

SEPTEMBER 2026

EAST BAY PLAIN SUBBASIN GROUNDWATER SUSTAINABILITY PLAN APPENDIX 3

PREPARED FOR

East Bay Municipal Utility District GSA and
City of Hayward GSA



PREPARED BY

Luhdorff & Scalmanini Consulting Engineers
Geosyntec
Brown and Caldwell
Environmental Science Associates
Dr. Jean Moran
Farallon Geographics



APPENDIX 3. SUSTAINABLE MANAGEMENT PLAN

- 3.A. Supporting Data for Groundwater Level SMC
- 3.B. Supporting Data for Groundwater Storage SMC
- 3.C. Supporting Data for Seawater Intrusion SMC
- 3.D. Supporting Information for Subsidence SMC
- 3.E. Supporting Data for Groundwater Quality SMC
- 3.F. Supporting Data for Surface Water Depletion SMC
- 3.G. Supplemental Monitoring Network

APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.A. Supporting Data for Groundwater Level SMC

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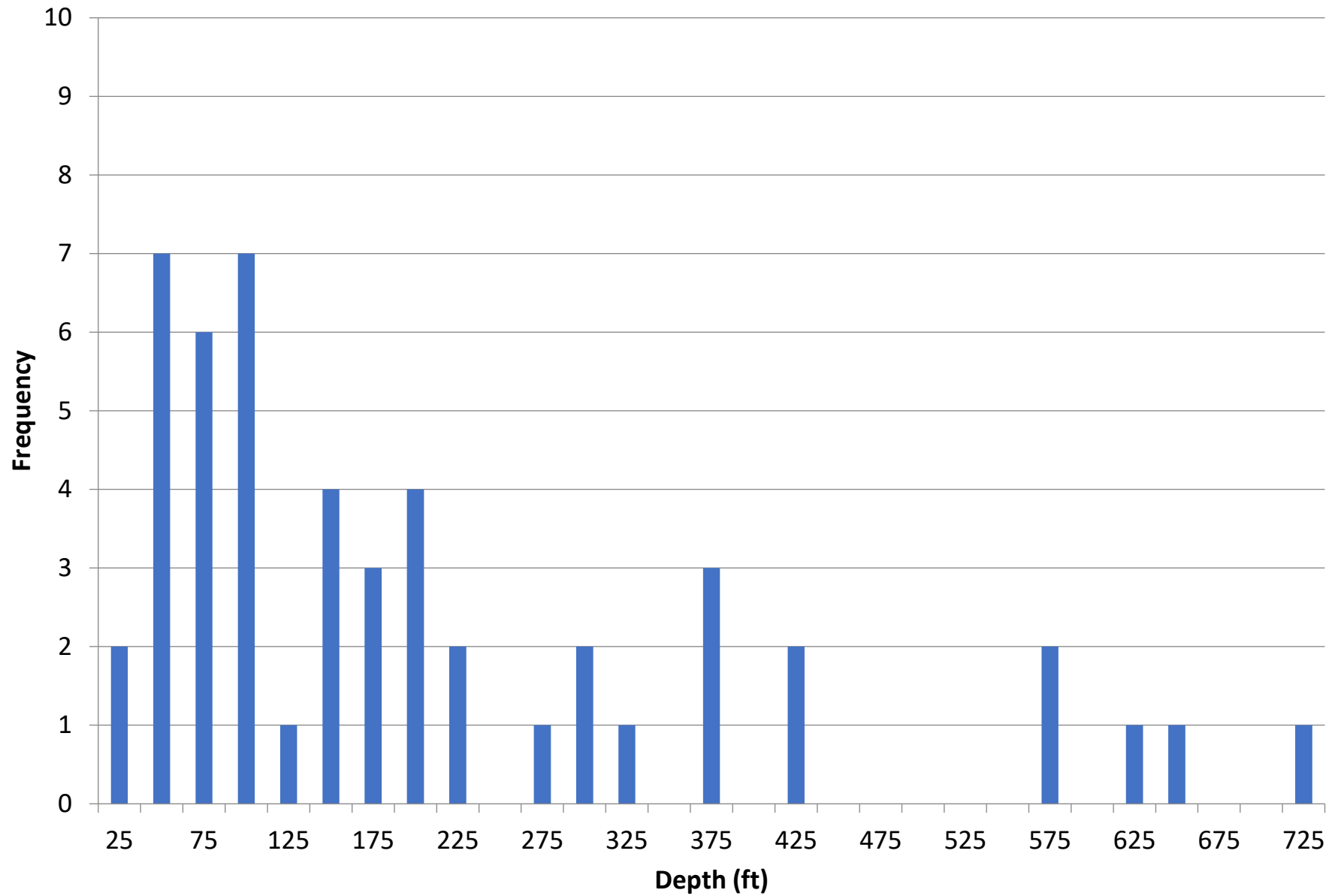
APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.A. Supporting Data for Groundwater Level SMC

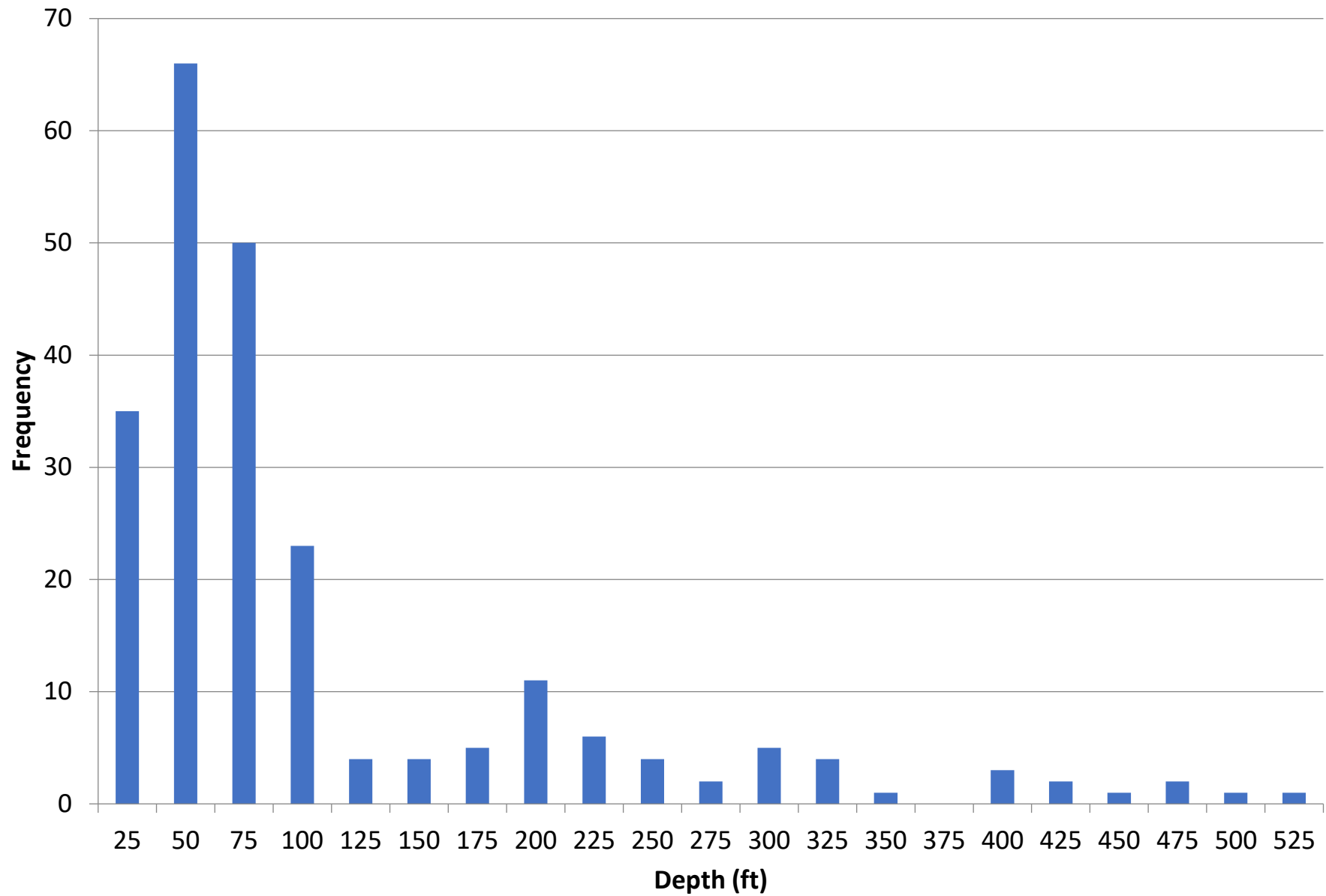
3.A.a DWR Well Completion Report Database Summary

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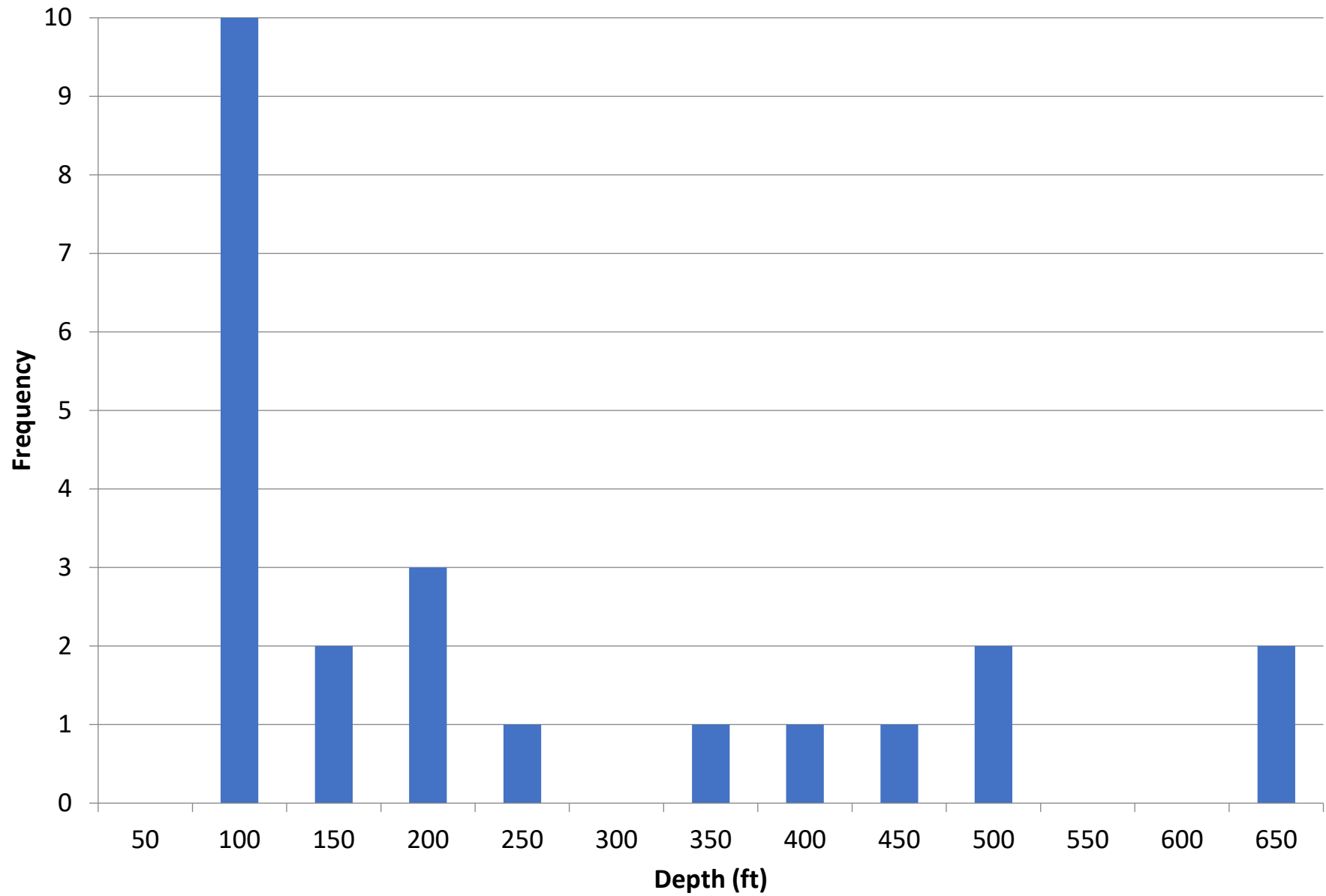
Histogram of Irrigation Wells Installed Since 1970



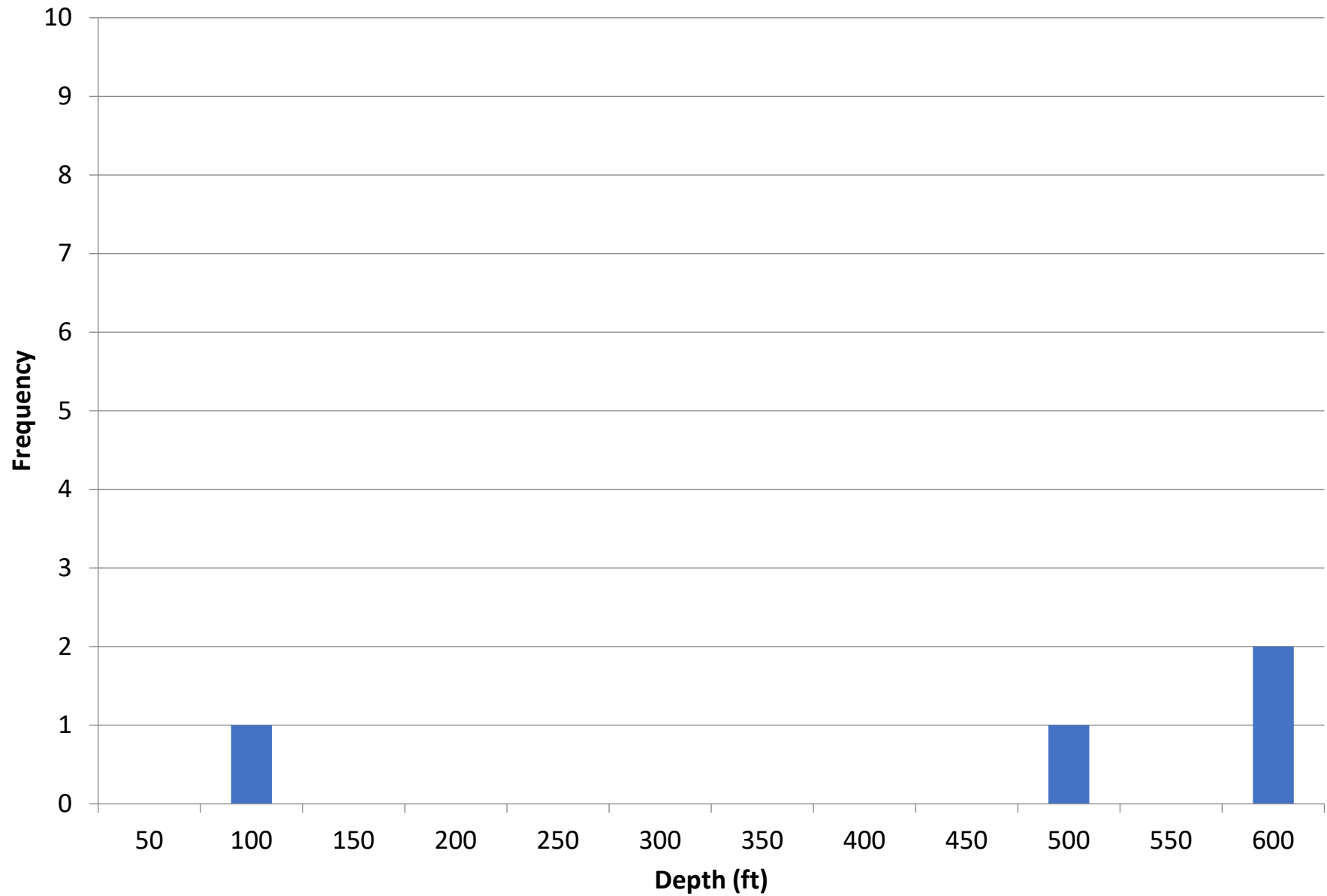
Histogram of Domestic Wells Installed Since 1970



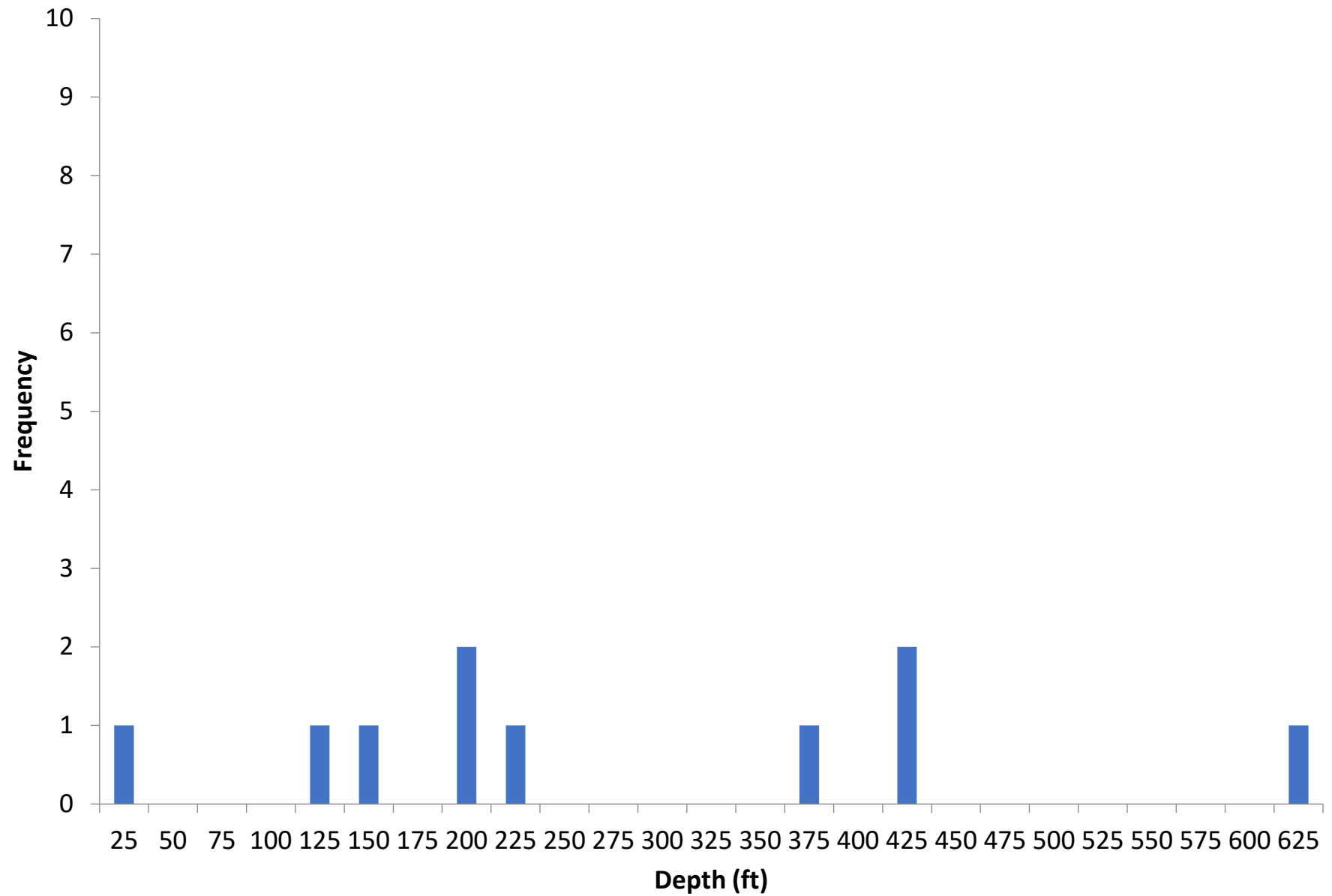
Histogram of industrial Wells Since 1970



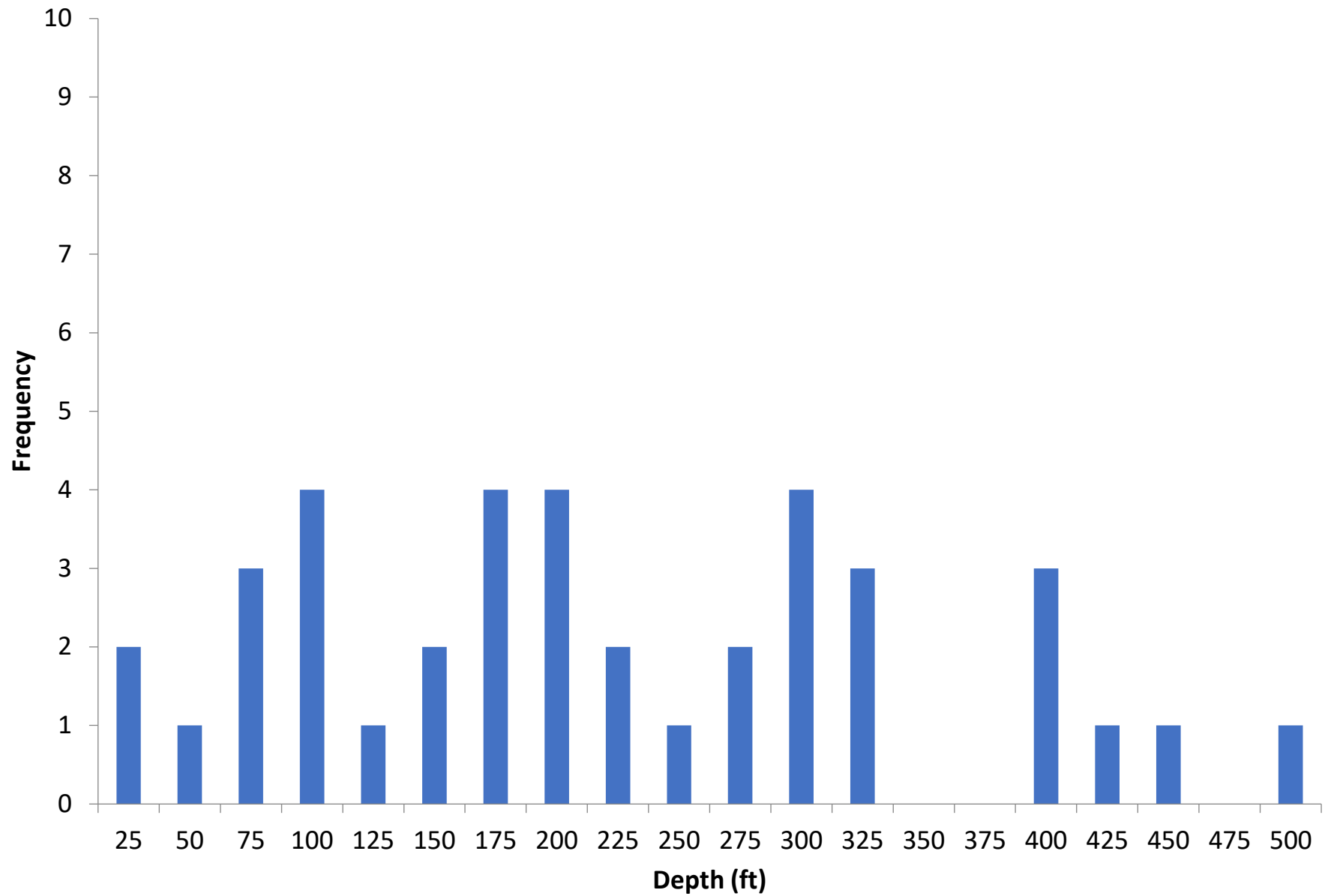
Histogram of Public Supply Wells Installed Since 1970



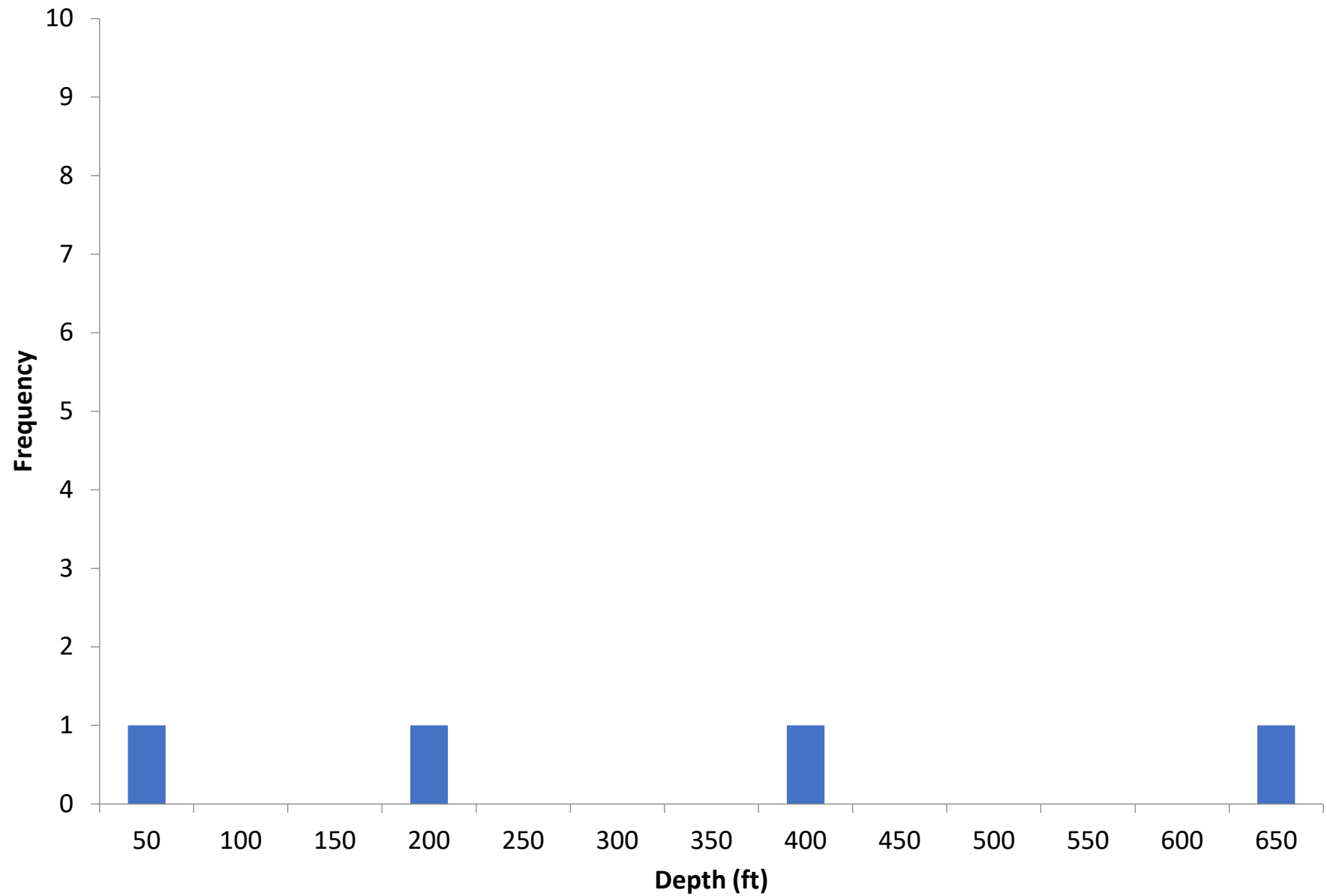
Histogram of Irrigation Wells Installed Since 1990



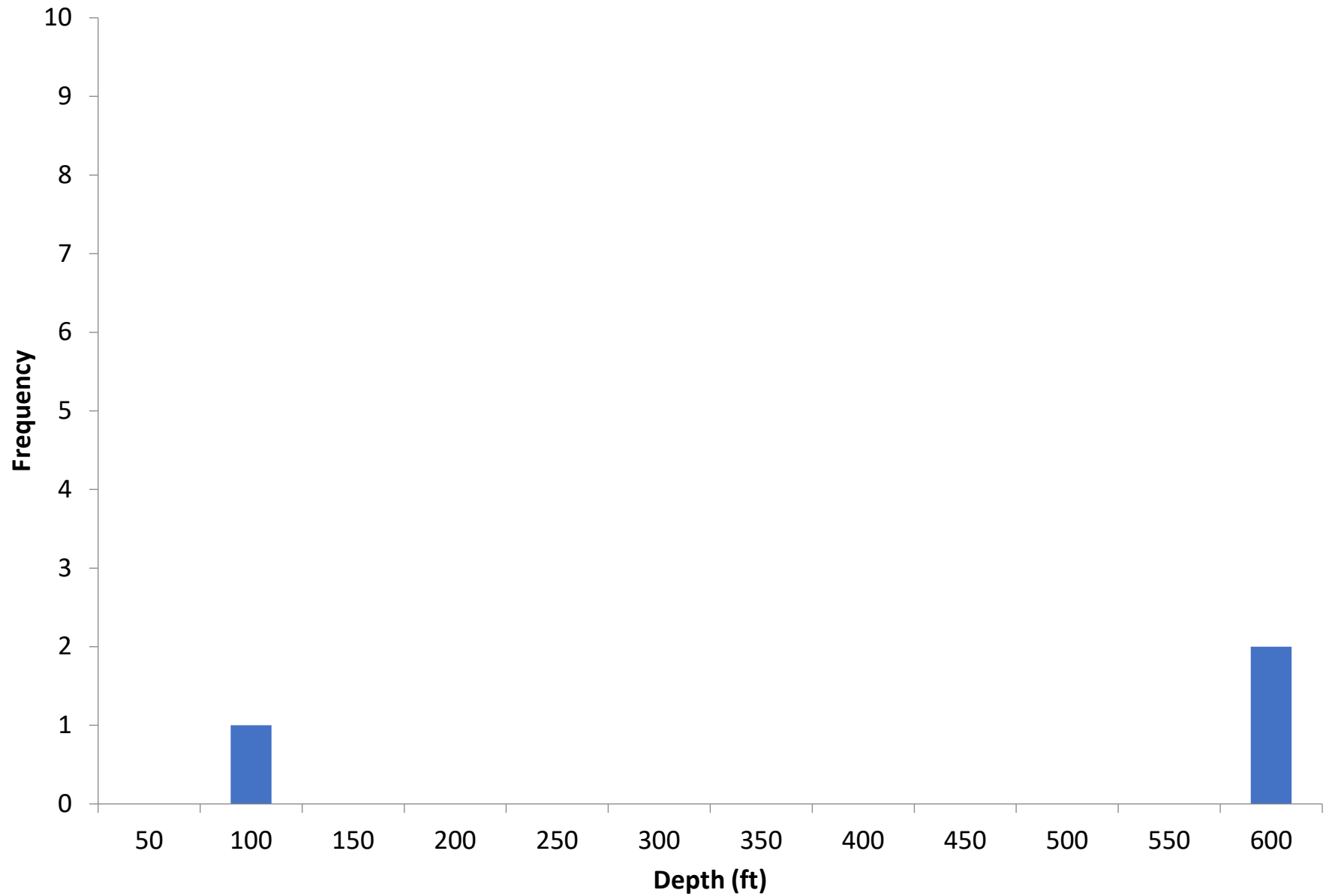
Histogram of Domestic Wells Installed Since 1990



Histogram of Industrial Wells Installed Since 1990



Histogram of Public Supply Wells installed Since 1990



APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

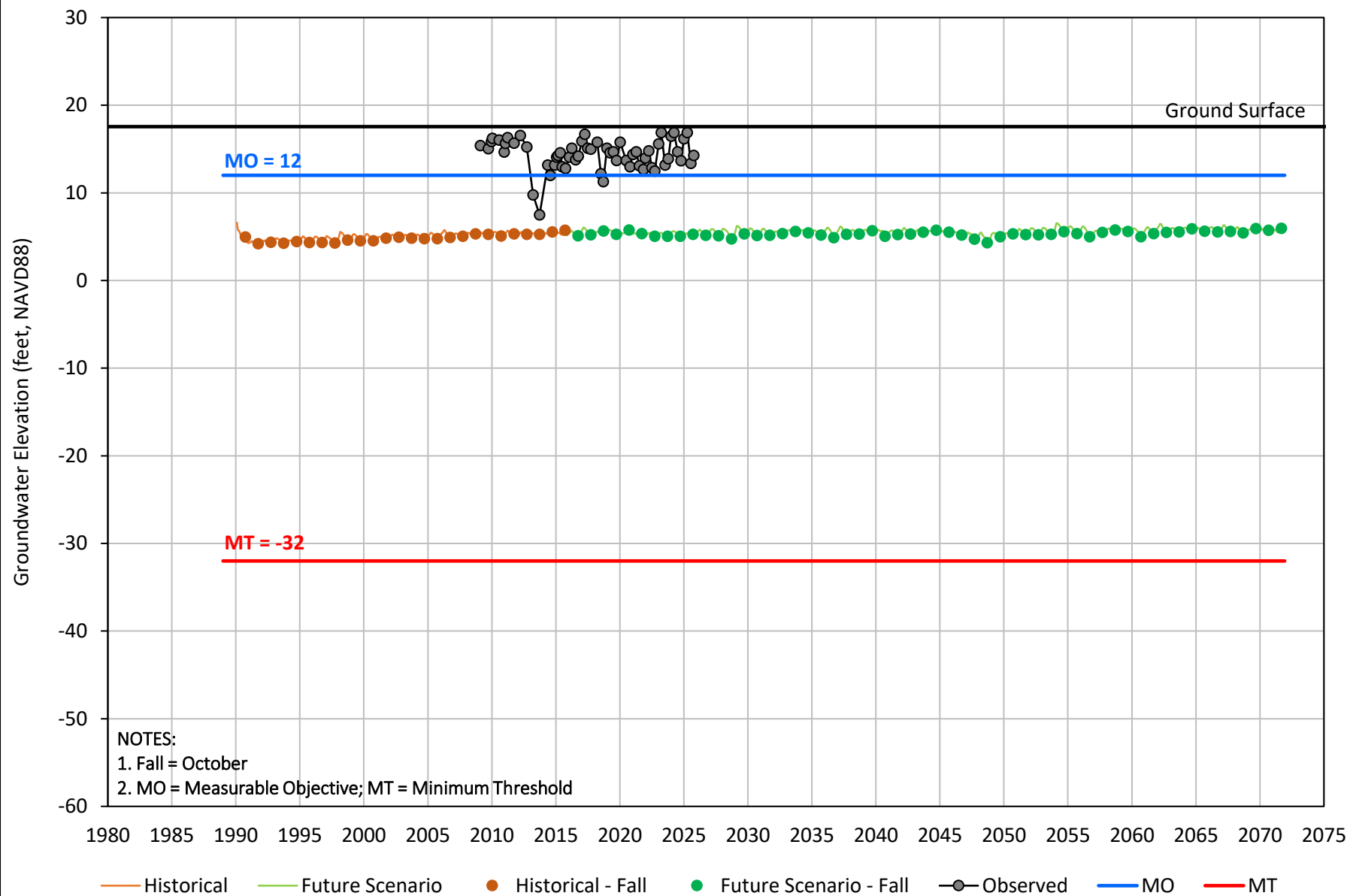
3.A. Supporting Data for Groundwater Level SMC

3.A.b Groundwater Level Hydrographs With MT/MO

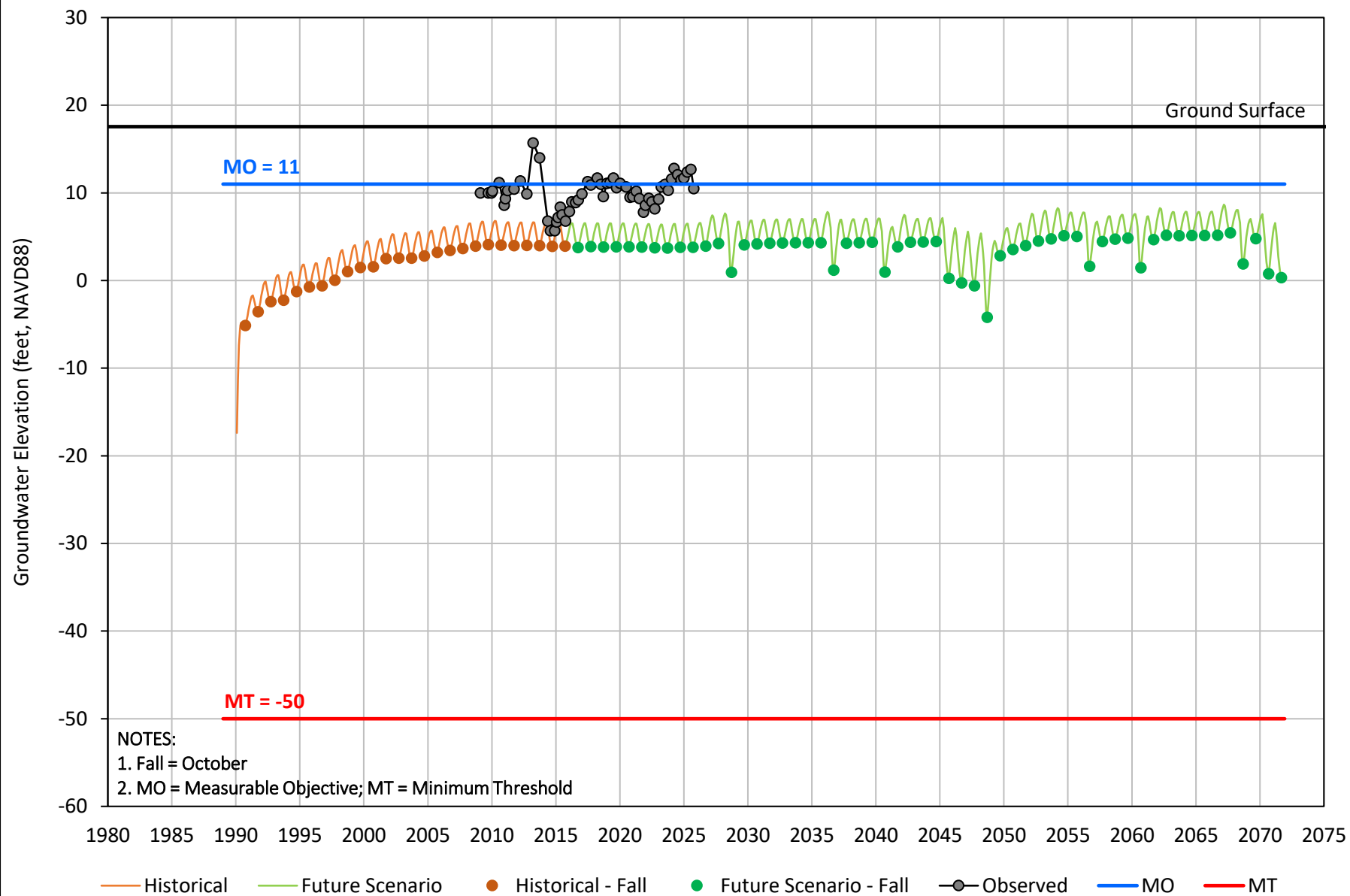
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Well Name: MW-5S

Aquifer: Shallow

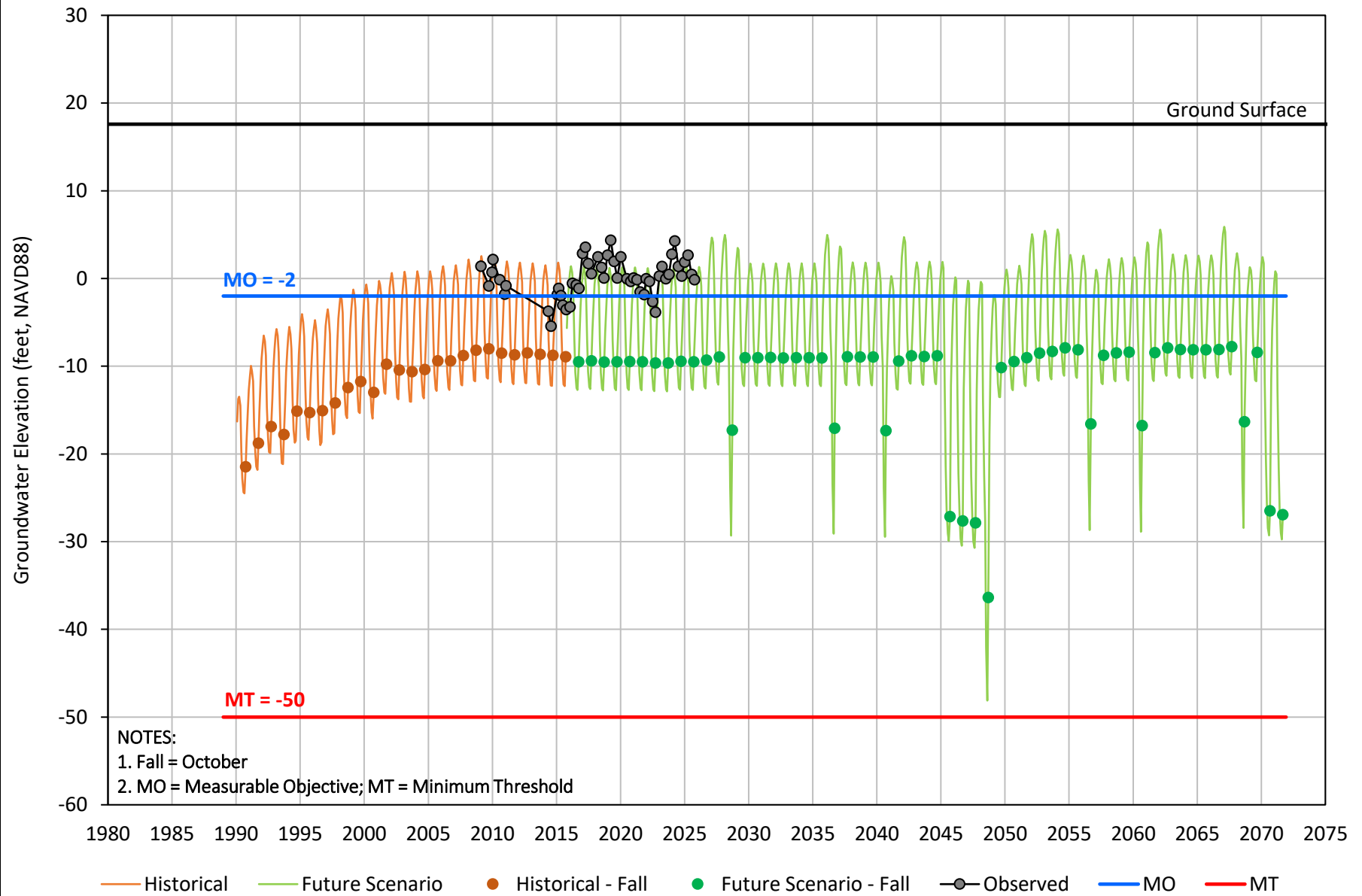


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Aquifer: Intermediate



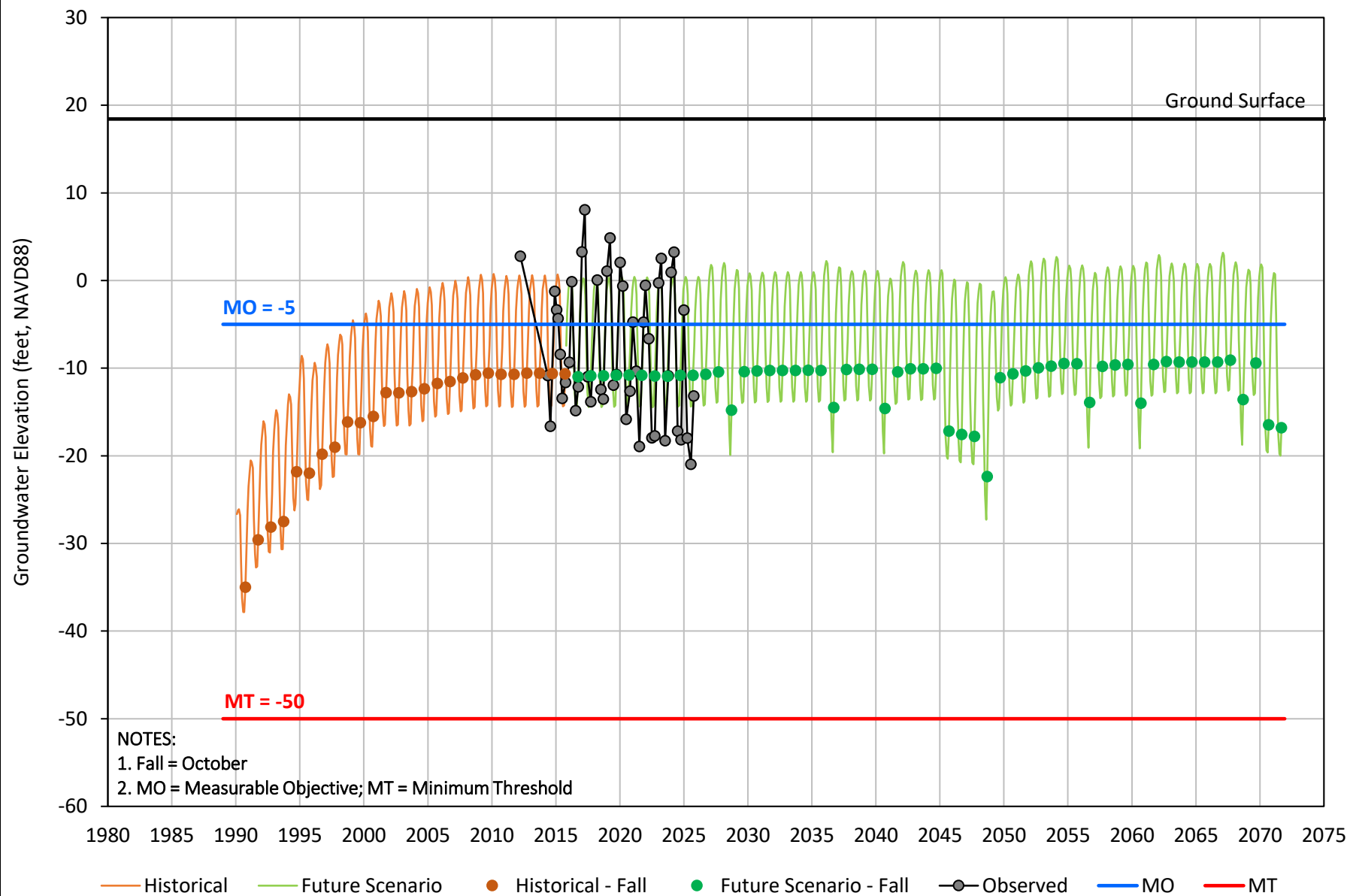
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Aquifer: Deep



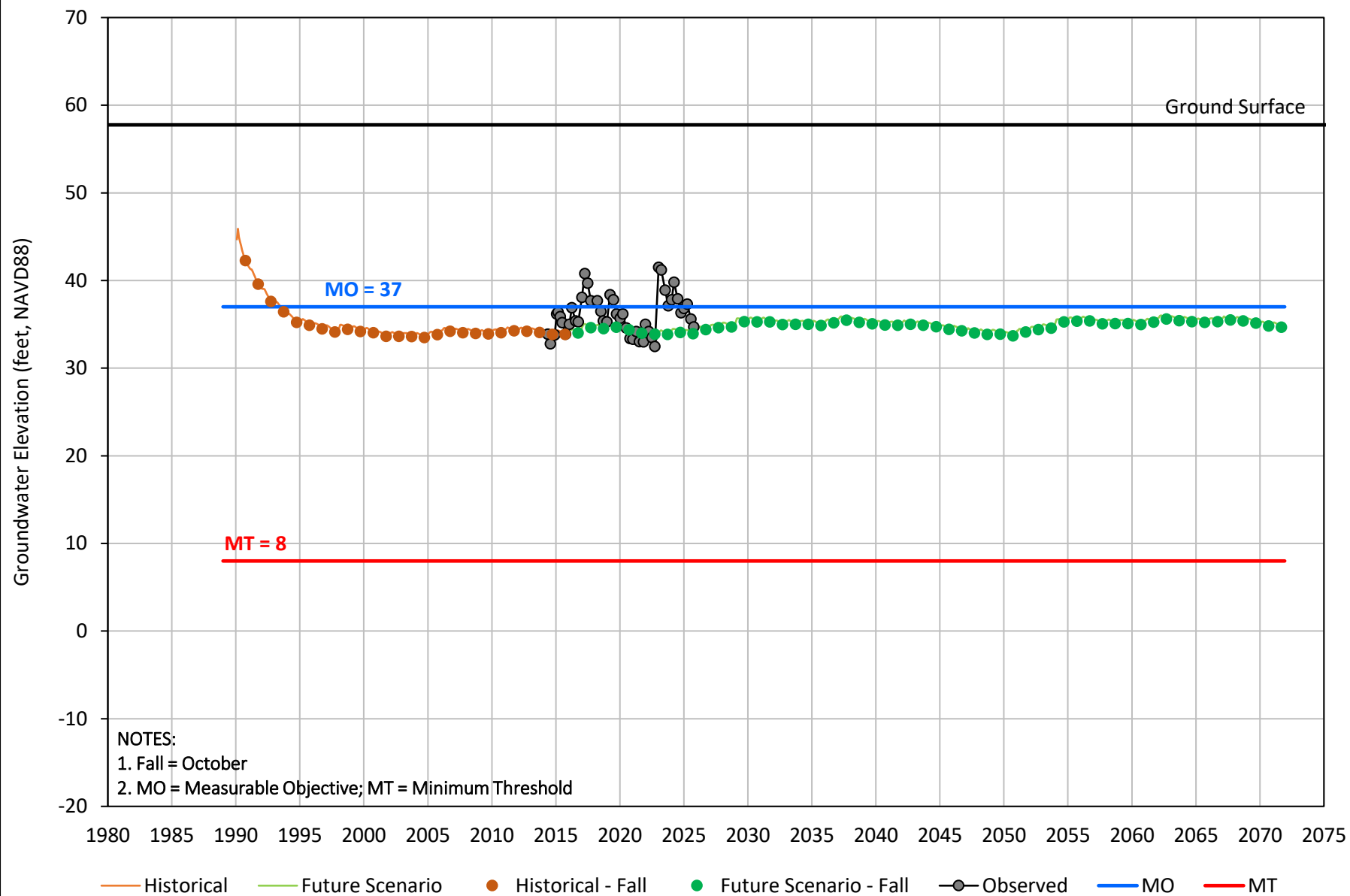
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Aquifer: Deep

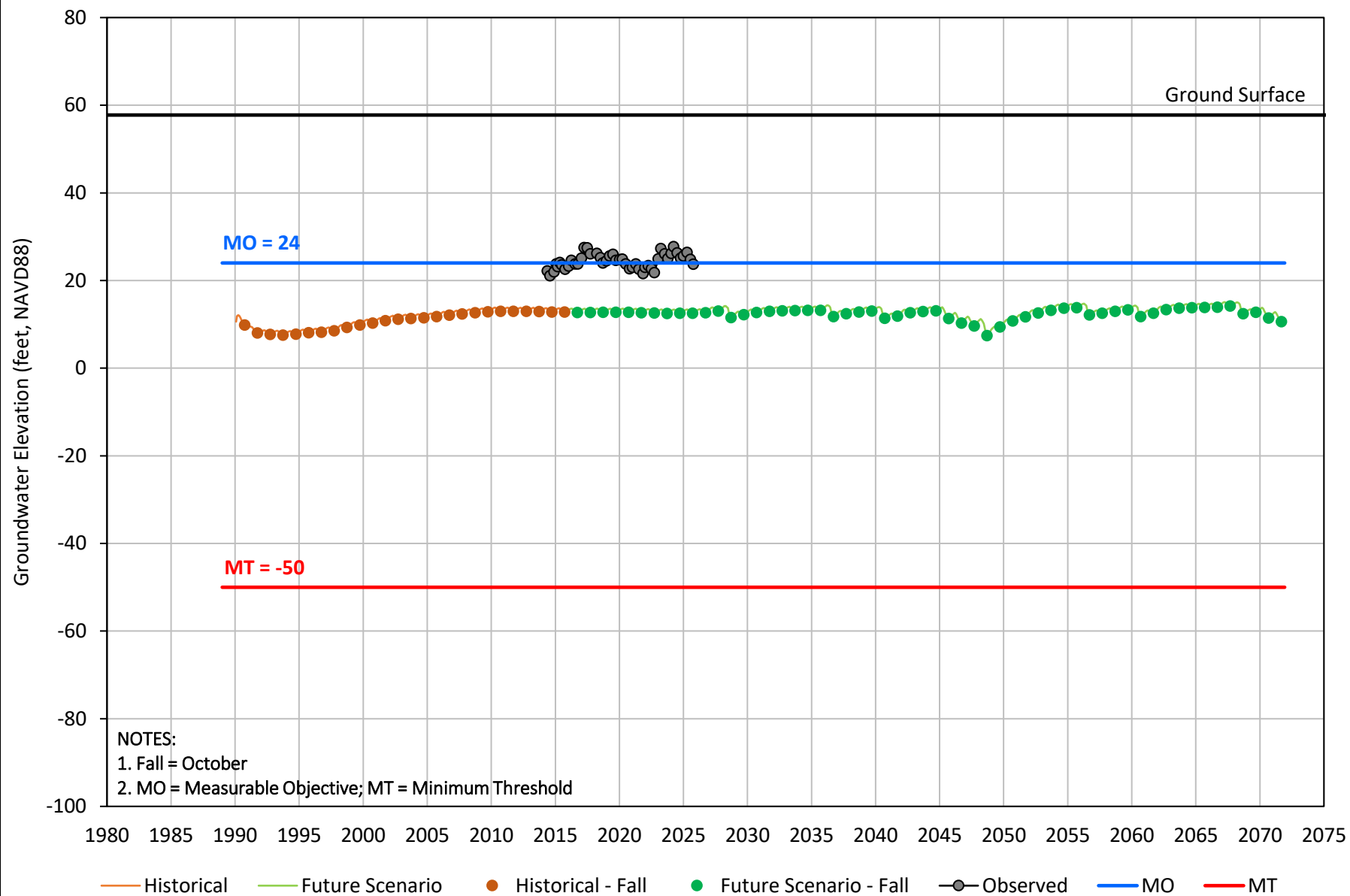


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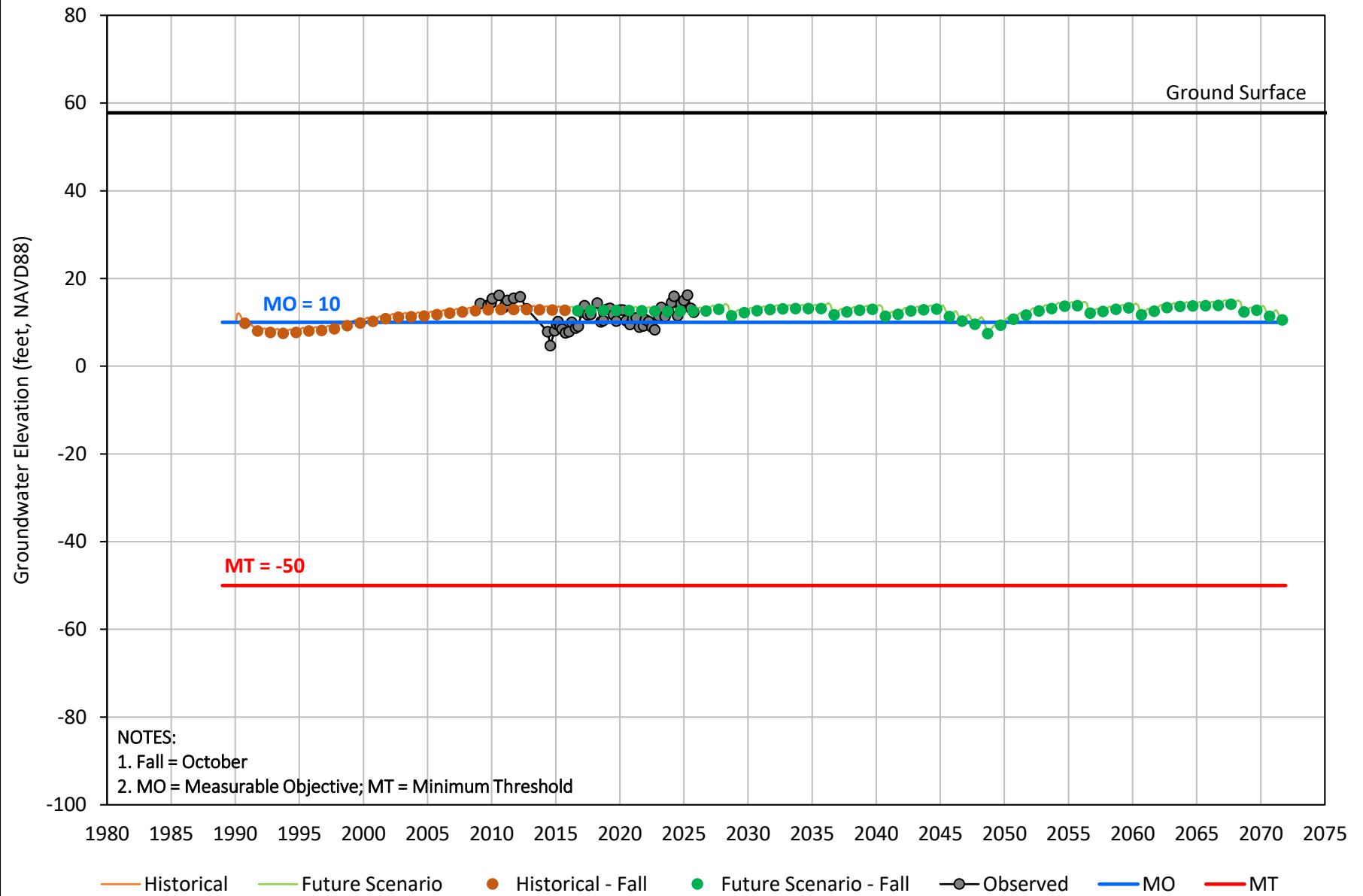


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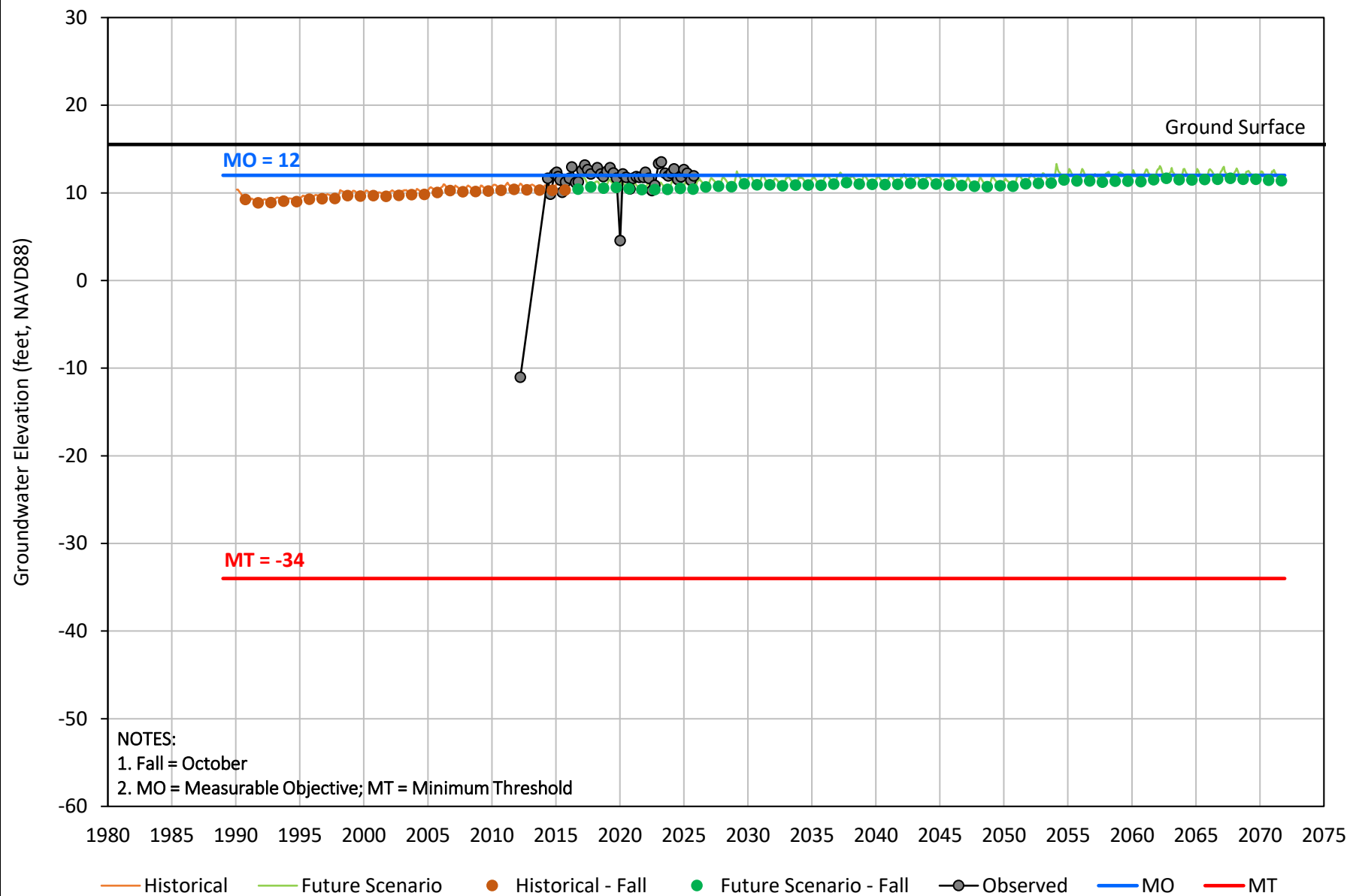
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Aquifer: Deep

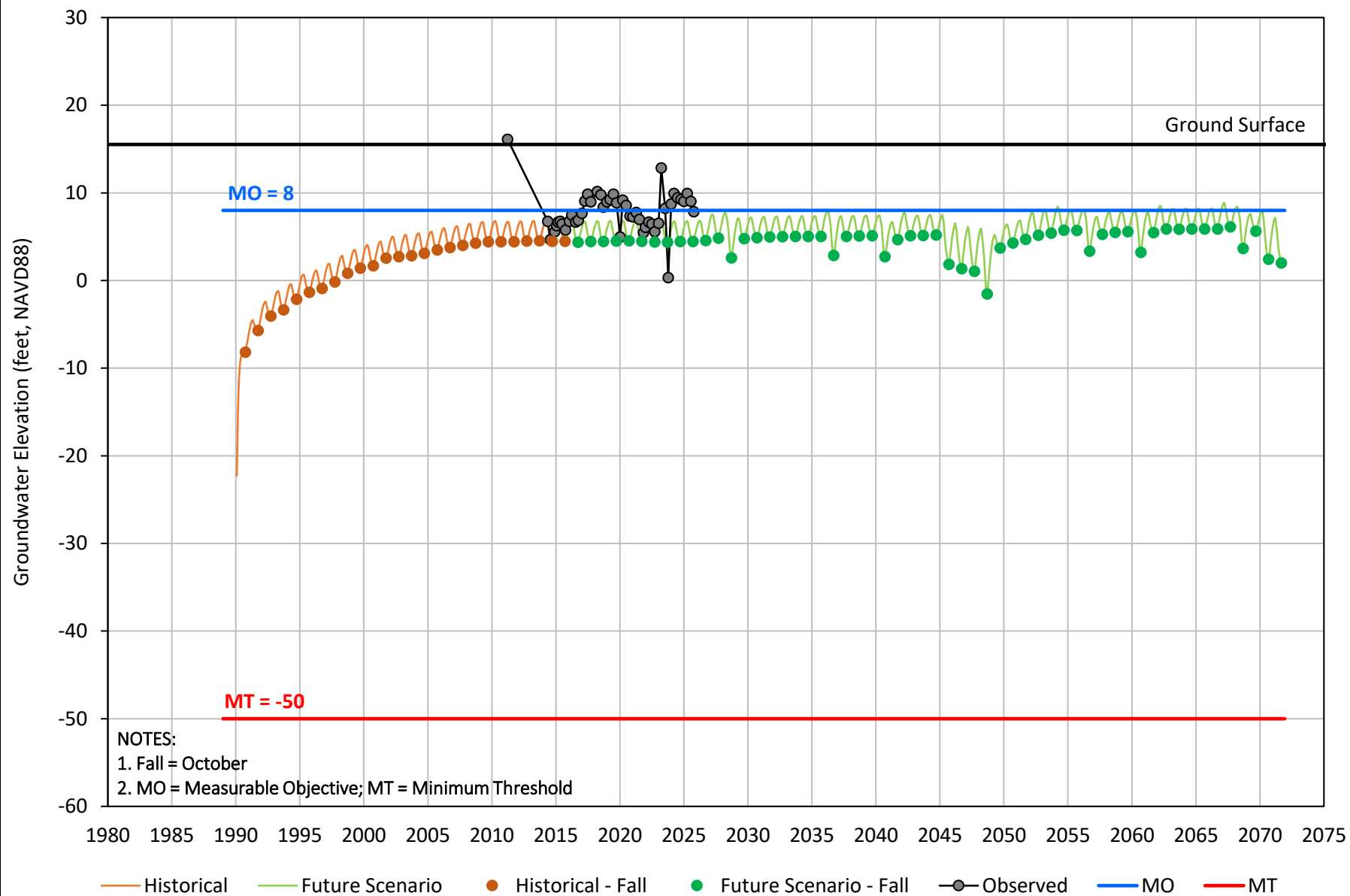


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Aquifer: Shallow

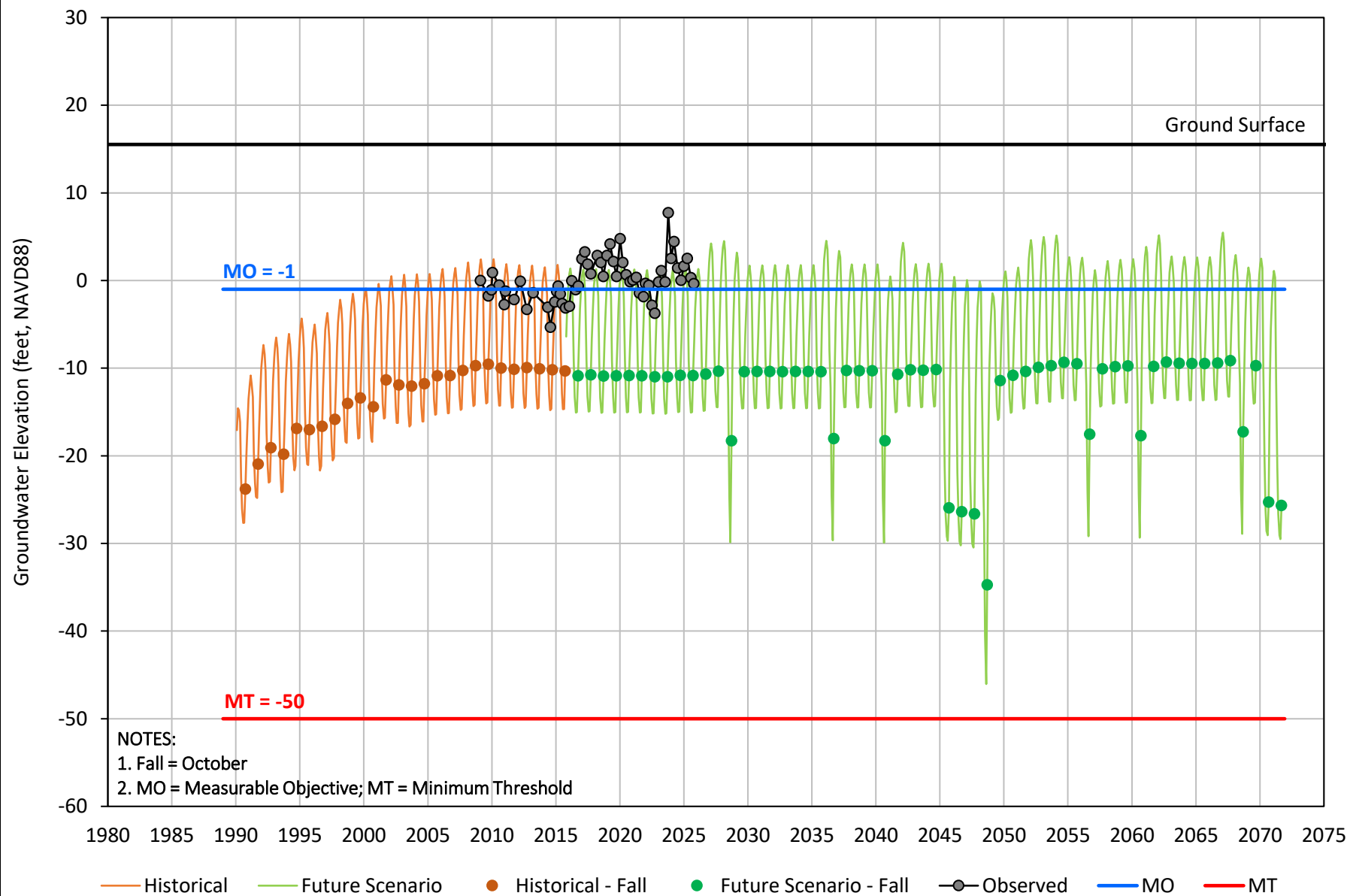


Well Name: MW-10I
Aquifer: Intermediate



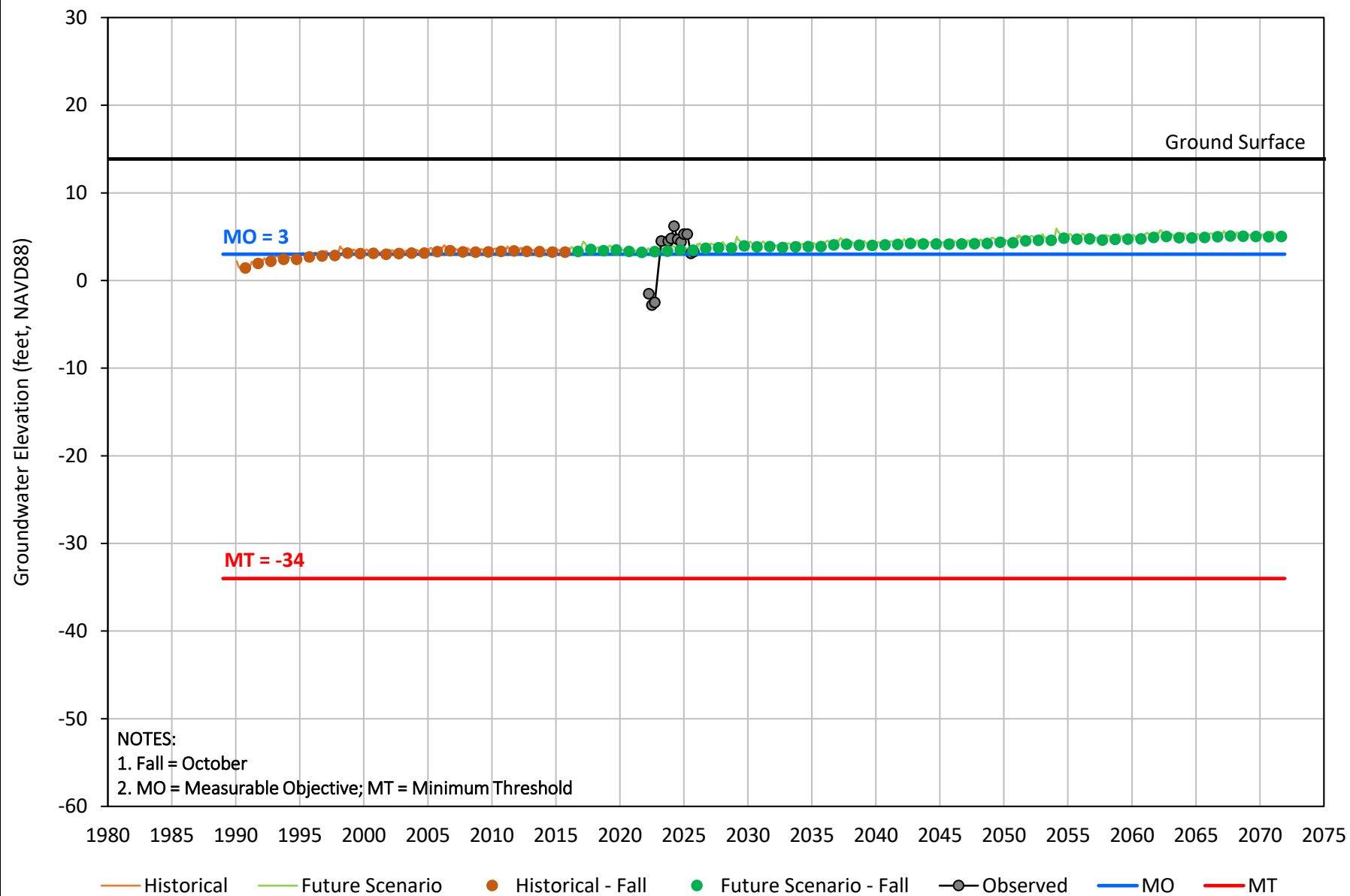
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Aquifer: Deep



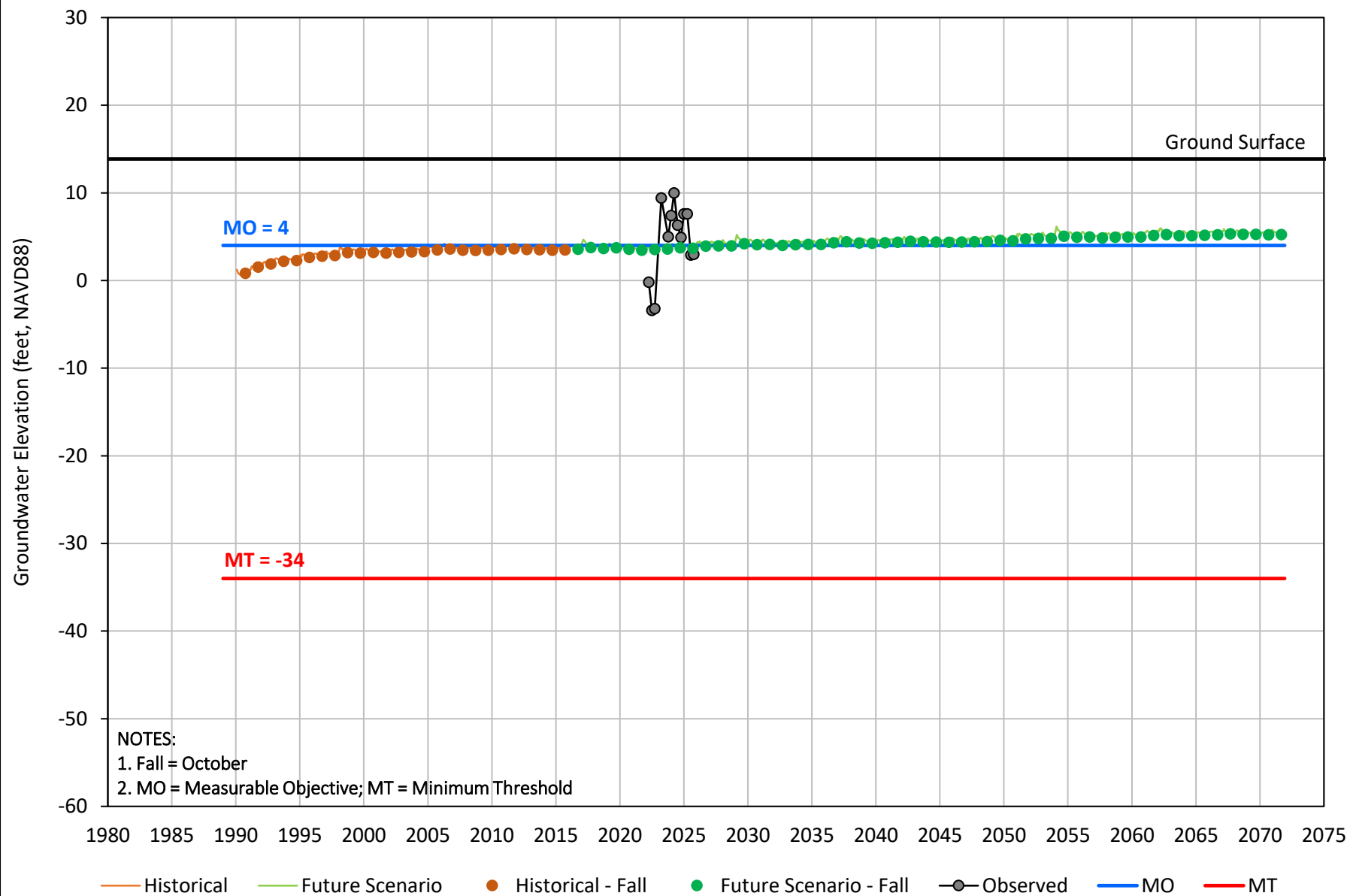
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Aquifer: Shallow



