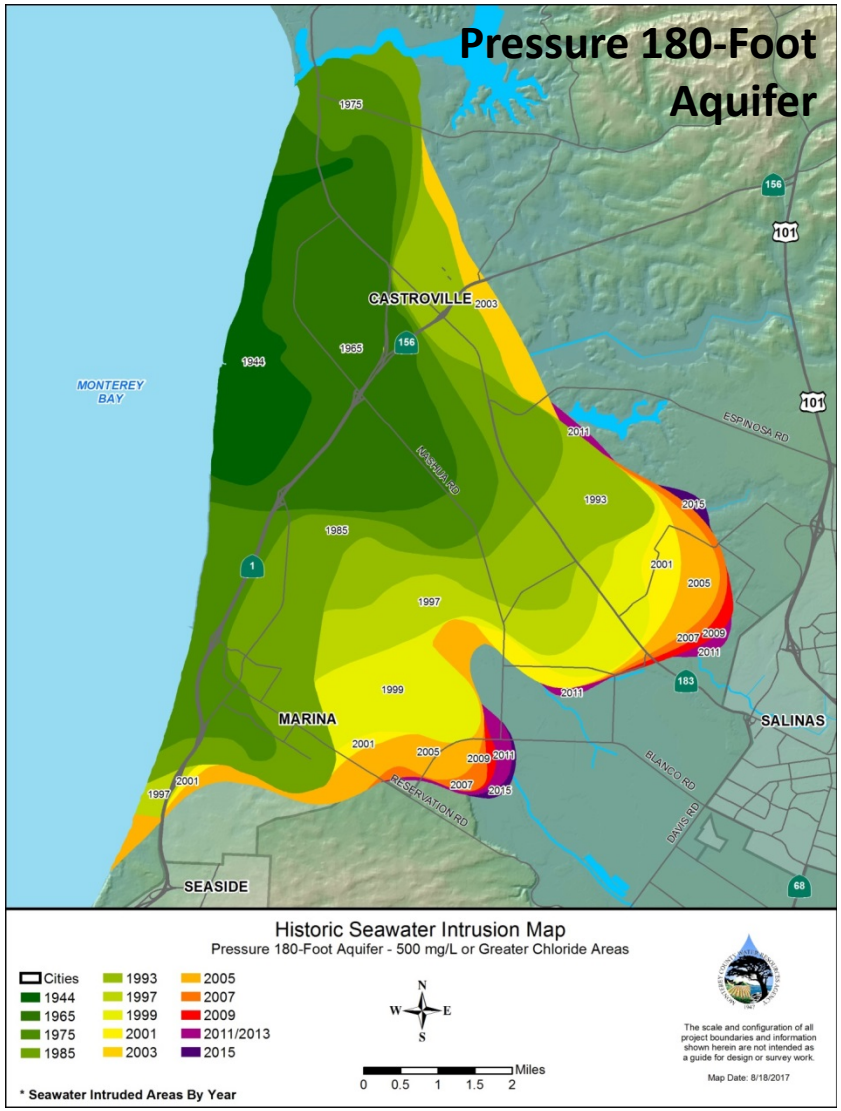
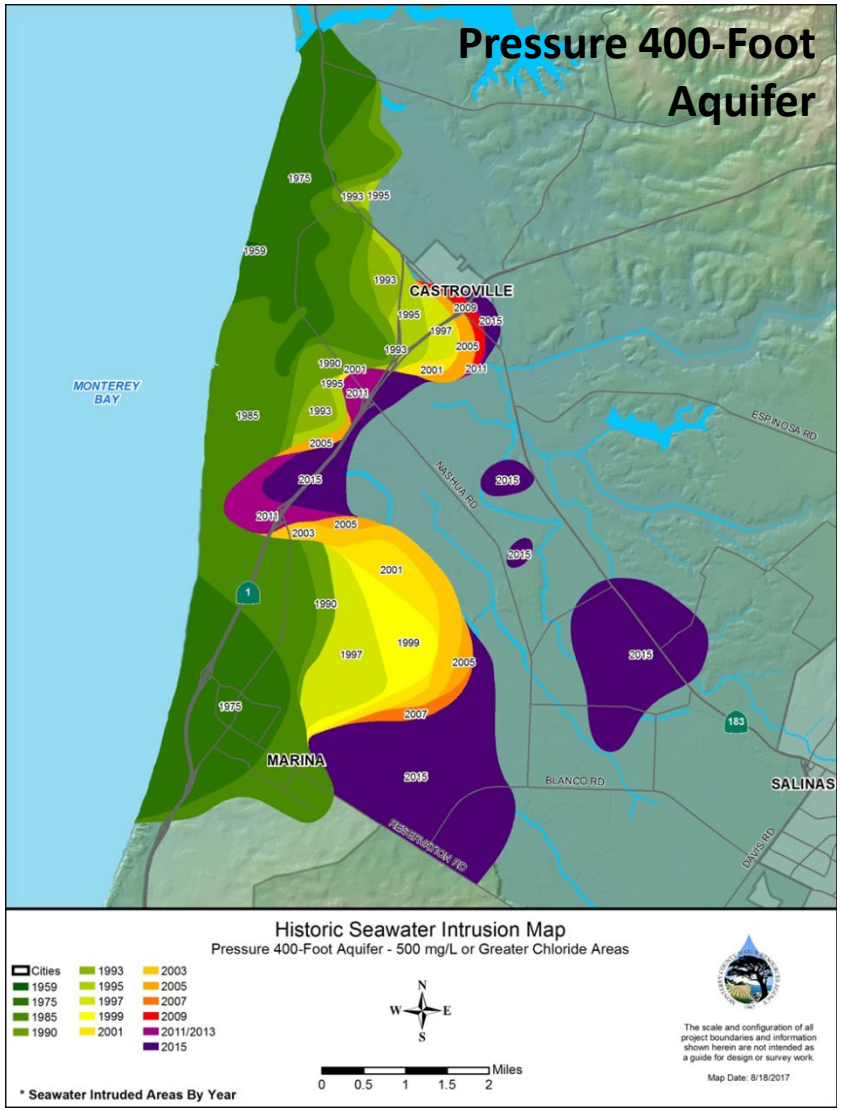
Deep Aquifers Roundtable Meeting

March 9, 2018

Background


Pressure 180-Foot Aquifer
MONTEREY BAY
CASTROVILLE
MARINA
SEASIDE
SALINAS
ESPINOSA RD
NASHUA RD
BLANCO RD
RESERVATION RD
DAVIS RD
Historic Seawater Intrusion Map
Pressure 180-Foot Aquifer - 500 mg/L or Greater Chloride Areas
Cities
1944
1965
1975
1985
1993
1997
1999
2001
2003
2005
2007
2009
2011/2013
2015
* Seawater Intruded Areas By Year
Miles
0 0.5 1 1.5 2
The scale and configuration of all project boundaries and information shown herein are not intended as a guide for design or survey work.
Map Date: 8/18/2017


Pressure 400-Foot Aquifer
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Background

- Agency released a report in October 2017 containing six recommendations to address the expansion of seawater intrusion.
- Two of the recommendations pertained specifically to the Deep Aquifers.
- Agency Board of Directors and Board of Supervisors have requested additional information on what a study of the Deep Aquifers would entail.

