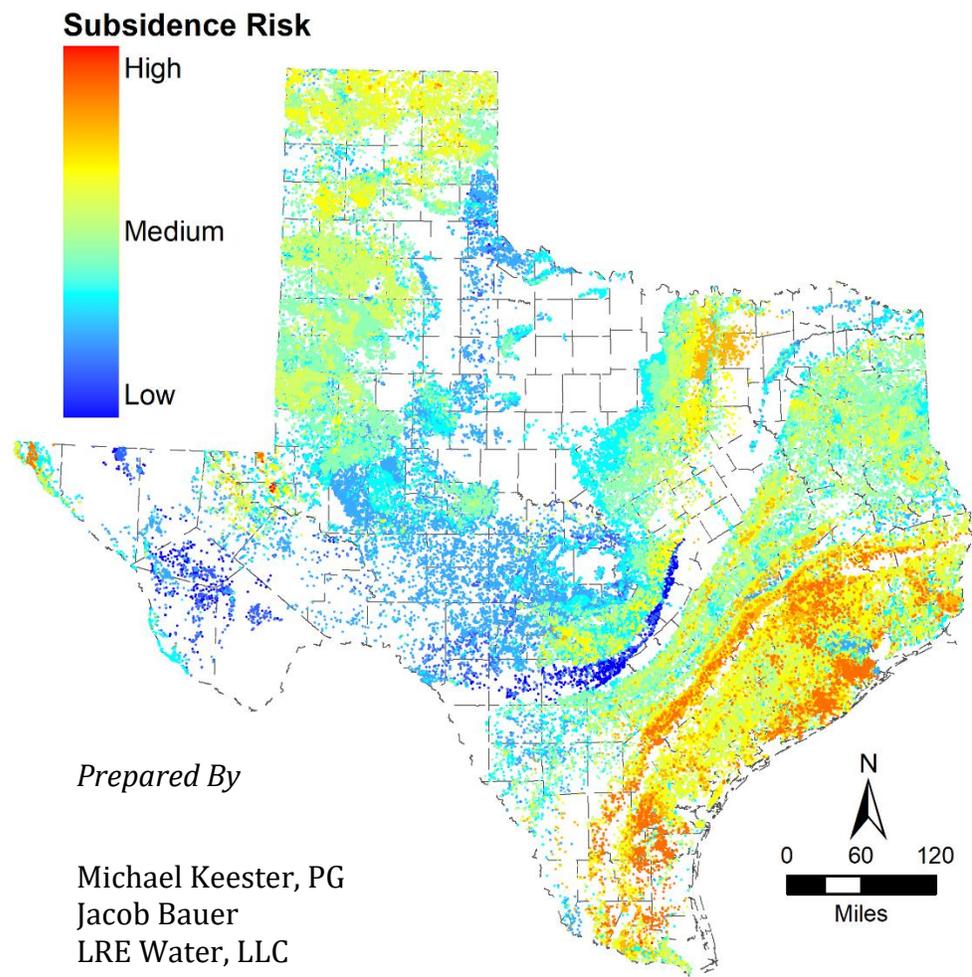


# Texas Aquifer Potential Subsidence Prediction Screening Tool User's Guide

Version 1.0

TWDB Contract Number  
1648302062



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# 1 Introduction

As part of our investigation of the vulnerability of the major and minor aquifers of Texas to subsidence with regard to groundwater pumping, we developed a tool to provide a screening-level analysis of subsidence potential. For ease of use by potential users, we developed the tool using Microsoft Excel 2016 (Version 1802, Build 9029.2167 Click-to-Run). The tool estimates land-surface subsidence, using the general expression for compaction or expansion of aquifer sediments based on user input and typical values for various parameters.

We have prepared this guide to provide users with a quick reference for how to use the subsidence prediction tool. For a more detailed discussion of the calculations performed by the tool, we refer the user to Section 6 of the final project report.

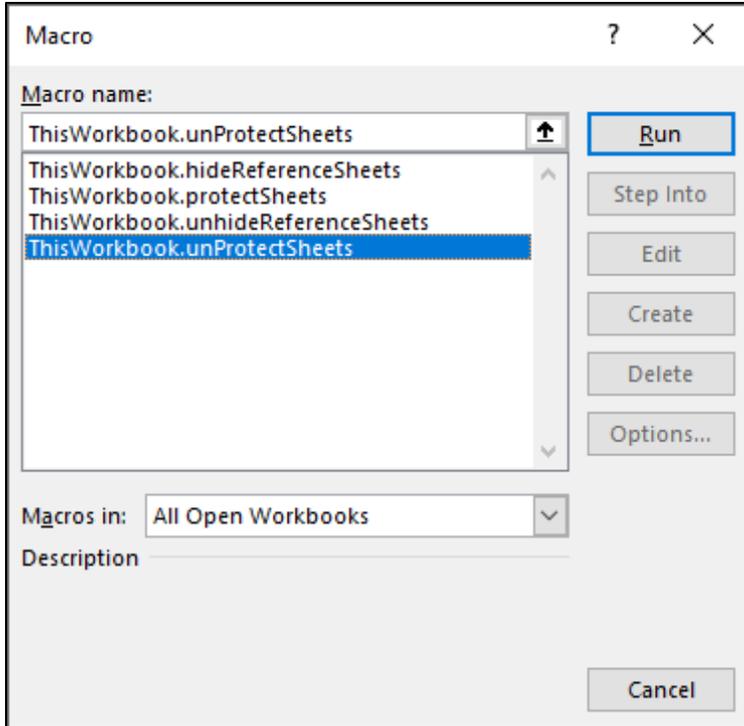
## 1.1 Subsidence Prediction Tool File Description

We saved the original file as an Excel Binary Workbook (\*.xlsb file extension). Some calculations in the workbook use custom functions written in Visual Basic for Applications (VBA). In addition, the tool populates some variables using macros. To effectively use the tool, users will need to allow macros to run within the application. To enable macros in Excel, click **Developer > Macro Security** and select the **Enable all macros** button. If the "Developer" tab is not visible, click **File > Options > Customize Ribbon** and select the **Developer** check box.

