HIGHEST PRIORITY PERSISTENT FLOW OUTFALL SOURCE IDENTIFICATION 2022-2023

(UPDATED OCTOBER 2023)

PREPARED FOR: **CITY OF CARLSBAD**
Environmental Management
1635 Faraday Ave.
Carlsbad, CA 92008

PREPARED BY: **D-MAX ENGINEERING, INC.**
5440 Morehouse Drive, Suite 4500
San Diego, CA 92121

City of Carlsbad California

DMAX

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1 Background

The City of Carlsbad (City) regularly completes required dry weather monitoring at highest priority persistent flow (HPPF) major outfalls. The City has previously investigated sources of flow at these outfalls, including additional laboratory analyses and a continuous flow monitoring. Additional laboratory analyses and desktop research were completed during the 2021/2022 and 2022/2023 monitoring years to further refine flow source categorization. This report summarizes the completed work and identifies, where applicable, likely flow sources based on field sampling results and historical source identification work completed by the City.

2 Methods

In addition to evaluating historical findings, two main methods were used to investigate sources of flow: researching geotechnical reports and collecting samples and analyzing them for levels of major ions. Both methods are described in detail below and site-specific conclusions can be found in the following section.

2.1 Geotechnical Report Research

Groundwater can contribute flow to the municipal separate storm sewer system (MS4) by infiltrating pipe joints or other means. Recent data from various monitoring wells obtained from the State Water Resources Control Board's GeoTracker website indicate that groundwater depths throughout Carlsbad can be relatively shallow,[1] suggesting that groundwater is more likely to infiltrate storm drain pipes. To better support the claims of groundwater infiltration, site specific depth to groundwater information from within the relevant outfall drainage area is preferred.

Geotechnical reports generally include information about depth to groundwater at the project sites based on borings and on either historical research or the geotechnical professional's knowledge of the area. The City and D-MAX staff located geotechnical reports for developments within a given outfall's drainage area, ideally in close proximity to the location(s) of suspected subsurface infiltration, and reviewed these documents to identify notes regarding shallow groundwater. Reports noting shallow groundwater were identified in areas upstream of three of the five highest priority major outfalls; site specific discussions and conclusions can be found in the sections below.

2.2 Piper Diagram Analysis

To better visualize the chemical composition of each sample and compare it to the profiles for known water sources, the laboratory results are displayed on Piper diagrams. The parameters used

[1] Raw data can be accessed using the link below, and maps in Section 3 provide site specific detail. https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/

to develop the chemical profiles included total dissolved solids (TDS), total alkalinity, chloride, calcium, magnesium, sulfate, and potassium. Two rounds of ion samples were collected at each HPPF outfall in monitoring year 2021/2022, one in November 2021 and one in June 2022, as well as one upstream sample from outfall 16C-61 in June 2022. More recently, ion samples were collected at the three new HPPF outfalls during the April sampling visit in 2023. Reference data used in this study was acquired from GeoTracker,[2] Carlsbad Municipal Water District,[3] and field sampling of known sources.[4] A summary of the raw data can be found in Attachment 1.

Piper diagrams are useful when analyzing the composition of water samples since they show the relative concentrations of major ions in solutions. In most natural water, these ions make up 95 to 100% of the ions in solution. The Piper diagram includes two trilinear diagrams, one for cations (on the lower left) and one for anions (on the lower right). For each sample, the information from each trilinear diagram is projected up into the central quadrilateral. Therefore, each sample will plot in each frame of the Piper diagram, one representing cations, one representing anions, and one representing the combination (Figure 1). Then the percentages of each ion relative to the total are calculated and plotted on the Piper diagram. Each trilinear diagram shows the relative percentages of the three ions. Each corner on the triangles represents 100% of the ion shown at that corner.

Interpreting Piper Diagrams

The anion profiles of drinking water, reclaimed water, and groundwater, as shown in the lower right triangle in the Piper diagram, typically display more separation in profiles for these sources than the cation or combination plots (Figure 1). For that reason, the anion triangle is generally the main focus of interpreting the Piper diagram to determine the source of discharges. However, good separation of sources was also seen in the combination plot during this study and the data were used as supplemental support.

[2] Data from wells L10003501496-MW-18, L10003501496-MW-20, and L10003501496-MW-21 were used for this study, and data can be accessed using the link below. Datasets were only used if enough constituents from a single sampling event could complete a Piper diagram. https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/.

[3] Online drinking water reference data was taken from Carlsbad Municipal Water District's Water Quality 2020 Report, which can be viewed using the following link: https://www.carlsbadca.gov/home/showpublisheddocument/178/637606488954170000.

[4] Four potable water samples, three groundwater samples, and one recycled water sample was collected by the City of Carlsbad and/or D-MAX staff.

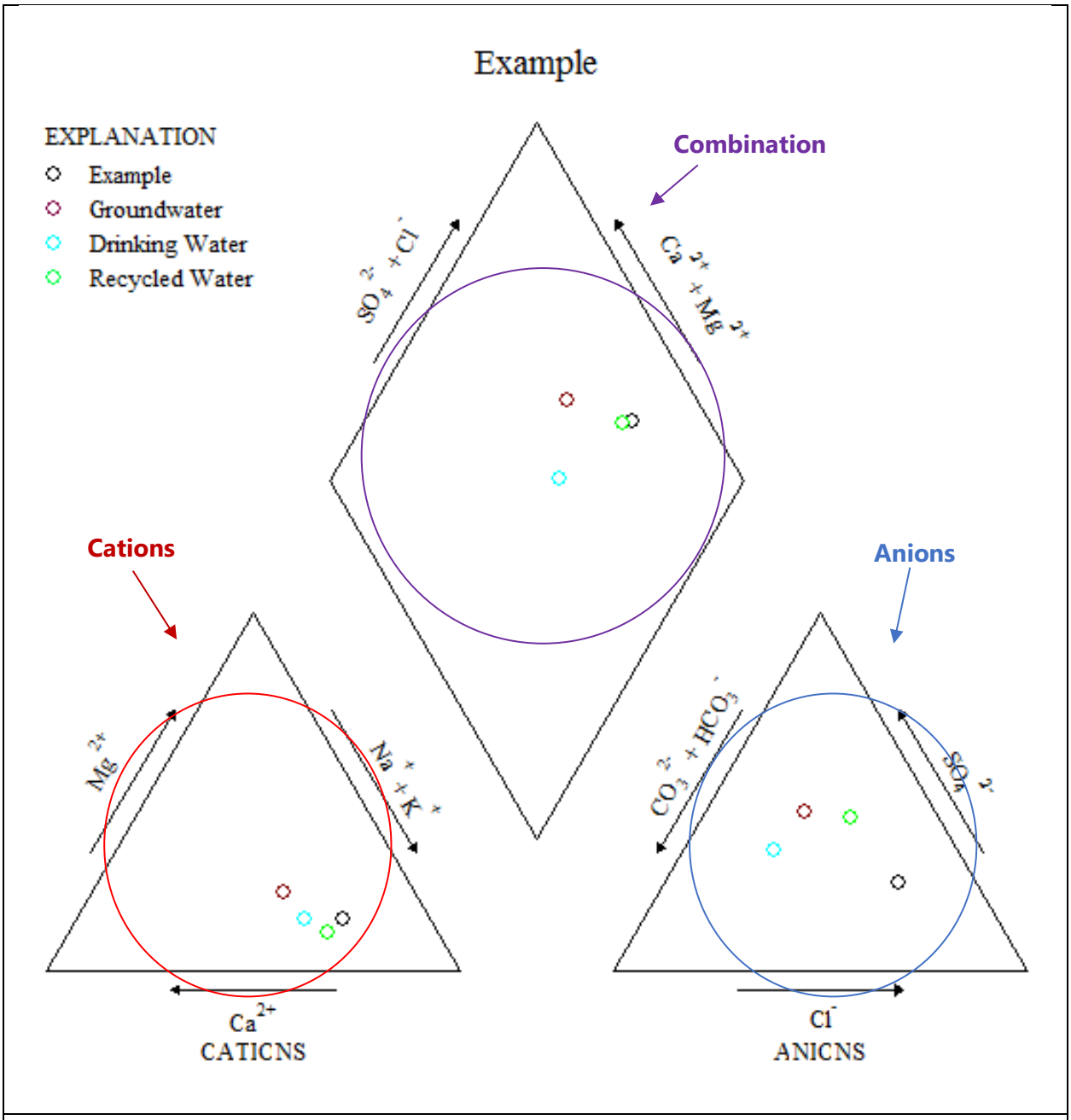

Figure 1. Example Piper Diagram

3 Results

A summary of the investigation results is presented in Table 1 below and an overview map of outfall locations and associated drainage areas can be seen in Figure 2. Details of historical findings, this year's conclusions, and recommended follow-up actions can be found in the following sections. The investigative ion sampling data can be viewed in Attachment 1 and geotechnical reports are included as Attachment 2.

Water seeping into a Municipal Separate Storm Sewer System (MS4) pipe may originate from sources other than surface level IC/IDs or groundwater. Accordingly, outfall observations and sampling data from the past four years were reviewed for evidence of impact from the sewer system. Typical indicators of a sewer source would include foul odor, low dissolved oxygen, water discoloration, and elevated analytical results related to ammonia, bacteria, and MBAS. Specific findings related to each HPPF outfall can be seen in the following sections.

Table 1. Summary of HPPF Outfall Flow Source Determinations

***Likely Flow Source(s)* from Monitoring Years 2021/2022 and 2022/2023**				
Outfall	**Groundwater**	**Irrigation Runoff**	**Unknown/ Inconclusive**	**Notes**
Site 1D-21	X	X	X	Low flow from curb cores identified and one instance of irrigation runoff observed in 2023. Ion data suggests groundwater is the main contributing source at the outfall.
Site 16C-61	X	X	X	Mix of sources including groundwater, irrigation runoff, and other transient discharges.
Site 19C-1	X	X		Irrigation runoff observed during the June 2022 investigation. Ion data suggests groundwater is the main contributing source at the outfall.
Site 29B-94	X	X		Transient contributions of irrigation runoff historically noted. Ion data suggests groundwater is the main contributing source.
Site 55A-51	X		X	Transient contributions from residential curb cores. Ion data suggests groundwater is the main contributing source at the outfall.

