

EPA Part 98 Mandatory Greenhouse Gas Reporting  
Subpart RR – Geologic Sequestration of Carbon Dioxide

40 CFR 98.446(f)(12)

2023 Annual Monitoring Report

Reporting Period: October 31 – December 31, 2023

MRV Number 1014505-1

Harvestone Low Carbon Partners, LLC.

Blue Flint Sequester Company

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## 40 CFR Part 98, Section 446, Paragraph (f)(12)

- i. A narrative history of the monitoring efforts conducted over the previous calendar year, including a listing of all monitoring equipment that was operated, its period of operation, and any relevant tests or surveys that were conducted.**

Blue Flint Sequester Company (BFS) is operating under an approved Monitoring, Reporting, and Verification (MRV) Plan for carbon capture and sequestration at its Blue Flint Underwood location. The plan includes multiple monitoring measures with approved monitoring equipment and its period of operation. It also lists tests and/or surveys that must be conducted in the 2023 calendar year. Continual monitoring and recording of the operational parameters commenced upon injection and continued throughout periods of temporary facility shutdowns.

Operational parameters, in accordance with the approved MRV Plan, include 1) periodic CO<sub>2</sub> stream, groundwater, atmospheric, and soil gas sampling and analysis; 2) continuous monitoring and recording of injection rate, pressures, temperatures, and volume for the MAG 1 injection well; 3) continuous monitoring and recording of pressures and temperatures for the MAG 2 monitor well and associated geologic formations; 4) corrosion monitoring; and 5) mechanical integrity of the wellbore; and 6) indirect reservoir monitoring.

BFS began commercial injection of carbon dioxide (CO<sub>2</sub>) into the Broom Creek formation via MAG 1 well on October 31, 2023. As of December 31, 2023, BFS injected 29,960.82 metric tonnes of CO<sub>2</sub> for permanent geologic storage.

Analysis of monitoring data collected within the Active Monitoring Area (AMA) revealed no evidence of surface or subsurface leakage of the CO<sub>2</sub> stream during the 2023 year. However, in the first quarter of 2024, a very slight CO<sub>2</sub> leak was identified. Alarms and shut-off devices were active and operating normally during this time, and no emergency shut-off triggering event occurred. Initial analysis of the monitoring data used to track the CO<sub>2</sub> plume and pressure front is consistent with preliminary reservoir modeling expectations.

For flowline and wellhead CO<sub>2</sub> exposure, corrosion coupons were sampled at the end of the first injection quarter. The results of the coupon analysis showed there was not any discernible pitting and minimal mass loss was observed. Therefore, the integrity of the flowline, wellhead, and injection tubing and packer was discerned to be impervious to the CO<sub>2</sub> stream for the 2023 calendar year.

Near-subsurface monitoring of groundwater, USDW, and soil gas wells were analyzed quarterly in the 2023 calendar year, including establishing a baseline and continuing upon injection. Analysis results were consistent with expected baseline ranges. BFS continuously collected flowline and wellhead surface and bottomhole pressures and temperatures, and seismic data, to

monitor the CO<sub>2</sub> plume and pressure front within the storage reservoir. The observed bottomhole pressure calculations in the storage reservoir are within the predicted ranges from the preliminary model simulations, demonstrating good overall conformance for the reporting period.

DTS data collected from the MAG 1 injection and MAG 2 monitor well during an unscheduled liquefaction plant shutdown period between December 28 – 30, 2023, was analyzed to confirm the integrity of the injection and monitor well casing and cement. Temperature profiles were examined to search for any potential anomalies. Third-party interpretation of the temperature data sets determined that there were not any indications of loss of mechanical integrity of the casing or cement during this timeframe.

The U.S. Geological Survey (USGS) Advanced National Seismic System (ANSS) showed that no events were detected in the state of North Dakota during 2023. It should be noted that the detection threshold for the USGS ANSS system is Magnitude 2.5. In accordance with the approved Testing and Monitoring Plan - Operational Frequency for data collection, BFS is scheduled to repeat the 2D seismic survey for time-lapse seismic data at the end of injection year 1 to provide a more detailed update to the storage reservoir projection prior to the 5-year review.

