COMMITMENT & INTEGRITY
DRIVE RESULTS

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TECHNICAL MEMORANDUM

PREPARED BY: Lauren Salberg, GIT and Kevin Almestad, GIT

REVIEWED BY: Jim Strandberg, PG, CHG and Dave Richardson, PE

DATE: October 16, 2019

RE: Windsor Basin Groundwater Arsenic Study

As part of the Water Master Plan Update 2019 (WMP Update), the Town of Windsor (Town) requested Woodard & Curran to conduct a literature review and document existing information on the presence of naturally occurring arsenic in groundwater beneath the Town. The last two wells the Town drilled in 2010 (Esposti Municipal and Bluebird B), both contained naturally occurring arsenic at levels that exceed the federal and state Primary Maximum Contaminant Level (MCL). A well development and treatment feasibility study conducted for the Esposti Municipal Well identified high costs associated with treating arsenic in groundwater, therefore the results of this study will be used for the siting of future off-river water supply well locations that may have low arsenic. The results of the study are documented in this Technical Memorandum (TM) and will be incorporated into the WMP Update. This TM is organized into the following sections:

1.0 Introduction

2.0 Sources of Information

3.0 Regional and Local Hydrogeology

4.0 Water Well Locations and Depths

5.0 Geochemistry and Arsenic Groundwater Quality Data

6.0 Conclusions and Recommendations

7.0 References

1.0 Introduction

Naturally occurring arsenic is present in raw groundwater in the Santa Rosa Plain Groundwater Basin beneath the Town and, in some areas and at some well screen depths, arsenic concentrations exceed the federal and state Primary Maximum Contaminant Level (MCL) of 10 micrograms per liter (ug/L) for drinking water. As part of the WMP Update, the Town requested Woodard & Curran to conduct a literature review to more fully understand and document existing information on the presence of naturally occurring arsenic in groundwater beneath the Windsor area. The study included communications with public and private entities to confirm known sources of information and to obtain additional information not readily available.

2.0 Sources of Information

In addition to information provided by the Town, Woodard & Curran obtained information from the following sources:

- United States Geological Survey (USGS);
- California Department of Water Resources (DWR);
- California State Water Resources Control Board (State Water Board);
- North Coast Regional Water Quality Control Board;
- Sonoma County Department of Health Services, Environmental Health and Safety;
- Sonoma County Water Agency (now known as Sonoma Water);
- Santa Rosa Plain Basin Advisory Panel;
- Santa Rosa Plain Groundwater Sustainability Agency;
- Consultant reports (BESST, GHD, RMC, and Winzler & Kelly); and
- Local private contractors (Alpha Analytical, Analytical Sciences, Weeks Drilling and Pump Company, and Clear Heart Drilling).

Online data sources included:

- California Statewide Groundwater Elevation Monitoring (CASGEM);
- DWR Well Completion Reports;
- Groundwater Ambient Monitoring and Assessment (GAMA) Program (including the Priority Basin Project, GAMA PBP);
- GeoTracker GAMA (including USGS Groundwater Quality Monitoring);
- Water Quality Portal (NWIS and STORET);
- SGMA Data Viewer;
- SGMA Basin Prioritization Dashboard;
- Santa Rosa Plain Groundwater Sustainability Agency Website; and
- Sonoma State University Tap Water Database.

3.0 Regional and Local Hydrogeology

3.1 Regional Geology and Hydrogeology

The Town lies within the northern portion of the Santa Rosa Plain sub-basin (DWR number 1-55.01) of the Santa Rosa Valley Groundwater Basin (DWR, 2003). The Santa Rosa Valley Groundwater Basin is one of a series of northwest-southeast trending structural depressions in the southern part of the North Coast Hydrologic Region. The Santa Rosa Plain sub-basin consists of five groundwater storage units, including the Windsor Basin shown on Figure 1 (USGS, 2013a). The Windsor Basin is bounded to the west by the Sebastopol Fault, by the Healdsburg fault zone and Mayacmas Mountains foothills to the east, and by the Trenton Ridge Fault to the south. The Trenton Ridge Fault trends in a northwest-southeast direction under the Santa Rosa Valley between the Rodgers Creek Fault to the east and the Sebastopol Fault to the west.

The main water-bearing units in the Santa Rosa Valley Groundwater Basin are young alluvial sediments of Quaternary age, older alluvial sediments of Tertiary age, sedimentary deposits including the Glen Ellen, Wilson Grove, and Petaluma formations of late Tertiary age, and Tertiary-age Sonoma

Volcanics. These Tertiary-age sedimentary and volcanic formations are underlain by basement rocks (bedrock), including the Franciscan Complex, which yield little to no groundwater. A west-to-east cross-section through the Windsor Basin from a three-dimensional lithologic model developed by the USGS (2013a) shows a higher percentage of coarser grained materials within 500 feet of ground surface compared to finer grained materials at greater depths (Figure 2). The Santa Rosa Plain Basin reportedly extends to a depth of 4,500 feet beneath the Town (USGS, 2013a).

A conceptual diagram of the geology and groundwater flow system in the Windsor Basin shows the Wilson Grove Formation is primarily located west of the Sebastopol Fault and the Sonoma Volcanics are primarily located east of the Rodgers Creek Fault (and Healdsburg fault zone, Figure 3). These geologic units underly the uplands surrounding the Santa Rosa Valley and interfinger with the basin-fill deposits and have limited lateral hydraulic communication and little influence on groundwater production rates and groundwater quality in the Windsor Basin beneath the Town. The structural trough beneath the Windsor Basin, represented by the greatest thickness of the Petaluma Formation, is skewed towards the eastern side of the valley closer to the Healdsburg and Rodgers Creek faults (i.e., Healdsburg fault zone).

3.2 Local Geology and Hydrogeology

The surficial geology of the Windsor Basin consists of Quaternary-age alluvium and the Tertiary-age sedimentary Glen Ellen Formation (Figure 4). The heterogeneous alluvial materials, ranging in size from clay-sized particles to sands and boulders, vary in thickness from a few feet along the edges of the valley to at least 600 feet in the valley center where Highway 101 passes through Town. Thicker deposits of alluvium support higher well production rates. The saturated alluvium has limited hydraulic communication with the underlying Glen Ellen Formation. Although heterogeneous, these materials comprise a continuous body of saturated material across the Windsor Basin.

Groundwater is recharged primarily from subsurface inflow, infiltration of precipitation, and seepage from streambeds. Discharge is primarily through water production wells and to a lesser extent from subsurface outflow and evapotranspiration from plants. Groundwater generally flows from the highlands on the east and west sides of the Windsor Basin towards the valley floor. The Healdsburg fault zone on the east edge and the Sebastopol Fault on west edge of the basin may influence local horizontal and vertical groundwater flow directions. Well production rates are highly variable in the alluvium and sedimentary formations with the Glen Ellen and Wilson Grove formations being the most permeable (USGS, 2013a). Hydrogeologic characteristics of these formations throughout the Santa Rosa Plain provided by the USGS (2013a) are summarized below:

- Glen Ellen Formation: Thickness is variable with a typical range of hundreds of feet but can be up to 3,000 feet. The substantial amount of clay-sized material, degree of compaction, and cementation limit the permeability of the formation. Well production is highly variable. Specific capacities are less than 10 gpm/foot. Specific yield values range from 3 to 7 percent. Hydraulic conductivity ranges from 13 to 23 feet/day.

- Wilson Grove Formation: Most of the consistently productive wells are constructed in the upper part of this formation with relatively clean sands and low degree of cementation. Specific capacities are reportedly 5 to 6 gpm/foot. Moderate to high storativity results in specific yield in the range of 10 to 20 percent, higher than any other rocks or sediments in the area. Hydraulic conductivity ranges from 2 to 65 feet/day.

4.0 Water Well Locations and Depths

The primary source for well locations shown on Figure 5 was the Town's GIS database. The Town's GIS database consultant, GTG, provided the location and depth of 1,765 wells for this study. Well locations and total depth were also obtained from public sources, including DWR and USGS online databases, and referenced literature. Many of the well locations available from these public sources are duplicative with information provided by GTG. Those that are thought to be different are also shown on Figure 5.

The primary sources for well construction details, specifically well screen intervals, were the DWR Well Completion Reports. According to the USGS (2010), most public supply wells in the Santa Rosa Plain Basin are drilled to depths of 200 to 500 feet.

