Longleaf CCS Hub

Longleaf CCS, LLC

Injection Well Plugging Plan

40 CFR 146.92

Facility Information

Facility Name: Longleaf CCS Hub

Facility Contact: Longleaf CCS, LLC
14302 FNB Parkway
Omaha, NE 68154

Well Locations: Mobile County, Alabama
LL#1: Latitude: 31.071303° N
Longitude: -88.094703° W
LL#2: Latitude: 31.070774° N
Longitude: -88.074523° W
LL#3: Latitude: 31.0447129° N
Longitude: -88.0736318° W
LL#4: Latitude: 31.0569516° N
Longitude: -88.1047433° W

Table of Contents

List of Figures

List of Tables

List of Acronyms/Abbreviations

AoR	Area of Review
CCS	Carbon capture and storage
CO_2	Carbon dioxide
CMG	Computer Modelling Group
DOE	Department of Energy
DAS	Distributed Acoustic Sensing
DTS	Distributed Temperature Sensing
EPA	Environmental Protection Agency
ERRP	Emergency and Remedial Response
ft	Feet
LL	Longleaf
MIT	Mechanical Integrity Test
MMcf/d	Million cubic feet/day
mg/l	Milligrams per liter
mt	Metric tons
Mt	Millions of metric tons
mt/d	Metric tons per day
mt/y	Metric tons per day
MT/y	Millions of metric tons per year
PISC	Post-Injection Site Care
PNC	Pulsed Neutron Capture Log
psi	Pounds per square inch
psi/ft	Pounds per square inch per foot
SS	Sub-Sea
TVD	True Vertical Depth
UIC	Underground Injection Control
USDW	Underground Source of Drinking Water

A. Introduction

Outlined in the following document is the description of the process that the Longleaf CCS Hub will follow to plug proposed CO_2 injection wells LL#1, LL#2, LL#3, and LL#4 in accordance with the EPA's requirements under 40 CFR 146.92 and 40 CFR 146.93(e) and the State of Alabama's requirements under ASR 400-1-4-.15-.16 to ensure that the abandoned wells maintain integrity and will not pose a threat to USDWs. Plugging activities at an injection well will begin following the cessation of CO_2 injection in that well. However, in certain situations, Longleaf CCS, LLC may choose to delay plugging selected injection wells and to use them, for some period of time, to monitor in-zone reservoir conditions post-injection. If delaying plugging of an injection well, per ASR 400-1-4-.17, Longleaf CCS, LLC will submit a request to the Alabama Oil and Gas Board for the well to be placed into a temporarily abandoned injection well status for a period of not more than a year, with a subsequent request submitted for a 1-year extension.

Following are notifications and reporting required with plugging an injection well, which shall be submitted separately for each well:

- **60-Day Notification**: The Longleaf CCS Hub will notify the UIC Program Director in writing at least 60 days prior to the plugging of an injection well. Any changes to this plan shall be submitted no later than with the notification (40 CFR 146.92(c)).
- **Well Plugging Report**: Within 30 days of plugging an injection well, Longleaf CCS Hub will submit a well plugging report using OGB AL Form OGB-11 to the UIC Program Director and Alabama Oil and Gas Board (40 CFR 146.92(d); ASR 400-1-4-.15).

A.1 Injection Well Configuration

Prior to plugging, the injection well configuration will include conductor casing, surface casing, and long string casing, all cemented to surface. The wells will also have an injection tubing string. LL#2, LL#3, and LL#4 without sliding sleeves in the tubing string will have a configuration as shown in **Figure 1**. LL#1 that utilizes sliding sleeves in the tubing string will have a configuration as shown in **Figure 2**.

