UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

Sent via email only

October 28, 2020

Rebecca Hollis
Clean Energy Systems
3035 Prospect Park Dr., Suite 120
Rancho Cordova, California 95670

Re: Technical Evaluation Comments and Information Request #4 for
CES-Mendota Site Underground Injection Control (UIC) Permit Application
Class VI Pre-Construction Permit Application No. R9UIC-CA6-FY20-1

Dear Ms. Hollis:

The United States Environmental Protection Agency, Region 9 (EPA) has conducted a technical evaluation of the proposed testing and monitoring activities, and the proposed construction and plugging procedures provided in Attachments B, C, D, E, and G of the subject permit application. Based on this evaluation, we have identified additional information and clarifications needed for EPA's continued evaluation of the permit application.

Please submit the supplemental information requested in the Enclosures by December 4, 2020. If you have any questions about this letter and the Enclosures, please contact me at (415) 972-3971 or call Calvin Ho at (415) 972-3262.

Sincerely,

DAVID ALBRIGHT
Digitally signed by DAVID ALBRIGHT
Date: 2020.10.28 09:38:46 -07'00'

David Albright
Manager, Groundwater Protection Section

Enclosures

cc (via email): Chris Jones, CalGEM Inland District
Clay Rodgers, Central Valley Regional Water Quality Control Board
John Borkovich, CA State Water Resources Control Board
Amit Garg, CalGEM
Vincent Agusiegbe, CalGEM

ENCLOSURE 1

Evaluation of Proposed Testing and Monitoring Activities at the CES-Mendota Class VI Project

This testing and monitoring evaluation report for the proposed Clean Energy Systems (CES)-Mendota Class VI geologic sequestration project summarizes EPA's evaluation of the testing and monitoring CES proposes to conduct during and following injection operations. Due to the similarities of certain monitoring activities (e.g., groundwater monitoring and plume and pressure front tracking) to be performed in the injection and post-injection phases, these activities (as described in Attachments C and E of the Class VI permit application) are evaluated in a single report. This review also identifies preliminary questions for CES.

CES notes that they will report the results of all injection-phase testing and monitoring activities in compliance with the requirements of 40 CFR 146.91. The results of post-injection testing and monitoring results will be submitted to EPA in annual reports within 60 days following the anniversary date of the date on which injection ceases.

Carbon Dioxide Stream Analysis

CES will sample the carbon dioxide (CO_2) stream on a quarterly basis at a location after the last stage of compression. The table below summarizes the analytical parameters that CES proposes for monitoring the CO_2 stream (from Table 1).

Parameter	Analytical Method(s)[1]
Oxygen	ISBT 4.0 (GC/DID) GC/TCD
Nitrogen	ISBT 4.0 GC/DID GC/TCD
Carbon Monoxide	ISBT 5.0 Colorimetric ISBT 4.0 (GC/DID)
Oxides of Nitrogen	ISBT 7.0 Colorimetric
Ammonia	ISBT 6.0 (DT)
Hydrogen Sulfide	ISBT 14.0 (GC/SCD)
CO_2 Purity	ISBT 2.0 Caustic absorption Zahm-Nagel ALI method SAM 4.1 subtraction method (GC/DID) GC/TCD

Note 1: An equivalent method may be employed with the prior approval of the UIC Program Director.

There are no EPA-approved analytical methods for CO_2 injection streams. The analytical methods CES proposes to use appear to be from the International Society of Beverage Technologists (ISBT). All of these analytical methods, except ISBT 6.0 have been employed for other CO_2 GS projects, so there is EPA precedent for their use in EPA Class VI permits.

Most of the proposed analytical parameters match the results of a gas stream analysis that is presented in Table 8 of the permit application narrative (replicated below). The application notes that the gas stream will contain 96.78% CO_2 with some impurities. It is unclear when this sample was taken.

Injectate Composition (Mass Fractions) From Table 8 of the permit application	
H_2O	0.002245
O_2	0.011536
H_2	0.000164
N_2	0.001475
CO	0.005322
CO_2	0.967834
Ar	0.01119
NO	9.01E-05
NO_2	9.03E-08
H_2S	0.000144
NH_3	1.93E-10

QA procedures for all of the analytical parameters proposed for the CO_2 stream analysis are documented and described in the QASP (Section A4a). Two additional parameters related to injectate analysis are mentioned in some portions of the QASP: total hydrocarbons (THC, ppm v/v as CH4) and sulfur dioxide (SO_2, ppm v/v). For example, they are mentioned on pages 21 and 35; but are not included in the summary of analytical parameters for the CO_2 stream in the QASP (Table 6).

Questions/Requests for CES:

- *In addition to the proposed injectate analytical parameters identified in Table 1 of the Testing and Monitoring Plan, argon and H_2 were detected in the analytical sample described on Table 8 of the permit application narrative. Please include these in the Testing and Monitoring Plan or explain why analyses for these parameters is not warranted.*
- *Total hydrocarbons and sulfur dioxide (SO_2) are mentioned as part of the QA procedures for injectate analysis in the QASP, but they are not on Table 1 in Attachment C. If these are not to be part of the injectate analysis, please remove them from the QASP.*
- *What is the date of the injectate characterization sample presented on Table 8 of the permit application narrative? EPA will require another baseline injectate sample be analyzed prior to commencement of injection.*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *If the geochemical modeling evaluation indicates that any injectate constituents may lead to geochemical reactions that could affect operations or change aquifer properties, additional analytical parameters for the injectate analysis may be warranted.*

Injection Well Testing

The subsections below describe the planned quarterly corrosion monitoring; continuous recording of injection pressure, rate, and volume to evaluate internal mechanical integrity; and annual external MITs that will meet the requirements at 40 CFR 146.90(b), (c), and (e).

Corrosion Monitoring

CES proposes to conduct corrosion monitoring using the coupon method. The coupons will be exposed to conditions similar to those in the borehole, in a parallel flow-through pipe arrangement containing the stream of high-pressure CO_2 at a location downstream of processing equipment and just upstream of actual injection into the well. According to CES, the samples will be handled and assessed in accordance with ASTM G1-03. The coupons will be inspected prior to testing and will be removed and inspected on a quarterly basis. Inspection equipment will be able to dimensionally measure at a tolerance of 0.0001 inches, to weigh at a tolerance of 0.0001 gram, and to photograph or visually inspect at a level of at least 10X magnification.

The proposed coupons will be composed of the materials summarized in Attachment C, Table 5, as excerpted below:

List of equipment coupons with material of construction (Table 5 of Attachment G)

Equipment Coupon	Material of Construction
Pipeline	Carbon Steel
Long String Casing (surface)	Carbon Steel
Long String Casing (Below Packer)	Chrome Alloy
Injection Tubing	Chrome Alloy
Wellhead	Chrome Alloy
Packer	Chrome Alloy

The materials identified for corrosion monitoring were compared to the list of proposed construction materials for the injection well, Mendota_INJ_1, and are shown in Attachment G, Table 2, *Casing Specifications*, Table 3, *Packer Specifications*, and Table 4, I*njection Tubing Specifications*, and excerpted below:

Casing specifications (Table 2 of Attachment G)

Name	Depth Interval (feet)	Outside Diameter (inches)	Inside Diameter (inches)	Weight (lb/ft)	Grade (API)	Design Coupling (Short or Long Threaded)	Thermal Conductivity @ 77°F (BTU/ft hr, °F)	Burst Strength (psi)	Collapse Strength (psi)
Conductor	86	22	21	197.41	B	Welded	26.13	2440	1950
Surface	1800	16	15.01	84	N80	Long	26.13	4330	1480
Intermediate	7432	10.75	9.760	55.5	N80	Long	26.13	6450	4020
Long-string	7332	7	5.920	38	T-95 Type 1	Long	26.13	12830	13430
Long-string	10412	7	5.920	38	TN 95Cr13	Long	14.92	12830	13430

As noted in Table 2 of Attachment G, the conductor, surface, and intermediate casing will be composed of carbon steel, grades B and N80. The long-string casing will be composed of alloy steel, grades T-95 and TN 95, containing relatively high chrome content.[1]

It appears that the carbon steel composition of the coupon for corrosion monitoring of the long-string casing (surface) in Table 5 (from Attachment C) is not representative of the materials, both chromium alloy steels, identified for the long-string casing in Table 2 (from Attachment G). It is not clear if the

[1] https://www.contalloy.com/products/grade/t95
https://metals.ulprospector.com/datasheet/e226076/tenaris-tn-95cr13

long-string casing (surface) listed in Table 5 would in fact be used at depth, given its label, and an equivalent surface long string casing is not listed in Table 2 of Attachment G.

