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By Electronic Transmission
Clerk of the Board
California Air Resources Board
1001 I Street
Sacramento, CA 95814

Re: Comments on ARB's Proposed Low Carbon Fuel Standard Regulation Amendments

Dear Clerk of the Board:

In response to the March 18, 2018 notice by the California Air Resources Board (Board or CARB) staff, these comments are submitted on the proposal to amend the Low Carbon Fuel Standard (LCFS) regulation and the proposed Carbon Capture and Sequestration Protocol. My comments consist of this letter and the attached Detailed Comments on the Carbon Capture and Sequestration (CCS) Protocol Under the Low Carbon Fuel Standard and the attached Detailed Comments on the Low Carbon Fuel Standard Proposed Order.

My major objection to the CCS Protocol is that the CARB staff has elected to propose requiring that post injection site care continue for an absolute minimum period of 100 years. That proposal represents a radical departure from the overwhelming consensus of all other international, national and subnational governments and organizations that have adopted or recommended regulatory frameworks for CCS. It also rejects the considered advice of CARB's own scientific experts as well as the other experts with extensive experience in the development and implementation of CCS pilot and demonstration projects and the oil and gas operators with the most experience designing and conducting carbon dioxide (CO_2) enhanced oil recovery (EOR) projects.

In addition, I have recommended a number of other revisions to the CCS Protocol, some of which are simply directed at correcting errors in language that have persisted in the document and need to be corrected. Other recommendations are designed to improve the CCS protocol while preserving its effectiveness.

With respect to the closure requirement, no other entity has chosen to impose a 100 year post injection site care (PISC) requirement. Even the U.S. Environmental Protection Agency (EPA), which uses a default period of fifty years, has not imposed that as an absolute requirement. Instead, EPA allows geologic sequestration (GS) projects to demonstrate that an alternative post-

injection site care timeframe of less than 50 years "is appropriate and ensures non-endangerment of USDWs." 40 CFR §146.93(c). Moreover, the 50 year PISC period is not absolute even in the absence of such a demonstration. Rather, closure can be approves whenever "the owner or operator can demonstrate to the satisfaction of the Director before 50 years or prior to the end of the approved alternative timeframe based on monitoring and other site-specific data, that the geologic sequestration project no longer poses an endangerment to USDWs." 40 CFR §146.93(b)(2). Likewise, the Director can extend the PISC if that demonstration cannot be made at the end of the 50 years.

Other regulatory frameworks and entities have taken similar approaches. Under the EPA greenhouse gas mandatory reporting regime, reporting continues for a GS facility until a request. for discontinuation of reporting is approved. Under 40 CFR §98.441(b)(2), that request must contain either of the following:

> (i) For wells permitted as Class VI under the Underground Injection Control program, a copy of the applicable Underground Injection Control program Director's authorization of site closure.
>
> (ii) For all other wells, and as an alternative for wells permitted as Class VI under the Underground Injection Control program, **a demonstration that current monitoring and model(s) show that the injected CO_2 stream is not expected to migrate in the future in a manner likely to result in surface leakage.**

The International Energy Agency's CCS Model Regulatory Framework takes a similar approach of not recommending imposition of only a ten-year PISC period with closure approval coming when the GS operator:

> a. Is in full compliance with all laws governing the storage facility.
>
> b. Shows that it has addressed all pending claims regarding the storage facility's operation.
>
> c. Shows that the storage reservoir is reasonably expected to retain the carbon dioxide stored in it.
>
> d. Shows that the carbon dioxide in the storage reservoir has become stable. Stored carbon dioxide is stable if it is essentially stationary or, if it is migrating or may migrate, that **any migration will be unlikely to cross the storage reservoir boundary**.

> e. Shows that all wells, equipment, and facilities to be used in the post closure period are in good condition and retain mechanical integrity.
>
> f. Shows that it has plugged wells, removed equipment and facilities, and completed reclamation work as required by the commission.

IEA, Carbon Capture and Storage: Model Regulatory Framework 100 (November 2010)

Under the World Resources Institute Guidelines for CCS, "Satisfactory completion of post-injection monitoring requires a demonstration with a high degree of confidence that the storage project does not endanger human health or the environment." This includes demonstrating all of the following:

> 1. the estimated magnitude and extent of the project footprint (CO_2 plume and area of elevated pressure), based on measurements and modeling;
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> 2. that CO2 movement and pressure changes match model predictions;
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> 3. the estimated location of the detectable CO2 plume based on measurement and modeling (measuring magnitude of saturation within the plume or mapping the edge of it);
>
> 4. either (a) no evidence of significant leakage of injected or displaced fluids into formations outside the confining zone, or (b) the integrity of the confining zone;
>
> 5. that, based on the most recent geologic understanding of the site, including monitoring data and modeling, **the injected or displaced fluids are not expected to migrate in the future in a manner that encounters a potential leakage pathway**; and
>
> 6. that wells at the site are not leaking and have maintained integrity.

WRI, Guidelines for Carbon Dioxide Capture, Transport, and Storage 103 (October 2008).

Consistent with these requirements and recommendations, CARB should replace the 100 year absolute minimum PISC requirement with a performance standard to be satisfied by a demonstration that "**the injected CO_2 stream is not expected to migrate in the future in a manner likely to result in surface leakage."**

Notably, one of the principal scientific advisors to CARB has agreed that the 100 year requirement is unwarranted. Dr. Jens Birkholzer, Director Energy Geosciences Division, Berkeley Lab, stated in comments on the previous draft of the protocol: "My experience is that a 100-year time period for monitoring well leakage is overly conservative and not supported by the current scientific knowledge of GCS and its potential risks."[1/]

In support of this statement, he emphasized the following points:

- Studies of core from CO_2-EOR wells have shown that portland cement retains its sealing capacity over decades of exposure to dissolved CO2 in brine, and-induced geochemical alteration of well cements tends to reduce permeability and heal fractures in cement (Carey et al., 2007; Crow et al., 2010).

- The specification of 100 years appears to be an arbitrary time period, not based on anything physical, chemical, or project-related.

- The US EPA Class VI regulations specify a 50-year time period for post-injection site care (PISC), but allow a shorter period at the discretion of the EPA Administrator.

- Following cessation of injection, free-phase CO2 plumes will tend to stabilize, i.e., stop growing and stop migrating. Upon confirmation of plume stability, the wells that are intersected by the free-phase CO2 plume will be known.

- Finally, the ARB protocol allows for revocation of the permanence certification (8(a) (p. 107) provision for revocation and/or re-issuance of permanence certification), so that if surface or subsurface leakage is suspected or detected, new monitoring efforts could be established following the end of PISC.

Other experts have echoed these comments in recommending deletion of the 100 year PISC requirement. I respectfully urge the Board to accept those recommendations and the detailed recommendations in my attached detailed comments.

Respectfully submitted

Robert F. Van Voorhees

Robert F. Van Voorhees
Principal

[1/] Comments on ARB's Draft Protocol for "Accounting and Permanence Protocol for Carbon Capture and Geologic Sequestration under Low Carbon Fuel Standard" (December 4, 2017).