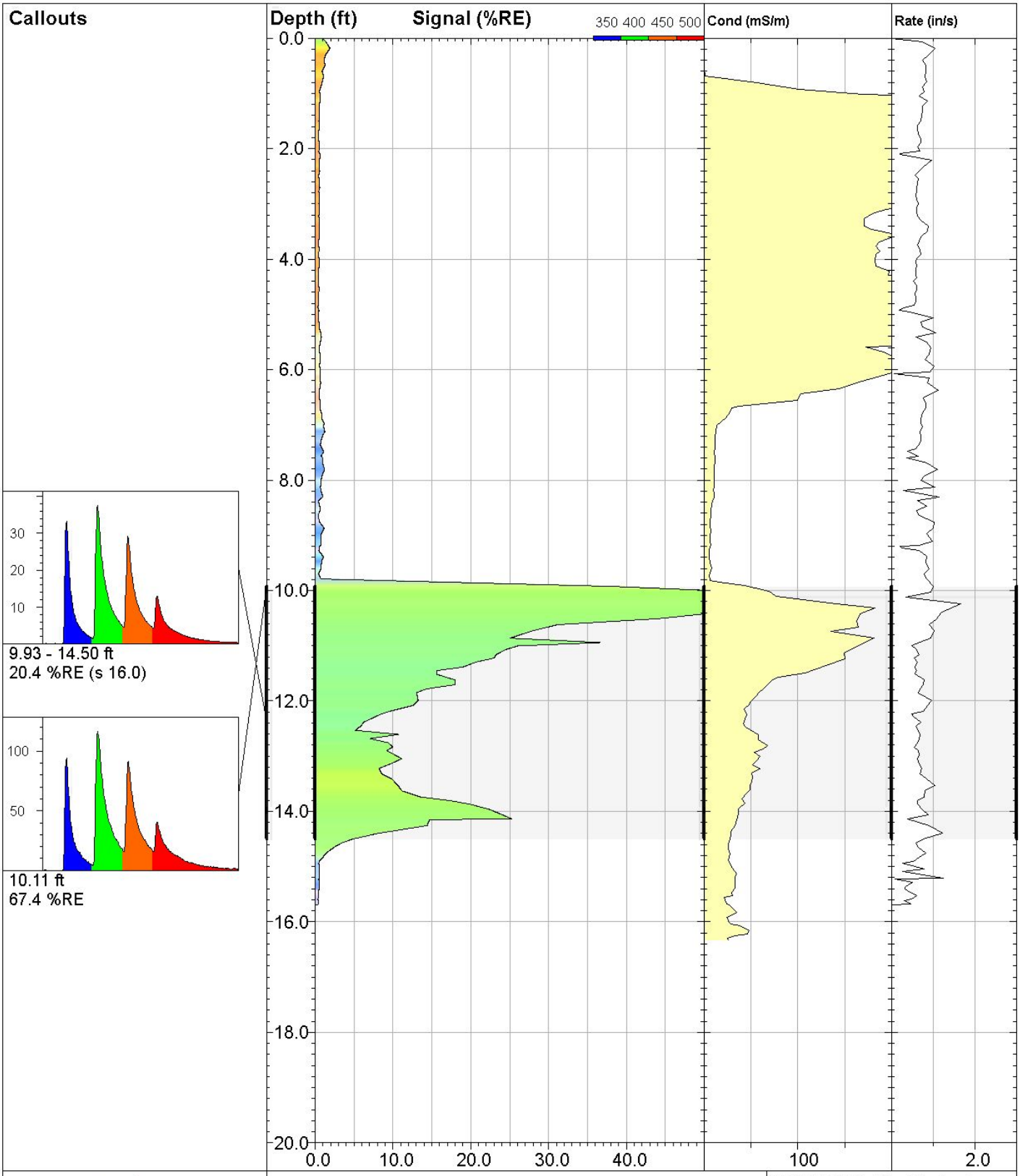
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.03 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **17.1 %RE @ 9.92 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 13:08 CDT**



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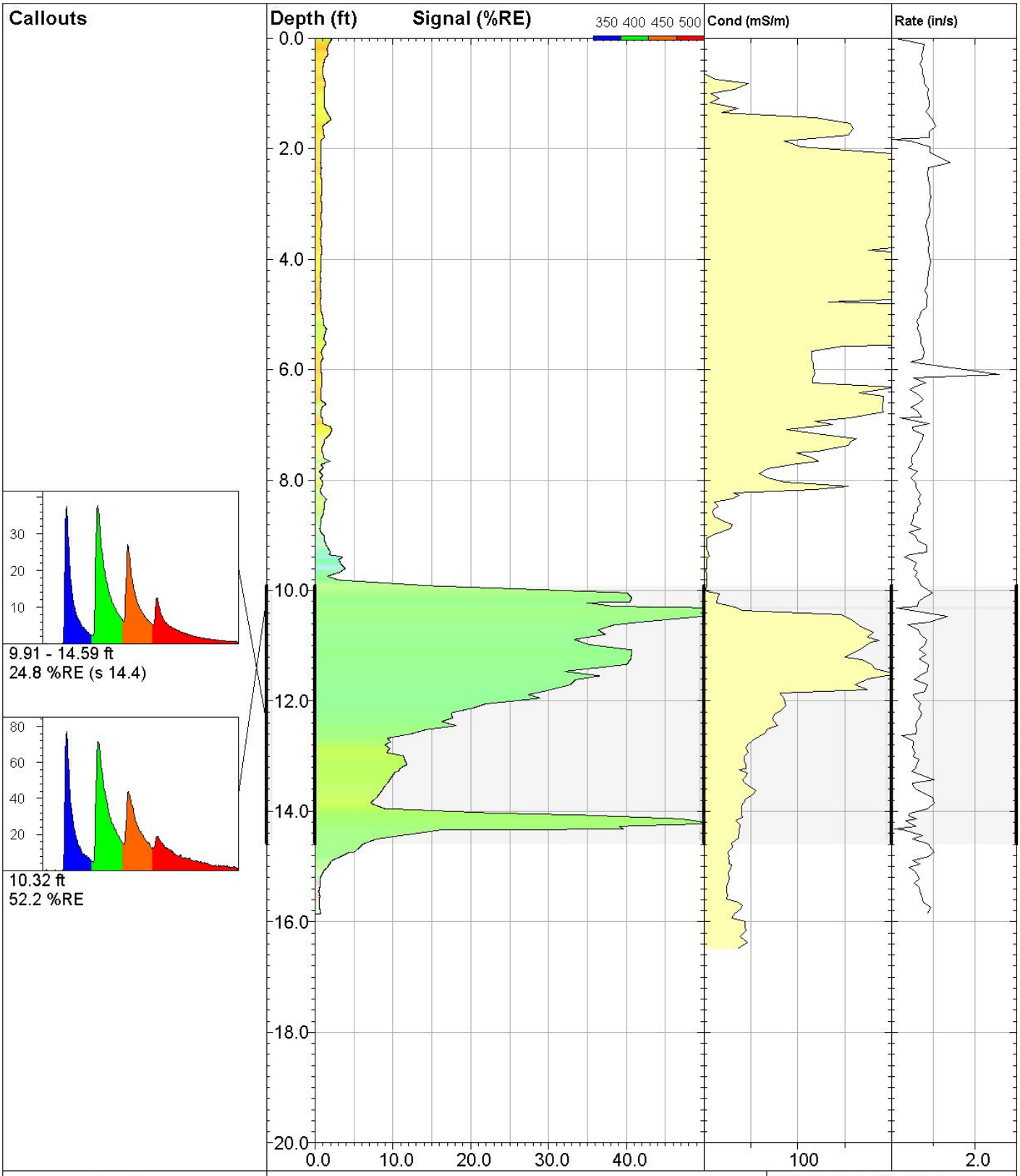
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.69 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **67.4 %RE @ 10.11 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 13:34 CDT**



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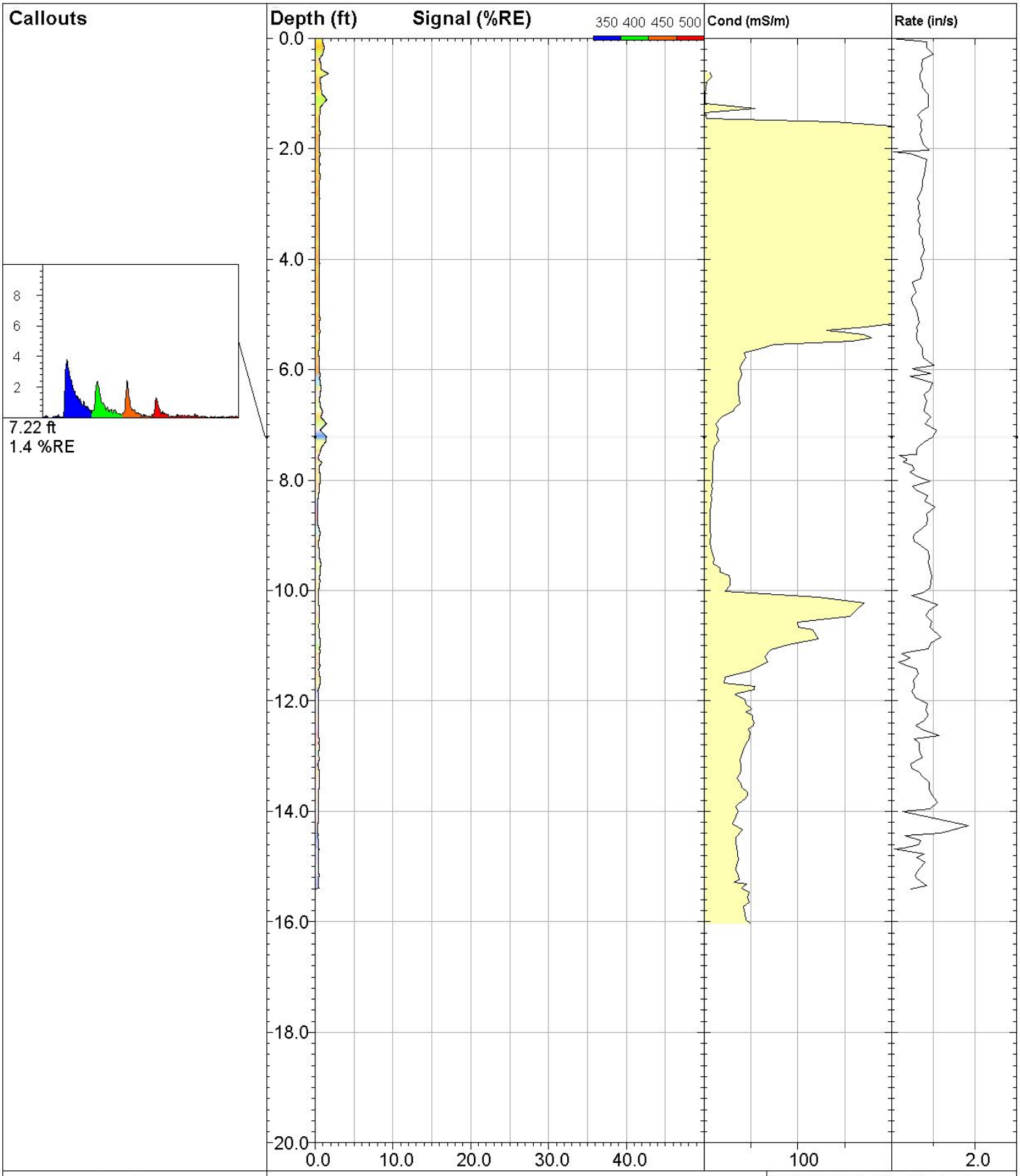
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.86 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **52.2 %RE @ 10.32 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 13:59 CDT**



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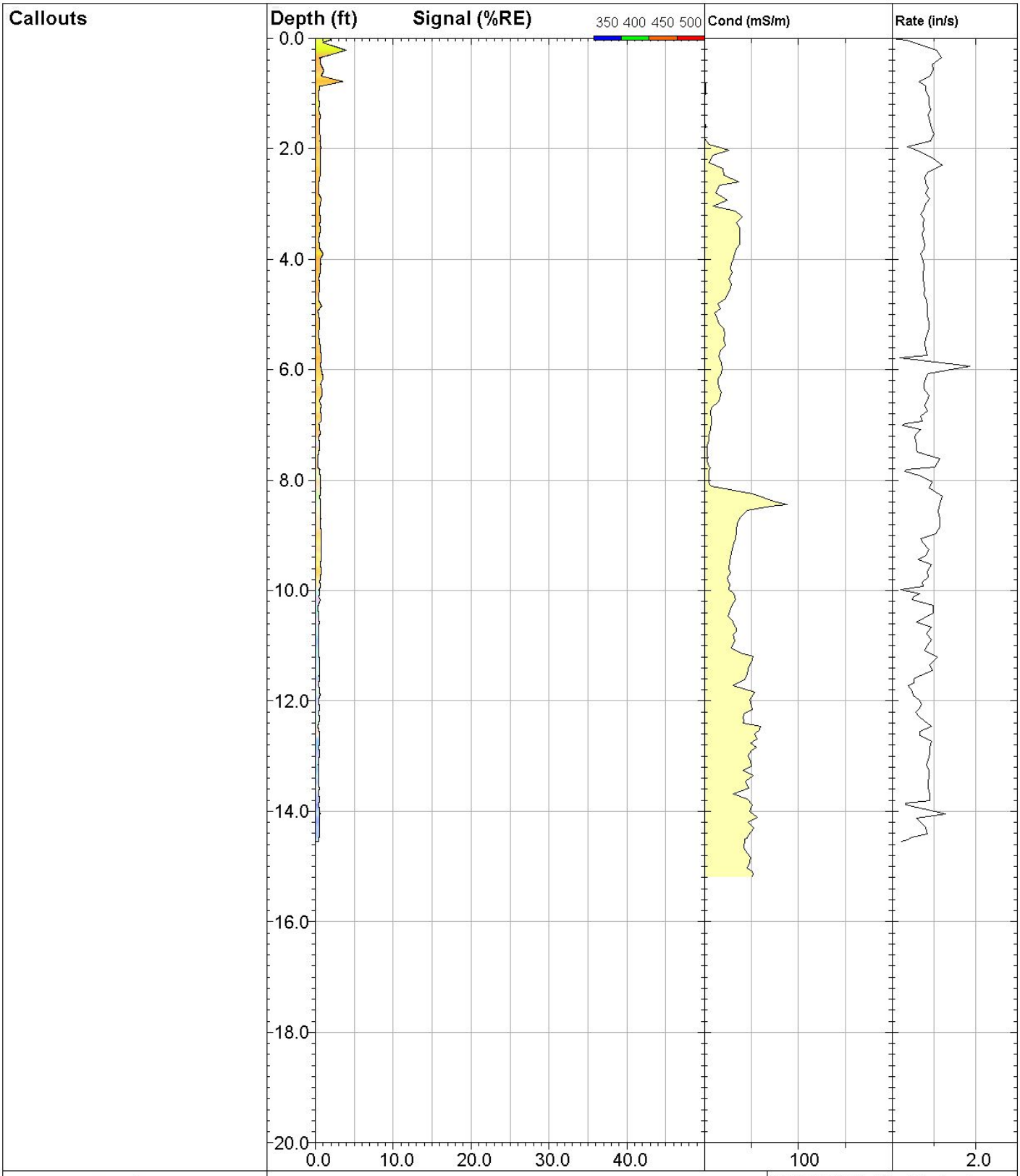
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.40 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.7 %RE @ 0.64 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 14:29 CDT**



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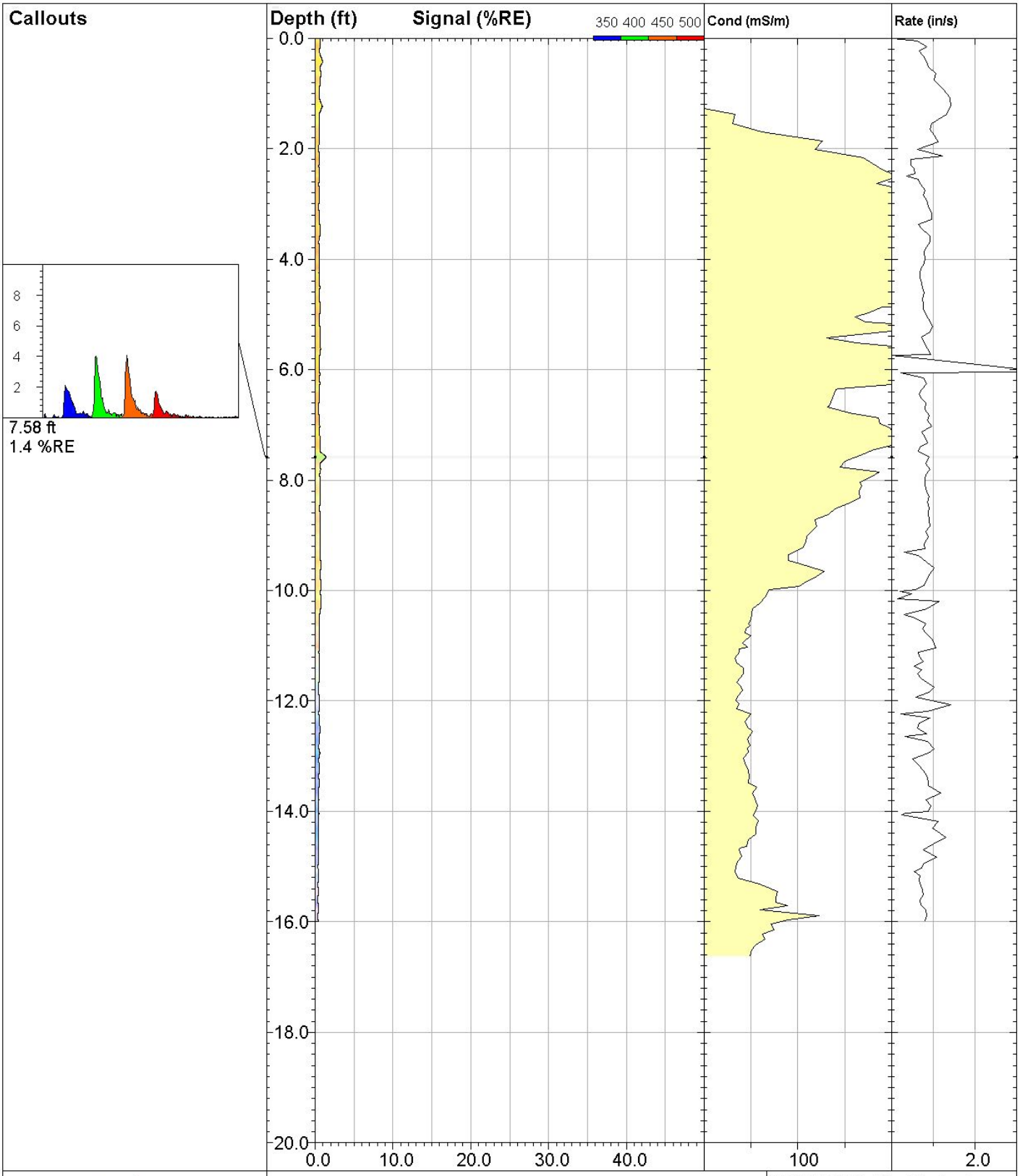
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.55 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.0 %RE @ 0.22 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 15:21 CDT**



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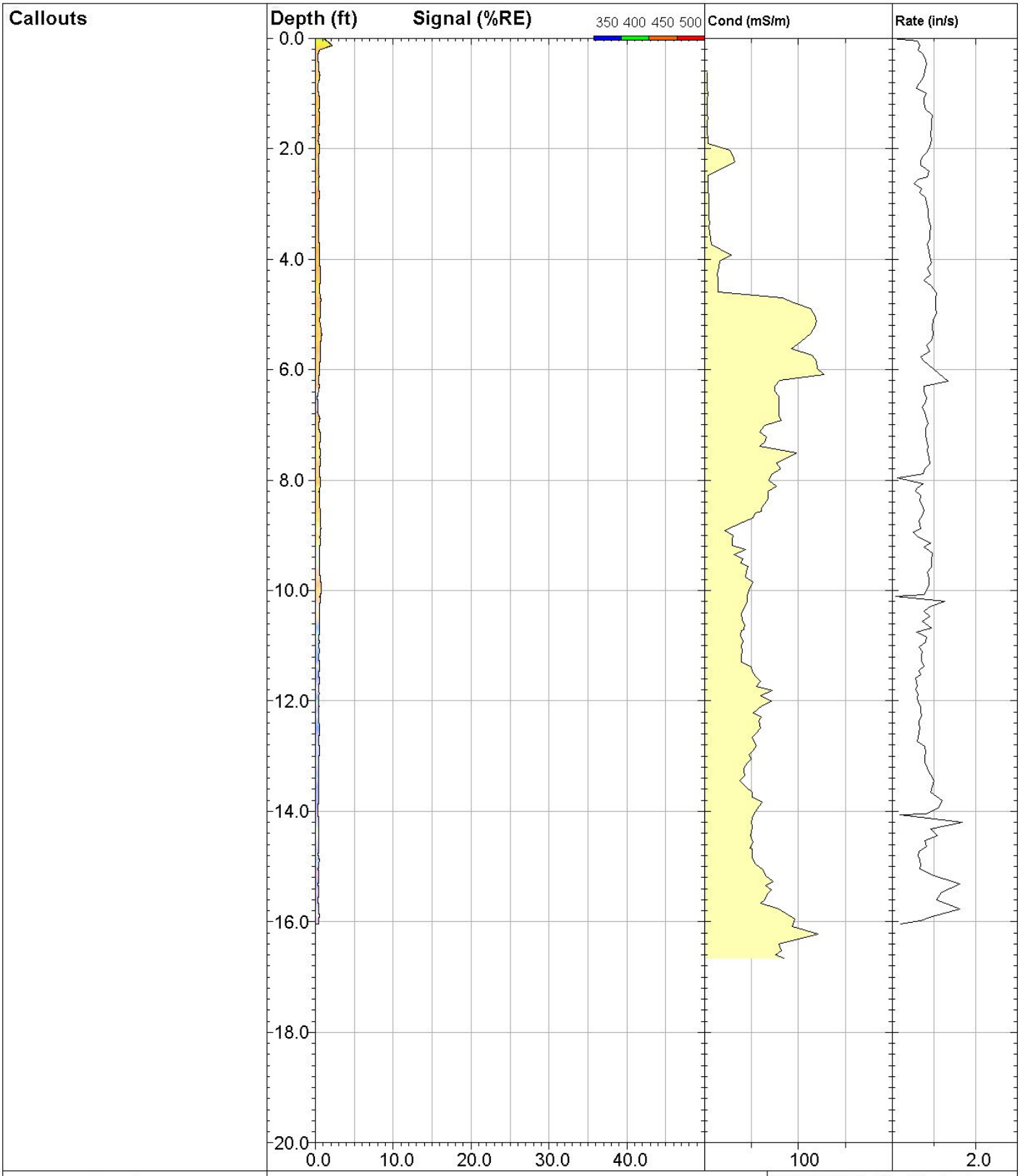
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 7.58 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 15:43 CDT**



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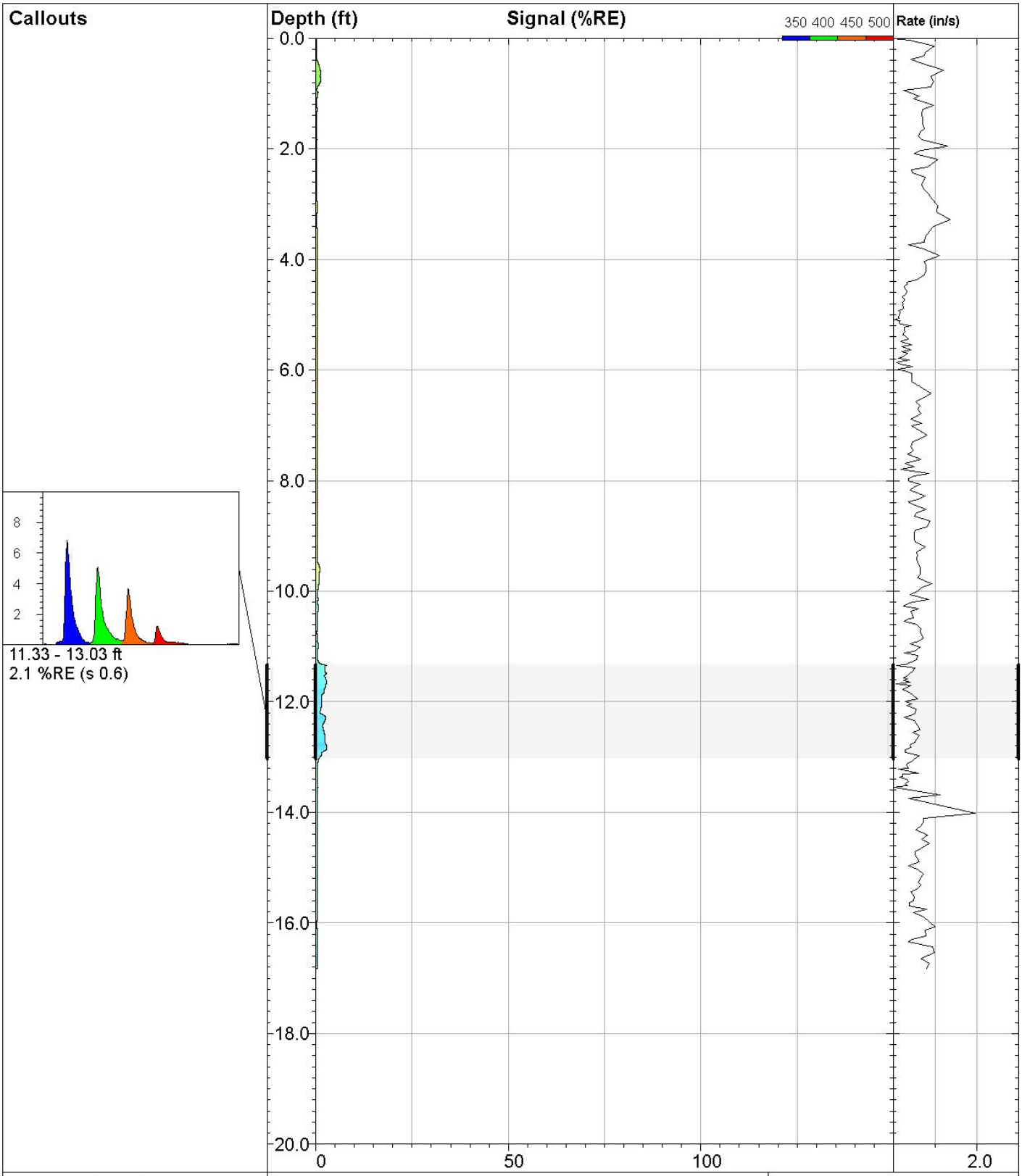
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 0.13 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 16:03 CDT**

Appendix D

UVOST® Logs at 150% RE



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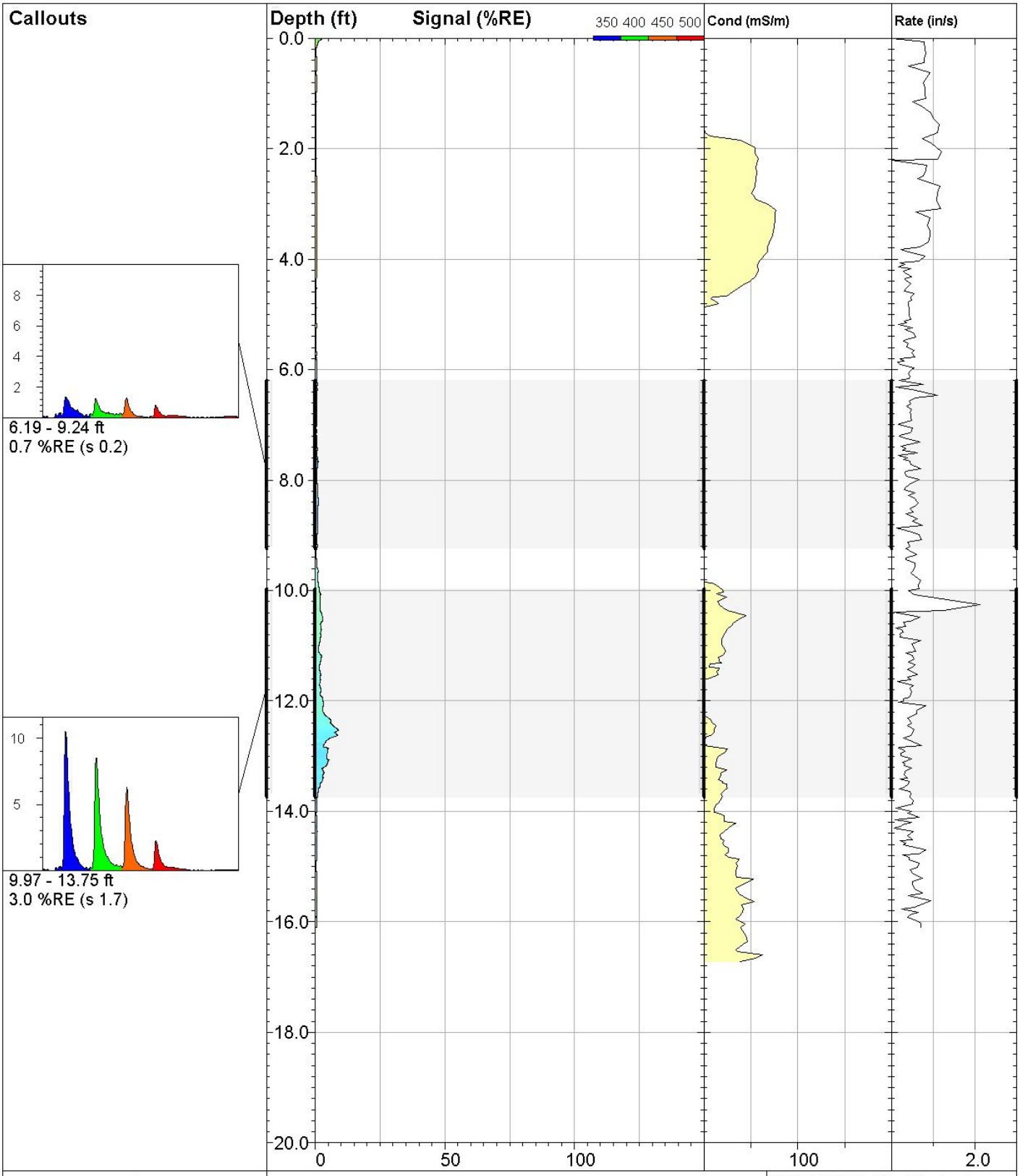
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.83 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.9 %RE @ 11.65 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 12:37 CDT**



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02-LIF

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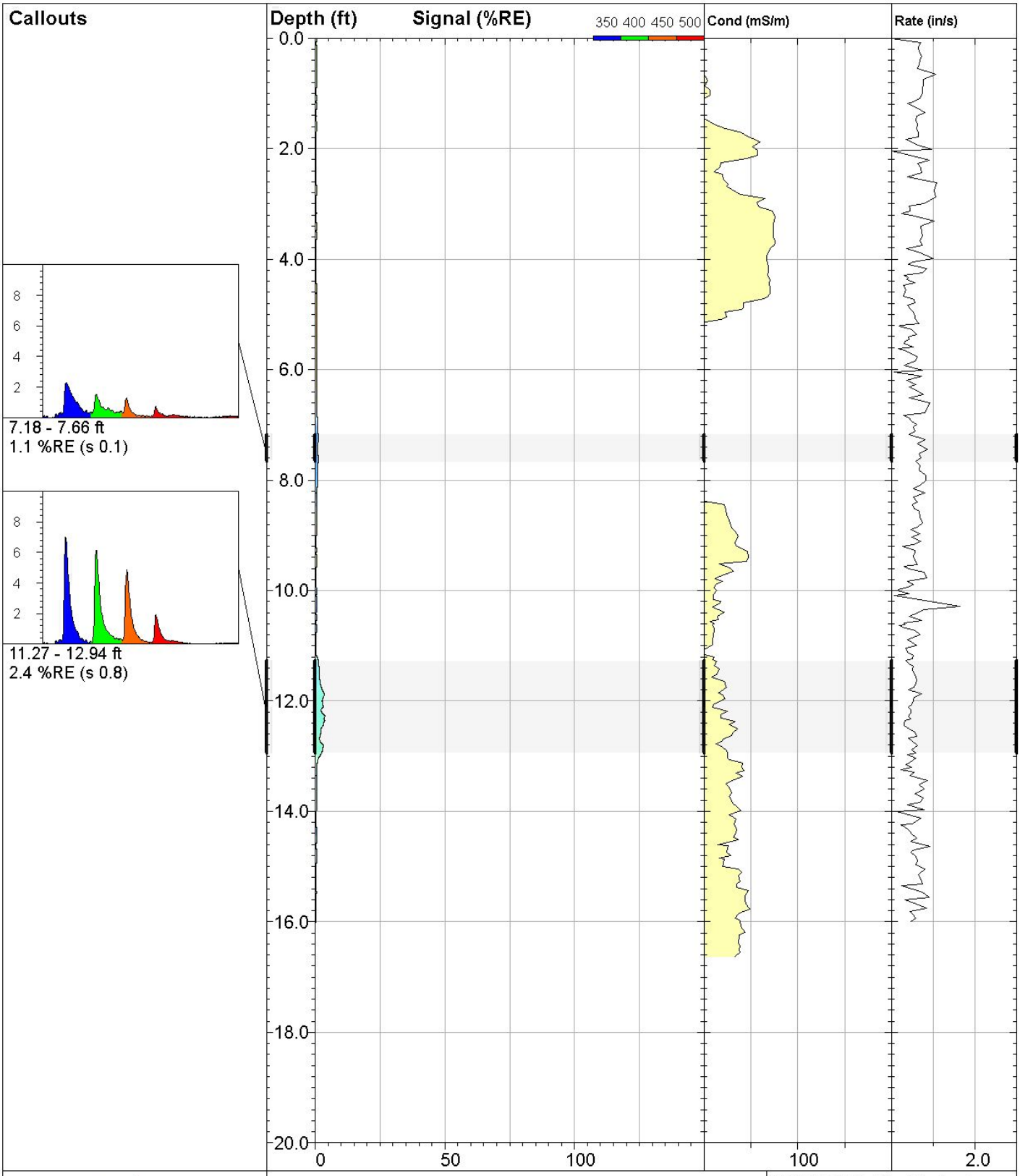
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.10 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **9.1 %RE @ 12.53 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 13:03 CDT**



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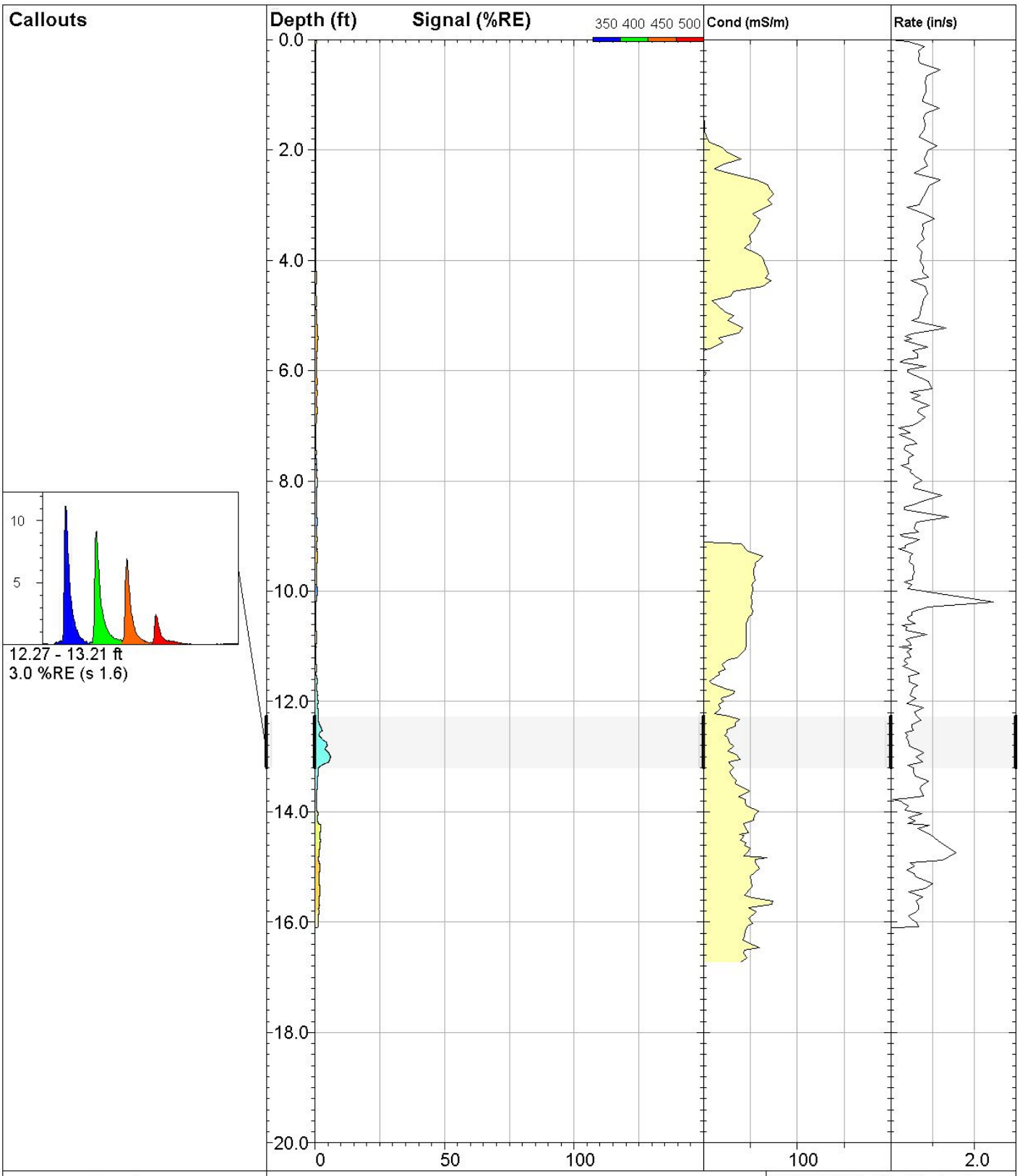
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.8 %RE @ 12.28 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 13:26 CDT**



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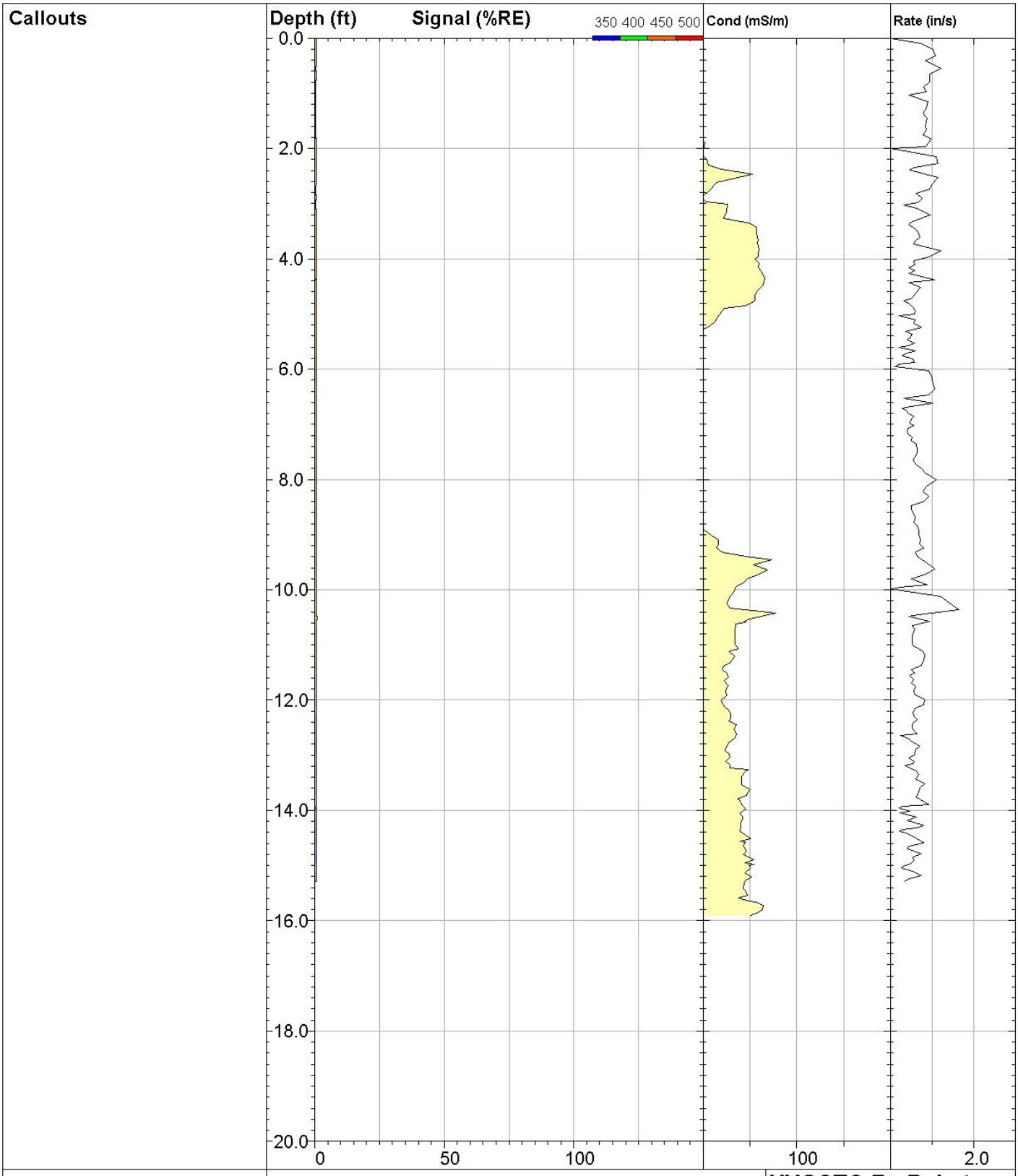
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.10 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.1 %RE @ 13.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 13:51 CDT**



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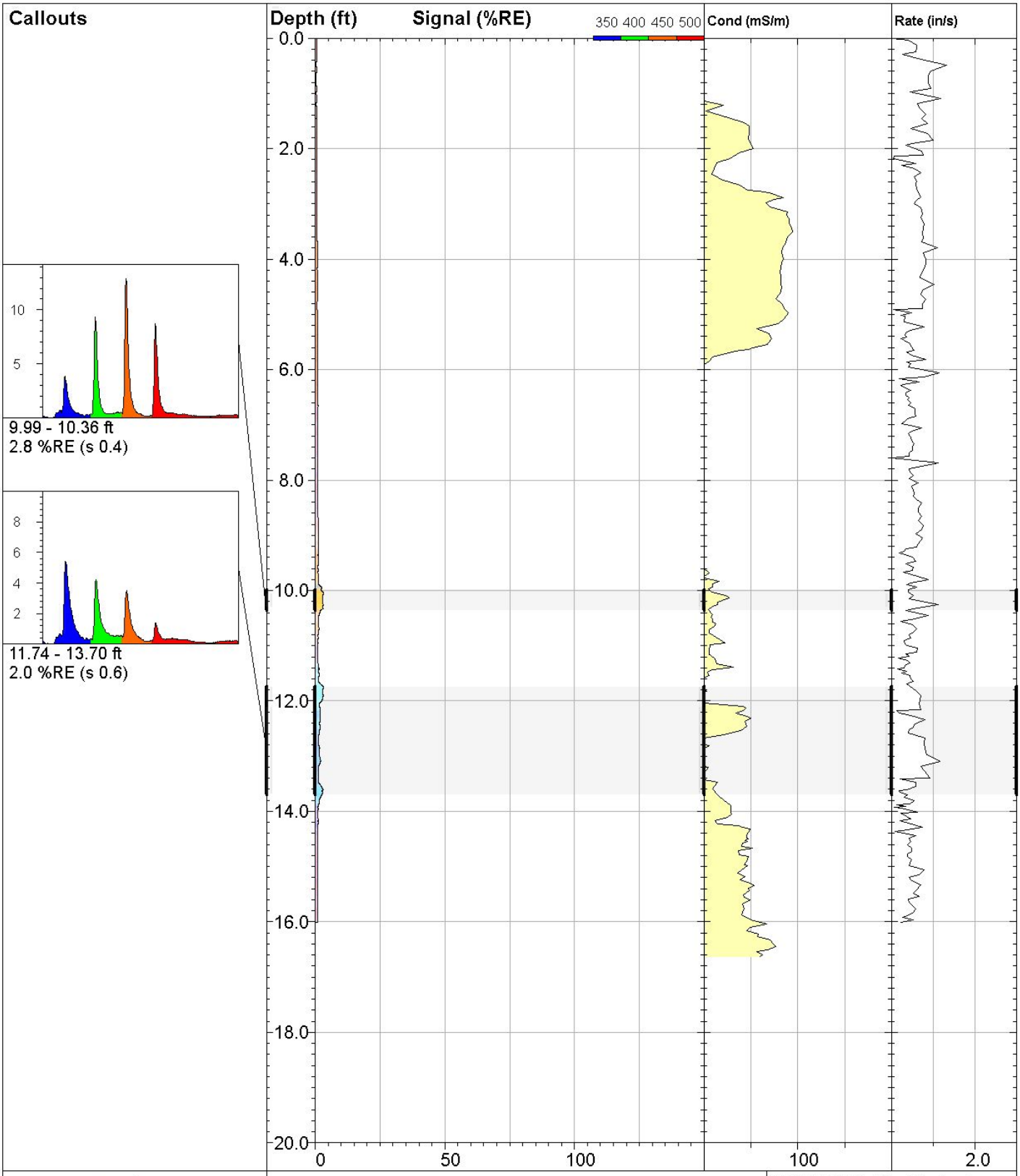
	Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.29 ft**
	Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **0.8 %RE @ 10.49 ft**
	Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 14:14 CDT**



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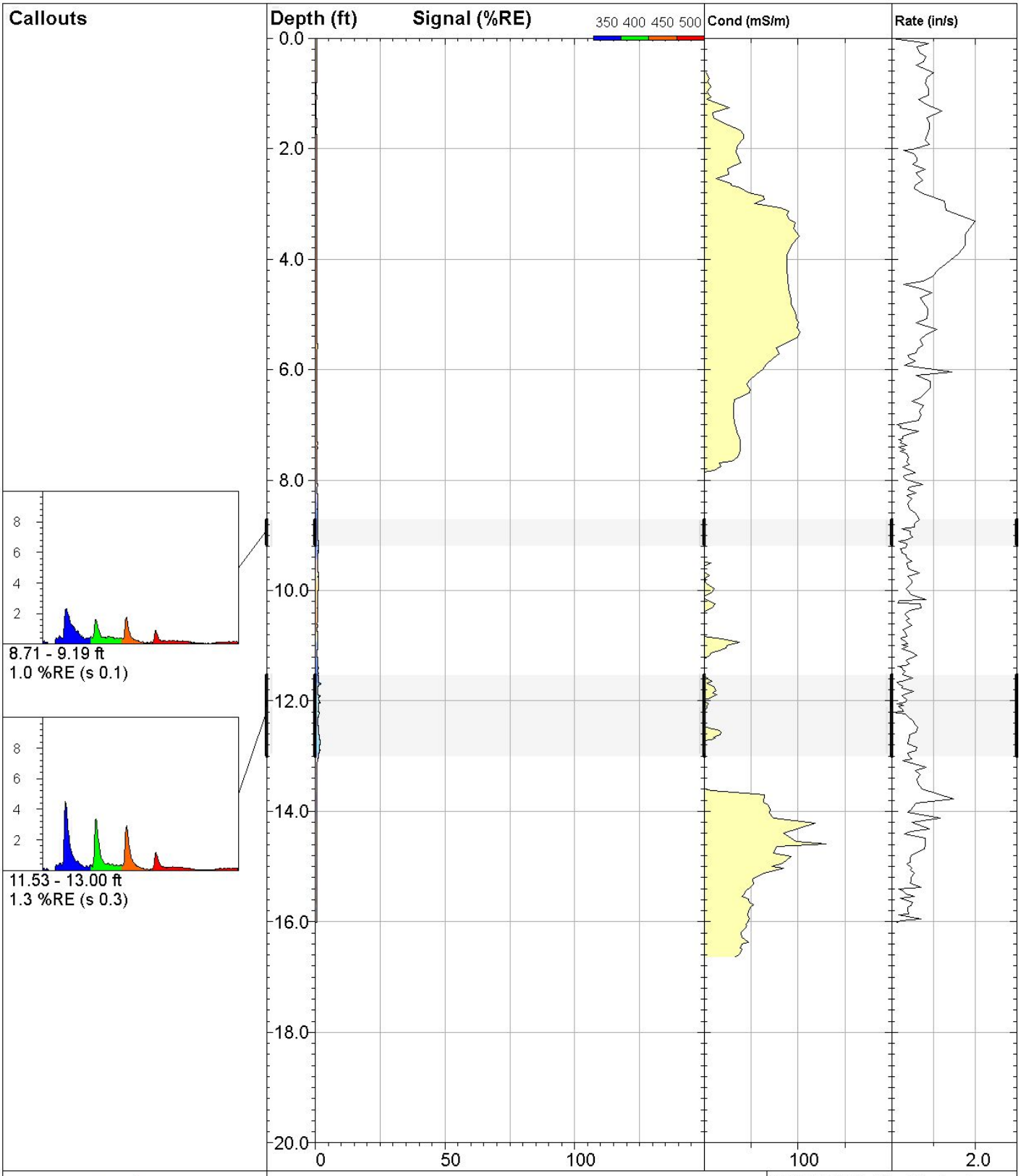
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.2 %RE @ 11.74 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 14:39 CDT**



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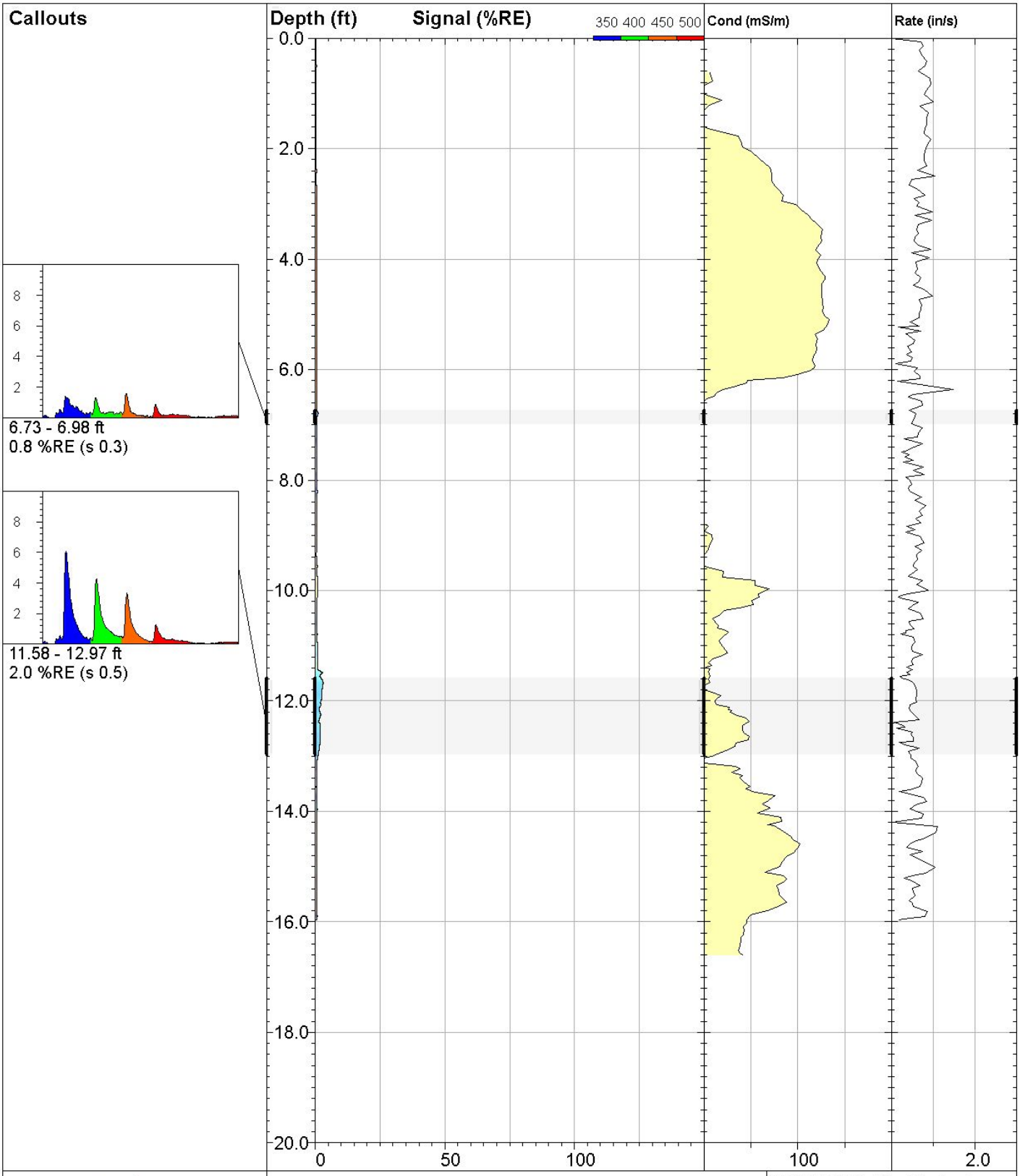
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.3 %RE @ 11.69 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 15:16 CDT**



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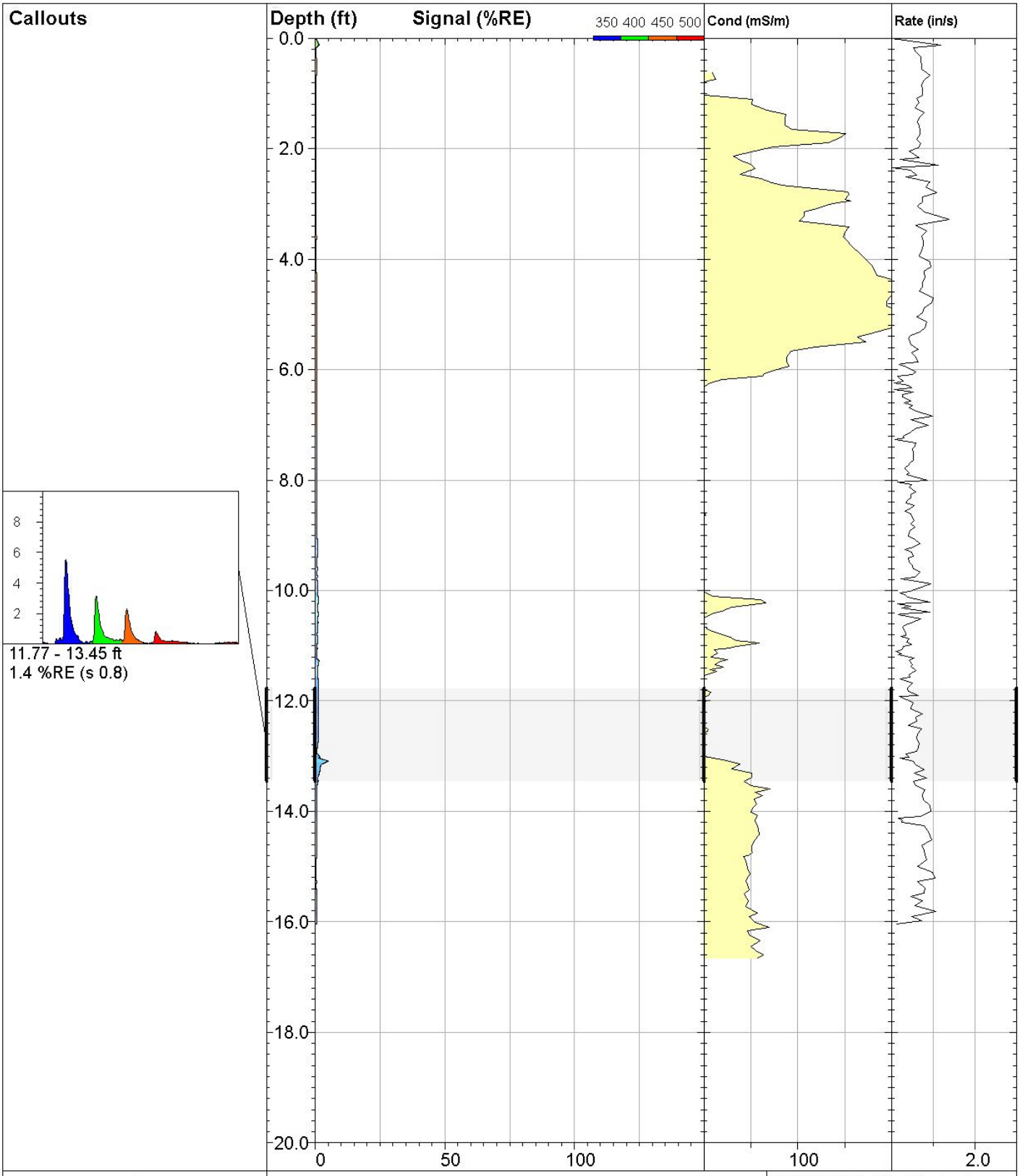
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.97 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.1 %RE @ 11.68 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 15:40 CDT**



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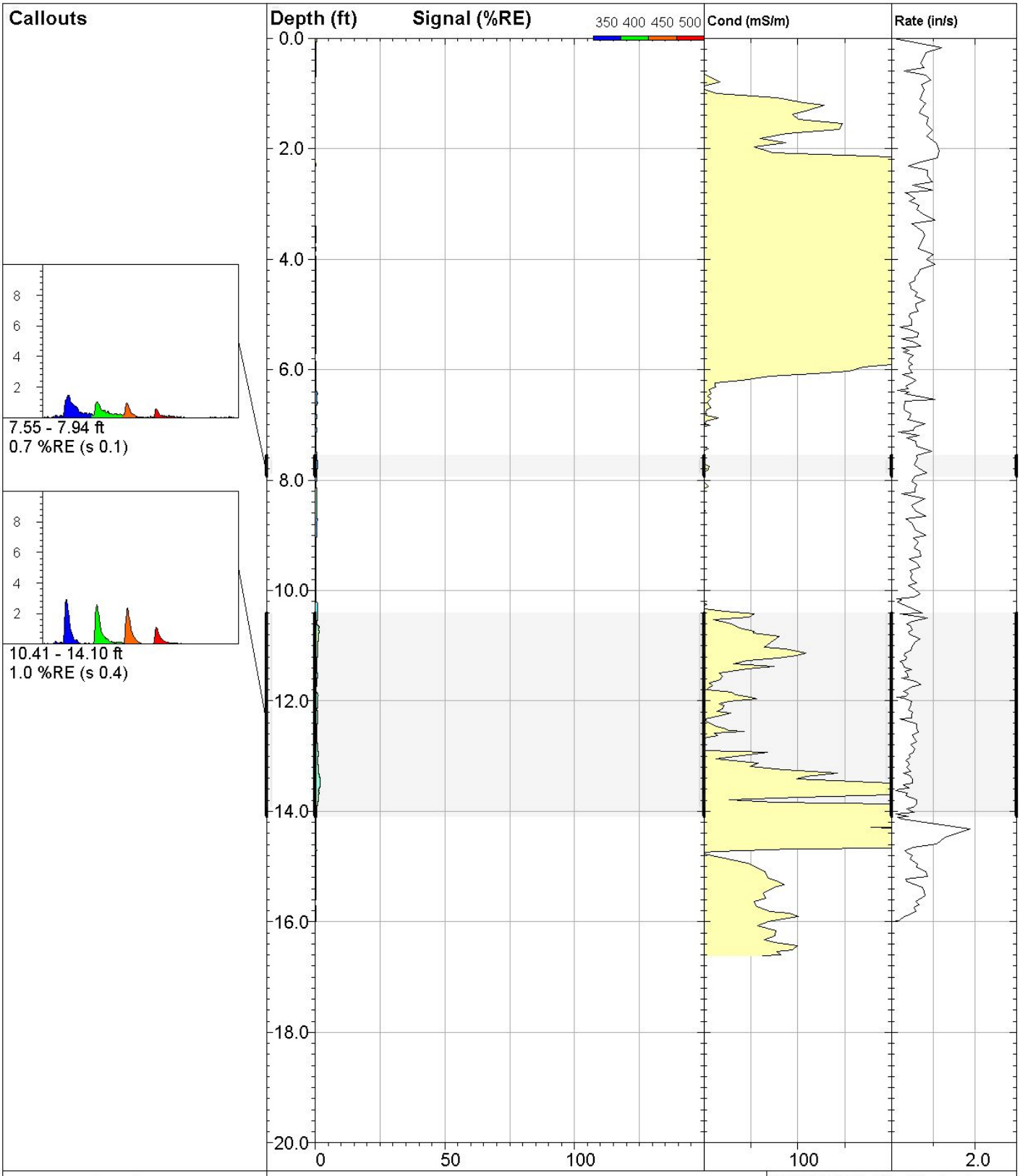
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.1 %RE @ 13.09 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-23 16:05 CDT**



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10-LIF

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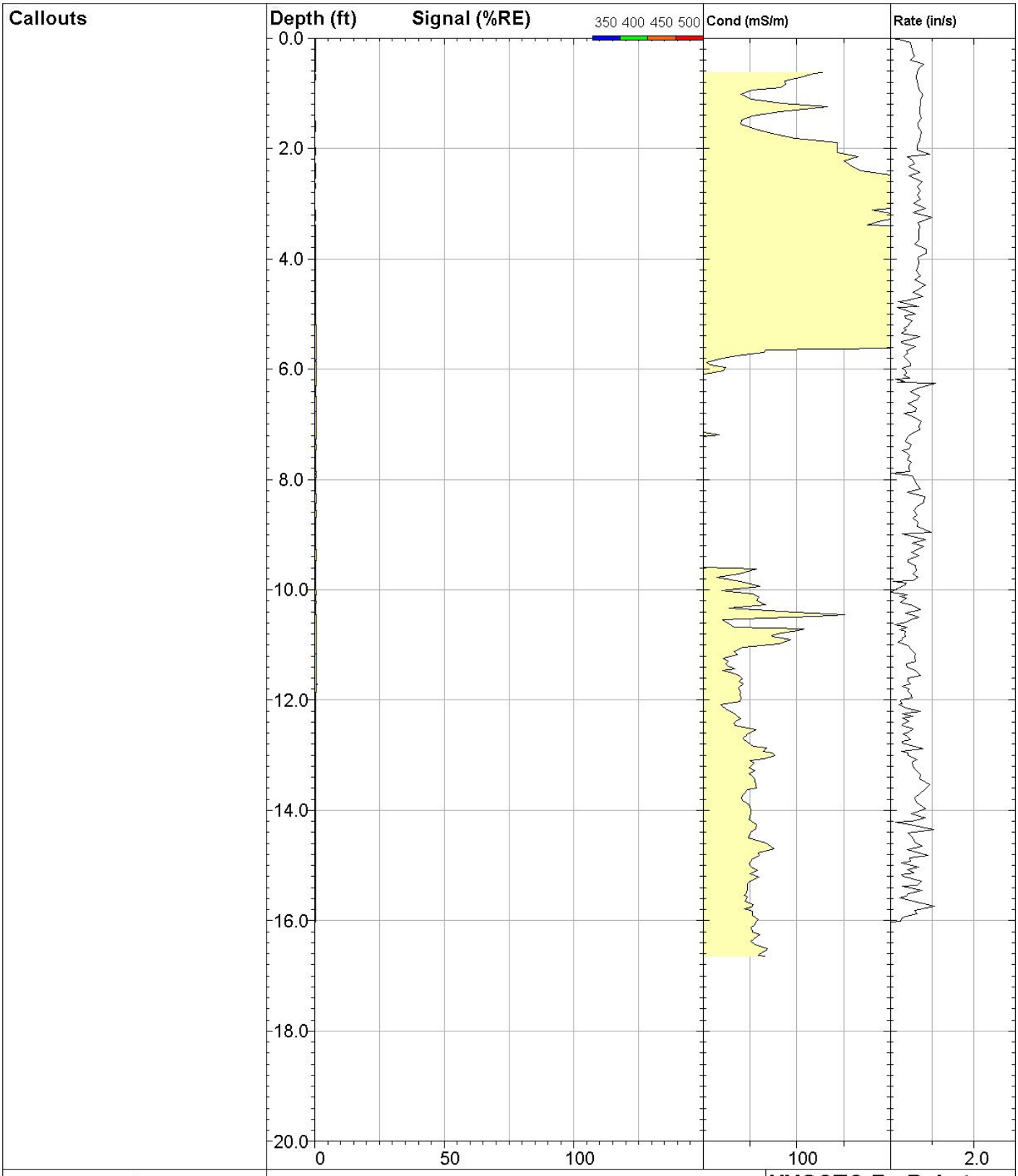
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.0 %RE @ 13.48 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 10:00 CDT**



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11-LIF

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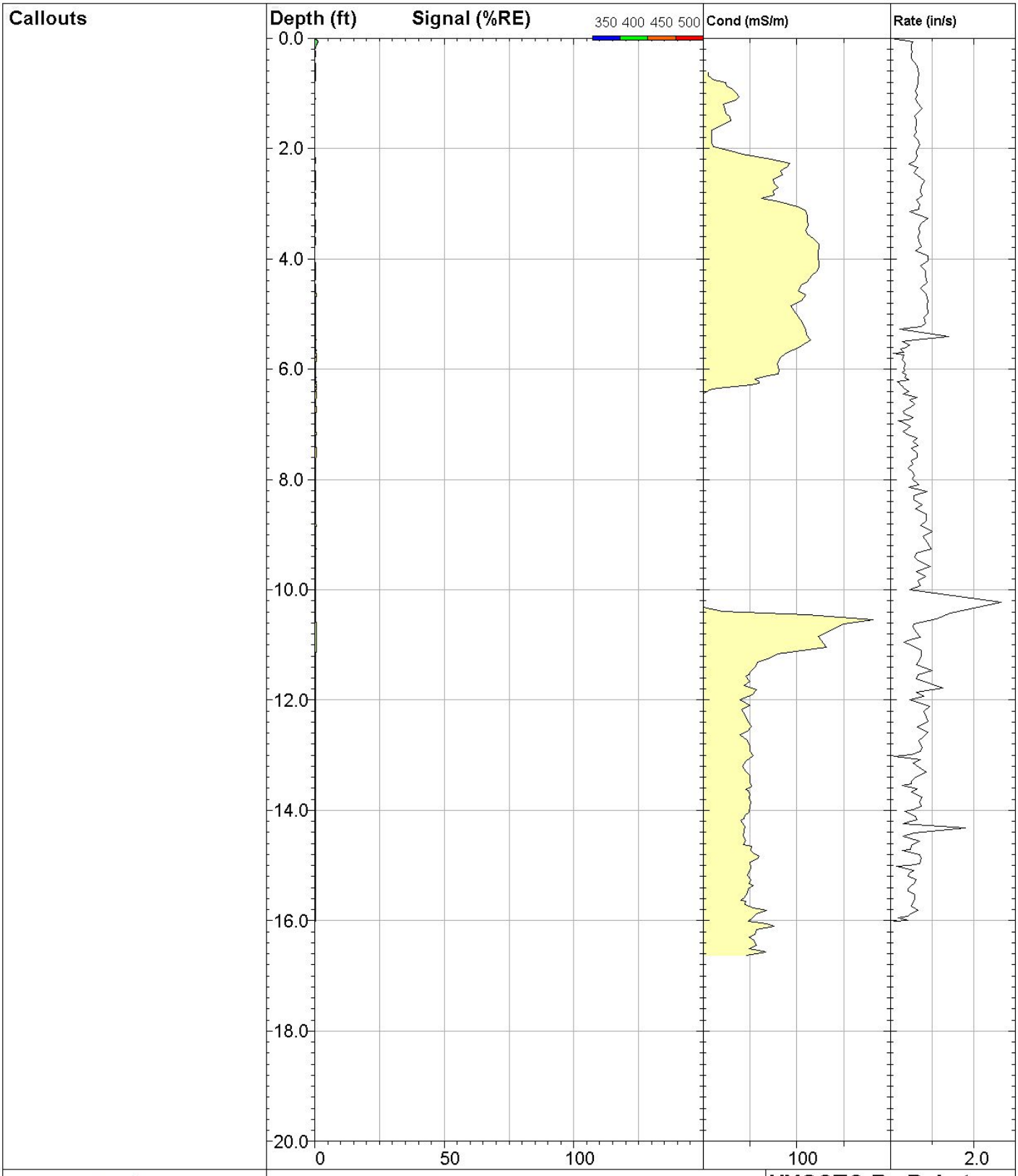
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **0.8 %RE @ 11.71 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 10:24 CDT**



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12-LIF

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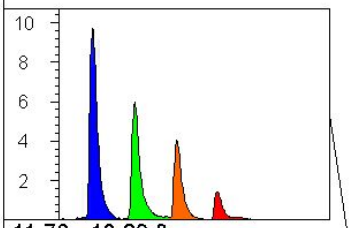
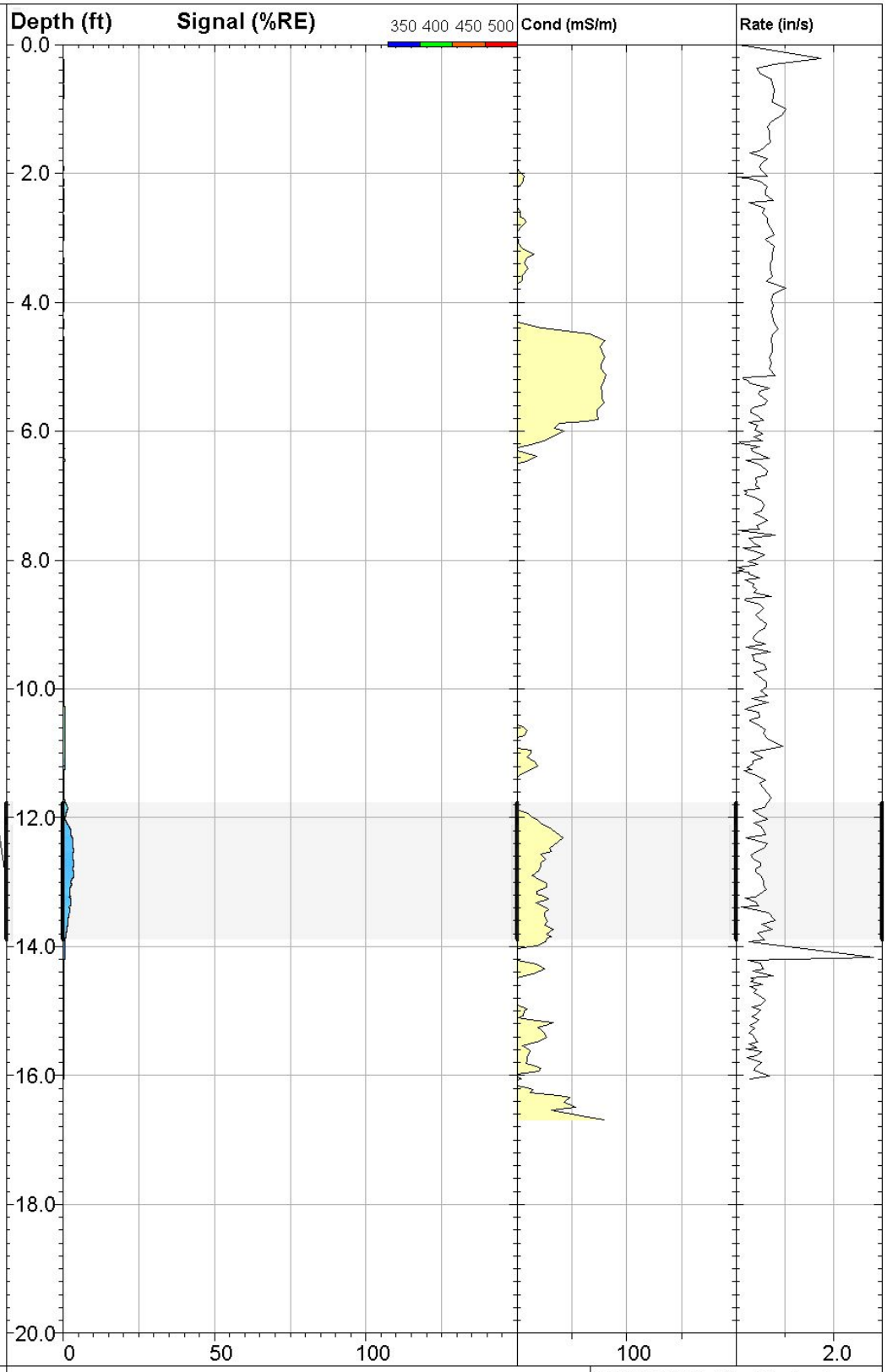
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.3 %RE @ 0.07 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 10:48 CDT**

Callouts



11.76 - 13.89 ft
2.3 %RE (s 0.9)

RESTRING DUE TO BENT MIP TUBE



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13-LIF

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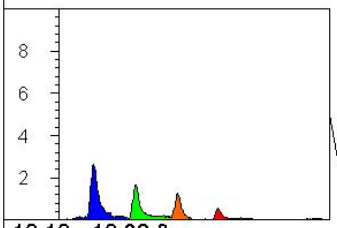
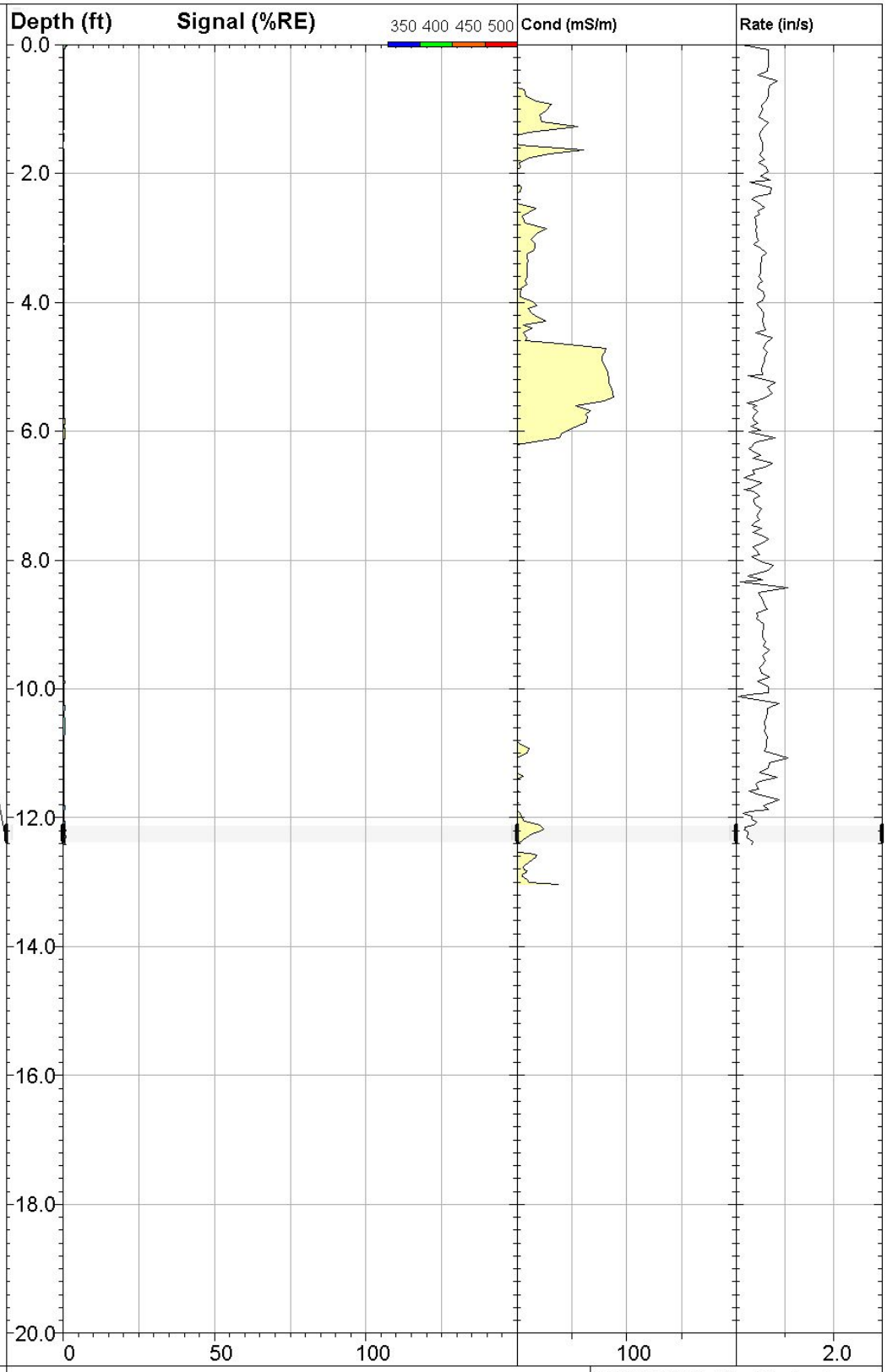
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.06 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.7 %RE @ 12.70 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 11:28 CDT**

Callouts



12.12 - 12.38 ft
0.7 %RE (s 0.1)

REFUSAL AT 12.42FT



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14-LIF

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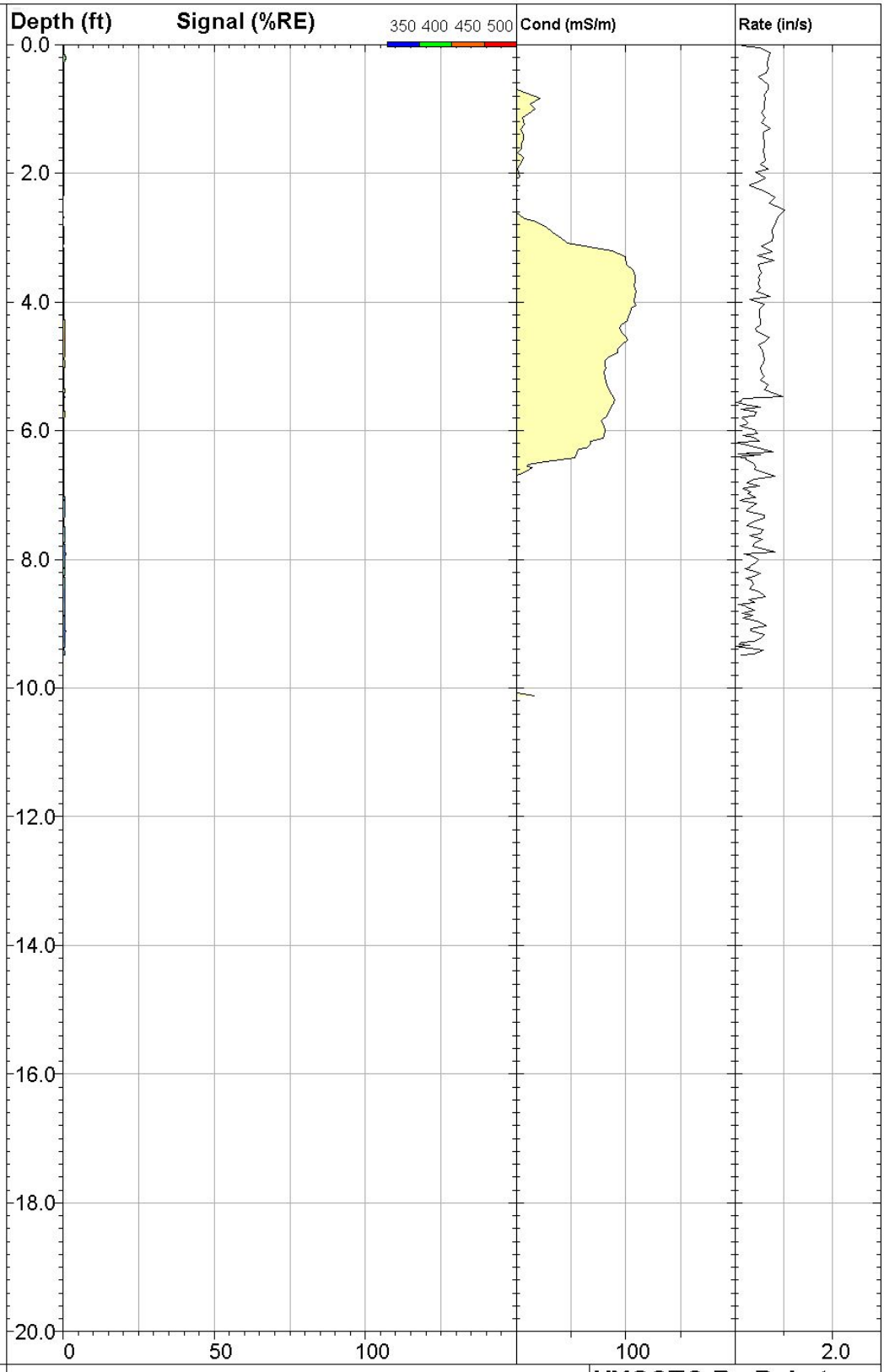
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **12.42 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.2 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 12:26 CDT**

Callouts
REFUSAL AT 9.49FT



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15-LIF

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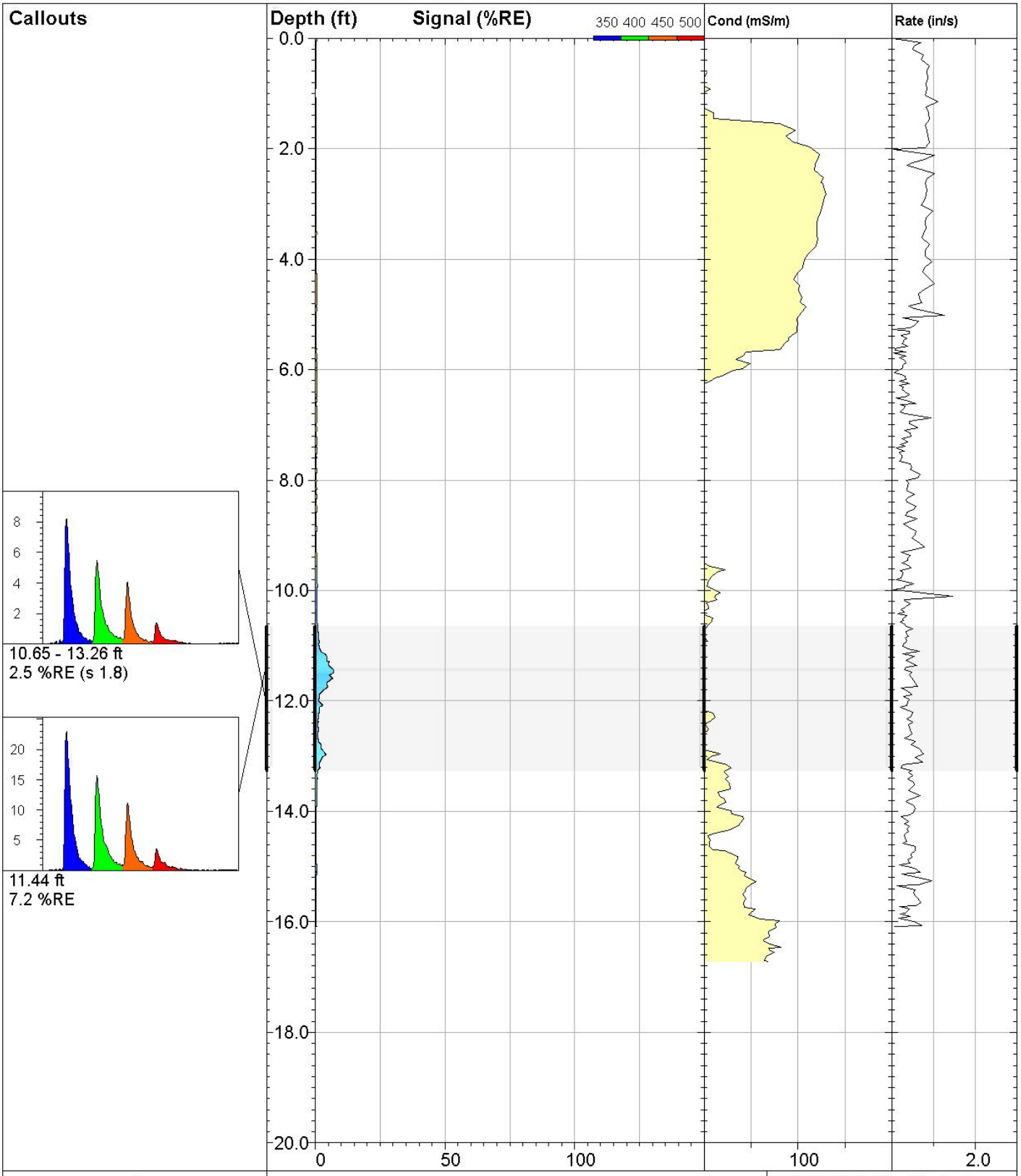
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **9.49 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.0 %RE @ 0.21 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 12:51 CDT**



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16-LIF

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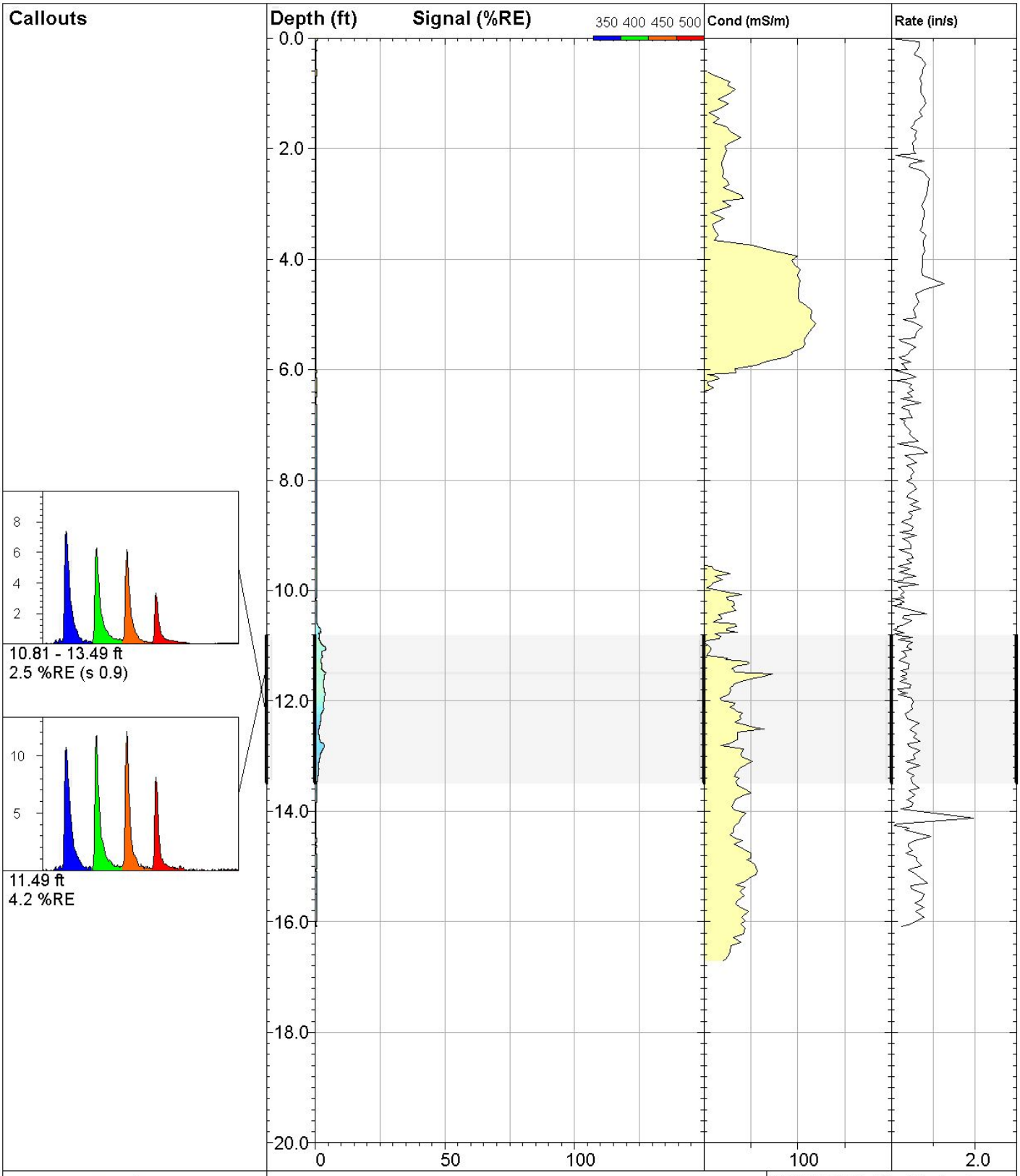
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **7.2 %RE @ 11.44 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 13:30 CDT**



17-LIF		**UVOST® By Dakota** www.DakotaTechnologies.com
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.2 %RE @ 11.49 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 13:51 CDT**

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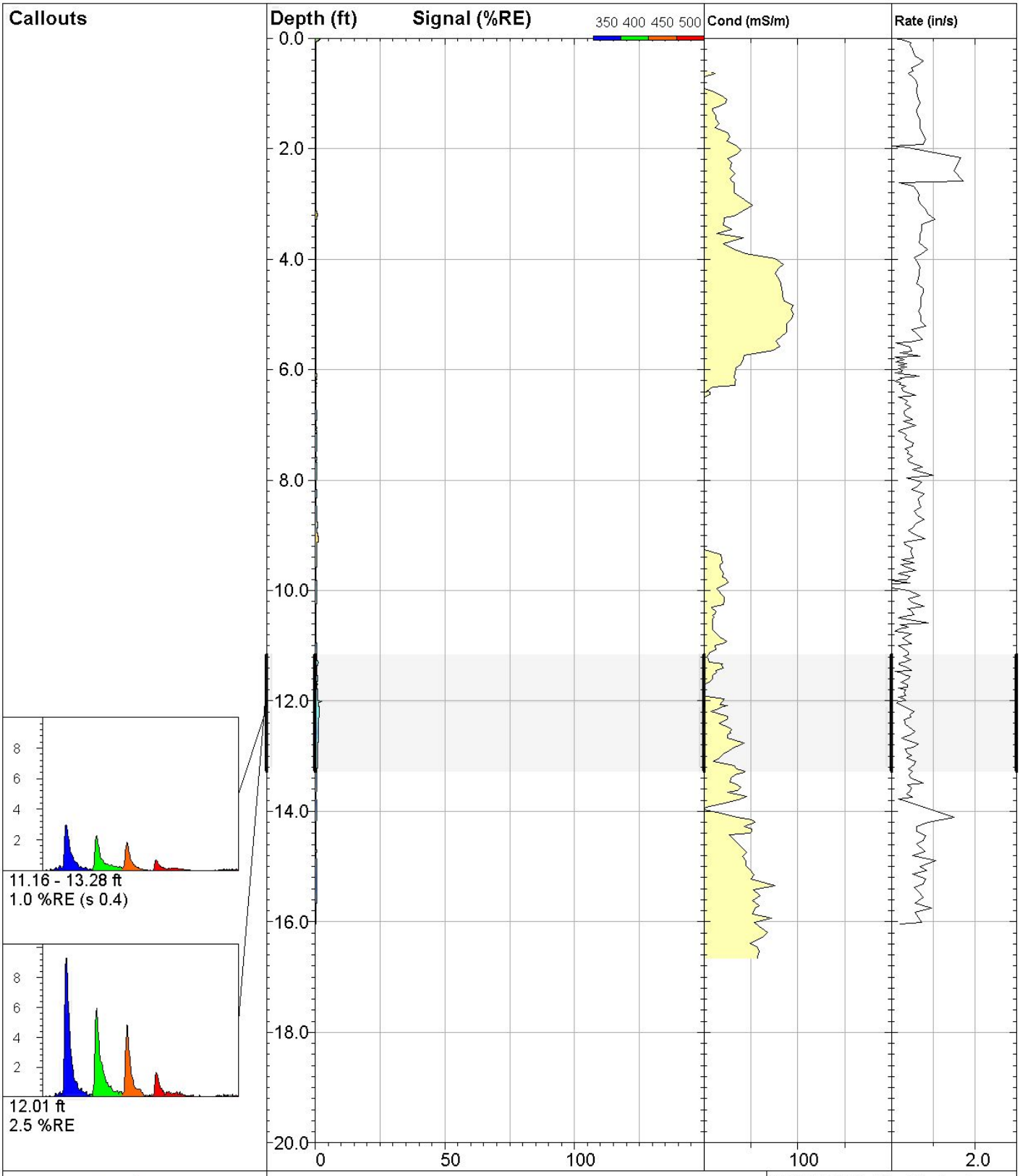

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18-LIF

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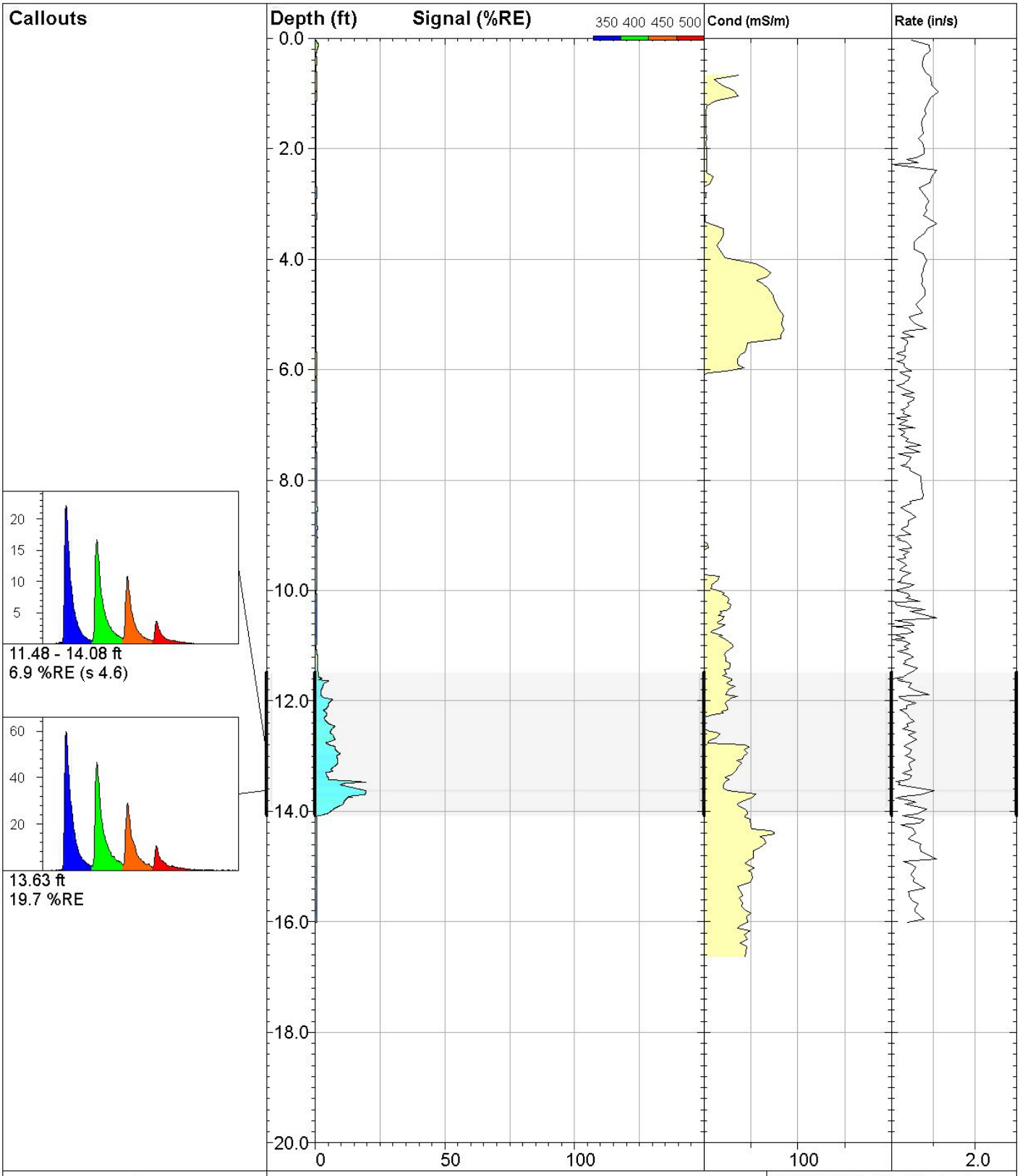
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.5 %RE @ 12.01 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 14:16 CDT**



