Rincon Consultants, Inc.

180 North Ashwood Avenue
Ventura, California 93003

805 644 4455 OFFICE AND FAX

info@rinconconsultants.com
www.rinconconsultants.com

December 28, 2022
Project No: 20-10008

Bryan Bondy, PG, CHG
Executive Director
Upper Ventura River Groundwater Agency
202 West El Roblar Drive
Ojai, California 93023
Via email: bbondy@uvrgroundwater.org

Subject: **Riparian Groundwater Dependent Ecosystems Monitoring for Water Year 2022**
Upper Ventura River Groundwater Agency, Ventura County, California

Dear Mr. Bondy:

Rincon Consultants, Inc. (Rincon) has prepared the attached Annual Data Deliverable Memorandum for the 2022 Water Year (October 1, 2021, through September 30, 2022) for Groundwater Dependent Ecosystem (GDE) monitoring activities performed at two GDE Units located within the Upper Ventura River Groundwater Basin in Ventura County California. The memorandum was prepared for Upper Ventura River Groundwater Agency (UVRGA) in accordance with UVRGA's *Monitoring and Data Collection Protocols and Data Quality Control Review Procedures.*

We are pleased to support UVRGA on this important project and look forward to discussing any questions you may have regarding the data presented in this report.

Sincerely,
Rincon Consultants, Inc.

Emily McCord
Watershed Scientist

Kiernan Brtalik, CPSWQ, QSD/P
Project Manager

Riparian Groundwater Dependent Ecosystems Monitoring for Water Year 2022

Upper Ventura River Groundwater Basin

prepared for

Upper Ventura River Groundwater Agency
202 West El Roblar Drive
Ojai, California 93023

prepared by

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December 2022

RINCON CONSULTANTS, INC.
Environmental Scientists | Planners | Engineers
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1 Introduction

In accordance with the Upper Ventura River Groundwater Agency (UVRGA) Groundwater Sustainability Plan (GSP) Section 5.3, this technical memorandum summarizes the monitoring of the riparian groundwater dependent ecosystems (GDEs) in the Upper Ventura River Groundwater Basin (UVRGB) for water year 2022 (UVRGA, 2022). This monitoring includes a desktop analysis of satellite-derived data, a comparison of this data to groundwater levels, and the assessment of available satellite imagery.

Two GDE units within the basin are identified in the GSP, termed the South Santa Ana and Foster Park units (Rincon 2021). The GSP presents analysis of Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) for each unit alongside groundwater level data and satellite imagery from 1985 through 2018. The GSP monitoring networks include ongoing monitoring of groundwater levels and vegetative health within these areas.

The following section presents a GDE location map (Figure 1) as well as figures presenting NDVI and NDMI trends in comparison to groundwater levels (Figure 2 and Figure 3) and satellite imagery for both Riparian GDE Units (Figure 4). Appendix A depicts NDVI, NDMI, and Groundwater Level Data for each Riparian GDE Unit.

2 Riparian GDE Desktop Analysis

Historical groundwater level data from two groundwater monitoring wells located north and south of the South Santa Ana Riparian GDE Unit, and one groundwater monitoring well located within the Foster Park Riparian GDE Unit were used for this analysis (Figure 1).[1] NDVI and NDMI were used to assess the relative health of the vegetation communities within the Riparian GDE Units.

NDVI provides an estimate of vegetation greenness, while NDMI estimates vegetation moisture, and these indices are correlated with vegetative growth (e.g., increasing values indicated increasing growth and decreasing values indicate decreasing growth). Both values are generated from surface reflectance corrected multispectral Landsat imagery corresponding to the period of July 9 to September 7 of each year, which represents the period when GDE species are most likely to use groundwater (Klausmeyer et al. 2019). NDVI and NDMI data from 1985 to 2022 were downloaded for specific GDE areas within the UVRGB from the TNC GDE Pulse website (TNC 2018). The data are provided according to indicators of GDE (iGDE) polygons. The average NDVI and NDMI values for the areas overlapping with each Riparian GDE Unit were calculated and are presented in the following figures (Figure 2 and Figure 3). Additional figures for NDVI and NDMI data by iGDE polygon are presented in Appendix A.

While these indices do not provide a definitive indication that other components of the ecosystem are thriving or under stress, they provide a reasonable first-order check on the connection between groundwater and the vegetation that compose the ecosystem. Previous work has shown that decreases in vegetation vigor are correlated to decreases in remote sensing metrics such as NDVI (e.g., Huntington et al. 2016) and that decreases in vegetation health often correlate with decreases in overall ecosystem health. NDVI and NDMI values can serve as a general indicator of ecosystem health, though they do not allow for differentiation between vegetation types, including differentiation between native and invasive species. Thus, visual analysis is necessary to confirm that NDVI and NDMI values represent canopy health/vegetation vigor of the same native plant species within a community over time, and that major species composition shifts have not occurred. Rincon previously assessed aerial imagery of each GDE Unit within the UVRGB was analyzed to confirm that the predominant species were consistent from 1985 to 2018 (Rincon 2021).

