
TECHNICAL MEMORANDUM

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DATE: November 6, 2025 (revised December 18, 2025, finalized January 2026)

RE: Summary of Analysis of BBGM Version 1.0, Update to BBGM Version 1.2, and Time Series Extension

The Butte Basin Groundwater Model (BBGM)—run using the Integrated Water Flow Model (IWFM) code maintained by the California Department of Water Resources (DWR)—was originally developed beginning in 1992. Since that time, the model has undergone several significant updates, with the previous update supporting the development of the Groundwater Sustainability Plans (GSPs) for the Vina, Butte, and Wyandotte Creek Groundwater Subbasins. This effort resulted in a version of the model called BBGM-2020 in the previous model documentation (BCDWRC, 2021) and is now referred to as BBGM Version 1.0.

Beginning in 2024 as part of the Inter-basin Coordination Analysis and Modeling project, BBGM Version 1.0 was analyzed to consider opportunities for enhancements to the model. The primary focus of the forthcoming update of BBGM Version 1.0 was twofold:

1. Revise model based on recommended improvements documented in the BBGM Version 1.0 (BCDWRC, 2021).
2. Enhance the model's simulation of interbasin flows and stream-aquifer interaction, as included in the Sustainable Groundwater Management (SGM) Grant Program's Implementation Round 2 grants received by the Vina and Wyandotte Creek Groundwater Subbasins. The Sacramento River model boundary was identified as the primary area of focus for interbasin flows and stream-aquifer interaction, though Feather River was investigated as well.

Many of the items analyzed in the following pages were concepts first identified in Section 5.3 of the BBGM Version 1.0 documentation for future refinement recommendations.

The sections of this technical memorandum cover:

- Analysis of BBGM Version 1.0 (formerly called BBGM2020) with comparisons to available regional models
- Update of the model to BBGM Version 1.2, with descriptions of changes to boundary conditions
- Update to the IWFM model code, and how that affected the model
- Extension of the time series in BBGM Version 1.2 through Water Year 2024, to develop BBGM Version 1.2 through Water Year (WY) 2024, referred to as BBGM Version 1.3 (BBGM 2025)
- Comparison of BBGM Version 1.2 to BBGM Version 1.0, and to recently released DWR model

The model inputs and functionalities analyzed or updated are summarized in Table 1, which includes major data category, minor data category, data source, and references to the applicable report section both in this technical memorandum as well as in the BBGM Version 1.0 model report. This table is a reproduction

of Table 2-1 in the BBGM Version 1.0 model report (BCDWRC, 2021); only relevant data categories considered in this technical memorandum are included in the table.

The goal of the updates described in this technical memorandum is to ensure that BBGM continues to serve as a reliable and practical tool for local analysis and for supporting Sustainable Groundwater Management Act (SGMA) activities in Butte County Subbasins, including the upcoming Periodic Evaluations due in early 2027. Specific goals of the analysis of and revisions to BBGM included:

- Support for continued SGMA implementation since the updated model can provide a technical foundation for 2027 Periodic Evaluations.
- Improved representation of Butte County Subbasins through the model refinements in BBGM Version 1.2, including boundary condition adjustments, IWFM version updates, and extended time series.
- Regional coordination since analysis of BBGM can highlight opportunities for collaboration with neighboring GSAs to ensure consistency with adjacent groundwater subbasin models and groundwater understanding.
- Streamlined model updates for future refinements to and extensions of BBGM.
- Comparisons to regional models to document how BBGM results align with the regional models.

Table 1: Model Input Data Summary including Data Category, Source, and Report Section

Major Data Category	Minor Data Category	Data Source	Analysis and BBGM Version 1.2 Update Section	IWFM Version Update and Time Series Extension Section	BBGM Version 1.0 Model Report Section
Hydrogeological Data	Geologic Stratification	AEM	1.5.1	n/a	2.11
	Ground Surface Elevation	DEM	1.2, 2.1.2	n/a	2.11
Hydrological Data	Stream Inflow	USGS and CDEC Stream Gages	n/a	3.1.2, 4.2.3	2.4.1
	Streambed Parameters	C2VSimFG v1.01	1.3, 2.1.3	n/a	2.4.5, 5.3.2
	Precipitation	PRISM	n/a	4.2.1	2.3
Agricultural Water Demand	Land Use	DWR Crop Survey	n/a	4.2.4	2.7
	Evapotranspiration	CIMIS	n/a	3.1.1, 4.2.2	2.8
Water Supply	Groundwater Pumping	Local agencies	n/a	3.1.3, 4.2.5	2.10.4
	Surface Water Diversions	Surface water supplier diversion records	n/a	4.2.6	2.10.1
Other	Boundary Conditions	C2VSimFG	1.1, 2.1.1	3.1.4, 4.2.7	2.12, 5.3.1
	Small-Stream Watersheds	n/a	1.4	n/a	none

1. ANALYSIS OF BBGM VERSION 1.0

This section describes the analysis of BBGM Version 1.0 (formerly called BBGM-2020) completed between summer 2024 and spring 2025. Specific topics selected for further analysis were determined using the BBGM Version 1.0 model report, the GSPs for the subbasins contained in BBGM, and the SGM grant applications for Vina and Wyandotte Creek Subbasins.

1.1 Boundary Conditions

In Section 5.3.1 of the BBGM Version 1.0 documentation recommendations section (BCDWRC, 2021), the western boundary of the BBGM Version 1.0 was noted to be an area for future refinement, as follows:

Interbasin flows along the western boundary of the BBGM are currently estimated using a variable specified head boundary condition developed from an earlier version of C2VSim. It is recommended that estimates of subsurface groundwater flows from and to neighboring basins be refined through coordination with neighboring subbasins and through review of more recent modeling tools that cover the Sacramento Valley region, including the C2VSim and SVSim integrated hydrologic model applications developed by DWR or refined by local agencies. It is recommended this evaluation also include an assessment of stream-aquifer interactions of the Sacramento River and their relation to subsurface flows. Ultimately, these refinements could involve updates to the specified boundary heads in the BBGM, or a general head boundary condition could be implemented.

As described in the BBGM Version 1.0 model report (BCDWRC, 2021; Section 2.12), BBGM Version 1.0 contained a variable specified head boundary condition around the northern, western, and part of the southern boundaries of the model (along Deer Creek and Sacramento River). A specified head boundary condition assumes a time series of head value for designated points of the boundary; for BBGM Version 1.0, groundwater levels assigned as specified head were estimated using C2VSimCG (Version R380). A general head boundary condition, on the other hand, is applied when the head value is known at a distance from the boundary nodes (e.g., groundwater observation wells in adjacent groundwater subbasins). In order to set up a general head boundary condition, a defined conductance is necessary. General head boundary conditions can be derived directly from available groundwater head data while specified head boundary conditions are derived from a regional model. Switching to a general head boundary therefore ties the model more directly to measurable conditions and facilitates future updates by reducing reliance on external models.

A general head boundary condition was initially developed and tested for BBGM Version 1.0 using an interim version of the DWR California-Central Valley Groundwater-Surface Water Simulation Model Fine Grid (C2VSimFG) prior to the release of the C2VSimFG Version 1.0; this version of the model is referred to as C2VSimFG Version 0.5. In order to match the 9 layers of BBGM Version 1.0 to the 4 layers of C2VSimFG Version 0.5, the layer thickness at each BBGM Version 1.0 node was matched with the closest C2VSimFG Version 0.5 node. The resulting layers were matched as follows in Table 2.

Table 2: Matching of BBGM and C2VSimFG Model Layers

BBGM Version 1.0 Layer	C2VSimFG Version 0.5 Layer
Layer 1	Layer 1
Layer 2	
Layer 3	Layer 1 or Layer 2 (depending on thickness)
Layer 4	Layers 1, 2, 3, or 4 (depending on thickness)
Layer 5	Layers 1, 2, or 3 (depending on thickness)
Layer 6	Layers 1, 2, 3, or 4 (depending on thickness)
Layer 7	Layers 2, 3, or 4 (depending on thickness)
Layer 8	
Layer 9	None matched (BBGM bottom layer has no boundary condition)

The conductance values at the boundary condition nodes were calculated from the uncalibrated BBGM Version 1.0 horizontal hydraulic conductivity, distance to the reference point, layer thickness, and the length of the boundary section represented by each node. The reference groundwater level time series at around 3,000 feet from the boundary were extracted from C2VSimFG Version 0.5. The extracted values were compared with the observed groundwater elevations from DWR’s water data library (WDL) and modified to better fit the observed elevations by trend and bias correction while protecting the spatial variation provided by the C2VSimFG Version 0.5. Much of this process was automated using a script, but manual adjustment was made by reviewing each boundary node individually.

A version of BBGM Version 1.0 with these general head boundary conditions described above was tested and various results were reviewed, including the stream-aquifer interaction along Sacramento and Feather Rivers, interbasin flows, groundwater budgets, and groundwater levels. The general head boundary conditions usually resulted in a dampening or smoothing of the boundary flow trends in comparison to those observed using a specified head boundary condition. Though the general head boundary condition appears steady compared to specified head boundary condition, it still has monthly and annual variation based on hydrology and water use, but on a smaller scale (Figure 1, Figure 2, and Figure 3). Boundary conditions are discussed further in Section 2.1.1 with regards to the update to BBGM Version 1.2.

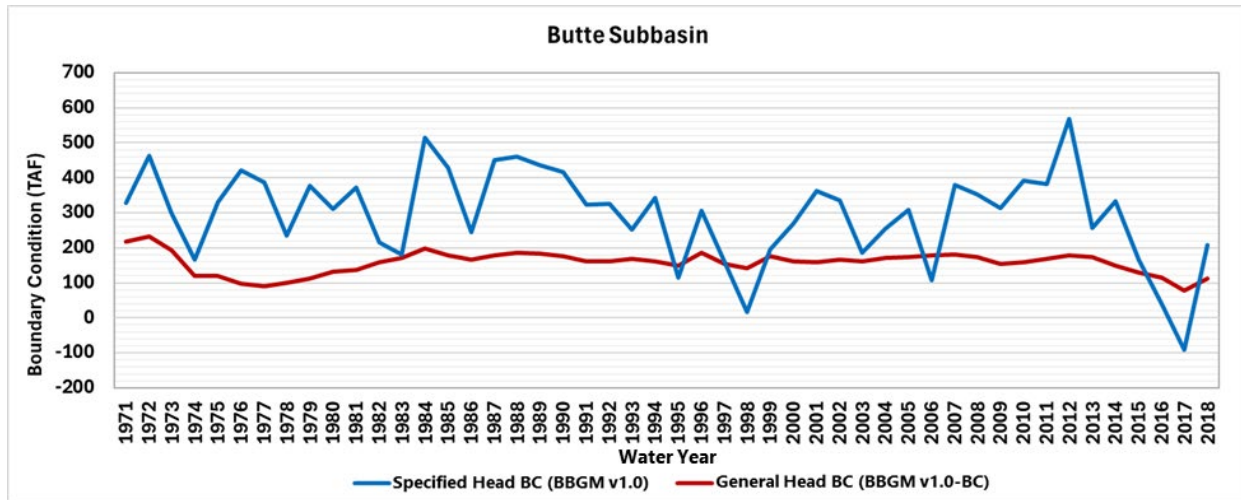


Figure 1: Annual Butte Subbasin General Head Versus Specified Head Boundary Conditions

Note: BBGM v1.0-BC is the version of BBGM Version 1.0 with general head boundary conditions. This is slightly different from the final boundary conditions updates implemented in BBGM Version 1.2.

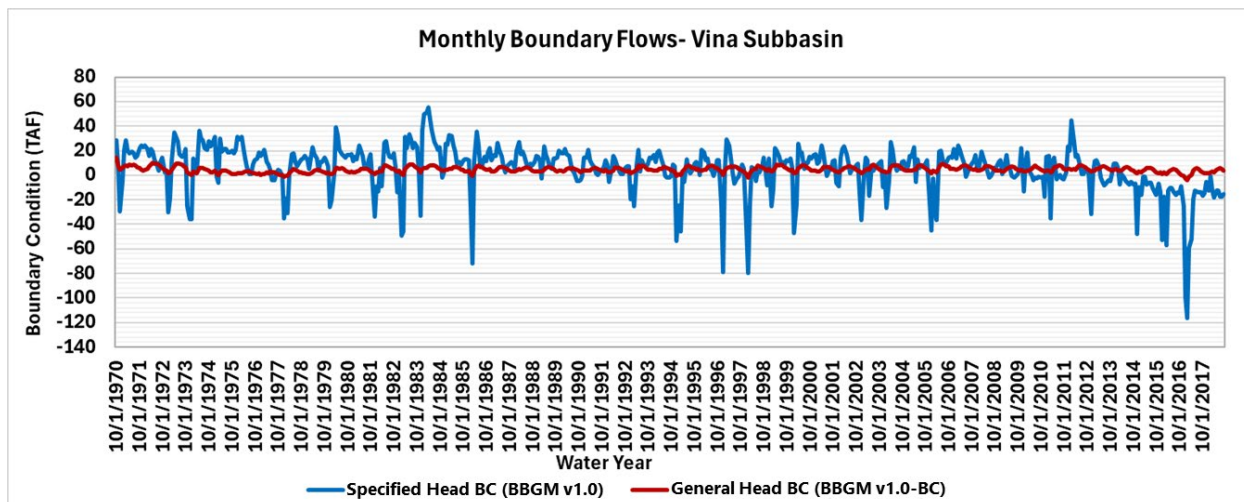


Figure 2: Monthly Vina Subbasin General Head Versus Specified Head Boundary Conditions

Note: BBGM v1.0-BC is the version of BBGM Version 1.0 with general head boundary conditions. This is slightly different from the final boundary conditions updates implemented in BBGM Version 1.2.

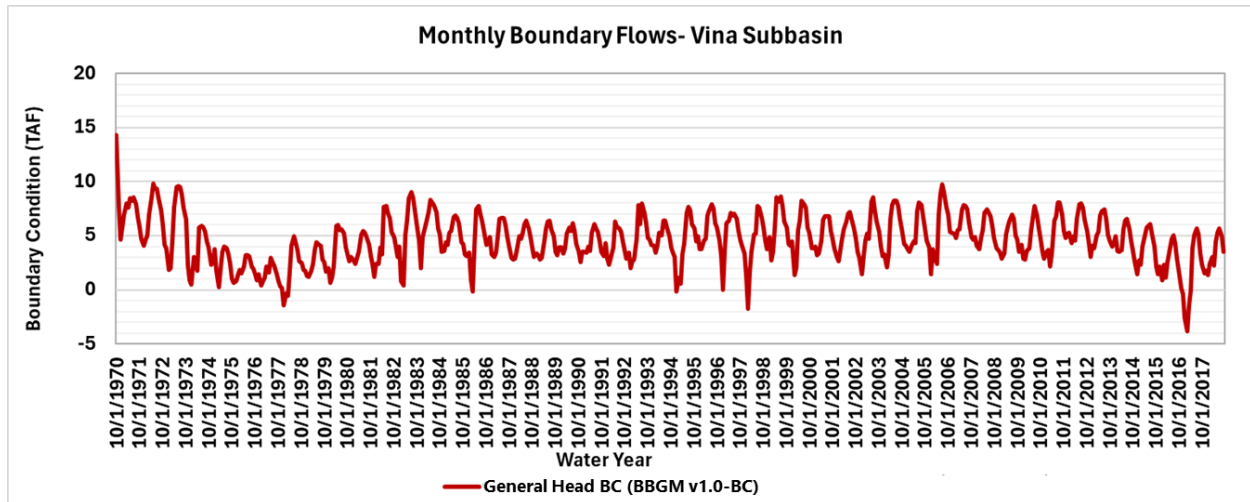


Figure 3: Monthly Vina Subbasin General Head Boundary Conditions

Note: BBGM v1.0-BC is the version of BBGM Version 1.0 with general head boundary conditions. This is slightly different from the final boundary conditions updates implemented in BBGM Version 1.2.

1.2 Ground Surface Elevation

During the update of BBGM Version 1.0, discrepancies were noticed between the ground surface elevations in the model and the ground surface elevations of foothill groundwater level calibration wells within the model area. To analyze the differences, the USGS's Digital Elevation Model (DEM) at 1/3 arc-second scale (approximately 10-meter resolution) was downloaded and extracted to the model nodes. When the DEM was directly compared against the ground surface elevations in the model, the elevation differences were sometimes hundreds of feet with the most dramatic differences occurring in the foothill zones within the Vina Subbasin portion of the model (see Figure 4).

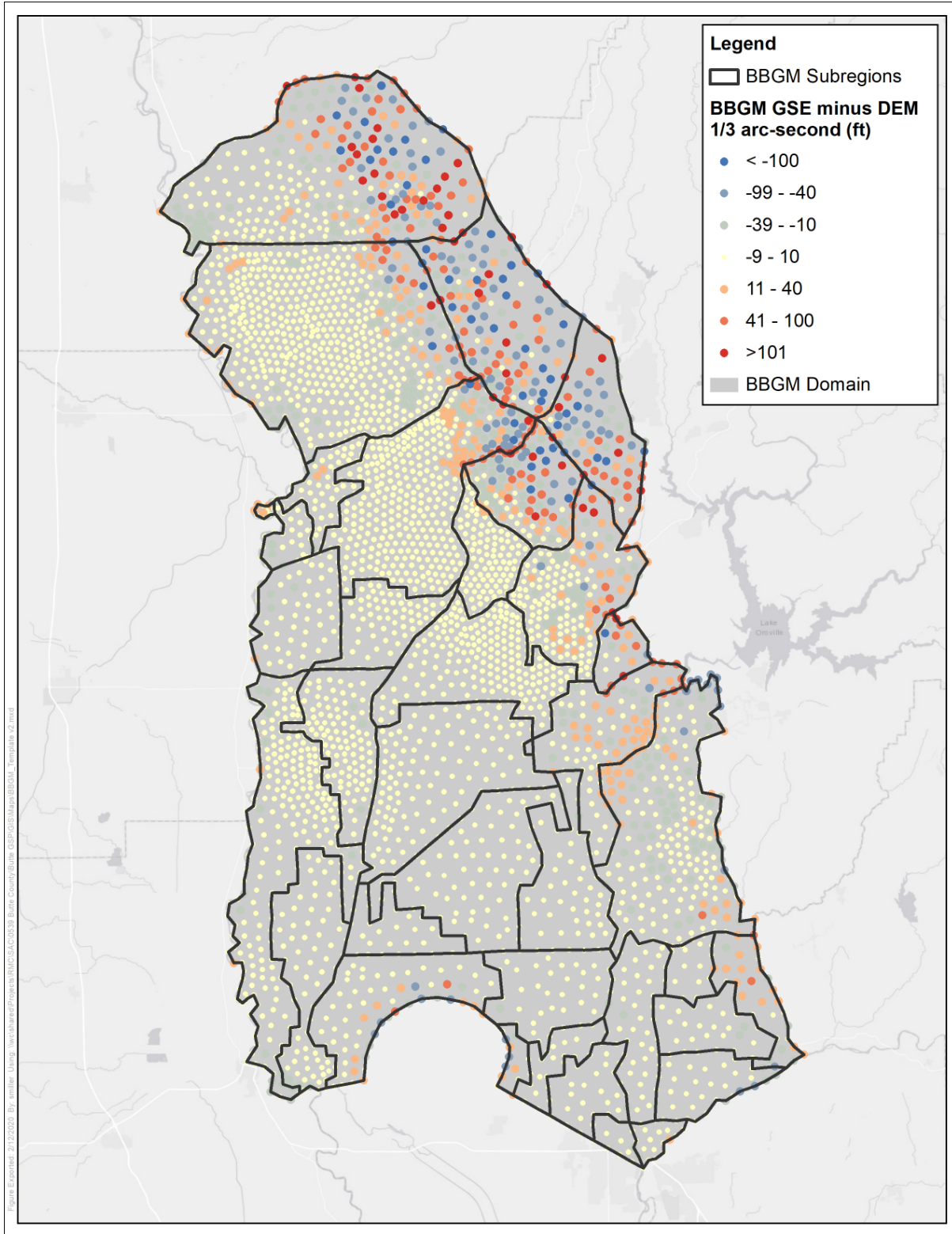


Figure 4: BBGM Version 1.0 Ground Surface Elevation Minus Digital Elevation Model

A version of BBGM Version 1.0 with ground surface elevations updated per the downloaded DEM was tested. To run the model with the updated ground surface elevations, the streambed elevations for 33 stream nodes and well perforations for 52 wells were adjusted so they were below the updated ground surface elevations. The change to the ground surface elevation had an overall minor impact on Sierra Nevada foothill groundwater budgets (Figure 5).

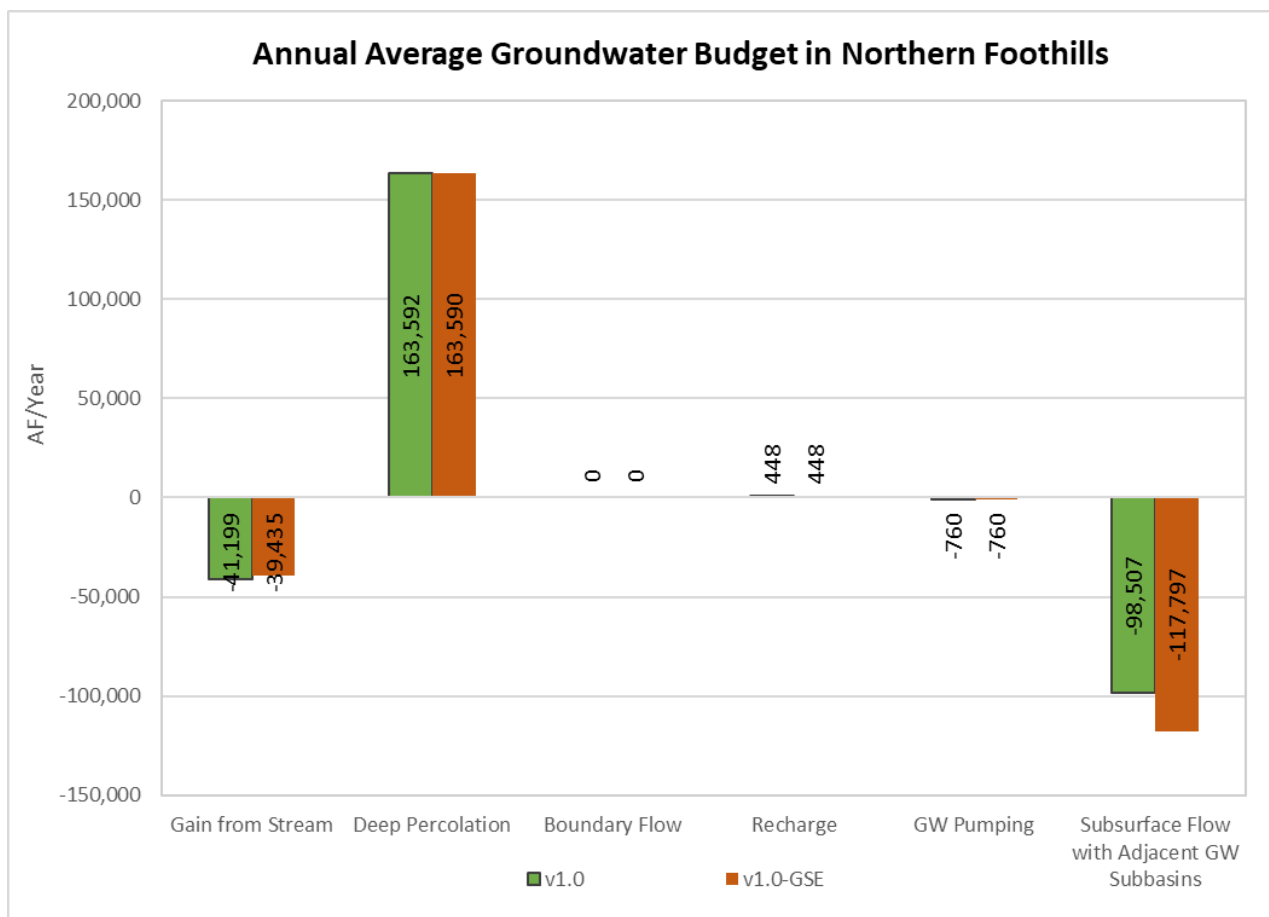


Figure 5: Select Groundwater Budget Components in the Northern Foothills Model Area with and without Ground Surface Elevation Updates

Note: BBGM v1.0-GSE is the version of BBGM Version 1.0 with ground surface elevation changes. These are the same ground surface elevation changes implemented in BBGM Version 1.2. The recharge term refers to canal losses and reservoir leakage to groundwater.

1.3 Sacramento River Streambed Hydraulic Conductance Sensitivity

In Section 5.3.2 of the BBGM Version 1.0 documentation recommendations section (BCDWRC, 2021), the western boundary of BBGM Version 1.0 was noted to be an area for future refinement, as follows:

*It is recommended that estimates of subsurface groundwater flows from and to neighboring basins be refined through coordination with neighboring subbasins and through review of more recent modeling tools that cover the Sacramento Valley region, including the C2VSim and SVSim integrated hydrologic model applications developed by DWR or refined by local agencies. It is recommended this evaluation also **include an assessment of stream-aquifer interactions of the Sacramento River and their***

relation to subsurface flows. *Ultimately, these refinements could involve updates to the specified boundary heads in the BBGM, or a general head boundary condition could be implemented.*

While comparing BBGM Version 1.0 against the overlapping regional models, it was noted that while long-term average stream inflows were mostly aligned, streambed hydraulic conductance were varied for the regional models. As described in the BBGM Version 1.0 model report (BCDWRC, 2021; Section 2.4.5), the streambed thickness is set to 1 foot for all BBGM stream nodes, so the conductance is the same as the streambed hydraulic conductivity; for BBGM Version 1.0, the streambed hydraulic conductivity (K) is set to 1 foot per day (ft/day) along all modeled stream nodes. After reviewing stream parameters in overlapping regional models (C2VSimFG and SVSim), it was determined the team should test the model sensitivity to streambed hydraulic conductivity along Sacramento River. Four streambed hydraulic conductivity sensitivity runs were completed where Sacramento River streambed hydraulic conductivity was changed from 1 foot per day to:

- Sacramento River streambed K divided by 5 (set equal to 0.2 ft/day)
- Sacramento River streambed K divided by 2 (set equal to 0.5 ft/day)
- Sacramento River streambed K multiplied by 2 (set equal to 2 ft/day)
- Sacramento River streambed K multiplied by 5 (set equal to 5 ft/day)

In the results of the sensitivity runs, it was expected that increased streambed hydraulic conductivity would increase gain from stream and boundary flows relative to the base version of BBGM. The expected increased gain from stream is observed, but the model impact is very minor (Figure 6). The impact of hydraulic conductivity on boundary flow is not as pronounced; it appears that gain from stream is directly impacted by streambed hydraulic conductivity, but boundary flow is only indirectly impacted. Overall, BBGM Version 1.0 streamflows and boundary condition flows do not appear to be very sensitive to Sacramento River streambed hydraulic conductivity. It should be noted that in BBGM, streambed hydraulic conductivity is the same as streambed conductance, and the terms can be used interchangeably.

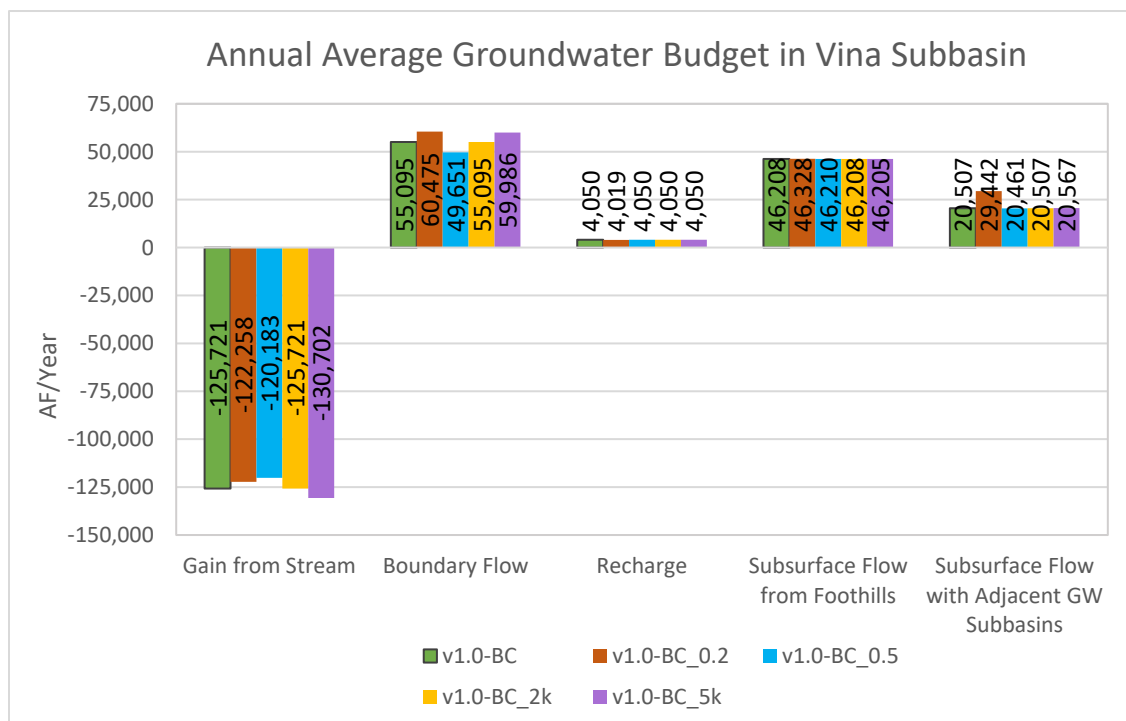


Figure 6: Selected Groundwater Budget Components in Vina Subbasin under Varying Sacramento River Streambed Hydraulic Conductivities

1.4 Eastern Boundary Flows

BBGM Version 1.0 assumed a no-flow boundary on the eastern edge of the model (Sierra Nevada Mountains) and around the Sutter Buttes. This differs from neighboring and overlapping IWFm local and regional models, which typically use the Small Watershed Component of IWFm to simulate inflows from foothill precipitation and small creeks.

Instead of utilizing the Small Watershed Component of IWFm, BBGM Version 1.0 represents these inflows using two subregions: Subregion 3 (Northern Foothills) and Subregion 8 (Foothill Area). These subregions provide estimates of the subsurface and surface flows that ultimately discharge into Los Molinos Subbasin, Vina Subbasin, and portions of Wyandotte Creek Subbasin. The remaining areas of BBGM Version 1.0, however, assume no foothill inflow; for example, North Yuba Subbasin has no simulated foothill contribution and Sutter Subbasin assumes no inflows from the Sutter Buttes.

There is very little observed data or measured flows to estimate the actual flow from the foothills that may enter the model. Regional models are not consistent on the amount of water that might enter the groundwater subbasins in the form of surface runoff or subsurface flow. Table 3 compares average simulated foothill inflows across BBGM Version 1.0, C2VSimFG v1.01, and SVSim Version 1.0 for a consistent time period, WY 1974 through 2015. The results highlight wide variation among models. BBGM should consider updating its representation of boundary conditions in future model updates.

Table 3: Average Flow from Foothills (acre-feet per year, AFY), WY 1974-2015

Model Version	Butte	Vina	Wyandotte Creek
BBGM Version 1.0	0	41,949	1,627
C2VSimFG v1.01	896	18,204	2,948
SVSim Version 1.0	1,245	8,837	4,101

1.5 Review of Additional New Data

Several types of additional data were reviewed for incorporation into the BBGM update. DWR provided subsurface geophysical information derived from airborne electromagnetic (AEM) surveys of Butte County Groundwater Subbasins. Construction of a slurry wall in a Feather River levee was reviewed to determine the impact on stream-groundwater flows. Additional data was also collected from local agencies.

1.5.1 AEM Survey Data

DWR recently conducted AEM surveys in high- and medium-priority groundwater basins across California. The purpose of the AEM surveys was to provide technical assistance to water managers implementing GSPs under SGMA by providing data on subsurface hydrogeologic characteristics for aquifer systems underlying the surveyed groundwater basins. AEM surveys provide high-resolution, geologically based data to support both validation and refinement of the existing understanding of the Subbasin’s aquifer system. AEM includes detailed resistivity and texture datasets and information related to the coarseness of sediments (sands versus clays), the degree of saturation of rock (saturated or not), and the water quality of saturated rock (saline or not). AEM surveys measure the electrical resistivity of subsurface materials, allowing geophysicists to interpret subsurface lithology, identify and map structural features such as faults, and assess water quality including the presence and extent of saltwater intrusion. This dataset is invaluable for refining layers by providing a new large-scale, vertically and horizontally continuous texture dataset, which is particularly useful in areas where existing well logs may not provide a full picture of subsurface conditions.

The BBGM area was surveyed in April and May 2022 (Figure 7). There was an earlier pilot project conducted in Butte and Glenn Counties that covered small areas of Vina and Butte Subbasins in December 2018; the results of the pilot project were not included in the processed data. The AEM data were processed and used to generate three resistivity inversion models: a smooth, a sharp, and a few-layer model. The AEM data were then processed using compiled lithologic well logs that were converted to coarse and fine material classifications. These binary classifications were correlated to the resistivity values to produce a percent coarse-fraction texture model for each flight line. This texture model, along with existing surficial geologic maps, was used to compare against the BBGM layers.

Cross sections for each flight line in the BBGM extent were developed, showing the AEM coarse-fraction data, supplemental well logs, and existing model layers (Figure 8 is representative; all 27 cross sections are included in Attachment 1). The figures show the AEM data along survey lines in the model domain with coloring according to the coarse fraction (darker=finer and coarser=lighter). Model layering is included as thin colorful lines representing BBGM model layers 1 through 9. Areas with data gaps in the AEM resistivity data usually indicate urban areas.

BBGM Version 1.0 layers align with AEM data reasonably well. Since AEM data are still being actively reviewed, especially by DWR, the decision was made to not update BBGM layering at this time. Many other models that have already incorporated AEM data into the model layering were doing so in order to add more layers to better represent the aquifer system and geology; BBGM Version 1.0 already has 9 layers. The



model layering may be reevaluated in future efforts. Data from the well logs released by DWR as part of their AEM data package may also be useful for refining hydraulic conductivity in future model updates.

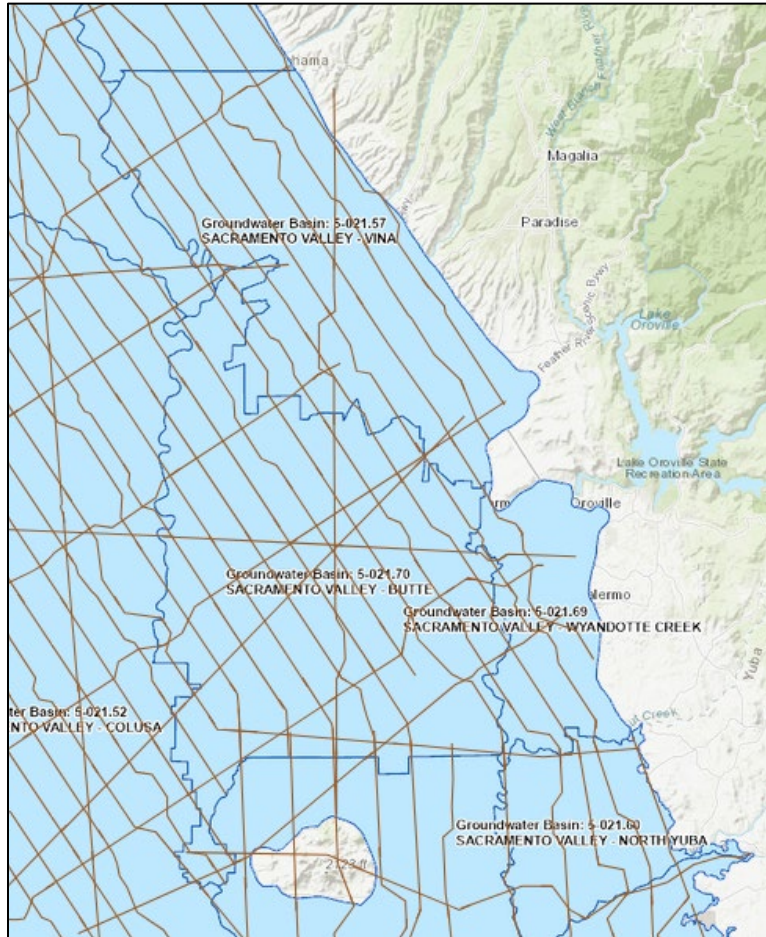


Figure 7: 2022 AEM Survey Lines Above BBGM Domain

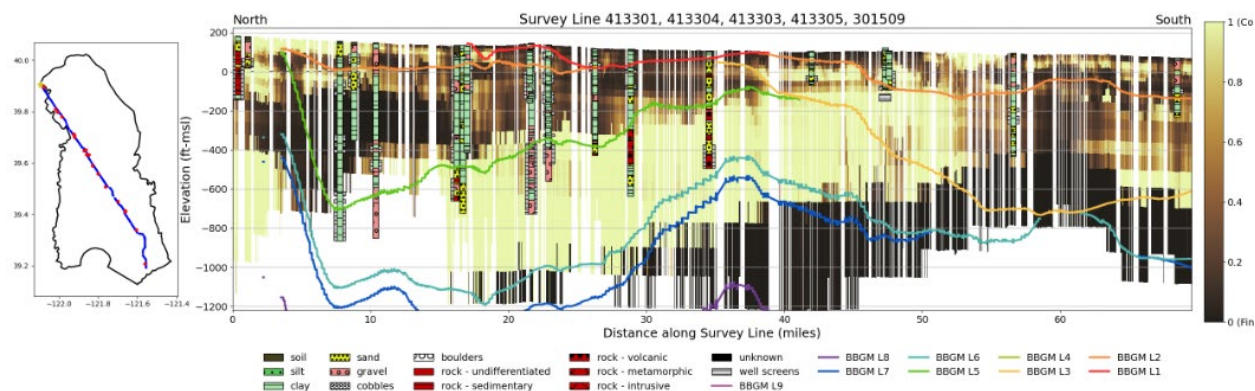


Figure 8: Cross Section 12 Showing AEM Data and Model Layers

1.5.2 Feather River Slurry Wall

The Feather River Slurry Wall is a project by the Sutter Butte Flood Control Agency to repair 44 miles of levees along the west side of the Feather River from Thermalito Afterbay to the Sutter Bypass. The project was operated as two separate projects, with the first extending from Thermalito Afterbay to Star Bend south of Yuba City and the second from Star Bend to the confluence of the Feather River and the Sutter Bypass. Both projects have been completed, and a variable-depth slurry wall was added to the west side of the Feather River; the maximum depth of the slurry wall is apparently 130 feet (SBFCA, 2019).

There was an interest to evaluate the potential to simulate this slurry wall with the BBGM to assess how groundwater flows are affected. The extent of BBGM where the slurry wall would be incorporated is about 50 model elements and 61 stream nodes along Feather River. Layer 1 of BBGM Version 1.0 in this area is primarily 200 feet and should contain the entire slurry wall, but a small portion of Feather River in this area has Layer 1 thickness of under 100 feet and would need to be investigated further. The following options for representing the slurry wall in BBGM were reviewed:

- Adjust Layer 1 horizontal hydraulic conductivity at the existing affected groundwater nodes along Feather River.
- Adjust Layer 1 horizontal hydraulic conductivity at the model elements on the left side of Feather River along the extent of the slurry wall. This would use IWFEM's ability to change aquifer parameters for anomaly elements.
- Modify the BBGM model grid to add slender elements representing the slurry wall extent. After that, adjust horizontal hydraulic conductivity at either the model element or node level as described in the bullets above.

Overall, it is unclear based on the information available on the project if the slurry wall impacts subsurface groundwater flow. Given that simulation of the wall would require a substantial revision to the model that would apply to the entire historical time period (e.g., model layering and hydraulic conductivity), it was decided not to incorporate the slurry wall at this time until there is more information, such as relevant observed water level data near the infrastructure to calibrate the model. The slurry wall may be considered for any baseline simulations representing future conditions.

1.5.3 Transboundary Flow Balance Index

The Transboundary Flow Balance Index (TFBI) is a metric that can be used to assess the net water exchange across basin boundaries. It is calculated using the formula:

TFBI = (FBA - FAB) / (FBA + FAB), where:

FAB = Flow from Basin A to Basin B

FBA = Flow from Basin B to Basin A

For example, if FAB = 100 AF/year and FBA = 200 AF/year, then:

$$\text{TFBI} = (200 - 100) / (200 + 100) = 0.33$$

To interpret results, a positive TFBI indicates Basin A is gaining water, while a negative TFBI would indicate Basin A is losing water. In the example above, Basin A is gaining water.

TFBI > 0: Basin A is gaining water (FBA > FAB)

TFBI < 0: Basin A is losing water (FBA < FAB)

This approach was applied to Feather River for BBGM Version 1.0 to help visualize the groundwater flow directions and potentially impact of the Feather River Slurry Wall. Feather River in BBGM is separated into 3 stream reaches: Reach 16 includes 16 stream nodes from Thermalito Diversion Dam to Thermalito Afterbay (approximately 8 miles) and Reaches 17 and 21 combined include 45 stream nodes downstream of Thermalito Afterbay (approximately 20 miles). Reach 17 spans from Thermalito Afterbay to South Honcut Creek and Reach 21 extends from South Honcut Creek to the Yuba River. Subsurface groundwater flow zones are mapped across the Feather River reaches. Zones are labeled from 1 to 6 and represent distinct hydrogeologic areas that influence groundwater movement and interaction with surface water. Figure 9 shows the six interbasin flow zones for BBGM Feather River stream Reach 16, Reach 17, and Reach 21.

The annual total subsurface flows across Feather River for each zone were extracted from BBGM and used to calculate the annual TFBI across each Feather River stream reach for 2000 through 2018 (Table 4). The average TFBI results are visualized with directional arrows indicating flow balance across zones in Figure 9. These values include 0.35, 0.44, and 0.06, representing the TFBI across different transboundary segments, with the arrow representing the direction of flow.

The following table presents TFBI values for subsurface groundwater flows between the zones on either side of Reach 16, Reach 17, and Reach 21 from 2000 to 2018. It also includes the average TFBI and total subsurface flow (in thousand acre-feet per year) for subsurface groundwater flow beneath each reach. This analysis shows that for this period groundwater flowed from west to east under the Feather River. During this period, the flow volume is always greater beneath Reach 17 than Reach 16. The overall average flow beneath Reach 21 is from west to east for 2000 through 2018, but the flow direction reversed for five years between 2012 and 2018, suggesting a change in either water supplies or water demands during this period. This analysis is not used again in the documentation but was included as an example of how groundwater flow may be visualized in future applications of BBGM.

Table 4: Feather River Transboundary Flow Balance Index

Year	Feather River Reach 16	Feather River Reach 17	Feather River Reach 21
2000	0.22	0.33	-0.07
2001	0.23	0.39	0.03
2002	0.26	0.50	0.18
2003	0.30	0.52	0.16
2004	0.32	0.50	0.10
2005	0.33	0.41	0.03
2006	0.32	0.38	0.00
2007	0.31	0.42	0.07
2008	0.33	0.48	0.16
2009	0.37	0.52	0.11
2010	0.41	0.54	0.12
2011	0.43	0.50	0.01
2012	0.42	0.45	-0.01
2013	0.44	0.43	-0.02
2014	0.45	0.48	0.13
2015	0.45	0.42	0.17
2016	0.43	0.32	-0.01
2017	0.39	0.32	-0.06
2018	0.33	0.32	-0.03
Average	0.35	0.44	0.06

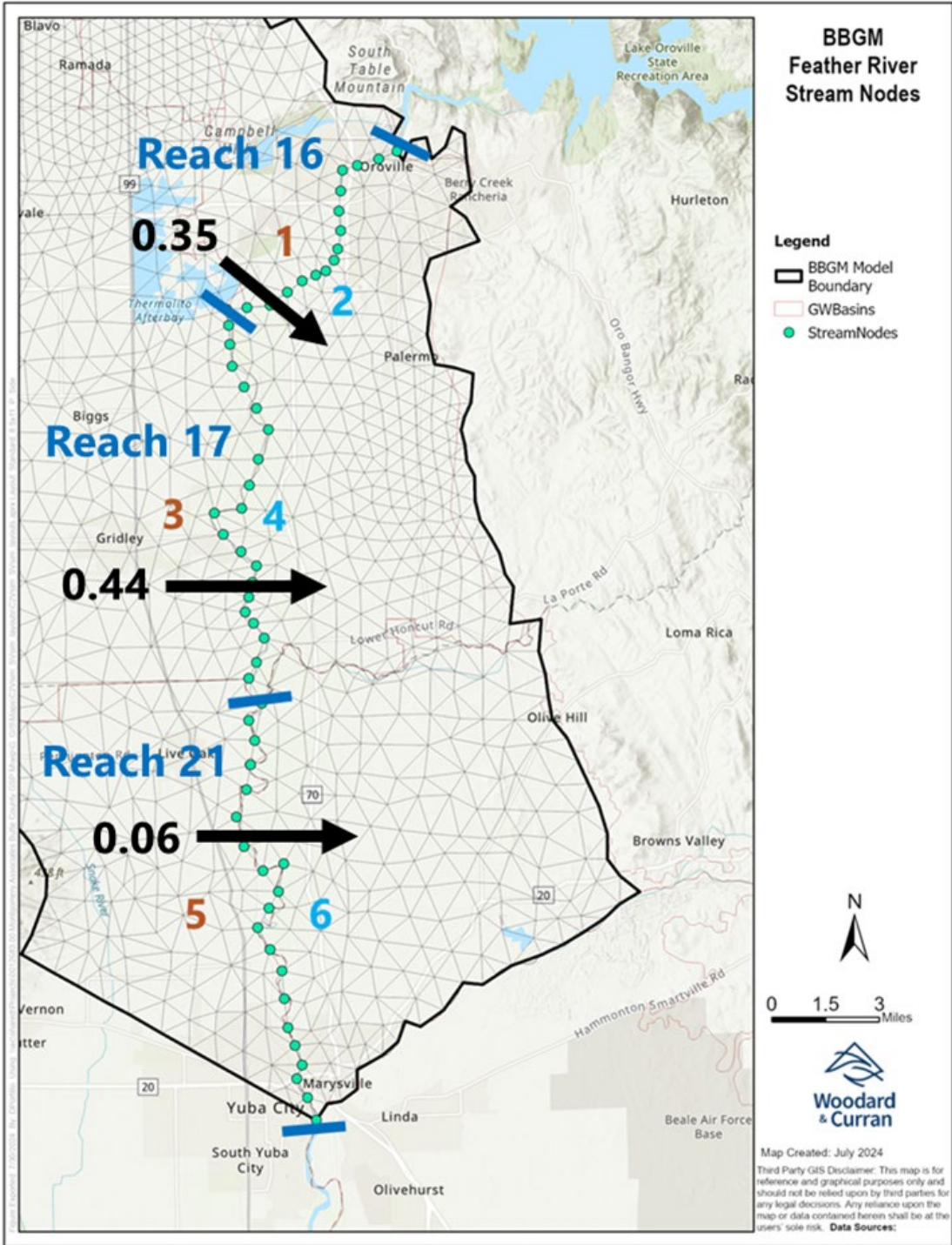


Figure 9: Feather River Average Transboundary Flow Balance Index (2000-2018)

1.5.4 Data from Local Agencies

As part of its involvement in activities related to SGMA, Butte County staff had various pieces of information available from agencies within the model domain. This section discusses the various additional data reviewed during the data collection and analysis phase of this project.

California Water Service (Cal Water) provided groundwater pumping data beginning in 2000 for its service areas within the model (Chico, Marysville, and Oroville). Much of the previous data in the model were applied evenly across all wells for an agency. The City of Chico especially has a large number of groundwater pumping wells, and updating BBGM to reflect accurate pumping distribution is a big improvement. This update was incorporated as part of the time series extension of the model discussed in Section 4.2.6.

Data were received for City of Chico wastewater treatment discharge from 2009 through 2024, which included treated effluent discharged to Sacramento River and stored in ponds or included as land diversion. After review of this data with the modeling team, it was concluded that the effluent discharge to the Sacramento River was relatively small compared to the large river flow volume and could be considered insignificant from a modeling and impacts perspective on the overall river flow volume. Insufficient information about potential recharge from the pond was available to currently include this in the model. This model improvement could be reconsidered in the future and would require clarifying elements from the City of Chico. More information about the amount of recharge potentially occurring through the pond/land diversion of treatment plant effluent should be available in the future, and the wastewater treatment plant may be increasing its capacity. This information may be incorporated into the model in the future, including for urban land refinement.

Representation of rural residential groundwater demand was discussed as a consideration to include in the update of the model. In Section 5.3.3 of the BBGM Version 1.0 documentation recommendations section (BCDWRC, 2021), rural residential groundwater pumping was discussed for inclusion in the model. Because rural domestic pumping is a very small amount compared to agricultural pumping in the Butte County Subbasins, it was not prioritized as an important item to revise. The effort required compared to the small potential improvement to the model did not warrant a revision. The focus of this recent model update was not on urban and agricultural water use, but future updates should consider this.

1.6 Comparison of BBGM Version 1.0 to Regional Models (SVSim Version 1.0, C2VSimFG Version 1.01, C2VSimFG Version 1.5)

It is useful to compare results of local models to regional models to assess similarities and differences in local and regional groundwater understanding and model representation. The regional models reviewed were all developed by DWR:

- Sacramento Valley Groundwater-Surface Water Simulation Model (SVSim Version 1.0) released May 2021
- California Central Valley Groundwater-Surface Water Simulation Model, Fine Grid (C2VSimFG Version 1.01) released April 2021
- C2VSimFG Version 1.5 released June 2025

1.6.1 Sacramento and Feather Rivers Stream-Aquifer Interaction

In order to better analyze the stream-aquifer interaction and overall stream flows of the portions of the Sacramento and Feather Rivers that fall within BBGM, Sacramento River was broken up into 4 segments at

groundwater subbasin boundaries and Feather River was broken up into 3 segments at subbasin boundaries. The reaches are as follows, also shown in Figure 10:

- Sacramento River
 - Reach A: Border of Vina and Corning Subbasins
 - Reach B: Border of Butte and Corning Subbasins
 - Reach C: Border of Butte and Colusa Subbasins
 - Reach D: Portion of Sacramento River within Colusa Subbasin
- Feather River
 - Reach FR1: Portion of Feather River within Wyandotte Creek Subbasin
 - Reach FR2: Border of Wyandotte Creek and Butte Subbasins
 - Reach FR3: Border of North Yuba and Sutter Subbasins

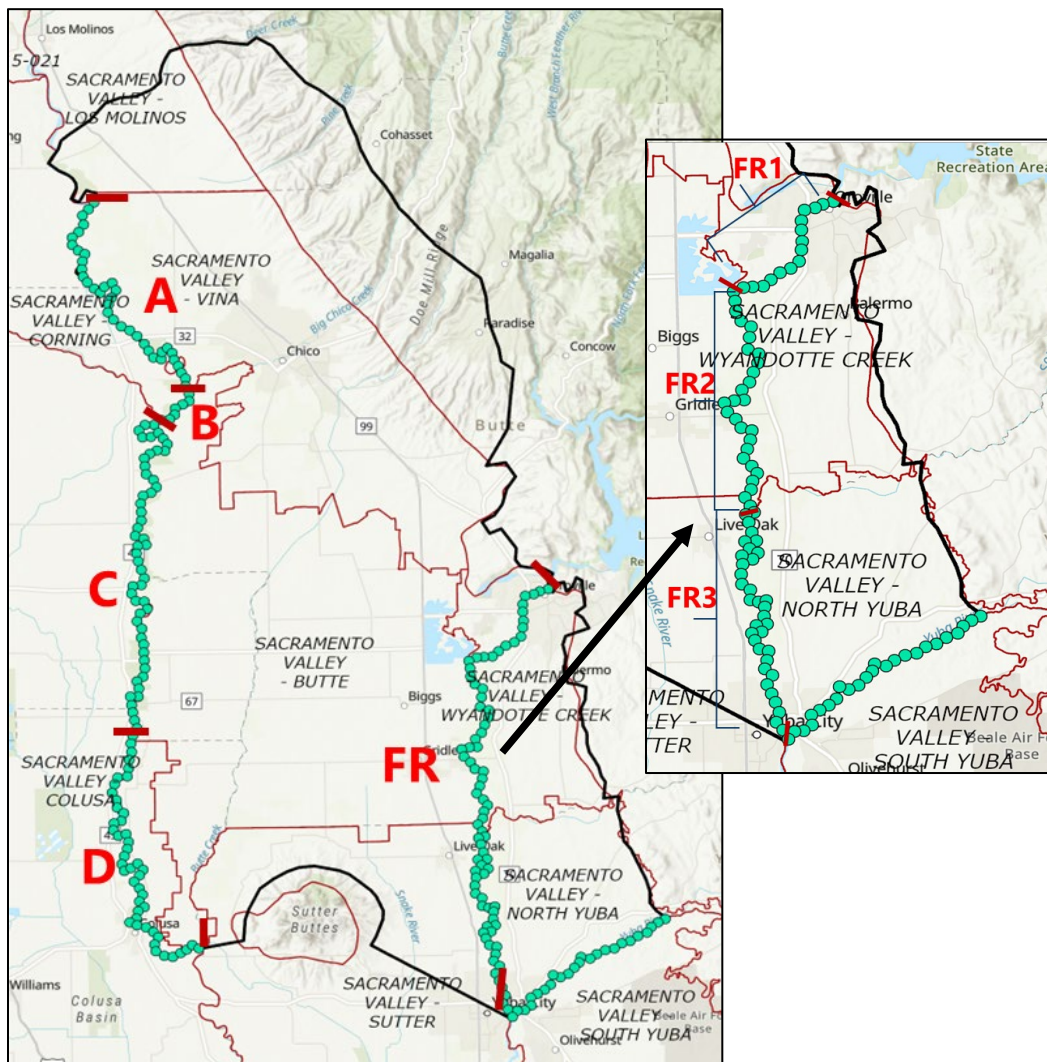


Figure 10: Sacramento and Feather River Reaches Within BSGM

The stream node budgets from IWFEM were processed for each local and regional model. The stream gain or loss from groundwater was calculated for each of the reaches listed above by adding the values from the individual stream nodes making up that reach. Stream inflow, though, is just the inflow value for the northernmost stream node in the reach and represents the total inflow to the reach. Net gains and losses are useful in indicating agreement if stream reaches are overall gaining or losing water to the groundwater system. Stream inflows are a useful comparison to check that stream reaches have the same amount of water flowing through them in different models.

To simplify the results, the entire Sacramento River in BBGM (Reaches A, B, C, and D) and entire Feather River in BBGM (Reaches FR1, FR2, and FR3) are included in this technical memorandum; Attachment 2 includes the results for all the individual reaches. Table 5 shows the annual averages for each model; averages are calculated over the entire simulation period, which differs depending on the model, and over a standard period of WY 1974 through 2015. All the models have similar inflows, but stream-aquifer interaction can vary dramatically depending on the model. In general, BBGM Version 1.0 agrees with C2VSimFG Version 1.01, while C2VSimFG Version 1.5 and SVSim both have less stream gain from groundwater. Figure 11 and Figure 12 show the annual totals for the portions of the Sacramento River and Feather River, respectively, in the BBGM model domain. In Figure 11, inflows are consistent across all the models, but in BBGM Version 1.0, interaction with the groundwater system is much more dramatic than the regional models' display. Sacramento River even shows a shift from overall gaining to losing for the last few years of the simulation. It is important to note that Sacramento River is a boundary of the BBGM model for most of the reaches, so boundary conditions are mostly driving the stream-aquifer interaction for that river. The regional models have the benefit of simulating the entire Central or Sacramento Valley. Figure 12 for the Feather River again shows similar inflows regardless of the model; the river is always gaining water for all the simulations. BBGM Version 1.0 is similar to C2VSimFG Version 1.01, while C2VSimFG Version 1.5 is similar to SVSim Version 1.0.

Table 5: Comparison of Sacramento River and Feather River Annual Averages for Stream Inflow and Gain/Loss

Model	Number of Stream Nodes	Model Time Period	Average Inflow (AFY)		Average Net Gain/Loss (AFY)	
			Average, Full Time Period	Average, WY 1974-2015	Average, Full Time Period	Average, WY 1974-2015
Entire Sacramento River within BBGM (Reaches A, B, C, and D)						
BBGM Version 1.0	131	WY 1971-2018	10,079,056	9,981,542	209,692	247,066
C2VSimFG Version 1.01	148	WY 1974-2015	10,127,178	10,127,178	223,381	223,381
C2VSimFG Version 1.5		WY 1974-2021	9,909,939	9,834,290	146,697	153,065
SVSim Version 1.0	153	WY 1974-2015	9,677,246	9,677,246	85,636	85,636
Entire Feather River within BBGM (Reaches FR1, FR2, and FR3)						
BBGM Version 1.0	57	WY 1971-2018	3,705,077*	3,464,717*	112,387	114,185
C2VSimFG Version 1.01	79	WY 1974-2015	3,217,282	3,217,282	126,008	126,008
C2VSimFG Version 1.5		WY 1974-2021	3,224,993	3,188,630	51,126	51,933
SVSim Version 1.0	80	WY 1974-2015	3,217,346	3,217,346	48,795	48,795

* Note: BBGM has two inflows for Feather River (upper and middle), while the regional models have one inflow. For comparison purposes, the Feather River inflow above is the sum of both upper and middle Feather River inflows.

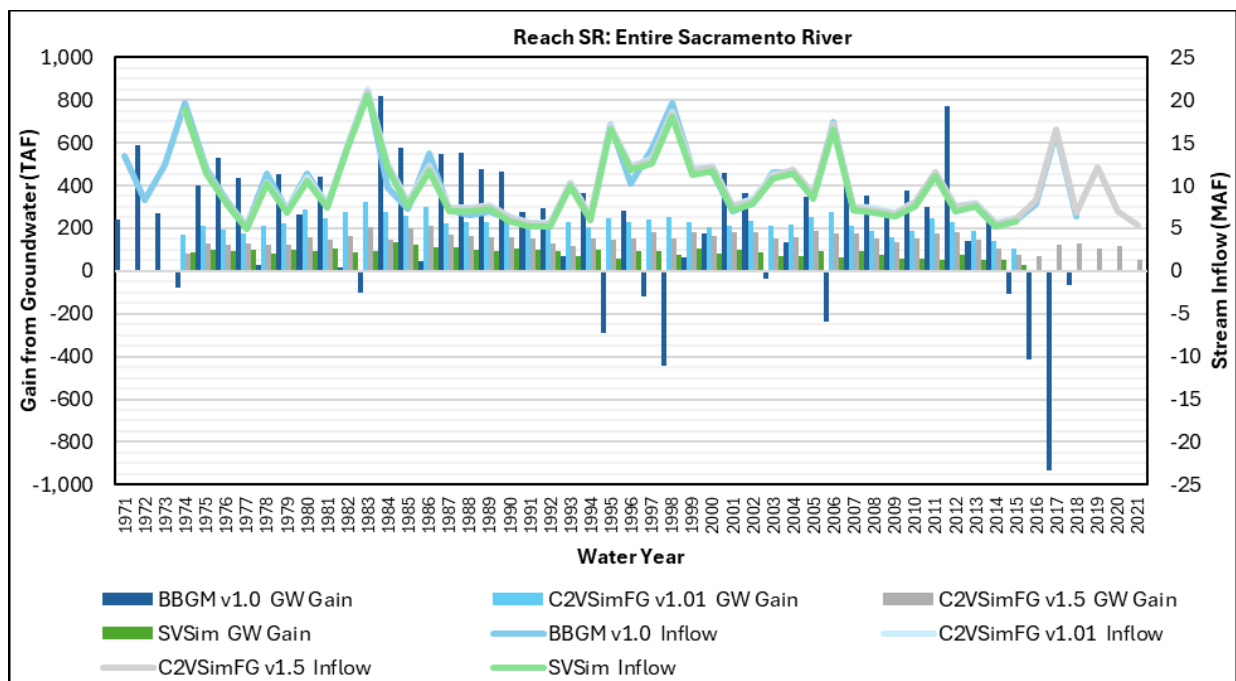


Figure 11: Comparison of Sacramento River Reaches Within BBGM

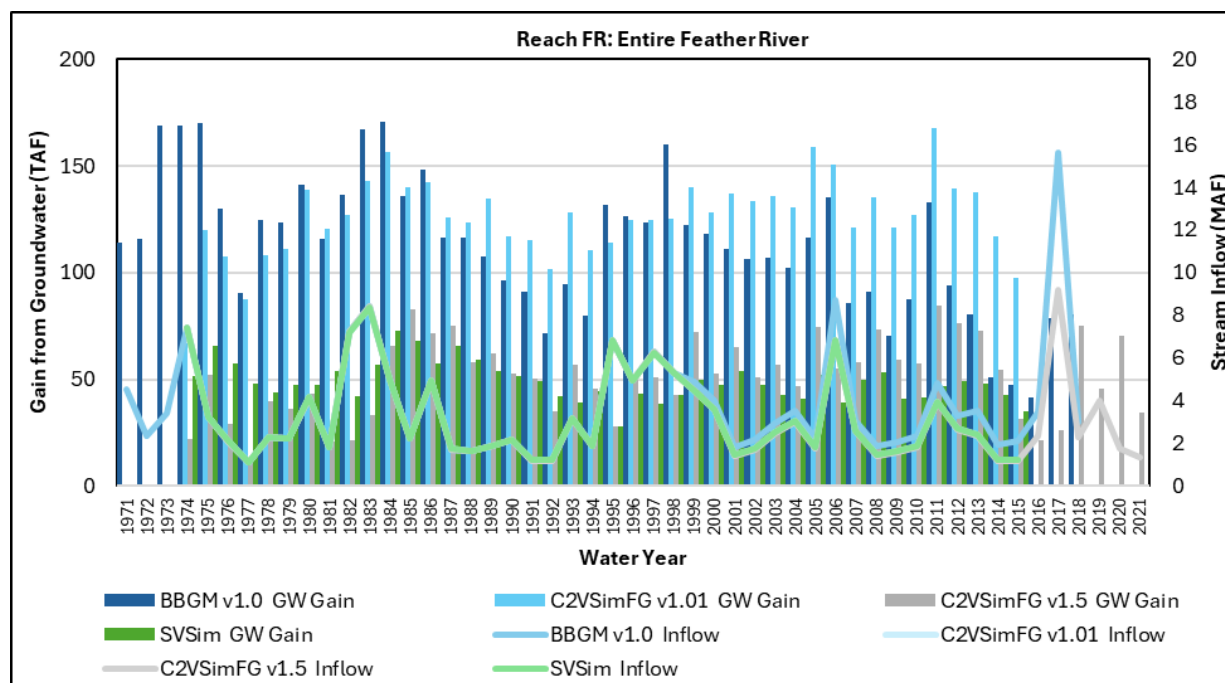


Figure 12: Comparison of Feather River Reaches Within BBGM

Note: BBGM has two inflows for Feather River (upper and middle), while the regional models have one inflow. For comparison purposes, the Feather River inflow above is the sum of both upper and middle Feather River inflows.

1.6.2 Subbasin Groundwater Budget

The primary components of the groundwater budget, corresponding to the major hydrologic processes affecting groundwater flow in the model area, are:

- Inflows:
 - Deep Percolation (from rainfall and irrigation)
 - Gain from Thermalito Reservoir
 - Subsurface Flow from Foothills
 - Canal and Reservoir Recharge
- Outflows
 - Groundwater Pumping
 - Root Water Uptake (only in regional models)
- Either Inflow or Outflow
 - Change in Groundwater Storage (either an inflow or outflow)
 - Interaction with Stream (net gain or loss of stream with groundwater system)
 - Subsidence (only in regional models)
 - Subsurface Flow with Outside BBGM
 - Subsurface Flow with Adjacent Subbasins

Groundwater budgets were processed for Vina, Butte, and Wyandotte Creek Subbasins for BBGM Version 1.0, C2VSimFG Version 1.01, C2VSimFG Version 1.5, and SVSim Version 1.0. All of the groundwater budget figures are included in Attachment 3. Table 6 includes some of the major groundwater budget components for each of the model versions for the groundwater subbasins, all averaged across a comparable period of WY 1974 through 2015. The results indicate variability between the models' simulations of the groundwater in three subbasins. While there is general agreement in magnitude of deep percolation and groundwater pumping across all the models, the other components (change in groundwater storage, interaction with stream, and subsurface flow with adjacent subbasins) sometimes have different flow directions among different models. Note that for BBGM Version 1.0, the subsurface flow with adjacent subbasins column includes the specified head boundary conditions plus flows within BBGM with the adjacent subbasins.

Table 6: Comparison of Major Groundwater Budget Components, Comparable Average (WY 1974-2015)

Model	Model Time Period	Change in Groundwater Storage	Interaction with Stream	Deep Percolation	Groundwater Pumping	Subsurface Flow with Adjacent Subbasins
Vina Subbasin						
BBGM Version 1.0	WY 1971-2018	17,232	-134,796	208,746	-220,551	83,871
C2VSimFG Version 1.01	WY 1974-2015	1,390	2,216	174,092	-210,279	4,130
C2VSimFG Version 1.5	WY 1974-2021	6,390	37,087	104,753	-167,991	5,784
SVSim Version 1.0	WY 1974-2015	15,710	28,468	101,100	-184,325	21,179
Butte Subbasin						
BBGM Version 1.0	WY 1971-2018	8,859	-552,520	268,791	-137,836	314,032
C2VSimFG Version 1.01	WY 1974-2015	-7,093	-151,159	253,640	-133,889	-33,844
C2VSimFG Version 1.5	WY 1974-2021	2,477	-41,026	223,047	-133,458	-20,707
SVSim Version 1.0	WY 1974-2015	-6,190	-51,681	144,926	-108,267	-50,421
Wyandotte Creek Subbasin						
BBGM Version 1.0	WY 1971-2018	3,002	-43,720	80,219	-42,180	-4,818
C2VSimFG Version 1.01	WY 1974-2015	578	-55,922	50,520	-30,657	28,273
C2VSimFG Version 1.5	WY 1974-2021	998	-7,536	46,256	-53,770	8,981
SVSim Version 1.0	WY 1974-2015	1,821	-30,087	32,474	-35,103	20,624

2. UPDATE TO BBGM VERSION 1.2

Based on the analysis of BBGM Version 1.0 discussed in the previous section, BBGM was updated to BBGM Version 1.2. Briefly, a model version called BBGM Version 1.1 was evaluated as an interim update to the model, but it was determined that the boundary conditions along Deer Creek were negatively impacting the water budget in Vina Subbasin. Boundary conditions were updated again to result in BBGM Version 1.2, as discussed further in Section 2.1.1.

2.1 Updates to Model

After the analysis of other data and testing of various parts of BBGM Version 1.0, the model was updated with the following changes:

1. Boundary condition update to general head boundary conditions along Sacramento River
2. Ground surface elevation update using DEM
3. Update Sacramento River streambed hydraulic conductivity to C2VSimFG values

The following sections discuss each update to the model in more detail.

2.1.1 Boundary Conditions

As described in Section 1.1, the specified head model boundary conditions were initially updated to general head boundary conditions along the northern and western model boundaries. This was implemented, along with the other changes described below, in BBGM Version 1.1. Upon further investigation of the groundwater budgets and the general head boundary conditions along Deer Creek, the general head boundary condition was found to be contributing to higher than actual water levels in the northern region of the model, and the decision was made to revert Deer Creek to the specified head boundary conditions of BBGM Version 1.0. This update to BBGM Version 1.1 for boundary conditions along Deer Creek resulted in BBGM Version 1.2, which only has the boundary conditions edited along the western model boundary of the Sacramento River. This is the model version carried forward for the remainder of the modeling work completed in 2025.

Since Deer Creek lies on the border of BBGM but is within Los Molinos Subbasin, coordination with that subbasin in the future may be useful to further update the boundary conditions along Deer Creek. A future updated and released version of C2VSimFG could be used to redevelop all the boundary conditions based on updated regional understanding. Recent groundwater level data available from DWR or other sources may allow for better refinement of groundwater level trends for model boundary conditions.

The model files edited to update the boundary conditions in BBGM Version 1.2 included:

- Groundwater Boundary Conditions Data File
- Specified Head Boundary Conditions Data File
- General Head Boundary Conditions Data File
- Time-Series Boundary Conditions Data File

2.1.2 Ground Surface Elevation

The source of the ground surface elevation data used for BBGM Version 1.0 was not described in the previous report (BCDWRC, 2021; Section 2.11). Based on the analysis described in Section 1.2, it was decided

to update the ground surface elevation data in the model to better align with actual data from groundwater well observations. As discussed previously, the ground surface elevation update mostly impacted the topographically diverse areas of the model, including the Sierra Nevada foothills and the Sutter Buttes. The ground surface elevation may be revisited in the event of future analysis and/or update of the model layering.

The model files edited to update the ground surface elevation in BBGM Version 1.2 included:

- Stratigraphy File
- Stream Component Main File
- Well Specifications Data File

2.1.3 Sacramento River Streambed Hydraulic Conductance

As noted previously, BBGM Version 1.0 is not especially sensitive to Sacramento River streambed hydraulic conductivity (or conductance). Even so, it was determined that BBGM should better align with the regional model by updating the Sacramento River streambed hydraulic conductivities for the 131 stream nodes of Sacramento River to match C2VSimFG Version 1.01 (also the same as C2VSimFG Version 1.5) streambed hydraulic conductivities. As described in the model documentation, Streambed conductance is based on a combination of texture data and values from C2VSimR374. During calibration, minor changes were made to streambed conductance in localized areas. Along Sacramento River, these hydraulic conductivities range from 1.08 to 7.316 ft/day with an average of 2.48 ft/day. In comparison, C2VSimFG average hydraulic conductivities from individual Sacramento River stream reaches range from 1.42-3.53 ft/day. The representation of the streams in BBGM should continue to be evaluated in future updates to the model.

The model file edited to update the Sacramento River streambed hydraulic conductivity in BBGM Version 1.2 included:

- Stream Component Main File

2.2 Model Results and Calibration Verification

BBGM Version 1.2 model results were post-processed, as described in the sections below. From individual tests on each update to the model, it was clear that the updates to the boundary conditions have a larger effect on the model results more than the other updates.

2.2.1 Sacramento and Feather Rivers Steam-Aquifer Interaction

The same reaches of the Sacramento and Feather Rivers were analyzed as described in Section 1.6.1 and the entire Sacramento and Feather Rivers are summarized and shown in Table 7, Figure 13, and Figure 14. Attachment 2 includes the results for all the individual reaches. In BBGM Version 1.2, both Sacramento River and Feather River are gaining during the entire model simulation period.

Table 7: Sacramento and Feather River Annual Averages for Stream Inflow and Gain/Loss for BBGM Version 1.2 (1971-2018)

Model	Number of Stream Nodes	Average Inflow (AFY)	Average Net Gain/Loss (AFY)
Entire Sacramento River in BBGM (Reaches A, B, C, and D)			
BBGM Version 1.2	131	9,932,479	352,421
Entire Feather River in BBGM (Reaches FR1, FR2, and FR3)			
BBGM Version 1.2	57	3,705,077	118,030

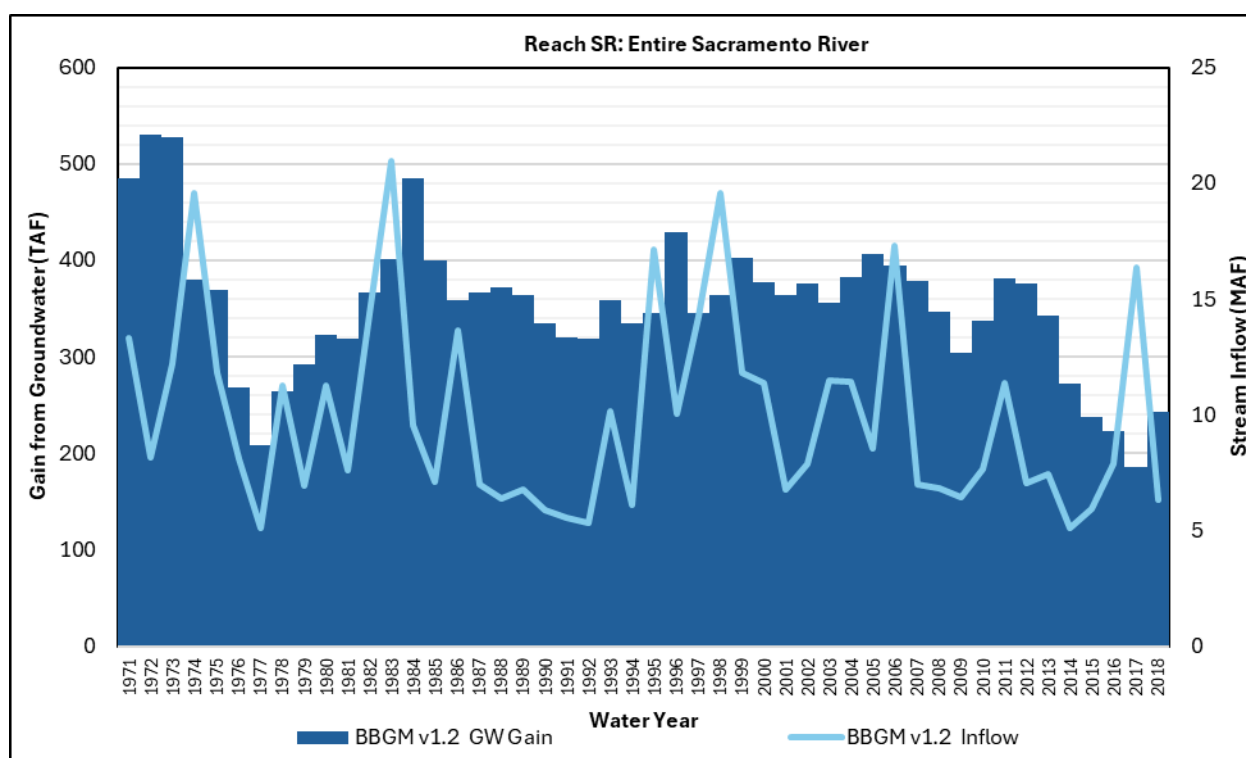


Figure 13: Sacramento River Reaches Within BBGM Version 1.2.

Note: Stream inflow is an order of magnitude greater than gains from groundwater.

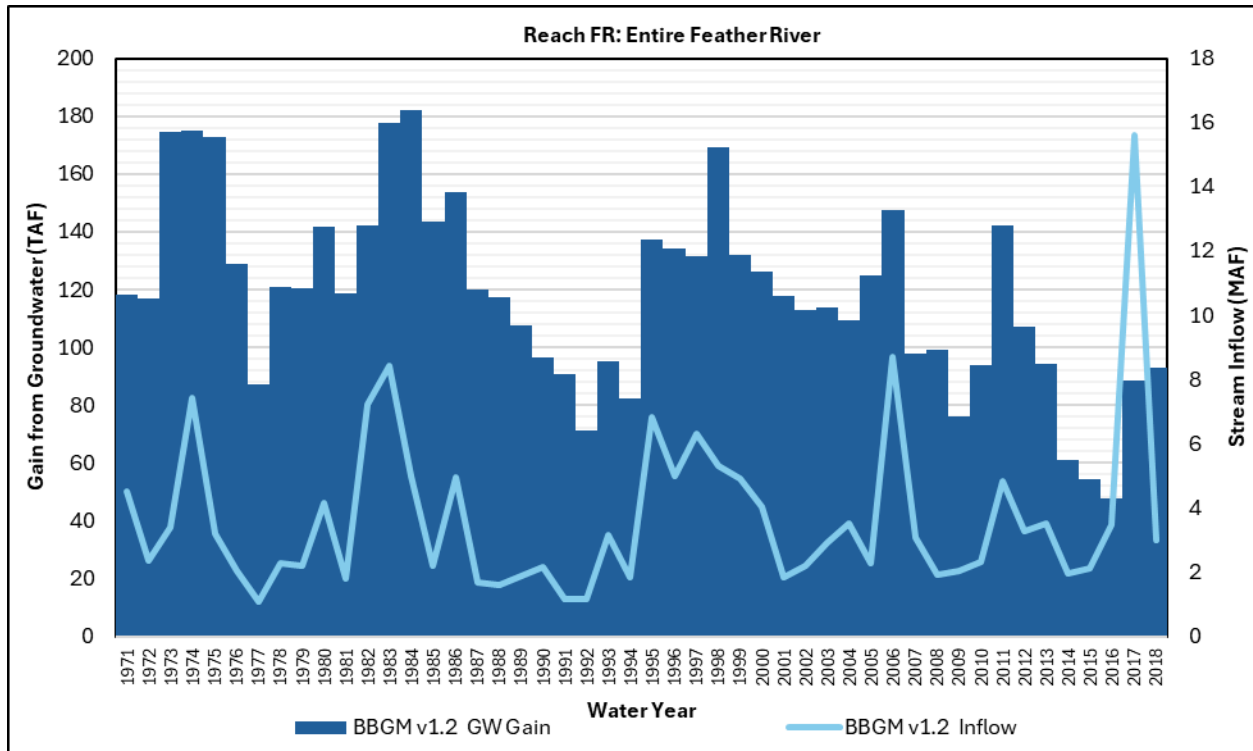
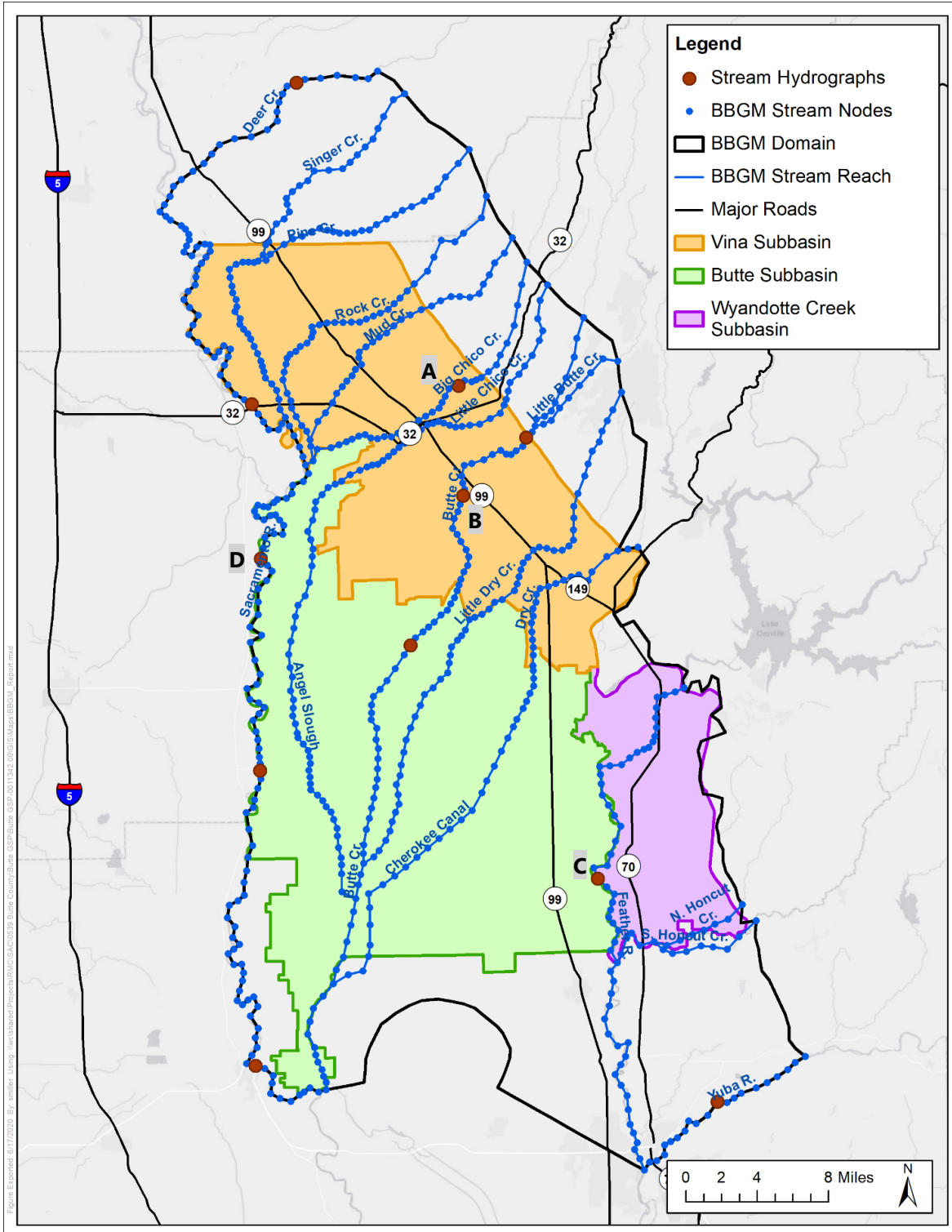


Figure 14: Feather River Reaches Within BBGM Version 1.2

Note: BBGM has two inflows for Feather River (upper and middle). For consistency with the regional models, the Feather River inflow above is the sum of both upper and middle Feather River inflows.

2.2.2 Stream Hydrographs

The BBGM simulates streamflow in 25 rivers, creeks, and canals across the model domain. Streamflow calibration is primarily performed by comparing the simulated streamflow at 11 locations with local data from USGS and CDEC stream gages (Table 3-1 and Figure 3-2 in BCDWRC, 2021). Stream flow calibration included analysis of the streambed hydraulic conductivity and stream gain from or loss to the groundwater system. Simulated stream flows were compared with observed records and exceedance charts were also used to check the model performance when simulating high and low flows at each gage location. Calibration results for select stream gages (see map in Figure 15) are included in Figure 16 through Figure 19. Note that the middle image for each stream gage calibration results figure represents the stream discharge on a log scale to more easily visualize the wide range of stream flows. Results for all stream gages are included in Attachment 4.



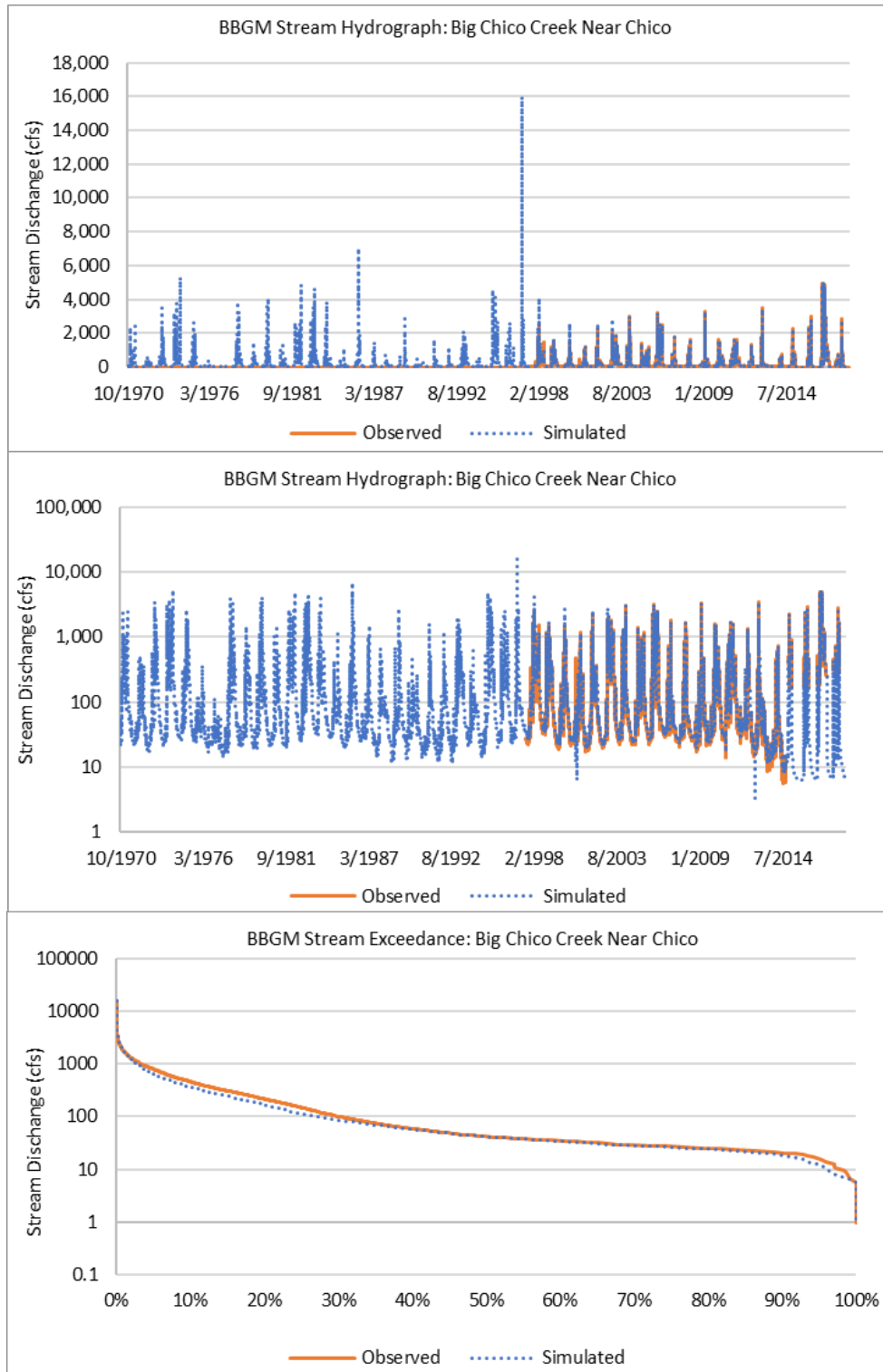


Figure 16: Stream Calibration for Big Chico Creek ("A" on Figure 15)

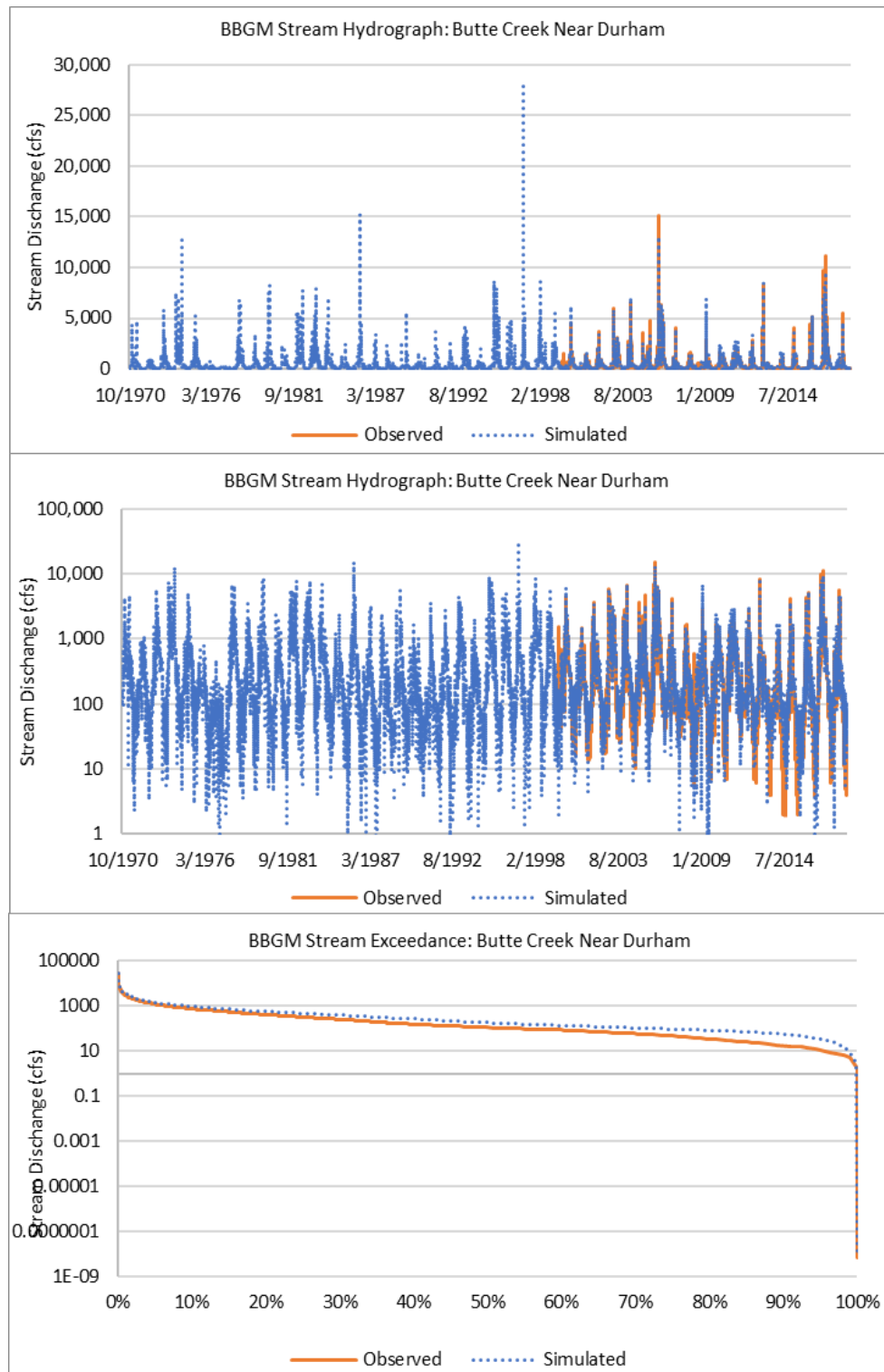


Figure 17: Stream Calibration for Butte Creek ("B" on Figure 15)

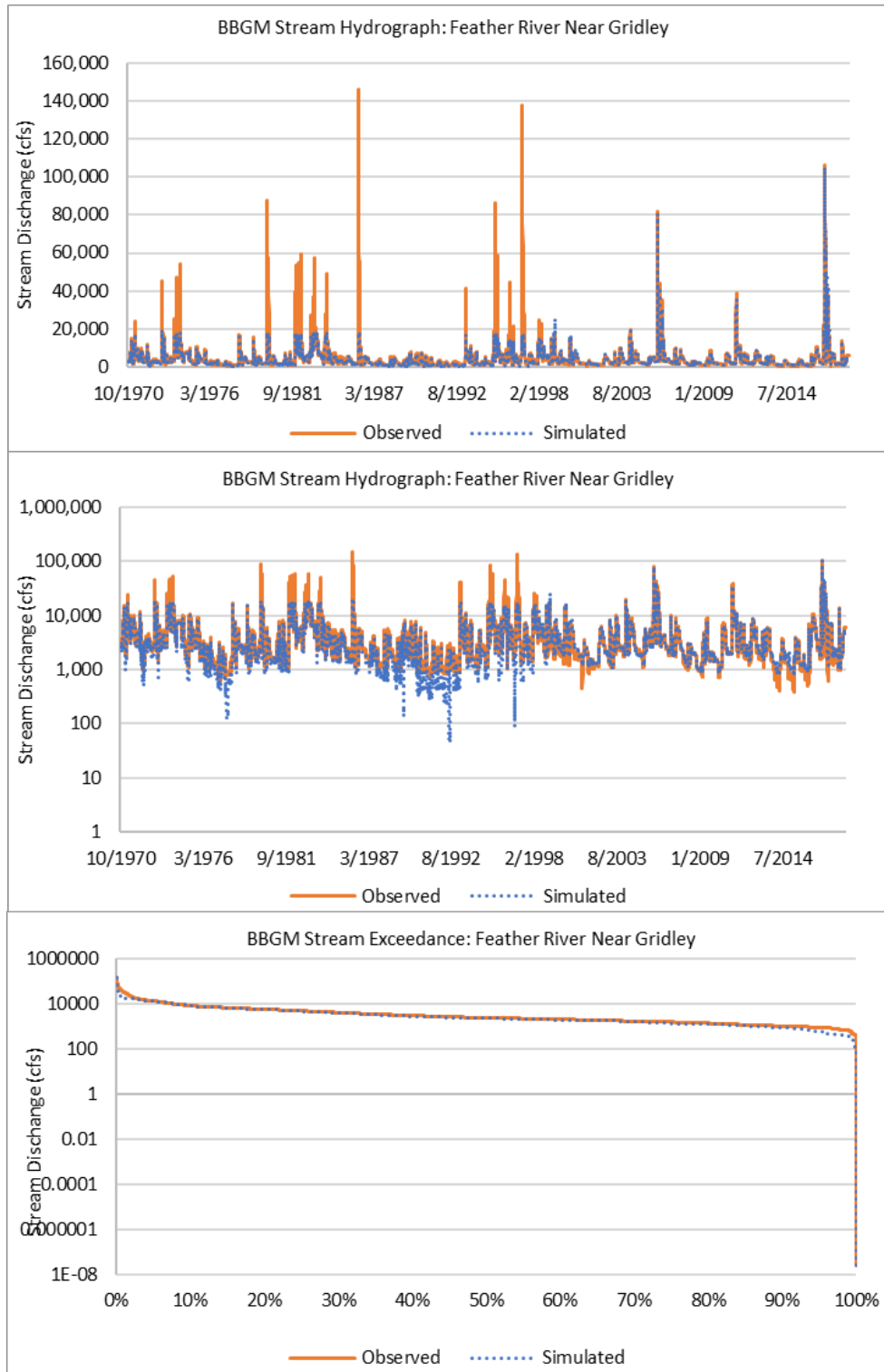


Figure 18: Stream Calibration for Feather River ("C" on Figure 15)

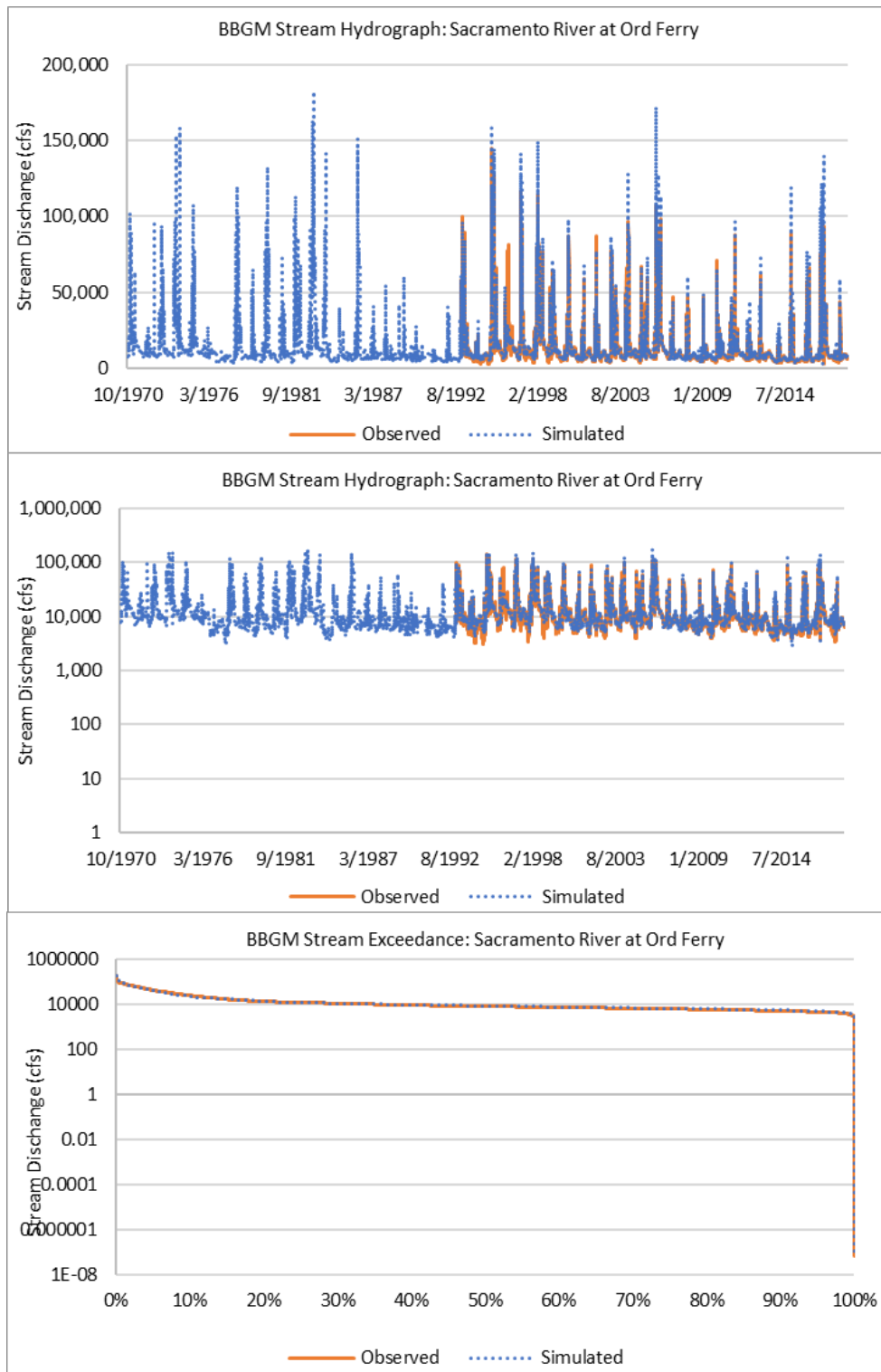


Figure 19: Stream Calibration for Sacramento River ("D" on Figure 15)

2.2.3 Groundwater Level Hydrographs and Residuals

The same 315 groundwater level hydrographs and observation data from BBGM Version 1.0's calibration were reviewed for BBGM Version 1.2 (see map in Figure 20). As in BBGM Version 1.0, groundwater observations are only for spring (March-May). Calibration statistics for groundwater levels are provided in Figure 21, and a map showing the location of absolute average groundwater head residuals by calibration well is in Figure 22. Groundwater level hydrographs may be viewed in Attachment 5. The results of the groundwater level calibration indicate that the BBGM Version 1.2, like BBGM Version 1.0, reasonably simulates the long-term hydrologic responses under various hydrologic conditions.

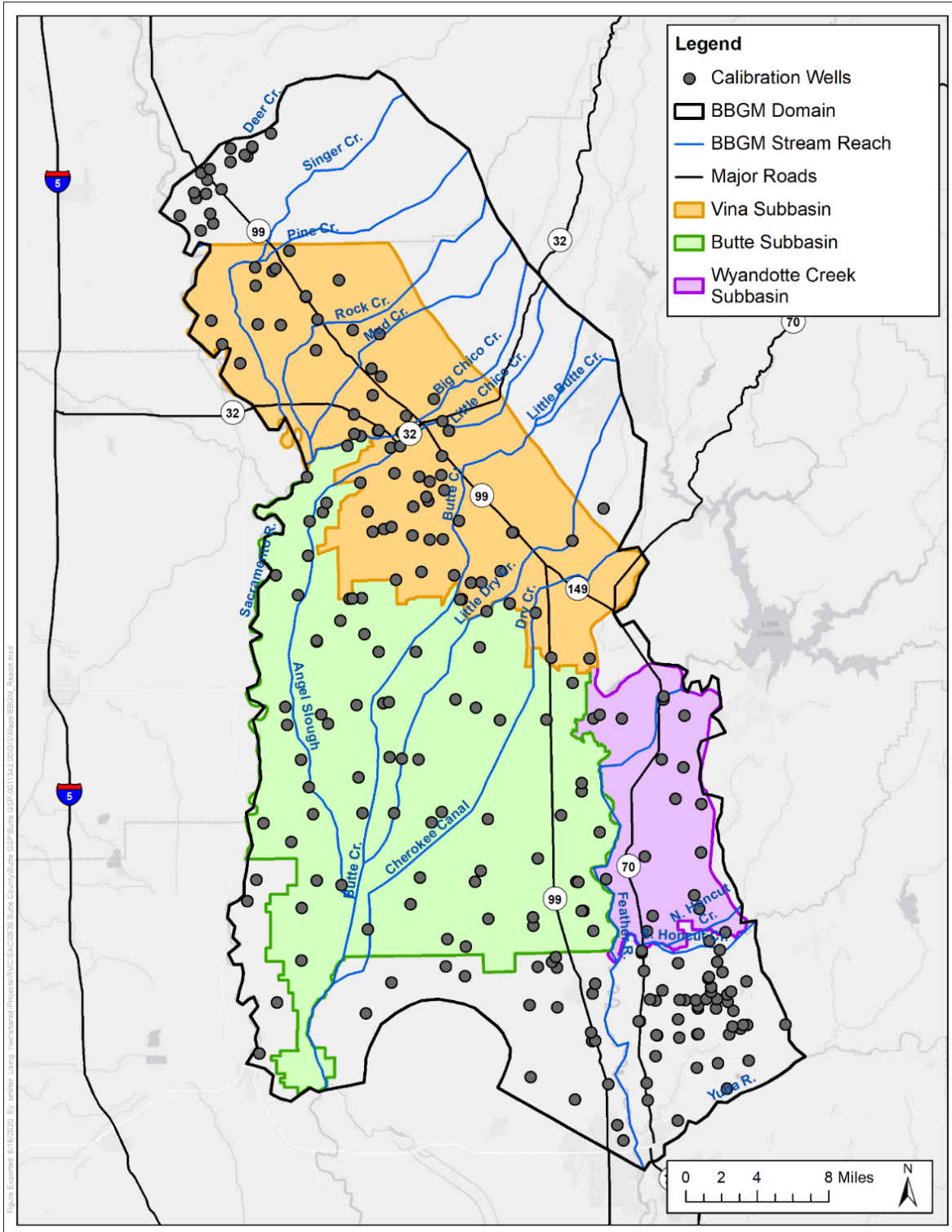


Figure 20: Groundwater Calibration Well Locations

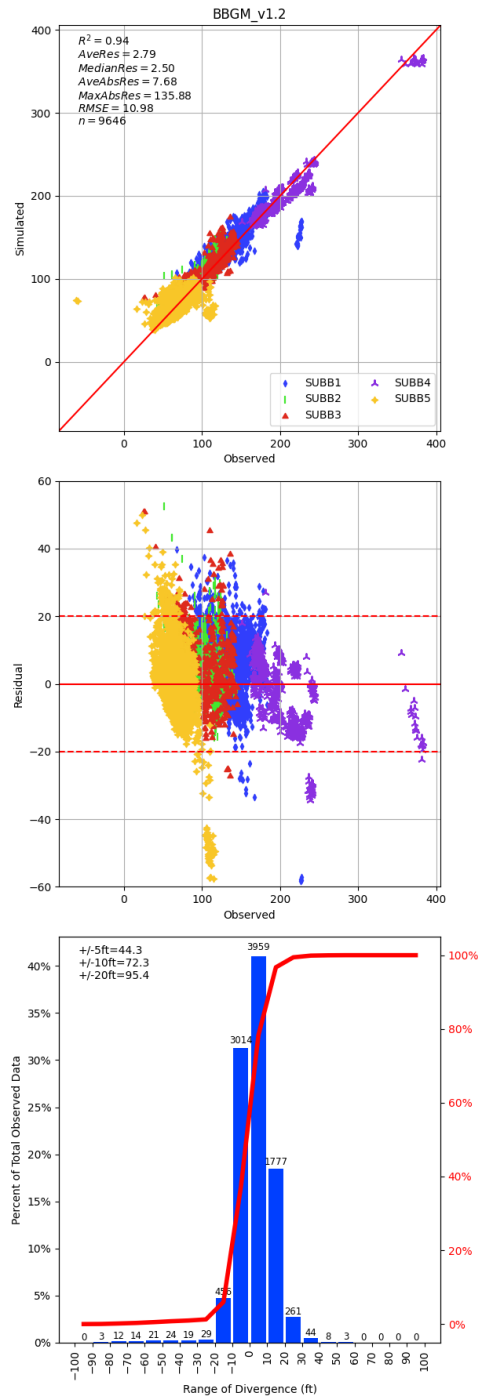


Figure 21: Scatter Plot and Residual Histogram of Entire BBGM Version 1.2

Note: Statistics calculated using only observed water levels for spring (March-May) 1990-2018

Key: SUBB1= Vina Subbasin, SUBB2= Butte Subbasin, SUBB3= Wyandotte Creek Subbasin, SUBB4= North of Vina Subbasin, SUBB5= South of Butte and Wyandotte Creek Subbasins

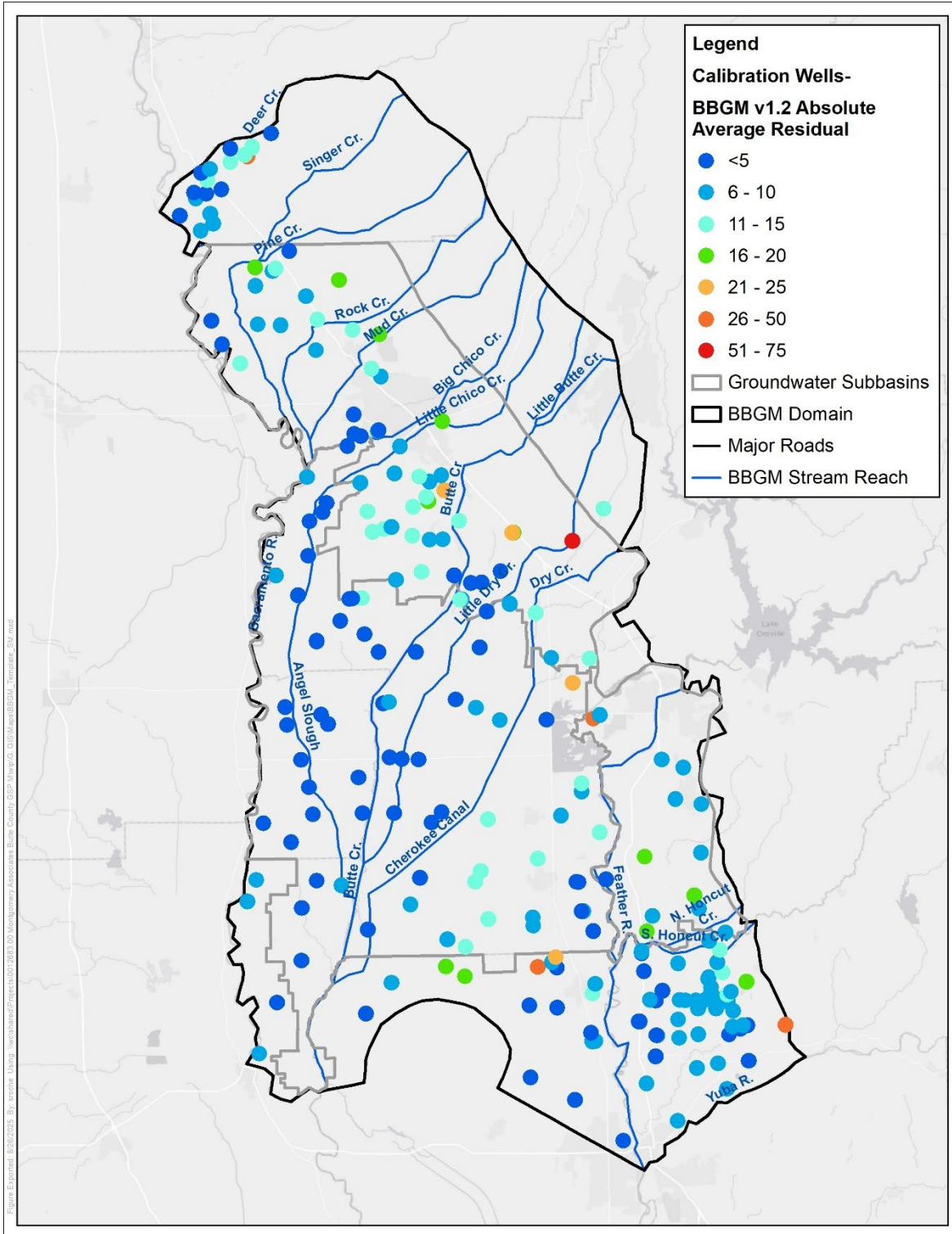


Figure 22: Absolute Average Residual Map of Entire BBGM Version 1.2

2.2.4 Subbasin Groundwater Budget

The groundwater budgets were analyzed as described in Section 1.6.2. Groundwater budgets are included for Vina, Butte, and Wyandotte Creek Subbasins as shown in the figures below.

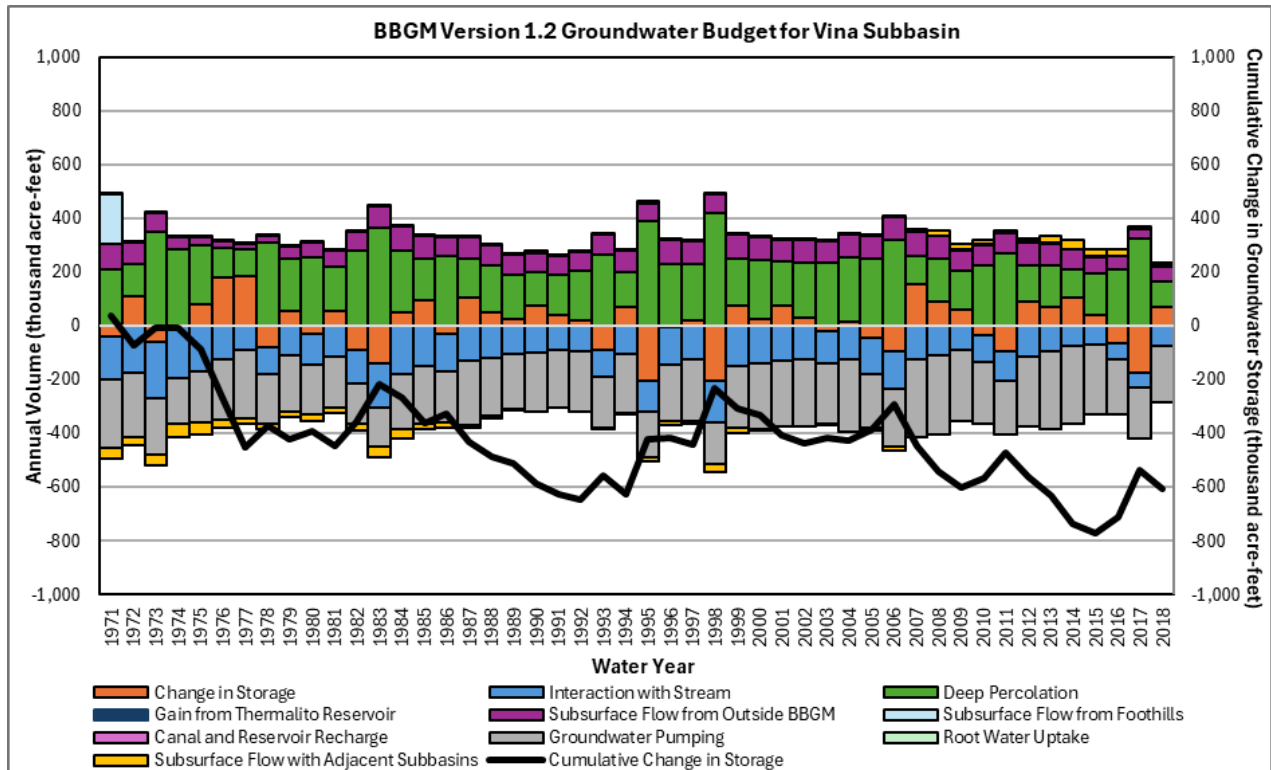


Figure 23: BBGM Version 1.2 Groundwater Budget for Vina Subbasin

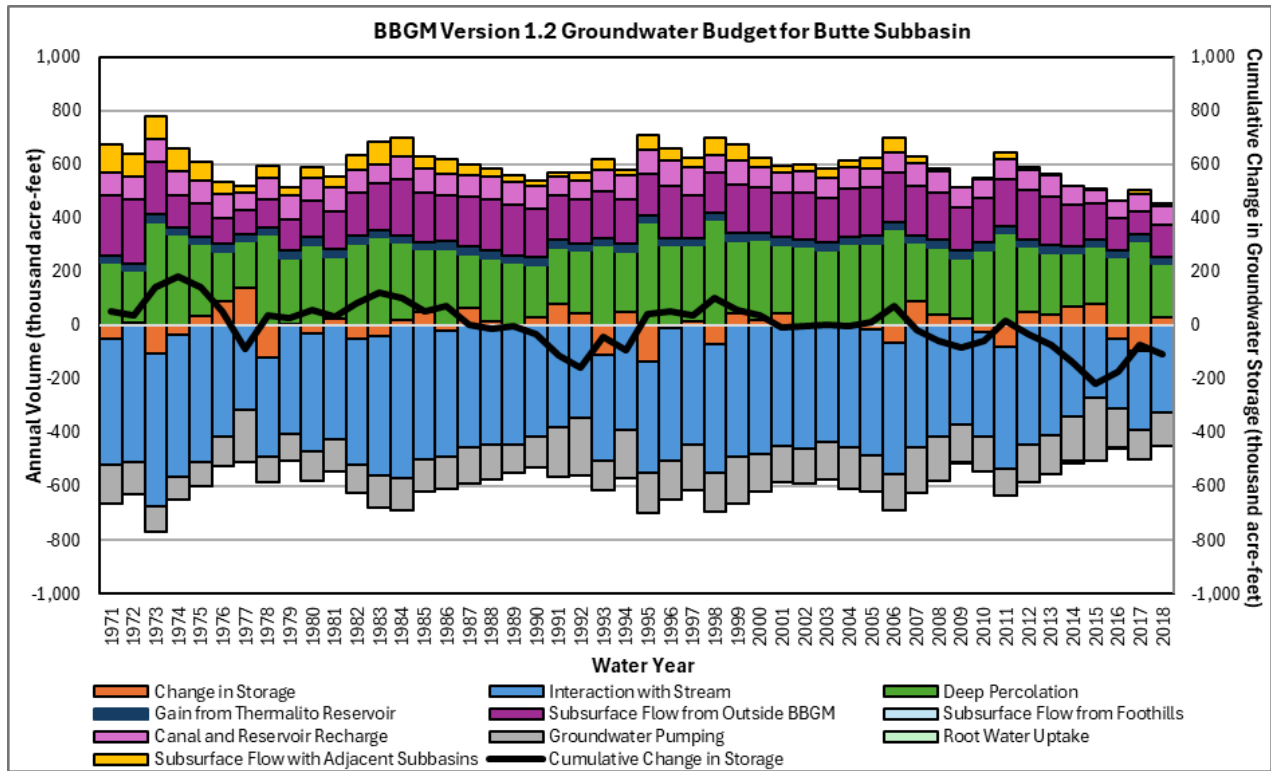


Figure 24: BBGM Version 1.2 Groundwater Budget for Butte Subbasin

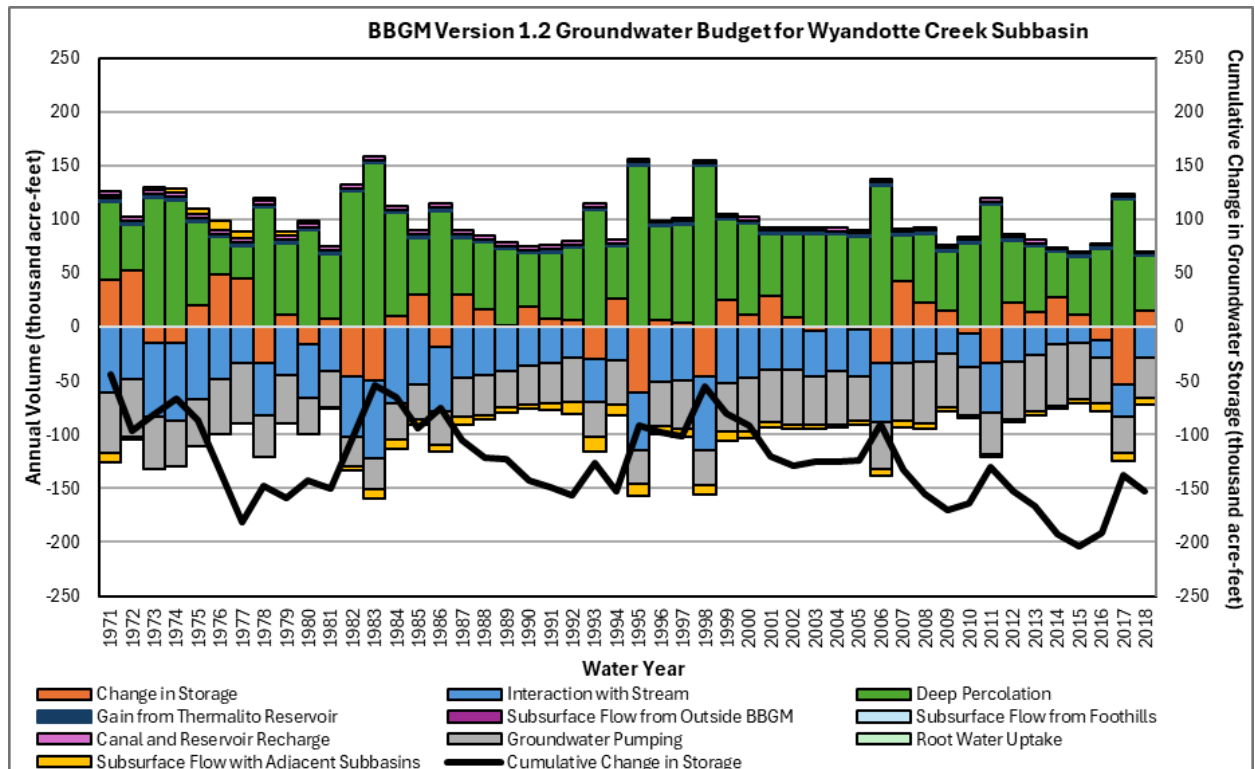


Figure 25: BBGM Version 1.2 Groundwater Budget for Wyandotte Creek Subbasin

3. IWFM VERSION

The Integrated Water Flow Model (IWFM) is the simulation engine behind BBGM. The version of IWFM used can directly impact model stability, runtime efficiency, and water budget results. BBGM Version 1.0 was developed using IWFM 2015.0.961, which at the time was the most recent version available. Since then, DWR has released multiple updates to IWFM with the most recent release of IWFM 2025.0.1688 on March 19, 2025. The prior release of IWFM 2024.2.1594 was October 8, 2024, and is the version used by C2VSimFG Version 1.5, released by DWR in June 2025.

DWR generally releases two or three IWFM updates each year. These updates can include bug fixes and the addition of new features. Significant updates to the IWFM simulation program occurred between the 2020 release of version 2015.0.961 and the 2024 release of version 2024.2.1594. Changes that may impact BBGM results include:

- Enhanced error detection to flag input file errors
- Updates to the Preconditioned Conjugate Gradient (PCG) solver implementation
- Proper simulation of groundwater heads in a layer when the groundwater head falls below the layer bottom elevation
- Maintaining the user-specified vertical pumping distribution between layers when supply adjustment is activated

Because IWFM updates incorporate bug fixes, efficiency improvements, and refinements to groundwater and surface water interactions, the choice of version is important for both long-term model performance and consistency with regional model applications. Additionally, DWR is sometimes unable to provide technical support related to older modeling engines, so updating the model engine allows for interaction with the coders of IWFM and the potential to improve the model for all users of IWFM.

3.1 Files Updated Due to New IWFM Version

BBGM input files required only one modification to run in the newer versions of IWFM. However, the enhanced error detection in the newer IWFM program identified several existing errors in the BBGM input files that had not previously been detected. All the updates to the model were made by Hydrolytics LLC and are outlined in the sections below.

3.1.1 Evapotranspiration

The daily evapotranspiration times series of BBGM Version 1.0 contained a few negative values that caused an error when running the updated versions of IWFM. These values were corrected by replacing them with their absolute values for the dates where this occurred: 12/16/2014 and 12/17/2014.

Model file edited to update the IWFM version includes:

- Evapotranspiration File

3.1.2 Stream Inflow

The daily stream inflow time series was missing Sacramento River inflow values for six days: 2/19/1986, 1/1/1997, 1/2/1997, 2/13/2017, 2/14/2017, and 2/15/2017. In order to make the model compatible with the updated versions of IWFM, each missing value was replaced with the corresponding value from the previous time step.

Model file edited to update the IWFM version includes:

- Stream Inflow File

3.1.3 Supply Adjustment and Well Specification

The newer IWFM versions do not allow supply adjustment to be active for both agricultural and urban purposes at the same time. Two files in BBGM were modified due to this update: the supply adjustment file and the well specification file that references the supply adjustment column relevant to each well. BBGM did not adjust supplies for both agricultural and urban purposes at the same time, so file changes had no effect on model performance. Thus, the supply adjustment file for BBGM was modified to remove Column 4, which contained the supply adjustment variable 11. In the well specification file, each well references a column in the supply adjustment file indicating for which purpose the well's groundwater pumping could be adjusted. With the deletion of one column in the supply adjustment file, the supply adjustment specifications pointing to Column 5 were modified to point to Column 4. No input files referenced the original supply adjustment Column 4, so the deletion of this column did not affect the simulation.

Model files edited to update the IWFM version include:

- Supply Adjustment Specifications File
- Well Specifications Data File

3.1.4 Boundary Conditions

An error in the newer IWFM versions causes the model to ignore the time unit provided in the specified flow boundary condition model file, which represents the amount of groundwater recharge from the 30 groundwater nodes representing Thermalito Afterbay. This error will likely be updated in future releases of the model version. In order to allow the model to produce similar results for the specified flow boundary condition representing Thermalito Afterbay groundwater recharge, the yearly flow of 1,000 acre-feet per year per node was updated to a daily flow of approximately 2.74 acre-feet per day per node. This change results in total Thermalito Afterbay groundwater recharge of about 30,000 acre-feet per year, which is the same as was included in BBGM Version 1.0.

Model files edited to update the IWFM version include:

- Specified Flow Boundary Conditions Data File

3.2 Results of IWFM Version Update

BBGM Version 1.0 was tested with updates to the latest IWFM versions, IWFM 2024.2.1594 and IWFM 2025.0.1688, also referred to as IWFM-2024 and IWFM-2025. Once all the errors were corrected, BBGM was able to run successfully under both of the newer IWFM versions.

Model run times using both versions of the newer IWFM simulation program were significantly faster than the run time with the older IWFM version. The IWFM-2015 run time was approximately three hours and the run time with the newer IWFM versions was less than two hours. The total number of supply adjustment iterations was similar with all three versions of the simulation program. It therefore seems likely that this reduction in run time is due to enhancements to the IWFM PCG solver.

Changes in how the newer versions of IWFM simulate the groundwater aquifer resulted in minor differences between the IWFM-2015 and newer simulation programs. Results from the 2024 and 2025 IWFM versions

were also consistent with one another. However, it appeared that initial conditions for the IWFM-2025 version might have slightly decreased the initial conditions compared to IWFM-2014 version. This affects the initial simulated heads and the change in storage. Conditions tend to stabilize during the rest of the model timeframe. The IWFM version update was not applied to BBGM Version 1.2 and was instead only included in the time series extension of BBGM Version 1.2 described in the section below.

Future BBGM applications should continue to adopt the most current IWFM version to take advantage of ongoing support from DWR, improved runtime efficiency, and more reliable representation of groundwater and surface water processes.

4. TIME SERIES EXTENSION: WATER YEAR 2019 TO 2024

BBGM Version 1.0 and BBGM Version 1.2 both end with WY 2018. The decision was made to update the model through WY 2024 (the most recent complete water year at the time the model update was finalized) in order to include recent water supply and demand information for use in the Periodic Evaluation for Butte County Subbasins. The revised model, referred to as BBGM Version 1.3 or BBGM 2025 (but often referred to herein as “BBGM Version 1.2 Through 2024”), will likely be used for continued SGMA analysis. The model continues to include daily values for many of the time series components; however, since much of the available data are monthly or annual, model users usually consider monthly or annual results.

4.1 Initial Analysis of Files to Update

With changes to consultants with the update of BBGM Version 1.0 to BBGM Version 1.2, much of the specific information about the previous time series extensions’ data sources was unavailable. As an initial step in considering a model time series extension, a file-by-file analysis was undertaken to determine which model files relied on time series data and from what sources the previous data relied. Information was gathered using the BBGM Version 1.0 model report (BCDWRC, 2021), notes included in BBGM model files, previous Excel spreadsheets shared by Butte County staff, and verbal information shared by Butte County staff and previous consultants. Based on the analysis of files, Davids Engineering, Inc. was assigned to update most of the root zone package-related files (e.g., land use, rice field operations, irrigation period, and evapotranspiration), and Woodard & Curran worked on the time series extension on the remaining model files.

4.2 Files Updated due to Time Series Extension

The following sections describe how the time series of BBGM Version 1.2 was extended to cover the six additional Water Years 2019–2024 (October 1, 2019, through September 30, 2024).

4.2.1 Precipitation

Daily precipitation data was extended by Woodard & Curran based on the same data used in BBGM Version 1.0, as described in the report (BCDWRC, 2021; Section 2.3). This is the 4-km gridded daily precipitation from the Parameter-elevation Relationships on Independent Slopes Model (PRISM). Each BBGM model element is assigned the precipitation value for the corresponding 246 PRISM grid cells, with elements mapped by their centroids to the appropriate PRISM cell. A future BBGM update effort could consider using the newly publicly available 800-m PRISM data for finer resolution of rainfall data across the model area.

Model files edited to extend the BBGM Version 1.2 time series include:

- Precipitation File

4.2.2 Evapotranspiration

Daily reference evapotranspiration (ET_o) data was extended by Davids Engineering, Inc. consistent with the previous update of data described in the BBGM Version 1.0 report (BCDWRC, 2021; Section 2.8). As with BBGM Version 1.0, the WY 2019–2024 updates estimated reference evapotranspiration based on the California Irrigation Management Information System (CIMIS) agronomic weather station at Durham (Station 12). However, data in recent years show some deterioration in quality with the Durham station. The Biggs CIMIS station is also within BBGM domain with a data record beginning in 2015; a monthly adjustment was applied to daily Durham CIMIS station ET_o data based on a comparison of daily data between Durham

and Biggs. In nearly all cases, this adjustment increased Durham station ETo. Crop coefficients (Kc) were not updated as part of this model update. Final ETc was calculated for each day and crop type by multiplying ETo by Kc.

In the future, coordination with parties responsible for maintenance of Durham CIMIS station to communicate and potentially address data quality issues would be appropriate. If Durham CIMIS station data quality continues to deteriorate, the Biggs CIMIS station could potentially be used in its place for ETo for BBGM. Additionally, remote sensing data (e.g., OpenET) has become more readily available, and work to incorporate it into modeling efforts would be beneficial. At a minimum, this includes review and potential updates to Kc values, but there are additional opportunities to improve spatial understanding of water use over time through directly integrating these data into the BBGM or utilizing them in separate water accounting efforts to support water planning and management.

Model files edited to extend the BBGM Version 1.2 time series include:

- Evapotranspiration File

4.2.3 Stream Inflow

Daily stream inflow data was extended by Woodard & Curran consistent with the previous update of data described in the BBGM Version 1.0 report (BCDWRC, 2021; Section 2.4.1). The BBGM includes simulation of the following 17 rivers and creeks: Sacramento River, Feather River, Yuba River, Singer Creek, Rock Creek, Pine Creek, Mud Creek, Big Chico Creek, Little Chico Creek, Little Dry Creek, Dry Creek, Butte Creek, North Honcut Creek, South Honcut Creek, and Deer Creek. Of these, seven streams were updated by downloading daily gage data from USGS or CDEC: Deer Creek, Big Chico Creek, Upper Butte Creek, Upper Feather River, Middle Feather River, Yuba River, and Sacramento River; the Upper Feather River's gage is inactive after WY 2023, so WY 2024 was estimated to repeat WY 2023 data. The remaining 10 streams were described in the BBGM Version 1.0 report as being estimated based on the Natural Resources Conservation Service (NRCS) curve number rainfall runoff approach, modified to be applied at a daily time step. The methodology for this update was not available, so instead, linear regression was used to tie inflow data to rainfall data to estimate the extended time series. Based on inspection of previous data, four streams (Big Chico Creek, Dry Creek, North Honcut Creek, and South Honcut Creek) have a baseflow value assigned when estimated or measured flow is not available. Table 8 below summarizes the stream inflow update in the extended BBGM Version 1.2 (Version 1.3).

Prior model documentation (BCDWRC, 2021; Section 5.3.2) recommended refinements to rim inflows (i.e., stream inflows) to limit or update the estimated flow values. As additional stream gaging data becomes available, it is recommended that stream flows and streambed parameters in BBGM be refined and calibrated to newly derived estimates of stream depletions or accretions.

Model files edited to extend the BBGM Version 1.2 time series include:

- Stream Inflow File

Table 8: Summary of Stream Inflow Locations and Data Sources

Rim Inflow	Stream Node	Data Source	Time Series Extension Method	Base Flow Assumed Based on Previous Data (cfs)	Average Daily Flow, WY 1970-2024 (cfs)
DEER CREEK (REACH 1)	1	Measured	USGS: 11383500 - DEER C NR VINA CA	n/a	322
SINGER CREEK (REACH 2)	23	Estimated	Precipitation linear regression	n/a	3
UPPER PINE CREEK (REACH 3)	47	Estimated	Precipitation linear regression	n/a	21
ROCK CREEK (REACH 5)	101	Estimated	Precipitation linear regression	n/a	11
MUD CREEK (REACH 6)	140	Estimated	Precipitation linear regression	n/a	11
BIG CHICO CREEK (REACH 7)	177	Measured	CDEC: BIC - BIG CHICO CREEK NEAR CHICO. Used hourly data to calculate daily average.	4	149
LITTLE CHICO CREEK (REACH 8)	209	Estimated	Precipitation linear regression	n/a	14
UPPER BUTTE CREEK (REACH 11)	300	Measured	USGS: 11390000 - BUTTE C NR CHICO CA	n/a	375
LITTLE BUTTE CREEK (REACH 10)	342	Estimated	Precipitation linear regression	n/a	29
LITTLE DRY CREEK (REACH 12)	351	Estimated	Precipitation linear regression	n/a	2
DRY CREEK (REACH 13)	409	Estimated	Precipitation linear regression	2	21
UPPER FEATHER RIVER (REACH 16)	506	Measured and Estimated	USGS: 11407000 - FEATHER R A OROVILLE CA. Gage inactive after 9/30/2023- Assume WY 2024 repeats WY 2023.	n/a	1,252
MIDDLE FEATHER RIVER (REACH 17)	522	Measured	USGS: 11406920 - THERMALITO AFTERBAY REL TO FEATHER R NR OROVILLE	n/a	3,746
NORTH HONCUT CREEK (REACH 18)	544	Estimated	Precipitation linear regression	14	61
SOUTH HONCUT CREEK (REACH 19)	552	Estimated	Precipitation linear regression	19	58
YUBA RIVER (REACH 20)	587	Measured	USGS: 11421000 - YUBA R NR MARYSVILLE CA	n/a	2,296
SACRAMENTO RIVER (REACH 22 - SAC_A)	608	Measured	CDEC: VIN - SACRAMENTO RIVER AT VINA BRIDGE- MAIN CH	n/a	13,029

4.2.5 Land Use

Annual land use data for each model element was extended by Davids Engineering, Inc. consistent with the previous update of data described in the BBGM Version 1.0 report (BCDWRC, 2021; Section 2.7). Data sources for land use data inputs included DWR's statewide crop mapping for 2019 through 2023 (DWR, 2019-2023), Cropland Data Layer from USDA NASS for 2019 through 2024 (USDA, 2019-2024), and Land IQ's data for the BBGM domain for 2024 (data provided by Land IQ). Land use data were classified as BBGM land use categories and aggregated spatially to calculate land use for each element within the BBGM for each year.

DWR's crop mapping efforts have changed in recent years. Historically, DWR would perform comprehensive land use surveys in a select number of counties in the state each year, resulting in only periodic comprehensive spatial land use data for each county. DWR's transition to statewide crop mapping has allowed for annual crop mapping data for 2019 through 2023 (and Land IQ data for 2024); however, not all land use classifications are included in these datasets. Semi-agricultural lands and managed wetland areas are excluded. In order to be consistent with previous years, the acreage for these two land use types were held constant from 2018 onward within each BBGM element, and acreages for other land uses were adjusted accordingly. For elements with semi-agricultural lands, idle, native, and urban acreages were adjusted (in that order, as available) to account for semi-agricultural land acreage. For elements with managed wetlands, riparian, idle, and native acreages were adjusted (in that order, as available). No large changes to semi-agricultural or managed wetland areas within the BBGM were anticipated or observed in the years covered under the BBGM time series extension.

Finally, there are some differences from year to year in how crops are classified in DWR's statewide crop mapping. For example, in some years, "Prunes" are independently identified, and in other years they are classified under "Miscellaneous Deciduous." Similarly, in some years "Corn" is independently identified, and in other years it is classified under "Corn, Sorghum, and Sudan" (which would be grouped under Miscellaneous Field Crops). These differences are not expected to have a major impact on overall simulated agricultural demand.

Future model updates could consider review of land use trends and potential refinement and edits to land use categories. For example, review of semi-agricultural and managed wetland areas in recent years would be beneficial to evaluate the assumption that these have stayed constant. Also, water use on managed wetlands can vary substantially (e.g., seasonal wetlands versus permanent wetlands) and mapping these different types of wetlands over space and time can improve understanding of their water use (including potentially implementing refinements to BBGM based on improved understanding).

Spatial land use data is becoming more readily available (e.g., datasets from DWR, USDA, and Land IQ). There are opportunities for improving spatial understanding of water flows over time (and variability of water flows within land use types) through utilizing these new data sources and developing new methods for modeling data within IDC/IWFM and/or independent water accounting.

Model files edited to extend the BBGM Version 1.2 time series include:

- Non-Ponded Crops Area Data File
- Ponded Crops Area Data File
- Urban Area Data File
- Native and Riparian Vegetation Area Data File

4.2.6 Groundwater Pumping and Well Specification

Monthly groundwater pumping data was extended by Woodard & Curran consistent with the previous update of data described in the BBGM Version 1.0 report (BCDWRC, 2021; Section 2.10.4). BBGM includes municipal and wetland pumping wells and time series for seven urban entities and one refuge entity (Gray Lodge Wildlife Area). Examination of the previous data in BBGM Version 1.0 revealed numerous instances where monthly data was split evenly across all agency wells and several cases where data was held constant across many water years. One of the specific goals of this update was to accurately reflect the pumping distribution across City of Chico wells.

For the extension of the model for WY 2019-2024, updated data was requested from agencies. As summarized in Table 9 below, complete monthly data for WY 2019-2024 was received (not all by well) for Biggs, Chico, Gridley, Marysville, and Oroville. Cal Water also provided data prior to WY 2018 that was used to update the groundwater pumping for Chico and Oroville and assign pumping to the appropriate well, rather than evenly distributing pumping across all wells. Additionally, some data before WY 2018 was updated for Gray Lodge. No updated data was received for Live Oak. Extended data for Live Oak as well as small remaining data gaps for Durham and Gray Lodge used a non-zero 20-year average by water year type (WY 1999-2018).

As in BBGM Version 1.0, agricultural groundwater pumping is calculated within IWFM using virtual wells to meet the agricultural demand computed at each model element. Consistent with BBGM Version 1.0, rural residential groundwater pumping is not represented in the model; it is expected to be very small relative to other flows impacting the groundwater system. For future updates, enhanced coordination with the local agencies will help eliminate remaining evenly distributed well pumping across cities and fill in remaining data gaps in time series extension data. Other available pumping volumes may be added (Thermalito Water and Sewer District, Yuba City, Paradise, etc.).

Prior model documentation (BCDWRC, 2021; Section 5.3.3) recommended including rural residential groundwater pumping and demand in BBGM. Future refinement could use population and per capita water use estimates for rural residential areas to be incorporated into the model. Potential sources of monthly pumping data may include, previous BBGM estimates, U.S. Census Bureau population estimates, and published per capita water use rates for the Sacramento Valley. Outdoor water use for rural residential populations may be estimated based on an estimate of the irrigated area associated with a rural residence, estimated ET rates, and estimated irrigation efficiencies.

Model files edited to extend the BBGM Version 1.2 time series include:

- Well Specifications Data File
- Time-Series Pumping File

Table 9: BBGM Groundwater Pumping Wells Data Extension

Entity	Well Type	Number of Wells	TS Extension in Model	Future Update
Biggs	Urban	2	Updated WY 2019-2024 data split evenly between the two wells	No local IDs provided. Consider assigning individual pumping to each well, if available.
Chico	Urban	73	Updated all data Jan. 2000 through WY 2024 (received from Cal Water)	Number of wells mismatched between agency spreadsheet and information in BBGM. Consider data request to confirm wells in BBGM with agency and refine remaining pumping distribution.
Durham	Urban	4	Data from agency for Jan. 2020-Sept. 2024 for the 3 active wells. Remainder of WY 2019 and 2020 with 20 year average by WYT (1999-2018).	Consider data request to eliminate remaining even pumping distribution.
Gridley	Urban	6	Data from agency for Oct. 2018-Dec. 2022 by well. Jan. 2023-Sept. 2024 is total for agency- Split evenly across 5 active wells.	Consider data request to eliminate remaining even pumping distribution.
Live Oak	Urban	5	No data received. Assume 20 year average by WYT (1999-2018).	Coordinate with agency to receive updated well data.
Marysville	Urban	13	Divided monthly total evenly across all wells for WY 2019-2024.	Coordinate with CalWater to match well IDs from agency to well locations included in BBGM; with well IDs included in BBGM, would be able to update all data Jan. 2000 onward with actual pumping distribution in agency data.
Oroville	Urban	10	Updated 3 wells with exact data for Jan. 2000 through WY 2024. Ignored high and low area info since didn't match up with previous data totals. Split remaining leased well (ORO-WP-01) among remaining 7 BBGM columns for Jan. 2007+.	Coordinate with CalWater to confirm pumping zone data included in spreadsheet.
Gray Lodge	Wetlands	17	Can't match up BBGM wells to spreadsheet, so just used monthly total. Updated data covering Mar. 2007 - Feb. 2019 and Oct. 2022 - Sept. 2024. Assume 20 year average by WYT (1999-2018) for remaining (Mar. 2019-Sept. 2022).	Consider data request to eliminate data gap.

4.2.7 Surface Water Diversions

Daily surface water diversion data was extended by Woodard & Curran consistent with the previous data update described in the BBGM Version 1.0 report (BCDWRC, 2021; Section 2.10.1). Some of the specific data sources used in previous updates of BBGM were unknown, so estimates and assumptions were made to extend the surface water time series data.

Based on examination of the 244 time series columns in BBGM Version 1.0, it was determined that only 56 diversions were active and needed a time series extension; the first 188 columns of the dataset were all zero after WY 1999 and were assumed to remain zero in the time series extension. Of these 56 diversion time series to update, 6 of the columns were zero for the entire time period and were assumed to remain zero for the time series extension of WY 2019-2024.

Of the 56 diversions, 6 remained zero for the entirety of the extended data, 11 were extended using downloaded or requested data, and the remaining 39 diversions were extended using a non-zero 20 year average by water year type (WY 1999-2018) to estimate monthly surface water deliveries. The actual data came from USGS, Electronic Water Rights Information Management System (eWRIMS), M&T Ranch, and United States Bureau of Reclamation (USBR) Table 28 showing Sacramento River deliveries for long-term contracts. The only daily data was from USGS, and all the other data was monthly. Listed below are the 11 diversions in BBGM updated with actual data:

- Feather River to Western Canal Water District for agriculture (data from USGS gage 11406880)
- Sacramento River to Reclamation District 1004 for agriculture (data from eWRIMS for the following water rights: A000027, S020164, S020166, S020167, and S020170)
- Sacramento River to M&T Ranch for agriculture (data received from M&T, total Sacramento River diversion to M&T and Parrott Ranches split proportionally based on historical data in model)
- Sacramento River to Llano Seco Ranch (now Parrott Ranch) for agriculture (data received from M&T, total Sacramento River diversion to M&T and Parrott Ranches split proportionally based on historical data in model)
- Butte Creek to M&T Ranch for agriculture (data received from M&T; total Butte Creek diversion to M&T and Parrott Ranches split proportionally based on historical data in model)
- Butte Creek to Llano Seco Ranch (now Parrott Ranch) for agriculture (data received from M&T; total Butte Creek diversion to M&T and Parrott Ranches split proportionally based on historical data in model)
- Sacramento River to Glenn Colusa Irrigation District for agriculture (data from eWRIMS for the following water rights: A000018, A001624, A001554, S007367, A030838, S007368, A030813, A000462, A000640, and A000892)
- Sacramento River to Provident and Princeton-Codora-Glenn Irrigation Districts for agriculture (USBR Table 28)
- Sacramento River to Green Valley Corporation (now Swenson Builders or Farms) for agriculture (USBR Table 28)
- Sacramento River to Maxwell Irrigation District for agriculture (data from eWRIMS for the following water rights: A008631, A011955, A011956, A013919, A014378, and A030445)
- Deer Creek to Sacramento Valley Rice Irrigation Company for agriculture (data from eWRIMS for the following water rights: A001041 and S000729)

Only one time series column was updated with daily data (from USGS); the remaining 55 columns had monthly data that was extrapolated to daily data using a script that took the existing distributions of daily data for the last 20 years of the model (WY 1999-2018) and calculated the fraction of that day out of the total month. These fractions were averaged by month, day, and water year type to determine how to distribute the extended monthly surface water diversion data to daily data.

A future update to surface water diversions should focus on combining all 244 time series columns into a continuous time series for the entire model. Additionally, sources of diversion data should be clear in the model files; potential eWRIMS and USGS matches found for several other diversions were not able to align to historical data in the model and had to be extended using averages. A more extensive data request could facilitate updating more diversions with actual data; for instance, DWR provided data for Butte Creek Watermaster that was too late to be incorporated in the most recent update.

Model files edited to extend the BBGM Version 1.2 time series include:

- Diversion Data File

4.2.8 Boundary Conditions

Boundary conditions were completely updated in BBGM Version 1.2, as described in Section 2.1.1. To extend the monthly time series through WY 2024, values were estimated using a 20-year average (WY 1999-2018) by Sacramento Valley water year type (DWR, 2024). In the future, this dataset could be updated by re-processing general head boundary conditions using an updated version of a regional model with simulated heads adjusted using nearby groundwater heads.

Model files edited to extend the BBGM Version 1.2 time series include:

- Time-Series Boundary Conditions Data File

4.2.9 Minor File Updates

Various other files in BBGM required updates to cover the time series extension of WY 2019 through 2024. The following section provides a brief overview of how these datasets were extended by Woodard & Curran or Davids Engineering, Inc.:

- Simulation Main: This file includes the model end date and was updated to run the model through September 30, 2024.
- Irrigation Period: The daily irrigation periods were adjusted for WY 2019 through 2024 based on the timing of diversions and deliveries. Data sources included diversion and delivery records for water suppliers within the BBGM domain.
- Ponded Depth: The daily ponded depths (in inches) were adjusted for WY 2019 through 2024 based on timing of diversions and deliveries to ponded lands. Data sources included diversion and delivery records for water suppliers within the BBGM domain providing water to ponded land uses (i.e., rice and wetlands).
- Ponded Operations Flows: The monthly data for ponded operations flows is constant after WY 2015 in BBGM Version 1.2. Woodard & Curran assumed the pattern continues 2019-2024.
- Target Soil Moisture: As described in the BBGM Version 1.0 report (BCDWRC, 2021; Section 2.9.2), the annual target soil moisture fraction was gradually reduced linearly between 1970 and 2010 in

BBGM but has been held constant since then. To extend the model from WY 2019 to 2024, it was assumed the pattern continued 2019 to 2024 and the annual target soil moisture fraction is constant after 12/31/2009. Additional information and investigation would be required to evaluate these values for potential updates. As noted in BBGM Version 1.0 model documentation, the decreased fraction was implemented to increase consumptive use fraction for orchards over this period, largely coinciding with transition to pressurized irrigation systems with a more precise application of water.

- Supply Adjustment: This file contains the annual indicator of whether supply is allowed to adjust to meet agricultural or urban water demand. In BBGM in the Butte Subbasin, water supply is allowed to adjust (via groundwater pumping) for agricultural purposes during surface water cutback years. In this file, one column designates full surface water supply years for the Feather River diverters as having no adjustments and cutback years as allowing agricultural supply adjustments. Butte County staff verbally provided the cutback years (2021 and 2022) for the time series extension of BBGM.

Prior model documentation (BCDWRC, 2021; Section 5.3.4) recommended refinements to rice and wetlands water flows and characterization. Those were not included in the recent update to BBGM and time series extension but could be re-evaluated and pursued in the future.

Model files edited to extend the BBGM Version 1.2 time series include:

- Simulation Main Input File
- Irrigation Period Data File
- Ponding Depth Data File
- Pond Operation Flows Data File
- Irrigation Target Moisture Data File
- Supply Adjustment Specifications File

4.3 Results of Time Series Extension

Due to minimal changes to data prior to 2019, the BBGM Version 1.2 through 2024 (Version 1.3) results are almost identical for the time period up through WY 2018.

4.3.1 Sacramento and Feather Rivers Steam-Aquifer Interaction

The same reaches of the Sacramento and Feather Rivers were analyzed as described in Section 1.6.1 and the entire Sacramento and Feather Rivers are summarized and shown in Table 10, Figure 26, and Figure 27. Attachment 2 includes the results for all the individual reaches. In BBGM Version 1.3, as was the case in BBGM Version 1.2, both Sacramento River and Feather River are gaining during the entire model simulation period. BBGM Version 1.3 is very similar to BBGM Version 1.2. Due to the update of some values prior to WY 2019, the averages Table 10 are slightly different from what was presented in Table 7.

Table 10: Sacramento and Feather River Annual Averages for Stream Inflow and Gain/Loss for BBGM Version 1.3

Number of Stream Nodes	Average Inflow (AFY)	Average Net Gain/Loss (AFY)
Sacramento River (BBGM Reaches A, B, C, and D)		
131	9,672,452	343,643
Feather River (BBGM Reaches FR1, FR2, and FR3)		
57	3,621,319	113,133

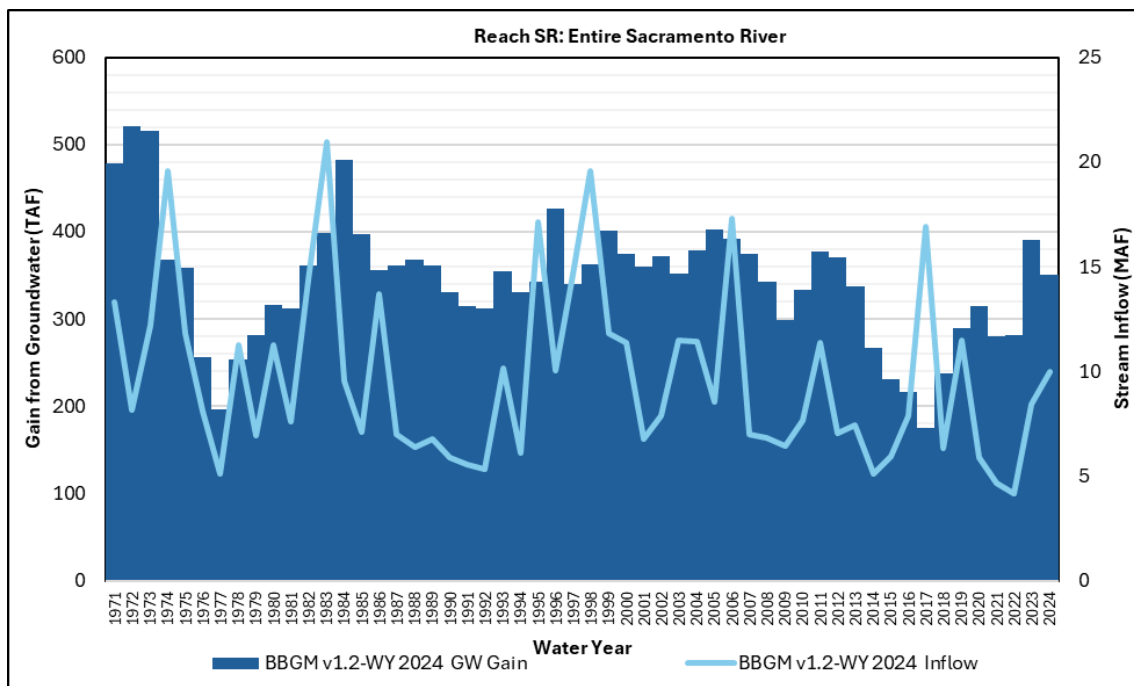


Figure 26: Sacramento River Reaches Within BBGM Version 1.2 Through WY 2024

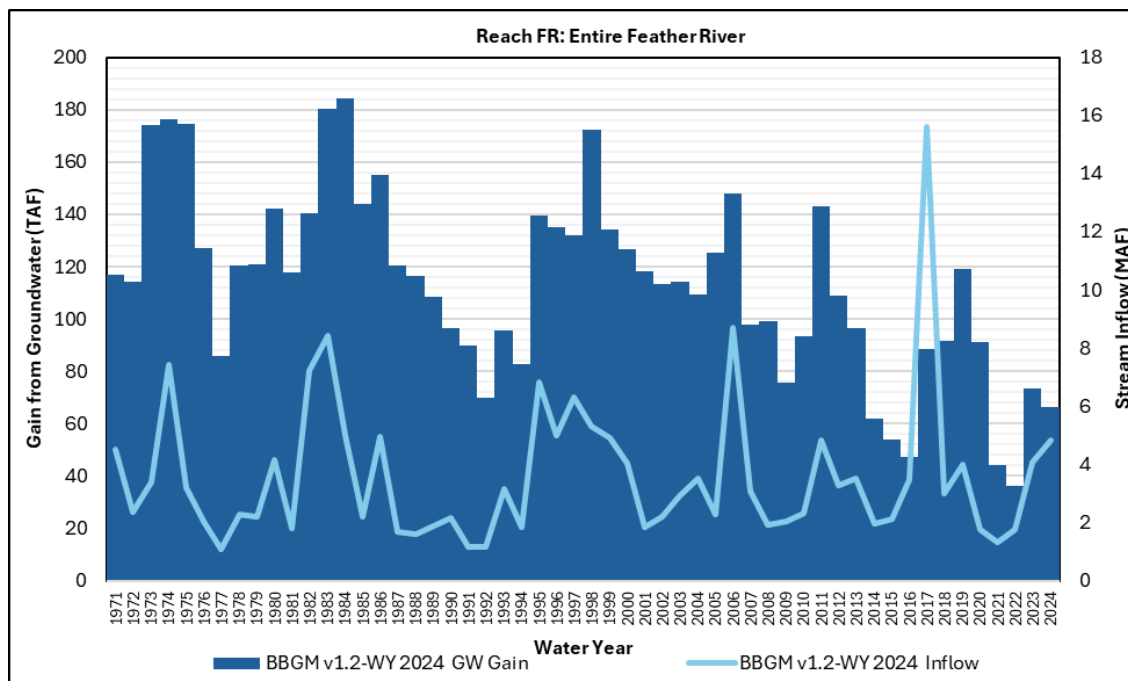


Figure 27: Feather River Reaches Within BBGM Version 1.2 Through WY 2024 (Version 1.3)

Note: BBGM has two inflows for Feather River (upper and middle). For consistency with the regional models, the Feather River inflow above is the sum of both upper and middle Feather River inflows.

4.3.2 Stream Hydrographs

The BBGM simulates streamflow in 25 rivers, creeks, and canals across the model domain. Streamflow calibration is primarily performed by comparing the simulated streamflow at 11 locations with local data from USGS and CDEC stream gages (Table 3-1 and Figure 3-2 in BCDWRC, 2021). Observed streamflow data was extended through WY 2024.

Streamflow calibration included analysis of the streambed hydraulic conductivity and stream gain from or loss to the groundwater system. Simulated stream flows were compared with observed records, and exceedance charts were also used to check the model performance when simulating high and low flows at each gage location. Calibration results for select stream gages (see map in Figure 15) are included in Figure 28 through Figure 31. Results for all stream gages are included in Attachment 4.

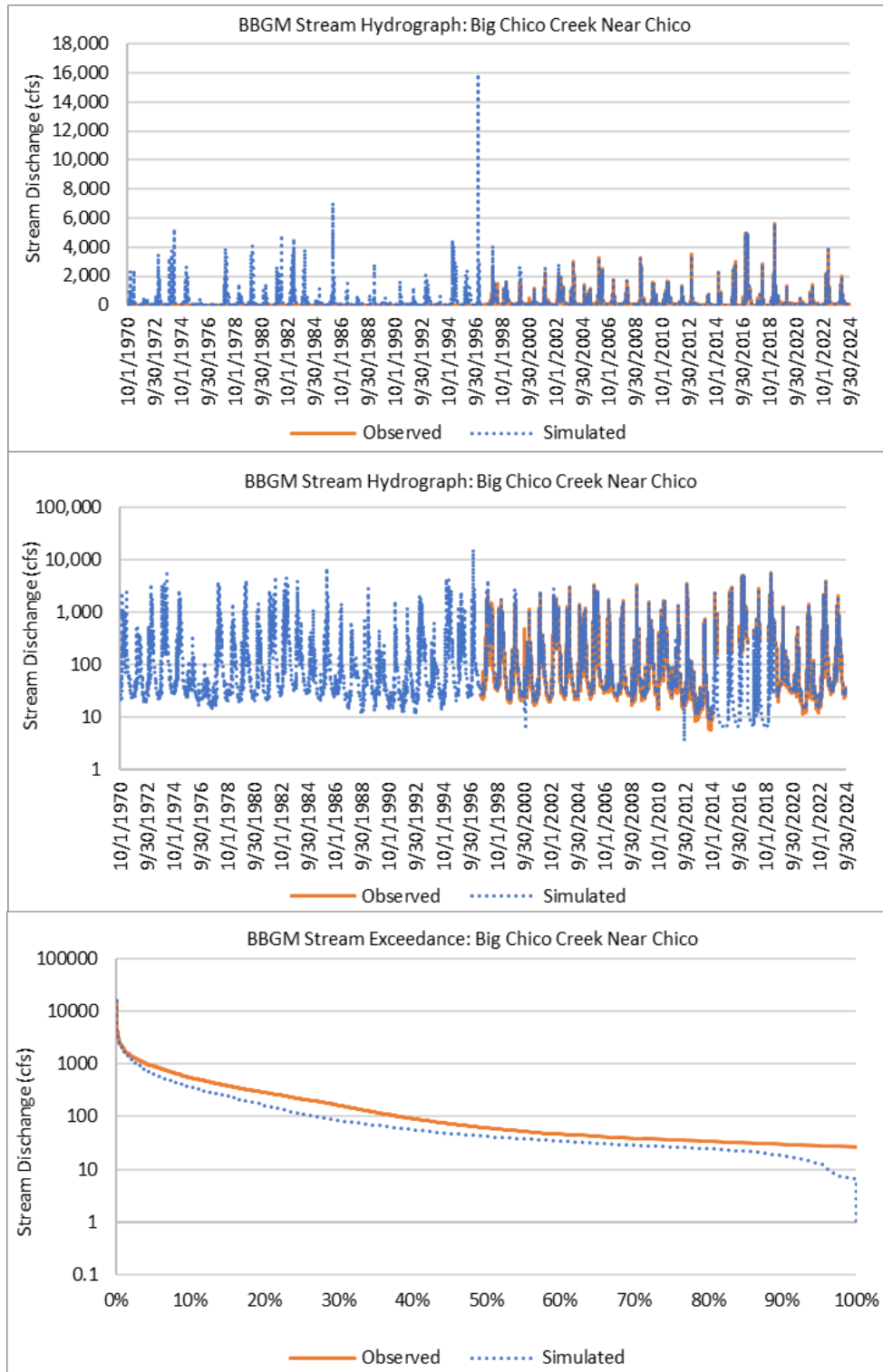


Figure 28: Stream Calibration for Big Chico Creek ("A" in map)

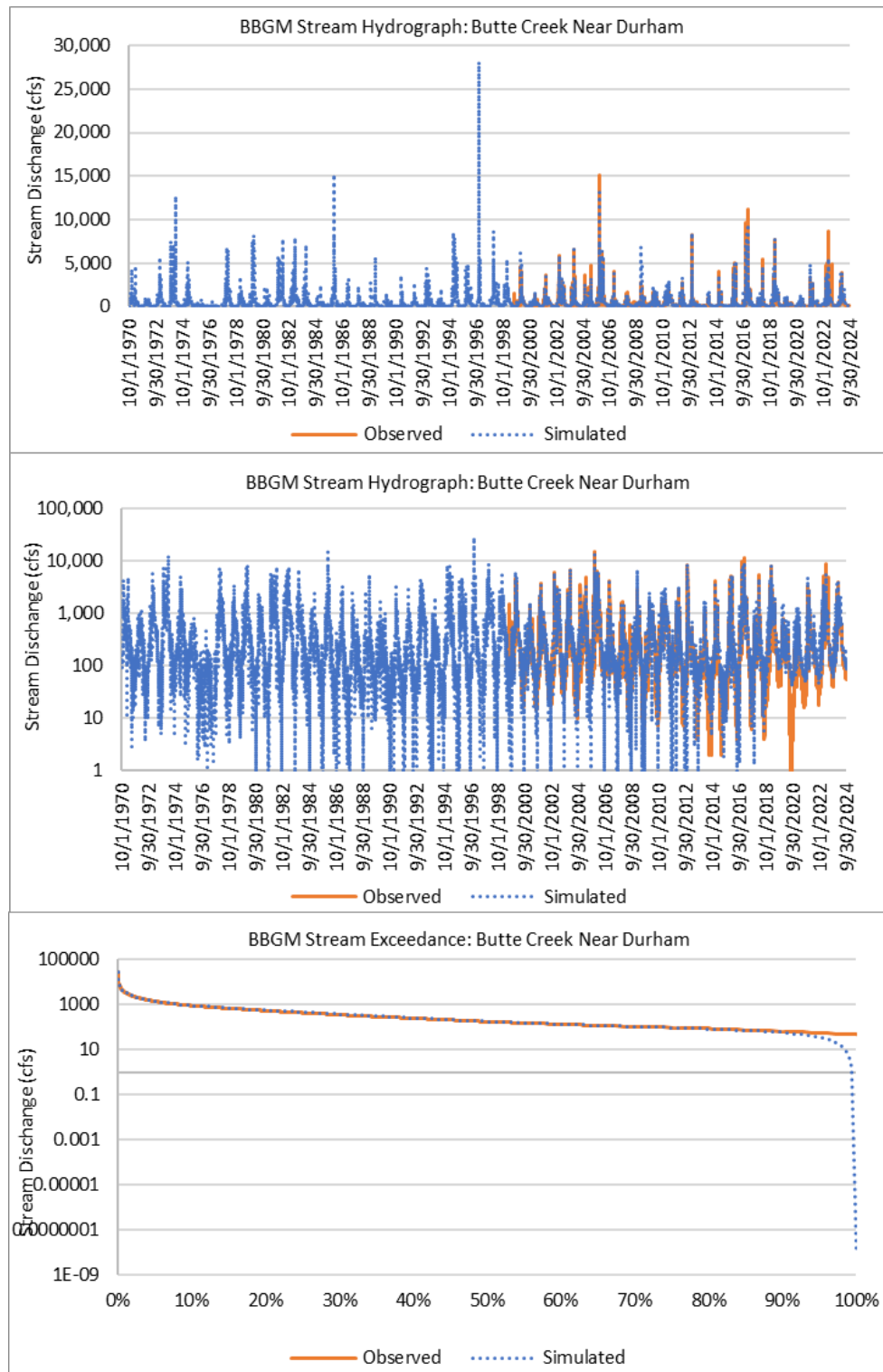


Figure 29: Stream Calibration for Butte Creek ("B" in map)

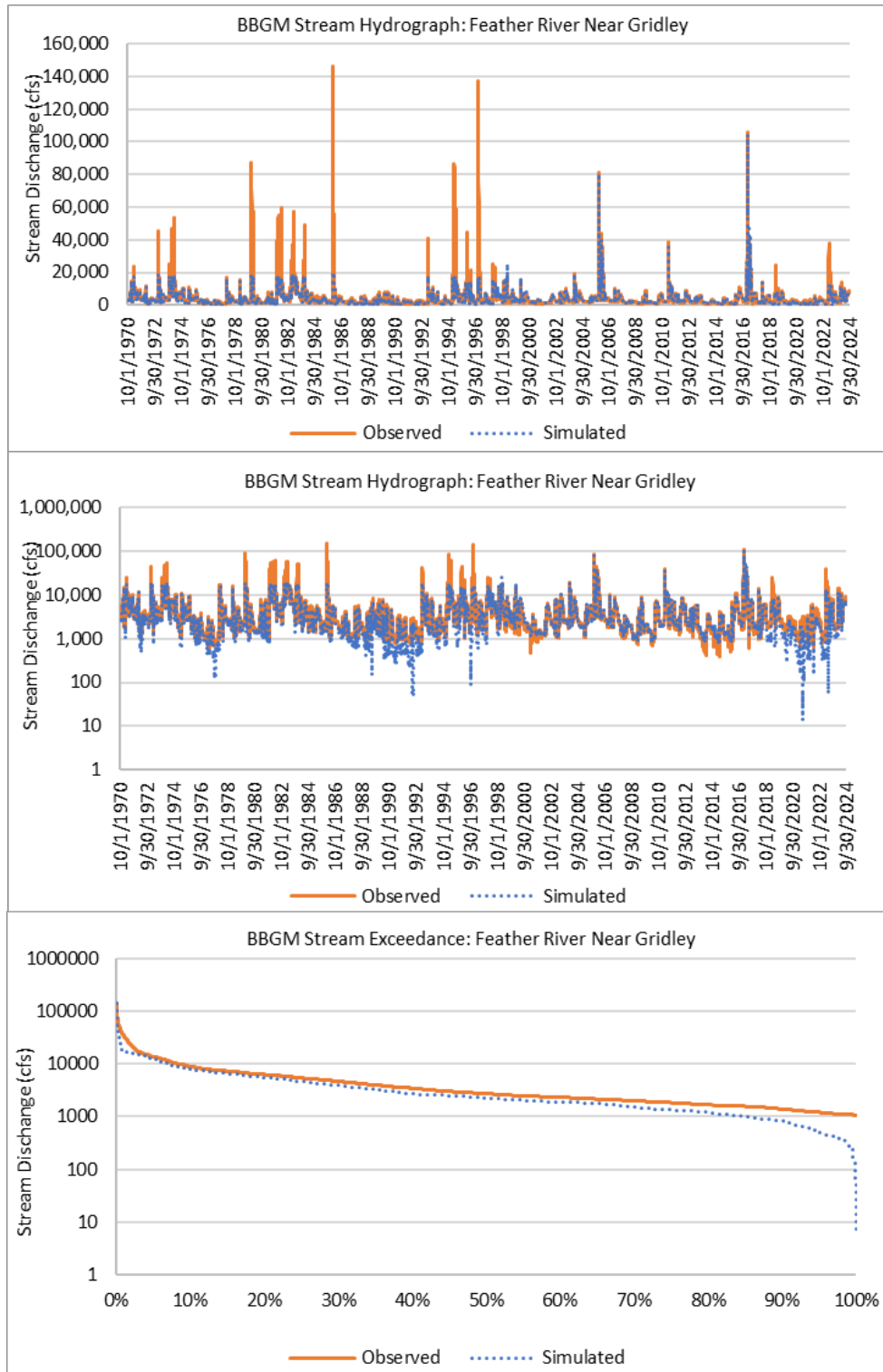


Figure 30: Stream Calibration for Feather River ("C" in map)

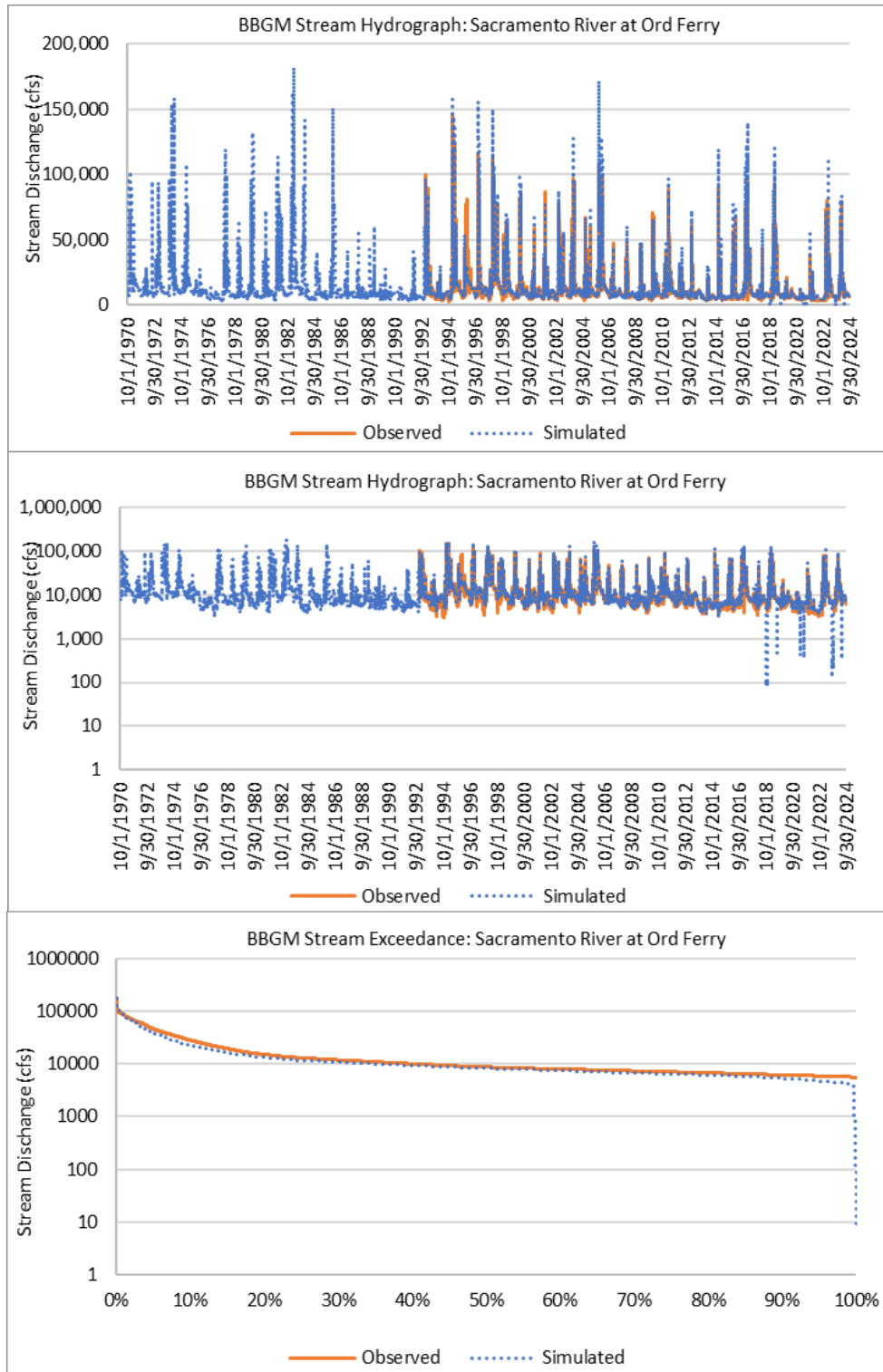


Figure 31: Stream Calibration for Sacramento River ("D" in map)

4.3.3 Groundwater Level Hydrographs and Residuals

The same 315 groundwater level hydrographs and observation data from BBGM Version 1.0's calibration were reviewed for BBGM Version 1.3 (see map in Figure 20). As in BBGM Version 1.0, groundwater observations are only for spring (March-May). Similar to stream hydrographs described above, groundwater levels were extended through 2024 for all available hydrographs using data downloaded from DWR via California Open Data.

Calibration statistics for groundwater levels are provided in Figure 32, and a map showing the location of absolute average groundwater head residuals by calibration well is in Figure 33. Groundwater level hydrographs may be viewed in Attachment 5. The time series extension added about 2,000 additional observation data points, and the calibration statistics and residual map indicate that the extended model (Version 1.3) is still behaving consistently with BBGM Version 1.2.

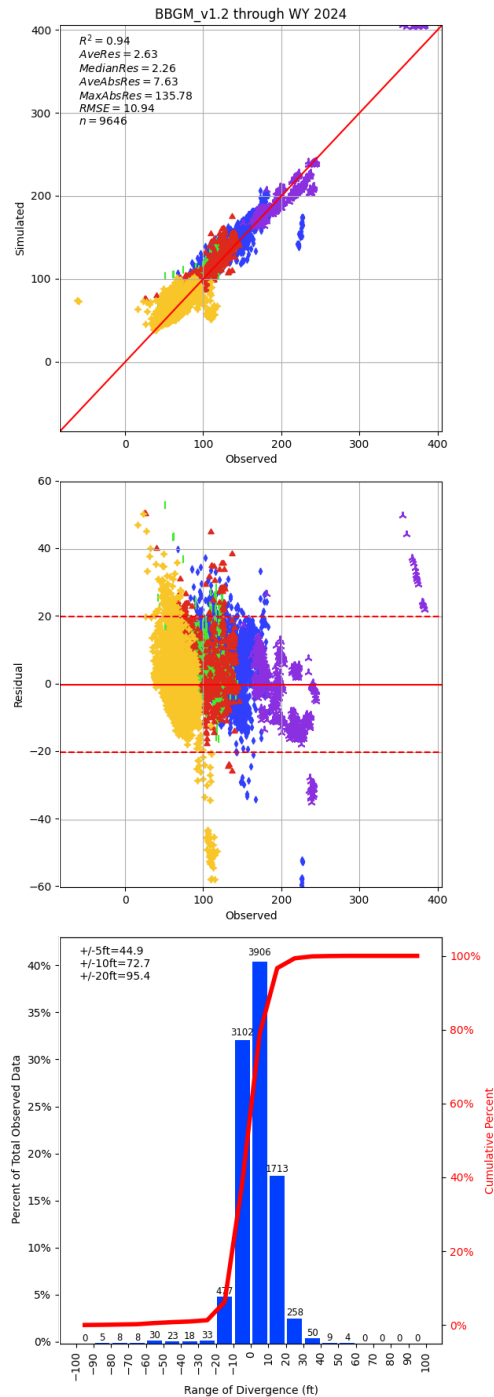


Figure 32: Scatter Plot and Residual Histogram of Entire BBGM Version 1.2 Extended Through 2024

Note: Statistics calculated using only observed water levels for spring (March-May) 1990-2018

Key: SUBB1= Vina Subbasin, SUBB2= Butte Subbasin, SUBB3= Wyandotte Creek Subbasin, SUBB4= North of Vina Subbasin, SUBB5= South of Butte and Wyandotte Creek Subbasins

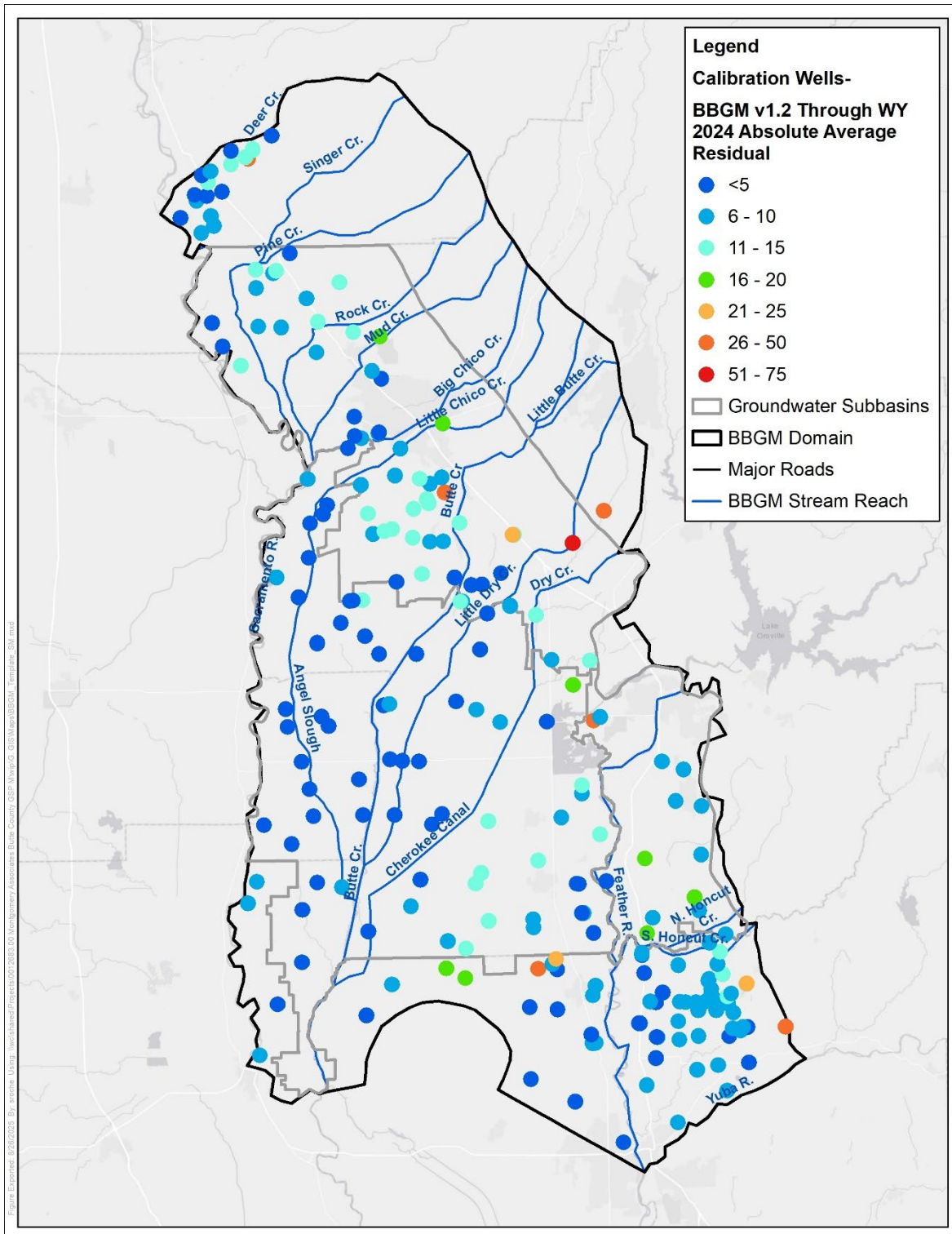


Figure 33: Absolute Average Residual Map of Entire BBGM Version 1.2 through 2024 (Version 1.3)

4.3.4 Subbasin Groundwater Budget

The groundwater budgets were analyzed as described in Section 1.6.2. Groundwater budgets are included for Vina, Butte, and Wyandotte Creek Subbasins as shown in the figures below.

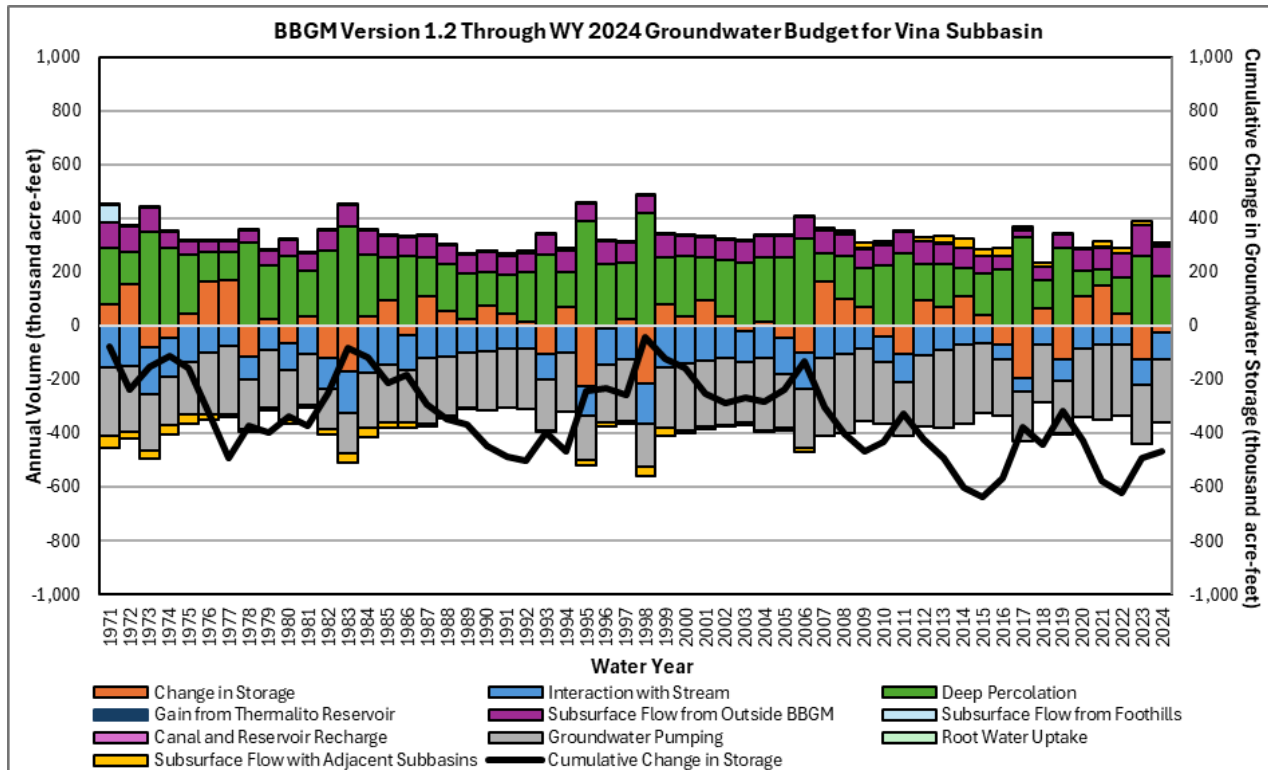


Figure 34: BBGM Version 1.2 through WY 2024 (Version 1.3) Groundwater Budget for Vina Subbasin

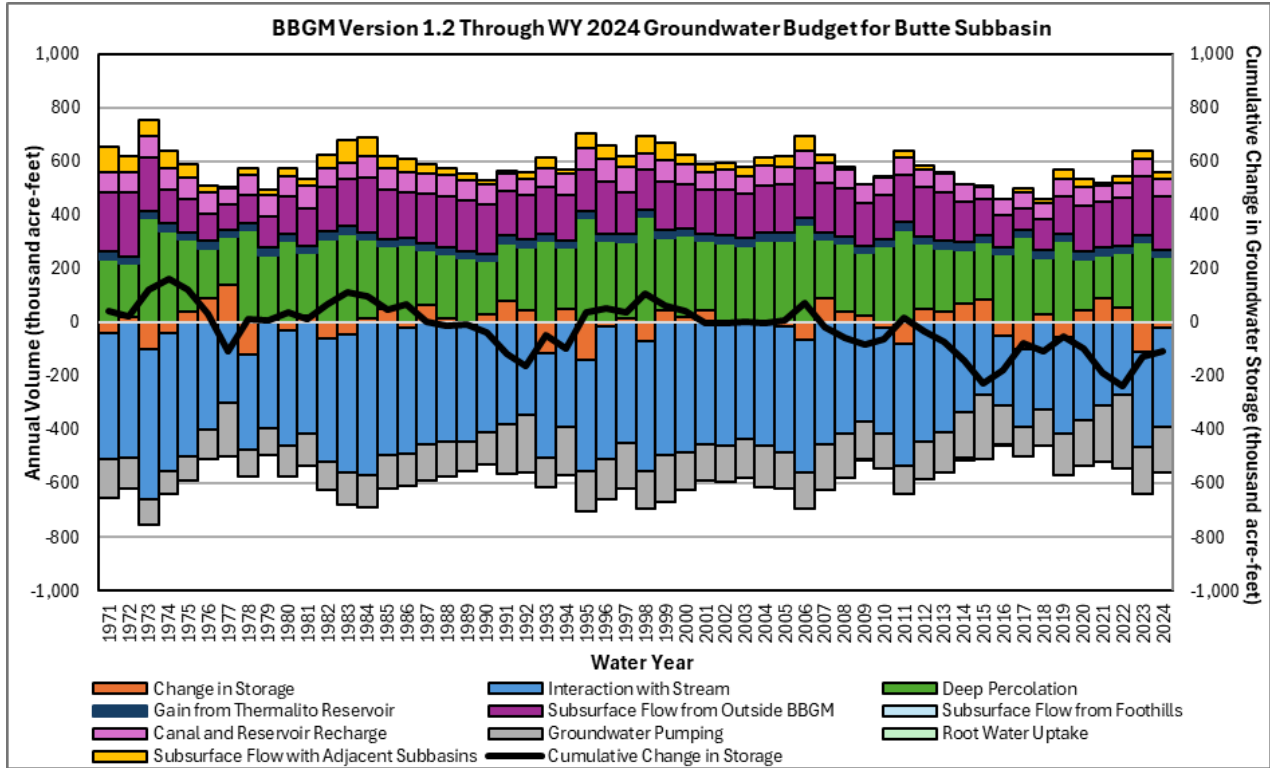


Figure 35: BBGM Version 1.2 through WY 2024 (Version 1.3) Groundwater Budget for Butte Subbasin

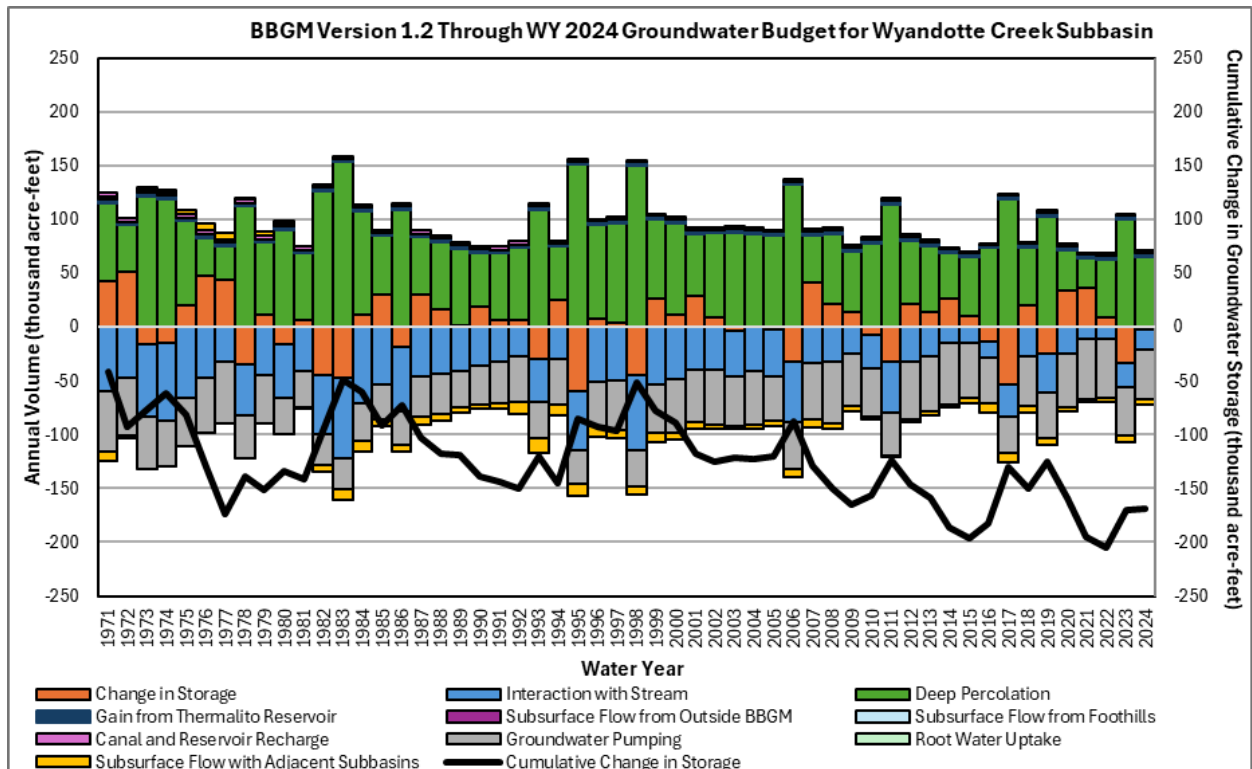


Figure 36: BBGM Version 1.2 through WY 2024 (Version 1.3) Groundwater Budget for Wyandotte Creek Subbasin

5. COMPARISON OF BBGM VERSION 1.2 TO BBGM VERSION 1.0

Section 2 describes all the changes made to BBGM Version 1.0 that resulted in BBGM Version 1.2. In order to understand the impact the changes had on the model, it is useful to look at results for the two models side-by-side. The following sections compare BBGM Version 1.2 to BBGM Version 1.0.

5.1 Sacramento and Feather Rivers Steam-Aquifer Interaction

The same reaches of the Sacramento and Feather Rivers were analyzed as described in Section 1.6.1, and the entire Sacramento and Feather Rivers are summarized and shown in Table 11, Figure 37, and Figure 38. Attachment 2 includes the results for all the individual reaches. The stream inflows for BBGM Version 1.0 and BBGM Version 1.2 are identical for Feather River and very similar for Sacramento River. The average net gain for Sacramento River is higher in BBGM Version 1.2 than BBGM Version 1.0, though Figure 13 indicates that BBGM Version 1.0's average is reduced due to the presence of many negative values (indicating loss of the stream to the groundwater system).

Table 11: Comparison of Sacramento and Feather River Annual Averages for Stream Inflow and Gain/Loss

Model	Number of Stream Nodes	Model Time Period	Average Inflow (AFY)	Average Net Gain/Loss (AFY)
Entire Sacramento River in BBGM (Reaches A, B, C, and D)				
BBGM Version 1.0	131	WY 1971-2018	10,079,056	209,692
BBGM Version 1.2		WY 1971-2018	9,932,479	352,421
Entire Feather River in BBGM (Reaches FR1, FR2, and FR3)				
BBGM Version 1.0	57	WY 1971-2018	3,705,077	112,387
BBGM Version 1.2		WY 1971-2018	3,705,077	118,030

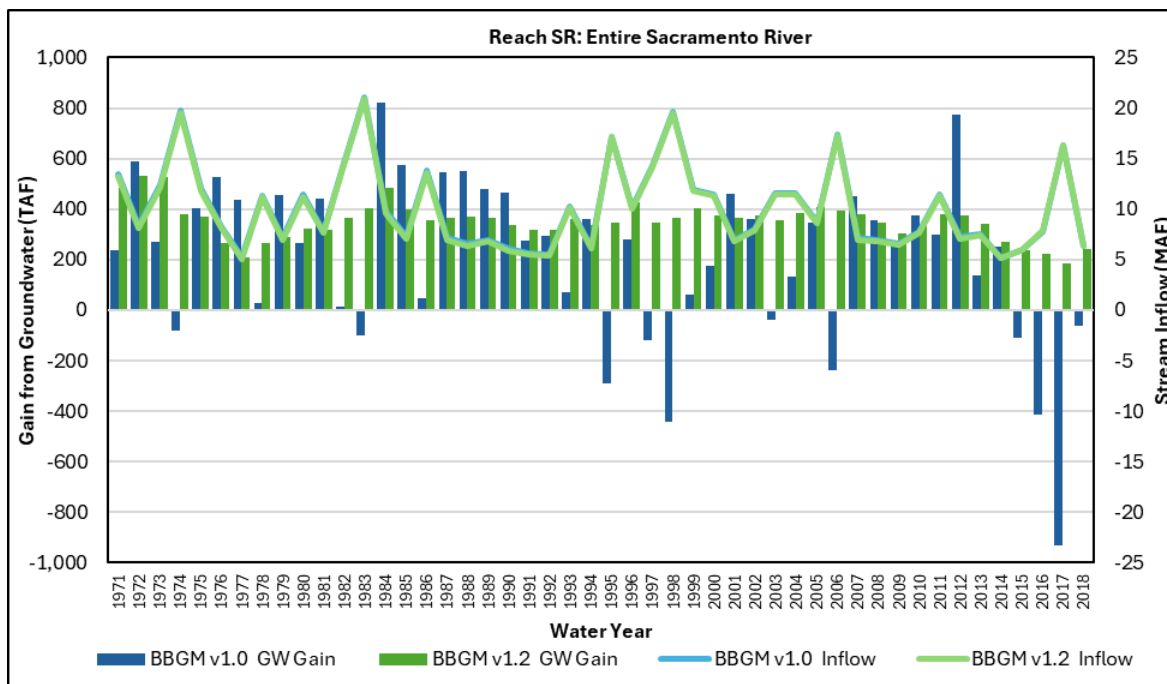


Figure 37: Comparison of Sacramento River Reaches Within BBGM

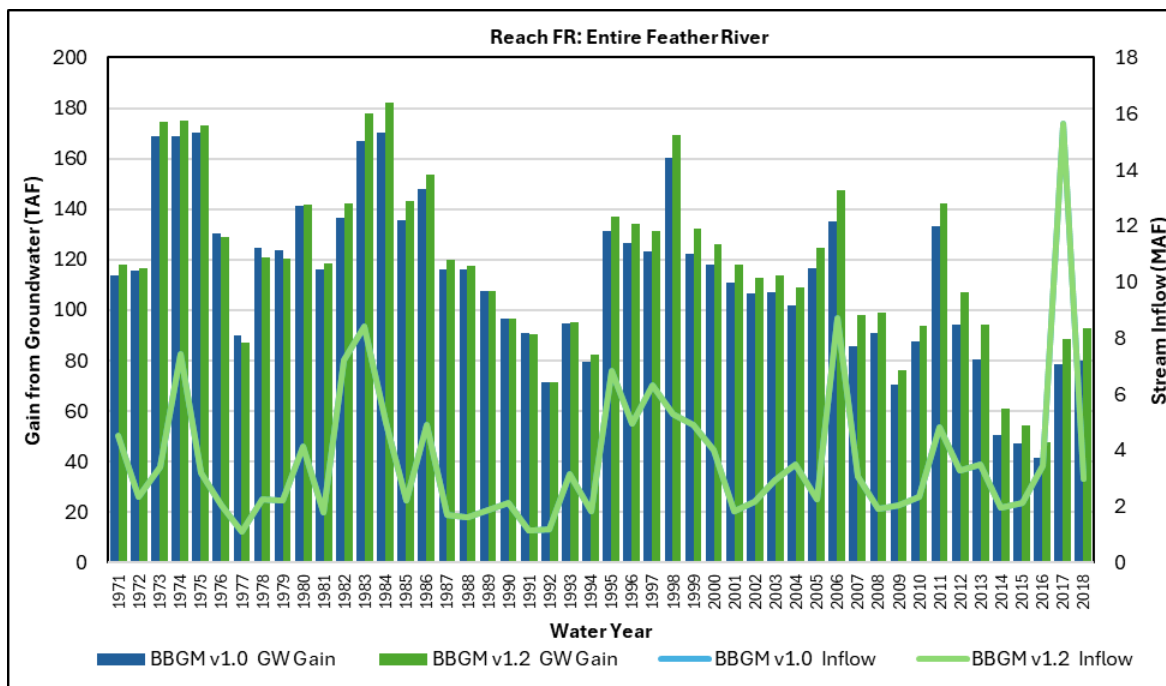


Figure 38: Comparison of Feather River Reaches Within BBGM

Note: BBGM has two inflows for Feather River (upper and middle). For consistency with the regional models, the Feather River inflow above is the sum of both upper and middle Feather River inflows.

5.2 Groundwater Level Hydrographs and Residuals

For comparison to BBGM Version 1.2, the groundwater level calibration statistics from BBGM Version 1.0 (also available in the BBGM Version 1.0 Model Report: BCDWRC, 2021) are provided below.

Both models have a similar calibration overall. The average water levels residual map also shows similar results but with some improvements, as expected, on the east side of the model domain, likely due to the revised ground surface elevation in the foothills area of the model.

Attachment 5 includes groundwater level hydrographs comparing all observation points to the BBGM Version 1.0, Version 1.2 and Version 1.2 extended through 2024. In general, BBGM Versions 1.2 and 1.2 extended through 2024 estimate higher water levels than BBGM Version 1.0. For the first decade or so of the model simulation timeframe, Version 1.2 estimates higher water levels in portions of the model domain compared to Version 1.2 extended through 2024. This can be attributed to the change in IWF program version, as explained in Section 3.