We applied several options to prevent accidental changes to the subsidence prediction tool. First, we made the calculation worksheet tab invisible. To view the tab, click **File > Options > Advanced** and under **Display options for this workbook** select the **Show sheet tabs** check box.

We also set password protection on the worksheets and VBA project. The password for all items in the application is *Water4Texas*. To unprotect a worksheet, click **Review > Unprotect Sheet** and enter the password. Alternatively, users can unprotect all of the worksheets at one time by clicking **Developer > Macros**, selecting *ThisWorkbook.unProtectSheets*, then clicking **Run** (see Figure 1.1). Listed in the **Macro** dialog box are a total of four macros that perform the following functions:

- *ThisWorkbook.hideReferenceSheets* hides all the worksheets in the tool except for the sheet on which the calculations are performed.
- *ThisWorkbook.protectSheets* applies password protection to all worksheets in the workbook.
- *ThisWorkbook.unhideReferenceSheets* makes all the worksheets visible to the user.
- *ThisWorkbook.unprotectSheets* removes protection from all worksheets in the workbook.



**Figure 1.1. Microsoft Excel macro dialog box.**

As stated above, we applied the protection to prevent accidental changes to the subsidence prediction tool. However, the user will need to unprotect the worksheet to make intentional changes, such as formatting the charts created by the tool (the charts are described in Section 2). For example, to adjust the scale of the axis on the charts, the user should run the macro for unprotecting the sheets, make the desired changes, then run the macro to protect the sheets.

We set the subsidence prediction tool to populate with default or suggested values each time the user opens the workbook. Upon opening the workbook, the tool will set the **Aquifer** to *General Calculation*, the **Well Name** to *Well*, and the **Water Levels to Use for Predictions** to *Current and Trend* (see Figure 1.2). Upon setting these initial values, the tool clears several of the **User Input Values** and recalculates the predicted water levels. However, if a user wishes to save a workbook with the entries for a particular well, the user should uncheck the box next to **Reset Subsidence Prediction Tool on Open**.

<b><u>Aquifer</u></b>	<b><u>General Calculation</u></b>	<input checked="" type="checkbox"/> Reset Subsidence Prediction Tool on Open
<b><u>Report Generated by</u></b>	USER	
<b><u>Report Date</u></b>	03/13/2018	
<b><u>Well Name</u></b>	Well	
<b><u>Water Levels to Use for Predictions</u></b>	Current and Trend	

**Figure 1.2. General information input section from the subsidence prediction tool.**

## 1.2 Subsidence Prediction Tool Explanation

We recommend saving a copy of the workbook prior to making changes to input variables. Light blue shading indicates manual input variables for the subsidence calculations. Orange shading indicates calculated and other automatically populated fields. The following provides a brief description of each input variable and its associated units:

- **Aquifer:** A drop-down menu for each major and minor aquifer where upon selection the aquifer properties are populated with the average values for that aquifer. Note that this drop-down menu also contains a "General Calculation" aquifer where the aquifer properties are left blank for the user to input the appropriate information.
- **Report Generated by:** a "Name" field intended to contain the identity of the tool user.
- **Well Name:** if applicable, the well identification where the user is calculating potential subsidence.
- **Water Levels to Use for Predictions:** A drop-down box that allows the user to base potential subsidence predictions on the current water level and the water level trend or the base and future water levels.
- **Land Surface (feet mean sea level):** The surface elevation.
- **Aquifer Top (feet mean sea level):** The elevation of the top of the aquifer.
- **Aquifer Thickness (feet):** The aquifer thickness.
- **Clay Thickness (feet):** Clay thickness in the aquifer.
- **Groundwater temperature (Degrees Celsius):** The temperature of the water within the aquifer.
- **Groundwater Total Dissolved Solids (TDS in milligrams per liter):** The TDS value of the groundwater within the aquifer.
- **Predevelopment Water Level (feet mean sea level):** The water level within the aquifer prior to any historical pumping.
- **Current Water Level (feet mean sea level):** The current aquifer water level.
- **Unsaturated Thickness (feet mean sea level):** Estimate of the unsaturated thickness below land surface above the water table. For a confined aquifer, the value represents the estimated depth from land surface to the water level in the aquifer or formation closest to land surface.
- **Preconsolidation Water Level (feet mean sea level):** The deepest measured water level within the aquifer.
- **Base Water Level (feet mean sea level):** The starting water level for subsidence prediction. This value could be the base year desired future condition water level.
- **Future Water Level (feet mean sea level):** The ending water level for subsidence prediction. This value could be the ending year desired future condition water level.
- **Beginning Year for Subsidence Evaluation:** The first year for the Water Level Prediction chart and aquifer Drawdown and Subsidence Prediction chart.
- **Ending Year for Subsidence Evaluation:** The final year for the Water Level Prediction chart and aquifer Drawdown and Subsidence Prediction chart.

Based on the above variables the tool populates the following default or suggested values (**Note:** blue shaded cells may be manually changed/overwritten):

- Water Level Trend (feet per year): The average water level trend for the aquifer. Negative values indicate declining water levels and positive values indicate rising water levels.
- Predominant Aquifer Lithology: The broad lithology classification for the aquifer. A drop-down menu provides the four available options.
- Aquifer Storage Coefficient (dimensionless): The storage coefficient for the aquifer, describing how much water is released per foot decline in aquifer water level.
- Aquifer Porosity (percent): The aquifer porosity entered as a number between 0 and 100. For example, 35 percent is entered as 35 and not as 0.35.
- Predominant Aquifer Clay Type: The predominant clay type within the aquifer. A drop-down menu provides the three available options.
- Aquifer Clay Porosity: The porosity of the clay within the aquifer based on the predominant aquifer clay type entered as a number between 0 and 100. For example, 35 percent is entered as 35 and not as 0.35.
- Minimum and Maximum Aquifer Compressibility ( $\text{psi}^{-1}$ ): The minimum and maximum values of the compressibility of the aquifer based on the predominant aquifer lithology. The values will automatically update to typical minimum and maximum values based on the selected Predominant Aquifer Lithology.
- Minimum and Maximum Clay Compressibility ( $\text{psi}^{-1}$ ): The minimum and maximum values of the compressibility of the clay within the aquifer based on the clay type. The values will automatically update to typical minimum and maximum values based on the selected Predominant Aquifer Clay Type.
- Minimum and maximum aquifer elastic specific storage ( $\text{foot}^{-1}$ ): The minimum and maximum values of the elastic component of specific storage ( $S_{ske}$ ).
- Minimum and maximum aquifer inelastic specific storage ( $\text{foot}^{-1}$ ): The minimum and maximum values of the inelastic component of specific storage ( $S_{skv}$ ).
- Total Weighted Risk for Well: The total weighted subsidence risk for the well according to the input parameters.