The Esposti Municipal Well was constructed with screen intervals in the range of 380 to 655 feet below ground surface (ft bgs). According to GHD (2017), the aquifer production characteristics are consistent with descriptions of the Glen Ellen Formation. The Bluebird B Well was constructed with a screen interval from 695 to 745 ft bgs. Based on the similar depth, it is assumed the well is also constructed in the Glen Ellen Formation.

Wells located near the northern Town limit are shown on Figure 6. The wells are located near Arata Lane and in the vicinity of the vacant Manchester property owned by the Town. The Assessor's Parcel Number for this property is 066-310-029. Information provided by the Town for 45 wells is summarized in Table 1. Thirty of the wells are relatively shallow with depths ranging from about 70 to 230 feet and reported production rates of 5 to 50 gallons per minute (gpm). Fifteen deeper wells ranging from about 350 to 800 feet have reported production rates ranging from 30 to 440 gpm. It is noteworthy that wells completed from 500 to 800 feet have reported production rates greater than 200 gpm.

Table 1: Windsor Wells near Arata Lane

Well ID	Depth (bgs)	Well Use Type	Production Rate (GPM)	Temperature
1[a]	804	Irrigation	440	Cool
2	703	Irrigation	703	--
3[b]	690	Irrigation	200	--
4	637	Domestic	200	--
5	585	Irrigation	100	83°F
6	490	Public	200	--
7	500	Public	200	--
8	470	Domestic	300	--
9	400	Other	100	--
10	390	Irrigation	50	Cool
11	381	Domestic	40	Cool
12	380	Irrigation	100	--
13	380	Domestic	90	--
14	352	Unknown	38	Cool
15	349	Domestic	30	--
16	227	Domestic	30	--
17	218	Domestic	50	Cool
18	216	Domestic	35	--
19	196	Domestic	45	--
20	190	Domestic	35	--
21	180	Domestic	20	--
22	178	Domestic	38	--

23	170	Domestic	35	Cool
24	164	Domestic	35	--
25	157	Domestic	20	--
26	152	Domestic	5	--
27	149	Domestic	--	--
28	143	Domestic	45	--
29	142	Domestic	30	--
30A	142	Domestic	35	--
30B	136	Domestic	--	--
31A	131	Domestic	6	--
31B	124	Domestic	24	--
32	129	Domestic	30	--
33	124	Domestic	15	--
34	123	Domestic	20	Cool
35	123	Domestic	18	--
36	120	Domestic	35	--
37	120	Domestic	20	--
38	112	Domestic	10	--
39A	107	Domestic	14	--
39B	89	Domestic	10	Cool
40	90	Domestic	12	--
41	68	Domestic	5	Cool
42	145	Domestic	30	--

bgs = Below ground surface
GPM = Gallons per minute
°F = Degrees Fahrenheit
[a] = Well is screened from 65 feet bgs to 805 feet bgs at various intervals.
[b] = Well is screened from 90-110 feet bgs and 160-200 feet bgs.

5.0 Geochemistry and Arsenic Groundwater Quality Data

The USGS (2010 and 2013a) has researched the presence of naturally occurring arsenic in groundwater basins in the Sonoma and Napa valleys. Arsenic is a tasteless, odorless, semi-metallic trace element which can be present in surface and groundwater from natural and anthropogenic sources (USGS, 2013a). A natural source of arsenic in groundwater is from the dissolution of arsenic-rich minerals including apatite and arsenian pyrite (USGS, 2010). USGS (2010) found that elevated arsenic concentrations in groundwater in the Santa Rosa Plain are primarily caused by the release of arsenic during dissolution of iron or manganese oxides under iron or manganese-reducing (anoxic) conditions.

The USGS (2013a) reports that arsenic in the natural environment is most commonly associated with sulfide and with ferromanganese-oxide minerals, particularly in areas characterized by geothermal water or high evaporation rates. Results of a USGS study (2013a) found that about 30 percent of the wells sampled for arsenic in the Windsor Basin and Wilson Grove storage unit had concentrations above the MCL for drinking water of 10 ug/L.

As part of the GAMA PBP in the North San Francisco Bay study unit, data from 44 wells in Sonoma, Napa, and Marin counties were used to identify the primary constituents associated with deep hydrothermal fluids (Forrest, et al., 2013). Arsenic is an element often used to determine whether hydrothermal mixing is occurring due to upwelling along fractures and faults. Elevated concentrations of arsenic may also be affected by water-rock interaction, including groundwater pumped from fine-grained deposits interbedded with coarser-grained deposits. These studies have identified a positive correlation of increasing arsenic concentrations with increasing water temperature. Elevated arsenic concentrations were also found to

have a positive correlation with reducing conditions (dissolved oxygen concentrations less than 1 milligram per liter) and/or high pH (greater than 7.8).

Lower concentrations of arsenic were found to correlate with wells constructed in alluvial materials. Research conducted in the area by the USGS indicates that lower arsenic concentrations correlate with cooler groundwater which is generally at shallower depths. Deeper water-bearing formations beneath the shallow alluvium, including the Glen Ellen, Wilson Grove, and Petaluma formations have variable but typically higher temperatures and higher arsenic concentrations. Water quality data from the USGS (2013a) is summarized in Table 2.

Concentrations of arsenic in groundwater samples collected from wells in the Windsor Basin were obtained from the referenced studies and DWR (water data for 2000 to 2012 provided by the Town), GAMA, and NWIS. Average arsenic concentrations and the number of measurements from 2000 to 2018 for wells in the Windsor Basin are shown on Figure 7. The average concentration of arsenic exceeds 10 ug/L in roughly one-half of the wells with the number of measurements ranging from one or two to over 40.

Groundwater temperature data are not available for most wells in the Windsor Basin. Most numerical data are available from GAMA and NWIS. Relative temperature information (e.g., cool) for wells located near the northern Town limit are provided in Table 1. Arsenic and temperature data were identified for only four wells, including the Town's Esposti Irrigation Well (Figure 8).

Plots of arsenic concentrations, depth, and/or temperature are shown on Figure 9. Arsenic concentrations with depth are shown for three Town wells, Esposti Irrigation Well, Esposti Municipal Well, and Bluebird A Well. The limited dataset suggests that arsenic concentrations may slightly increase with depth in the Glen Ellen Formation at these wells. A plot of temperature with depth could only be prepared for the Esposti Irrigation Well (GHD, 2017). This dataset is inconclusive. A plot of arsenic concentrations with temperature could also only be prepared for the Esposti Irrigation Well (GHD, 2017). This dataset appears to support the correlation of increasing arsenic concentrations with increasing water temperature.

Table 21: Arsenic Water Quality Data (USGS, 2013a)

Number of wells in shallow aquifer	Number of wells in deep aquifer	Total number of wells	Parameter units MCL, SMCL, or NL	Constituent: Specific conductance (µS/cm) [1]900	Chloride (mg/L) [1]250	Total dissolved solids computed (mg/L) [1]500	Nitrate as N (mg/L) [2]10	Arsenic (µg/L) [3]10	Boron (µg/L) [4]1,000	Iron (µg/L) [5]300	Manganese (µg/L) [5]50
Windsor groundwater storage unit											
7	—	—	Number of samples	7	7	7	5	1	6	2	2
7	—	—	Maximum	590	98.0	534	4.8	1.9	620	420	1,000
7	—	—	Minimum	339	8.0	267	0.2	1.9	<10	42	150
7	—	—	Median	477	39.0	396	0.9	1.9	100	231	575
—	9	—	Number of samples	6	9	9	2	5	8	5	7
—	9	—	Maximum	2,700	480.0	1,804	0.3	20.0	2,100	1,200	1,545
—	9	—	Minimum	206	10.5	161	0.1	6.0	100	50	230
—	9	—	Median	331	13.0	337	0.2	9.0	184	280	726
—	—	29	Number of samples	26	29	29	15	7	24	15	16
—	—	29	Maximum	2,700	480.0	1,804	17.6	20.0	2,100	1,200	1,545
—	—	29	Minimum	206	7.0	161	0.02	1.9	40	10	20
—	—	29	Median	377	26.0	321	0.5	6.0	106	320	675
—	—	29	Wells above regulatory level	1	1	3	1	2	2	8	15

6.0 Conclusions and Recommendations

6.1 Conclusions

Information gathered and compiled for this study revealed the presence of roughly 2,000 wells within and near the Town limit. The total depth of most wells is known but well construction details, specifically, depth of the screen interval(s), are limited to wells with DWR Well Completion Reports filed by the driller at the time of construction. This dataset has not been thoroughly reviewed to date. While it is reasonable to assume the well screen interval extends to the total depth of the well, the presence of shallow and deep screen intervals in deep wells is largely unknown. This current uncertainty creates a challenge to the characterization of groundwater quality in the Windsor Basin and the lateral and vertical distribution of arsenic concentrations above the MCL.