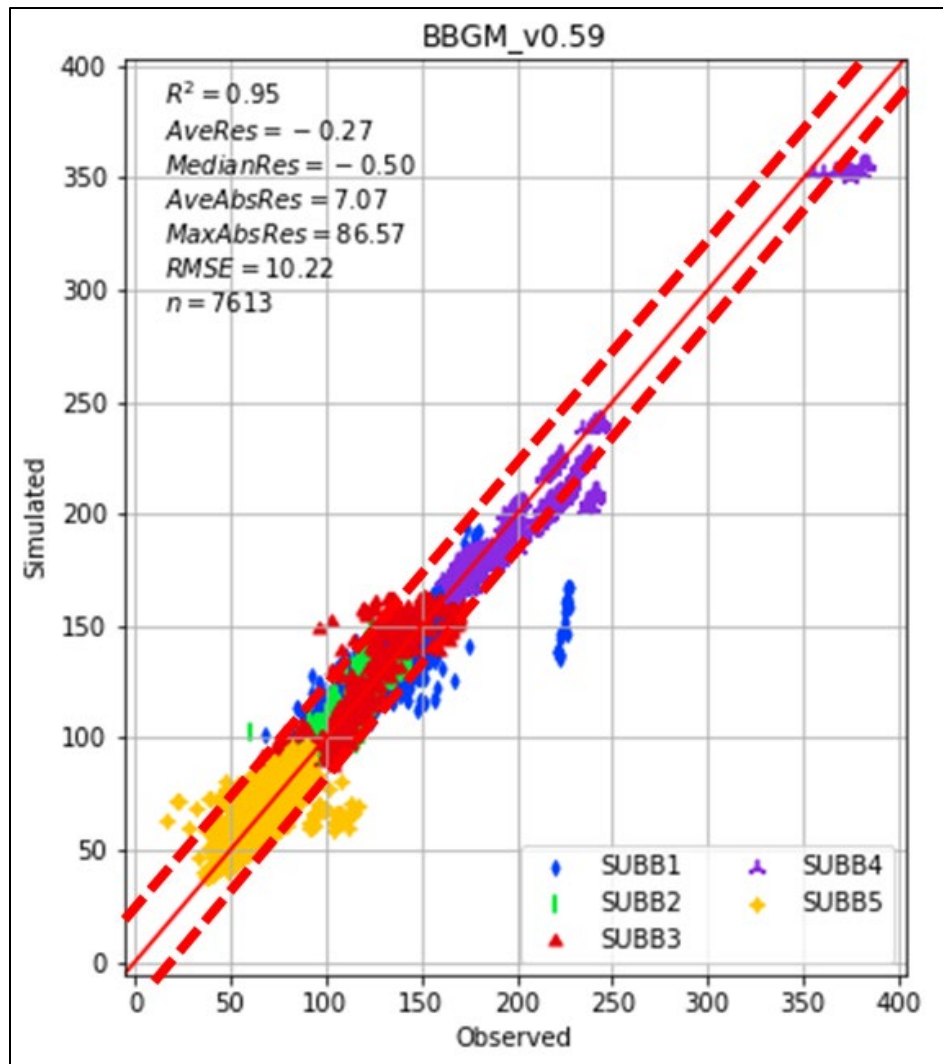


Figure 39: Scatter Plot of Entire BBGM v 1.0

Note: Statistics calculated using only observed water levels for spring (March-May) 1990-2018

Key: SUBB1= Vina Subbasin, SUBB2= Butte Subbasin, SUBB3= Wyandotte Creek Subbasin, SUBB4= North of Vina Subbasin, SUBB5= South of Butte and Wyandotte Creek Subbasins

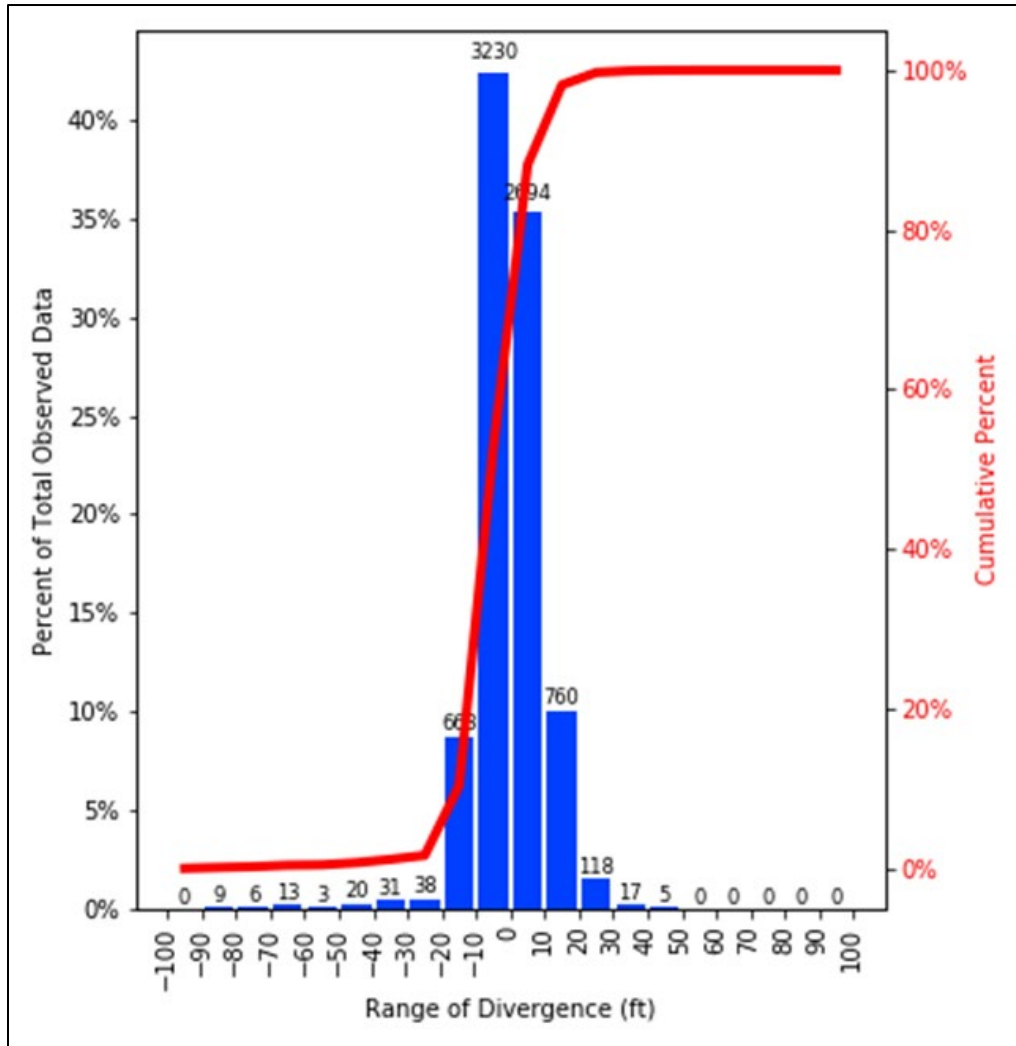


Figure 40: Residual Histogram of Entire BBGM v1.0

Note: Observed water levels only for spring (March-May) 1990-2018

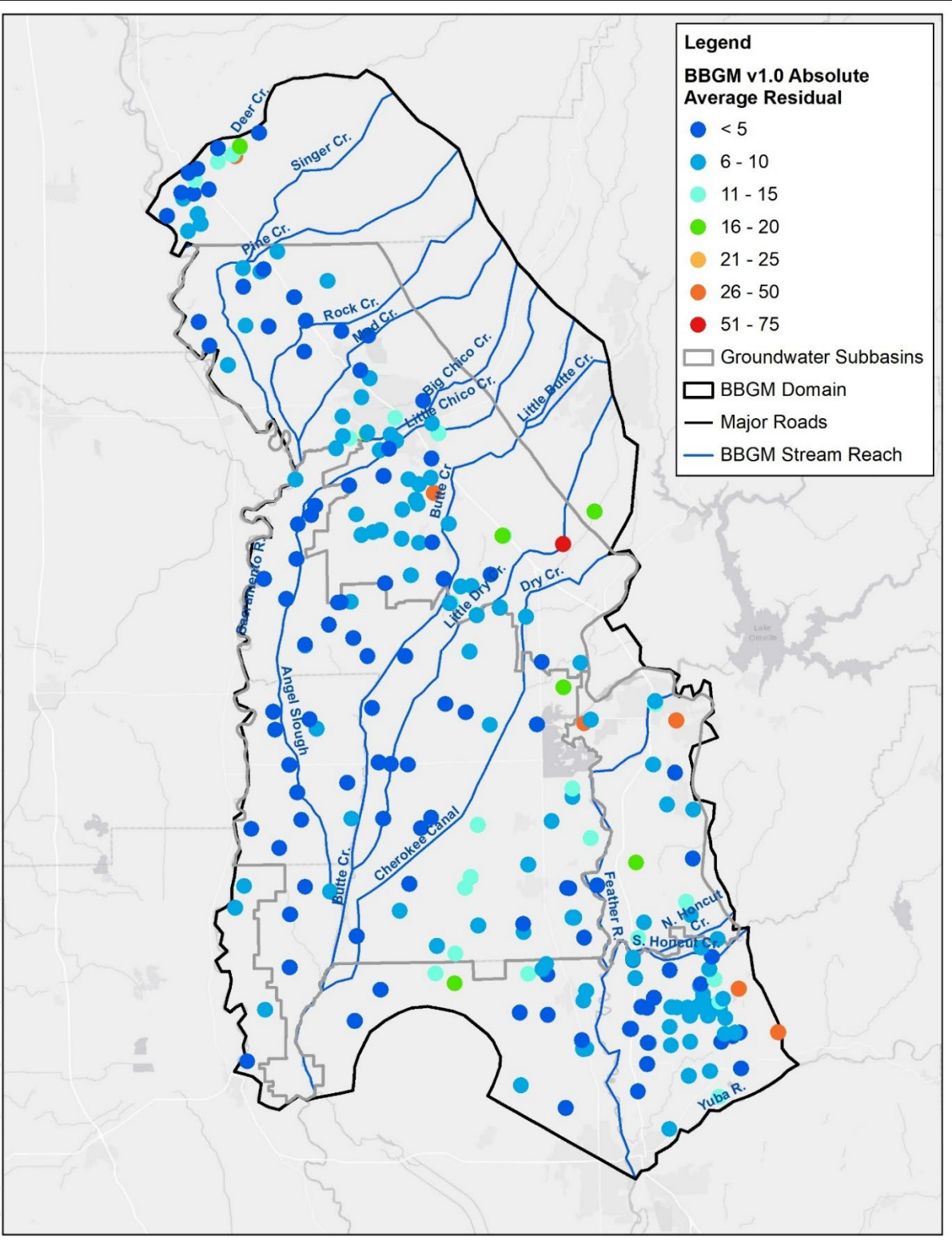


Figure Escondido_42352026 By author Using: twchahard/Projects/0012683/00_Montgomery Associates Blaine County GSP Map/06_GIS/Maps/BBGM_Template_S1.mxd

Figure 41: Absolute Average Residual Map of Entire BBGM Version 1.0

5.3 Subbasin Groundwater Budget

The groundwater budgets were analyzed as described in Section 1.6.2. Groundwater budgets are included for Vina, Butte, and Wyandotte Creek Subbasins as shown in Table 12 below for averages of the major groundwater budget components. All the groundwater budget figures and summary tables are included in Attachment 3. The results indicate many similarities between BBGM Version 1.2 and BBGM Version 1.0; the main areas of the groundwater budget that changed dramatically were the interaction with streams and the subsurface flow with adjacent subbasins, which was expected due to the changes that were made to BBGM Version 1.2. BBGM Version 1.2's transition from specified head to general head boundary conditions reduced the subsurface flow coming into the model, which in turn caused an almost identical reduction in the interaction with stream category. Both Butte and Vina Subbasins display this behavior, with Butte Subbasin at a much larger magnitude than Vina Subbasin.

Table 12: Comparison of Major Groundwater Budget Components, Comparable Average (WY 1971-2018)

Model	Model Time Period	Change in Groundwater Storage	Interaction with Stream	Deep Percolation	Groundwater Pumping	Subsurface Flow with Adjacent Subbasins
Vina Subbasin						
BBGM Version 1.0	WY 1971-2018	15,881	-118,889	209,876	-220,226	65,582
BBGM Version 1.2	WY 1971-2018	12,619	-121,814	209,870	-220,218	61,378
Butte Subbasin						
BBGM Version 1.0	WY 1971-2018	3,536	-536,058	268,062	-135,918	302,083
BBGM Version 1.2	WY 1971-2018	2,203	-432,123	268,116	-135,784	199,256
Wyandotte Creek Subbasin						
BBGM Version 1.0	WY 1971-2018	3,137	-43,367	80,137	-42,578	-4,851
BBGM Version 1.2	WY 1971-2018	3,182	-44,166	80,137	-42,578	-4,059

6. COMPARISON OF BBGM TO C2VSIMFG V1.5

The previous sections compared BBGM Version 1.2 to BBGM Version 1.0, both of which were separately compared to the most recent regional model from DWR (C2VSIMFG Version 1.5). The information below shows the results of all three models together.

Table 13 includes some of the major groundwater budget components for each of the model versions for the groundwater subbasins, all averaged across a comparable period of WY 1974 through 2015. All the groundwater budget figures are included in Attachment 3. As was seen in the comparison of BBGM Version 1.0 with the three regional models in Section 1.6.2, the results indicate some disagreement between BBGM and the regional model. Change in groundwater storage, deep percolation, and groundwater pumping indicate the same flow direction in all three models, though magnitudes are sometimes very different. Both BBGM versions show the aquifer losing water to the streams in the three subbasins (indicating gaining streams), while C2VSIMFG Version 1.5 shows the aquifer losing water to the streams in Vina and Wyandotte Creek Subbasins, but gaining water from the streams in the Butte Subbasin (indicating losing streams). This trend was not seen in C2VSIMFG Version 1.5's budget for Vina Subbasin's portion of Sacramento River, so it must be occurring in other interior streams in the subbasin. C2VSIMFG Version 1.5 indicates that Butte Subbasin is losing water via subsurface flow to adjacent subbasins, and Wyandotte Creek Subbasin is gaining water from the adjacent subbasins; both BBGM models indicate the opposite occurring (Butte Subbasin receiving water from surrounding subbasins and Wyandotte Creek losing water to adjacent subbasins).

Table 13: Comparison of Major Groundwater Budget Components, Annual Average (WY 1974-2015)

Model	Model Time Period	Change in Groundwater Storage	Interaction with Stream*	Deep Percolation	Groundwater Pumping	Subsurface Flow with Adjacent Subbasins
Vina Subbasin						
BBGM Version 1.0	WY 1971-2018	17,232	-134,796	208,746	-220,551	83,871
BBGM Version 1.2	WY 1971-2018	18,163	-121,547	208,740	-220,539	62,313
C2VSIMFG Version 1.5	WY 1974-2021	6,390	37,087	104,753	-167,991	5,784
Butte Subbasin						
BBGM Version 1.0	WY 1971-2018	8,859	-552,520	268,791	-137,836	314,032
BBGM Version 1.2	WY 1971-2018	8,651	-435,960	268,833	-137,721	197,486
C2VSIMFG Version 1.5	WY 1974-2021	2,477	-41,026	223,047	-133,458	-20,707
Wyandotte Creek Subbasin						
BBGM Version 1.0	WY 1971-2018	3,002	-43,720	80,219	-42,180	-4,818
BBGM Version 1.2	WY 1971-2018	2,928	-44,484	80,219	-42,180	-3,987
C2VSIMFG Version 1.5	WY 1974-2021	998	-7,536	46,256	-53,770	8,981

* Negative value indicates streams are gaining water from the groundwater aquifer.

7. CONCLUSIONS AND RECOMMENDATIONS

BBGM Version 1.0 was updated to incorporate important revisions and refinements to boundary conditions and to extend the model in time through Water Year 2024.

The model timeframe extension requires substantial effort due to the large number of surface water diversions and pumping wells that are specified in the model on a daily time step. This level of detail requires thorough record keeping and the need to develop assumptions when water districts do not provide comprehensive data required to create the model input files, as discussed in the sections above. The model is only as good as the input data. Creating a more streamlined process for model updates would be ideal and has not yet been fully established.

BBGM Version 1.2 performs better than BBGM Version 1.0 at stream boundaries, while not substantially modifying the calibration. However, when comparing to regional models, like C2VSimFG, values are quite different, even though some of the local Butte County model data were recently incorporated by DWR into the C2VSimFG Version 1.5. model. This shows that the complexity and level of detail of the inputs and the assumptions for parameters make a big difference for models, even if using the same overall code, IWFm.

Some recommendations for future improvements include:

- Developing a streamlined model update workflow for efficiency improvement
- Revisiting BBGM updates related to specific findings in model files as discussed in Sections 1 and 2, such as:
 - Update the representation of boundary conditions for subsurface inflows from the foothills
 - Reevaluate model layering with further processed AEM data, with DWR support; data from the well logs released by DWR as part of their AEM data package may also be useful for refining hydraulic conductivity in future model updates
 - Representation of the Feather River slurry wall may be considered for any baseline simulations representing future conditions
 - Refine pumping data after establishing a more streamlined process to receive accurate pumping data from agencies
 - Update the boundary condition along Deer Creek in collaboration with Los Molinos Subbasin GSA
 - Further explore the discrepancy of observed and simulated stream inflow for the Feather River
 - The representation of the streams in BBGM should continue to be evaluated in future updates to the model.
- A future updated and released version of C2VSimFG could be used to redevelop all the boundary conditions based on updated regional understanding. Recent groundwater level data available from DWR or other sources may allow for better refinement of groundwater level trends for model boundary conditions.

- Future BBGM applications should continue to adopt the most current IWFM version to take advantage of ongoing support from DWR, improved runtime efficiency, and more reliable representation of groundwater and surface water processes.
- Reassessing the need to have a daily groundwater flow model when most of the input data are provided at the monthly scale. A hybrid approach would be to process the IDC information on a daily basis, and then aggregate the results to incorporate into a monthly IWFM version.
- Regional coordination on modeling and collaboration with DWR for future model updates (e.g., code updates to IWFM and C2VSim calibrations for boundary conditions updates)
 - C2VSimFG is actively undergoing continuing updates, with a C2VSimFG Version 2.0 planned for late 2026. This version would be recalibrating Version 1.5.
 - Local model updates should be coordinated with the regional model updates

BBGM Version 1.2 extended through Water Year 2024 (Version 1.3) is a useful tool that can be used as a baseline model for the three Subbasin Periodic Evaluations in Butte County.

8. REFERENCES

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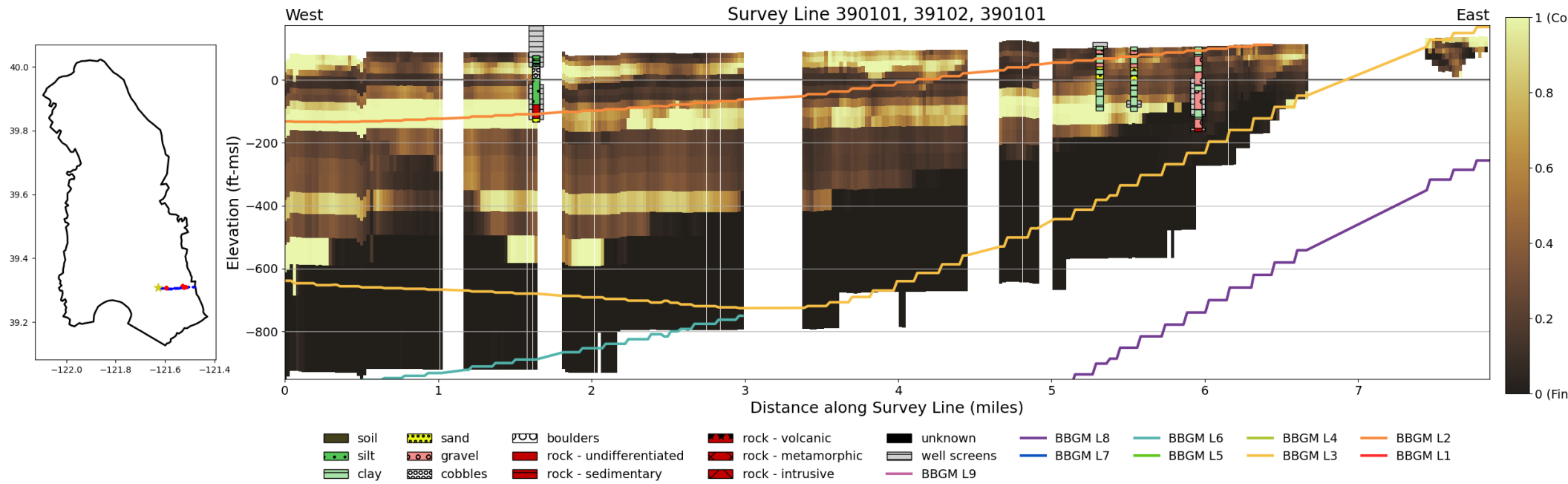
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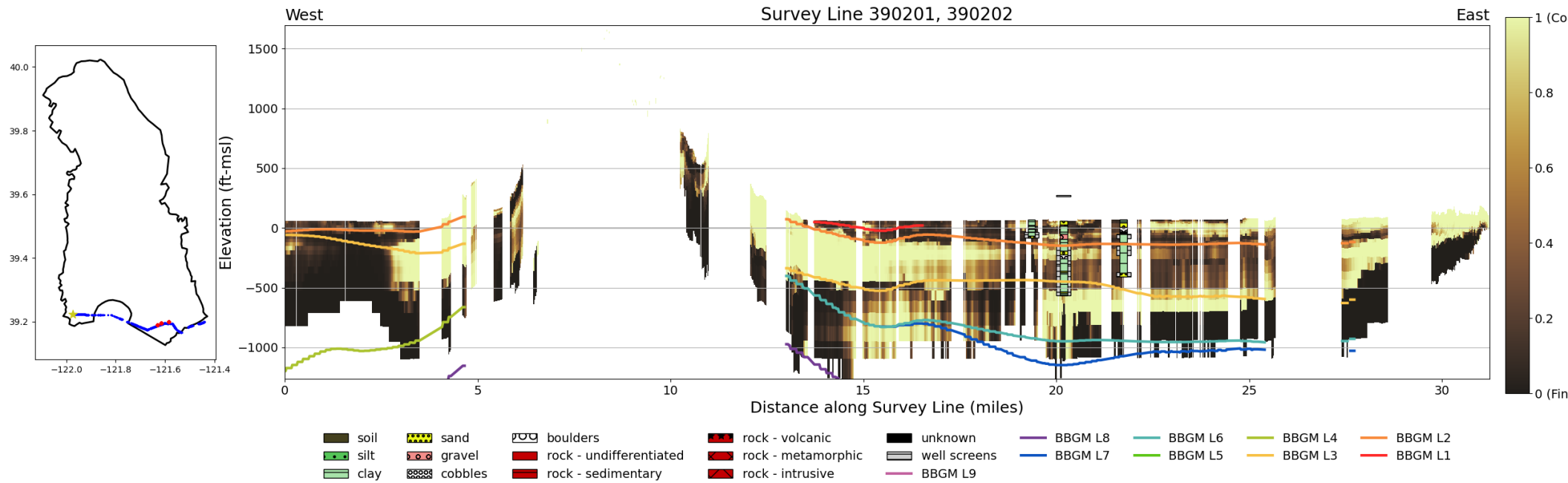
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Attachment 1. Cross-Sections Showing AEM Data and Model Layers

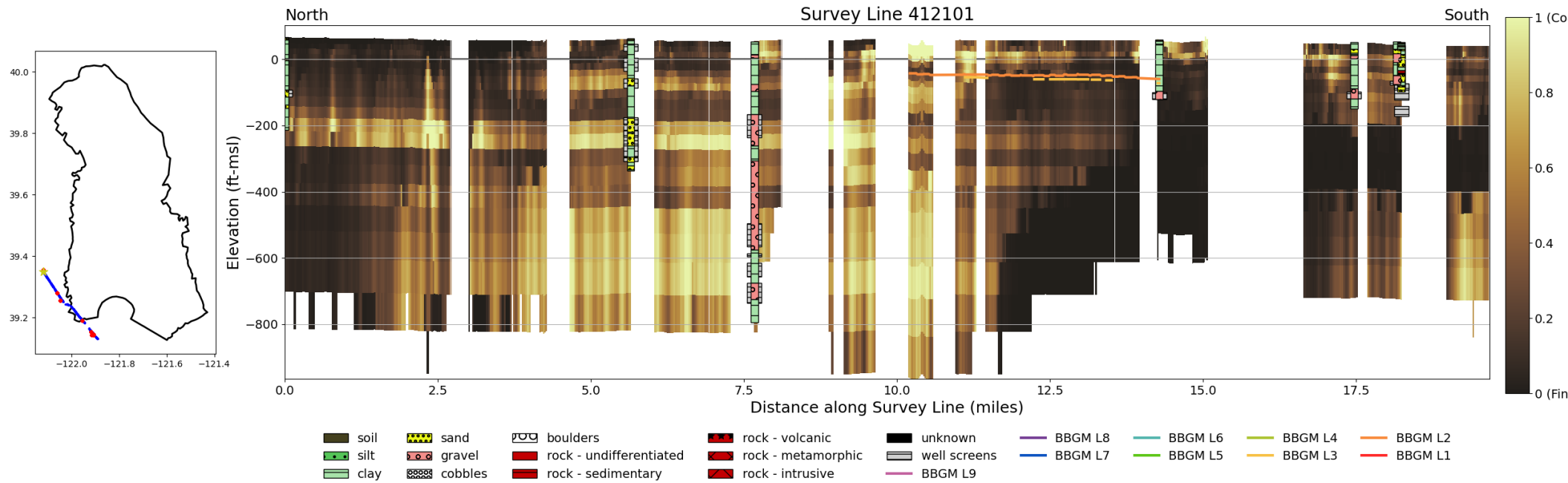
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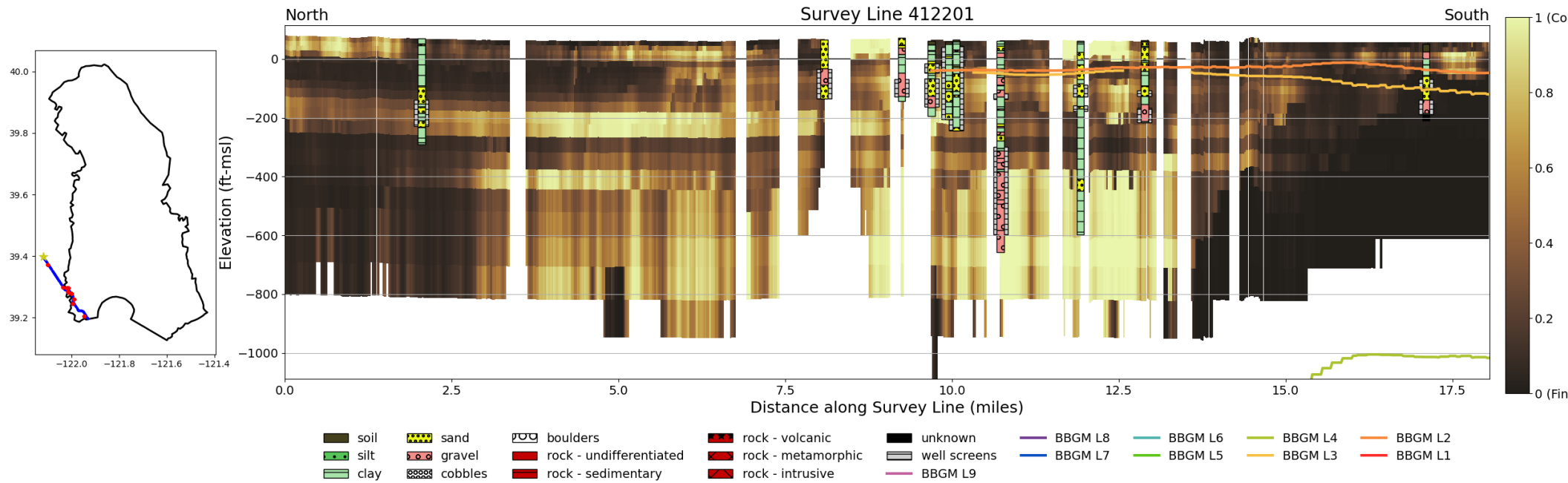
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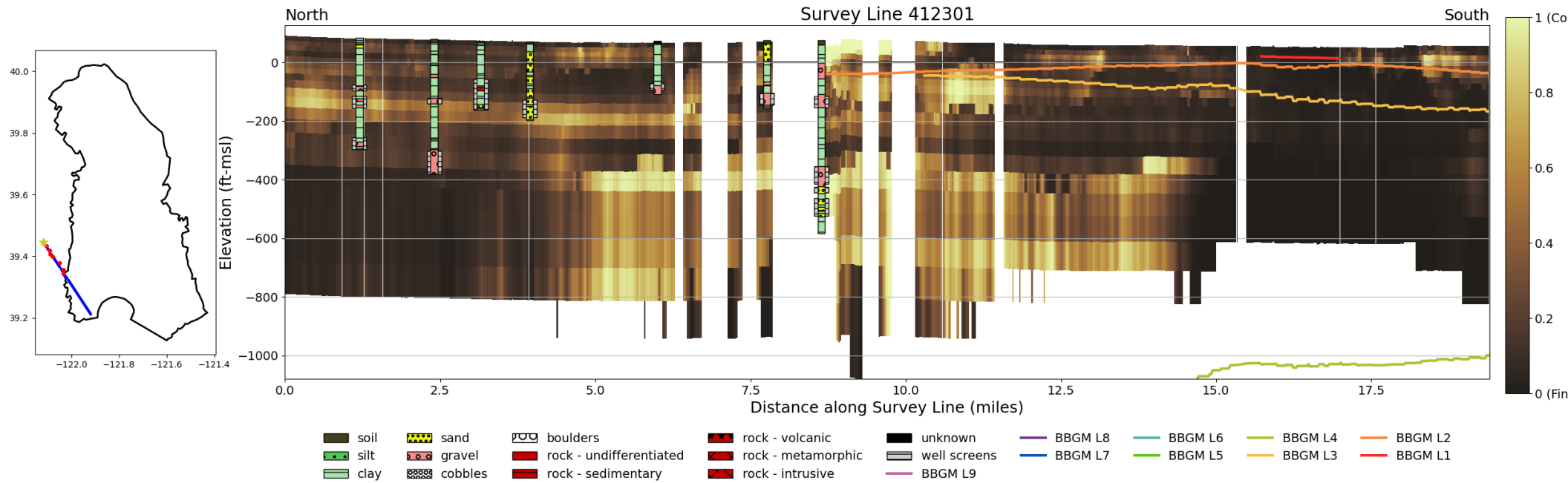
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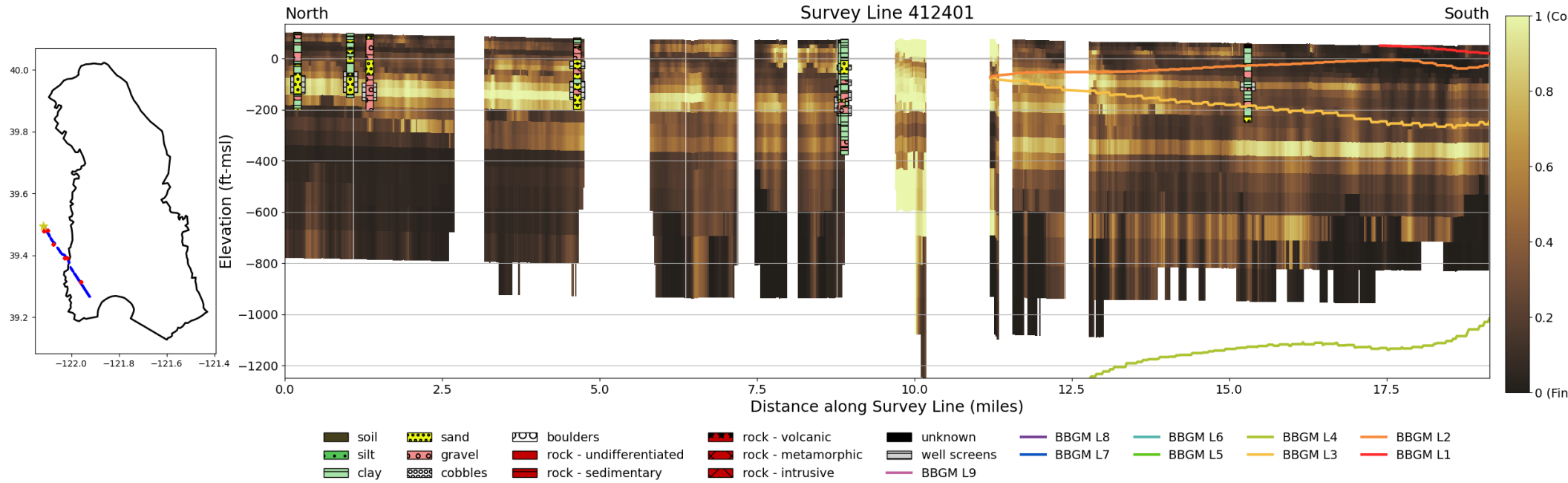
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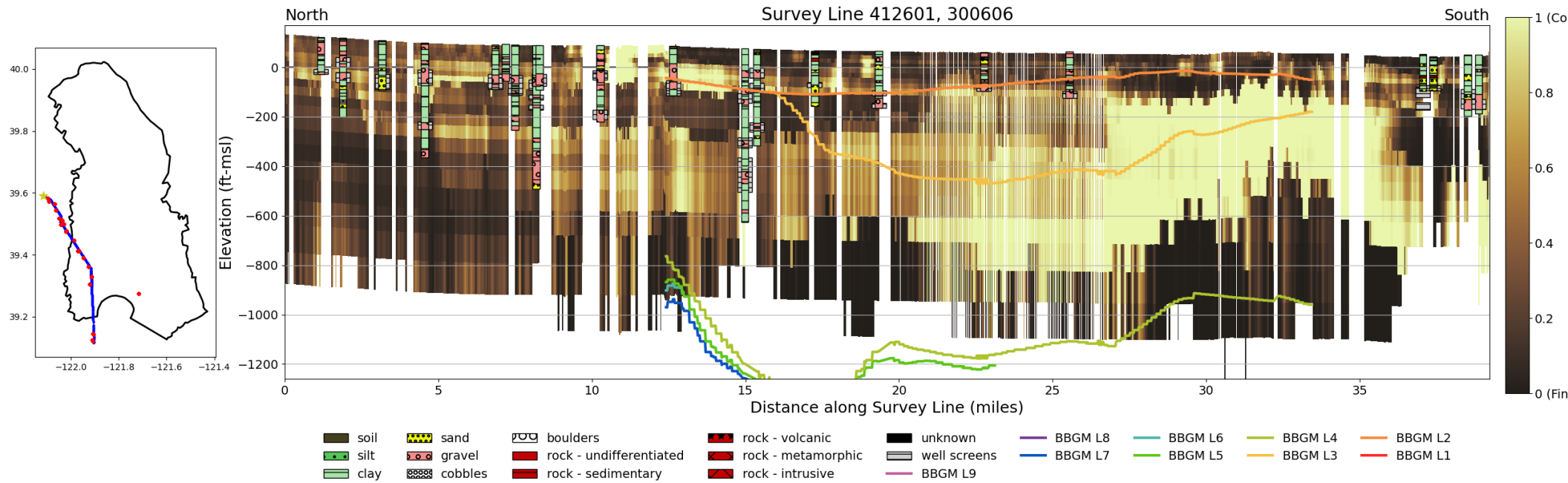
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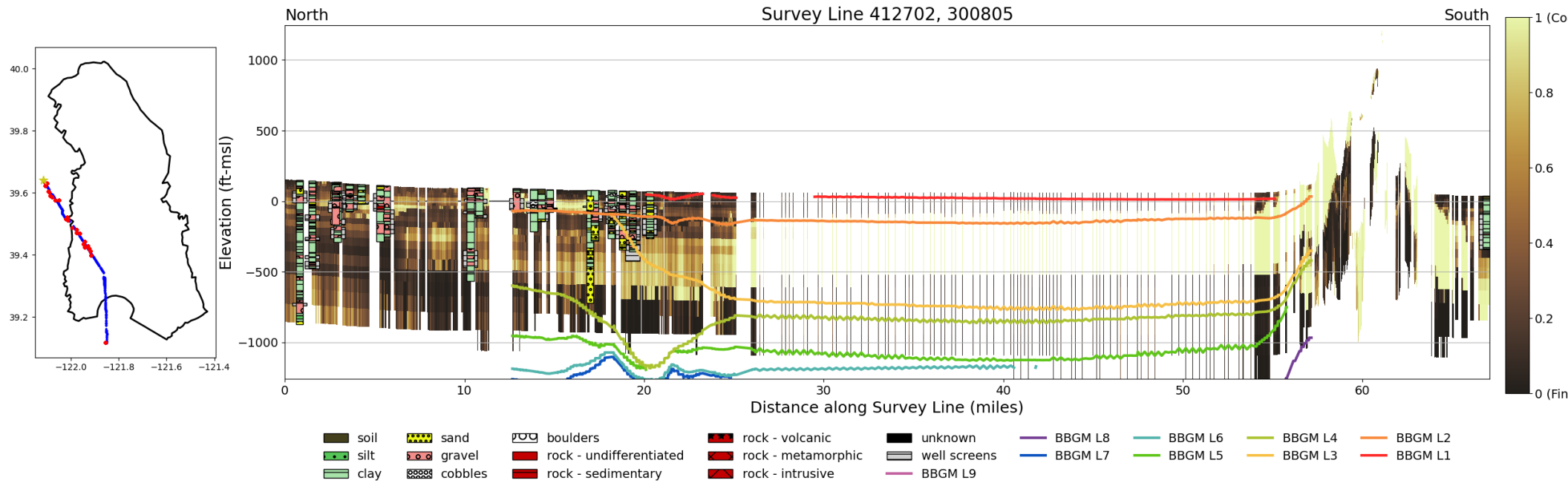
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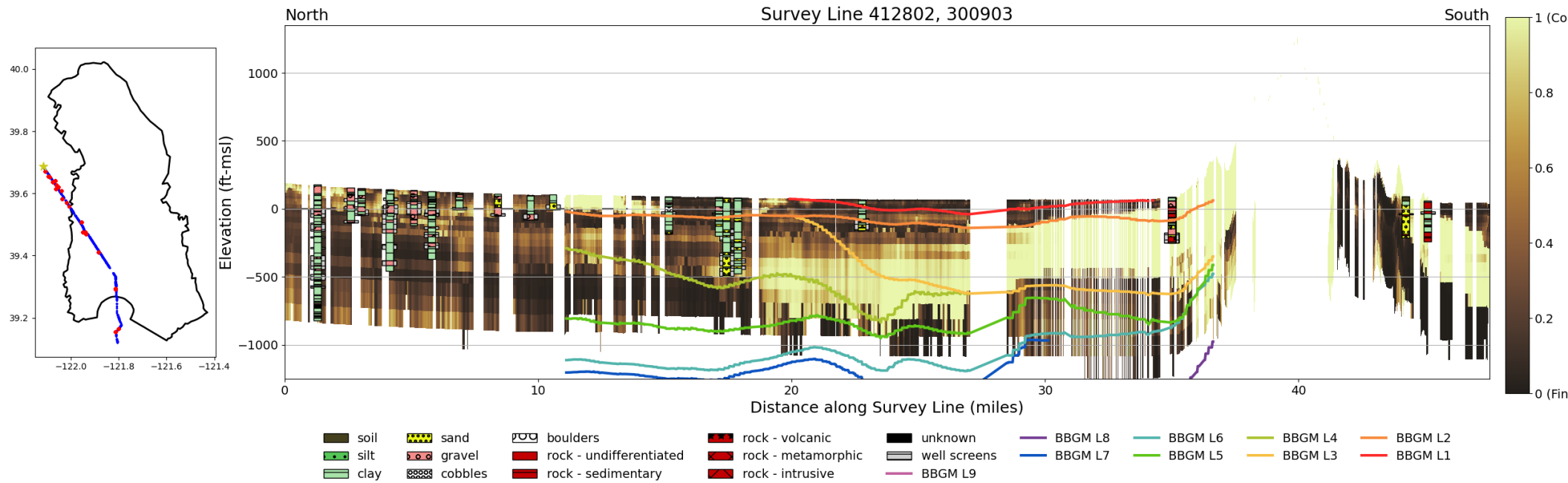
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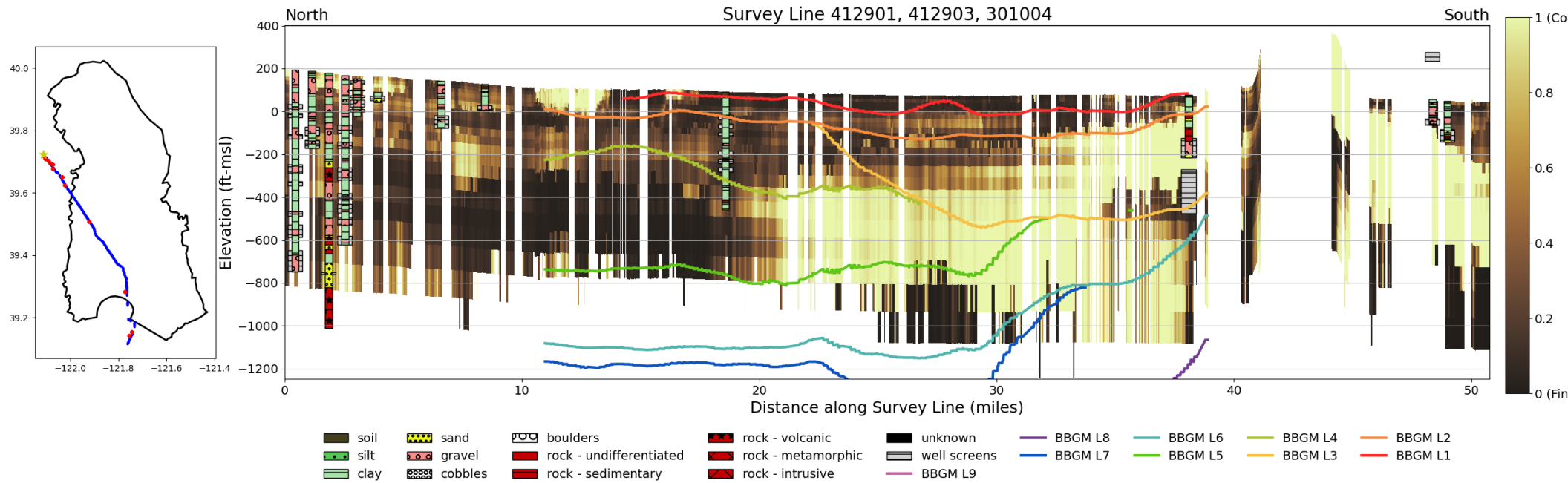
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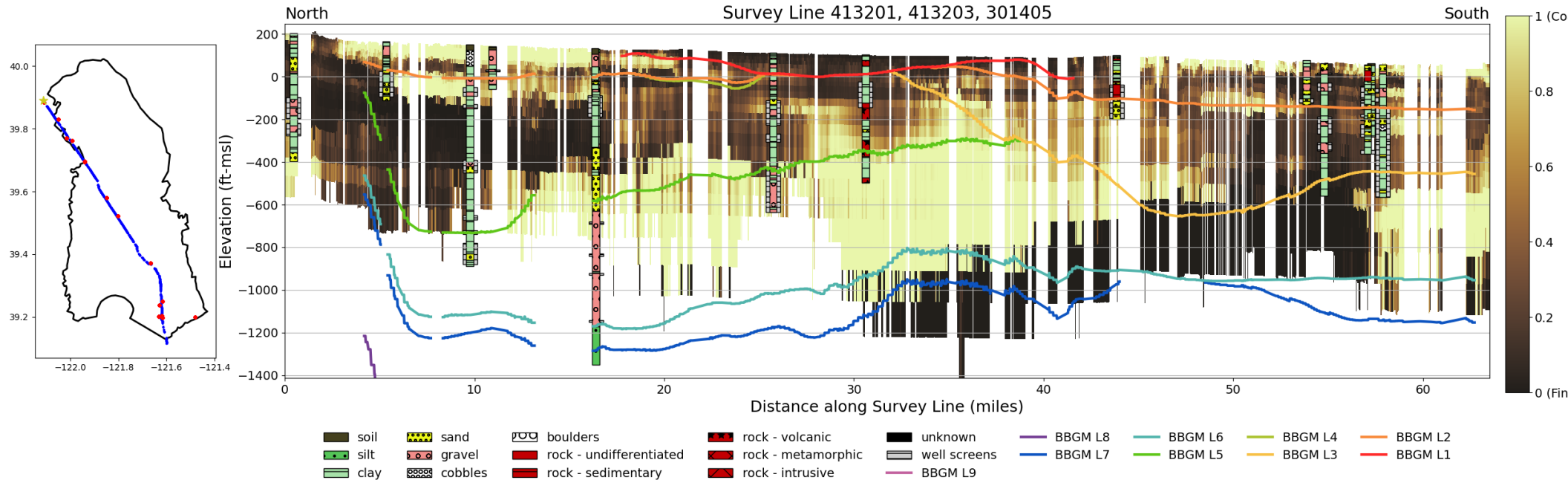
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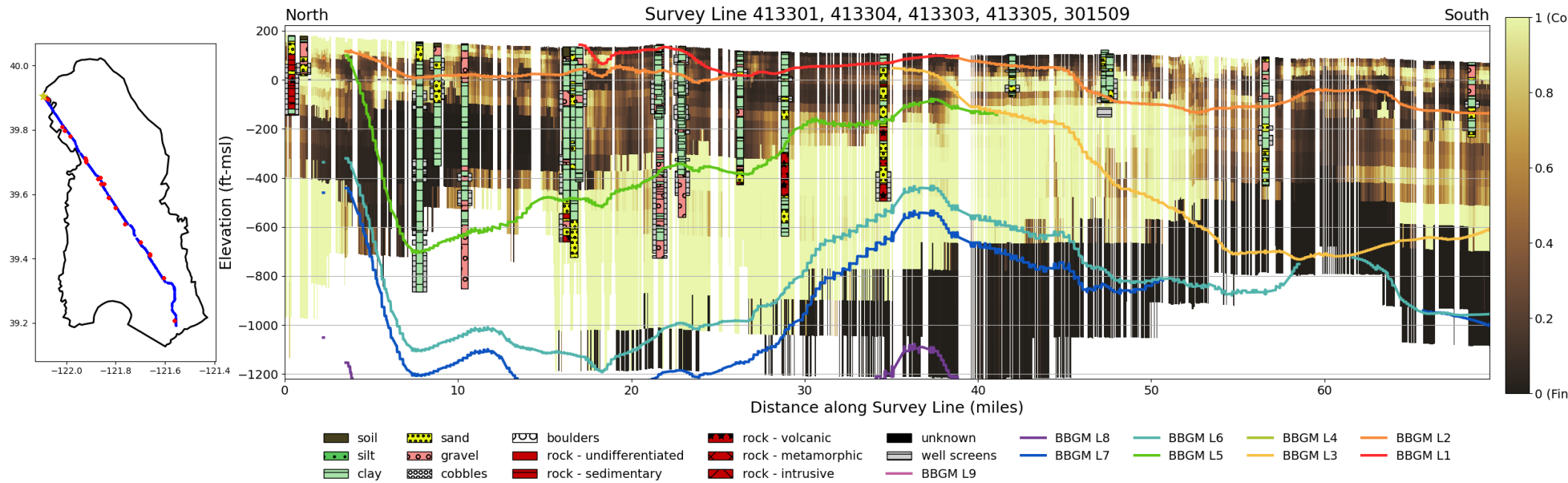
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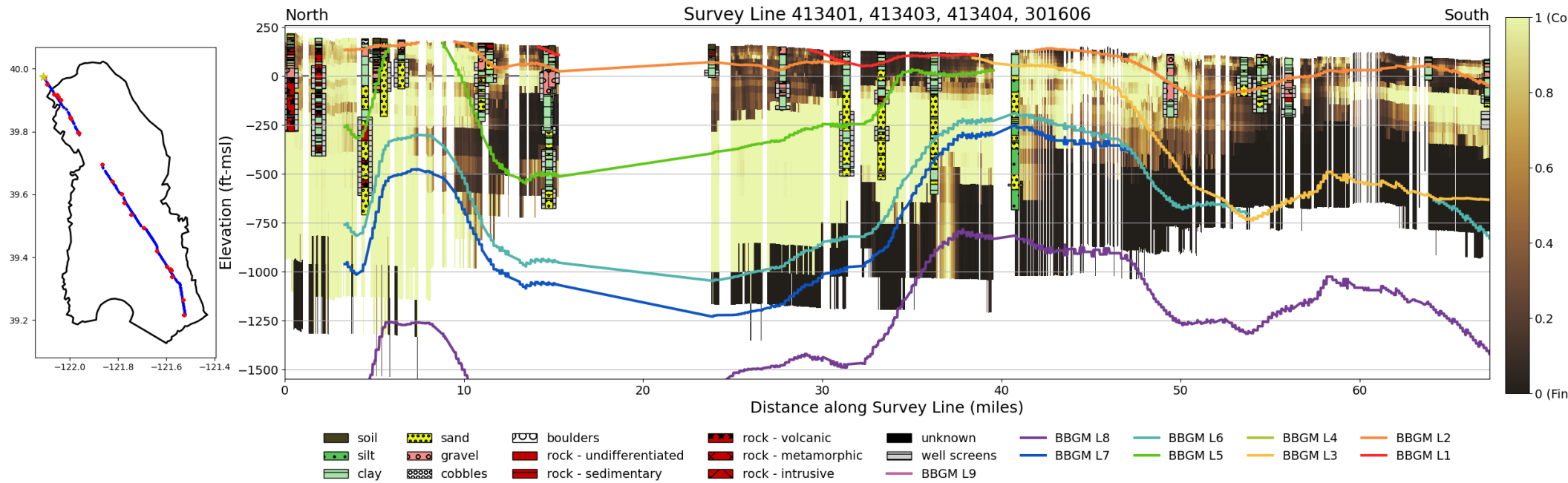
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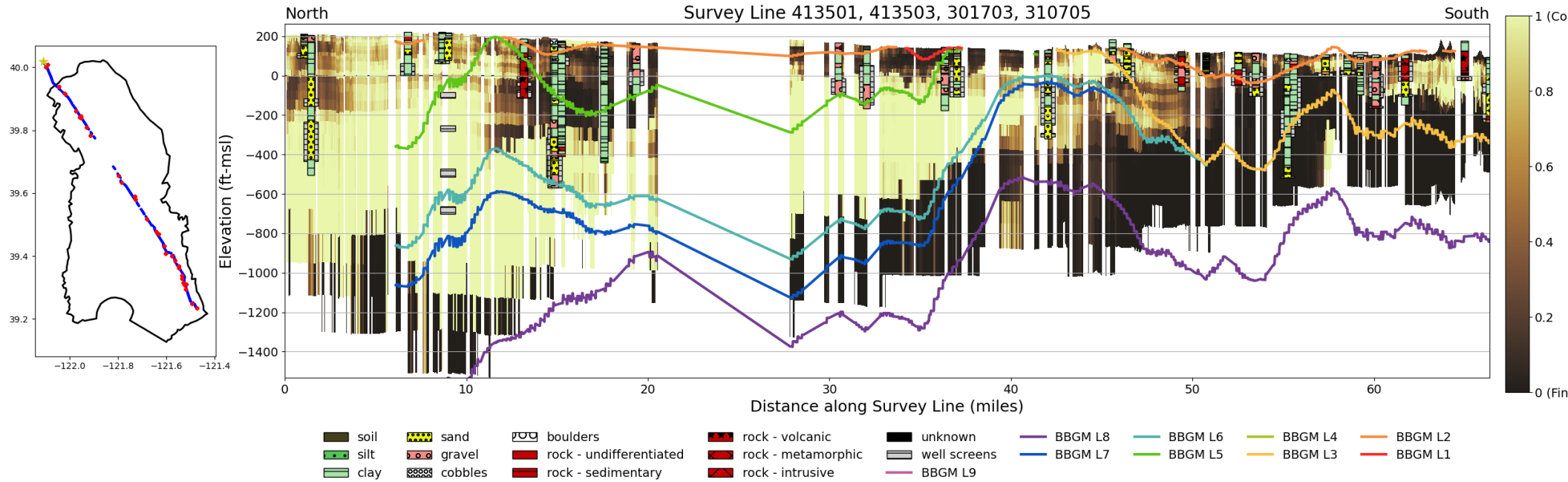
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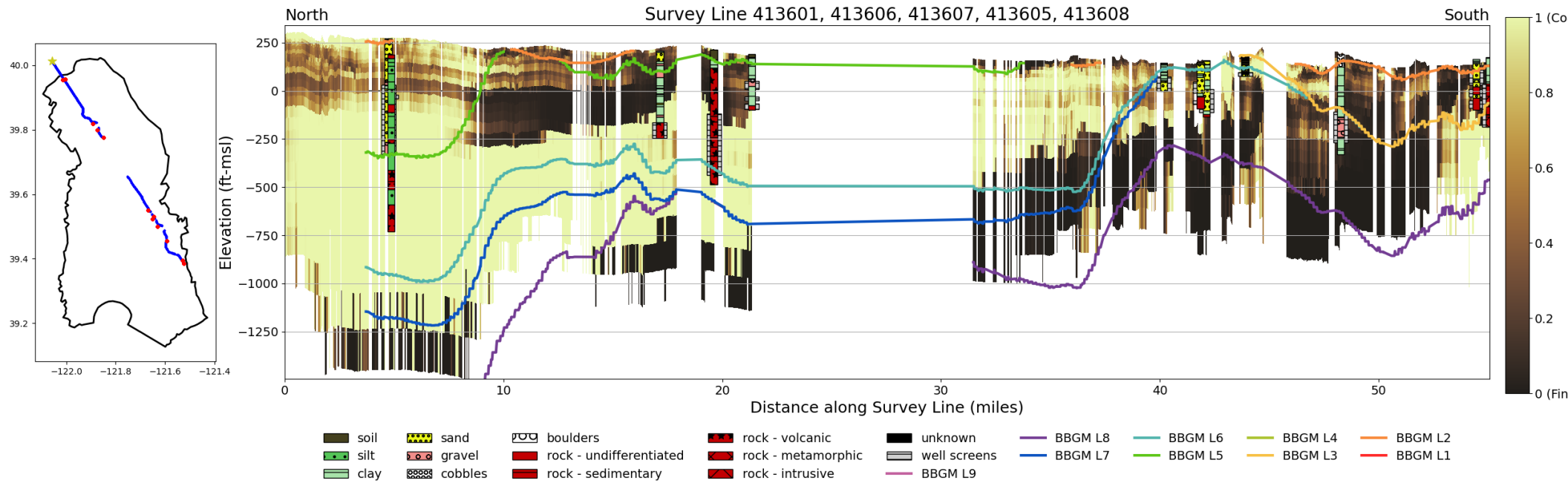


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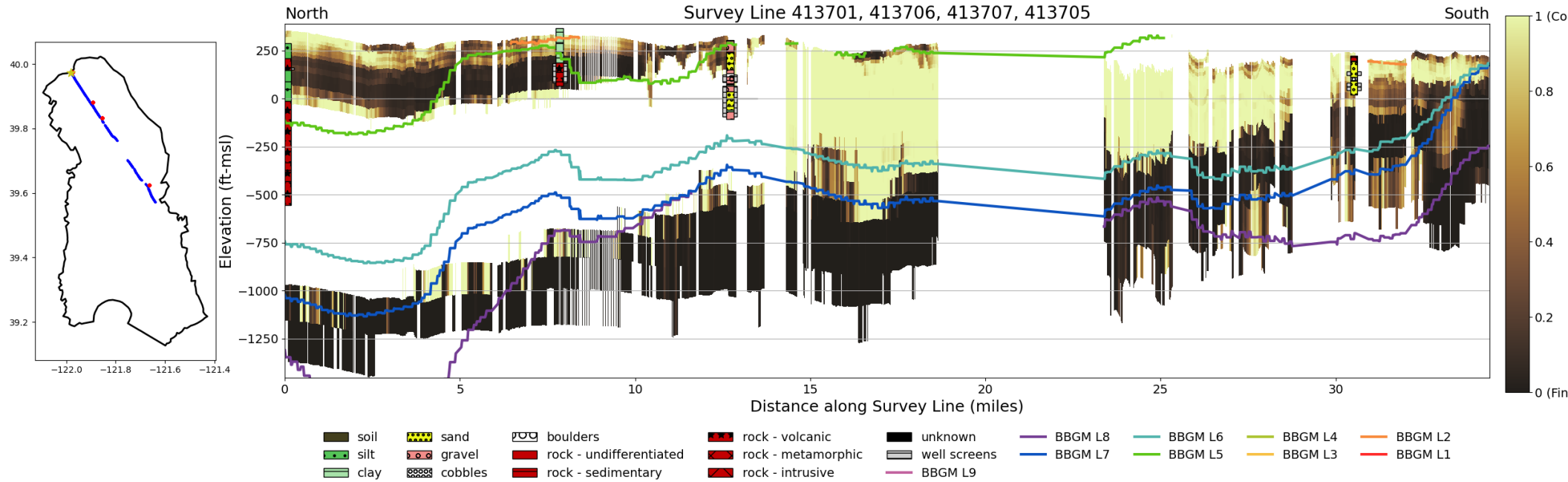


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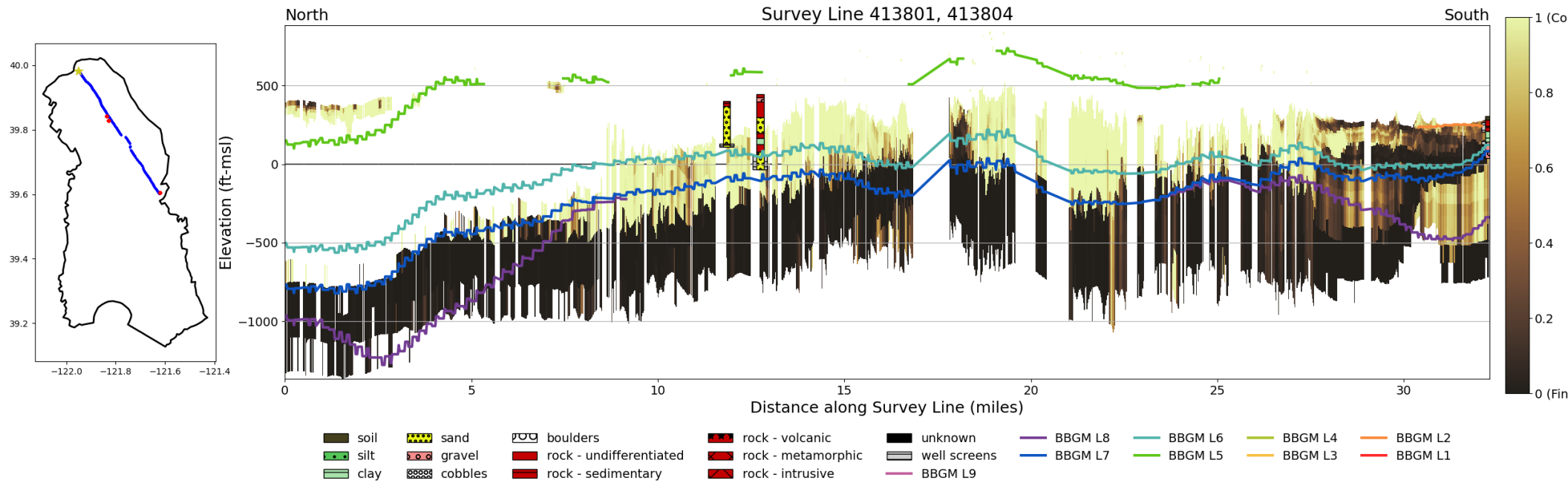




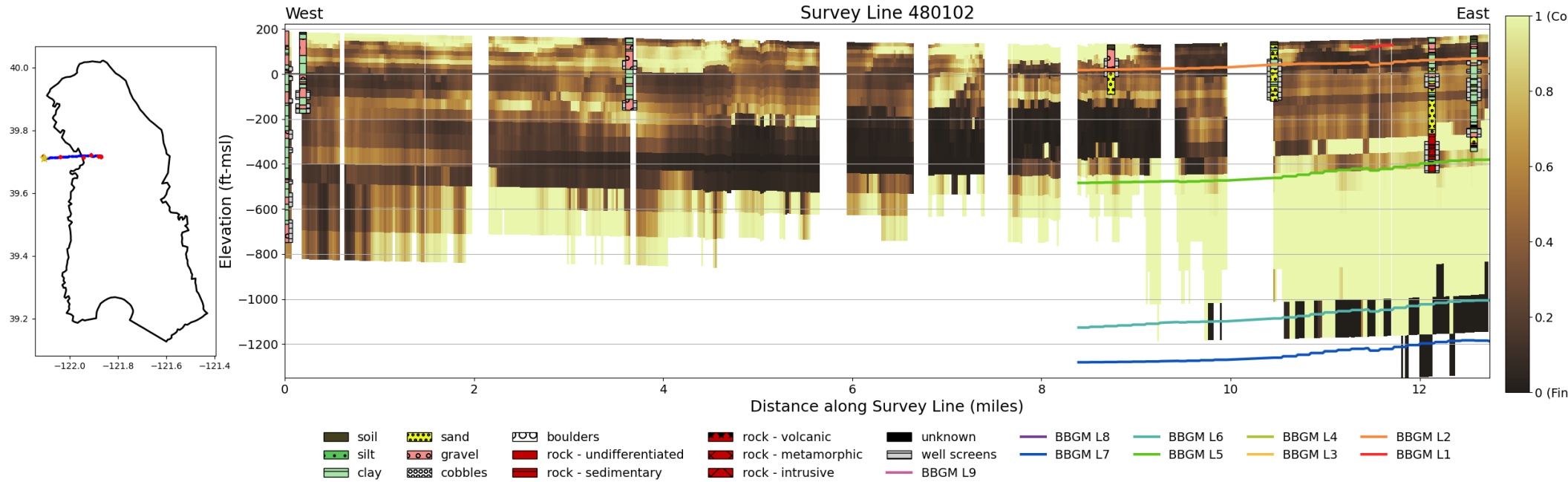
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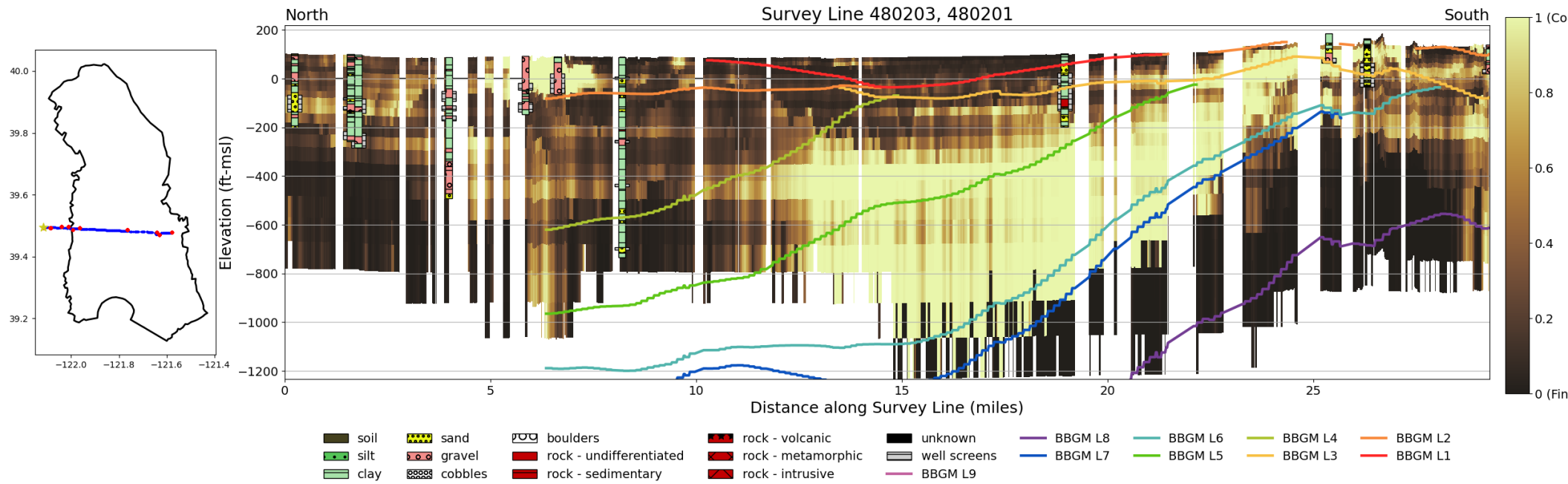


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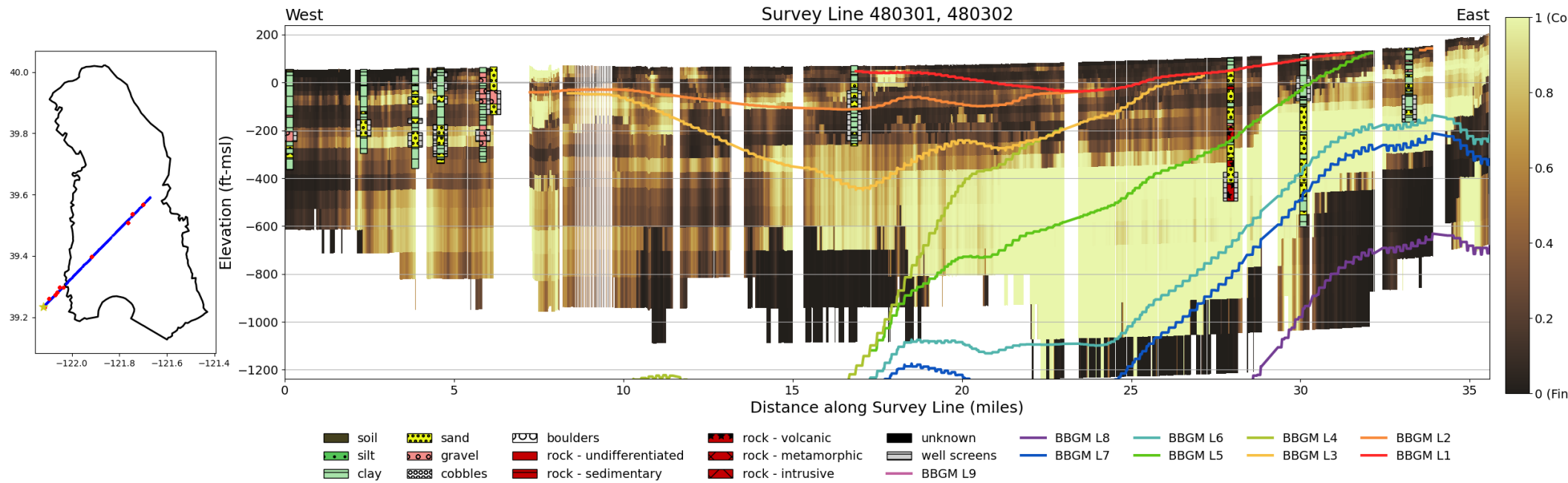


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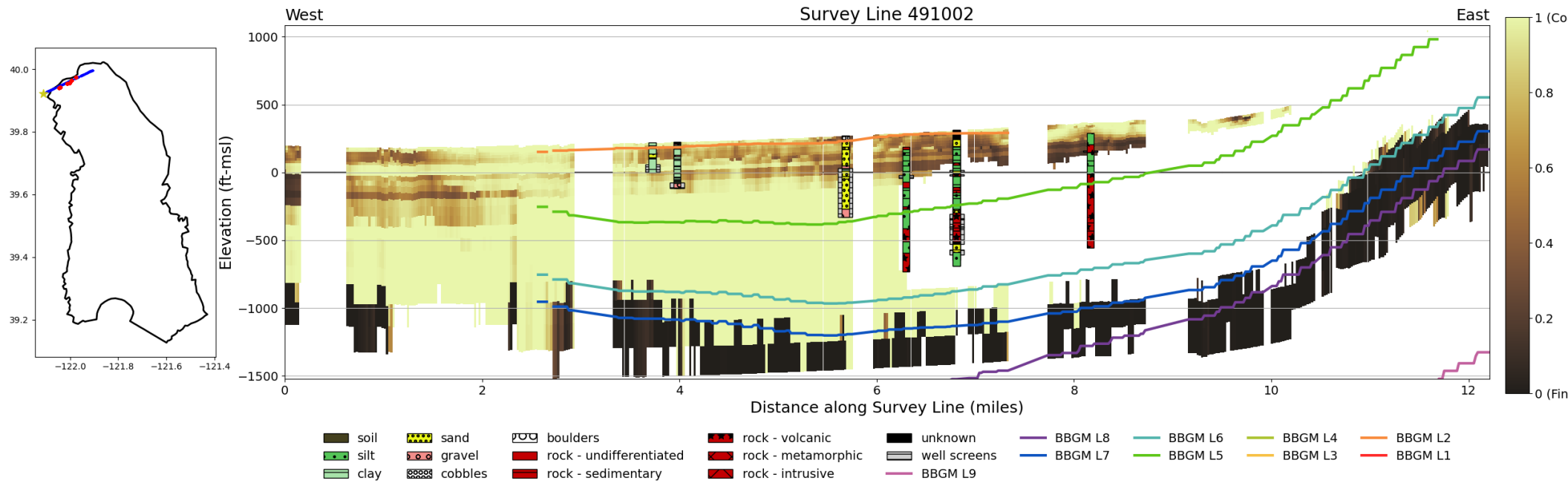




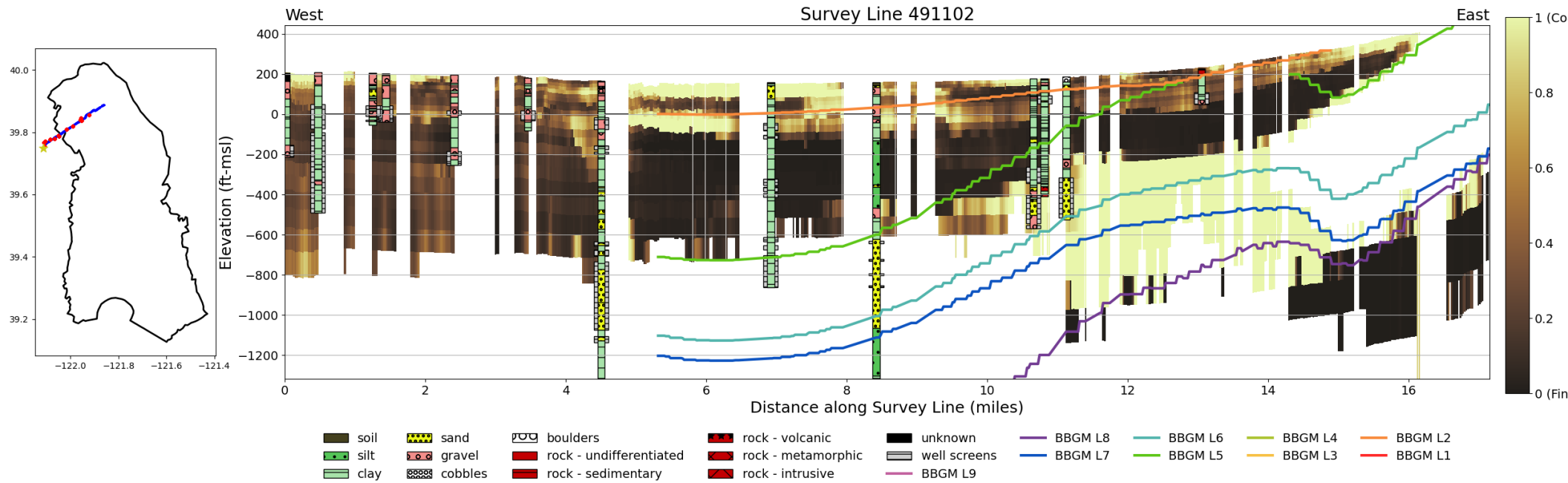
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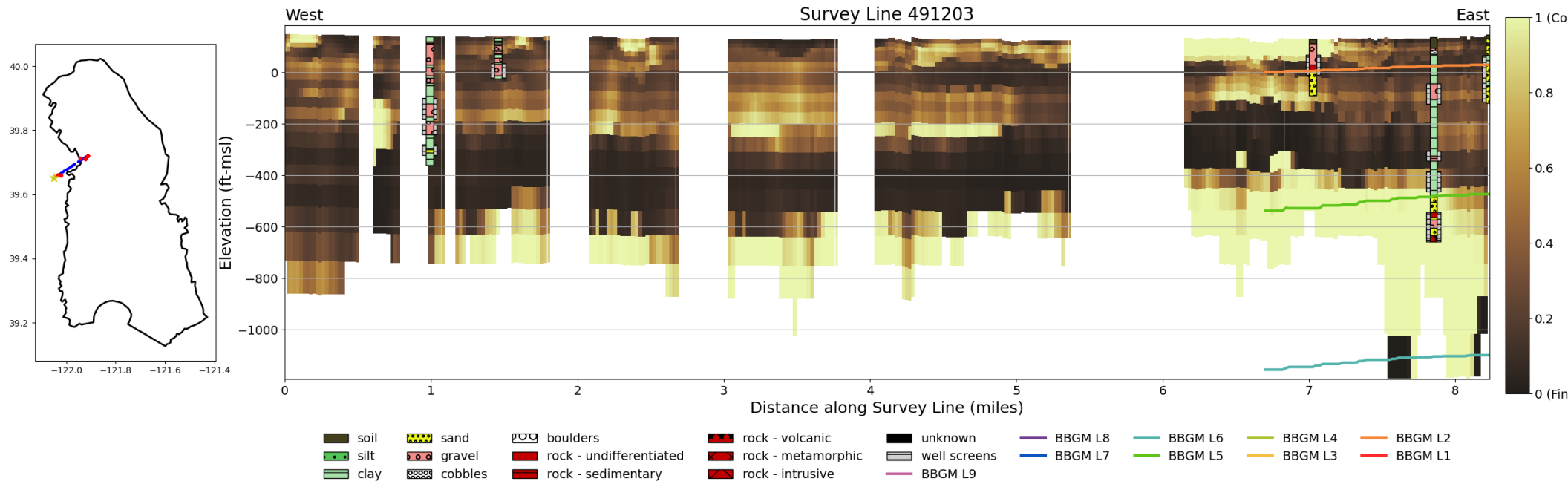


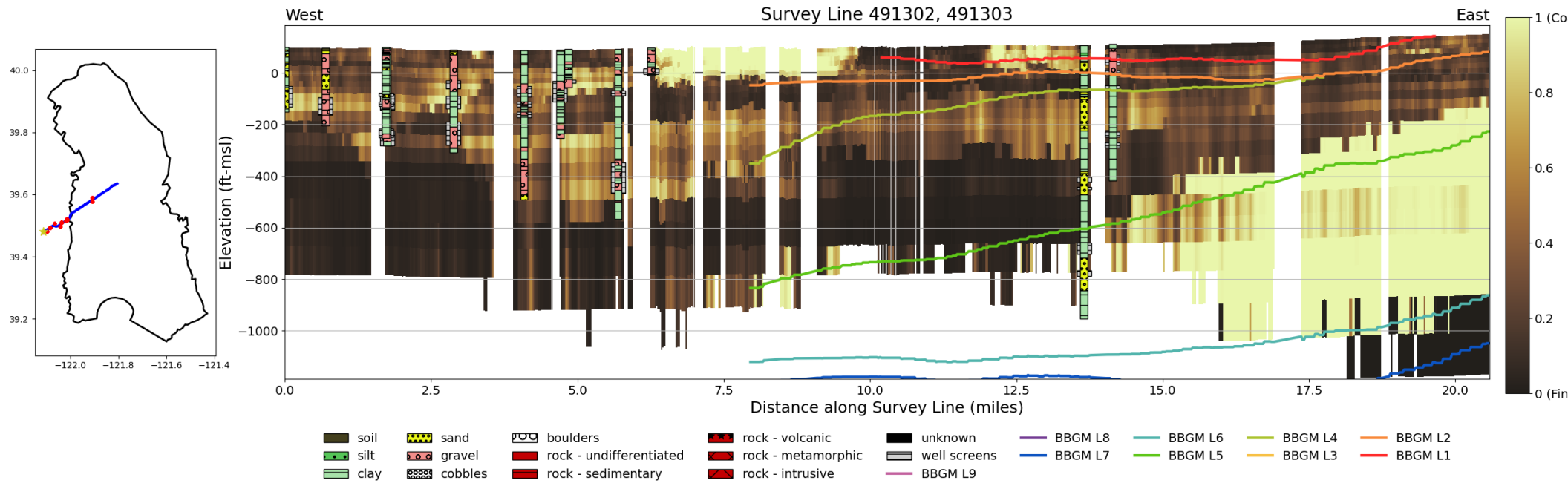
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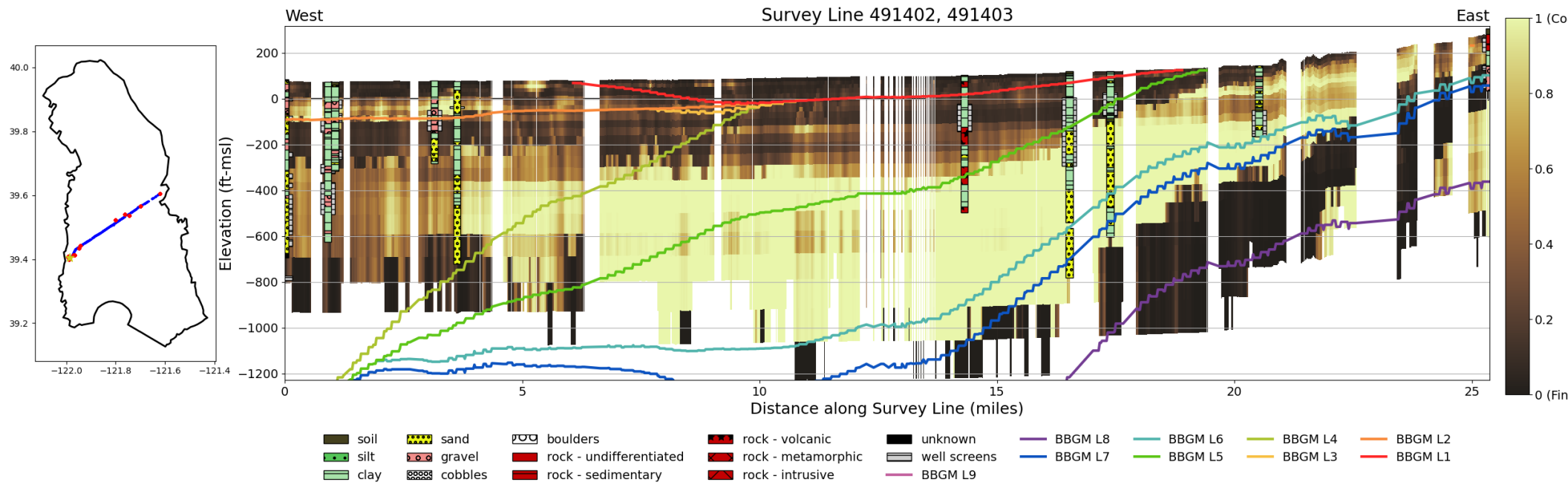
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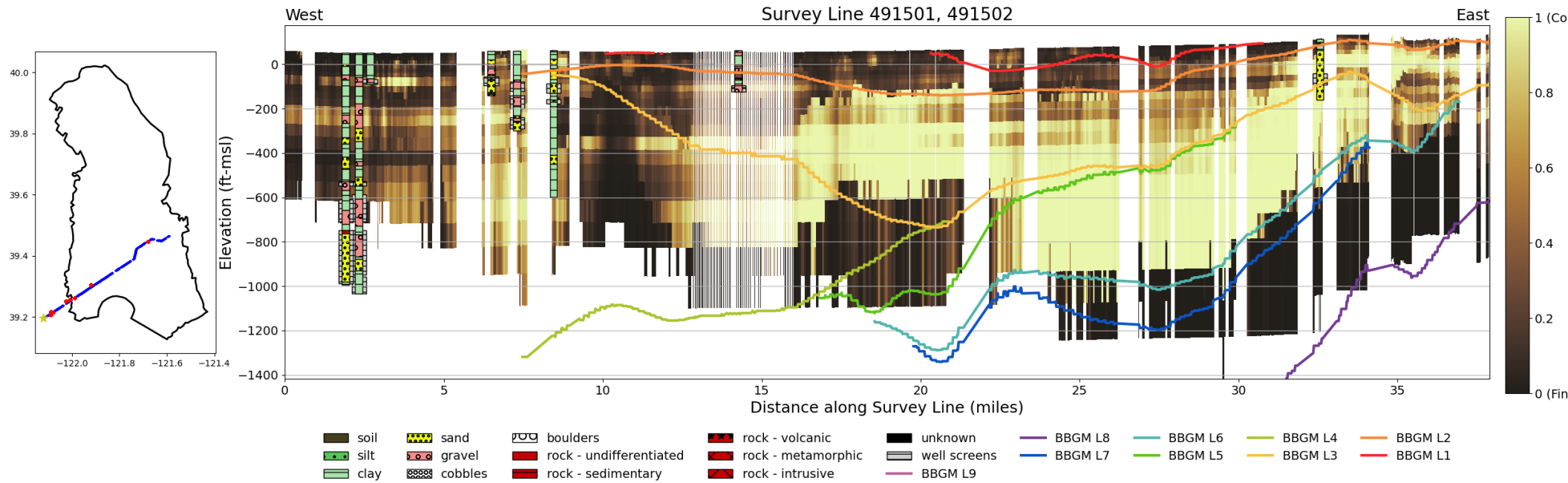




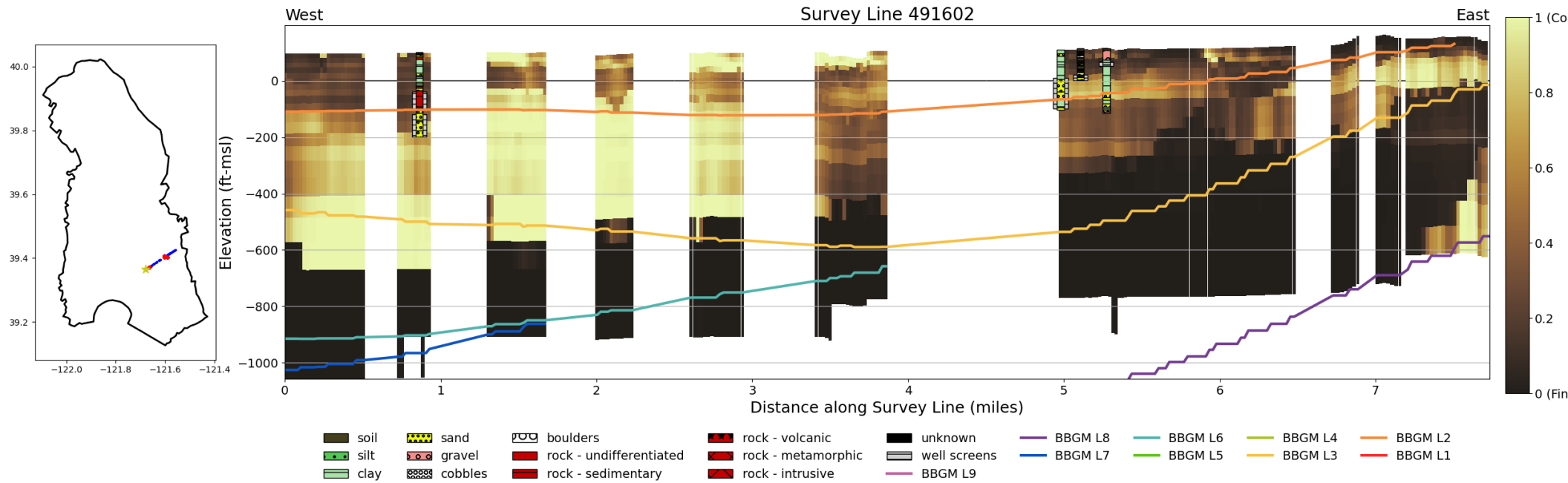


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Cross-Section 27



ATTACHMENT 2: STREAM REACH BUDGETS

Figures in this section show stream reach inflow and stream reach gain from groundwater for the BBGM v1.0, BBGM v1.2, and C2VSimFG v1.5 models.

Tables in this section show stream reach budgets for each model for major stream reaches for the BBGM v1.0, BBGM v1.2, and C2VSimFG v1.5 models. All values in thousand acre-feet per year.

Table 1. Average Stream Gain from Groundwater, Water Years 1974-2018 [TAF/Year]

Model	BBGM Version 1.2	BBGM Version 1.0	C2VSimFG Version 1.5
Reach A	107,245	130,962	38,309
Reach B	13,406	93,229	-5,076
Reach C	145,248	202,567	82,014
Reach D	70,436	-227,500	35,048
Reach FR	117,213	111,024	51,190
Reach FR1	18,758	18,668	-1,793
Reach FR2	47,252	46,423	19,161
Reach FR3	44,528	39,899	33,822

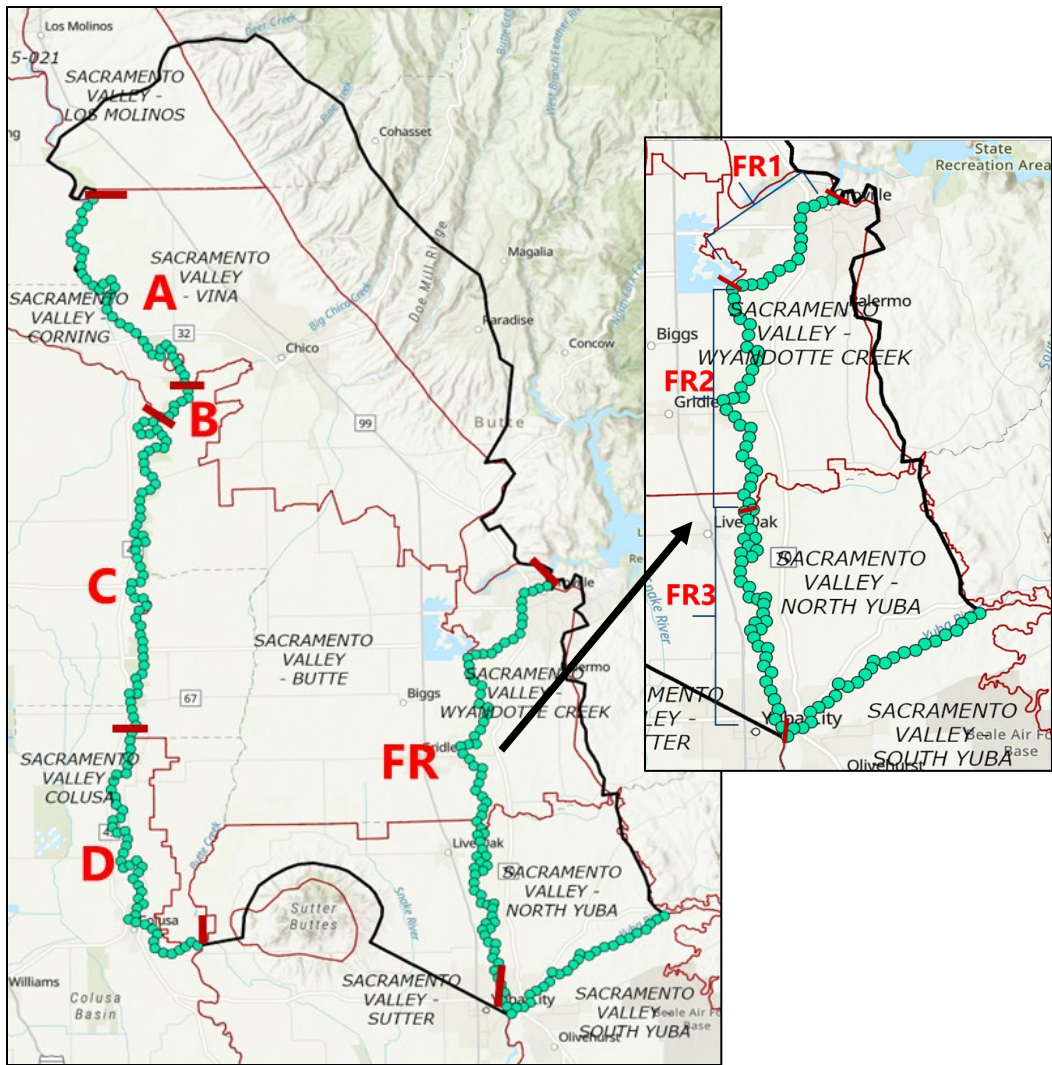


Figure 1. Sacramento and Feather River Reaches Within BSGM

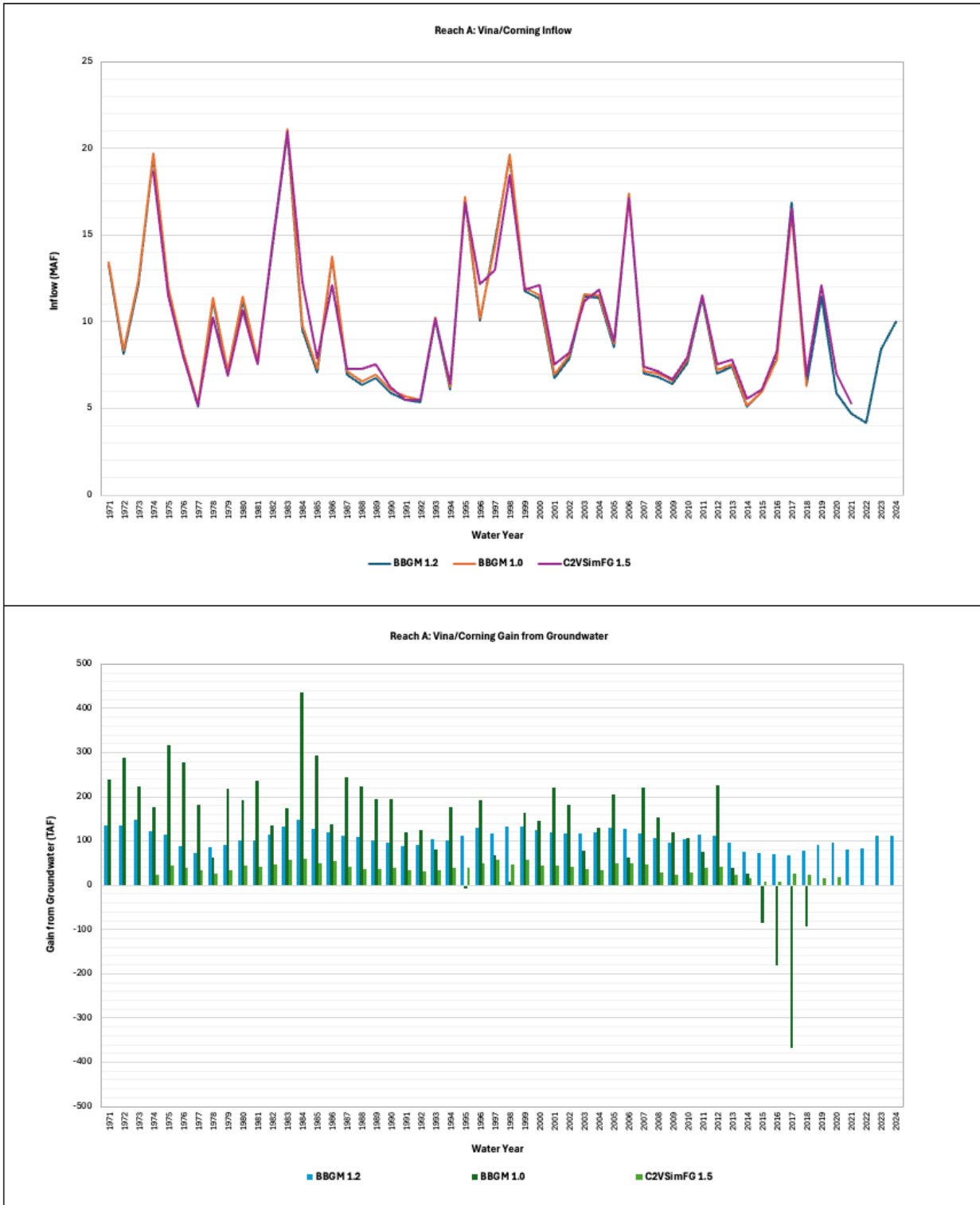


Figure 2. Reach A Stream Inflow and Gain from Groundwater

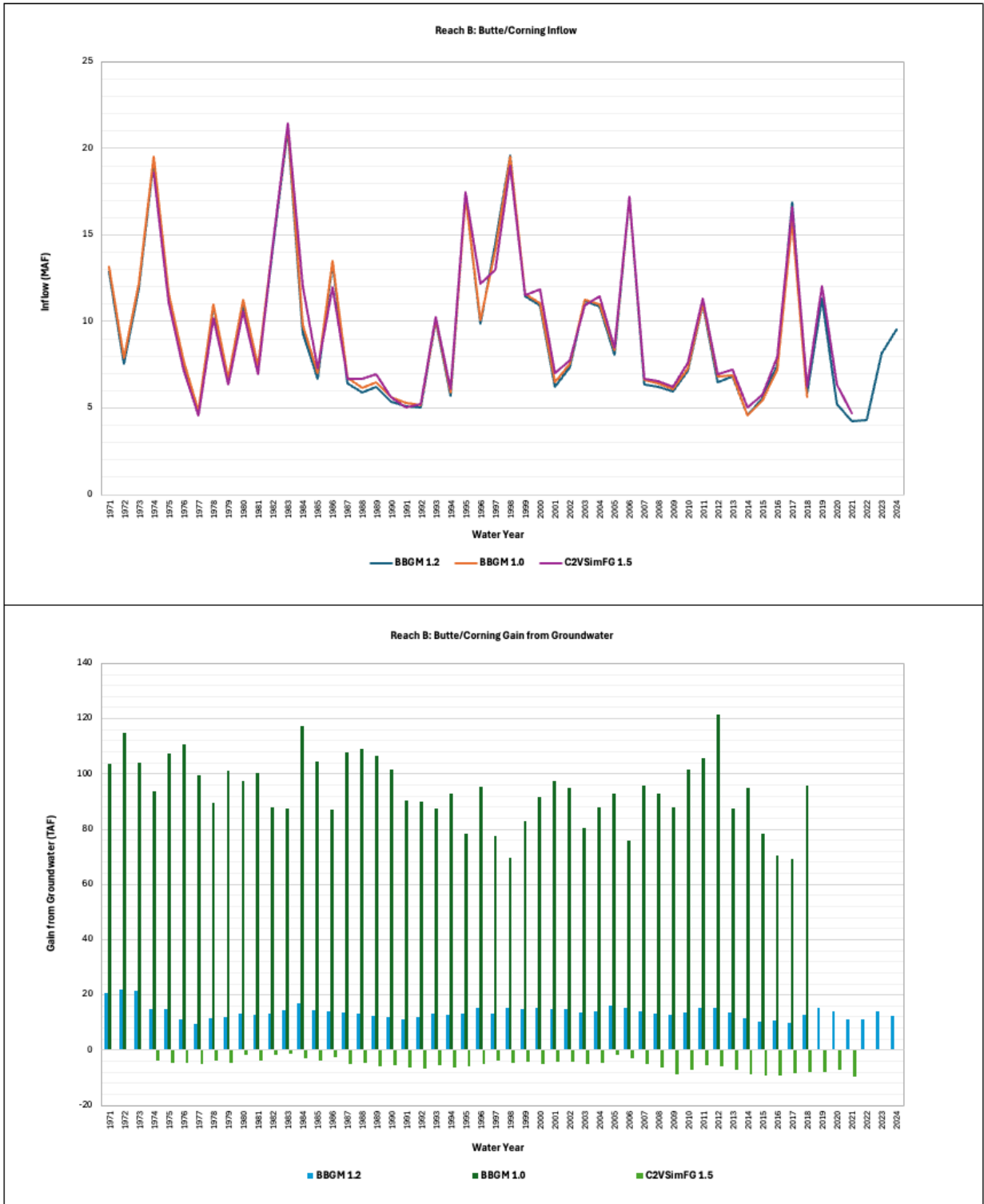


Figure 3. Reach B Stream Inflow and Gain from Groundwater

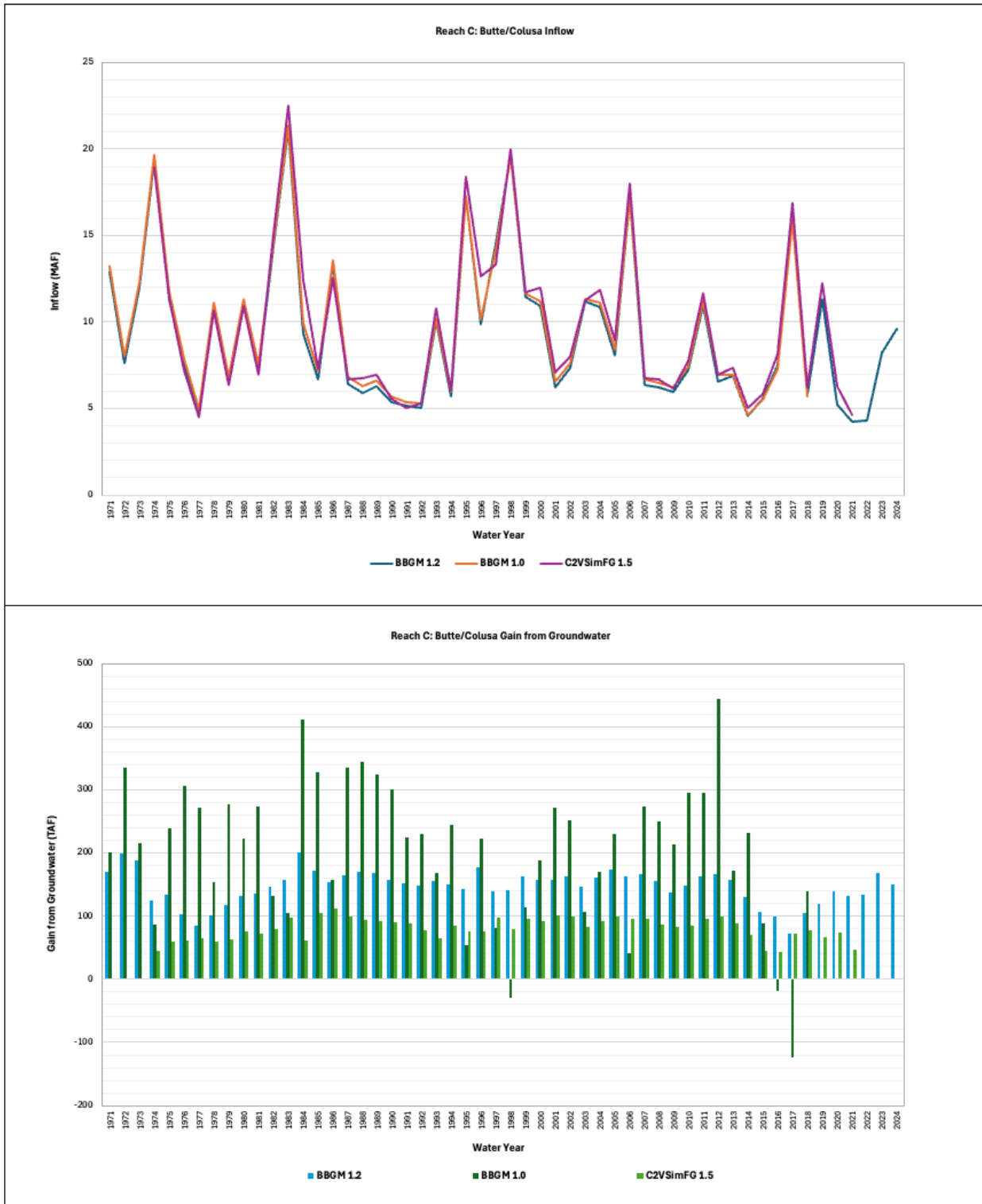


Figure 4. Reach C Stream Inflow and Gain from Groundwater

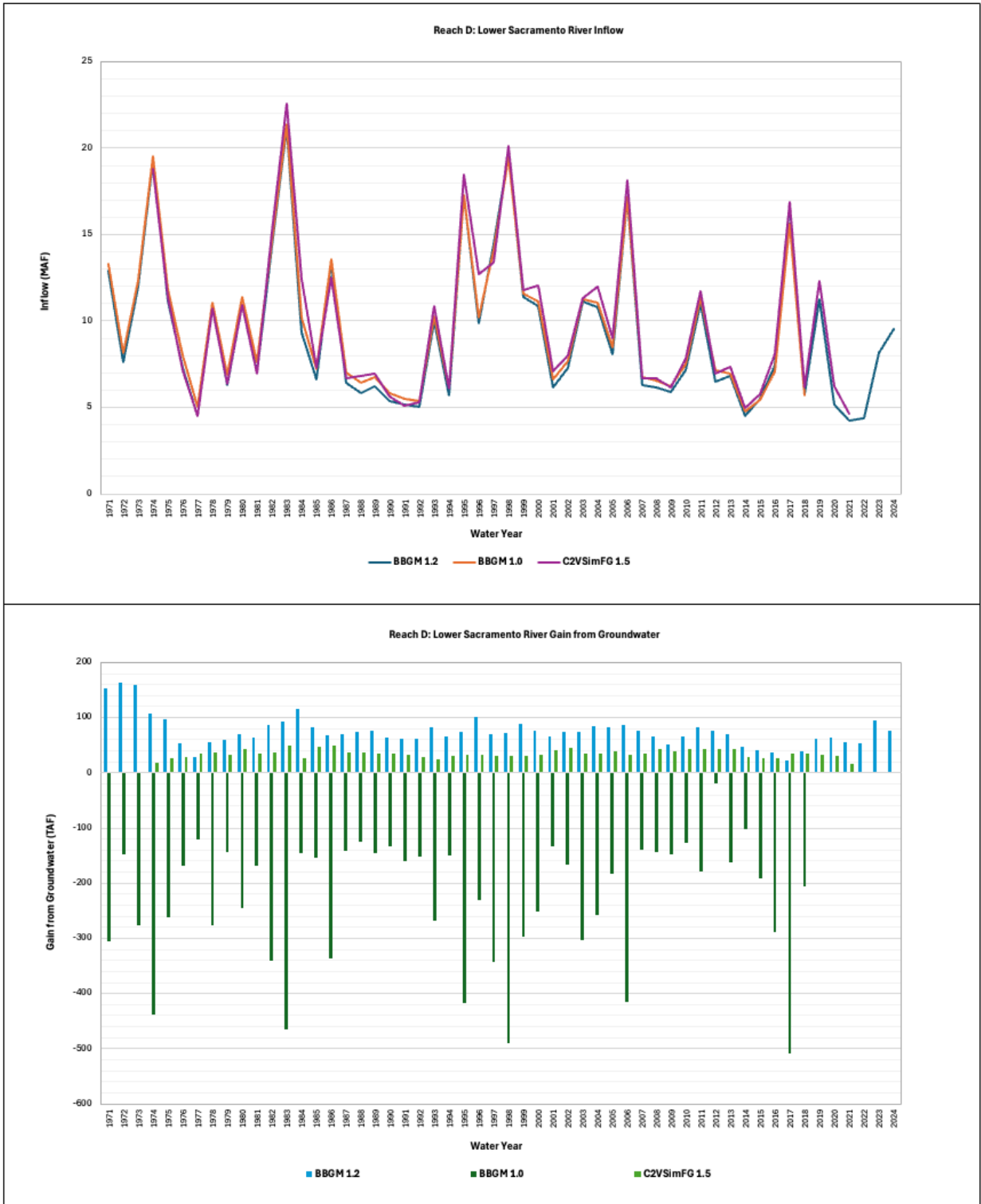


Figure 5. Reach D Stream Inflow and Gain from Groundwater

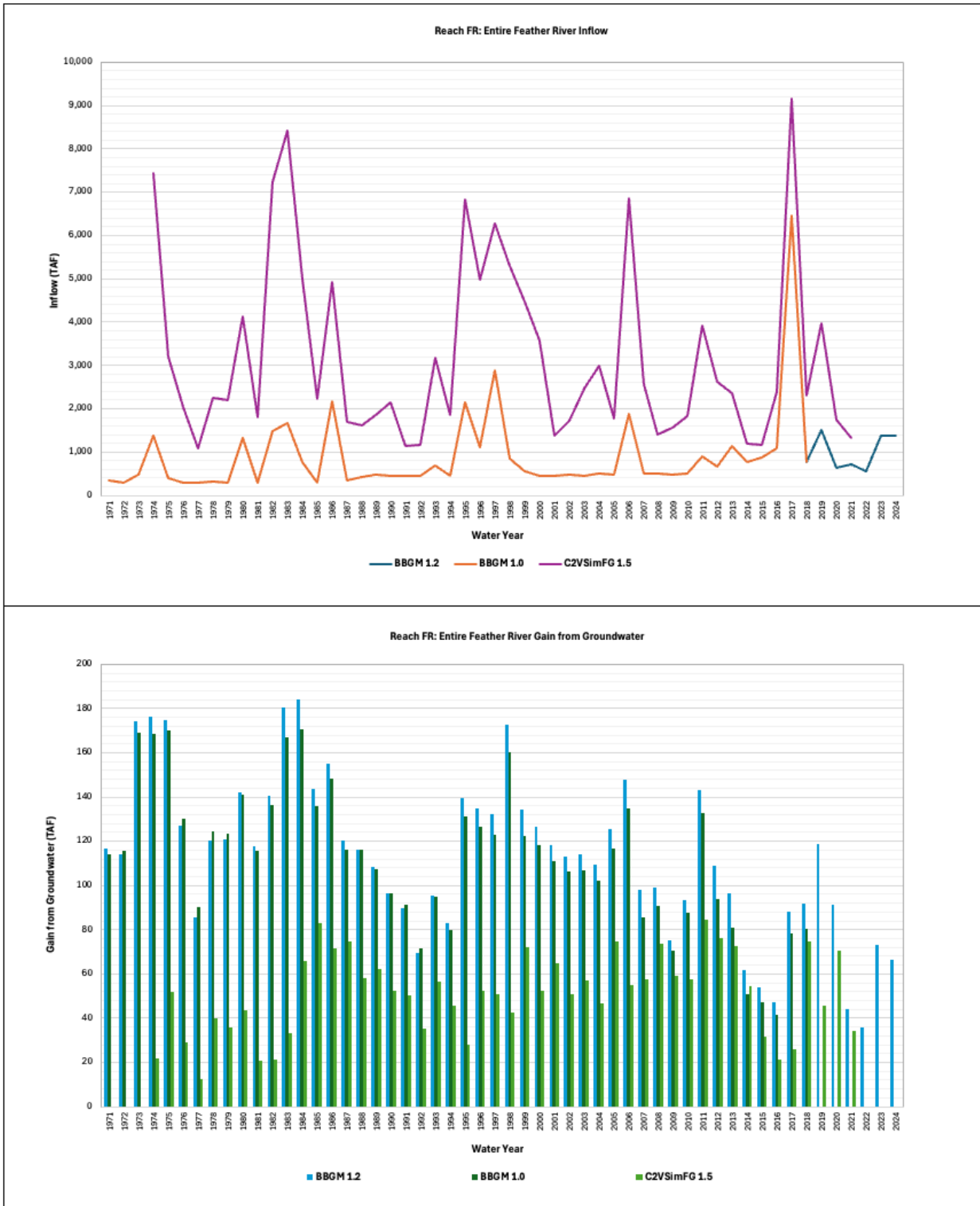


Figure 6. Entire Feather River Stream Inflow and Gain from Groundwater

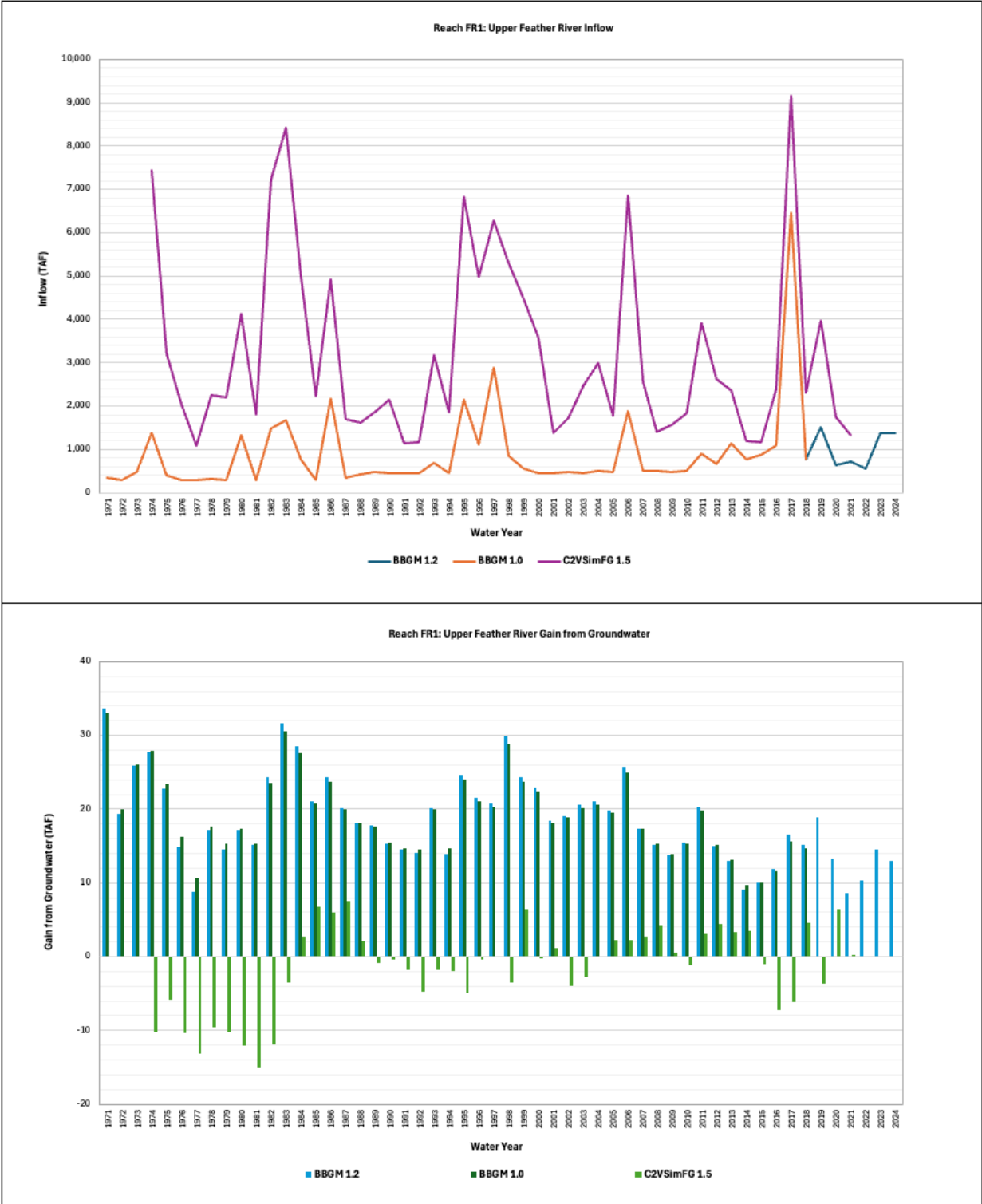


Figure 7. Reach FR1 Stream Inflow and Gain from Groundwater

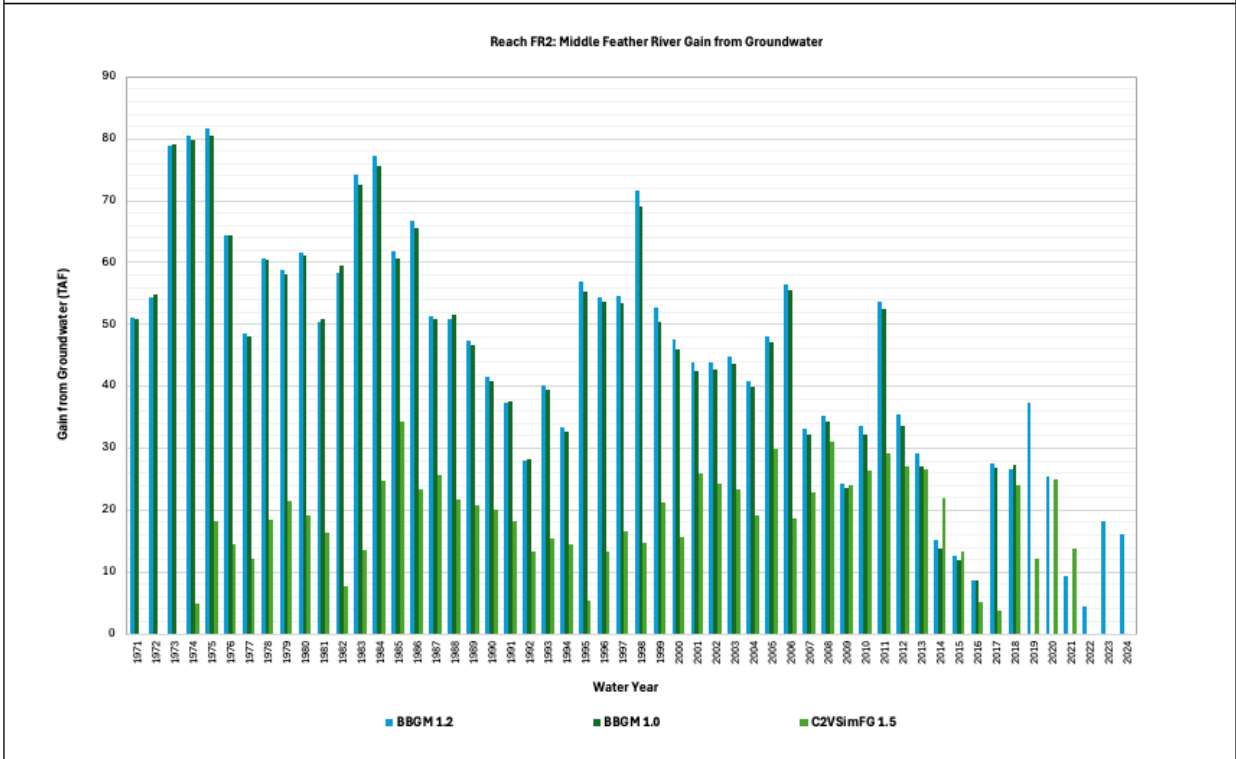
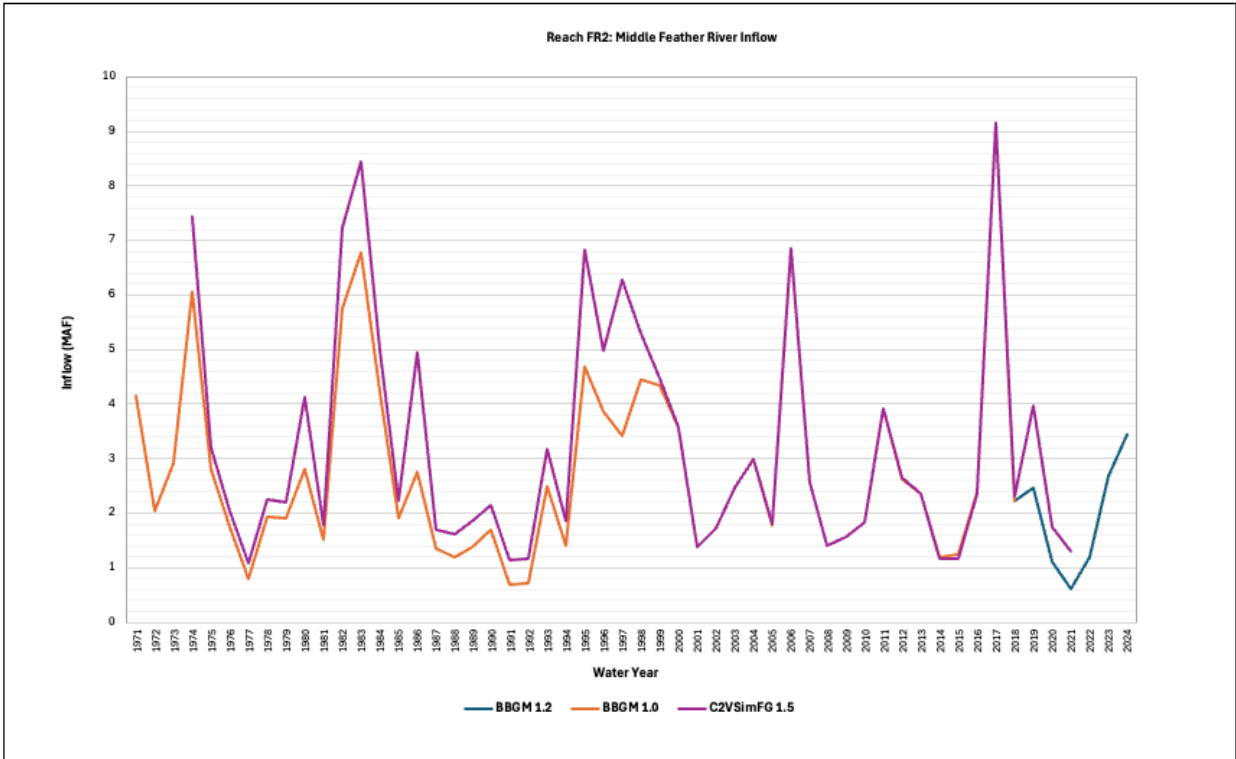


Figure 8. Reach FR2 Stream Inflow and Gain from Groundwater

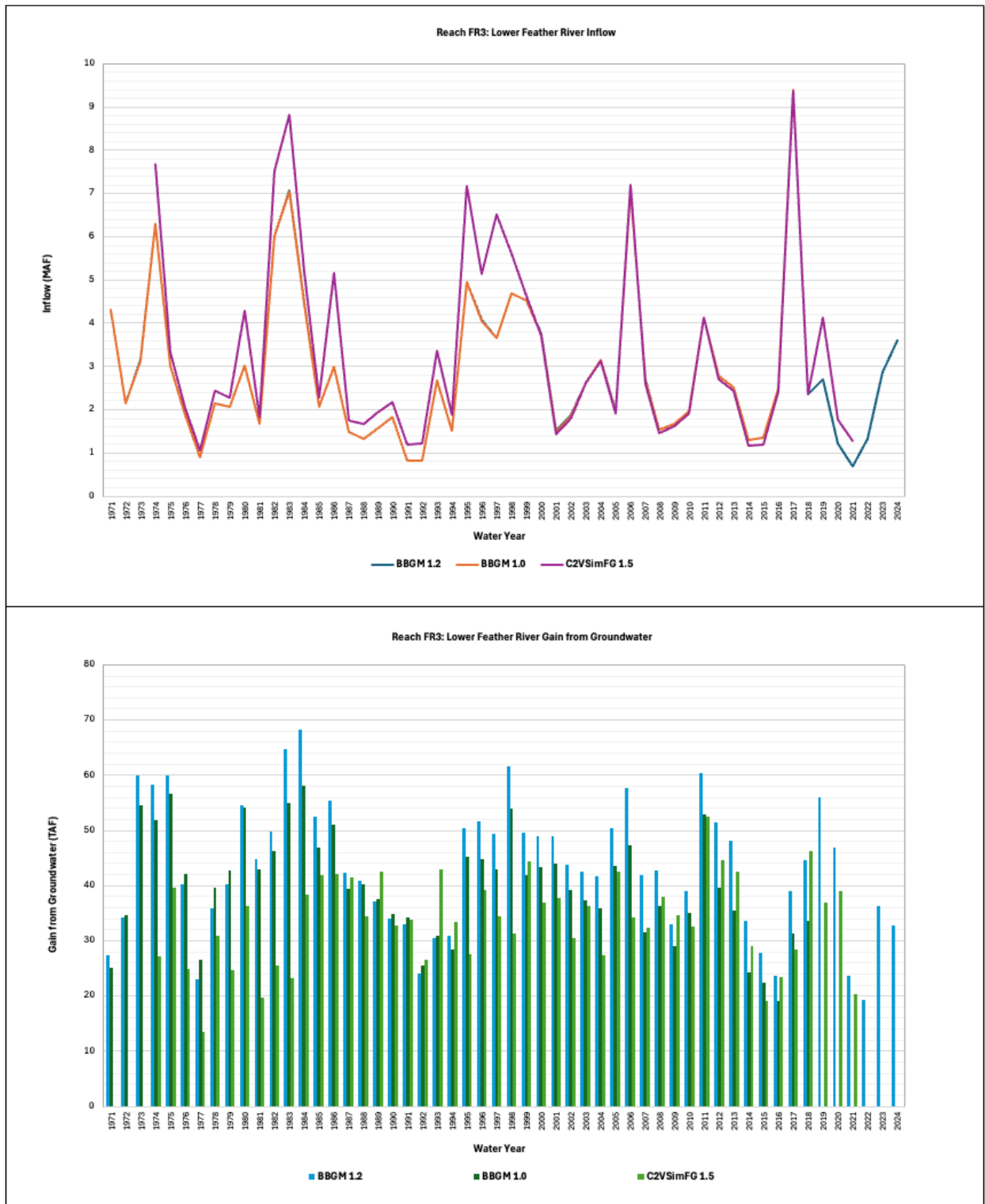


Figure 9. Reach FR3 Stream Inflow and Gain from Groundwater

Table 2. Reach A Stream Reach Budget, BBGM v1.2

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	13,285	4	0	134	757	12,911
1972	8,142	1	0	136	818	7,566
1973	12,192	7	0	148	735	11,953
1974	19,579	3	0	121	780	19,363
1975	11,808	5	0	114	898	11,294
1976	8,090	2	0	90	882	7,392
1977	5,077	1	0	72	638	4,567
1978	11,252	7	0	85	787	10,910
1979	6,951	4	0	92	835	6,397
1980	11,248	8	0	101	693	10,992
1981	7,596	6	0	101	769	7,118
1982	14,372	8	0	114	600	14,334
1983	20,937	18	0	133	506	21,146
1984	9,527	10	0	149	682	9,323
1985	7,094	4	0	127	710	6,671
1986	13,674	12	0	119	816	13,389
1987	6,976	2	0	113	807	6,423
1988	6,391	3	0	110	776	5,876
1989	6,780	4	0	103	822	6,257
1990	5,896	2	0	97	755	5,360
1991	5,531	3	0	90	628	5,132
1992	5,345	5	0	90	558	5,028
1993	10,143	10	0	103	563	10,042
1994	6,074	4	0	102	631	5,676
1995	17,111	21	0	111	604	17,275
1996	10,037	10	0	131	651	9,860
1997	14,646	9	0	117	729	14,477
1998	19,551	19	0	133	626	19,612
1999	11,793	3	0	134	768	11,434
2000	11,345	7	0	126	823	10,924
2001	6,771	6	0	121	845	6,211
2002	7,882	6	0	118	886	7,343
2003	11,478	12	0	117	863	11,175
2004	11,403	10	0	119	934	10,868
2005	8,556	9	0	131	871	8,087
2006	17,294	15	0	128	864	17,128
2007	6,997	4	0	118	934	6,334
2008	6,828	7	0	106	890	6,214
2009	6,444	7	0	96	793	5,962
2010	7,646	11	0	104	827	7,186
2011	11,369	9	0	115	818	11,008
2012	7,048	7	0	113	841	6,518
2013	7,450	6	0	96	905	6,853

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2014	5,109	3	0	77	759	4,549
2015	5,935	8	0	72	600	5,582
2016	7,851	7	0	69	691	7,484
2017	16,903	12	0	68	746	16,854
2018	6,335	4	0	79	782	5,817
2019	11,478	15	0	92	781	11,307
2020	5,882	2	0	96	879	5,219
2021	4,676	2	0	81	581	4,263
2022	4,148	5	0	83	132	4,282
2023	8,413	8	0	113	699	8,172
2024	9,972	7	0	112	771	9,566

Table 3. Reach B Stream Reach Budget, BBGM v1.2

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	12,908	0	0	21	0	12,929
1972	7,564	0	0	22	0	7,586
1973	11,951	0	0	22	0	11,973
1974	19,362	0	0	15	0	19,377
1975	11,293	0	0	15	0	11,308
1976	7,392	0	0	11	0	7,403
1977	4,566	0	0	10	0	4,576
1978	10,909	0	0	12	0	10,921
1979	6,396	0	0	12	0	6,408
1980	10,991	0	0	13	0	11,004
1981	7,118	0	0	13	0	7,130
1982	14,333	0	0	13	0	14,346
1983	21,145	0	0	15	0	21,160
1984	9,322	0	0	17	0	9,338
1985	6,670	0	0	15	0	6,684
1986	13,388	0	0	14	0	13,402
1987	6,422	0	0	14	0	6,436
1988	5,875	0	0	13	0	5,888
1989	6,256	0	0	13	0	6,268
1990	5,359	0	0	12	0	5,371
1991	5,131	0	0	11	0	5,142
1992	5,027	0	0	12	0	5,039
1993	10,041	0	0	13	0	10,054
1994	5,675	0	0	13	0	5,688
1995	17,274	0	0	13	0	17,287
1996	9,859	0	0	15	0	9,874
1997	14,476	0	0	13	0	14,489

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1998	19,611	0	0	15	0	19,626
1999	11,433	0	0	15	0	11,448
2000	10,923	0	0	15	0	10,938
2001	6,210	0	0	15	0	6,225
2002	7,342	0	0	15	0	7,356
2003	11,174	0	0	14	0	11,188
2004	10,867	0	0	14	0	10,881
2005	8,086	0	0	16	0	8,102
2006	17,127	0	0	15	0	17,142
2007	6,332	0	0	14	0	6,347
2008	6,212	0	0	13	0	6,226
2009	5,961	0	0	13	0	5,974
2010	7,185	0	0	14	0	7,199
2011	11,007	0	0	15	0	11,022
2012	6,517	0	0	15	0	6,532
2013	6,852	0	0	14	0	6,866
2014	4,548	0	0	11	0	4,559
2015	5,582	0	0	10	0	5,592
2016	7,483	0	0	11	0	7,494
2017	16,854	0	0	10	0	16,864
2018	5,816	0	0	13	0	5,829
2019	11,306	0	0	15	0	11,321
2020	5,218	0	0	14	0	5,232
2021	4,262	0	0	11	0	4,273
2022	4,281	0	0	11	0	4,292
2023	8,171	0	0	14	0	8,185
2024	9,565	0	0	12	0	9,578

Table 4. Reach C Stream Reach Budget, BBGM v1.2

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	12,929	5	1	165	162	12,938
1972	7,586	3	1	192	185	7,597
1973	11,973	7	1	182	200	11,962
1974	19,377	6	1	120	191	19,312
1975	11,308	5	1	129	216	11,227
1976	7,403	3	1	100	206	7,301
1977	4,576	3	1	84	182	4,481
1978	10,921	7	1	99	208	10,820
1979	6,408	4	1	115	226	6,302
1980	11,004	5	0	128	208	10,929
1981	7,130	4	0	131	226	7,040

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1982	14,346	5	0	142	183	14,310
1983	21,160	9	0	153	146	21,175
1984	9,338	5	0	195	189	9,349
1985	6,684	2	0	168	222	6,633
1986	13,402	6	0	150	197	13,361
1987	6,436	1	0	160	187	6,410
1988	5,888	2	0	166	196	5,860
1989	6,268	3	0	164	192	6,243
1990	5,371	2	0	153	179	5,346
1991	5,142	3	0	148	141	5,151
1992	5,039	4	0	144	144	5,043
1993	10,054	6	0	151	175	10,036
1994	5,688	3	0	146	155	5,682
1995	17,287	11	0	139	150	17,287
1996	9,874	6	0	173	178	9,875
1997	14,489	5	0	136	184	14,446
1998	19,626	8	0	137	166	19,605
1999	11,448	2	0	157	191	11,416
2000	10,938	2	0	154	244	10,851
2001	6,225	5	0	153	244	6,139
2002	7,356	2	0	159	246	7,273
2003	11,188	5	0	142	215	11,120
2004	10,881	4	0	156	232	10,809
2005	8,102	3	0	168	205	8,068
2006	17,142	6	0	158	188	17,118
2007	6,347	2	0	161	232	6,277
2008	6,226	3	0	152	238	6,143
2009	5,974	2	0	135	235	5,876
2010	7,199	4	0	144	211	7,136
2011	11,022	4	0	159	180	11,005
2012	6,532	4	0	162	200	6,497
2013	6,866	2	0	152	226	6,795
2014	4,559	1	0	126	175	4,512
2015	5,592	3	0	104	187	5,512
2016	7,494	2	0	97	177	7,415
2017	16,864	6	0	71	178	16,763
2018	5,829	2	0	103	195	5,738
2019	11,321	5	0	117	180	11,263
2020	5,232	1	0	136	177	5,192
2021	4,273	0	0	129	176	4,227
2022	4,292	2	0	130	34	4,391
2023	8,185	3	0	163	168	8,184
2024	9,578	2	0	146	189	9,537

Table 5. Reach D Stream Reach Budget, BBGM v1.2

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	12,932	5	1	145	85	13,913
1972	7,590	2	1	157	78	8,352
1973	11,956	9	1	152	89	13,283
1974	19,308	5	1	102	91	20,825
1975	11,224	4	1	92	85	12,394
1976	7,298	2	1	50	87	7,950
1977	4,479	2	1	27	75	4,936
1978	10,817	7	1	51	88	11,981
1979	6,298	4	1	56	83	7,184
1980	10,925	6	0	66	78	12,130
1981	7,036	3	0	60	92	7,896
1982	14,306	5	0	83	83	15,784
1983	21,171	7	0	89	79	22,879
1984	9,343	4	0	110	90	10,555
1985	6,628	2	0	78	85	7,449
1986	13,357	4	0	64	82	14,646
1987	6,406	1	0	67	82	7,099
1988	5,855	3	0	71	84	6,609
1989	6,238	3	0	73	86	7,057
1990	5,342	2	0	62	81	6,003
1991	5,147	3	0	59	85	5,809
1992	5,039	3	0	59	88	5,703
1993	10,031	7	0	79	99	11,230
1994	5,678	3	0	62	98	6,404
1995	17,283	9	0	70	102	19,139
1996	9,869	6	0	97	110	11,171
1997	14,442	7	0	67	114	15,903
1998	19,601	7	0	69	86	21,273
1999	11,411	2	0	85	97	12,484
2000	10,846	2	0	72	32	12,084
2001	6,135	2	0	63	27	7,095
2002	7,268	3	0	71	19	8,396
2003	11,116	4	0	71	14	12,483
2004	10,804	4	0	81	17	12,149
2005	8,063	3	0	79	16	9,349
2006	17,113	7	0	81	15	19,041
2007	6,272	1	0	72	20	7,231
2008	6,138	3	0	63	20	7,132
2009	5,872	2	0	49	19	6,822
2010	7,131	4	0	63	15	8,340
2011	11,000	4	0	79	15	12,580
2012	6,492	3	0	72	18	7,581
2013	6,790	3	0	67	17	7,862

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2014	4,509	1	0	46	11	5,286
2015	5,509	4	0	38	13	6,224
2016	7,413	2	0	35	10	8,281
2017	16,761	5	0	21	13	18,347
2018	5,735	2	0	38	14	6,592
2019	11,260	5	0	59	27	12,720
2020	5,188	2	0	61	32	5,996
2021	4,223	1	0	52	28	4,828
2022	4,387	3	0	50	13	5,151
2023	8,179	4	0	90	21	9,488
2024	9,533	4	0	73	23	10,669

Table 6. Feather River Stream Reach Budget, BBGM v1.2

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	355	99	18	112	0	6,555
1972	301	107	17	108	0	3,322
1973	491	150	18	165	0	5,313
1974	1,369	142	18	167	0	9,819
1975	389	137	18	164	0	5,088
1976	293	99	17	119	0	2,706
1977	293	60	17	81	0	1,172
1978	324	140	18	114	0	4,137
1979	293	112	18	114	0	3,289
1980	1,328	130	20	133	0	6,008
1981	294	122	20	110	0	2,436
1982	1,487	157	19	133	0	10,465
1983	1,662	161	13	171	0	11,303
1984	761	141	16	174	0	7,465
1985	302	117	14	136	4	2,983
1986	2,182	134	13	147	5	5,912
1987	334	98	12	114	5	2,124
1988	428	92	13	110	6	1,977
1989	481	109	12	102	6	3,161
1990	458	101	12	91	6	2,522
1991	451	102	12	85	6	1,735
1992	461	84	12	66	7	1,477
1993	686	125	12	91	8	4,825
1994	452	77	12	78	8	2,205
1995	2,137	159	12	132	9	8,608
1996	1,116	117	12	127	9	6,813
1997	2,882	142	12	125	10	7,071

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1998	842	119	12	163	10	7,822
1999	546	78	12	127	11	6,797
2000	457	114	13	120	12	5,186
2001	464	76	13	111	12	2,067
2002	471	96	13	107	12	2,868
2003	465	109	13	108	12	4,095
2004	506	97	13	103	14	4,222
2005	469	90	13	118	14	3,430
2006	1,873	153	13	140	15	11,024
2007	502	74	13	92	16	3,379
2008	500	72	13	93	16	2,185
2009	482	74	13	71	15	2,654
2010	508	87	13	88	16	3,079
2011	909	127	13	135	16	7,288
2012	654	84	13	102	17	3,868
2013	1,143	89	13	90	18	3,539
2014	779	57	13	58	16	1,747
2015	886	55	10	51	16	1,760
2016	1,087	71	10	44	17	3,895
2017	6,462	123	9	83	17	14,542
2018	761	64	10	86	17	3,804
2019	1,521	148	10	112	14	5,266
2020	634	79	11	86	15	1,909
2021	713	45	10	41	16	1,048
2022	563	89	10	34	16	1,939
2023	1,386	115	11	69	14	5,659
2024	1,388	103	12	62	13	5,064

Table 7. Reach FR1 Stream Reach Budget, BBGM v1.2

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	355	5	1	34	0	394
1972	301	3	1	19	0	324
1973	491	8	1	26	0	525
1974	1,369	7	1	28	0	1,405
1975	389	6	1	23	0	418
1976	293	3	1	15	0	312
1977	293	3	1	9	0	305
1978	324	7	1	17	0	349
1979	293	5	1	15	0	313
1980	1,328	7	0	17	0	1,352
1981	294	6	0	15	0	315

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1982	1,487	10	0	24	0	1,521
1983	1,662	13	0	32	0	1,706
1984	761	8	0	28	0	798
1985	302	4	0	21	0	328
1986	2,182	10	0	24	0	2,216
1987	334	5	0	20	0	360
1988	428	5	0	18	0	451
1989	481	6	0	18	0	505
1990	458	5	0	15	0	478
1991	451	7	0	15	0	472
1992	461	6	0	14	0	481
1993	686	11	0	20	0	718
1994	452	4	0	14	0	470
1995	2,137	12	0	25	0	2,174
1996	1,116	7	0	21	0	1,145
1997	2,882	9	0	21	0	2,912
1998	842	12	0	30	0	884
1999	546	6	0	24	0	577
2000	457	7	0	23	0	487
2001	464	5	0	18	0	487
2002	471	7	0	19	0	496
2003	465	9	0	21	0	495
2004	506	7	0	21	0	535
2005	469	8	0	20	0	497
2006	1,873	12	0	26	0	1,911
2007	502	5	0	17	0	524
2008	500	6	0	15	0	521
2009	482	7	0	14	0	503
2010	508	8	0	15	0	531
2011	909	10	0	20	0	940
2012	654	7	0	15	0	676
2013	1,143	7	0	13	0	1,162
2014	779	5	0	9	0	794
2015	886	6	0	10	0	902
2016	1,087	8	0	12	0	1,107
2017	6,462	15	0	17	0	6,494
2018	761	8	0	15	0	784
2019	1,521	16	0	19	0	1,556
2020	634	6	0	13	0	653
2021	713	5	0	9	0	727
2022	563	9	0	10	0	582
2023	1,386	10	0	14	0	1,411
2024	1,388	8	0	13	0	1,408

Table 8. Reach FR2 Stream Reach Budget, BBGM v1.2

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	4,171	9	1	51	0	4,232
1972	2,035	9	1	54	0	2,099
1973	2,908	13	1	79	0	3,001
1974	6,066	13	1	81	0	6,161
1975	2,821	12	1	82	0	2,917
1976	1,760	10	1	64	0	1,835
1977	800	5	1	49	0	855
1978	1,941	12	1	61	0	2,015
1979	1,910	9	1	59	0	1,979
1980	2,817	10	1	62	0	2,890
1981	1,500	14	1	50	0	1,565
1982	5,739	17	1	58	0	5,815
1983	6,771	13	1	74	0	6,859
1984	4,231	15	1	77	0	4,323
1985	1,911	12	1	62	0	1,986
1986	2,752	12	1	67	0	2,831
1987	1,356	8	1	51	0	1,416
1988	1,189	12	1	51	0	1,253
1989	1,383	14	1	47	0	1,445
1990	1,695	9	1	42	0	1,747
1991	702	7	0	37	0	747
1992	715	7	1	28	0	750
1993	2,482	13	0	40	0	2,536
1994	1,398	7	1	33	0	1,439
1995	4,692	15	1	57	0	4,765
1996	3,856	12	1	54	0	3,923
1997	3,430	13	1	55	0	3,498
1998	4,449	12	1	72	0	4,533
1999	4,357	7	1	53	0	4,417
2000	3,571	9	1	48	0	3,628
2001	1,383	6	1	44	0	1,434
2002	1,719	9	1	44	0	1,773
2003	2,462	10	1	45	0	2,517
2004	3,001	11	1	41	0	3,054
2005	1,788	9	1	48	0	1,845
2006	6,846	16	1	57	0	6,920
2007	2,570	9	1	33	0	2,613
2008	1,408	9	1	35	0	1,452
2009	1,565	8	1	24	0	1,599
2010	1,819	10	1	34	0	1,864
2011	3,913	16	1	54	0	3,983
2012	2,636	10	1	36	0	2,682
2013	2,364	10	1	29	0	2,403

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2014	1,186	6	1	15	0	1,209
2015	1,241	6	1	13	0	1,261
2016	2,376	8	1	9	0	2,393
2017	9,164	14	1	28	0	9,206
2018	2,216	9	1	27	0	2,252
2019	2,453	15	1	37	0	2,506
2020	1,116	10	1	25	0	1,152
2021	606	7	1	9	0	623
2022	1,186	13	1	4	0	1,205
2023	2,686	10	1	18	0	2,715
2024	3,455	11	1	16	0	3,483

Table 9. Reach FR3 Stream Reach Budget, BBGM v1.2

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	4,326	85	16	27	0	6,555
1972	2,151	95	15	34	0	3,322
1973	3,142	130	16	60	0	5,313
1974	6,307	123	16	58	0	9,819
1975	3,031	119	16	60	0	5,088
1976	1,888	87	15	40	0	2,706
1977	898	52	15	23	0	1,172
1978	2,155	120	16	36	0	4,137
1979	2,071	99	16	40	0	3,289
1980	3,020	113	19	55	0	6,008
1981	1,665	103	19	45	0	2,436
1982	6,019	130	18	50	0	10,465
1983	7,062	134	13	65	0	11,303
1984	4,468	118	15	68	0	7,465
1985	2,074	101	14	53	4	2,983
1986	2,989	112	13	55	5	5,912
1987	1,486	85	12	42	5	2,124
1988	1,329	75	12	41	6	1,977
1989	1,561	89	12	37	6	3,161
1990	1,836	86	11	34	6	2,522
1991	833	89	12	33	6	1,735
1992	836	70	12	24	7	1,477
1993	2,686	101	12	30	8	4,825
1994	1,507	66	11	31	8	2,205
1995	4,955	131	11	50	9	8,608
1996	4,069	97	11	52	9	6,813
1997	3,652	121	12	49	10	7,071

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1998	4,700	95	12	62	10	7,822
1999	4,525	65	12	50	11	6,797
2000	3,749	97	12	49	12	5,186
2001	1,499	65	12	49	12	2,067
2002	1,870	80	12	44	12	2,868
2003	2,630	91	12	43	12	4,095
2004	3,144	79	12	42	14	4,222
2005	1,948	74	12	50	14	3,430
2006	7,098	125	12	58	15	11,024
2007	2,691	60	12	42	16	3,379
2008	1,534	58	12	43	16	2,185
2009	1,680	59	12	33	15	2,654
2010	1,958	69	12	39	16	3,079
2011	4,135	101	12	60	16	7,288
2012	2,783	67	12	52	17	3,868
2013	2,510	72	12	48	18	3,539
2014	1,293	46	12	34	16	1,747
2015	1,344	43	10	28	16	1,760
2016	2,502	55	9	24	17	3,895
2017	9,402	94	8	39	17	14,542
2018	2,359	47	10	45	17	3,804
2019	2,696	116	10	56	14	5,266
2020	1,230	63	10	47	15	1,909
2021	692	34	10	24	16	1,048
2022	1,325	67	10	19	16	1,939
2023	2,874	94	10	36	14	5,659
2024	3,600	85	11	33	13	5,064

Table 10. Reach FR2+3 Stream Reach Budget, BBGM v1.2

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	8,497	94	17	79	0	10,787
1972	4,186	104	17	89	0	5,421
1973	6,049	143	17	139	0	8,314
1974	12,373	135	17	139	0	15,979
1975	5,852	131	17	142	0	8,004
1976	3,648	96	17	105	0	4,541
1977	1,699	57	16	72	0	2,026
1978	4,096	133	17	97	0	6,152
1979	3,981	108	17	99	0	5,268
1980	5,838	123	20	116	0	8,897
1981	3,166	117	20	95	0	4,001

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1982	11,759	147	19	108	0	16,281
1983	13,833	148	13	139	0	18,162
1984	8,699	133	16	145	0	11,788
1985	3,985	112	14	114	4	4,969
1986	5,741	124	13	122	5	8,743
1987	2,841	93	12	94	5	3,539
1988	2,518	87	13	92	6	3,230
1989	2,944	103	12	85	6	4,606
1990	3,531	96	12	76	6	4,269
1991	1,535	96	12	71	6	2,482
1992	1,551	77	12	52	7	2,228
1993	5,169	114	12	71	8	7,361
1994	2,906	73	12	64	8	3,643
1995	9,647	147	12	107	9	13,373
1996	7,925	109	12	106	9	10,736
1997	7,082	133	12	104	10	10,569
1998	9,149	107	12	133	10	12,355
1999	8,882	71	12	102	11	11,214
2000	7,320	106	13	97	12	8,814
2001	2,882	71	13	93	12	3,501
2002	3,589	90	13	88	12	4,641
2003	5,093	101	13	87	12	6,613
2004	6,145	90	13	82	14	7,276
2005	3,736	83	13	98	14	5,275
2006	13,944	141	13	114	15	17,944
2007	5,261	69	13	75	16	5,991
2008	2,941	66	13	78	16	3,638
2009	3,245	67	13	57	15	4,253
2010	3,777	80	13	73	16	4,943
2011	8,048	117	13	114	16	11,271
2012	5,420	77	13	87	17	6,550
2013	4,874	82	13	77	18	5,942
2014	2,479	52	13	49	16	2,955
2015	2,586	49	10	40	16	3,021
2016	4,878	63	10	32	17	6,288
2017	18,567	107	9	67	17	23,748
2018	4,574	56	10	71	17	6,056
2019	5,149	132	10	93	14	7,772
2020	2,346	73	11	72	15	3,061
2021	1,298	40	10	33	16	1,670
2022	2,511	81	10	24	16	3,144
2023	5,560	105	11	55	14	8,374
2024	7,055	96	12	49	13	8,547

Table 11. Reach A Stream Reach Budget, BBGM v1.0

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	13,448	4	0	239	757	13,168
1972	8,330	1	0	288	818	7,899
1973	12,356	7	0	225	735	12,187
1974	19,722	4	0	178	780	19,552
1975	12,003	5	0	316	898	11,687
1976	8,288	2	0	278	882	7,777
1977	5,252	1	0	183	638	4,853
1978	11,393	7	0	63	787	11,027
1979	7,142	4	0	218	835	6,710
1980	11,423	8	0	193	693	11,253
1981	7,782	6	0	238	769	7,435
1982	14,521	8	0	136	600	14,494
1983	21,087	18	0	173	506	21,319
1984	9,774	10	0	436	682	9,837
1985	7,305	4	0	294	710	7,034
1986	13,806	12	0	138	816	13,525
1987	7,176	2	0	243	807	6,743
1988	6,584	3	0	223	776	6,174
1989	6,966	4	0	194	822	6,527
1990	6,079	2	0	195	755	5,636
1991	5,686	3	0	120	628	5,314
1992	5,498	5	0	124	558	5,211
1993	10,279	10	0	80	563	10,148
1994	6,240	4	0	176	631	5,909
1995	17,213	21	0	-7	604	17,244
1996	10,208	10	0	193	651	10,075
1997	14,361	9	0	67	729	14,123
1998	19,658	19	0	8	626	19,566
1999	11,957	3	0	163	768	11,602
2000	11,502	6	0	146	823	11,080
2001	6,952	6	0	222	845	6,482
2002	8,049	6	0	182	886	7,561
2003	11,612	13	0	79	863	11,260
2004	11,553	9	0	130	934	11,016
2005	8,731	9	0	207	871	8,324
2006	17,416	16	0	62	864	17,168
2007	7,182	5	0	221	934	6,613
2008	6,990	7	0	154	890	6,417
2009	6,594	7	0	119	793	6,132
2010	7,787	10	0	106	827	7,323
2011	11,504	8	0	76	818	11,092
2012	7,241	7	0	226	841	6,817
2013	7,569	7	0	39	905	6,910

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2014	5,195	3	0	27	759	4,584
2015	5,944	8	0	-85	600	5,434
2016	7,816	7	0	-180	691	7,198
2017	16,295	14	0	-368	746	15,802
2018	6,325	6	0	-92	782	5,631

Table 12. Reach B Stream Reach Budget, BBGM v1.0

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	13,154	0	0	104	0	13,258
1972	7,884	0	0	115	0	7,999
1973	12,174	0	0	104	0	12,278
1974	19,540	0	0	94	0	19,633
1975	11,673	0	0	107	0	11,780
1976	7,763	0	0	111	0	7,874
1977	4,841	0	0	99	0	4,940
1978	11,016	0	0	89	0	11,106
1979	6,698	0	0	101	0	6,799
1980	11,241	0	0	97	0	11,338
1981	7,423	0	0	100	0	7,524
1982	14,483	0	0	88	0	14,571
1983	21,308	0	0	88	0	21,396
1984	9,822	0	0	117	0	9,939
1985	7,021	0	0	105	0	7,125
1986	13,514	0	0	87	0	13,601
1987	6,730	0	0	108	0	6,838
1988	6,160	0	0	109	0	6,269
1989	6,514	0	0	106	0	6,620
1990	5,624	0	0	102	0	5,725
1991	5,304	0	0	90	0	5,394
1992	5,201	0	0	90	0	5,291
1993	10,138	0	0	87	0	10,225
1994	5,899	0	0	93	0	5,992
1995	17,235	0	0	78	0	17,313
1996	10,064	0	0	95	0	10,159
1997	14,115	0	0	78	0	14,193
1998	19,559	0	0	70	0	19,628
1999	11,593	0	0	83	0	11,676
2000	11,070	0	0	92	0	11,161
2001	6,471	0	0	98	0	6,569
2002	7,551	0	0	95	0	7,646
2003	11,252	0	0	80	0	11,332

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2004	11,007	0	0	88	0	11,095
2005	8,314	0	0	93	0	8,407
2006	17,160	0	0	76	0	17,235
2007	6,603	0	0	96	0	6,699
2008	6,408	0	0	93	0	6,501
2009	6,124	0	0	88	0	6,211
2010	7,312	0	0	102	0	7,414
2011	11,080	0	0	106	0	11,186
2012	6,803	0	0	121	0	6,924
2013	6,901	0	0	87	0	6,988
2014	4,574	0	0	95	0	4,669
2015	5,426	0	0	78	0	5,505
2016	7,192	0	0	70	0	7,262
2017	15,795	0	0	69	0	15,864
2018	5,621	0	0	96	0	5,717

Table 13. Reach C Stream Reach Budget, BBGM v1.0

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	13,258	5	0	212	162	13,313
1972	7,999	3	0	343	185	8,160
1973	12,278	8	0	226	200	12,311
1974	19,633	5	0	100	191	19,547
1975	11,780	5	0	249	216	11,819
1976	7,874	3	0	314	206	7,985
1977	4,940	3	0	279	182	5,040
1978	11,106	7	0	163	208	11,067
1979	6,799	4	0	285	226	6,861
1980	11,338	5	0	231	208	11,366
1981	7,524	4	0	281	226	7,583
1982	14,571	5	0	144	183	14,537
1983	21,396	9	0	117	146	21,376
1984	9,939	5	0	417	189	10,172
1985	7,125	2	0	335	222	7,241
1986	13,601	6	0	168	197	13,578
1987	6,838	2	0	342	187	6,994
1988	6,269	2	0	350	196	6,426
1989	6,620	3	0	330	192	6,760
1990	5,725	2	0	307	179	5,854
1991	5,394	3	0	233	141	5,489
1992	5,291	4	0	238	144	5,388
1993	10,225	6	0	178	175	10,234

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1994	5,992	3	0	251	155	6,091
1995	17,313	11	0	67	150	17,241
1996	10,159	6	0	230	178	10,217
1997	14,193	5	0	91	184	14,105
1998	19,628	8	0	-15	166	19,455
1999	11,676	2	0	123	191	11,610
2000	11,161	3	0	196	244	11,117
2001	6,569	2	0	279	244	6,606
2002	7,646	3	0	258	246	7,661
2003	11,332	5	0	118	215	11,240
2004	11,095	4	0	180	232	11,046
2005	8,407	3	0	238	205	8,442
2006	17,235	6	0	54	188	17,108
2007	6,699	3	0	280	232	6,749
2008	6,501	3	0	257	238	6,523
2009	6,211	3	0	221	235	6,200
2010	7,414	5	0	301	211	7,509
2011	11,186	4	0	300	180	11,309
2012	6,924	3	0	446	200	7,172
2013	6,988	2	0	180	226	6,945
2014	4,669	1	0	239	175	4,734
2015	5,505	3	0	98	187	5,419
2016	7,262	4	0	-6	177	7,084
2017	15,864	6	0	-109	178	15,583
2018	5,717	2	0	148	195	5,672

Table 14. Reach D Stream Reach Budget, BBGM v1.0

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	13,323	5	0	-308	85	13,746
1972	8,166	3	0	-156	78	8,506
1973	12,320	8	0	-281	89	13,103
1974	19,560	5	0	-437	91	20,425
1975	11,828	4	0	-266	85	12,531
1976	7,992	2	0	-176	87	8,326
1977	5,047	2	0	-126	75	5,277
1978	11,077	7	0	-279	88	11,817
1979	6,868	4	0	-149	83	7,443
1980	11,374	7	0	-249	78	12,155
1981	7,591	3	0	-175	92	8,090
1982	14,547	4	0	-343	83	15,479
1983	21,388	7	0	-462	79	22,446

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1984	10,177	5	0	-152	90	10,998
1985	7,248	3	0	-159	85	7,715
1986	13,590	4	0	-337	82	14,374
1987	7,000	2	0	-149	82	7,381
1988	6,431	3	0	-132	84	6,874
1989	6,766	3	0	-151	86	7,259
1990	5,861	2	0	-139	81	6,223
1991	5,497	3	0	-164	85	5,850
1992	5,396	3	0	-156	88	5,760
1993	10,243	7	0	-270	99	11,005
1994	6,098	3	0	-156	98	6,502
1995	17,252	9	0	-415	102	18,520
1996	10,224	6	0	-234	110	11,079
1997	14,116	7	0	-343	114	15,057
1998	19,469	7	0	-486	86	20,469
1999	11,620	2	0	-300	97	12,184
2000	11,125	2	0	-255	32	11,914
2001	6,613	2	0	-140	27	7,261
2002	7,667	3	0	-172	19	8,440
2003	11,250	4	0	-306	14	12,134
2004	11,055	4	0	-261	17	11,930
2005	8,450	3	0	-188	16	9,352
2006	17,120	7	0	-414	15	18,424
2007	6,756	1	0	-145	20	7,372
2008	6,530	3	0	-149	20	7,200
2009	6,207	2	0	-153	19	6,846
2010	7,513	5	0	-134	15	8,419
2011	11,314	4	0	-183	15	12,513
2012	7,173	4	0	-30	18	8,051
2013	6,953	3	0	-167	17	7,669
2014	4,741	2	0	-109	11	5,256
2015	5,428	3	0	-194	13	5,813
2016	7,096	2	0	-288	10	7,545
2017	15,598	5	0	-503	13	16,566
2018	5,681	2	0	-208	14	6,227

Table 15. Feather River Stream Reach Budget, BBGM v1.0

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	355	102	0	109	0	6,535
1972	301	113	0	110	0	3,307
1973	491	152	0	160	0	5,288
1974	1,369	145	0	160	0	9,792
1975	389	133	0	161	0	5,057
1976	293	98	0	123	0	2,689
1977	293	63	0	85	0	1,159
1978	324	141	0	118	0	4,122
1979	293	114	0	116	0	3,272
1980	1,328	129	0	133	0	5,982
1981	294	121	0	109	0	2,409
1982	1,487	156	0	129	0	10,438
1983	1,662	161	0	158	0	11,275
1984	761	141	0	161	0	7,433
1985	302	116	0	128	4	2,958
1986	2,182	134	0	140	5	5,891
1987	334	97	0	110	5	2,105
1988	428	95	0	110	6	1,965
1989	481	108	0	102	6	3,146
1990	458	100	0	91	6	2,509
1991	451	103	0	86	6	1,722
1992	461	85	0	68	7	1,466
1993	686	126	0	90	8	4,811
1994	452	79	0	76	8	2,188
1995	2,137	159	0	125	9	8,588
1996	1,116	116	0	120	9	6,789
1997	2,882	142	0	117	10	7,048
1998	842	120	0	152	10	7,797
1999	546	79	0	116	11	6,773
2000	457	114	0	112	12	5,163
2001	463	74	0	105	12	2,043
2002	471	95	0	101	12	2,846
2003	465	108	0	101	12	4,071
2004	506	95	0	97	14	4,199
2005	469	91	0	110	14	3,407
2006	1,873	154	0	128	15	10,995
2007	502	74	0	81	16	3,350
2008	500	72	0	86	16	2,162
2009	482	74	0	67	15	2,633
2010	508	87	0	83	16	3,057
2011	909	127	0	125	16	7,263
2012	654	84	0	88	17	3,835
2013	1,143	89	0	76	18	3,507

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2014	779	58	0	48	16	1,719
2015	886	54	0	44	16	1,740
2016	1,087	70	0	39	17	3,877
2017	6,462	123	0	74	17	14,523
2018	761	65	0	76	17	3,781

Table 16. Reach FR1 Stream Reach Budget, BBGM v1.0

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	355	5	0	33	0	393
1972	301	3	0	20	0	324
1973	491	8	0	26	0	525
1974	1,369	7	0	28	0	1,404
1975	389	6	0	23	0	418
1976	293	3	0	16	0	312
1977	293	3	0	11	0	306
1978	324	7	0	18	0	349
1979	293	5	0	15	0	314
1980	1,328	7	0	17	0	1,353
1981	294	6	0	15	0	315
1982	1,487	10	0	24	0	1,520
1983	1,662	13	0	31	0	1,705
1984	761	8	0	28	0	797
1985	302	4	0	21	0	327
1986	2,182	10	0	24	0	2,216
1987	334	5	0	20	0	360
1988	428	5	0	18	0	451
1989	481	6	0	18	0	505
1990	458	5	0	16	0	478
1991	451	7	0	15	0	473
1992	461	6	0	15	0	482
1993	686	11	0	20	0	718
1994	452	4	0	15	0	471
1995	2,137	12	0	24	0	2,174
1996	1,116	7	0	21	0	1,145
1997	2,882	9	0	20	0	2,911
1998	842	12	0	29	0	883
1999	546	6	0	24	0	576
2000	457	7	0	22	0	486
2001	463	5	0	18	0	487
2002	471	7	0	19	0	496

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2003	465	9	0	20	0	494
2004	506	7	0	21	0	535
2005	469	8	0	19	0	497
2006	1,873	13	0	25	0	1,910
2007	502	5	0	17	0	525
2008	500	6	0	15	0	521
2009	482	7	0	14	0	503
2010	508	8	0	15	0	531
2011	909	10	0	20	0	939
2012	654	7	0	15	0	676
2013	1,143	7	0	13	0	1,163
2014	779	5	0	10	0	794
2015	886	6	0	10	0	902
2016	1,087	8	0	12	0	1,106
2017	6,462	15	0	16	0	6,493
2018	761	8	0	15	0	784

Table 17. Reach FR2 Stream Reach Budget, BBGM v1.0

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	4,171	8	0	51	0	4,230
1972	2,035	10	0	55	0	2,100
1973	2,908	13	0	79	0	2,999
1974	6,066	12	0	80	0	6,158
1975	2,821	11	0	81	0	2,912
1976	1,760	9	0	64	0	1,833
1977	800	6	0	48	0	854
1978	1,941	11	0	60	0	2,013
1979	1,910	9	0	58	0	1,977
1980	2,817	11	0	61	0	2,889
1981	1,500	13	0	51	0	1,564
1982	5,739	16	0	59	0	5,815
1983	6,771	13	0	73	0	6,856
1984	4,231	15	0	76	0	4,321
1985	1,911	10	0	61	0	1,982
1986	2,752	13	0	66	0	2,830
1987	1,356	8	0	51	0	1,414
1988	1,189	12	0	52	0	1,253
1989	1,383	14	0	47	0	1,443
1990	1,695	10	0	41	0	1,746
1991	702	7	0	38	0	747

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1992	715	7	0	28	0	750
1993	2,482	13	0	39	0	2,535
1994	1,398	7	0	33	0	1,438
1995	4,692	15	0	55	0	4,762
1996	3,856	11	0	54	0	3,921
1997	3,430	13	0	54	0	3,496
1998	4,449	12	0	69	0	4,530
1999	4,357	7	0	50	0	4,415
2000	3,571	8	0	46	0	3,626
2001	1,383	6	0	42	0	1,431
2002	1,719	9	0	43	0	1,771
2003	2,462	9	0	44	0	2,515
2004	3,001	10	0	40	0	3,051
2005	1,788	9	0	47	0	1,844
2006	6,846	15	0	56	0	6,917
2007	2,570	8	0	32	0	2,610
2008	1,408	8	0	34	0	1,450
2009	1,565	8	0	24	0	1,597
2010	1,819	10	0	32	0	1,861
2011	3,913	16	0	52	0	3,981
2012	2,636	10	0	34	0	2,679
2013	2,364	10	0	27	0	2,401
2014	1,186	6	0	14	0	1,206
2015	1,241	6	0	12	0	1,259
2016	2,376	7	0	9	0	2,391
2017	9,164	13	0	27	0	9,205
2018	2,216	9	0	27	0	2,252

Table 18. Reach FR3 Stream Reach Budget, BBGM v1.0

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	4,320	90	0	25	0	6,535
1972	2,148	100	0	35	0	3,307
1973	3,137	132	0	55	0	5,288
1974	6,302	125	0	52	0	9,792
1975	3,023	116	0	57	0	5,057
1976	1,884	85	0	42	0	2,689
1977	895	55	0	27	0	1,159
1978	2,150	122	0	40	0	4,122
1979	2,066	100	0	43	0	3,272
1980	3,016	111	0	54	0	5,982
1981	1,660	102	0	43	0	2,409

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1982	6,015	130	0	46	0	10,438
1983	7,056	135	0	55	0	11,275
1984	4,463	118	0	58	0	7,433
1985	2,068	102	0	47	4	2,958
1986	2,986	111	0	51	5	5,891
1987	1,482	84	0	39	5	2,105
1988	1,326	79	0	40	6	1,965
1989	1,557	88	0	37	6	3,146
1990	1,832	86	0	35	6	2,509
1991	831	89	0	34	6	1,722
1992	834	72	0	26	7	1,466
1993	2,683	102	0	31	8	4,811
1994	1,504	68	0	28	8	2,188
1995	4,950	132	0	45	9	8,588
1996	4,064	98	0	45	9	6,789
1997	3,648	120	0	43	10	7,048
1998	4,694	96	0	54	10	7,797
1999	4,520	65	0	42	11	6,773
2000	3,743	98	0	43	12	5,163
2001	1,494	63	0	44	12	2,043
2002	1,865	80	0	39	12	2,846
2003	2,626	90	0	37	12	4,071
2004	3,140	78	0	36	14	4,199
2005	1,944	75	0	44	14	3,407
2006	7,092	126	0	47	15	10,995
2007	2,686	61	0	32	16	3,350
2008	1,528	58	0	36	16	2,162
2009	1,676	59	0	29	15	2,633
2010	1,952	69	0	35	16	3,057
2011	4,130	101	0	53	16	7,263
2012	2,777	67	0	40	17	3,835
2013	2,504	73	0	36	18	3,507
2014	1,288	46	0	24	16	1,719
2015	1,340	42	0	22	16	1,740
2016	2,499	55	0	19	17	3,877
2017	9,400	94	0	31	17	14,523
2018	2,357	48	0	34	17	3,781

Table 19. Reach FR2+3 Stream Reach Budget, BBGM v1.0

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1971	4,171	4	0	239	757	13,168
1972	2,035	1	0	288	818	7,899
1973	2,908	7	0	225	735	12,187
1974	6,066	4	0	178	780	19,552
1975	2,821	5	0	316	898	11,687
1976	1,760	2	0	278	882	7,777
1977	800	1	0	183	638	4,853
1978	1,941	7	0	63	787	11,027
1979	1,910	4	0	218	835	6,710
1980	2,817	8	0	193	693	11,253
1981	1,500	6	0	238	769	7,435
1982	5,739	8	0	136	600	14,494
1983	6,771	18	0	173	506	21,319
1984	4,231	10	0	436	682	9,837
1985	1,911	4	0	294	710	7,034
1986	2,752	12	0	138	816	13,525
1987	1,356	2	0	243	807	6,743
1988	1,189	3	0	223	776	6,174
1989	1,383	4	0	194	822	6,527
1990	1,695	2	0	195	755	5,636
1991	702	3	0	120	628	5,314
1992	715	5	0	124	558	5,211
1993	2,482	10	0	80	563	10,148
1994	1,398	4	0	176	631	5,909
1995	4,692	21	0	-7	604	17,244
1996	3,856	10	0	193	651	10,075
1997	3,430	9	0	67	729	14,123
1998	4,449	19	0	8	626	19,566
1999	4,357	3	0	163	768	11,602
2000	3,571	6	0	146	823	11,080
2001	1,383	6	0	222	845	6,482
2002	1,719	6	0	182	886	7,561
2003	2,462	13	0	79	863	11,260
2004	3,001	9	0	130	934	11,016
2005	1,788	9	0	207	871	8,324
2006	6,846	16	0	62	864	17,168
2007	2,570	5	0	221	934	6,613
2008	1,408	7	0	154	890	6,417
2009	1,565	7	0	119	793	6,132
2010	1,819	10	0	106	827	7,323
2011	3,913	8	0	76	818	11,092
2012	2,636	7	0	226	841	6,817
2013	2,364	7	0	39	905	6,910

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2014	1,186	3	0	27	759	4,584
2015	1,241	8	0	-85	600	5,434
2016	2,376	7	0	-180	691	7,198
2017	9,164	14	0	-368	746	15,802
2018	2,216	6	0	-92	782	5,631

Table 20. Reach A Stream Reach Budget, C2VSimFG v1.5

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1974	18,680	215	0	24	788	18,111
1975	11,498	203	0	44	824	10,897
1976	7,996	36	0	39	819	7,224
1977	5,137	24	0	34	615	4,548
1978	10,291	338	0	26	753	9,880
1979	6,907	141	0	33	813	6,240
1980	10,693	241	0	44	656	10,299
1981	7,558	159	0	42	912	6,820
1982	14,569	246	1	48	777	14,067
1983	20,987	506	1	57	627	20,908
1984	12,313	259	1	60	851	11,758
1985	7,853	122	0	51	824	7,177
1986	12,137	304	0	54	816	11,657
1987	7,275	97	0	41	801	6,585
1988	7,262	119	0	36	795	6,593
1989	7,526	120	0	36	855	6,801
1990	6,199	60	0	40	721	5,549
1991	5,470	124	0	35	659	4,942
1992	5,516	176	0	31	540	5,154
1993	10,209	310	0	35	588	9,945
1994	6,447	127	0	40	608	5,988
1995	16,891	543	0	39	577	16,878
1996	12,185	278	0	49	574	11,915
1997	13,018	220	0	58	689	12,582
1998	18,475	581	0	46	610	18,479
1999	11,828	165	0	58	747	11,289
2000	12,127	195	0	43	760	11,581
2001	7,568	140	0	45	830	6,895
2002	8,205	161	0	42	798	7,582
2003	11,165	252	0	37	796	10,635
2004	11,848	260	0	35	923	11,207
2005	8,869	245	0	50	860	8,281

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2006	17,146	365	0	50	850	16,690
2007	7,427	91	0	46	922	6,607
2008	7,158	161	0	30	876	6,439
2009	6,711	129	0	23	785	6,047
2010	7,954	227	0	29	815	7,369
2011	11,538	248	0	40	826	10,982
2012	7,529	144	0	43	870	6,814
2013	7,847	139	0	24	909	7,069
2014	5,556	78	0	17	656	4,964
2015	6,077	173	0	9	571	5,660
2016	8,308	216	0	9	785	7,719
2017	16,573	339	0	26	822	16,093
2018	6,894	83	0	25	889	6,080
2019	12,150	382	0	16	802	11,723
2020	7,040	66	0	20	855	6,236
2021	5,282	38	0	0	646	4,634

Table 21. Reach B Stream Reach Budget, C2VSimFG v1.5

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1974	18,573	6	0	-4	13	18,320
1975	11,111	6	0	-5	11	11,100
1976	7,245	2	0	-5	24	7,216
1977	4,553	2	0	-5	30	4,517
1978	10,229	11	0	-4	17	10,141
1979	6,361	5	0	-5	20	6,339
1980	10,574	8	0	-2	18	10,406
1981	6,925	6	0	-4	27	6,898
1982	14,494	10	0	-2	12	14,485
1983	21,468	20	0	-1	5	21,266
1984	12,030	10	0	-3	12	11,978
1985	7,261	5	0	-4	21	7,238
1986	12,018	11	0	-3	20	11,866
1987	6,688	4	0	-5	25	6,659
1988	6,695	5	0	-5	22	6,670
1989	6,968	5	0	-6	24	6,940
1990	5,622	3	0	-5	25	5,592
1991	5,049	6	0	-6	19	5,026
1992	5,259	7	0	-6	23	5,234
1993	10,263	13	0	-5	17	10,251

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1994	6,066	5	0	-6	20	6,043
1995	17,481	23	0	-6	17	17,374
1996	12,216	11	0	-5	18	12,201
1997	12,961	8	0	-4	25	12,863
1998	19,021	25	0	-4	20	18,943
1999	11,541	4	0	-4	25	11,515
2000	11,826	7	0	-5	30	11,795
2001	6,999	5	0	-4	23	6,973
2002	7,756	6	0	-4	22	7,734
2003	10,958	12	0	-5	19	10,944
2004	11,449	10	0	-5	21	11,418
2005	8,474	9	0	-2	17	8,461
2006	17,246	14	0	-3	19	17,204
2007	6,722	3	0	-5	21	6,690
2008	6,559	6	0	-6	21	6,530
2009	6,197	5	0	-9	22	6,163
2010	7,592	9	0	-7	17	7,571
2011	11,352	13	0	-5	14	11,340
2012	6,964	6	0	-6	19	6,938
2013	7,241	5	0	-7	21	7,211
2014	5,054	3	0	-9	21	5,019
2015	5,779	7	0	-9	22	5,745
2016	7,955	8	0	-9	15	7,932
2017	16,597	12	0	-8	13	16,582
2018	6,234	3	0	-8	16	6,206
2019	12,064	13	0	-8	14	12,049
2020	6,333	2	0	-7	15	6,305
2021	4,683	1	0	-10	12	4,654

Table 22. Reach C Stream Reach Budget, C2VSimFG v1.5

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1974	18,906	109	7	45	88	18,804
1975	11,396	104	7	60	98	11,416
1976	7,219	43	6	61	91	7,179
1977	4,517	29	5	64	76	4,478
1978	10,673	152	6	61	92	10,711
1979	6,363	86	7	64	102	6,361
1980	10,901	134	7	75	87	10,902
1981	6,928	101	7	72	96	6,956

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1982	15,036	125	7	80	77	15,124
1983	22,483	202	5	98	65	22,576
1984	12,428	123	6	61	74	12,467
1985	7,289	55	1	105	93	7,309
1986	12,496	117	1	113	87	12,526
1987	6,661	43	2	99	77	6,674
1988	6,766	53	2	93	74	6,791
1989	6,943	54	3	93	75	6,961
1990	5,593	31	3	91	68	5,605
1991	5,028	66	2	89	60	5,082
1992	5,269	89	2	77	69	5,325
1993	10,766	133	1	66	90	10,852
1994	6,050	91	2	86	73	6,108
1995	18,375	209	3	77	71	18,502
1996	12,661	133	3	77	93	12,743
1997	13,340	109	1	98	98	13,365
1998	19,973	229	2	81	77	20,141
1999	11,746	80	2	96	93	11,797
2000	12,012	93	2	93	106	12,053
2001	7,065	85	2	101	107	7,102
2002	7,994	94	1	100	117	8,036
2003	11,270	116	3	84	108	11,337
2004	11,856	127	2	93	62	11,962
2005	8,960	124	1	99	115	9,033
2006	18,015	153	2	96	90	18,123
2007	6,737	61	2	96	112	6,712
2008	6,694	90	2	87	117	6,684
2009	6,166	66	2	83	114	6,134
2010	7,764	109	2	86	111	7,793
2011	11,631	114	2	97	89	11,696
2012	6,962	79	2	100	95	6,985
2013	7,345	73	2	89	103	7,337
2014	5,019	38	1	70	78	4,974
2015	5,827	72	1	46	76	5,789
2016	8,145	76	1	43	90	8,098
2017	16,850	129	2	73	89	16,905
2018	6,207	39	2	77	94	6,155
2019	12,242	139	2	66	96	12,293
2020	6,306	38	1	75	89	6,253
2021	4,654	21	1	46	0	4,637

Table 23. Reach D Stream Reach Budget, C2VSimFG v1.5

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1974	18,804	7	1	18	105	14,748
1975	11,416	7	1	27	128	10,464
1976	7,179	4	0	28	146	7,049
1977	4,478	2	0	34	128	4,369
1978	10,711	6	0	37	131	8,802
1979	6,361	5	0	32	138	6,200
1980	10,902	6	1	43	134	8,492
1981	6,956	5	1	35	134	6,733
1982	15,124	7	1	38	124	12,999
1983	22,576	7	0	49	93	15,652
1984	12,467	7	0	27	132	10,909
1985	7,309	1	0	47	132	7,194
1986	12,526	3	0	48	109	9,313
1987	6,674	1	0	37	105	6,551
1988	6,791	1	0	37	119	6,645
1989	6,961	1	0	35	110	6,798
1990	5,605	1	0	34	104	5,517
1991	5,082	2	0	33	75	5,024
1992	5,325	2	0	29	68	5,239
1993	10,852	7	0	24	100	9,711
1994	6,108	2	0	31	100	6,019
1995	18,502	11	0	33	97	13,441
1996	12,743	5	0	33	116	11,021
1997	13,365	4	0	30	117	10,507
1998	20,141	9	0	31	119	14,637
1999	11,797	1	0	30	122	11,050
2000	12,053	2	0	32	118	9,915
2001	7,102	1	0	40	120	6,946
2002	8,036	2	0	45	112	7,658
2003	11,337	3	0	35	103	10,496
2004	11,962	3	0	35	116	10,401
2005	9,033	2	0	40	111	8,722
2006	18,123	4	0	32	109	14,679
2007	6,712	1	0	36	127	6,569
2008	6,684	2	0	43	125	6,539
2009	6,134	1	0	39	123	5,982
2010	7,793	2	0	43	108	7,575
2011	11,696	3	0	42	106	10,800
2012	6,985	1	0	43	111	6,885
2013	7,337	1	0	43	112	7,156
2014	4,974	1	0	28	86	4,888
2015	5,789	1	0	27	83	5,697

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2016	8,098	1	0	26	102	7,796
2017	16,905	3	0	34	93	13,927
2018	6,155	1	0	35	113	6,047
2019	12,293	3	0	33	93	10,894
2020	6,253	1	0	30	100	6,156
2021	4,637	0	0	17	83	4,539

Table 24. Feather River Stream Reach Budget, C2VSimFG v1.5

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1974	7,438	156	8	22	171	7,629
1975	3,213	125	10	52	181	3,275
1976	2,053	64	8	29	186	1,910
1977	1,094	33	7	13	111	970
1978	2,269	154	7	40	153	2,401
1979	2,205	117	8	36	176	2,201
1980	4,149	147	10	43	171	4,261
1981	1,795	113	11	21	174	1,751
1982	7,238	189	10	21	153	7,520
1983	8,434	221	10	33	127	8,843
1984	5,003	157	8	66	162	5,181
1985	2,214	151	4	83	163	2,259
1986	4,940	225	4	72	147	5,214
1987	1,691	95	9	75	152	1,686
1988	1,618	79	10	58	160	1,583
1989	1,866	112	12	62	157	1,910
1990	2,154	84	11	52	162	2,110
1991	1,156	84	11	50	102	1,188
1992	1,177	102	11	35	104	1,204
1993	3,174	155	11	57	140	3,368
1994	1,851	67	13	46	159	1,796
1995	6,839	205	11	28	155	7,193
1996	4,975	123	12	52	166	5,095
1997	6,284	137	11	51	174	6,454
1998	5,298	202	11	42	161	5,616
1999	4,474	101	10	72	186	4,552
2000	3,575	119	11	53	188	3,639
2001	1,384	81	12	65	191	1,337
2002	1,721	107	11	51	199	1,699
2003	2,465	111	12	57	187	2,539
2004	3,004	98	14	47	219	3,008

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2005	1,789	97	12	75	198	1,818
2006	6,853	169	11	55	198	7,136
2007	2,571	62	10	58	230	2,446
2008	1,409	96	10	74	204	1,366
2009	1,566	76	10	59	196	1,505
2010	1,820	101	10	58	190	1,830
2011	3,918	155	10	85	189	4,119
2012	2,638	86	11	76	193	2,620
2013	2,366	84	11	73	202	2,337
2014	1,187	54	11	55	181	1,065
2015	1,180	78	9	32	115	1,150
2016	2,378	96	9	21	195	2,301
2017	9,172	169	9	26	180	9,349
2018	2,297	78	10	75	197	2,259
2019	3,980	158	10	46	175	4,094
2020	1,750	62	8	71	203	1,651
2021	1,320	54	9	34	147	1,193

Table 25. Reach FR1 Stream Reach Budget, C2VSimFG v1.5

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1974	7,435	10	0	-10	0	7,430
1975	3,211	7	0	-6	0	3,207
1976	2,053	2	0	-10	0	2,039
1977	1,094	1	0	-13	0	1,076
1978	2,266	9	0	-10	0	2,260
1979	2,204	5	0	-10	0	2,194
1980	4,147	8	1	-12	0	4,137
1981	1,795	5	1	-15	0	1,779
1982	7,232	11	0	-12	0	7,227
1983	8,427	17	0	-4	0	8,436
1984	5,000	8	0	3	0	5,006
1985	2,214	3	0	7	0	2,218
1986	4,936	10	0	6	0	4,947
1987	1,691	4	0	8	0	1,697
1988	1,617	5	0	2	0	1,619
1989	1,864	7	0	-1	0	1,865
1990	2,154	4	0	0	0	2,152
1991	1,154	7	0	-2	0	1,154
1992	1,176	6	0	-5	0	1,172

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1993	3,170	12	0	-2	0	3,175
1994	1,851	9	0	-2	0	1,853
1995	6,832	16	0	-5	0	6,838
1996	4,973	10	0	0	0	4,977
1997	6,281	10	0	0	0	6,285
1998	5,292	17	0	-4	0	5,300
1999	4,473	10	0	7	0	4,485
2000	3,572	8	0	0	0	3,575
2001	1,384	6	0	1	0	1,385
2002	1,720	7	0	-4	0	1,717
2003	2,464	9	0	-3	0	2,465
2004	3,002	10	0	0	0	3,006
2005	1,789	7	0	2	0	1,791
2006	6,849	13	0	2	0	6,859
2007	2,570	6	0	3	0	2,568
2008	1,408	7	0	4	0	1,407
2009	1,566	7	0	1	0	1,562
2010	1,820	9	0	-1	0	1,817
2011	3,915	12	0	3	0	3,924
2012	2,637	7	0	4	0	2,637
2013	2,364	6	0	3	0	2,362
2014	1,187	6	0	4	0	1,175
2015	1,179	6	0	-1	0	1,178
2016	2,377	10	0	-7	0	2,361
2017	9,167	17	0	-6	0	9,164
2018	2,296	8	0	5	0	2,293
2019	3,975	17	0	-4	0	3,975
2020	1,750	6	0	6	0	1,744
2021	1,320	5	0	0	0	1,305

Table 26. Reach FR2 Stream Reach Budget, C2VSimFG v1.5

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1974	7,430	38	3	5	5	7,673
1975	3,207	30	3	18	5	3,339
1976	2,039	11	3	14	5	2,038
1977	1,076	5	2	12	5	1,062
1978	2,260	38	2	18	5	2,425
1979	2,194	24	3	21	5	2,278
1980	4,137	35	4	19	5	4,300
1981	1,779	24	4	16	5	1,833

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1982	7,227	49	3	8	5	7,522
1983	8,436	66	3	13	5	8,808
1984	5,006	35	3	25	5	5,202
1985	2,218	9	0	34	2	2,269
1986	4,947	35	0	23	2	5,158
1987	1,697	12	0	26	2	1,743
1988	1,619	13	0	22	3	1,662
1989	1,865	20	1	21	4	1,948
1990	2,152	10	1	20	5	2,180
1991	1,154	18	1	18	5	1,206
1992	1,172	18	1	13	5	1,215
1993	3,175	40	0	15	3	3,367
1994	1,853	14	0	14	3	1,887
1995	6,838	59	0	5	3	7,181
1996	4,977	30	0	13	3	5,138
1997	6,285	32	0	17	3	6,504
1998	5,300	57	0	15	3	5,610
1999	4,485	18	0	21	3	4,629
2000	3,575	23	0	16	3	3,709
2001	1,385	14	0	26	3	1,435
2002	1,717	20	0	24	3	1,795
2003	2,465	28	0	23	2	2,622
2004	3,006	27	1	19	4	3,136
2005	1,791	23	0	30	3	1,901
2006	6,859	52	0	19	2	7,197
2007	2,568	12	0	23	4	2,602
2008	1,407	17	0	31	4	1,457
2009	1,562	14	0	24	3	1,610
2010	1,817	24	0	26	3	1,916
2011	3,924	40	0	29	2	4,145
2012	2,637	17	0	27	3	2,706
2013	2,362	14	0	27	4	2,430
2014	1,175	9	0	22	4	1,177
2015	1,178	13	0	13	3	1,187
2016	2,361	20	0	5	4	2,405
2017	9,164	43	0	4	4	9,383
2018	2,293	15	0	24	4	2,351
2019	3,975	38	0	12	3	4,122
2020	1,744	8	0	25	4	1,767
2021	1,305	6	0	14	4	1,278

Table 27. Reach FR3 Stream Reach Budget, C2VSimFG v1.5

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1974	7,676	108	5	27	165	7,629
1975	3,340	88	6	40	175	3,275
1976	2,038	51	5	25	181	1,910
1977	1,062	27	4	14	106	970
1978	2,428	107	4	31	147	2,401
1979	2,279	87	5	25	170	2,201
1980	4,303	104	6	36	166	4,261
1981	1,834	85	7	20	168	1,751
1982	7,527	128	6	25	148	7,520
1983	8,815	137	6	23	122	8,843
1984	5,205	113	5	38	157	5,181
1985	2,269	139	4	42	160	2,259
1986	5,162	180	4	42	145	5,214
1987	1,743	79	9	42	150	1,686
1988	1,663	61	10	34	157	1,583
1989	1,950	84	11	42	153	1,910
1990	2,180	70	10	33	157	2,110
1991	1,208	59	10	34	97	1,188
1992	1,216	78	10	26	99	1,204
1993	3,370	104	11	43	138	3,368
1994	1,887	45	13	33	156	1,796
1995	7,187	130	10	28	152	7,193
1996	5,140	84	11	39	162	5,095
1997	6,507	95	11	34	171	6,454
1998	5,616	127	10	31	158	5,616
1999	4,630	72	10	44	183	4,552
2000	3,711	88	10	37	186	3,639
2001	1,435	61	12	38	188	1,337
2002	1,796	80	11	31	197	1,699
2003	2,623	73	11	36	185	2,539
2004	3,138	61	13	27	215	3,008
2005	1,901	68	11	42	195	1,818
2006	7,201	104	11	34	196	7,136
2007	2,602	44	10	32	226	2,446
2008	1,458	72	10	38	200	1,366
2009	1,611	55	10	35	193	1,505
2010	1,917	68	10	33	188	1,830
2011	4,149	103	10	53	187	4,119
2012	2,707	63	11	45	190	2,620
2013	2,432	64	10	42	199	2,337
2014	1,178	39	11	29	177	1,065
2015	1,188	58	9	19	112	1,150

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2016	2,407	66	9	23	192	2,301
2017	9,388	109	9	28	176	9,349
2018	2,352	55	10	46	193	2,259
2019	4,126	103	10	37	172	4,094
2020	1,768	48	8	39	199	1,651
2021	1,278	43	8	20	142	1,193

Table 28. Reach FR2+3 Stream Reach Budget, C2VSimFG v1.5

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
1974	7,433	146	8	32	171	7,629
1975	3,209	118	9	58	181	3,275
1976	2,039	62	8	39	186	1,910
1977	1,076	32	6	26	111	970
1978	2,263	145	6	49	153	2,401
1979	2,194	111	8	46	176	2,201
1980	4,139	139	10	55	171	4,261
1981	1,780	109	10	36	174	1,751
1982	7,232	177	9	33	153	7,520
1983	8,443	203	10	37	127	8,843
1984	5,009	148	8	63	162	5,181
1985	2,218	148	4	76	163	2,259
1986	4,950	215	4	66	147	5,214
1987	1,698	91	9	67	152	1,686
1988	1,619	74	10	56	160	1,583
1989	1,867	105	12	63	157	1,910
1990	2,153	80	11	53	162	2,110
1991	1,156	77	11	52	102	1,188
1992	1,173	96	11	40	104	1,204
1993	3,179	143	11	58	140	3,368
1994	1,853	59	13	48	159	1,796
1995	6,845	190	11	33	155	7,193
1996	4,979	114	12	53	166	5,095
1997	6,288	127	11	51	174	6,454
1998	5,306	184	11	46	161	5,616
1999	4,486	90	10	66	186	4,552
2000	3,577	111	11	53	188	3,639
2001	1,386	75	12	64	191	1,337
2002	1,718	100	11	55	199	1,699
2003	2,466	101	12	60	187	2,539
2004	3,008	88	14	47	219	3,008

Water Year	Upstream & Tributary Inflow (+)	Runoff & Return Flow (+)	Pond Drainage (+)	Gain from Groundwater (+)	Diversion (-)	Downstream Outflow (-)
2005	1,792	91	11	72	198	1,818
2006	6,863	156	11	53	198	7,136
2007	2,568	56	10	55	230	2,446
2008	1,408	89	10	69	204	1,366
2009	1,563	69	10	59	196	1,505
2010	1,818	93	10	59	190	1,830
2011	3,927	143	10	82	189	4,119
2012	2,638	79	11	72	193	2,620
2013	2,364	78	11	69	202	2,337
2014	1,175	48	11	51	181	1,065
2015	1,178	71	9	33	115	1,150
2016	2,363	86	9	29	195	2,301
2017	9,170	152	9	32	180	9,349
2018	2,294	69	10	70	197	2,259
2019	3,979	141	10	49	175	4,094
2020	1,744	56	8	64	203	1,651
2021	1,305	49	9	34	147	1,193

ATTACHMENT 3: GROUNDWATER BUDGETS

Groundwater budgets are provided in graphical and tabular format for each Butte County groundwater subbasin and each model for BBGM Version 1.2 through 2024 (Version 1.3), BBGM Version 1.0, and C2VSimFG Version 1.5.