South Santa Ana Riparian GDE Unit

Figure 2 depicts the trends in groundwater level and average NDVI and NDMI values for the South Santa Ana Riparian GDE Unit from 1985 through 2022. Depth to Water (DTW) from a static reference point was measured quarterly at wells both north and south of the South Santa Ana GDE Unit (Figure 1). While DTW varied widely at these groundwater monitoring wells (from a high of 7.5 feet in February 1998 to a low of 62.7 feet in December 2013), these wells do not reflect the actual DTW within the South Santa Ana GDE Unit, but rather provide insight to the changing groundwater conditions.[2] Trends in these groundwater levels provide an indication of the relative seasonal and interannual groundwater level trends expected in the GDE unit. Annual rainfall during 1998 was the highest on record (49.20 inches) since 1906 (VRWC 2021). A period of drought occurred between

[1] No groundwater monitoring sites are located within the South Santa Ana Riparian GDE Unit. This is a data gap that will be addressed during GSP implementation.

[2] UVRGA understands this is a data gap and plans to develop a monitoring well network that includes a groundwater monitoring well in the South Santa Ana Riparian GDE Unit.

2012 and 2016, during which time groundwater levels did not rise above 20 feet below ground level. Following periods of heavier rainfall in early 2017, groundwater levels rebounded rapidly to pre-drought levels. While groundwater levels north of the Riparian GDE Unit appear to have seasonal highs similar to pre-drought levels from 2018 through 2022, levels at the well south of the unit decreased in late 2017 and did not rise above 35 feet below ground level from 2018 through 2022.

NDVI and NDMI values fluctuate over time and generally decrease with decreasing DTW. During drought conditions that occurred between 2012 and 2016, NDVI and NDMI values showed a persistent decline. However, these values also rebounded as DTW increased again in 2017. A visual analysis of aerial imagery confirmed a decrease in vegetative growth during this recent period of severe drought, followed by a resurgence of growth and canopy health in subsequent years with more rain. NDVI and NDMI values in 2022 showed a slight rebound in 2022 after an approximate 0.1-point drop observed between 2020 and 2021. A visual analysis of 2022 aerial imagery shows that the approximate vegetation distribution and vigor are generally aligned with 2021 conditions.

Foster Park Riparian GDE Unit

Figure 3 depicts trends in groundwater levels and average NDVI and NDMI values for the Foster Park Riparian GDE Unit from 1985 through 2022. DTW from a static reference point was measured quarterly at a well within the Foster Park Riparian GDE Unit (Figure 1). DTW varied from a high of 6.80 feet in February 1998 to a low of 29.6 feet in February 1991. During the recent drought period, DTW values lowered to 23.1 feet in February 2013 and 24.2 feet in December 2014. Following periods of heavier rainfall in early 2017, groundwater levels rebounded to almost pre-drought levels and have remained stable through 2022.

Similar to the Santa Ana Riparian GDE Unit, NDVI and NDMI values fluctuate over time and generally decrease with decreasing DTW. While a general increasing trend of NDVI and NDMI was observed for the Foster Park Riparian GDE Unit for the 1985 to 2022 time period, the potential cause is currently unclear. According to Rincon's previous assessment, this could be related to influences of past floods or management actions in Foster Park. Aerial imagery confirmed the decrease in NDVI and NDMI values in 2005 and subsequent increase in NDVI and NDMI values from 2006 to 2012 correlated with vegetation removal and subsequent revegetation following flood events that occurred in 2005 (Rincon 2021). Following a period of increasing index values from 2006 to 2012, NDVI and NDMI values declined during recent drought conditions, but then increased again in 2017 following a water year with moderate precipitation. Similar to the South Santa Ana Riparian GDE Unit, analysis of aerial imagery confirmed a decrease of vegetative growth during this recent period of severe drought, followed by rebounding growth and canopy cover in subsequent years with more rain (Rincon 2021). NDVI and NDMI values in 2022 showed a slight rebound in 2022 after an approximate 0.05-point drop observed between 2020 and 2021. A visual analysis of 2022 aerial imagery shows that the approximate vegetation distribution and vigor are generally aligned with 2021 conditions (Figure 4).