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19-LIF

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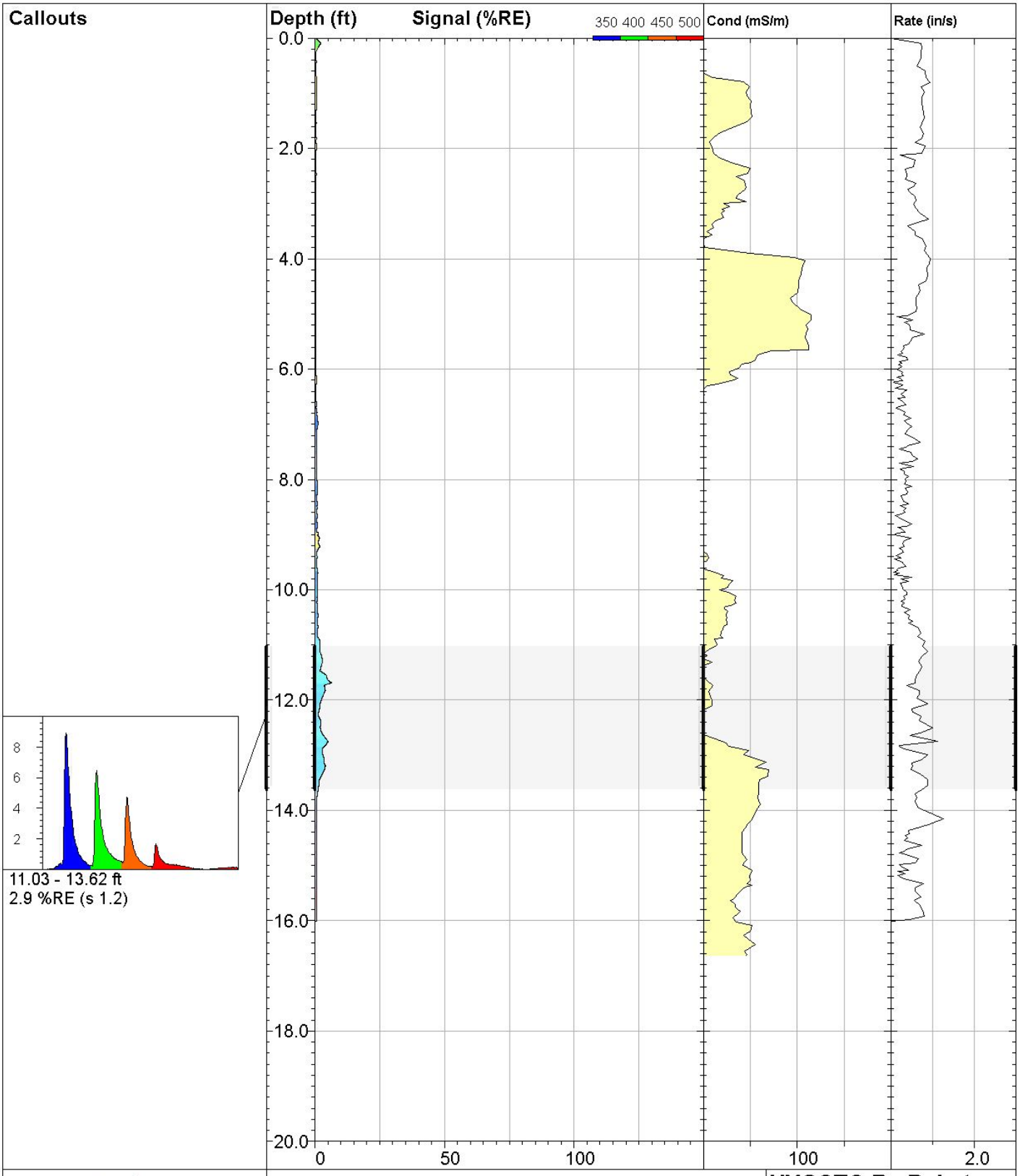
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **19.7 %RE @ 13.63 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 14:35 CDT**



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20-LIF

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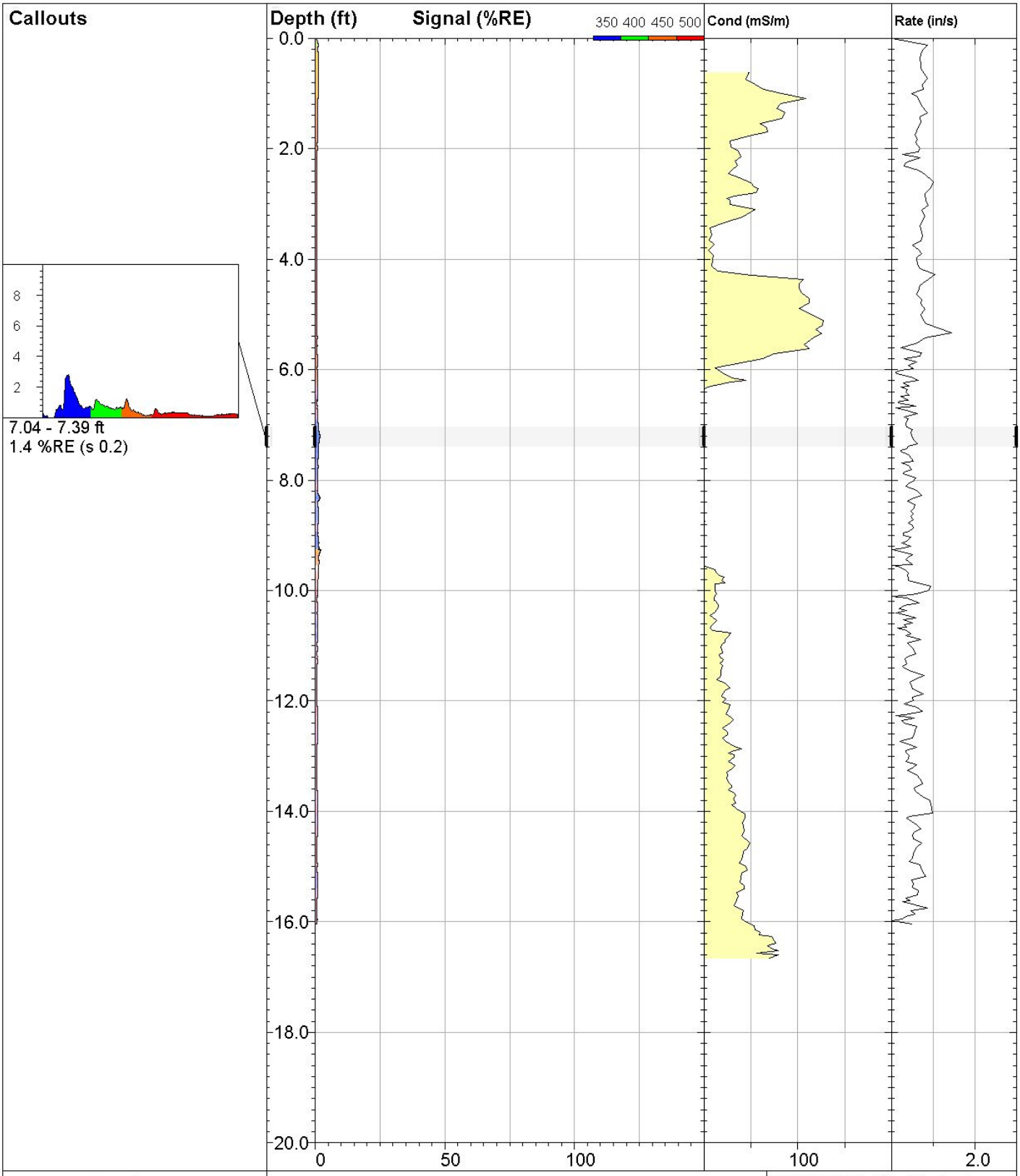
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.4 %RE @ 11.69 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 15:04 CDT**



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21-LIF

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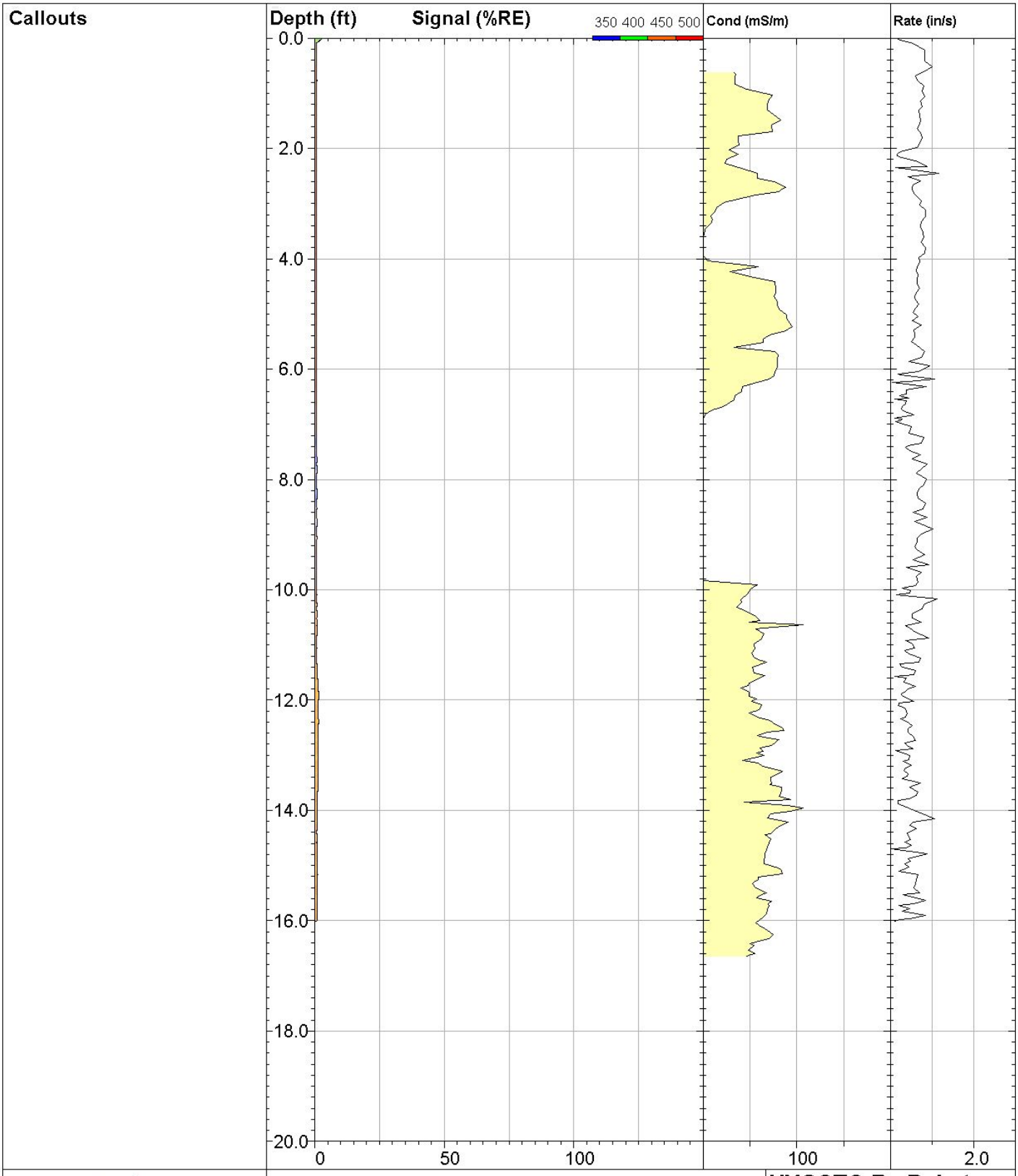
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.03 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 9.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 15:27 CDT**



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22-LIF

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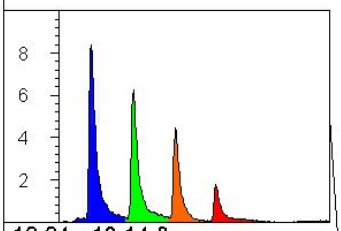
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.7 %RE @ 0.01 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 15:55 CDT**

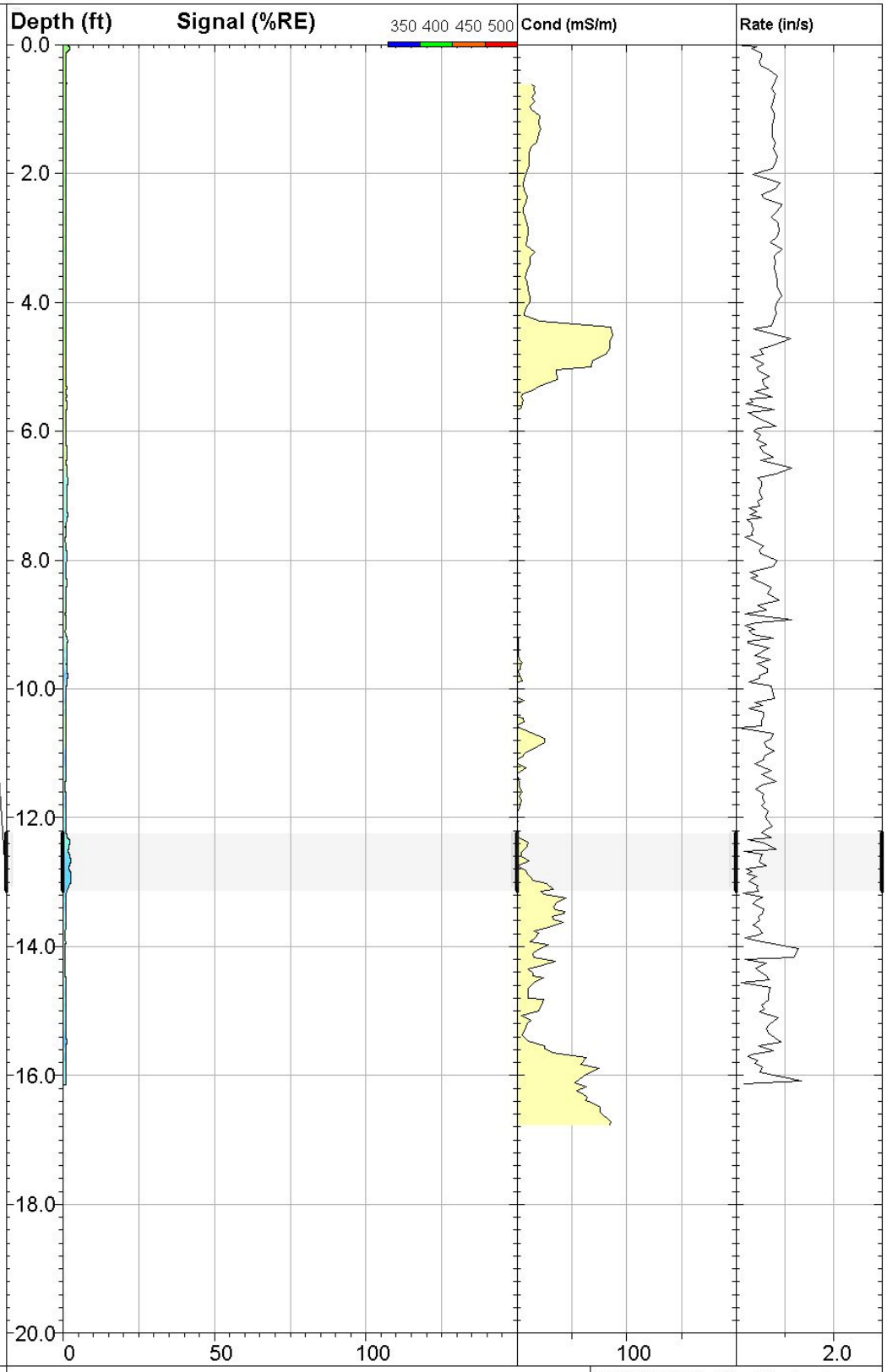
Callouts



12.24 - 13.14 ft
2.0 %RE (s 0.5)

ELEVATED BACKGROUND DUE TO SCRATCH ON WINDOW. WINDOW UNABLE TO BE REMOVED. MELDED TO SPOC WITH THE DIFFICULT DRILLING

CONDITIONS. ENTIRE TOOL STRING WILL BE SWAPPED OUT.



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23-LIF

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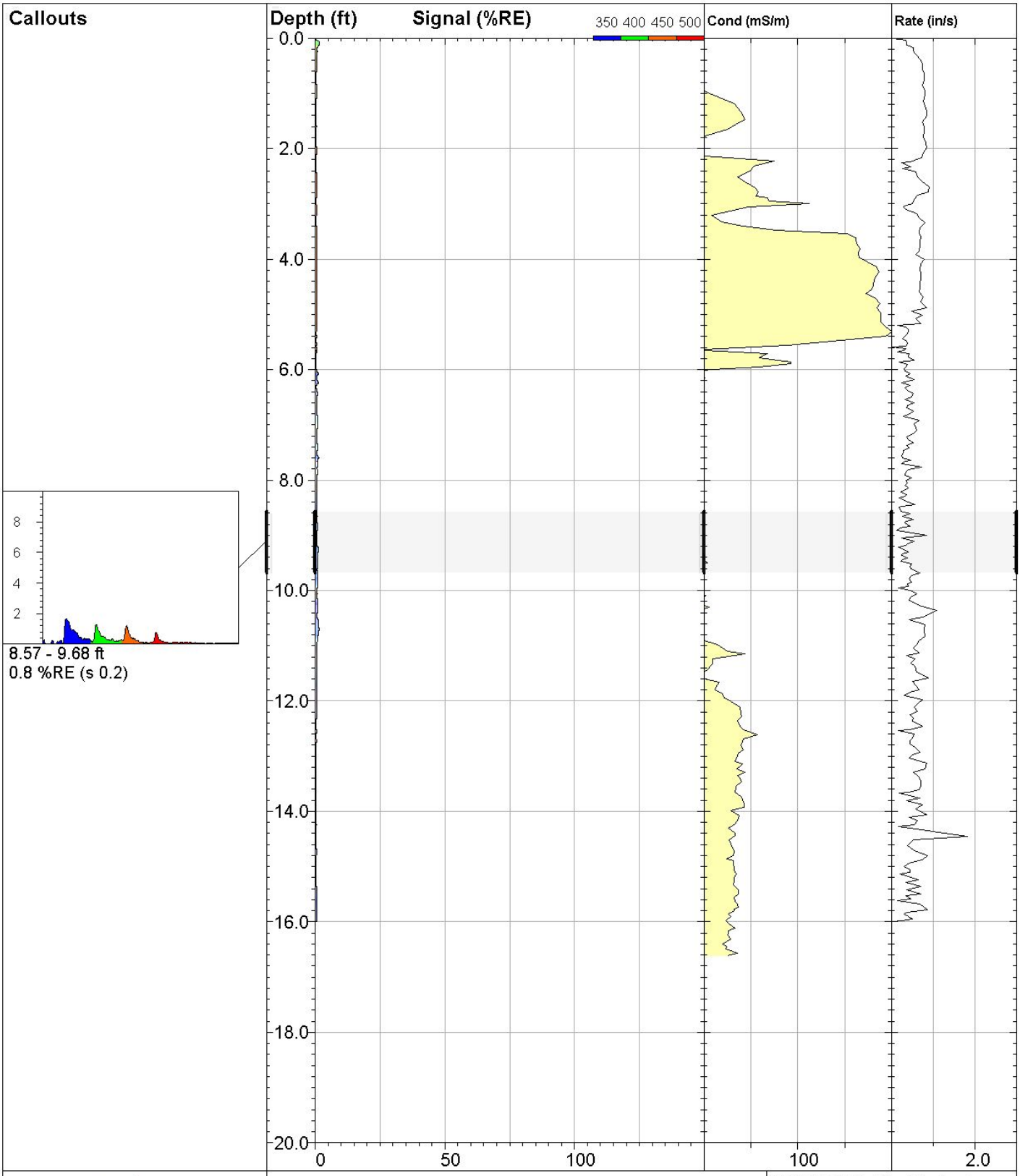
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.14 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.7 %RE @ 12.91 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-24 16:34 CDT**



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24-LIF

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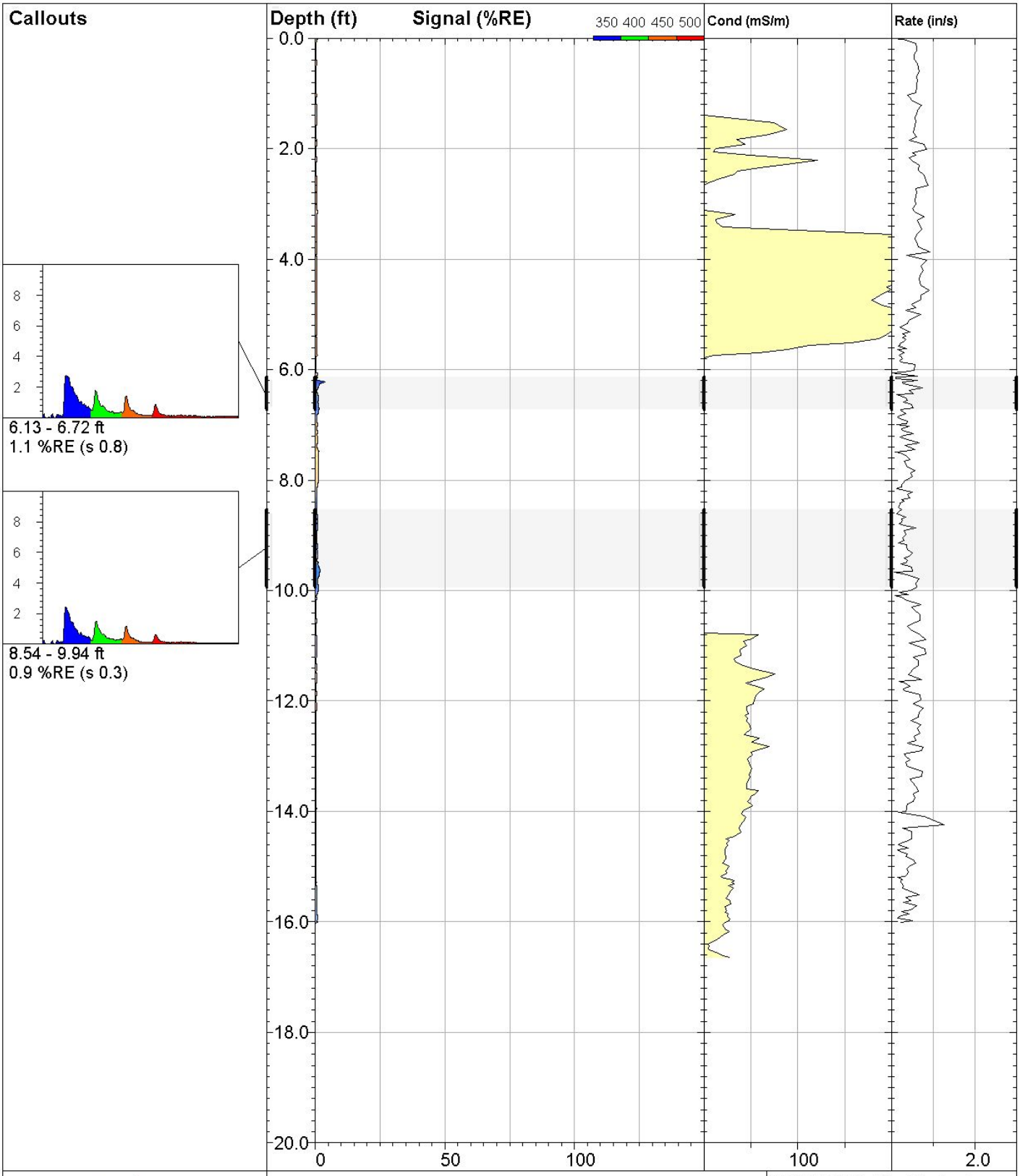
Site:	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **/**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.6 %RE @ 0.12 ft**
Operator / Unit: **/ UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 09:24 CDT**



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25-LIF

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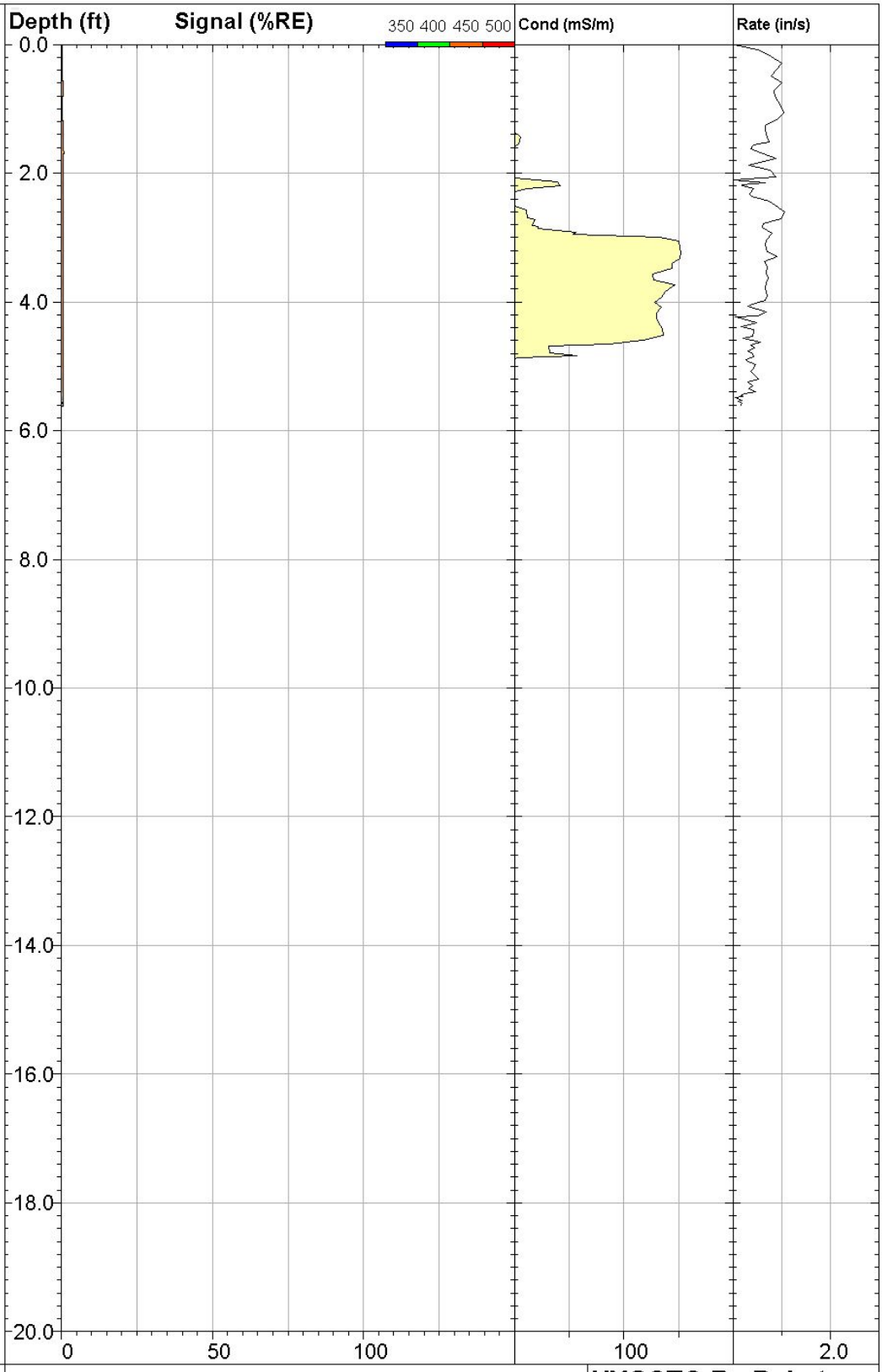
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.0 %RE @ 6.23 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 09:51 CDT**

Callouts
REFUSAL AT 5.62FT



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26-LIF

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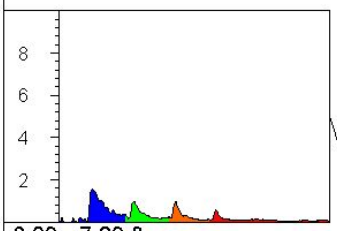
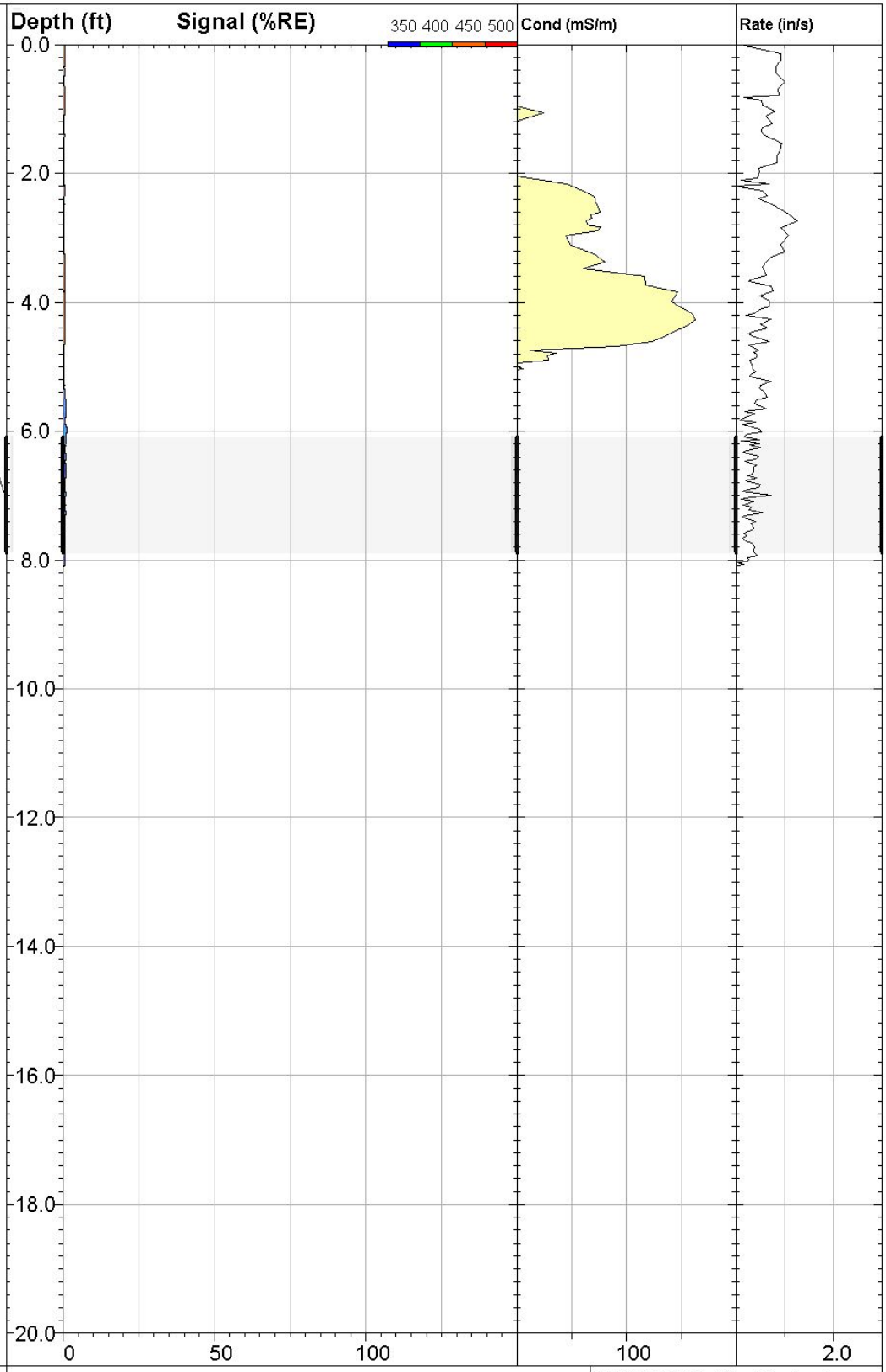
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **5.62 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **0.8 %RE @ 1.68 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 10:17 CDT**

Callouts



6.09 - 7.89 ft
0.7 %RE (s 0.2)

REFUSAL AT 8.09FT



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27-LIF

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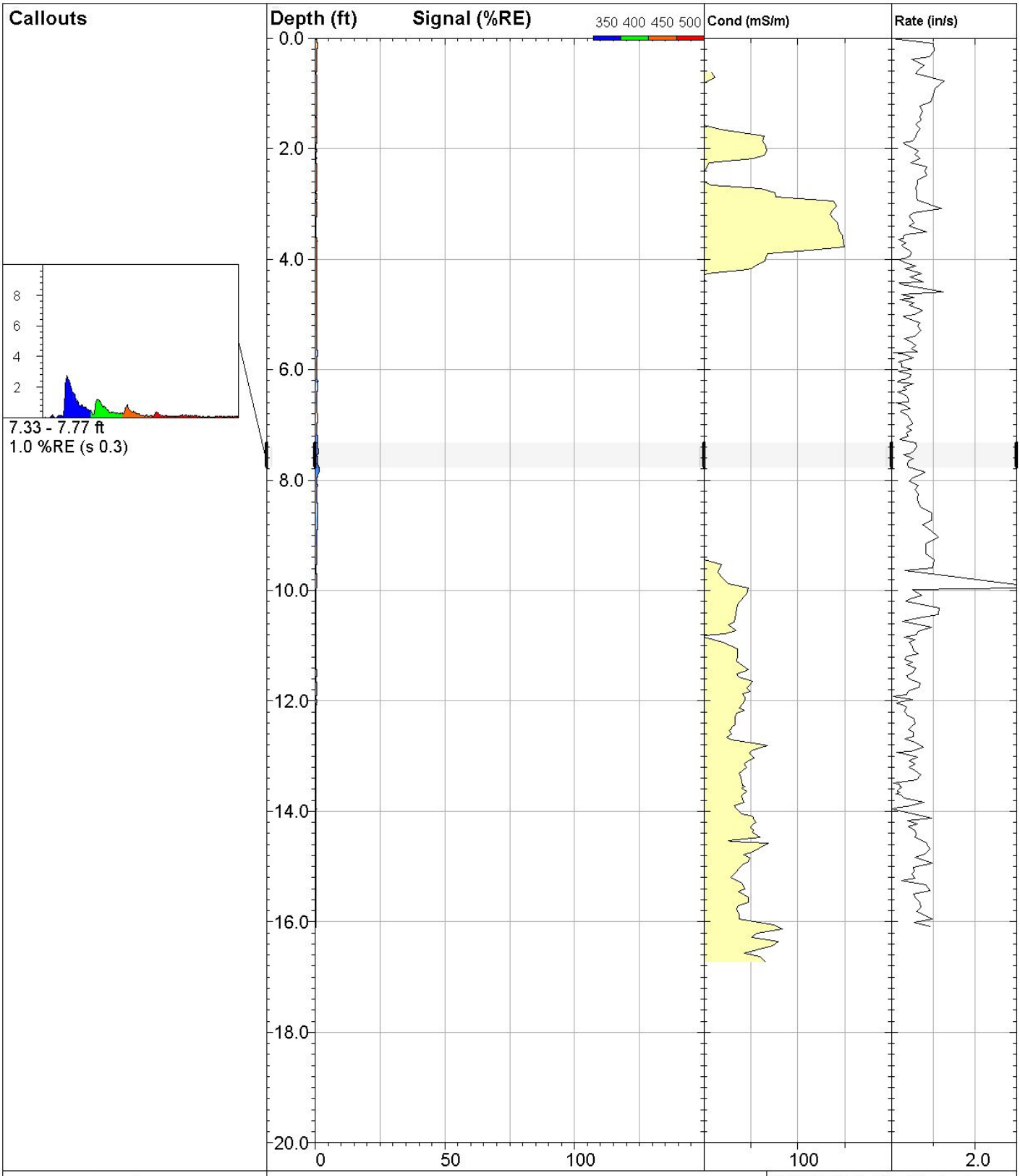
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **8.09 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 5.97 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 10:32 CDT**



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28-LIF

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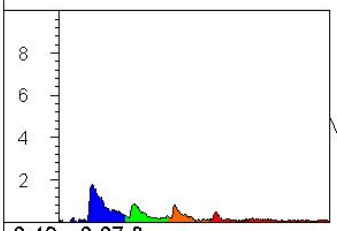
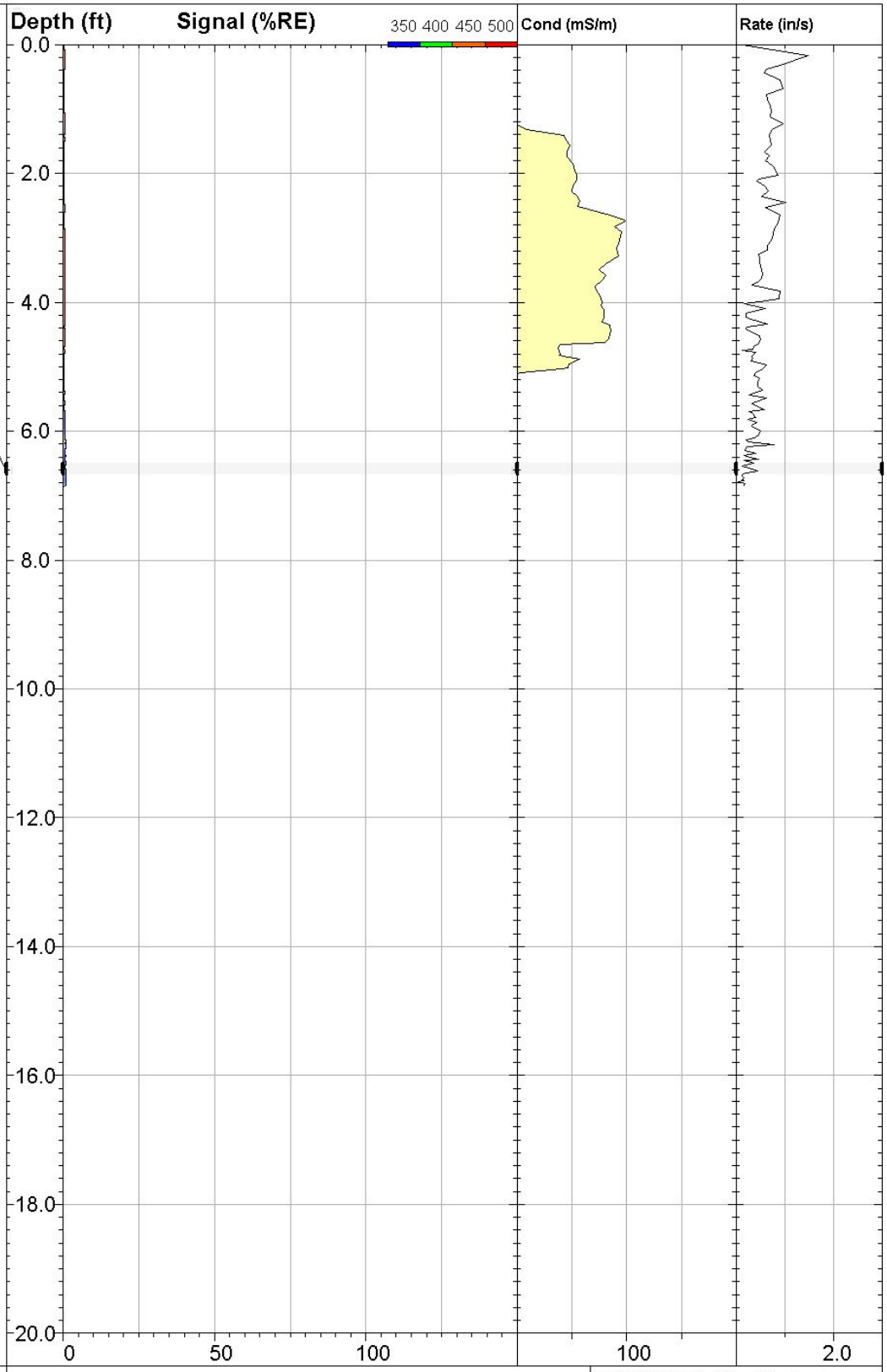
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.6 %RE @ 7.85 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 10:56 CDT**

Callouts



6.49 - 6.67 ft
0.8 %RE (s 0.1)

REFUSAL AT 6.85FT



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29-LIF

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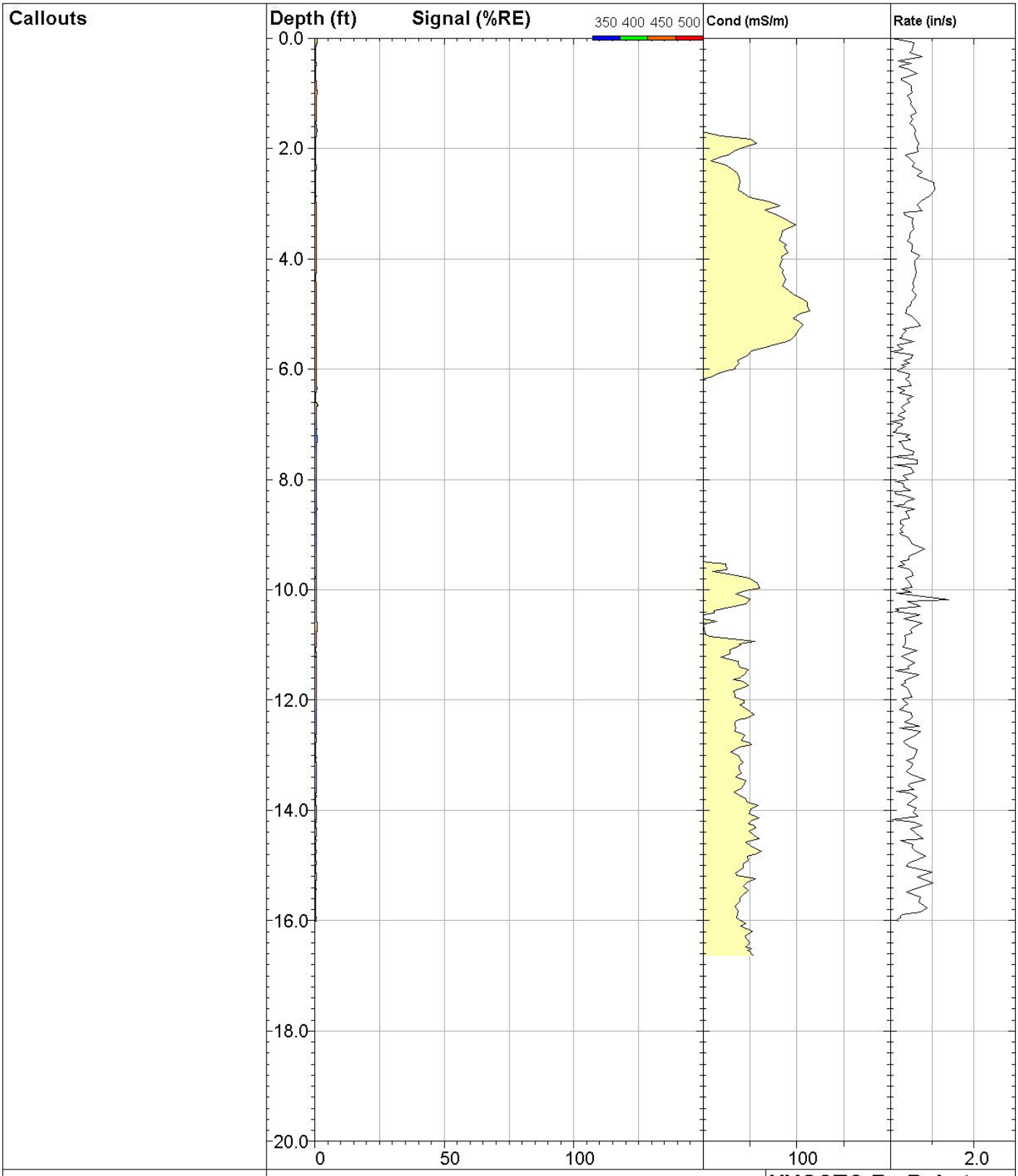
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **6.85 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.0 %RE @ 6.83 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 11:19 CDT**



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30-LIF

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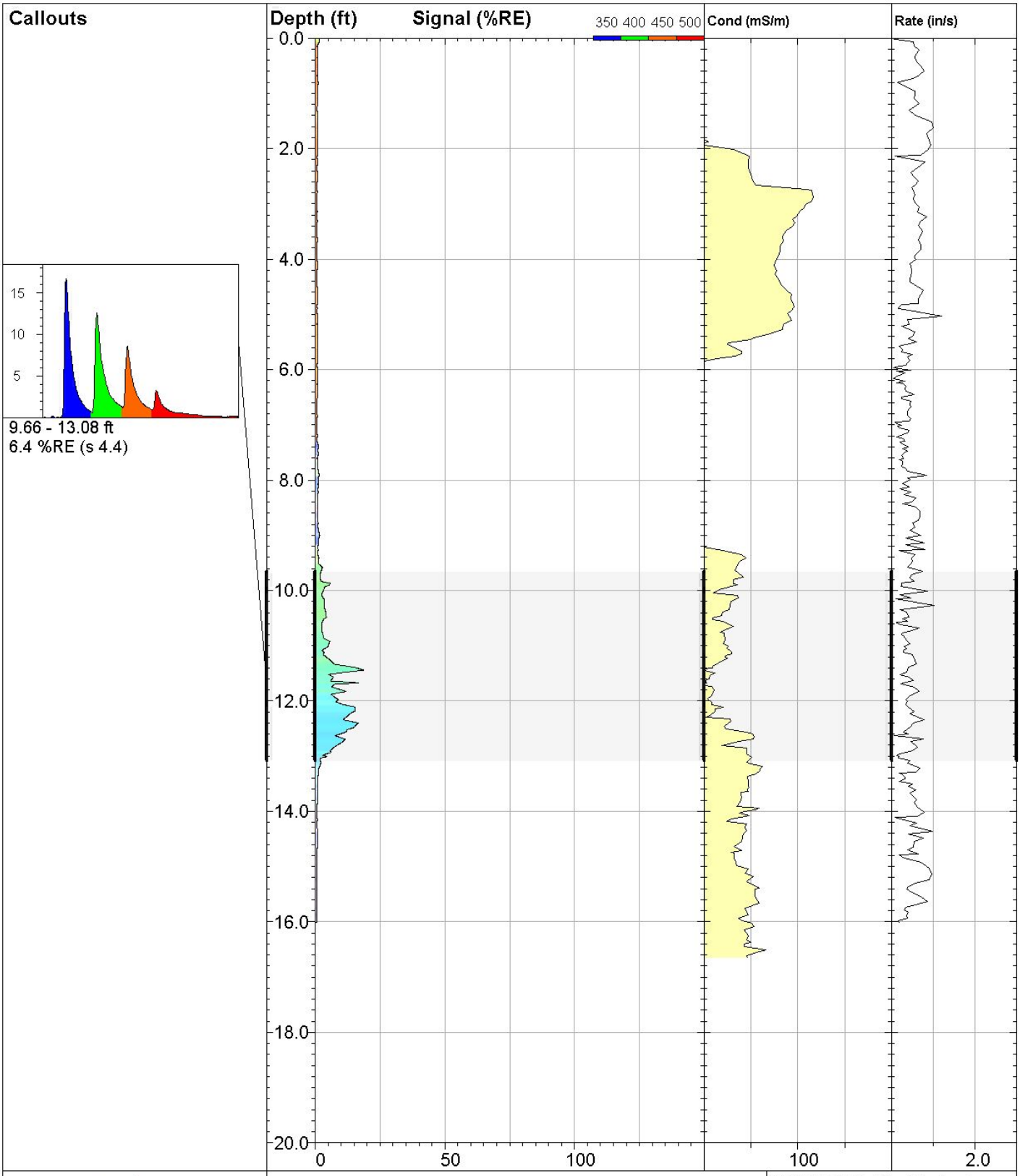
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.2 %RE @ 6.65 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 11:36 CDT**



31-LIF		**UVOST® By Dakota** www.DakotaTechnologies.com
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.7 %RE @ 11.44 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 12:38 CDT**

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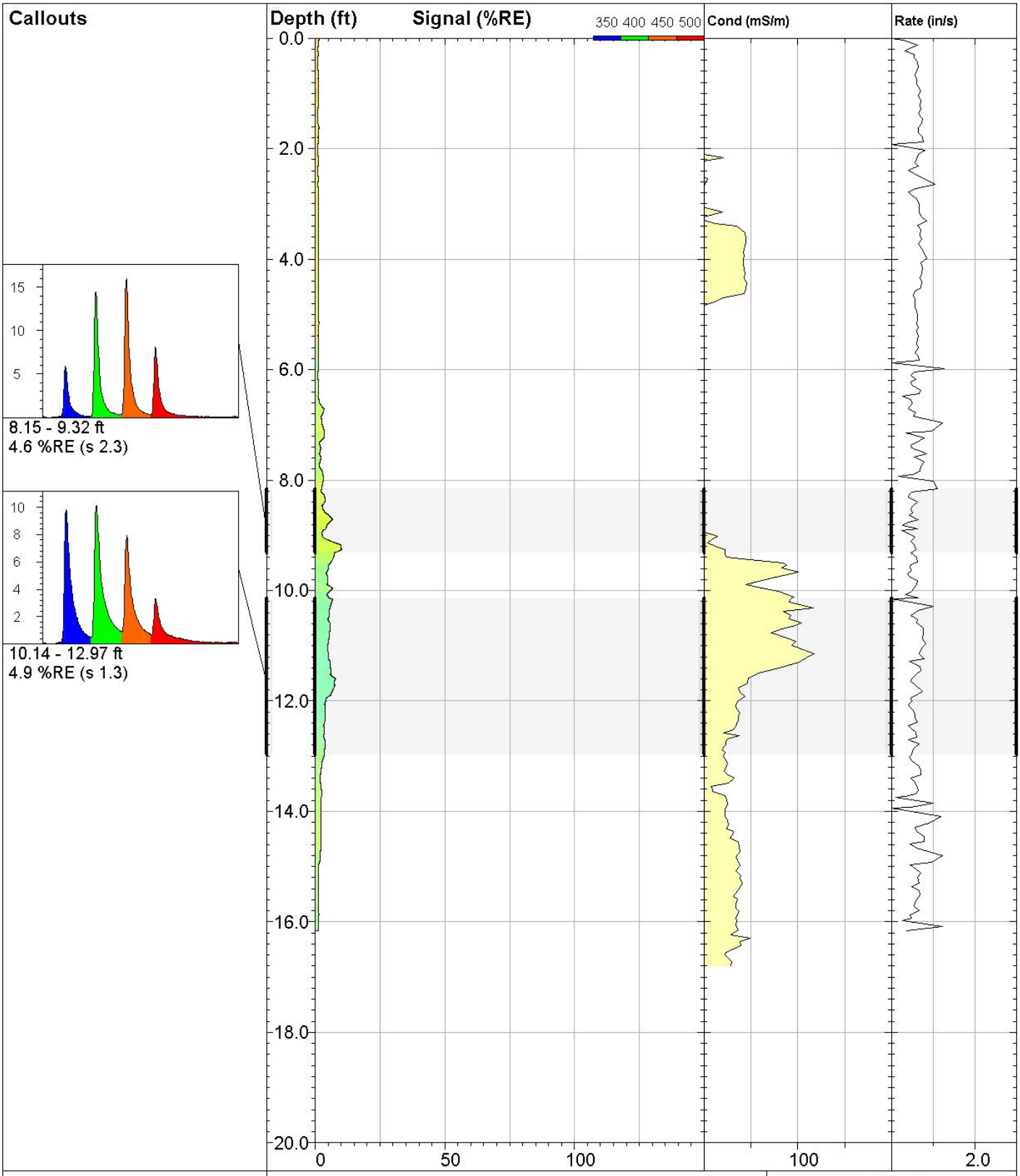

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32-LIF

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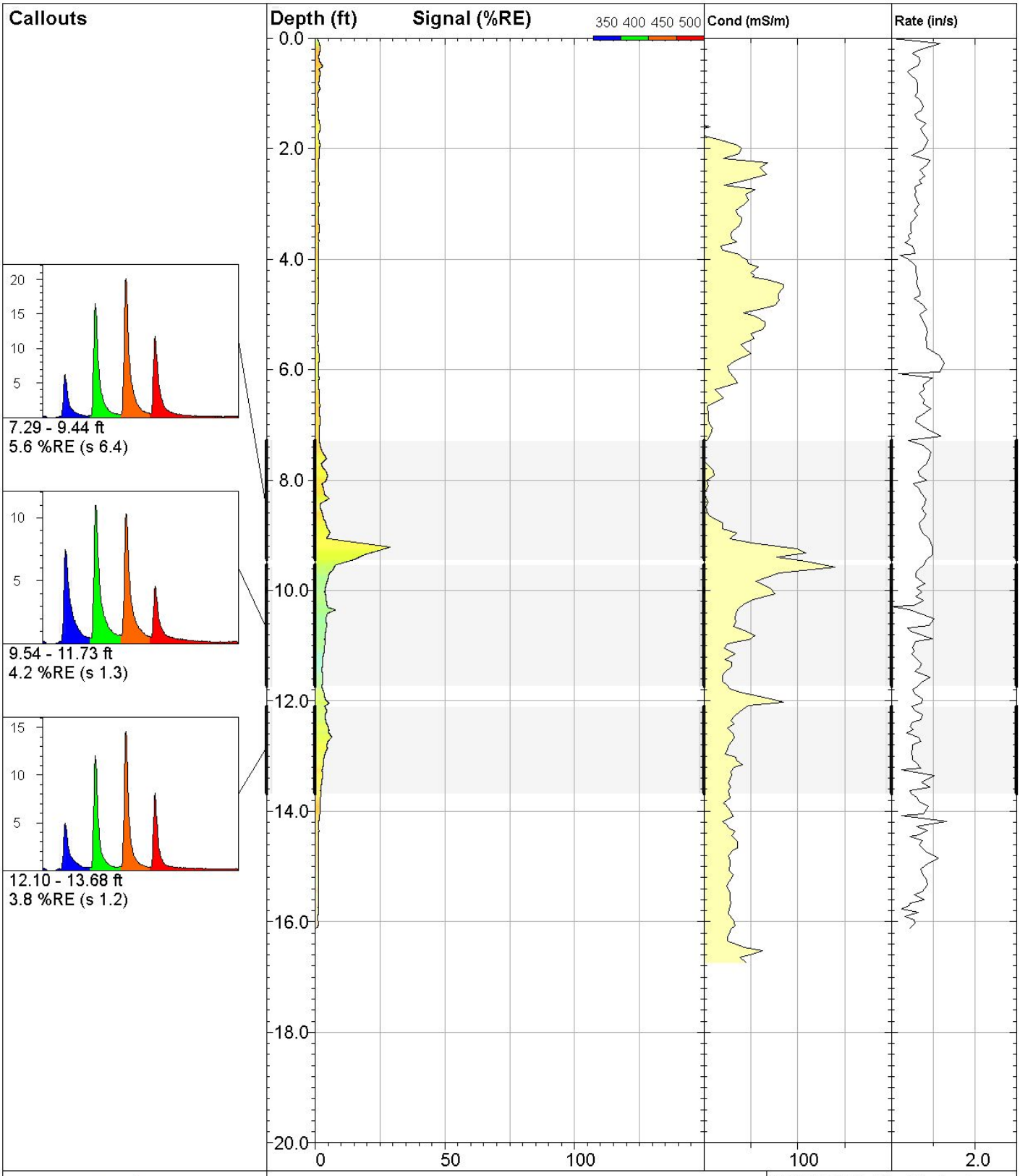
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.16 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **10.2 %RE @ 9.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 15:10 CDT**



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33-LIF

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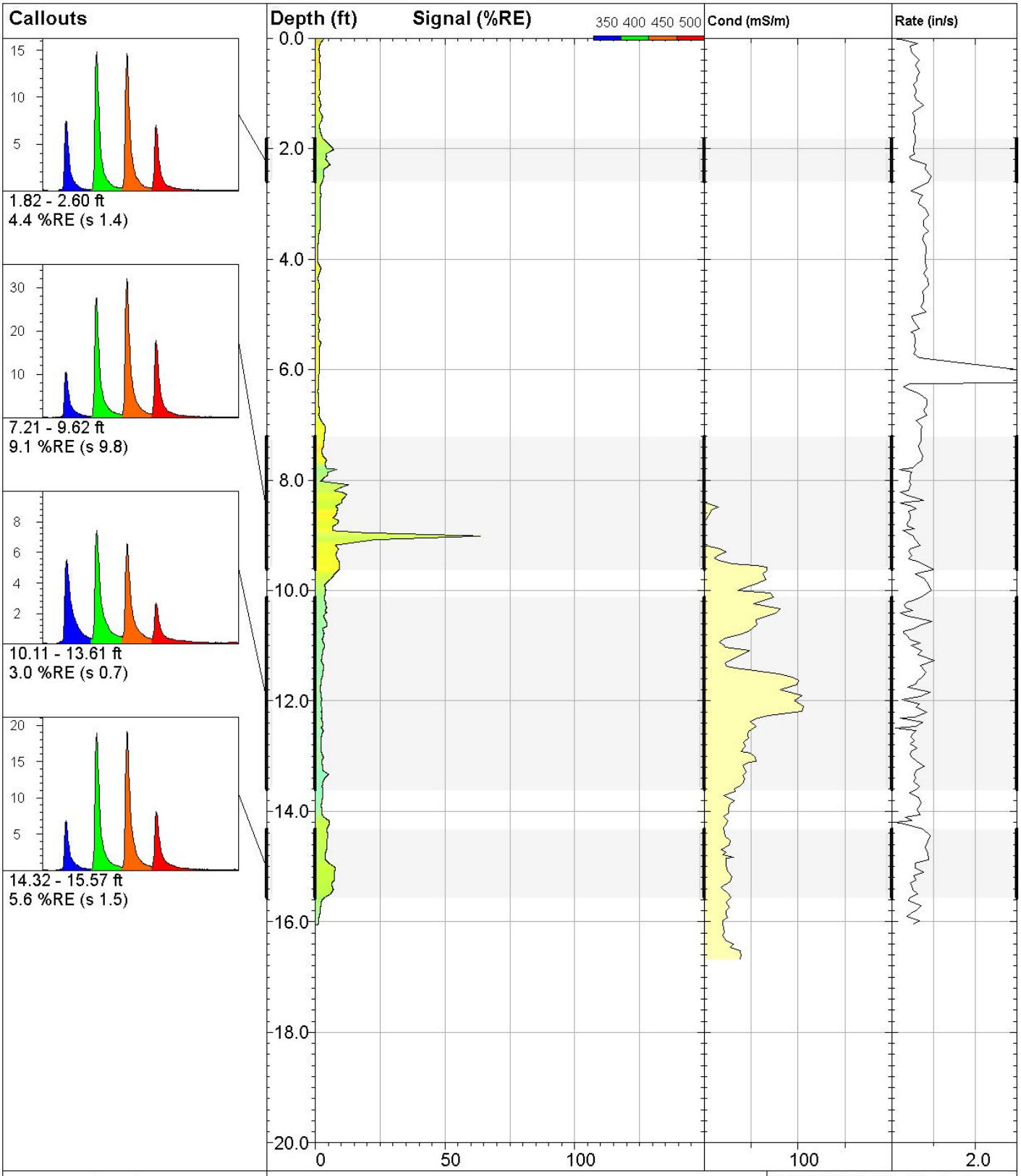
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.11 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **28.9 %RE @ 9.21 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 15:37 CDT**



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34-LIF

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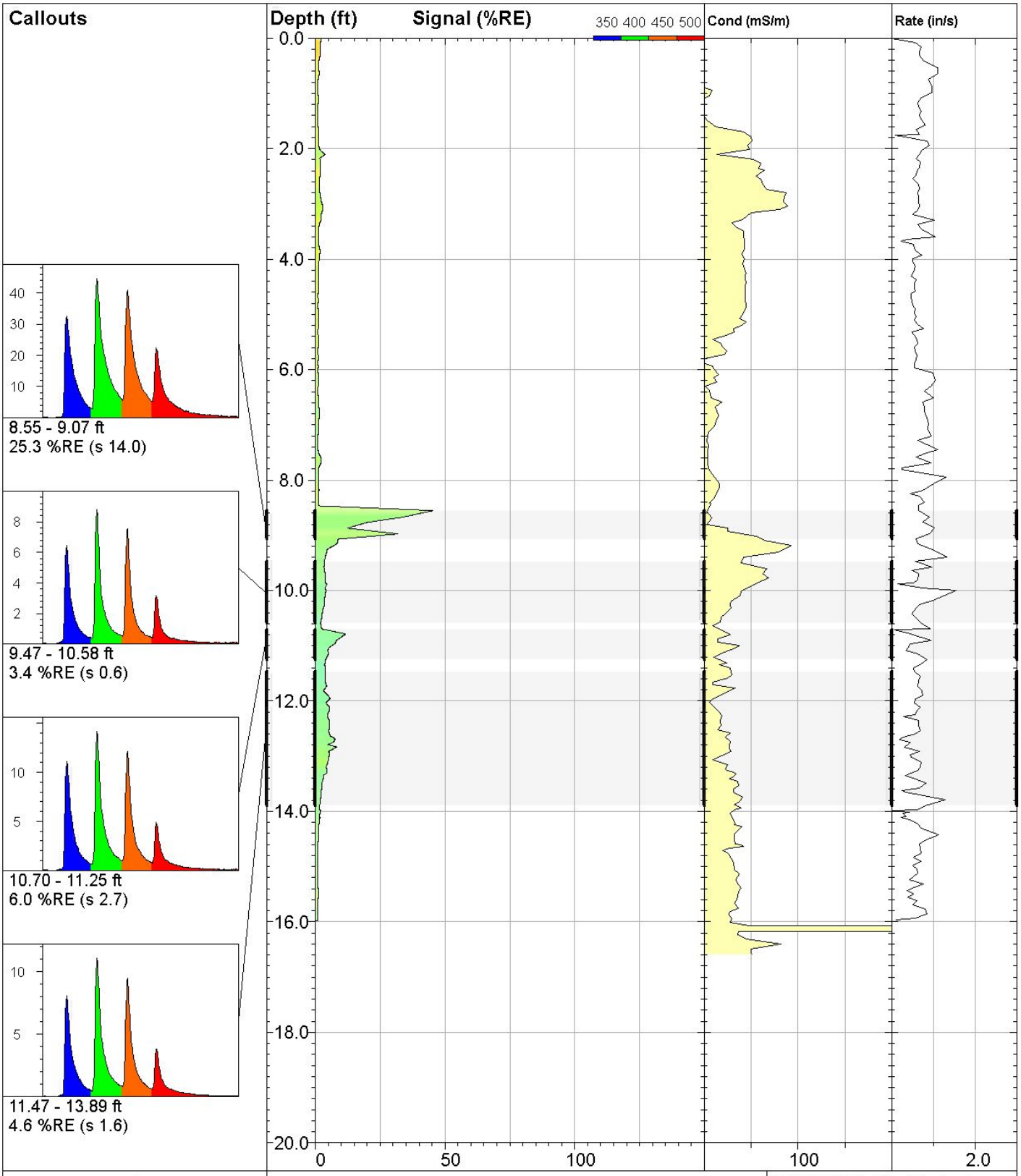
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.05 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **63.7 %RE @ 9.01 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 16:05 CDT**



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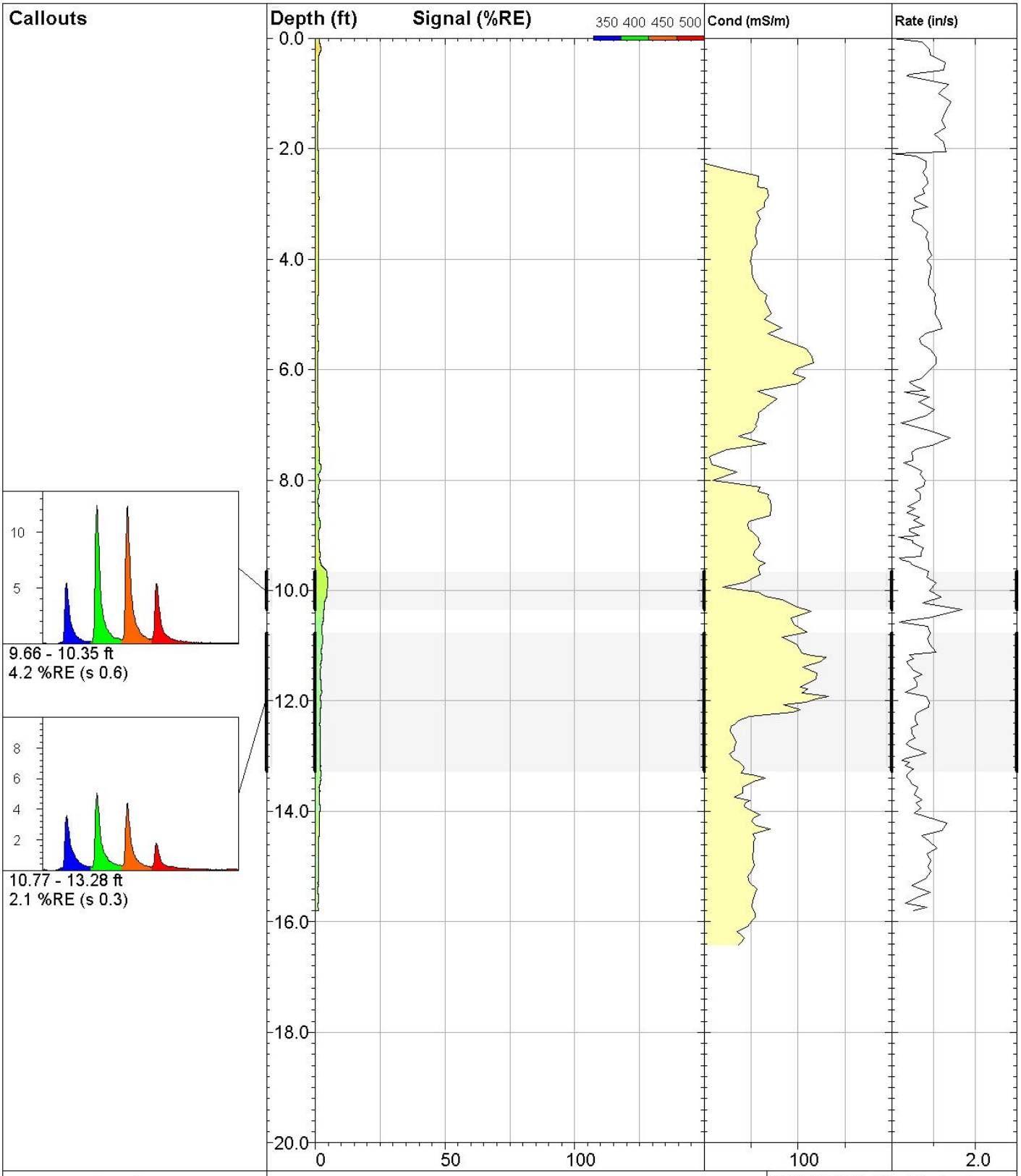
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.97 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **45.3 %RE @ 8.55 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 16:49 CDT**



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36-LIF

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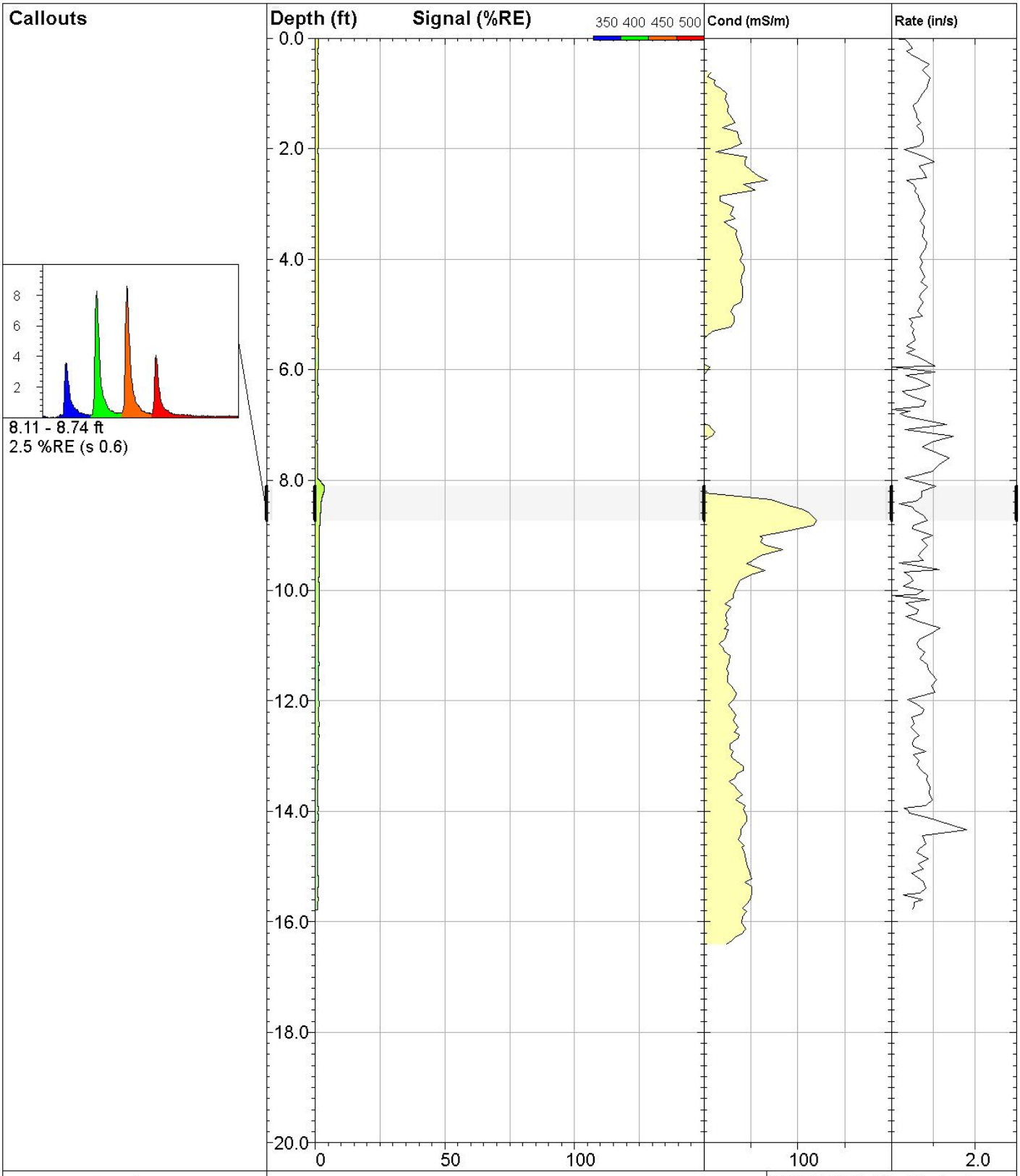
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.80 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.8 %RE @ 9.87 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 17:11 CDT**



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37-LIF

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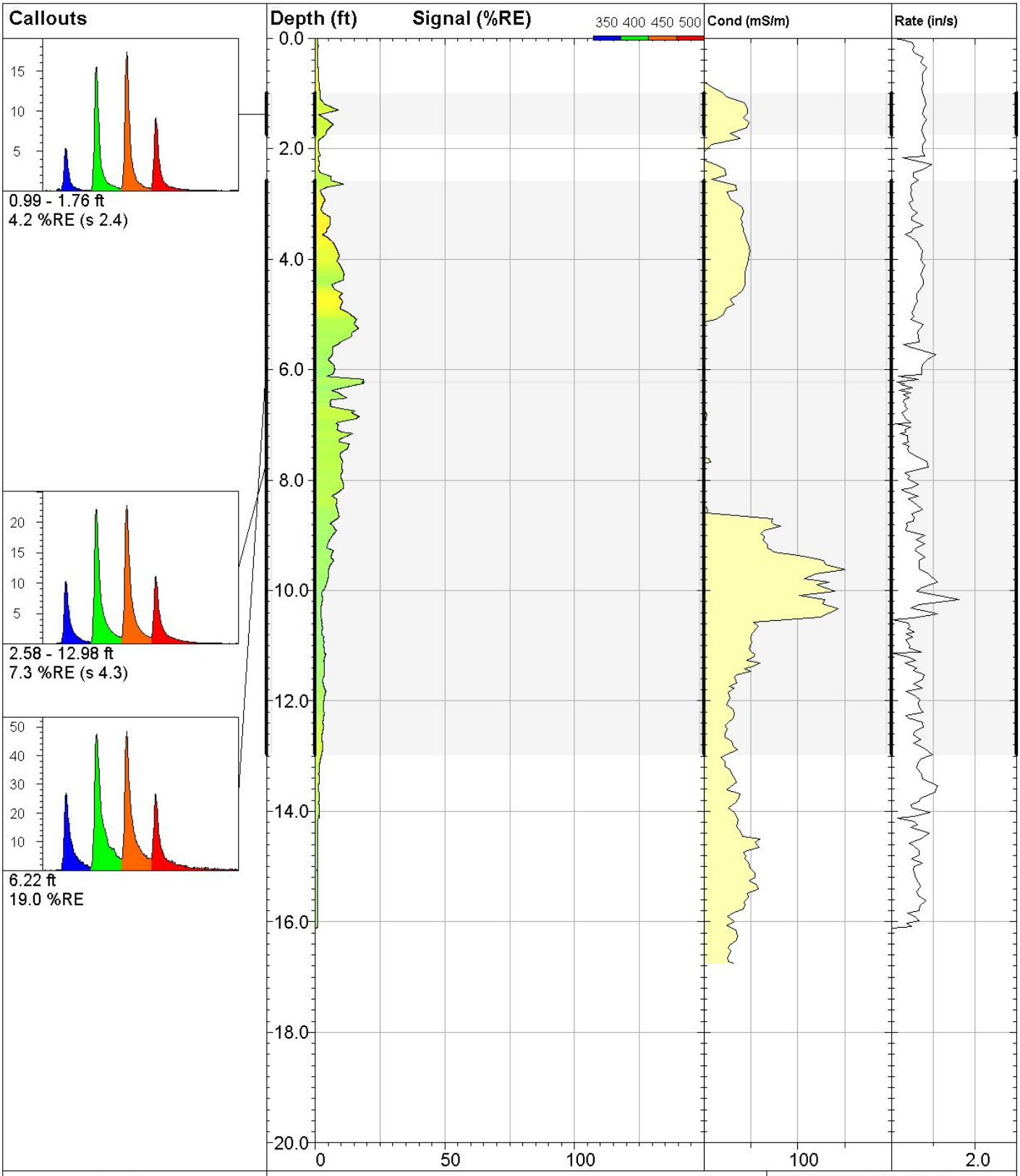
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.78 ft**
Client / Job: **WCEC / 138**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.6 %RE @ 8.11 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-25 17:39 CDT**



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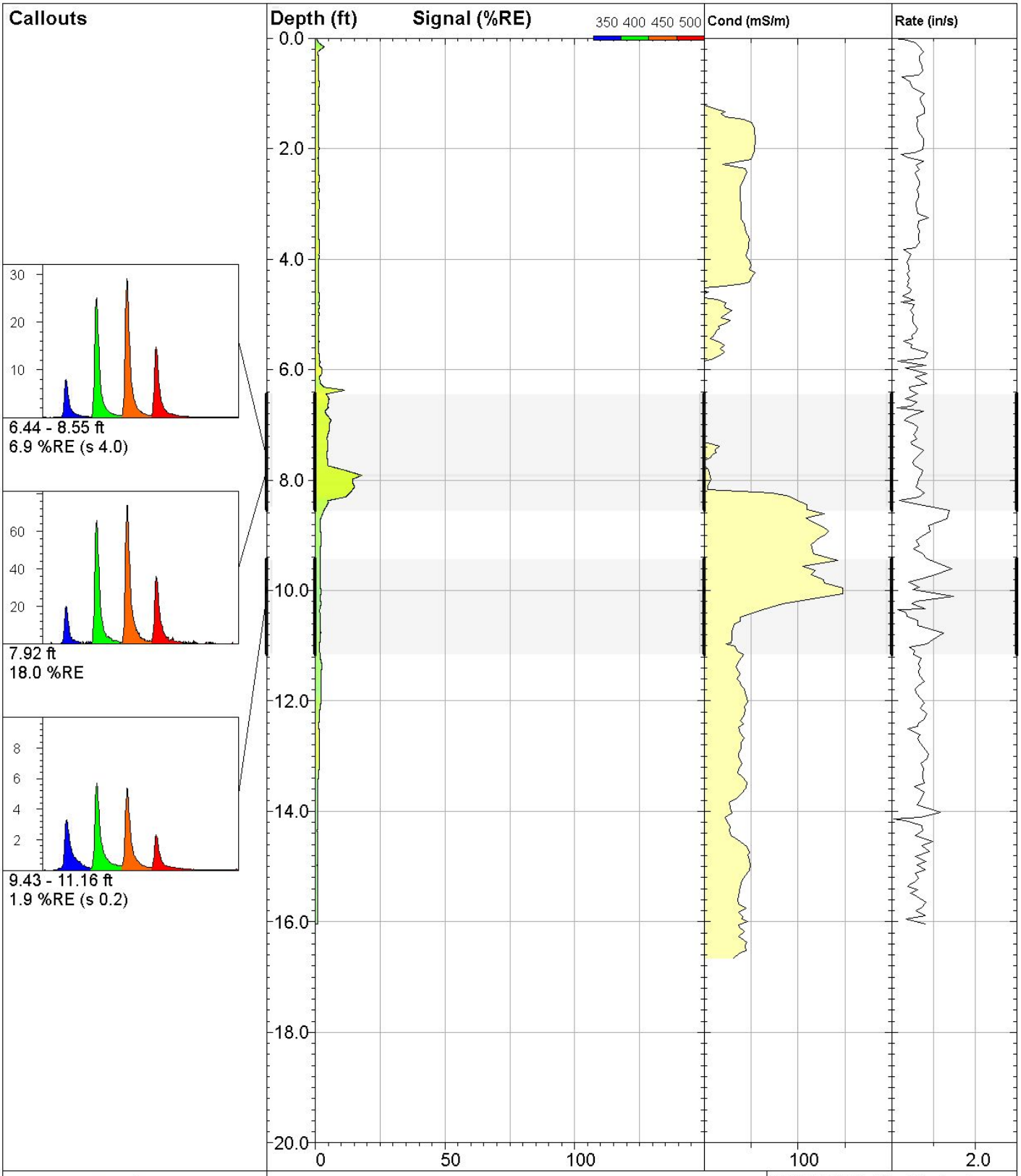
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.12 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **19.0 %RE @ 6.22 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 09:26 CDT**



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39-LIF

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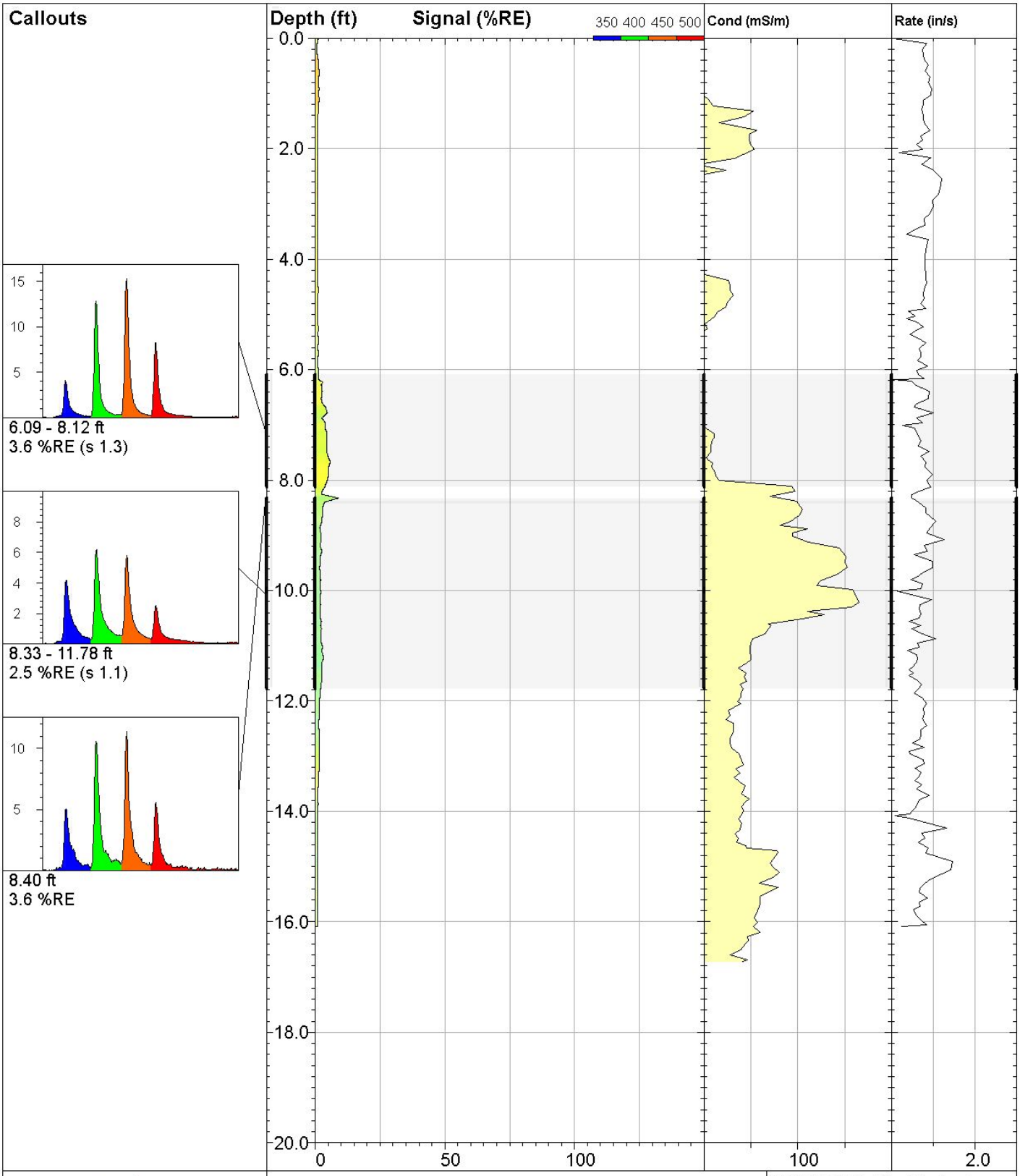
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.0 %RE @ 7.92 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 09:48 CDT**



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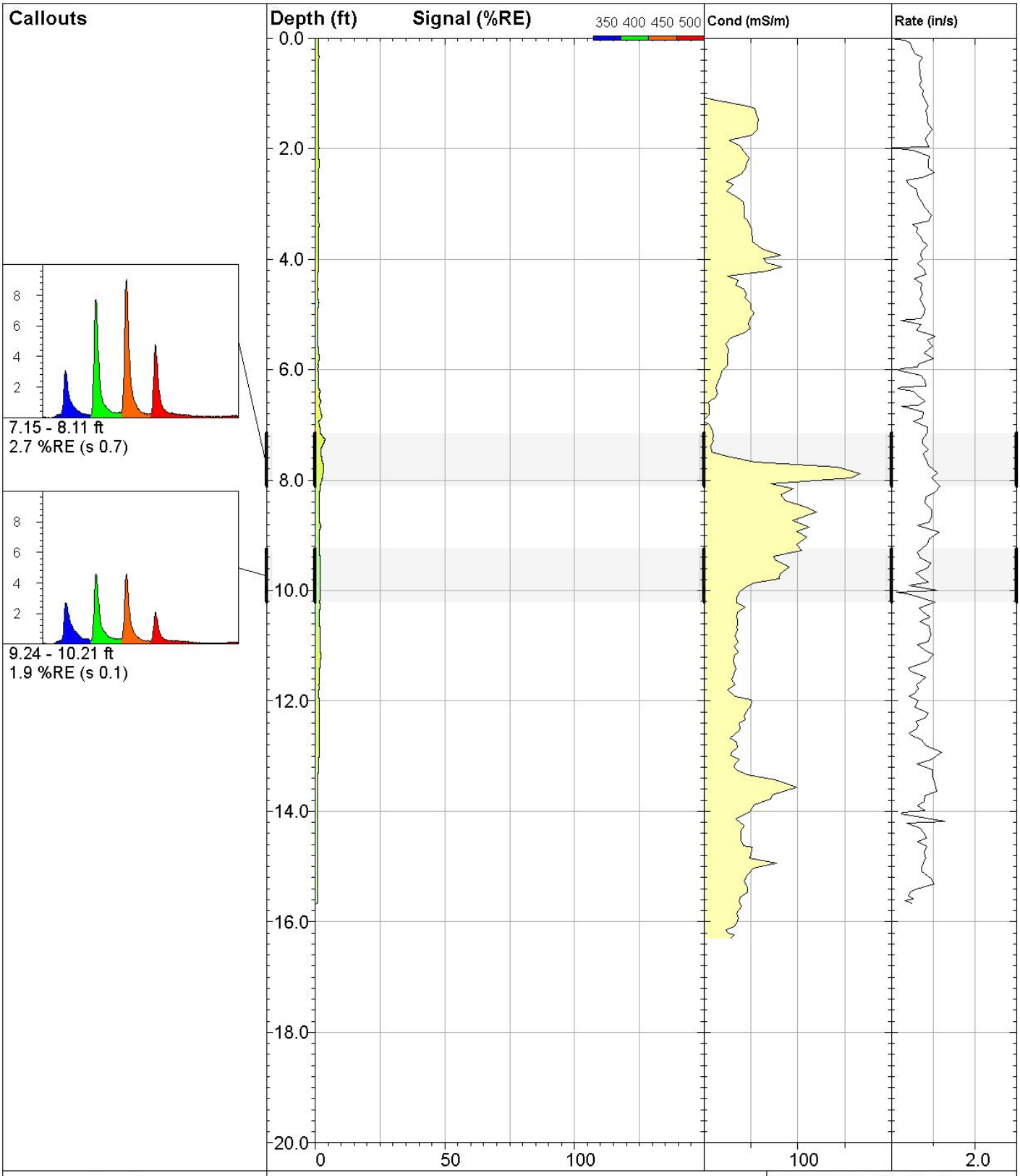
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.09 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **9.0 %RE @ 8.33 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 10:29 CDT**



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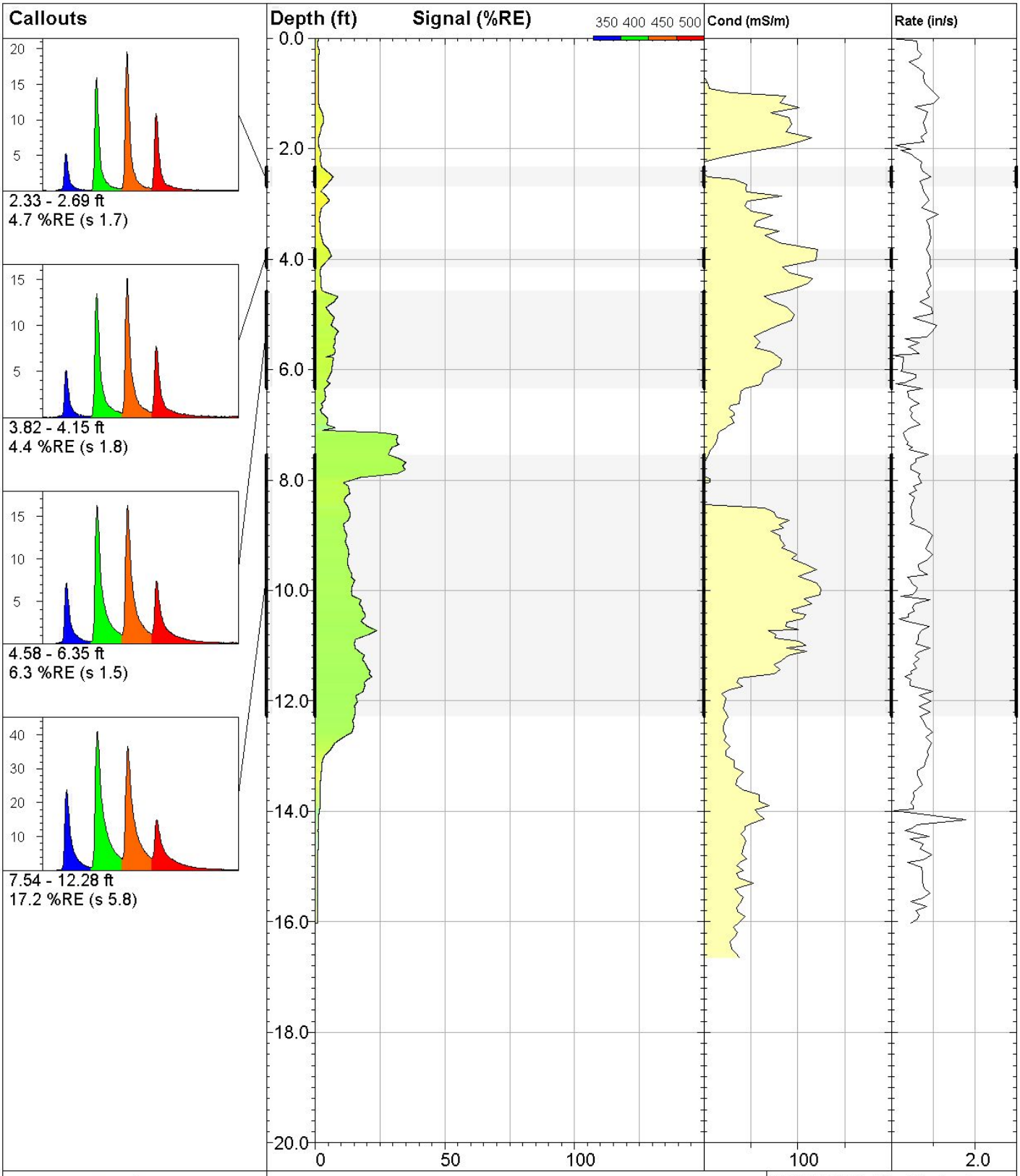
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.67 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.8 %RE @ 7.27 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 10:51 CDT**



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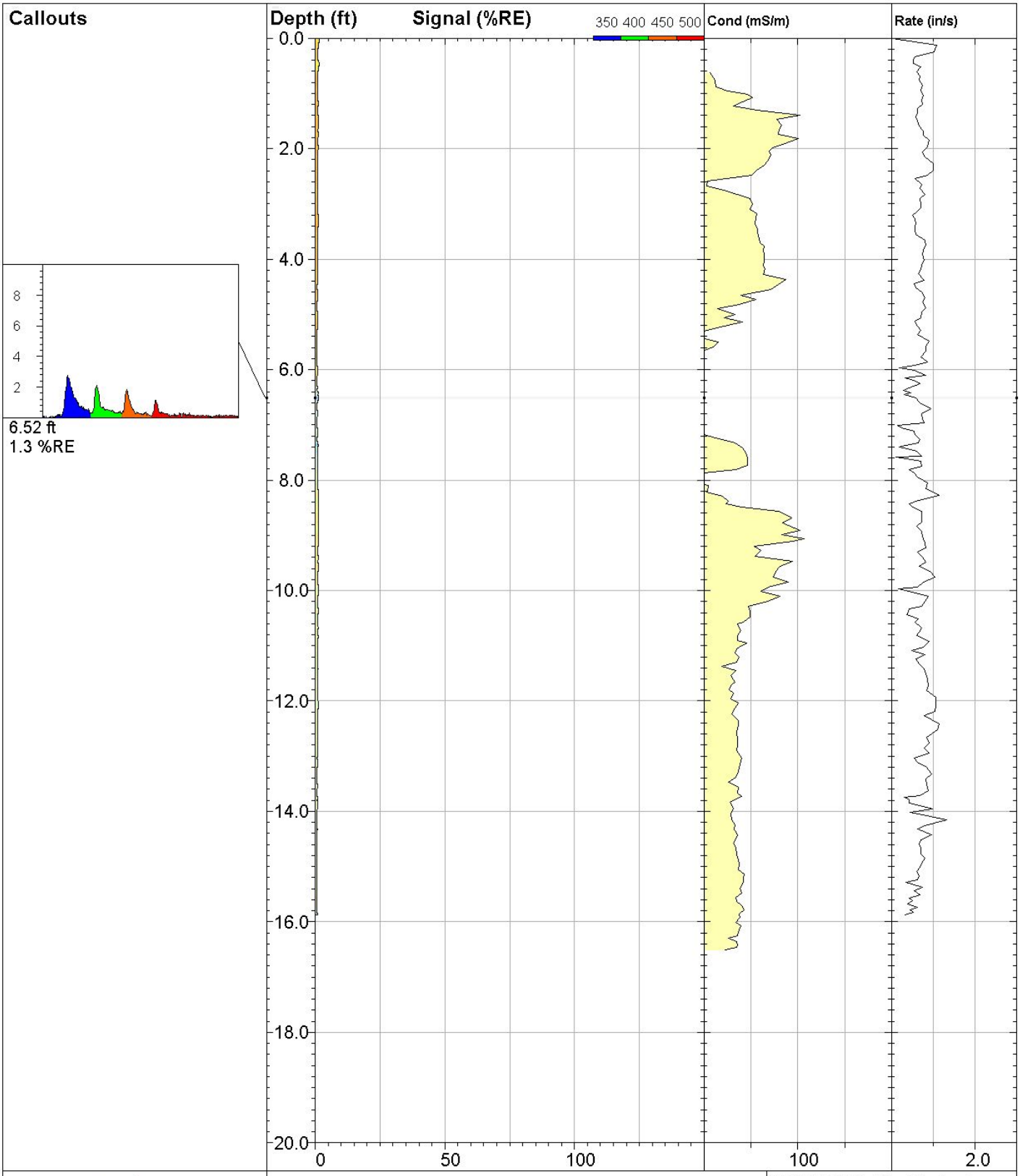
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **35.0 %RE @ 7.68 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 11:23 CDT**



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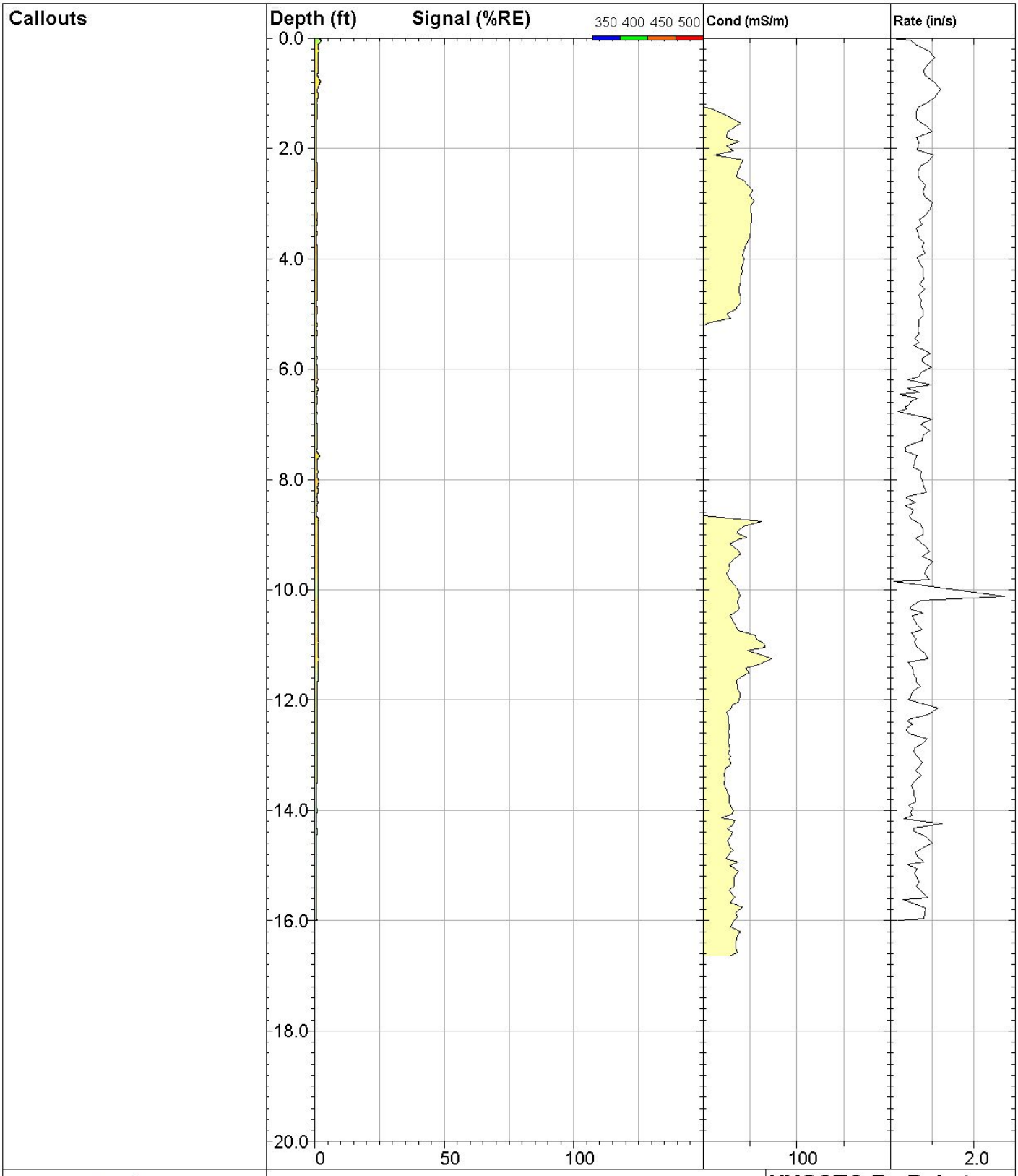
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.88 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.6 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 12:03 CDT**



