



5x-ADSA Analysis

As part of the WST permit process, operators are required to identify any geologic features (such as faults) present within five times the proposed stimulation area (5x-ADSA), evaluate whether those features could act as a migration pathway for injected WST or displaced formation fluids, and assess the risk that injected fluids will communicate with geologic features (CCR § 1784 (a)(3)). Moreover, if the 5x-ADSA extends beyond the productive horizon, operators are required to assess whether the following mechanical rock properties of the adjacent formation(s) will ensure geologic and hydrologic isolation (CCR § 1784 (a)(4)):

- Permeability
- Relative Hardness (Young's Modulus)
- Relative Elasticity (Poisson's Ratio)
- Other relevant characteristics

Verification of Proper Documentation

The first step in determining if operators are complying with the 5x-ADSA evaluation is to assess whether the proper supporting documentation has been submitted. Typically, 5x-ADSA supporting documentation consists of the following:

1. Narrative identifying faults (or other geologic features) in the 5x-ADSA, migration pathway evaluation, and risk assessment of fluid communication.
2. Professional certification of the 5x-ADSA analysis.
3. A structural contour map of the first formation/zone contact overlaying the production zone in proximity to the proposed WST well with a projection of the cross-section line.
4. Cross-section showing the productive horizon and the overlying formations in proximity to the proposed WST well.
5. Rock mechanic properties of the stimulated formation, and any adjacent formation if 5x-ADSA extends beyond the production horizon.

The second step in the verification process is to determine if the 5x-ADSA extends beyond the productive horizon, by verifying whether the vertical extent of the 5x-ADSA submitted in the WST permit application form is accurate. A CalGEM engineering geologist will

create an excel spreadsheet to calculate the extent of the 5x-ADSA by gathering the following data:

- Top and bottom depth as true vertical depth (TVD) of the shallowest WST stage.
- Top and bottom depth as TVD of the deepest WST stage.
- Midpoint depth as TVD of the shallowest and deepest WST stage.
- Fracture height of the shallowest and deepest WST stage.
- Contact depth in TVD at the top of the productive formation.
- Contact depth in TVD at the bottom of the productive formation.

This information can be found in the following sources:

- WST permit application.
- Operator well casing diagram.
- Operator geologic cross-section.
- Notice of intent to drill a new well (NOI).
- Local type E-logs.

The top of the productive formation depth can be obtained from the casing diagram for the proposed WST well submitted by the operator. The productive formation top depth should also be compared to the notice of intent to drill a new well (NOI) submitted by the operator to the district office.

The cross-sections submitted by the operator depict the bottom of the productive formation and the depth can be estimated using the vertical scale. However, if the information is not portrayed on the submitted cross-section, an E-log of a local well near the proposed WST well can be used. Type E-logs are usually obtained from the CalGEM Underground Injection Control (UIC) program electronic files.

Using the data obtained from various sources, the engineering geologist can now use the Excel spreadsheet to calculate the shallowest and deepest extent of the 5x-ADSA.

The top of the 5x-ADSA is then compared with the top of the production formation. The bottom of the 5x-ADSA is compared with the top of the formation underlying the production. If the 5x-ADSA extends beyond the production formation into either the overlying or underlying formation, then the operator is required to provide the rock mechanic properties of the adjacent formation.

Review of the Operators 5x-ADSA Evaluation

5X-ADSA EVALUATION NARRATIVE

The following questions are considered while reviewing the 5x-ADSA evaluation for compliance with regulation:

1. Are faults or the absence of faults (or other geologic features) noted and what evidence is provided as a basis?
2. Does the evaluation include an adequate assessment of whether the fault(s) may act as a migration pathway for injected WST or displaced formation fluids?
3. Does the evaluation include a risk assessment that injected fluids will communicate with any identified fault?

If any of these questions are left unanswered or the conditions of regulation are inadequately addressed, the 5x-ADSA evaluation should be returned to the operator for correction.

STRUCTURAL CONTOUR MAP AND CROSS-SECTION

The operator submits a structural contour map of the top of the production zone and a corresponding cross-section to demonstrate their assertion of whether faults are within the 5x-ADSA. The cross-section should pass through, or in proximity to, the subject well to be stimulated. Details to observe while reviewing the structural contour map and cross-section include, but are not limited to, the following:

- Proper labeling of the cross-section and corresponding cross-section line projected on the structural contour map.
- Projection of the 5x-ADSA on both the structural contour map and in profile on the cross-section, if practical.
- Accurate labeling of formation contacts and production zone markers.
- Clear and concise presentation of data, labels, and explanations.

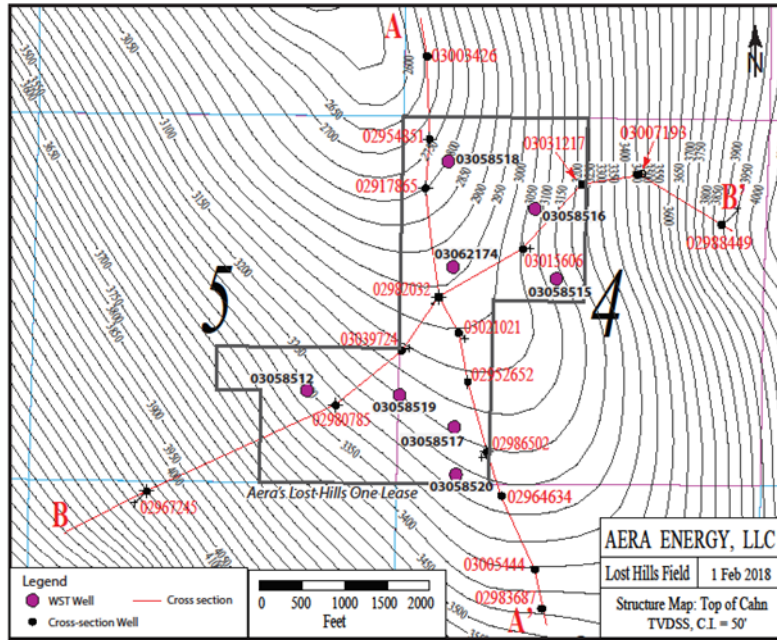


Figure 1. a structural contour map of the top of the Antelope member of the Monterey

