hydrogeologic divide, there is no flow occurring across the north and south boundaries of the model domain or through the Hawthorn Group at the bottom. The boundary conditions on the top model layer are noted on Figure 23.

Recharge was applied uniformly to the land surface at a rate of 4.13 inches/year, which is based upon estimates for the proposed mine area calculated by the USGS (2003). The conceptual model evaluations above, noted that estimates can range from 3.5 to 4.5 inches/year (Holt, 2019d and Holt 2020a). A sensitivity analysis was conducted to note the impact of recharge uncertainty on model results.

The bottom boundary was considered a no-flow boundary because the Hawthorn Formation at the base of the Surficial Aquifer has very low permeability and flow through it is negligible in comparison to flow conditions in the Surficial Aquifer.

Wetlands are discharge areas for groundwater. Stream channels in the area may recharge groundwater during periods of rainfall events but are otherwise locations of groundwater discharge. The drain boundary in MODFLOW-NWT was used to represent wetlands and streams. The drain boundary allows water to flow out of the groundwater system when water levels are at or above a prescribed "drain" elevation – no flow occurs when groundwater levels are below the "drain" elevation. The streambed elevation or the elevation of the wetland were assigned as the "drain" elevations. The drain boundary includes a conductance term to represent sediments at the bottom of the streams, wetlands, or lining of the streambed. A high conductance value (10^7 ft^2/d) was used for the drains to allow water to freely drain without resistance from near surface depositions or alterations.

Prescribed water level conditions (prescribed head conditions of MODFLOW-NWT) were provided along the east and west lateral model boundaries in all model layers. The prescribed water level elevation was set to land surface at the location of wetlands, and to 1 foot below land surface where there were no wetlands along the boundary. The prescribed water level conditions were not provided in layer 1 at locations also coincident with drain boundary conditions. The northern and southern lateral boundaries were no-flow conditions because they are parallel to the direction of groundwater flow with minimal flow across them.

5.0 MODEL CALIBRATION

The numerical model was constructed using Groundwater Vistas Version 8 (Rumbaugh and Rumbaugh, 2020). Model files were then generated for MODFLOW-NWT, which runs the model and creates output files that were then imported into Groundwater Vistas for further analysis. A model developed with preliminary estimates of the hydrogeologic properties usually does not match site conditions very well and requires "calibration", which is done by adjusting the model parameters to obtain a best fit between the model calculations and the field data. Model calibration was performed using expert hydrogeological judgement aided with automatic calibration tools provided by the computer software PEST (Doherty, 2010). Consistency with the conceptual model was also evaluated and adjustments were made to modeled hydraulic conductivity values within reasonable ranges for each of the hydrogeologic units, until the model was considered calibrated.

All available field data were used for model calibration and include average water level measurements of Figure 19 and water level differences between piezometer pairs noted on Figure 21. The water level contour maps of Figure 20 were also evaluated visually during calibration. Finally, in areas outside of wetland or stream channels, the calibration was constrained to try and keep water levels below land surface.