Cleath-Harris Geologists, Inc.
71 Zaca Lane, Suite 140
San Luis Obispo, CA 93401
(805) 543-1413

Technical Memorandum

Date: December 7, 2018

From: Spencer Harris, HG 633

To: Matt Turrentine
North Fork Vineyard

SUBJECT: Sustainability Thresholds for Northwestern Region, Cuyama Valley Groundwater Sustainability Plan.

As requested, Cleath-Harris Geologists has considered strategies for establishing Groundwater Sustainability Plan (GSP) sustainability thresholds in the Northwestern Region of the Cuyama Valley Groundwater Basin. This memorandum presents sustainability thresholds that are based on local hydrogeology and land use, and are appropriate for the Northwestern Region where North Fork Vineyard is located.

Introduction

Six regions are used in draft GSP materials to represent areas where different groundwater conditions or land use may need different rationale to establish Minimum Threshold (MT) and Measurable Objective (MO) sustainability thresholds. The Northwestern Region includes a portion of the Cuyama River valley, and is separated from the Central Region by the Russell fault to the east and from the Western Region by a straight line boundary to the south, located mid-slope on the northeastern flank of the Sierra Madre Mountains (see Attachment).

Sustainability Thresholds

The MT is a numeric value for a given sustainability indicator metric that, if exceeded, would cause significant, unreasonable effects and produce undesirable results. The MO specifies goals for sustainability indicator metrics that provide operational flexibility (sustainability) under periods of adverse conditions, such as drought.

2015 Water Level Strategy

MT thresholds based on maintaining 2015 water levels are being considered by the Cuyama Basin Groundwater Sustainability Agency. This strategy is primarily designed to halt lowering of groundwater levels and associated reductions in groundwater storage, which have been

occurring for decades in portions of the basin and are considered a significant and unreasonable depletion of the water supply.

Aquifers in the Northwestern Region, however, were effectively full in 2015. Groundwater levels and associated groundwater in storage have not changed significantly between available historical measurements in the 1960's and monitoring data from 2015, based on a comparison of historical groundwater elevations presented in Figure 1. Groundwater elevations at North Fork Vineyard wells measured in Summer 2015 averaged 5 feet lower than water levels at wells in similar locations during Spring 1966.

Water use on ranches in the Northwestern Region over the last few decades was primarily for domestic purposes and stock water. Therefore, 2015 water levels do not define a value that, if exceeded, would produce undesirable results. In fact, setting sustainability thresholds based on a strategy of maintaining 2015 water levels would limit sustainable access to groundwater for Northwestern Region users.

Land Subsidence / Saturated Aquifer Thickness Strategy

The MT threshold should be based on characterizing how and when significant and unreasonable impacts occur in order to prevent undesirable results. Two criteria were used to constrain the thresholds, (1) avoiding infrastructure damage from land subsidence; and (2) ensuring adjacent pumpers have access to groundwater.

