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TECHNICAL MEMORANDUM

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PROJECT: GSP Implementation Technical Support

SUBJECT: Sonoma County Groundwater Subbasins Well Inventory

INTRODUCTION

This technical memorandum (TM) describes the process for developing a well inventory for Groundwater Sustainability Plan (GSP) implementation in the Santa Rosa Plain Subbasin, Sonoma Valley Subbasin, and Petaluma Valley Basin (Subbasin[s]). The well inventory and TM are prepared for the Sonoma County Water Agency (Sonoma Water; SCWA) under its technical service agreements with the Subbasin's Groundwater Sustainability Agencies (GSAs). The purpose of the inventory is to compile well information from various sources into a single comprehensive inventory to use for GSP implementation and well permitting. For example, the refined well inventory provides a better understanding of the locations, depths, and purposes of groundwater extraction in the Subbasins, can help evaluate drought risks to shallow wells, and may inform groundwater conditions monitoring.

The TM documents the data compilation process, a summary of results, and recommendations for additional potential steps for further refining the well inventory. The TM documents the methodology used to merge well information from a variety of sources, remove abandoned wells, resolve duplicates, and refine well attributes such as location and construction data. Next, the inventory results and remaining uncertain information are summarized and the inventory is compared to the GSA's Groundwater Users Information Data Exchange (GUIDE) database being used by the GSAs to estimate and track water use information in the Subbasins. Finally, the TM recommends steps that could be taken to help further refine well locations in future updates, such as identifying additional data sources, tools, and methods.

METHODS FOR WELL INVENTORY DEVELOPMENT

This section describes the data sources used for the initial well inventory compilation, the processes for merging these datasets, and the initial process for resolving duplicates, refining locations, and quality assurance and quality control (QA/QC) review.

Data Sources

The well inventory was compiled using a combination of statewide and local Sonoma County information. The data sources for the inventory are statewide datasets from the California Department of Water Resources (DWR) and the California State Water Resources Control Board (SWRCB) and local information provided by Sonoma Water and Permit Sonoma, as further described below.

DWR Data Sources

DWR gathers statewide well data for various programs. DWR well data used for this inventory includes the following:

- Online System for Well Completion Reports (OSWCR)
  DWR maintains the OSWCR statewide database of well locations including construction information, intended use, and copies of well completion reports. OSWCR contains a unique identifier, the "well completion report number," which can be linked to other data sources. Older records are also identified using a "legacy log number," which predates the well completion report number system and is also used as a link to other older sources. Links to online well completion report PDFs are included, which can be used to verify source data and interpretations. OSWCR has several known issues, including missing records or information, duplicate records, and approximate data for well locations. For example, many well locations are placed at the centroid of a 1x1-mile Public Land Survey System (PLSS) section if better information was either not available or not identified by DWR when reviewing the well completion report.
- California Statewide Groundwater Elevation Monitoring (CASGEM) Program
  The CASGEM database was used by DWR prior to SGMA to store groundwater level data collected by local monitoring entities. The dataset includes attributes and locations for wells, some of which have been refined by field verification during groundwater monitoring events.

SWRCB Data Sources

The SWRCB gathers statewide groundwater water quality data for various programs. The following SWRCB well information was used for this inventory:

- Groundwater Ambient Monitoring and Assessment (GAMA) Program
  The GAMA program gathers groundwater quality data from publicly available sources. Well locations and construction information in the GAMA database applicable to this well inventory are from the Division of Drinking Water (DDW) and United States Geological Survey (USGS) National Water Information System (NWIS). The DDW and USGS-NWIS datasets include well type and location and often include basic well construction attributes.
- DDW's Drinking Water Watch
  The DDW's Drinking Water Watch public supply well database provides lists of wells used by each water system monitored by the SWRCB and designates active and inactive supply well locations. The database can be used to confirm active and inactive supply well status for wells in other SWRCB databases, like GAMA, but does not include well locations.
- Safe and Affordable Funding for Equity and Resilience (SAFER)
  SWRCB prepares annual statewide aquifer risk maps for their SAFER program that include domestic and public supply well locations and water system service areas. The well locations on the aquifer risk map are from OSWCR, so do not provide additional well location information for this inventory. Water system service areas on the aquifer risk maps can be used to verify well locations from GAMA and other sources.

Sonoma Water Data Sources

Sonoma Water compiles well information for managing groundwater, coordinating basin-wide studies with USGS, and preparing the GSPs and Annual Reports. They also provided the following for updating the well inventory:

- Well Inventory for GSP Development
  Sonoma Water gathered well construction information from various sources to develop the 2022 GSPs. The inventory includes well locations, location methods, location accuracy, well type, construction information, legacy log number, and state well number. The information was compiled from DWR well records, USGS's local well inventory, and Permit Sonoma's database, among other sources.