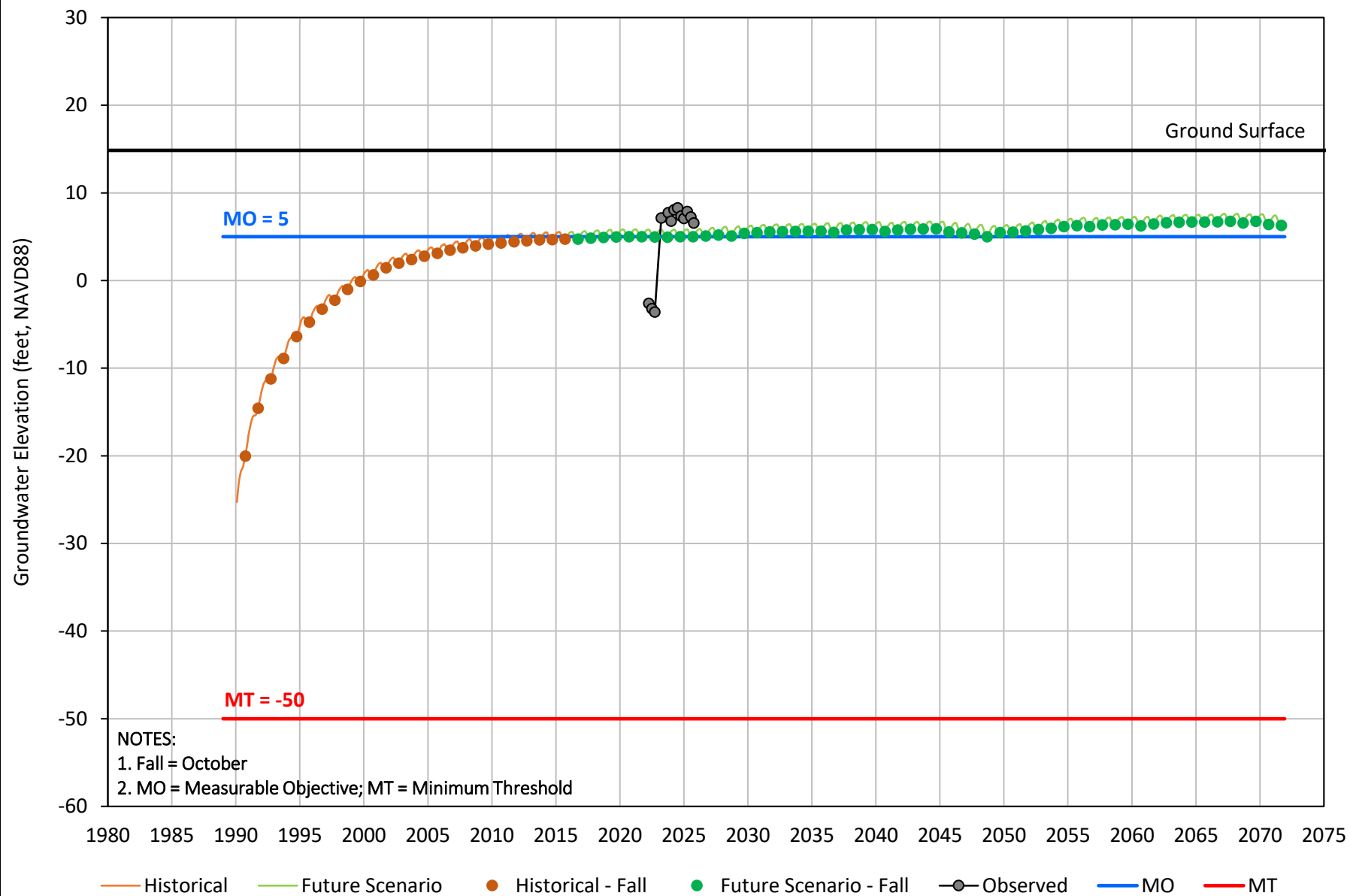
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Aquifer: Shallow

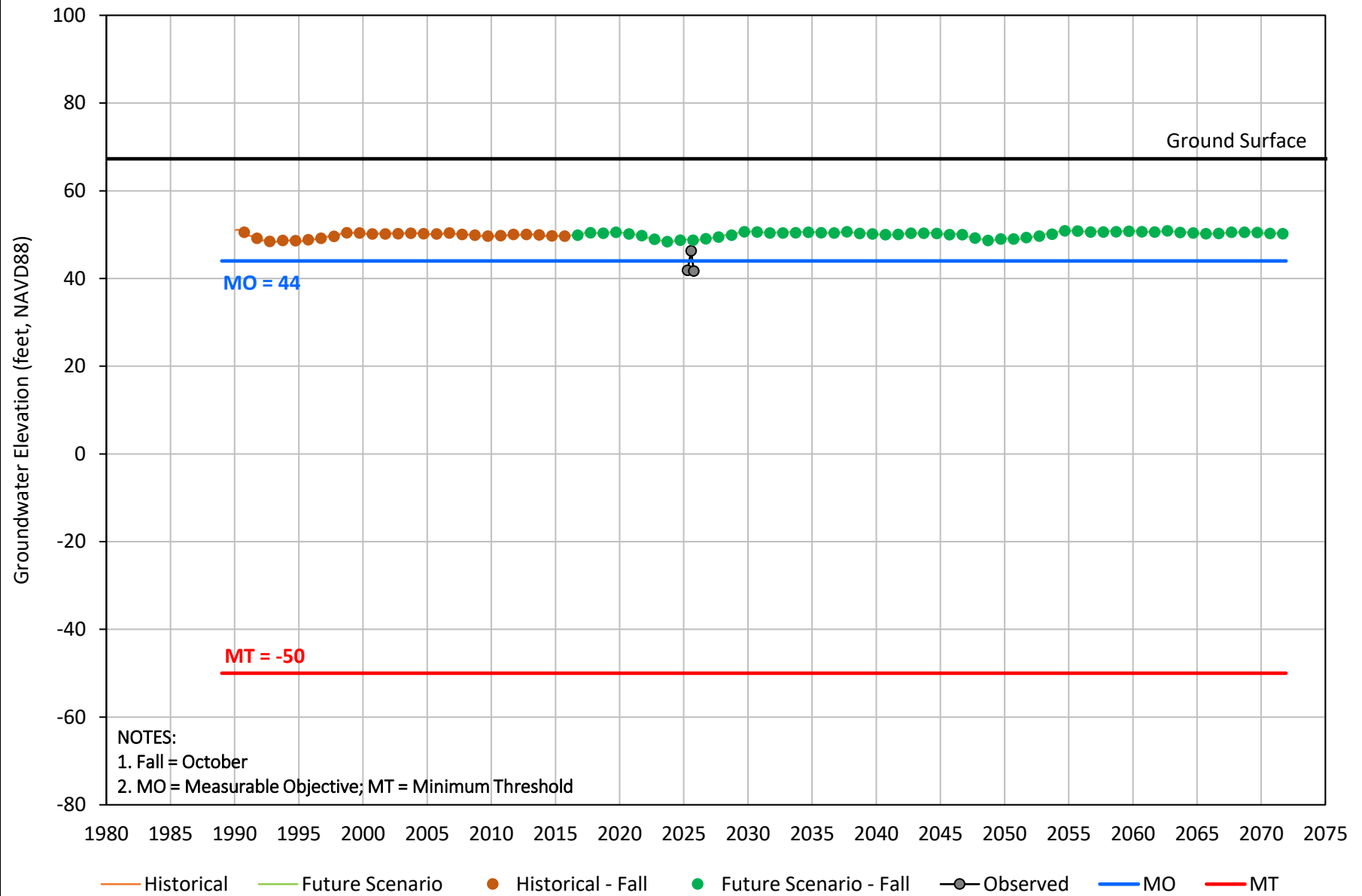


Well Name: S2-MWD1

Aquifer: Deep

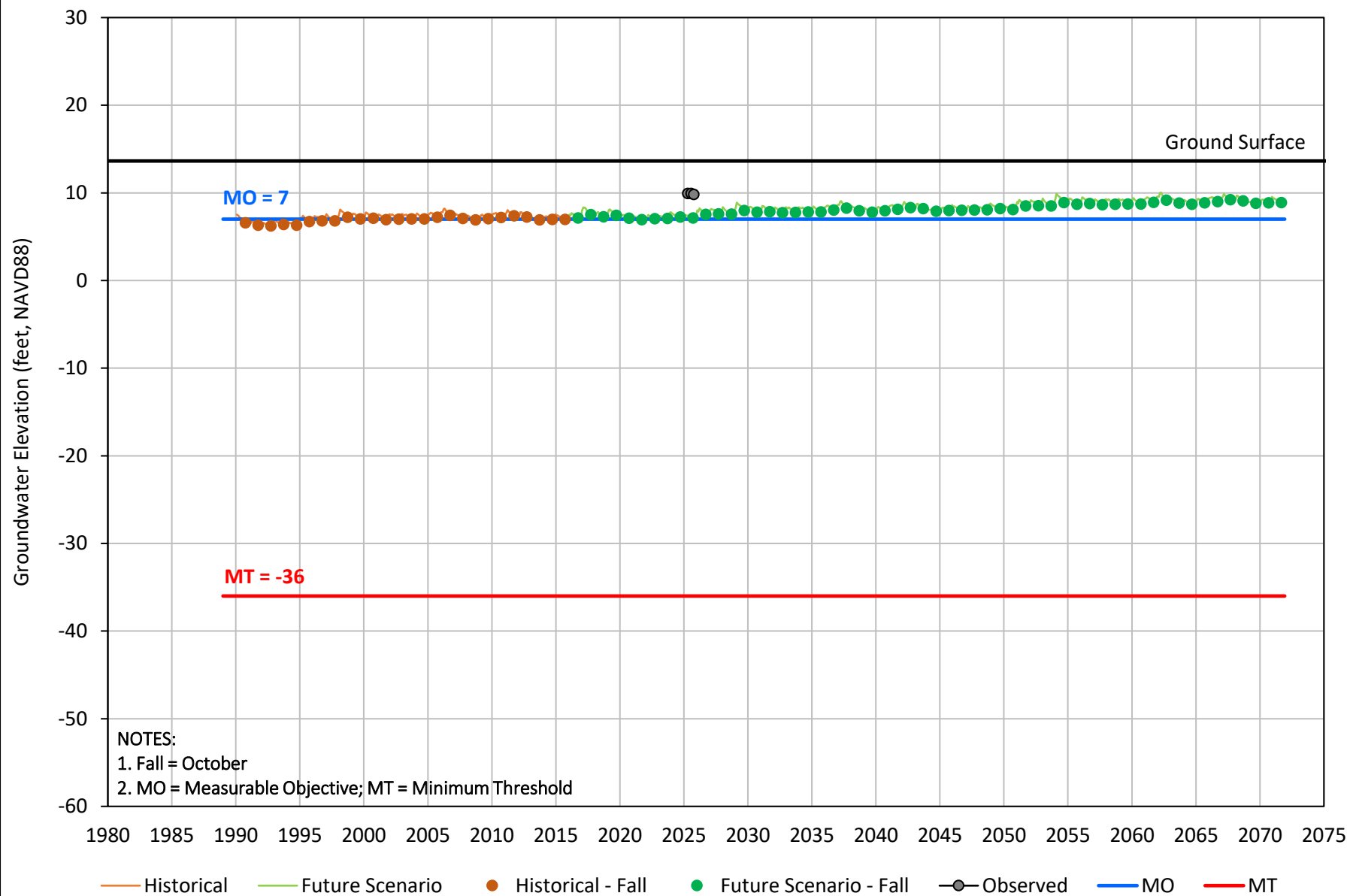


Well Name: MW-N1I
Aquifer: Intermediate

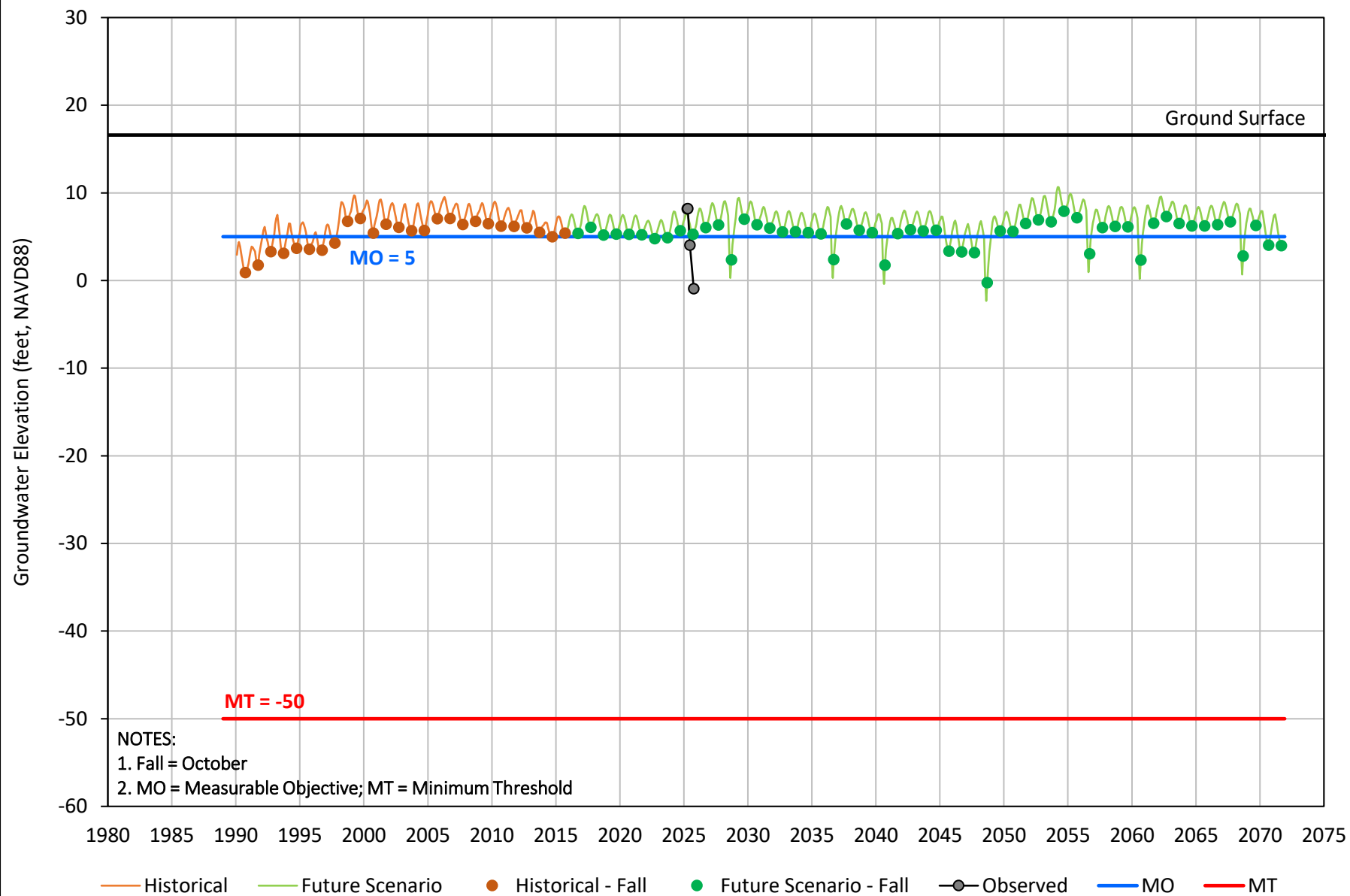


Well Name: MW-N3S

Aquifer: Shallow

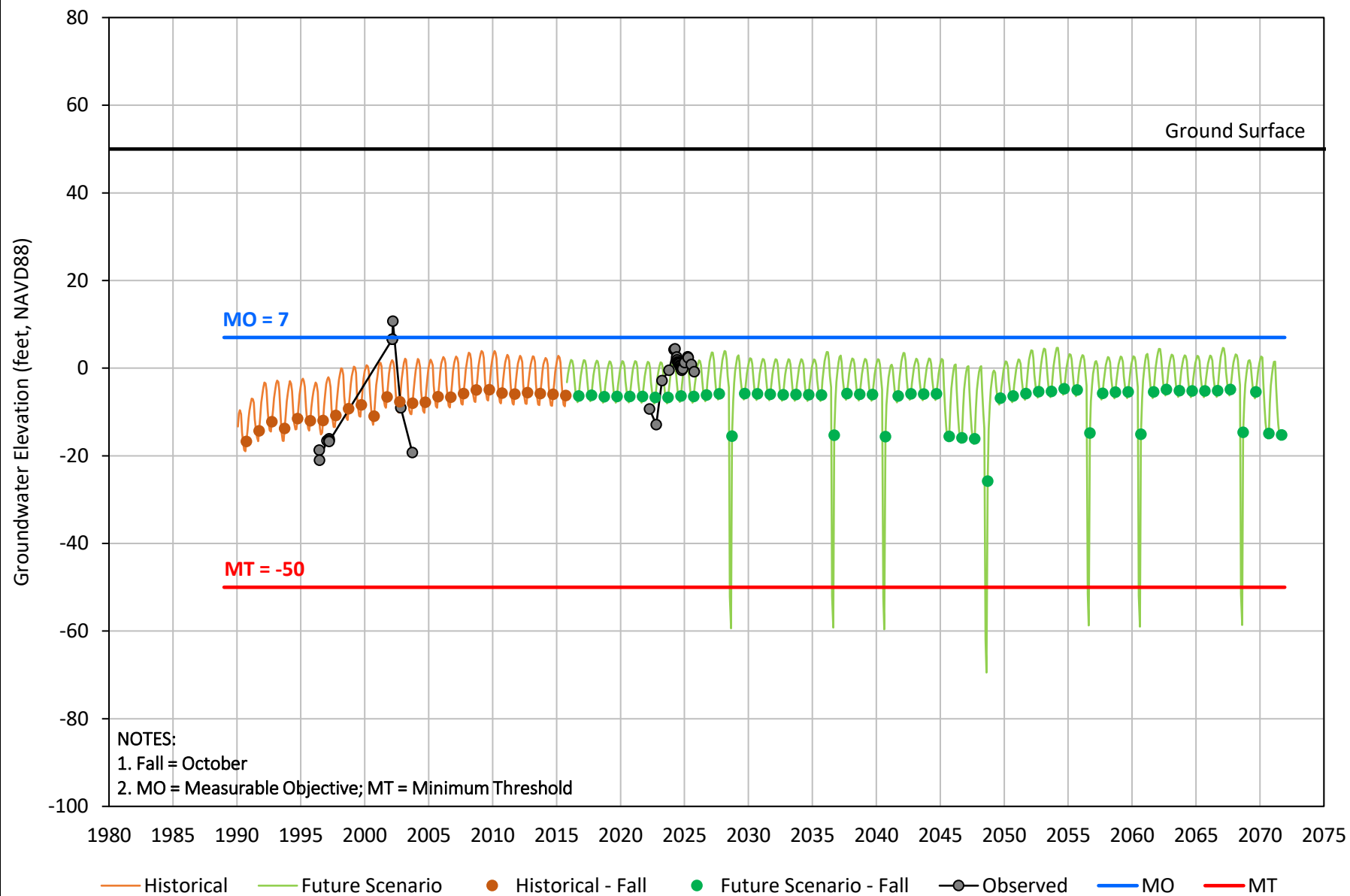


Well Name: MW-S2I
Aquifer: Intermediate



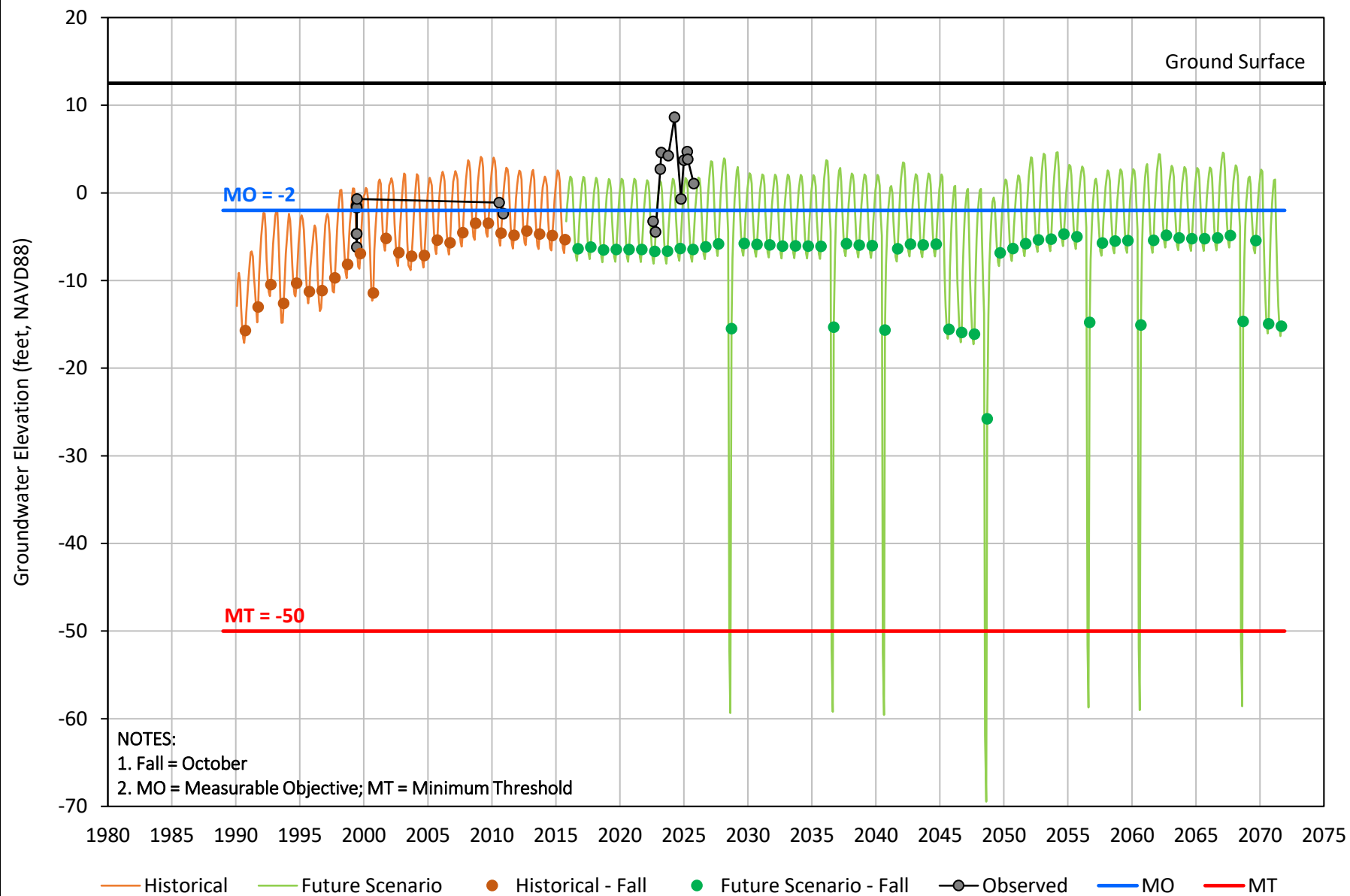
Well Name: Well D

Aquifer: Deep



Well Name: Well E

Aquifer: Deep



APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.B. Supporting Data for Groundwater Storage SMC

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APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.B. Supporting Data for Groundwater Storage SMC

3.B.a Muir Reports With Groundwater Pumping Estimates

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GROUNDWATER DISCHARGE
IN THE
EAST BAY PLAIN AREA
ALAMEDA COUNTY, CALIFORNIA

BY: KENNETH S. MUIR

PREPARED FOR THE
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
HAYWARD, CA 94544
UNDER CONTRACT NUMBER C-95-320
JULY, 1996

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ABSTRACT

There were two forms of groundwater discharge occurring in the area of the East Bay Plain in 1995: natural discharge (evapotranspiration and subsurface discharge); and artificial discharge (pumpage).

The following table lists the values determined for the various discharge elements in the East Bay Plain area in 1995:

DISCHARGE ELEMENT	DISCHARGE (ACRE-FEET PER YEAR)
NATURAL DISCHARGE	
EVAPOTRANSPIRATION	25,800
SUBSURFACE	<u>13,500</u>
SUBTOTAL	39,300
ARTIFICIAL DISCHARGE	
AGRICULTURAL USE	910
DOMESTIC USE	620
INDUSTRIAL USE	<u>1,820</u>
SUBTOTAL	3,350
TOTAL	42,650

The values shown in the table illustrate that natural discharge was the predominant form of groundwater discharge from the East Bay Plain area in 1995.

Data indicates that over the past 30 years artificial groundwater discharge (pumping) has decreased and the subsurface discharge element of natural discharge has increased. Evapotranspiration has probably remained nearly constant.

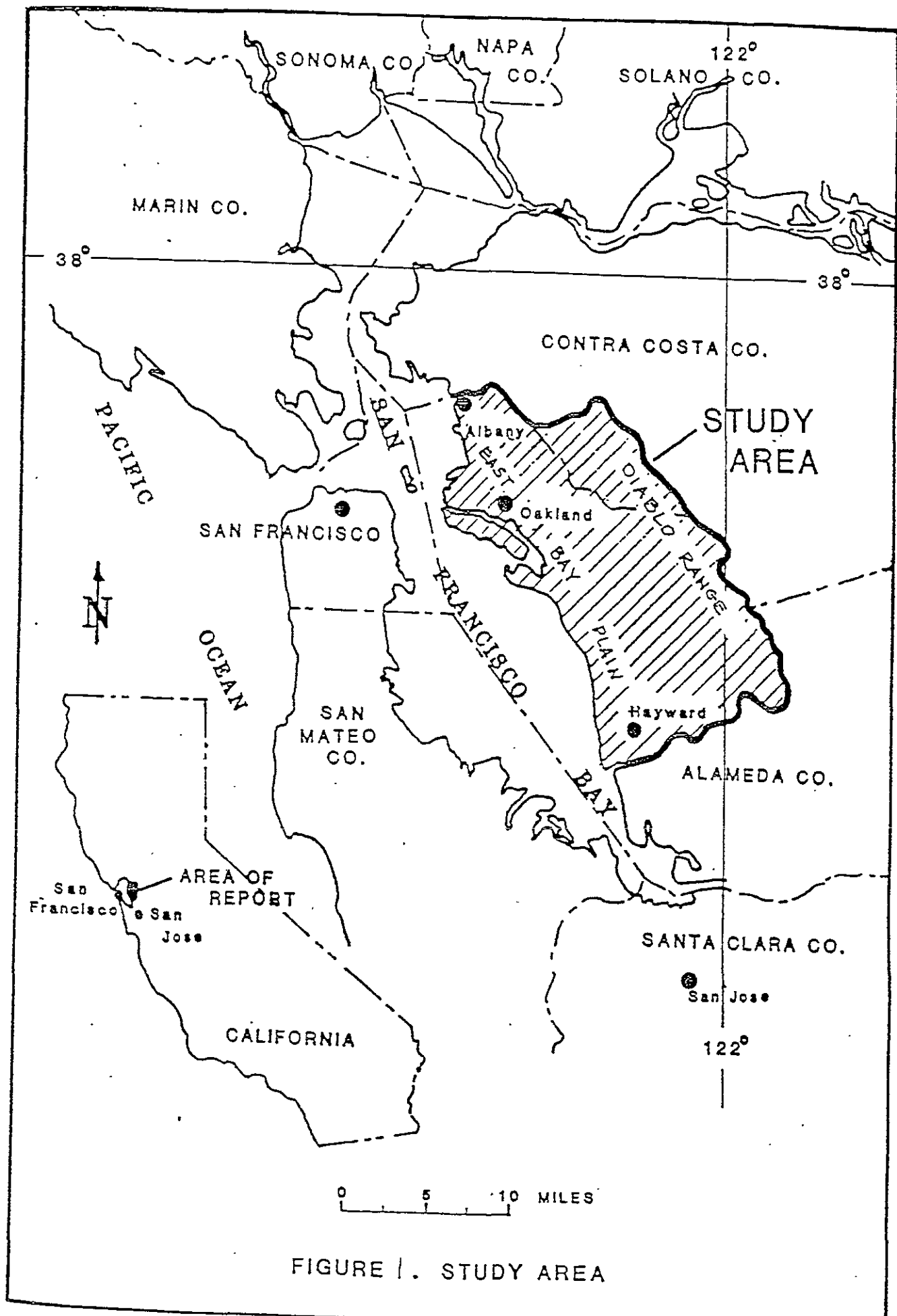
INTRODUCTION

Purpose and Scope

The purpose of this study was to delineate and determine amounts of groundwater discharge in the East Bay Plain area of Alameda County, California (Figure 1).

The scope of this study included the following:

1. A description of the different elements of groundwater discharge that occur in the East Bay Plain area;
2. An estimate of the amount of the groundwater discharge for each of the individual elements; and



3. A discussion of how groundwater discharge has changed over the years.

This report deals with another phase of continuing studies that are designed to supply the elements needed for the understanding of the groundwater resources of the East Bay Plain area.

A previous report (Muir, 1995) discussed and evaluated the items of inflow (recharge) to the groundwater reservoir. This present report deals with the items of groundwater outflow (discharge).

The Alameda County Flood Control and Water Conservation District will utilize the information from the present study and associated studies to assist them in their groundwater management and planning decisions. The District has the responsibility, through the act that established it, to protect the groundwater and surface-water resources of the East Bay Plain area for beneficial use.

Location and General Features

The East Bay Plain area comprises about 222 square miles in Alameda and Contra Costa Counties. The area is made up of about 108 square miles of mountainous, uplands and about 114 square miles of flat, alluviated lowlands and bay and tidal marshes. The lowland area is known as the East Bay Plain (Figure 1). The present report focuses on these flat alluviated lowlands. The study area extends westward from the Hayward Fault to San Francisco Bay and from Albany on the north to Hayward on the south (Figure 1 and 2). Oakland is the largest city in the study area. The study area includes all of the groundwater subareas shown on Figure 2, except the Niles Cone and the Castro Valley Basin.

Principal land uses in the East Bay Plain area are residential, commercial, and industrial. There is also some agricultural use.

The study area has a mediterranean type climate. The summers are dry and warm and the winters wet. Most of the rain occurs during the months of November through March. Mean annual precipitation ranges from 16 inches in the lower elevations to over 26 inches in the higher elevations within the study area. The average annual precipitation over the entire area is approximately 23 inches.

San Leandro and San Lorenzo Creeks are the principal drainages. These creeks originate in the eastern highlands of the Diablo Range and drain westerly across the East Bay Plain into San Francisco Bay.

Two categories of geologic units are found in the East Bay Plain area: (1) consolidated rocks of Jurassic, Cretaceous, and Tertiary age, and (2) unconsolidated deposits of Pleistocene and Holocene age.

The consolidated rocks are mostly found in the hills east of the Hayward Fault and beneath the unconsolidated deposits. They form the bottom and

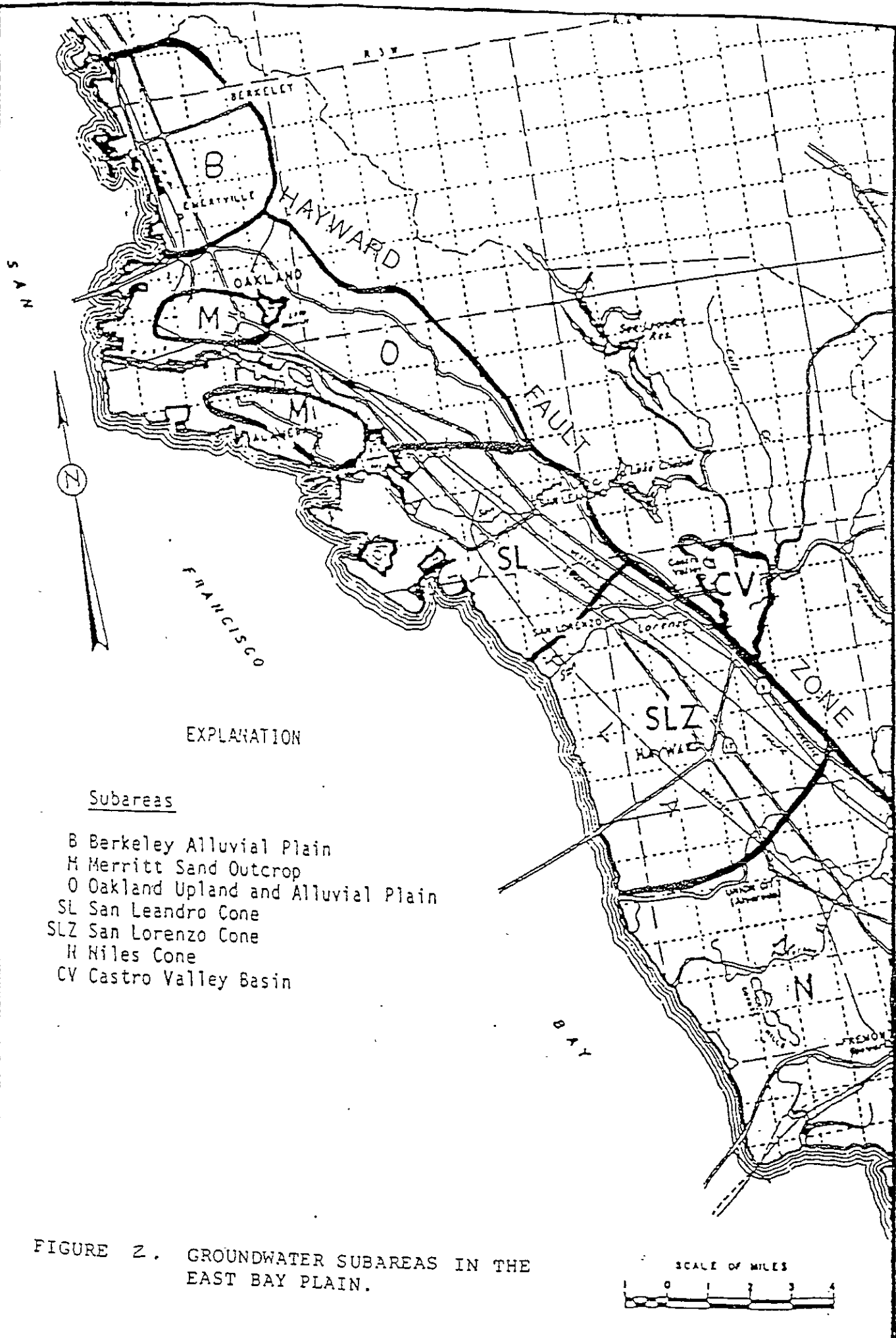


FIGURE 2. GROUNDWATER SUBAREAS IN THE EAST BAY PLAIN.

eastern boundaries of the East Bay Plain aquifer system. These units are probably about 10,000 feet thick.

The unconsolidated deposits lie beneath the East Bay Plain. Collectively, they make up the groundwater reservoir of the East Bay Plain area. They have a maximum thickness of about 1,100 feet.

The direction of groundwater flow beneath the East Bay Plain area is from the foothills of the Diablo Range westward toward San Francisco Bay.

Groundwater beneath the East Bay Plain is found mostly under confined conditions. Only some near surface deposits and the upper portions of the San Lorenzo and San Leandro Cones (Figure 2) contain groundwater under unconfined conditions.

G R O U N D W A T E R D I S C H A R G E

There were two forms of groundwater discharge occurring in the area of the East Bay Plain in 1995: natural discharge (evapotranspiration and subsurface discharge); and artificial discharge (pumpage). In the past several other forms of natural groundwater discharge may have occurred: groundwater discharge to streams and spring discharge; neither of these forms of natural discharge were occurring in 1995.

Figure 3 graphically illustrates the elements that make up the groundwater inventory of the East Bay Plain area. Those elements lying on the left hand side of the diagram collectively represent recharge to the groundwater reservoir and those on the right discharge. This report evaluates the discharge elements. A previous report (Muir, 1995) evaluated the recharge elements. It should be noted that the element in the diagram labeled "surface runoff" represents discharge from the groundwater reservoir not runoff from rainfall. It is an inconsequential element in groundwater discharge at the present.

Natural Discharge

Natural discharge includes two elements: evapotranspiration and subsurface discharge.

Evapotranspiration

Evapotranspiration (ET) is the use of water by growing vegetation plus water evaporation from adjacent soils. It is considered a form of groundwater discharge (Figure 3) when evaluating groundwater-reservoir storage, and its recharge and discharge elements.

ET was determined by Muir (1995) for his groundwater-recharge report and is only summarized in this present report.

Muir (1995) developed an average effective yearly ET by using long-term climatic data from the East Bay Plain and correlating this data with ET

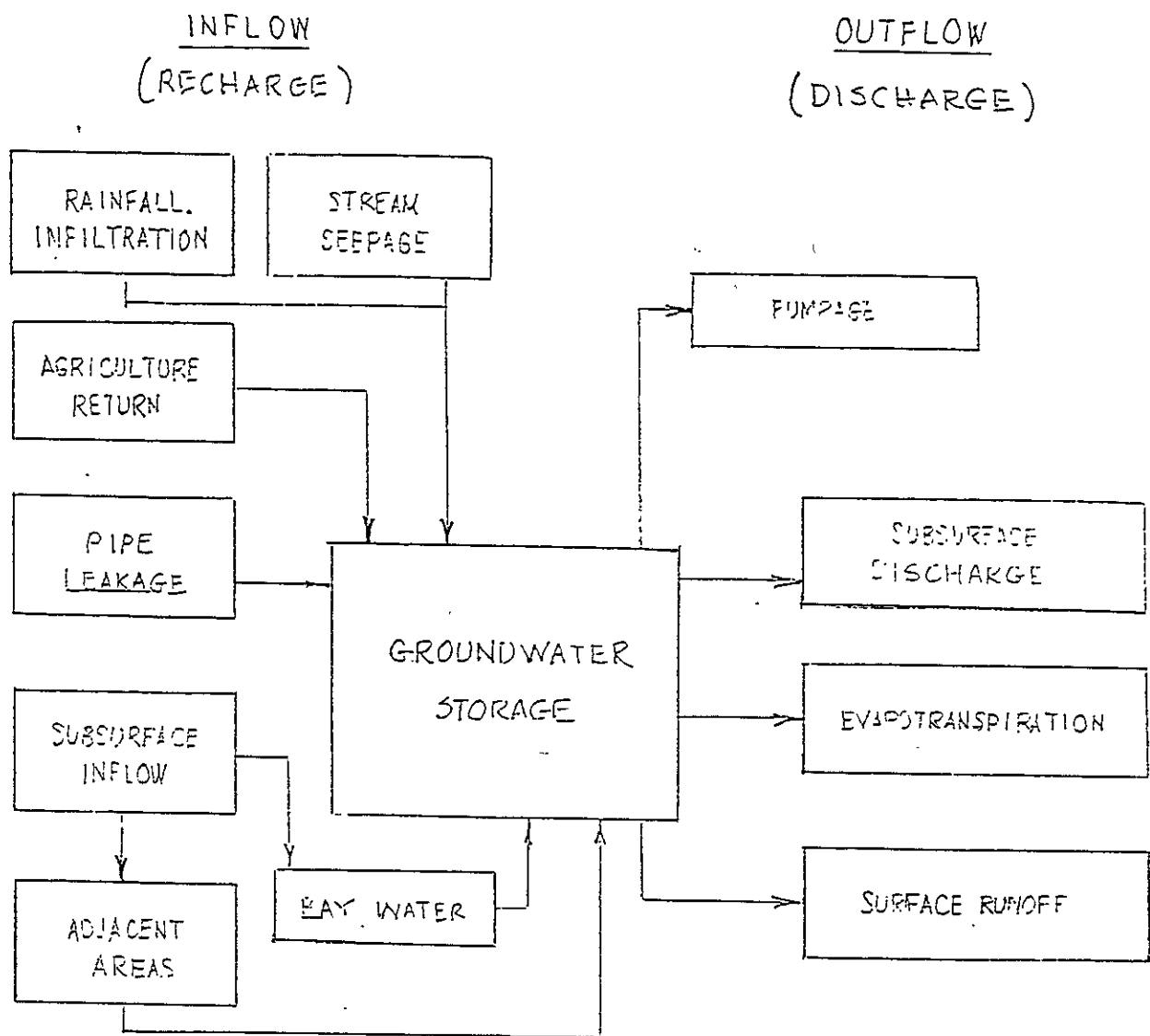


FIGURE 3. GROUNDWATER INVENTORY

studies made in comparable areas of California. He found that the average ET for the East Bay Plain was approximately 8 inches per year. This indicates that ET consumes about 38 percent of the water available from average rainfall. He then calculated the amount of water removed (discharged) from each groundwater subarea by ET. The following table lists the values that were obtained for the East Bay Plain.

TABLE 1

YEARLY AVERAGE EVAPOTRANSPIRATION FOR THE EAST BAY PLAIN	
GROUNDWATER SUBAREAS (SEE FIGURE 2)	EVAPOTRANSPIRATION (ACRE-FEET)
BERKELEY ALLUVIAL PLAIN	3,260
OAKLAND UPLAND AND ALLUVIAL PLAIN	7,250
MERRITT SAN OUTCROP	2,920
SAN LORENZO CONE	6,520
SAN LEANDRO CONE	5,830
TOTAL	25,780

Subsurface Discharge

Water level contours and gradients found beneath the East Bay Plain subareas (Figure 2) indicate that the direction of most groundwater flow is from east to west - from near the Hayward Fault towards San Francisco Bay.

There is some question as to what is occurring with groundwater flow in the south end of the study area, near Union City (Figure 2). The few water-level measurements available in this area make it impossible to make a definitive statement regarding direction of groundwater flow. However, the meager water-level data suggest that groundwater in the lower aquifer zones may be moving north while that in the upper zones may be moving south, probably resulting in a net subsurface flow of near zero.

The conclusion made by the author for the present report, based on water-level contours and gradients, is that the vast majority of subsurface groundwater discharge in 1995-96 was occurring at the bay margin, with flow toward the west and under San Francisco Bay.

Following are the steps, procedures, and criteria used in this report to determine the amount of subsurface groundwater discharge from the East Bay Plain:

1. The hydraulic conductivities used in this report are based on those developed by Woodward-Clyde (1992, 93) and Brown and Coldwell (1986) in the Hayward and San Leandro areas.
2. Determined average water levels and depth to water for each subarea at bay margin from drillers logs and monitor wells, taking into consideration the fact that the upper water-bearing zone is unconfined and the lower confined.
3. Determined groundwater gradient at bay margin for each subarea from water-level contour maps.
4. Determined average thickness of unconsolidated deposits at bay margin for each subarea.
5. Determined width of each subarea at bay margin.
6. Determined from water-level data how much of each subareas unconsolidated vertical section at its bay margin is saturated. This was a factor in the calculation of transmissivity.
7. For subsurface discharge calculations in the San Leandro and San Lorenzo Cones limited the depth of unconsolidated deposits to upper 600 feet. The few drillers and electric logs of wells that penetrate deeper than 600 feet indicate very little aquifer material in the zone from 600 feet to 1000 feet. The subsurface discharge calculations should be revised if, in the future, more deep wells are drilled and their lithologic data indicates that there are actually aquifer zones in the interval from 600 feet to 1000 feet.
8. Determined a transmissivity factor for each subarea for the depth zones of 5 feet to 200 feet and 200 feet to 600 feet. The transmissivities were calculated using the hydraulic conductivity data from Woodward-Clyde (1992, 93) and Brown and Caldwell (1986), and aquifer thickness based on aquifer-aquiclude percentages from Table 3 of Muir's geologic framework report (1992).

It should be noted that hydraulic conductivity and width of the subareas will remain constant and the variable to subsurface discharge will be the saturated aquifer thickness and the groundwater gradient at, or near, the bay margin. Whatever influences the groundwater levels, be it aquifer recharge or discharge, will, in turn, govern the amount of subsurface discharge from the East Bay Plain.

Table 2 and Table 3 lists the values developed to determine subsurface groundwater discharge from the East Bay Plain. The results shown in Table 3 indicate that subsurface discharge in 1995 was 13,500 acre-feet.

TABLE 2

HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY OF AQUIFERS AT BAY MARGIN

GROUNDWATER SUBAREA (SEE FIGURE 2)	AVERAGE THICKNESS OF UNCONSOLIDATED DEPOSITS AT BAY MARGIN	AQUIFER PERCENTAGE	SATURATED AQUIFER THICKNESS (1)			HYDRAULIC CONDUCTIVITY (GPD/FT ²) (2)			TRANSMISSIVITY (GPD/FT) (3)	
			BY DEPTH ZONES (FEET)			BY DEPTH ZONES (FEET)			BY DEPTH ZONES (FEET)	
			5-30	30-200	200-600	5-30	30-200	200-600	5-200	200-600
									(4)	
BERKELEY ALLUVIAL PLAIN	350	31	8	53	47	161	700	320	32,400	15,040
OAKLAND ALLUVIAL PLAIN	550	25	6	43	88	161	700	320	26,500	28,200
SAN LEANDRO CONE	950	18	5	31	72	161	700	320	17,800	23,040
SAN LORENZO CONE	1,000	18	5	31	72	161	700	320	17,800	23,040

(1) ONLY UPPER 600 FEET OF DEPOSITS CONSIDERED.
DEPOSITS BELOW 600 FEET CONSIDERED TO HAVE LITTLE
AQUIFER MATERIAL, LOW TRANSMISSIVITY, AND SLIGHT
GROUNDWATER GRADIENTS; SO LITTLE FLOW.

(2) HYDRAULIC CONDUCTIVITY, IN GALLONS PER DAY PER FOOT SQUARED (GPD/FT²).

(3) TRANSMISSIVITY, IN GALLONS PER DAY PER FOOT (GPD/FT).

(4) TRANSMISSIVITY FOR THE 5-200 FOOT ZONES ARE A WEIGHTED AVERAGE
BASED ON THE HYDRAULIC CONDUCTIVITIES FOR THE 5-30 FOOT AND
30-200 FOOT ZONES AND THE SATURATED AQUIFER THICKNESS.

TABLE.2.1996

TABLE 3

SUBSURFACE - GROUNDWATER DISCHARGE AT BAY MARGIN, APRIL 1995

GROUNDWATER SUBAREA (SEE FIGURE 2)	TRANSMISSIVITY (GPD/FT) (1)		WIDTH AT BAY MARGIN (FEET)	GROUNDWATER GRADIENT (2)		OUTFLOW AT BAY MARGIN (ACRE-FEET) (ROUNDED)		TOTAL
	BY DEPTH ZONES (FEET)			BY DEPTH ZONES (FEET)				
	5-200	200-600		5-200	200-600	5-200	200-600	
BERKELEY ALLUVIAL PLAIN	32,400	15,040	23,760	1.1X10 ⁻³	4X10 ⁻³	900	1,600	2,500
OAKLAND ALLUVIAL PLAIN	26,500	28,200	31,680	2.5X10 ⁻³	2.9X10 ⁻³	2,300	2,900	5,200
SAN LEANDRO CONE	17,800	23,040	31,680	1.6X10 ⁻³	2.0X10 ⁻³	1,000	1,600	2,600
SAN LORENZO CONE	17,800	23,040	31,680	2.9X10 ⁻³	1.7X10 ⁻³	1,800	1,400	3,200
TOTAL						6,000	7,500	13,500

(1) TRANSMISSIVITY, IN GALLONS PER DAY PER FOOT (GPD/FT).

(2) GRADIENTS ARE BASED ON APRIL 1995, WATER-LEVEL DATA

TABLE.3.1996

Artificial Discharge

Artificial discharge includes all forms of groundwater pumpage from wells, whether it be for agricultural, domestic, or industrial uses.

Pumpage

Agricultural Use - Five elements were considered in the determination of agricultural pumpage for the East Bay Plain: golf courses, cemeteries, schools and colleges, parks, and crops. Data from California Department of Water Resources Bulletins No. 113-3 (1975) and No. 113-4 (1986) and Sunset (1961) were used to make the estimates of agricultural pumpage.

Golf Courses - Only two golf courses located in the East Bay Plain use wells for irrigation purposes; all others use either reclaimed sewage water or water stored in lakes from captured rainfall runoff. It was estimated that the two golf courses pumped 390 acre-feet of groundwater in 1995.

Cemeteries - There are three cemeteries that use well water for irrigation purposes. These pumped a total of about 450 acre-feet in 1995.

Schools and Colleges - Several high schools and colleges use well water to irrigate athletic fields. Their total pumpage for 1995 was estimated to be only 20 acre-feet.

Parks - A number of parks in the East Bay Plain have wells for irrigation purposes. However, there is little use of these wells. Total park pumpage in 1995 was estimated to be 25 acre-feet.

Crops - In 1995 there were only 14 acres of row crops and several hot houses in the area of the East Bay Plain. Their estimated pumpage totaled 25 acre-feet.

Table 4 summarizes the estimates that were determined for agricultural pumpage in the East Bay Plain for 1995. Total pumpage for all agricultural purposes was estimated to be 910 acre-feet.

TABLE 4

GROUNDWATER PUMPAGE FOR AGRICULTURAL USE IN THE EAST BAY PLAIN, 1995	
	<u>ACRE-FEET</u>
PUMPAGE FOR GOLF COURSES	390
PUMPAGE FOR CEMETERIES	450
PUMPAGE FOR SCHOOLS AND COLLEGES	20
PUMPAGE FOR PARKS	25
PUMPAGE FOR CROPS	25
TOTAL	910

Domestic Use

Pumpage from individual domestic wells, wells operated by a mutual water association, and several private water system wells constitute the domestic use of groundwater in the East Bay Plain.

It was difficult to determine how much groundwater is being pumped by individual domestic wells. Most of the pumpage is from shallow wells in the depth range of 50 to 100 feet and is used for lawn and garden irrigation. Some of the groundwater pumped by individual domestic wells is consumed by household use. The pumpage estimates were based mostly on data supplied by Dave Williamson and Julio Abino of the East Bay Municipal Utility District (EBMUD) (oral and written communication, 1996) and Eileen Hughes of the California Environmental Protection Agency - Department of Toxic Substances Control (DTSC) (oral and written communication, 1993).

The EBMUD requires back-flow valves on any residential services that also have a well connected to the house plumbing. They supplied the author with a computer printout that listed registered residential services, by city, for those customers with back-flow valves. They said that they are certain that there are some residents with wells that are connected to their plumbing for which there are no back-flow valves, and consequently, no record with EBMUD of well use; also, that there are a number of individual domestic wells in their service area that are not connected into house plumbing. To develop pumpage values from the EBMUD data several assumptions were made: (1) 60 percent of the domestic wells pump in any one year period, (2) the number of home owners who haven't told EBMUD that they have wells connected to their house plumbing is probably about 5 percent of those registered, and (3) the number of domestic wells that are not connected to house plumbing probably is about 10 percent of those that are registered.

The factor used for domestic well use per year was based on data collected by DTSC. In 1987 they made a survey of domestic well use in a limited area of San Leandro. They obtained data on 31 wells. In 1987 these wells had a reported total yearly pumpage of 8.2 acre-feet or an average pumpage of 0.26 acre-feet per well per year. If it is assumed that these wells were used for the period spring thru fall, a period of 28 weeks, each well would have pumped about 3100 gallons of water per week. This translated into a pumping rate for each well of 6 gallons per minute if the pumps are in operation for 3 hours per day and 3 days per week. This pumping rate was considered reasonable by the author and was used to calculate pumpage by domestic wells.

Table 5 lists, by city, the amount of domestic wells and their pumpage in the areas serviced by the EBMUD in the East Bay Plain in 1995.

Table 6 lists groundwater pumpage determined for all domestic uses in the East Bay Plain in 1995.

TABLE 5

GROUNDWATER PUMPAGE BY DOMESTIC WELLS, IN 1995, IN THE AREA OF THE
EAST BAY PLAIN SERVICED BY THE EAST BAY MUNICIPAL UTILITY DISTRICT

AREA	WELLS REGISTERED WITH EBMUD (1)	UNACCOUNTED WELLS (2)	TOTAL WELLS	PUMPAGE (ACRE-FeET) (3)
ALAMEDA	112	17	129	20
BERKELEY	12	2	14	2
EMERYVILLE	1	1	2	1
HAYWARD	46	7	53	8
OAKLAND	104	16	120	19
PIEDMONT	39	6	45	7
SAN LEANDRO	1,720	258	1,978	309
SAN LORENZO	504	76	580	90
TOTAL	2,538	383	2,921	456

(1) 1995, EBMUD = EAST BAY MUNICIPAL UTILITY DISTRICT

(2) ESTIMATED TO BE 15 PERCENT OF NUMBER OF REGISTERED
WELLS: 5 PERCENT CONNECTED TO HOUSE PLUMBING AND 10 PERCENT NOT.

(3) BASED ON 60 PERCENT OF WELLS PUMPING AT 0.26 ACRE-FeET
PER YEAR PER WELL.

TABLE.5.1996

TABLE 6

GROUNDWATER PUMPAGE FOR DOMESTIC USE IN THE EAST BAY PLAIN, 1995	
	<u>ACRE-FEET</u>
*PUMPAGE BY DOMESTIC WELLS IN SERVICE AREA OF EAST BAY MUNICIPAL UTILITY DISTRICT	456
PUMPAGE BY MOHRLAND MUTUAL WATER ASSOCIATION, WEST HAYWARD AREA	69
*PUMPAGE BY DOMESTIC WELLS IN AREA OF CITY OF HAYWARD NOT SERVICES BY THE EAST BAY MUNICIPAL UTILITY DISTRICT	60
PUMPAGE BY PRIVATE DOMESTIC WATER SYSTEMS	32
TOTAL	617

*USED MOSTLY FOR LAWN AND GARDEN IRRIGATION

Industrial Use

Industrial use includes groundwater pumped by industrial concerns and by remediation projects.

A variety of sources were utilized to determine the amount of groundwater pumped for industrial purposes. The following individuals and agencies supplied data that were critical in the determination of industrial pumpage: Julio Albino of the EBMUD, Eileen Hughes of the DTSC, John Camp in the Environmental Compliance Department of the San Leandro Water Pollution Control District, and Joe Lucia the Water Source Administrator for the Hayward Sewage Treatment Plant. Using data supplied by the preceding and a list of industrial wells from county files individual industrial concerns were contacted to determine if they used groundwater.

It was found that only ten industrial concerns were using groundwater in the East Bay Plain. They pumped a total of 1015 acre-feet of groundwater in 1995.

The groundwater was used mainly in food processing and product manufacturing. The groundwater was pumped from wells deeper than 200 feet.

It was estimated that there are about 60 remediation projects in operation in the East Bay Plain in any one year period. These pump about 800 acre-feet of groundwater each year, all from wells less than 100 feet deep.

Total groundwater pumpage for industrial use in 1995 was 1815 acre-feet.

SUMMARY AND CONCLUSIONS

Table 7 lists the values determined for the various elements of groundwater discharge in the East Bay Plain area in 1995.

TABLE 7

GROUNDWATER DISCHARGE IN THE EAST BAY PLAIN AREA IN 1995	
DISCHARGE ELEMENT	DISCHARGE (ACRE-FEET PER YEAR) (ROUNDED)
NATURAL DISCHARGE	
EVAPOTRANSPIRATION	25,800
SUBSURFACE	<u>13,500</u>
SUBTOTAL	39,300
ARTIFICIAL DISCHARGE	
AGRICULTURAL USE	910
DOMESTIC USE	620
INDUSTRIAL USE	<u>1,820</u>
SUBTOTAL	3,350
TOTAL	<u>42,650</u>

Table 7 illustrates that artificial discharge (pumpage) was a small increment of overall groundwater discharge.

For projection purposes the figures shown in Table 7 are probably valid for about the past 5 years and into the near future.

Thirty years ago artificial discharge was much greater than it is at the present time. At that time about 14,000 acres of crops were being irrigated with groundwater and over 50 industrial wells were in operation.

In contrast, with groundwater pumpage up and water levels down, subsurface discharge, which is directly related to the groundwater gradient at the bay margin, was less than at the present time.

During these same 30 years evapotranspiration has probably remained nearly constant.

REFERENCES

Brown and Caldwell, 1986, Final Report, Evaluation of Ground Water Resources and Proposed Design of Emergency Water Supply Wells: Prepared for the Department of Public Works, City of Hayward. Five Chapters and appendixes.

California Department of Water Resources, 1975, Vegetative Water Use in California, 1974: California Department of Water Resources Bulletin No. 113-3, 43 p.

California Department of Water Resources, 1986, Crop Water Use in California: California Department of Water Resources Bulletin No. 113-4, 116 p.

Muir, Kenneth S., 1993, Geologic Framework of the East Bay Plain Groundwater Basin, Alameda County, California: Alameda County Flood Control and Water Conservation District, 37 p.

Muir, Kenneth S., 1994, Groundwater Recharge in the East Bay Plain Area, Alameda County, California: Alameda County Flood Control and Water Conservation District, typewritten report, 20 p.

Sunset, 1961, Western Garden Book, 384 p.

Woodward-Clyde Consultants, 1992, Regional Hydrogeology of Central San Leandro, the 139th Avenue Site, the Factor Avenue Site, and the Singer-Friden Site: Prepared for the California Environment Protection Agency, Department of Toxic Substances Control, Berkeley, CA. Section 1-4, with many figures and tables.

Woodward-Clyde Consultants, 1993, Hydrogeology of Central San Leandro and Remedial Investigation of Regional Groundwater Contamination, San Leandro Plume, San Leandro, California: Prepared for the California Environmental Protection Agency, Department of Toxic Substances Control, Berkeley, CA. Volume I, Section 1-3, Volume 2, Section 4-8, with many tables, figures and appendixes.

GROUNDWATER YIELD
OF THE
EAST BAY PLAIN
ALAMEDA COUNTY, CALIFORNIA

BY: KENNETH S. MUIR

PREPARED FOR THE
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

HAYWARD, CA 94544

UNDER CONTRACT NUMBER C-95-320

NOVEMBER, 1996

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A B S T R A C T

The yield of the groundwater reservoir in the area of the East Bay Plain is the rate at which water can be pumped from wells year after year without decreasing groundwater in storage to the point where the intrusion of seawater from San Francisco Bay would occur.

It was estimated that at the present time the groundwater yield of the East Bay Plain is approximately 10,000 acre-feet per year.

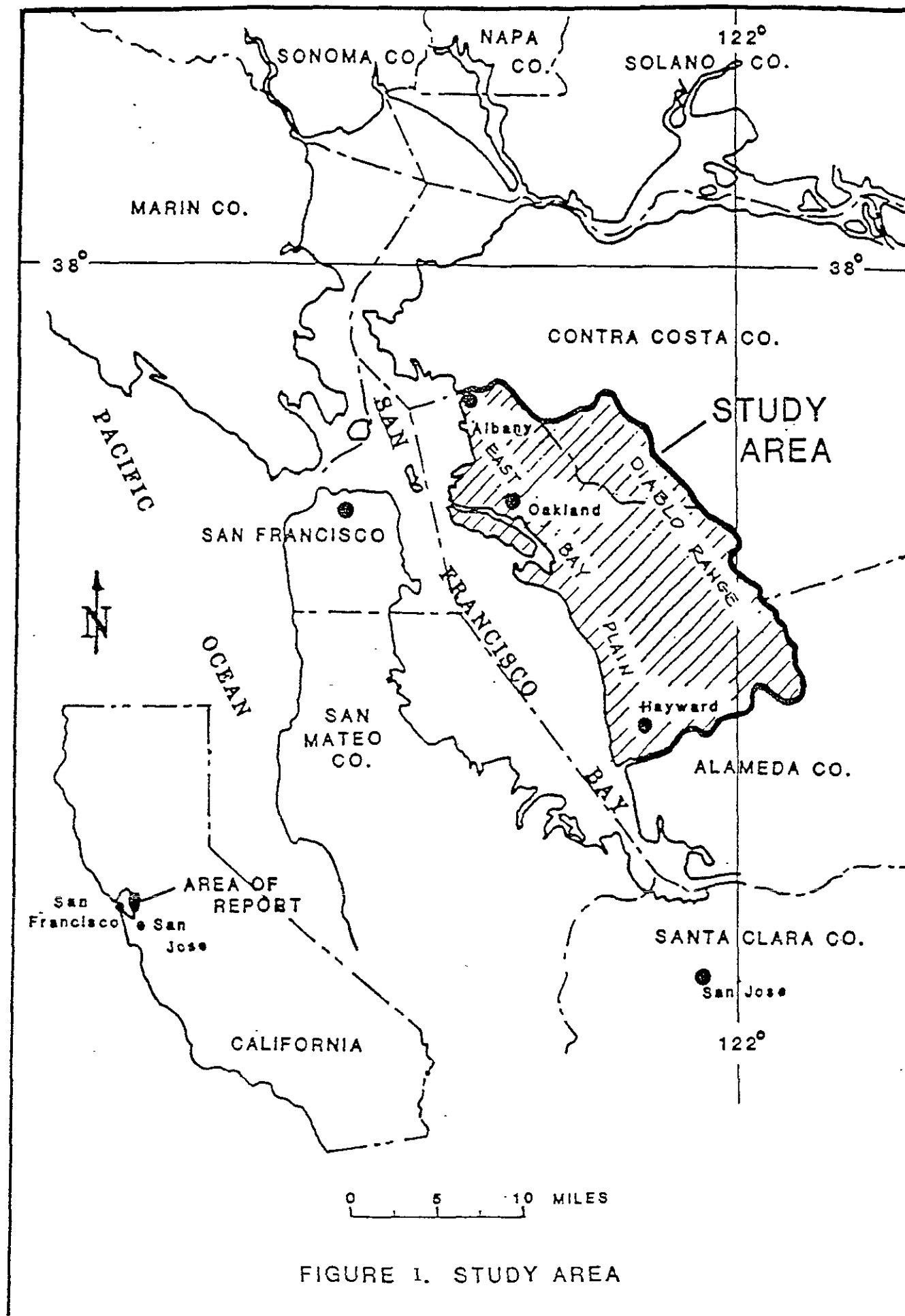
I N T R O D U C T I O N

This report is the continuation of a series of reports prepared by the author (see bibliography) to define and evaluate the geologic features and hydrologic values of the groundwater reservoir that lies beneath the East Bay Plain (Figure 1). This report pertains to the groundwater yield of the reservoir.

Y I E L D

The term "groundwater yield" has many definitions, all of which are based on the long-term dependability of the water supply, as expressed by the balance of the items of the groundwater inventory (Figure 2). Rainfall infiltration, pipe leakage, and stream seepage are the more important sources of inflow to the study area (Muir, 1994). Evapotranspiration and subsurface discharge are the main items of outflow (Muir, 1996). The yield of the groundwater reservoir in the area of the East Bay Plain is the rate at which water can be pumped from wells year after year without decreasing groundwater in storage to the point where the pumping lift would become economically infeasible or where water of poor quality would begin to intrude into the reservoir. In this area because it lies adjacent to San Francisco Bay the intrusion of water of poor quality (seawater) probable, would occur first. In this case yield is tied in with groundwater storage. The groundwater storage can be depleted by pumping until water levels near the Bay are drawn down to near sea level. When this occurs, the average annual pumpage should not exceed a quantity equal to the long-term average inflow to the reservoir minus the quantity of subsurface discharge that must flow to the Bay annually to maintain a barrier against seawater intrusion. This would be the groundwater yield of the East Bay Plain Area.

This sounds simple enough - monitor the status of groundwater levels near the Bay and when they reach sea level evaluate inflow and outflow to obtain yield. Complicating this approach is the fact that in the East Bay Plain groundwater is stored in a reservoir system in which both unconfined and confined conditions occur - with most of the groundwater stored in the confined zone. This means that changes in storage reflect changes in



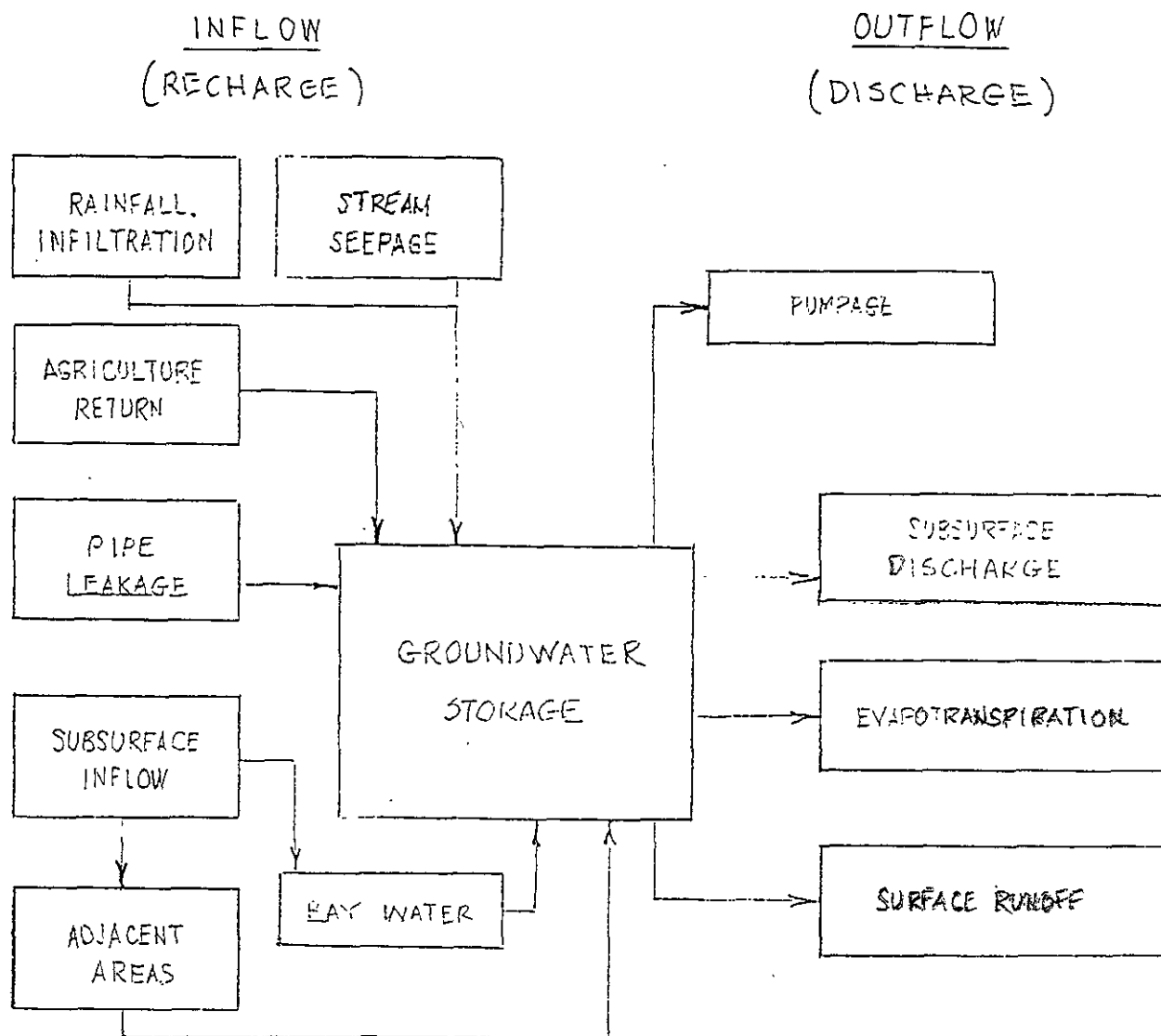


FIGURE 2. GROUNDWATER INVENTORY

pressure more than removal of water from the reservoir system. This is illustrated by a study done by the California Department of Water Resources (DWR, 1994) in which they estimated that about 2,500,000 acre-feet of groundwater is stored under the East Bay Plain - with about 80,000 acre-feet of this groundwater stored in the aquifers above sea level. They also state that groundwater levels (Figures 9 and 10) in some areas of the East Bay Plain indicate groundwater in storage below sea level has been and continues to be used, apparently with limited adverse impacts.

The main reason the determination of yield in the East Bay Plain cannot be estimated with a high degree of accuracy at the present time is because of the lack of complete data on inflow, outflow, aquifer transmissivity and because groundwater within the reservoir is not static, which means that the natural inflow - outflow relations of the reservoir system will probably continue to change.

To make an approximation of the value of groundwater yield of the East Bay Plain inflow - outflow estimates from 1965 and 1995, rainfall data from Niles and Berkeley (Figure 3), hydrographs of selected wells (Figures 5-10), and the history of water use for the thirty-year period 1965 thru 1995 were utilized.

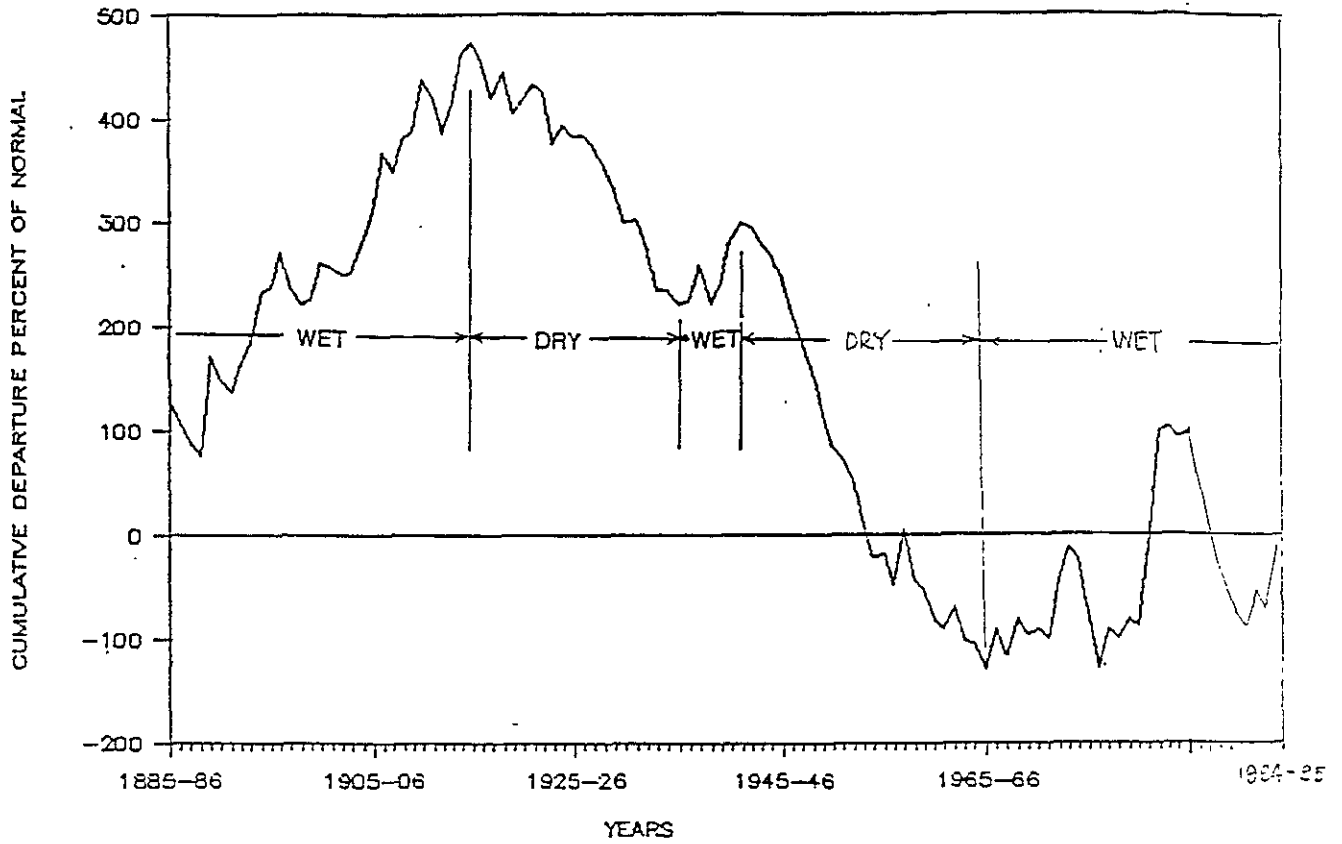
There were dramatic changes in land use in the East Bay Plain between the years 1965 and 1995. The area went from an industrial-agricultural land use to one of mostly urban growth. Along with urban growth came the decrease to almost nothing by 1995 in industrial-agricultural pumpage. The urbanized areas are supplied by water piped in from surface water sources from areas outside the East Bay Plain. Therefore, since about 1965 the draft on the groundwater reservoir both in the unconfined and confined zones has been reduced and water levels are rising and storage is increasing. For the period 1965 to 1995 water levels in the unconfined zone have shown fluctuations from no change to a rise of 10 feet and in the confined zone the increases range from an increase of 60 to 90 feet (see hydrographs of wells in Figures 5 thru 10 - see Figure 4 for their location). This was during a series of years where rainfall averaged slightly higher than the long-term normal and the area was experiencing a relatively minor wet cycle (Figure 3). Based on data from the DWR Report (DWR, 1984) it is estimated that groundwater storage in the zone from 0 to 200 feet increased about 25,000 acre-feet between 1965 and 1995. This indicates inflow was greater than outflow and that groundwater yield was not being exceeded. 1994

It is estimated that groundwater outflow from the East Bay Plain in 1965 was about 81,000 acre-feet and inflow was about 30,000 acre-feet. In 1995 inflow was about 46,000 acre-feet while outflow was about 43,000 acre-feet. This points out why water levels and consequently, groundwater storage have been on the increase since 1965. How inflow and outflow have varied and progressed over the past 30 years is unknown.