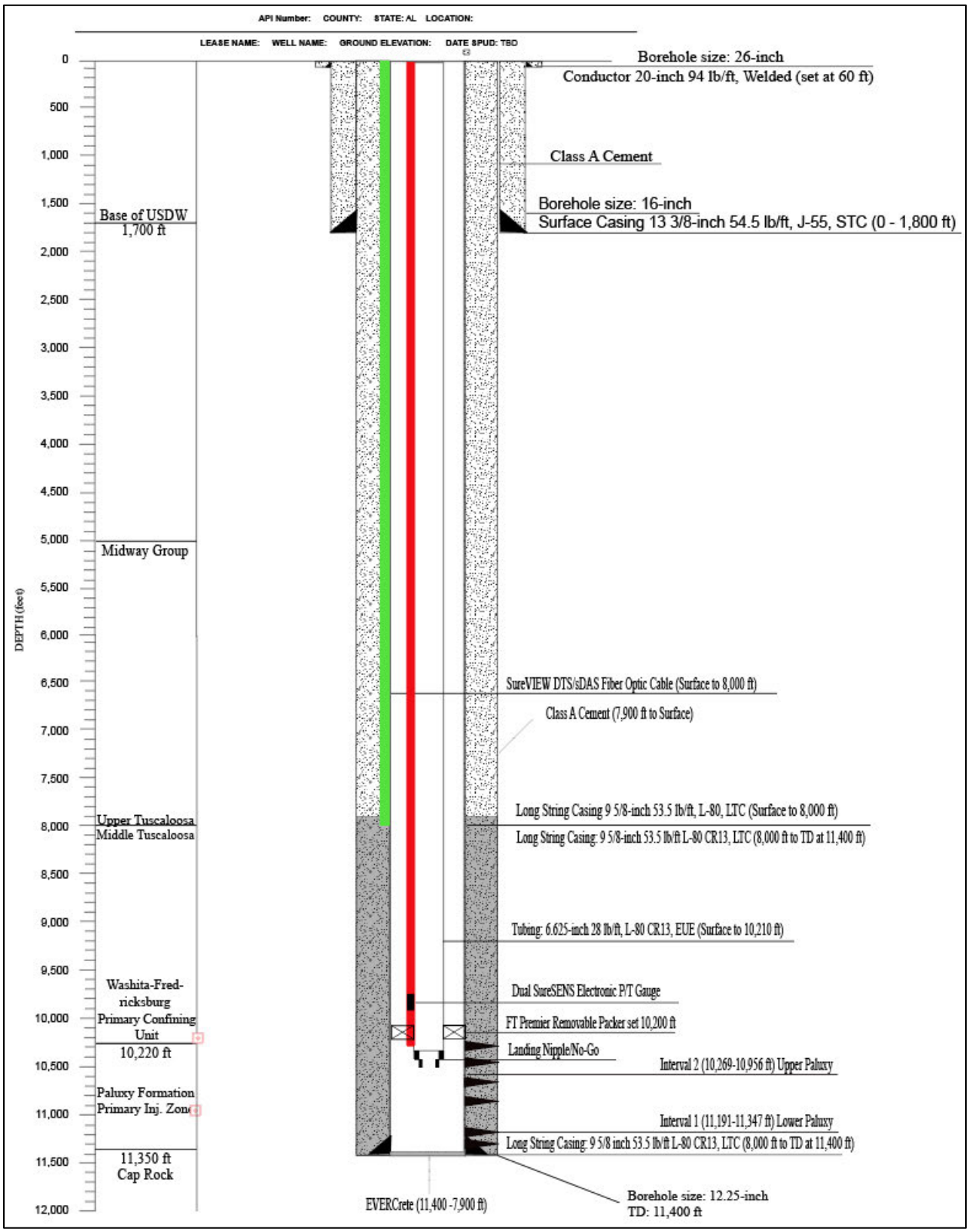

Figure 1. Injection Wells LL#2, LL#3, and LL#4 Configuration, without Sliding Sleeves