- USGS basin-wide study for Sonoma Subbasin
  Sonoma Water provided a spreadsheet of well locations compiled for a USGS basin-wide study in the early 2000s. This dataset includes well parcels, addresses, and detailed well construction information such as well depth and screen intervals, state well number, and legacy log number, if available.
- Monitoring Wells Identified in GSP
  Tables of wells identified as monitoring sites in the GSPs include local well name, state well number, and location.

Permit Sonoma Data Sources

Permit Sonoma maintains well permit records, monitoring locations, and special study data that were used to update the inventory, including the following:

- Well Permit Database

  This dataset includes countywide well permits from January 1, 1960, through April 10, 2024. Well permits issued by the County are not always linked to well completion reports submitted to DWR, particularly for older records. Useful information compiled by Permit Sonoma includes well permit numbers, well address, parcel number, well type, and in some recent locations the DWR well completion report number.
- Water Quality and Metering Database

  Permit Sonoma monitors specific supply well locations for the County's water quality and water use tracking programs. The dataset includes a permit number, well coordinates, location method, and location method accuracy.
- Special Study for 2015 Drought
  Permit Sonoma compiled a dataset for well depth analysis work related to the 2015 drought. It includes a permit number, well coordinates, well depths, and legacy log number.

Inventory Compilation Process

The OSWCR database was used as the starting point for compiling the well inventory for GSP implementation. OSWCR was selected as the primary source as it provides a unique well identifier, includes location data for all wells, contains extensive information regarding well construction details, and provides active links to well completion report PDFs. We considered this dataset to be the most extensive, though not necessarily most accurate, record of wells in the County. The methodology for updating OSWCR with other data sources and refining information is summarized on Figure 1.

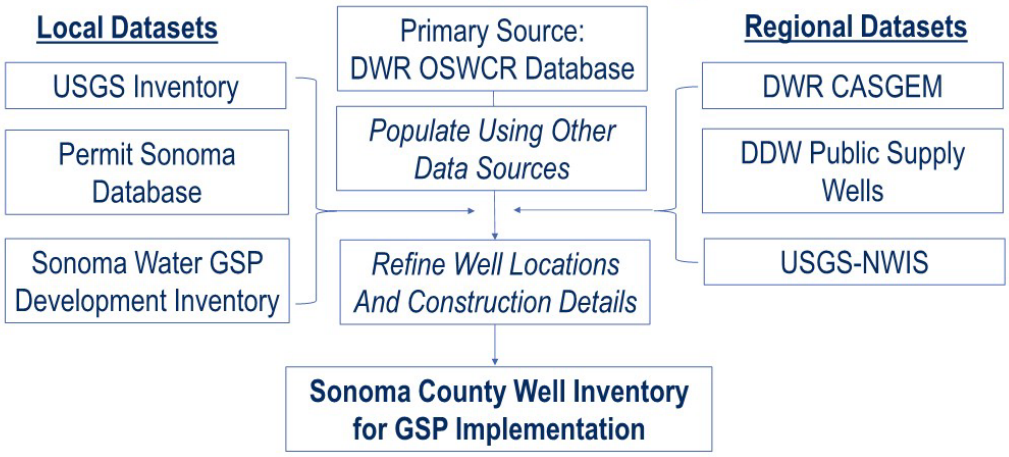

Figure 1. Well Inventory Development Methodology

Refinement of OSWCR Datasets within Sonoma County

OSWCR records were downloaded on April 10, 2024, and clipped to PLSS sections intersecting the Subbasins. An initial review of the data was performed to remove obvious errors in the database. For example, there are some locations in OSWCR placed using incorrect coordinates on the well completion report. If a well address or parcel number was given that was outside of the Subbasins, the location was removed from the dataset.

Before merging OSWCR with other datasets, duplicate well completion reports were removed. Duplicate legacy log numbers, the precursor to well completion report numbers, were identified and investigated by viewing the well completion report PDFs, well construction data, or location information. Confirmed duplicate records are removed from the inventory. In some rare cases, different well completion reports are given the same legacy log number; in this case, both records were preserved in the inventory.

Fields from the OSWCR database included in the well inventory are based on the following criteria: ability to join with other datasets (well completion report number, legacy log number, permit number); use in refining locations (coordinates, address fields, parcel number, well location method); and use in supporting implementation tasks (well use, well depth, and screen intervals). The well completion report number field was chosen as the unique identifier for wells.

Introducing Other Data Sources

The next step in the data compilation process was to add wells from other sources to the base OSWCR datasets. New fields were created to include useful information from each source, such as the unique well naming scheme. New data sources were joined to OSWCR using Microsoft Access query and join functions. Data joins were based on the naming system for each dataset,

such as the legacy log number, well completion report number, or the unique local, state, or USGS well identification naming schemes. Occasionally other methods were required to confirm record match, such as location and well construction information. New data sources were added systematically from the most extensive well lists to the least extensive.