Figure 1 Riparian GDE Units and nearby Groundwater Monitoring Wells

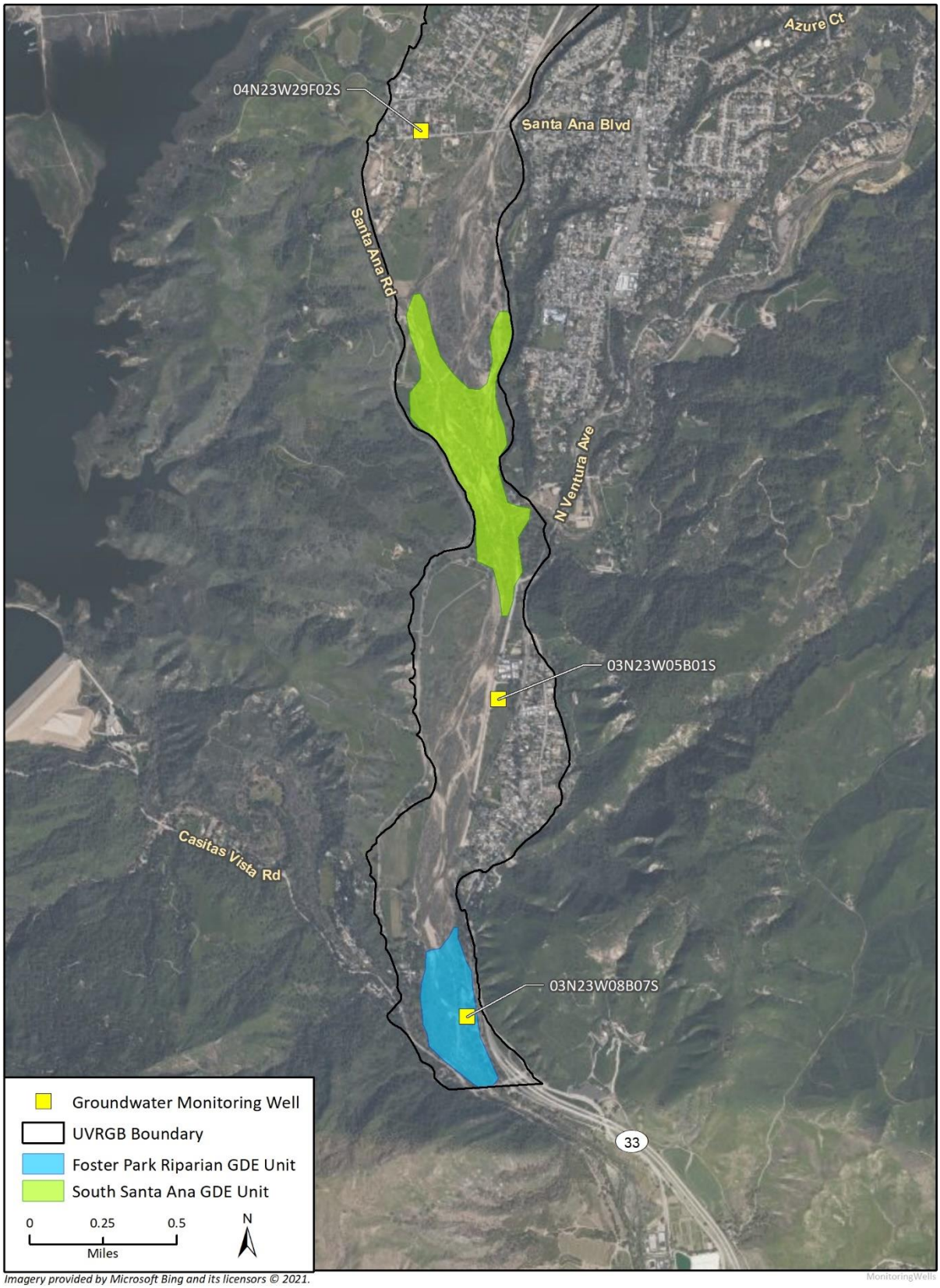


Figure 2 Groundwater Level Compared to Average NDVI and NDMI for the South Santa Ana Riparian GDE Unit (1985 to 2022)