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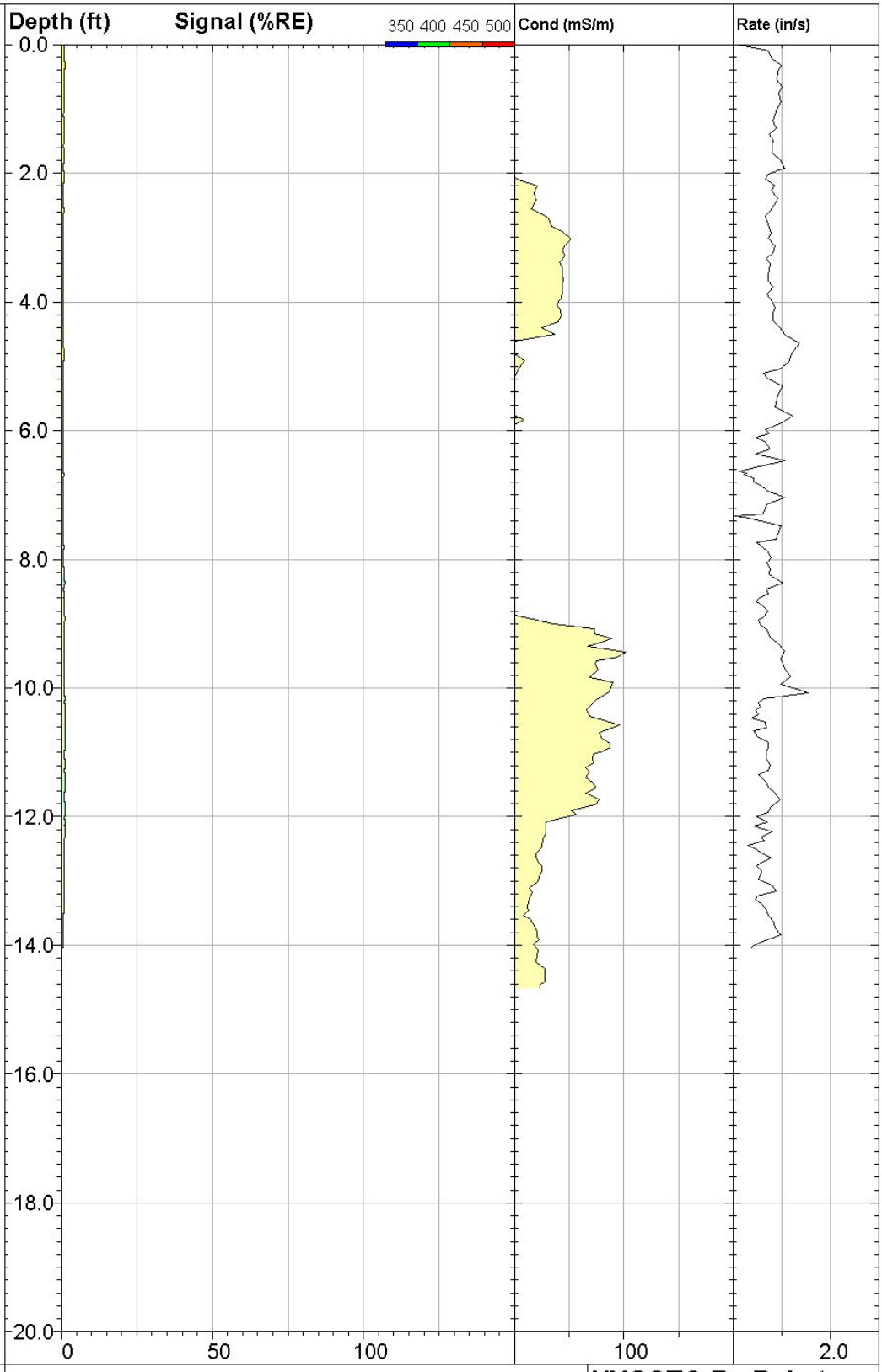
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.6 %RE @ 0.04 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 13:34 CDT**

Callouts
preprobe hit refusal just past 14.5ft



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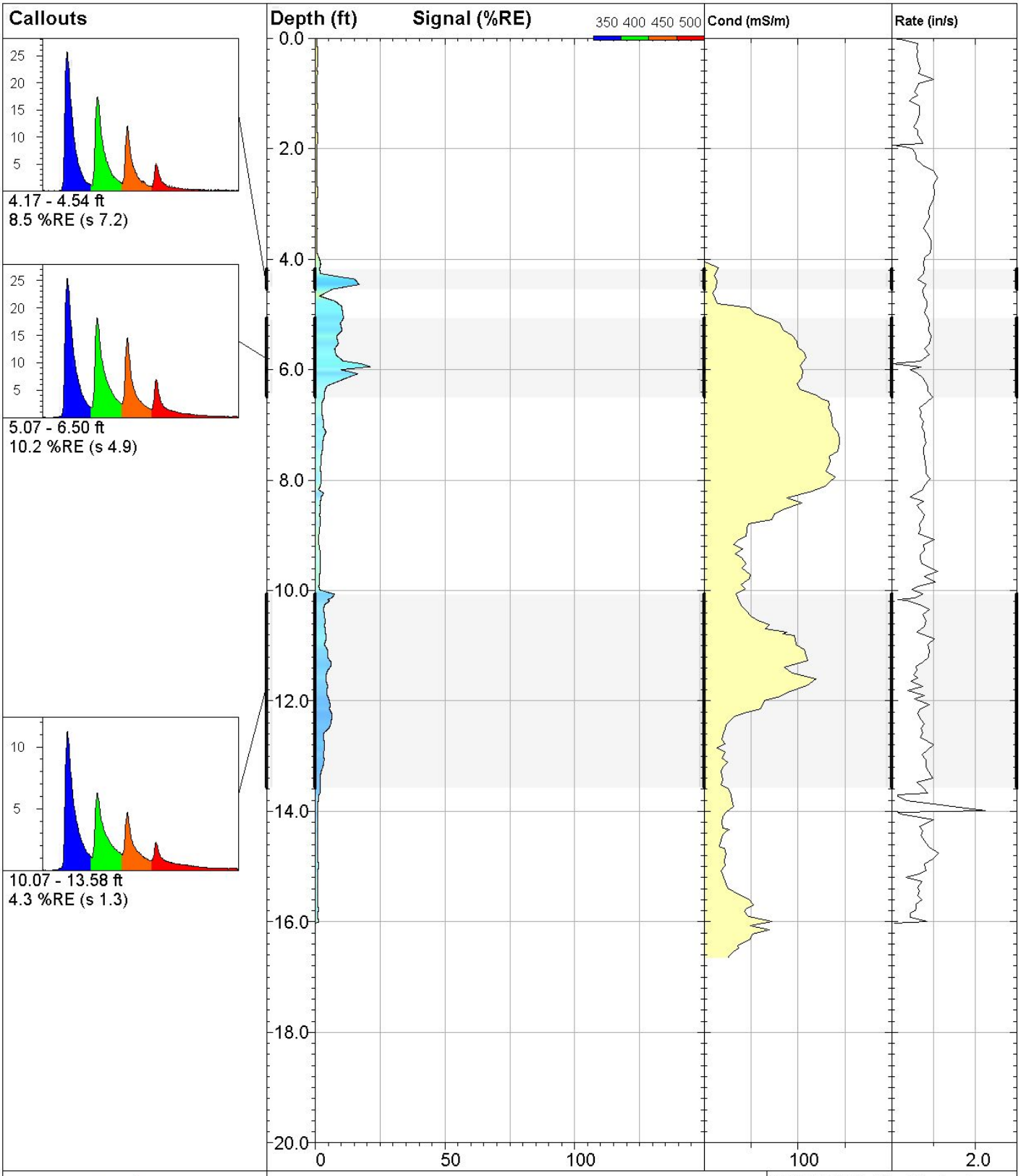
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.2 %RE @ 10.46 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 13:52 CDT**



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46-LIF

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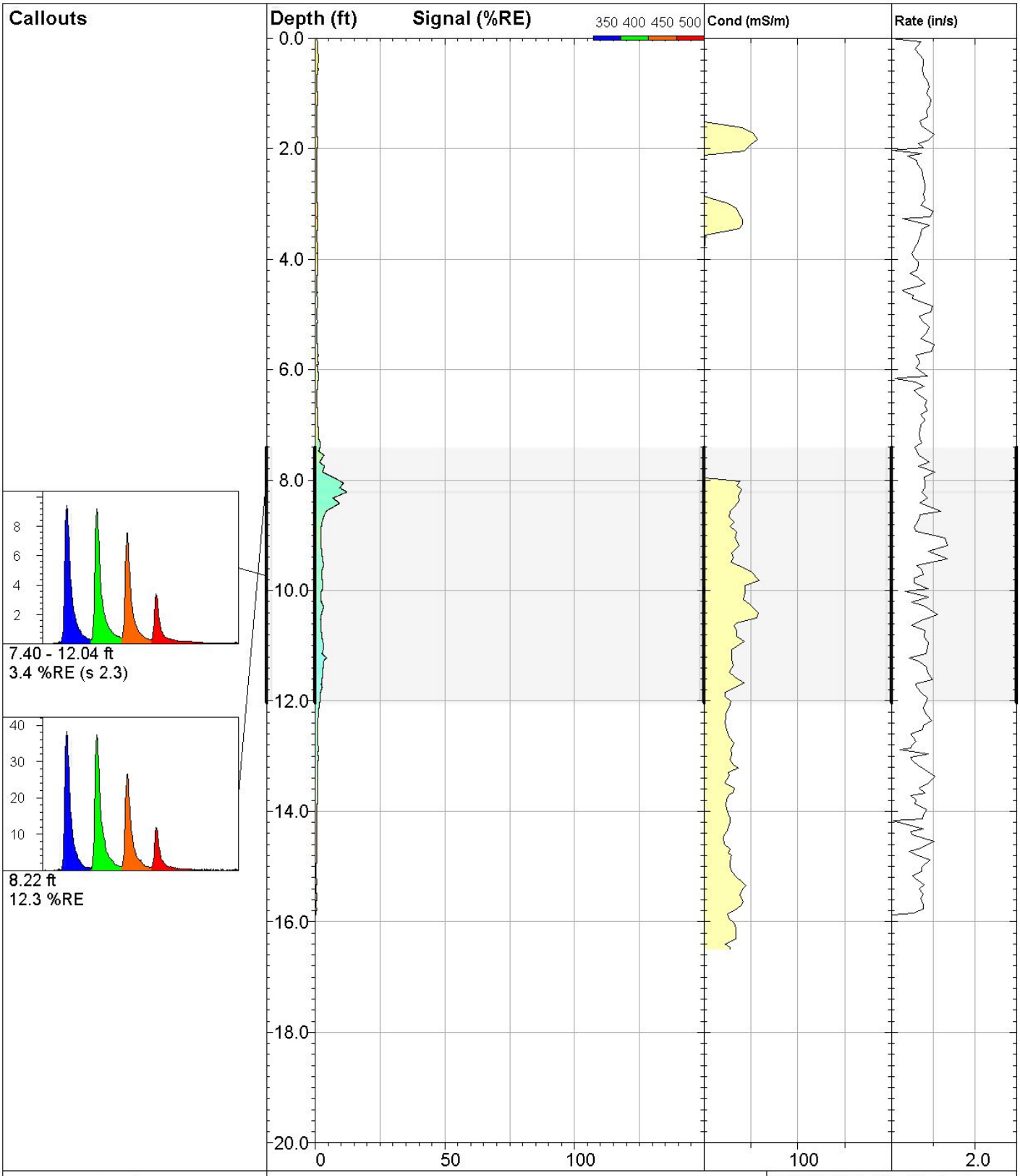
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **21.2 %RE @ 5.95 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 14:25 CDT**



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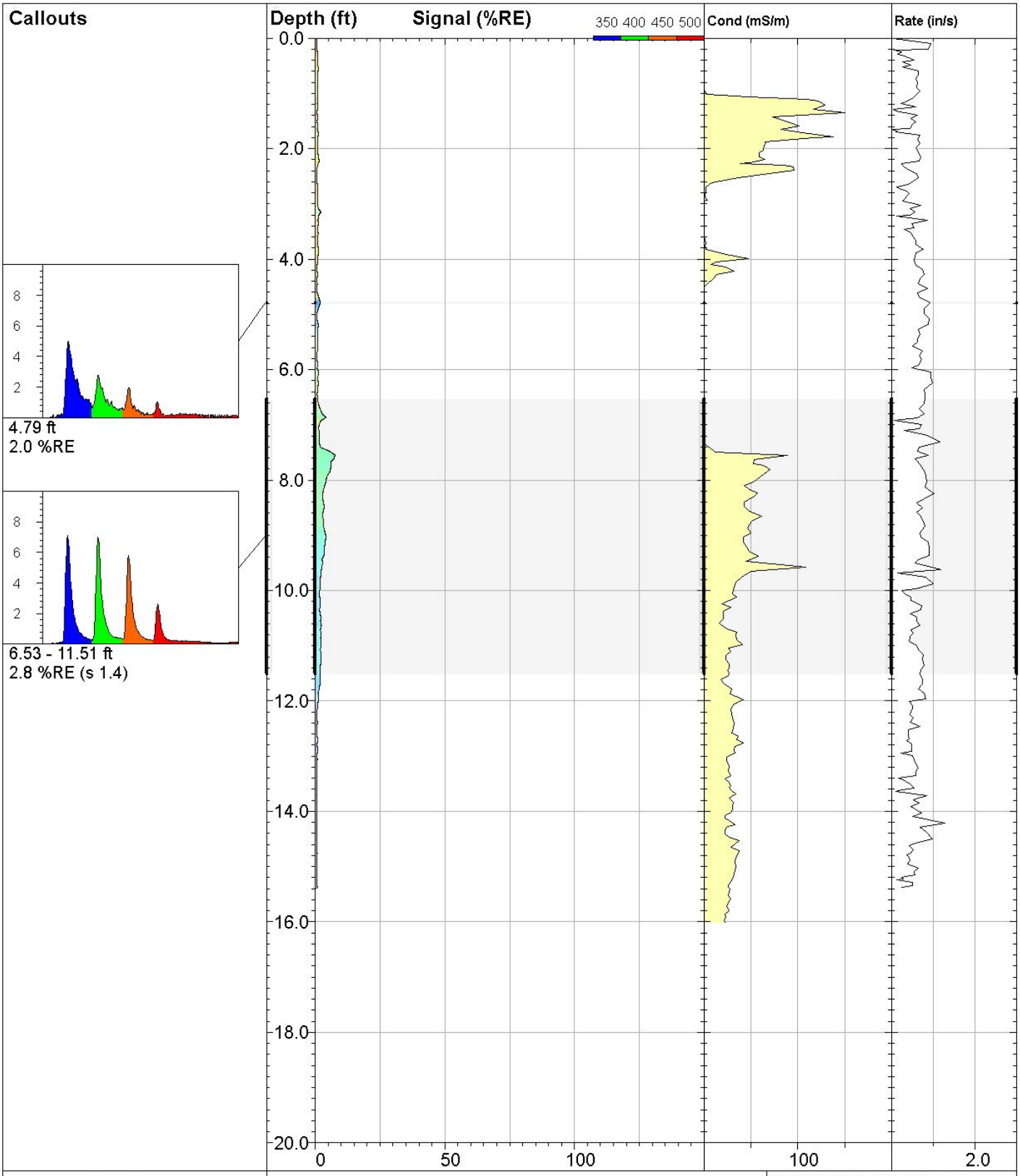
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.87 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.3 %RE @ 8.22 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 14:54 CDT**



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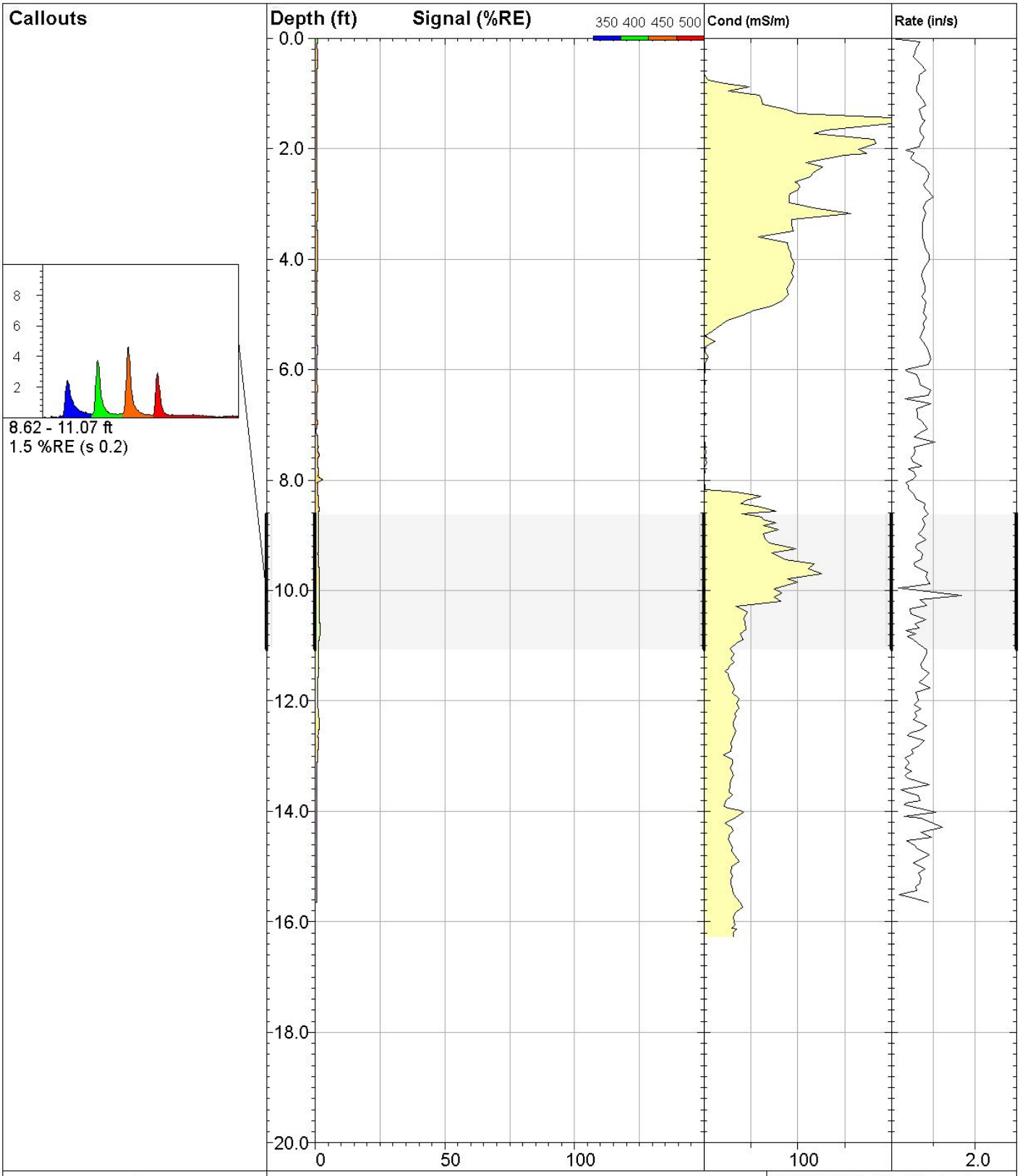
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.39 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **7.7 %RE @ 7.55 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 16:55 CDT**



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49-LIF

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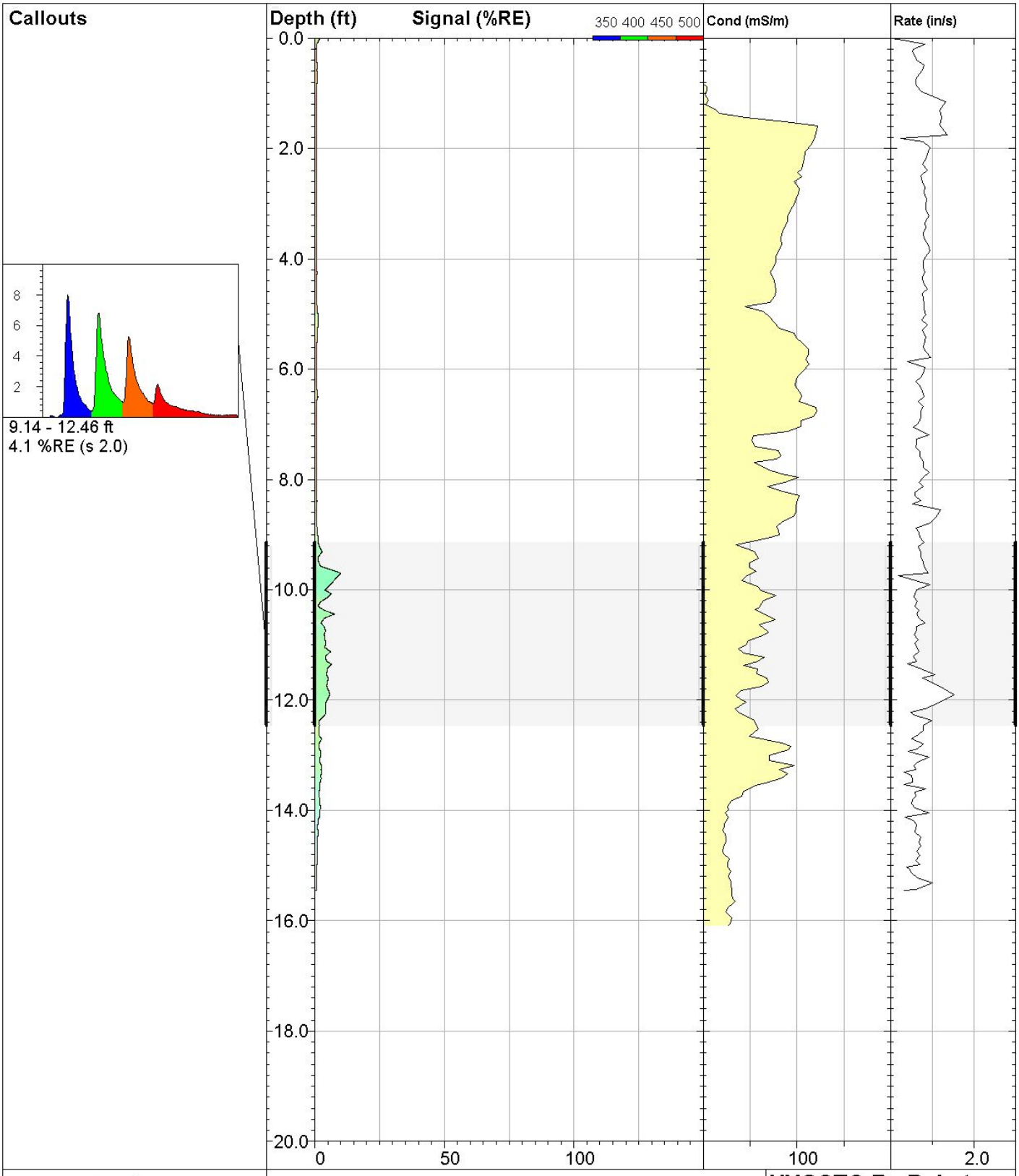
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.65 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.9 %RE @ 7.99 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 17:20 CDT**



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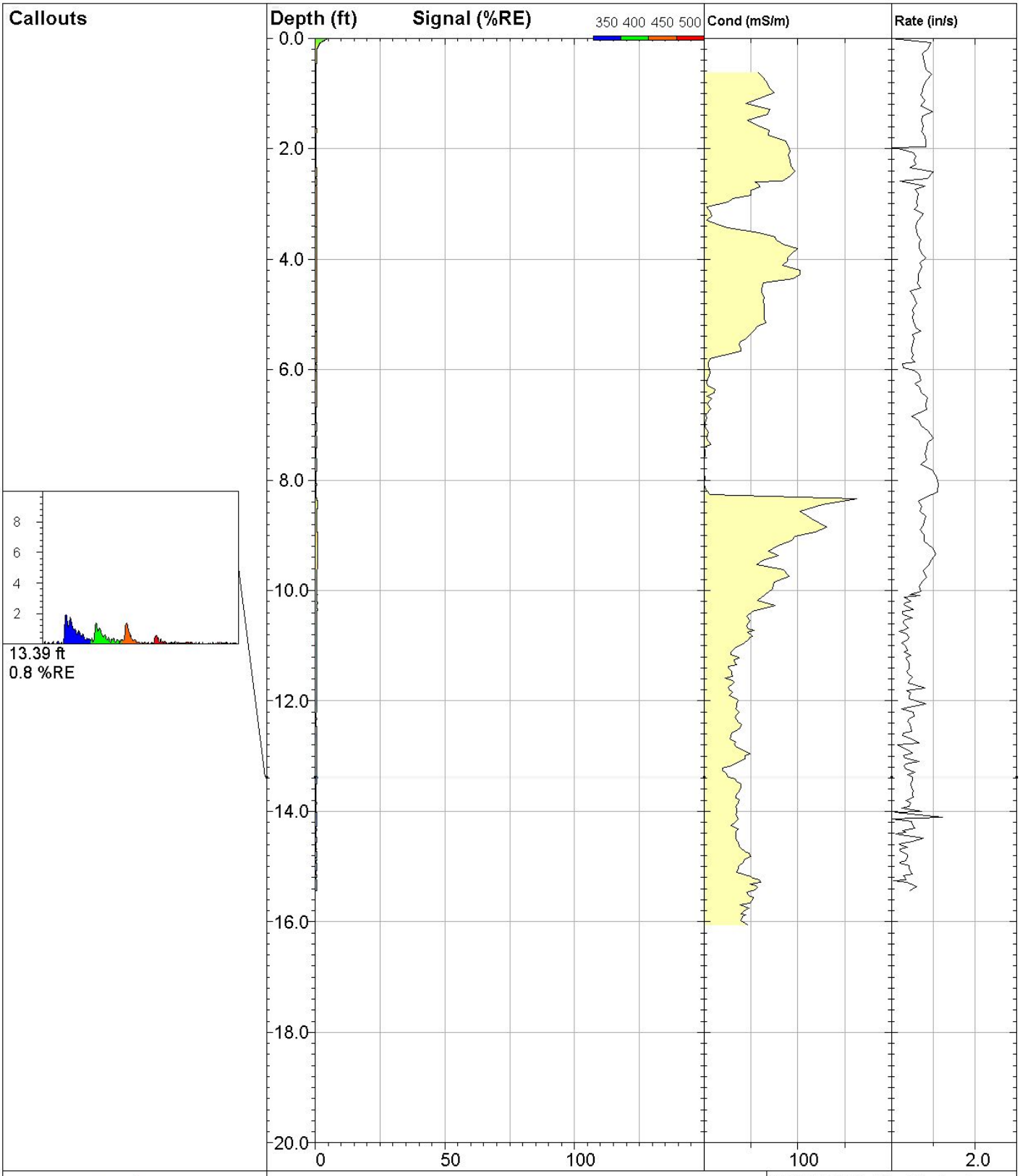
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.46 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **10.0 %RE @ 9.70 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-26 17:44 CDT**



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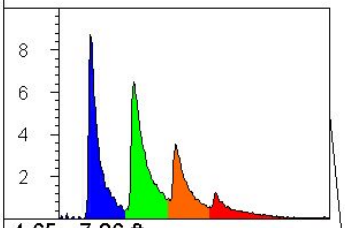
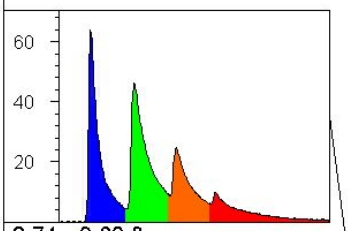
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.43 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.0 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 09:28 CDT**

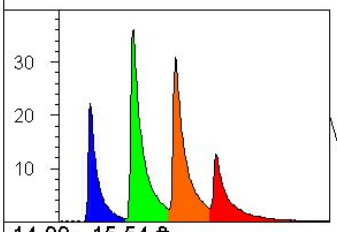
Callouts



4.65 - 7.86 ft
3.0 %RE (s 2.5)

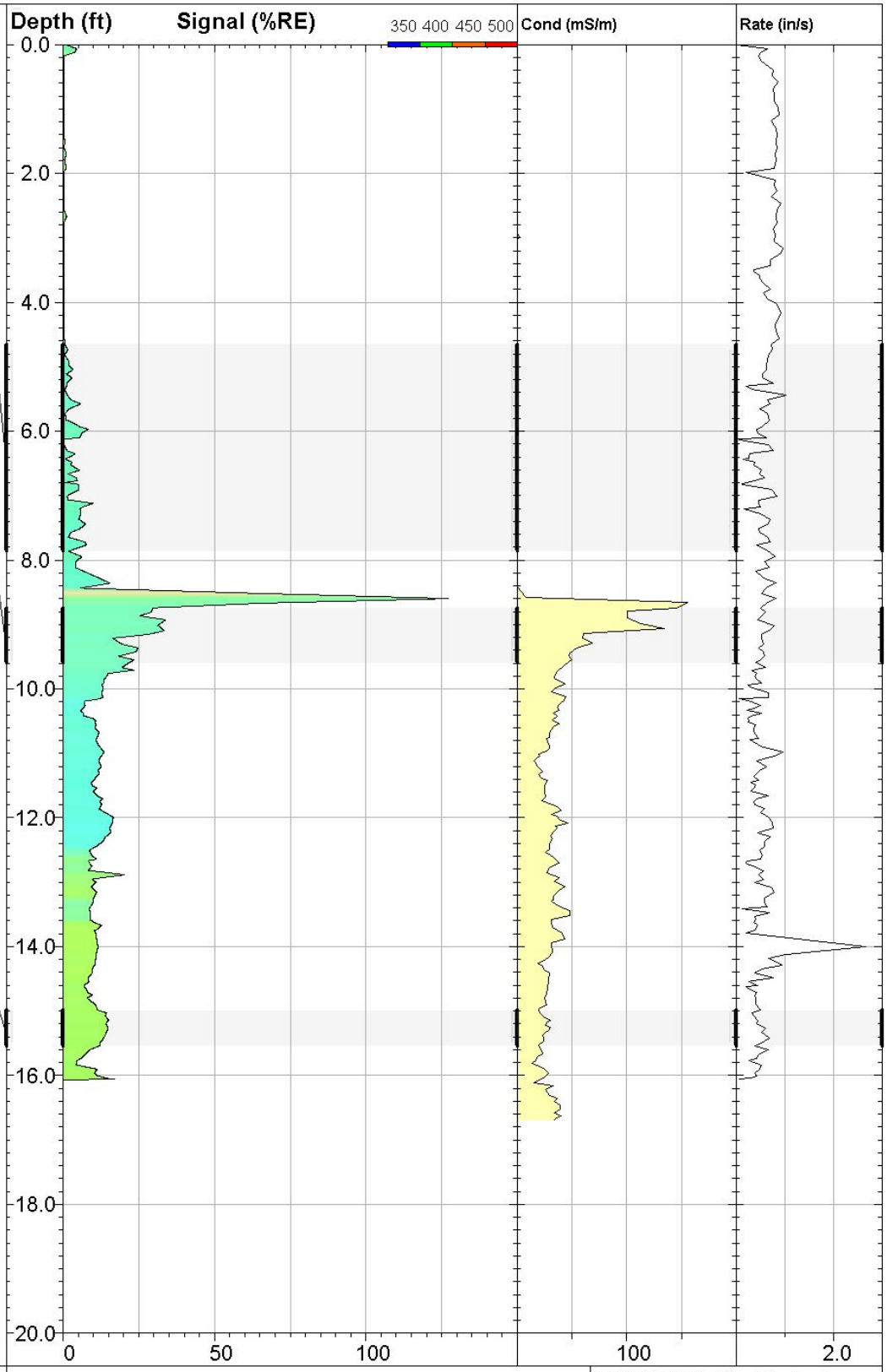


8.74 - 9.60 ft
25.6 %RE (s 5.5)



14.99 - 15.54 ft
13.6 %RE (s 1.2)

BORING REACHED THE END OF PILOT HOLE.



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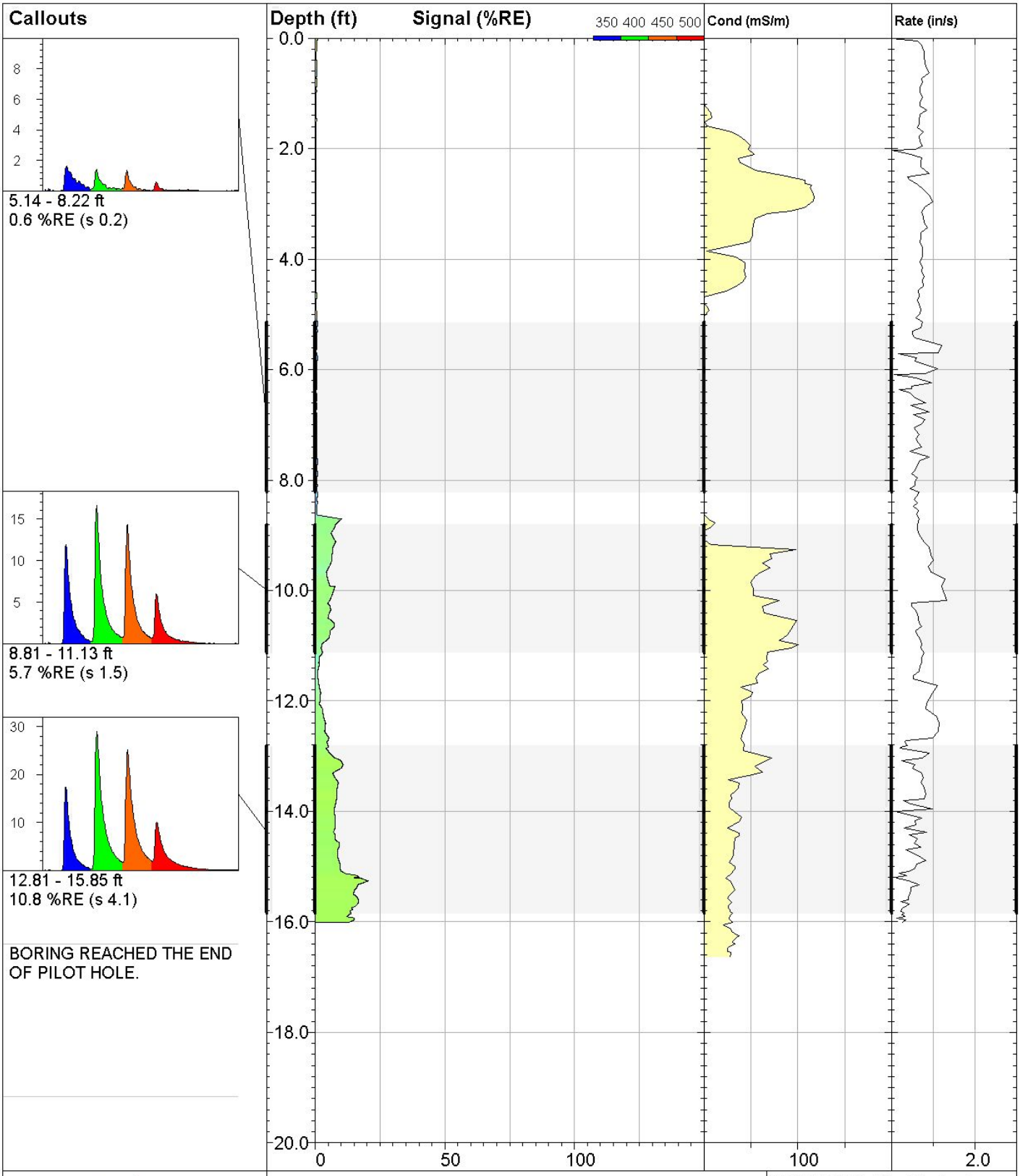
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.06 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **127.9 %RE @ 8.60 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 10:03 CDT**



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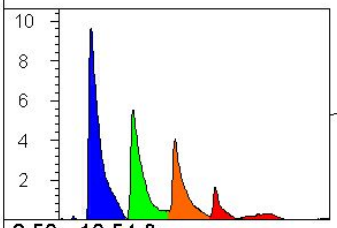
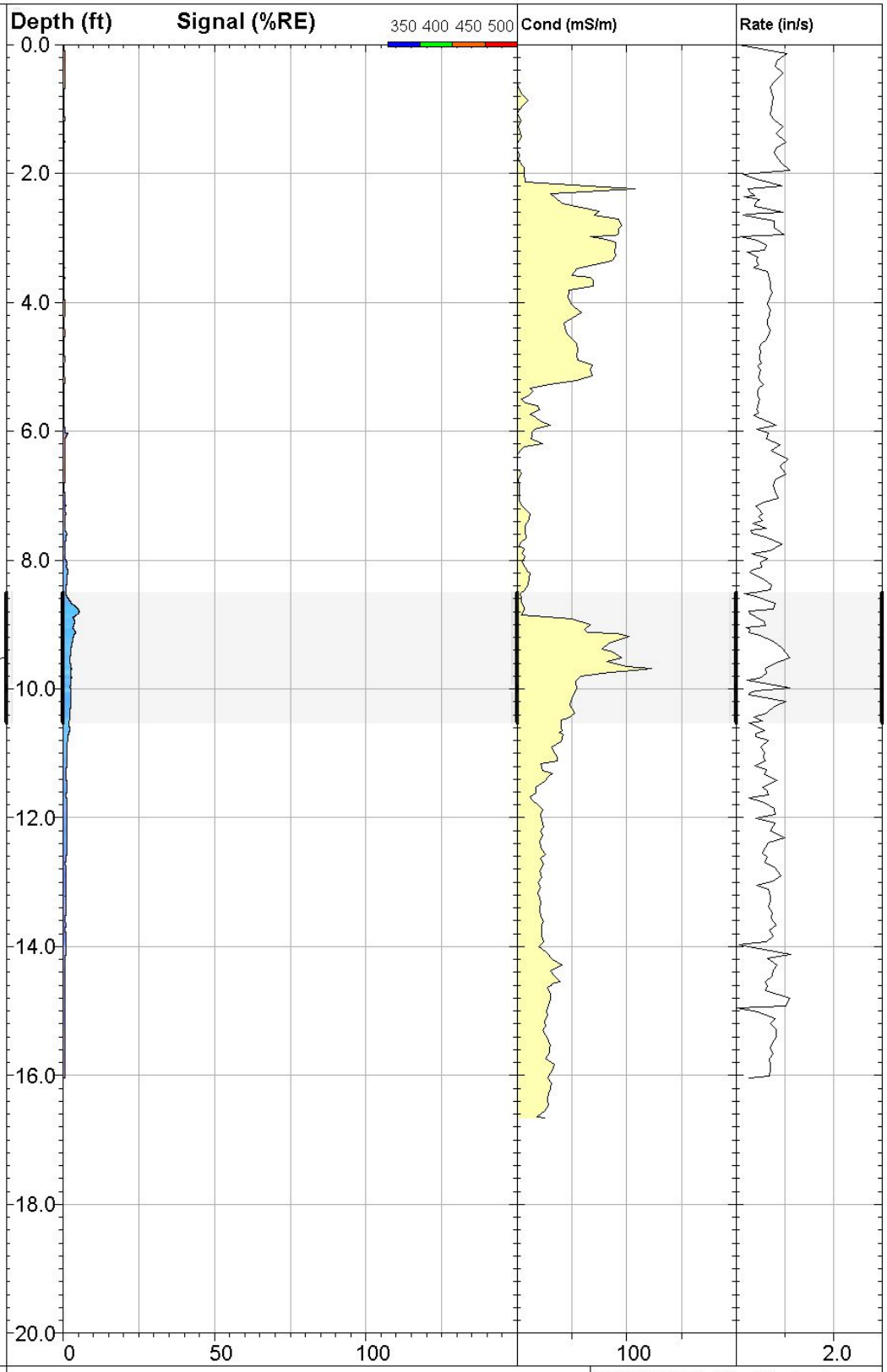
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.01 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **20.4 %RE @ 15.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 10:37 CDT**

Callouts



8.50 - 10.54 ft
2.8 %RE (s 1.0)

BORING REACHED THE END OF PILOT HOLE.



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54-LIF

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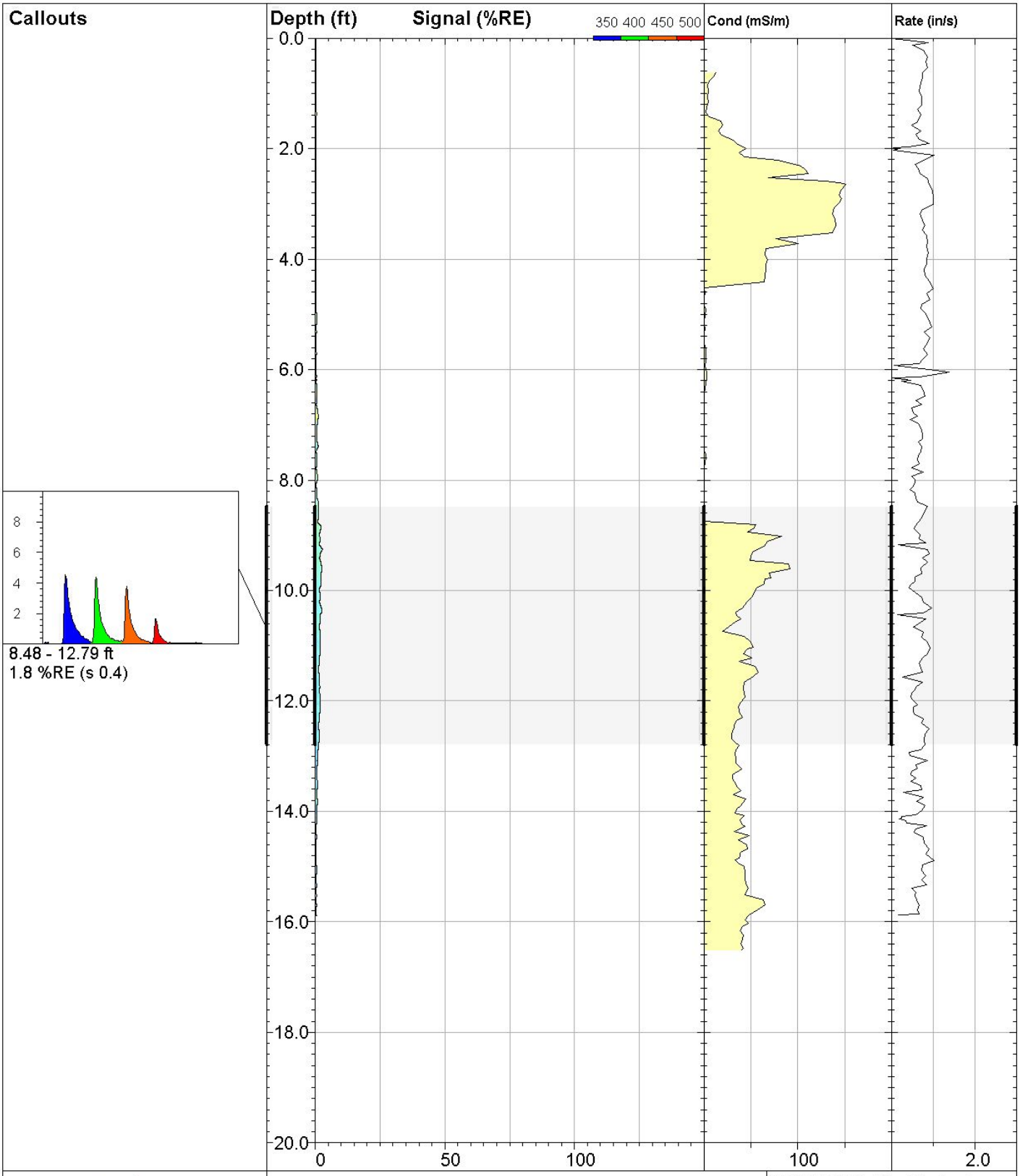
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.3 %RE @ 8.80 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 11:05 CDT**



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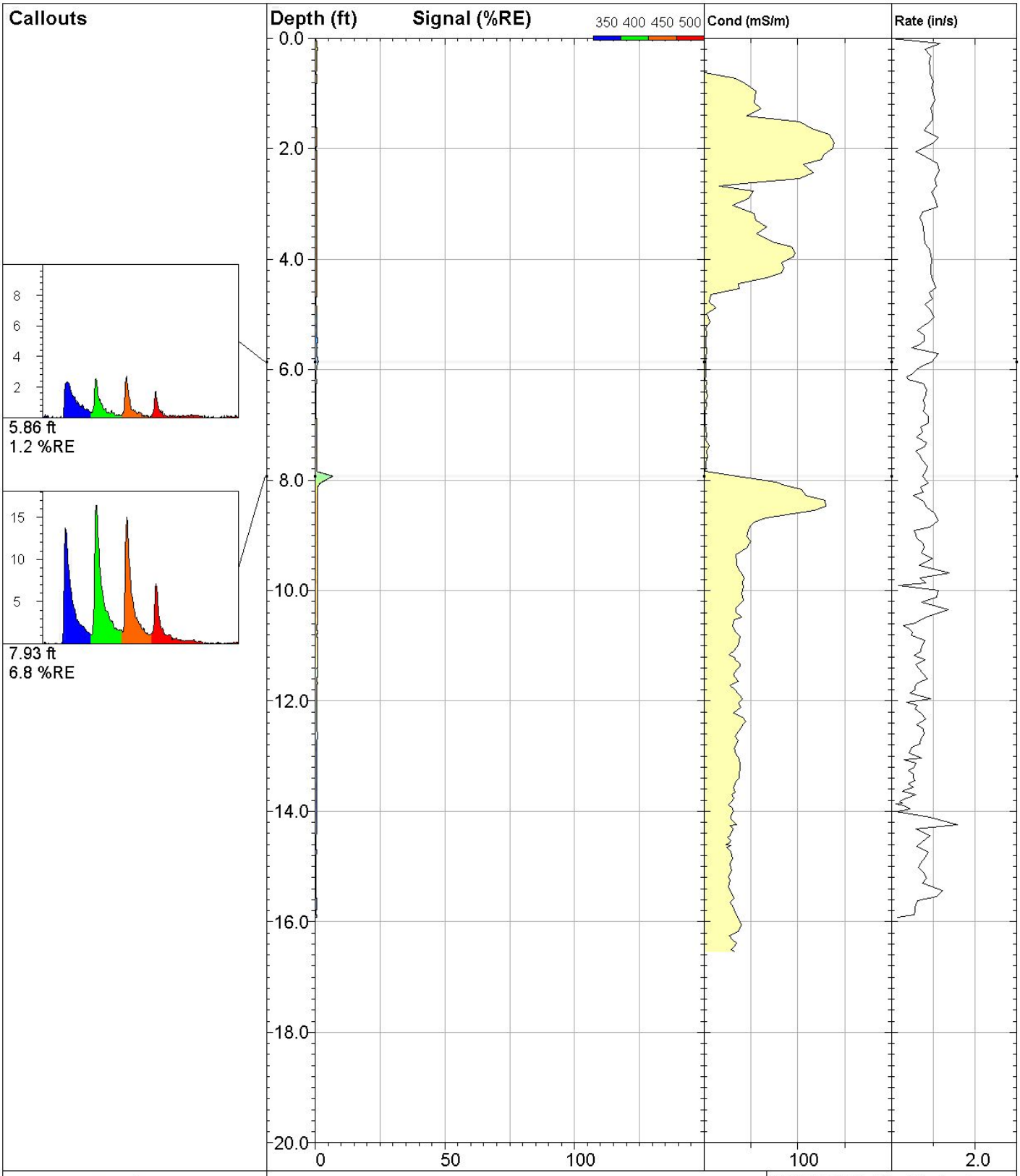
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.89 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.8 %RE @ 9.26 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 11:41 CDT**



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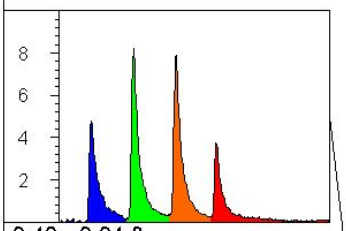
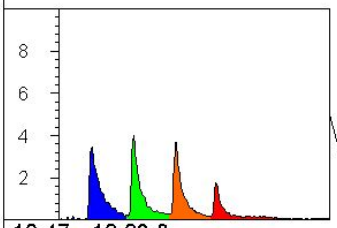
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.92 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.8 %RE @ 7.93 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 12:24 CDT**

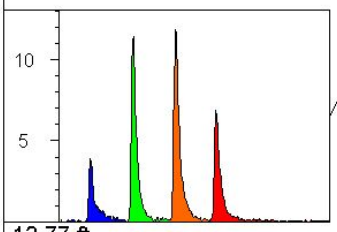
Callouts



9.40 - 9.94 ft
3.1 %RE (s 0.4)

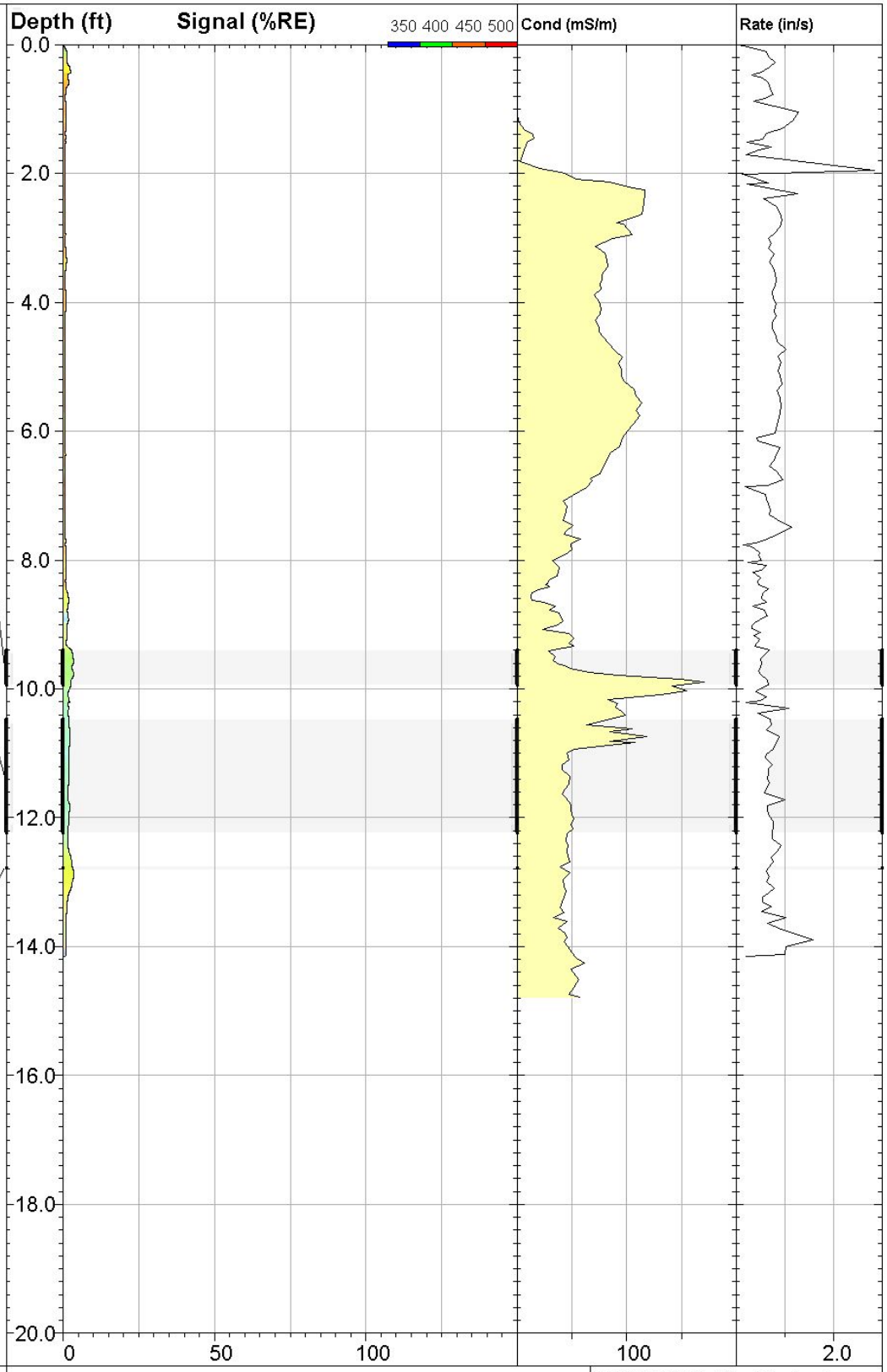


10.47 - 12.23 ft
1.9 %RE (s 0.2)



12.77 ft
3.0 %RE

BORING COMPLETED TO
END OF PREPROBE



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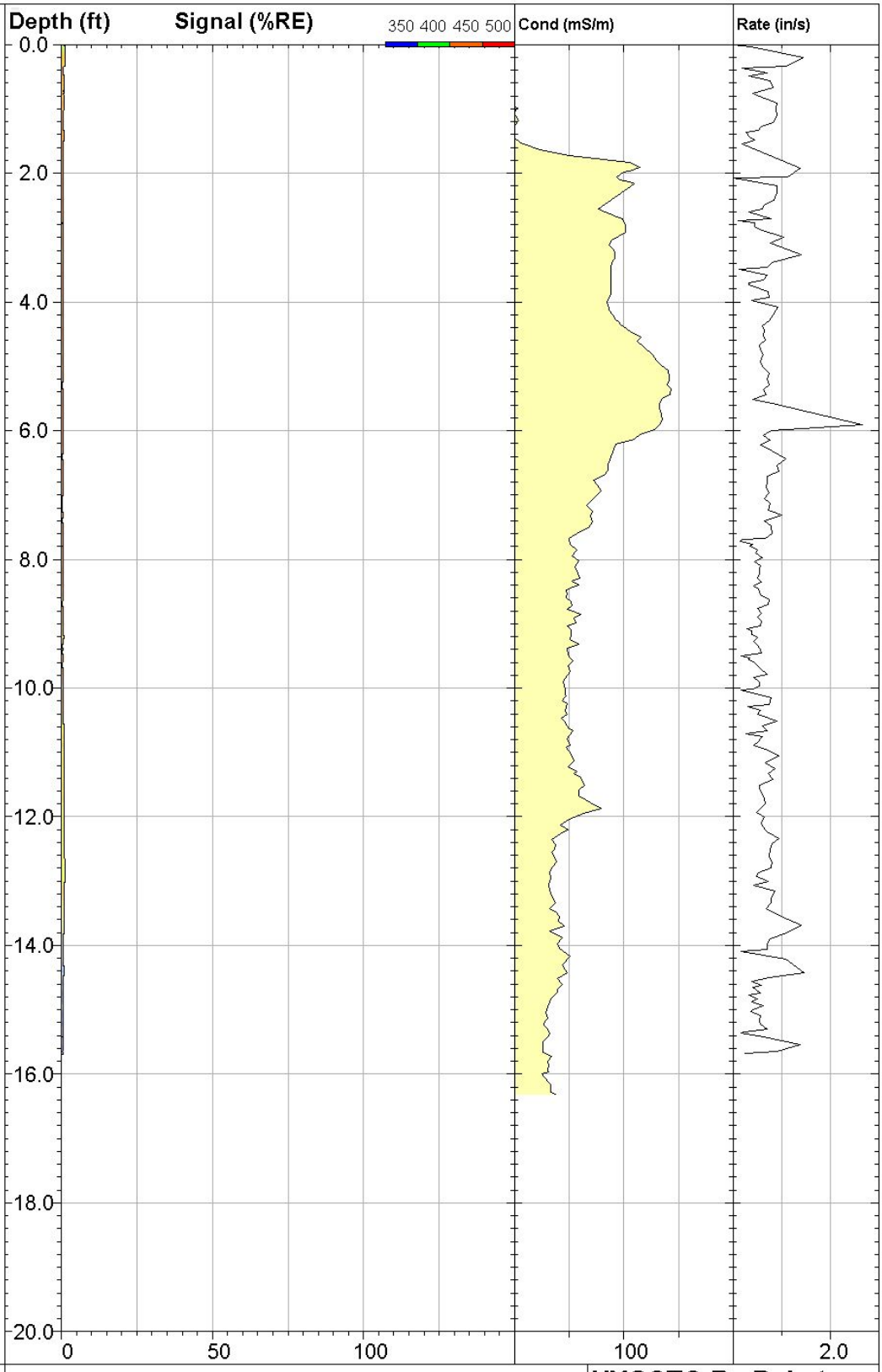
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.16 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.6 %RE @ 9.78 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 14:11 CDT**

Callouts
BORING COMPLETED TO END OF PREPROBE



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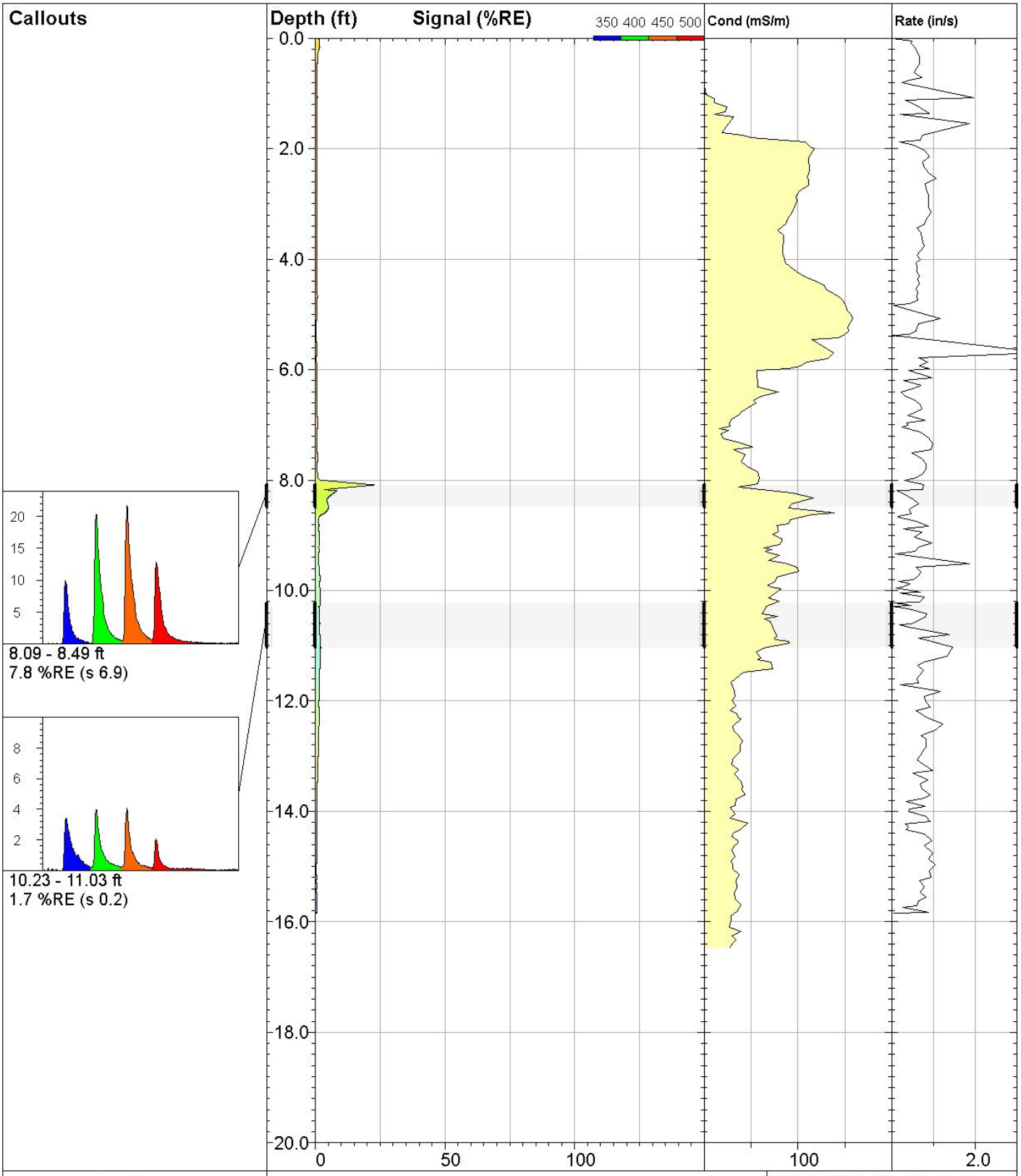
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.70 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 15.70 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 14:31 CDT**



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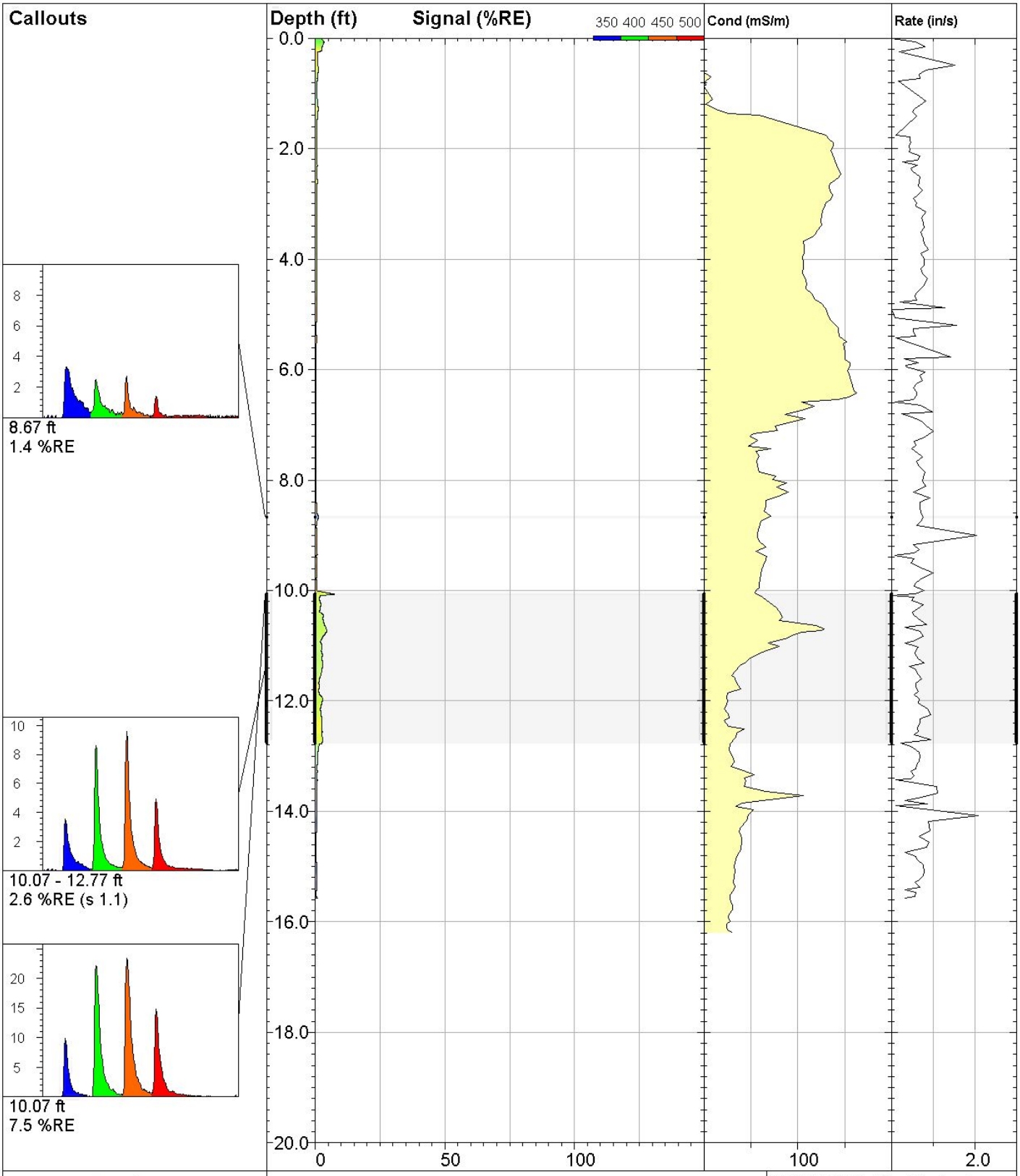
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.85 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **22.9 %RE @ 8.09 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 15:03 CDT**



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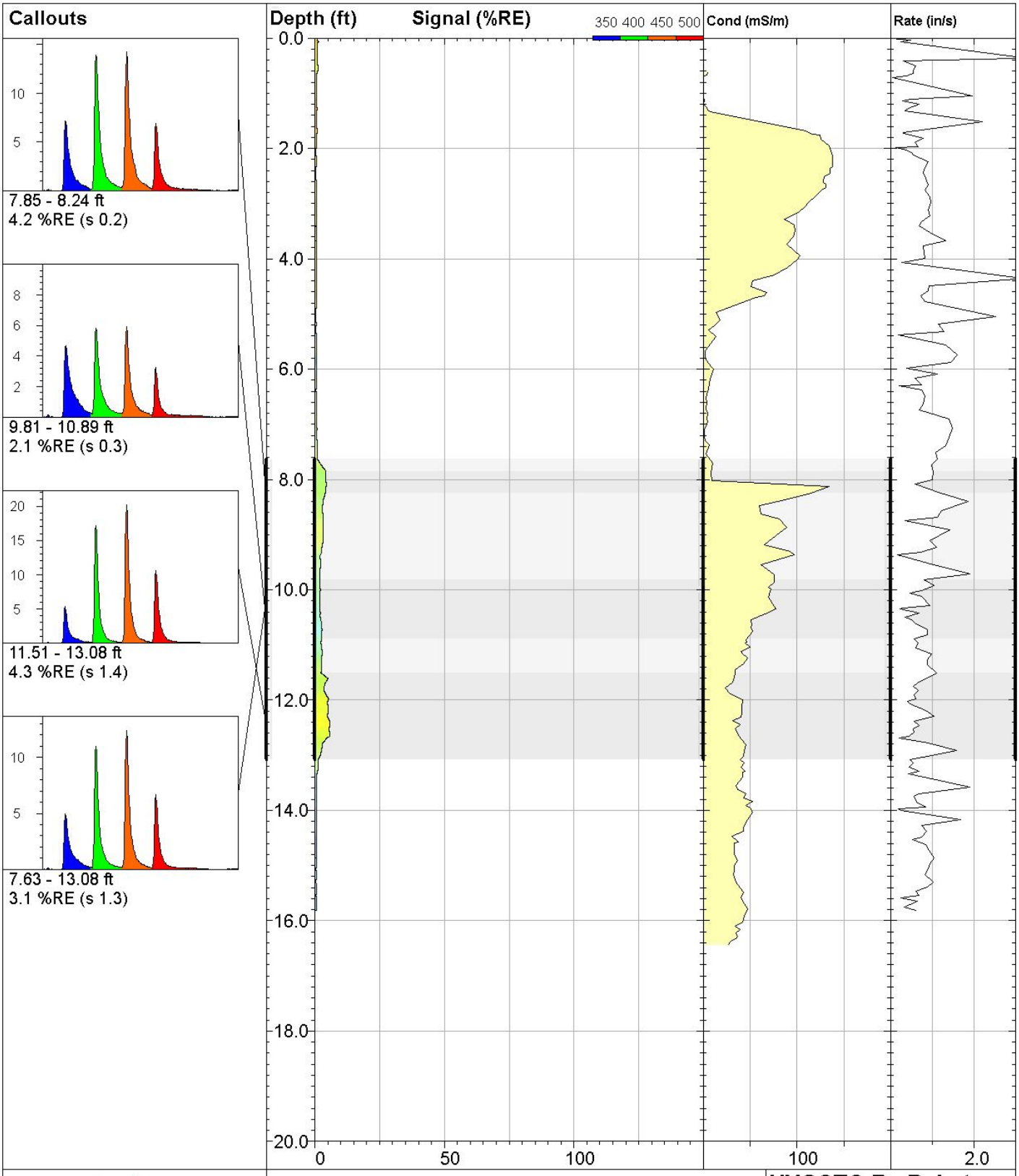
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.57 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **7.5 %RE @ 10.07 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 15:34 CDT**



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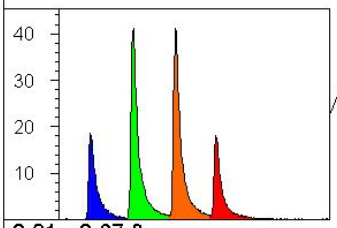
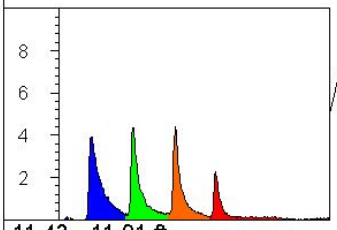
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.82 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **5.9 %RE @ 12.46 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 16:04 CDT**

Callouts

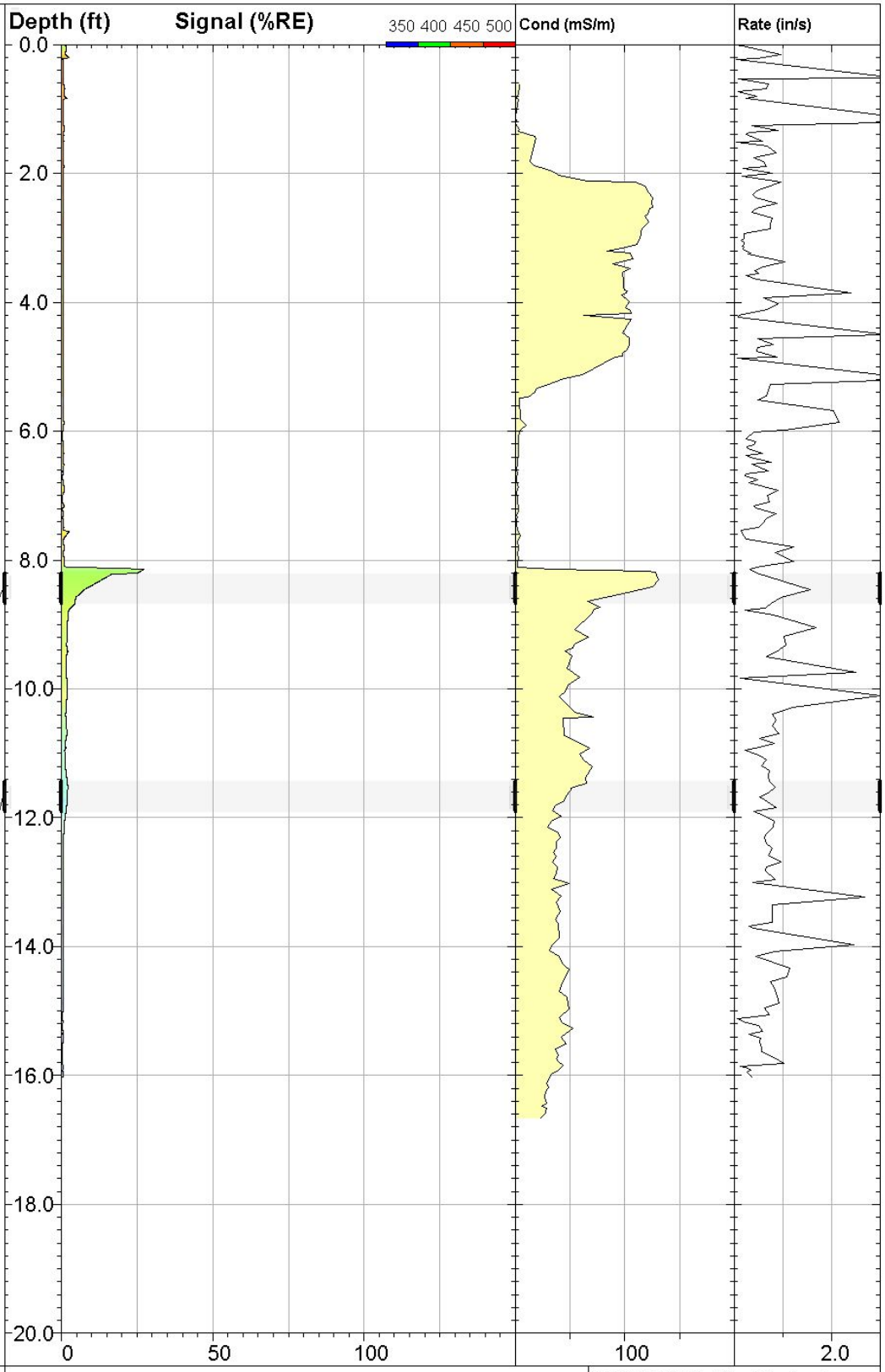


8.21 - 8.67 ft
11.7 %RE (s 8.9)



11.43 - 11.91 ft
1.8 %RE (s 0.2)

SEVERAL VOID SPACES
DURING ADVANCEMENT.
RATE JUMPED



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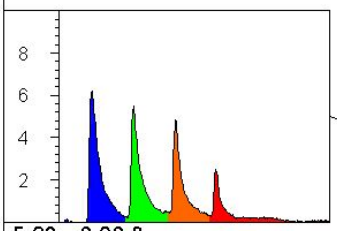
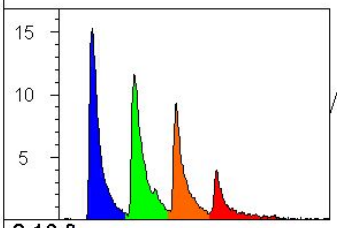
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.03 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **27.4 %RE @ 8.14 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 16:32 CDT**

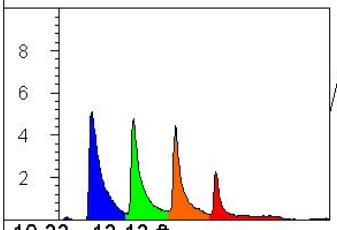
Callouts



5.23 - 6.06 ft
2.7 %RE (s 0.8)

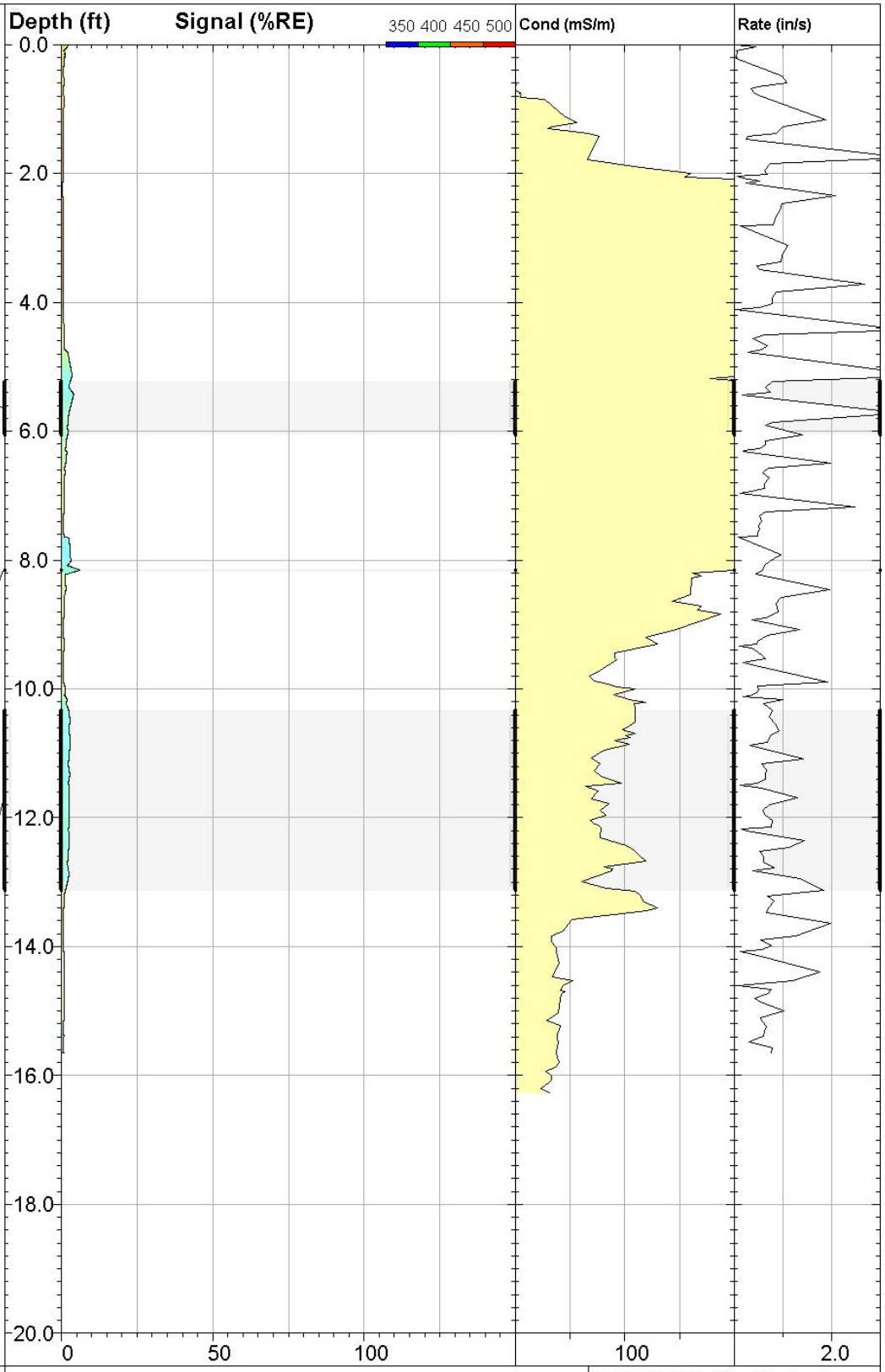


8.16 ft
6.2 %RE



10.33 - 13.13 ft
2.4 %RE (s 0.3)

SEVERAL VOID SPACES
DURING ADVANCEMENT.
RATE JUMPED



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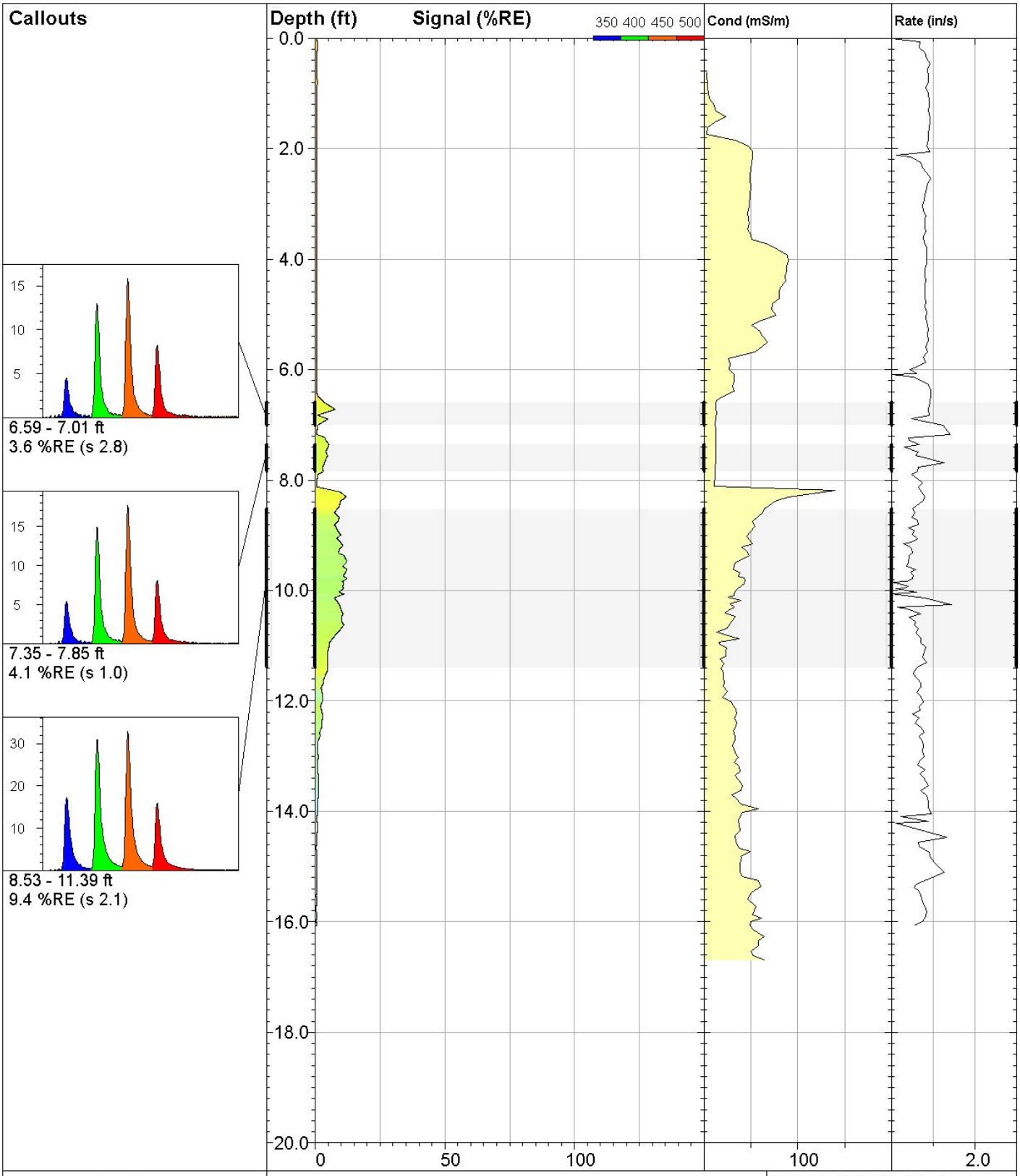
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.65 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.2 %RE @ 8.16 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-27 17:07 CDT**



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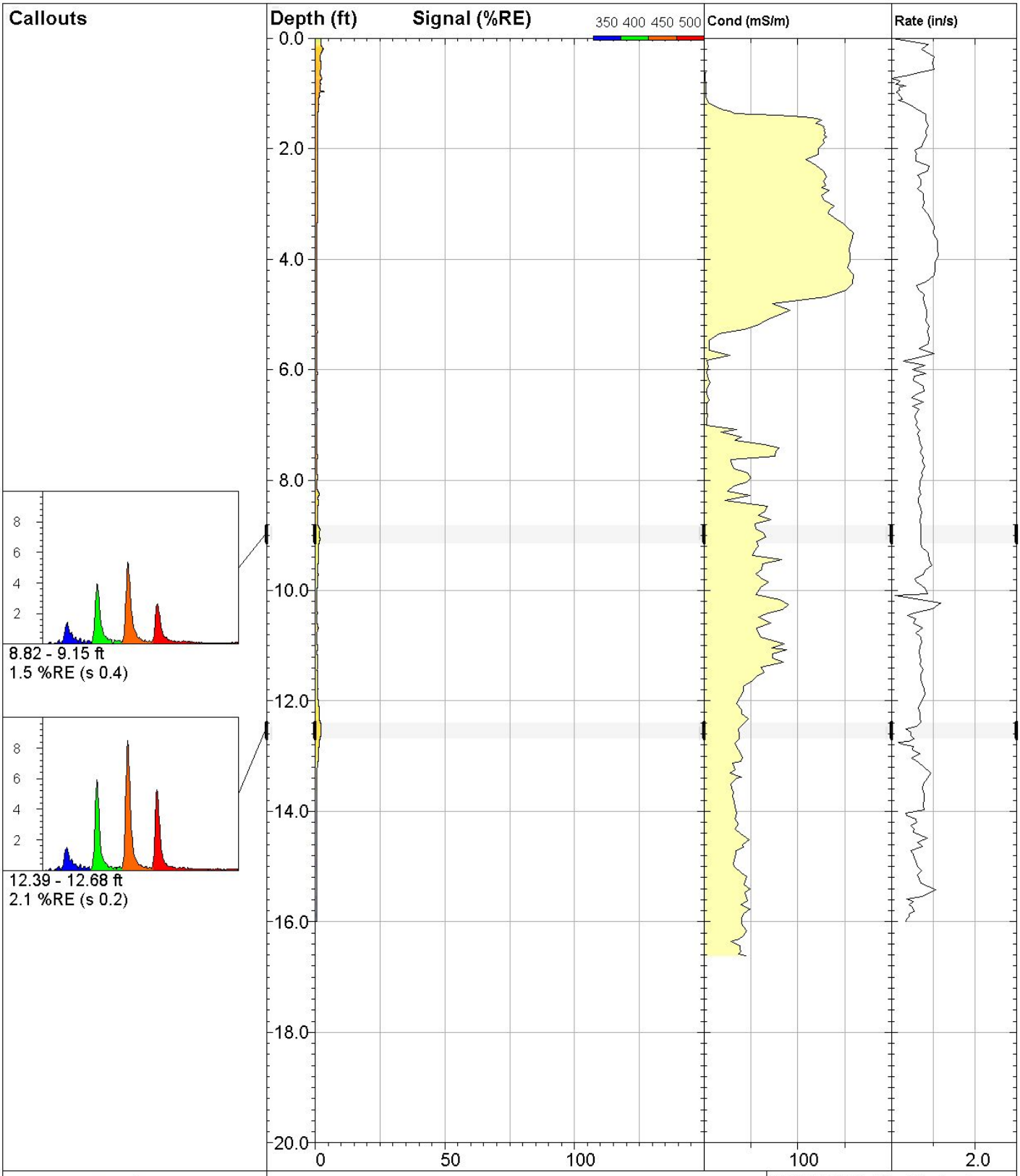
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.07 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.3 %RE @ 9.62 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 10:55 CDT**



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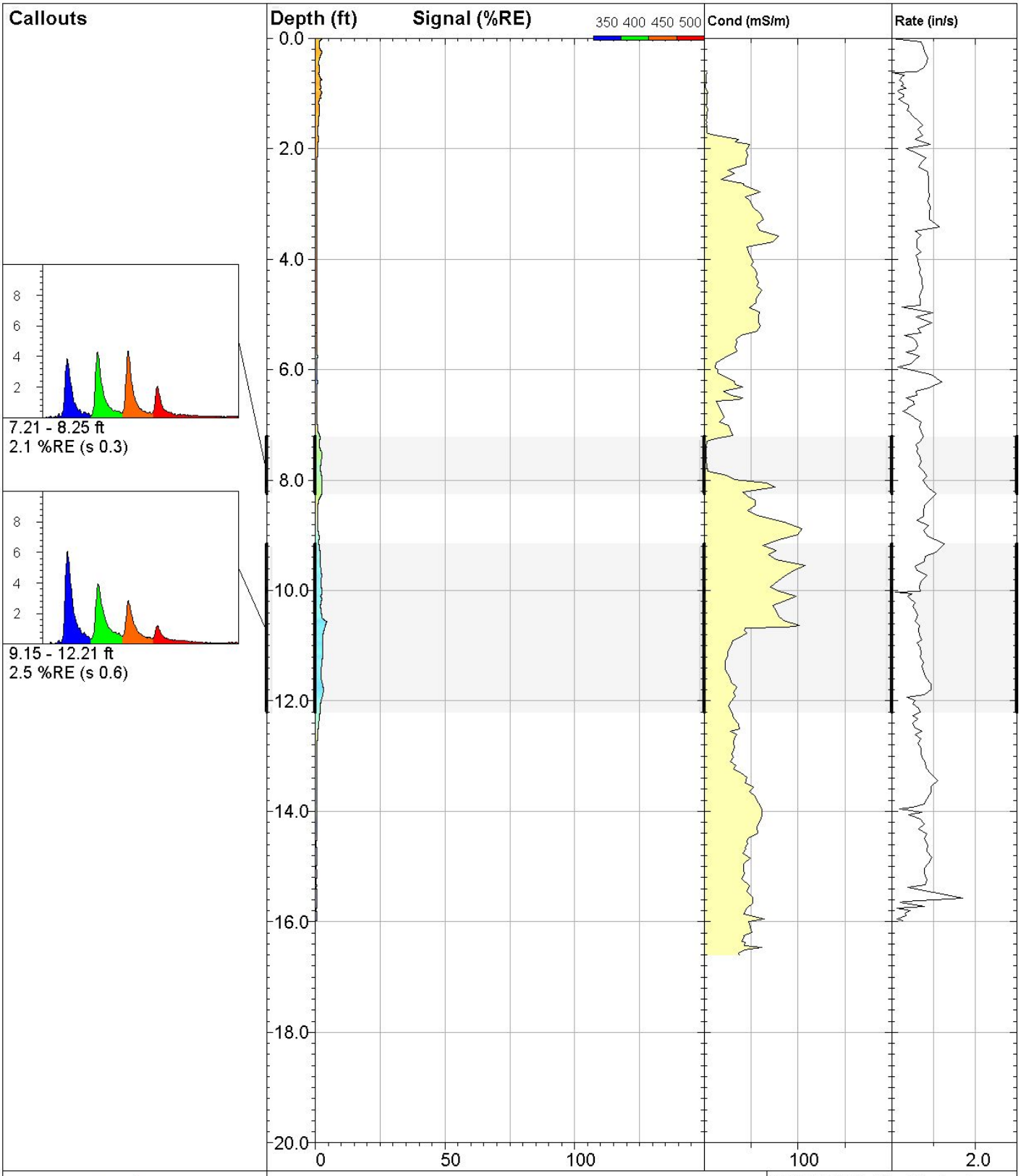
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.5 %RE @ 0.97 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 11:14 CDT**



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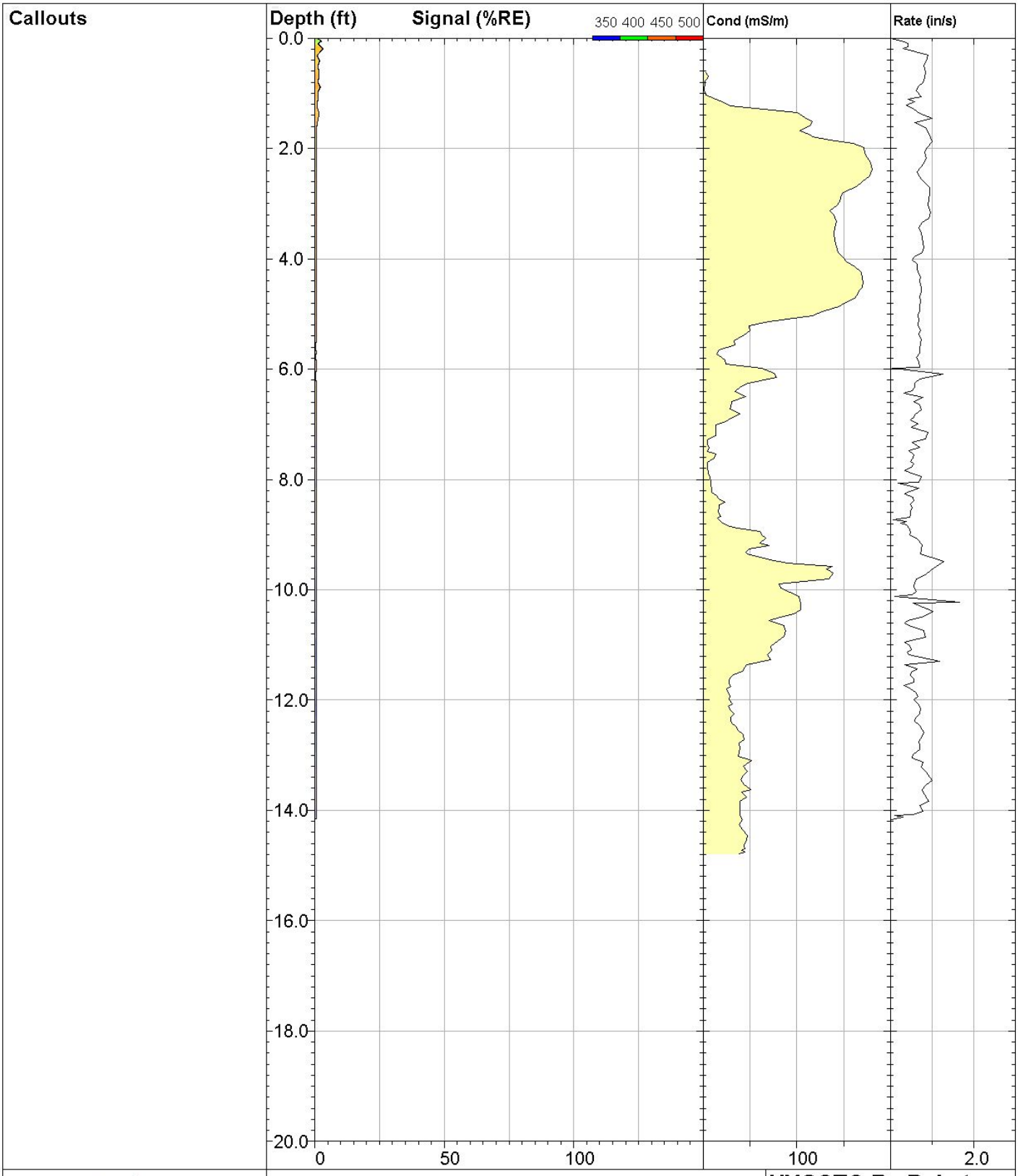
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.4 %RE @ 10.56 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 11:41 CDT**



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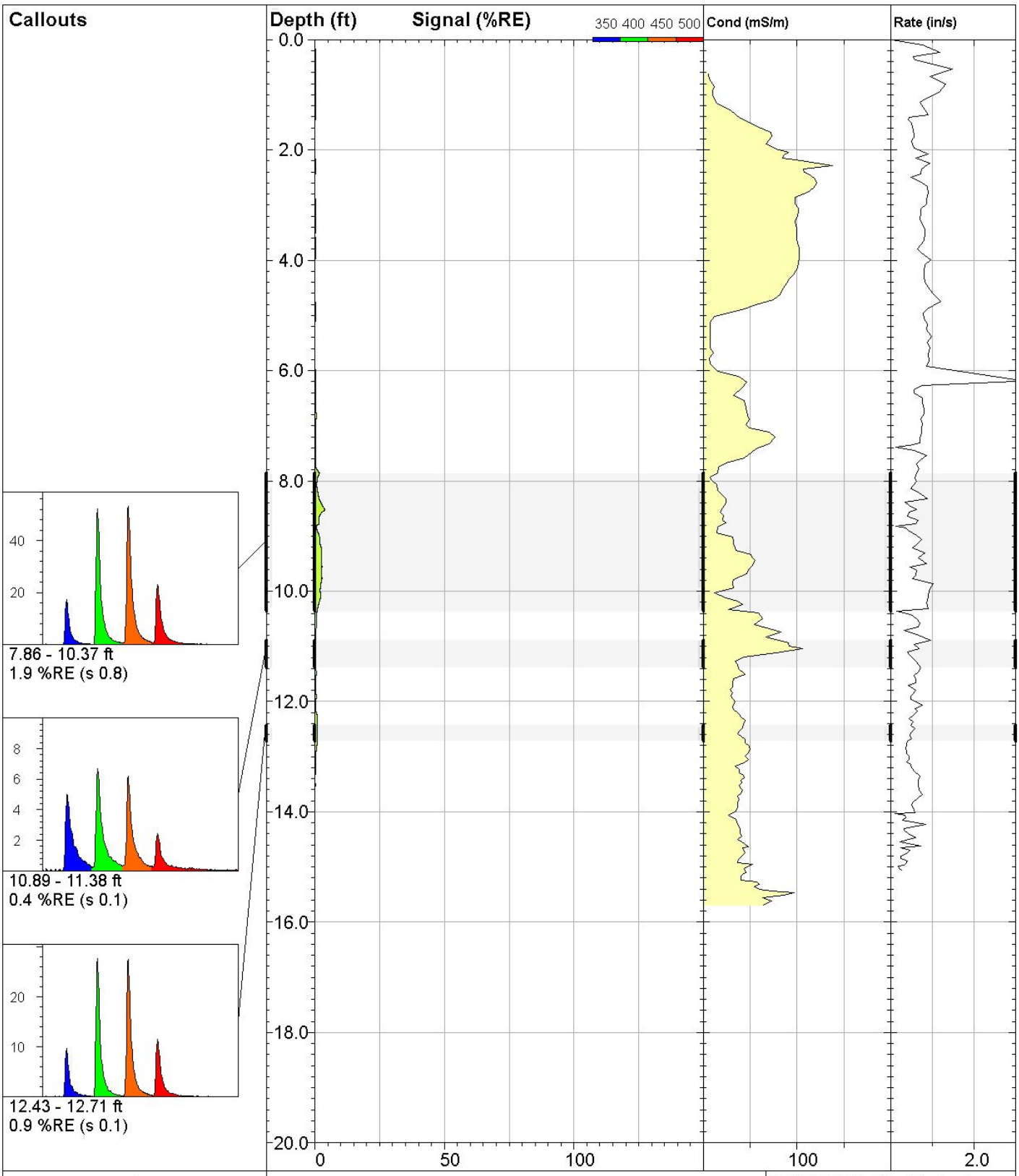
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.16 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.3 %RE @ 0.19 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 12:28 CDT**



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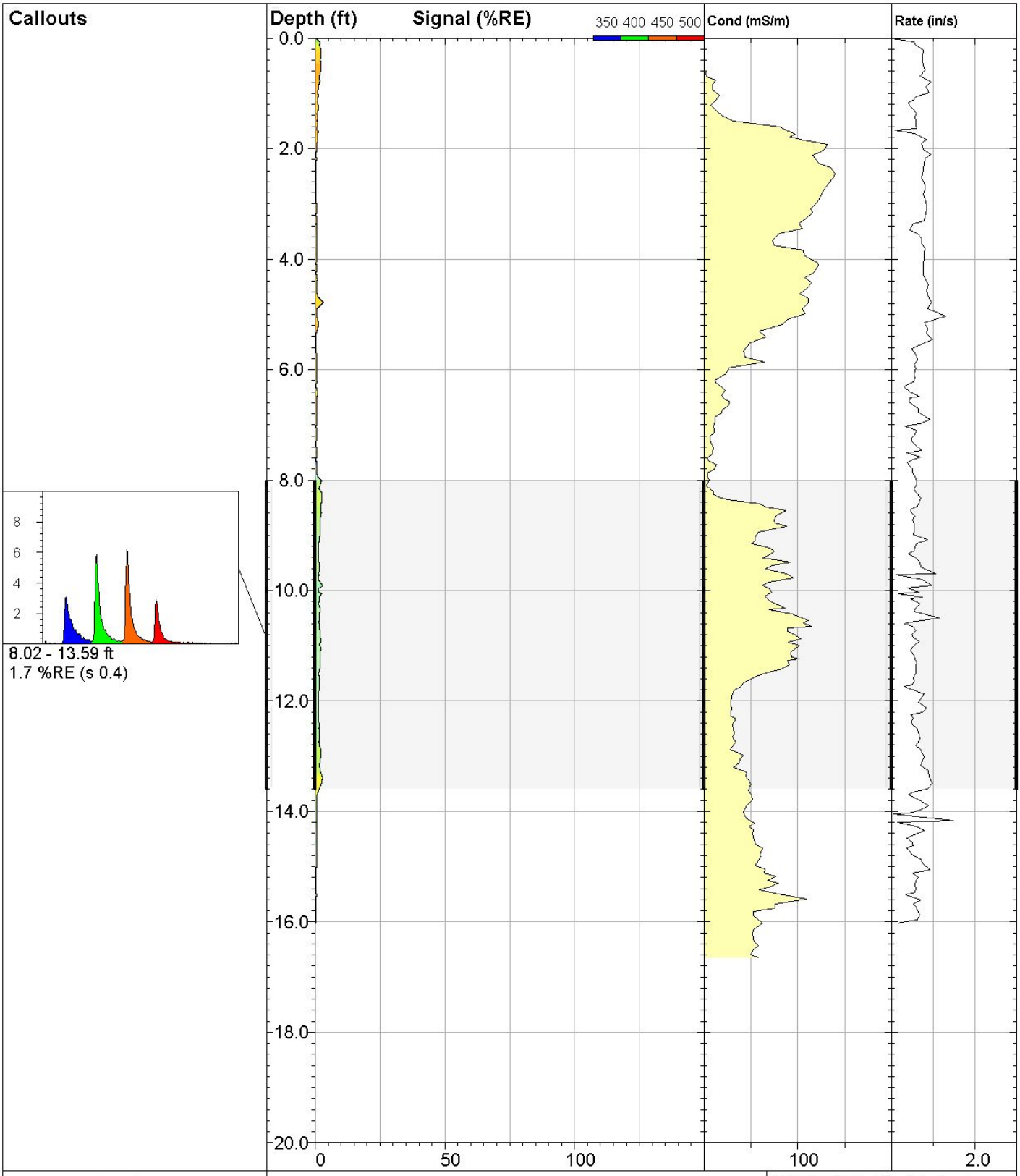
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.06 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.9 %RE @ 8.53 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 13:41 CDT**