Using information found in the preceding paragraphs and data presented by Muir in 1994 and 1995 (Muir, 1994 and Muir, 1996) it was estimated that subsurface discharge to maintain the seawater - freshwater interface at the

CUMULATIVE DEPARTURE

STATION 50, NILES 1 SW



STATION 91, BERKELEY

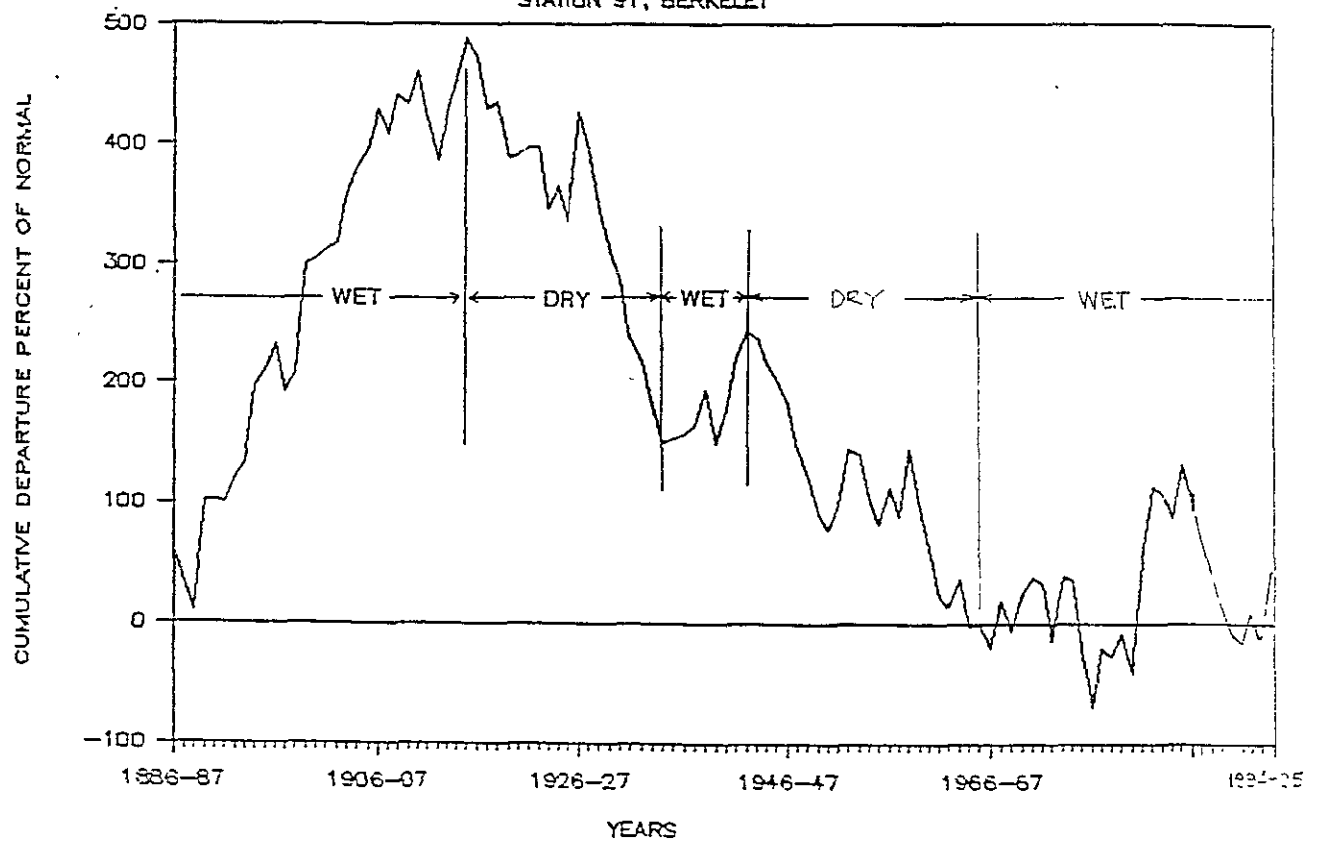
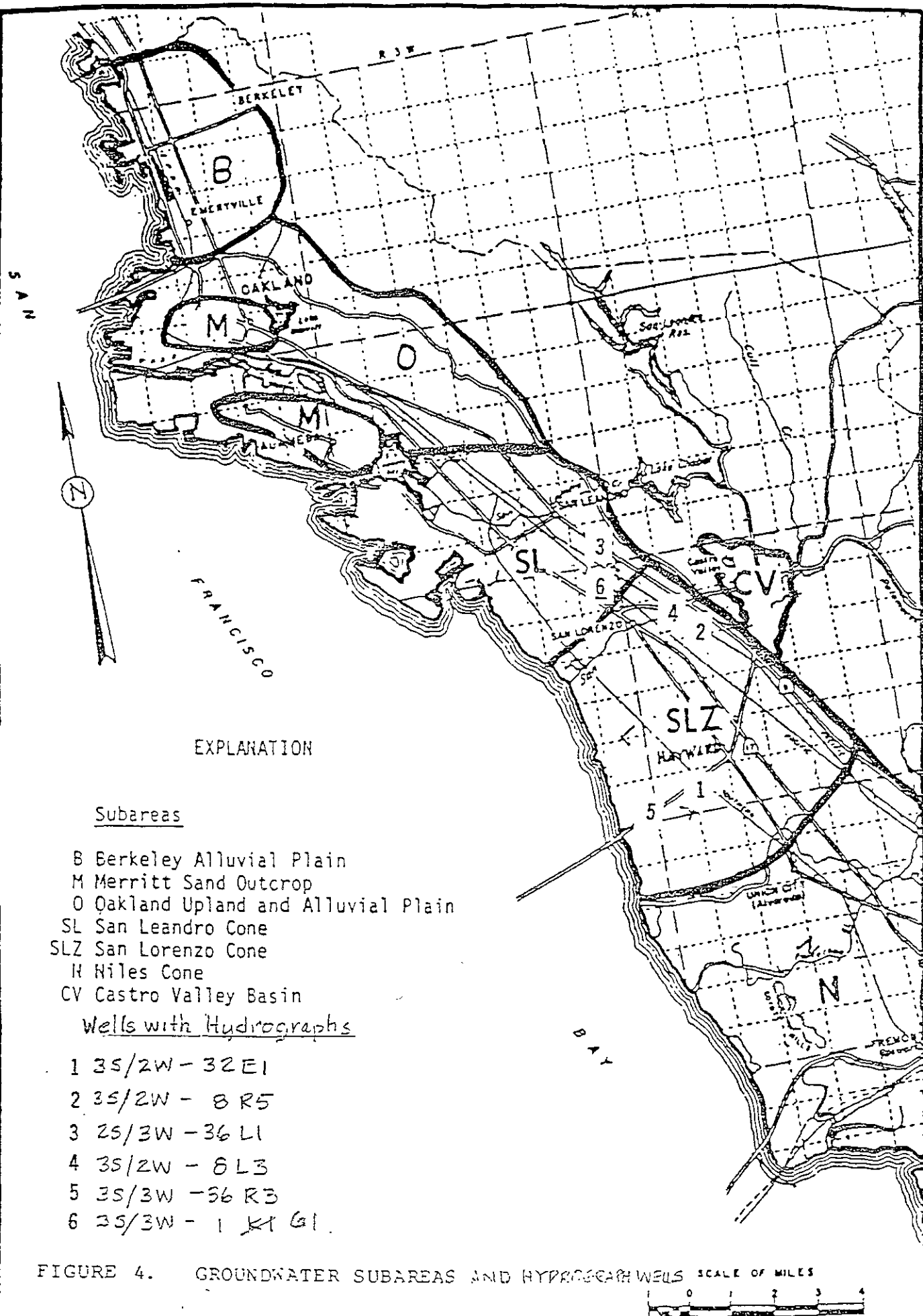


FIGURE 3. Cumulative Departure of Rainfall.



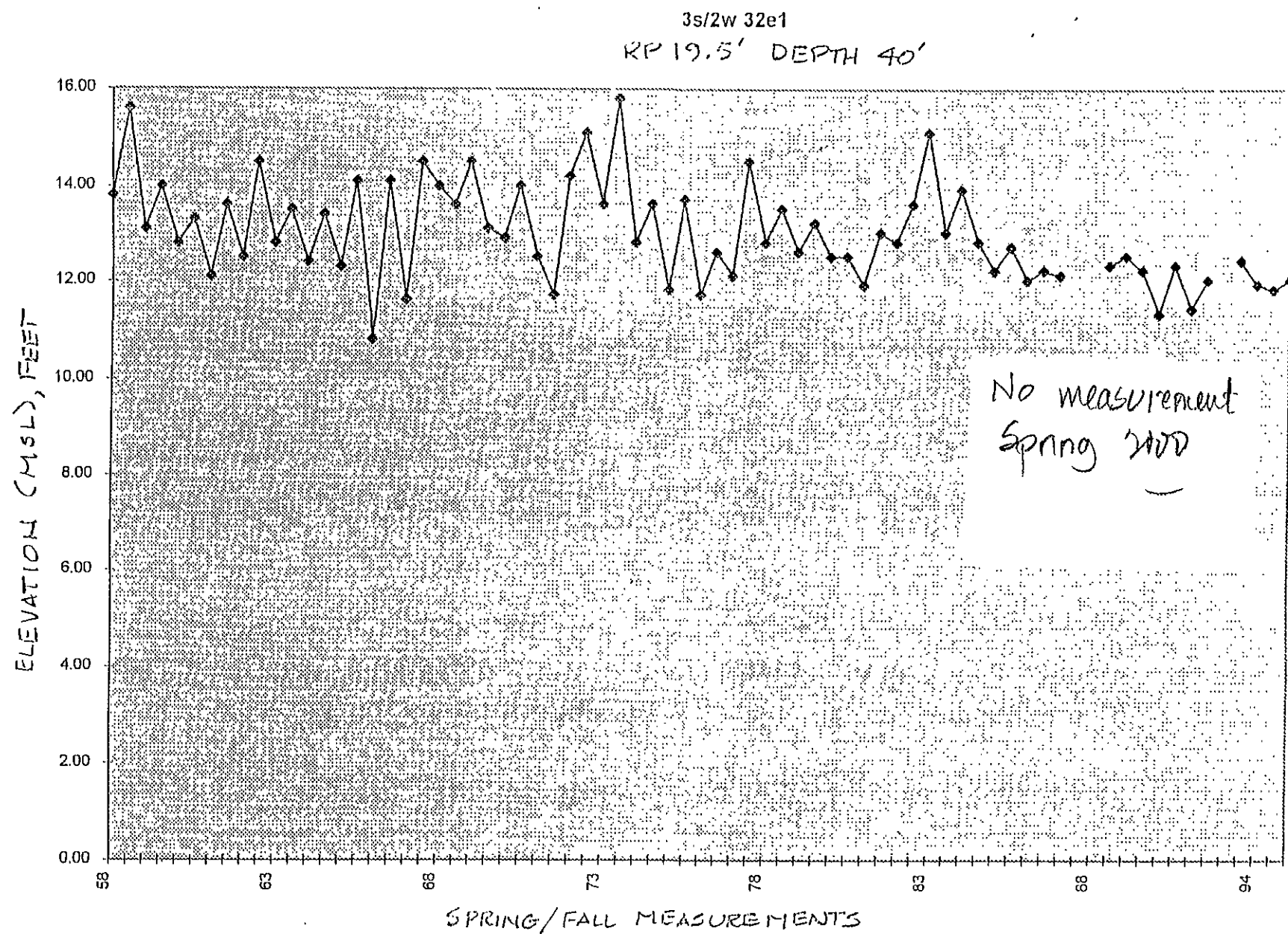


FIGURE 5. FLUCTUATIONS OF WATER LEVELS IN SHALLOW ZONE

3s/2w 8r5
RP 64' DEPTH 85'

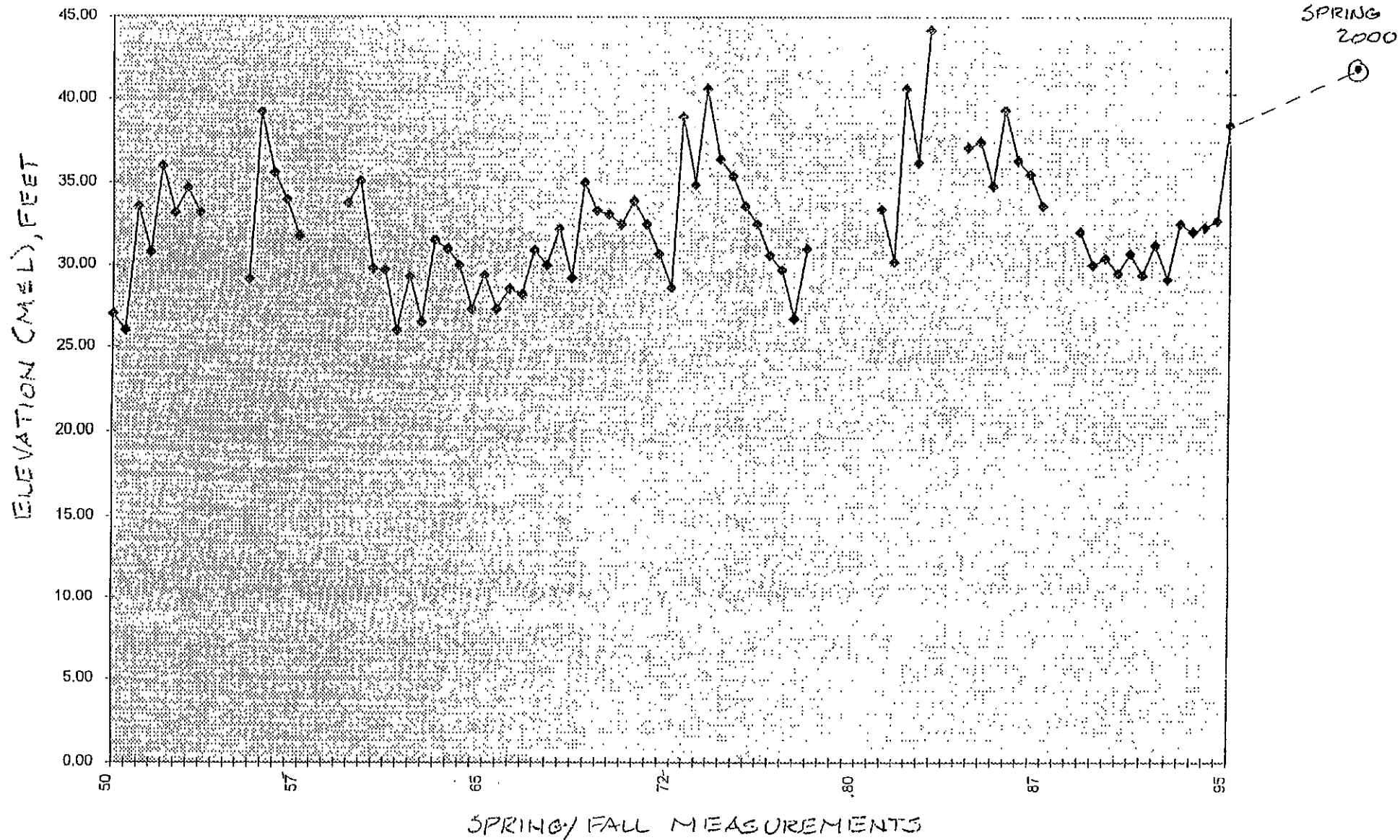


FIGURE 6. FLUCTUATIONS OF WATER LEVELS IN SHALLOW ZONE

2s/3w 36Li

RP 44' DEPTH 120'

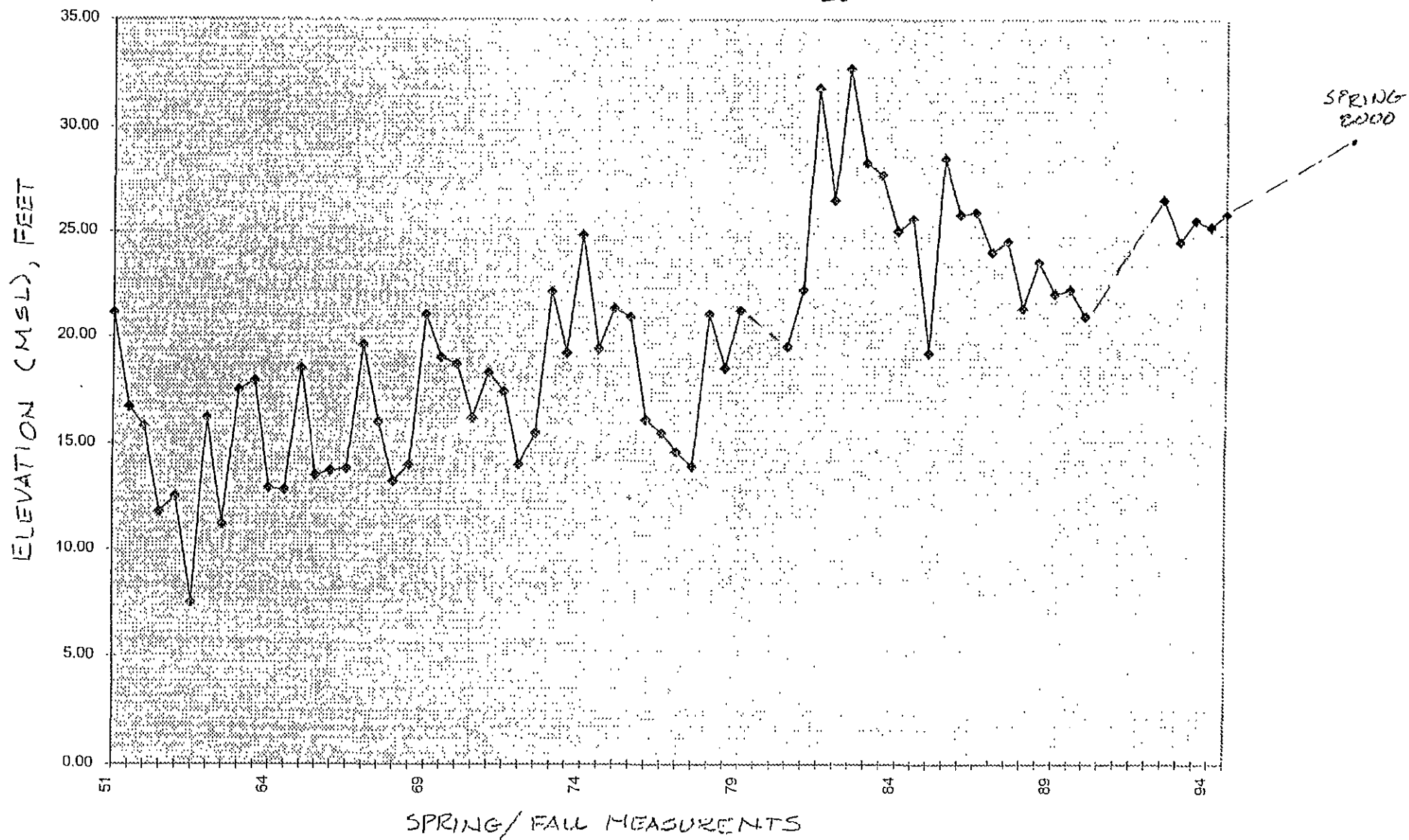


FIGURE 7. FLUCTUATIONS OF WATER LEVELS IN SHALLOW ZONE

3s/2w 813
RP 57' DEPTH 211'

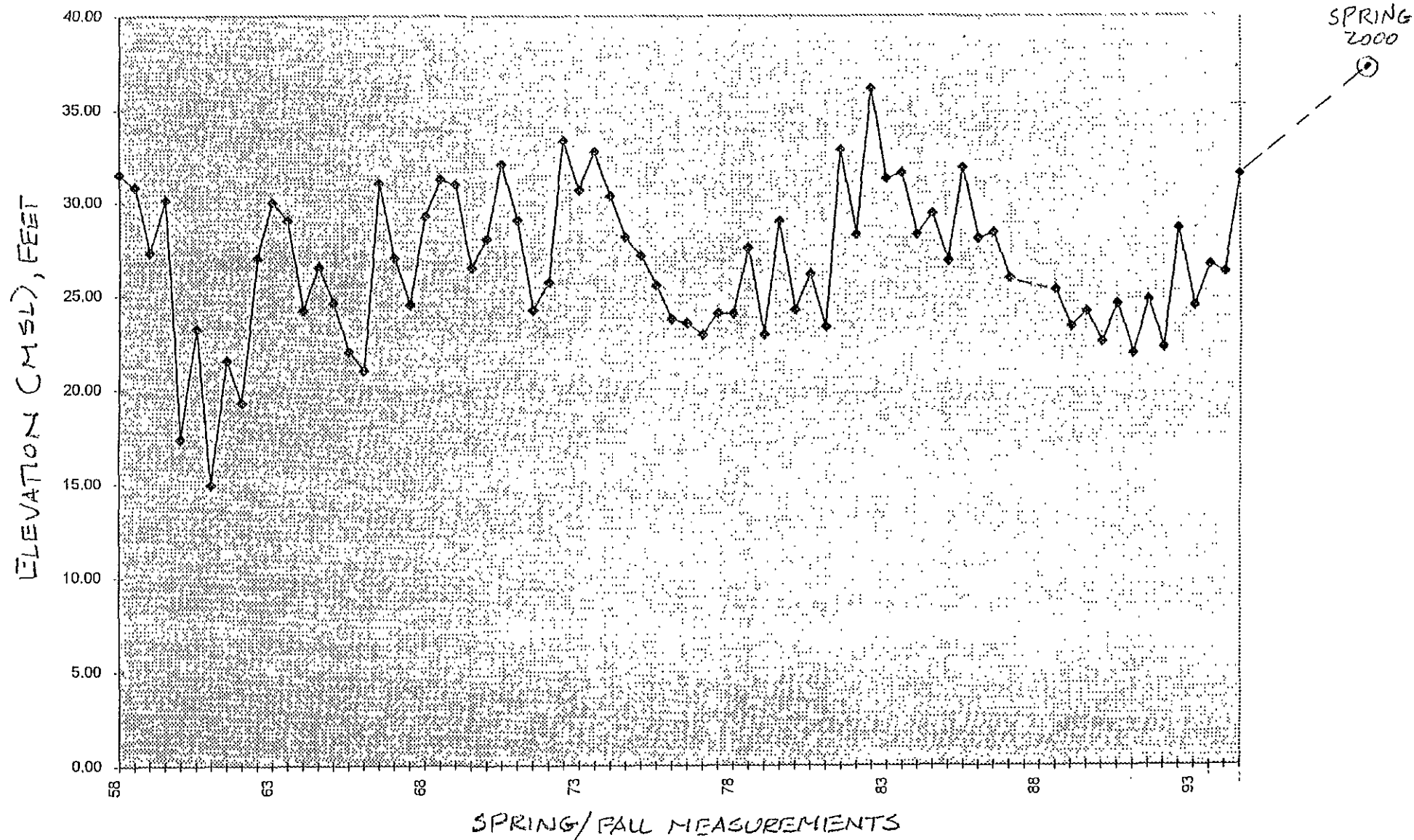


FIGURE 8. FLUCTUATIONS OF WATER LEVELS IN SHALLOW ZONE

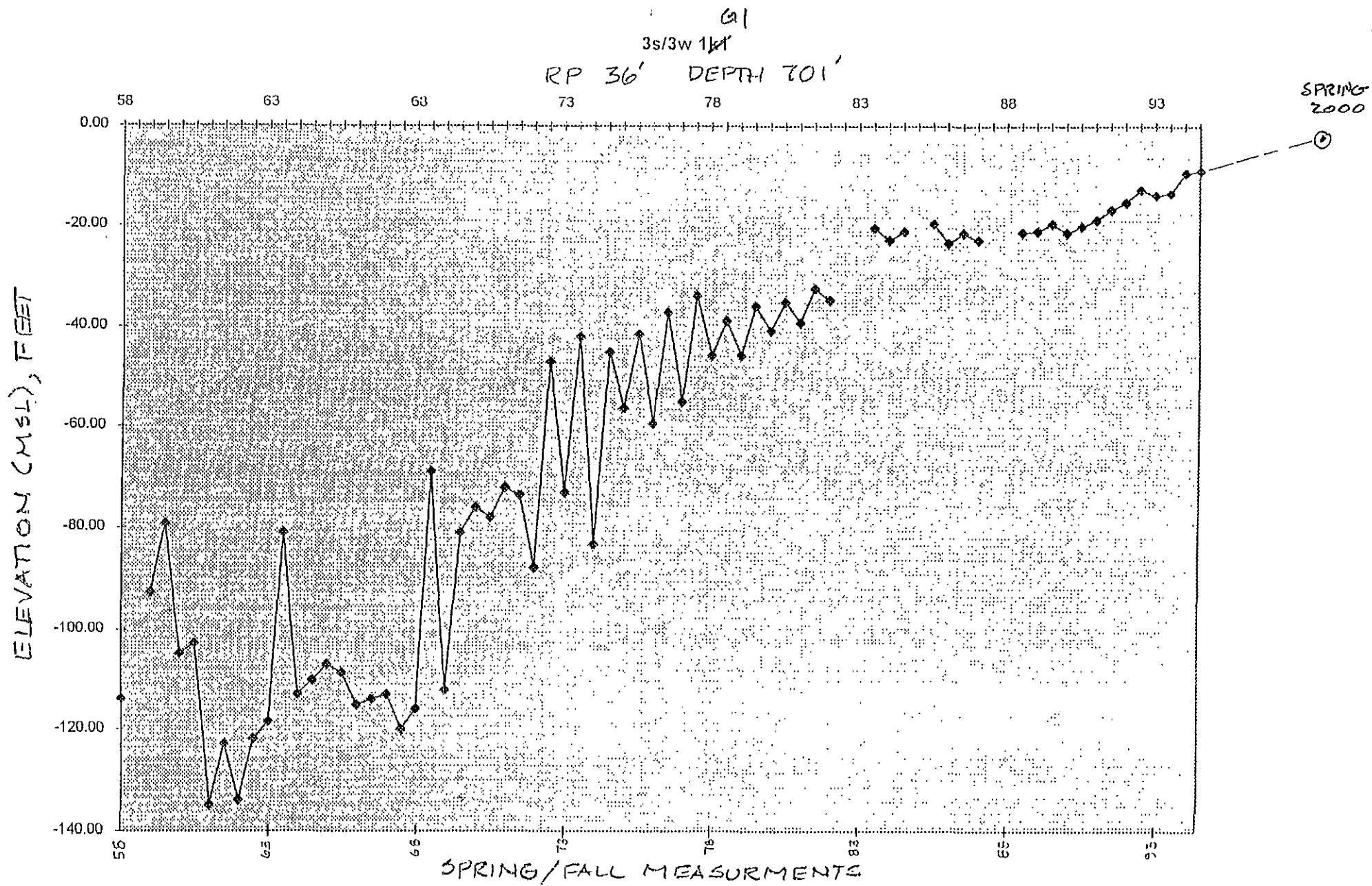


FIGURE 10. FLUCTUATIONS OF WATER LEVELS IN DEEP ZONE

Bay Margin was about 10,200 acre-feet per year. Based on the figure of 10,200 acre-feet per year for subsurface discharge and 25,800 acre-feet per year for evapotranspiration groundwater yield of the East Bay Plain is estimated to be about 10,000 acre-feet per year.

As previously stated the determination of groundwater yield for the East Bay Plain was made difficult because of the lack of the hydrologic parameters needed for a viable evaluation. However, the author felt that a yield figure based on even scanty data would be better than none at all. It establishes a starting point and the yield value can be revised when more hydrologic data becomes available.

R E F E R E N C E S

Department of Water Resources, 1994. Ground Water Storage Capacity of a Portion of the East Bay Plain, Alameda County, California: 35 p.

APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.B. Supporting Data for Groundwater Storage SMC

3.B.b NEBIGSM Groundwater Pumping Estimates

DRAFT



DRAFT MEMORANDUM

To:	Mike Tognolini, EBMUD Eric Cartwright, ACWD	CC:	Dan Wendell
From:	Chris Smith, and Yiguo Liang	Date:	November 18, 2002
Reviewed by:	Ali Taghavi		
Subject:	Estimates of GW Pumping in the SEBP-NCGB IGSM		

The purpose of this memorandum is to document the methodology of estimating the groundwater pumping for input into the IGSM for the Southeast Bay Plain and Niles Cone Groundwater Basin Integrated Ground and Surface water Model (IGSM).

There are currently total of 328 records in the pumping data set. The groundwater pumping input data is developed in two separate sets of records, in the NCGB area and in the SEBP area, as follows:

- Records 1-280 are groundwater pumping in the NCGB area by specific wells
- Records 281-315 (except 285, and 299) are groundwater pumping in the SEBP area by specific wells
- Records 285 and 299 are groundwater pumping records for Holy Sepulchre Cemetery and Mission Hill Golf Course, which are new records added to the NCGB area
- Records 316-317 are groundwater recharge records in the NCGB area
- Record 318 is estimated agricultural groundwater pumping in the NCGB area prior to 1974, and subsequent to 1974, data is represented in metered well pumping
- Record 319 is estimated urban pumping in the BHF area prior to 1974, and subsequent to 1974, data is represented in metered well pumping
- Record 320 is estimated recharge in the Dry Creek
- Record 321 is not used
- Record 322 is the total recharge above and below Hayward fault in the NCGB area
- Record 323 is total domestic pumping in the SEBP area
- Records 324-328 are the estimated agricultural pumping for sub-regions 5-9, respectively.

Following are detailed description of the sources of data, analysis and/or interpretation methods used for each data in the above records.

The NCGB records are from the original NCGB IGSM input data sets except records 285 and 299, which were not included in the NCGB IGSM model input data. The historical monthly values for October 1964 to September 1985 are from the original calibrated NCGB model input database, and monthly values for October 1985 to September 2000 are from the NCGB model database that is updated to December 2001. Because this portion of data is directly incorporated into the current model, this

this memo will not describe those records. The SEBP records and the two additional NCGB records (285 and 299) are described below.

Pumping data for records 281 to 315 are compiled based on three databases:

1. **Database 1 (DB 1):** Summary Table.xls. This database is compiled by EBMUD and contains the annual (1964 to 2000) pumping estimation for 19 groups of pumping records, primarily the industrial pumping in SEBP area. However, there are records of groundwater pumping for irrigation wells as well as domestic pumping for the SEBP area.
2. **Database 2 (DB 2):** BSPNORES.shp. This database is compiled by EBMUD and contains annual surface water delivery records to 83 SEBP industrial customers that potentially use groundwater as part of their water supply. These customers are identified to be potential groundwater users because they have backflow devices installed. These customers are in the cities of San Leandro, San Lorenzo, Oakland, Alameda, and Hayward, for the years 1986-2000. In addition, the deliveries for February and August are provided in this database.
3. **Database 3 (DB 3):** Hunts (082202).xls. This database is compiled by ACWD and contains annual pumping estimation and monthly distribution pattern for the Hunts cannery plants.

Because the model input database is in monthly time step, the annual database is distributed into monthly based on specific patterns for use categories of industrial, non-agricultural, irrigation, domestic, and agricultural/irrigation, as described below.

Two other sources of pumping are not included in the NCGB pumping. These include shallow groundwater pumping at gas stations and other spill sites; although the deeper extractions that may be from the Newark aquifer are included. In addition, domestic pumping from wells whose discharge opening are less than 2 inches, and irrigating sites less than one acre are not metered, and therefore, are not included in the groundwater pumping database.

Industrial Wells:

The annual industrial pumping records are distributed to monthly data based on monthly patterns for municipal/industrial water use in the study area. The primary monthly water use pattern is developed from charts available in the Department of Water Resources (DWR) publication "Municipal and Industrial Water Use: San Francisco Bay District, October 1965". The general patterns recorded in this publication showed peak water use in the summer months and less water use during the winter. The primary monthly pattern was adjusted for the industries or users that a February and August surface water use rate was provided in DB 2 data source. In some cases, the February and August water use rates could not fit the patterns from the DWR publication. These unusual patterns may be attributed to inaccurate data records or to unknown factors particular to each industry. In these cases, the primary monthly pattern from the DWR publication was used.

There are five industries in DB2 that have relatively large surface water use but no groundwater pumping estimates were provided in DB1. These five industries are: Alameda Gateway, George Burehler Jr., Monarch Ventures, P. F. Holdings LLC, R & A Truiking. In order to estimate the groundwater pumping for these five industries, an analysis was conducted for nine other industries for

Table 1. Comparison of Groundwater

Estimated Groundwater Pumping *(AF/Yr)												
Year/Name	AB&I	Fleischman's/ Standard Brand	GP Gypsum	Hudson Lumber	Kelloggs / HB Chapman	Rattos	Red Star Yeast	Sconza Candy	Tharco	TOTAL		
1986	673	390	384	14	59	32	246	0	0	1797		
1987	673	411	384	14	59	32	246	0	0	1818		
1988	673	547	384	19	34	32	246	0	31	1966		
1989	673	521	384	25	23	32	246	0	31	1934		
1990	307	530	384	16	23	32	267	37	31	1627		
1991	307	399	384	16	12	32	261	37	31	1479		
1992	307	455	384	8	0	32	252	37	31	1506		
1993	307	439	384	0	0	32	264	37	31	1494		
1994	307	165	353	0	0	32	258	37	31	1183		
1995	40	478	322	0	0	32	252	37	31	1193		
1996	40	329	322	0	0	32	252	37	31	1043		
1997	40	394	322	0	0	32	246	37	31	1102		
1998	40	243	322	0	0	32	252	37	0	926		
1999	40	226	322	0	0	32	243	37	0	900		
2000	40	201	322	0	0	32	240	37	0	873		
Average	298	382	357	7	14	32	251	27	20	1389		

Surface Water Delivery (AF/Yr)												
Year/Name	AB&I	Fleischman's/ Standard Brand	GP Gypsum	Hudson Lumber	Kelloggs / HB Chapman	Rattos	Red Star Yeast	Sconza Candy	Tharco	TOTAL		
1986	94	541	138	30	0	6	78	2	18	907		
1987	176	520	77	27	0	7	208	2	22	1039		
1988	31	636	53	21	0	20	335	3	17	1114		
1989	56	488	119	16	0	4	332	2	18	1034		
1990	11	394	148	18	0	4	254	3	21	853		
1991	14	429	53	17	96	5	258	2	19	892		
1992	17	451	142	26	175	6	239	2	15	1074		
1993	19	713	116	36	191	5	268	7	20	1376		
1994	18	912	53	29	129	0	254	2	24	1421		
1995	27	950	12	21	174	6	255	3	18	1466		
1996	27	1011	68	23	7	2	219	2	17	1376		
1997	37	869	110	21	3	0	258	1	20	1321		
1998	44	677	93	17	2	0	273	1	16	1122		
1999	29	496	89	4	3	0	267	1	18	906		
2000	40	444	31	1	3	0	247	1	16	780		
Average	43	635	87	20	52	4	250	2	19	1112		

*Source: EBMUD

There are five industries in DB2 that have relatively large surface water use but no groundwater pumping estimates were provided in DB1. These five industries are: Alameda Gateway, George Burehler Jr., Monarch Ventures, P. F. Holdings LLC, R & A Truiking. In order to estimate the groundwater pumping for these five industries, an analysis was conducted for nine other industries for which both surface water delivery and groundwater pumping data is available. These nine industries are listed in Table 1. This table compares the surface water delivery (from DB2) and estimated groundwater pumping provided by EBMUD. Note that the amount of surface water delivery is approximately the same as that for groundwater pumping for these nine industries as a whole, and for most of them individually. Therefore, an assumption was made that most of these industries receive approximately same amount of surface water and groundwater for their operation. This assumption was extended to estimate the groundwater pumping for the five industries listed above for the period of 1986-2000.

Since there is no surface water delivery data in DB2 for the period 1964-1985, the groundwater pumping for this period is estimated based on correlation to DB1 dataset. The 1964-85 annual groundwater pumping for the five industries listed above, and four municipal users (City of Alameda, City of San Leandro, San Leandro School District, and the San Lorenzo School District) was estimated based on average ratio of groundwater pumping between total annual pumping for all industries in DB1 and these users, for the period 1986-2000. The ratio was applied to a linearly extrapolated groundwater pumping based on industries in DB1 database back to 1965, to develop groundwater pumping for the above municipal users and industries. The annual estimated groundwater pumping data was then distributed to monthly based on the monthly pattern of surface water use.

Annual pumping records for the cannery industry was distributed to monthly data based on the monthly patterns available from Hunts Pumping data. This pattern was used for both Del Monte and Hunts canneries. Fleischman Yeast has monthly pumping records from 1986 to 2000. The monthly pattern for this period was used to estimate monthly pumping for the period 1964 and 1985. Similarly, Red Star Yeast is assumed to have the same monthly pattern of groundwater pumping as the Fleischmann due to the similarity of water use. Records of annual groundwater pumping for Kellogs and Granny Goose are evenly distributed to monthly due to lack of more detailed information on them, and assuming that these industries pumped evenly for washing and cleaning throughout the year. These records are shown on Table 2.

Table 2 Method of Monthly Distribution of Pumping for Each Industry			
Pumping Record No.	Industry Name	Data Source	Distribution Method
281	American Brass & Iron	EBMUD (Summary Table.xls)	Adjusted DWR Monthly Pattern
282	Alameda Gateway	EBMUD (Summary Table.xls)	Adjusted DWR Monthly Pattern
289	Del Monte Well1	(BPSNORES.SHP)	Hunts (canning) pumping pattern
290	Del Monte Well2	EBMUD (Summary Table.xls)	Hunts (canning) pumping pattern
291	Fleischmann	EBMUD (Summary Table.xls)	Pattern from measured 1986-2000 data
292	George Burehler Jr.	EBMUD (BPSNORES.SHP)	Adjusted DWR Monthly Pattern
293	GP Gypsum	EBMUD (Summary Table.xls)	Adjusted DWR Monthly Pattern
294	Granny Goose	EBMUD (Summary Table.xls)	Evenly distributed to each month
295	Not Used	N/A	N/A
296	Hudson Lumber	EBMUD (Summary Table.xls)	Adjusted DWR Monthly Pattern
297	Kellogs	EBMUD (Summary Table.xls)	Evenly distributed to each month
301	Monarch Ventures	EBMUD (BPSNORES.SHP)	Adjusted DWR Monthly Pattern
302	P.F. Holdings	EBMUD (BPSNORES.SHP)	Adjusted DWR Monthly Pattern
303	Hunt PlantA Well	ACWD (Hunts_082202.xls)	From ACWD (Hunts_082202.xls)
304	Hunt PlantB Well1	ACWD (Hunts_082202.xls)	From ACWD (Hunts_082202.xls)
305	Hunt PlantB Well2	ACWD (Hunts_082202.xls)	From ACWD (Hunts_082202.xls)
306	Hunt PlantB Well3	ACWD (Hunts_082202.xls)	From ACWD (Hunts_082202.xls)
307	R & A Trucking	EBMUD (BPSNORES.SHP)	Adjusted DWR Monthly Pattern

308	Rattos	EBMUD (Summary Table.xls)	Adjusted DWR Monthly Pattern
309	Red Star Yeast	EBMUD (Summary Table.xls)	Same pattern as the Fleischmann
310	Sconza Candy	EBMUD (Summary Table.xls)	Adjusted DWR Monthly Pattern
314	Tharco	EBMUD (Summary Table.xls)	Adjusted DWR Monthly Pattern
315	Trailer Haven	EBMUD (Summary Table.xls)	Adjusted DWR Monthly Pattern

Irrigation Wells

Wells in golf courses, cemeteries, and school districts are assumed to pump water for irrigation purpose. Therefore, the monthly distribution of groundwater pumping is assumed to be the same pattern as the monthly ET pattern for turf grass. Annual pumping for San Leandro and San Lorenzo school districts for the period of 1964-1985 is estimated as described in Industrial Wells. The cemetery pumping quantity provided in DB1 includes pumping for three cemeteries, two of which are outside the model area. Therefore, the pumping for Holy Sepulchre Cemetery is estimated proportional to the relative acreage to the total acreage of all three cemeteries. The records for the other two cemeteries that are outside model area are assumed zero. Table 3 lists the records used for irrigation water use.

Table 3 Records of Groundwater Pumping for Irrigation Use	
Pumping Record No.	Pumper Name
283	Alameda Golf Course
284	Cemetery-Cypress (Not in Model Area)
285	Cemetery-Holy Sepulchre
286	Cemetery-Mt View (Not in Model Area)
298	Marina Golf Course
299	Mission Hill Golf Course
311	San Leandro School District
312	San Lorenzo School District
313	San Lorenzo Park

Municipal Wells

Wells in City of Alameda, City of San Leandro, and Mohrland Mutual Water Co are assumed to pump water in the same monthly pattern as the city water use, as obtained from the Department of Water Resources (DWR) publication "Municipal and Industrial Water Use: San Francisco Bay District, October 1965". Annual pumping estimations for users of City of Alameda and City of San Leandro for the period of 1964-1985 are described in Industrial Wells. The municipal wells are listed in Table 4.

Table 4 Records of Groundwater Pumping for Municipal Use	
Pumping Record No.	Pumper Name
287	City of Alameda
288	City of San Leandro
300	Mohrland Mutual Water Co.

Domestic Pumping

The domestic pumping is estimated to be 439 AF/Yr, based on Kenneth Muir's estimates (EBMUD DB 1). The domestic pumping is typically used for domestic irrigation, and therefore is distributed to monthly data based on turf grass ET monthly pattern. The spatial distribution of the domestic pumping is based on location of available backflow devices as mapped by EBMUD. The domestic pumping is therefore distributed to each model element based on the density of backflow device estimated to be in each finite element. Record number 323 in model input data file is assigned to domestic pumping in SEBP area.

Agricultural Pumping

Agricultural pumping in the SEBP area is estimated based on the unit water use methodology. Since the Alameda and Marina/Tony Lema Golf Courses have groundwater pumping data and irrigated acreage data, the unit water use for turf irrigation in SEBP area is estimated based on long-term average value for these two golf courses. Table 5 shows the average unit water use for these two golf courses to be 2.4 AF/AC. This unit water use is applied to other turf irrigation acreages based on irrigation area from DWR land use data.

Table 5. Average Unit Water Use for Turf Irrigation in SEBP Area*

	Acreage**	Pumping*** (AF/Yr)	Unit Water Use (AF/AC)
Marina/Tony Lema Golf Course	155	399	2.6
Alameda Golf Course	188	430	2.3
Average	172	415	2.4

* Data for Marina/Tony Lema Golf Course is for 1982-2000 and for Alameda Golf Course is for 1965-1986.

** Based on USGS quad sheet.

*** Reported by EBMUD

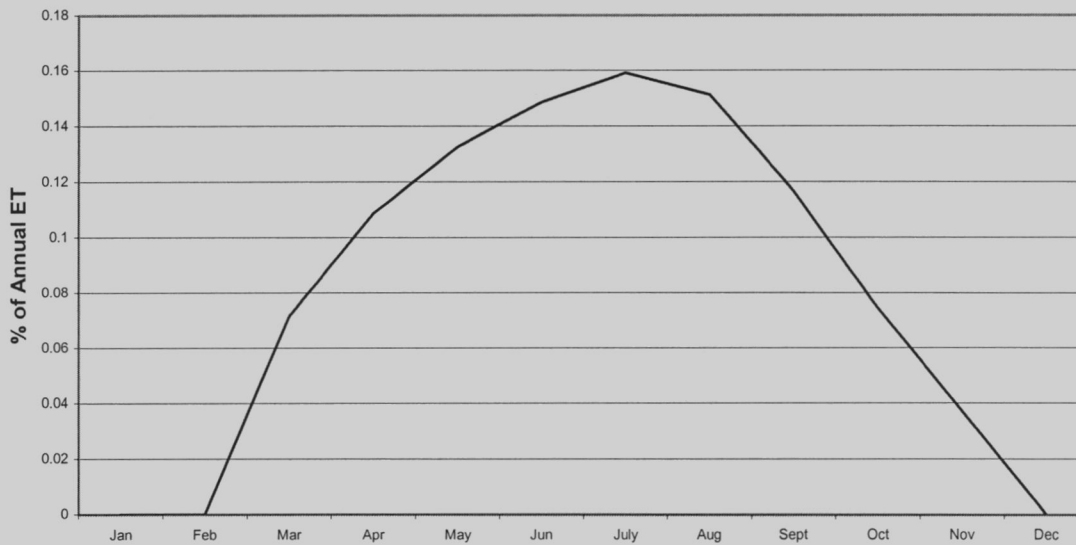
Table 6. NCGB-SEBP IGSM South East Bay Plain Acreage and Water Supply Summary

	ACREAGE			Irrigated Turf Water Supply				Urban Water Supply				Unit Water Use (Unit: AF/AC)		
	Irrigation	Urban	Total Developed	Irrigation By Well ¹	Estimated Ag. Pumping ²	Reclaimed Water ³	Total	M&D Pumping ¹	Industrial Pumping ¹	Imported Surface Water ¹	Total	Turf Irrigation ⁴	D&I ⁵	Overall ⁶
1965	1102	34510	35612	595	1743	0	2338	733	4846	70379	75958	2 12	2 20	2 20
1966	1102	34510	35612	591	1743	0	2334	727	4804	71508	77039	2 12	2 23	2 23
1967	1102	34510	35612	588	1743	0	2331	722	4750	71496	76967	2 12	2 23	2 23
1968	1102	34510	35612	584	1743	0	2327	716	4693	72913	78322	2 11	2 27	2 26
1969	1102	34510	35612	579	1743	0	2322	711	4639	73167	78516	2 11	2 28	2 27
1970	1102	34510	35612	576	1743	0	2319	705	4584	74465	79754	2 10	2 31	2 30
1971	1099	34497	35596	572	1743	0	2315	700	4529	69596	74825	2 11	2 17	2 17
1972	1097	34485	35582	568	1740	0	2308	695	4475	73257	78427	2 10	2 27	2 27
1973	1093	34474	35567	565	1731	0	2296	689	4419	68390	73498	2 10	2 13	2 13
1974	1092	34461	35553	560	1724	0	2284	684	4365	66879	71928	2 09	2 09	2 09
1975	1088	34450	35538	557	1718	0	2275	678	4310	68368	73355	2 09	2 13	2 13
1976	1086	34437	35523	553	1710	0	2263	672	4255	71151	76078	2 08	2 21	2 21
1977	1083	34425	35508	549	1703	0	2252	667	4303	46594	51564	2 08	1 50	1 52
1978	1080	34414	35494	546	1695	0	2241	662	3868	47586	52115	2 07	1 51	1 53
1979	1076	34402	35478	541	1688	0	2229	656	4014	55669	60339	2 07	1 75	1 76
1980	1075	34392	35467	537	1684	0	2221	650	3759	55037	59446	2 07	1 73	1 74
1981	1071	34379	35450	534	1673	0	2207	645	3525	59874	64045	2 06	1 86	1 87
1982	1068	34368	35436	885	1669	0	2554	640	3373	59431	63443	2 39 ⁷	1 85	1 86
1983	1065	34355	35420	926	1661	0	2587	634	3319	61078	65030	2 43	1 89	1 91
1984	1063	34344	35407	921	1655	0	2576	628	3263	66357	70249	2 42	2 05	2 06
1985	1059	34332	35391	917	1648	0	2565	624	3208	68648	72480	2 42	2 11	2 12
1986	1057	34319	35376	903	1639	0	2542	703	3020	69654	73377	2 40	2 14	2 15
1987	1063	34316	35379	515	1632	430 ⁸	2577	724	2872	68503	72099	2 42	2 10	2 11
1988	1070	34314	35384	453	1652	430	2535	732	2976	60525	64233	2 37	1 87	1 89
1989	1077	34312	35389	447	1668	430	2545	591	3026	57230	60847	2 36	1 77	1 79
1990	1084	34310	35394	448	1683	430	2561	545	1907	57677	60129	2 36	1 75	1 77
1991	1091	34307	35398	446	1701	430	2577	544	1780	52630	54954	2 36	1 60	1 63
1992	1098	34305	35403	440	1721	430	2590	552	1731	53167	55450	2 36	1 62	1 64
1993	1106	34301	35407	449	1738	430	2617	567	1748	55310	57625	2 37	1 68	1 70
1994	1113	34299	35412	451	1751	430	2632	549	1562	57745	59856	2 36	1 75	1 76
1995	1120	34296	35416	447	1768	430	2644	536	1361	57931	59828	2 36	1 74	1 76
1996	1120	34296	35416	463	1785	430	2677	537	1353	61620	63510	2 39	1 85	1 87
1997	1120	34296	35416	473	1785	430	2687	545	1307	62785	64636	2 40	1 88	1 90
1998	1120	34296	35416	472	1785	430	2687	538	1232	59623	61393	2 40	1 79	1 81
1999	1120	34296	35416	480	1785	430	2695	535	1164	62056	63755	2 41	1 86	1 88
2000	1120	34305	35425	457	1785	430	2672	536	1141	64478	66156	2 39	1 93	1 94
Avg	1091	34385	35476	572	1716	430	2455	638	3208	63133	66978	2 25	1 95	1 96
Note:														
1	Base on data received from EBMUD. See text for estimation method													
2	Data estimated based on unit water use from Alameda Golf Course and Marina/Tony Lema Golf Course													
3	Reclaimed water used by Alameda Golf Course. Estimated based on 1987 reported reclamation wate use													
4	Total turf irrigation water divided by irrigation acreage													
5	Total domestic and industrial water supply divided by urban acreage													
6	The sum of total irrigation water supply and total urban water supply divided by total developed acreage													
7	Tony Lema Golf Course went into operation													
8	Alameda Golf Course stopped to use G.W and started to use reclaimed water													

Table 7. NCGB-SEBP IGSM NCGB Acreage and Water Supply Summary

	Acreage			Agricultural Water Supply ¹				Municipal Water Supply ¹					Unit Water Use (Unit ² AF/AC)		
	Agricultural	Urban	Total Developed	Agricultural	City Parks	Non-Municipal Recreation	Total Ag Water Supply	ACWD GW Production	CUCC GW Production ⁷	Industrial	Surface Water	Total Muni. Water Supply	Ag ²	M&I ³	Overall ⁴
1965	10733	15318	26051	19367 ⁵	145	0	19512	10605	0	28	10885	21518	1.82	1.40	1.58
1966	9782	15715	25497	18438	145	0	18583	11286	0	28	12704	24017	1.90	1.53	1.67
1967	8828	16108	24936	14213	145	0	14358	12135	0	26	13726	25887	1.63	1.61	1.61
1968	7875	16500	24375	13109	145	0	13254	12936	0	25	12630	25591	1.68	1.55	1.59
1969	6922	16892	23814	12110	145	0	12255	13842	0	24	12419	26286	1.77	1.56	1.62
1970	7122	17284	24406	12776	145	0	12921	13577	0	23	12955	26555	1.81	1.54	1.62
1971	4917	17676	22593	8728	145	0	8873	13336	0	22	14058	27416	1.80	1.55	1.61
1972	4716	18589	23305	8668	145	0	8813	13660	0	24	15221	28904	1.87	1.55	1.62
1973	4617	19501	24118	8379	145	0	8524	12750	0	22	16521	29294	1.85	1.50	1.57
1974	4917	20414	25331	4339 ⁶	431	4	4774	11838	185	20	18152	30195	0.97	1.48	1.38
1975	5019	21326	26345	6114	911	541	7566	16100	2079	4727	17205	40111	1.51	1.88	1.81
1976	5019	22239	27258	7986	1029	764	9779	14373	2135	4326	19293	40128	1.95	1.80	1.83
1977	4694	23151	27845	5517	685	847	7049	9133	621	2648	22691	35094	1.50	1.52	1.51
1978	4716	23622	28338	4726	756	438	5920	11336	254	2101	17788	31479	1.26	1.33	1.32
1979	4414	24092	28506	4838	546	478	5862	11994	1169	1751	23170	38084	1.33	1.58	1.54
1980	4315	24563	28878	4511	1056	653	6220	14939	270	1711	20815	37735	1.44	1.54	1.52
1981	4517	25032	29549	4657	1372	627	6656	15963	678	1520	18800	36960	1.47	1.48	1.48
1982	3814	25505	29319	3211	1301	436	4947	14804	0	1346	12532	28683	1.30	1.12	1.15
1983	3814	25975	29789	3293	1351	432	5076	14443	0	1273	20193	35910	1.33	1.38	1.38
1984	3012	26447	29459	3239	919	363	4521	16729	276	1368	17396	35769	1.50	1.35	1.37
1985	2710	26917	29627	3192	1021	366	4579	17731	356	1507	27148	46741	1.69	1.74	1.73
1986	3012	27388	30400	2443	1181	382	4006	19457	372	1428	25890	47147	1.33	1.72	1.68
1987	2912	27387	30299	2664	1389	604	4657	22987	680	1816	27936	53419	1.60	1.95	1.92
1988	2776	27861	30637	2345	1399	437	4181	22914	708	1685	28524	53830	1.51	1.93	1.89
1989	2640	28338	30978	1634	1387	343	3364	22696	810	1868	29302	54676	1.27	1.93	1.87
1990	2503	28818	31321	1382	1489	463	3334	24029	392	2121	25143	51686	1.33	1.79	1.76
1991	2368	29295	31663	1516	1049	392	2957	23260	769	2004	22317	48350	1.25	1.65	1.62
1992	2230	29759	31989	1220	1158	416	2793	25258	819	2109	24863	53049	1.25	1.78	1.75
1993	2094	30203	32297	1329	1124	299	2752	22349	274	1970	23499	48091	1.31	1.59	1.57
1994	1960	30735	32695	1352	1319	223	2894	16030	0	1777	36320	54127	1.48	1.76	1.74
1995	2394	31283	33677	1199	1173	202	2574	15306	0	1793	29765	46863	1.08	1.50	1.47
1996	2394	31283	33677	1095	1471	210	2776	15618	0	1682	31035	48334	1.16	1.55	1.52
1997	2394	31283	33677	733	1743	240	2716	20642	0	1637	38252	60530	1.13	1.93	1.88
1998	2394	31283	33677	424	1259	46	1729	16938	0	1570	37793	56301	0.72	1.80	1.72
1999	2394	31283	33677	246	1117	57	1420	19554	0	1462	35162	56178	0.59	1.80	1.71
2000	2394	31283	33677	326	1335	129	1789	20570	0	1876	39212	61658	0.75	1.97	1.88
Avg	4259	24732	28991	5314	897	289	6500	16420	357	1426	22537	40739	1.53	1.63	1.66
Note:	1	Data from ACWD													
	2	Total agricultural water supply divided by agricultural acreage													
	3	Total municipal water supply divided by urban acreage													
	4	The sum of total agricultural water supply and total municipal water supply divided by total developed acreage													
	5	From 1965 to 1973, agricultural demand was restimated using CUAW method.													
	6	Since 1974, agricultural demand is metered.													
	7	ACWD acquired CUCC service area in 1994.													

Figure 1. ET monthly pattern for pasture in the SEBP_NCGB area



Water Use Consistency

In order to ensure that the water uses in the two basins are consistent, an annual analysis of water use by type and land use acreage was performed. Tables 6 and 7 show the results. According to these tables, overall water use in each area is 1.96 AF/AC and 1.66 AF/AC in SEBP and NCGB, respectively.

Summary

Based on the available data for the Southeast Bay Plain and Niles Cone groundwater basin, the long-term average annual groundwater pumping for all model area is estimated to be approximately 39,797 AF/Yr. Tables 8 and 9 summarize the average annual groundwater pumping by each basin and for each category. Figures 2 and 3 show the categorized annual groundwater pumping for the SEBP and NCGB areas, respectively.

Table 8. Average Annual Pumping (AF) in the SEBP Areas (1965-2000)		
	Pumping Category	Amount
Sub Total M&I		3,842
	Domestic Use	439
	Municipal Wells	199
	Industrial Wells	3,208
Sub Total Agricultural		2,288
	Crop Irrigation	N/A
	Turf Irrigation by Well	572
	Turf Irrigation by Estimation	1716
Total Groundwater Pumping		6,130

Table 9. Average Annual Pumping (AF) in the NCGB Area (1965-2000)

Pumping Category		Amount
Sub-total Irrigation		6,211
	Agricultural Crop Irrigation	5,314
	Turf Irrigation	897
Sub-total M&I		21,787
	Industrial	1,426
	Non-municipal recreation	289
	Citizen's Utility Co.(inherited by ACWD)	357
	ACWD production	16,420
	Estimated Urban	3,295
Sub-total Others		5,669
	Aquifer Reclamation	4,676
	Salinity Barrier	65
	L.U.F.T. cases	25
	Misc.	917
Total NCGB		33,666

Figure 2. Annual Groundwater Pumping in the SEBP Area

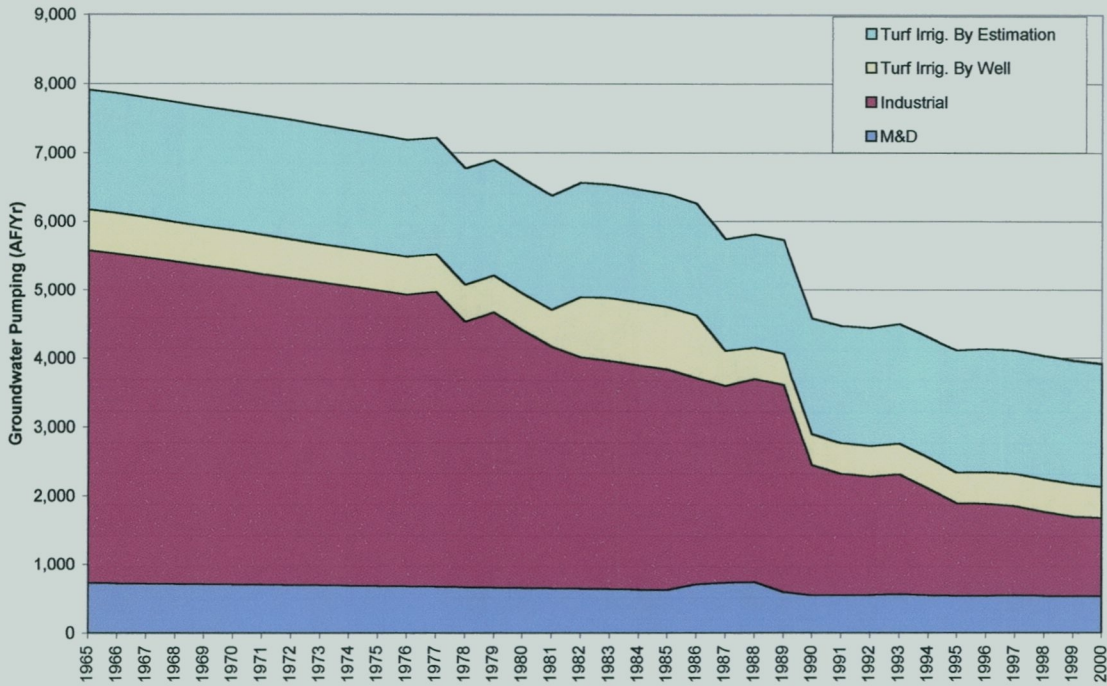
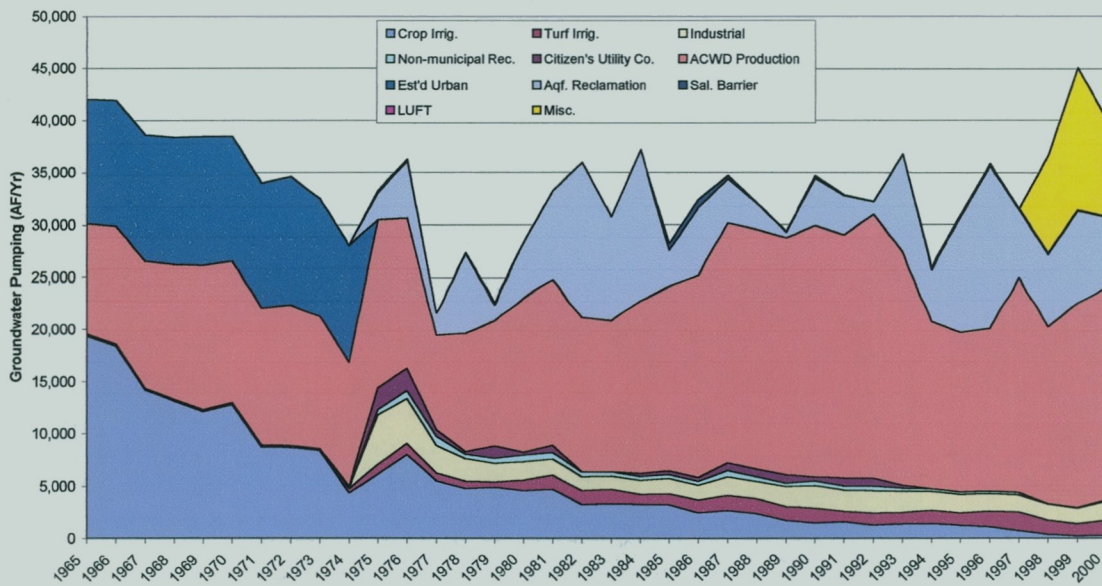


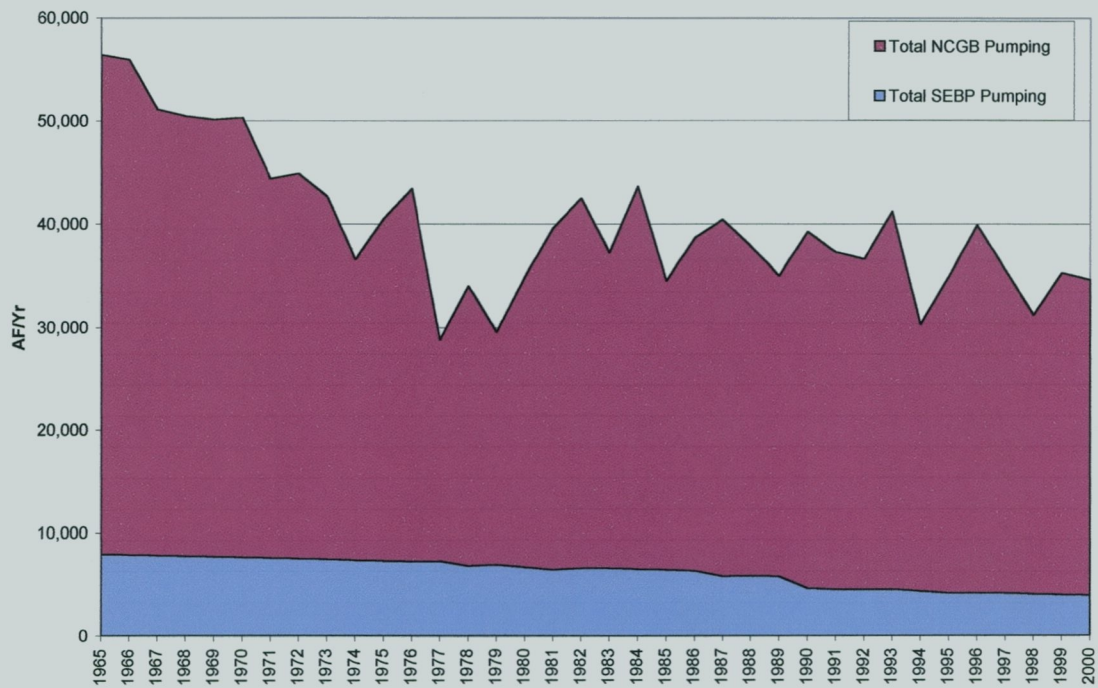
Figure 3. Annual Groundwater Pumping in the NCGB Area



capline
w/ pipe
"uppulling"

Figure 4 shows the annual groundwater pumping for NCGB and SEBP areas for the 1965 to 2000 water years.

Figure 4. Annual Groundwater Pumping for NCGB and SEBP Areas



APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.C. Supporting Data for Seawater Intrusion SMC

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APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.C. Supporting Data for Seawater Intrusion SMC

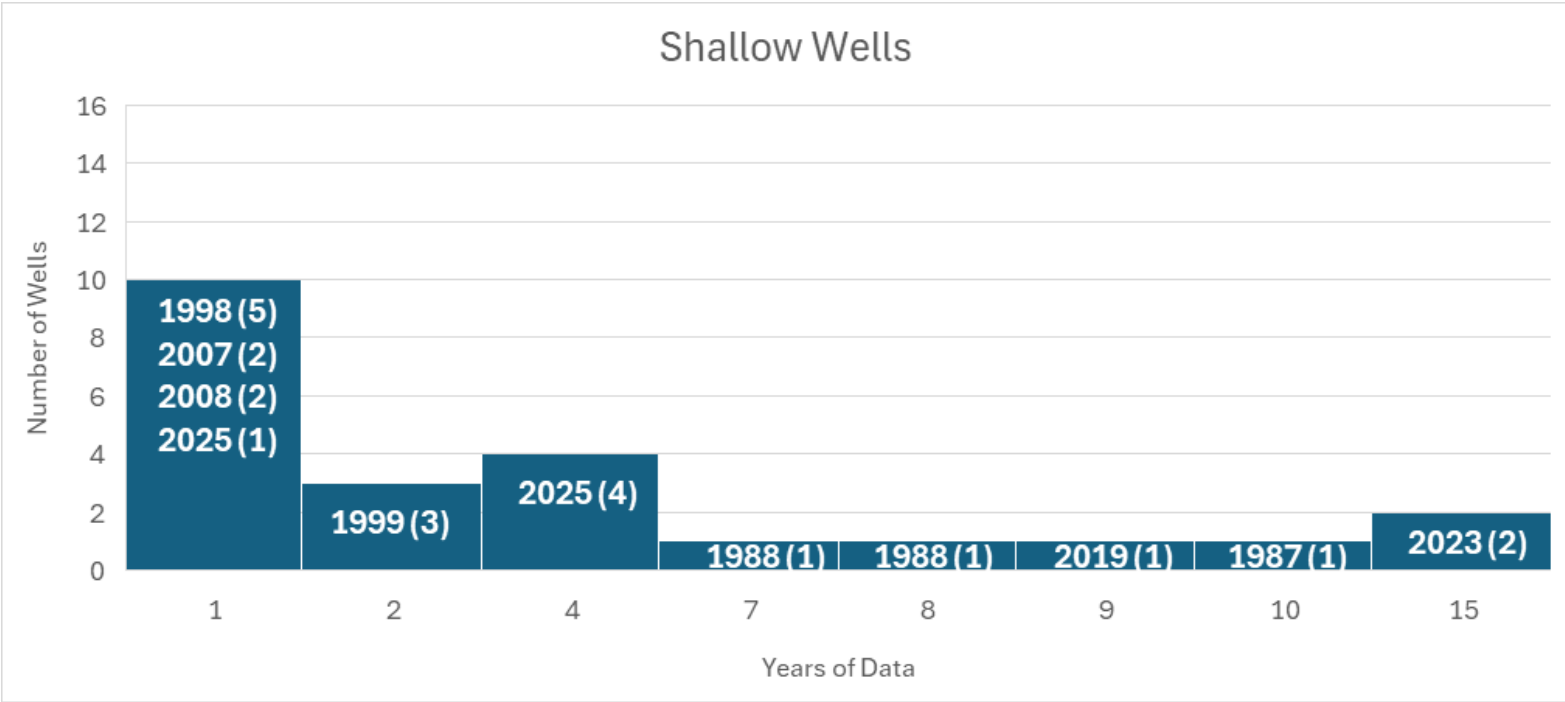
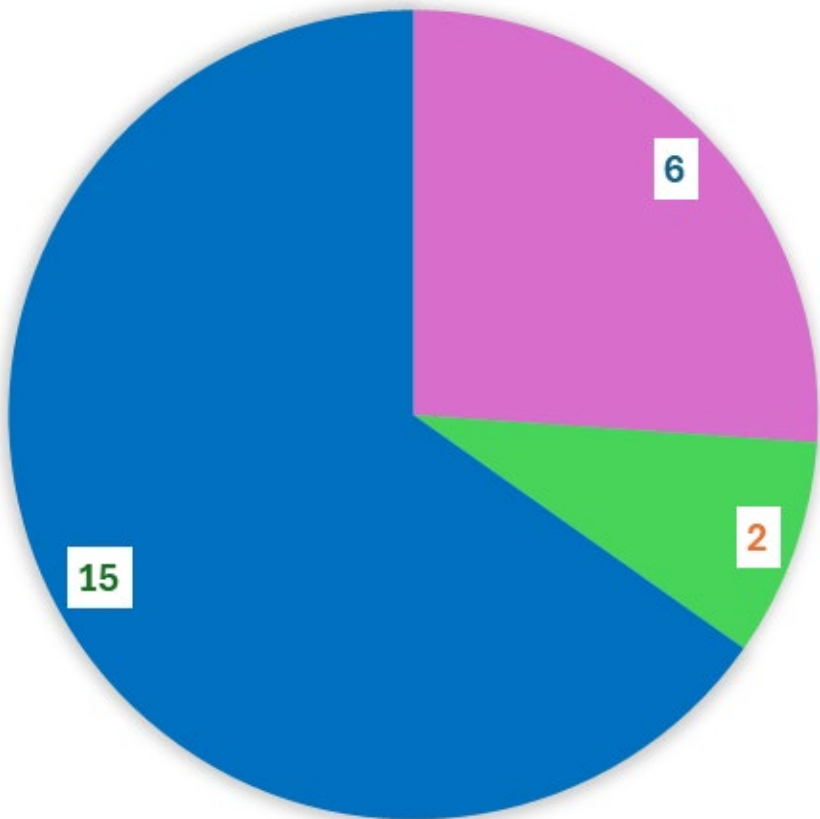
3.C.a Summary of Chloride Concentrations by Aquifer

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Chloride Concentrations – Shallow Aquifer

SHALLOW WELL CONCENTRATIONS

Over 500 mg/L 200 - 500 mg/L Less than 200 mg/L

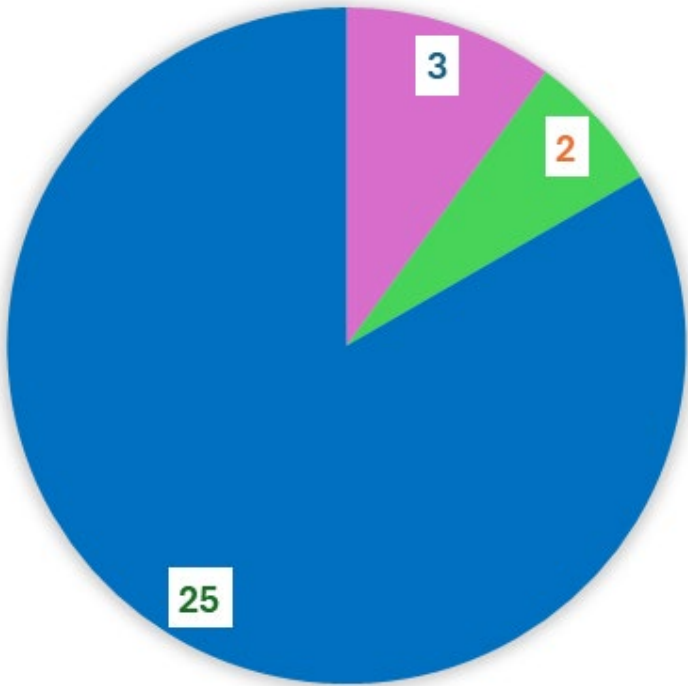


Note: In the columns, Year followed by a number in parentheses denotes the following:
Year = The most recent year with data
Number = The number of wells that were last sampled in that year
E.g. 1998 (4) = 4 wells were last sampled in 1998

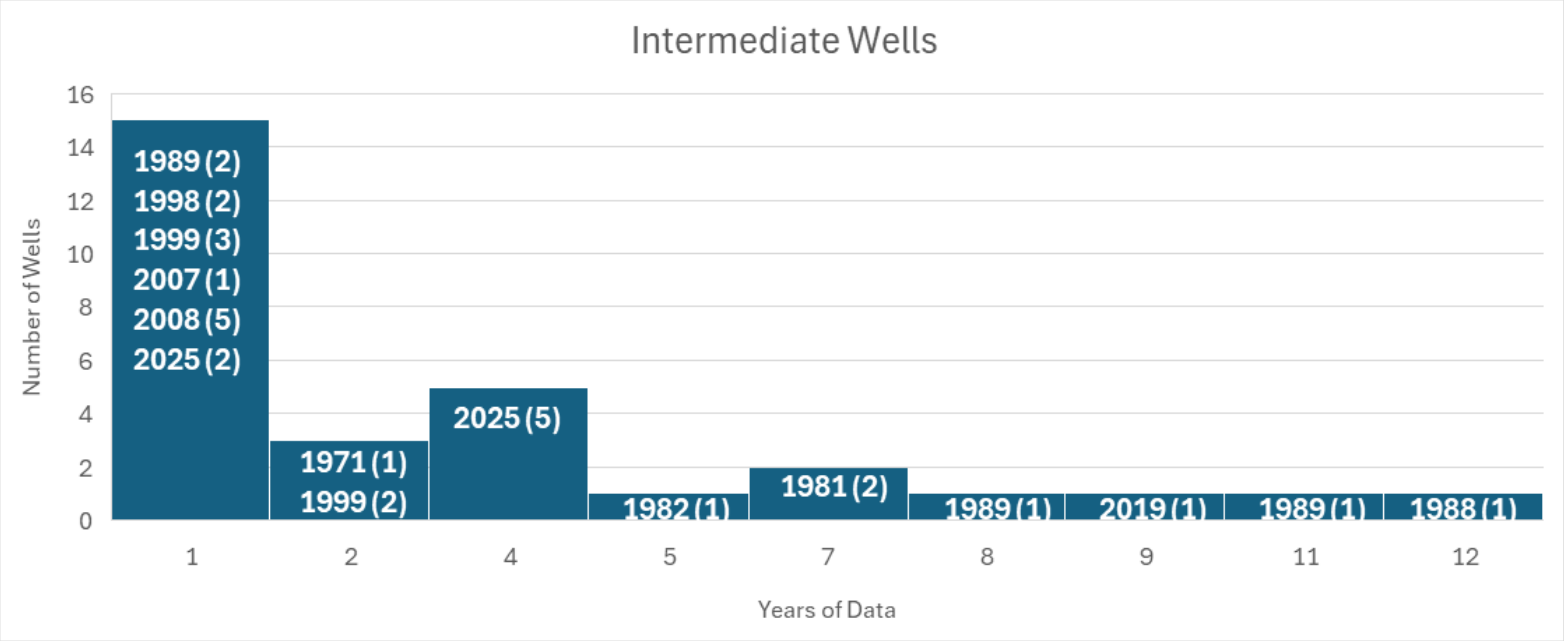
Chloride Concentrations – Intermediate Aquifer

INTERMEDIATE WELL CONCENTRATIONS

Over 500 mg/L 200 - 500 mg/L Less than 200 mg/L



Wells with concentrations over 500 mg/L have total depths in the intermediate zone, but no information on screen intervals. These wells likely include screen intervals in the shallow zone.

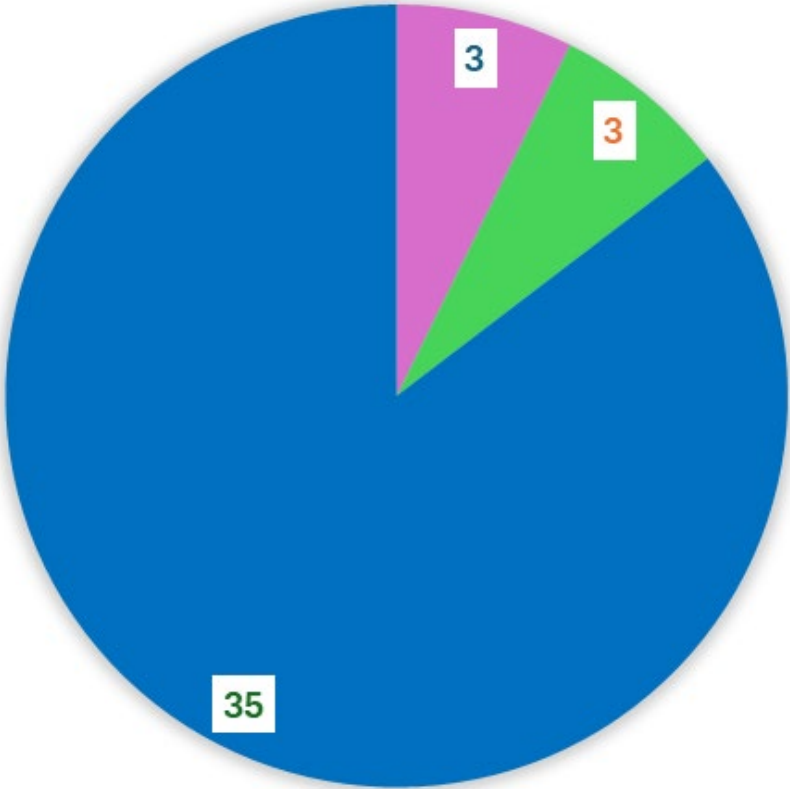


Note: In the columns, Year followed by a number in parentheses denotes the following:
Year = The most recent year with data
Number = The number of wells that were last sampled in that year
E.g. 1989 (2) = 2 wells were last sampled in 1989

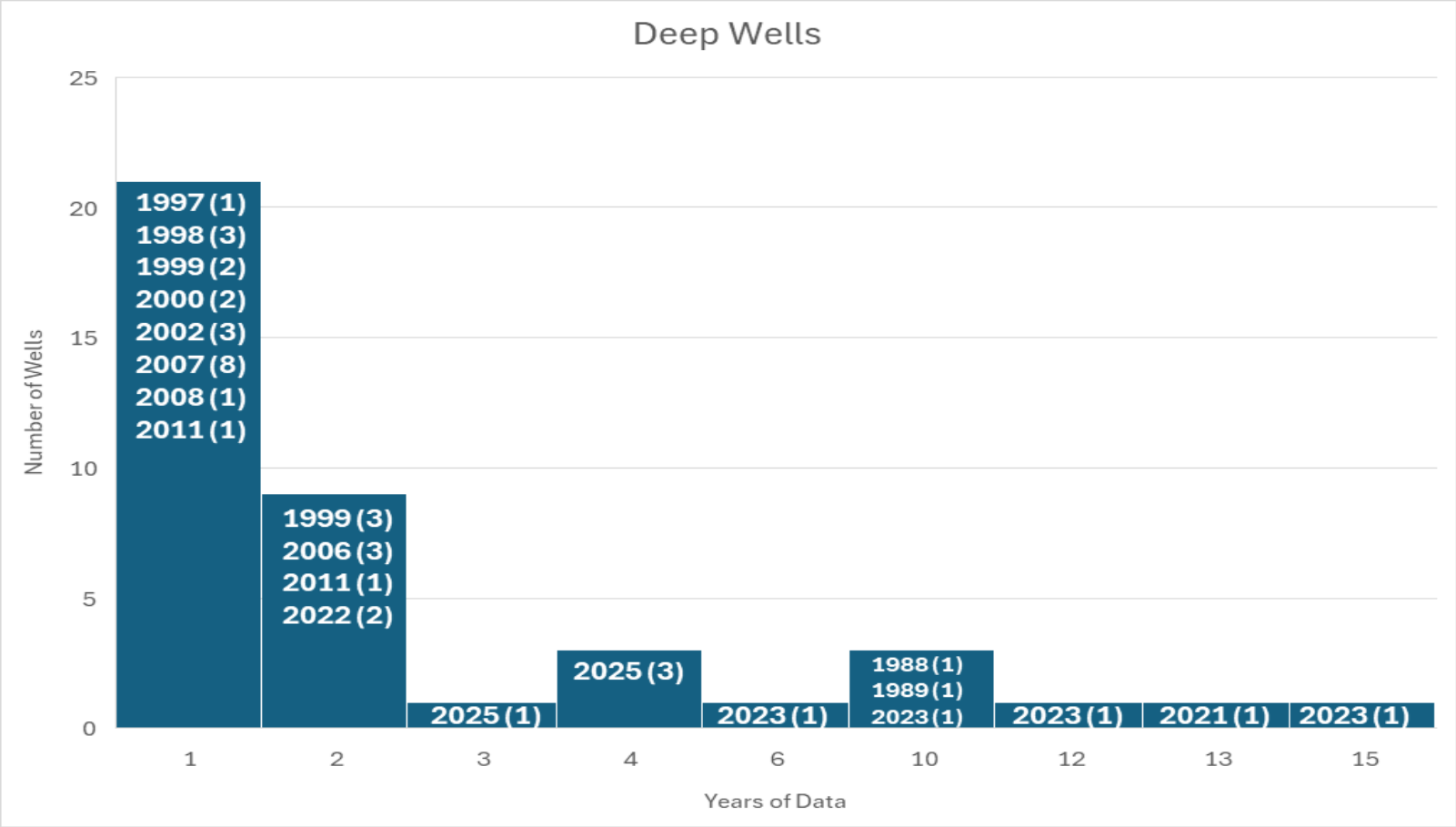
Chloride Concentrations – Deep Aquifer

DEEP WELL CONCENTRATIONS

Over 500 mg/L 200 - 500 mg/L Less than 200 mg/L



Wells with concentrations over 500 mg/L have total depths in the deep zone, but no information on screen intervals. These wells likely include screen intervals in the shallow zone.