Background

- Goals of today's meeting are to:
  - Discuss current understanding of the Deep Aquifers
  - Identify unknowns and gaps in current knowledge
  - Conceptualize the questions work necessary to address unknowns

Terminology

- Aquifer has been referred to as:
  - Deep aquifer
  - Deep zone
  - 900-foot aquifer
  - 1500-foot aquifer

- Data from wells suggests two aquifer systems
  - Agency is using the term “Deep Aquifers”

Stratigraphy

- Granitic basement
  - Form the Sierra de Salinas and Gabilan Range
- Lower/Middle Miocene sedimentary rocks
  - Marine arkosic sandstone and Monterey Formation

Stratigraphy

- Upper Miocene to Pliocene marine sequence
  - Exposed on land in Monterey County
    - Santa Margarita sandstone
  - Offshore outcrops in Monterey Bay
    - Santa Cruz mudstone
    - Purisima Formation
- Pancho Rico Formation (Pliocene) also present in the Gabilan Range and subsurface

Stratigraphy

- Pliocene and Quaternary non-marine
  - Paso Robles Formation
  - Aromas Sand
  - Quaternary surficial deposits
    - Not a major water supply source
- Frequent surface expression in lower Salinas Valley

Hydrostratigraphy

- Primary water bearing formations in Deep Aquifers:
  - Paso Robles
    - Terrestrial sand, gravel, silt, clay
  - Purisima / Santa Margarita
    - Marine sandstone, clay, shale

Hydrostratigraphy

Period/Epoch		Formation	Hydrostratigraphy
Quaternary 2.5 MYA to present	Holocene	Recent Alluvium	Shallow Aquifer
	Pleistocene	Valley Fill	Salinas Valley Aquitard
			Pressure 180-Foot Aquifer
		Aromas Sands (near coast)	Pressure 180/400-Ft Aquitard
			Pressure 400-Foot Aquifer
		Paso Robles	Pressure 400-Foot/Deep Aquitard
Tertiary 23 to 2.5 MYA	Pliocene	Purisima / Pancho Rico	Deep Aquifers
	Miocene	Santa Margarita	
		Monterey	Minimally water-bearing
Mesozoic		Granitic basement	Non water-bearing

Not to scale.

MYA = Million Years Ago

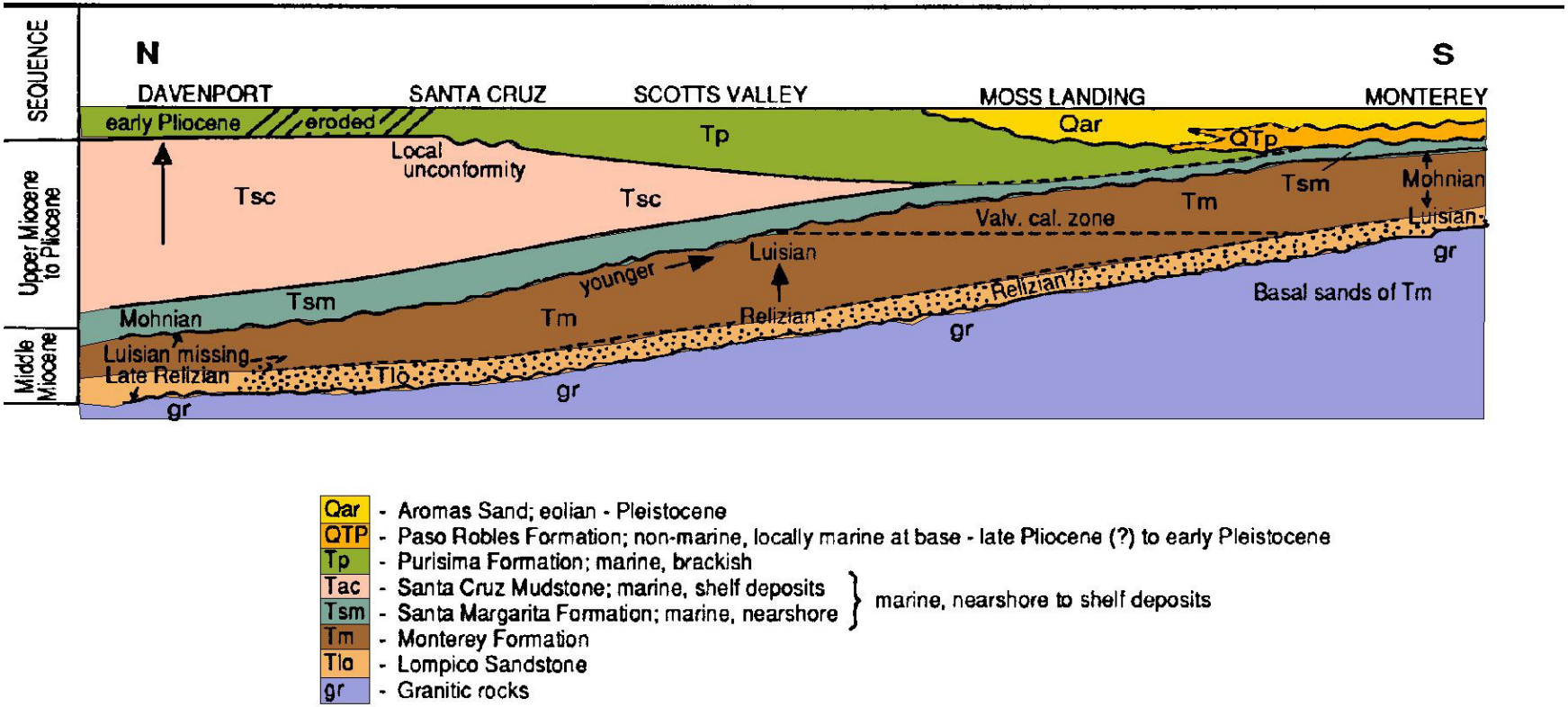
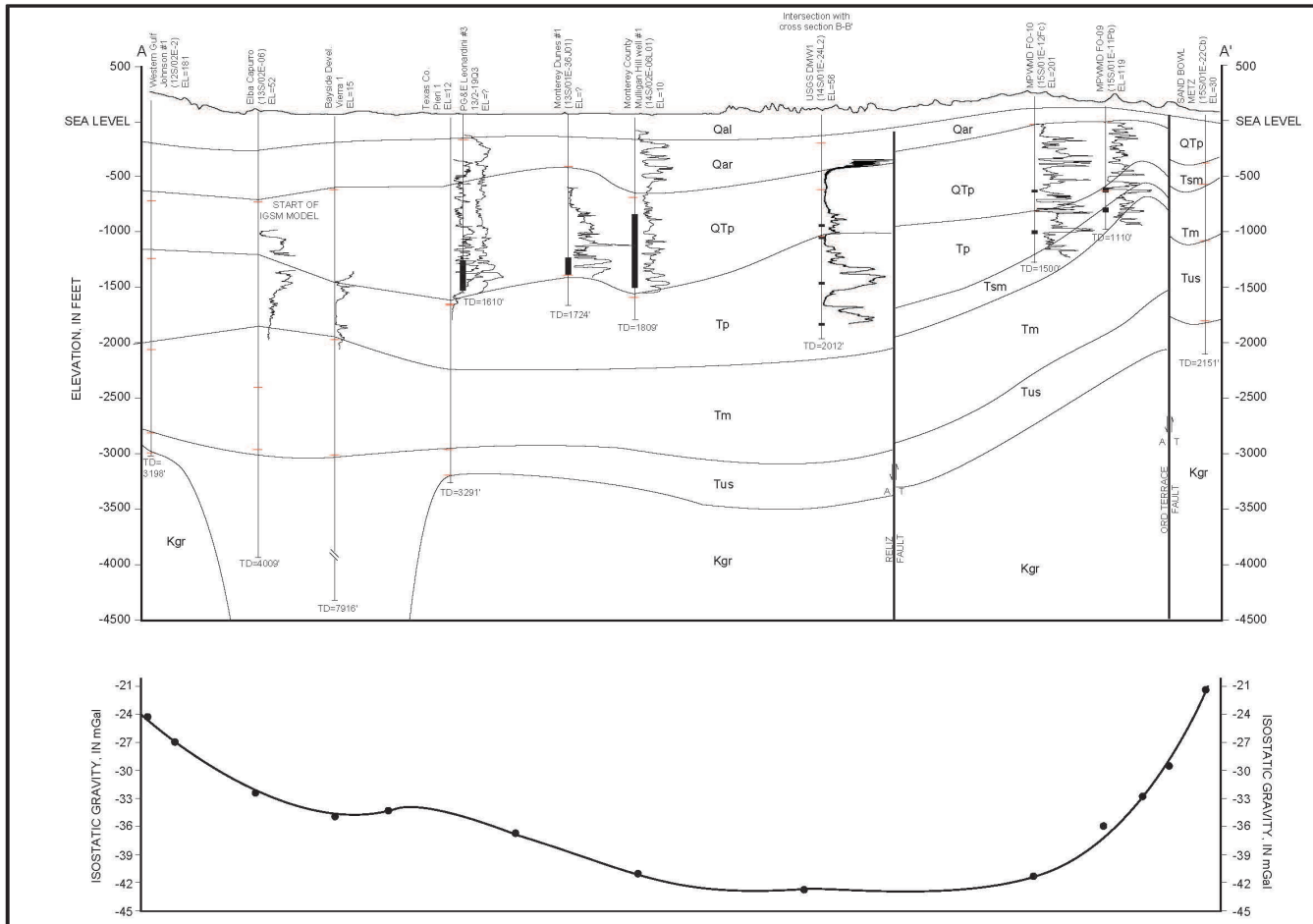
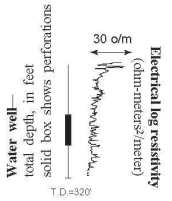