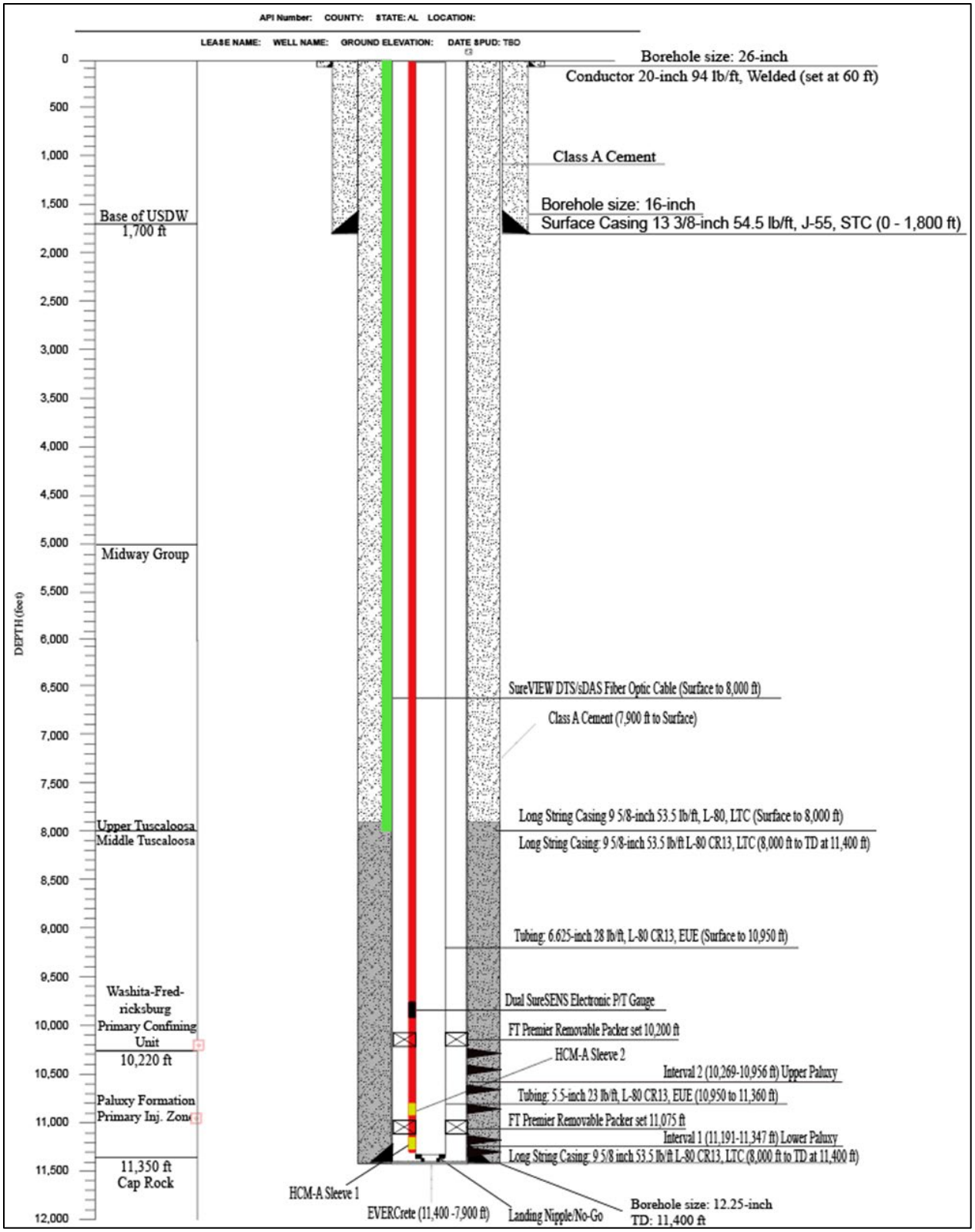

Figure 2. Injection Well LL#1 Configuration, with Sliding Sleeves

B. Injection Well Tests

B.1. Tests or Measures for Determining Bottom-Hole Reservoir Pressure

Bottom-hole pressure measurements will be performed and recorded throughout the project. Pressure gauges will be placed in the injection tubing or in the deep casing string within the injection zone. These pressure-measurement devices will allow for continuous, real-time, surface readout of the pressure data. The bottom-hole reservoir pressure will be obtained using the final measurements from the pressure gauges in the injection zone after the CO_2 injection period has ended.

After the bottom-hole pressure is determined, a buffered fluid (brine) will be used to flush and fill the well to maintain pressure control of the well. The measured bottom-hole pressure will be used to determine the proper weight brine that should be used to stabilize the well. These data may also be used to determine the blend of cement to be used to plug the well (i.e., weight range of cement to prevent leak-off into formation or flowing of well, or to prevent premature setting and curing of the cement).

B.2 Testing Method to Ensure External Mechanical Integrity

The mechanical integrity of the well will be demonstrated after CO_2 injection and prior to the plugging of the well to ensure no communication has been established between the injection zone and the USDWs or ground surface (per 40 CFR 146.92(b)(2)). Such well integrity testing will use a temperature log, noise log, or an activated-oxygen log to be run in the well. A temperature log will be run over the entire depth of the injection well. Data from the logging run will be evaluated for anomalies in the temperature curve, which would be indicative of fluid migration outside of the injection zone. This data will also be compared to the information gathered from the baseline logs performed prior to injection of CO_2 into the well. Should deviations be noted between the temperature logs performed before and after the injection of CO_2 raise issues related to the integrity of the well casing or cement, this topic will be addressed promptly.

C. Plugging Plan

C.1 Procedures/Etc.