Table 1. Summary of HPPF Outfall Flow Source Determinations (continued)

***Likely Flow Source(s)* from Monitoring Years 2021/2022 and 2022/2023**				
Outfall	**Groundwater**	**Irrigation Runoff**	**Unknown/ Inconclusive**	**Notes**
Site 38D-13	X		X	Transient contributions from residential curb cores. Ion data suggests groundwater is the main contributing source at the outfall.
Site 58A-73	X		X	Transient contributions from residential curb cores. Ion data suggests groundwater is the main contributing source at the outfall.
Site 63A-49	X		X	Transient contributions from residential curb cores. Ion data suggests groundwater is the main contributing source at the outfall.

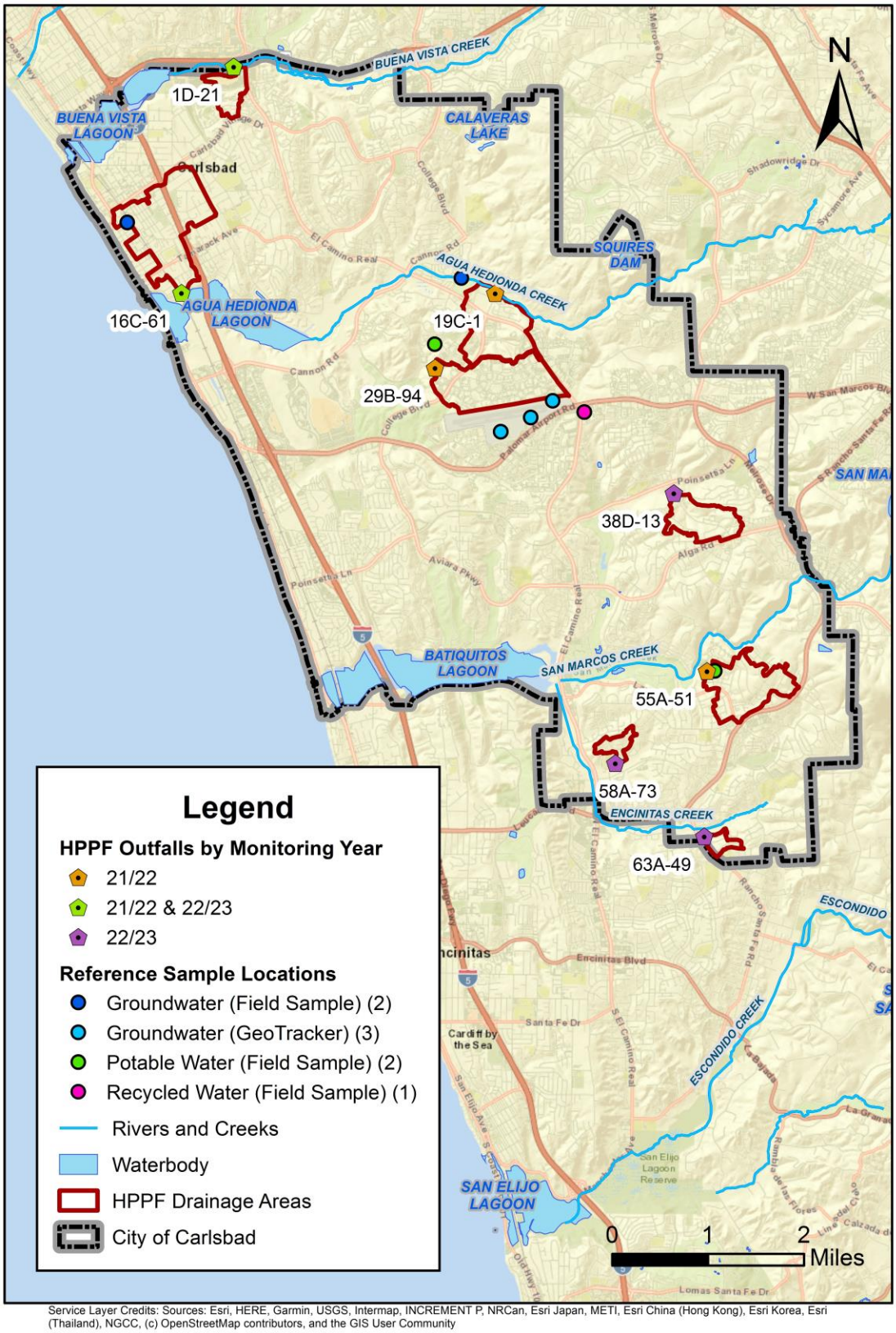

Figure 2. Overview of Carlsbad's HPPF outfalls and reference sample locations

Site 1D-21

Historical Information

- Observations of irrigation runoff have been noted in the drainage area, but the sources only explain a small portion of the flow at the outfall.
- Flow for the past four dry weather monitoring visits was visually estimated between 8-10 gpm.
- Average flow of approximately 7 gpm during 2019/2020 continuous flow special study.[5]
    - Flow rates were relatively consistent over the course of the day, which does not suggest irrigation runoff is a major source of flow (Figure 3).

Findings

- Ion data from the site most closely resembles groundwater (Figure 4).
- GeoTracker depth to groundwater information collected after the year 2000 indicates groundwater within and near the drainage area was observed at depths between 3 and 14 feet (Figure 5, Table 2).
- Two geotechnical reports from projects within the drainage area encountered groundwater at depths that may allow water to infiltrate the MS4 (Table 2, Figure 5).
- Low flow from curb drains were the only surface level sources observed during monitoring and totaled to well less than the flow observed at the outfall.
- Major MS4 outfall sampling results from 2017 – 2023 do not suggest the sewer is a likely source of flow.

Conclusions and Recommendations

- Data suggests the main source of flow originates from groundwater.
    - Consistent flow is observed between years.
    - Identified sources only explain a small portion of the flow at the outfall.
    - Groundwater in the drainage area can be shallow enough to infiltrate the MS4.
    - Ion data most closely resembles groundwater.

[5] Alta Environmental 2020. *2019-2020 Flow Monitoring Special Study Technical Report*. Prepared for the City of Carlsbad.

Table 2. Geotechnical Reports Identified Upstream of Outfall 1D-21

Approximate boring location	Reference ID	Approximate depth to groundwater from boring	Approximate depth to nearby MS4 main line	Potential groundwater influence
Plaza Camino Real Shopping Center (33.1782, -117.331)	825-3; CT 76-18	10-15 ft	~10ft[1]	Yes
2270 Avenida Magnifica	227-1; CT 81-41	30-55 ft	~7ft	Maybe[2]

Notes:

[1] GIS data did not provide invert elevations of the nearby main line, the noted depth is an estimate from field observations.

[2] While the nearby MS4 is shallower than the noted groundwater, the topography in the area is rather steep and the outfall is approximately 70 feet below the location of boring; water may enter the conveyance closer to the receiving water (Figure 5).

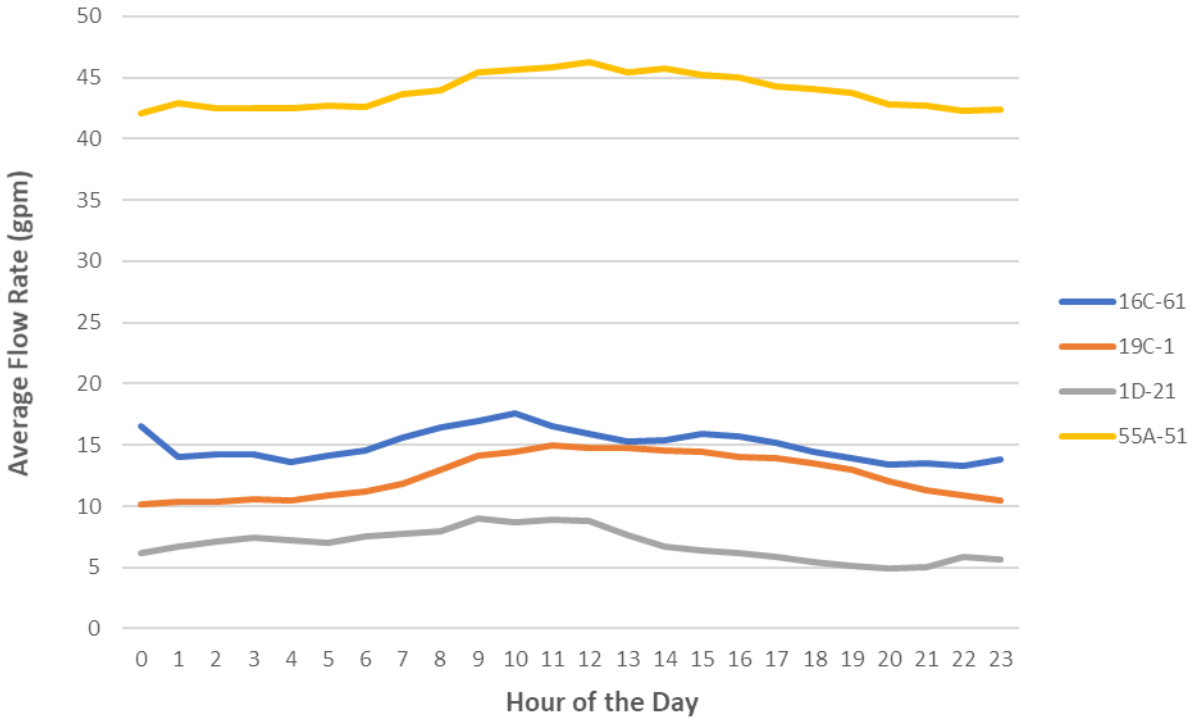

Figure 3. 2019/2020 Special Study Average Hourly Flow Rates for Sites 1D-21, 16C-61, 19C-1, and 55A-51

Note: this graph was prepared based on data collected in the 2019/2020 special study. The average flow rate for each hour at each site is the average of all flow rates recorded during that hour at that site over the course of the study. For example, the average flow rate for hour "0" is the average of all flow measurements recorded between 12:00 AM and 12:59 AM over all days of the study.