Two data sources contain a significant number of records that were not added to the inventory yet because the naming conventions did not match. Adding locations with different names that are already in OSWCR or other sources would introduce duplicates into the inventory. Many well permit records from Permit Sonoma could not be matched easily to OSWCR, because historically the County well permit number is not submitted to DWR with the well completion report. There are several thousand unmatched well permit records in the Subbasins that are likely duplicates with records in OSWCR. These records could potentially be matched with well completion reports using a combination of parcel numbers and well type, assuming this information is consistent with OSWCR, but this effort may take a significant effort and has not been performed yet.

Updating Well Locations

After datasets were merged, well locations were reviewed and refined if possible. A standard hierarchy was used to systematically update well location information. Table 1 summarizes the location sources and methods ranked from high to low accuracy.

Table 1. Location Hierarchy

Rank	Location Source	Location Method
1	Permit Sonoma	Coordinates
2	Digital Aerial Photo, GPS, or Surveyed to a Benchmark coordinates from OSWCR	Coordinates
3	CASGEM and GSP Monitoring Wells	Coordinates
4	Permit Sonoma, USGS Study, SCWA, and OSWCR parcel (in this order)	Centroid of parcel
5	Permit Sonoma, USGS Study, SCWA, and OSWCR address (in this order)	Geocoded address
6	OSWCR	Coordinates identified using unknown location method
7	GAMA	Coordinates source not available
8	SCWA, OSWCR (in this order)	Centroid of PLSS section

(1=assumed highest accuracy; 8=assumed lowest accuracy)

Location coordinates are the most trusted location source, assuming that the well was accurately located with GPS or other accurate mapping methods. After coordinates, the parcel number and then address are the next trusted methods, with the location being placed at the centroid of the parcel or geocoded address. Parcel location is prioritized over geocoded address because wells located using geocoded addresses were often placed in the right-of-way, not within the intended parcel. Since the GSA uses the parcel-based GUIDE database for groundwater management, locating wells using parcels was more useful for the intended purposes for the inventory. Less accurate or unknown location methods followed in the hierarchy. Finally, the PLSS section centroid is considered the least accurate locating method. The assumed order for assigning locations from sources using the same methods was Permit Sonoma, USGS, Sonoma Water, and then OSWCR. This order was selected based on the method accuracy fields in the datasets.

Updating Well Information

Additional information such as well use, depth, and screen interval are added to the inventory if identified in the various sources. Blank fields in OSWCR were updated if data was available from any of the sources. Key observations and decisions for updating well information include the following:

- When Sonoma Water's inventory for GSP development had different well uses than OSWCR, we retained the OSWCR well use.
- The USGS inventory from the early 2000s includes multiple well screen intervals for some wells built with blank casing between screen sections. To match the simplified, single well screen interval format in the other well inventory records the top of the first screen and bottom of the last screen were retained as the screen interval.
- Well destruction permit information from the Permit Sonoma database is linked where possible to identify and remove abandoned well locations from the inventory.

Data Refinement

After the initial data compilation was completed, the inventory was further refined to remove duplicates between sources, update locations, and review well completion reports for accuracy of information and identify well abandonments.

Duplicate Removal

Wells from sources that could not be matched with records from OSWCR based on legacy log number, locations, or attributes were reviewed to determine if they were likely duplicates. For duplicates, the existing well inventory record was kept, and additional attributes were added. For non-duplicates, additional records were added to the well inventory with a unique identifying

name (based on either the local well name or program-assigned well name) used for the unique identifier field. We did not add unmatched records from Permit Sonoma to avoid introducing additional duplicates.

Location Field Refinement

After the initial inventory was compiled, many wells were still located at section centroids despite having some location information in the available records. Available location information may not have been recognized during prior well locating efforts using well completion reports for a few reasons including misspelling, formatting, extra or missing parcel digits, or the address or parcel may no longer exist. The address and parcel information for wells located at section centroids was reviewed and records were corrected if the information was available. Updated locations were matched to the Sonoma County assessor parcel number (APN). If there was a match, the coordinates of the centroid of the parcel were updated. If not, the address was geocoded and the coordinates of the centroid of the closest parcel were used.

After refining well locations, all wells in the inventory were spatially joined in ArcGIS Pro to the Sonoma County parcel layer, and the APN and address of the intersecting parcel was added to the inventory table. Several wells located by address/geocode from the Sonoma Water data sources had coordinates in the right-of-way, and thus could not be spatially joined (intersected) with the parcel layer. For these wells, addresses in the Sonoma Water layer were matched to the address field in the Sonoma County parcel layer if possible. If there was no match, the closest parcel was assigned using a spatial join (nearest); while the APN and address for these matching or nearest parcels was added to the inventory record for these wells in the right-of-way, the locations of the wells were not changed.