## 2 Calculating Subsidence Predictions

Upon opening the subsidence prediction tool, the user will see the information similar to Figure 2.1 and Figure 2.2 (actual display will vary depending on screen size). As shown in Figure 2.1, the tool opens with a *General Calculation* specification for the **Aquifer**, where the input variables are blank and the parameters shown in Figure 2.2 are populated with default values. The user will input values for each of the blank parameters to calculate a **Total Weighted Risk** for the well. Within the tool, blue cells indicate user input parameters, orange cells indicate calculated parameters, and gray cells indicate a drop-down menu.

To populate the **User Input Values** with the average values for a specific aquifer, the user may select the aquifer of interest from the drop-down menu (see Figure 2.3). Figure 2.4 illustrates the population of the **User Input Values** with the average values for the Pecos Valley Aquifer when the user selects *Pecos Valley* for the **Aquifer**. If the user is uncertain of the specific information for a particular well location, these default values will provide an initial estimate of the subsidence risk which for the Pecos Valley Aquifer is 5.78 (see Figure 2.4).

The user may refine the **User Input Values** by entering specific information for a well while leaving the default suggested values for unknown parameters. For example, if a user is investigating the subsidence potential for the well completed in the Pecos Valley Aquifer with Tracking Number 417430 in the Submitted Drillers Report database, the user could enter the aquifer information at the well site (see Figure 2.5). The subsidence tool will use the entered values along with the default suggested values to calculate a **Total Weighted Risk for Well** of 6.72 indicating high subsidence risk at the location (see Figure 2.6).

The **Total Weighted Risk for Well** is one of the primary outputs for the tool. The calculated value allows the user to quickly assess the potential risk for subsidence at the location using a scale from 0 (lowest potential subsidence risk) to 10 (highest potential subsidence risk). Users are referred to Section 3.4 of the final project report for a detailed discussion regarding the calculation of the subsidence risk value.

Scrolling down the worksheet, the user will see two charts. The **Water Level Prediction** chart illustrates the predicted water level, land surface elevation, preconsolidation water level, and the aquifer top and bottom. The tool calculates the predicted water level using the **Water Levels to Use for Predictions** selection. For either possible selection the tool calculates estimates from the **Beginning Year for Subsidence Evaluation**. If the user selects *Current and Trend*, then the tool calculates the predicted water level using the **Water Level Trend** and **Current Water Level**; if the user selects *Base and Future*, then the tool calculates the predicted water level using the **Base Water Level** and **Future Water Level** assuming a linear trend between the **Beginning Year for Subsidence Evaluation** and **Ending Year for Subsidence Evaluation**. The starting and ending years on the chart are based on the **Beginning Year for Subsidence Evaluation** and **Ending Year for Subsidence Evaluation** values. Figure 2.7 illustrates the **Water Level Prediction** chart for

the well completed in the Pecos Valley Aquifer with Tracking Number 417430 described above.

The **Drawdown and Subsidence Prediction** chart illustrates the change in water level per the **Water Levels to Use for Predictions** selection along with the minimum and maximum subsidence predictions based on the water level change. The tool calculates the compaction of aquifer material based on the change in stress associated with changing water levels (see Equation 16 in Section 6.1 of the final project report). Figure 2.8 illustrates the **Drawdown and Subsidence Prediction** chart for the well completed in the Pecos Valley Aquifer with Tracking Number 417430 described above.

As described in Section 3.4.4. of the final project report, the tool uses both options for predicting water level changes when calculating the **Total Weighted Risk for Well**. Since the tool uses both options, the risk value is not affected by the **Water Levels to Use for Predictions** selection. However, the **Water Level Prediction** chart and **Drawdown and Subsidence Prediction** chart can be affected by the user's selection. Figure 2.9 illustrates the **Water Level Prediction** chart and Figure 2.10 illustrates the **Drawdown and Subsidence Prediction** chart for the well completed in the Pecos Valley Aquifer with Tracking Number 417430 described above when the user selects *Base and Future* as the **Water Levels to Use for Predictions**.

Below the two charts, the tool also provides a table of the water level, drawdown, and subsidence estimates that the tool references to create the charts discussed above. Table 2.1 is an excerpt of the table in the subsidence prediction tool. The water level values are calculated using either the **Current Water Level** and the **Water Level Trend** or the **Base Water Level** and **Future Water Level** assuming a linear trend between the **Beginning Year for Subsidence Evaluation** and **Ending Year for Subsidence Evaluation**. However, users may overwrite the formulas in these cells to allow for predictions other than a simple linear trend. Building upon the example provided previously, suppose the user wished to show an abrupt water-level decline in 2030, followed by a continued decline of two feet per year, and subsequent recovery of one foot per year, then the user could enter these water-level values into the table and the tool would predict potential subsidence based on the entries. Figure 2.11 illustrates the predicted drawdown and subsidence based on this hypothetical scenario. To reset the predicted water levels to the calculated values, the user simply needs to reselect the **Water Levels to Use for Predictions**.