Tubing specifications (Table 3 of Attachment G)

Name	Depth Interval (feet)	Outside Diameter (inches)	Inside Diameter (inches)	Weight (lb/ft)	Grade (API)	Design Coupling (Short or Long Thread)	Burst strength (psi)	Collapse strength (psi)
Injection tubing	9430	3.5	2.992	9.2	L80Cr13	Long	10160	10540

The proposed injection tubing for the injection well will be composed of L80Cr13, or Cr13L80, an alloy steel with high chromium content, for which the proposed coupon in Table 5 is representative.

Packer specifications (Table 4 of Attachment G)

Packer Type and Material	Packer Setting Depth (feet bgs)	Length (inches)	Nominal Casing Weight (lbs/ft)	Packer Main Body Outer Diameter (inches)	Packer Inner Diameter (inches)
Seal Bore Packer in Super 13Cr	9300	64	38	5.685	4.0

Tensile Rating (lbs)	Burst Rating (psi)	Collapse Rating (psi)	Max. Casing Inner Diameter (inches)	Min. Casing Inner Diameter (inches)
133.12@250degF	5000	5000	6000	5.949

Similarly, the coupon proposed in Table 5 for the packer is representative of the Super 13Cr steel alloy proposed for the packer in the injection well.

Although the materials of construction for the pipeline and wellhead are not described in Attachment G, it is assumed that coupons would be selected to represent these materials.

In addition to the corrosion monitoring described above, CES proposes to perform casing inspection logs (CILs) to measure the thickness of the injection well casing at the subsurface (as described on page 17 of Attachment C, and on pages 15 and 18 of Attachment G). (See also the summaries of MITs in Tables 5 and 6 of Attachment G.) The proposed CIL would be performed prior to injection, and at one year intervals thereafter. CES proposes the following logging tools for this testing: ultrasonic imaging (PowerFlex), magnetic flux leakage (MFL), casing bond log (CBL) and electro-magnetic imaging (EMIT). A reduction in thickness of more than 20% of API standard thickness would prompt further investigation.

Questions/Requests for CES:

- *Please revise the list of casing strings and materials in Attachment C, Table 5 to reflect Attachment G, Table 2, Casing Specifications. For example, please provide a coupon material representative of long string casing (surface) e.g., chrome alloy.*
- *Please provide the list of construction materials to be used for the pipeline and wellhead so that they can be compared to the proposed coupon materials for the corrosion testing program.*

Continuous Monitoring to Evaluate Internal Mechanical Integrity

CES proposes continuous monitoring of temperature and pressure via gauges at three locations within the injection well: (1) at the surface, (2) in the tubing at the packer, and (3) from the surface to the tubing packer, via distributed temperature sensing (DTS) fiber. The continuous monitoring program is summarized in Table 2 of Attachment C, as excerpted below.
Monitoring Injection Rate and Pressure: injection rate and pressure will be monitored via the electronic temperature/pressures gauges connected to the distributive control system (DCS). The DCS will ensure that maximum pressure of **2,026 psi** at the surface and of **5,677 psi** at the bottom hole are not reached.

Monitoring Annular Pressure: the annulus will be filled with brine during injection operations. During injection, the surface injection pressure should always be at least **1,142 psi,** as noted on page 14 of Attachment C. During shutdown, the surface annulus pressure must maintain the 100 psi difference between the annulus and the casing. The proposed annulus monitoring system, composed of the continuous pressure gauge, the head tank, two sets of pressure regulators, and a flood level indicator, will maintain an annulus pressure between **1,100 and 1,200 psi** (see page 14 of Attachment C).

Table 2: Sampling devices, locations, and frequencies for continuous monitoring.

Parameter	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Injection pressure		Surface	10 seconds	5 minutes (3)
Injection pressure		Reservoir – Proximate to packer	10 seconds	5 minutes (3)
Injection rate		Surface	10 seconds	5 minutes (3)
Injection volume		Surface	10 seconds	5 minutes (3)
Annular pressure		Surface	10 seconds	5 minutes (3)
CO_2 stream temperature		Surface	10 seconds	5 minutes (3)
Temperature		Reservoir – Proximate to packer	10 seconds	5 minutes (3)
Temperature	DTS	Along wellbore to packer	10 seconds	1 hour
Annulus fluid volume		Surface	4 hour	24 hour

It appears that the annulus pressure of **2,126 psig** proposed in the Table of Injection Well Operating Conditions, in Attachment A is higher than the range of pressures, of **1,100 psi to 1,200 psi,** to be maintained in the annual pressure monitoring system described in the Testing and Monitoring Plan (see bottom of page 14 of Attachment C).

Questions/Requests for CES:

- *Please describe more explicitly the location/depth of the pressure/temperature gauges at the packer.*
- *Please explain the discrepancy between the annulus pressure to be maintained in the annulus monitoring system, of 1100 psi to 1200 psi, and the proposed operating annulus pressure of 2126 psi in Attachment A.*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *The maximum pressure thresholds identified for continuous monitoring and the annulus pressure in Attachment C may need to be adjusted based on the determination of final permit conditions.*

External MITs

As described in the pre-operation testing plan in Sections 4 and 5 of Attachment G, in addition to deviation checks to be conducted during well construction, CES proposes to perform MITs in both the injection well and the deep monitoring wells (ACZ_1 And OBS 1, which are described in the section on Groundwater Quality Monitoring below), in compliance with the regulatory requirements as summarized in Tables 5 and 6 of Attachment G, excerpted below.

Summary of the Mendota_INJ_1 MITs and pressure fall-off tests to be performed prior to injection (Table 5 of Attachment G)

Class VI Rule Citation	Rule Description	Test Description	Program Period
40 CFR 146.89(a)(1)	MIT – Internal	Pressure test	Prior to operation
40 CFR 146.87(a)(4)	MIT – External	Pressure test	Prior to operation
40 CFR 146.87(a)(4)	MIT – External	Casing inspection Ultrasonic and CBL	Prior to operation
40 CFR 146.87(e)(1)	Testing prior to operating	Pressure fall-off test	Prior to operation

MITs to be performed on the deep monitoring well(s), Mendota_OBS 1 and Mendota_ACZ_1 (Table 6 of Attachment G)

Rule Description	Test Description	Program Period
MIT – Internal	Pressure test	Prior to operation
MIT – External	Pressure test	Prior to operation
MIT – External	Casing inspection, EMIT, MFL, Ultrasonic and CBL	Prior to operation
Testing prior to operating	Pressure fall-off test	Prior to operation

During injection operations, CES proposes conducting at least one of four MITs to confirm external mechanical integrity as summarized in Attachment C, Table 8, which is excerpted below. (Note that, per 40 CFR 146.89(c), at least one of the MITs must be an approved tracer survey such as an oxygen-activation log or a temperature or noise log, unless an alternate test is approved by the EPA Administrator.)

Table 8: Mechanical integrity testing (MIT).

Test Description	Location
Temperature Log / Survey	Along wellbore using Distributed Temperature Sensing (DTS) or conventional wireline well log
Oxygen Activation Log	Wireline Well Log
Pulsed Neutron Logging	Wireline Well Log
Acoustic (or Noise) Log/Survey coupled with Temperature Log/Survey	Along wellbore using Distributed Acoustic Sensing (DAS); DAS equivalent or conventional wireline well log

Oxygen activation logging, temperature logging, or acoustic (or noise) logging procedures are described in Attachment C, Section 7.2.1.3 (oxygen activation), Section 7.2.1.1 (temperature), and Sections 7.2.1.5 and 7.2.1.6 (noise). In Section 7.2.1.4, CES proposes testing using pulsed neutron logging.