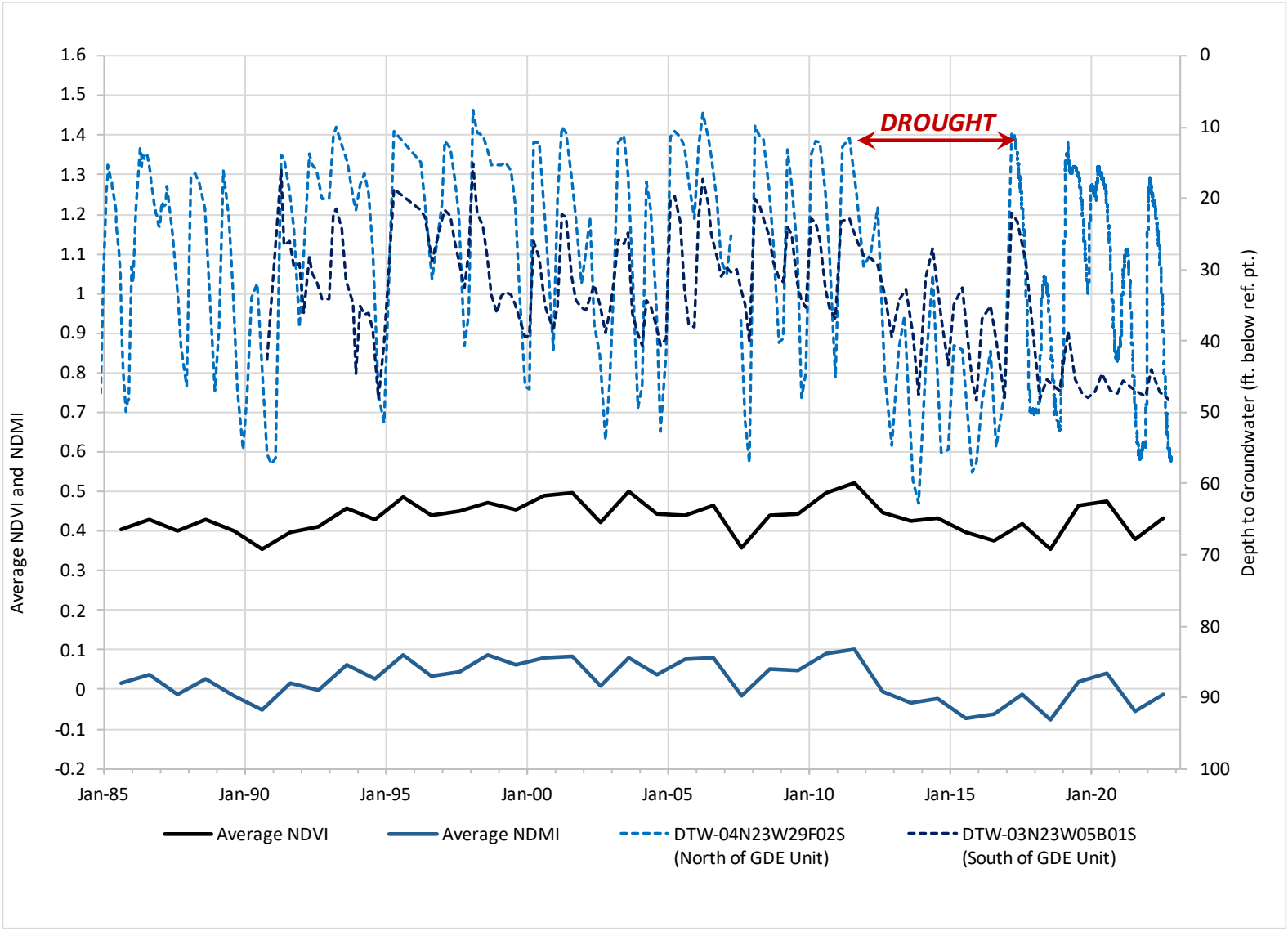


Figure 3 Groundwater Level Compared to Average NDVI and NDMI for the Foster Park Riparian GDE Unit (1985 to 2022)