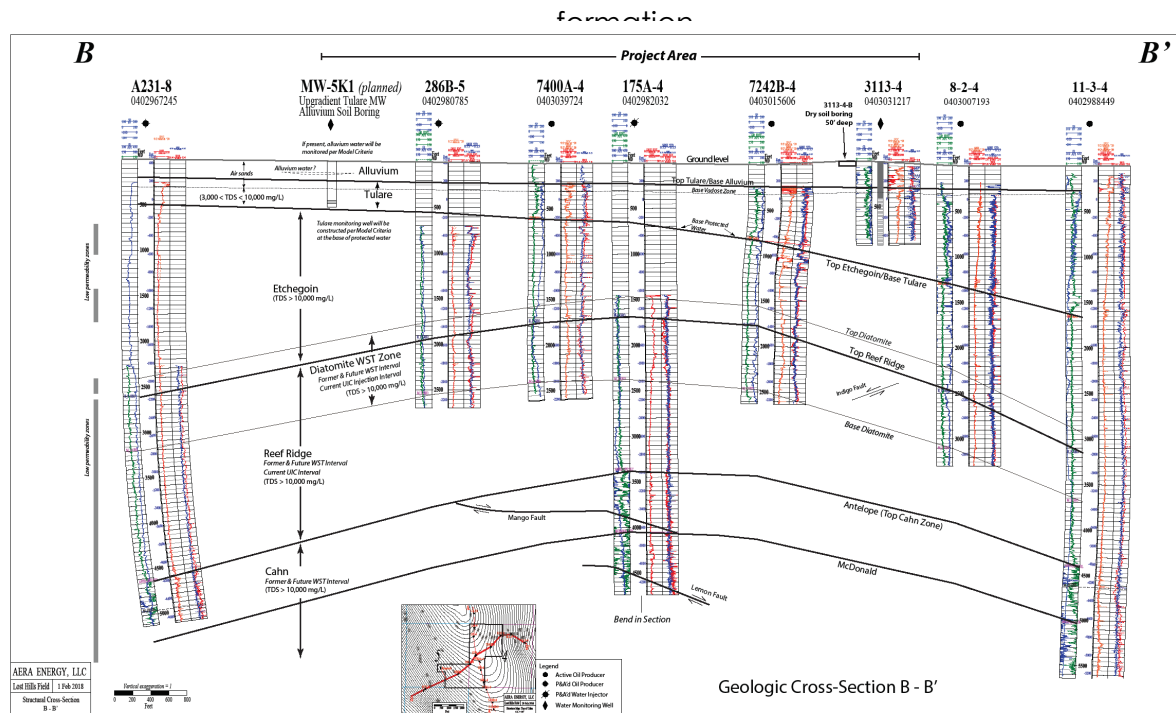


Figure 2. Cross-section B-B' that corresponds to the structural contour map shown in Figure 1.

Figure 1 is an example of a structural contour map of the top of the Antelope member of the Monterey formation (locally known as the Cahn) within the Lost Hills Oil Field. Features are clearly labeled. Figure 2 is cross-section B-B' that corresponds to the structural contour map shown in Figure 1. The oil production zones are depicted (i.e. Diatomite, Cahn), and as well as the formation names (Reef Ridge formation, and Antelope, McDonald members of the Monterey formation).

Clarity of graphical presentation is not only essential to proper review of the 5x-ADSA, but will also benefit future review by any third party reviewers and the general public. Any inadequacies in the structural contour map or cross-section should be returned to the operator for correction.

ADJACENT FORMATION ROCK MECHANIC PROPERTIES

As explained above, if the 5x-ADSA extends vertically above or below the production formation, the operator is obligated by regulation to submit the rock mechanic properties of the adjacent formation. The formation or production zone associated with the presented rock mechanic property data should be adequately identified.

Any deficiencies in the rock mechanic properties presentation should be returned to the operator for correction.

APPROVAL/SUMMATION

After the evaluation has been completed and found adequate, the engineering geologist will prepare a memo documenting and summarizing the 5x-ADSA analysis review process and submit it to the CalGEM Permitting Engineer(s). The 5x-ADSA review summary will include the following with respect to the 5x-ADSA evaluation:

- Additional issues encountered while reviewing the 5x-ADSA evaluation.
- Justification for approving the 5x-ADSA evaluation.
- Elements needed to support the Permitting Engineer's preparation of the ADSA write-up.

Following approval of the 5x-ADSA evaluation, the Permitting Engineer will prepare a write up incorporating results of both the 5x-ADSA evaluation review and the 2x-ADSA review. The ADSA narrative will be sent to the State Water Resources Control Board (SWRCB) and affiliated Regional Water Quality Control Board (RWQCB).