The study also found that arsenic concentrations are available for a limited number of wells. The lack of arsenic concentrations for more wells and lack of well construction details in deep wells limits the development of a more complete understanding of the potential correlation of arsenic concentrations with temperature, depth, and lithology (i.e., alluvium and the Glen Ellen, Wilson Grove, and Petaluma formations). Groundwater monitoring also indicates that arsenic concentrations can vary from the time of well drilling, well development, and pumping production - further complicating efforts to locate wells in low arsenic areas.

Research conducted in the area by the USGS indicates that lower arsenic concentrations correlate with cooler groundwater which generally occurs at shallower depths for wells constructed in alluvial materials. The alluvium, consisting of clay- to boulder-size materials, ranges in thickness from a few feet along the edges of the valley to at least 600 feet in the valley center where Highway 101 passes through Town. Thicker sections of alluvium support higher well production rates. Deeper water-bearing formations beneath the alluvium, including the Glen Ellen, Wilson Grove, and Petaluma, have variable but typically lower yields, higher temperatures, and higher arsenic concentrations. Data from some wells thought to be constructed in the upper part of the Wilson Grove Formation, however, are some of the most consistently productive wells.

The currently available arsenic concentrations shown on Figure 7 exceed the MCL throughout most of the Town vicinity. However, the available data also indicate an exception in the north to northwestern portion of Town. Arsenic results are available for only one well in this area, but the average arsenic concentration based on 11 to 40 sampling events from 2000 to 2018 is lower than the MCL. This area, which includes the Manchester property and Arata Lane, is near Highway 101 where the axis of the valley and thickness of alluvium would be greater. A second area that may be promising is the southwestern portion of Town near Pool Creek. This area, however, has been identified based only on the absence of arsenic concentrations. Therefore, the results of the Windsor Basin Groundwater Arsenic Study indicate that the northern part of Town closest to the middle of the basin where alluvial deposits are thickest and groundwater temperatures are lower, is the most favorable location for a new off-river water supply well.

6.2 Recommendations

Woodard & Curran recommends further evaluation of the northern part of Town with the objective of identifying the location of a test well site. This evaluation would be conducted in accordance with a Water Quality Study Plan or similar document. The plan would describe the approach, scope, cost, and duration of the evaluation. Additional information to be collected would include available well construction details, lithologic logs to identify the lithology in the well screen intervals, and information on well operation, including pump depth, production rates, dynamic water levels, as possible.

Based on this information, a subset of wells would be ranked for the collection of additional well-specific data and water quality monitoring. Prior to requesting site/well access, a plan or standard operating procedure would be prepared for activities that may include measuring groundwater temperature and other field water quality parameters, collecting groundwater samples for laboratory analysis of arsenic concentration, and possibly some form of well capacity testing. Data analysis would include evaluating potential correlations of arsenic concentrations with location, lithology, depth, and temperature. The recommendation of the study would be the identification of a site(s) for drilling a test well, possibly the Manchester property.

7.0 References

BESST. 2017a. *Root Cause Analysis of Arsenic Compliance Problems at Newly Constructed Public Supply Wells: An Alternative Exploration Process to Minimize and Avoid Water Quality Failure.* July.

BESST. 2017b. *Review of 2017 Draft, Town of Windsor Esposti Supply Well Report and the 2010 Town of Windsor Groundwater Well Installation and Testing Report*. July 31.

California Department of Water Resources. 2003. Bulletin 118, Update 2014, California's Groundwater.

California Department of Water Resources. 2018. Water Data for 2000 – 2012. Provided by Elizabeth Cargay, Town of Windsor, July 17.

Forrest, M.J., et al. 2013. *Hydrothermal Contamination of Public Supply Wells in Napa and Sonoma Valleys, California.* Applied Geochemistry.

GHD. 2017. *Esposti Supply Well Redevelopment, Pumping Test and Treatment Feasibility Study.* October 3.

RMC. 2008. *Windsor Water Master Plan Update – Water Supply Evaluation Technical Memorandum.* June 26.

RMC. 2009. *Windsor Phase I Off-River Supply Development Program – Bluebird Well Dynamic Profile Testing Technical Memorandum.* April 21.

RMC. 2009. *Well Installation and Testing Field Work Plan, Town of Windsor, California.* July.

RMC. 2012. *Town of Windsor Off-River Supply Program – Status, Draft Technical Memorandum.* July 19.

Santa Rosa Plain Basin Advisory Panel. 2014. *Santa Rosa Plain Watershed Groundwater Management Plan*. Available at http://www.scwa.ca.gov/files/docs/projects/srgw/SRP_GMP_12-14.pdf

Santa Rosa Plain Groundwater Sustainability Agency **WEBSITE**: http://santarosaplaingroundwater.org/conditions/

Santa Rosa Plain Groundwater Sustainability Agency. *Santa Rosa Plain Groundwater Conditions Fact Sheet*. Undated. Available at http://santarosaplaingroundwater.org/wp-content/uploads/SRP-Basin-Conditions.pdf

USGS. 2006. *Ground-Water Quality Data in the North San Francisco Bay Hydrologic Provinces, California, 2004: Results from the California Ground-Water Ambient Monitoring and Assessment (GAMA) Program.* Available at https://www.waterboards.ca.gov/gama/docs/nsfb_dsr_final.pdf

USGS. 2008. *Source, Distribution, and Management of Arsenic in Water from Wells, Eastern San Joaquin Ground-Water Subbasin, California.* Open File 2008 – 1272. October. Available at https://pubs.usgs.gov/of/2008/1272/pdf/ofr20081272.pdf

USGS. 2010. *Groundwater Quality in the North San Francisco Bay Groundwater Basins, California.* Fact Sheet 2010 – 3060. September. Available at https://www.waterboards.ca.gov/gama/docs/nsfb_facts.pdf

USGS. 2013a. *Hydrologic and Geochemical Characterization of the Santa Rosa Plain Watershed, Sonoma County, California.* Scientific Investigations Report 2013 – 5118. Available at *https://pubs.usgs.gov/sir/2013/5118/pdf/sir20135118.pdf*

USGS. 2013b. *Santa Rosa Plain Groundwater Study: Phase 1 – Hydrogeologic and Geochemical Characterization, July 2013.* Available at http://www.scwa.ca.gov/files/docs/projects/srgw/SRGW%20USGS%20Conceptual%20Study%20Summary.pdf

USGS. 2014. *Simulation of Groundwater and Surface-Water Resources of the Santa Rosa Plain Watershed, Sonoma County, California.* Available at https://pubs.usgs.gov/sir/2014/5052/

USGS. 2018. *Status and Understanding of Groundwater Quality in the North San Francisco Bay Shallow Aquifer Study Unit, 2012: California GAMA Priority Basin Project.* Scientific Investigations Report 2017 5051, Version 1.1. February. Available at https://pubs.usgs.gov/sir/2017/5051/sir20175051_v1.1.pdf

Winzler & Kelly. 2007. *Draft Technical Memorandum No. 1 Town of Windsor – Groundwater Well Siting.* August 3.