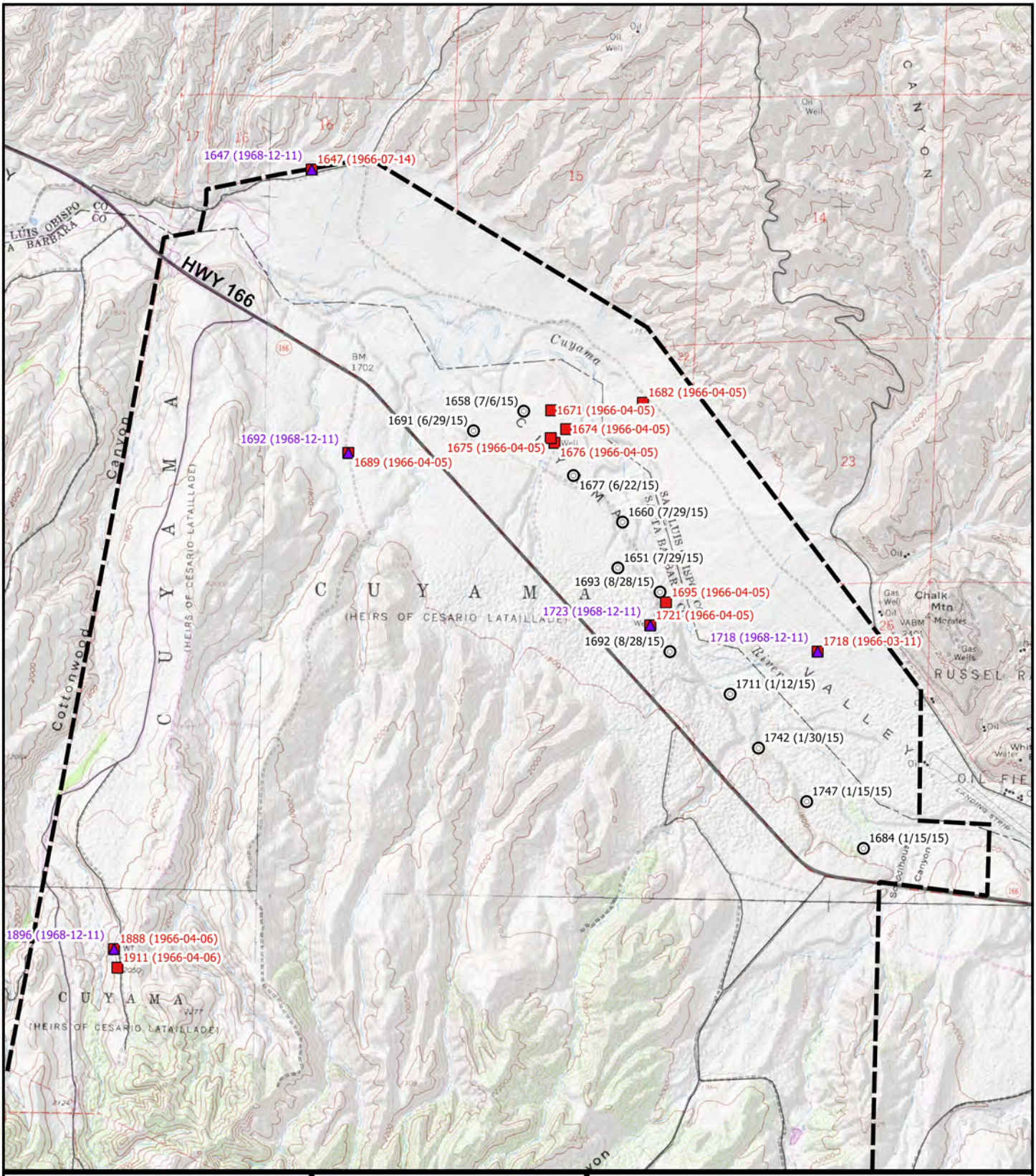
Land Subsidence

The Northwestern Region has been historically at, or close to, full capacity, and subsidence can be expected with water level decline. The minimum threshold for subsidence is the point at which tangible or unreasonable damage begins to manifest. To date, no tangible damage to infrastructure from subsidence has been reported in the Northwestern Region. In urbanized areas, damage can begin with as little as four inches of subsidence (Cleveland, 1980[1]). In agricultural areas, the light levels of infrastructure limit the effects of subsidence.

Permanent infrastructure in the Northwestern Region includes Highway 166, petroleum pipelines and agricultural infrastructure including wells, pipelines, and some building (both domestic and agricultural use). Subsidence in the Northwestern Region is assumed to be highly variable based on the distribution of clays in the principal aquifers.

A literature review indicates the level at which the effects of subsidence have been noticeable, although not necessarily a problem in rural agricultural areas, is around 2 feet of settlement at

[1] Cleveland, G.B., 1980, Drought and Ground Deformation in Cambria, San Luis Obispo County, *California Geology*, p 29-35, February 1980.



0 1500 3000 ft

NORTH

Basemaps:
USGS Topographic Maps
Coordinate System:
State Plane Zone V, ft - NAD83

Explanation

- 1968 Water Level Elev.
- 1966 Water Level Elev.
- 2015 Water Level Elev.

Figure 1
Historical Groundwater Elevations

North Fork Vineyard
Cuyama, Ca

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ground surface. Therefore, a maximum settling parameter of 2 feet was used for the MT. Examples of fissuring occurred with as little as three feet of subsidence in the Wasco-Tulare area (Holzer, 1984[2]) and well damage was beginning to occur with 2 feet of subsidence in the El Nido area (Borchers and Carpenter, 2014[3]). Maintaining water levels to keep regional subsidence under two feet would mitigate the potential for significant and unreasonable damage to agricultural infrastructure in the area.

Observed vertical shrinkage rates in San Luis Obispo County range from 0.5% for very lean clays (Cleveland, 1980) to 10% for very organic rich clays (SLO County, 1999[4]). Clays within the Morales Formation are generally lean, and a value of 2.5% shrinkage was considered conservative for developing the threshold. At a 2.5% vertical shrinkage rate, an average water level decline of approximately 180 feet below Spring 2017 water levels would be needed to dewater sufficient clay thickness for 2 feet of subsidence.