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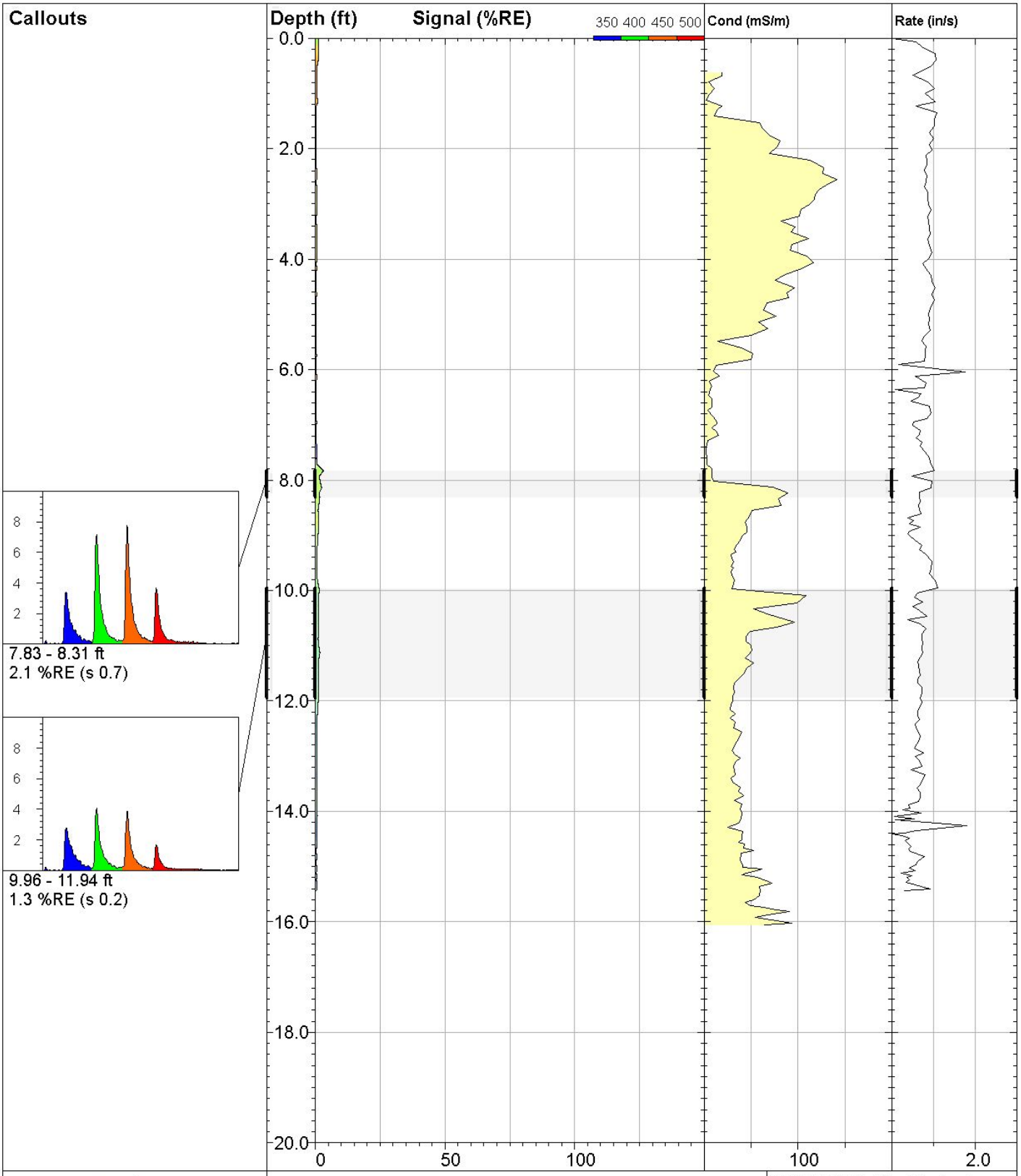
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.2 %RE @ 4.78 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 14:15 CDT**



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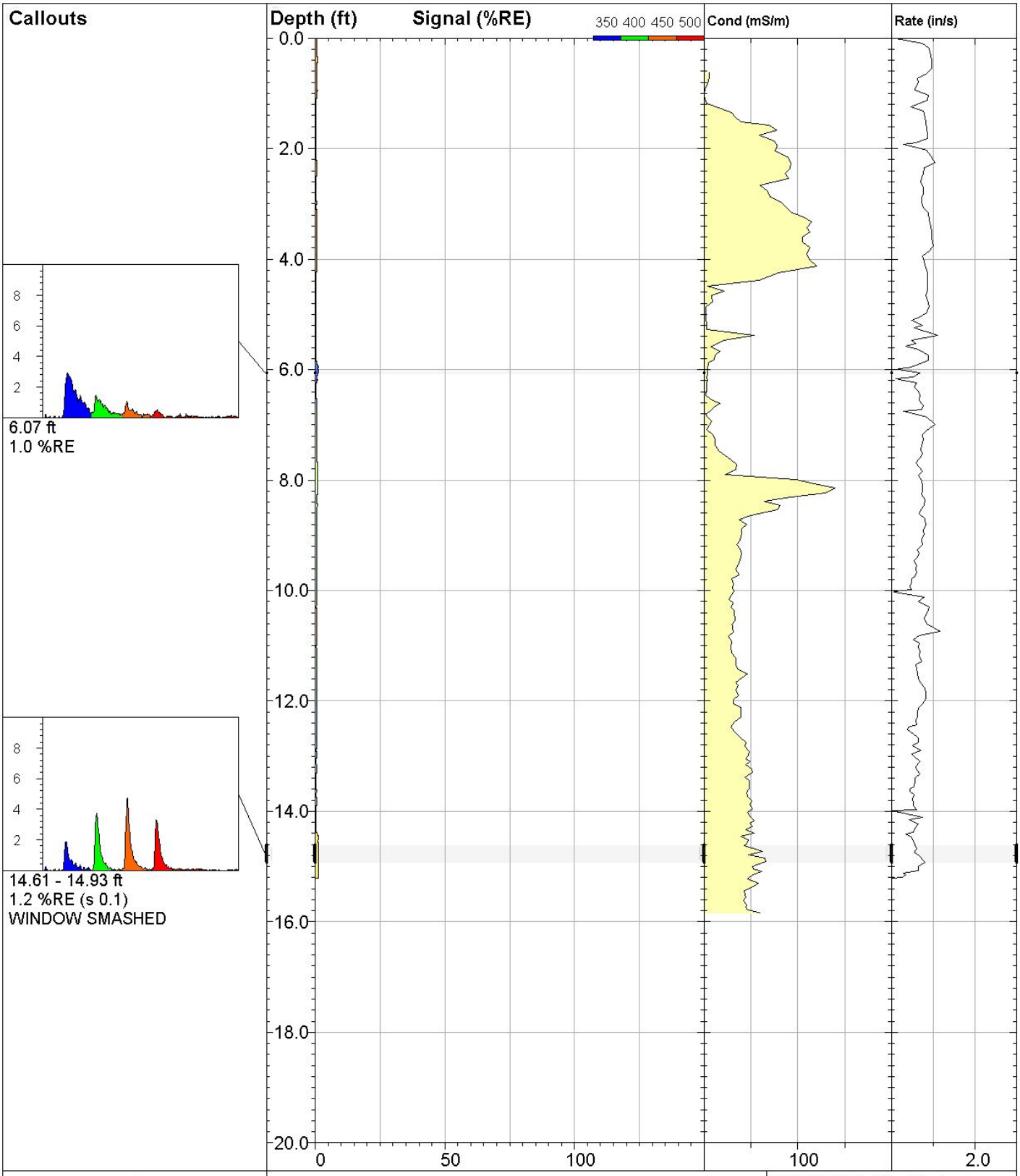
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.44 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.2 %RE @ 7.83 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 14:43 CDT**



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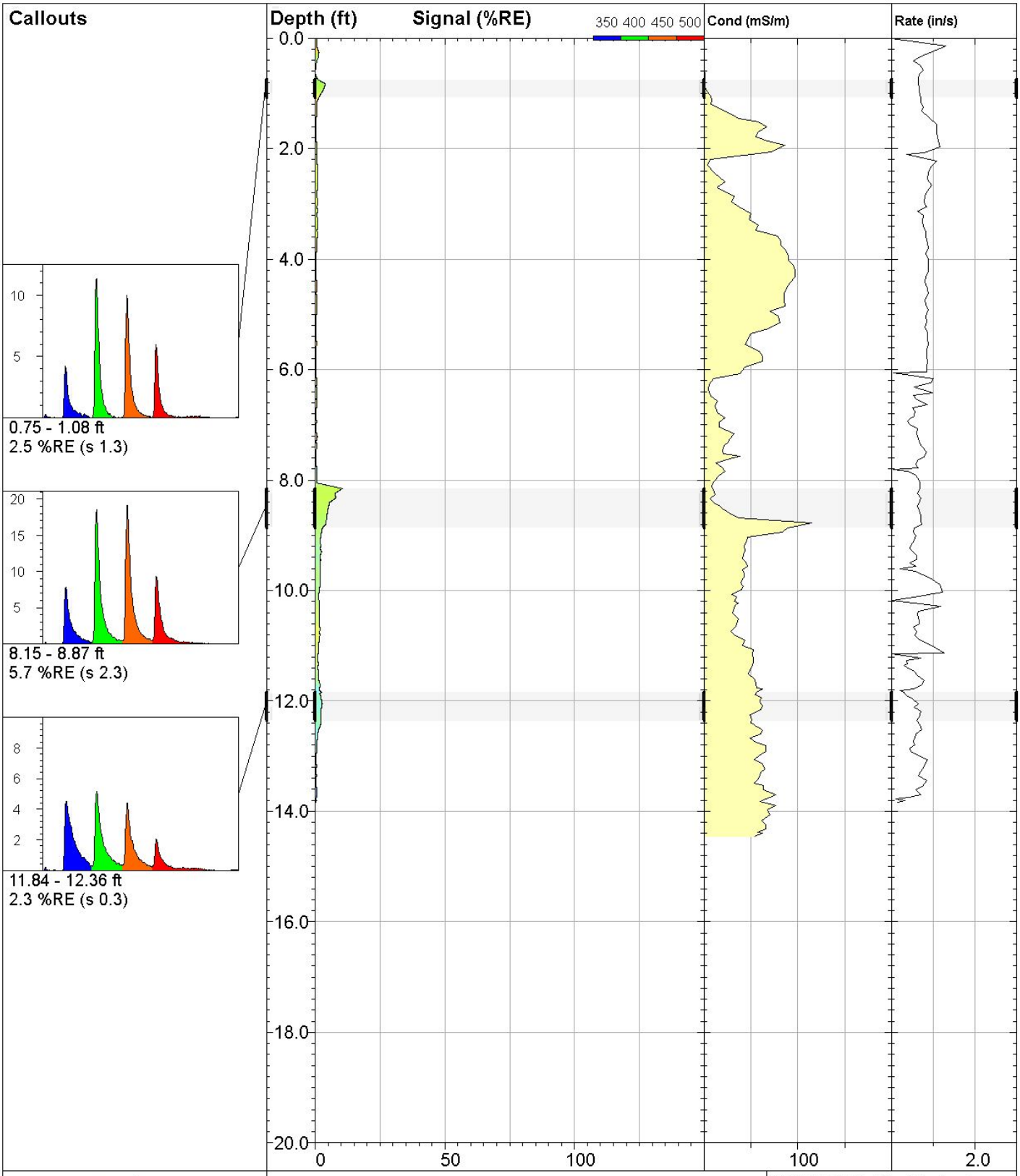
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.22 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 6.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 15:10 CDT**



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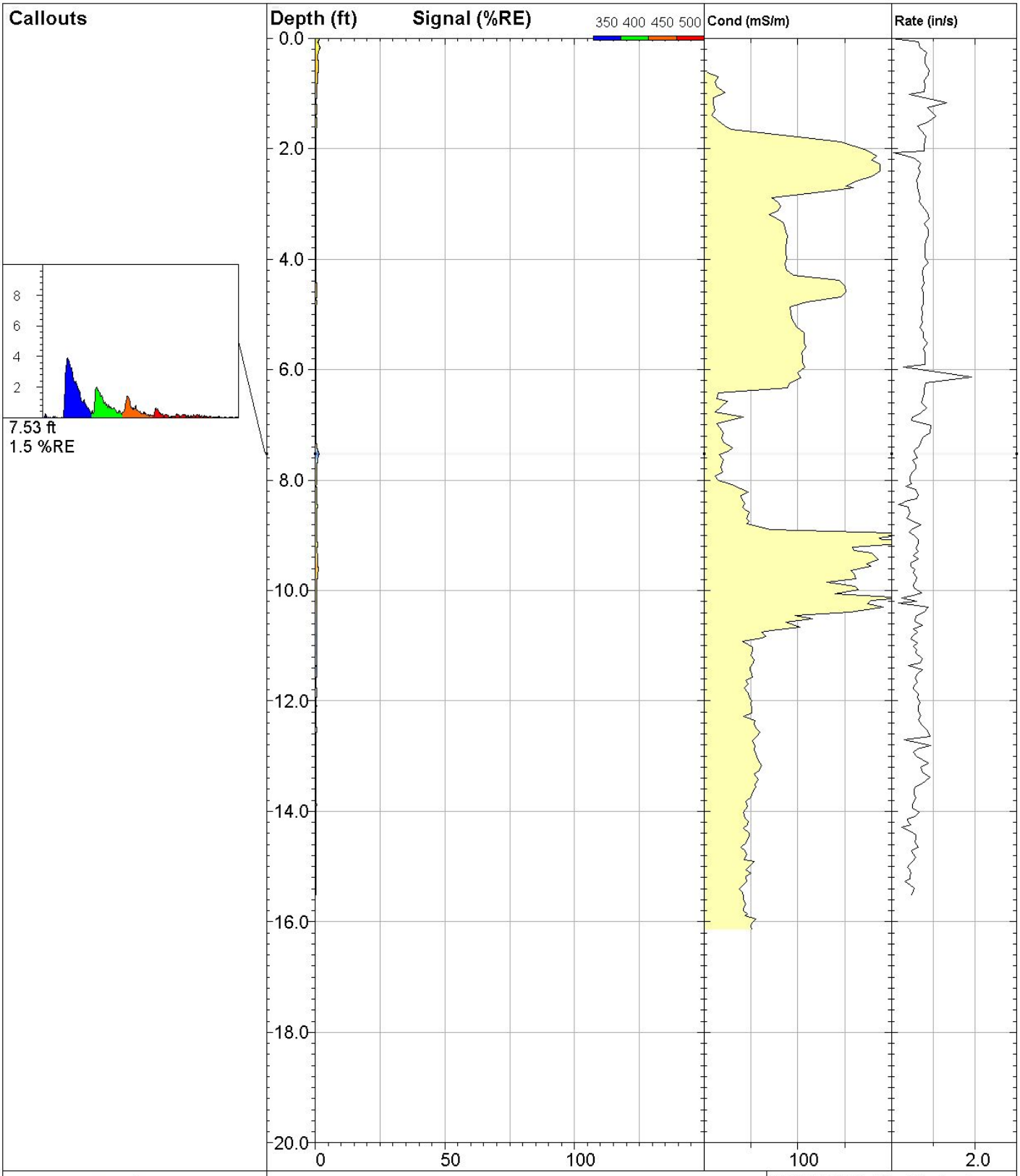
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **13.83 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **10.5 %RE @ 8.15 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 15:53 CDT**



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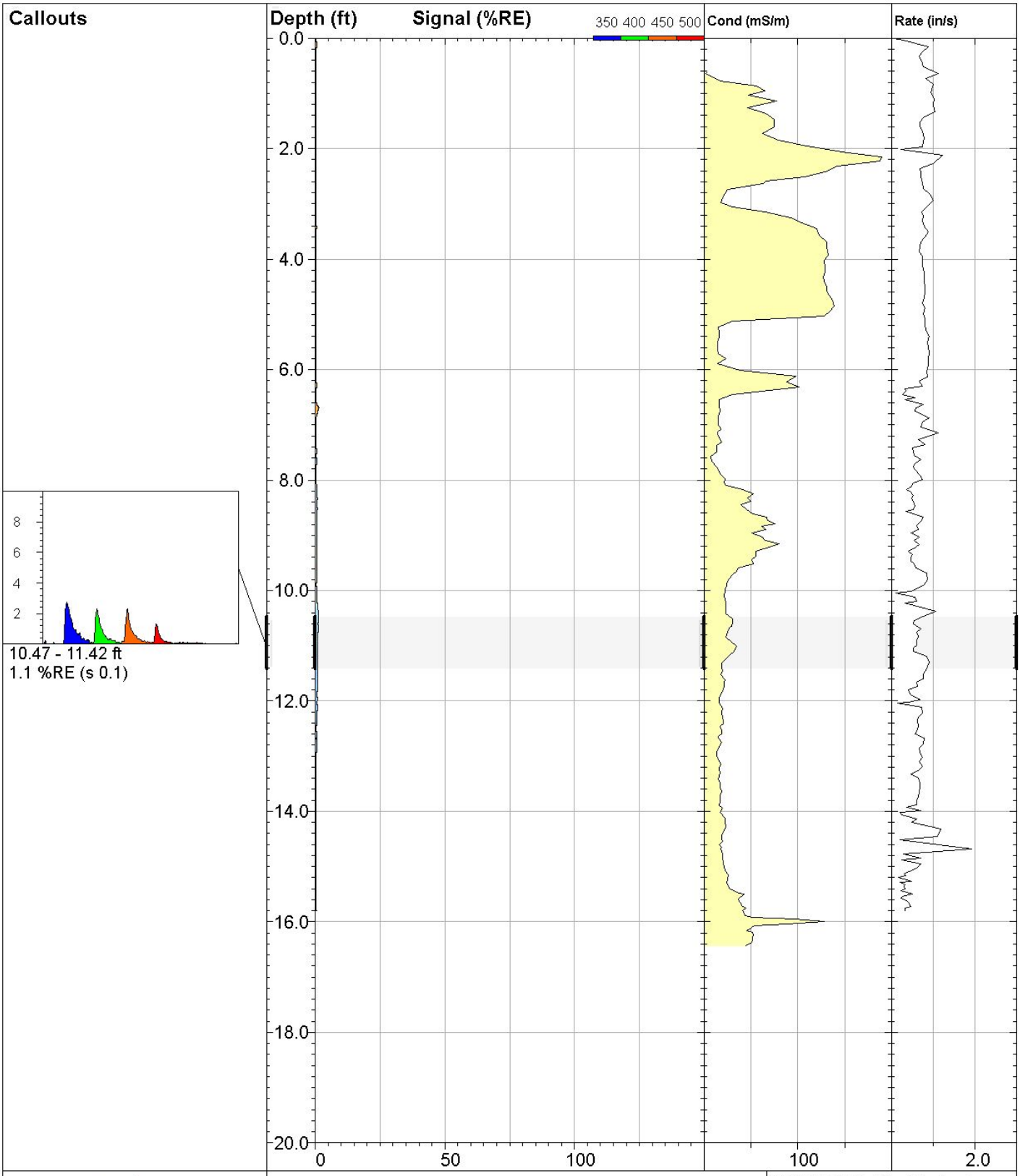
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.51 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.9 %RE @ 0.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 16:25 CDT**



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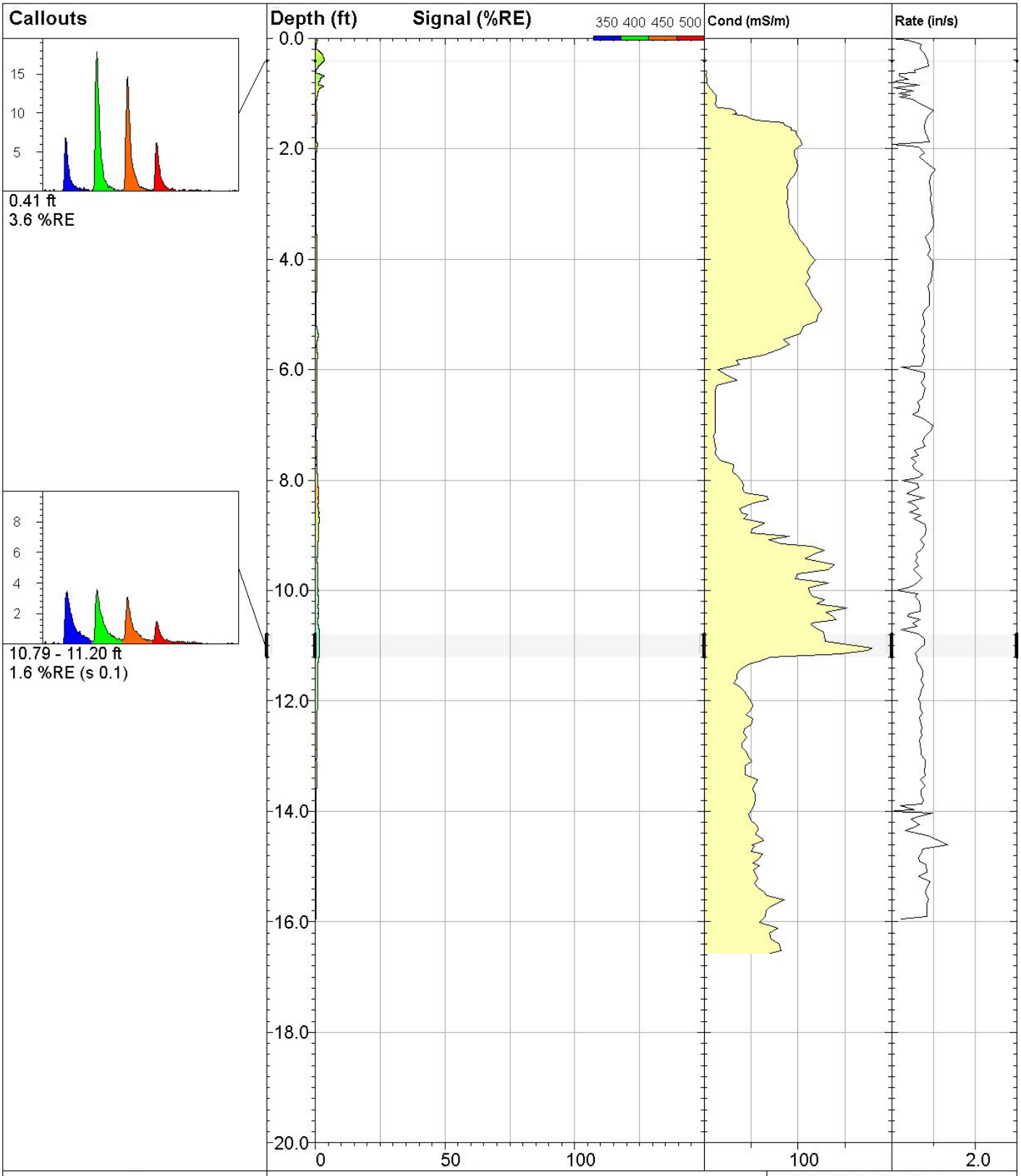
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.80 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 6.69 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 16:50 CDT**



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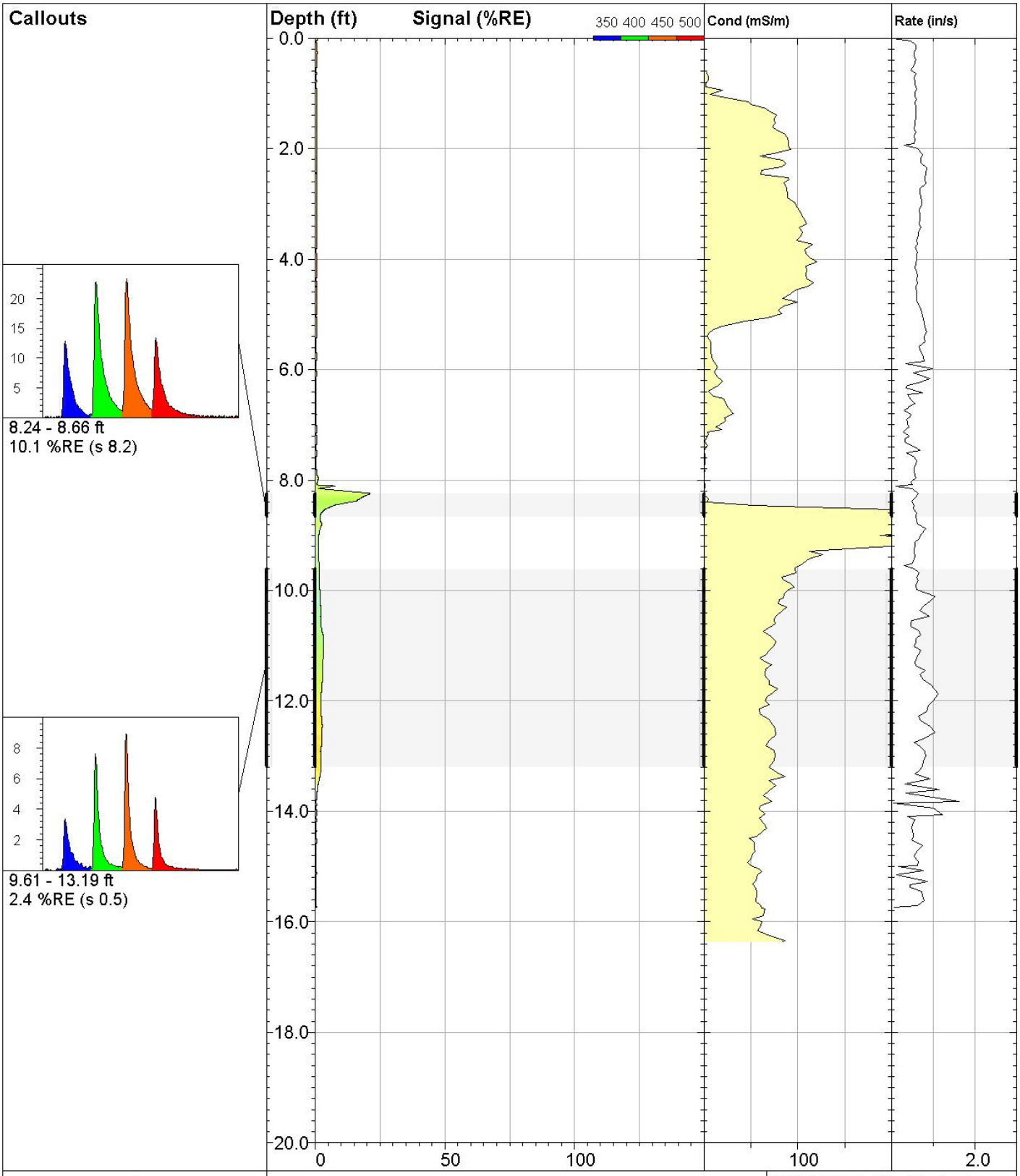
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.94 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.6 %RE @ 0.41 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-04-30 17:26 CDT**



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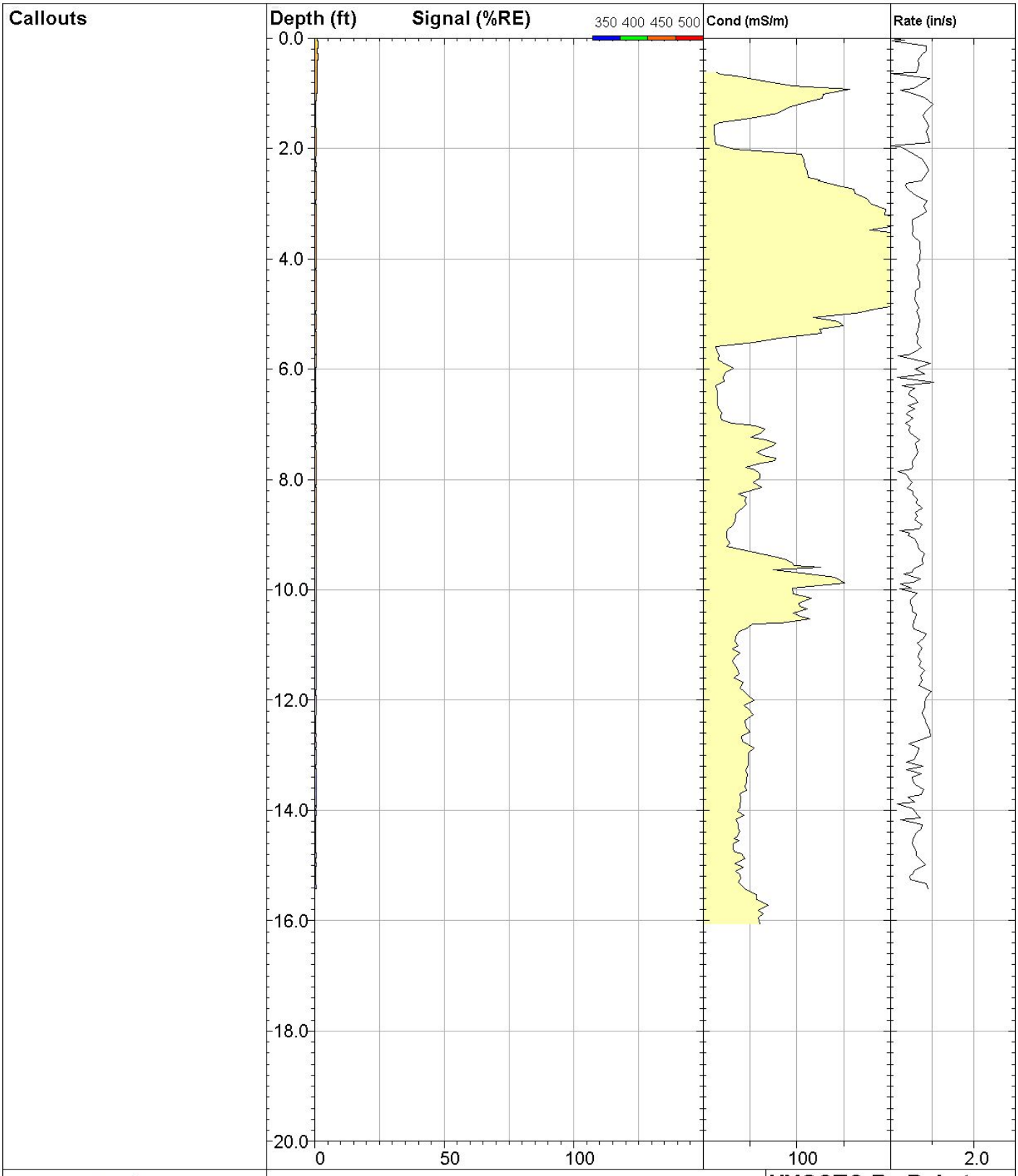
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.74 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **21.4 %RE @ 8.24 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 10:31 CDT**



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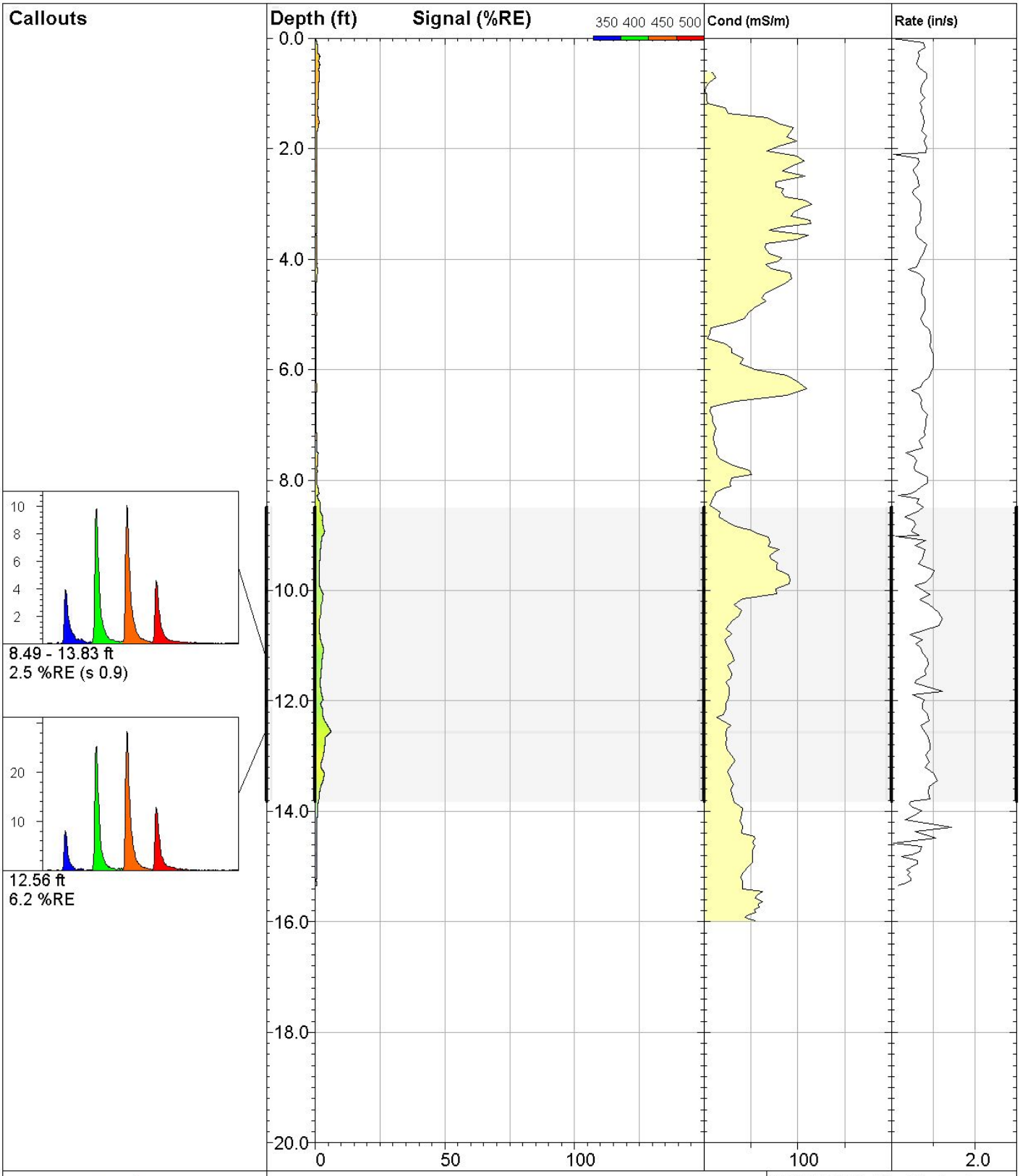
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.43 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 0.14 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 10:59 CDT**



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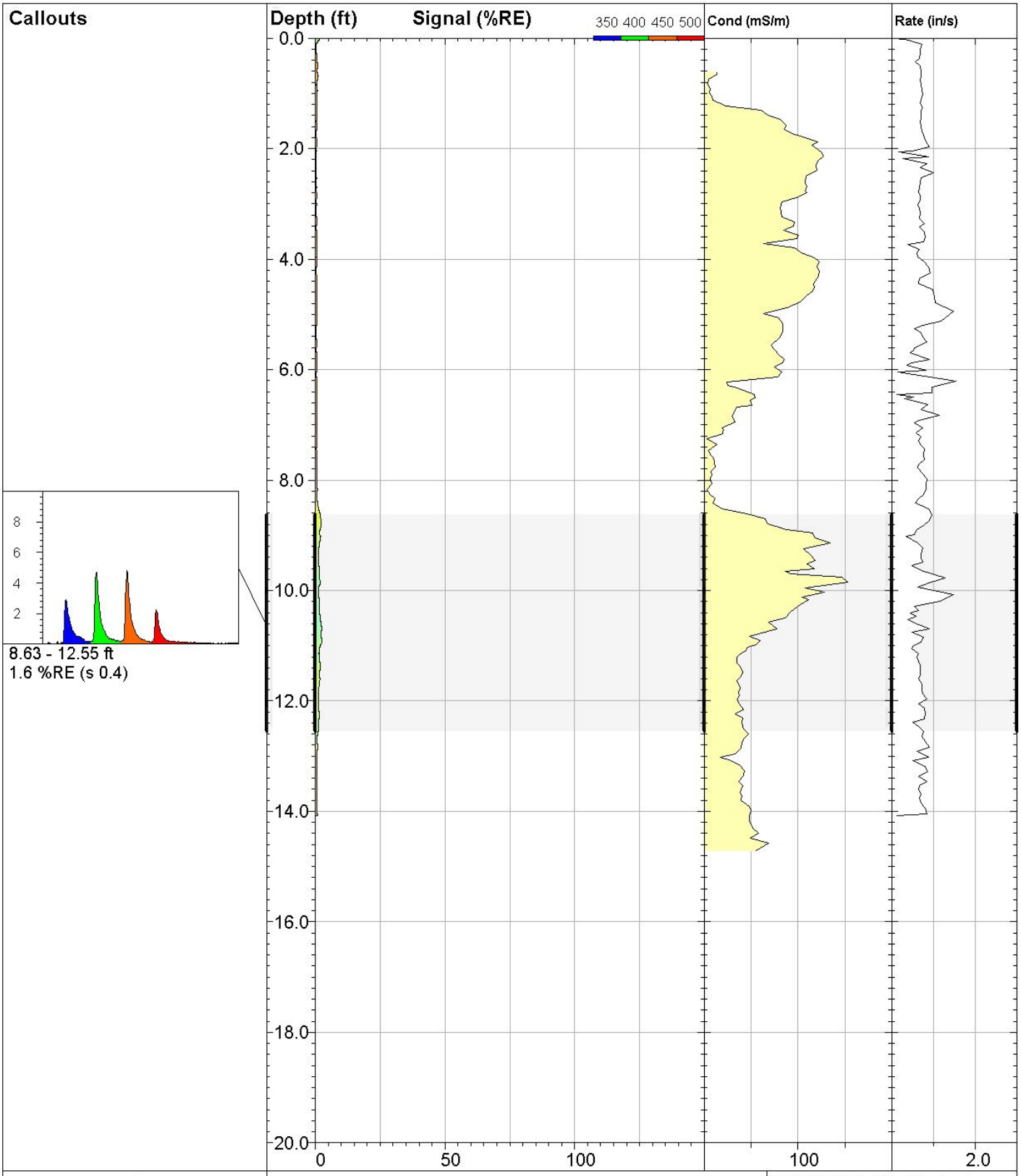
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.35 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **6.2 %RE @ 12.56 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 11:36 CDT**



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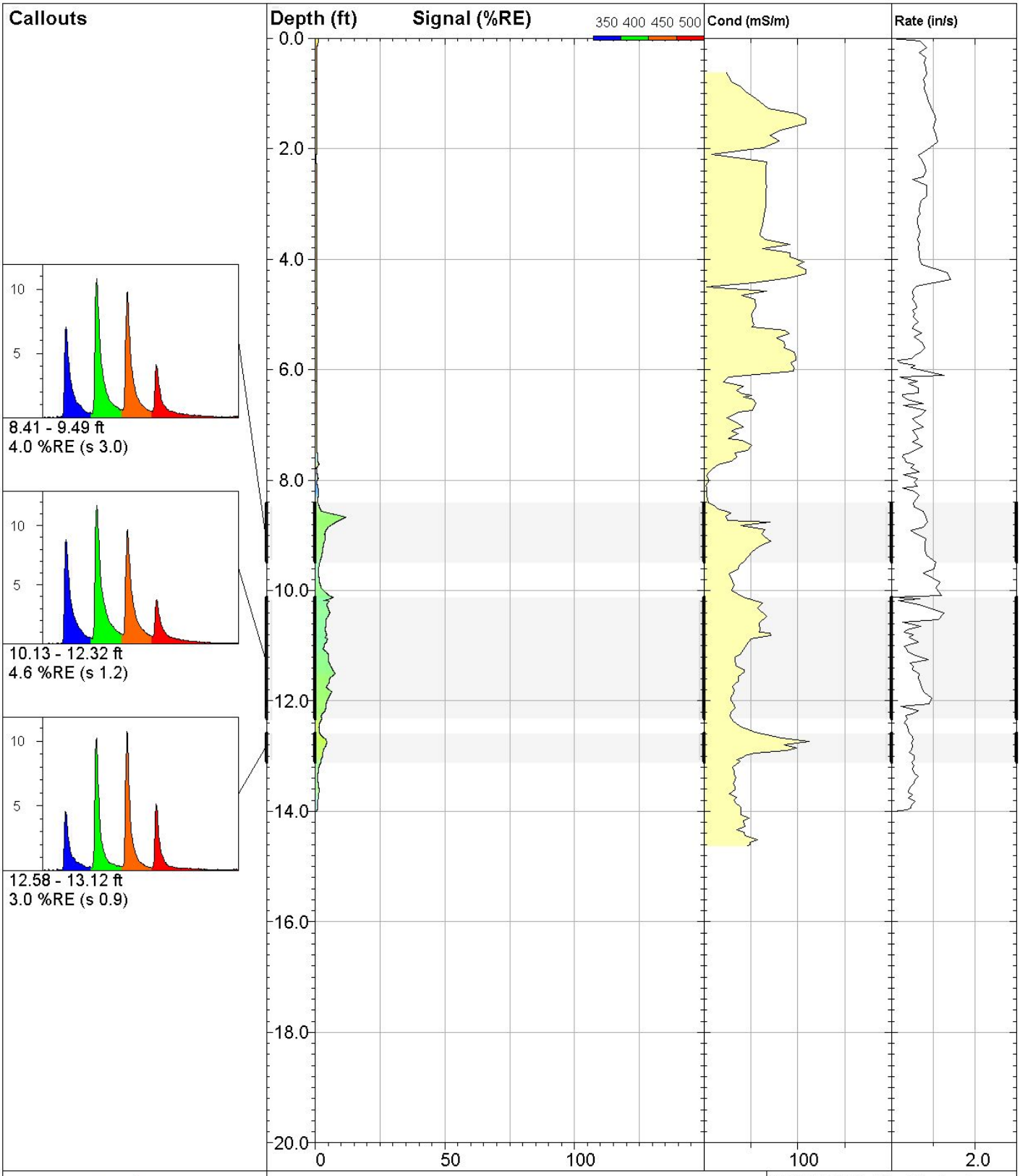
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.08 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.6 %RE @ 10.94 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 12:23 CDT**



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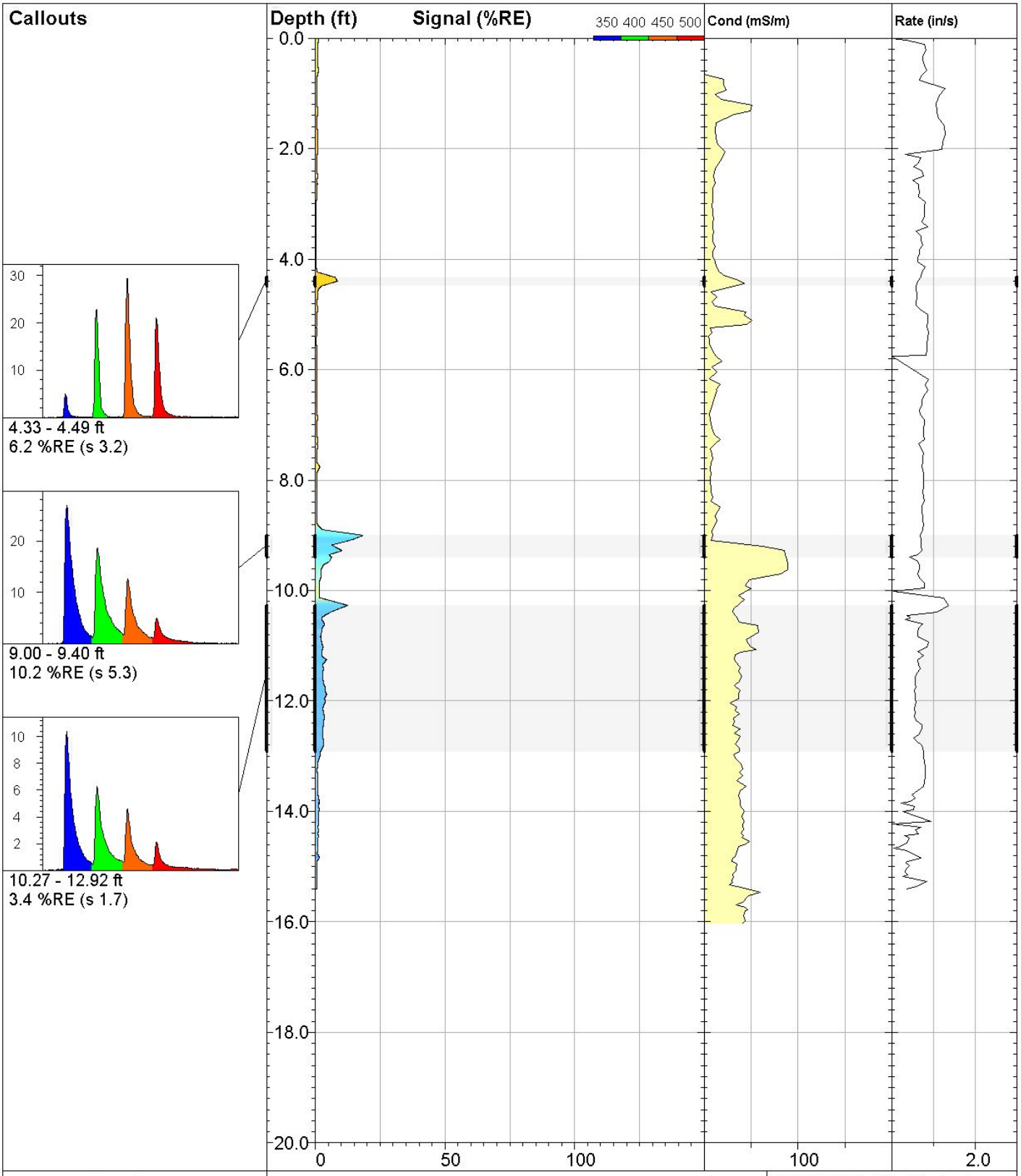
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **11.8 %RE @ 8.67 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 12:57 CDT**



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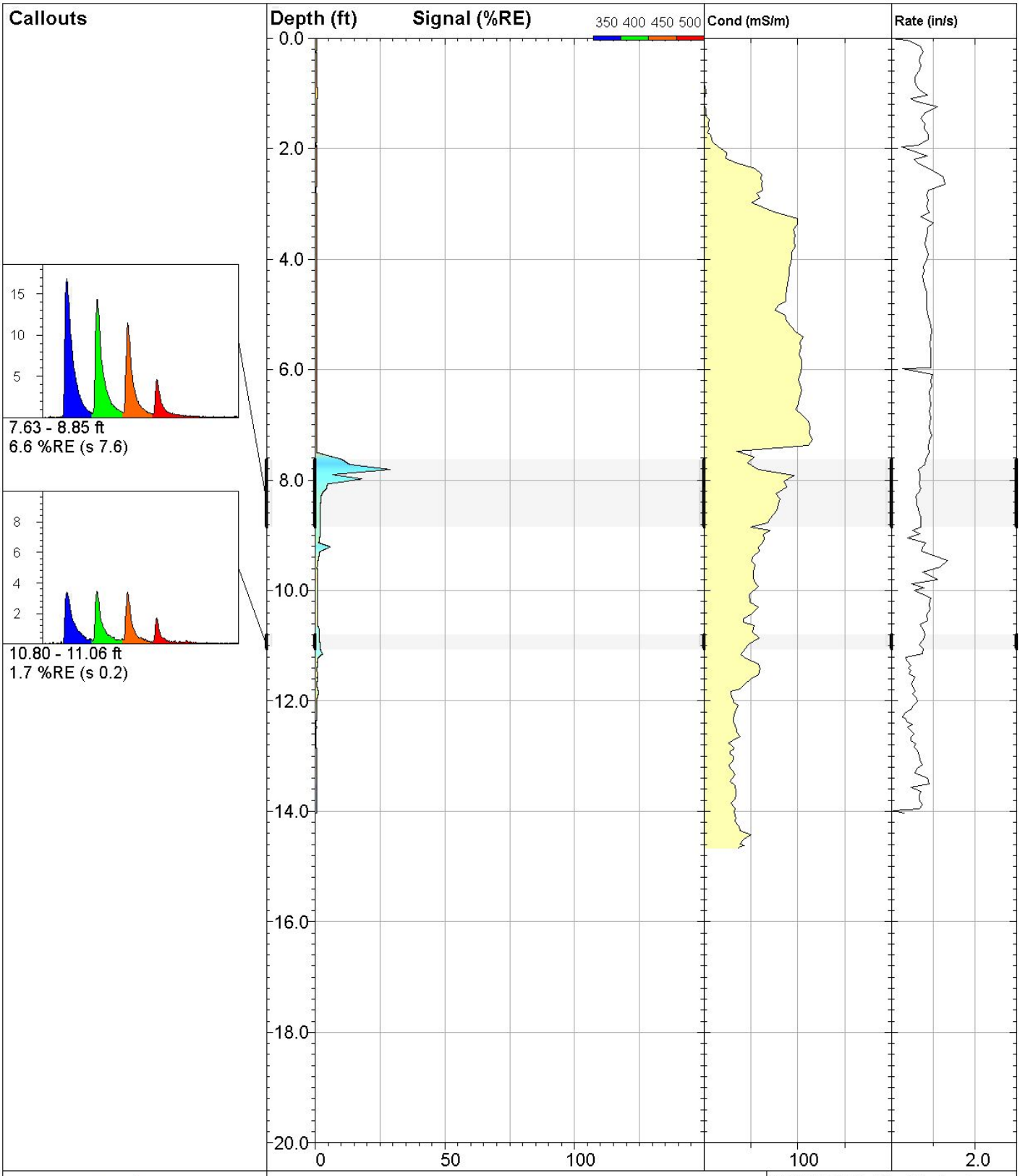
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.40 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.4 %RE @ 9.00 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 15:05 CDT**



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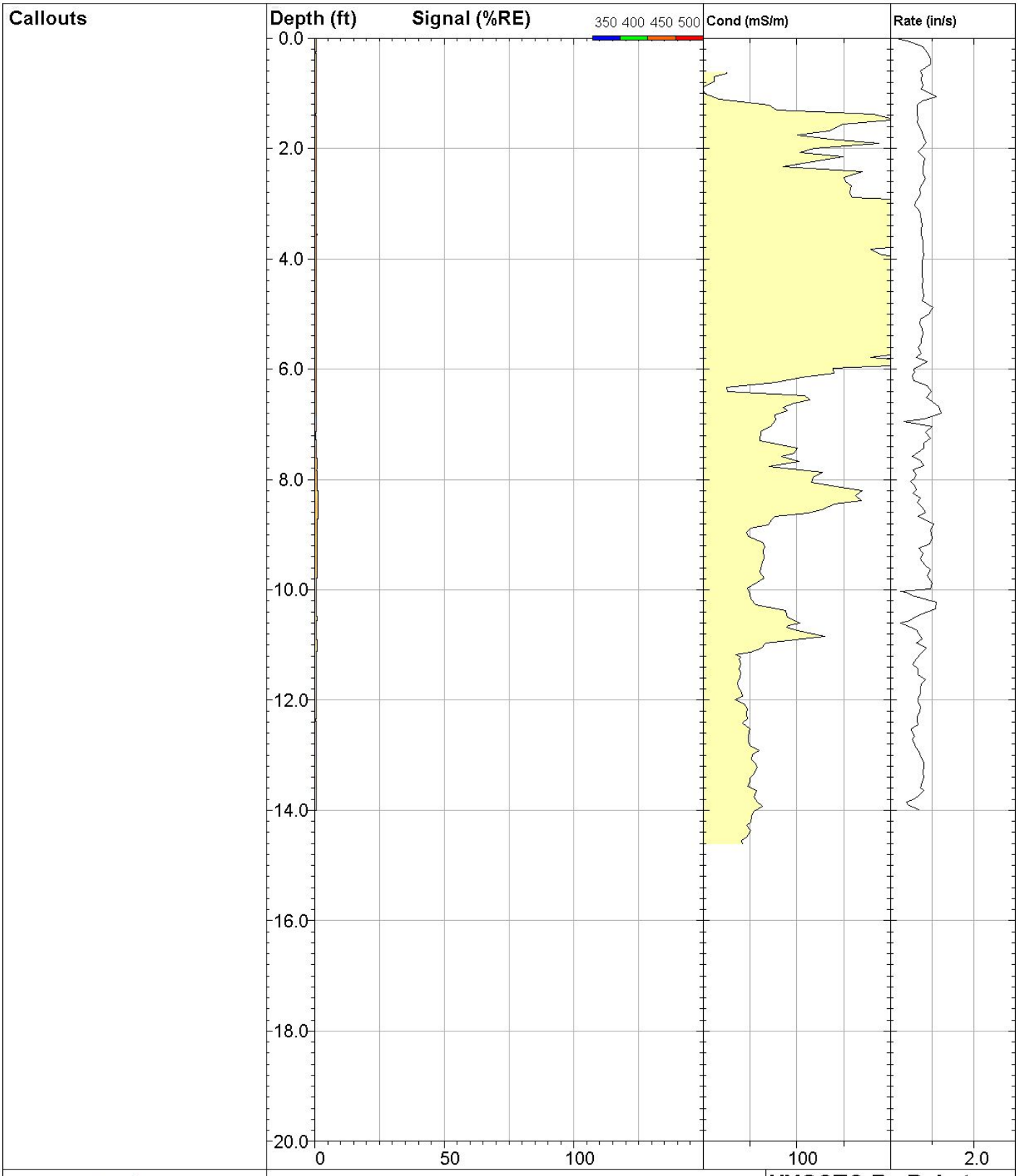
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **28.9 %RE @ 7.81 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 15:31 CDT**



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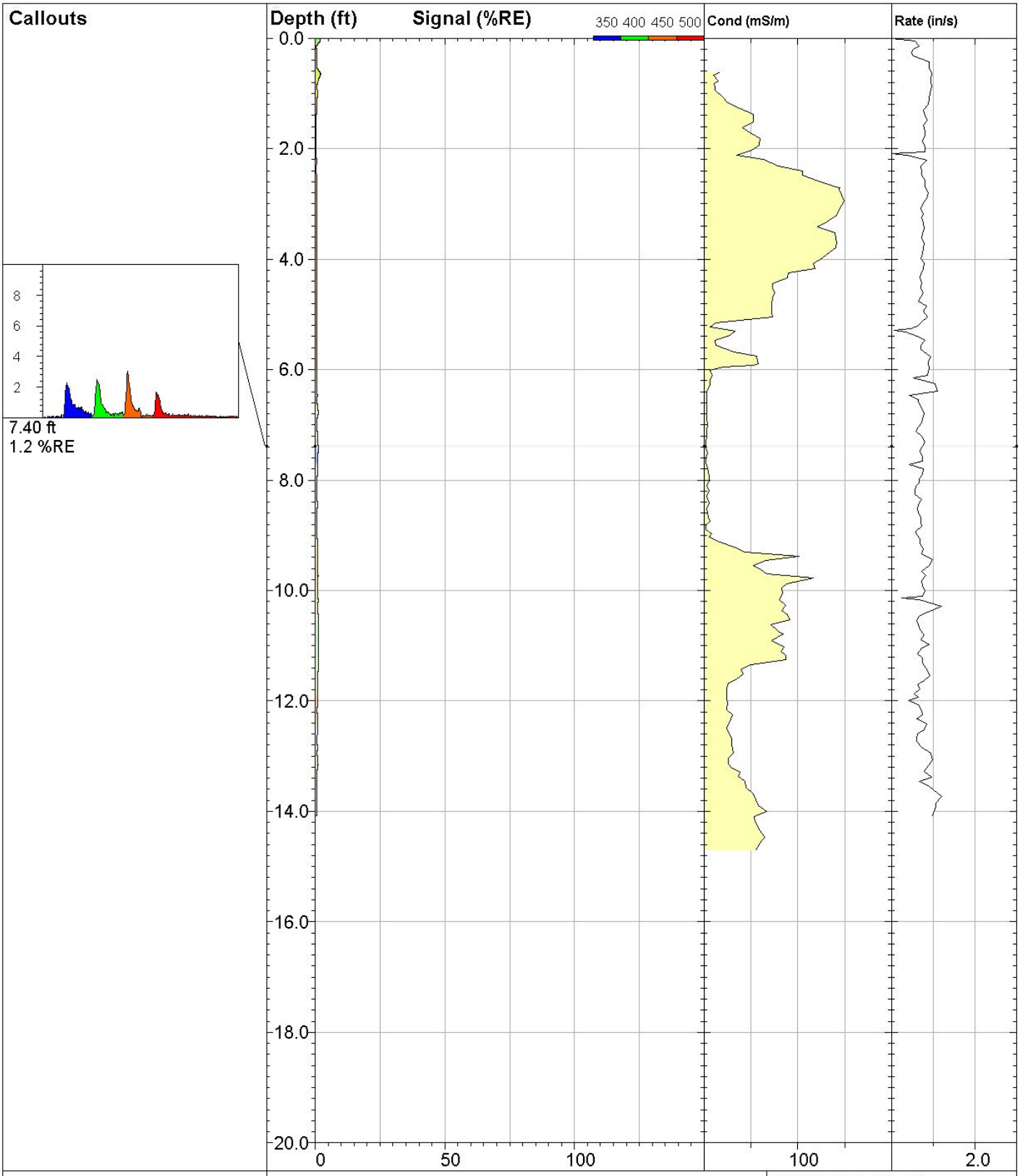
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.00 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 8.34 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 16:40 CDT**



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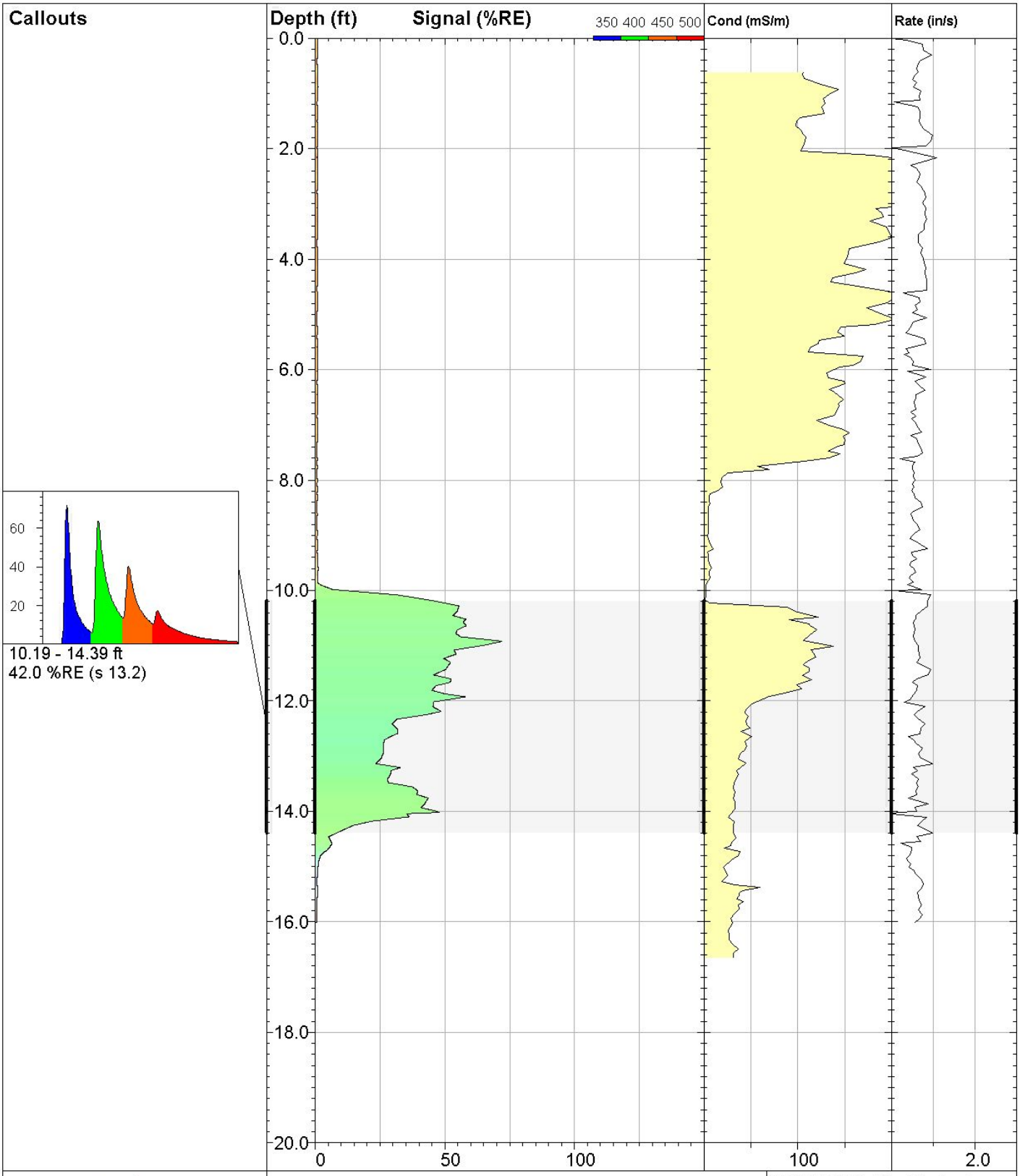
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.08 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 0.65 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-01 17:14 CDT**



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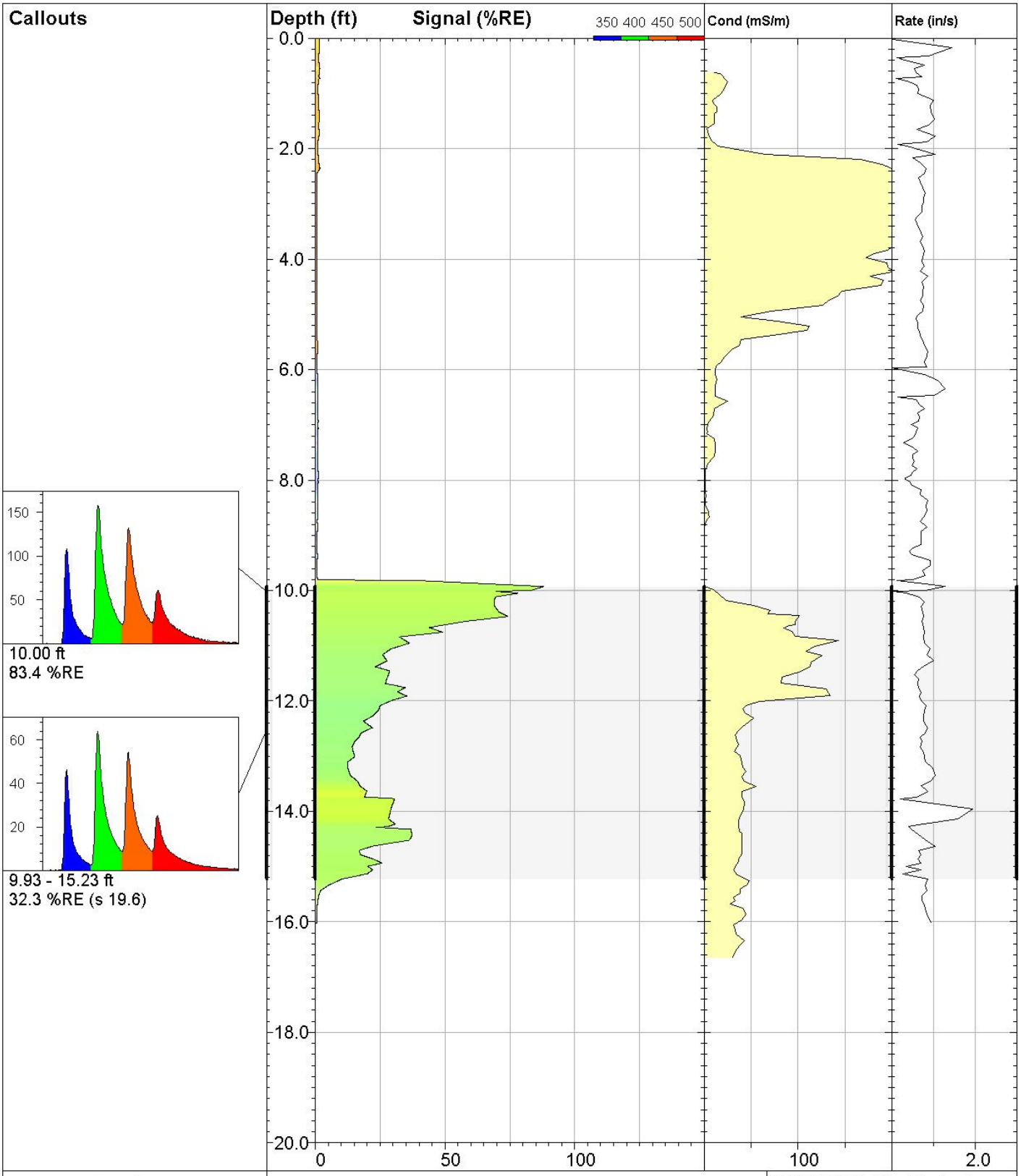
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **72.2 %RE @ 10.92 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 10:19 CDT**



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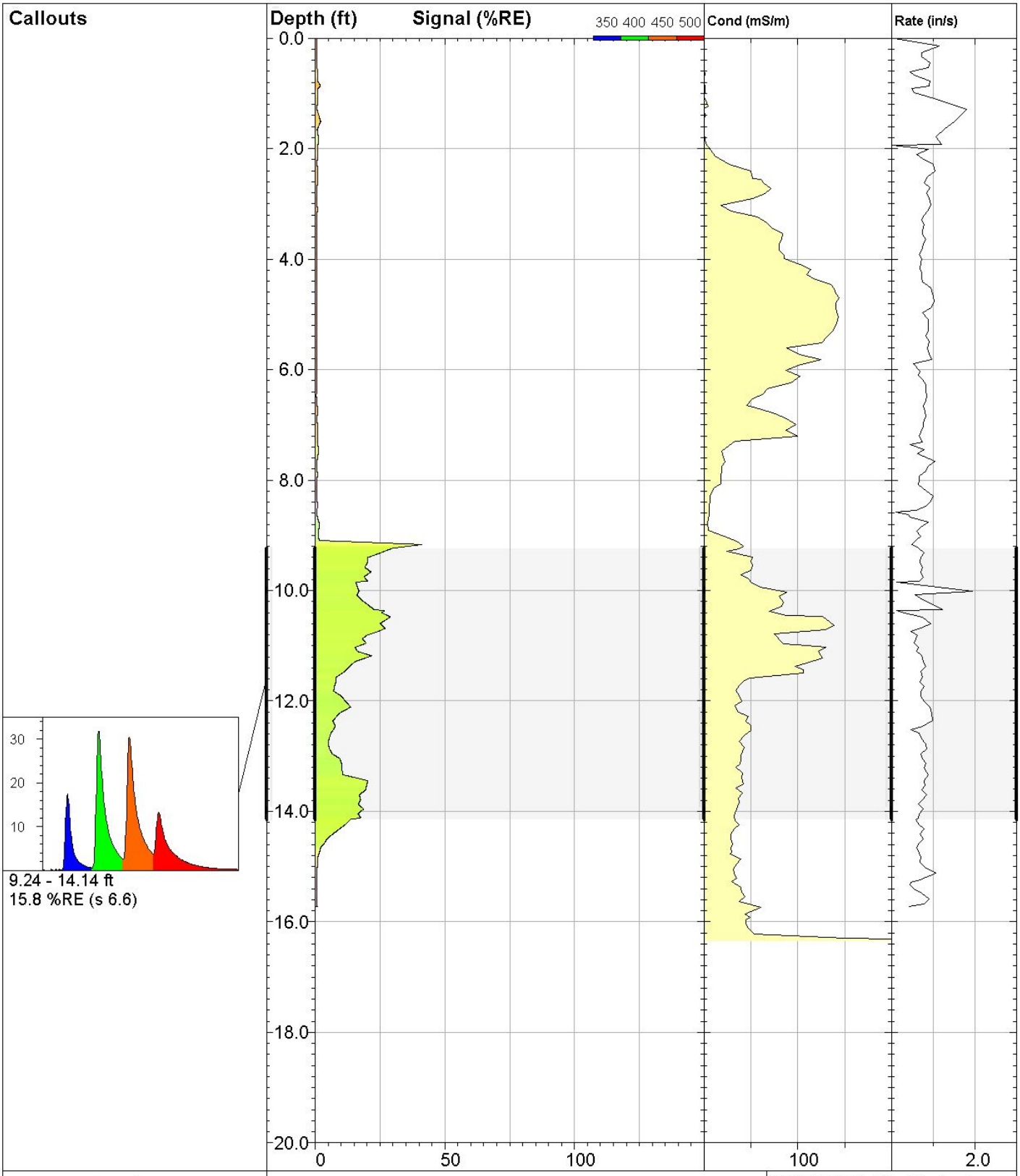
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.02 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **87.9 %RE @ 9.93 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 10:49 CDT**



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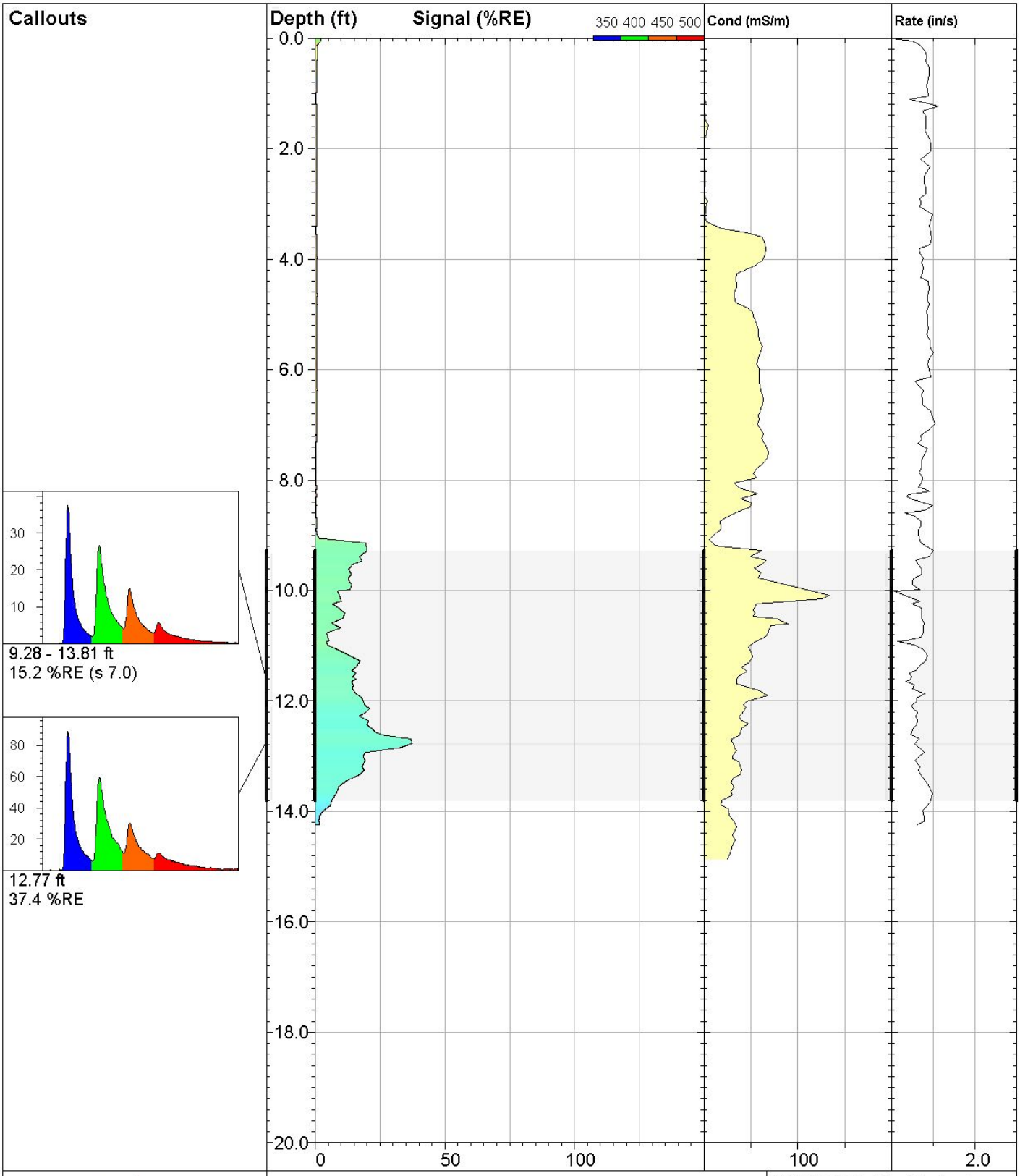
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.73 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **41.1 %RE @ 9.17 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 11:13 CDT**



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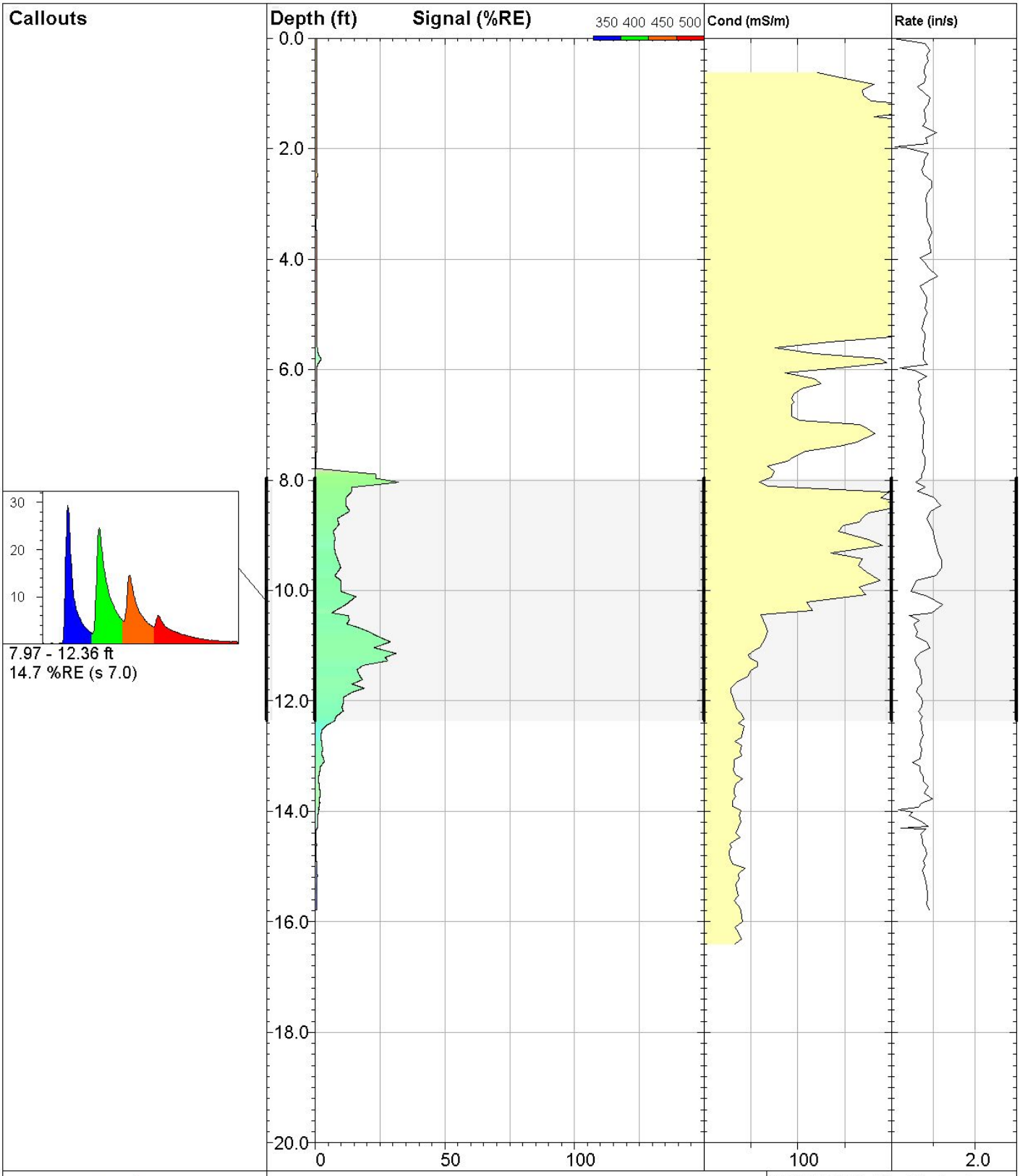
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.24 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **37.4 %RE @ 12.77 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 11:45 CDT**



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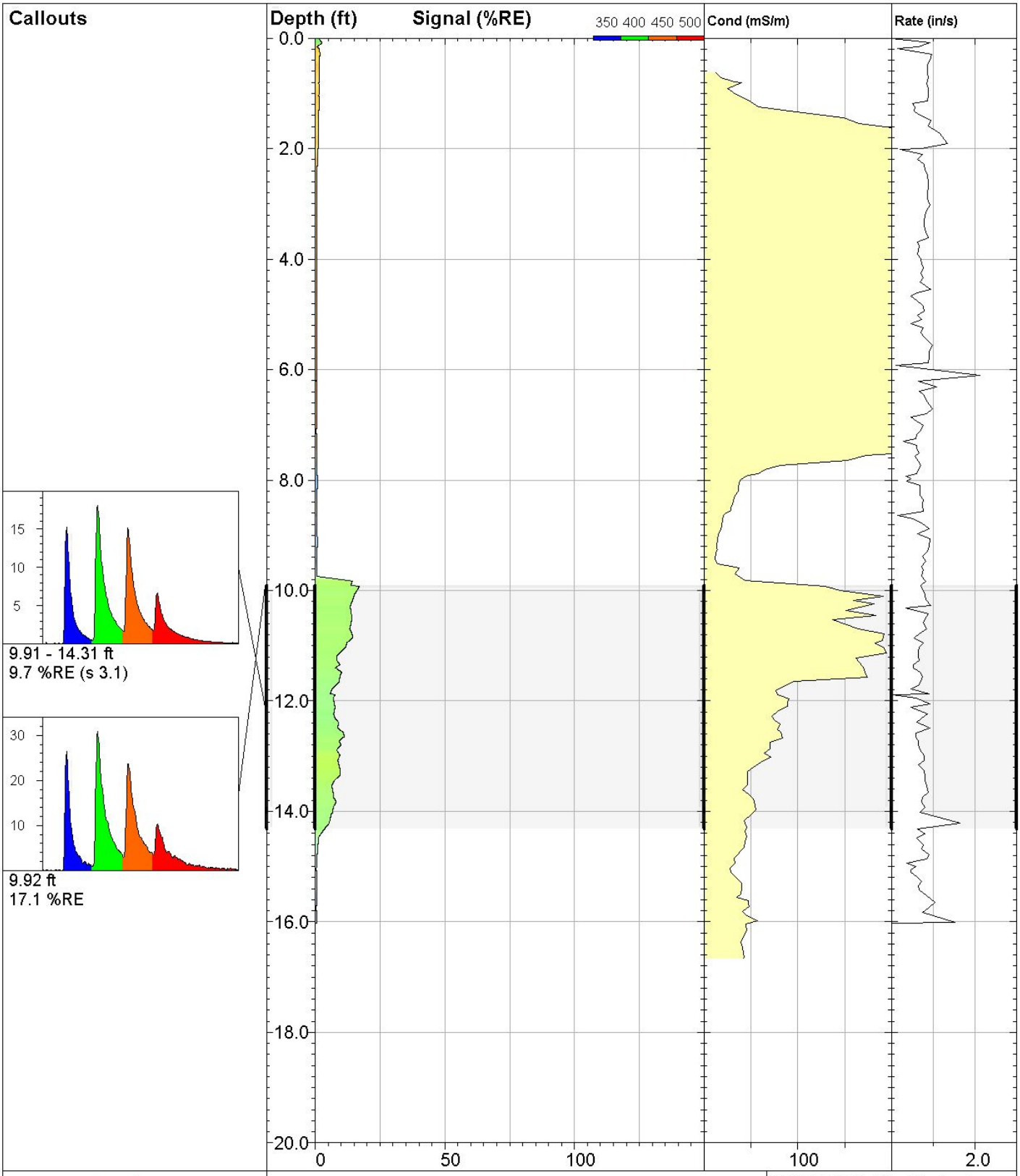
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.78 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **32.3 %RE @ 8.04 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 12:20 CDT**



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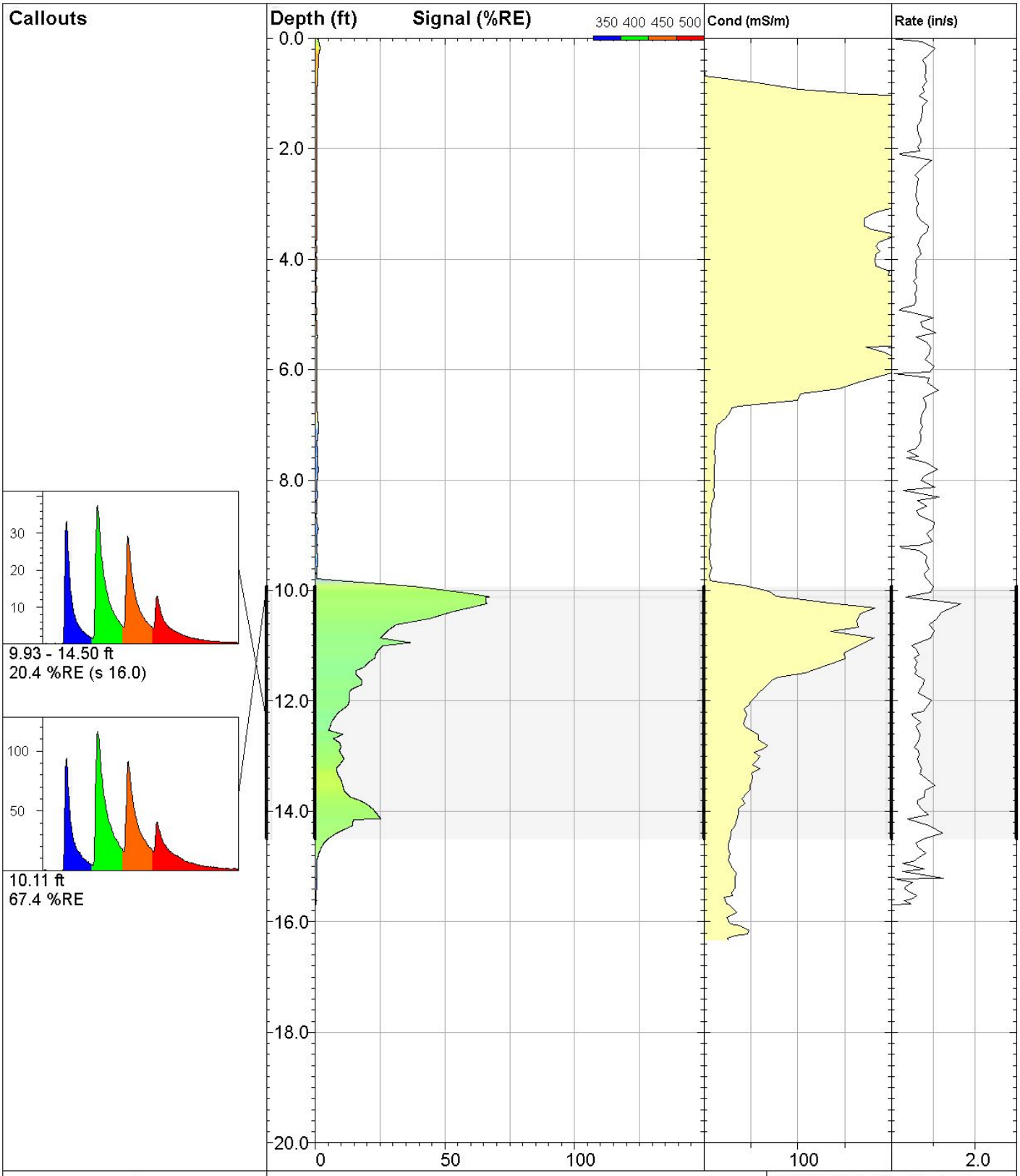
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.03 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **17.1 %RE @ 9.92 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 13:08 CDT**



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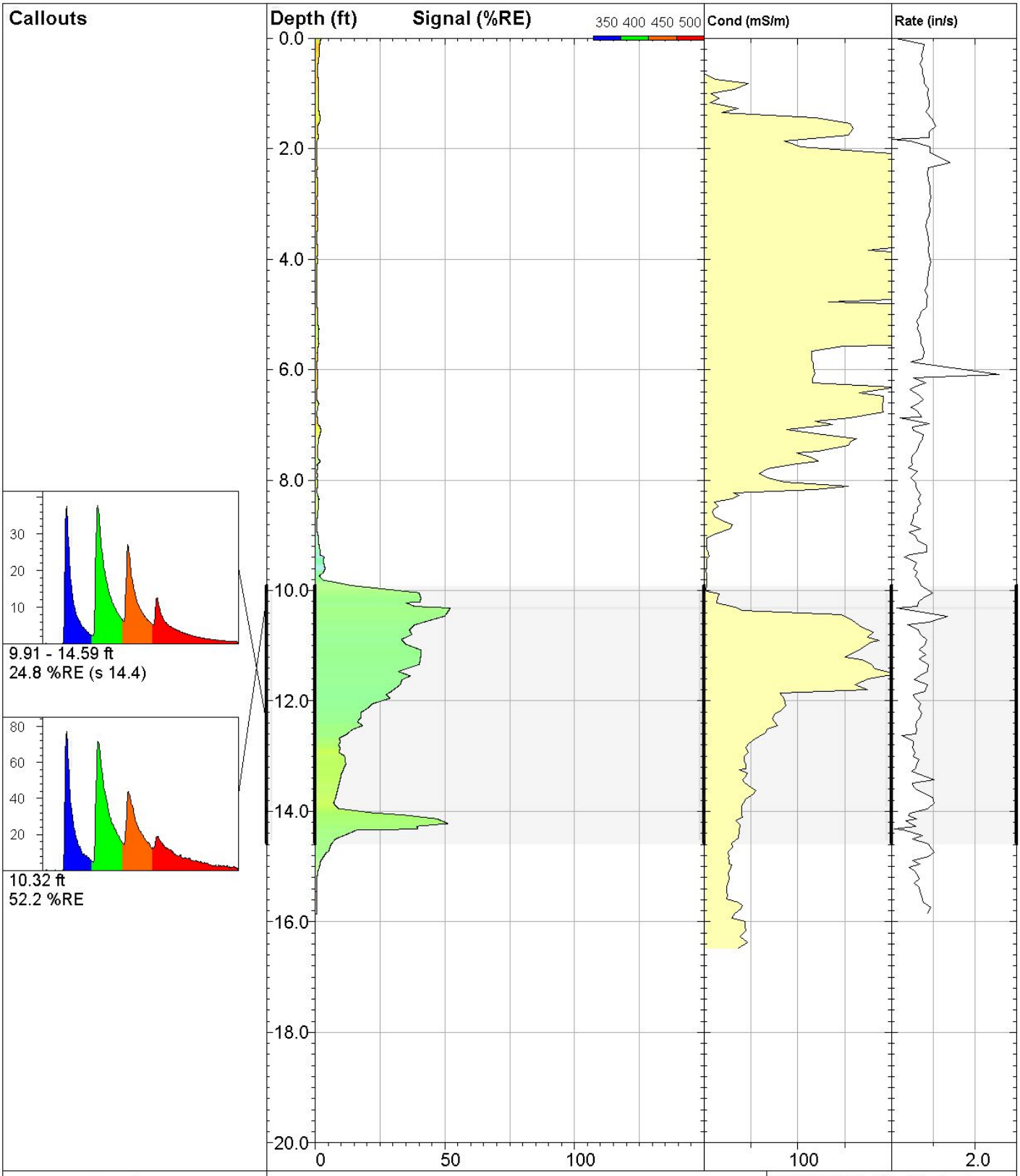
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.69 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **67.4 %RE @ 10.11 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 13:34 CDT**



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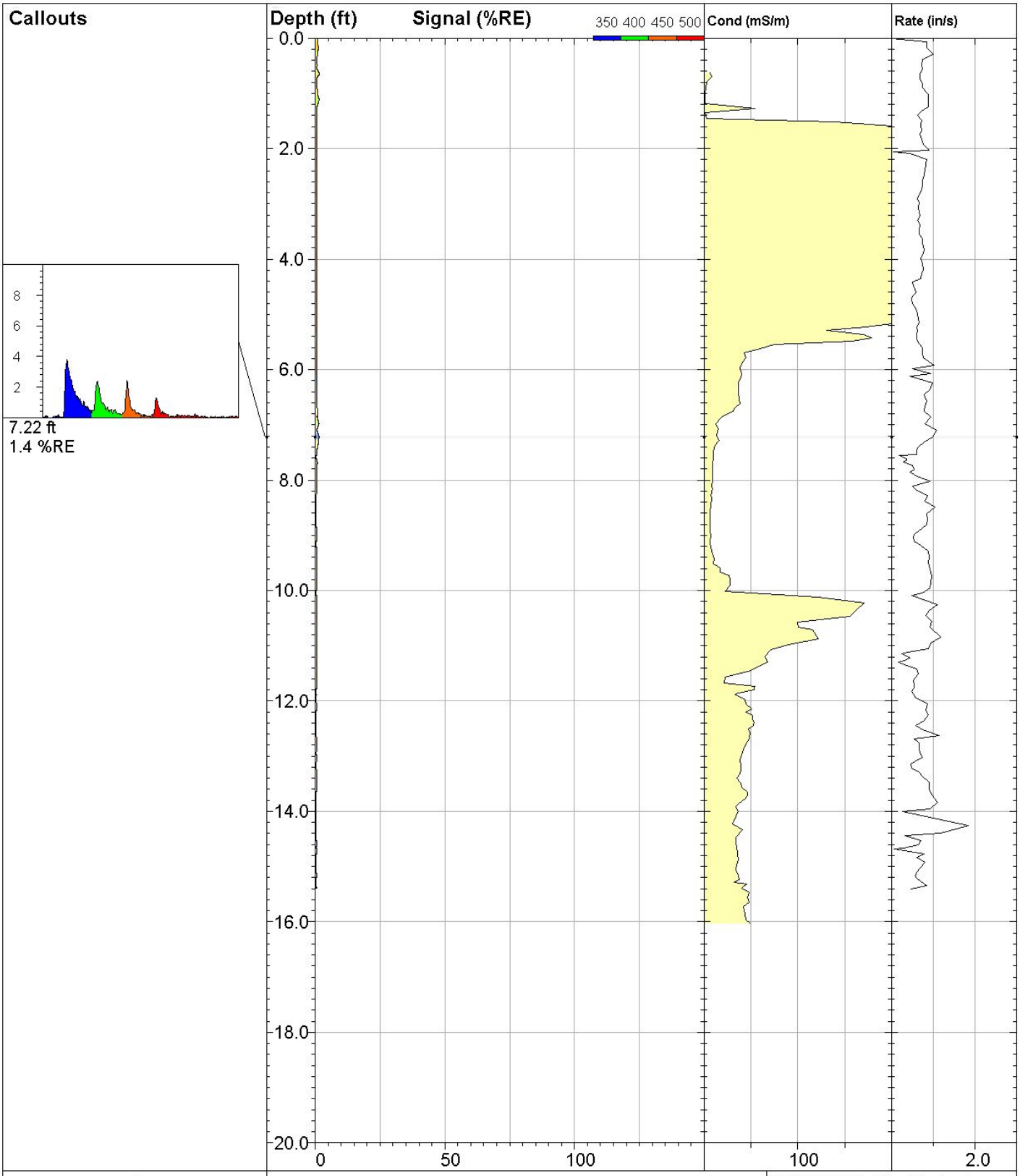
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.86 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **52.2 %RE @ 10.32 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 13:59 CDT**



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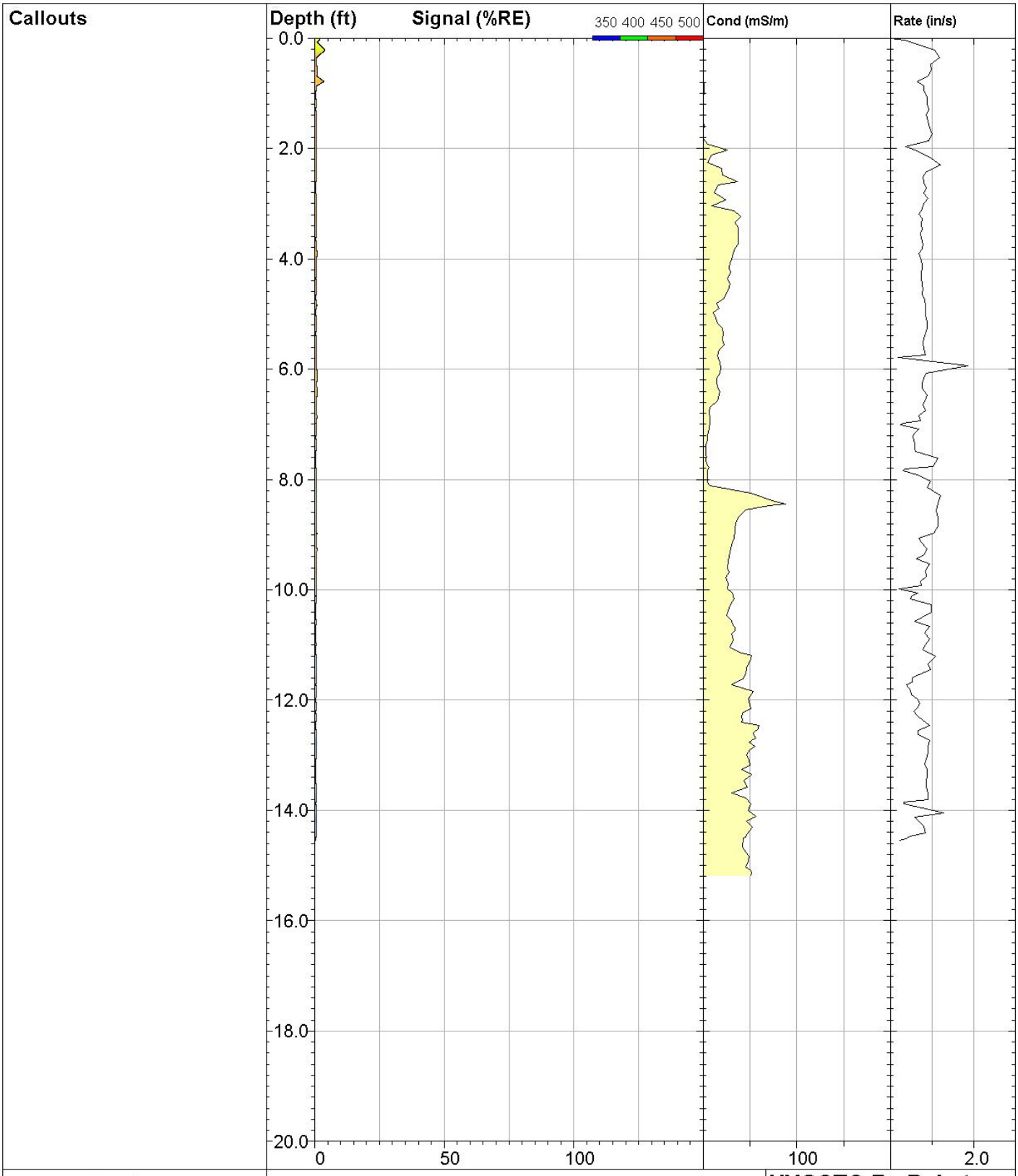
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.40 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.7 %RE @ 0.64 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 14:29 CDT**



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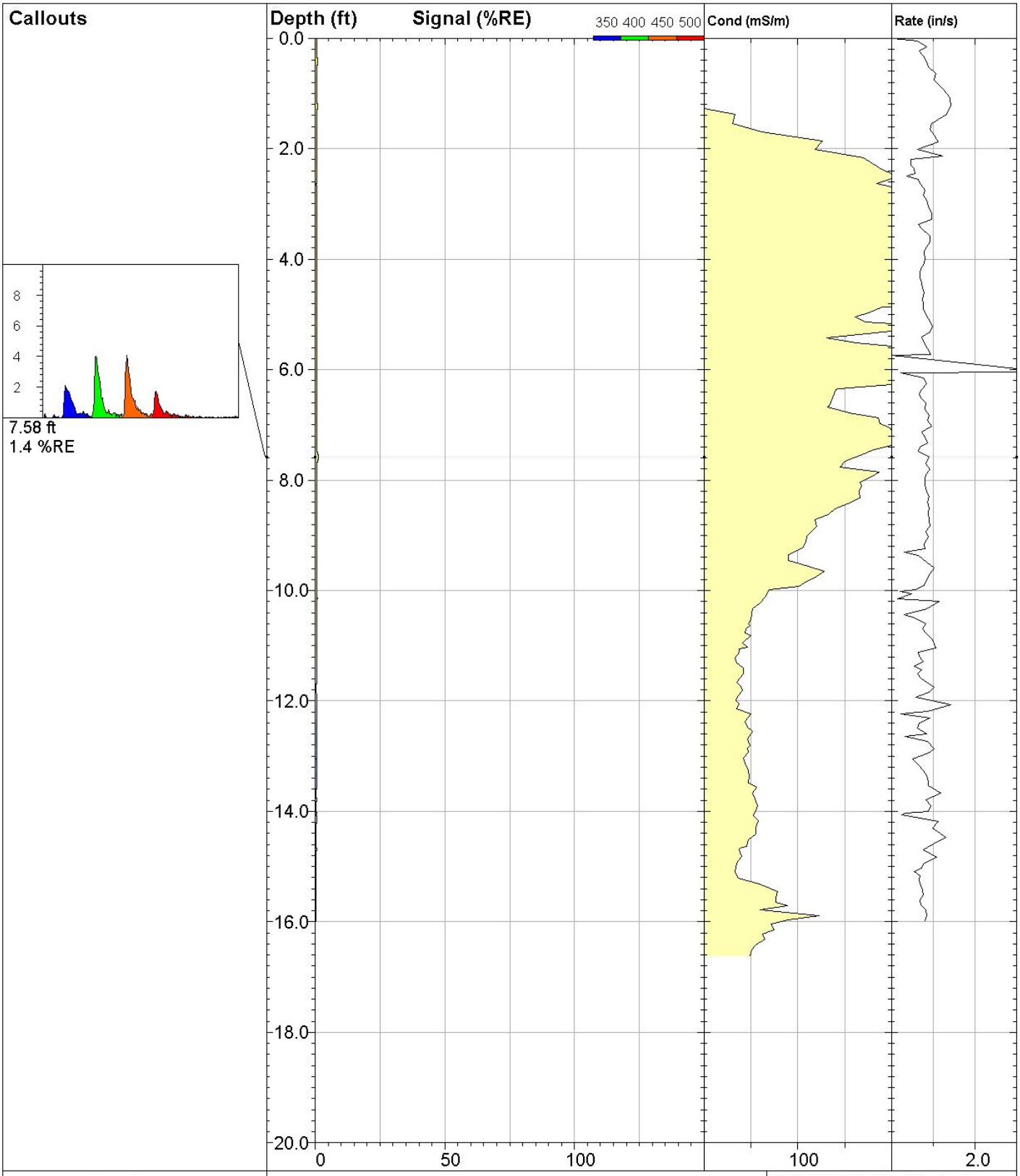
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **14.55 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.0 %RE @ 0.22 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 15:21 CDT**



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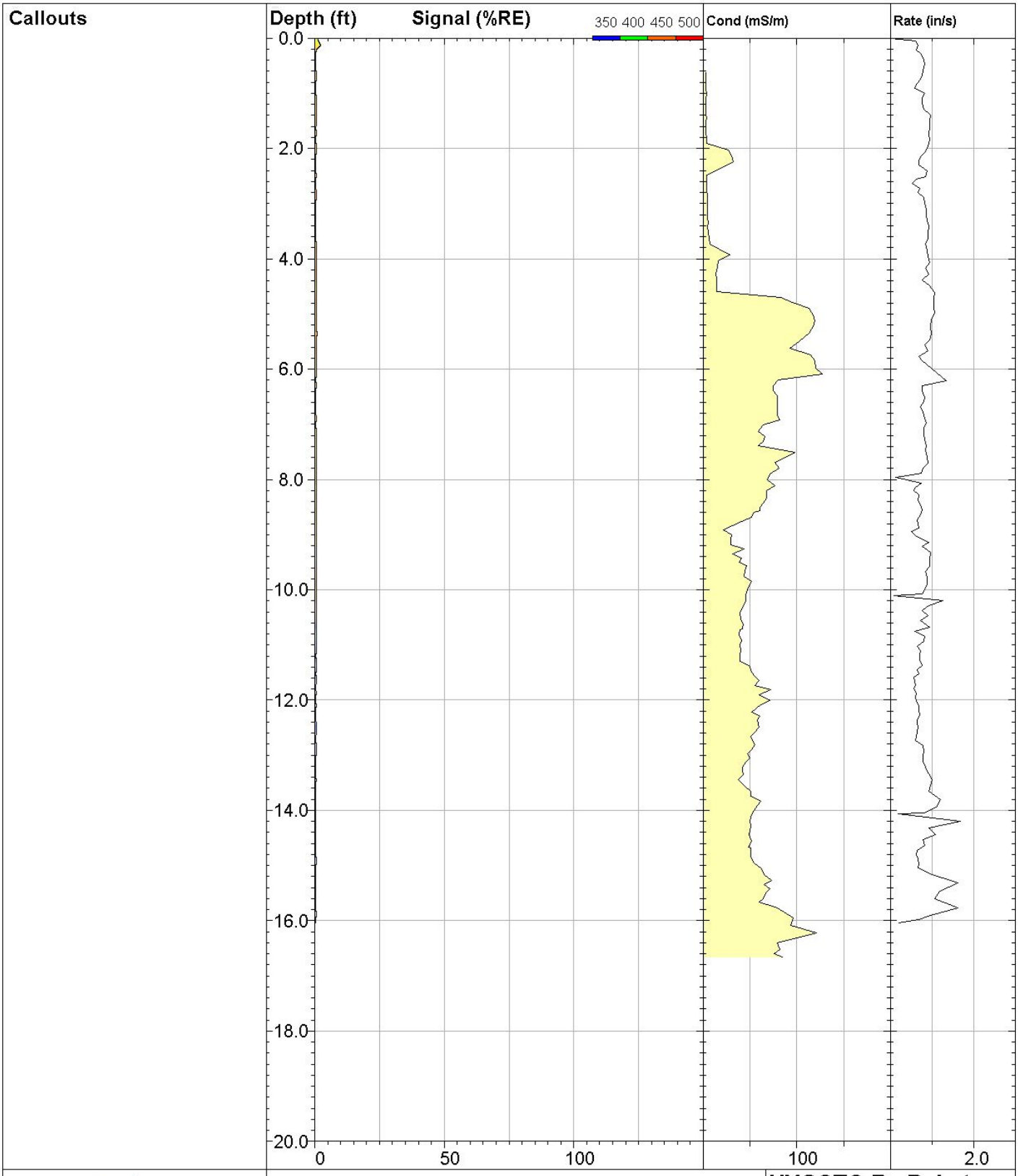
Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **15.99 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.4 %RE @ 7.58 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 15:43 CDT**



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Site: **DEQ COLUMBUS**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **16.04 ft**
Client / Job: **WCEC /**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 0.13 ft**
Operator / Unit: **SWM / UVOST1004**	*Elevation:* **Unavailable**	*Date & Time:* **2018-05-02 16:03 CDT**

Appendix E

UVOST® Reference Log

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UVOST® Reference Log

Main Plot:
Signal (total fluorescence) versus depth where signal is relative to the Reference Emitter (RE). The total area of the waveform is divided by the total area of the Reference Emitter yielding the %RE. This %RE scales with the NAPL fluorescence. The fill color is based on relative contribution of each channel's area to the total waveform area (see callout waveform). The channel-to-color relationship and corresponding wavelengths are given in the upper right corner of the main plot.