Figure from Greene (1977)



EXPLANATION

Qal	Alluvium (Holocene)
Qar	Aromas Sand (Pleistocene)
QTp	Paso Robles Formation (Pleistocene-Pliocene?)
Tp	Purisima Formation (Pliocene)
Tsm	Santa Margarita Sandstone (late Miocene)
Tm	Monterey Formation (middle Miocene)
Tus	Unnamed sandstone (middle Miocene)
Kgr	Granitic rocks (late Cretaceous)
	Fault
	Contact



SCALE

10000 feet

Vertical exaggeration = 10X

1000 feet

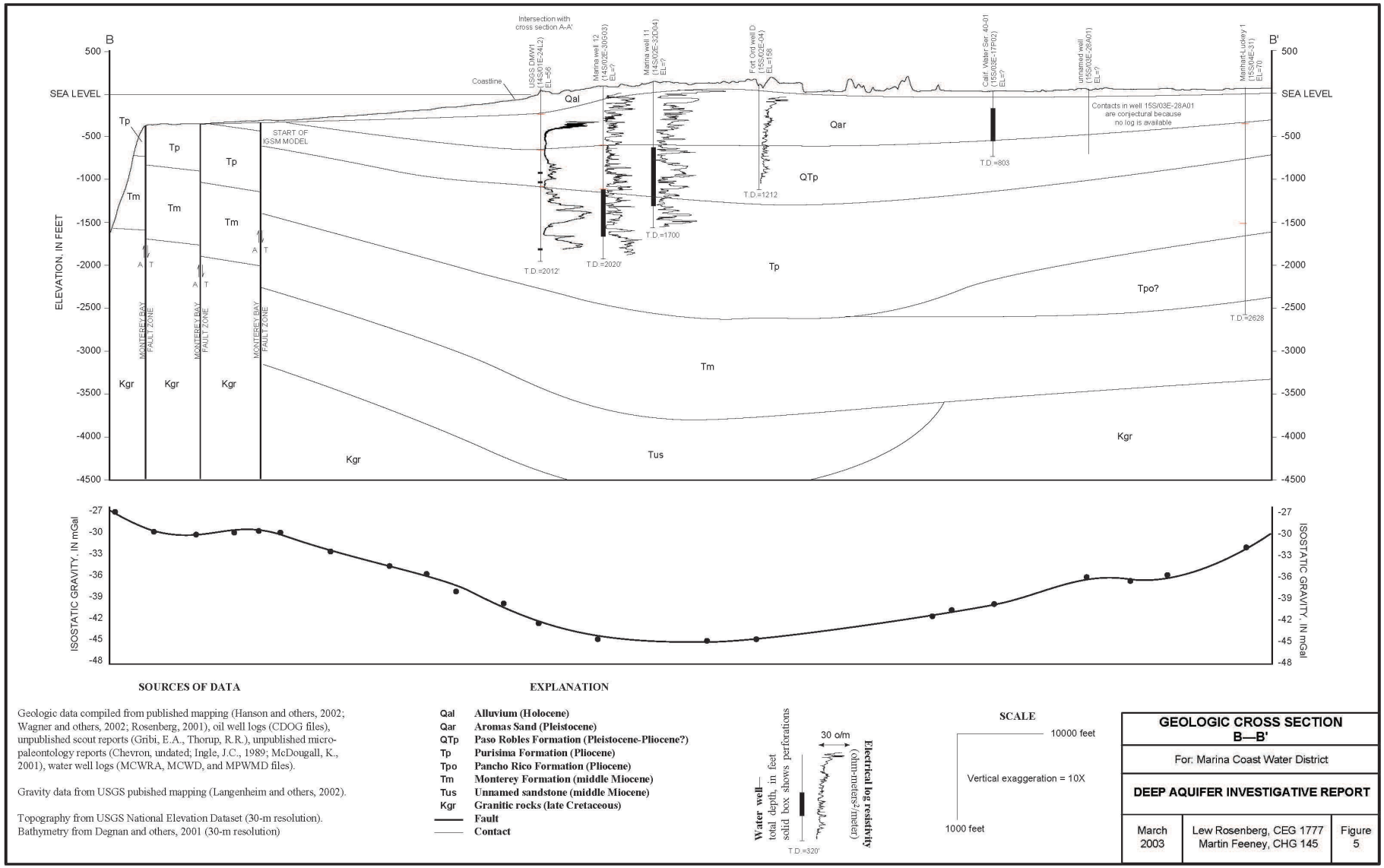
SOURCES OF DATA

Geologic data compiled from published mapping (Hanson and others, 2002; Wagner and others, 2002; Rosenberg, 2001), oil well logs (CDOG files), unpublished scout reports (Gribi, E.A., Thorup, R.R.), unpublished micro-paleontology reports (Chevron, undated; Ingle, J.C., 1989; McDougall, K., 2001), water well logs (MCWRA, MCWD, and MPWMD files).

Gravity data from USGS pubished mapping (Langenheim and others, 2002).

Topography from USGS National Elevation Dataset (30-m resolution). Bathymetry from Degnan and others, 2001 (30-m resolution)

GEOLOGIC CROSS SECTION A—A'		
For: Marina Coast Water District		
DEEP AQUIFER INVESTIGATIVE REPORT		
March 2003	Lew Rosenberg, CEG 1777 Martin Feeney, CHG 145	Figure 4