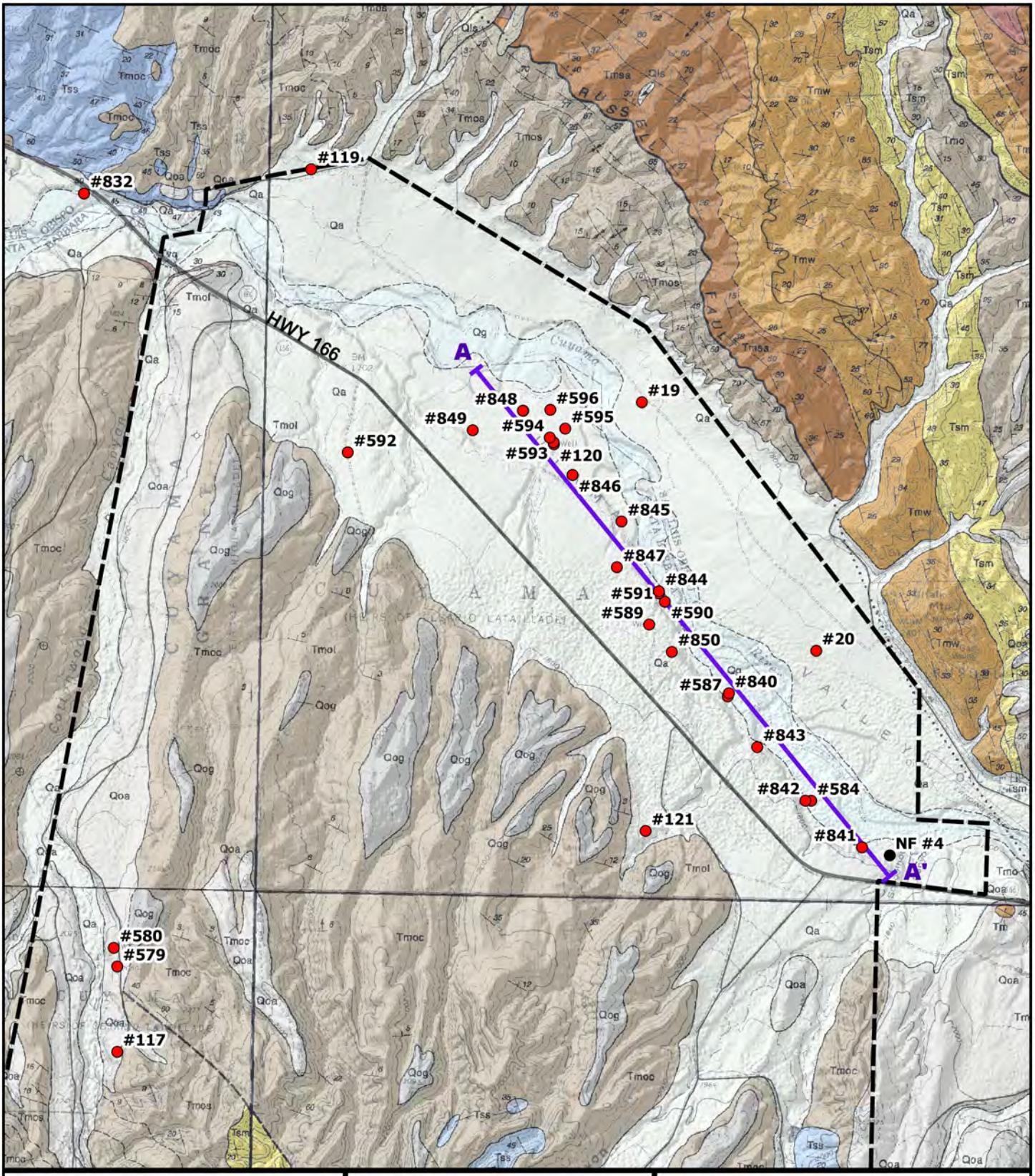
Access to Groundwater

There would be an undesirable result if adjacent pumpers were significantly impacted. Pumping in the Northwestern Region is unlikely to impact adjacent Regions due to structural and hydrogeologic considerations. The Russell fault separates the Northwestern Region from the Central Region, and low permeability clay in the lower Morales Formation, faulting and bedrock highs separate the Northwestern Region from the Western Region. The Northwestern Region is also hydraulically downgradient of other regions. The GSP will include a monitoring program to confirm that other regions aren't affected by the Northwestern Region MT. Therefore, for the practical purposes of setting an initial MT, the strategy is to prevent undesirable losses in pumping capacity at wells in the Northwestern Region.

