APPENDIX D
SURFICIAL
GEOPHYSICS

Time-domain electromagnetic (TEM) geophysical surveys were conducted at Sites 1–3 within the Flathead Valley (fig. D1) to determine the presence and thickness of the glaciolacustrine aquitard (Breitmeyer, 2022). Analysis and interpretation of these results were conducted as a Montana Tech master's thesis by Elizabeth Breitmeyer in conjunction with the Department of Geological Engineering and the Mon-tana Bureau of Mines and Geology's Ground Water Investigation Program. The TEM method allows for non-invasive identification of different geological layers in the subsurface based on their differing electrical conductivity properties (fig. D2). Relative to drilling, TEM surveys are cost-effective, but they do have

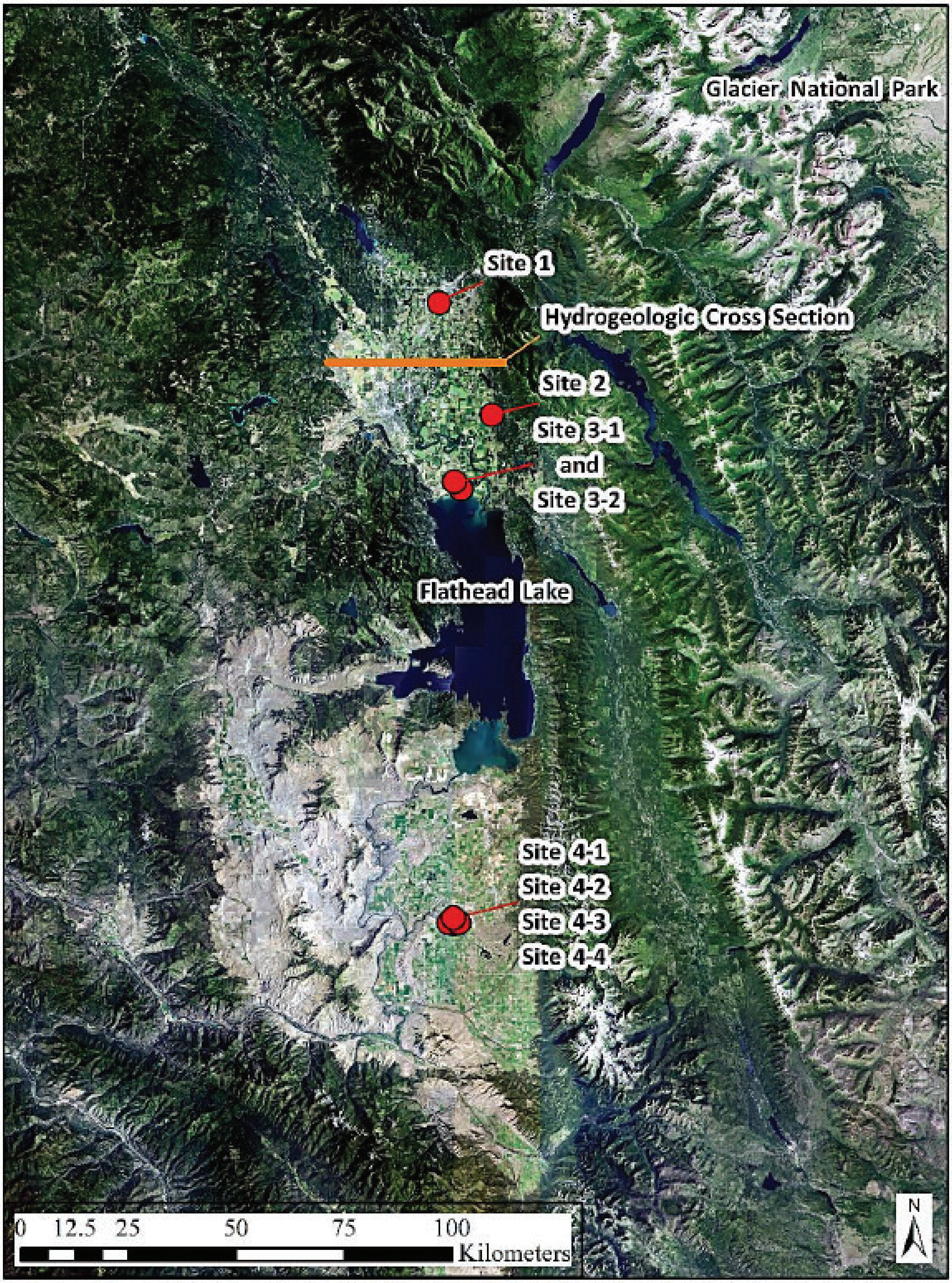

Figure D1. TEM surveys were conducted at 4 sites, 3 of which were in the Flathead Valley. Some sites included multiple geophysical surveys. The deep well (BFF#5) was drilled at Site 3-1.