The methods and materials described in this part are based upon current understanding of the geology at the site and the current well designs. If necessary, the plan will be updated to reflect the latest well designs. Any changes to the plan will be submitted at least 60 days prior to the plugging of well and approved by EPA prior to commencing plugging activities. This plan also complies with Alabama Oil and Gas Board requirements in ASR 400-1-4-.14(1)-(2) that state:

> "A cement plug shall be placed across each hydrocarbon-bearing, abnormally pressured, or injection zone or a permanent-type bridge plug shall be placed at the top of each hydrocarbon-bearing zone or injection zone, but in either event a cement plug at least two hundred (200) feet in length shall be placed immediately above the uppermost hydrocarbon-bearing or injection zone. When the base of fresh water is penetrated, a cement plug at least two hundred (200) feet in length shall be placed at least fifty (50) feet below and shall extend to at least one hundred fifty (150) feet above the base of fresh water."

The following procedure includes operations to place a solid column of cement from the total depth of the well to the top of the casing string.

After the injection is terminated permanently, the injection tubing and packer will be removed. Then, the balanced-plug placement method will be used to plug the well. If, after flushing, the tubing and packer cannot be released, an electric line with tubing cutter will be used to cut off the tubing above the packer and the packer will be left in the well. The cement retainer method will be used for plugging the injection formation below the abandoned packer.

To further ensure no communication from the injection zone to the USDW zone or ground surface, the injection well casing will be plugged with cement.

Table 1 presents the intervals that will be plugged and the materials and methods that will be used to plug the intervals. The portion of the well corresponding to the injection

zone will be plugged using Schlumberger's EverCRETE or similar CO_2-resistant cement with a retainer method. The cement retainer will be set 100 ft above the contact between the Paluxy Sandstone and the overlaying confining unit and will be constructed of corrosion-resistant materials. Approximately 220 sacks of CO_2-resistant cement will be used to plug the Paluxy injection interval (this includes a 10 percent excess volume to be squeezed through the perforations into the Paluxy Sandstone).

Table 1. Intervals to Be Plugged and Materials/Methods Used

Description	Top (ft)	Bottom (ft)	Type	Quantity
Lift 1	10,900	11,400	EverCRETE	220 sacks
Lift 2	10,400	10,900	EverCRETE	190 sacks
Lift 3	9,900	10,400	EverCRETE	190 sacks
Lift 4	9,400	9,900	EverCRETE	190 sacks
Lift 5	8,900	9,400	EverCRETE	190 sacks
Lift 6	8,400	8,900	EverCRETE	190 sacks
Lift 7	7,900	8,400	EverCRETE	190 sacks
Lift 8	7,400	7,900	Class A	190 sacks
Lift 9	6,900	7,400	Class A	190 sacks
Lift 10	6,400	6,900	Class A	190 sacks
Lift 11	5,900	6,400	Class A	190 sacks
Lift 11	5,400	5,900	Class A	190 sacks
Lift 13	4,900	5,400	Class A	190 sacks
Lift 14	4,400	4,900	Class A	190 sacks
Lift 15	3,900	4,400	Class A	190 sacks
Lift 16	3,400	3,900	Class A	190 sacks
Lift 17	2,900	3,400	Class A	190 sacks
Lift 18	2,400	2,900	Class A	190 sacks
Lift 19	1,900	2,400	Class A	190 sacks
Lift 20	1,400	1,900	Class A	190 sacks
Lift 21	900	1,400	Class A	190 sacks
Lift 22	400	900	Class A	190 sacks
Lift 23	0	400	Class A	155 sacks

The pressure used to squeeze the cement will be determined from the bottom-hole pressure data measured before beginning the plugging and abandonment process. A maximum pressure threshold of 90% of the determined reservoir fracture pressure for the Paluxy Sandstone will be utilized to constrain pressure increases during the cement injection process. If it appears that the injection pressure will exceed the 90% fracture pressure threshold and the total amount of cement has not been pumped into the injection zone, cement pumping will cease. Then, the tubing will be removed from the cement retainer to allow the pressure to return to static condition. After allowing the pressure to decline, the tubing will be re-strung through the cement retainer, and cement pumping will be attempted again. A rapid increase in pressure on the tubing would indicate that the Paluxy perforations have been sealed with cement, and no additional cement will be added to the zone or plug.

Cementing operations will continue to plug the entire wellbore. Cement will be pumped in 500 ft lifts (190 sacks) using a balance method. This will ensure efficient cement placement and prevent tubing from sticking in the cement column. **Figure 3** shows the details of the injection well after plugging and abandonment.