The proposed MT strategy limits reductions in saturated aquifer thickness, as measured between the top and bottom of the representative well screens, to no more than 20 percent of the total thickness. Saturated aquifer thickness, aquifer transmissivity, and well specific capacity are related, and a reduction in saturated aquifer thickness tapped by wells will directly reduce well production, and potentially create an undesirable result. A 20 percent limit on reduction was used based on the level at which losses to well field production would become significant.

Figure 2 shows the OPTI wells in the vicinity of the North Fork Vineyard well field, and the geologic cross-section alignment. The OPTI well identification system is used for the Cuyama Basin GSP and includes wells with current or historical data. A subset of the OPTI wells are designated as representative wells for the GSP monitoring program. Figure 3 shows geologic cross-section A-A' with the well screen intervals. Lithologic logs and well construction

[2] Holtzer, T.L. ed., 1984, Man-induced Land Subsidence, *Geological Society of Americas Reviews in Engineering Geology* Vol. 6: 221, January 1984.
[3] Borchers, J.W., and Carpenter, M., 2014, Land Subsidence from Groundwater Use in California, *California Water Foundation Full Report of Findings*, April 2014.
[4] County of San Luis Obispo, 1999, Safety Element, *San Luis Obispo County General Plan*.



0 1500 3000 ft

NORTH

Basemaps:
Dibblee (DB0178, DB0181, DB0183)
Coordinate System:
State Plane Zone V, ft - NAD83

Explanation

- Property Boundary
- Cross-section Line
- #849 OPTI Wells

Figure 2
OPTI Well Locations

North Fork Vineyard
Cuyama, Ca

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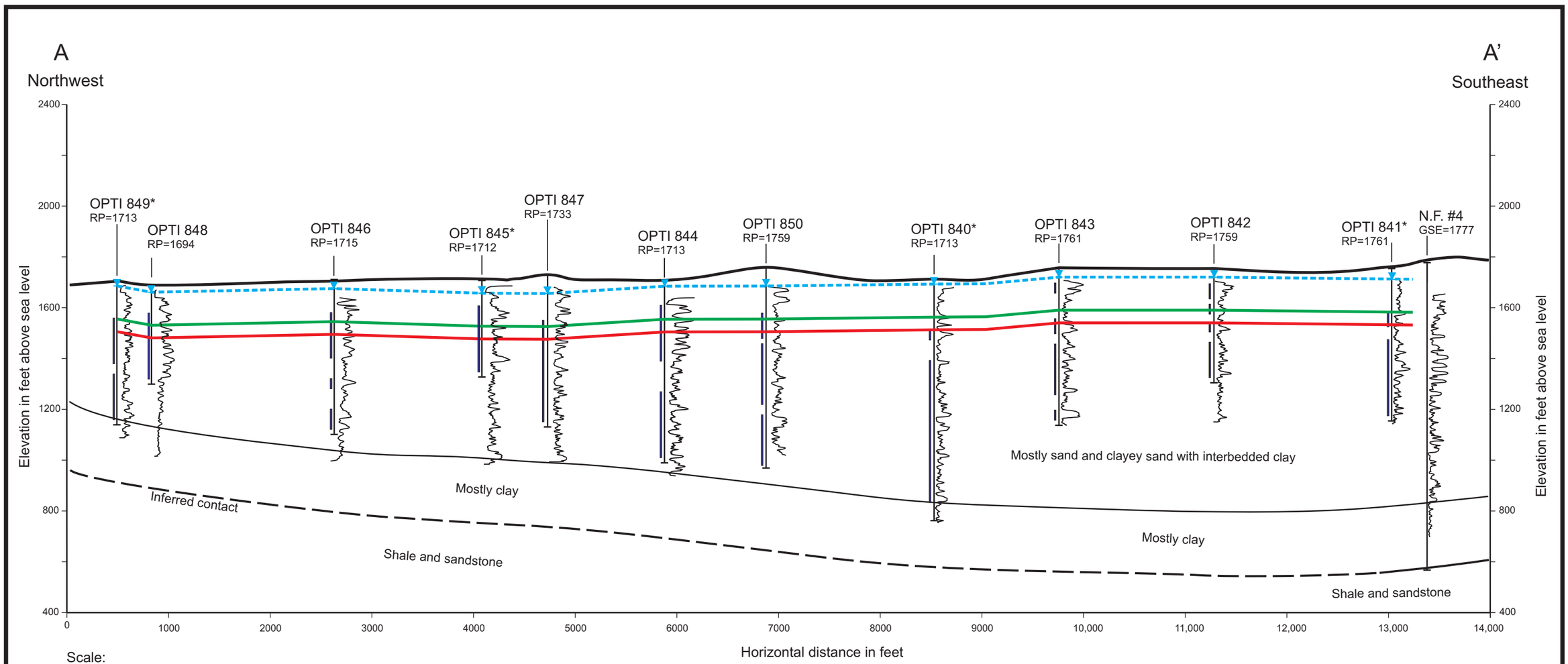

Scale:
1 inch = 400 feet (vertical)
1 inch = 1,000 feet (horizontal)

Cross-section alignment shown on Figure 2

Explanation

OPTI 845*
RP=1712

WELL SCREEN

Irrigation well showing perforated interval. Ground surface elevation (GSE) in feet above sea level.