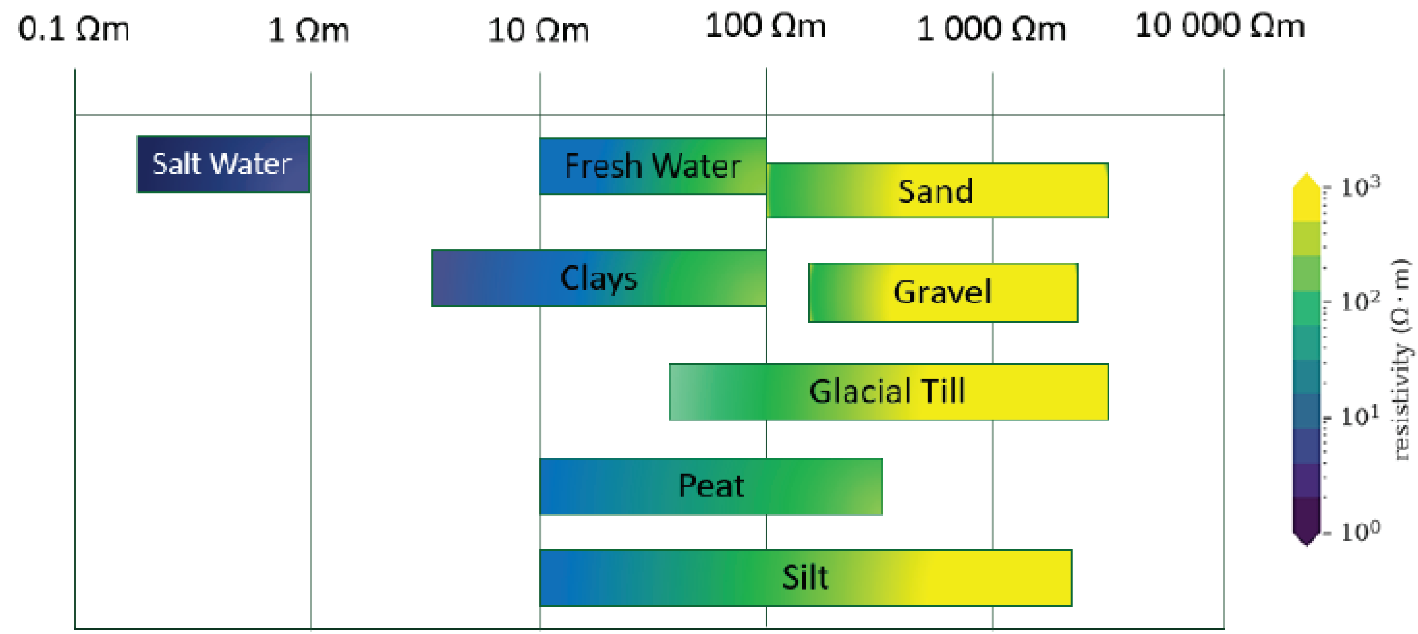

Figure D2. Range of geoelectrical resistivity values for post-glacial intermontane valleys, adapted from Palacky (1987) and Veleva (2005).

drawbacks, including electromagnetic interference from infrastructure (i.e., power lines, buried pipes, fences), limited total depth of investigation based on survey loop size, decreasing resolution with increased depth, and the necessity for specific data processing software and expertise.

A lack of deep wells near Site 1 (fig. D3) limited ground-truthing of the geophysical results, but in general the near-surface lithology (consisting of mixtures of clay, sand, and gravel) showed a low-to-moderate electrical resistivity (<1000 ohm-m). A higher resistivity (~5000 ohm-m) zone extends from 20 to 220 m (65–720 ft), which would be consistent with a deeper sand and gravel layer. At greater depths (>220 m, 720 ft) a low-resistivity zone was modeled (<2000 ohm-m); however, this is below the calculated depth of investigation (DOI), so should be considered tentative.

Wells drilled at Site 2 (fig. D4) were installed to a maximum depth of 85 m (280 ft) to determine the absence or presence of the confining layer. Similar to Site 1, the near-surface silty material at Site 2 showed a low resistivity (~100 ohm-m), consistent with that type of geologic material. The coarse-grained sands and gravels of the shallow and deep aquifer layers were detected as higher resistivity (~2000 ohm-m), at the same depths and extent as seen from drilling. TEM results indicate this high-resistivity sand-and-gravel zone extends to a depth of around 115 m (377 ft) before transitioning into a moderate-resistivity zone (~1000 ohm-m) from 115 to 175 m (377–574 ft) deep, consistent with a siltier zone of the deep aquifer. Below 175 m (574 ft), a low-resistivity zone (<200 ohm-m) was modeled, which may indicate a silt-dominated zone, but this is again tentative since it is almost entirely below the DOI.