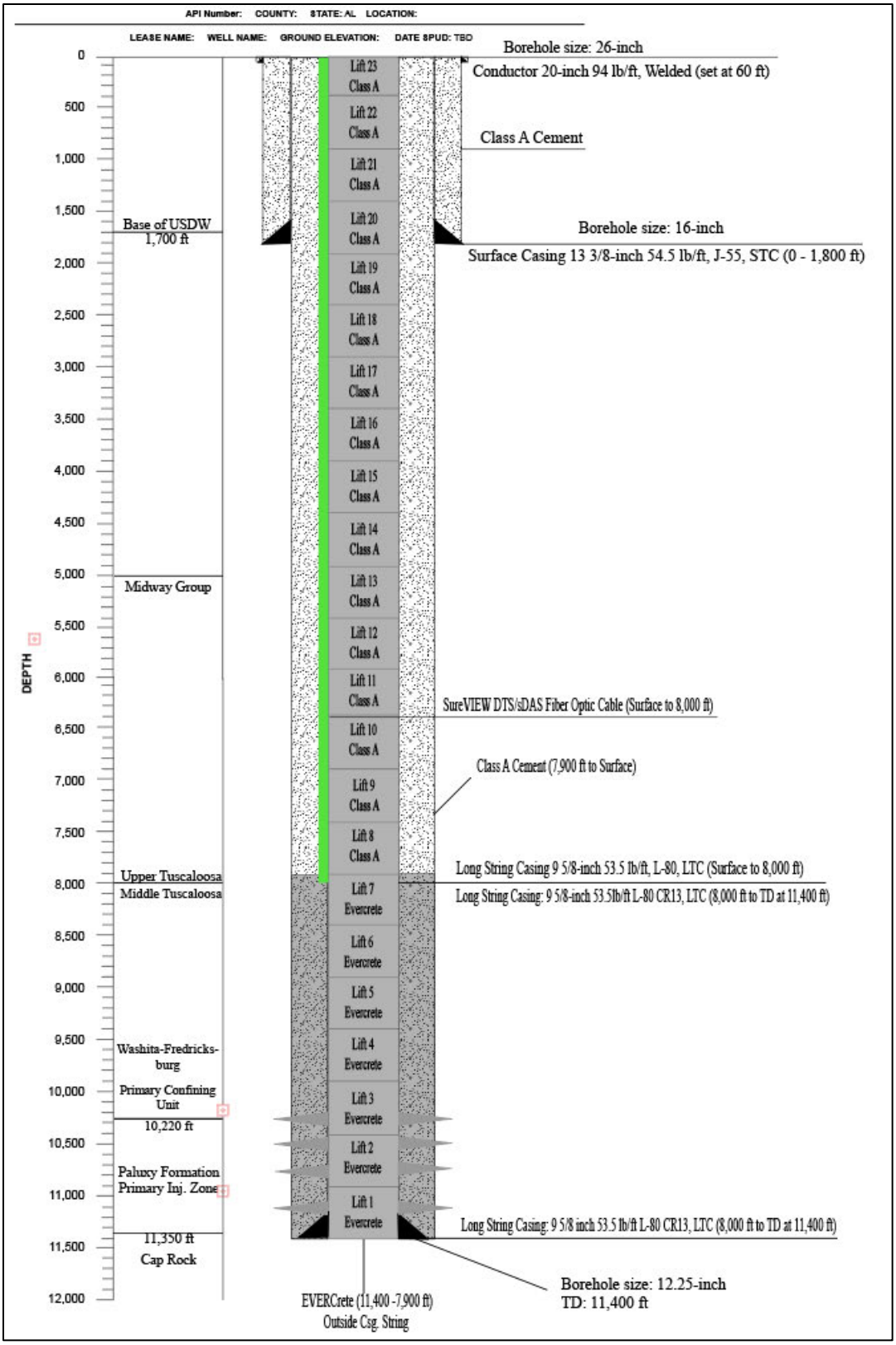

Figure 3. Diagram of the Injection Well After Plugging and Abandonment

After the remainder of the casing has been filled with cement, the casing sections will be cut off approximately 5 ft below surface and a steel cap will be welded to the top of the deep casing string. The cap will have the well identification number, the Class VI UIC well permit number, and the date of plug and abandonment inscribed on it. Soil will be backfilled around the well to bring the area around the well back to pre-well-installation conditions. This area will then be planted with natural vegetation.

C.2 OGB AL Documents and Forms

After the completion of the plugging activities, a plugging report (OGB AL Form OGB-11) will be submitted to the UIC Program Director, as well as the Alabama Oil and Gas Board, describing the methods and tests that were performed on the well during plugging. This report will be submitted to the UIC Program Director within 60 days of completing the plugging activities.