Wells remaining in the center of PLSS sections either had no address or parcel information or had address or parcel information that was not recognizable. Wells that remained in the center of PLSS sections were not spatially joined to the parcel layer.

QA/QC in Targeted Locations

Additional QA/QC was performed on wells in specific areas of concern. Detailed QA/QC was performed in 2 PLSS sections in the Sonoma Valley Subbasin (M05N05W17 in Vineburg and M05N06W10 in El Verano) that are associated with chronic lowering of water levels undesirable results. Detailed QA/QC was also performed for wells located in the Baylands region adjacent to San Pablo Bay in Sonoma Valley Subbasin and Petaluma Valley Basin, that has saline groundwater and not many wells. For wells in these QA/QC areas, well completion report PDFs were reviewed, including those located at section centroids. Location and construction information gleaned from well completion reports was used to refine locations.

Targeted review resulted in several findings that likely apply to other areas of the Subbasins:

- There were wells placed incorrectly due to a typo on the well completion report coordinates. Some of these wells were actually outside the Subbasins, so were removed from the inventory. Identifying locations with coordinate typos and no other well location fields is likely an issue with other locations in the inventory, but is impossible to detect without reviewing well completion report PDFs.
- Sometimes wells are installed at an address that no longer exists. For example, a former U.S. Navy Station at Skaggs Island in the Sonoma Baylands had several wells that were decommissioned.
- Sometimes the parcel number no longer exists as it had been combined or split with other parcels. Often the inset map or written description on the well completion report can be reviewed to identify approximately where the well was installed despite referencing a parcel number that no longer exists.

Matching Well Abandonments with Completion Reports

Only well completion reports for new wells were included in the inventory; well completion reports for abandonments and modifications were flagged in the inventory to avoid confusion with active well locations. OSWCR and Permit Sonoma well location files include well abandonment permits in addition to installations, however these are often not matched to the same well. Well abandonment completion reports in OSWCR were reviewed to try to identify and remove abandoned wells from the inventory. We found that abandonments could not easily be matched with prior installations since there is no historical tracking or unifying naming system for matching well completions and abandonments. Contributing challenges are that older well locations are less well documented in OSWCR for wells that are abandoned. Given the age of some of the abandonment records, it's likely that abandoned wells predated well completion records. A summary of OSWCR well abandonment records for each Subbasin is shown in Table 2. Wells outside the Subbasins are included in Table 2 since many of these lack specific location information and are placed at the center of the PLSS Section, so could be within the Subbasins.

Table 2. Summary of Well Abandonments in OSWCR

	Sonoma Valley Subbasin	Petaluma Valley Basin	Santa Rosa Plain Subbasin	Outside Basins	Total
Domestic	40	19	158	69	**286**
Industrial	1	1	5	0	**7**
Irrigation	5	3	14	9	**31**
Monitoring	31	125	635	62	**853**
Other	36	77	295	68	**476**
Public Supply	8	0	9	1	**18**
Unknown	343	556	2,457	441	**3,797**
Total	**464**	**781**	**3,573**	**650**	**5,468**

WELL INVENTORY RESULTS

A comprehensive well inventory database was created to support GSP implementation and provide a well information repository that the GSAs, Sonoma Water and Permit Sonoma could use for future work. The database was compiled in Excel table format, with a schema table describing each of the fields in the database, data sources, and notes about any analysis related to these fields. A file geodatabase was also created for well mapping, with a feature class of the well inventory wells, including their locations and attributes. A separate tab and GIS layer with unmatched well locations in the Subbasins in Permit Sonoma records were included for future updates.

Well Inventory Summary

The well inventory includes just over 19,000 wells in the sections intersecting the 3 Subbasins. These wells are shown on Figure 2 through 4 and summarized in Table 3. Wells outside the Subbasins are included in Table 3 since many of these lack specific location information and are placed at the center of the PLSS Section, so could be within the Subbasins. The well inventory includes improved well location and construction data compared to the OSWCR database. Well depth and/or screen interval depths are documented for 89% of wells in the well inventory, and reported well use/type is documented for 87% of wells. Locations of many wells were refined, and considerably fewer wells were located at section centroids following initial QA/QC. Nevertheless, 34% of wells still have insufficient location data and are located at section centroids.