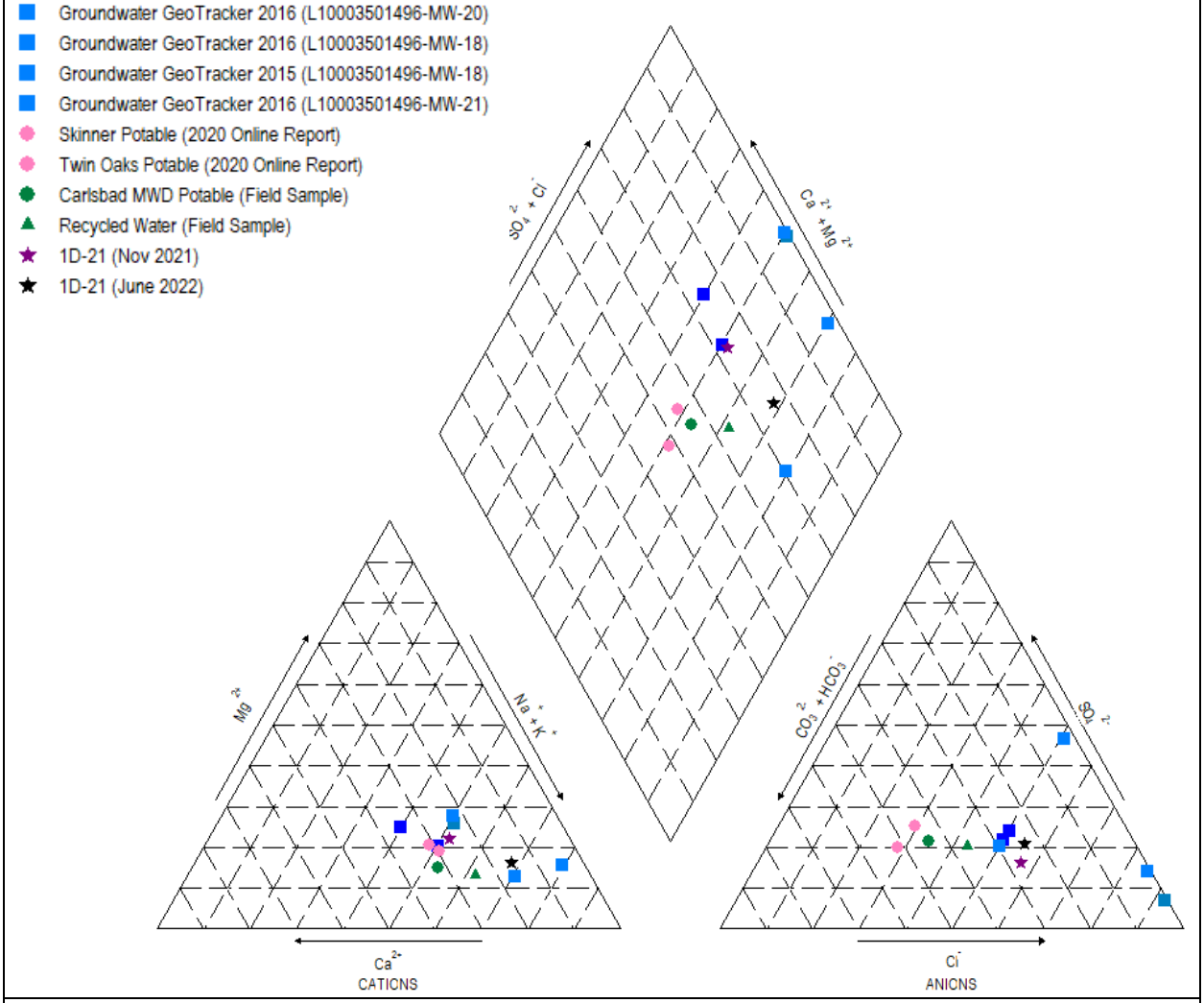

Figure 4. Site 1D-21 Piper Diagram

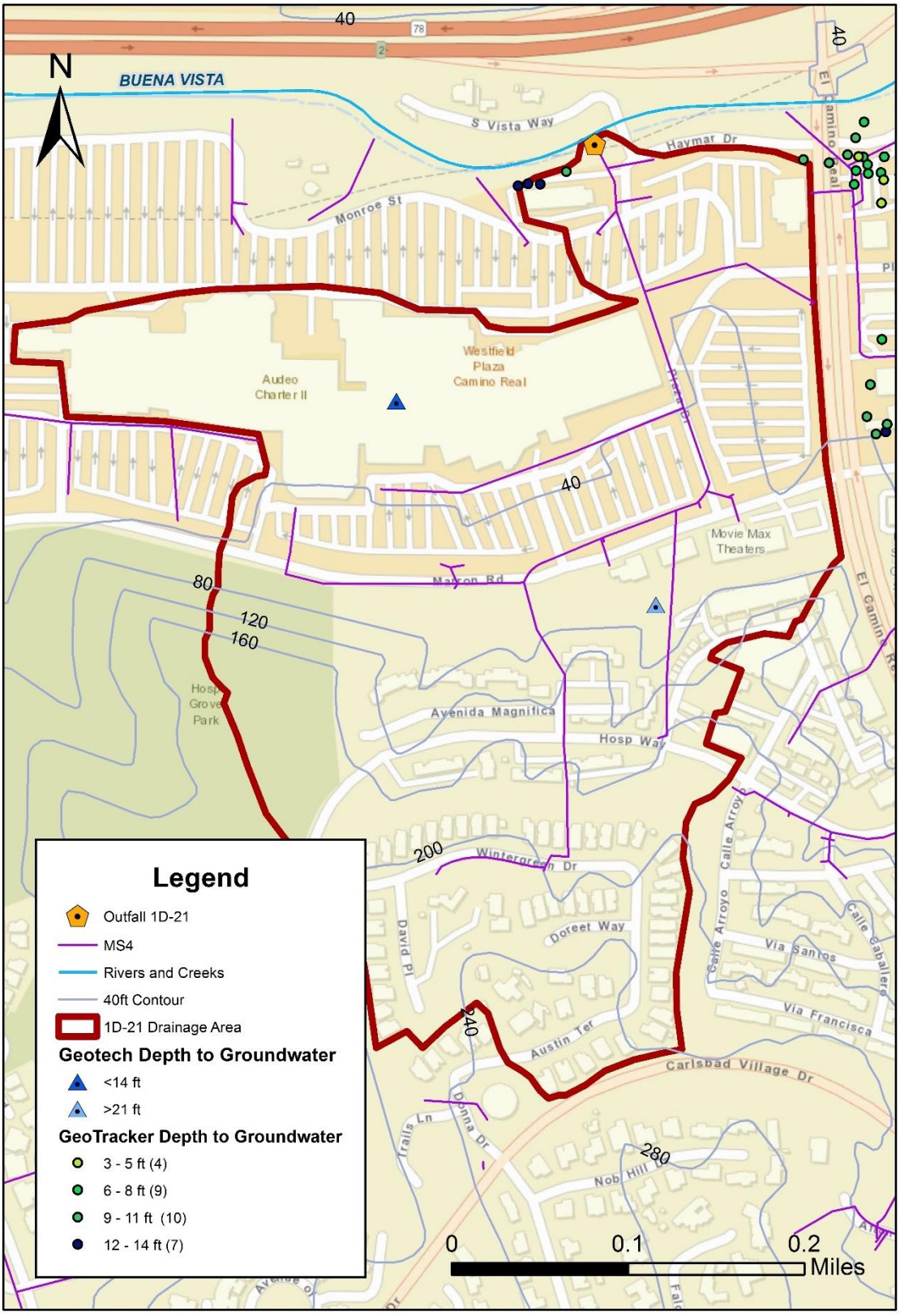

Figure 5. Overview of Outfall 1D-21

Site 16C-61

Historical Information

- Flow from the past four outfall monitoring visits was estimated between 10-18 gpm.
- Average flow of 15 gpm observed during 2019/2020 continuous flow special study.[6]
    - Flow rates were relatively consistent over the course of the day, which does not suggest irrigation runoff is a major source of flow (Figure 3).
- Persistent flow of approximately 5 gpm appears to originate beneath I-5 between the east and west segments of Pine Avenue.
    - Surface level sources have been observed in the drainage area, but they only explain a small portion of the total flow seen downstream.
    - An investigative ion sample was collected from the downstream segment of Pine Avenue west of the I-5 in June 2022 (sample ID 16C-61-US, Figure 6, Figure 7).

Findings

- GeoTracker depth to groundwater information collected after the year 2000 indicates groundwater within the upper portion of the drainage area was observed at depths between 11 and 14 feet below ground surface (Figure 6).
    - The noted wells are within 1,000 ft of the primary source location identified by Alta Environmental (beneath I-5 between east and west Pine Avenue).
- 10 geotechnical reports for studies within the drainage area note that groundwater was encountered, some at depths shallow enough to infiltrate the MS4 (Table 3).
- Ion data initially resembles a mix of sources (Figure 7).
    - Looking closer at the raw data, calcium, magnesium, sodium, chloride, sulfate, and TDS concentrations in the field ion samples are well above levels that are present in potable or recycled water but within ranges identified in groundwater; this suggests groundwater contributes flow to the site (Attachment 1).
- Major MS4 outfall sampling results from 2017 – 2023 do not suggest the sewer is a likely source of flow.

Conclusions and Recommendations

- Ion data suggests flow of approximately 5 gpm originating beneath the I-5 is likely groundwater.
- Flow rates have been in the same range over the years, which suggests a relatively consistent flow source.
- Some groundwater in the area is shallow enough to infiltrate the MS4 (Table 3).

[6] Alta Environmental 2020. *2019-2020 Flow Monitoring Special Study Technical Report*. Prepared for the City of Carlsbad.