CES proposes performing these tests annually, which is consistent with the Class VI requirements. The proposed pulsed neutron logging would occur, as described on page 23 of Attachment C, on a quarterly basis for 18 months after authorization, and then annually.

Questions/Requests for CES:

- *Please justify the use of pulsed activation logging as an alternative tool, beyond the MITs described at 40 CFR 146.89(c), or clarify in the Testing and Monitoring Plan that at least one of the tests identified at 40 CFR 146.89(c) will be performed each year.*

Pressure Fall-Off Testing

CES described nearly identical PFOT procedures in the Testing and Monitoring Plan and in the Construction Plan (Attachment G). See the construction and plugging evaluation report for the results of our review of the PFOT procedures. At the conclusion of the reviews, the Testing and Monitoring Plan will need to be revised to address any issues identified.

Questions/Requests for CES:

- *The testing and monitoring plan quotes the Class VI Rule requirement that a PFOT be performed at least every 5 years. It also states (under "Timing of Falloff Tests and Report Submission") that falloff tests must be conducted annually. Please clarify the planned frequency of PFOTs during the injection phase.*

Groundwater Quality Monitoring

CES plans to monitor groundwater quality above the confining zone using direct and indirect methods.

Direct Groundwater Quality Monitoring

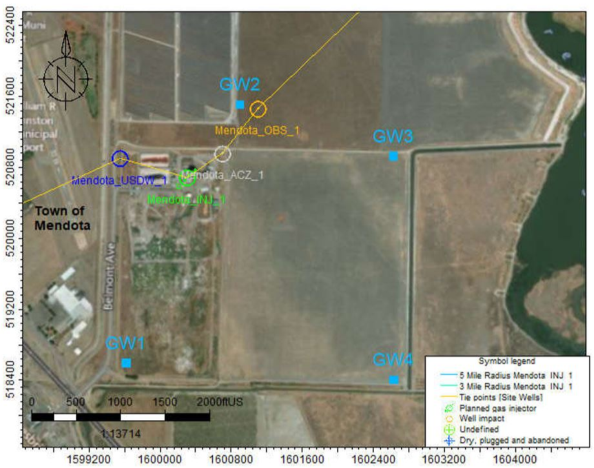
CES plans to perform direct groundwater quality monitoring via four (4) shallow groundwater monitoring wells (GW1, GW2, GW3, and GW4), a USDW monitoring well (USDW1), and an above confining zone monitoring well (ACZ1).

The approximate locations of the monitoring wells are shown on the map on the left in the figure below (from Figure 1 of Attachment C). The locations are preliminary and are expected to be refined as the project develops.

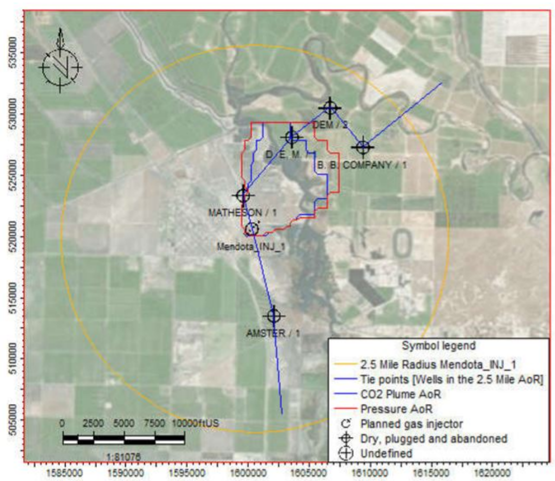
- GW1, GW2, GW3, and GW4 are shallow groundwater monitoring wells used to monitor the quaternary/shallow aquifers around the site that are sources of drinking water. CES plans to sample in one interval. The precise depths of these groundwater monitoring wells will be determined when the groundwater characteristics of the site are better understood, but they are expected to be somewhere between 50 and 500 feet deep.
- Mendota USDW 1 will be used to sample from the Santa Margarita or the base of the USDW, and it will be located within 1,000 feet of the injection well.
- The ACZ1 monitoring well will be completed in the Garzas Formation or the first permeable sandstone above the Moreno Shale (confining zone). The well will be in the up-dip direction of the Moreno Formation, or in the event a potential fault is identified on the 3D seismic within the

AoR, CES states that “the well will be in the direction of the fault intersection of the Moreno formation.”

- In addition, the Mendota OBS 1 monitoring well will be completed in the Panoche Sand and will be used to monitor plume migration. See “CO_2 Plume Monitoring,” below.



Location of monitoring wells



Delineated AoR

The map of monitoring well locations can be compared to the expected extent of the plume after 20 years, as shown on the map to the right of the figure above (from Figure 12 of Attachment B). While the scales of the maps in the plans are different, they have the same legend and it appears that the monitoring wells will be located within the defined AoR and in the anticipated direction of plume and pressure front movement. The suitability of these proposed locations will be refined as the AoR modeling evaluation proceeds.

CES indicates that the precise locations of the wells will be determined in future phases of the project (it is unclear what this means relative to construction of the injection well and pre-operational testing). However, the location and construction of the wells will need to be approved prior to issuing a Class VI permit. This is typically included with the permit to construct the injection well; if this is not possible, the permit will need to include conditions such that authorization to inject cannot be given until a separate review of the monitoring well locations and their construction is performed. CES should note that the Central Valley Water Board indicated that any newly drilled monitoring wells must be approved by the Water Board and, while existing wells would not need to be approved, the Water Board expressed interest in any plans to use existing wells as monitoring wells.

Groundwater quality monitoring above the confining zone will include baseline monitoring and monitoring during the injection and post-injection phases of the project:

- Baseline fluid sampling at the shallow monitoring wells (GW1, GW2, GW3, and GW4) and USDW 1 will occur quarterly for at least one year prior to injection.
- Baseline fluid sampling at Mendota ACZ 1 will occur during well construction and once prior to injection.
- Injection phase groundwater quality monitoring will be performed quarterly in GW1, GW2, GW3, GW4, and USDW 1 and annually in ACZ 1.

- During the post-injection phase, monitoring in GW1, GW2, GW3, GW4, and USDW 1 will be quarterly for 3 to 5 years post-injection and then annually afterwards. Monitoring in ACZ 1 will be annual for years 1 through 3, then in years 5, 7, and 10 after injection ceases.

Table 7 of the Testing and Monitoring Plan (replicated below) identifies the analytical and field parameters for groundwater sampling above the confining zone. CES proposes to analyze for the same parameters in Table 2 of the PISC and Site Closure Plan. Groundwater quality analytical methods are all EPA-approved Methods and are addressed in the QASP.

The parameters appear to be appropriate for groundwater quality monitoring needs for GS projects, and are consistent with other Class VI monitoring programs. It is recommended that CES add zinc to the groundwater quality monitoring parameters to complement the monitoring of other commonly occurring heavy metals (Cu, Pb, Cr, Co). Note that, as additional information is gathered based on the reviews of other parts of the permit application or pre-operational data collection, recommendations or requirements for additional analytical parameters may be provided.

Parameters	Analytical Methods [1]
Quaternary / Shallow strata sources of drinking water	
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography, EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Total Dissolved Solids	Gravimetry; Method 2540 C [1]
Alkalinity	Method 2320 B [1]
pH (field)	EPA 150.1
Specific conductance (field)	Method 2510-B [1]
Temperature (field)	Thermocouple
Santa Margarita or base of USDW	
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography, EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry
Total Dissolved Solids	Gravimetry; Method 2540 C [1]
Alkalinity	Method 2320 B [1]
pH (field)	EPA 150.1
Specific conductance (field)	Method 2510-B [1]
Temperature (field)	Thermocouple
Garzas	
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb Se, and Tl	ICP-MS, EPA Method 6020
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-OES, EPA Method 6010B
Anions: Br, Cl, F, NO_3, and SO_4	Ion Chromatography, EPA Method 300.0
Dissolved CO_2	Coulometric titration, ASTM D513-11
Isotopes: $\delta^{13}C$ of DIC	Isotope ratio mass spectrometry
Total Dissolved Solids	Gravimetry; Method 2540 C [1]
Alkalinity	Method 2320 B [1]
pH (field)	EPA 150.1
Specific conductance (field)	Method 2510-B [1]
Temperature (field)	Thermocouple

Note 1: ICP = inductively coupled plasma; MS = mass spectrometry; OES = optical emission spectrometry; GC-P = gas chromatography - pyrolysis. An equivalent method may be employed with the prior approval of the UIC Program Director.