Butte Subbasin

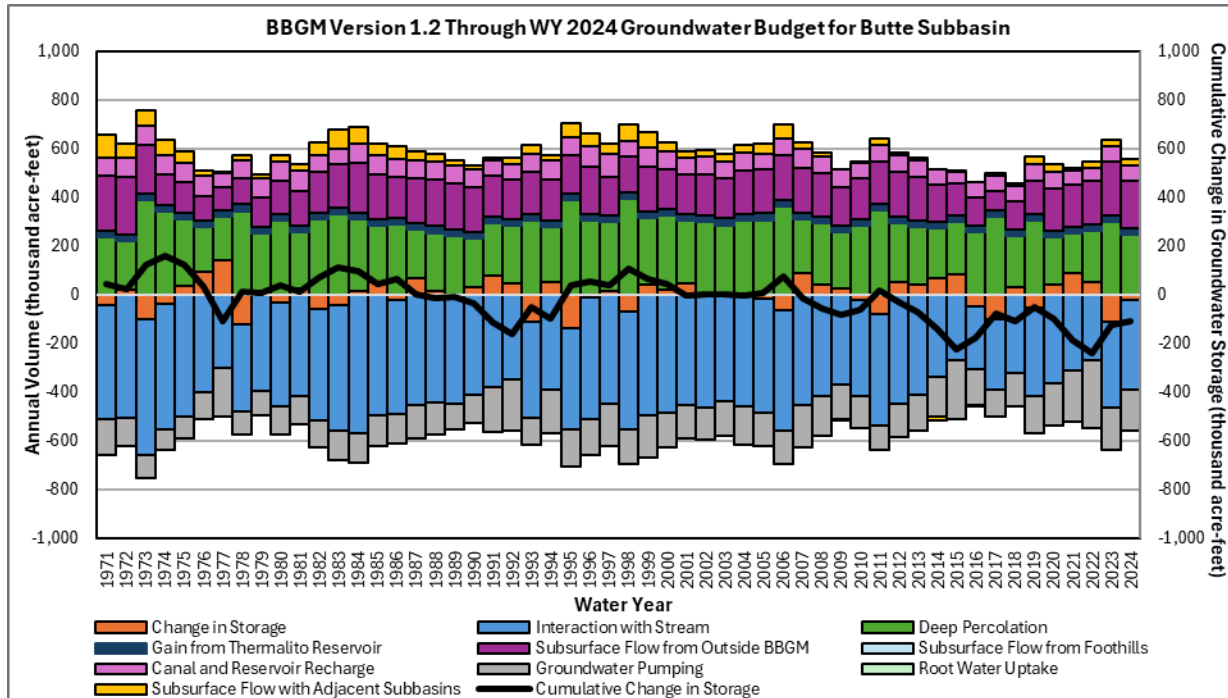


Figure 1. BBGM Version 1.3 (aka Version 1.2 through 2024) Groundwater Budget for Butte Subbasin

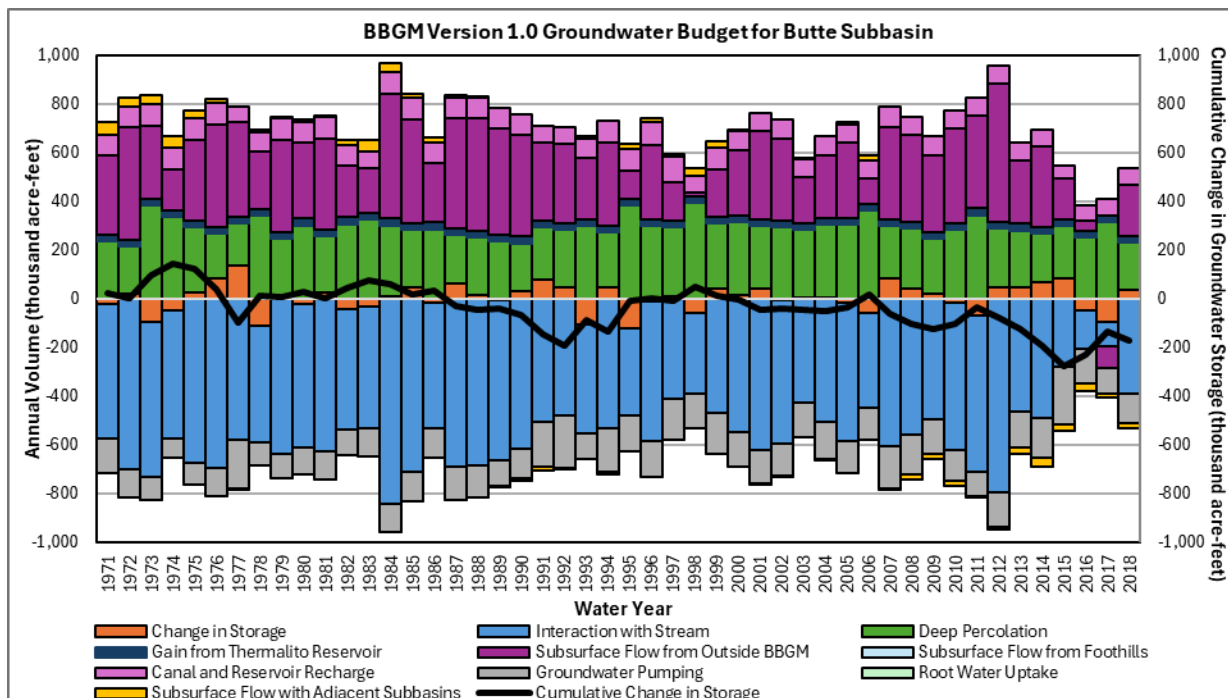


Figure 2. BBGM Version 1.0 Groundwater Budget for Butte Subbasin

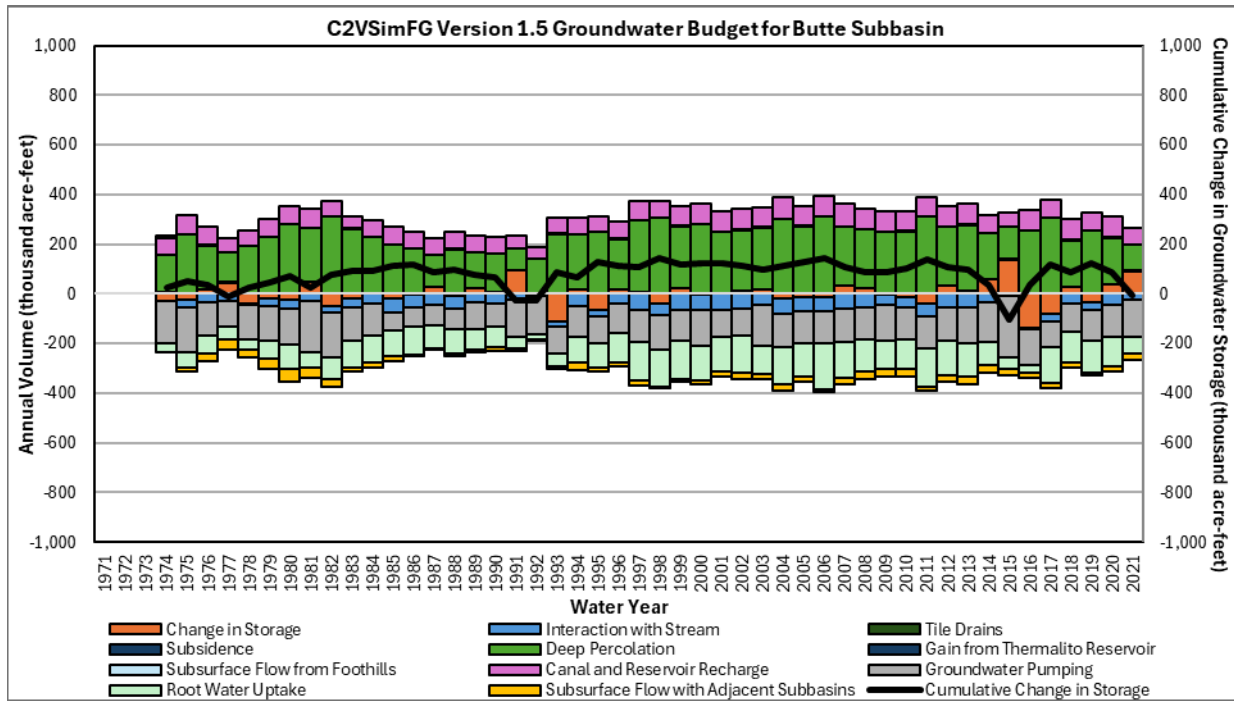


Figure 3. C2VSimFG Version 1.5 Groundwater Budget for Butte Subbasin

Butte Subbasin Groundwater Budget, BBGM Version 1.3 (Thousand Acre-Feet)

Water Year	Deep Percolation	Canal and Reservoir Recharge	Gain from Streams	Groundwater Pumping	Inflow from Thermalito Reservoir	Subsurface Inflow from Adjacent Subbasins	Subsurface Inflow from Outside BBGM	Inflow From Groundwater Storage
1971	237	74	-469	-145	0	123	223	-42
1972	199	77	-503	-118	0	88	239	19
1973	388	78	-559	-95	0	88	200	-100
1974	341	80	-516	-82	0	91	125	-38
1975	270	79	-500	-89	0	77	126	38
1976	185	80	-399	-112	0	51	102	92
1977	177	58	-302	-197	0	28	95	141
1978	343	73	-354	-96	0	50	107	-122
1979	246	80	-392	-102	0	45	119	5
1980	303	76	-429	-114	0	55	139	-31
1981	230	82	-414	-119	0	52	143	27
1982	310	72	-460	-108	0	78	165	-58
1983	331	61	-517	-119	0	108	178	-43
1984	292	78	-569	-121	0	98	206	16
1985	234	79	-496	-124	0	73	185	50
1986	287	73	-470	-120	0	80	170	-20
1987	202	74	-454	-135	0	64	184	66
1988	240	76	-444	-132	0	55	191	14
1989	240	76	-438	-108	0	49	188	-7
1990	200	76	-411	-117	0	41	182	30
1991	215	62	-378	-185	0	37	167	81
1992	237	62	-345	-215	0	50	166	45
1993	303	73	-392	-111	0	65	174	-113
1994	229	79	-389	-181	0	44	167	51
1995	388	76	-414	-150	0	83	156	-138
1996	305	84	-495	-151	0	78	191	-13
1997	286	94	-447	-172	0	67	157	14
1998	394	61	-484	-144	0	95	146	-69
1999	274	78	-495	-172	0	90	182	43
2000	302	72	-483	-141	0	63	165	22
2001	258	69	-454	-136	0	55	163	45
2002	297	72	-458	-132	0	53	171	-3
2003	286	66	-433	-143	0	61	166	-3
2004	299	73	-457	-157	0	58	176	7
2005	307	65	-472	-132	0	68	180	-15
2006	363	68	-495	-137	0	82	183	-64
2007	220	75	-454	-171	0	56	186	89
2008	252	71	-415	-165	0	38	178	41
2009	232	70	-369	-141	0	24	158	26
2010	285	65	-392	-131	0	32	164	-22
2011	346	66	-456	-104	0	52	175	-79
2012	244	67	-446	-138	0	39	183	50
2013	236	71	-409	-150	0	32	180	40
2014	200	62	-336	-166	0	15	154	70
2015	216	47	-267	-242	0	31	133	83
2016	255	59	-258	-148	0	22	119	-50
2017	318	63	-291	-108	0	38	79	-99
2018	209	63	-322	-137	0	39	116	31
2019	303	64	-361	-151	0	61	139	-55
2020	192	68	-364	-170	0	58	172	44
2021	162	60	-309	-211	0	36	172	90
2022	208	54	-270	-275	0	52	178	53
2023	298	62	-353	-173	0	56	221	-112
2024	244	64	-367	-172	0	53	198	-20

Butte Subbasin Groundwater Budget, BBGM Version 1.0 (Thousand Acre-Feet)

Water Year	Deep Percolation	Canal and Reservoir Recharge	Gain from Streams	Groundwater Pumping	Inflow from Thermalito Reservoir	Subsurface Inflow from Adjacent Subbasins	Subsurface Inflow from Outside BBGM	Inflow From Groundwater Storage
1971	234	234	-551	-144	27	-108	329	-21
1972	193	193	-698	-117	27	-82	463	21
1973	385	385	-632	-95	27	-272	299	-97
1974	337	337	-522	-83	27	-213	167	-50
1975	268	268	-675	-89	27	-155	331	26
1976	185	185	-696	-112	27	-91	421	82
1977	172	172	-581	-195	27	-119	388	137
1978	340	340	-481	-93	27	-257	236	-110
1979	244	244	-635	-100	27	-161	377	4
1980	301	301	-592	-111	27	-218	312	-20
1981	231	231	-626	-117	27	-143	372	24
1982	306	306	-495	-108	27	-211	215	-40
1983	327	327	-498	-116	27	-217	182	-31
1984	289	289	-840	-120	27	-172	514	12
1985	235	235	-710	-123	27	-139	429	47
1986	286	286	-516	-120	27	-189	244	-16
1987	201	201	-690	-134	27	-117	452	60
1988	235	235	-686	-130	27	-157	460	17
1989	235	235	-657	-106	27	-163	435	-7
1990	196	196	-618	-117	27	-133	416	31
1991	214	214	-507	-184	27	-165	323	78
1992	233	233	-481	-214	27	-173	327	47
1993	298	298	-447	-108	27	-214	251	-105
1994	226	226	-534	-177	27	-155	342	45
1995	384	384	-355	-149	27	-283	116	-124
1996	300	300	-576	-146	27	-200	305	-11
1997	282	282	-412	-168	27	-180	159	11
1998	392	392	-326	-143	27	-297	16	-61
1999	270	270	-467	-172	27	-164	196	39
2000	297	297	-549	-138	27	-219	269	16
2001	257	257	-621	-135	27	-189	364	39
2002	294	294	-593	-130	27	-224	336	-4
2003	282	282	-426	-141	27	-213	186	3
2004	297	297	-503	-153	27	-227	255	7
2005	305	305	-571	-132	27	-229	310	-15
2006	359	359	-390	-135	27	-272	108	-56
2007	217	217	-607	-171	27	-144	380	81
2008	249	249	-559	-164	27	-195	353	41
2009	228	228	-495	-139	27	-183	315	20
2010	282	282	-600	-127	27	-237	392	-19
2011	344	344	-640	-102	27	-282	381	-71
2012	242	242	-797	-139	27	-188	569	45
2013	234	234	-465	-147	27	-186	258	47
2014	199	199	-488	-165	27	-172	333	67
2015	214	214	-281	-236	27	-191	167	85
2016	253	253	-157	-147	27	-223	40	-46
2017	314	314	-98	-107	27	-265	-90	-95
2018	198	198	-388	-125	27	-152	208	34

Butte Subbasin Groundwater Budget, C2VSimFG Version 1.5 (Thousand Acre-Feet)

Water Year	Deep Percolation	Canal and Reservoir Recharge	Gain from Streams	Groundwater Pumping	Root Water Uptake	Subsurface Inflow from Adjacent Subbasins	Subsurface Inflow from Outside BBGM	Inflow From Groundwater Storage
1973	0	0	0	0	0	0	0	0
1974	176	7	220	-226	-8	0	4	-174
1975	109	8	129	-244	-3	6	2	-6
1976	63	7	54	-250	0	30	0	96
1977	41	7	21	-265	0	59	0	138
1978	108	7	194	-239	-3	0	5	-73
1979	89	8	118	-258	-1	10	3	31
1980	119	8	146	-230	-3	-9	4	-34
1981	82	8	92	-283	0	20	2	80
1982	161	7	225	-225	-9	-37	6	-128
1983	186	7	197	-192	-14	-66	7	-125
1984	124	8	101	-272	-5	-28	3	68
1985	93	8	75	-220	-1	2	2	42
1986	112	7	121	-198	-4	-7	4	-36
1987	64	7	52	-224	0	21	2	79
1988	66	6	66	-115	0	22	2	-46
1989	64	8	103	-221	0	19	2	25
1990	66	8	76	-222	0	23	2	49
1991	61	7	79	-224	0	27	2	49
1992	68	7	89	-240	0	30	2	43
1993	95	9	176	-272	-3	9	4	-19
1994	57	9	78	-269	0	40	2	85
1995	131	8	225	-213	-7	-20	5	-129
1996	116	7	129	-188	-5	-11	5	-54
1997	107	9	110	-308	-3	6	3	74
1998	126	7	184	-224	-7	-10	6	-82
1999	113	8	107	-259	-4	2	3	30
2000	89	9	116	-314	-2	31	3	69
2001	83	8	82	-297	0	45	3	76
2002	96	8	119	-307	0	45	3	36
2003	113	9	147	-284	-1	30	3	-16
2004	109	9	116	-308	-1	37	3	35
2005	135	8	134	-258	-1	29	5	-52
2006	152	9	169	-294	-7	-1	5	-32
2007	96	9	66	-181	0	39	3	-31
2008	75	8	71	-185	0	34	3	-5
2009	71	8	87	-160	0	31	3	-39
2010	78	8	104	-160	-1	22	4	-55
2011	145	8	135	-116	-5	-12	5	-161
2012	96	9	34	-107	-1	8	3	-42
2013	81	8	44	-119	0	7	3	-24
2014	57	7	16	-128	0	17	3	29
2015	54	7	40	-117	0	10	3	3
2016	65	9	85	-116	-1	-2	4	-44
2017	108	8	141	-115	-9	-43	7	-98
2018	65	9	29	-127	-1	-8	4	29
2019	67	8	110	-128	-5	-28	5	-29
2020	42	9	13	-144	-1	1	3	75
2021	34	9	21	-145	0	10	2	70

Vina Subbasin

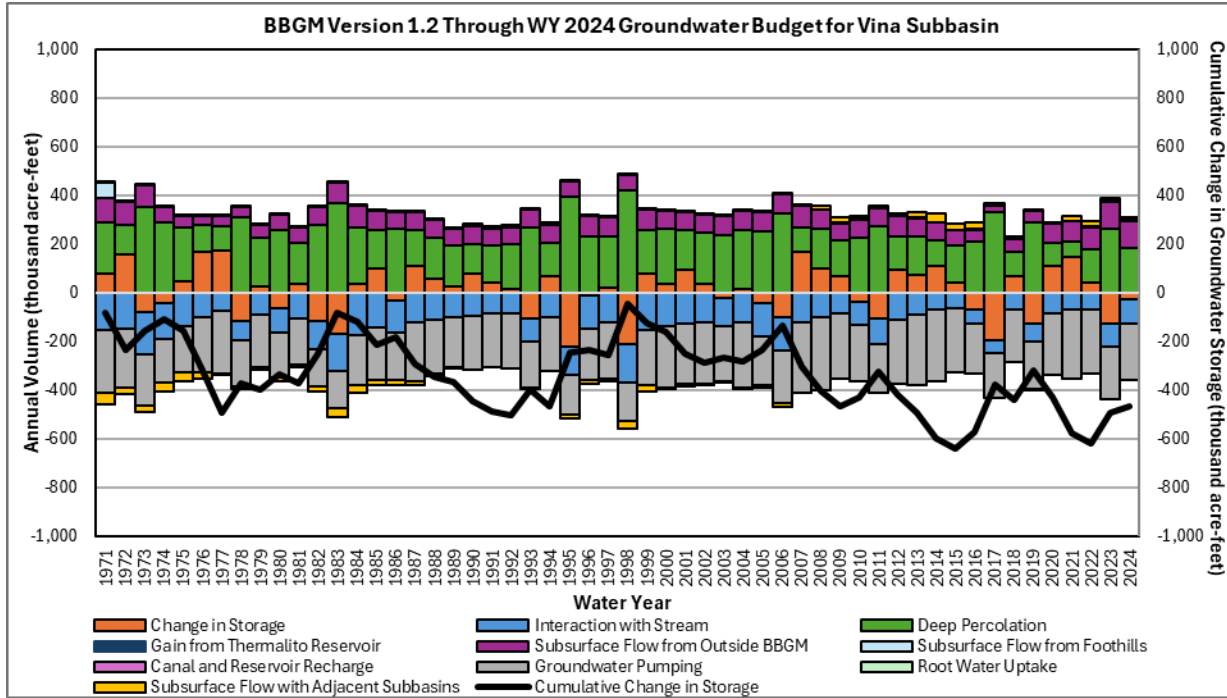


Figure 4. BBGM Version 1.3 (aka Version 1.2 through 2024) Groundwater Budget for Vina Subbasin

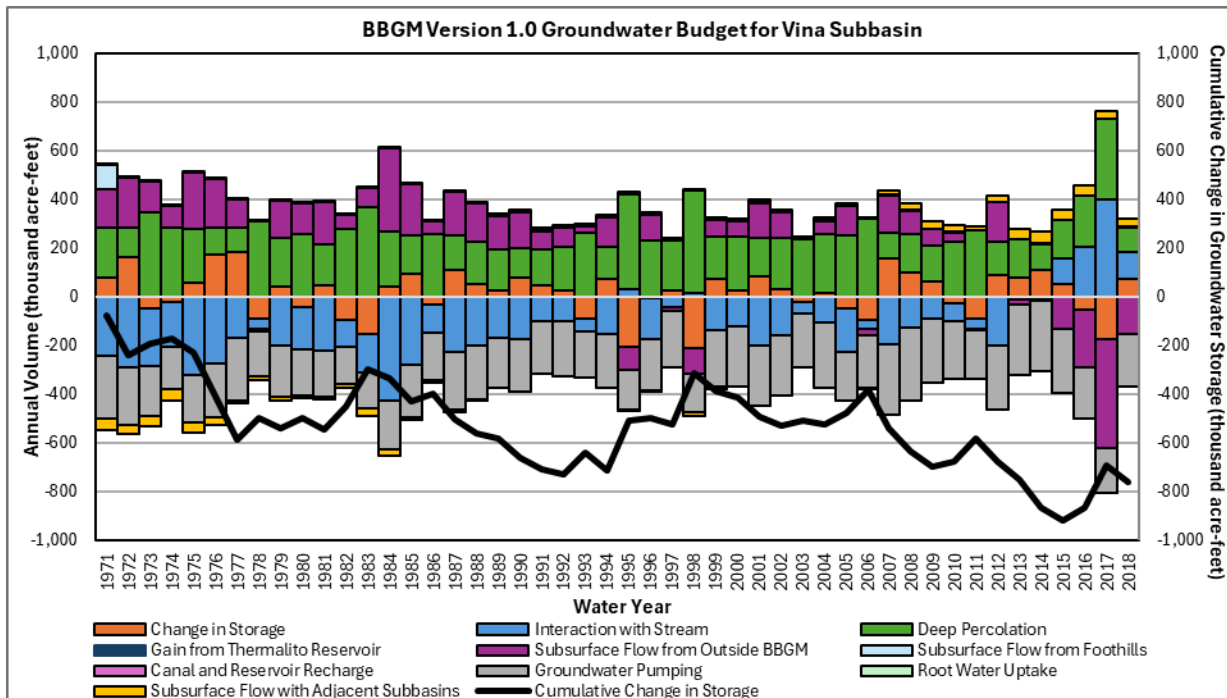


Figure 5. BBGM Version 1.0 Groundwater Budget for Vina Subbasin

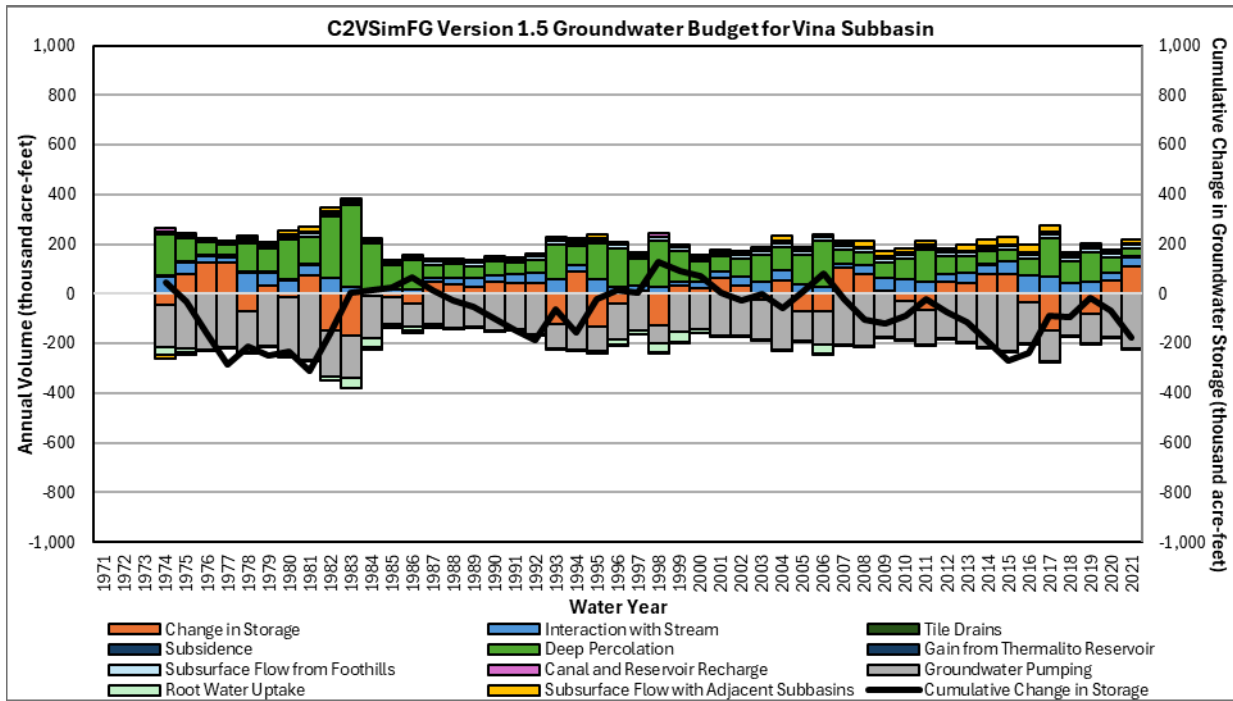


Figure 6. C2VSimFG Version 1.5 Groundwater Budget for Vina Subbasin

Vina Subbasin Groundwater Budget, BBGM Version 1.3 (Thousand Acre-Feet)

Water Year	Deep Percolation	Canal and Reservoir Recharge	Gain from Streams	Groundwater Pumping	Inflow from Thermalito Reservoir	Subsurface Inflow from Adjacent Subbasins	Subsurface Inflow from Outside BBGM	Inflow From Groundwater Storage
1971	210	4	-154	-257	0	21	97	80
1972	119	3	-150	-242	0	18	94	157
1973	350	4	-170	-211	0	19	90	-82
1974	289	5	-147	-178	0	14	61	-44
1975	222	4	-137	-192	0	8	50	44
1976	112	3	-101	-227	0	9	40	165
1977	104	2	-75	-255	0	16	38	170
1978	311	4	-81	-184	0	25	43	-117
1979	200	4	-91	-213	0	22	52	25
1980	258	4	-100	-186	0	25	62	-63
1981	168	4	-103	-192	0	24	65	35
1982	280	4	-114	-152	0	27	73	-119
1983	370	4	-153	-150	0	19	79	-170
1984	233	4	-176	-204	0	21	89	34
1985	160	3	-144	-215	0	22	77	97
1986	260	4	-132	-193	0	25	69	-33
1987	147	3	-122	-241	0	27	75	110
1988	173	3	-113	-221	0	30	72	55
1989	169	4	-100	-203	0	35	71	23
1990	124	3	-94	-220	0	38	72	77
1991	149	4	-86	-218	0	38	70	43
1992	185	3	-86	-226	0	39	70	14
1993	265	4	-95	-188	0	42	76	-104
1994	133	4	-101	-221	0	39	76	68
1995	391	6	-111	-166	0	40	65	-224
1996	232	6	-137	-211	0	37	82	-9
1997	210	5	-124	-229	0	40	75	23
1998	422	6	-154	-159	0	35	63	-212
1999	177	7	-152	-228	0	34	82	80
2000	225	3	-138	-249	0	48	76	35
2001	163	3	-128	-247	0	42	75	92
2002	209	3	-120	-251	0	47	76	37
2003	236	3	-114	-226	0	45	77	-21
2004	241	3	-122	-268	0	52	81	13
2005	253	3	-134	-199	0	42	79	-45
2006	323	3	-135	-217	0	47	80	-101
2007	104	3	-120	-290	0	52	86	166
2008	160	3	-103	-298	0	59	79	100
2009	146	3	-87	-265	0	64	72	67
2010	227	3	-94	-234	0	63	73	-39
2011	272	4	-107	-198	0	58	75	-104
2012	135	3	-110	-264	0	59	84	94
2013	159	3	-89	-289	0	69	76	70
2014	108	2	-67	-295	0	73	70	109
2015	156	1	-63	-262	0	67	62	40
2016	211	3	-57	-206	0	71	48	-70
2017	328	4	-53	-186	0	72	27	-193
2018	103	3	-68	-216	0	62	49	66
2019	289	4	-78	-195	0	55	49	-125
2020	94	3	-87	-250	0	52	77	111
2021	62	2	-71	-280	0	58	80	148
2022	138	2	-67	-265	0	62	88	42
2023	260	4	-95	-218	0	62	113	-126
2024	185	3	-99	-232	0	61	109	-27

Vina Subbasin Groundwater Budget, BBGM Version 1.0 (Thousand Acre-Feet)

Water Year	Deep Percolation	Canal and Reservoir Recharge	Gain from Streams	Groundwater Pumping	Inflow from Thermalito Reservoir	Subsurface Inflow from Adjacent Subbasins	Subsurface Inflow from Outside BBGM	Inflow From Groundwater Storage
1971	207	207	-244	-255	0	-150	156	77
1972	118	118	-288	-241	0	-78	207	164
1973	347	347	-233	-210	0	-328	125	-49
1974	285	285	-188	-174	0	-276	86	-19
1975	220	220	-323	-191	0	-214	230	59
1976	107	107	-275	-222	0	-95	203	174
1977	101	101	-171	-253	0	-77	118	182
1978	308	308	-42	-183	0	-290	-12	-89
1979	197	197	-200	-210	0	-180	153	42
1980	256	256	-173	-185	0	-237	129	-44
1981	166	166	-219	-192	0	-144	175	47
1982	278	278	-112	-150	0	-259	59	-95
1983	367	367	-161	-147	0	-356	81	-151
1984	229	229	-425	-203	0	-209	339	39
1985	158	158	-278	-214	0	-126	211	91
1986	258	258	-119	-192	0	-227	53	-31
1987	145	145	-226	-240	0	-109	175	108
1988	170	170	-202	-219	0	-132	158	54
1989	167	167	-170	-201	0	-125	139	24
1990	122	122	-173	-219	0	-77	147	77
1991	146	146	-99	-215	0	-99	73	47
1992	184	184	-103	-225	0	-139	76	23
1993	262	262	-53	-187	0	-219	25	-91
1994	132	132	-155	-219	0	-82	120	73
1995	388	388	33	-166	0	-346	-93	-205
1996	230	230	-169	-210	0	-182	107	-7
1997	209	209	-43	-229	0	-153	-16	24
1998	420	420	14	-158	0	-377	-110	-208
1999	175	175	-140	-227	0	-125	71	71
2000	222	222	-124	-247	0	-161	60	27
2001	161	161	-199	-246	0	-100	142	82
2002	207	207	-156	-250	0	-148	107	33
2003	234	234	-48	-224	0	-178	3	-19
2004	239	239	-105	-268	0	-177	56	15
2005	252	252	-179	-199	0	-199	119	-46
2006	320	320	-34	-215	0	-267	-28	-97
2007	102	102	-195	-289	0	-34	156	158
2008	158	158	-129	-298	0	-84	98	97
2009	144	144	-90	-264	0	-66	68	64
2010	225	225	-77	-233	0	-153	39	-26
2011	270	270	-44	-197	0	-205	-4	-90
2012	133	133	-200	-262	0	-58	164	90
2013	157	157	-11	-288	0	-72	-20	78
2014	106	106	-4	-294	0	-16	-10	111
2015	154	154	106	-261	0	-72	-133	53
2016	209	209	204	-205	0	-124	-241	-52
2017	326	326	401	-185	0	-247	-448	-173
2018	98	98	114	-212	0	-16	-155	72

Vina Subbasin Groundwater Budget, C2VSimFG Version 1.5 (Thousand Acre-Feet)

Water Year	Deep Percolation	Canal and Reservoir Recharge	Gain from Streams	Groundwater Pumping	Root Water Uptake	Subsurface Inflow from Adjacent Subbasins	Subsurface Inflow from Outside BBGM	Inflow From Groundwater Storage
1973	0	0	0	0	0	0	0	0
1974	248	75	99	-354	-48	-9	1	-13
1975	261	81	23	-376	-32	4	1	38
1976	220	85	8	-353	-13	9	0	44
1977	187	66	-1	-376	-8	25	0	107
1978	338	72	54	-321	-30	-2	2	-113
1979	252	76	31	-375	-17	7	1	25
1980	367	78	17	-381	-35	5	1	-51
1981	279	79	32	-434	-16	6	1	53
1982	441	74	23	-364	-56	5	2	-125
1983	388	57	28	-353	-80	0	3	-43
1984	281	73	-3	-397	-33	7	2	70
1985	240	74	3	-337	-20	13	1	28
1986	308	69	22	-320	-40	7	2	-48
1987	155	72	1	-256	-21	0	0	49
1988	191	73	23	-281	-19	2	1	10
1989	184	71	48	-283	-18	-2	1	0
1990	168	71	7	-261	-16	2	1	29
1991	135	55	4	-291	-11	13	1	94
1992	150	54	40	-314	-9	28	1	50
1993	285	66	88	-309	-27	27	2	-132
1994	213	69	21	-373	-15	19	1	66
1995	386	66	83	-302	-54	7	2	-188
1996	258	67	21	-360	-33	9	2	37
1997	377	75	36	-526	-27	27	2	36
1998	379	63	100	-413	-56	10	3	-86
1999	363	77	12	-474	-30	12	1	38
2000	371	80	45	-514	-28	16	1	29
2001	188	74	7	-298	-20	3	1	45
2002	218	77	28	-279	-25	5	2	-25
2003	309	72	56	-429	-28	5	2	14
2004	275	89	55	-454	-33	10	2	55
2005	276	79	48	-329	-25	4	2	-55
2006	388	79	63	-390	-62	10	3	-91
2007	178	87	23	-414	-20	7	1	138
2008	228	83	19	-341	-19	6	2	23
2009	225	81	54	-394	-16	13	2	35
2010	298	80	73	-383	-23	0	2	-47
2011	355	79	31	-326	-36	6	3	-111
2012	233	79	19	-397	-22	6	2	81
2013	261	79	37	-405	-18	16	2	28
2014	176	63	45	-401	-14	12	2	117
2015	179	52	69	-362	-10	14	2	55
2016	232	87	108	-362	-18	2	2	-52
2017	326	81	58	-213	-51	8	3	-212
2018	159	87	27	-375	-20	5	2	115
2019	270	83	63	-303	-36	4	3	-84
2020	165	88	24	-400	-16	9	2	128
2021	151	73	57	-347	-9	2	2	72

Wyandotte Creek Subbasin

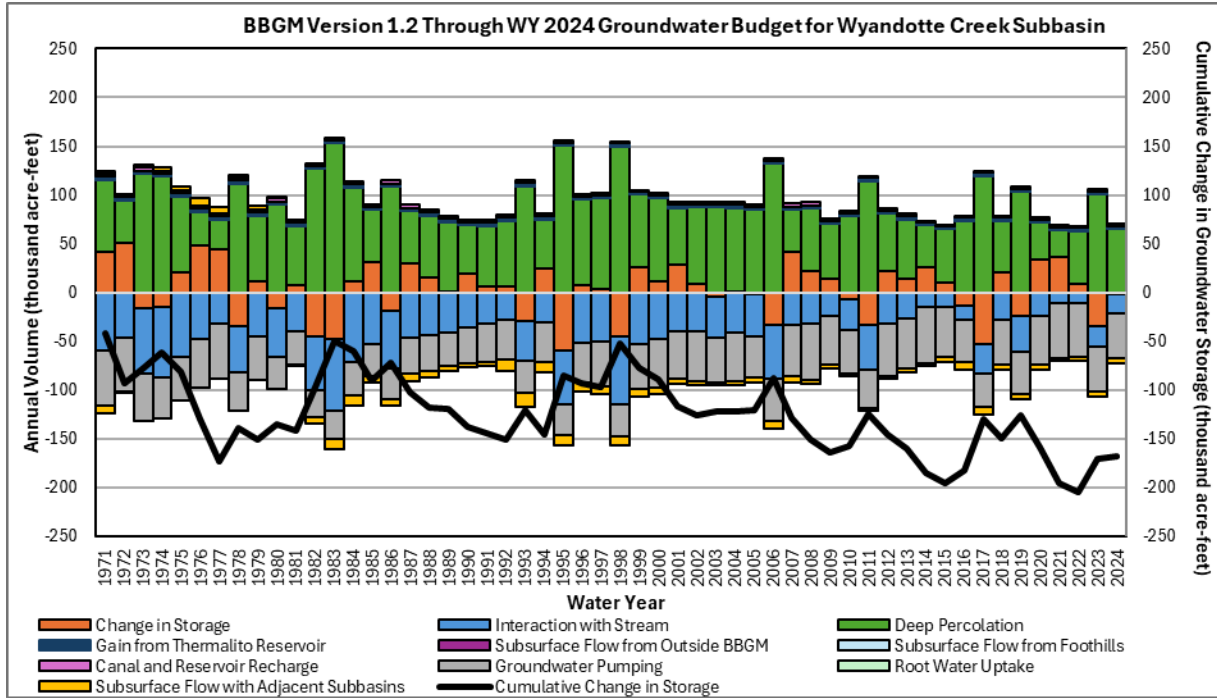


Figure 7. BBGM Version 1.3 (aka Version 1.2 through 2024) Groundwater Budget for Wyandotte Creek Subbasin

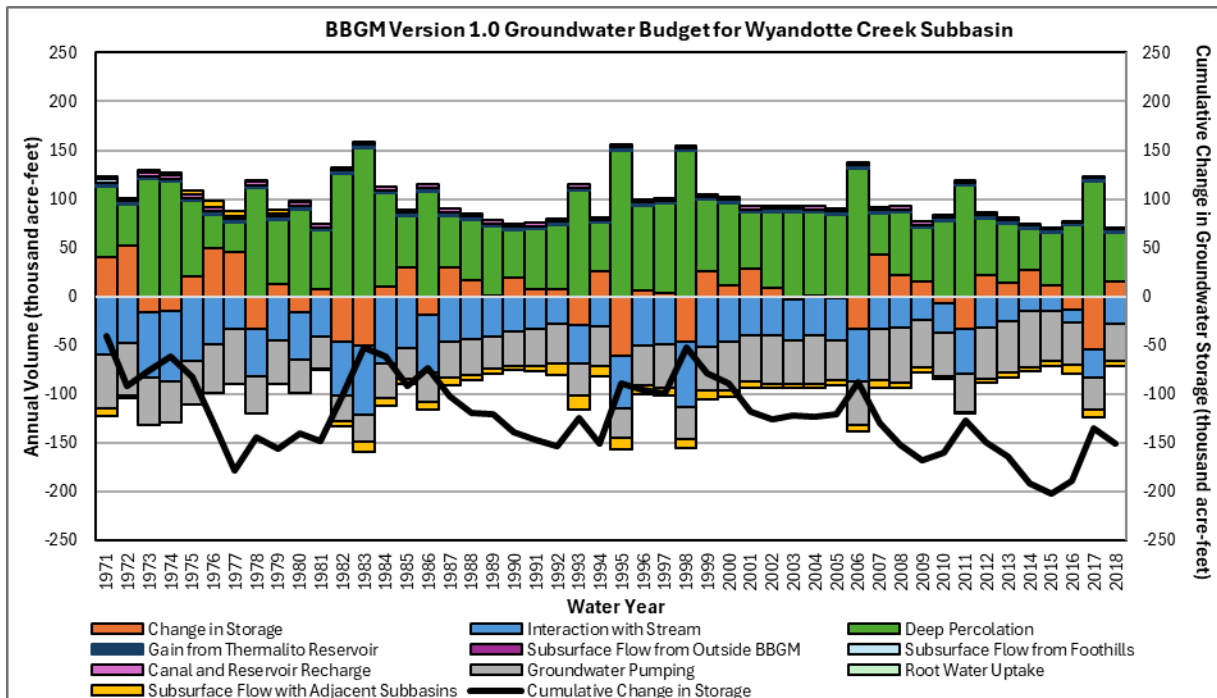


Figure 8. BBGM Version 1.0 Groundwater Budget for Wyandotte Creek Subbasin

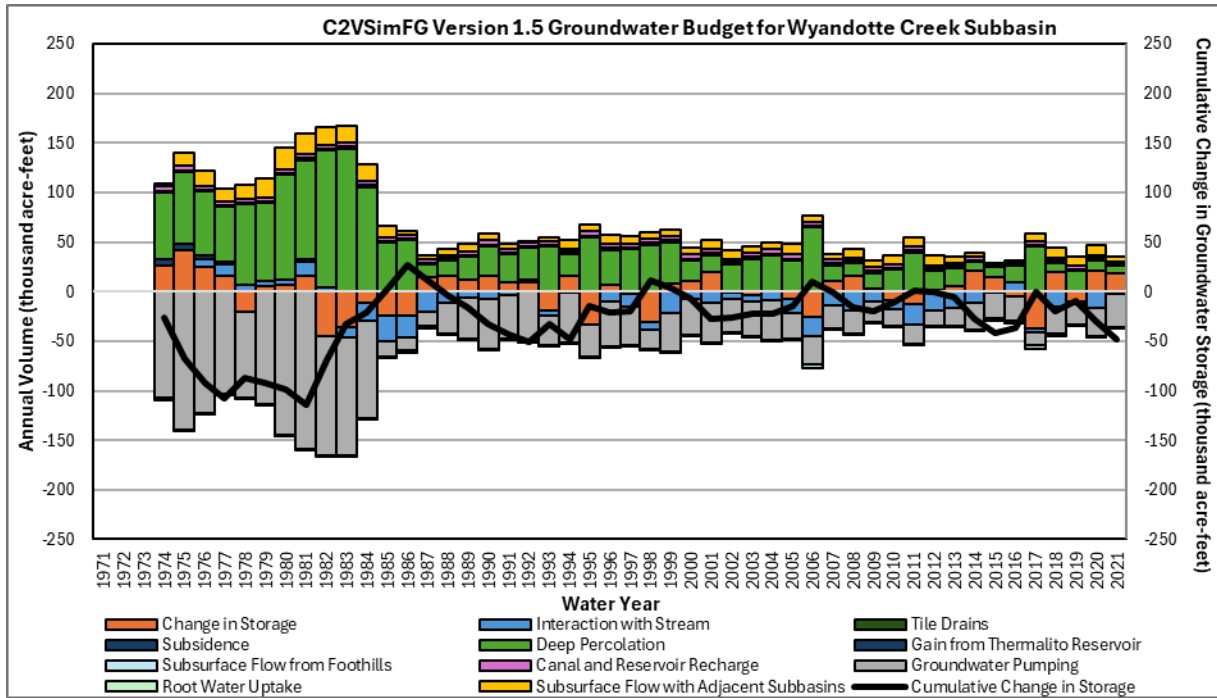


Figure 9. C2VSimFG Version 1.5 Groundwater Budget for Wyandotte Creek Subbasin

Wyandotte Creek Subbasin Groundwater Budget, BBGM Version 1.3 (Thousand Acre-Feet)

Water Year	Deep Percolation	Canal and Reservoir Recharge	Gain from Streams	Groundwater Pumping	Inflow from Thermalito Reservoir	Subsurface Inflow from Adjacent Subbasins	Subsurface Inflow from Outside BBGM	Inflow From Groundwater Storage
1971	73	3	-60	-56	0	-2	0	42
1972	44	3	-47	-55	0	4	0	51
1973	121	3	-67	-49	0	8	0	-16
1974	119	3	-72	-43	0	8	0	-15
1975	78	3	-66	-45	0	9	0	20
1976	35	3	-47	-51	0	12	0	48
1977	31	3	-32	-57	0	11	0	44
1978	112	3	-48	-40	0	7	0	-34
1979	67	3	-45	-45	0	8	0	11
1980	90	3	-50	-34	0	7	0	-16
1981	61	3	-40	-34	0	3	0	7
1982	127	3	-56	-28	0	-2	0	-45
1983	153	3	-74	-29	0	-5	0	-48
1984	96	3	-71	-35	0	-5	0	11
1985	54	3	-54	-32	0	-1	0	30
1986	108	3	-60	-31	0	-2	0	-19
1987	53	3	-46	-37	0	-3	0	30
1988	63	3	-44	-37	0	-1	0	16
1989	71	3	-41	-34	0	-1	0	1
1990	49	3	-36	-37	0	1	0	19
1991	62	3	-33	-38	0	0	0	6
1992	67	3	-28	-42	0	-7	0	6
1993	109	3	-40	-33	0	-9	0	-30
1994	50	2	-30	-42	0	-5	0	25
1995	151	2	-55	-31	0	-6	0	-60
1996	88	2	-51	-41	0	-5	0	7
1997	93	2	-50	-46	0	-3	0	4
1998	150	2	-70	-33	0	-3	0	-45
1999	74	2	-54	-45	0	-4	0	26
2000	86	2	-48	-50	0	-1	0	11
2001	58	3	-40	-49	0	0	0	28
2002	79	3	-40	-51	0	1	0	8
2003	88	2	-42	-46	0	2	0	-4
2004	86	3	-41	-50	0	1	0	0
2005	85	2	-44	-41	0	0	0	-2
2006	132	3	-55	-44	0	-2	0	-33
2007	43	3	-33	-53	0	-1	0	42
2008	65	3	-32	-58	0	1	0	22
2009	56	3	-24	-50	0	1	0	14
2010	78	2	-31	-45	0	3	0	-8
2011	114	2	-47	-39	0	3	0	-33
2012	59	3	-32	-53	0	2	0	22
2013	61	3	-27	-52	0	1	0	13
2014	43	1	-15	-57	0	2	0	26
2015	55	1	-15	-51	0	0	0	10
2016	73	1	-15	-43	0	-3	0	-13
2017	119	1	-30	-34	0	-3	0	-53
2018	53	1	-28	-46	0	-1	0	20
2019	103	2	-37	-42	0	-1	0	-25
2020	38	3	-25	-50	0	0	0	34
2021	27	2	-11	-56	0	2	0	36
2022	54	2	-11	-55	0	1	0	9
2023	100	2	-22	-45	0	-1	0	-34
2024	65	2	-20	-46	0	0	0	-2

Wyandotte Creek Subbasin Groundwater Budget, BBGM Version 1.0 (Thousand Acre-Feet)

Water Year	Deep Percolation	Canal and Reservoir Recharge	Gain from Streams	Groundwater Pumping	Inflow from Thermalito Reservoir	Subsurface Inflow from Adjacent Subbasins	Subsurface Inflow from Outside BBGM	Inflow From Groundwater Storage
1971	73	73	-59	-56	3	-74	0	40
1972	43	43	-48	-54	3	-39	0	52
1973	120	120	-68	-48	3	-112	0	-16
1974	118	118	-72	-42	3	-110	0	-15
1975	77	77	-66	-44	3	-68	0	21
1976	34	34	-49	-50	3	-22	0	50
1977	30	30	-34	-56	3	-20	0	46
1978	111	111	-48	-39	3	-104	0	-33
1979	66	66	-45	-45	3	-58	0	12
1980	89	89	-49	-34	3	-83	0	-16
1981	60	60	-41	-33	3	-57	0	7
1982	126	126	-55	-27	3	-127	0	-46
1983	152	152	-72	-28	3	-158	0	-50
1984	96	96	-69	-34	3	-101	0	10
1985	53	53	-53	-32	3	-55	0	30
1986	108	108	-59	-31	3	-110	0	-19
1987	53	53	-46	-37	3	-55	0	30
1988	62	62	-44	-37	3	-63	0	16
1989	71	71	-41	-33	3	-72	0	1
1990	49	49	-35	-36	3	-49	0	19
1991	62	62	-33	-38	3	-63	0	7
1992	66	66	-28	-41	3	-74	0	7
1993	108	108	-40	-32	3	-118	0	-30
1994	49	49	-31	-41	3	-55	0	26
1995	150	150	-53	-31	3	-158	0	-61
1996	87	87	-50	-41	3	-93	0	6
1997	92	92	-49	-45	3	-96	0	3
1998	149	149	-68	-33	3	-155	0	-46
1999	74	74	-52	-45	3	-80	0	25
2000	85	85	-47	-50	3	-87	0	11
2001	58	58	-39	-48	3	-60	0	29
2002	78	78	-39	-50	3	-78	0	8
2003	87	87	-41	-46	3	-86	0	-3
2004	86	86	-40	-49	3	-85	0	0
2005	84	84	-43	-41	3	-86	0	-2
2006	131	131	-54	-44	3	-134	0	-33
2007	43	43	-33	-54	3	-45	0	42
2008	64	64	-31	-58	3	-64	0	23
2009	56	56	-24	-49	3	-56	0	15
2010	77	77	-30	-45	3	-76	0	-7
2011	113	113	-46	-39	3	-112	0	-33
2012	58	58	-32	-53	3	-57	0	22
2013	61	61	-26	-52	3	-61	0	14
2014	42	42	-15	-57	3	-43	0	28
2015	54	54	-15	-51	3	-57	0	11
2016	73	73	-14	-43	3	-78	0	-13
2017	118	118	-29	-34	3	-123	0	-54
2018	50	50	-28	-38	3	-54	0	15

Wyandotte Creek Subbasin Groundwater Budget, C2VSimFG Version 1.5 (Thousand Acre-Feet)

Water Year	Deep Percolation	Canal and Reservoir Recharge	Gain from Streams	Groundwater Pumping	Root Water Uptake	Subsurface Inflow from Adjacent Subbasins	Subsurface Inflow from Outside BBGM	Inflow From Groundwater Storage
1973	0	0	0	0	0	0	0	0
1974	210	49	643	-106	-74	-666	6	-64
1975	207	50	565	-107	-69	-668	4	17
1976	156	48	397	-116	-47	-479	0	41
1977	159	55	134	-105	-41	-268	0	67
1978	280	51	523	-89	-77	-595	8	-102
1979	235	55	447	-91	-69	-576	4	-4
1980	294	50	543	-82	-89	-668	6	-53
1981	202	56	411	-101	-67	-539	2	37
1982	344	46	674	-70	-114	-778	10	-111
1983	405	43	700	-56	-148	-839	10	-115
1984	269	53	552	-92	-119	-715	4	49
1985	227	54	425	-78	-94	-581	3	44
1986	283	46	507	-63	-107	-644	6	-27
1987	186	54	376	-73	-81	-525	2	61
1988	205	45	383	-68	-74	-513	3	20
1989	222	56	438	-60	-78	-560	2	-21
1990	207	53	346	-82	-76	-509	1	59
1991	154	47	265	-88	-52	-383	3	54
1992	205	56	268	-77	-60	-401	3	6
1993	288	53	575	-80	-91	-667	6	-85
1994	216	61	298	-157	-67	-459	2	106
1995	318	51	649	-65	-93	-743	6	-122
1996	311	44	583	-86	-105	-732	8	-22
1997	300	57	502	-65	-101	-659	5	-39
1998	296	40	657	-84	-118	-759	8	-39
1999	240	52	557	-90	-104	-697	4	39
2000	244	58	522	-85	-91	-684	4	31
2001	204	50	408	-96	-79	-556	3	68
2002	219	52	445	-101	-72	-584	4	36
2003	248	47	567	-142	-76	-650	5	1
2004	258	53	525	-107	-84	-647	5	-3
2005	268	42	535	-91	-82	-653	7	-26
2006	318	42	649	-90	-106	-764	9	-57
2007	235	55	420	-104	-81	-526	2	0
2008	198	53	355	-102	-76	-457	4	25
2009	177	45	422	-103	-67	-497	3	21
2010	222	43	529	-93	-81	-599	5	-27
2011	257	43	647	-84	-105	-724	6	-38
2012	174	49	476	-102	-74	-582	3	56
2013	186	50	449	-110	-67	-540	3	29
2014	131	53	241	-111	-44	-354	2	83
2015	171	45	265	-94	-46	-354	3	11
2016	200	56	401	-139	-55	-475	4	7
2017	263	43	723	-103	-96	-750	8	-88
2018	173	54	413	-135	-59	-530	2	81
2019	250	50	639	-133	-84	-692	7	-37
2020	160	57	342	-149	-55	-466	2	108
2021	134	54	260	-150	-37	-341	1	80

ATTACHMENT 4: STREAMFLOW CALIBRATION HYDROGRAPHS

Streamflow calibration hydrographs for 11 locations (shown on Figure 1) from BBGM v1.0, BBGM v1.2, and C2VSimFG v1.5 are displayed on Figures 2-12. Three figures are presented for each observation location: Simulated and observed streamflow, \log_{10} simulated versus \log_{10} observed streamflow, and BBGM v1.2 stream exceedance.

Simulated streamflow values for BBGM v1.0 and BBGM v1.2 generally track observed values within the BBGM model domain better than C2VSimFG 1.5. This reflects the more refined model components of the BBGM versions. The BBGM versions also reasonably replicate observed Sacramento River streamflow.

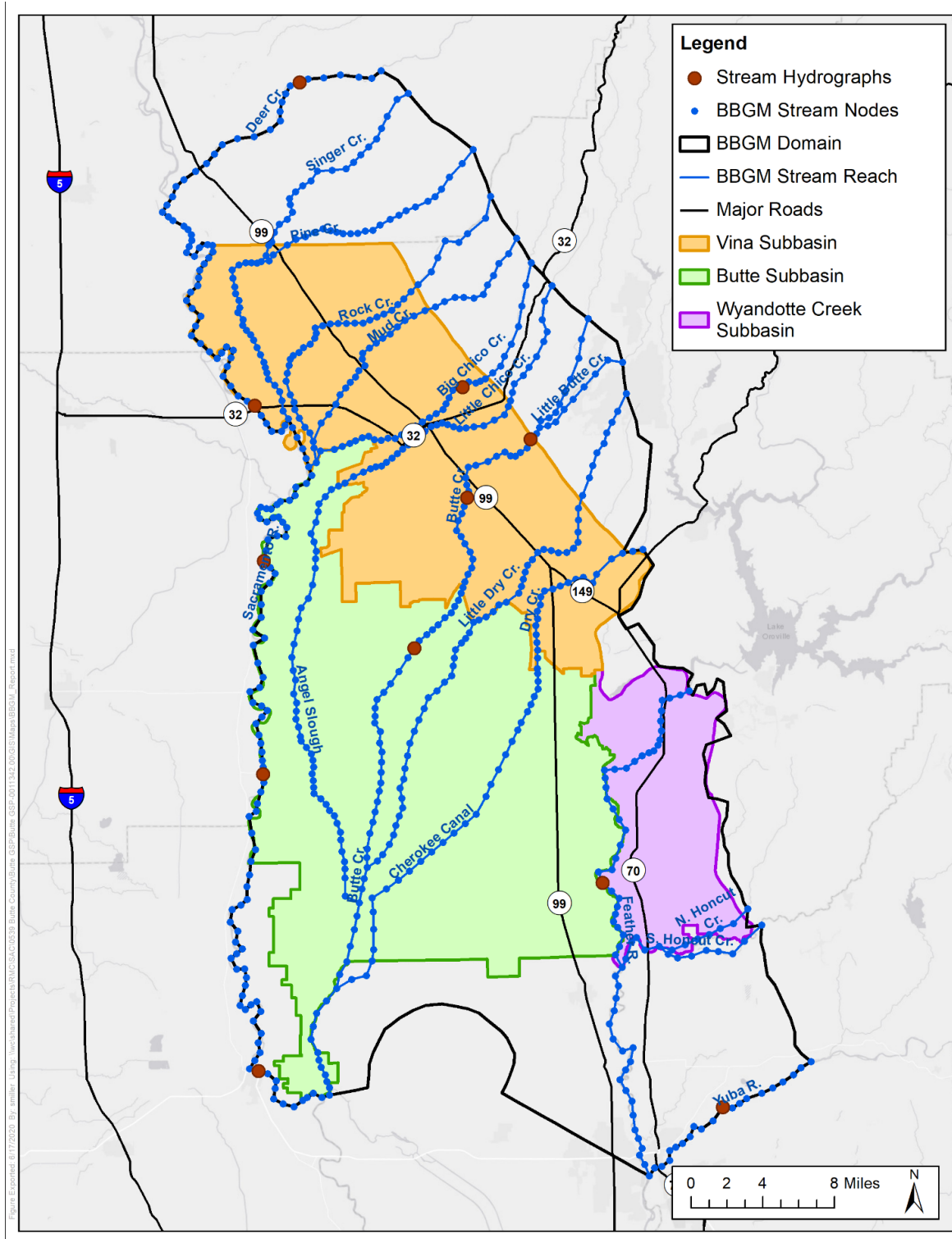


Figure 1. Calibration Stream Gage Locations

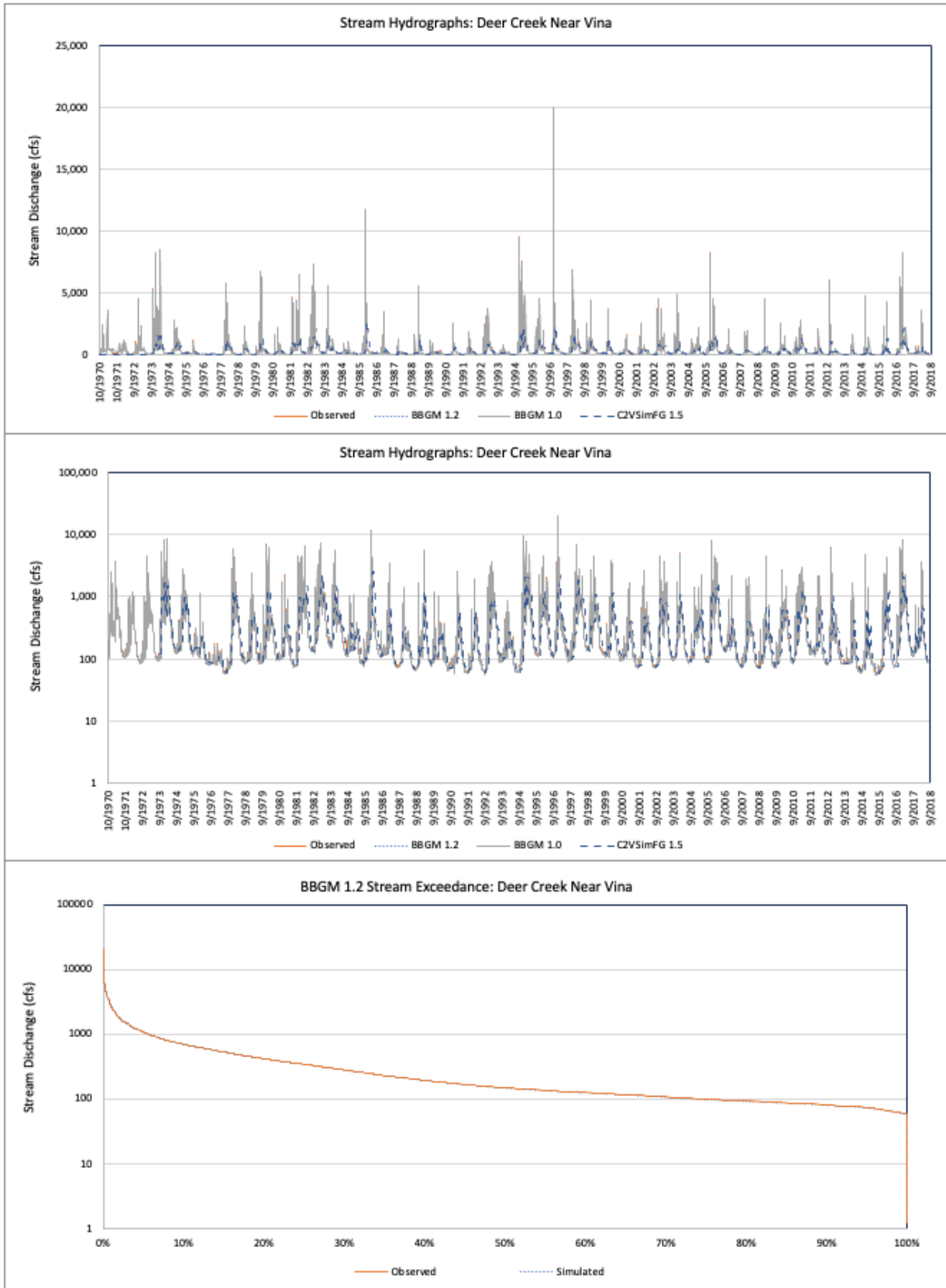


Figure 2. Deer Creek near Vina

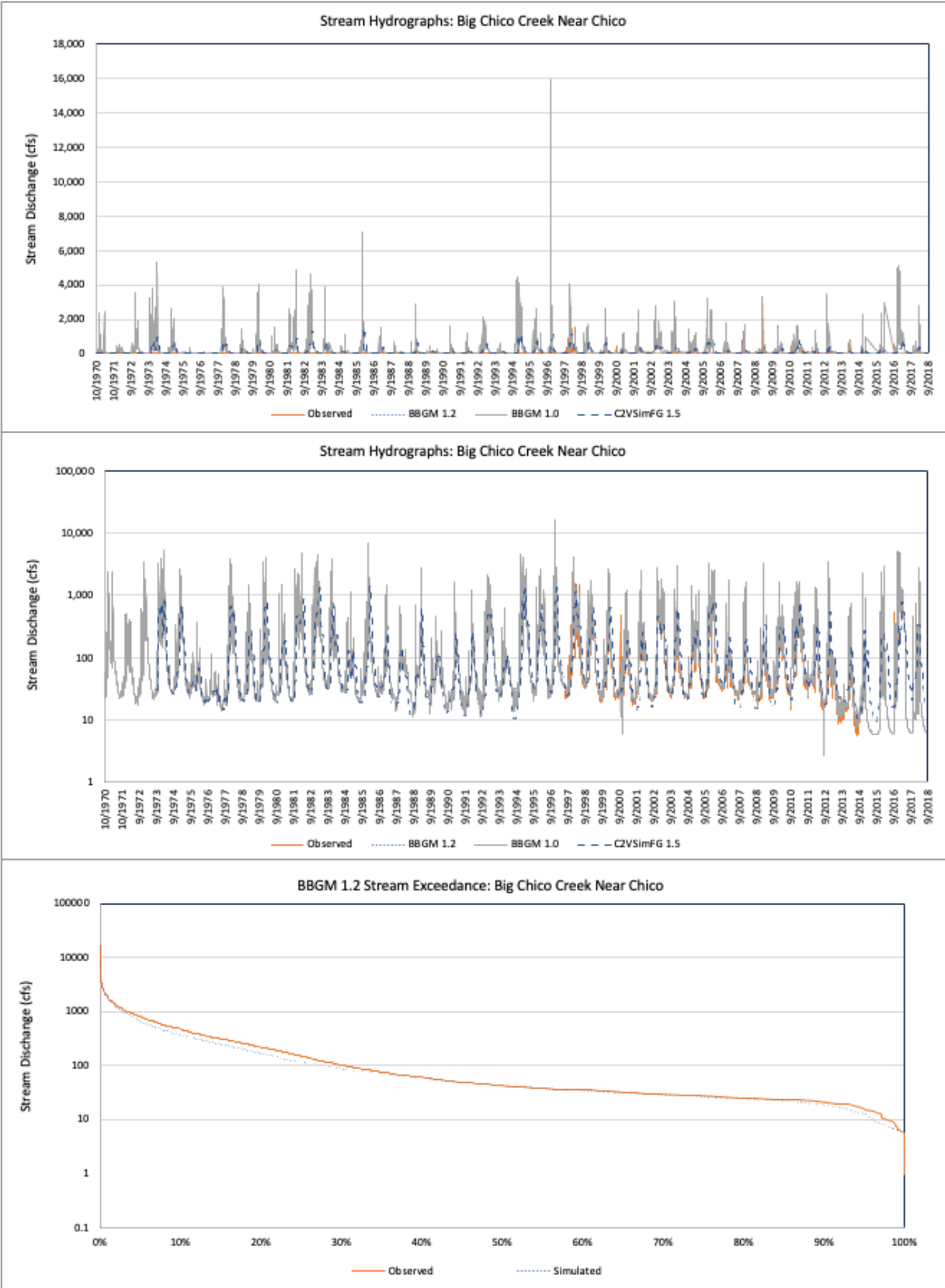


Figure 3. Big Chico Creek near Chico

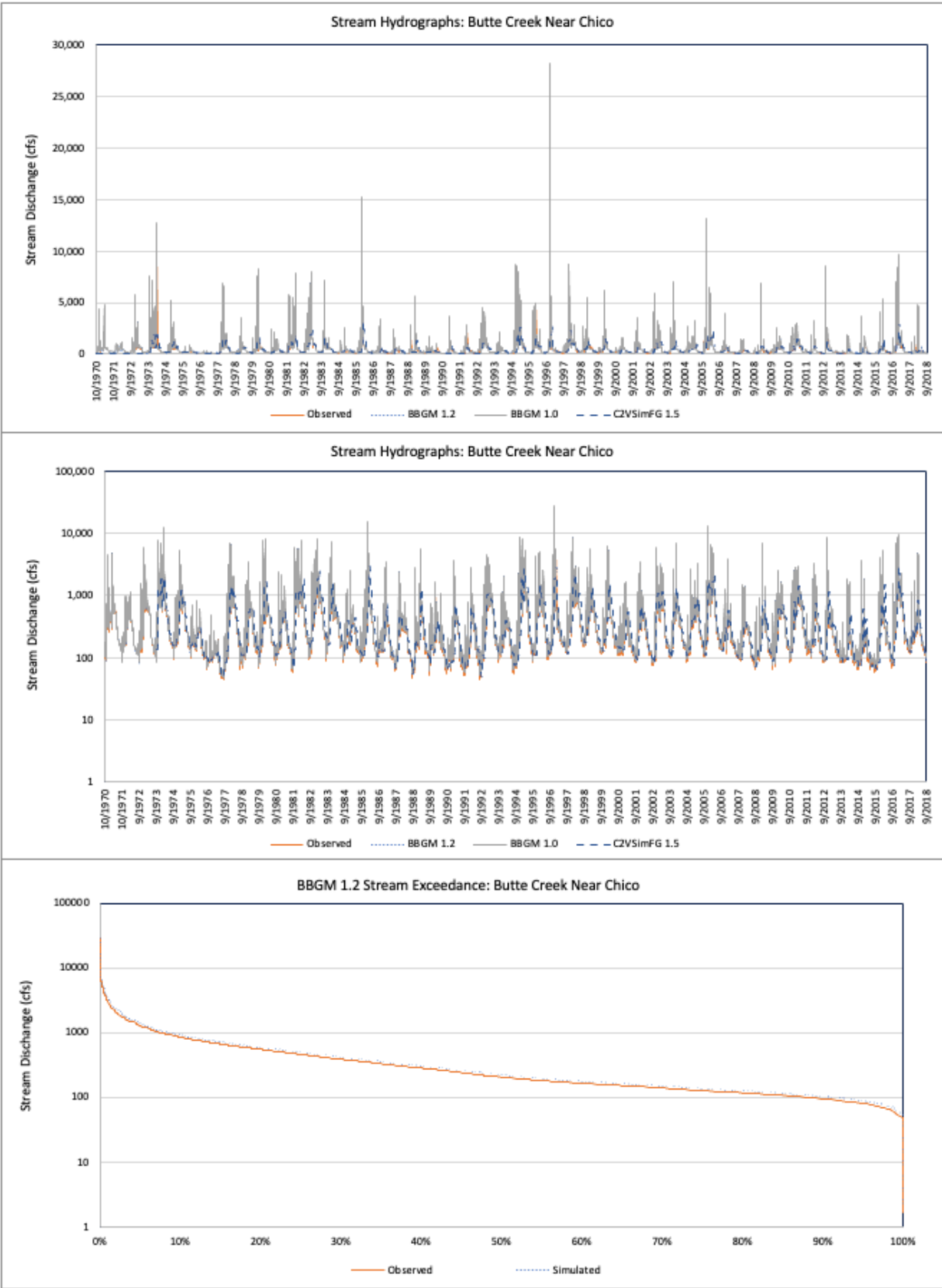


Figure 4. Butte Creek near Chico

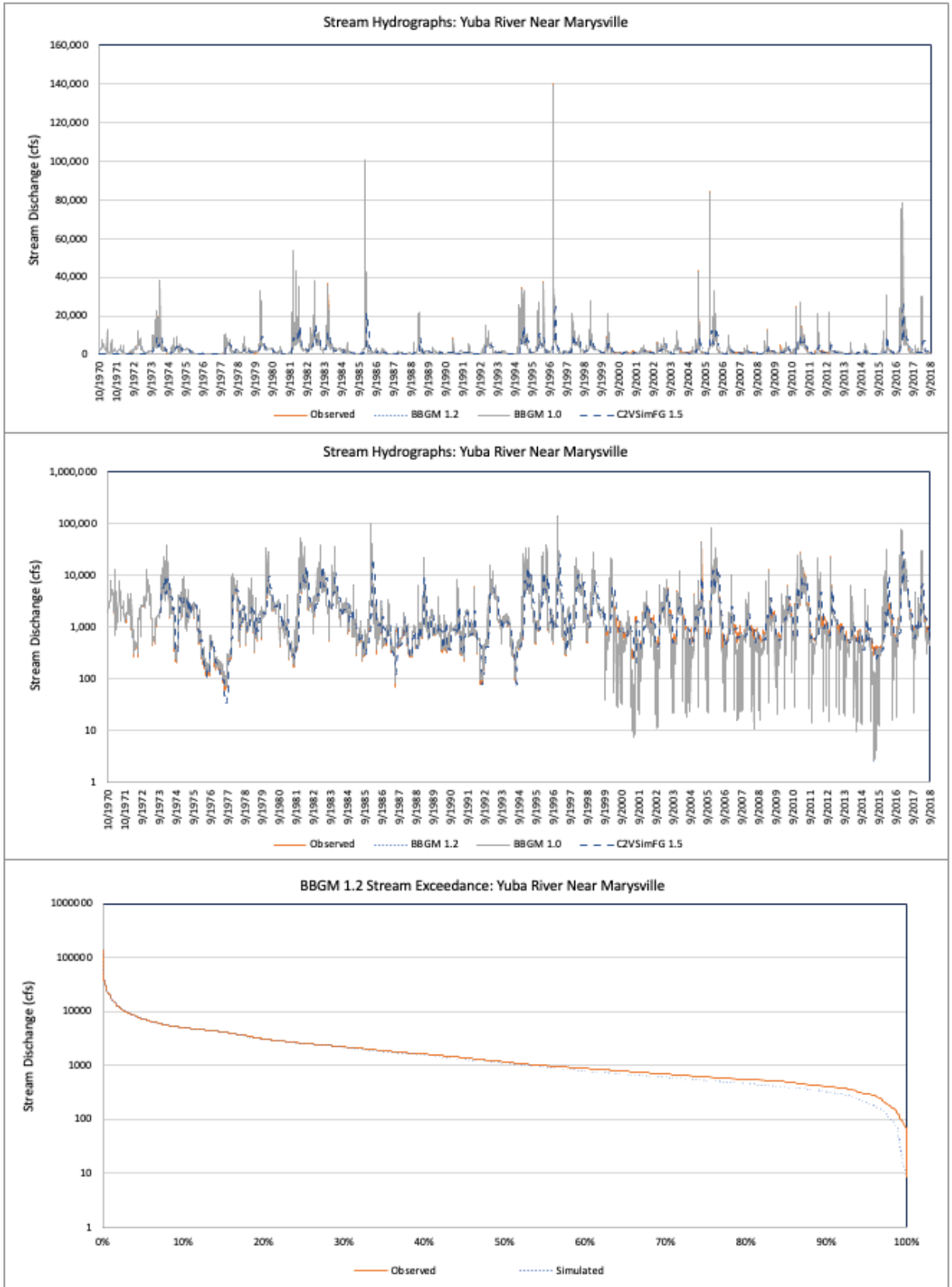


Figure 5. Yuba River near Marysville

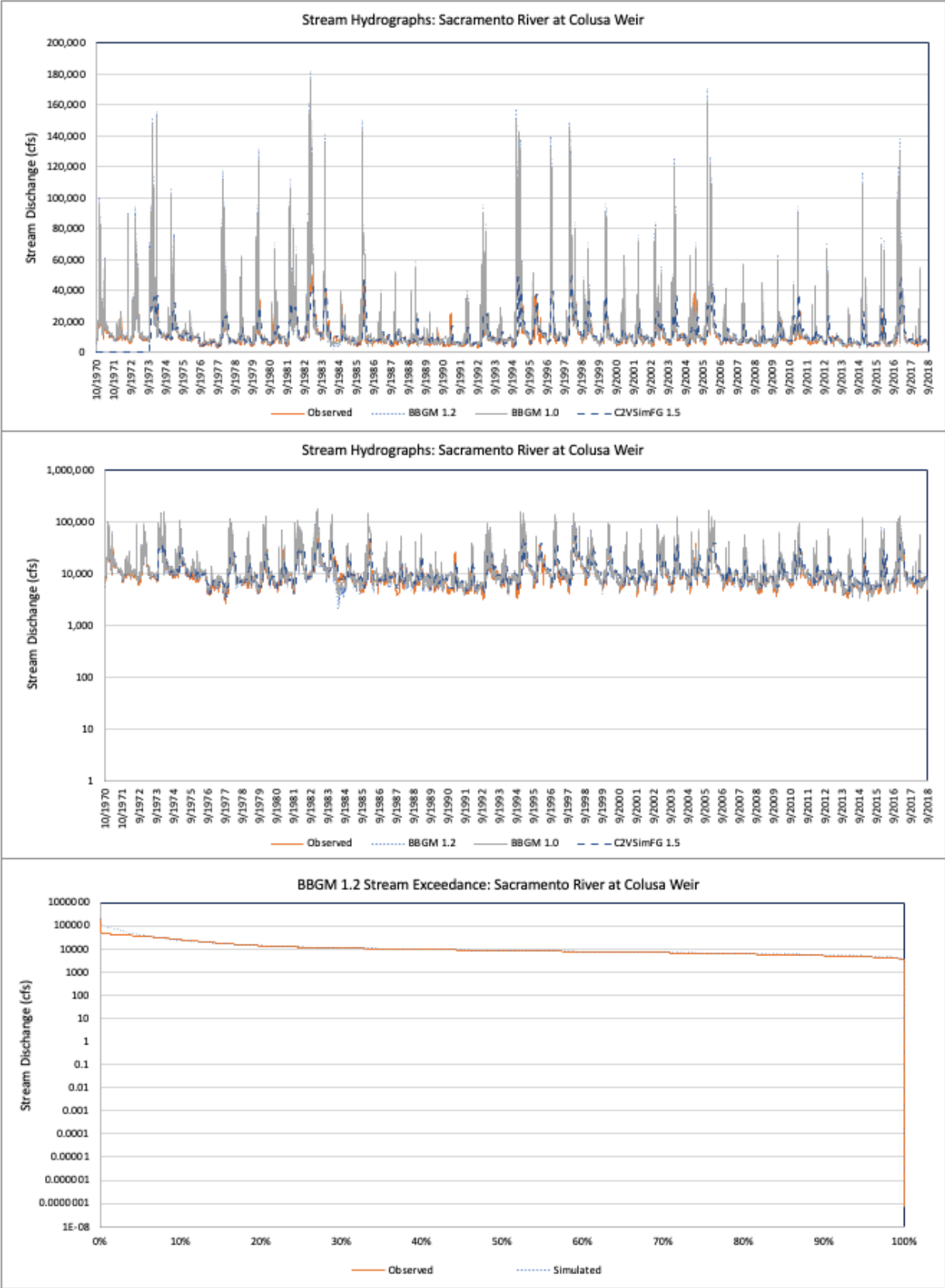


Figure 6. Sacramento River at Colusa Weir

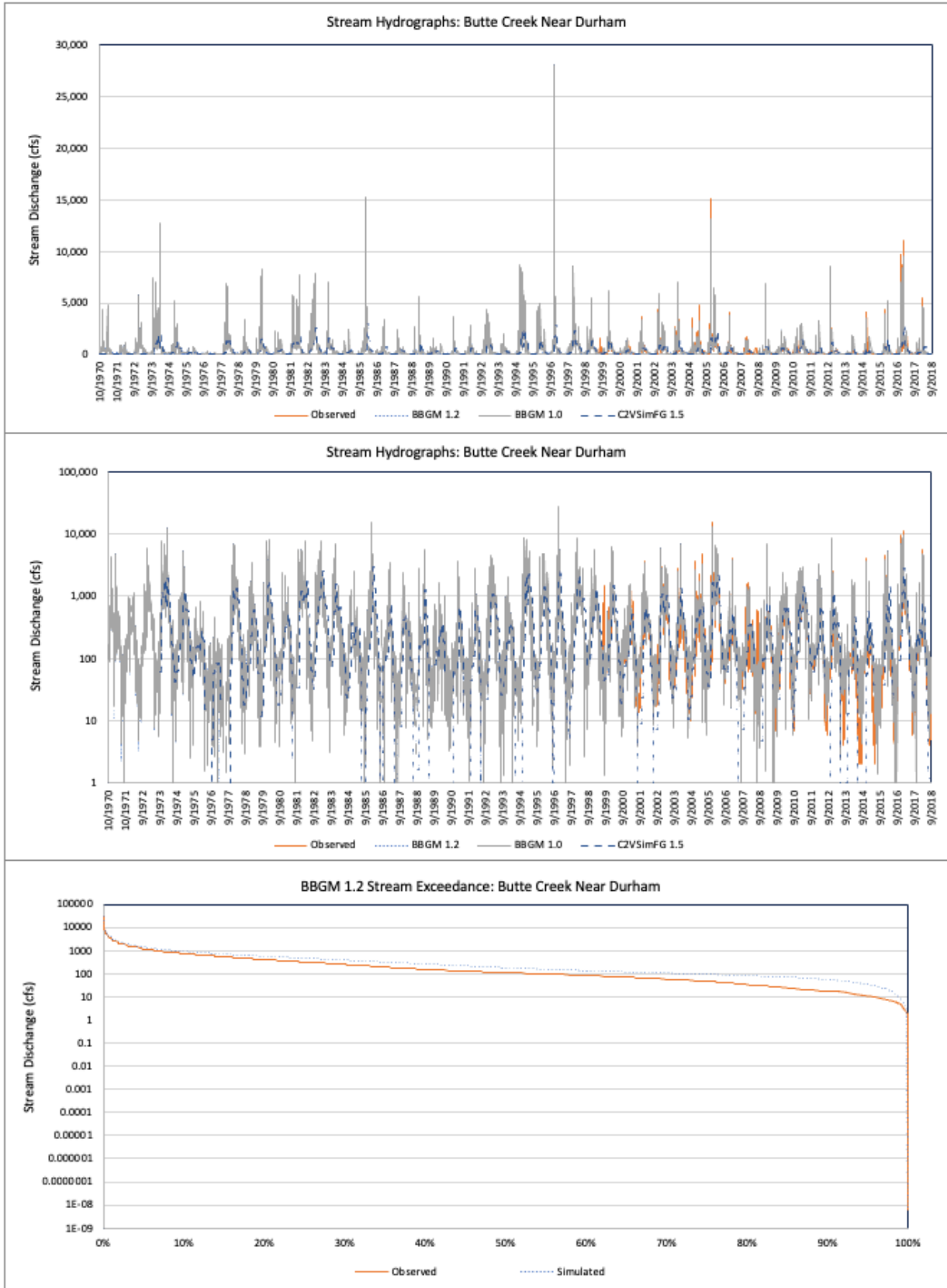


Figure 7. Butte Creek near Durham

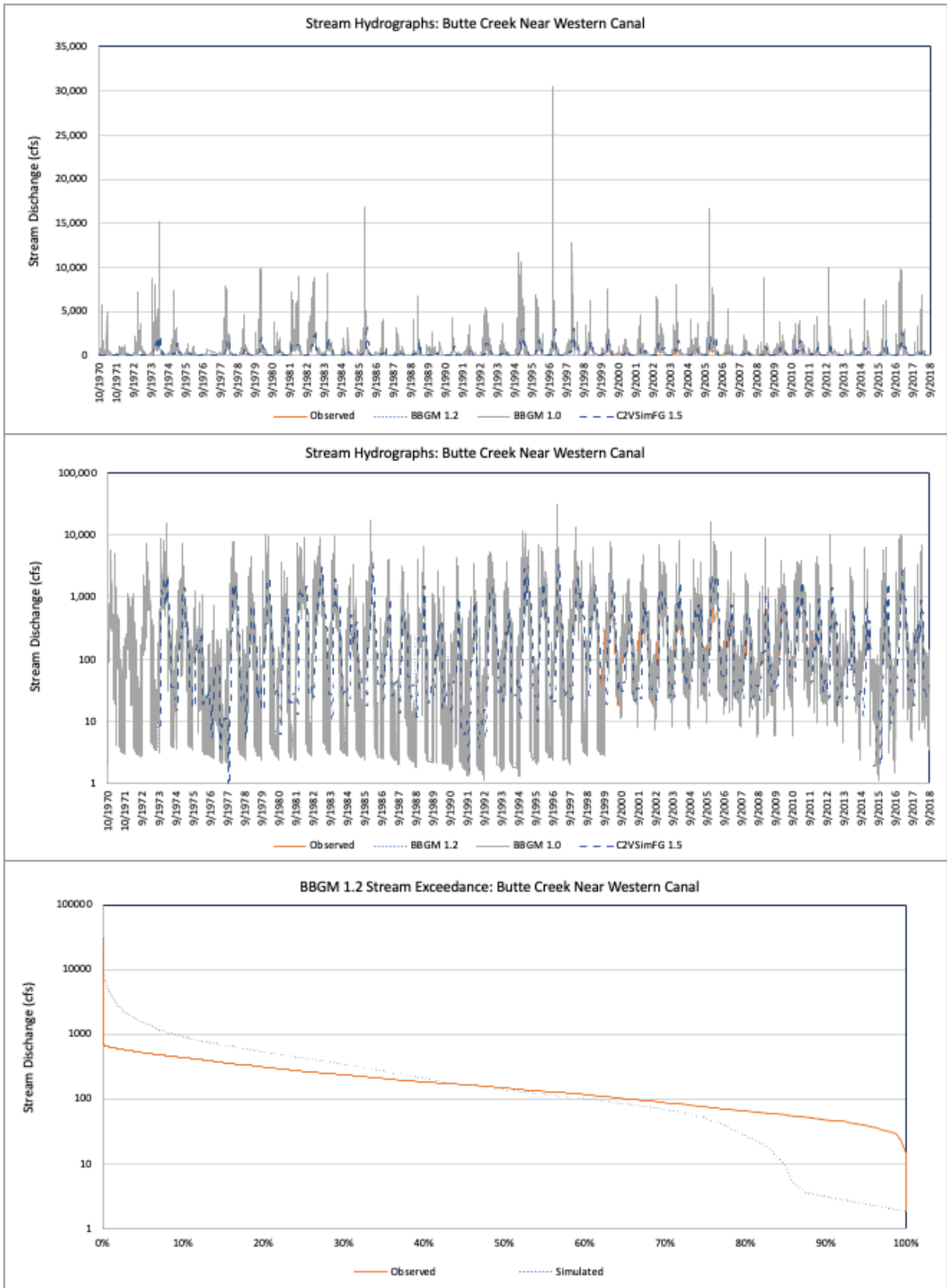


Figure 8. Butte Creek near Western Canal

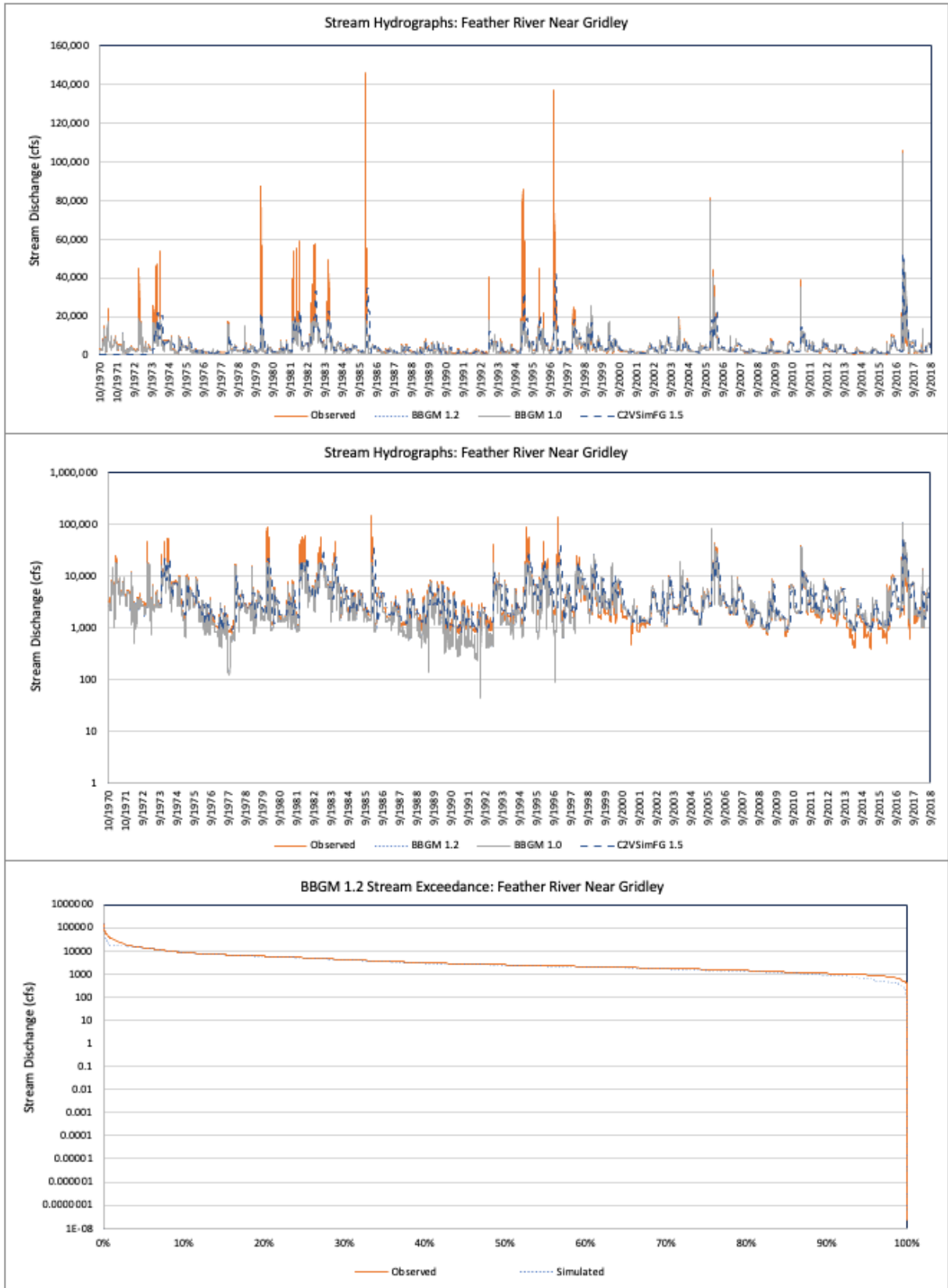


Figure 9. Feather River near Gridley

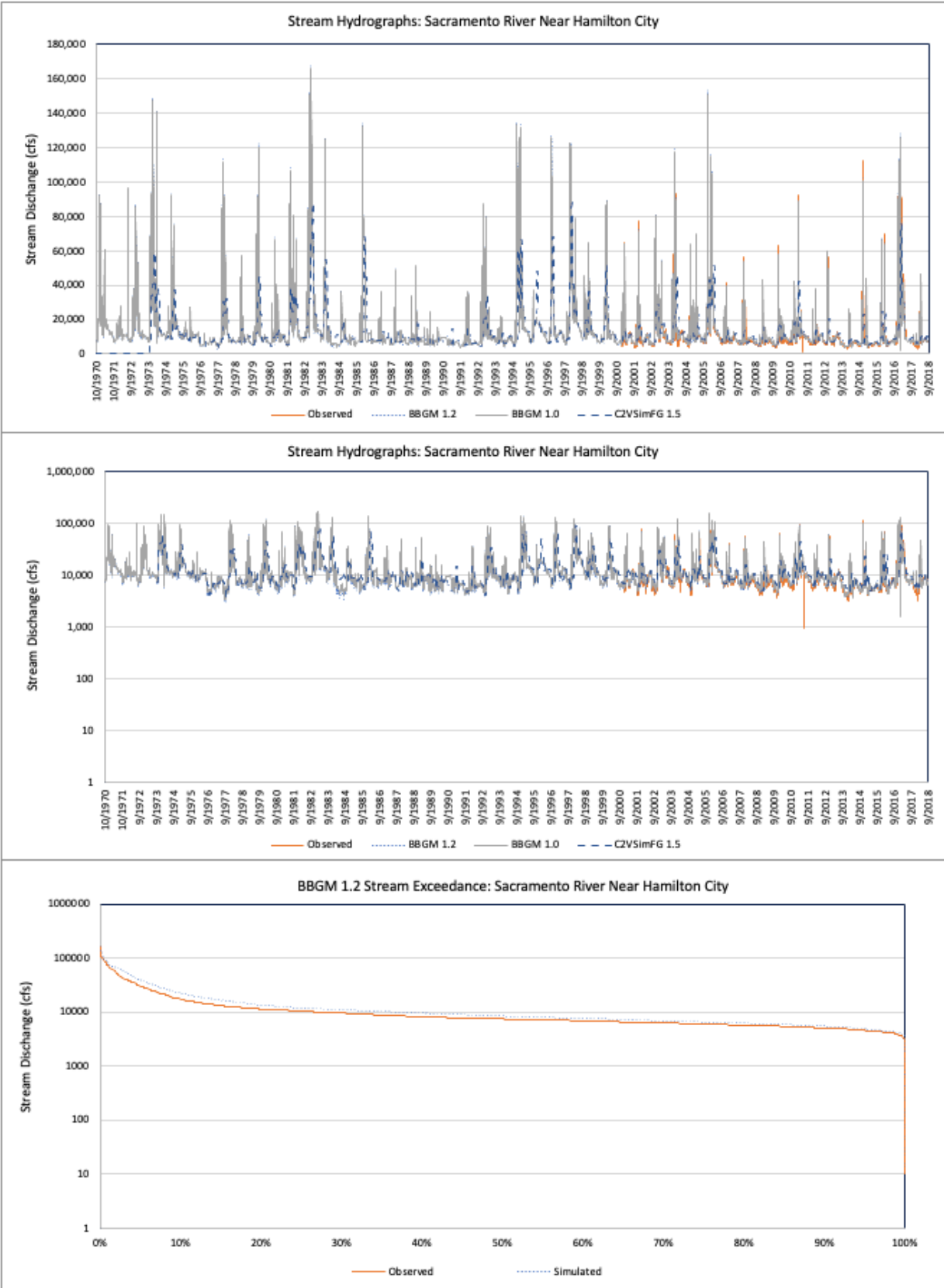


Figure 10. Sacramento River near Hamilton City

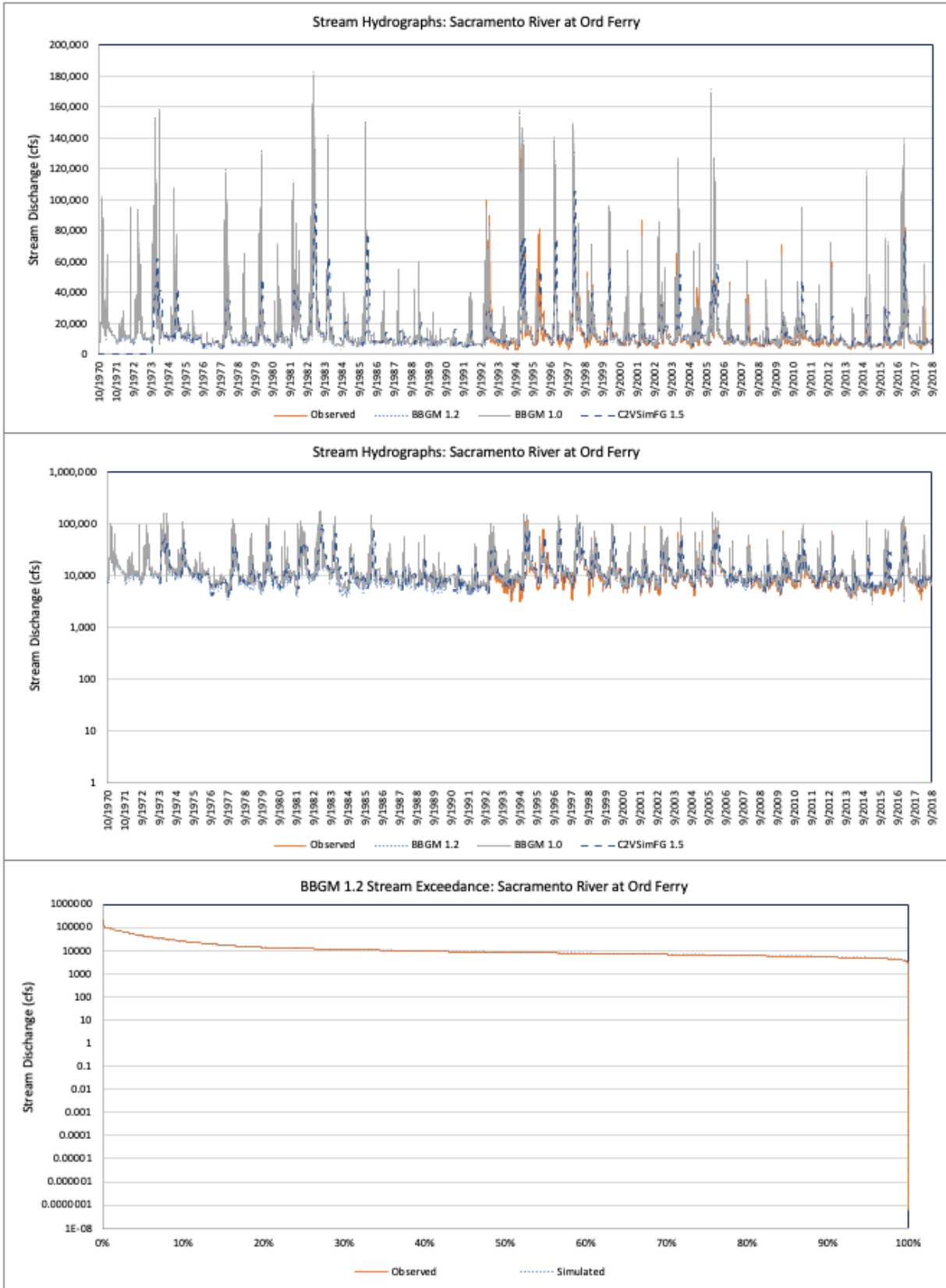


Figure 11. Sacramento River at Ord Ferry

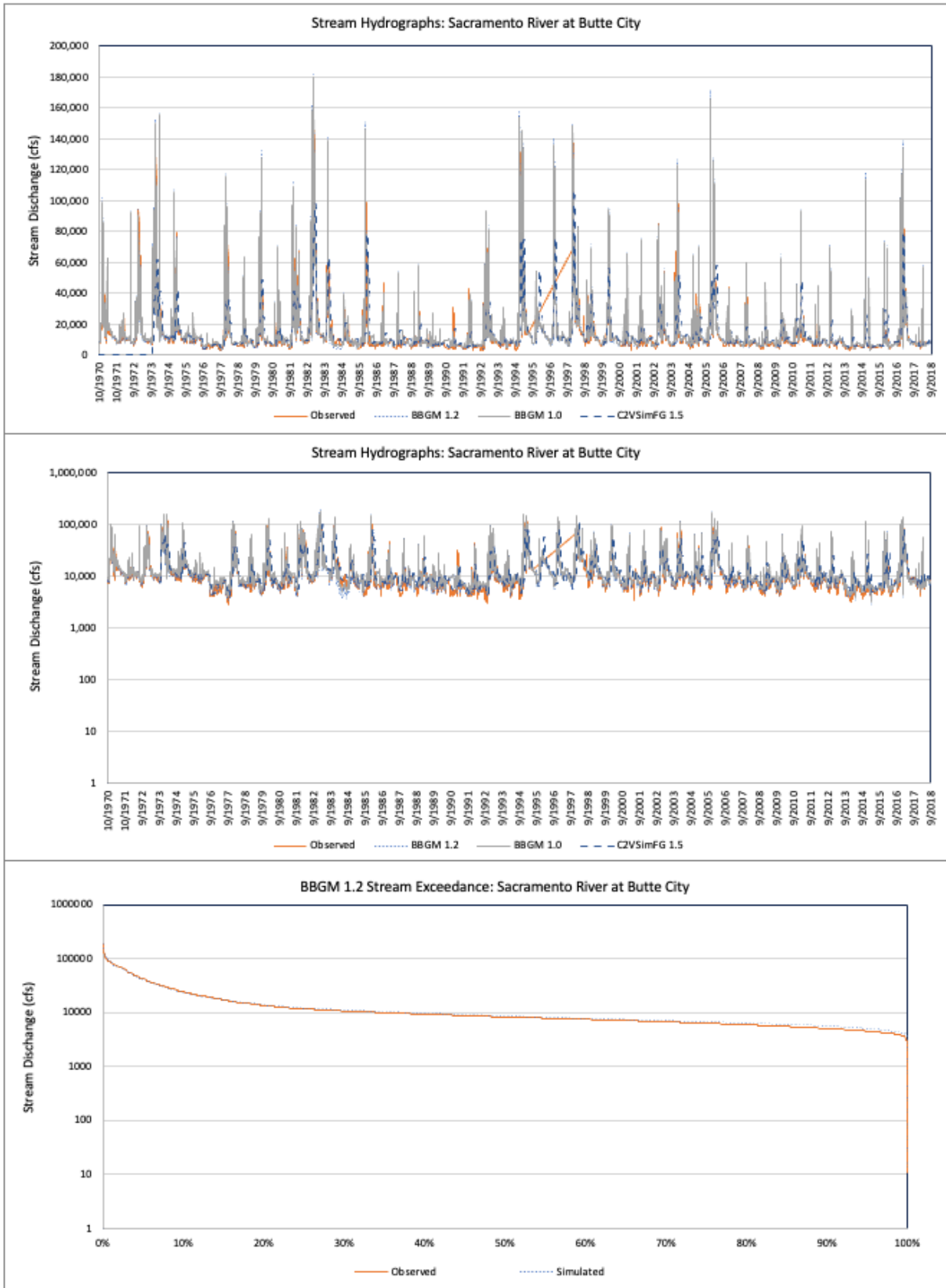


Figure 12. Sacramento River at Butte City

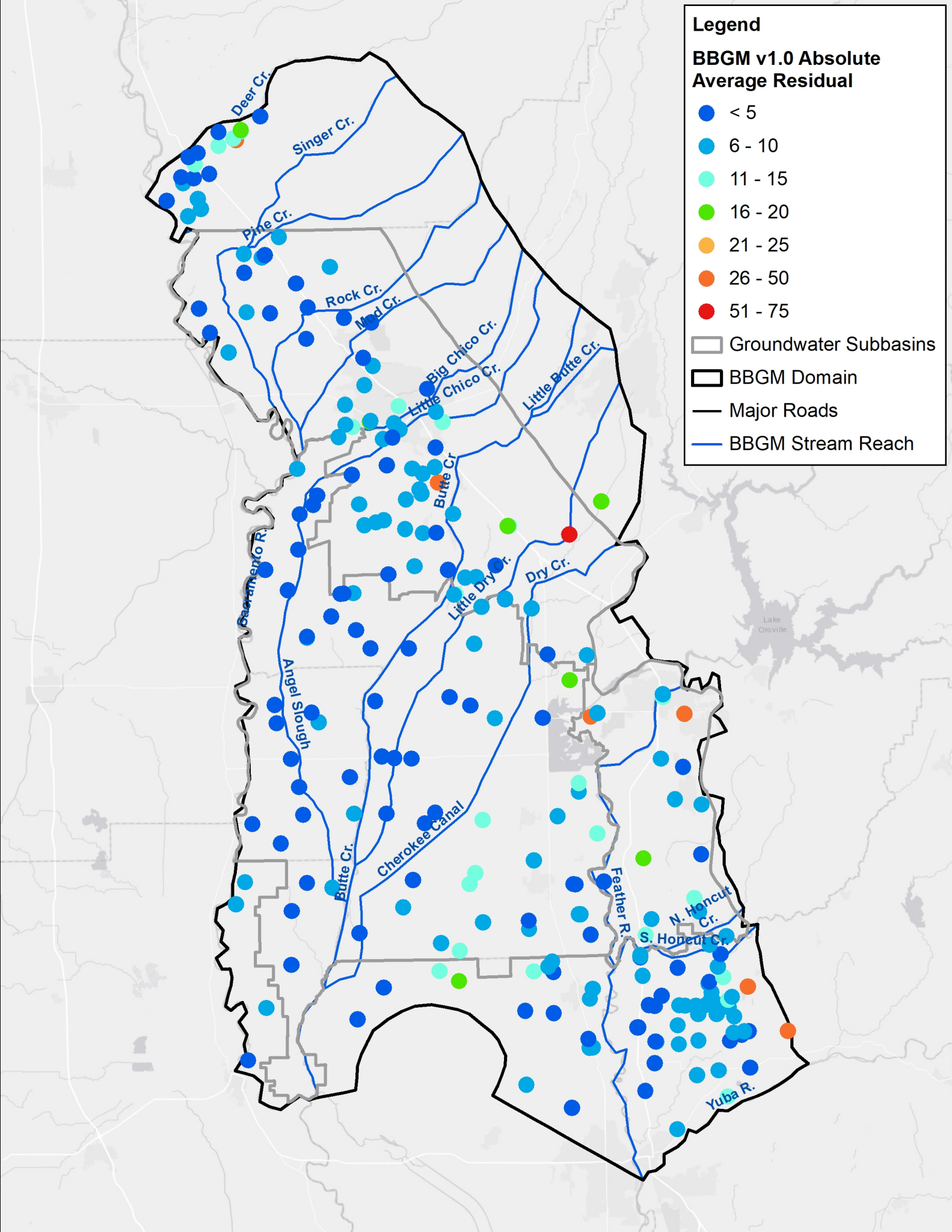
ATTACHMENT 5: GROUNDWATER LEVEL CALIBRATION HYDROGRAPHS AND RESIDUALS

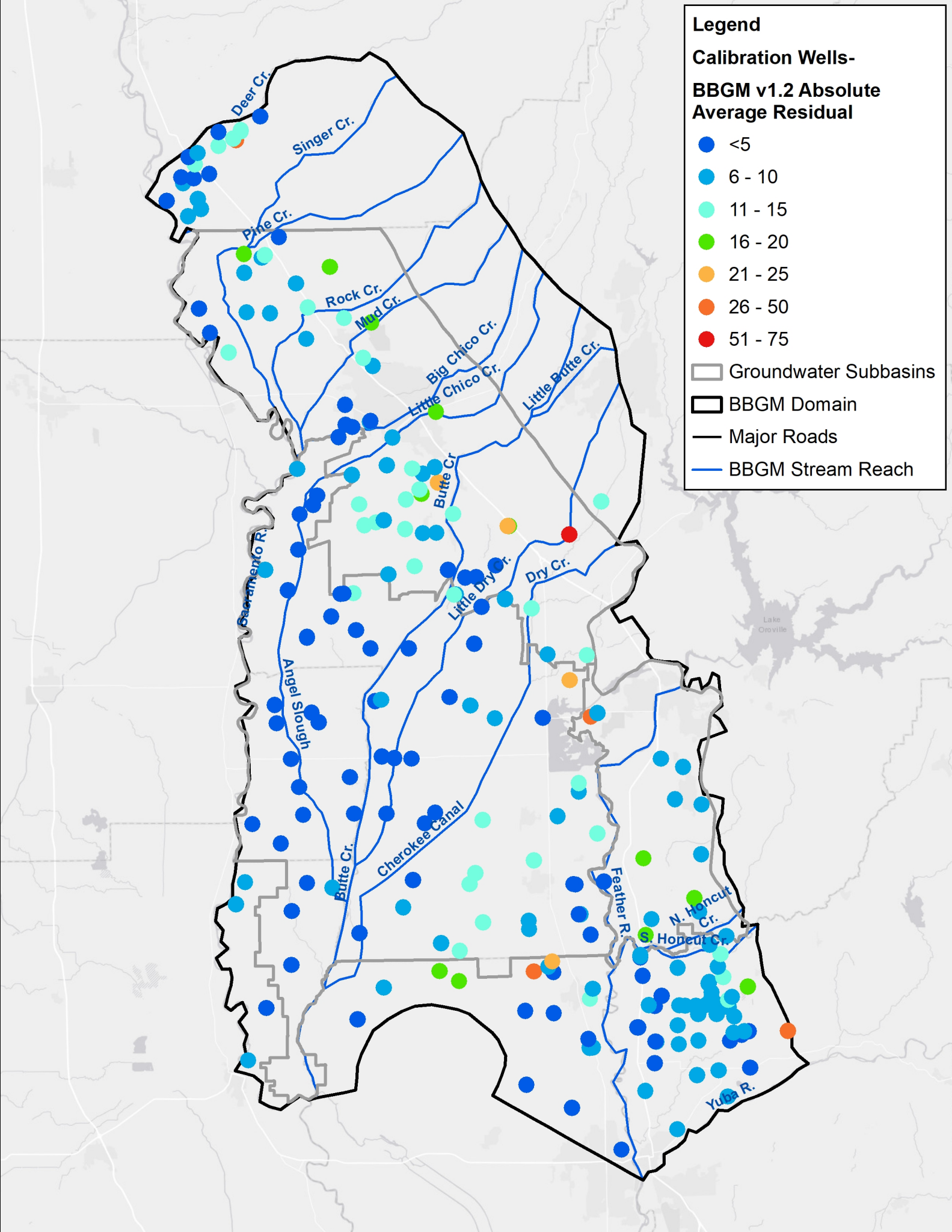
Figures in this section show groundwater level calibration hydrographs for the BBGM v1.0, BBGM v1.2, and BBGM v1.2 through 2024 models. The first 3 maps show the average water level residuals for each of the calibration wells hydrographs.

Legend

BBGM v1.0 Absolute Average Residual

- < 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 50
- 51 - 75
- Groundwater Subbasins
- ▭ BBGM Domain
- Major Roads
- BBGM Stream Reach





Legend

Calibration Wells-

**BGM v1.2 Through WY
2024 Absolute Average
Residual**

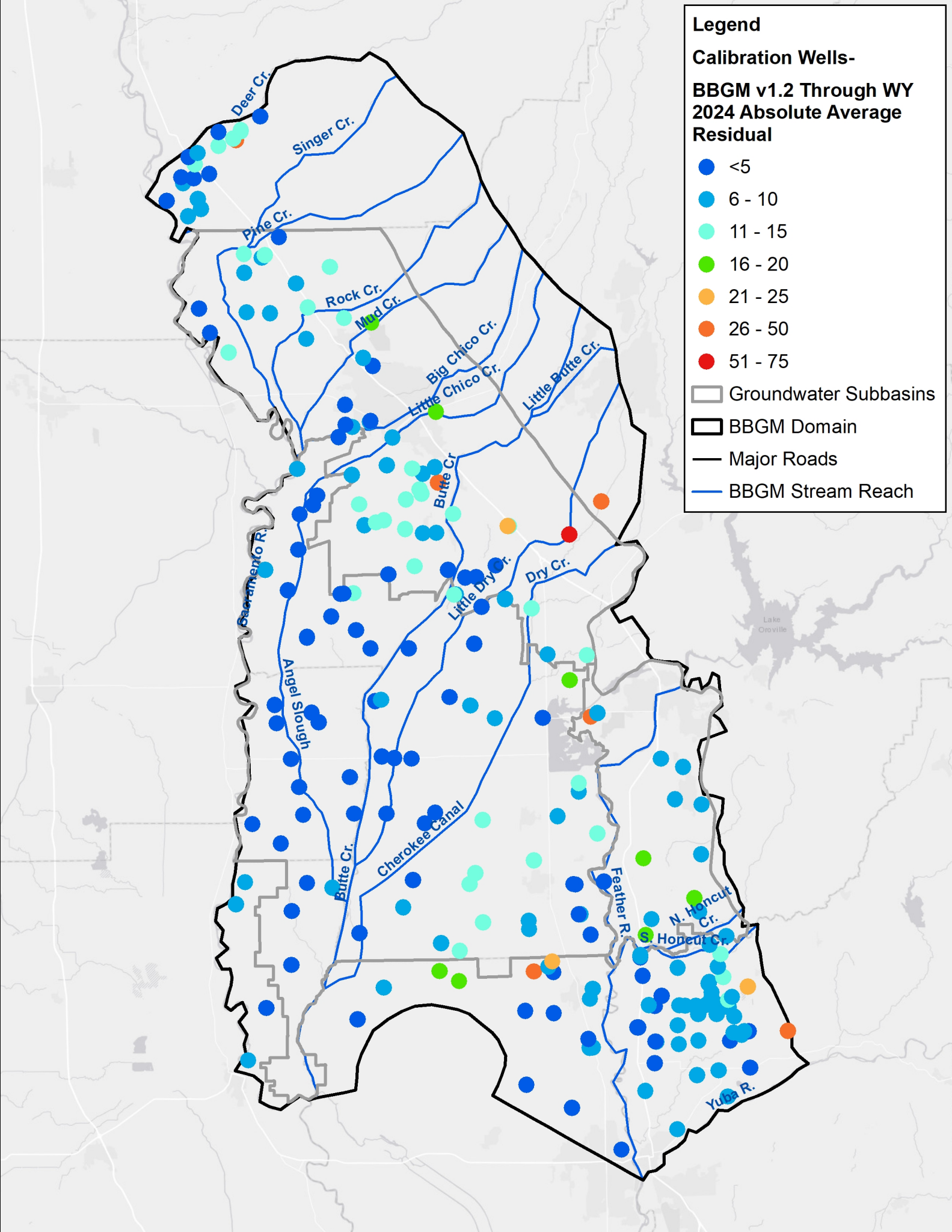
- <5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 50
- 51 - 75

□ Groundwater Subbasins

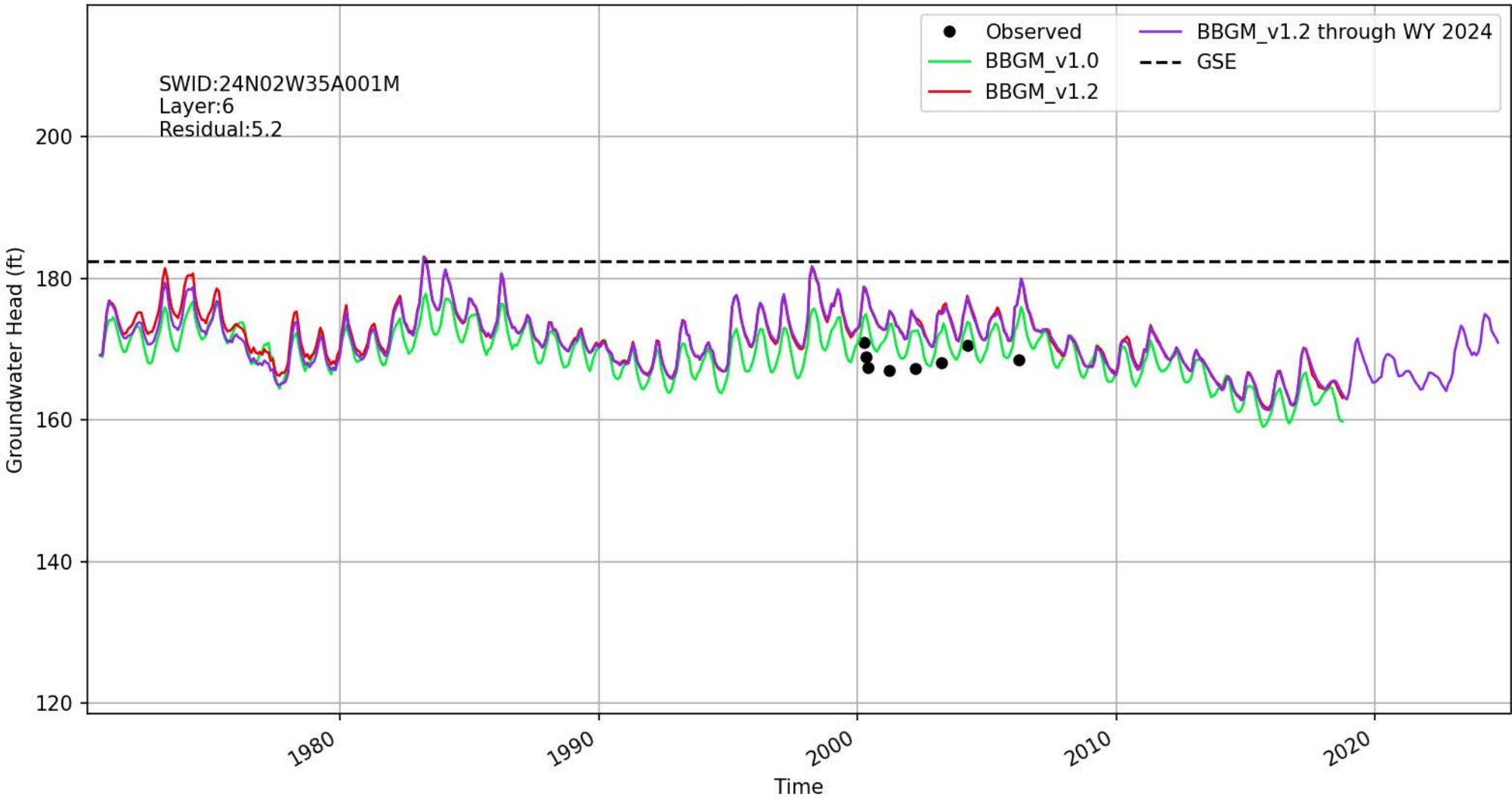
▭ BGM Domain

— Major Roads

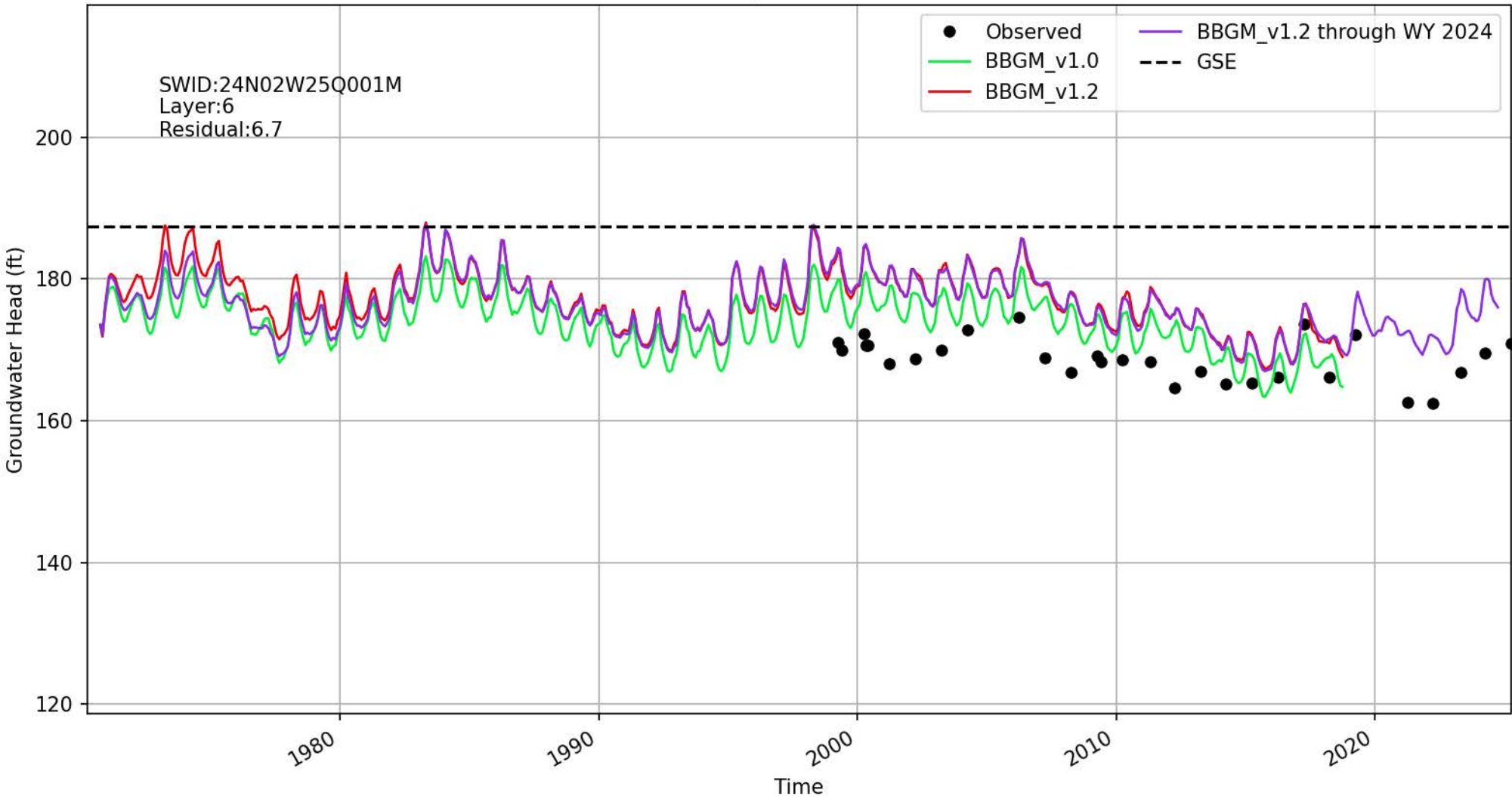
— BGM Stream Reach



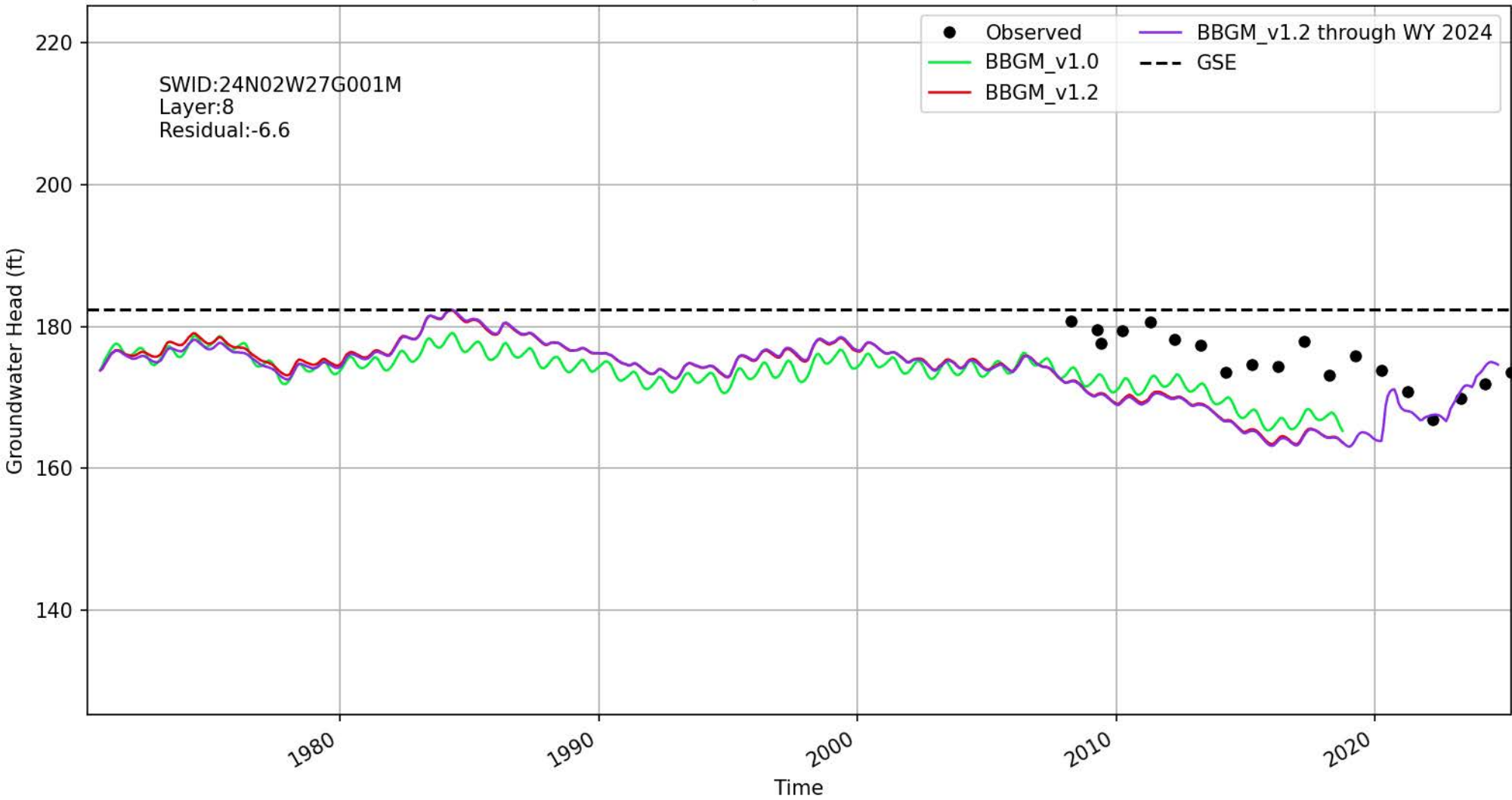
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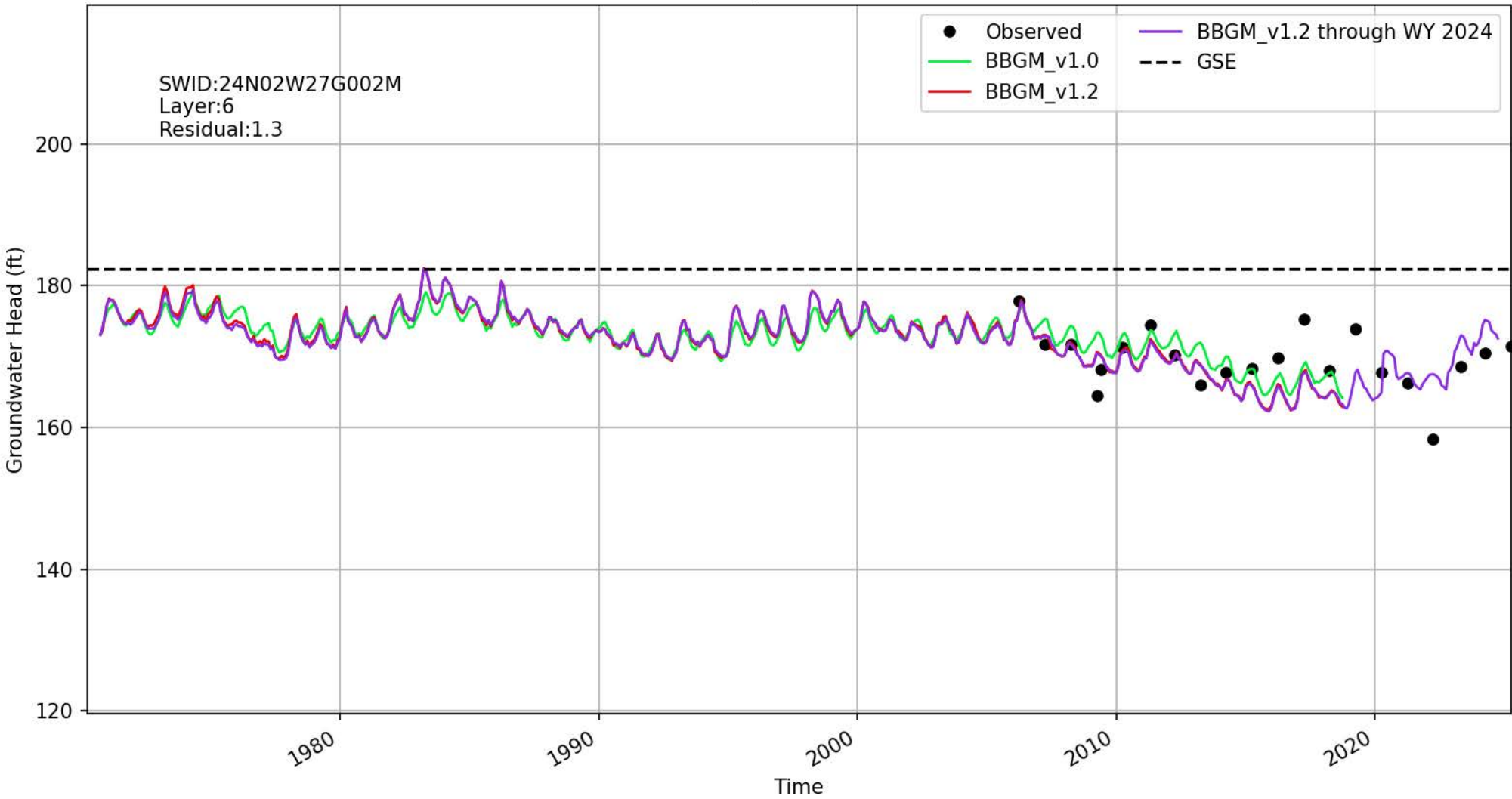
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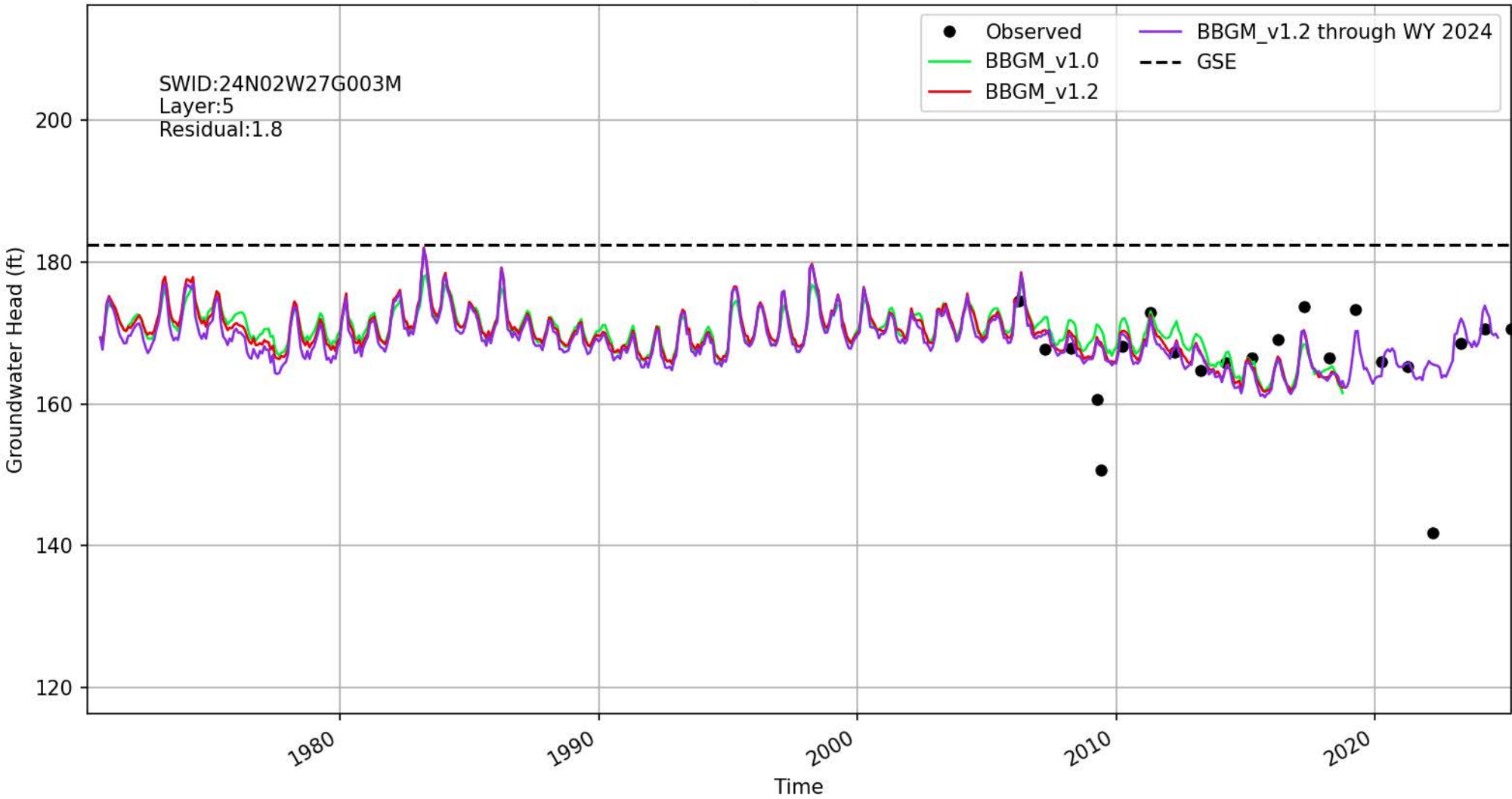
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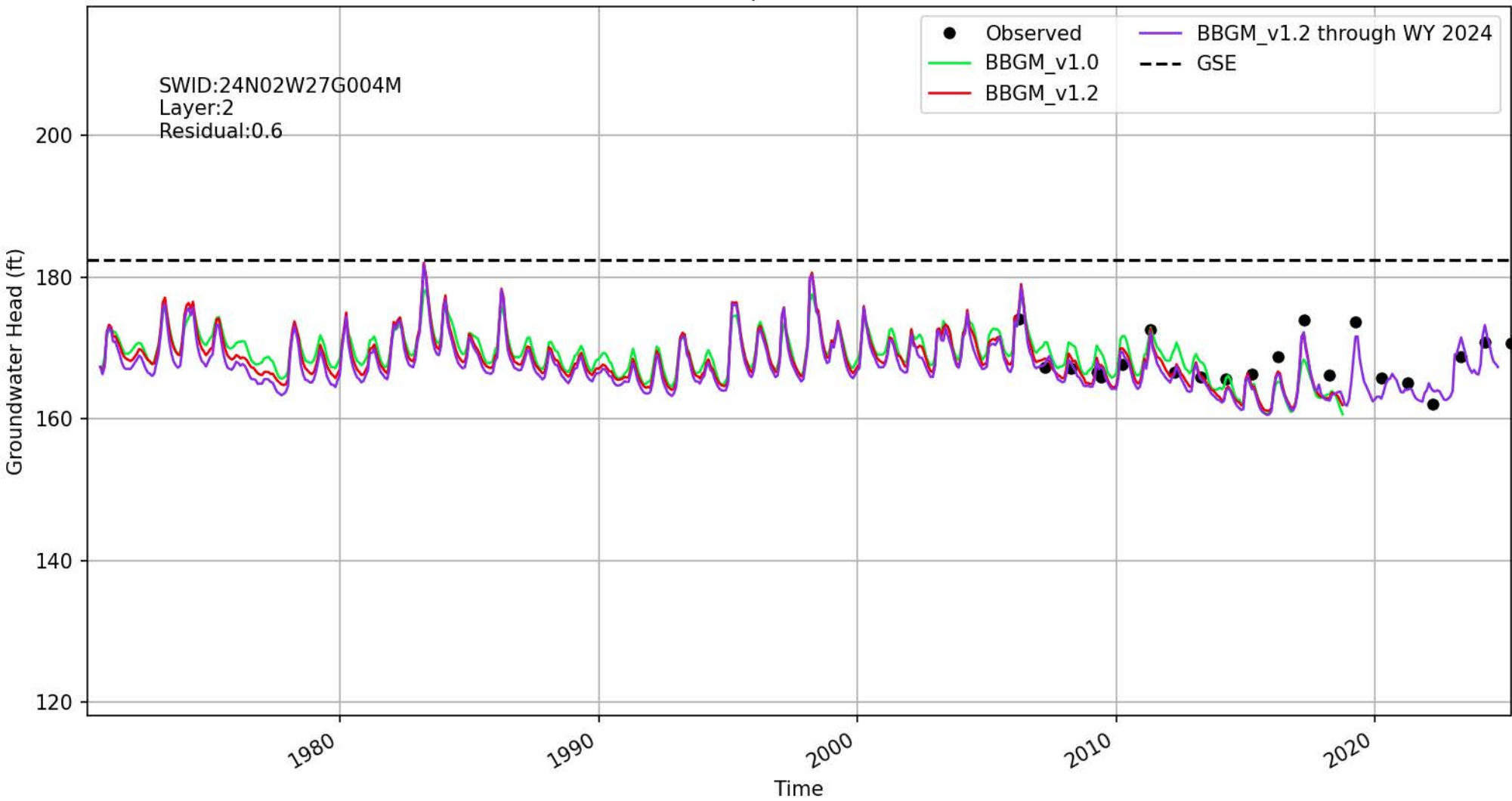
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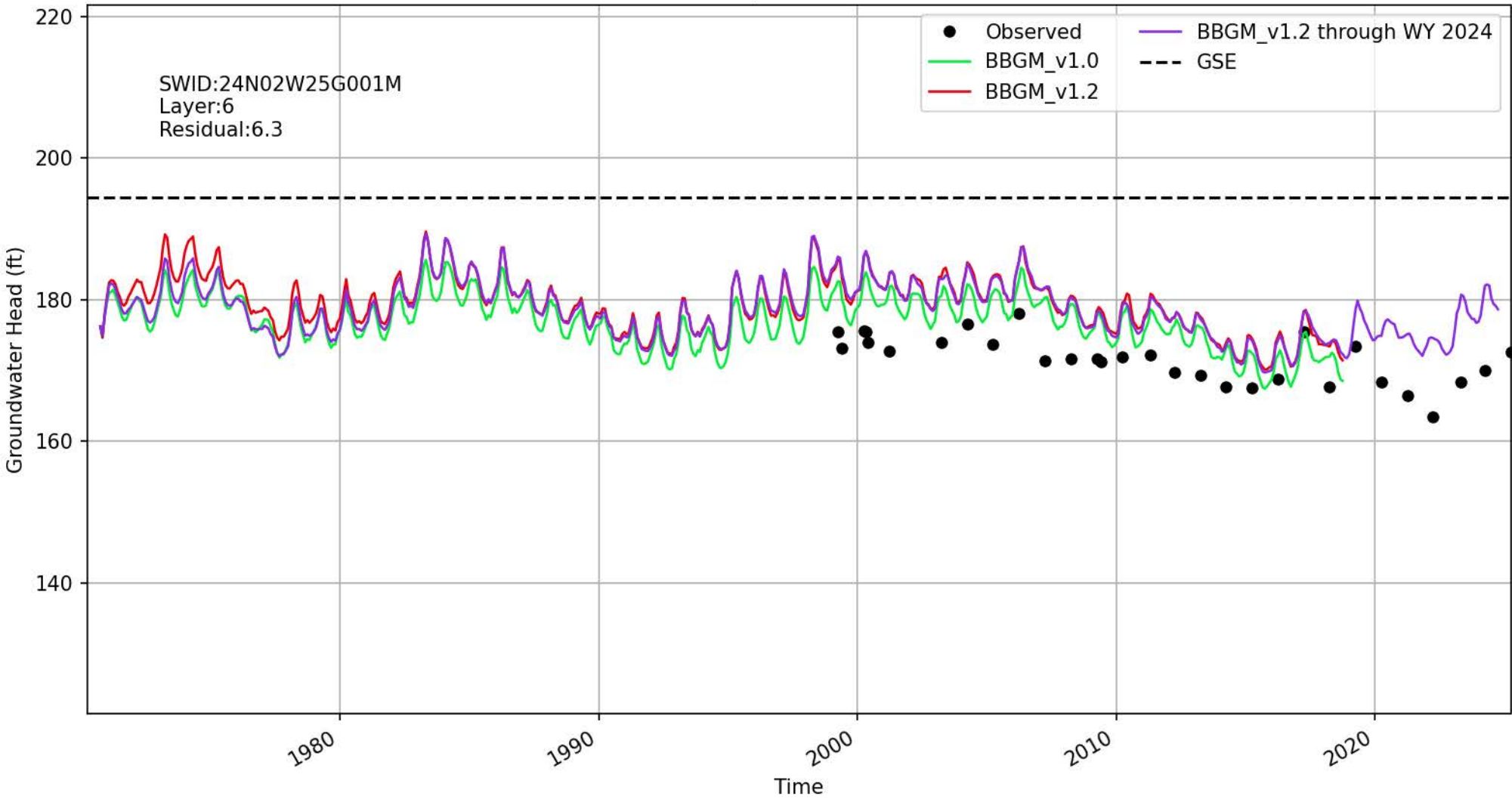
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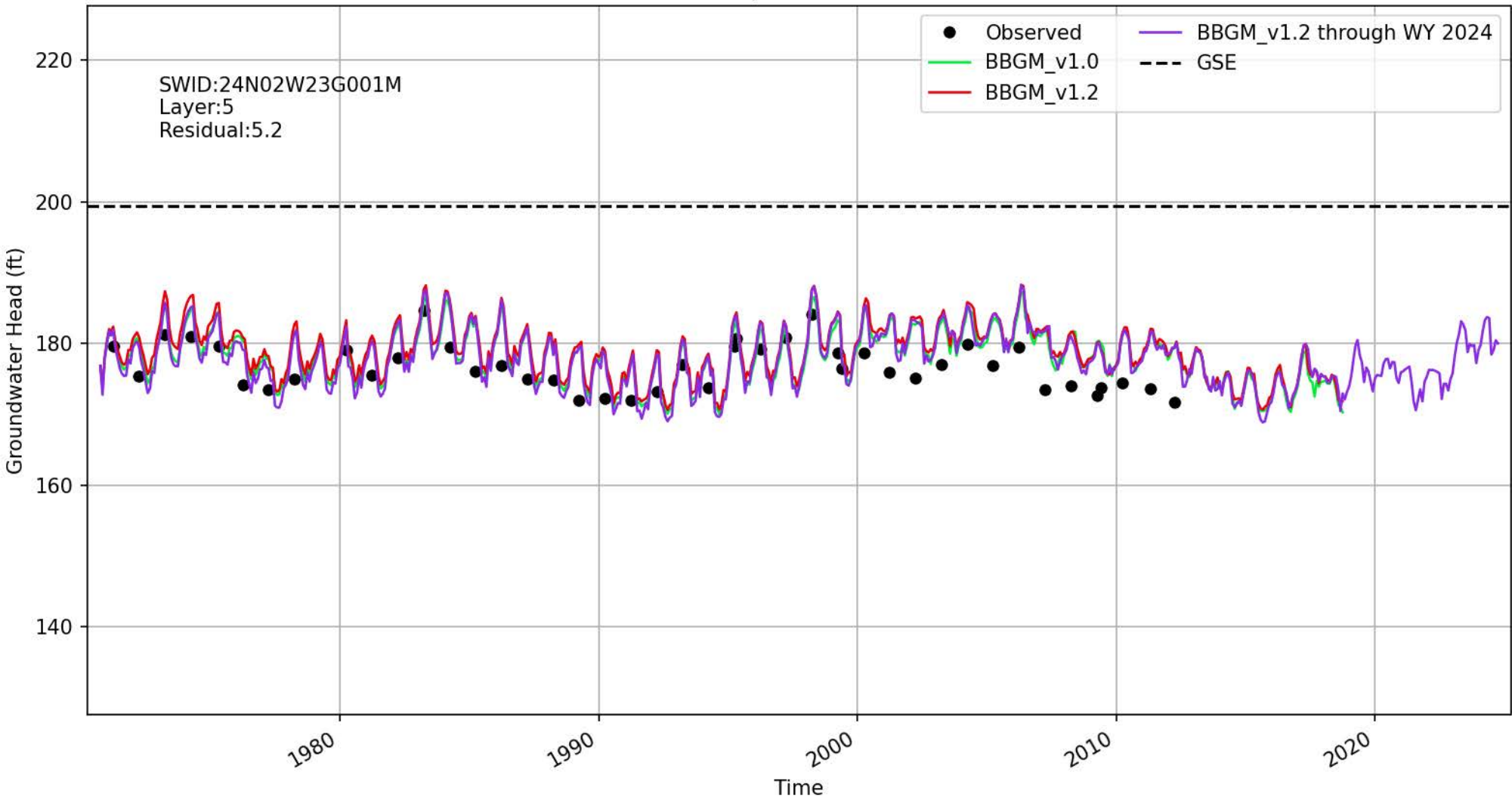
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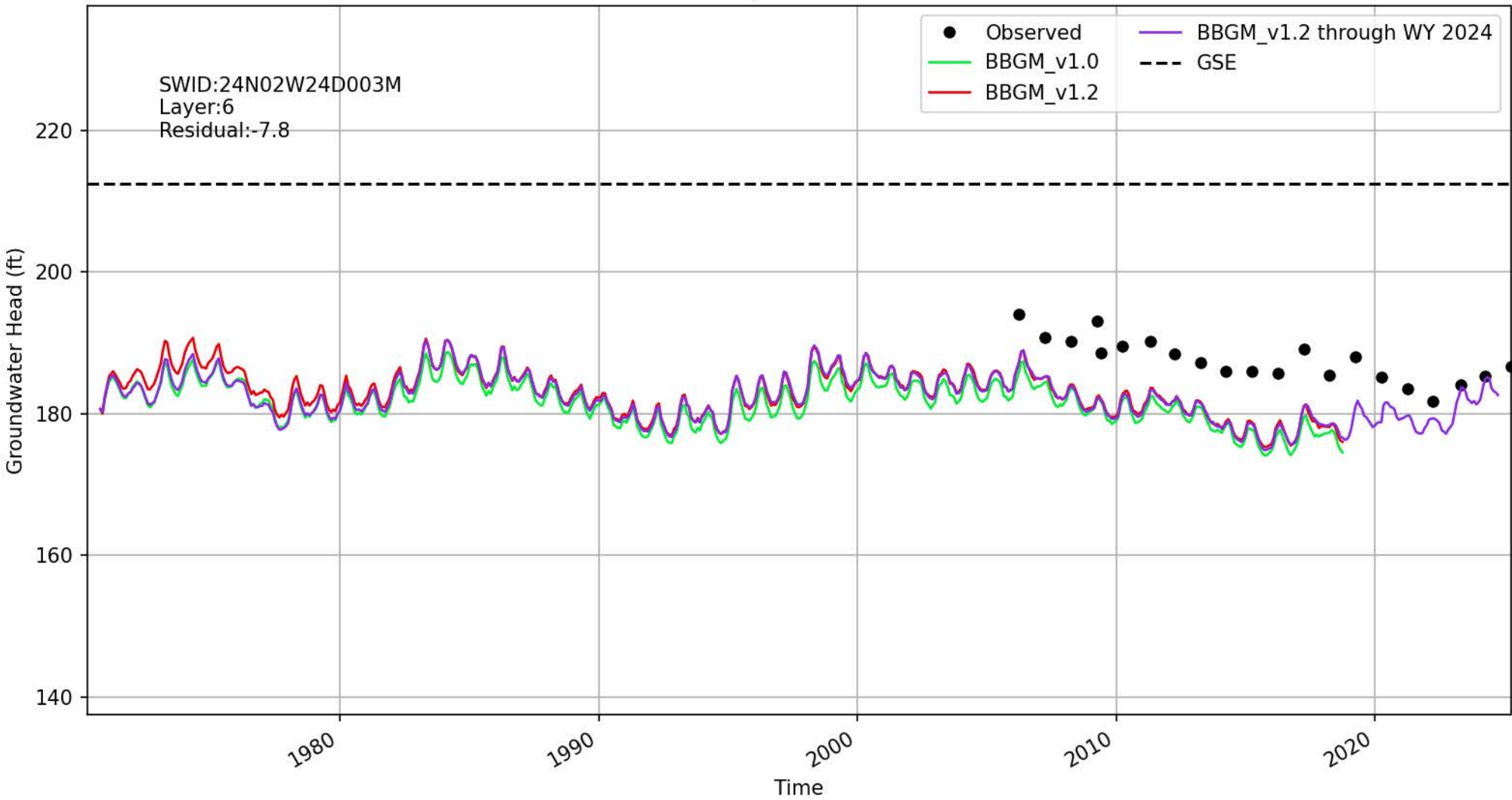
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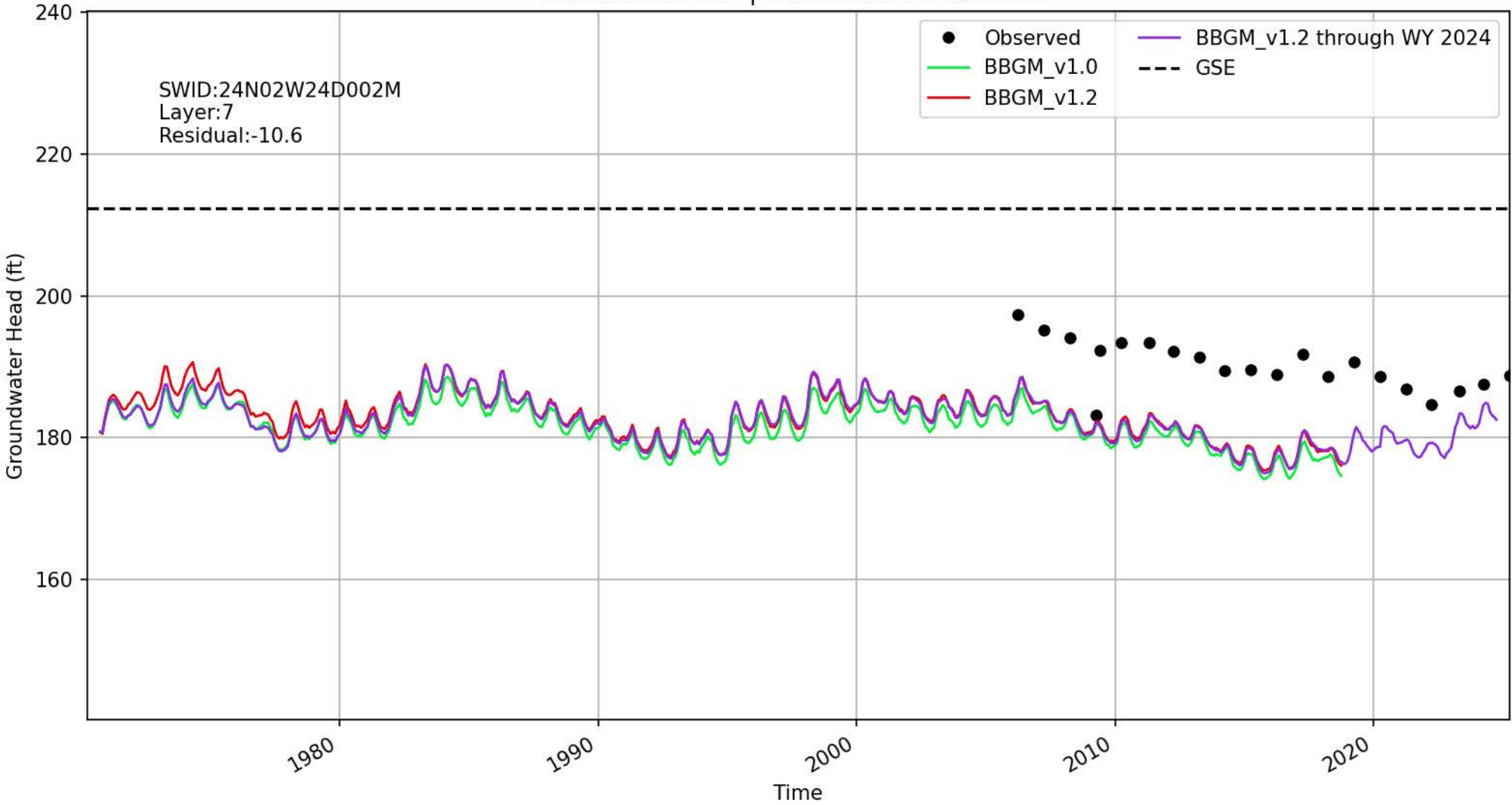
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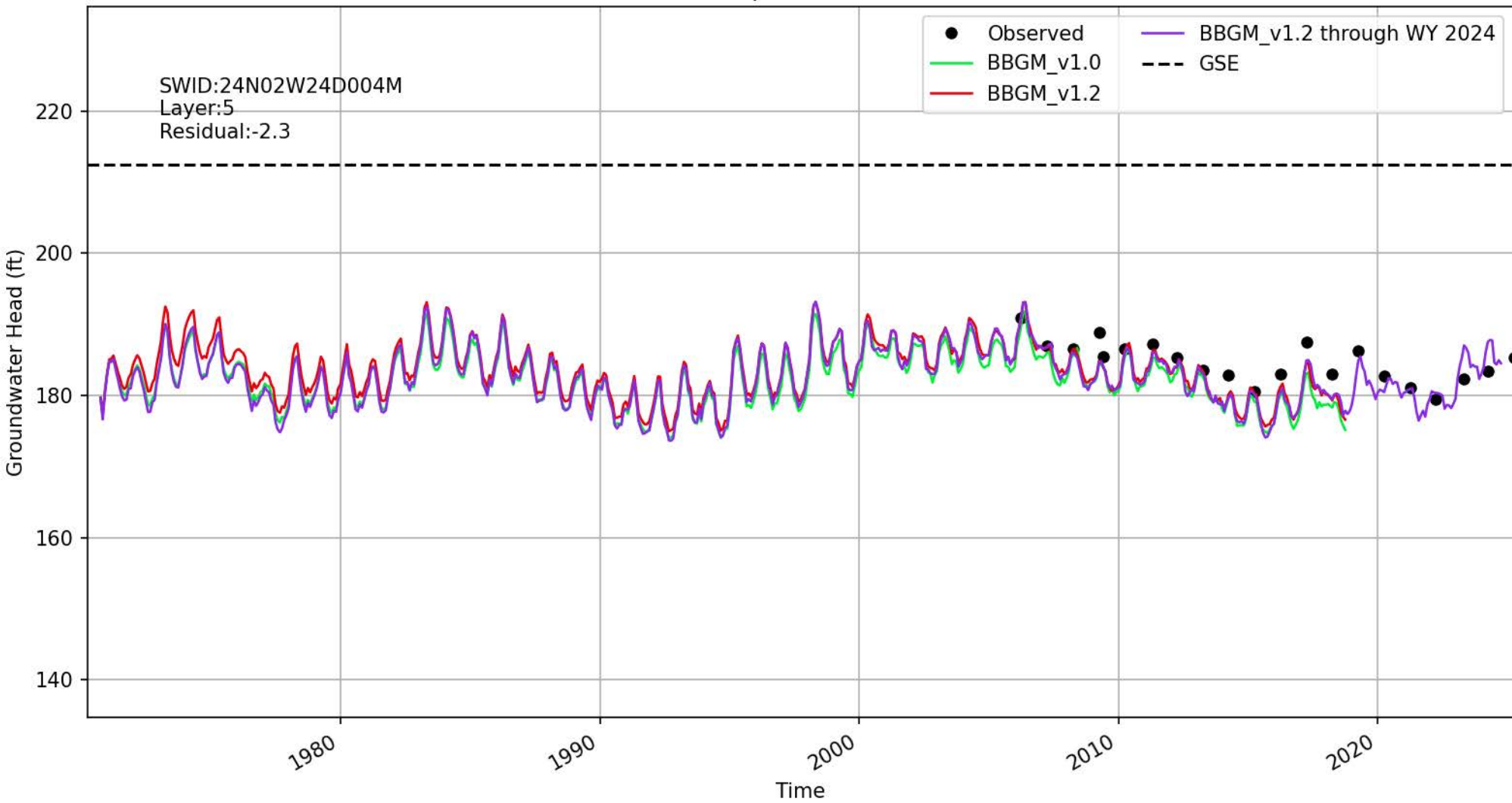
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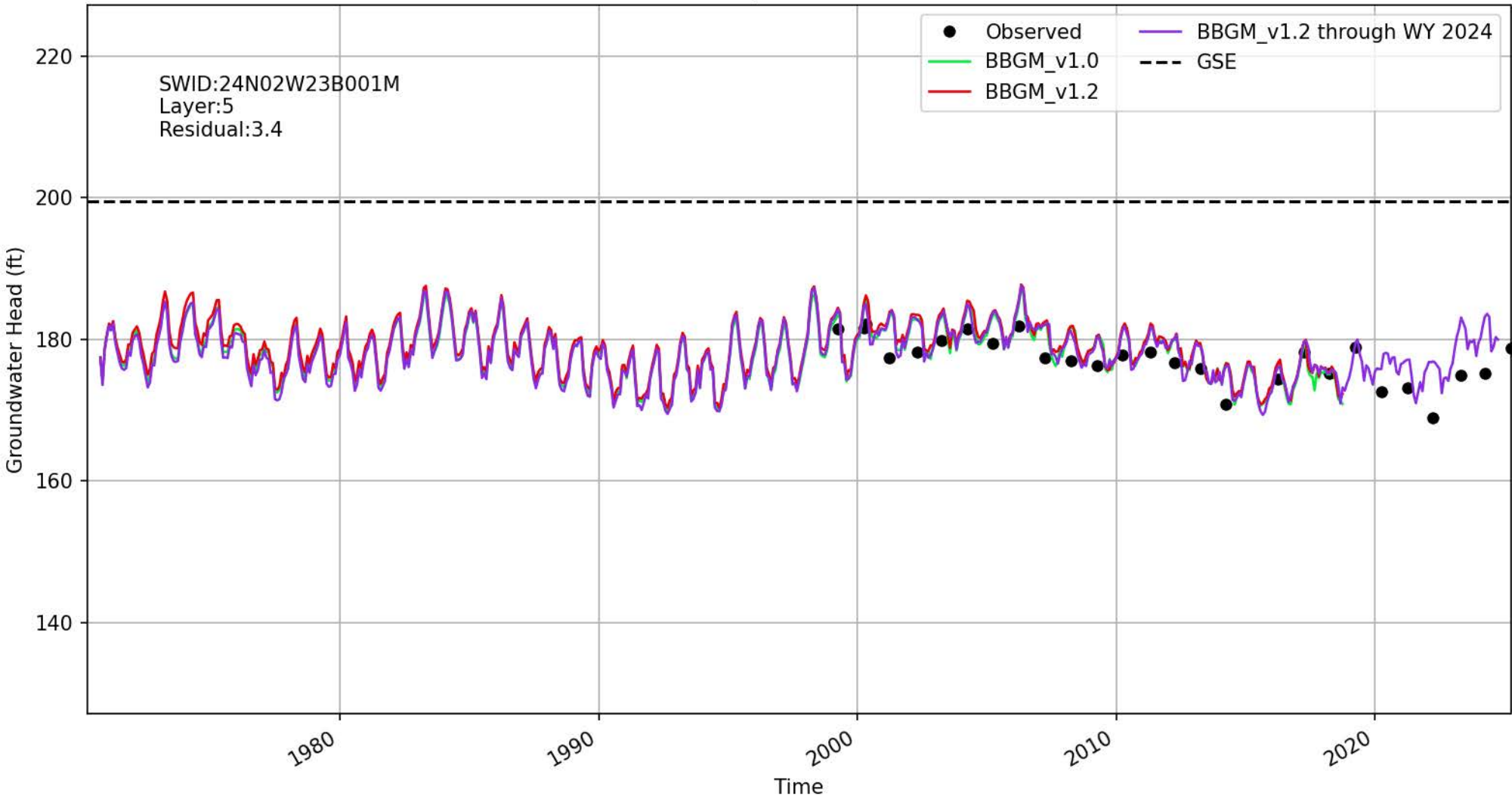
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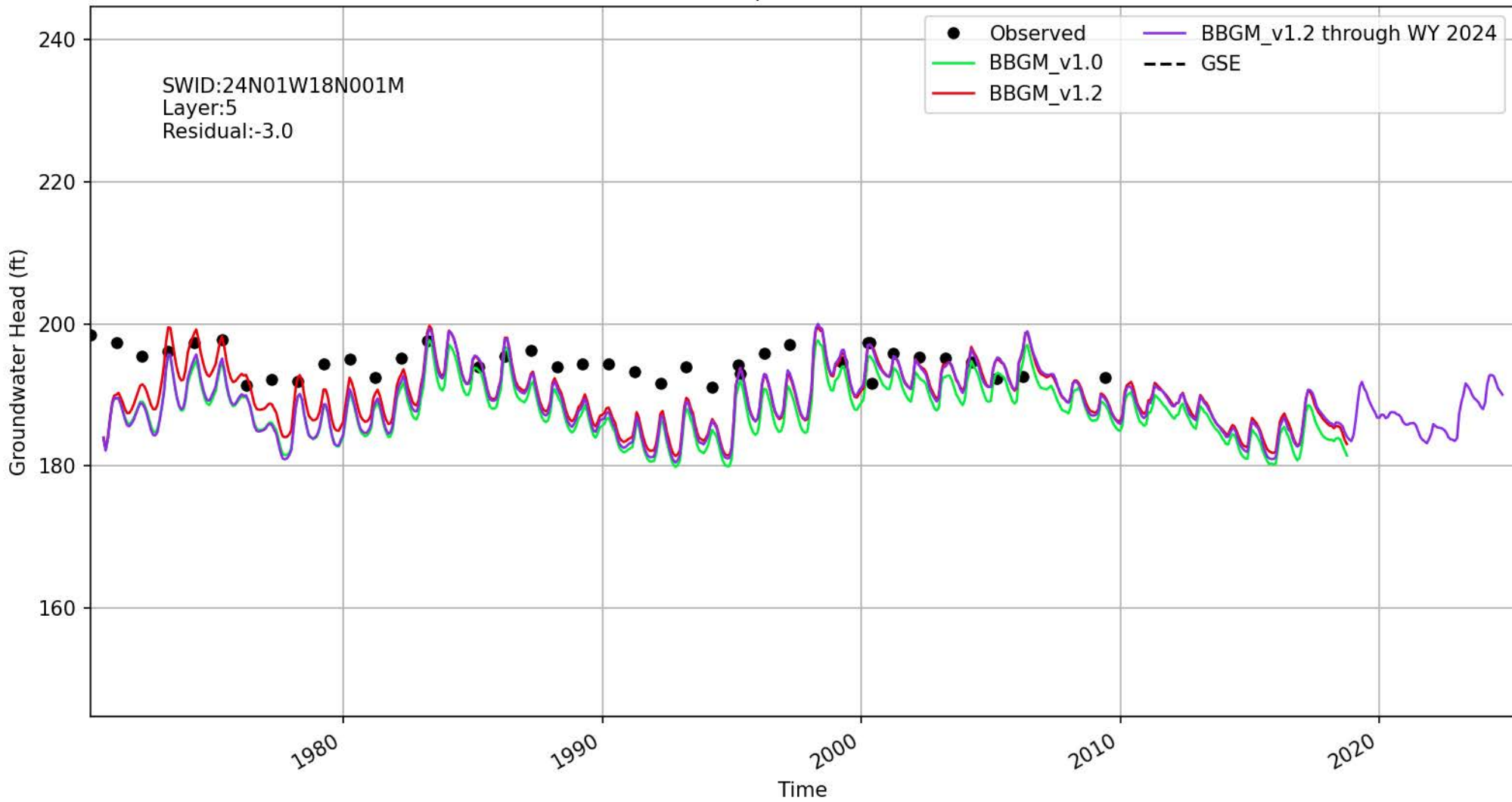


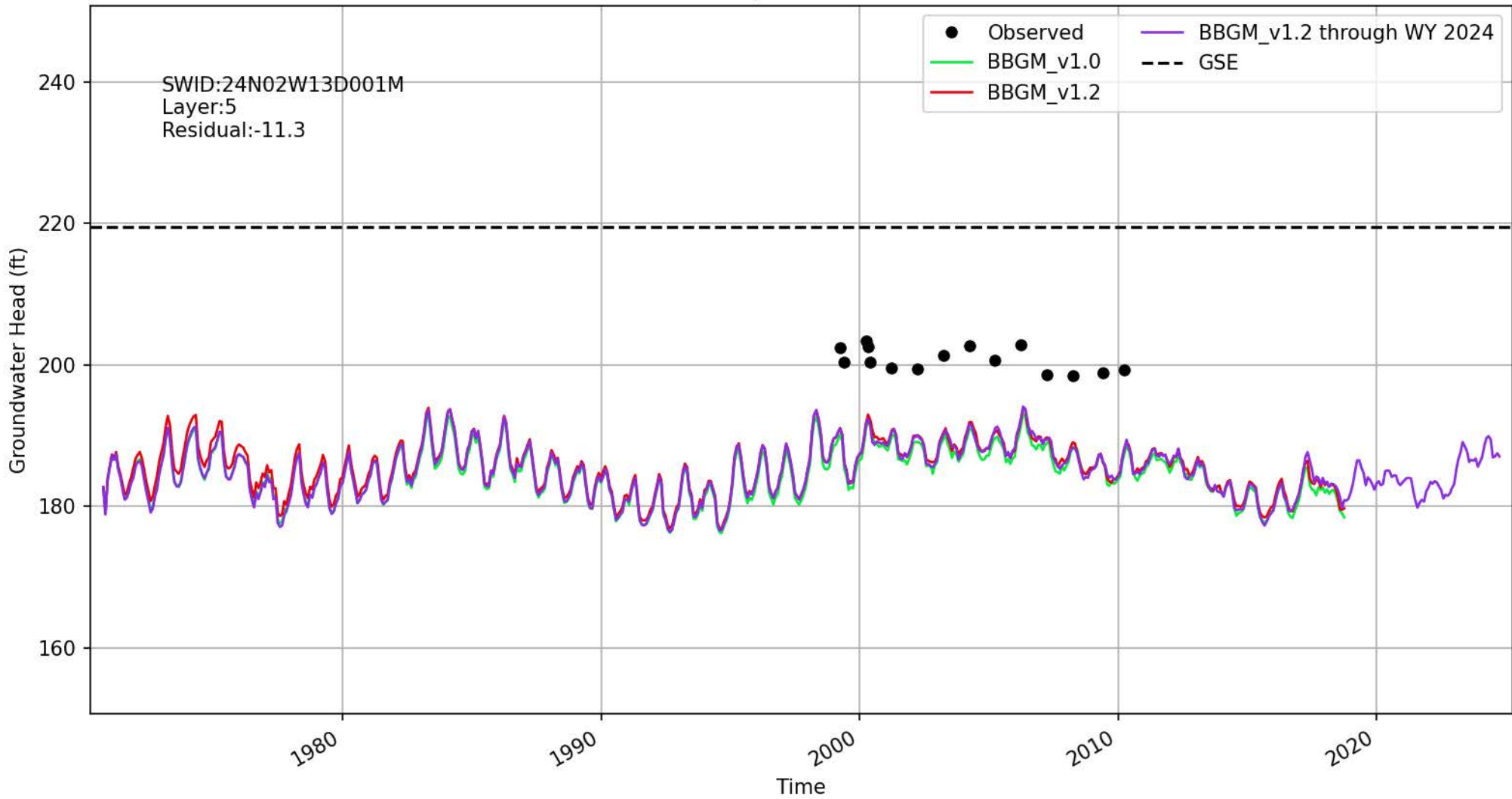
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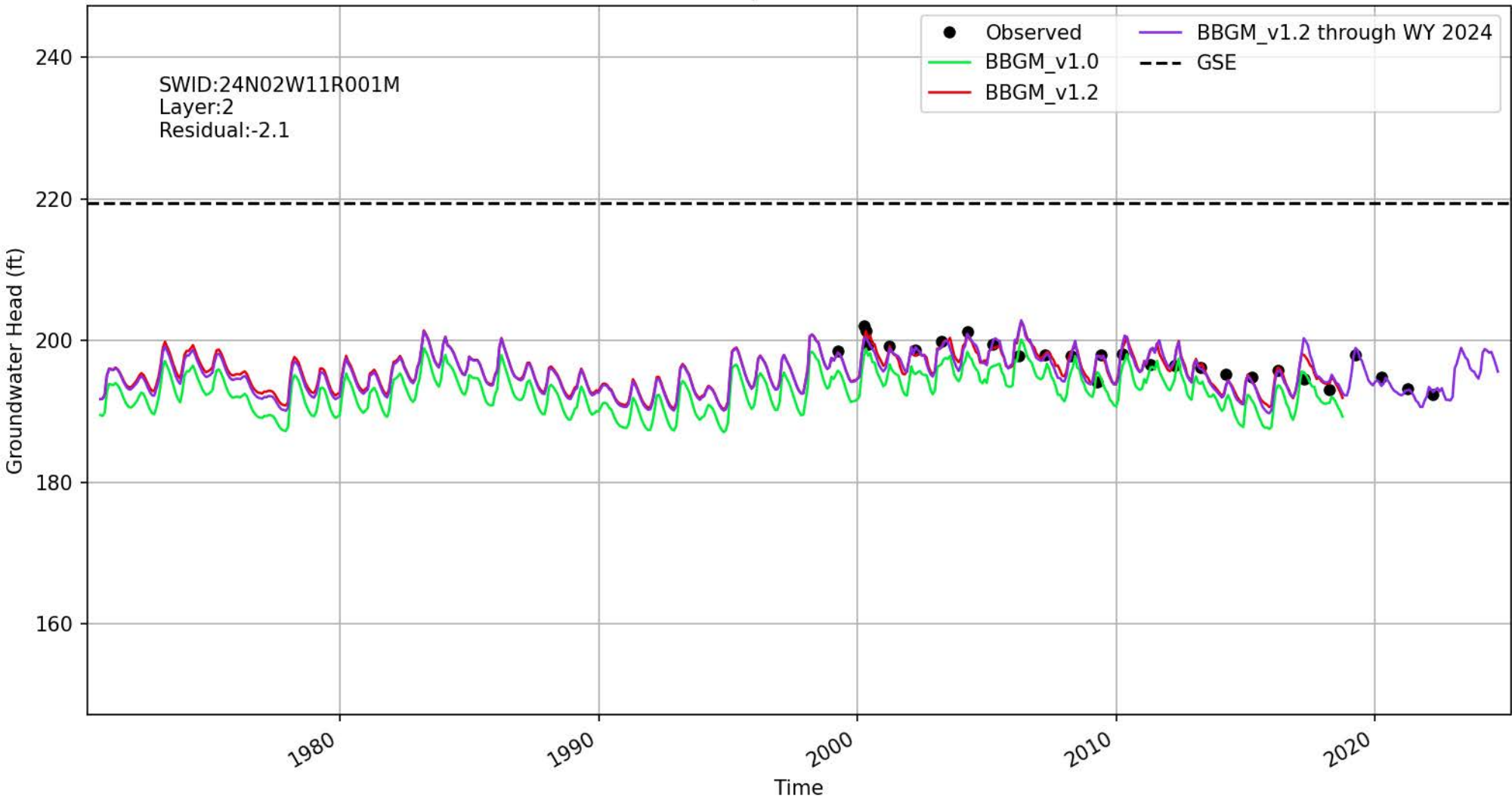
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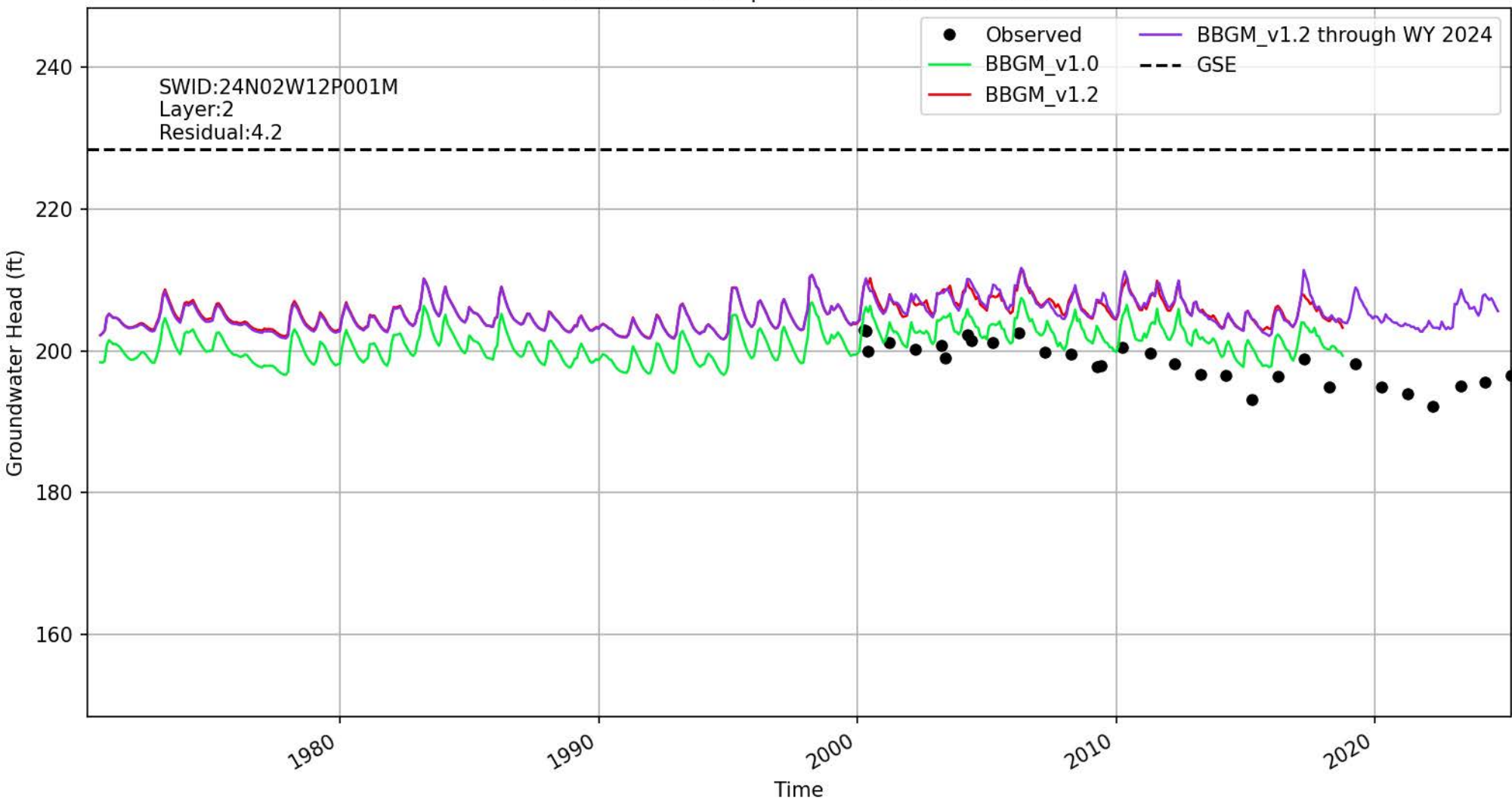




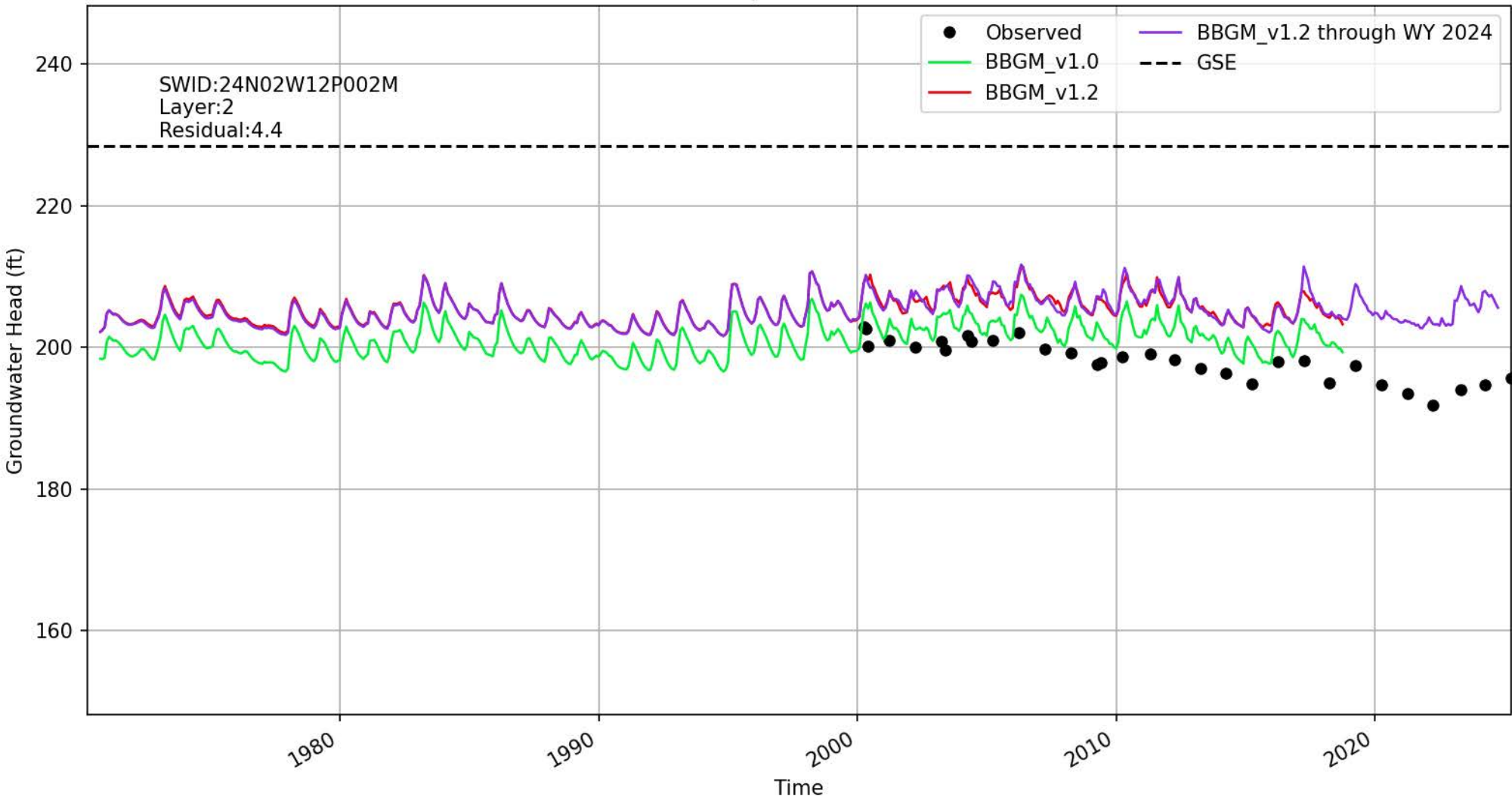
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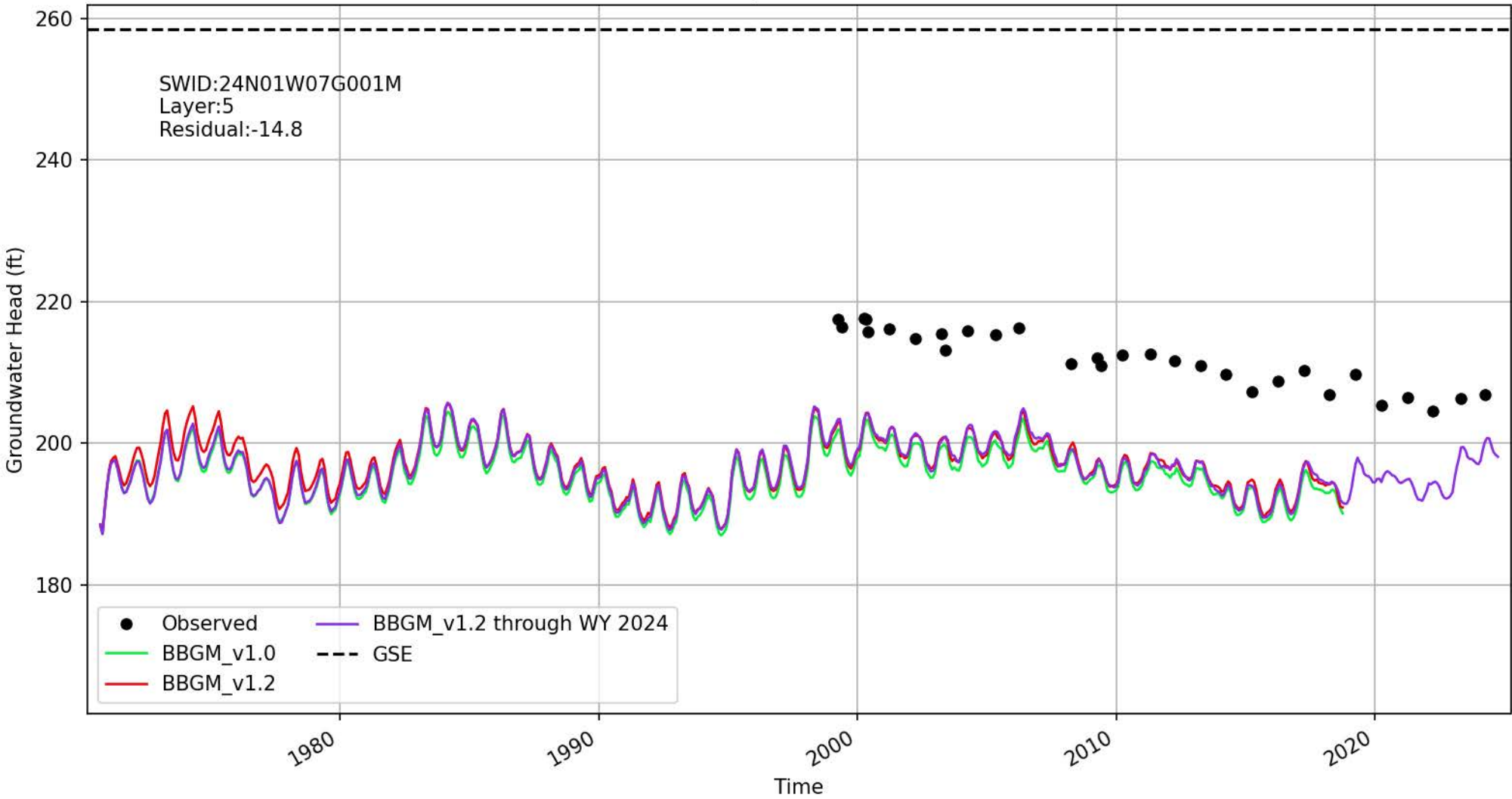
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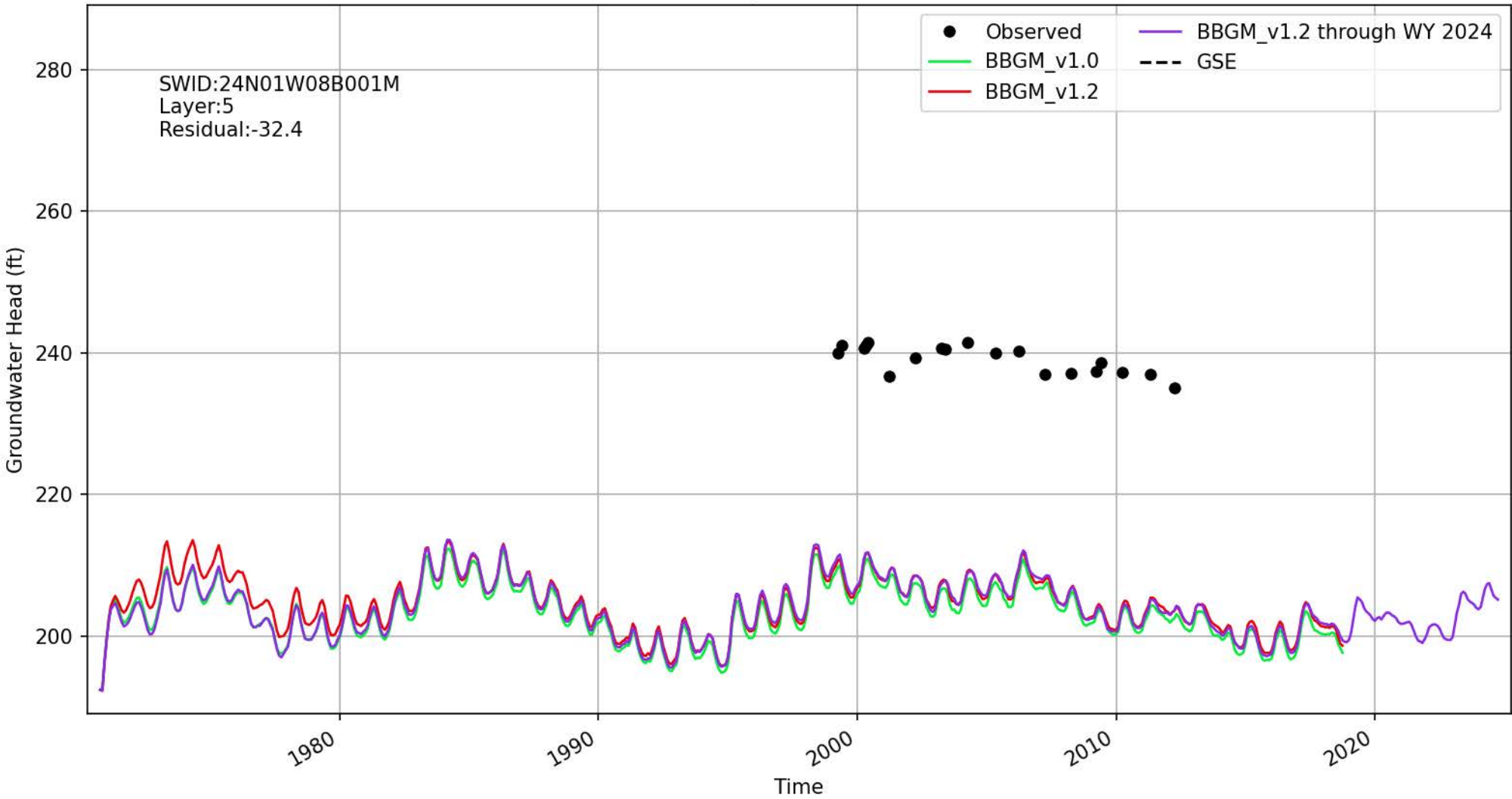
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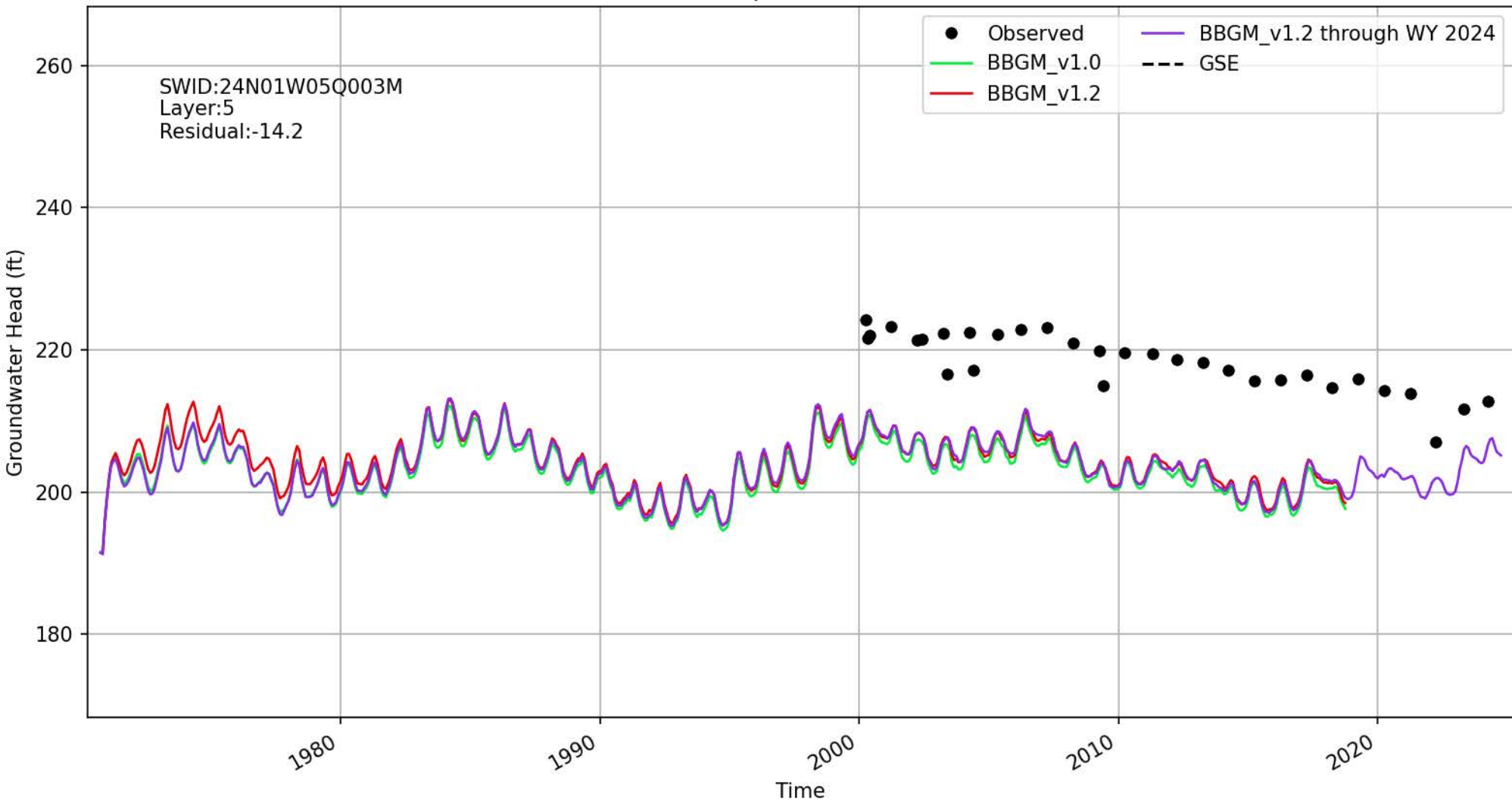
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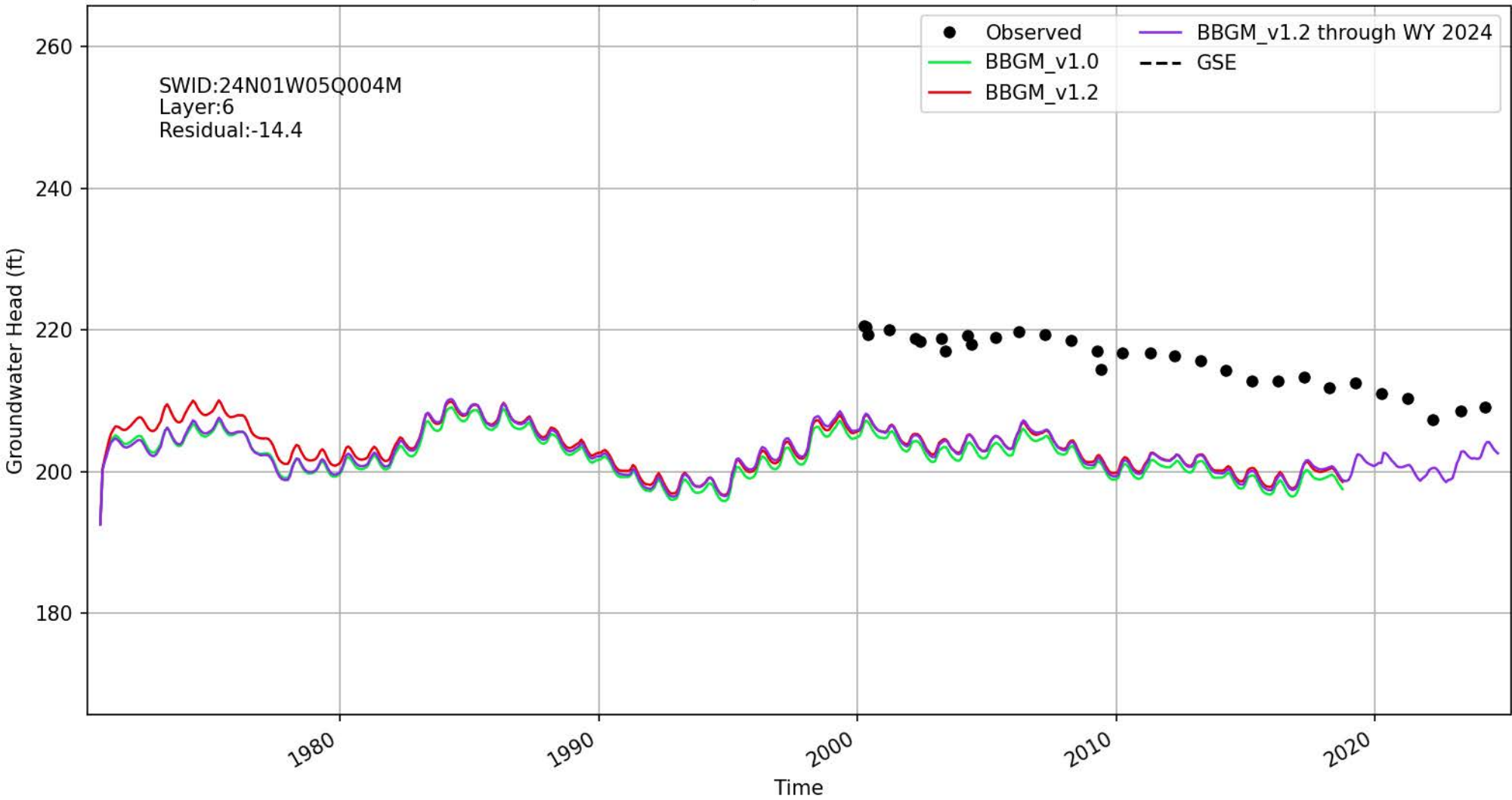
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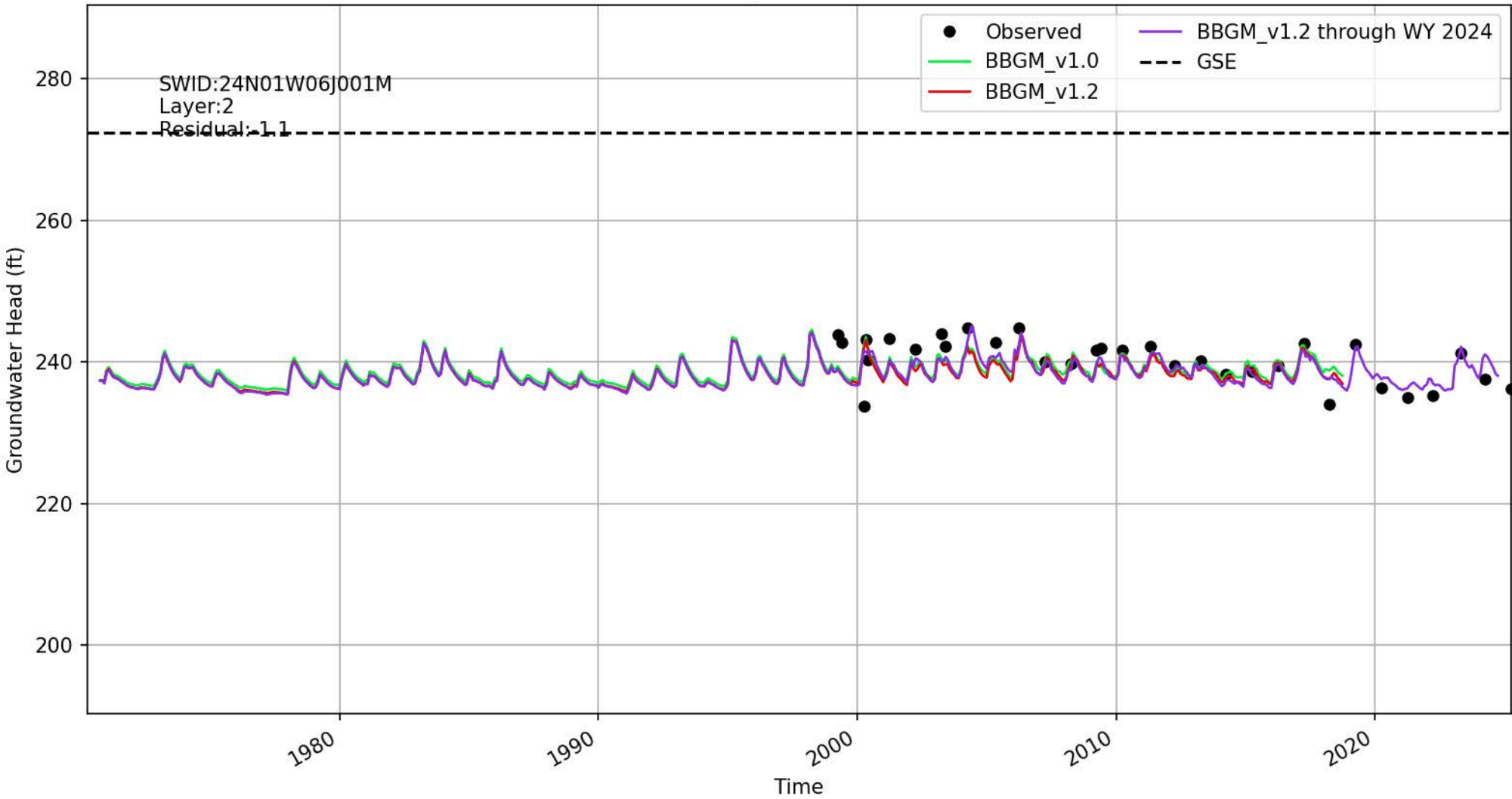
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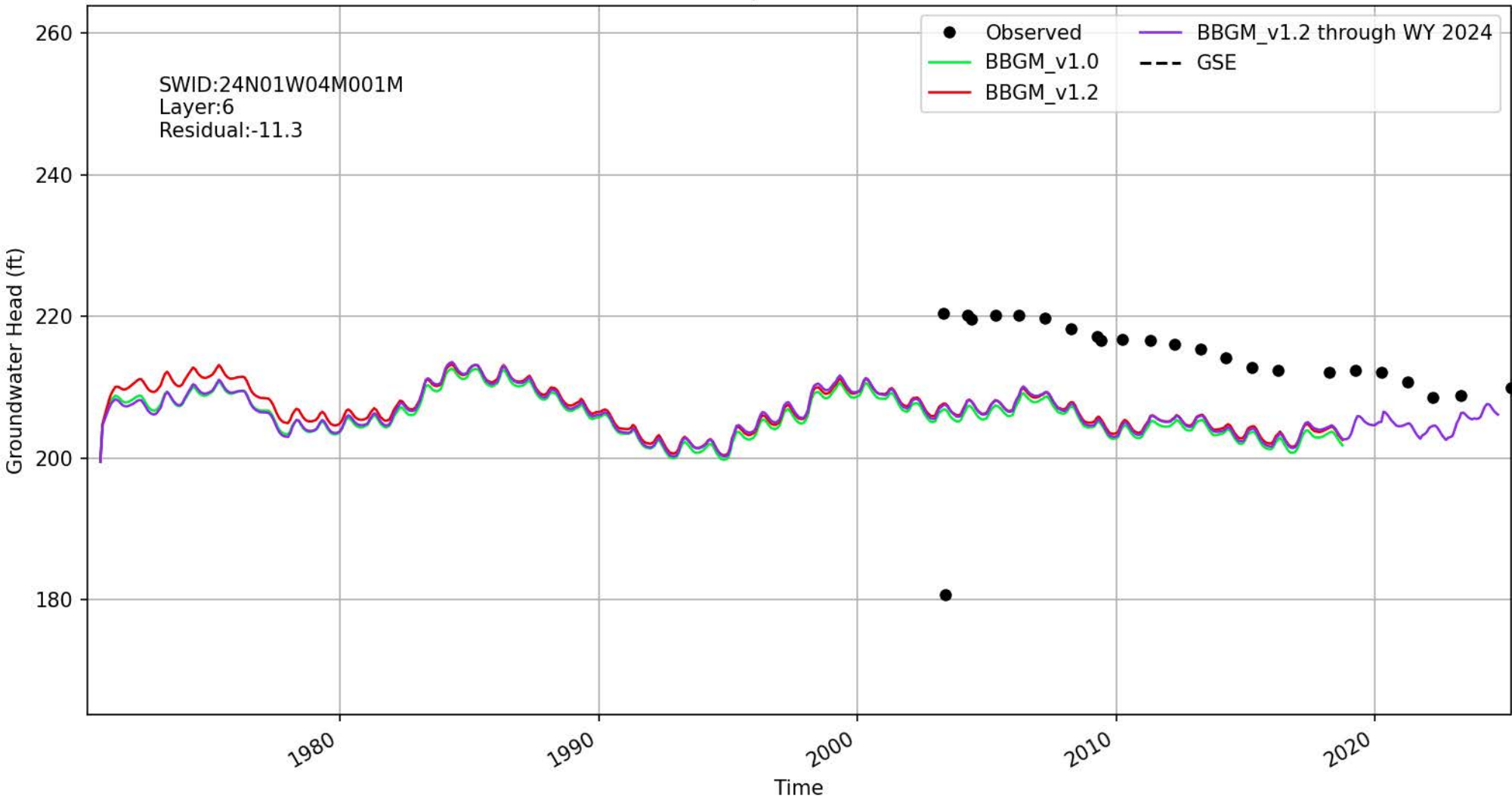
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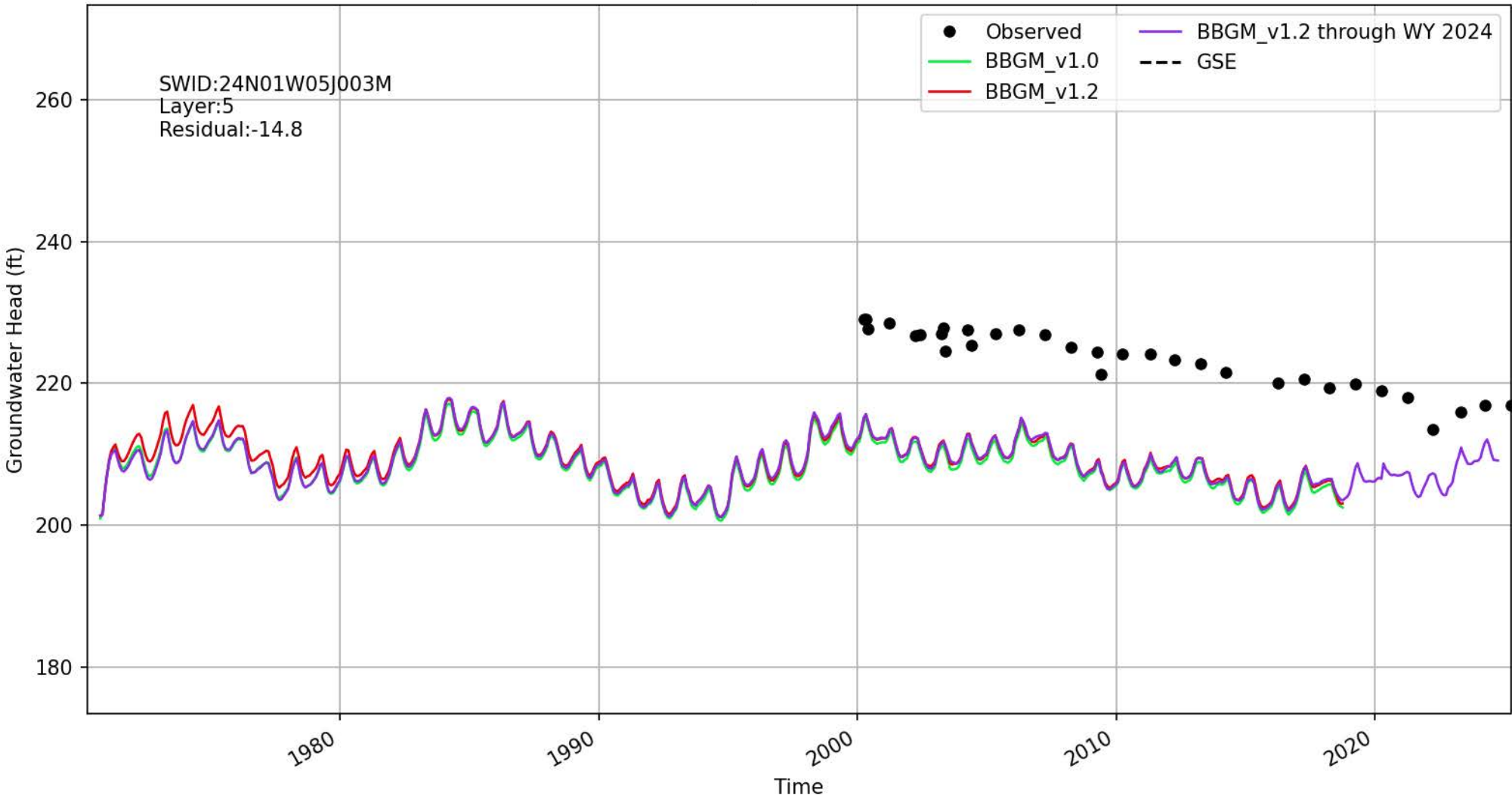
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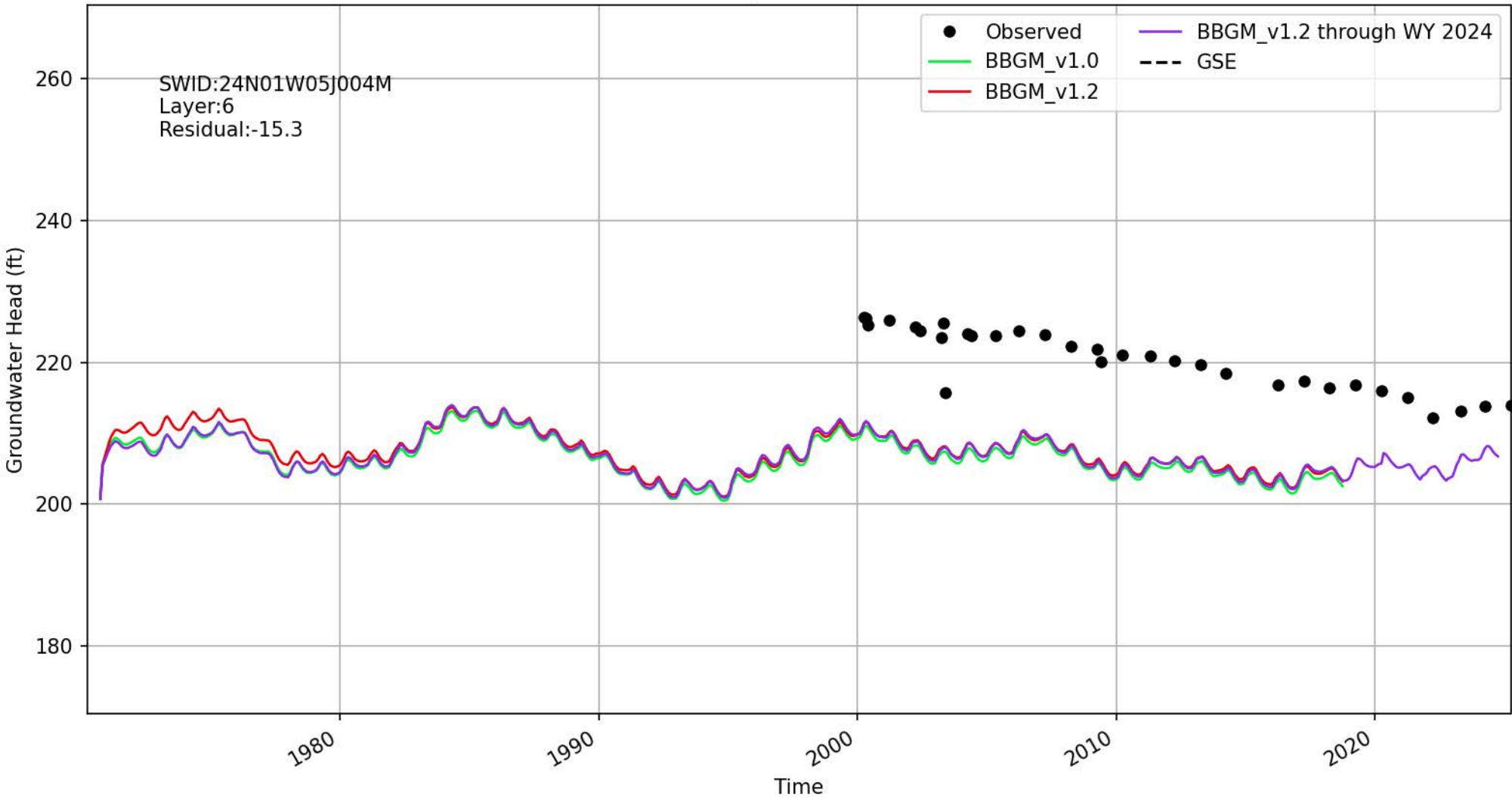
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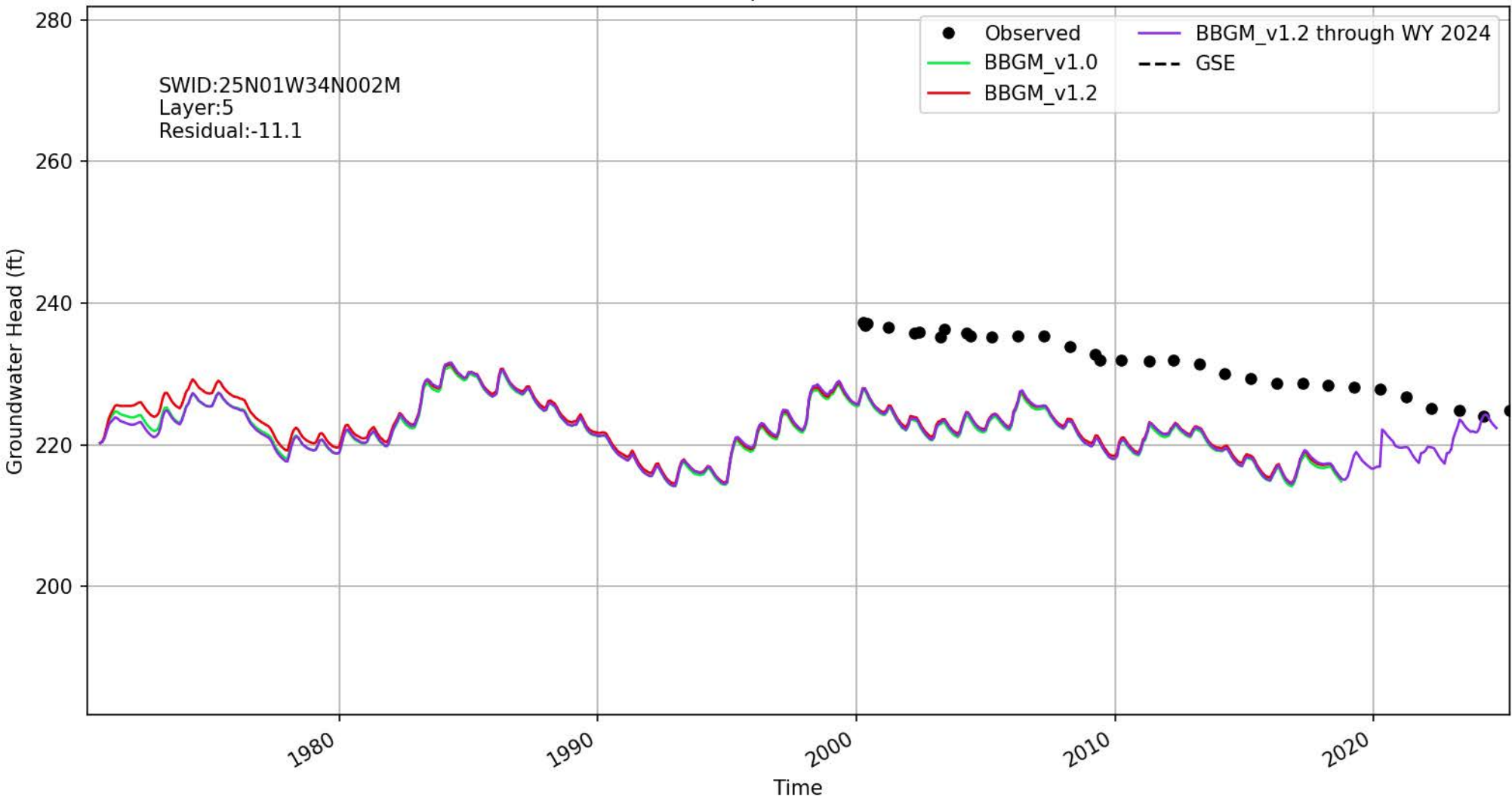
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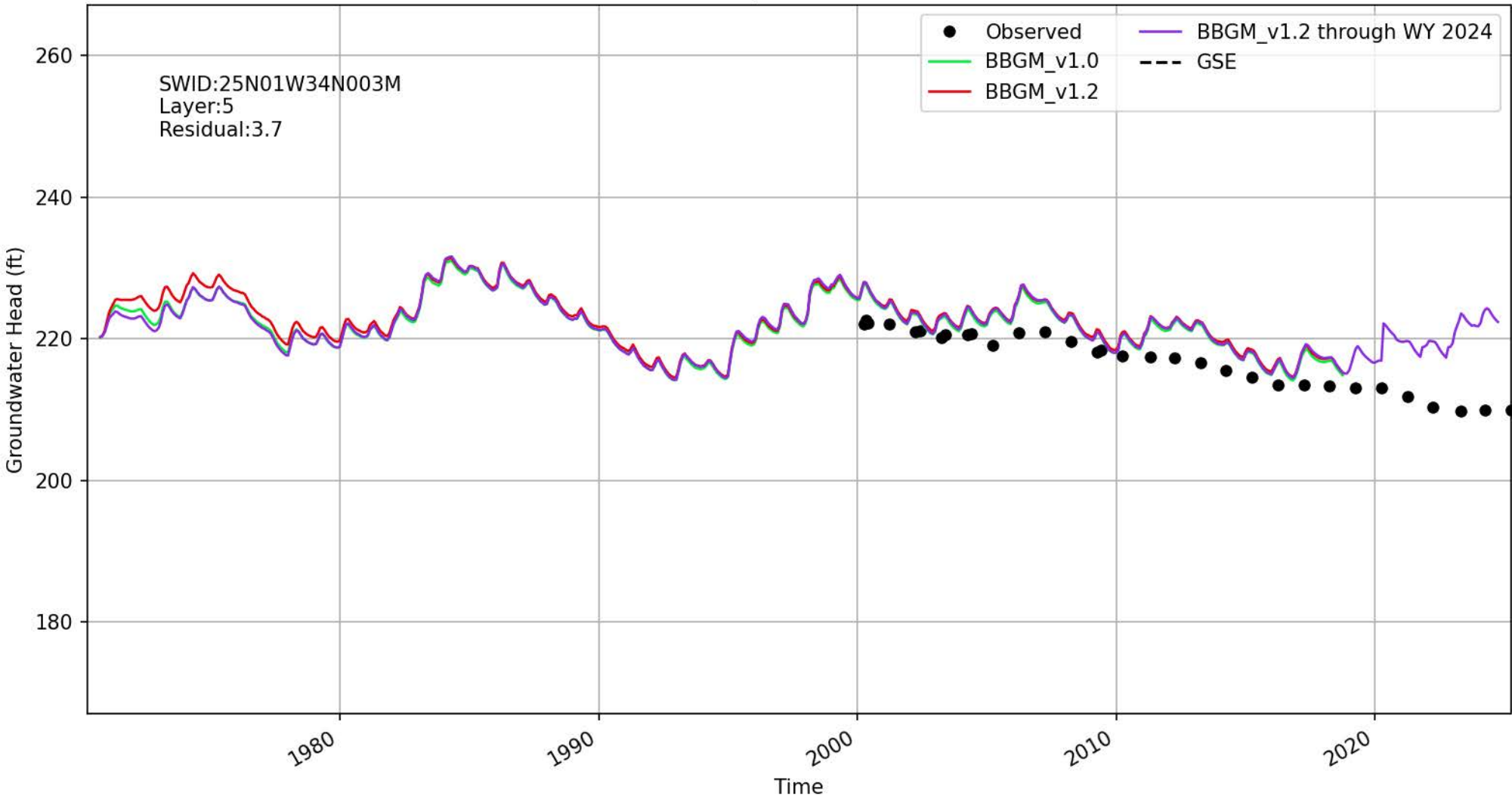
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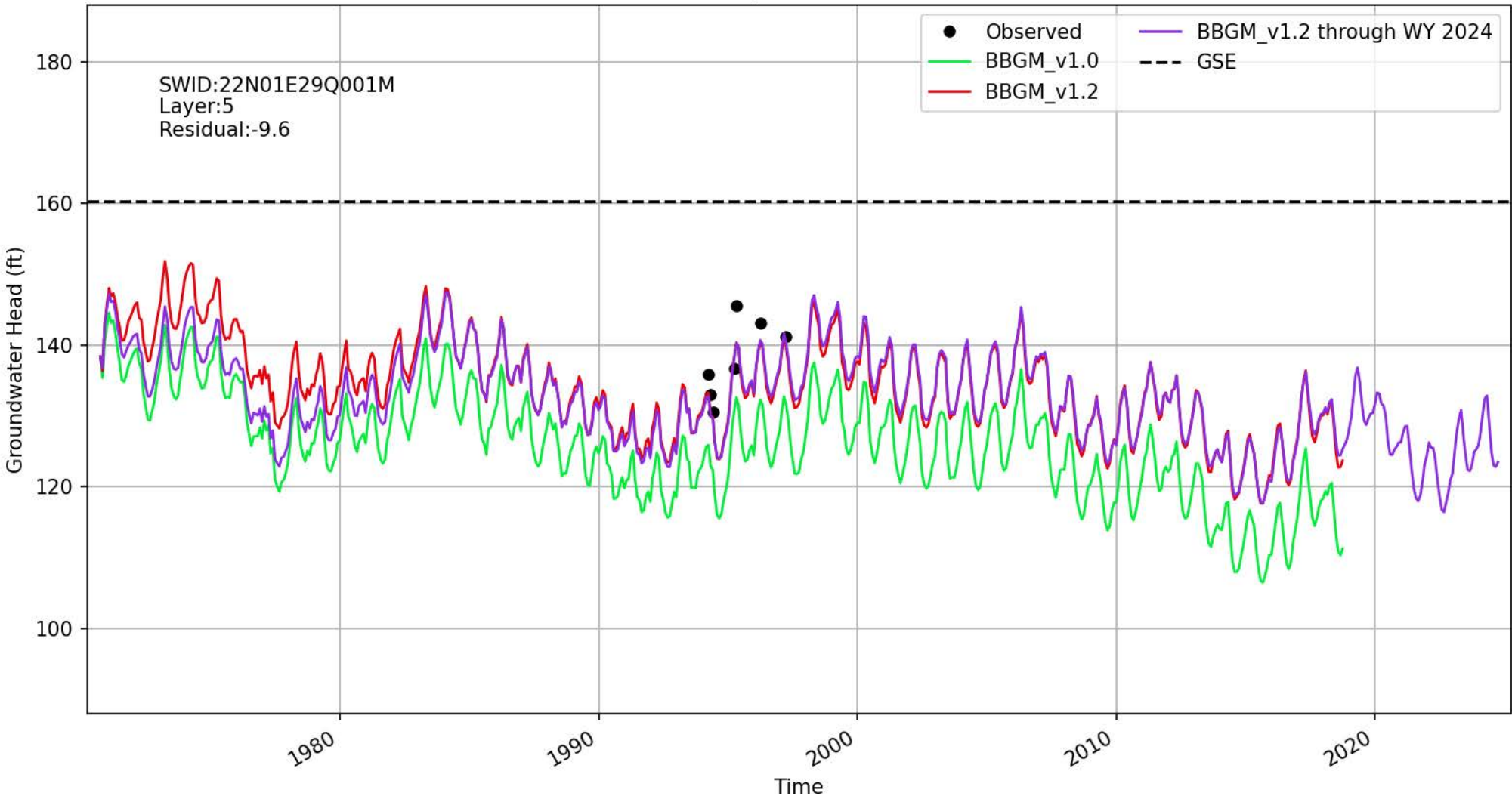
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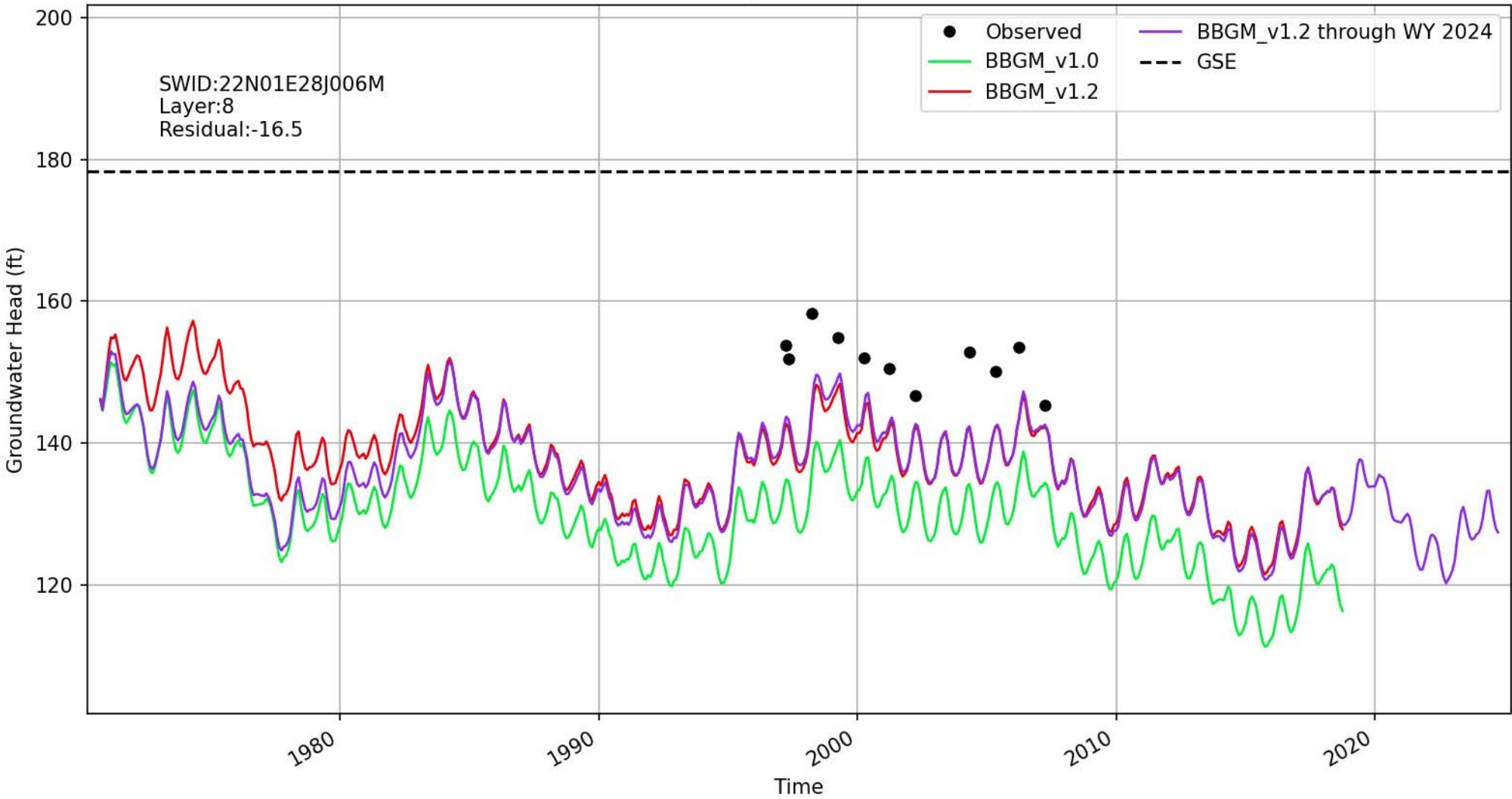
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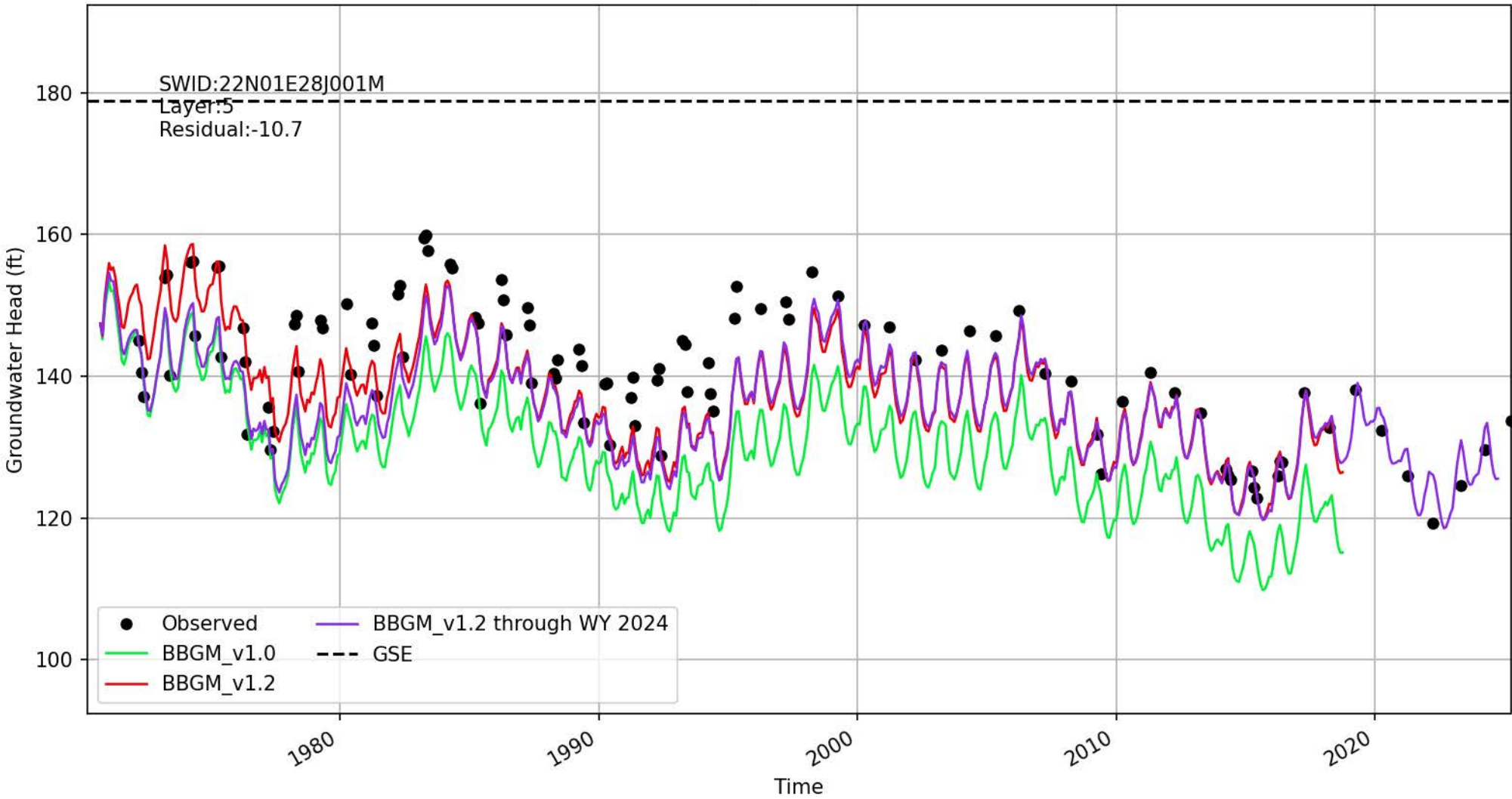