Table 3. Geotechnical Reports Identified Upstream of Outfall 16C-61

Approximate boring location	Reference ID	Approximate depth to groundwater from boring	Approximate depth to nearby MS4 main line	Potential groundwater influence
Near 411 Tamarack Avenue	SCST No. 150448P3.3-01	18 ft	23 ft	Yes
Juniper Avenue and Washington Street	SCST No. 150448P3.3-01	16 ft	23 ft	Yes
Near 365 Acacia Avenue	SCST No. 150448P3.3-01	21.5 ft	20 ft	Maybe
Pine Avenue and Washington Street	SCST No. 150448P3.3-01	20 ft	17 ft	Maybe
Oak Avenue and State Street (2 reports)	SCST No. 150448P3.3-01 & CT 14-01	13 ft	12 ft	Maybe
Oak Avenue and Madison Street	CT 2017-0004	21 ft	8 ft	No
Palm Avenue and Harding Street	473-2A; SDP 06-12A	11 ft	14 ft	Yes
Chestnut Avenue and Adams Street	398-6A; PD 01-12	8-9.5 ft	10 ft	Yes
1284 Pine Avenue	518-7A; MS 16-05	38 ft	16 ft	No

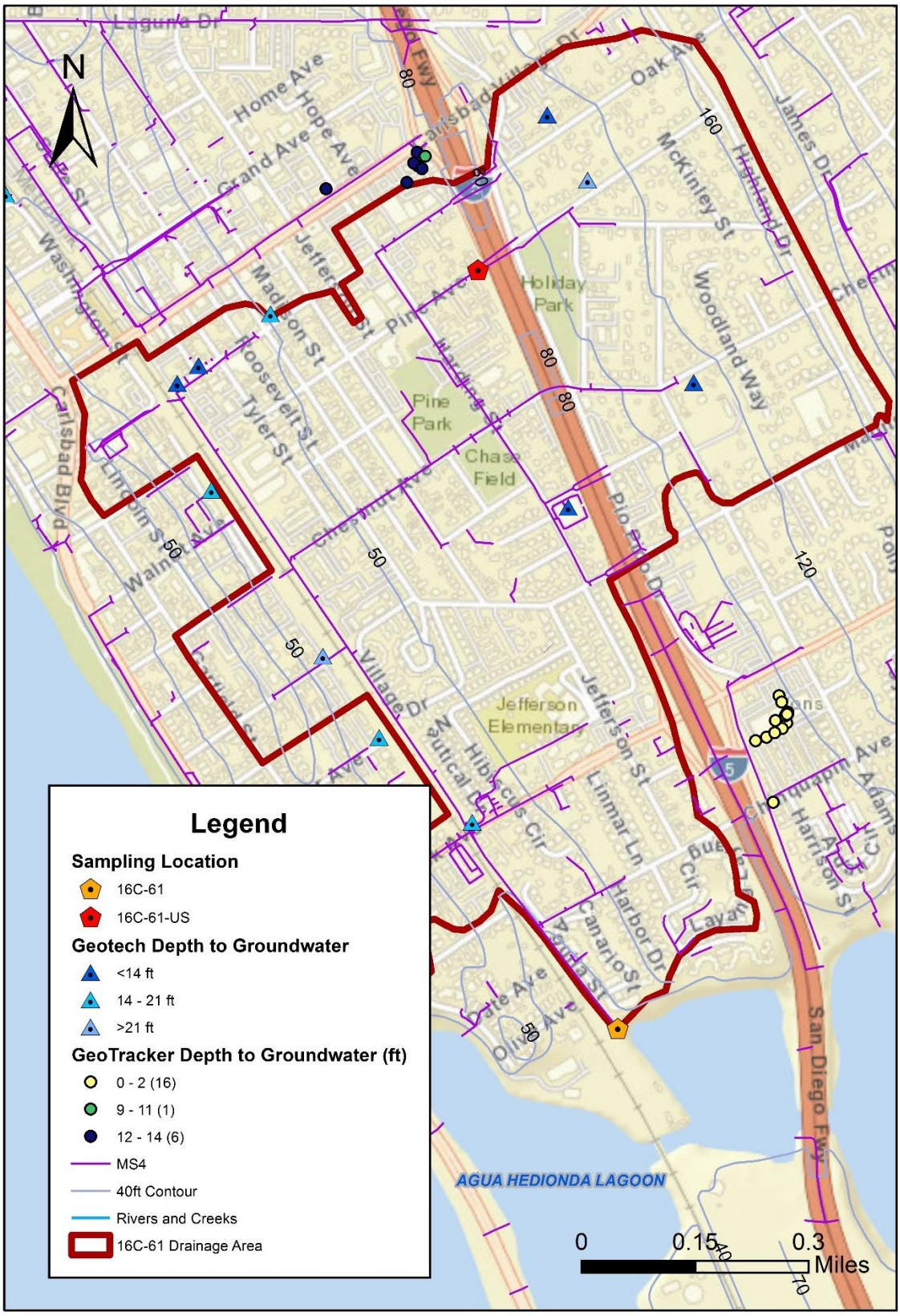

Figure 6. Overview of Outfall 16C-61

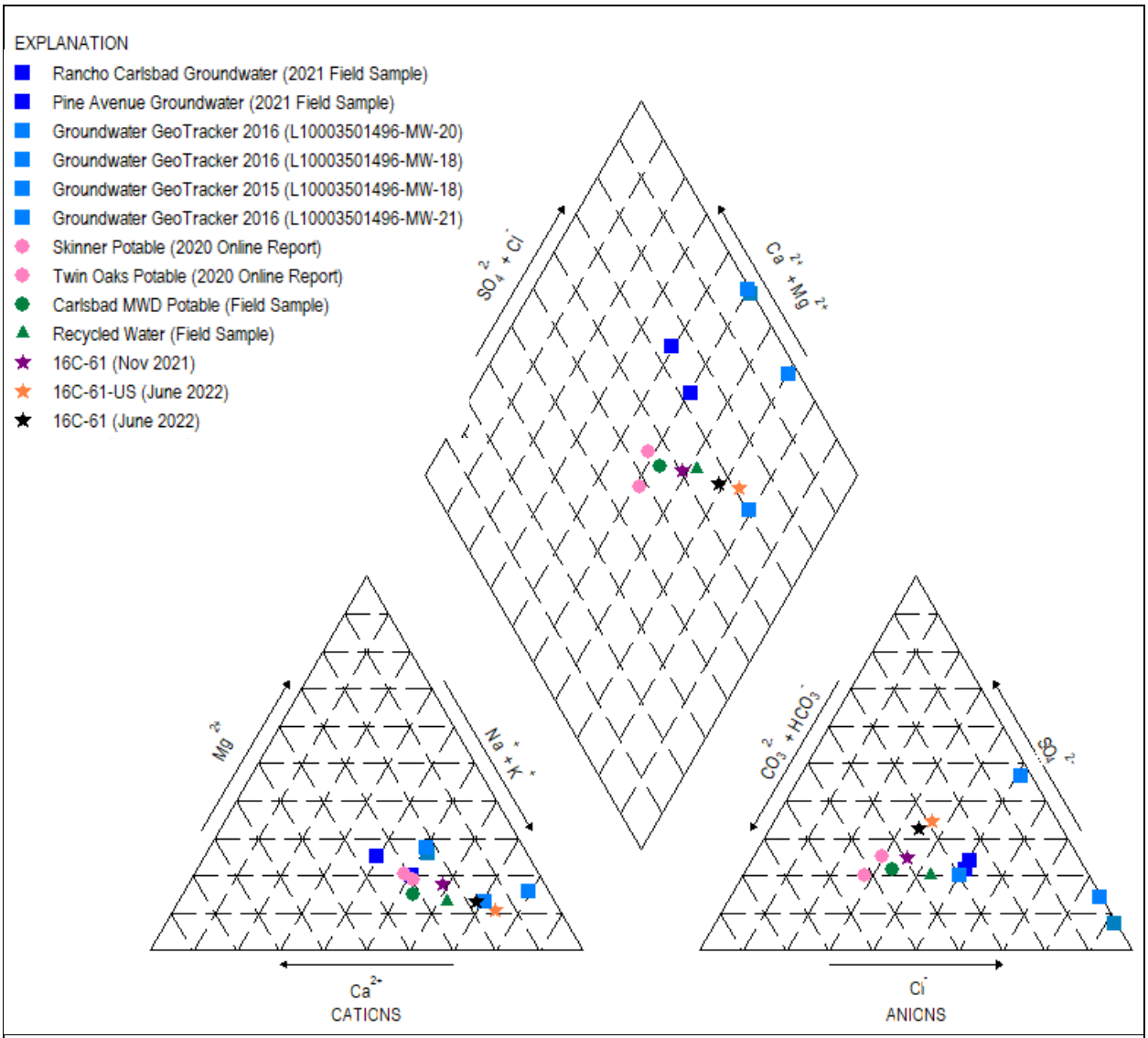

Figure 7. Site 16C-61 Piper Diagram

Site 19C-1

Historical Information

- Flow from the past four monitoring visit was visually estimated between 12-15 gpm.
- Observed average flow of approximately 12.5 gpm during 2019/2020 continuous flow special study.[7]
    - Flow rates were relatively consistent over the course of the day, which does not suggest irrigation runoff is a major source of flow (Figure 3).
    - Historical source investigations have identified that most flow infiltrates the MS4 south of Fermi Court. Surface level sources have occasionally been observed but only explain a small portion of the total flow seen at the outfall.

Findings

- Ion data most closely resembles groundwater (Figure 8).
- One geotechnical report, identified for a project near the downstream portion of the drainage area, reported encountering groundwater at depths shallow enough to infiltrate the MS4 (Table 4, Figure 9).
- Laboratory analytical data indicate consistently high TDS, which is often an indicator of groundwater influence. Groundwater monitoring wells near the drainage area display elevated results similar to the outfall.[8]
- Major MS4 outfall sampling results from 2017 – 2023 do not suggest the sewer is a likely source of flow.

Conclusions and Recommendations

- The main source of flow is believed to originate from groundwater.
    - Consistent flow observed over the years.
    - Few surface level sources have been observed in the drainage area and sources only explain a small portion of the flow at the outfall.
    - Groundwater in the area can be shallow enough to infiltrate the MS4.
    - Ion data most closely resembles groundwater.