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SCALE

10000 feet

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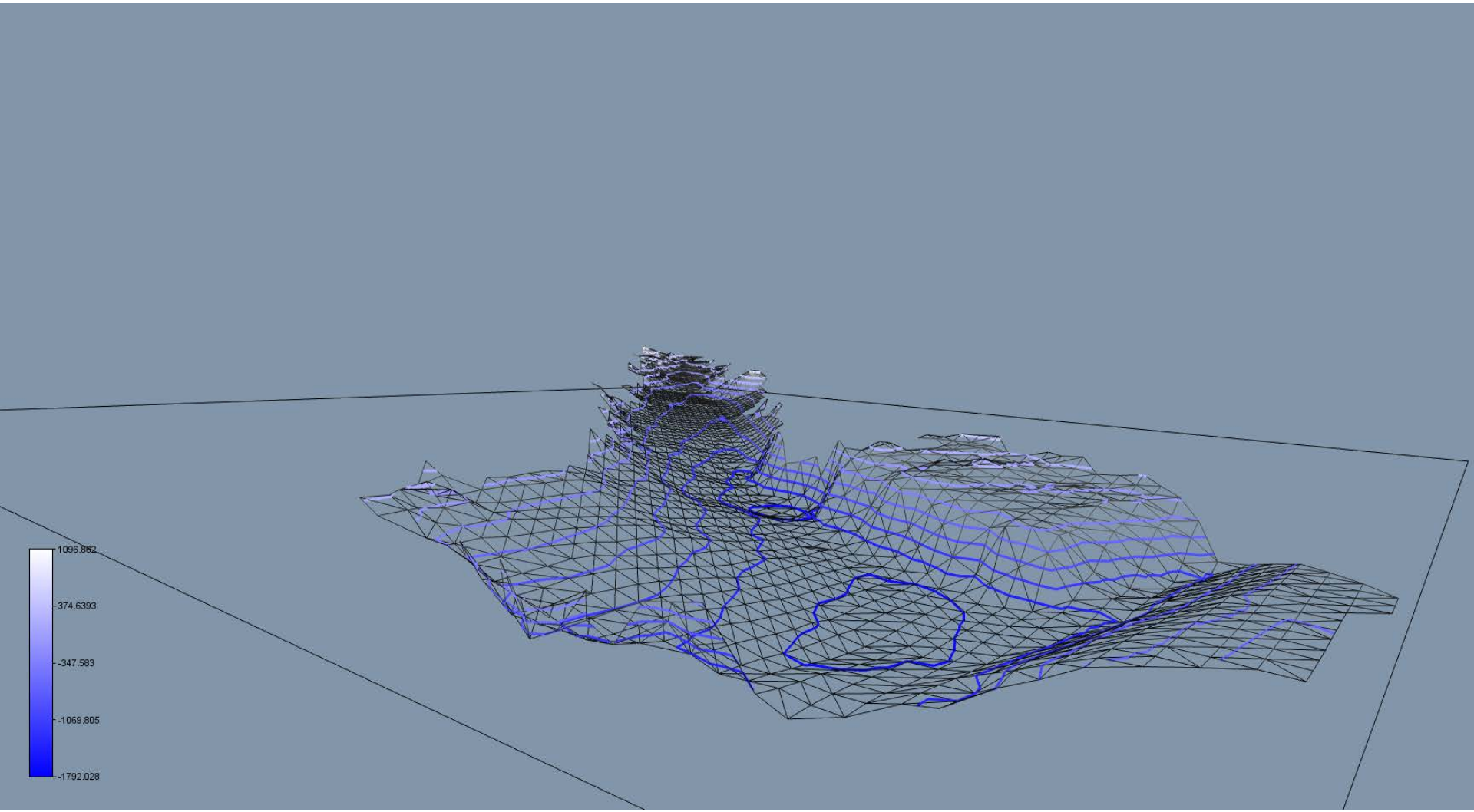
1000 feet

GEOLOGIC CROSS SECTION B—B'

For: Marina Coast Water District

DEEP AQUIFER INVESTIGATIVE REPORT

March 2003	Lew Rosenberg, CEG 1777 Martin Feeney, CHG 145	Figure 5


1096.862
374.6393
-347.583
-1069.805
-1792.028

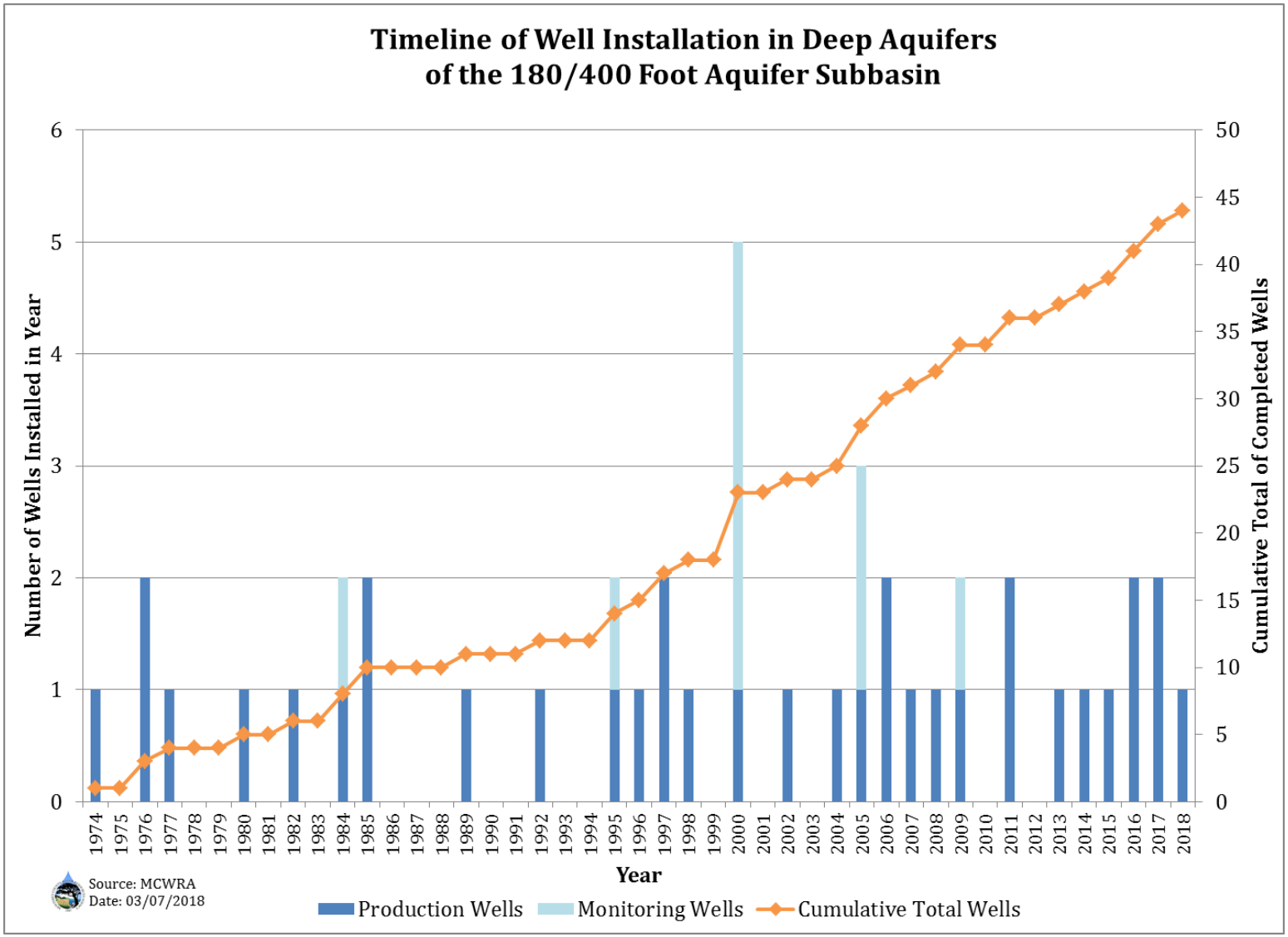
Wells

- First water well in the Deep Aquifers was installed in 1974
- Currently there are:
  - 33 production wells
  - 9 monitoring wells
- Two additional production wells have been proposed for construction