Callouts:
Waveforms from selected depths or depth ranges showing the multi-wavelength waveform for that depth. The four peaks are due to fluorescence at four wavelengths and referred to as "channels". Each channel is assigned a color.

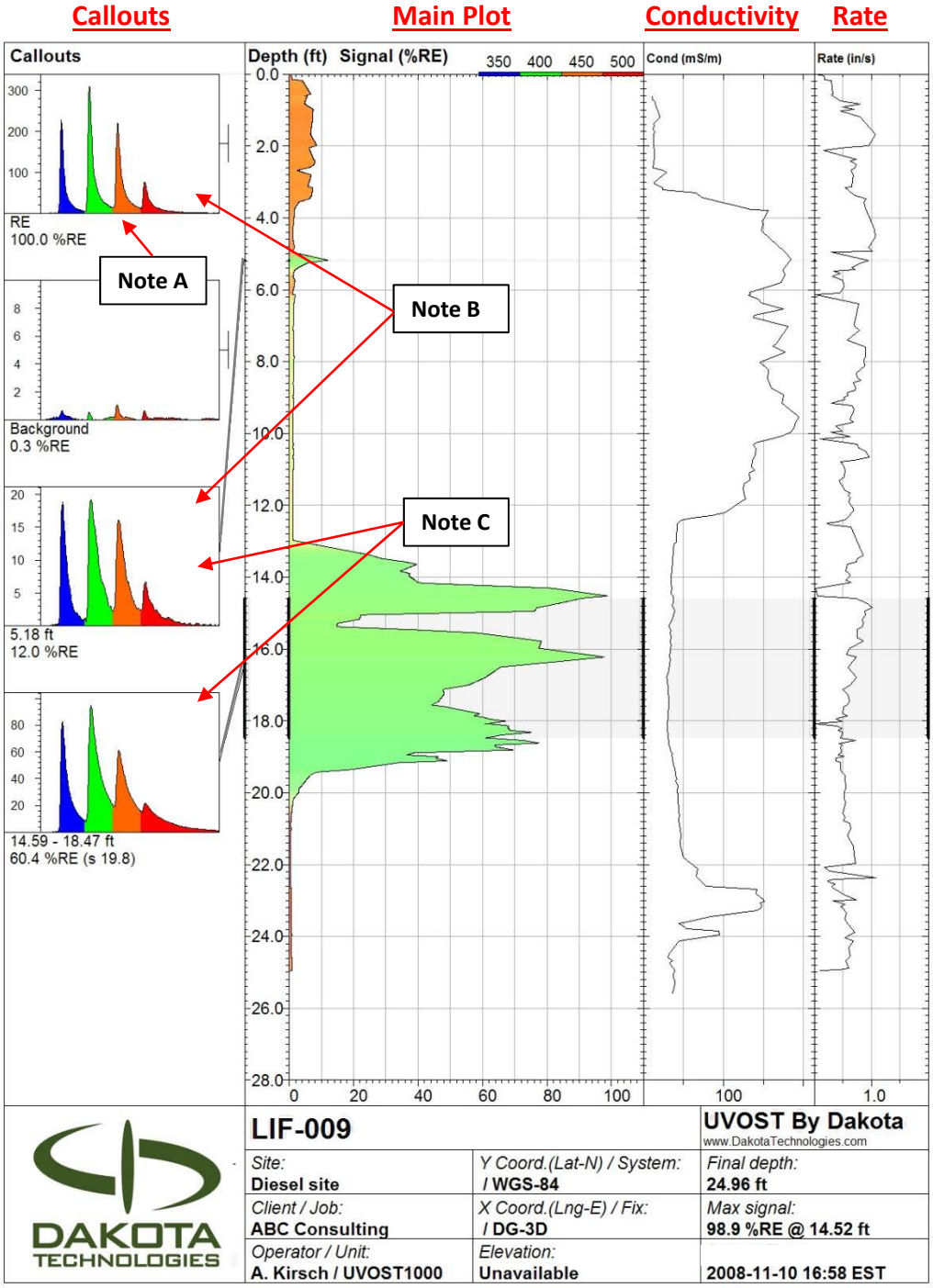
Various NAPLs will have a unique waveform "fingerprint" due to the relative amplitude of the four channels and/or broadening of one or more channels. Basic waveform statistics and any operator notes are given below the callout.

Conductivity Plot:
The Electrical Conductivity (EC) of the soil can be logged simultaneously with the UVOST data. EC often provides insight into the stratigraphy. Note the drop in EC from 10 to 13 feet, indicating a shift from finer (clay) to larger grain size (sand) stratigraphy. This correlates with the observed NAPL distribution.

Rate:
The rate of probe advancement. Approx. 0.8 inches (2cm) per second is preferred. A noticeable decrease in the rate of advancement may be indicative of difficult probing conditions (gravel, angular sands, etc.) such as that seen here at approx. 5 ft.

Note that this log was terminated arbitrarily, not due to "refusal," which would have been indicated by a sudden rate drop at final depth.

Information Box:
Contains pertinent log information, including name and location.



Note A:
Time is along the x axis. No scale is given on callouts, but it is a consistent 320ns wide. The y axis is in mV and directly corresponds to the amount of light striking the photodetector.

Note B:
These two waveforms are clearly different. The top box is the Reference Emitter (a blend of NAPLs) always taken before each log for calibration, and the lower box is weathered diesel from the log itself.

Note C:
Callouts can be a single depth (see 3rd callout) or a range (see 4th callout). The range is noted on the depth axis by a bold line. When the callout is a range, the average and standard deviation in %RE is given below the callout.

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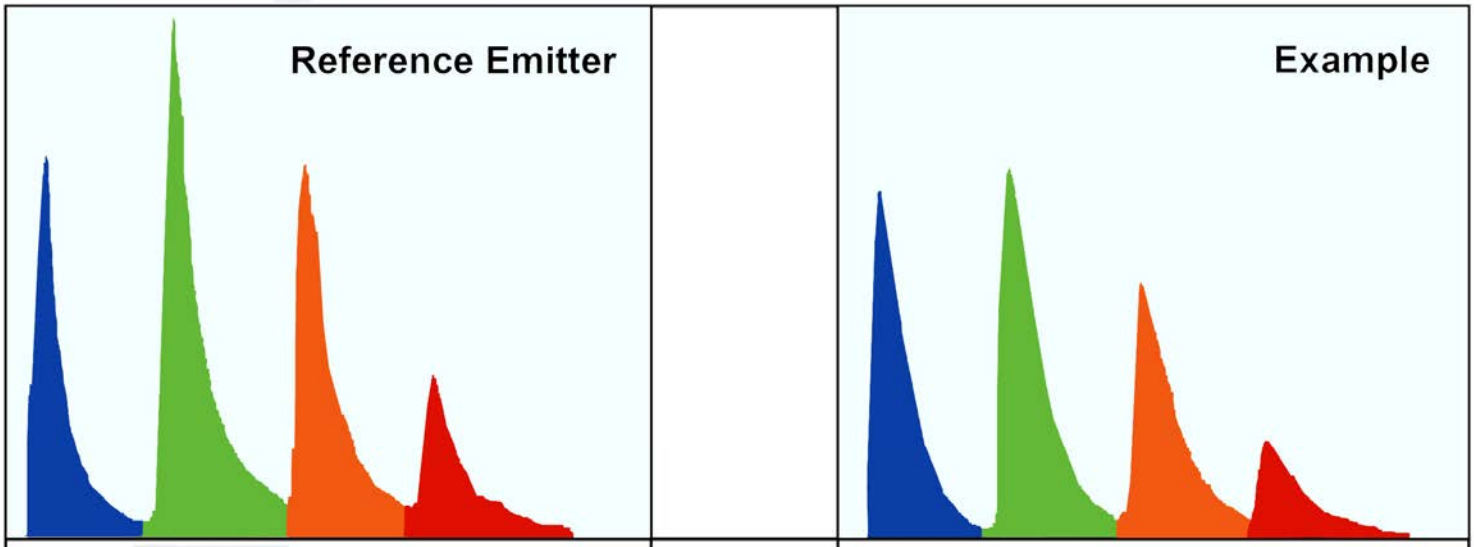
UVOST® Reference Log

Waveform Signal Calculation

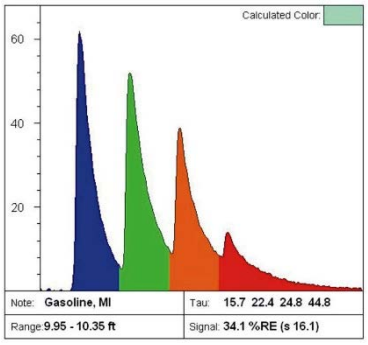


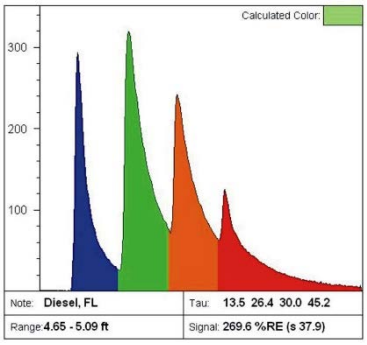
CH1		CH2		CH3		CH4		Total	Channel	CH1		CH2		CH3		CH4		Total
4820	+	8108	+	6249	+	2984	=	**22161**	***Area (pVs)***	4923	+	5743	+	4166	+	1735	=	**16587**
21.7		36.6		28.2		13.5		**100%**	***Percent RE***	22.3		25.9		18.8		7.8		**75%**

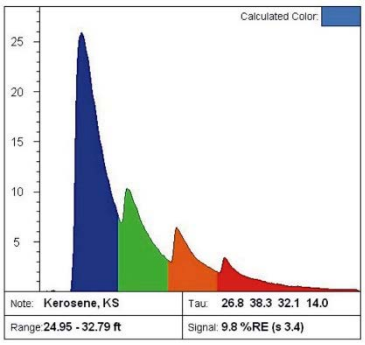
Data Files

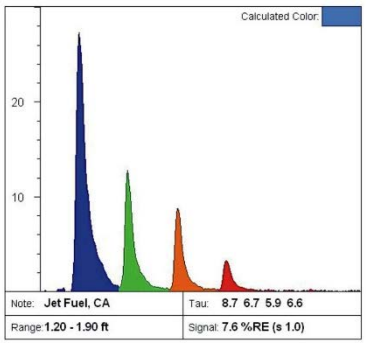
***.lif.raw.bin**	Raw data file. Header is ASCII format and contains information stored when the file was initially written (e.g. date, total depth, max signal, GPS, etc., and any information entered by the operator). All Raw waveforms are appended to the bottom of the file in a binary format.
***.lif.plt**	Stores the plot scheme history (e.g. callout depths) for associated Raw file. Transfer along with the Raw file in order to recall previous plots.
***.lif.jpg**	A .jpg image of the OST log including the main signal vs. depth plot, callouts, information, etc.
***.lif.dat.txt**	Data export of a single Raw file. Tab delimited format. No string header is provided for the columns to make importing into some programs easier. Each row is a unique depth reading. The columns are: 1-Depth; 2-Total Signal (%RE); 3-CH1%; 4-Ch2%; 5-CH3%; 6-Ch4%; 7-Rate; 8-EC Depth; 9-EC Signal; 10-Hammer Rate Depth; 11-Hammer Rate; 12-Color (RRGGBB). Summing channels 1 to 4 yields the Total Signal.
***.lif.sum.txt**	A summary file for a number of Raw files. ASCII tab delimited format. The file contains a string header. The summary includes one row for each Raw file and contains information for each filed including: the file name, GPS coordinates, max depth, max signal, and depth at which the max signal occurred.
***.lif.log.txt**	An activity log generated automatically is located in the OST application directory in the 'log' subfolder. Each OST unit the computer operates will generate a separate log file per month. A log file contains much of the header information contained within each separate Raw file, including: data rate, total depth, max signal, etc.

Common Waveforms (highly dependent on soil, weathering, etc.)









Appendix B

UVOST Waveform Cluster Plots

The following information was provided by Randy St. Germain of Dakota Technologies:

Cluster Plots

The amount of data in an LIF log can be overwhelming. With cluster plots the information from the hundreds (or sometimes even thousands) of waveforms from a single LIF log are "condensed" and then plotted on a 2D surface as color-coded spheres, allowing a spatial method of identifying clusters of similar LIF waveforms vs outliers or highly variable waveforms.

<u>X-Axis: Wavelength (color of fluorescence light)</u>

In general terms the "center of mass" of the response curve that makes up a multi-wavelength fluorescence waveform determines the x-axis position on the cluster plot for each sphere that represents a waveform. For example, a waveform that is dominated by a large blue peak will be plotted far to the left on the x-axis, while a waveform dominated by the red peak plots far to the right on the x-axis. Those with balanced wavelengths (all four equal or the central two peaks dominating) will plot near the middle on the x-axis.

<u>Y-Axis: Lifetime (duration/ratios)</u>

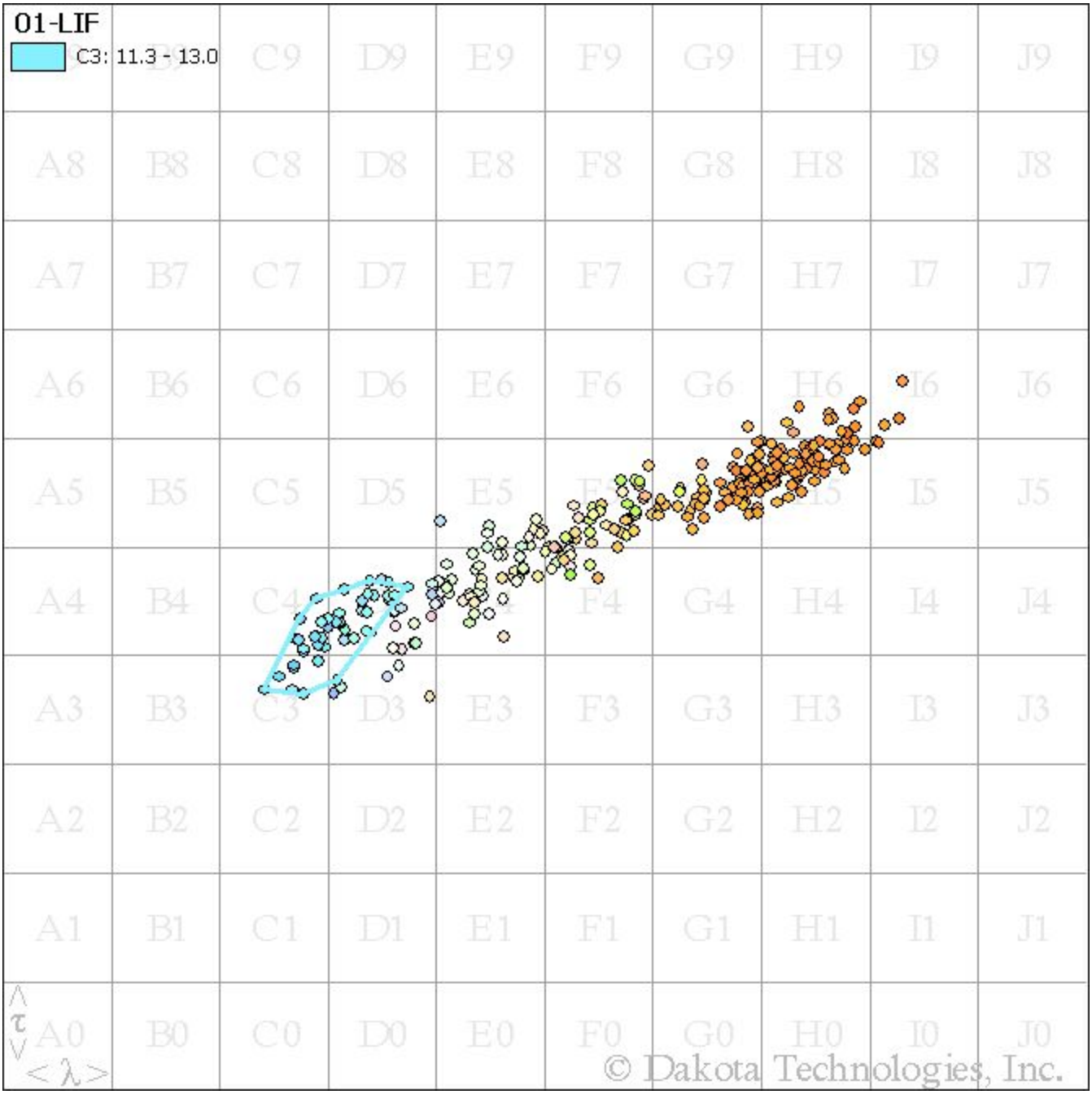
The lifetime (decay of fluorescence over time) of the waveform's four peaks (described in crude terms as the "width" of the peaks at 1/3 their maximum height) determines the y-axis position of the scatter plot data spheres. The relationship to the position on the y-axis is not directly relatable to the lifetimes, but instead the ratio of certain channel's lifetimes divided by others. The system used was designed to achieve "maximum spread" between differing waveforms to maximize differentiation. In general waveforms with short lifetimes and lifetime consistency between all four channels are plotted low on the y-axis. The longer the lifetimes of the four peaks (i.e. the "wider" the peaks get, especially at the base) and the greater the differences between lifetimes of the four peaks the higher on the y-axis that waveform's oval is plotted.

<u>Colorization</u>

The ovals that represent each waveform are filled with the same colors that are used in the field log's Signal (%RE) plot. That way one can use the fill colors to determine the depth on the UVOST field log where certain clustering ovals originated. This allows one to target depths on the log to make further examination of the waveforms themselves in order to identify key sampling depths, to see if waveforms match or are distinctly different than others encountered at the site or otherwise generally investigate the UVOST data set more fully in order to identify areas of similar vs. dissimilar fluorescence responses.

<u>Callouts</u>

Callouts are listed in the upper left of the cluster plot. The depth of singular callouts and the depth ranges of range callouts, along with the notes from under that callout, are displayed here. Any singular waveform callouts from the log are circled with the same color as that waveform on the log. In addition to this any range of waveforms selected for callouts results in a colored box (of matching fill color) being drawn on the cluster plot. This box surrounds the majority of ovals representing waveforms that were selected in the range callout.