Table 3. Well Inventory Summary

Well Use	Sonoma Valley Subbasin	Petaluma Valley Basin	Santa Rosa Plain Subbasin	Outside Subbasins	Total
Domestic	1,280	920	6,320	2,841	**11,361**
Industrial	36	18	107	23	**184**
Irrigation	206	95	546	201	**1,048**
Monitoring	182	451	1,805	153	**2,591**
Other	69	49	487	67	**672**
Public Supply	46	58	293	41	**438**
Unknown	536	289	1,672	662	**3,159**
Total	**2,355**	**1,880**	**11,230**	**3,988**	**19,453**

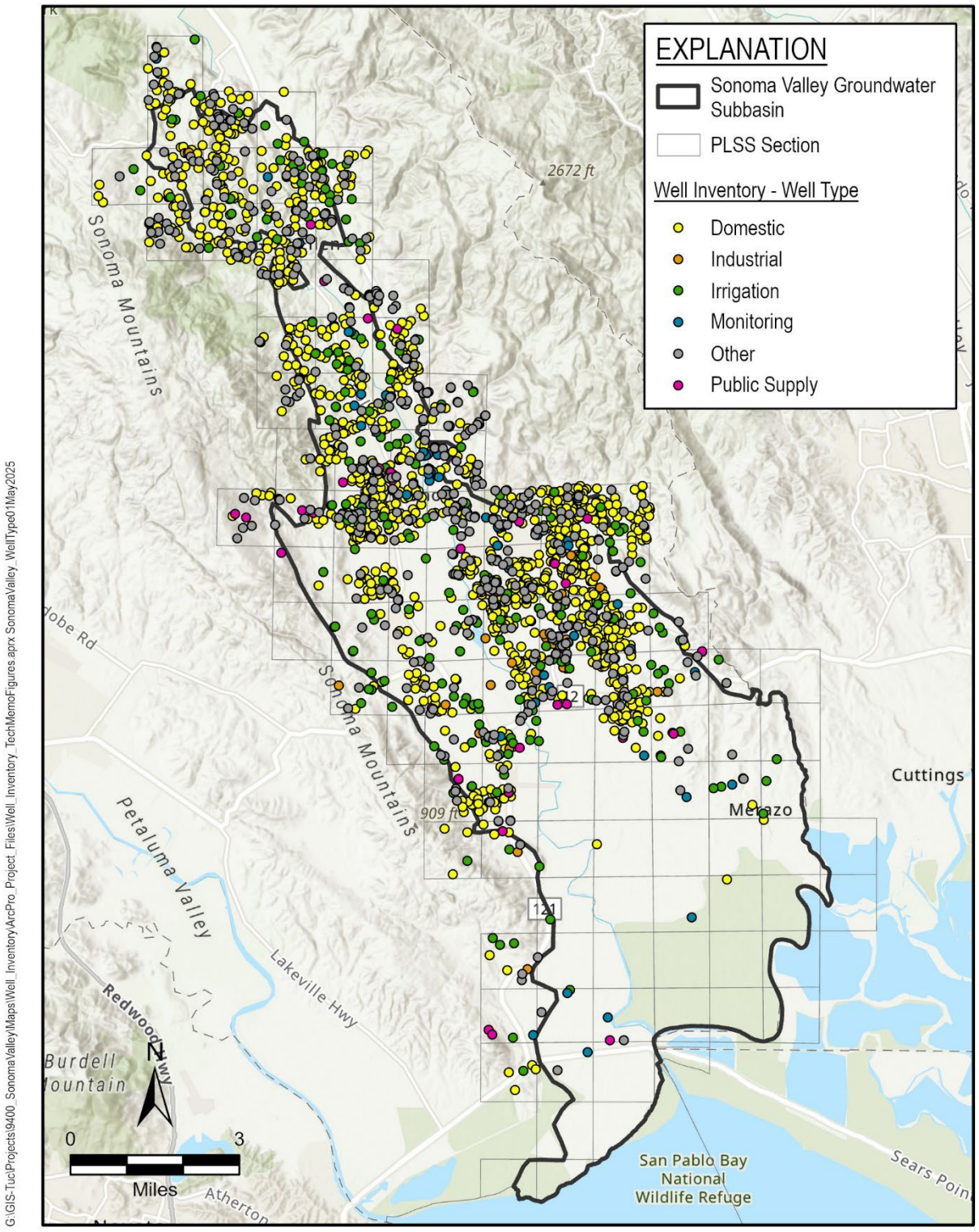

Figure 2. Well Inventory for Sections Intersecting the Sonoma Valley Groundwater Subbasin