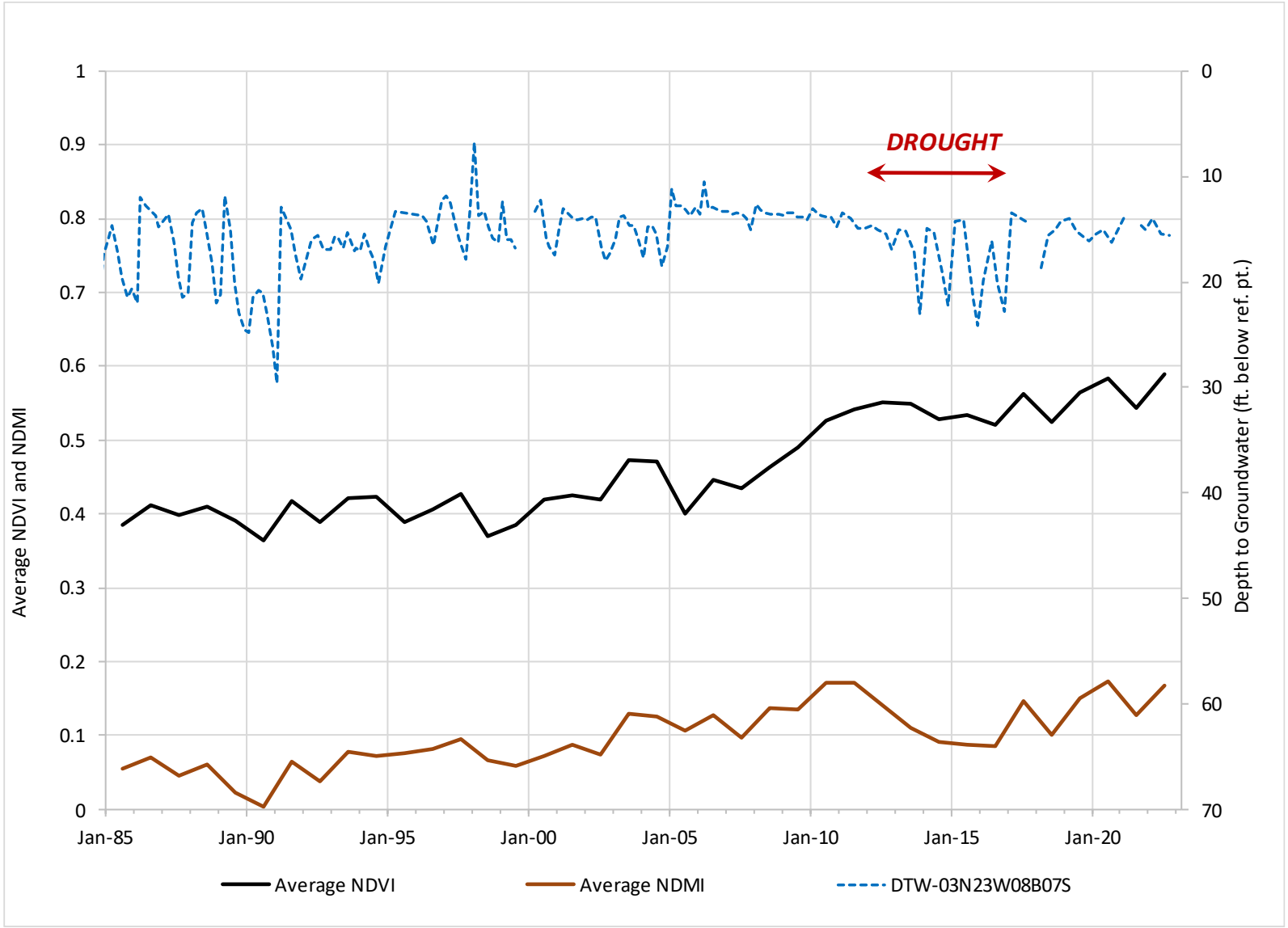
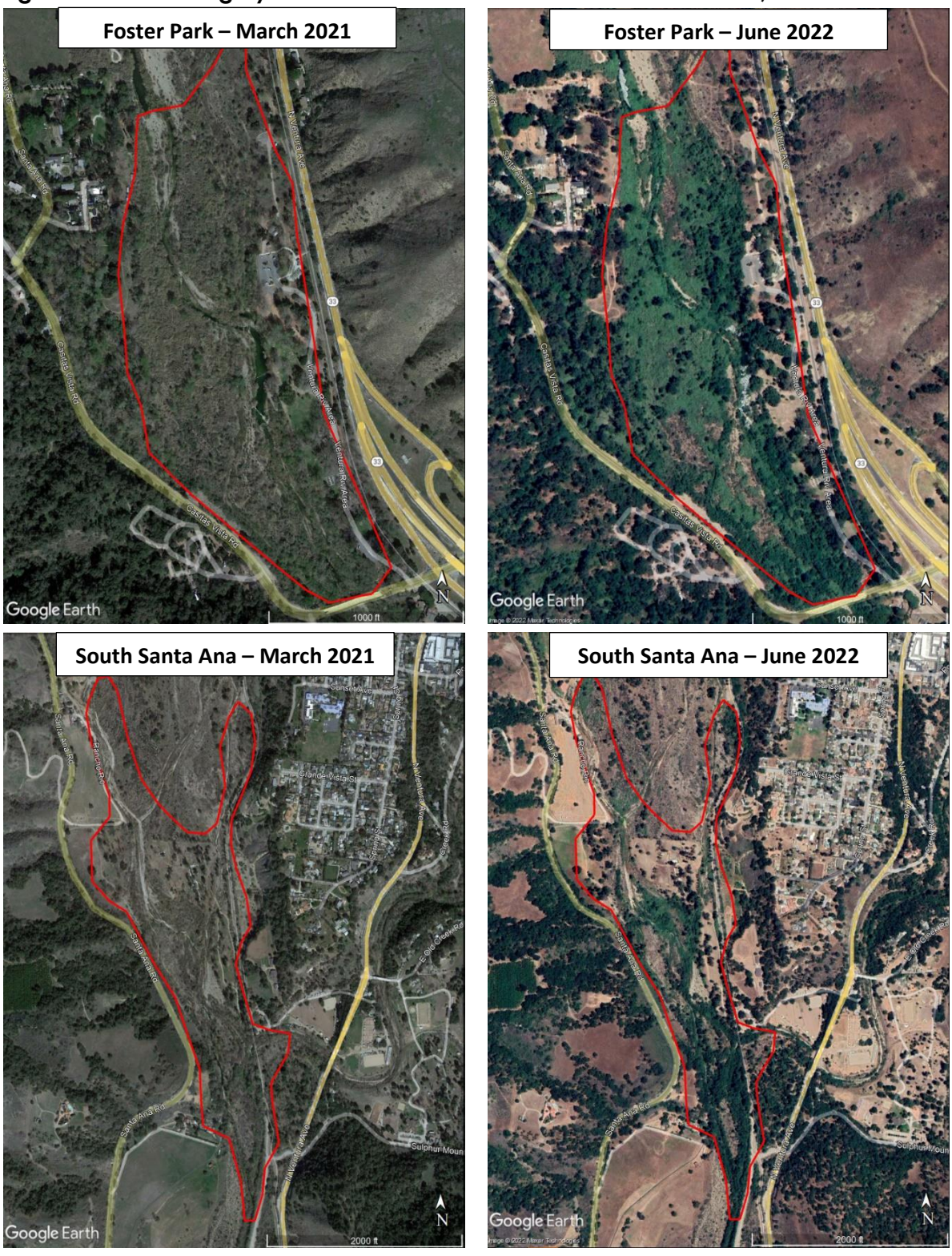


Figure 4 Aerial Imagery of Foster Park and South Santa Ana GDE Units, 2021-2022



3 References

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The Nature Conservancy (TNC). 2018. GDE Pulse. Online Database of NDVI and NDMI values by groundwater basin. Available at: https://gde.codefornature.org/#/home.