01-LIF
C3: 11.3 - 13.0
C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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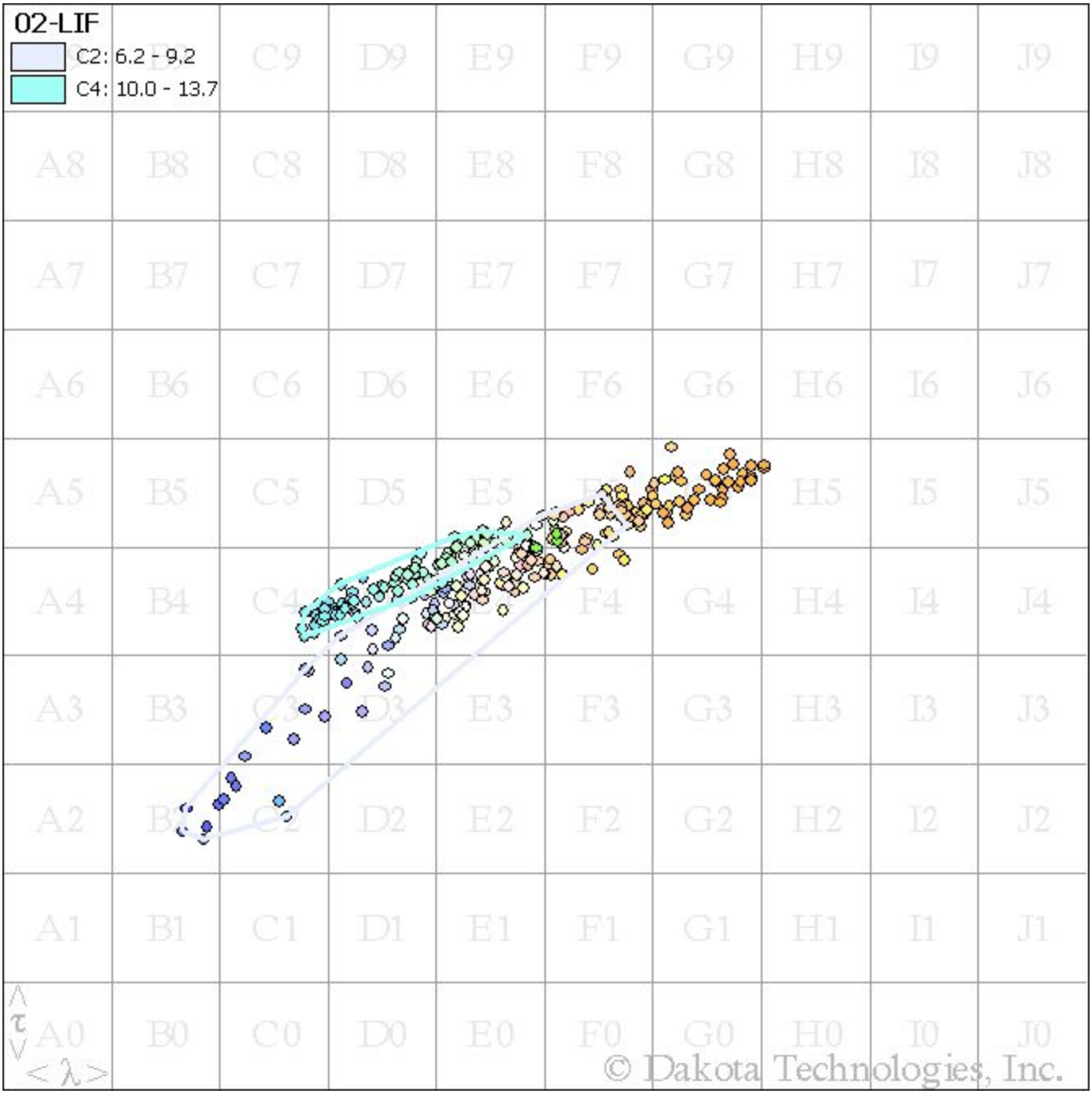
02-LIF
C2: 6.2 - 9.2
C4: 10.0 - 13.7
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 D3 E3 F3 G3 H3 I3 J3
A2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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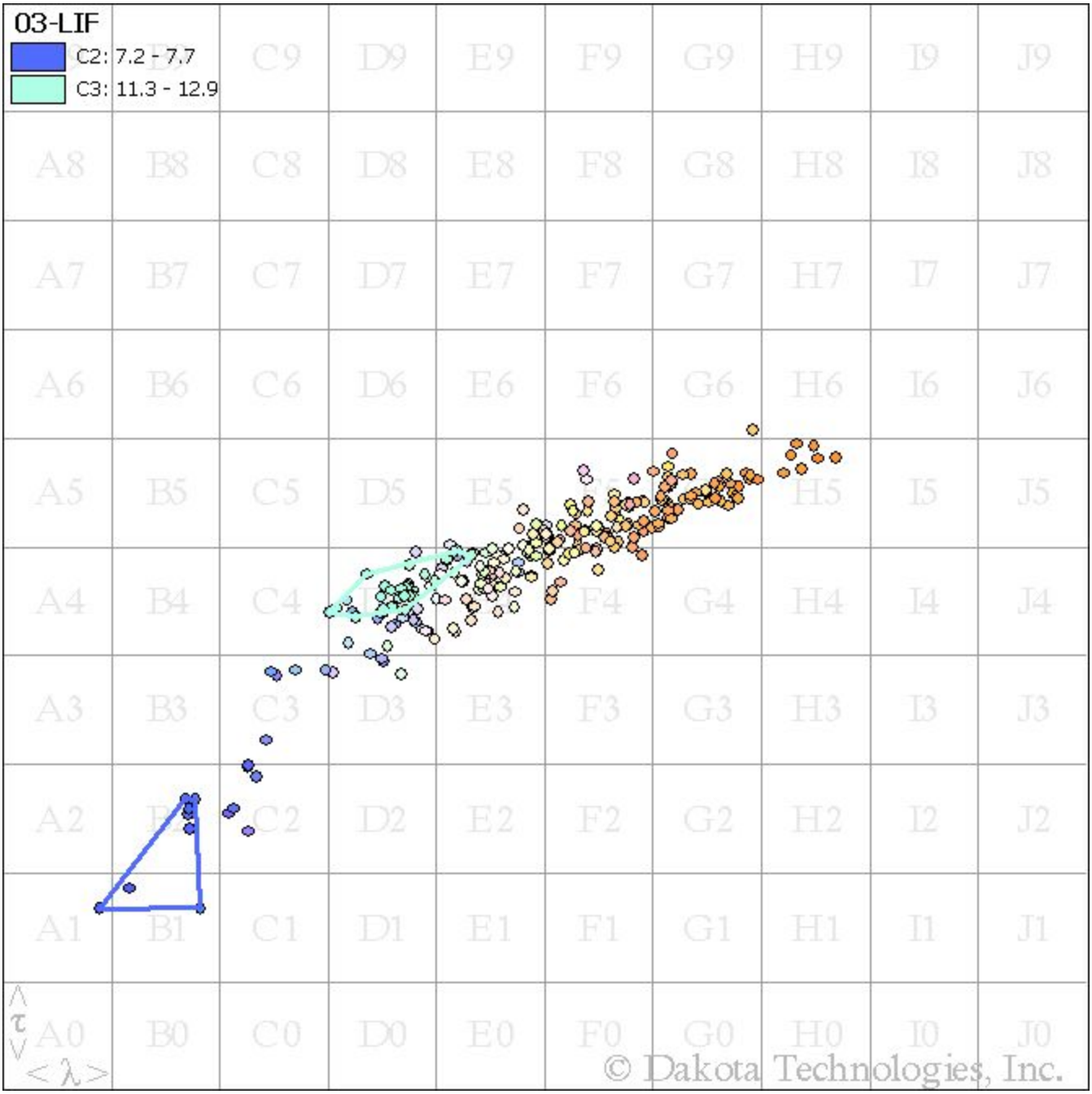
03-LIF
C2: 7.2 - 7.7
C3: 11.3 - 12.9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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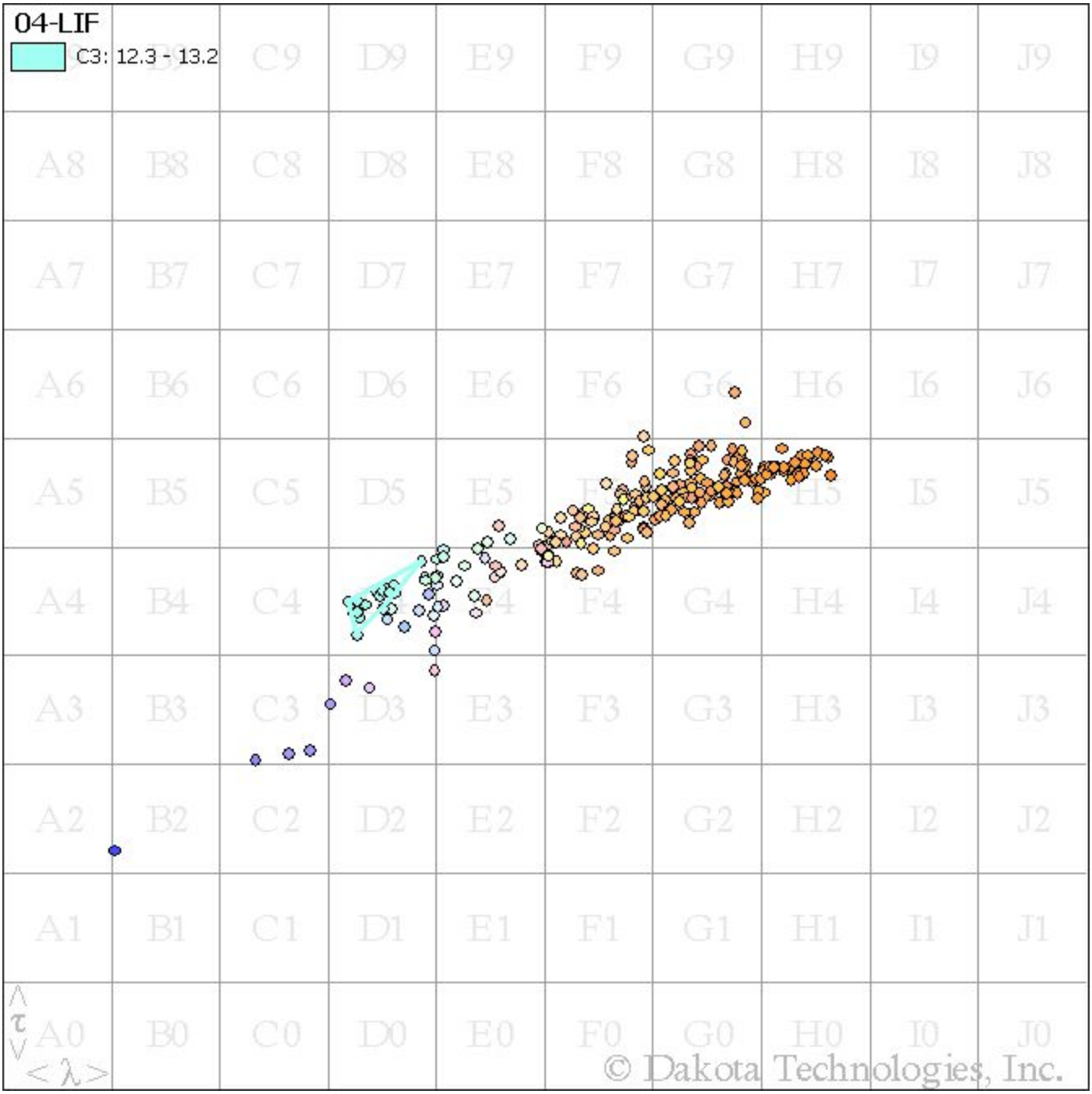
04-LIF
C3: 12.3 - 13.2
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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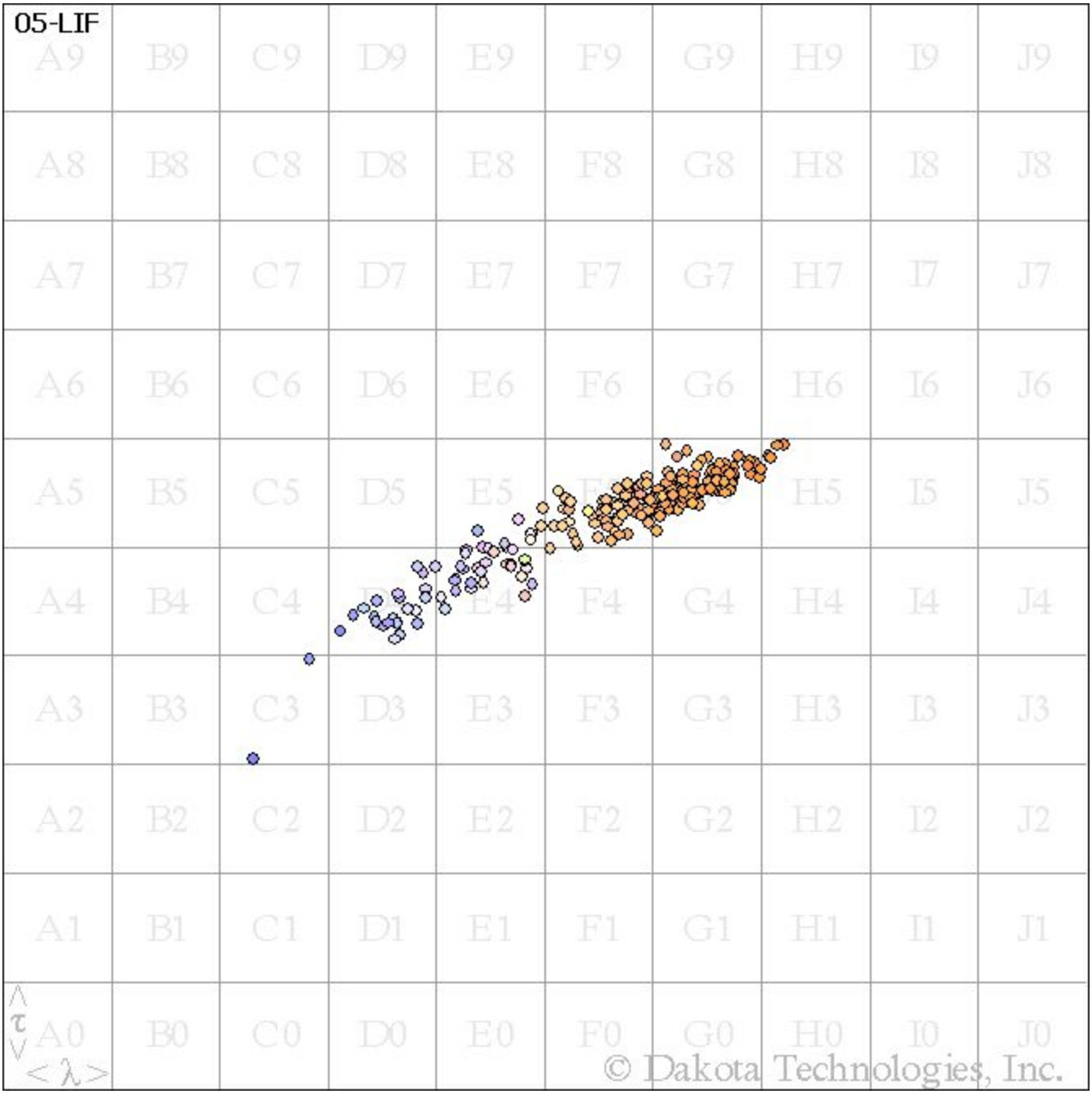
05-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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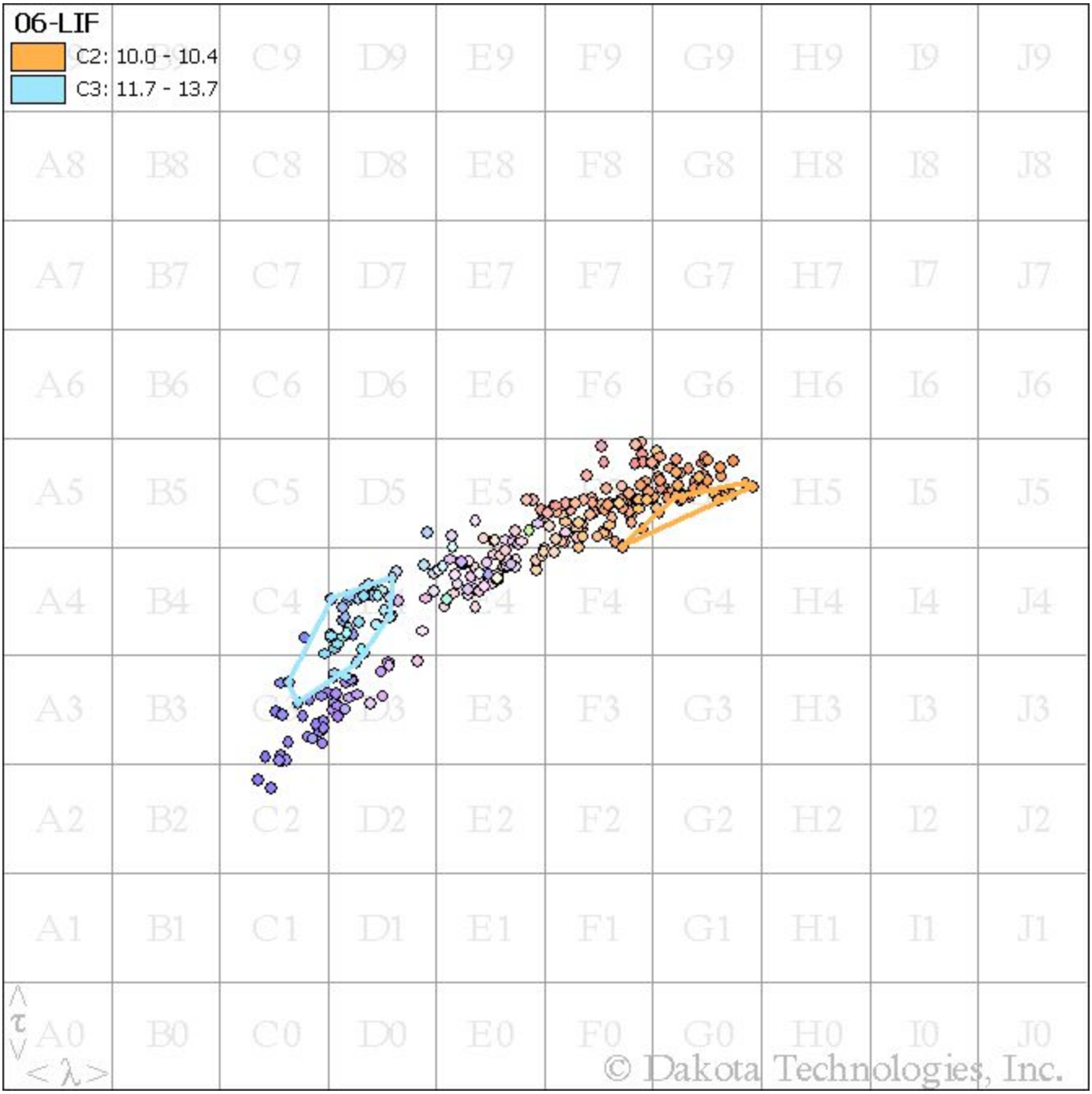
06-LIF
C2: 10.0 - 10.4
C3: 11.7 - 13.7
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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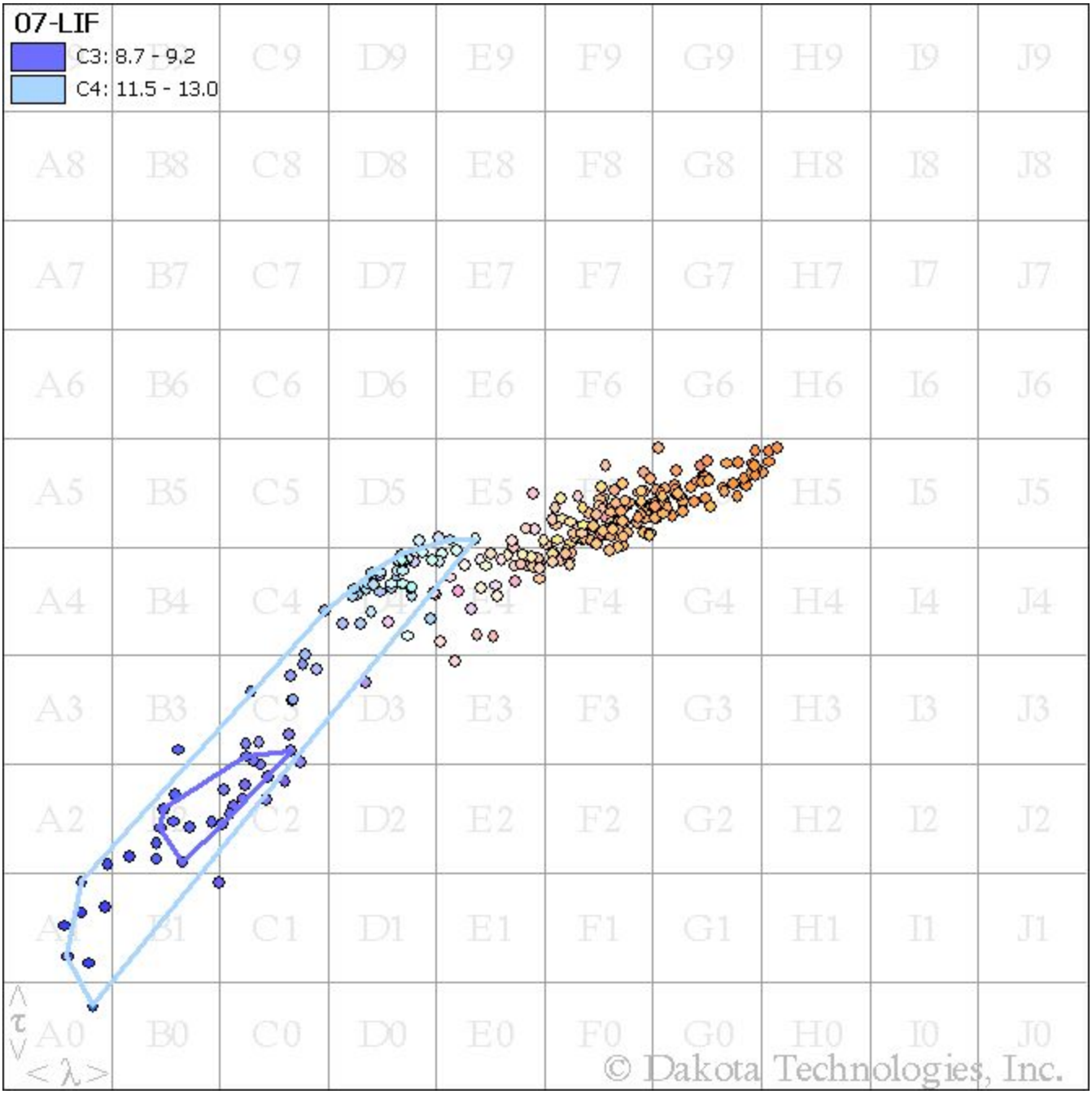
07-LIF
C3: 8.7 - 9.2
C4: 11.5 - 13.0
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 D3 E3 F3 G3 H3 I3 J3
A2 C2 D2 E2 F2 G2 H2 I2 J2
B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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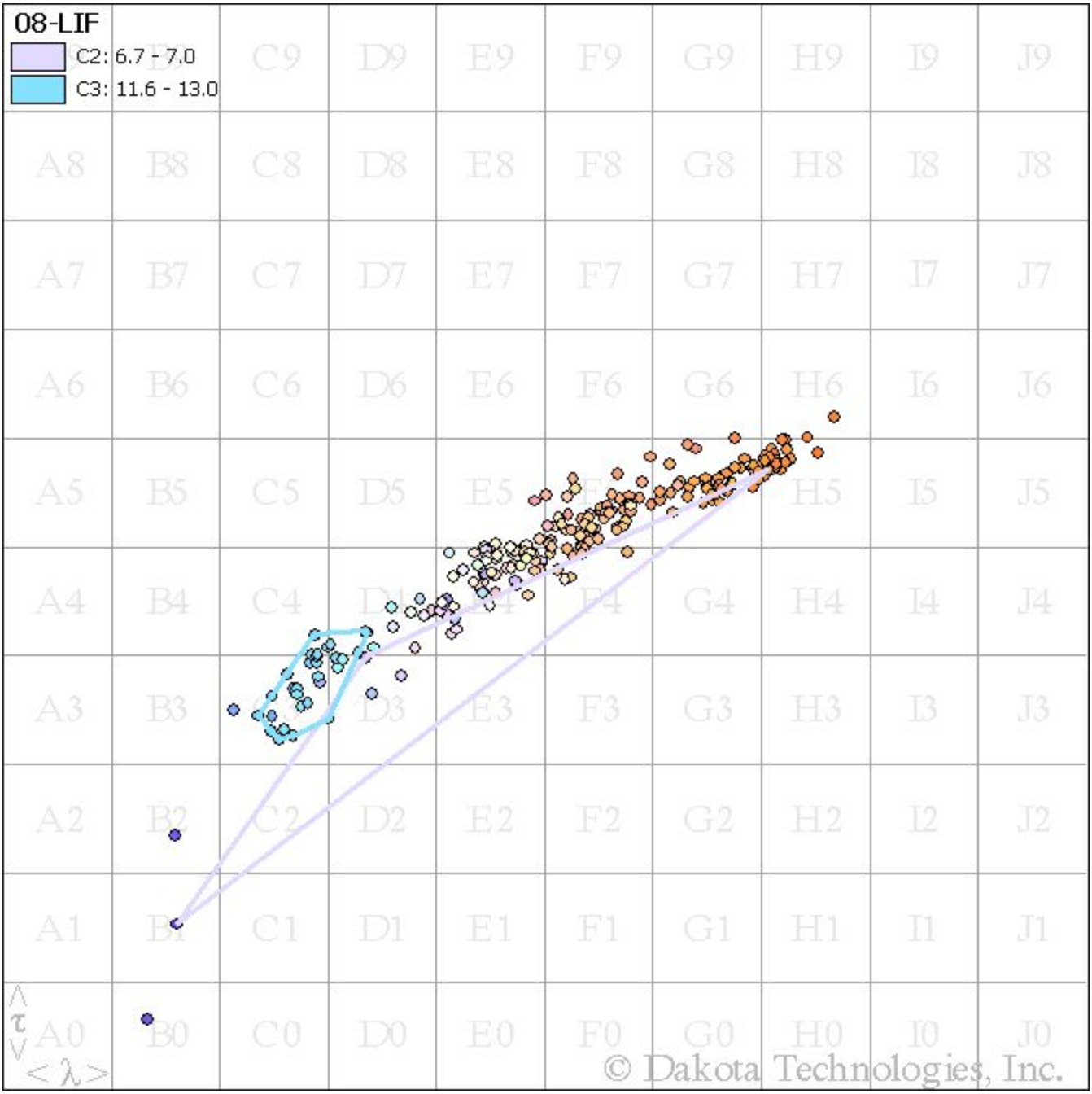
08-LIF
C2: 6.7 - 7.0
C3: 11.6 - 13.0
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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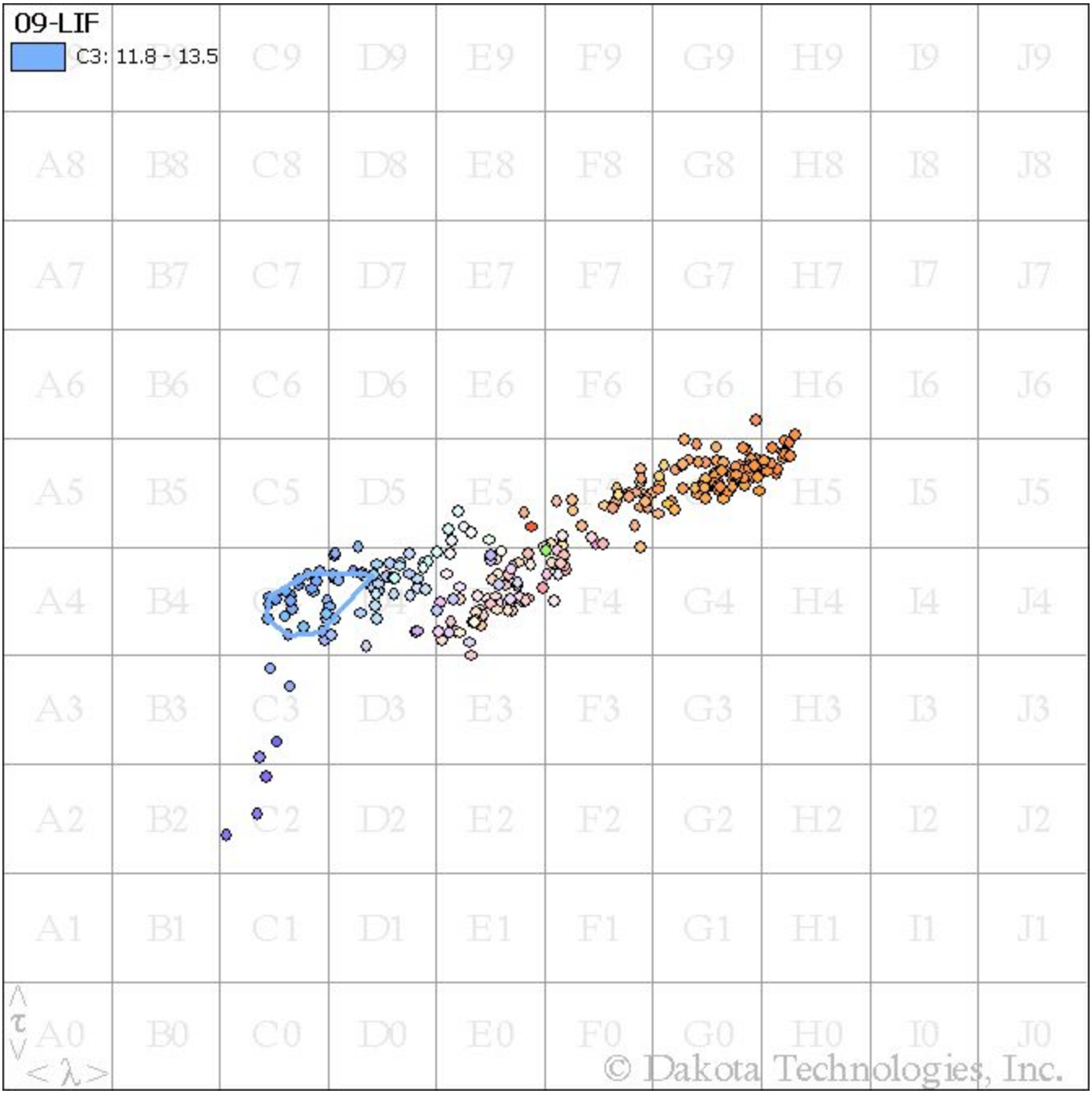
09-LIF
C3: 11.8 - 13.5
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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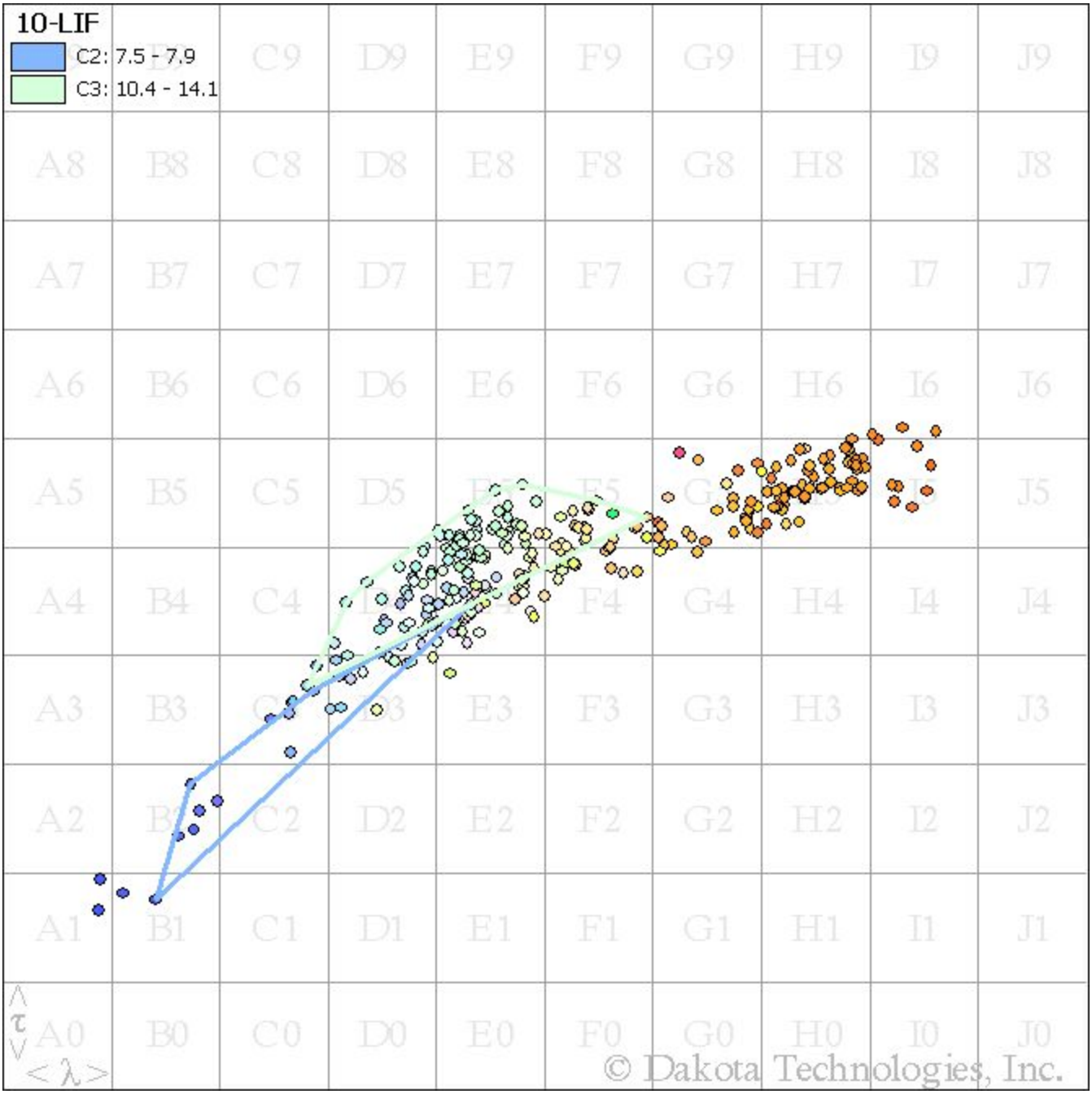
10-LIF
C2: 7.5 - 7.9
C3: 10.4 - 14.1
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 E3 F3 G3 H3 I3 J3
A2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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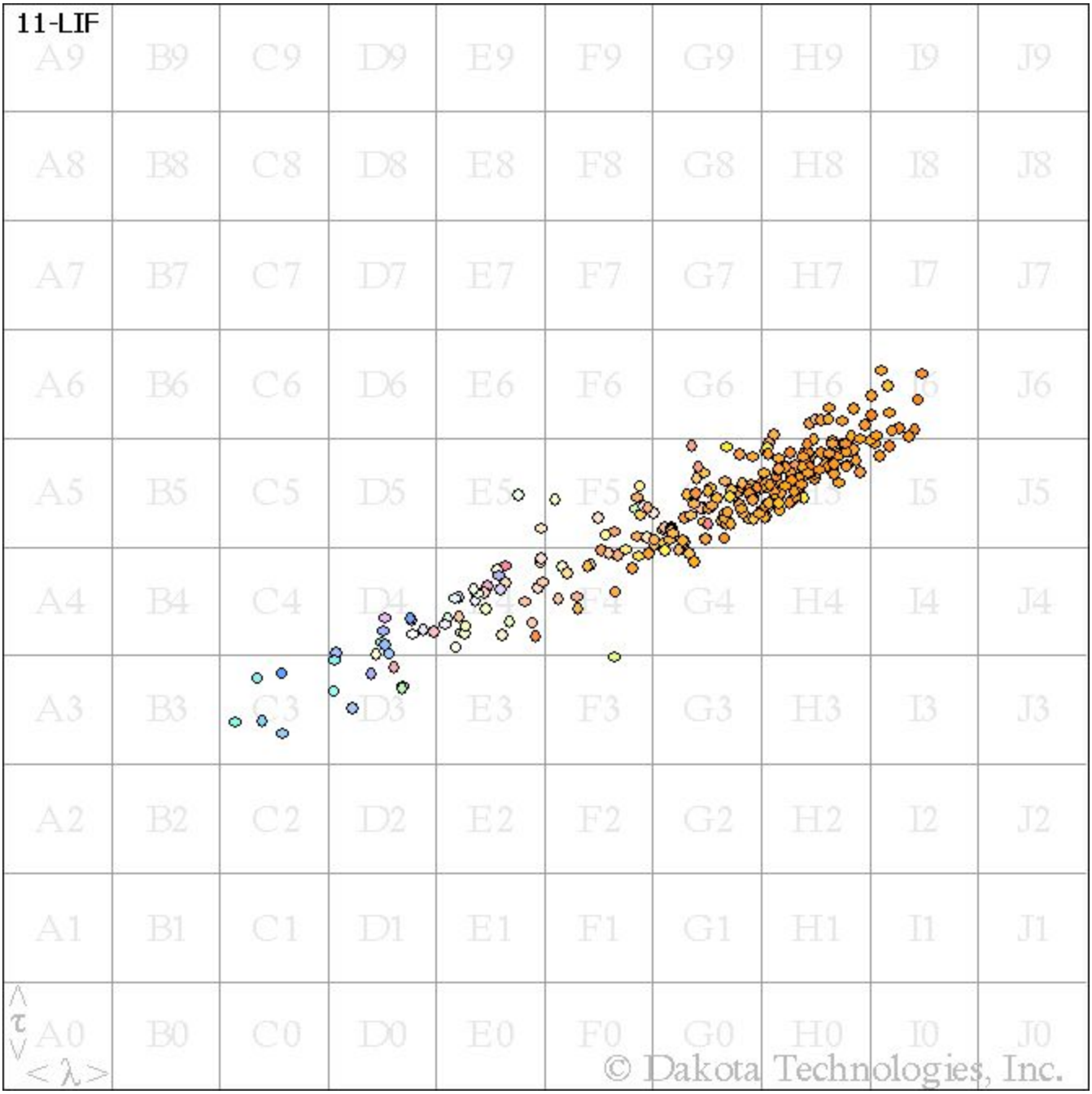
11-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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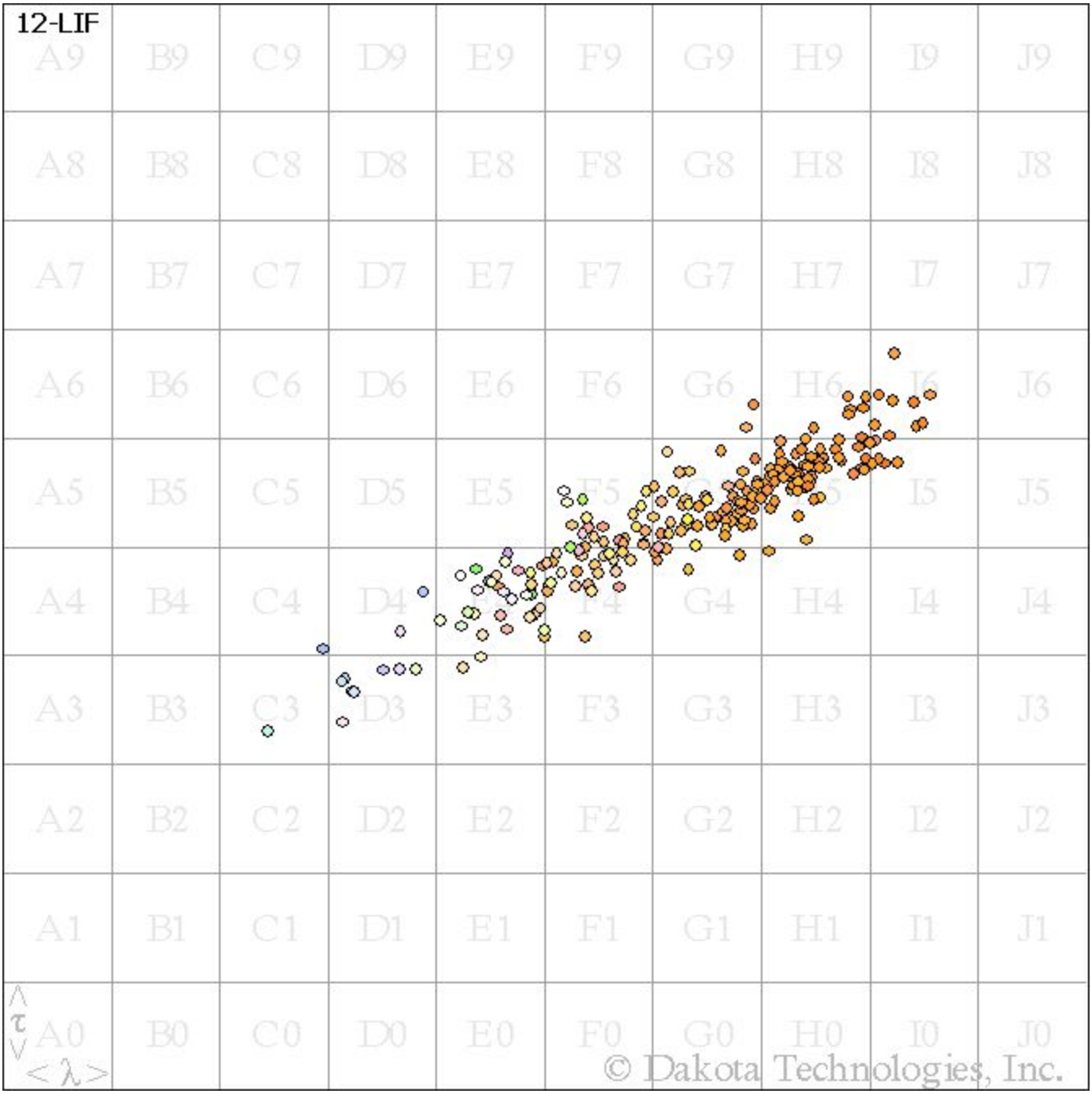
12-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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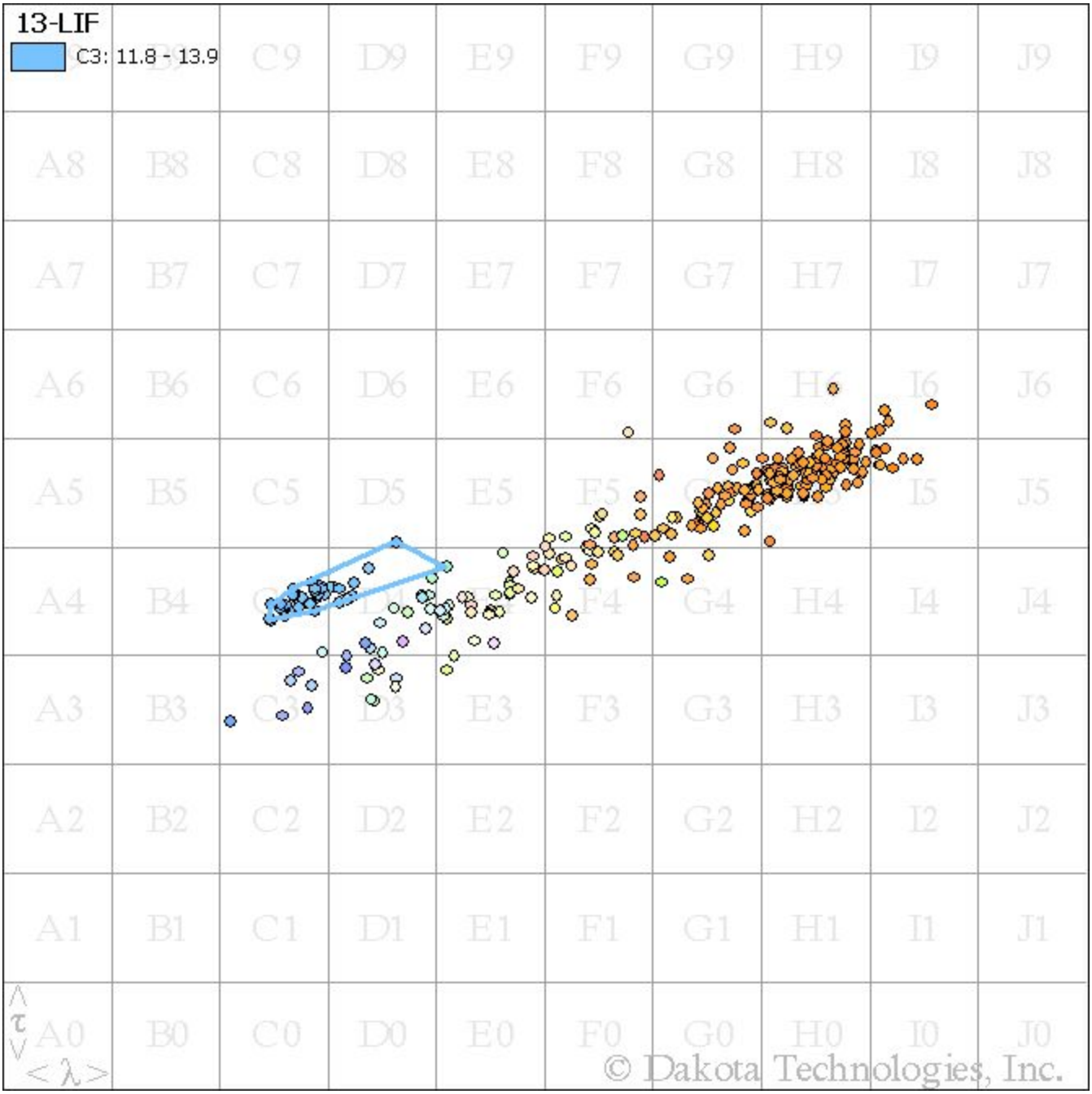
13-LIF
C3: 11.8 - 13.9
C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 I5 J5
A4 B4 F4 G4 H4 I4 J4
A3 B3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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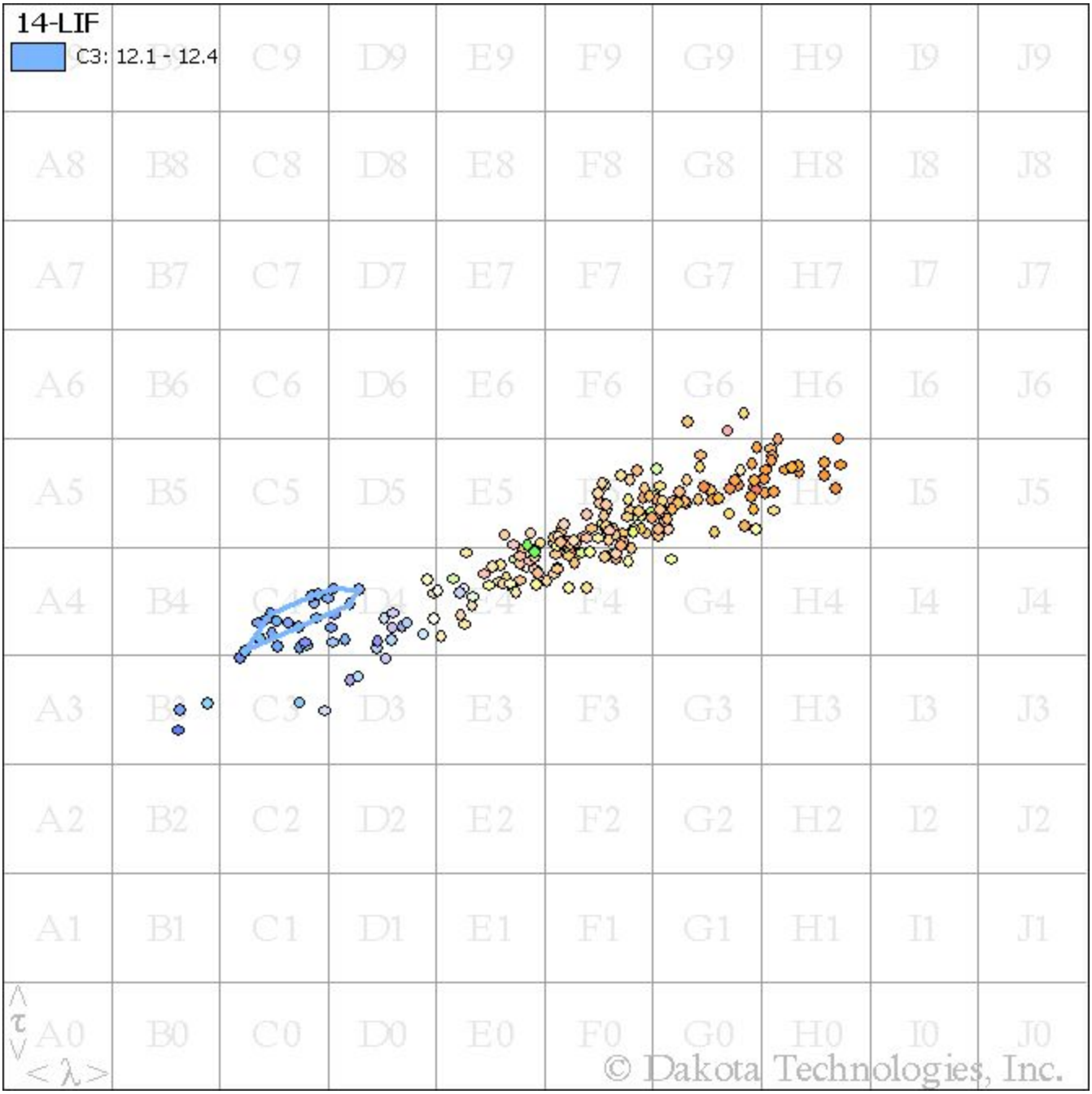
14-LIF
C3: 12.1 - 12.4
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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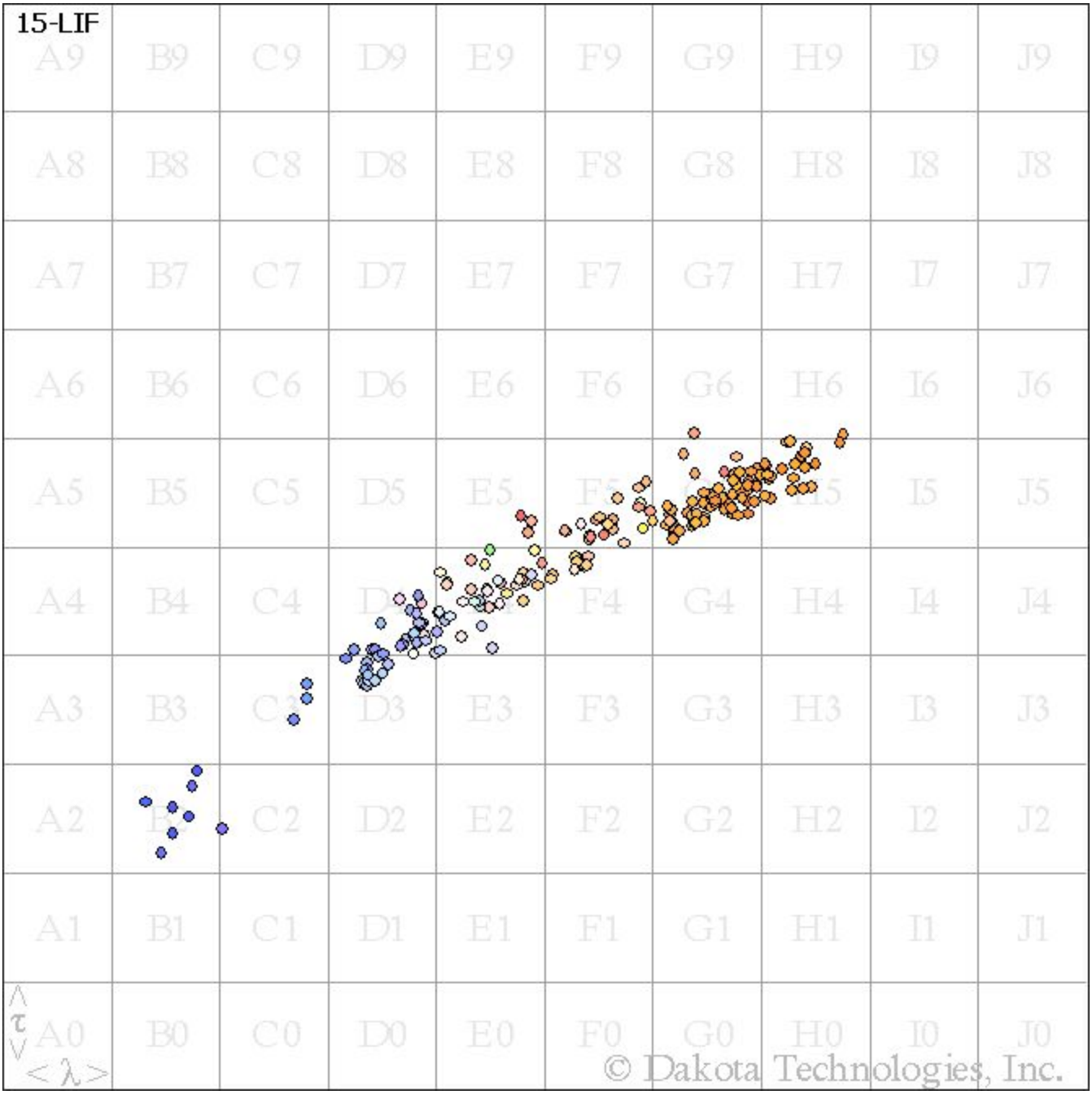
15-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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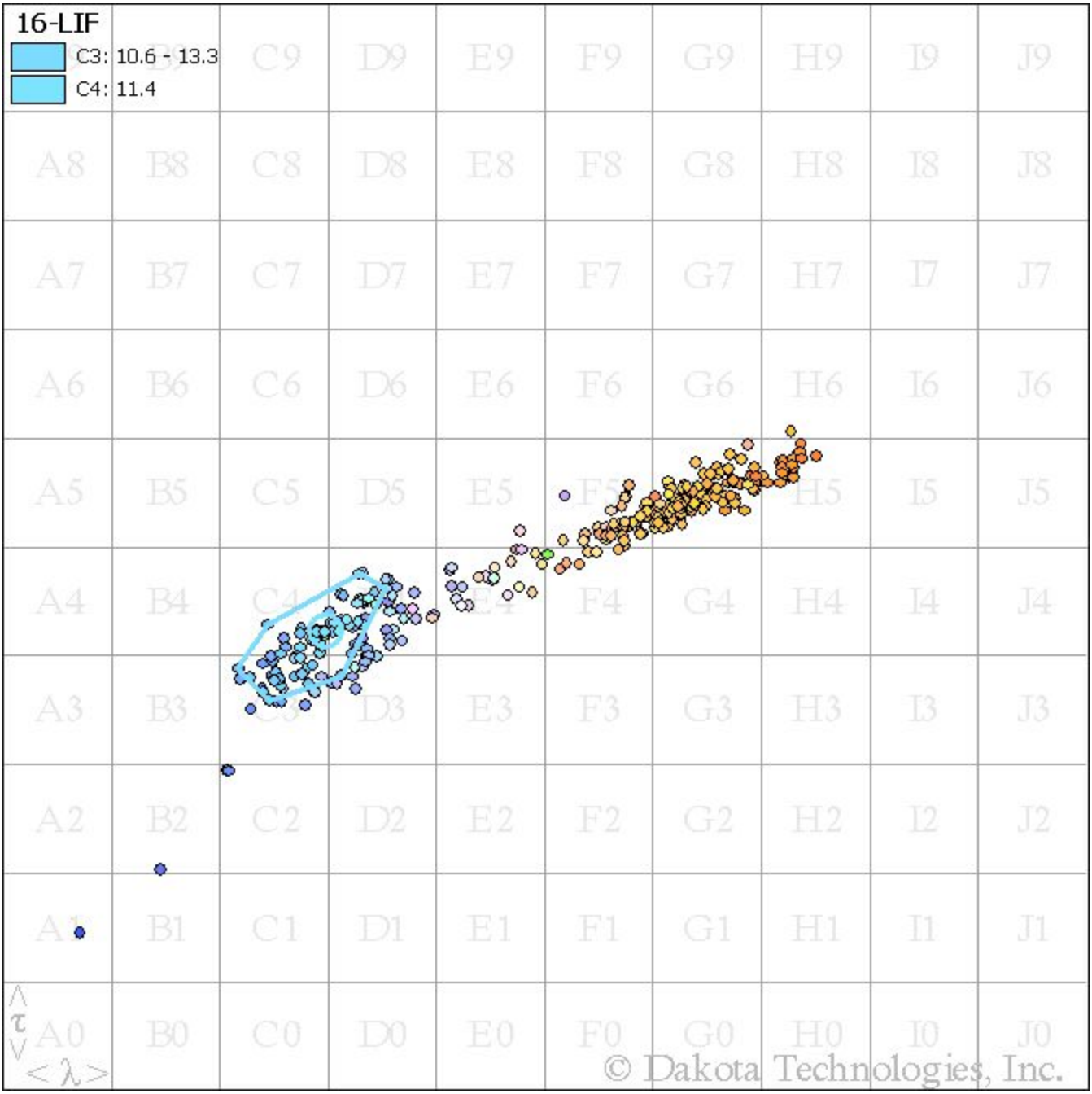
16-LIF
C3: 10.6 - 13.3
C4: 11.4
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 E4 F4 G4 H4 I4 J4
A3 B3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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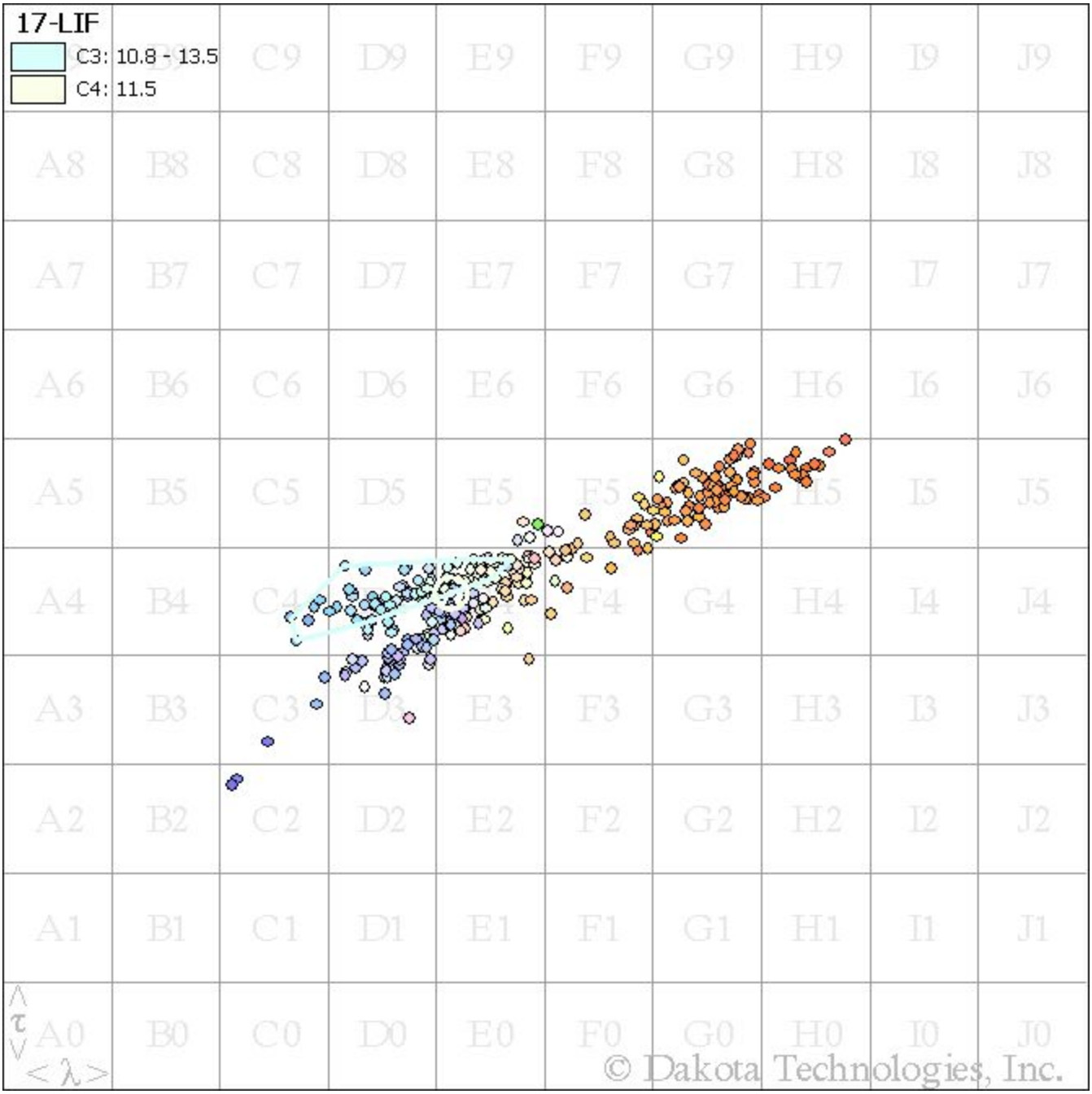
17-LIF
C3: 10.8 - 13.5
C4: 11.5
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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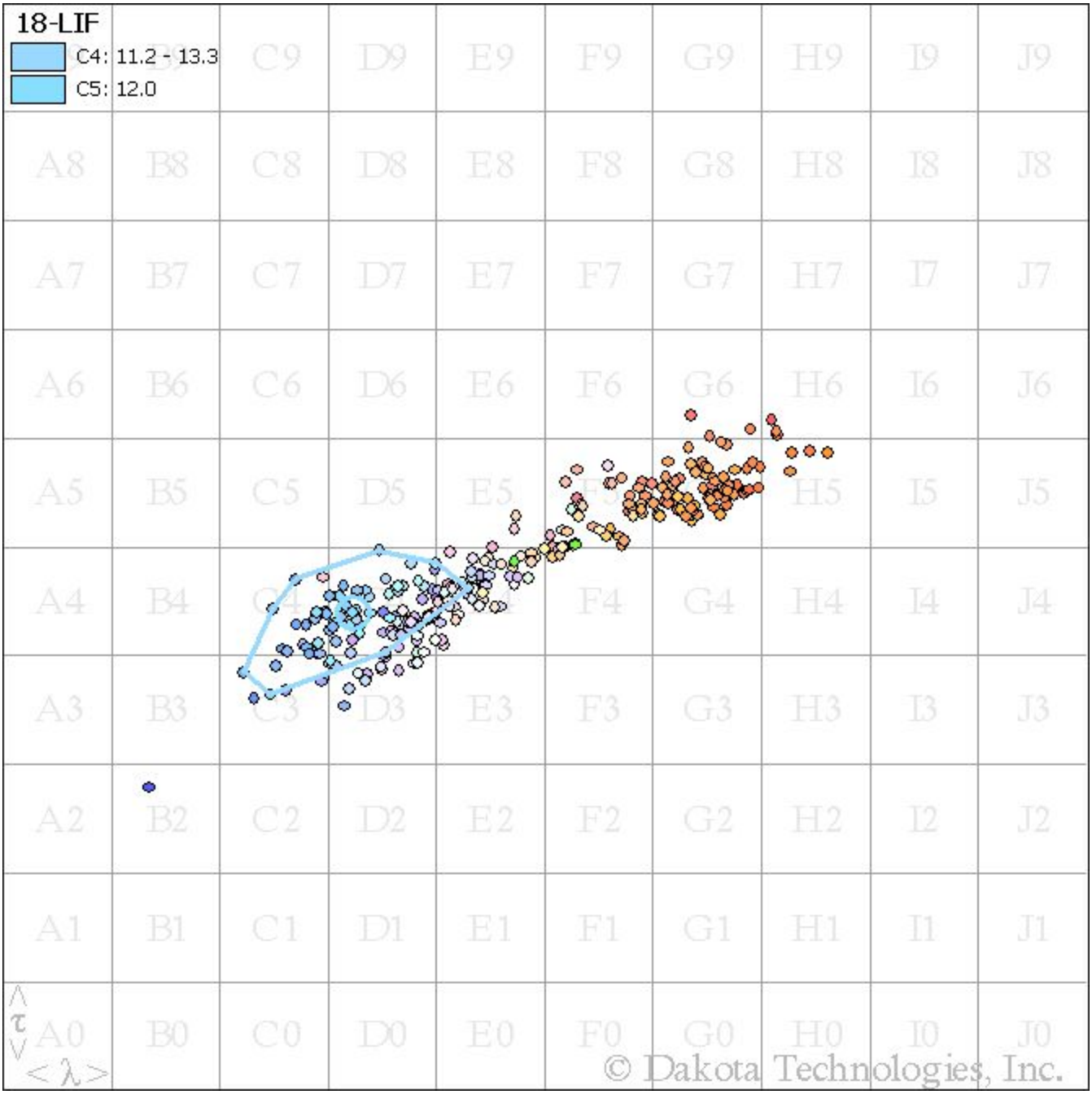
18-LIF
C4: 11.2 - 13.3
C5: 12.0
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 F4 G4 H4 I4 J4
A3 B3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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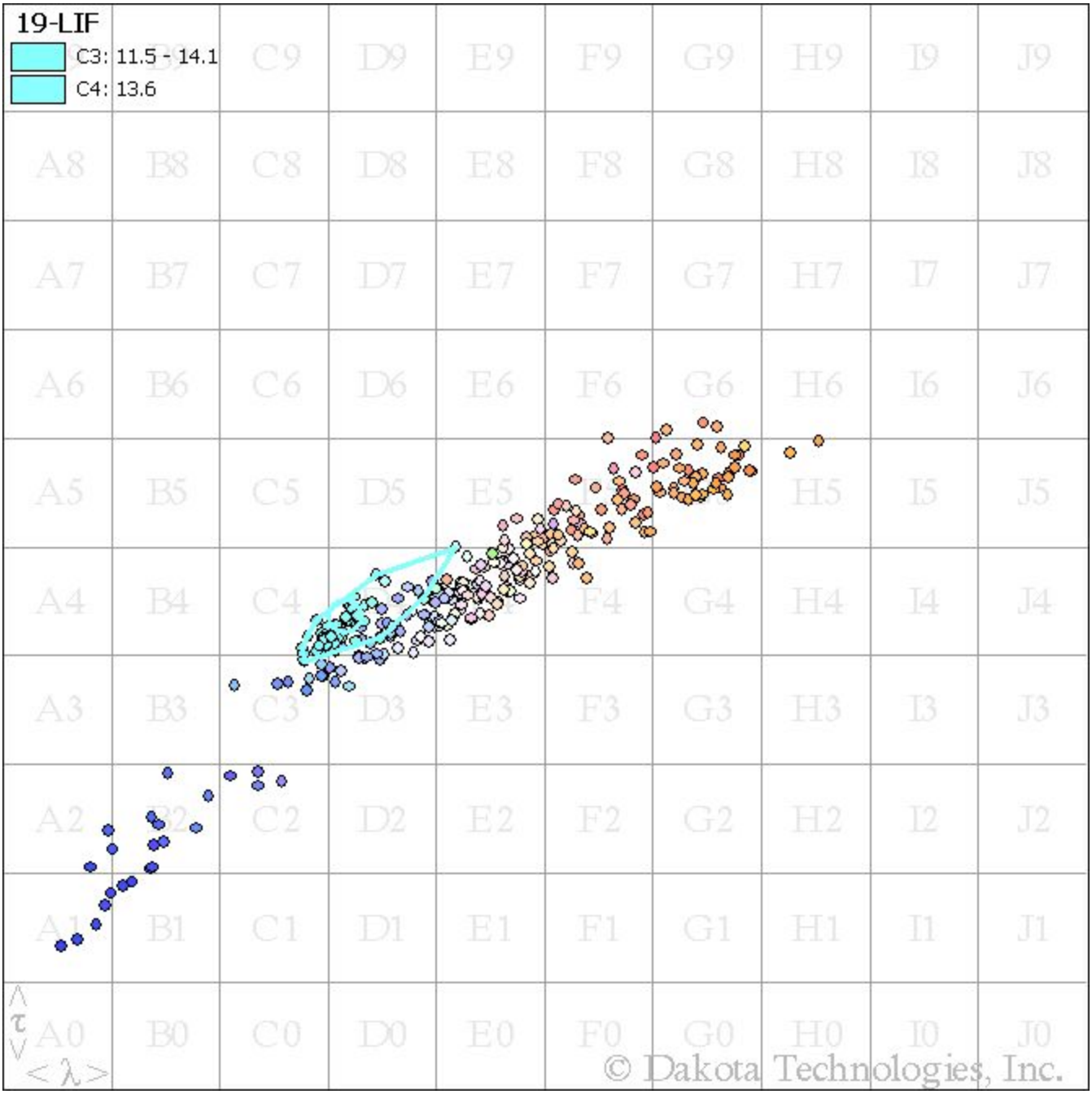
19-LIF
C3: 11.5 - 14.1
C4: 13.6
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 C2 D2 E2 F2 G2 H2 I2 J2
B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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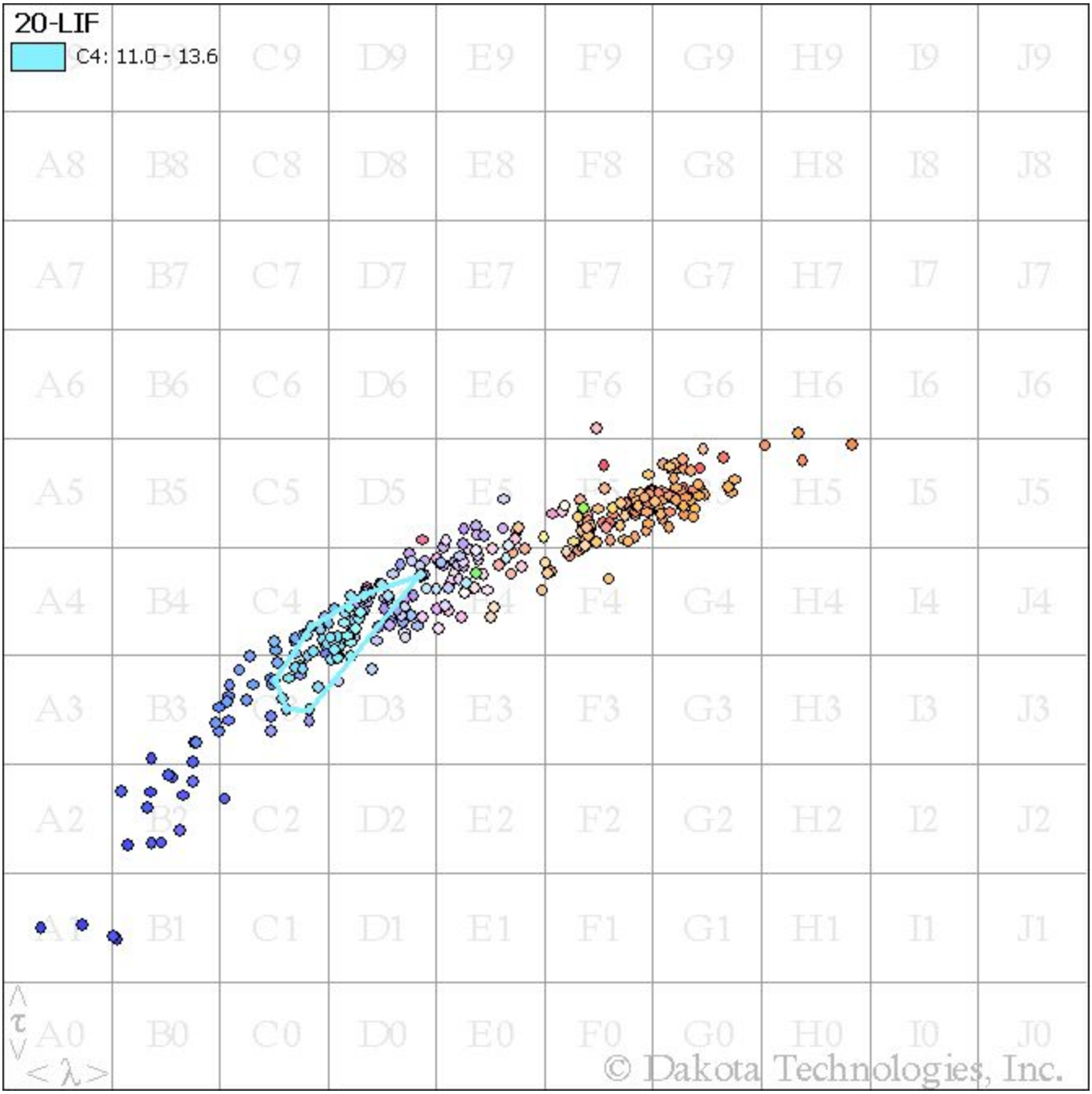
20-LIF
C4: 11.0 - 13.6
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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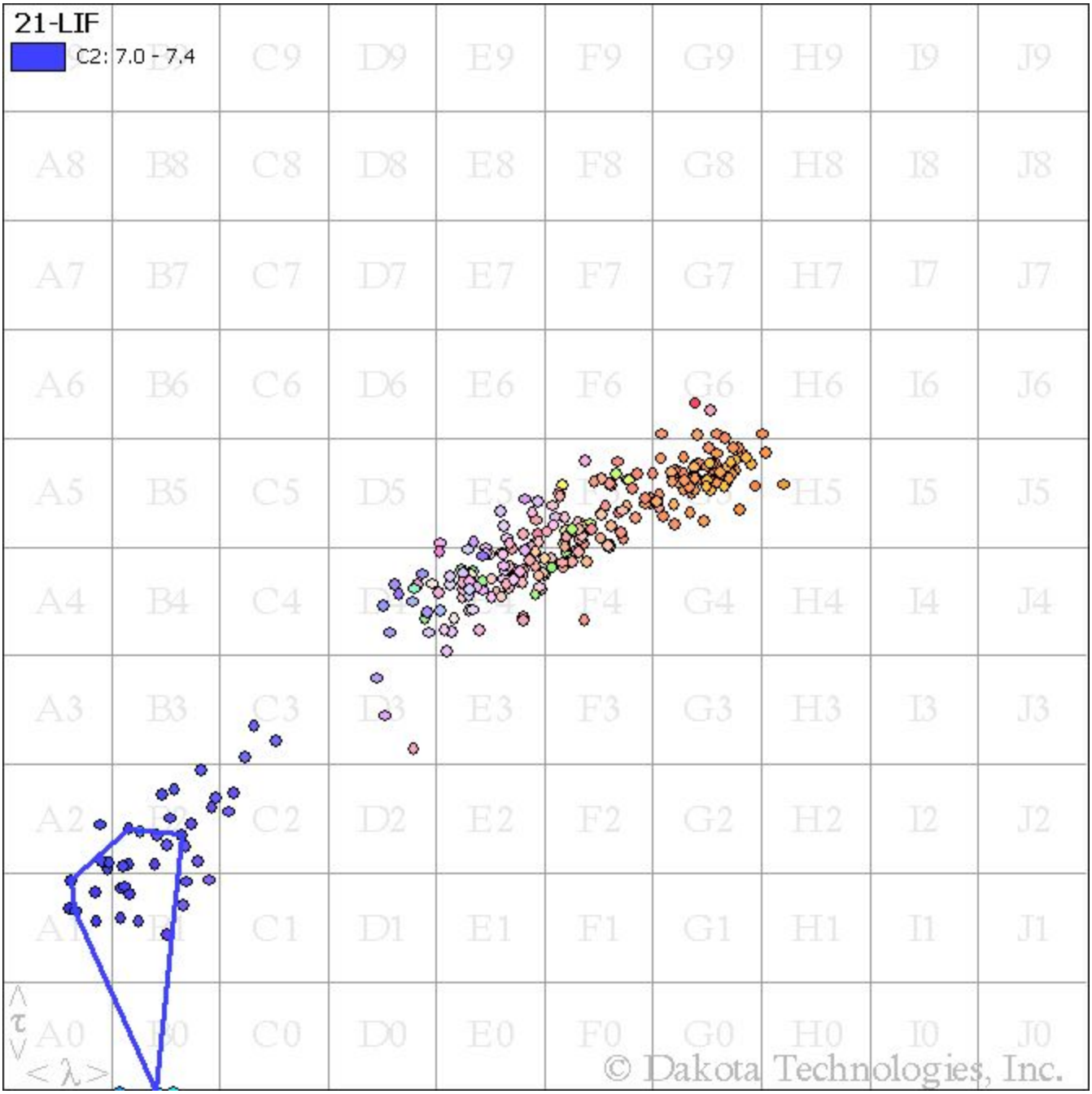
21-LIF
C2: 7.0 - 7.4
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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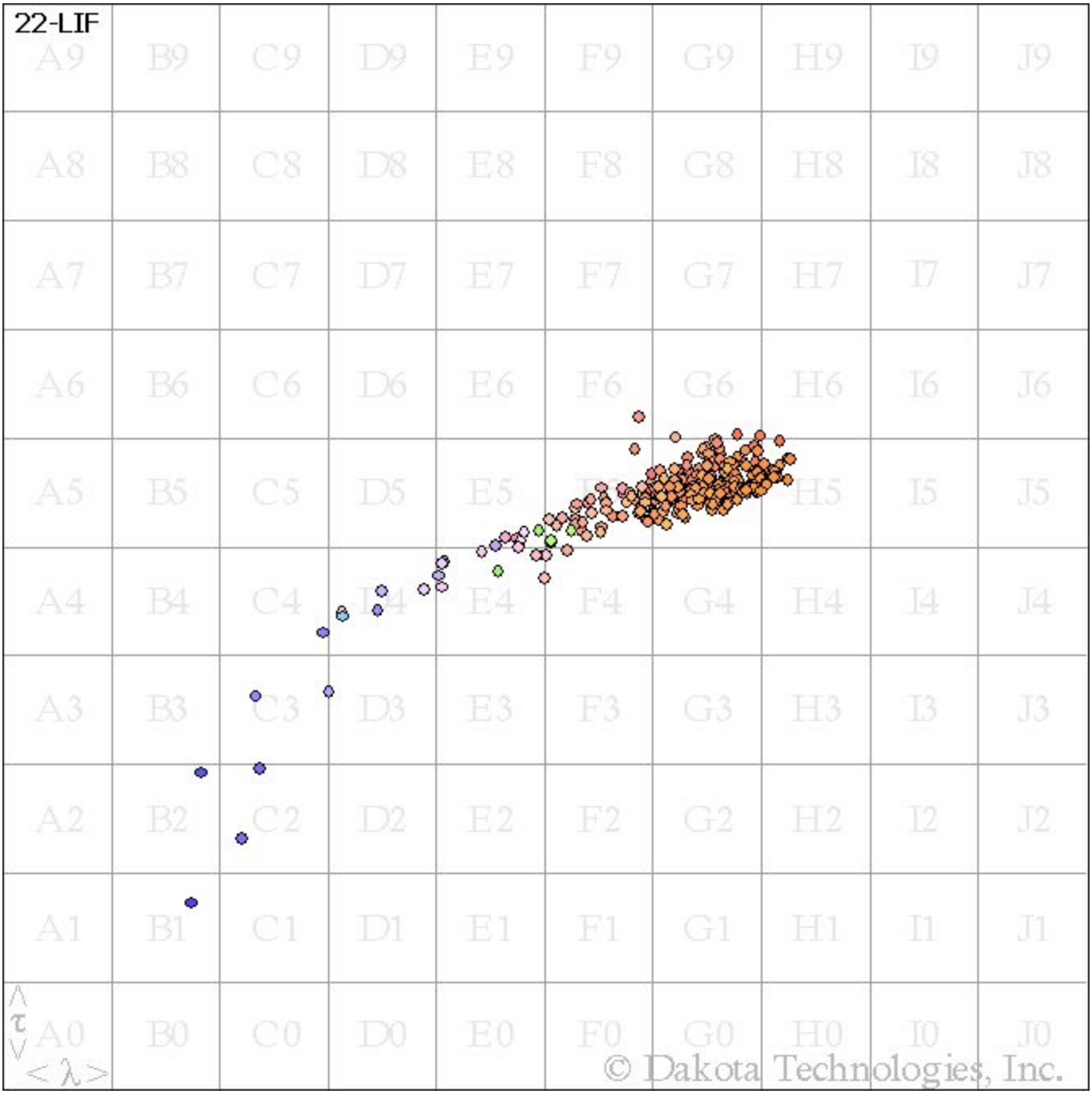
22-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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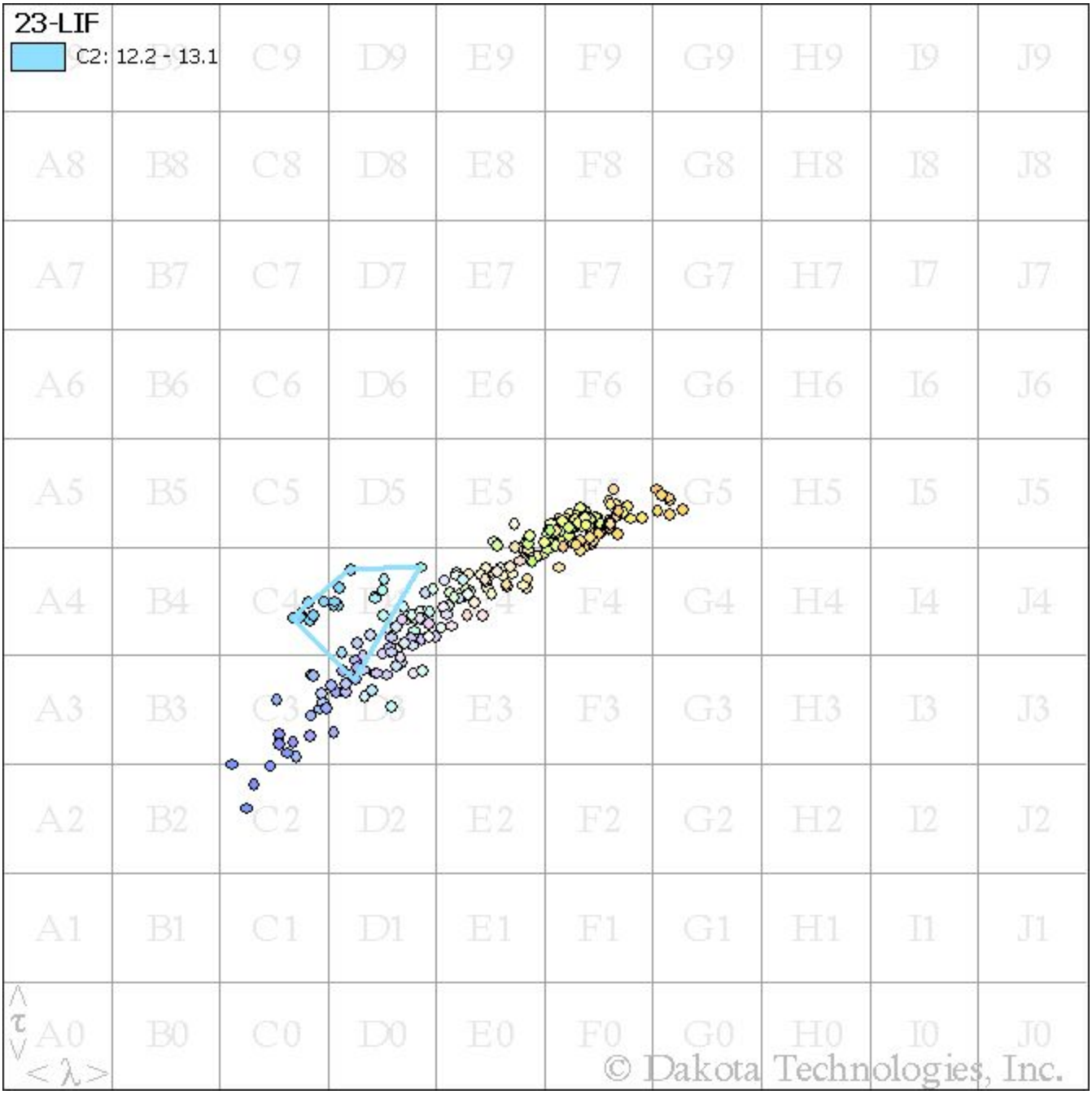
23-LIF
C2: 12.2 - 13.1
C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
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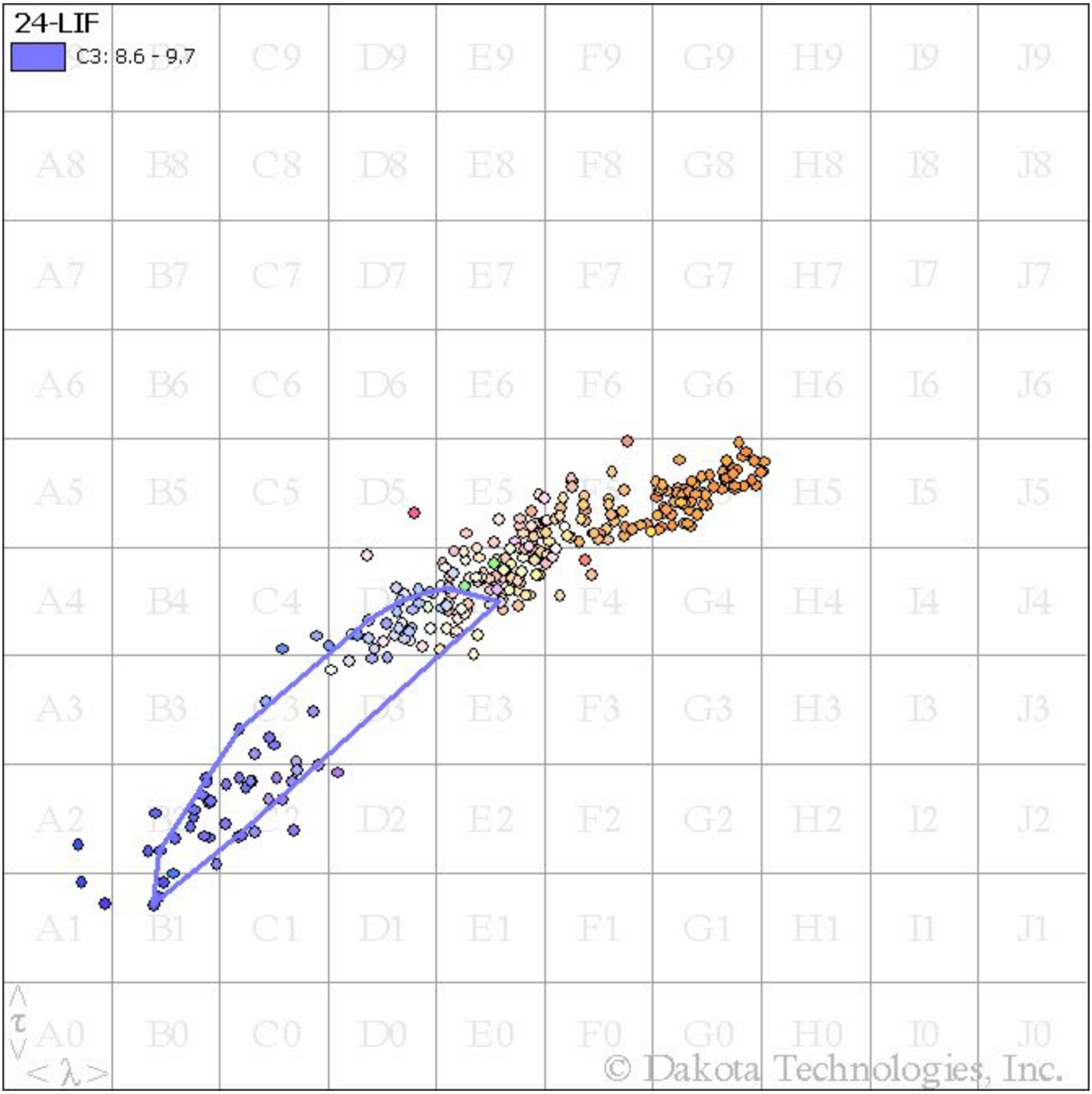
24-LIF
C3: 8.6 - 9.7
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 E3 F3 G3 H3 I3 J3
A2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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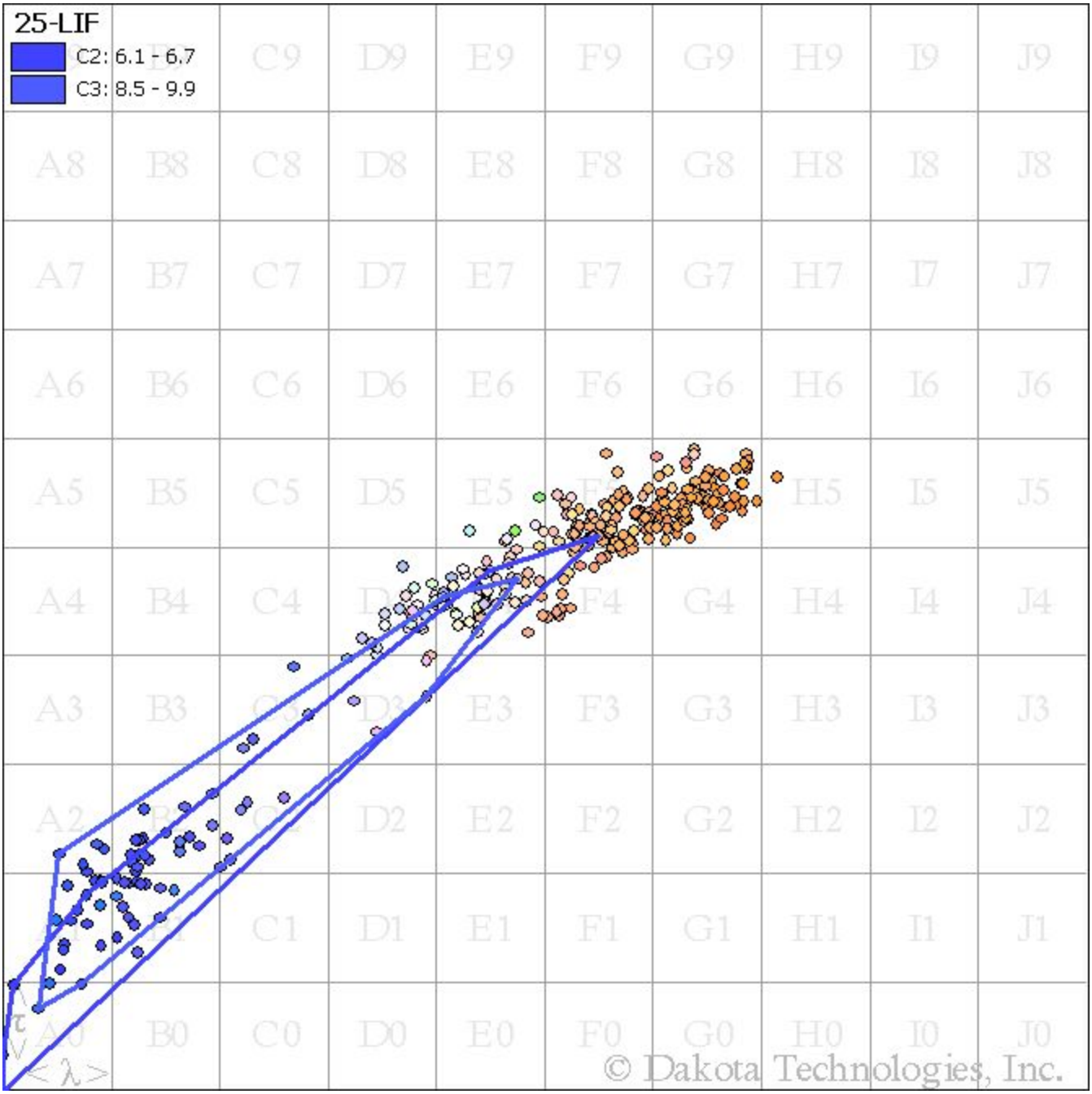
25-LIF
C2: 6.1 - 6.7
C3: 8.5 - 9.9
C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 E3 F3 G3 H3 I3 J3
D2 E2 F2 G2 H2 I2 J2
C1 D1 E1 F1 G1 H1 I1 J1
B0 C0 D0 E0 F0 G0 H0 I0 J0
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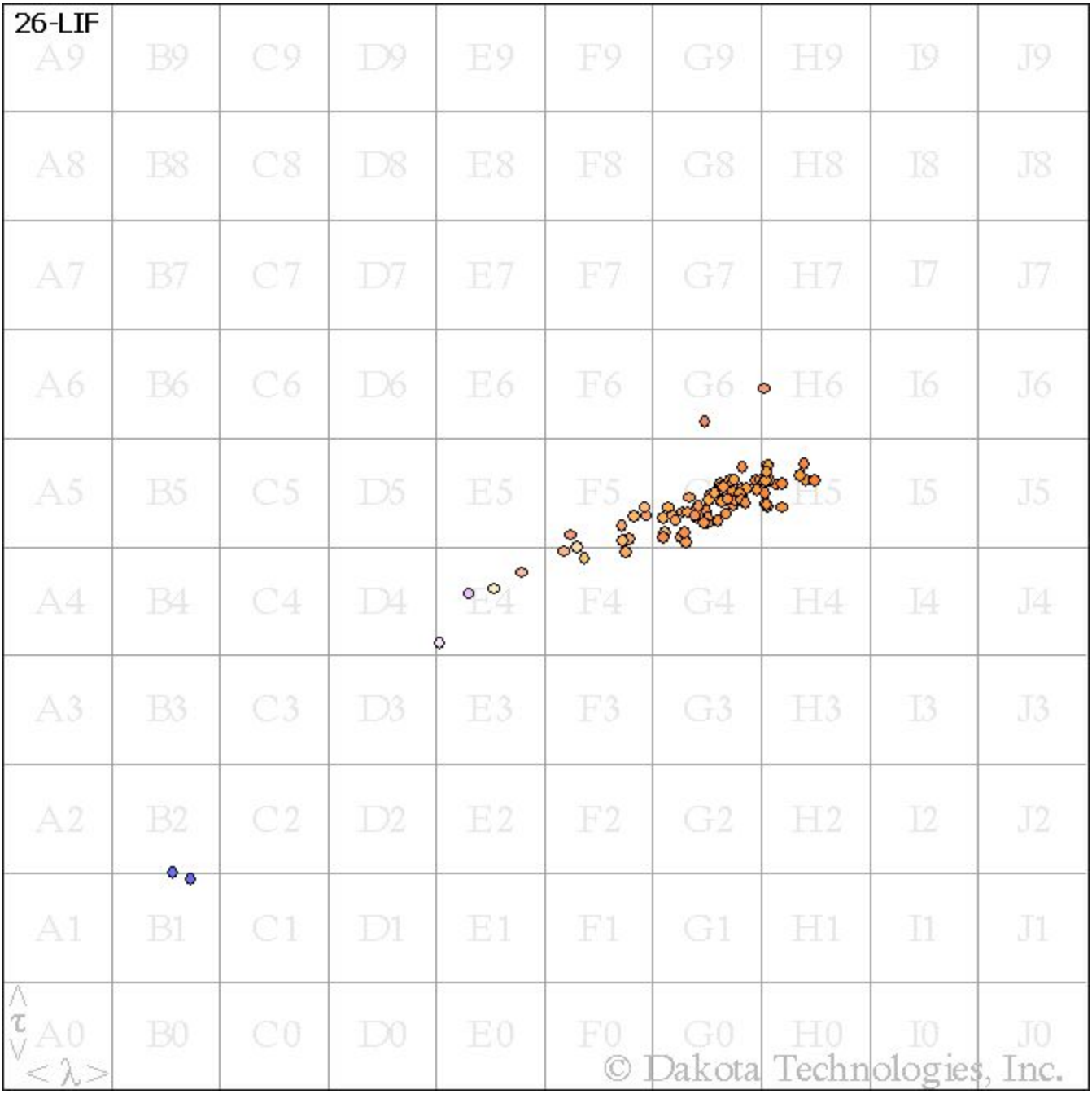
26-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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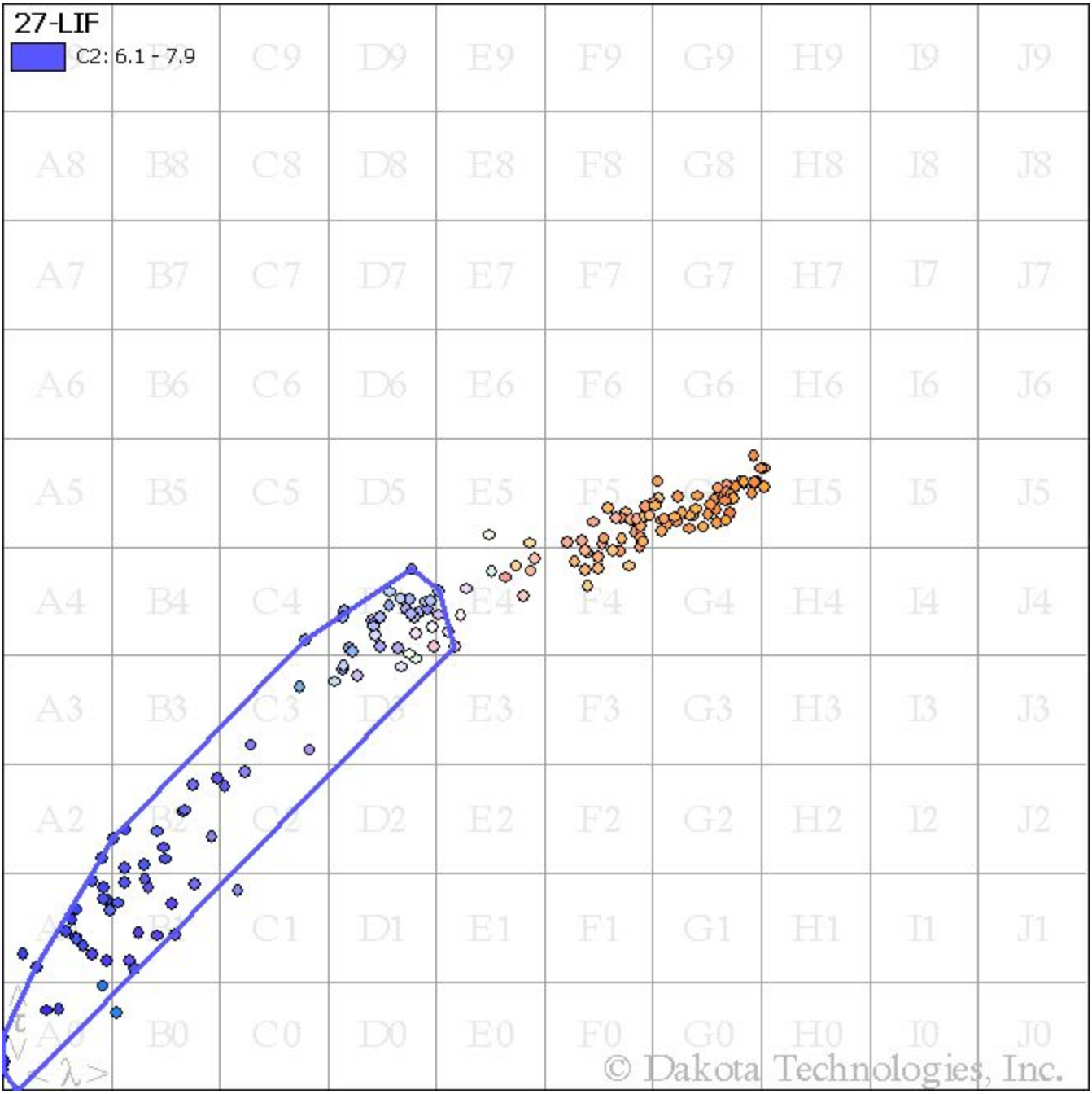
27-LIF
C2: 6.1 - 7.9
C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 E4 F4 G4 H4 I4 J4
A3 B3 C3 E3 F3 G3 H3 I3 J3
A2 D2 E2 F2 G2 H2 I2 J2
C1 D1 E1 F1 G1 H1 I1 J1
B0 C0 D0 E0 F0 G0 H0 I0 J0
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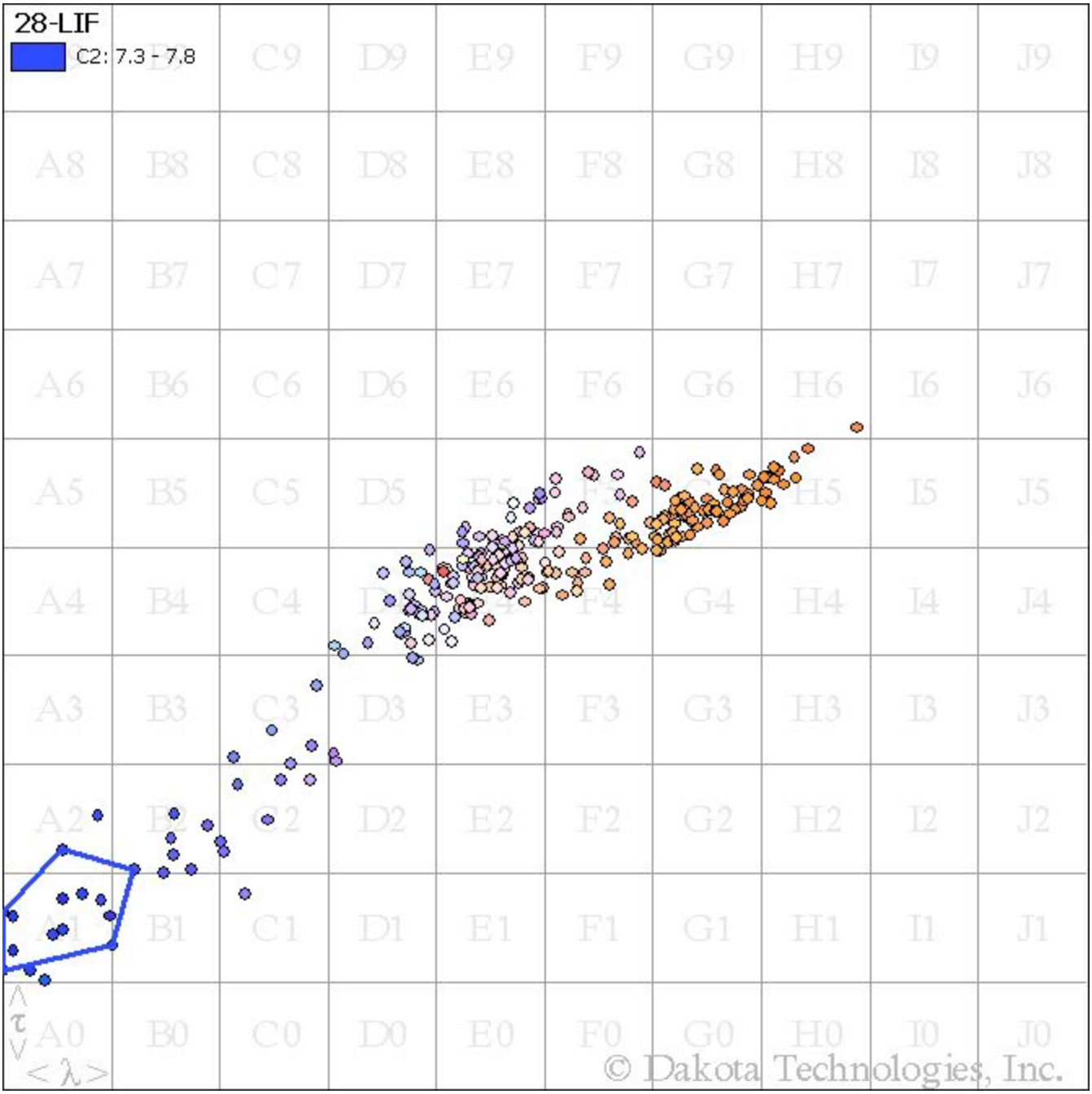
28-LIF
C2: 7.3 - 7.8
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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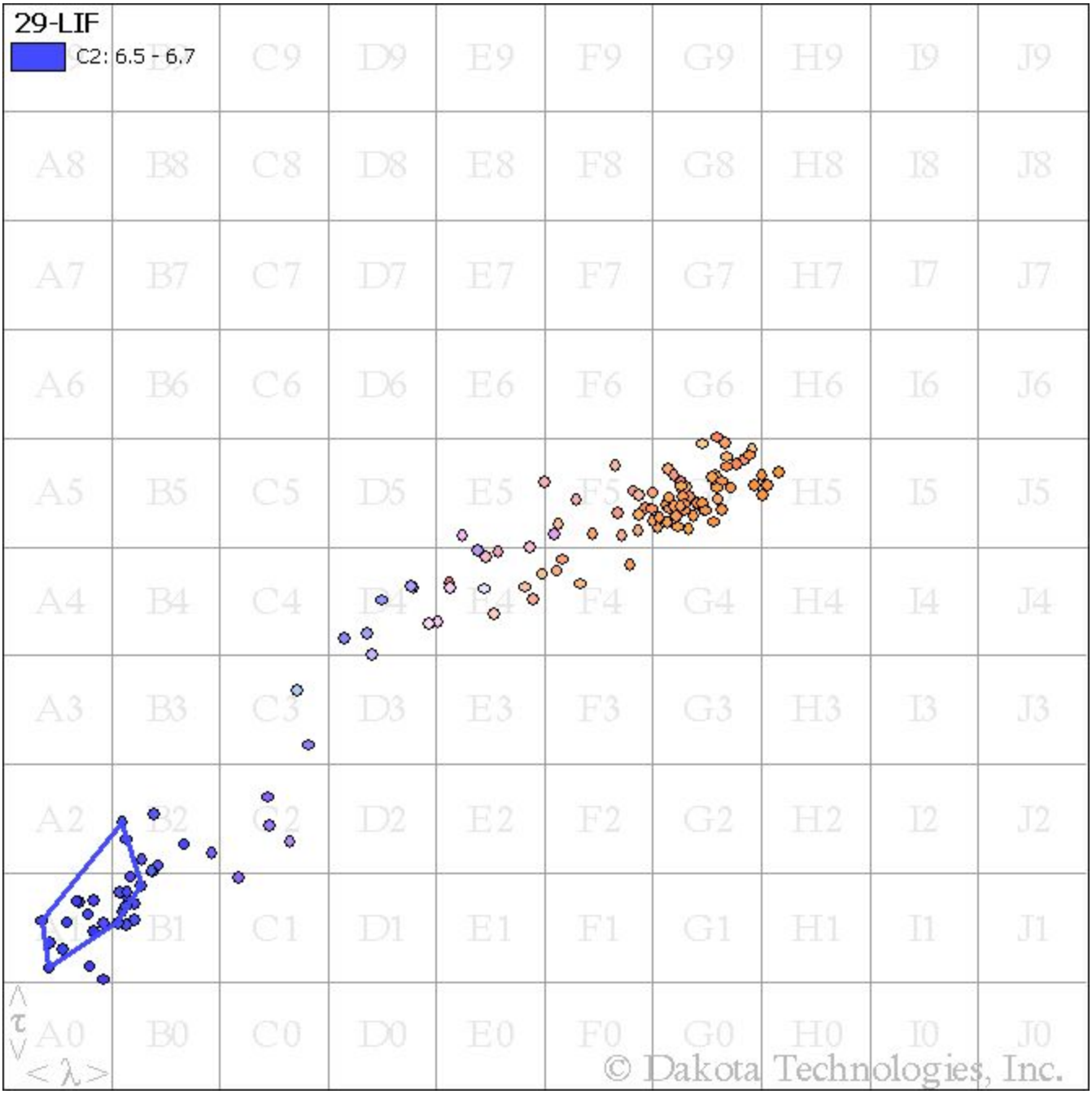
29-LIF
C2: 6.5 - 6.7
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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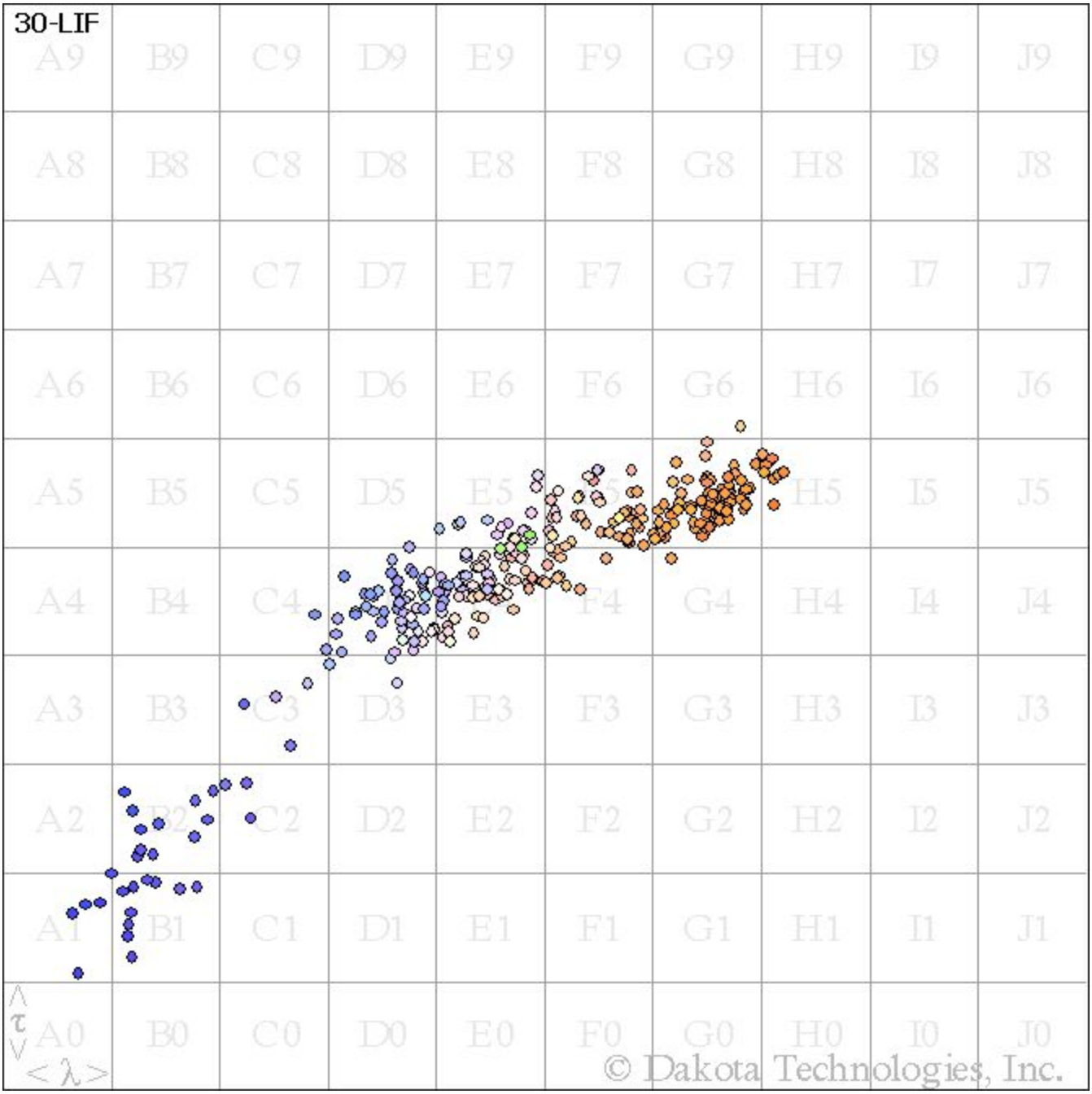
30-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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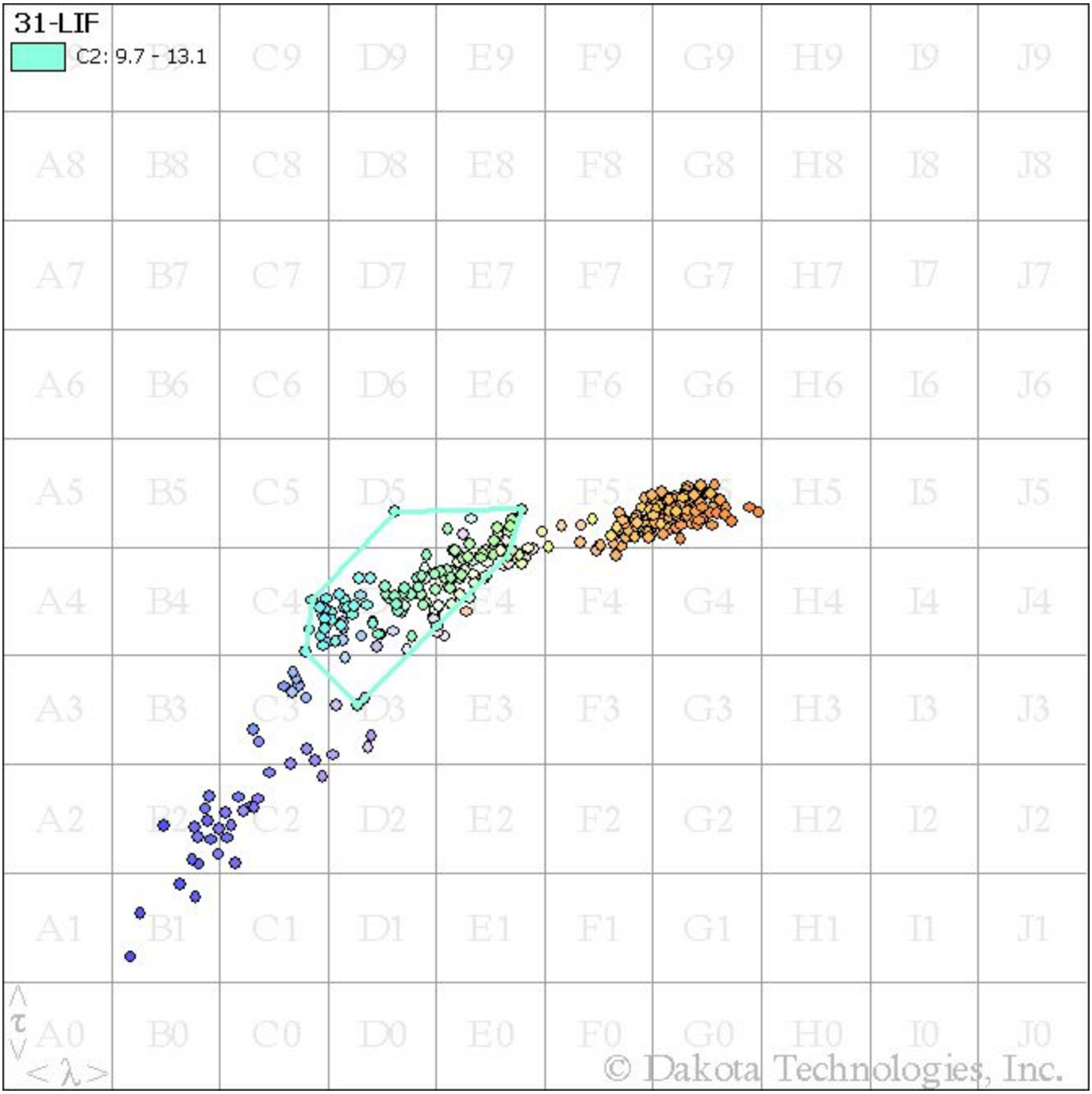
31-LIF
C2: 9.7 - 13.1
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
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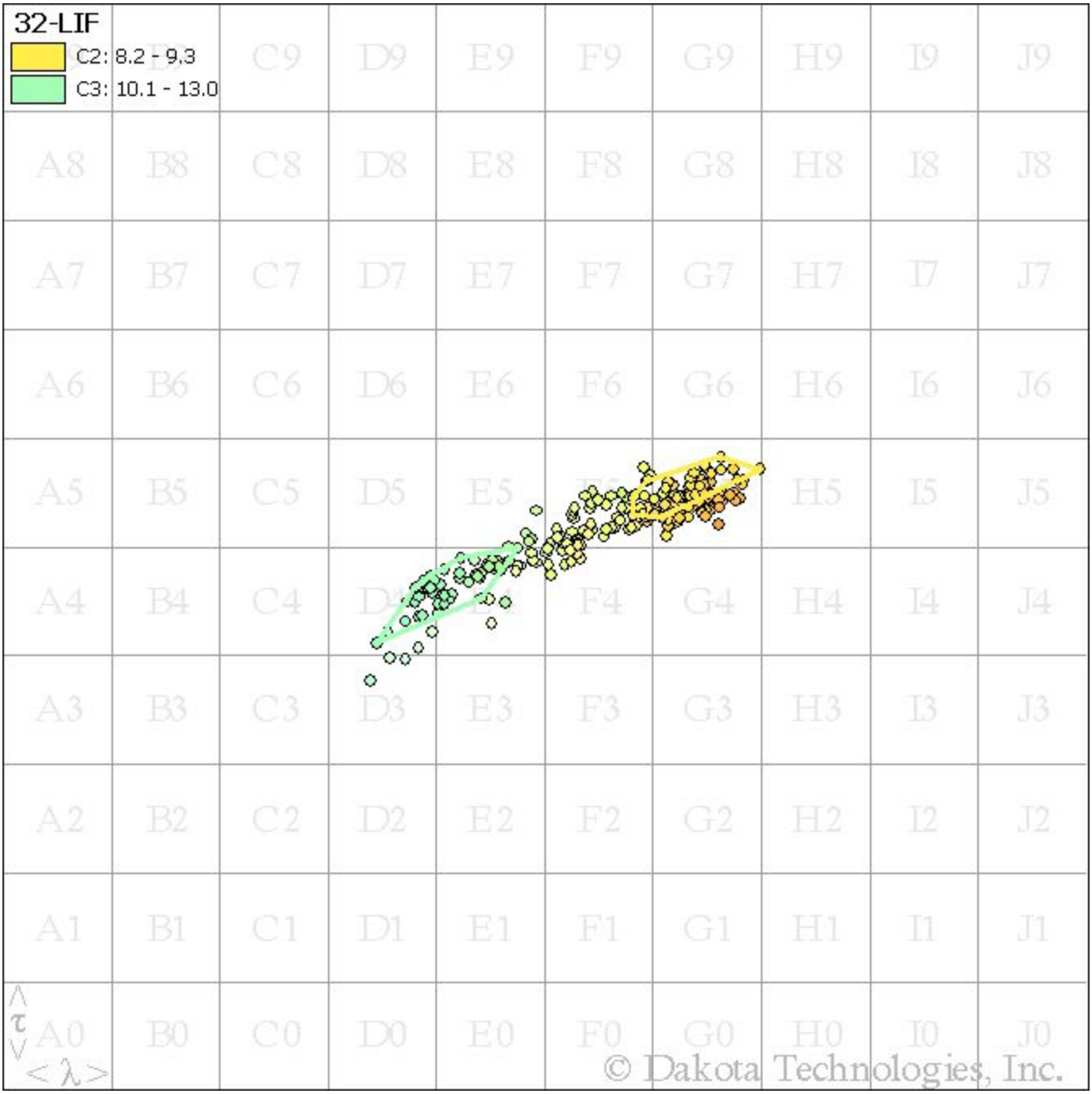
32-LIF
C2: 8.2 - 9.3
C3: 10.1 - 13.0
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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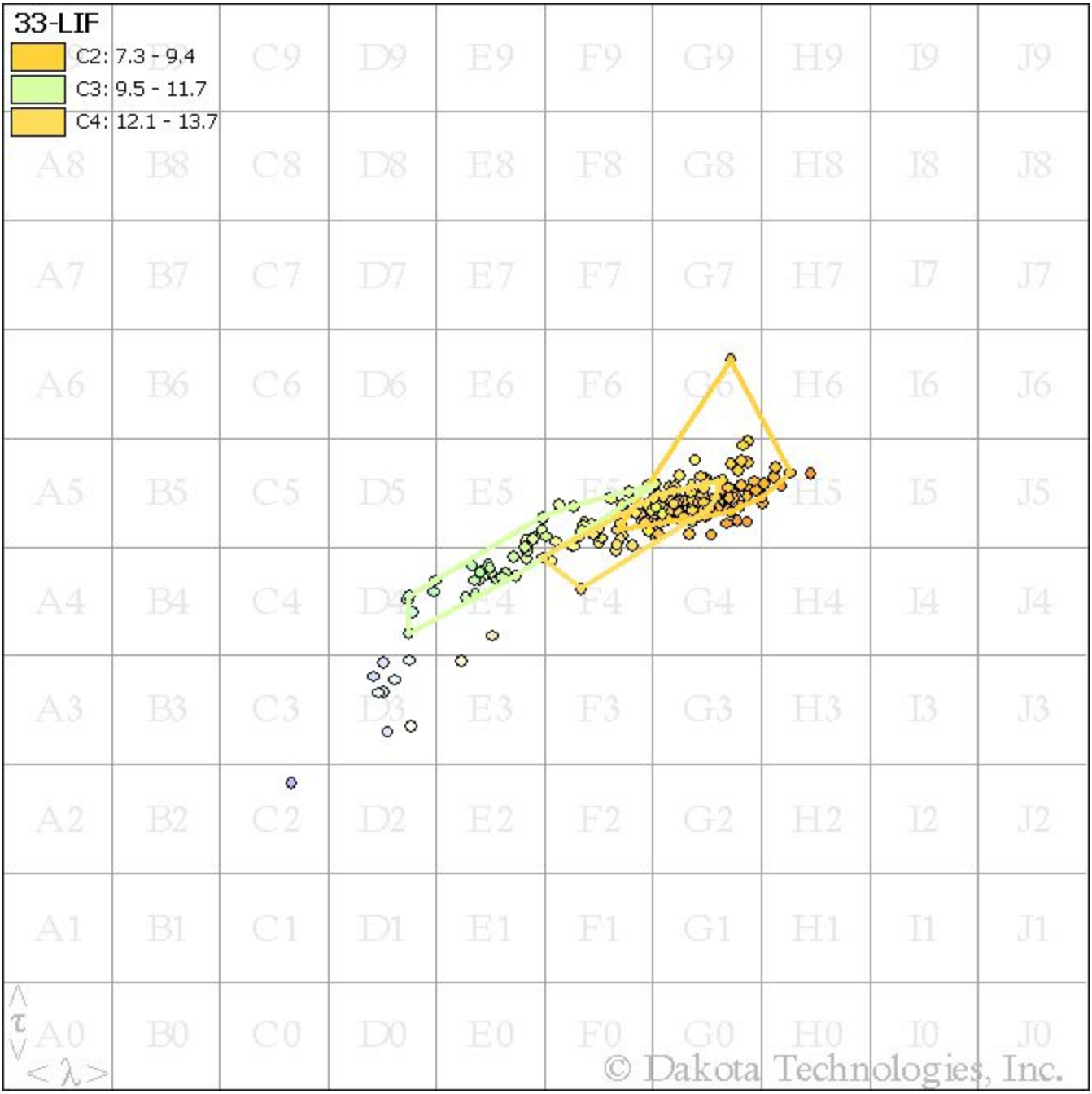
33-LIF
C2: 7.3 - 9.4
C3: 9.5 - 11.7
C4: 12.1 - 13.7
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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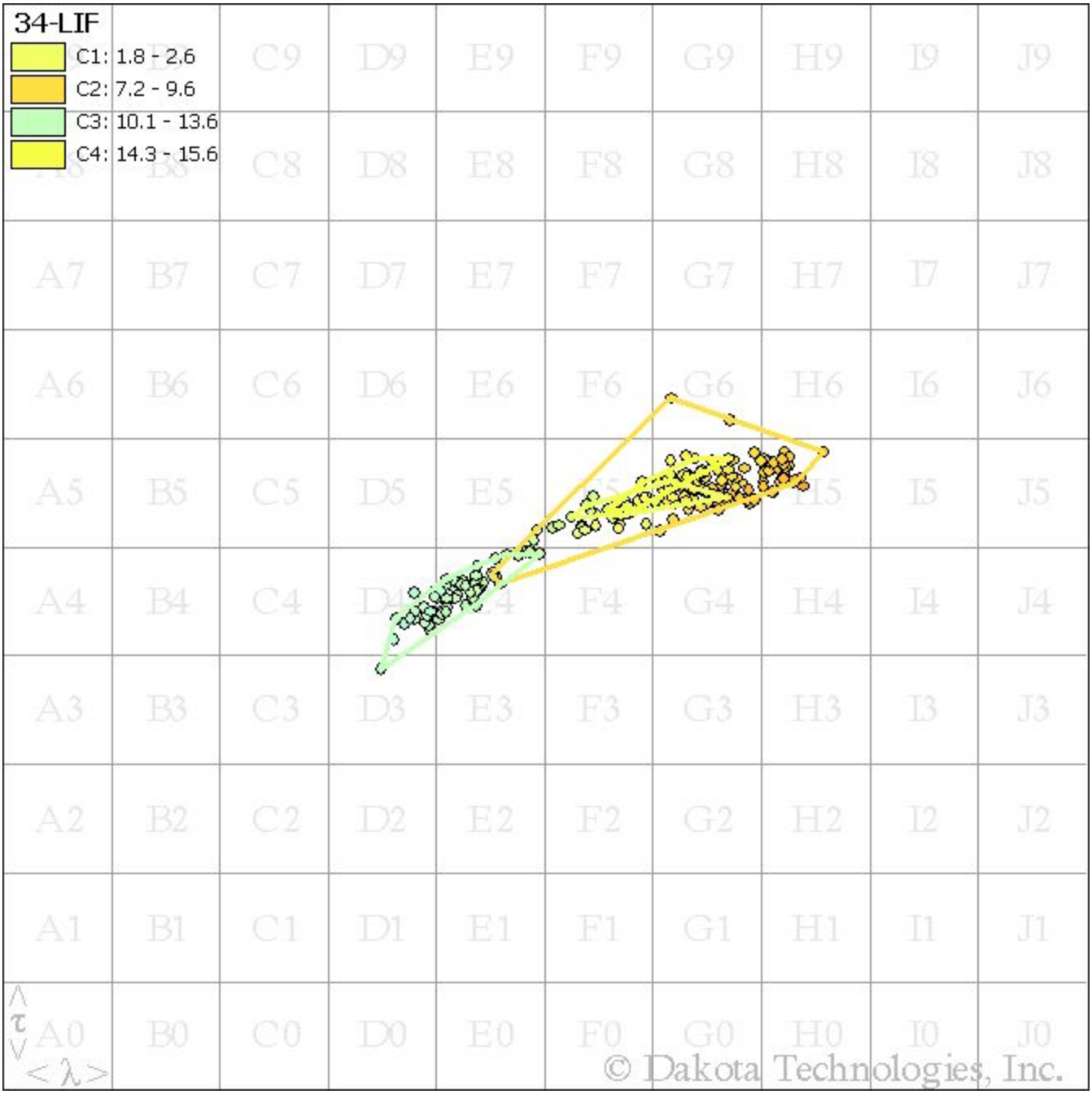
34-LIF
C1: 1.8 - 2.6
C2: 7.2 - 9.6
C3: 10.1 - 13.6
C4: 14.3 - 15.6
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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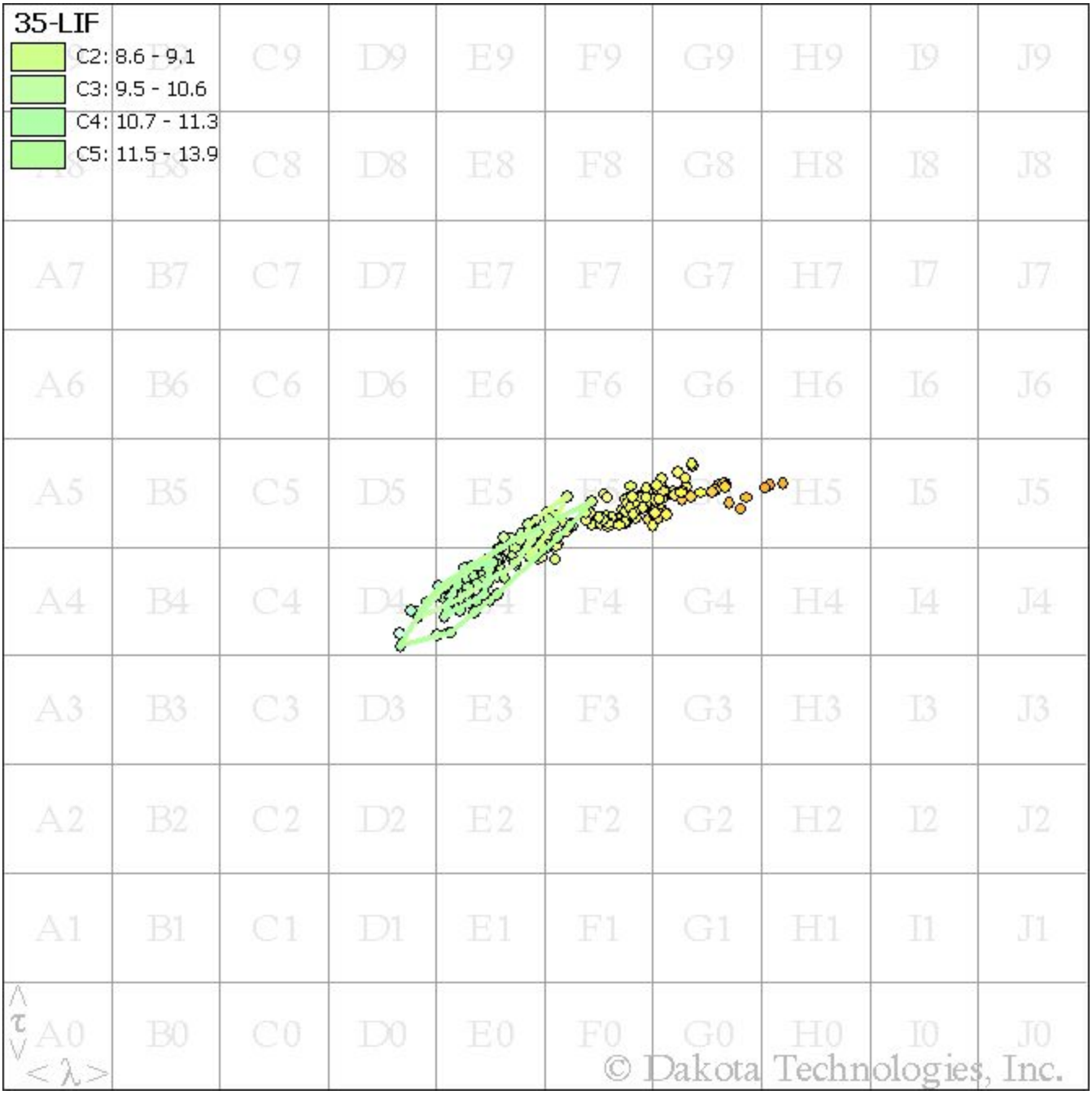
35-LIF
C2: 8.6 - 9.1
C3: 9.5 - 10.6
C4: 10.7 - 11.3
C5: 11.5 - 13.9
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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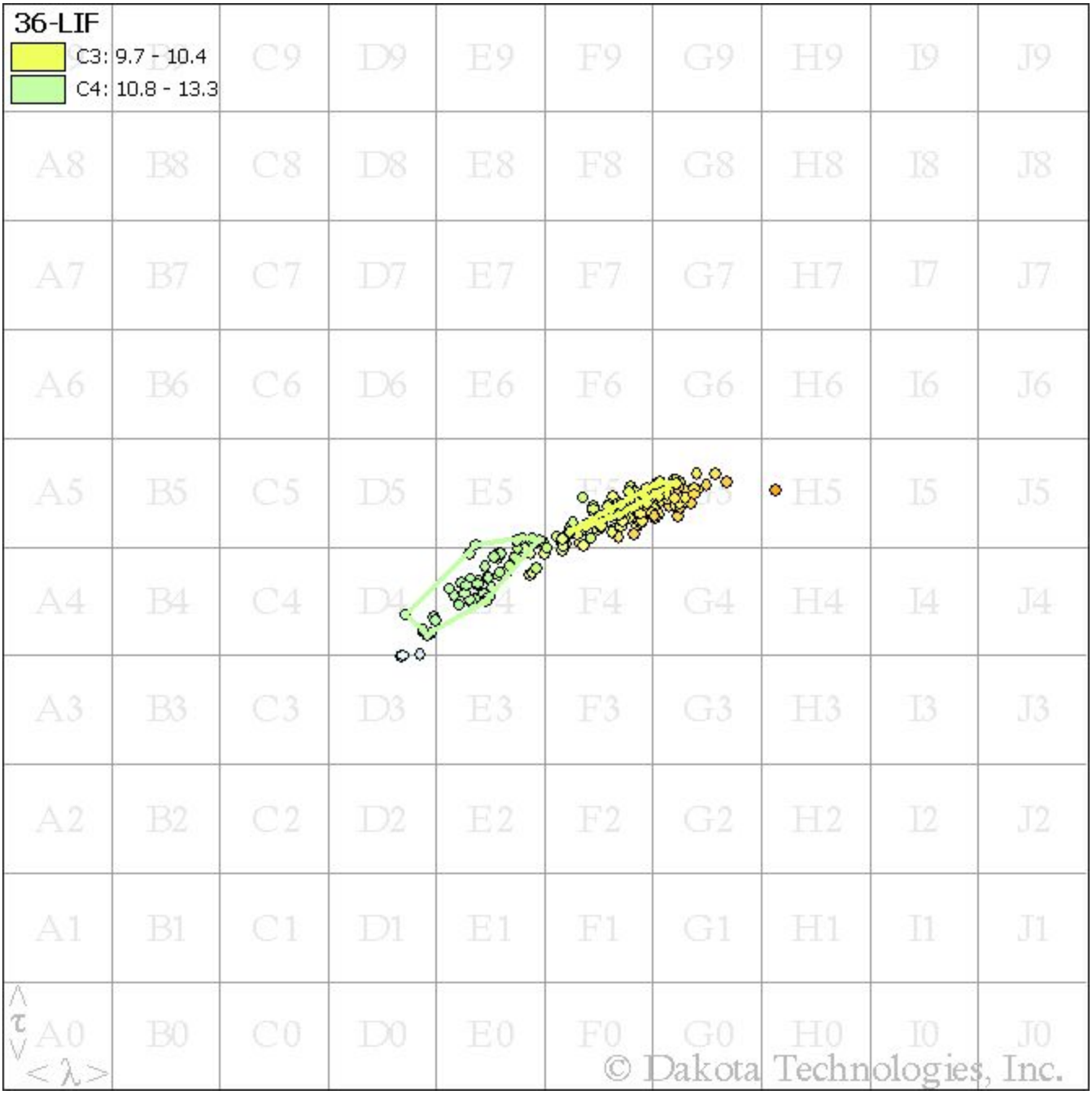
36-LIF
C3: 9.7 - 10.4
C4: 10.8 - 13.3
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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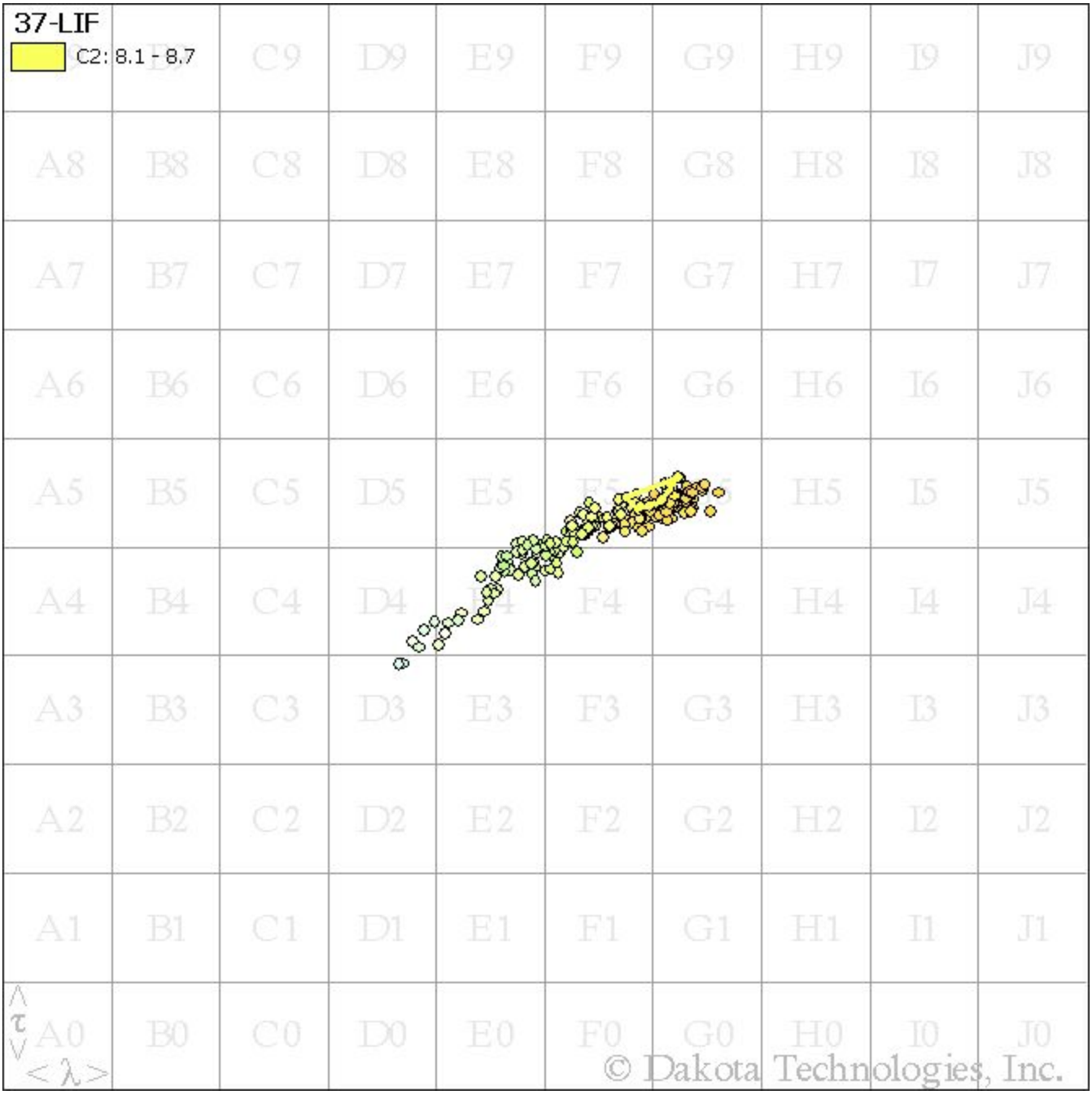
37-LIF
C2: 8.1 - 8.7
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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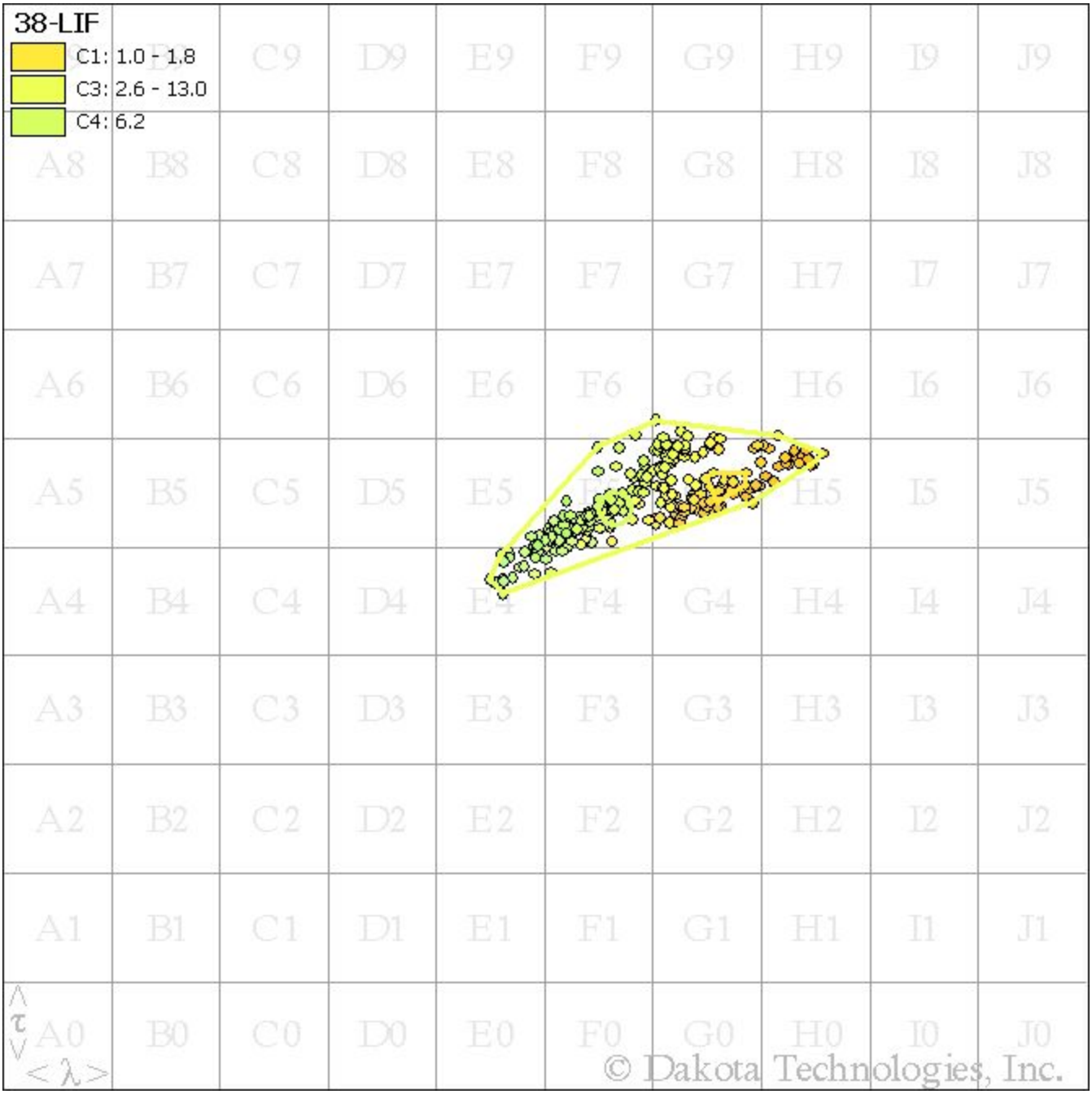
38-LIF
C1: 1.0 - 1.8
C3: 2.6 - 13.0
C4: 6.2
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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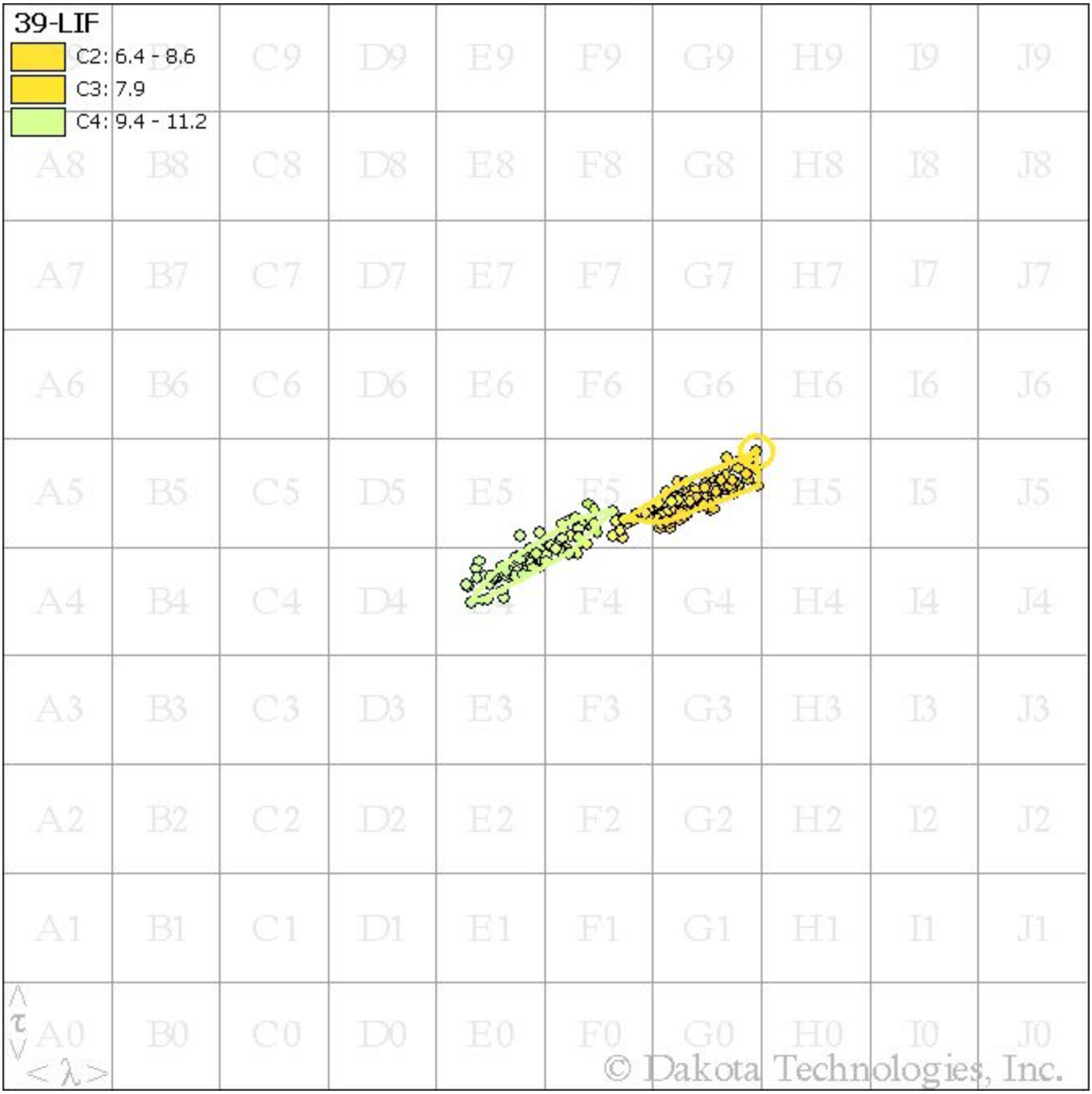
39-LIF
C2: 6.4 - 8.6
C3: 7.9
C4: 9.4 - 11.2
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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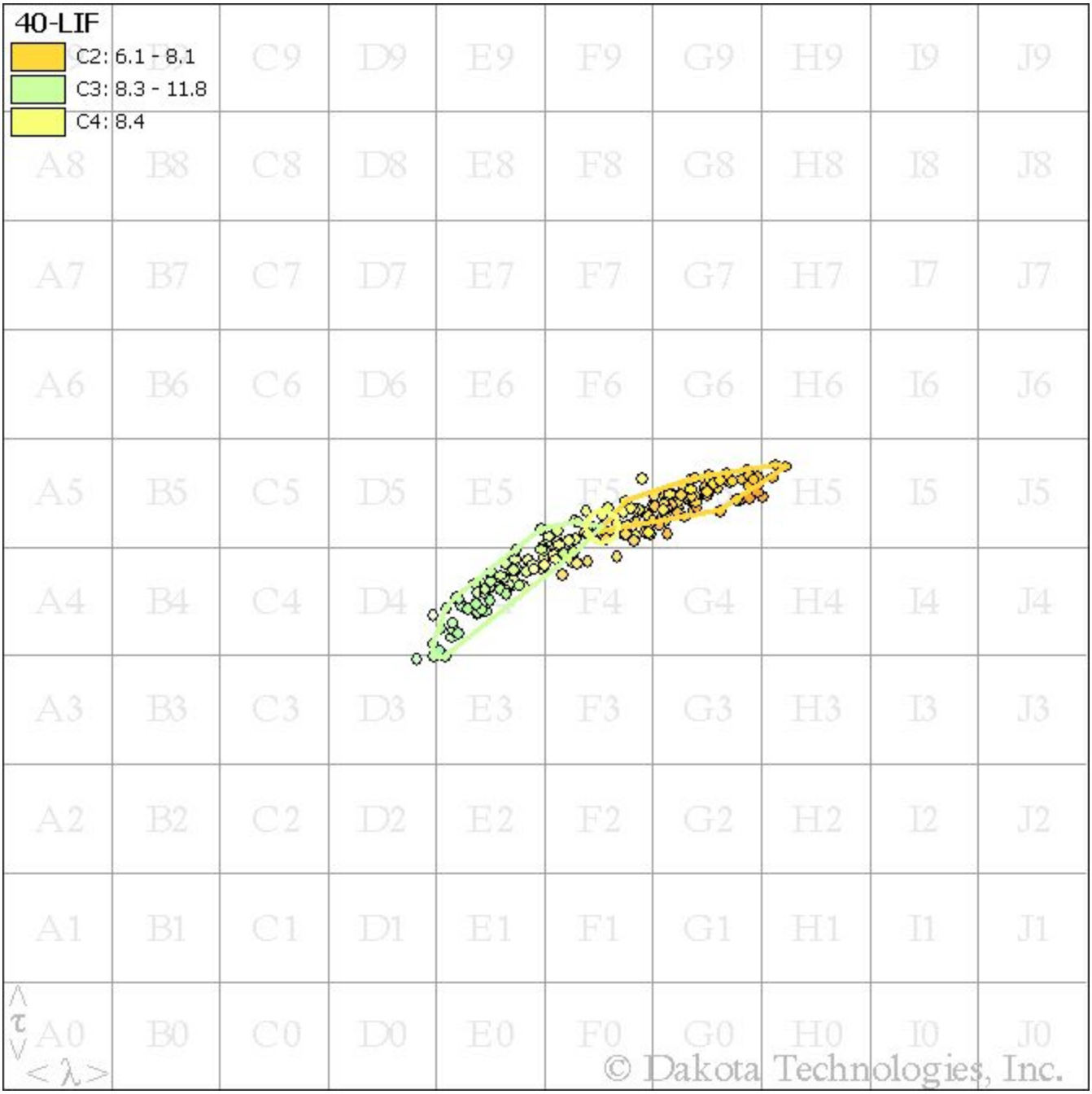
40-LIF
C2: 6.1 - 8.1
C3: 8.3 - 11.8
C4: 8.4
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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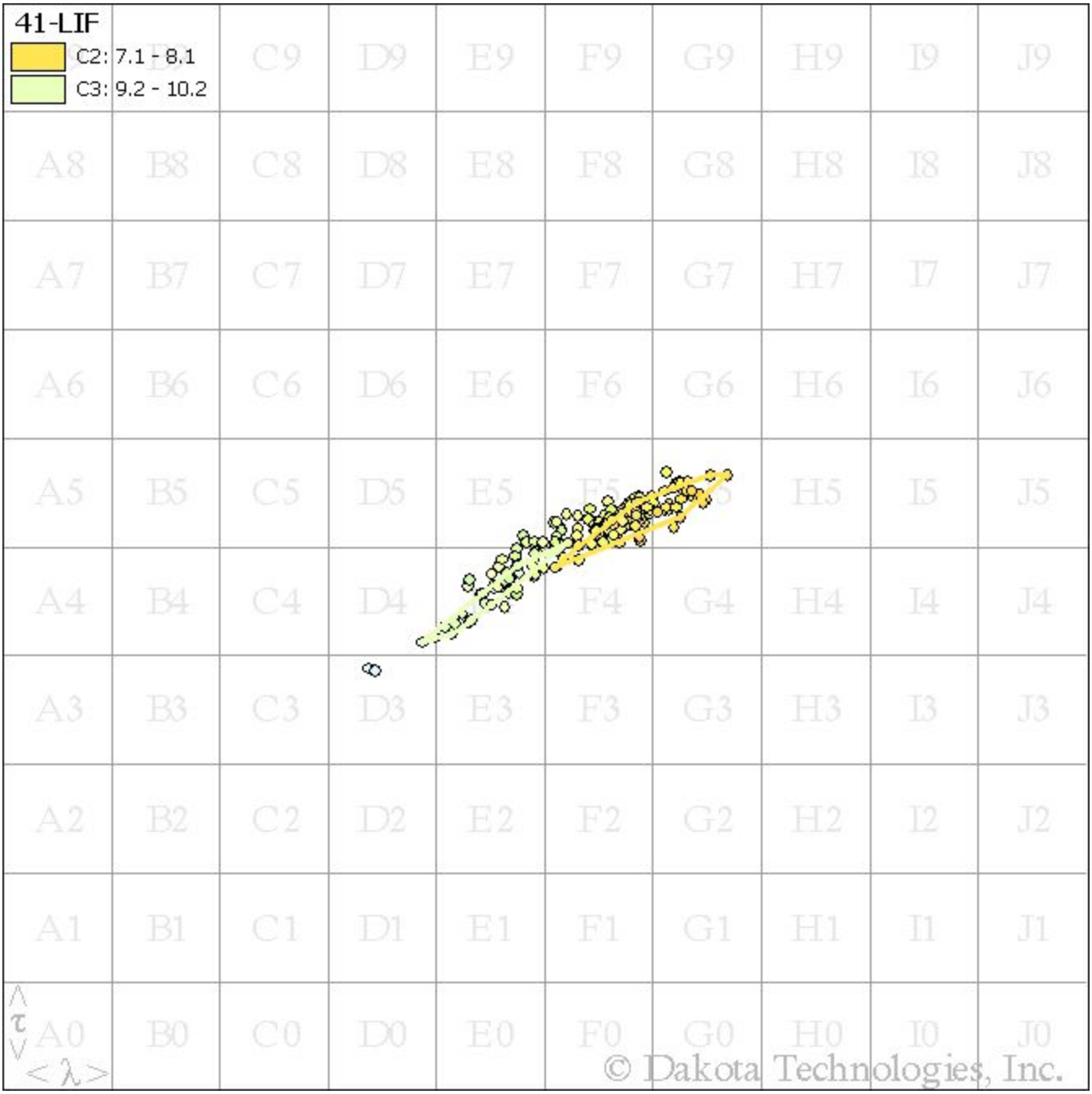
© Dakota Technologies, Inc.