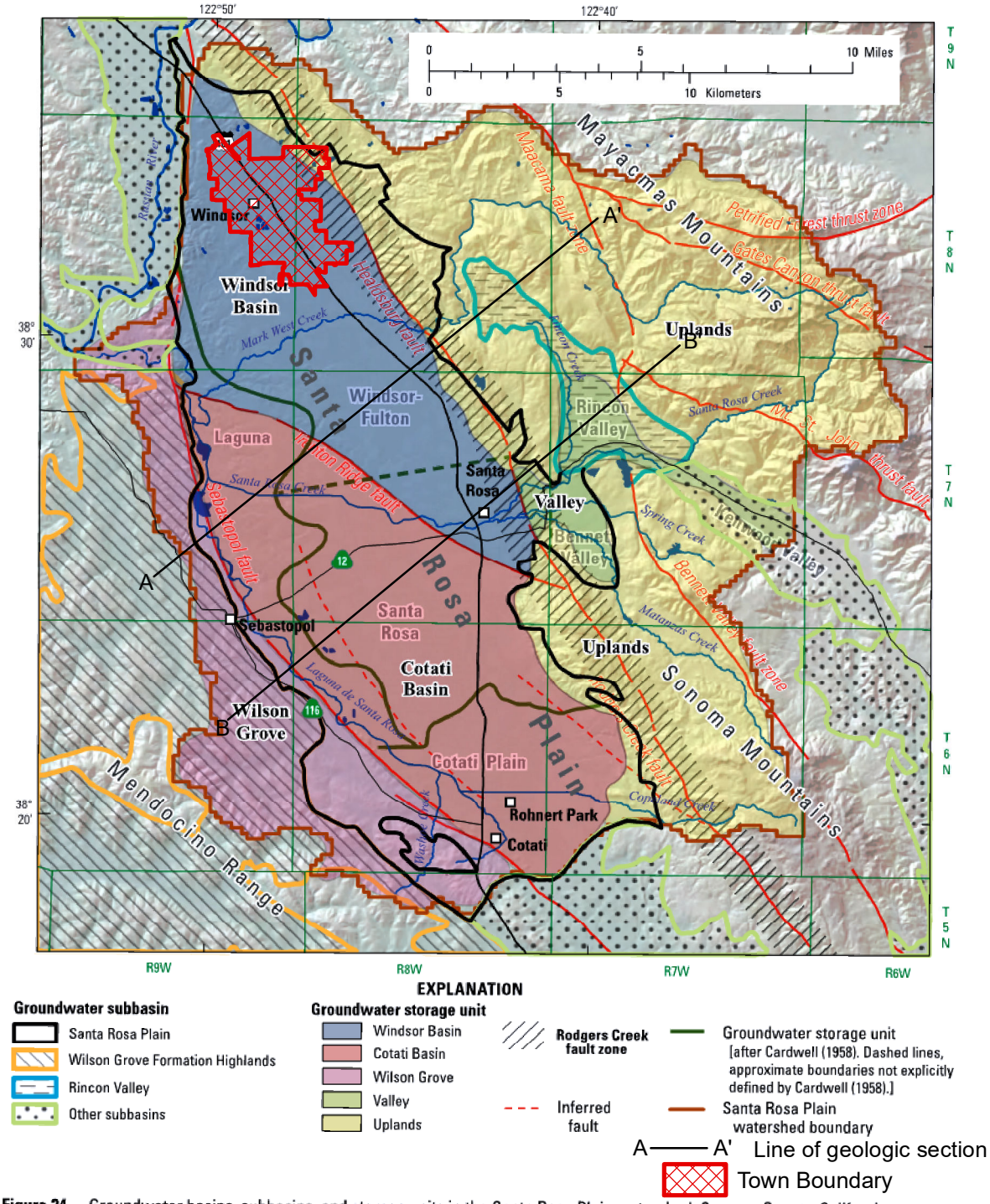


Figure 24. Groundwater basins, subbasins, and storage units in the Santa Rosa Plain watershed, Sonoma County, California.

Groundwater Basins and Subbasins	Source: USGS, 2013a. Modified by Woodard & Curran	**Figure 1** WOODARD &CURRAN Project #: 0011187

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Lithologic Cross Sections

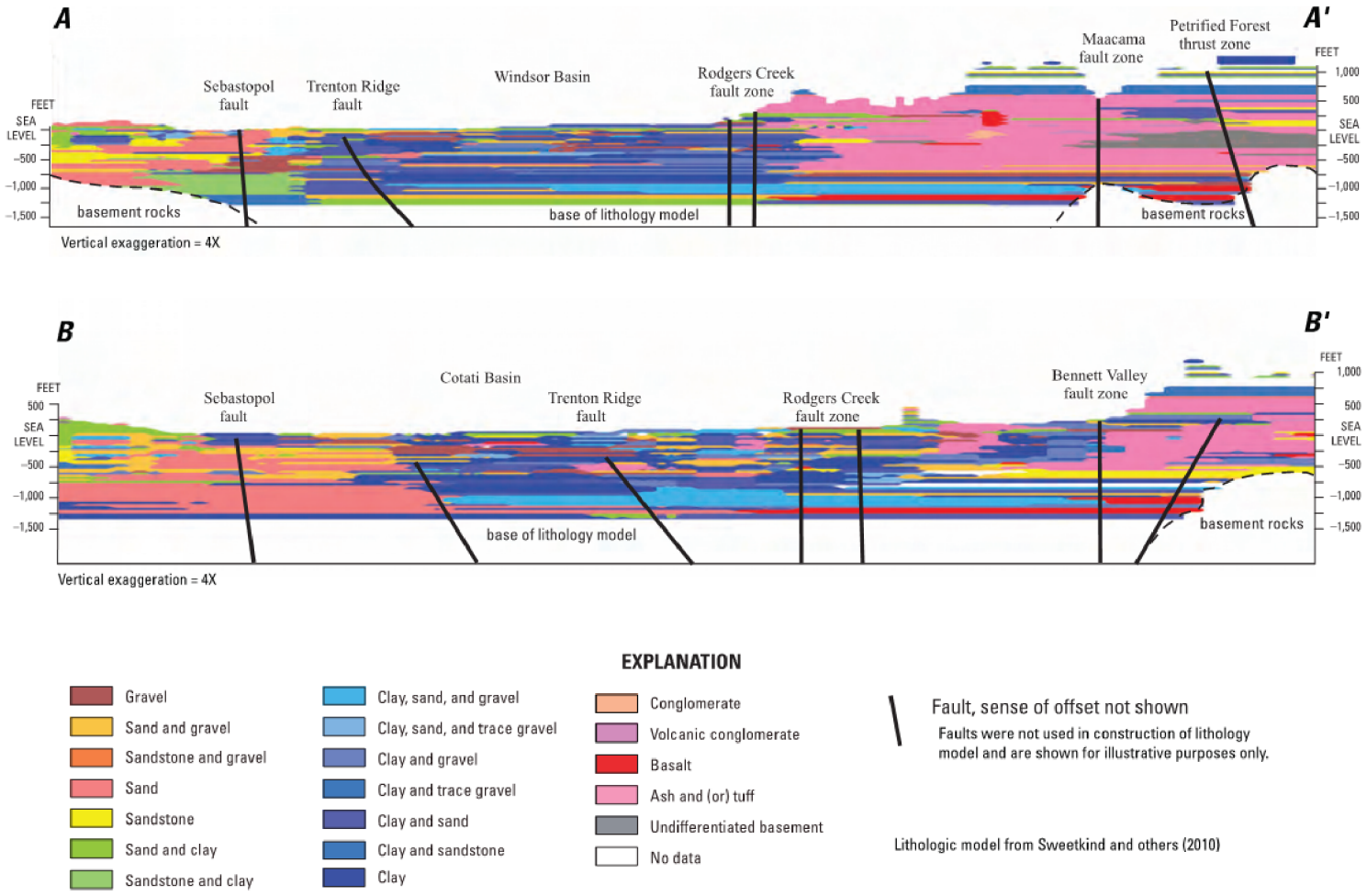


Figure 25. Vertical sections from three-dimensional lithologic model of the Santa Rosa Plain watershed, Sonoma County, California.