Note: In the columns, Year followed by a number in parentheses denotes the following:
Year = The most recent year with data
Number = The number of wells that were last sampled in that year
E.g. 1997 (1) = 1 well was last sampled in 1997

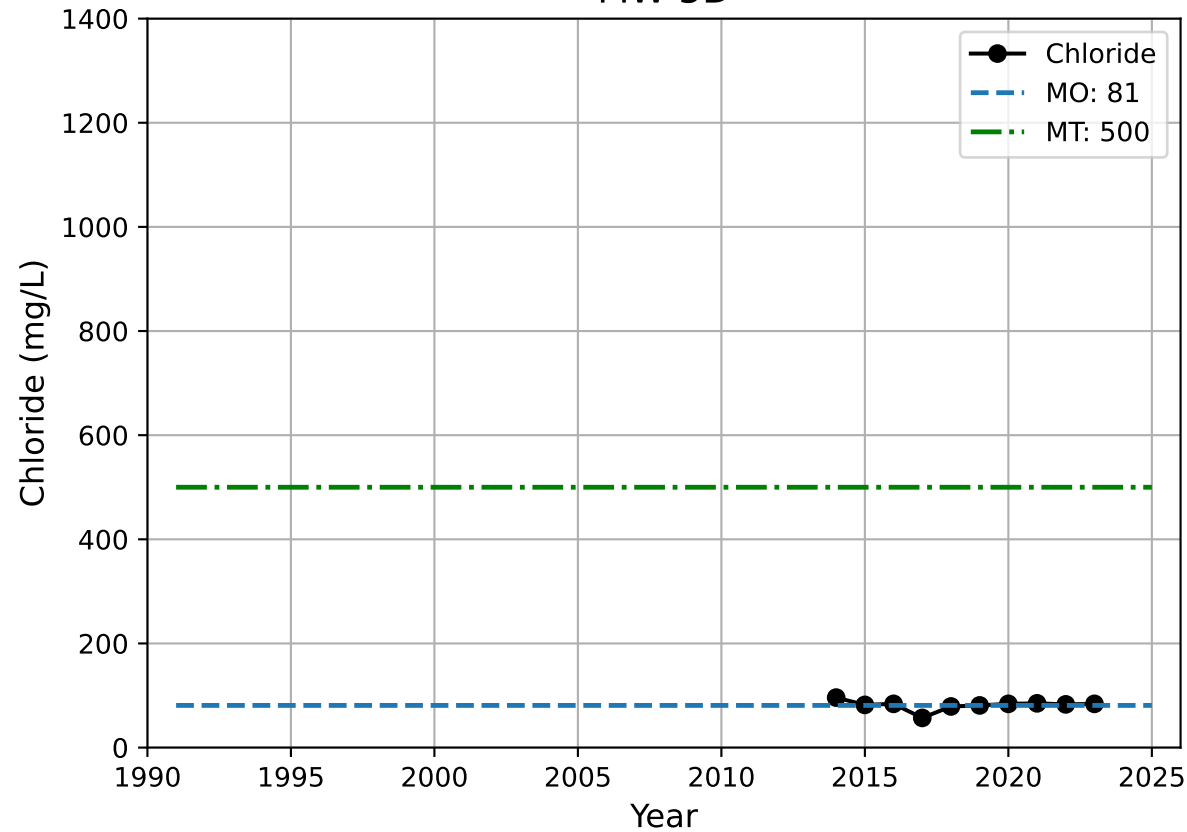
APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.C. Supporting Data for Seawater Intrusion SMC

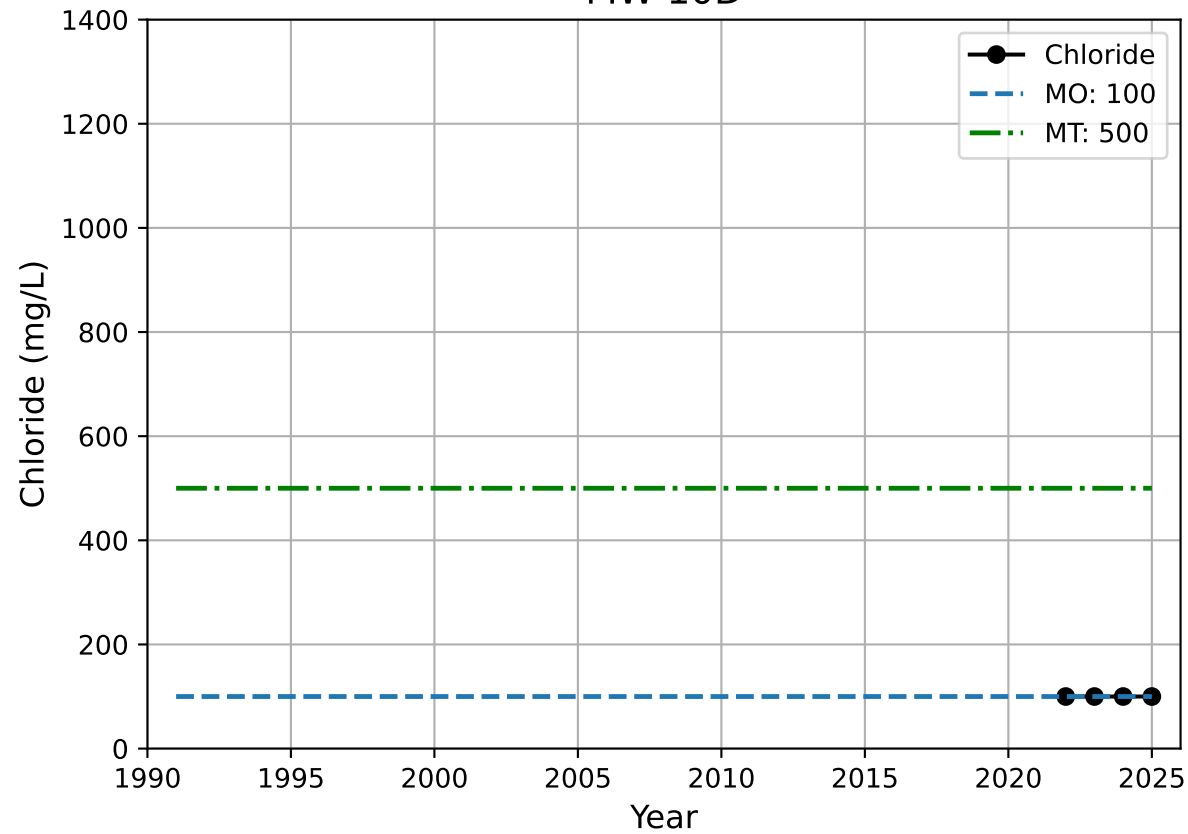
3.C.b Chloride Concentrations Time-Series Graphs

DRAFT

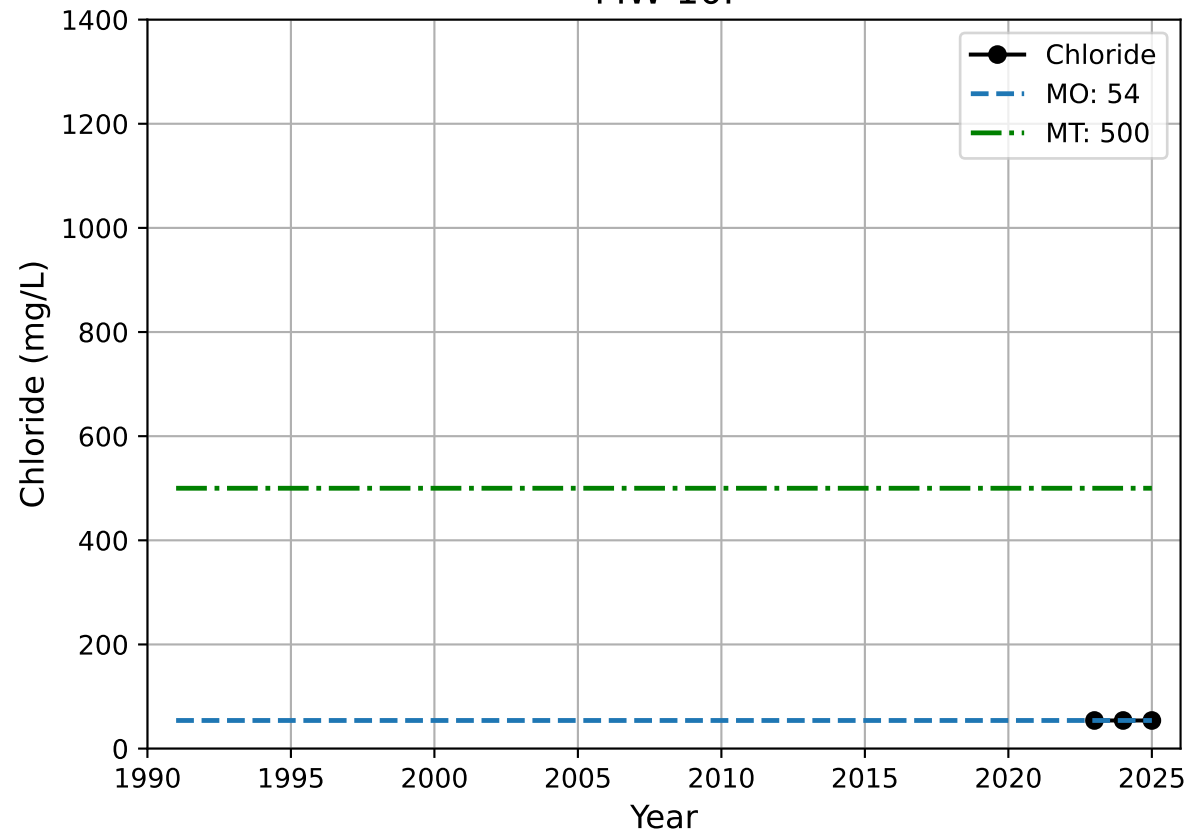
MW-5D



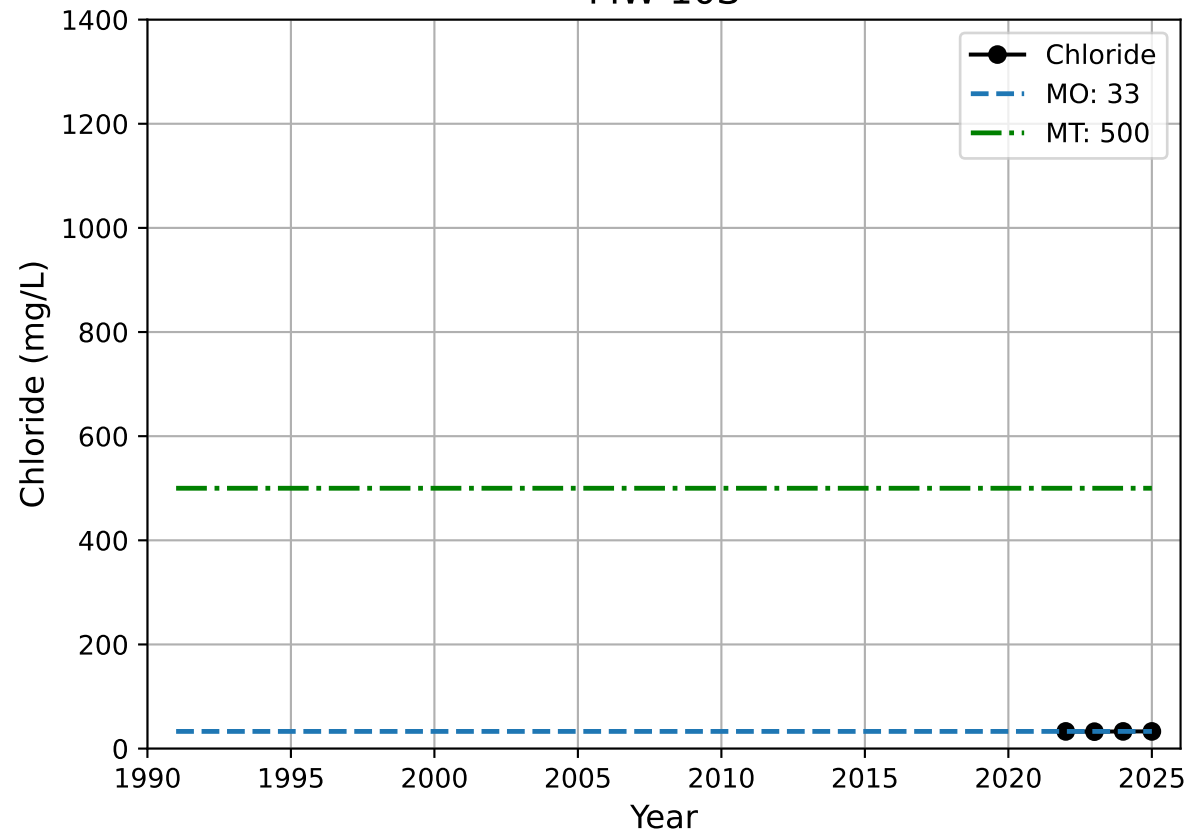
MW-10D



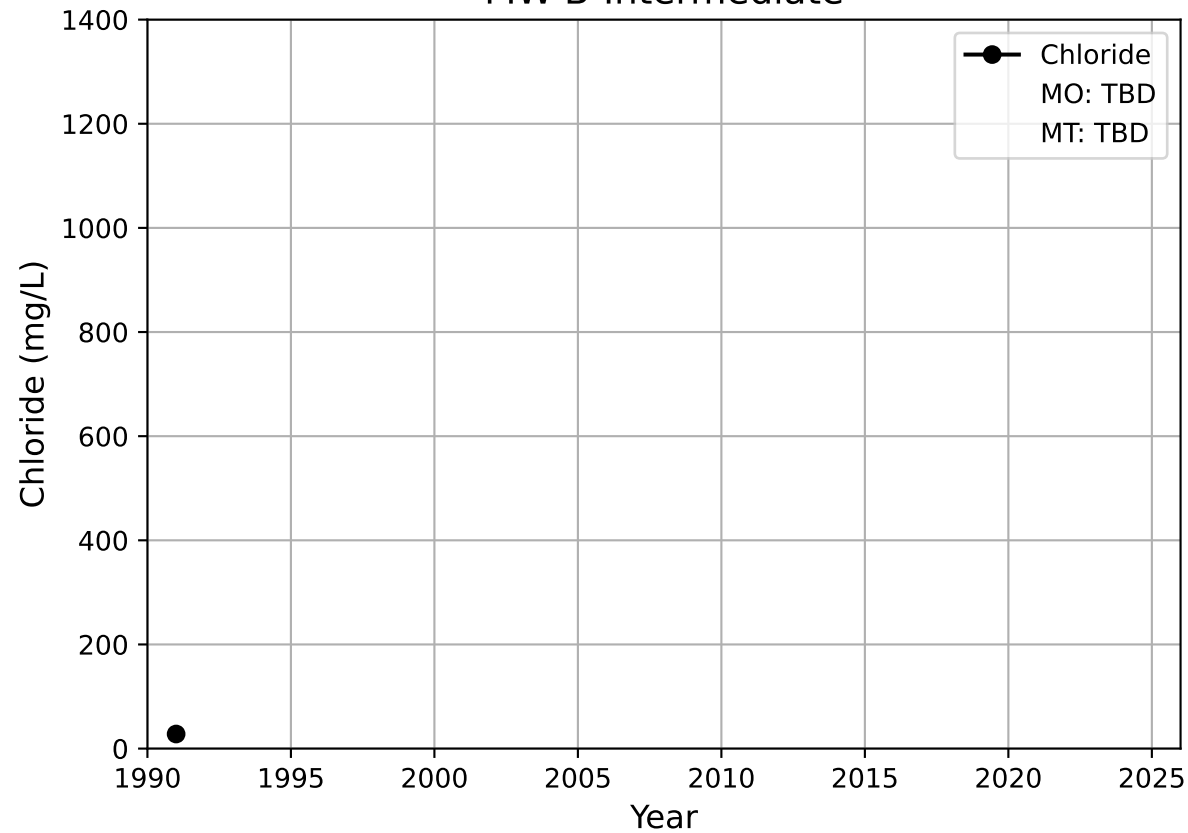
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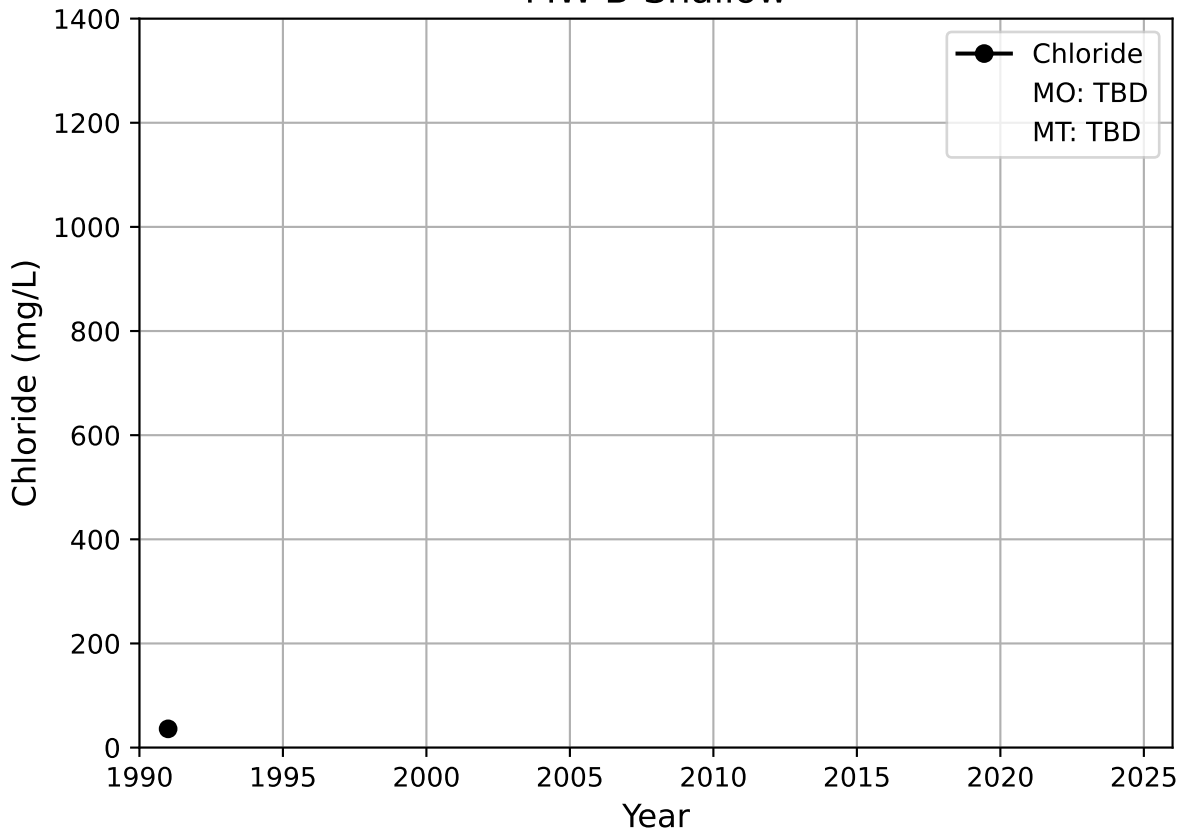
MW-10S



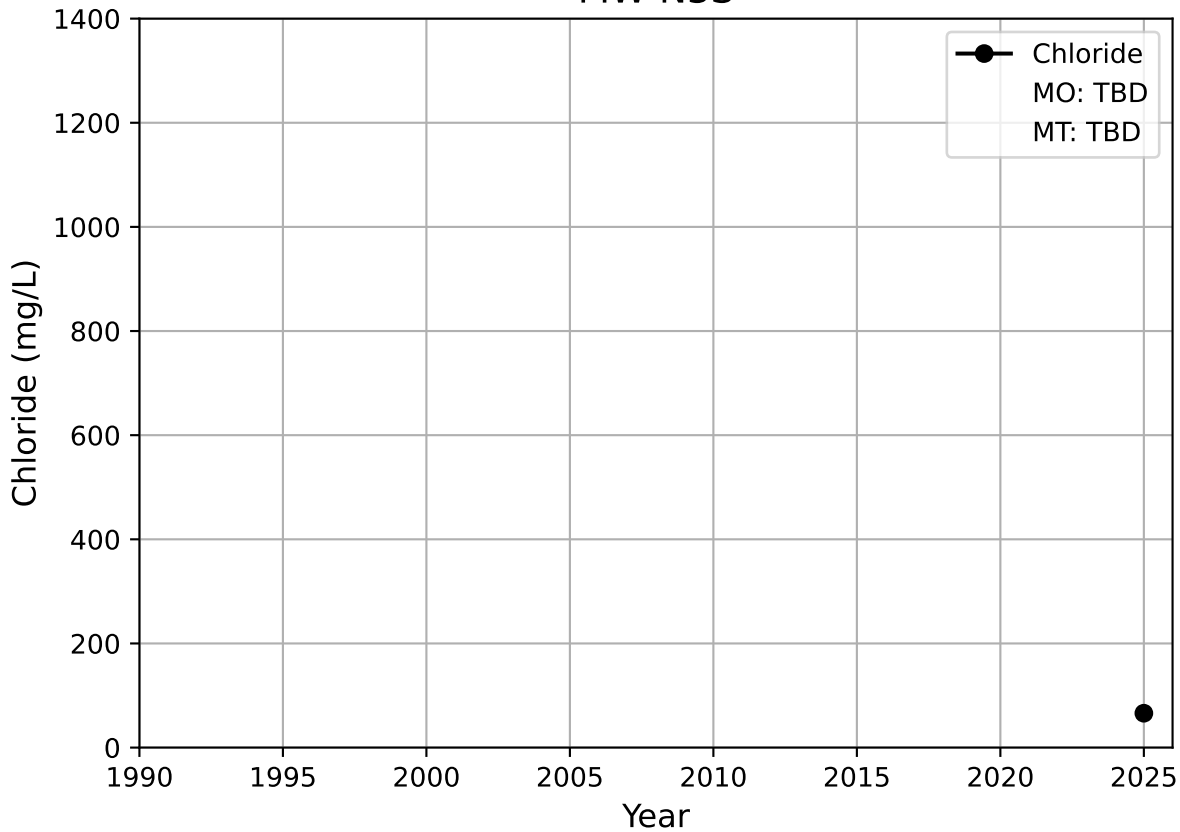
MW-B-Intermediate



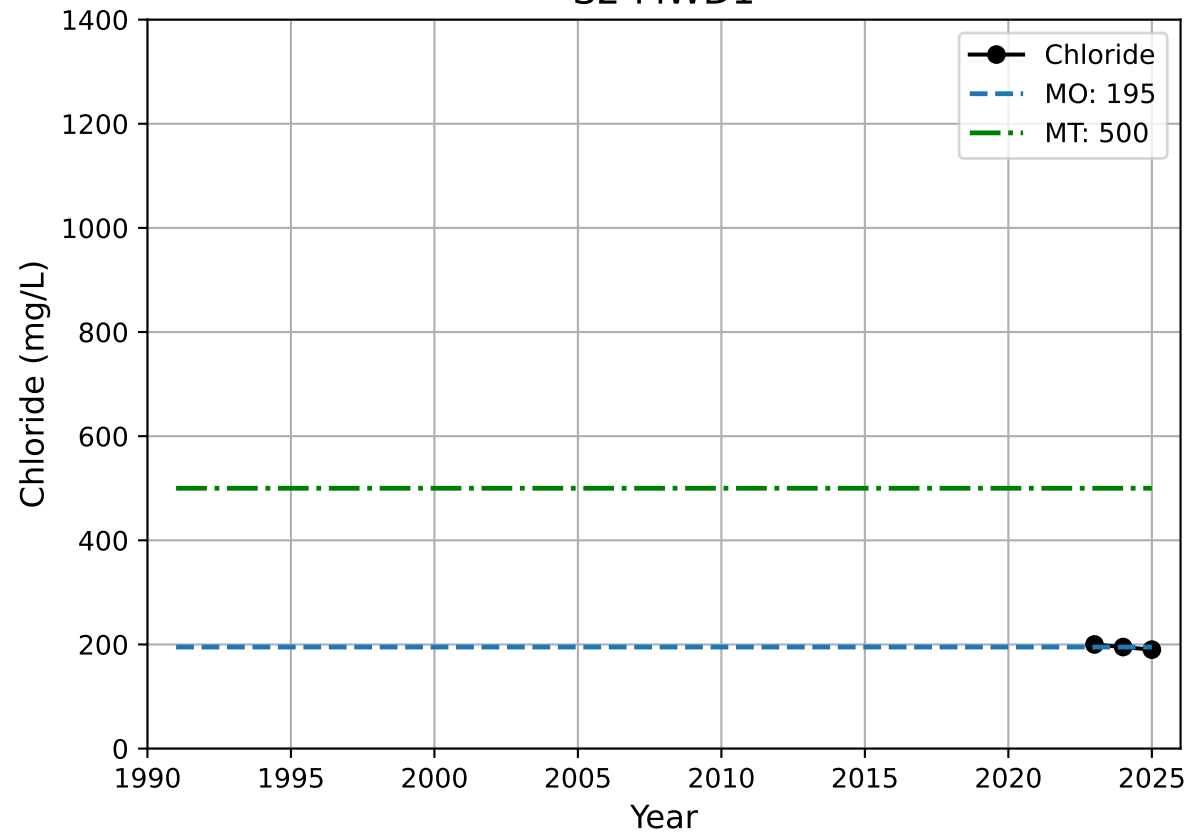
MW-B-Shallow



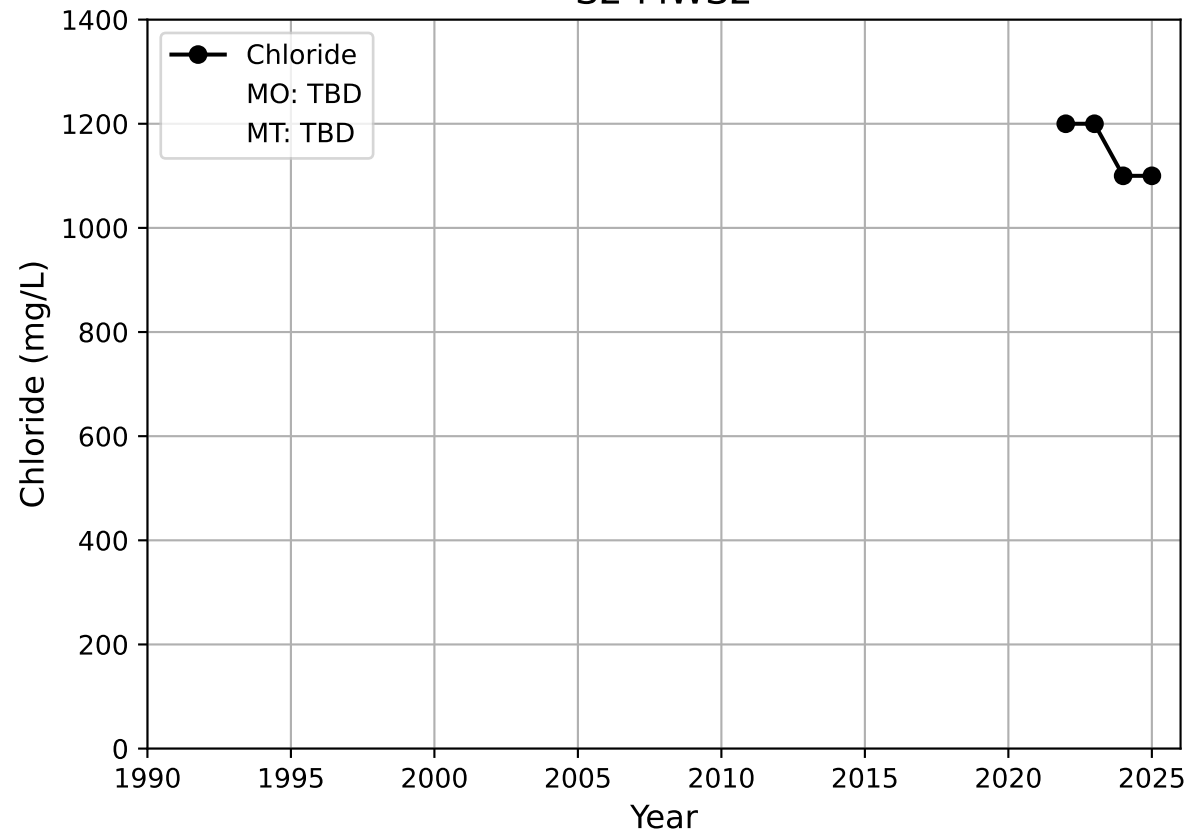
MW-N3S



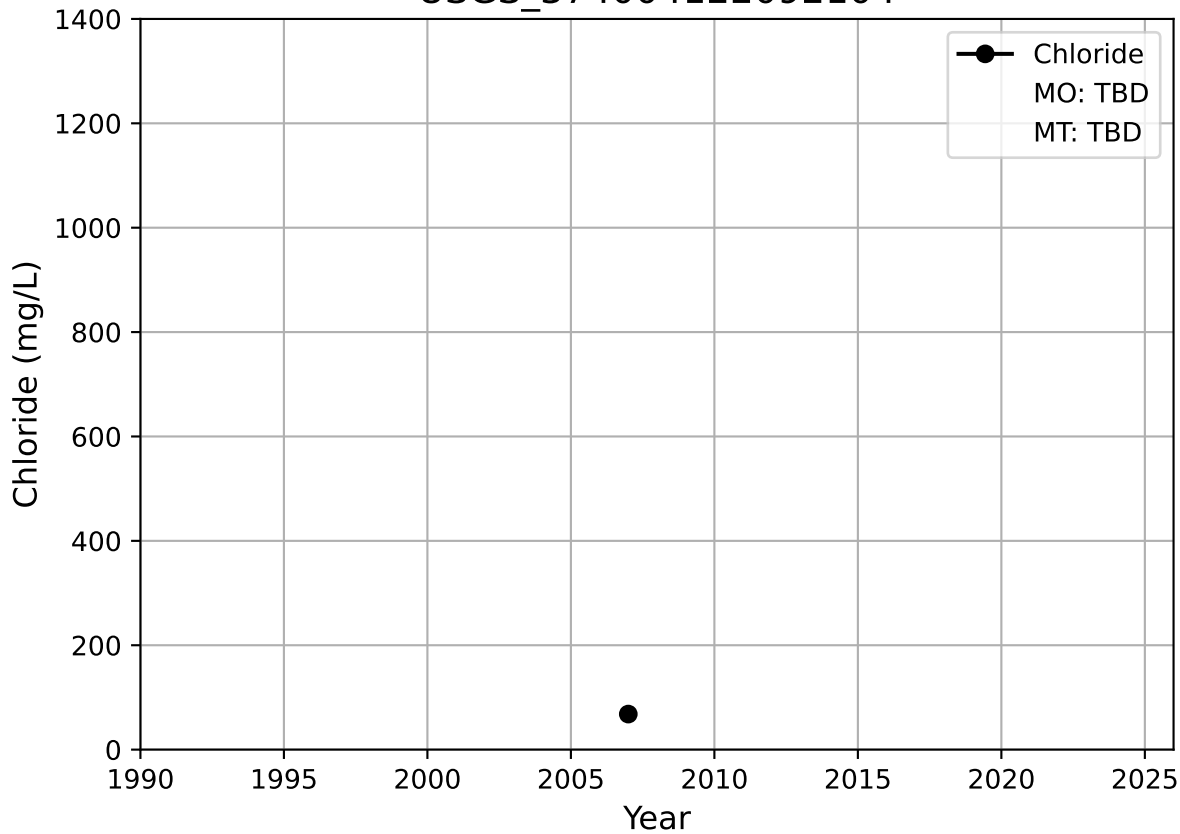
S2-MWD1



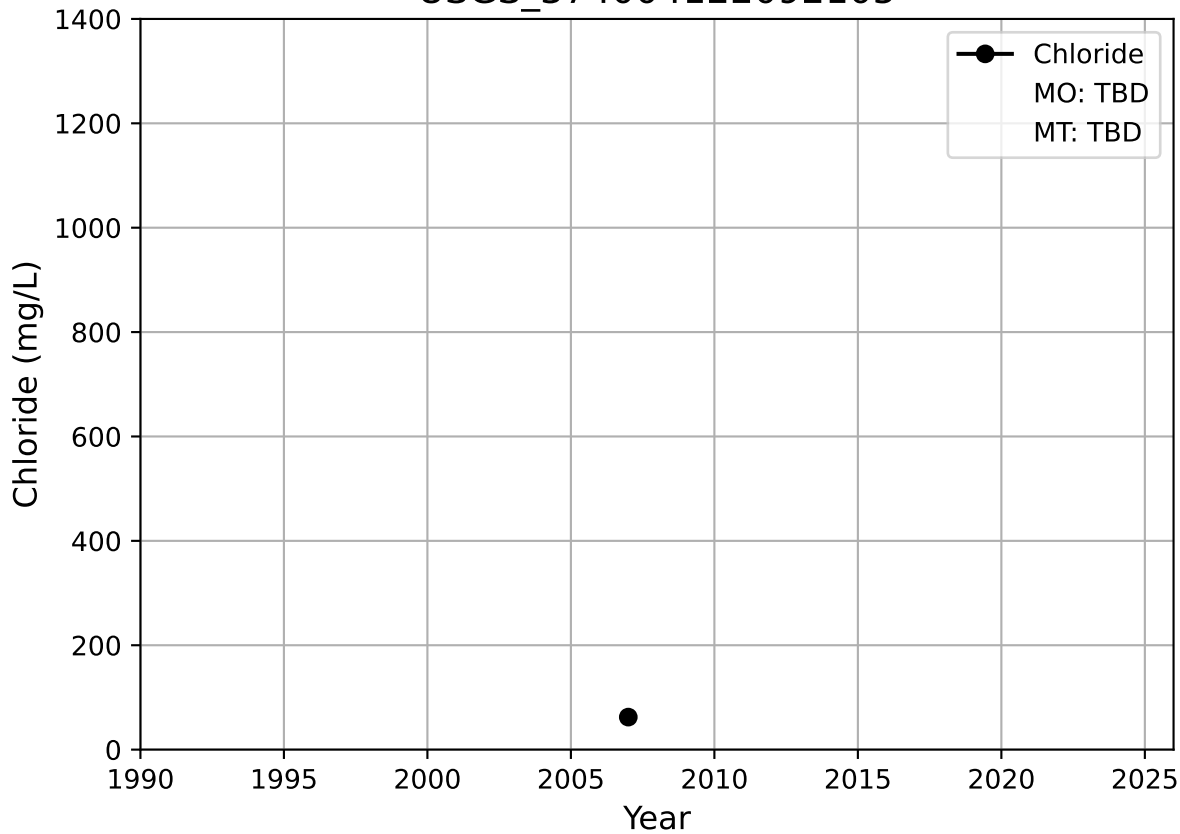
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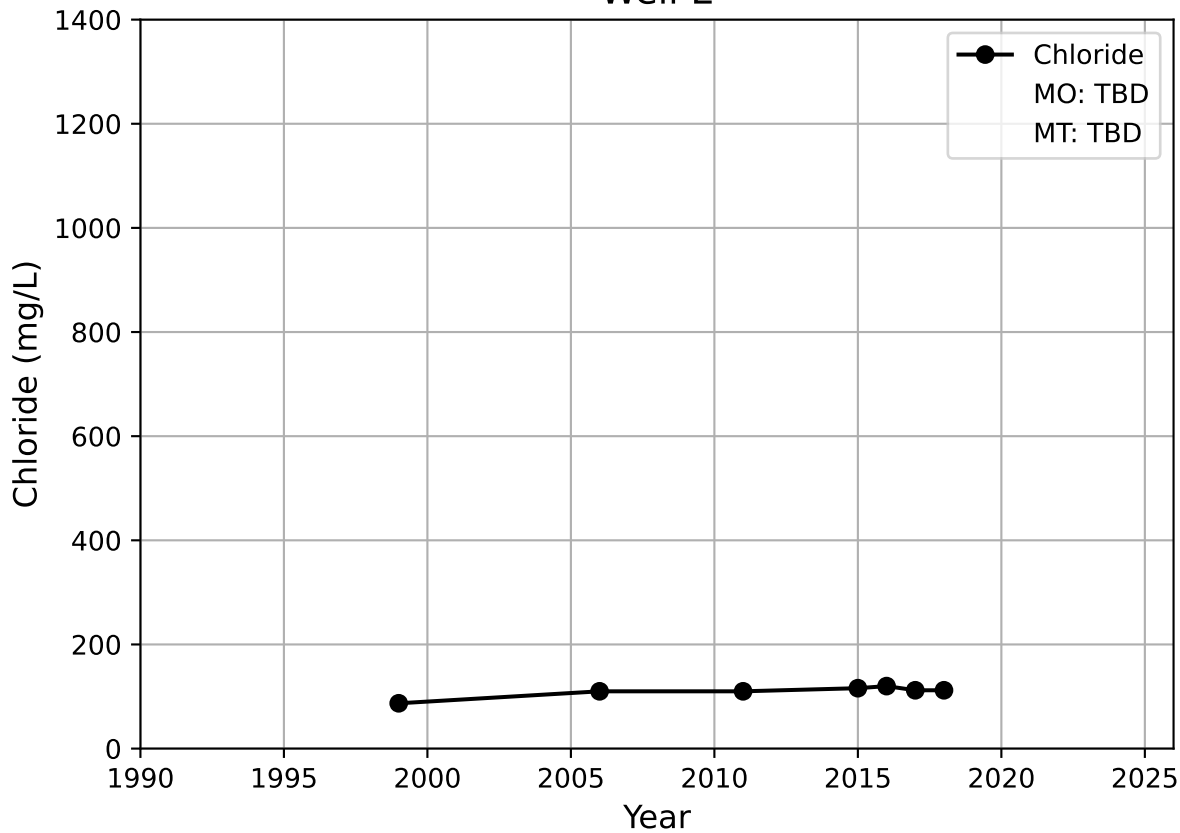
USGS_374004122092104



USGS_374004122092105



Well E



APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.D. Supporting Information for Subsidence SMC

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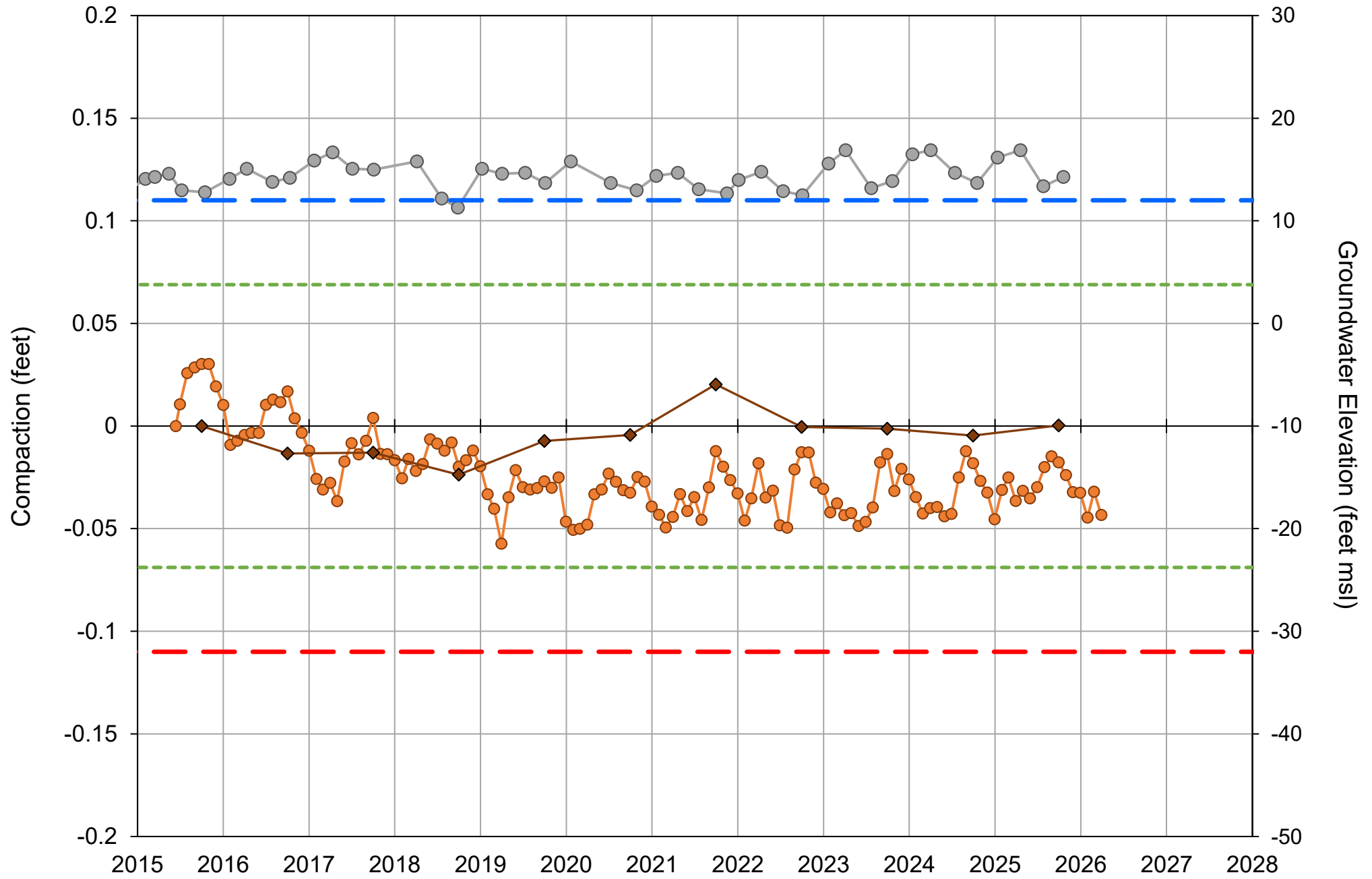
APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.D. Supporting Information for Subsidence SMC

3.D.a InSAR Data Time-Series Graphs

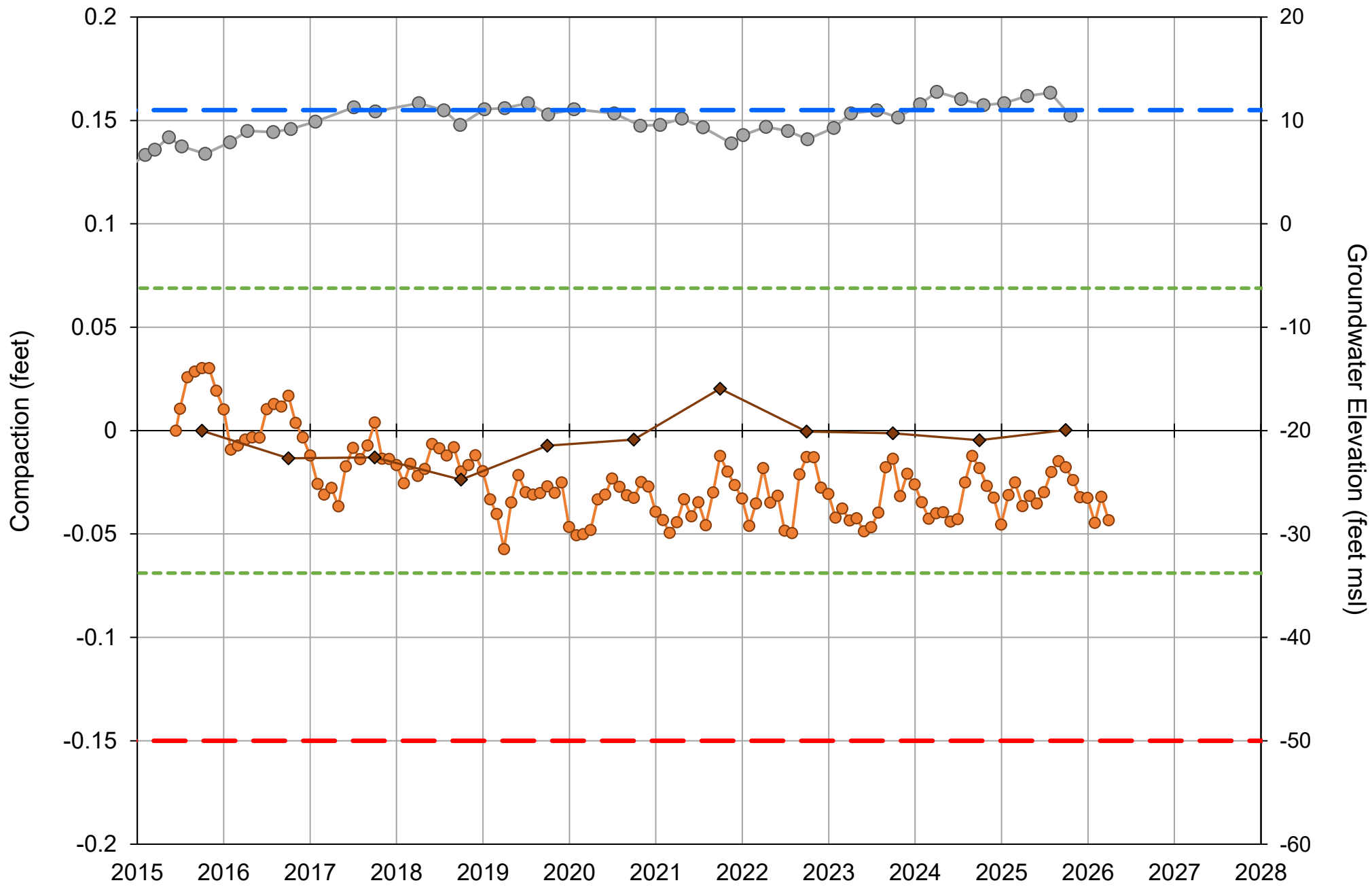
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MW-5S



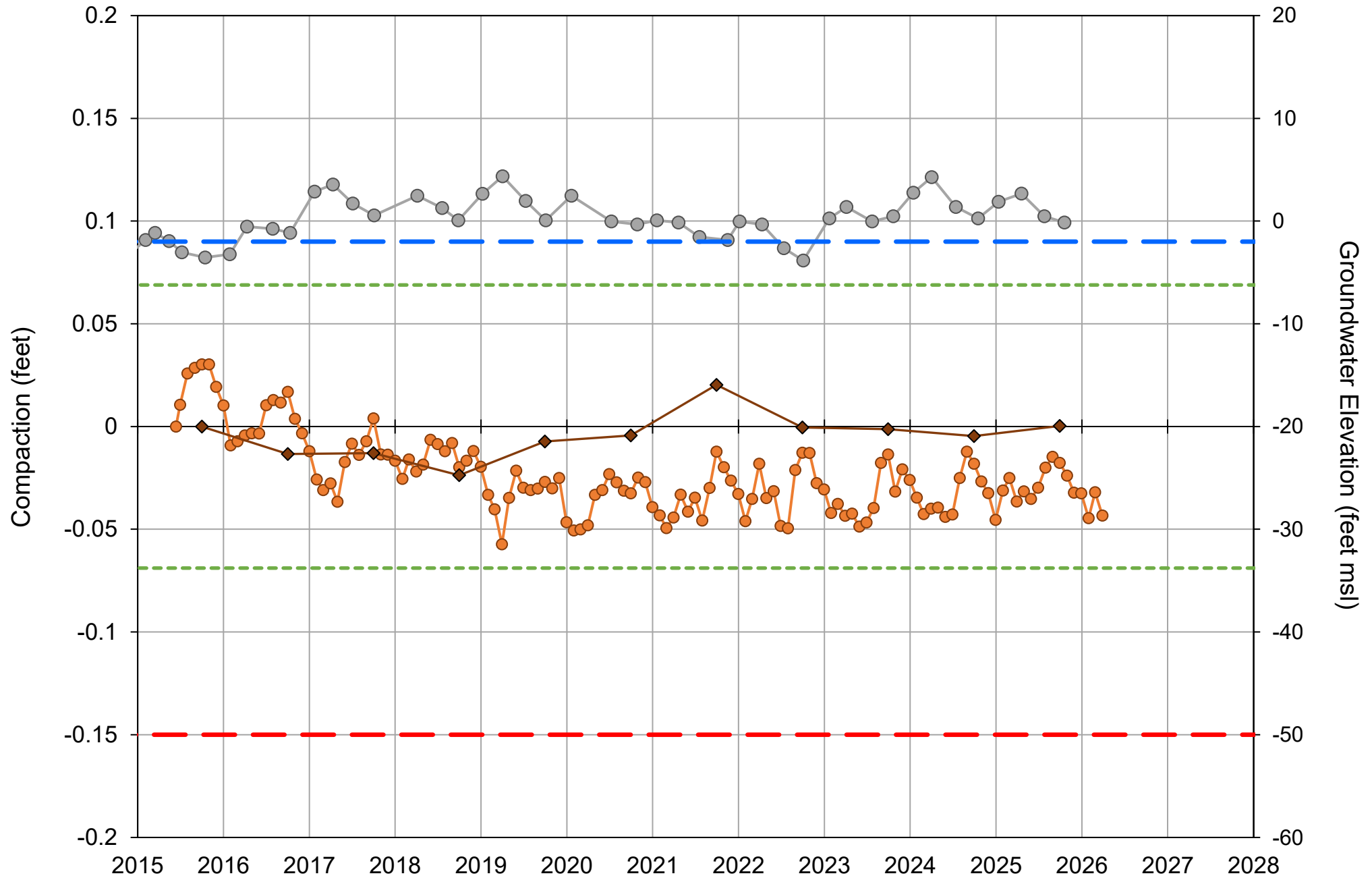
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-5I



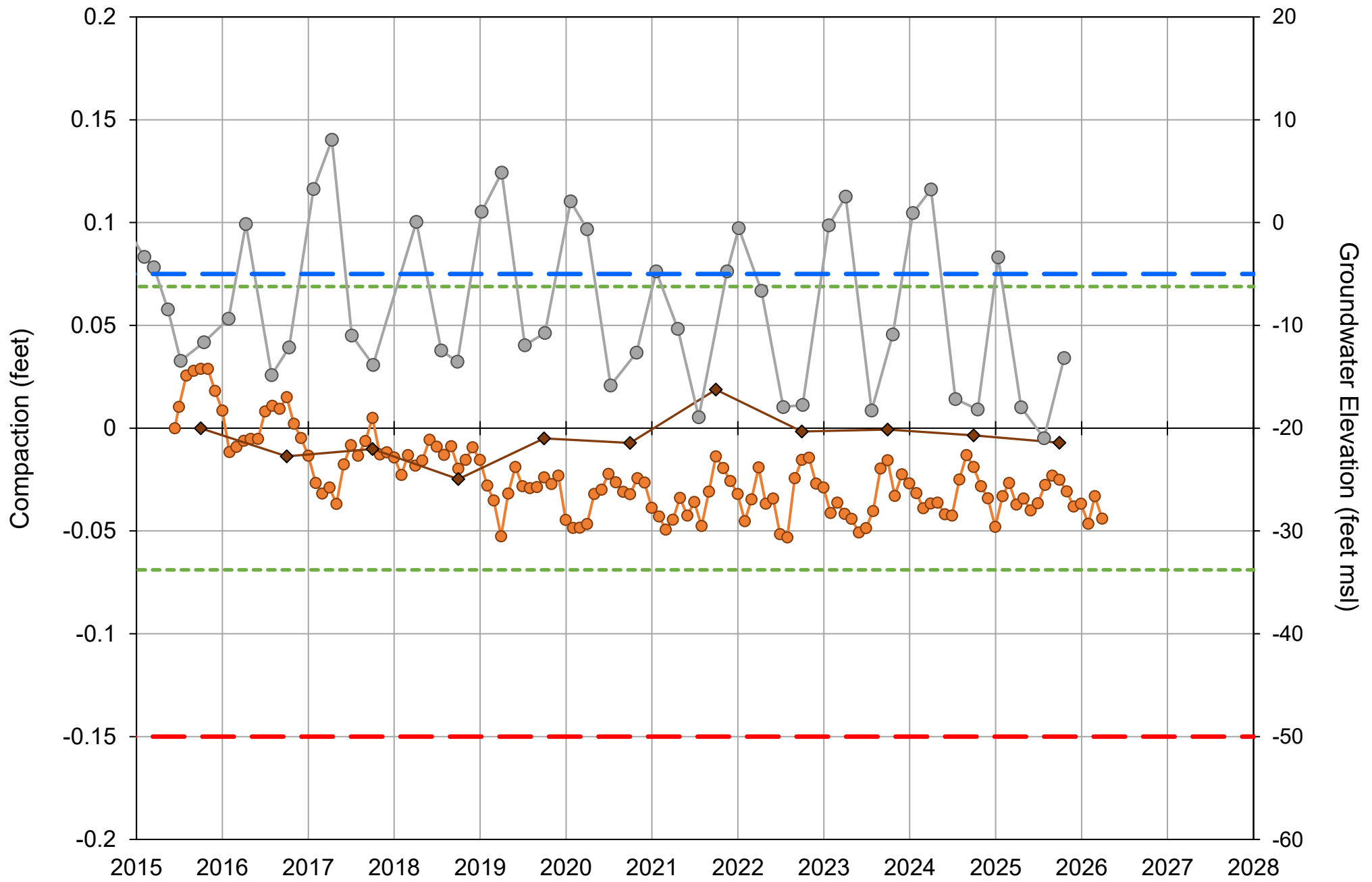
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-5D



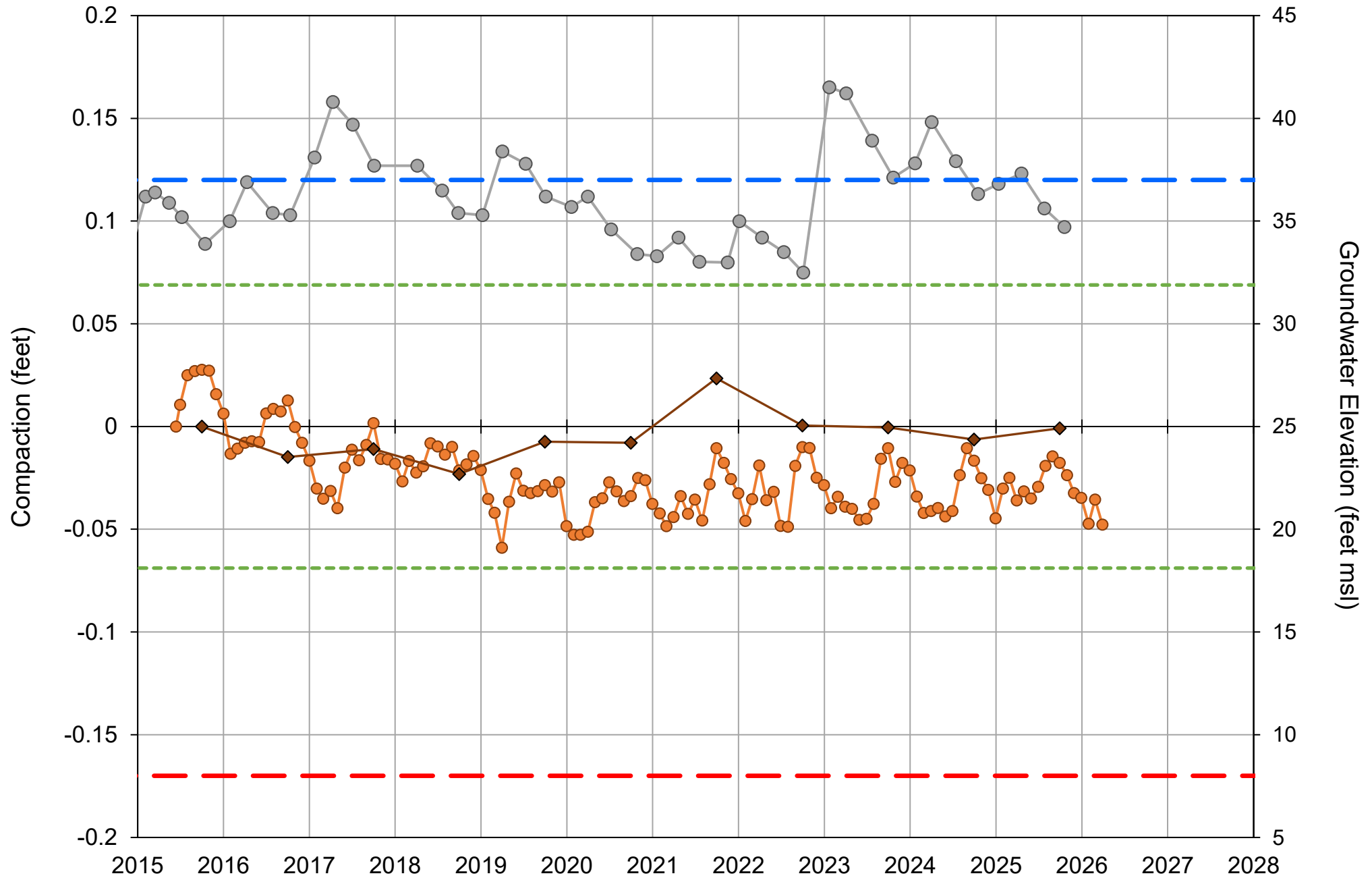
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 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-8D



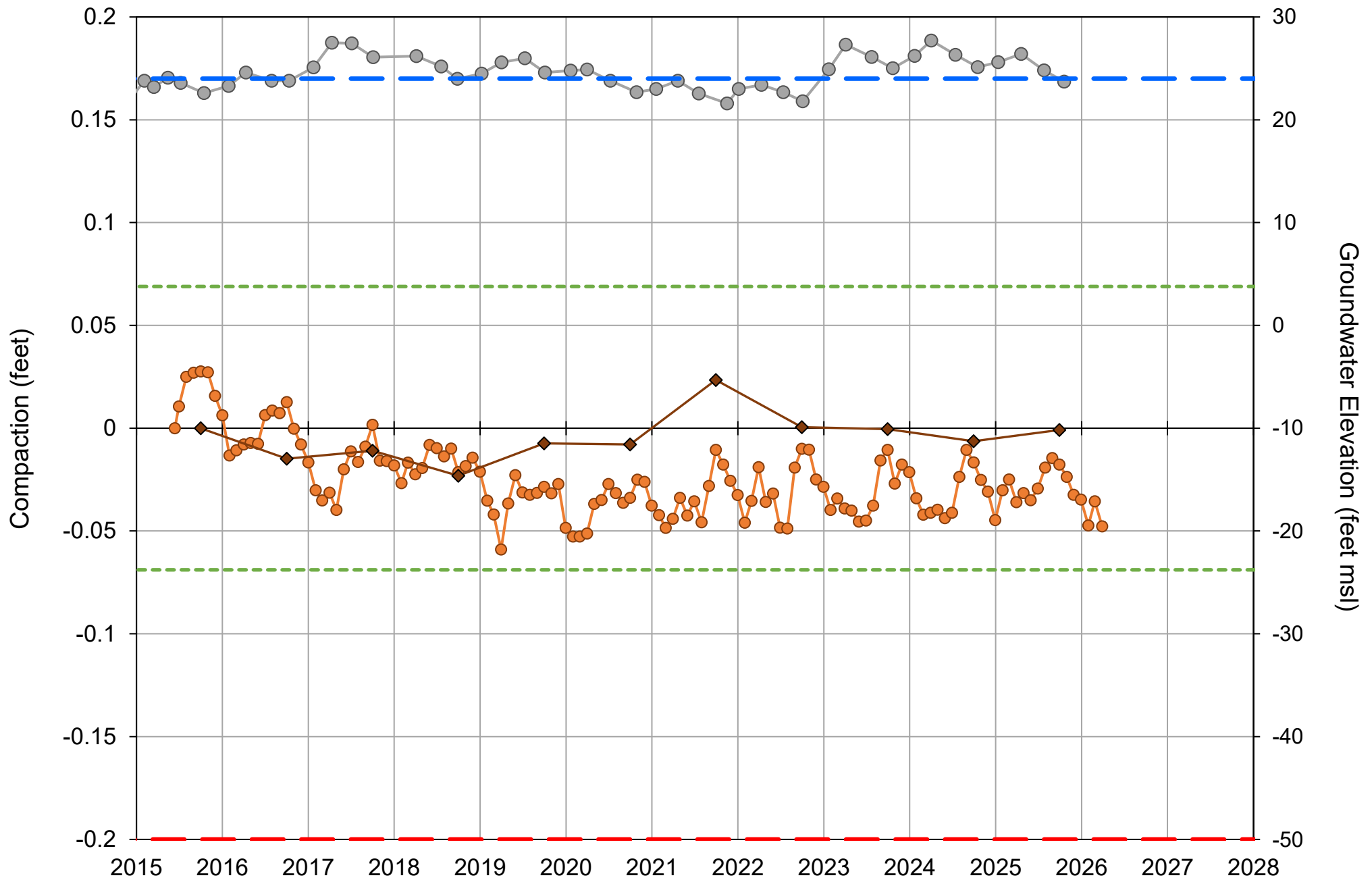
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-9S



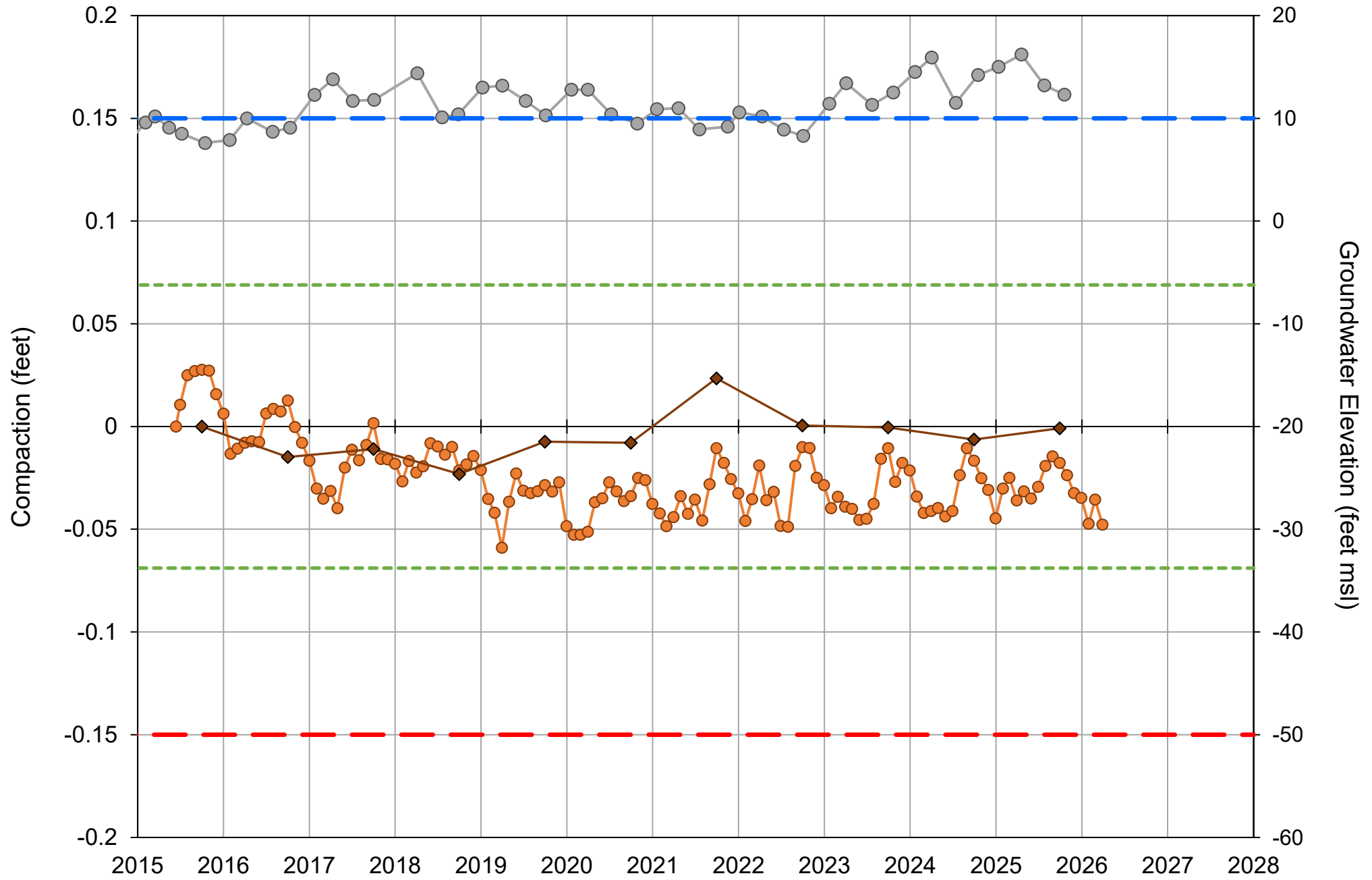
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-9I



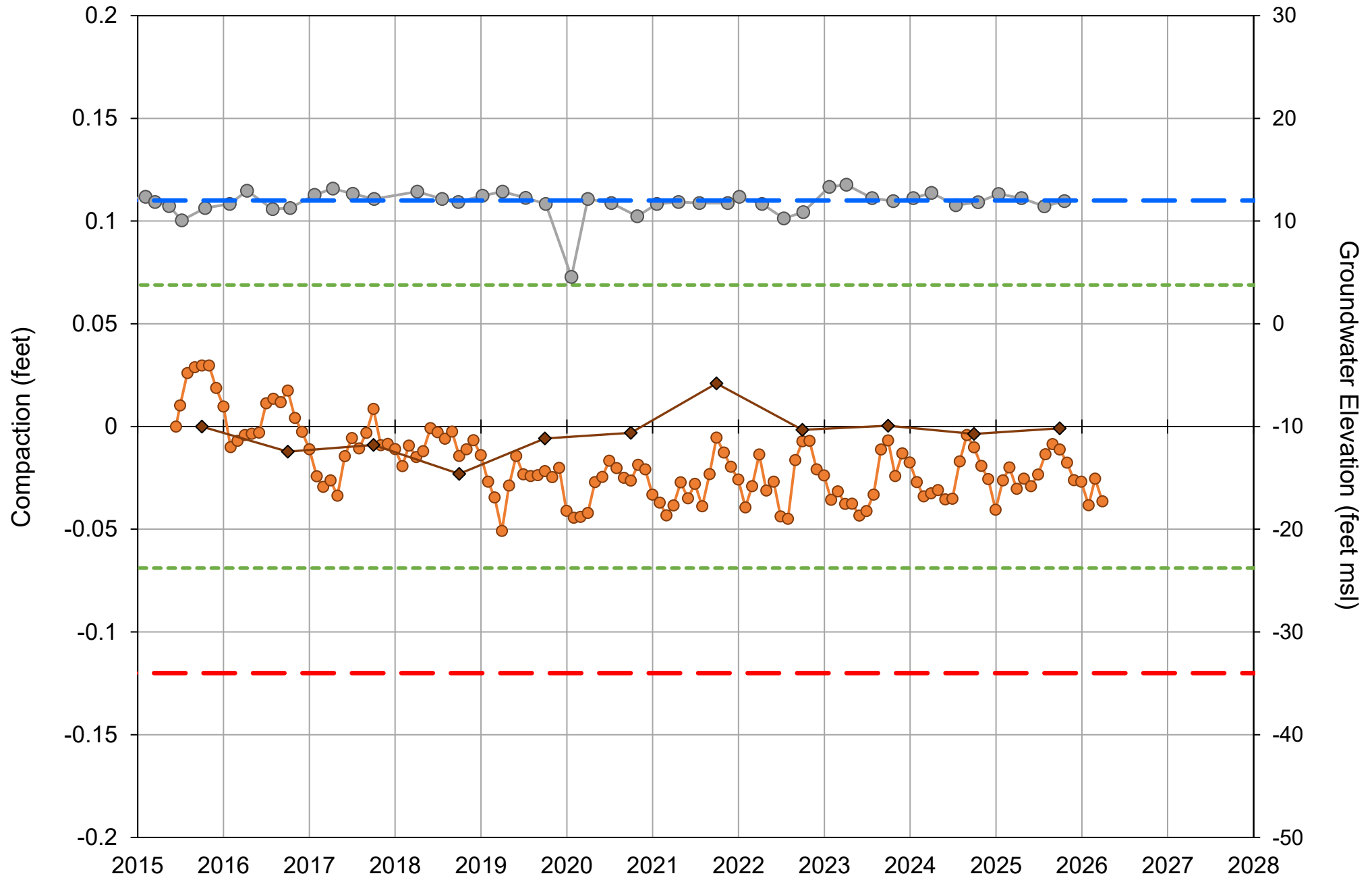
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-9D



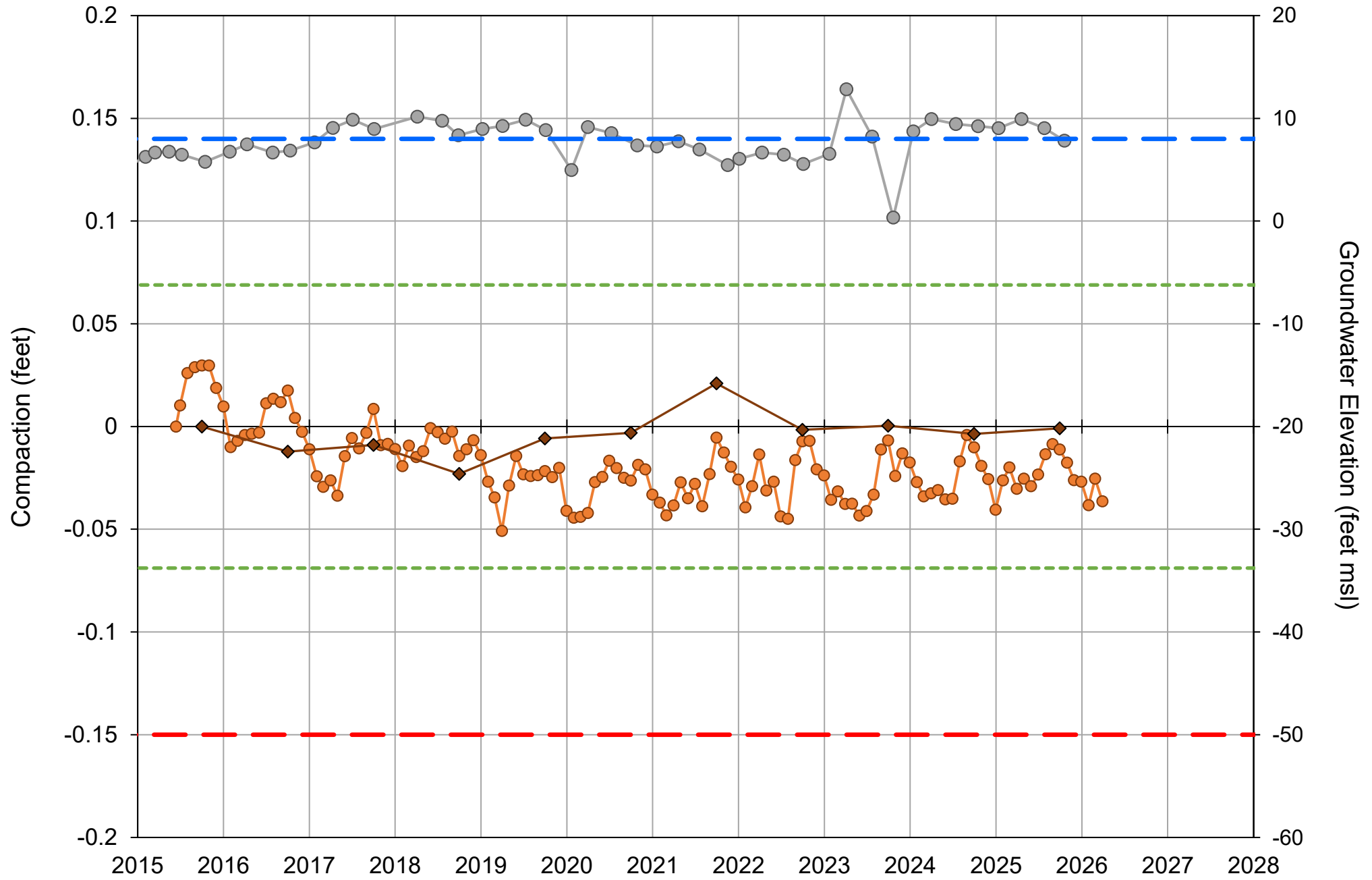
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-10S



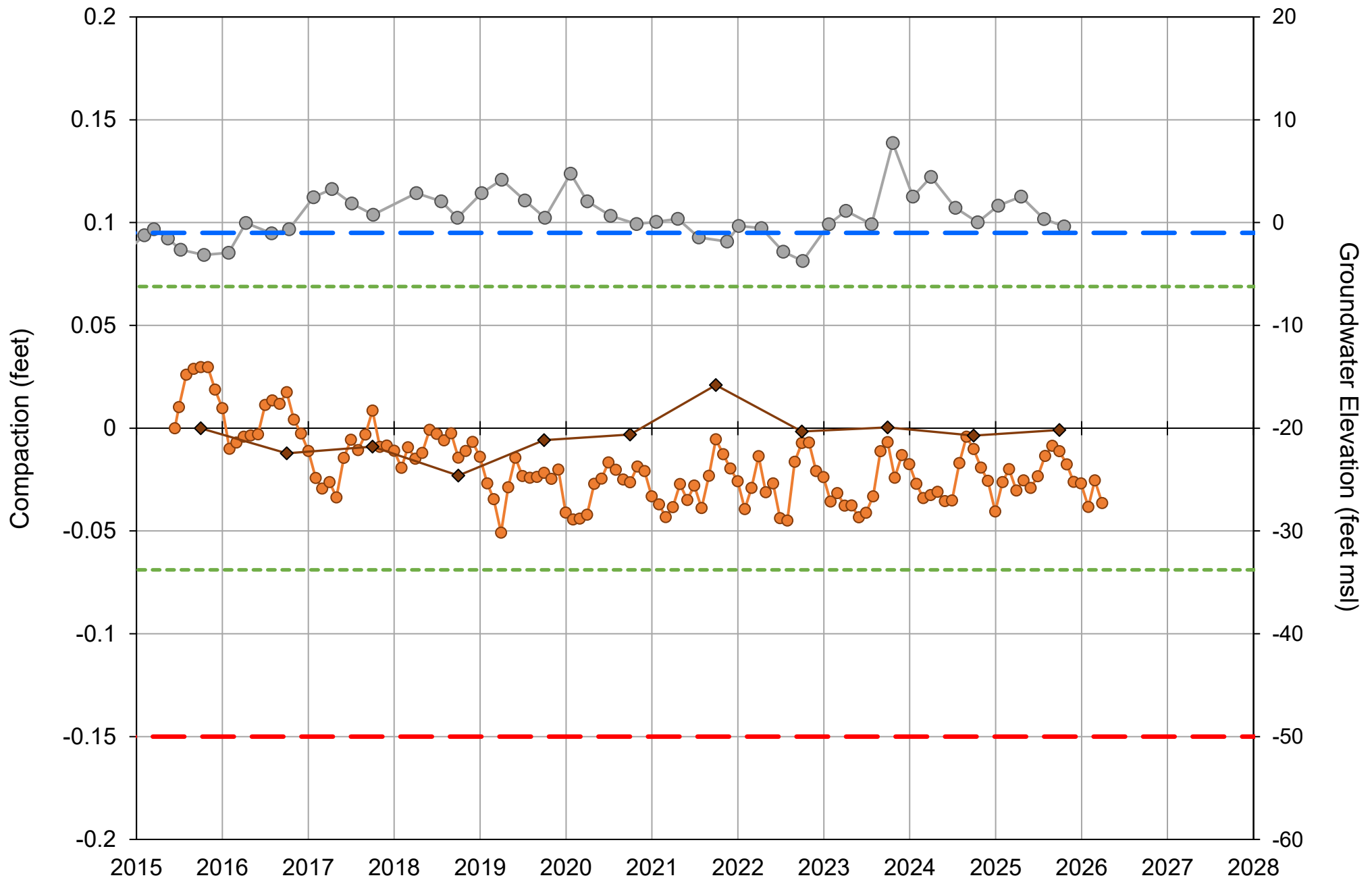
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-10I