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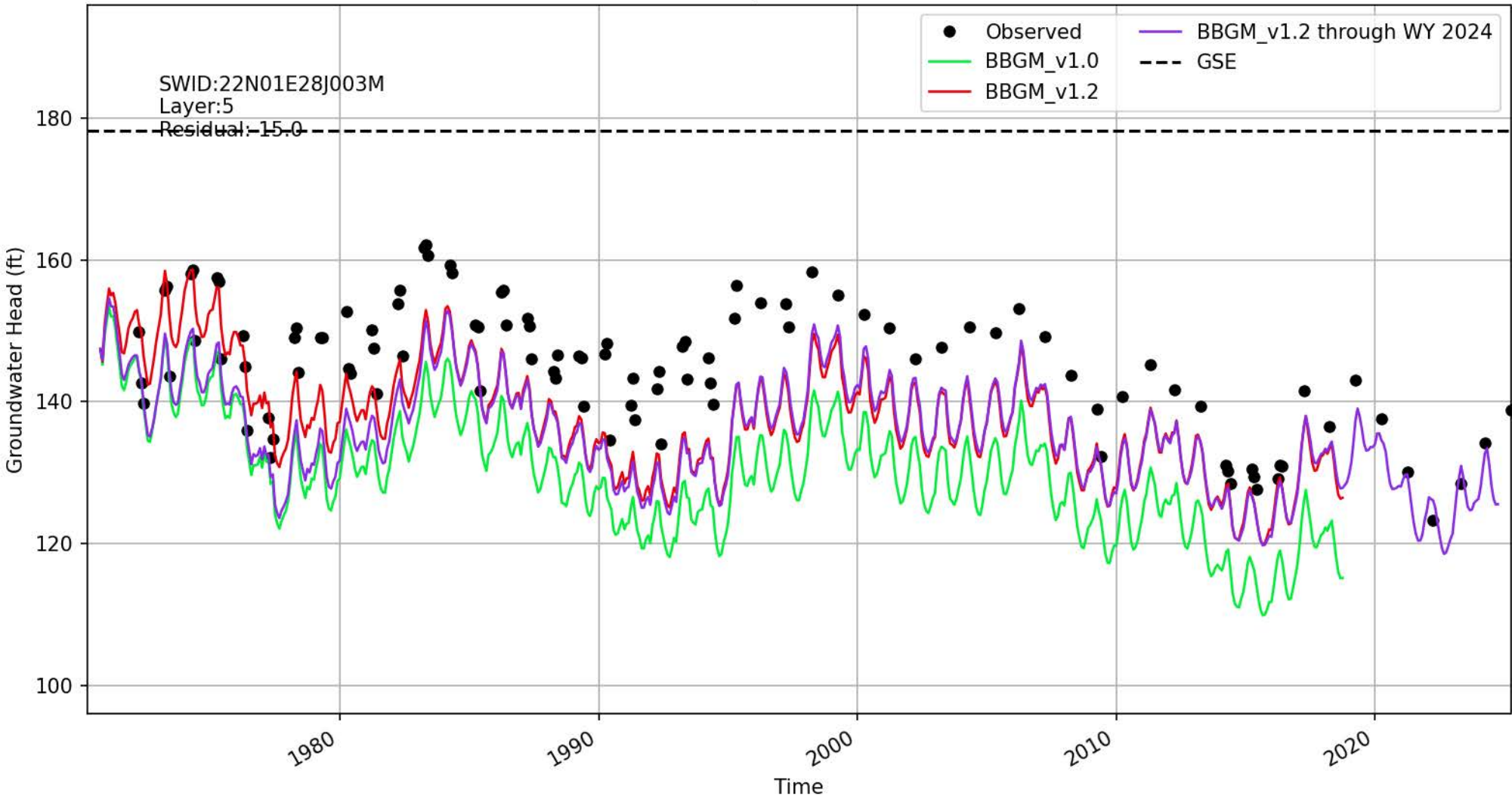


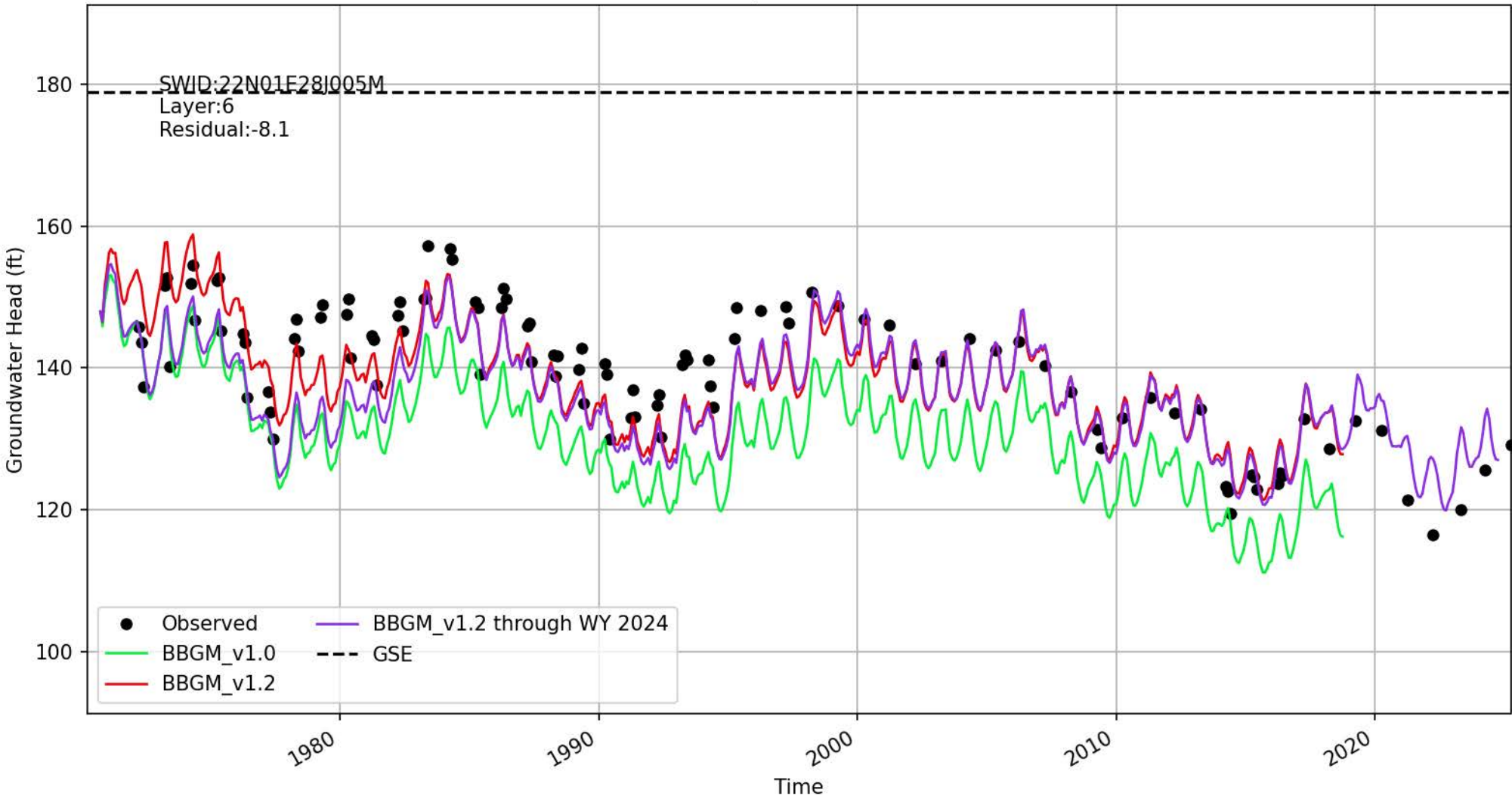
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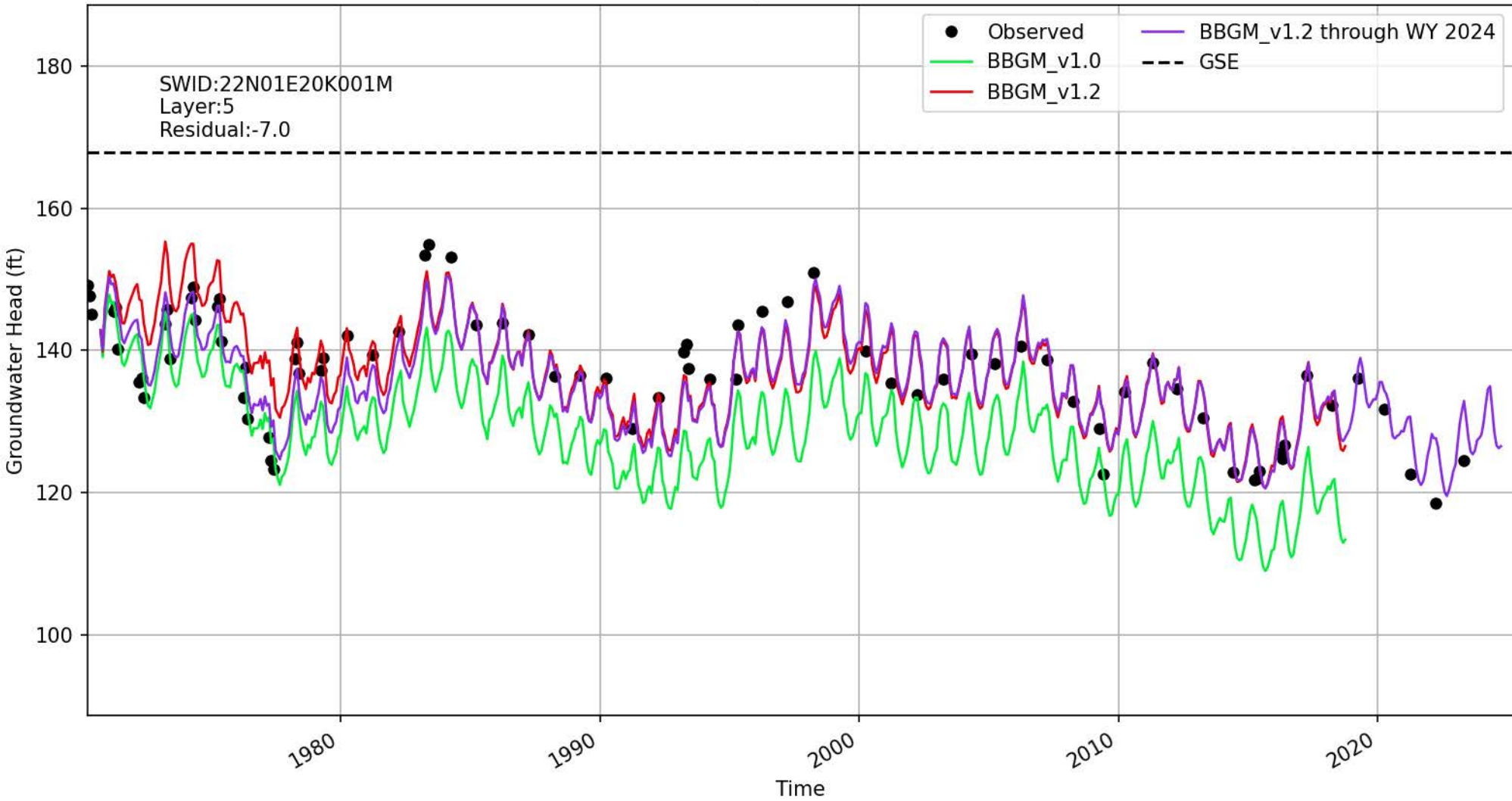


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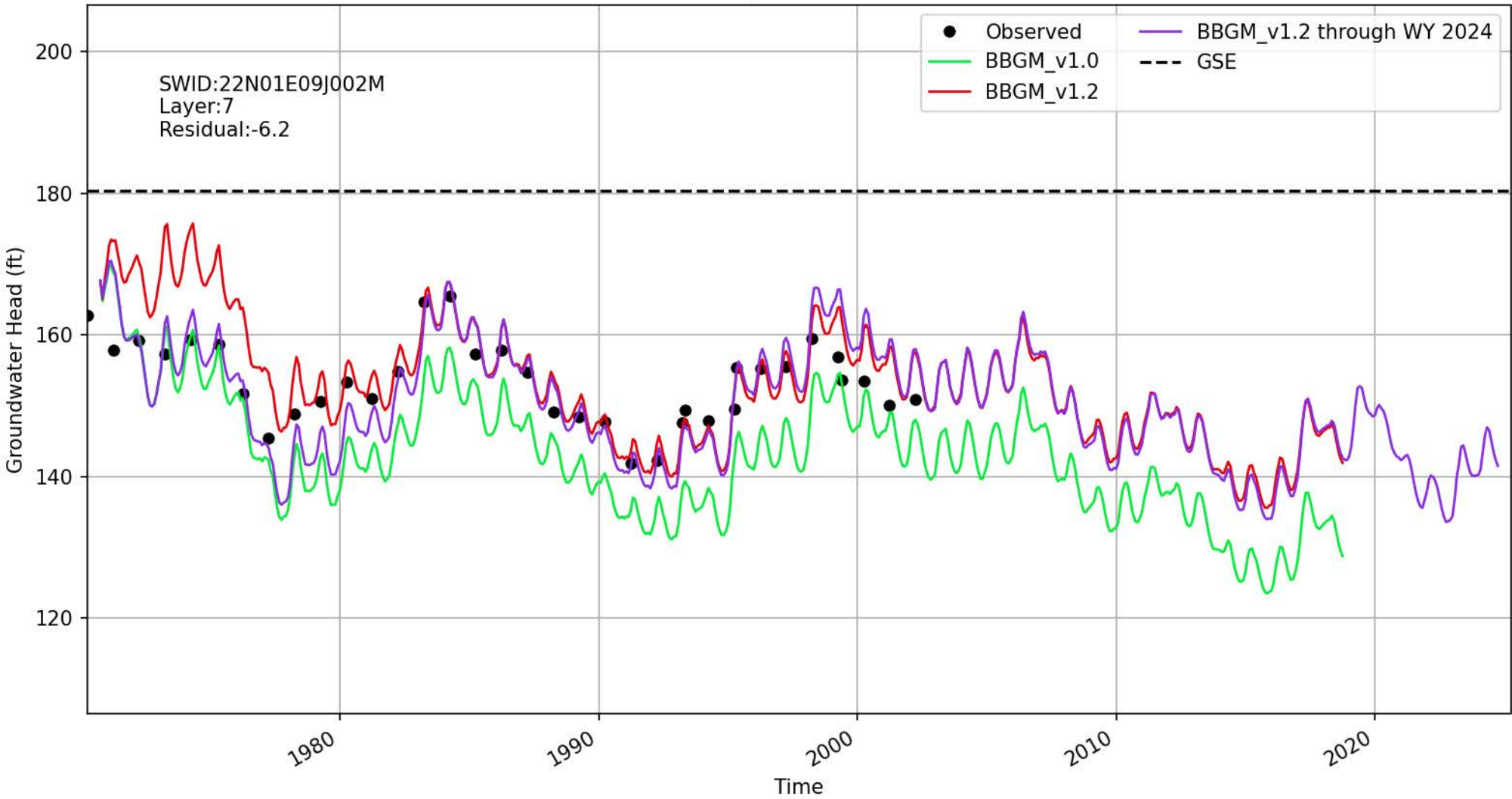


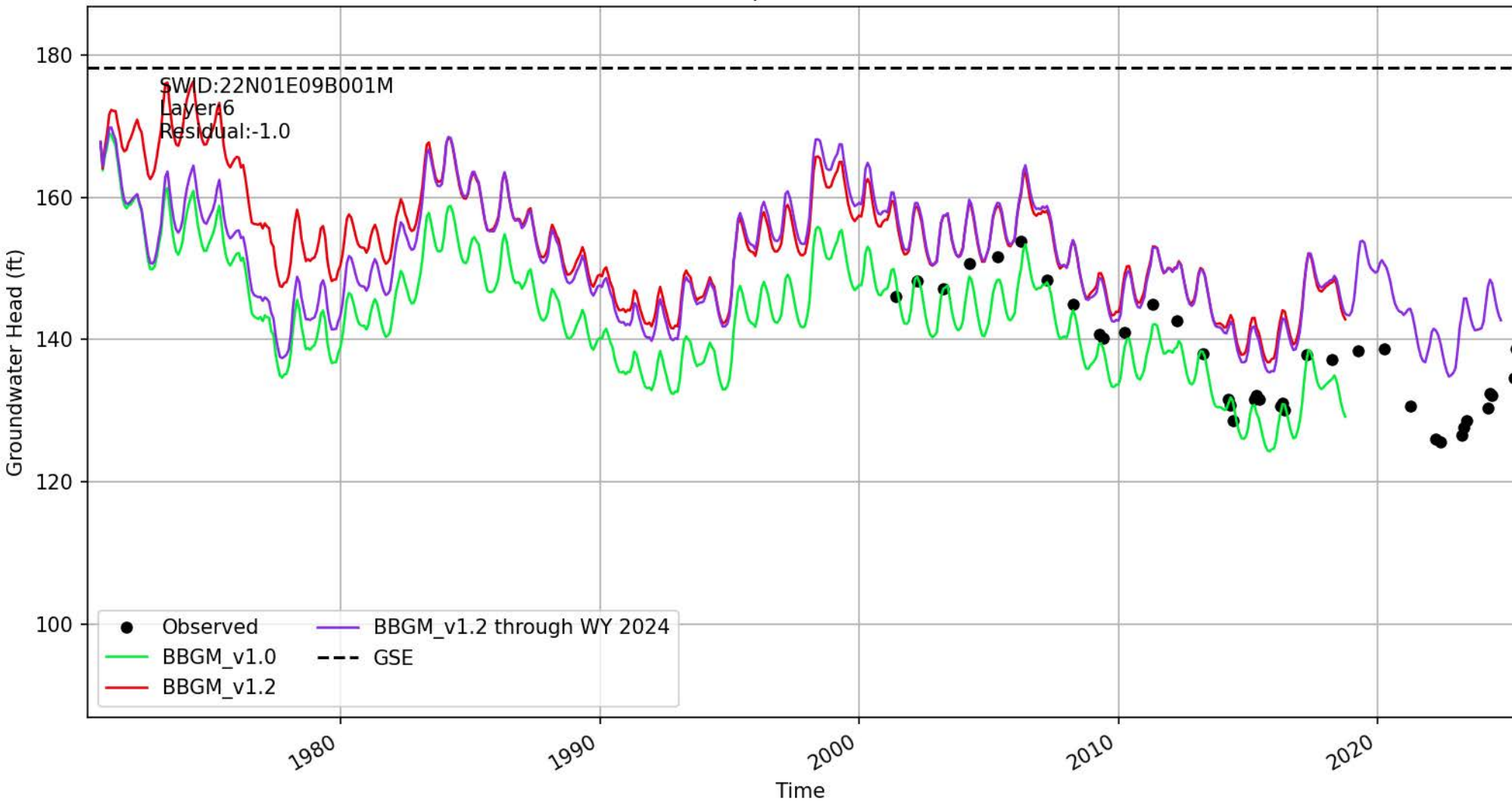


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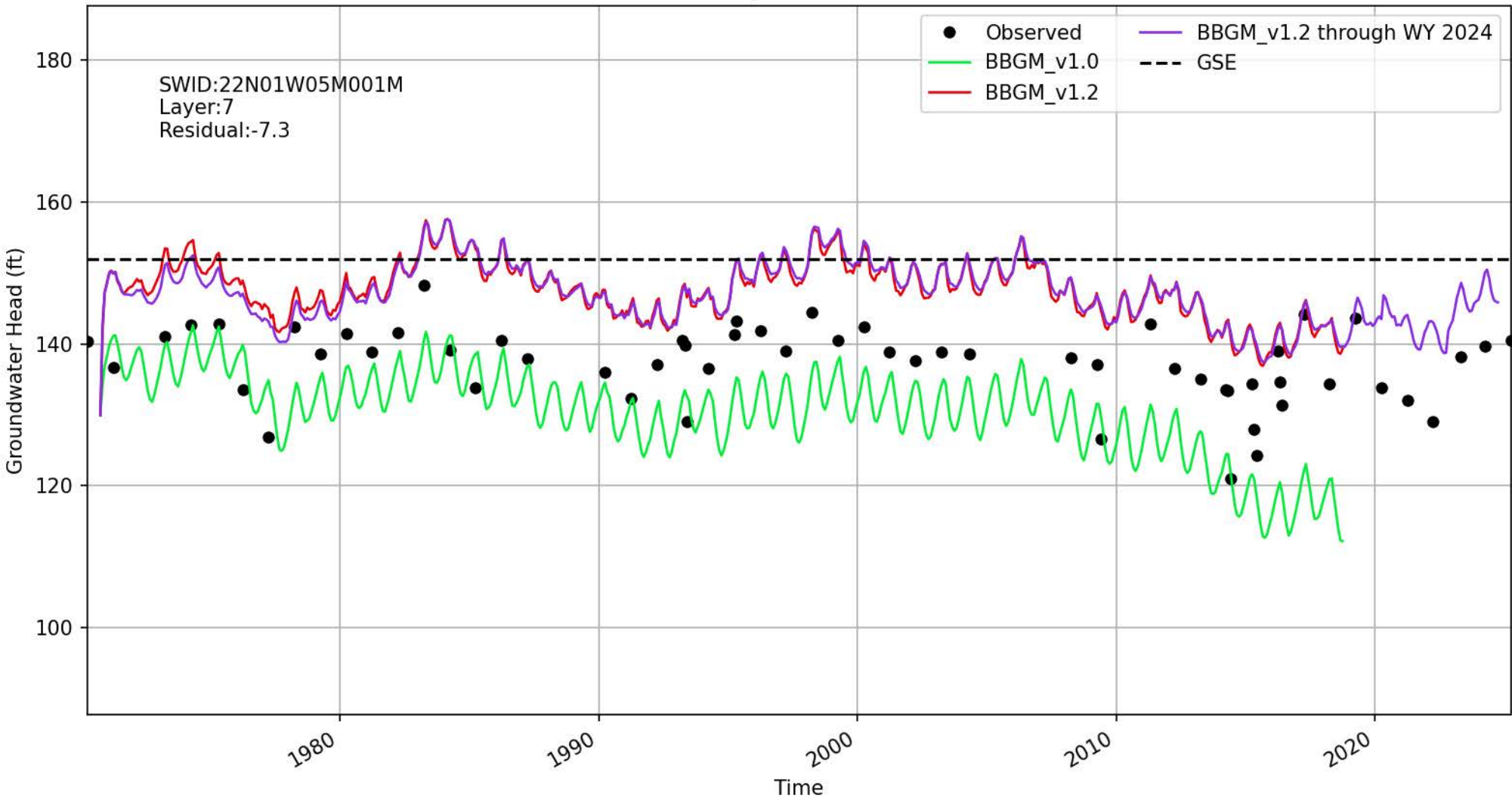


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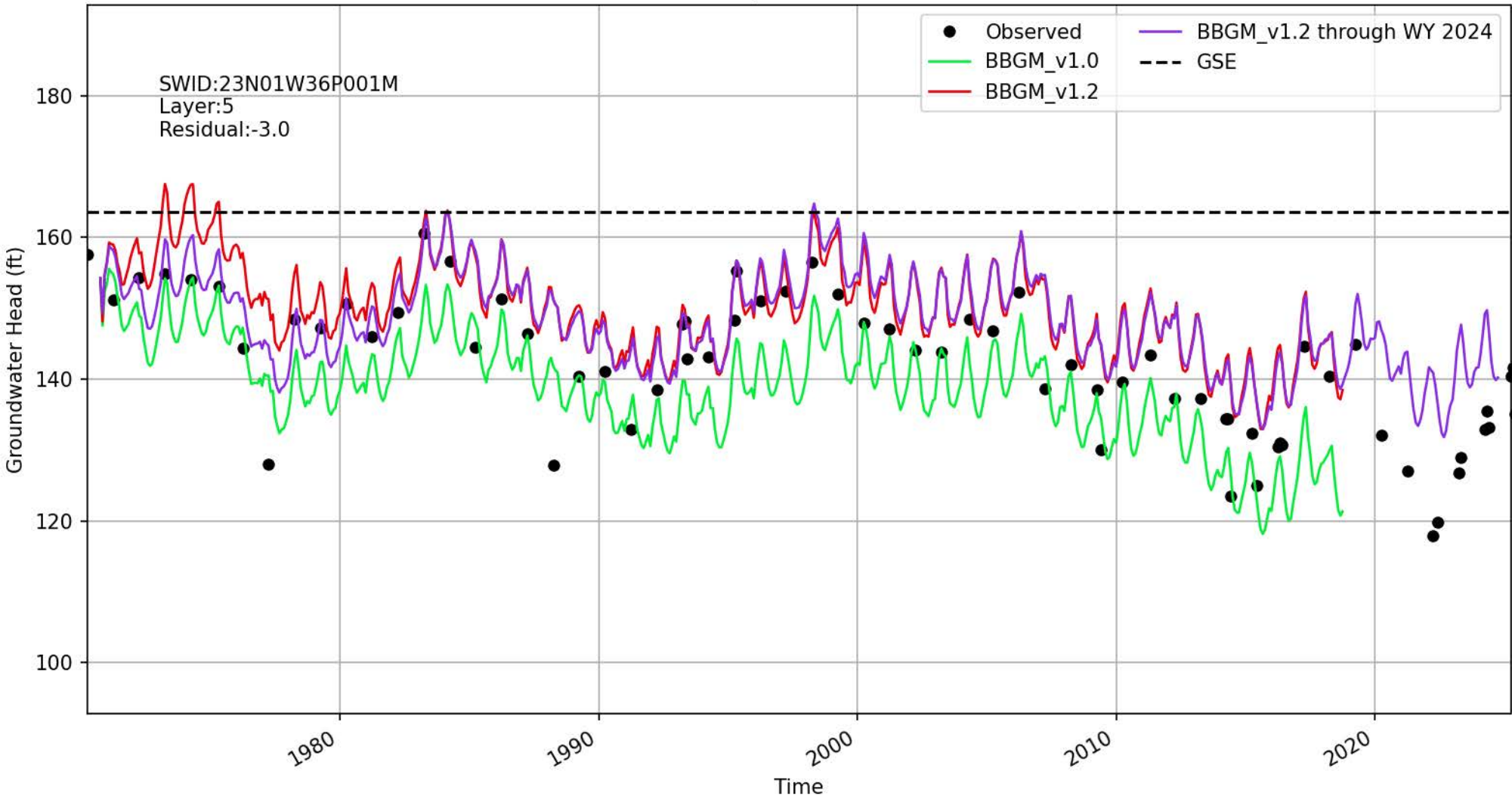




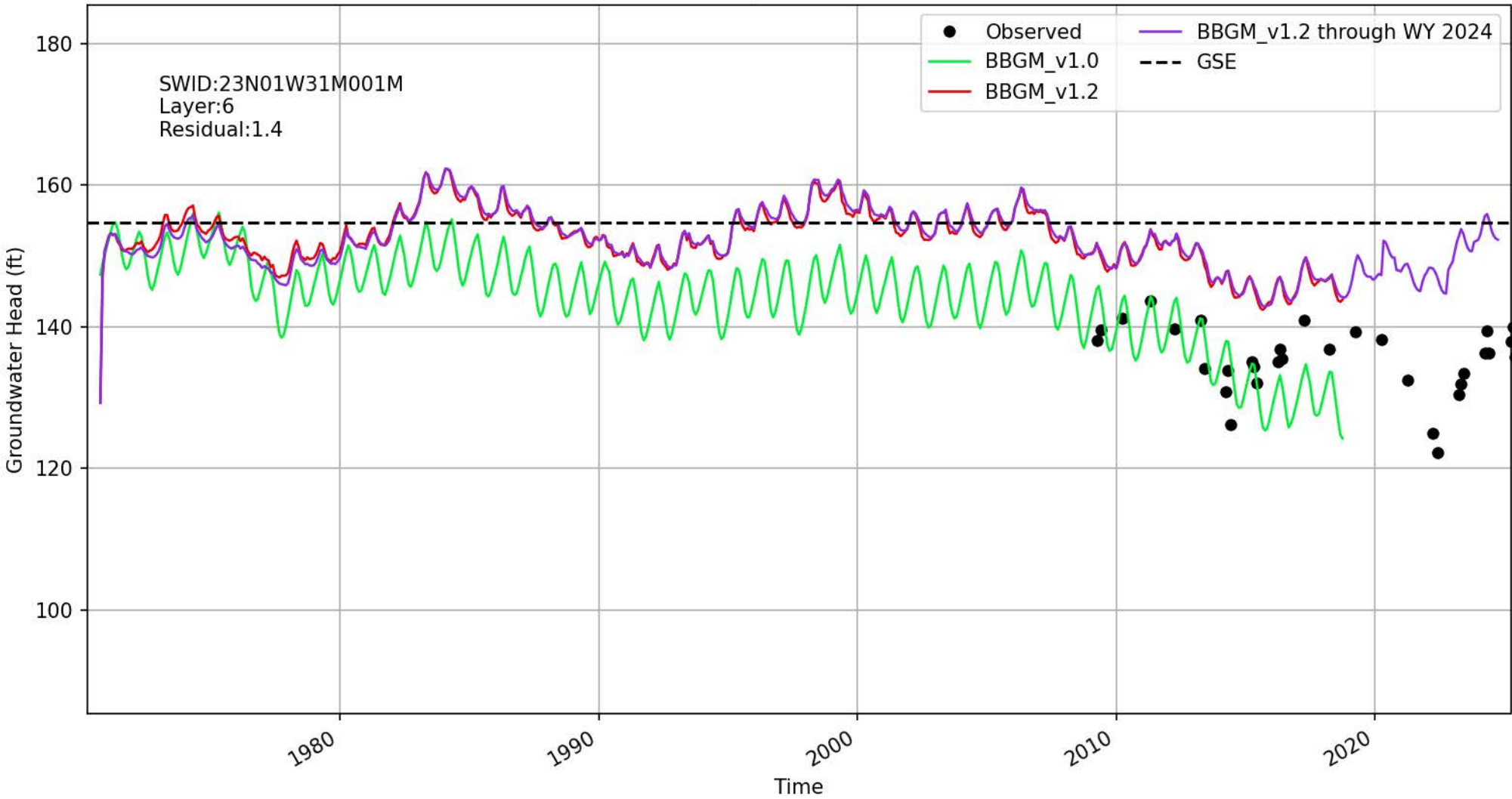
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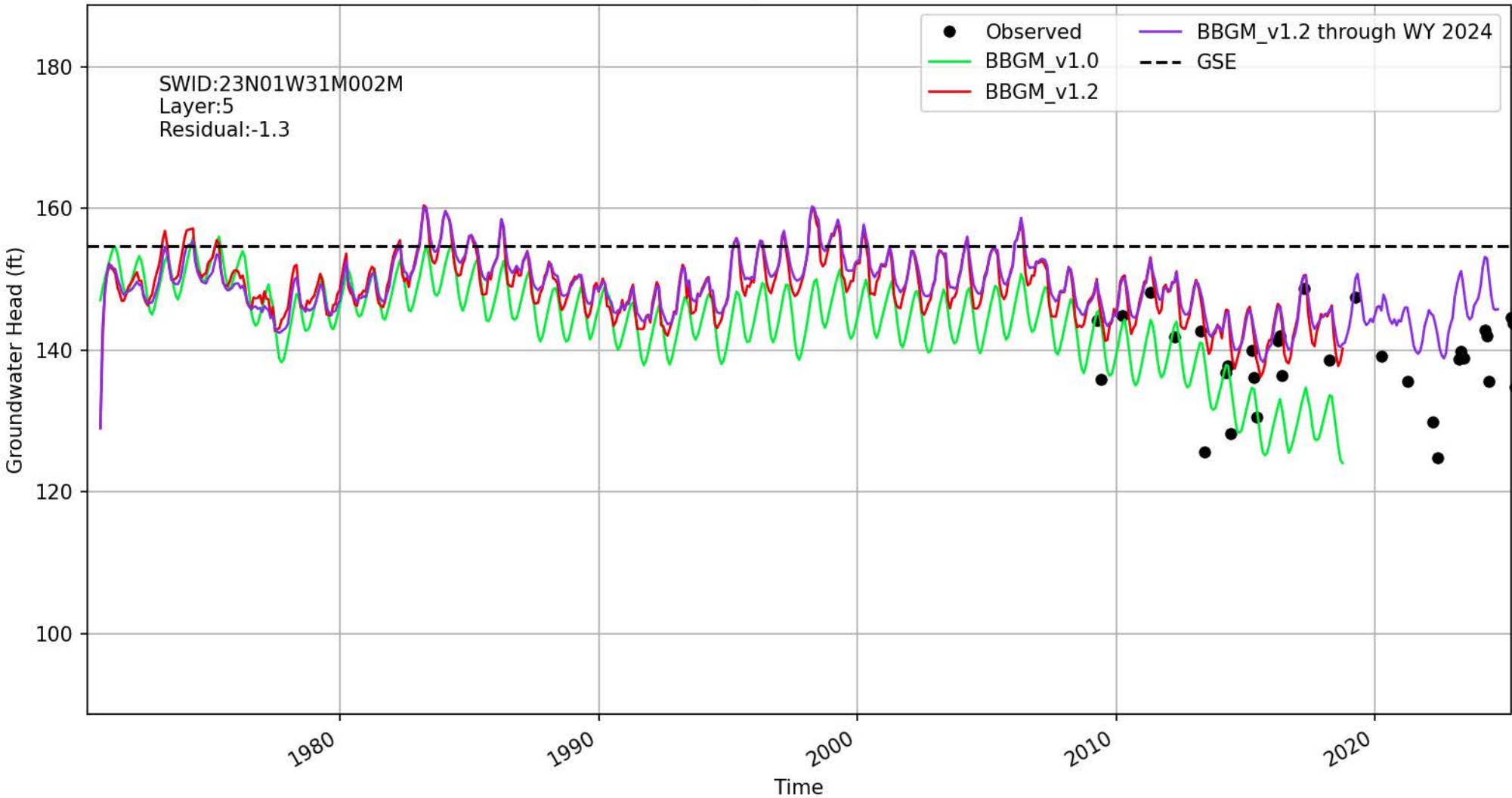
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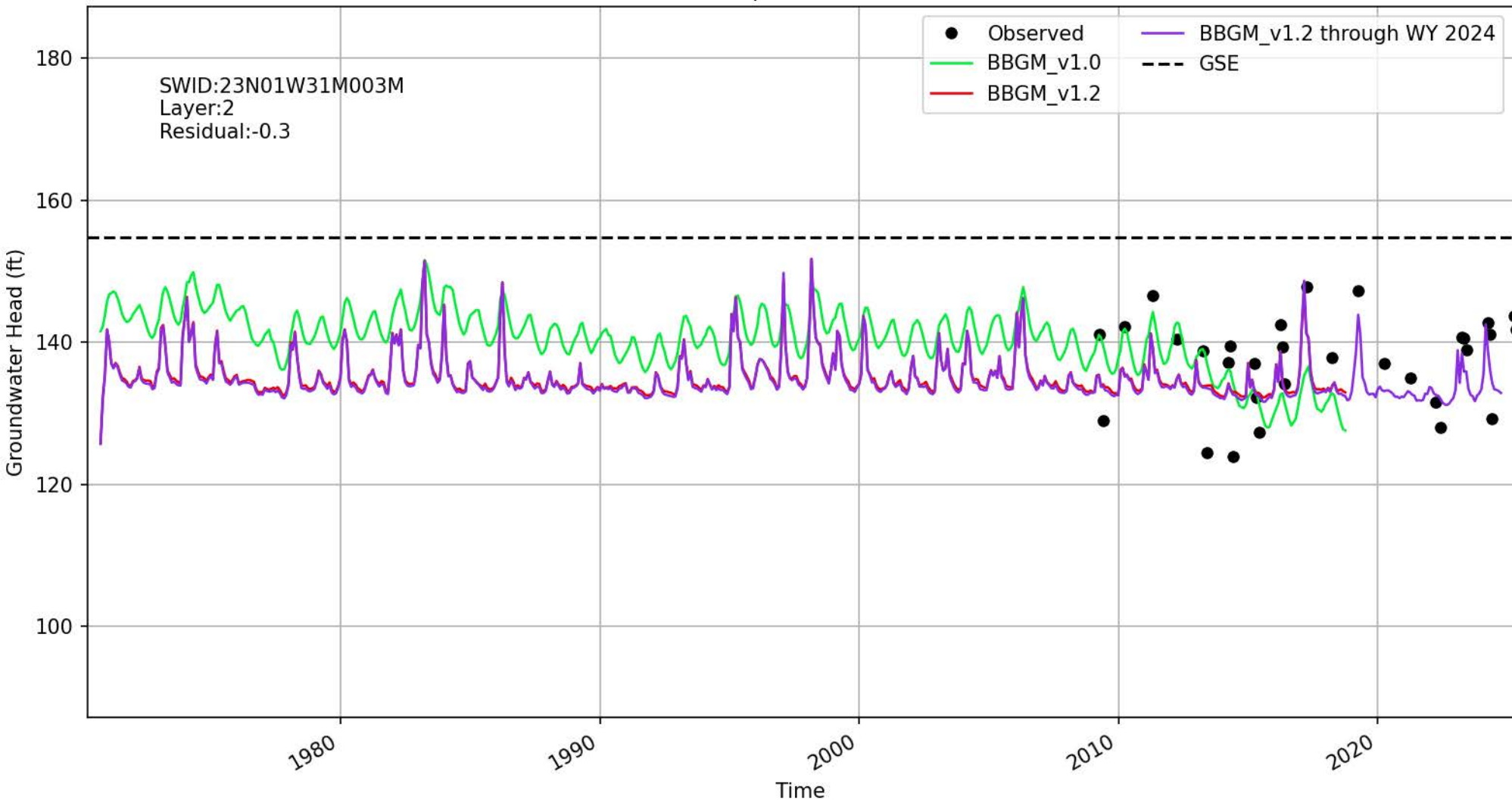
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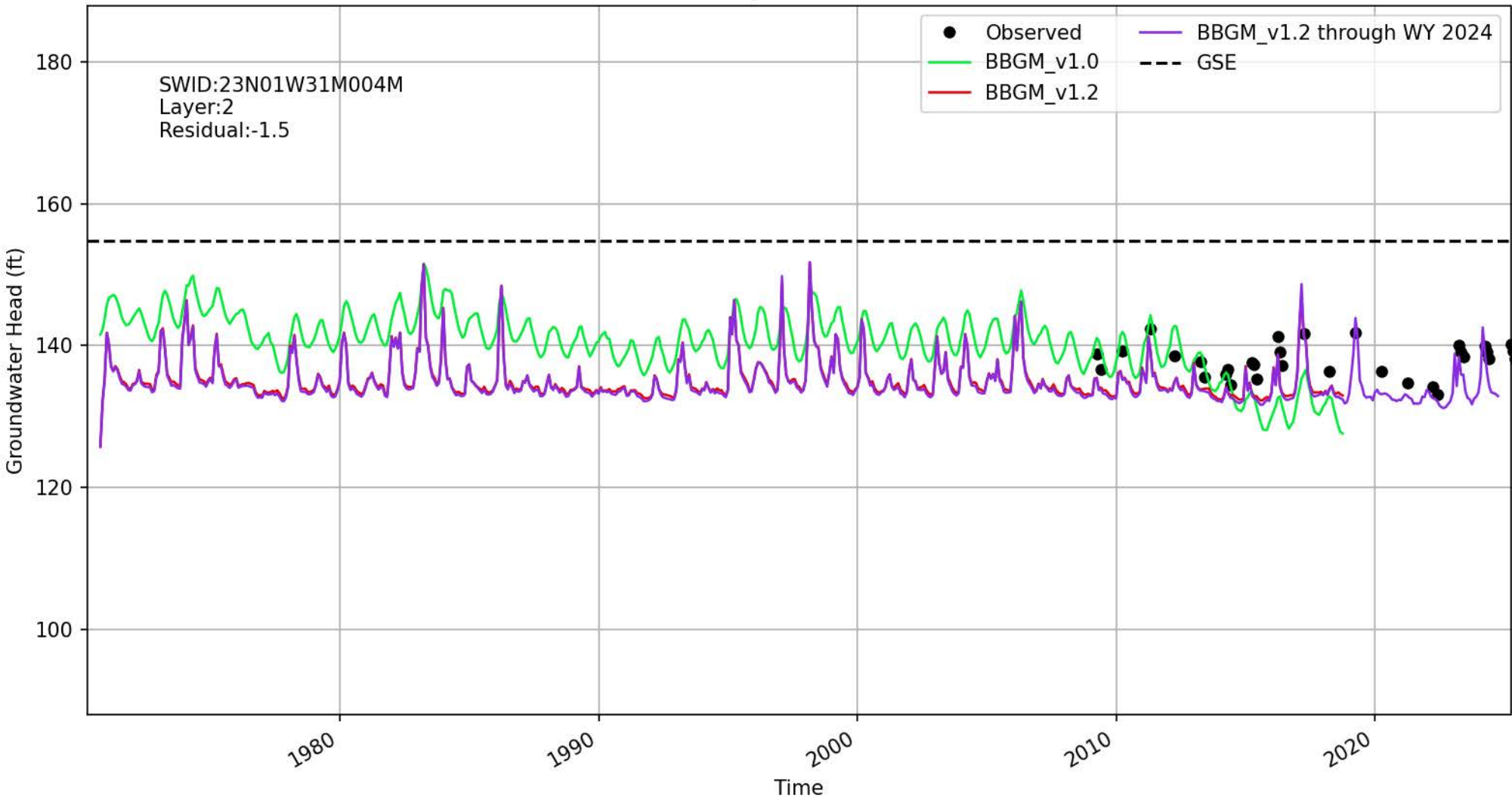
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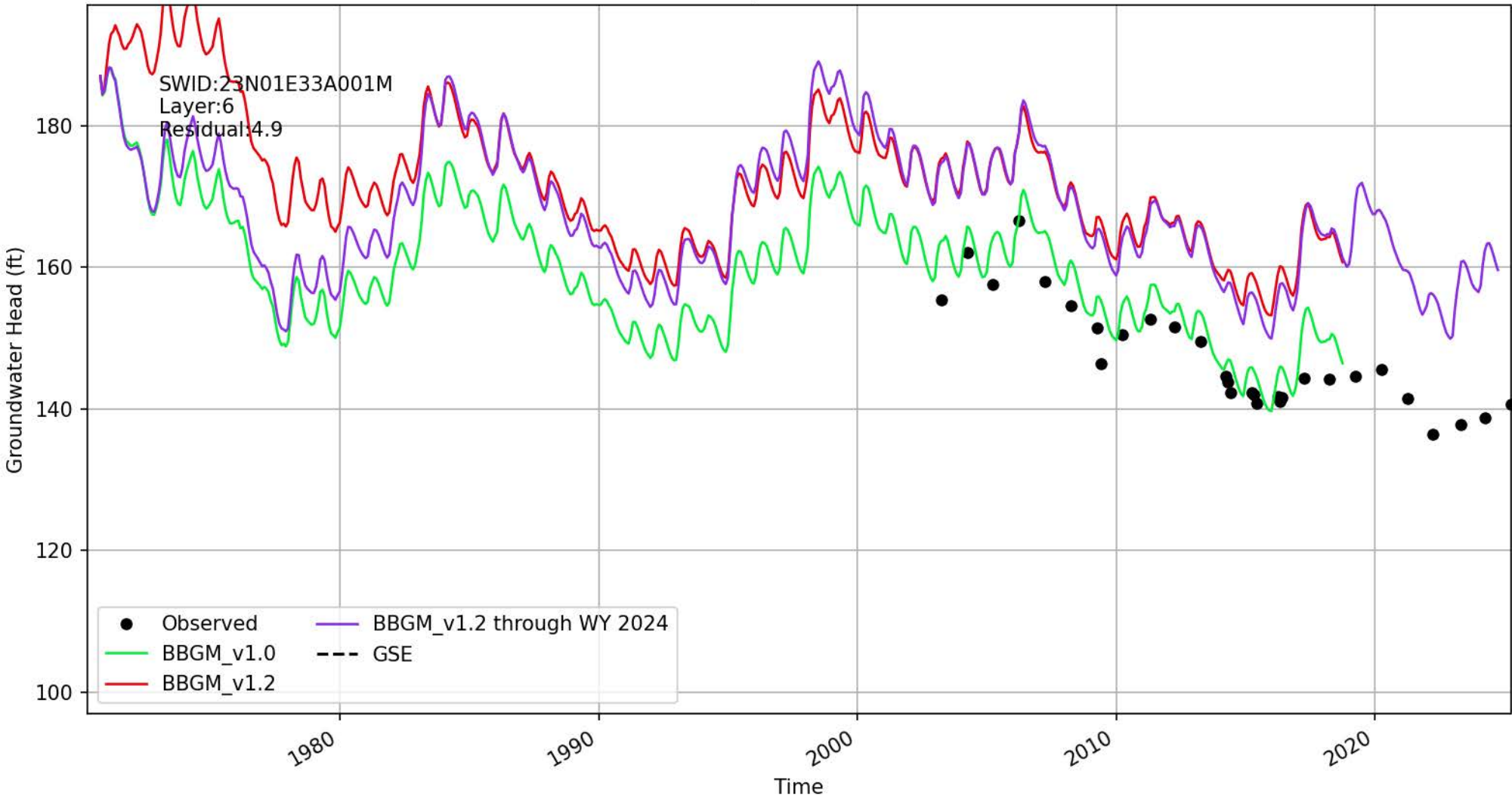


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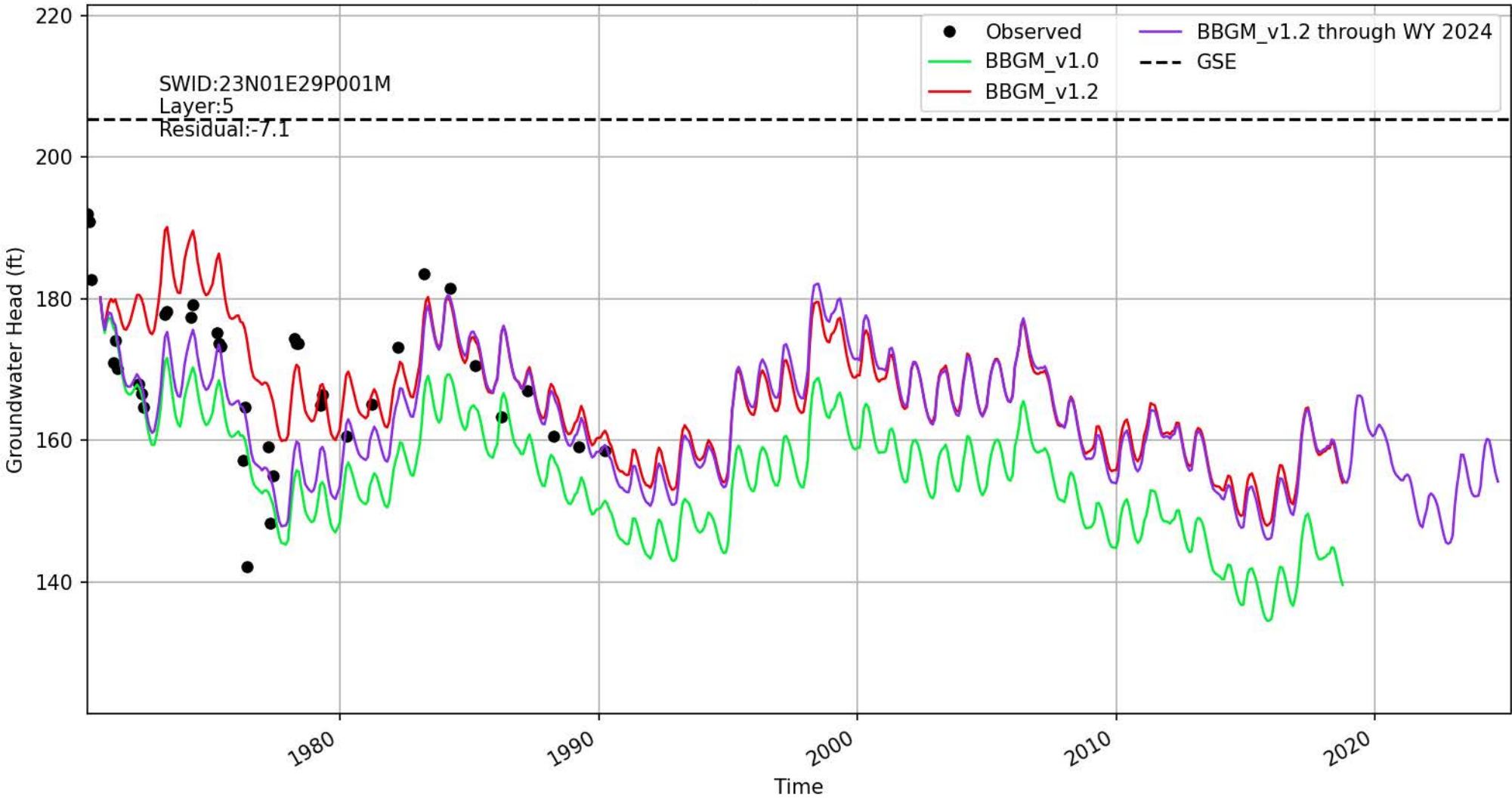


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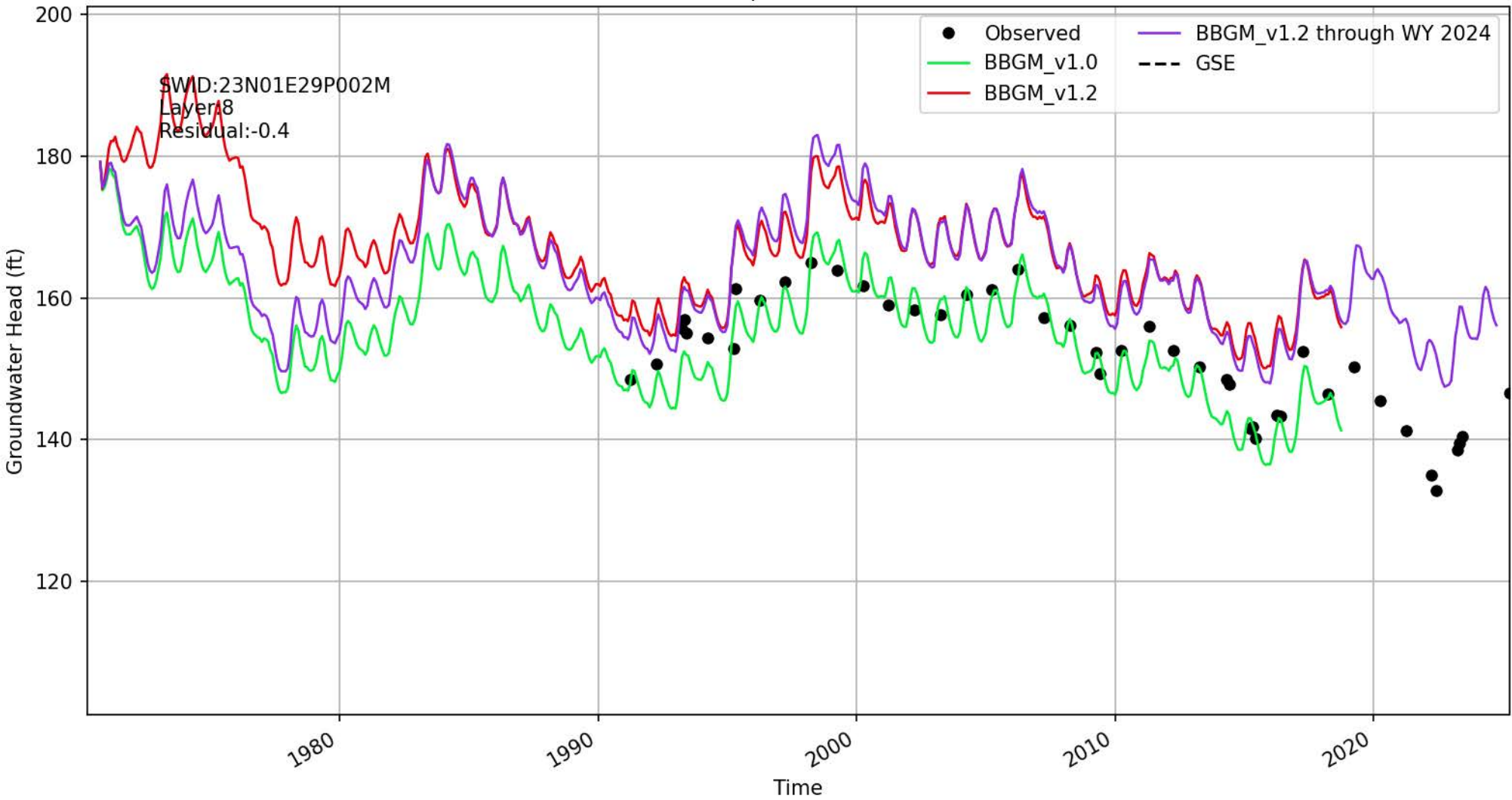




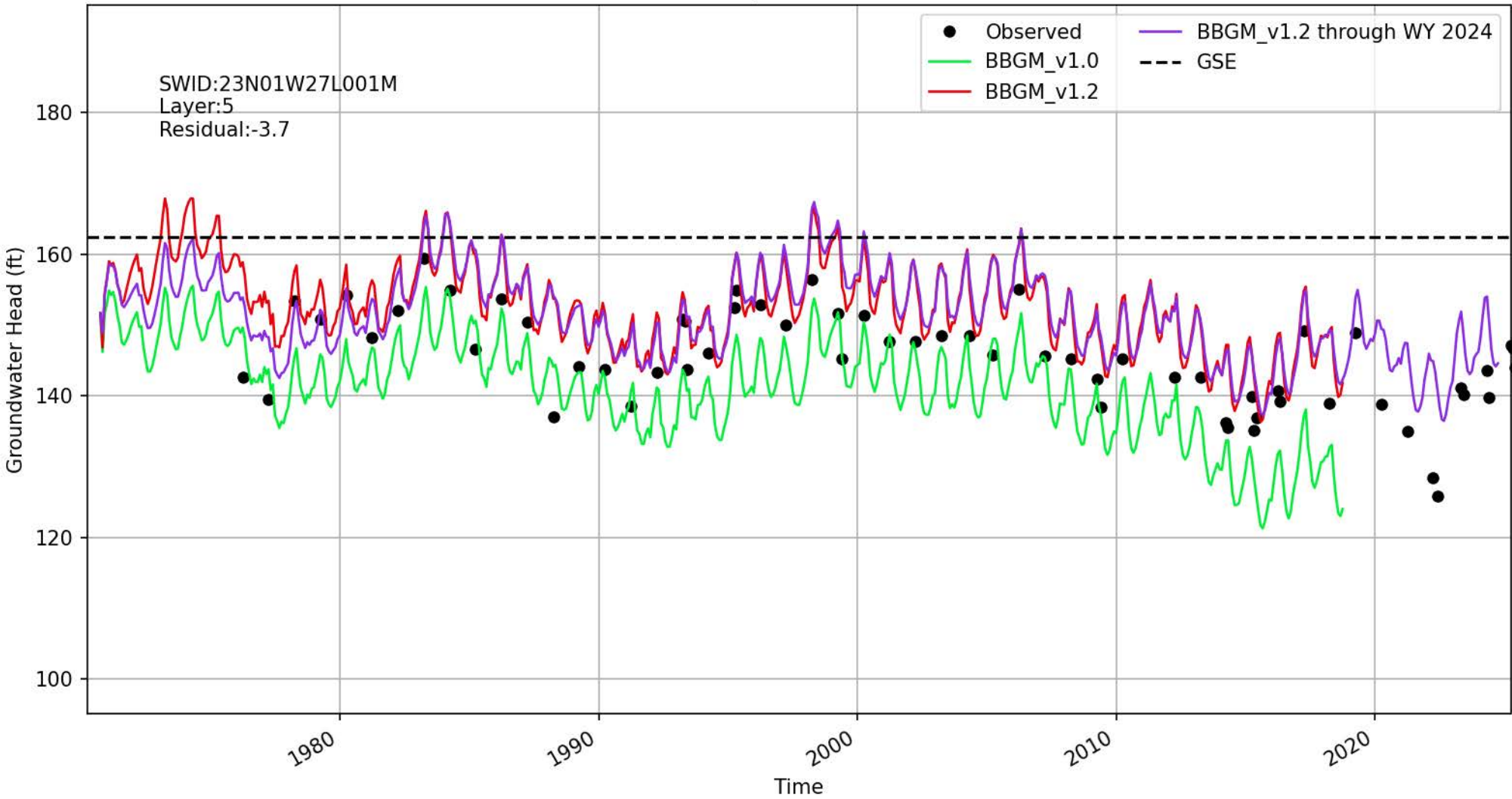
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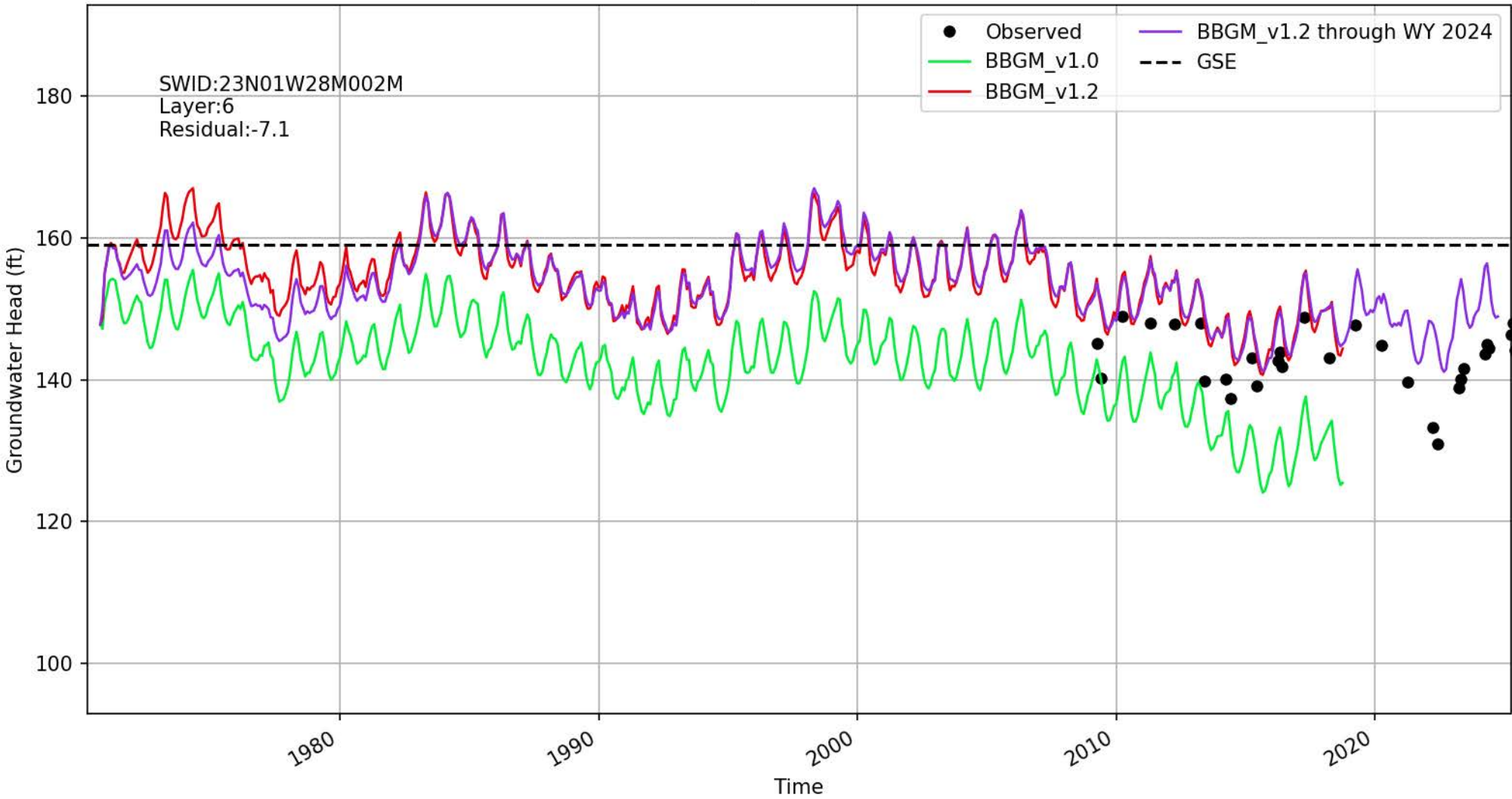
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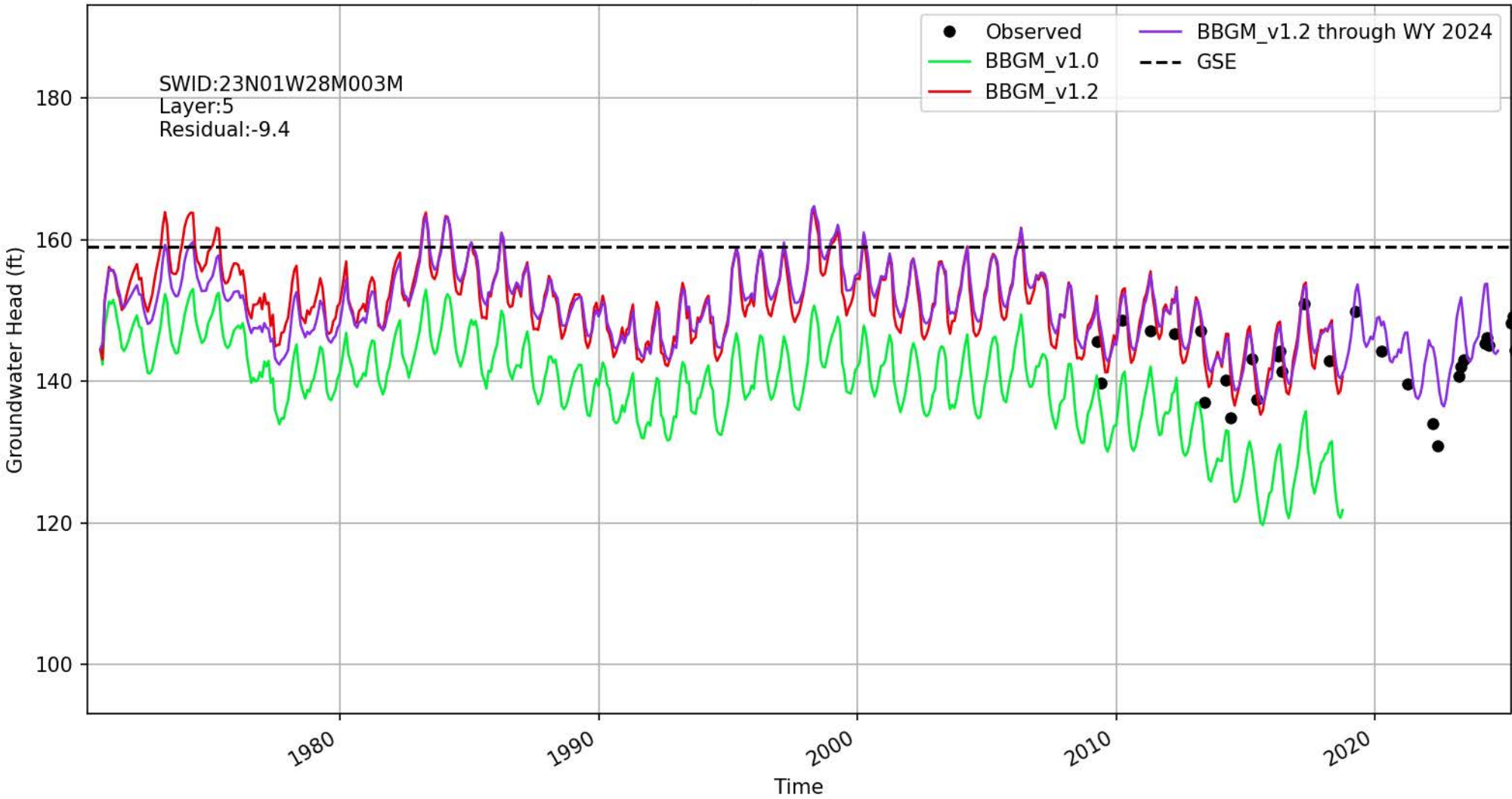
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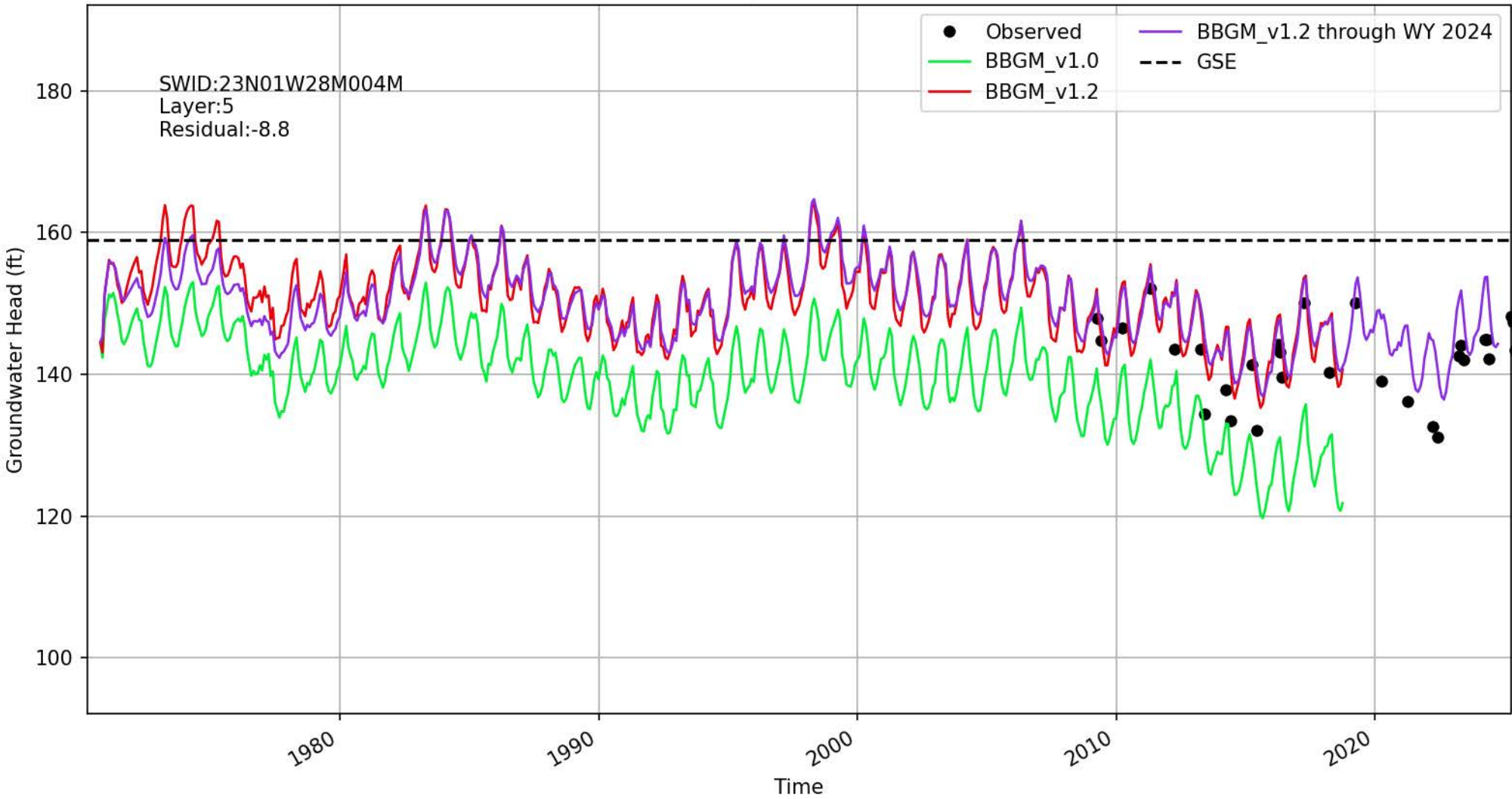
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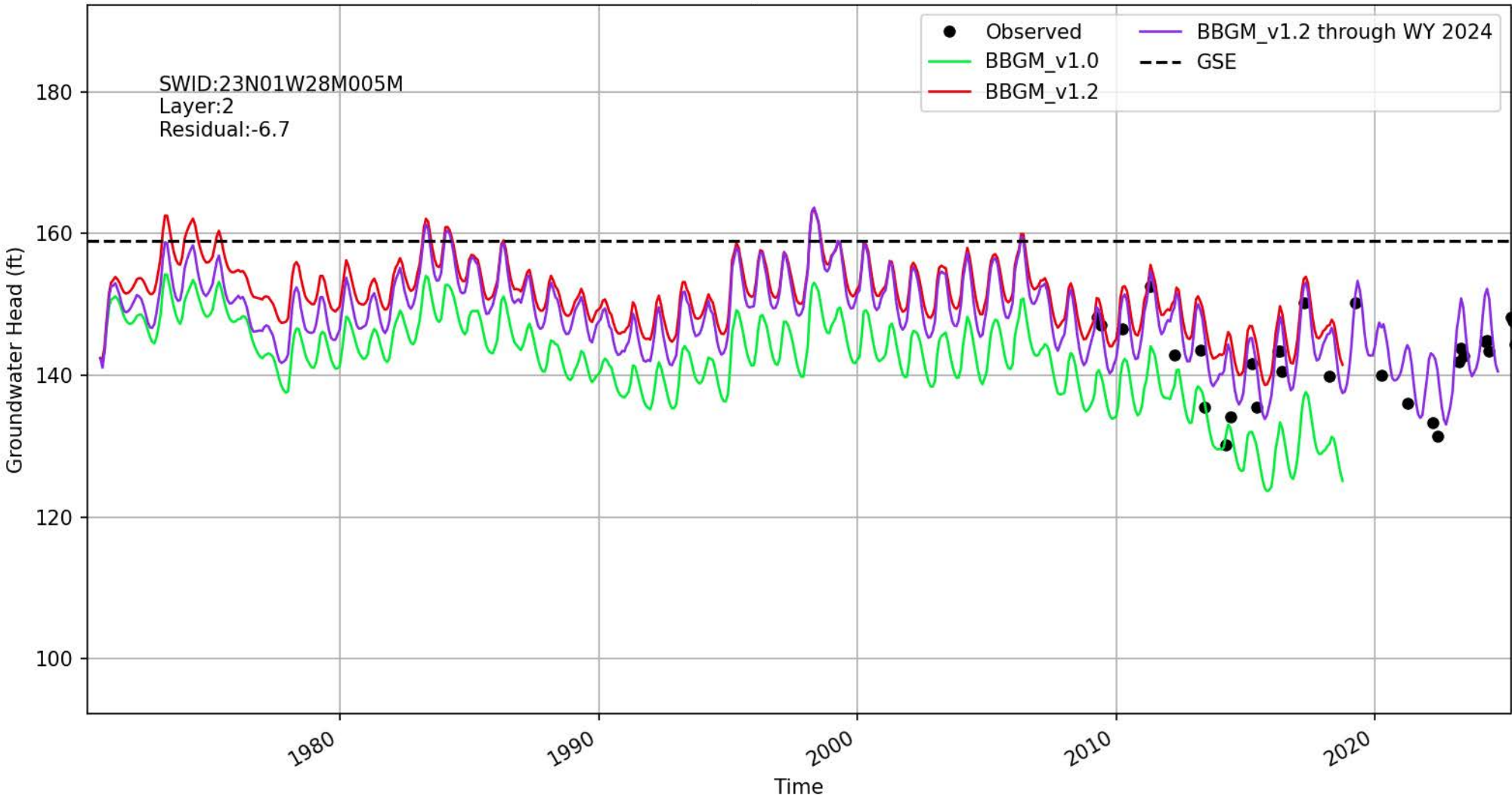
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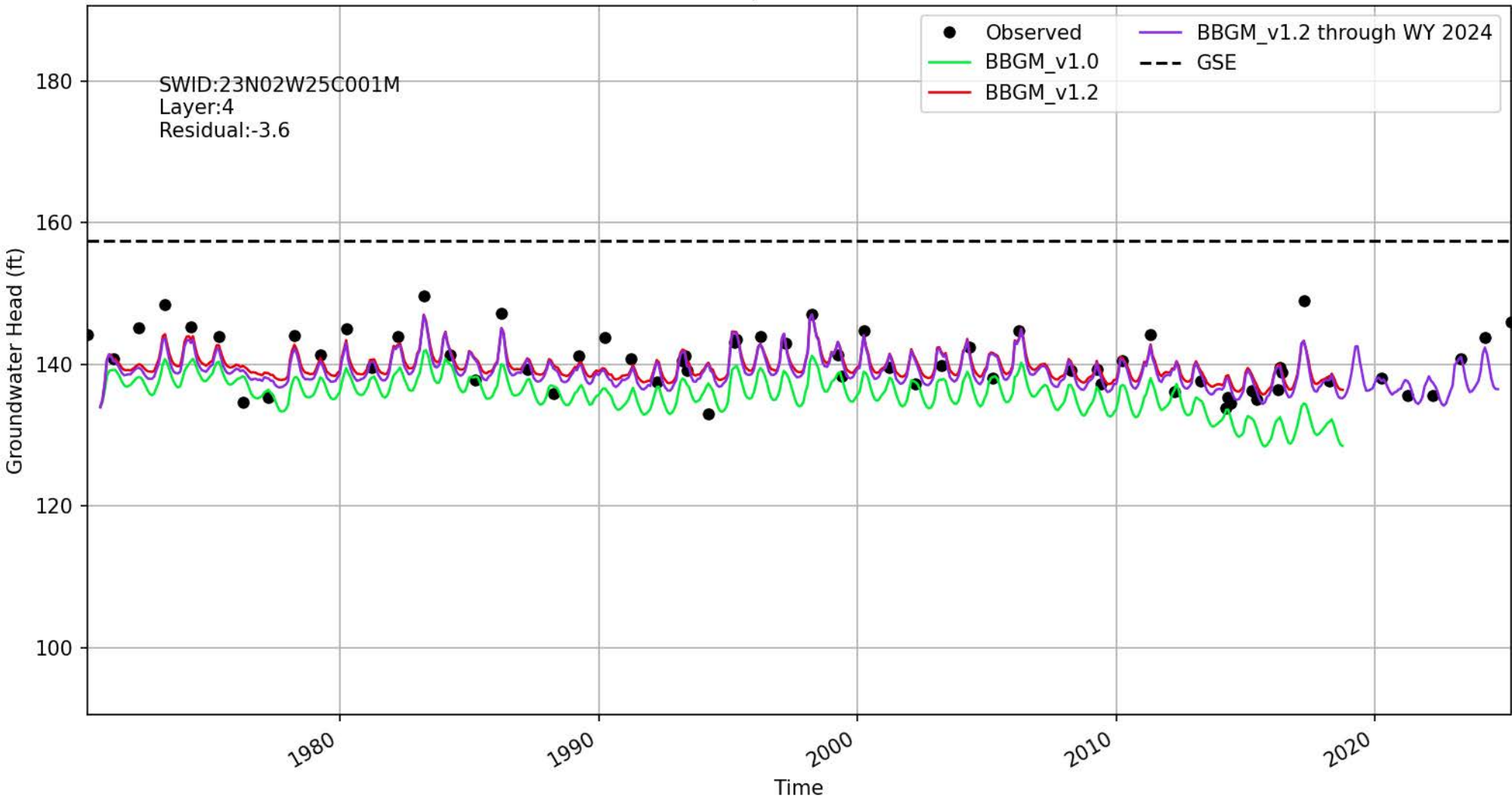
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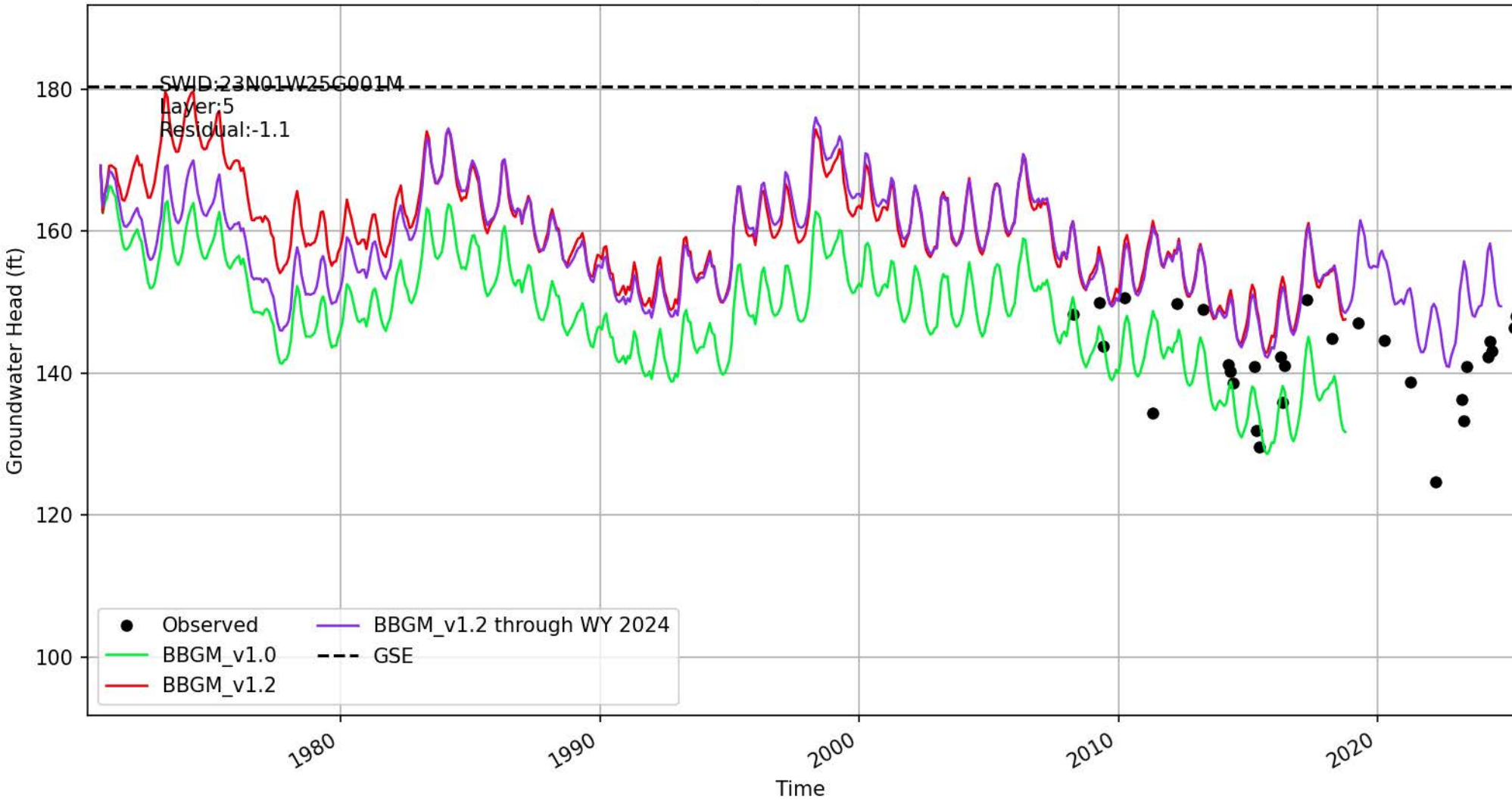


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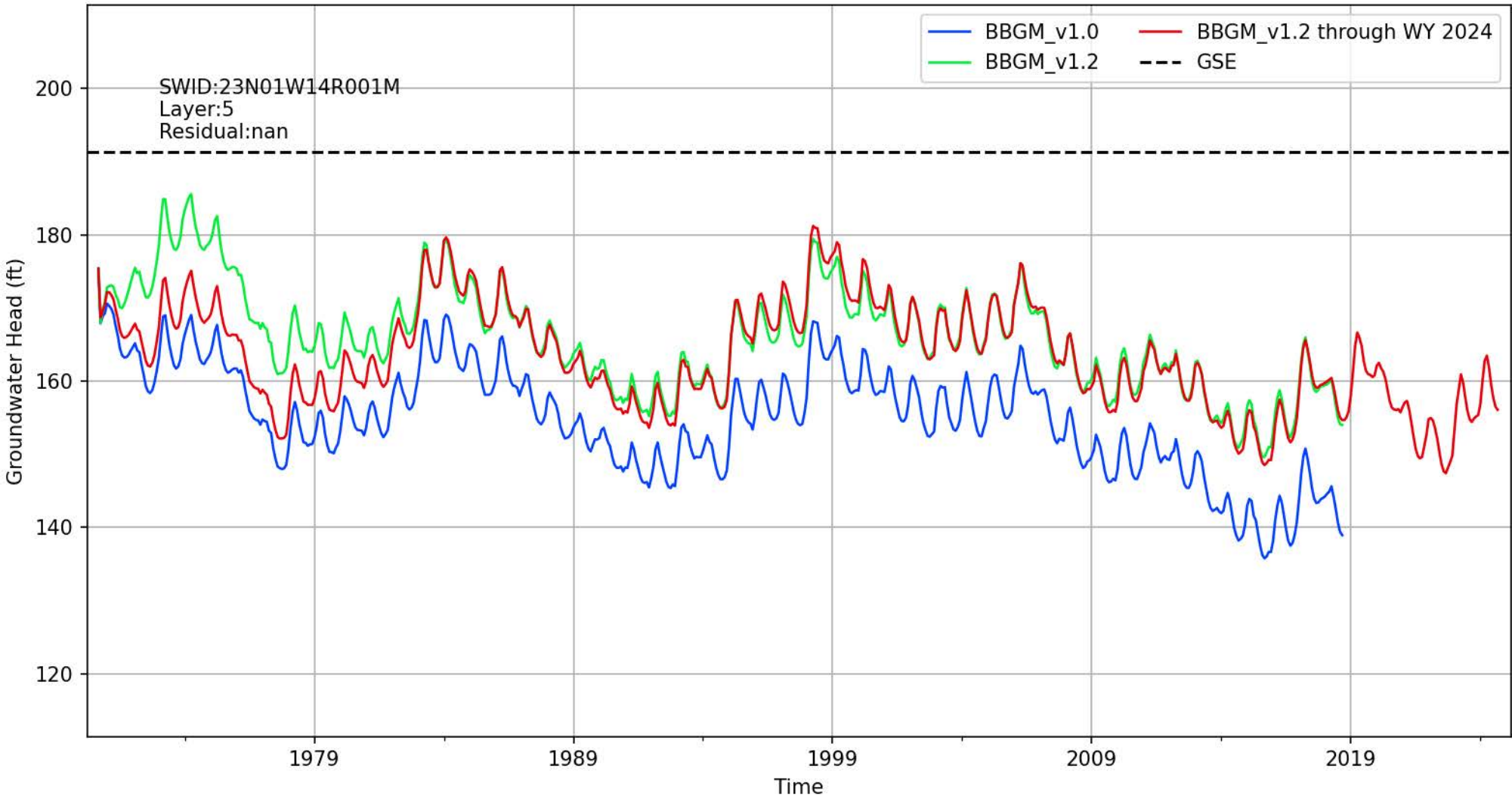


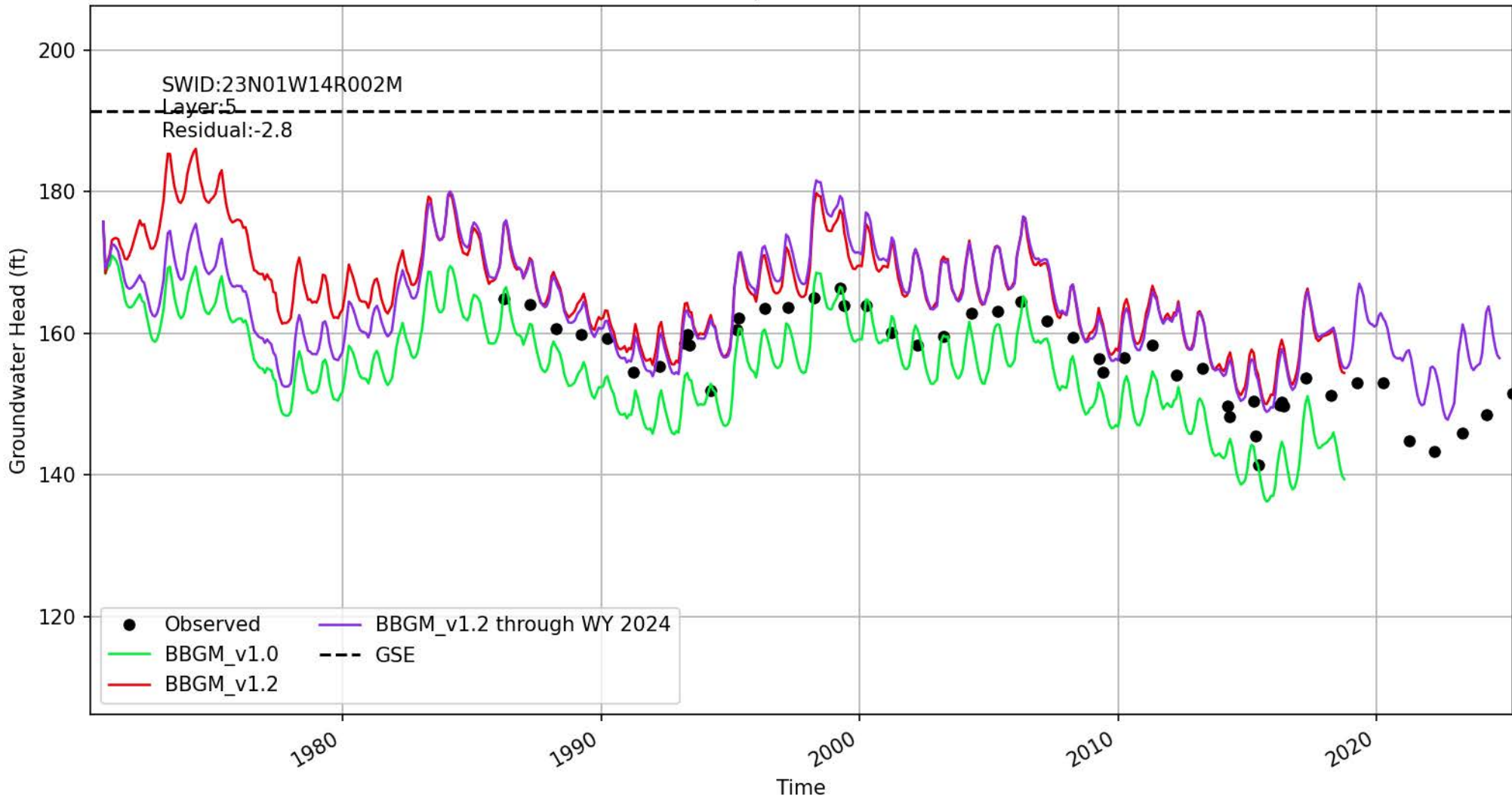
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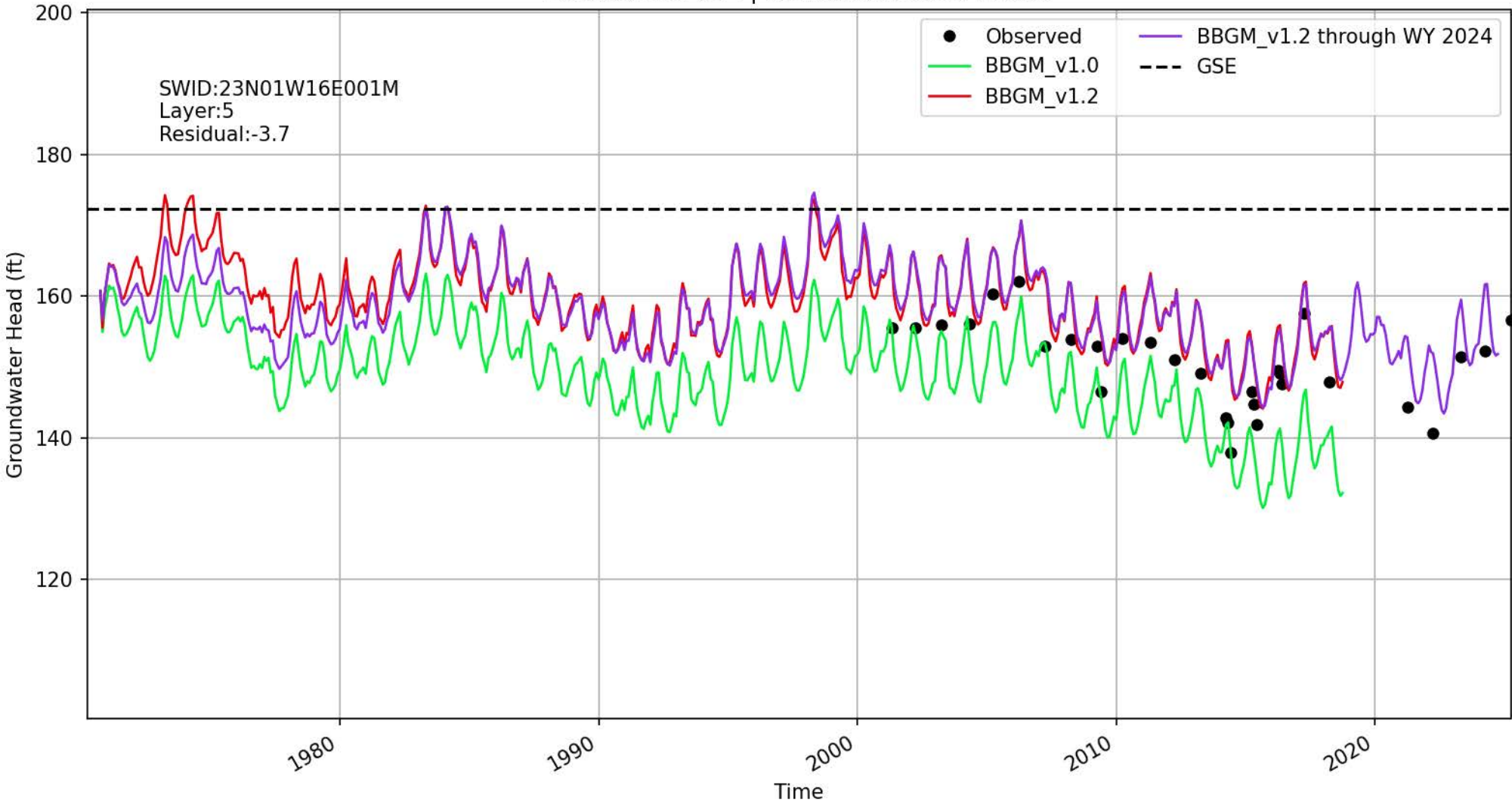


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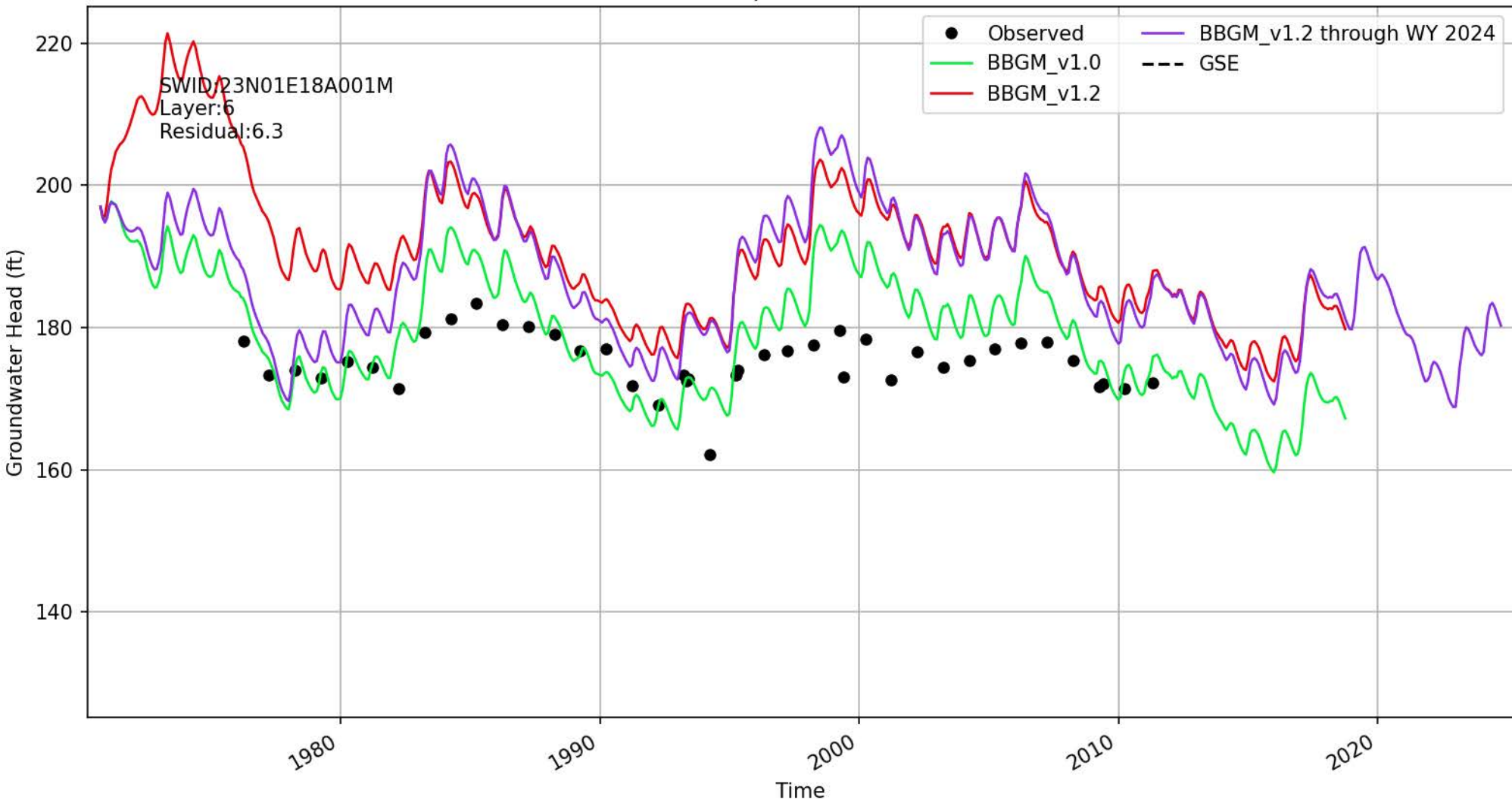




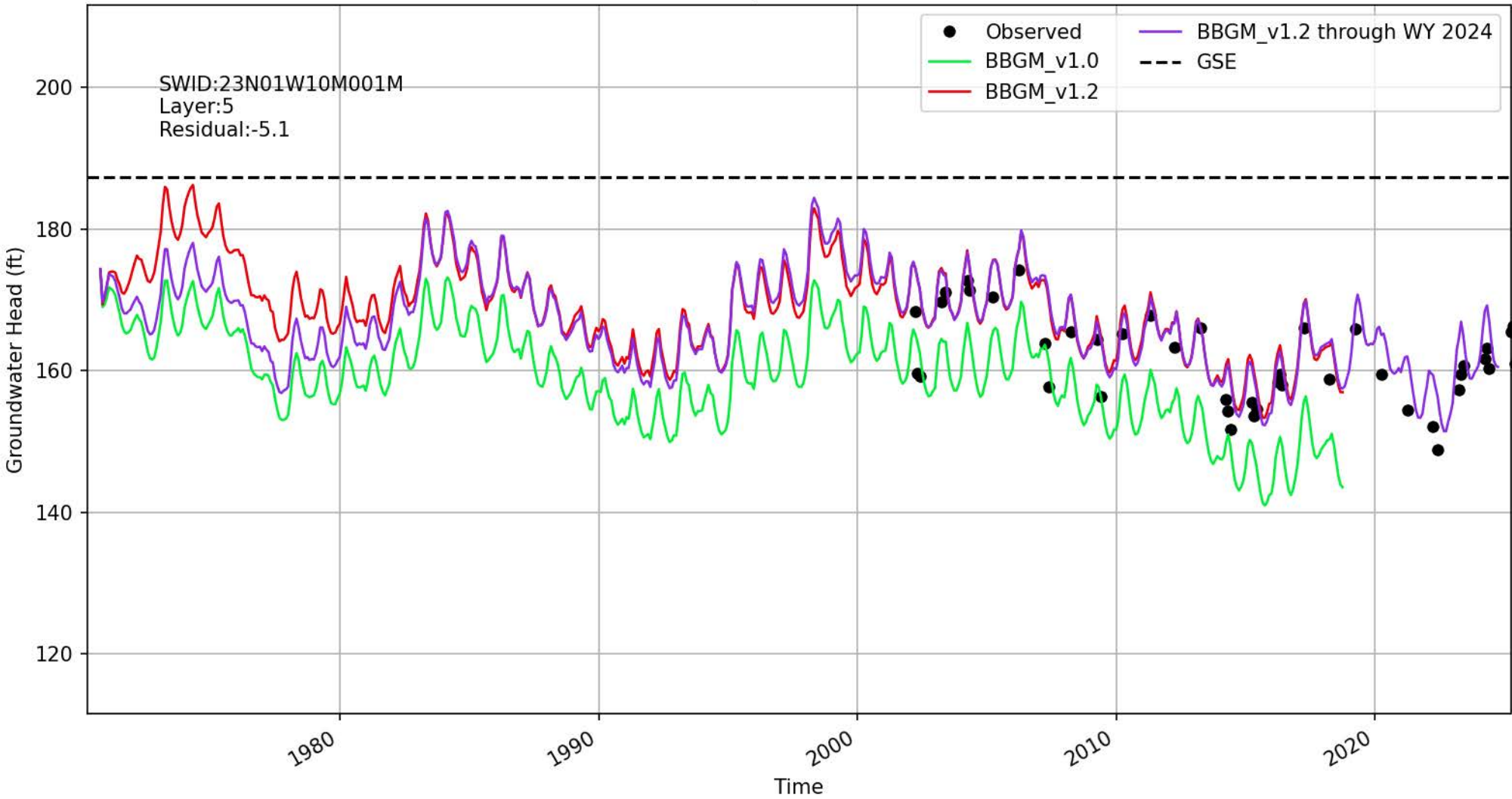
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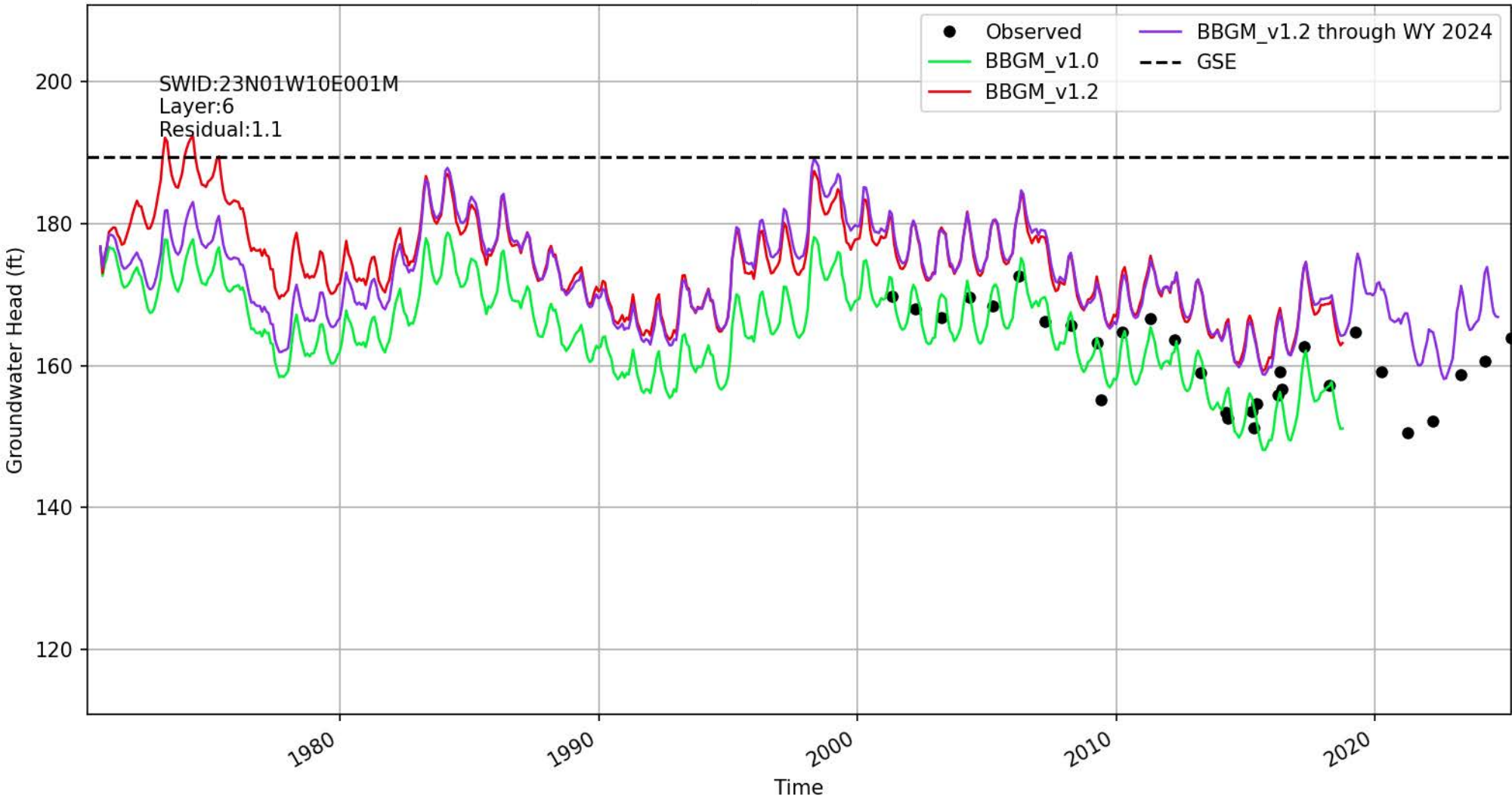
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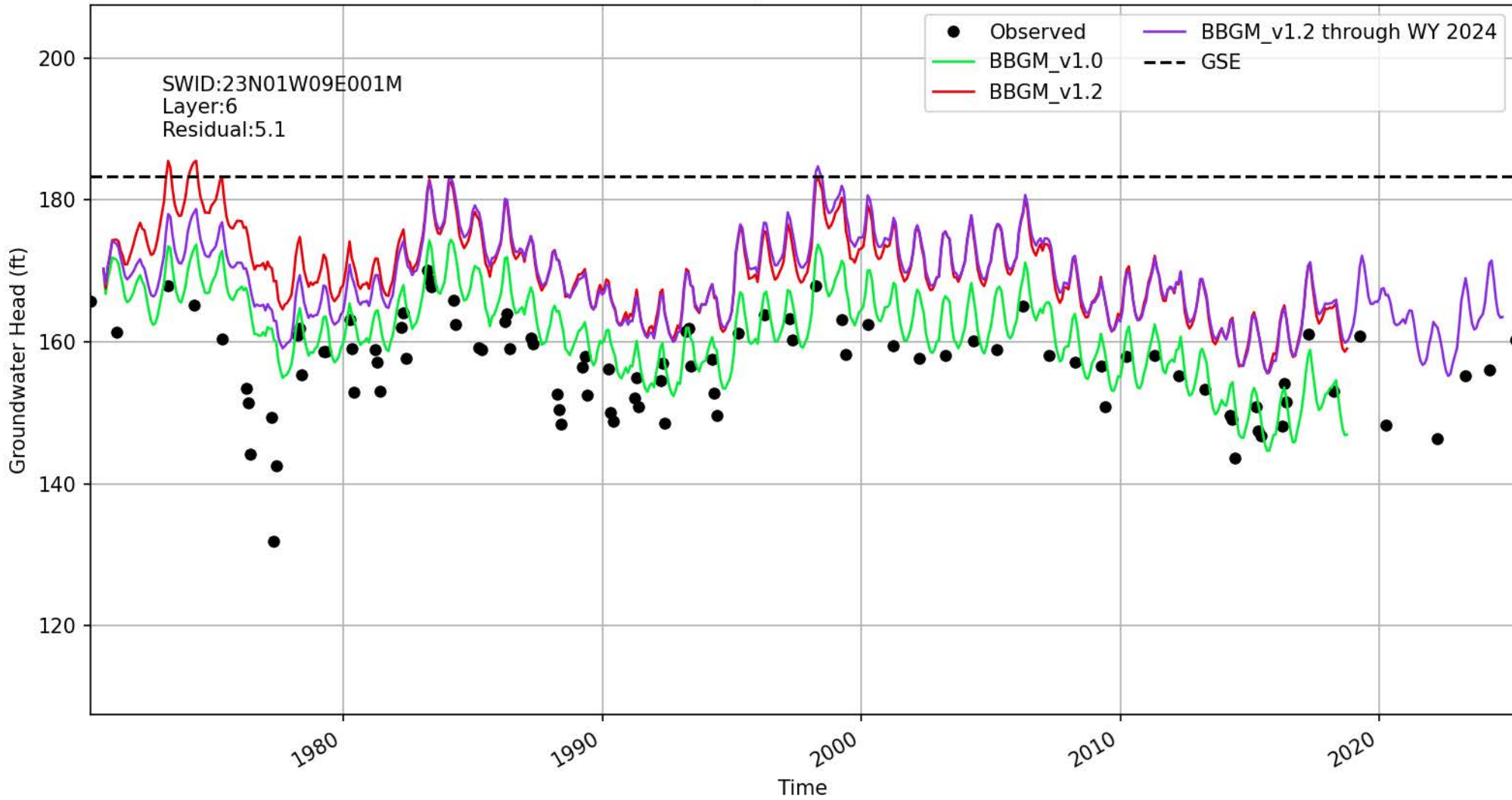


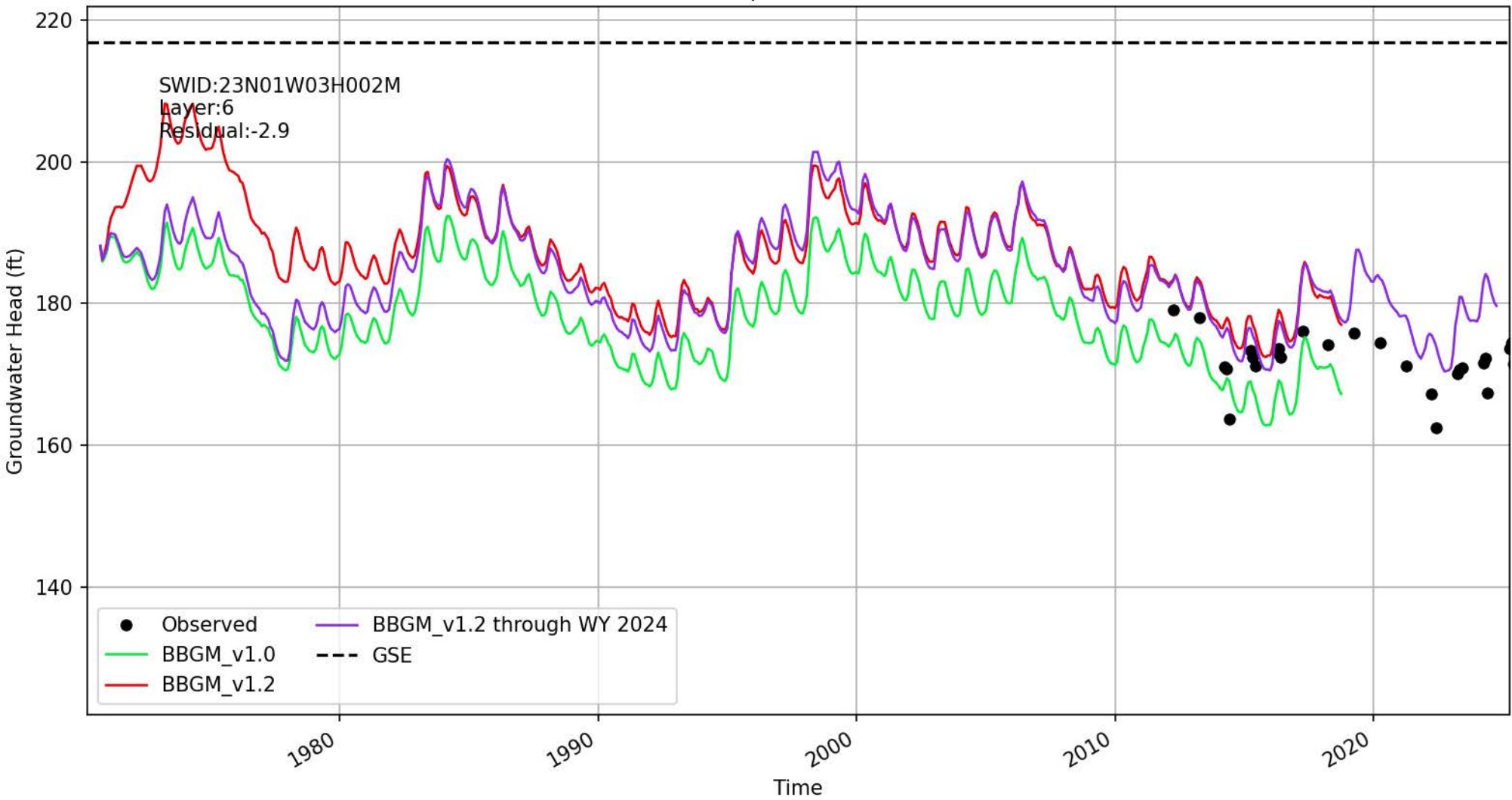
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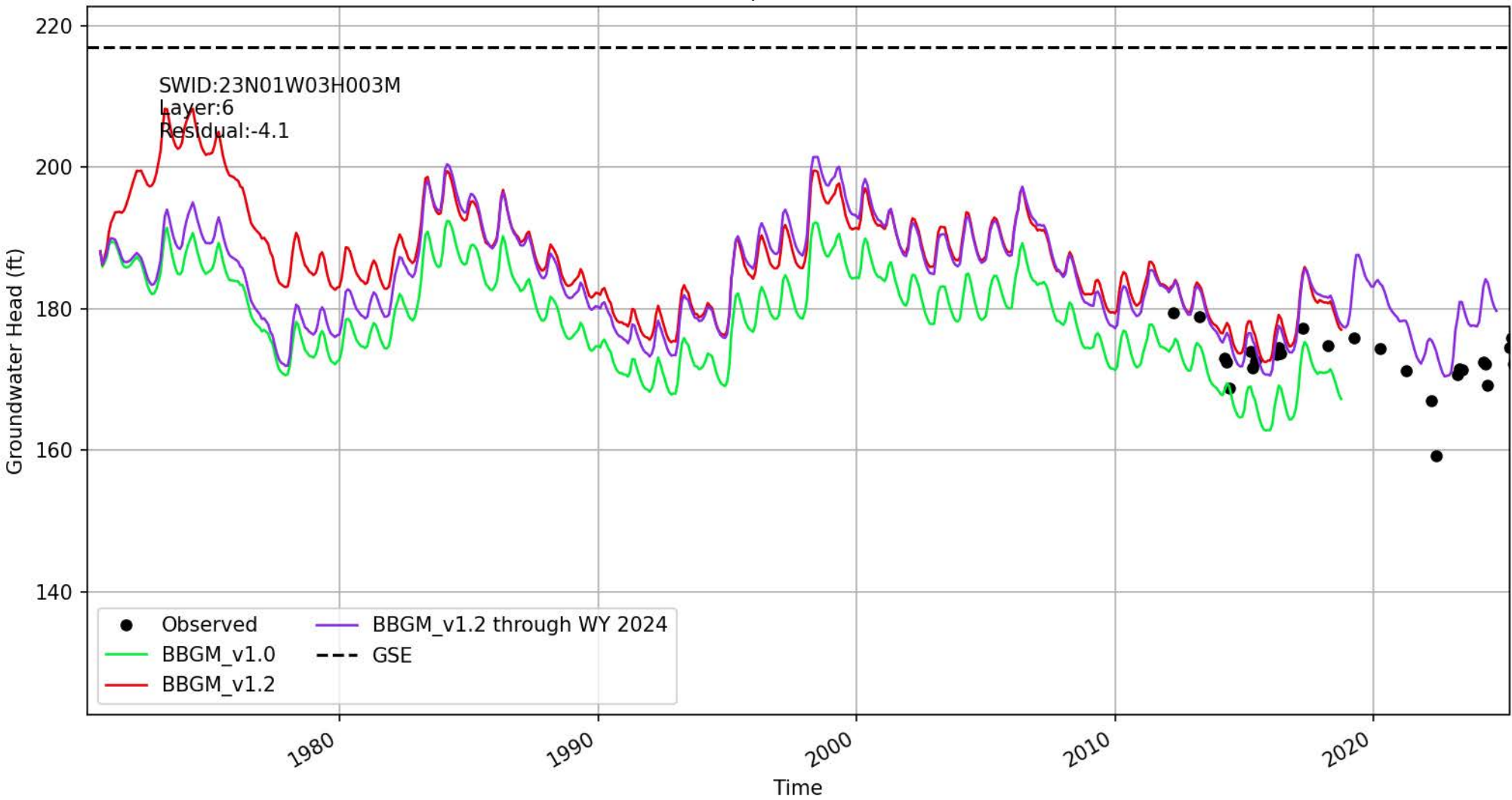


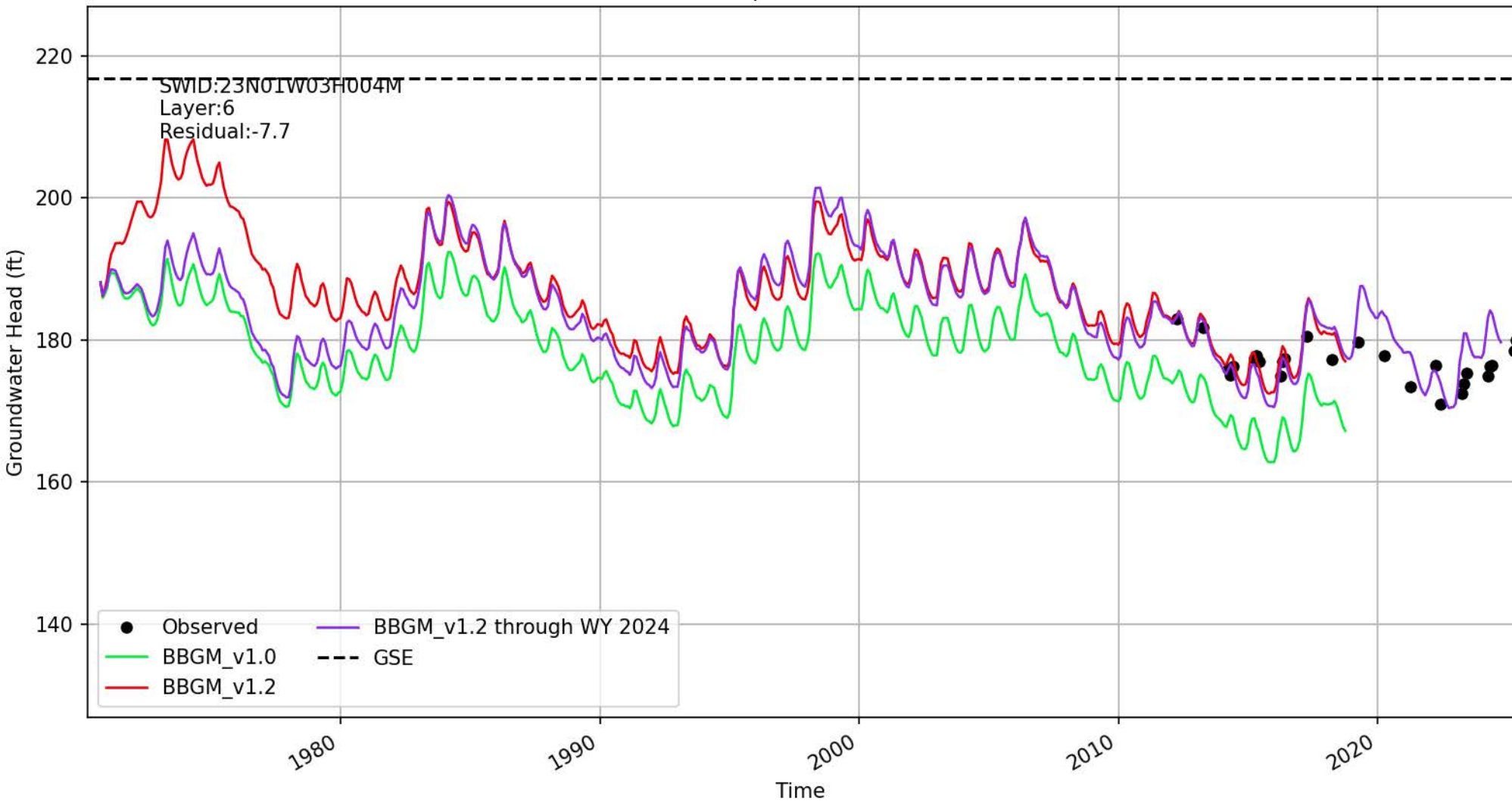
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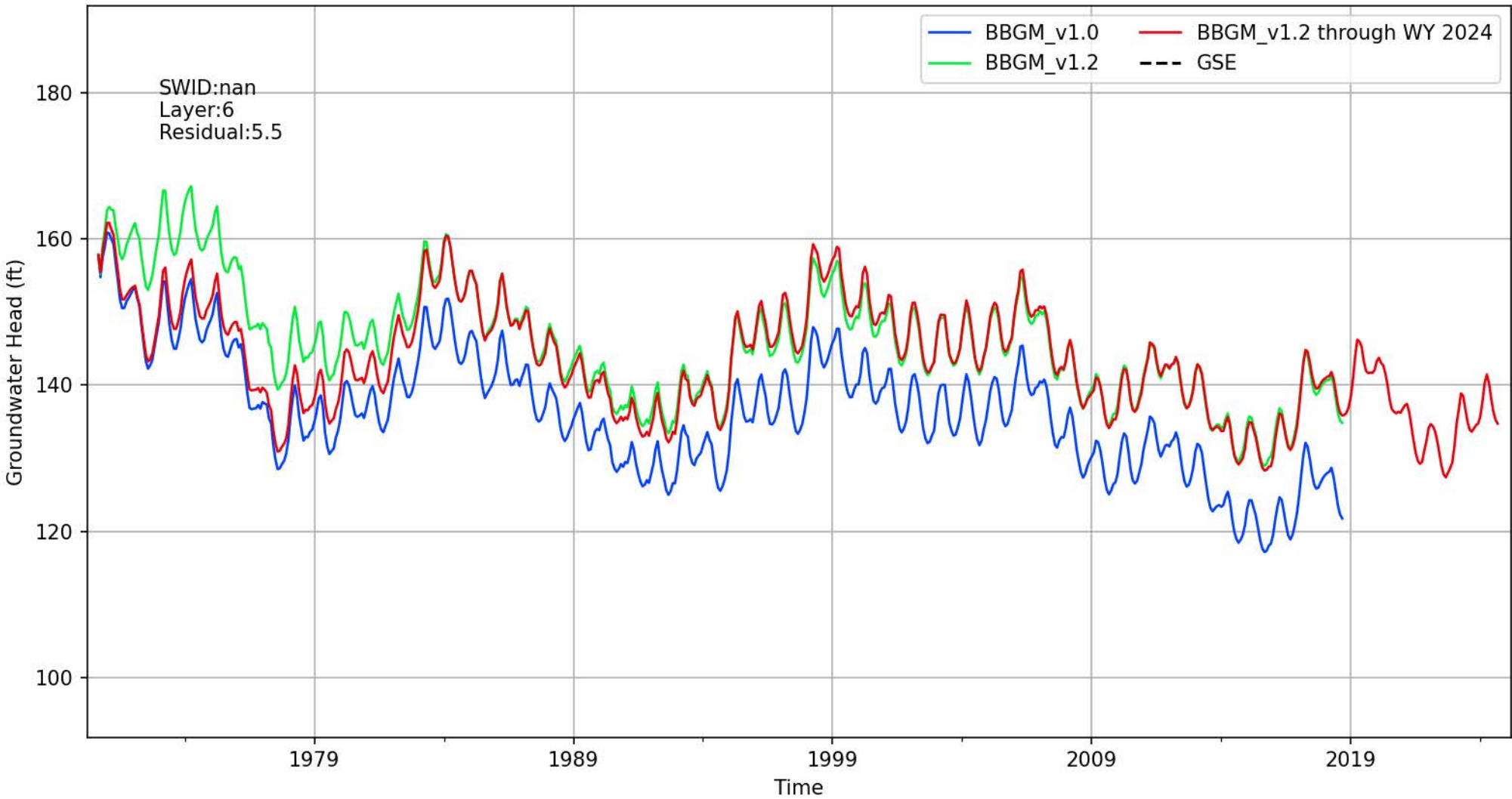




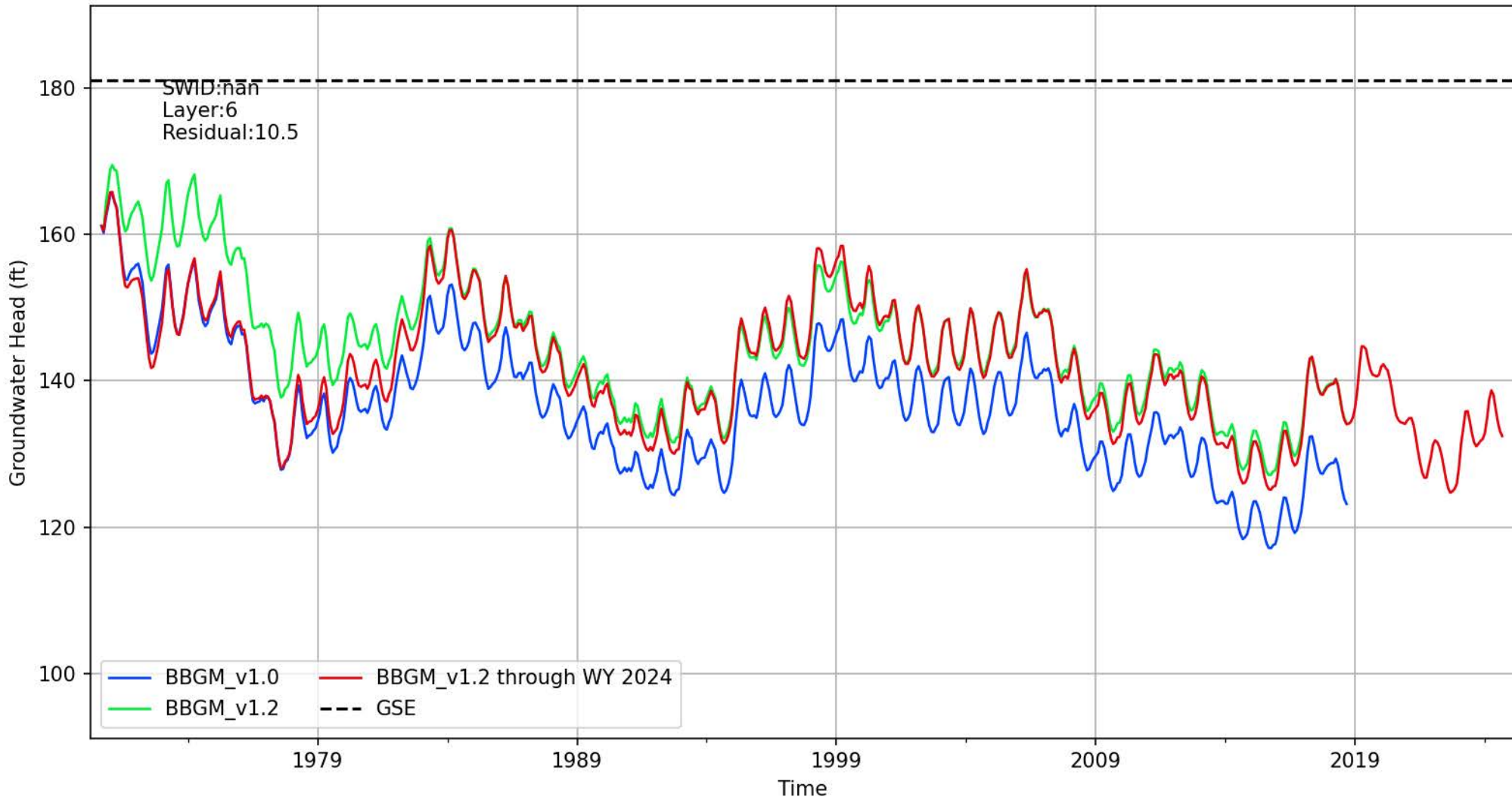




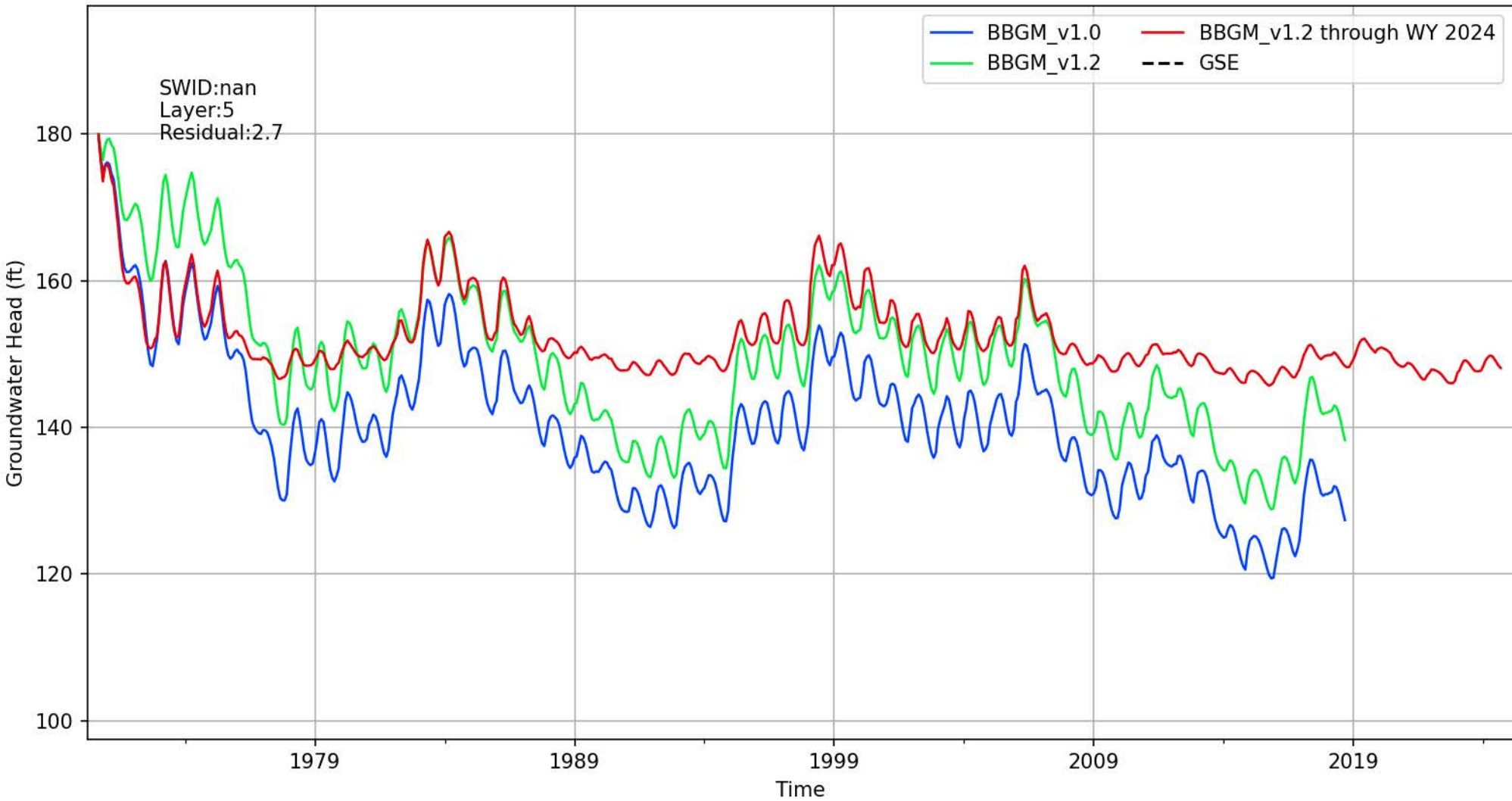
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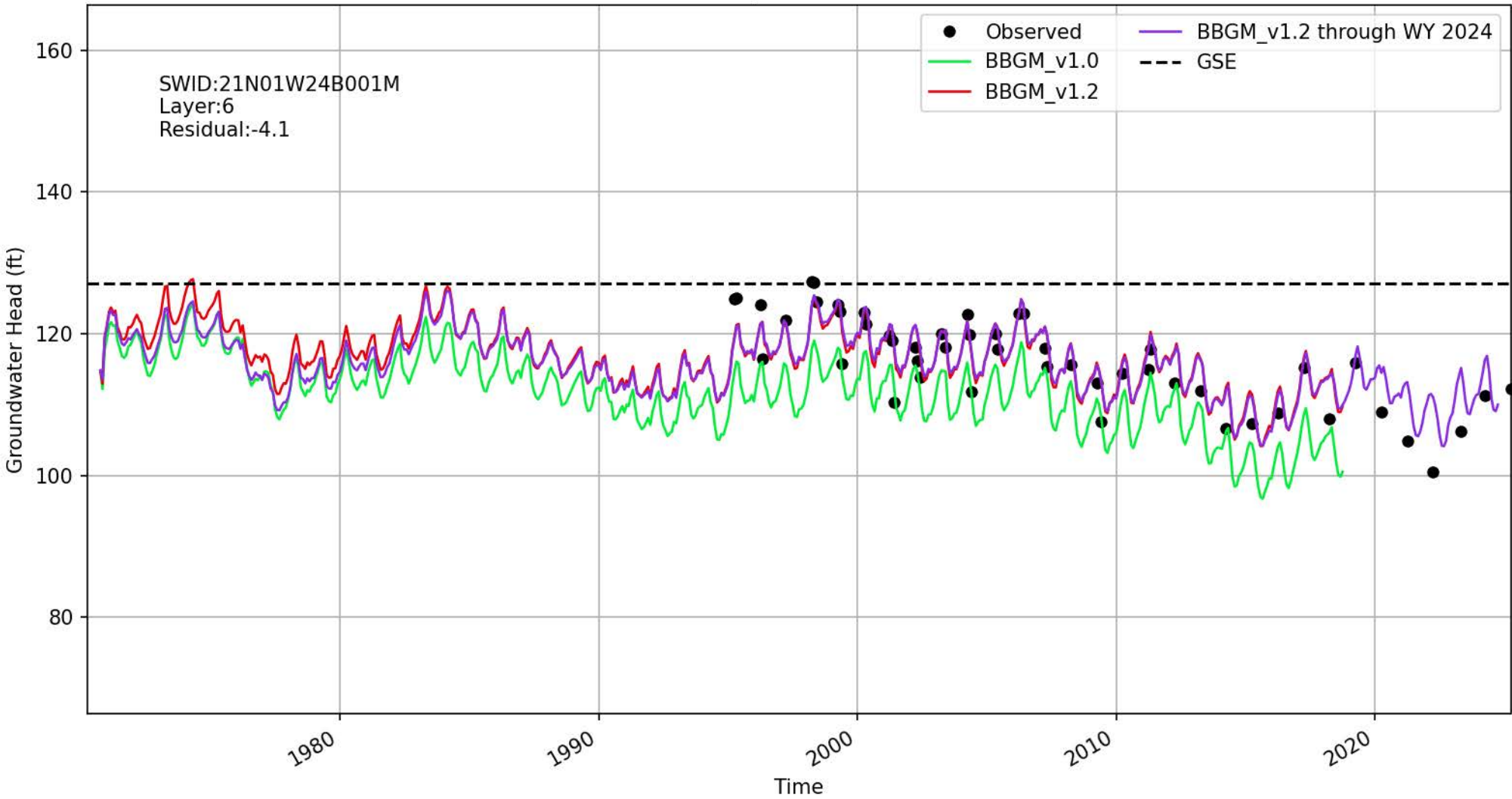
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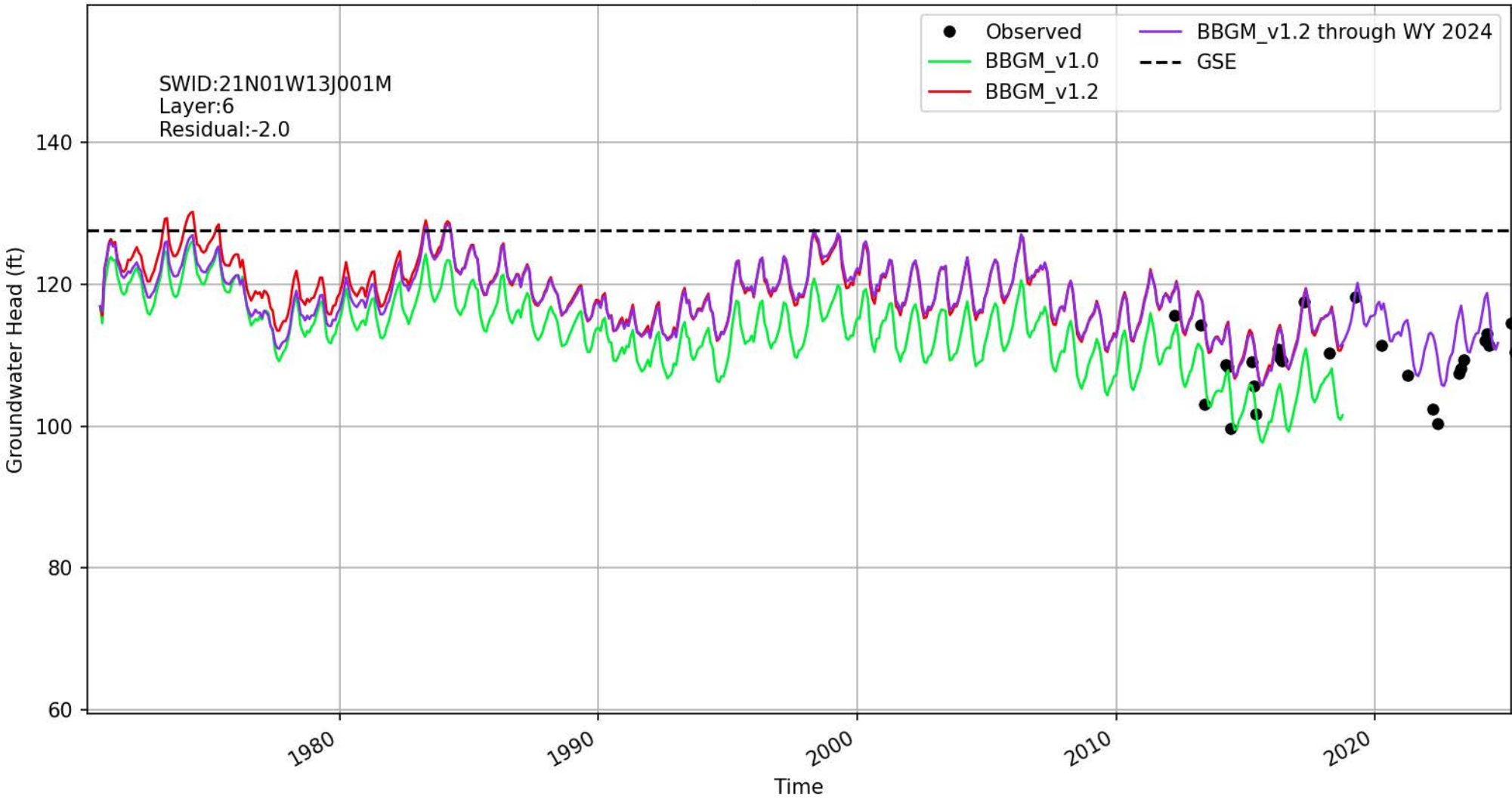
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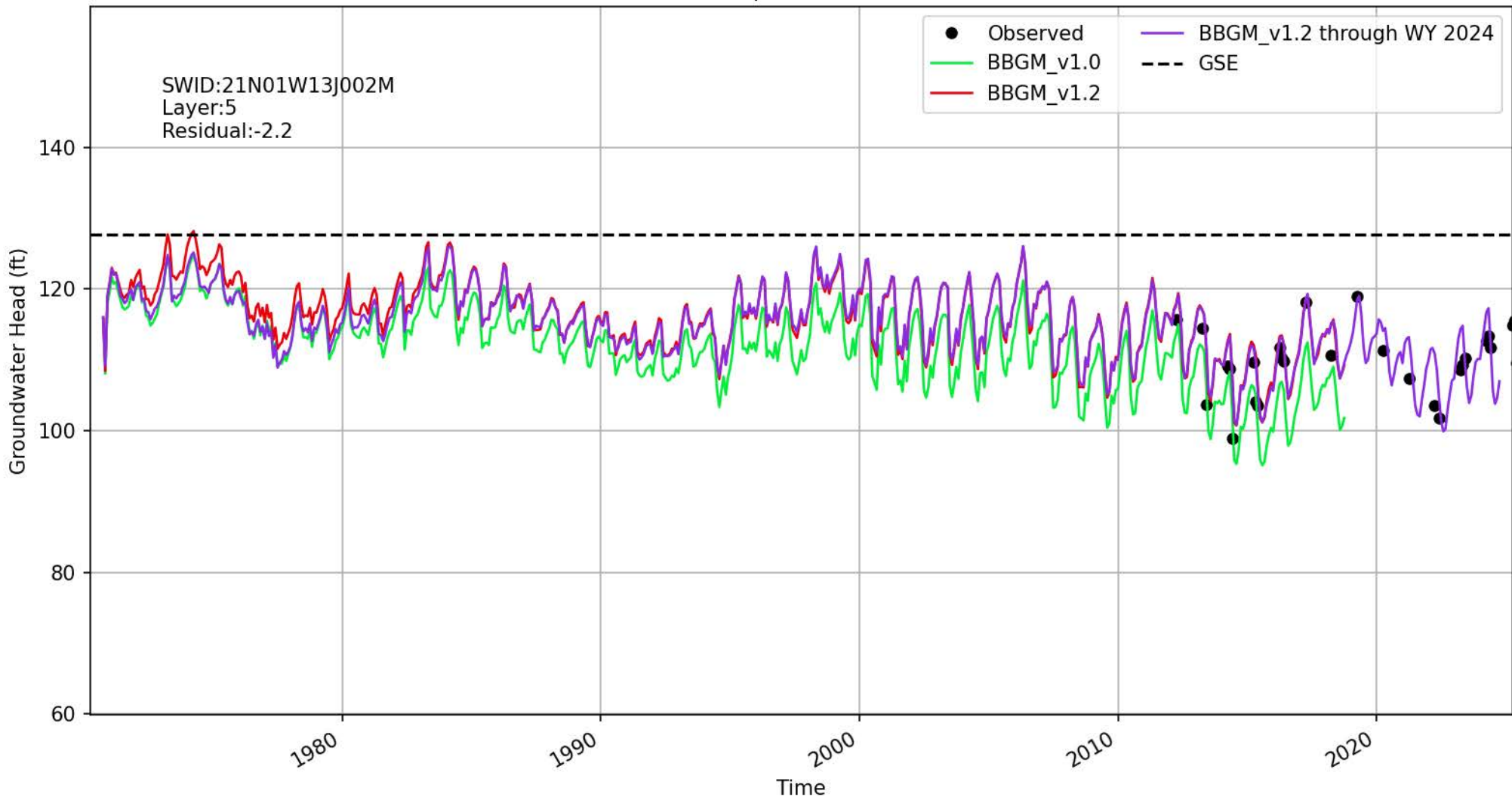


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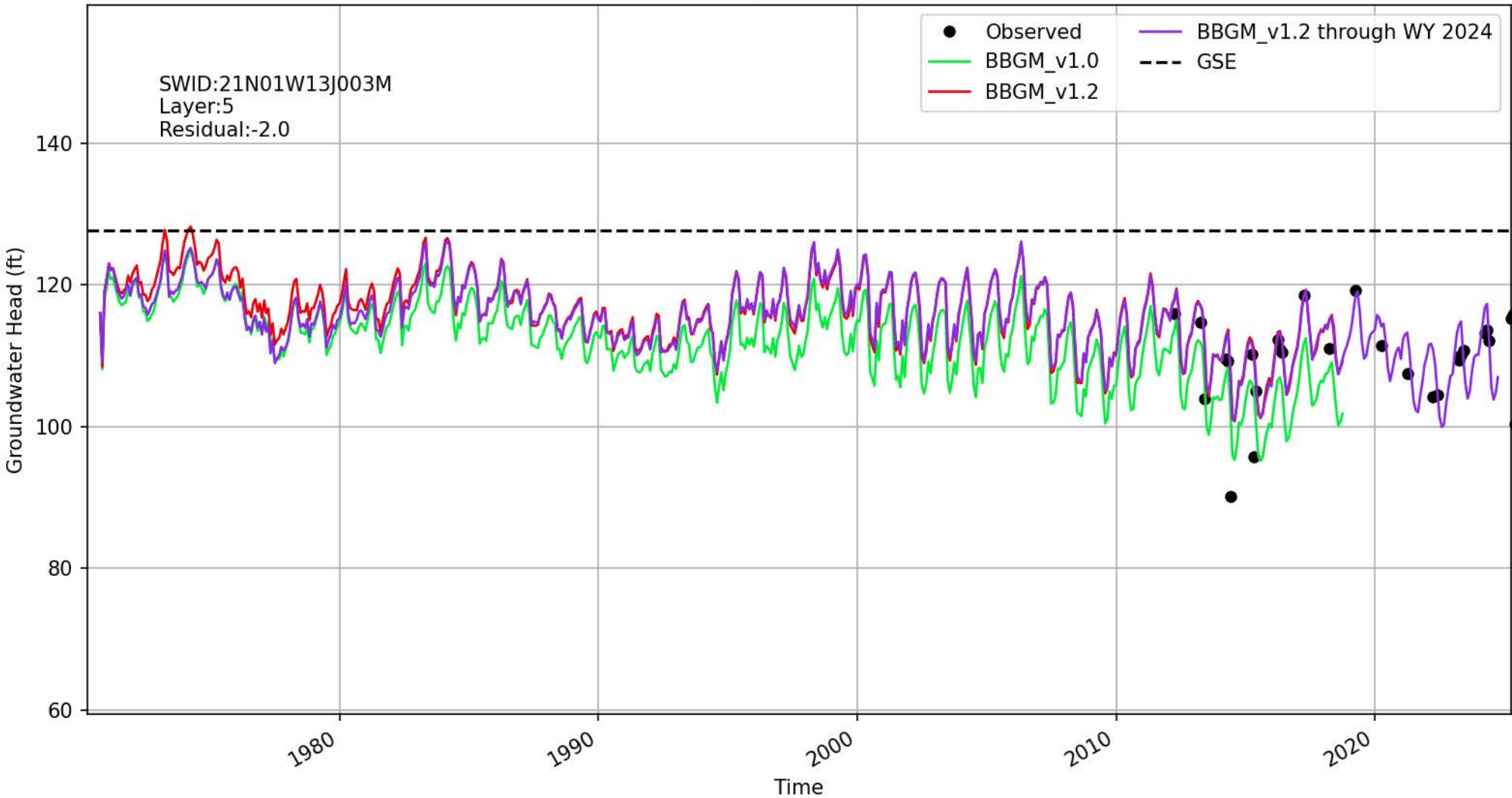


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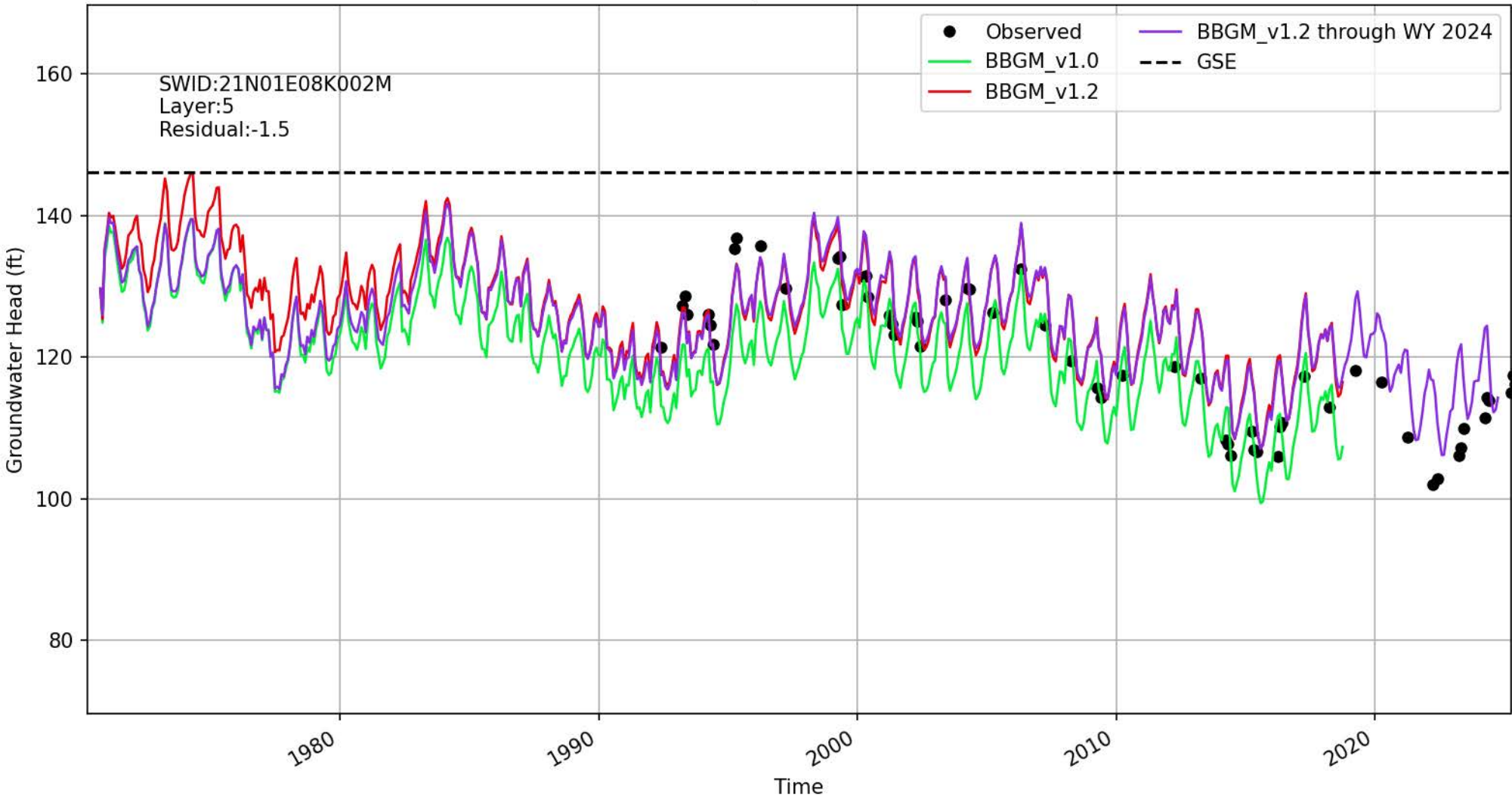




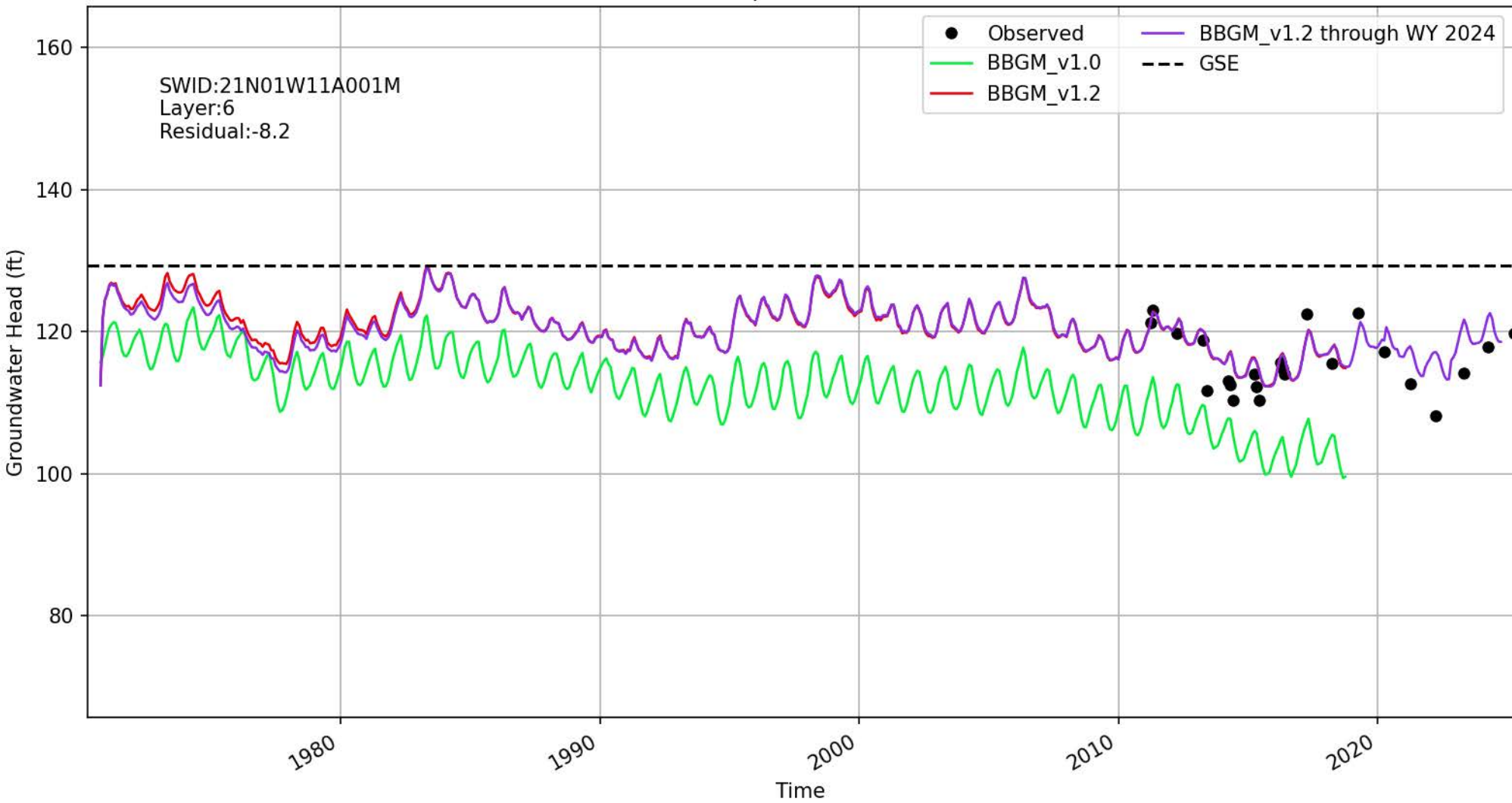
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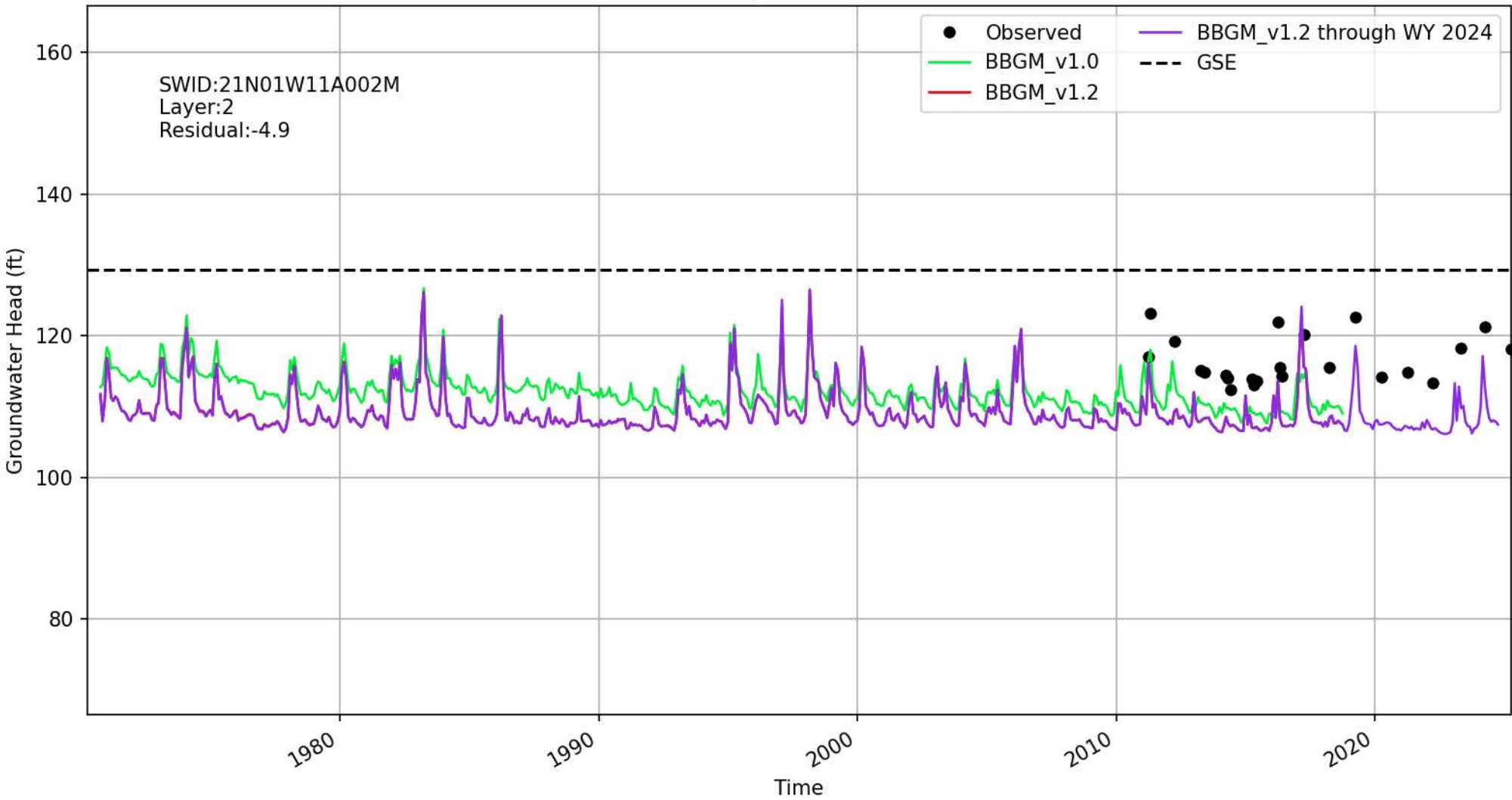
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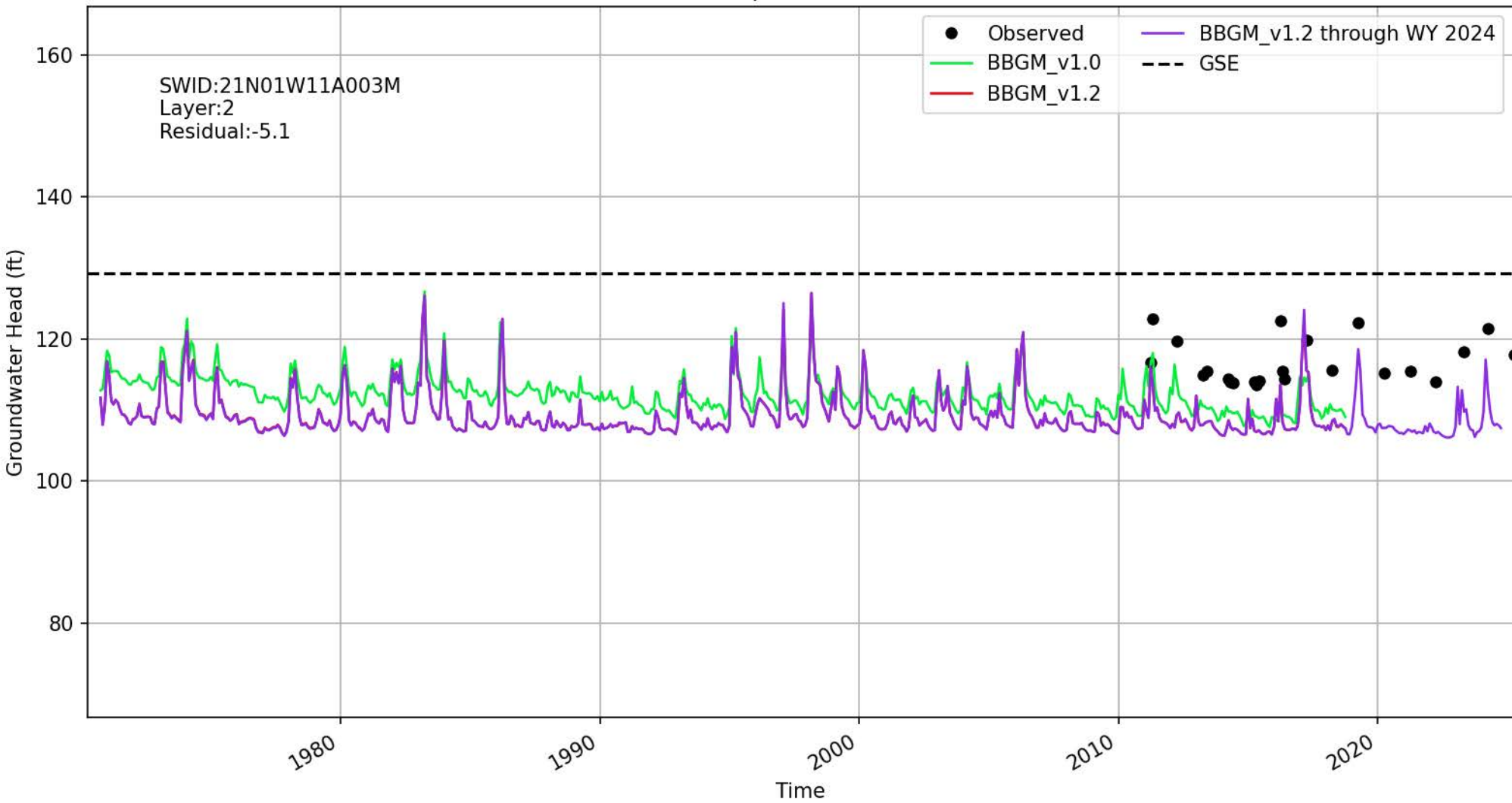
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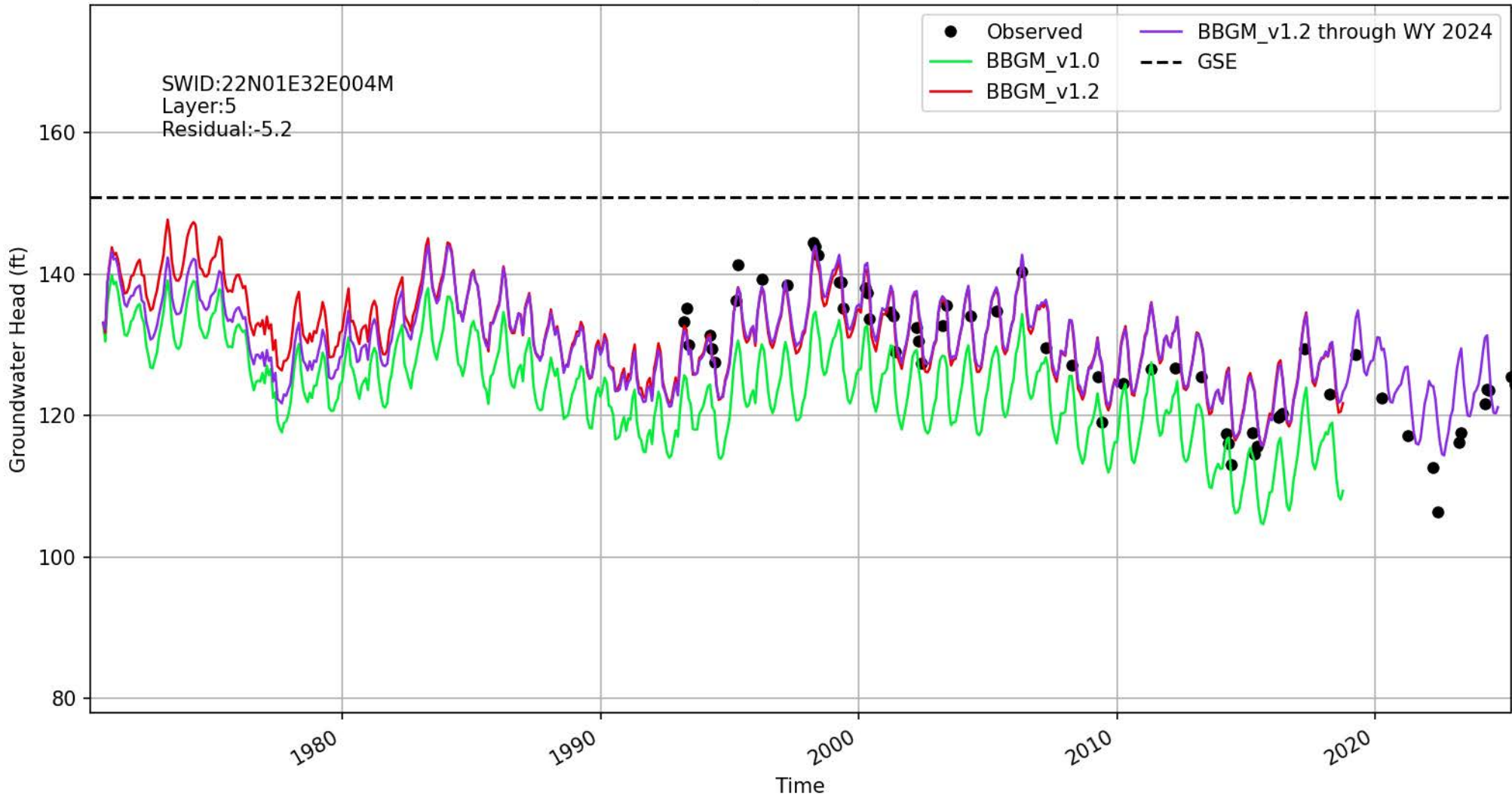


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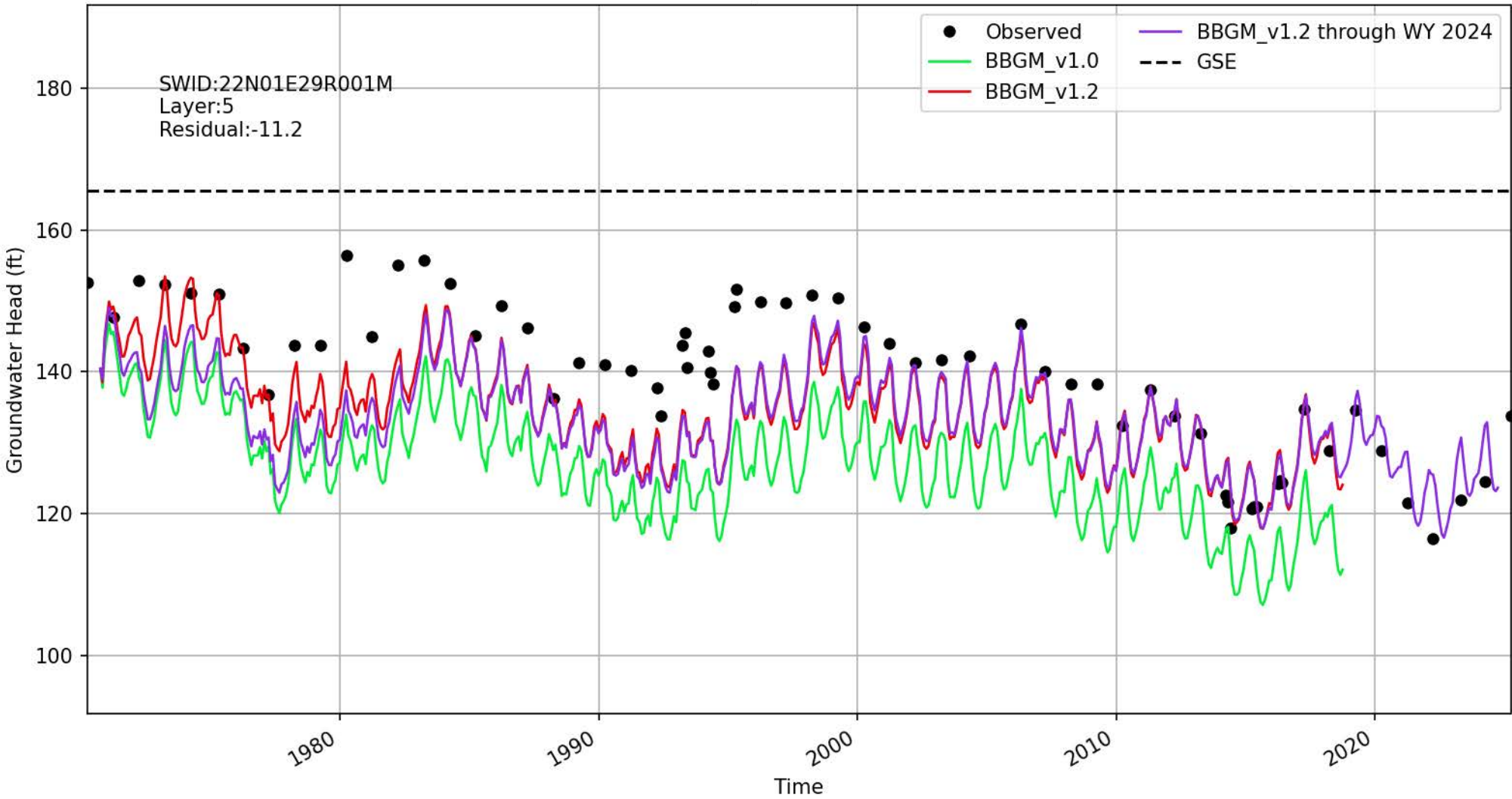


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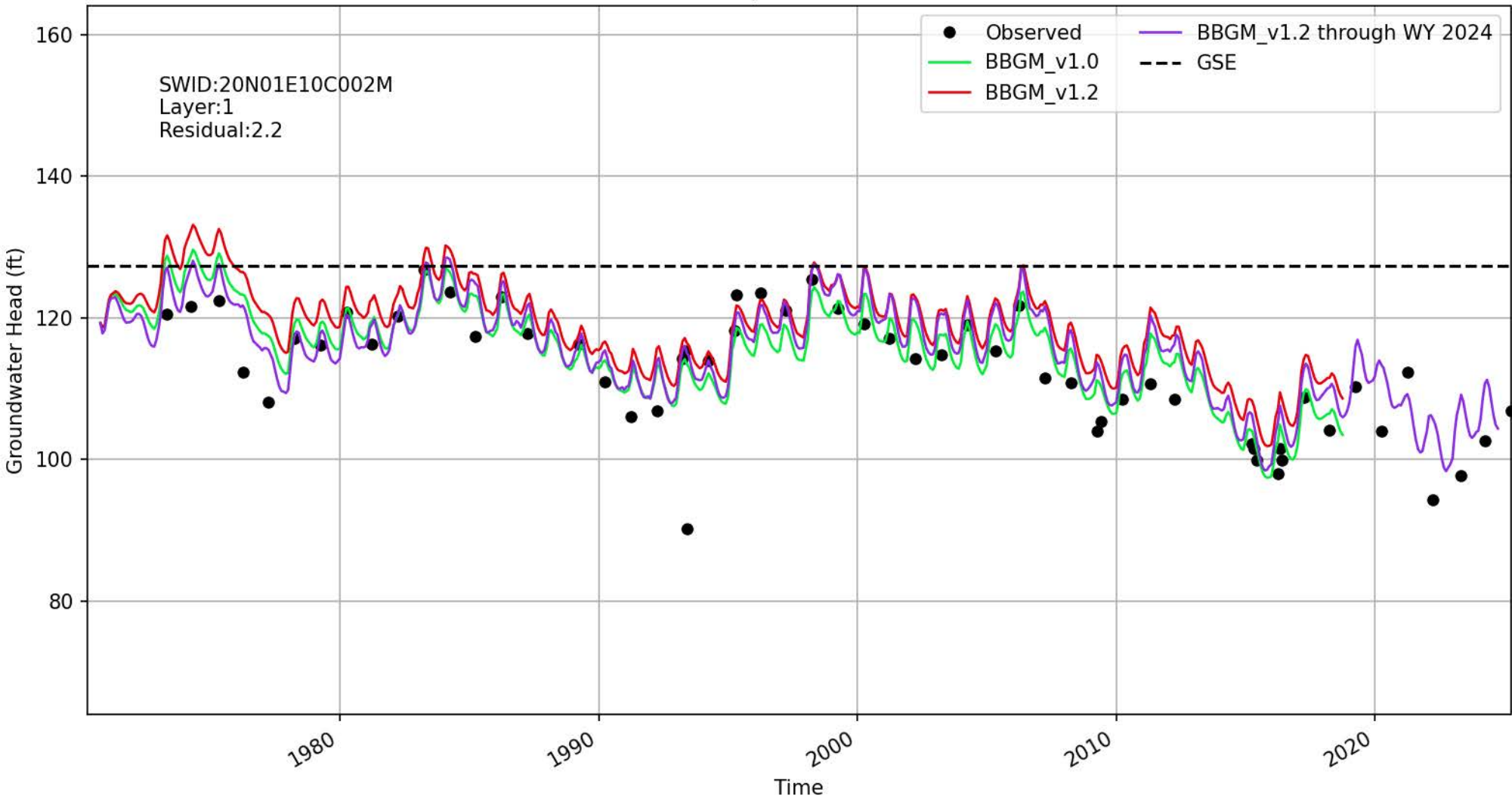




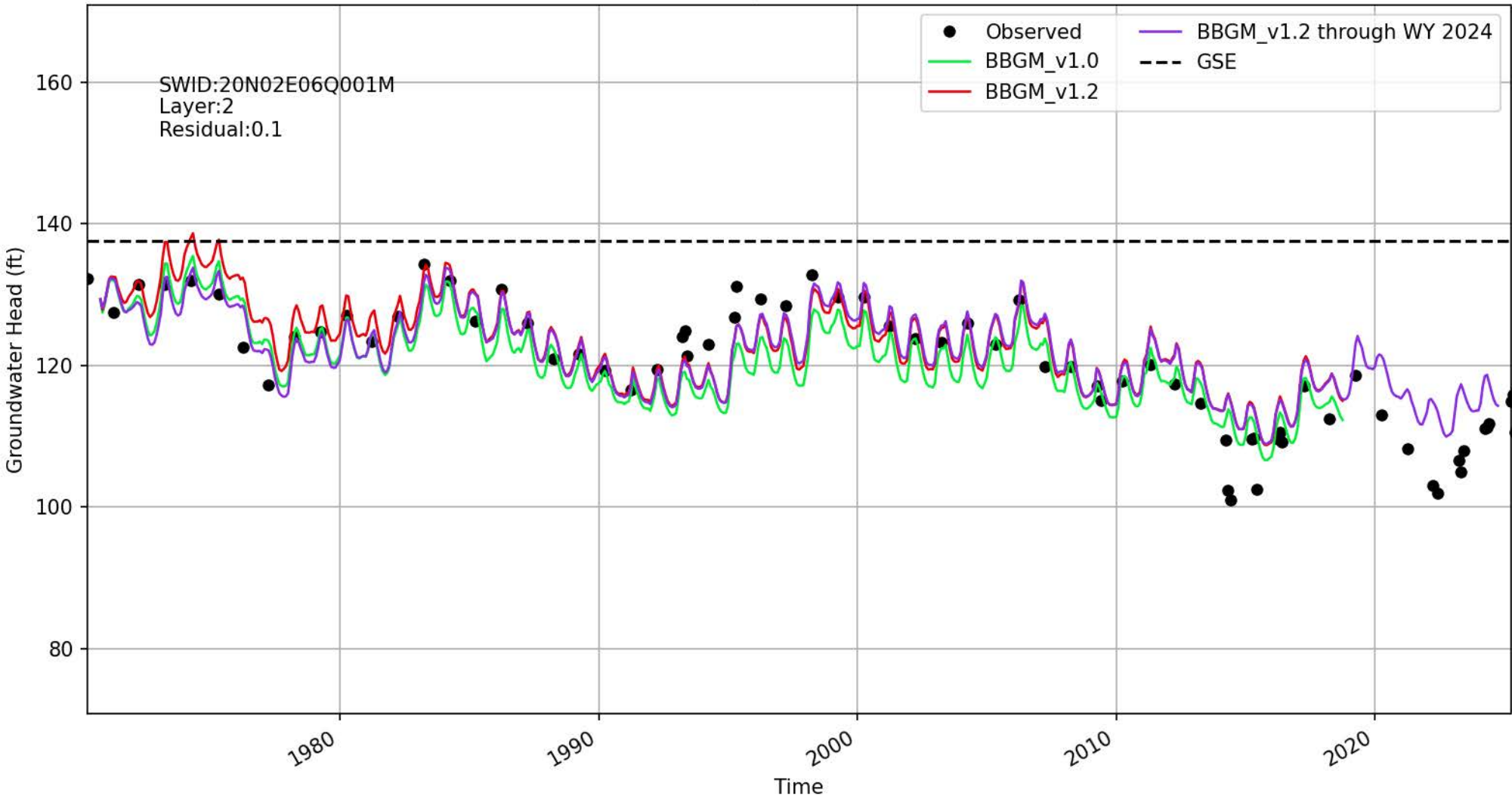
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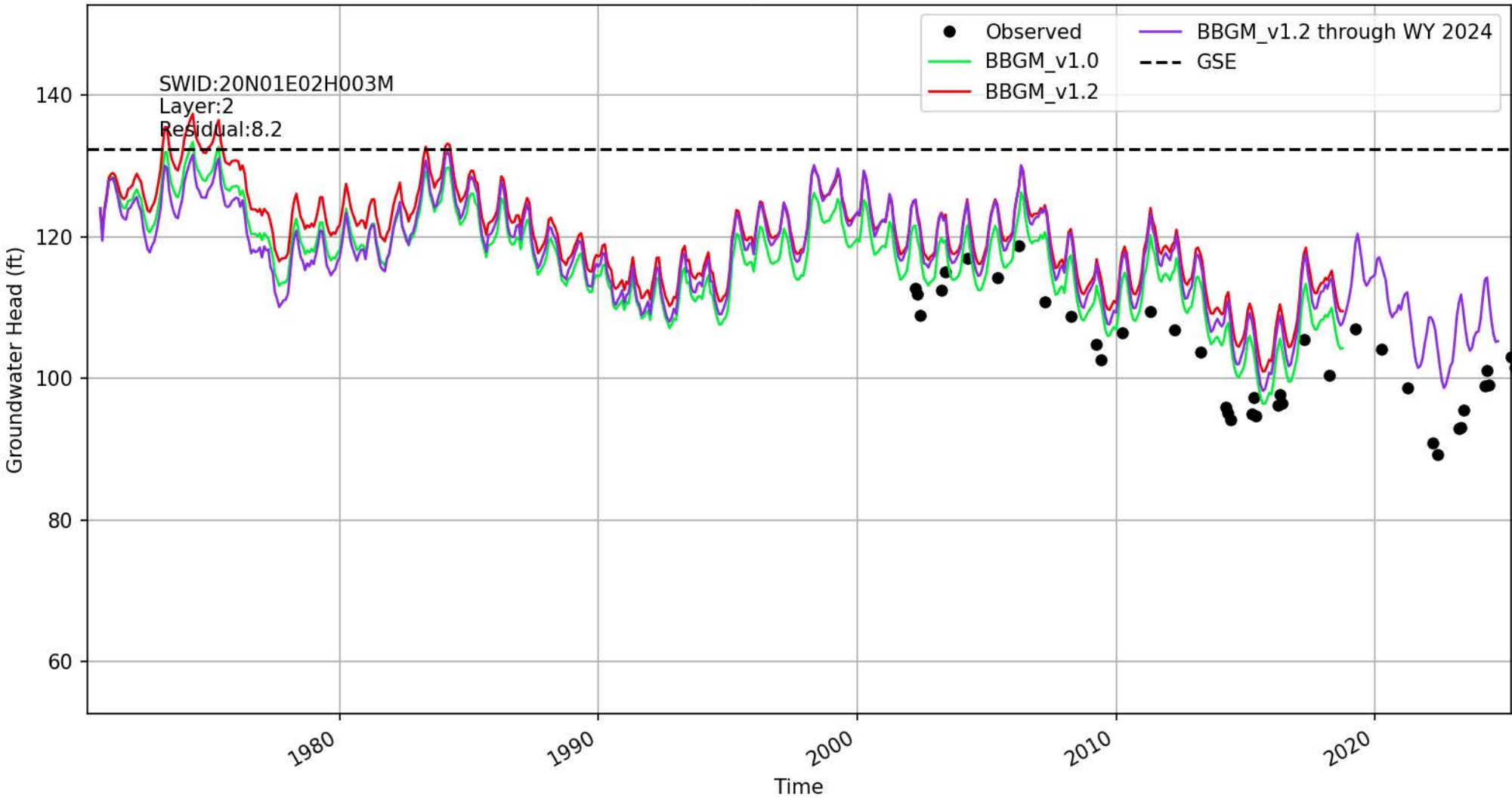
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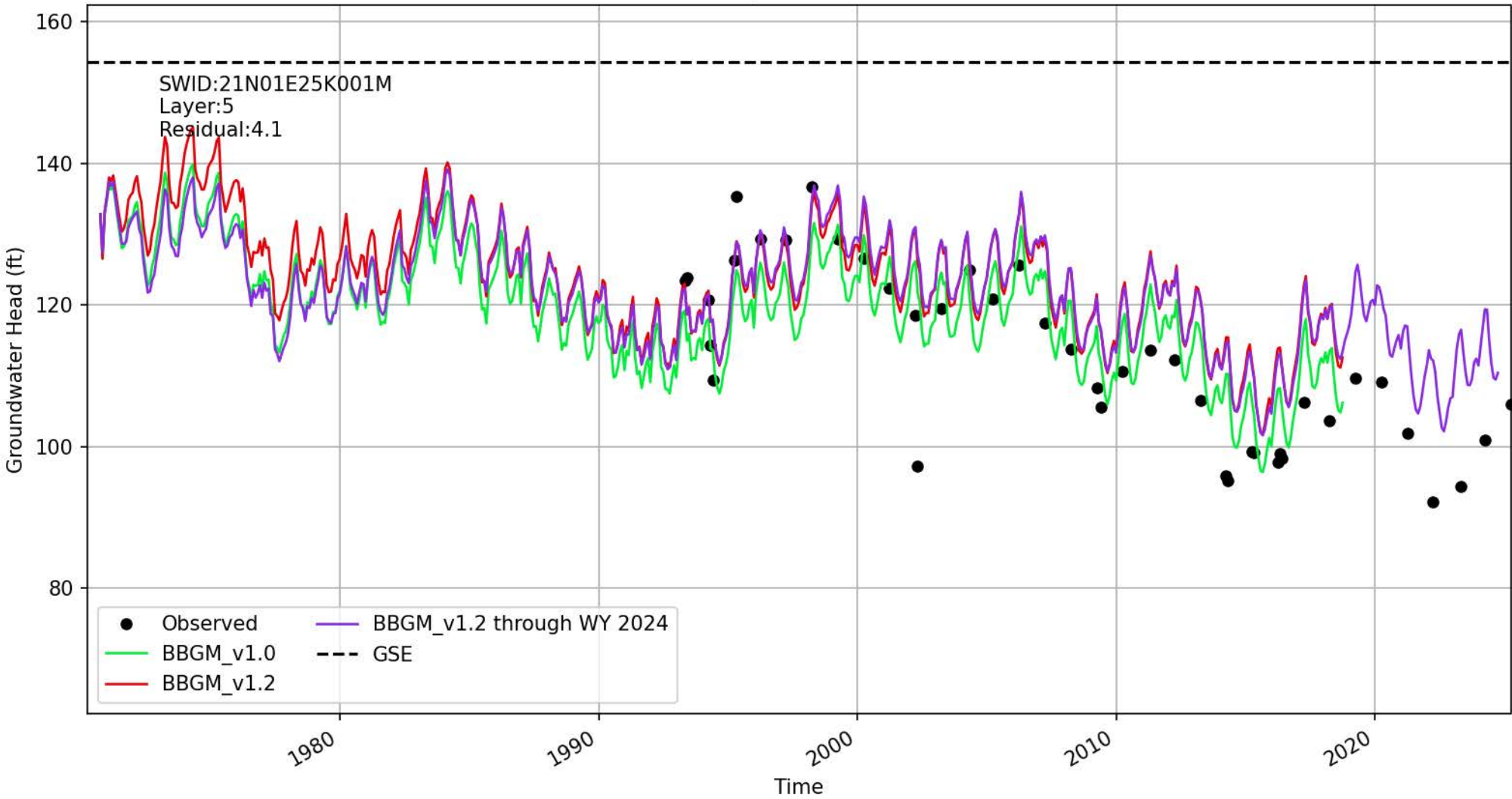


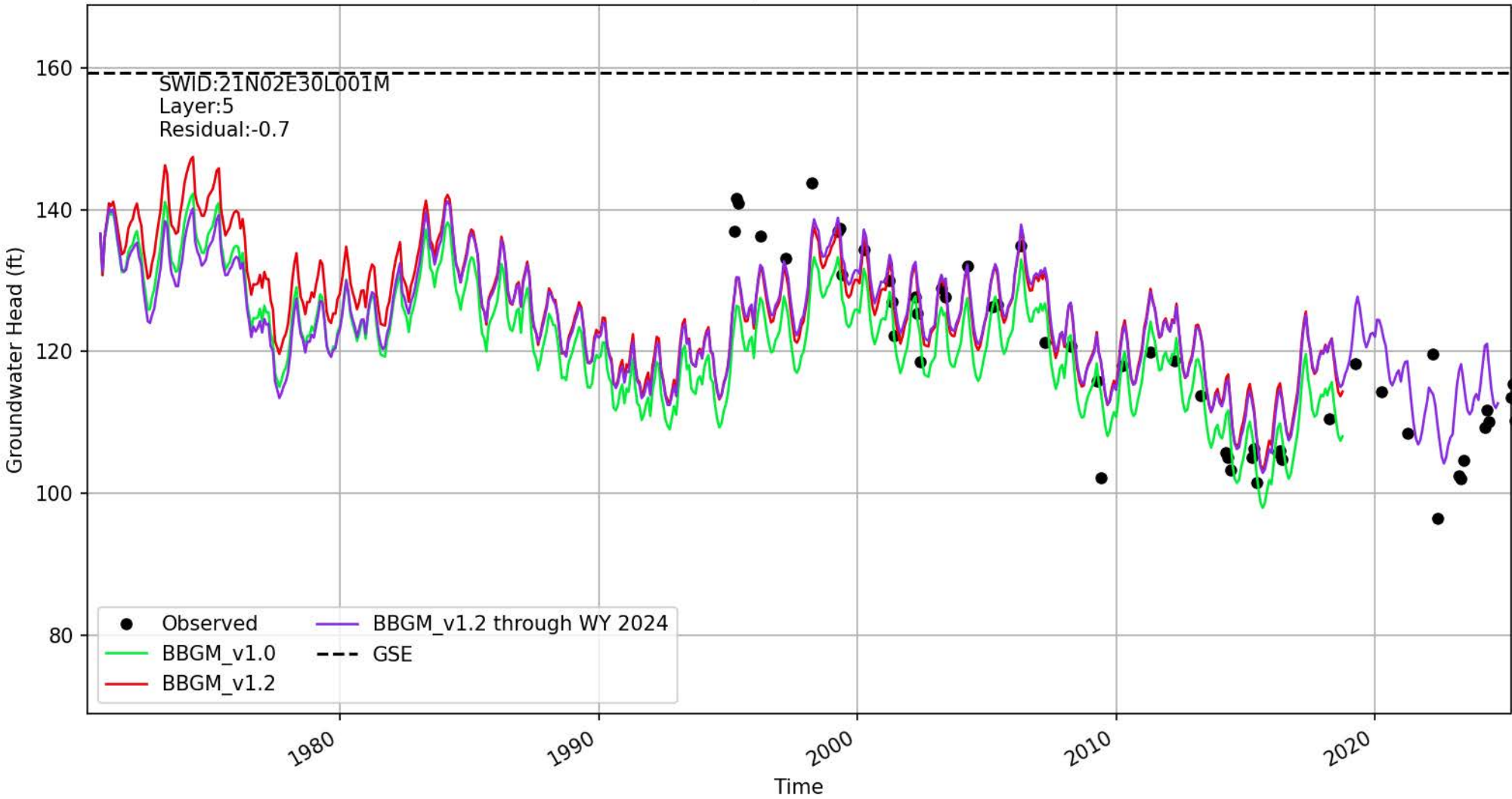
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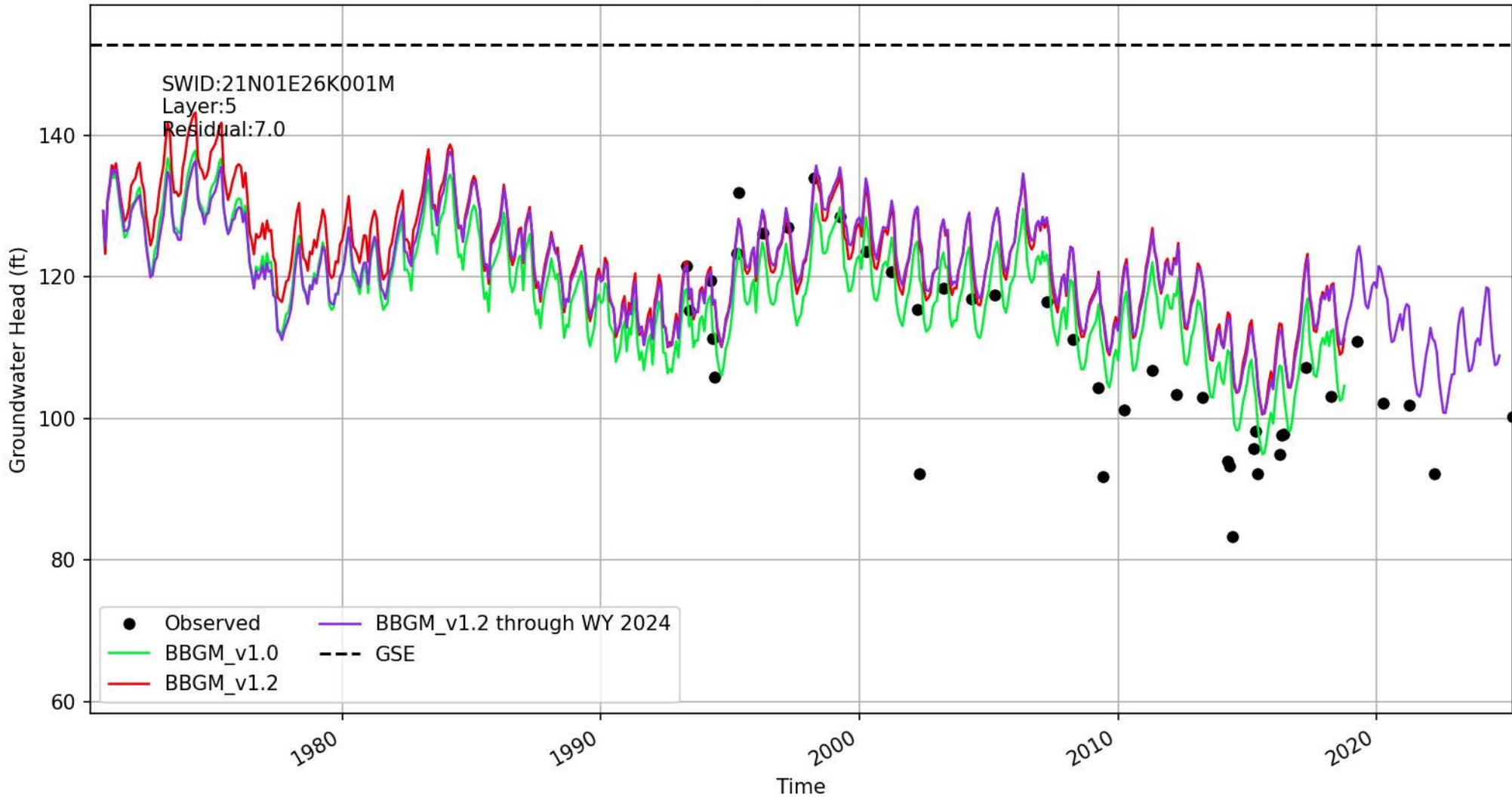


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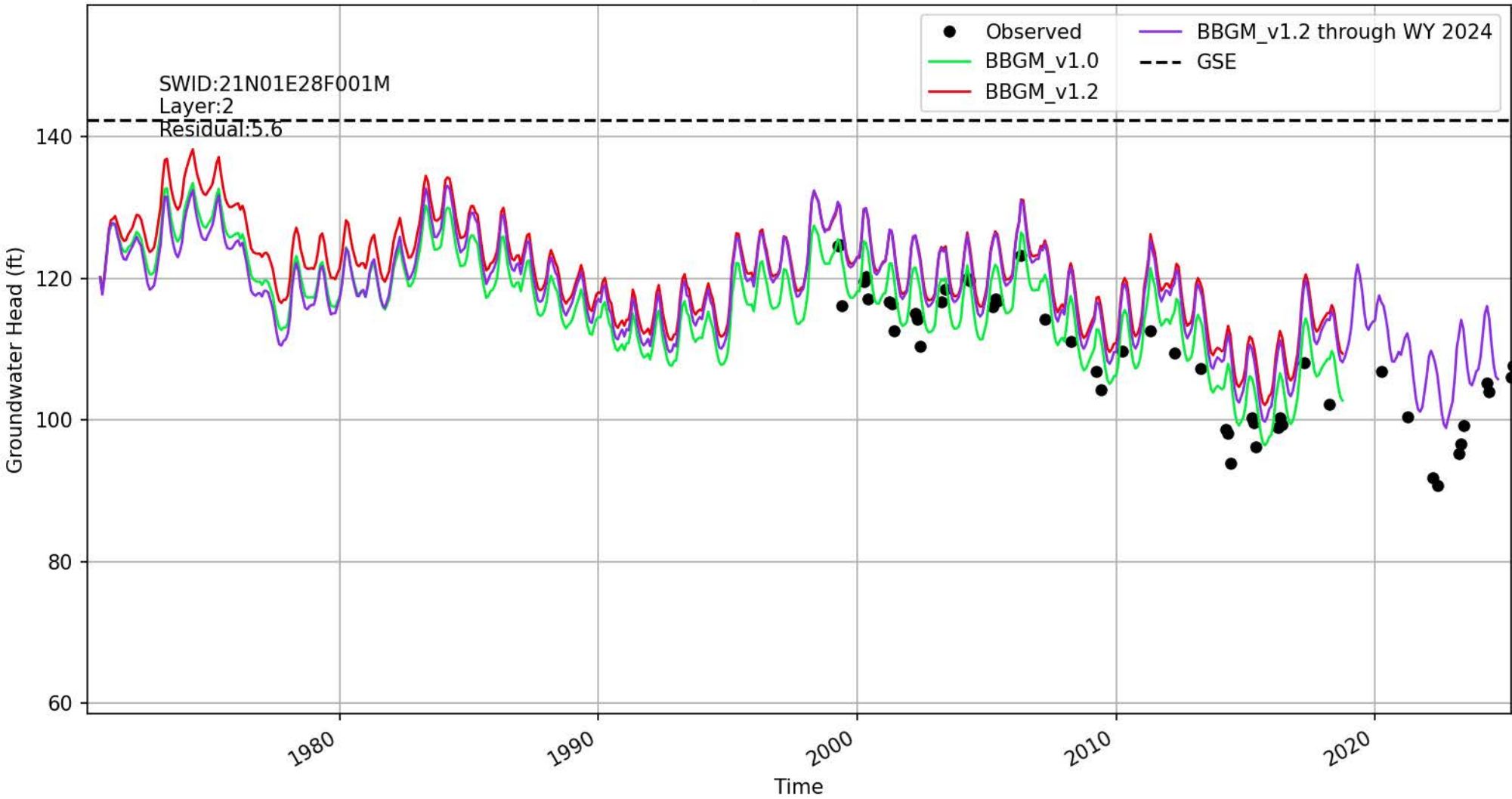