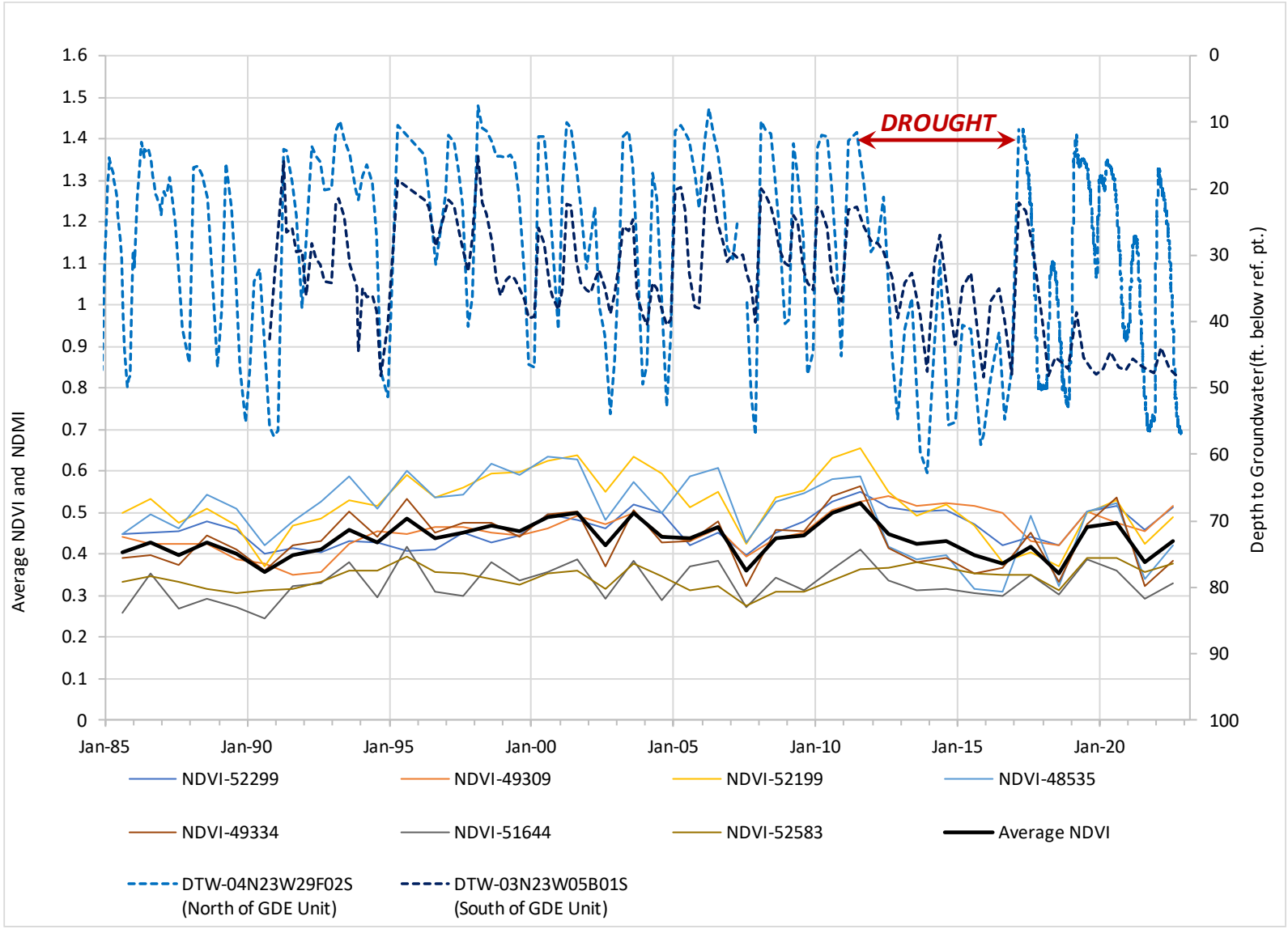
Ventura River Watershed Council (VRWC). 2015. Ventura River Watershed Council Ventura River Watershed Management Plan. March.

Upper Ventura River Groundwater Agency (UVRGA). 2022. Upper Ventura River Valley Basin Groundwater Sustainability Plan.