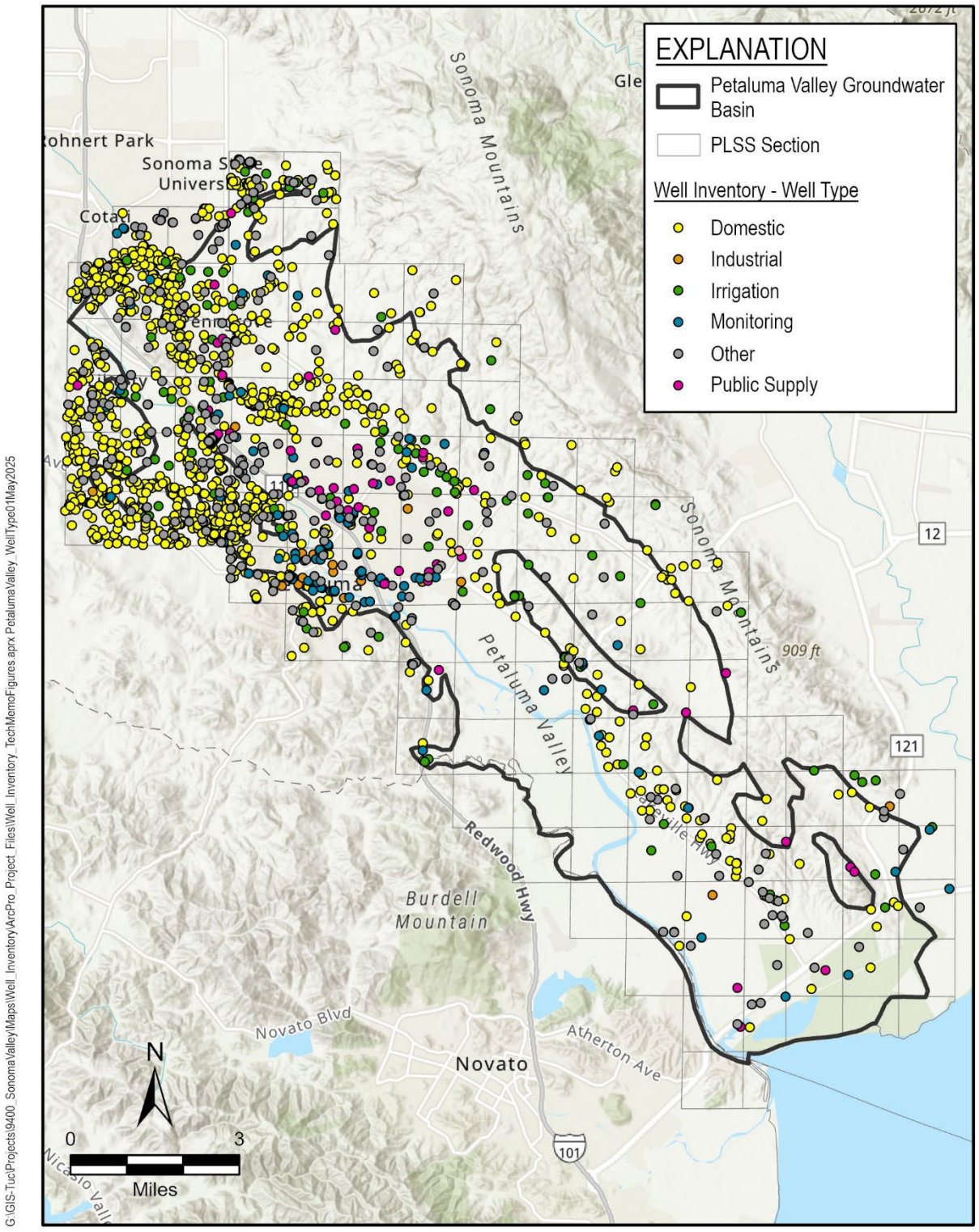

Figure 3. Well Inventory for Sections Intersecting the Petaluma Valley Groundwater Basin