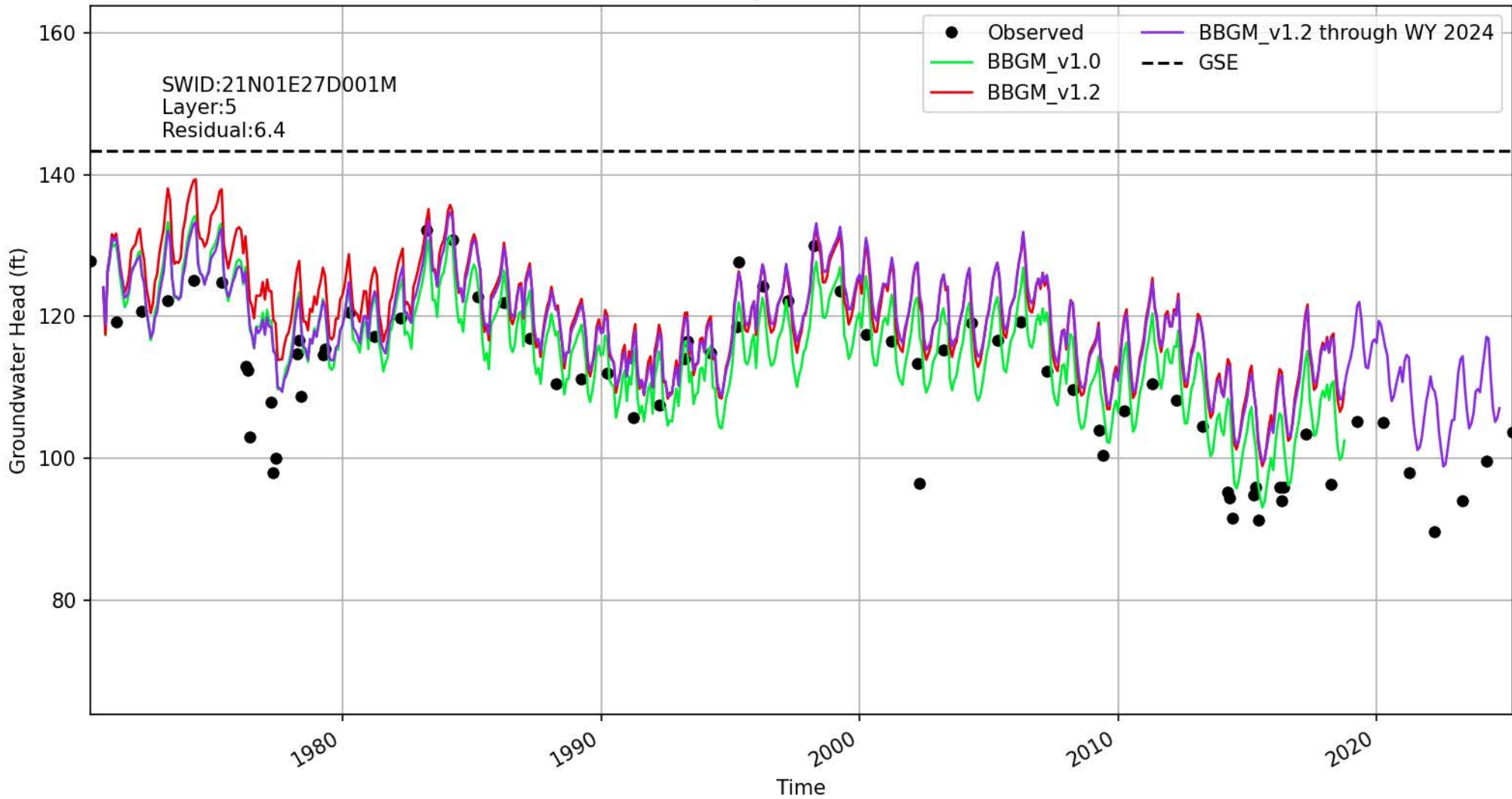


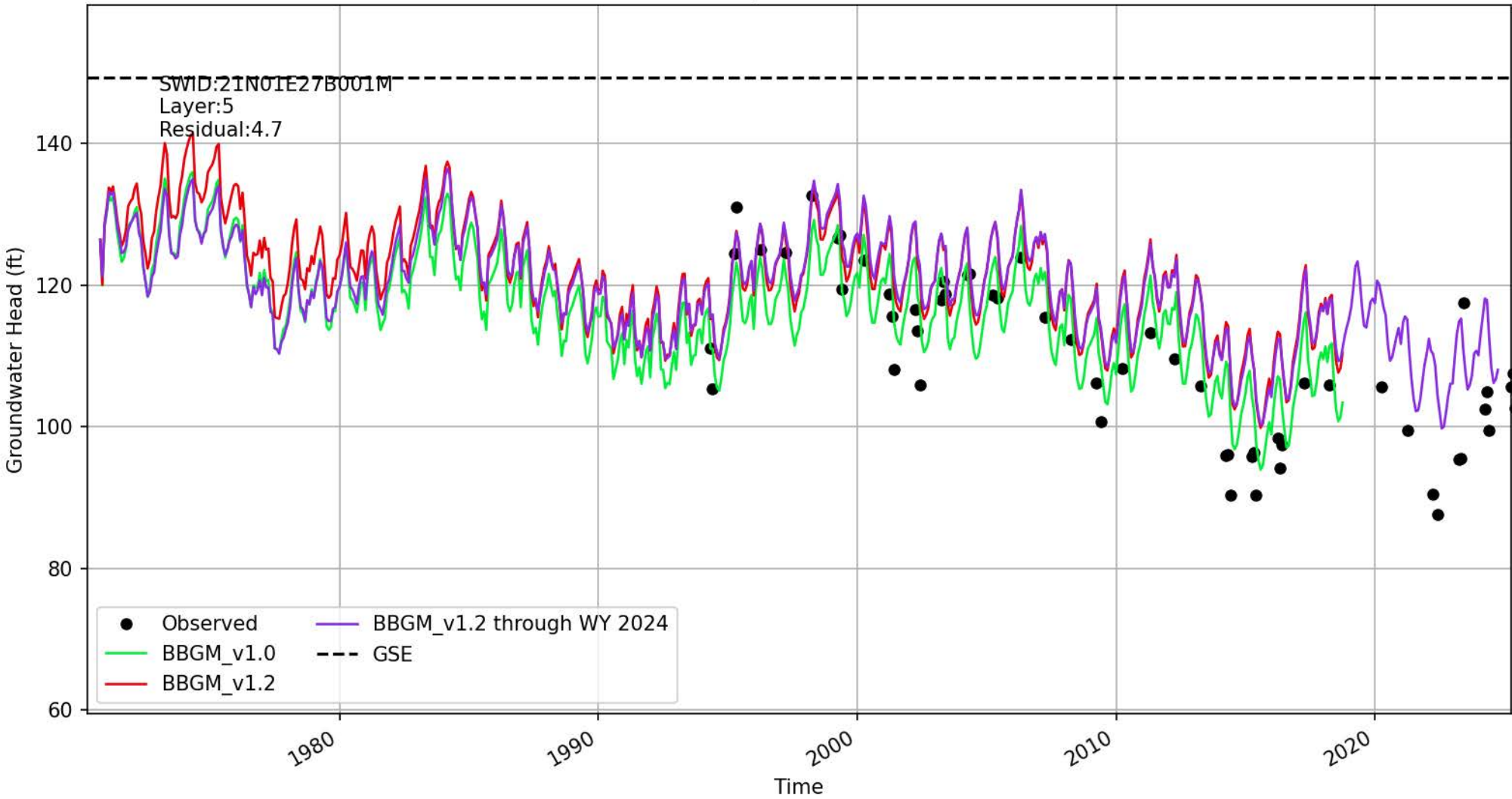




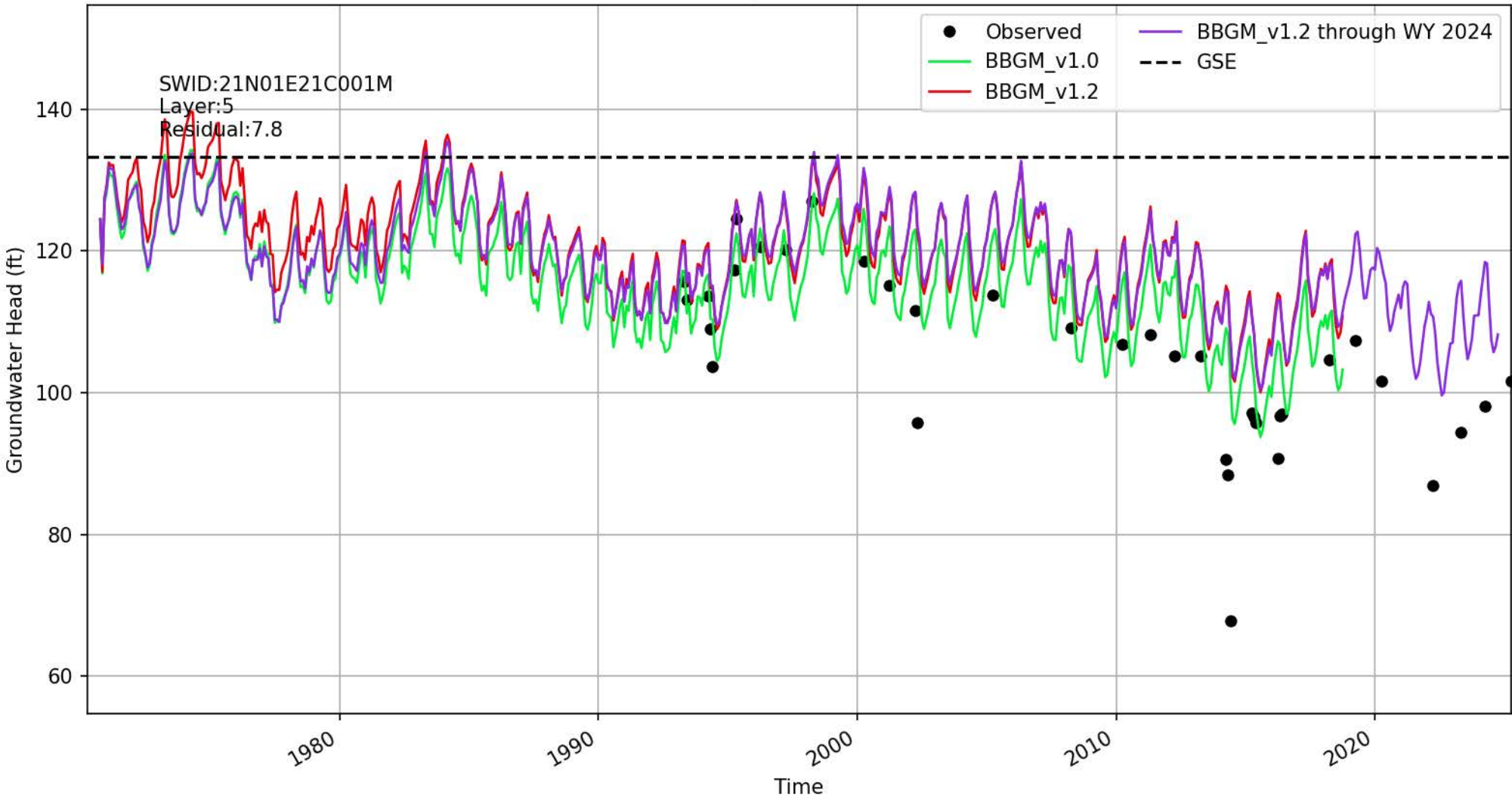
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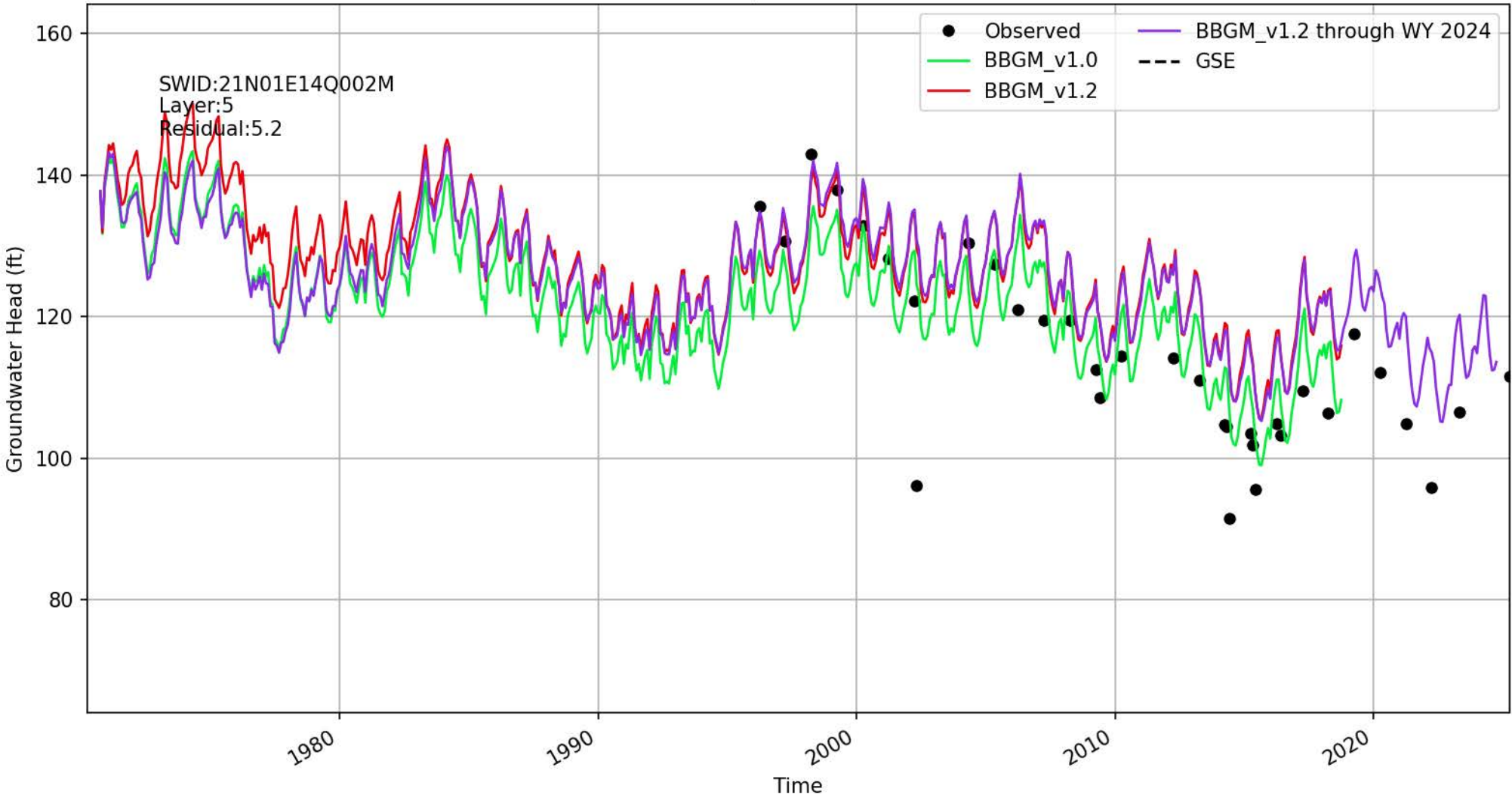


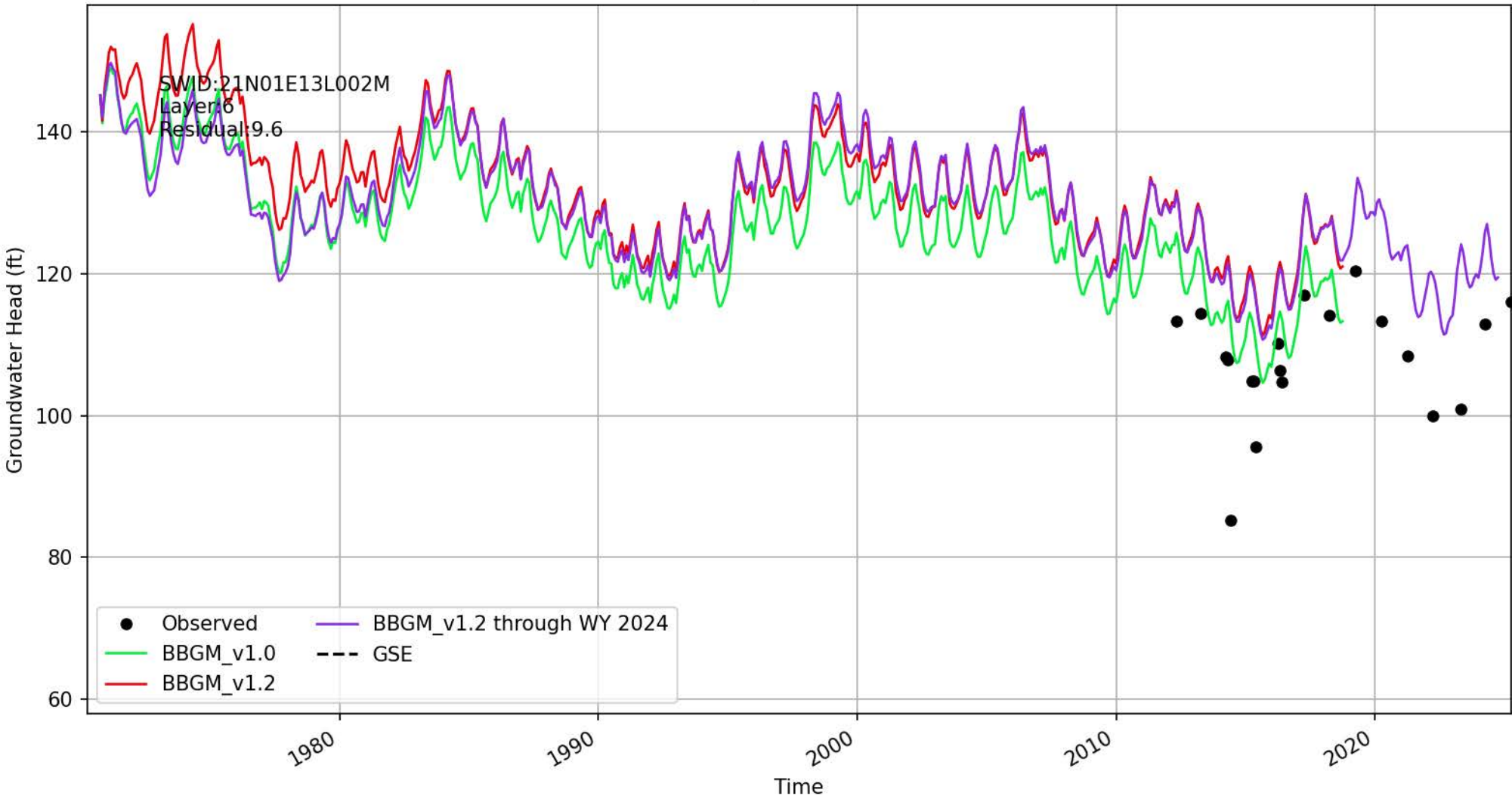


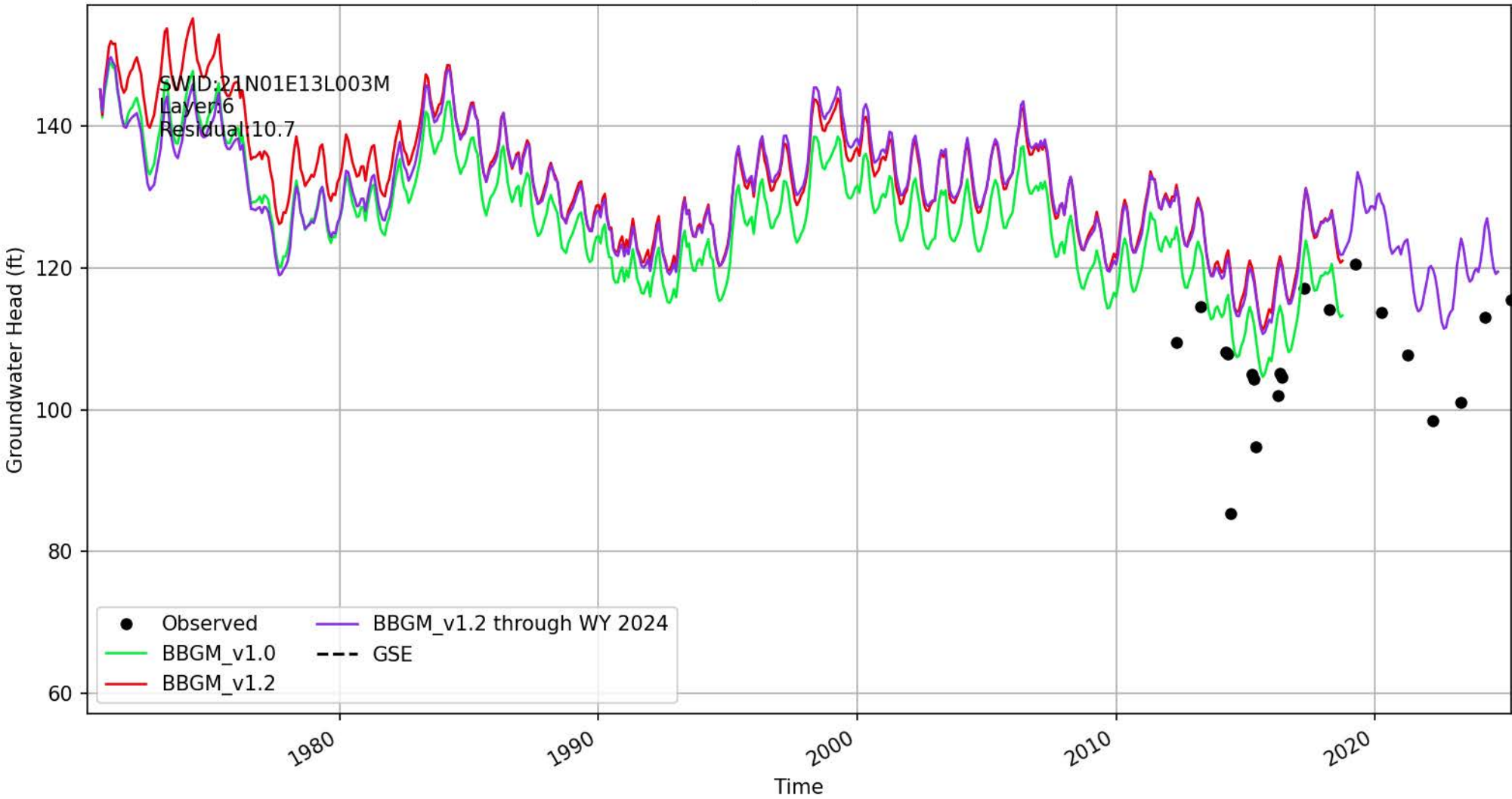
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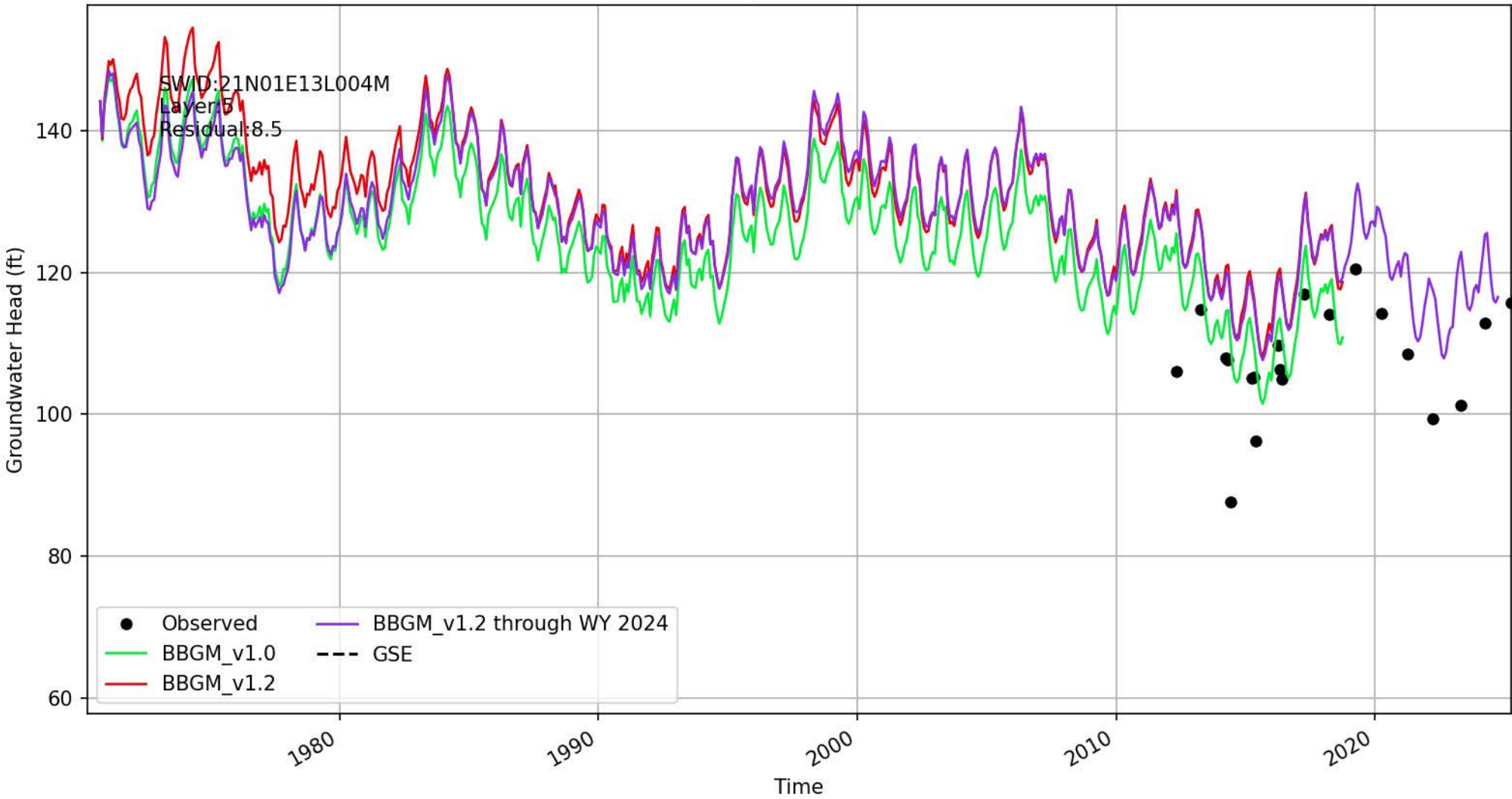


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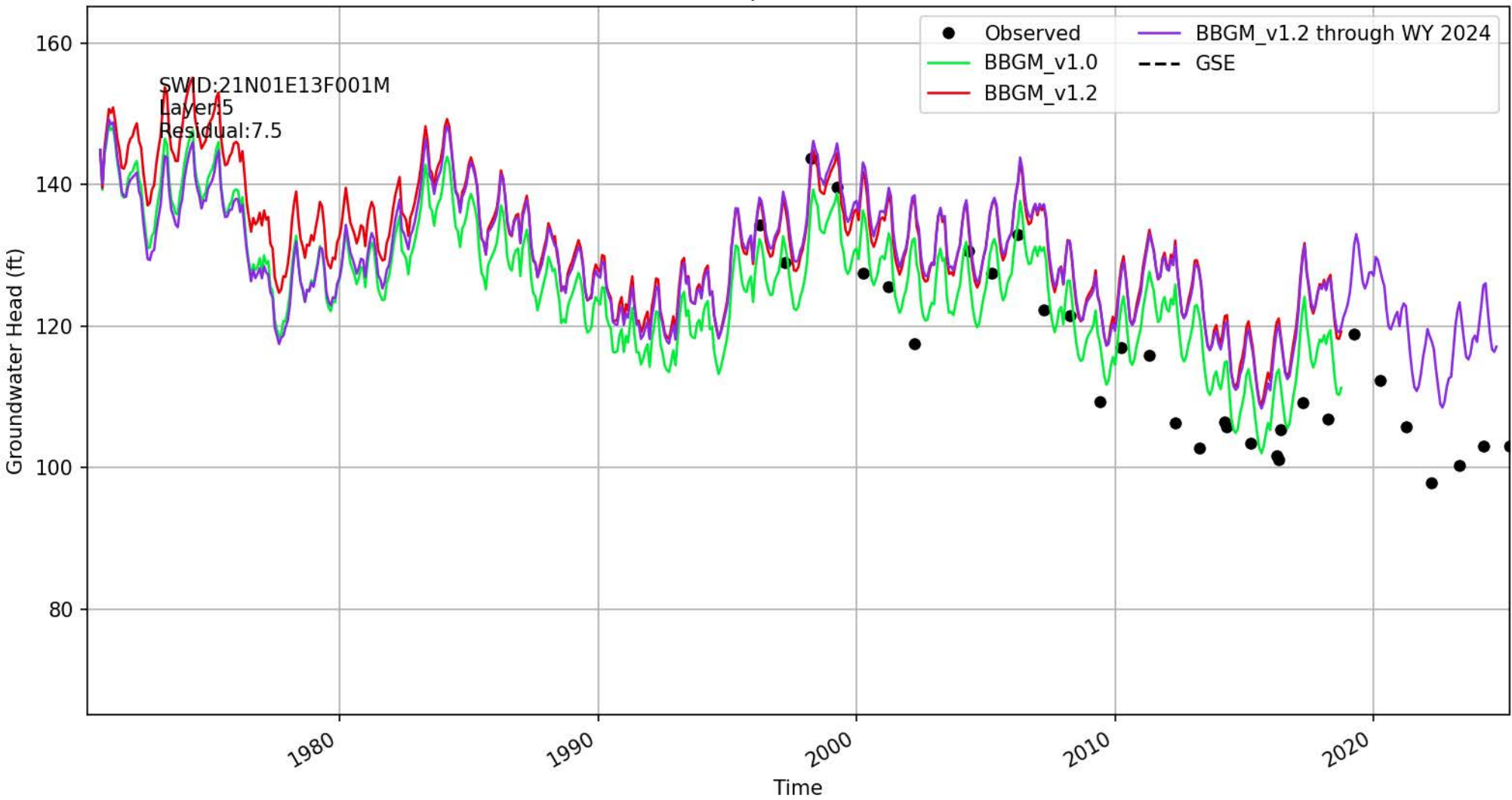


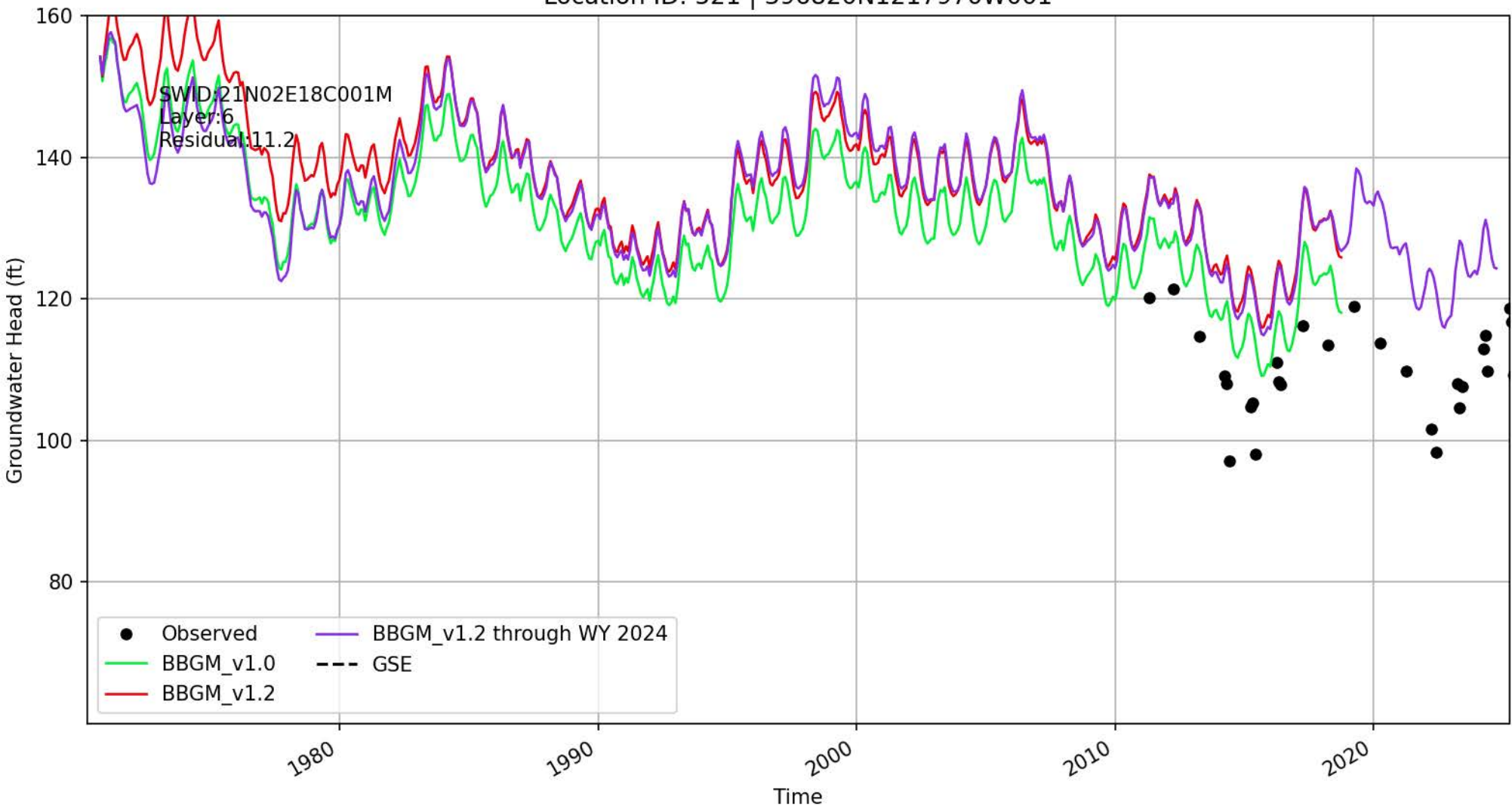


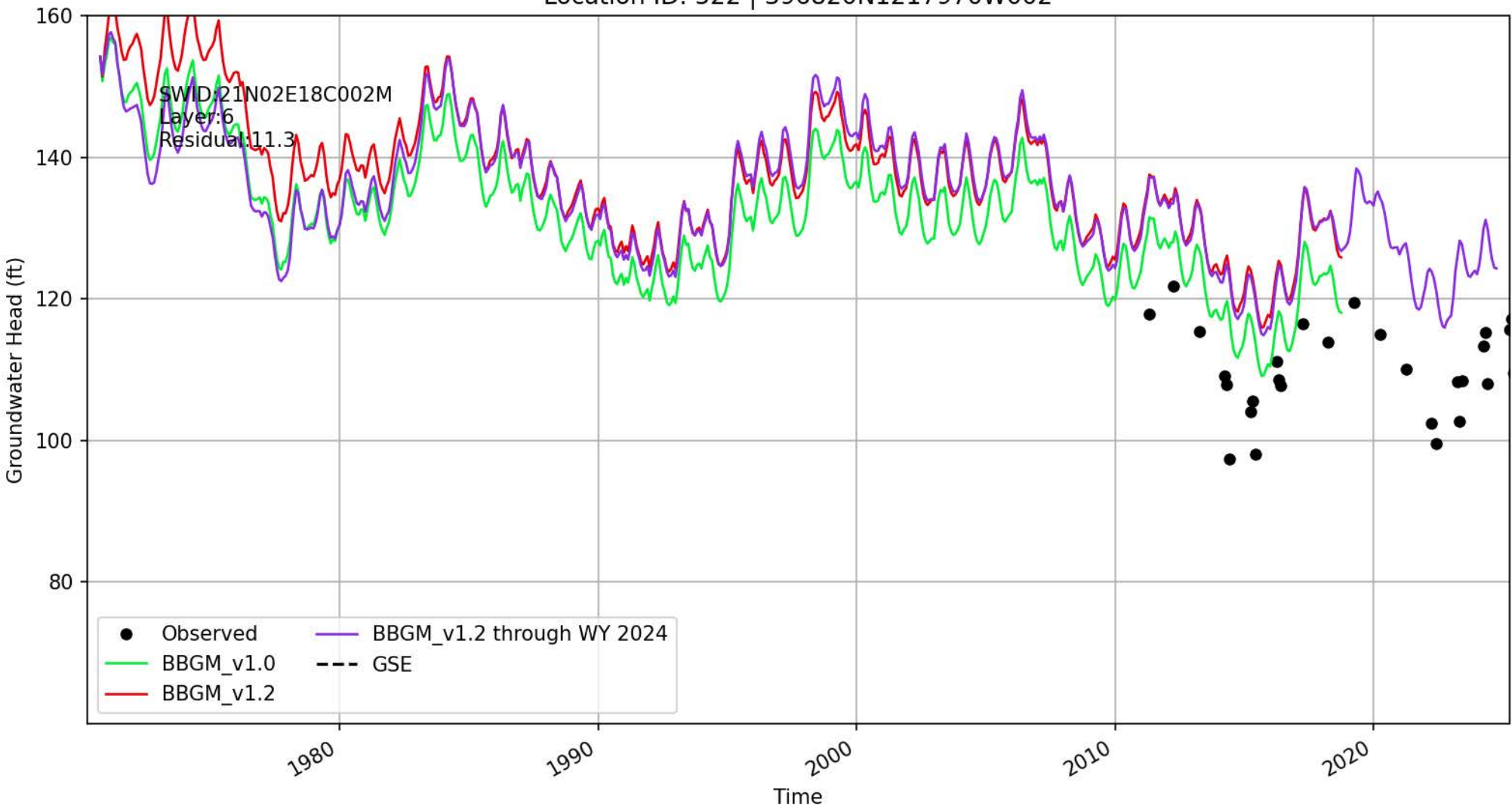




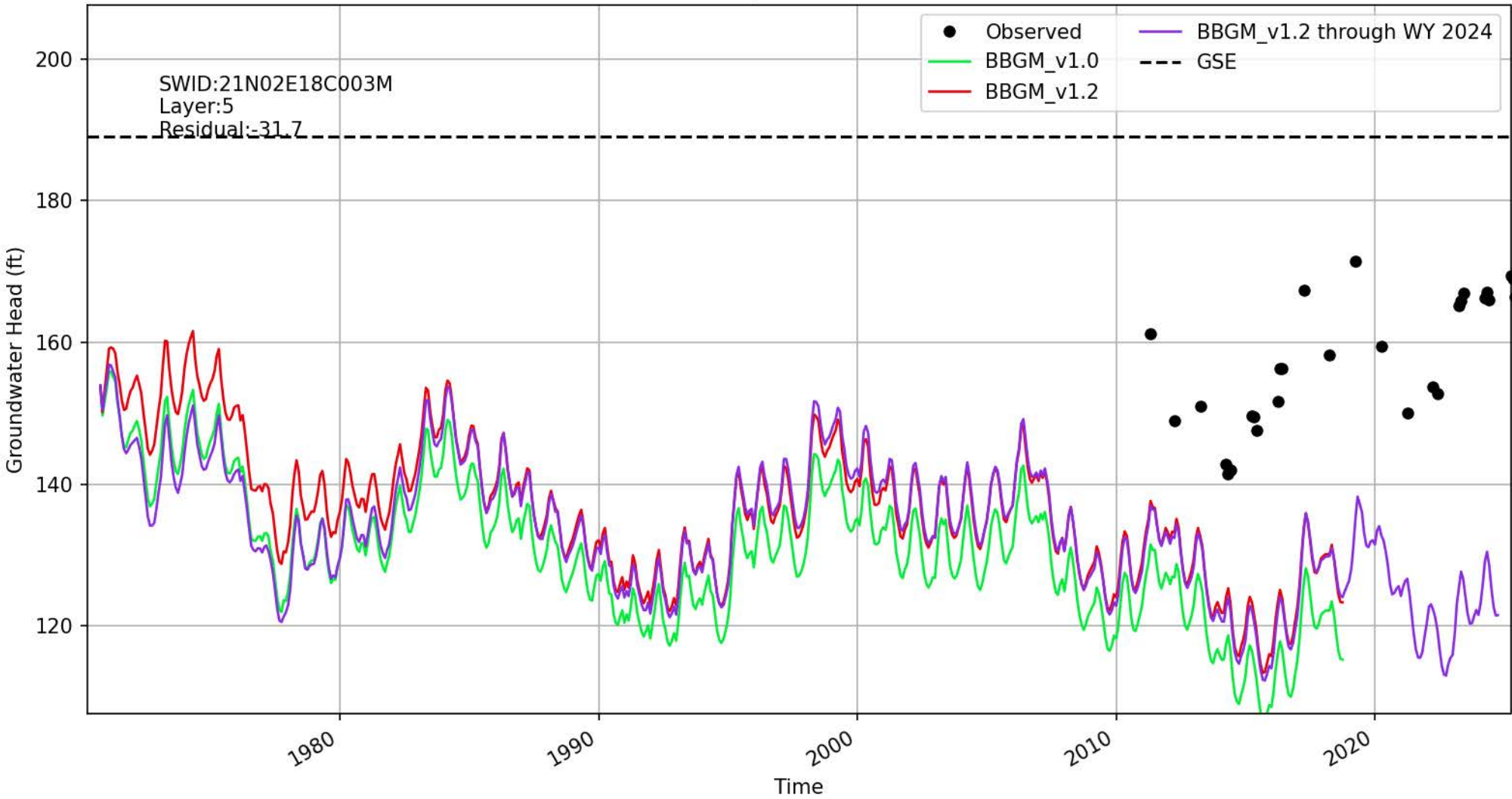
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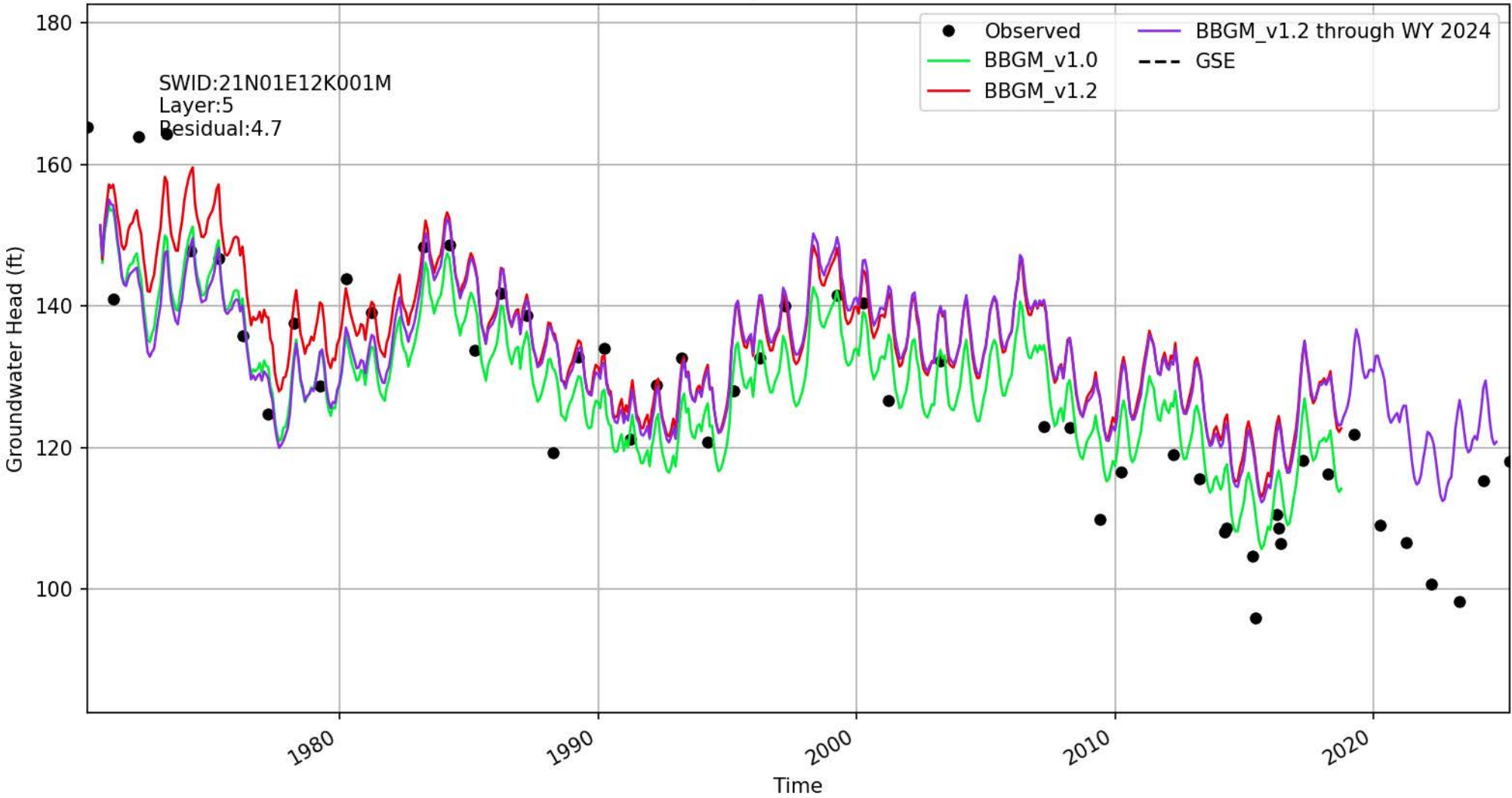




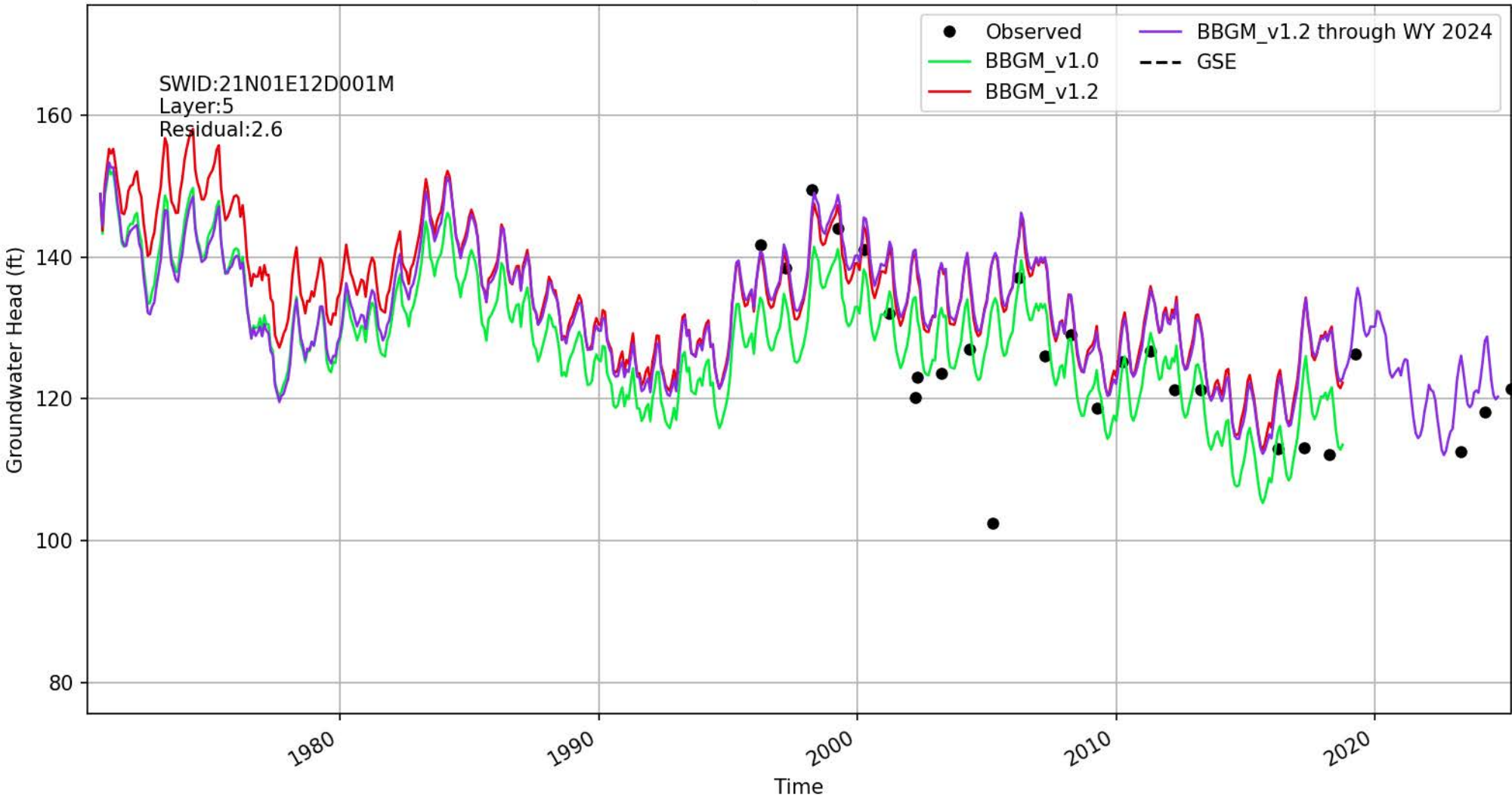
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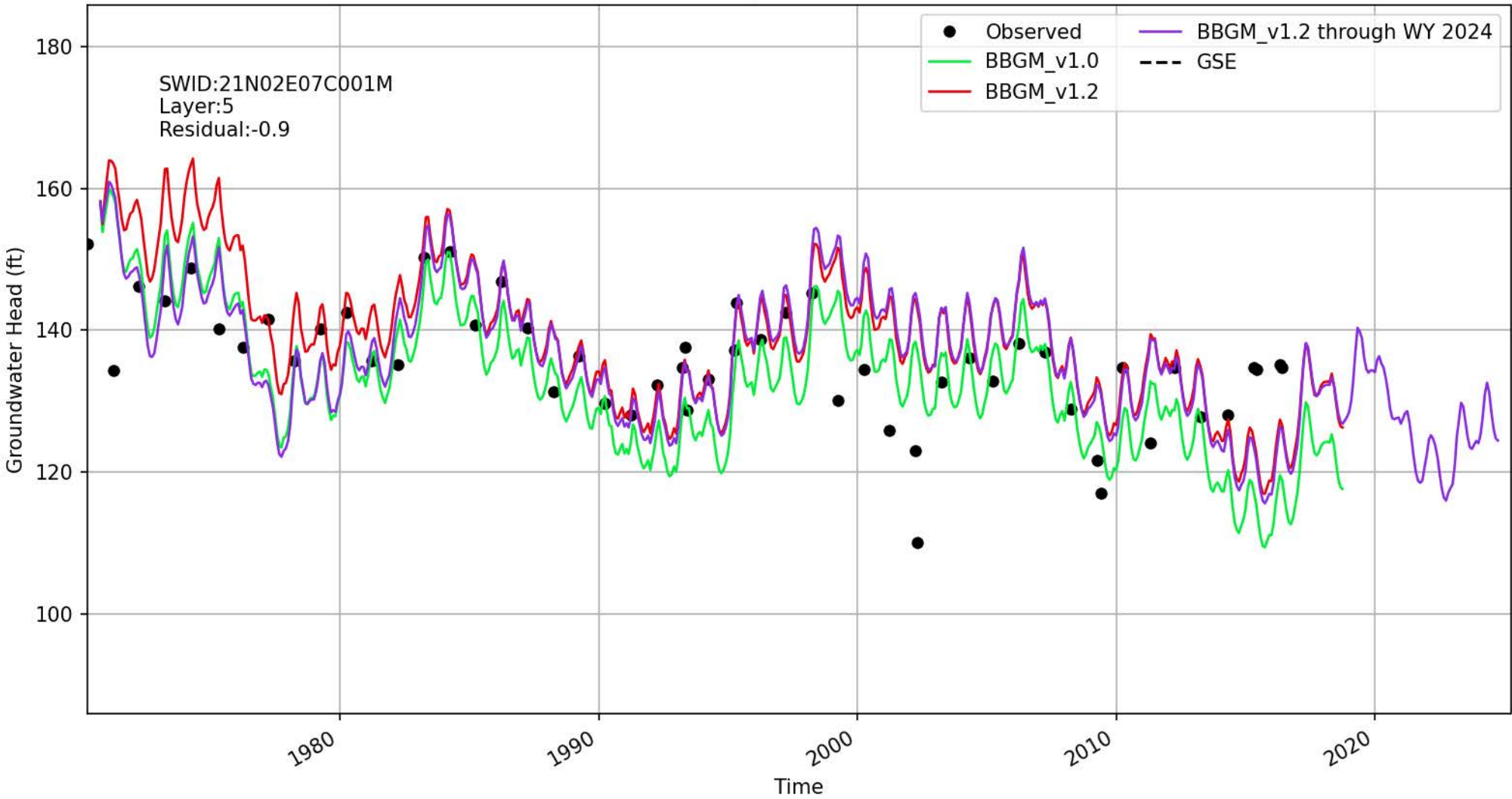
Location ID: 525 | 396892N1218121W001



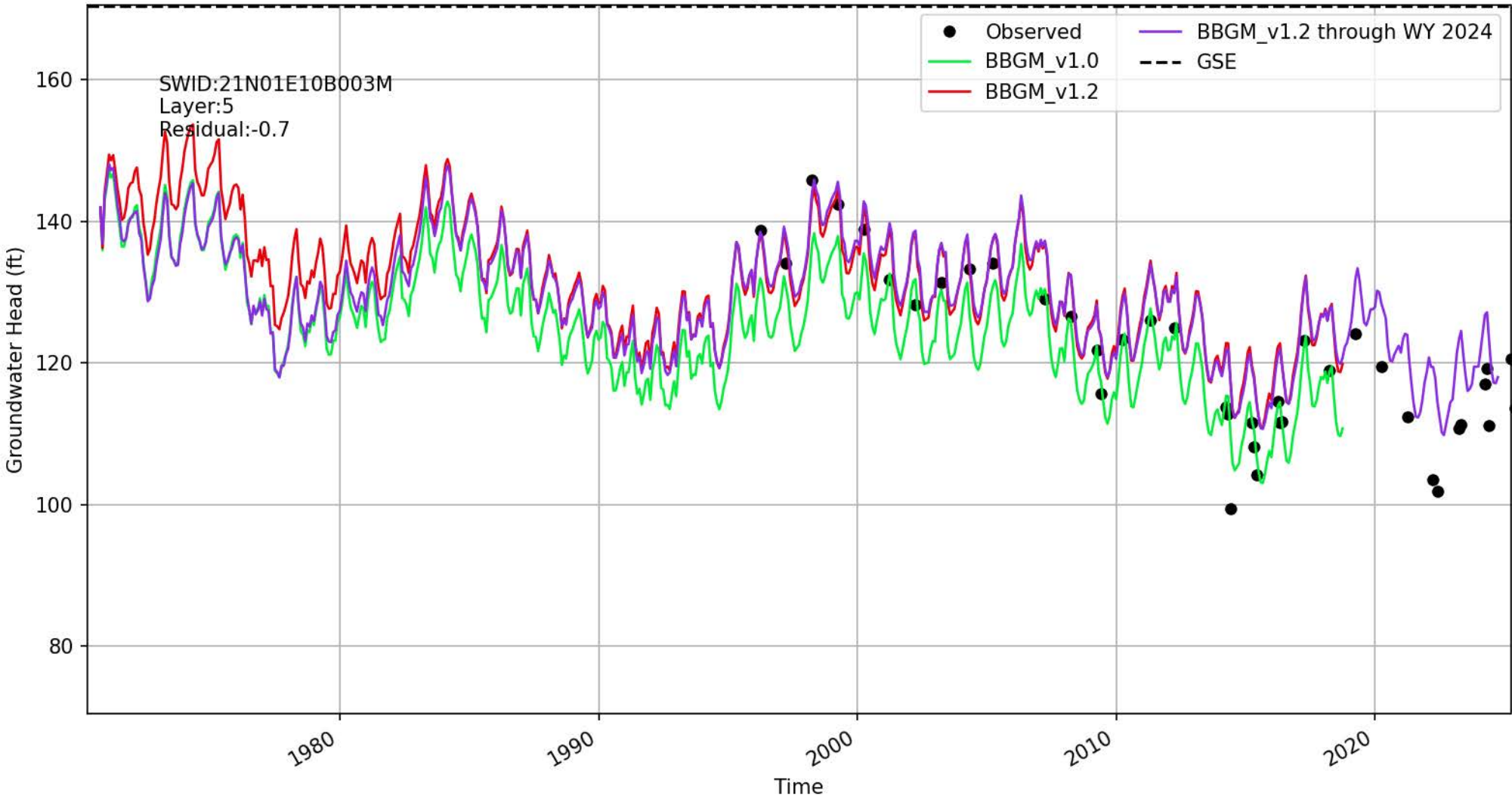
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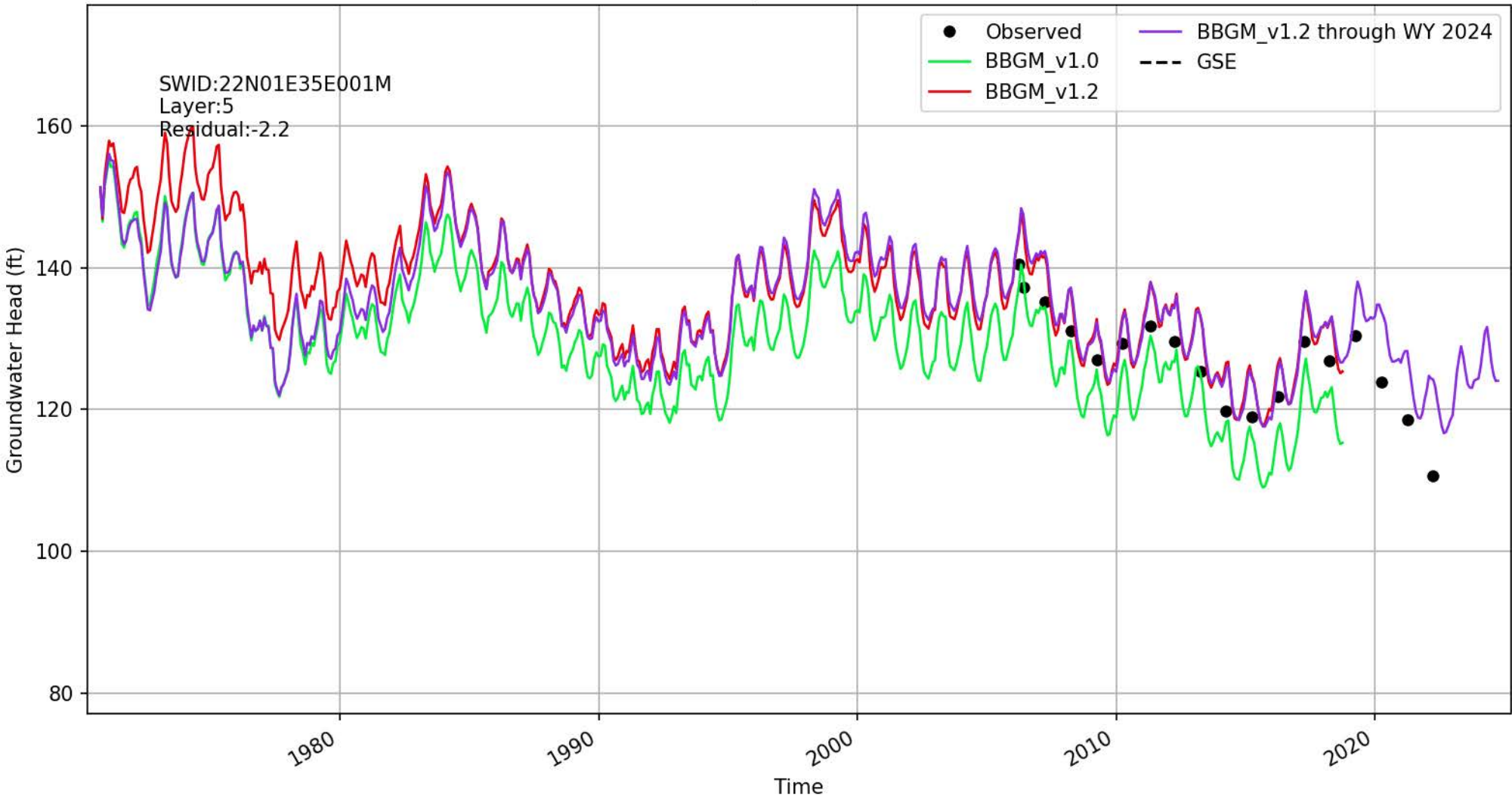
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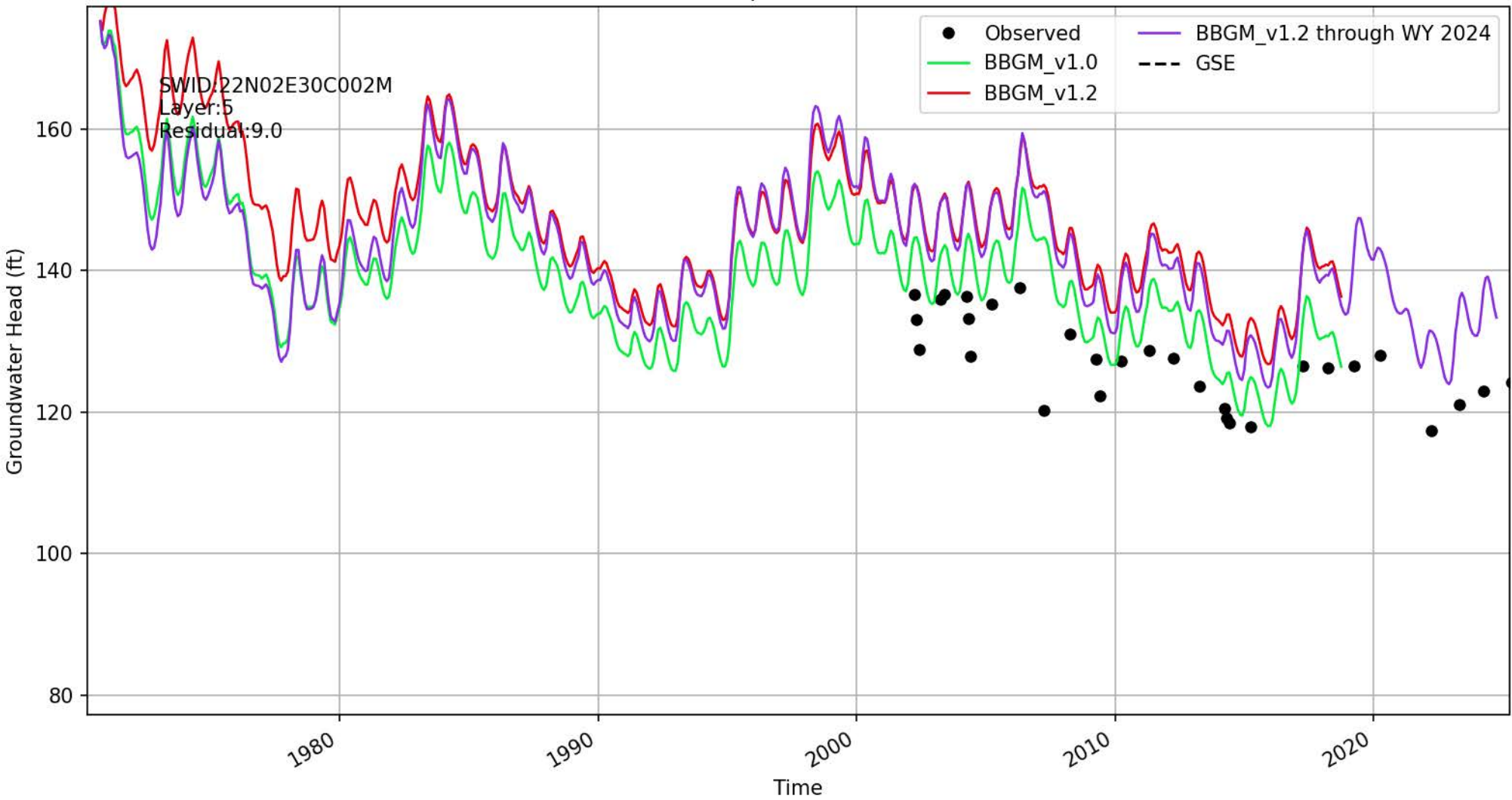
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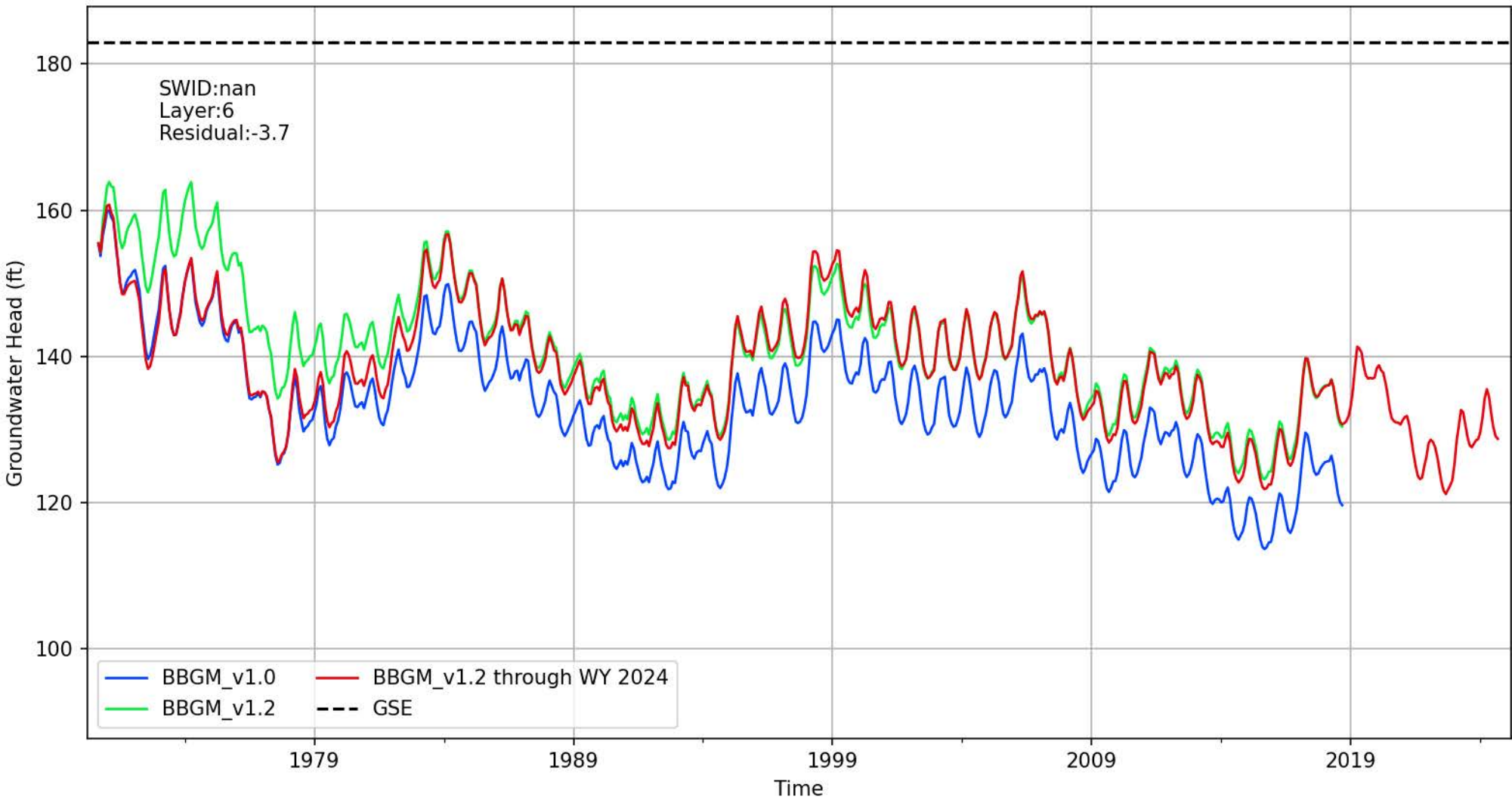
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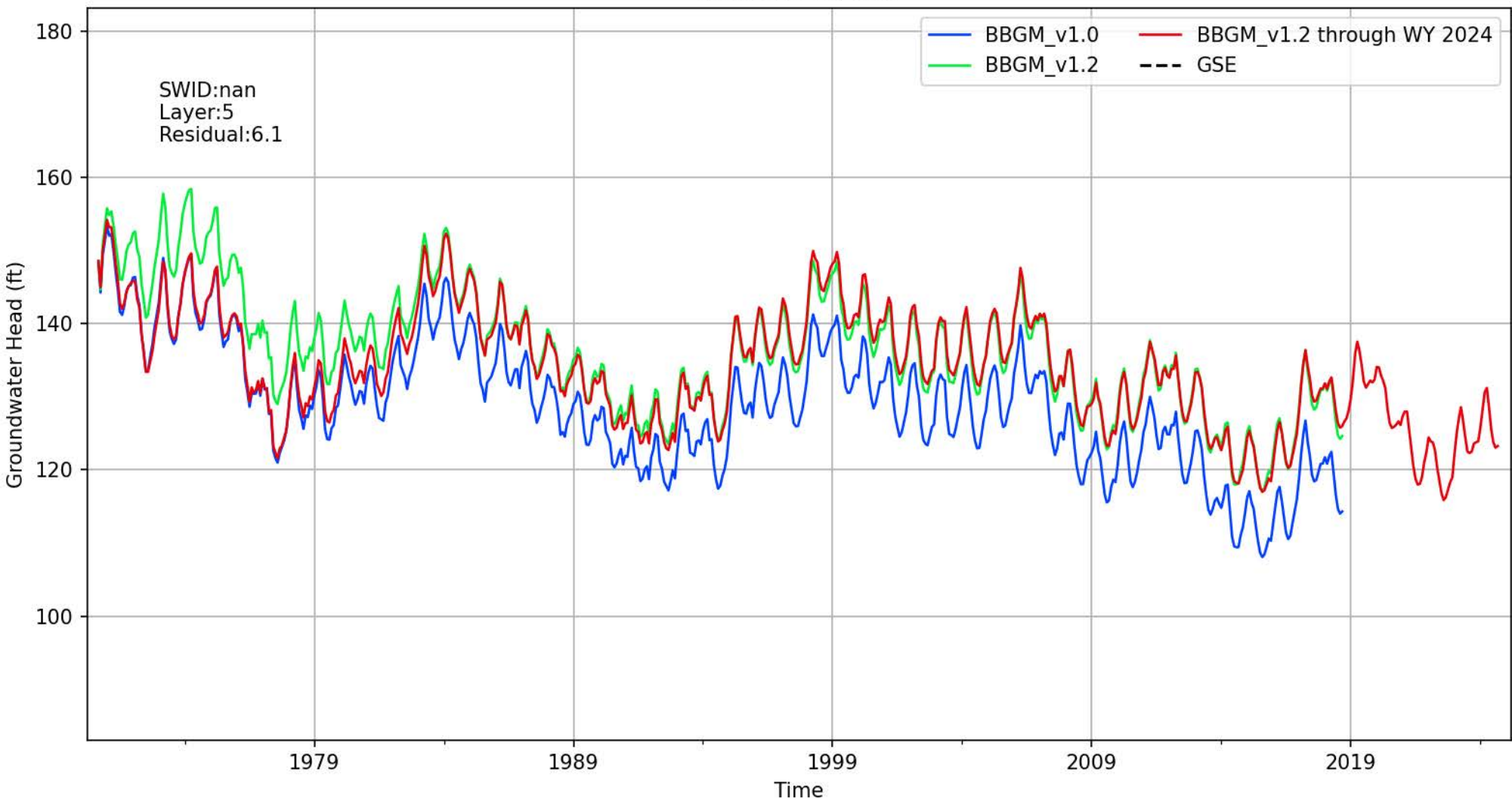
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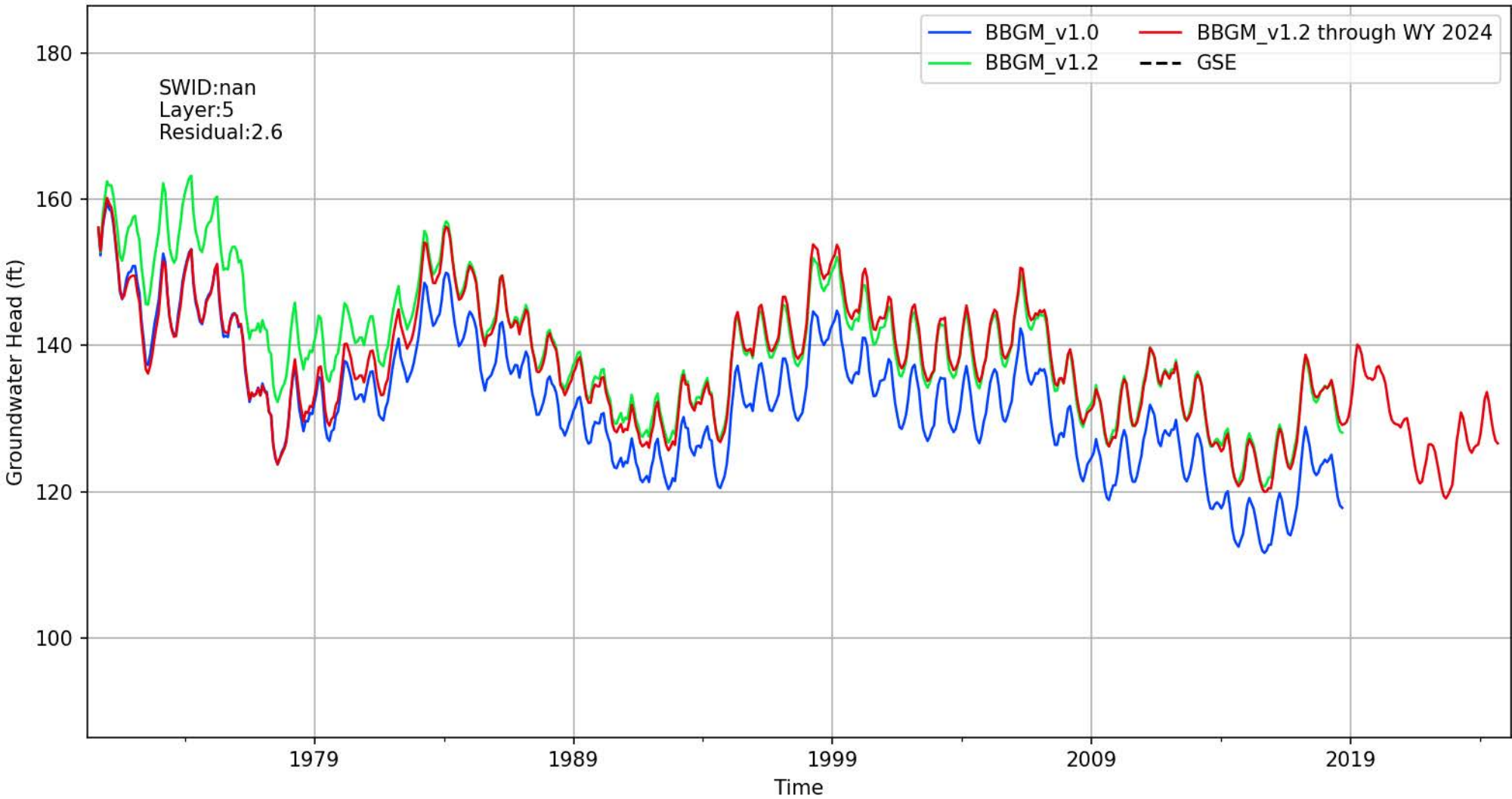
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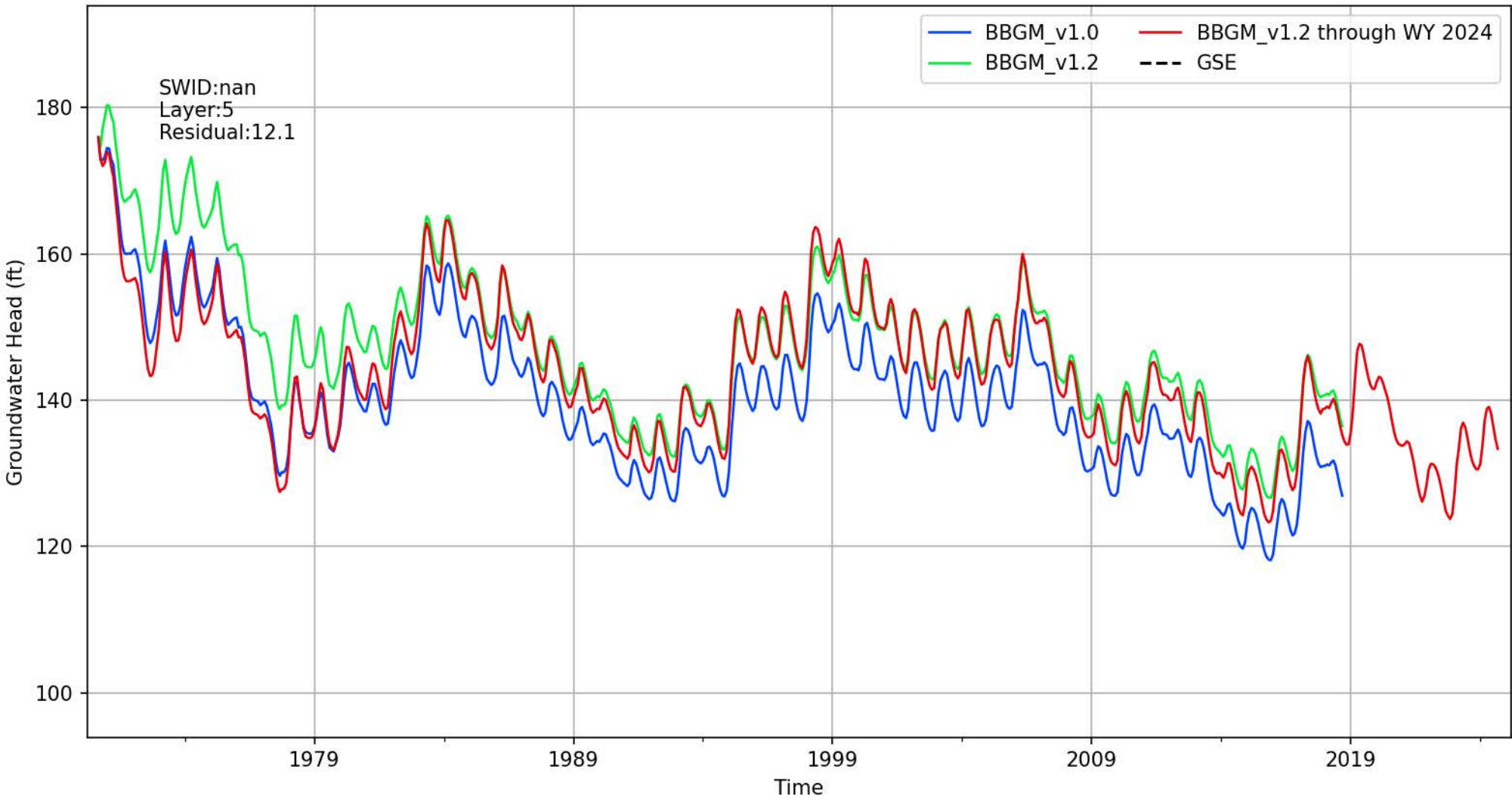
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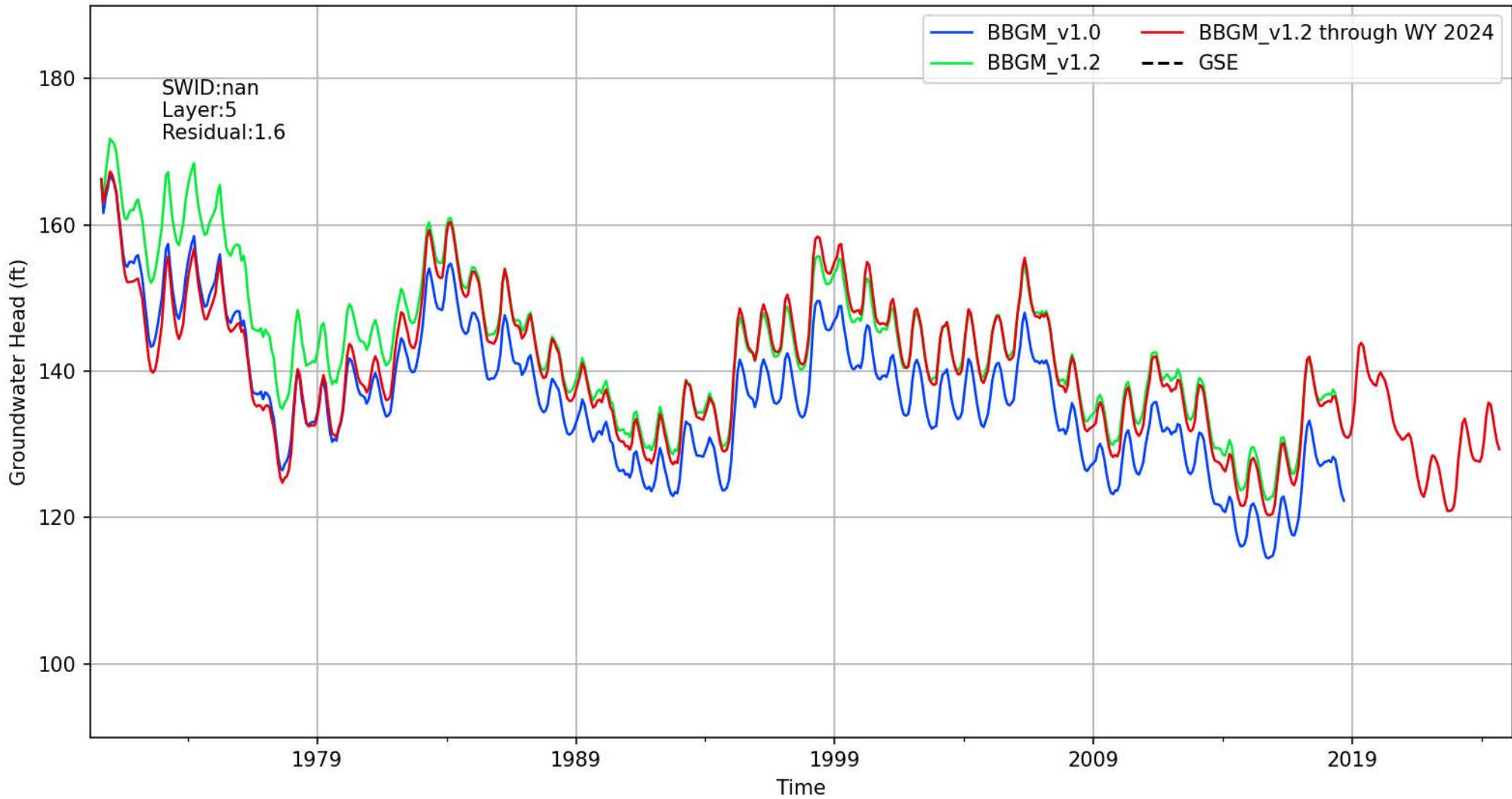
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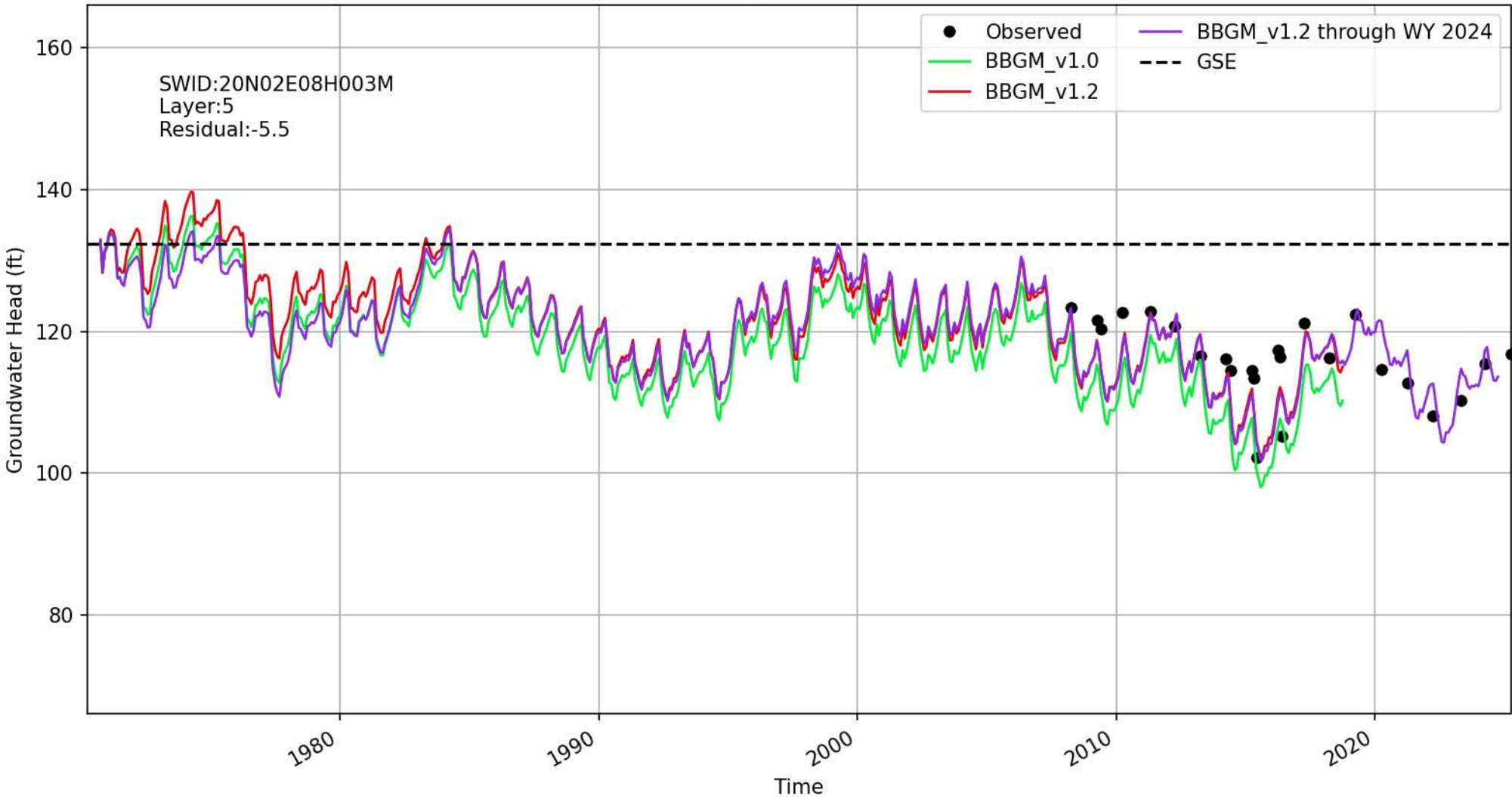
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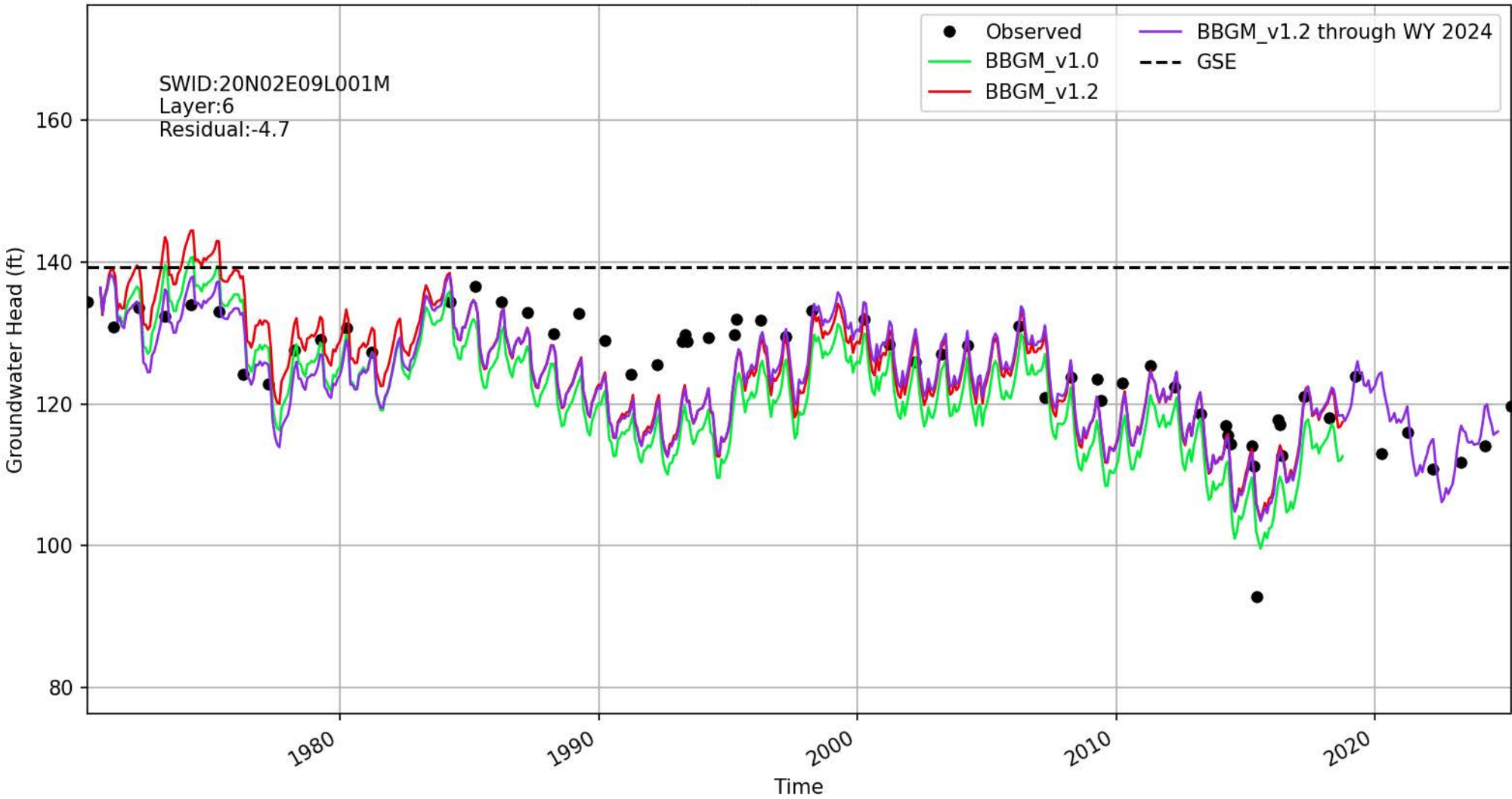


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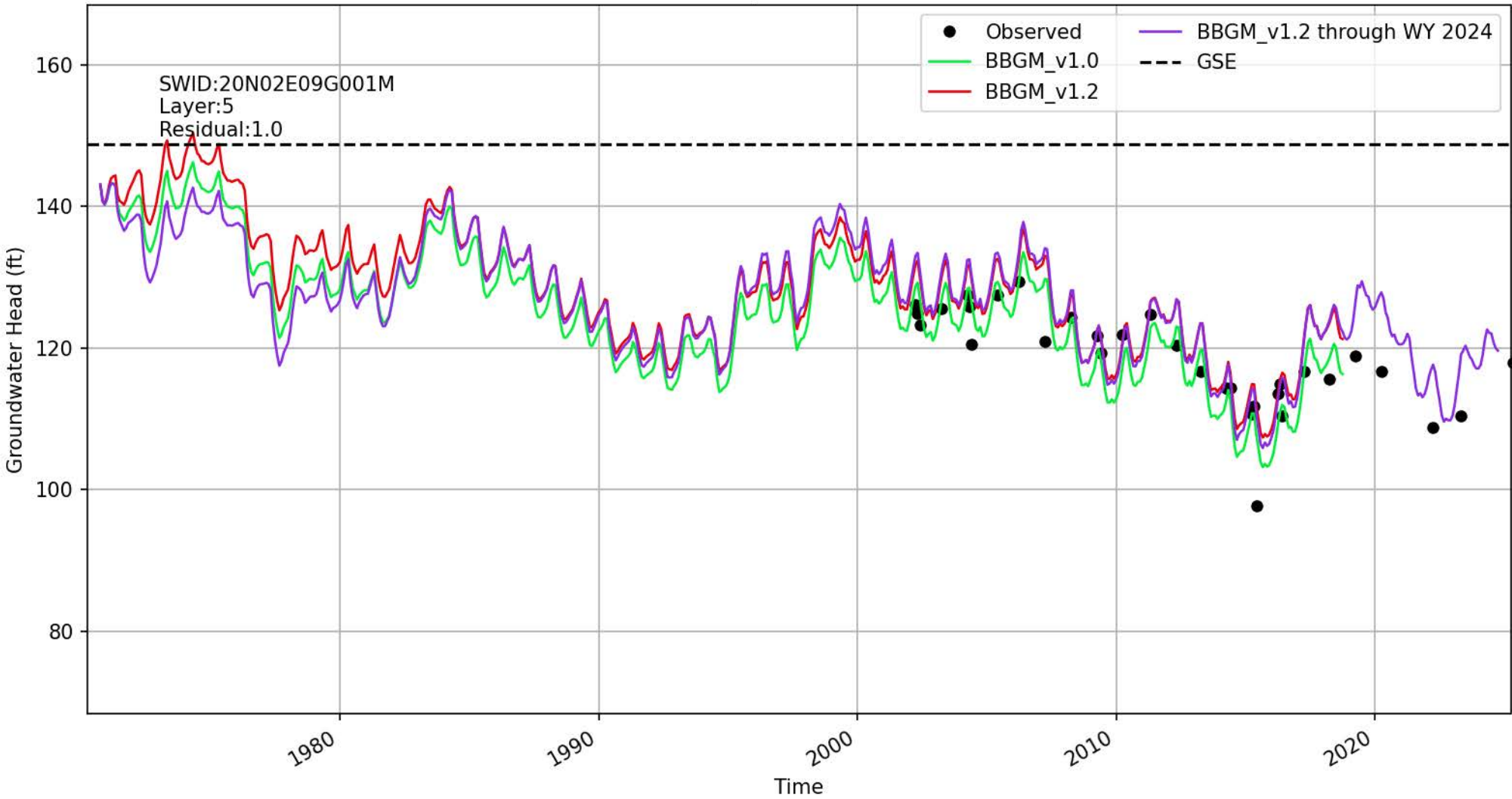


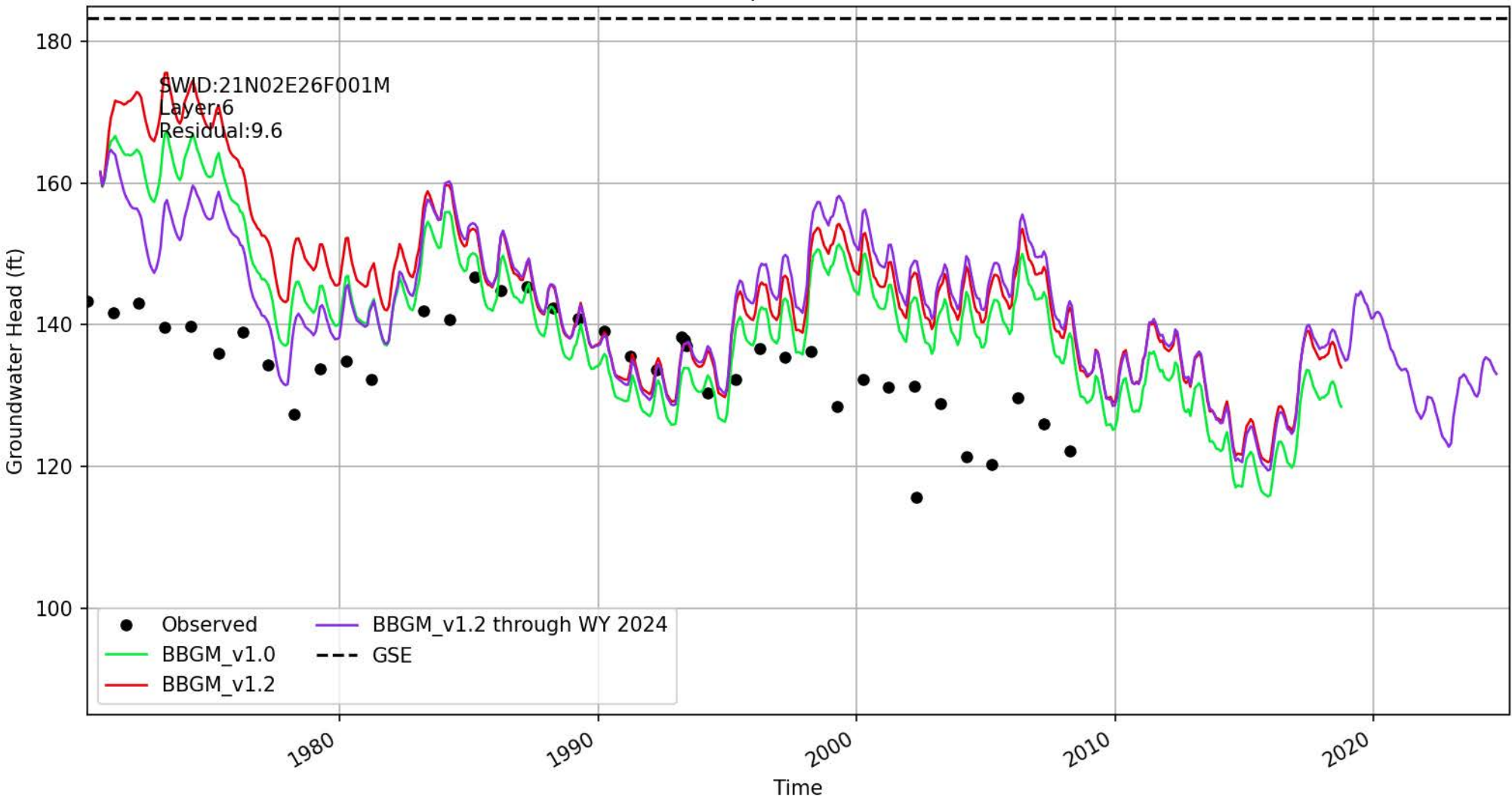
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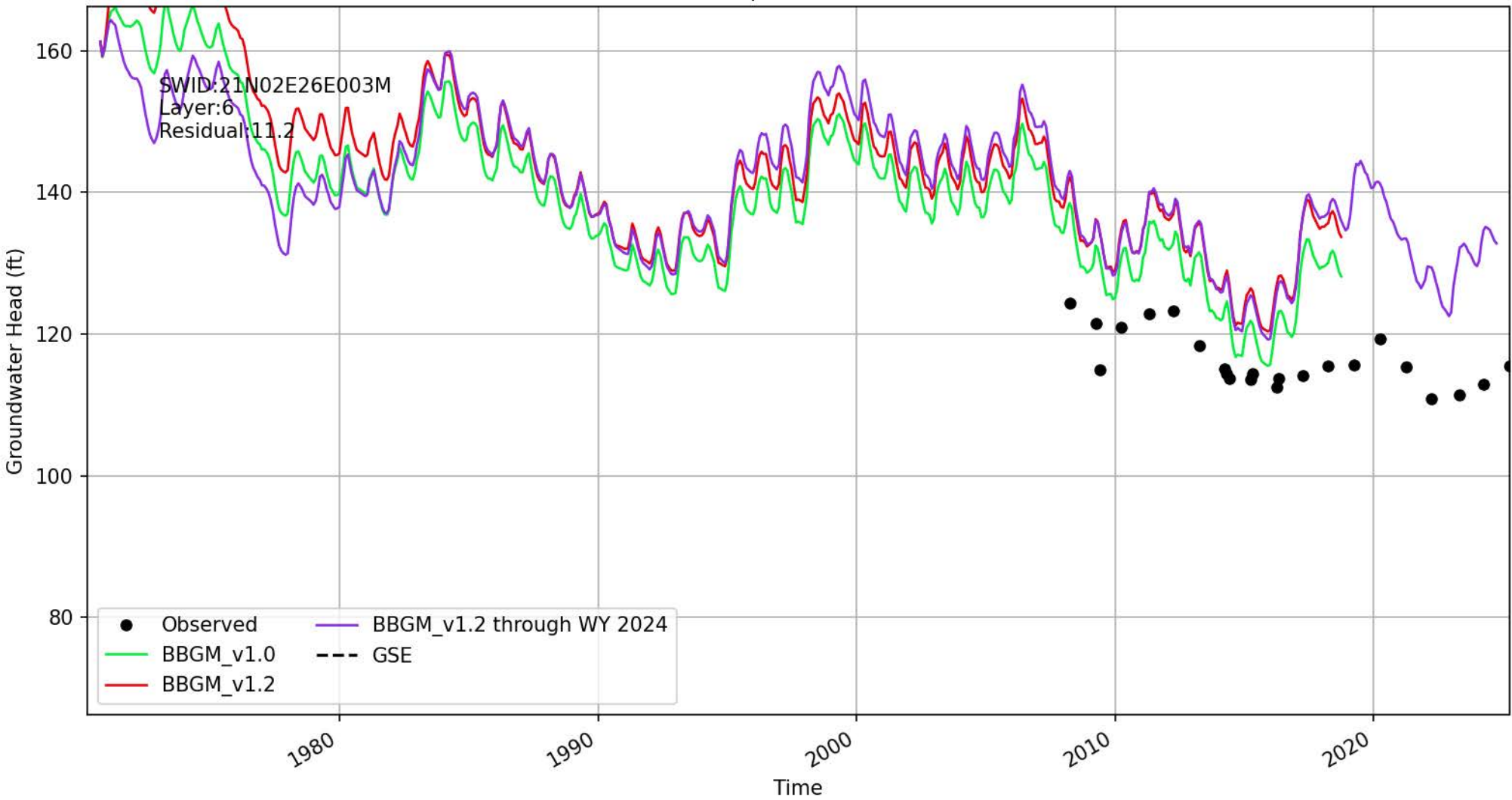


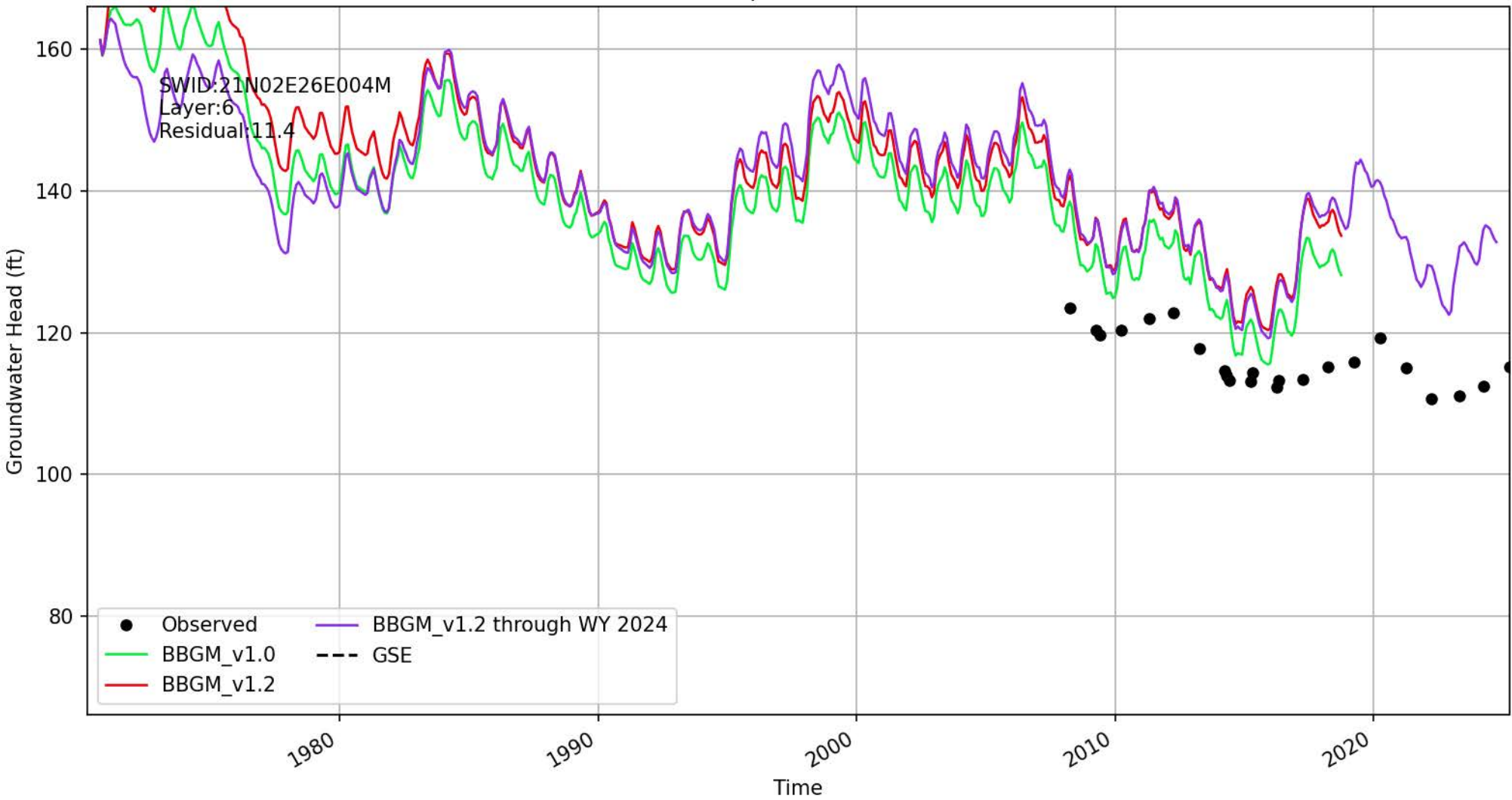


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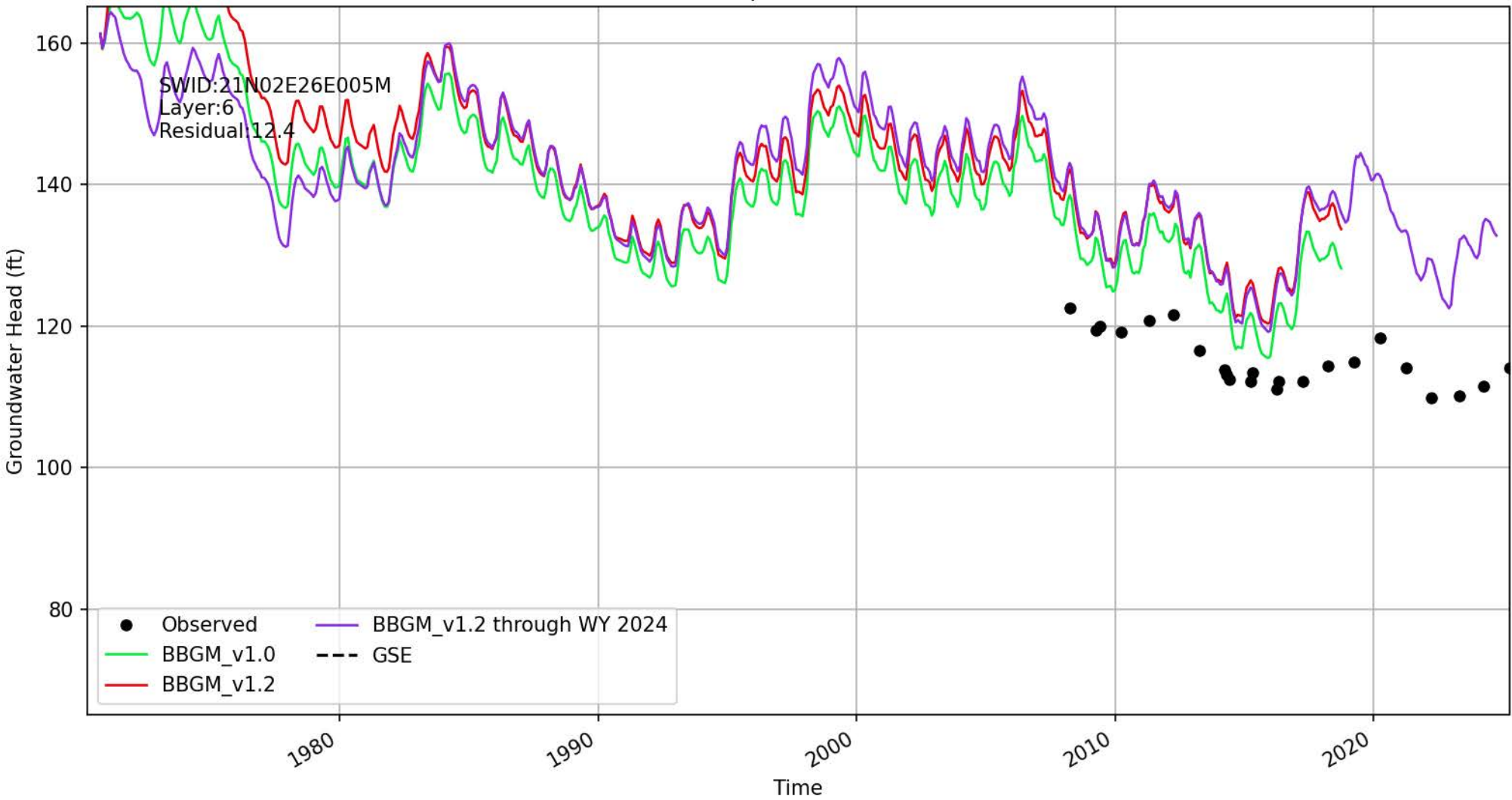


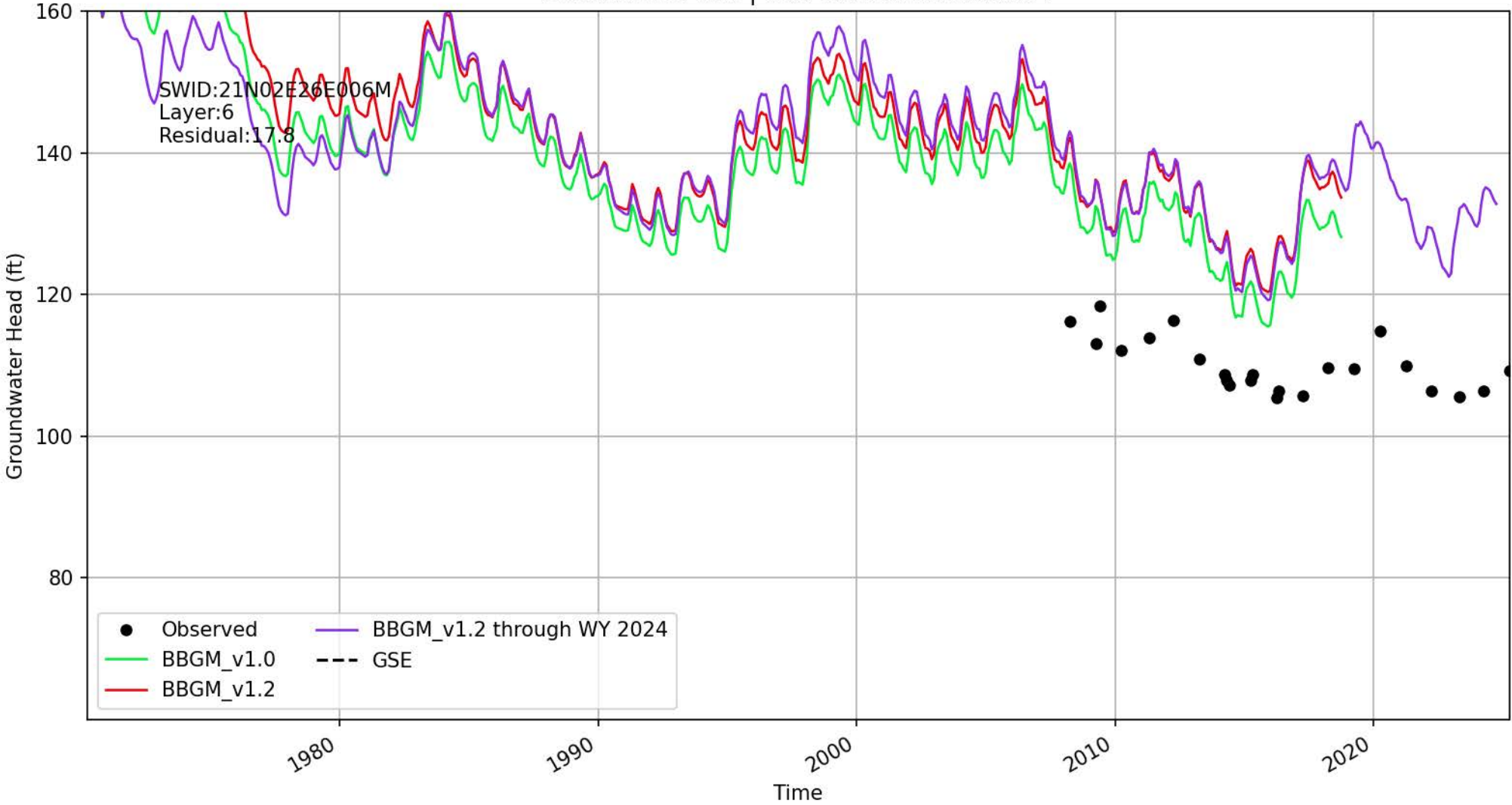




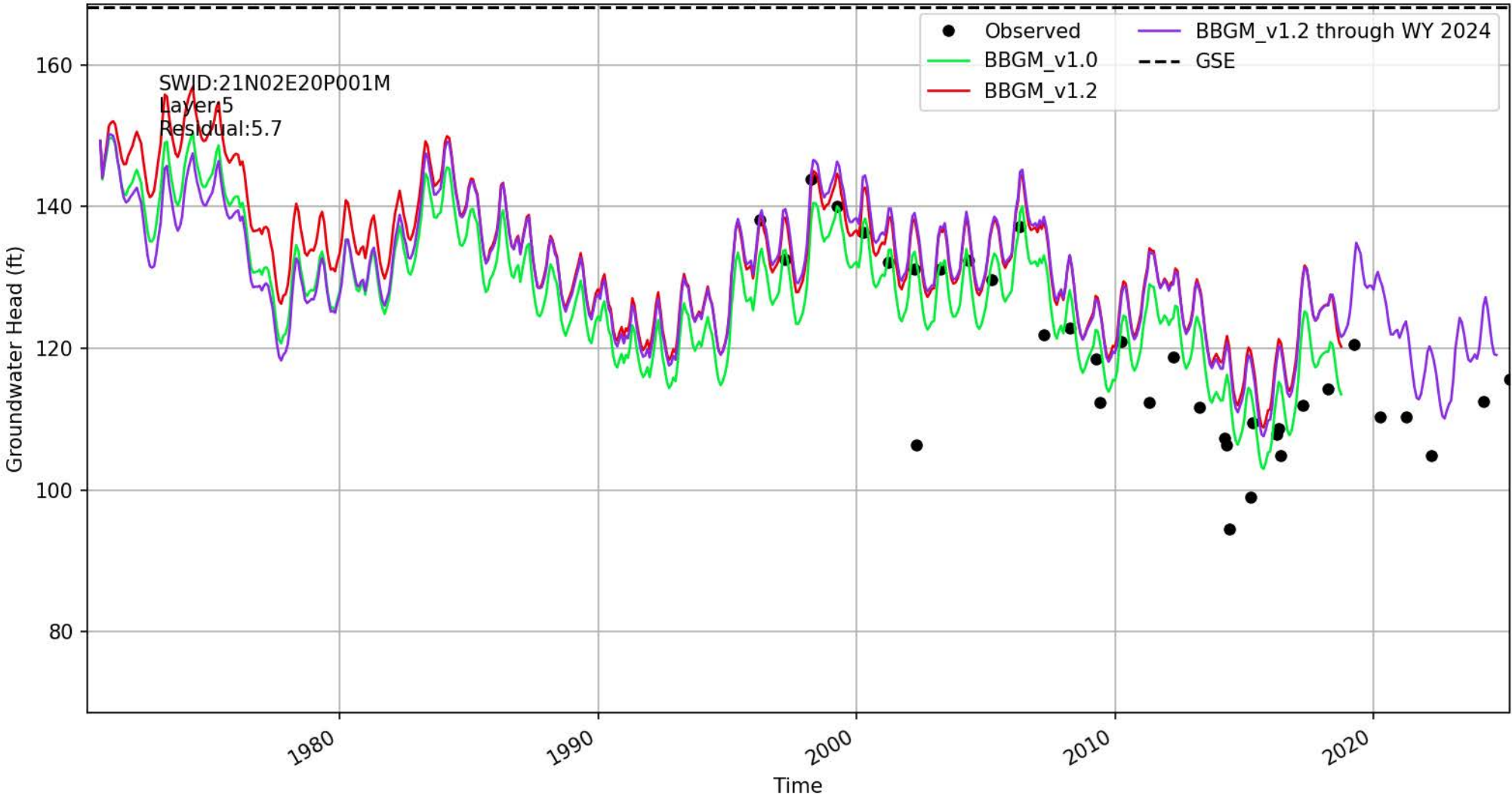


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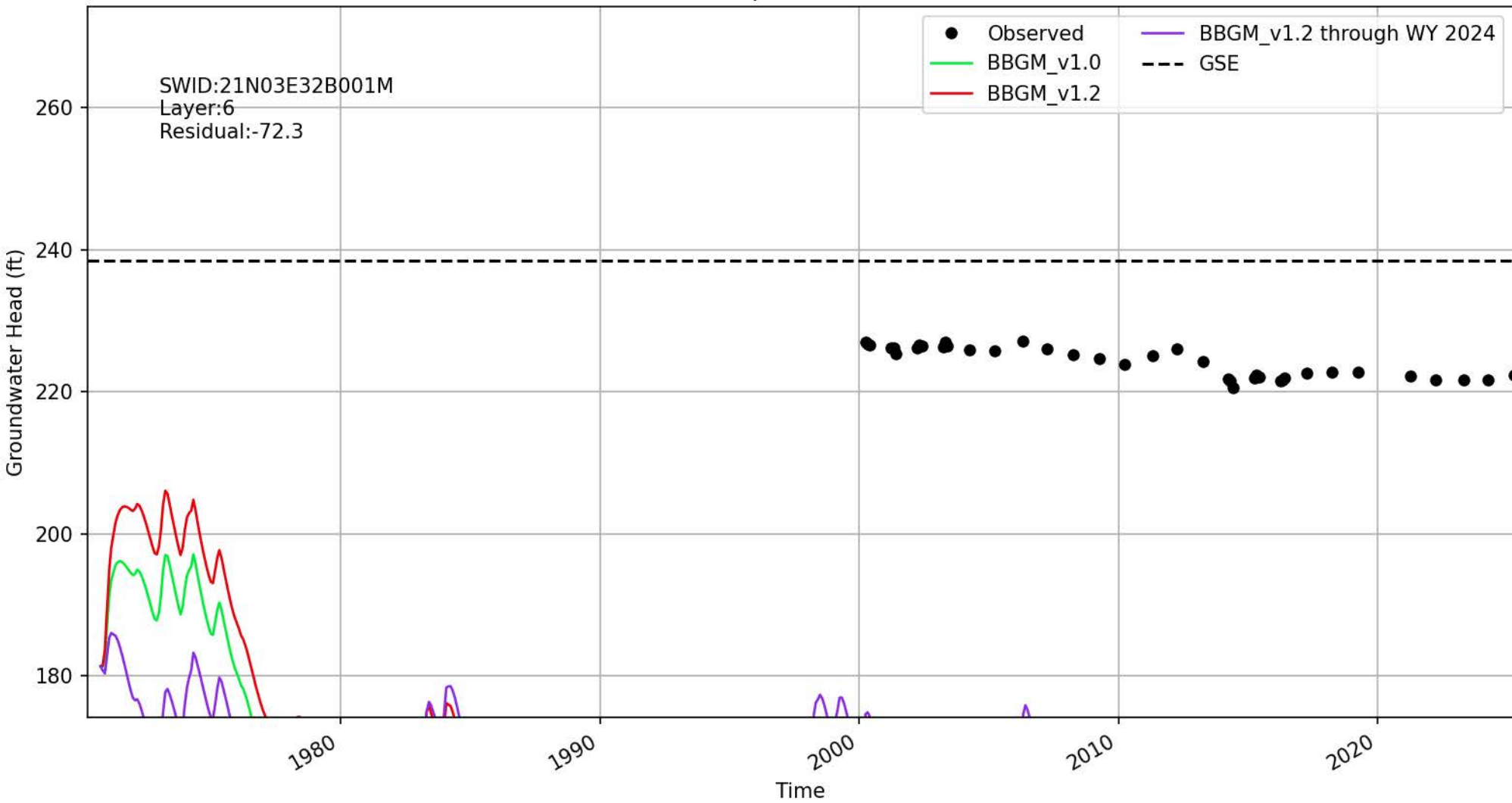




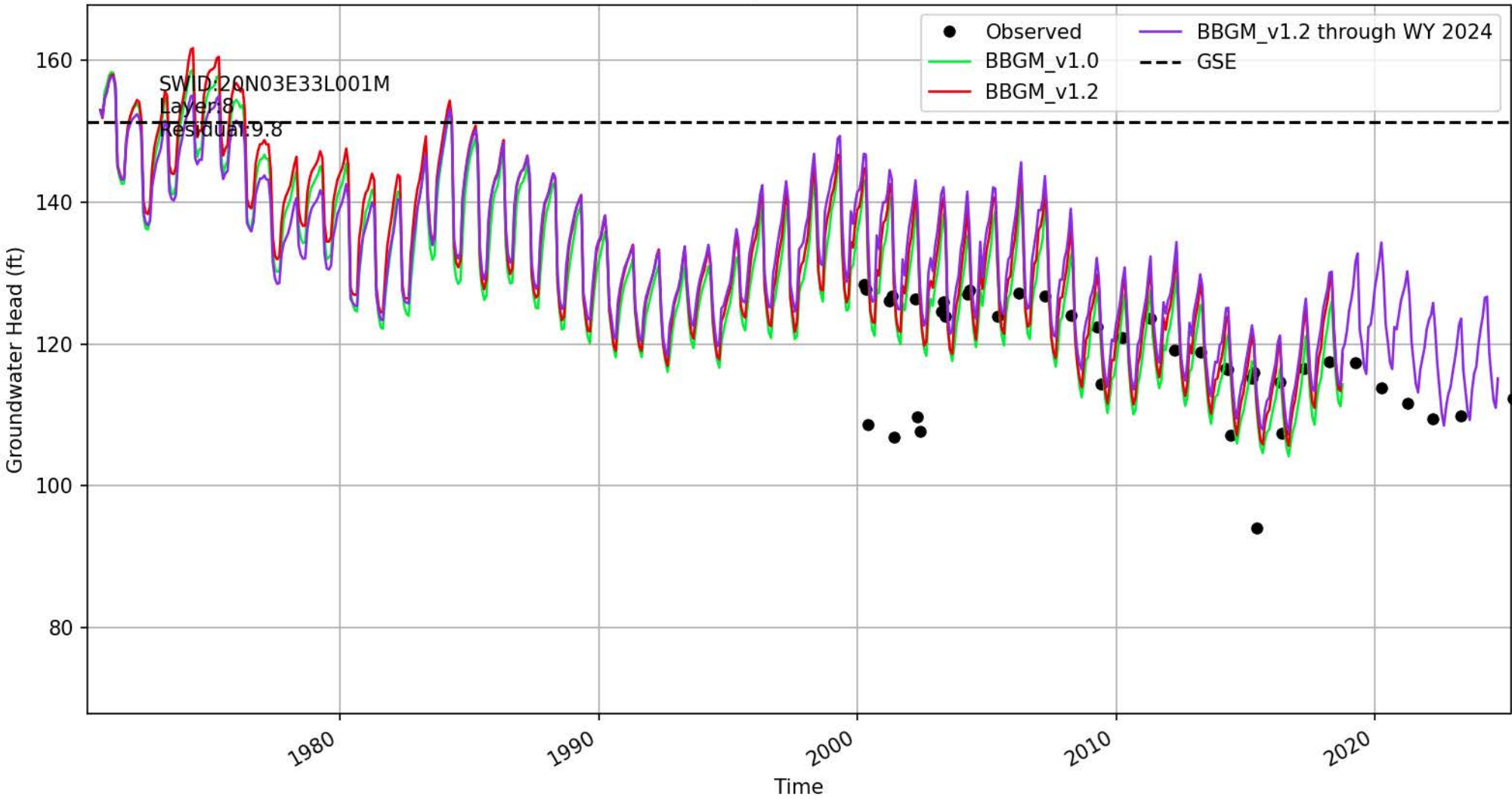
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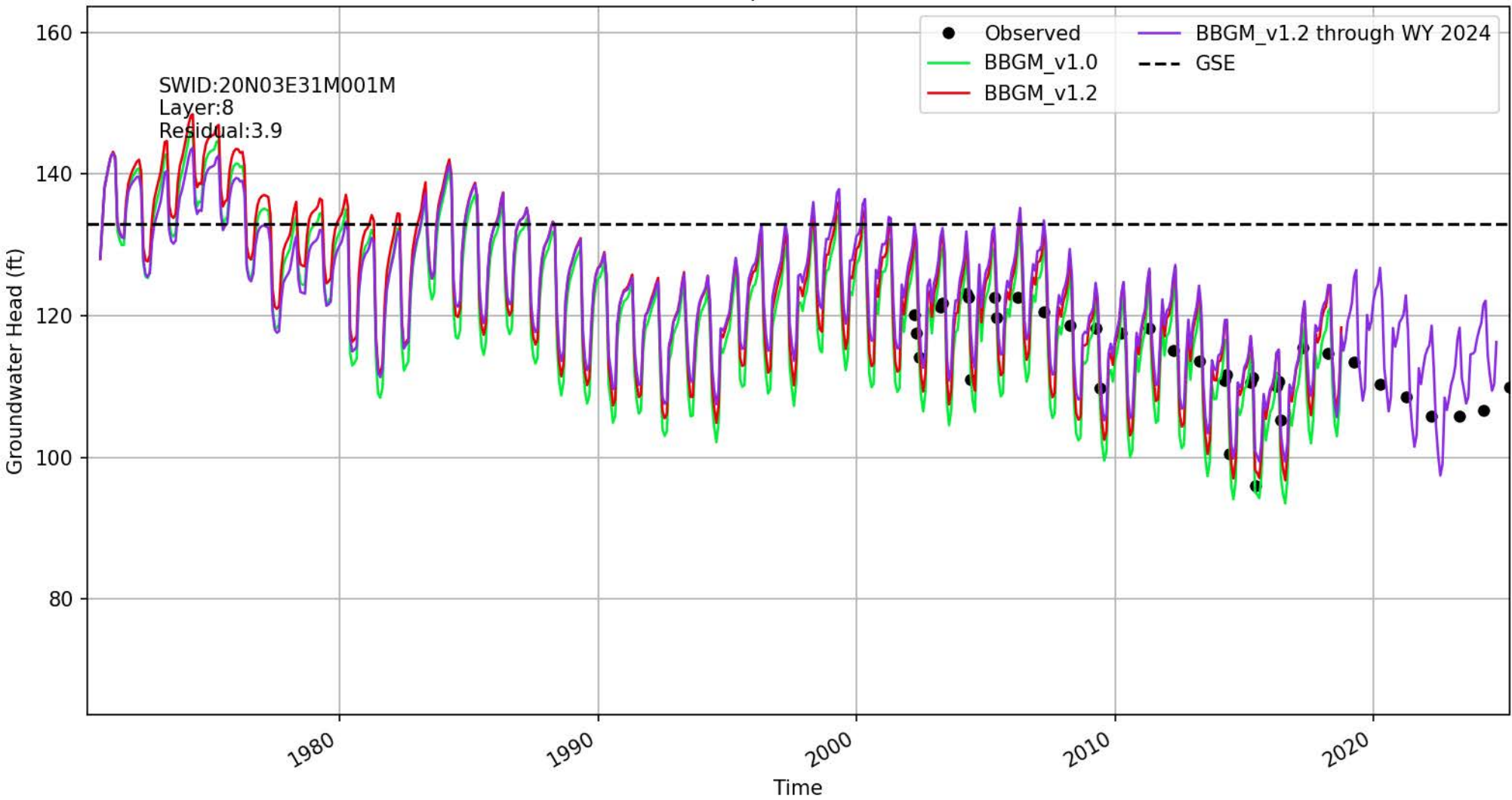
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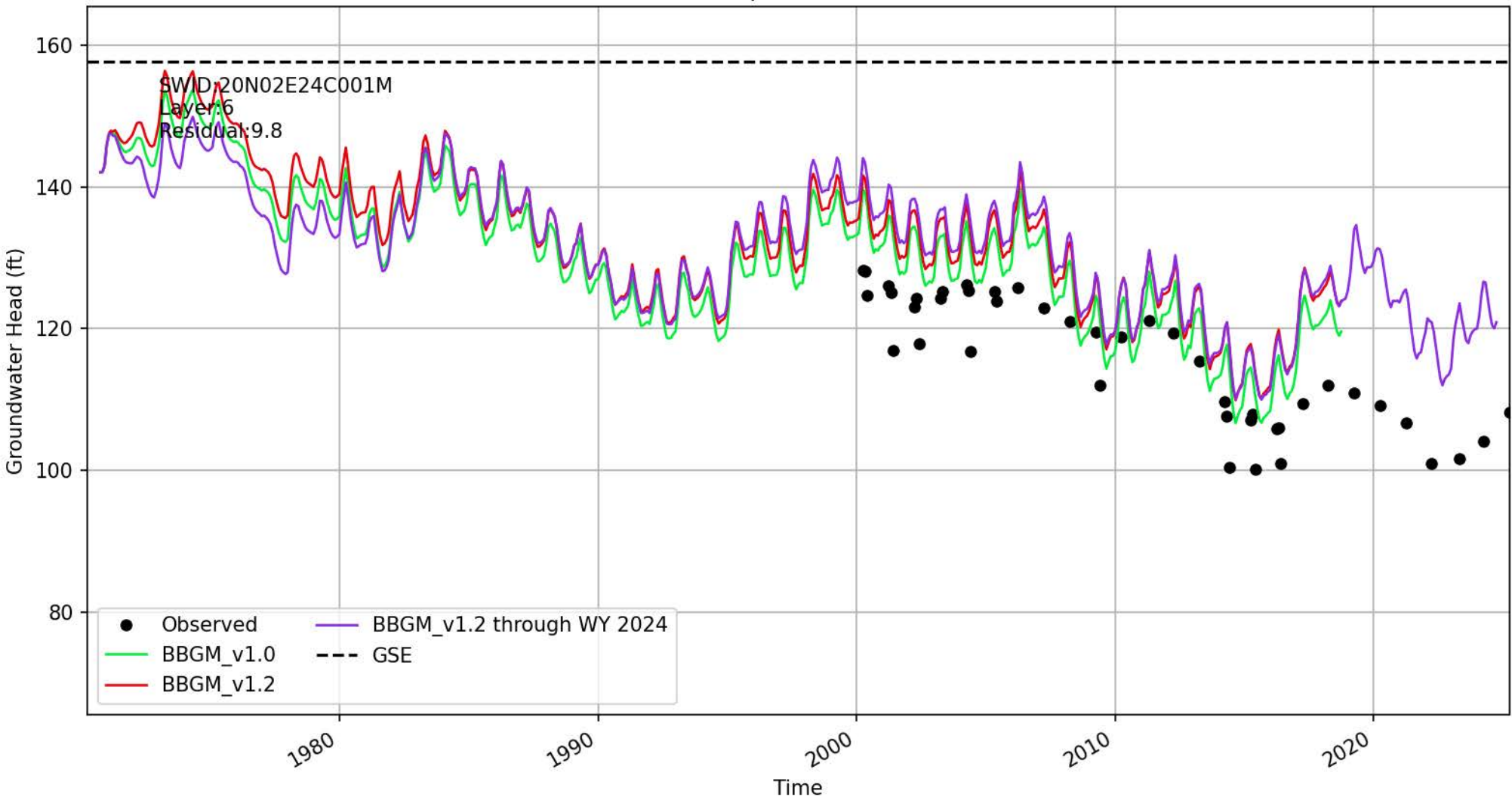


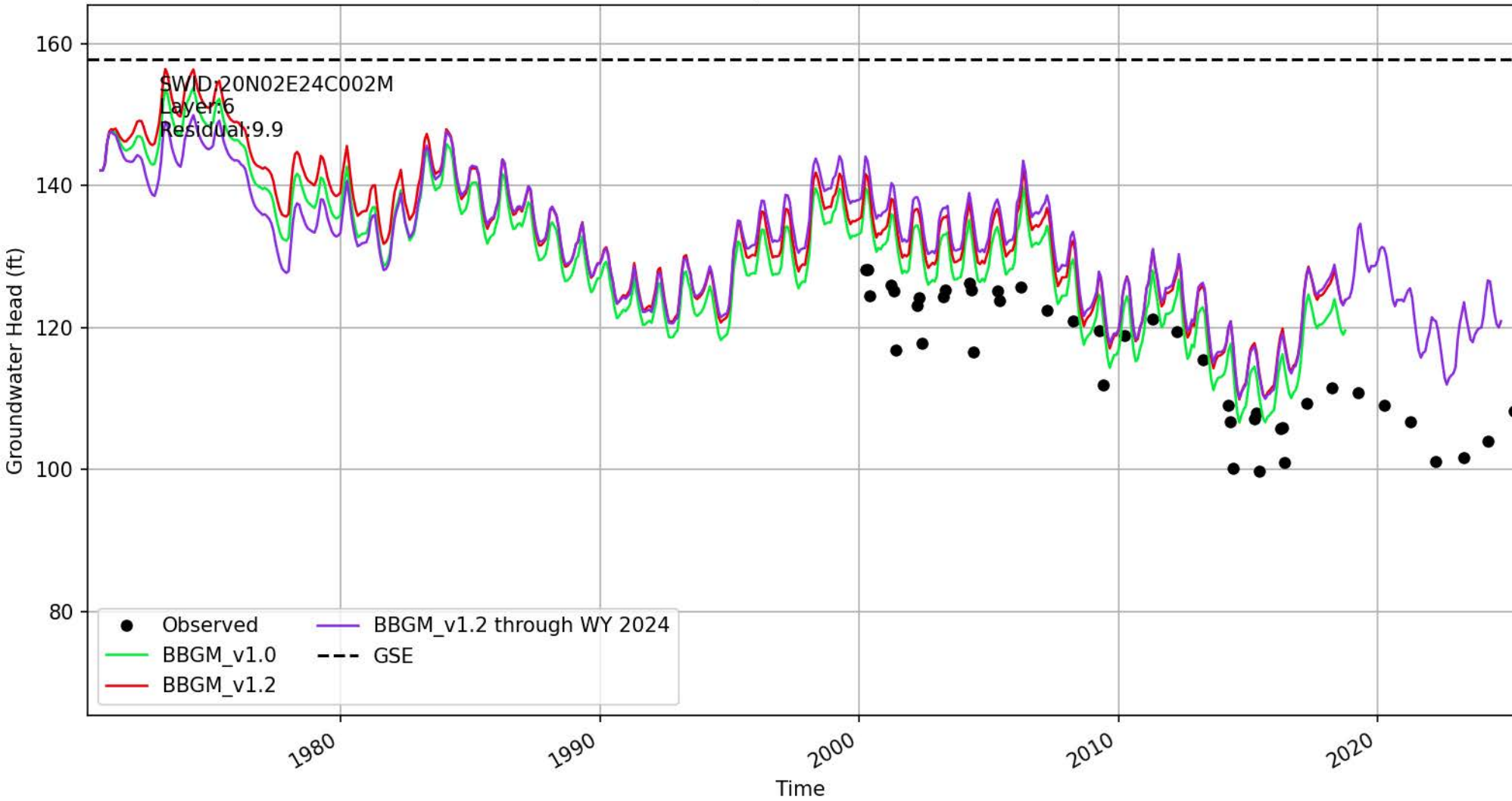
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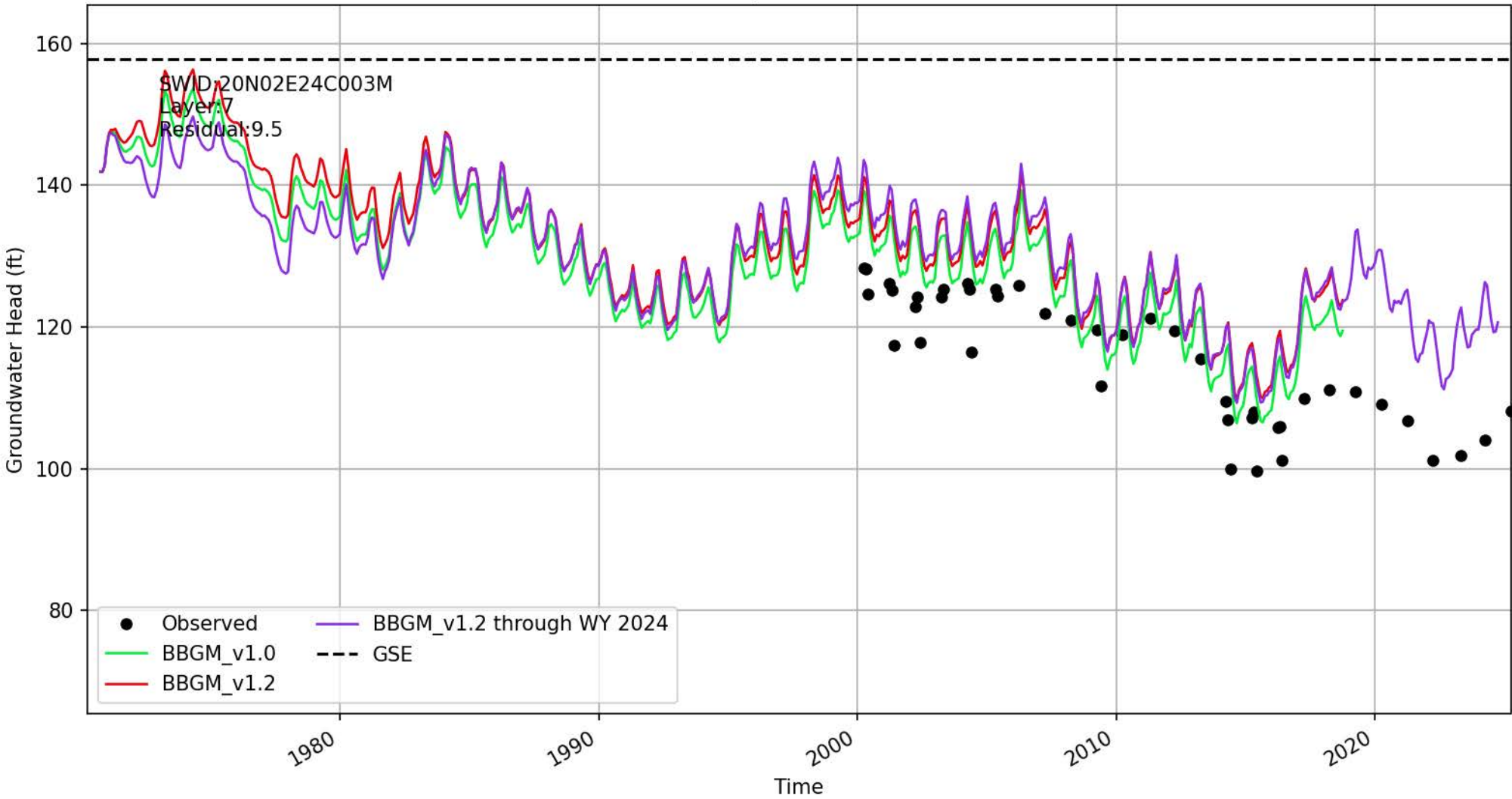


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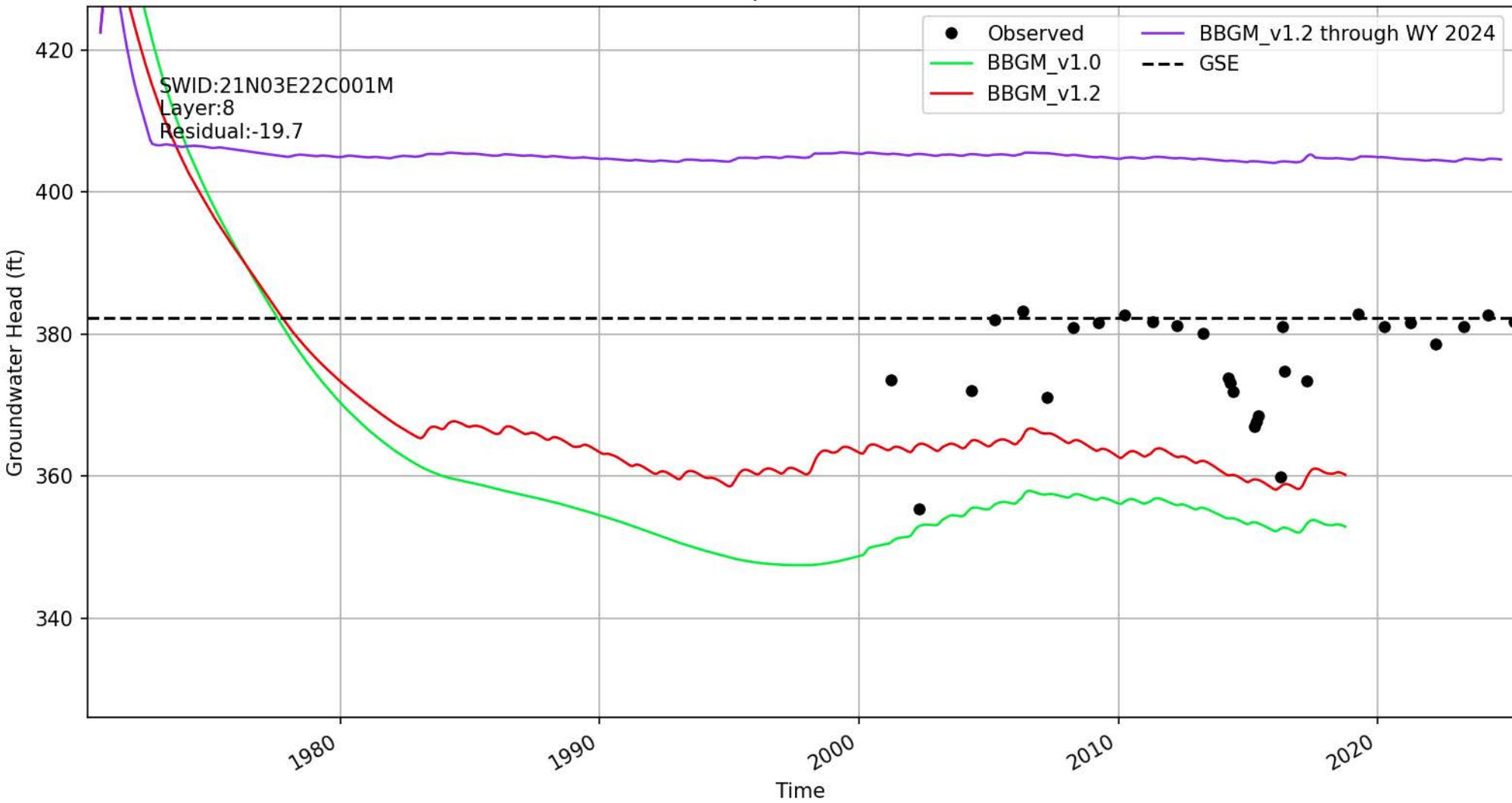


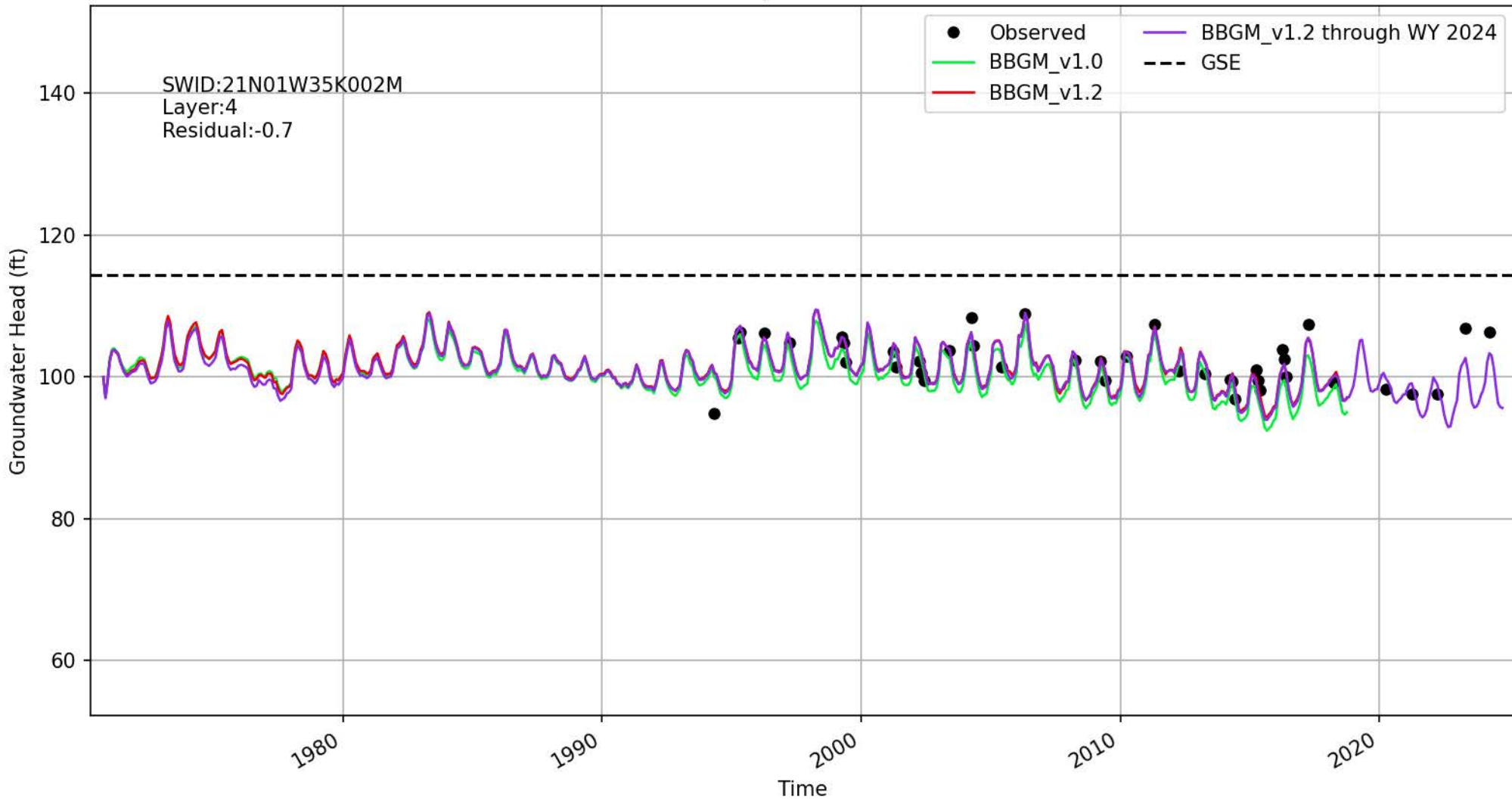


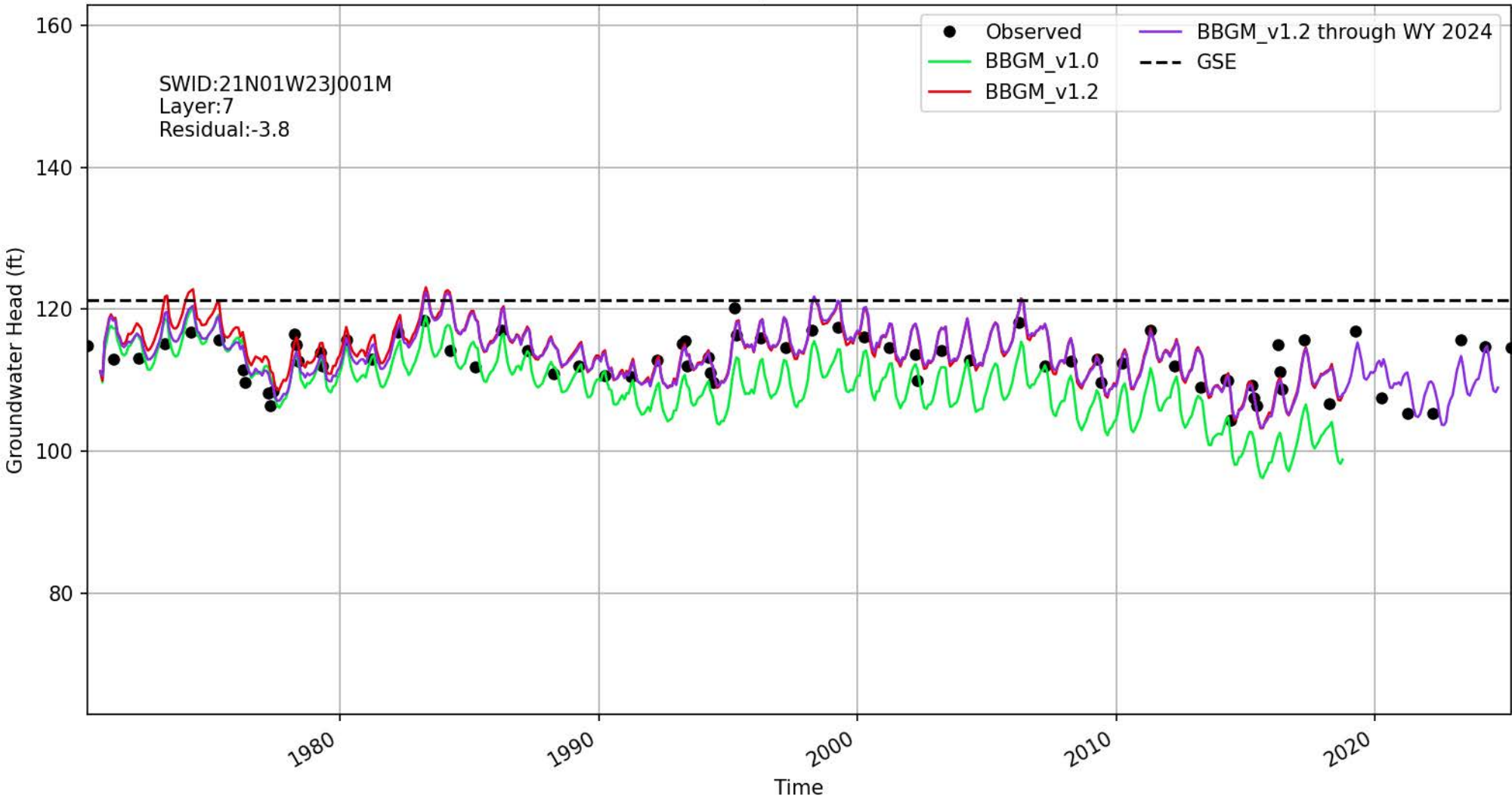


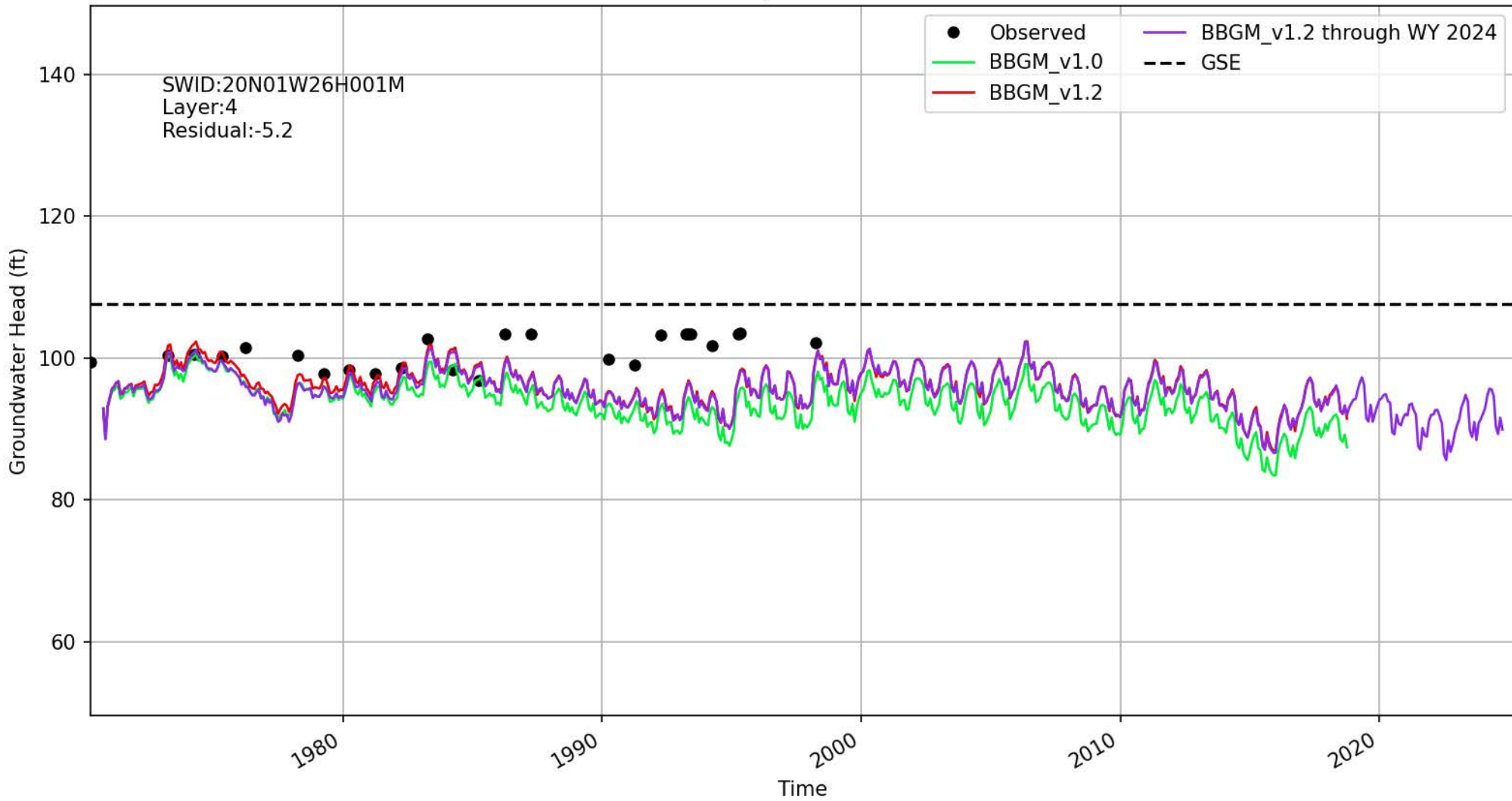


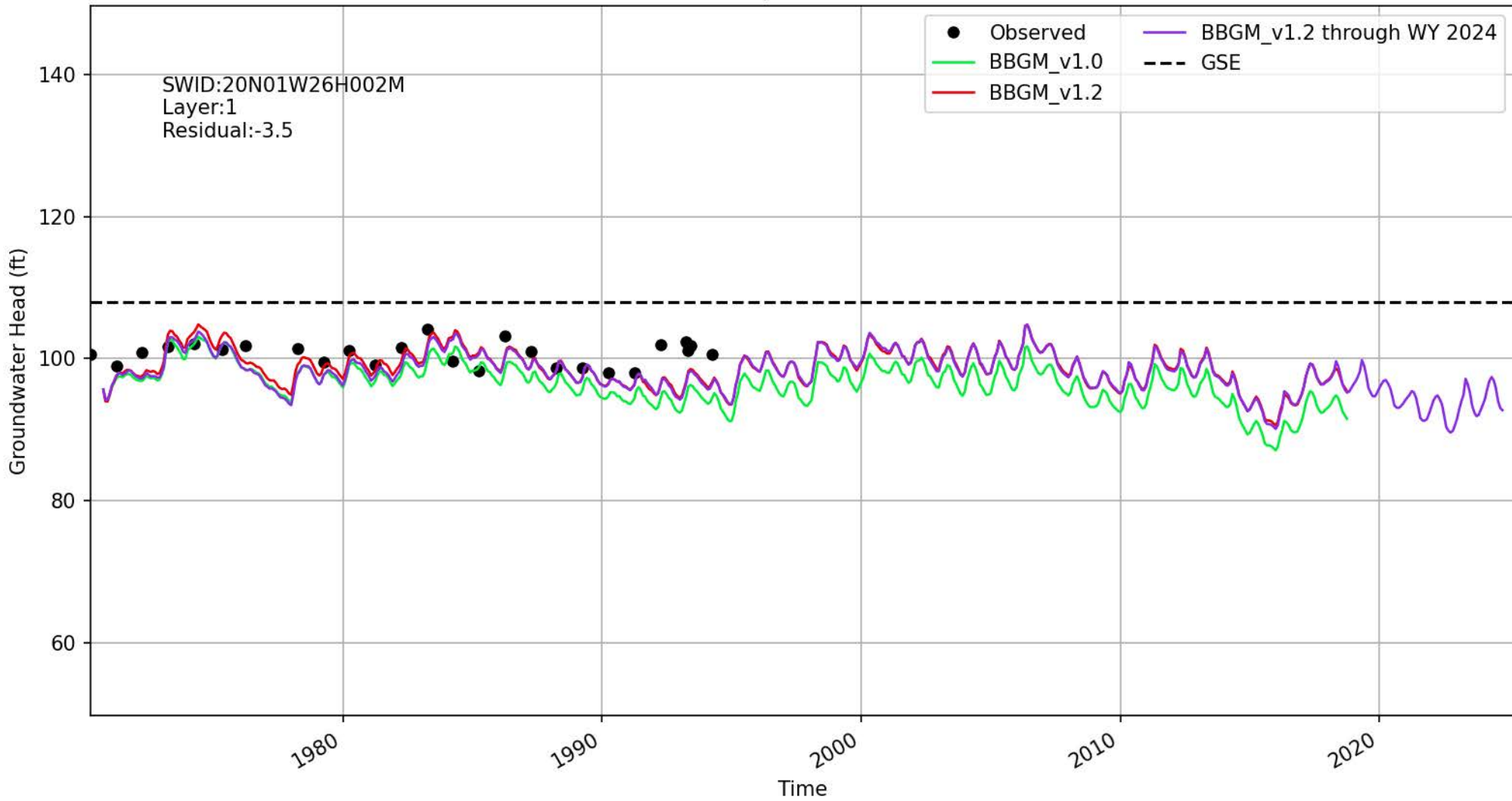
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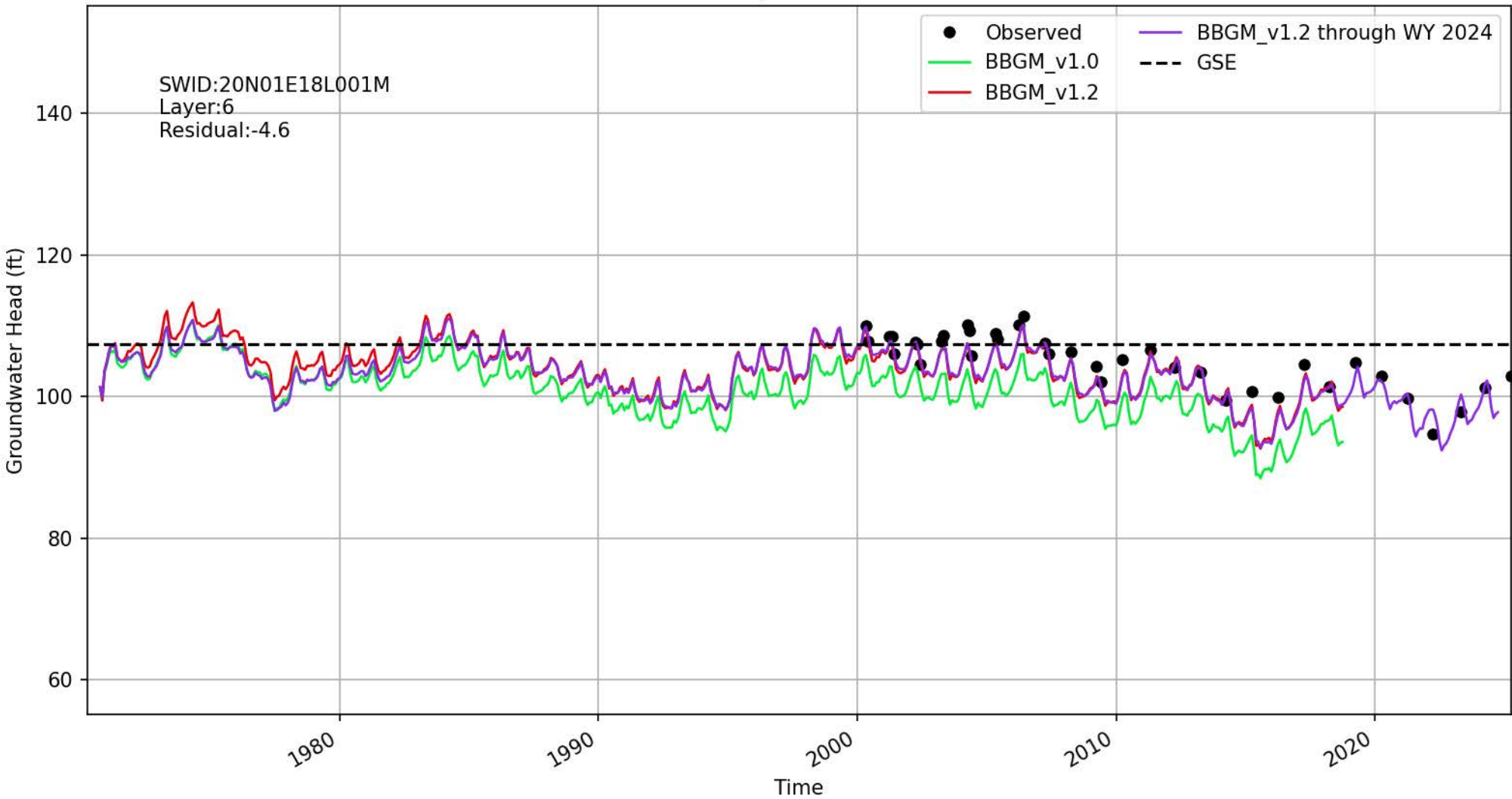


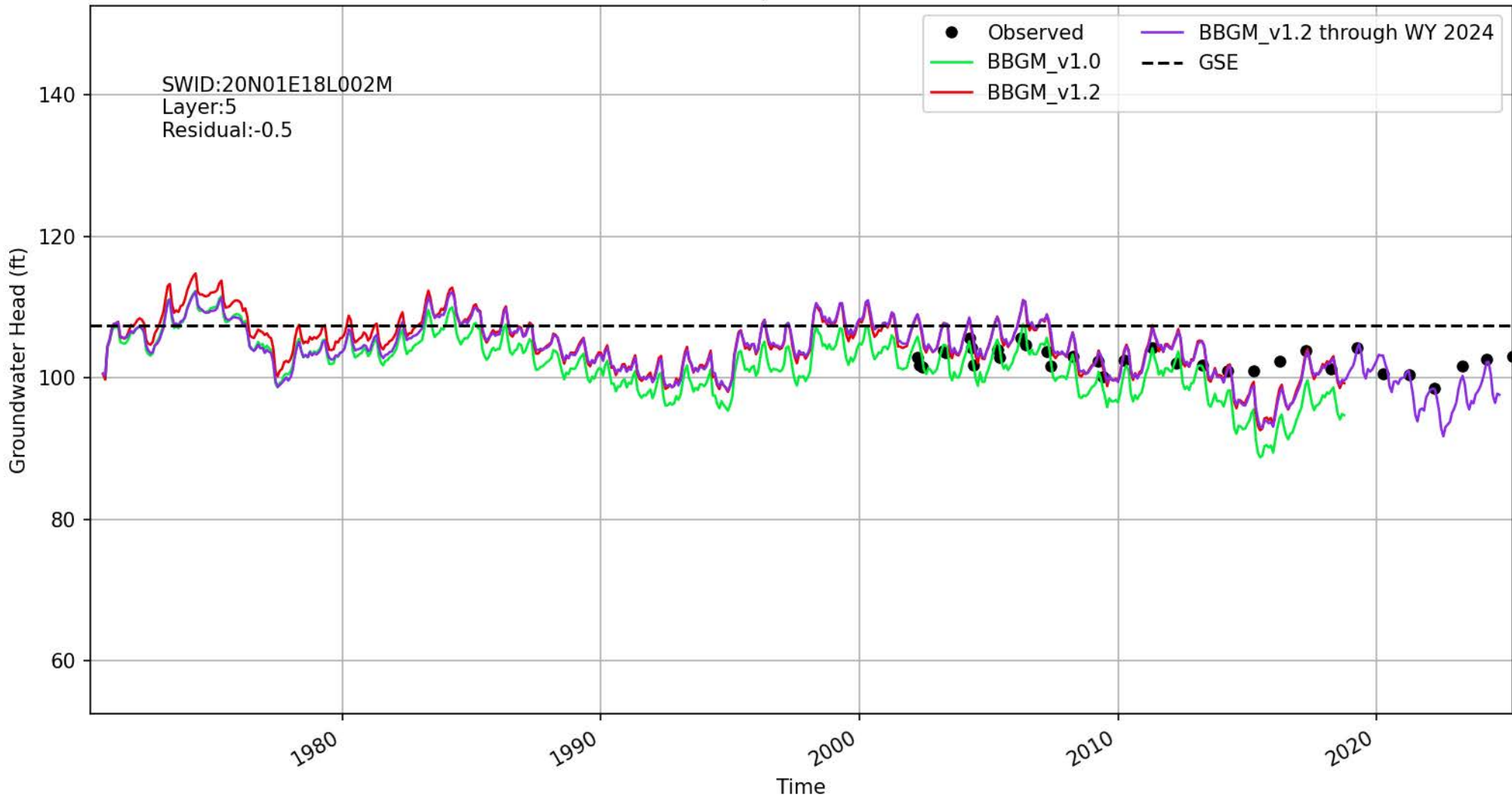


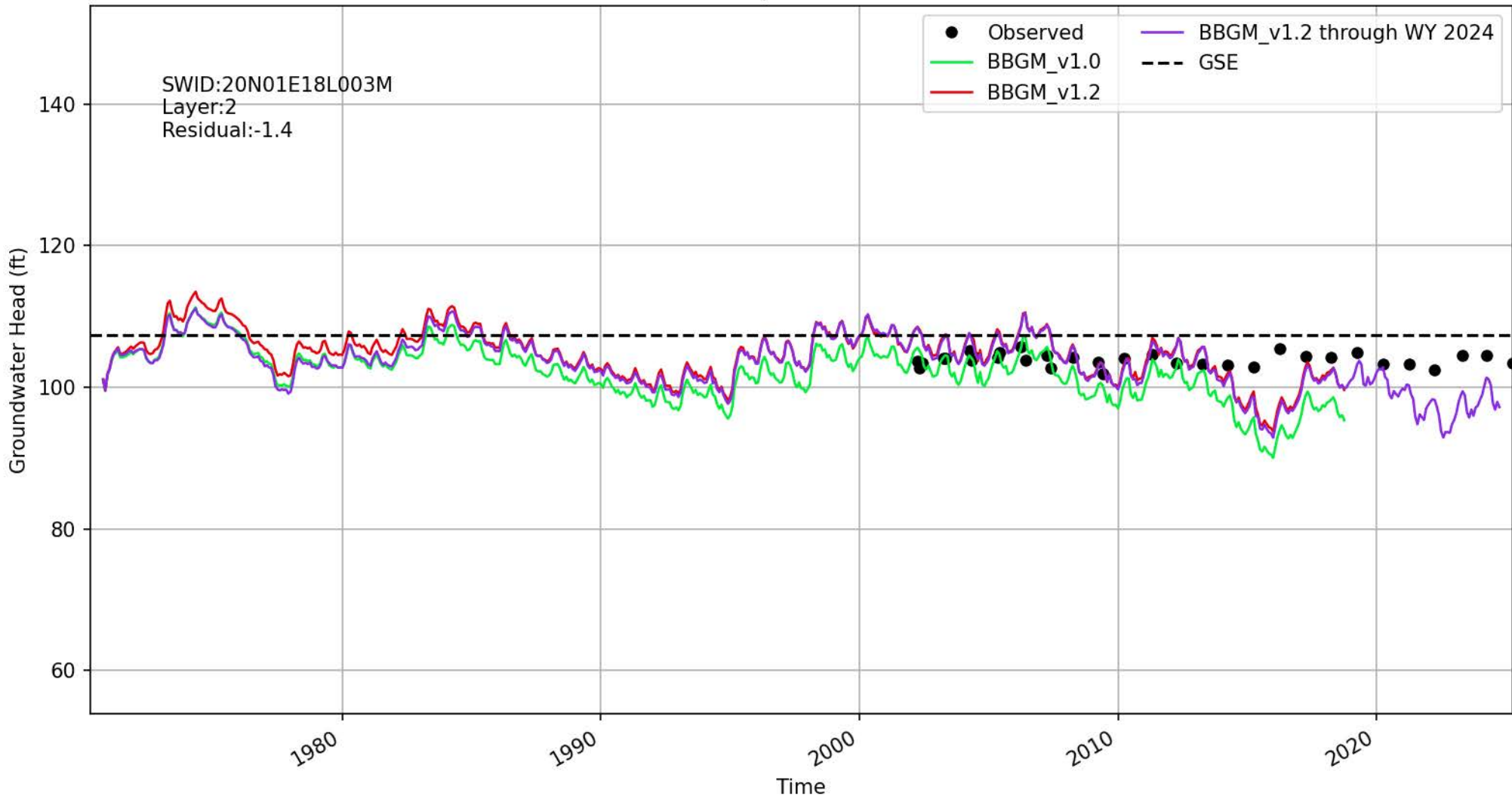




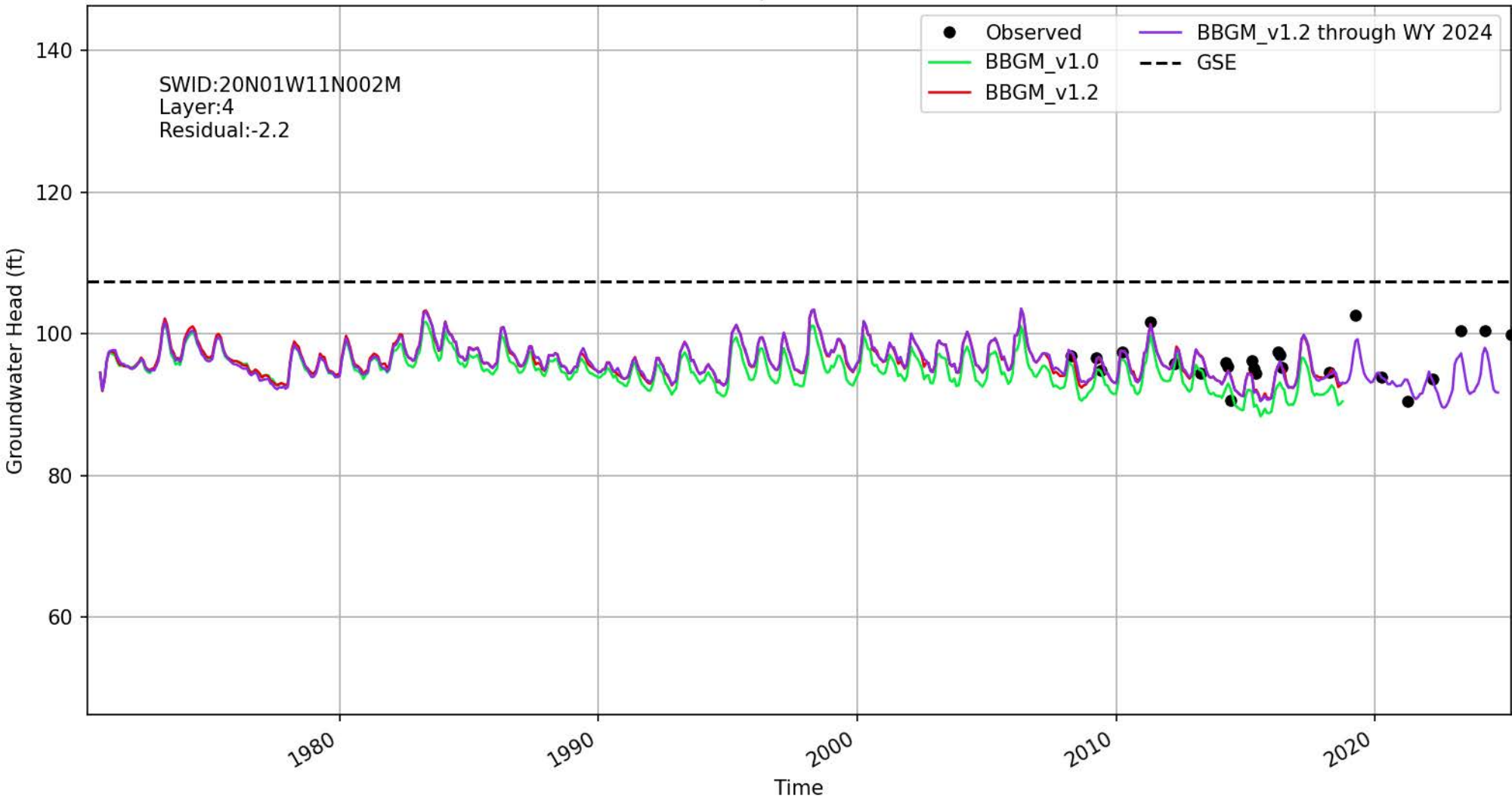




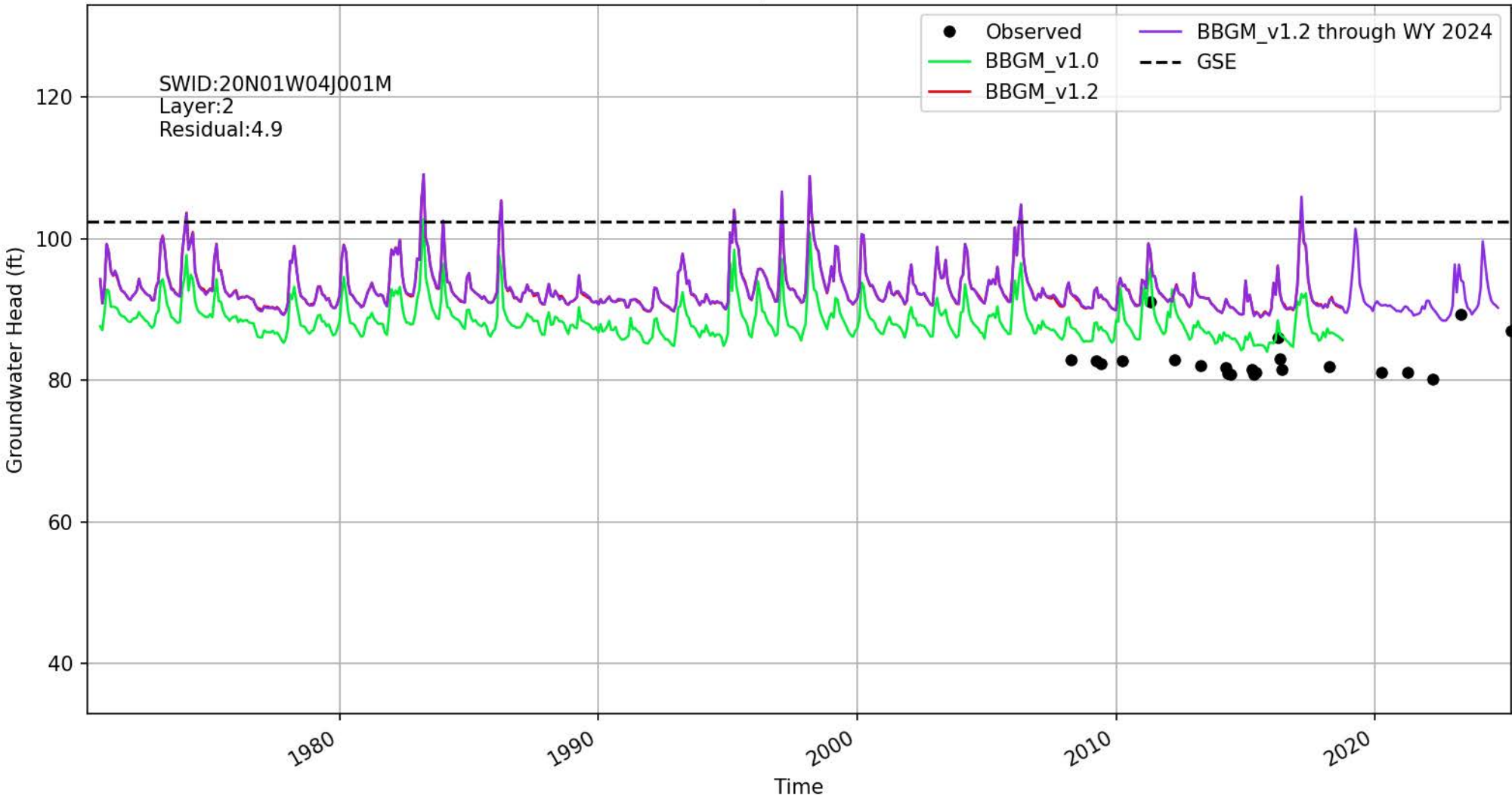


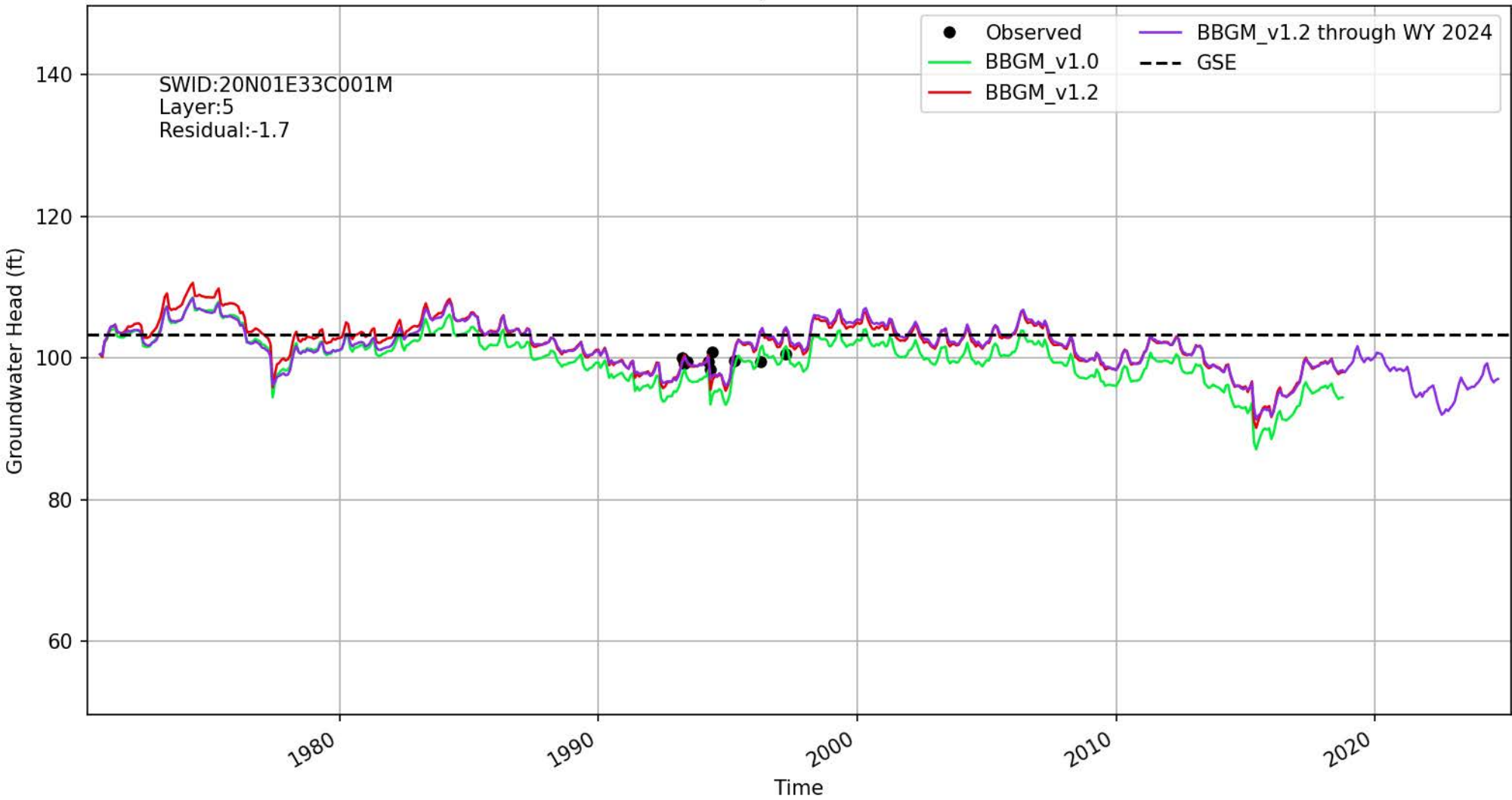


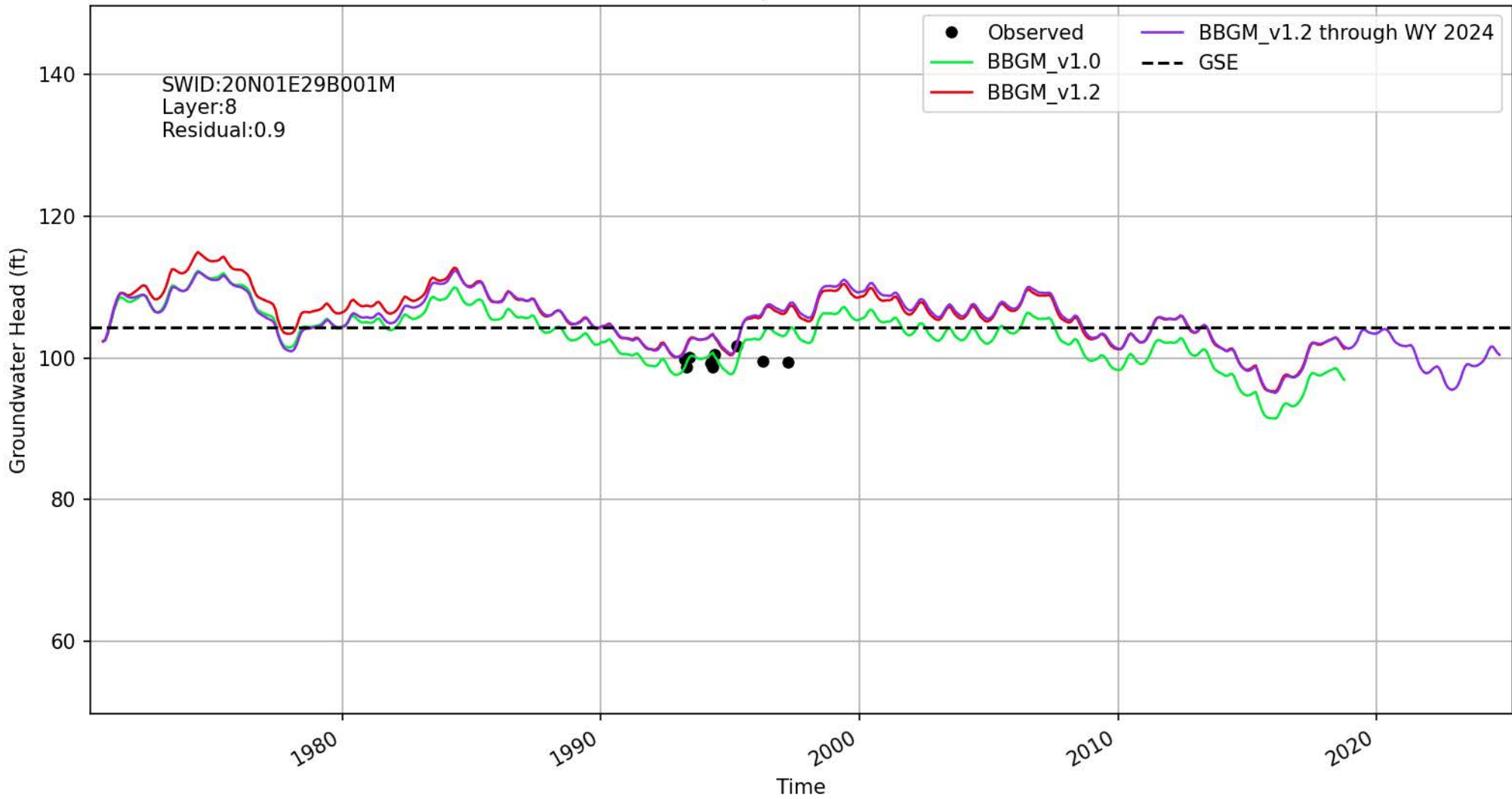
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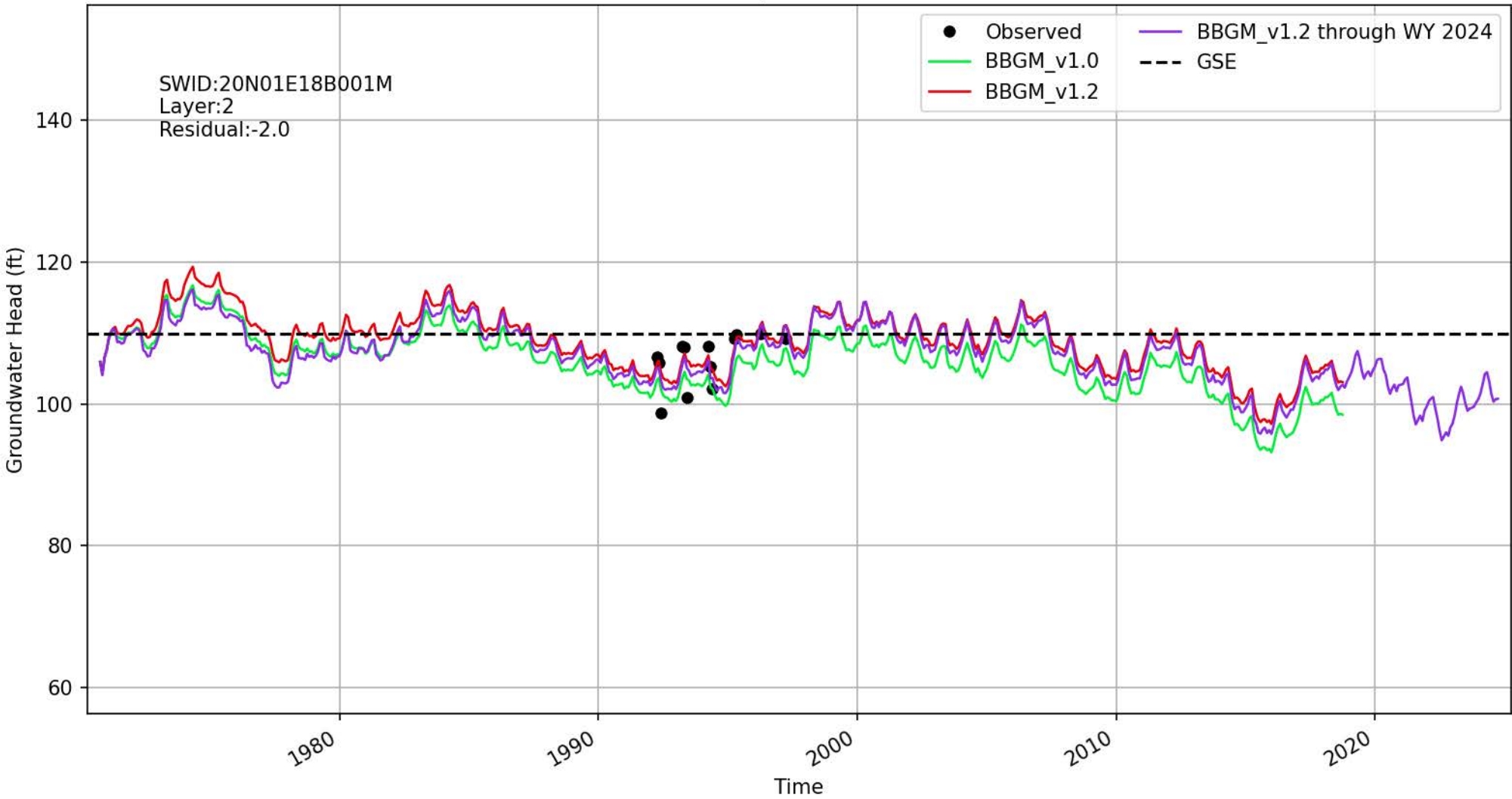


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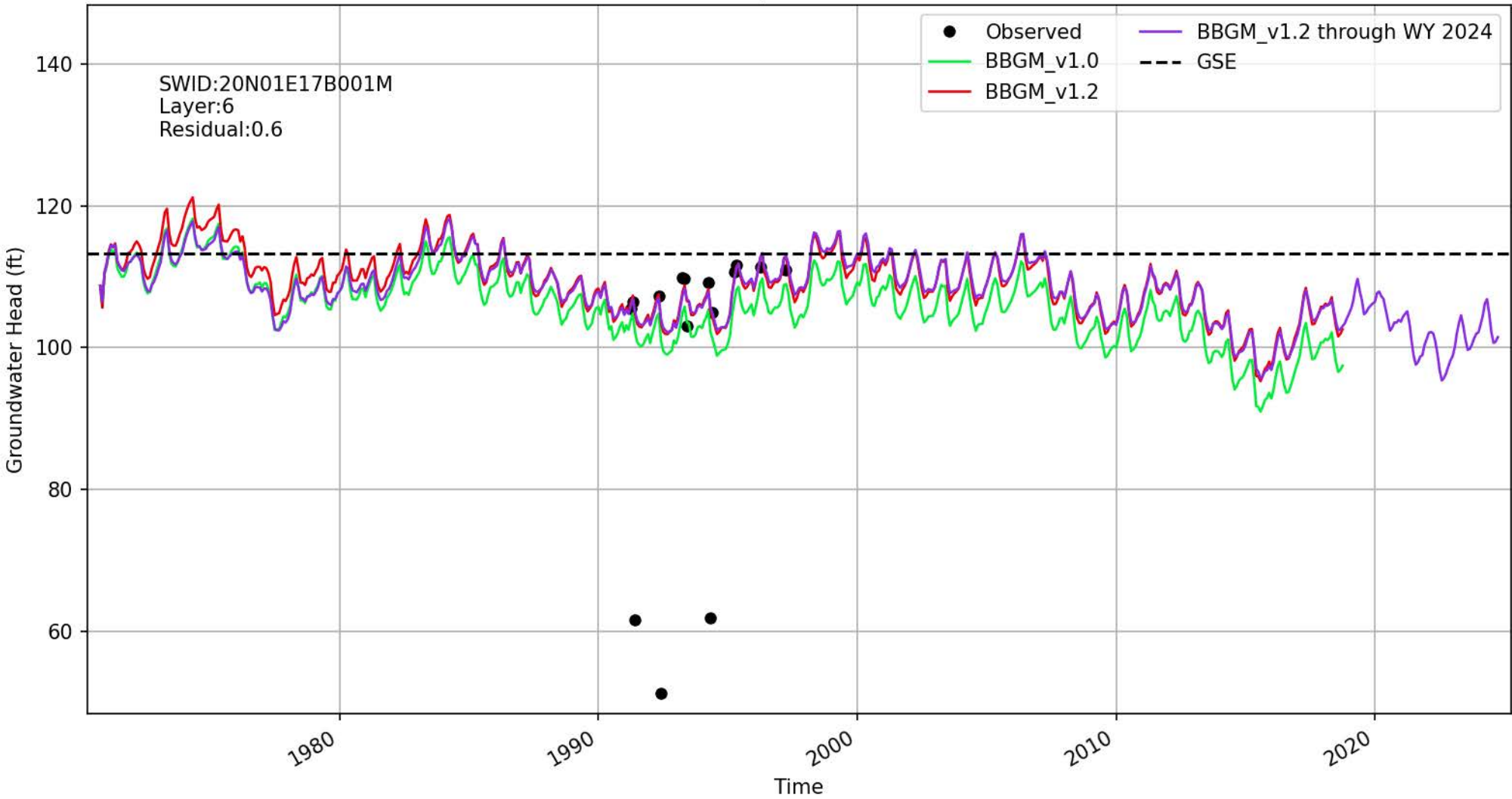