Resistivity log shown adjacent to well.

* Inidicates representative well

Spring 2017 Static Water Levels

Measurable Objective
(50 feet above Minimum Threshold)

Minimum Threshold
(180 feet below Spring 2017 levels)

Figure 3
Geologic Cross-Section A-A'
North Fork Vineyard
Grapevine Capital Partners

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information used for developing the sustainability thresholds have been provided to the GSP preparer, Woodard & Curran. Table 1 summarizes the information used to calculate the MT.

Table 1 - Well Field Information				
Well	GSE	Top of Screen	Bottom of Screen	Depth to Water Spring 2017
	(feet)	(depth in feet)		(feet)
OPTI 840*	1713	200	880	19.7
OPTI 841*	1761	170	580	45.2
OPTI 842	1759	60	430	34.0
OPTI 843	1761	60	600	37.7
OPTI 844	1713	100	720	25.6
OPTI 845*	1712	100	360	46.1
OPTI 846	1715	130	590	37.2
OPTI 847	1733	180	580	76.4
OPTI 848	1694	110	370	28.7
OPTI 849*	1713	150	550	21.7
OPTI 850	1759	180	780	76.4
CHG-A (Hwy 166)	1775	200	474	84.6
Average	1734	137	576	44

GSE - ground surface elevation
*Representative Well

Per Table 1, the average saturated thickness of basin sediments between the top and bottom of well screens is 439 feet (576 feet - 137 feet). Water level declines are limited to 20 percent of total thickness, or 88 feet (439 feet * 0.2). The MT, expressed as an average water level decline would be 225 feet below ground surface (137 feet + 88 feet), or 181 feet below the average depth to water for the Spring 2017 condition (225 feet - 44 feet). This is consistent with the MT based on land subsidence.

MO Sustainability Threshold

The strategy for setting MO thresholds in draft GSP materials is to provide 5 years of groundwater in storage above the MT as a buffer during drought. This would be appropriate for the Northwestern Region, provided that the MT is set based on avoiding undesirable consequences as characterized above. A 50-foot water level increase above the MT is proposed for the Northwestern Region MO.

The interpreted boundary of the upper Morales Formation groundwater storage reservoir in the vicinity of North Fork Vineyard encompasses close to 4,000 acres. A synclinal structure with an axis parallel to the Cuyama River valley has created an elongated trough of basin sediments up to approximately 900 feet deep at the well field (Figure 3). The deeper portion of the storage reservoir (below the MT) and within the Cuyama River valley encompasses roughly 2,700 acres. The amount of groundwater in storage in 50 feet of saturated sediments over 2,700 acres, at an estimated specific yield of 0.08, is equivalent to 11,000 acre-feet. This would provide more than sufficient groundwater in storage for the well field as a drought buffer between the MT and MO thresholds.

Summary of Proposed Northwestern Region MT and MO

The Northwestern Region MT was developed by estimating the water level depth at which significant and unreasonable impacts would occur, based on the potential for land subsidence and for declines in local well production, as follows:

- Limit potential inelastic land subsidence due to water level declines to a maximum of 2 feet, based on a vertical shrinkage factor of 2.5 percent for dewatered clays.
- Limit reductions in saturated aquifer thickness at wells due to water level declines to a maximum of 20 percent, based on average top and bottom elevations of well screens, which are representative of producing zones within the aquifer.

The resulting MT would correspond to Spring water levels of 180 feet below Spring 2017 water levels, or an average of 225 feet below ground surface (Figure 3).

The proposed strategy for establishing the MO for the Northwestern Region is:

- Maintain a minimum 5-year drought buffer in groundwater storage reserves above the Minimum Threshold.

The resulting MO would correspond to Spring water levels of 50 feet above the Minimum Threshold, or an average of 175 feet below ground surface (Figure 3).

ATTACHMENT

Threshold Regions from draft GSP Materials

Source: Presentation materials in 12/3/2018 CBGSA Board Packet