41-LIF
C2: 7.1 - 8.1
C3: 9.2 - 10.2
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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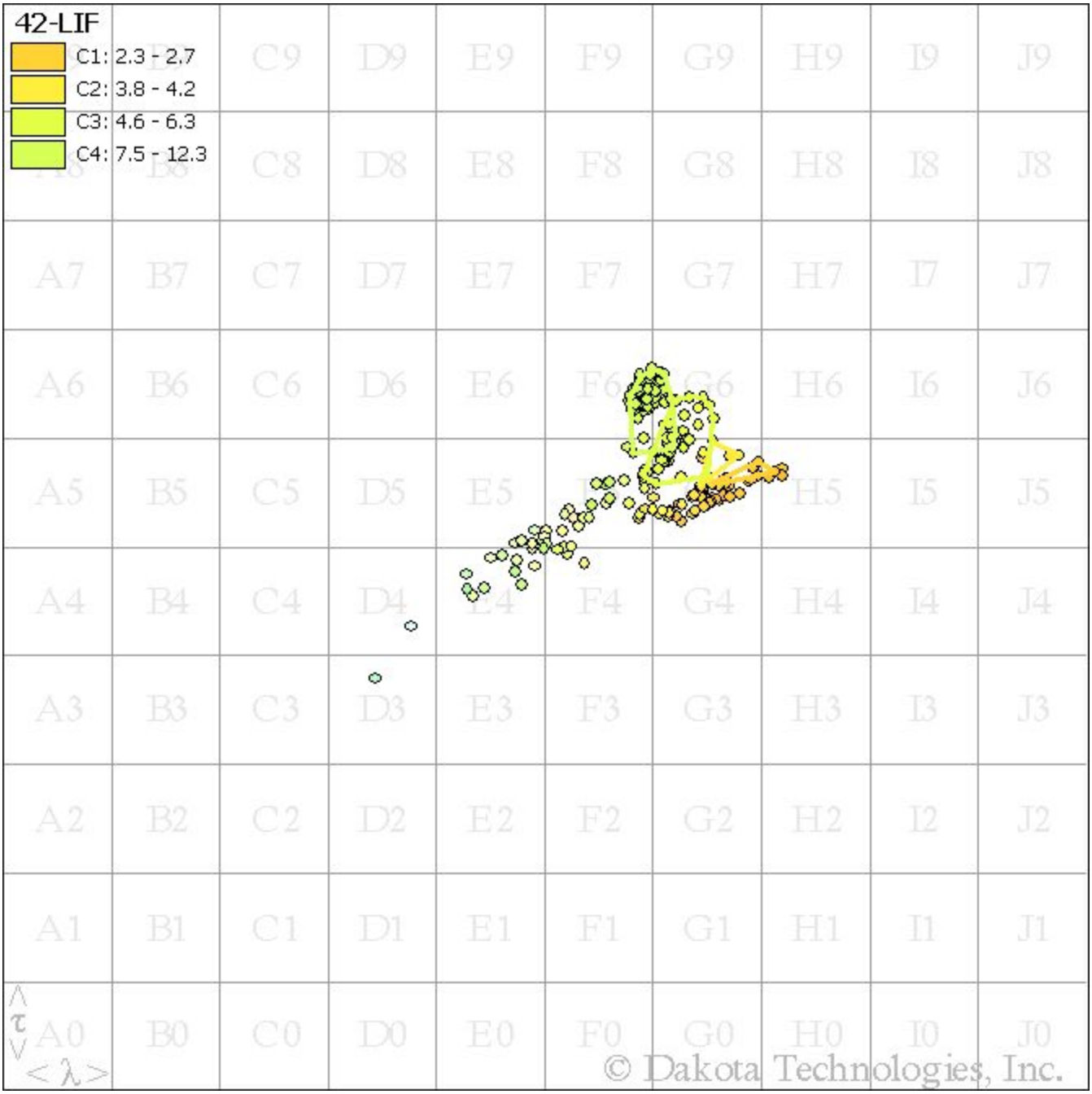
42-LIF
C1: 2.3 - 2.7
C2: 3.8 - 4.2
C3: 4.6 - 6.3
C4: 7.5 - 12.3
C9 D9 E9 F9 G9 H9 I9 J9
C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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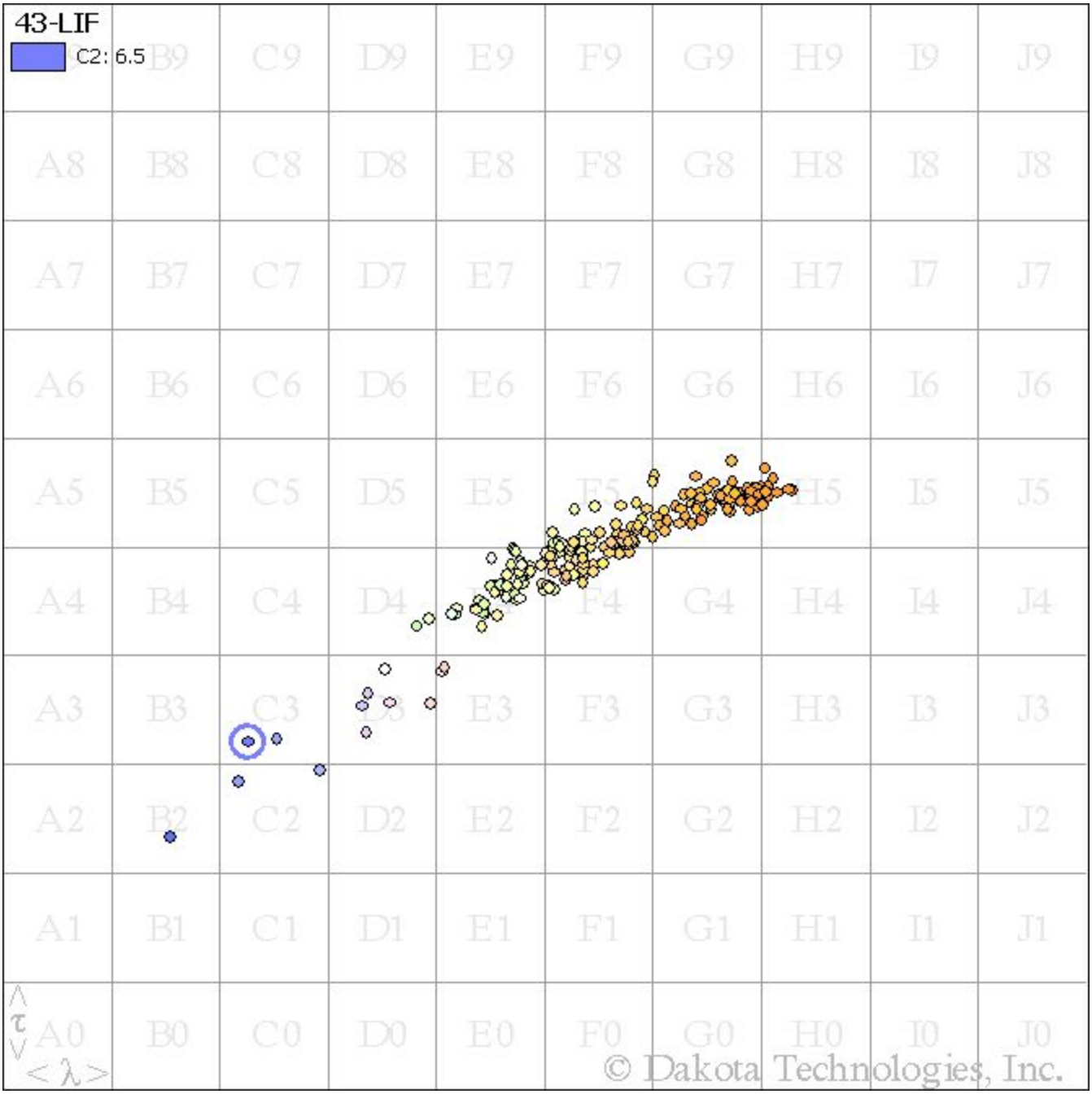
43-LIF
C2: 6.5
B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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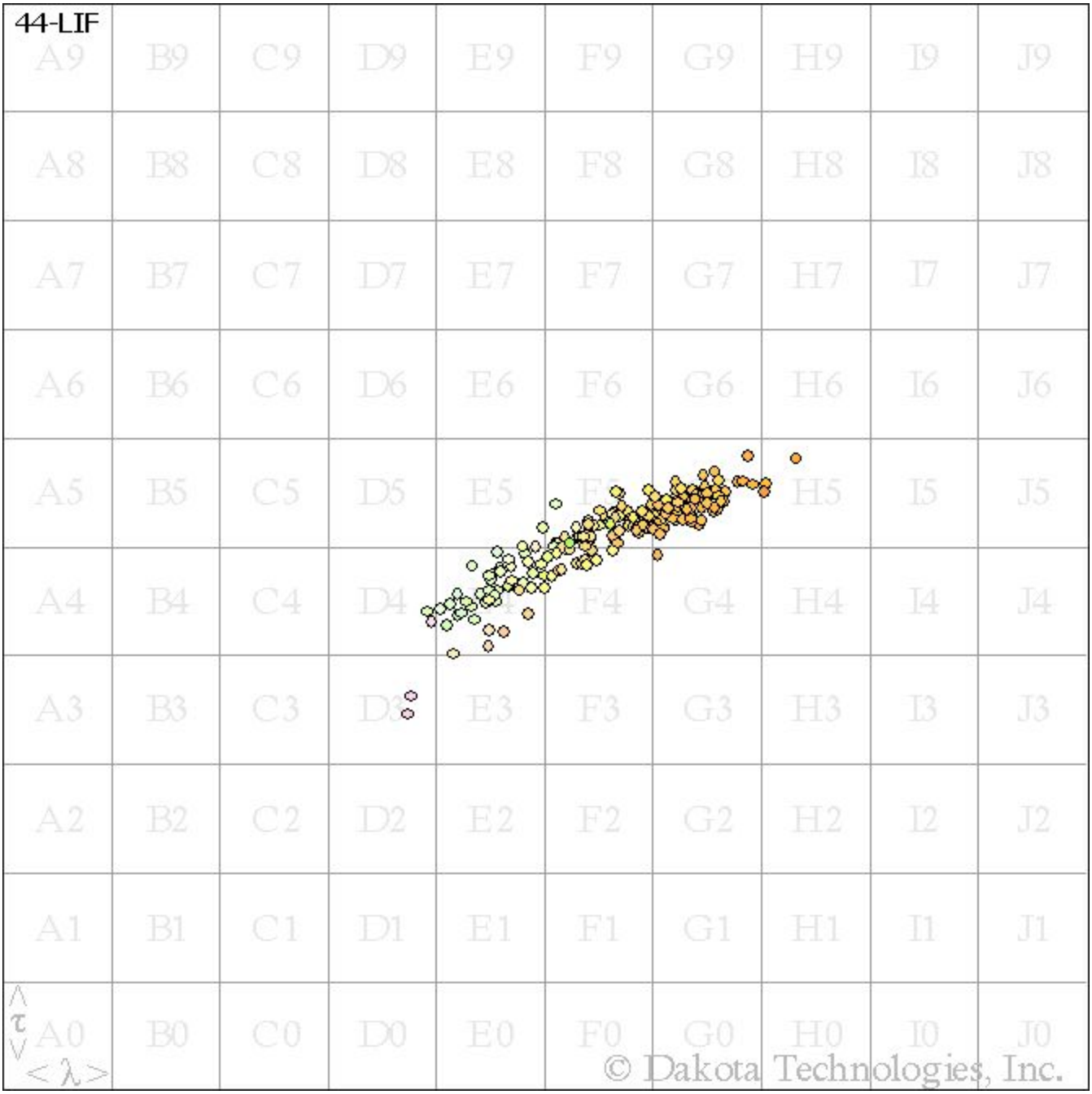
44-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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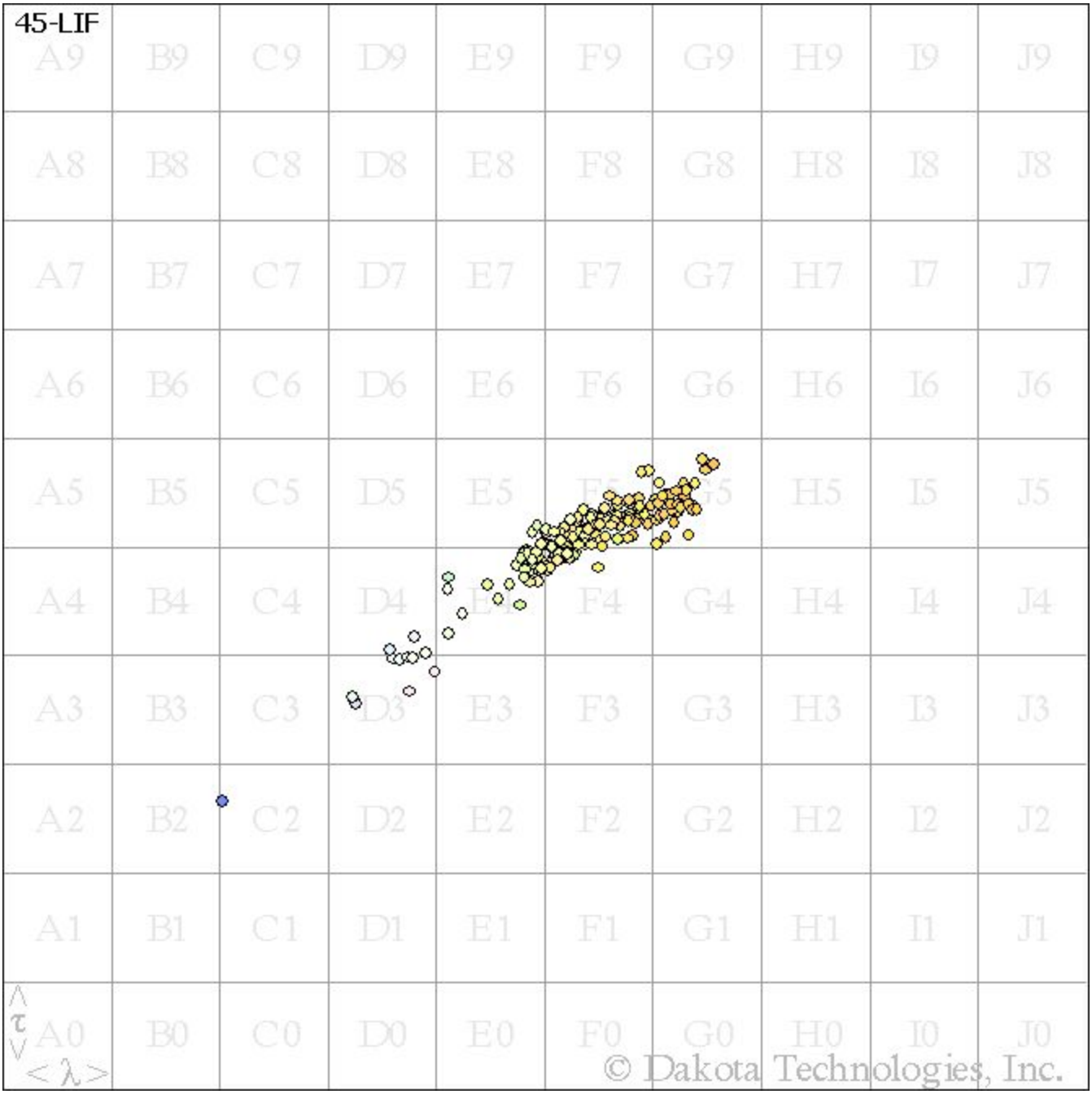
45-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
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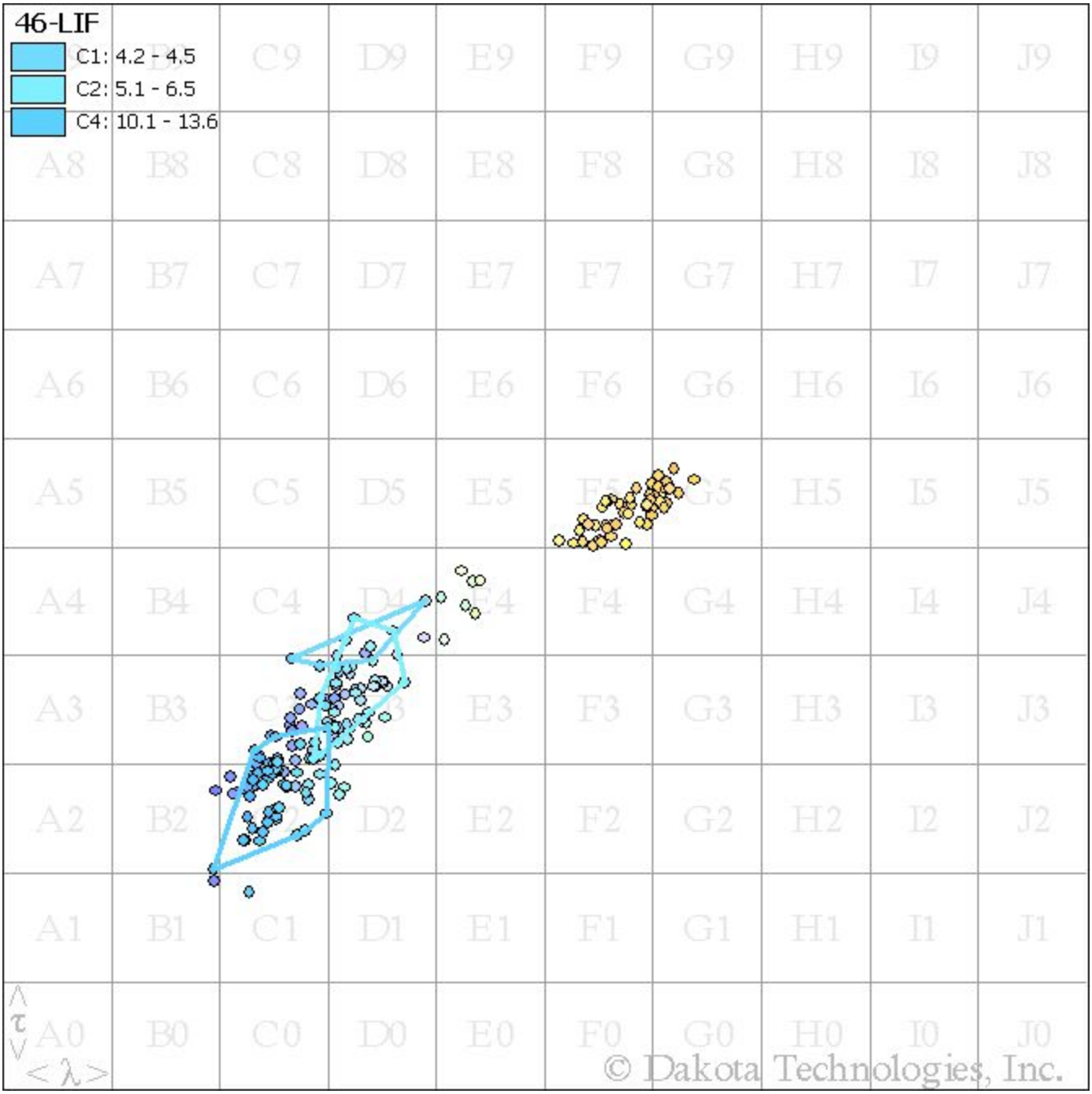
46-LIF
C1: 4.2 - 4.5
C2: 5.1 - 6.5
C4: 10.1 - 13.6
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
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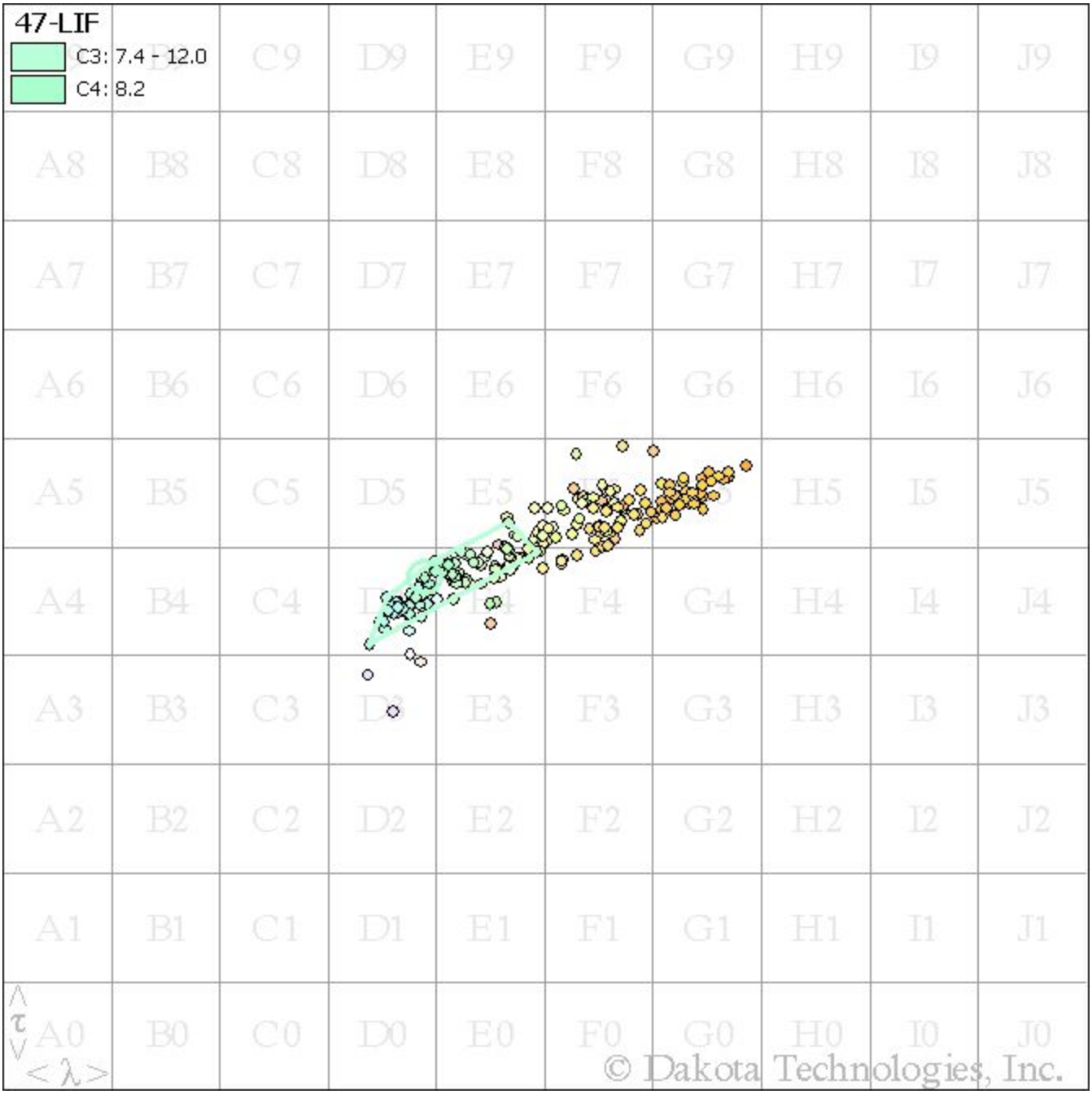
47-LIF
C3: 7.4 - 12.0
C4: 8.2
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 C3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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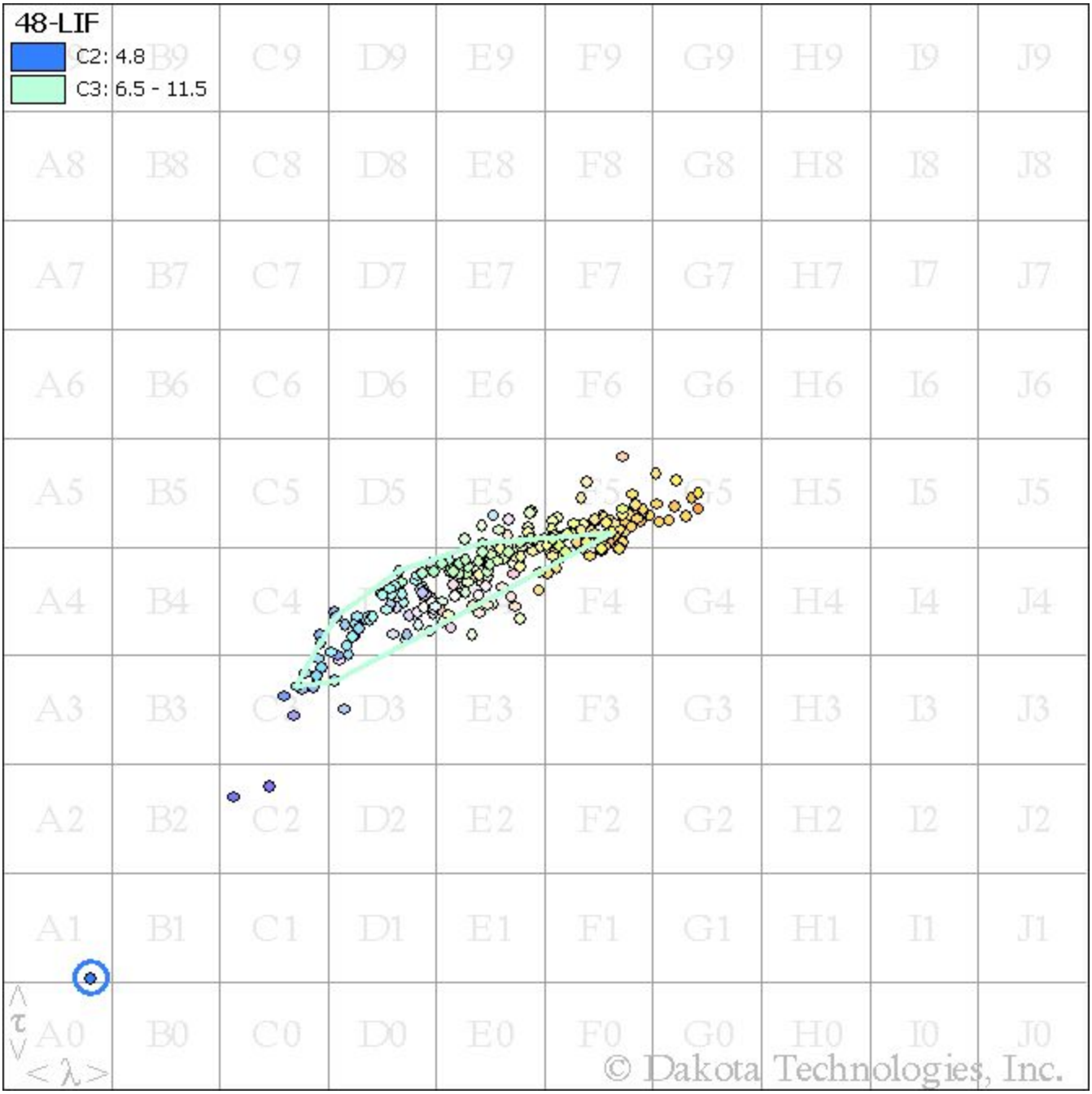
48-LIF
C2: 4.8
C3: 6.5 - 11.5
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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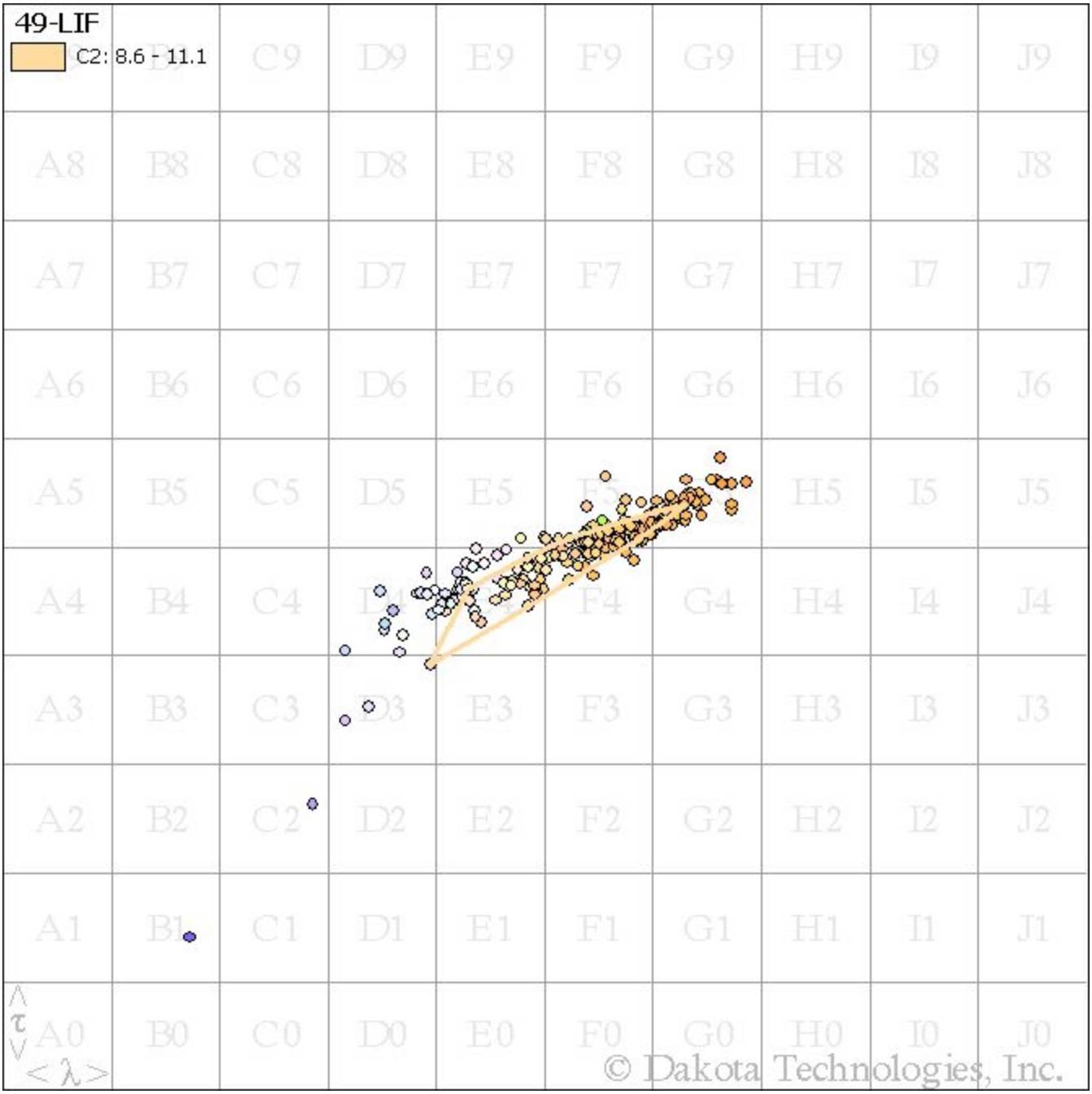
49-LIF
C2: 8.6 - 11.1
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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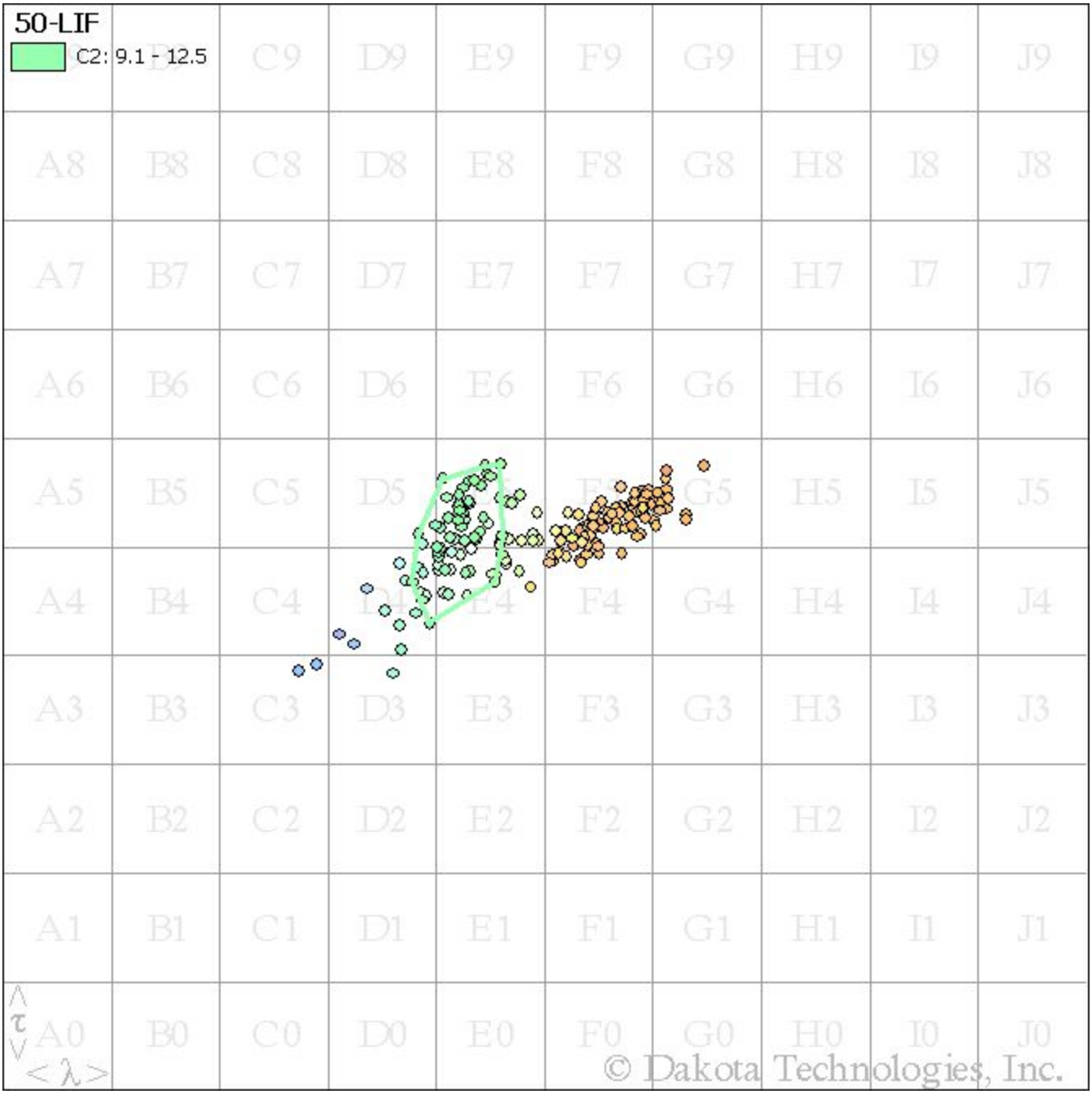
50-LIF
C2: 9.1 - 12.5
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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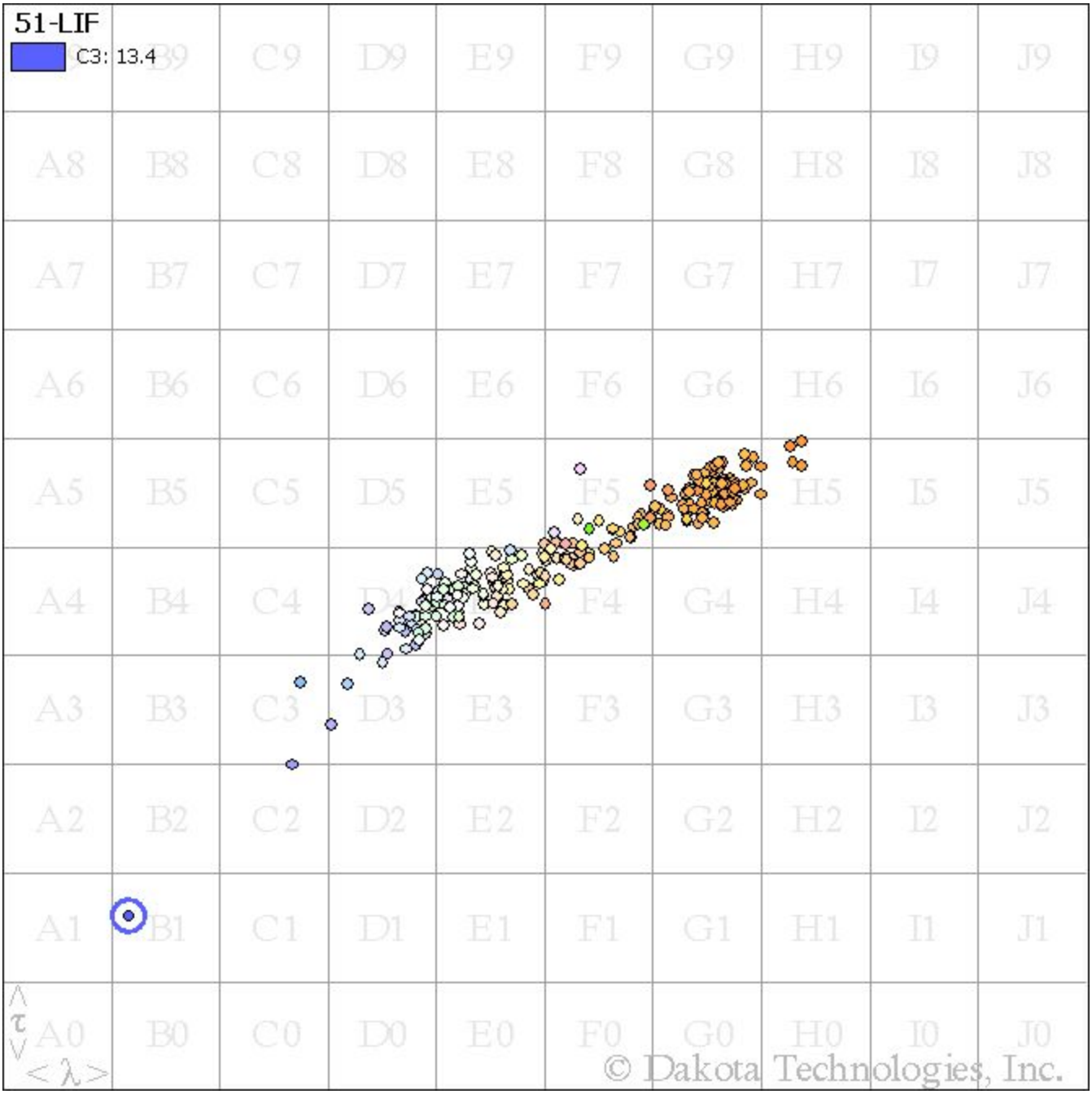
51-LIF
C3: 13.4
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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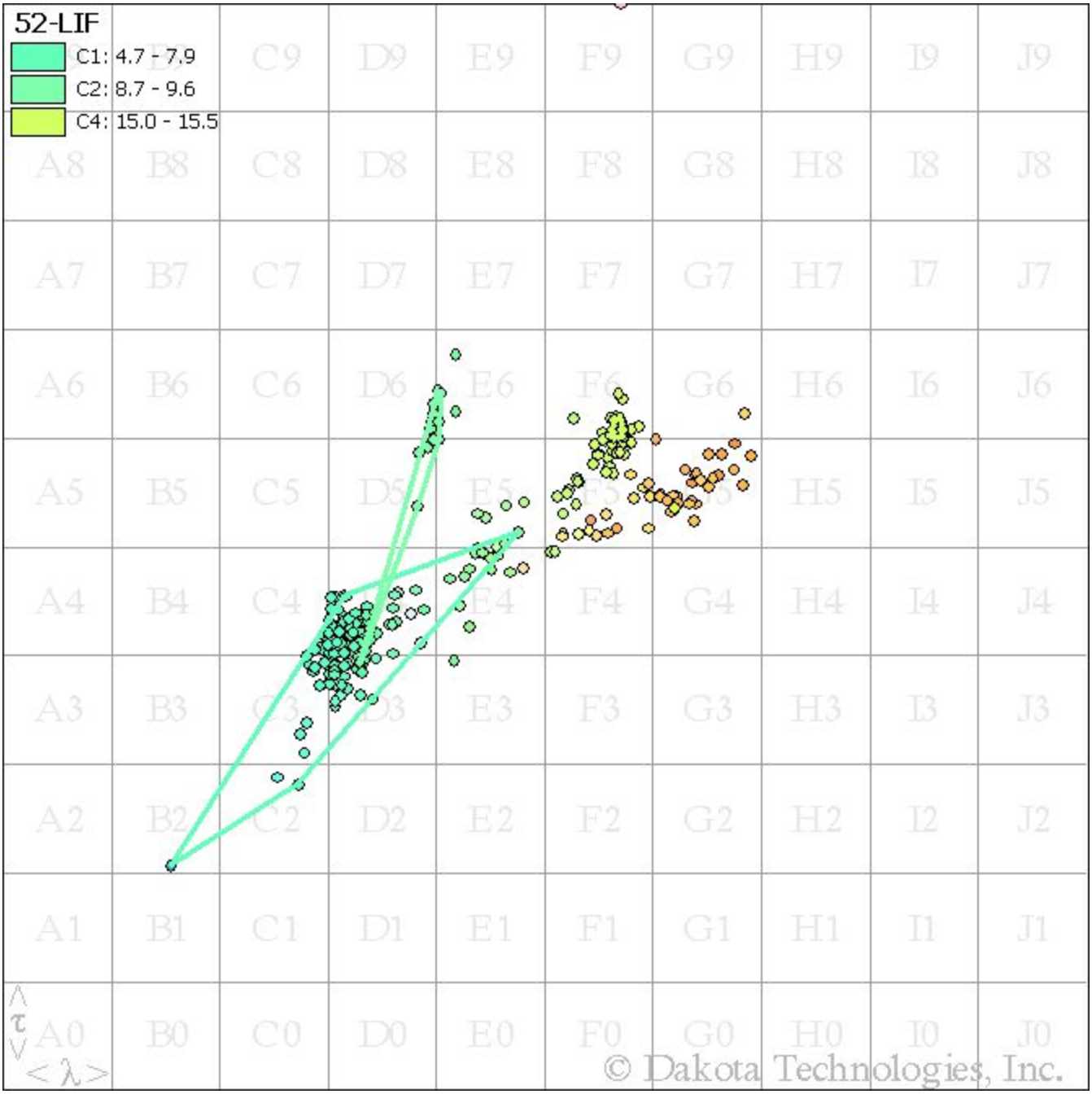
52-LIF
C1: 4.7 - 7.9
C2: 8.7 - 9.6
C4: 15.0 - 15.5
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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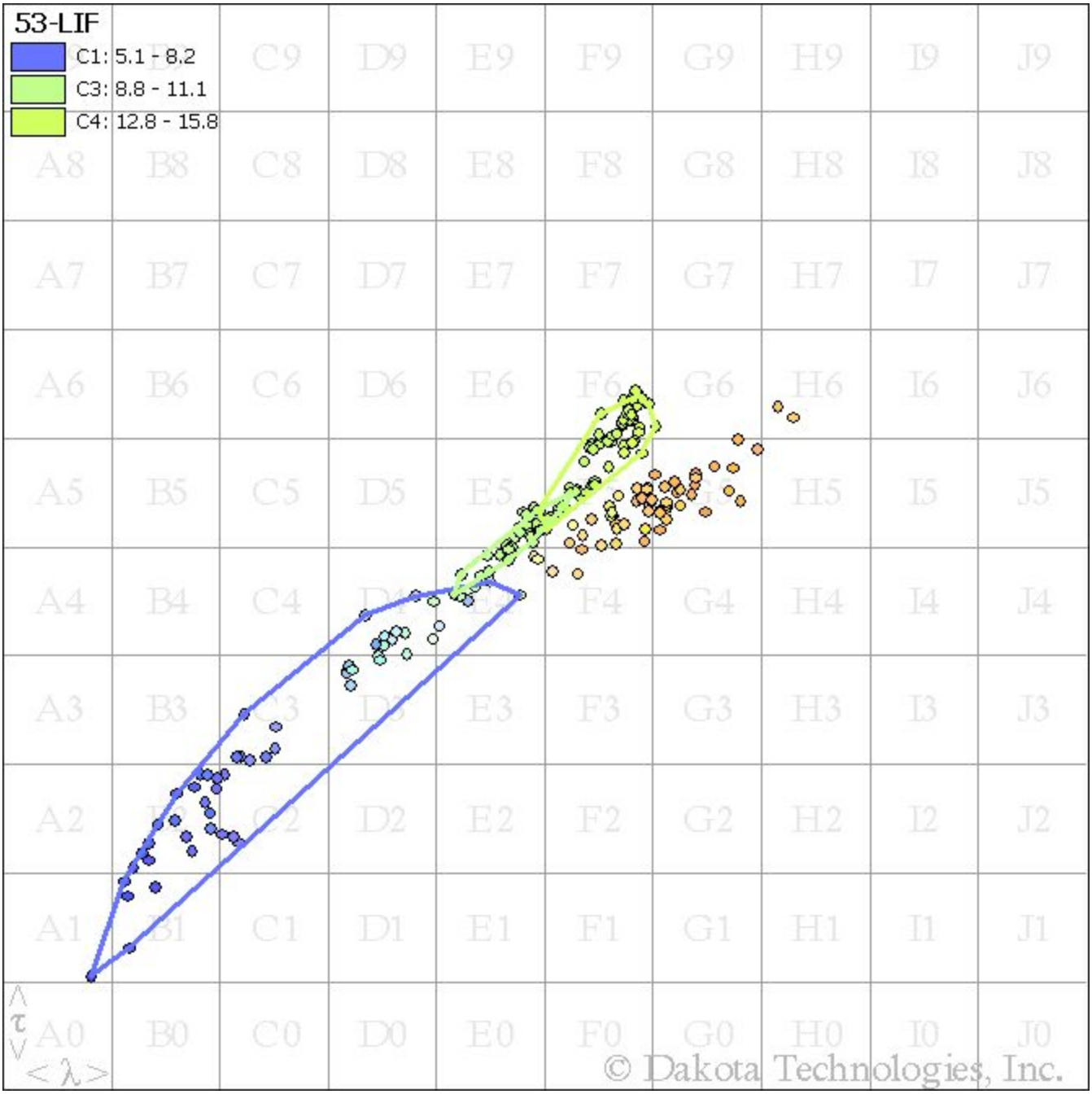
53-LIF
C1: 5.1 - 8.2
C3: 8.8 - 11.1
C4: 12.8 - 15.8
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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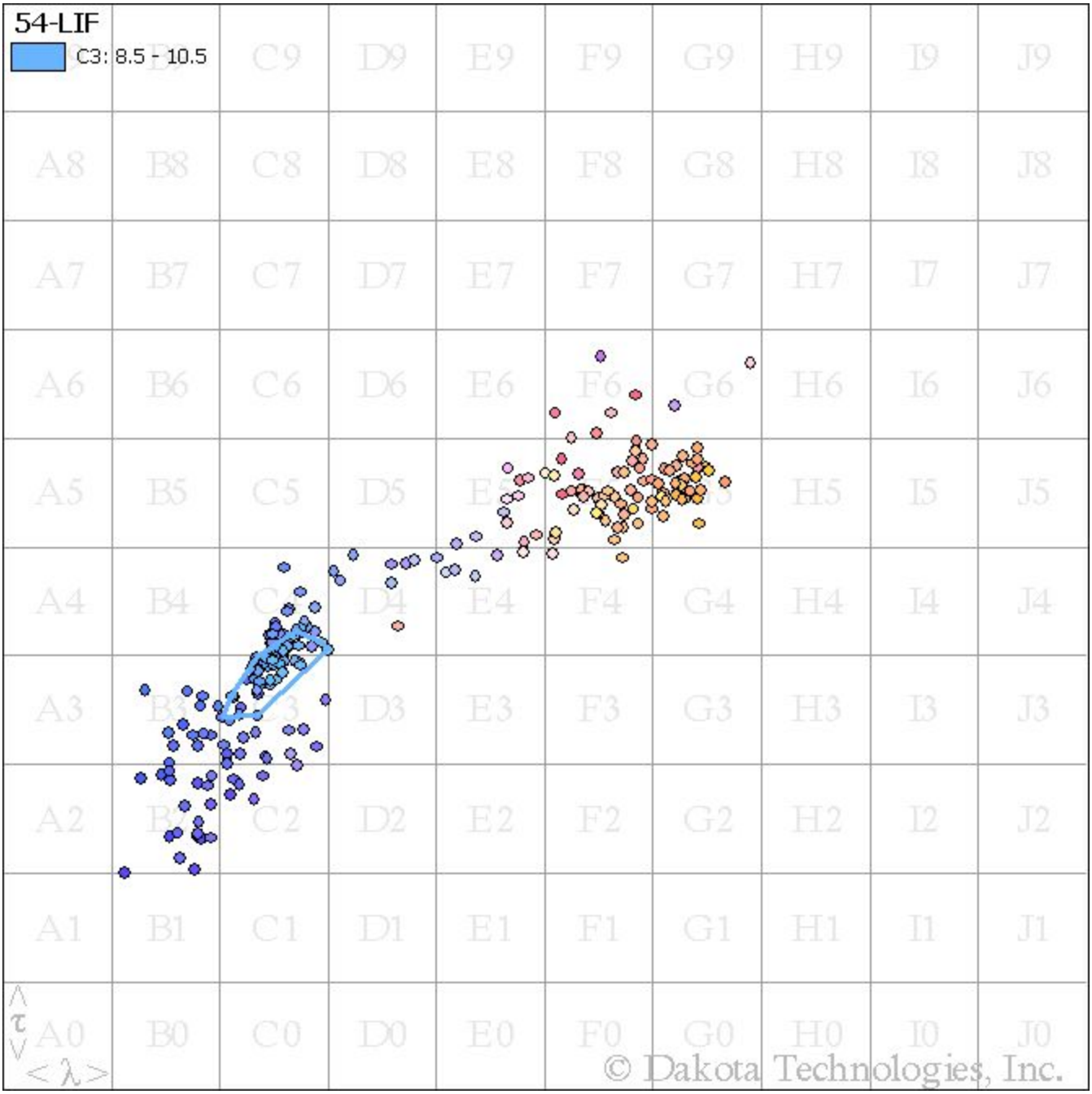
54-LIF
C3: 8.5 - 10.5
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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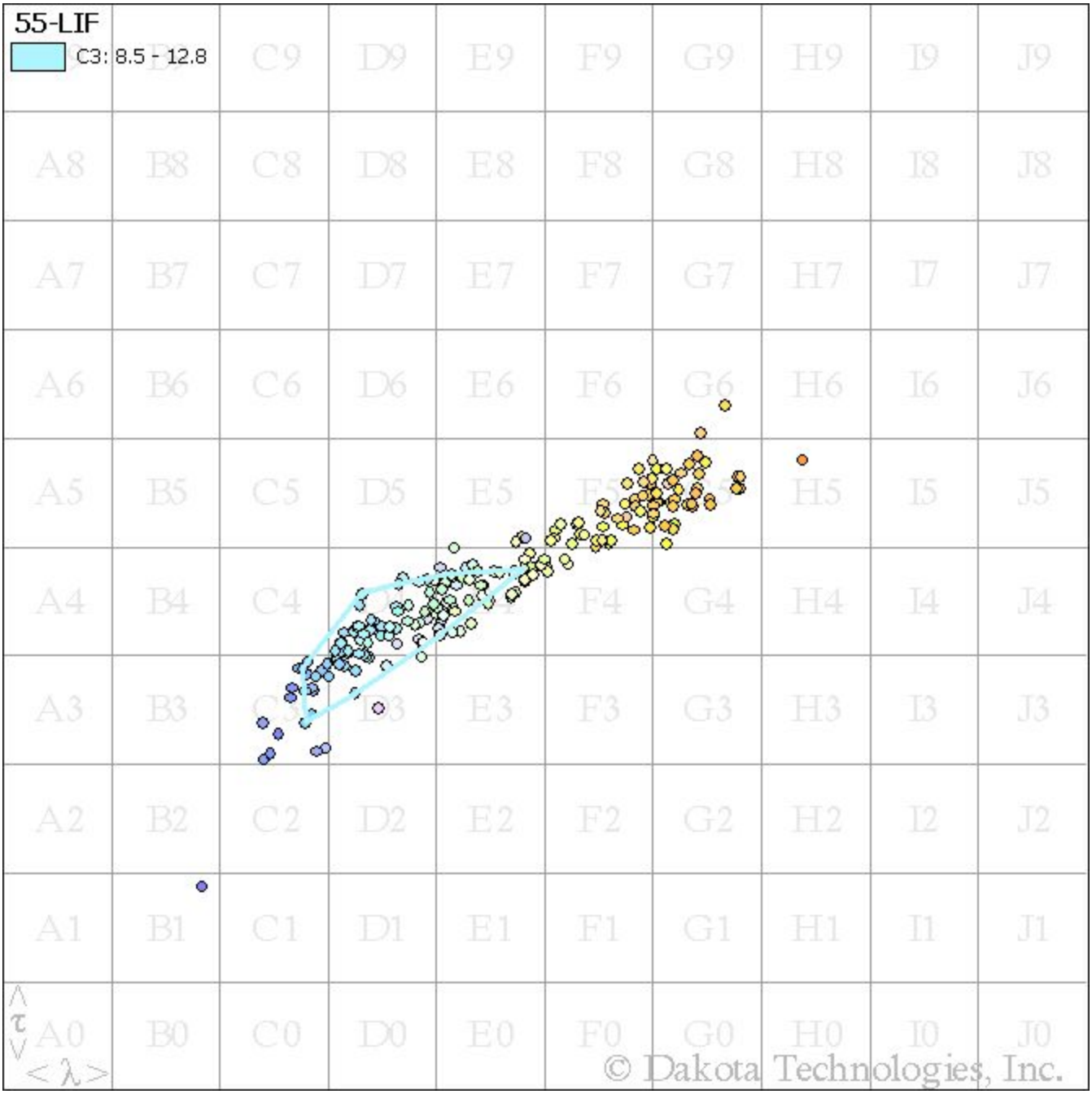
55-LIF
C3: 8.5 - 12.8
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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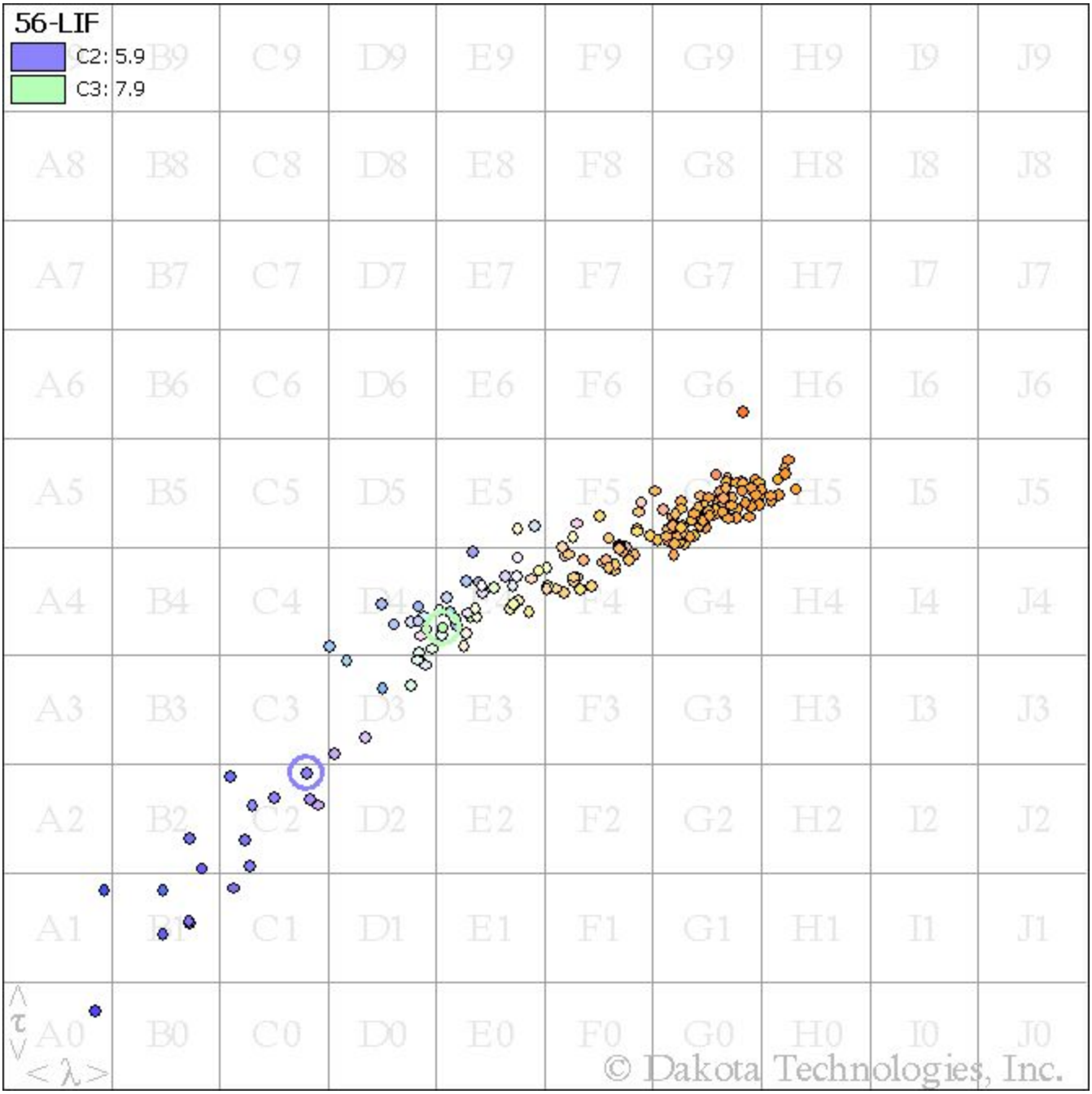
56-LIF
C2: 5.9
C3: 7.9
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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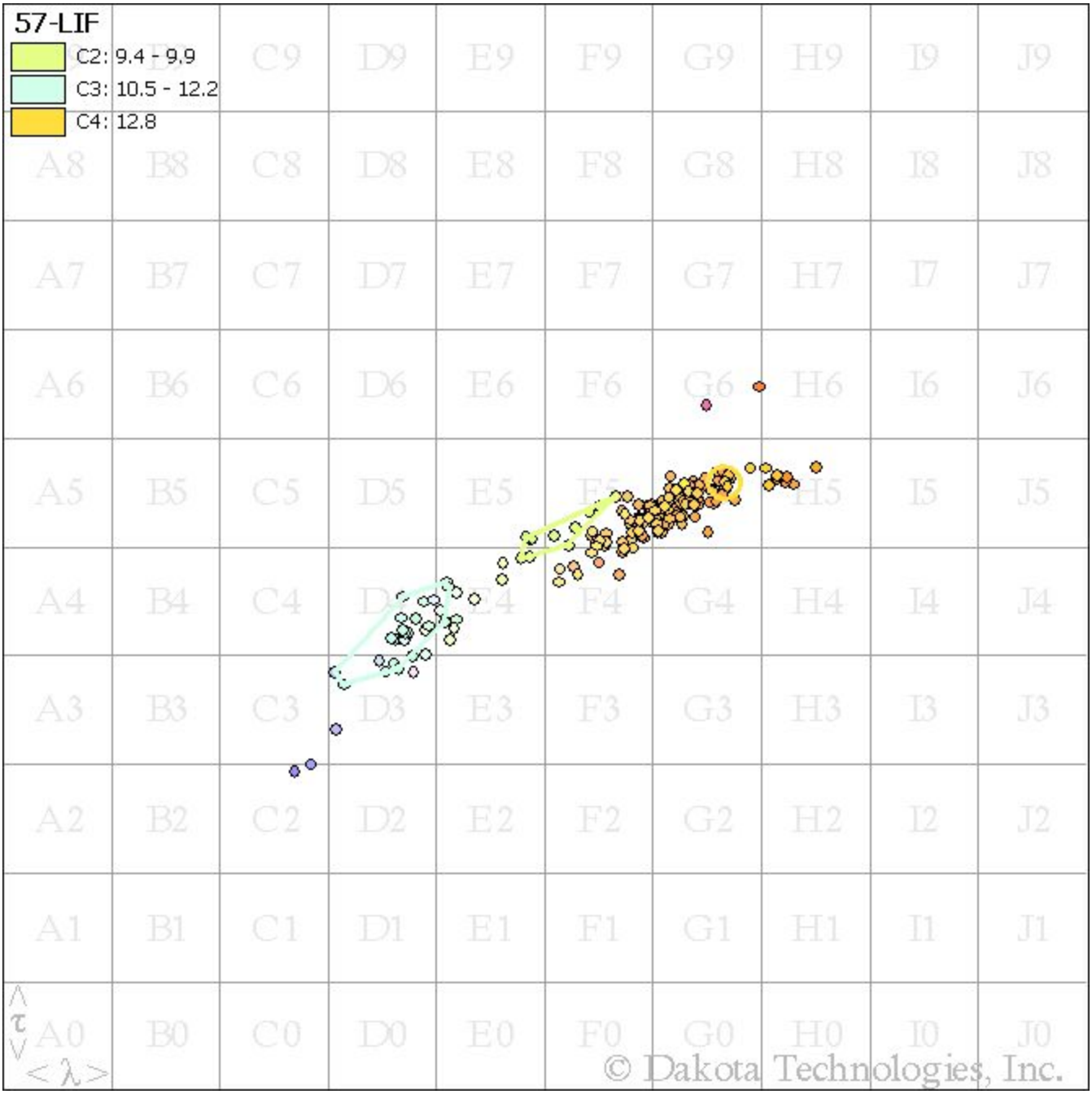
57-LIF
C2: 9.4 - 9.9
C3: 10.5 - 12.2
C4: 12.8
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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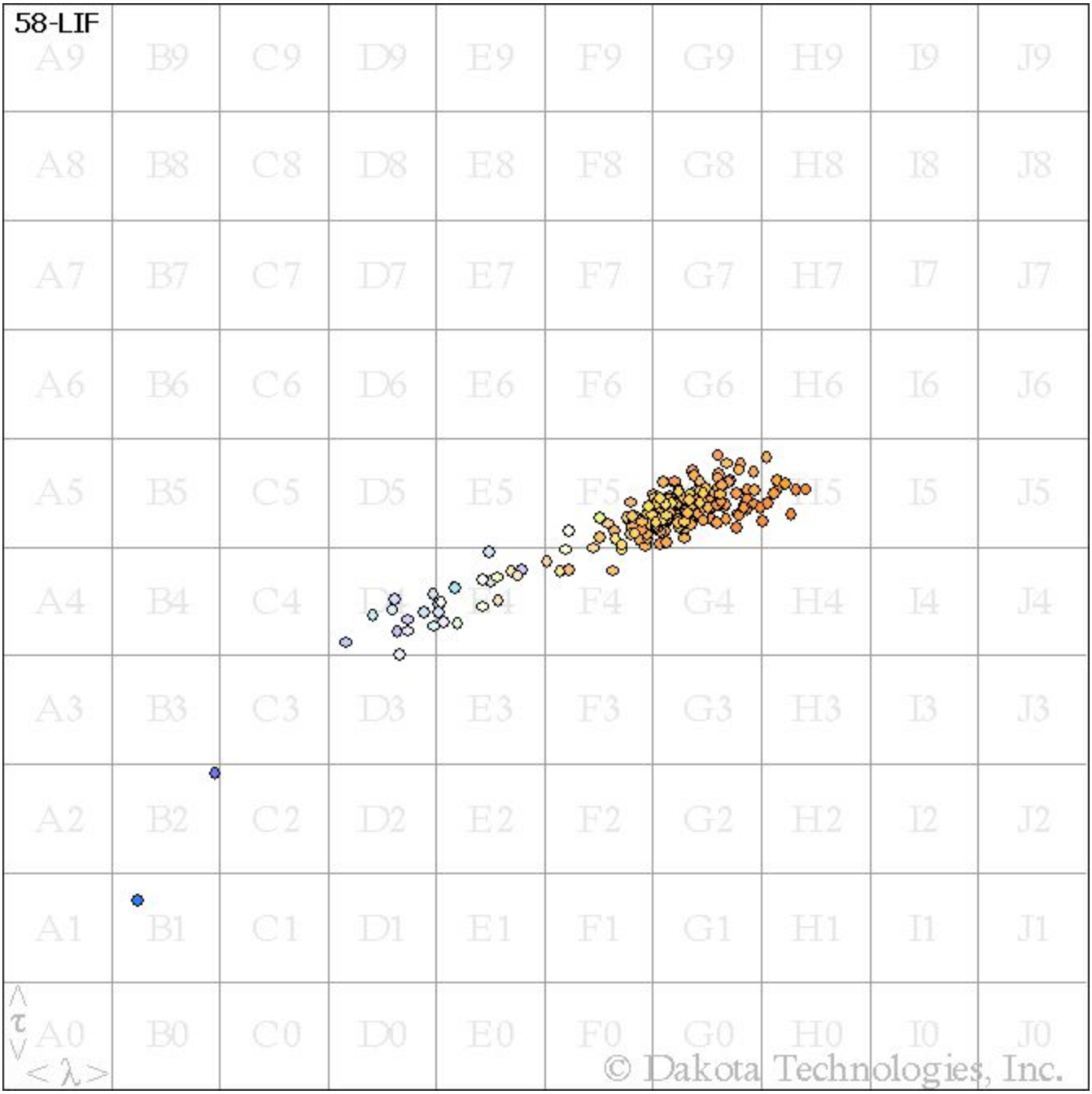
58-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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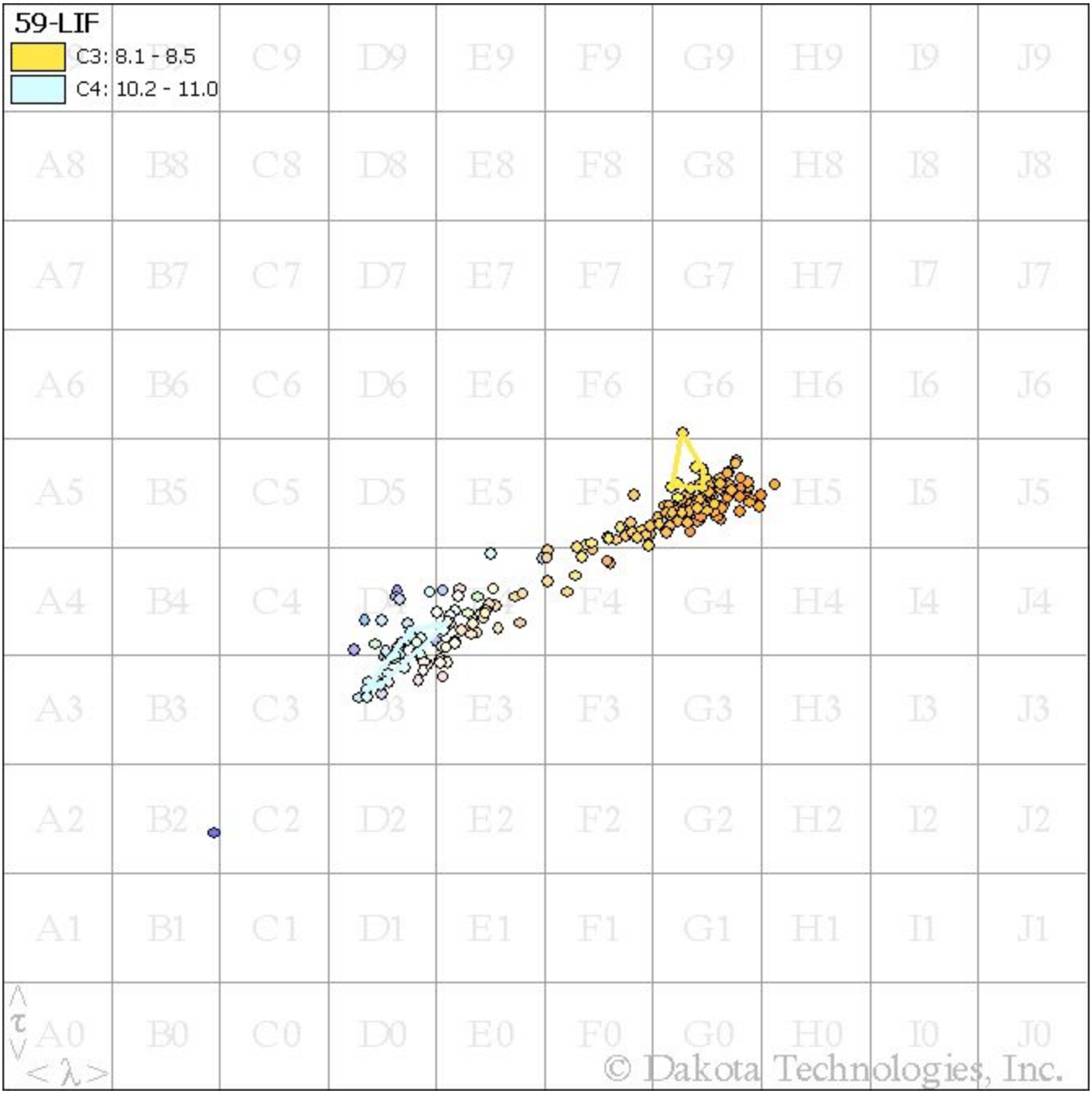
59-LIF
C3: 8.1 - 8.5
C4: 10.2 - 11.0
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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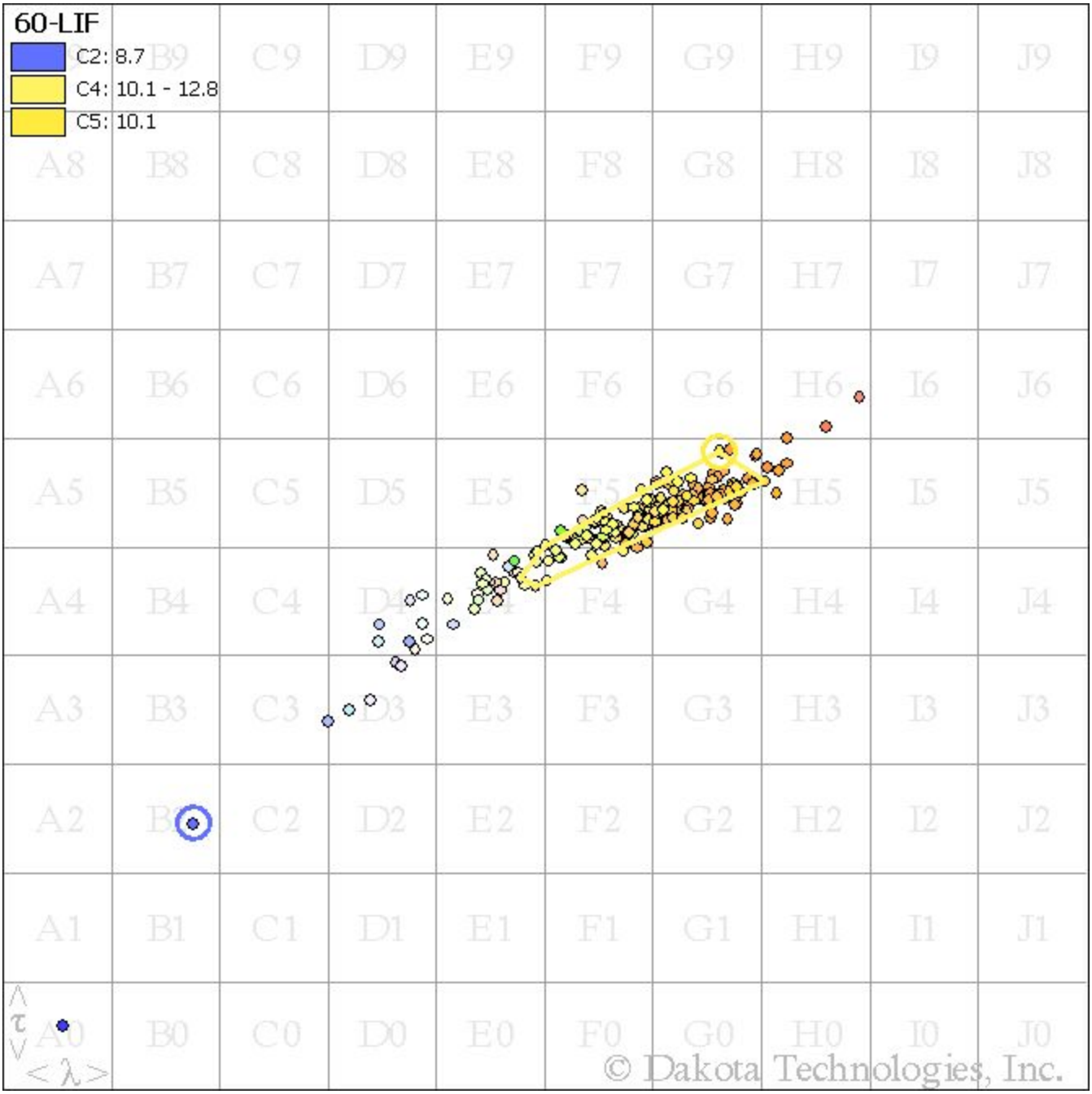
60-LIF
C2: 8.7
C4: 10.1 - 12.8
C5: 10.1
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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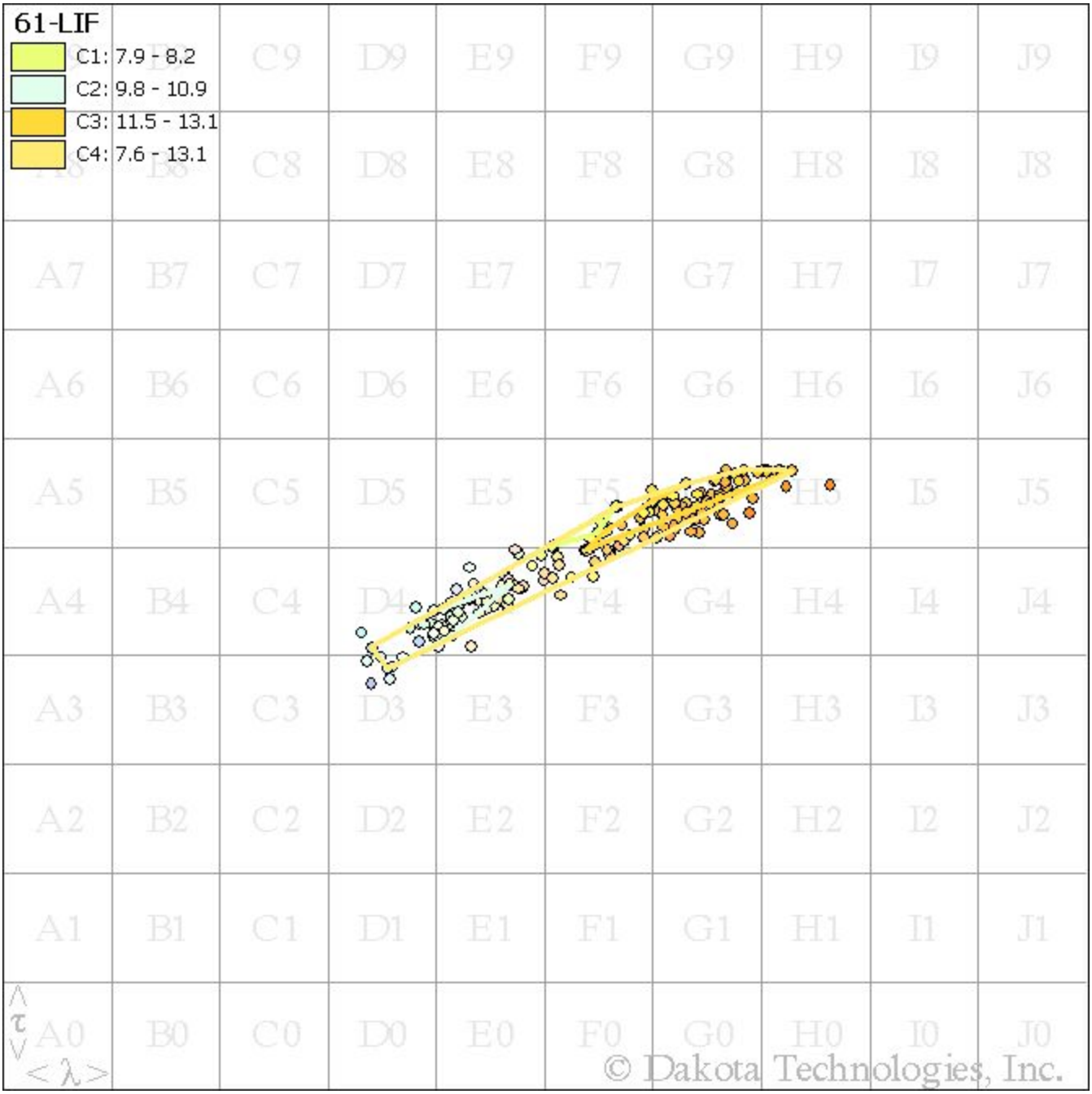
61-LIF
C1: 7.9 - 8.2
C2: 9.8 - 10.9
C3: 11.5 - 13.1
C4: 7.6 - 13.1
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
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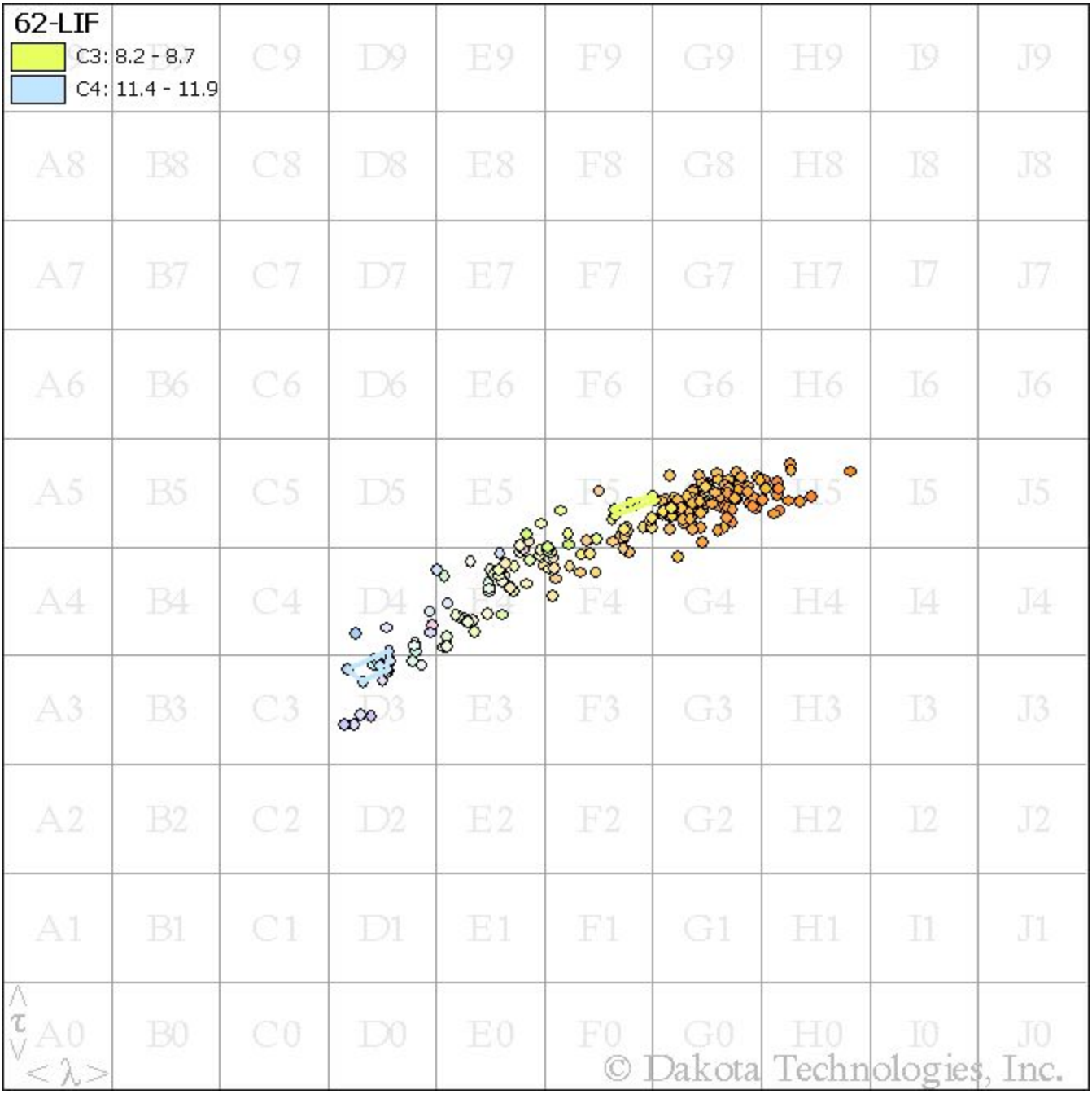
62-LIF
C3: 8.2 - 8.7
C4: 11.4 - 11.9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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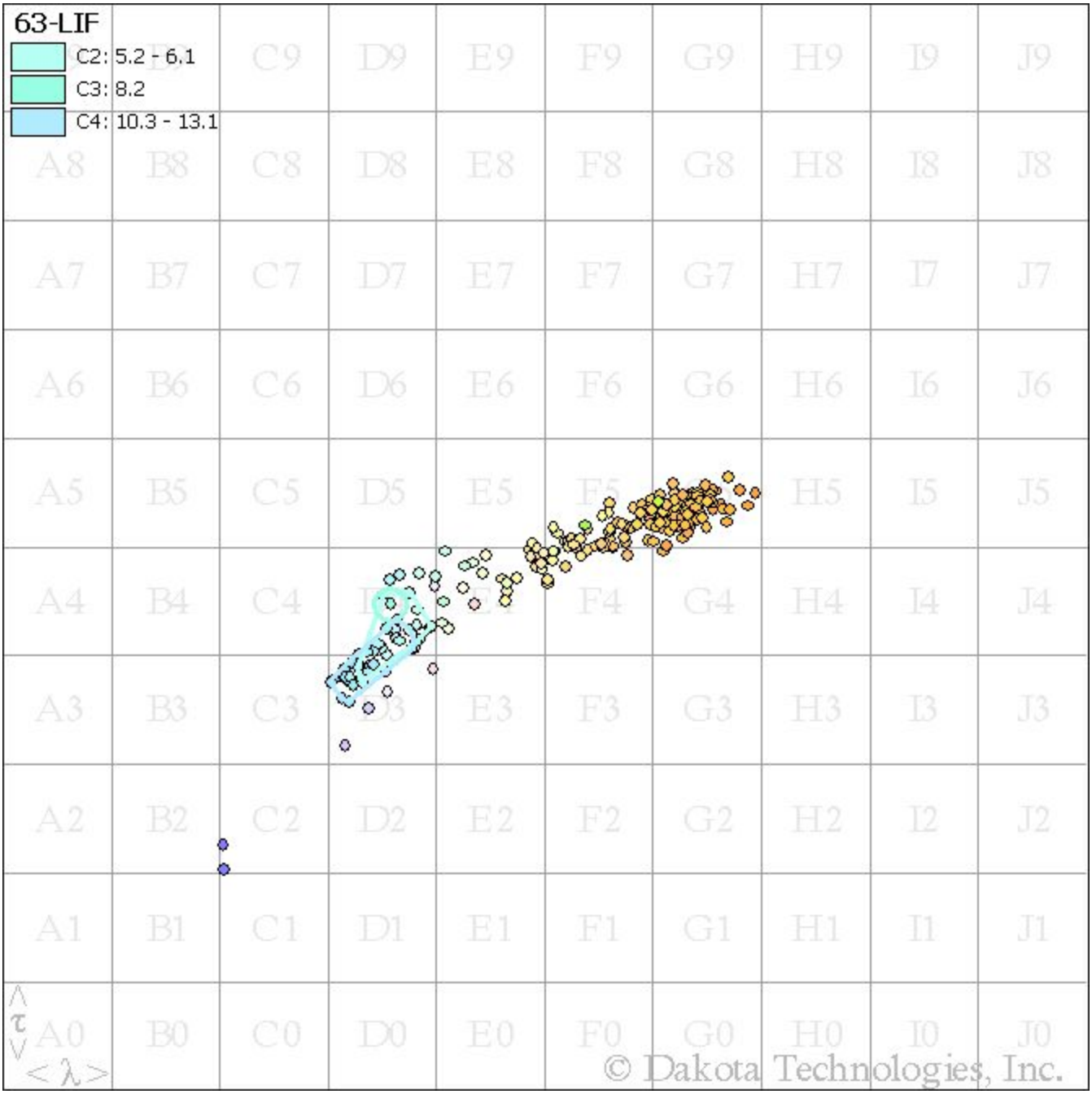
63-LIF
C2: 5.2 - 6.1
C3: 8.2
C4: 10.3 - 13.1
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 E4 F4 G4 H4 I4 J4
A3 B3 C3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
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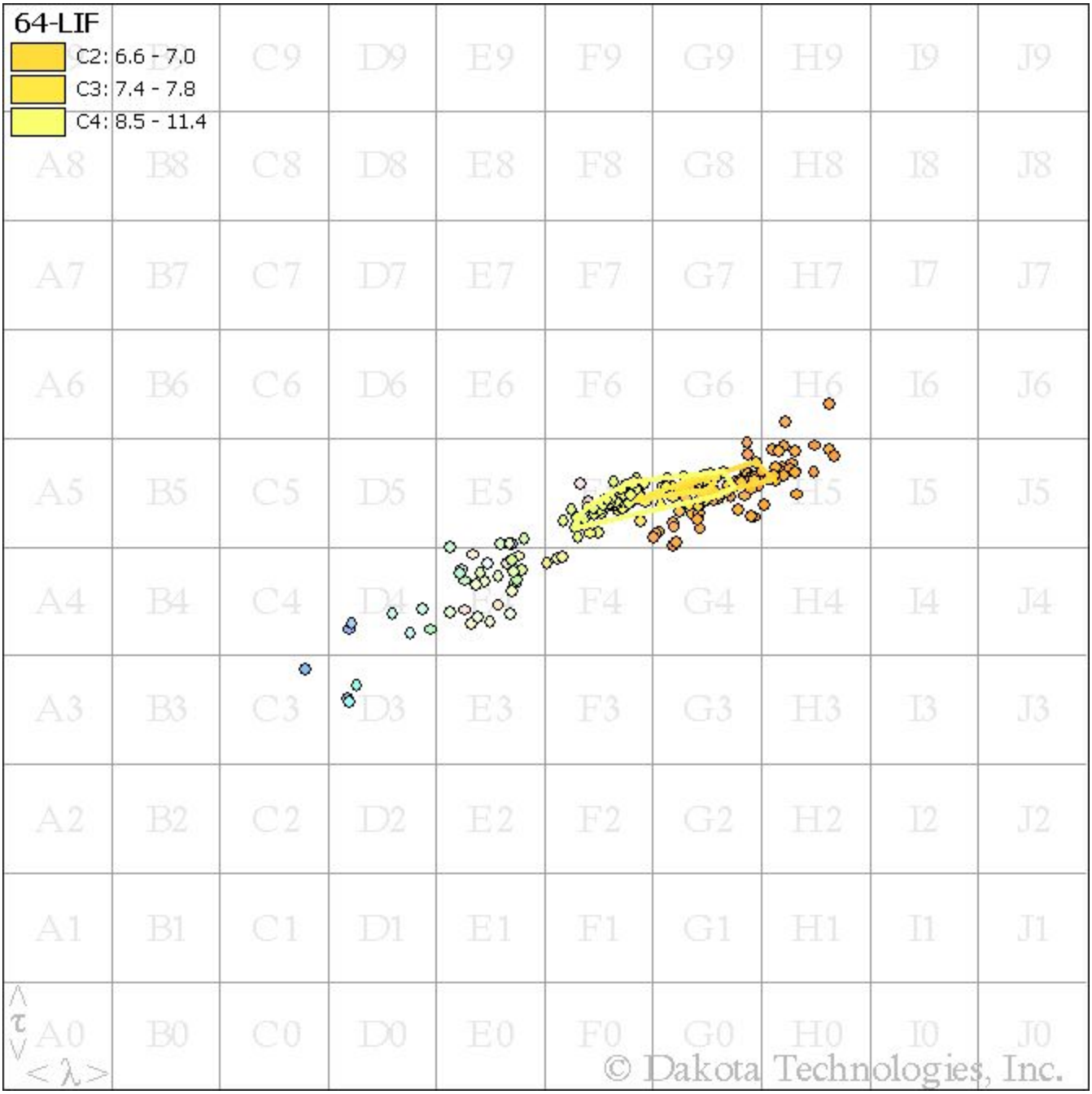
64-LIF
C2: 6.6 - 7.0
C3: 7.4 - 7.8
C4: 8.5 - 11.4
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
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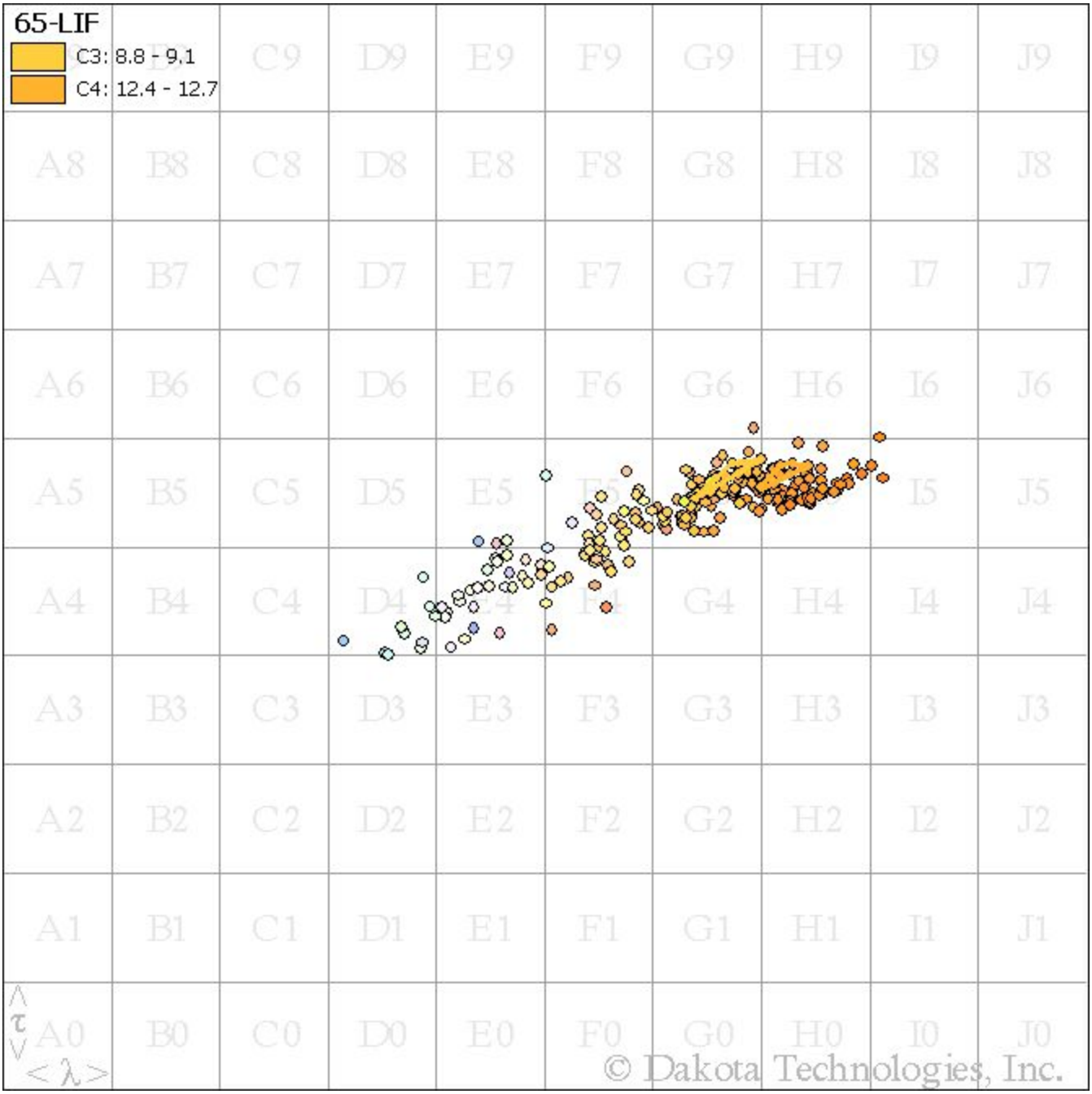
65-LIF
C3: 8.8 - 9.1
C4: 12.4 - 12.7
C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
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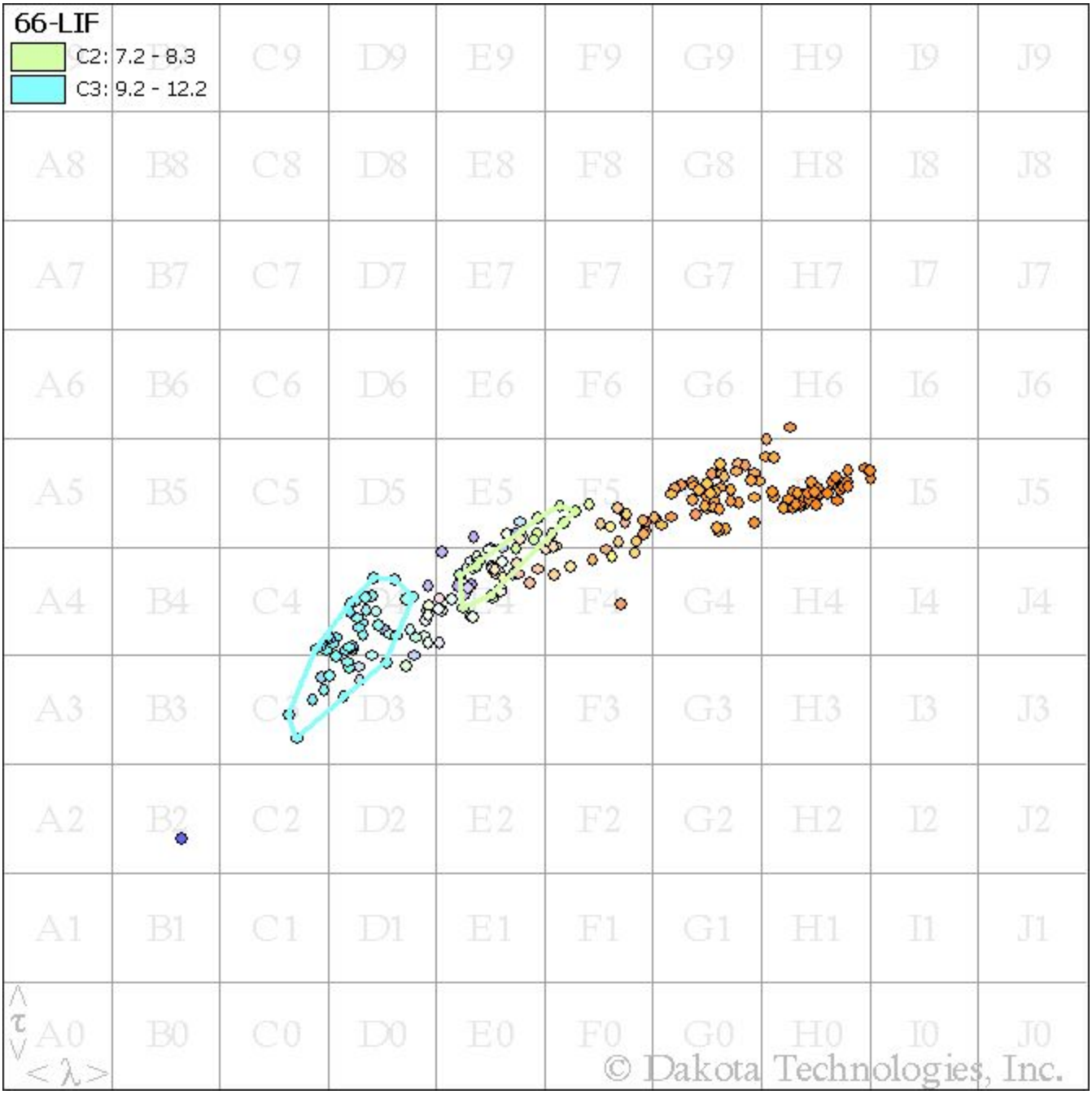
66-LIF
C2: 7.2 - 8.3
C3: 9.2 - 12.2
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
< τ >
< λ >
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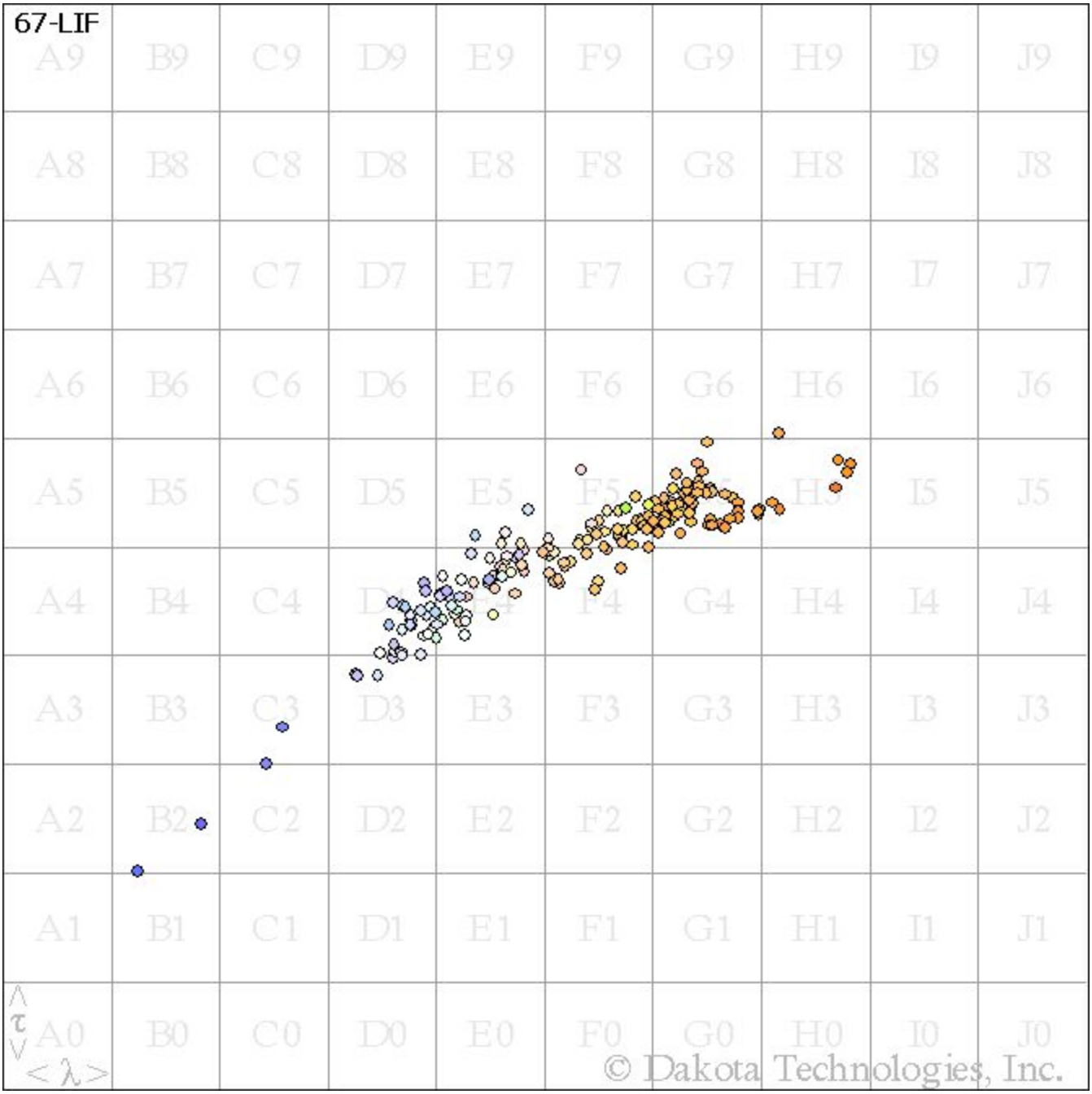
67-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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< λ >
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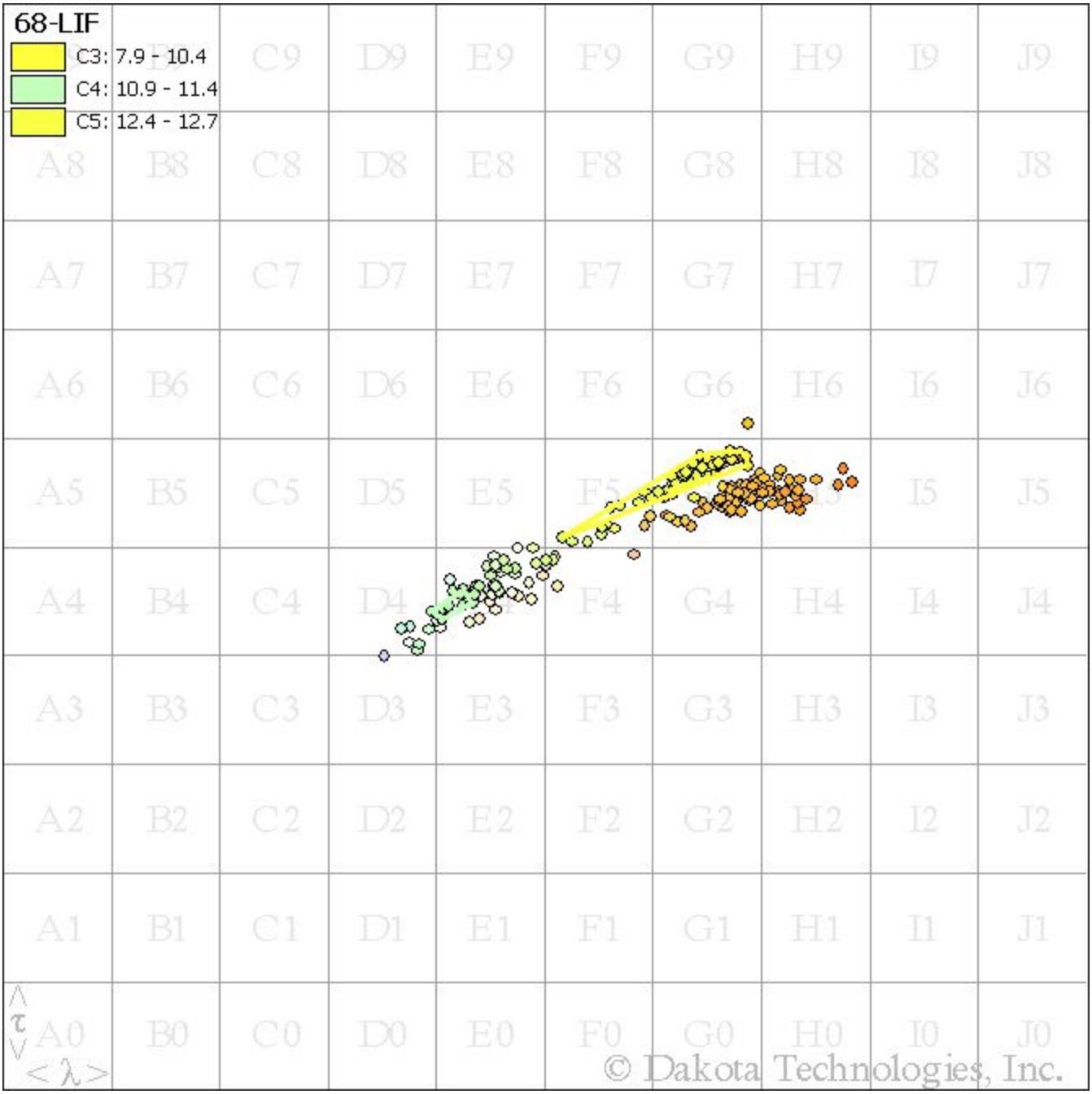
68-LIF
C3: 7.9 - 10.4
C4: 10.9 - 11.4
C5: 12.4 - 12.7
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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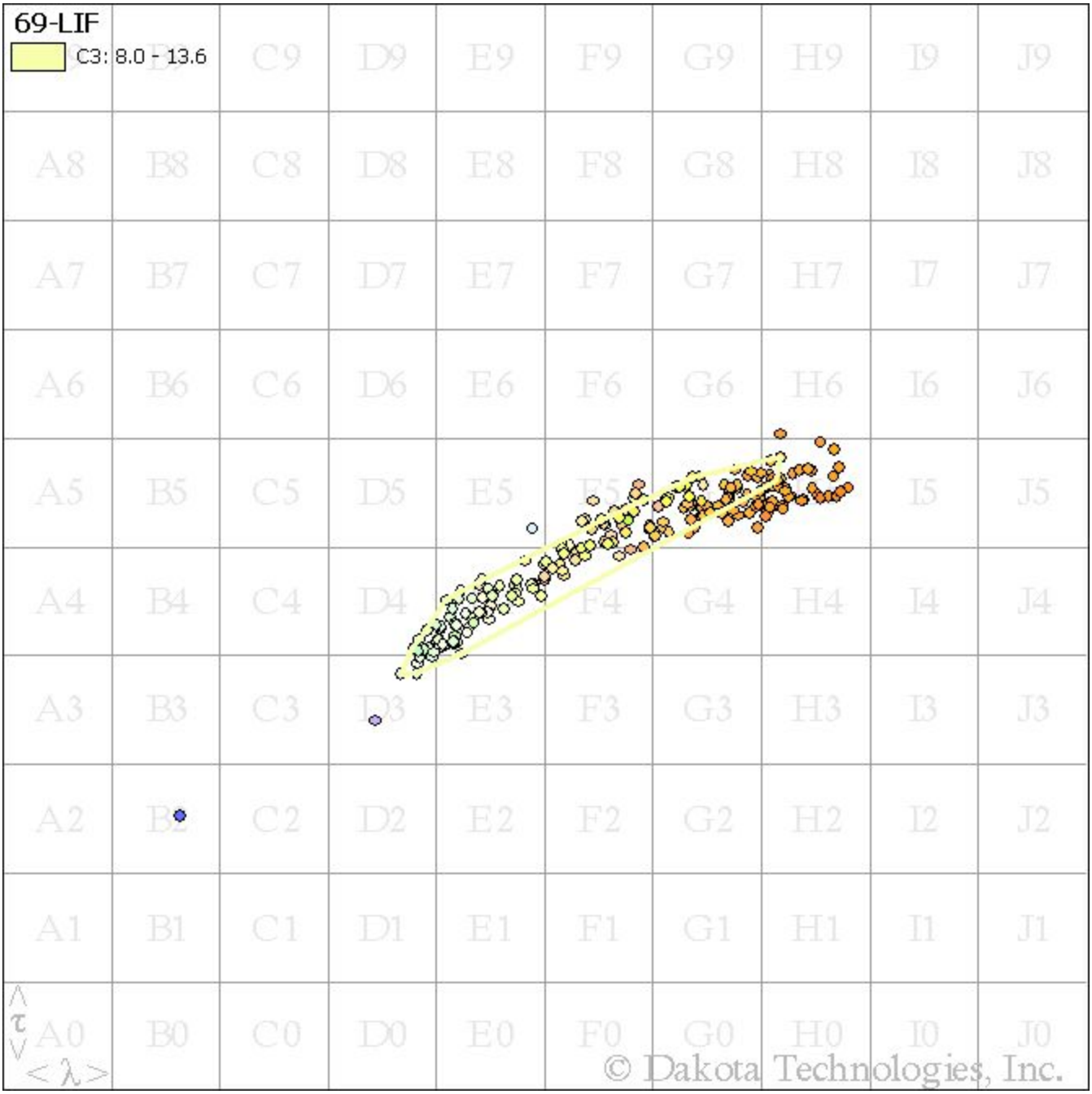
69-LIF
C3: 8.0 - 13.6
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
< τ >
< λ >