Indirect Groundwater Quality Monitoring

Indirect groundwater quality monitoring activities above the confining zone will include DAS (distributed temperature/acoustic) monitoring and pulsed neutron monitoring in ACZ 1, OBS 1, and INJ 1 (the injection well). Following a baseline log, DAS monitoring will be continuous throughout injection phase and during the first three years of post-injection phase monitoring.

Questions/Requests for CES:

- *Please provide a map that shows the location of the monitoring wells at a scale that also shows the extent of the plume and pressure front (i.e., Figure 12 of Attachment B and Figure 1 of Attachment C at the same scale).*
- *Table 6 indicates that quarterly monitoring in the shallow wells and USDW_1 will occur in years 1 and 2 of the injection phase. Please also specify the proposed frequency at which groundwater sampling will be performed in the remaining years of the injection phase.*
- *EPA requests that CES include quarterly monitoring in ACZ1 in Table 6 (at least for the first 5 years of injection) since this is a porous formation right above the confining zone and is close to the injection well. Please revise Table 6 accordingly.*
- *Please remove DAS and pulsed neutron monitoring from Table 6, as these are not groundwater monitoring techniques.*
- *Please add zinc to the groundwater quality monitoring parameters in Table 7 to complement the monitoring of other commonly occurring heavy metals (Cu, Pb, Cr, Co).*
- *Please analyze the $\delta^{13}C$ of the injectate and include it among the injectate testing parameters.*
- *EPA will require including water density in the ACZ1 monitoring parameters to allow comparisons of water quality monitoring parameters above and below the confining zone and to support understanding of fluid density in the USDW for calculation of the critical pressure.*
- *Please explain the sequence of events regarding data collection (i.e., seismic and water quality evaluations and updated AoR modeling) and the determination of monitoring well placement and depths. It is not clear based on the Testing and Monitoring Plan how CES proposes to collect the data to inform proposed monitoring well placement.*
- *The Testing and Monitoring Plan, on page 17 states that to meet the requirements at 40 CFR 146.95(f)(3)(i), CES will also monitor groundwater quality in the first USDWs immediately above and below the injection zone(s). The requirement to monitor USDWs below the injection zone only applies to projects operating under injection depth waivers and does not apply to the CES project. Please edit the sentence accordingly.*
- *Table 6 of the Testing and Monitoring Plan indicates that fluid sampling will be performed in OBS 1; however, Table 7 does not include Panoche sampling for water quality testing. Please clarify whether the sampling proposed to be performed in OBS 1 is for the purpose of groundwater quality monitoring or plume tracking, and update either Table 6 or Table 7 accordingly.*
- *The spreadsheet of proposed testing and monitoring activities submitted with the application indicates that continuous DAS monitoring will be performed in INJ_1; however, this is not included in Table 6 of the Testing and Monitoring Plan. Please clarify the discrepancy.*
- *Please specify the proposed sampling and recording frequencies for continuous DAS monitoring during the injection phase (i.e., include information similar to Table 3 of the PISC and Site Closure Plan in the Testing and Monitoring Plan).*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *If new information or updates to the geochemical modeling based on pre-operational testing raises additional concerns about subsurface geochemical processes (e.g., potential changes in subsurface properties or potential contaminant mobilization),the list of groundwater quality analytical parameters will need to be revisited to make sure that all relevant parameters are represented. In particular, the list of analytes should be compared against comprehensive groundwater chemistry analyses and information on the mineralogy and whole-rock chemistry of the solids in the injection zone and upper confining zone. This comparison will help finalize the groundwater chemistry analyte list.*
- *CES proposes a 10-year alternative post-injection site care time frame and notes in the PISC and Site Closure Plan (Attachment D) that the post injection site care plan will be finalized based on the results of AoR modeling performed using the data to be collected after pre-operational testing is complete. If, based on the updated modeling, this timeframe is insufficient, the post-injection groundwater monitoring strategy will need to be revised accordingly (e.g., to describe monitoring after year 10 post-injection).*
- *EPA will need to review construction procedures and specifications for each of the monitoring wells prior to construction; additional information is provided in the well construction and plugging review report.*
- *The location of ACZ_1 will depend on the final site characterization evaluation and findings about the transmissive nature of any faults based on 3D seismic.*

CO_2 Plume and Pressure Front Tracking

CES described plans for CO_2 plume and pressure front tracking that include (1) the use of direct methods for tracking the pressure front within the injection zone [40 CFR 146.90(g)(1)] and (2) direct measurements at OBS 1 and indirect geophysical techniques to track the extent of the CO_2 plume [40 CFR 146.90(g)(2)].

CO_2 Plume Monitoring

CES proposes direct monitoring of the extent of the CO_2 plume will be accomplished by fluid sampling in the Second Panoche Sand in the Mendota OBS 1 well to the northeast of the injection well to help confirm predictions of CO_2 plume movement. The precise location of this well will be based on where the AoR delineation model predicts detectable pressure change within 6 months and CO_2 saturation of 10 to 20% within approximately one year.

Baseline sampling to monitor the CO_2 plume will be performed during well construction and then once prior to injection. The monitoring frequency during the injection phase will be annual; and during the post-injection phase, monitoring will be annual during years 1 through 3 and in years 5, 7, and 10. However, if CES anticipates CO_2 saturations of 10-20% at OBS 1 within the first year of injection, it would be appropriate to sample more frequently in the first one or two years in case the predictions are an underestimate or overestimate. The analytical parameters are the same as those planned for groundwater quality monitoring above the confining zone, with the additional parameter of water density.

Proposed indirect CO_2 plume monitoring activities include pulsed neutron monitoring, a 3D surface seismic survey or a combination of borehole and surface seismic, and time-lapse vertical seismic profile (VSP) survey:

- Pulsed neutron logging within the Panoche Sands will be performed in OBS 1 and the injection well (Mendota INJ 1) to monitor the formation CO_2. Following a baseline log in each well, pulsed neutron logging during the injection phase will be quarterly through year 1.5, then annually afterwards; post-injection phase logging will be performed in years 1, 3, 5, 7, and 10.
- Time-lapse VSP surveys will be performed at Mendota OBS 1 to monitor the migration of the plume over an area of about 100 to 2,000 acres. The surveys will be performed during well construction to establish a baseline, and during years 2, 3, and 4 of the injection phase. There will be no VSP monitoring during the post-injection phase.
- Surface 3D seismic surveys will be performed prior to construction to establish a baseline and in year 3 of the injection phase. Post-injection phase 3D seismic surveys will be performed during years 1, 5, and 10 after injection ceases.

The Testing and Monitoring Plan is unclear as to whether time-lapse VSP surveys or 3D surface seismic surveys (or both) are planned. This decision will need to be made prior to issuing the Class VI permit (or at least prior to authorization to inject). If CES only plans to perform time-lapse VSP, this monitoring activity will need to extend into the post-injection phase, and the imaging will need to encompass an area on the larger end of the range CES identifies in order to encompass the entire 2.2 square mile AoR.

Pressure Front Monitoring

Proposed direct pressure front monitoring activities include continuous pressure/temperature (P/T) monitoring and distributed temperature sensing (DTS). This monitoring will target the First, Second, and Third Panoche Sands at Mendota OBS 1 and the injection interval at the Mendota INJ 1 injection well. Following baseline measurements, continuous direct pressure front monitoring will occur throughout the injection phase and in Years 1-3 of the post-injection phase. After year 3 post-injection, annual P/T measurements will be taken (with no additional DTS).

Proposed additional pressure front monitoring will be accomplished via continuous passive seismic monitoring to detect seismic events over M1.0 within the AoR. The application states that there will be multiple target locations at a combination of borehole and seismic stations within the AoR but does not identify the specific locations.