[7] Alta Environmental 2020. *2019-2020 Flow Monitoring Special Study Technical Report*. Prepared for the City of Carlsbad.

[8] To view an example of the data, search for monitoring well L10003501496-MW-21 using the link below; other monitoring wells in the area display a similar trend.
https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/

Table 4. Geotechnical Reports Identified Upstream of Outfall 19C-1

Approximate boring location	Reference ID	Approximate depth to groundwater from boring	Approximate depth to nearby MS4 main line	Potential groundwater influence
Near 5420 Sunny Creek Road	CT 96-02	13-15ft	10-23ft	Yes

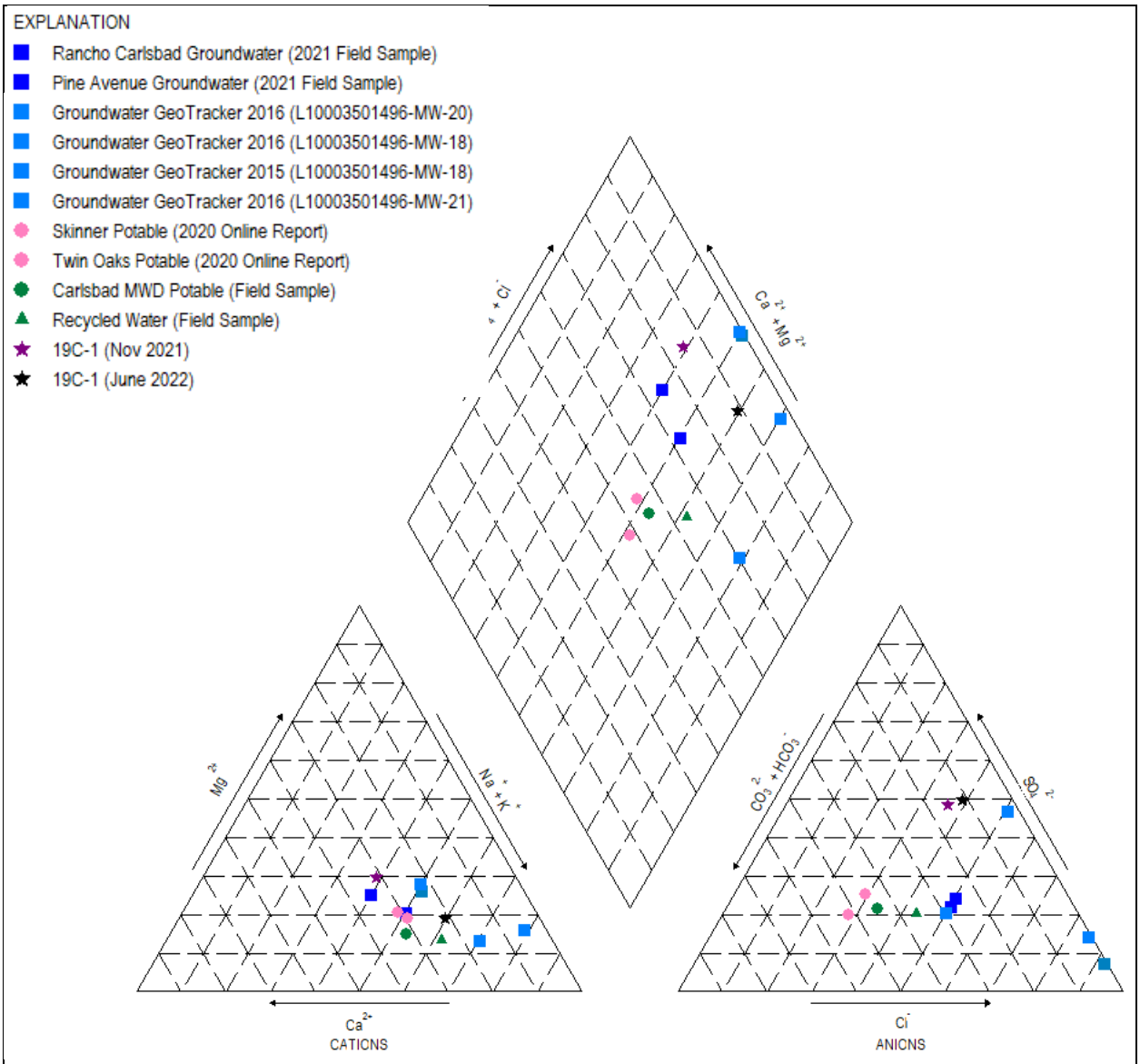

Figure 8. Site 19C-1 Piper Diagram

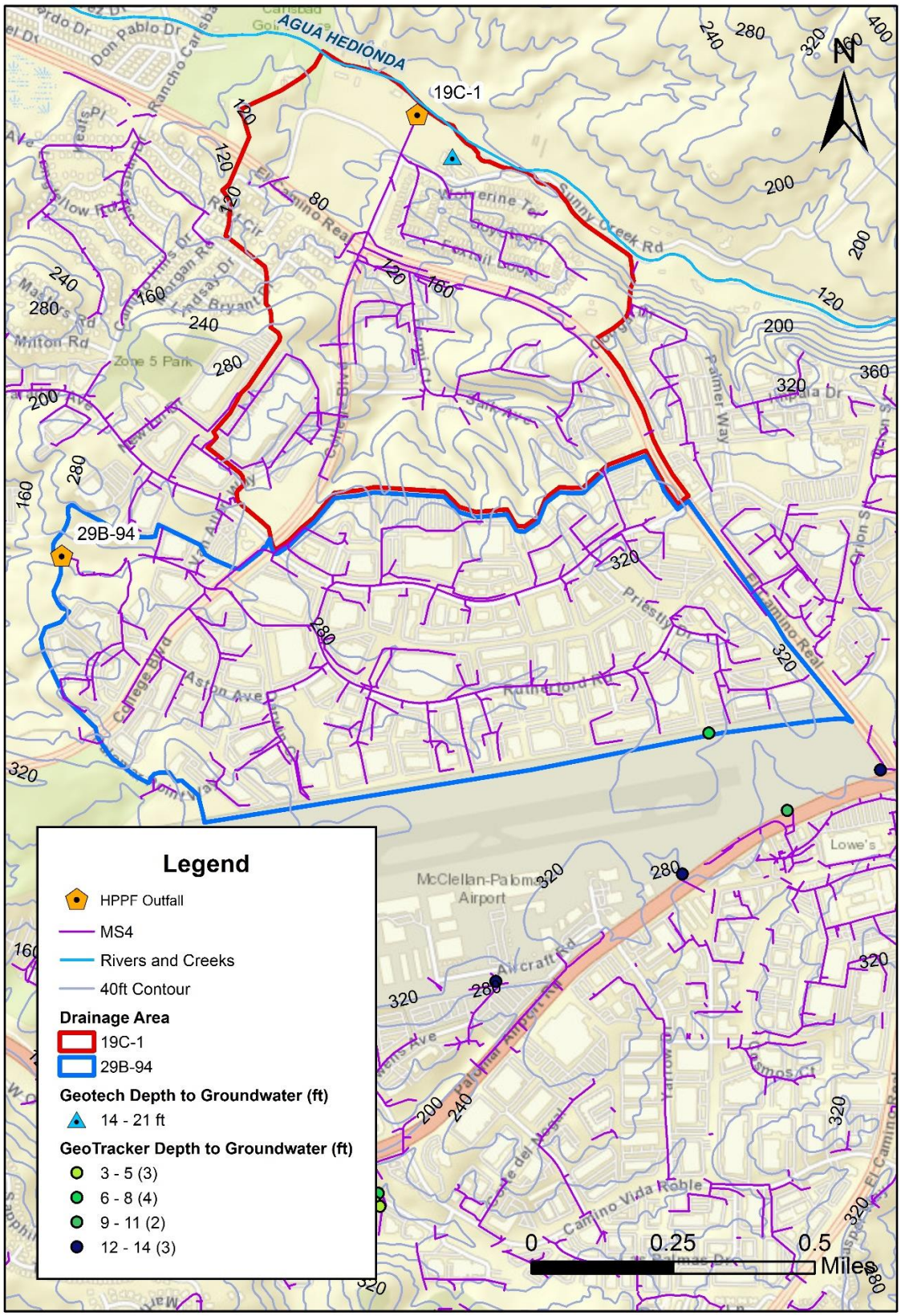

Figure 9. Overview of Outfalls 19C-1 and 29B-94

Site 29B-94

Historical Information

- Flow from the past four outfall monitoring visits was estimated between 12-17 gpm.
- Observed average flow of 10 gpm during 2019/2020 continuous flow special study.[9]
    - Diurnal pattern of flow observed, with consistently higher average flow rates at night and in the early morning hours. Since most landscape irrigation occurs at night and in the morning, this pattern suggests irrigation runoff is a source of flow (Figure 10).
    - Historical observations indicate irrigation runoff is observed relatively frequently in this drainage area, but sources only explain a portion of the total flow seen at the outfall.

Findings

- GeoTracker depth to groundwater information collected after the year 2000 indicates groundwater near the southern portion of the drainage area (McClellan Palomar Airport) was observed at depths as shallow as 5 ft (Figure 9).
- No geotechnical reports noting depth to groundwater were identified within the drainage area.
- Ion data most closely resembles groundwater (Figure 11).
- Major MS4 outfall sampling results from 2017 – 2023 do not suggest the sewer is a likely source of flow.

Conclusions and Recommendations

- The main source of flow is believed to originate from groundwater.
    - Consistent flow is observed between years.
    - Some surface sources have been observed but they do not explain the flow rate observed at the site.
    - Ion data resembles groundwater.
- Supplemental flow is suspected to originate from irrigation runoff.
    - Ion data resides near groundwater and recycled water.
    - Historical observations indicate irrigation runoff is observed relatively frequently in this drainage area.
- A pressure washing IC/ID was observed upstream of the site during sampling, which may have impacted ion results. Consider re-sampling for major ions to correct for potential impact of the power washing IC/ID.
- Continue irrigation runoff identification and elimination efforts.