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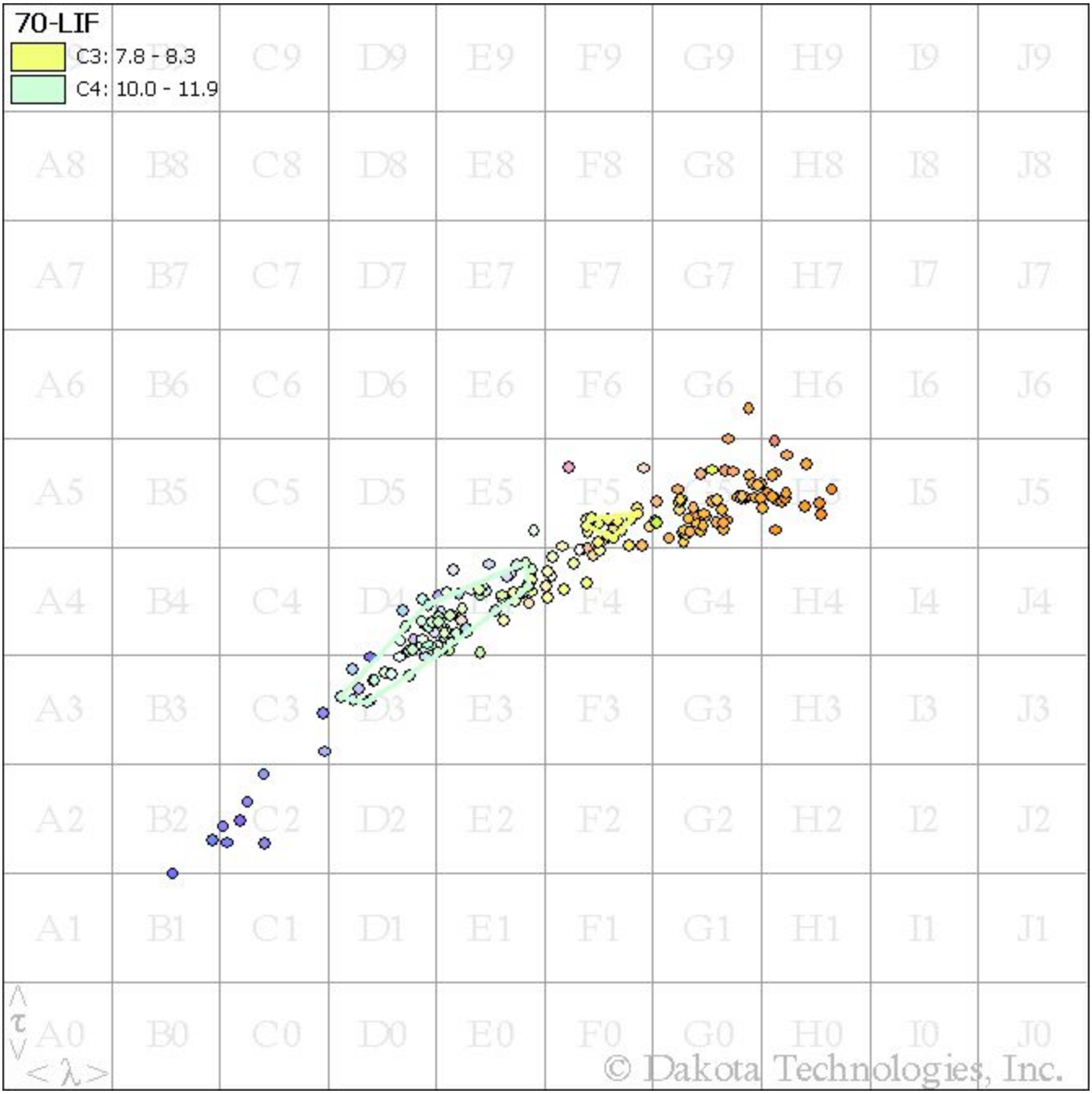
70-LIF
C3: 7.8 - 8.3
C4: 10.0 - 11.9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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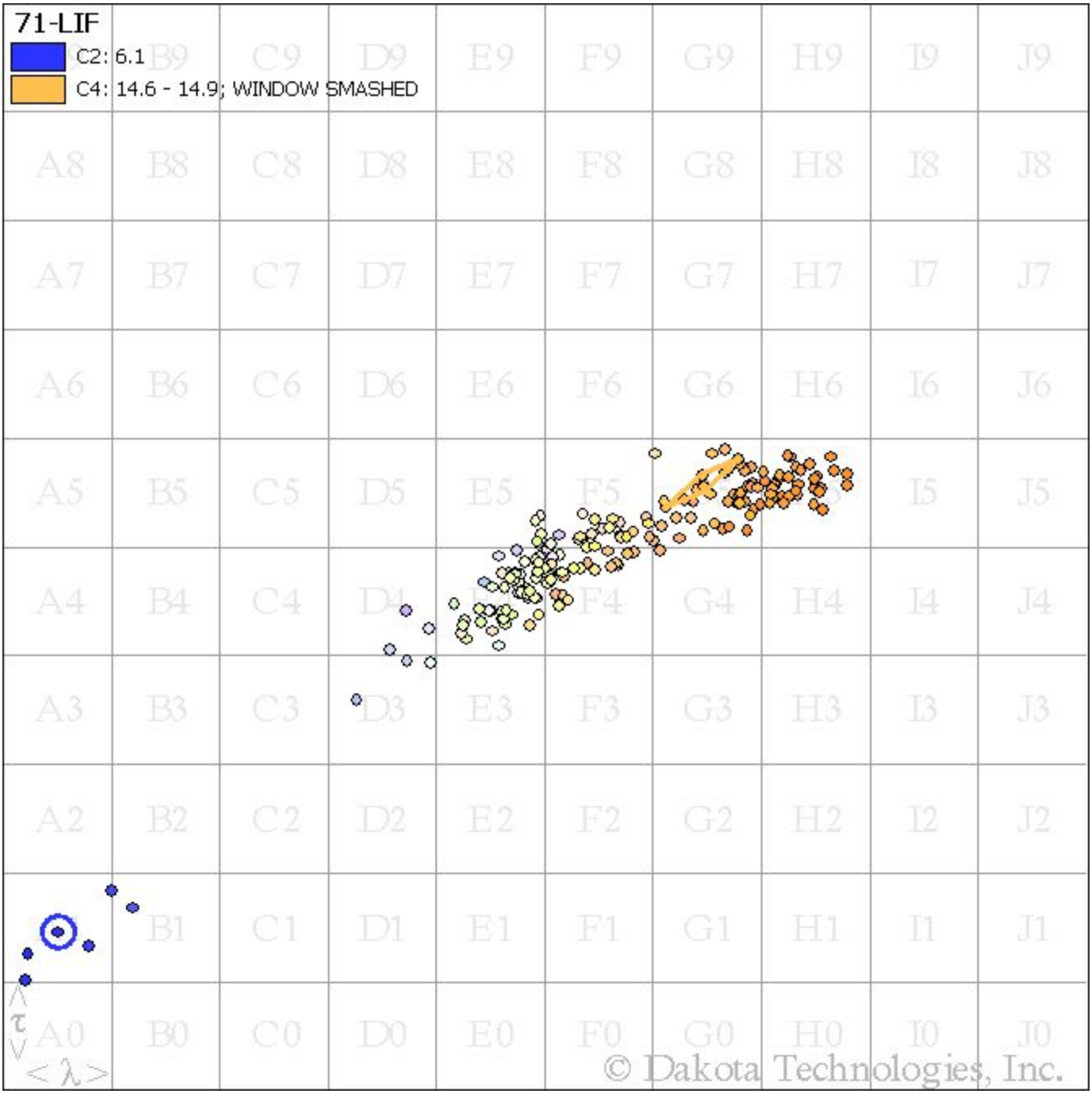
71-LIF
C2: 6.1
C4: 14.6 - 14.9; WINDOW SMASHED
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
< τ >
< λ >
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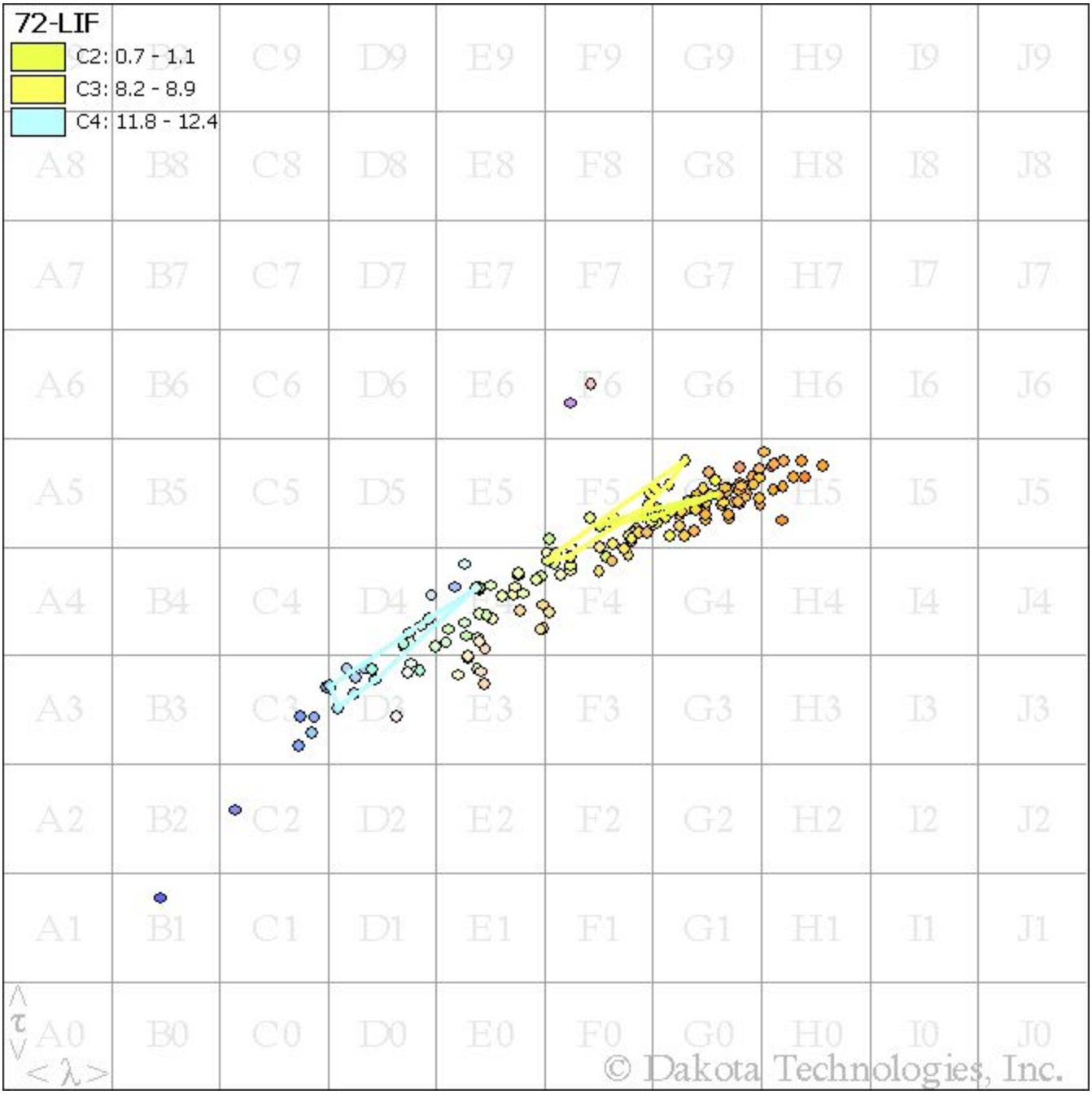
72-LIF
C2: 0.7 - 1.1
C3: 8.2 - 8.9
C4: 11.8 - 12.4
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
< τ >
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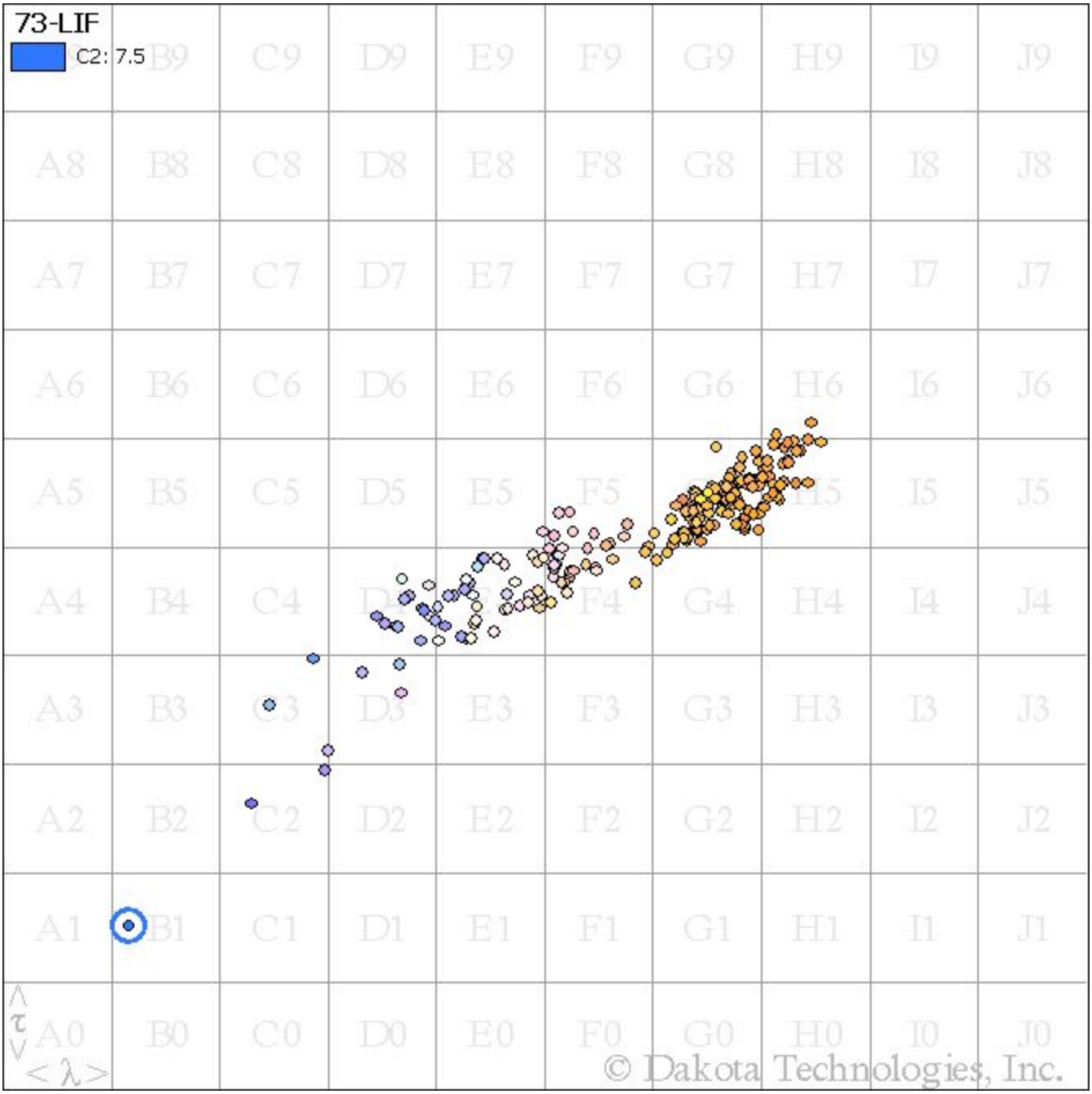
73-LIF
C2: 7.5
B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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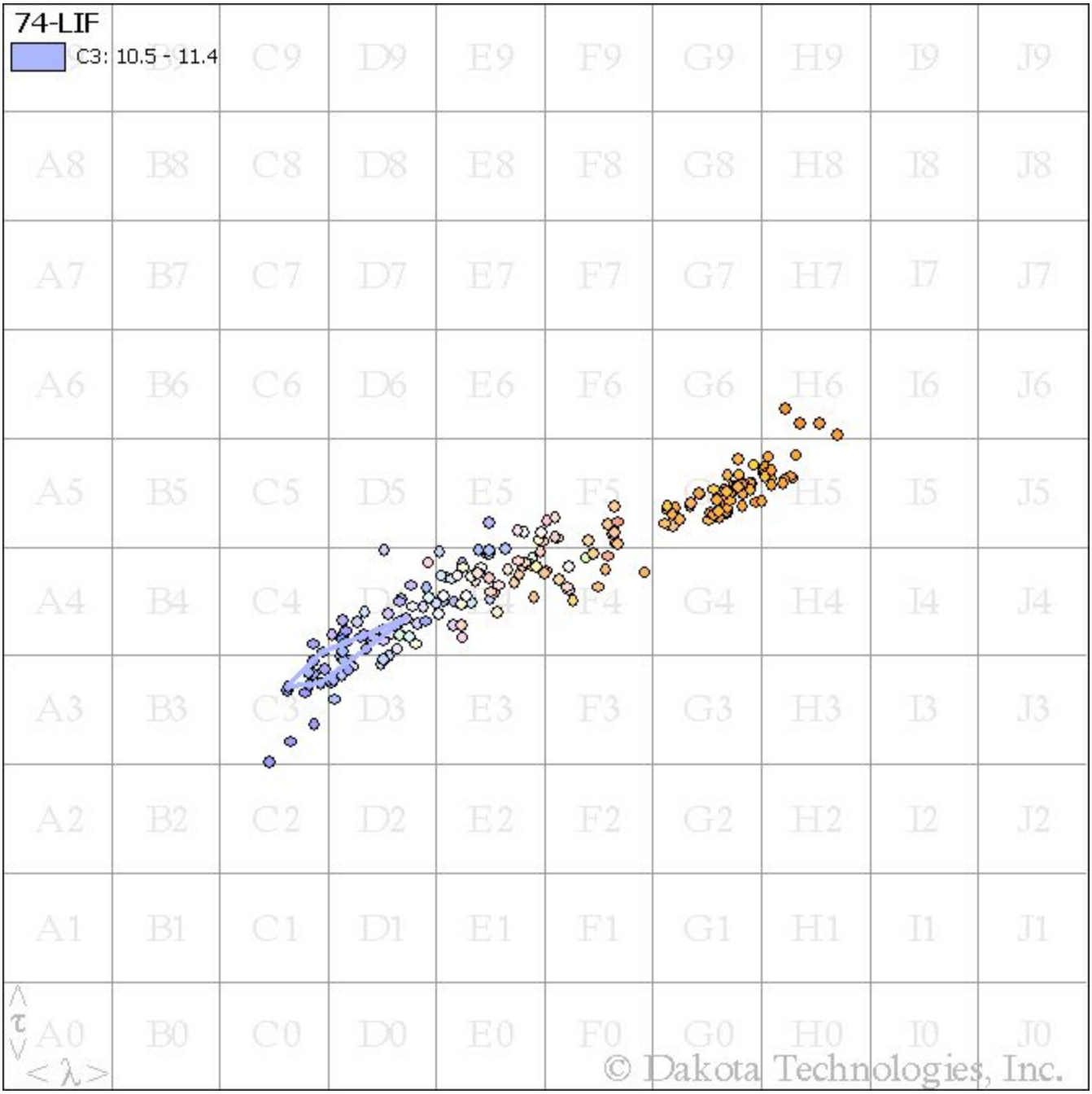
74-LIF
C3: 10.5 - 11.4
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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< λ >
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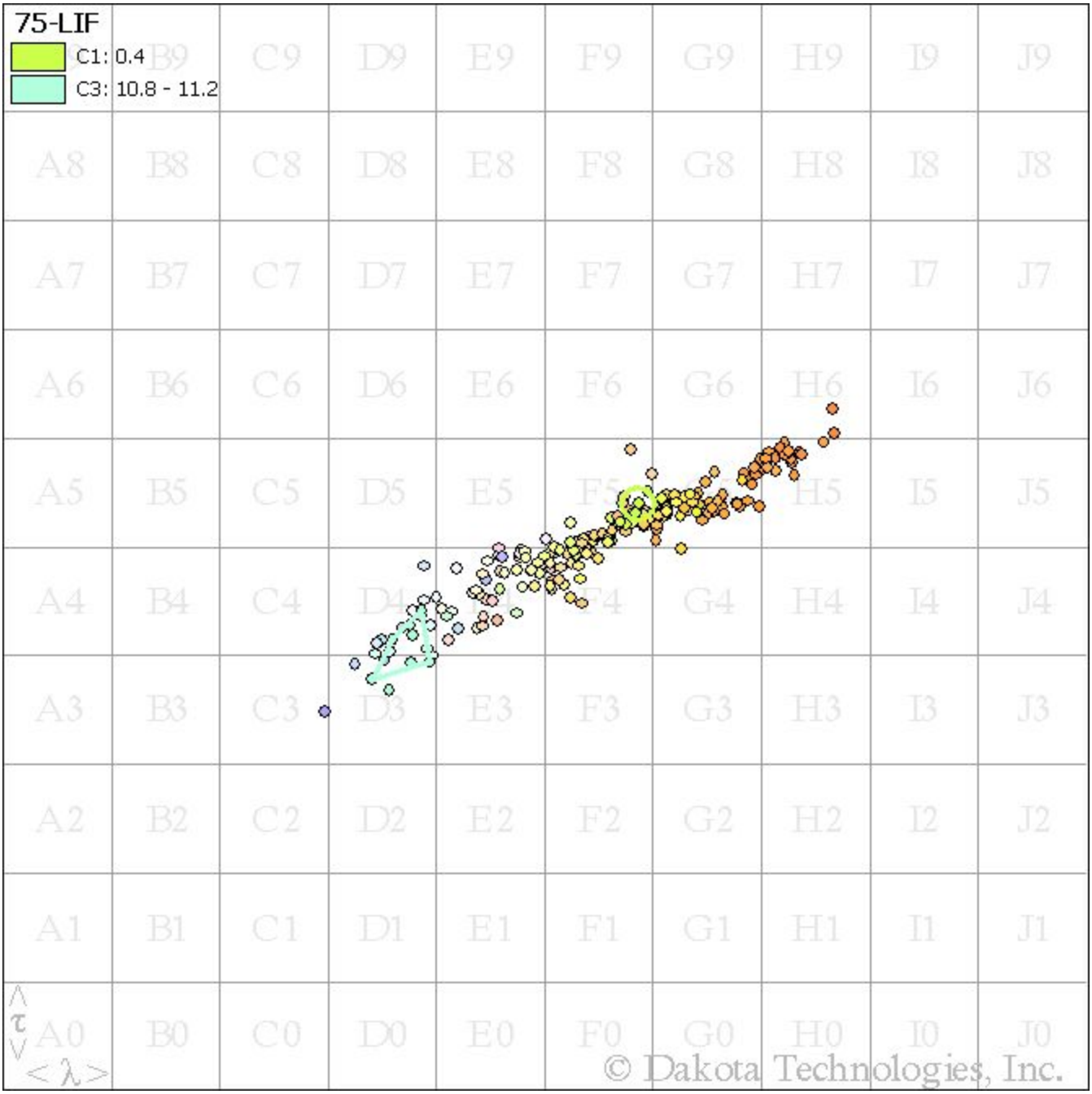
75-LIF
C1: 0.4
C3: 10.8 - 11.2
B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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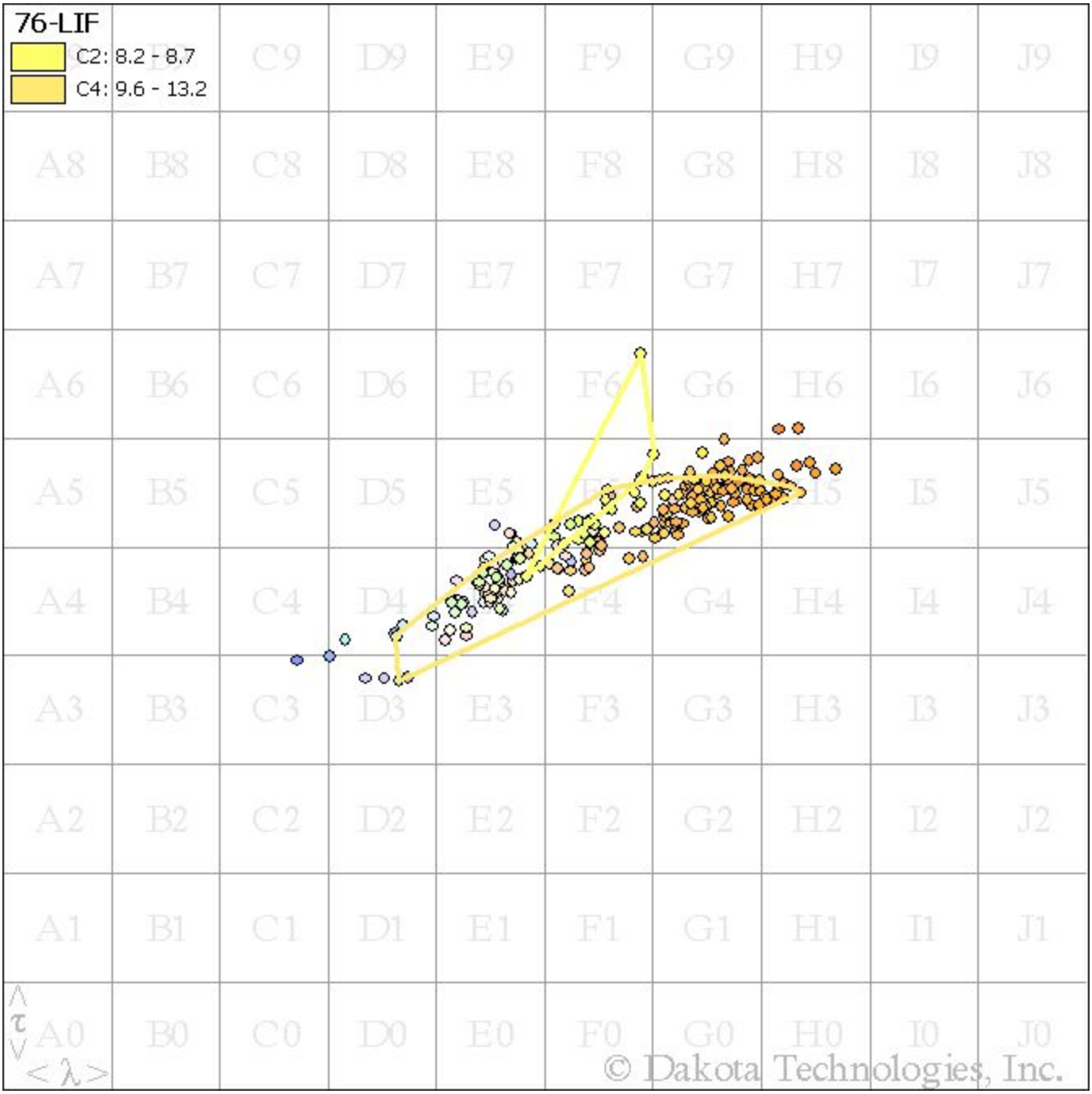
76-LIF
C2: 8.2 - 8.7
C4: 9.6 - 13.2
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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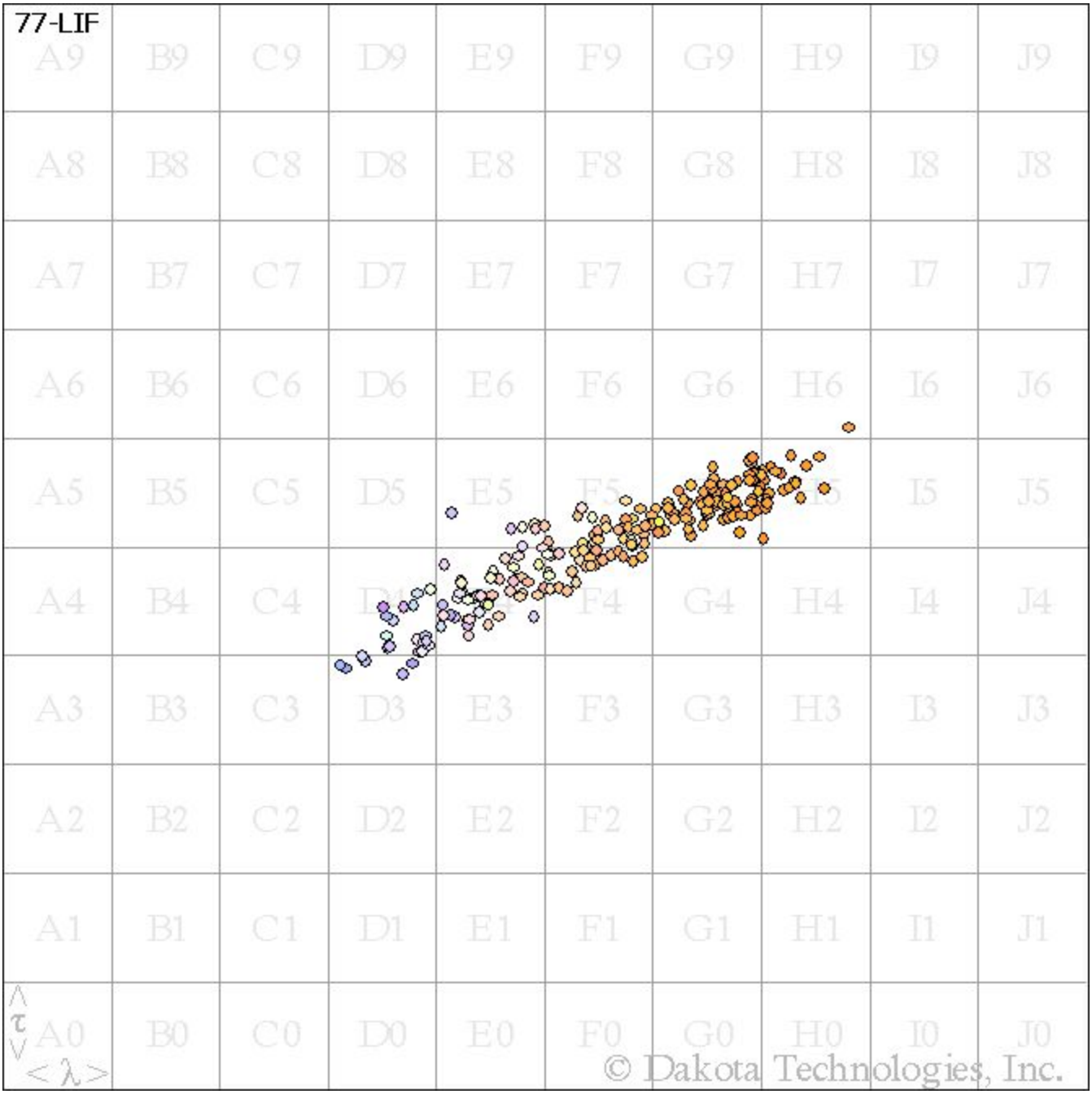
77-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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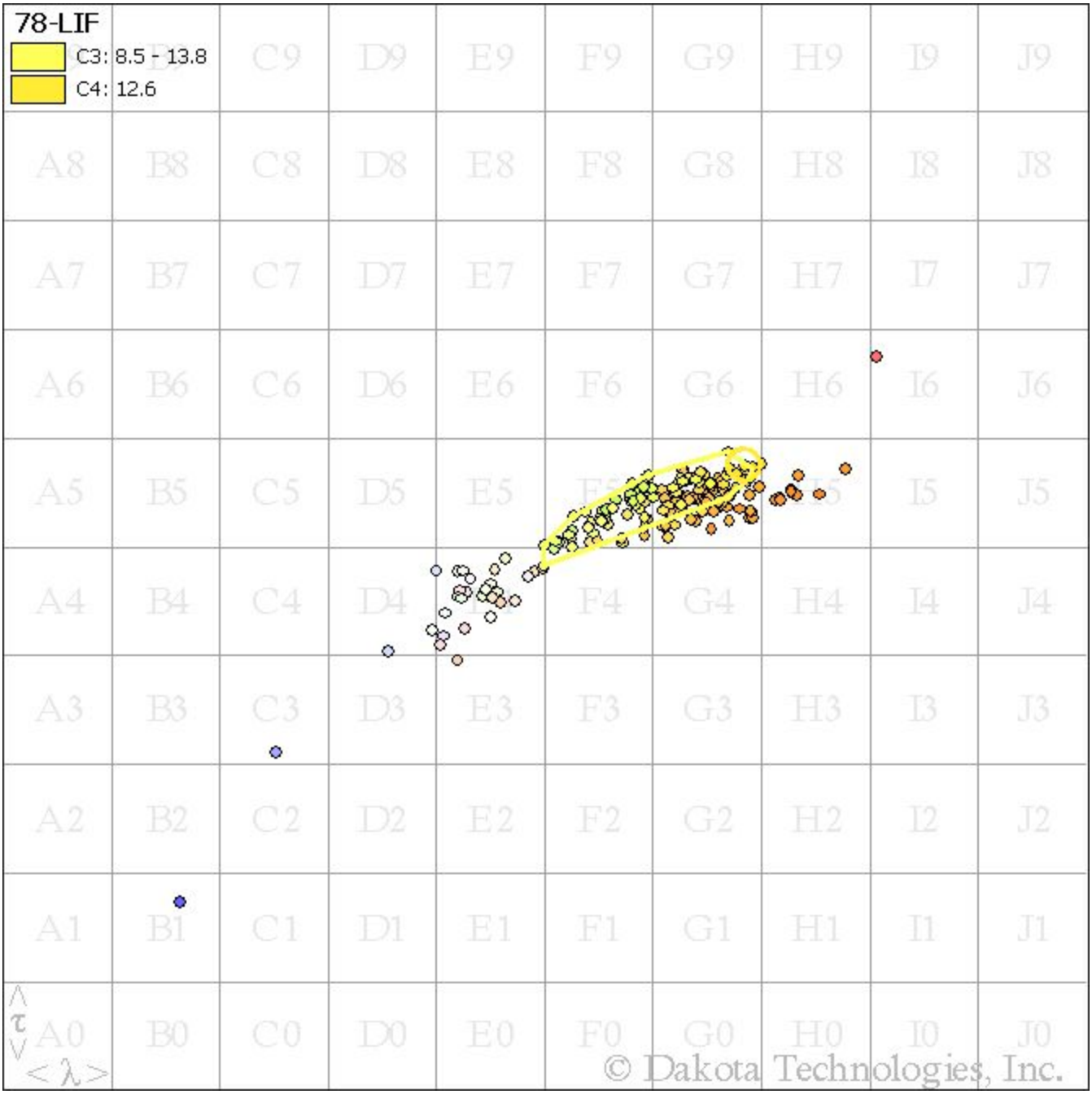
78-LIF
C3: 8.5 - 13.8
C4: 12.6
C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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< λ >
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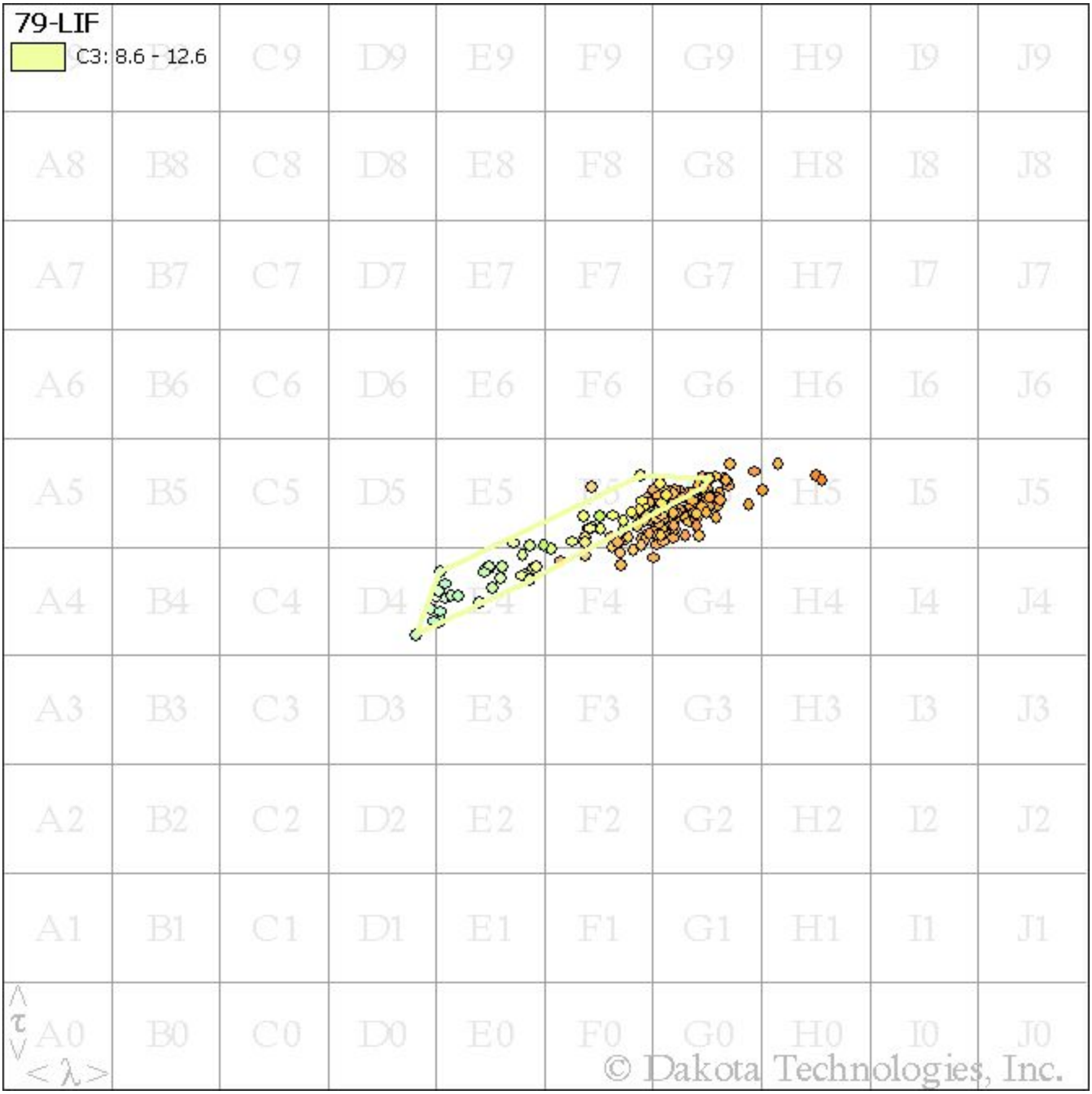
79-LIF
C3: 8.6 - 12.6
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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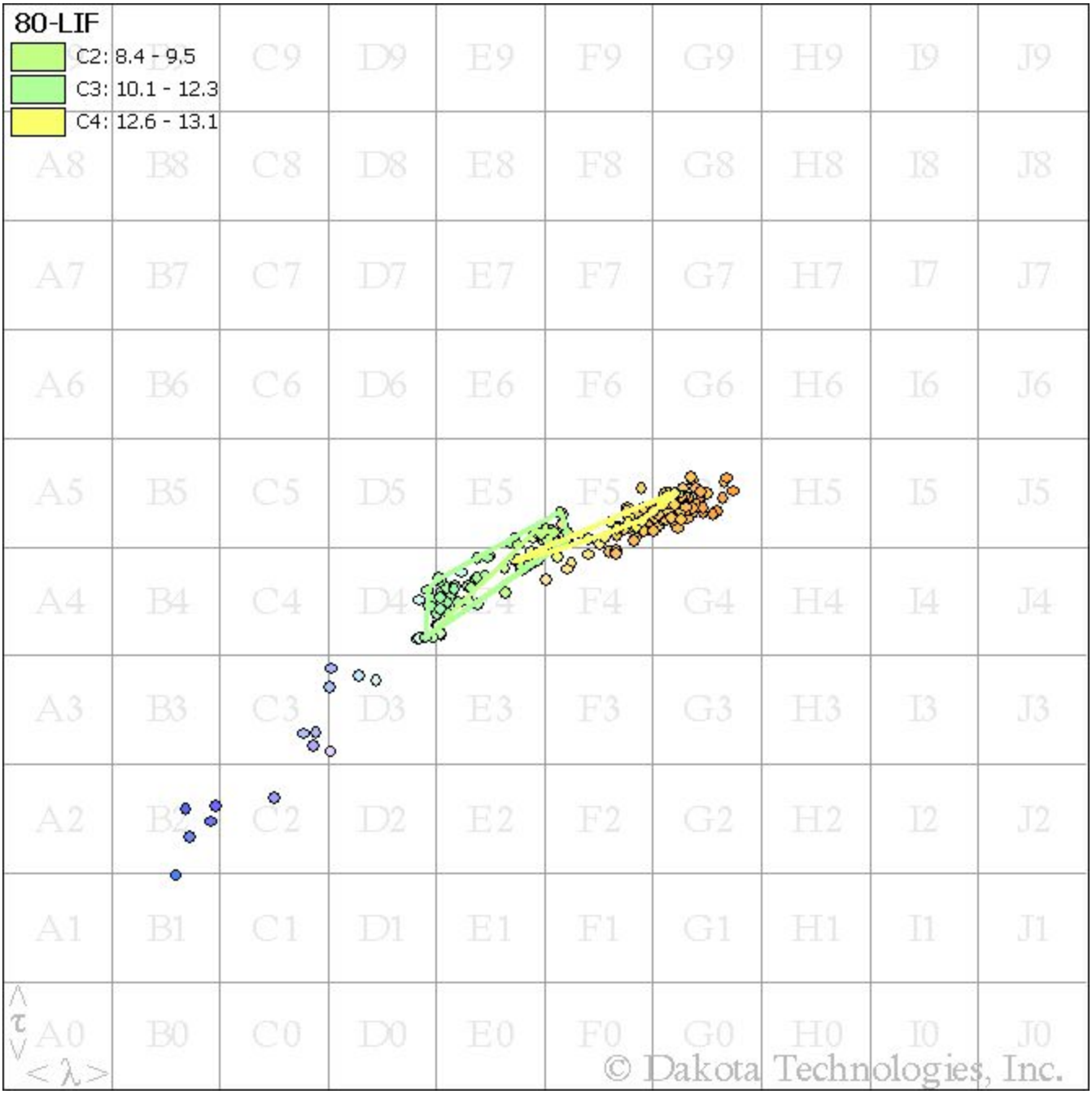
80-LIF
C2: 8.4 - 9.5
C3: 10.1 - 12.3
C4: 12.6 - 13.1
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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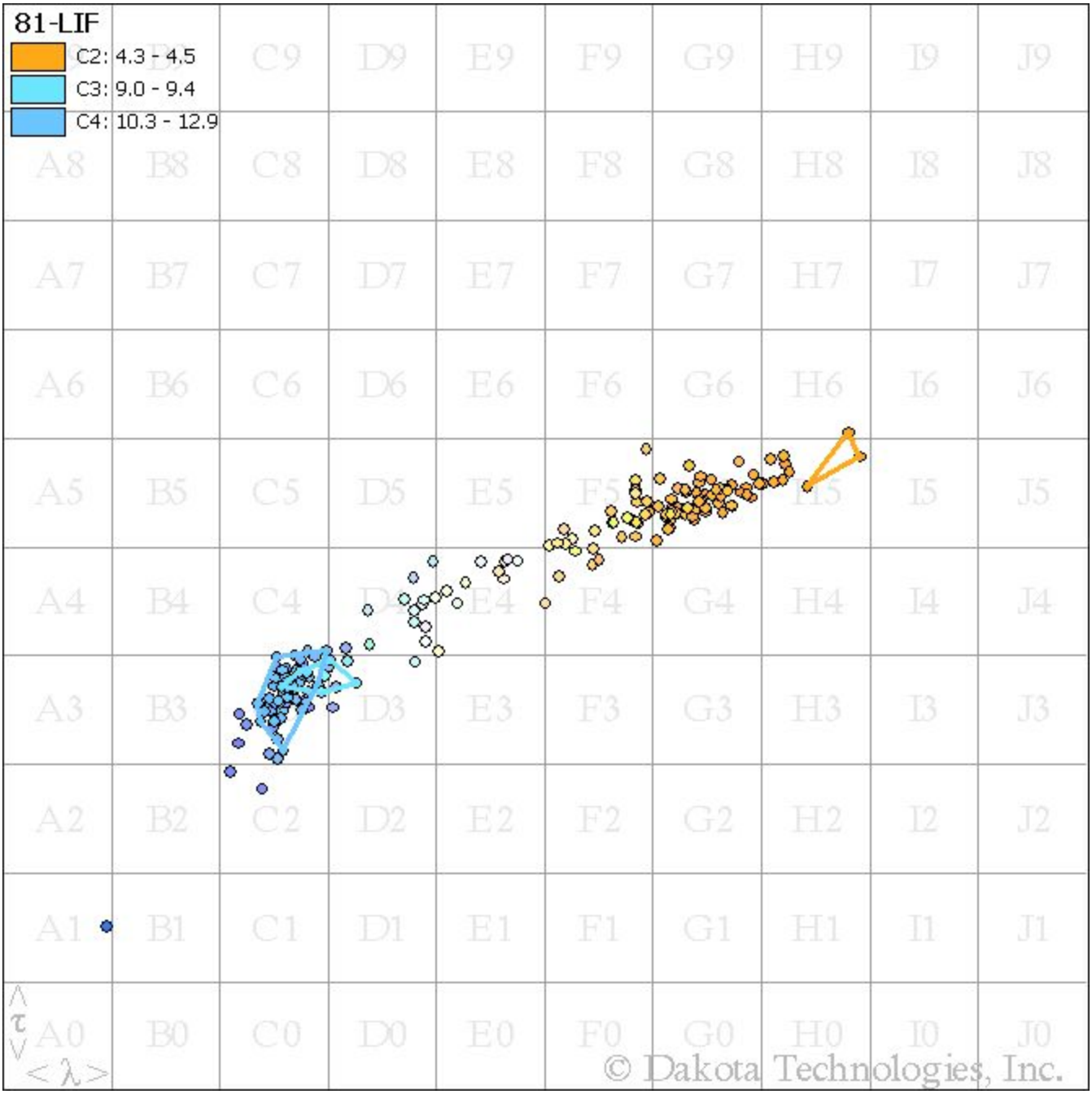
81-LIF
C2: 4.3 - 4.5
C3: 9.0 - 9.4
C4: 10.3 - 12.9
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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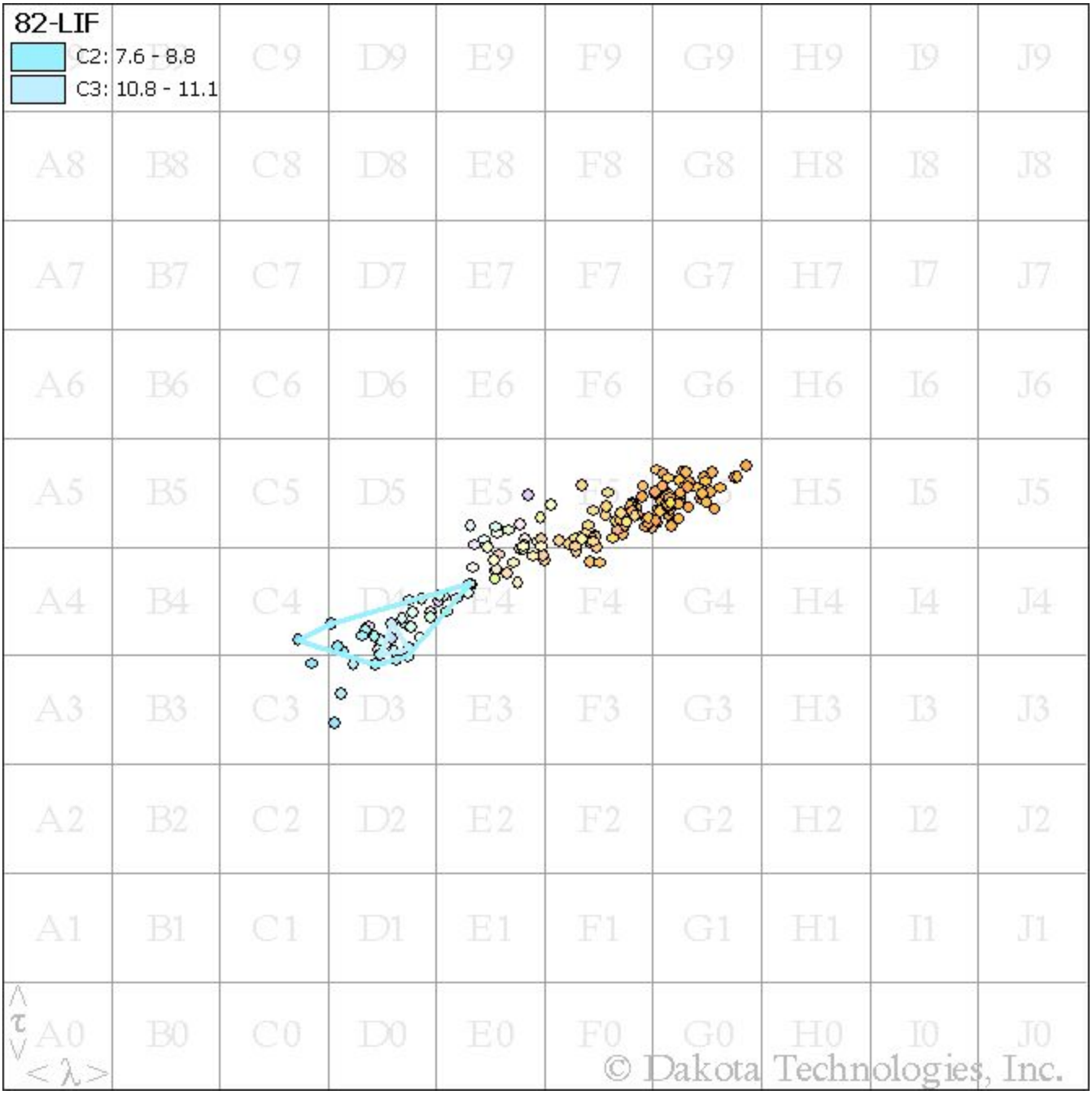
82-LIF
C2: 7.6 - 8.8
C3: 10.8 - 11.1
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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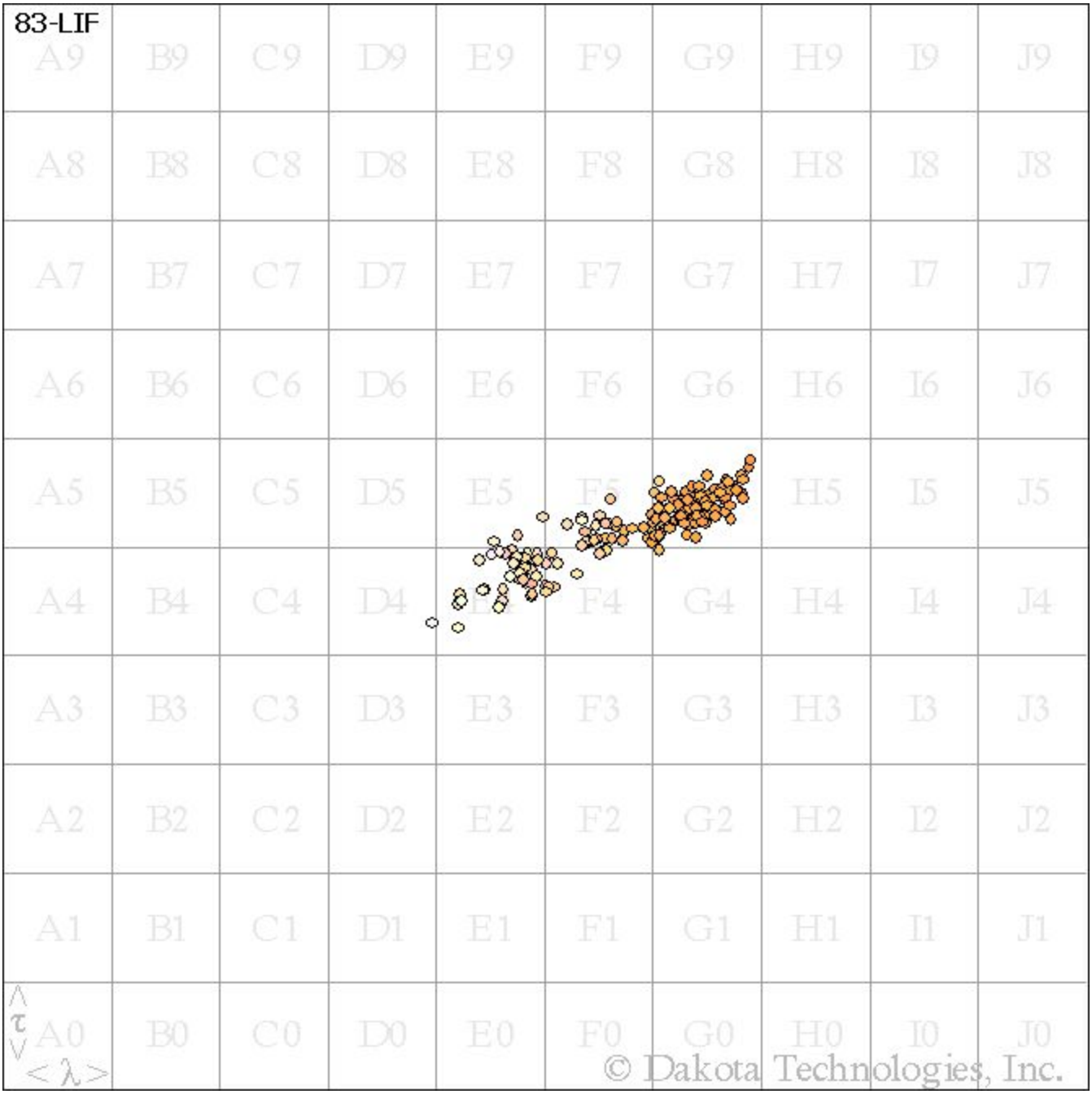
83-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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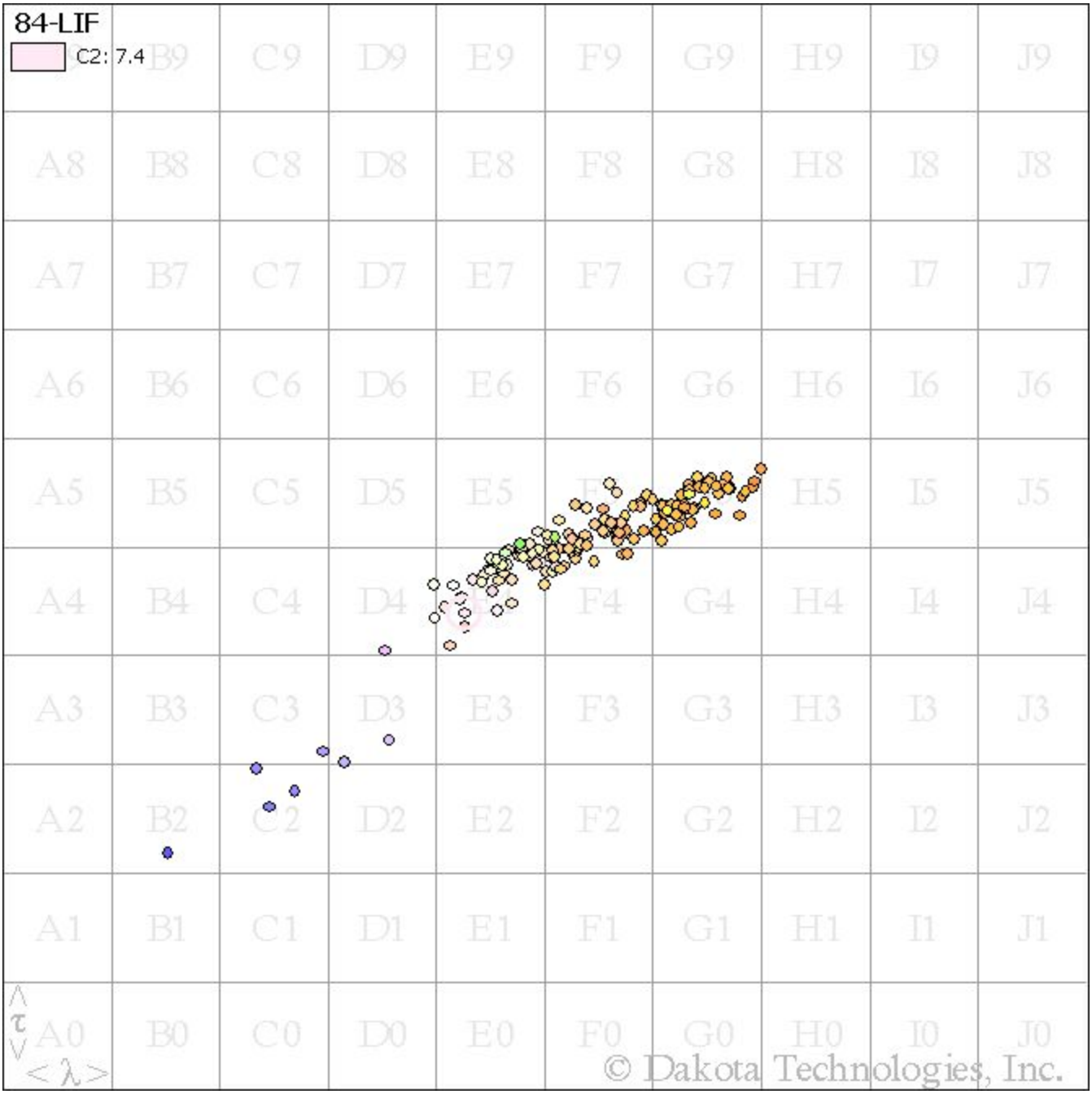
84-LIF
C2: 7.4
B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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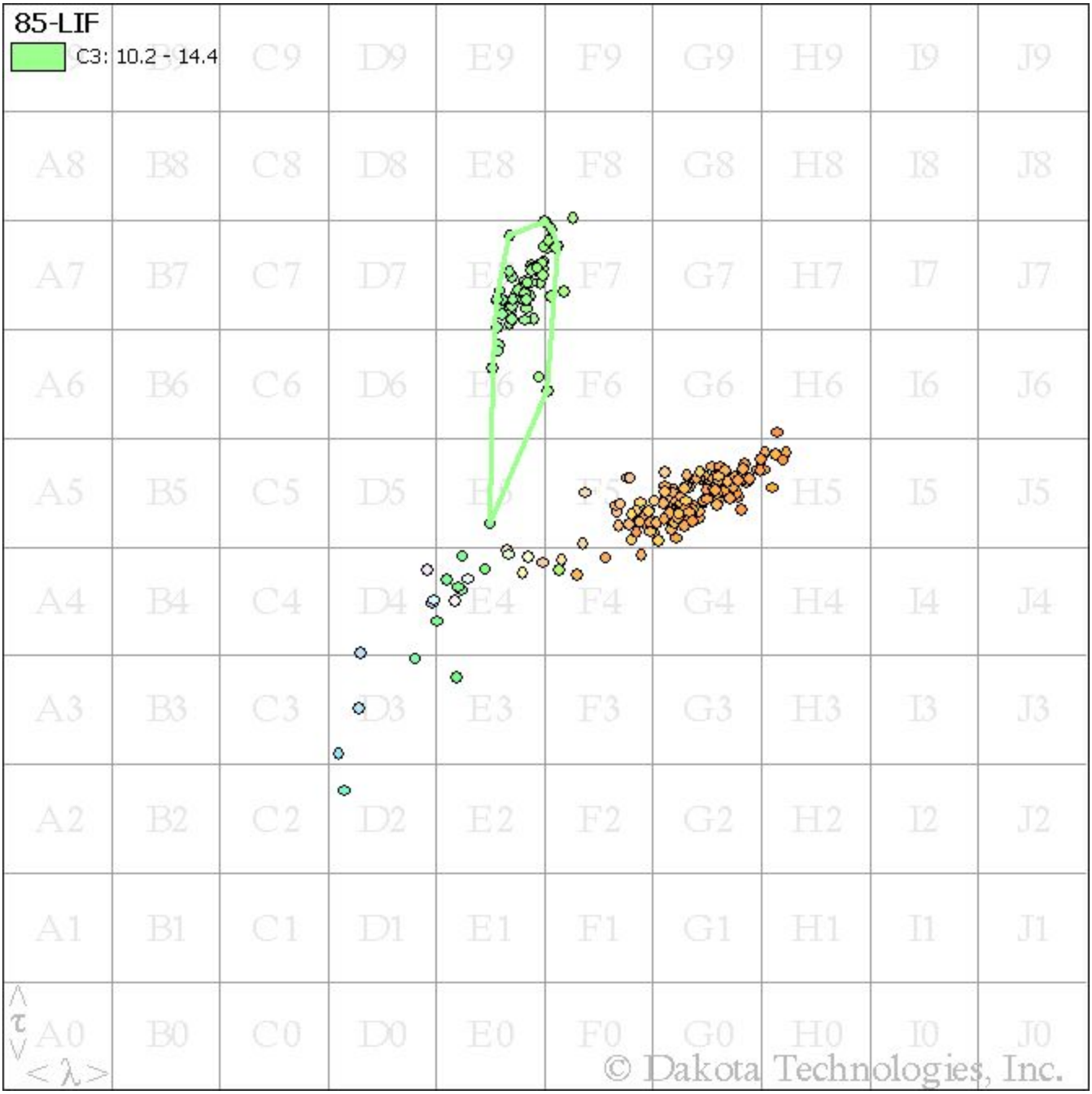
85-LIF
C3: 10.2 - 14.4
C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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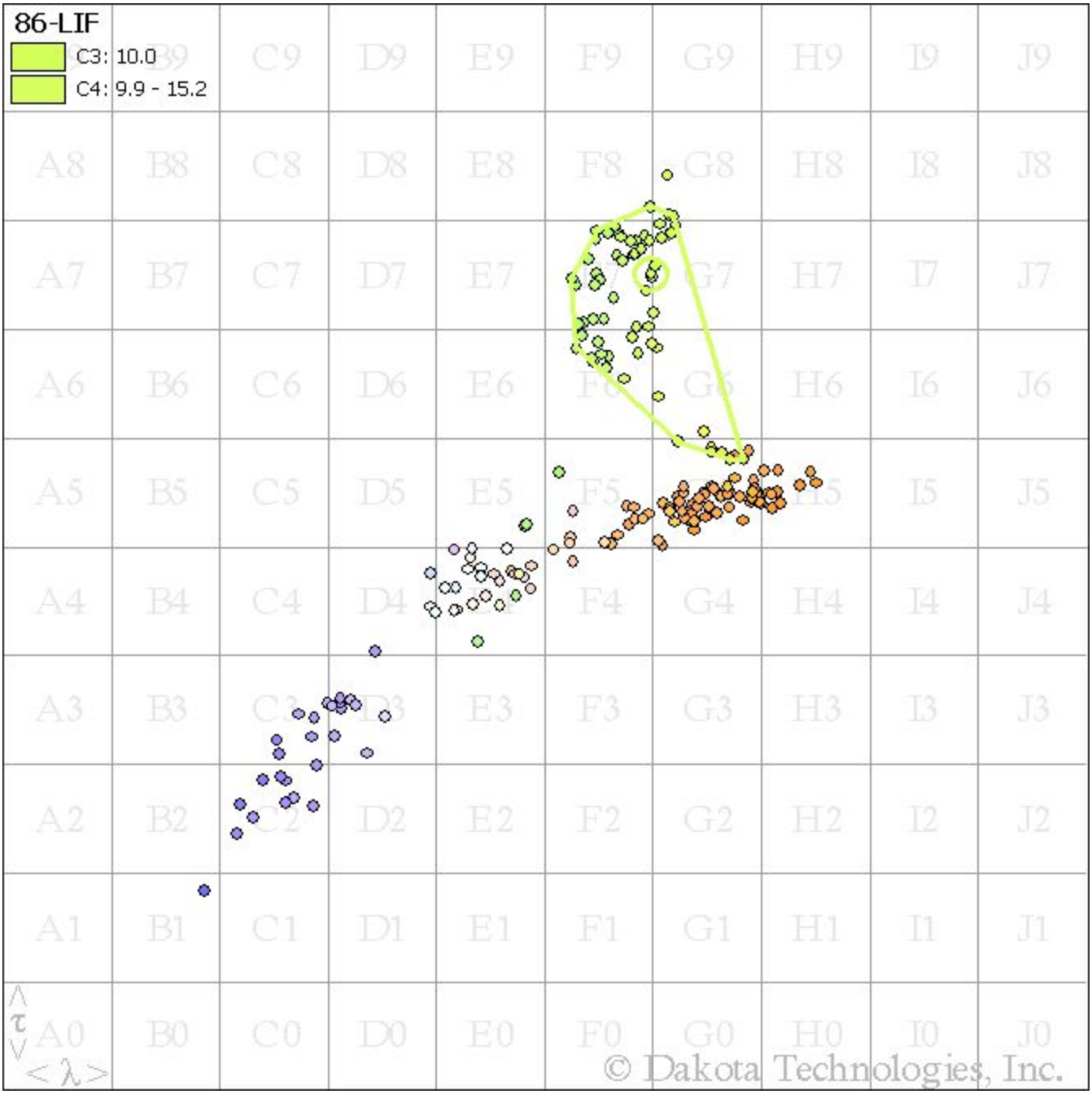
86-LIF
C3: 10.0
C4: 9.9 - 15.2
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 G7 H7 I7 J7
A6 B6 C6 D6 E6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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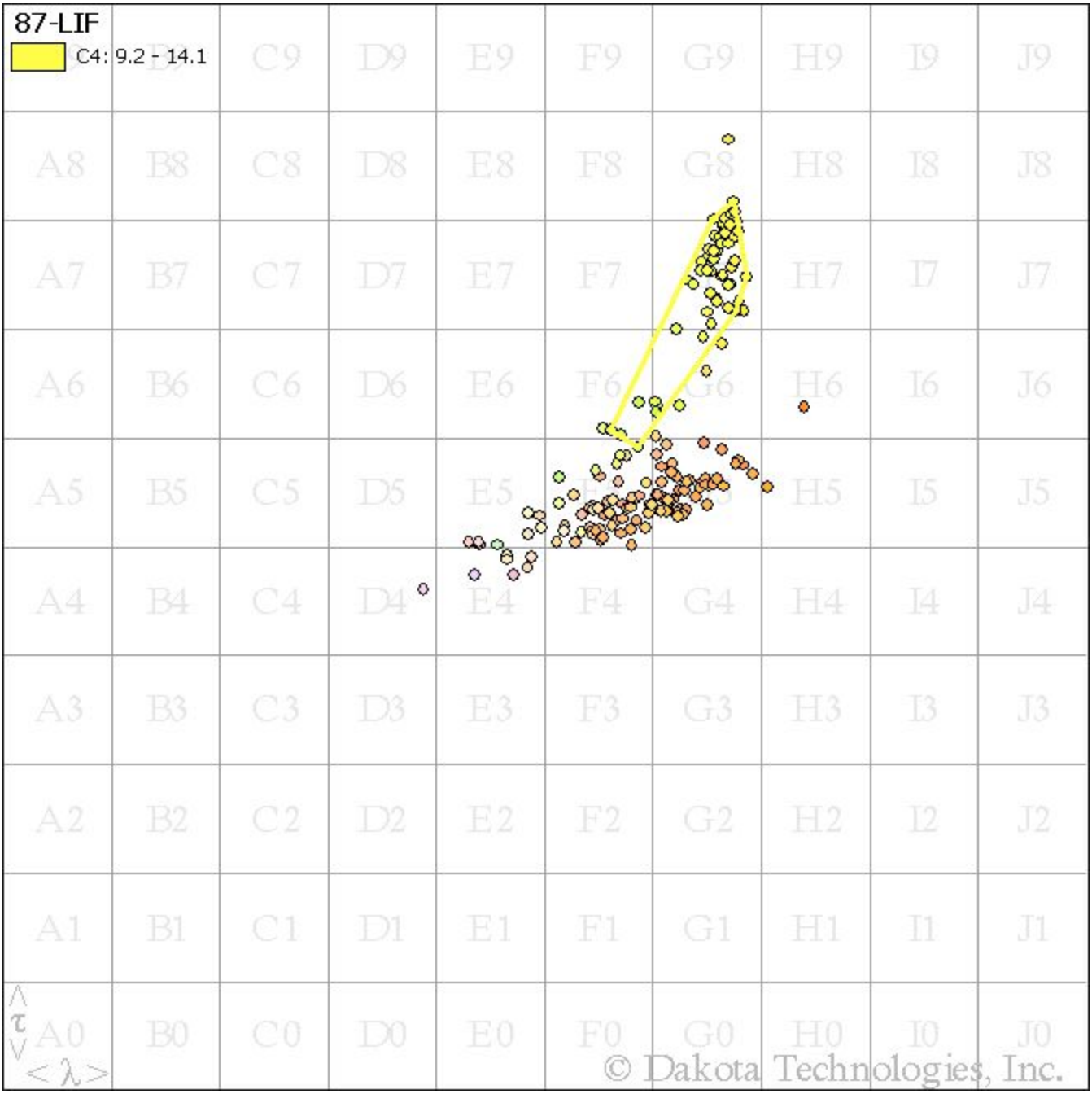
87-LIF
C4: 9.2 - 14.1
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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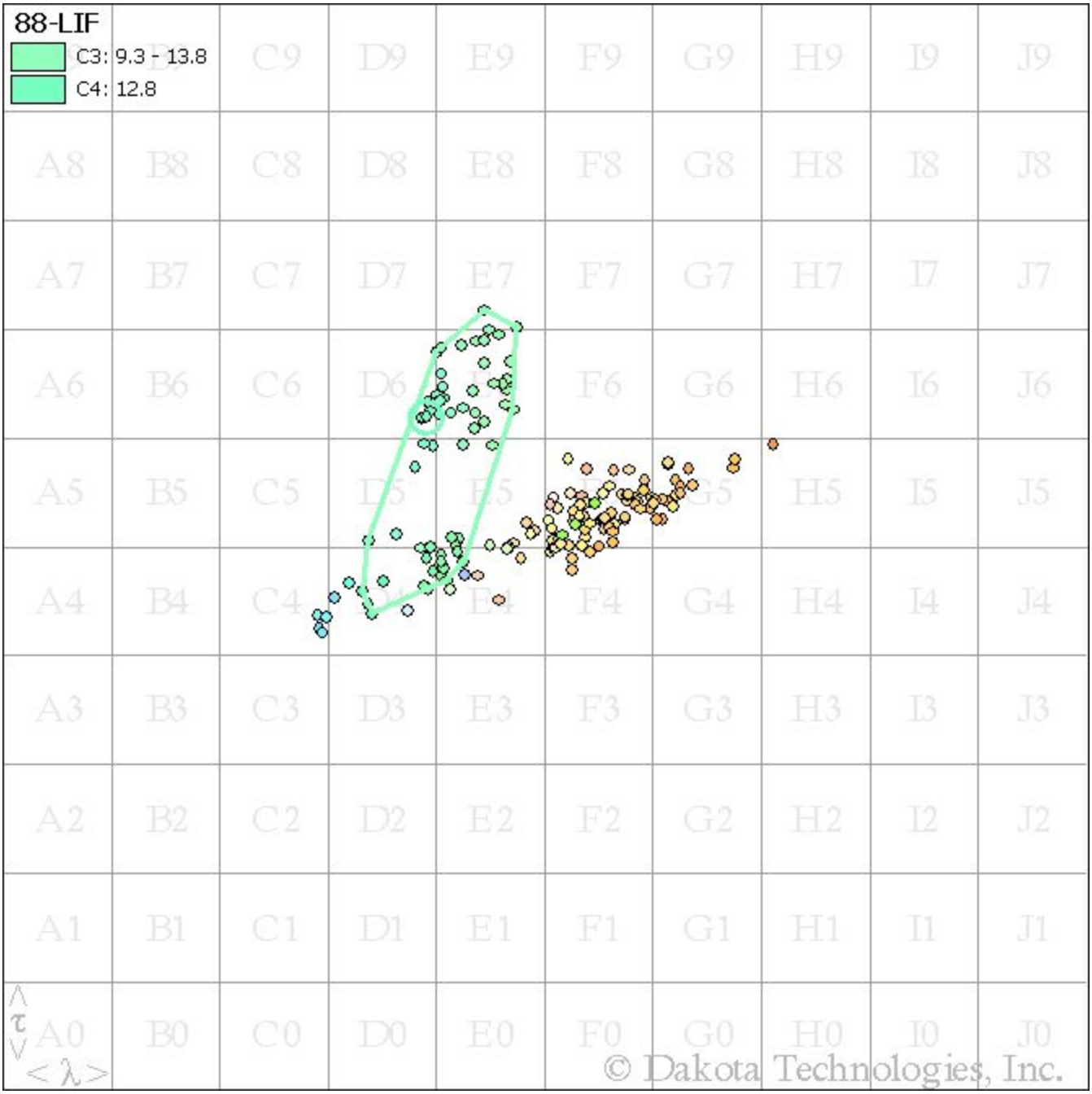
88-LIF
C3: 9.3 - 13.8
C4: 12.8
C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 G5 H5 I5 J5
A4 B4 C4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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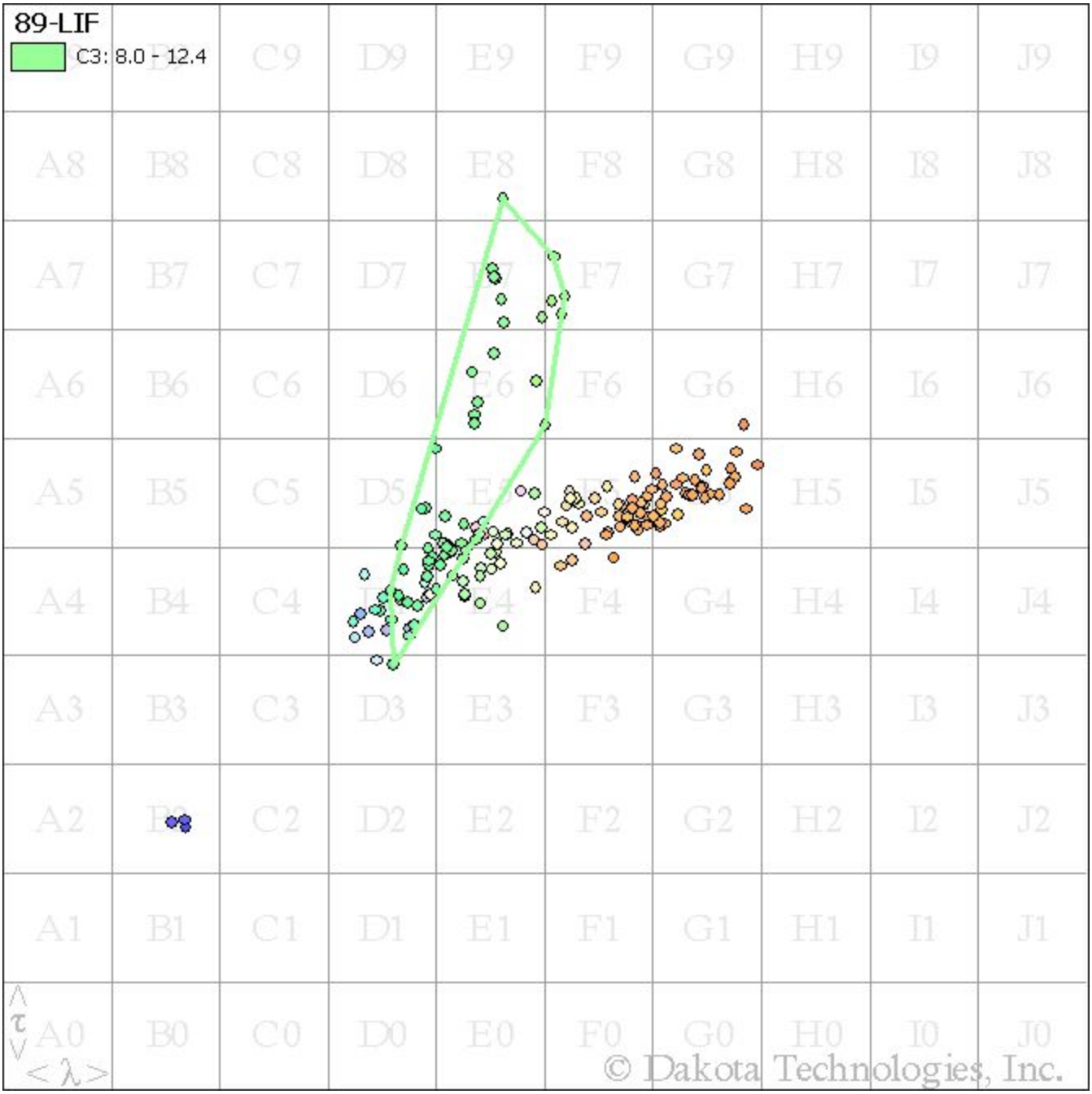
89-LIF
C3: 8.0 - 12.4
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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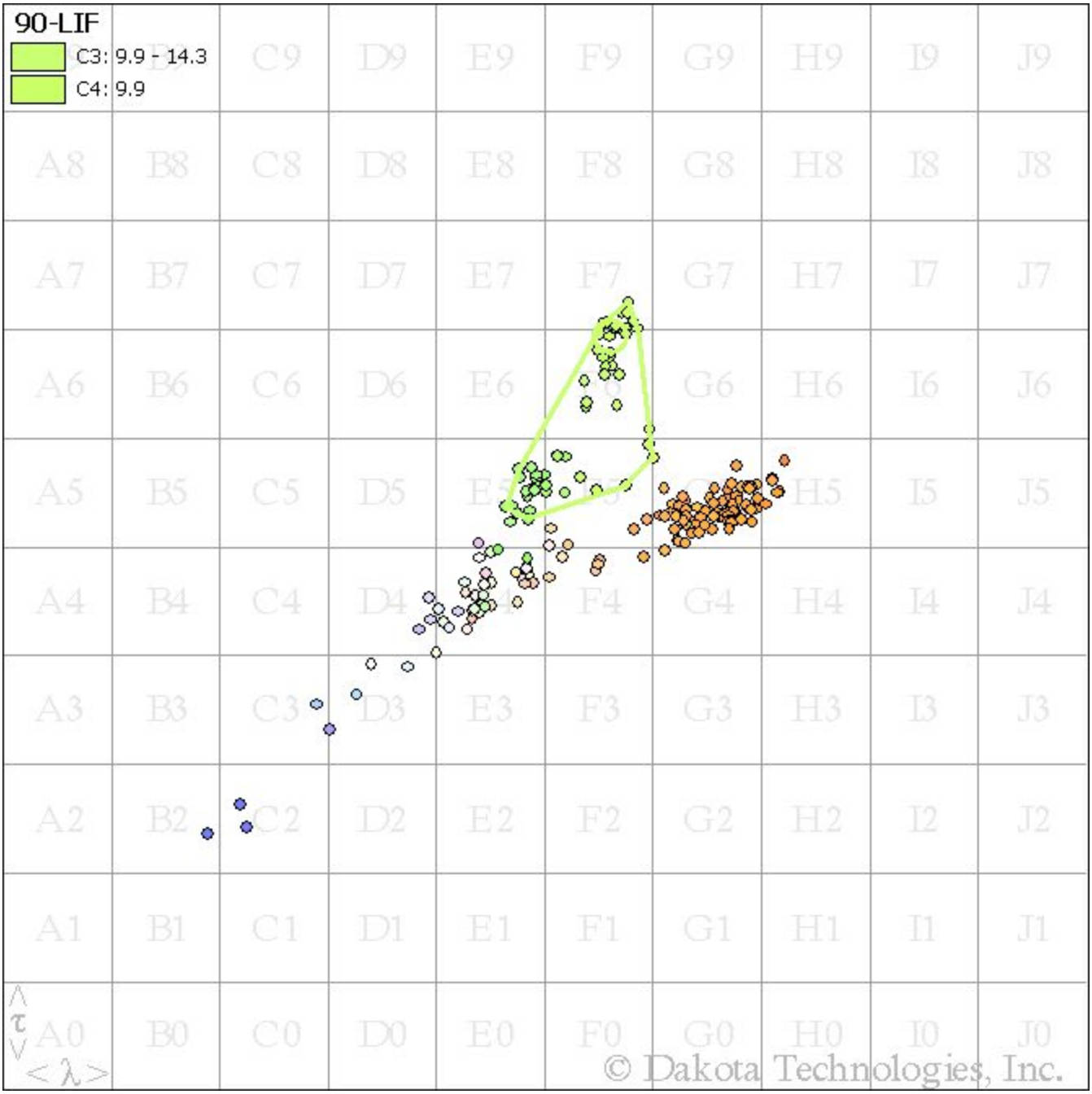
90-LIF
C3: 9.9 - 14.3
C4: 9.9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 G6 H6 I6 J6
A5 B5 C5 D5 H5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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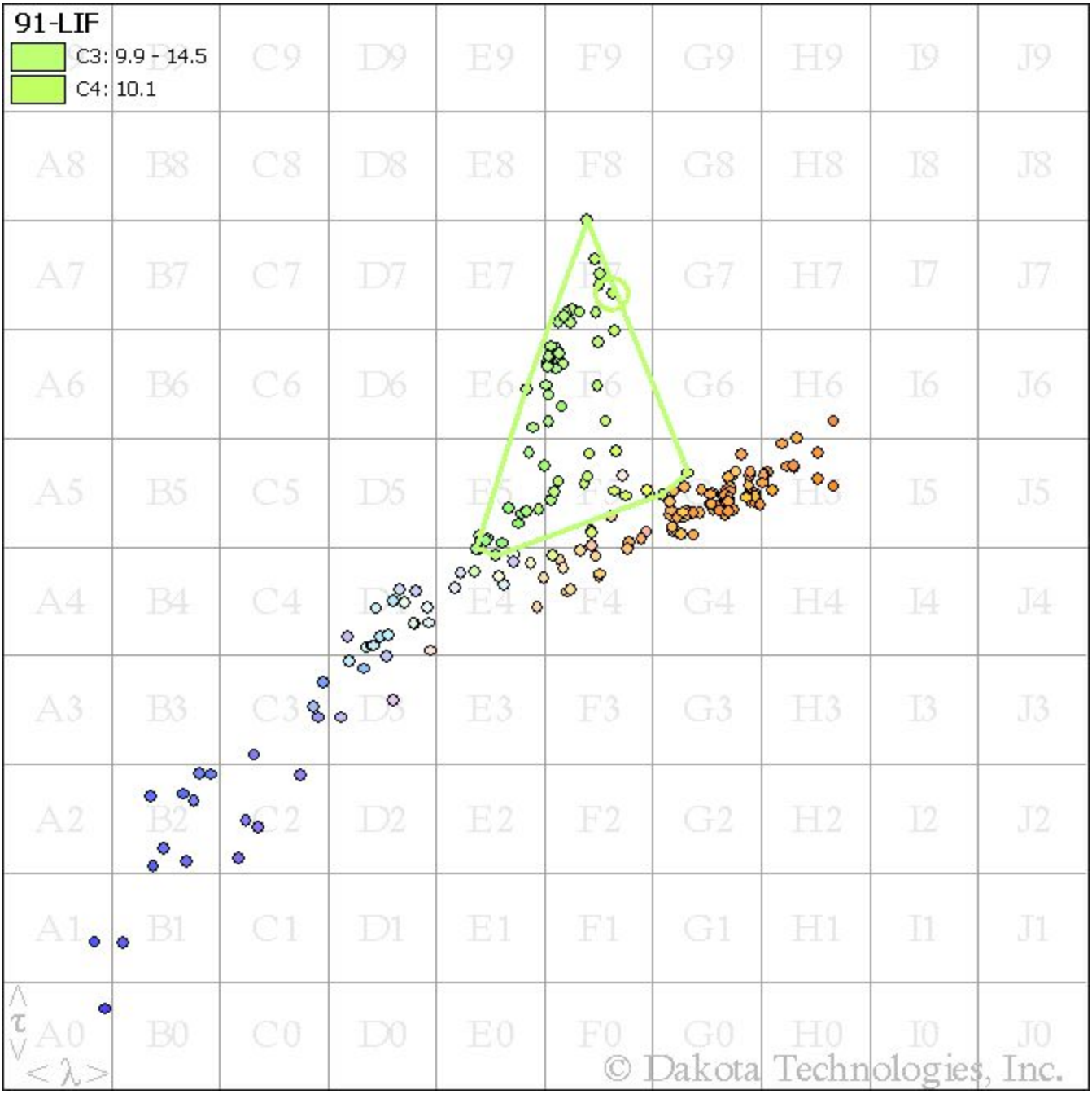
91-LIF
C3: 9.9 - 14.5
C4: 10.1
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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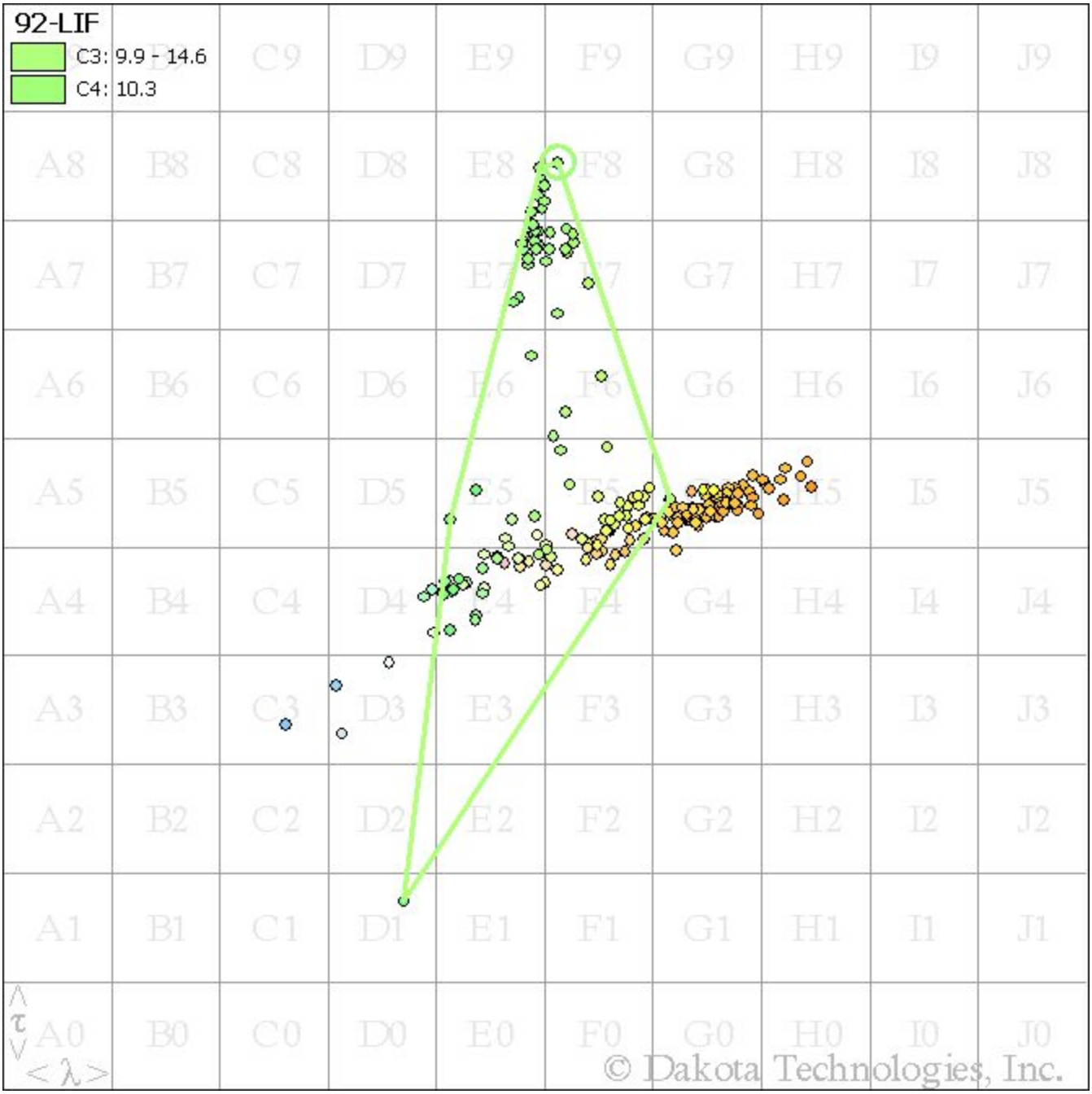
92-LIF
C3: 9.9 - 14.6
C4: 10.3
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
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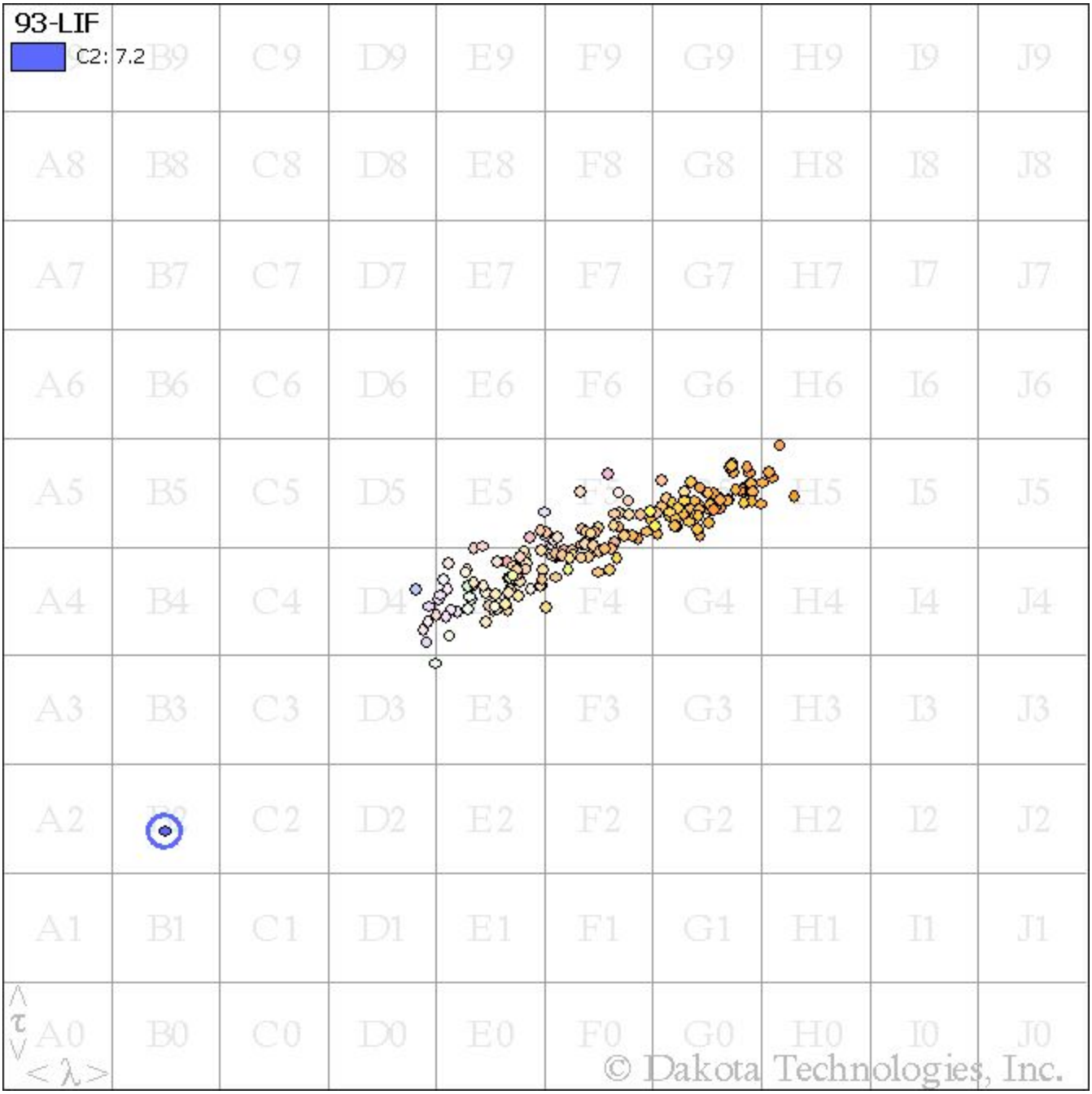
93-LIF
C2: 7.2
B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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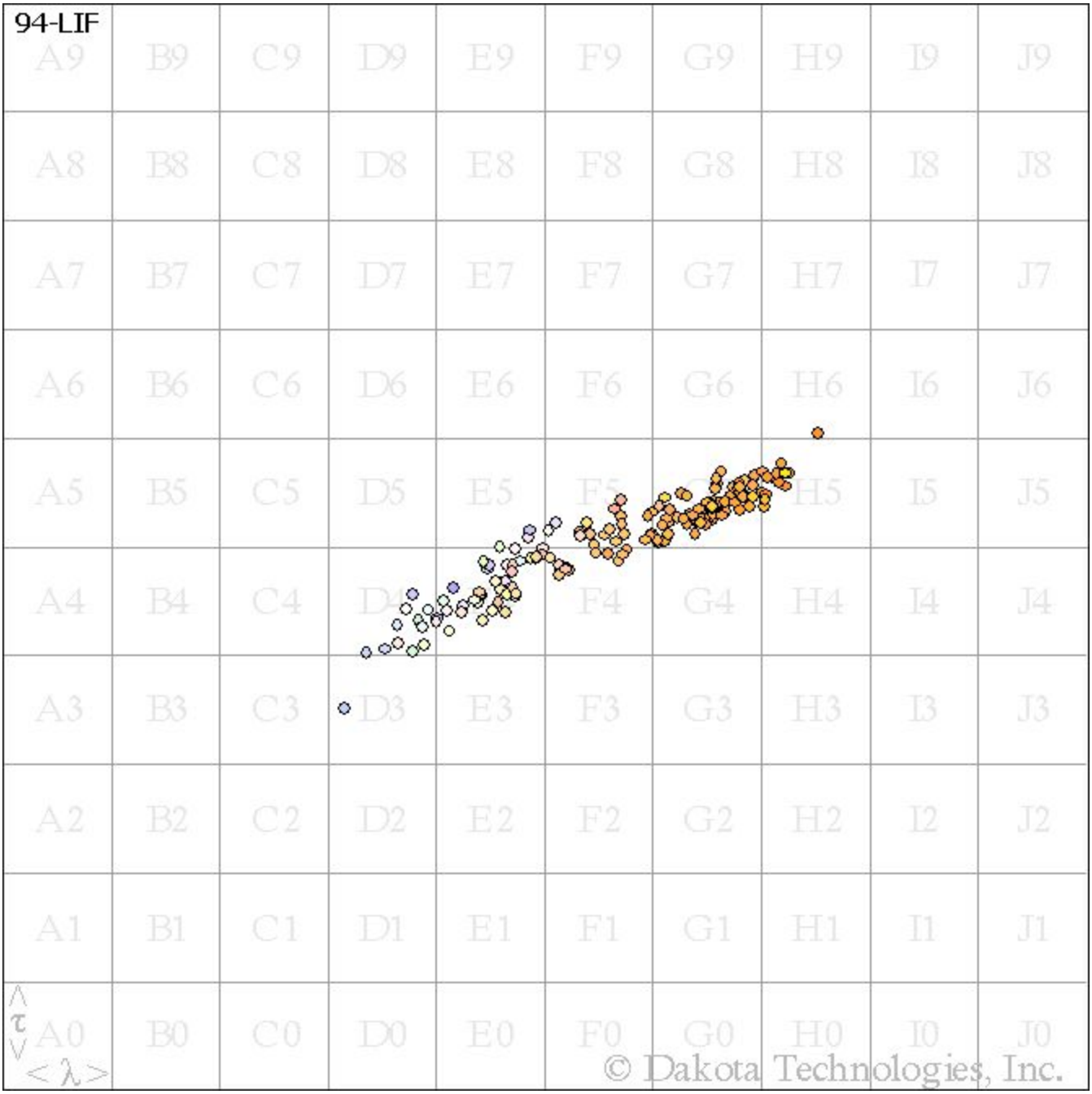
94-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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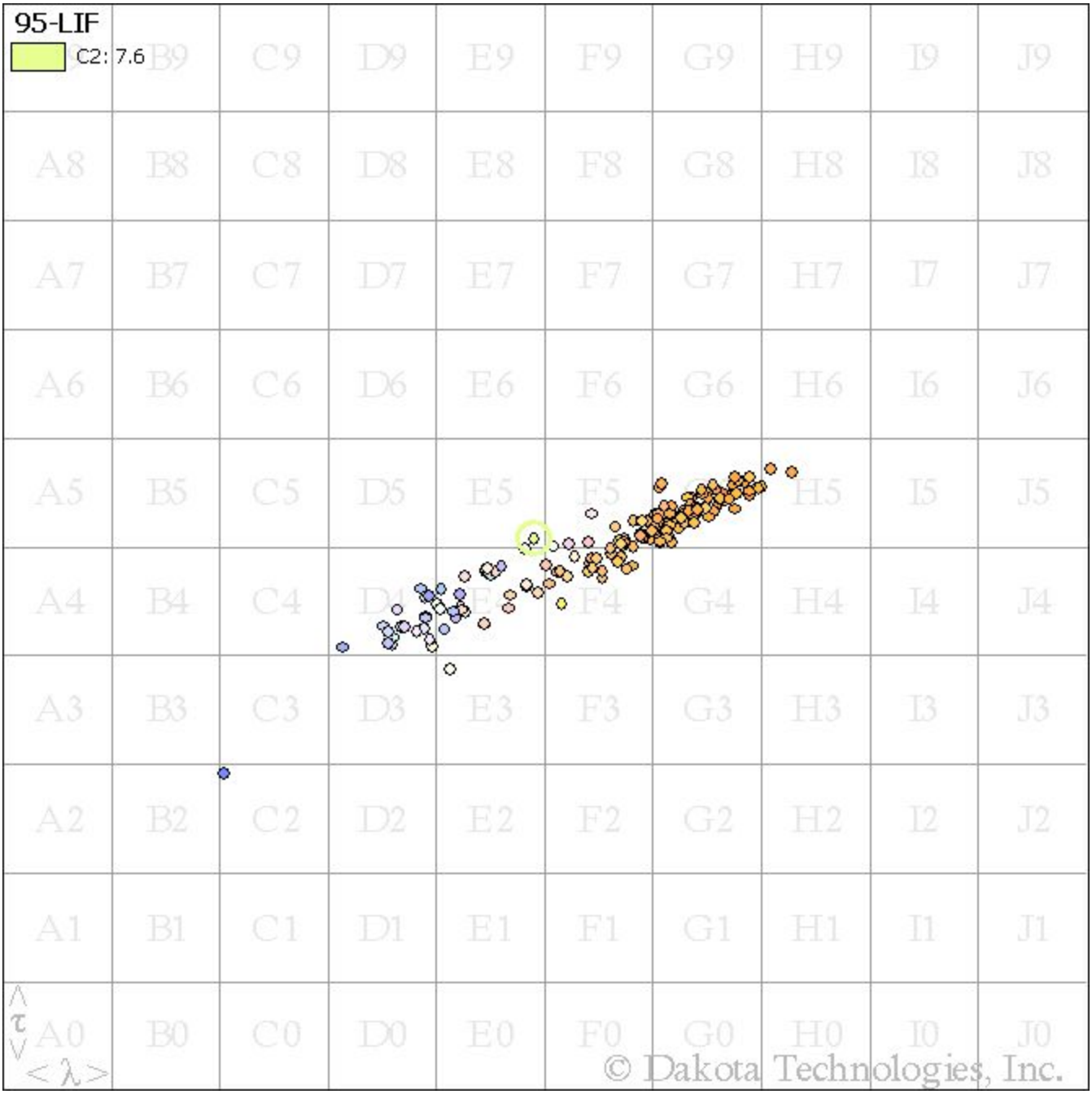
95-LIF
C2: 7.6
B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 H5 I5 J5
A4 B4 C4 D4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
τ
λ
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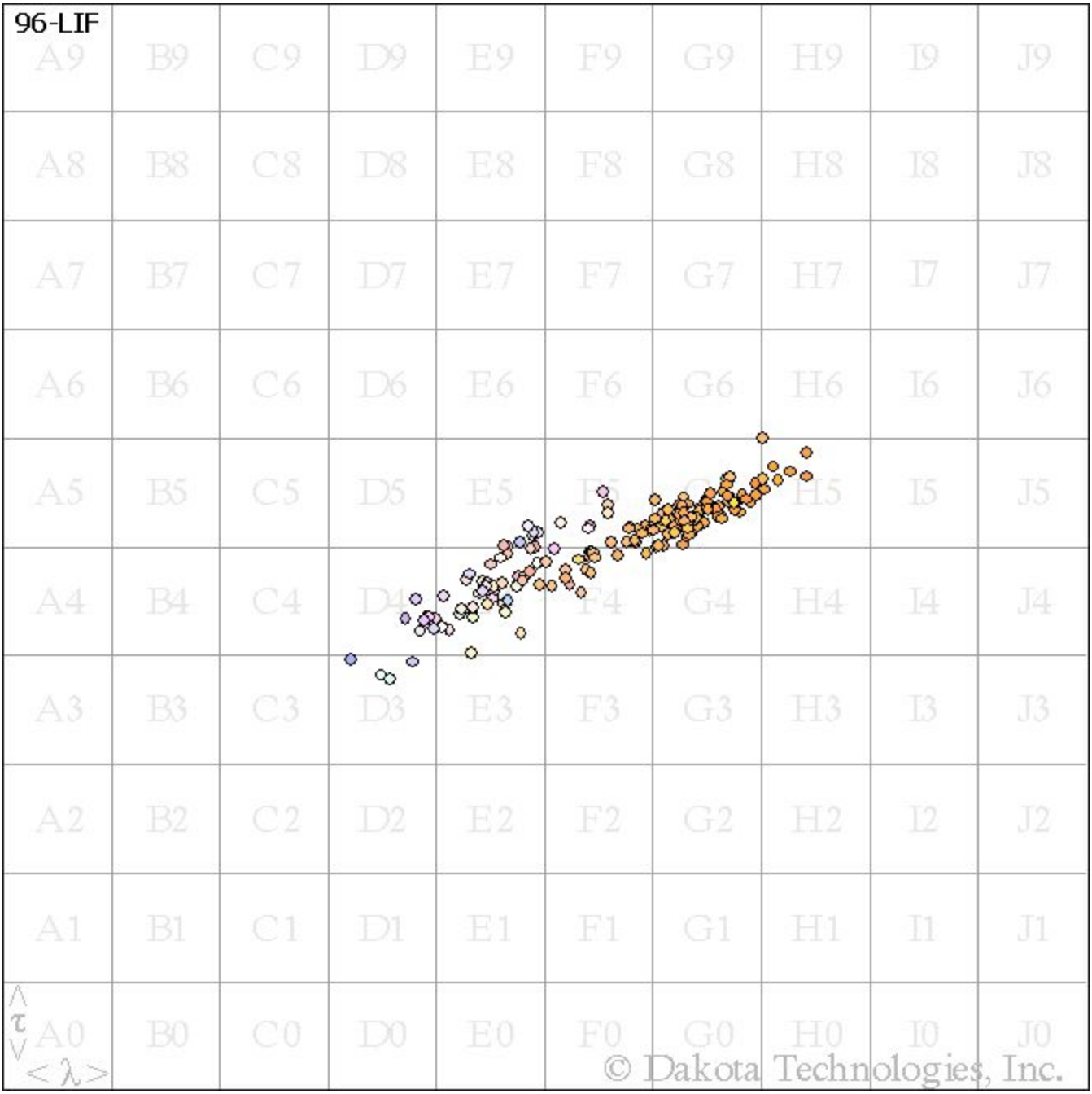
96-LIF
A9 B9 C9 D9 E9 F9 G9 H9 I9 J9
A8 B8 C8 D8 E8 F8 G8 H8 I8 J8
A7 B7 C7 D7 E7 F7 G7 H7 I7 J7
A6 B6 C6 D6 E6 F6 G6 H6 I6 J6
A5 B5 C5 D5 E5 F5 G5 H5 I5 J5
A4 B4 C4 D4 E4 F4 G4 H4 I4 J4
A3 B3 C3 D3 E3 F3 G3 H3 I3 J3
A2 B2 C2 D2 E2 F2 G2 H2 I2 J2
A1 B1 C1 D1 E1 F1 G1 H1 I1 J1
A0 B0 C0 D0 E0 F0 G0 H0 I0 J0
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