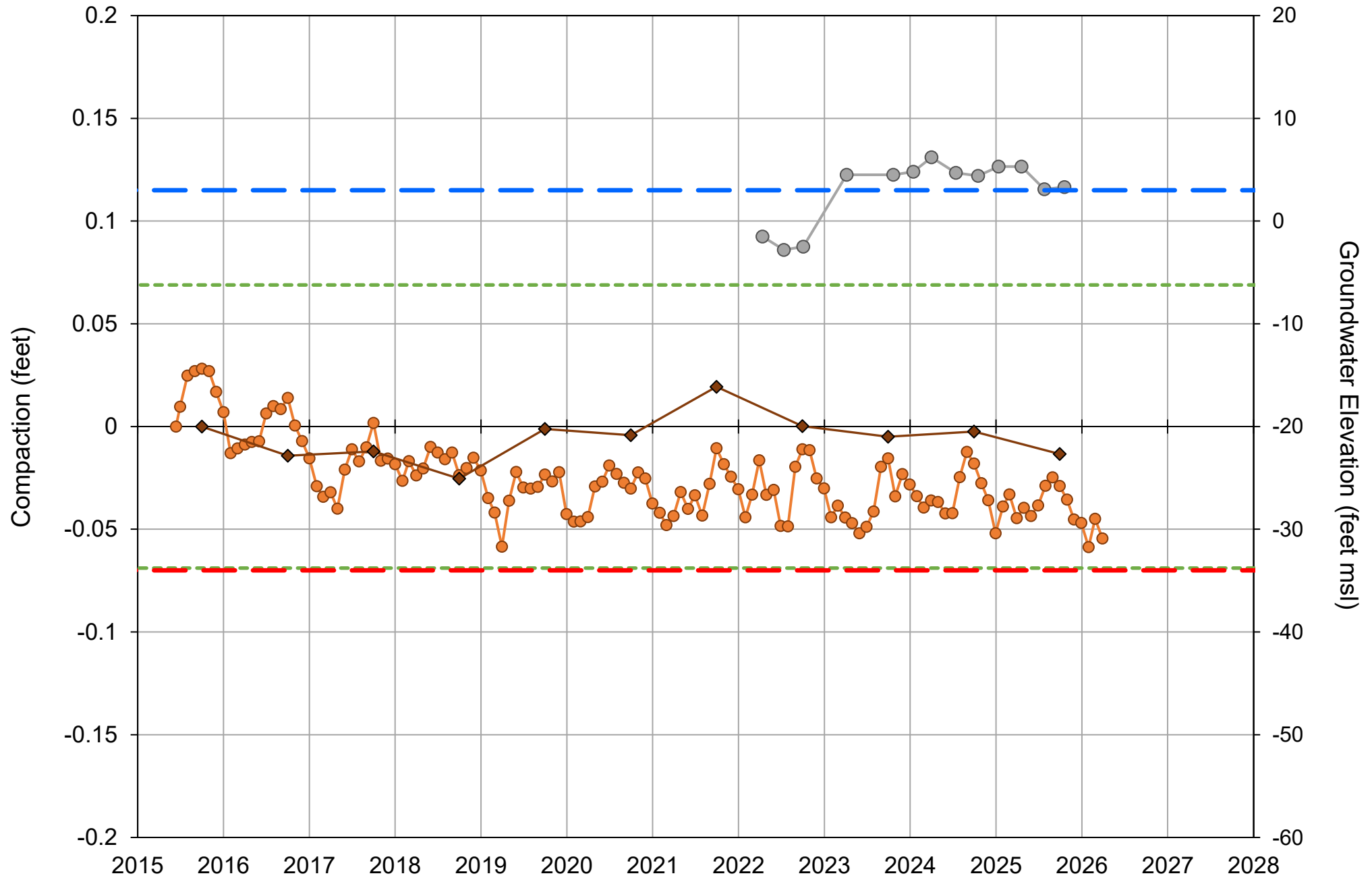
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-10D



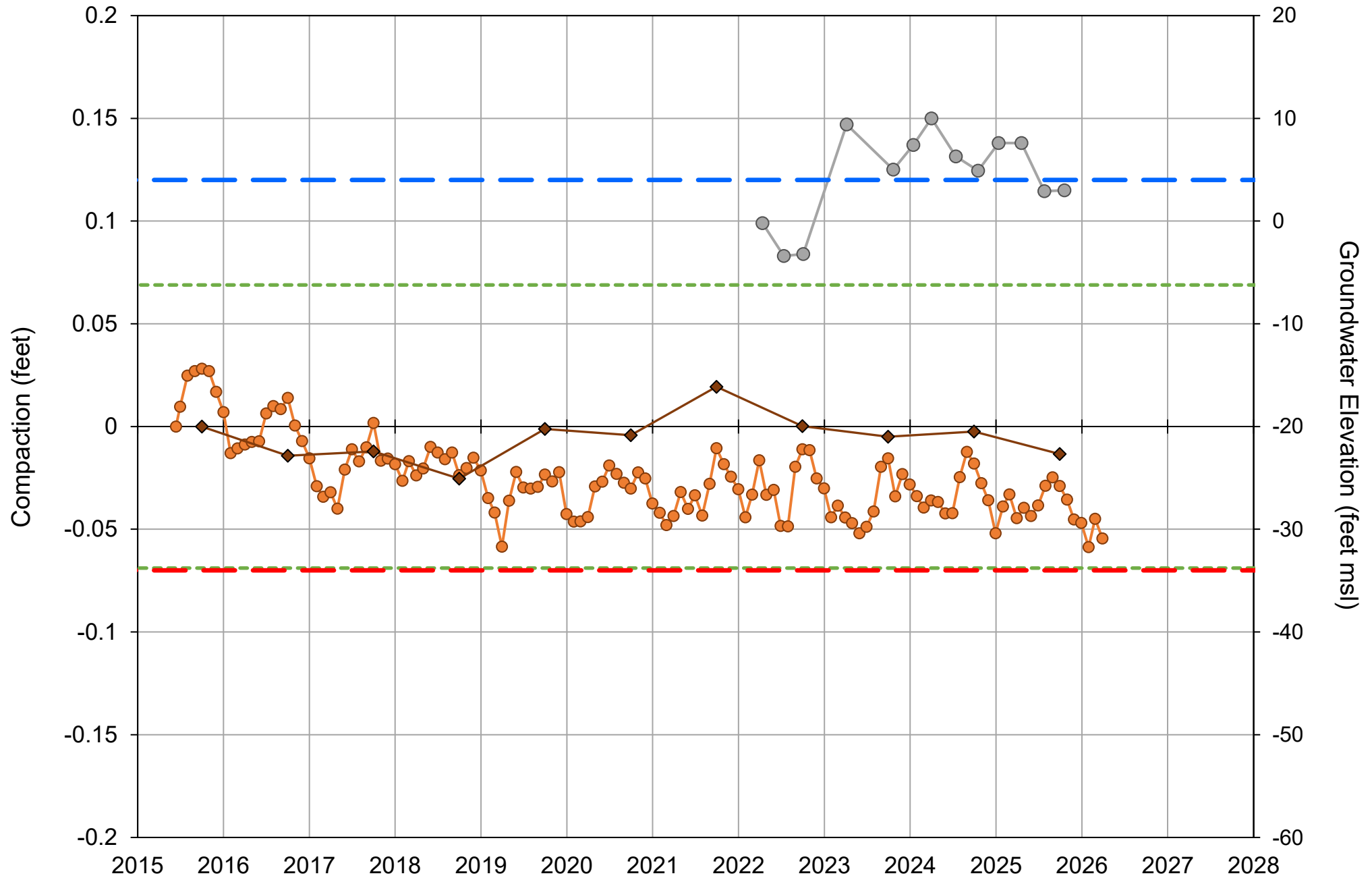
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

S2-MWS1



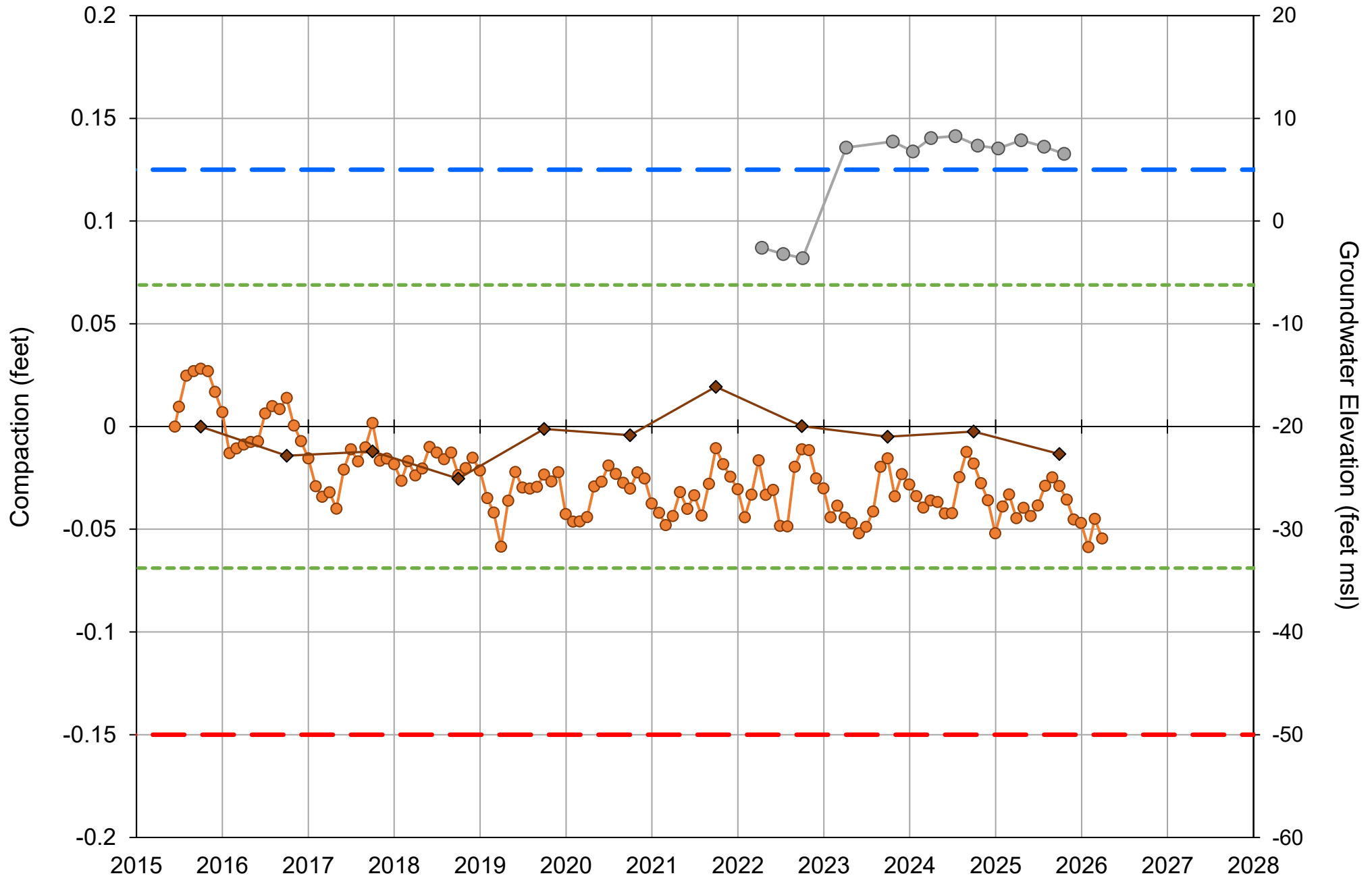
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

S2-MWS2



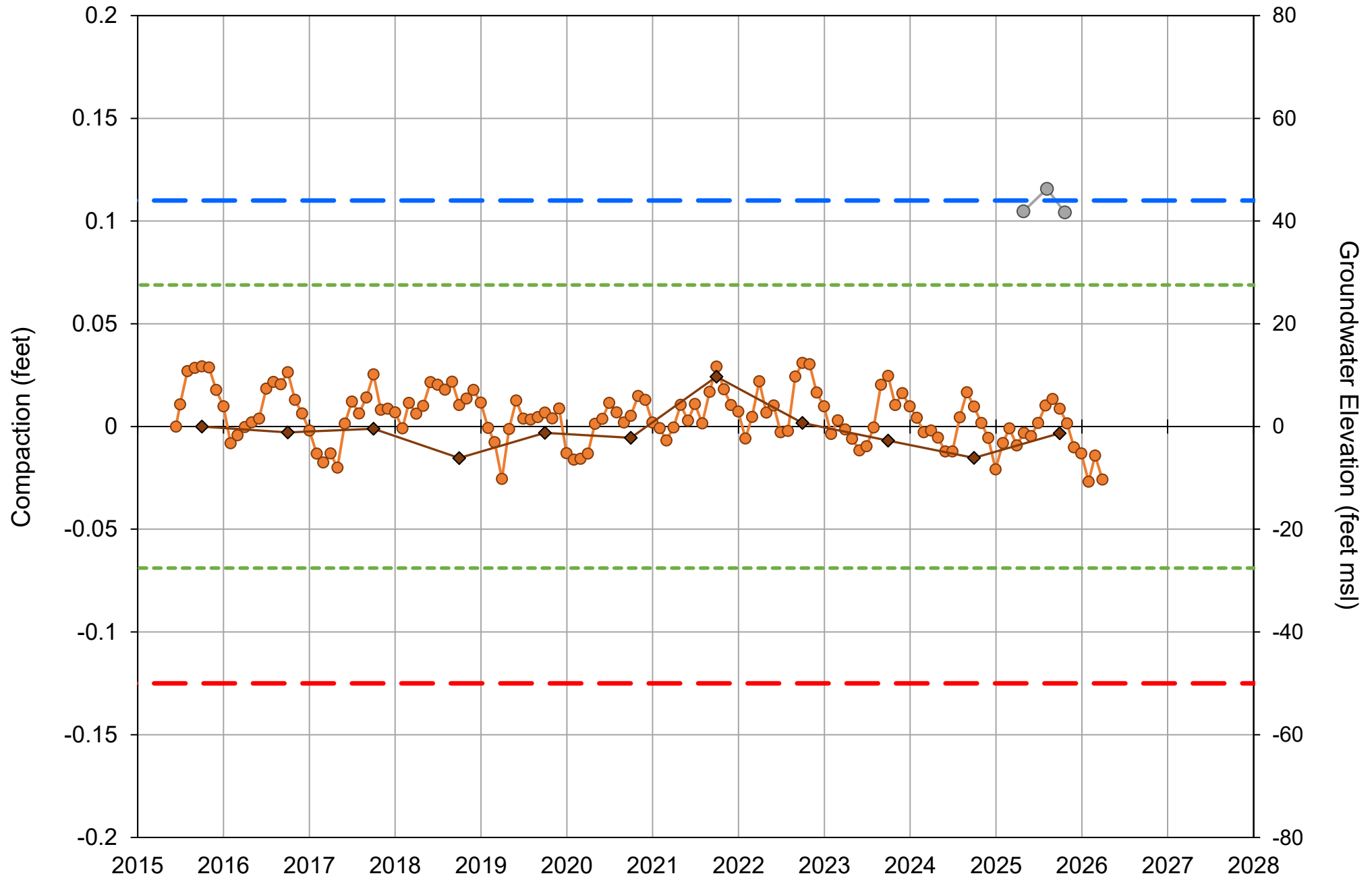
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

S2-MWD1



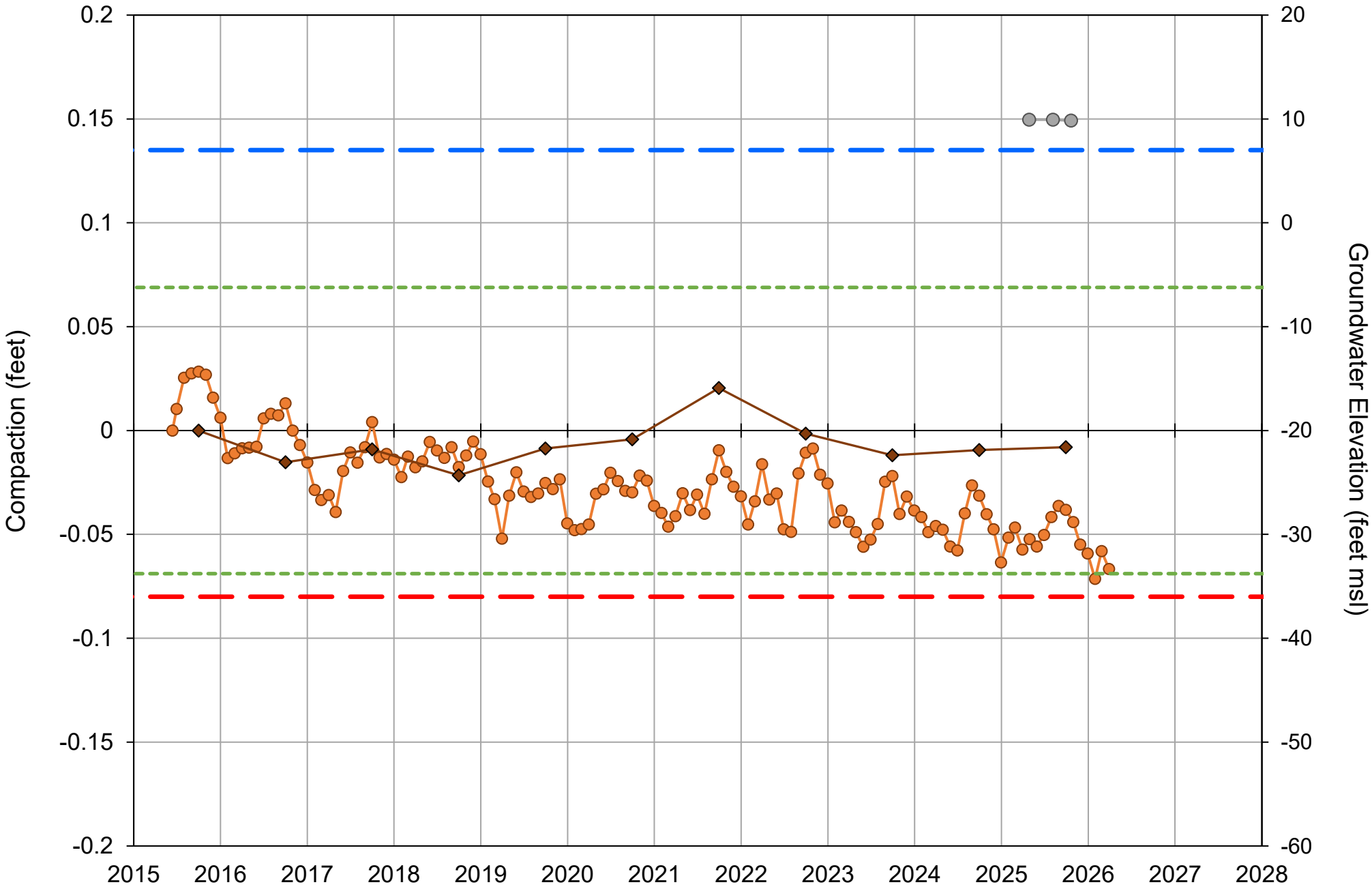
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-N1I



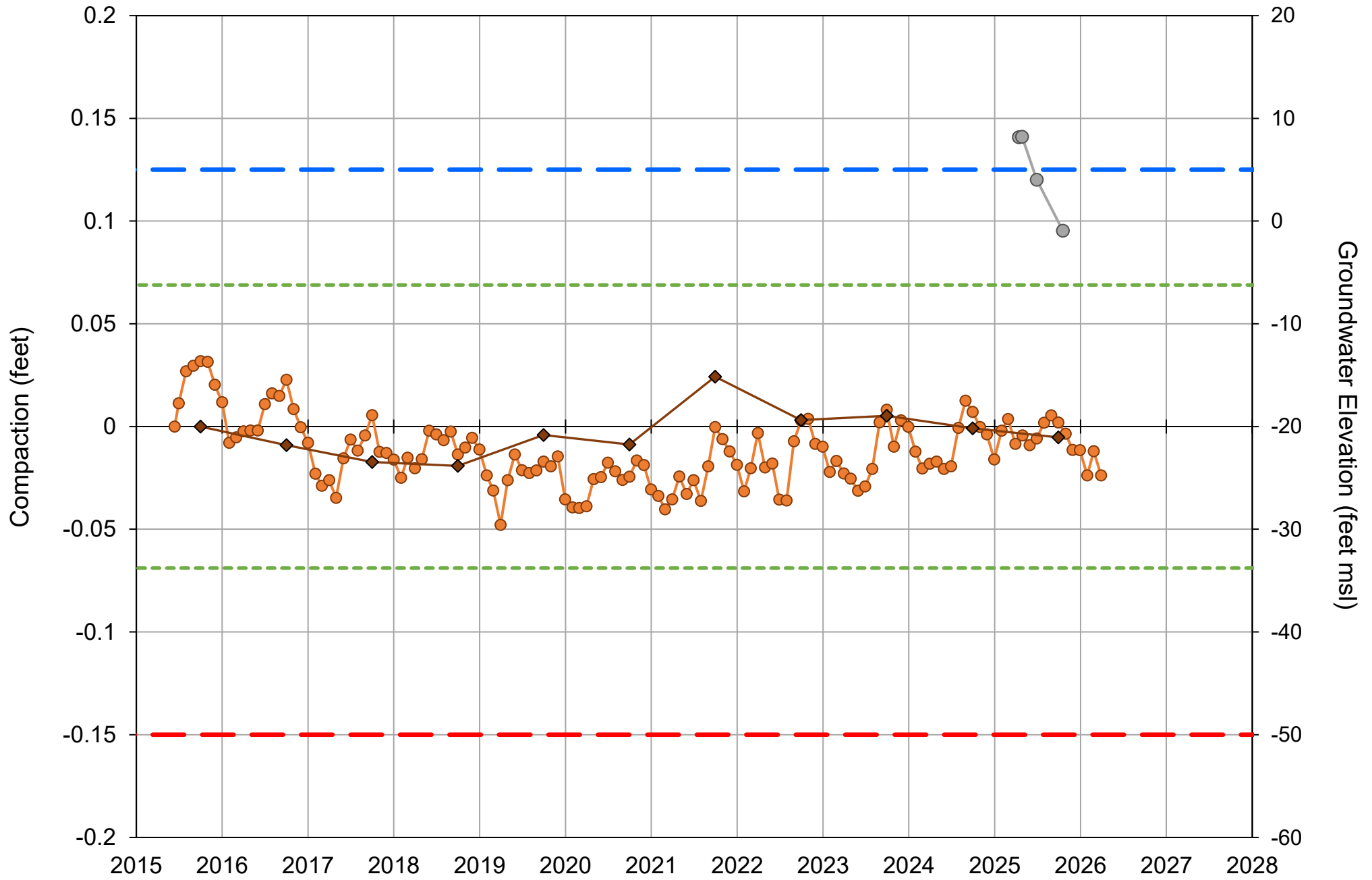
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

MW-N3S



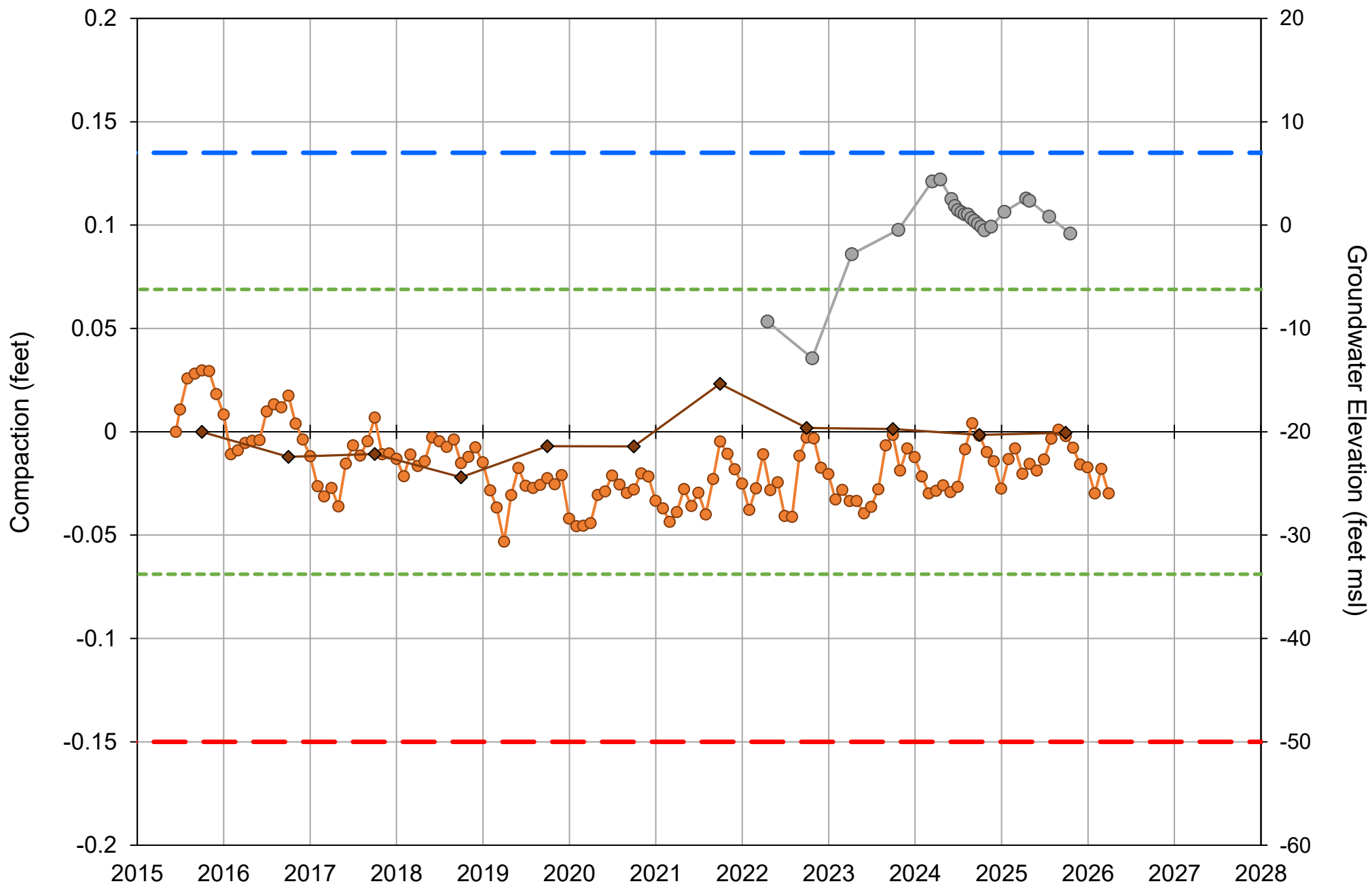
—●— InSAR_Cumulative —◆— InSAR_Annual_October - - - InSAR Measurement Error —●— WSE — GWL_MT — GWL_MO

MW-S2I



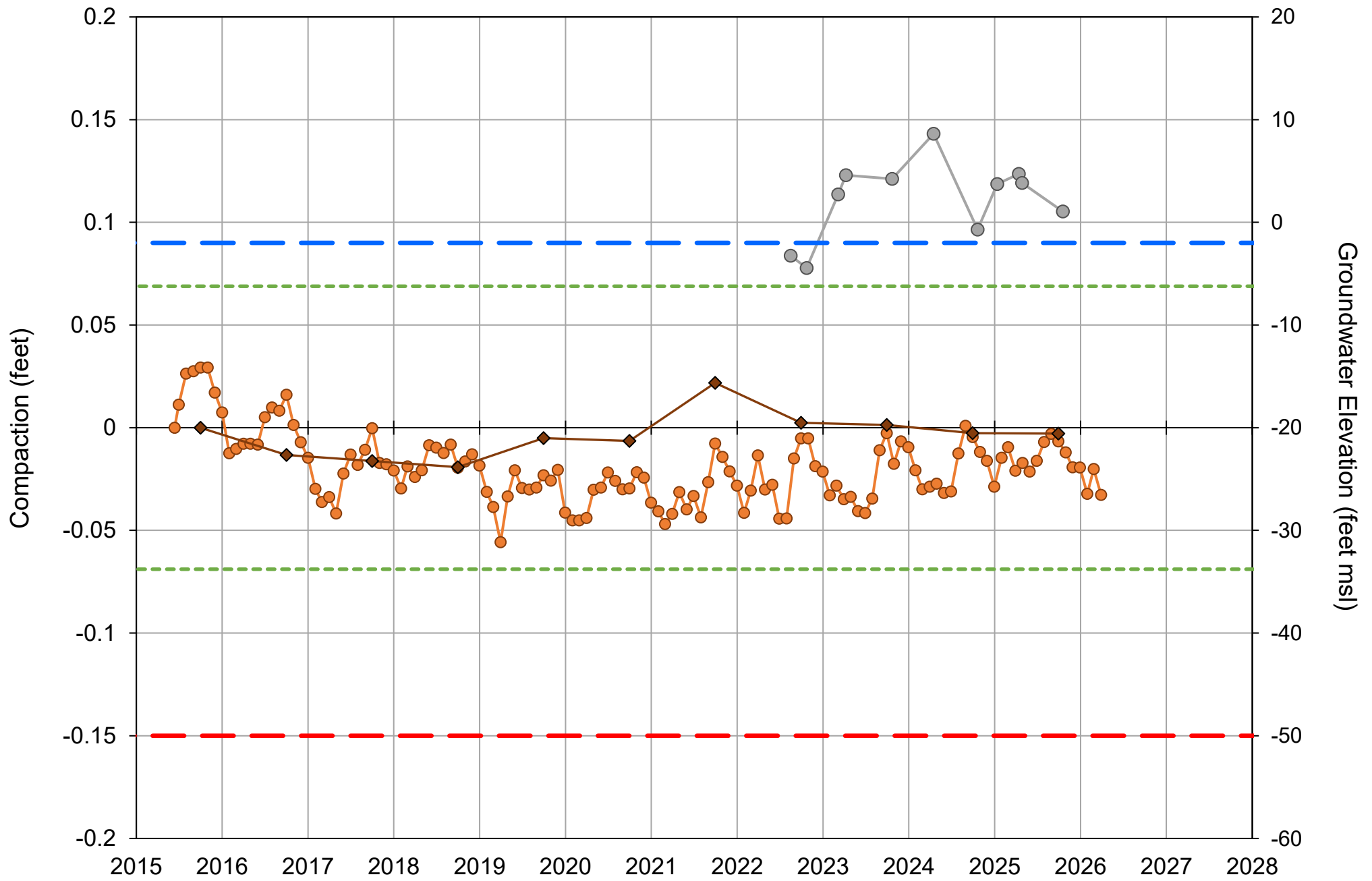
—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

Well D



—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

Well E



—●— InSAR_Cumulative
 —◆— InSAR_Annual_October
 - - - InSAR Measurement Error
 —●— WSE
 - - - GWL_MT
 - - - GWL_MO

APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.E. Supporting Data for Groundwater Quality SMC

DRAFT

APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.E. Supporting Data for Groundwater Quality SMC

3.E.a Historical Groundwater Quality Data for RMS Wells

DRAFT

Table E-1. Summary of Groundwater Quality Data for Representative Monitoring Sites.

RMS ID	Aquifer	Sample Date	Arsenic (ug/L)	Nitrate as N (mg/L)	Chloride (mg/L)	TDS (mg/L)	GSA
MW-5S	Shallow	5/19/2003	1.4		43	350	EBMUD
		12/15/2008	3.4		56	459	
		12/15/2008				469	
		10/26/2022	2.7	<0.023	57	430	
		4/19/2023	2.33	<0.023	57	470	
		10/18/2023	2.34	<0.023	56	470	
		4/17/2024	2.5	<0.048	56	460	
		4/29/2025	2.53	<0.0048	57	450	
		5/11/2026	2.3	<0.0044	58	450	
MW-5I	Intermediate	12/15/2008	18.7		63	454	EBMUD
		12/15/2008				459	
		11/17/2022	11	<0.023	59	460	
		4/19/2023	9.76	<0.023	60	470	
		10/18/2023	9.92	<0.023	60	440	
		4/17/2024	10.1	<0.048	60	440	
		4/30/2025	9.27	<0.048	60	440	
		5/11/2026	9.83	<0.0044	60	440	
MW-5D	Deep	5/20/2003	0.5		79	470	EBMUD
		7/12/2007	0.45	<0.085	93	460	
		12/16/2014		<0.009	96	490	
		11/18/2015		<0.009	82	450	
		12/21/2016		<0.013	84	470	
		12/19/2017		0.19	83	450	
		12/10/2018		0.19	79	460	
		10/10/2019		<0.07	81	460	
		8/10/2020		<0.035	84	460	
		11/1/2021		<0.071	85	470	
		11/16/2022	1.2	<0.23	80	450	
		4/19/2023	0.616	<0.23	82	450	
		10/18/2023	0.585	<0.45	82	480	
		4/17/2024	0.733	<0.48	78	460	
		4/24/2025	0.666	<0.48	80	470	
		5/12/2026	0.61	<0.044	85	470	
MW-9S	Shallow	12/17/2008	1.5		52	577	EBMUD
		12/17/2008				614	
		10/27/2022		8.4	50	590	
		10/31/2022	1.4	9.4	49	680	
		4/20/2023	1.43	9.6	50	630	
		10/19/2023	1.42	9.9	49	620	
		4/18/2024	1.61	9.7	47	610	
		4/23/2025	1.56	9.7	48	610	
		5/6/2026	1.37	10	49	610	
MW-9I	Intermediate	12/17/2008	2.2		47	428	EBMUD
		12/17/2008				433	
		10/27/2022	3	<0.023	48	440	
		4/20/2023	1.53	<0.023	48	400	
		10/19/2023	1.51	<0.023	48	440	
		4/18/2024	1.71	<0.048	48	420	
		4/23/2025	1.65	<0.048	48	420	
		5/6/2026	1.54	<0.11	48	430	

Table E-1. Summary of Groundwater Quality Data for Representative Monitoring Sites.

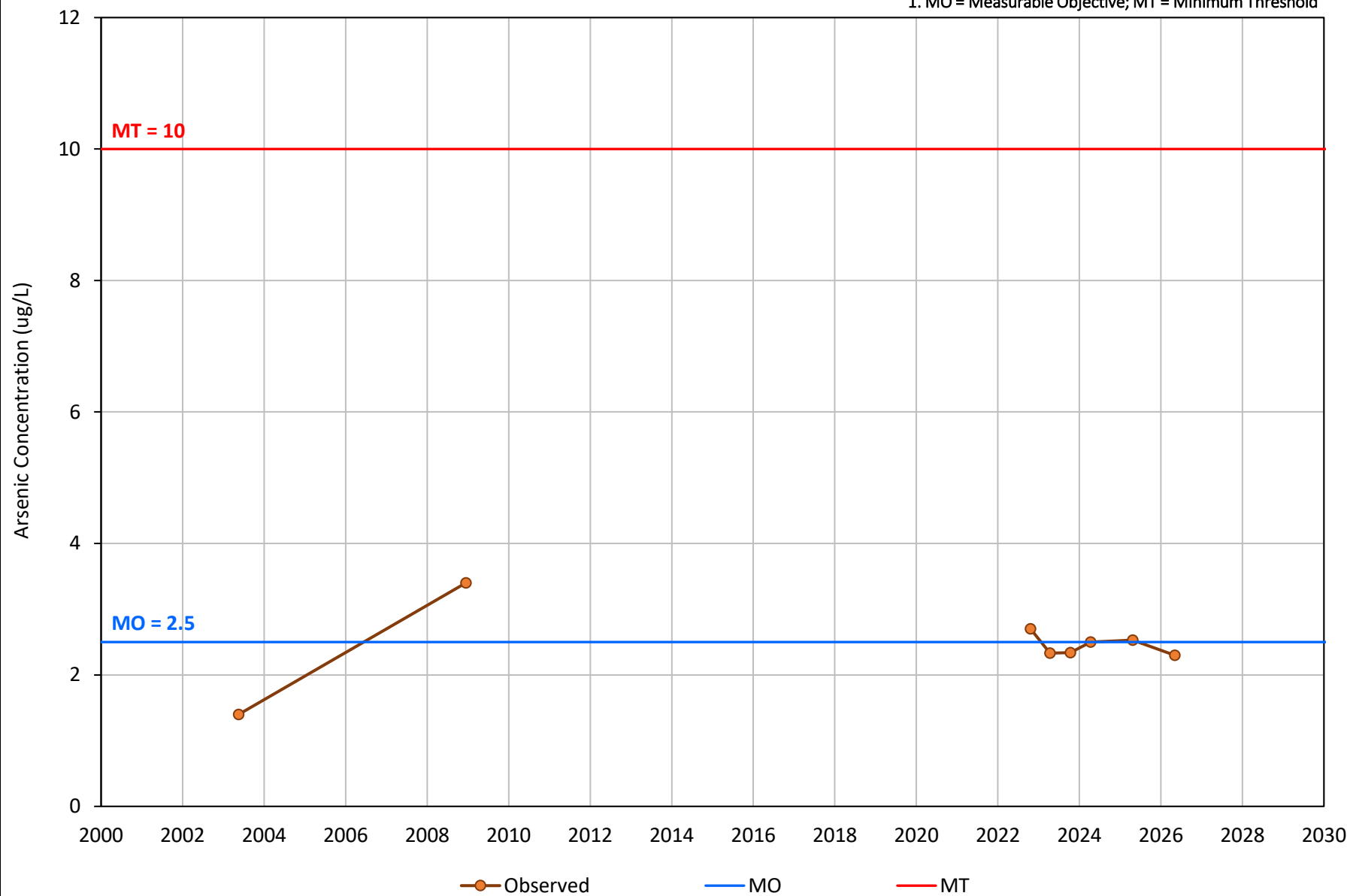
RMS ID	Aquifer	Sample Date	Arsenic (ug/L)	Nitrate as N (mg/L)	Chloride (mg/L)	TDS (mg/L)	GSA
MW-9D	Deep	12/17/2008	3.2		53	474	EBMUD
		12/17/2008				477	
		11/15/2022	3	<0.023	51	400	
		4/20/2023	2.52	<0.023	51	460	
		10/19/2023	2.5	<0.023	51	490	
		4/18/2024	2.79	<0.048	51	450	
		4/22/2025	2.67	<0.048	51	450	
		5/6/2026	2.49	<0.048	52	450	
MW-10S	Shallow	12/16/2008	6		43	390	EBMUD
		12/16/2008				396	
		10/27/2022	24	0.77	33	320	
		4/18/2023	3.69	0.72	33	380	
		10/17/2023	3.84	0.57	32	360	
		4/16/2024	3.96	0.64	33	370	
		5/1/2025	3.65	0.58	33	350	
		4/23/2026	3.72	0.54	33	360	
MW-10I	Intermediate	12/16/2008	6		53	464	EBMUD
		12/16/2008				465	
		11/15/2022	5.8	0.078	54	440	
		4/18/2023	5	<0.023	54	460	
		10/17/2023	5.04	<0.023	54	450	
		4/16/2024	5.4	<0.048	54	470	
		5/1/2025	4.94	<0.048	54	450	
		4/27/2026	5.18	<0.0044	55	450	
MW-10D	Deep	12/16/2008	1.9		123	528	EBMUD
		12/16/2008				540	
		11/15/2022	2.4	<0.12	100	480	
		4/18/2023	1.06	<0.12	100	510	
		10/17/2023	1.05	<0.12	100	530	
		4/16/2024	1.23	<0.24	100	520	
		5/1/2025	0.842	<0.12	100	500	
		4/27/2026	0.919	<0.0044	110	520	
S2-MWS1	Shallow	1/20/1999			15,000	27,000	EBMUD
		10/25/2022		<2.3	18,000	37,000	
		10/25/2022	61	<2.3	18,000	36,000	
		4/17/2023	24.1	<12	16,000	32,000	
		10/16/2023	29	<12	17,000	42,000	
		4/15/2024	33.7	<24	16,000	29,000	
		5/6/2025	21.9	<2.4	17,000	38,000	
		4/28/2026	21.6	<8.8	17,000	34,000	
S2-MWS2	Shallow	1/20/1999			3,500	6,100	EBMUD
		10/25/2022	3.4	6.9	1,200	2,700	
		4/17/2023	2.13	7.7	1,200	2,600	
		10/16/2023	2.21	7.9	1,100	3,600	
		4/15/2024	3.03	7.6	1,100	2,800	
		5/6/2025	1.8	5.5	1,100	2,400	
		4/28/2026	1.74	6.2	1,000	2,600	

Well Name: MW-5S

Aquifer: Shallow

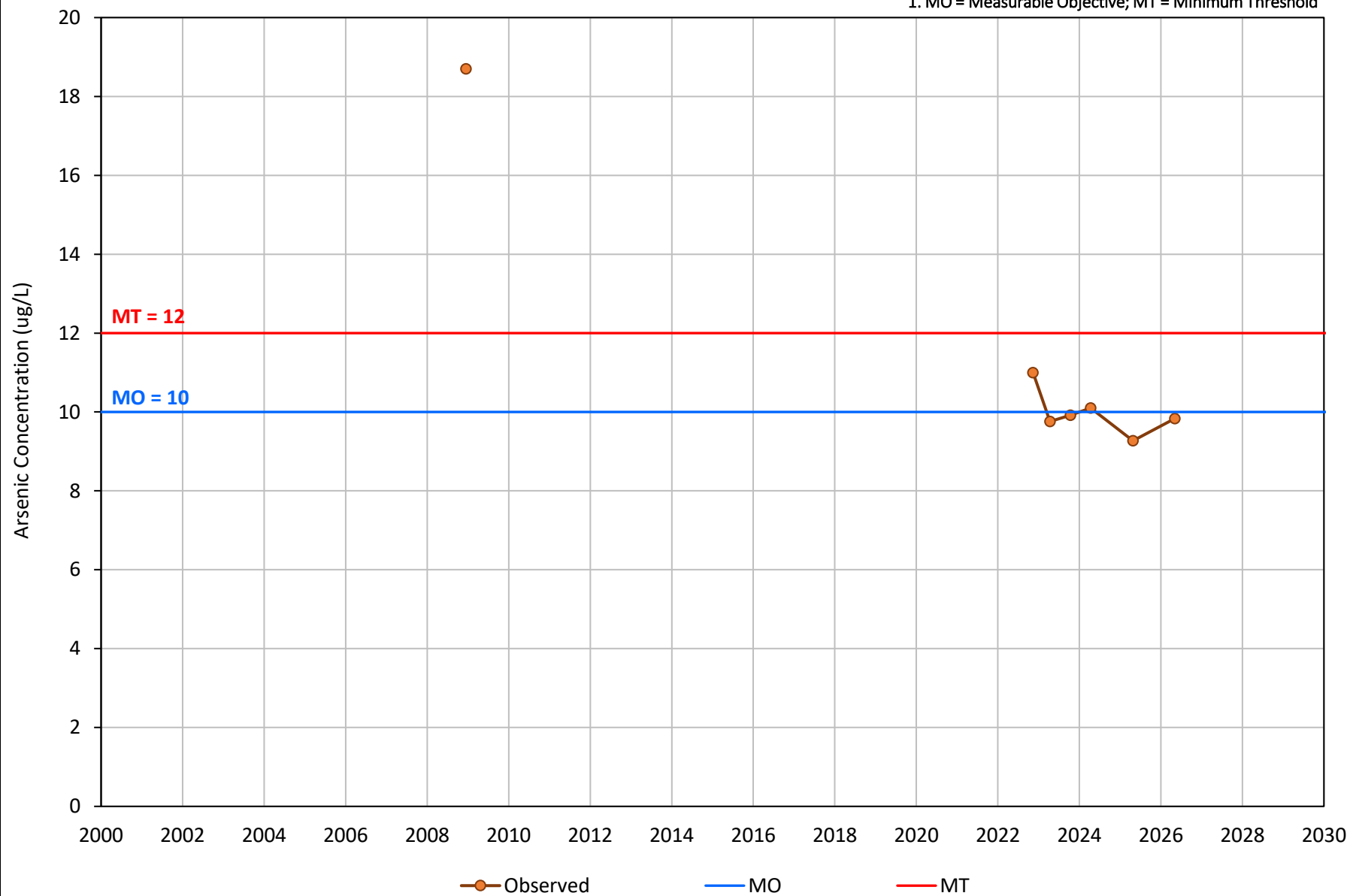
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-5I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

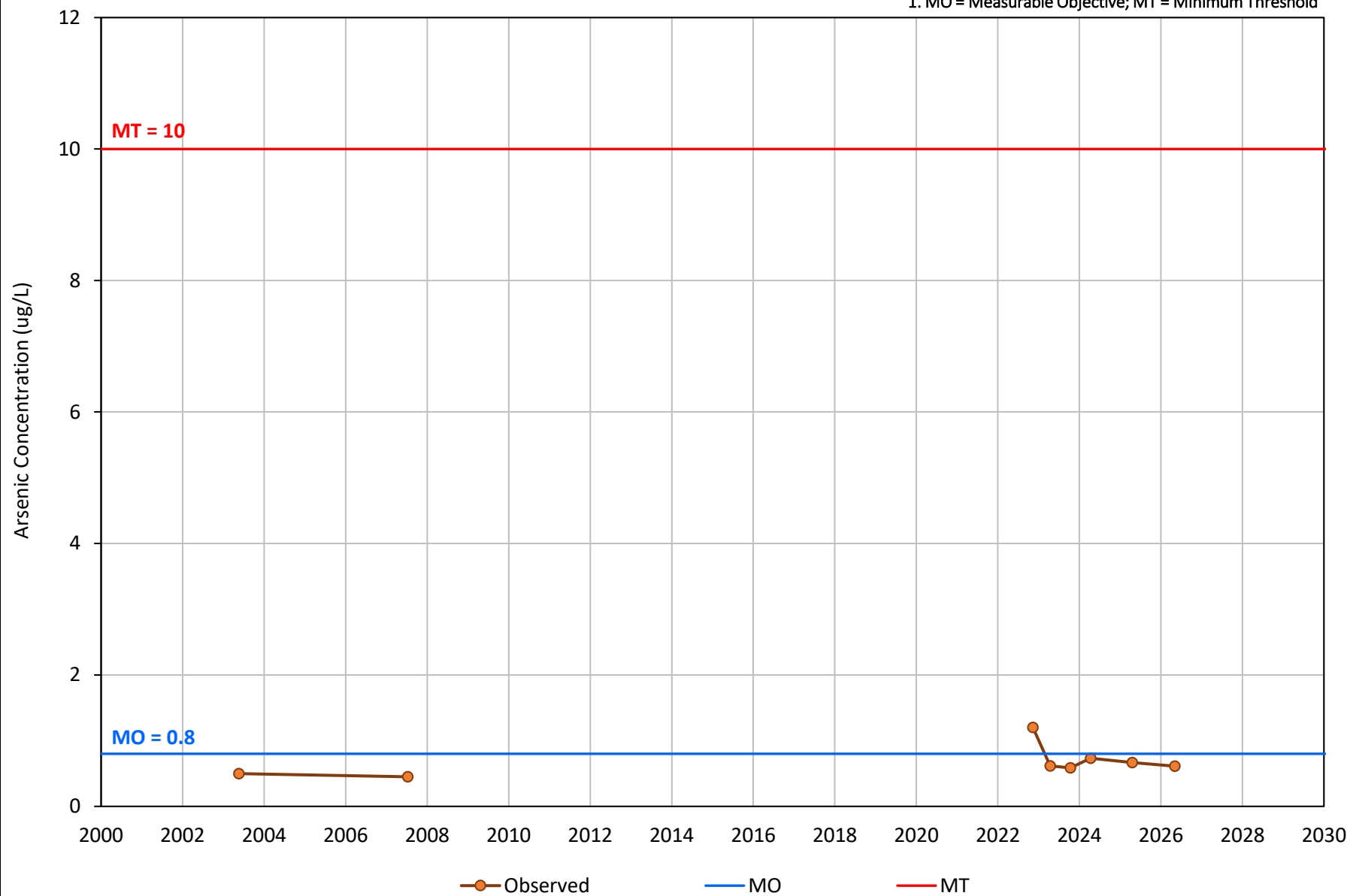


Well Name: MW-5D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

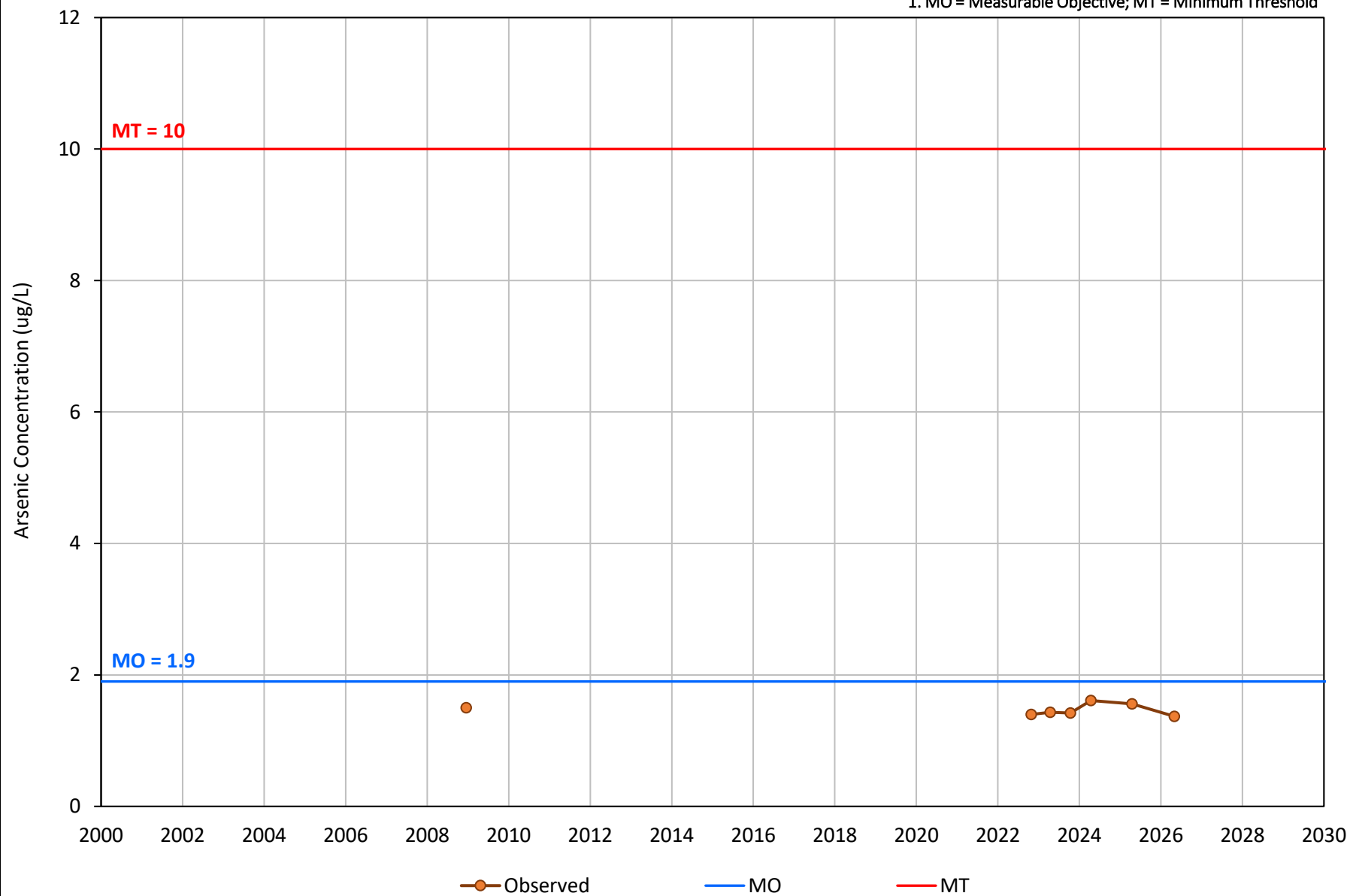


Well Name: MW-9S

Aquifer: Shallow

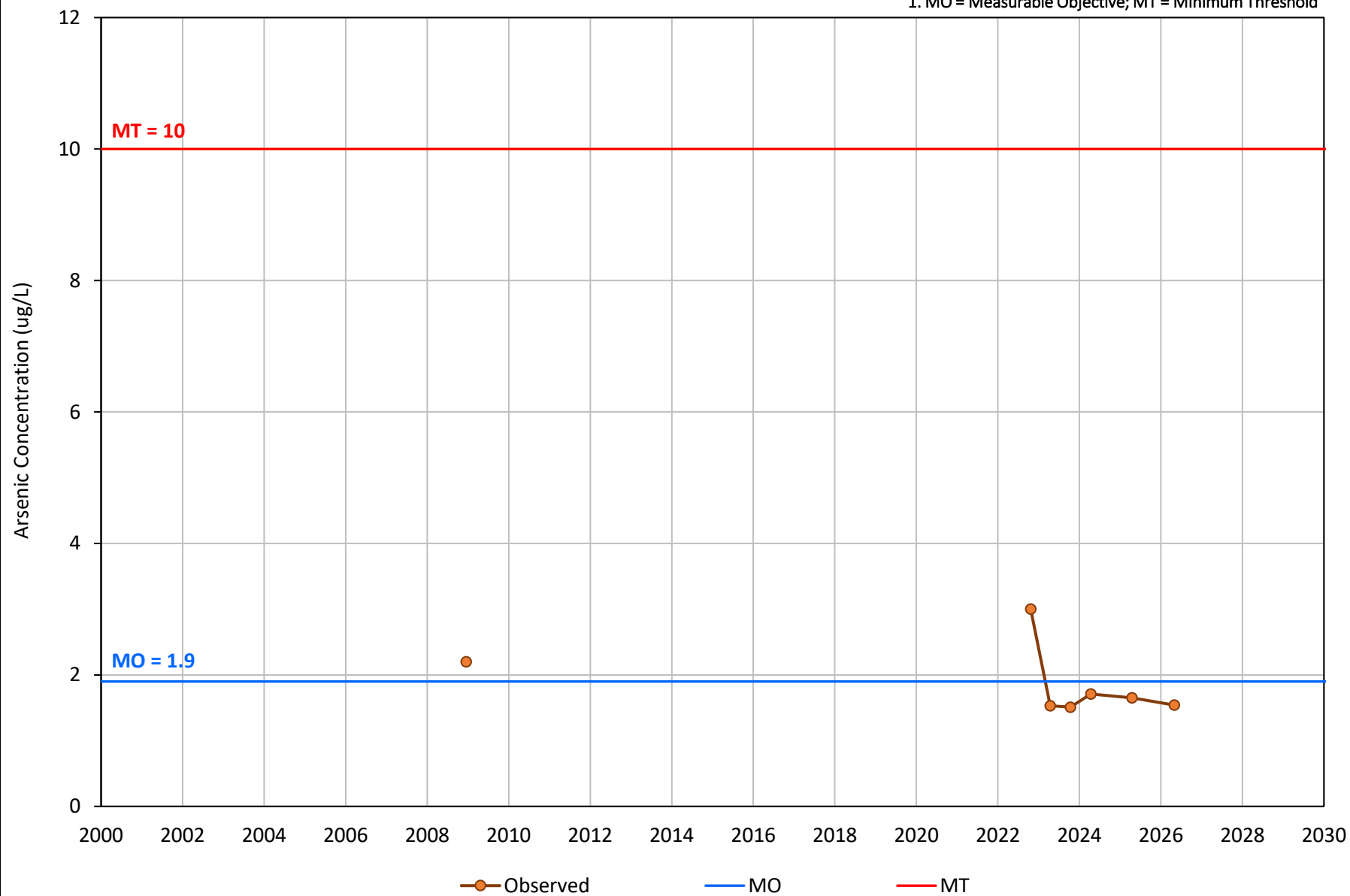
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-9I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

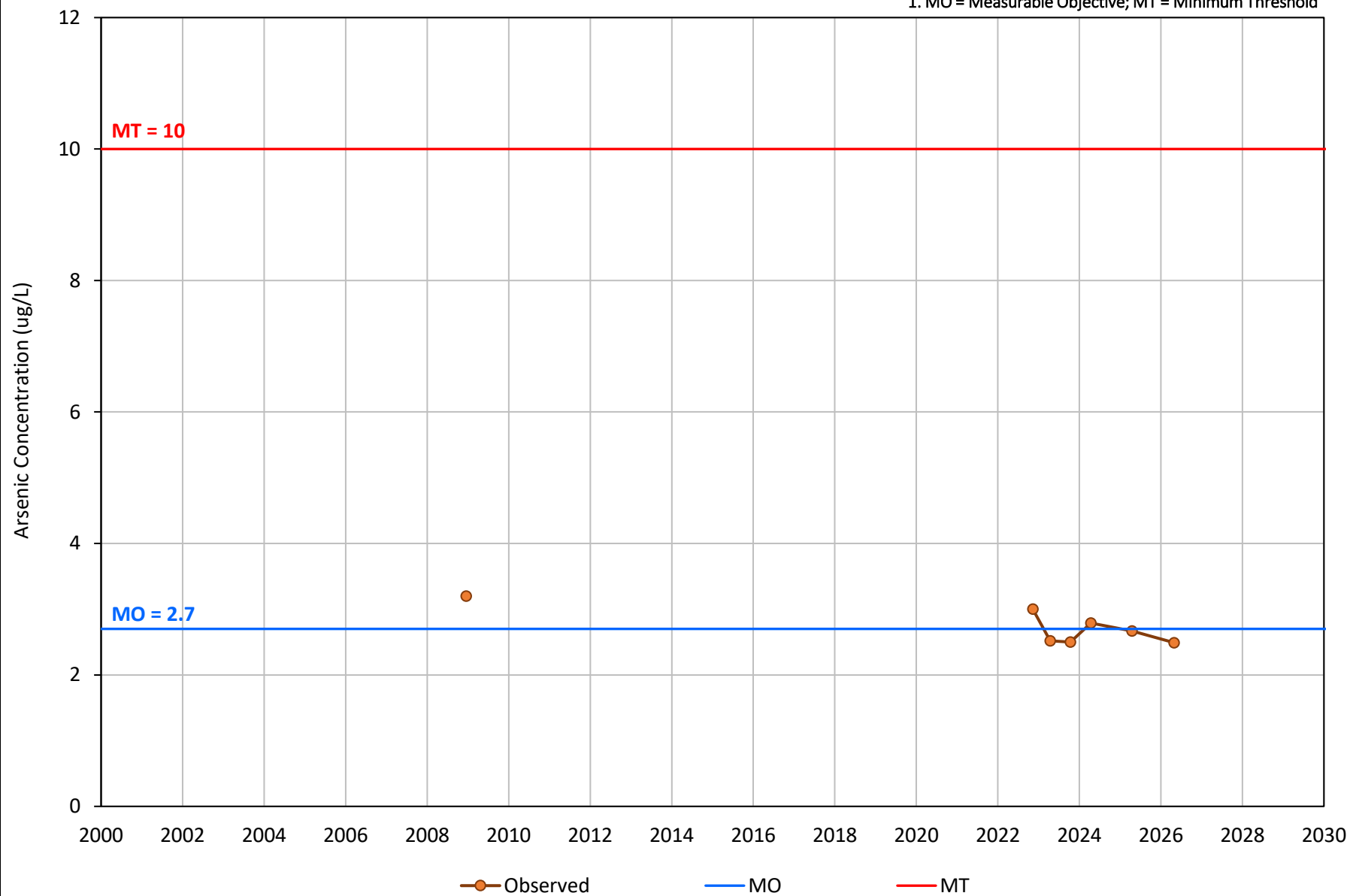


Well Name: MW-9D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

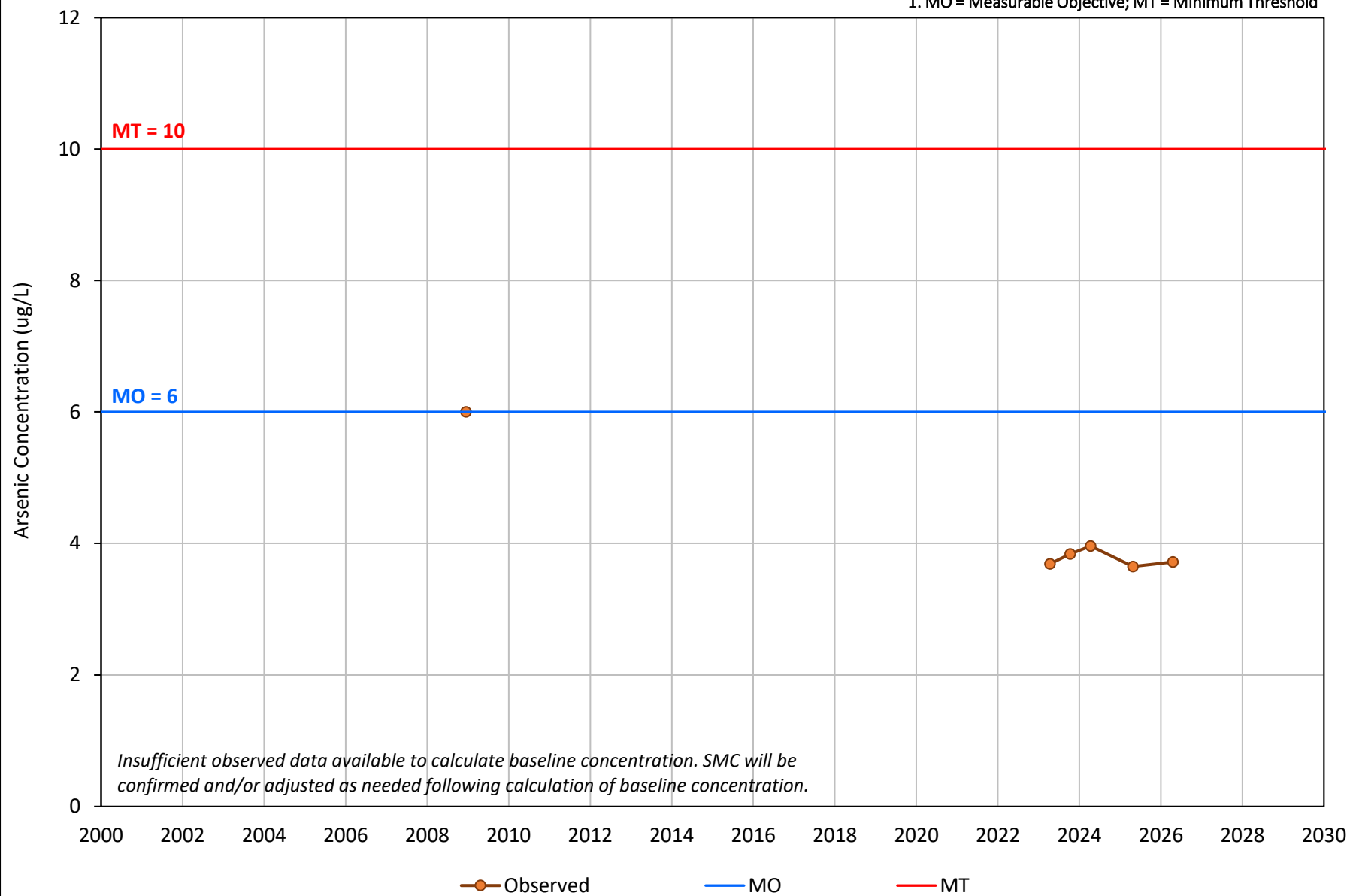


Well Name: MW-10S

Aquifer: Shallow

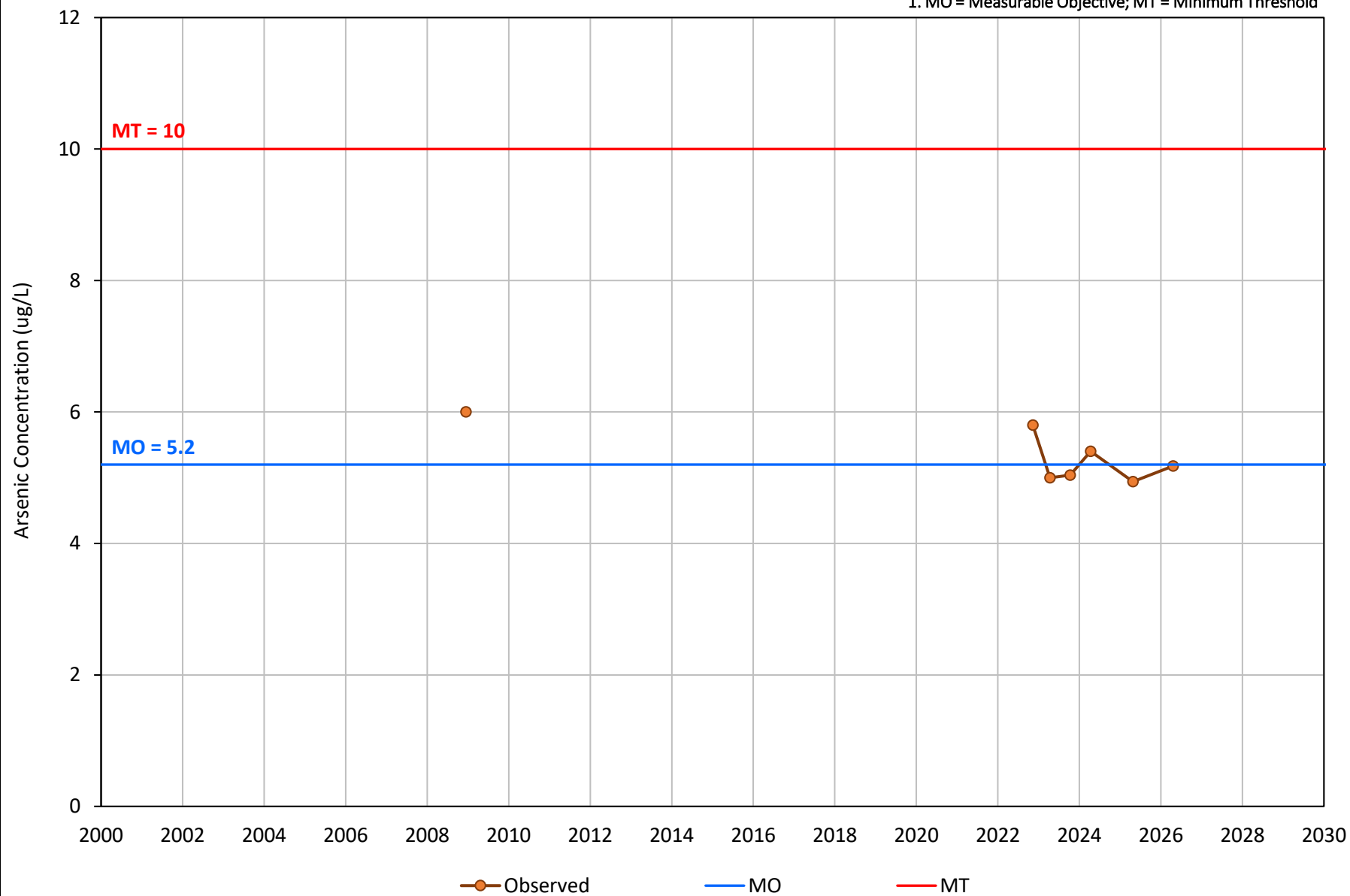
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-10I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