[9] Alta Environmental 2020. *2019-2020 Flow Monitoring Special Study Technical Report*. Prepared for the City of Carlsbad.

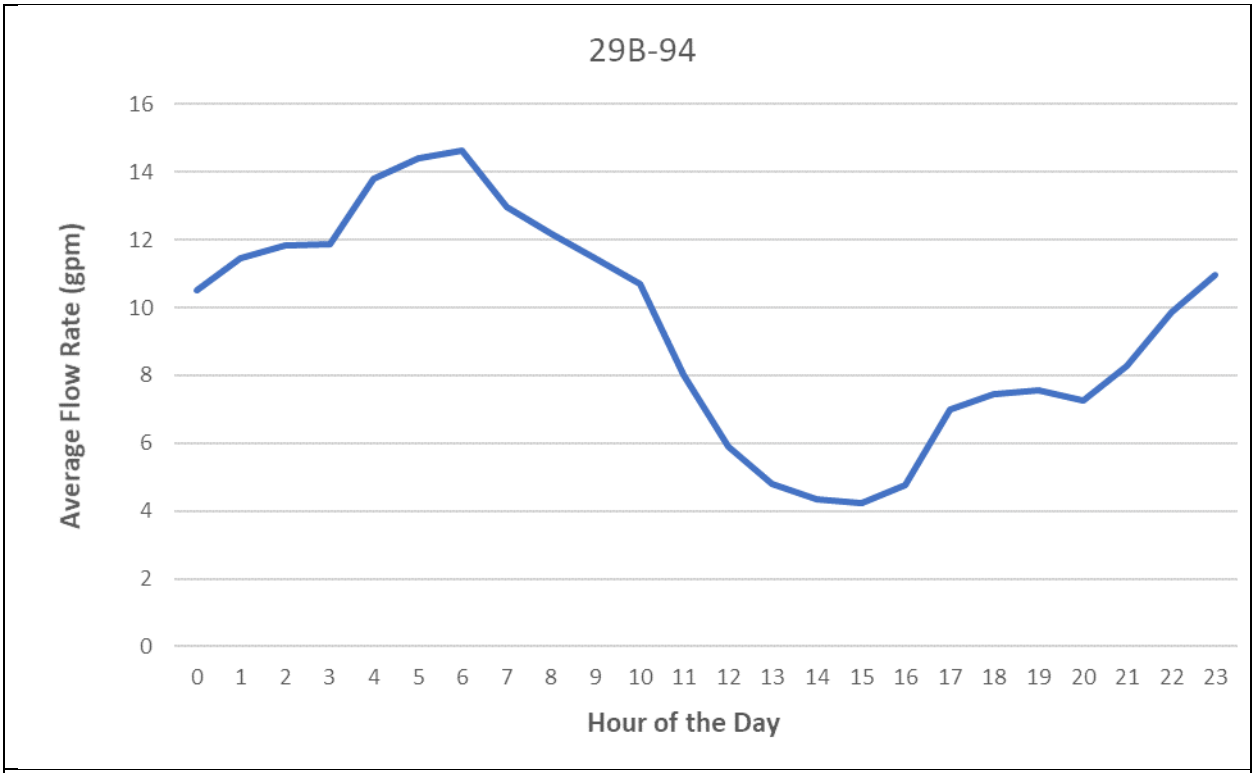

Figure 10. 2019/2020 Special Study Average Hourly Flow Rates for Site 29B-94

Note: this graph was prepared based on data collected in the 2019/2020 special study. The average flow rate for each hour is the average of all flow rates recorded during that hour over the course of the study. For example, the average flow rate for hour "0" is the average of all flow measurements recorded between 12:00 AM and 12:59 AM over all days of the study.

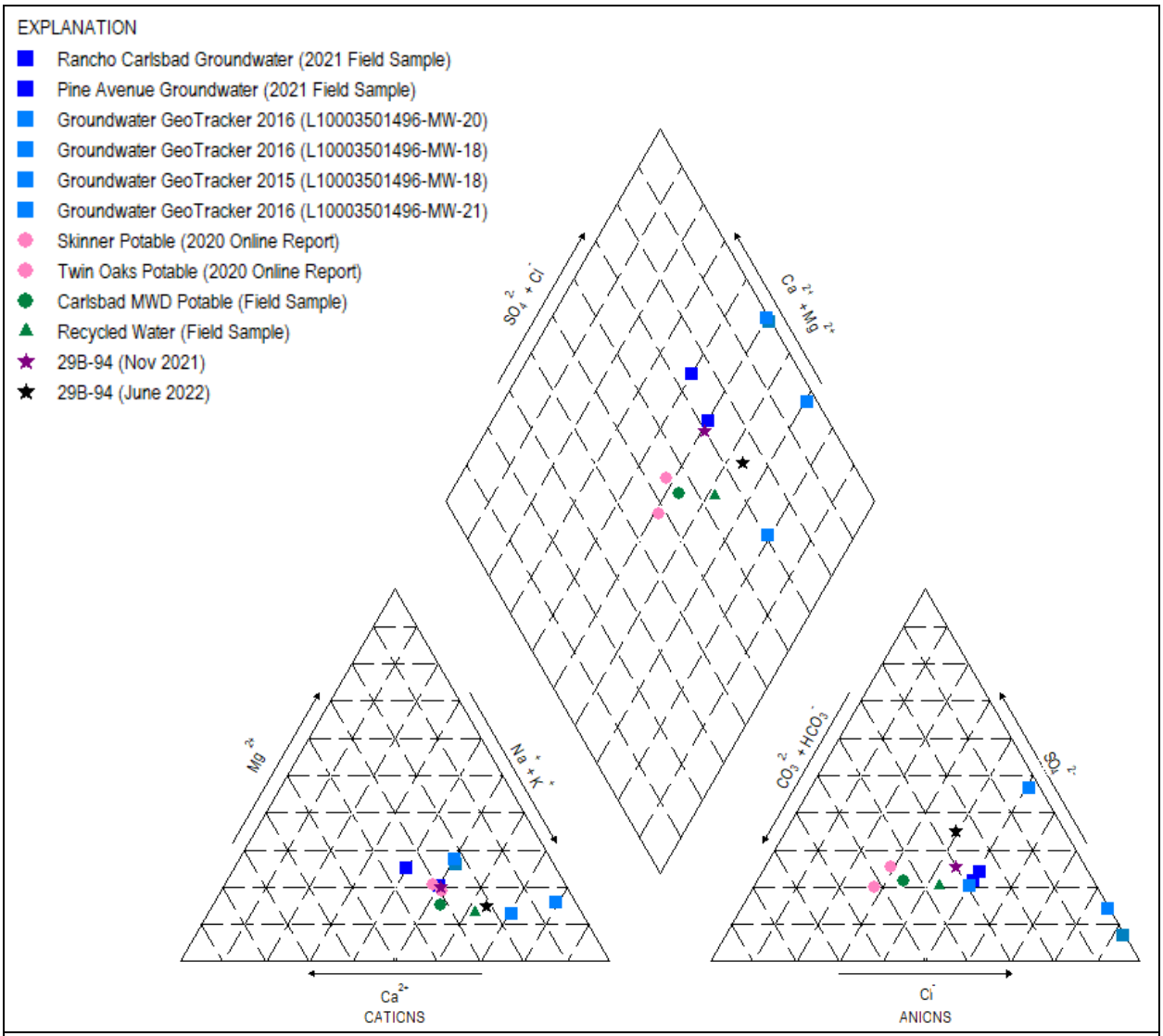

Figure 11. Site 29B-94 Piper Diagram

Site 55A-51

Historical Information

- Flow from the past four outfall monitoring visits was estimated between 20-37 gpm.
- Observed average flow of approximately 44 gpm during 2019/2020 continuous flow special study.[10]
    - Flow rates were relatively consistent over the course of the day, which does not suggest irrigation runoff is a major source of flow (Figure 3).
    - Many low flow curb drains and/or instances of irrigation runoff are typically observed in the residential community but amounts to a small percentage of flow observed at the outfall.

Findings

- Ion data most closely resembles groundwater (Figure 12).
- Laboratory analytical data consistently shows relatively high levels of iron, manganese, and total dissolved solids (TDS), while levels of other constituents have been relatively low.
    - Regional data indicates iron and manganese originate from natural deposits, and groundwater within the City of Carlsbad can contain levels greater than MS4 Permit specified action levels.[11,12]
    - Black and orange staining was noted in upstream conveyance lines during the previous year's investigations; the observed residue is indicative of high levels of manganese and iron in the water, respectively.
- No geotechnical reports noting depth to groundwater were identified within the drainage area.
- Major MS4 outfall sampling results from 2017 – 2023 do not suggest the sewer is a likely source of flow.

Conclusions and Recommendations

- The main source of flow is believed to originate from groundwater.
    - Consistent flow is observed between years.
    - Surface sources have been observed but flow totals to a small percentage of that observed at the outfall.
    - Historically elevated laboratory results related to TDS, iron, and manganese.
    - Ion data most closely resembles groundwater.

[10] Alta Environmental 2020. *2019-2020 Flow Monitoring Special Study Technical Report*. Prepared for the City of Carlsbad.

[11] San Diego River study noting the presence of iron and manganese from natural sources https://www.researchgate.net/publication/334206126_Microbial_Geochemistry_Reflecting_Sulfur_Iron_Manganese_and_Calcium_Sources_in_the_San_Diego_River_Watershed_Southern_California_USA
City of San Diego drinking water data indicates manganese typically leaches from natural deposits https://www.sandiego.gov/sites/default/files/water_quality_report_2018_final.pdf

[12] GAMA well L10003501496-MW-24 provides data showing groundwater within the City of Carlsbad containing relatively high levels of iron and manganese; other wells in the area display similar data.