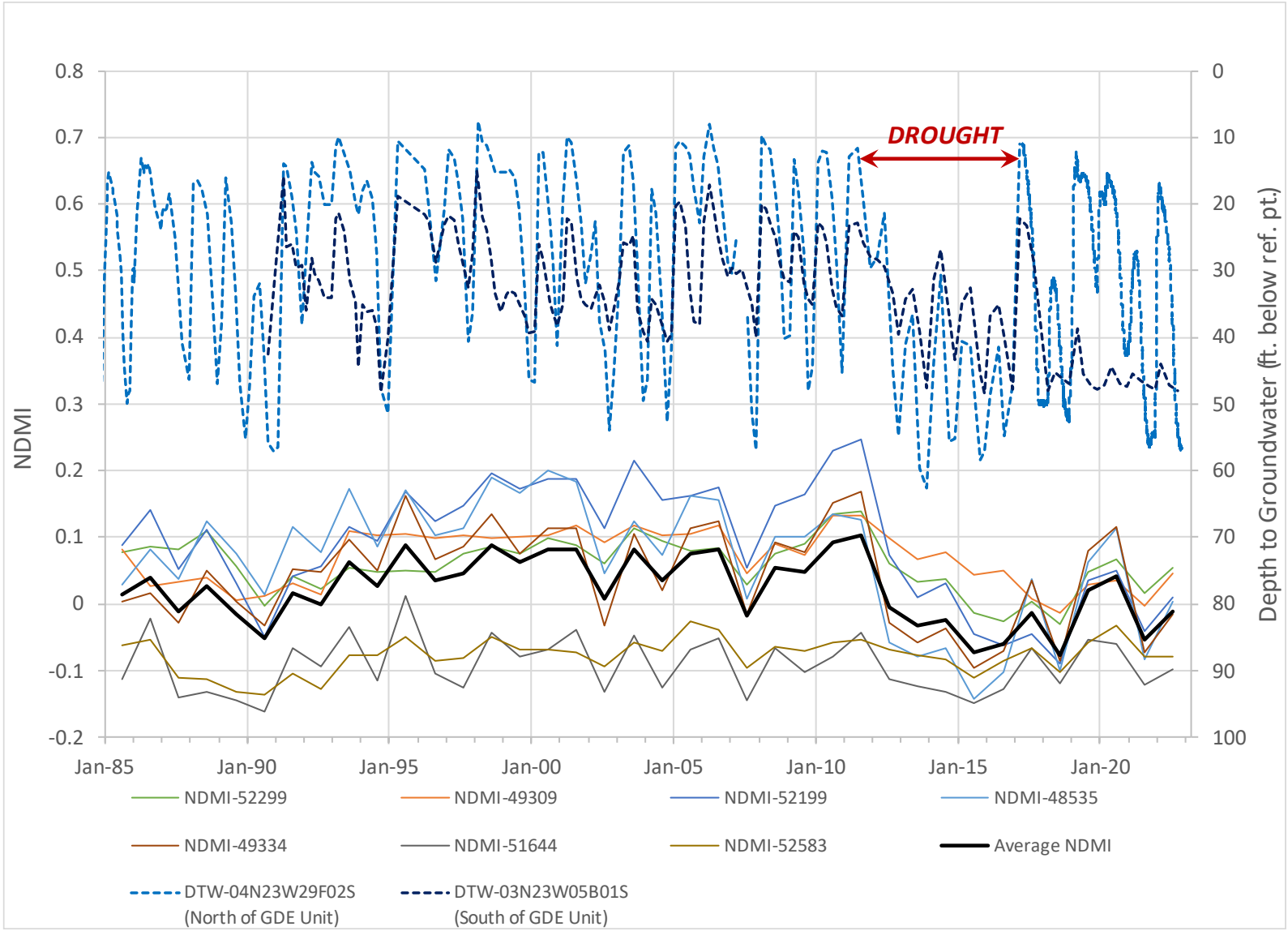
Appendix A

NDVI, NDMI, and Groundwater Level Data for each Riparian GDE Unit

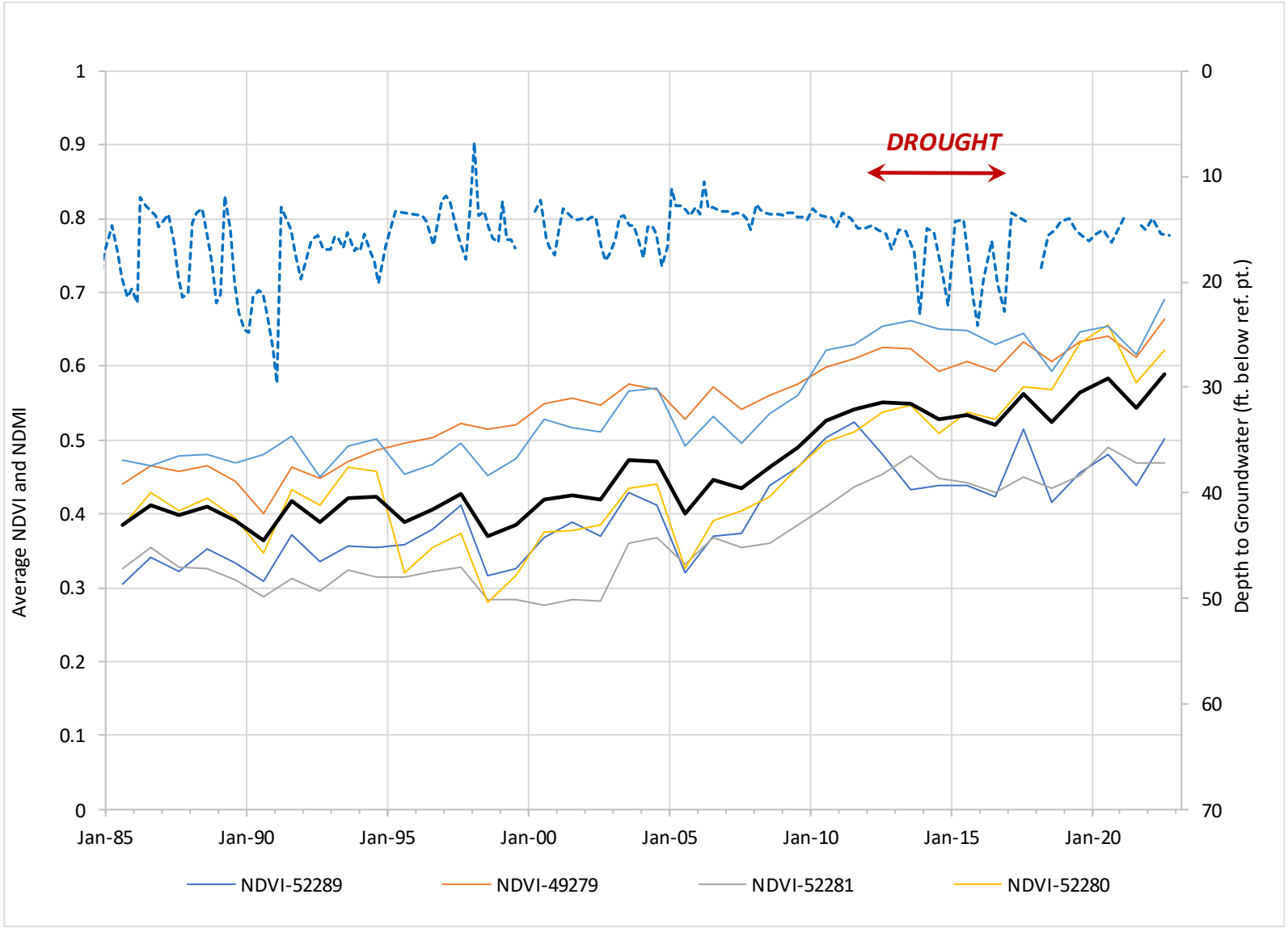
Groundwater Level Compared to NDVI iGDE Polygons for the South Santa Ana Riparian GDE Unit (1985 to 2022)