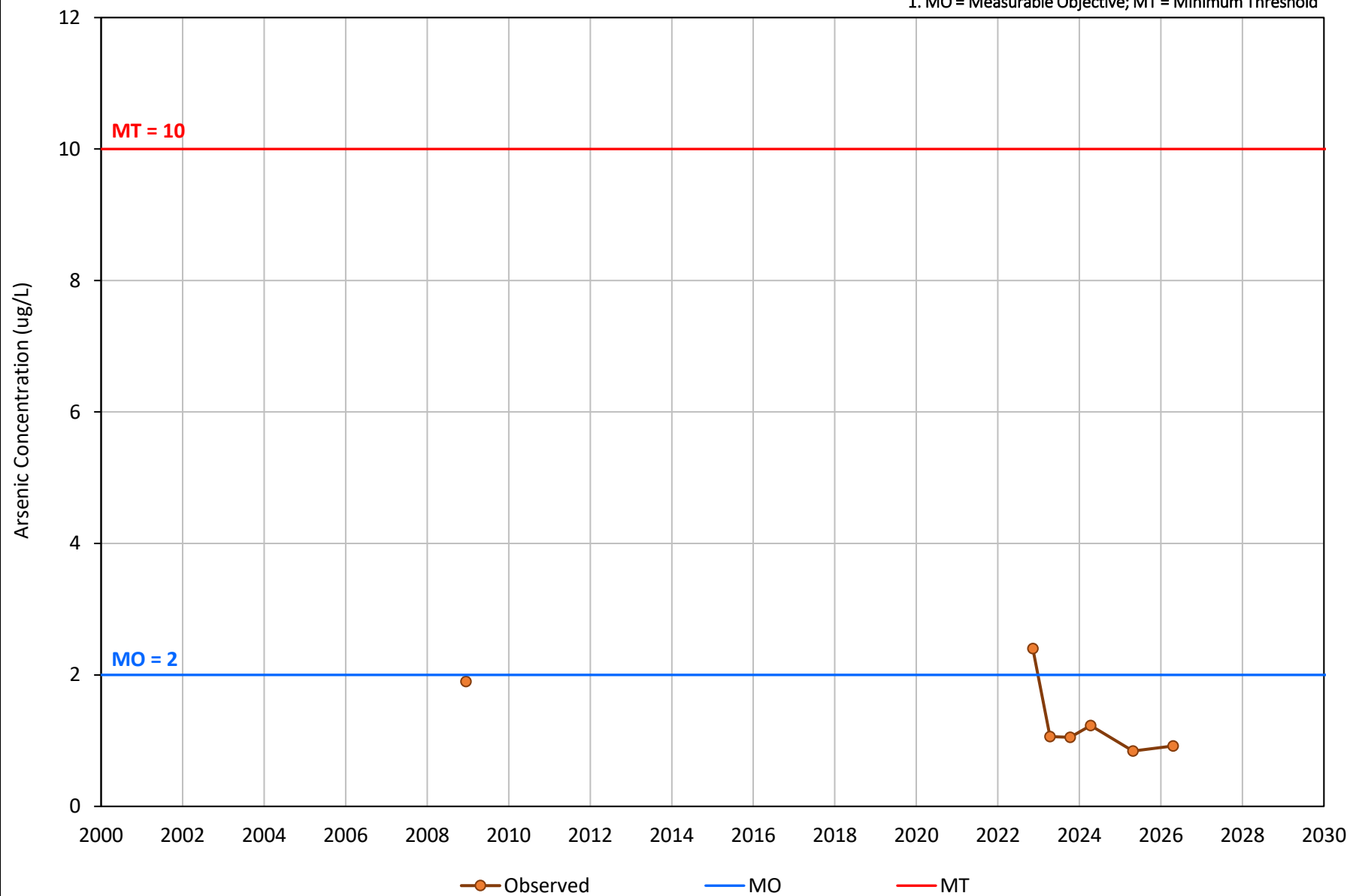


Well Name: MW-10D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

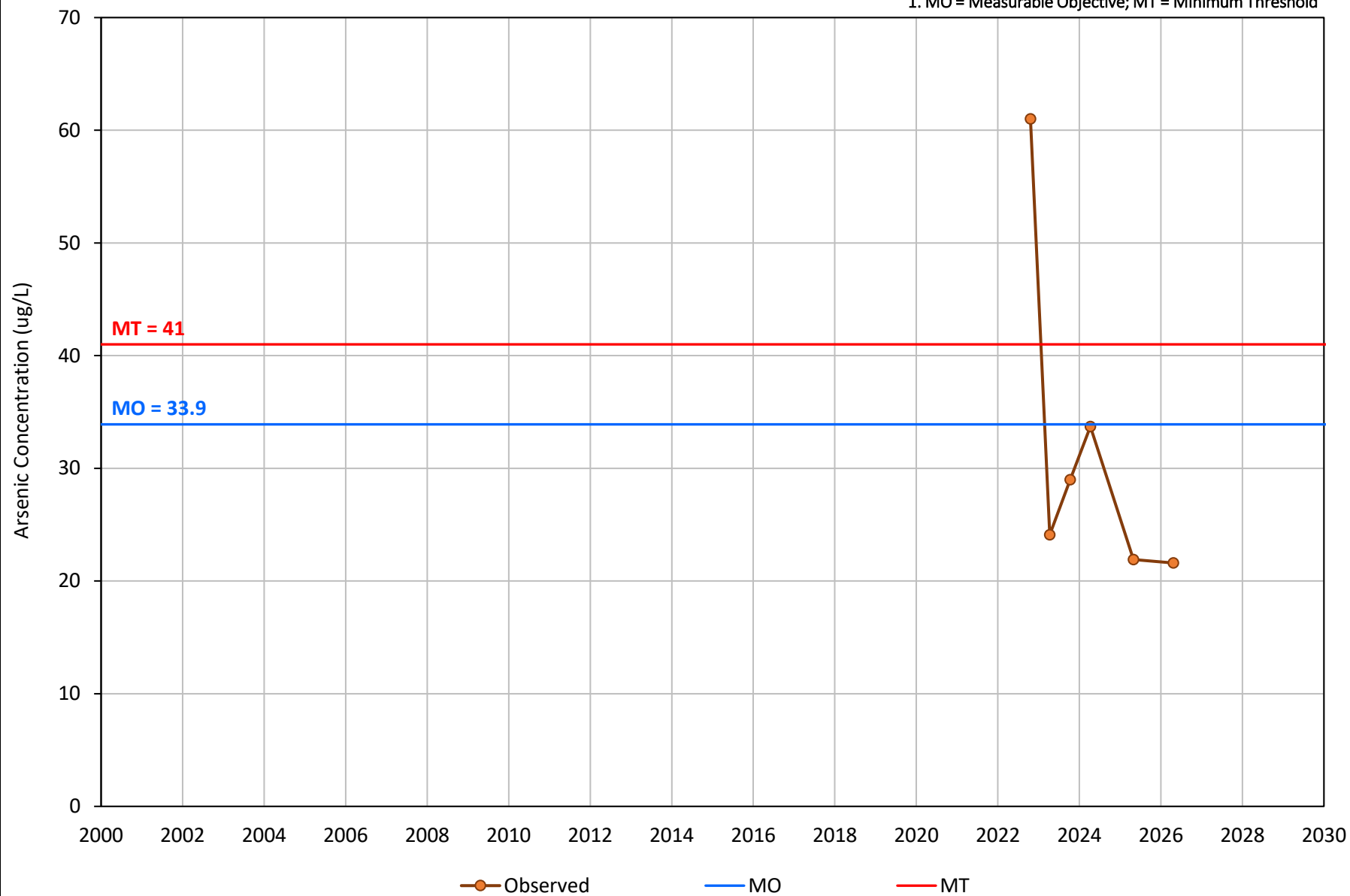


Well Name: S2-MWS1

Aquifer: Shallow

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

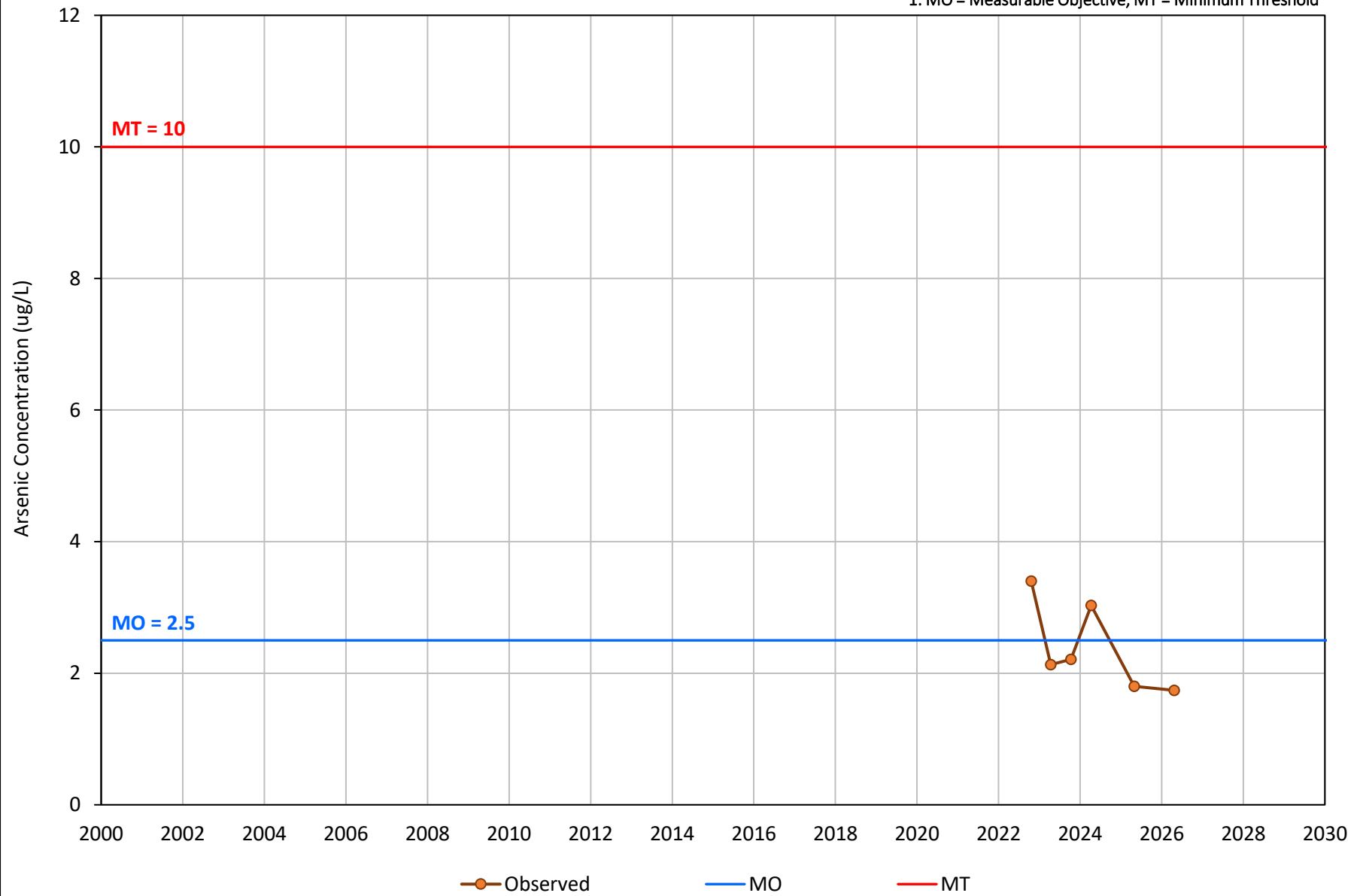


Well Name: S2-MWS2

Aquifer: Shallow

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

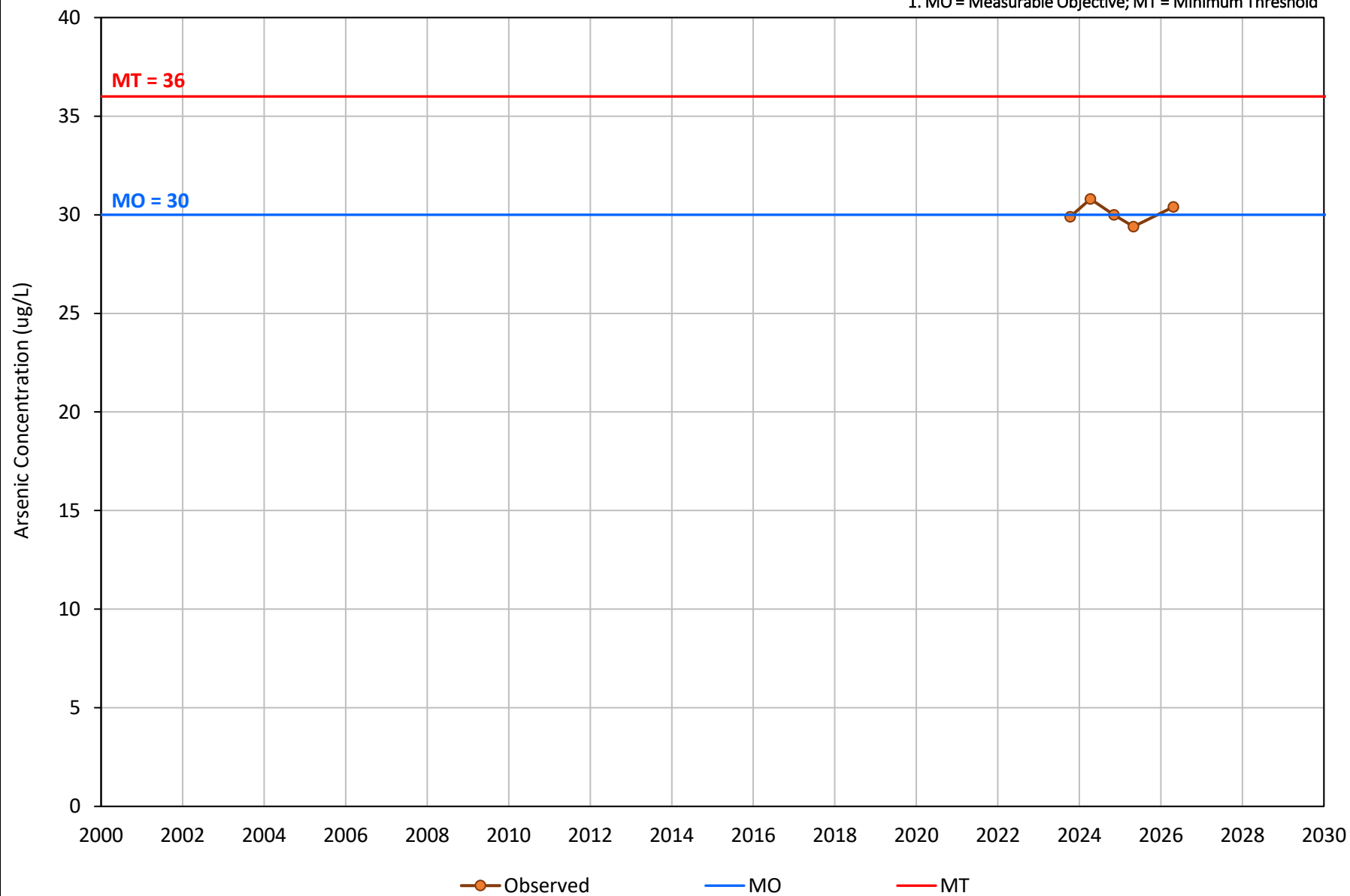


Well Name: S2-MWD1

Aquifer: Deep

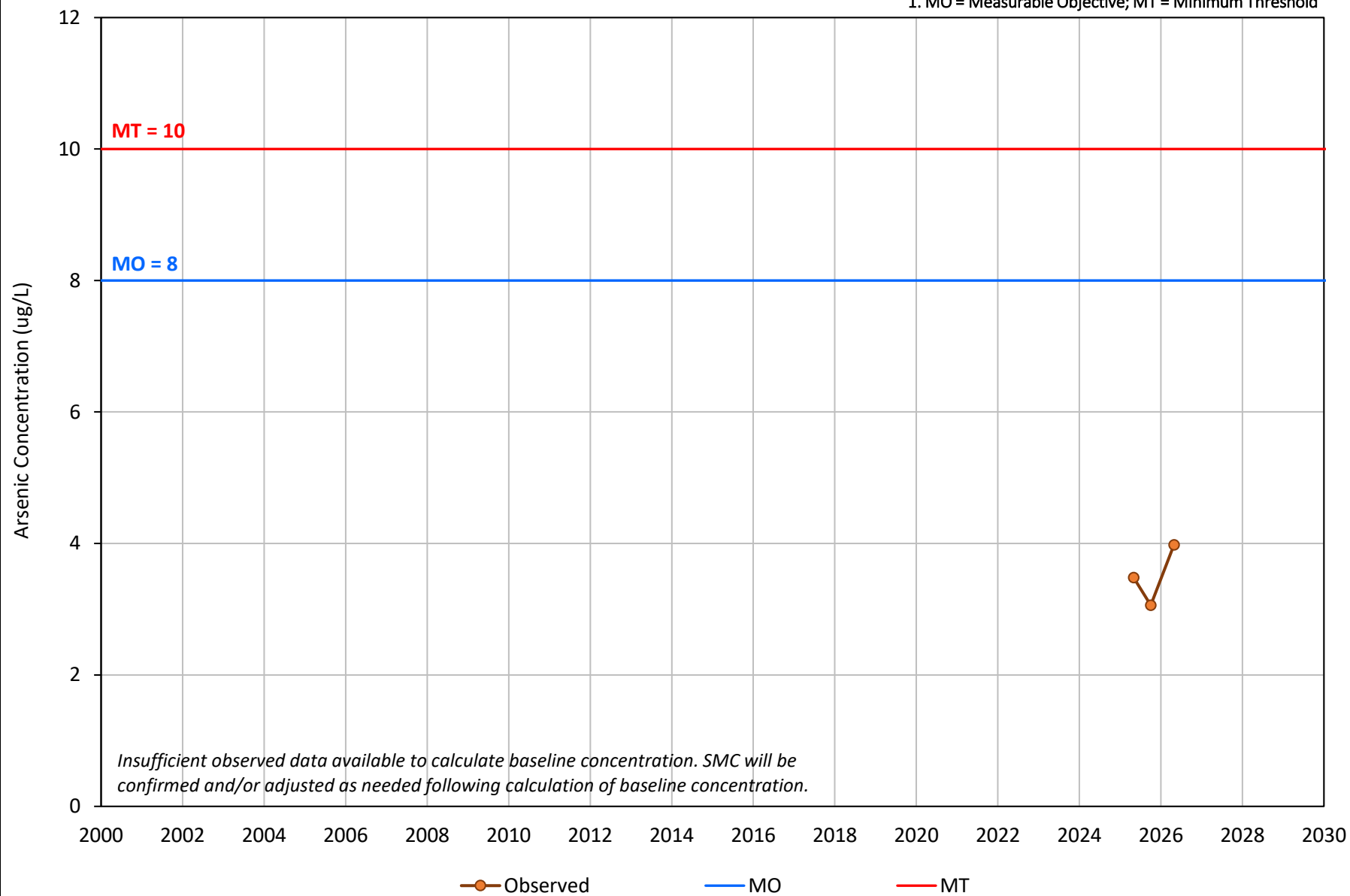
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-N1I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

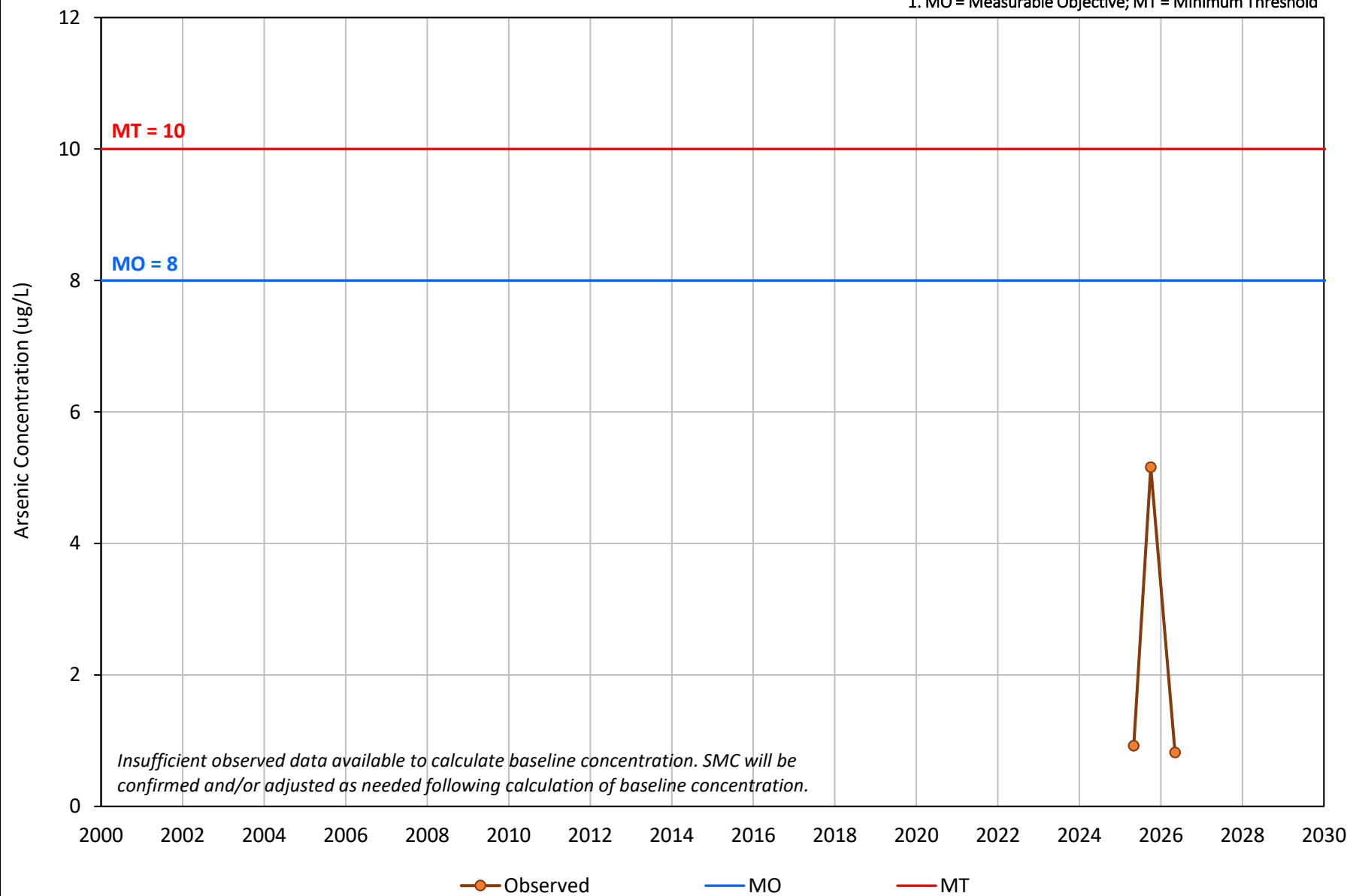


Well Name: MW-N3S

Aquifer: Shallow

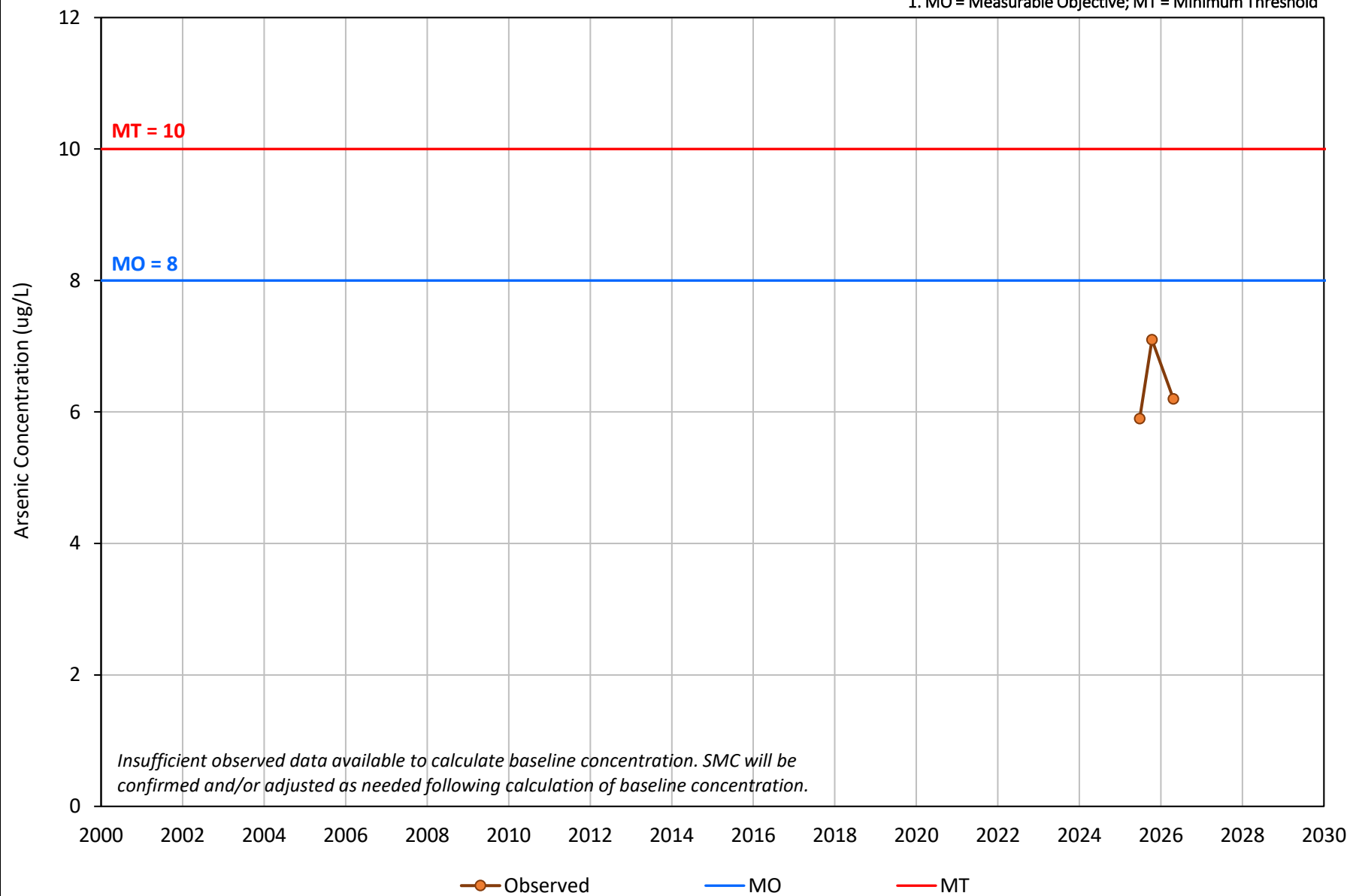
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-S2I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold



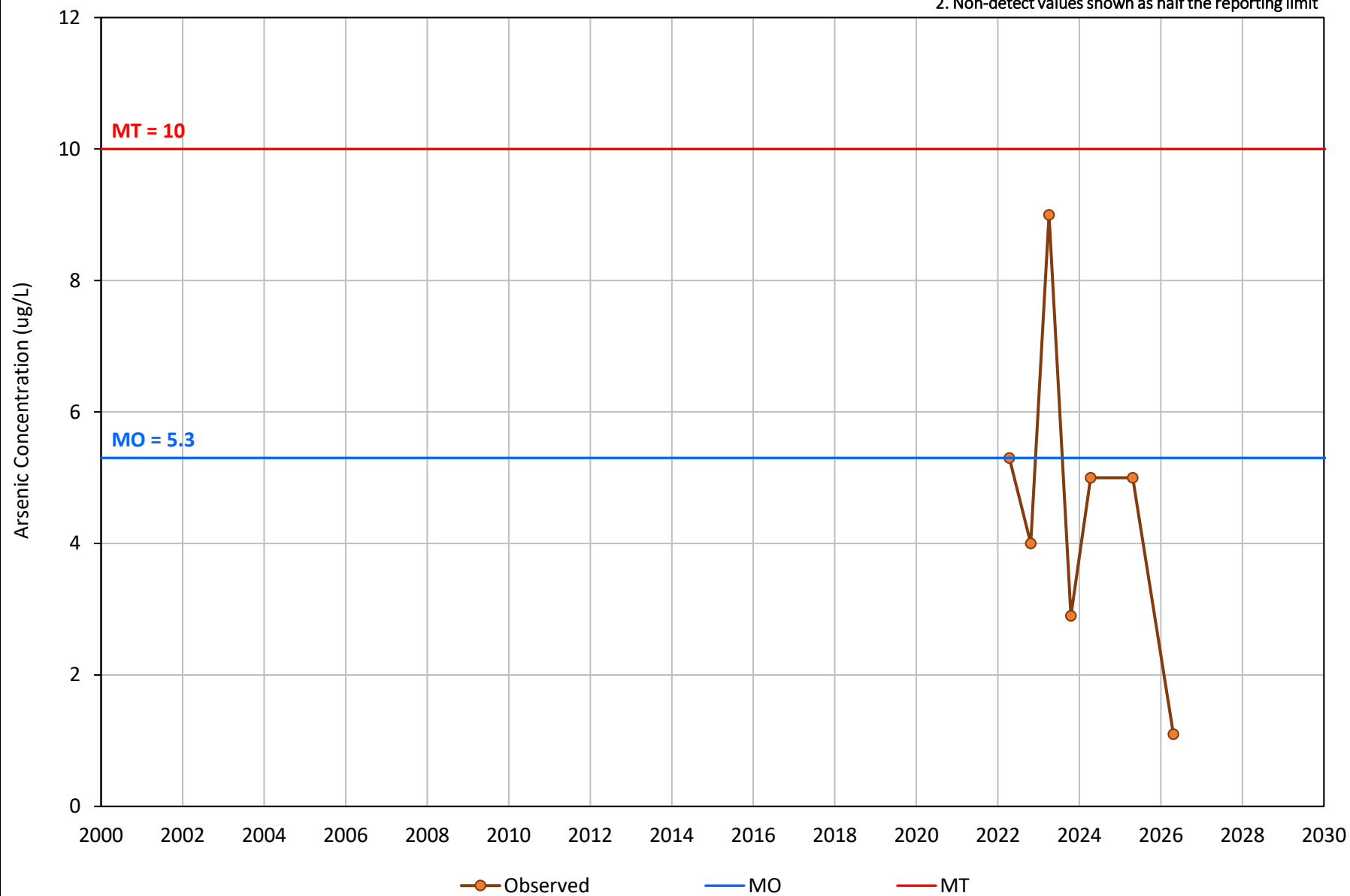
Well Name: Well D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

2. Non-detect values shown as half the reporting limit

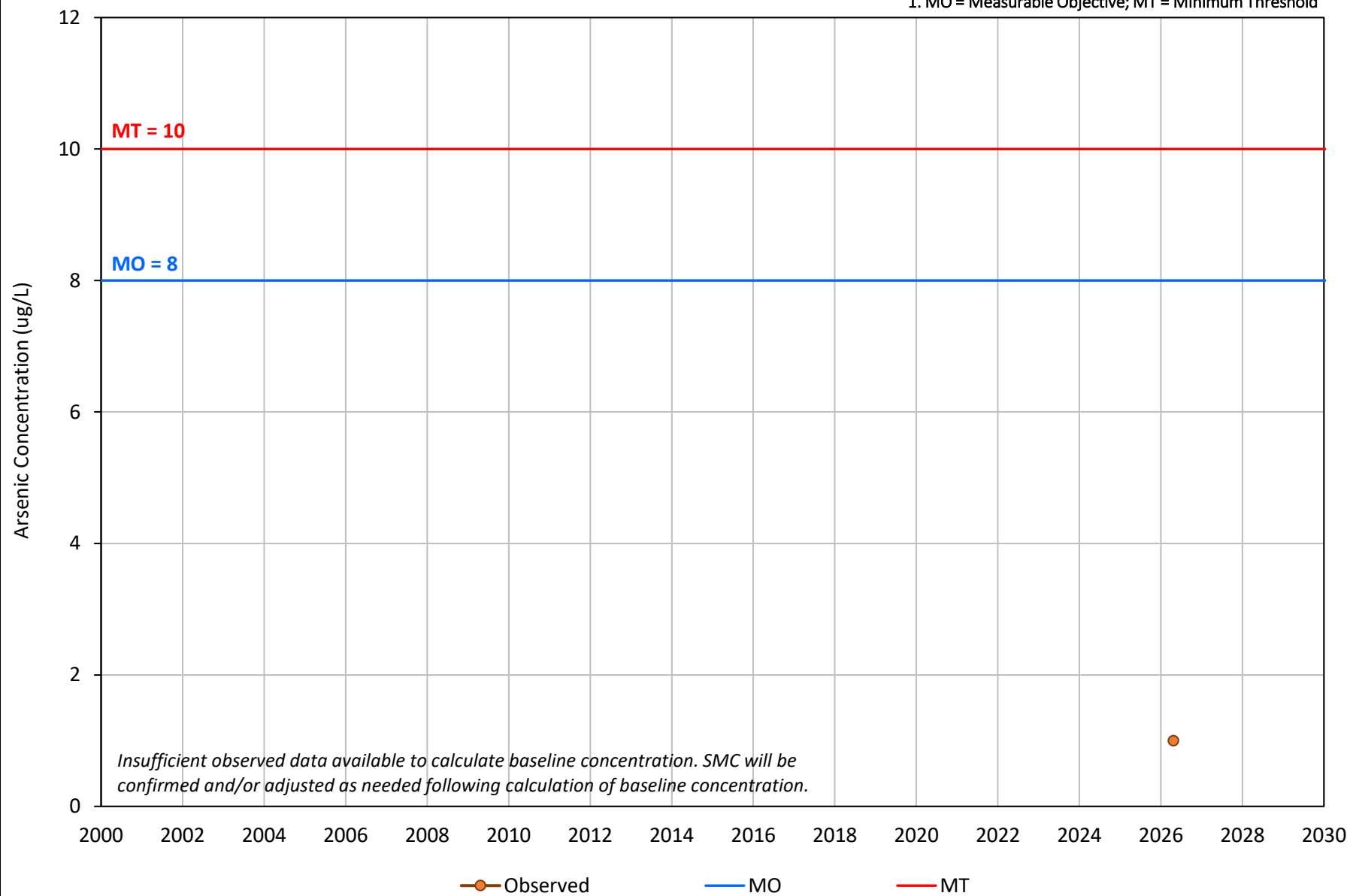


Well Name: Well E

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



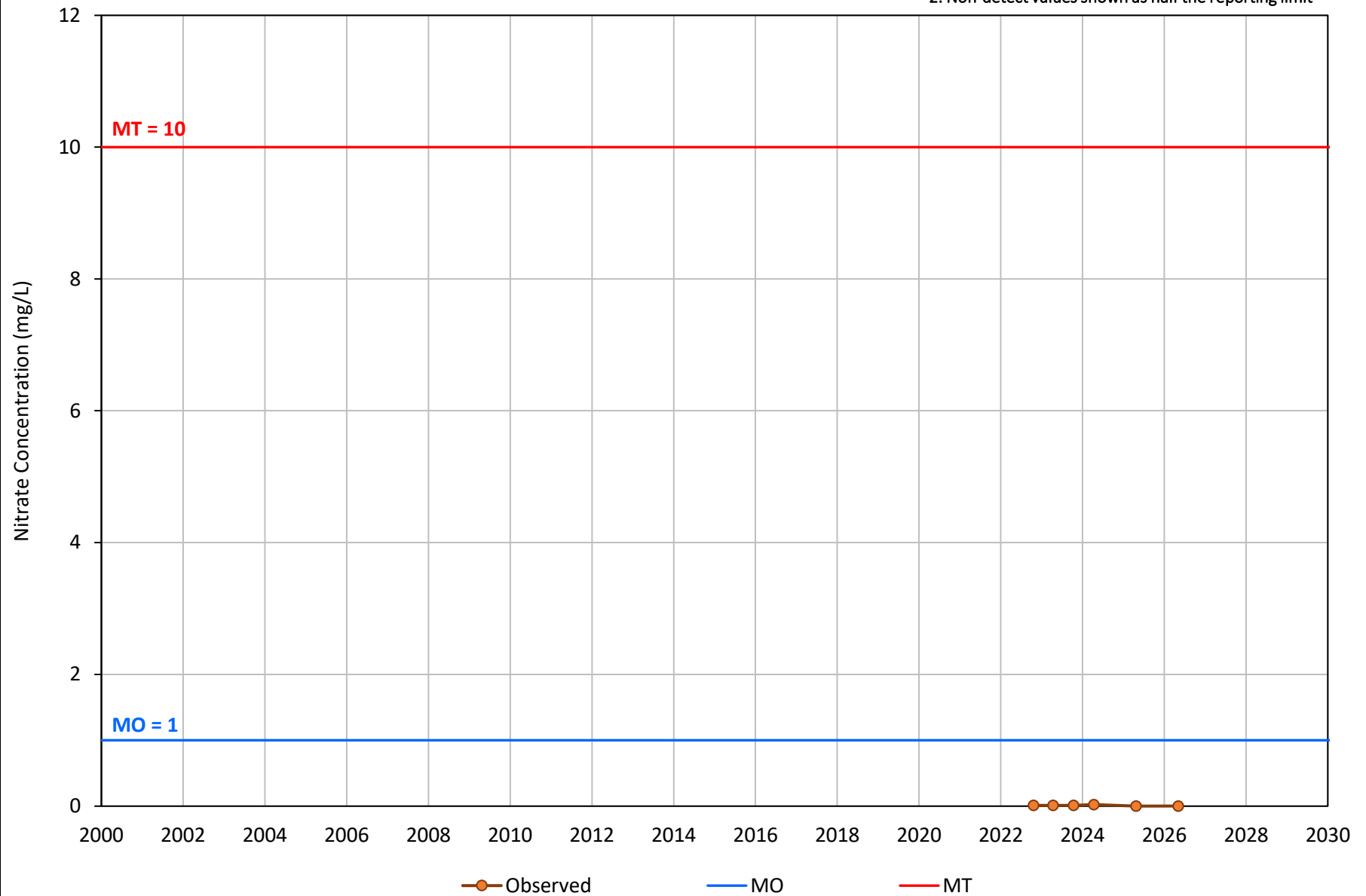
Well Name: MW-5S

Aquifer: Shallow

NOTES:

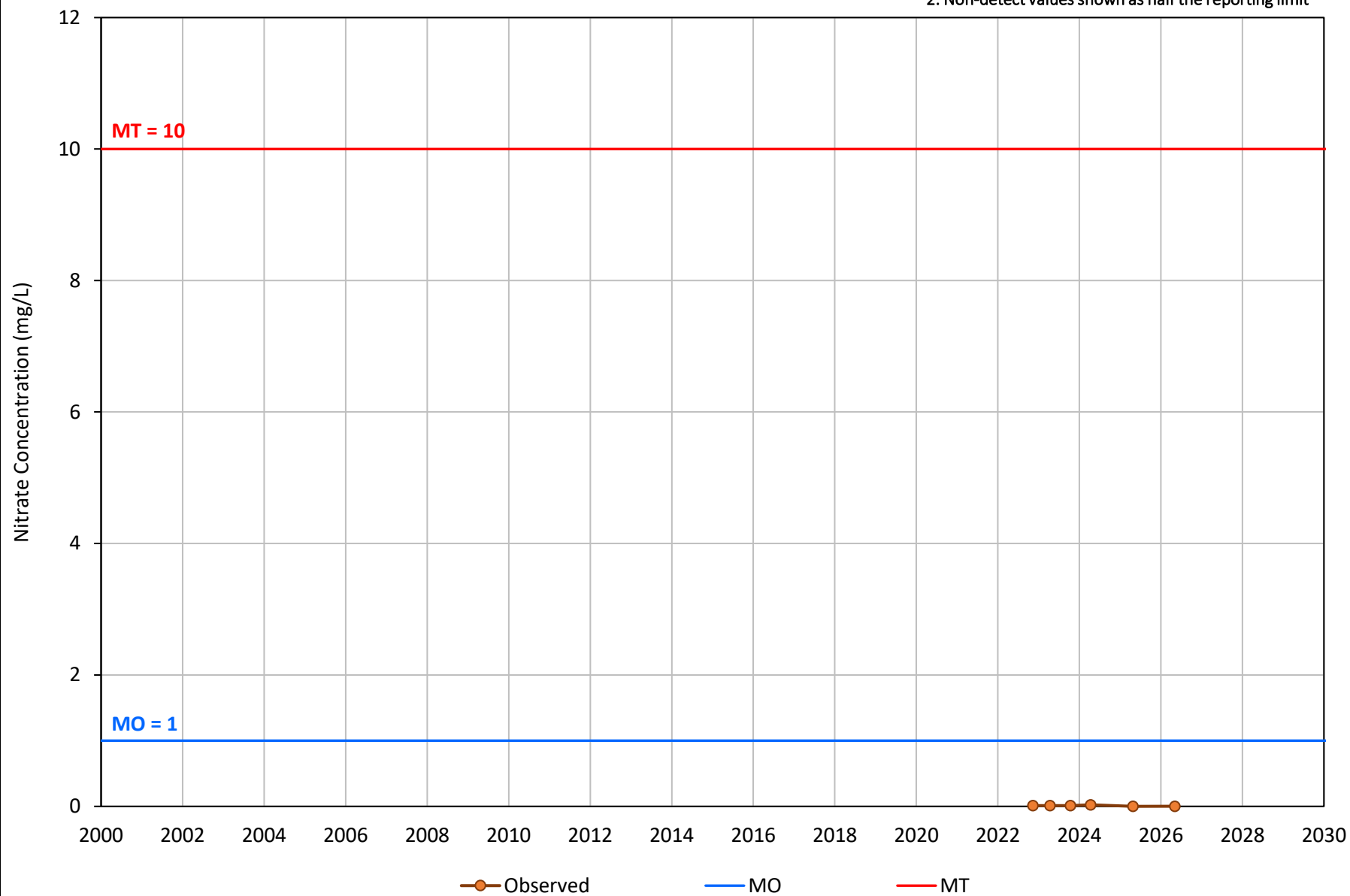
1. MO = Measurable Objective; MT = Minimum Threshold

2. Non-detect values shown as half the reporting limit



Well Name: MW-5I
Aquifer: Intermediate

- NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold
 2. Non-detect values shown as half the reporting limit



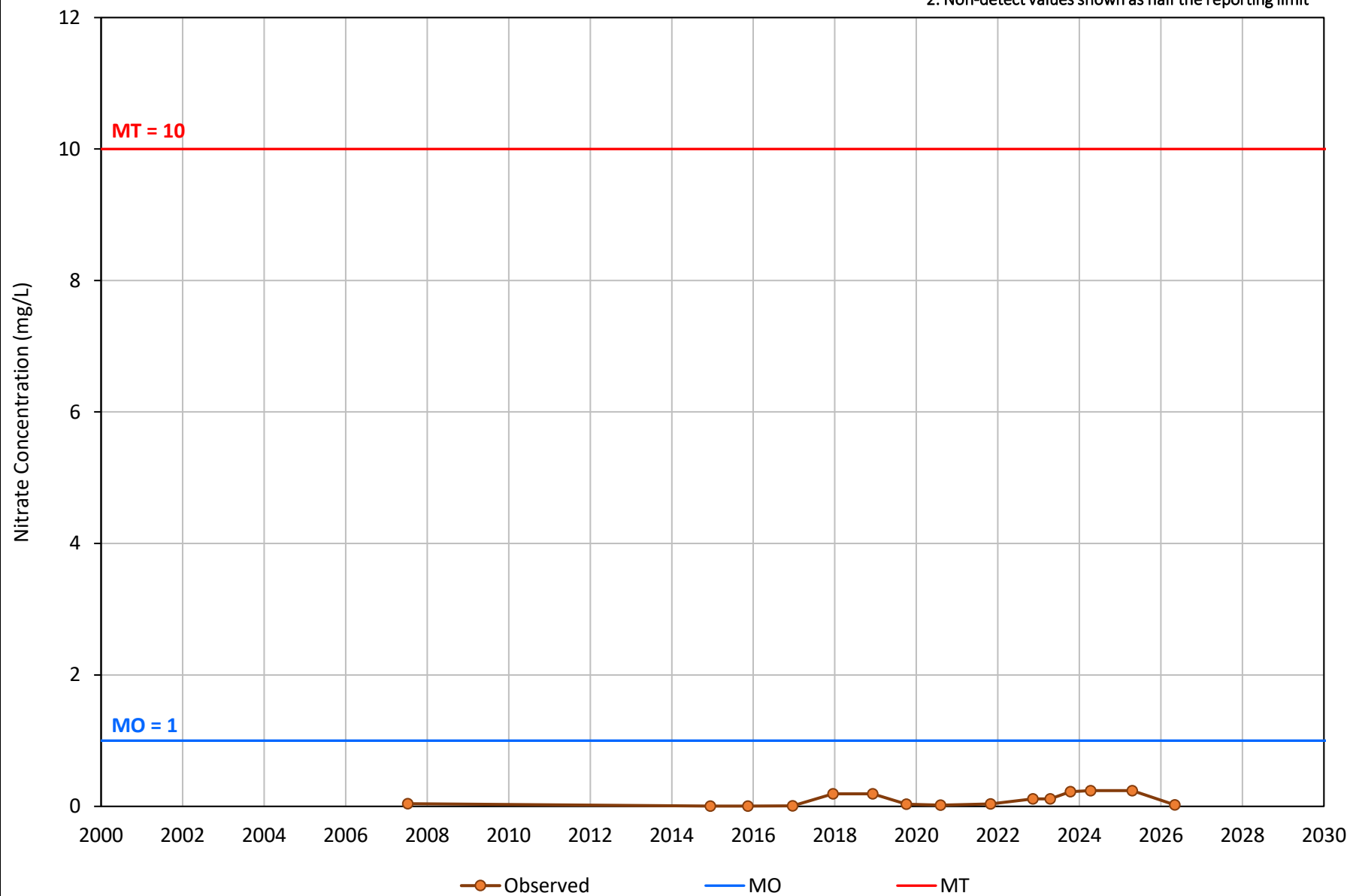
Well Name: MW-5D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

2. Non-detect values shown as half the reporting limit

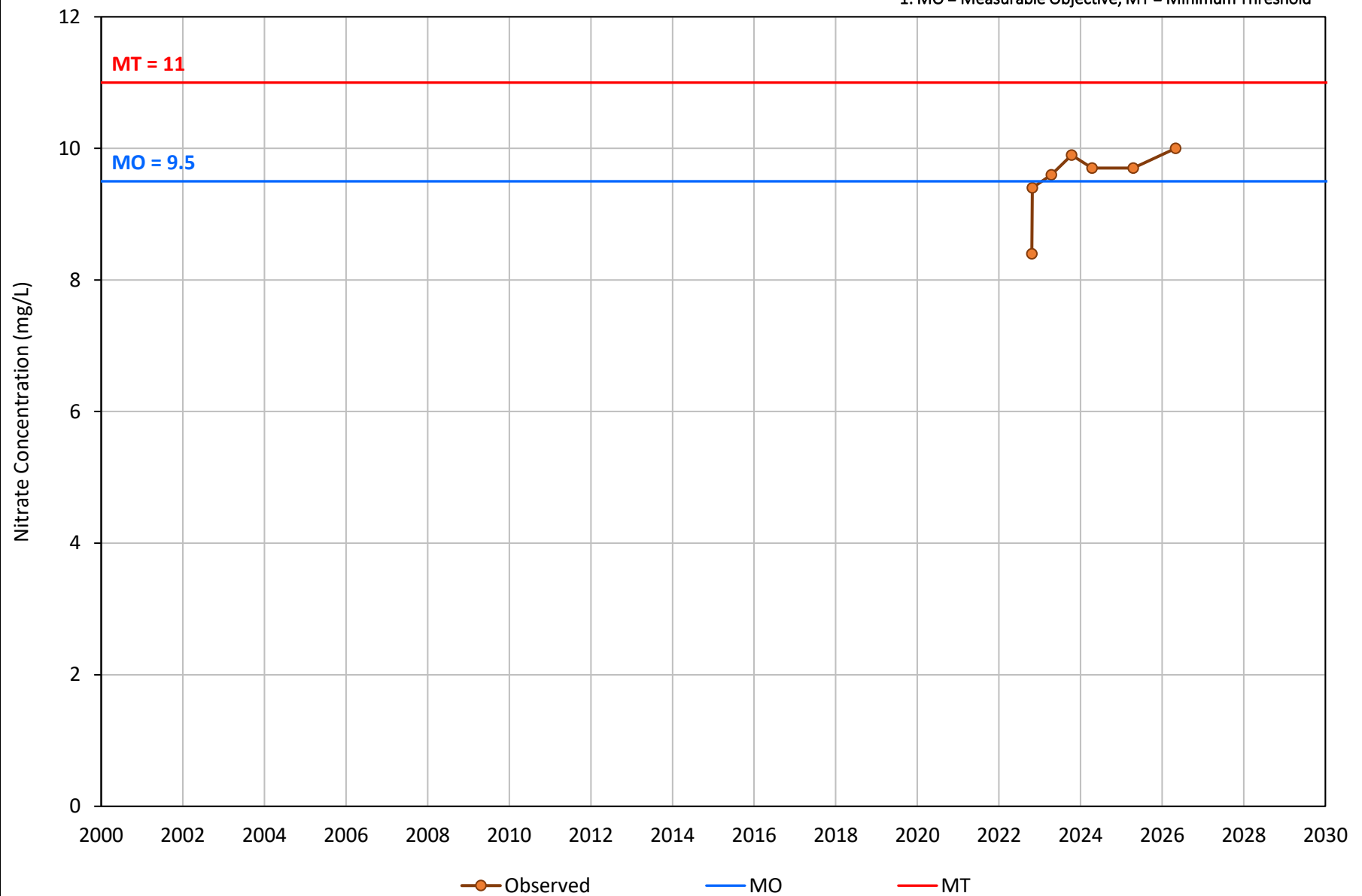


Well Name: MW-9S

Aquifer: Shallow

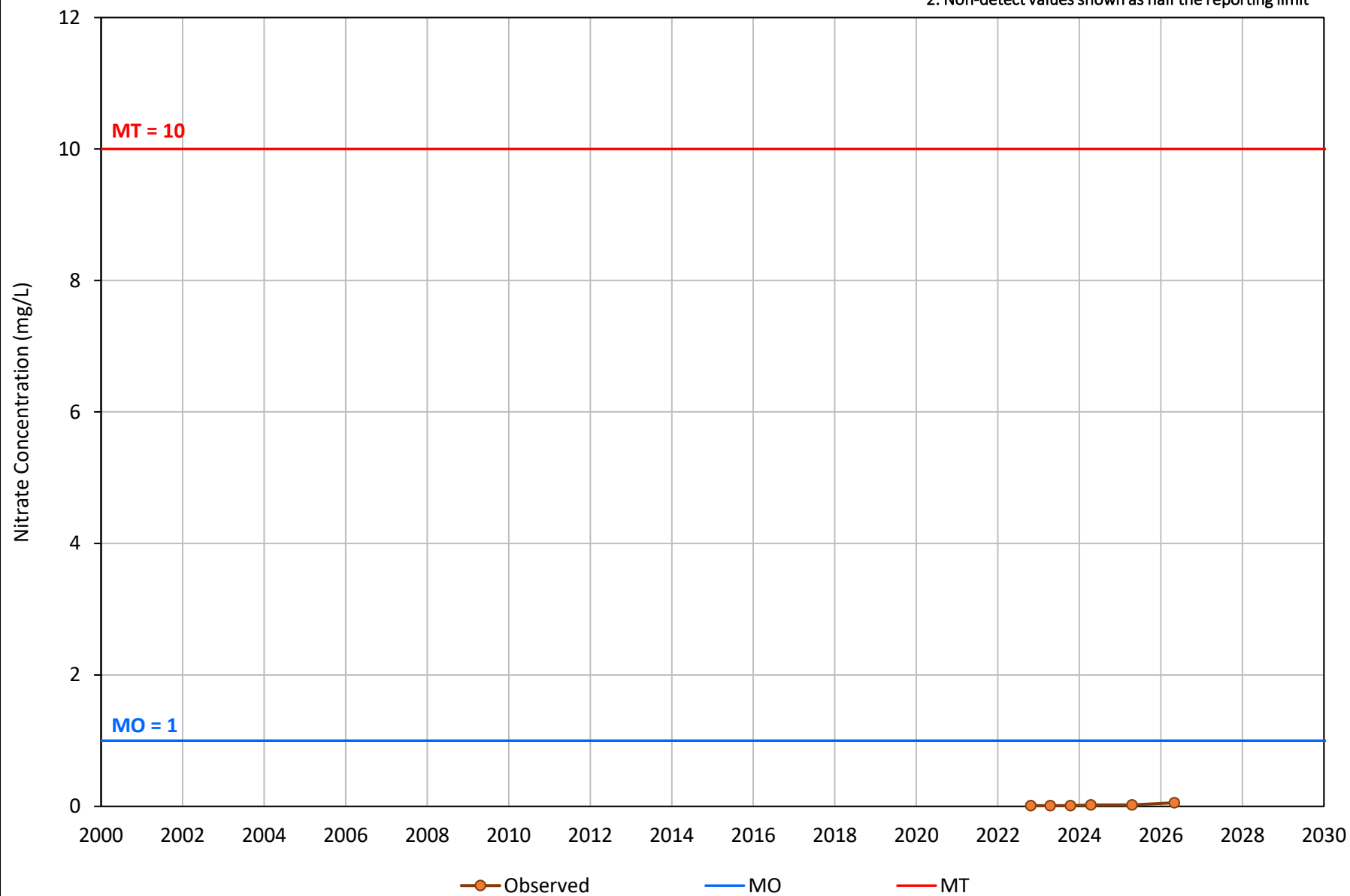
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-9I
Aquifer: Intermediate

- NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold
2. Non-detect values shown as half the reporting limit



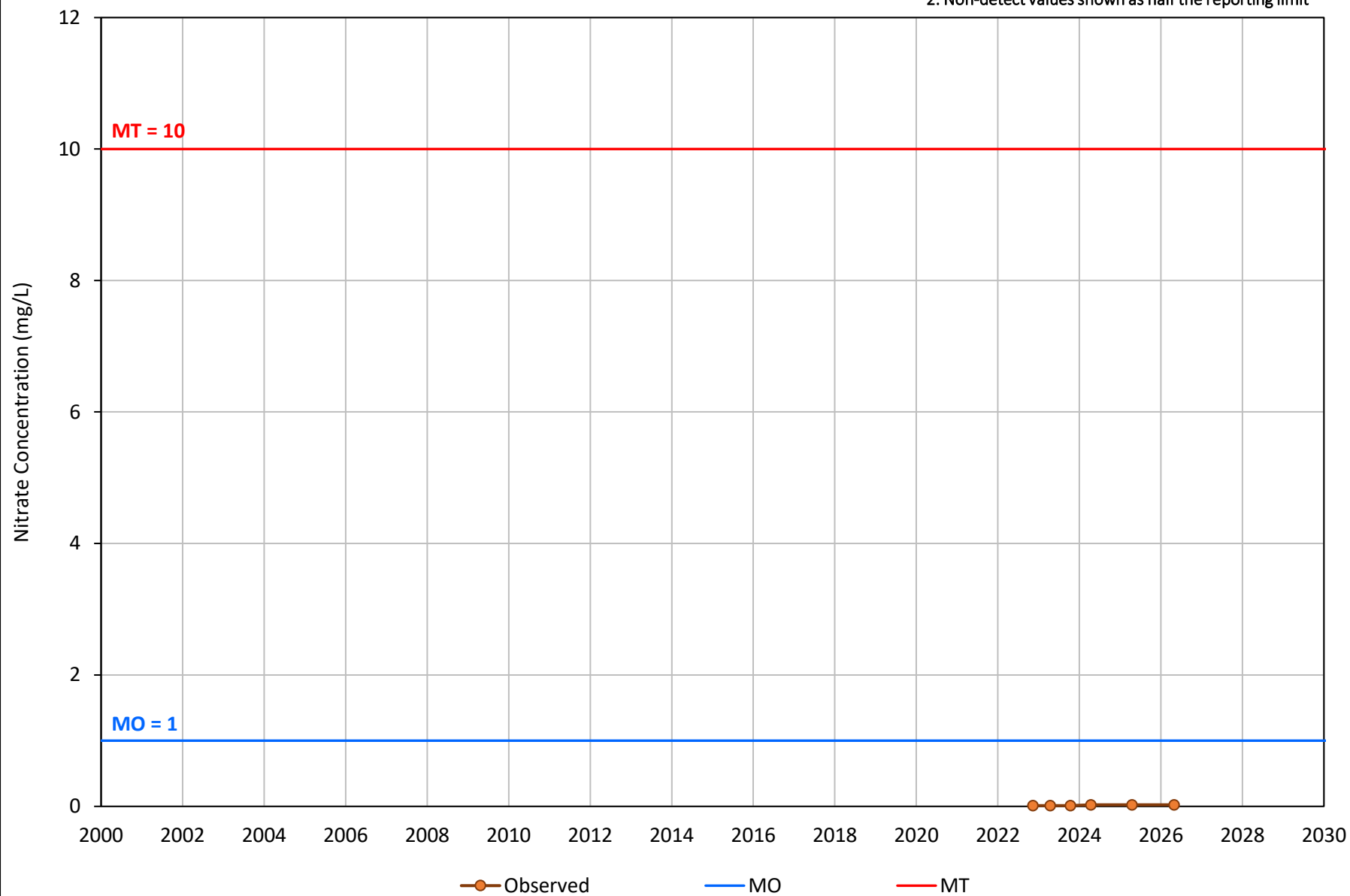
Well Name: MW-9D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

2. Non-detect values shown as half the reporting limit

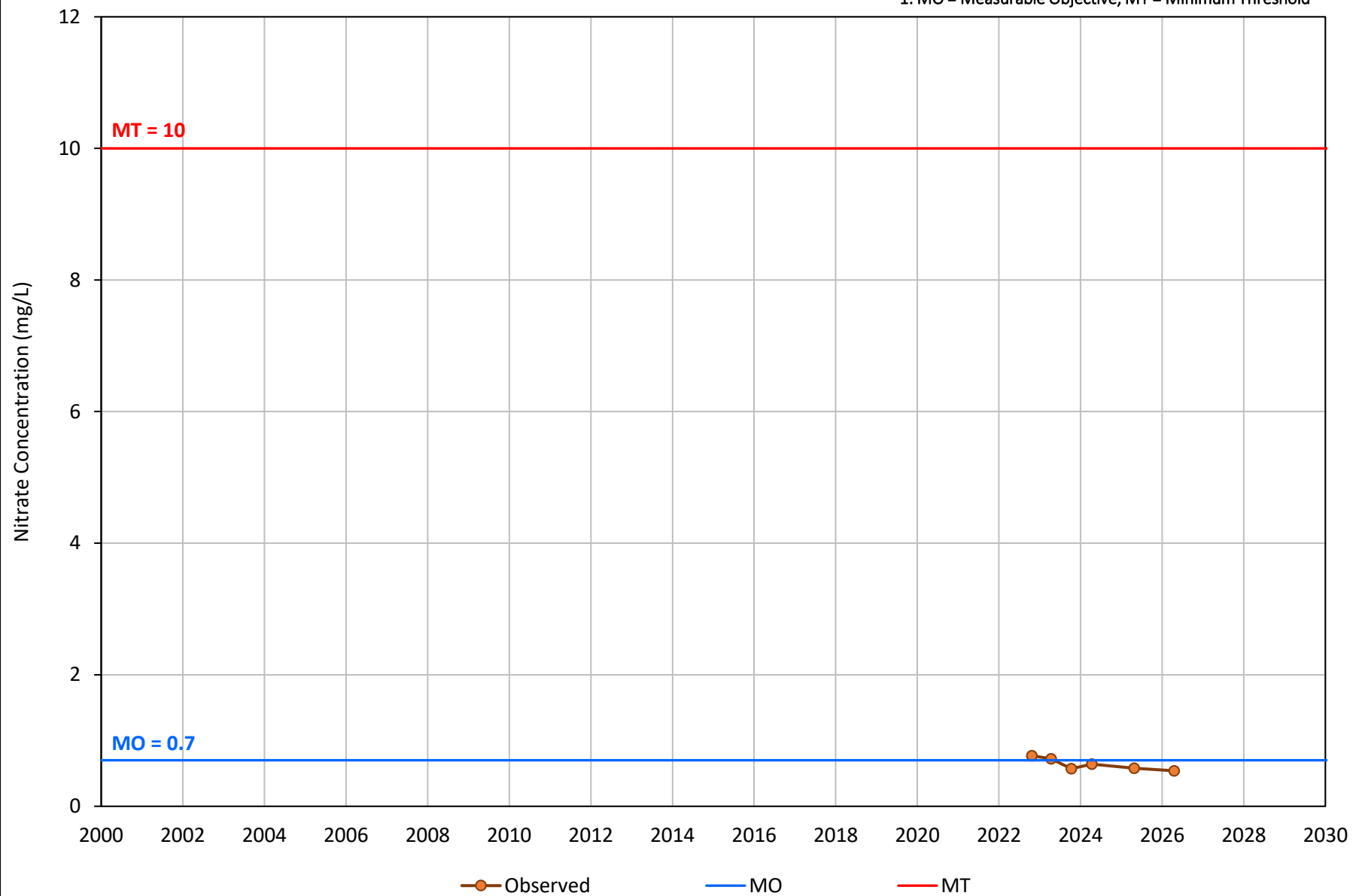


Well Name: MW-10S

Aquifer: Shallow

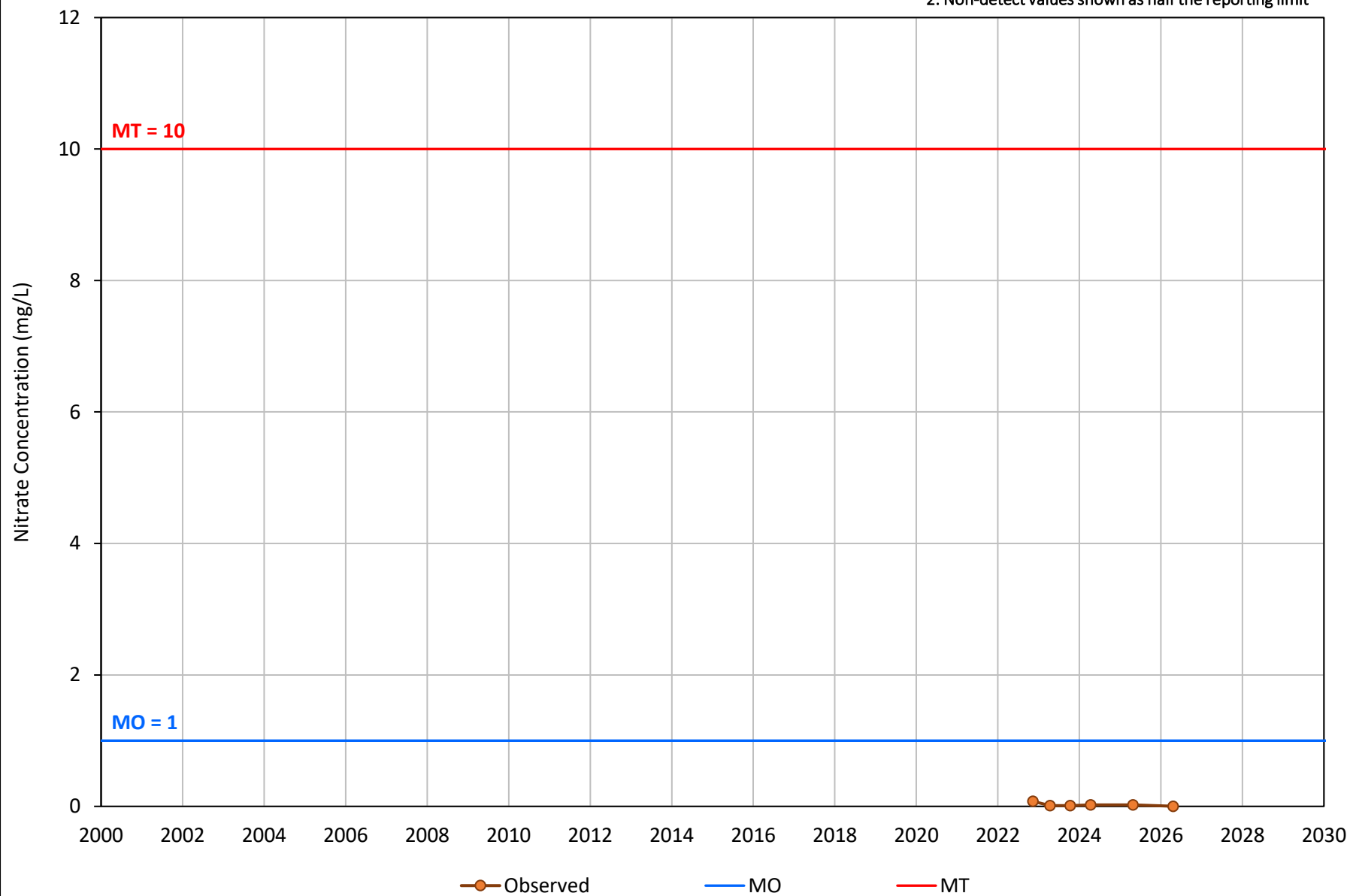
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-10I
Aquifer: Intermediate

- NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold
 2. Non-detect values shown as half the reporting limit



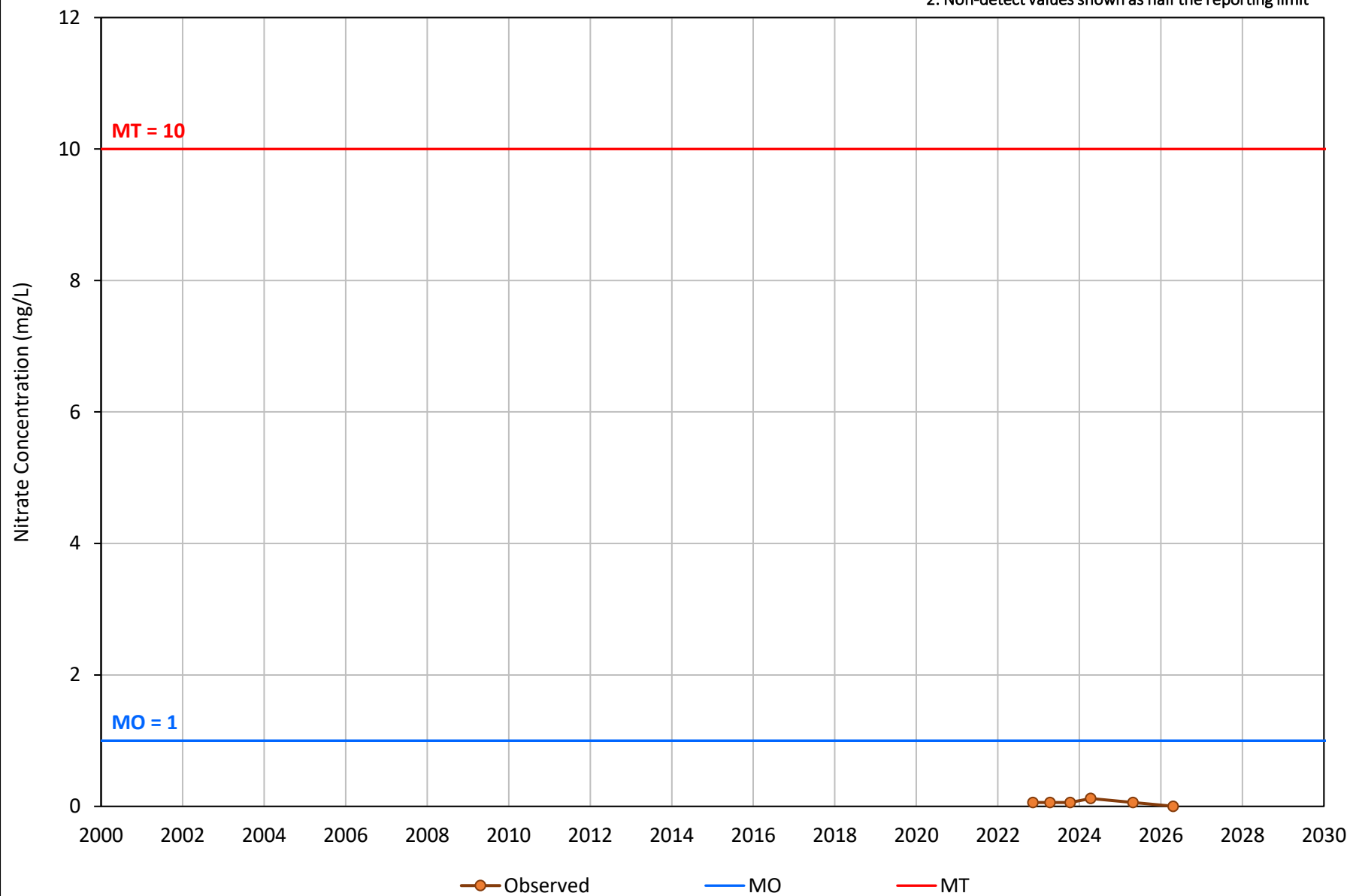
Well Name: MW-10D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

2. Non-detect values shown as half the reporting limit



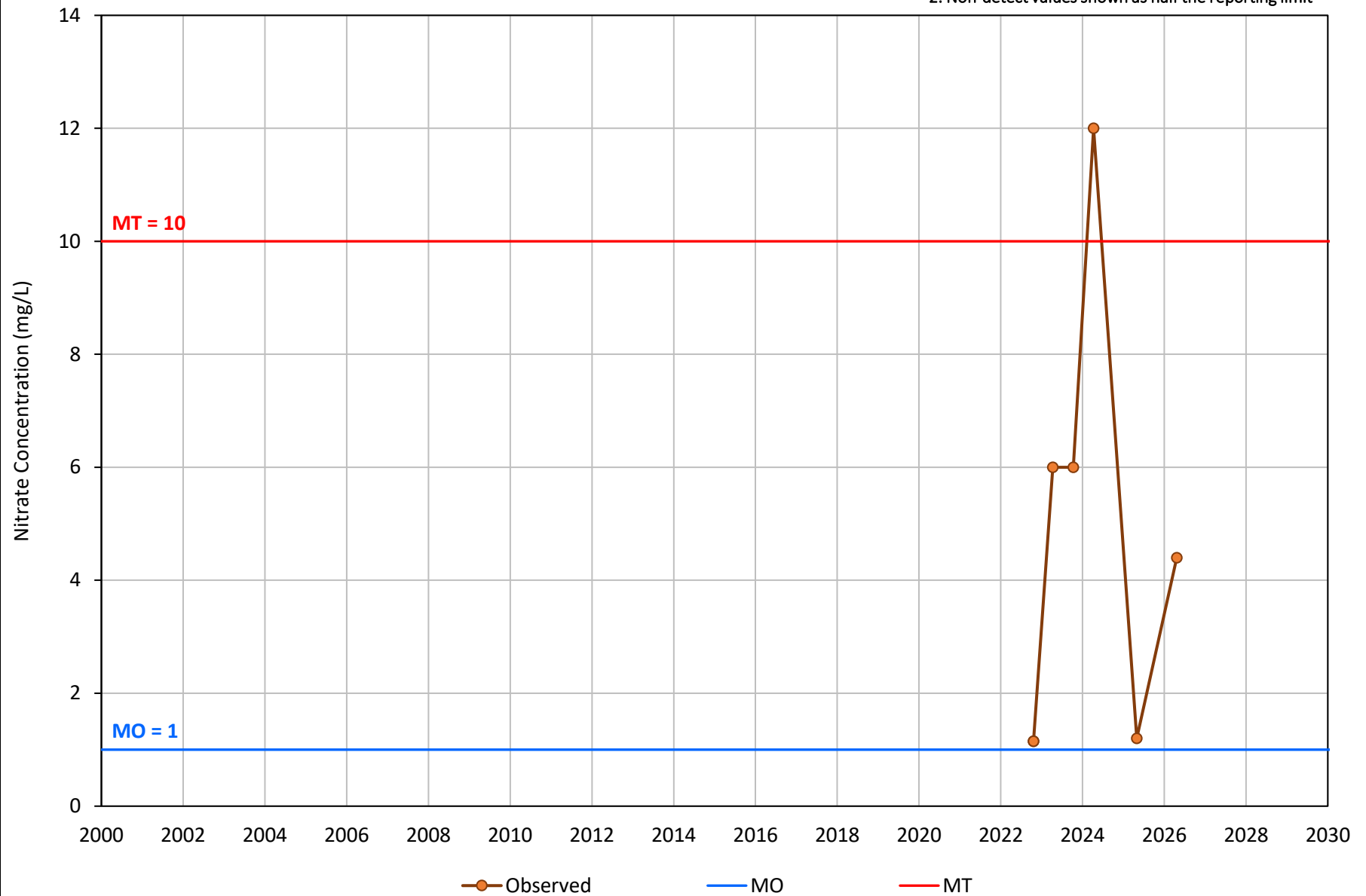
Well Name: S2-MWS1

Aquifer: Shallow

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

2. Non-detect values shown as half the reporting limit

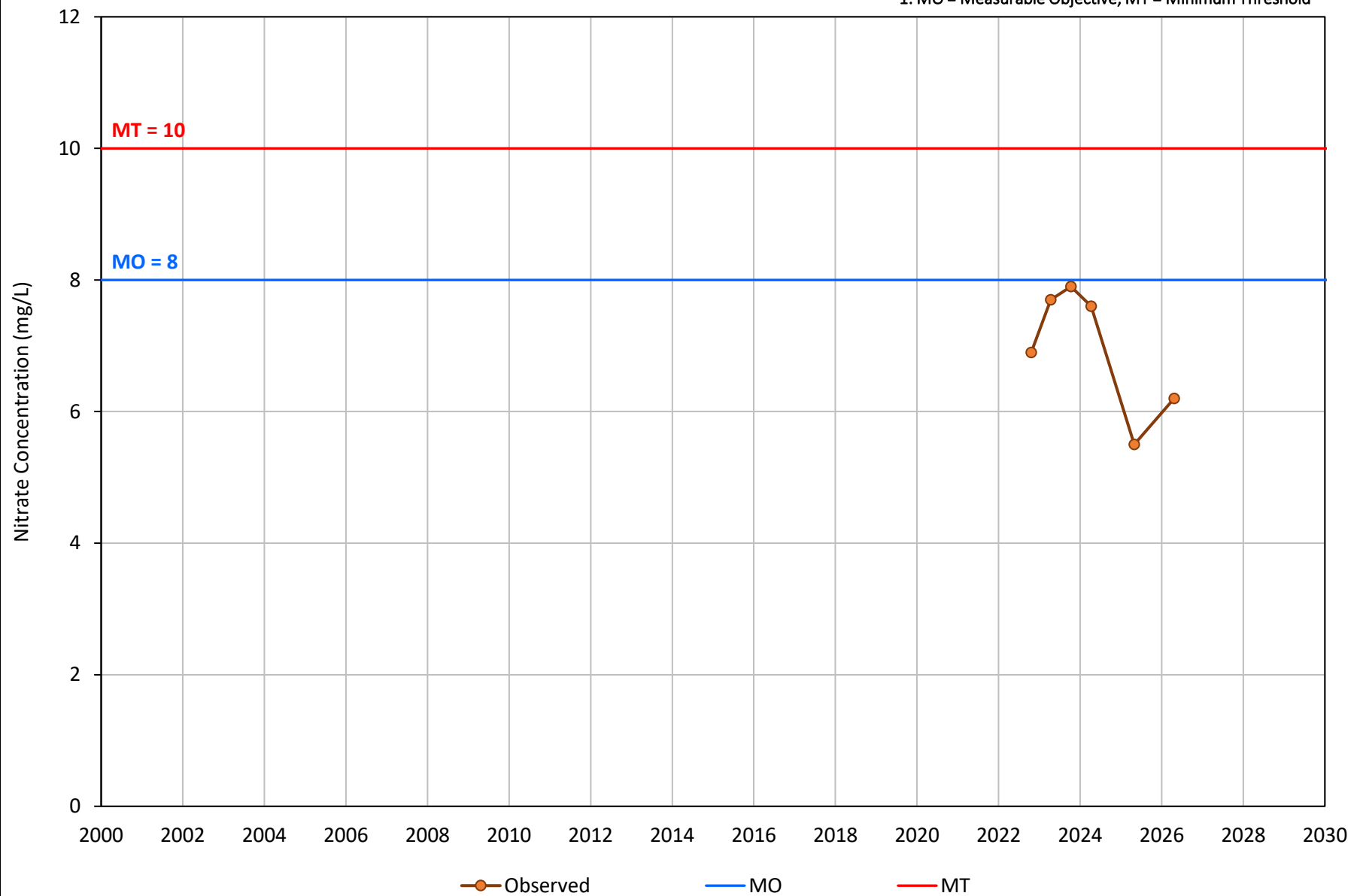


Well Name: S2-MWS2

Aquifer: Shallow

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



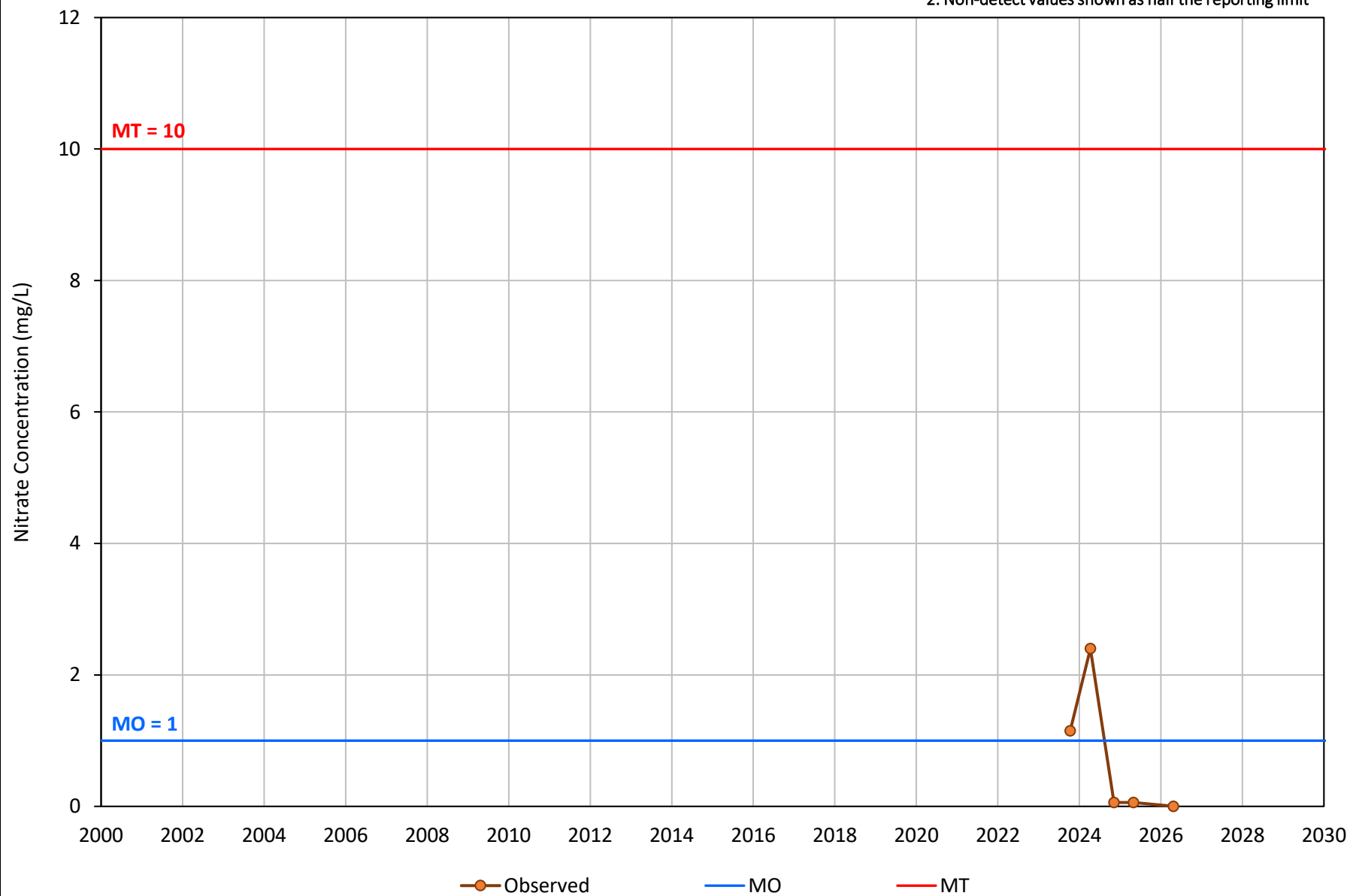
Well Name: S2-MWD1

Aquifer: Deep

NOTES:

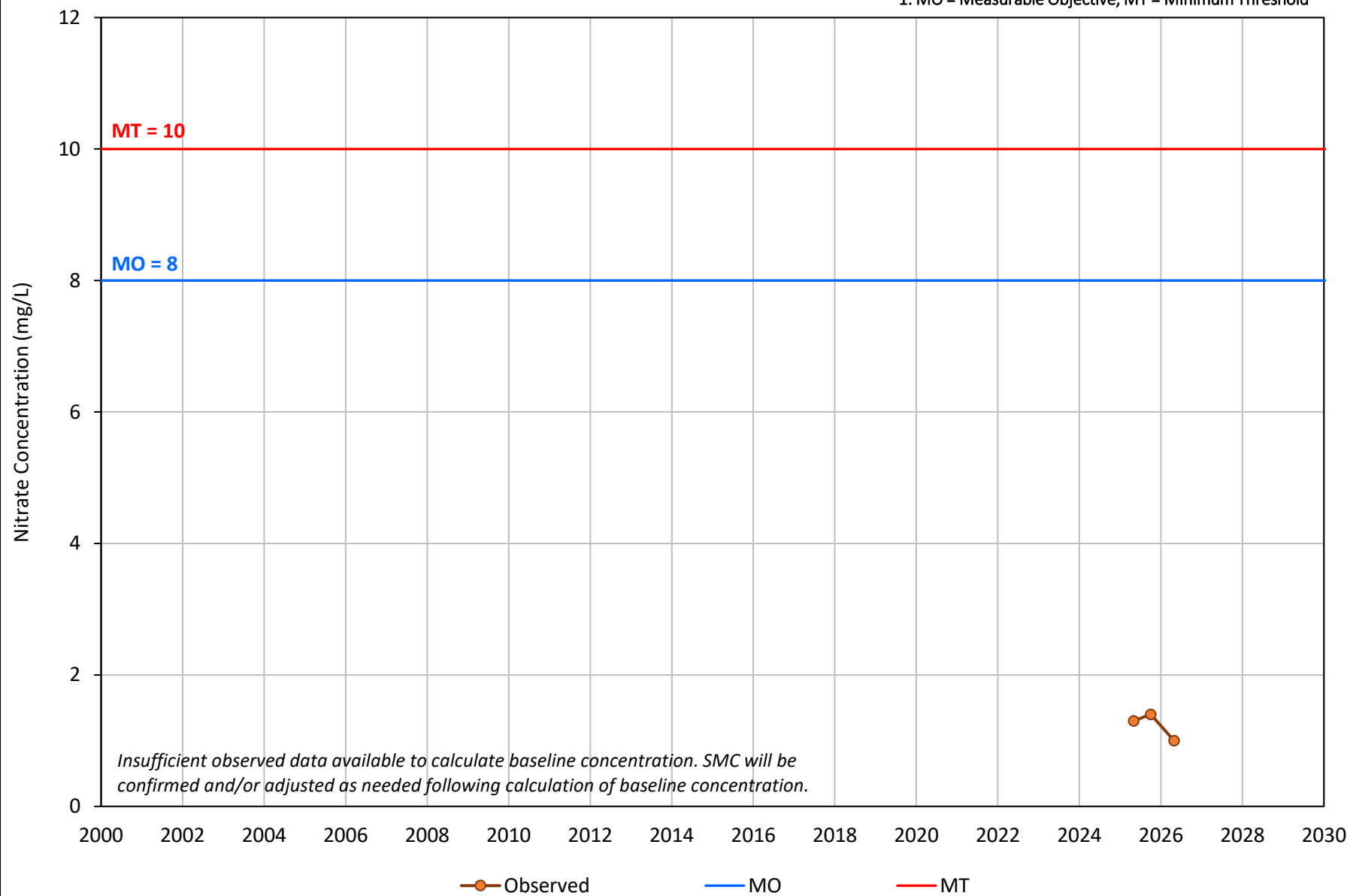
1. MO = Measurable Objective; MT = Minimum Threshold