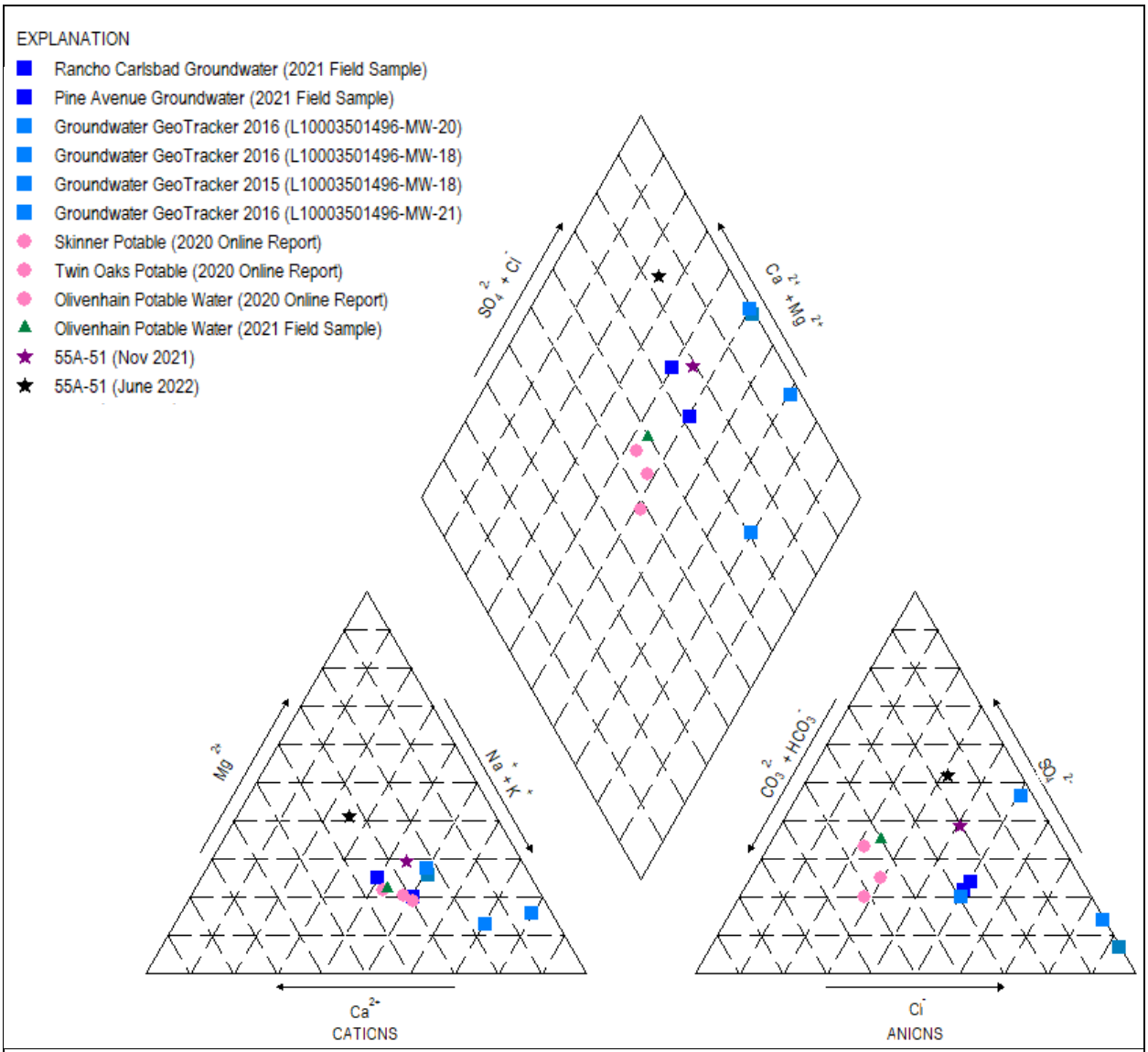

Figure 12. Site 55A-51 Piper Diagram

Site 58A-73

Historical Information

- Flow from the past four outfall monitoring visits was estimated between 5-10 gpm.
    - Many low flow curb drains are typically observed in the residential community but amounts to a small percentage of flow observed at the outfall.

Findings

- Ion data most closely resembles groundwater (Figure 13).
- Laboratory analytical data consistently shows relatively high levels of iron, manganese, and total dissolved solids (TDS), while levels of other constituents have been relatively low.
    - Regional data indicates iron and manganese originate from natural deposits, and groundwater within the City of Carlsbad can contain levels greater than MS4 Permit specified action levels.[13,14]
- Major MS4 outfall sampling results do not suggest the sewer is a likely source of flow.

Conclusions and Recommendations

- The main source of flow is believed to originate from groundwater.
    - Consistent flow is observed between years.
    - Surface sources have been observed but flow totals to a small percentage of that observed at the outfall.
    - Historically elevated laboratory results related to TDS, iron, and manganese.
    - Ion data most closely resembles groundwater.

[13] San Diego River study noting the presence of iron and manganese from natural sources https://www.researchgate.net/publication/334206126_Microbial_Geochemistry_Reflecting_Sulfur_Iron_Manganese_and_Calcium_Sources_in_the_San_Diego_River_Watershed_Southern_California_USA
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[14] GAMA well L10003501496-MW-24 provides data showing groundwater within the City of Carlsbad containing relatively high levels of iron and manganese; other wells in the area display similar data.

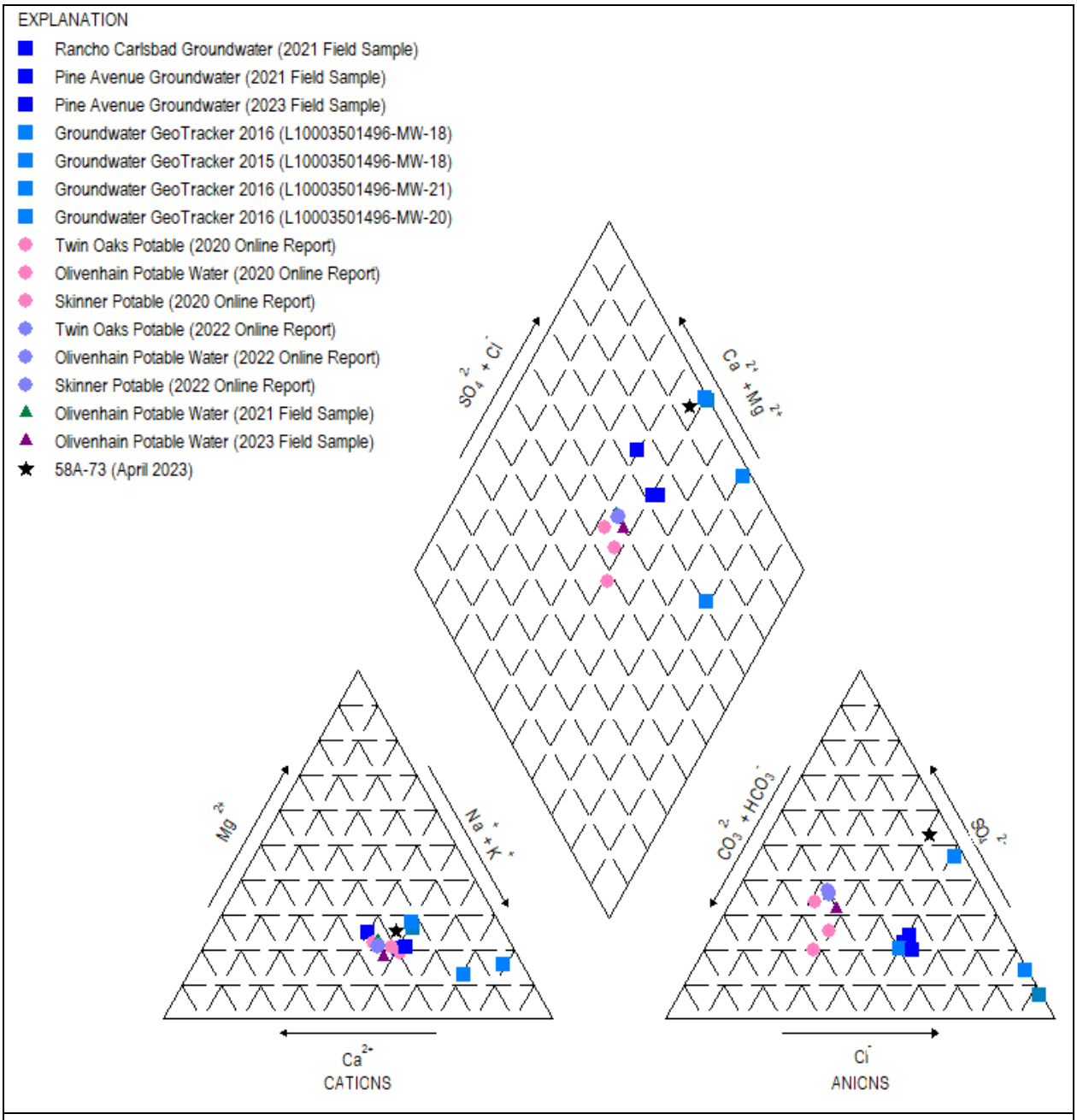

Figure 13. Site 58A-73 Piper Diagram

Site 63A-49

Historical Information

- Flow from the past four outfall monitoring visits was estimated between 3-5 gpm.
    - Many low flow curb drains and/or instances of irrigation runoff are typically observed in the residential community but amounts to a small percentage of flow observed at the outfall.

Findings

- Ion data most closely resembles groundwater (Figure 14).
- Laboratory analytical data consistently shows relatively high levels of iron, manganese, and total dissolved solids (TDS), while levels of other constituents have been relatively low.
    - Regional data indicates iron and manganese originate from natural deposits, and groundwater within the City of Carlsbad can contain levels greater than MS4 Permit specified action levels.[15,16]
- Major MS4 outfall sampling results do not suggest the sewer is a likely source of flow.

Conclusions and Recommendations

- The main source of flow is believed to originate from groundwater.
    - Consistent flow is observed between years.
    - Surface sources have been observed but flow totals to a small percentage of that observed at the outfall.
    - Historically elevated laboratory results related to TDS, iron, and manganese.
    - Ion data most closely resembles groundwater.