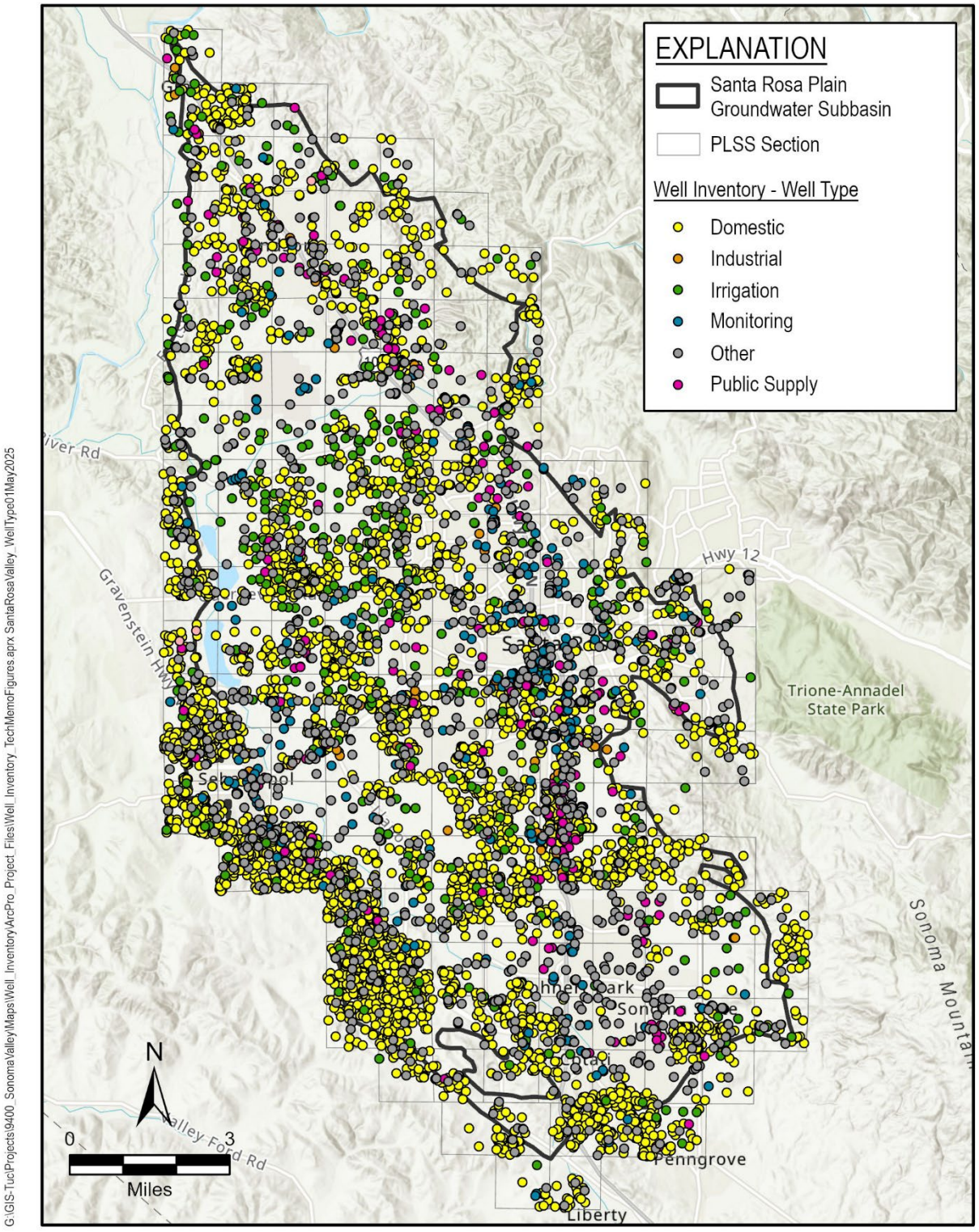

Figure 4. Well Inventory for Sections Interesecting the Santa Rosa Plain Groundwater Subbasin

Comparison with GUIDE

The well inventory was compared with GUIDE, the GSA's well registration and parcel-based water use information database, to assess potential accuracy and to assist in data sharing. Information about wells and water use is compiled for each parcel in the Subbasins in GUIDE. This information includes the number of wells on the parcel and estimated groundwater use in acre-feet. Parcels with wells in the inventory were compared to parcels identified as having wells and/or groundwater use in GUIDE.

Parcels with groundwater use in GUIDE are summarized in Table 4. Note that some parcels have multiple water uses like rural residential and agriculture. The number of parcels in GUIDE that are connected to public supply systems or have existing wells is provided, but it is uncertain whether the water supplied on the parcel is from public supply or the well. For example, 148 parcels with a public supply connection also have agricultural groundwater use likely sourced by private irrigation well(s).

Of the 12,024 parcels identified in GUIDE as having groundwater use, only 4,462, or 37%, are identified in the well inventory as having supply wells. Of the 1,387 parcels identified in GUIDE as having both a groundwater use and agriculture use category (dry farm or irrigated farm properties), 729, or 53%, are identified in the well inventory as having supply wells. On the other hand, 54% of parcels identified as having at least 1 well in the well inventory were also identified in GUIDE as having groundwater use. These relatively low percentages may be due to several factors, including that parcels identified as using groundwater may use an older well that predates well completion report records, may have a well with poor location accuracy placed in the center of a PLSS section, may use a well on a neighboring parcel, or the inference in GUIDE that groundwater is used may be incorrect.

A much higher percentage of parcels match when comparing GUIDE to the well inventory based on the "Well Count" field in GUIDE. There are fewer parcels with at least 1 well identified in GUIDE than in the well inventory. Of the 4,078 parcels identified in GUIDE as having at least 1 well, 3,550 (87%) were also identified as having at least 1 well in the well inventory. Of the 6,546 parcels identified as having at least 1 well in the well inventory, 54% were identified as having at least 1 well in GUIDE. The same potential differences between the datasets listed above likely contribute to the mismatch between the inventory and GUIDE parcels with a well.

Of note, both GUIDE and the well inventory used Sonoma Water's initial Well Inventory for GSP Development as a principal source. In particular, the "Well Count" field in GUIDE draws heavily from this database, so it is not surprising that a high percentage of parcels identified in GUIDE as having at least 1 well were also identified as having at least 1 well in the well inventory. However, the well inventory identifies more parcels with wells than does GUIDE,

which is likely due to the well inventory's inclusion of additional source datasets. Likewise, the groundwater use estimate in GUIDE incorporates additional data sources, including GUIDE survey responses, leading to further divergence between the number of parcels identified as having groundwater use in GUIDE and the number of parcels identified as having wells in the well inventory.