2. Non-detect values shown as half the reporting limit



Well Name: MW-N1I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

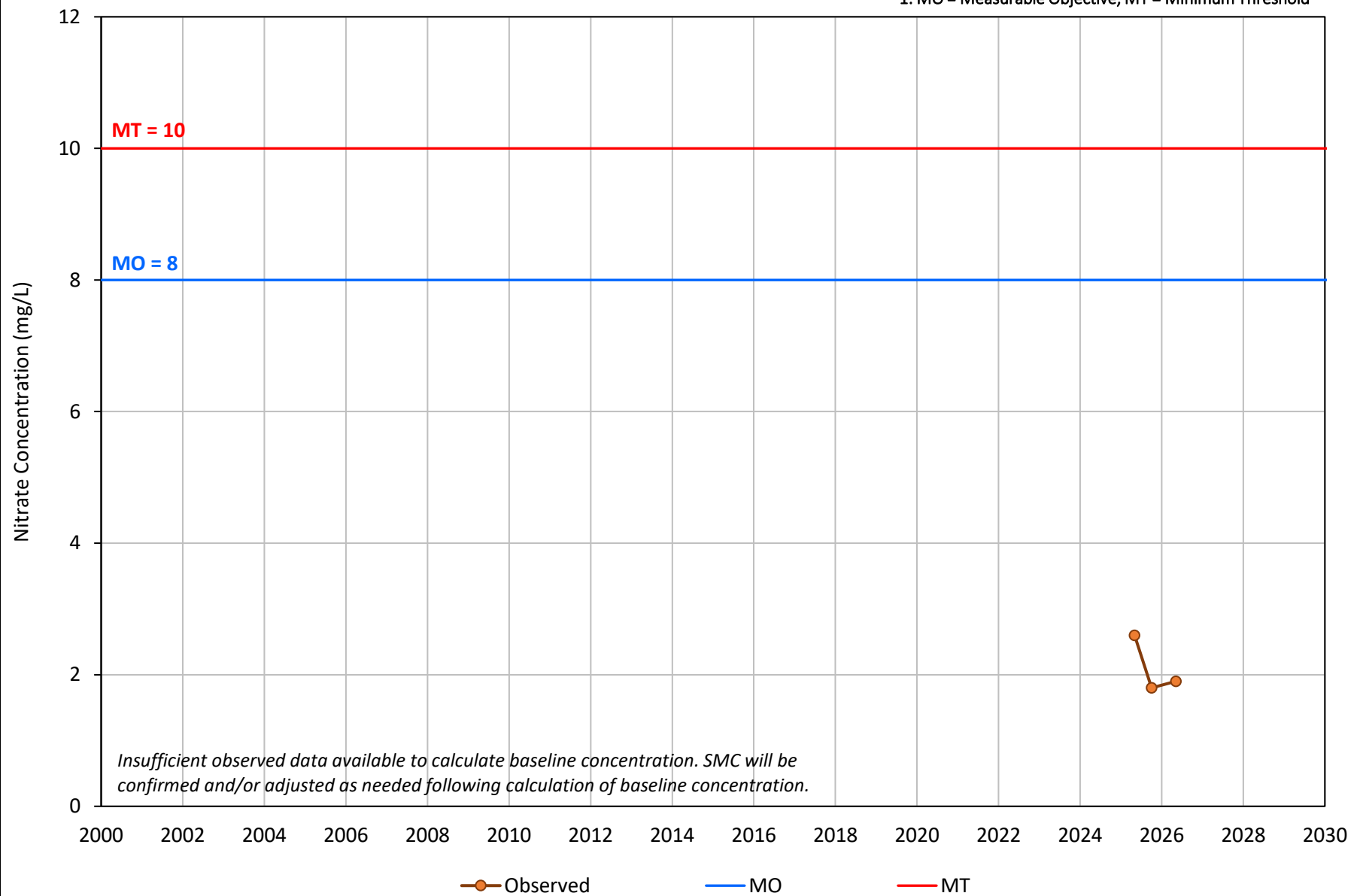


Well Name: MW-N3S

Aquifer: Shallow

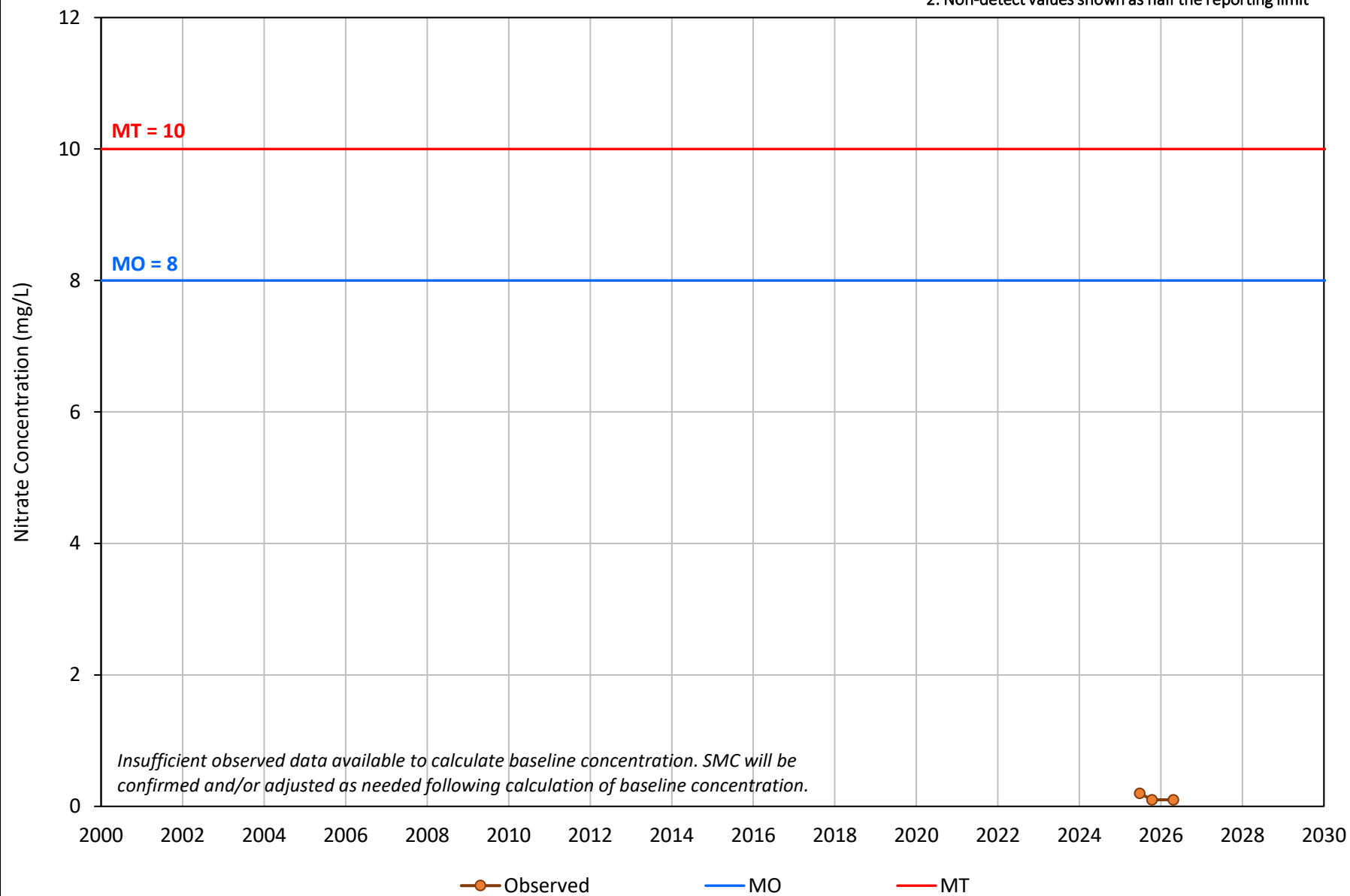
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-S2I
Aquifer: Intermediate

- NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold
2. Non-detect values shown as half the reporting limit



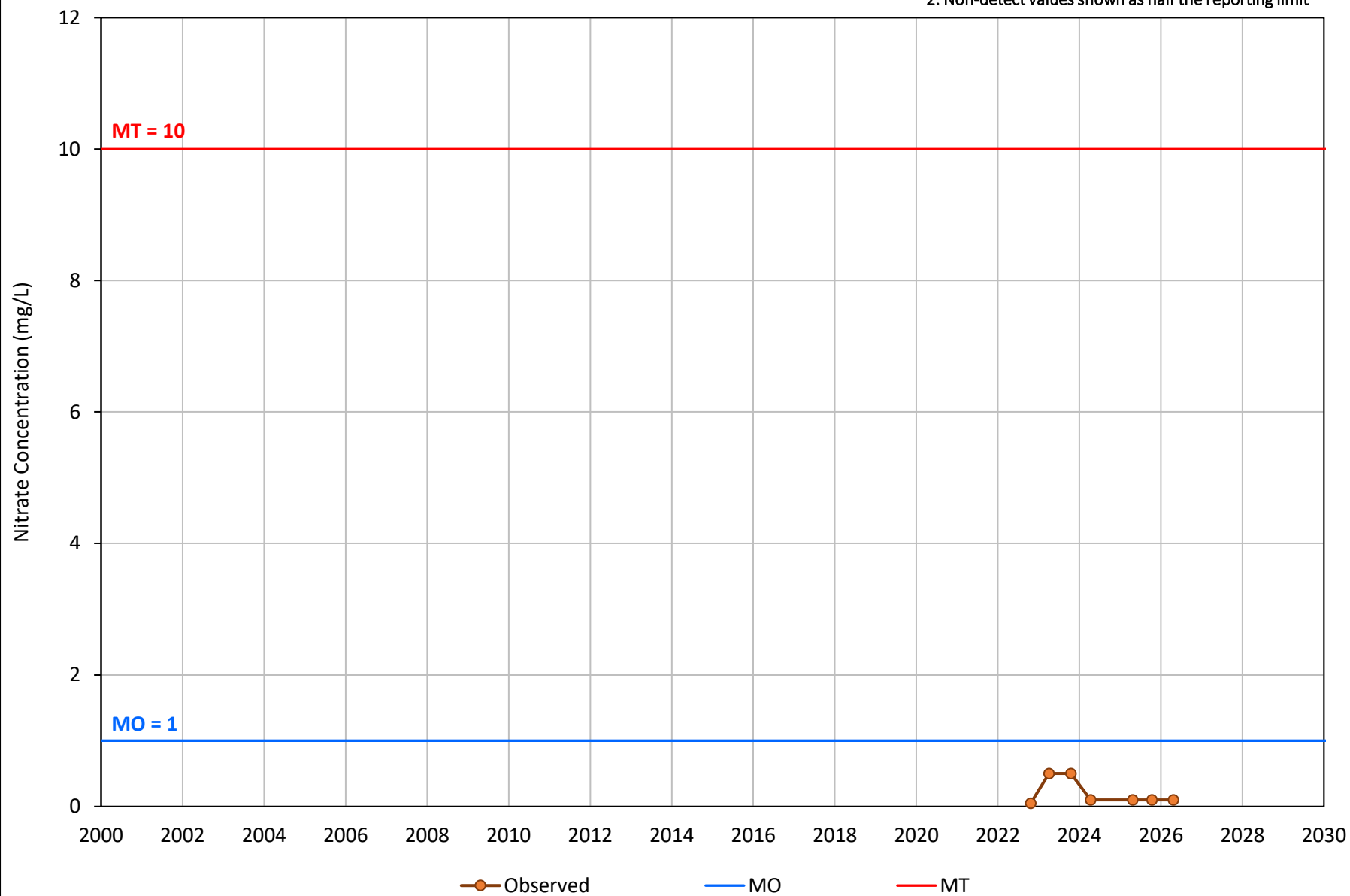
Well Name: Well D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

2. Non-detect values shown as half the reporting limit



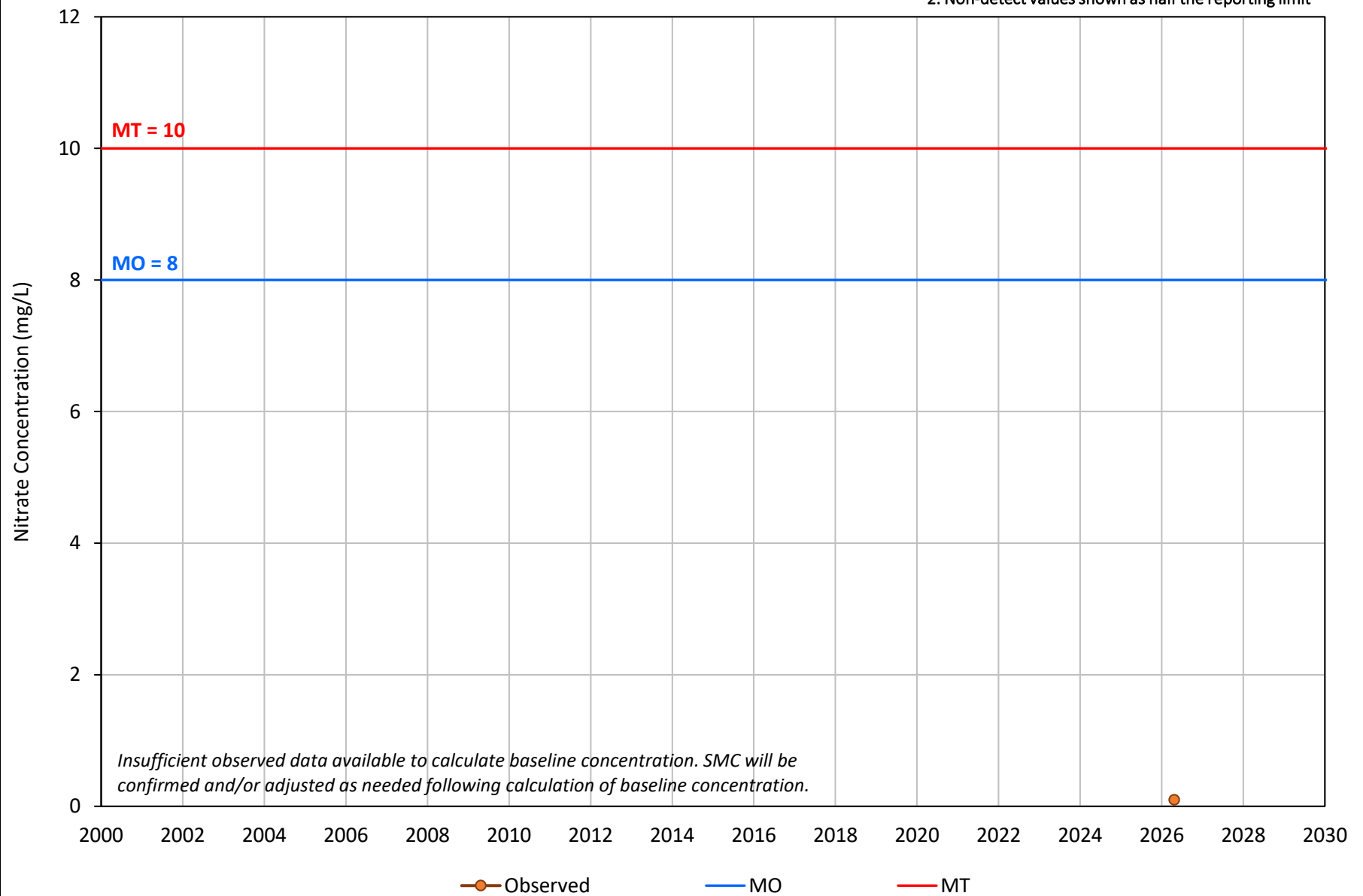
Well Name: Well E

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

2. Non-detect values shown as half the reporting limit

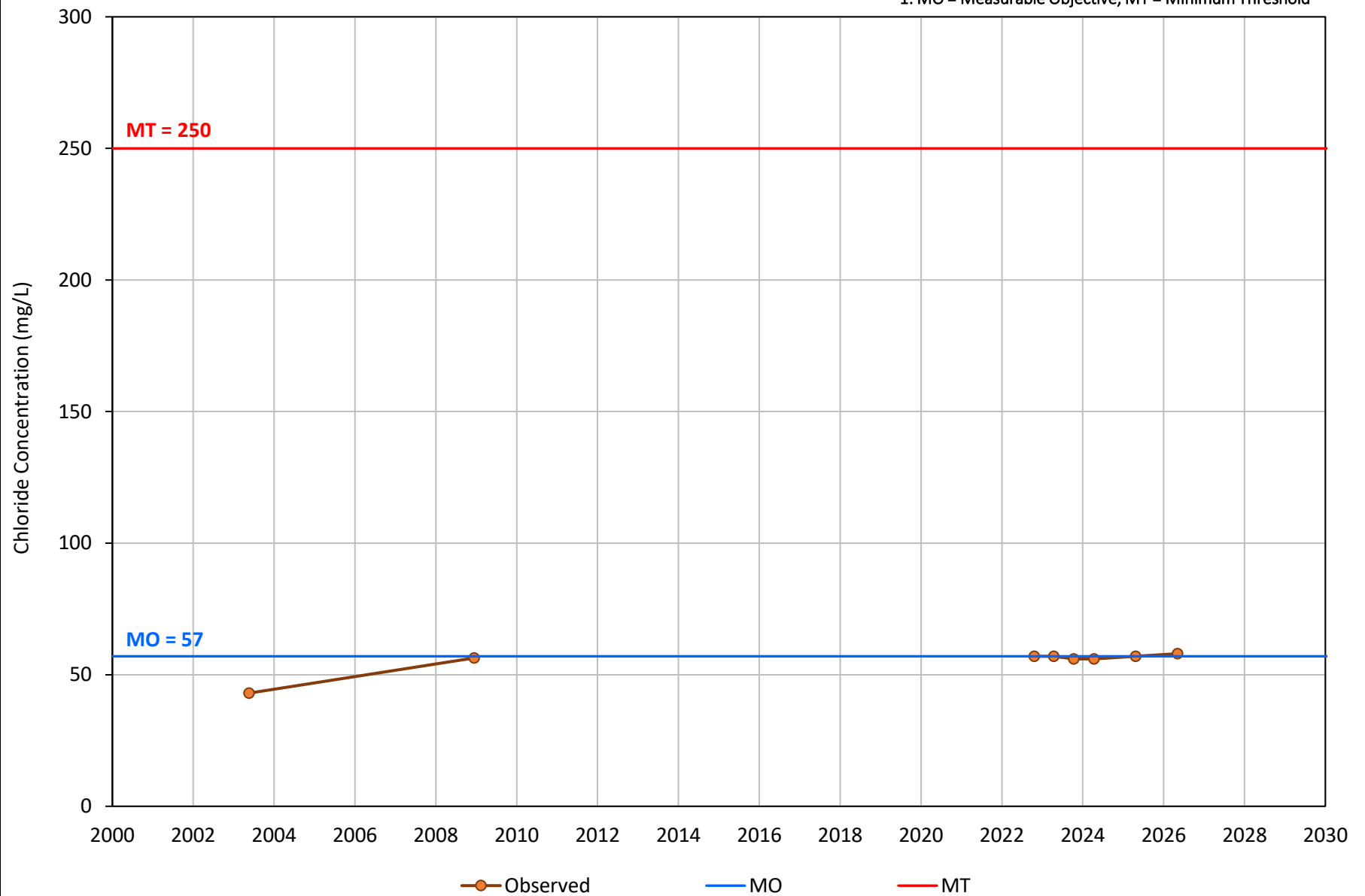


Well Name: MW-5S

Aquifer: Shallow

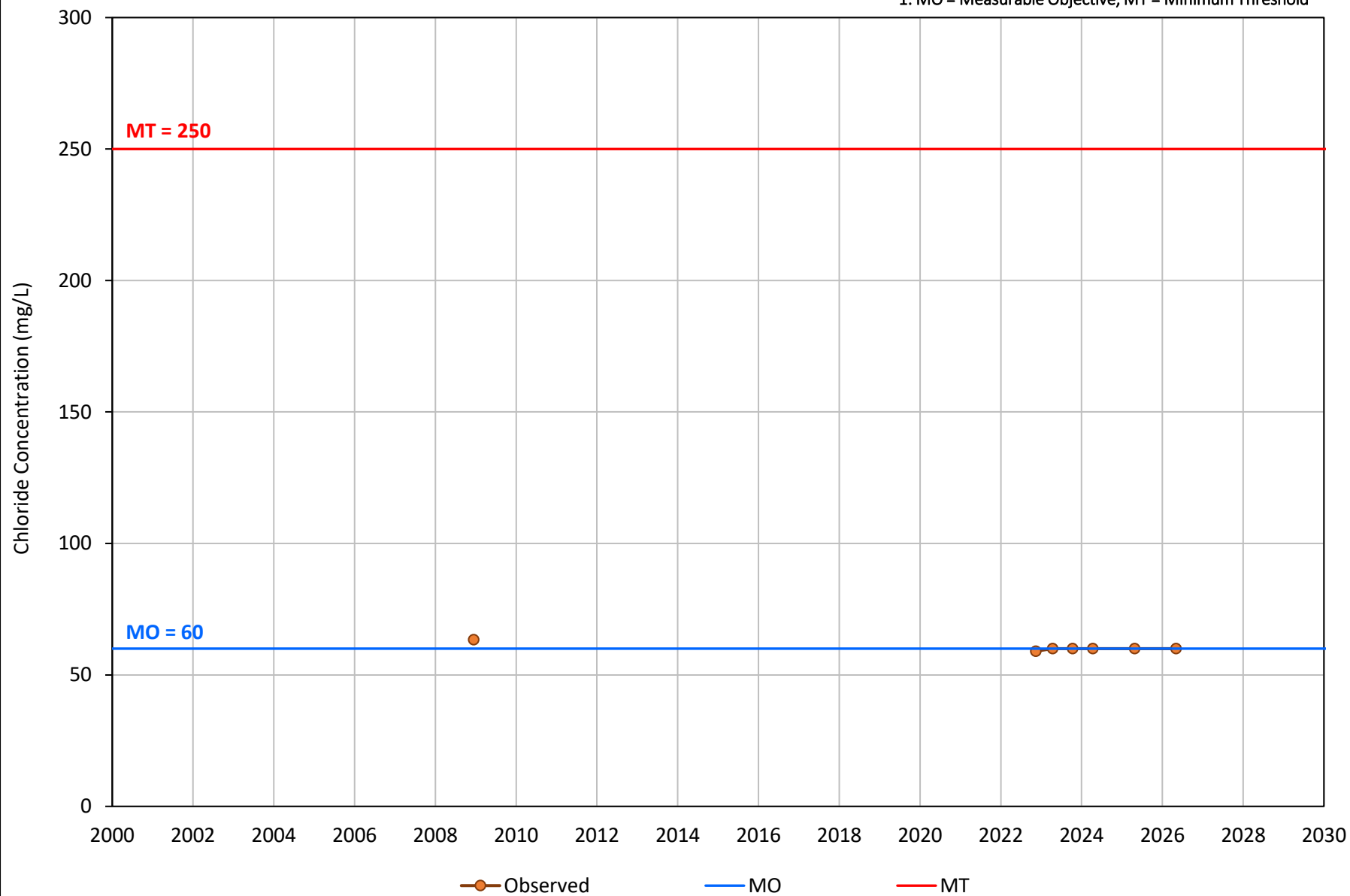
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-5I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

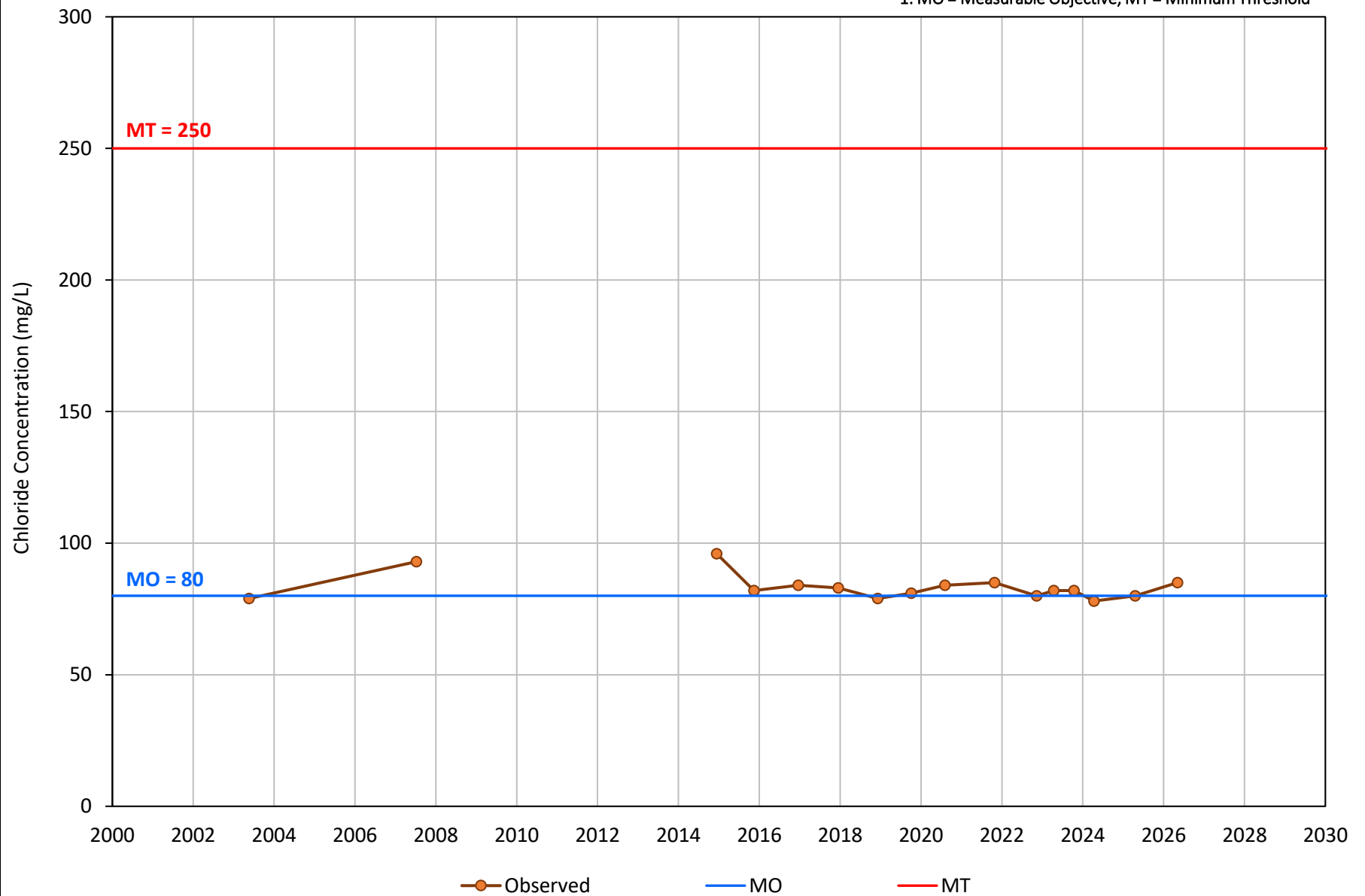


Well Name: MW-5D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

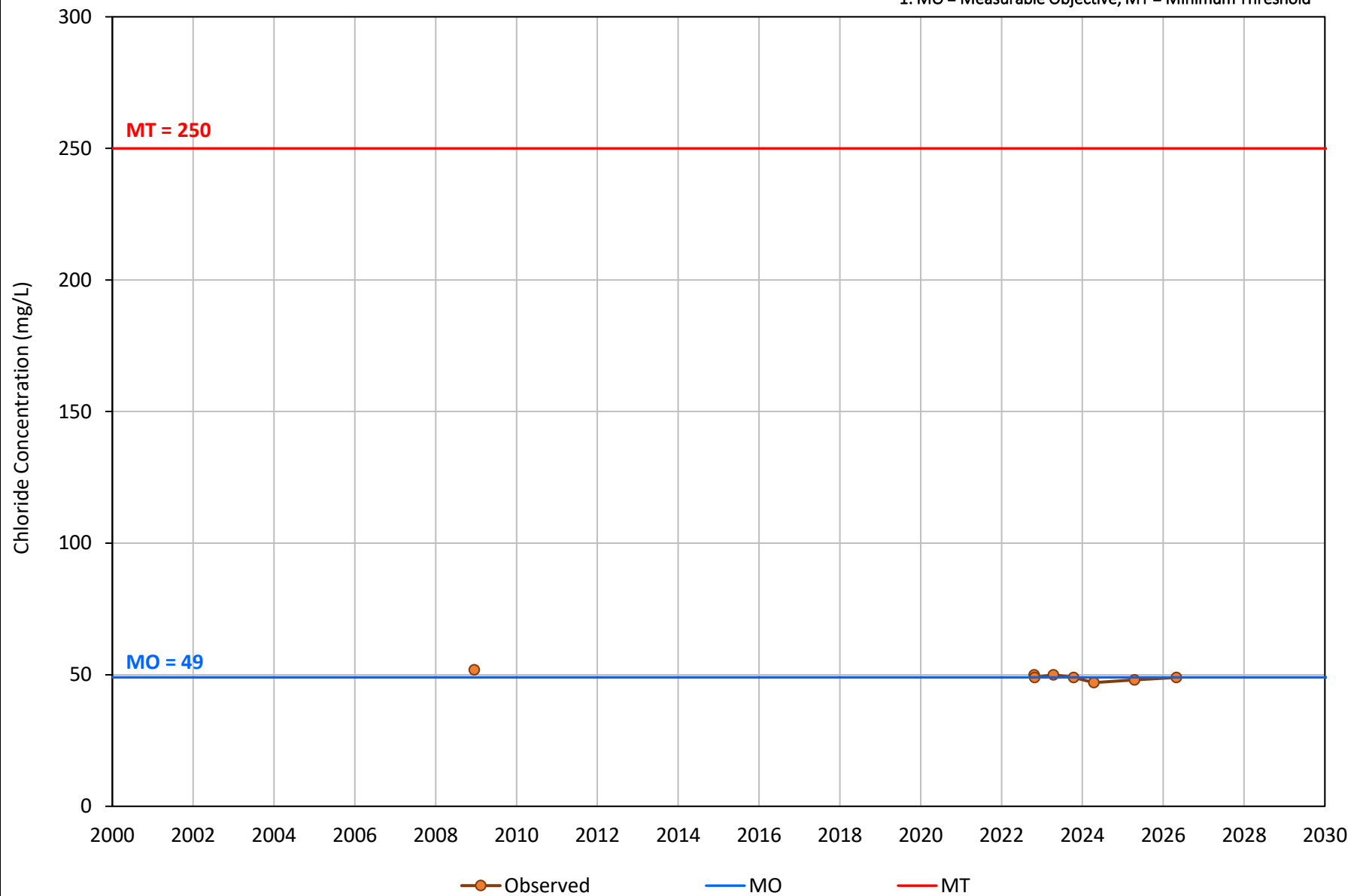


Well Name: MW-9S

Aquifer: Shallow

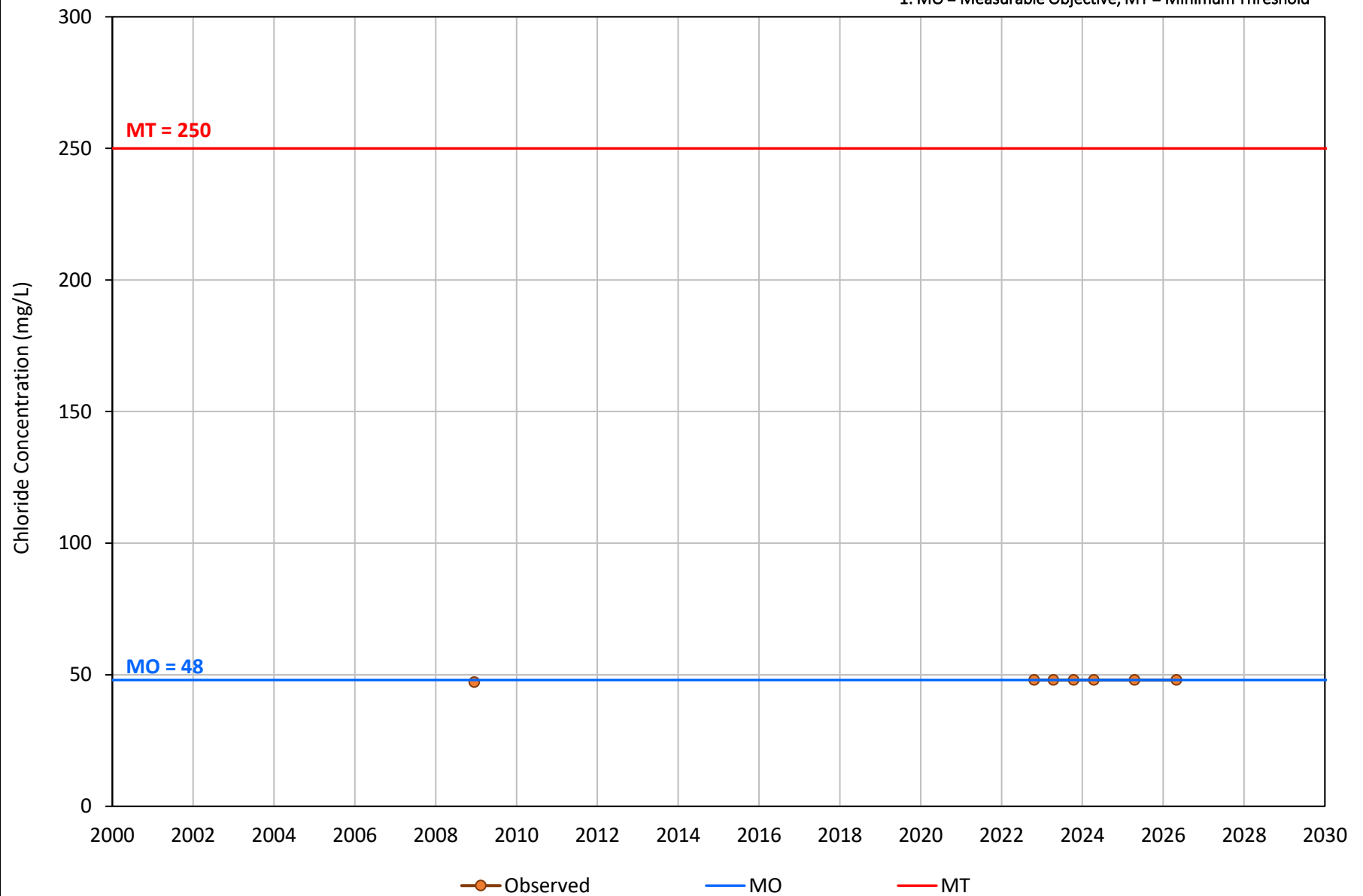
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-9I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

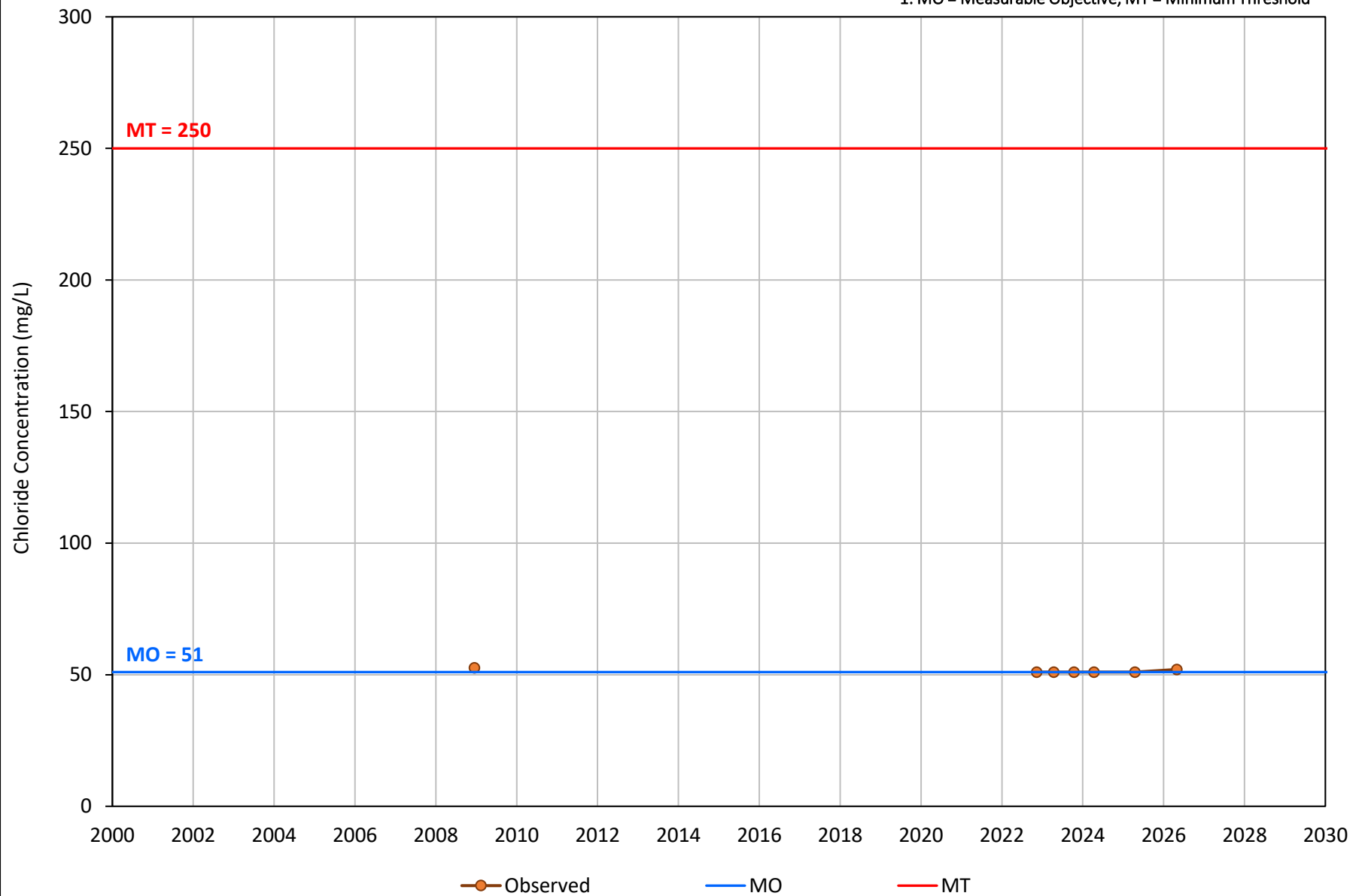


Well Name: MW-9D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

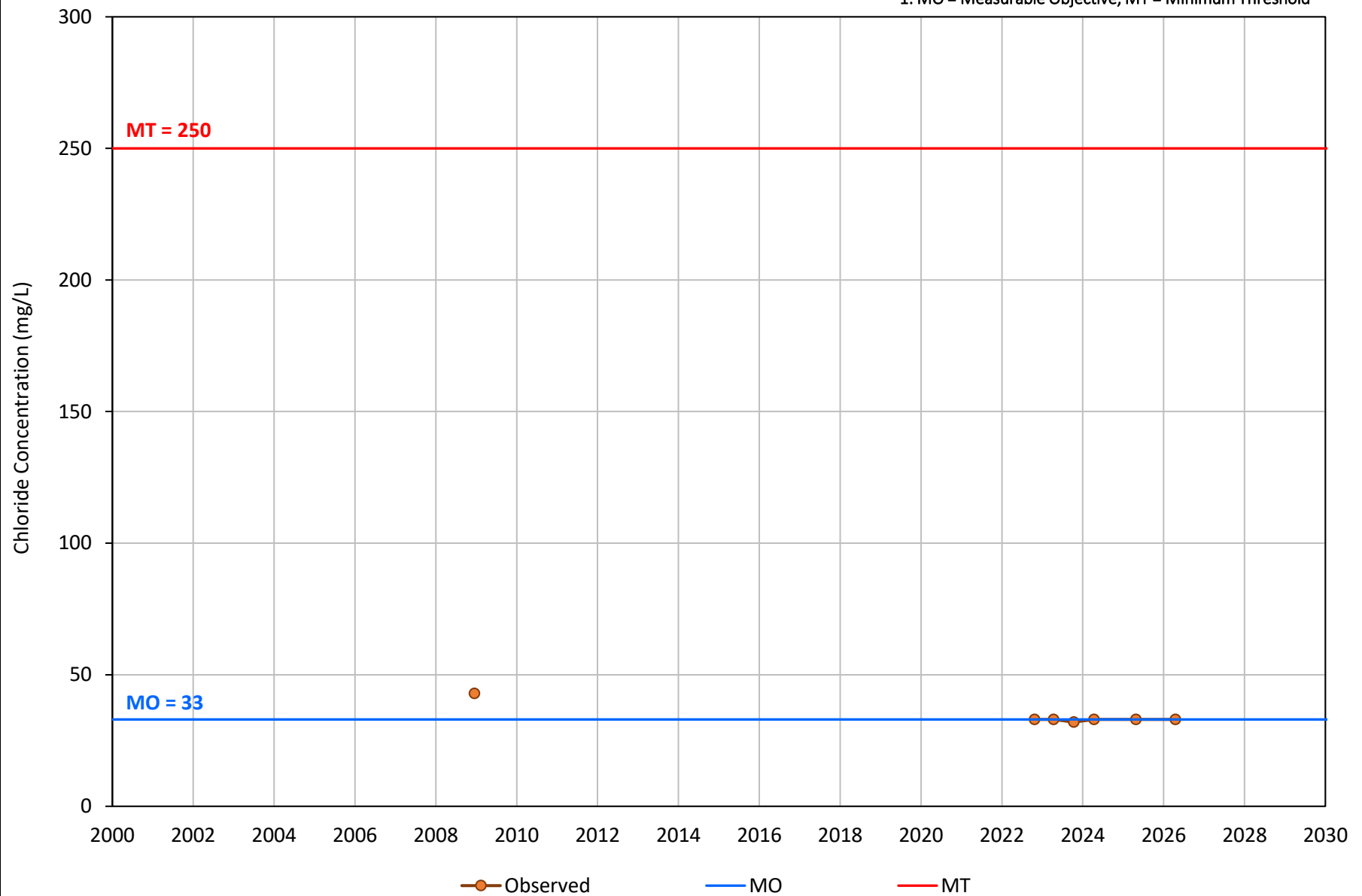


Well Name: MW-10S

Aquifer: Shallow

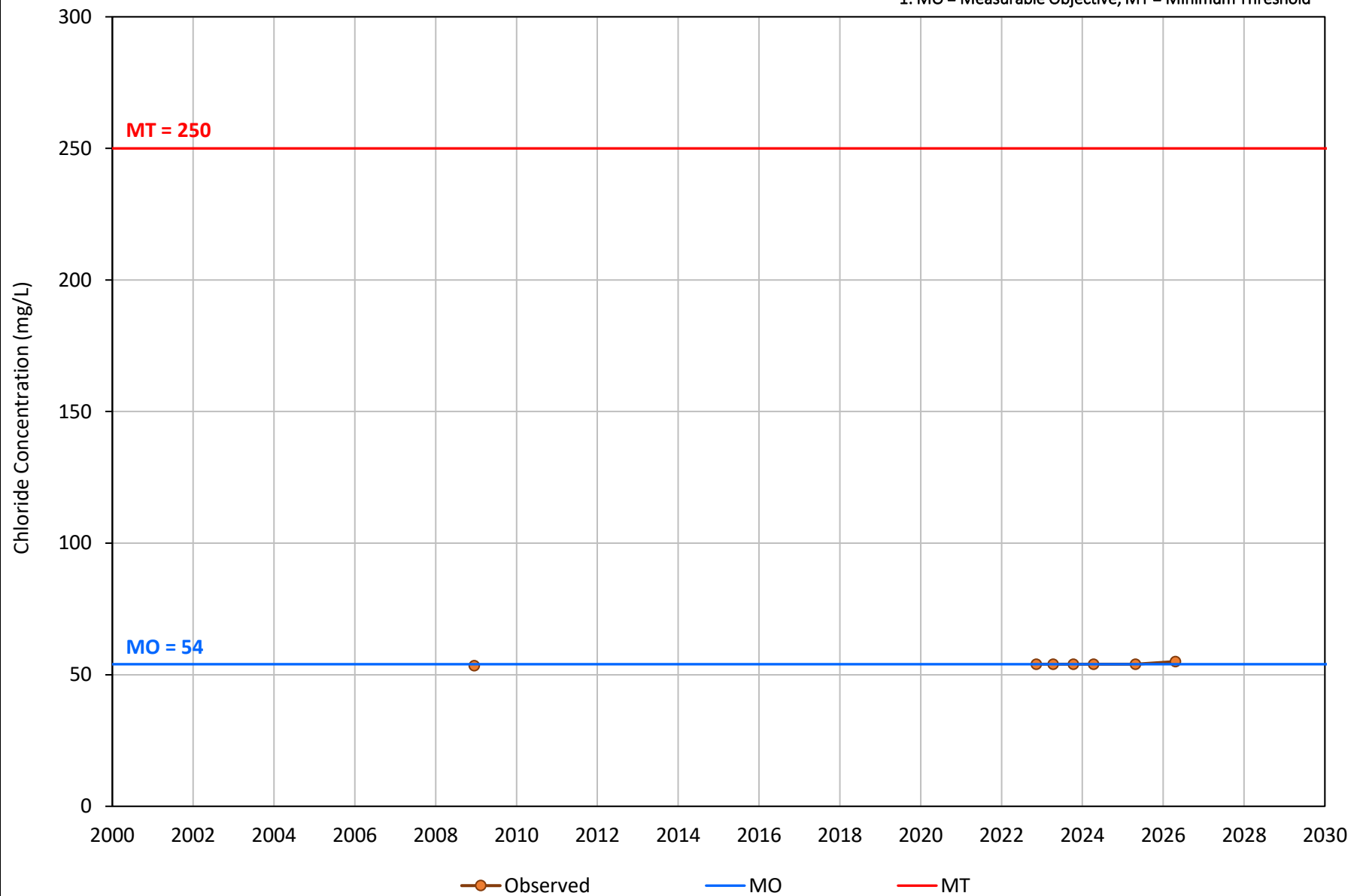
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-10I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

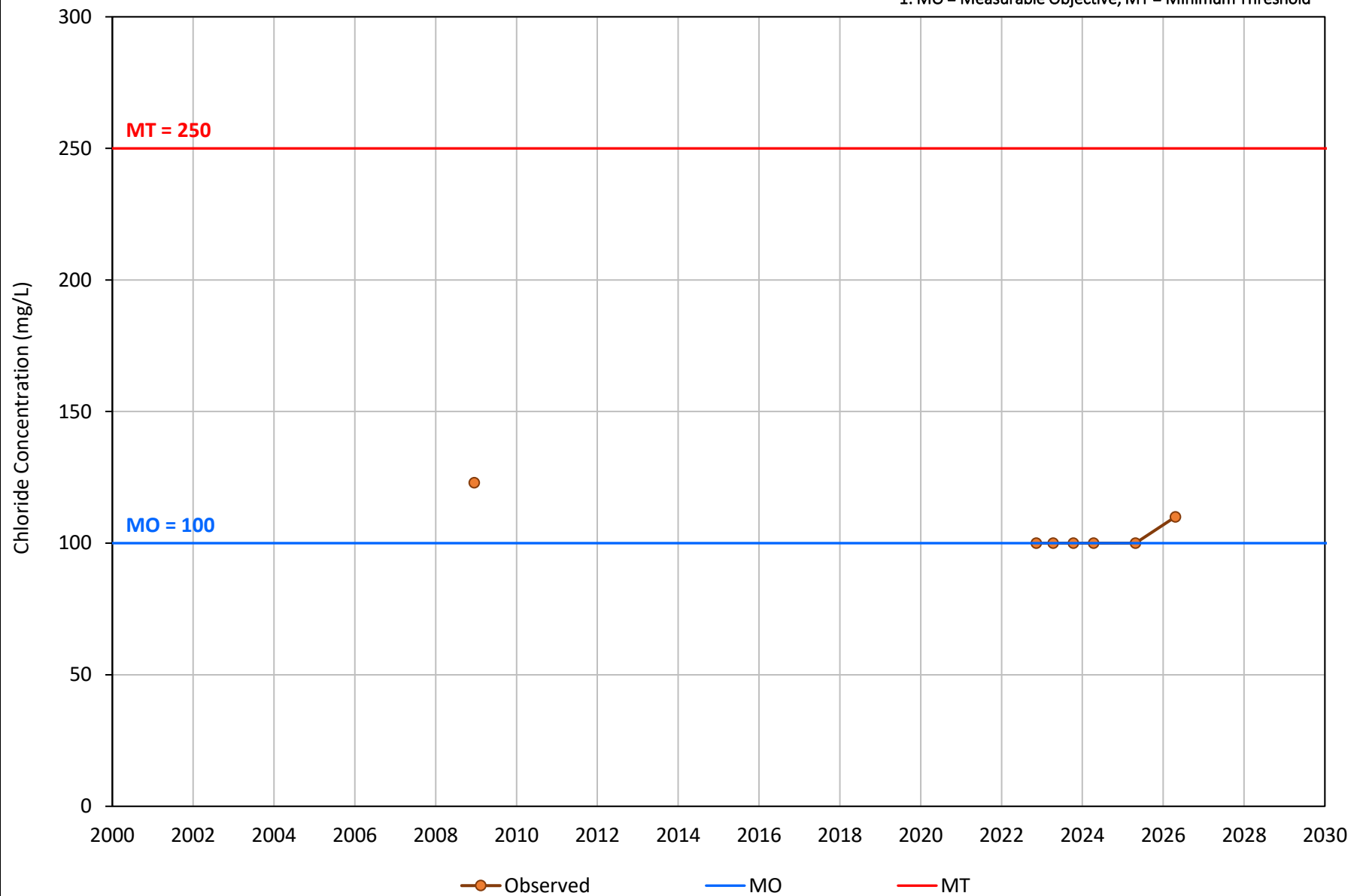


Well Name: MW-10D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

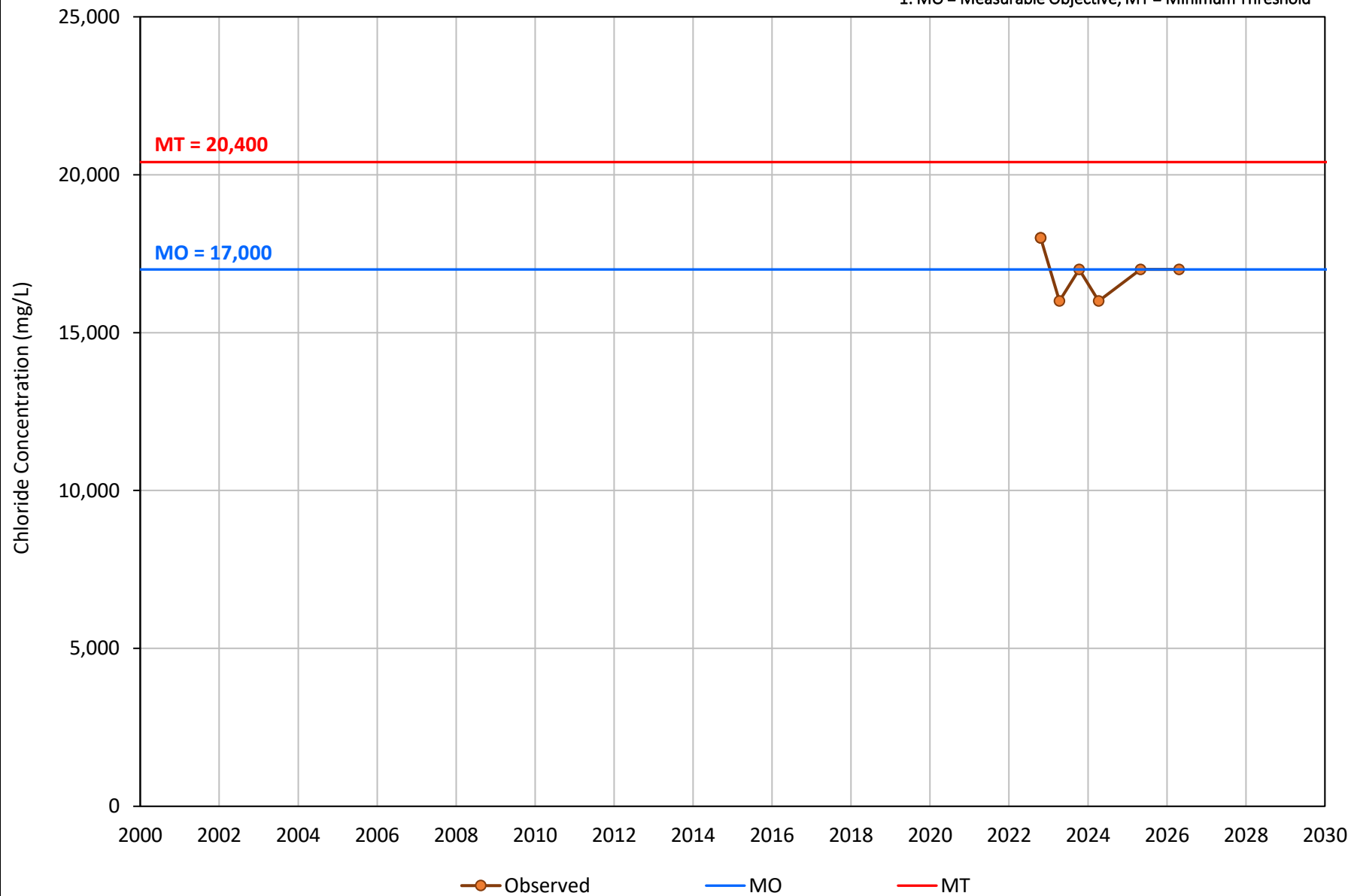


Well Name: S2-MWS1

Aquifer: Shallow

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

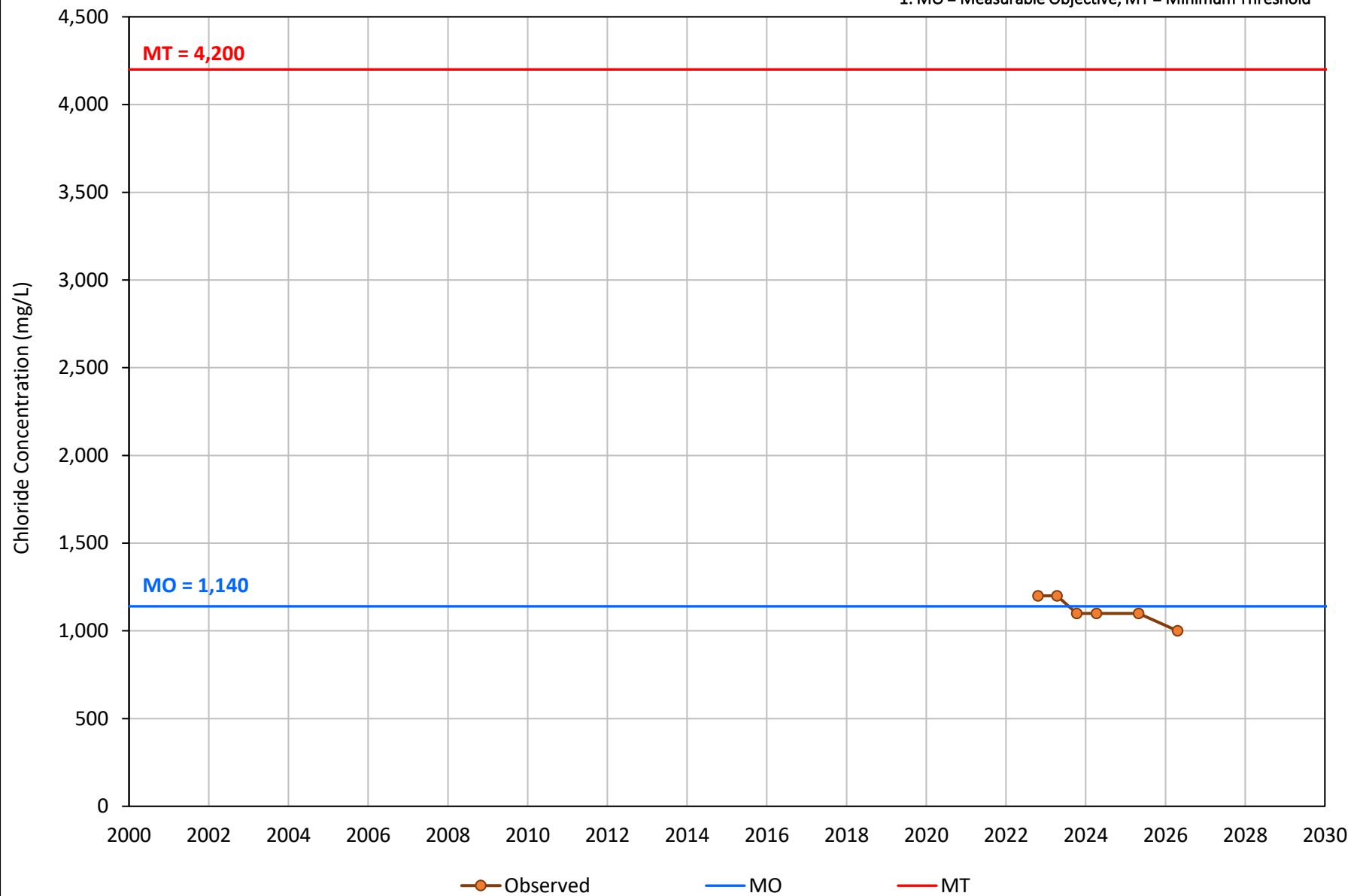


Well Name: S2-MWS2

Aquifer: Shallow

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

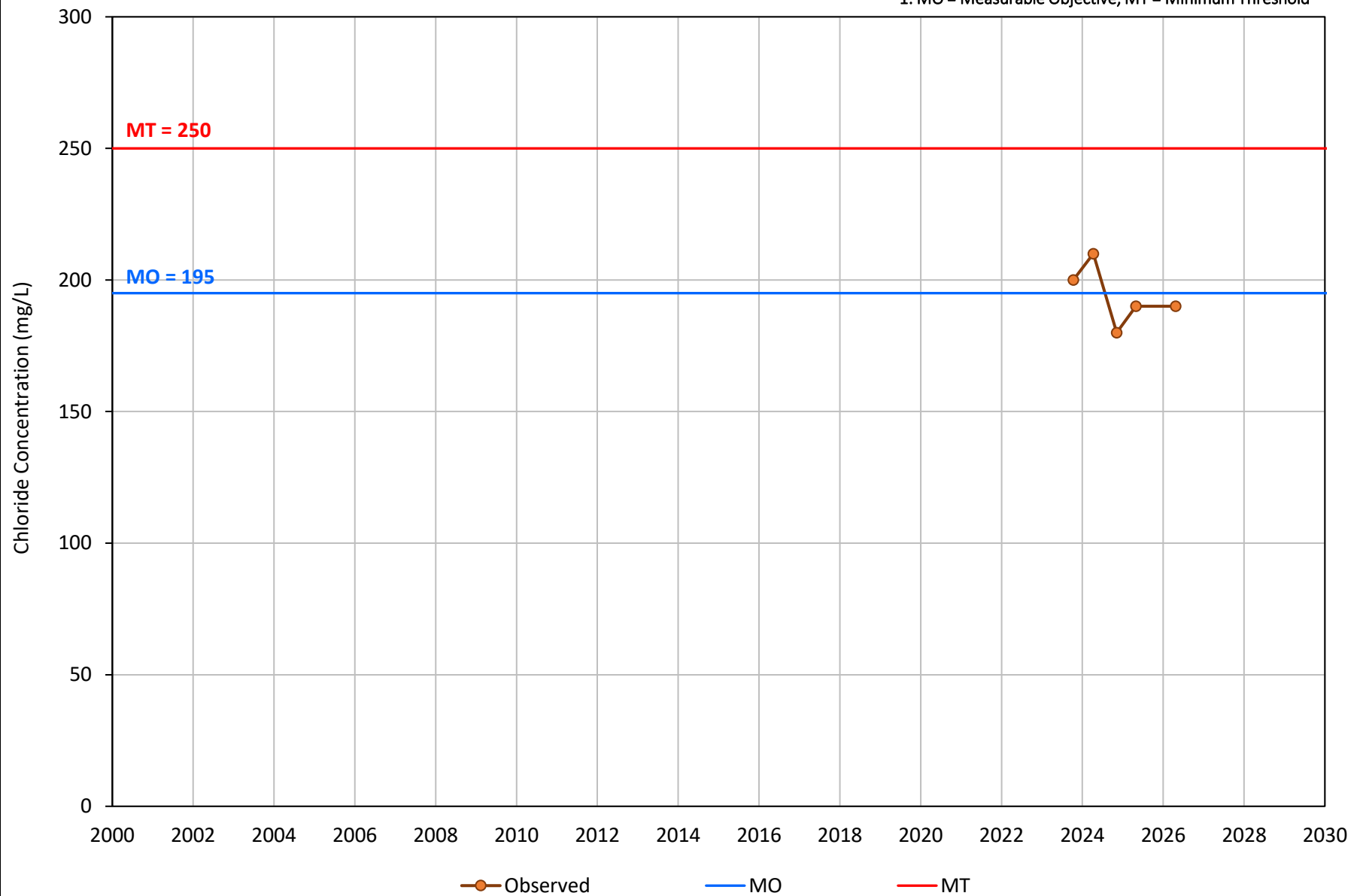


Well Name: S2-MWD1

Aquifer: Deep

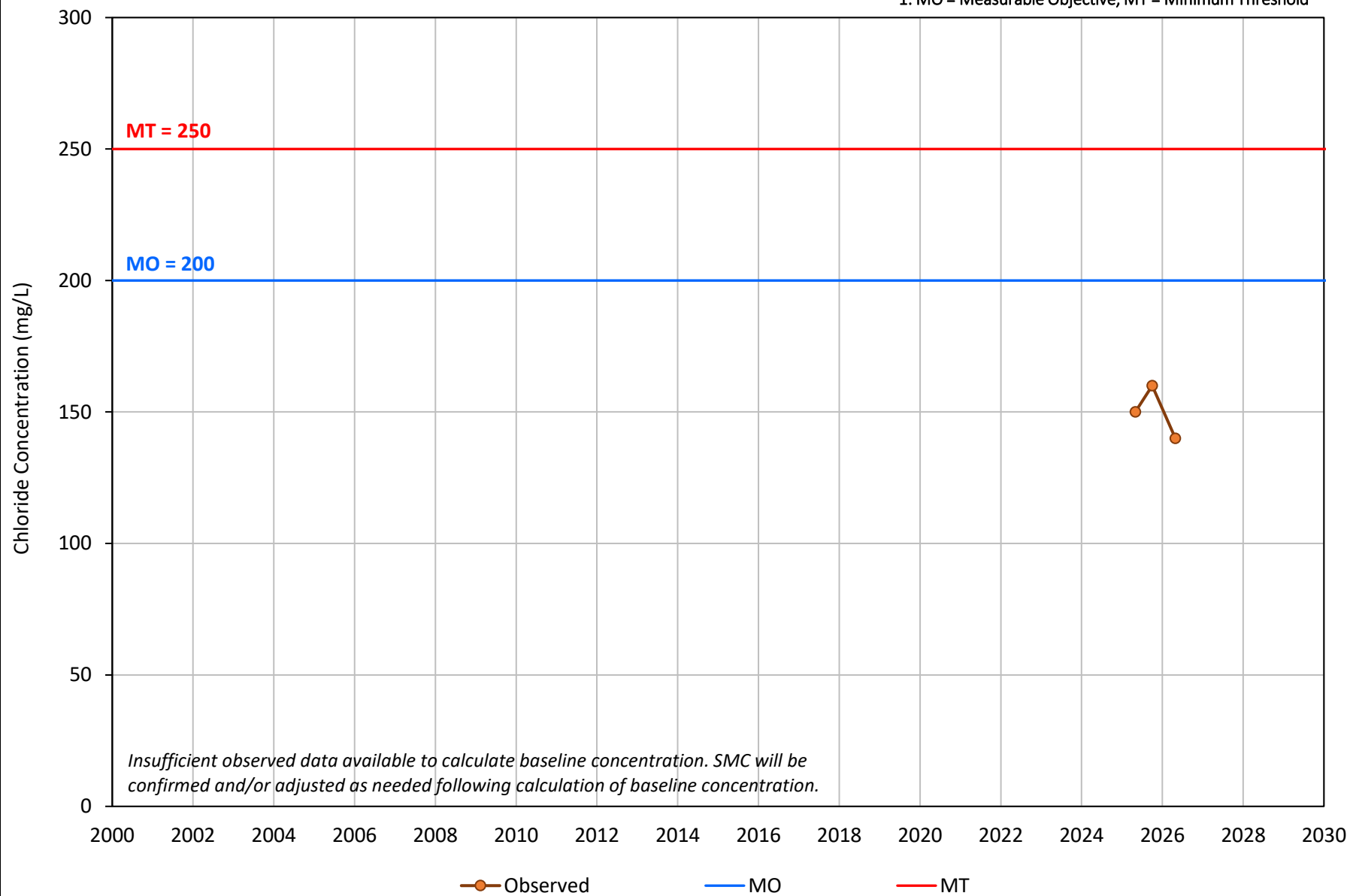
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-N1I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

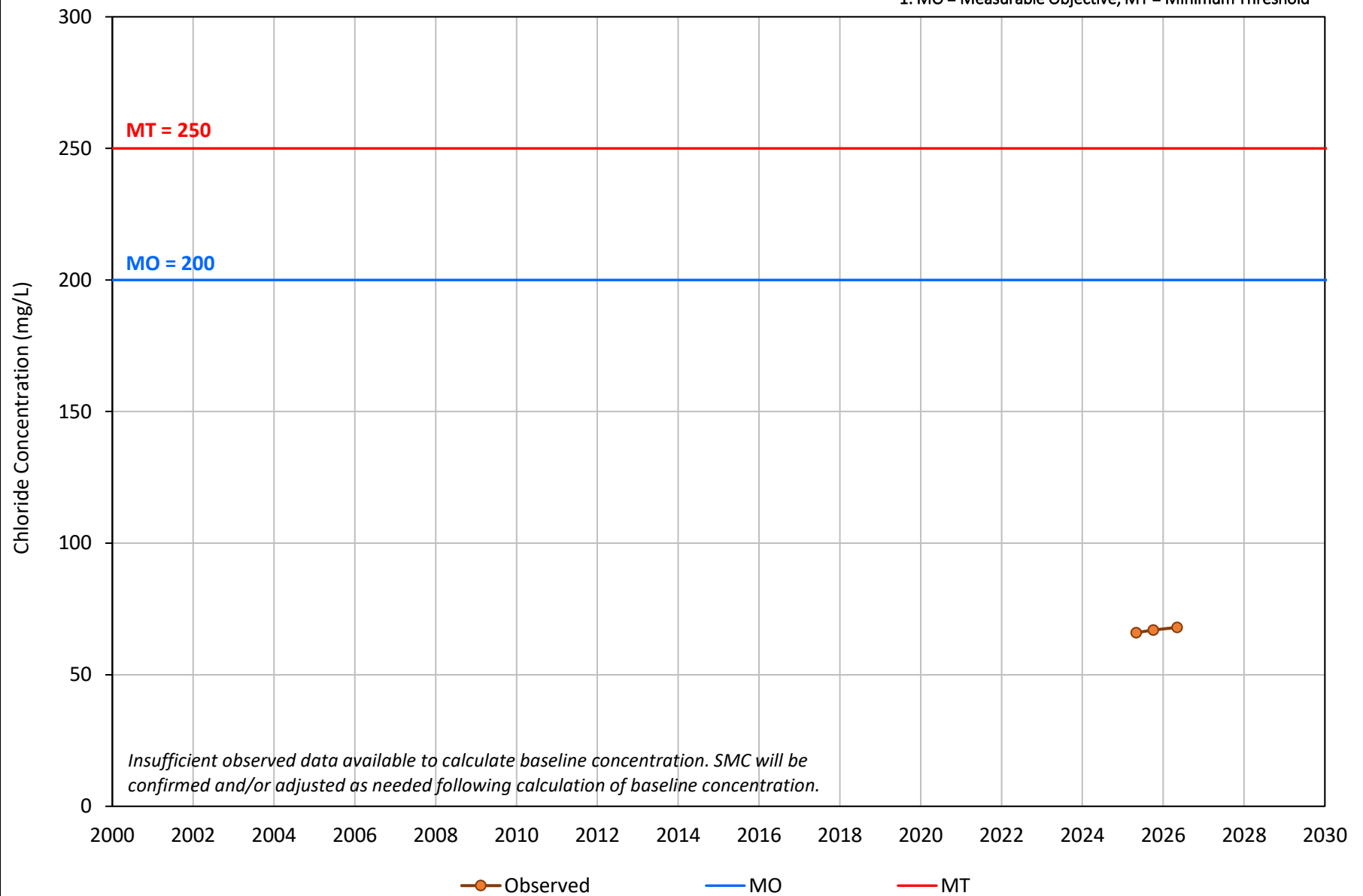


Well Name: MW-N3S

Aquifer: Shallow

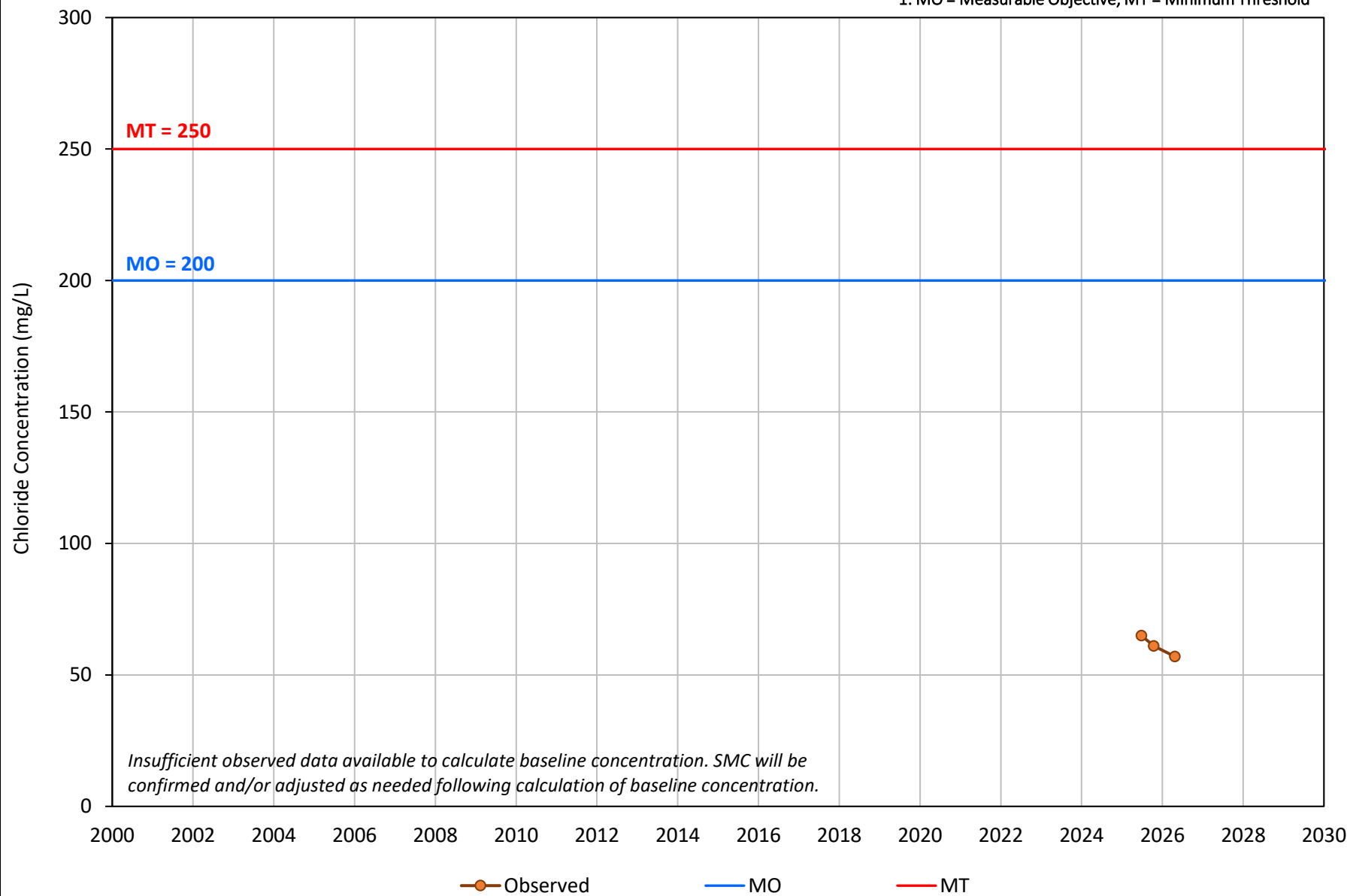
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-S2I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