<b><u>Aquifer</u></b>	<b><u>General Calculation</u></b>	<input checked="" type="checkbox"/> Reset Subsidence Prediction Tool on Open	<b><u>Legend</u></b>
<b><u>Report Generated by</u></b>	M. Keester		User Input values
<b><u>Report Date</u></b>	03/13/2018		Calculated
<b><u>Well Name</u></b>	Well		Drop-down menu
<b><u>Water Levels to Use for Predictions</u></b>	Current and Trend		
<b><u>Location and Water Level Based</u></b>	<b><u>User Input Values</u></b>		
<b><u>User Input</u></b>		<b><u>Units</u></b>	
Land Surface (feet MSL)		feet	
Aquifer Top (feet MSL)		feet	
Aquifer Thickness		feet	
Clay Thickness within Aquifer		feet	
Groundwater Temperature		Degrees Celsius	
Groundwater Total Dissolved Solids (TDS)		mg/l	
Predevelopment Water Level (feet MSL)		feet	
Current Water Level (feet MSL)		feet	
Unsaturated Thickness		feet	
Preconsolidation (deepest) Water Level (feet MSL)		feet	
Base Water Level (feet MSL)		feet	
Future Water Level (feet MSL)		feet	
Beginning Year for Subsidence Evaluation	2010	year	
Ending Year for Subsidence Evaluation	2070	year	

Figure 2.1. Subsidence prediction tool opening page.

Note that this sheet estimates subsidence as described in *Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping* (TWDB Contract Number 1648302062). Estimates provided by this tool are approximate and actual subsidence may vary significantly from the estimates provided by this tool. In addition, time delay of subsidence is not included in the calculation.

**Aquifer Subsidence Calculations based on overall aquifer information and user supplied input values**

		<u>Units</u>
Water Level Trend	0.00	ft/year; negative for decline
Predominant Aquifer Lithology	Unconsolidated Clastic	Description
Aquifer Storage Coefficient	0.15	Dimensionless
Aquifer Porosity	35	Percent
Predominant Aquifer Clay Type	Plastic Clay	Type
Aquifer Clay Porosity	50	Percent
Minimum Aquifer Compressibility	3.59E-04	psi <sup>-1</sup>
Maximum Aquifer Compressibility	6.89E-04	psi <sup>-1</sup>
Minimum Clay Compressibility	1.79E-03	psi <sup>-1</sup>
Maximum Clay Compressibility	1.38E-02	psi <sup>-1</sup>
Minimum Elastic Specific Storage ( $S_{ske}$ )		ft <sup>-1</sup>
Maximum Elastic Specific Storage ( $S_{ske}$ )		ft <sup>-1</sup>
Minimum Inelastic Specific Storage ( $S_{skv}$ )		ft <sup>-1</sup>
Maximum Inelastic Specific Storage ( $S_{skv}$ )		ft <sup>-1</sup>
<b>Total Weighted Risk for Well</b>		
<b>0 (low risk) to 10 (high risk)</b>		

Figure 2.2. Subsidence prediction tool opening page default values.

<b><u>Aquifer</u></b>	<b>General Calculation</b>
<b><u>Report Generated by</u></b>	General Calculation
<b><u>Report Date</u></b>	Blaine
<b><u>Well Name</u></b>	Blossom
<b><u>Water Levels to Use for Predictions</u></b>	Bone Spring-Victorio Peak
	Brazos River Alluvium
	Capitan Reef Complex
	Carrizo-Wilcox
	Dockum

Figure 2.3. Subsidence prediction tool aquifer drop-down menu.

<b><u>Aquifer</u></b>	<b><u>Pecos Valley</u></b>	<input checked="" type="checkbox"/> Reset Subsidence Prediction Tool on Open	<b><u>Legend</u></b>
<b><u>Report Generated by</u></b>	M. Keester		User Input values
<b><u>Report Date</u></b>	03/13/2018		Calculated
<b><u>Well Name</u></b>	Well		Drop-down menu
<b><u>Water Levels to Use for Predictions</u></b>	Current and Trend		
<b><u>Location and Water Level Based</u></b>	<b><u>User Input Values</u></b>		
<b><u>User Input</u></b>		<b><u>Units</u></b>	
Land Surface (feet MSL)	2,706	feet	
Aquifer Top (feet MSL)	2,706	feet	
Aquifer Thickness	549	feet	
Clay Thickness within Aquifer	36	feet	
Groundwater Temperature	21	Degrees Celsius	
Groundwater Total Dissolved Solids (TDS)	2,550	mg/l	
Predevelopment Water Level (feet MSL)	2,662	feet	
Current Water Level (feet MSL)	2,614	feet	
Unsaturated Thickness	89	feet	
Preconsolidation (deepest) Water Level (feet MSL)	2,622	feet	
Base Water Level (feet MSL)	2,626	feet	
Future Water Level (feet MSL)	2,576	feet	
Beginning Year for Subsidence Evaluation	2010	year	
Ending Year for Subsidence Evaluation	2070	year	

**Figure 2.4. Subsidence prediction tool Pecos Valley Aquifer average values.**

<b><u>Aquifer Subsidence Calculations based on overall aquifer information and user supplied input values</u></b>		<b><u>Units</u></b>
Water Level Trend	-0.27	ft/year; negative for decline
Predominant Aquifer Lithology	Unconsolidated Clastic	Description
Aquifer Storage Coefficient	0.15	Dimensionless
Aquifer Porosity	35	Percent
Predominant Aquifer Clay Type	Plastic Clay	Type
Aquifer Clay Porosity	50	Percent
Minimum Aquifer Compressibility	3.59E-04	psi <sup>-1</sup>
Maximum Aquifer Compressibility	6.89E-04	psi <sup>-1</sup>
Minimum Clay Compressibility	1.79E-03	psi <sup>-1</sup>
Maximum Clay Compressibility	1.38E-02	psi <sup>-1</sup>
Minimum Elastic Specific Storage ( $S_{ske}$ )	1.64E-06	ft <sup>-1</sup>
Maximum Elastic Specific Storage ( $S_{ske}$ )	5.60E-06	ft <sup>-1</sup>
Minimum Inelastic Specific Storage ( $S_{skv}$ )	1.64E-04	ft <sup>-1</sup>
Maximum Inelastic Specific Storage ( $S_{skv}$ )	5.60E-04	ft <sup>-1</sup>
<b>Total Weighted Risk for Well 0 (low risk) to 10 (high risk)</b>	<b>5.78</b>	