[15] San Diego River study noting the presence of iron and manganese from natural sources https://www.researchgate.net/publication/334206126_Microbial_Geochemistry_Reflecting_Sulfur_Iron_Manganese_and_Calcium_Sources_in_the_San_Diego_River_Watershed_Southern_California_USA
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[16] GAMA well L10003501496-MW-24 provides data showing groundwater within the City of Carlsbad containing relatively high levels of iron and manganese; other wells in the area display similar data.

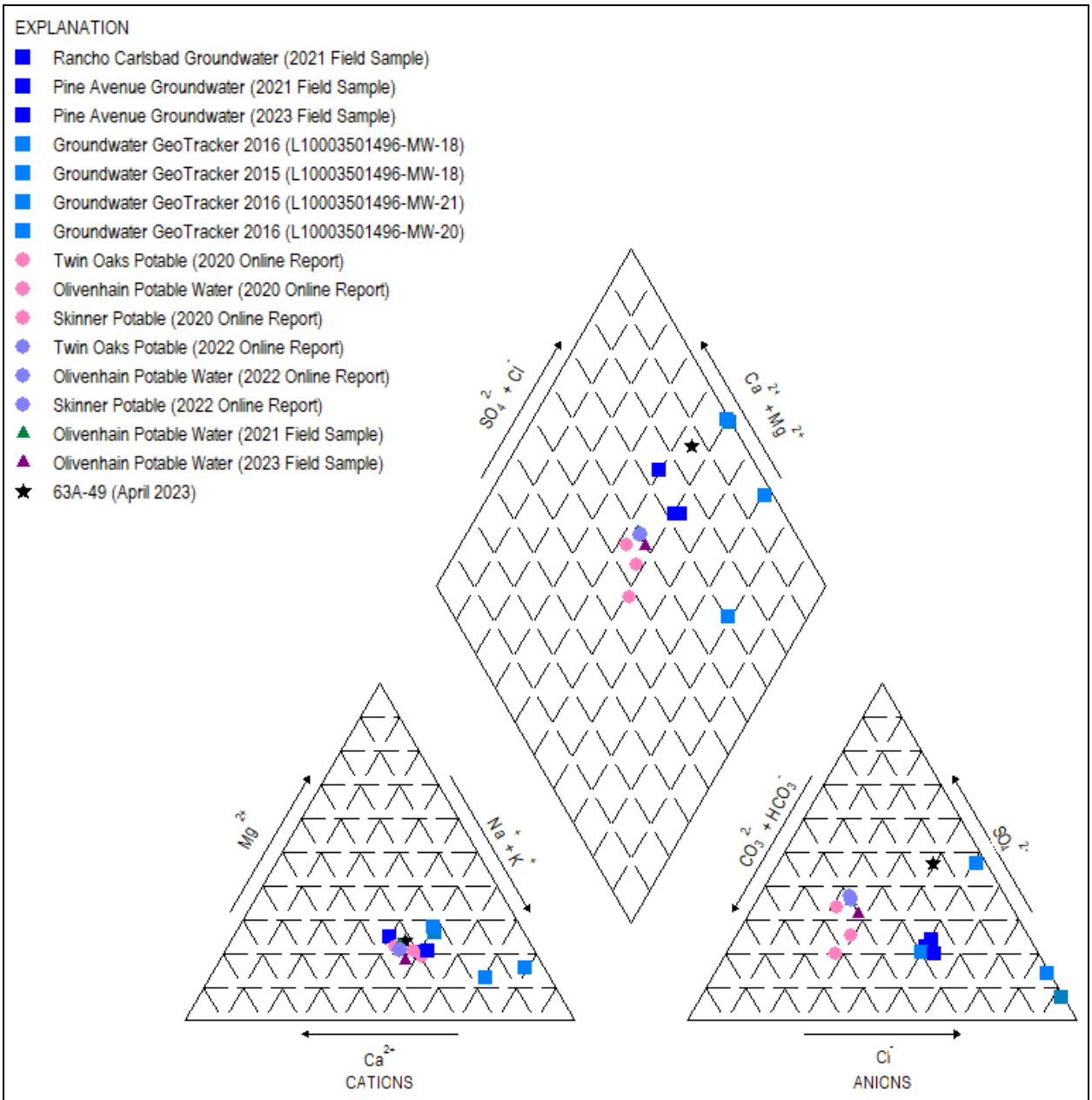

Figure 14. Site 63A-49 Piper Diagram

Site 38D-13

Historical Information

- Flow from the past four outfall monitoring visits was estimated between 1-7 gpm.
    - Many low flow curb drains and/or instances of irrigation runoff are typically observed in the residential community but amounts to a small percentage of flow observed at the outfall.

Findings

- Ion data most closely resembles groundwater (Figure 15).
- Laboratory analytical data consistently shows relatively high levels of iron, manganese, and total dissolved solids (TDS), while levels of other constituents have been relatively low.
    - Regional data indicates iron and manganese originate from natural deposits, and groundwater within the City of Carlsbad can contain levels greater than MS4 Permit specified action levels.[17,18]
- Major MS4 outfall sampling results do not suggest the sewer is a likely source of flow.

Conclusions and Recommendations

- The main source of flow is believed to originate from groundwater.
    - Consistent flow is observed between years.
    - Surface sources have been observed but flow totals to a small percentage of that observed at the outfall.
    - Historically elevated laboratory results related to TDS, iron, and manganese.
    - Ion data most closely resembles groundwater.

[17] San Diego River study noting the presence of iron and manganese from natural sources https://www.researchgate.net/publication/334206126_Microbial_Geochemistry_Reflecting_Sulfur_Iron_Manganese_and_Calcium_Sources_in_the_San_Diego_River_Watershed_Southern_California_USA
City of San Diego drinking water data indicates manganese typically leaches from natural deposits https://www.sandiego.gov/sites/default/files/water_quality_report_2018_final.pdf

[18] GAMA well L10003501496-MW-24 provides data showing groundwater within the City of Carlsbad containing relatively high levels of iron and manganese; other wells in the area display similar data.

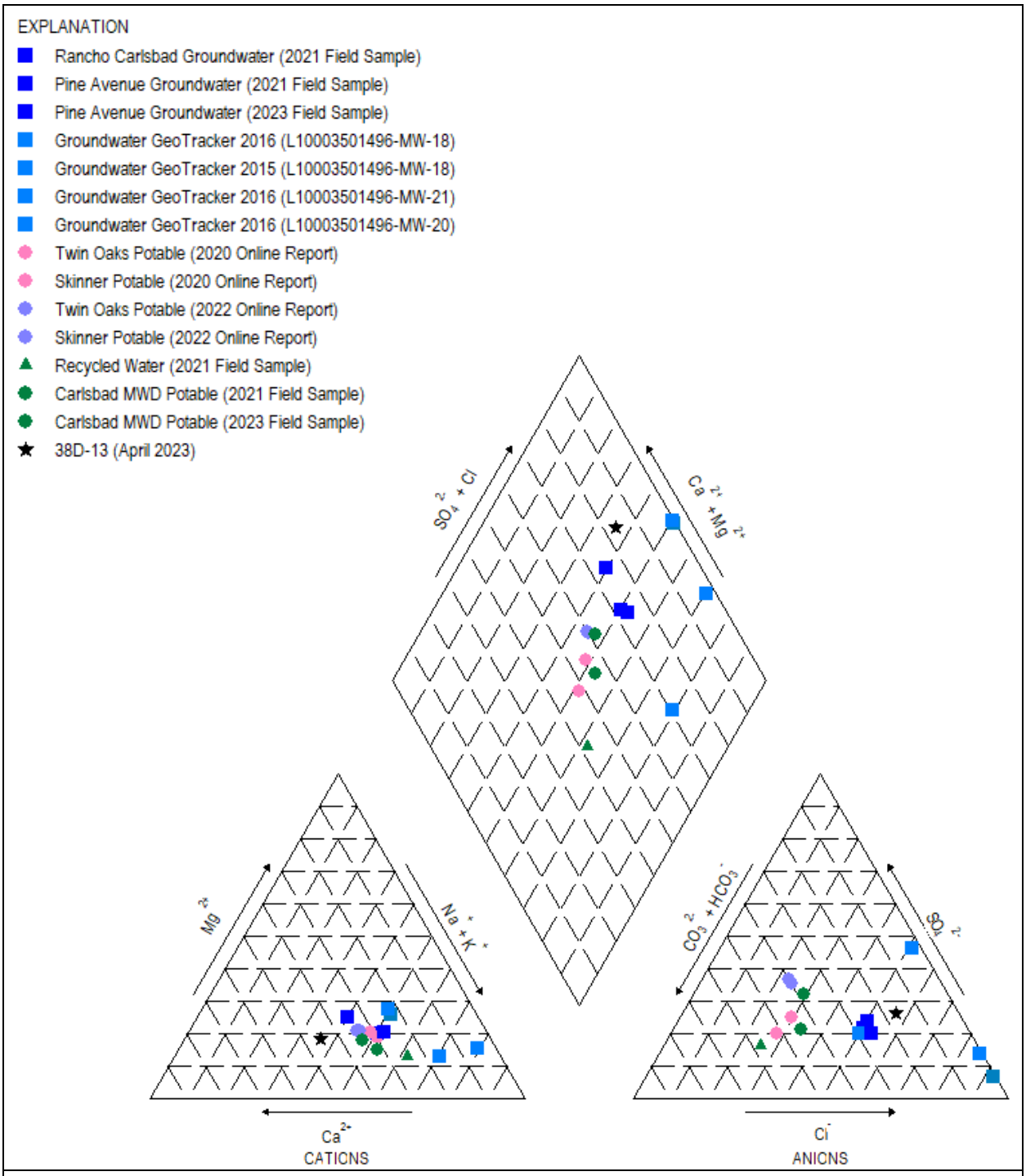

Figure 15. Site 38D-13 Piper Diagram

Attachment 1

Compiled Carlsbad Major Ion Data

(submitted electronically only)

Attachment 2

Compiled Geotechnical Reports with Notes Regarding Groundwater

(submitted electronically only)