Source: USGS, 2013a

Figure 2

WOODARD &CURRAN

Project #: 1234567

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Conceptual Groundwater System Diagram

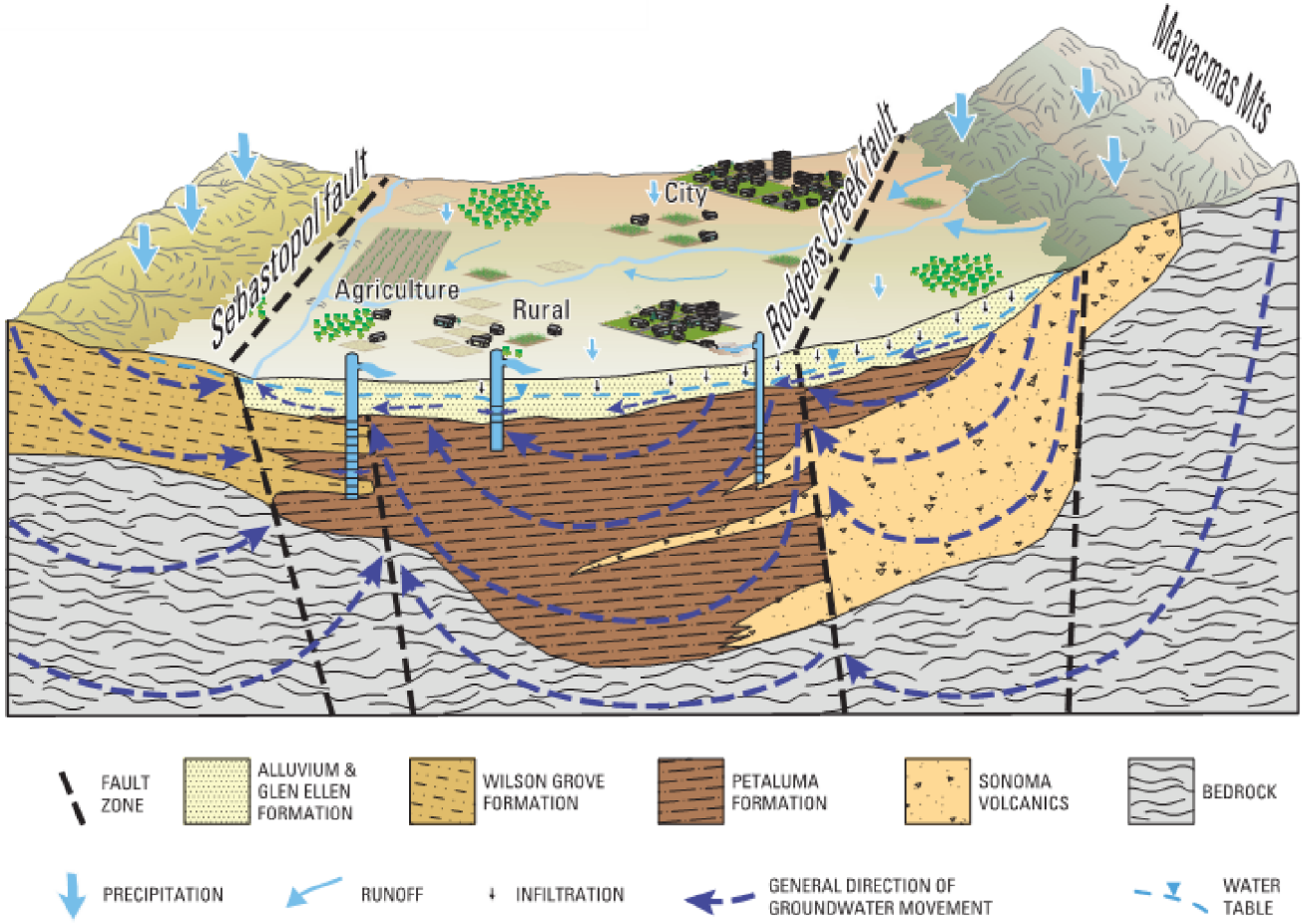


Figure 23. Conceptual diagram of the groundwater system, Santa Rosa Plain watershed, Sonoma County, California.

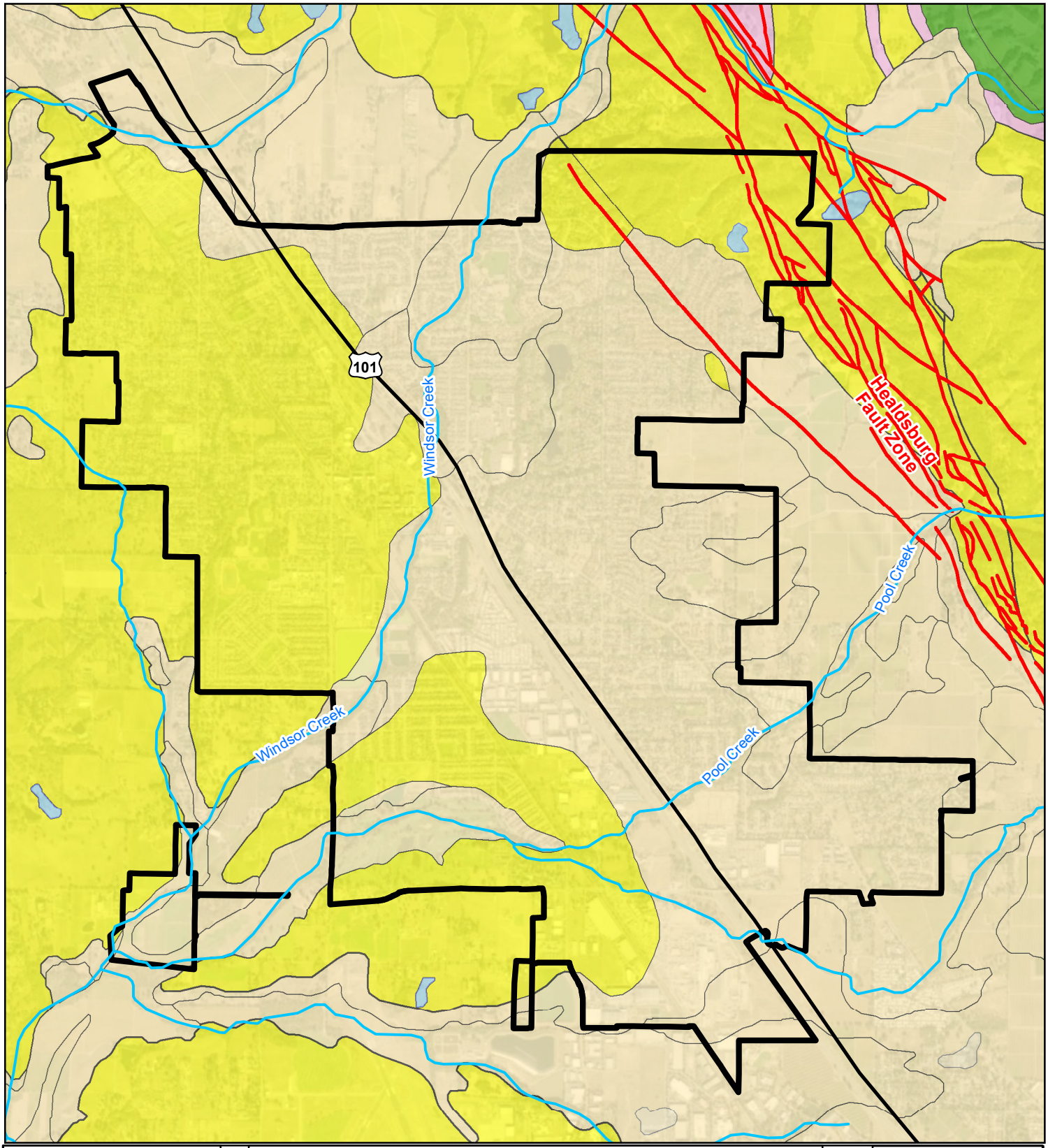
Source: USGS, 2013a

Figure 3

WOODARD &CURRAN

Project #: 1234567

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Geologic Map of the Windsor Basin

Legend

- Town of Windsor
- Creeks
- Highway 101
- Fault Trace

Geologic Units

- Quaternary Deposits
- Glenn Ellen Formation
- Sonoma Volcanics
- Great Valley Sequence
- Water