**ii. A description of any changes to the monitoring program that you concluded were not material changes warranting submission of a revised MRV plan under §98.448(d).**

As injection operations were about to commence, BFS discovered and immediately notified North Dakota Department of Mineral Resources – Oil and Gas Division (DMR-O&G), that the tubing conveyed bottomhole pressure and temperature gauge in MAG 1 ceased communicating to the surface control system on October 26, 2023. ND DMR-O&G staff rectified a provisional solution for the discontinuance of the tubing conveyed bottomhole pressure/temperature (BHPT) gauge readings by conducting hourly bottomhole pressure calculations based on the wellhead surface injection pressure. The BHPT gauge was provided by a third-party vendor, whose technicians were unable to reestablish communications without implementing a workover for pulling the injection tubing out of the wellbore. Discussions with DMR-O&G deemed this action to be a higher risk to the well integrity than continuing the provisional solution. In the interim, bottomhole pressure calculations are being performed, recorded, monitored hourly, and reported daily to the ND DMR-O&G staff, using real-time continuous surface pressure gauge and injection rate data at the wellhead. A modeling program, PROSPER, was utilized to derive accurate BHP calculations including change of friction loss associated with the CO<sub>2</sub> injection rates in the 2-7/8” tubing. PROSPER calculations utilize the Peng Robinson equation of state and can model the CO<sub>2</sub> properties using the actual densities acquired from the Coriolis meter measurements of the CO<sub>2</sub> stream. Short-term mitigations with the ND DMR-O&G are to continue the daily calculation of the bottomhole pressure. Long-term mitigations involve

replacing the tubing conveyed bottomhole pressure/temperature gauge when the well requires a workover procedure involving removing the tubing from the wellbore or when additional testing and monitoring requirements involve a well workover.

Assurance for protection of the sequestration and sealing formations, in addition to protecting the USDW, involves the operational limitation of the surface injection pressure due to the maximum flowline pressure of 1900 psi. At a maximum flowline surface pressure of 1900psi, the bottomhole pressure is calculated at 2505 psi, attributed to significantly higher tubing friction and the high permeability of the Broom Creek formation. The potential to even approach the approved Class VI permit stipulations for a maximum allowable bottomhole pressure of 2936 psi is substantially minimized due to two automated emergency shutdown valves installed at the wellhead on the flowline, set to alarm at 1850psi and set to close at 1900psi. Additionally, the high-pressure pump at the liquefaction plant is not capable of producing pressure greater than 1900psi. Therefore, Blue Flint assures operational protection of sequestration, sealing zones, and the USDW.

With a temporary provision in place and whilst undergoing discussions with DMR-O&G staff, BFS will continue to assess the situation according to the MRV Plan and submit a revised MRV Plan when deemed necessary.

**iii. A narrative history of any monitoring anomalies that were detected in the previous calendar year and how they were investigated and resolved.**

There were not any direct or indirect monitoring anomalies detected in the 2023 calendar year. From the commencement of injection, thorough and continuous review of the operational monitoring parameters was conducted by the BFS engineers and third-party technicians.

There have not been any pressure or temperature anomalies identified to indicate issues with the mechanical integrity of the well casing and cement in either MAG 1 or MAG 2 wellbores. Continuous monitoring of the internal and external mechanical integrity of the longstring casing in the MAG 1 injection well and MAG 2 monitor well was performed by surface, bottomhole, and annulus pressures and temperature profile analyses tubing/casing conveyed Distributed Temperature Sensing (DTS).

Scheduled and unexpected mechanical issues in the liquefaction plant caused periods of downtime and reduced CO<sub>2</sub> injection activity during the operational period in 2023. Monitoring and recording of the pressures and temperature readings continued throughout the downtime periods. Observations of the DTS profiles in MAG 1 indicated rapid geothermal recovery of the injection zone during downtimes.

**iv. A description of any surface leakages of CO<sub>2</sub>, including a discussion of all methodologies and technologies involved in detecting and quantifying the surface leakages and any assumptions and uncertainties involved in calculating the amount of CO<sub>2</sub> emitted.**

The BFS facility did not have any known surface leakages of CO<sub>2</sub> during the 2023 calendar year. As per EPA 40 CFR Part 98 Subpart W, no reporting is required as threshold is greater than the estimated total emission volume for the listed facilities downstream of the injection meter. However, in the first quarter of 2024, a slight CO<sub>2</sub> leak was identified in the injection tubing to casing annulus. This leak was identified in the wellbore from the fluctuating annulus pressure and maintained in the wellbore by applying a higher annulus pressure once the issue was identified. The CO<sub>2</sub> surface leakage volume was estimated to have vented through the Wellhead Annulus Monitoring System tank and the volume was back calculated into 2023, with a volume of 1.8 metric tonnes, as reported in the e-GRRT report.

Assurance for no additional surface leakages was supported by monitoring multiple operational direct and indirect surface and subsurface parameters, as per the approved MRV Plan. Surface components of the injection system, including the aboveground portions of the CO<sub>2</sub> transport flowline and wellhead, were monitored throughout the injection period. Routine visual inspections were conducted along the flow line, CO<sub>2</sub> sensors and alarms were active, and Distributed Temperature Sensing (DTS) fiber data was continuously monitored for anomalies by system operators and BFS engineers, with no additional surface CO<sub>2</sub> leaks observed or detected during the injection reporting period in 2023.