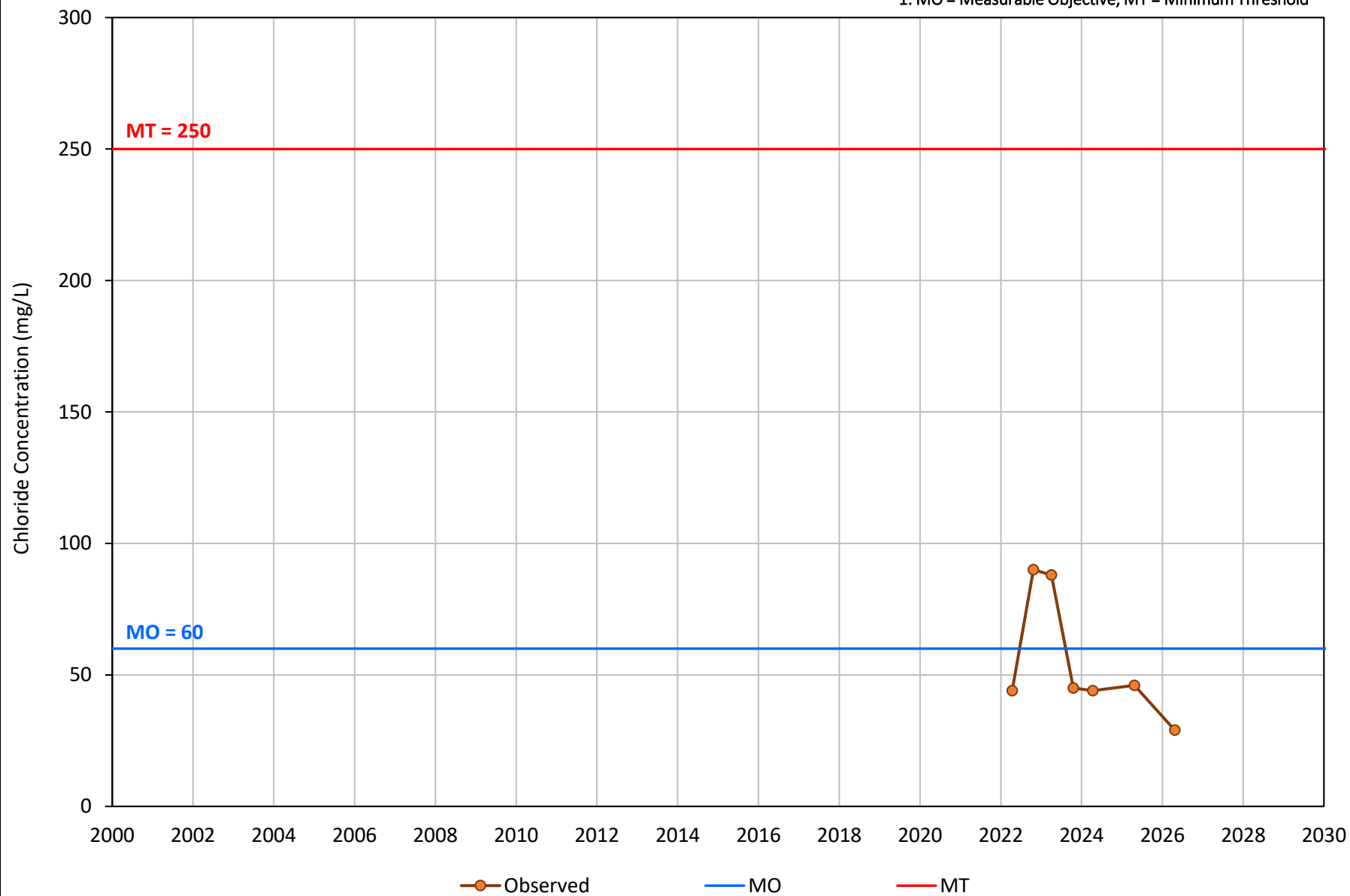


Well Name: Well D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

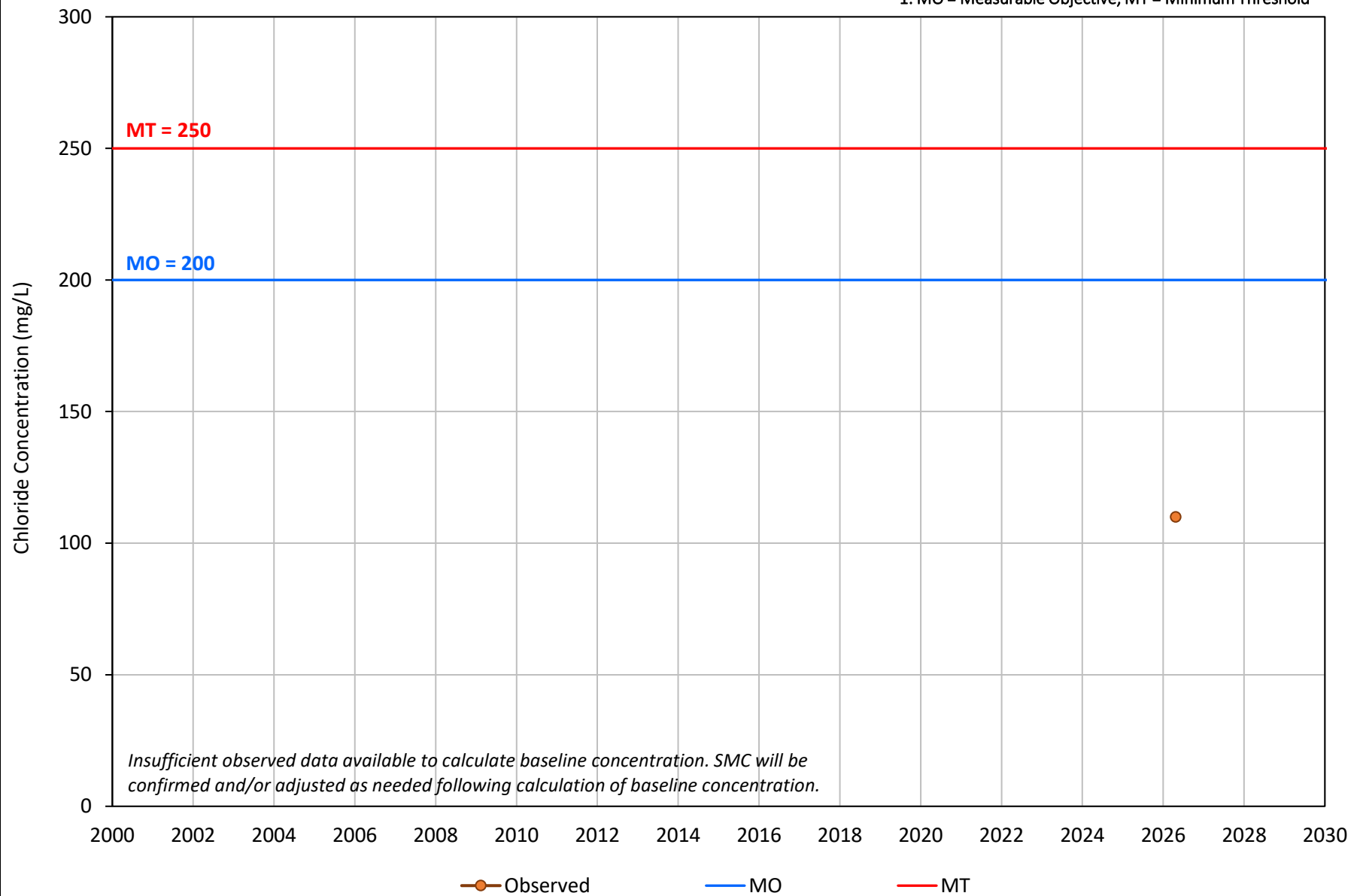


Well Name: Well E

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

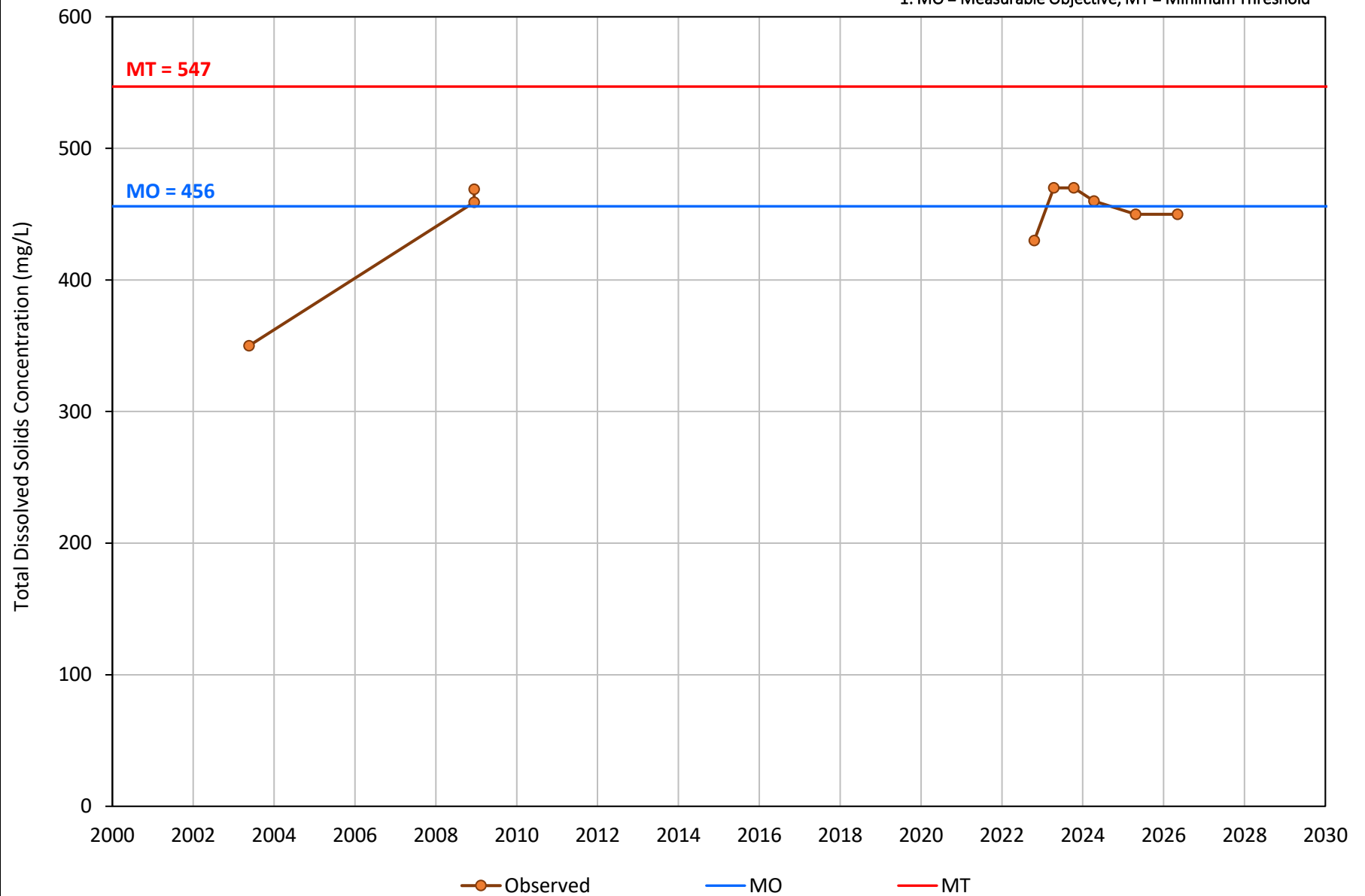


Well Name: MW-5S

Aquifer: Shallow

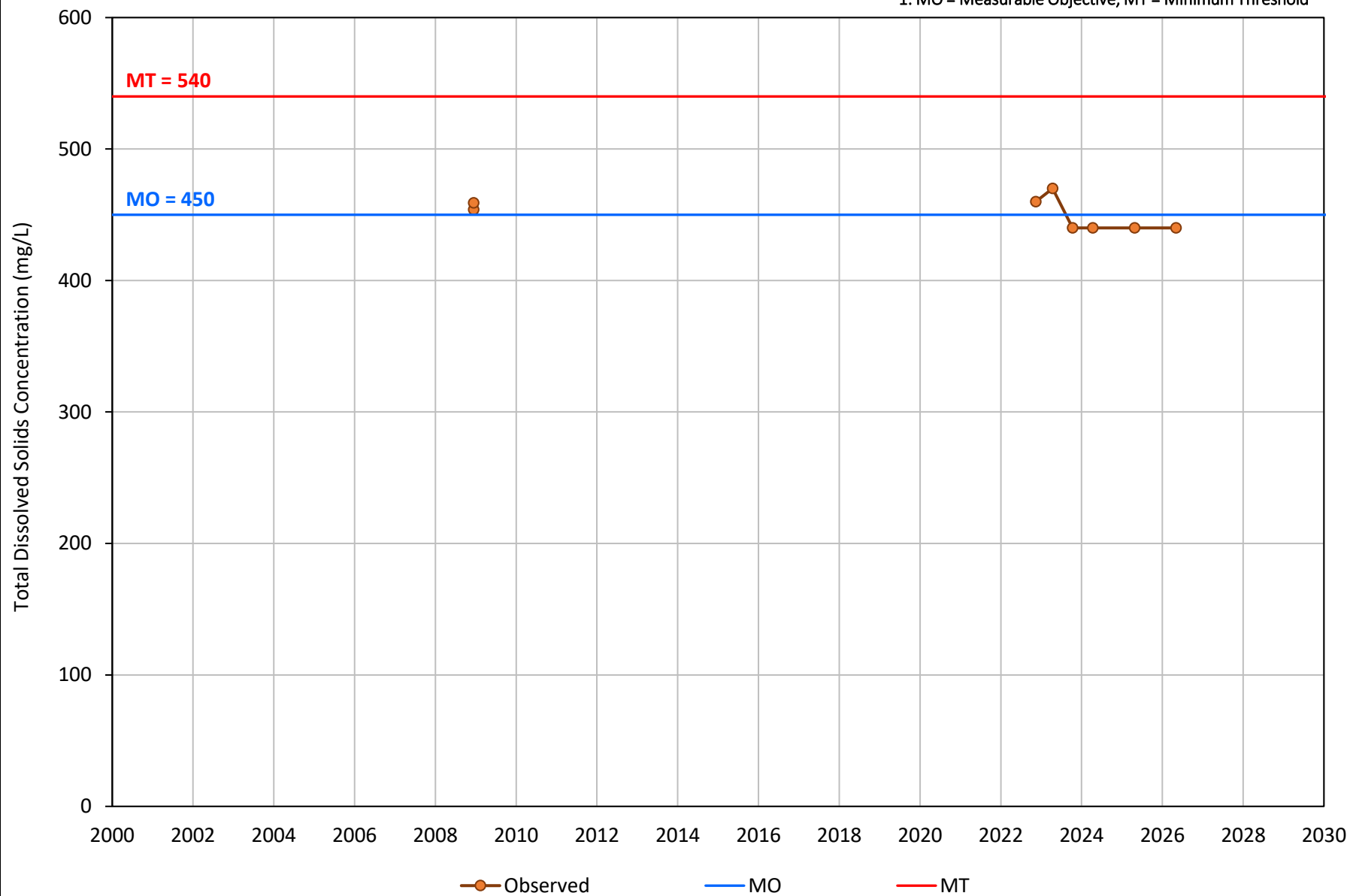
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-5I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

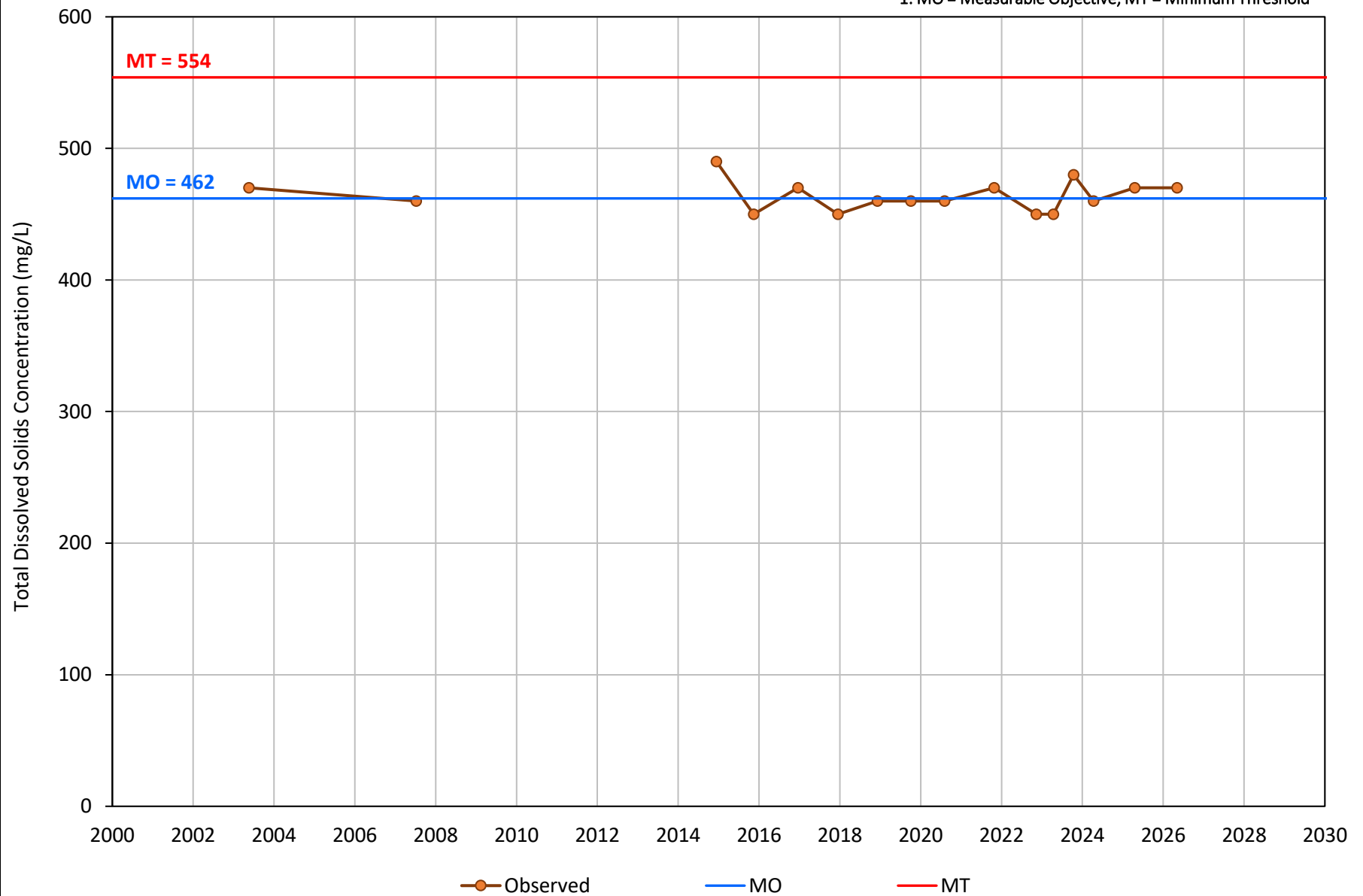


Well Name: MW-5D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

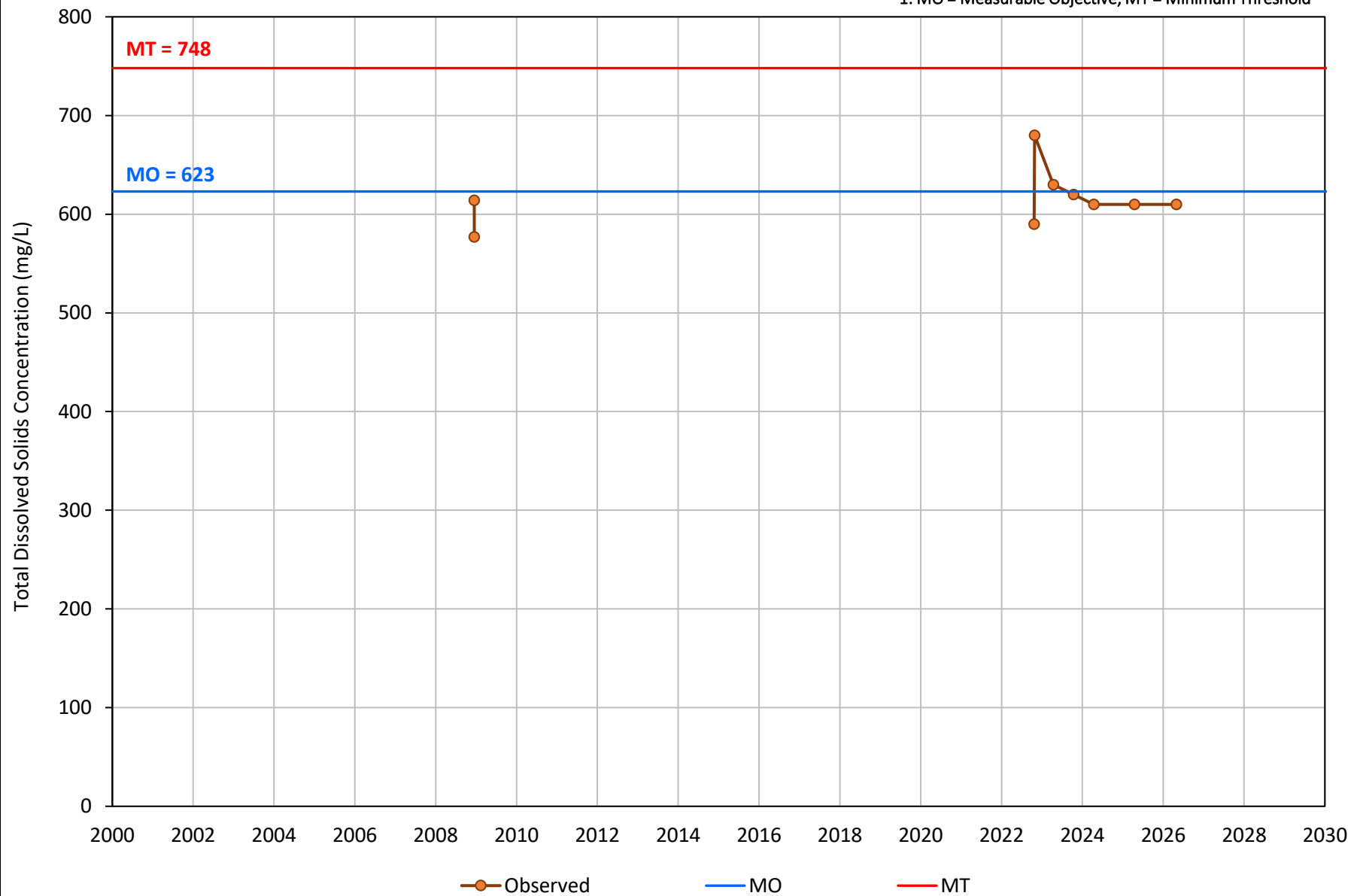


Well Name: MW-9S

Aquifer: Shallow

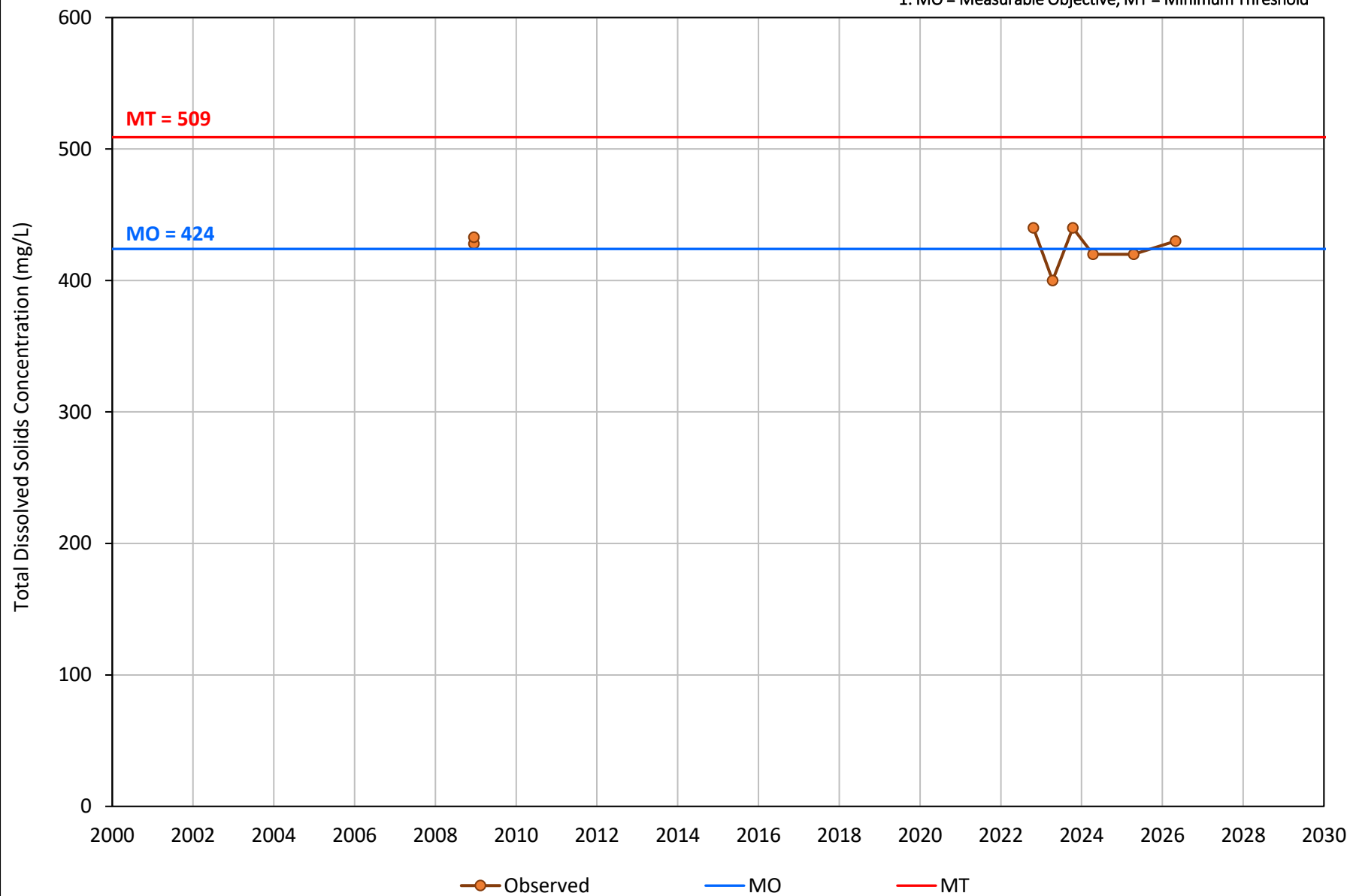
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-9I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

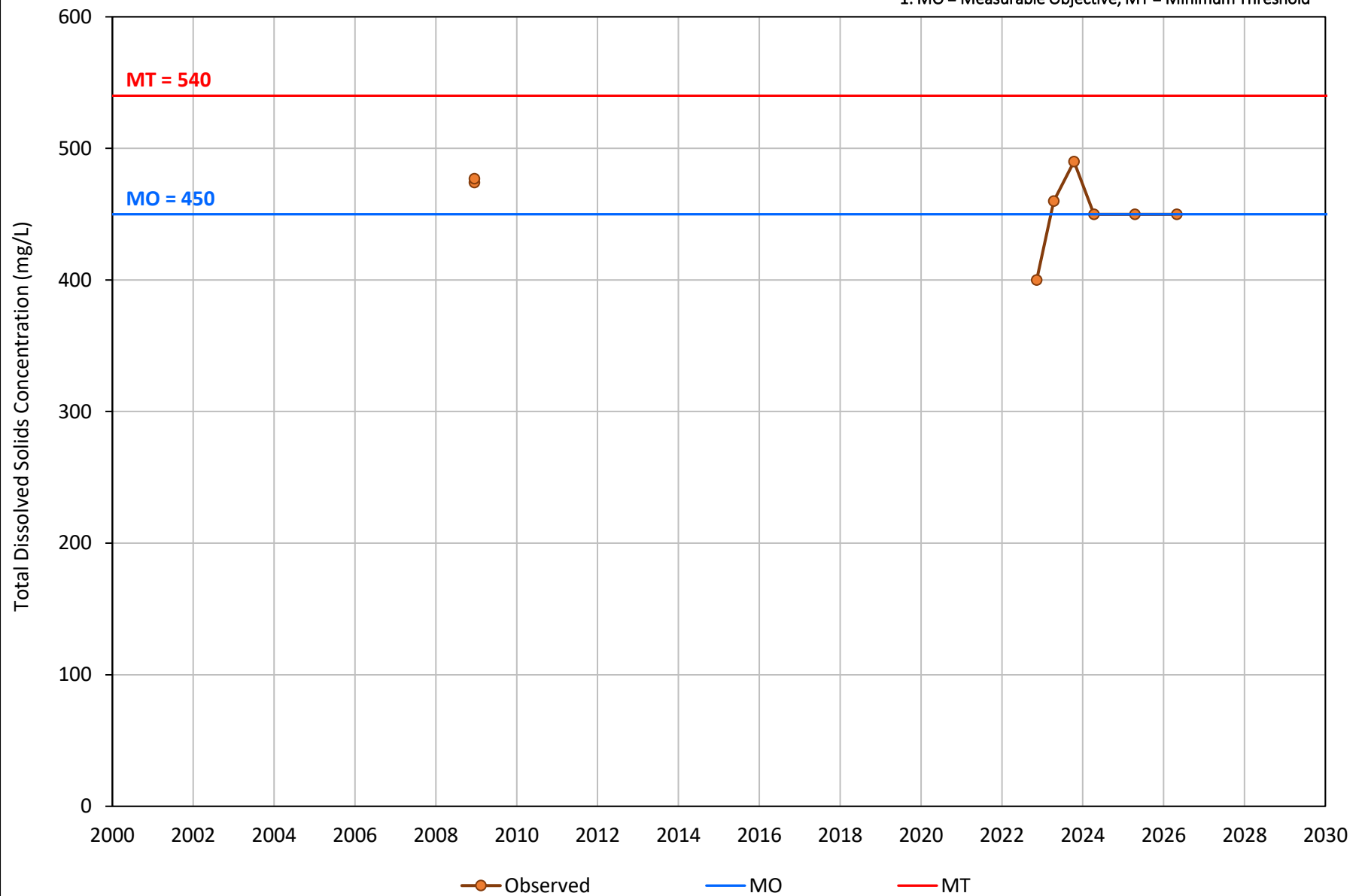


Well Name: MW-9D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

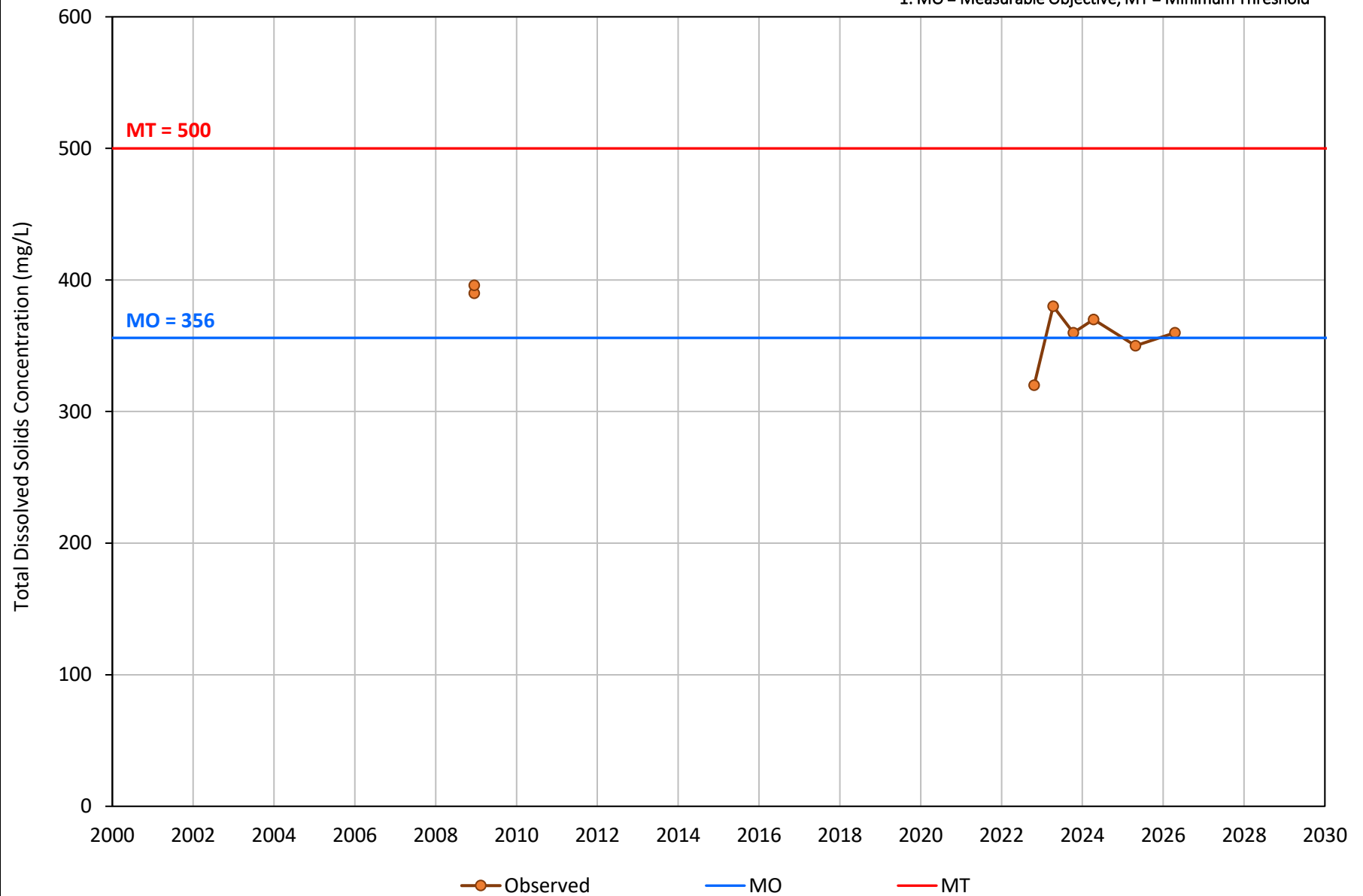


Well Name: MW-10S

Aquifer: Shallow

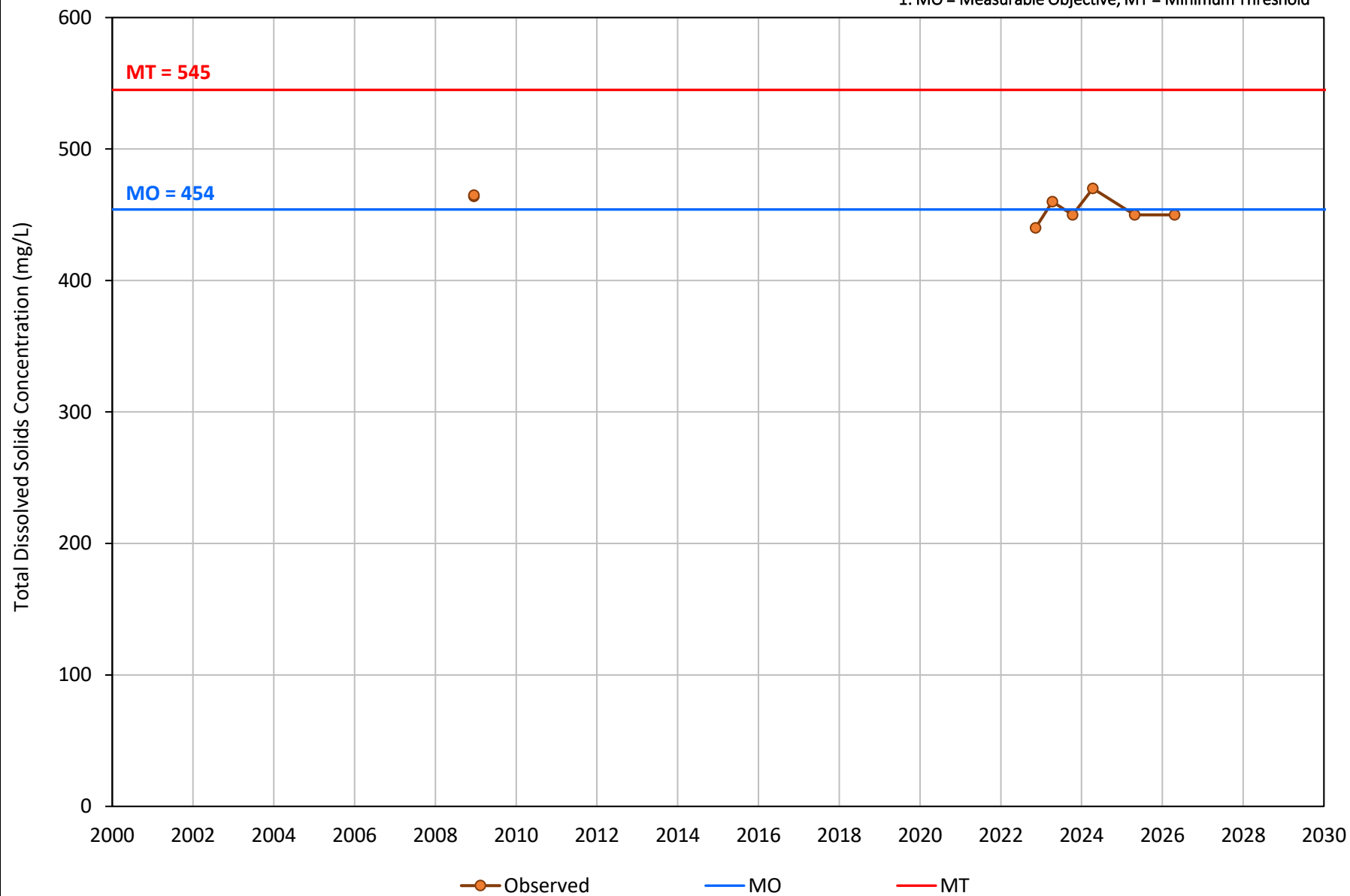
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-10I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

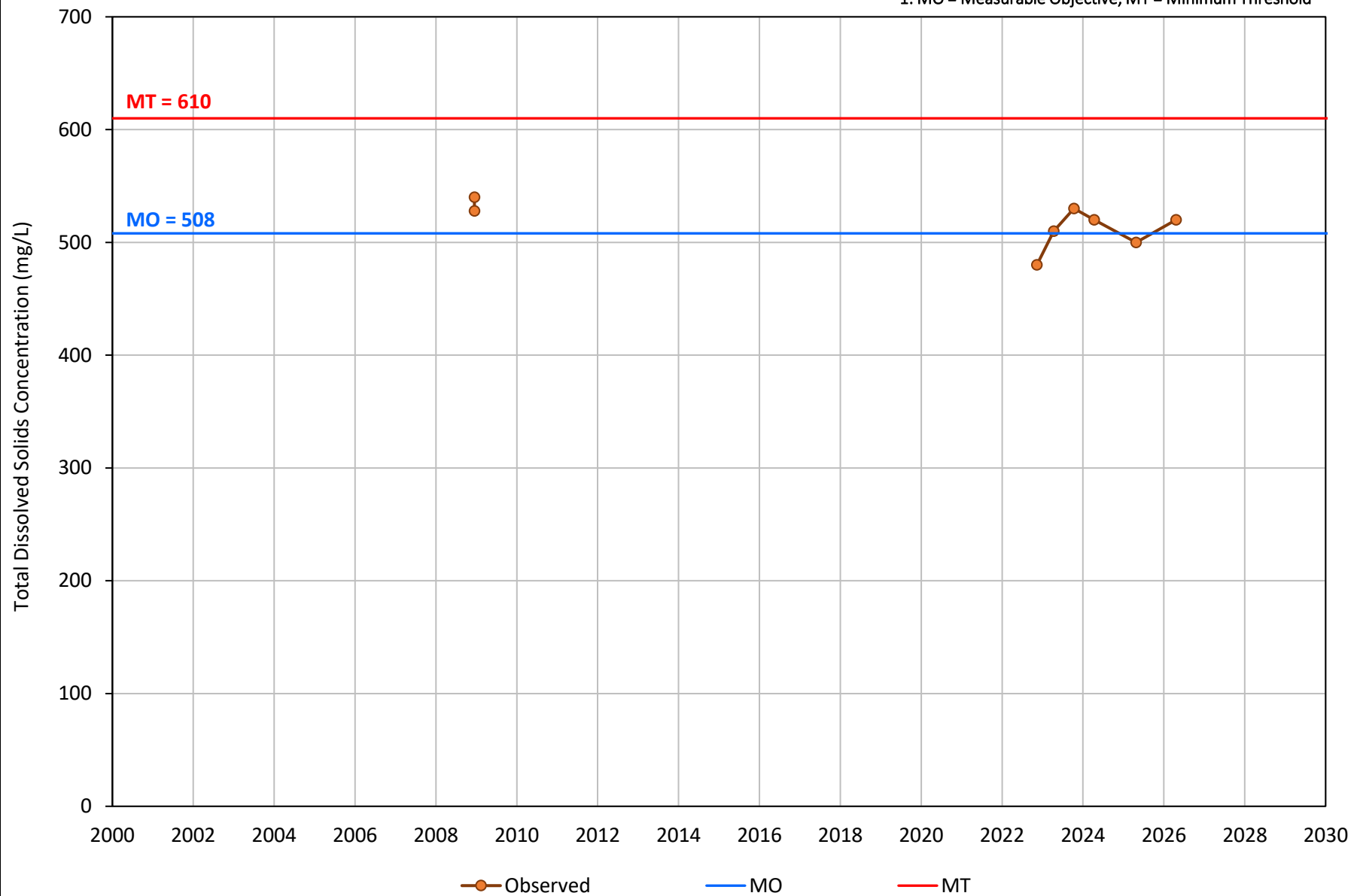


Well Name: MW-10D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

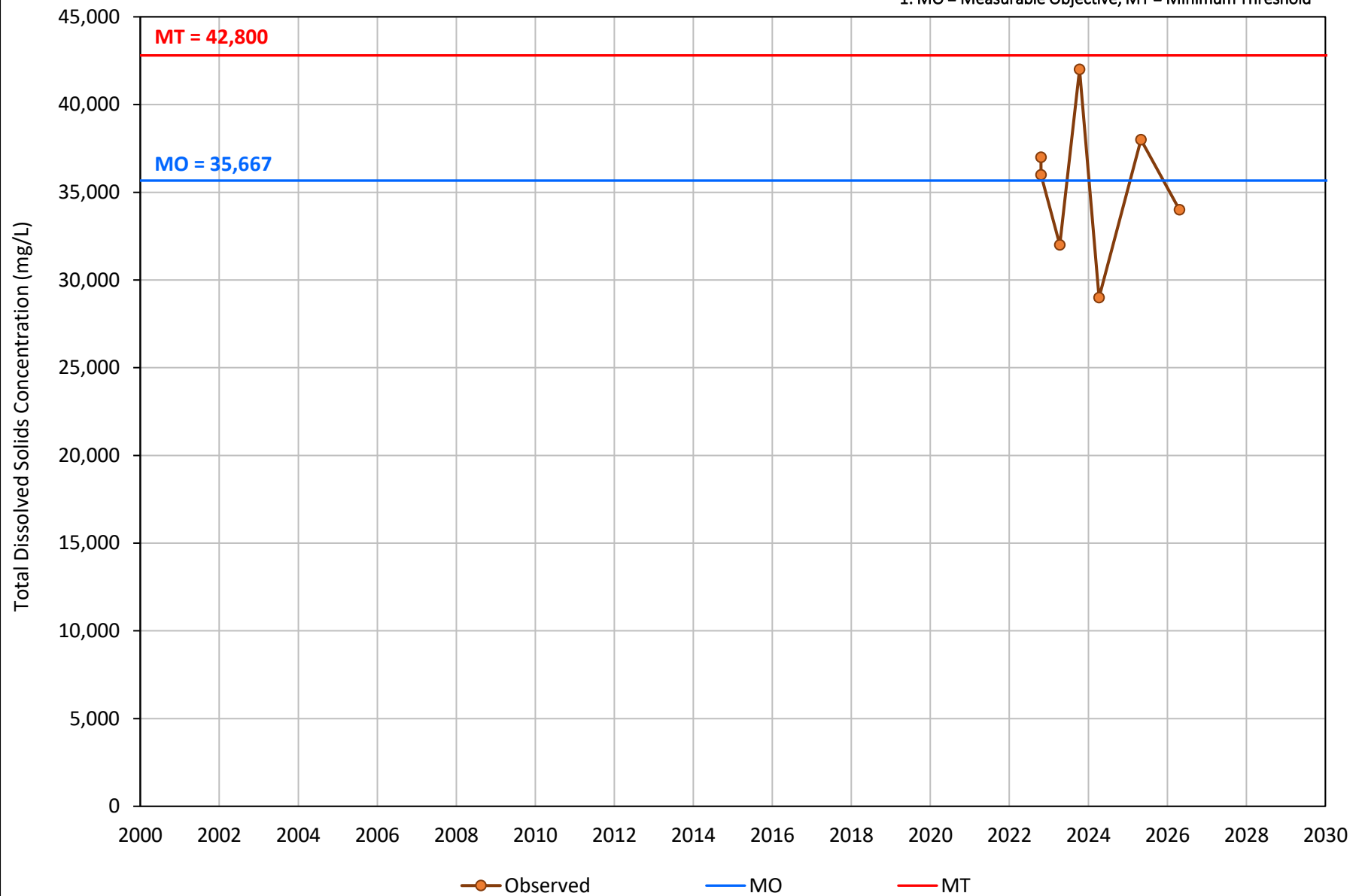


Well Name: S2-MWS1

Aquifer: Shallow

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

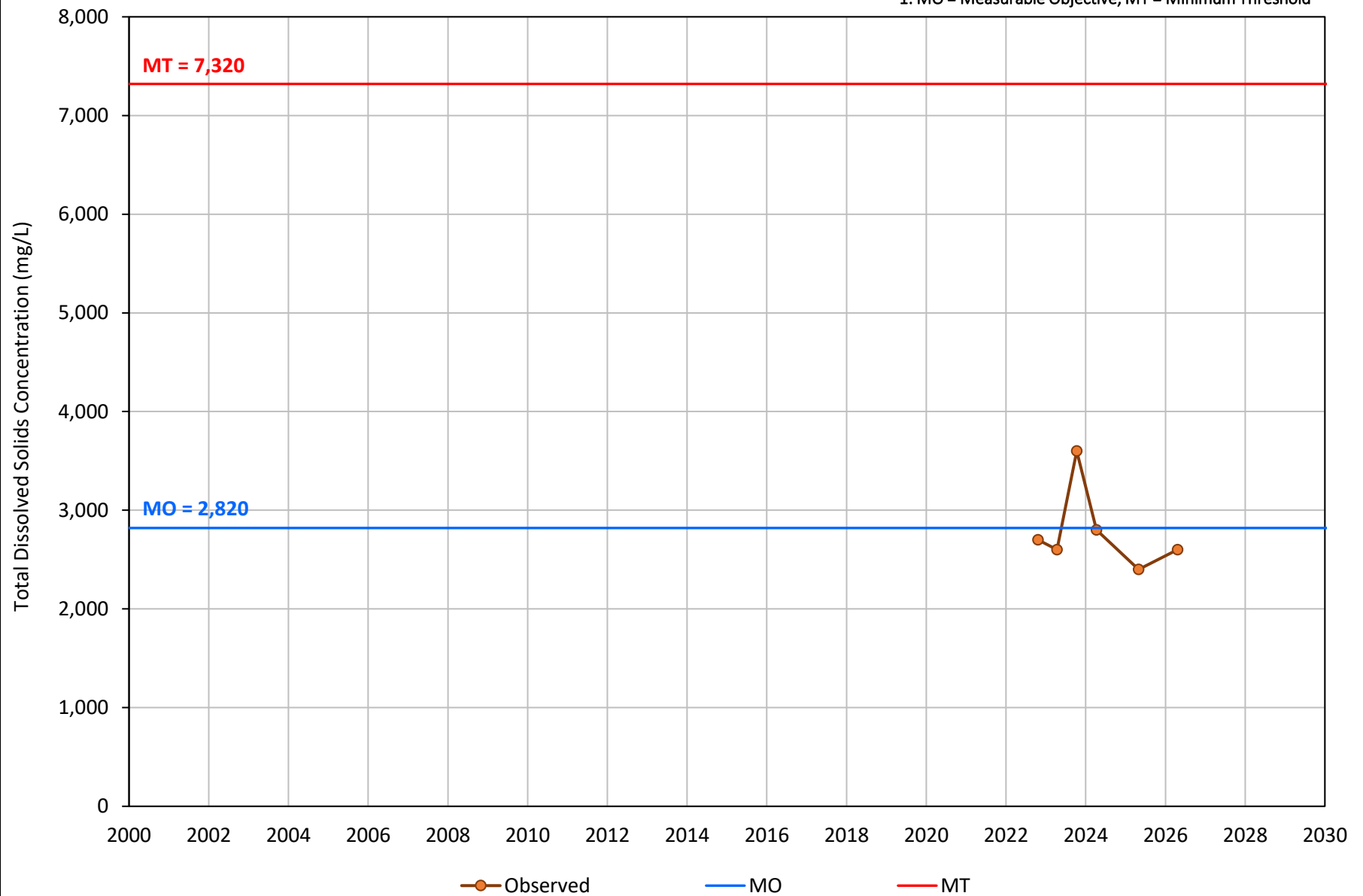


Well Name: S2-MWS2

Aquifer: Shallow

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

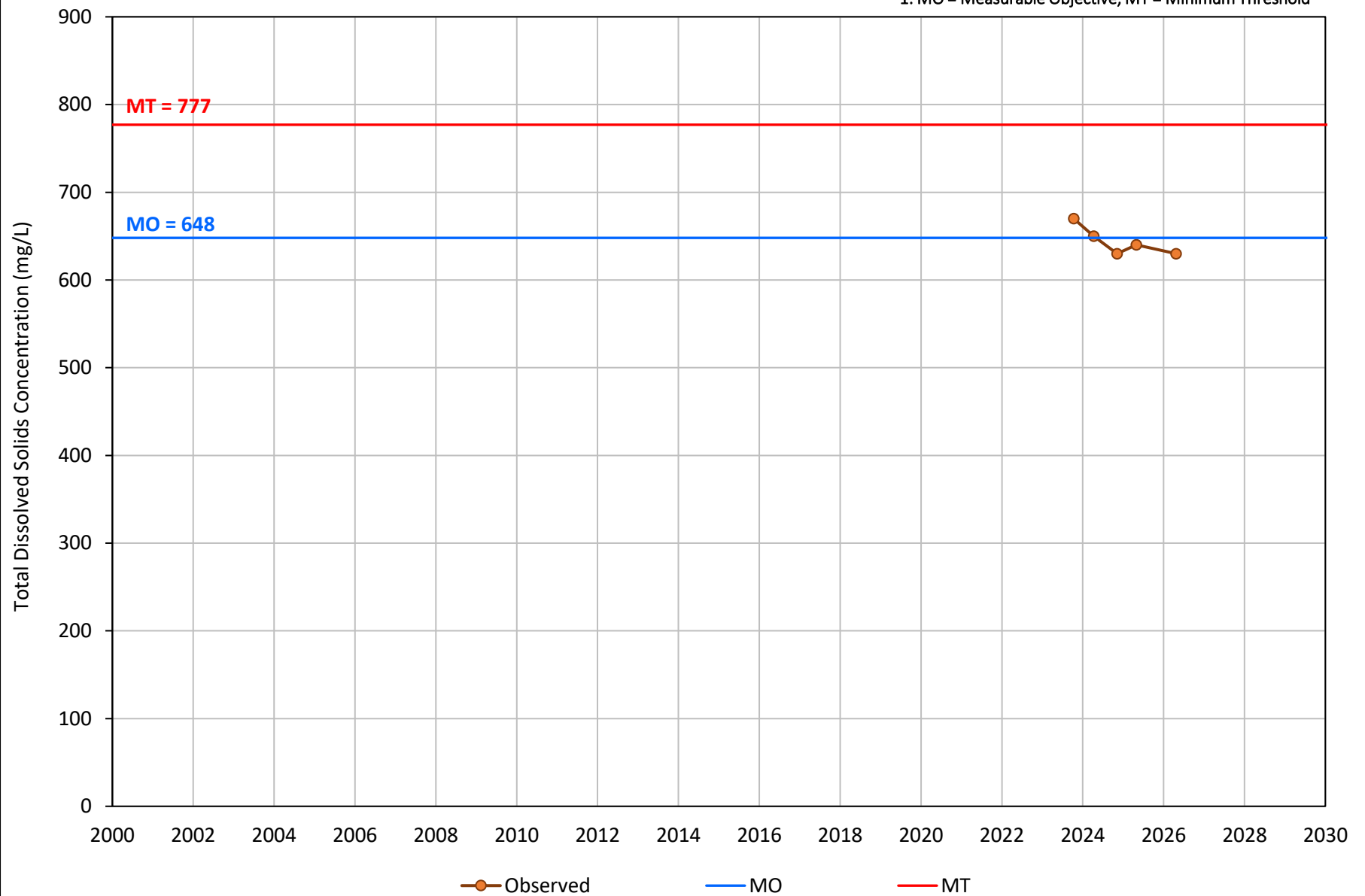


Well Name: S2-MWD1

Aquifer: Deep

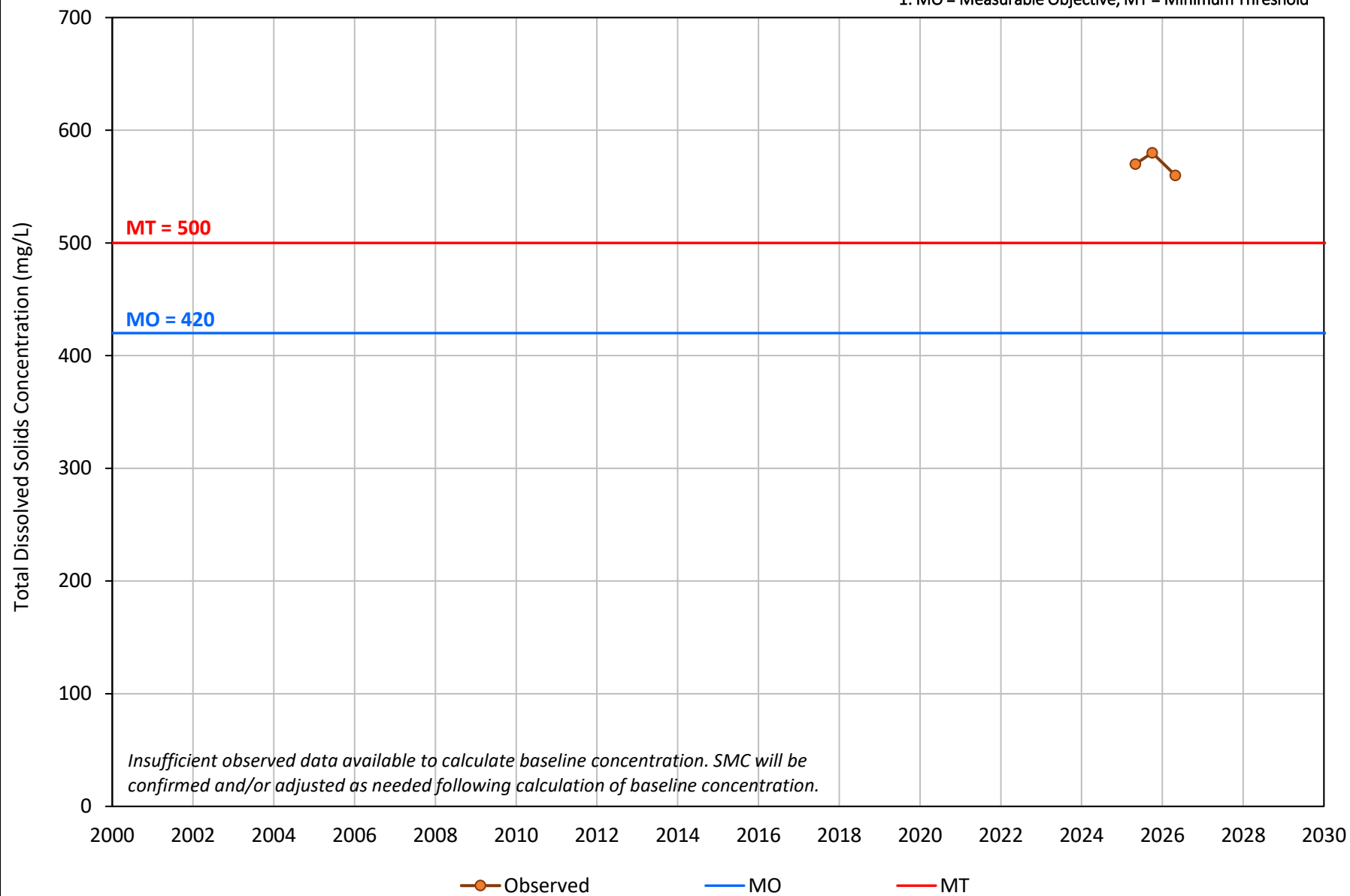
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-N1I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

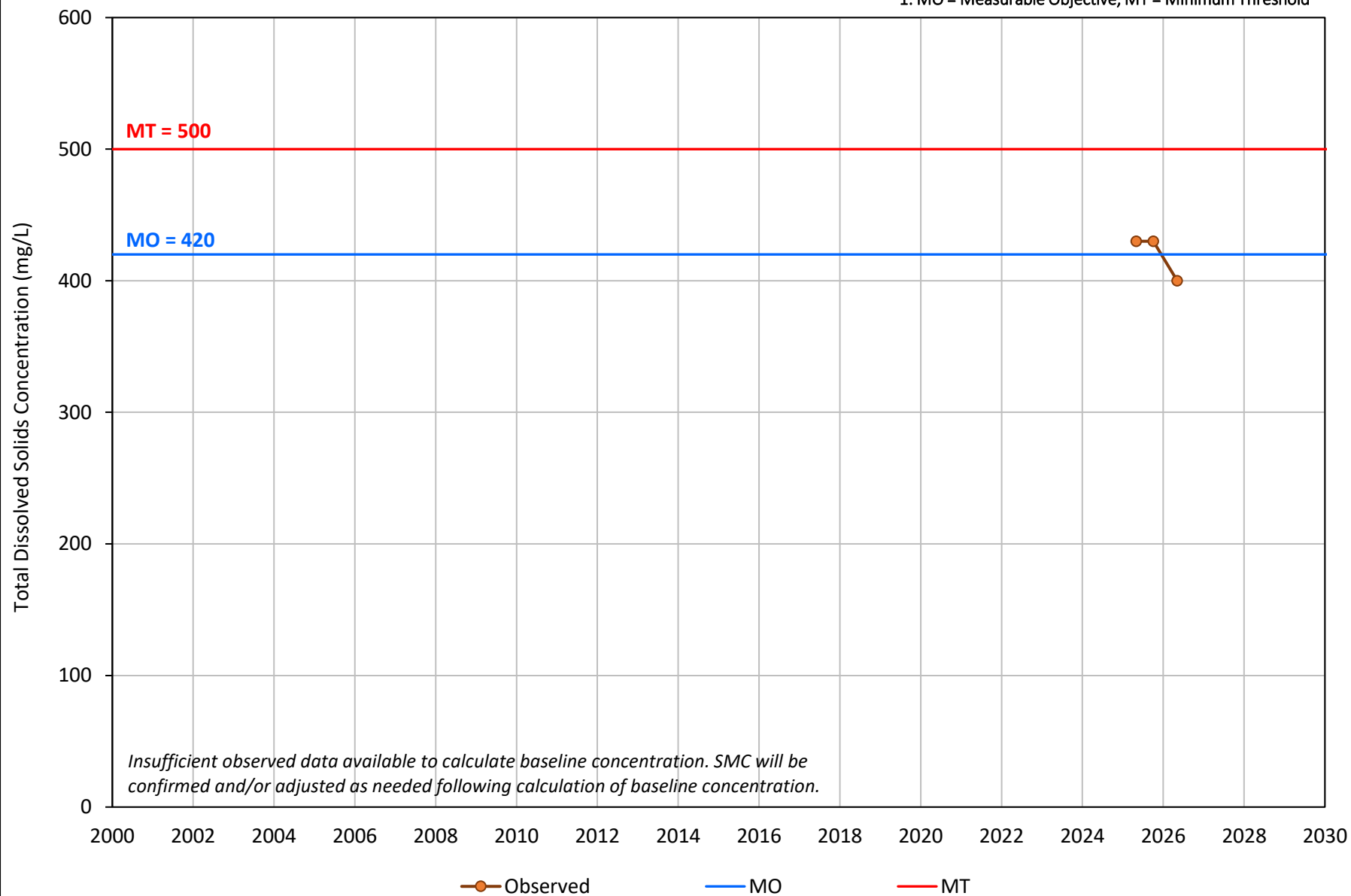


Well Name: MW-N3S

Aquifer: Shallow

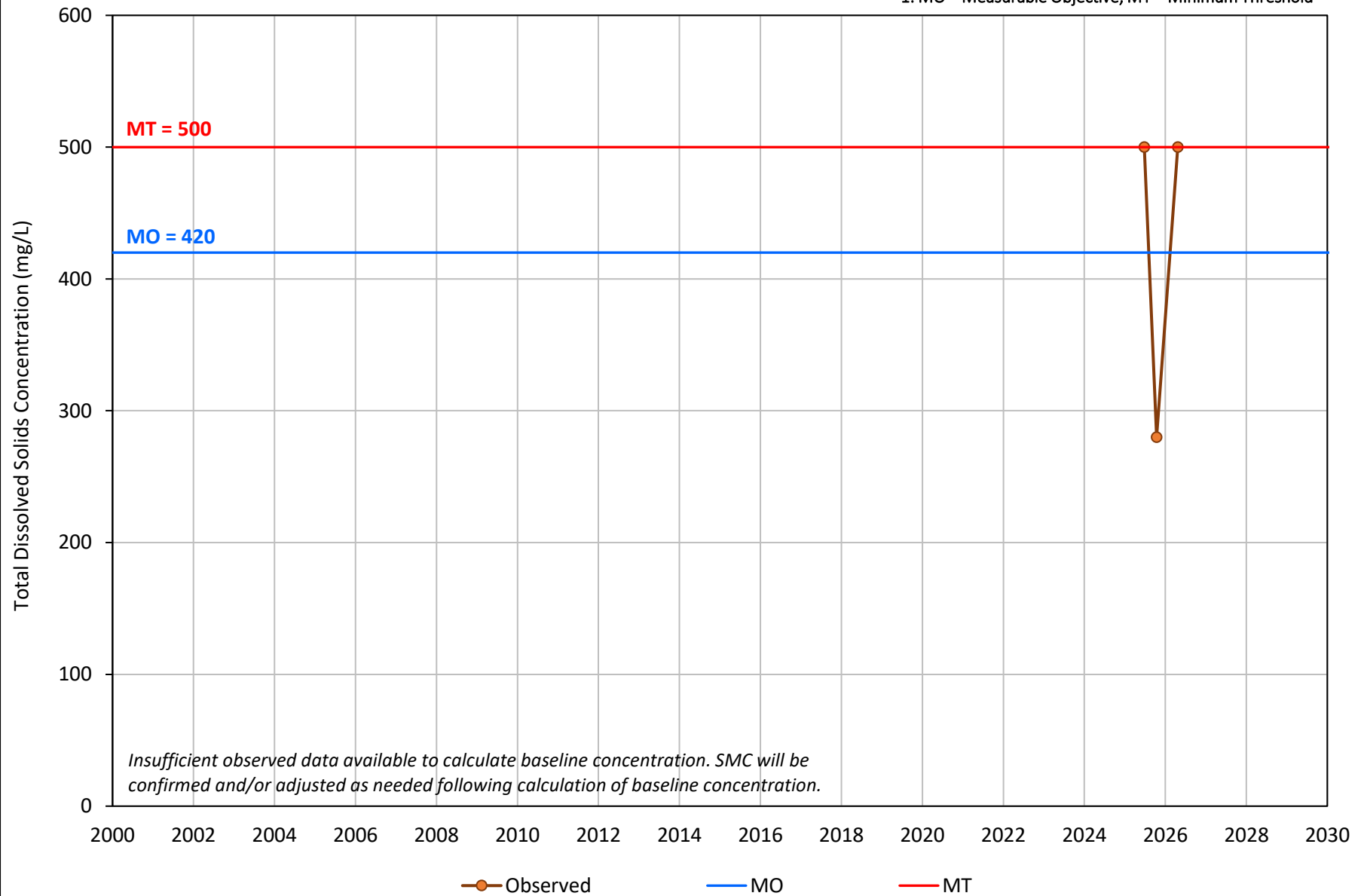
NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



Well Name: MW-S2I
Aquifer: Intermediate

NOTES:
1. MO = Measurable Objective; MT = Minimum Threshold

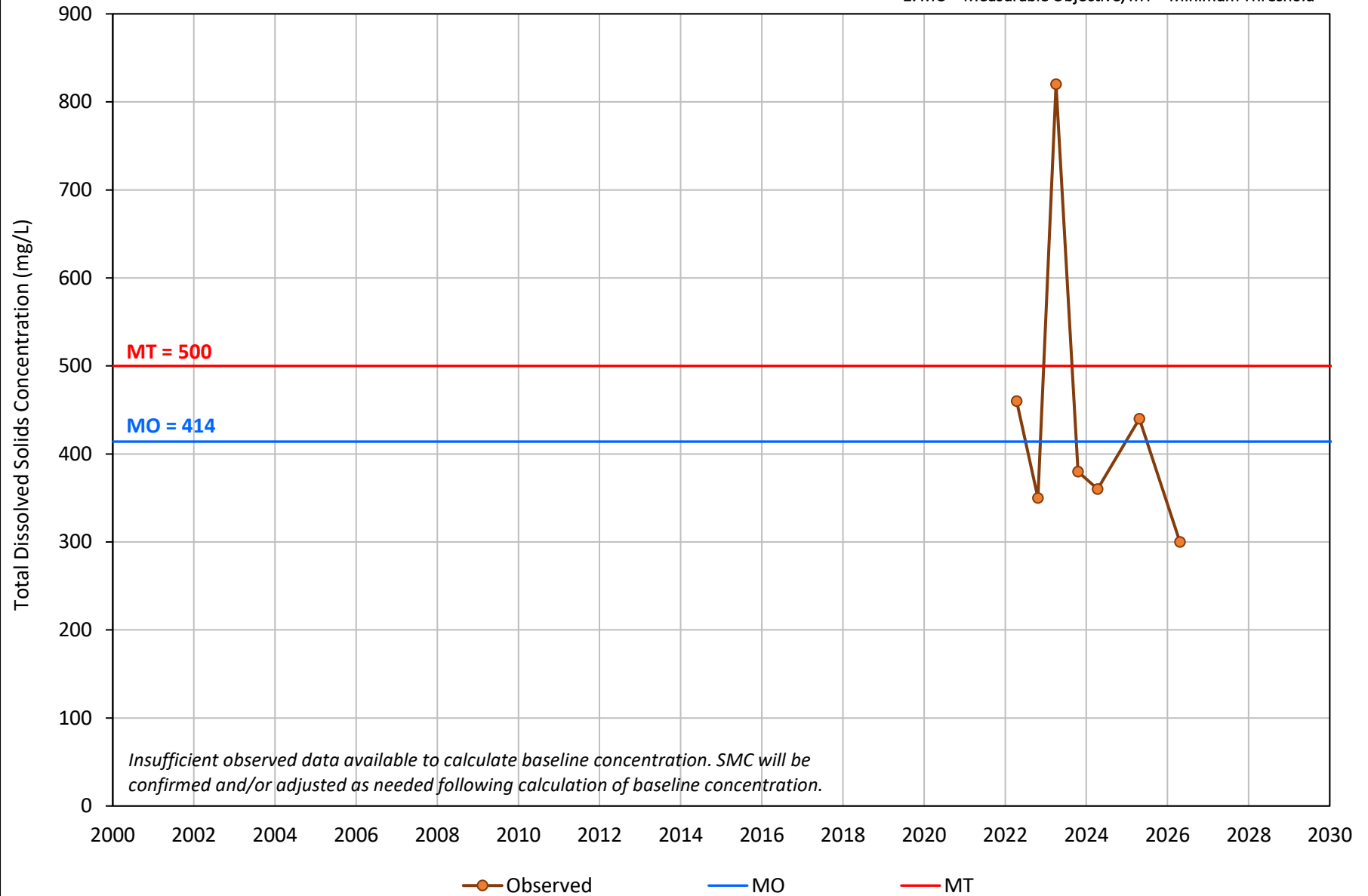


Well Name: Well D

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold

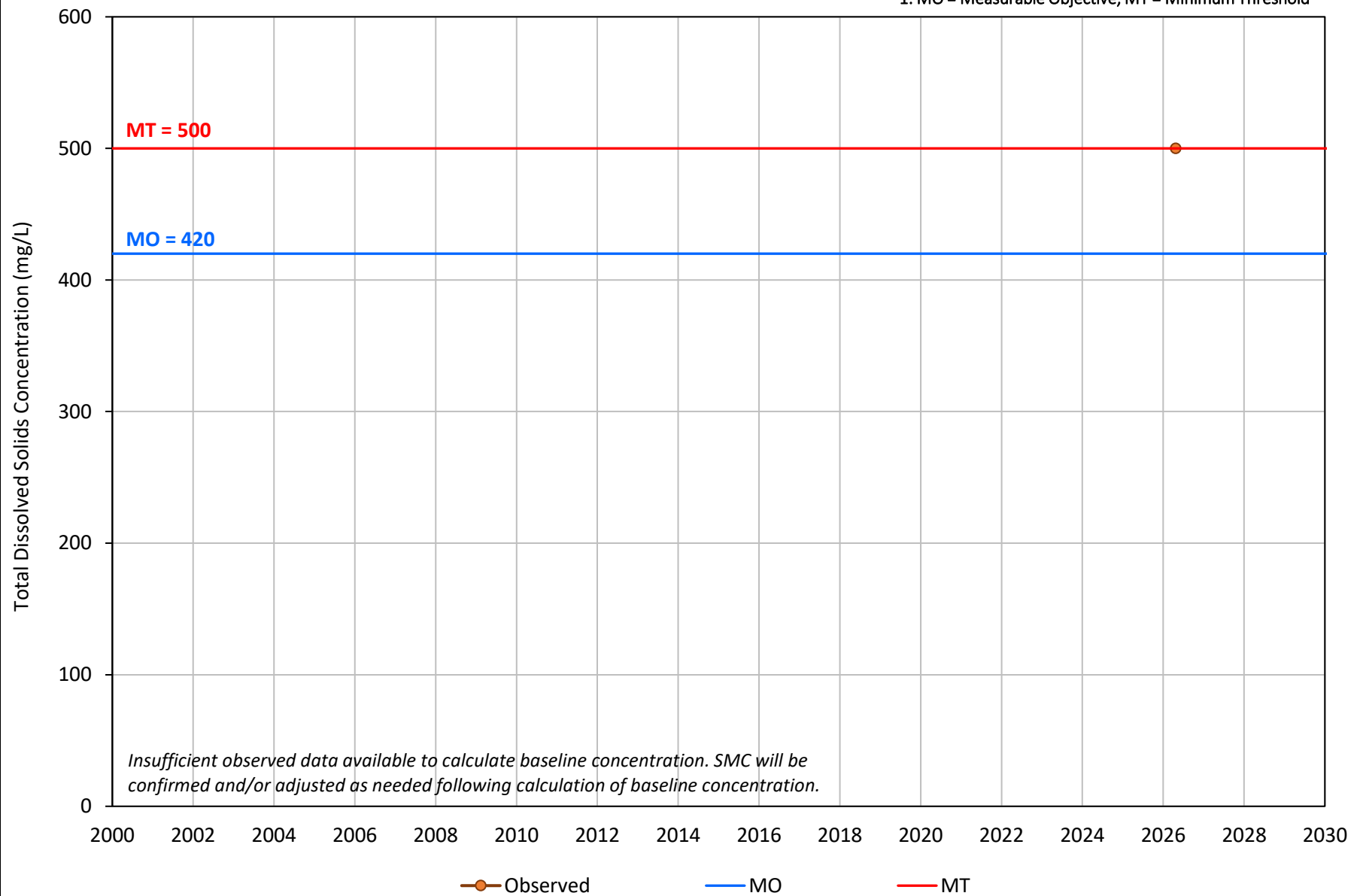


Well Name: Well E

Aquifer: Deep

NOTES:

1. MO = Measurable Objective; MT = Minimum Threshold



APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.F. Supporting Data for Surface Water Depletion SMC

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APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.F. Supporting Data for Surface Water Depletion SMC

3.F.a Surface Water – Groundwater Interaction Model Data Summary

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Table F-1. Percentage of Stream Reaches Connected to Groundwater Under Steady-State Conditions

Scenario	Average Annual Pumping (AFY)	Average Annual Injection (AFY)	San Pablo	Wildcat	Sausal	Peralta	San Leandro	San Lorenzo
Baseline w/ SLR 2022 to 2071	3,600	0	98%	75%	14%	38%	100%	61%
Sustainable Yield w/ SLR 2022 to 2017	12,500	0	98%	68%	14%	25%	100%	61%
Sustainable Yield Change from Baseline	8,900	0	0%	-7%	0%	-13%	0%	0%
Baseline w/o SLR; 2000 to 2015	3,600	0	98%	75%	14%	38%	100%	61%
1960s Pumping w/o SLR; 1960s	23,000	0	98%	71%	7%	25%	71%	24%
1960s Change from Baseline	19,400	0	0%	-4%	-7%	-13%	-29%	-37%

Note: Change in connectivity on Peralta Creek is due to change in only one grid square out of 8 total grid square comprising creek (i.e., creek reach is limited distance so one grid square = 13%);

Changes in connectivity on San Lorenzo Creek are unlikely to impact streamflow very much because majority of creek reach within EBP Subbasin is lined.

Table F-2. Average Streamflow (cfs) Under Steady-State Conditions

Scenario	Average Annual Pumping (AFY)	Average Annual Injection (AFY)	San Pablo	Wildcat	Sausal	Peralta	San Leandro	San Lorenzo
Baseline w/ SLR 2022 to 2071	3,600	0	6.5	4.4	NA	NA	8.8	15.7
Sustainable Yield w/ SLR 2022 to 2017	12,500	0	5.9	4.1	NA	NA	8.4	15.7
Sustainable Yield Change from Baseline	8,900	0	-0.6	-0.3			-0.4	0.0
Baseline w/o SLR; 2000 to 2015	3,600	0	5.8	4.2	NA	NA	8.4	15.2
1960s Pumping w/o SLR; 1960s	23,000	0	5.5	4.1	NA	NA	6.9	14.6
1960s Change from Baseline	19,400	0	-0.3	-0.1			-1.5	-0.6

Note: These changes in streamflow among different scenarios do not quantify how such changes may impact summer baseflows (assuming baseflows occur), because of insufficient field data.

Table F-3. Net Groundwater Inflow (cfs) to Streams Under Steady-State Conditions

Scenario	Average Annual Pumping (AFY)	Average Annual Injection (AFY)	San Pablo	Wildcat	Sausal	Peralta	San Leandro	San Lorenzo
Baseline w/ SLR 2022 to 2071	3,600	0	0.1	-0.7	NA	NA	0.1	1.1
Sustainable Yield w/ SLR 2022 to 2017	12,500	0	-0.6	-1.0	NA	NA	-0.3	1.1
Sustainable Yield Change from Baseline	8,900	0	-0.7	-0.3	NA	NA	-0.4	0.0
Baseline w/o SLR; 2000 to 2015	3,600	0	-0.4	-0.8	NA	NA	0.0	1.0
1960s Pumping w/o SLR; 1960s	23,000	0	-0.8	-0.8	NA	NA	-1.5	0.3
1960s Change from Baseline	19,400	0	-0.4	0.0	NA	NA	-1.5	-0.7

Table F-4. Average Shallow Zone Groundwater Levels Near Streams

Scenario	Average Annual Pumping (AFY)	Average Annual Injection (AFY)	SPC-2 San Pablo	SPC-3 San Pablo	SPC-1 San Pablo	SLC-2 San Leandro	SLC-1 San Leandro
Baseline w/ SLR 2022 to 2071	3,600	0	59.3	50.7	29.0	45.6	6.2
Sustainable Yield w/ SLR 2022 to 2017	12,500	0	59.3	50.2	27.6	44.8	4.4
Sustainable Yield Change from Baseline	8,900	0	0.0	-0.5	-1.4	-0.8	-1.8
Baseline w/o SLR; 2000 to 2015	3,600	0	59.3	50.7	28.9	45.5	5.9
1960s Pumping w/o SLR; 1960s	23,000	0	59.2	50.6	28.8	42.5	-0.1
1960s Change from Baseline	19,400	0	-0.1	-0.1	-0.1	-3.0	-6.0

Table F-5. Comparison of Changes in Connectivity, Streamflow, Net Groundwater Inflow, and Shallow GW Levels along Major Creeks

	San Pablo	Wildcat	San Leandro
Sustainable Yield Change in Connectivity	0%	-7%	0%
Sustainable Yield Change in Streamflow	-0.6	-0.3	-0.4
Sustainable Yield Change in Net GW to Stream (cfs)	-0.7	-0.3	-0.4
Sustainable Yield Change in Shallow GWLs	0.0 to -1.4	0.0 to -1.4	-0.8 to -1.8
1960s Change in Connectivity (%)	0%	-4%	-29%
1960s Change in Streamflow (cfs)	-0.3	-0.1	-1.5
1960s Change in Net GW to Stream (cfs)	-0.4	0.0	-1.5
1960s Change in Shallow GWLs (ft)	-0.1	-0.1	-3.0 to -6.0

Notes: Change in groundwater levels for Wildcat Creek assumed to be same as change in groundwater levels at San Pablo Creek

APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.G. Supplemental Monitoring Network

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APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

3.G. Supplemental Monitoring Network

3.G.a Non-RMS Candidate Wells

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Table 3G-1. Summary of Candidate Wells for Possible Inclusion in EBP Subbasin GSP Non-RMS Well Monitoring Network.

Well I.D.	Reference Point Elevation (ft MSL)	Well Depth (ft bgs)	Screen Top-Bottom (ft bgs)	Aquifer Designation	Last Known Measurement Date	Well Owner	GSA Location
OW-1	148 ^a	300	140-220; 240-300	Shallow and Intermediate	4/16/26	Richmond Country Club	EBMUD
OW-2	52 ^a	400	135-195; 235-315; 335-395	Shallow and Intermediate	4/16/26	Contra Costa CCD	EBMUD
OW-3	72 ^a	240	120-130; 150-200; 210-230	Shallow and Intermediate	4/16/26	Salesian High School	EBMUD
MW-3B	13.91 ^b	85	60-80	Shallow	12/10/97	Port of Oakland	EBMUD
MW-3C	14.20 ^b	210	185-205	Shallow	12/10/97	Port of Oakland	EBMUD
MW-5B	12.80 ^b	85	60-80	Shallow	12/10/97	Port of Oakland	EBMUD
MW-5C	12.94 ^b	185	160-180	Shallow	12/10/97	Port of Oakland	EBMUD
MW-4	8.61 ^c	650	520-650	Deep	Ongoing ^d	EBMUD	EBMUD
MW-6	9.20 ^c	655	480-650	Deep	Ongoing ^d	EBMUD	EBMUD
MW-7	7.38 ^c	640	510-630	Deep	Ongoing ^d	EBMUD	EBMUD
Farmhouse	52 ^e	540	500-530	Deep	8/3/2007	EBMUD	EBMUD
EBAY-2	7.0 ^f	860	830-860	Deep	Ongoing ^g	EBMUD	EBMUD
EBAY-3	7.0 ^f	550	530-550	Deep	Ongoing ^g	EBMUD	EBMUD
EBAY-4	7.0 ^f	318	298-318	Intermediate	Ongoing ^g	EBMUD	EBMUD
EBAY-5	7.0 ^f	138	128-138	Shallow	Ongoing ^g	EBMUD	EBMUD
EBAY-6	7.0 ^f	45	35-45	Shallow	Ongoing ^g	EBMUD	EBMUD
Well A	NA ^h	550	245-265; 440-450; 475-530	Int/Deep	7/7/26	Hayward	Hayward
Well B MW-S	NA ^h	232	172-182; 212-222	Shallow and Intermediate	7/7/26	Hayward	Hayward
Well B MW-I	NA ^h	382	302-312; 362-372	Intermediate	7/7/26	Hayward	Hayward
Well B MW-D	12.5	535	440-450; 505-525	Deep	7/7/26	Hayward	Hayward
Well C	12.5	466	370-410; 422-456	Intermediate and Deep	7/7/26	Hayward	Hayward

^aReported Reference Point in CASGEM online system; estimated value that is not surveyed.

^bReported Reference Point is relative to a Port of Oakland datum known as Mean Lower Low Water (MLLW).

^cReported Reference Point from May 2009 survey relative to NGVD 29.

^dOngoing groundwater level readings are collected with transducers installed and maintained by EBMUD.

^eEstimated land surface elevation from Google Earth.

^fEstimated Land Surface Elevation relative to National Geodetic Vertical Datum (NGVD) 1929 from USGS (2015).

^gOngoing measurements collected by USGS as part of extensometer monitoring program.