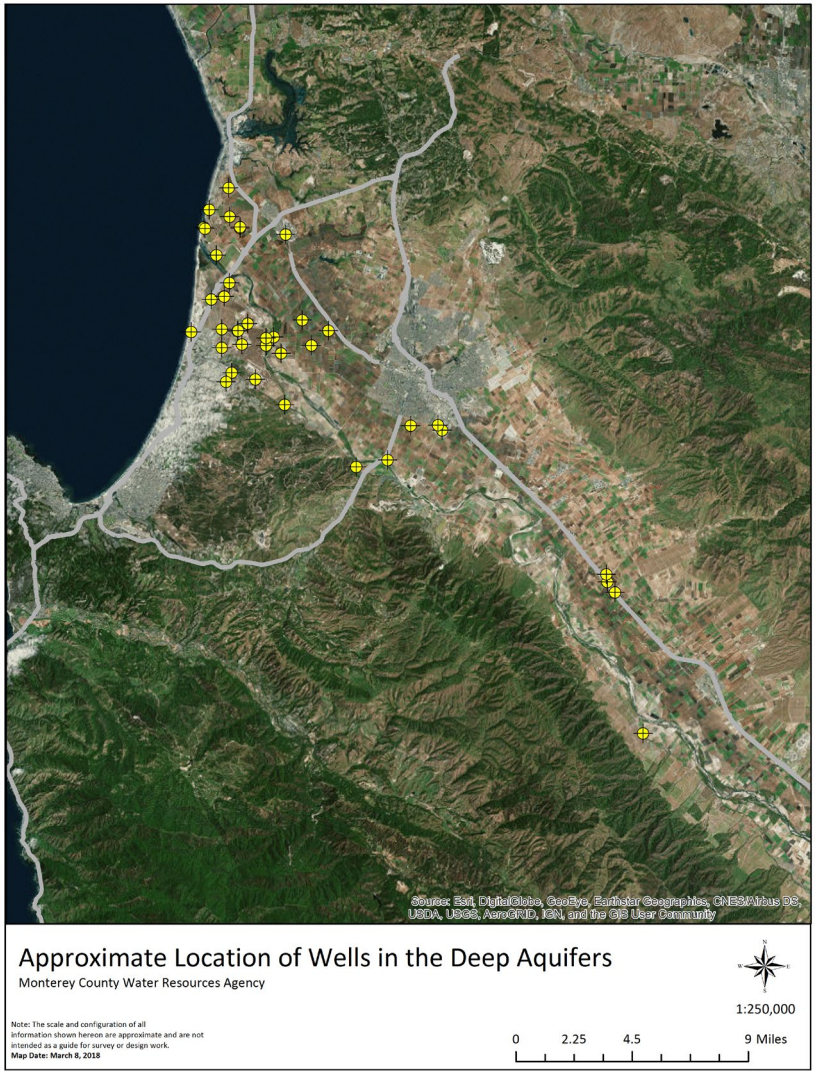
Wells

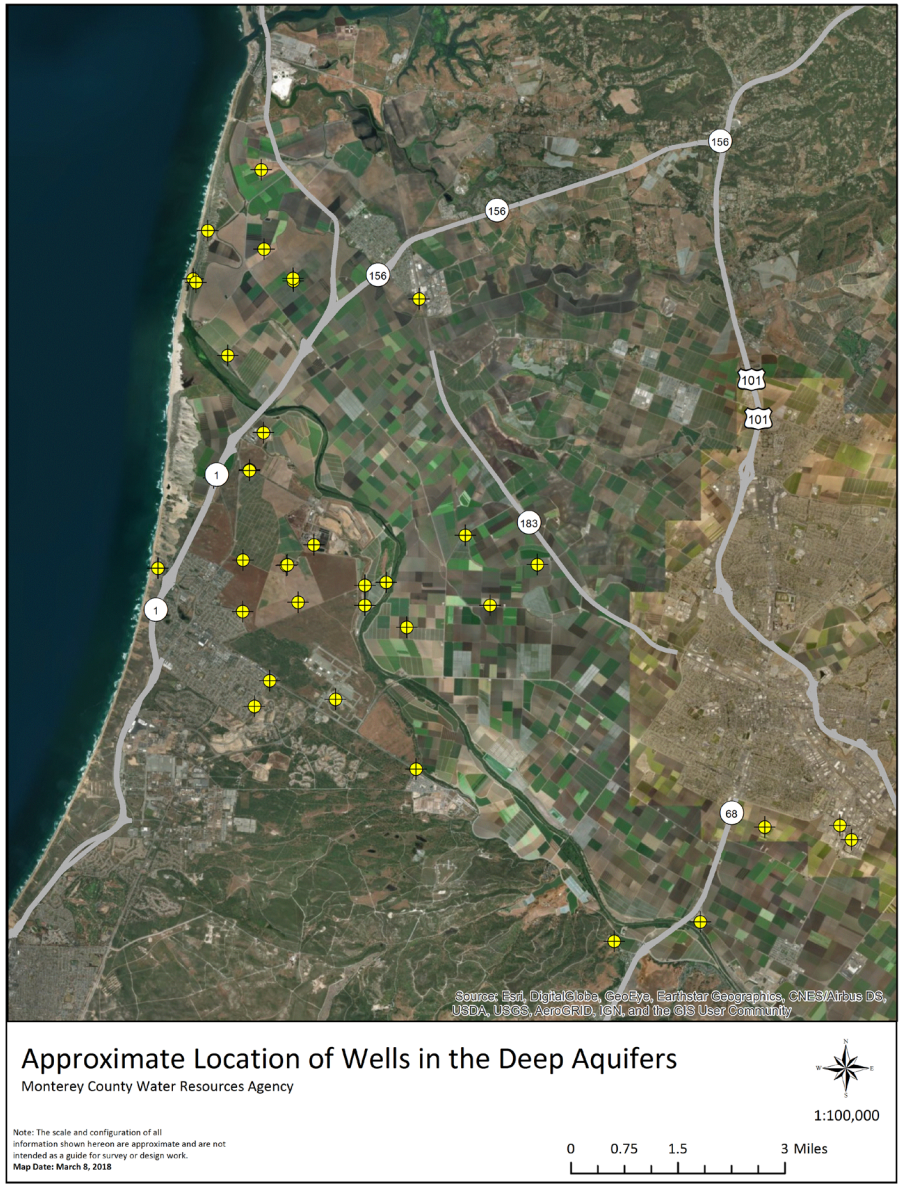
- Of the existing 33 production wells
  - 20 are agricultural wells
  - 7 are municipal wells
  - 6 are industrial, residential, or unknown use

Wells


Timeline of Well Installation in Deep Aquifers
of the 180/400 Foot Aquifer Subbasin
Number of Wells Installed in Year
Cumulative Total of Completed Wells
Year
Source: MCWRA
Date: 03/07/2018
Production Wells
Monitoring Wells
Cumulative Total Wells

Wells


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Approximate Location of Wells in the Deep Aquifers
Monterey County Water Resources Agency
Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.
Map Date: March 8, 2018
1:250,000
0
2.25
4.5
9 Miles