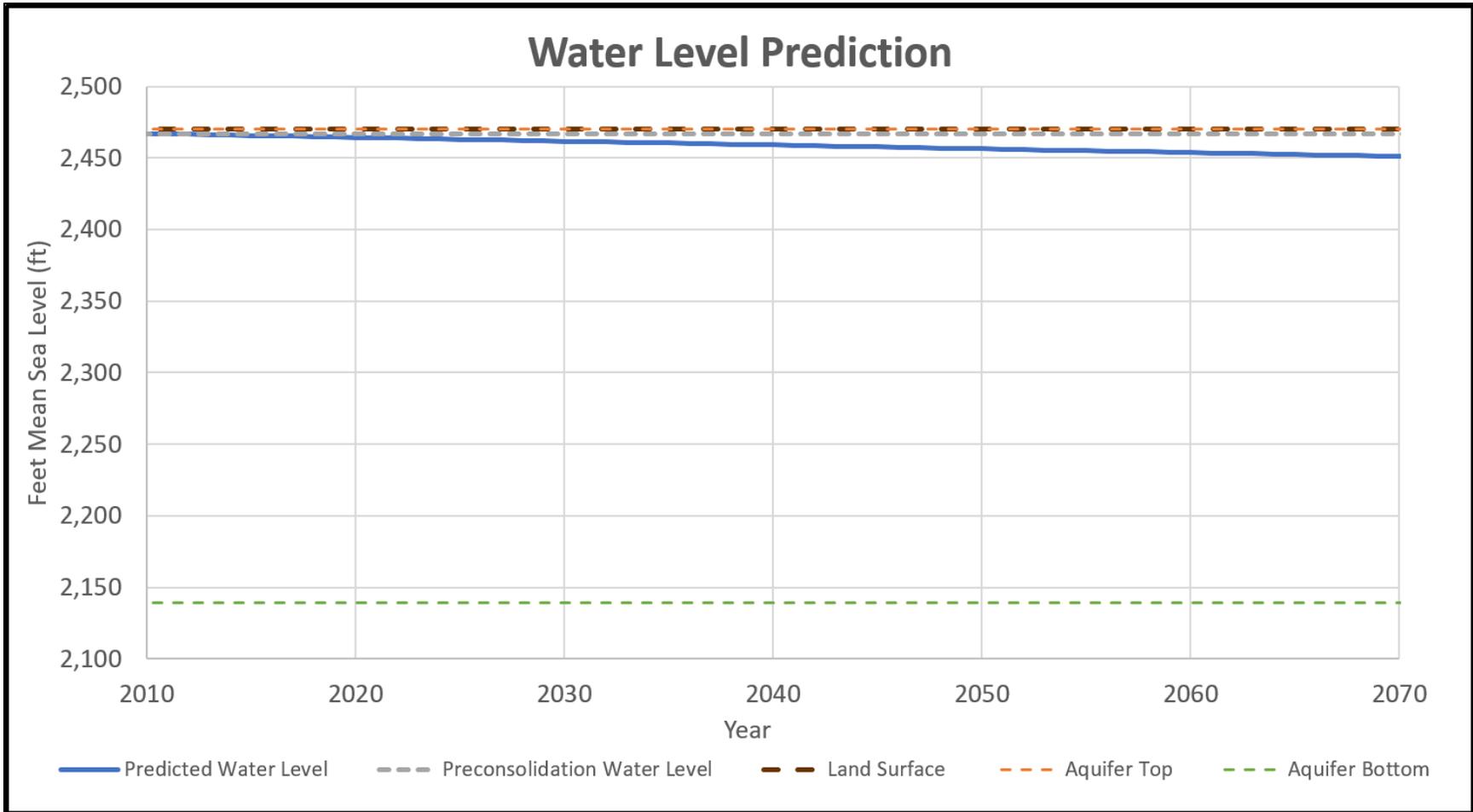
Figure 2.4. Subsidence prediction tool Pecos Valley Aquifer average values (continued).

<b><u>Aquifer</u></b>	<b><u>Pecos Valley</u></b>	<input checked="" type="checkbox"/> Reset Subsidence Prediction Tool on Open	<b><u>Legend</u></b>
<b><u>Report Generated by</u></b>	M. Keester		User Input values
<b><u>Report Date</u></b>	03/13/2018		Calculated
<b><u>Well Name</u></b>	Tracking Number 417430		Drop-down menu
<b><u>Water Levels to Use for Predictions</u></b>	Current and Trend		
<b><u>Location and Water Level Based</u></b>	<b><u>User Input Values</u></b>		
<b><u>User Input</u></b>		<b><u>Units</u></b>	
Land Surface (feet MSL)	2,470	feet	
Aquifer Top (feet MSL)	2,470	feet	
Aquifer Thickness	331	feet	
Clay Thickness within Aquifer	135	feet	
Groundwater Temperature	20	Degrees Celsius	
Groundwater Total Dissolved Solids (TDS)	1,095	mg/l	
Predevelopment Water Level (feet MSL)	2,474	feet	
Current Water Level (feet MSL)	2,467	feet	
Unsaturated Thickness	42	feet	
Preconsolidation (deepest) Water Level (feet MSL)	2,467	feet	
Base Water Level (feet MSL)	2,474	feet	
Future Water Level (feet MSL)	2,462	feet	
Beginning Year for Subsidence Evaluation	2010	year	
Ending Year for Subsidence Evaluation	2070	year	