Site 3 (fig. D5) is at the location of the deep well drilled for this project (BFF#5). The same relationships between lithology and electrical resistivity from the TEM surveys were seen as at Site 1 and Site 2. Unlike Sites 1 and 2, the overall greater degree of silt within all layers at Site 3 has reduced the measured electrical resistivity significantly at all depths, with no values greater than 300 ohm-m recorded. In general, the sand–silt–gravel zone of the upper 65 m (213 ft) had a relatively higher electrical resistivity (~250 ohm-m). The confining layer, recorded in drilling as a sticky tan clay from 65 to 125 m in depth (213–410 ft), was detected as a low-resistivity zone (~50 ohm-m). Below the confining layer, which transitioned back into gravel of the deep aquifer, electrical resistivity values increased to ~250 ohm-m. The DOI for this site was at 140 m (460 ft), so the TEM method was unable to image the bottom of the deep aquifer at 366 m (1,200 ft).

These TEM results helped to confirm the range of electrical resistivity values associated with the expected geological materials in the Flathead Valley, with

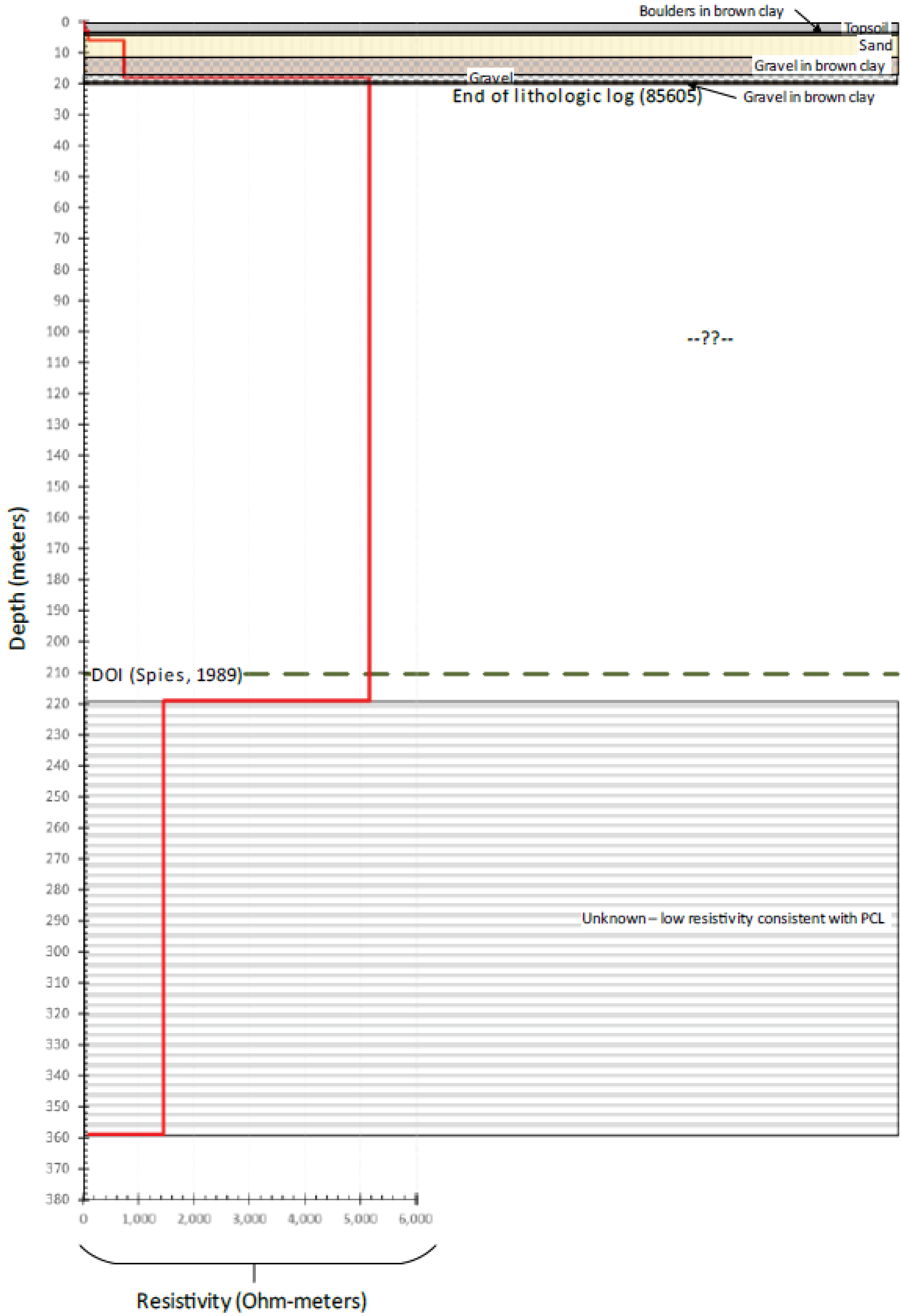

Figure D3. Six-layer depth comparison of well 85605 well completion report lithology and the Site 1 1D 6-layer geoelectric model layer depths (Montana Bureau of Mines and Geology Ground Water Information Center, 1998–2022).

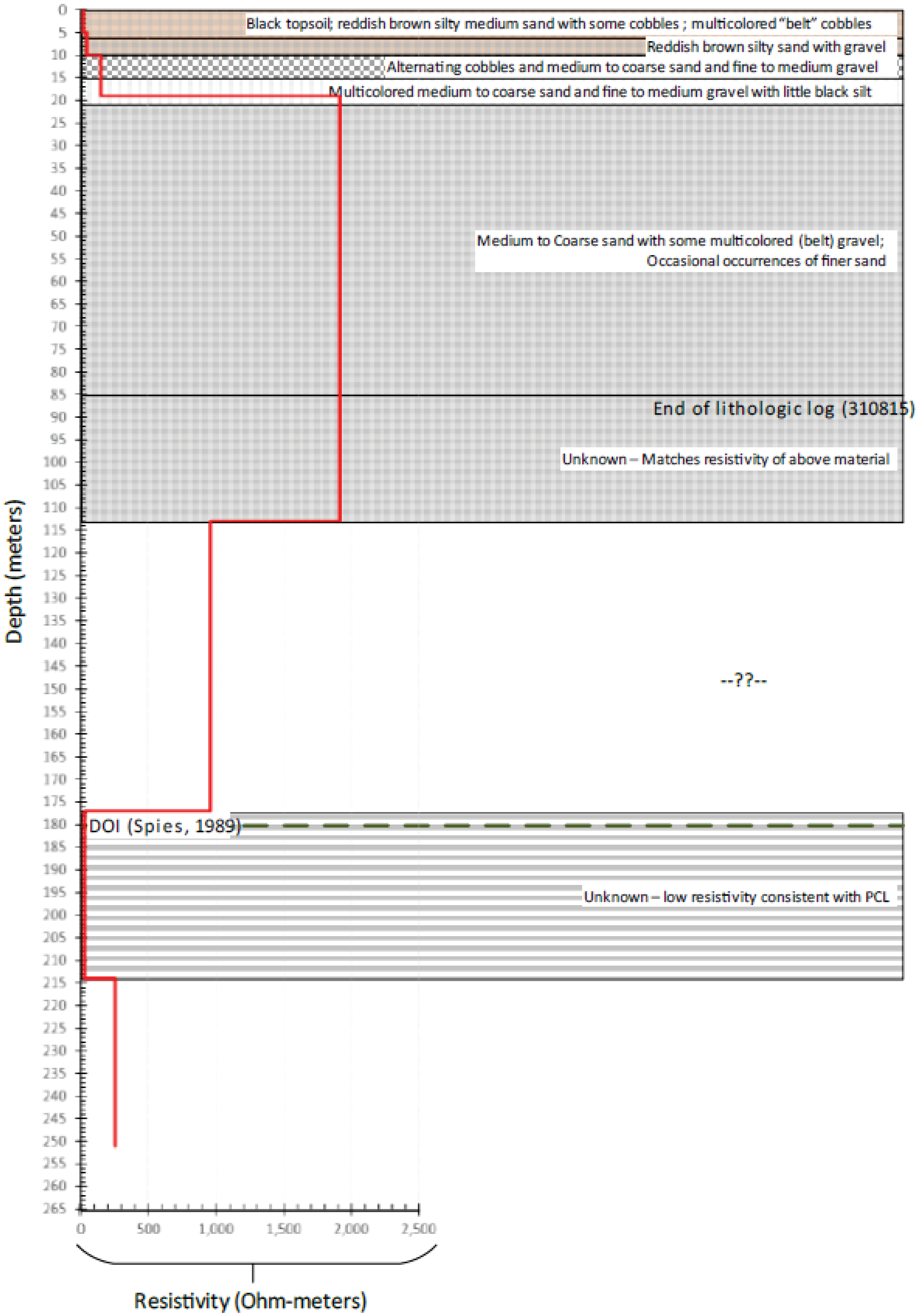

Figure D4. 1D geoelectric resistivity model of Site 2 with lithology of well 310815 (Montana Bureau of Mines and Geology Ground Water Information Center, 1998–2022).