Approximate Location of Wells in the Deep Aquifers

Monterey County Water Resources Agency

1:100,000

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Map Date: March 8, 2018

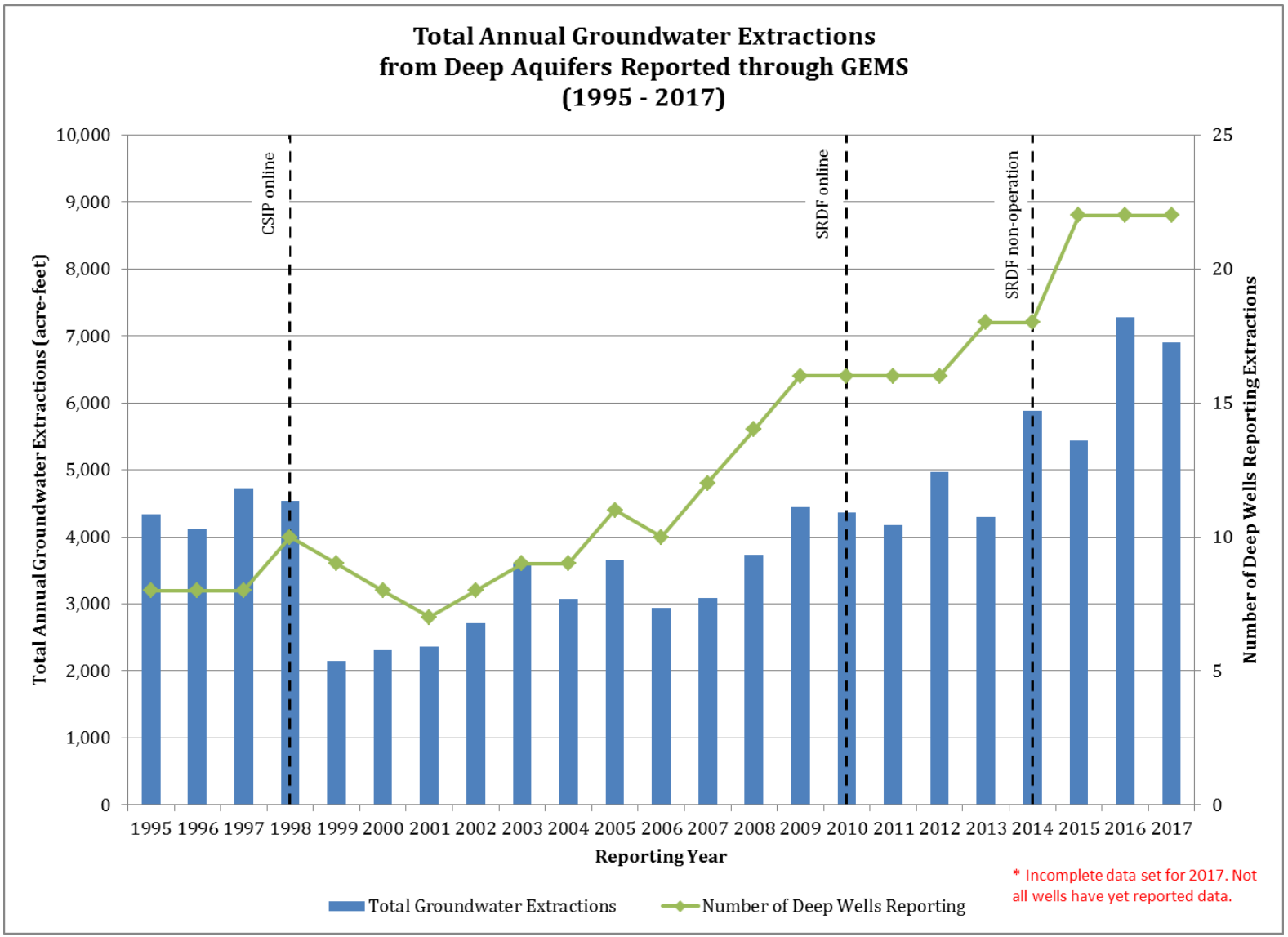
0 0.75 1.5 3 Miles

Groundwater Extractions

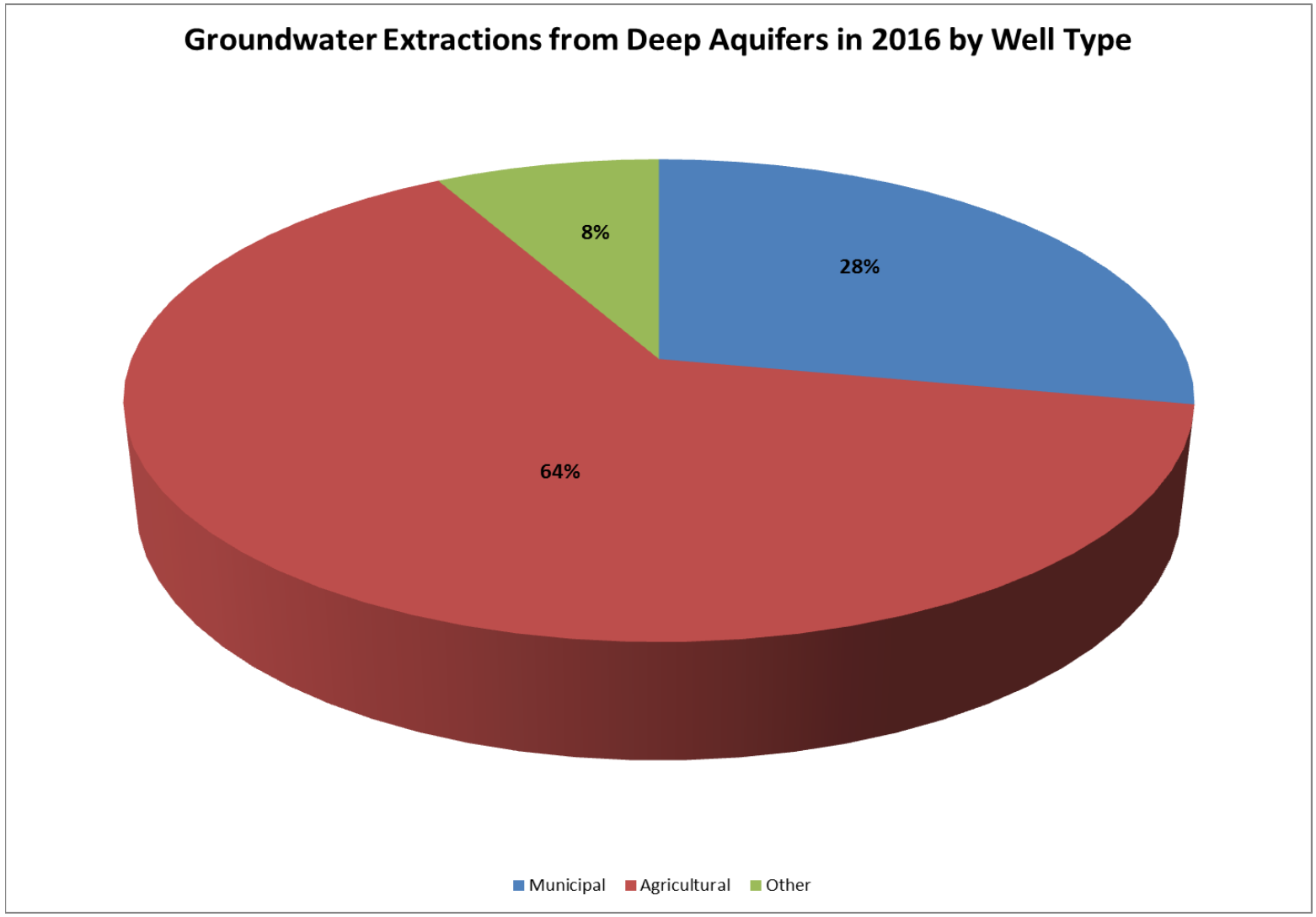
- Recorded pumping rates range from 140 gpm to 2,100 gpm

- Total annual extractions range from 2,100 to 7,200 acre-feet per year (1995 to 2017)

Groundwater Extractions



Groundwater Extractions



Groundwater Extractions

- Segmenting wells into “coastal Deep Aquifers” vs “inland Deep Aquifers”
  - Using 2016 extraction data
    - 81% of pumping from wells in coastal Deep Aquifers
    - 19% of pumping from wells in inland Deep Aquifers

Agency Monitoring Programs

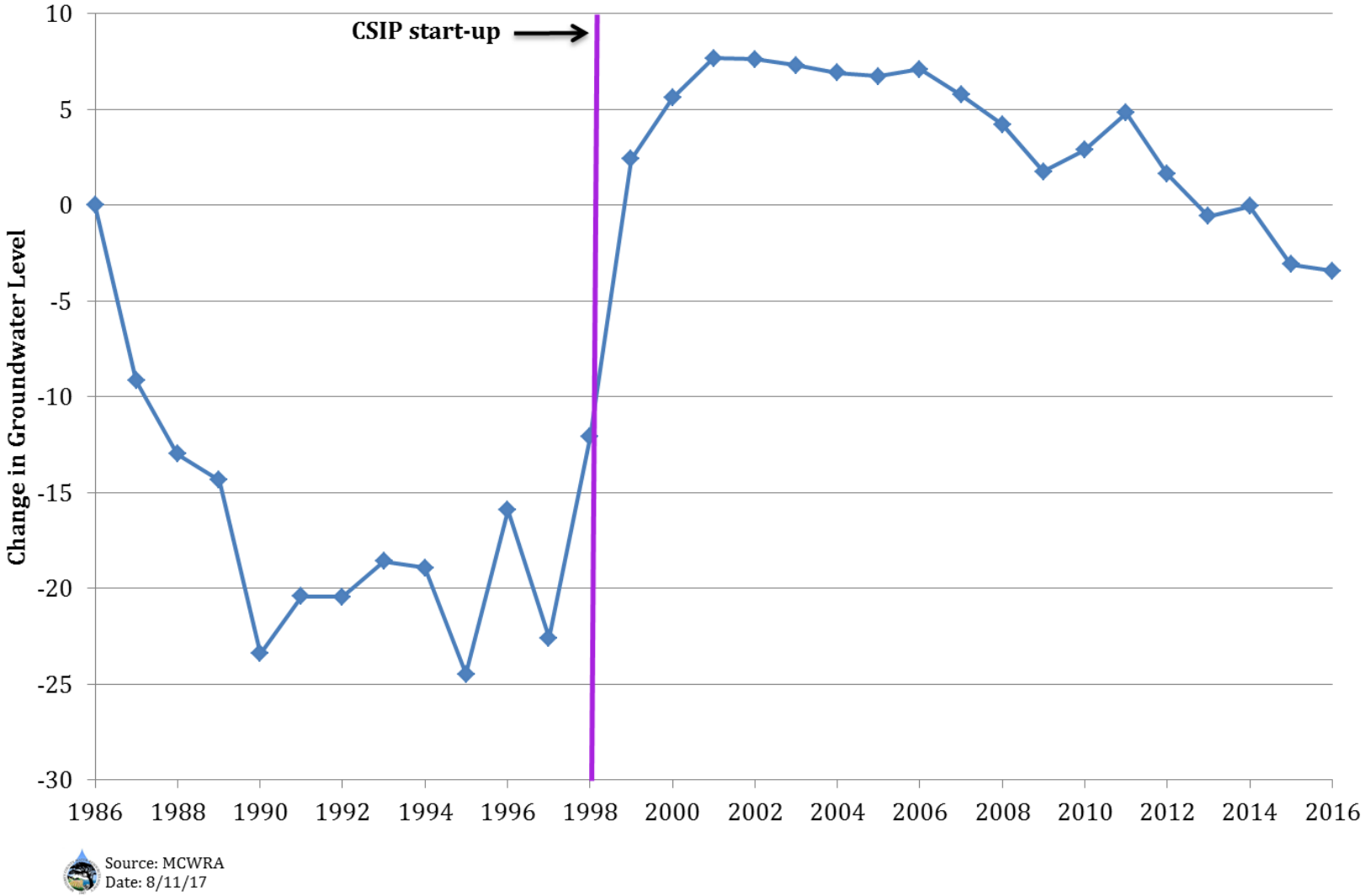
- Wells in the Deep Aquifers are monitored by the Water Resources Agency for water quality and/or groundwater levels
  - Water quality: 10 wells
  - Groundwater levels: 12 wells