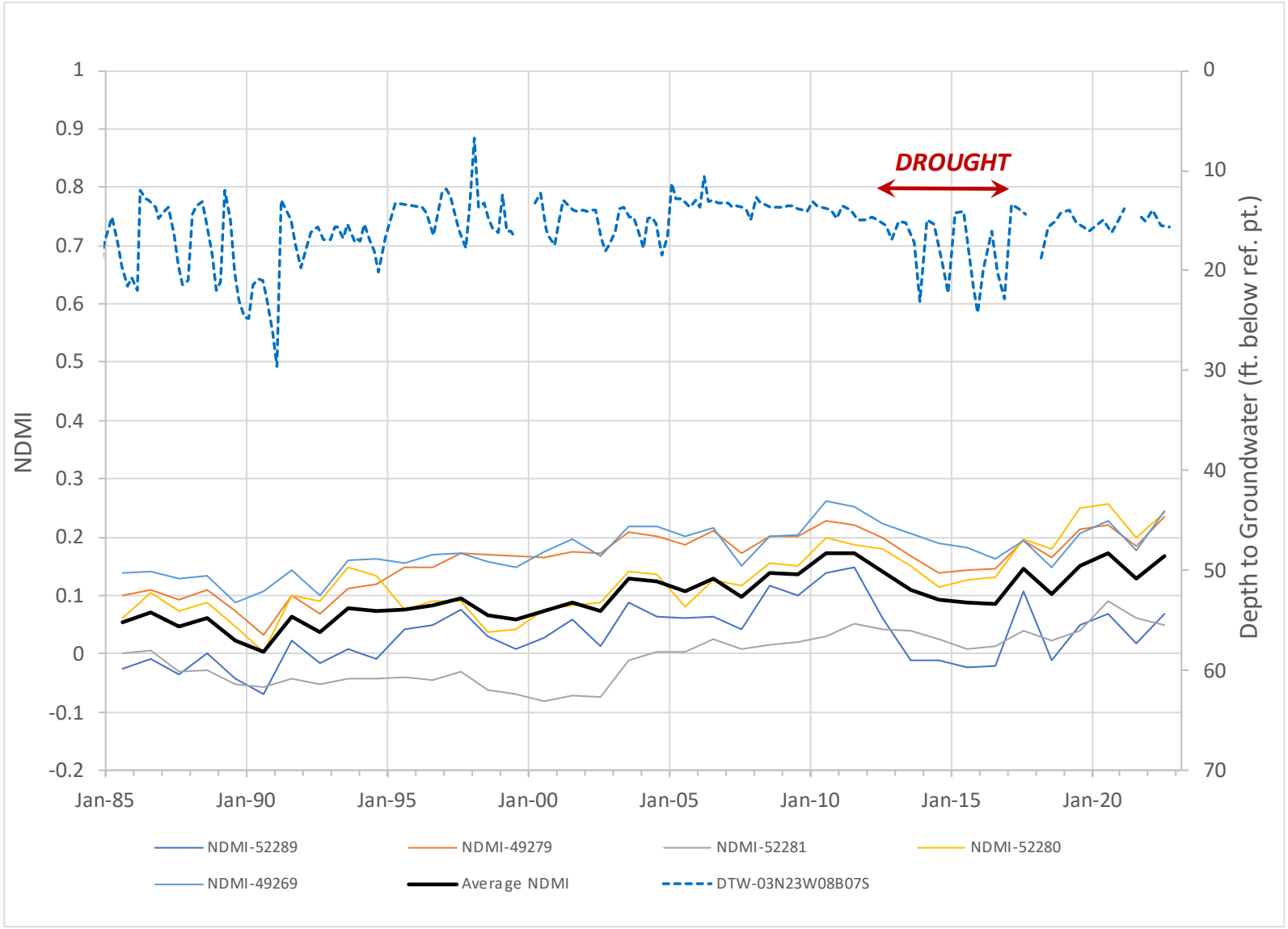
Groundwater Level Compared to NDMI iGDE Polygons for the South Santa Ana Riparian GDE Unit (1985 to 2022)



Groundwater Level Compared to NDVI iGDE Polygons for the Foster Park Riparian GDE Unit (1985 to 2022)



Groundwater Level Compared to NDMI iGDE Polygons for the Foster Park Riparian GDE Unit (1985 to 2022)



Appendix B

Raw NDVI and NDMI Data for each Riparian GDE Unit (Provided Electronically)