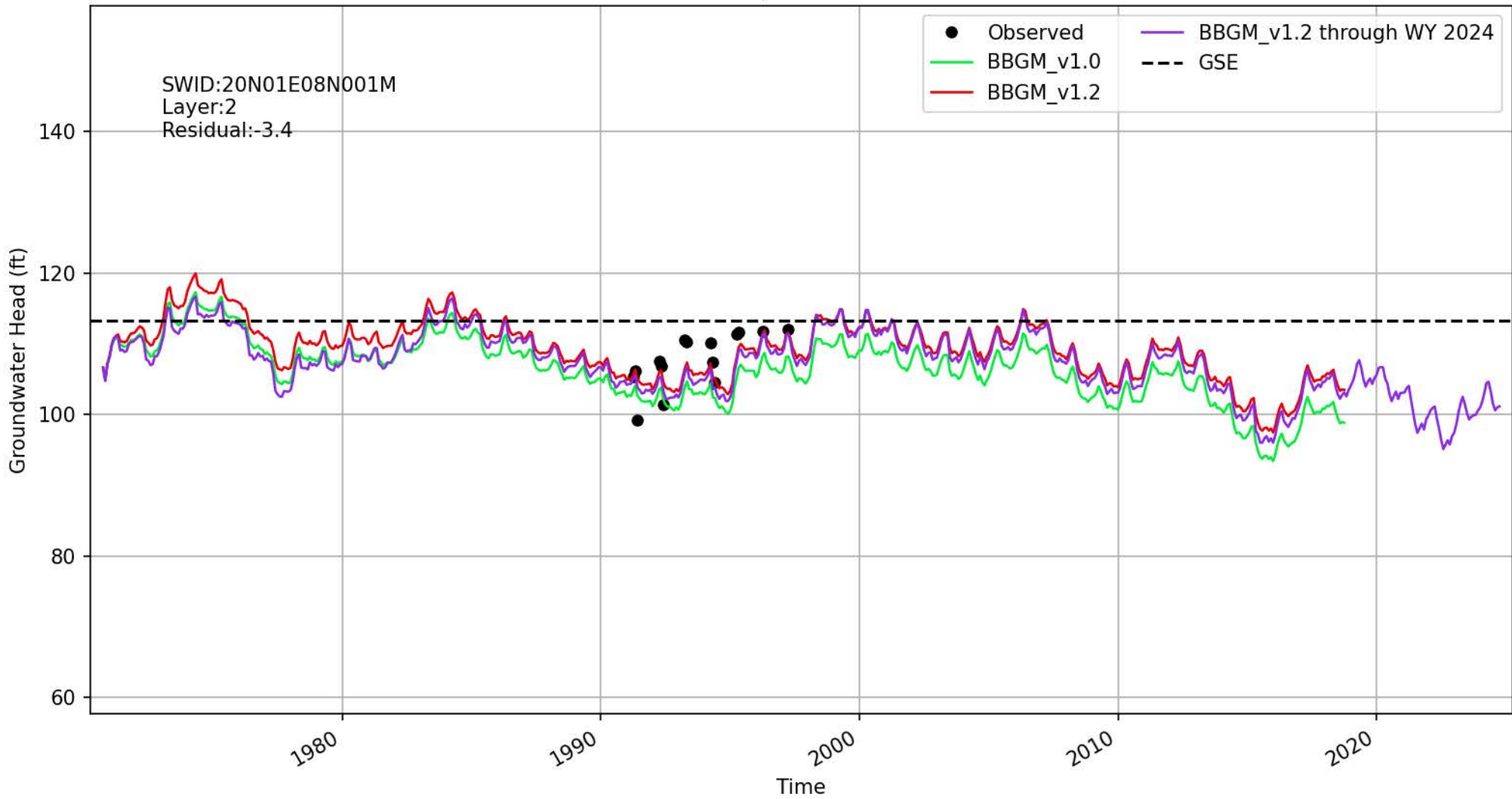


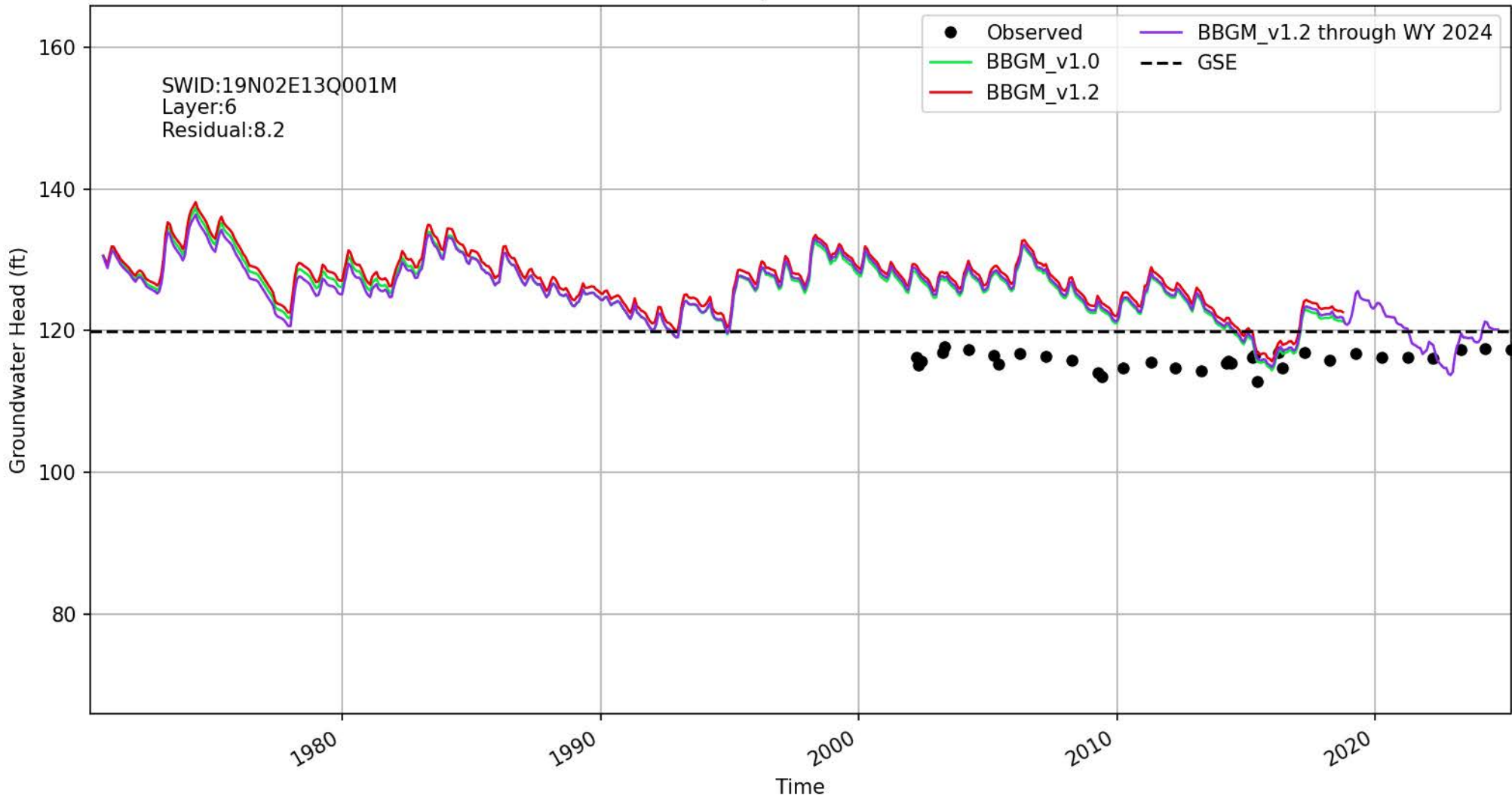


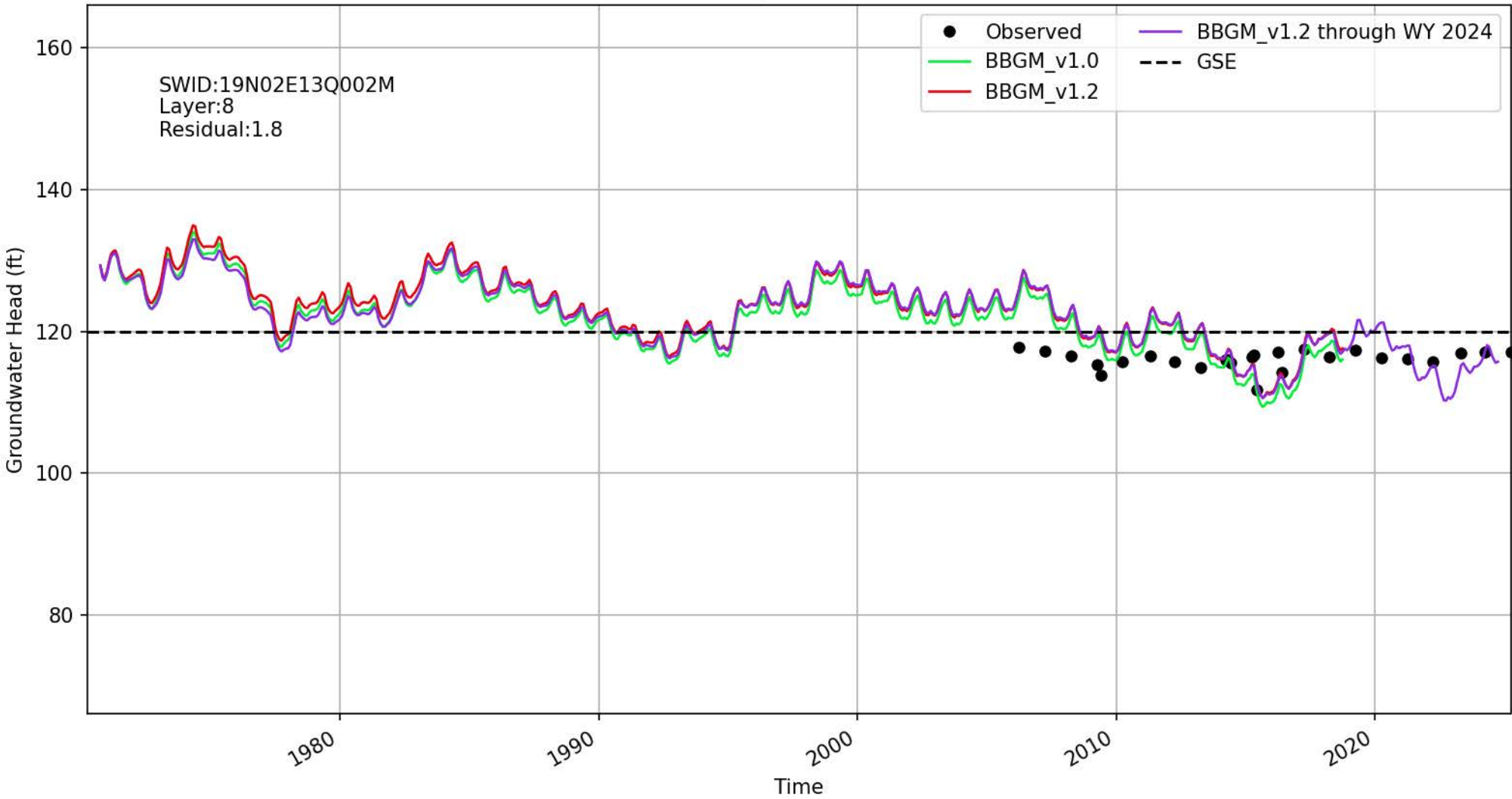


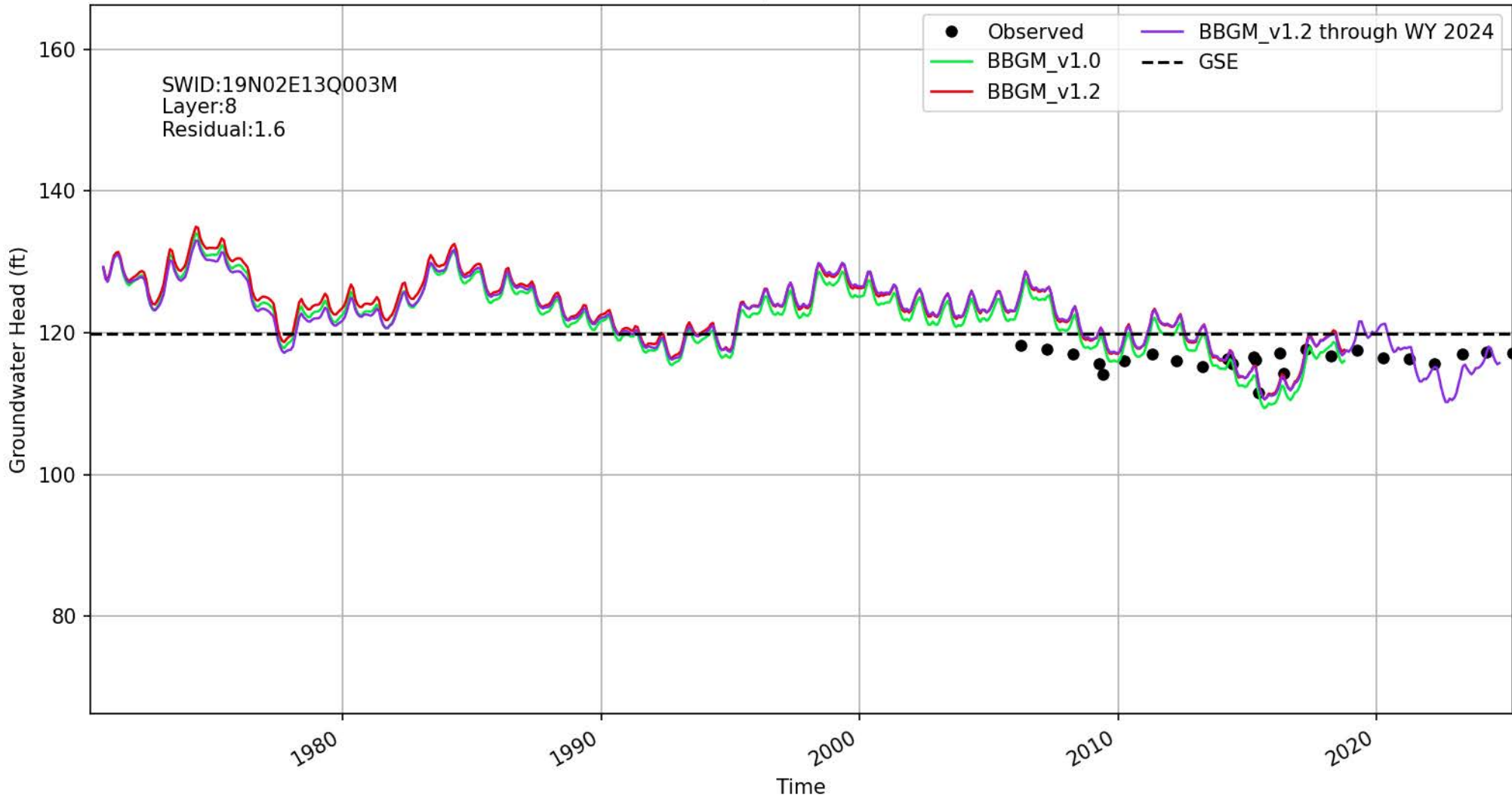
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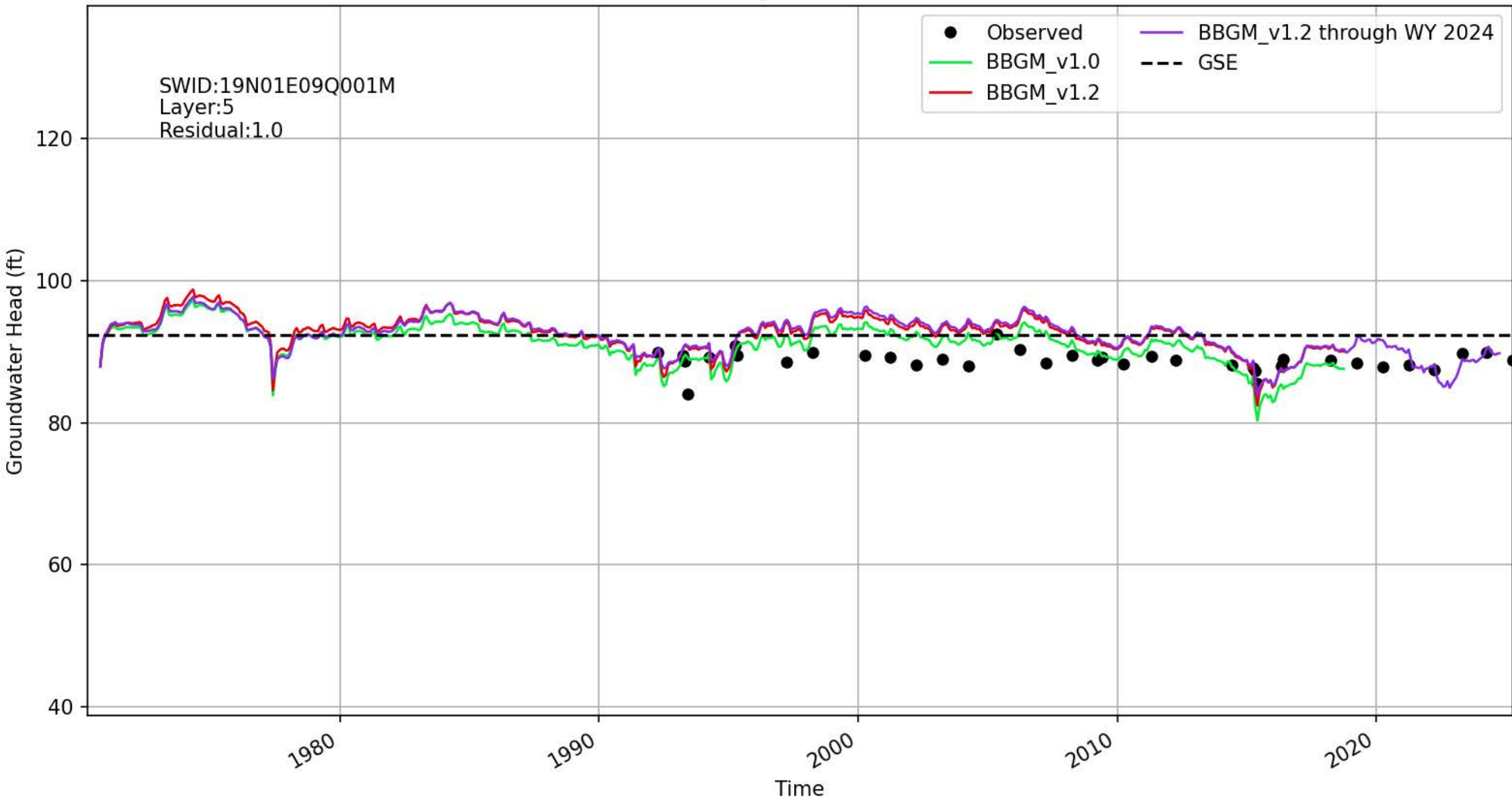


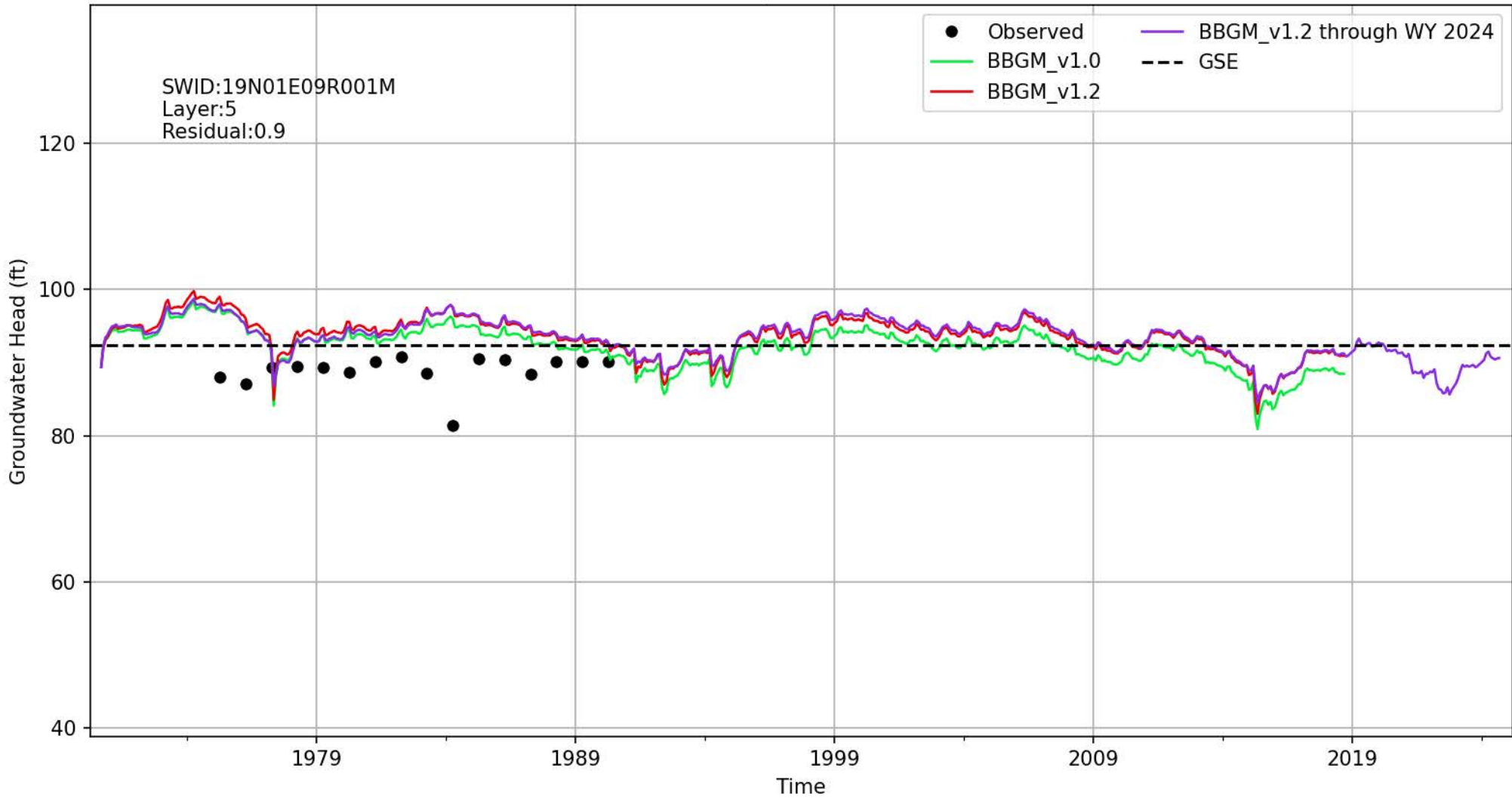


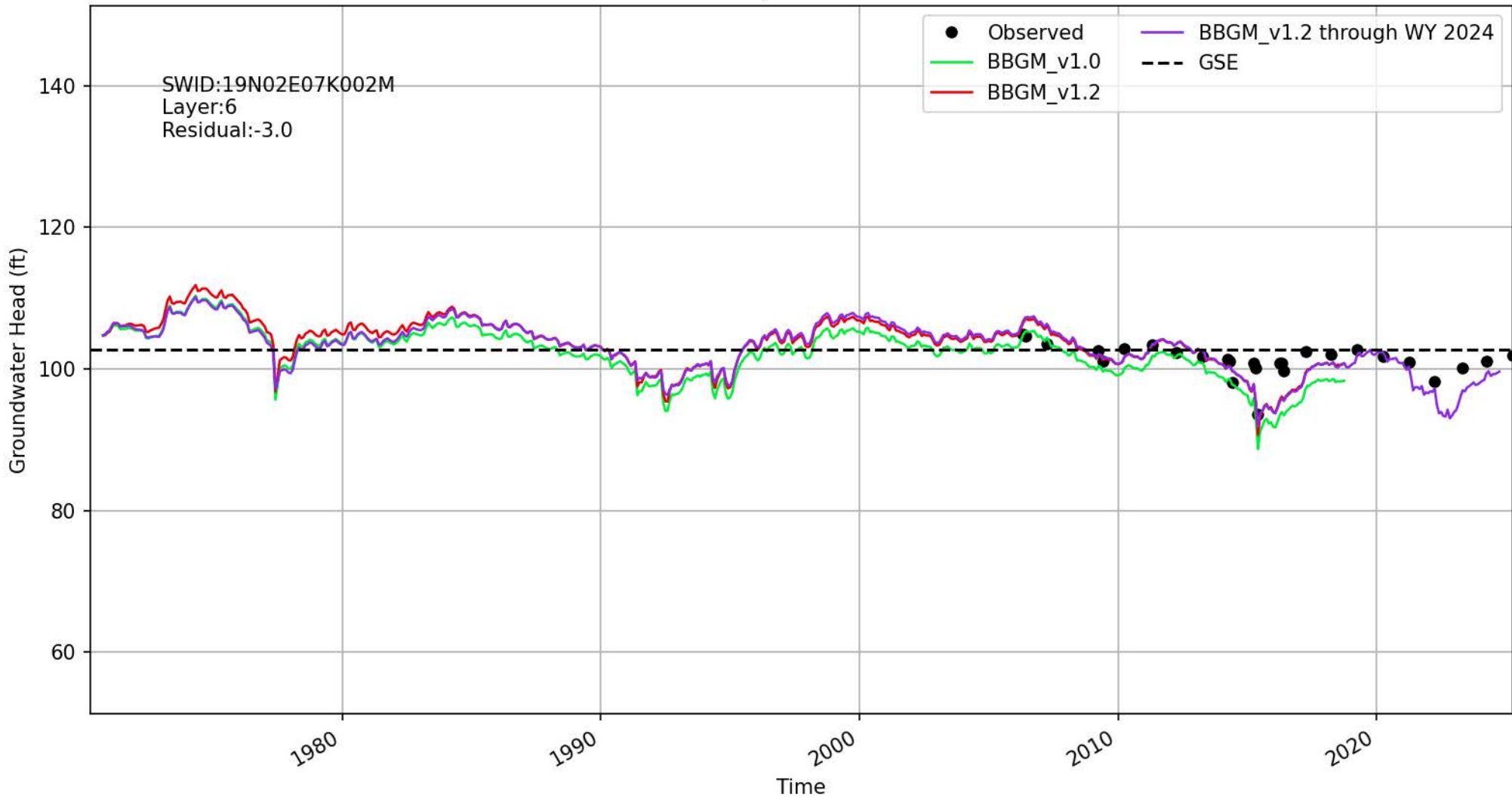


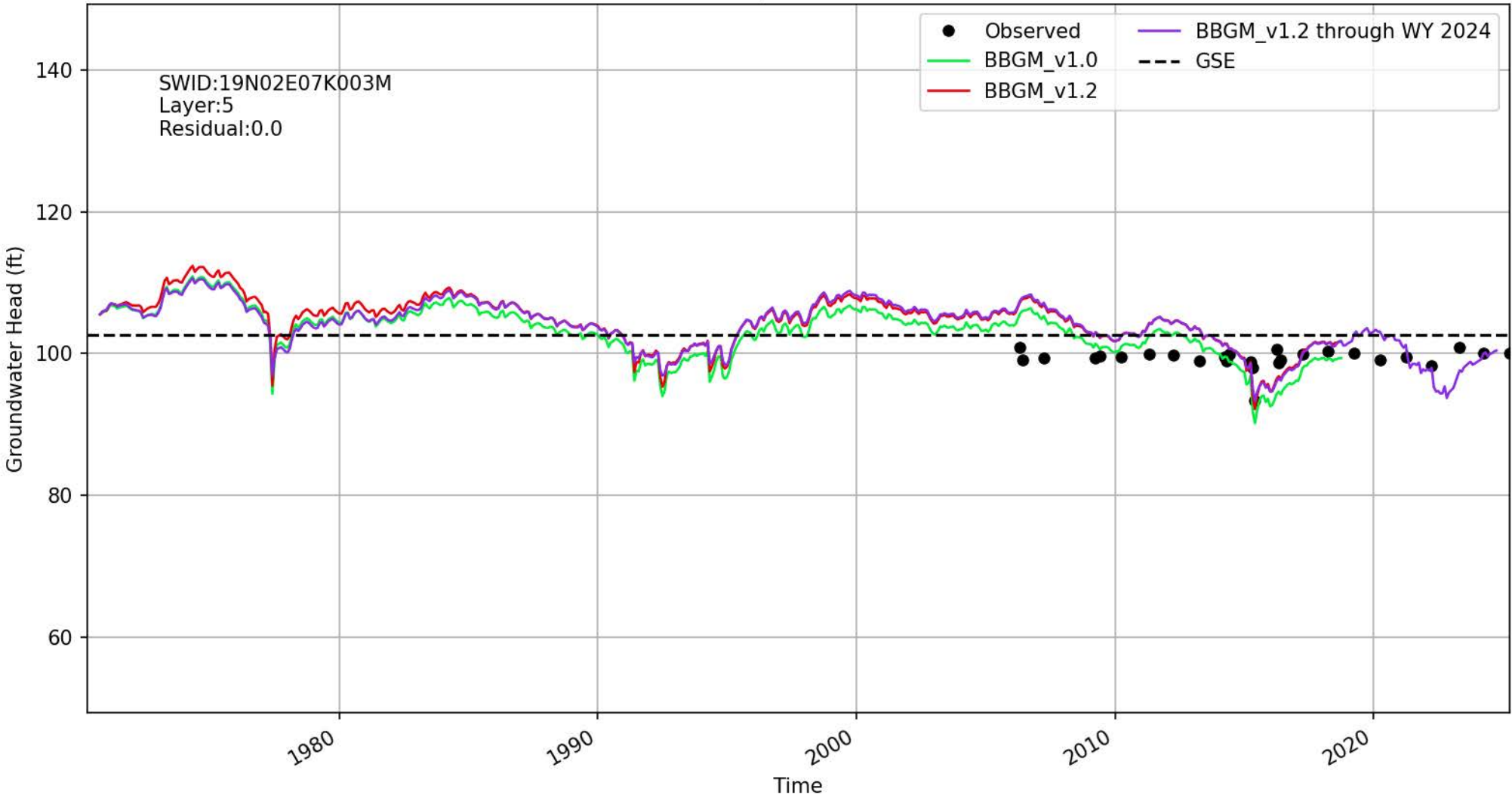


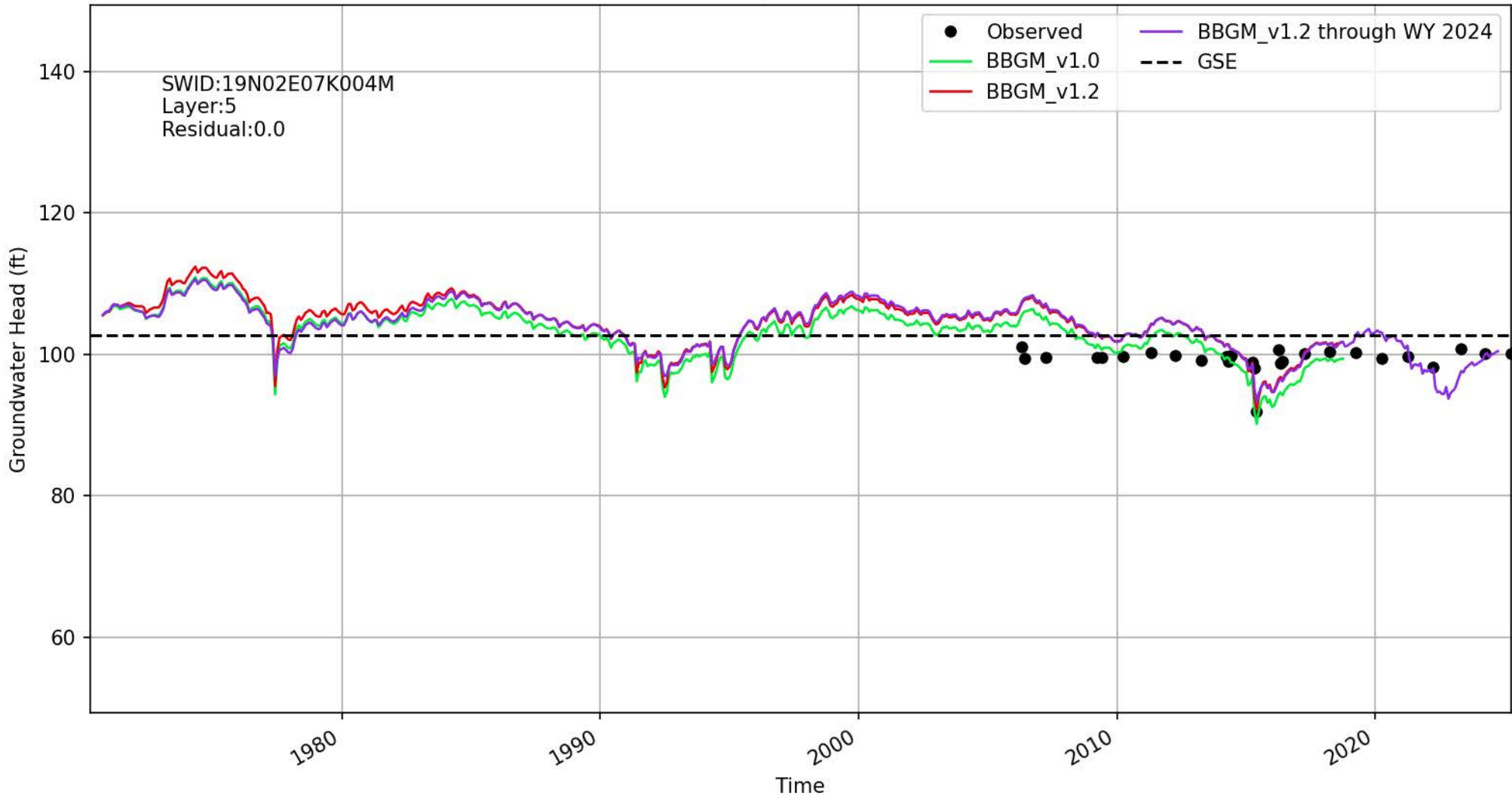


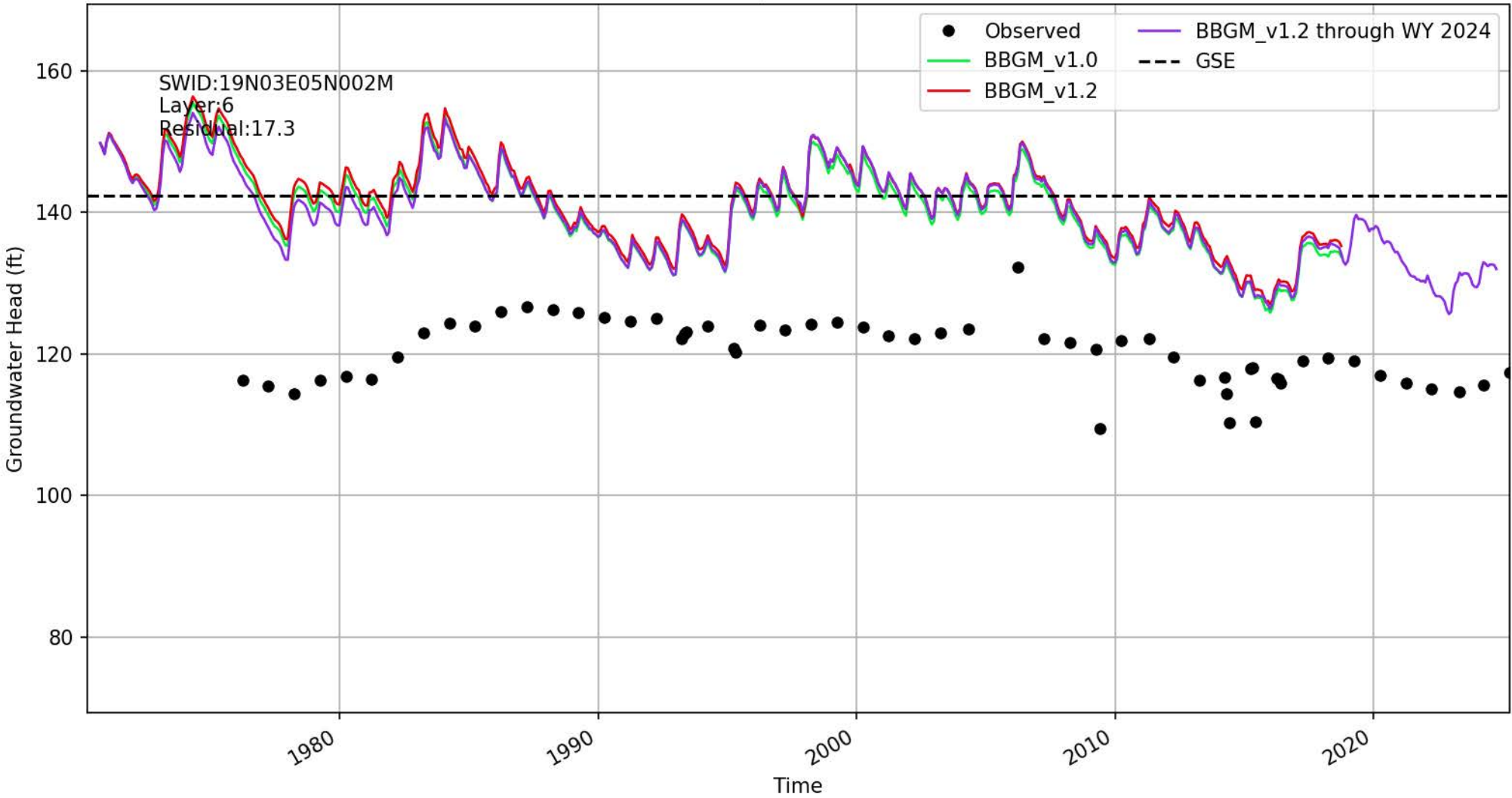


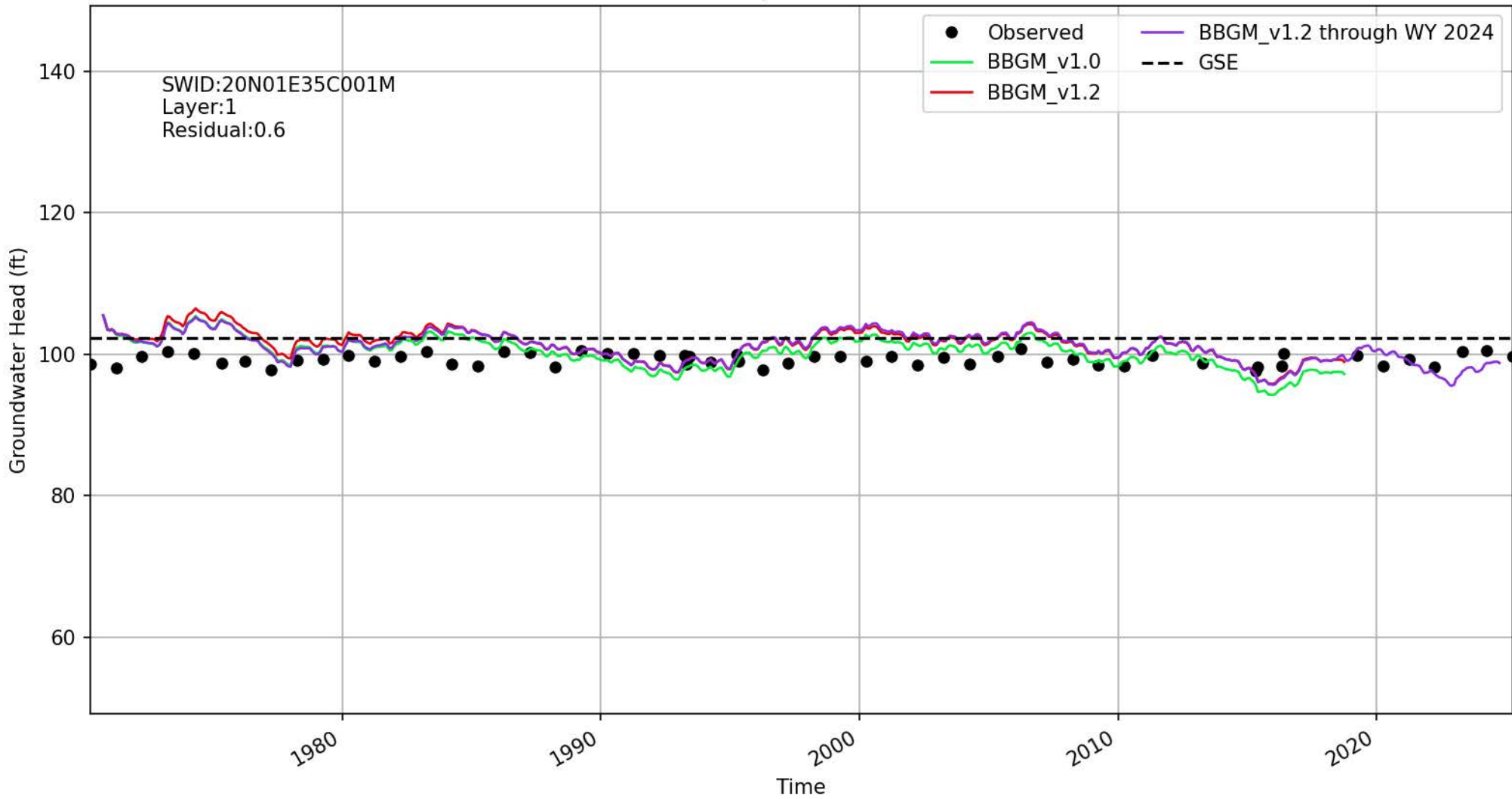


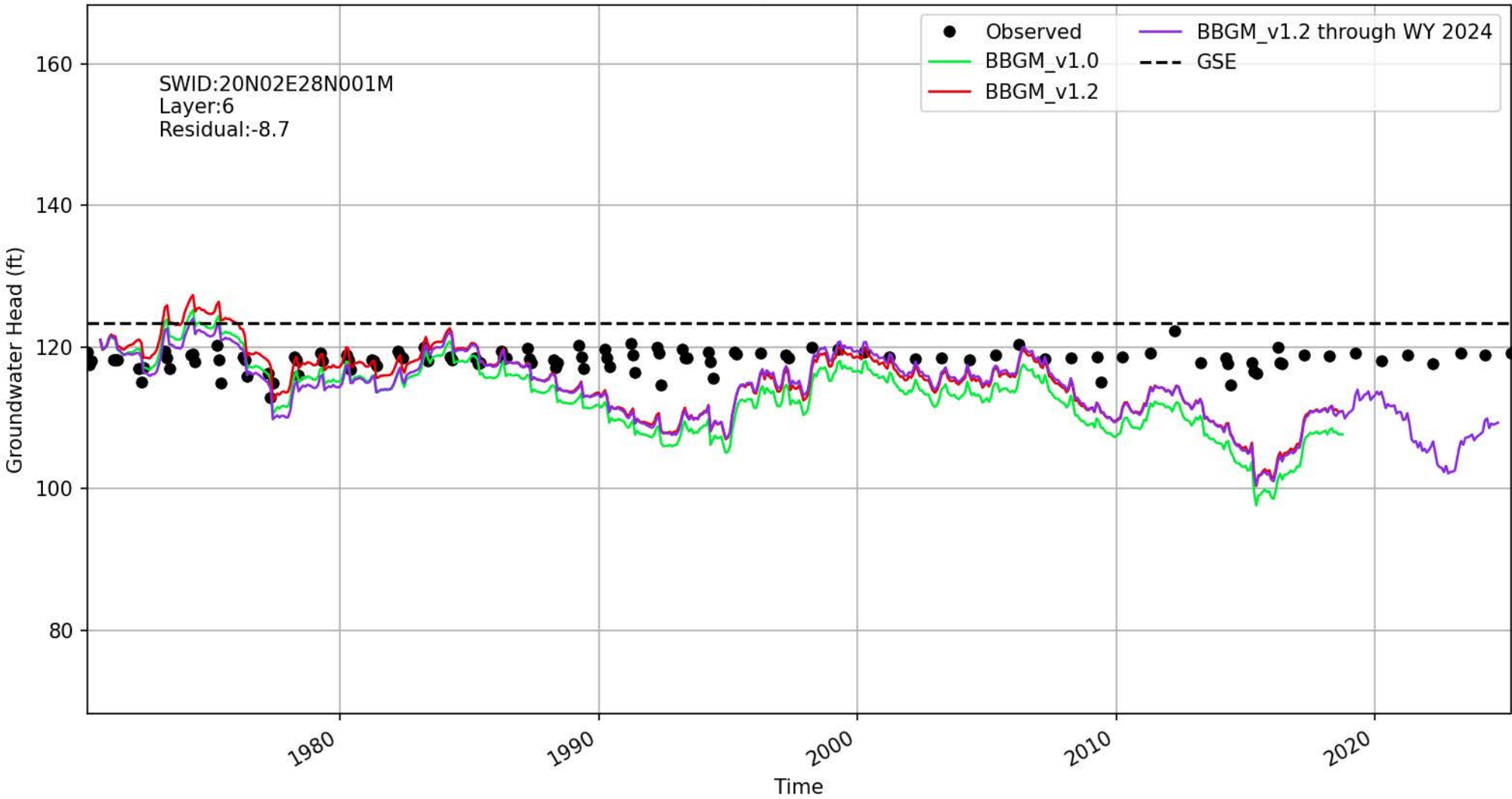


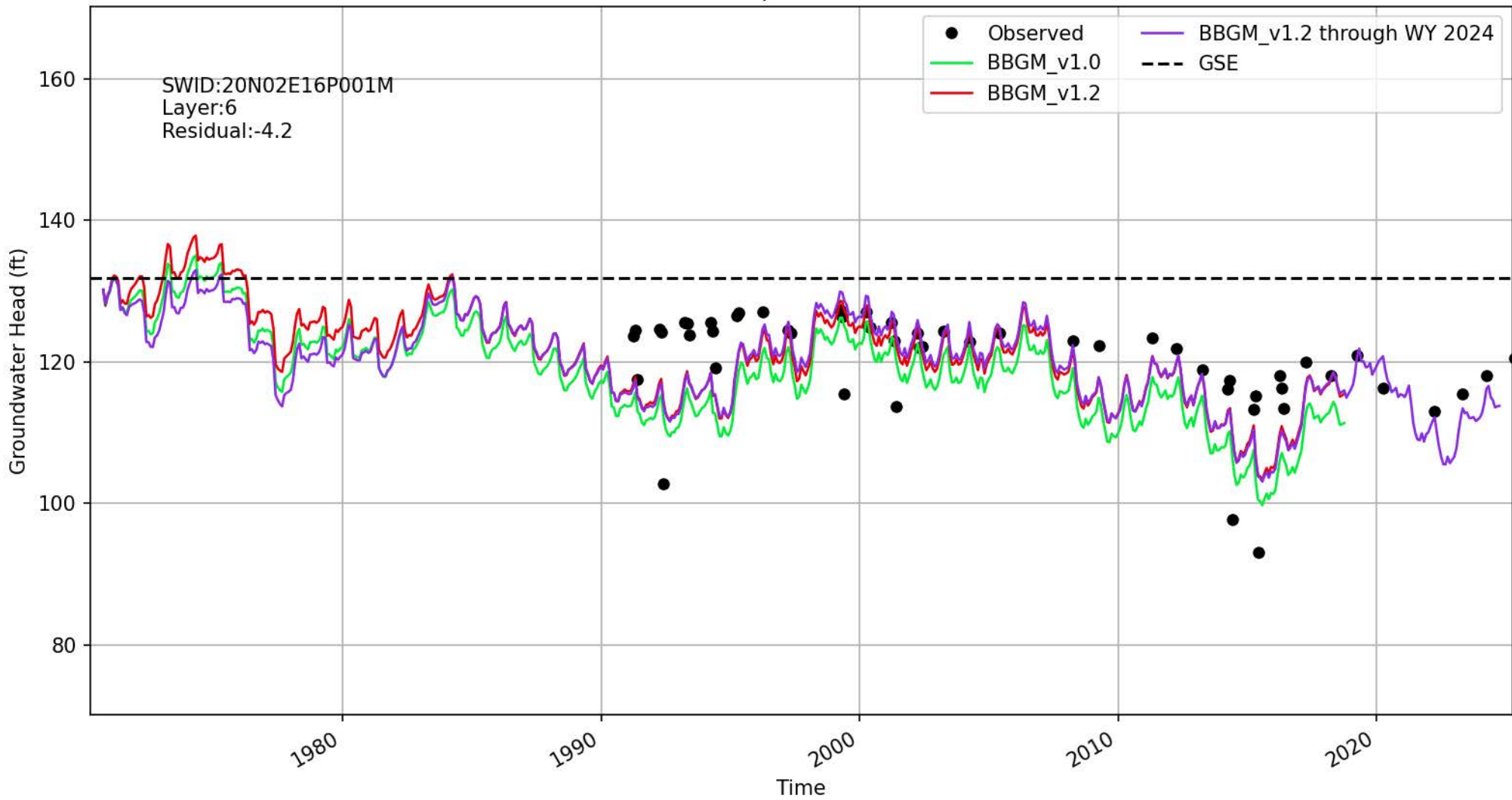


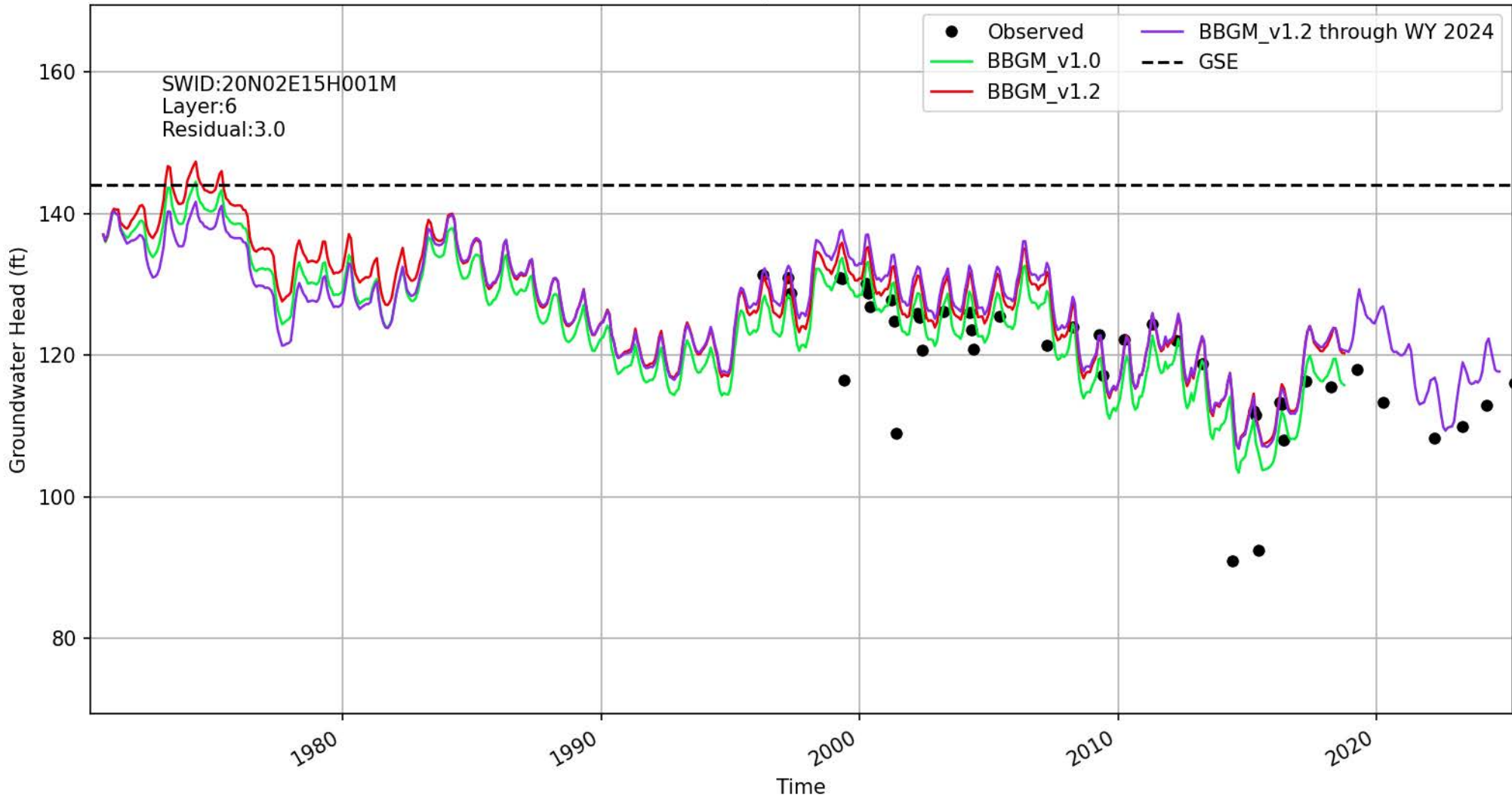


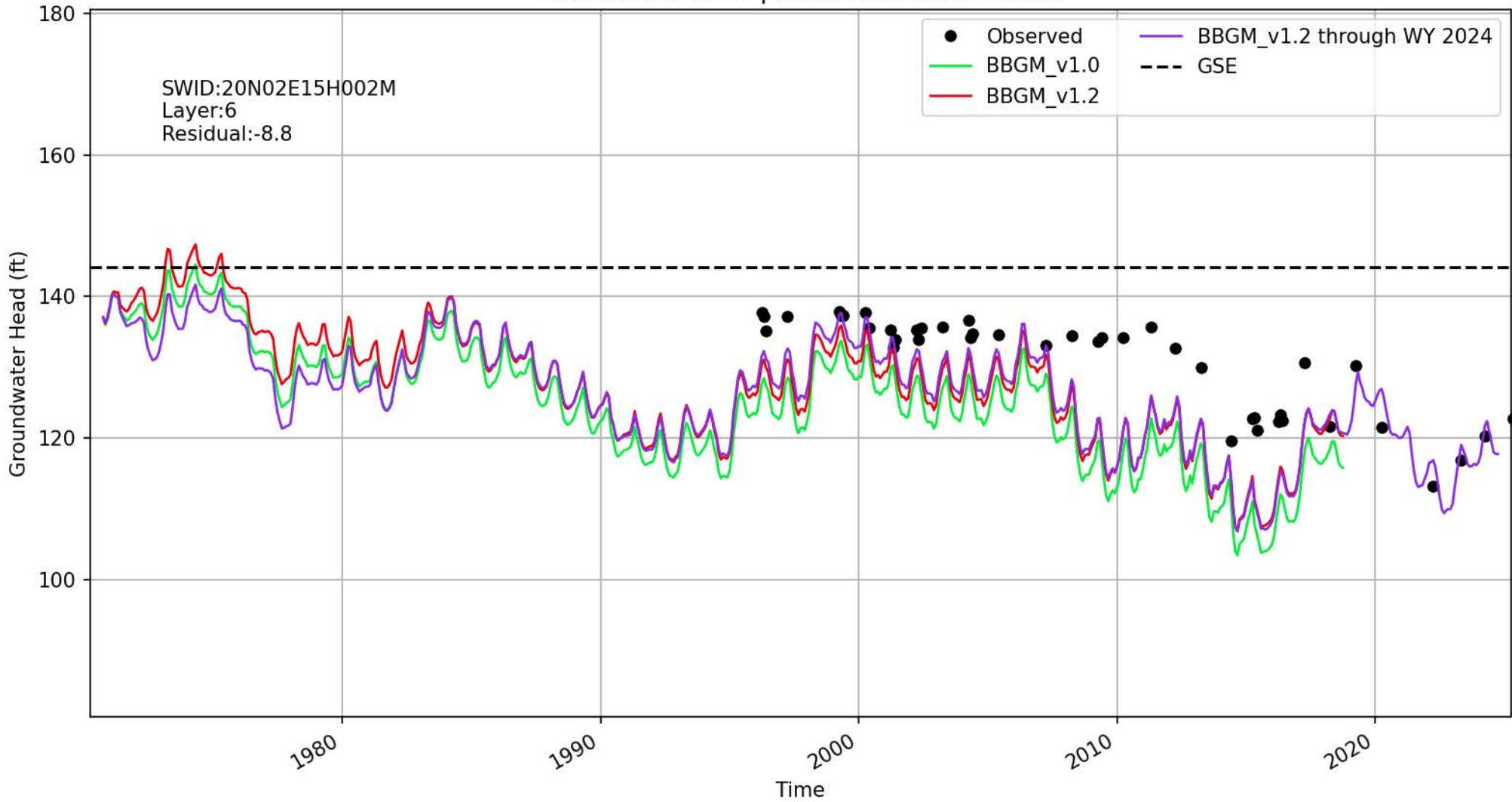


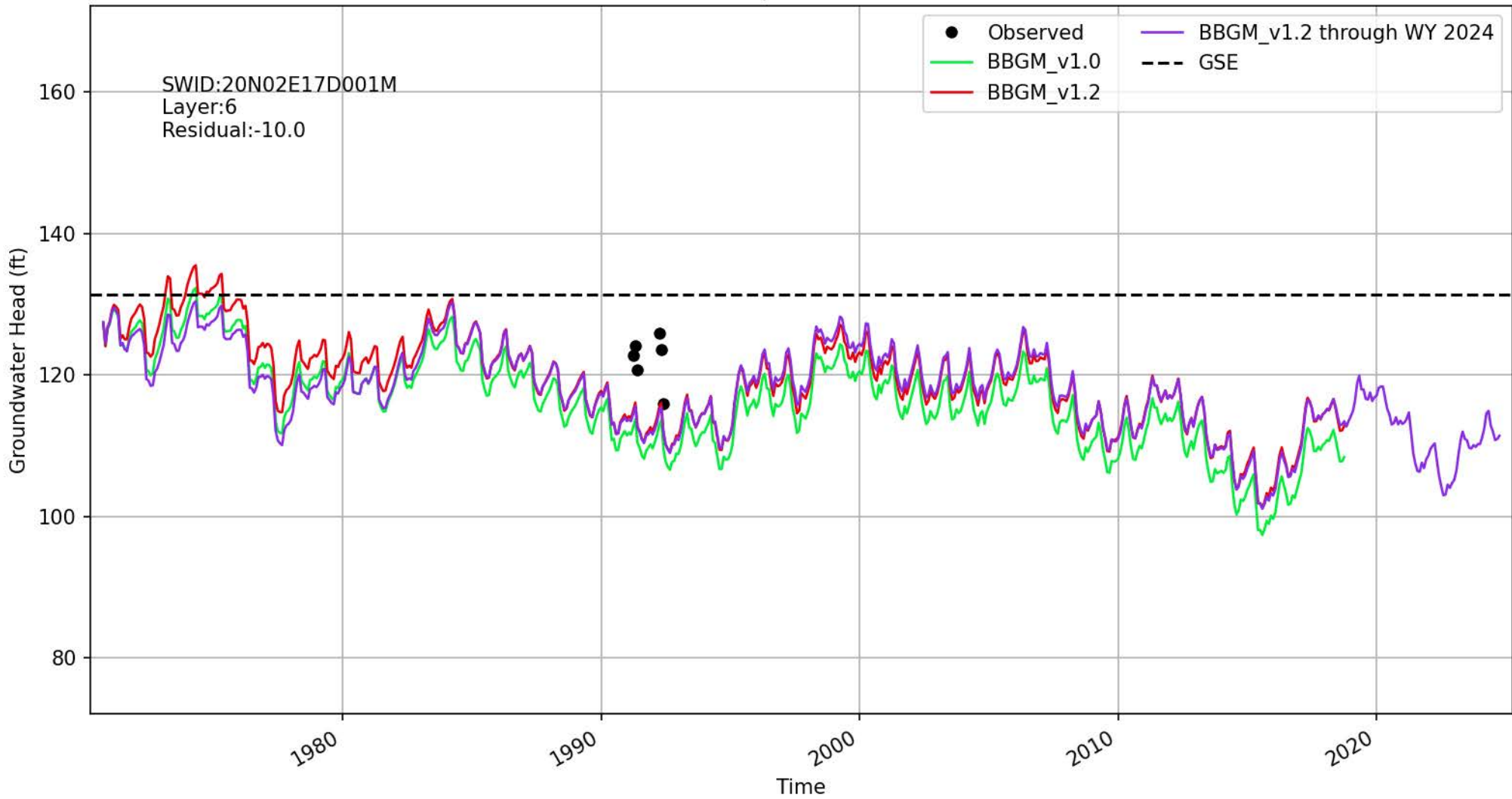




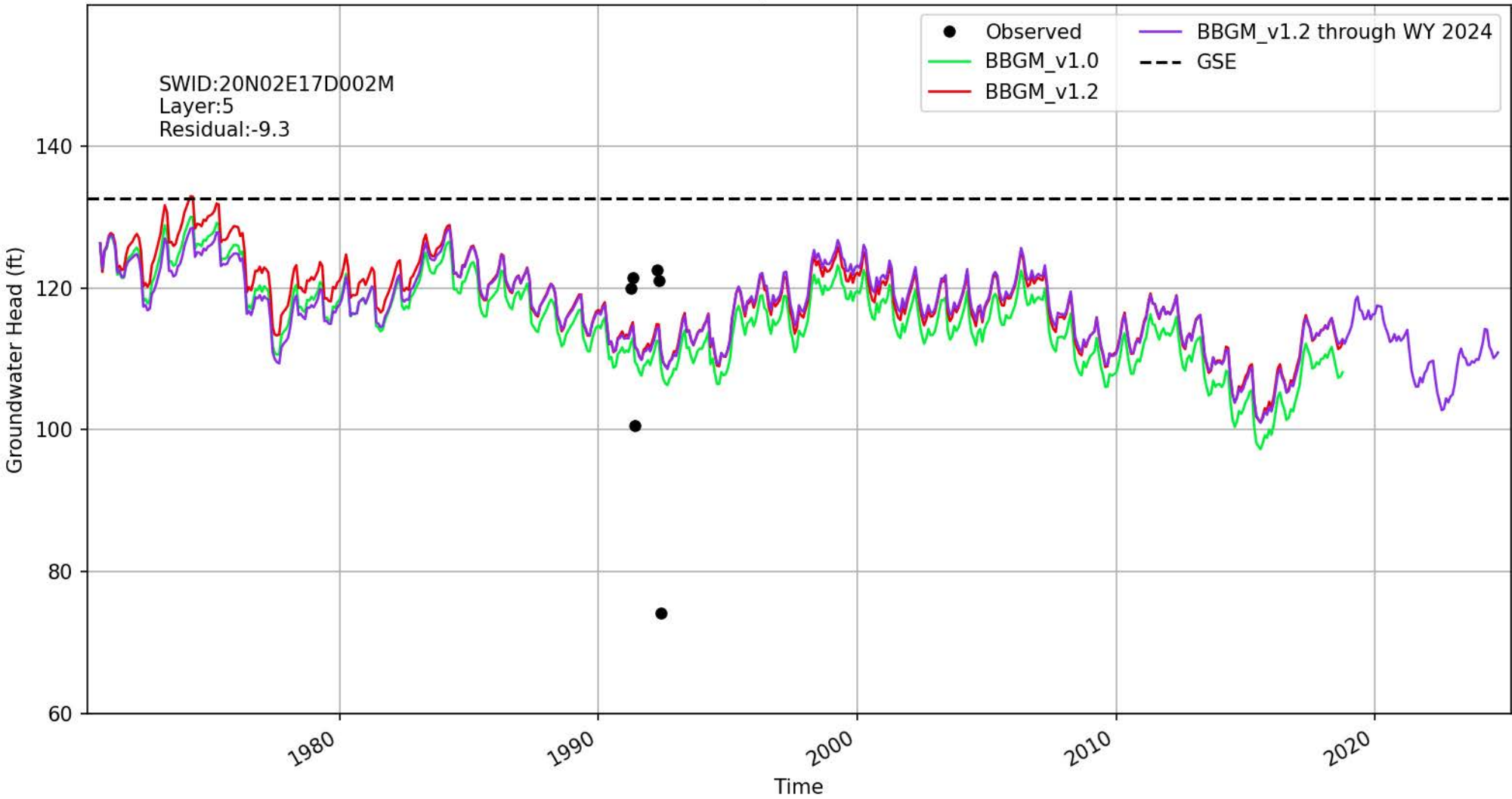




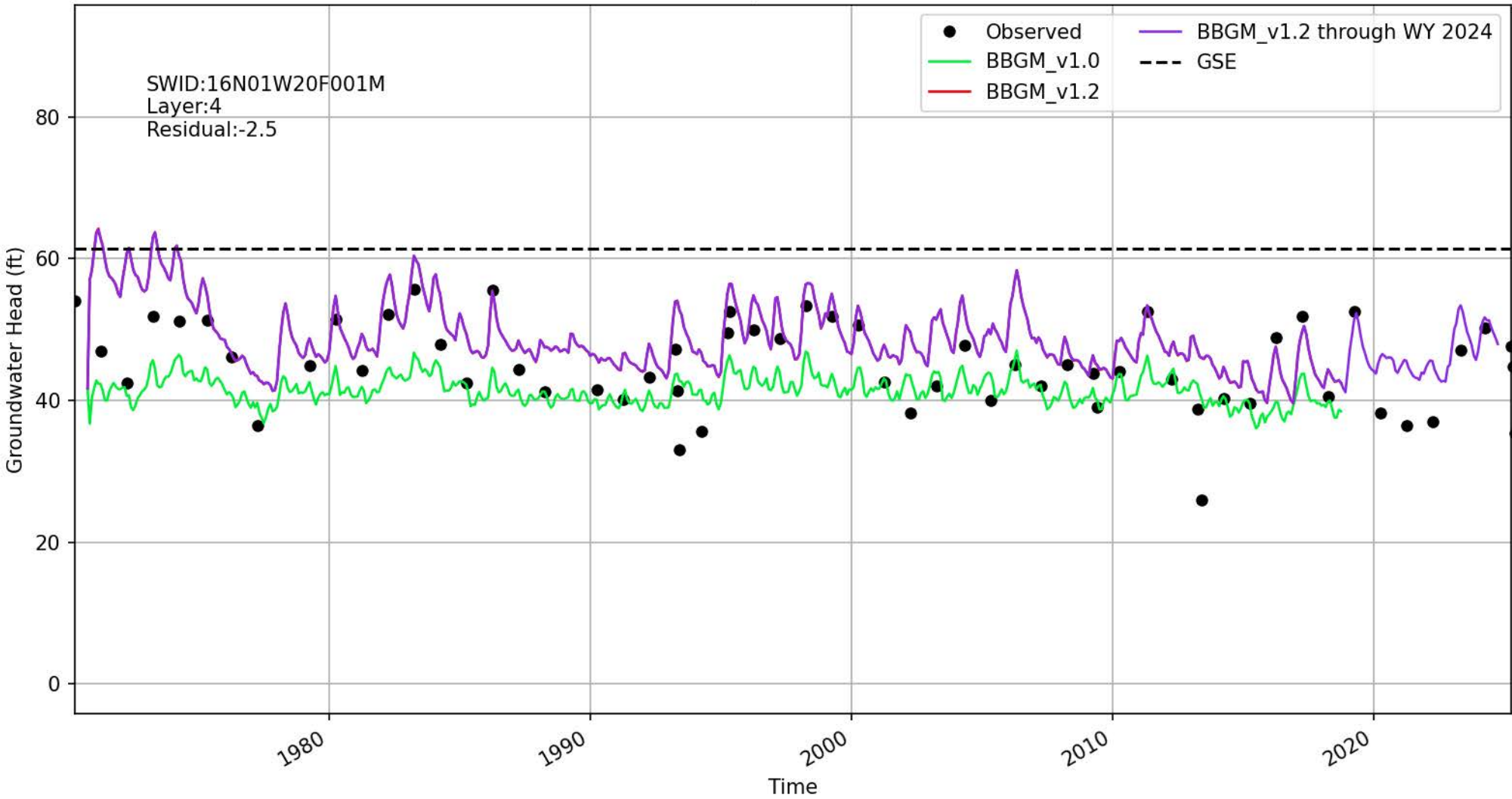


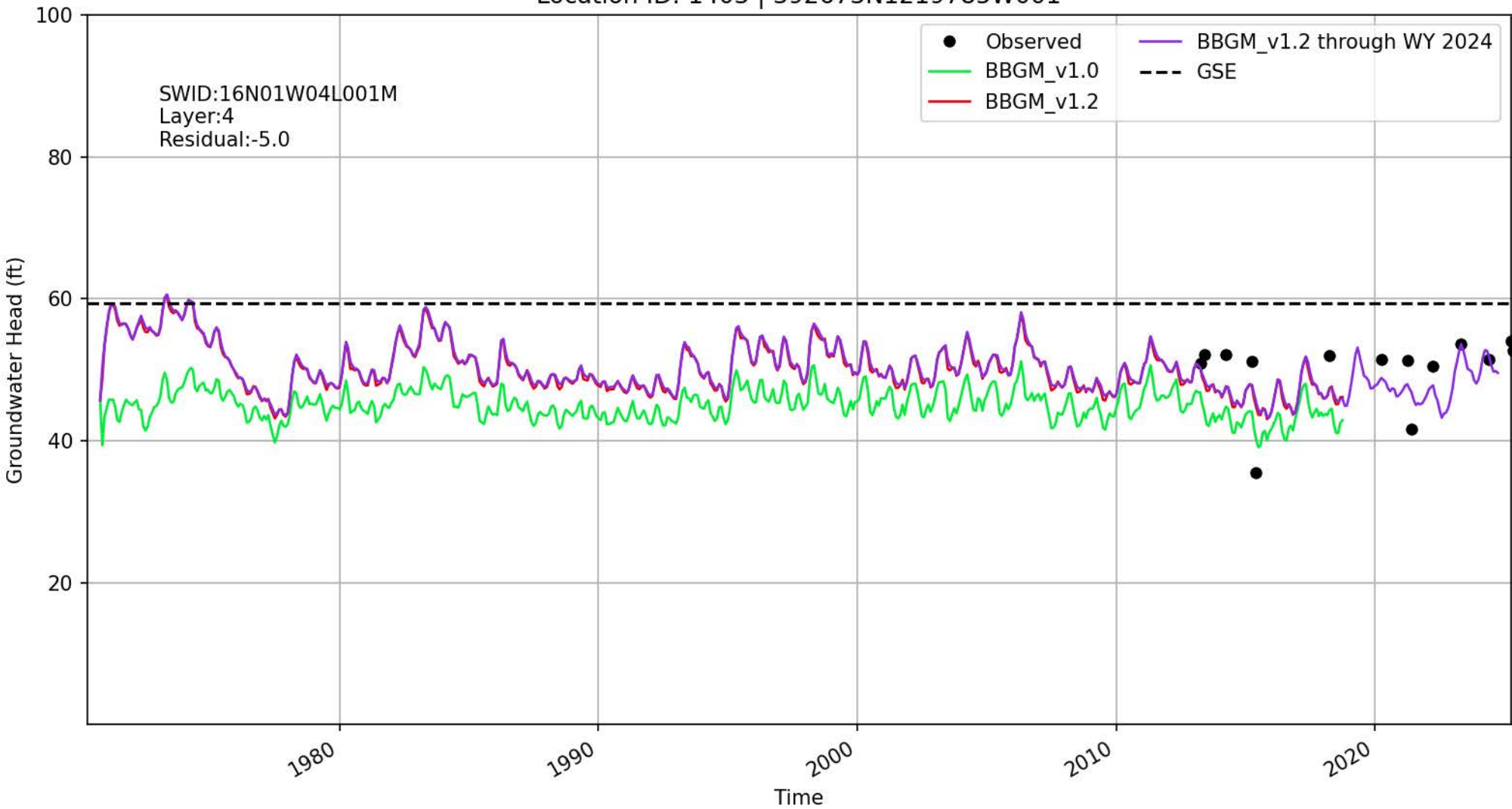


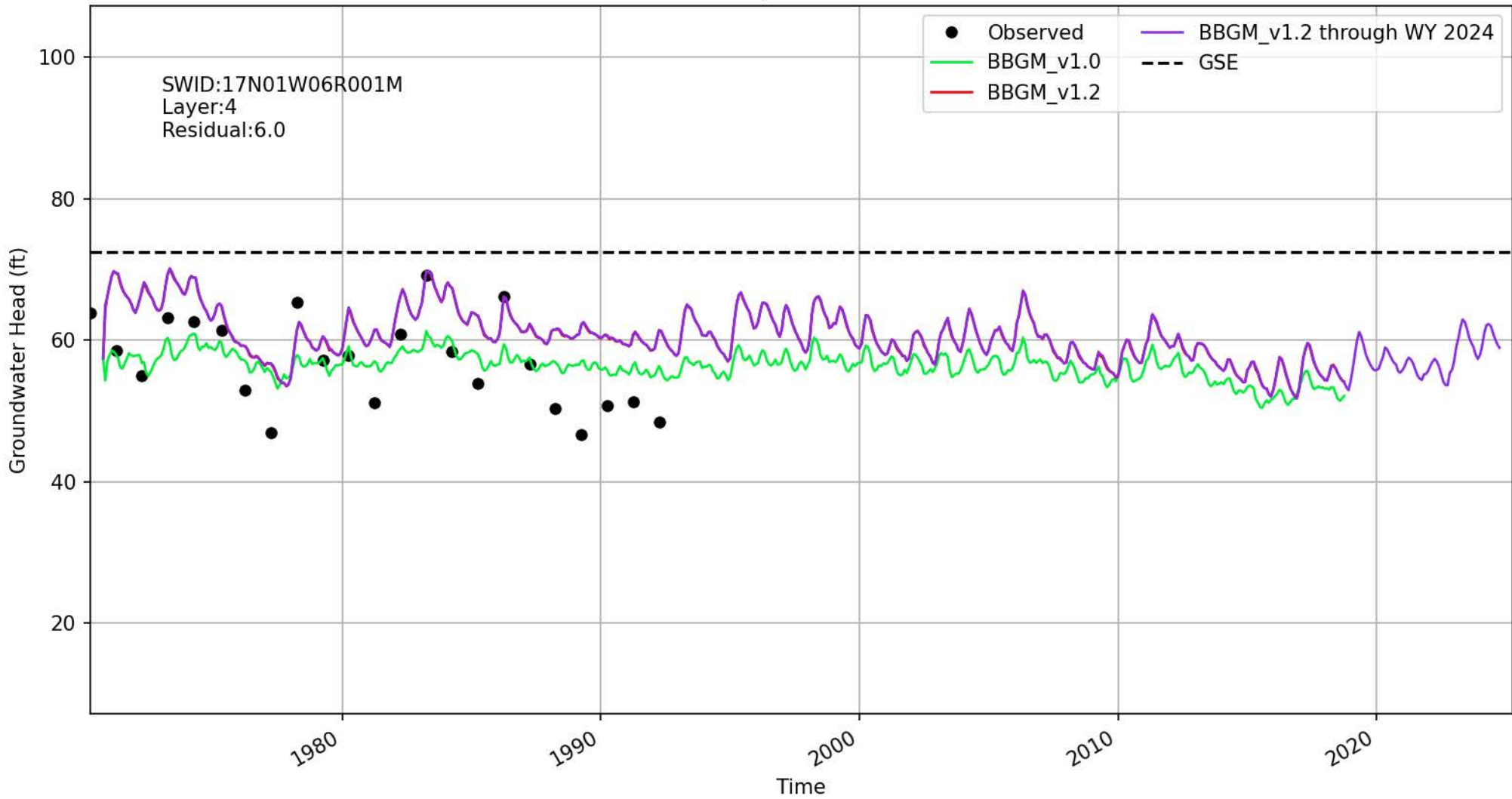
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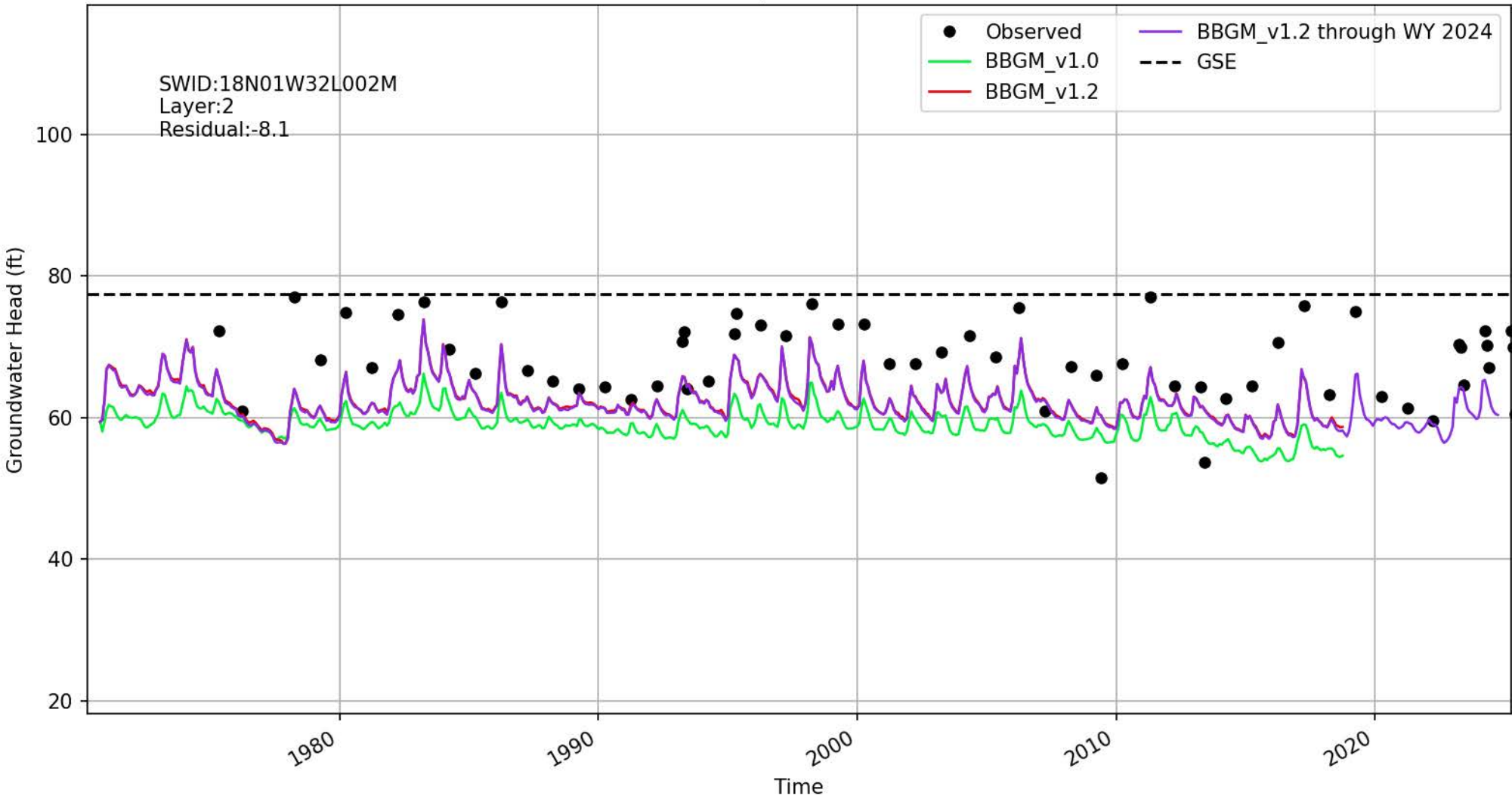


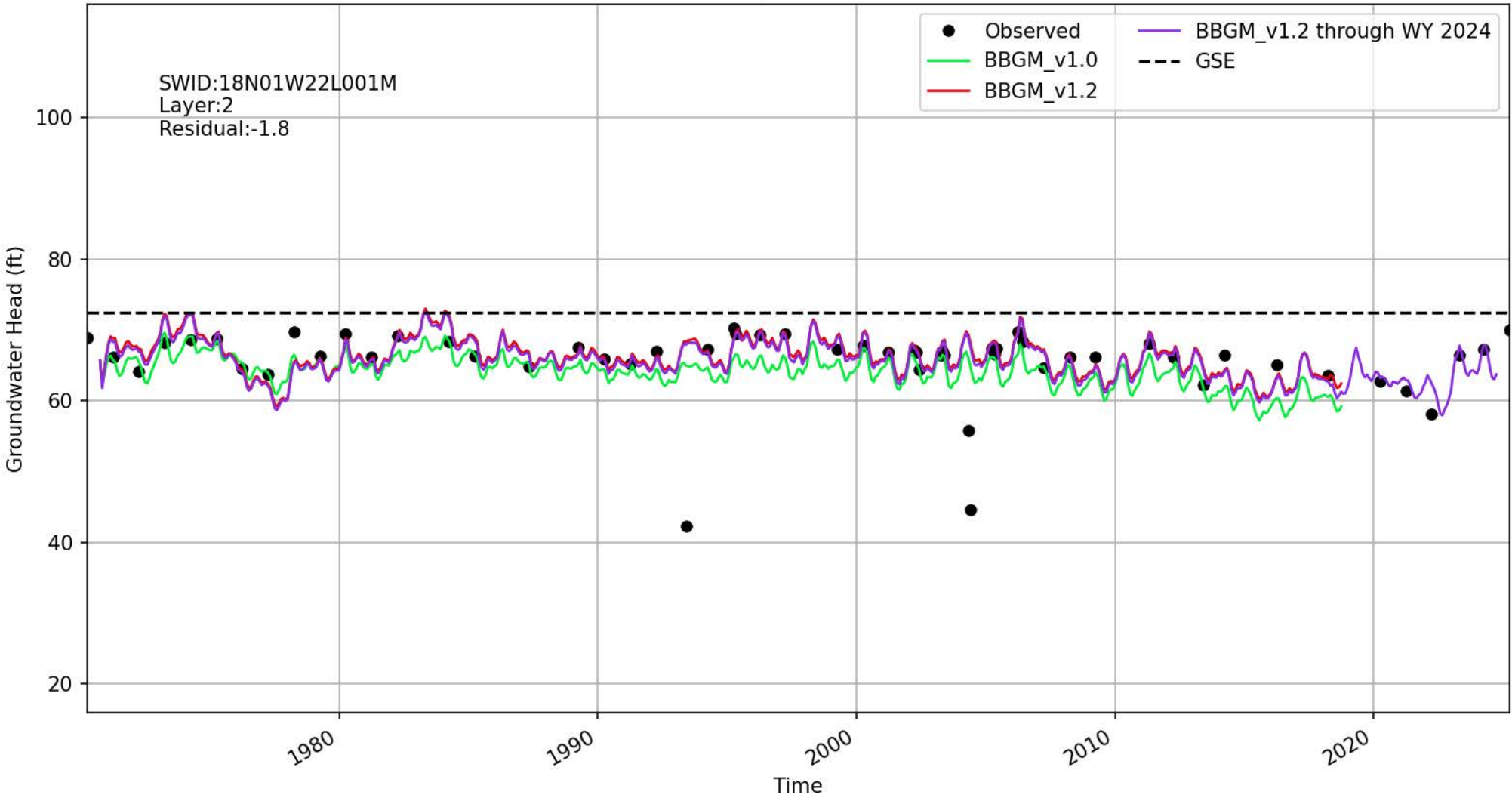
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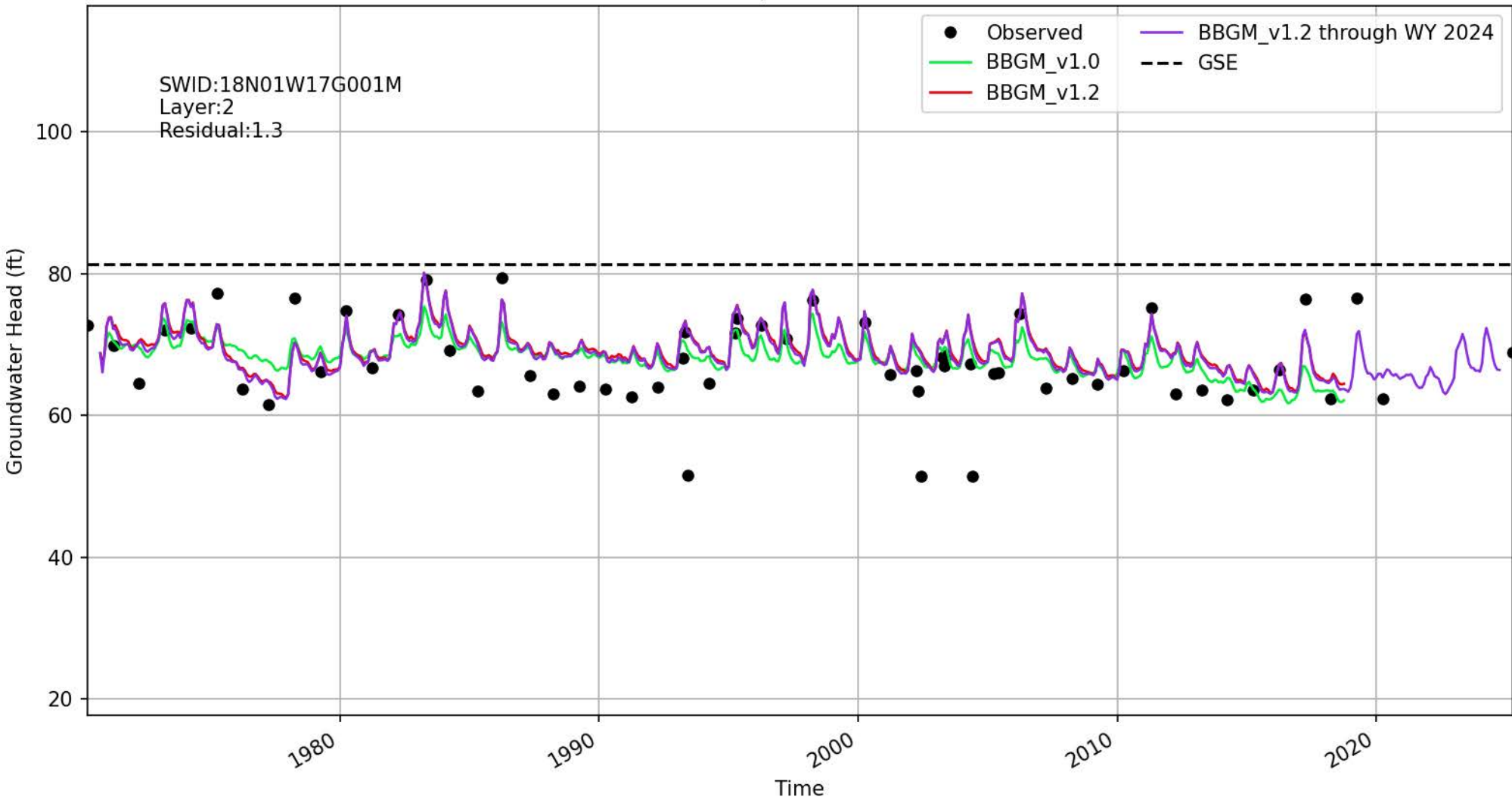


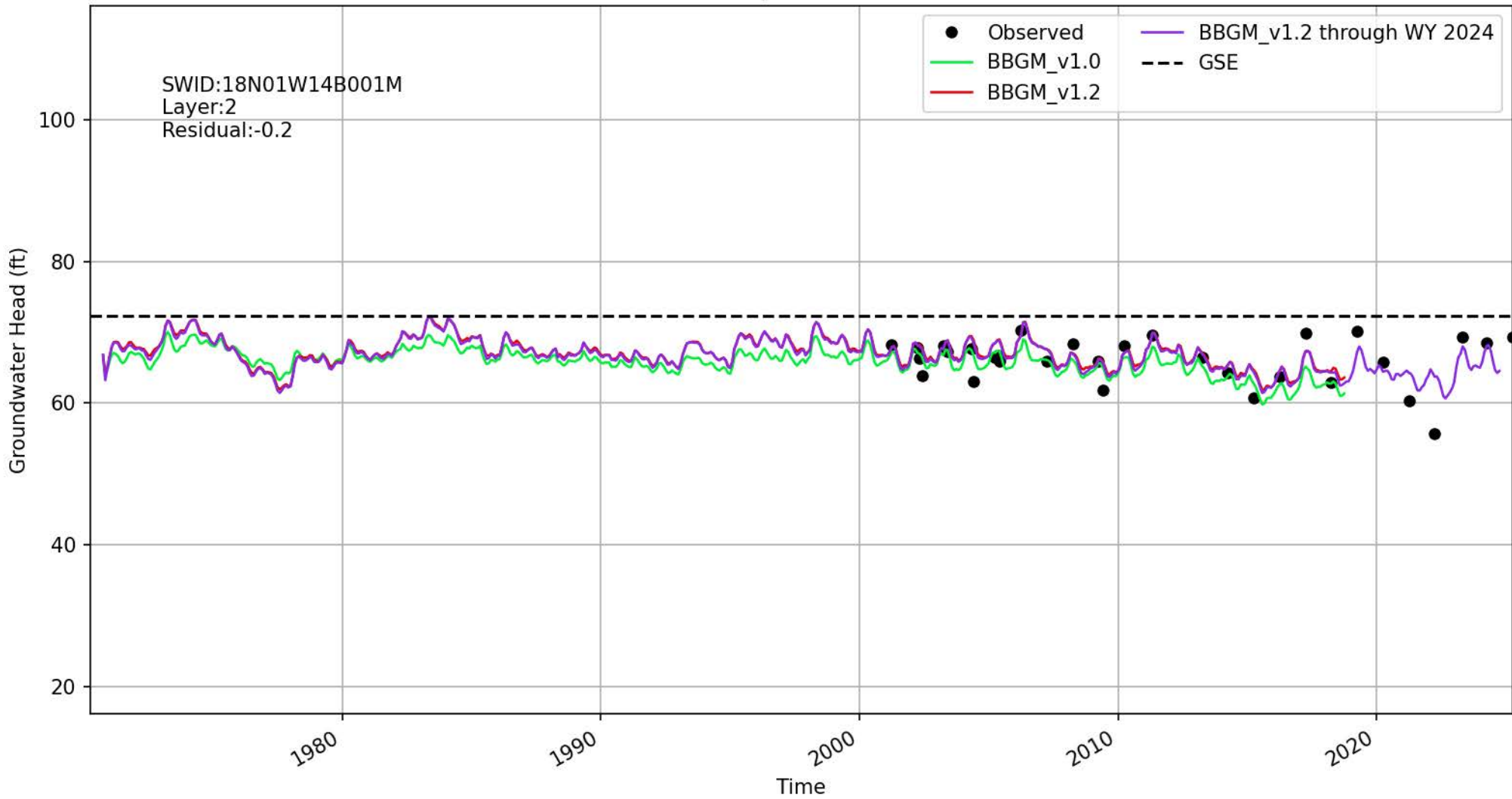


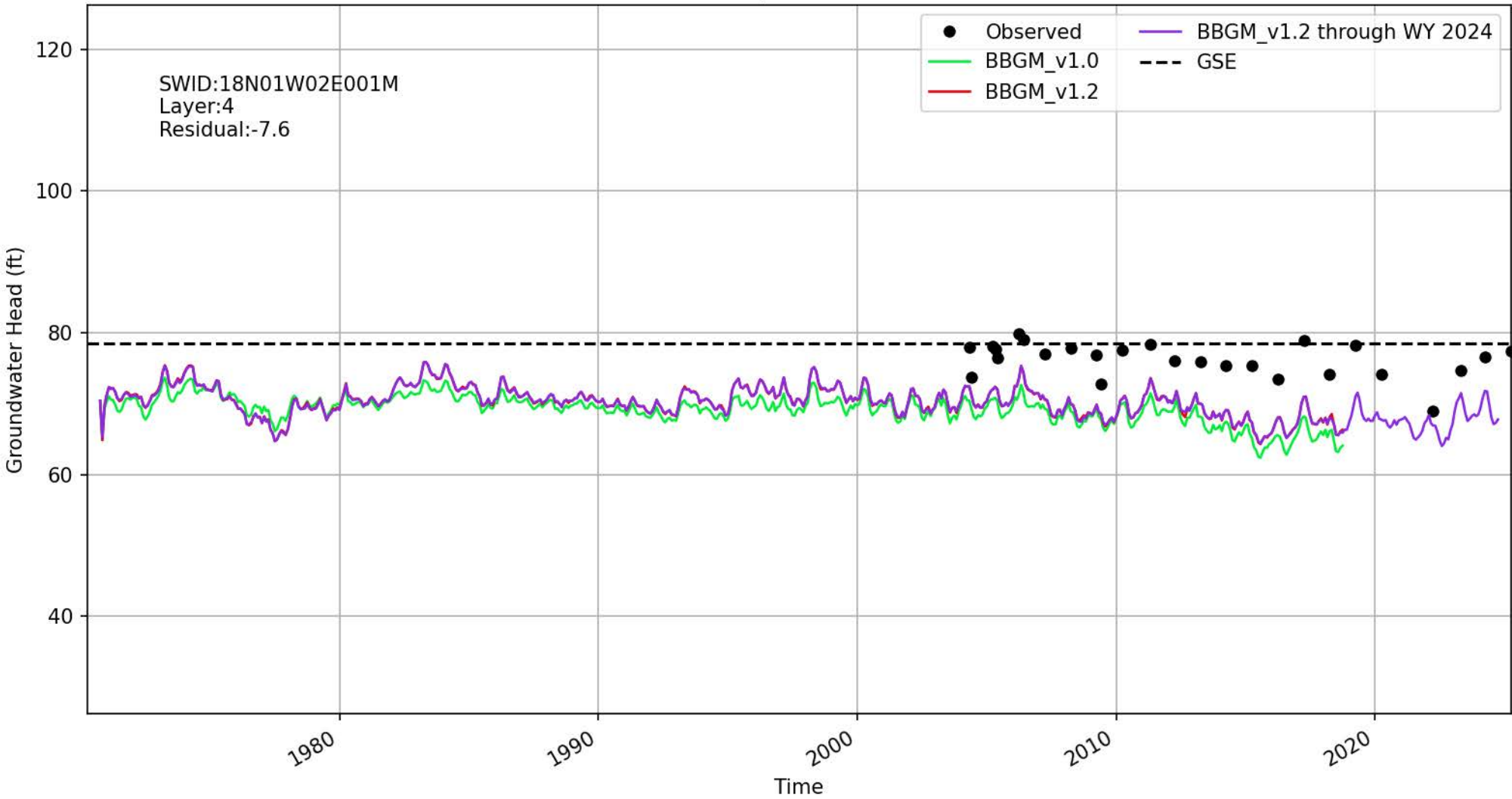




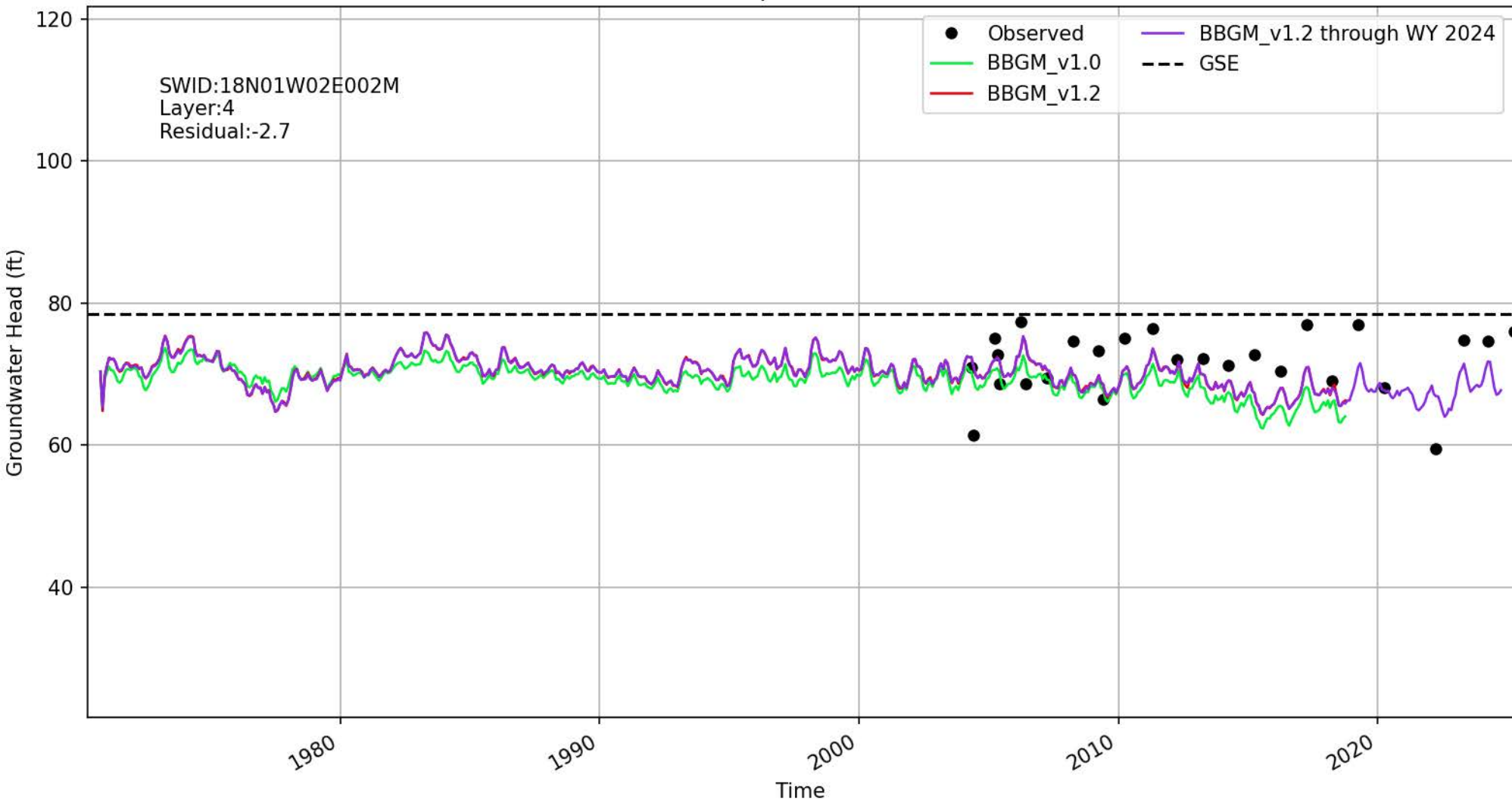




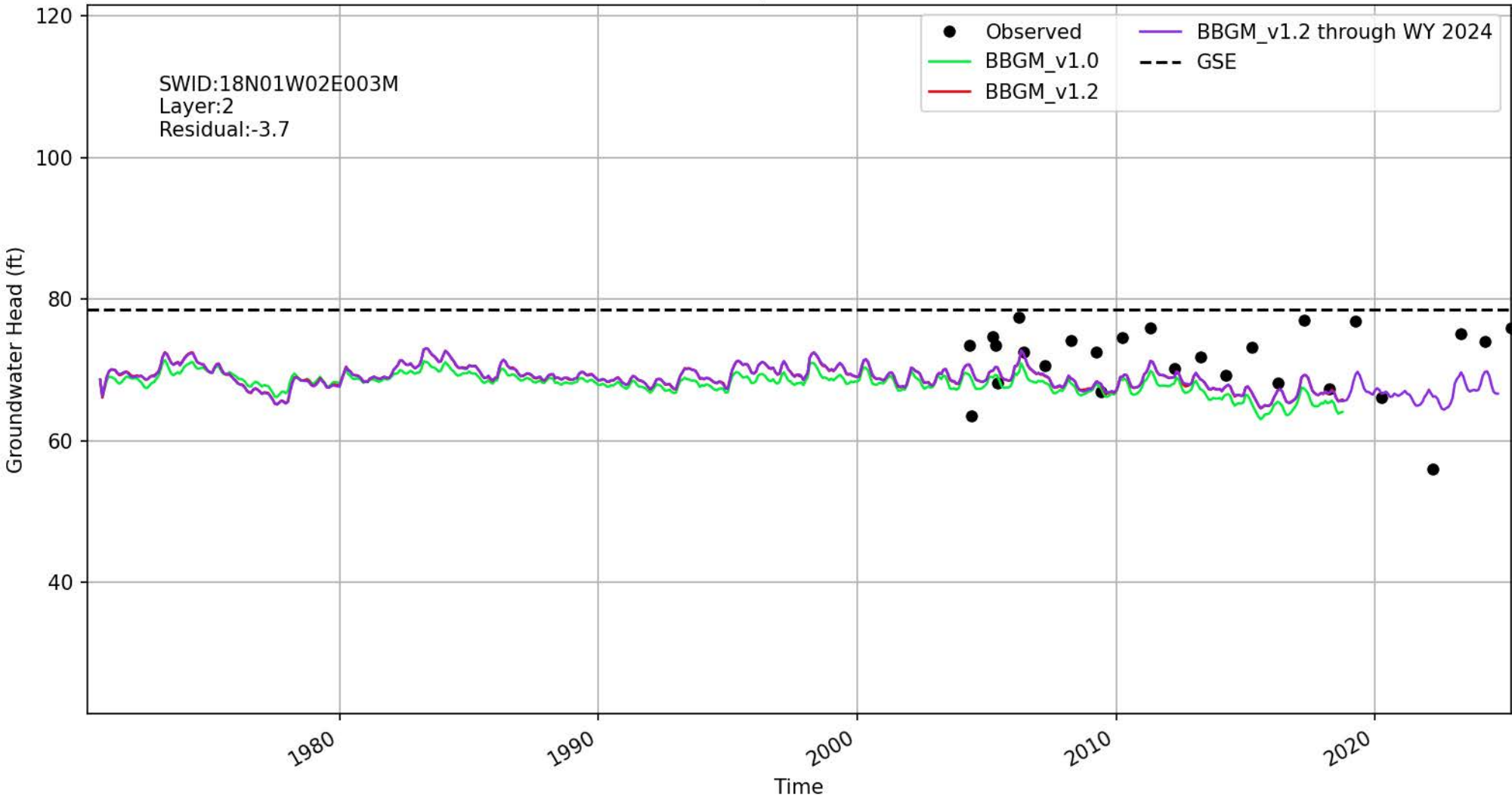


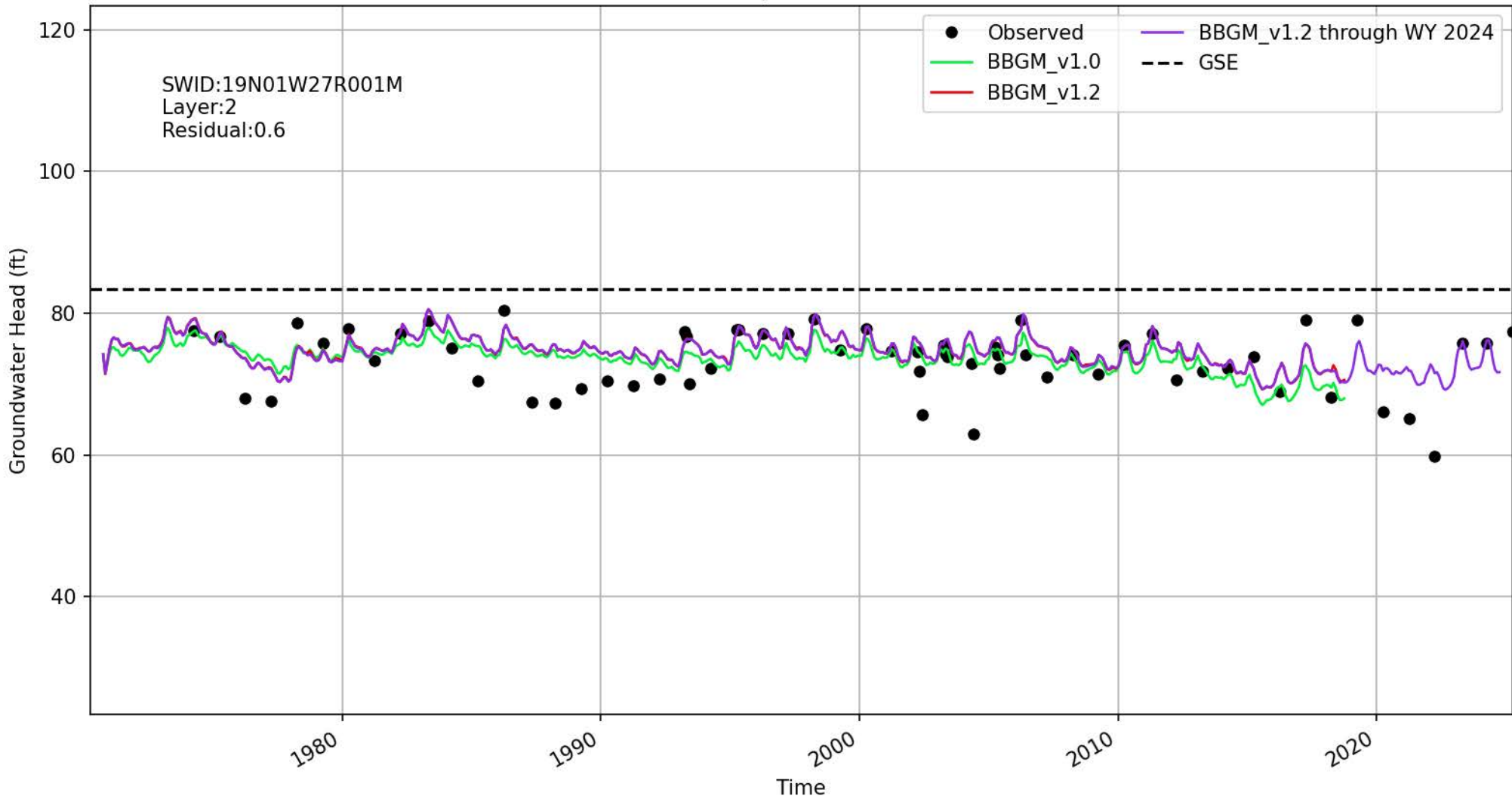


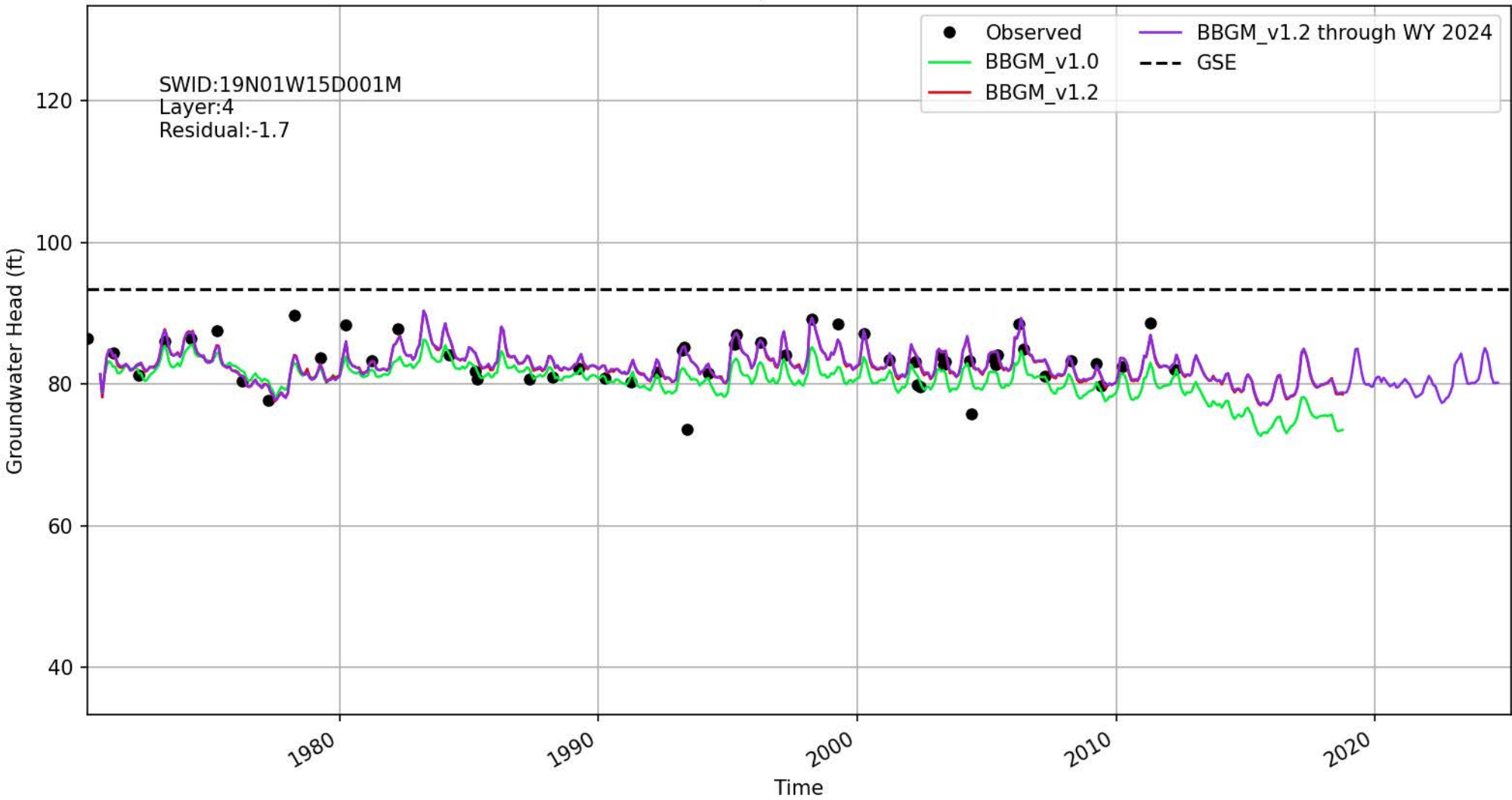
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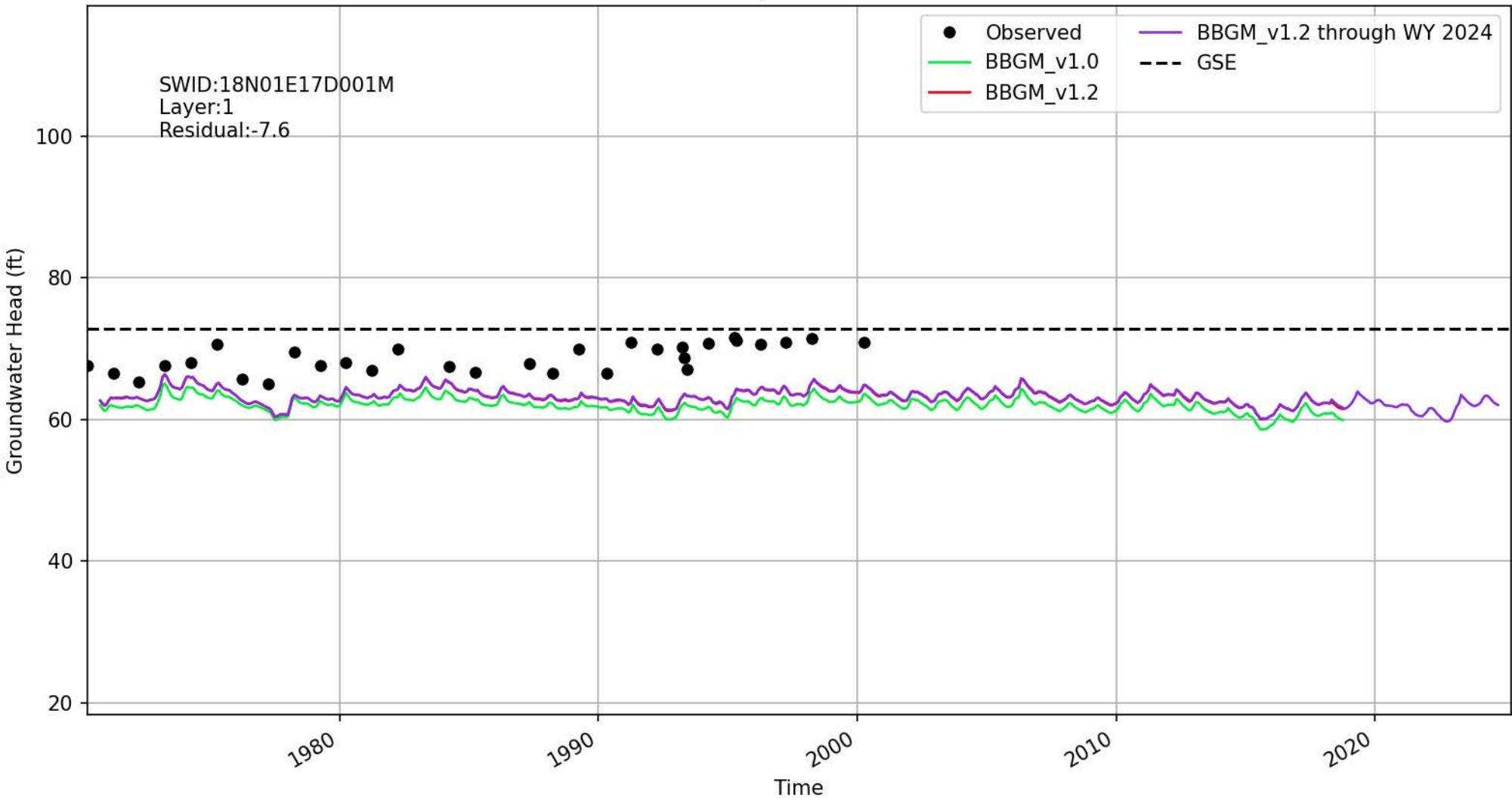


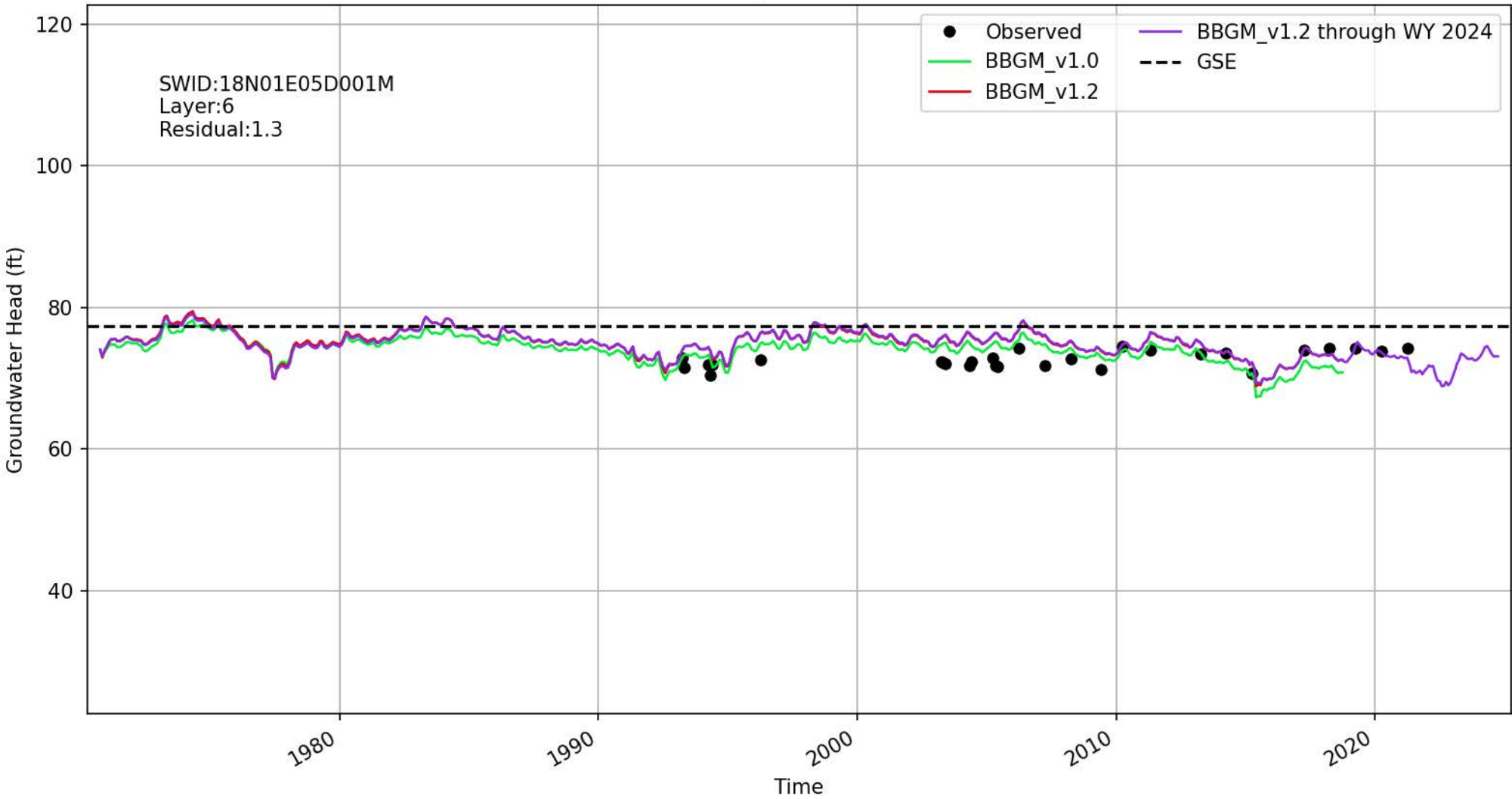
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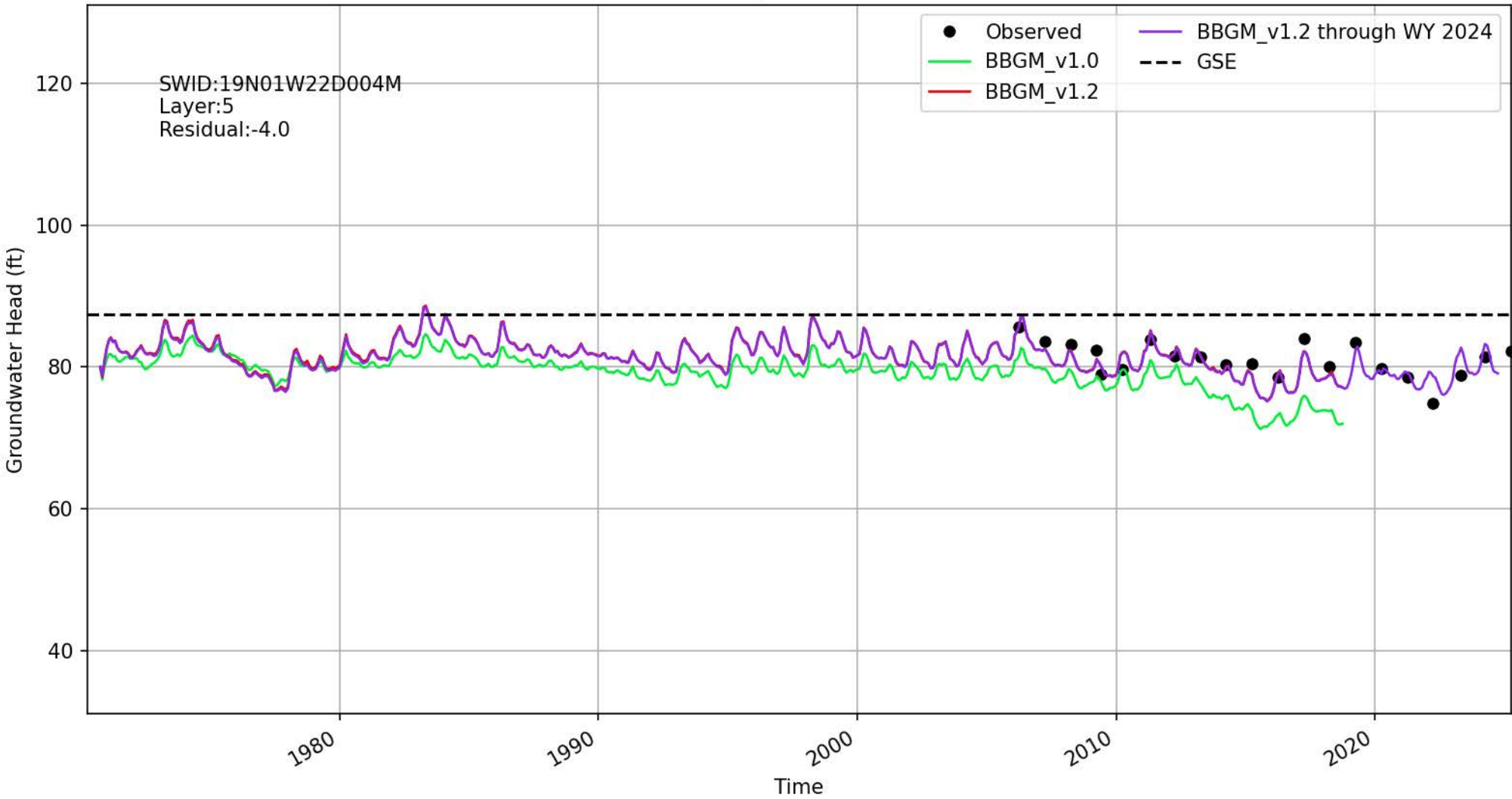


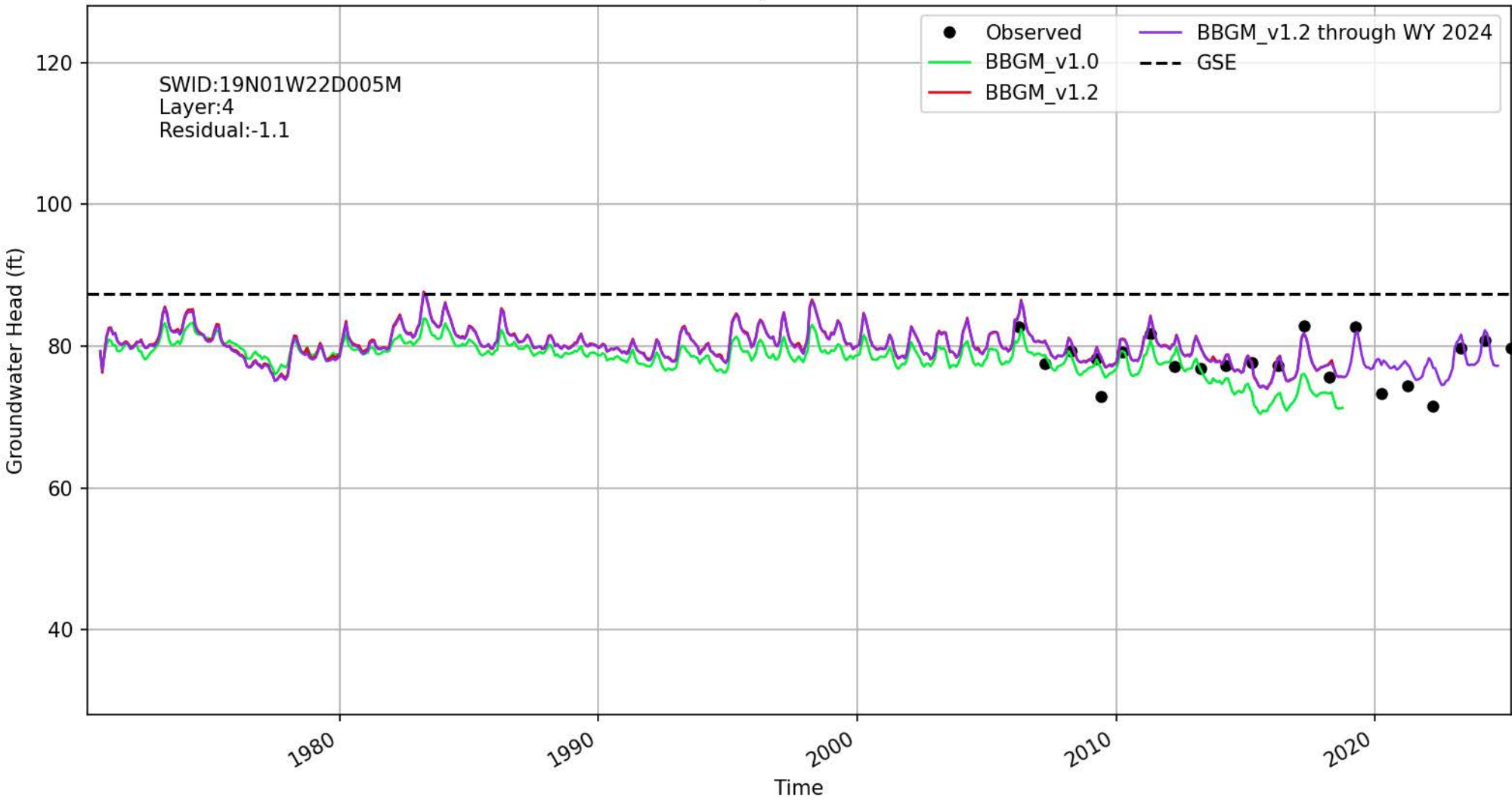


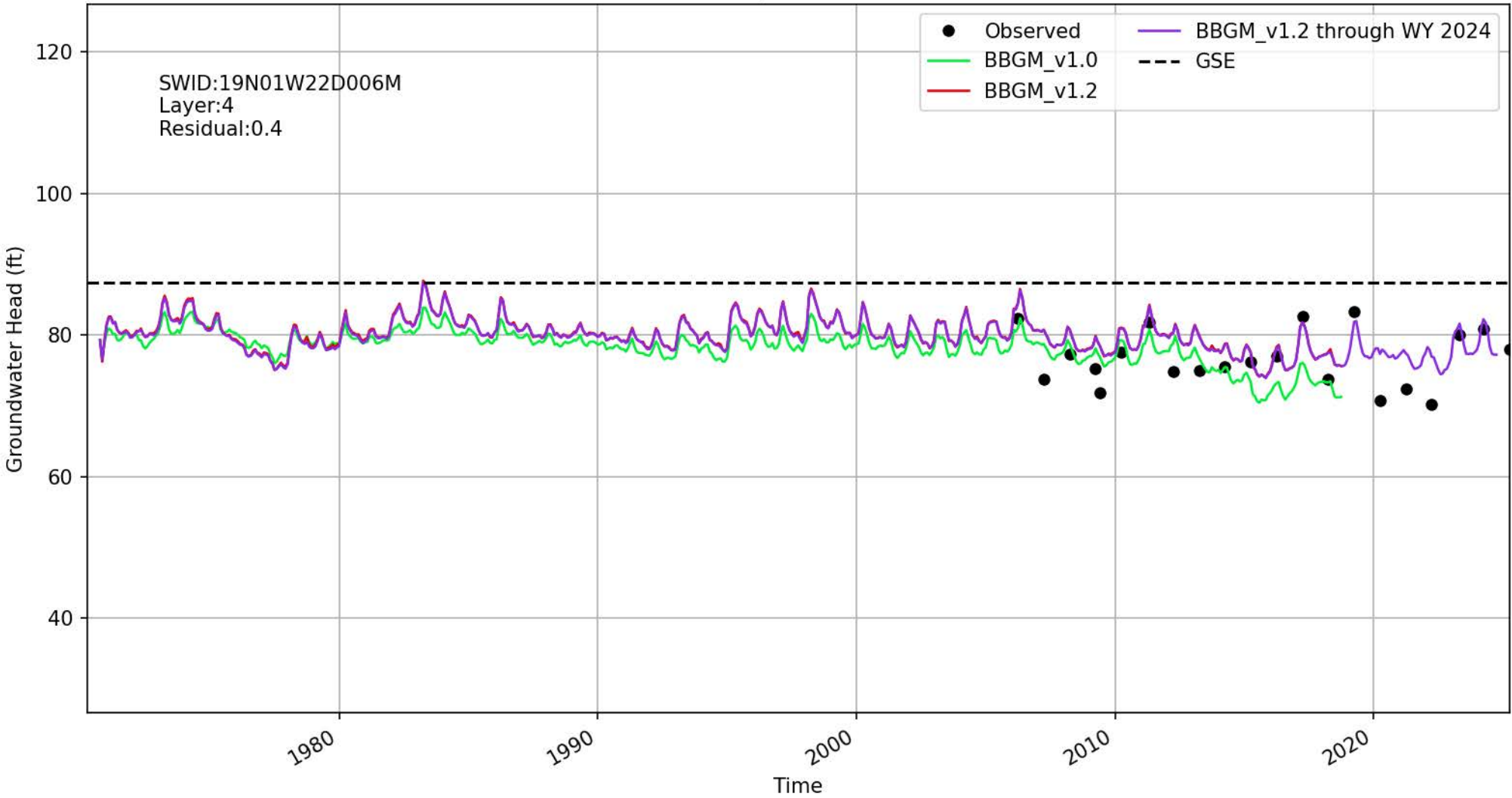


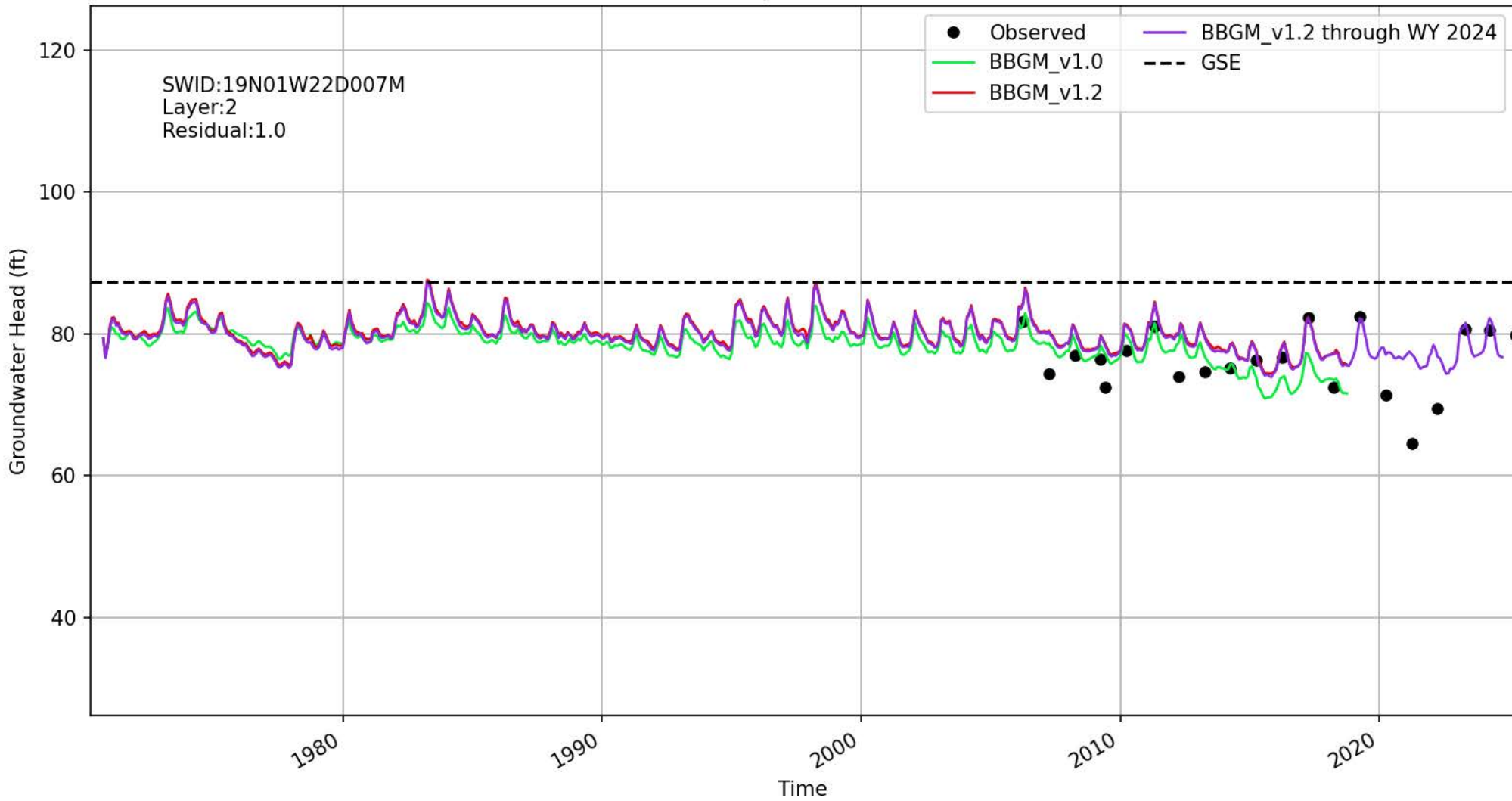


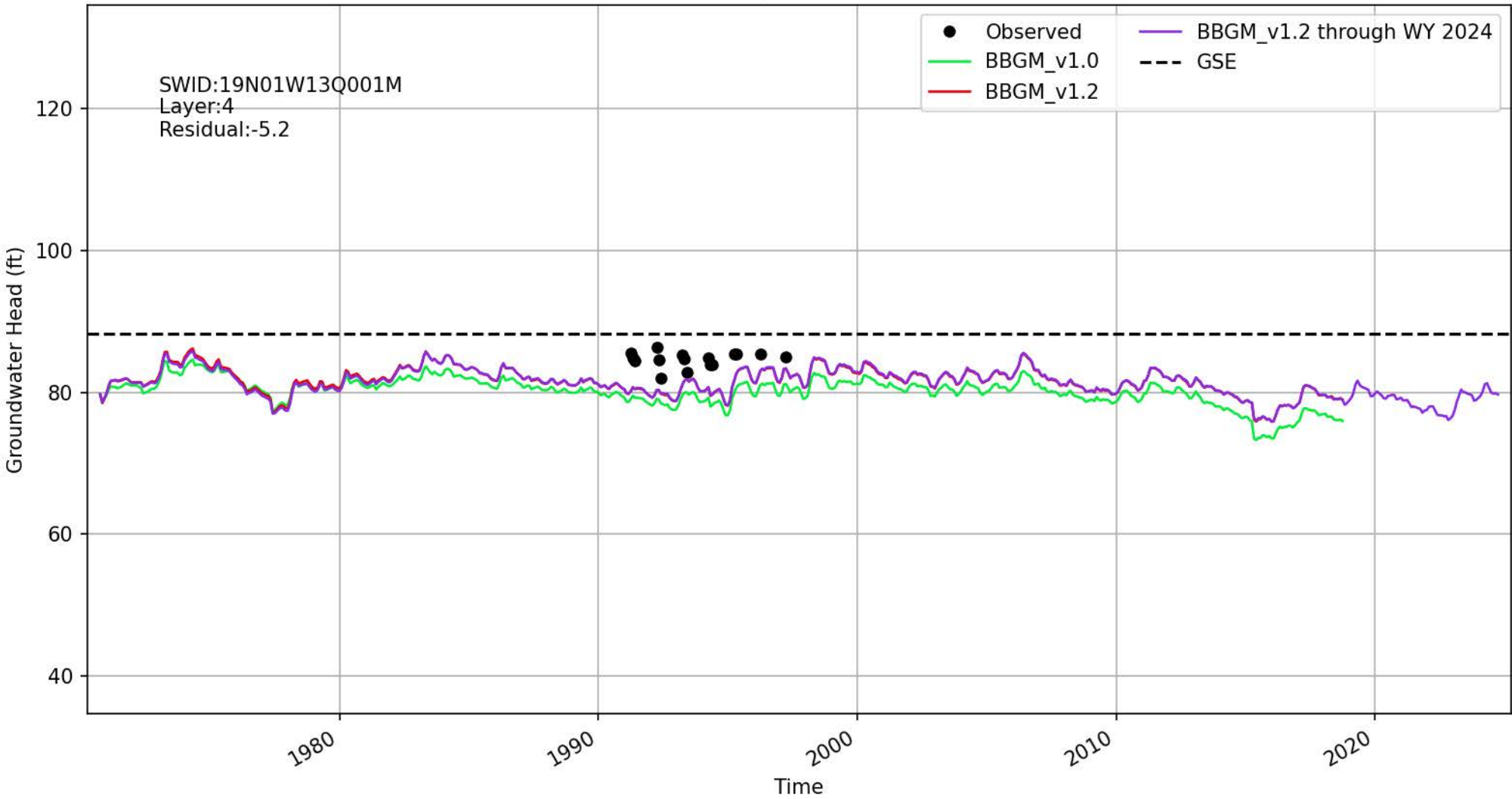


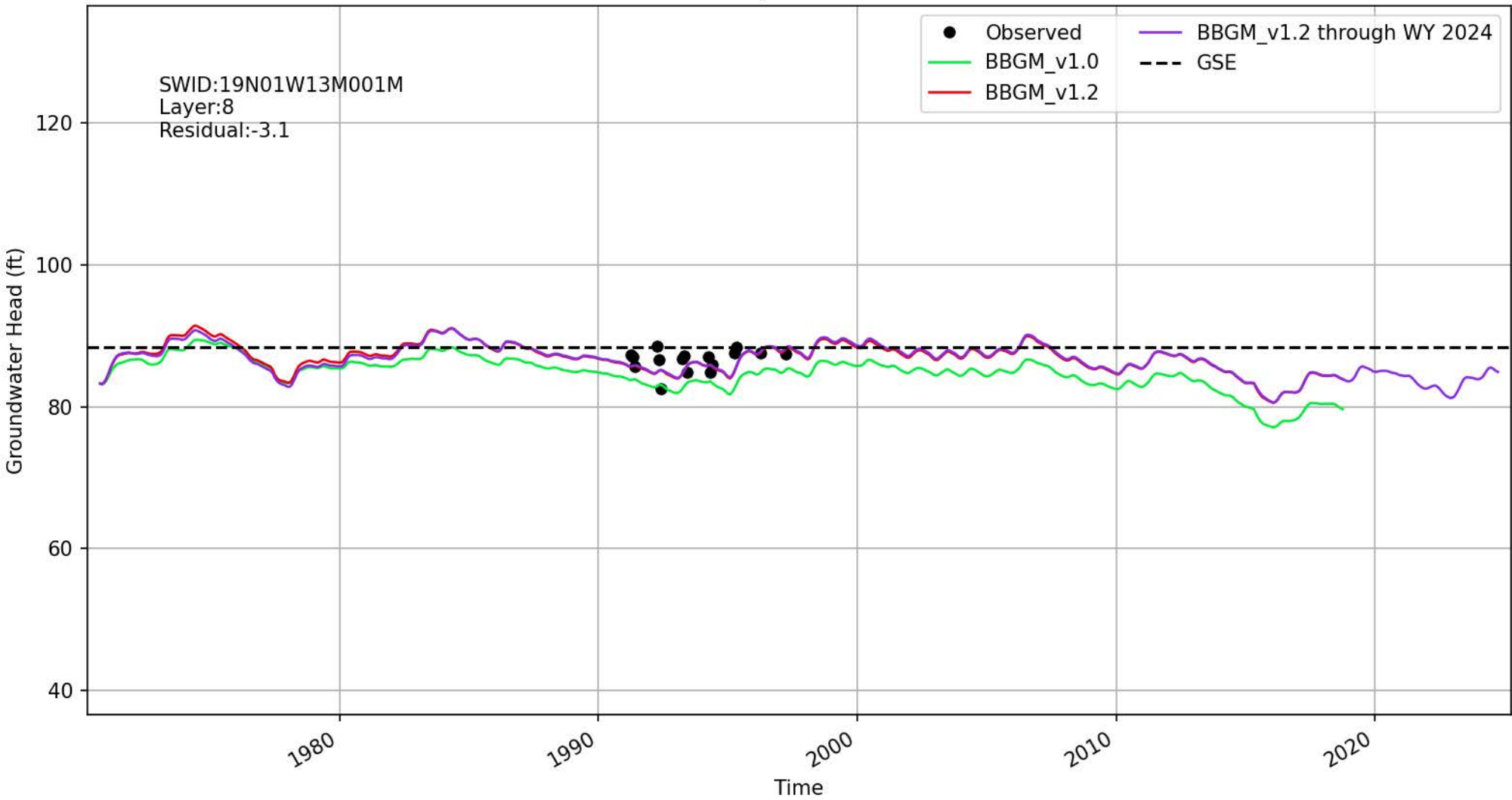




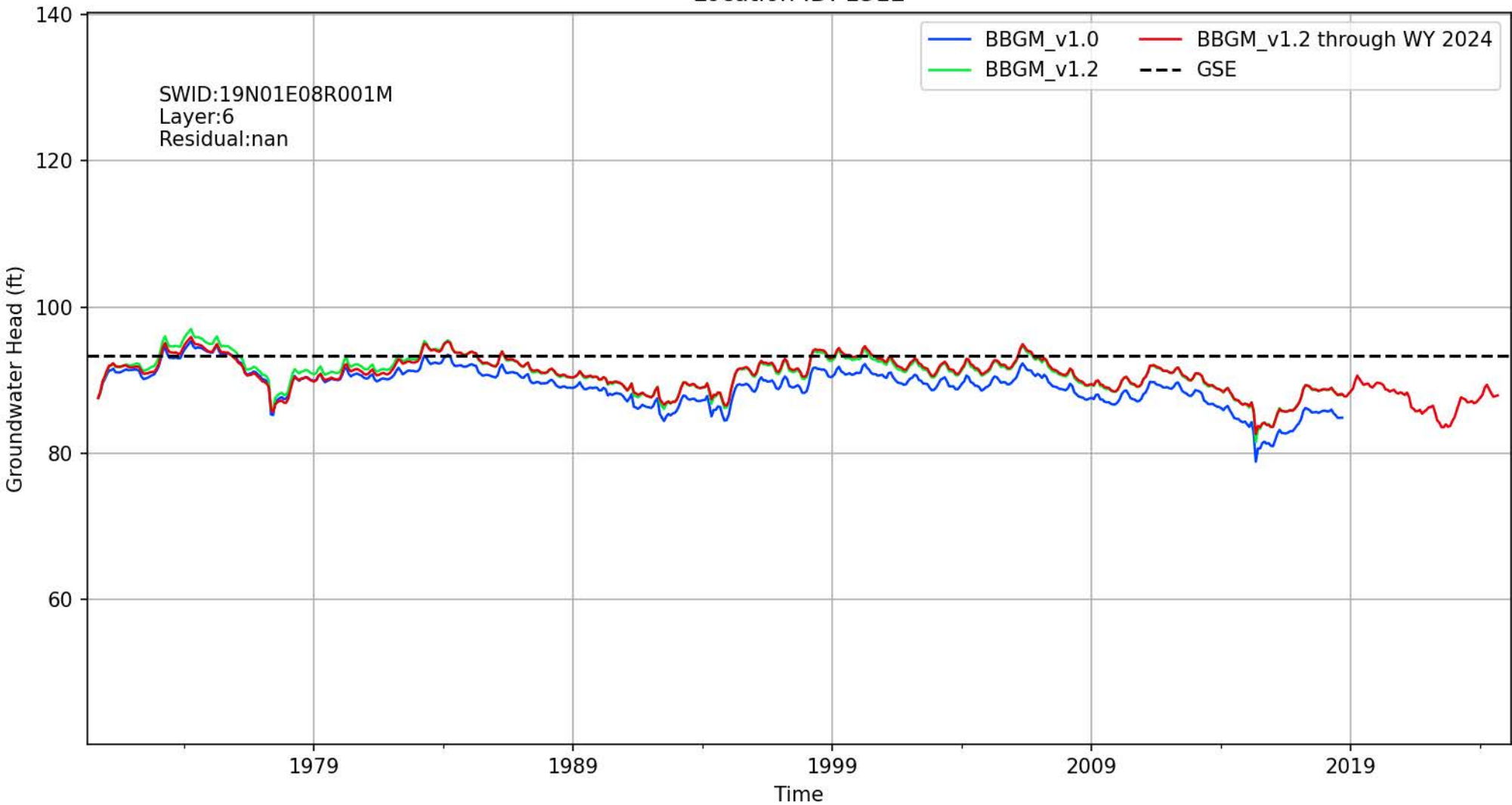


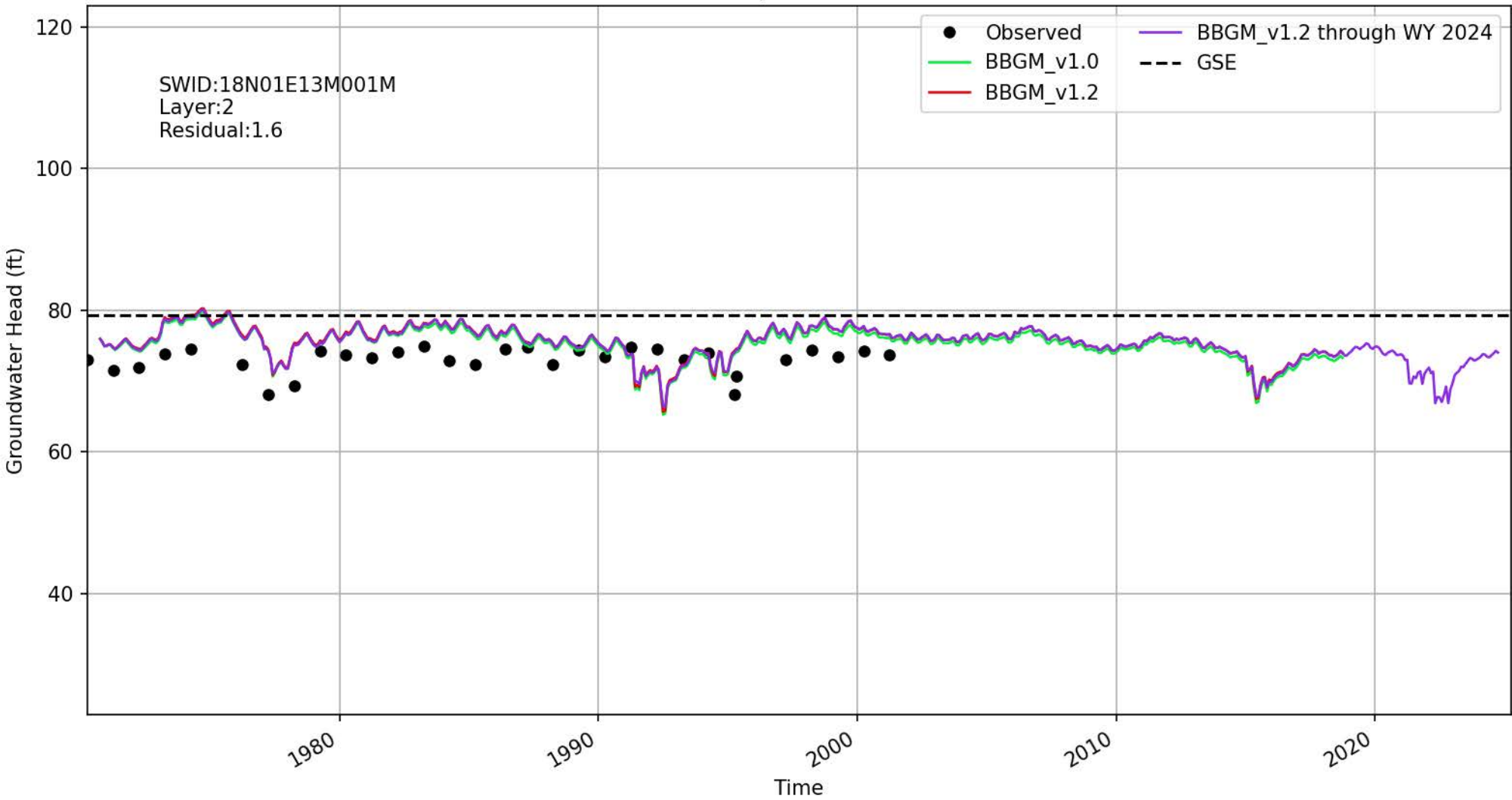


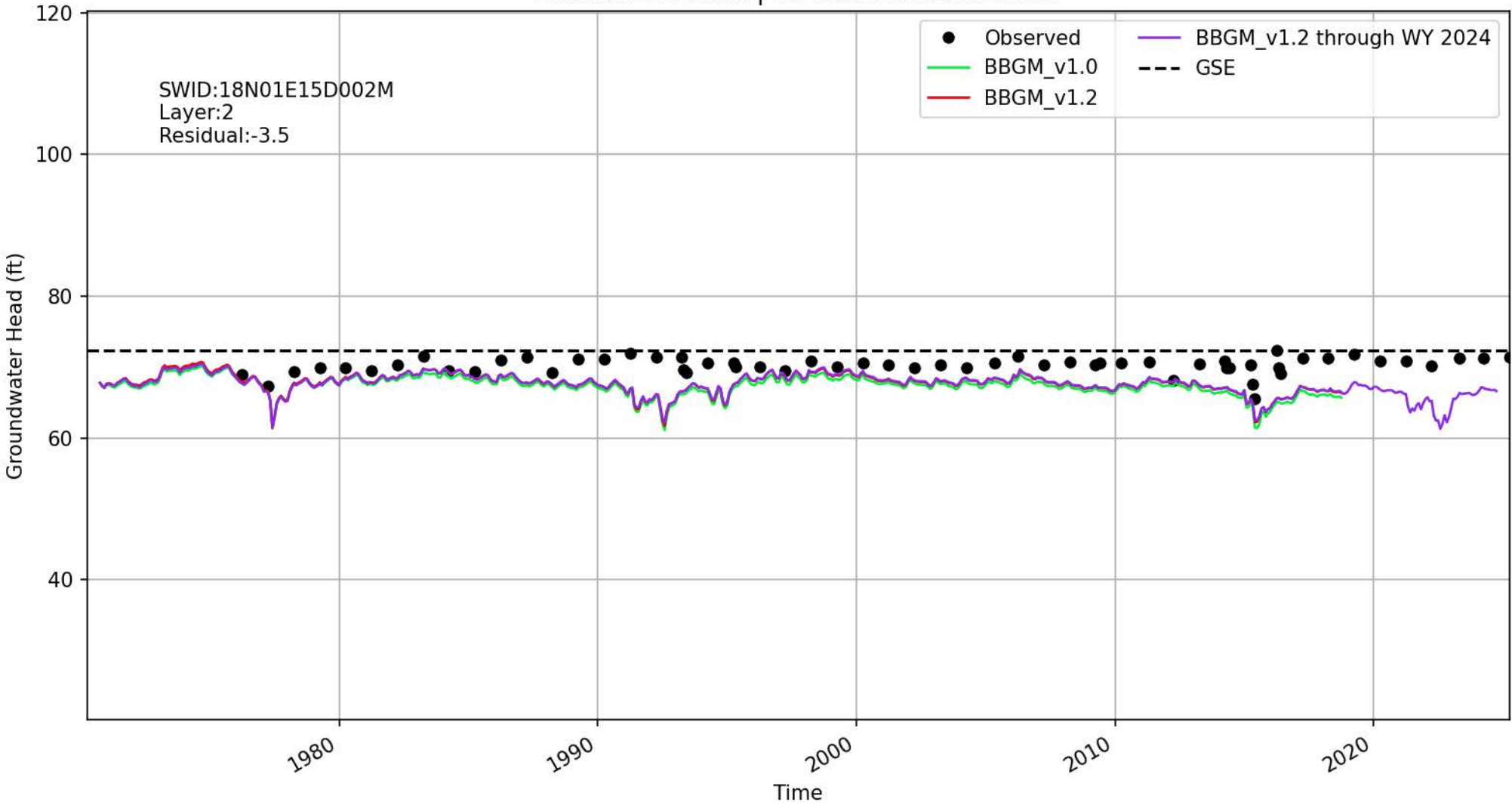


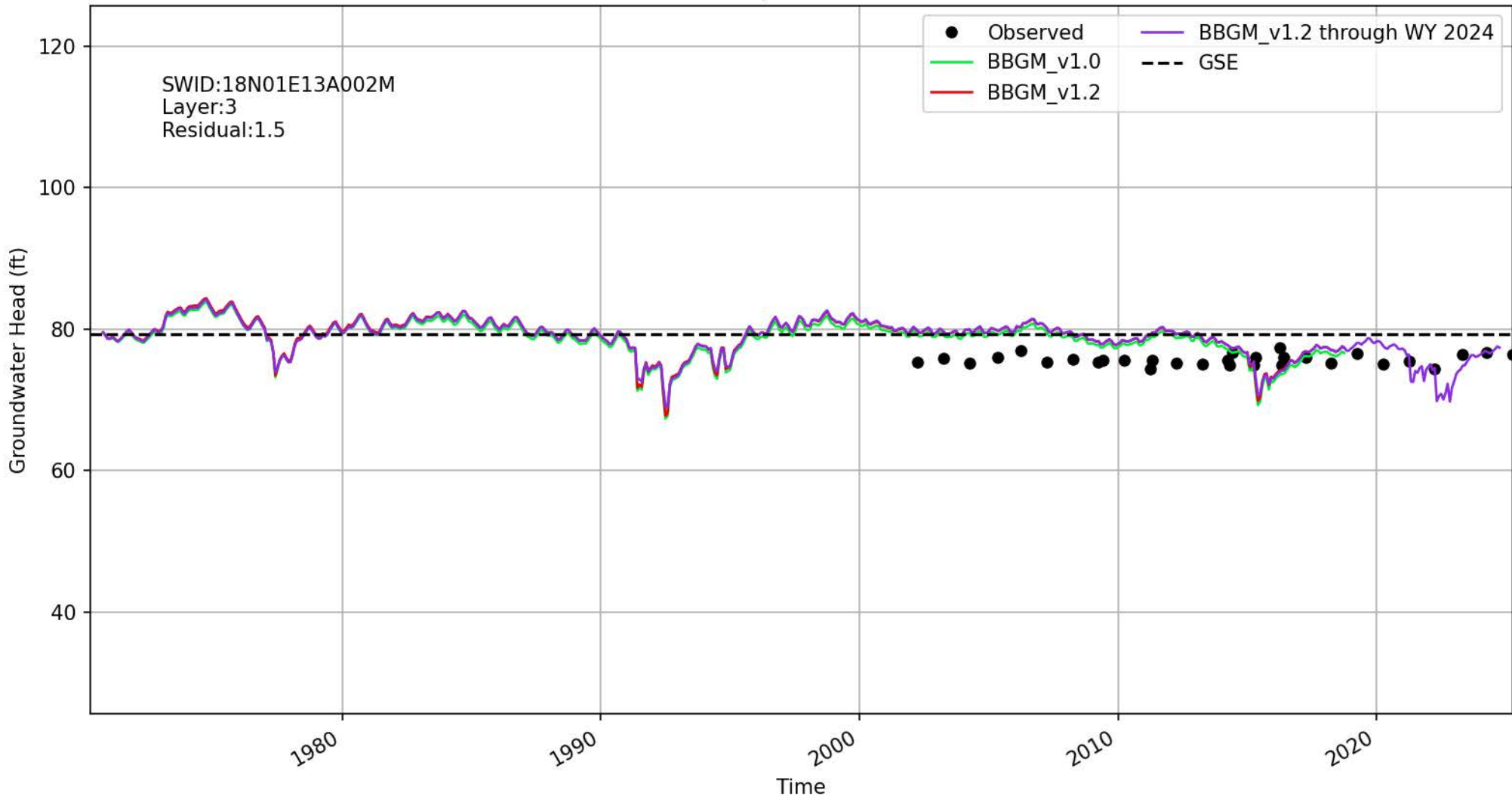


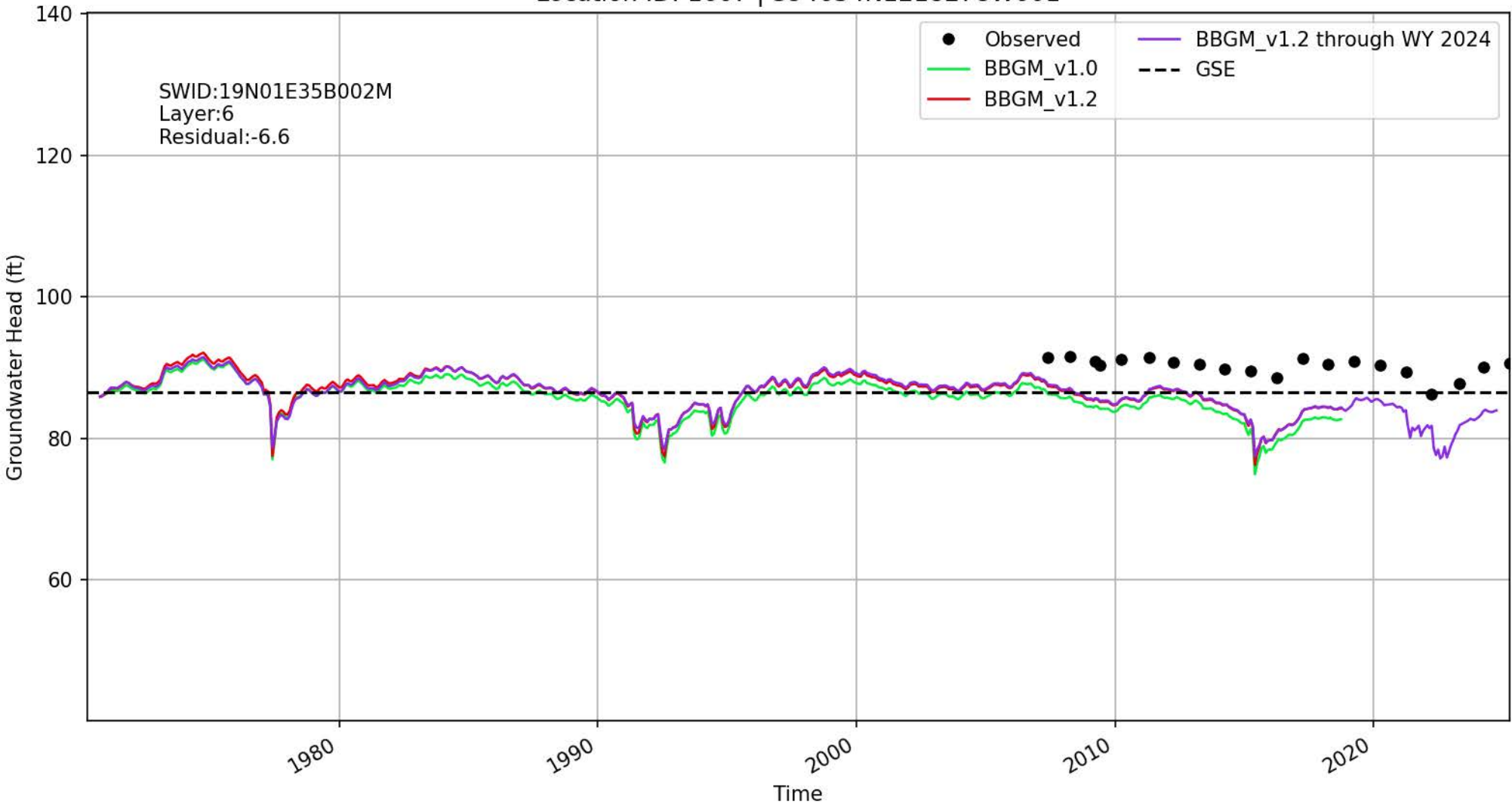
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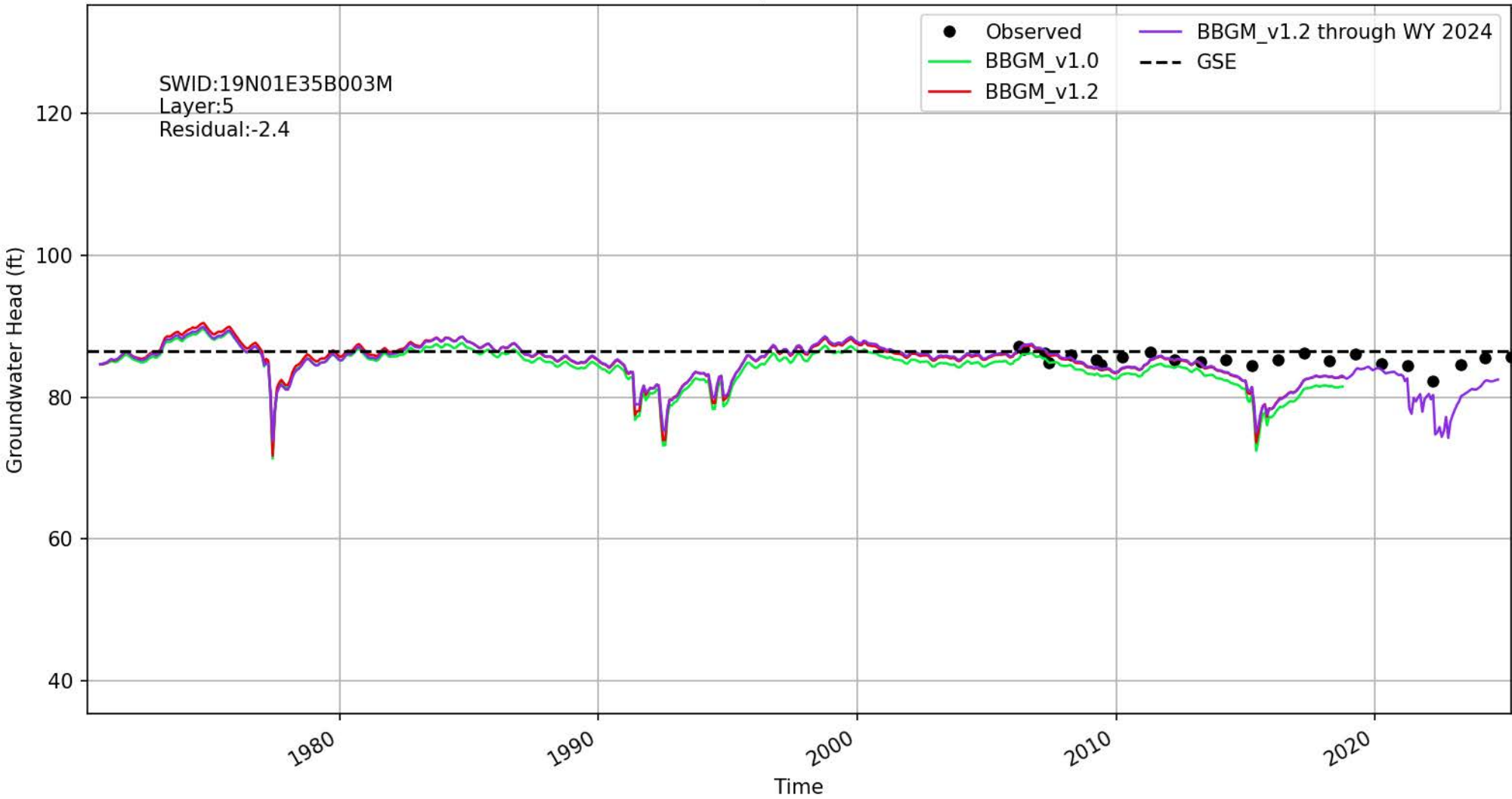


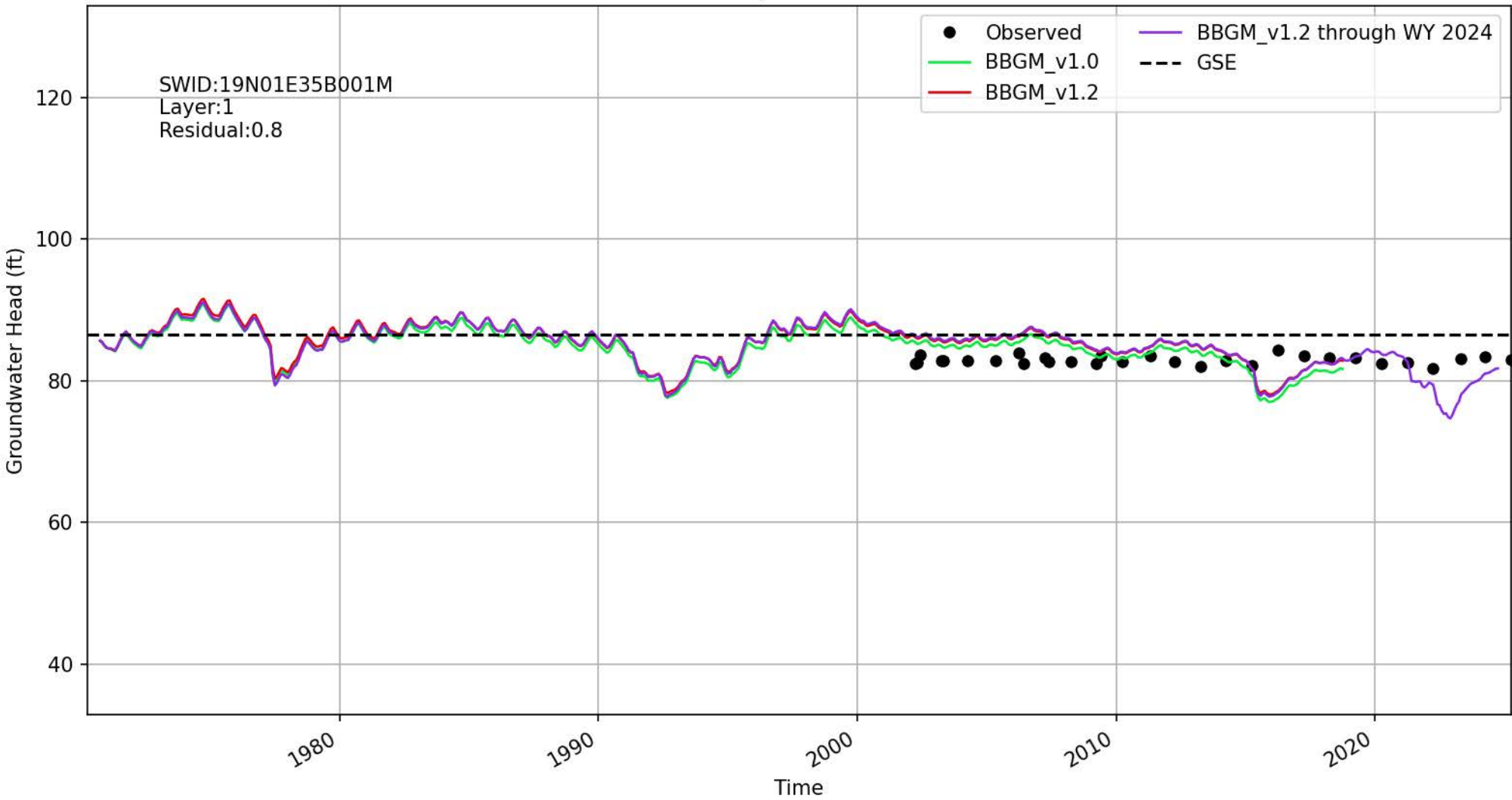


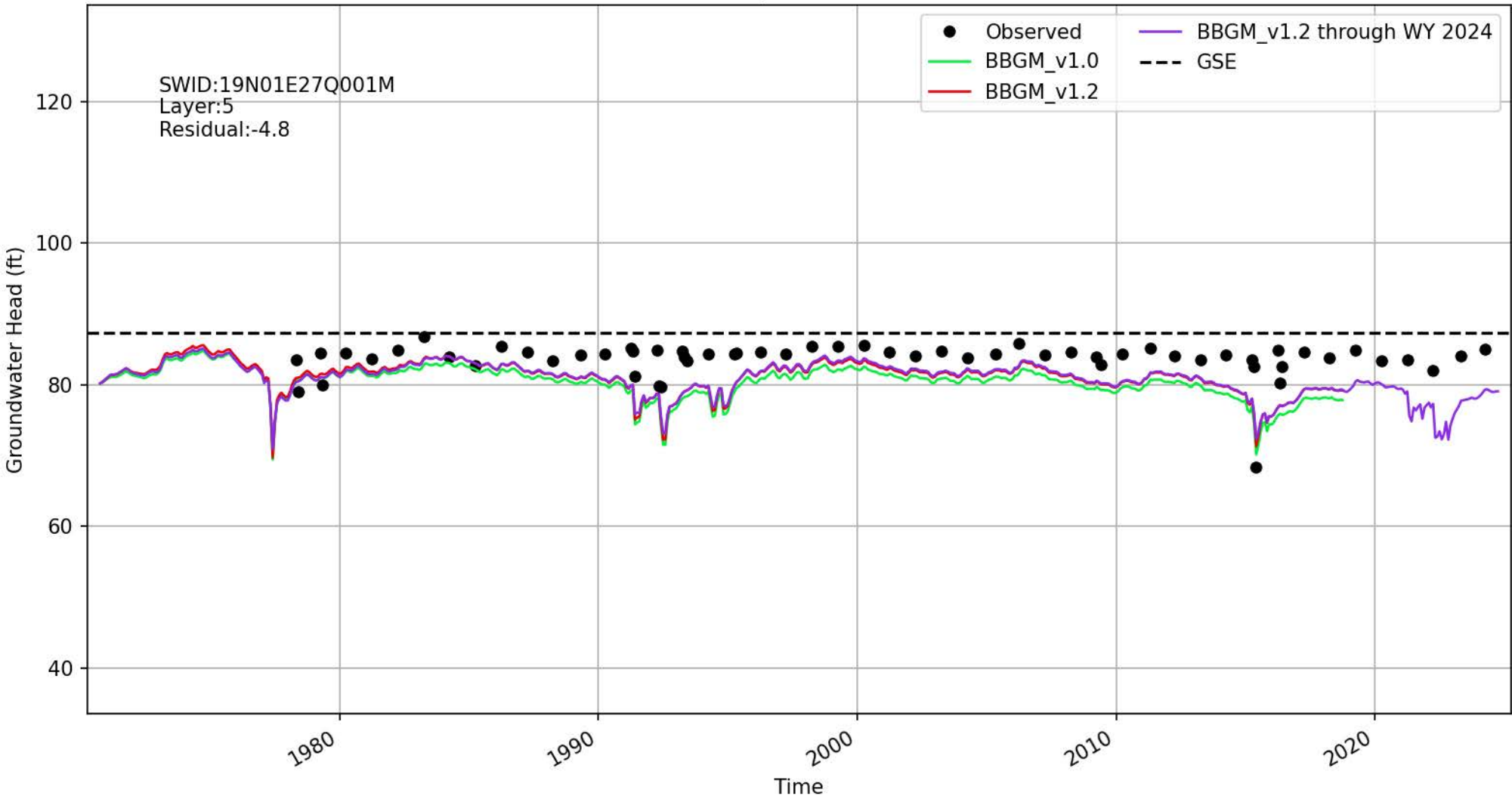


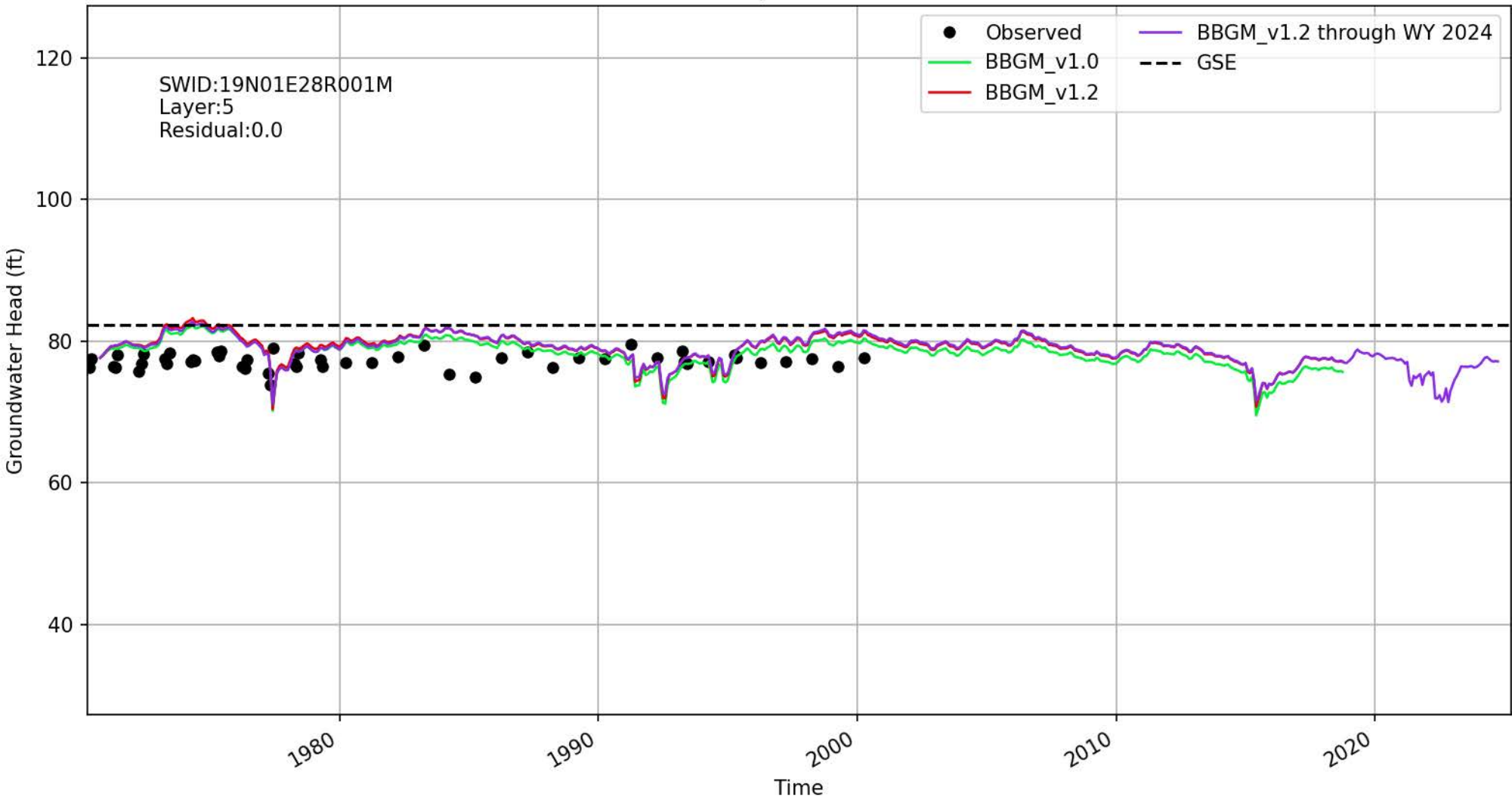


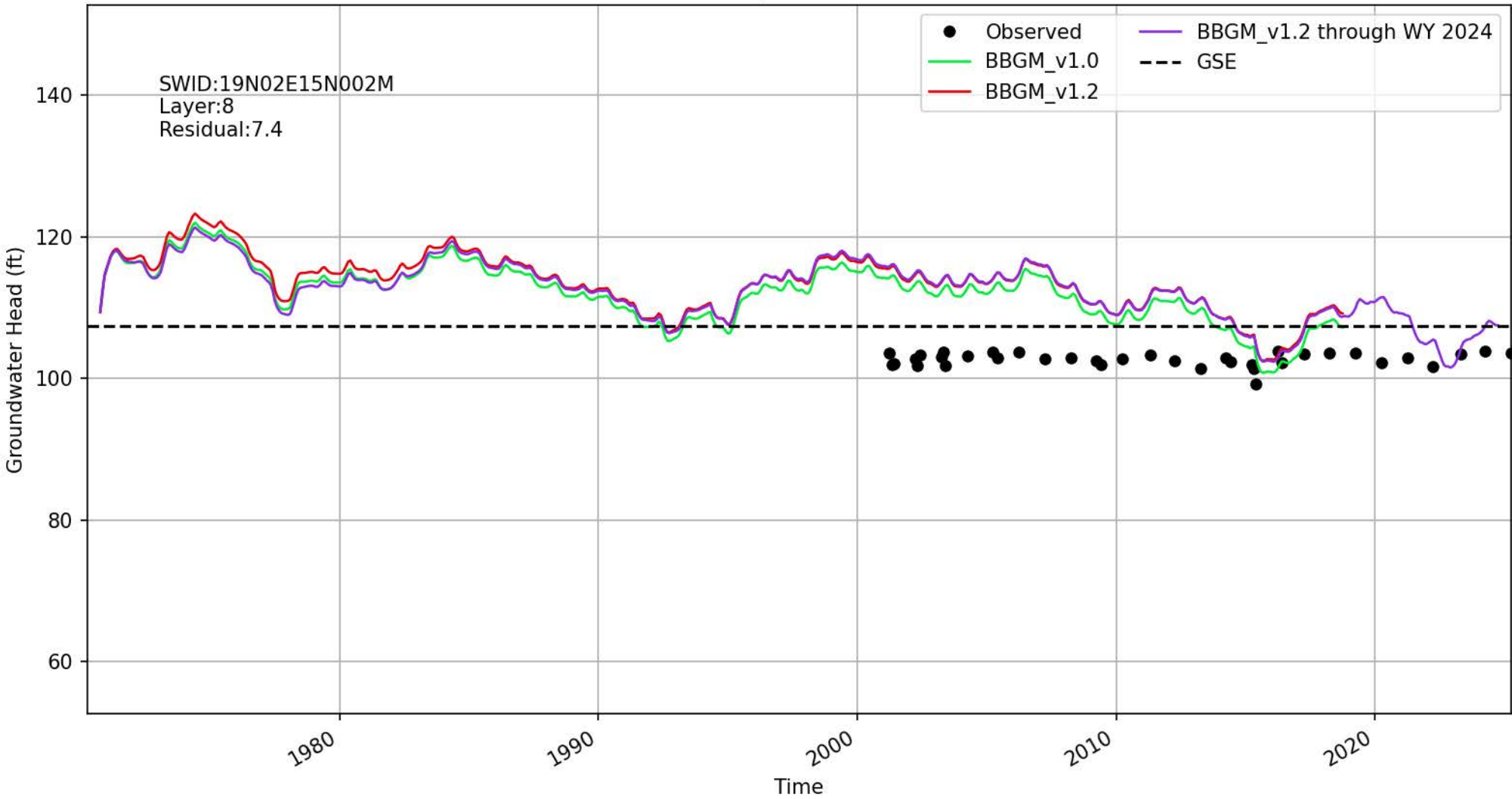


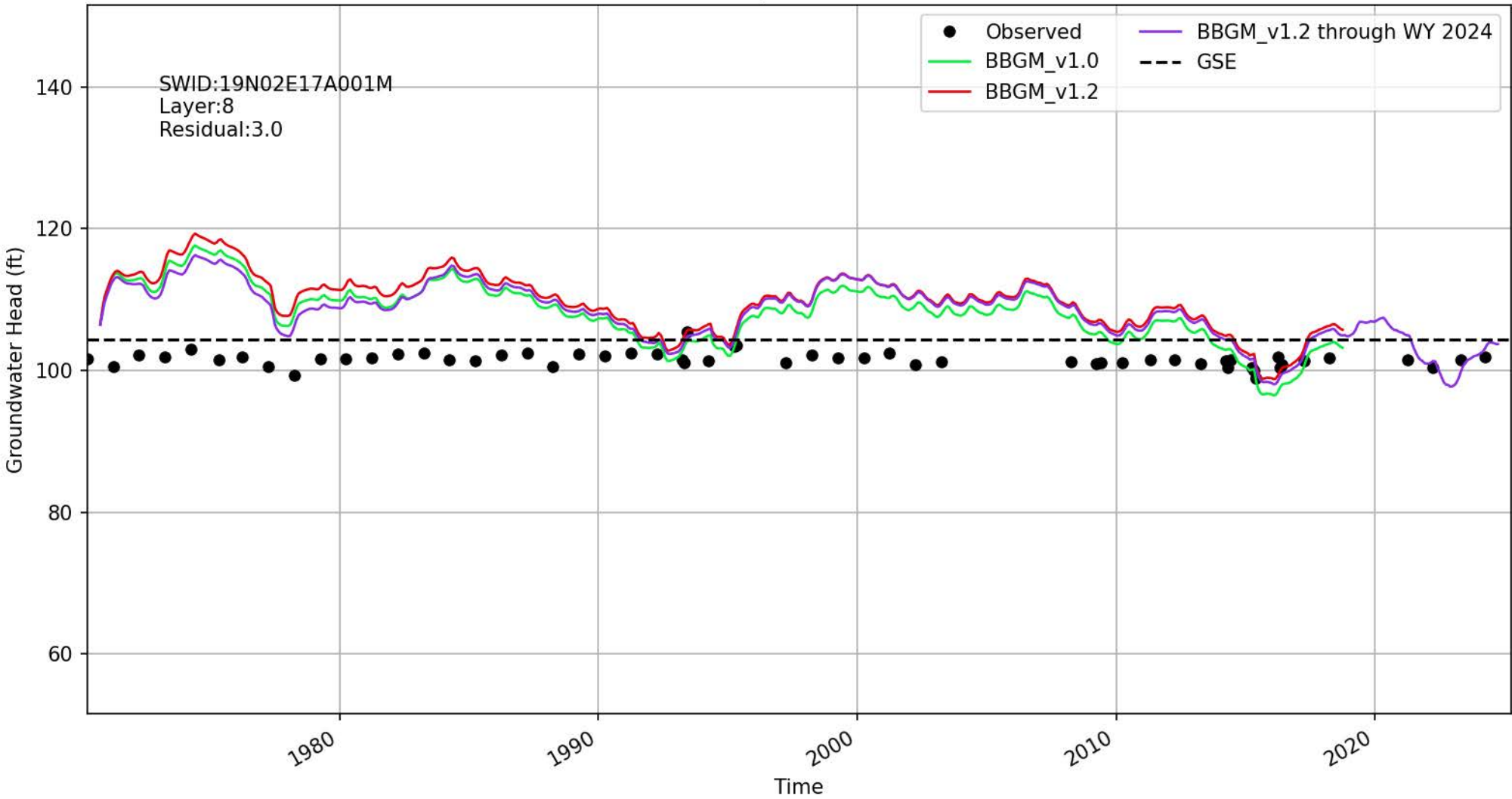


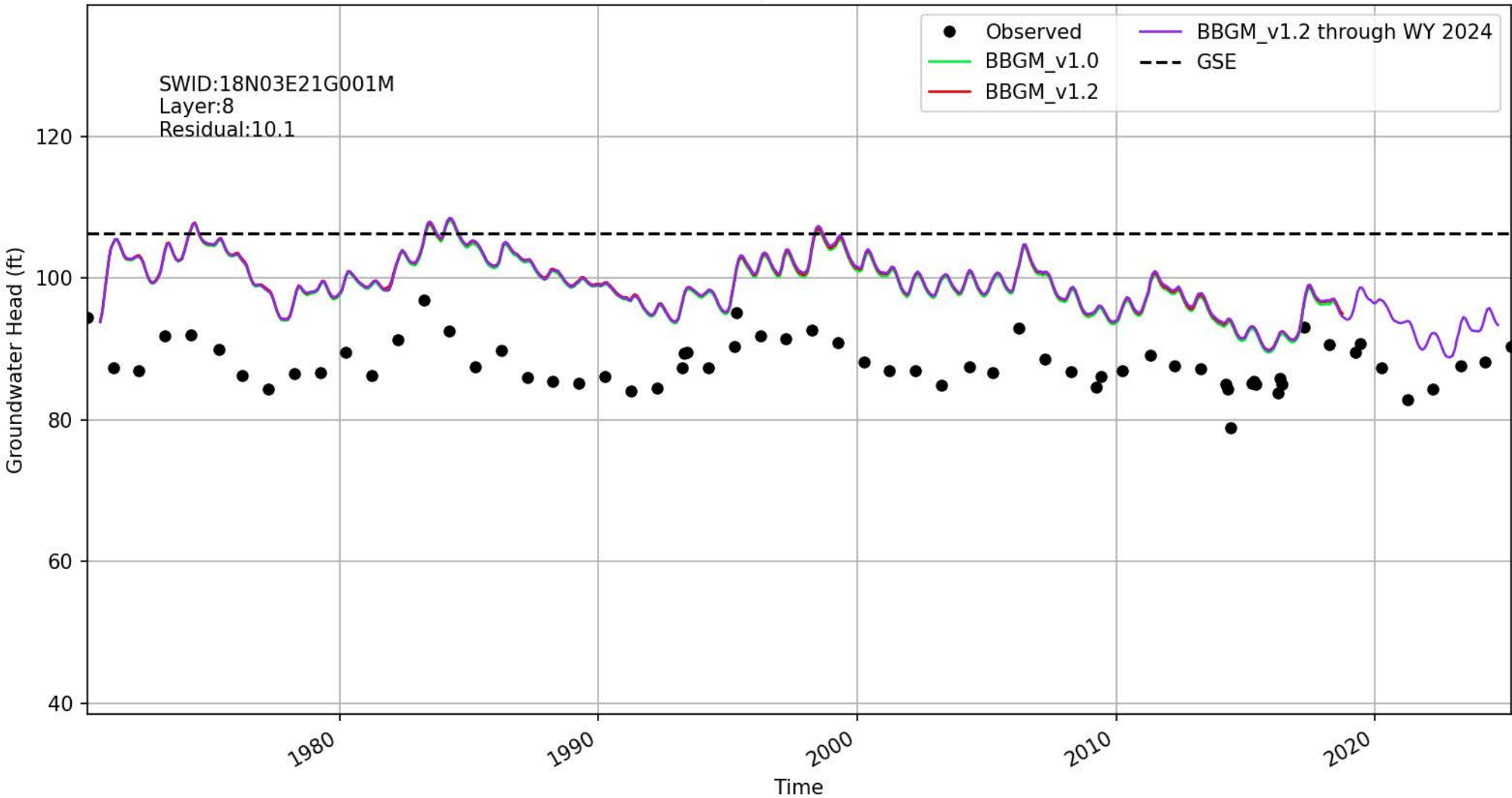


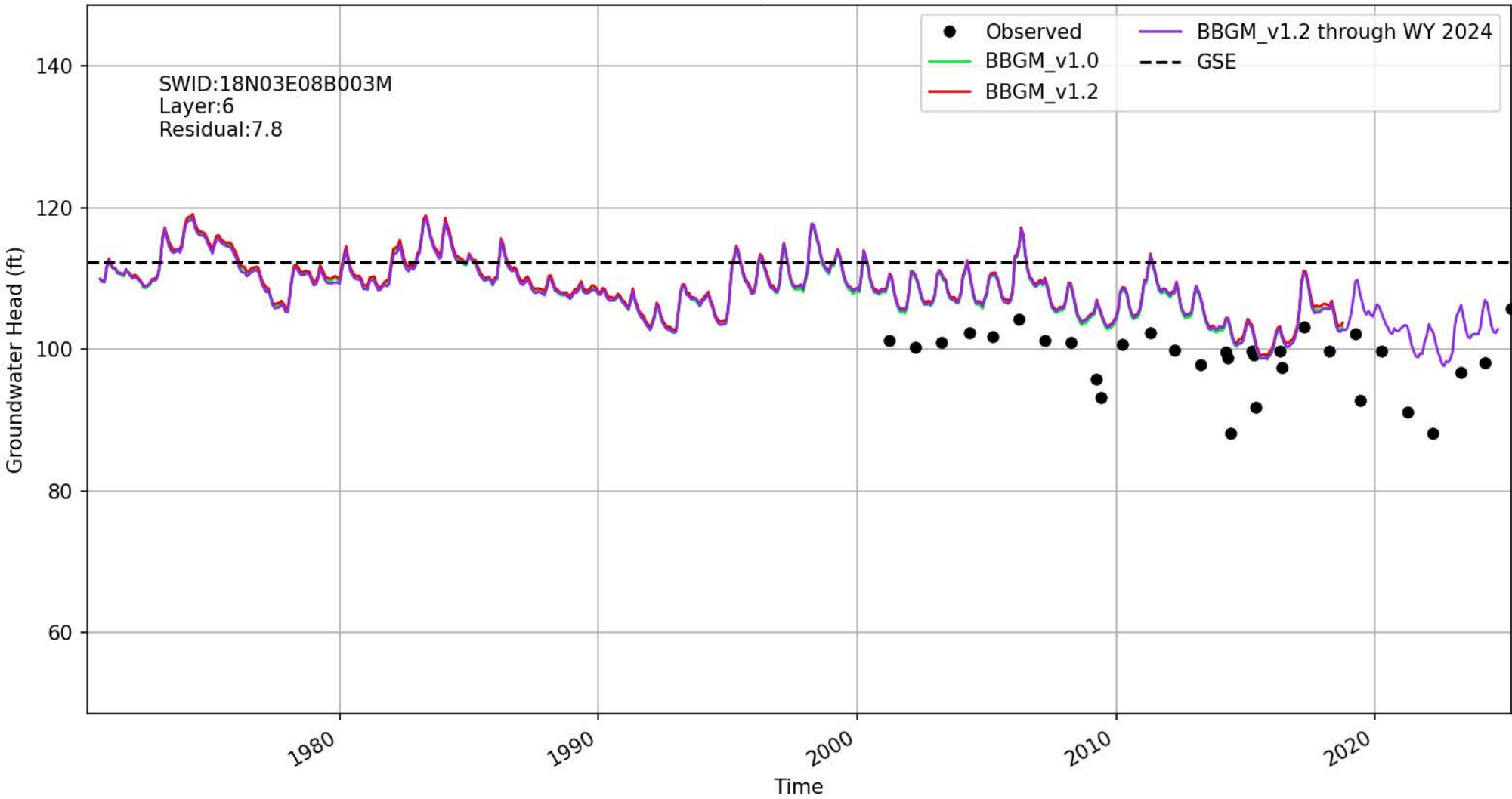


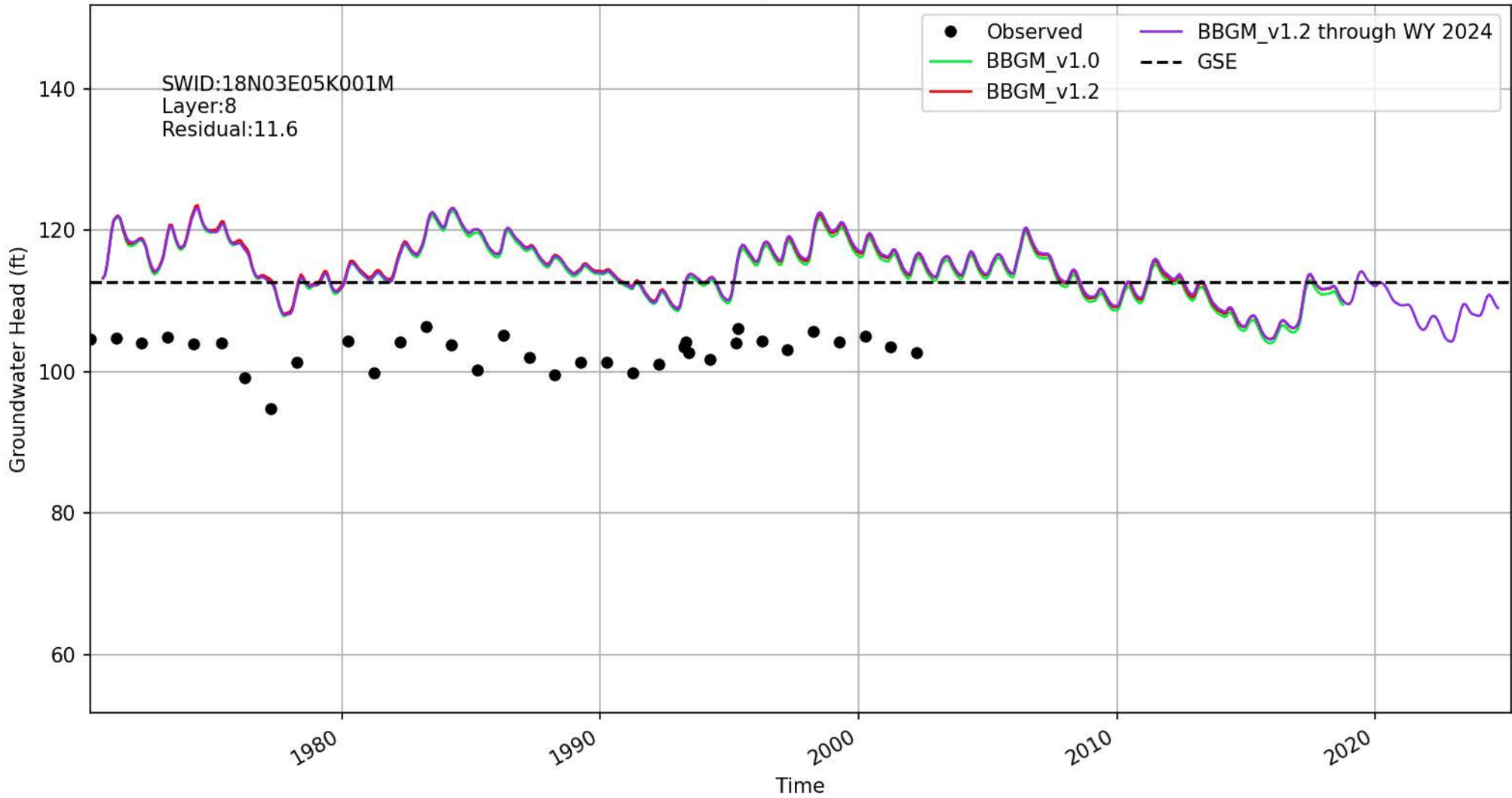




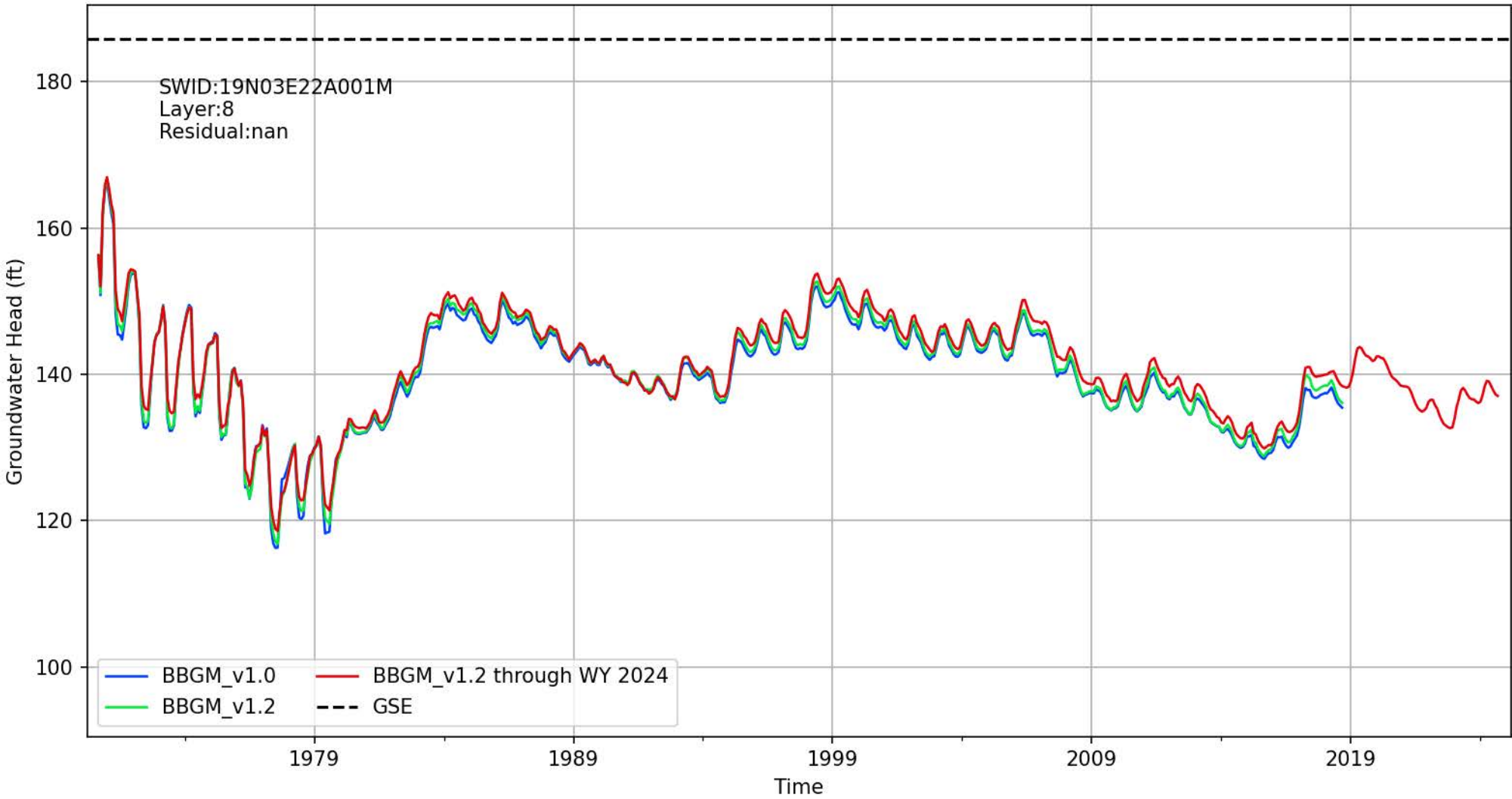


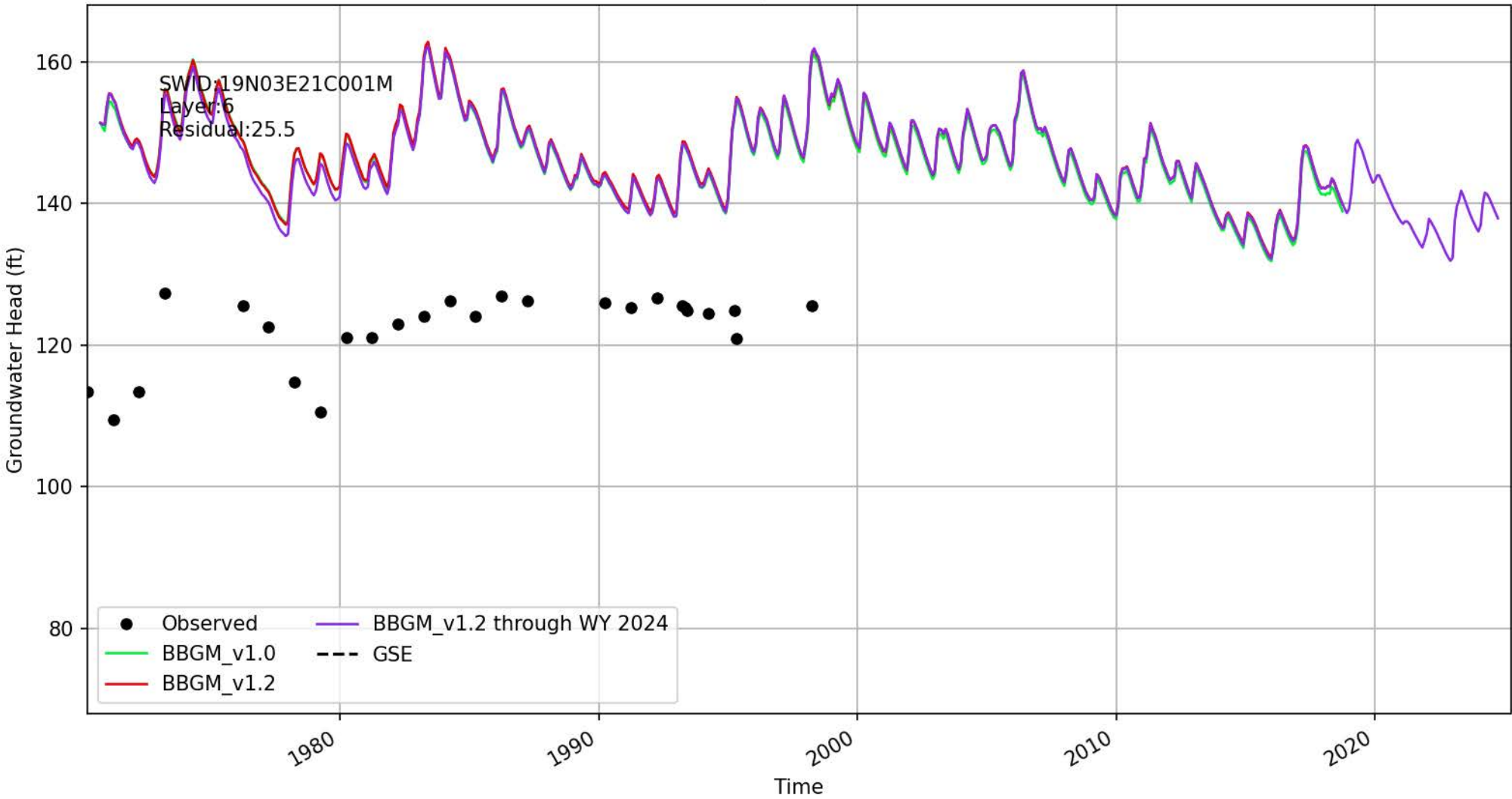


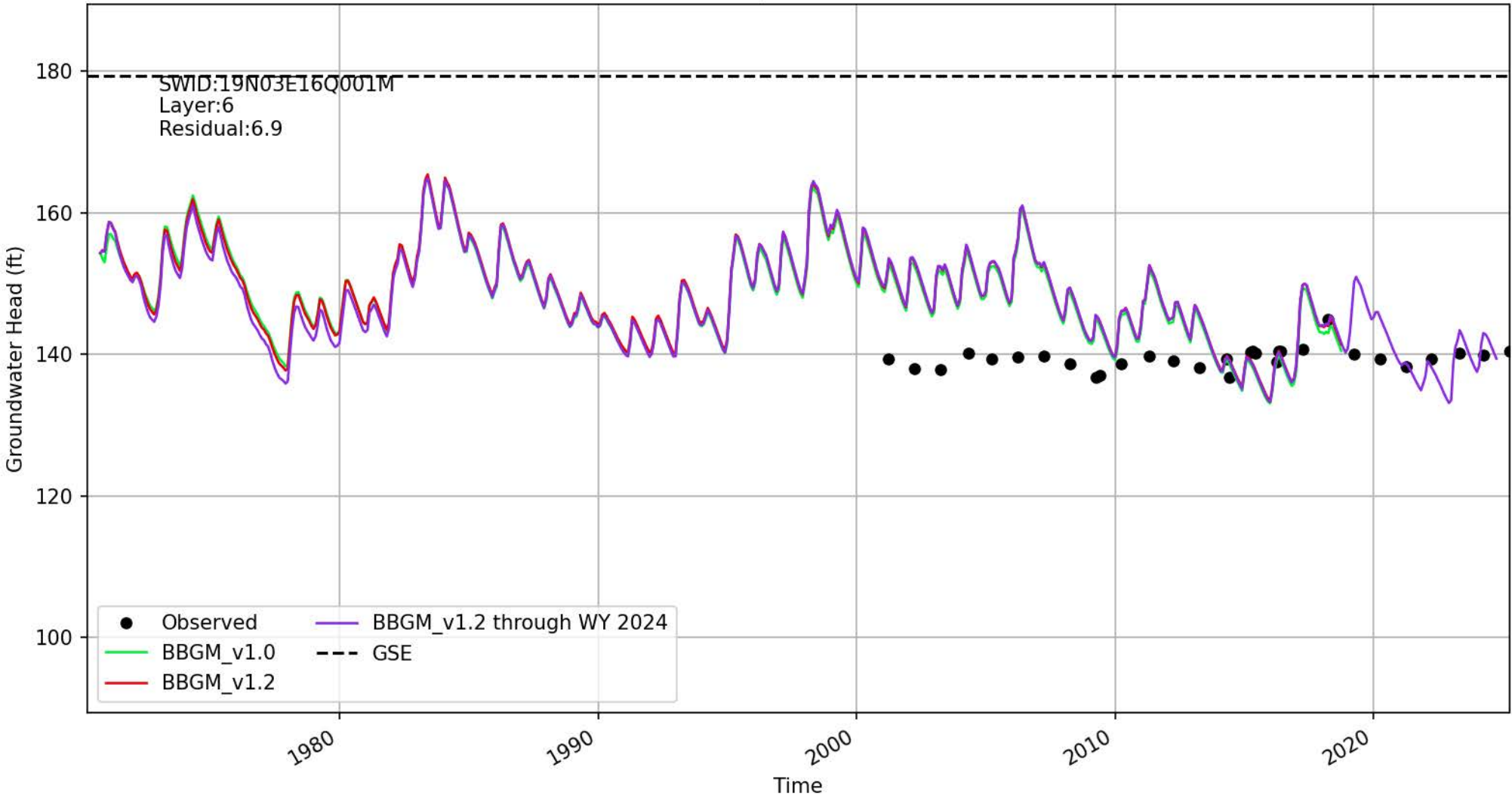


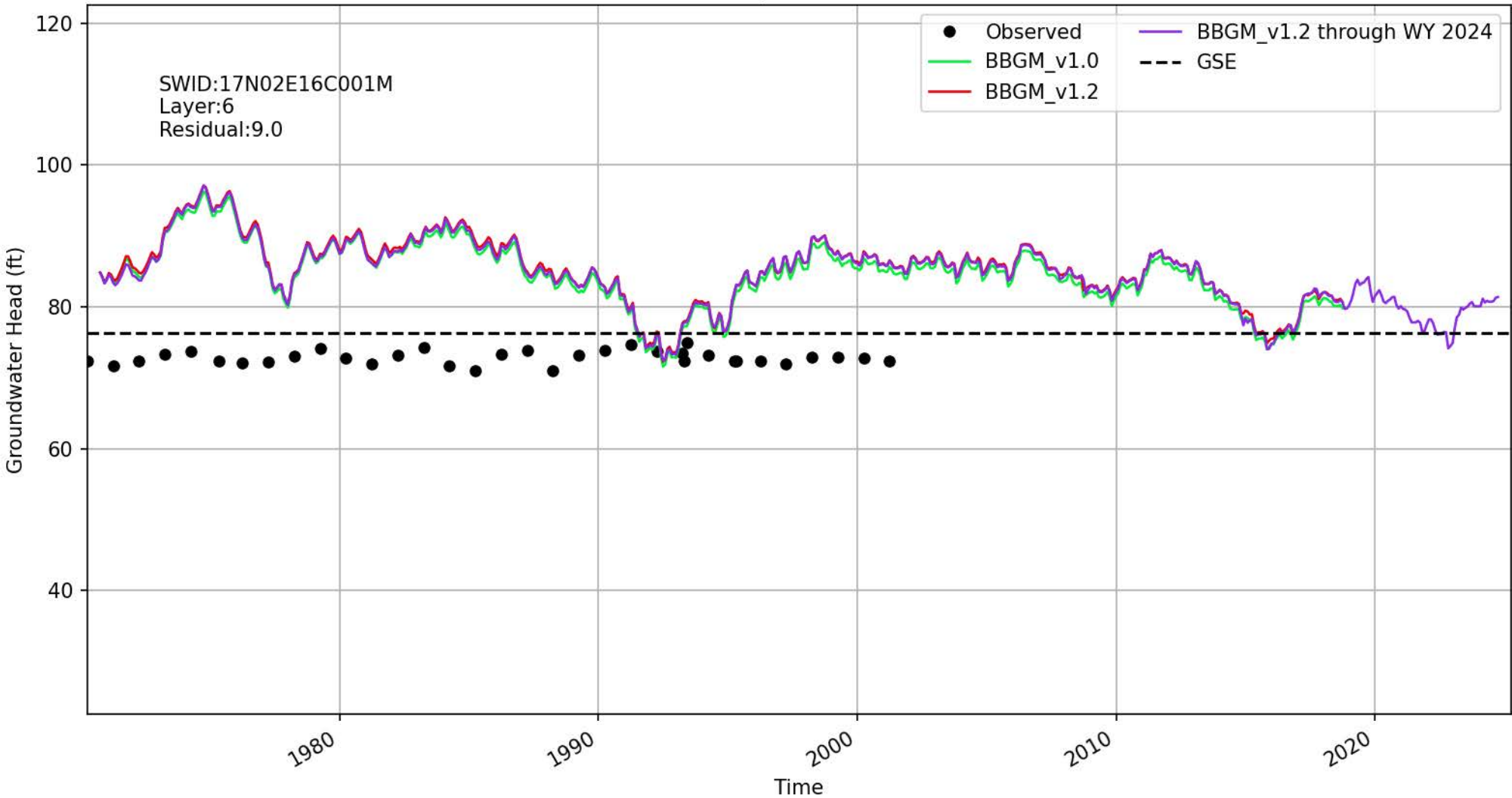


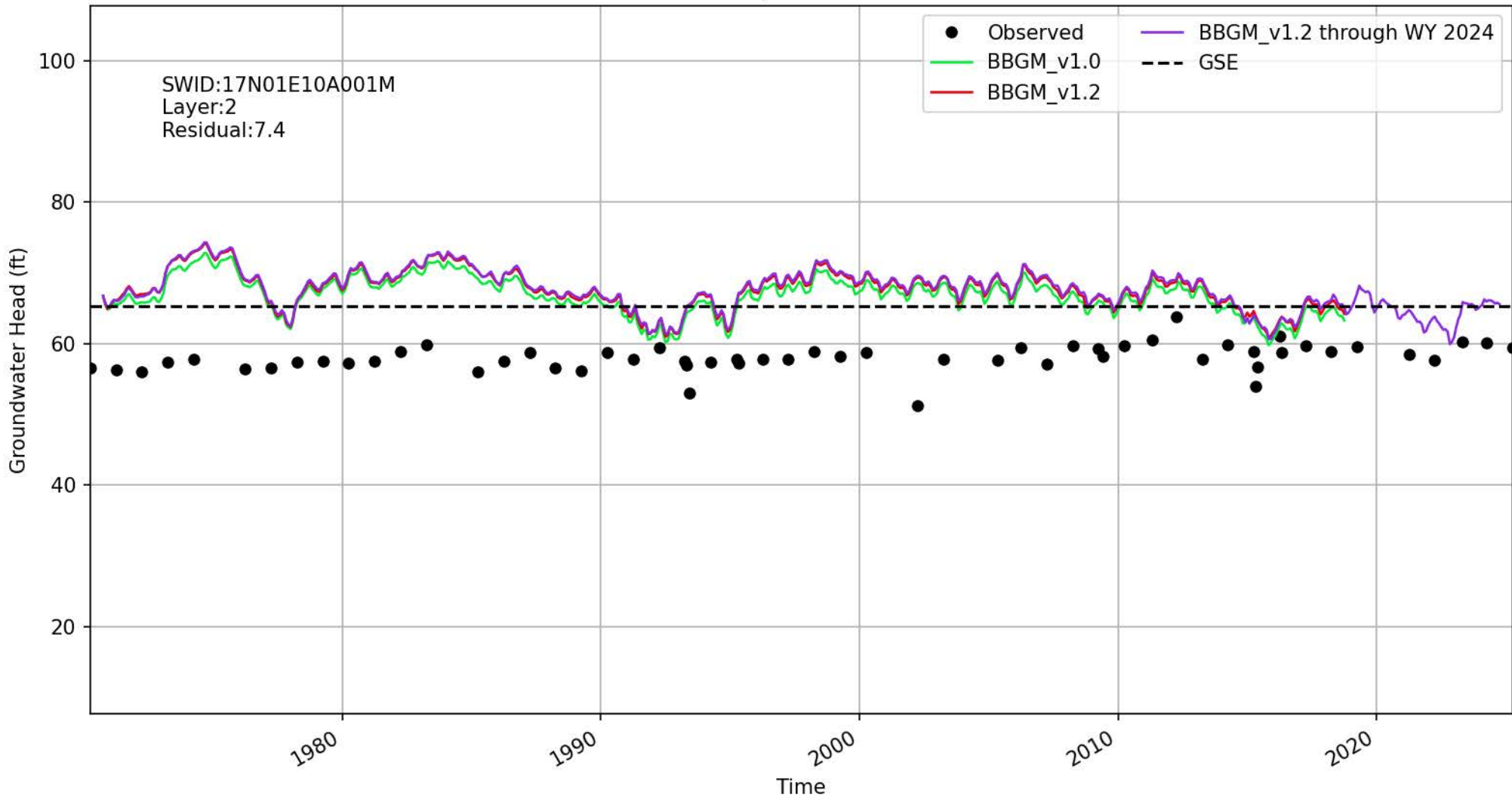
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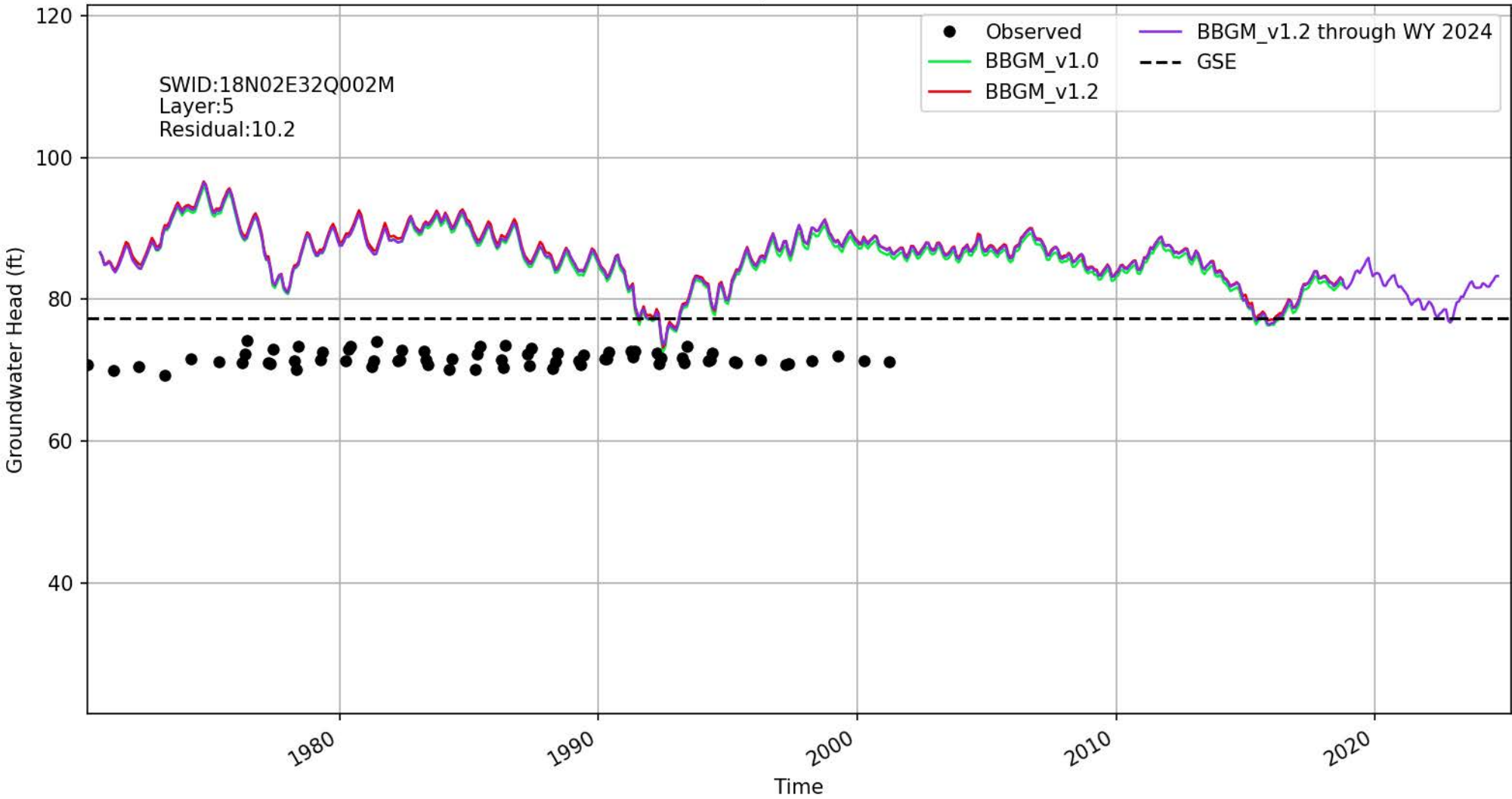