Groundwater Levels

- Water level data shows:
  - Late 1980's decline; leveling out in the mid-1990's
  - Quick increase of water levels after CSIP came on line
  - Gradual decline of water levels since 2001

- Wells used in average change chart are concentrated in northern part of the coastal region.

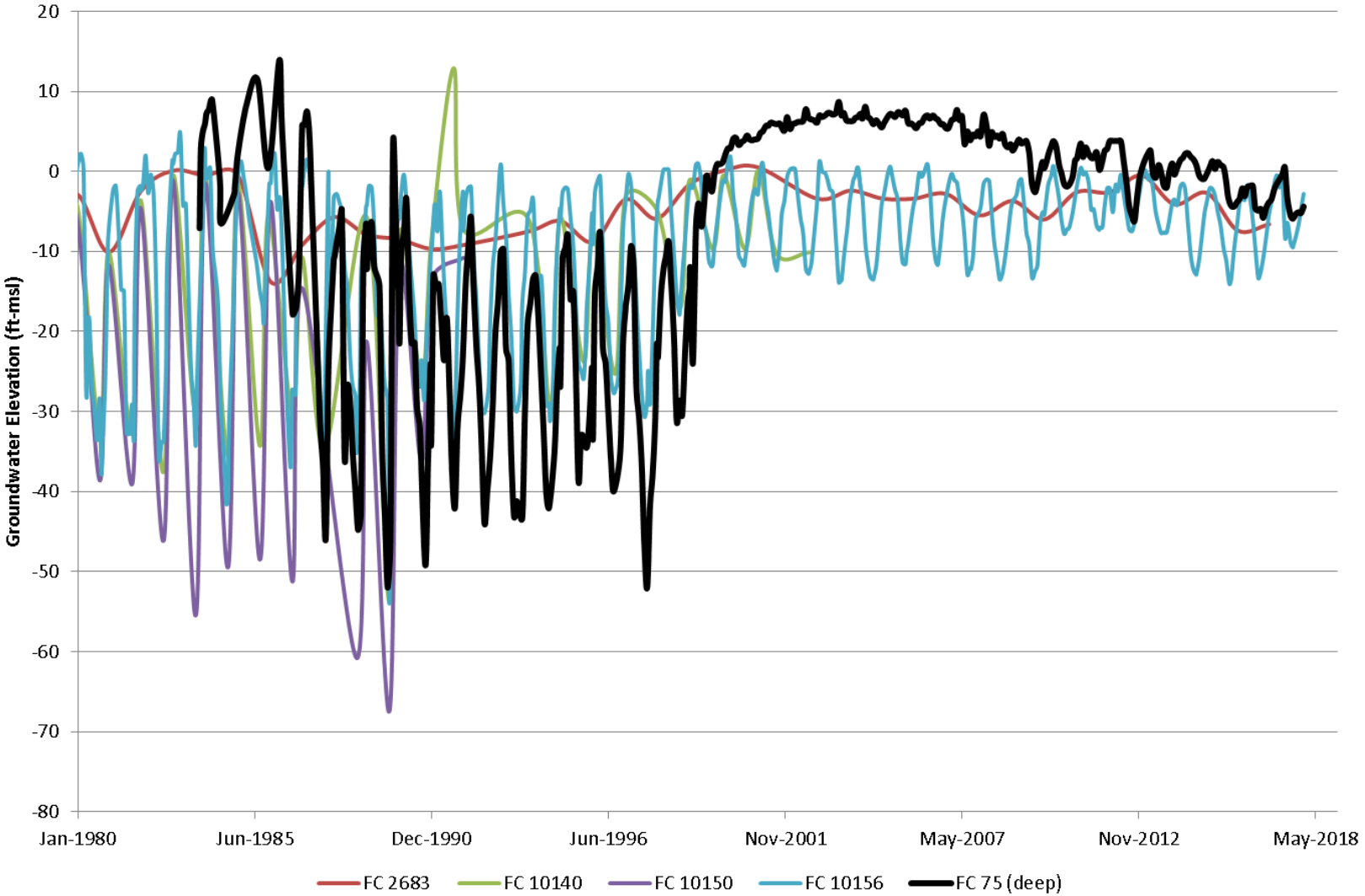
Average Groundwater Level Changes in the Deep Aquifers 1986-2016



Groundwater Levels

- Study for Marina Coast Water District (Feeney and Rosenberg, 2003) indicated a pattern in water level history in three wells:
  - Water levels close to sea level at time of well construction
  - Rapid decline in static water levels during first several years of operation
  - Static water levels stabilize and fluctuate minimally at an elevation below sea level