0 1,500 3,000 Feet

N

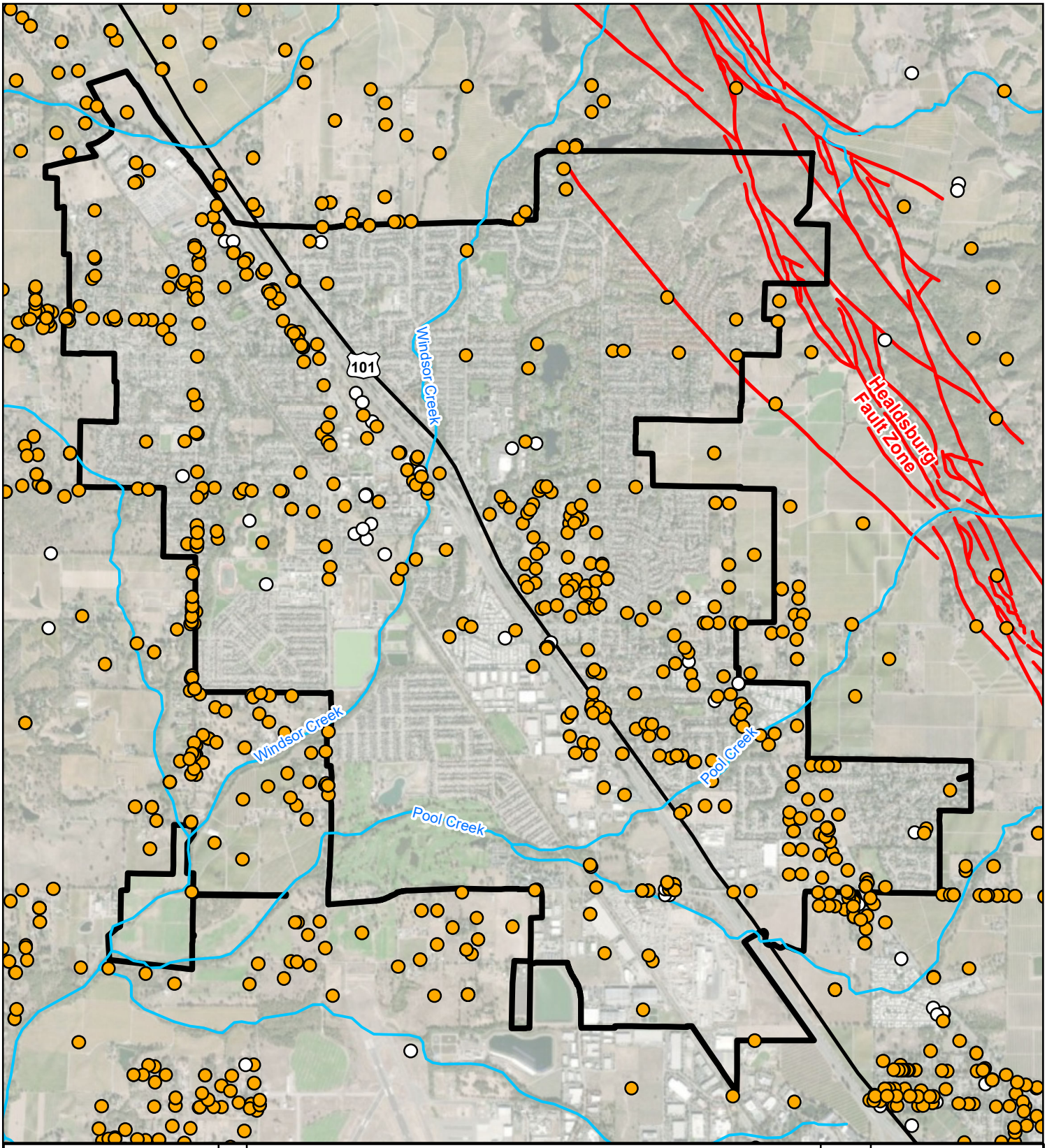
Figure 4

WOODARD &CURRAN

Project #: 0011187
Map Created: Aug. 2019

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Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources: USGS Open-File Report 97-744, USGS Scientific Investigations Map 3410.**



Town of Windsor Wells

2000 - 2018

Legend

- Town of Windsor
- Highway 101
- Creeks
- Fault Trace

All Known Windsor Wells

- Known Depth
- Unknown Depth

Note: Dots may represent multiple wells.

0 1,500 3,000 Feet

N

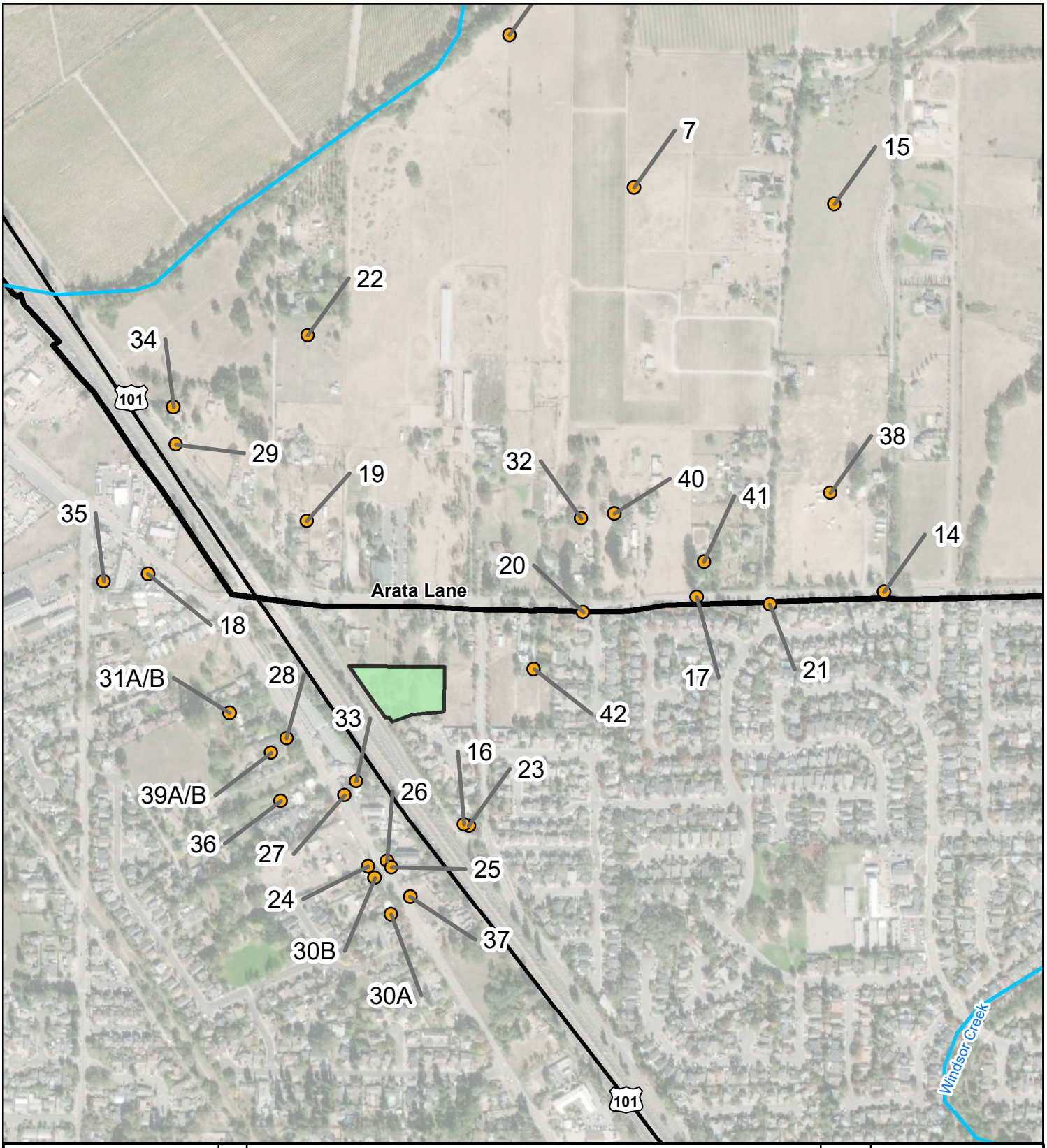
Figure 5

WOODARD &CURRAN

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Map Created: Aug. 2019

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Windsor Wells near Arata Lane

2000 - 2018

Legend

- Well Location
- Town of Windsor
- Manchester Property
- Highway 101
- Creeks

Notes:
1) Well label numbers correspond to the Well IDs in Table 1.
2) Not all wells referenced in Table 1 are shown.
3) Well locations are approximate based on figures provided by the Town of Windsor.