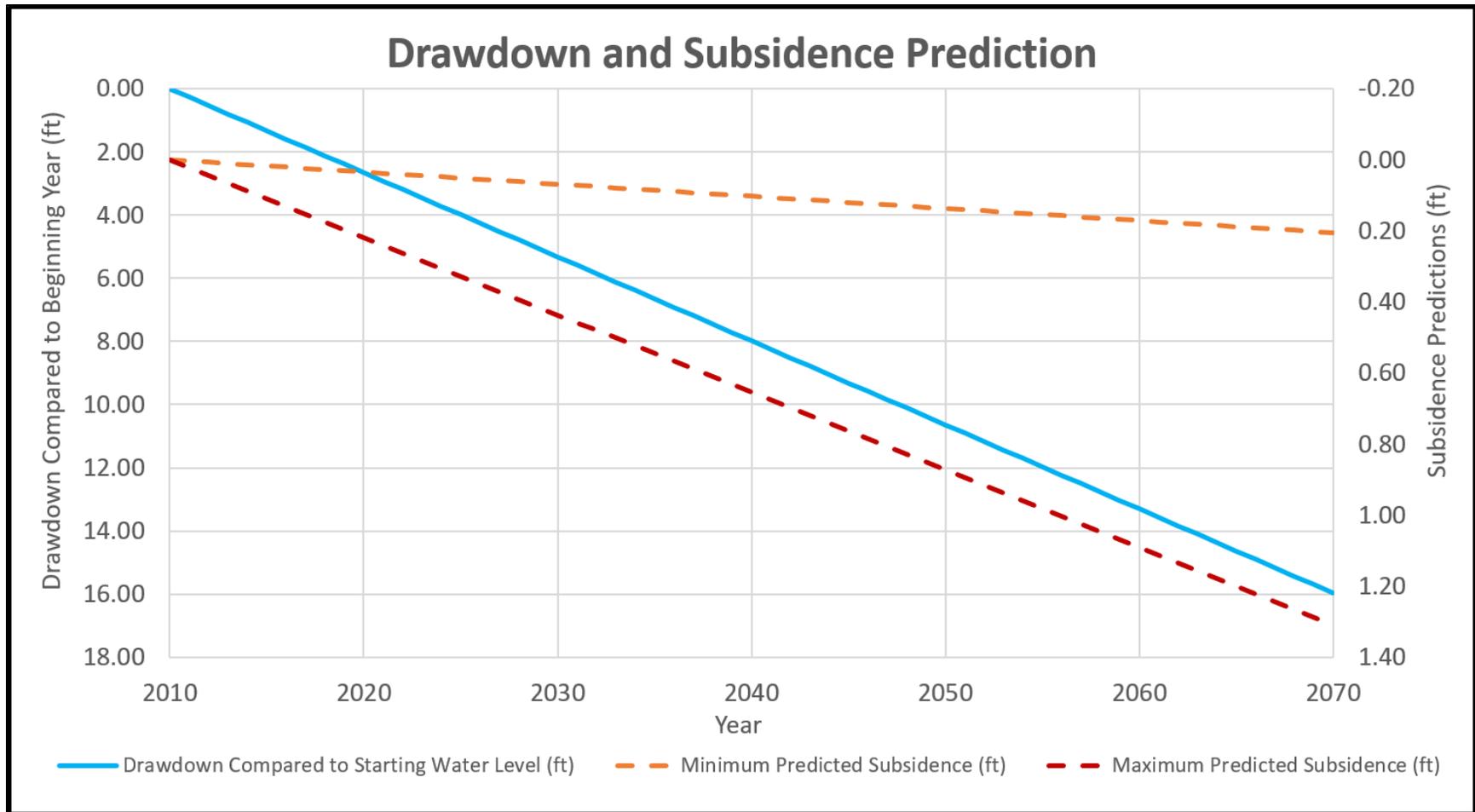
**Figure 2.5. Subsidence prediction tool Pecos Valley Aquifer input values for Tracking Number 417430 in the Submitted Drillers Report database.**

<b><u>Aquifer Subsidence Calculations based on overall aquifer information and user supplied input values</u></b>		<b><u>Units</u></b>
Water Level Trend	-0.27	ft/year; negative for decline
Predominant Aquifer Lithology	Unconsolidated Clastic	Description
Aquifer Storage Coefficient	0.15	Dimensionless
Aquifer Porosity	35	Percent
Predominant Aquifer Clay Type	Plastic Clay	Type
Aquifer Clay Porosity	50	Percent
Minimum Aquifer Compressibility	3.59E-04	psi <sup>-1</sup>
Maximum Aquifer Compressibility	6.89E-04	psi <sup>-1</sup>
Minimum Clay Compressibility	1.79E-03	psi <sup>-1</sup>
Maximum Clay Compressibility	1.38E-02	psi <sup>-1</sup>
Minimum Elastic Specific Storage ( $S_{ske}$ )	3.87E-06	ft <sup>-1</sup>
Maximum Elastic Specific Storage ( $S_{ske}$ )	2.47E-05	ft <sup>-1</sup>
Minimum Inelastic Specific Storage ( $S_{skv}$ )	3.87E-04	ft <sup>-1</sup>
Maximum Inelastic Specific Storage ( $S_{skv}$ )	2.47E-03	ft <sup>-1</sup>
<b>Total Weighted Risk for Well 0 (low risk) to 10 (high risk)</b>	<b>6.72</b>	