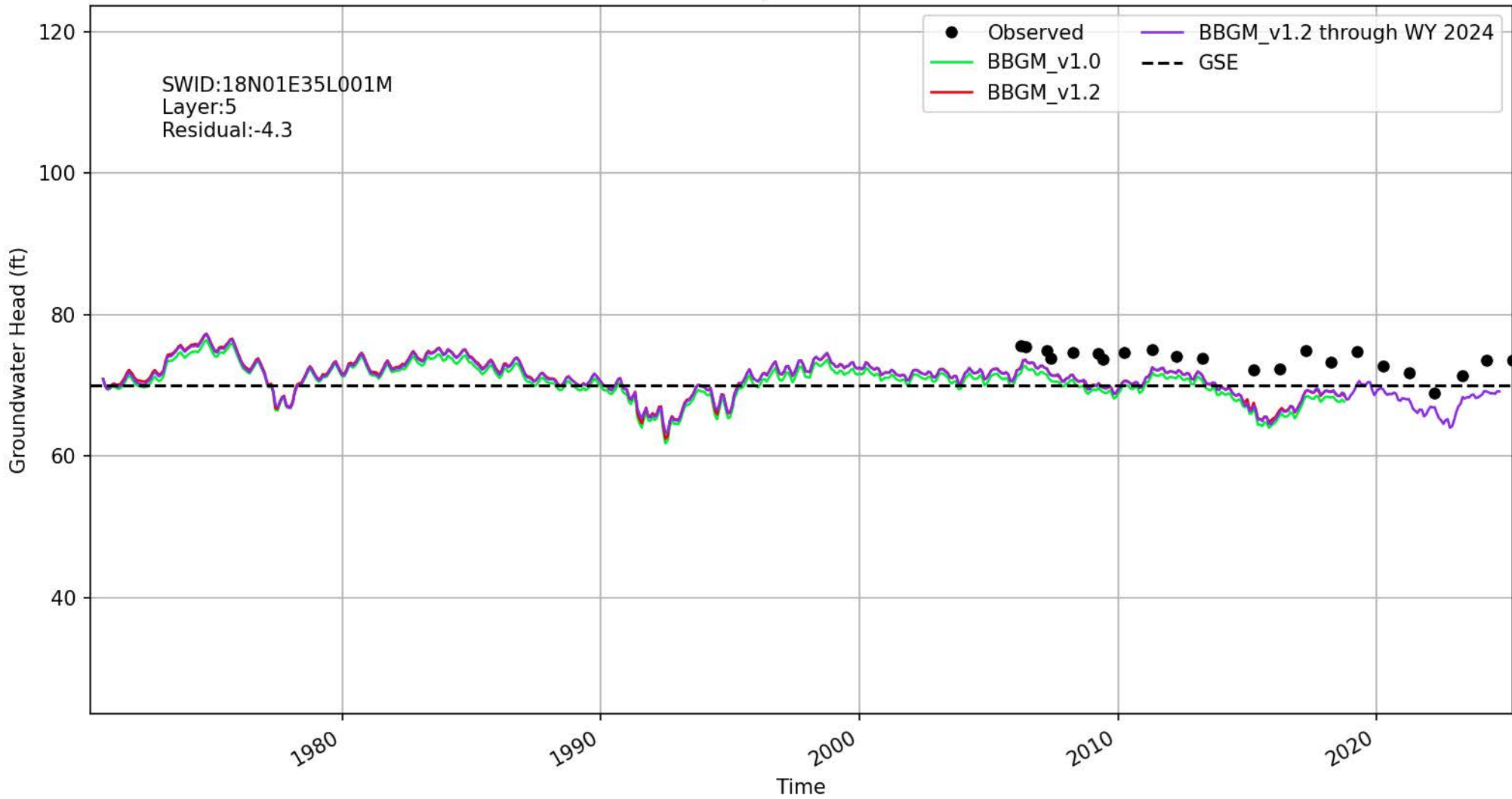




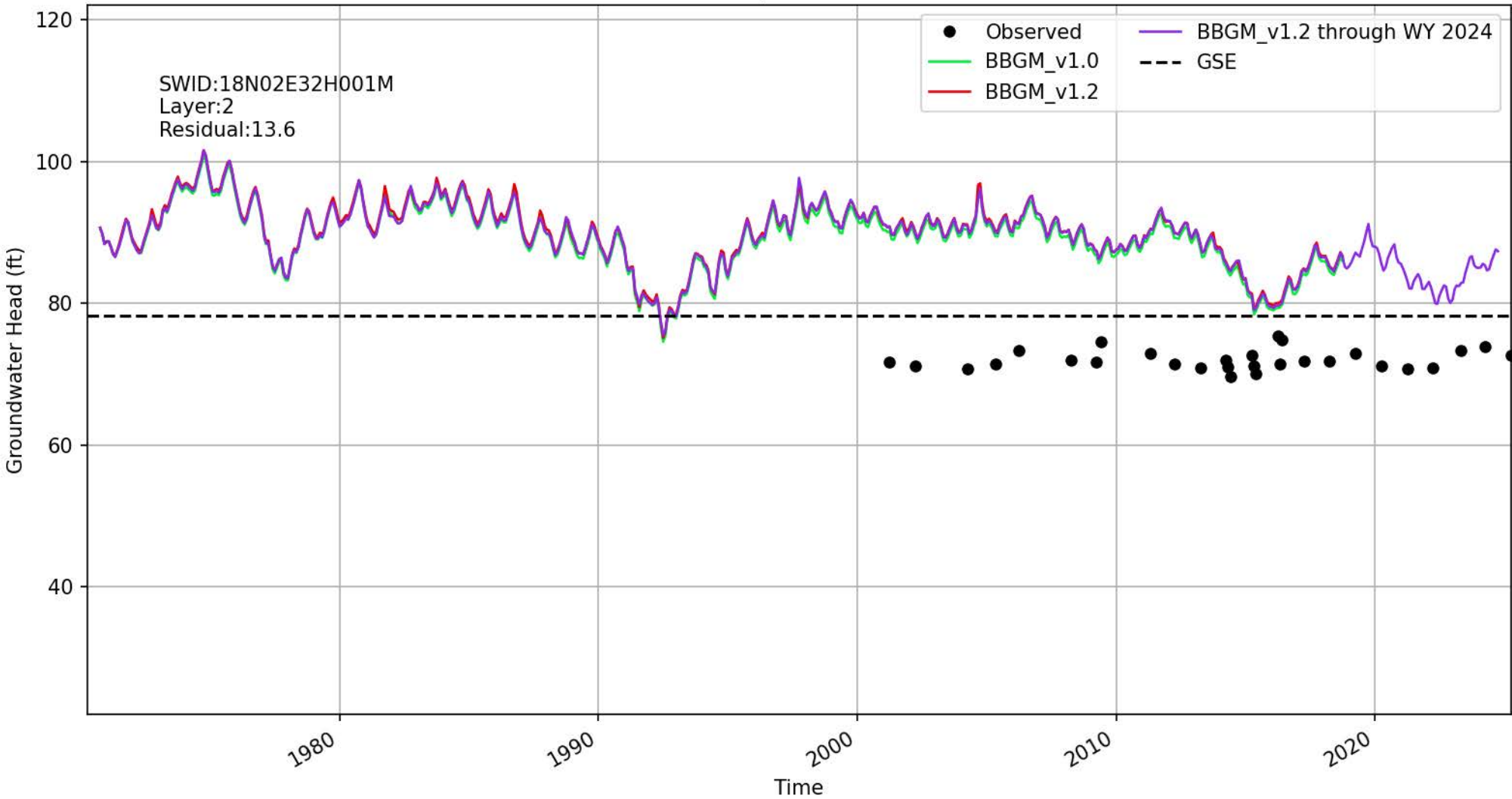


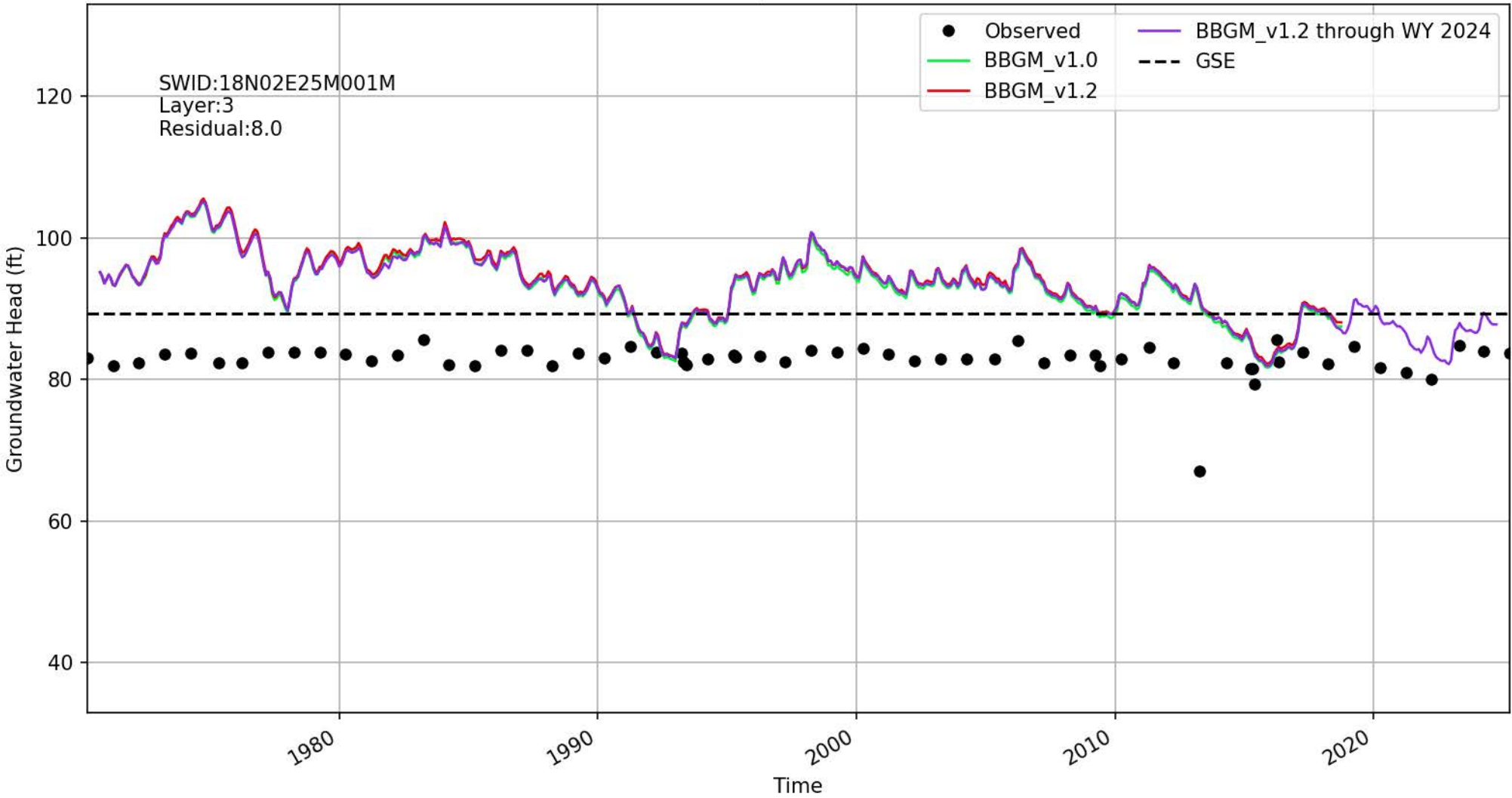


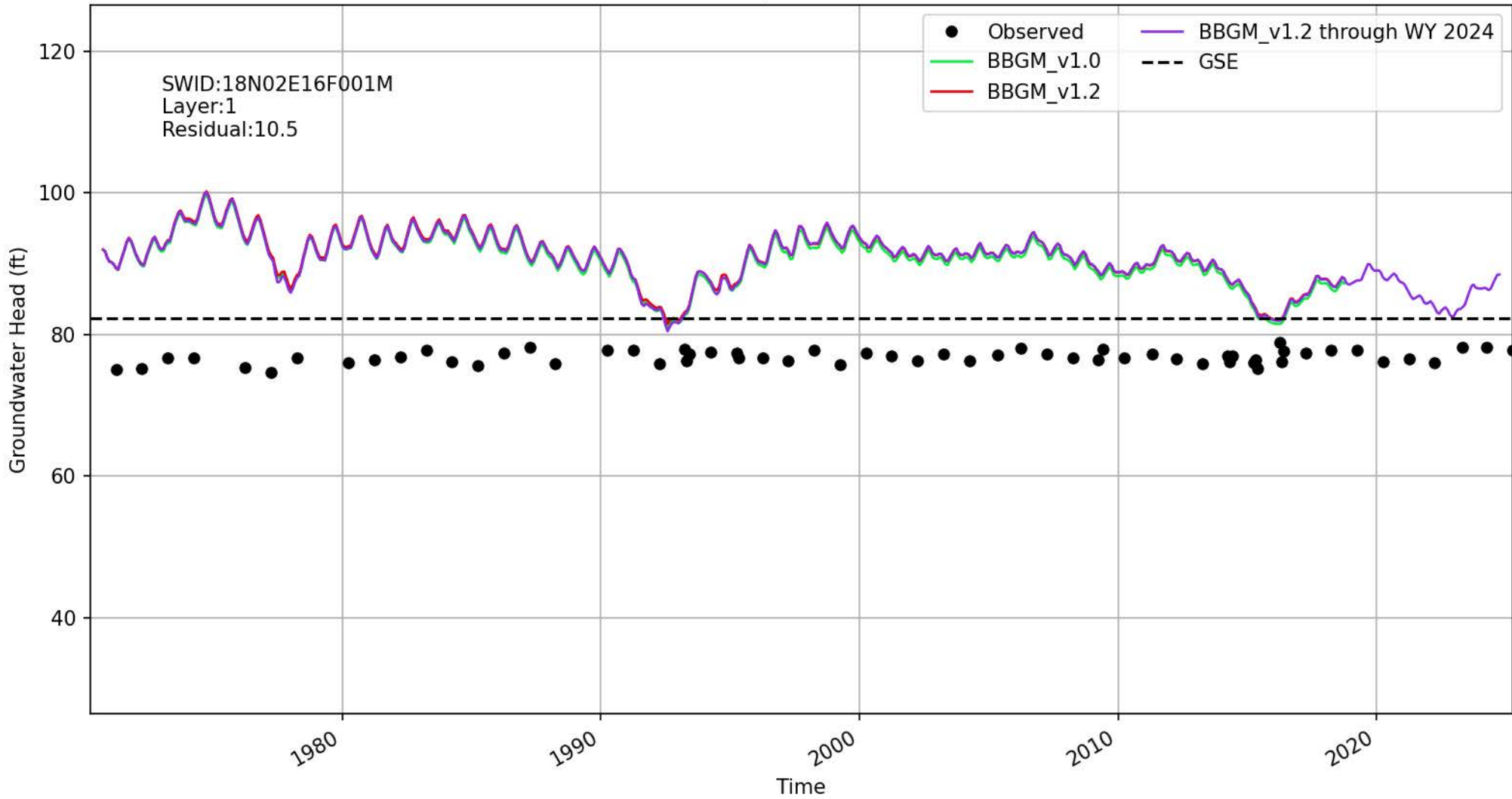


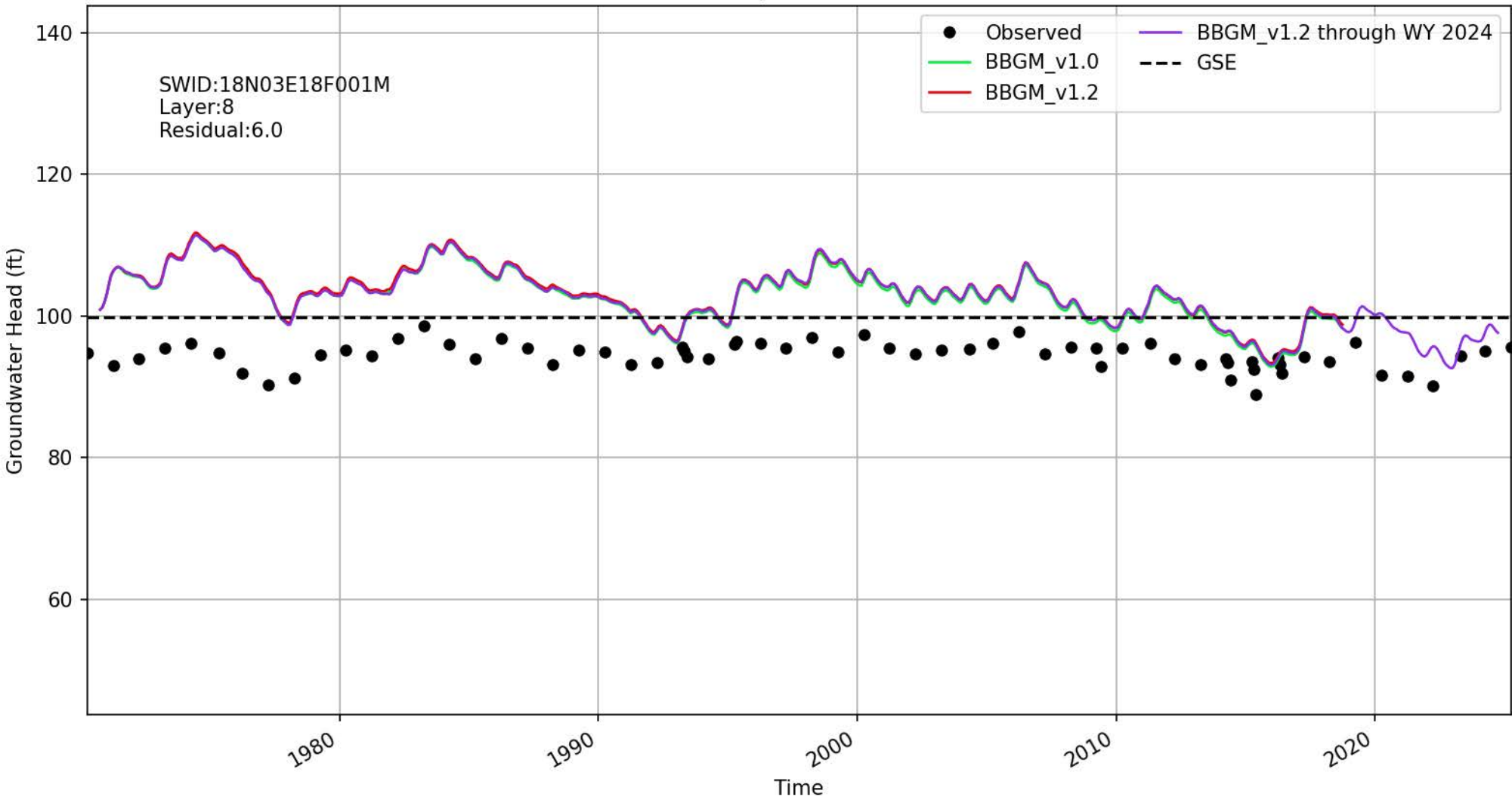


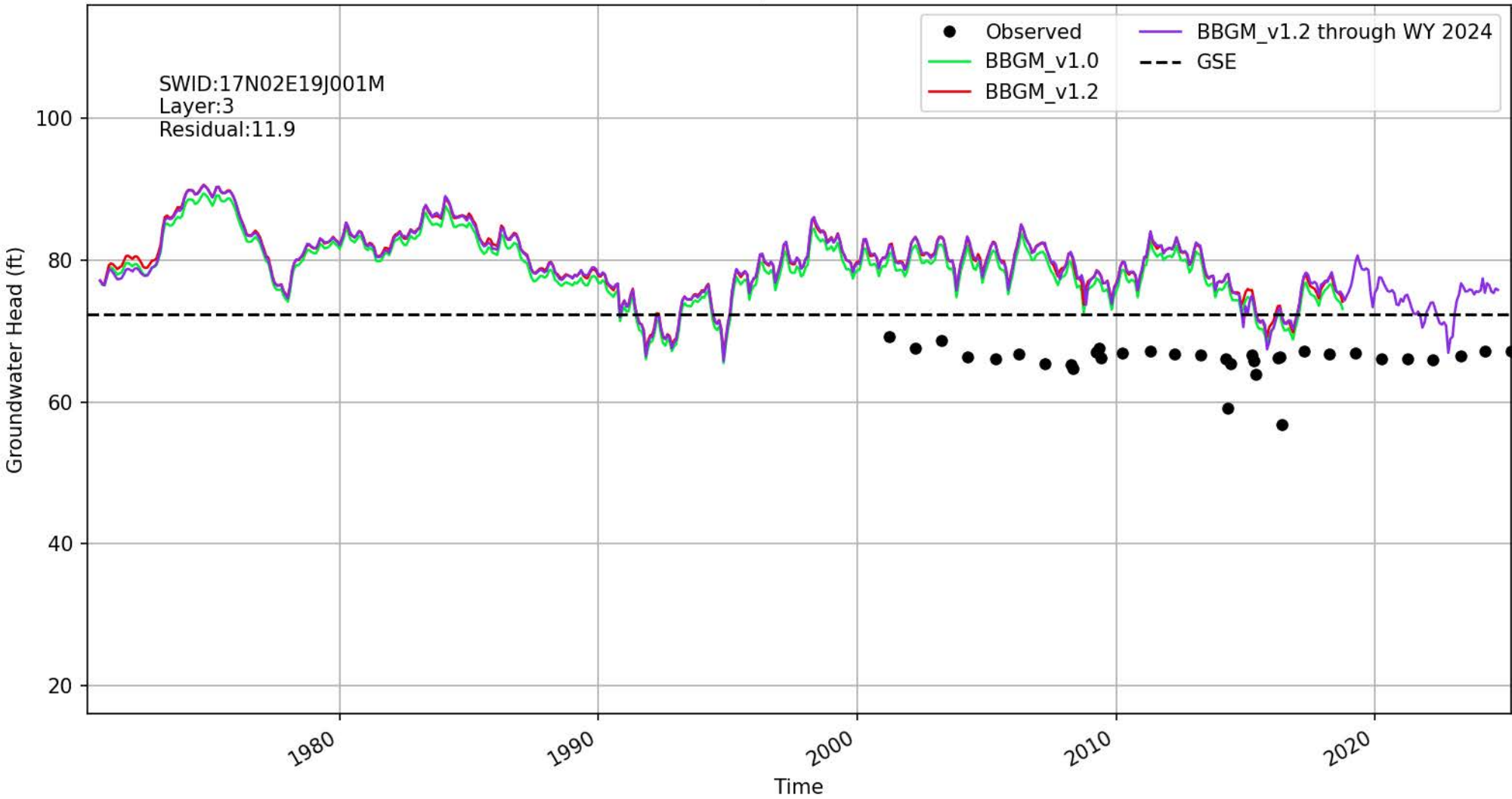
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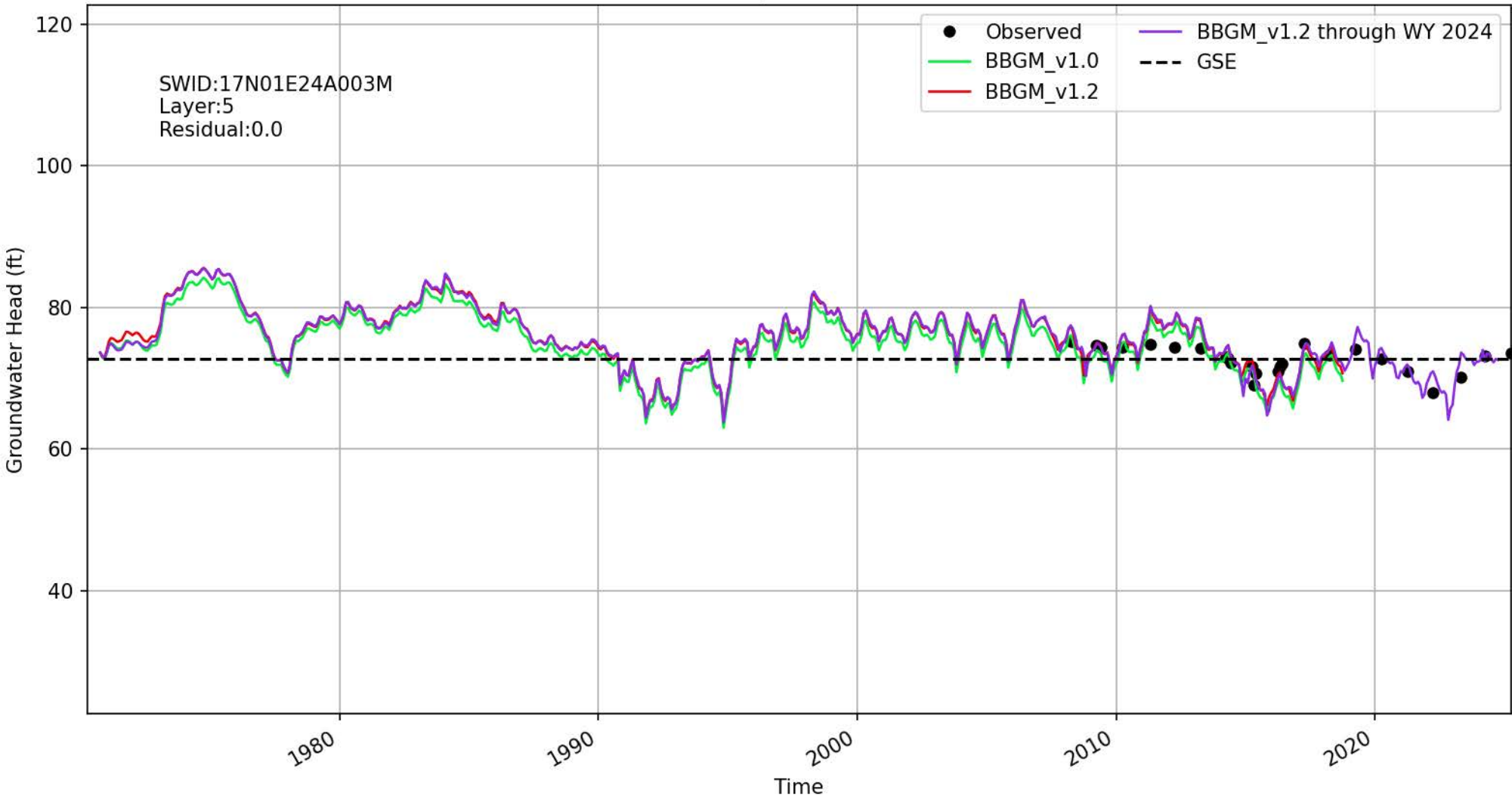


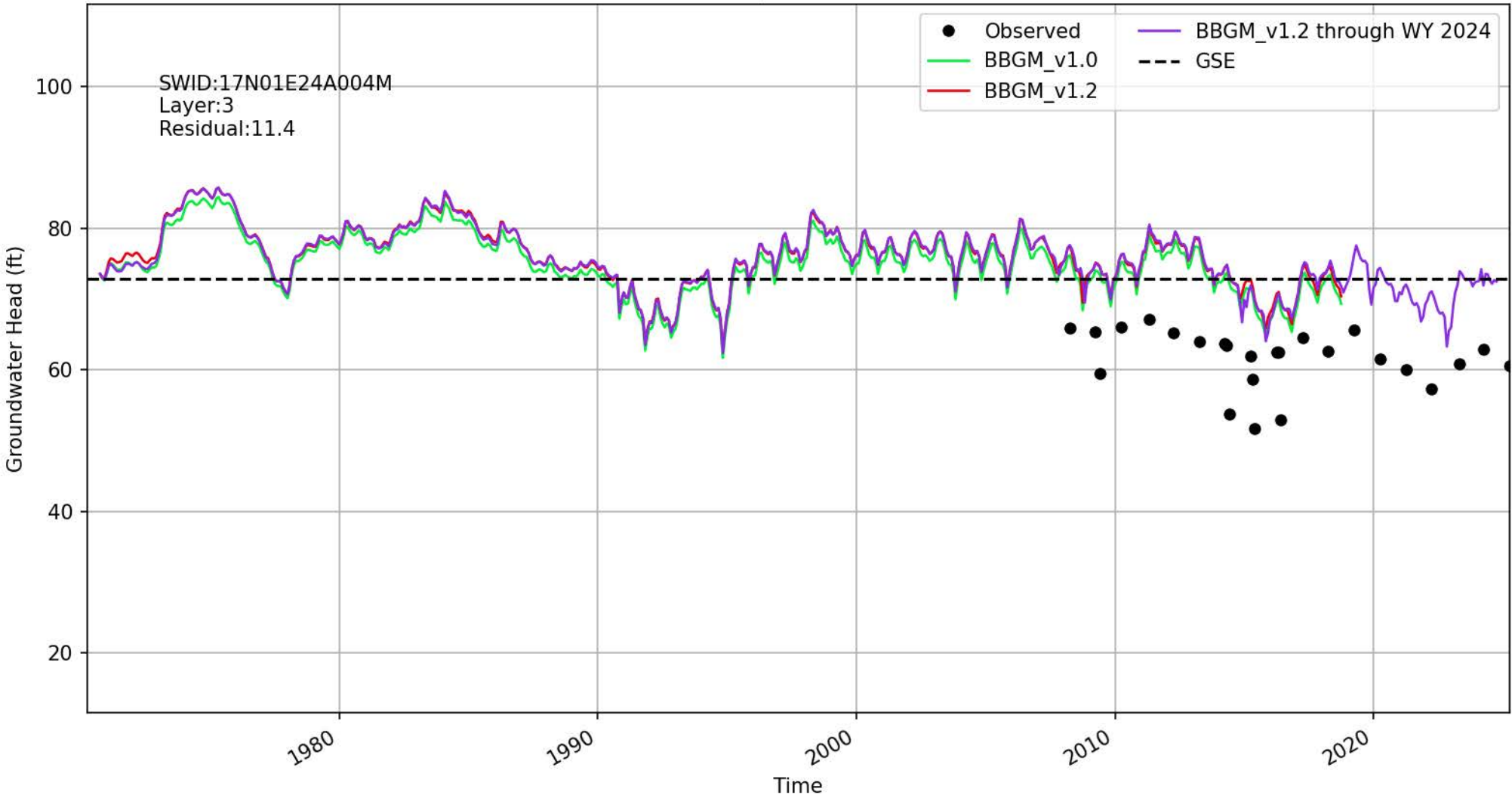


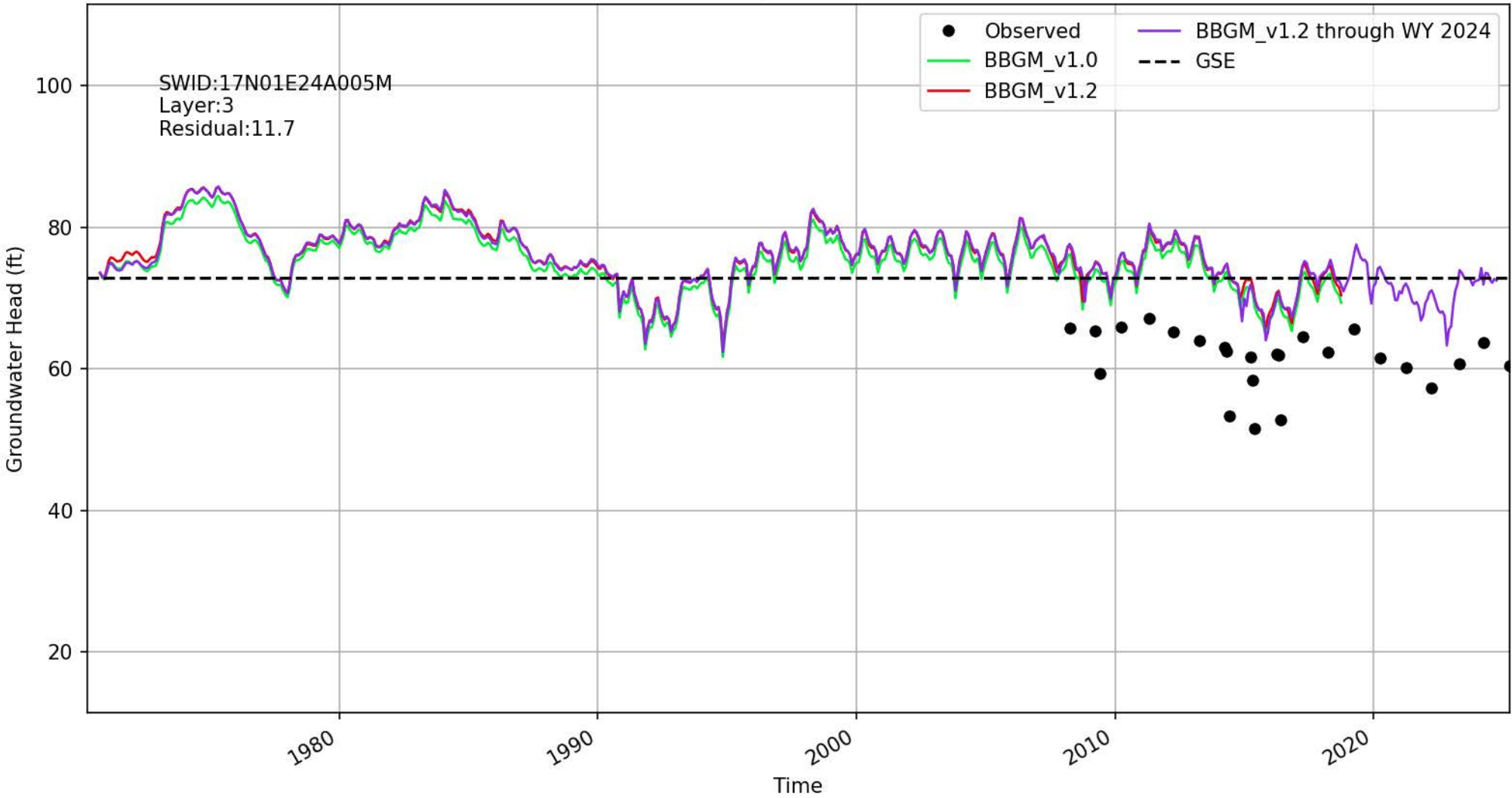




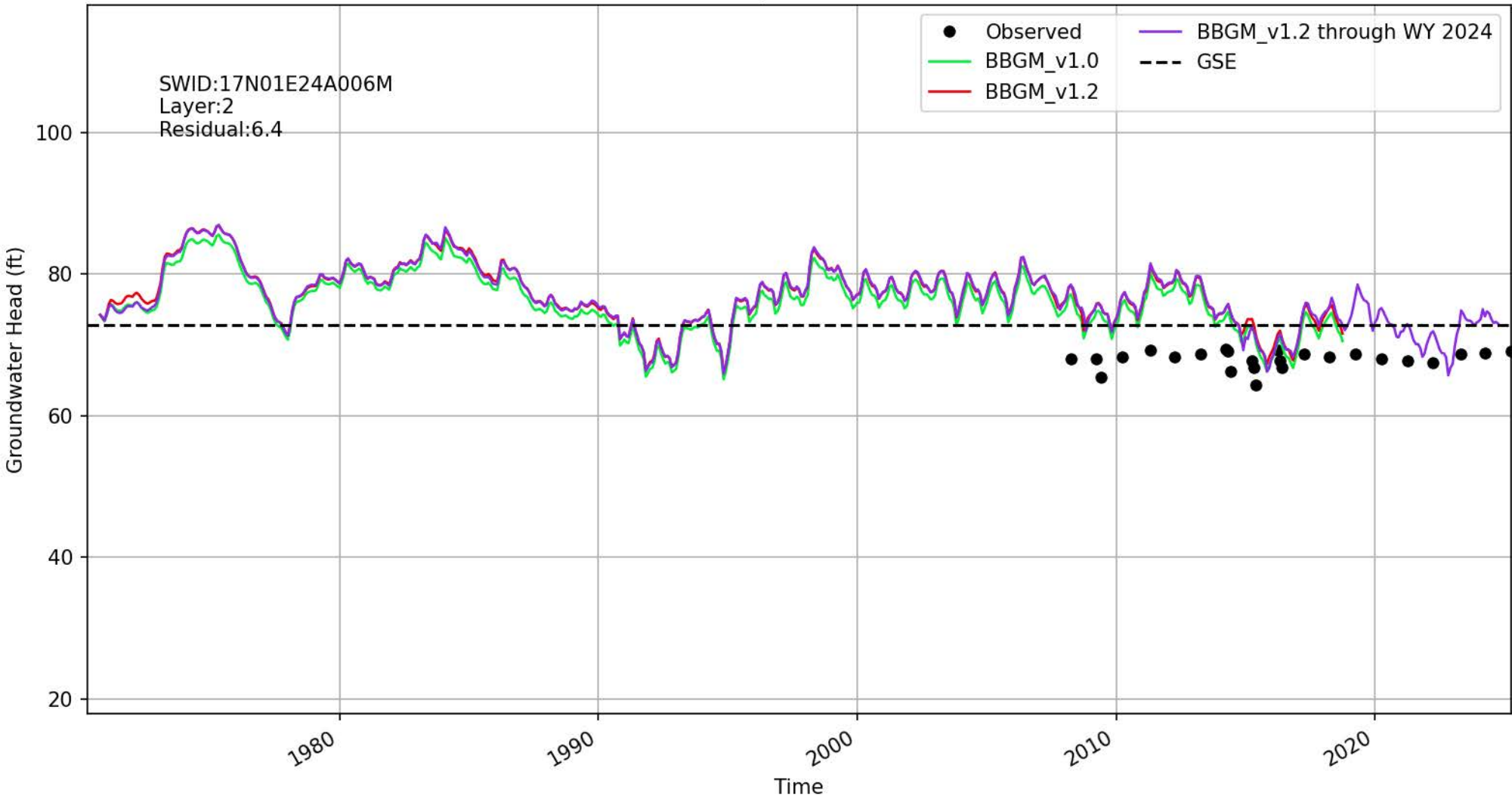
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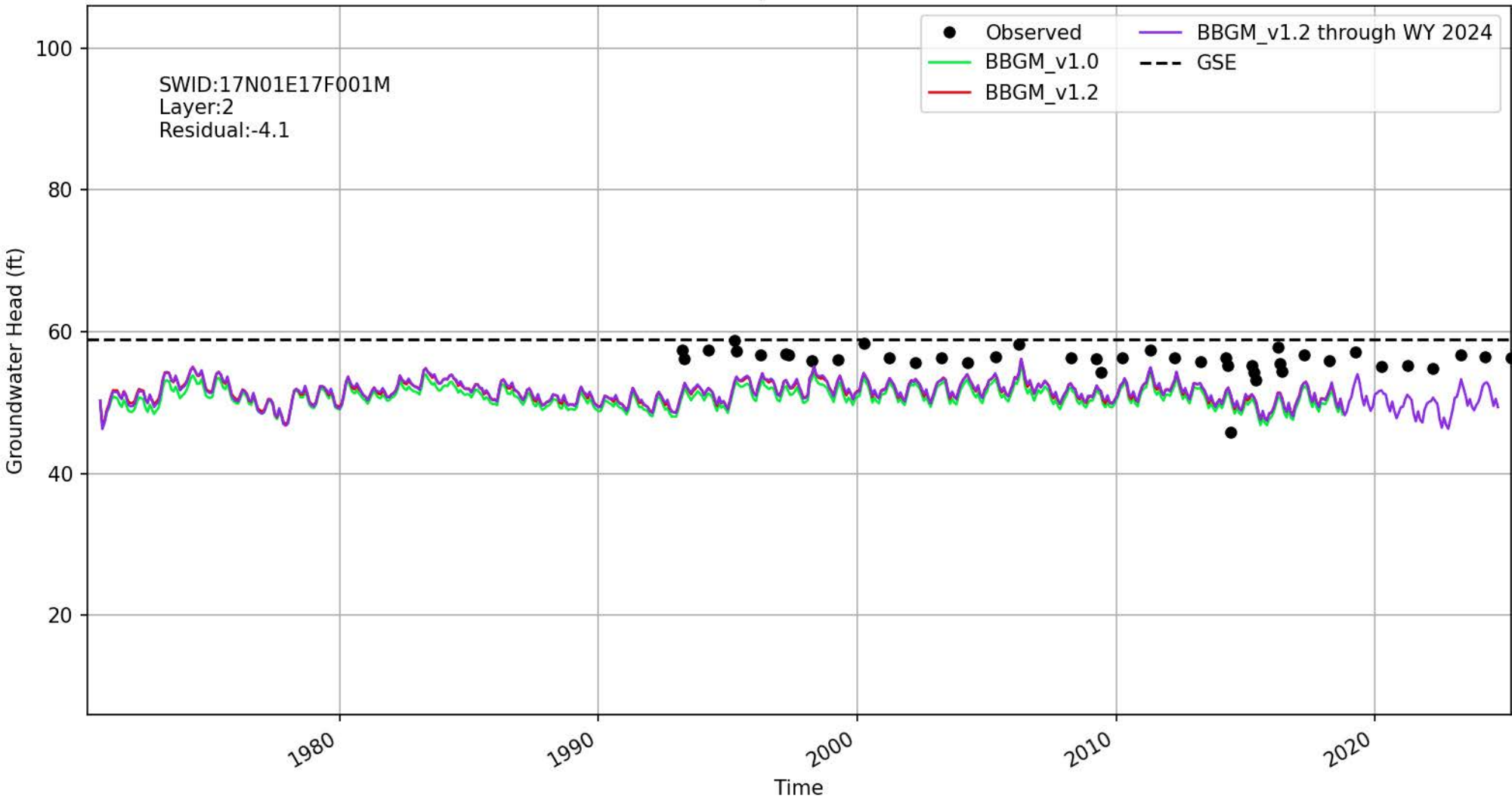


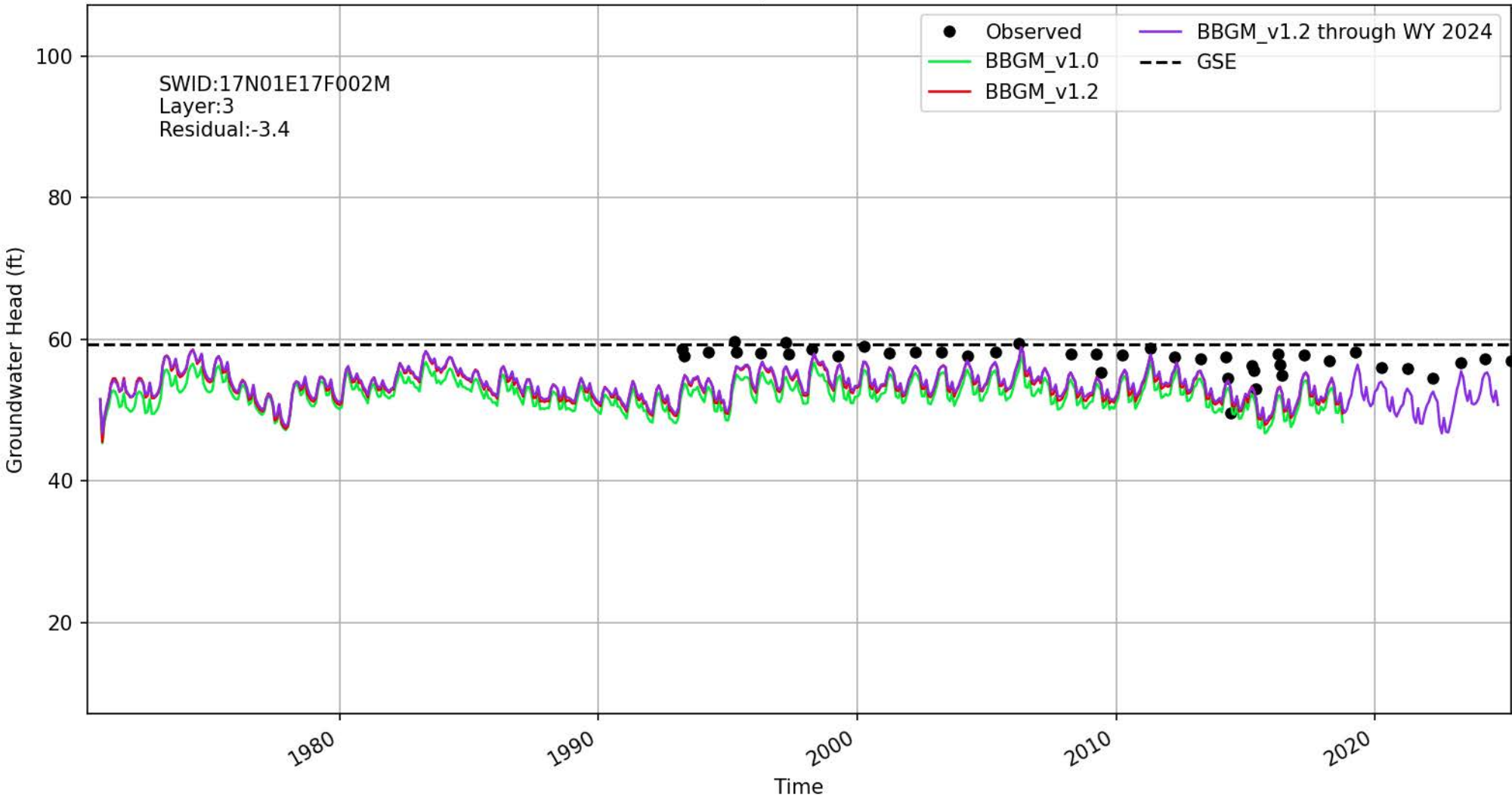


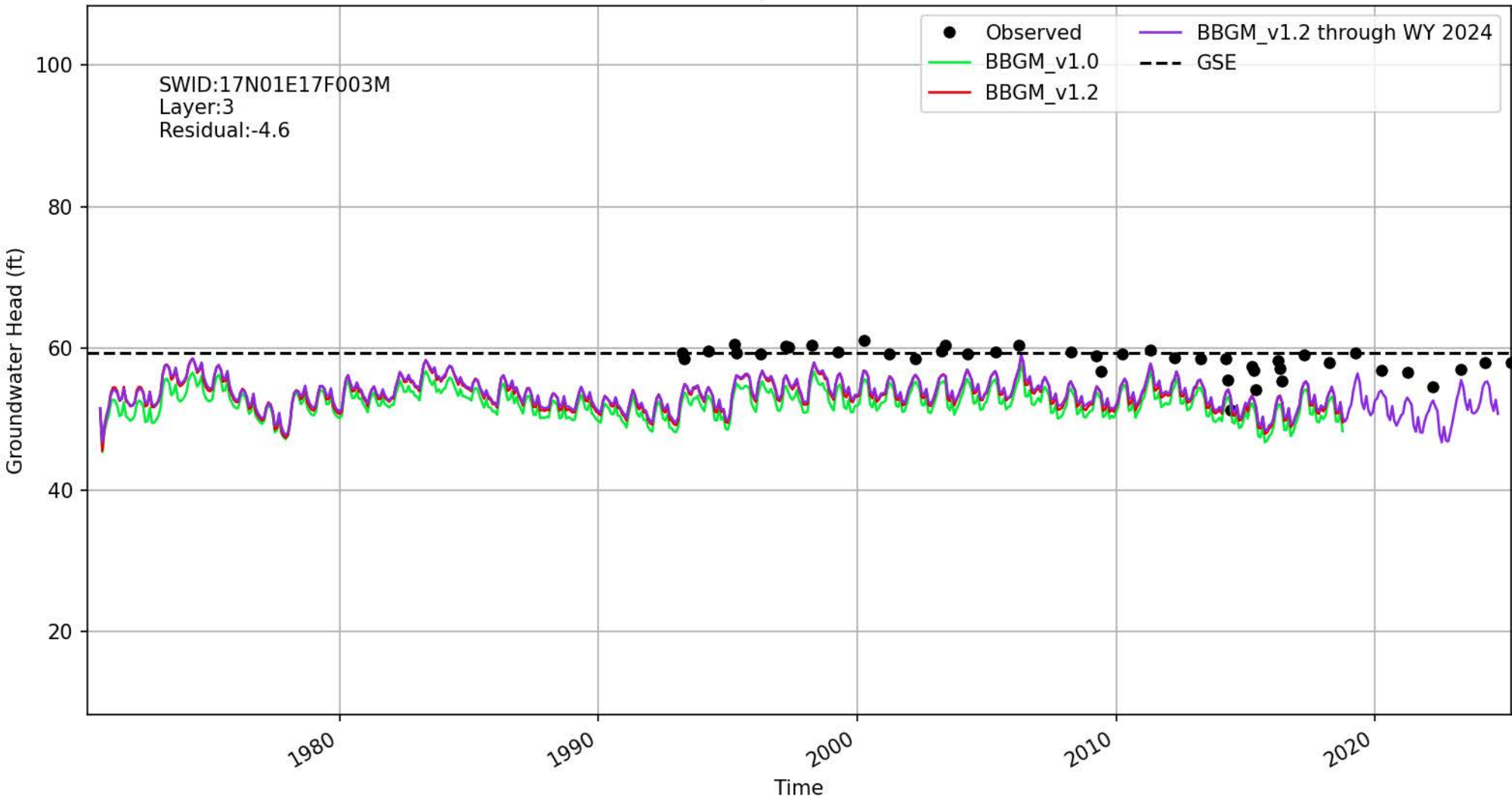
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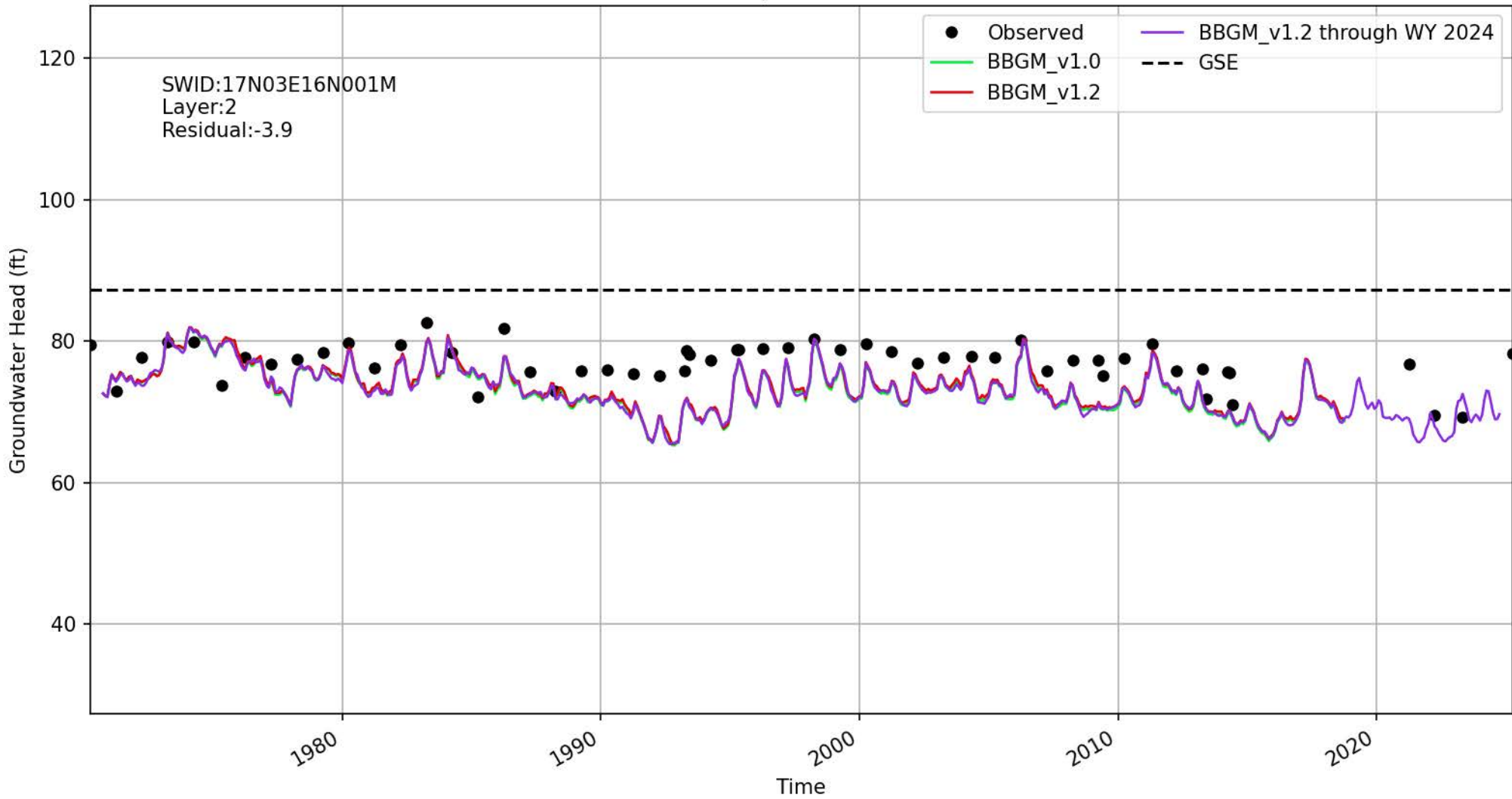


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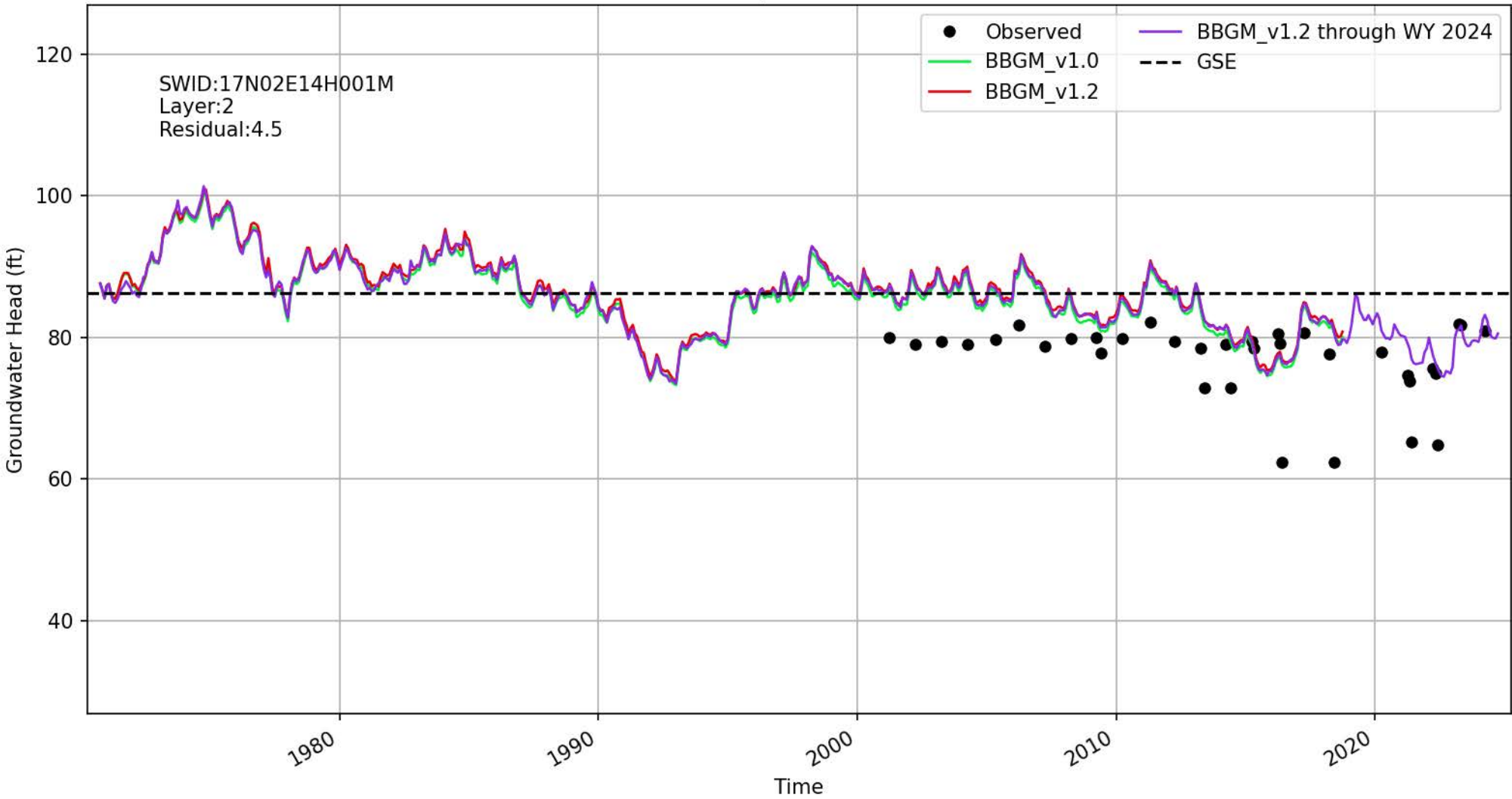


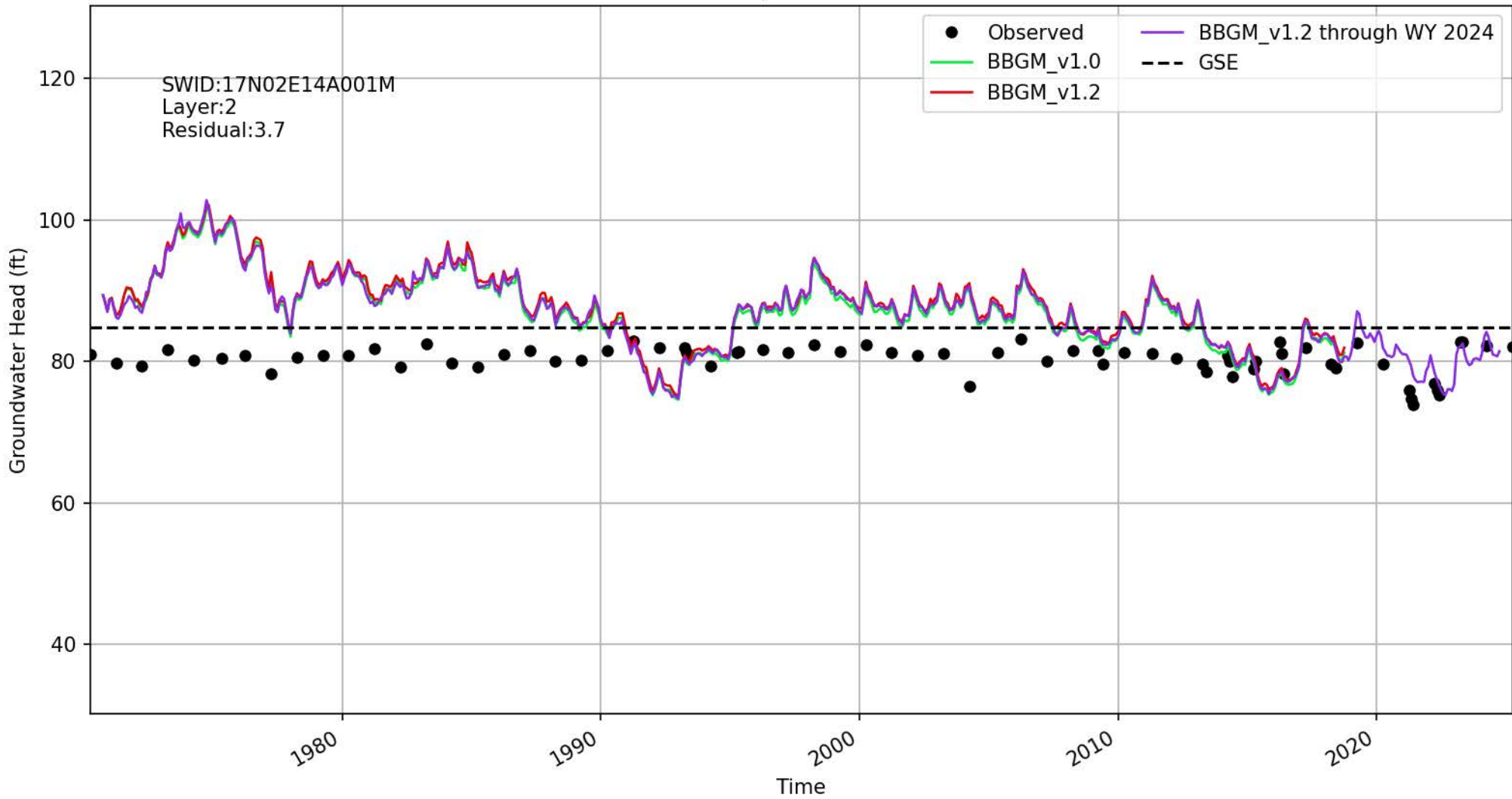




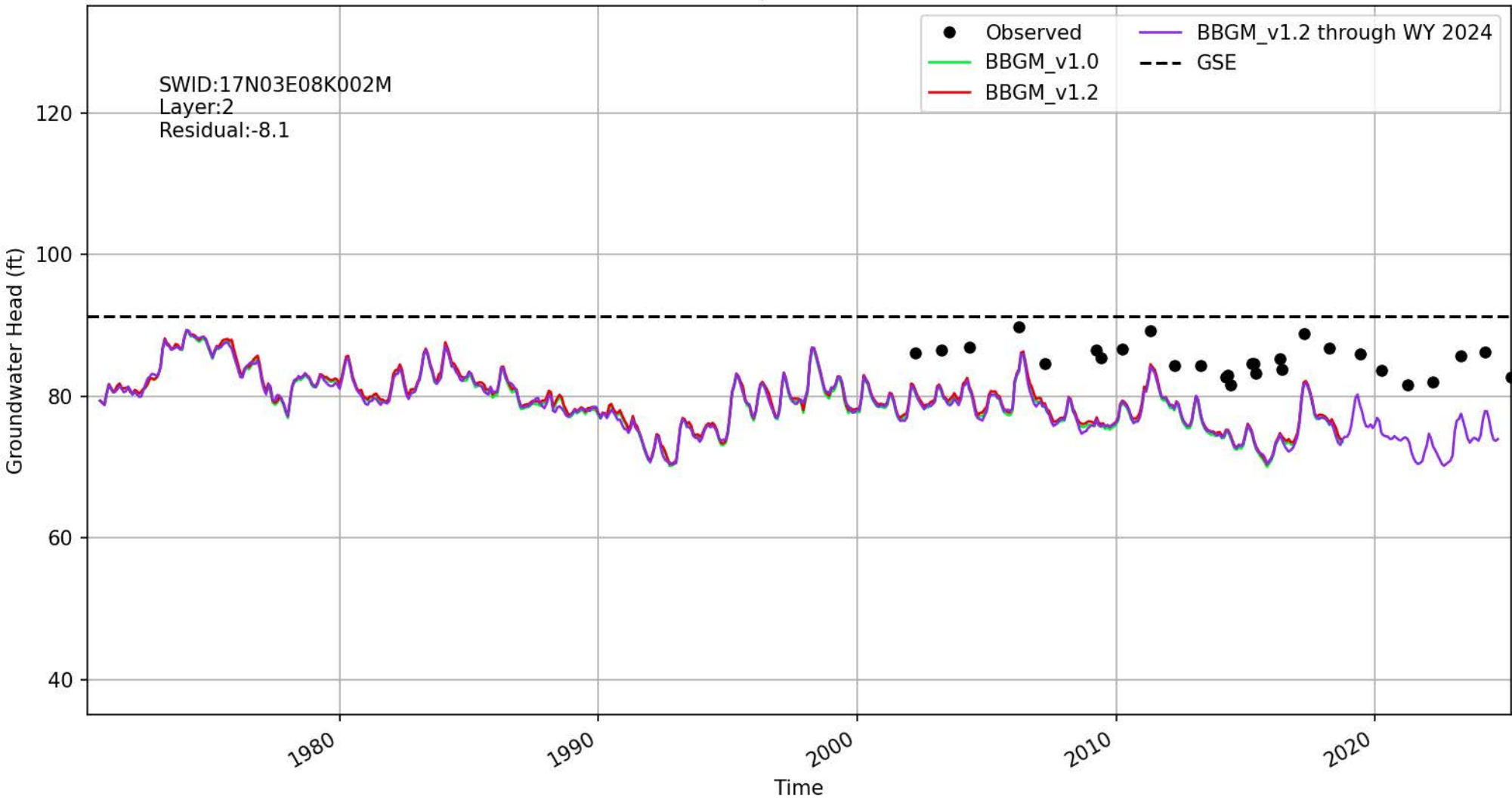


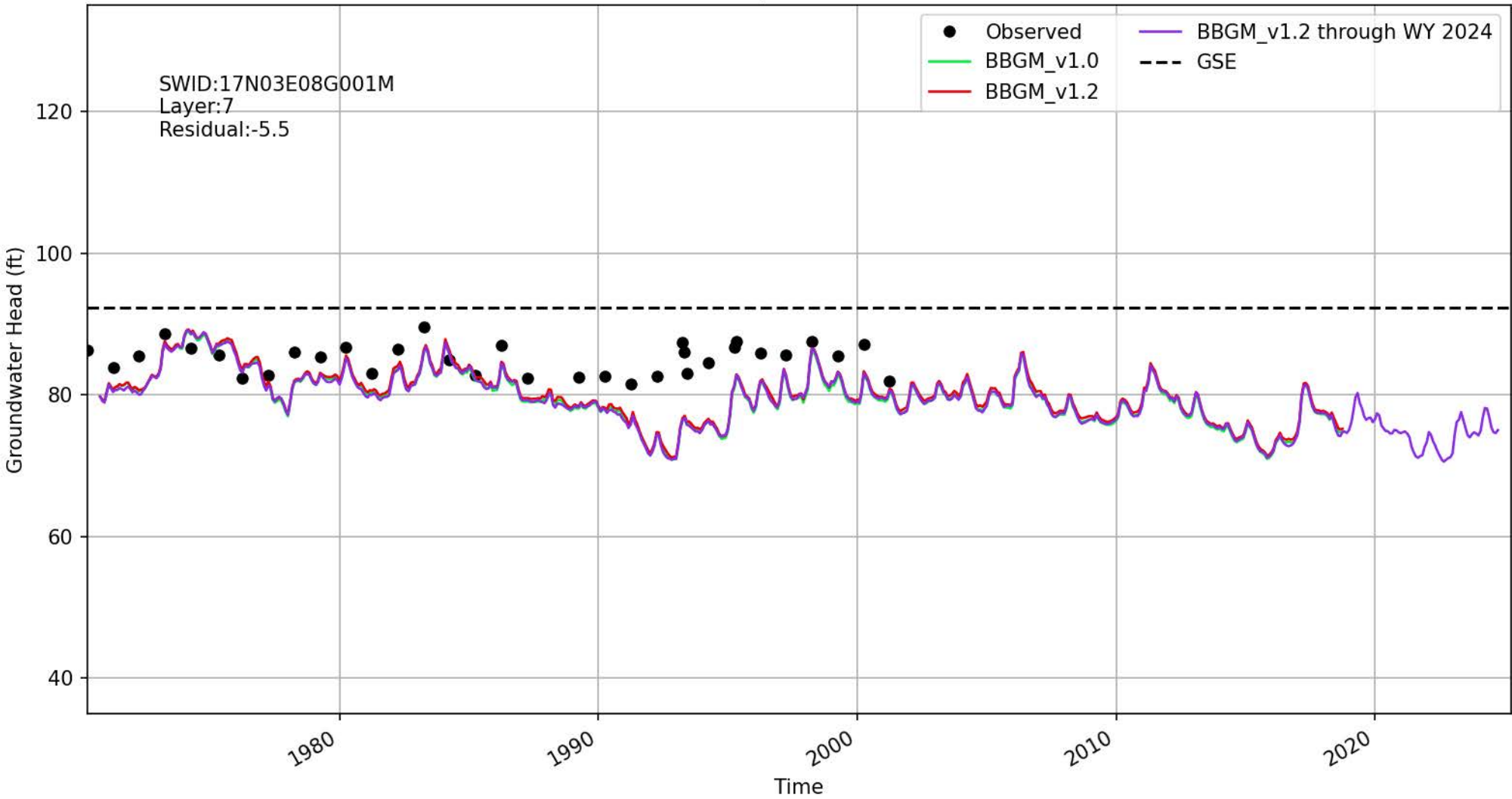
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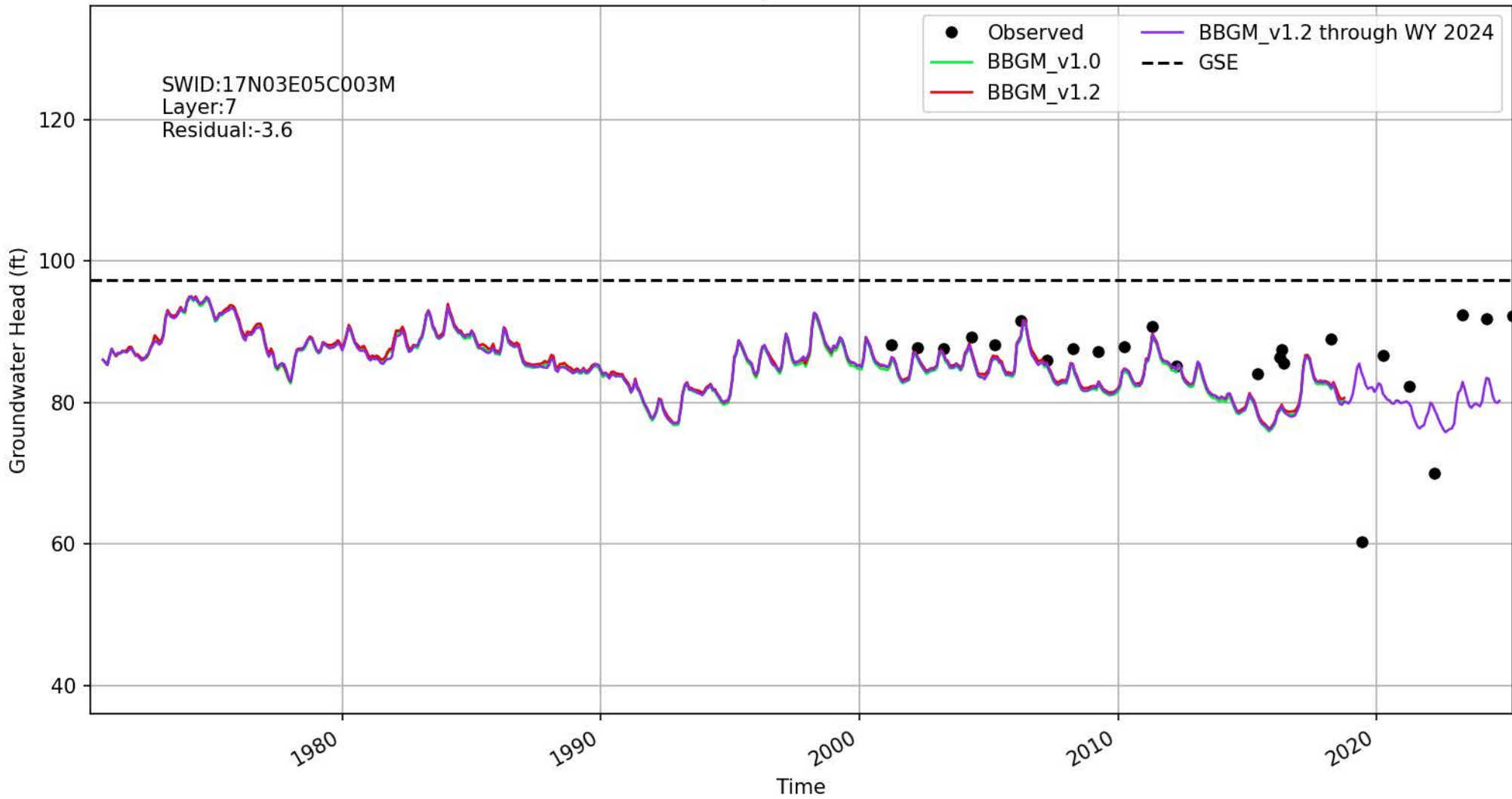


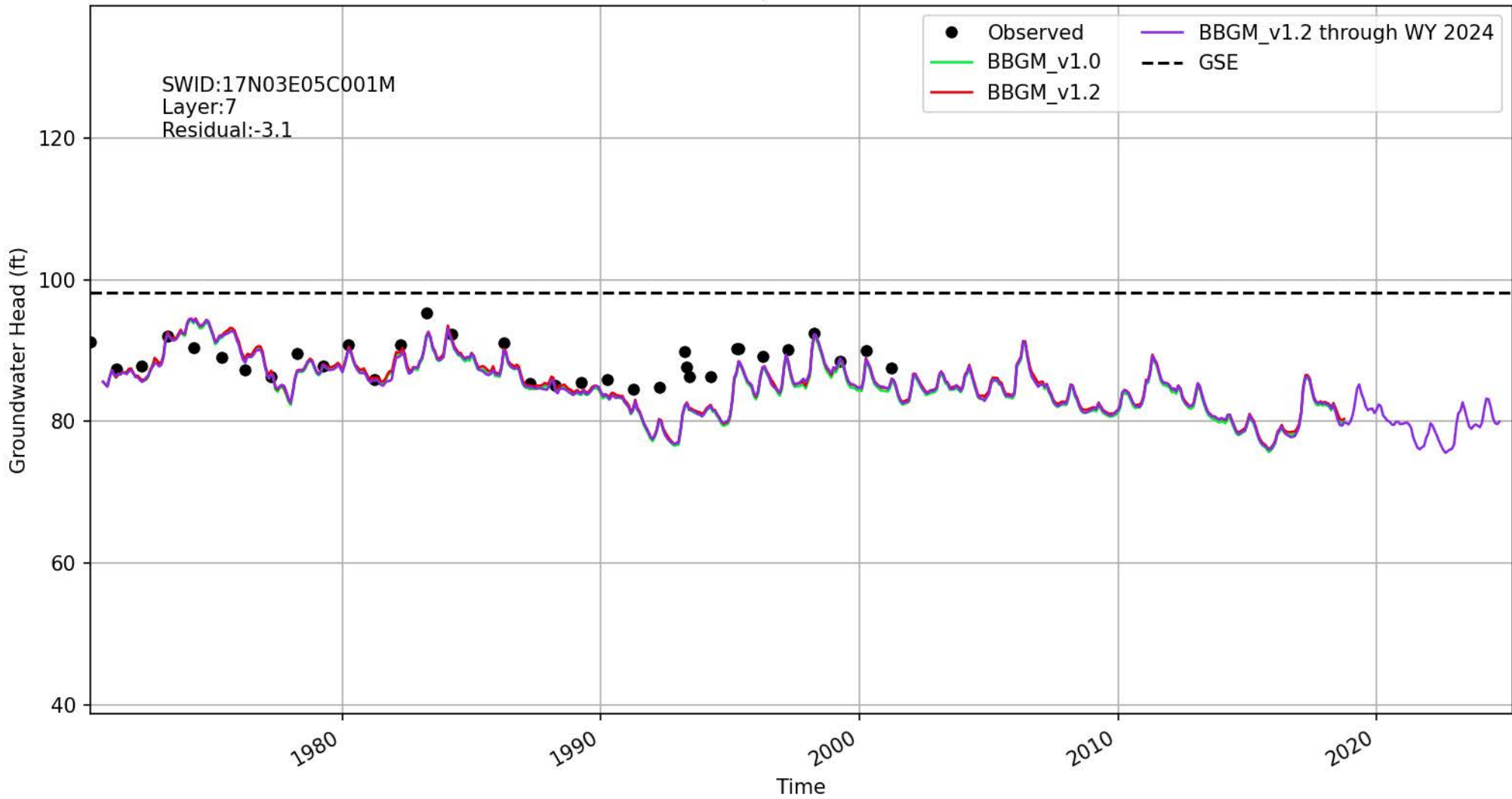


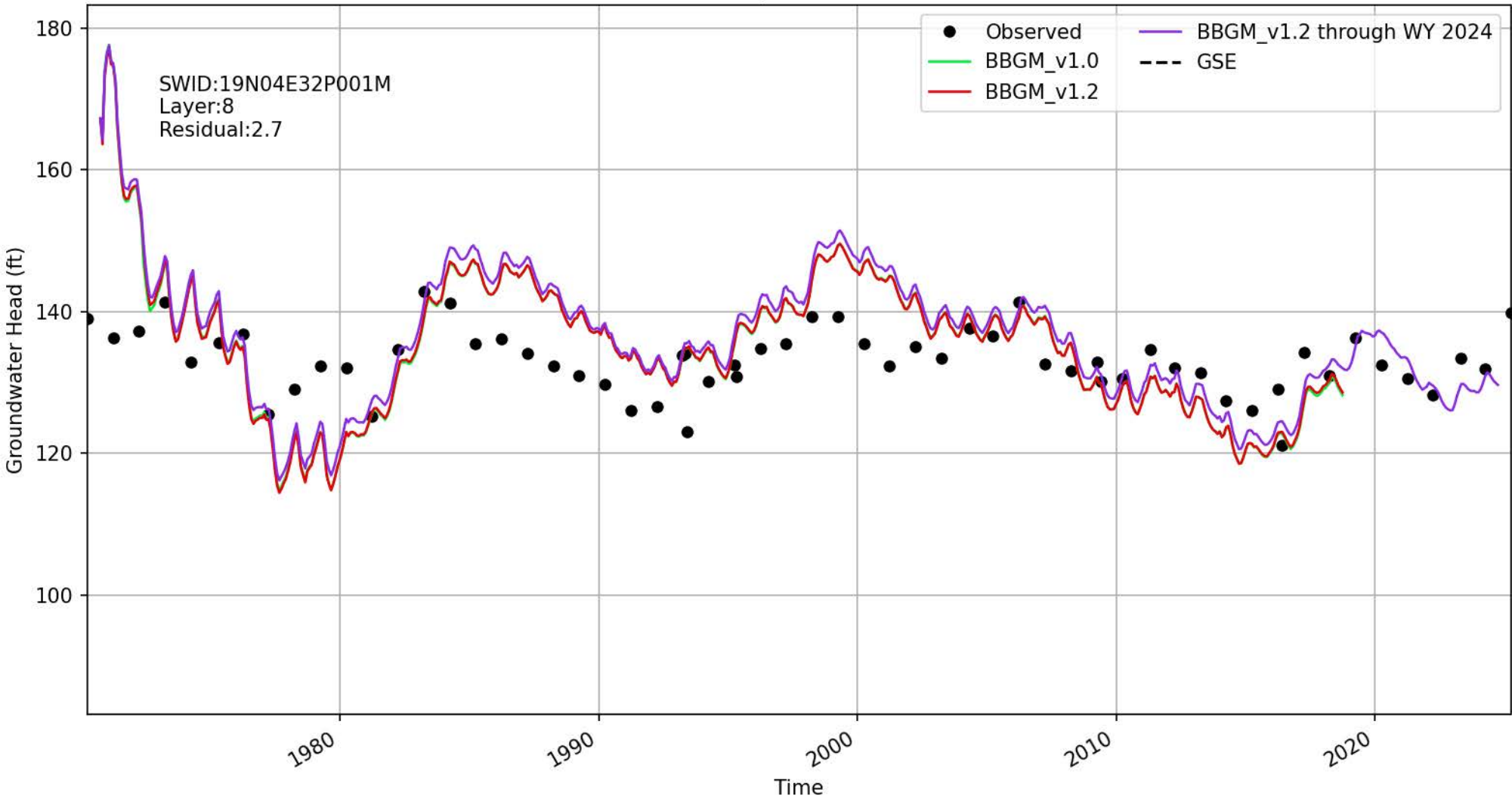
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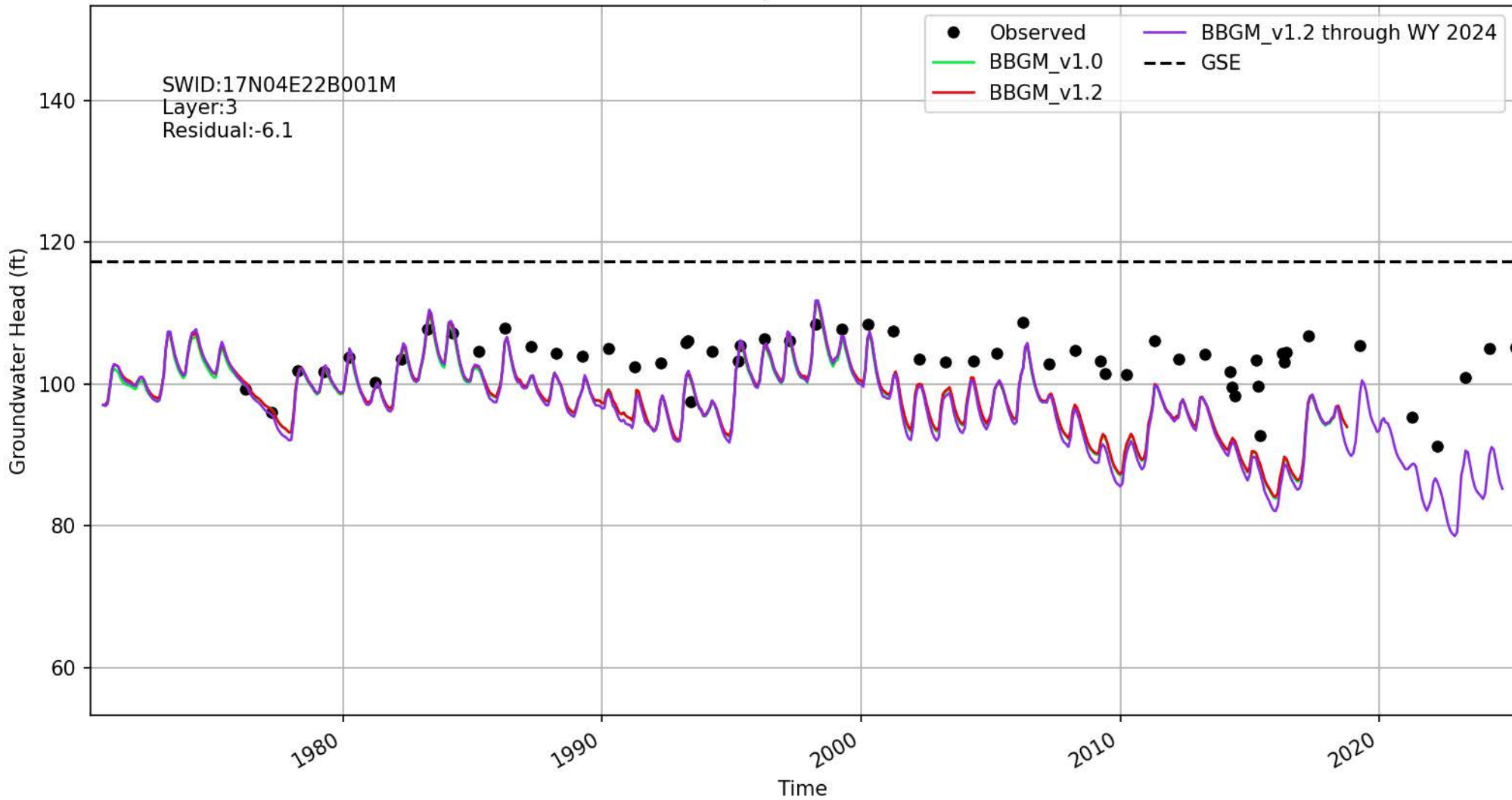


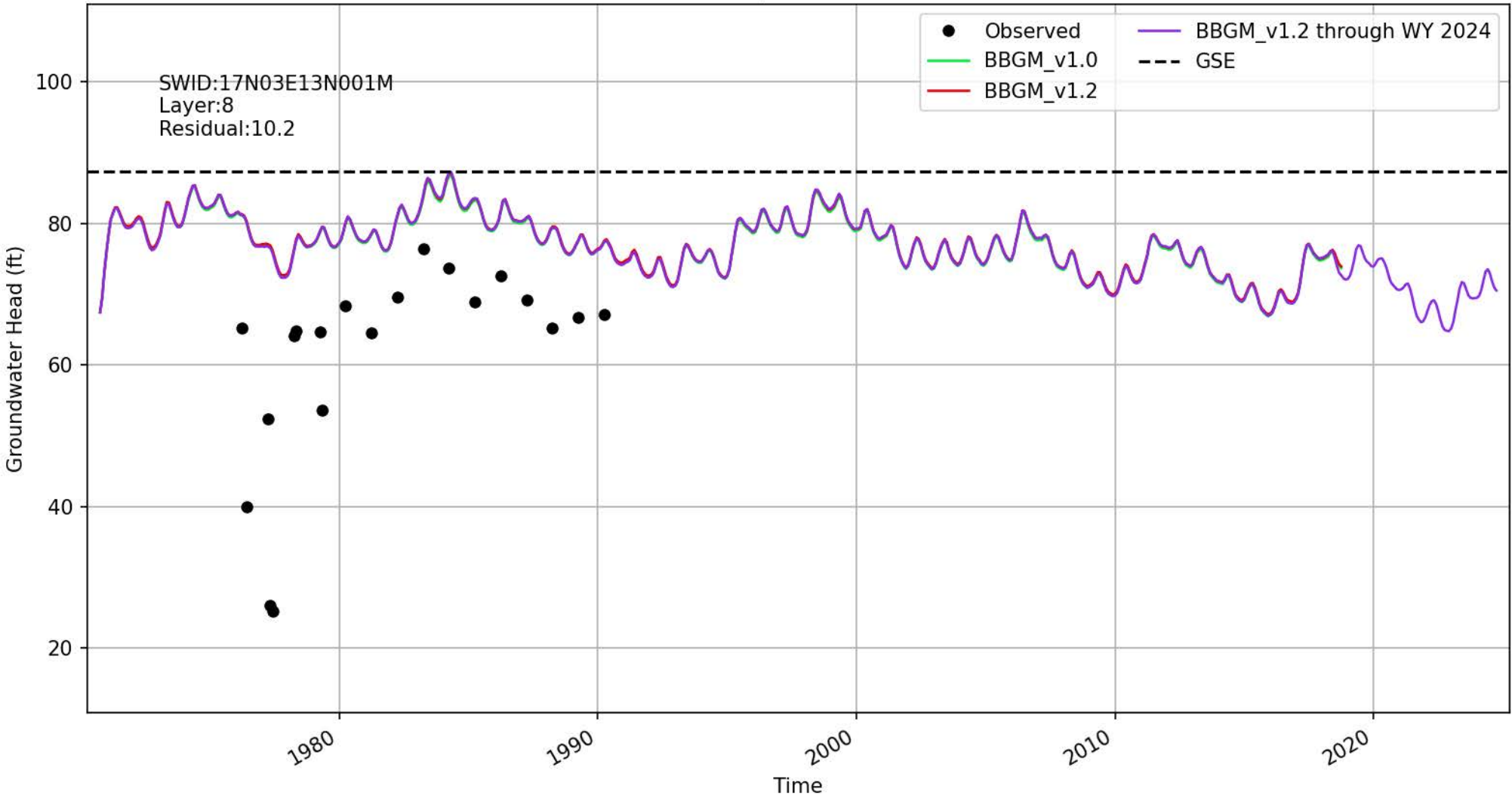




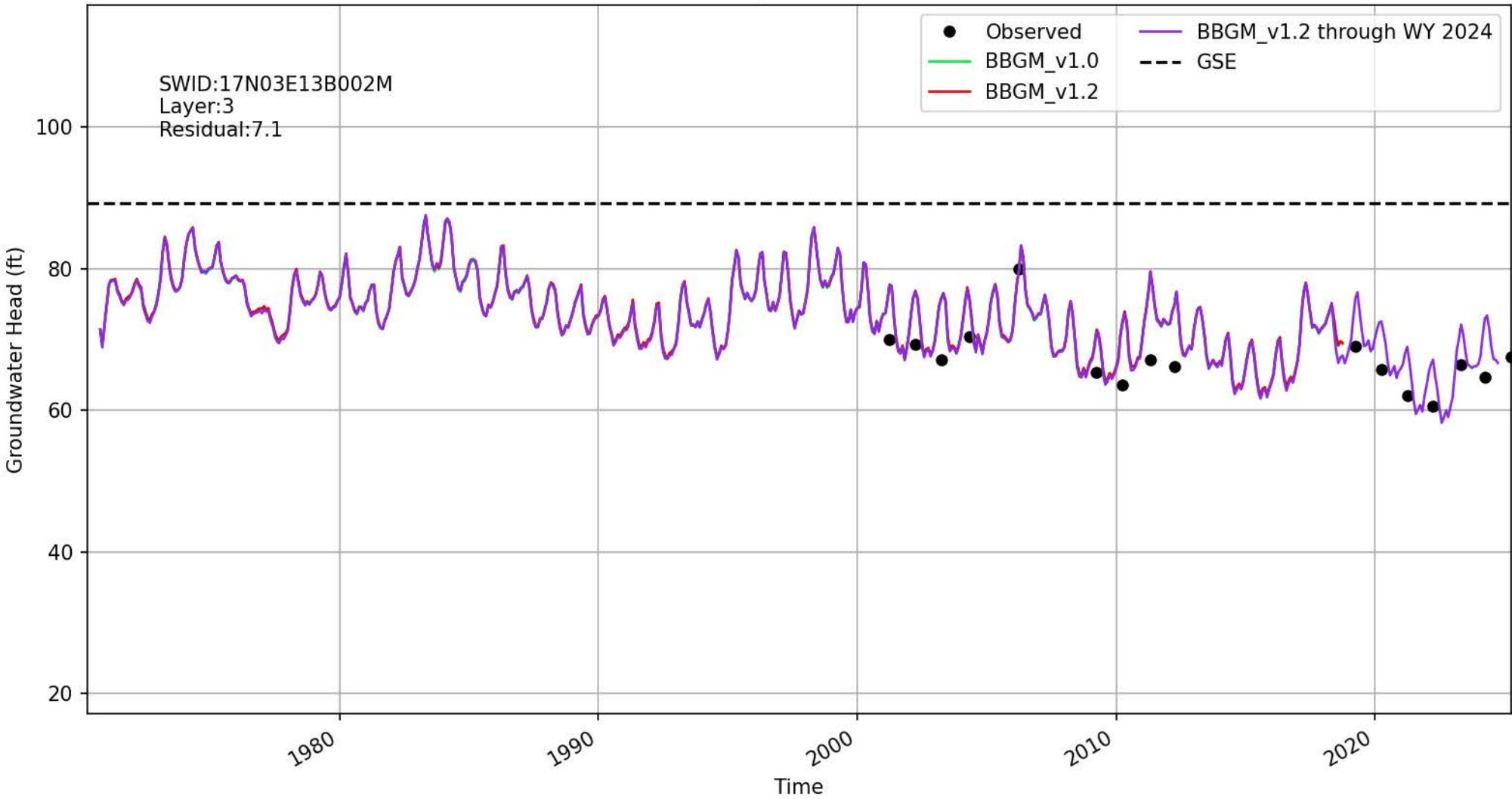


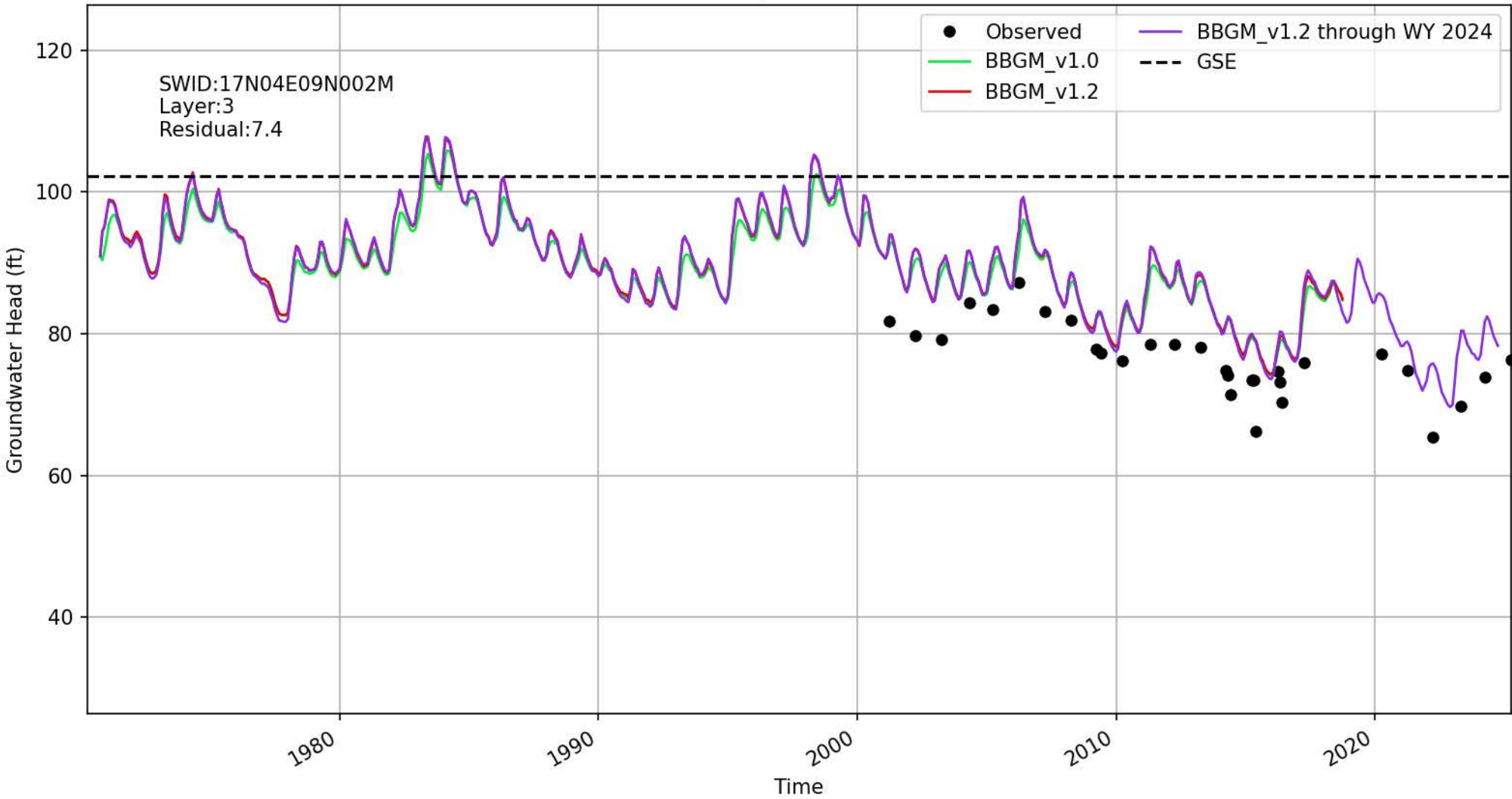


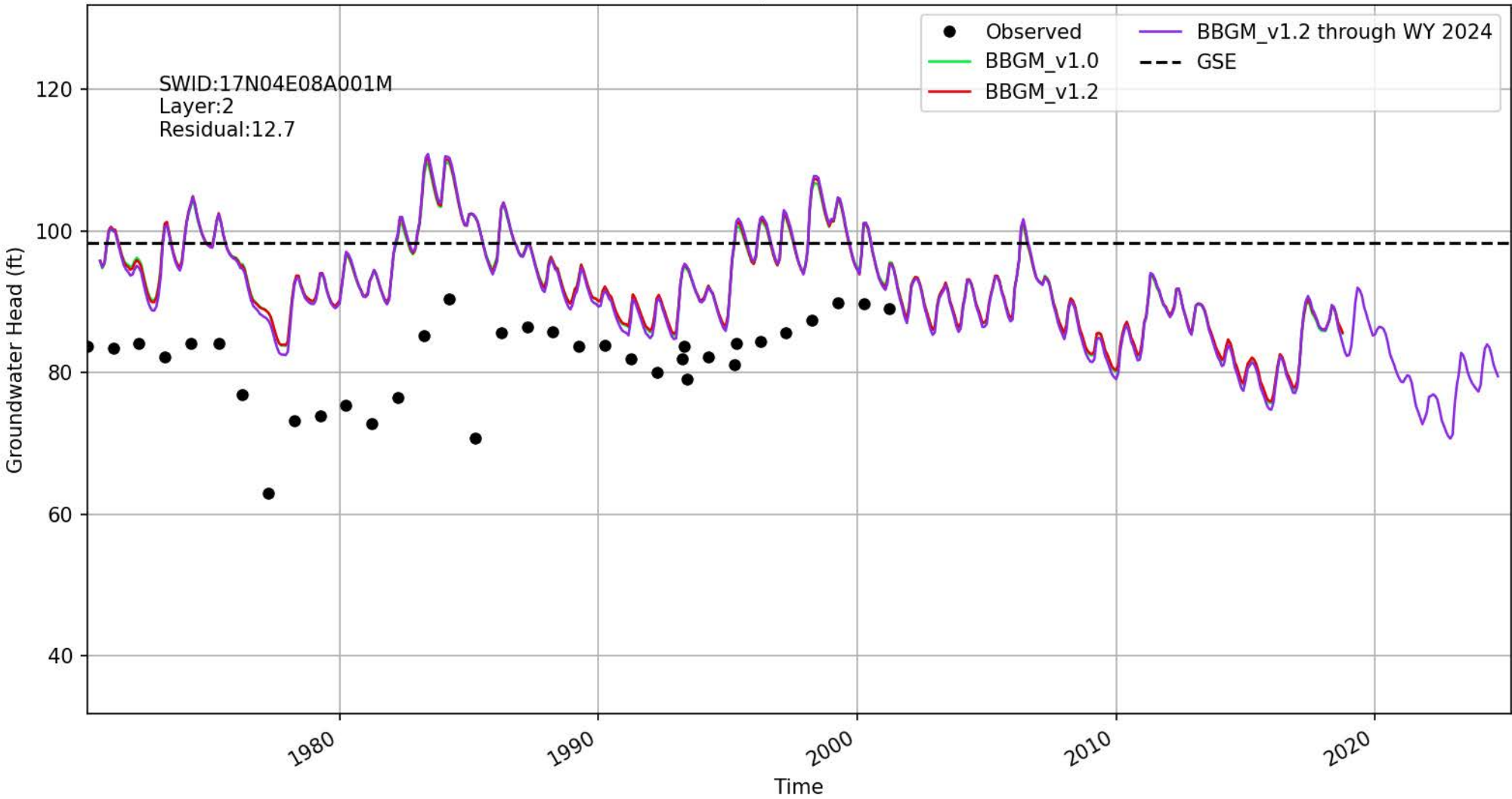


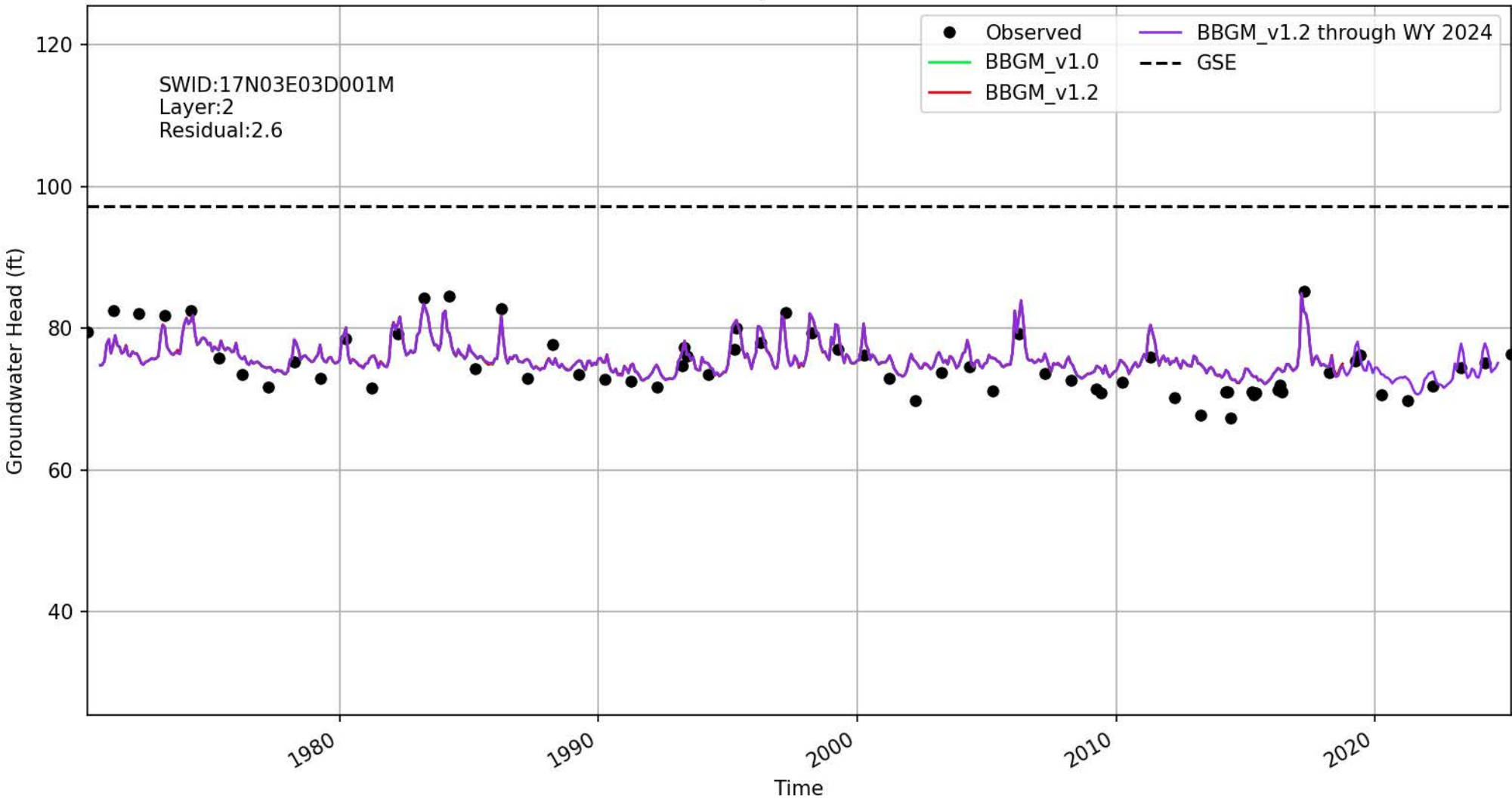


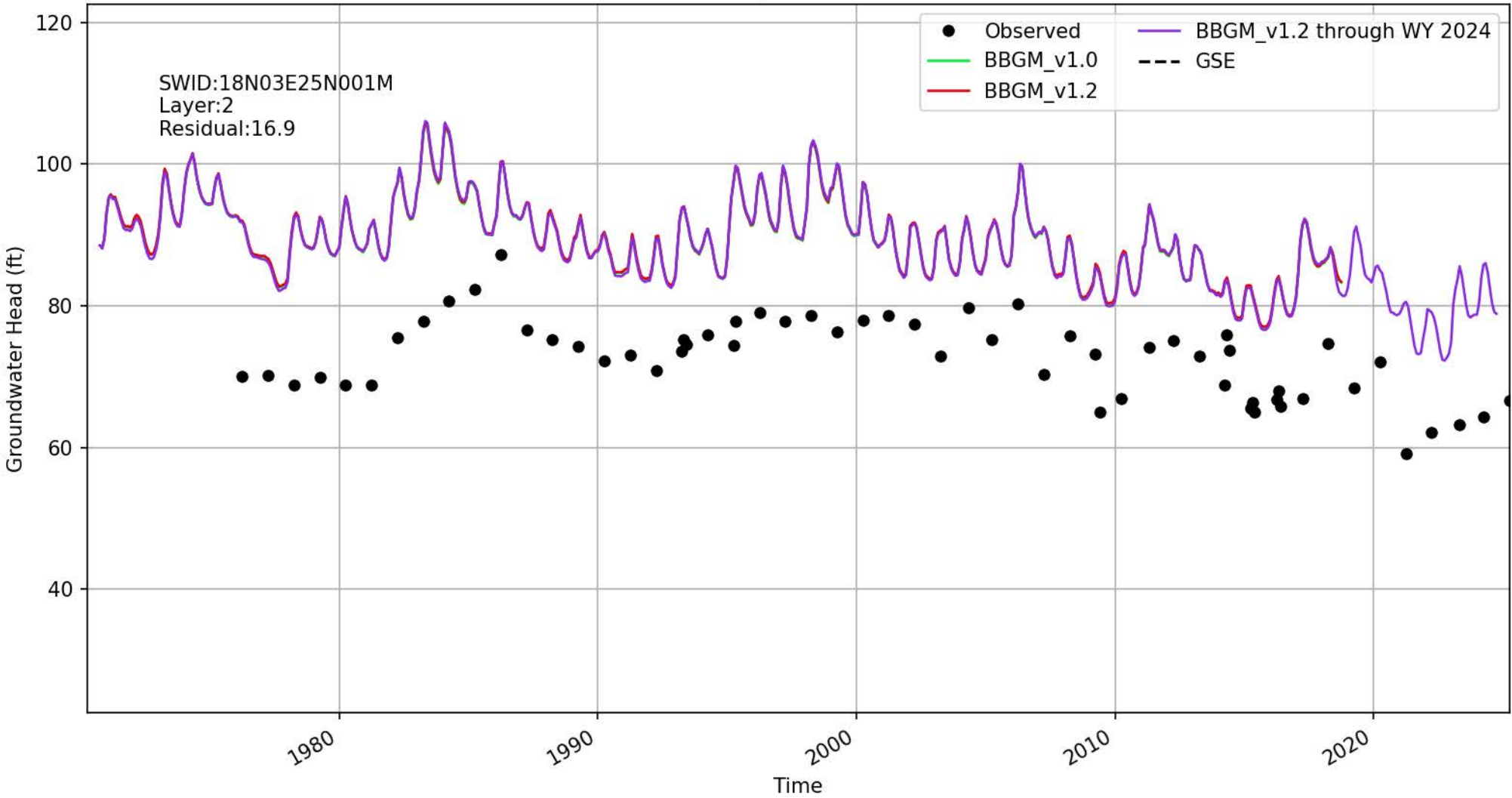
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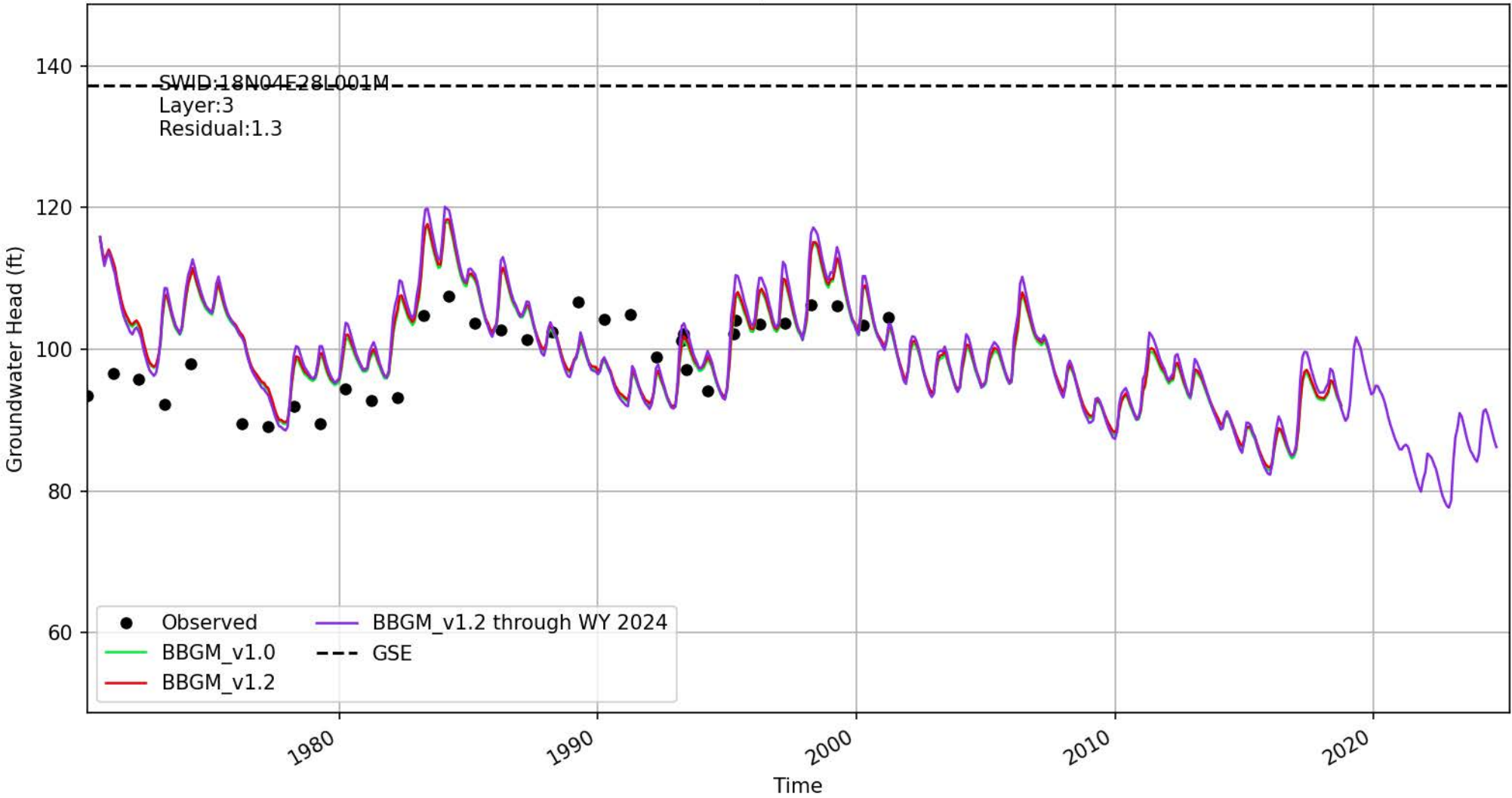


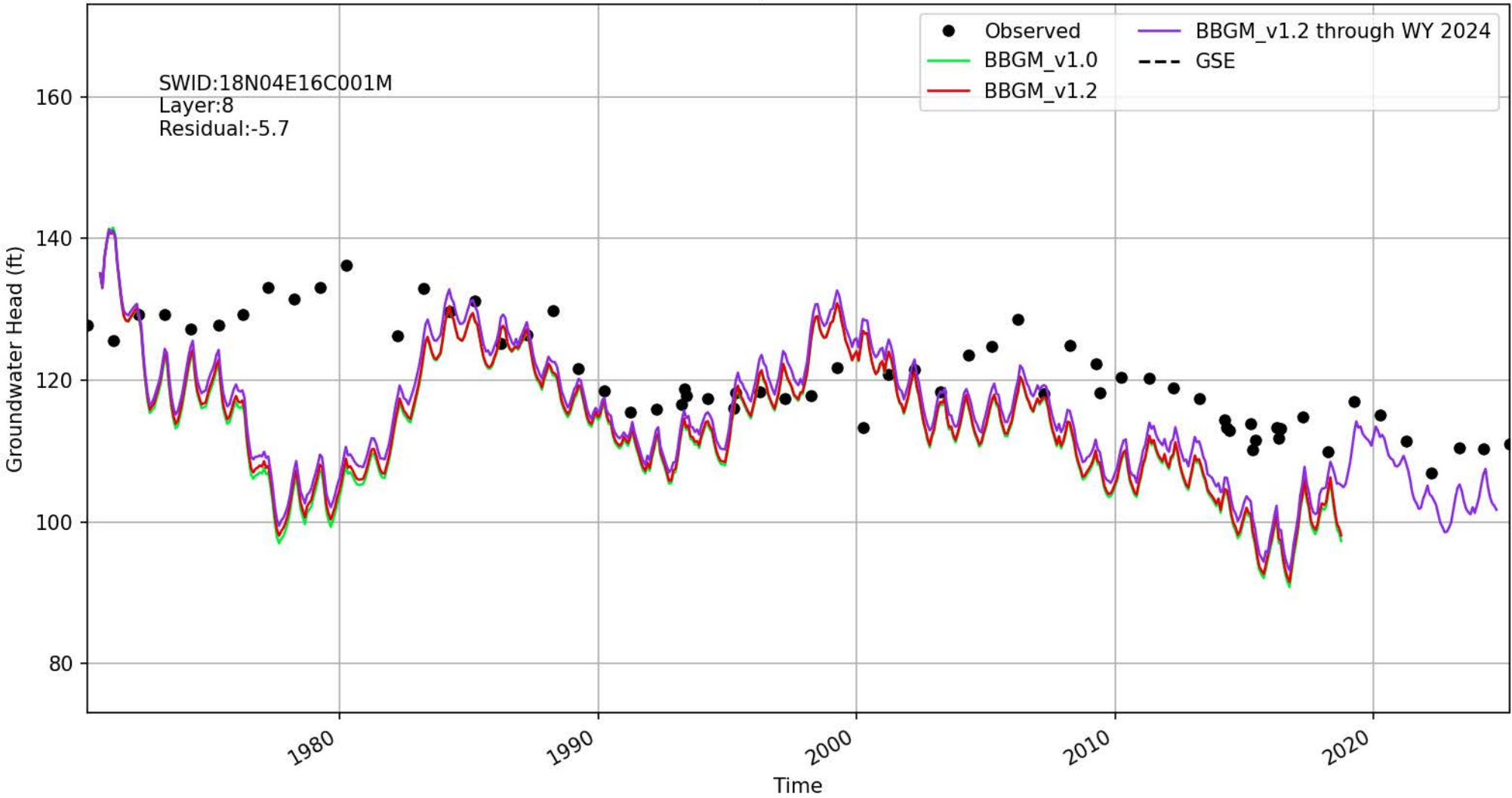


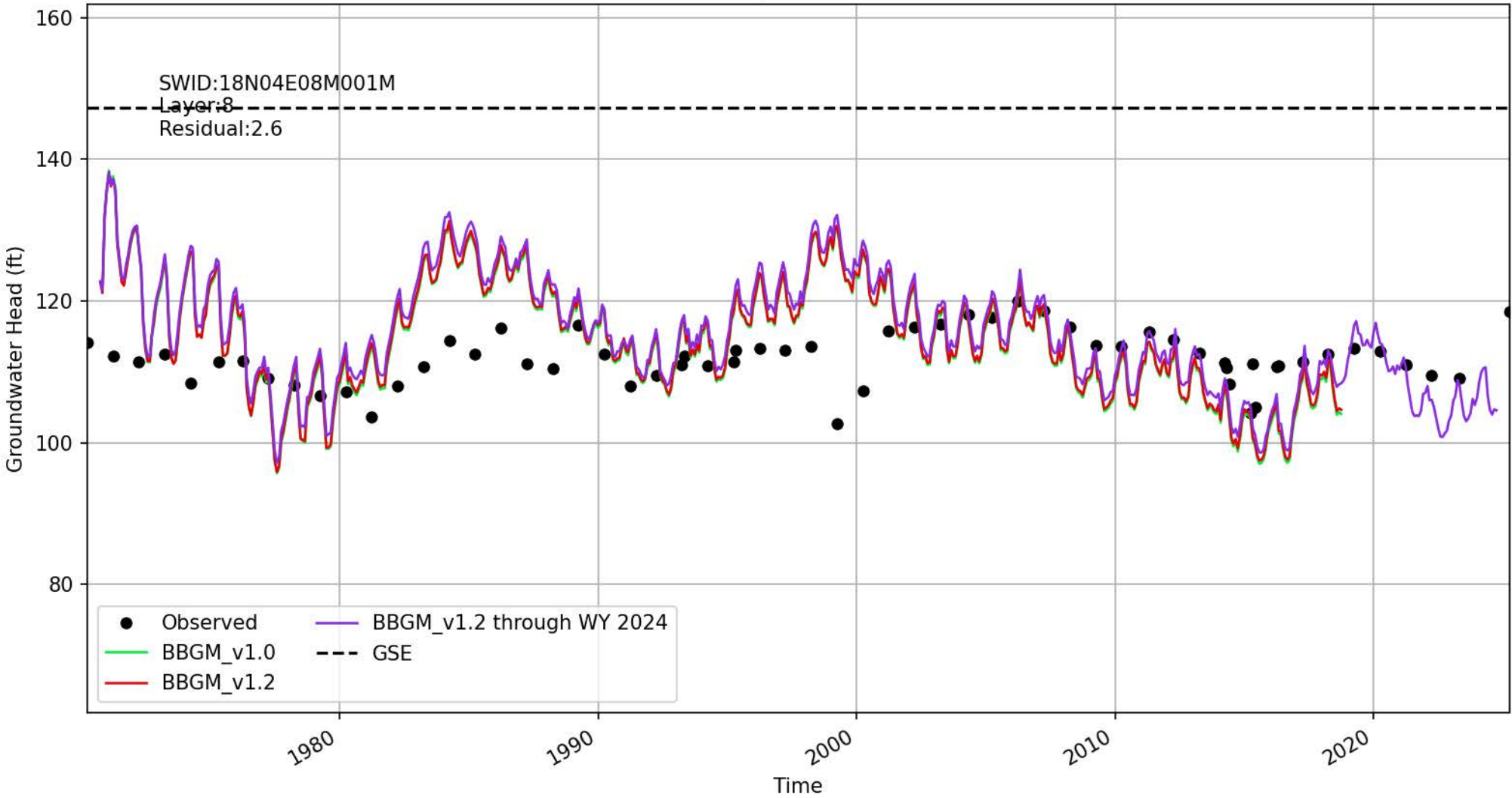


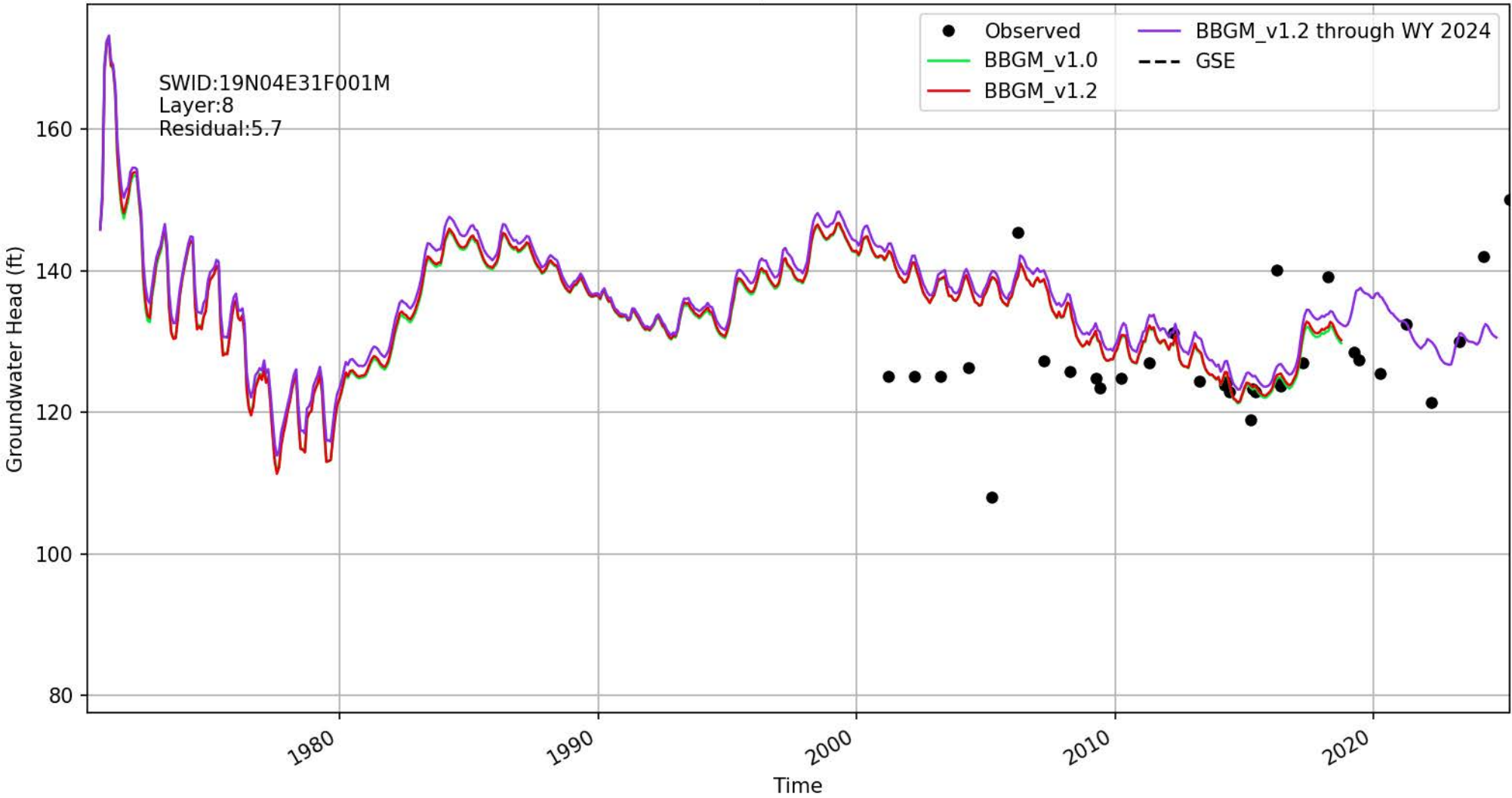




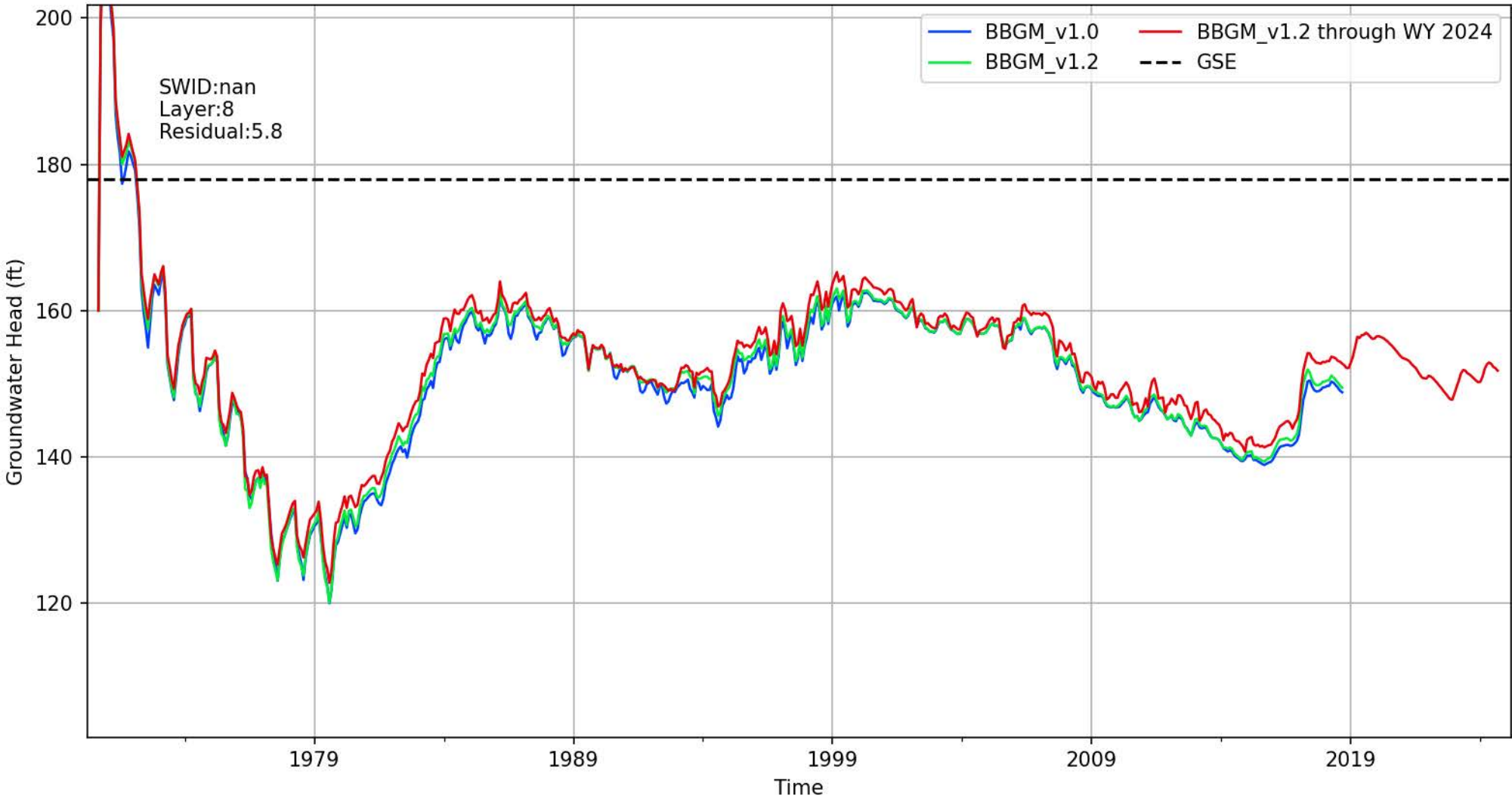




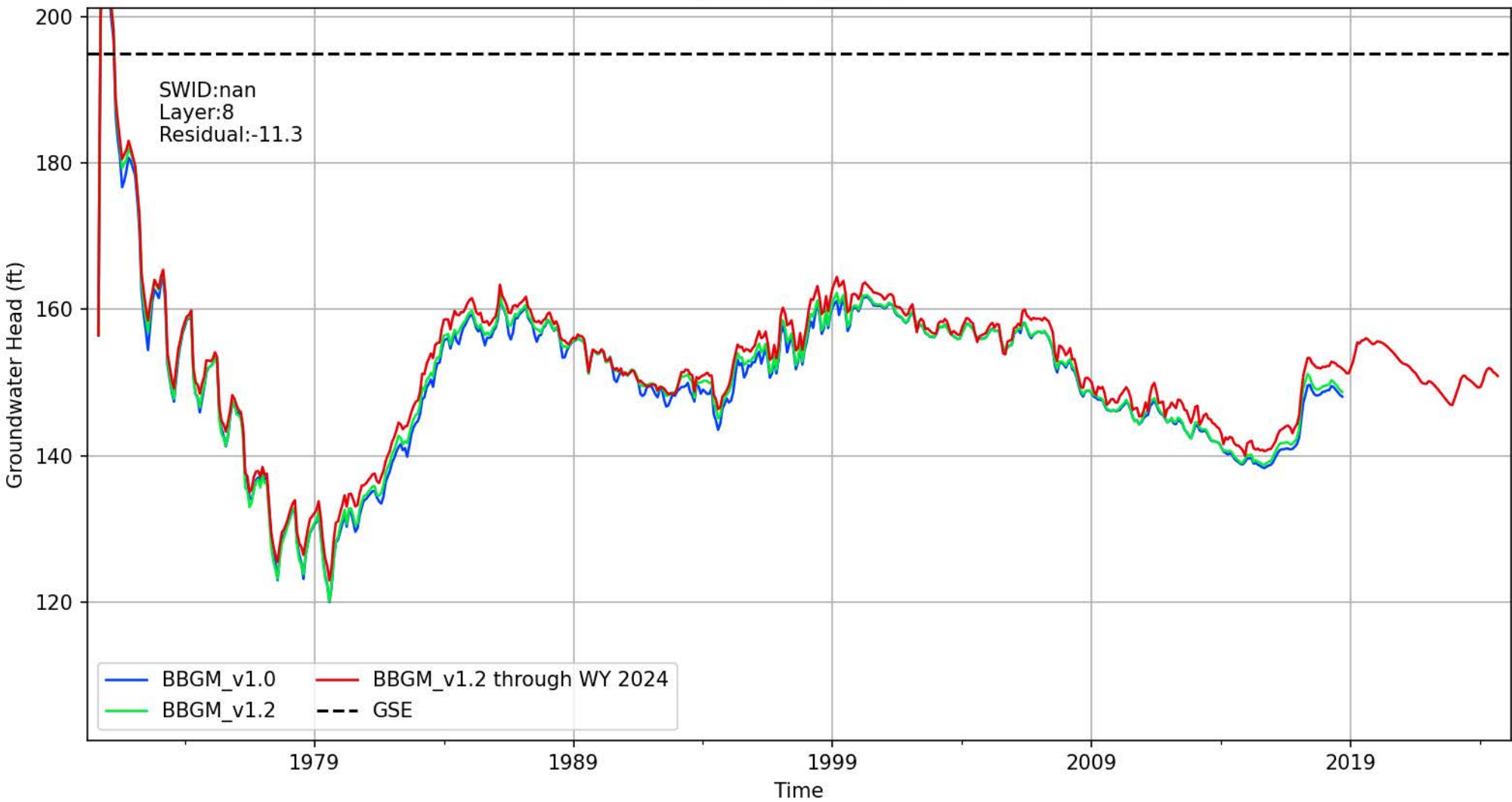




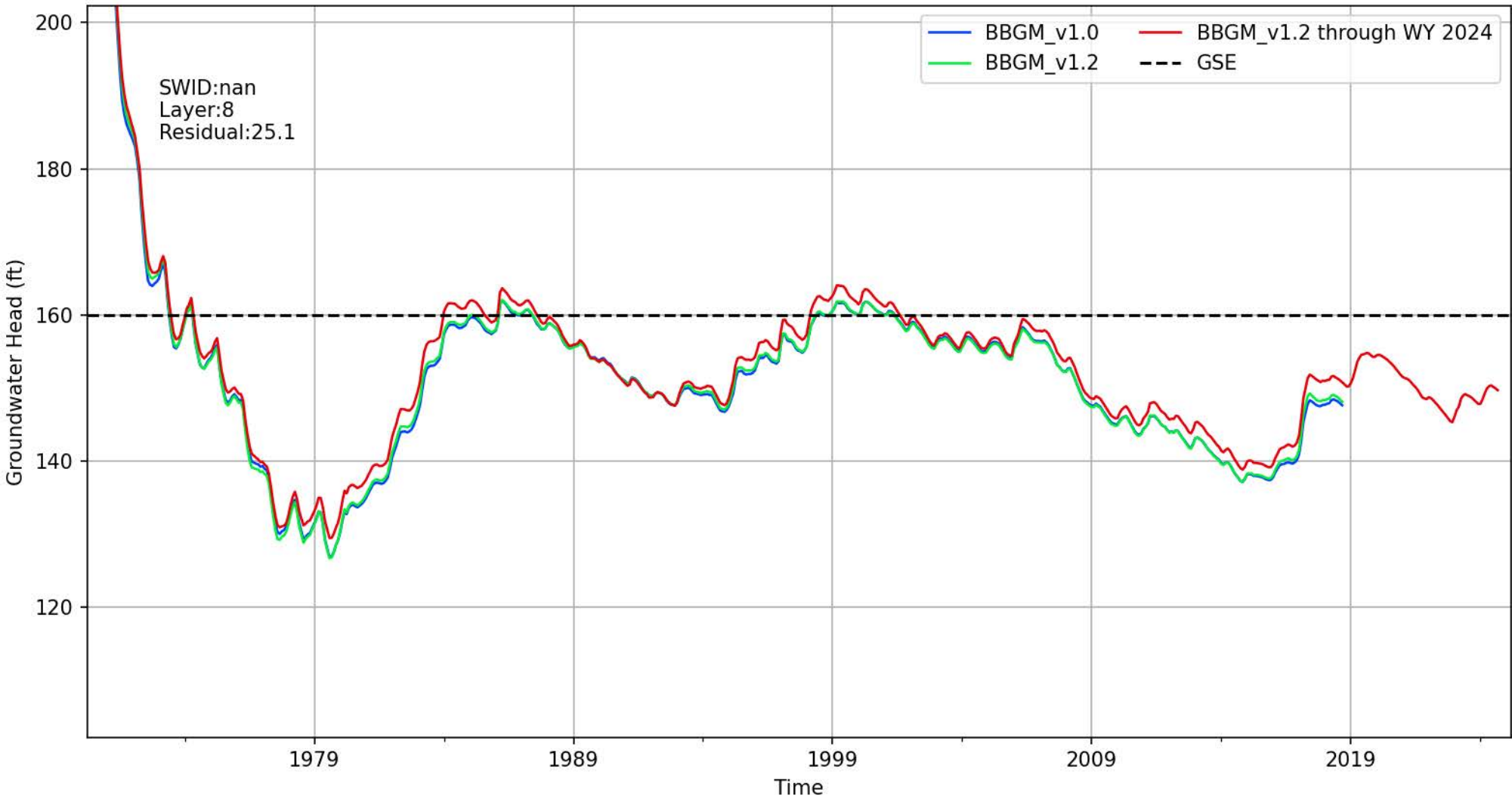
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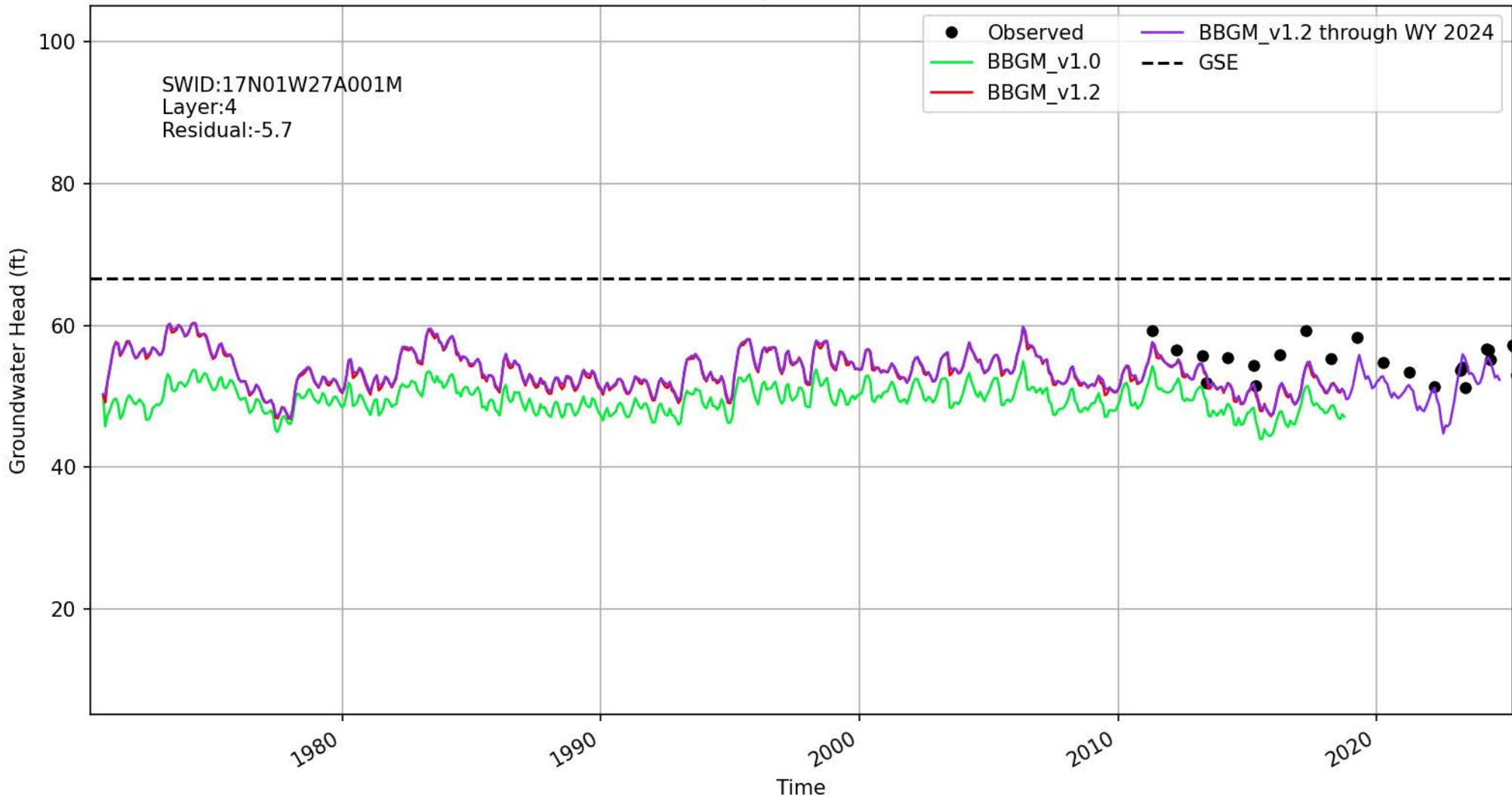


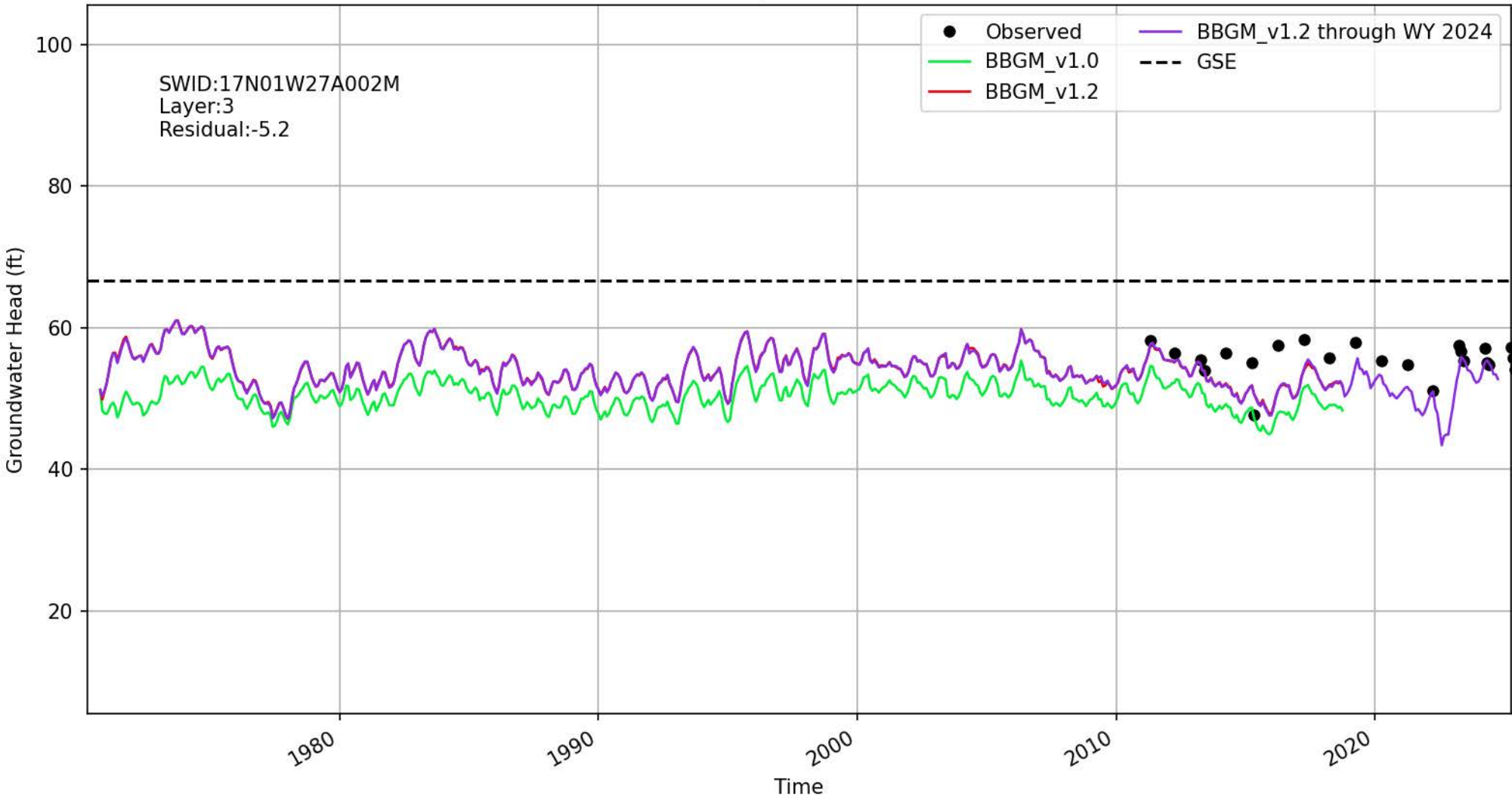
Location ID: 2198

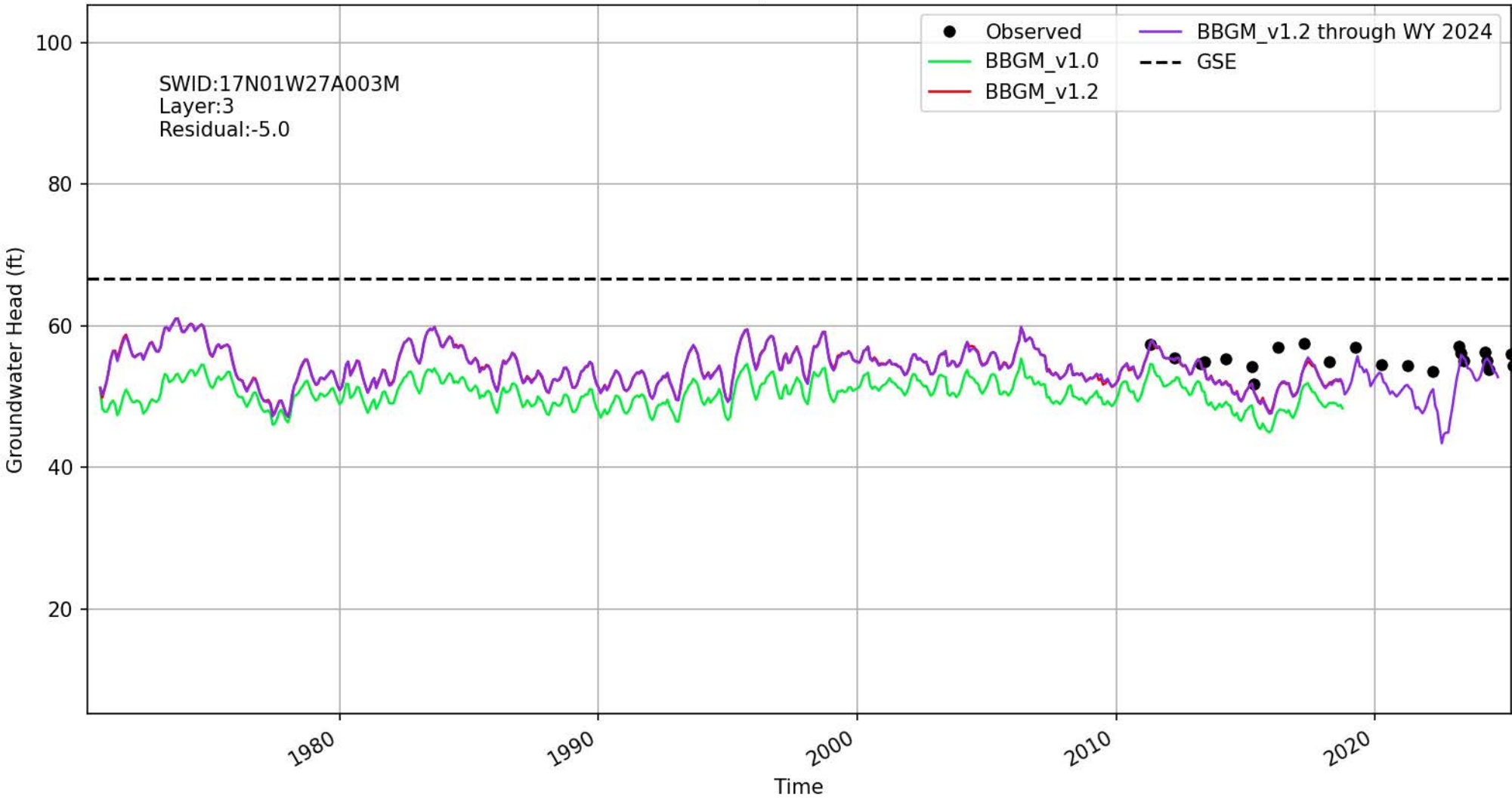


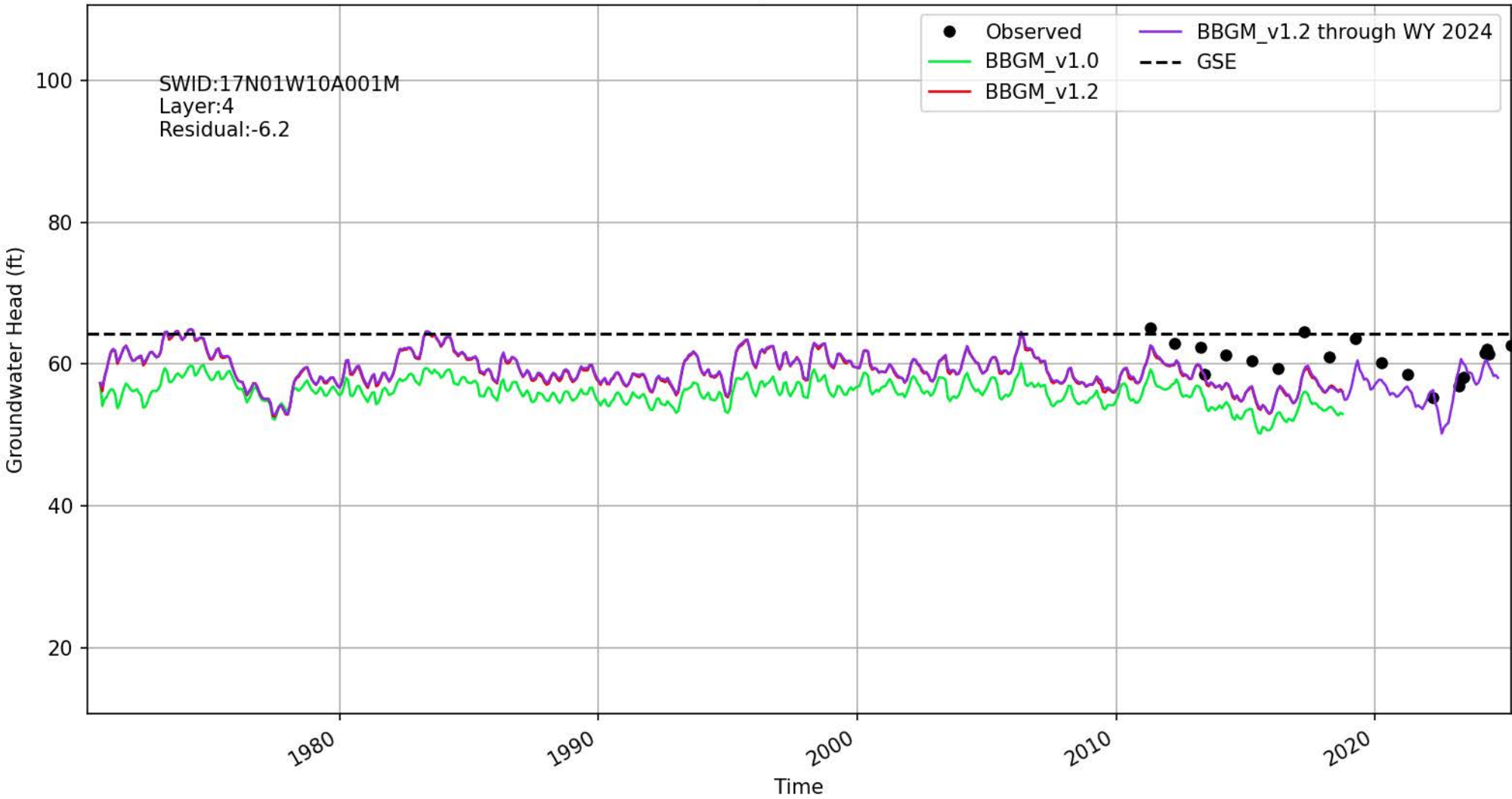
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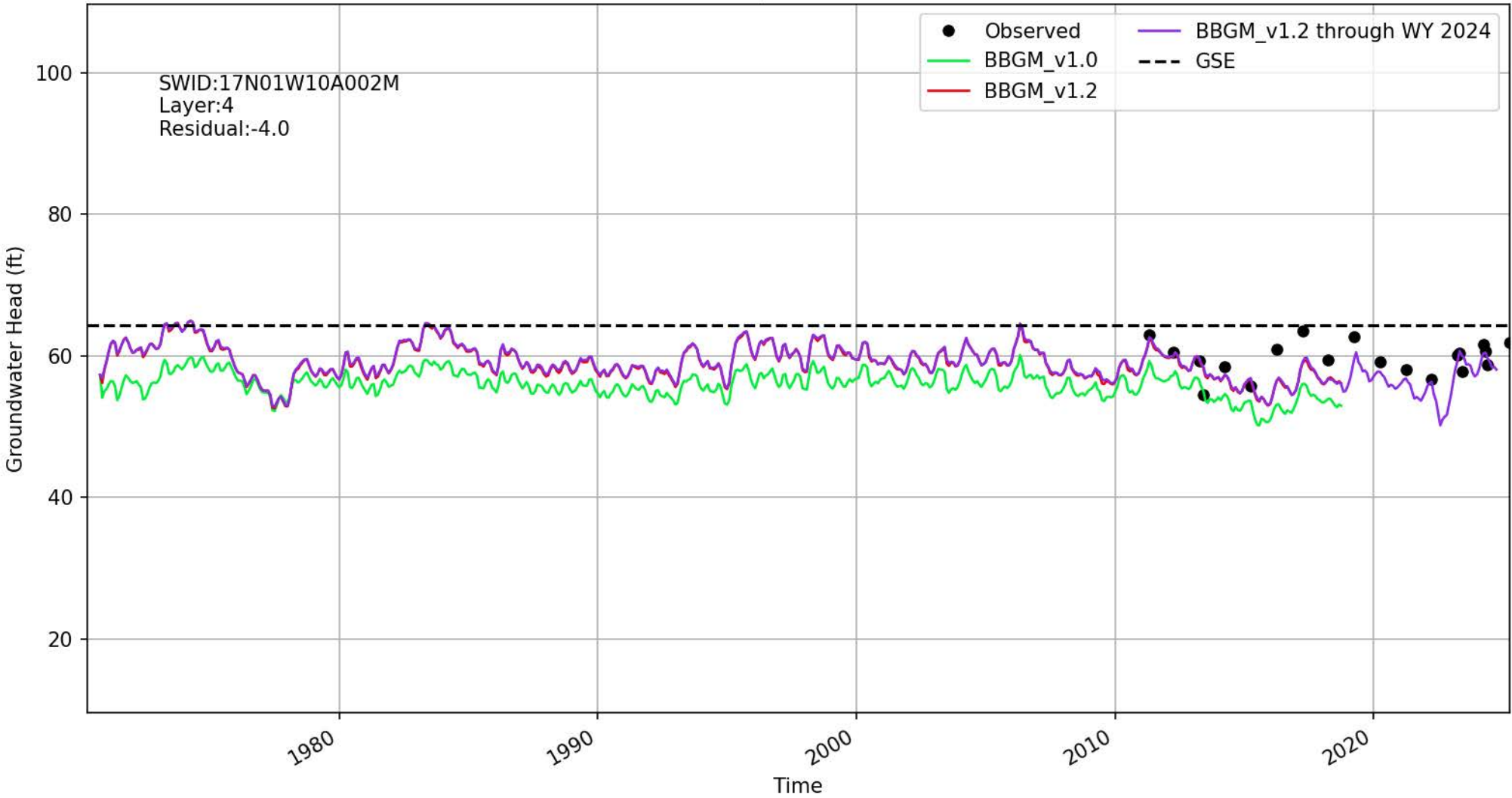