0 375 750 Feet

N

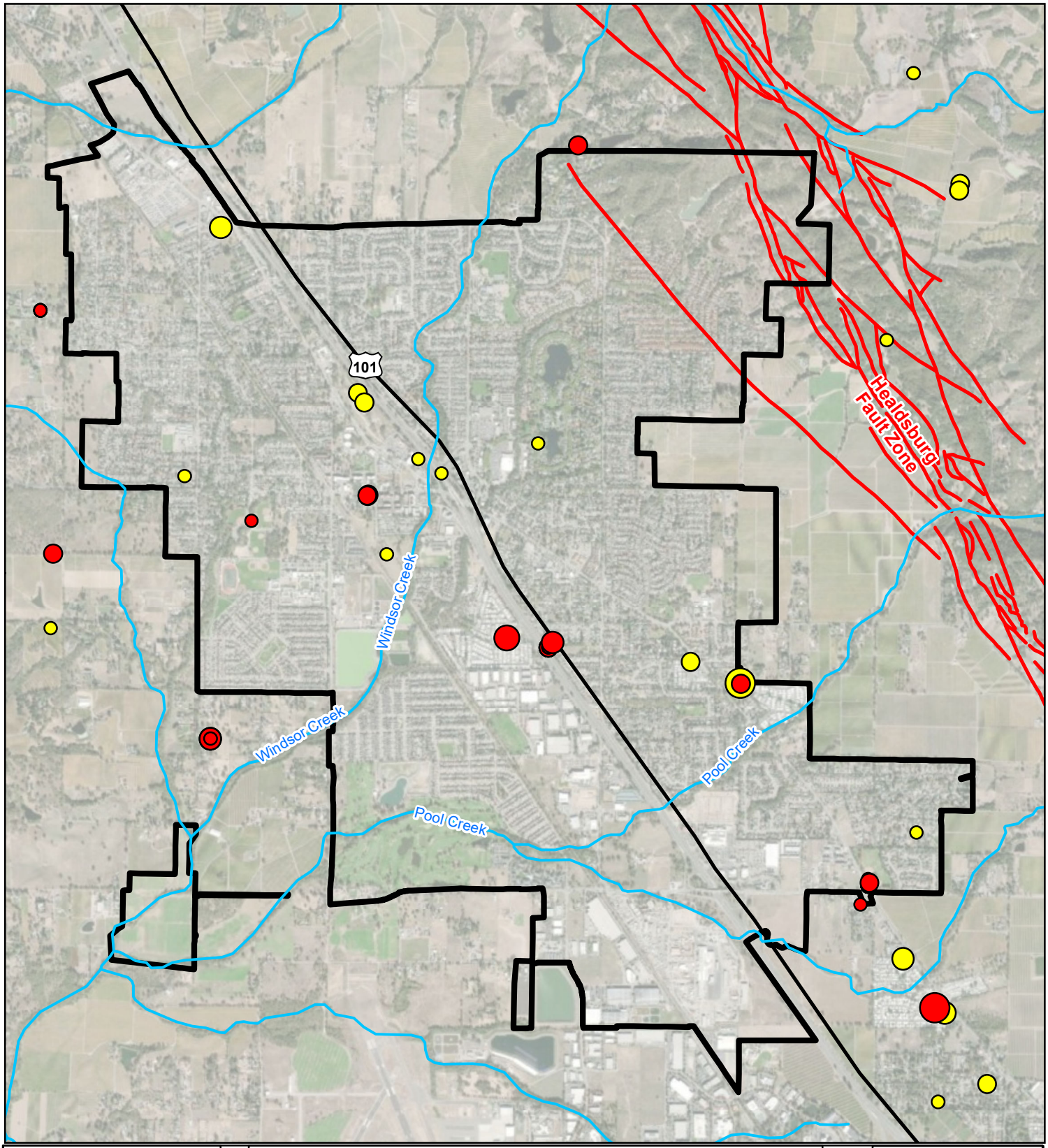
Figure 6

WOODARD &CURRAN

Project #: 0011187
Map Created: Aug. 2019

Figure Exported: 8/26/2019 By: kalmestad Using: \\woodardcurran.net\shared\Projects\RMC\WCR\0143 - Windsor\0011187 2018 WMP\G. GIS\Maps\Water Quality TM\Windsor_TOW_Wells.mxd

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources: Town of Windsor**



Average Arsenic Concentrations & Number of Measurements

2000 - 2018

Legend

- Town of Windsor
- Highway 101
- Creeks
- Fault Trace

No. of Measurements

- 1 - 2
- 3 - 5
- 6 - 10
- 11 - 40
- 40+

Avg. Arsenic 2000-2018

- < 10 ug/L
- > 10 ug/L

0 1,500 3,000 Feet

N

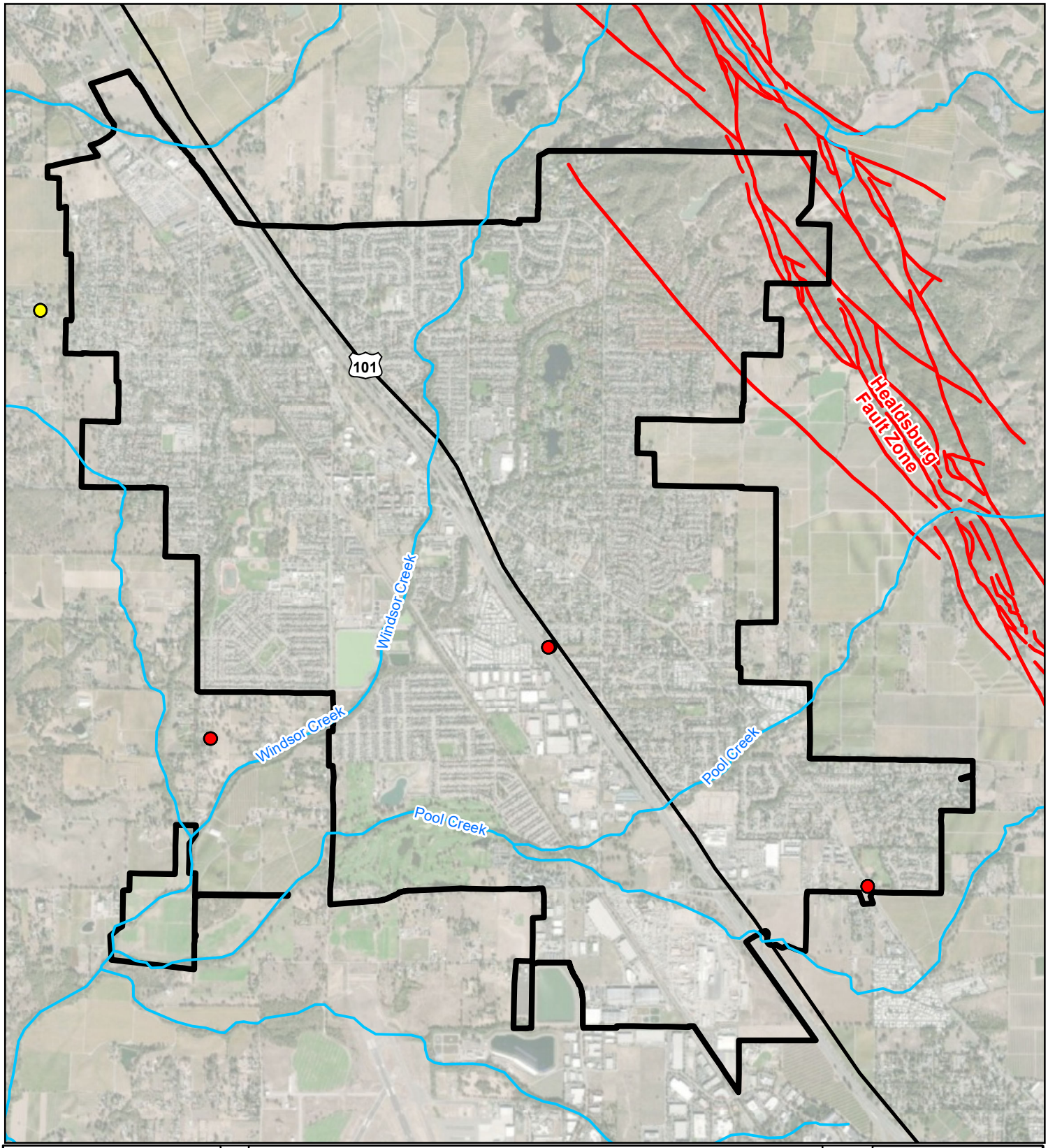
Figure 7

WOODARD &CURRAN

Project #: 0011187
Map Created: Aug. 2019

Figure Exported: 8/27/2019 By: kalmestad Using: \\woodardcurran.net\shared\Projects\RMC\WCR\t0143 - Windsor\0011187 2018 WMP\G. GIS\Maps\Water Quality TM\Windsor_Ars+Measurement No..mxd