Questions/Requests for CES:

- *Table 9 indicates that fluid sampling for CO_2 plume and pressure front tracking will be performed in OBS 1. What parameters does CES propose to analyze?*
- *EPA will require that direct CO_2 monitoring in OBS 1 be performed more frequently than annually in the initial years of injection (i.e., through year 2) to validate modeled predictions of CO_2 plume movement.*
- *The spreadsheet of testing and monitoring activities identifies injection profile monitoring (Spinner) surveys in INJ 1 and CO_2 analysis as direct CO_2 plume monitoring activities and monitoring of injection volume in INJ_1 as a pressure front monitoring technique; however, these do not appear to be plume and pressure front monitoring techniques. Please remove them from the testing and monitoring strategy or clarify how they will be used to track the CO_2 plume and pressure front in the subsurface.*
- *Table 9 indicates that VSP in OBS 1 will be performed in Years 2, 3, and 4 of the injection phase. EPA will require that additional VSP be performed in the later years of the injection phase to provide additional data points for the non-endangerment demonstration.*

- *Please clarify how the VSP and 3D seismic will work together to provide plume tracking (taking into account the capabilities and strengths of each method). In particular, it is important that each test is employed at a consistent frequency throughout the injection and post-injection phases to allow data comparisons to support the non-endangerment demonstration.*
- *What is the planned resolution and extent of the 3D seismic surveys?*
- *There are numerous inconsistencies between the tables in Attachments C and E and the spreadsheet of testing and monitoring activities (e.g., in the frequencies at which various testing and monitoring activities are to be performed). Please revise the spreadsheet or the plans as needed or resolve the discrepancies.*
- *Please describe the proposed passive seismic monitoring network (i.e., the number and location of monitoring stations). Are any state or federally operated (e.g., USGS) seismic monitoring stations nearby that will inform seismic monitoring of the CES project?*
- *The spreadsheet of testing and monitoring activities indicates that continuous DTS monitoring will be performed for pressure front tracking in OBS 1 for the first 3 years of the post-injection site care timeframe, but this is not included in Table 6 of the PISC and Site Closure Plan. Please clarify the discrepancy.*
- *Please also explain why additional DTS monitoring is not proposed beyond year 3 post-injection, or what data trends may indicate that additional temperature monitoring is not warranted, particularly in consideration of collecting post-injection phase data to support the non-endangerment demonstration.*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *Updated modeling (numerical multiphase transport modeling and geochemical modeling) to demonstrate the adequacy of the proposed 10-year alternative post injection site care time frame will be conducted in the pre-operational testing phase. If this timeframe is insufficient based on the updated modeling, the post-injection plume and pressure front tracking strategy will need to be revised accordingly.*
- *The maps in the application on which monitoring locations are overlain (e.g., Figures 3 through 7 of the Testing and Monitoring Plan) are based on the pre-construction AoR modeling results; any changes to the predicted position of the CO_2 plume and pressure front based on the AoR modeling evaluation may necessitate reexamination of the well locations and revision of these maps and cross sections.*
- *Mendota OBS 1 is currently described as targeting the Second Panoche Sand; if the Fourth Panoche (the alternate injection zone) is selected, this monitoring well should penetrate and be screened in that sand. Likewise, pressure/ temperature monitoring in that zone would be necessary as well.*
- *CES will need to clarify which seismic methods will be used (i.e., VSP and/or surface seismic survey) prior to authorization of injection. If only VSP is planned, the imaging area will need to be at a range closer to the high end of the range (i.e., 2,000 acres) to encompass the entire AoR.*
- *The QASP may need to be updated when final determinations are made based on pre-operational testing about specific testing and monitoring activities (e.g., related to plume and pressure front tracking)*

  .

Air/Soil or Other Testing and Monitoring

Based on the currently available information about the geologic setting (i.e., the depth of the injection formations and the lack of evidence for the presence of transmissive faults or fractures), surface air and/or soil gas monitoring are not needed to detect movement of fluid that could endanger USDWs within the AoR.

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *If, based on the results of planned pre-operational testing, uncertainties about the geologic setting are identified, the need for air and/or soil gas monitoring or other monitoring will be reconsidered.*

Quality Assurance Procedures

EPA evaluated the Quality Assurance Surveillance Plan (QASP) submitted with the permit application to verify that all of the testing activities, analytes, etc., included in the QASP are consistent with planned injection and post-injection phase testing and monitoring. The QASP described sampling methods; sample handling and custody; analytical methods; quality control; instrument/equipment testing, inspection, and maintenance; data management, e.g., recordkeeping and tracking practices; and data review, verification, and validation procedures.

Most monitoring activities listed in Attachment C: Testing and Monitoring Plan were addressed in the QASP. The exceptions are two MITs: temperature logging and oxygen activation (OA) logging. The procedures for these MITs should be described in the QASP as they are not sufficiently detailed and described in the Testing & Monitoring Plan.

All of the monitoring activities listed in Attachment E: Post-Injection Site Care and Site Closure Plan were addressed in the QASP.

Questions/Requests for CES:

- *For completeness, please revise the QASP to include the details of the temperature and oxygen activation procedures to demonstrate external MI (including specific calibration procedures for OA logging).*

ENCLOSURE 2

Evaluation of Planned Construction and Plugging Procedures at the CES-Mendota Class VI Site

This well construction and plugging evaluation report for the proposed Clean Energy Systems (CES)-Mendota Class VI geologic sequestration (GS) project summarizes EPA's evaluation of several related activities associated with constructing and plugging the injection well and monitoring wells associated with the planned GS project and corrective action in the area of review. Due to the similarities of these activities, they are evaluated in a single report. These activities are described in Attachments B, D, E, and G of the permit application. This review also identifies preliminary questions for CES.

Injection Well Construction

Section 5 of the permit application narrative and Attachment G describe the proposed injection well construction design. The proposed injection well design is presented in Figure 1 of Attachment G and Figure 51 of the narrative. The figure shows the position of the various casing, tubing and perforations to be implemented in the Mendota_INJ_1 injection well.

The proposed injection well will be a new vertical well, to be drilled with a deviation of less than 5 degrees. The application explains that well logs to provide formation properties and any needed formation sampling will be run from 7,432 feet to 1,800 feet (see additional evaluation under "Pre-Operational Testing of the Injection Well," below). If, based on cement and casing evaluation logs, a competent formation to set casing is found above the Third Panoche Shale, then the 9-5/8 inch hole may not be drilled to 10,412 feet. A 7 inch, 38 lb/ft, L-80 casing from 0 to 7,332 feet and then 7 inch 38 lb/ft L-80 13Cr casing from 7,332 feet to 10,412 feet will be run into the hole and cemented to surface. After the cased hole logs are run, the well will be perforated and completed with an injection packer and 3-1/2 inch L-80 13Cr tubing string. The perforation interval will be selected based on the log analysis, but is anticipated to be from about 9,600 feet to 9,820 feet.

Well construction will provide 3 casing barriers with generously cemented annuluses covering the USDW from the surface to 1,800 feet. Covering the USDW will be the 16 inch, 10-¾ inch, and 7 inch casings.

A removable 3-½ inch tubing string with a retrievable seal bore packer will be used to facilitate movement and changeout of the tubing string and allow for needed testing. The tubing string will be fitted with nipple profiles to facilitate testing of the tubing, packers, and tubing annulus. Pressure and temperature monitors will be installed downhole and at surface on the various annular ports for the casing wellhead and tubing.

All casings will be cemented to surface. The application states that there are currently no known conditions preventing bringing cement to surface without a stage collar on the surface, intermediate, and long strings. Coverage of the annulus and cement strength will be evaluated with wireline cement bond log (CBL) and ultra-sonic cement evaluation logs.

The conductor casing is expected to be driven but a provision has been allowed to drill a hole and cement the casing if soil conditions do not permit driving the casing to 86 feet.

The surface casing will cover the USDW at a maximum depth of 1,615 feet TVD. Surface casing depth is expected to be 1,800 feet. Type II/V cement meets ASTM Specification C 150. It is a low alkali Portland cement for general use and where high sulfate resistance is required.