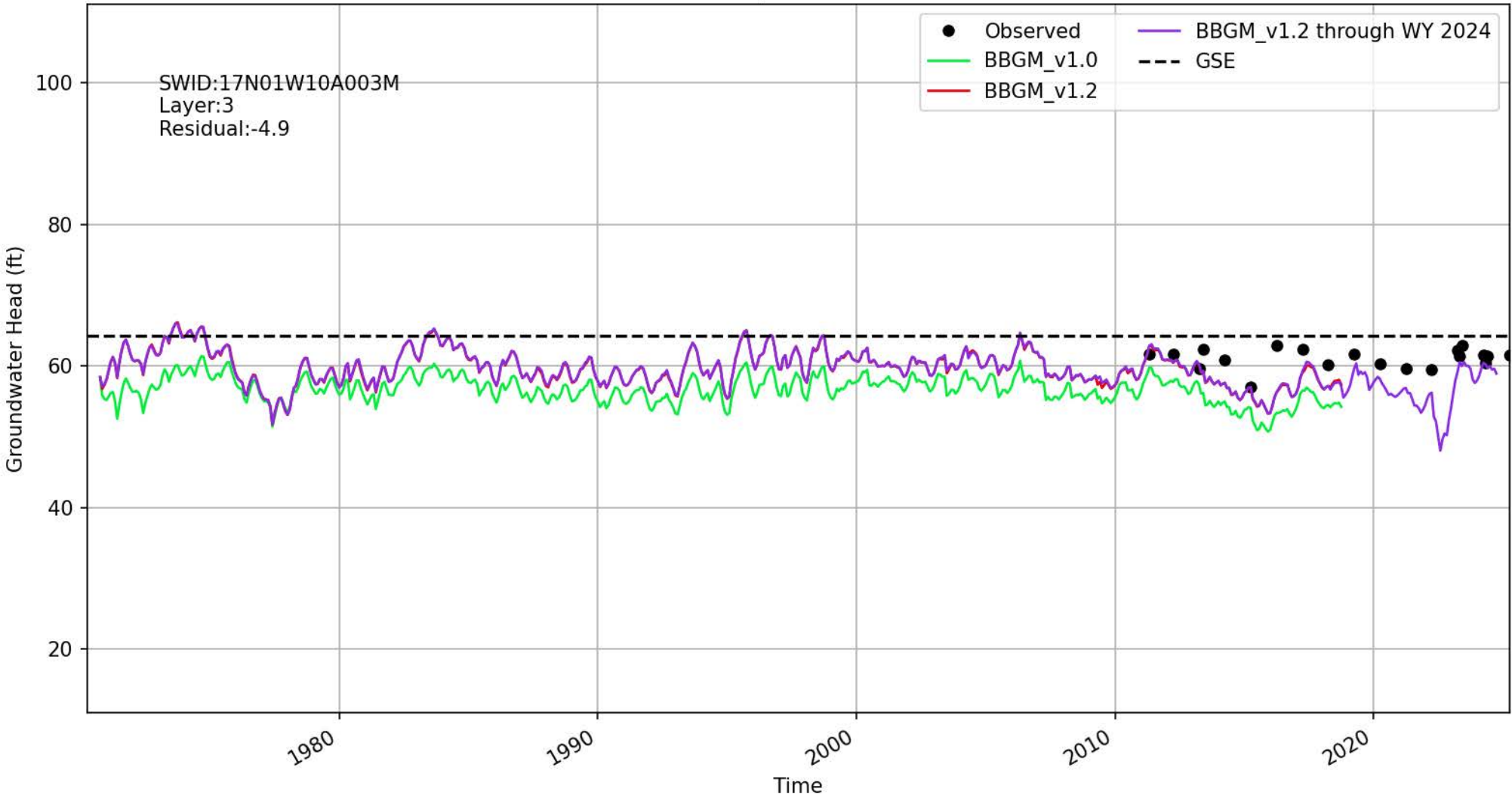


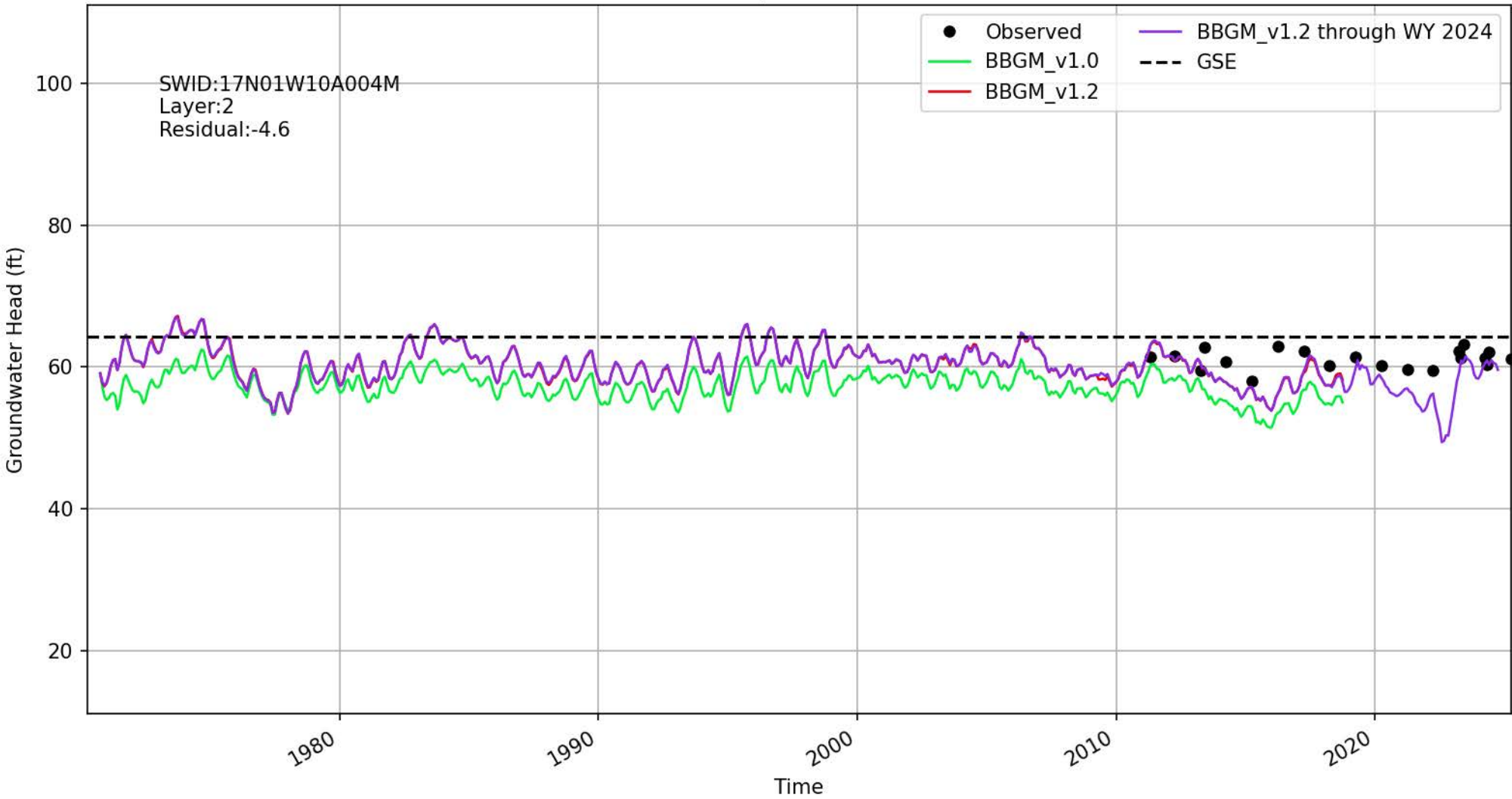


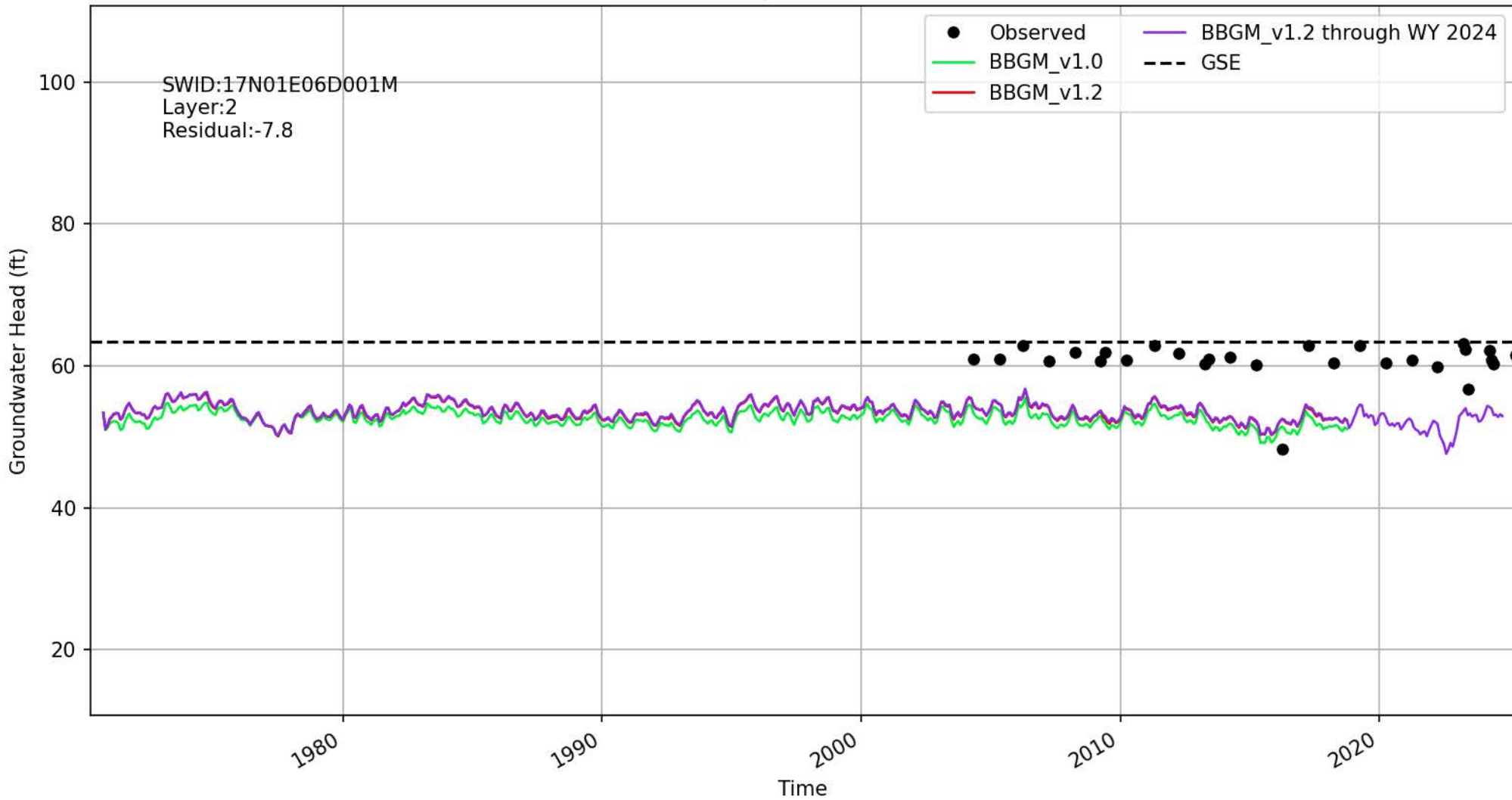


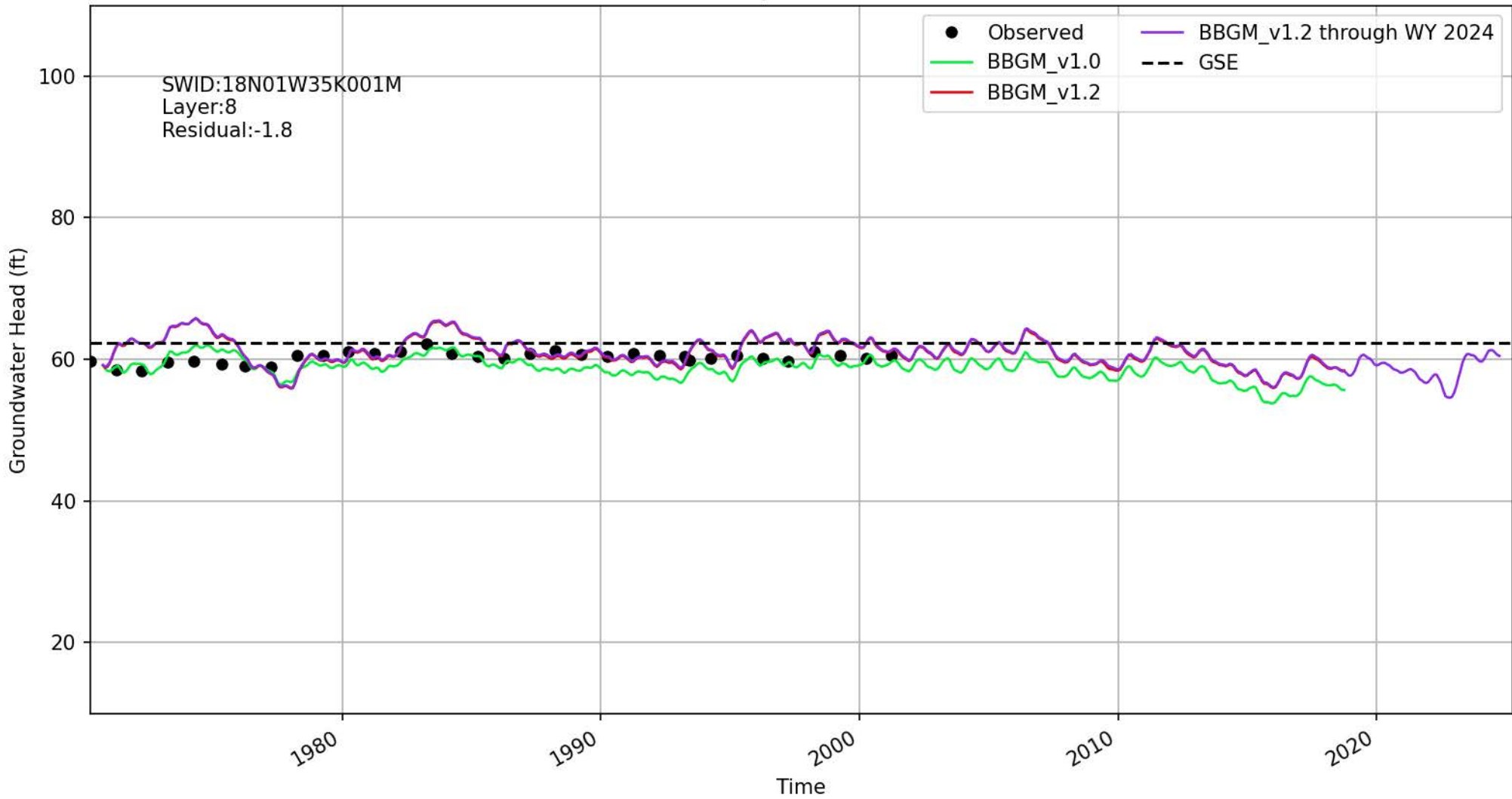


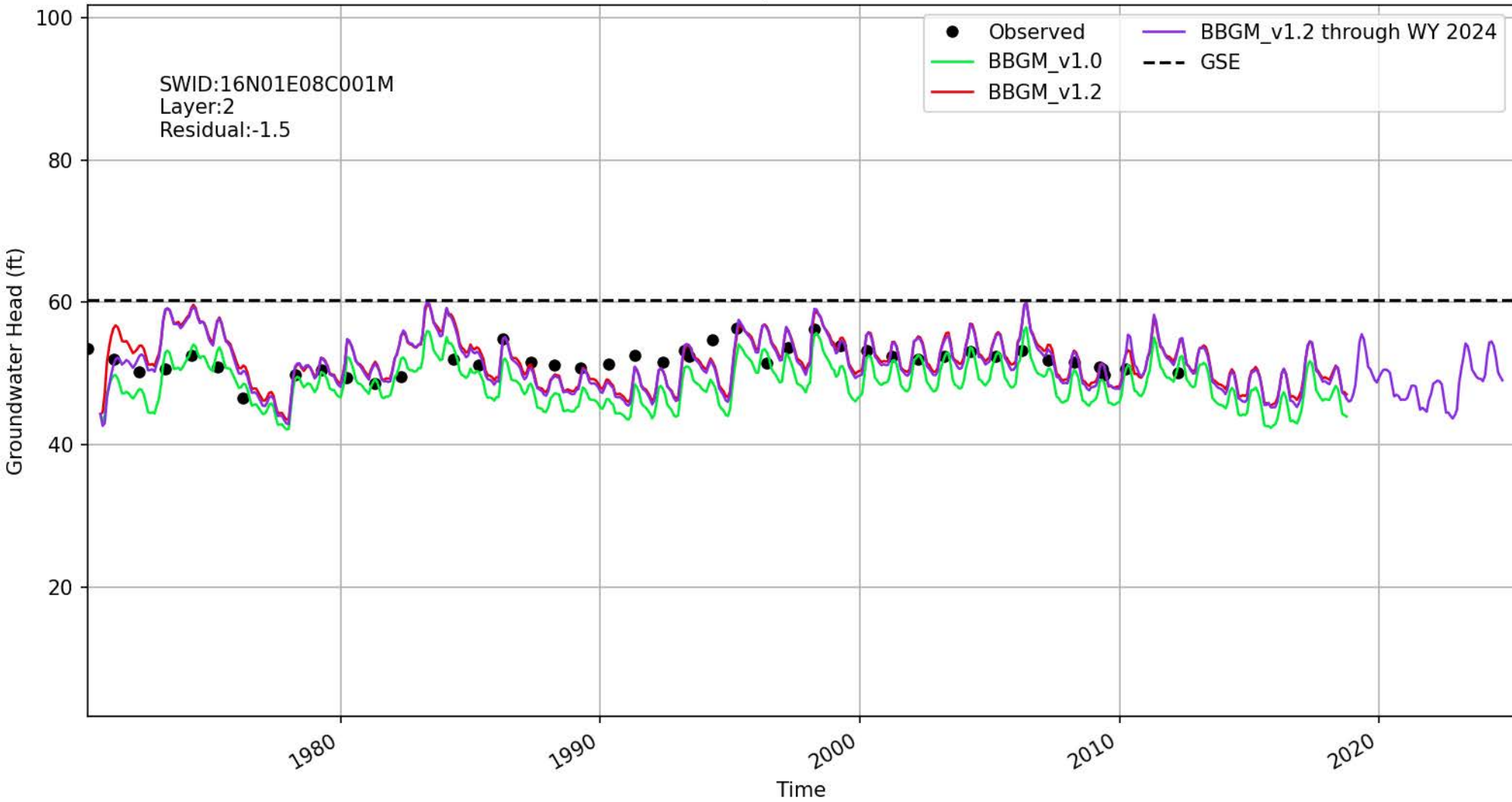


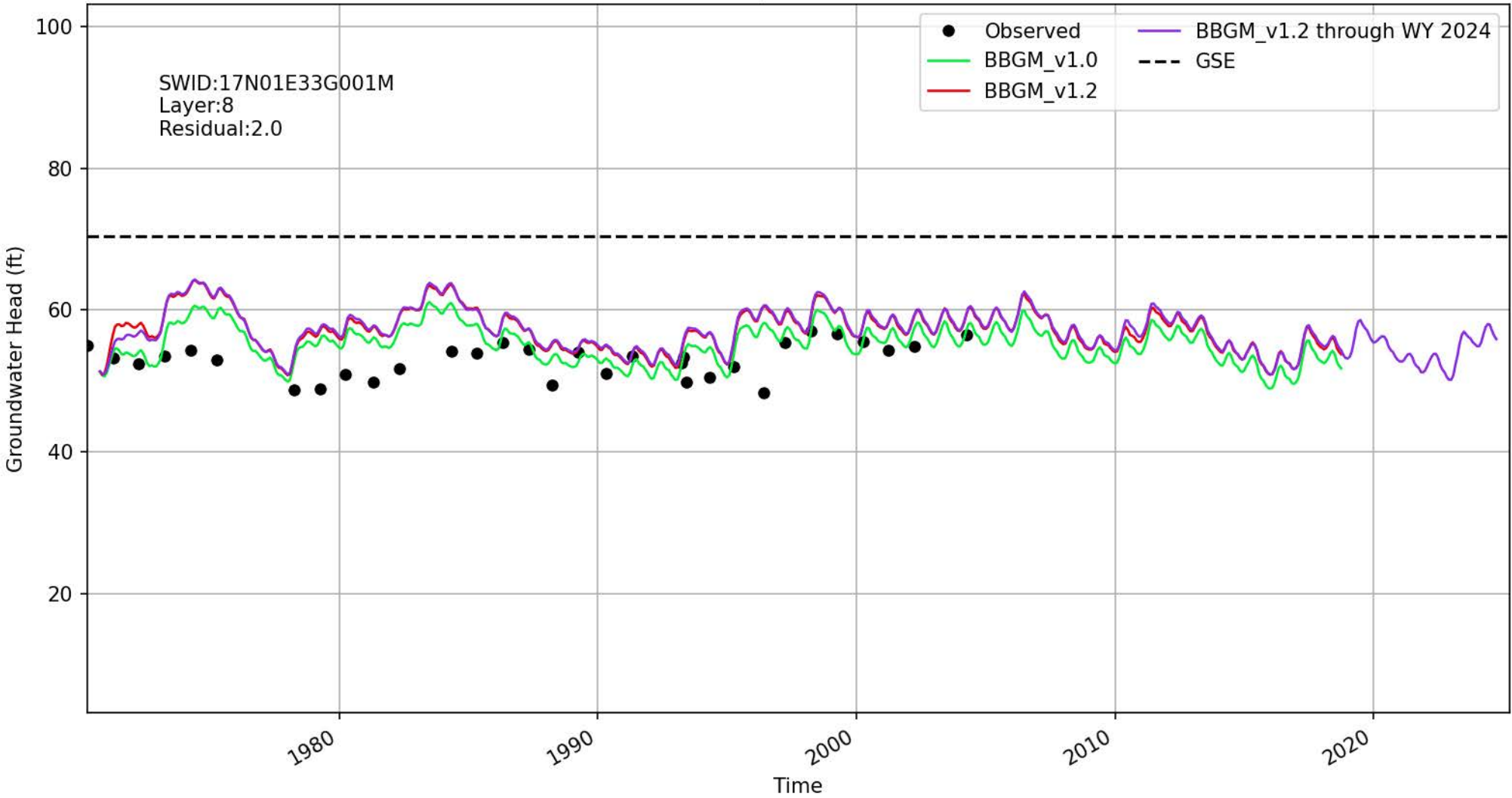


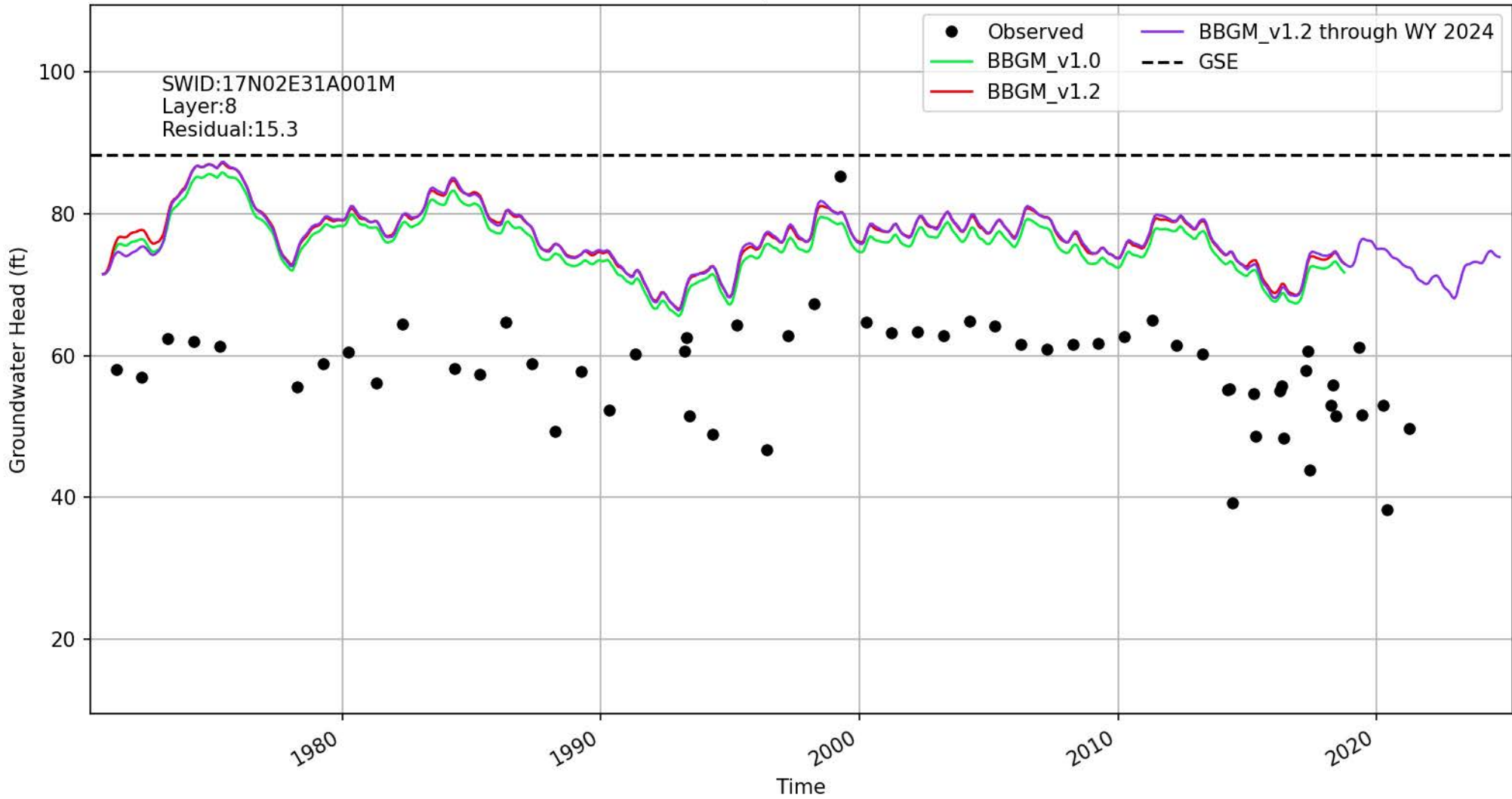


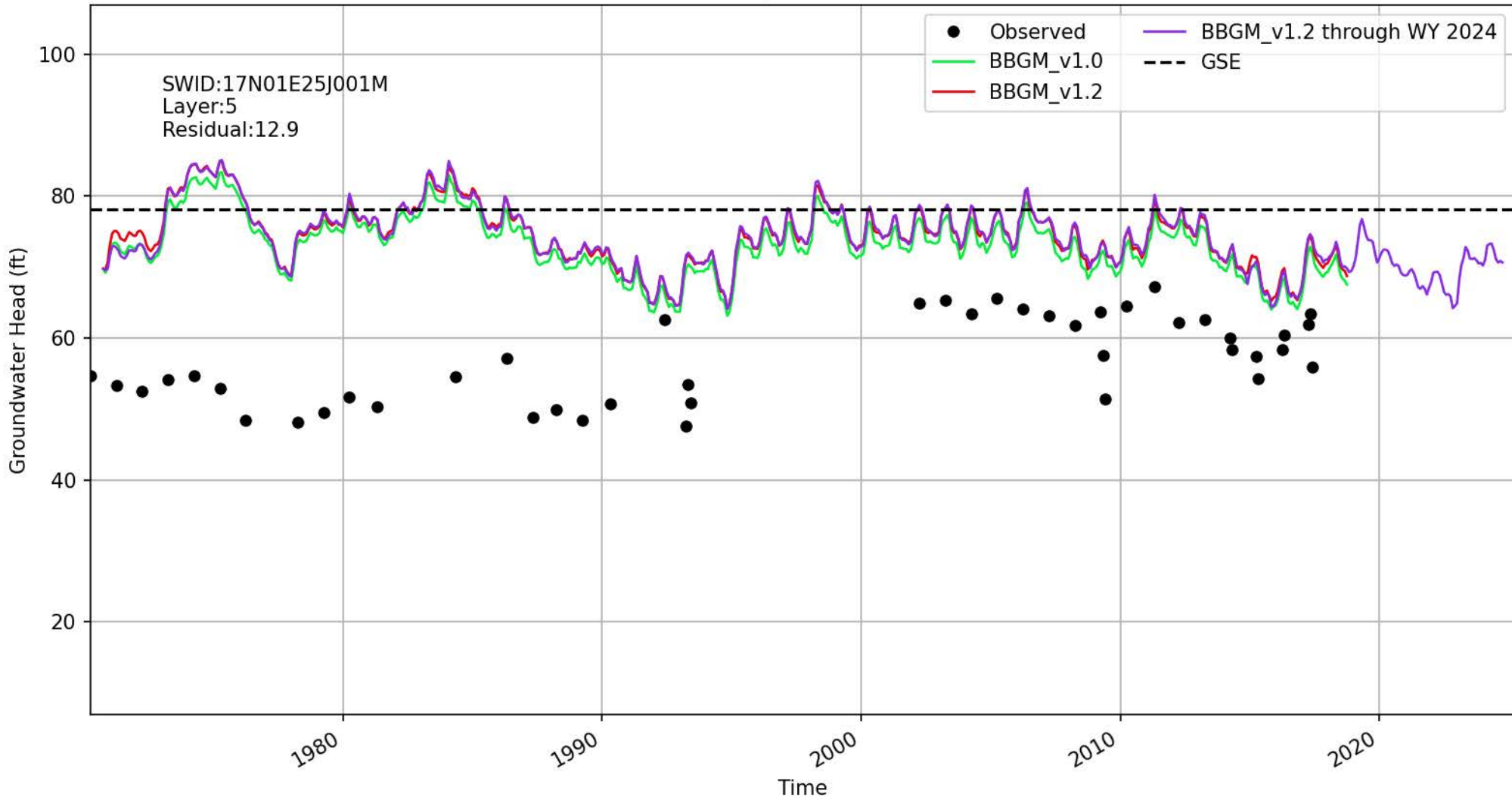


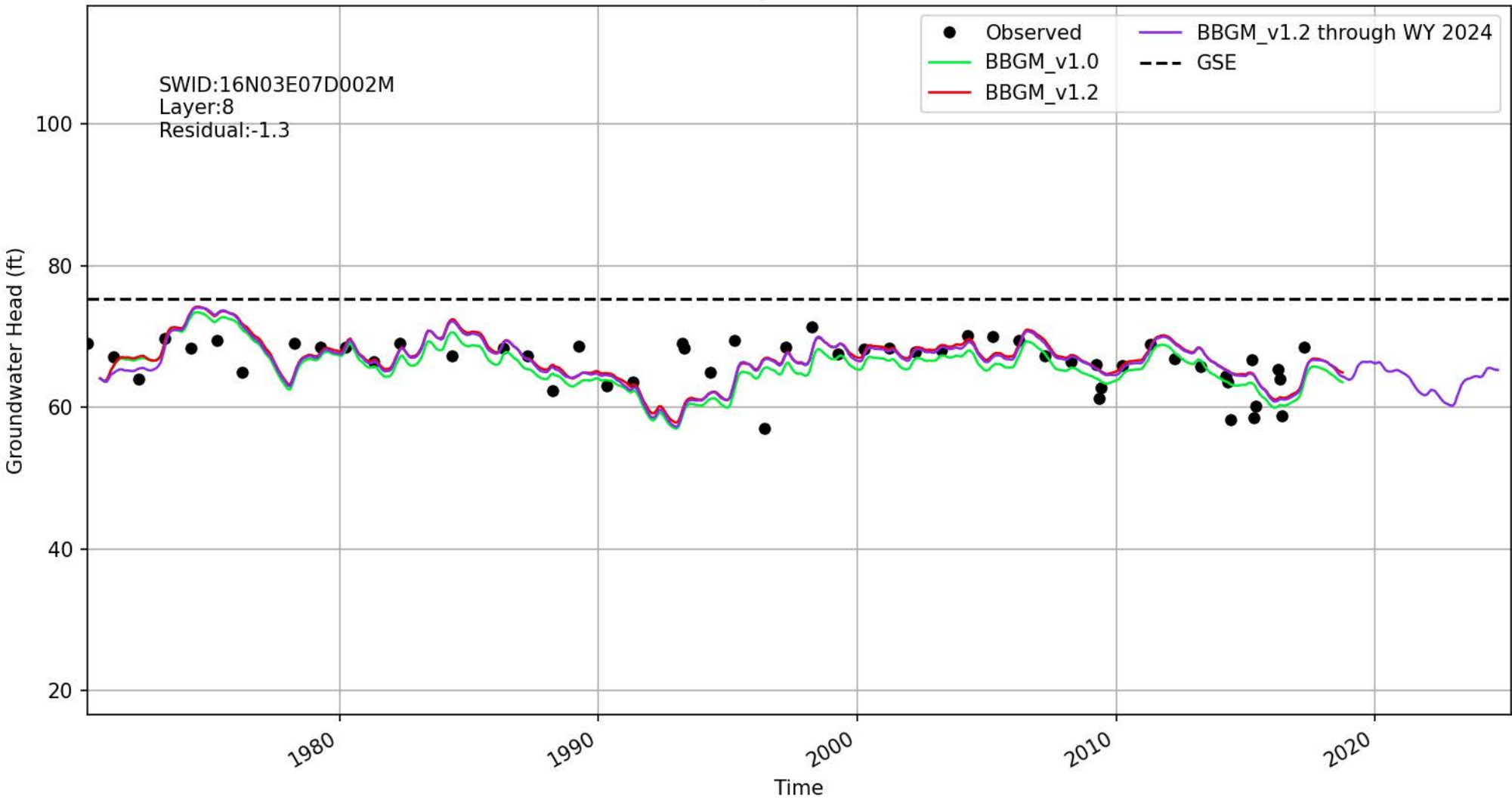


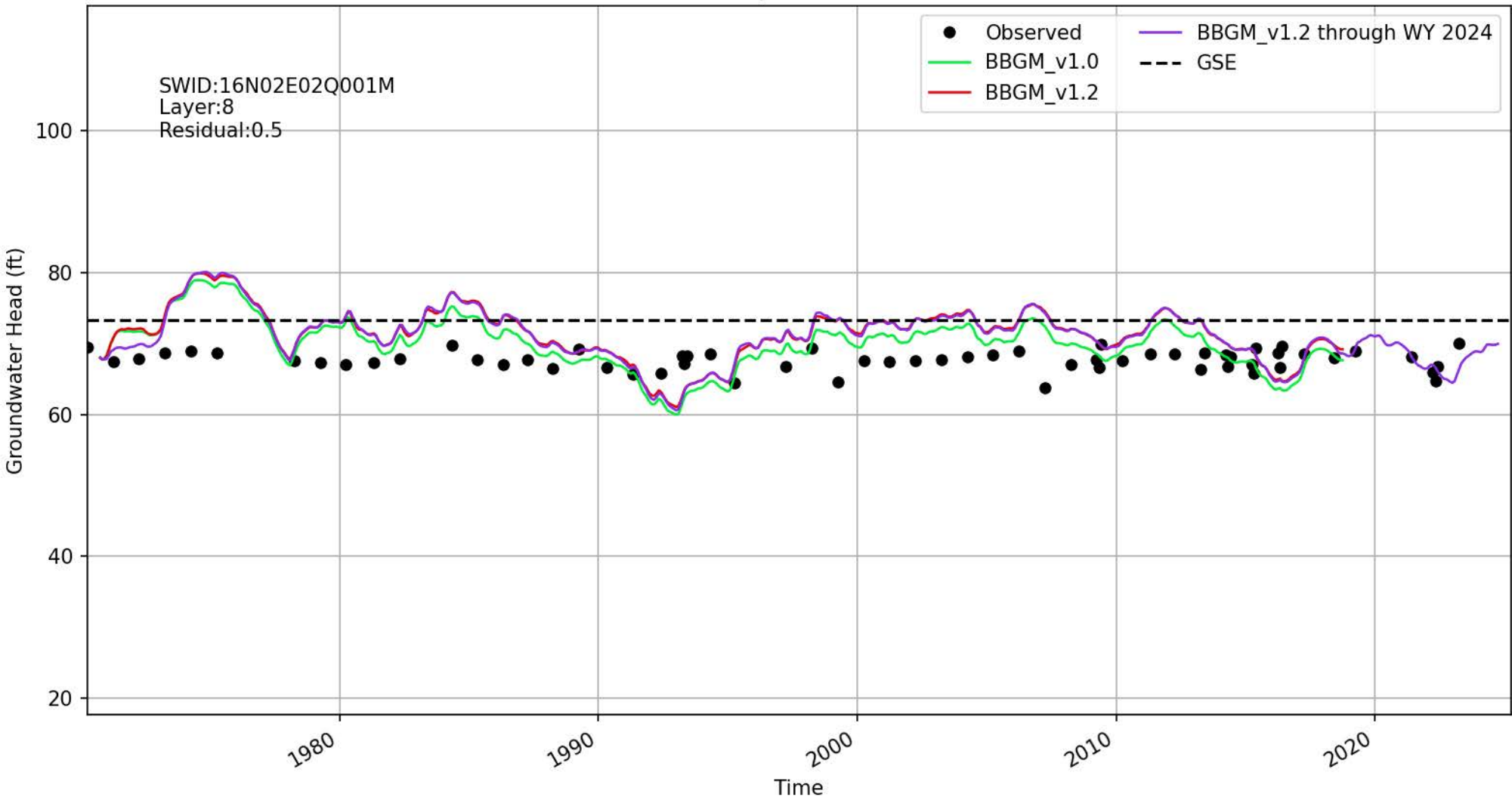




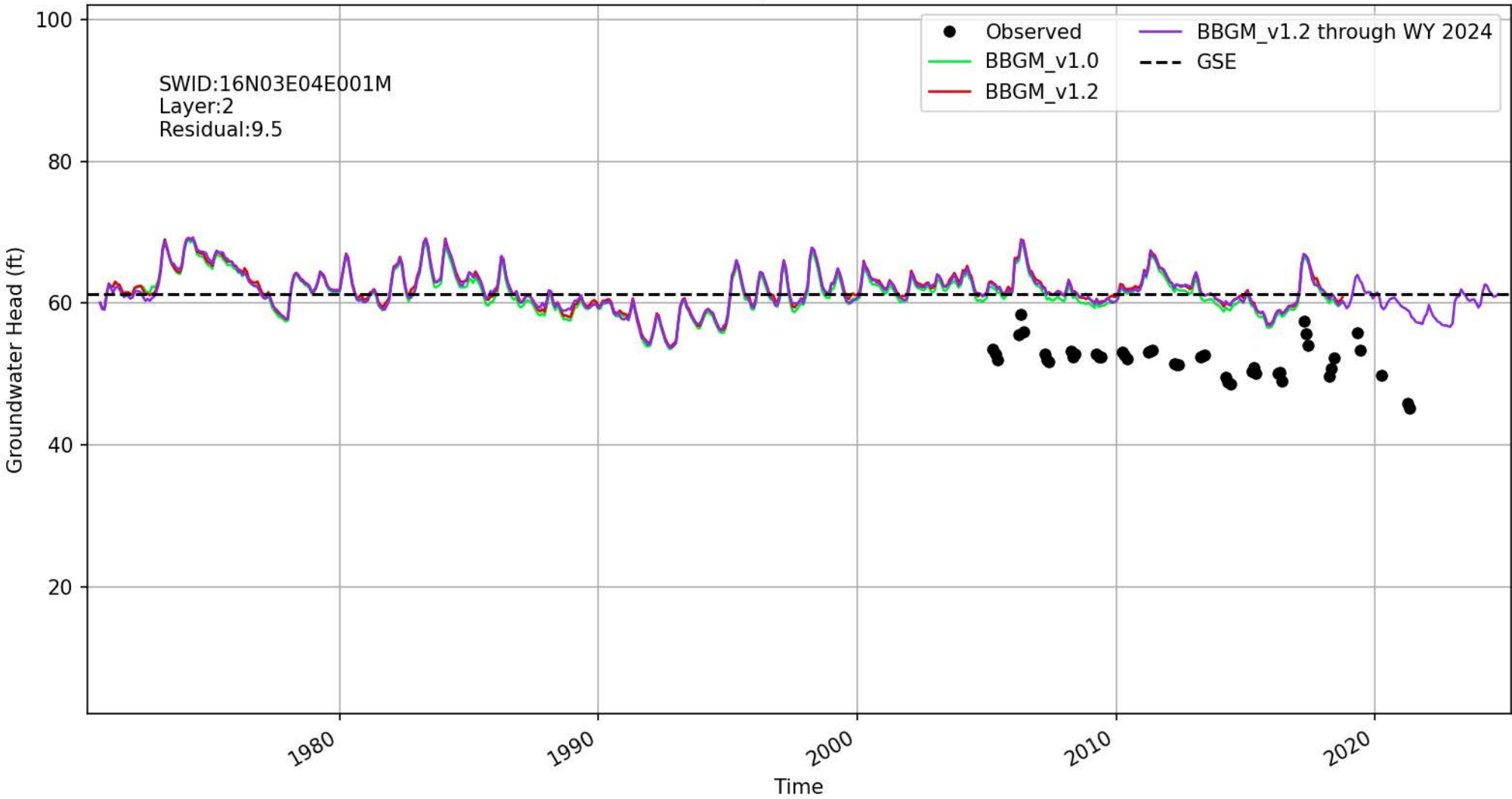


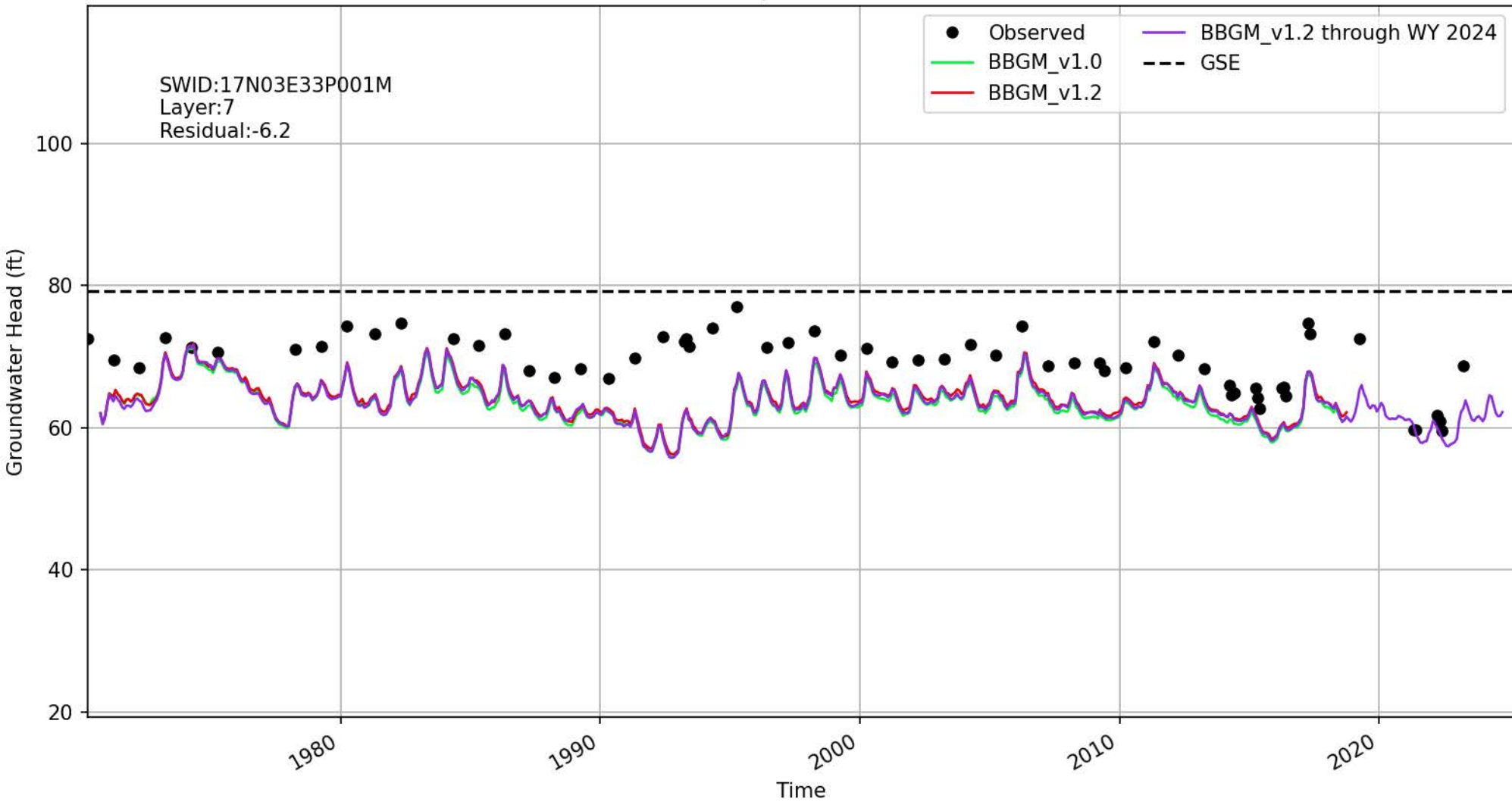


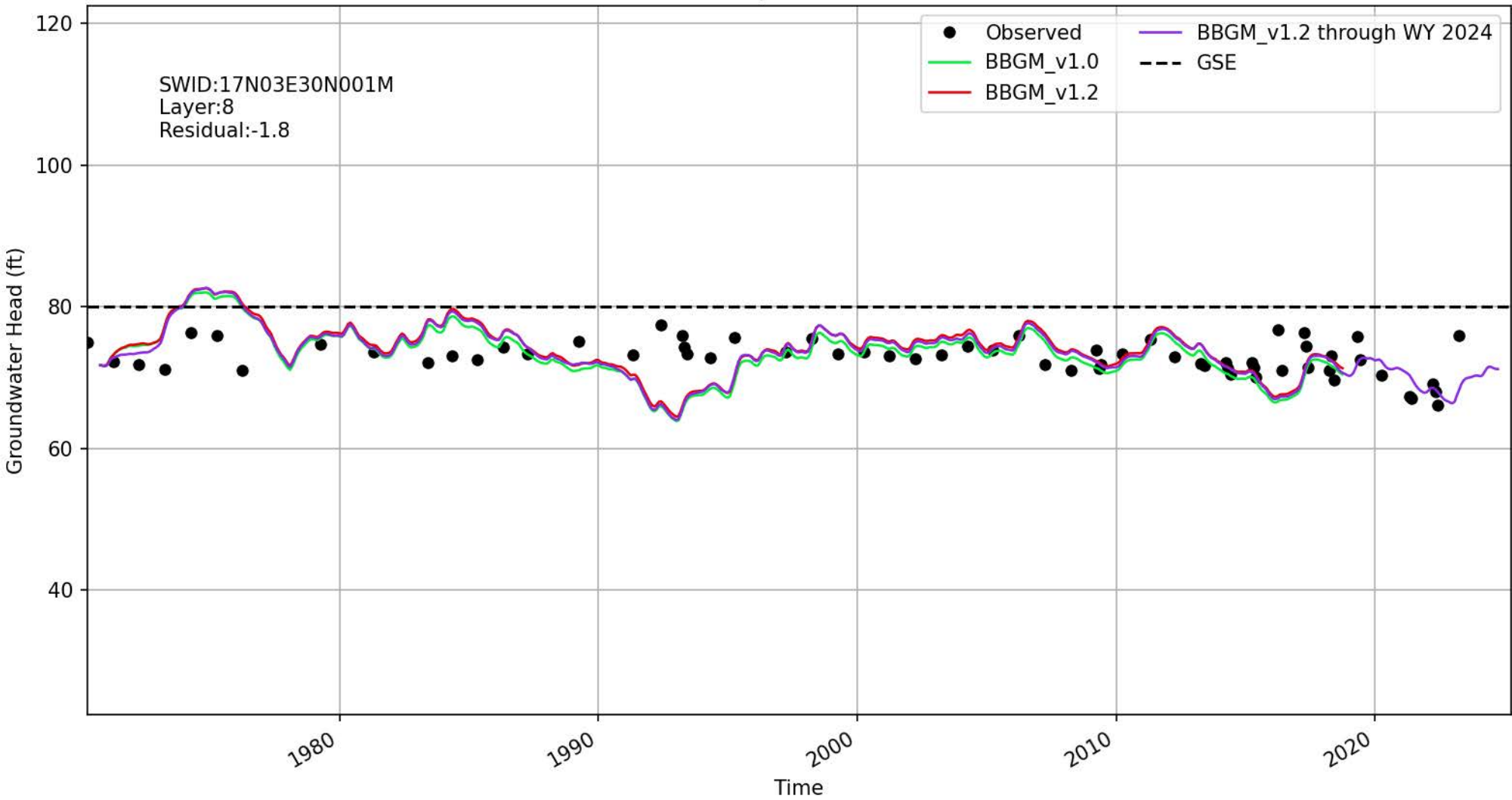


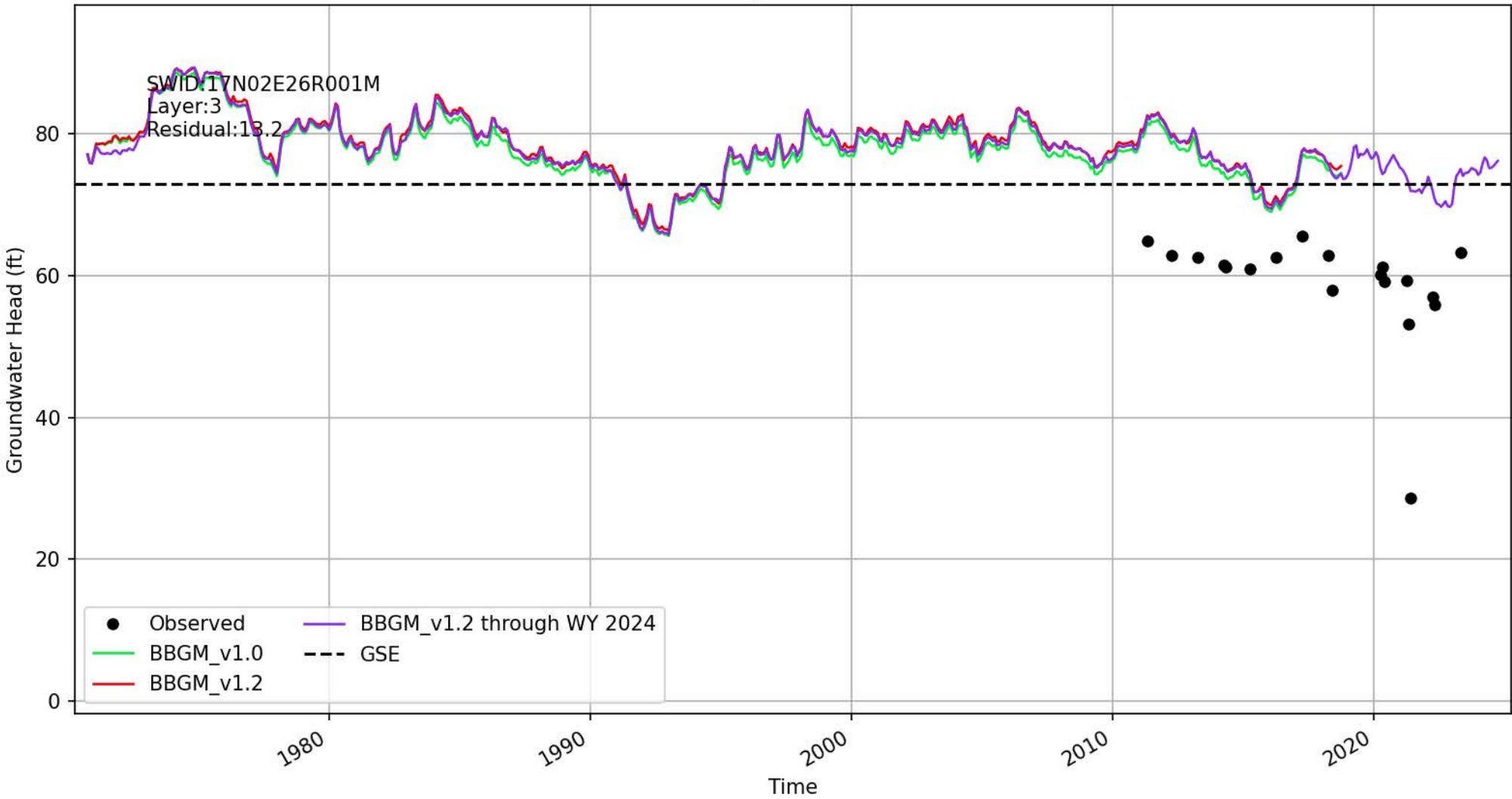


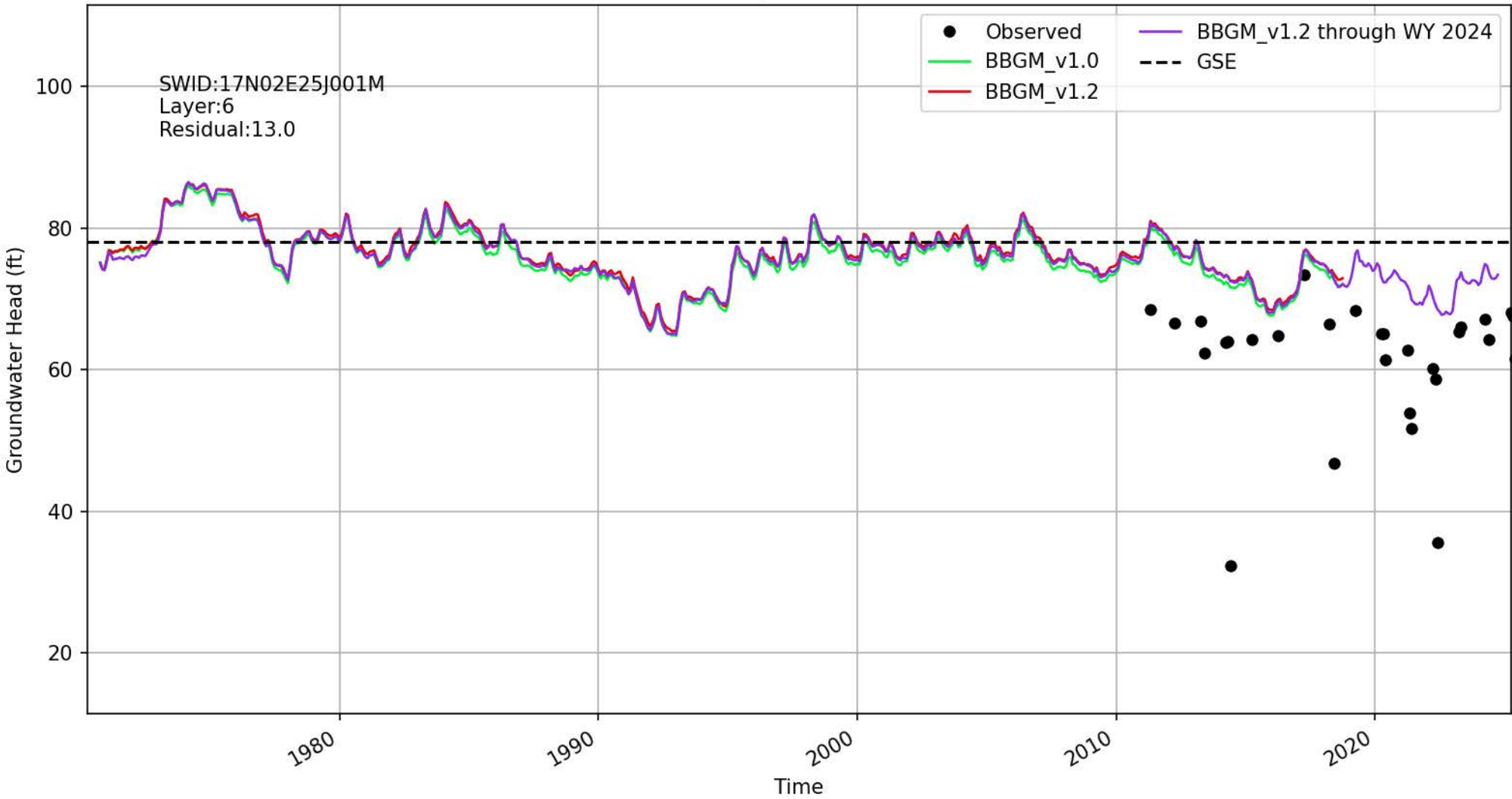
Location ID: 2403 | 392712N1216493W001

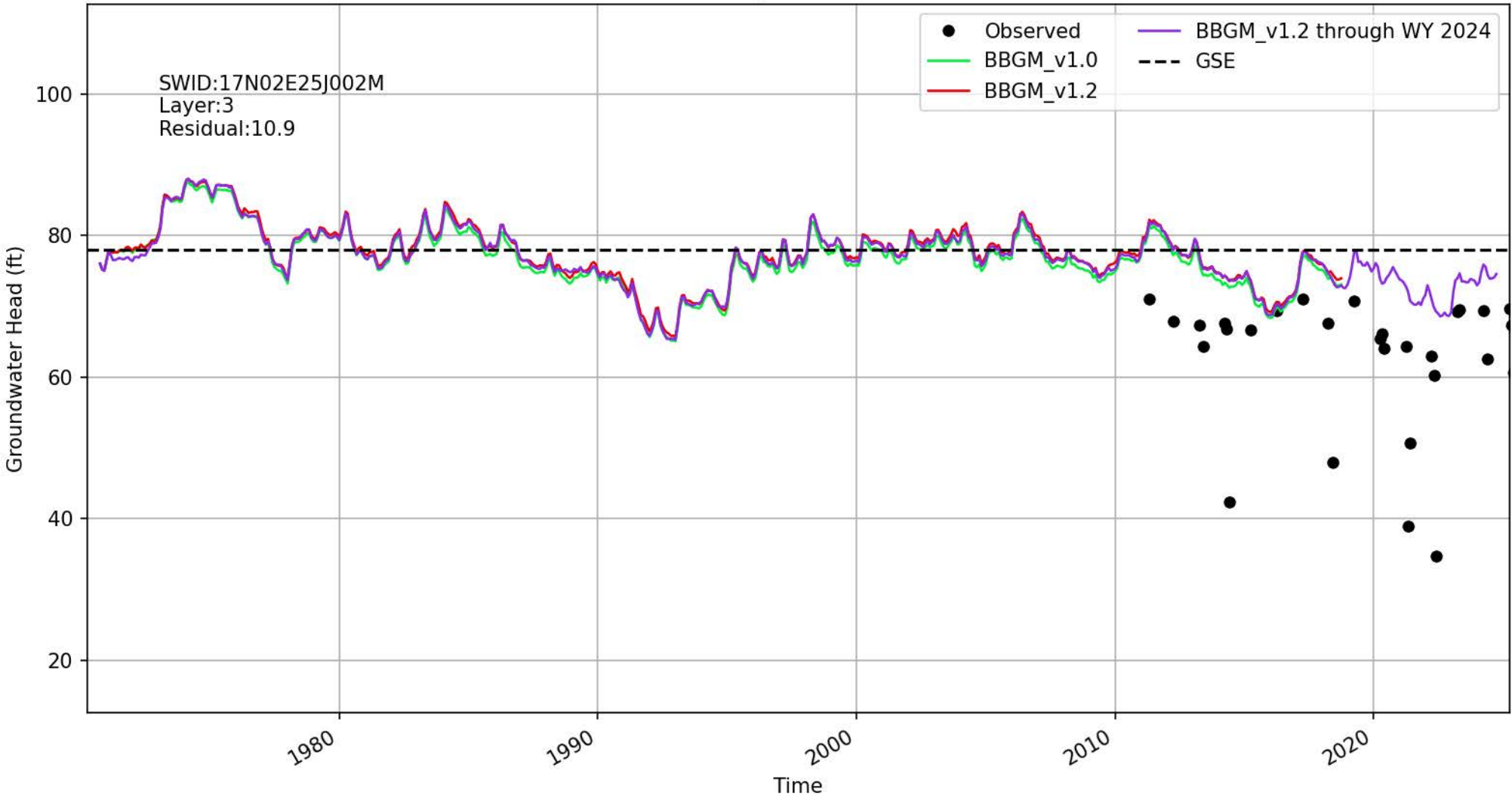


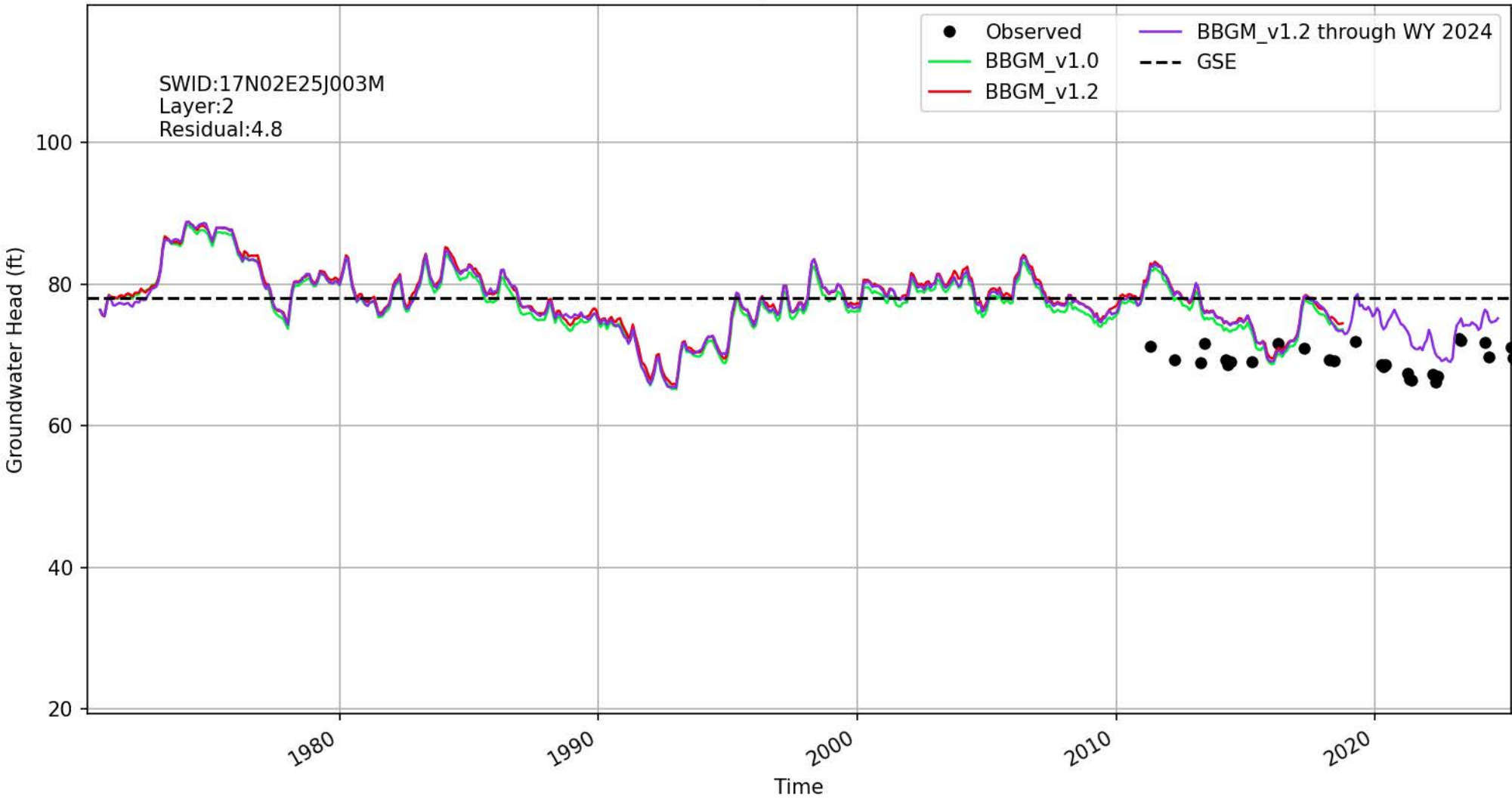


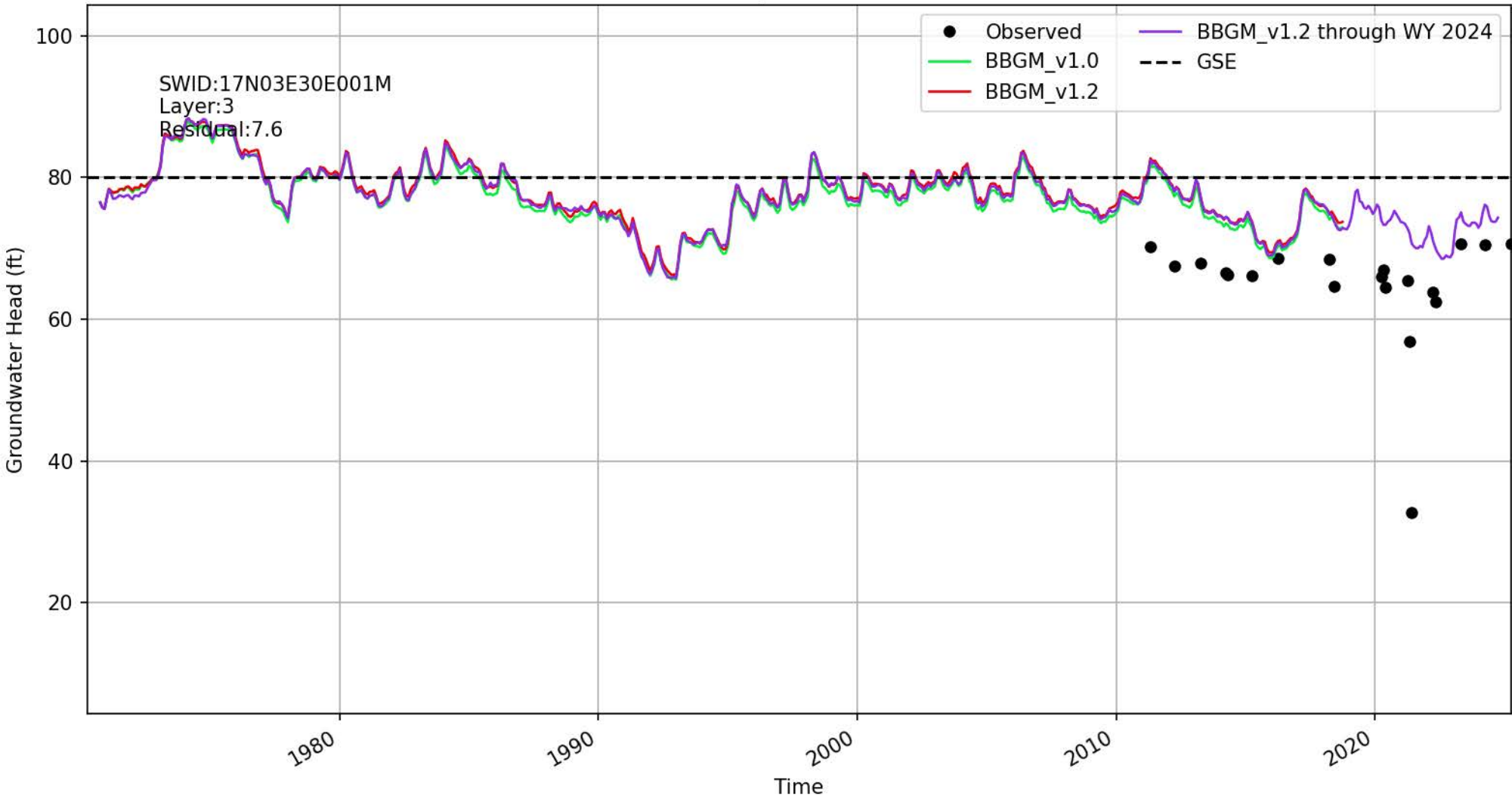


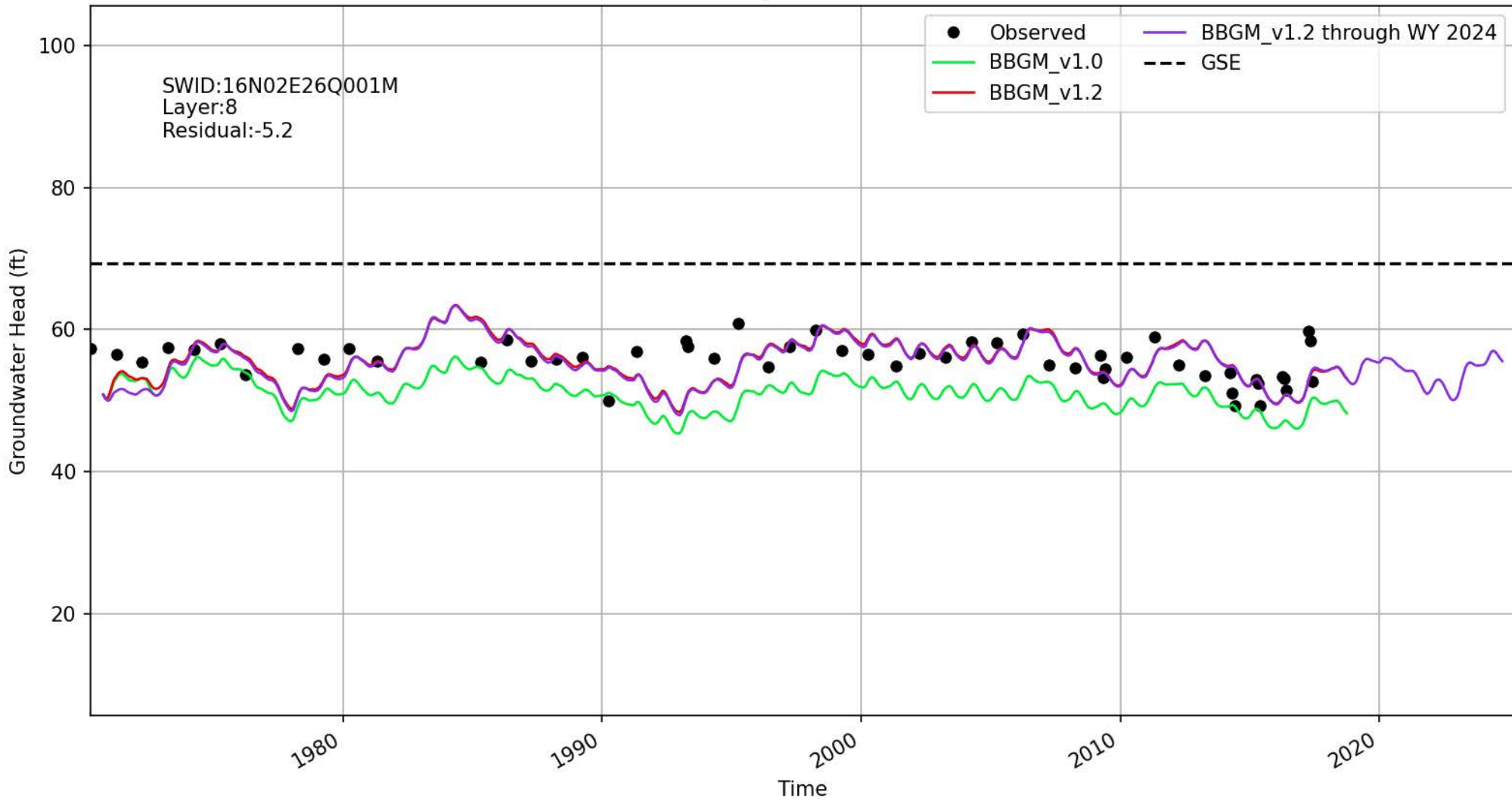


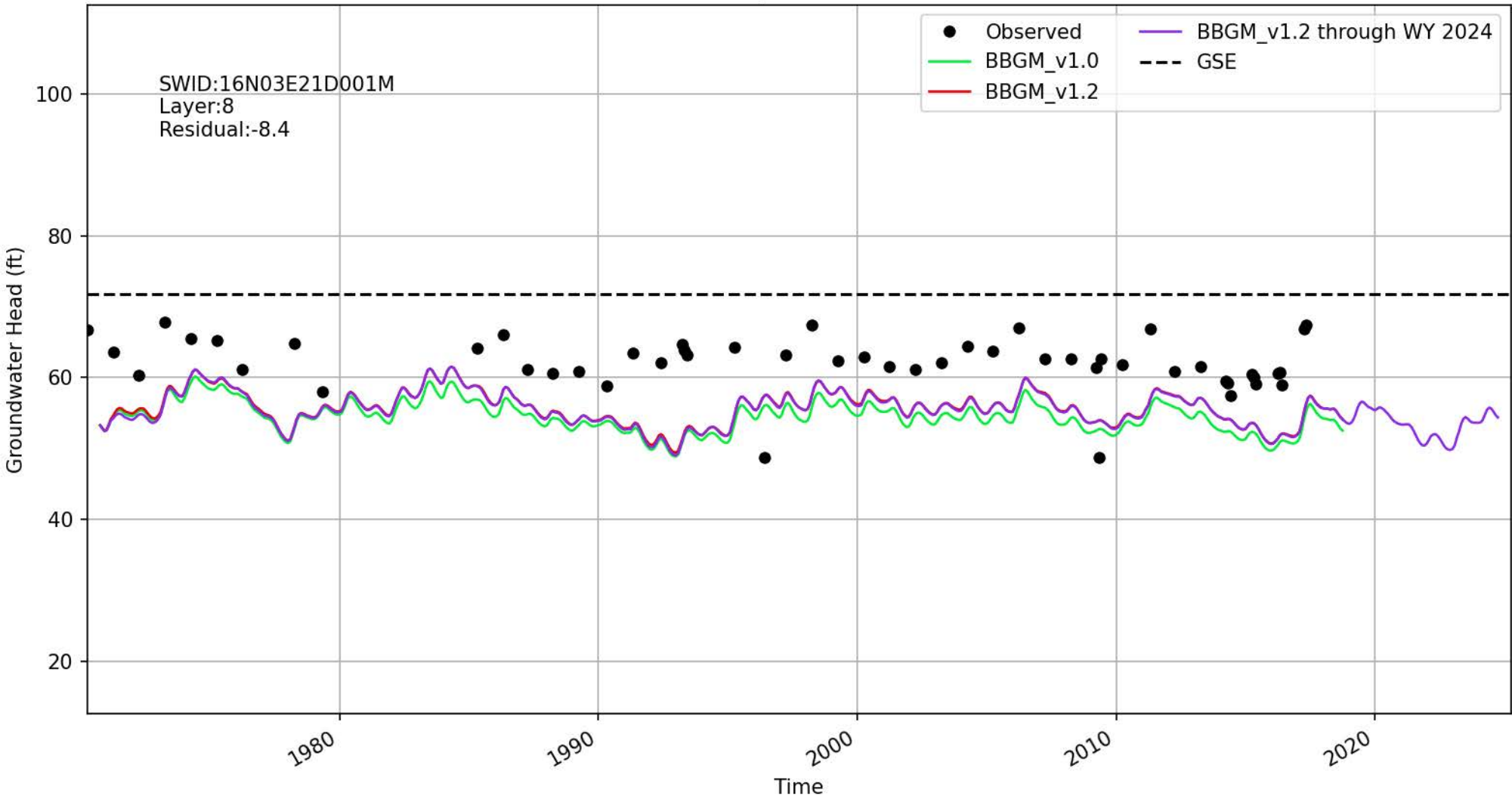


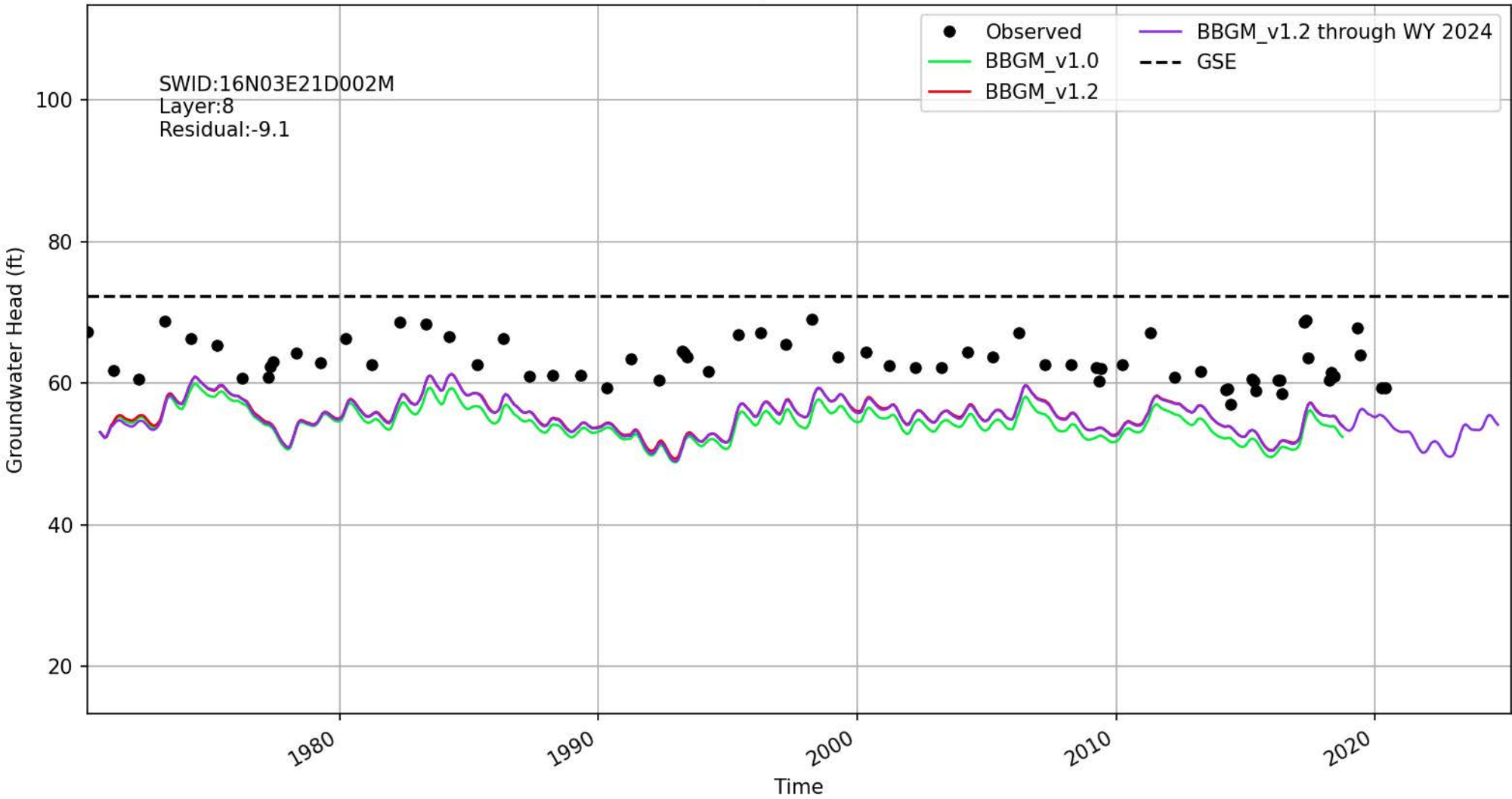


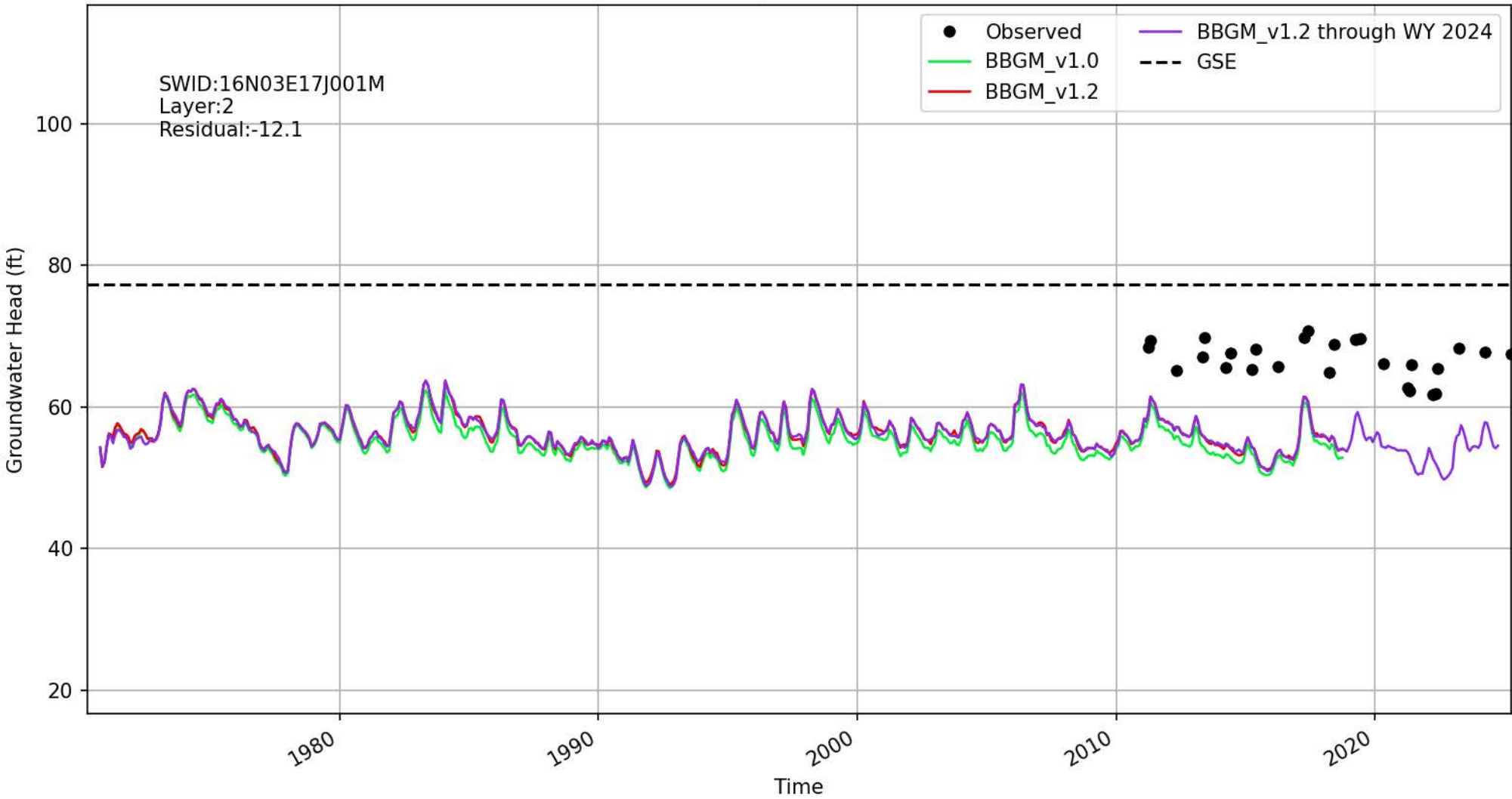


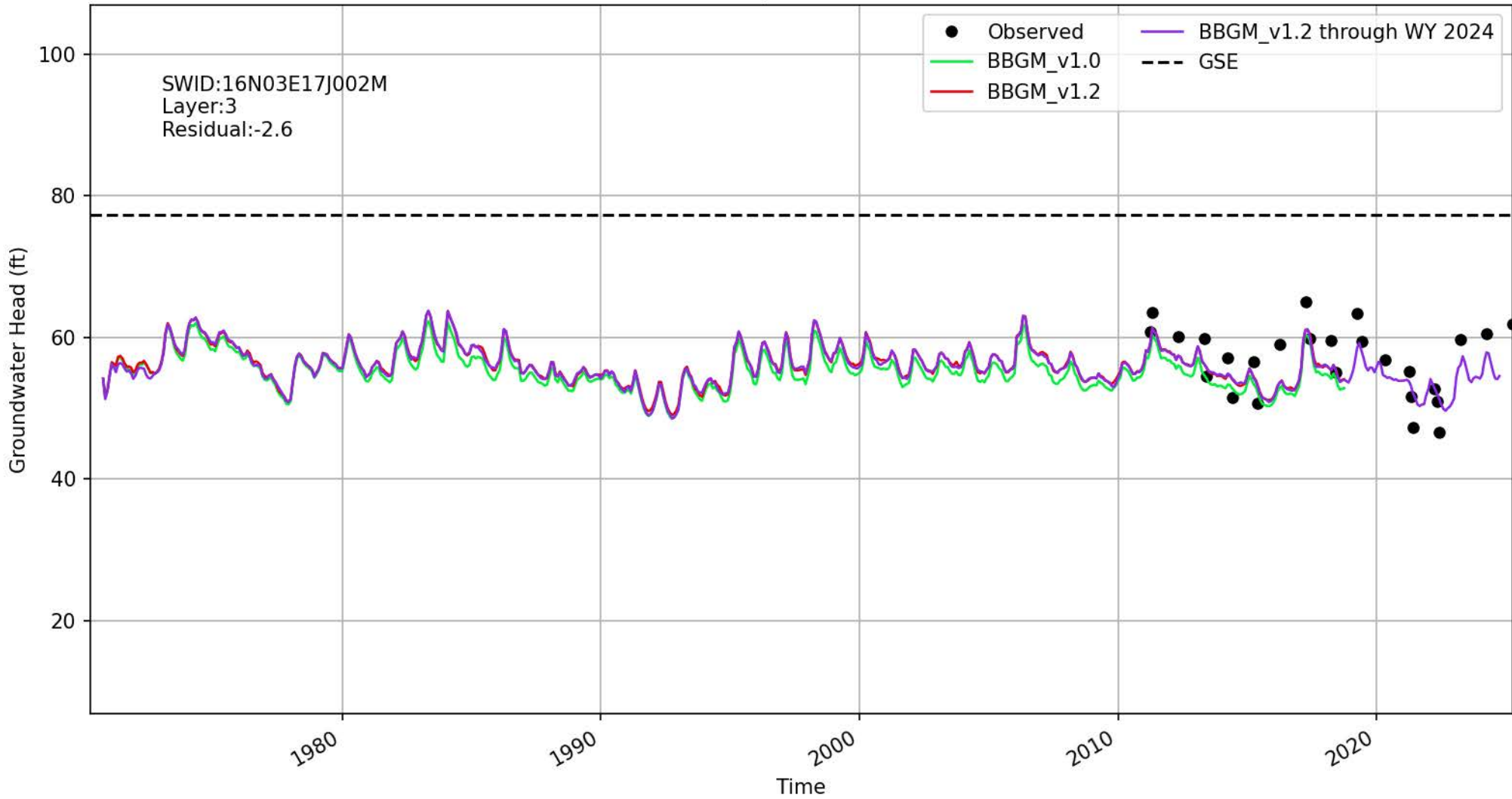


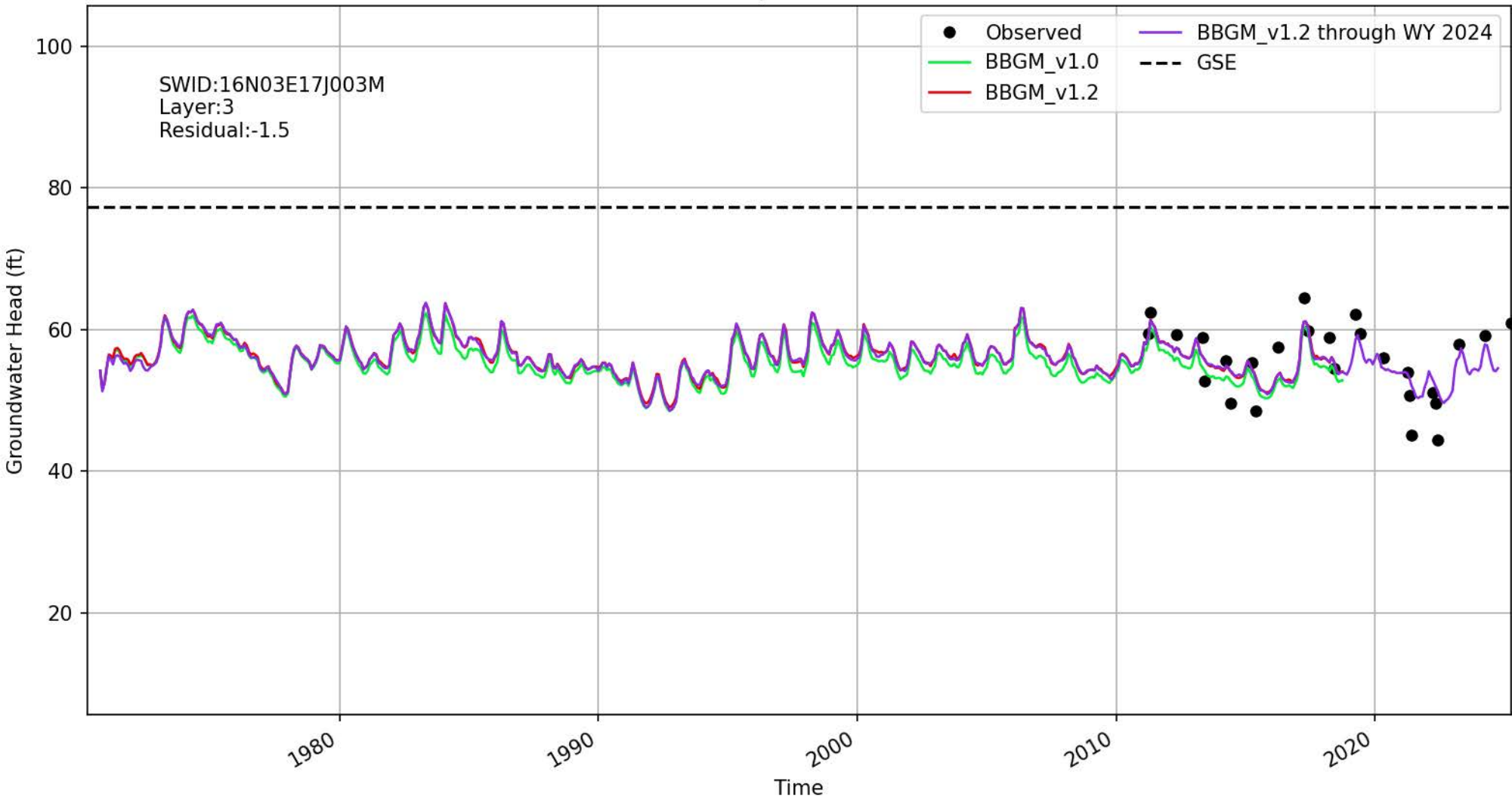


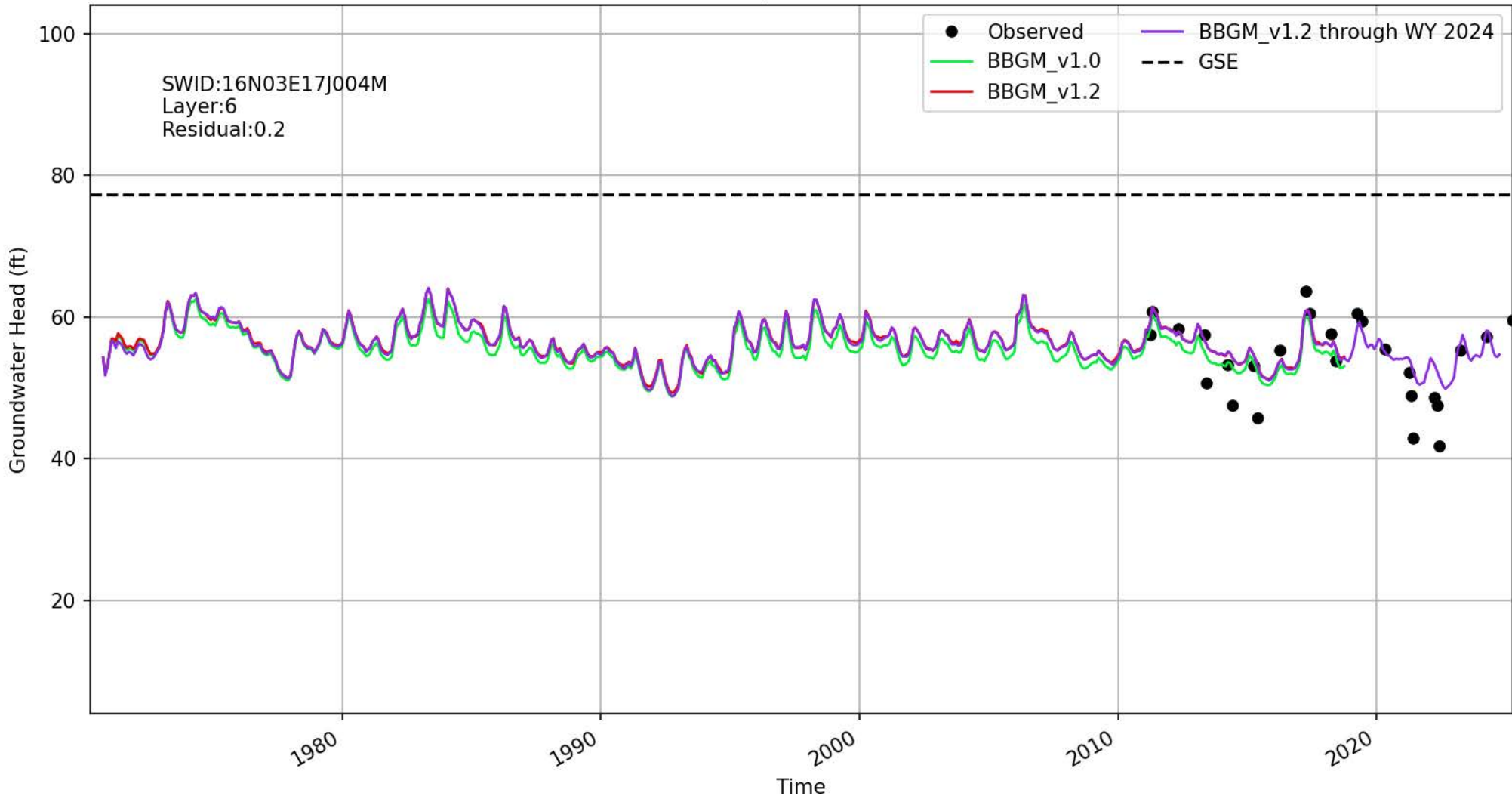


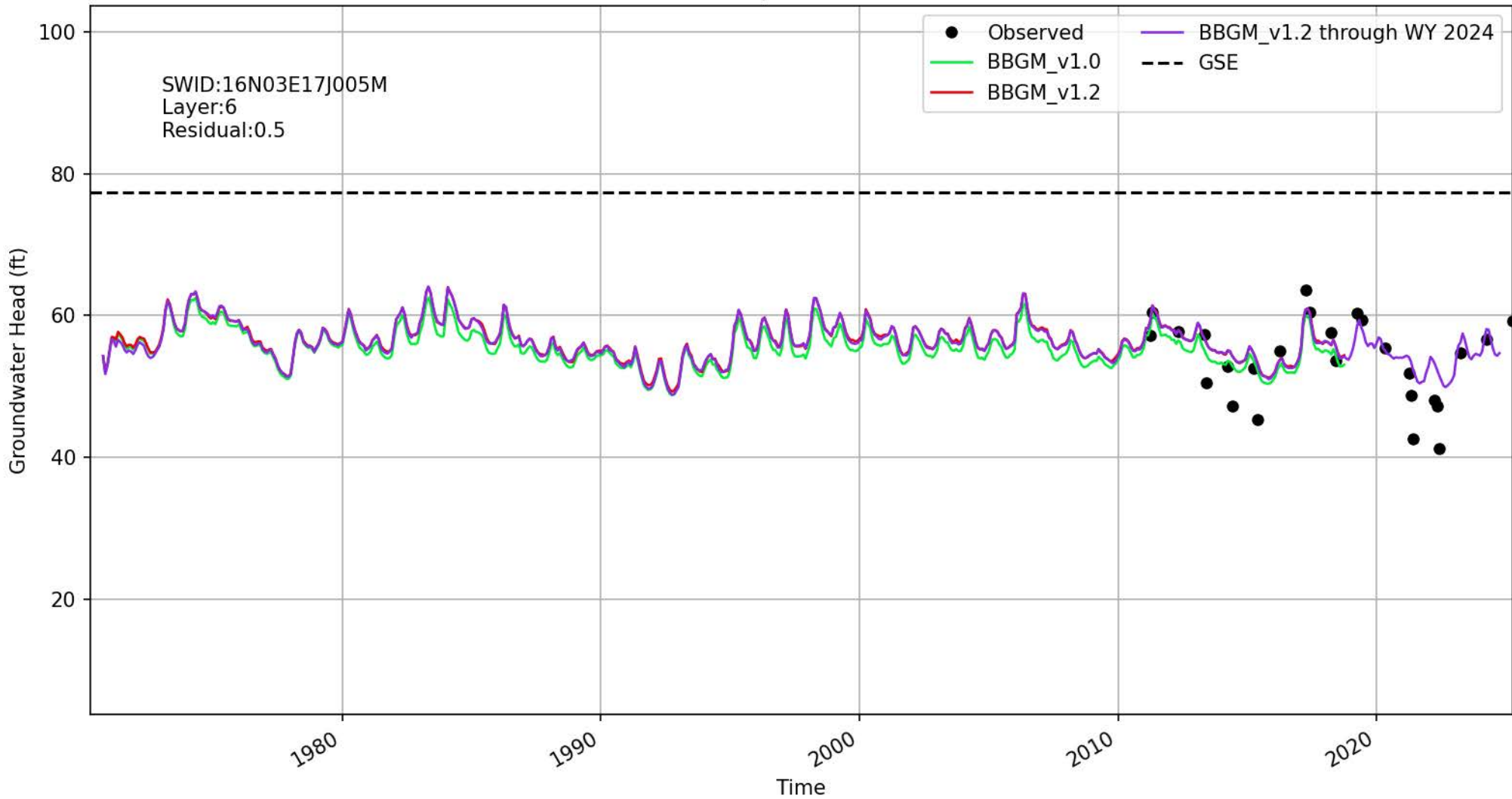












Location ID: 2701 | 391851N1216691W001

SWID:15N03E05D002M
Layer:2
Residual:-3.4

- Observed
- BBGM_v1.0
- BBGM_v1.2
- GSE
- BBGM_v1.2 through WY 2024

Groundwater Head (ft)

80
60
40
20
0

1980

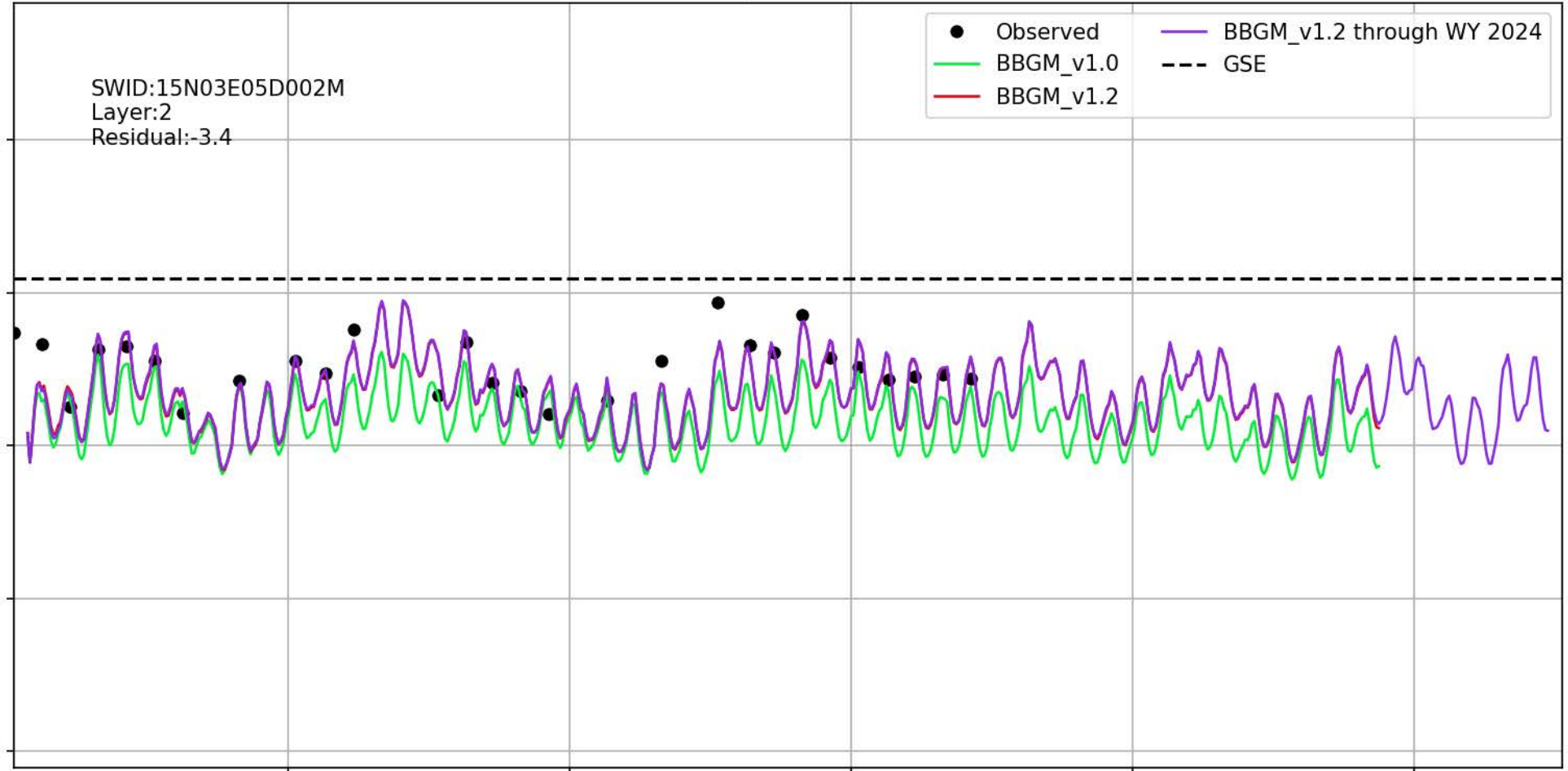
1990

2000

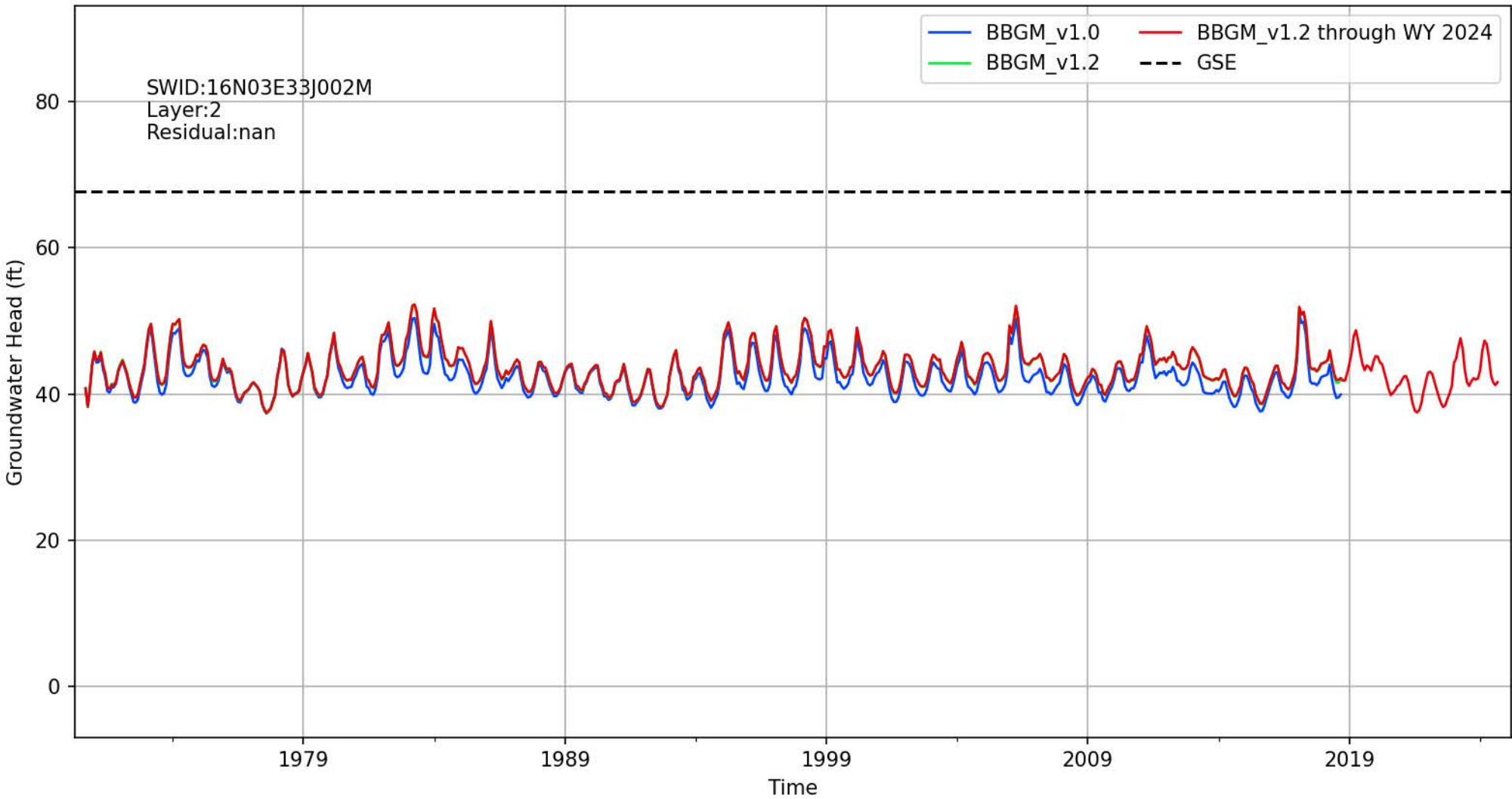
2010

2020

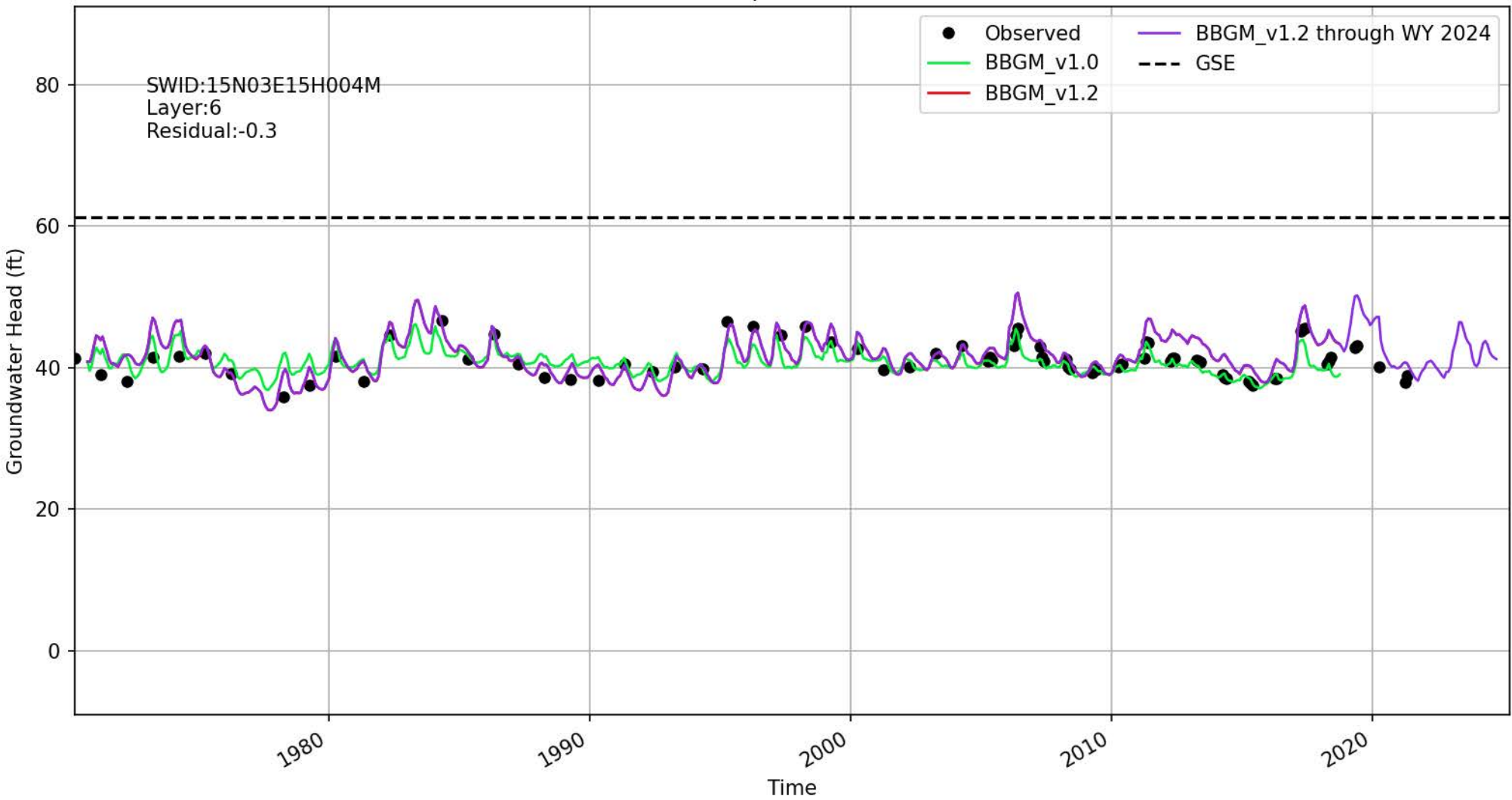
Time



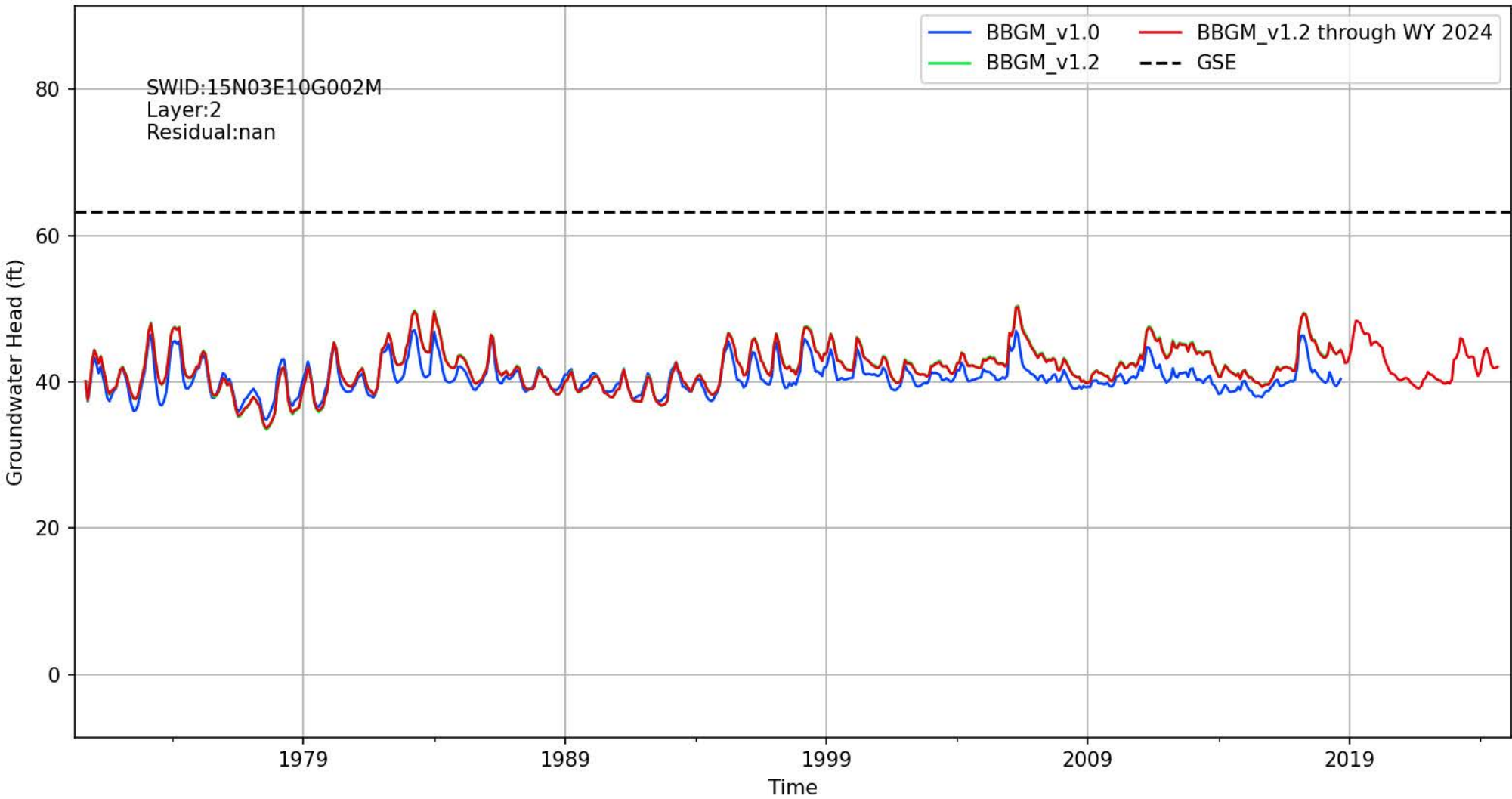
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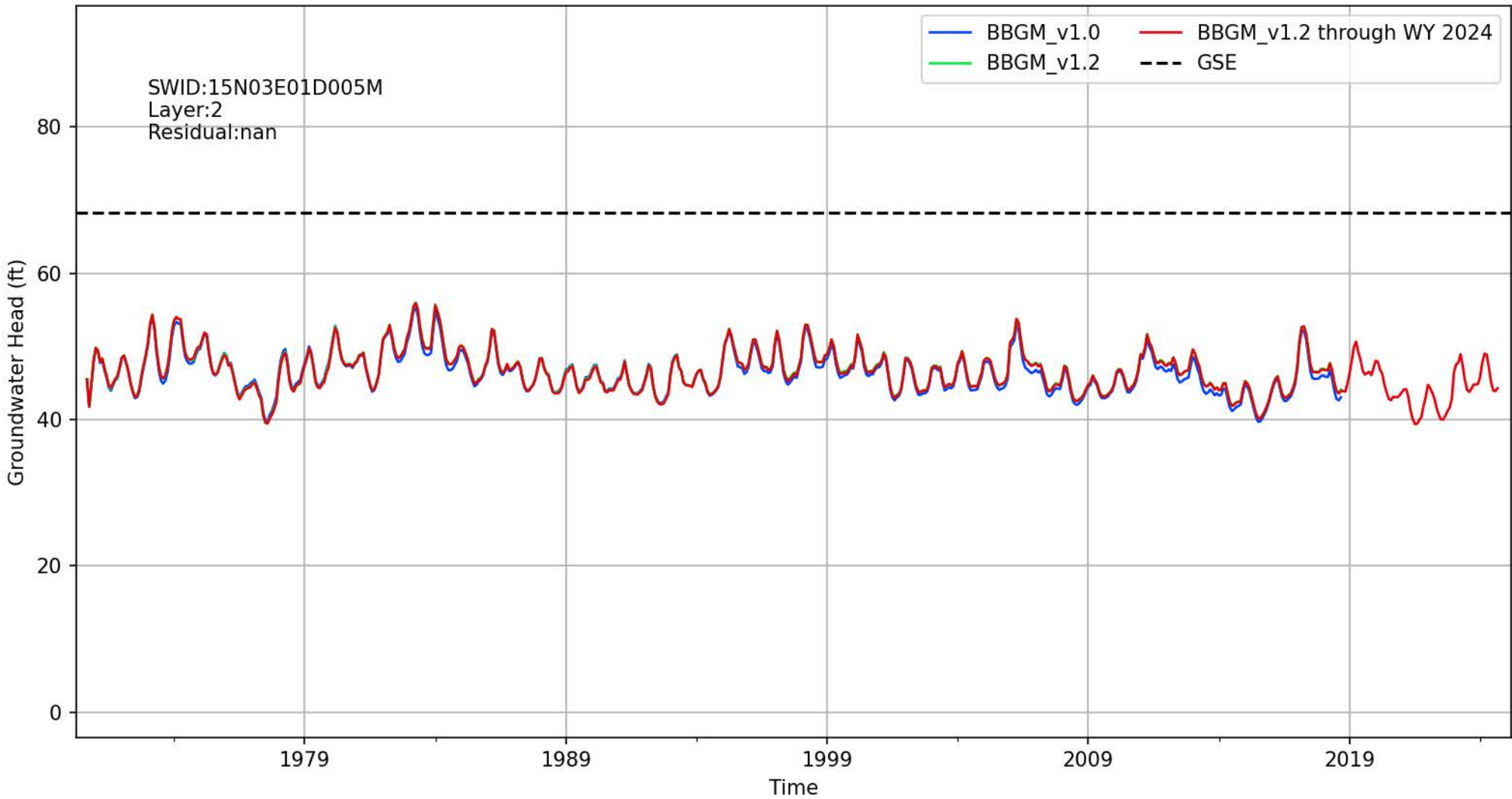
Location ID: 2801 | 391512N1216190W001

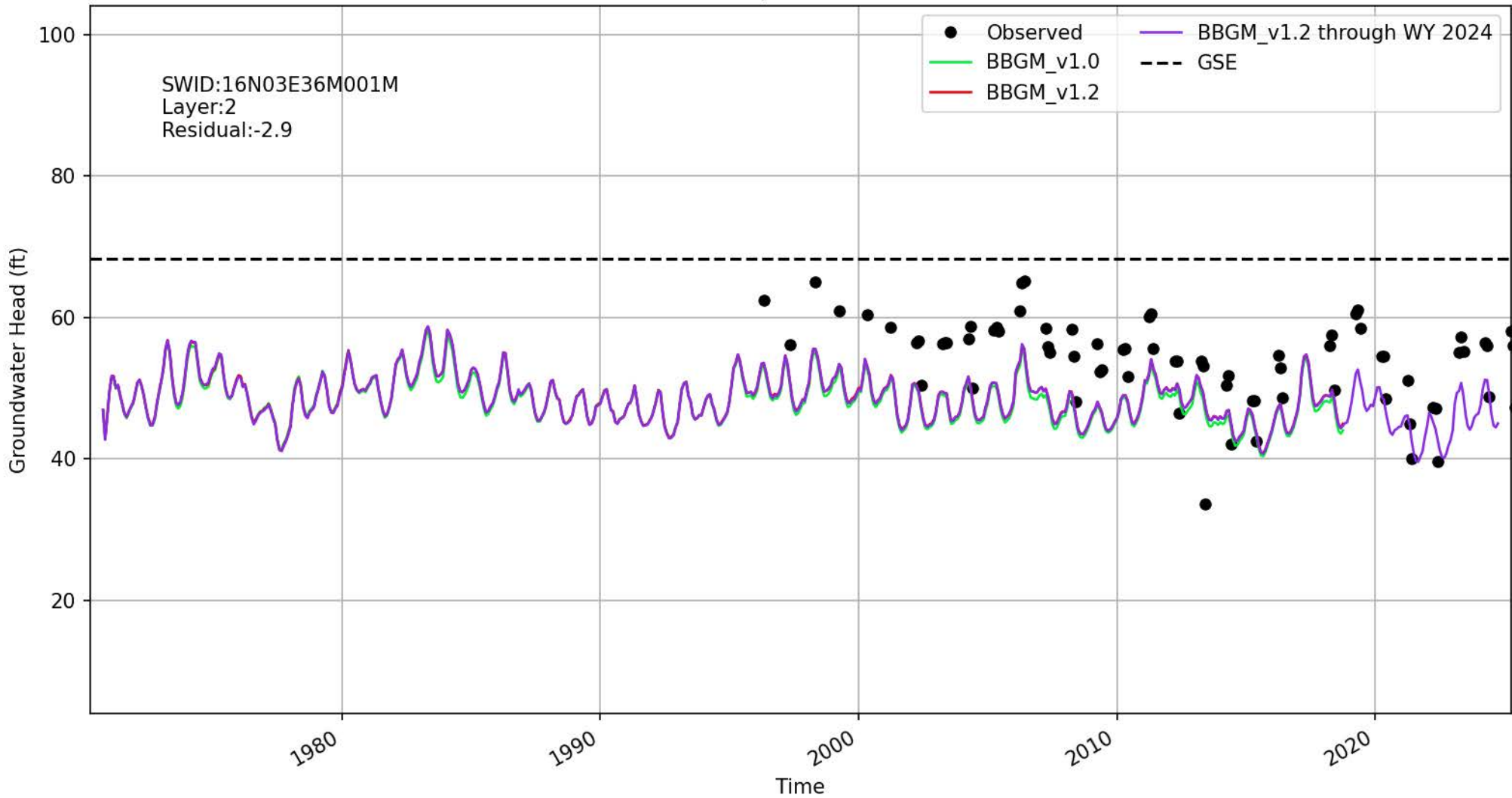


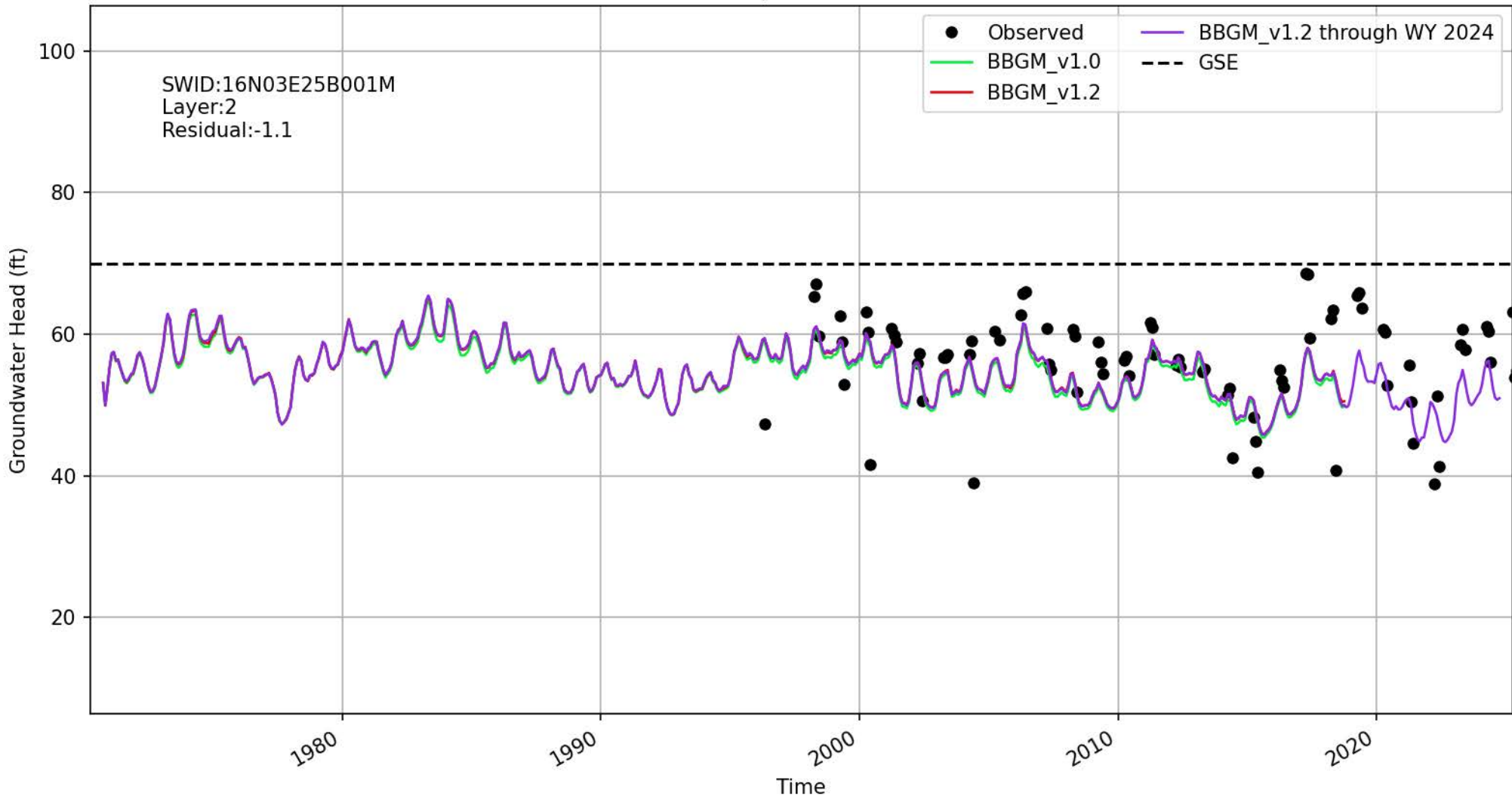
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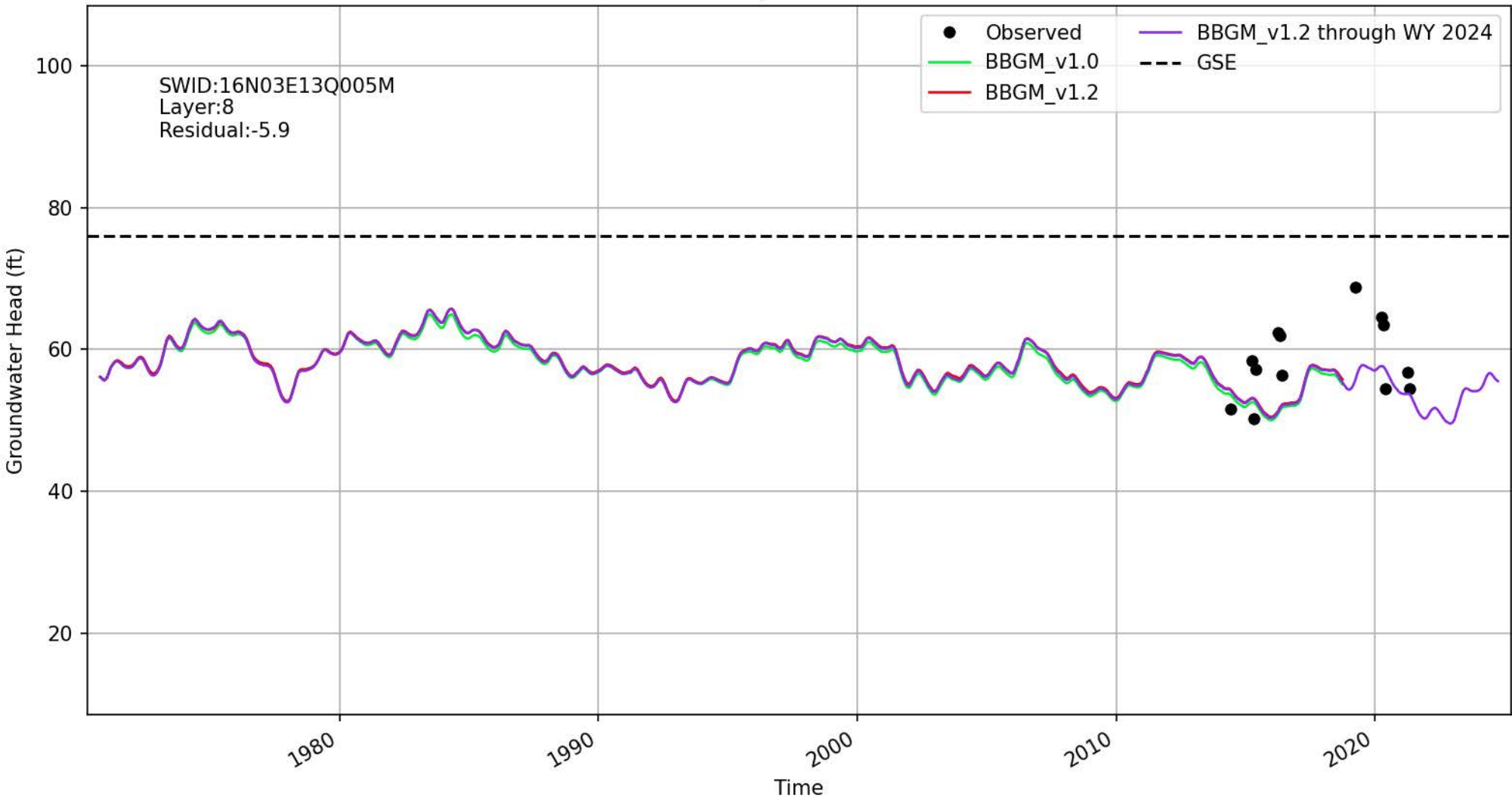


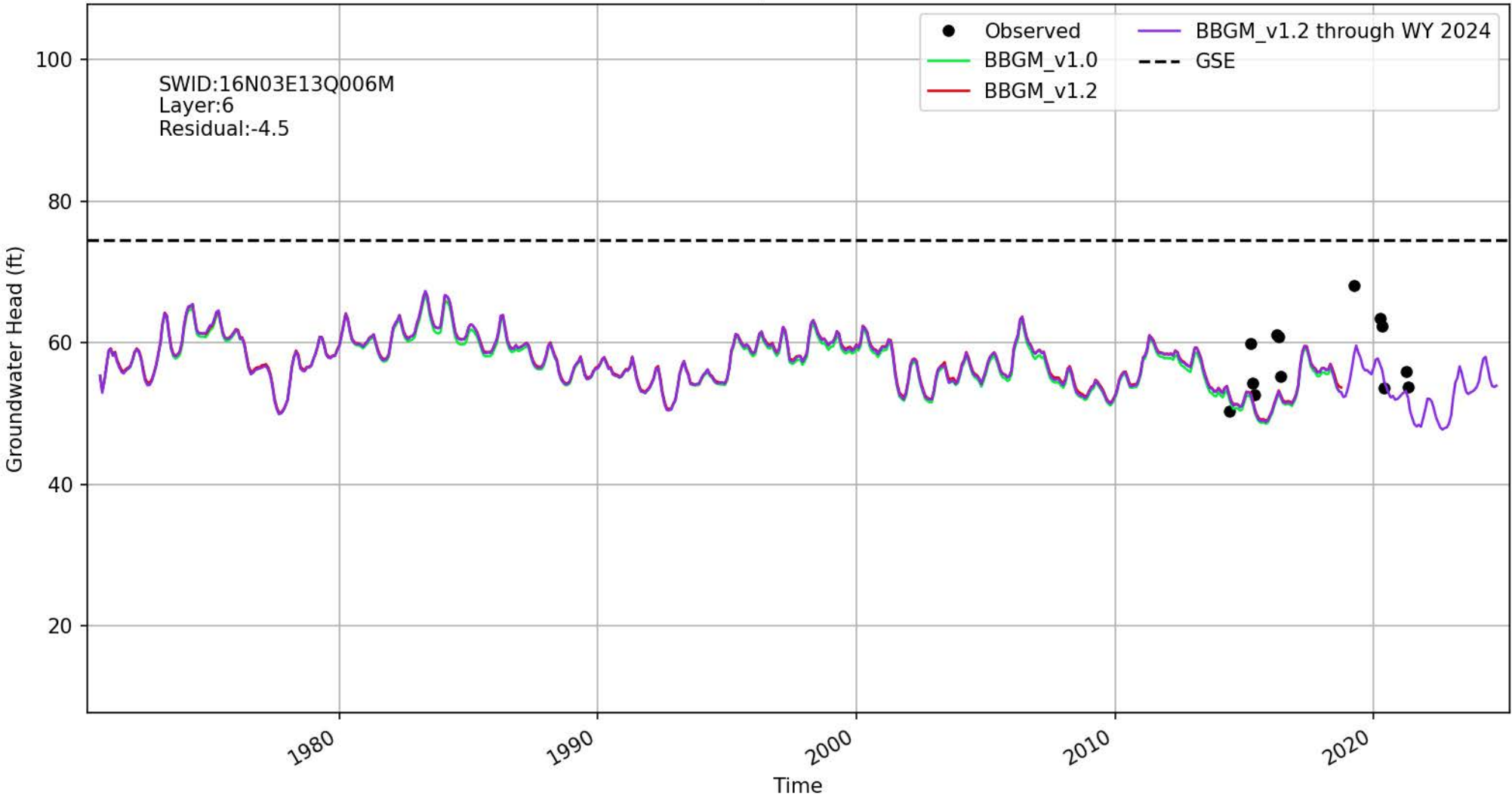
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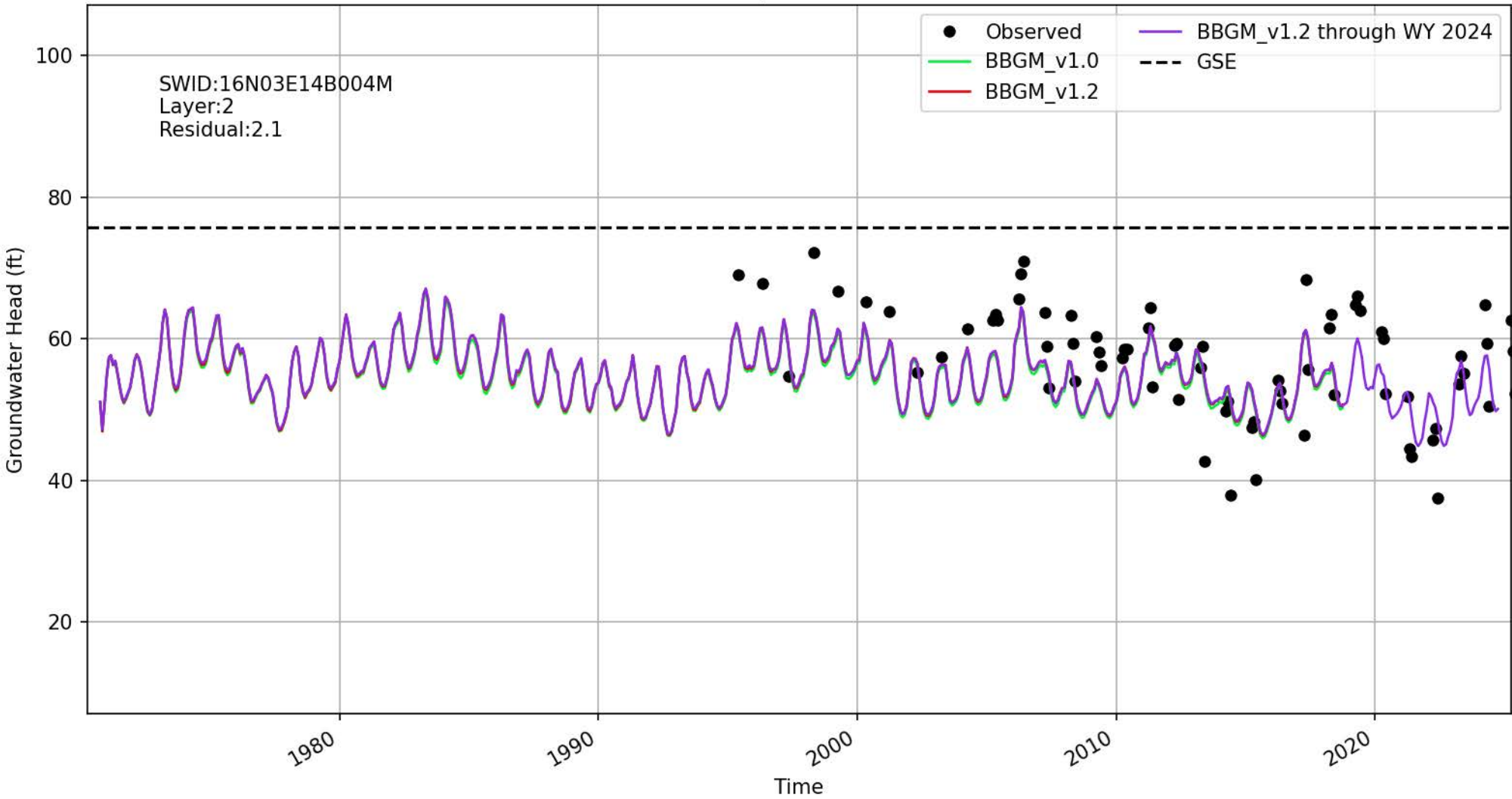


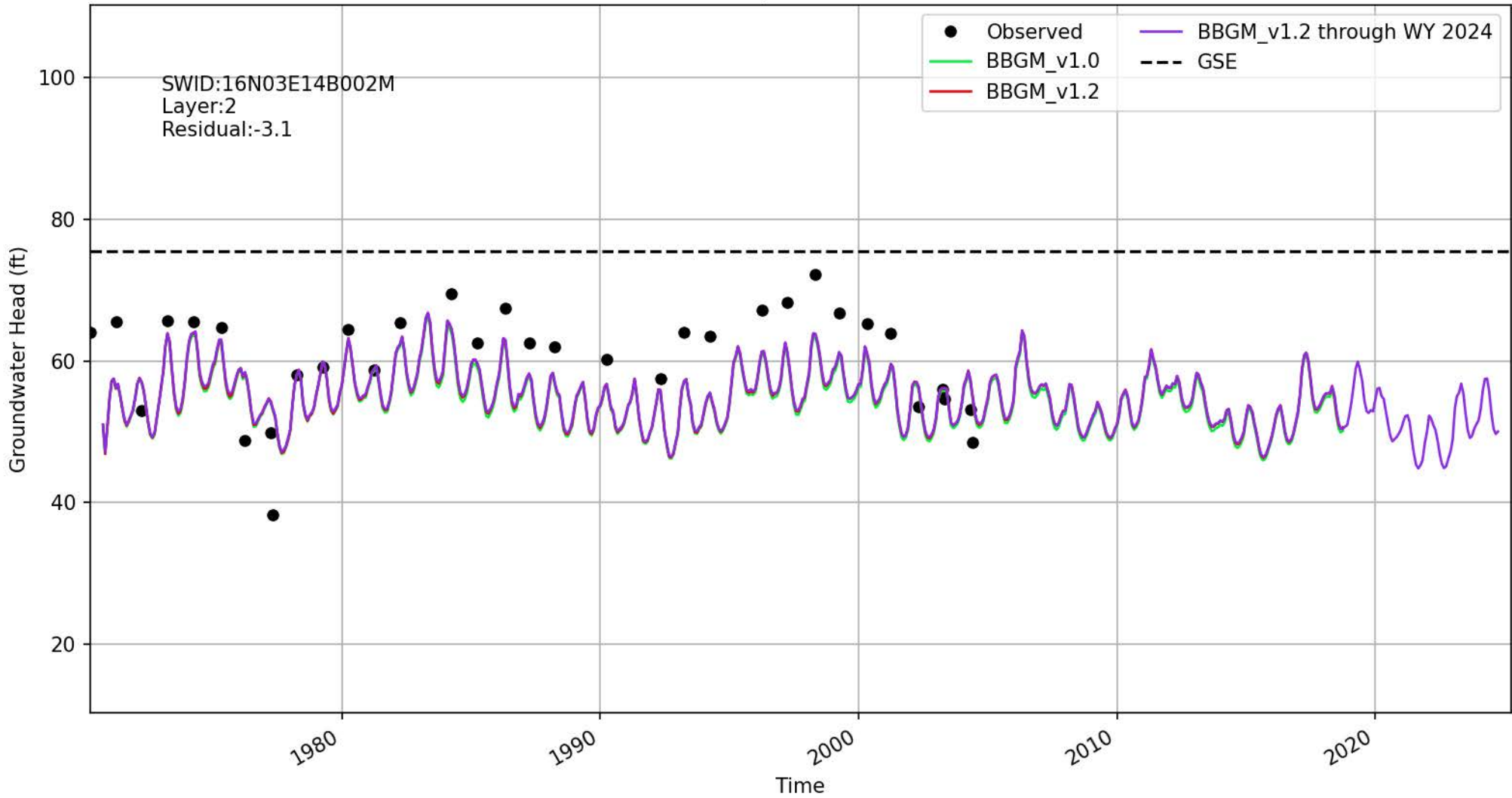


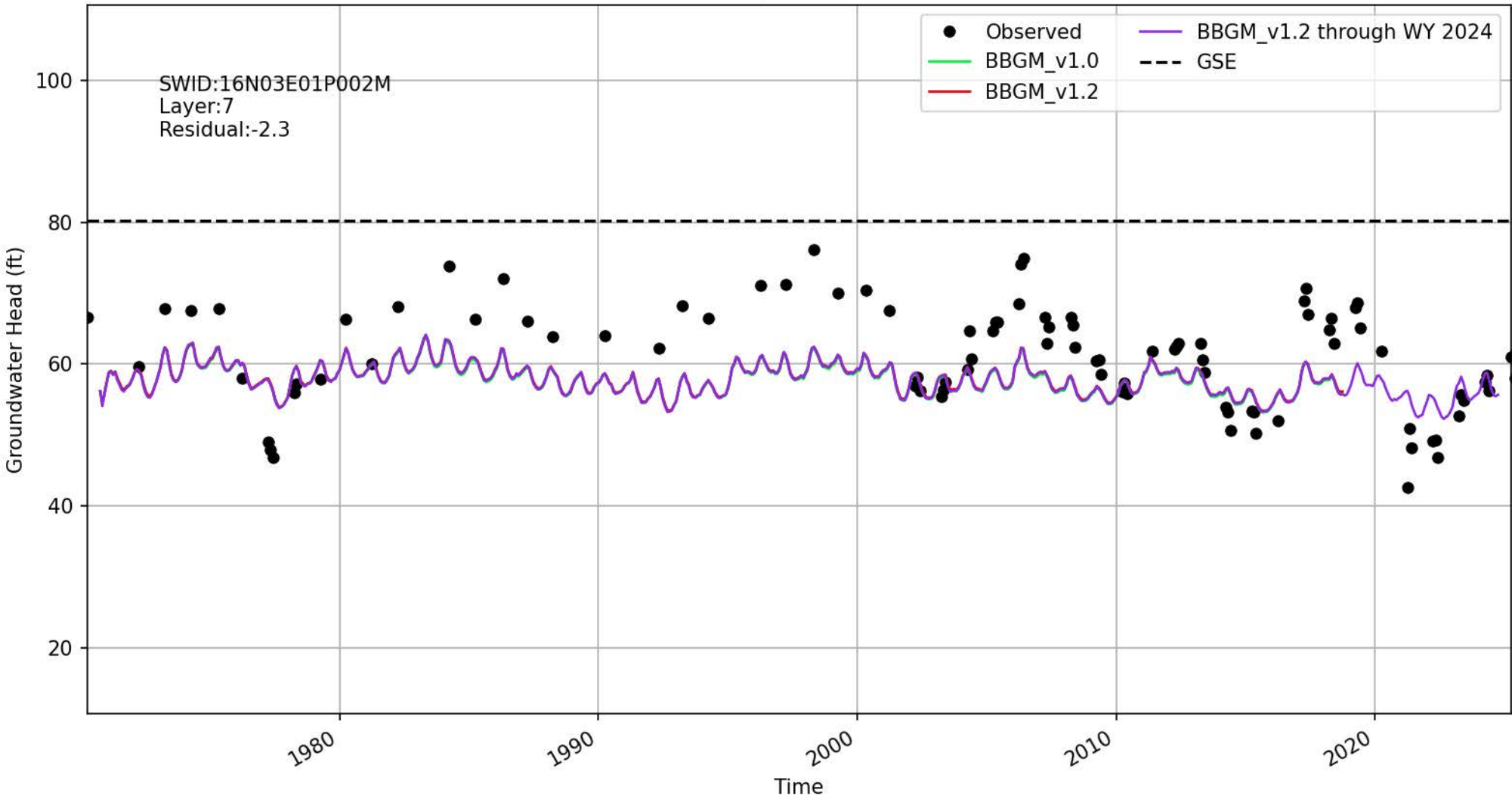


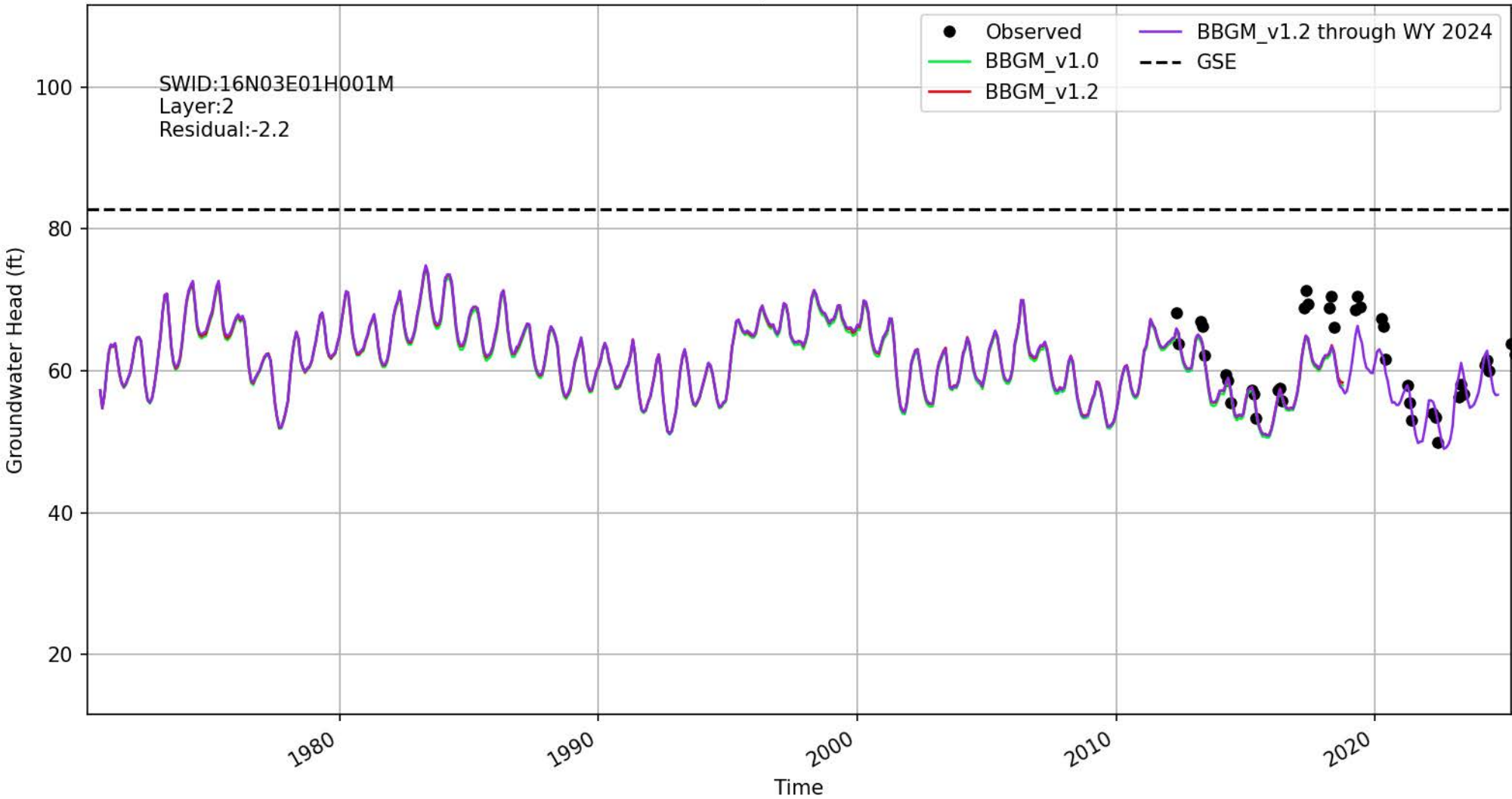


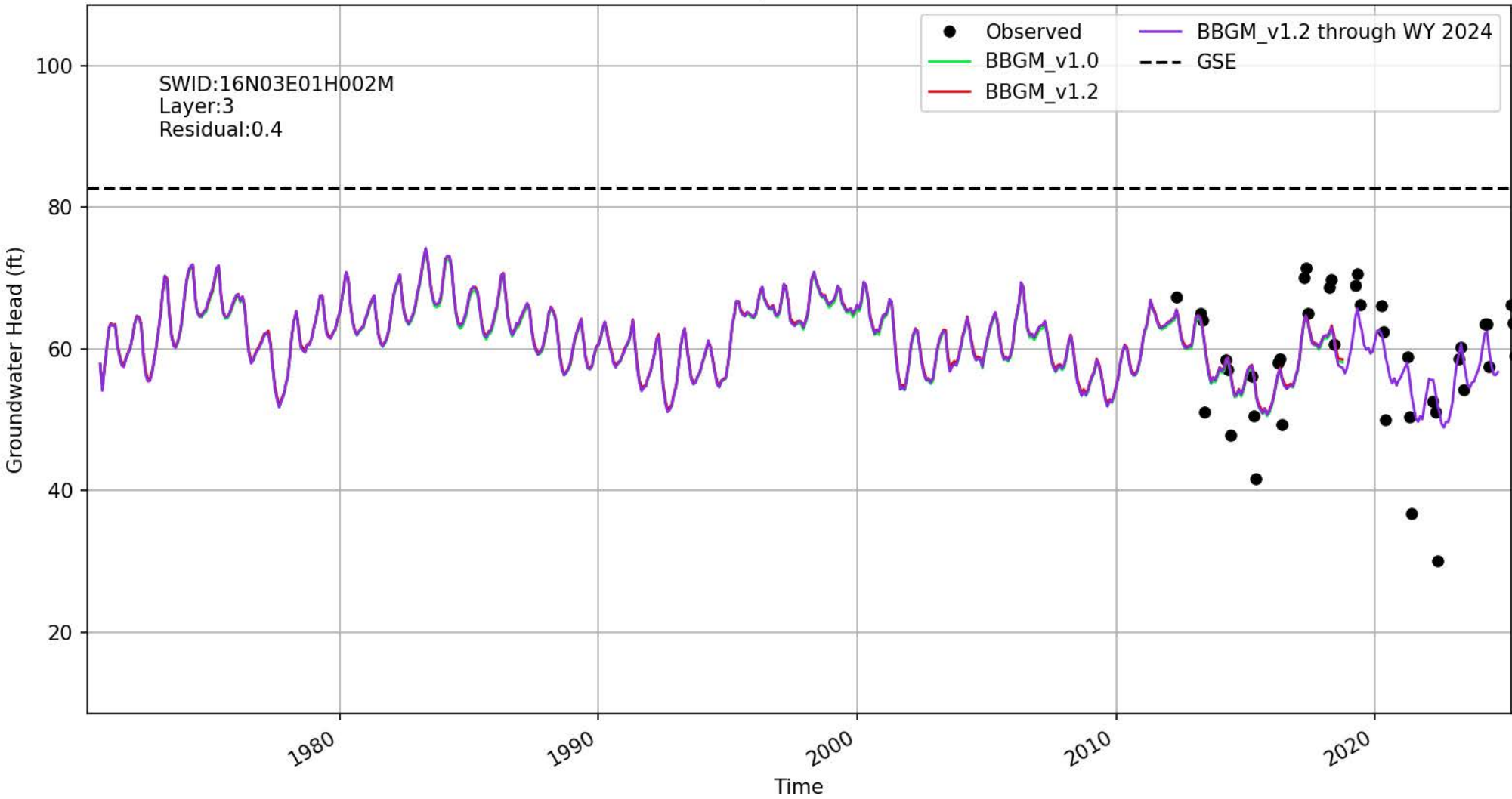


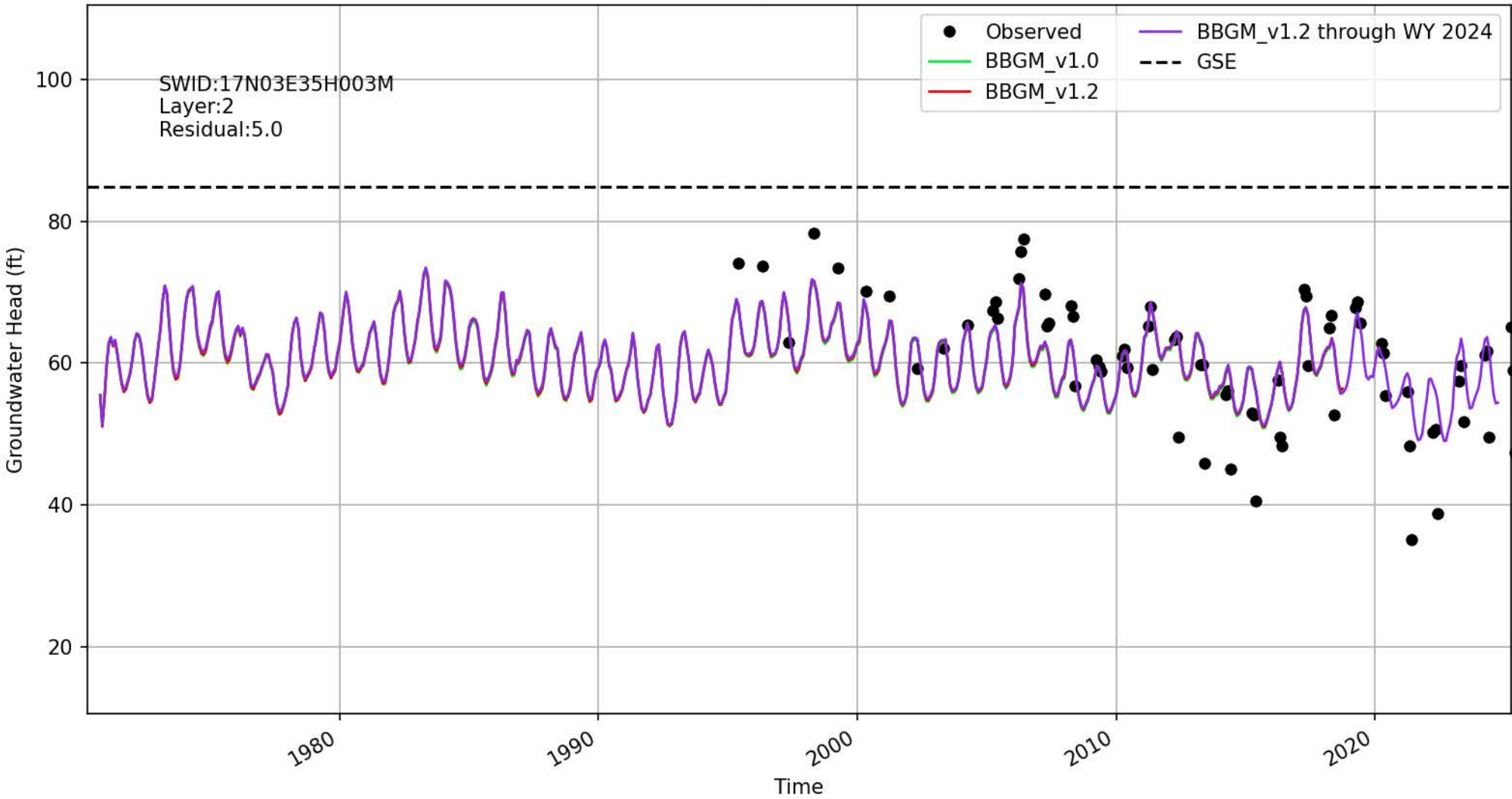


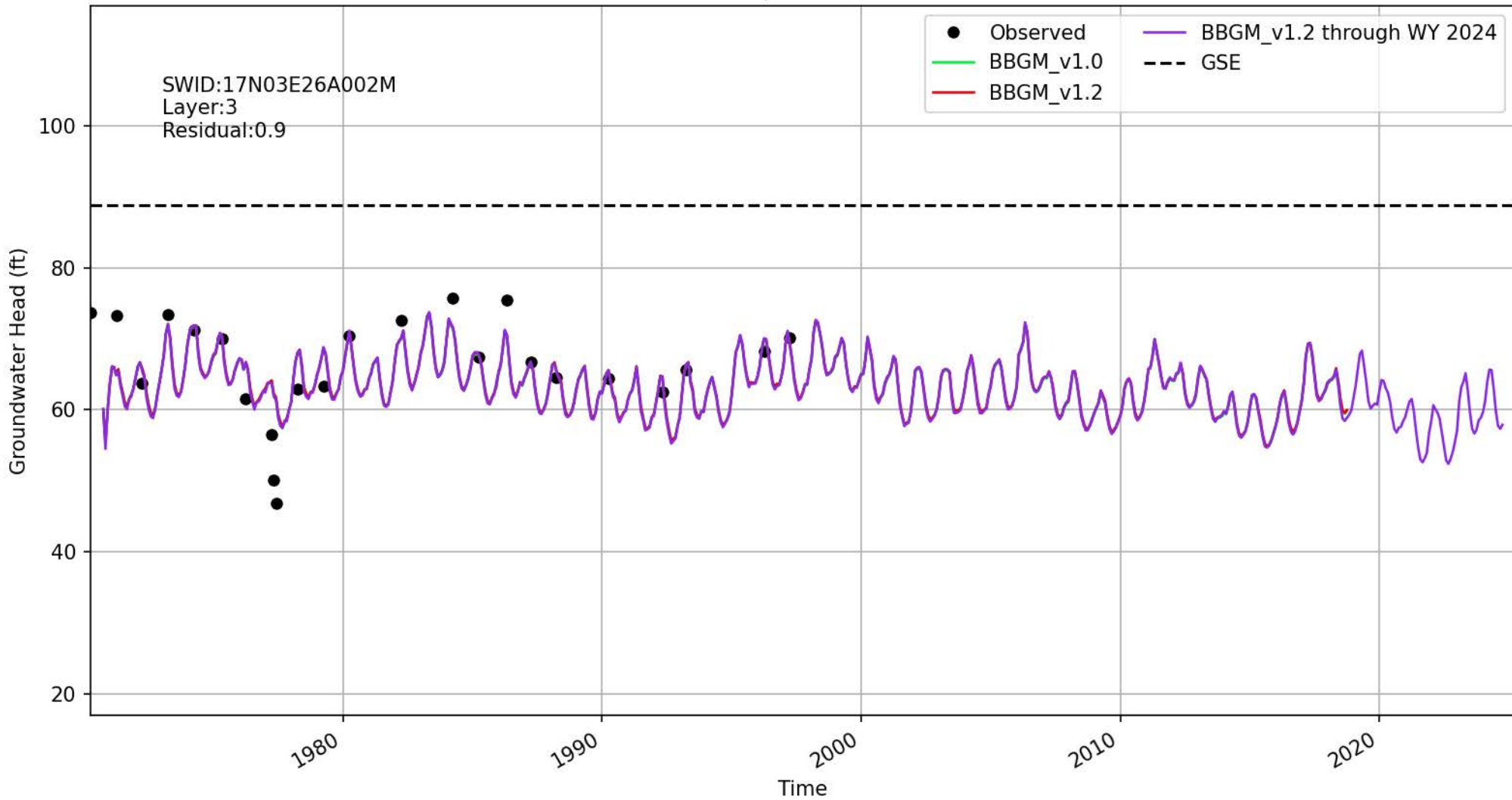


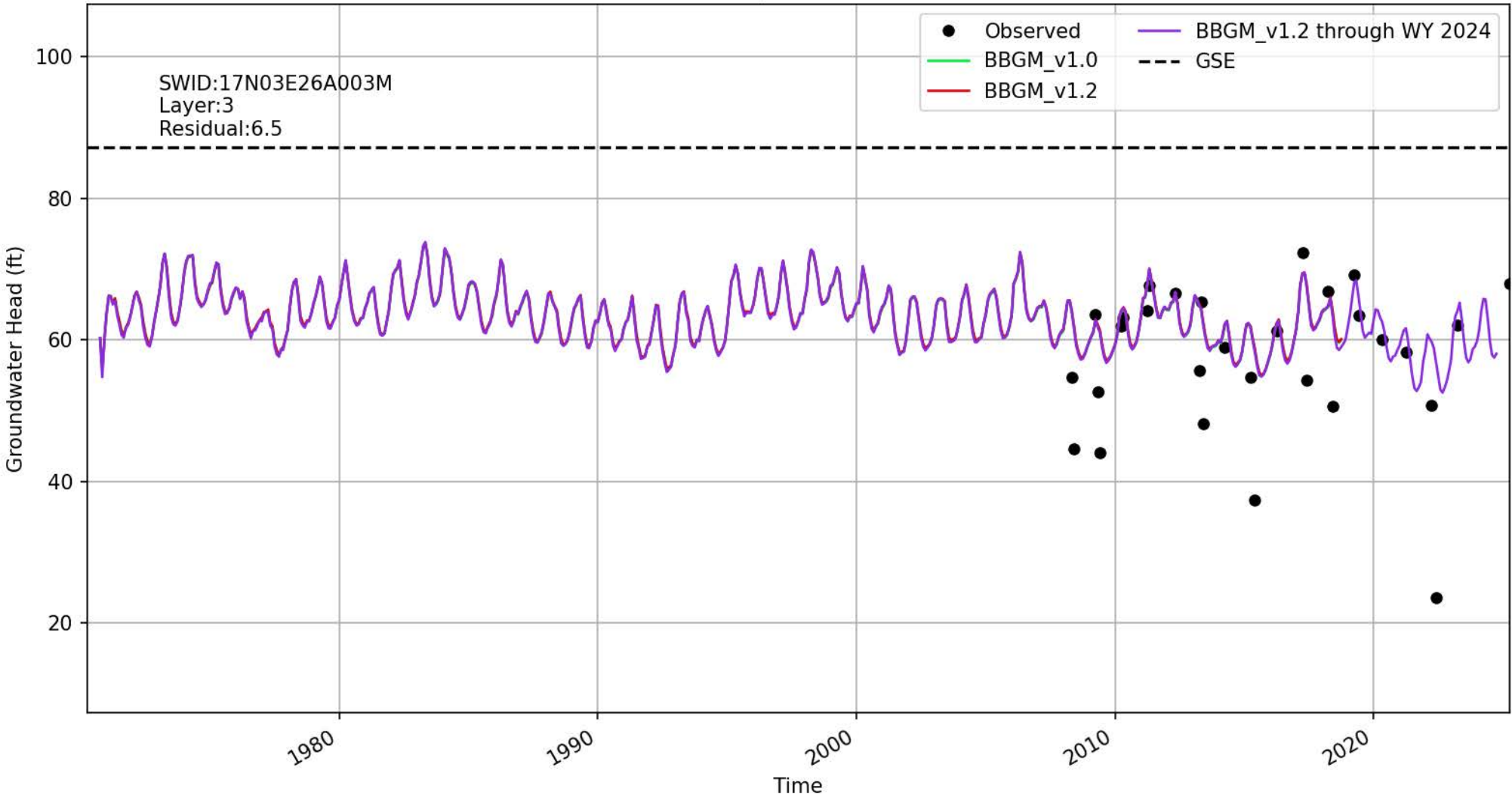


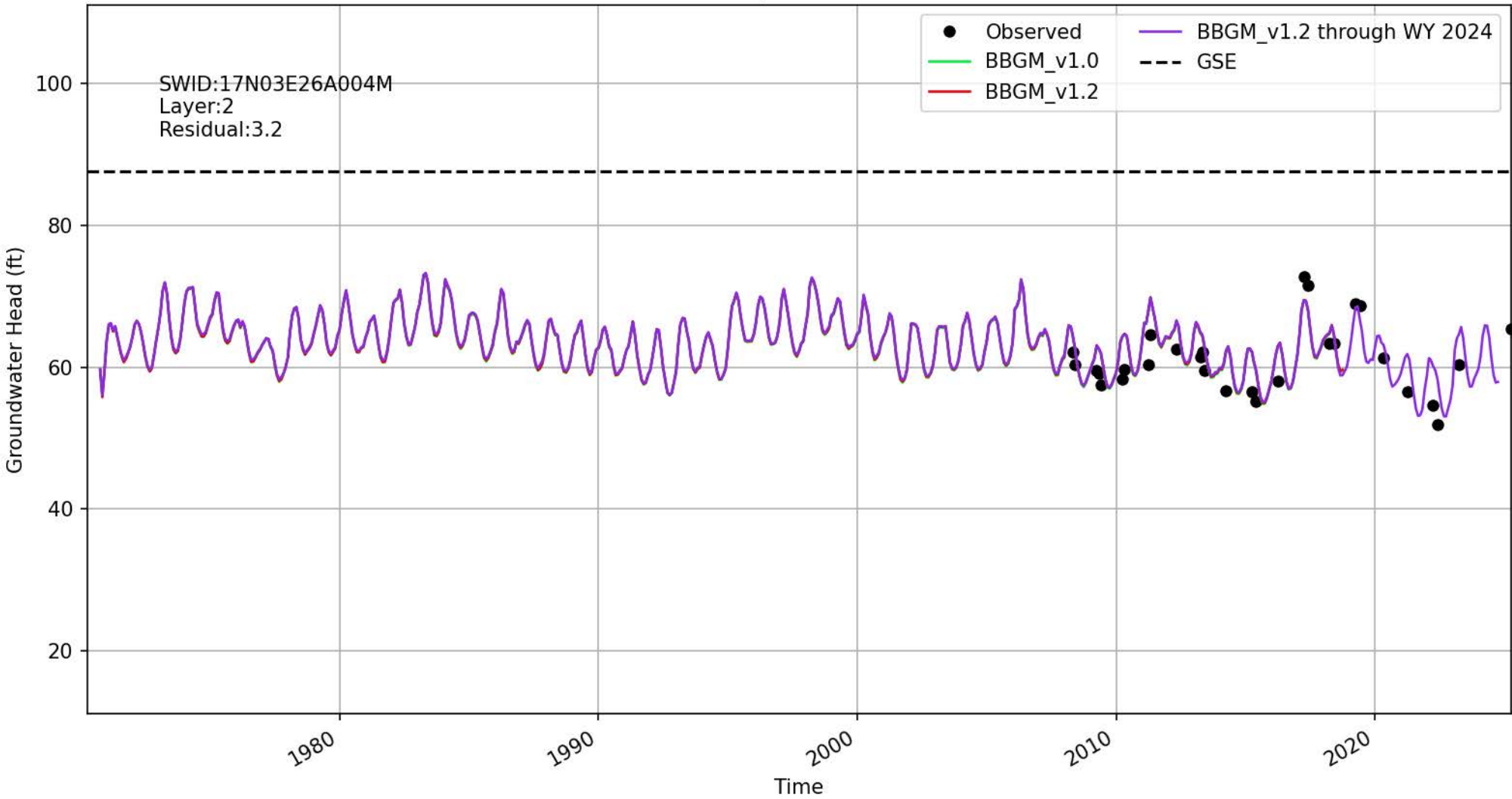




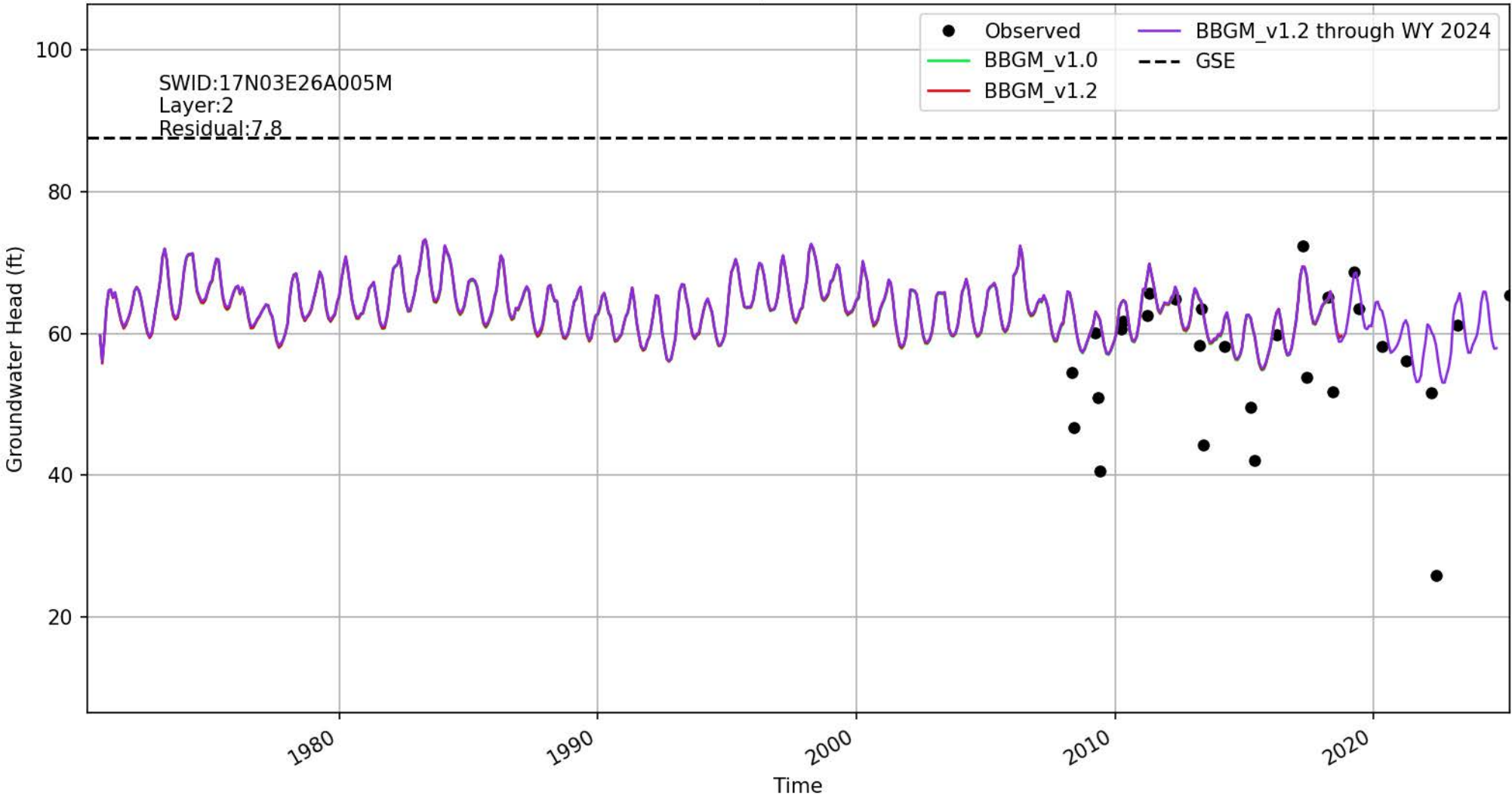


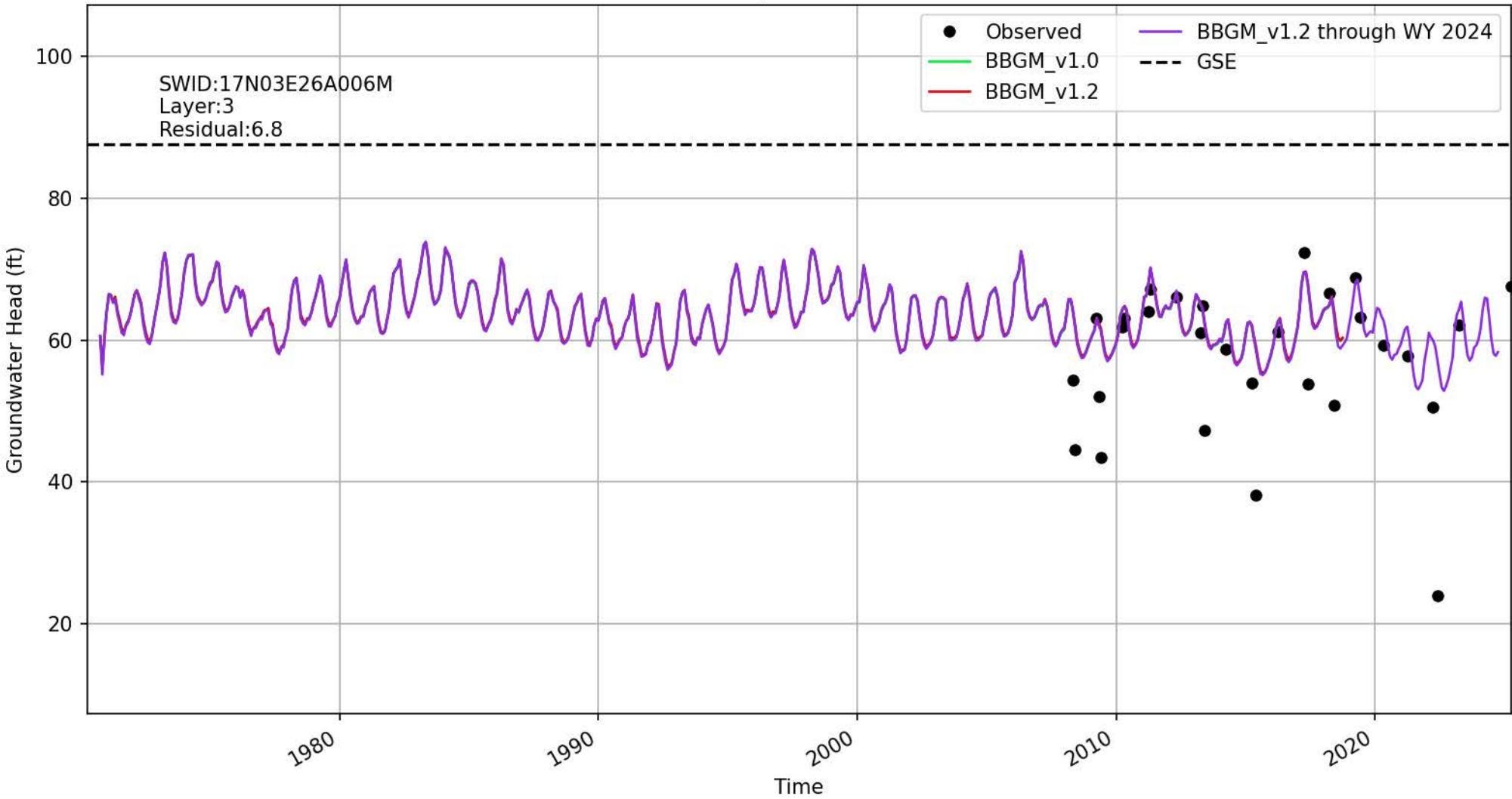


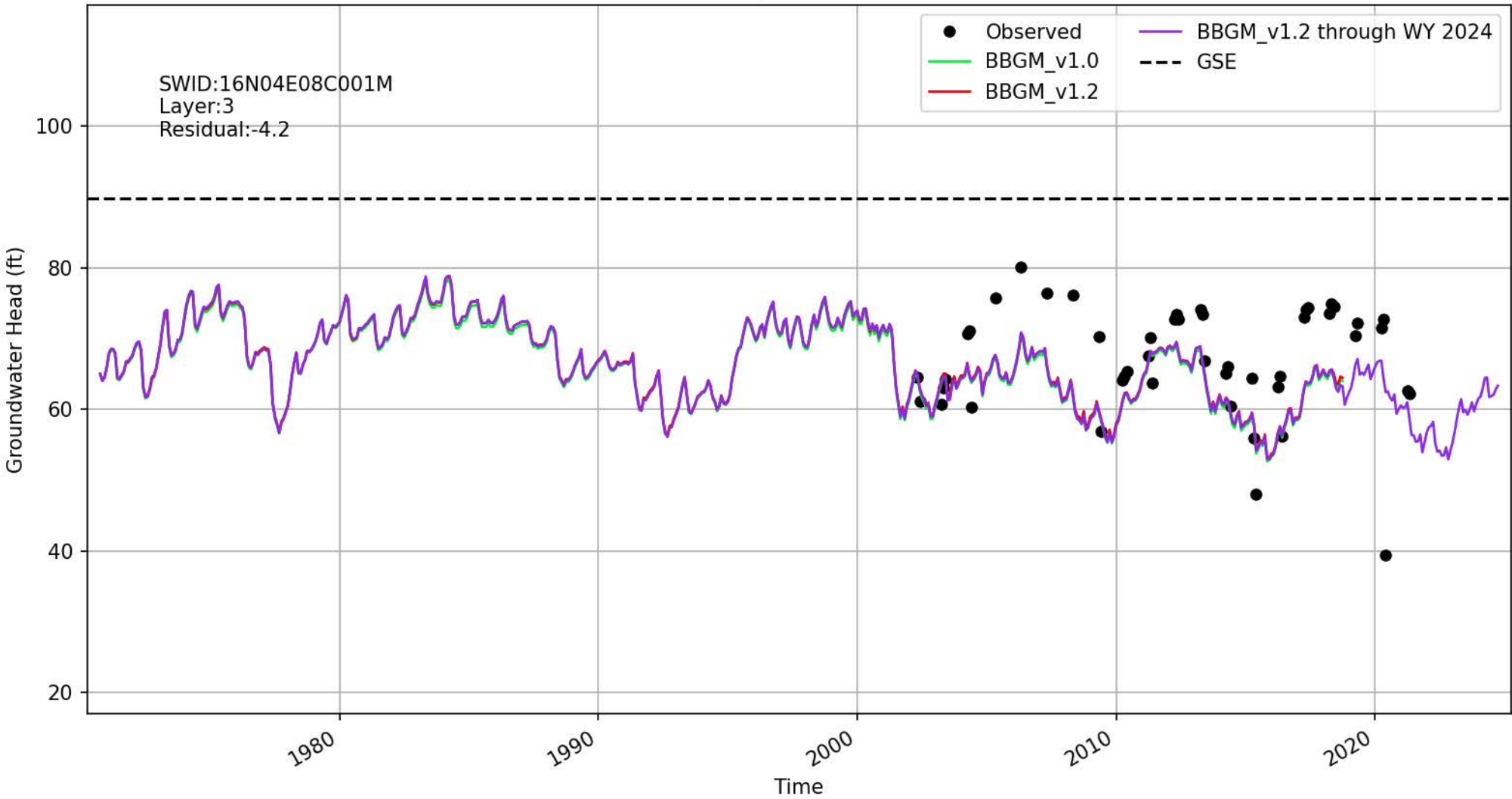


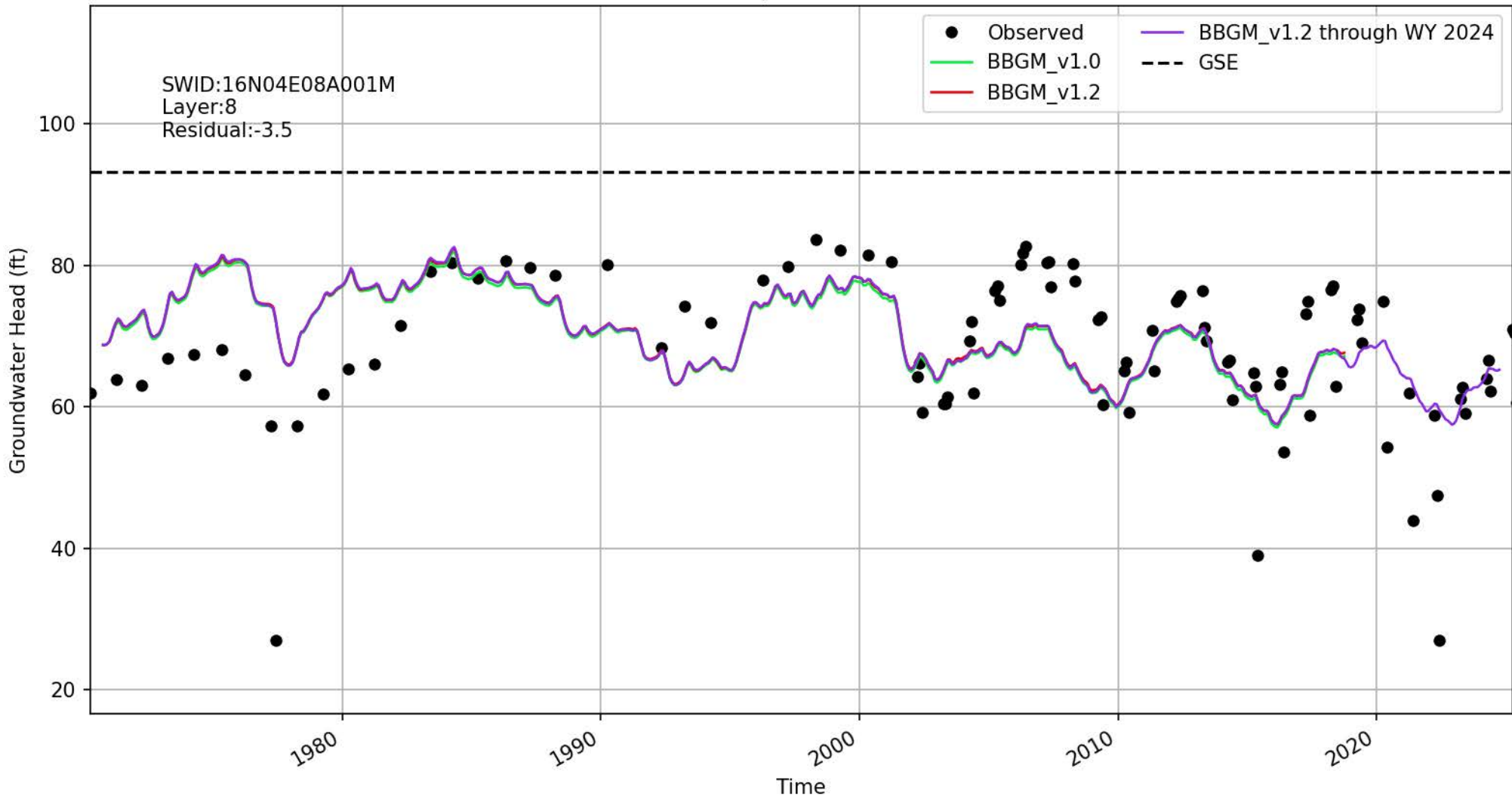


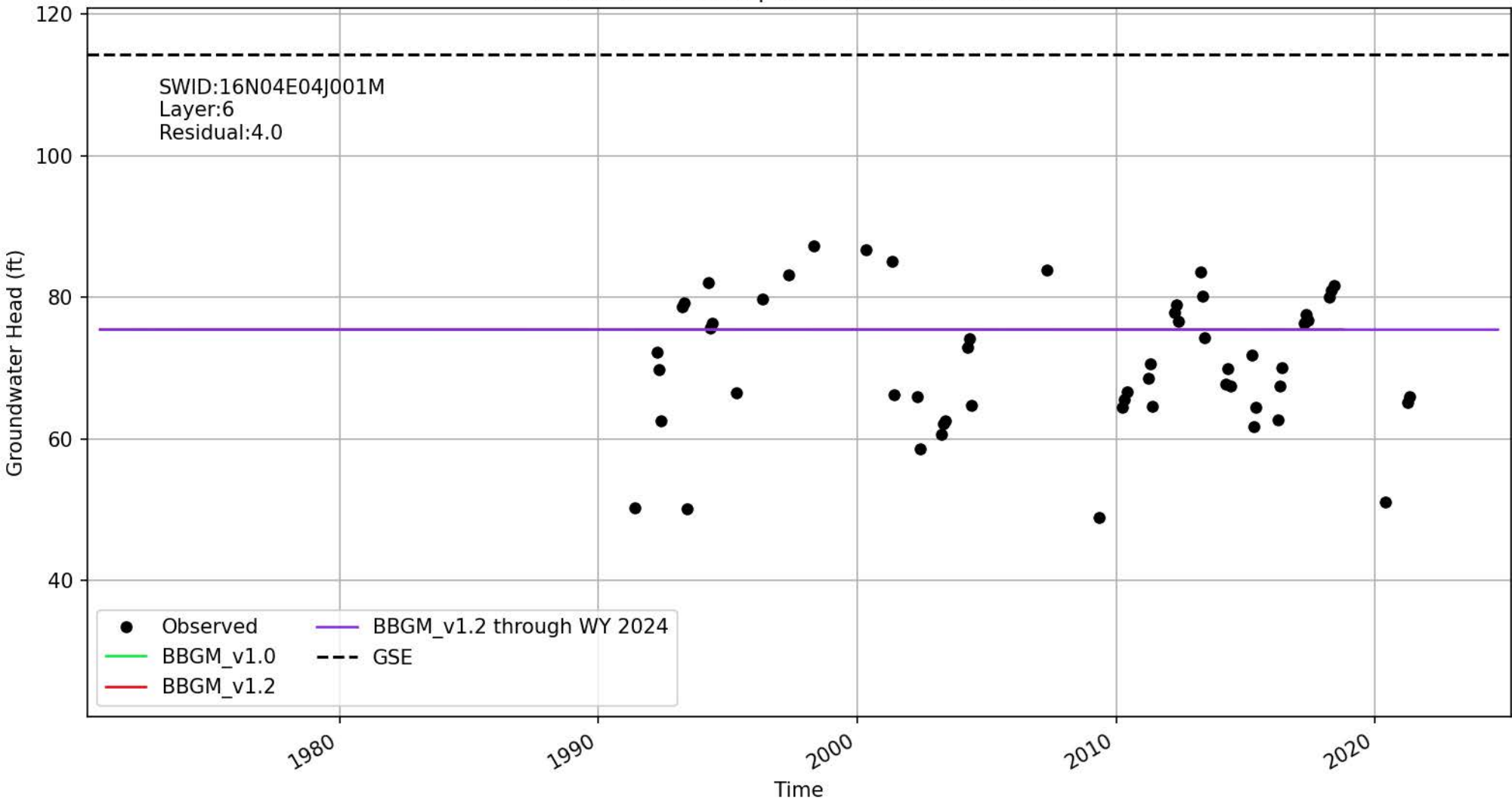
Location ID: 2919 | 393054N1215973W002

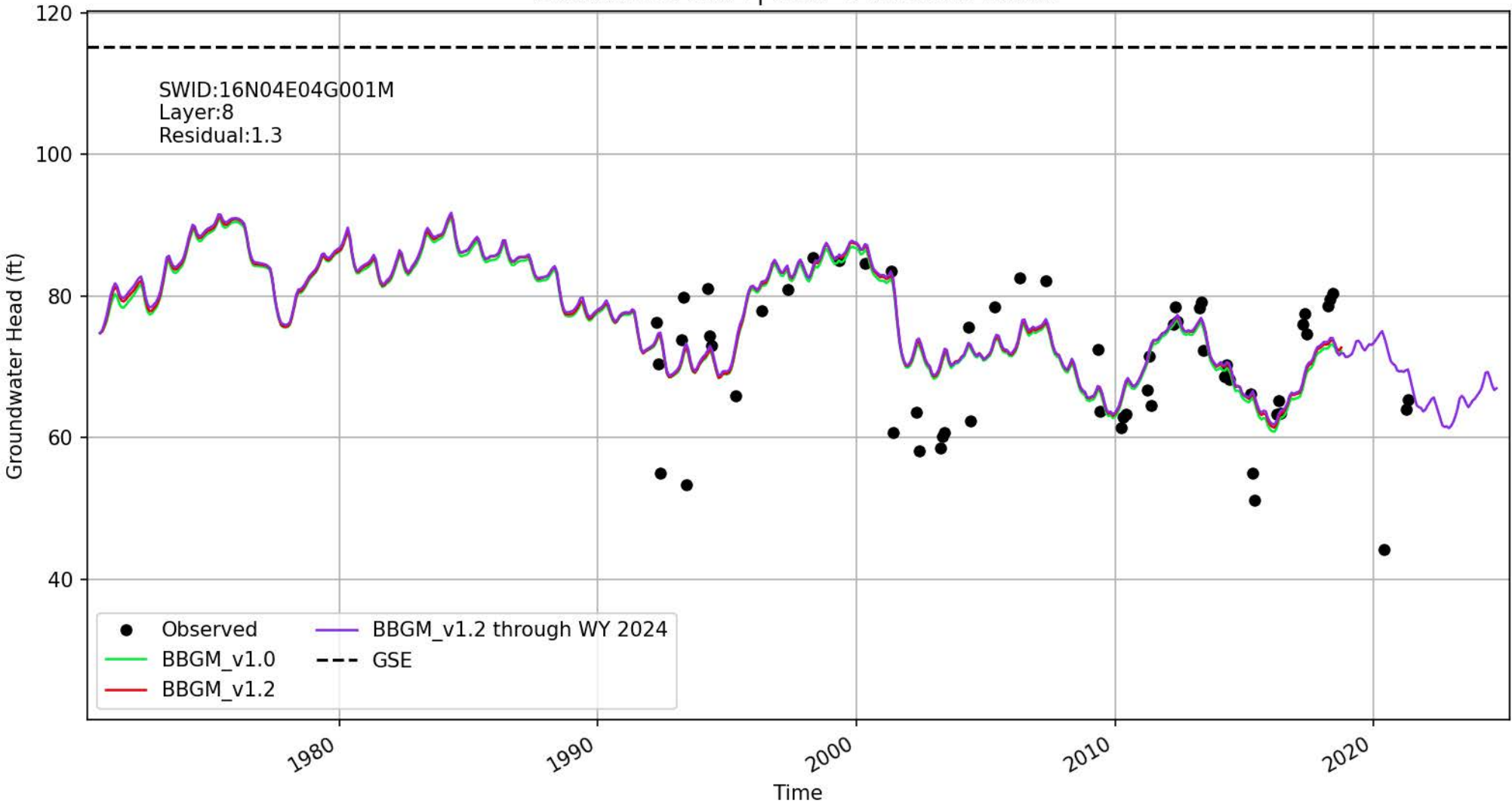


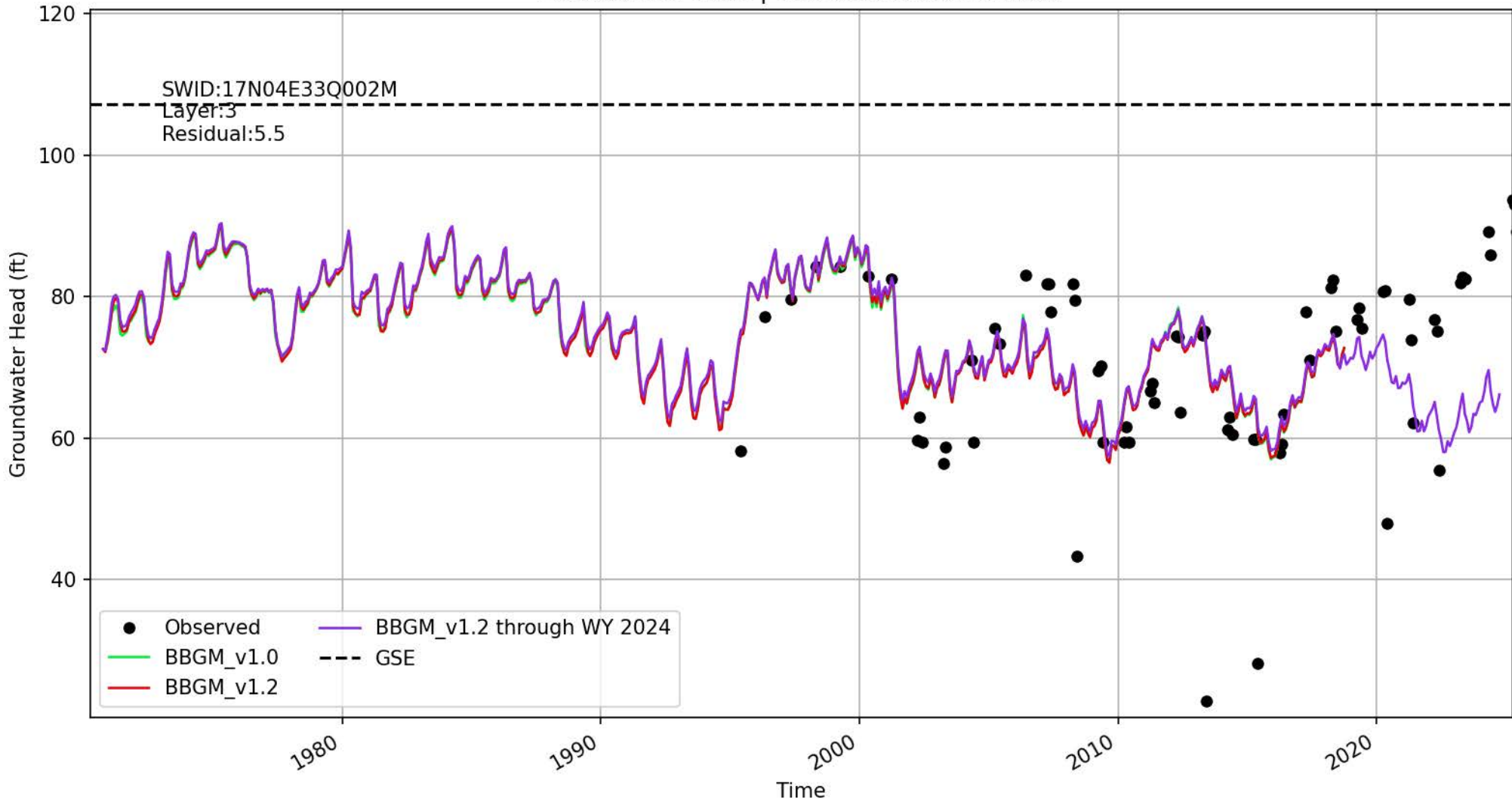


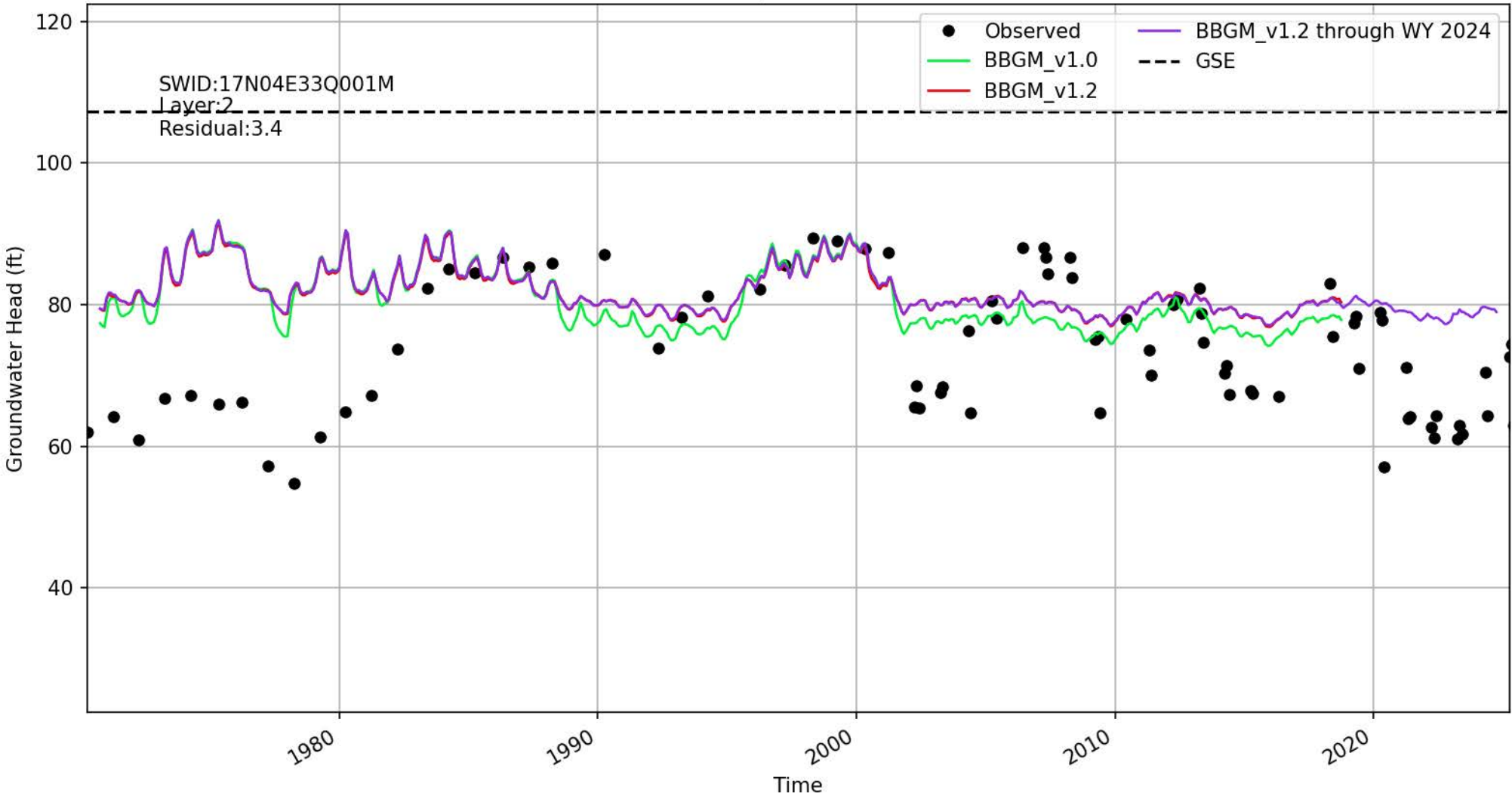


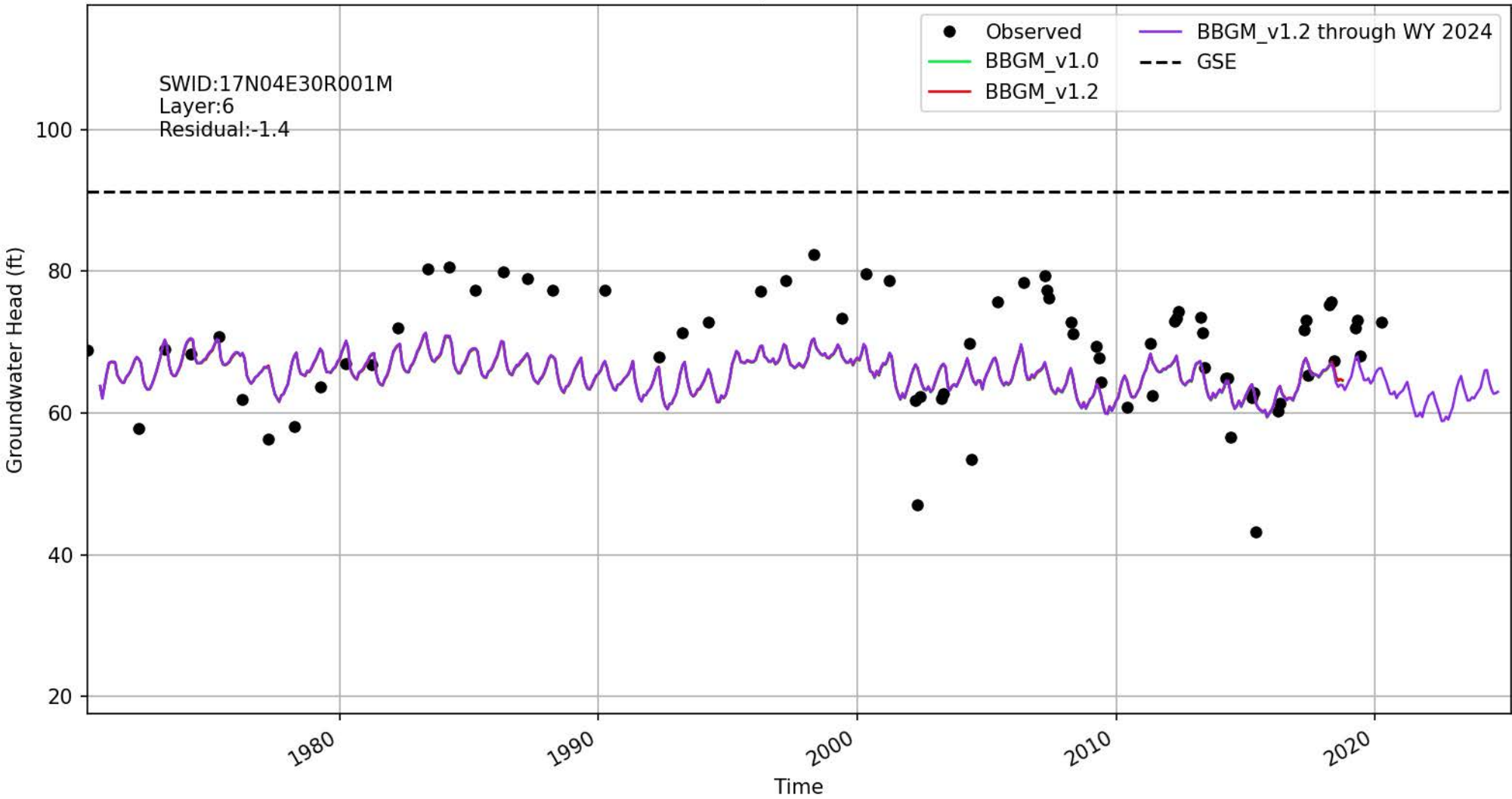




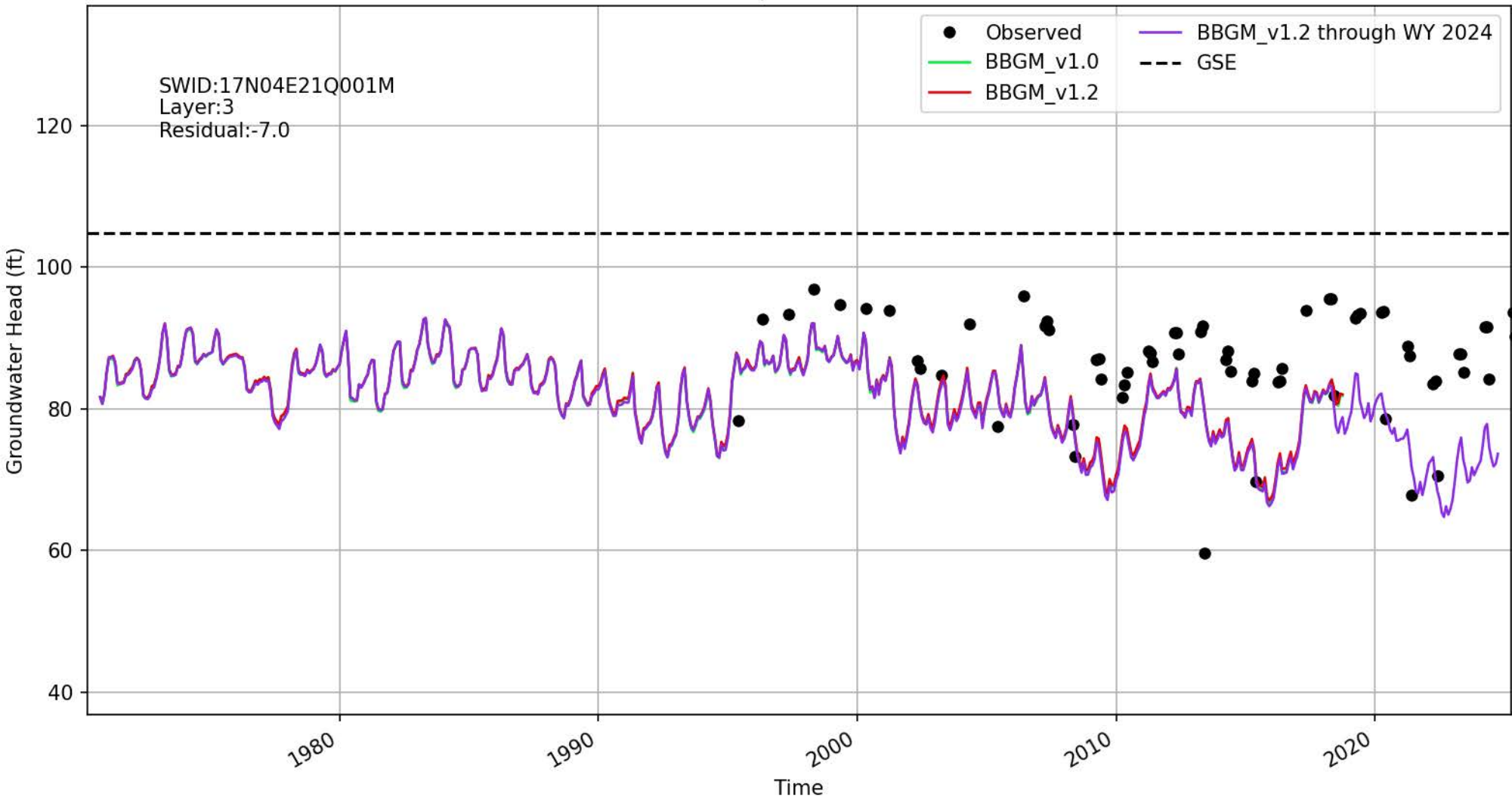


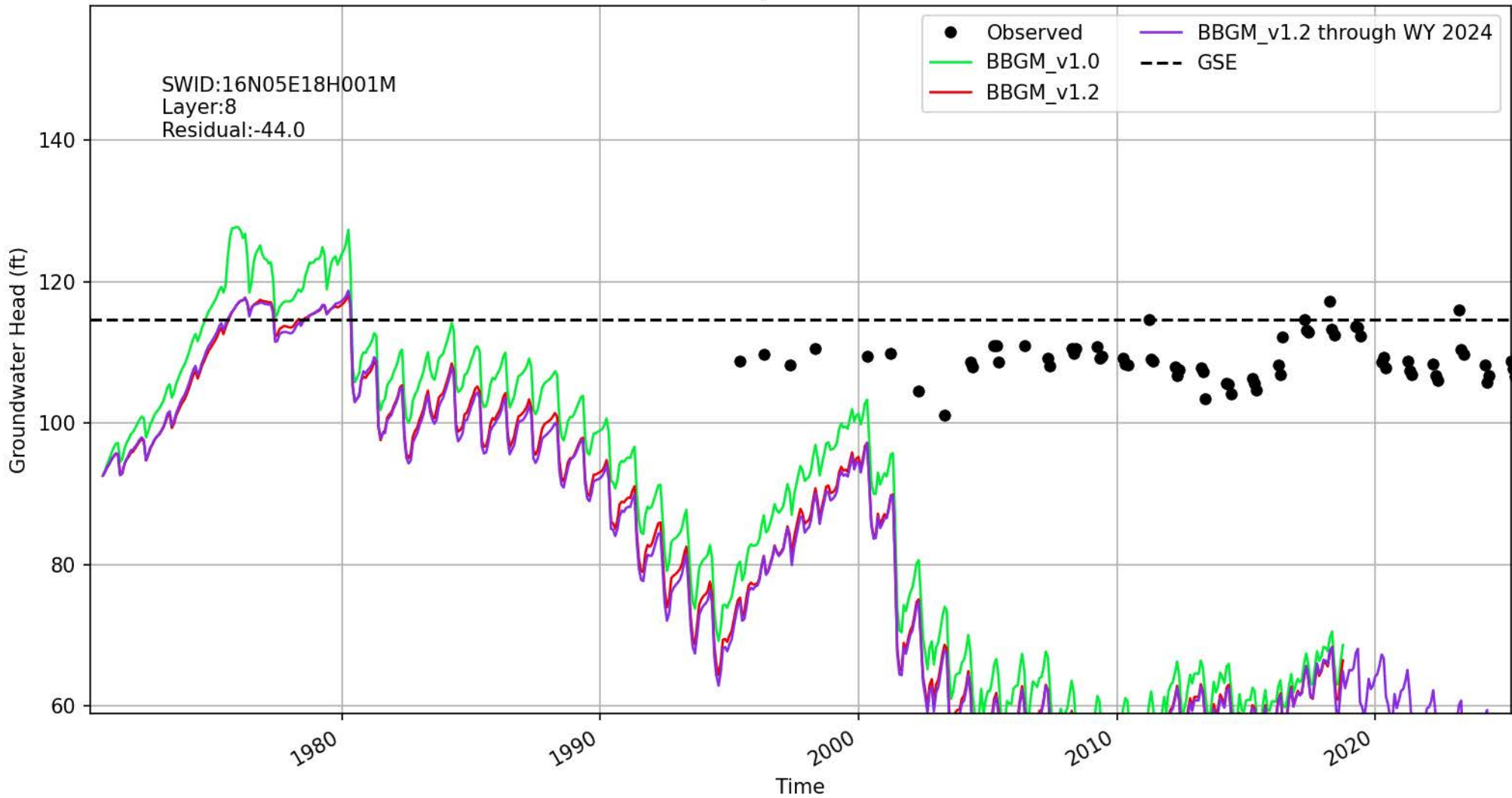


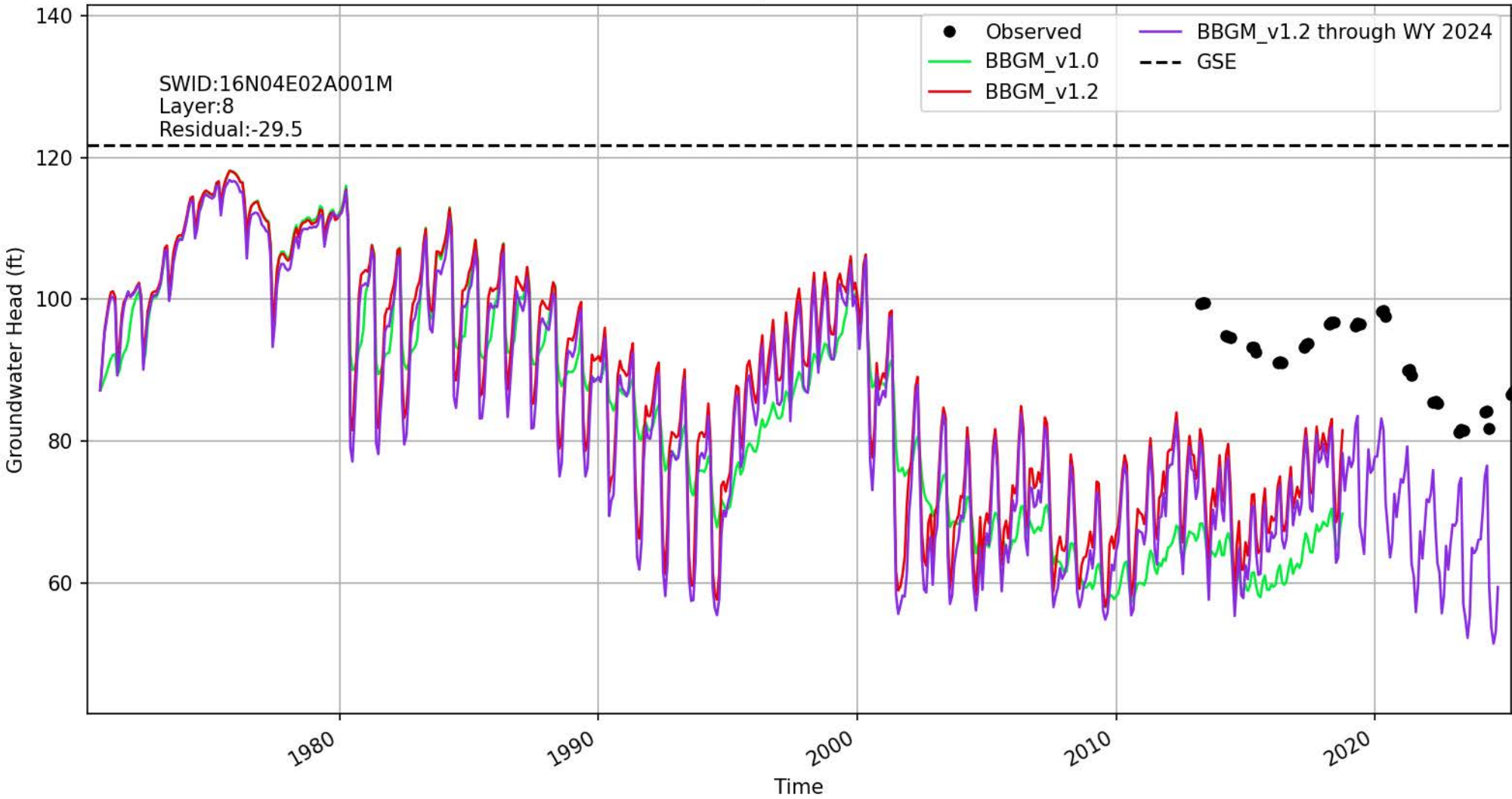


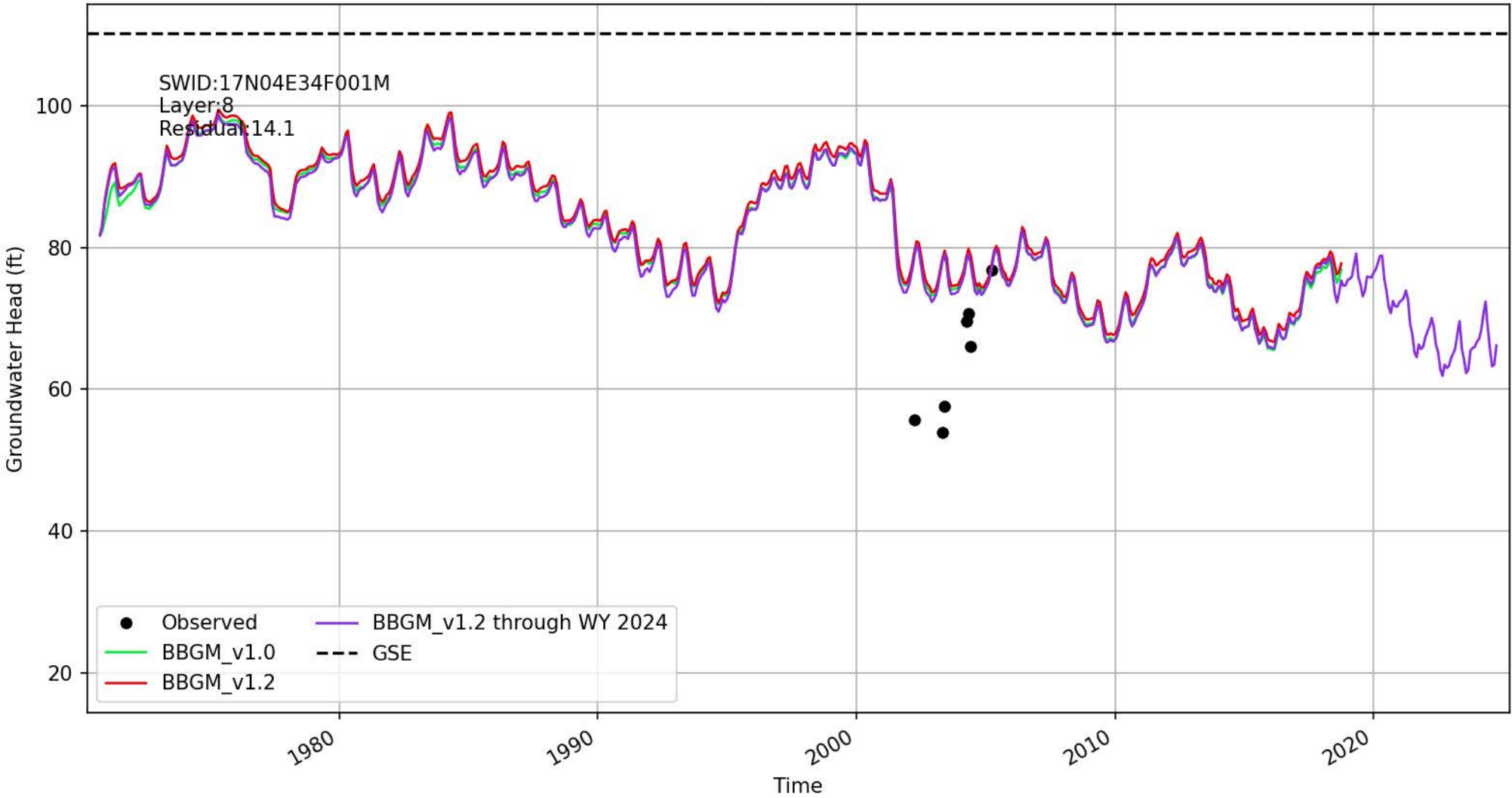


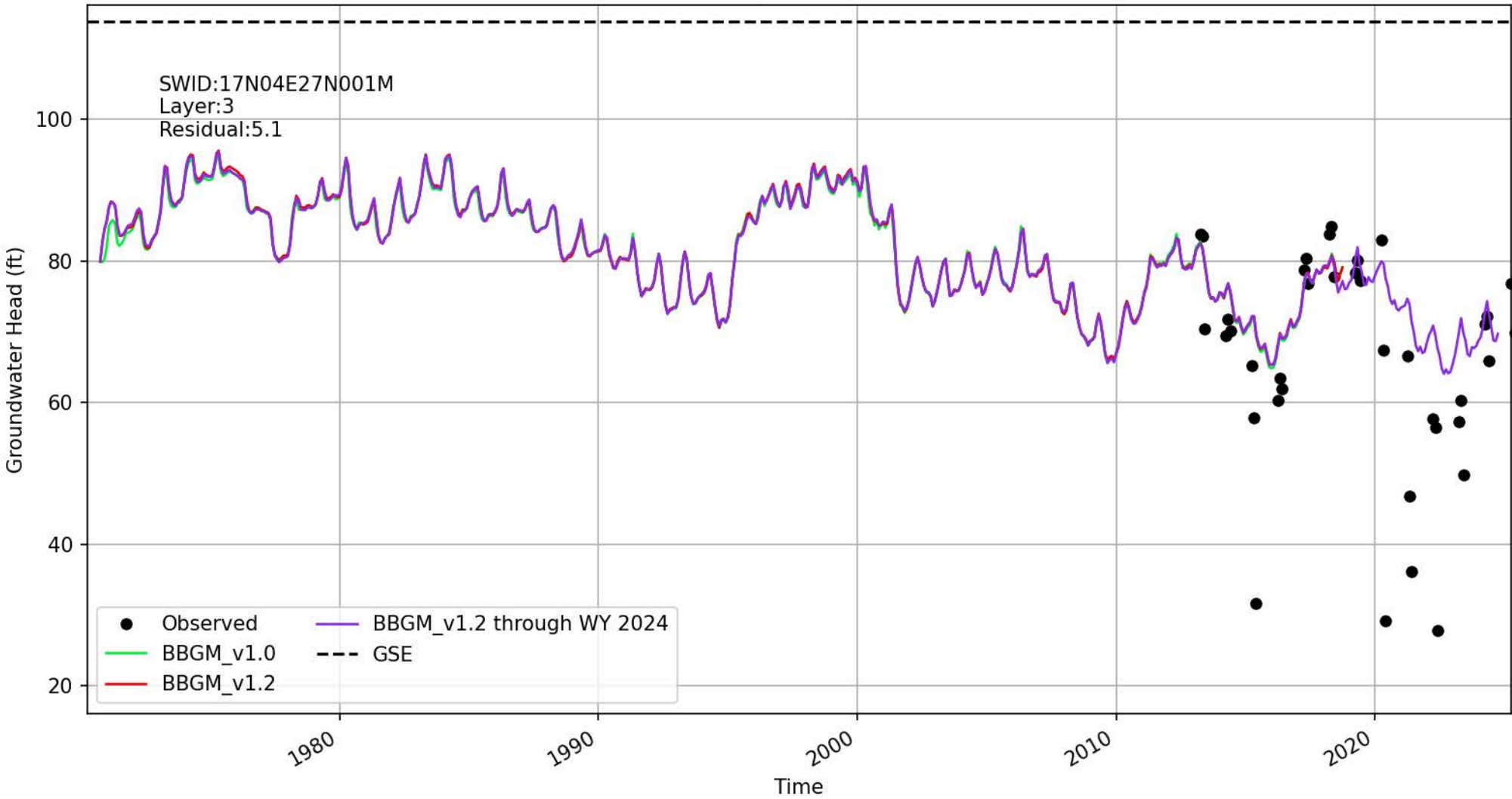
Location ID: 3009 | 393117N1215252W001



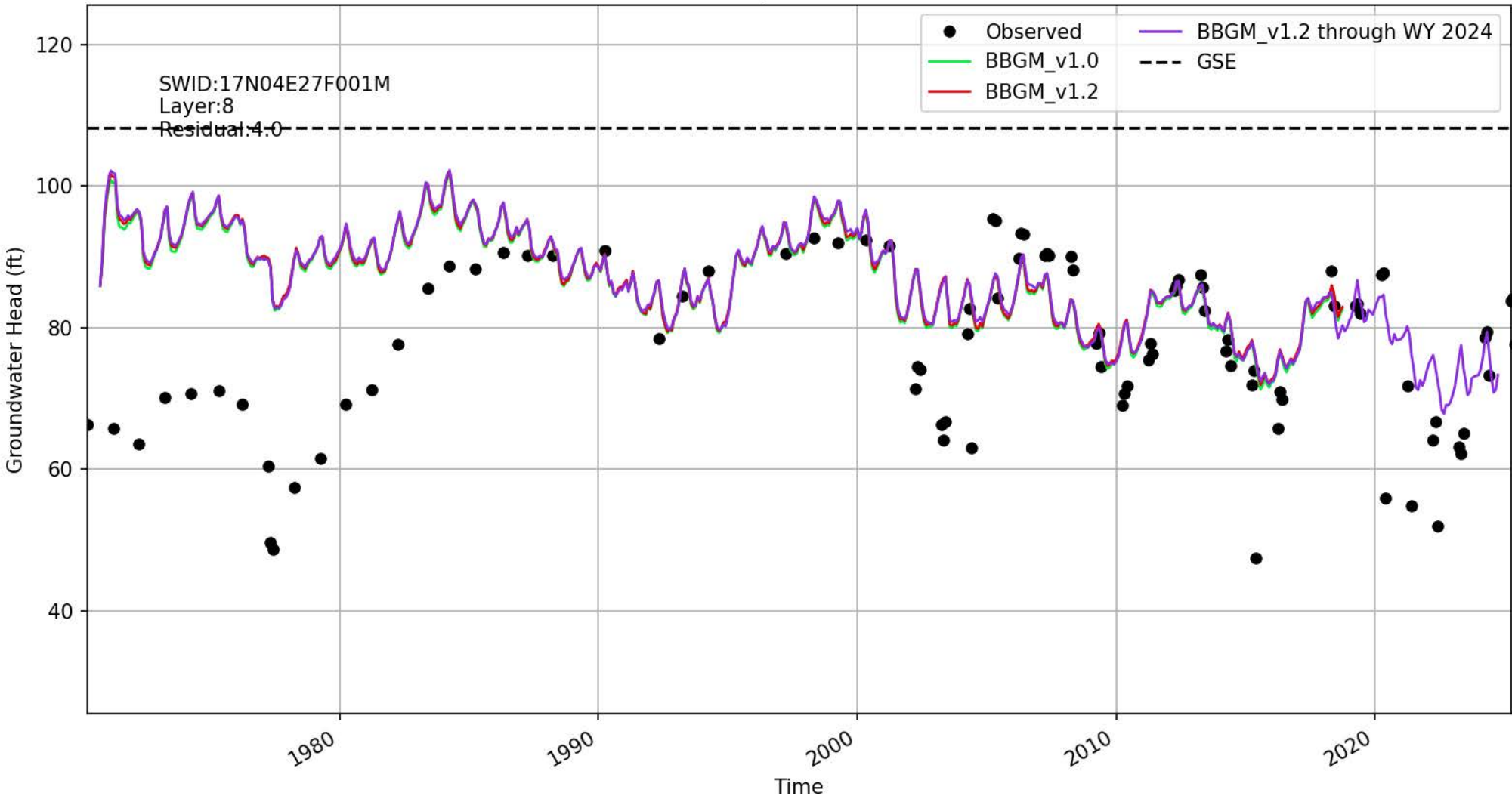


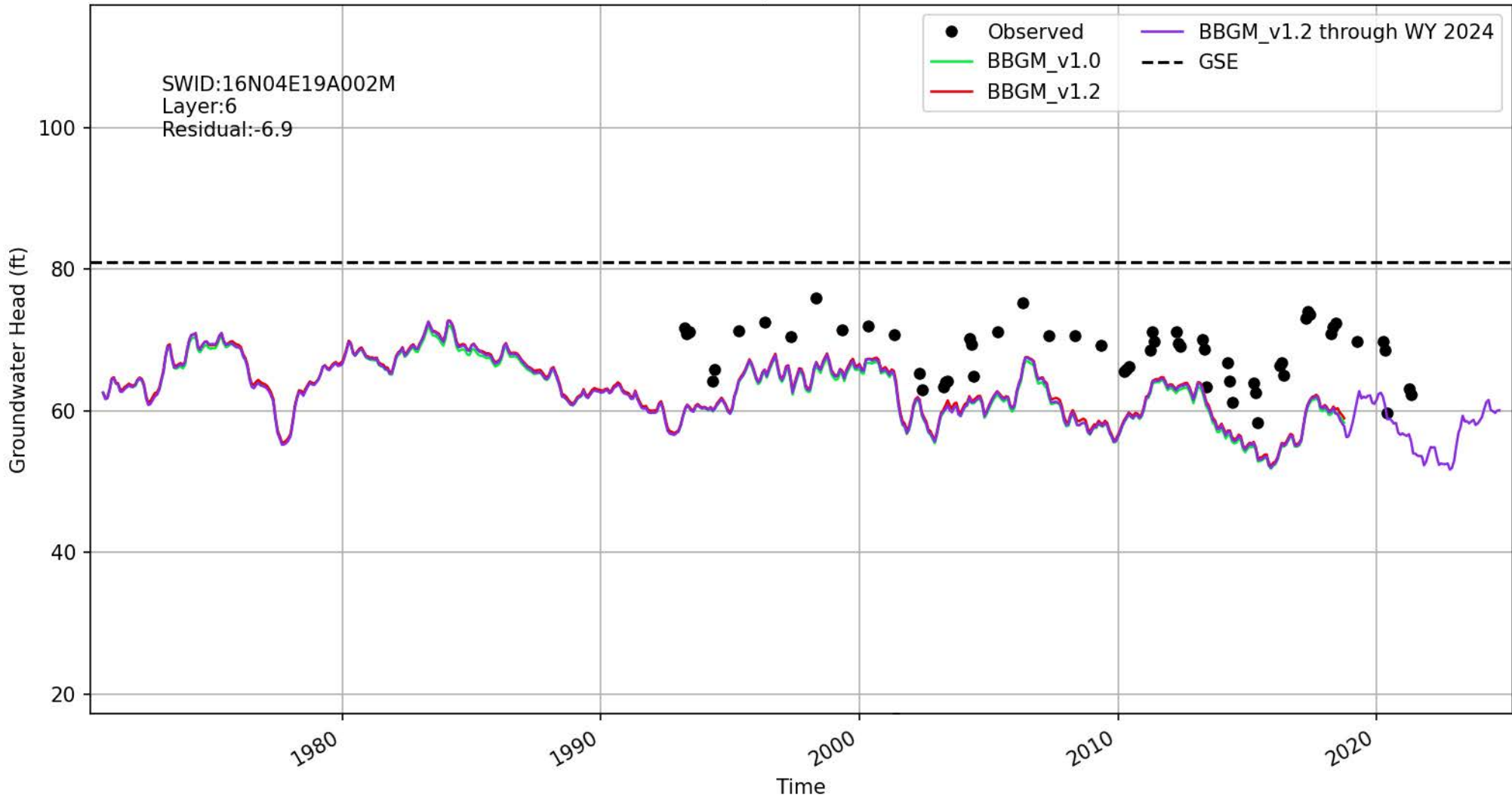


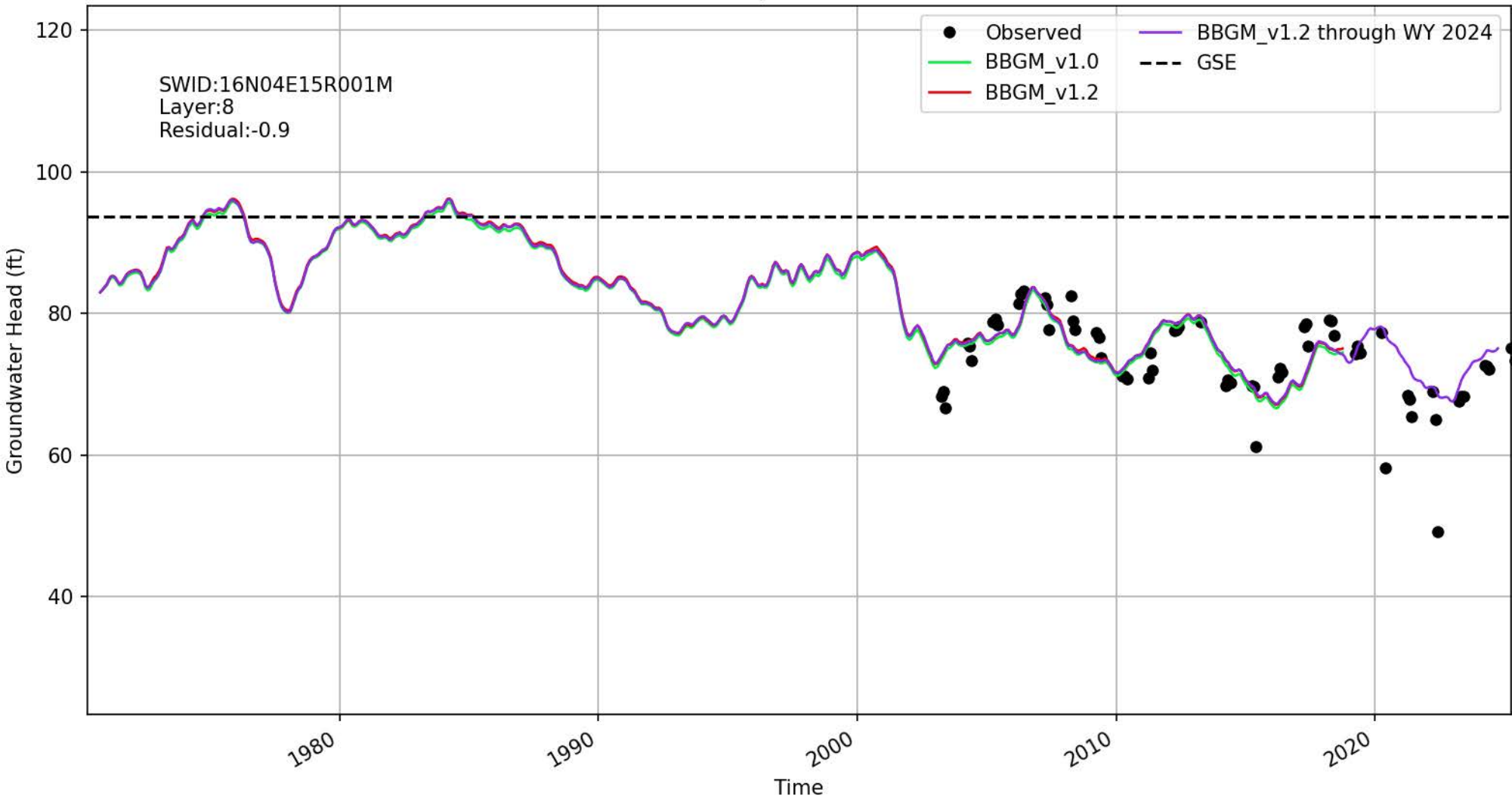




Location ID: 3105 | 393050N1215147W001







Location ID: 3214