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Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources: DWR, GAMA, NWIS, WQP, USGS Scientific Investigations Map 3410.**



Wells with Arsenic & Temperature Data

2000 - 2018

Legend

- Town of Windsor
- Highway 101
- Creeks
- Fault Trace

Avg. Arsenic 2000-2018

- < 10 ug/L
- > 10 ug/L

0 1,500 3,000 Feet

N

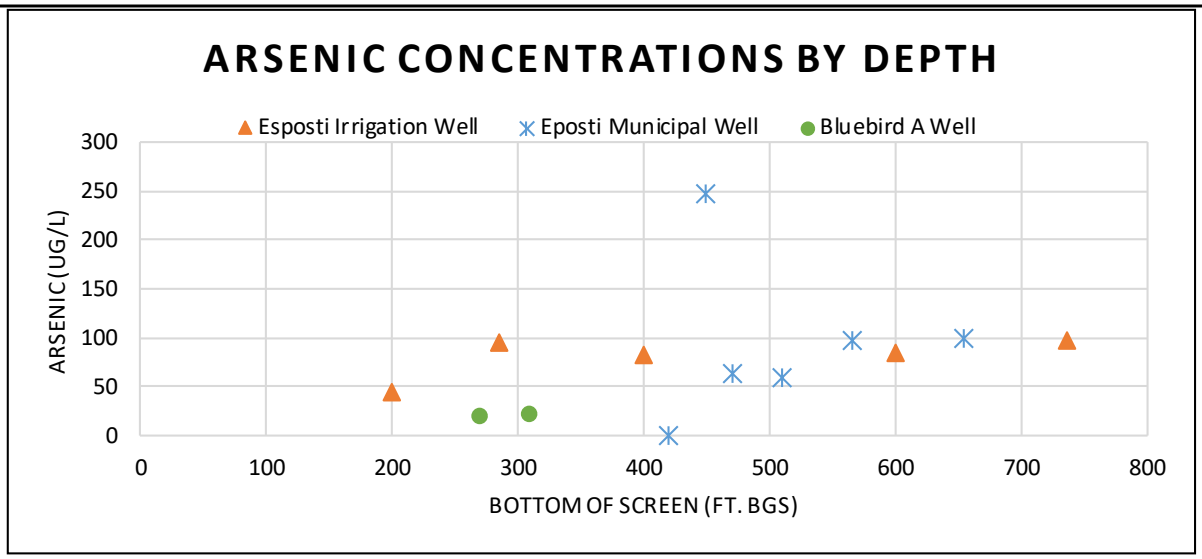
Figure 8

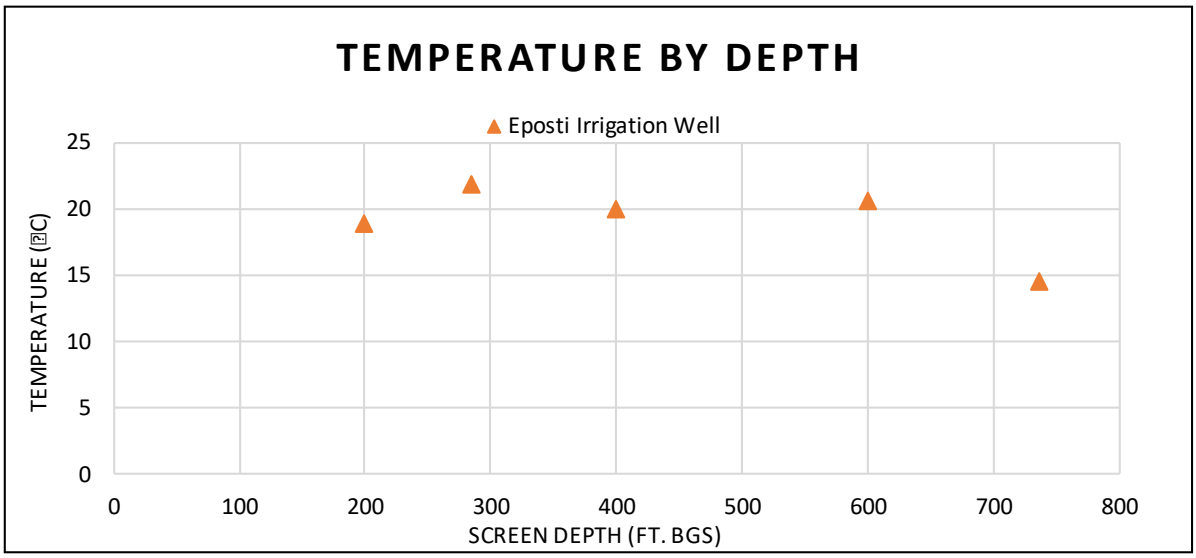
WOODARD &CURRAN

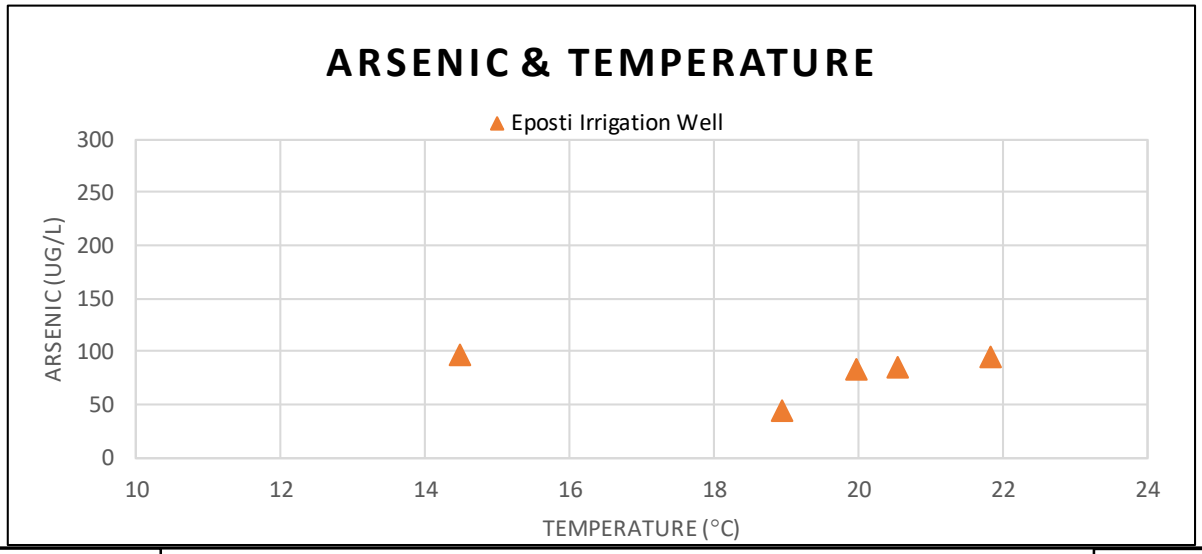
Project #: 0011187
Map Created: Aug. 2019

Figure Exported: 8/27/2019 By: kalmestad Using: \\woodardcurran.net\shared\Projects\RMC\WCR\01143 - Windsor\0011187 2018 WMP\G. GIS\Maps\Water Quality \MWindsor_Ars+Temp.mxd

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Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources: DWR, GAMA, NWIS, WQP, USGS Scientific Investigations Map 3410.**







Arsenic Concentration by Depth and Temperature

Sources:
RMC, 2009a; RMC 2009b; BESST, 2017b.

Figure 9

WOODARD &CURRAN

Project #: 0011187
Graphs Created: Aug. 2019

Figure Exported: 10/18/2019 By: cvanlienden Using: \\woodardcurran.net\shared\Projects\RMC\WCR\0143 - Windsor\0011187.2018 WMP\G. GIS\Maps\Water Quality TM\Windsor_Graphs_18Oct2019.mxd