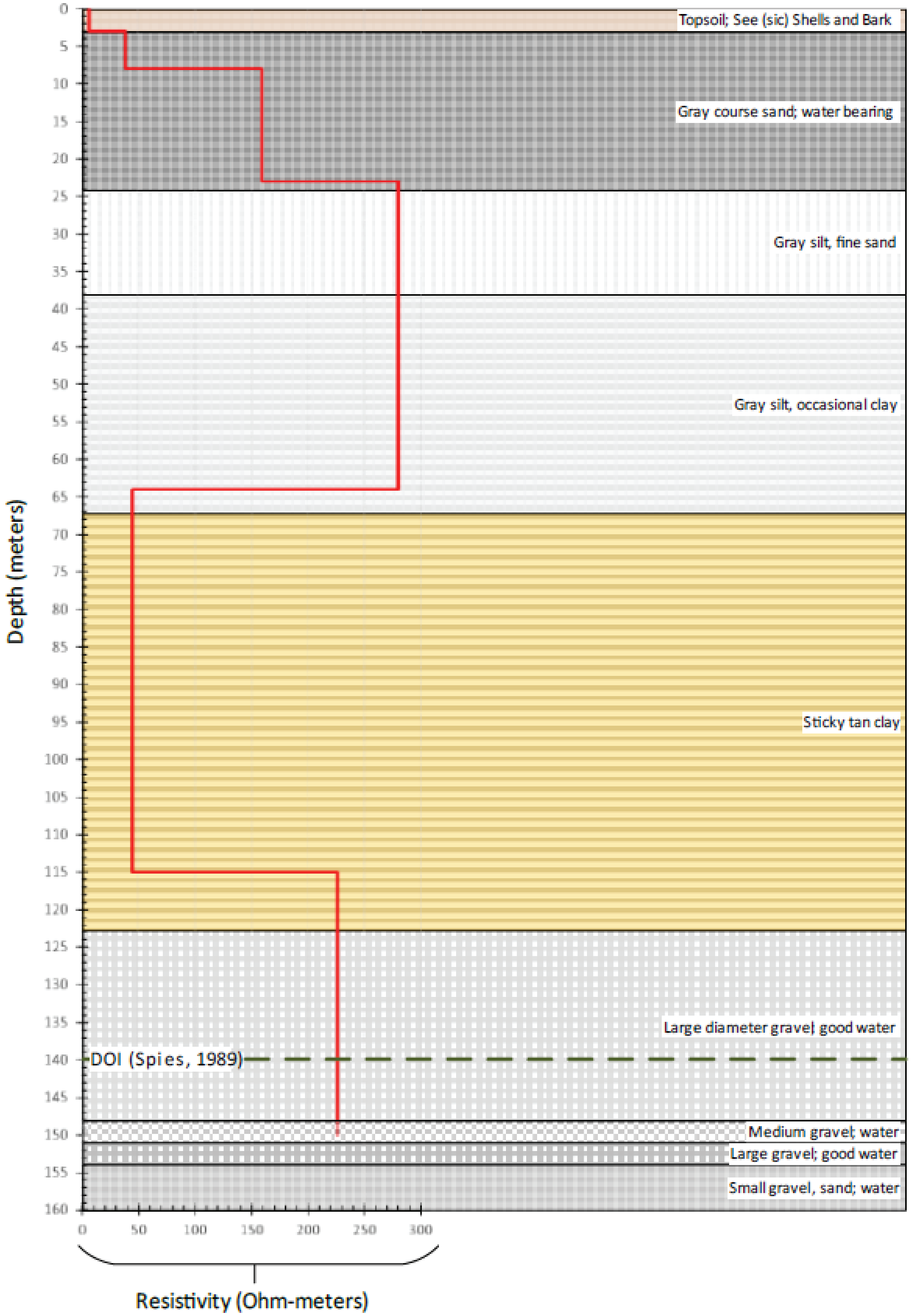

Figure D5. 1D geoelectric resistivity model of Site 3-1 with lithology of well 317644 (Montana Bu-reau of Mines and Geology Ground Water Information Center, 1998–2022).