Comparison of Groundwater Elevation in Pressure 400-Foot and Deep Aquifers Wells



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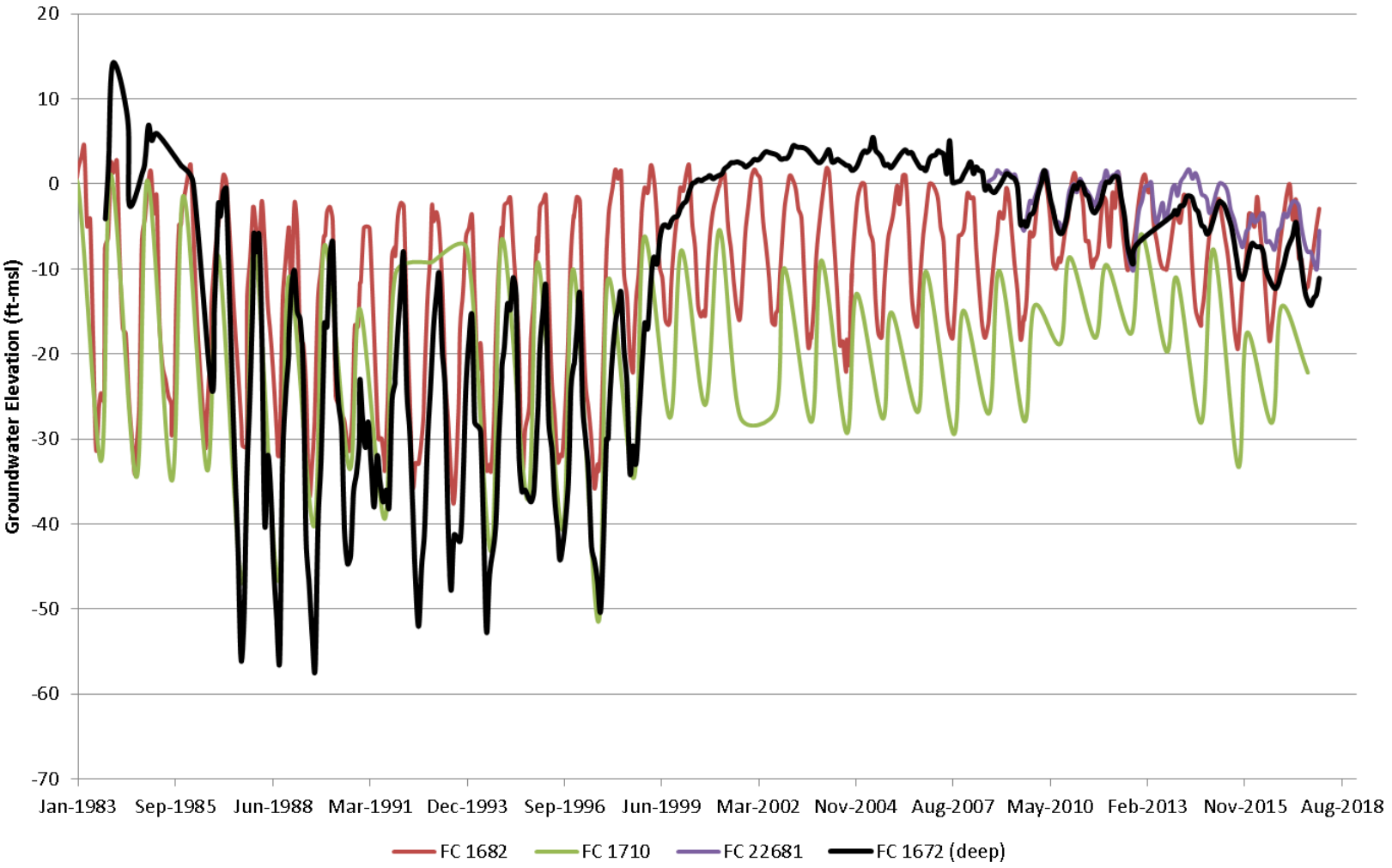
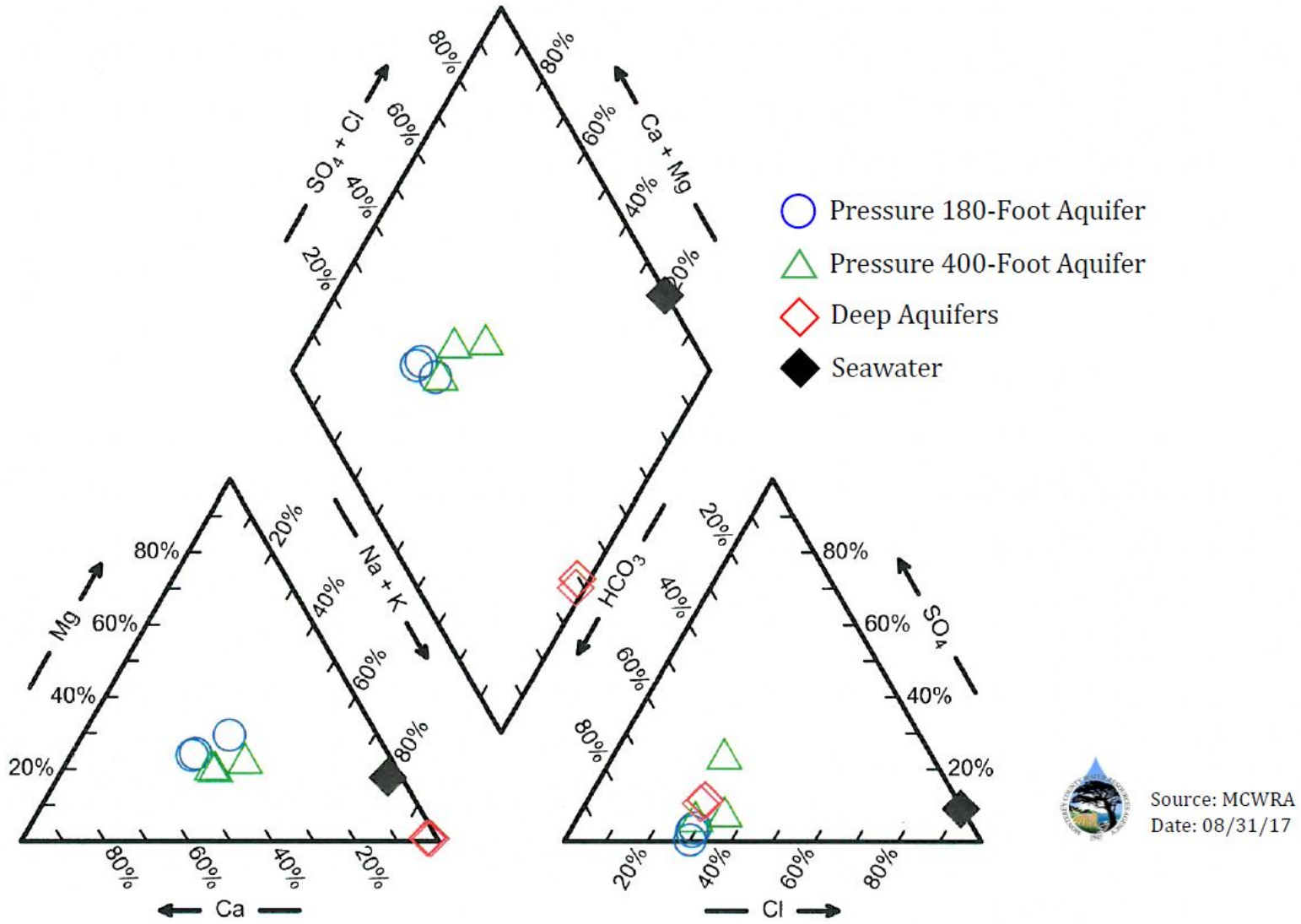


Water Quality

- Higher pH than water in Pressure 180-Foot or 400-Foot Aquifers
- Warmer temperatures (>90°F observed)
- "Old" groundwater based on isotope analysis
  - Data suggests that recharge did not occur under current climate conditions

Pressure Subarea Aquifers-Water Quality



Source: MCWRA
Date: 08/31/17

Water Quality

- From Feeney and Rosenberg (2003)
  - Marina Coast Water District's wells show stable TDS and chloride over time
  - Similar data from wells in Castroville
  - Water quality appears to decline with increasing depth of well

Recharge

- Direct recharge to Deep Aquifer formations is limited
  - Purisima is not exposed on land in Monterey County
  - Extensive outcrops of the Paso Robles Formation in the Salinas Valley, however…
    - Overlain by Salinas Valley alluvium and Aromas Sands
    - Minimal precipitation in areas where Paso Robles is exposed (<12” annually)

Recharge

- Hydrocomp model (1985) indicated a “strong likelihood” of flow through the confining layer

- Water level history of MCWD wells supposed the idea that extractions from the Paso Robles and Purisima are primarily supported by leakage from overlying shallow aquifers (Feeney and Rosenberg, 2003)

Recharge

- Thorup (1983) estimated a recharge rate of 65,500 acre-feet annually

- Lateral recharge from valley margins estimated by Thorup, used by Hydrocomp (1985)
  - West side of valley
    - 1,500 to 2,120 acre-feet/year
  - East side of valley
    - 640 to 1,700 acre-feet/year

Hydraulic Properties

- Range of transmissivity values based on pumping tests at 4 wells (Hydrocomp, 1985)
  - 10,000 gpd/ft to 36,000 gpd/ft

Storage and Areal Extent

- Thorup (1976) estimated that the Deep Aquifers extended from Greenfield to the mouth of the Salinas River
  - Storage estimate of 11 million acre-feet
  - Later revised to 4.6 million acre-feet

Where to expand understanding?

- Nature of the confining layer between the Pressure 400-Foot and Deep Aquifers
- Recharge
  - Sources and rates
- Ocean interface
- Hydraulic properties
  - Is further field investigation necessary?
- Extent of depositional environment