Table 4. Summary of GUIDE Parcels with Groundwater Use or On-site Wells

GUIDE Parcel Type with Groundwater Use	Number of Parcels			
	Sonoma Valley Subbasin	Petaluma Valley Basin	Santa Rosa Plain Subbasin	Total
Agriculture	580	146	840	**1,566**
Residential	1,656	1,120	6,605	**9,381**
Commercial	114	98	488	**700**
Urban Irrigated	19	107	1,176	**1,302**
School or Golf Course	63	37	128	**228**
Served by Public Water Supply	109	152	1,301	**1,562**
Total Parcels Using Groundwater	2,033	1,367	8,624	**12,024**
Parcels with well(s) – including parcels without groundwater use	991	662	2,425	**4,078**

RECOMMENDATIONS

The well inventory represents an initial comprehensive compilation of well data in the Sonoma County SGMA Subbasins. Additional steps could be taken to further refine the well inventory with additional data sources or innovative tools. As this well inventory is maintained and updated over time, the GSA may consider the following actions to further refine the well inventory.

Additional Location Refinement

There are some steps that could be taken to further refine well locations in the inventory. For the initial QA/QC, all of the centroid of PLSS section well completion reports were reviewed for 2 PLSS sections in areas of interest. In section M05N05W17 there are 119 locations at the center of the section, 4 of which were refined, and 16 of which had additional well screen information. In section M05N06W10, there are 113 locations at the center of the section, 8 of which were refined and 14 of which had additional well screen information. Given these manual review

methods were relatively time consuming, taking about 2 hours for each section, and did not result in a substantial number of refinements, it may not be useful to expand this method to all sections in the study area; however, targeting a limited number of additional sections in specific areas of concern could be worthwhile. There are 166 sections in the Santa Rosa Plain Subbasin, 138 in Petaluma Valley Basin, and 129 in Sonoma Valley Subbasin, and about 6,000 wells still located at section centroids in the refined inventory.

Additional Parcel and Address Refinement

Many wells were located in the right-of-way or had a parcel number or address listed that did not match with the current Sonoma County parcel layer. We found that sometimes parcels and addresses no longer exist, as they are dynamic locations that can be combined or split and given a new APN. Well completion report parcel numbers that could not be confirmed were associated with the nearest current parcel based on other location information such as address or coordinates, which may be inaccurate. To address this potential inaccuracy, further efforts could be taken to associate former parcel numbers and addresses to current parcels. This would likely require digitized versions of historical Sonoma County parcel layers.

Removal of Abandoned Wells

The link between existing and abandoned well records in the source data was not well established. To better identify and remove abandoned wells from the inventory, a process could be developed to match well completion report records to well abandonment records based on location, well name, and construction information, and well permit records. This process may require matching additional Permit Sonoma locations to OSWCR locations, or reviewing well completion report PDFs, which as described above can be time consuming and will not result in all abandoned locations being matched with wells in the inventory.

Incorporate Other Sources

The well inventory compiles all existing information available from known sources to Sonoma Water and Permit Sonoma. Some of the wells from these sources lack identifying information that can be used to match them to well completion reports and other records in the well inventory. Therefore, obtaining more information could help identify duplicates and refine accuracy. It is also possible there are new wells or better information available from other data sources. For example, well permits from Permit Sonoma could be further reviewed to determine whether they are duplicates of existing wells in the well inventory or should be added to the inventory.

There may also be information that is refined by other entities that has not been incorporated into this inventory yet. For example, the Community Water Center is performing a statewide

domestic well locating effort that was not available yet when this inventory was compiled but could be useful for refining some uncertain domestic well locations in the Subbasins in the future.

Furthermore, there is an opportunity for integration of data collected through GUIDE. While we recognize that GUIDE and the Well Inventory are 2 separate efforts and products, data can still be shared. For example, new or updated well completion reports or other well-related information submitted in GUIDE surveys could be periodically shared, and these data could be incorporated into the Well Inventory. Likewise, updates to the Well Inventory could also be periodically updated in GUIDE. If practicable, we recommend maintaining continuity between these databases as they are updated and evolve.

Scan Well Completion Reports with Artificial Intelligence Tools

Development of artificial intelligence (AI) tools to review well completion reports for additional data is more efficient than was previously possible. AI could be used to review PDFs to glean additional information. There are several caveats to this approach, including that multiple formats of well completion reports would need to be recognized by AI and the information in the reports may be incorrect or illegible. To use these tools effectively, DWR or the County would also need to provide unredacted versions of well completion reports that include well owner information. Nevertheless, further research into potential AI tools may be warranted.

Maintain Database with New Well Records

This database is an inventory of well records through April 2024. As new wells are installed and old wells are abandoned, we recommend collecting well permit, completion, and abandonment information from Permit Sonoma and/or OSWCR to maintain a current version of the inventory.