The intermediate casing will be set 100 feet into the top of the Moreno Shale confining zone. Cement will be brought back to surface from 7,432 feet TVD. Class G cement is an API grade cement with specifications defined in various API standards, primarily API Spec 10A. Pozzolan will be an additive to reinforce the cement slurry.

The long casing string will be set 100 feet into the Third Panoche Shale but may be set higher if an appropriate formation can be found. Cement will be brought back to surface from 10,412 feet TVD without a need for staging equipment. The CO_2 resistant EverCRETE* will be taken to above the Moreno Shale with a top of 7,332 feet to 7,000 feet. The application describes EverCRETE* as state of the art for storage of CO_2 for GS and enhanced oil recovery projects that can be incorporated into standard primary cementing operations for zonal isolation of new CO_2 injection wells.

Comments on Well Construction Procedures and Materials

The Class VI Rule requires that well component materials be compatible with the planned injectate and formation fluids that may be encountered and can resist corrosion for the duration of the project. The application states that materials suitable for CO_2 environment are clearly specified in API, ANSI/NACE and ASTM standards and that suppliers of components will be required to demonstrate and provide certification that their equipment has been tested and evaluated against these standards and that they are suitable for purpose in the environment defined.

While a preliminary injectate composition is described in the narrative, the application also states that well construction materials will be reviewed following tests of the composition, properties and corrosiveness of the injectate. When CES provides details about the specific materials, EPA will conduct a fuller evaluation. However, based on the impurities anticipated to be in the CO_2 injectate, as listed in Table 8 of the narrative (i.e., H_2O, O_2, H_2, N_2, CO, Ar, NO, NO_2, $H2_S$, and NH_3), CES's proposed approach to construction appears to be acceptable.

The strength of all proposed well materials must be capable of resisting all of the forces encountered. The application states that casing selection has been evaluated against industry standard worst-case loads to determine if selected casing sizes, material thickness and grade are suitable for the environment in terms of pressure and temperature. Where applicable, special loads were created to determine if the casing could handle a load not covered by current standards. Areas evaluated are casing/tubing burst, collapse, axial and compressive strengths in unilateral, bilateral and triaxial (Von Mises) load scenarios.

Tables 10 to 14 in the application narrative provide casing design specifications and details. There are inconsistencies between the text and the casing details in Tables 13 and 14 regarding the casing grade to be used in the surface, intermediate, and long string casings. The text states the grades as L-80 for the intermediate casing and long string casing but T-95 in the two tables. The grades listed in Tables 13 and 14 are also inconsistent for the surface and intermediate casing strings. The injection well construction procedures and materials are satisfactory except as discussed and noted below.

Comments on Cementing

The proposed cementing procedures must provide a continuous sheath of cement from the bottom of each casing string to the surface with placement of the surface casing below the depth of the lowermost USDW. The application states that all three casing strings will be cemented from total depth to the surface and will provide three casing barriers with cemented annuluses covering the USDW from surface to 1,800 feet. As noted in the geologic evaluation report, formation sampling will be performed to confirm the depth of the lowermost USDW; however, a surface casing depth of 1,800 feet is likely to be adequate.

CO_2 resistant EverCRETE cement will be placed from the total depth of the wellbore through the Panoche Formation to above the Moreno Shale. The EverCRETE* system should provide zonal isolation during injection, throughout the life of the well, and after plugging. CES states that it has proved to be highly resistant to CO_2 attack in the most extreme laboratory conditions, including environments with wet supercritical CO_2 and CO_2 water saturation in downhole conditions. As with the well construction materials described above, a definitive determination of the proposed cementing plan is pending final analysis of the injectate; however, based on the anticipated impurities in the CO_2 stream, CES's proposed cementing approach appears to be acceptable.

Questions/Requests for CES:

- *Please clarify the casing grade for the surface, intermediate, and long string casings in the text and in Tables 13 and 14.*
- *Please provide data from the manufacturer that demonstrates EverCRETE is more protective than Portland Cement under the deep well conditions of CO_2 attack. How long will EverCRETE endure under long term CO_2 corrosive conditions, and what data support these conclusions?*
- *Are capillary tubes used for installation of either fiber optics or other equipment external to the casing? If so, what is their internal diameter, and how will they be plugged at the end of the well's life?*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *CES will need to demonstrate that the selected well component materials are compatible with formation fluids that may be encountered, as described in the results of pre-injection formation testing, and that they can resist corrosion for the duration of the project.*
- *The surface casing depth/cementing specifications may need to be modified based on the results of analyses of sampled formation water during drilling of the injection and monitoring wells to determine the base of the lowermost USDW.*
- *Following the pre-construction measurement of the composition, properties, and corrosiveness of the injectate, the well construction materials and cement will need to be reviewed based on the results of these tests.*
- *The final construction schematics should reflect CES's decision to inject into the Second Panoche (the primary injection target) or the Fourth Panoche (the alternate injection zone).*

Safety Valves and Shut-off Devices

The wellhead will be equipped with safety valves and shut-off devices at the injection system and annulus of the well. Automatic shutdown devices would be activated under certain conditions, including when wellhead pressure exceeds the specified shutdown pressure and/or the annulus pressure indicates a loss of external or internal well containment.

The Emergency and Remedial Response Plan, described in Attachment F and Section 4.0 of the application, provides a description of the events that may necessitate gradual or immediate shutdown of the well depending on the severity of the event. Attachment A describes the shutdown procedures.

Questions/Requests for CES:

- *Please provide additional information about the types of safety valves and shut-off devices that CES proposes to use; in particular, please describe how they will be linked to the continuous injection and annulus monitoring system.*
- *Please revise the injection well schematics to show the surface and downhole pressure and temperature gauges that are referenced in the Testing and Monitoring Plan.*

Pre-Operational Testing of the Injection Well

The proposed pre-operational formation and well testing program required at 40 CFR 146.82(a)(8) and 146.87 is described at Section 6 of in the permit application narrative and in Attachment G. Attachment G describes tests and logs to be performed: at the surface, in the surface section of wellbore, the intermediate section of wellbore, and the total depth section of wellbore, along with tests to be performed during and after casing installation (i.e., cement evaluation and mechanical integrity, formation CO_2 saturation testing, and formation testing). The proposed testing and logging program is considered comprehensive and acceptable, except as noted below.

Questions/Requests for CES:

- *Please add caliper logs to the logging program before surface, intermediate, and long string casing are installed, in accordance with 40 CFR 146.87.*
- *Please add temperature logging after each casing string is set and cemented in accordance with 40 CFR 146.87.*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *As described in other reports (e.g., the AoR modeling evaluation and the testing and monitoring evaluation reports), the proposed formation testing program will provide information to support the setting of operating conditions of the permit, provide inputs for modeling to delineate the final AoR, and establish a baseline for parameters that will be measured during injection and post-injection phases. As needed, these considerations may be revised as the reviews proceed to ensure that the pre-operational testing and logging program will collect the information needed to verify the well is properly constructed; gather information on subsurface formations and fluid geochemistry; and address all identified uncertainties.*

Pressure Fall-off Testing (FOT)

General Comments

The proposed fall-off test procedures presented in Attachment G are duplicated in Attachment C (the Testing and Monitoring Plan), but with minor differences between the two attachments. The differences were noted in step 18 of the Falloff Test Report Requirements and in a missing step 2 in the Evaluation of the Test Results in Attachment C that is present in Attachment G. Also, the steps in Attachment C should be re-numbered for consistency with Attachment G. In addition, steps 3, 4, and 5 in the Pretest Planning section of Attachment C are inconsistent with steps 3 and 4 in Attachment G and the reference to an appendix concerning pressure gauges is missing in Attachment C. The referenced appendix is included in the Region 9 FOT Guidelines document.

Questions/Requests for CES:

- *Please address the discrepancies between Attachments C and G discussed above and provide a complete and correct copy of the proposed pressure fall-off test procedures and a copy of the referenced Appendix.*
- *Please also include this in the Testing and Monitoring Plan.*

The proposed FOT procedures in Section 8 of Attachments C and G are nearly identical to the Region 9 FOT Guidelines document, except as noted below:

Timing and of Fall-off Testing and Report Submission

The initial FOT should be performed upon well completion, but before injection operations begin and annually thereafter, as described in 40 CFR 143.87(e)(1) and the PFOT Guidelines. See additional discussion of the FOT timing in the testing and monitoring evaluation report.