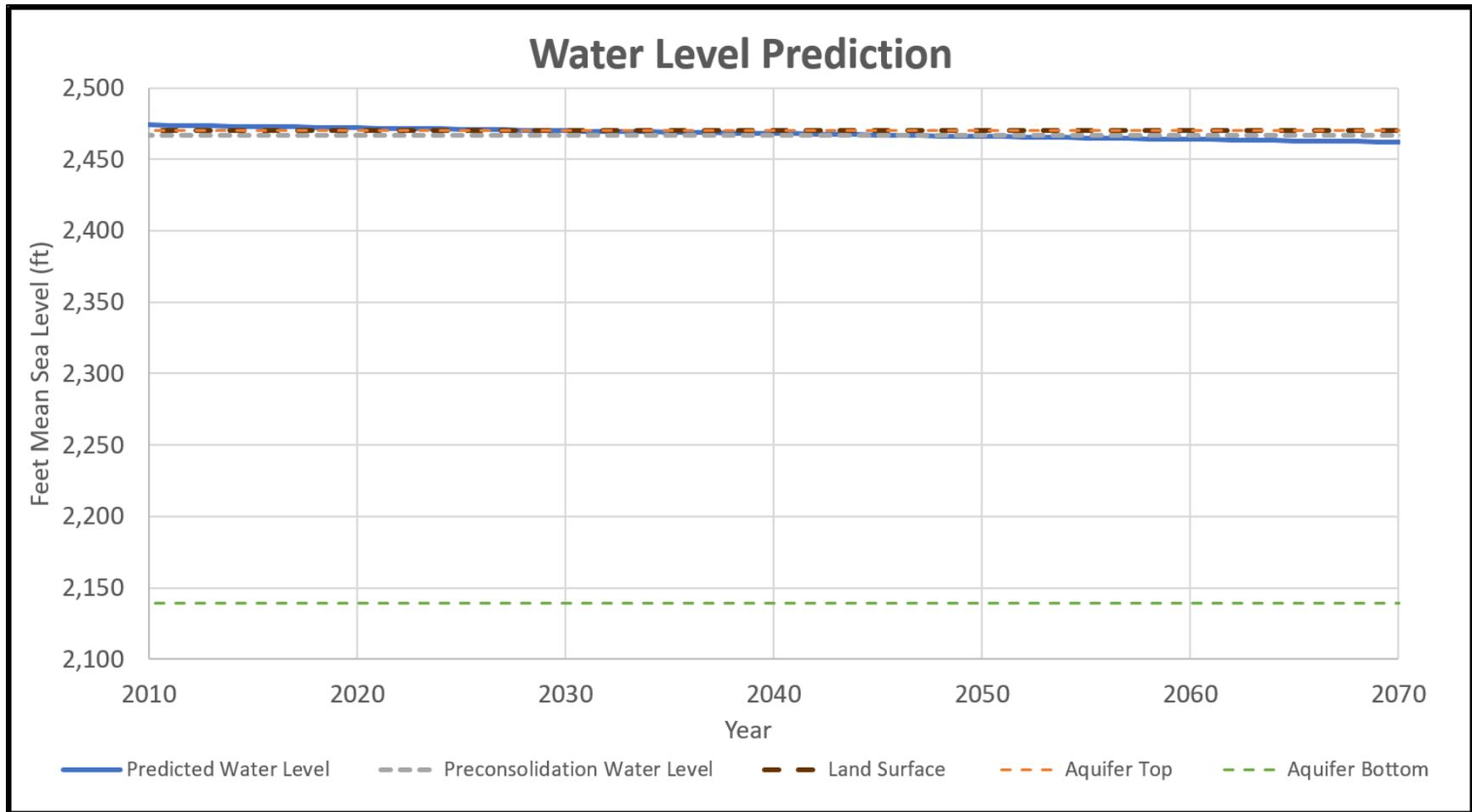
Figure 2.6. Subsidence prediction tool Pecos Valley Aquifer input and calculated values for Tracking Number 417430 in the Submitted Drillers Report database.



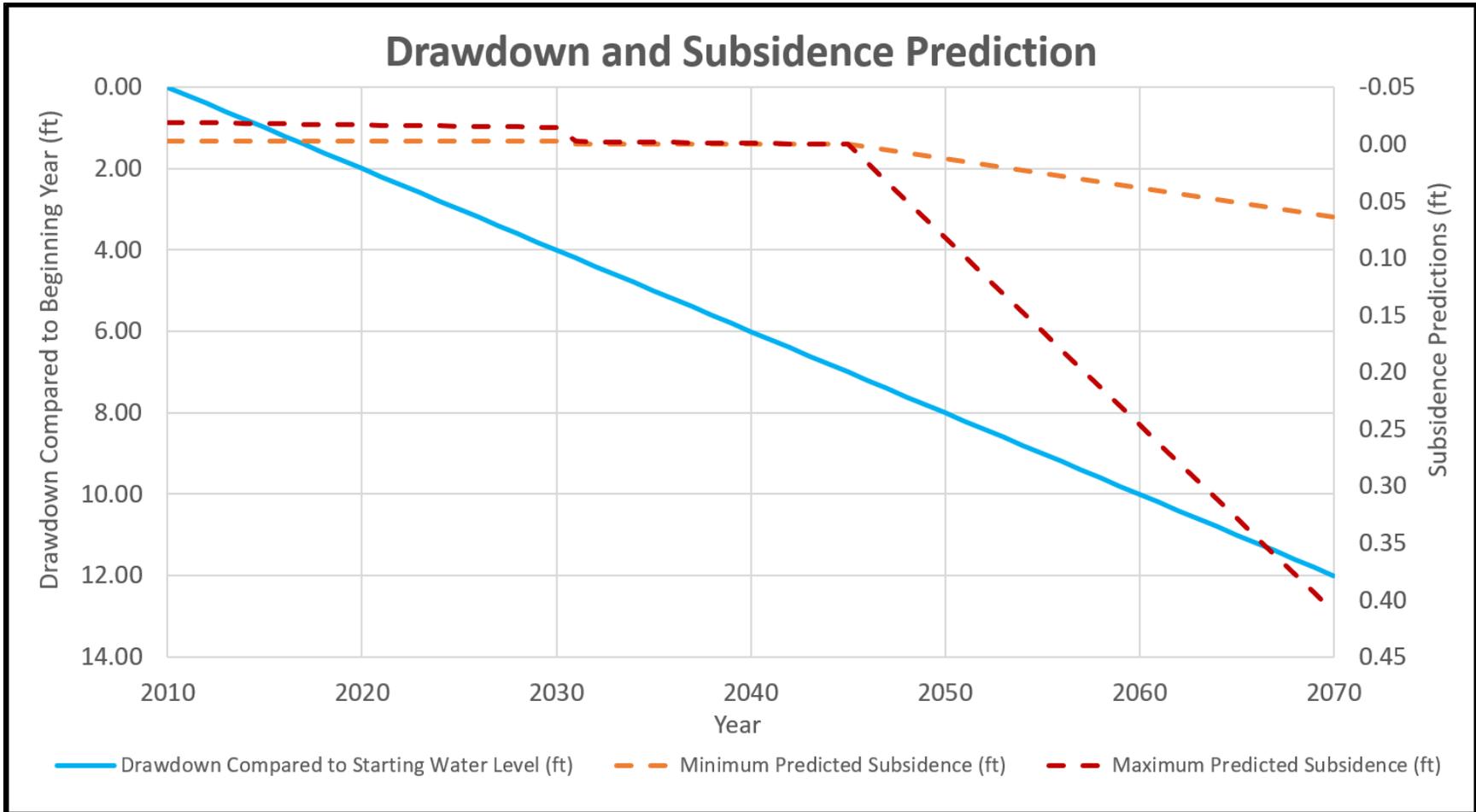
**Figure 2.7.** Subsidence prediction tool predicted water level chart based on the *Current and Trend Water Levels to Use for Predictions for Tracking Number 417430* in the Submitted Drillers Report database.