Fall-off Test Report Requirements

Questions/Requests for CES:

- *Please add "elapsed time" to the end of the first bullet of Step 18 in Attachment C.*

Planning

The ninth bullet is not included in the Region 9 FOT Guidelines. The testing options described would be subject to EPA approval.

Questions/Requests for CES:

- *Please add that the testing options for use of other pressure transient tests described in the ninth bullet under "Planning" are subject to EPA approval.*

Pretest Planning

Step 3: Bottomhole pressure measurements are not only superior to surface pressure measurements but are required in all pressure transient tests unless measurement of only surface pressures is approved in advance by EPA. The second sentence is also not applicable to FOTs unless approved by EPA.

Step 4: This language was added by CES and is acceptable.

Step 5: This is identical to Step 4 in the Region 9 FOT Guidelines except for omission of the reference to the Appendix in the Guidelines. This step is included in Attachment C, but not in Attachment G; as noted above, EPA requests that the two attachments be consistent.

Questions/Requests for CES:

- *Please revise Step 3 under "Pretest Planning" to require bottomhole pressure in addition to surface pressure gauges for conducting FOTs performed without advance EPA approval for use of only surface pressure gauges.*

Conducting the Fall-off Test

Steps 6 through 11 are not included in the Region 9 FOT Guidelines and were added by CES. They are acceptable with the following exception in Step 9: the maximum injection pressure should not exceed the maximum allowable surface injection pressure specified in the permit, which will be limited based on the formation fracture pressure and a safety factor.

Questions/Requests for CES:

- *Please revise Step 9 under "Conducting the Fall-off Test" to state that the injection pressure will not exceed the maximum allowable surface injection pressure specified in the permit.*

Evaluation of Test Results

Step 2 in Attachment G is missing in the FOT procedures in Attachment C but is not included in the Region 9 FOT Guidelines. It is an acceptable addition to the procedure, but the Attachment C and G FOT procedures should be consistent.

Step 3 in Attachment C (Step 4 in Attachment G), fourth bullet in the Attachment C version of the FOT procedure omits the phrase "and skin pressure drop" that is included in the FOT procedure in Attachment G.

Step 5 in Attachment C (Step 6 in Attachment G) is not included in the FOT Guidelines but is an acceptable addition to the FOT procedure.

The language added by CES that follows Step 5 in Attachment C (Step 6 in Attachment G) is acceptable, but the second paragraph referring to "unusual petition approval conditions" is not applicable to Class VI wells. Likewise, the discussion of comparisons of FOT results to no-migration petition data is not applicable to Class VI permits. However, this information may be relevant to AoR reevaluations.

Questions/Requests for CES:

- *Please add Step 2 to the FOT procedure in Attachment C.*
- *Please add the language referring to skin pressure to the FOT procedure in Attachment C for consistency with the language in Step 4 in Attachment G.*

- *Consider revising the discussion in the second paragraph to discuss how unanticipated FOT results might inform AoR reevaluations.*

Monitoring Well Construction

EPA recommends in Class VI guidance that monitoring well construction be reviewed in a manner that is similar to the injection well review (especially for the deep ground water monitoring wells).

CES describes seven proposed monitoring wells in the Testing and Monitoring Plan and indicates that the location and design will be finalized in a later phase of the project. EPA requests that CES provide construction procedures and specifications for each well (particularly ACZ_1 and OBS_1) for EPA to review in the context of updated geologic information.

Note that EPA understands that the California Regional Water Quality Control Board will need to approve the construction of any new monitoring wells. While this will not be a UIC permit condition, it is relevant to CES's planning of its monitoring well network and is being shared for informational purposes.

Questions/Requests for CES:

- *Please propose construction procedures and specifications for the proposed monitoring wells. While EPA understands that final locations and depths of the monitoring wells are pending, any available information about the casing, cement, and devices that will be used to sample fluids and measure temperature, pressure, etc., that are described in the Testing and Monitoring Plan is requested.*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *The monitoring well construction details and locations will need to be reviewed and modified as necessary based on updated geologic information collected during drilling of the injection well and planned pre-operational seismic surveys.*

Injection Well Plugging Plan

The CES injection well plugging plan in Attachment D of the application describes planned tests or measures to determine bottom-hole reservoir pressure and planned internal and external mechanical integrity tests. The MITs are listed in Table 1, and include an acoustic survey and temperature log, as required by 40 CFR 146.92. It also provides information on plugs (with materials and methods noted in Table 2), and a narrative description of plugging procedures. The Post Plug and Abandonment Well Diagram is provided in Figure 6.4.

Table 2 of Attachment D (reproduced below) presents the plugging details.

Plug Information	**Plug #1**	**Plug #2**	**Plug #3**	**Plug #4**
Diameter of boring in which plug will be placed (in.)	5.92	5.92	5.92	5.92
Depth to bottom of tubing or drill pipe (ft)	9637	7782	1950	100
Sacks of cement to be used (each plug)	145	51	51	20
Slurry volume to be pumped (bbl)	30	11	11	4
Slurry weight (lb./gal)	15.8	15.8	15.8	15.8
Calculated top of plug (ft)	8837	7582	1650	0
Bottom of plug (ft)	9637	7882	1950	100

Type of cement or other material	CO2 Resistant	Class G	Class G	Class G
Method of emplacement (e.g., balance method, retainer method, or two-plug method)	Balanced	Balanced	Balanced	Balanced

The bottom-most plug (the only one that is anticipated to come into contact with the CO_2 injectate after injection operations cease) is to be composed of CO_2-resistant cement, and the remaining plugs will be Class G cement. It is not clear why CES is not proposing to use the same EverCRETE product that is proposed in well construction to plug the injection well. If, based on their responses to EPA's questions about EverCRETE, this system is approved, it may be appropriate to use the same product when plugging the injection well.

The plugging procedures state that the test pressure should be maintained +/- 10% for 30 minutes in order to pass the test (page 8). The well test pressure during the plugging procedure should not change more than 5 percent in 30 minutes.

The Injection Well Plugging Plan is subject to revisions to reflect the actual depths of the Moreno and Panoche Formations, selection of the injection zone, and determination of the base of USDWs and final well construction details, based on geophysical logs and interpretation of site geology after the injection well is drilled. Estimated depths of the Moreno and Panoche Formations, injection zone, USDW base, and significant water and hydrocarbon bearing zones encountered should be included in the well plugging schematic.

The cement plug at the base of the intermediate casing is misplaced on the plugging diagram and in Table 2. It should be placed at 7,582 to 7,382 feet instead of 7,782 to 7,582 feet. The surface plug appears to be placed from +/-10 feet to the surface but is described as from 100 to 0 feet in the plugging diagram and in Table 2.

According to Figure 6.4, the perforations are 9,337 – 9,537 ft and the bridge plug is proposed to be set at 9,637 ft. This would mean that the bridge plug would be set below the injection perforations, followed by balancing a Class G cement plug across those perforations. EPA recommends the following changes to provide a solid block of CO_2-resistant cement covering the injection perforations and have the benefit of a cement retainer on top of the block with another plug on top of that:

1. Set bridge plug at 9,637'.
2. Set cement retainer at 9,237'.
3. Pump CO_2-resistant cement through cement retainer under pressure (to squeeze some cement into the perforations). Use enough cement to fill the ~400' of 7" casing between the bridge plug and the cement retainer.
4. String out of cement retainer and balance 100' - 200' of CO_2 resistant cement atop the cement retainer.

Questions/Requests for CES:

- *Please revise the plugging procedure to state that the test pressures should be maintained at +/-5 % for 30 minutes.*
- *Please add the estimated depths of the Moreno and Panoche Formations, the selected injection zone, the base of the lowest USDW, and significant water and hydrocarbon saturated zones encountered in the wellbore to the well plugging schematic.*
- *Please correct or clarify the depths of the cement plugs at the intermediate casing shoe and the*

base of the conductor pipe to the surface in the plugging diagram and in Table 2.

- *Please revise the depth and procedures associated with the bridge plug at the bottom of the well as described above.*
- *Please explain why CES plans to use different cement to plug the well than the one proposed for use in construction.*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *The Injection Well Plugging Plan and well schematic will need to be revised to represent actual depths of the Moreno and Panoche Formations, the selected injection zone, and the base of the lowest USDW based on geophysical logs and modified interpretation of site geology after the injection well is drilled and completed.*
- *The final well plugging schematics will need to reflect CES's decision to inject into the Second Panoche (the primary injection target) or the Fourth Panoche (the alternate injection zone) and reflect the final well construction.*

Monitoring Well Plugging Plan

The proposed plugging and abandonment procedures are described in Section 7.1 of Attachment E (the PISC and Site Closure Plan). The attachment describes generally the procedures CES will use to plug the monitoring wells, including removal of surface fixtures; use of appropriate materials (cements and plugs) for use in CO_2 environments; and performance of internal and external MITs and other logs. The application notes that well specific procedures will be developed and submitted prior to starting operations.

The plugging and abandonment procedures are generally satisfactory but, as noted above, monitoring well construction information was not provided. Without well construction details and plugging schematics, the plugging procedures are deficient and cannot be evaluated.

Questions/Requests for CES:

- *Please provide proposed construction details and plugging schematics for each of the monitoring wells.*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *EPA will need to review the plugging procedures based on updated geologic information and construction schematics after the wells are drilled and completed.*

Corrective Action on Wells in the AoR

Attachment B describes two wells within the AoR that penetrate the Moreno Shale confining zone: Amstar 1 (drilled into the First Panoche Sands) and BB Co. 1 (drilled to basement rock). The Attachment describes the five wellbores located within the AoR and the condition of the two deficient wellbores.

The attachment describes the process by which CES identified wells within a 2.5-mile radius of the proposed injection well, determined which wells penetrate the Moreno Shale confining zone, and reviewed drilling and abandonment records for the wells that penetrate the confining zone. It appears that

CES used appropriate methods to identify all artificial penetrations throughout the AoR and the list of artificial penetrations is complete (see the AoR modeling report for additional information).

Attachment D describes the plugging procedures for the Amstar 1 and BB Co 1 wells (the two wells that require corrective action). Figures 14 and 15 from Attachment B are inserted below to illustrate the wellbore condition after the plugging procedure is completed in each wellbore.

CES

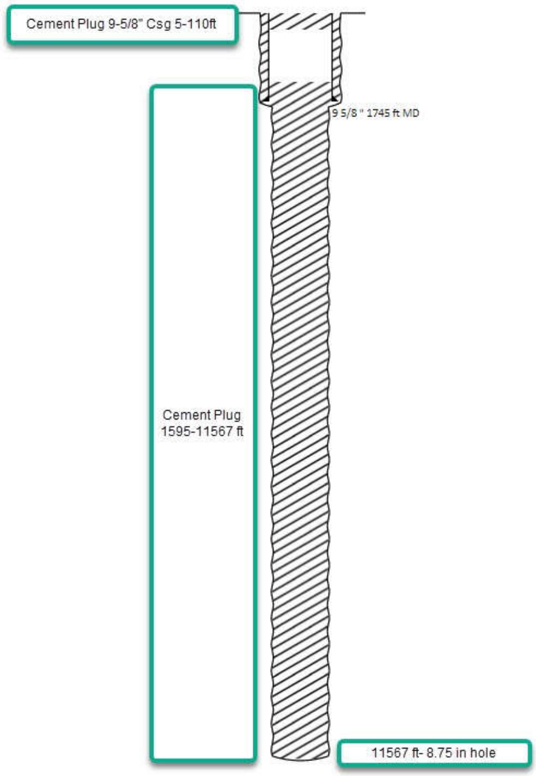


Figure 14: BB Co. 1 wellbore after P&A operation

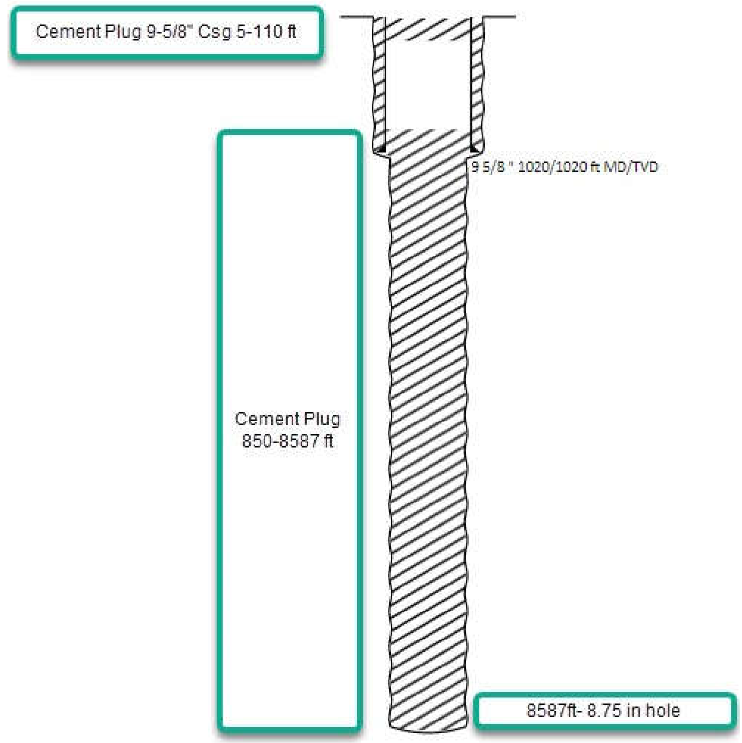


Figure 15: Amstar 1 wellbore after P&A operation

The Amstar 1 and BB Co 1 wells currently have only one relatively shallow casing installed (the Amstar 1 has a cemented surface casing at 1,020 feet and the BB Co 1 has a cemented surface casing at 1,745 feet). Each well was drilled much deeper but no production casing was installed and instead each was open-hole plugged and abandoned, meaning just a small plug of cement is present inside each well's drilled production hole. CES proposes to re-enter these two wells, drill out these plugs, and re-plug them. Under the CES proposed plan, the two wellbores would be filled with Class G cement from total depth upward into the surface casing and from 110 to 5 feet inside the surface casing. It is unclear why CES is proposing the use of Class G cement, instead of a CO_2 corrosion-resistant cement. The depth to the base of USDWs in each well is not provided.

CES proposes to re-plug and abandon the Amstar 1 well prior to injection operations because it is located within 1.5 miles of the proposed injection well while the BB Co 1 well is located more than 2.32 miles from the proposed injection well and beyond the modeled AoR. The schedule for re-plugging the BB Co 1 well is not provided except that it will be scheduled second to the Amstar 1 well.

Questions/Requests for CES:

- *The deepest USDW (calculated at ~1,609 feet bgs) is 5,700 feet above the Moreno Shale which is the secondary confining zone, as stated in the application. Please provide the depth to the base of USDWs in each of the two wells to be re-plugged and abandoned for corrective action.*
- *Please clarify whether CES proposes to re-plug and abandon the BB Co 1 well prior to commencement of injection activities.*
- *The plugging procedures for Amstar 1 and BB Co 1 on pages 25 and 26 reference a casing diameter of 9 5/8 inches; however, figures 14 and 15 show that the hole is 8.75 inches. Please clarify the discrepancy.*
- *Given that the Amstar 1 and BB Co 1 wellbores may eventually come into contact with the injected CO_2, use of a CO_2 corrosion-resistant cement will be required.*
- *Figure 46 of the permit application narrative shows the centroids of the water well locations. Please provide verified actual locations of the water wells.*

Considerations based on the results of Pre-Operational Testing/Modeling Updates:

- *The AoR modeling and corrective action evaluation will need to be reviewed based on confirmation of the thicknesses and depths of the injection and confining zones and the depth of the lowest USDW at the project site through seismic imaging and information gained during drilling of the injection well and deep monitoring well.*