**Figure 2.8. Subsidence prediction tool predicted drawdown and potential subsidence chart based on the *Current and Trend* Water Levels to Use for Predictions for Tracking Number 417430 in the Submitted Drillers Report database.**



**Figure 2.9.** Subsidence prediction tool predicted water level chart based on the *Base and Future Water Levels to Use for Predictions* for Tracking Number 417430 in the Submitted Drillers Report database.

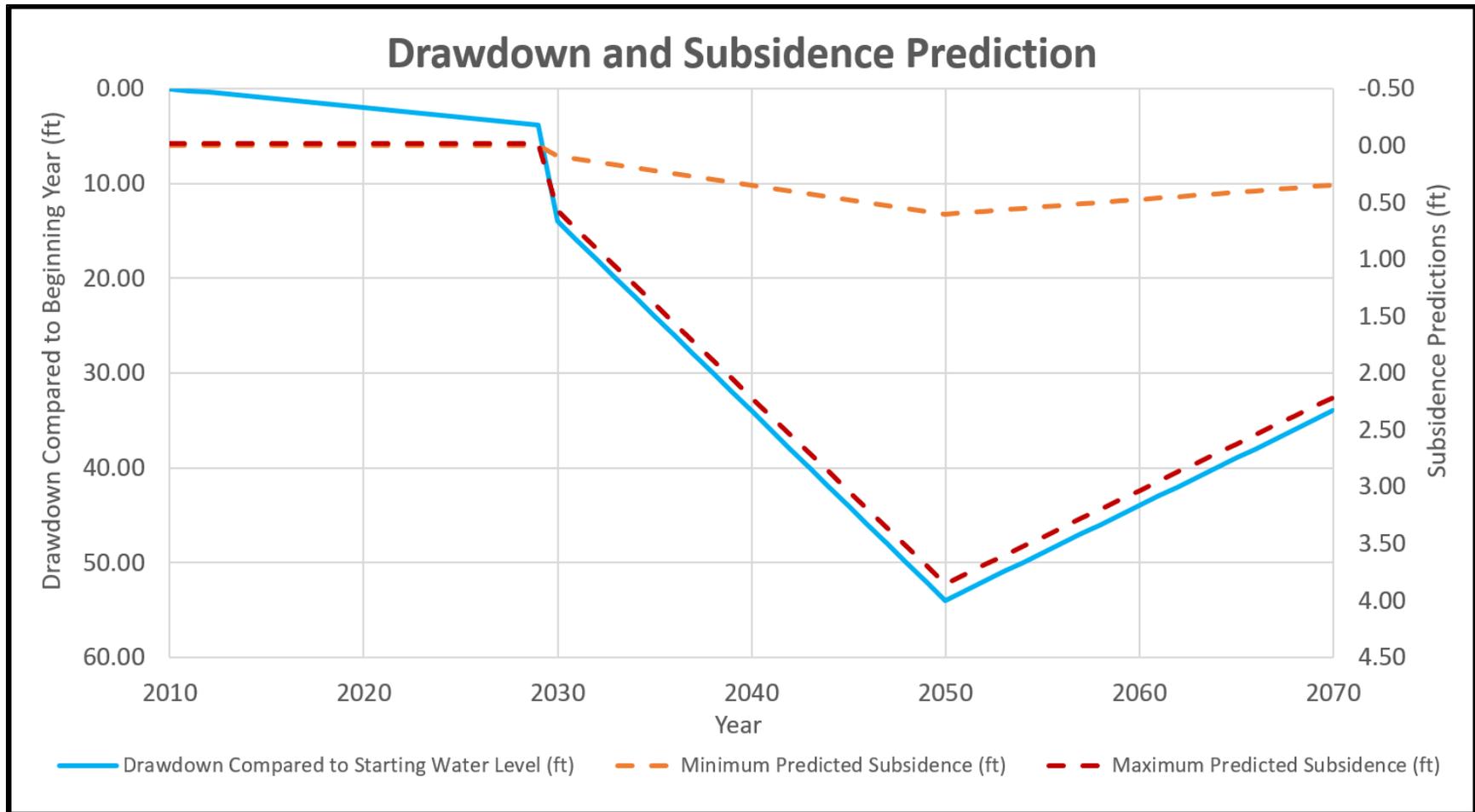


**Figure 2.10. Subsidence prediction tool predicted drawdown and potential subsidence chart based on the *Base and Future Water Levels to Use for Predictions for Tracking Number 417430 in the Submitted Drillers Report database.***

**Table 2.1. Excerpt of the subsidence prediction tool table of predicted water level, drawdown, and potential subsidence for Tracking Number 417430 in the Submitted Drillers Report database.**

**Water Level and Subsidence Estimates based on Aquifer Trend**

Year	Water Level (ft)	Drawdown compared to Starting Water Level (ft)	Minimum Predicted Subsidence (ft)	Maximum Predicted Subsidence (ft)
2010	2,467	0.00	0.30	1.90
2011	2,467	0.27	0.30	1.92
2012	2,466	0.53	0.30	1.94
2013	2,466	0.80	0.31	1.96
2014	2,466	1.06	0.31	1.99
2015	2,466	1.33	0.31	2.01
2016	2,465	1.60	0.32	2.03
2017	2,465	1.86	0.32	2.05
2018	2,465	2.13	0.32	2.07
2019	2,465	2.39	0.33	2.09
2020	2,464	2.66	0.33	2.12
2021	2,464	2.93	0.33	2.14
2022	2,464	3.19	0.34	2.16
2023	2,464	3.46	0.34	2.18
2024	2,463	3.72	0.34	2.20
2025	2,463	3.99	0.35	2.23
2026	2,463	4.26	0.35	2.25
2027	2,462	4.52	0.36	2.27
2028	2,462	4.79	0.36	2.29
2029	2,462	5.05	0.36	2.31
2030	2,462	5.32	0.37	2.33



**Figure 2.11. Subsidence prediction tool predicted drawdown and potential subsidence chart based on the *Base and Future Water Levels to Use for Predictions for Tracking Number 417430 in the Submitted Drillers Report database with manual modifications to the predicted water levels.***