Figures

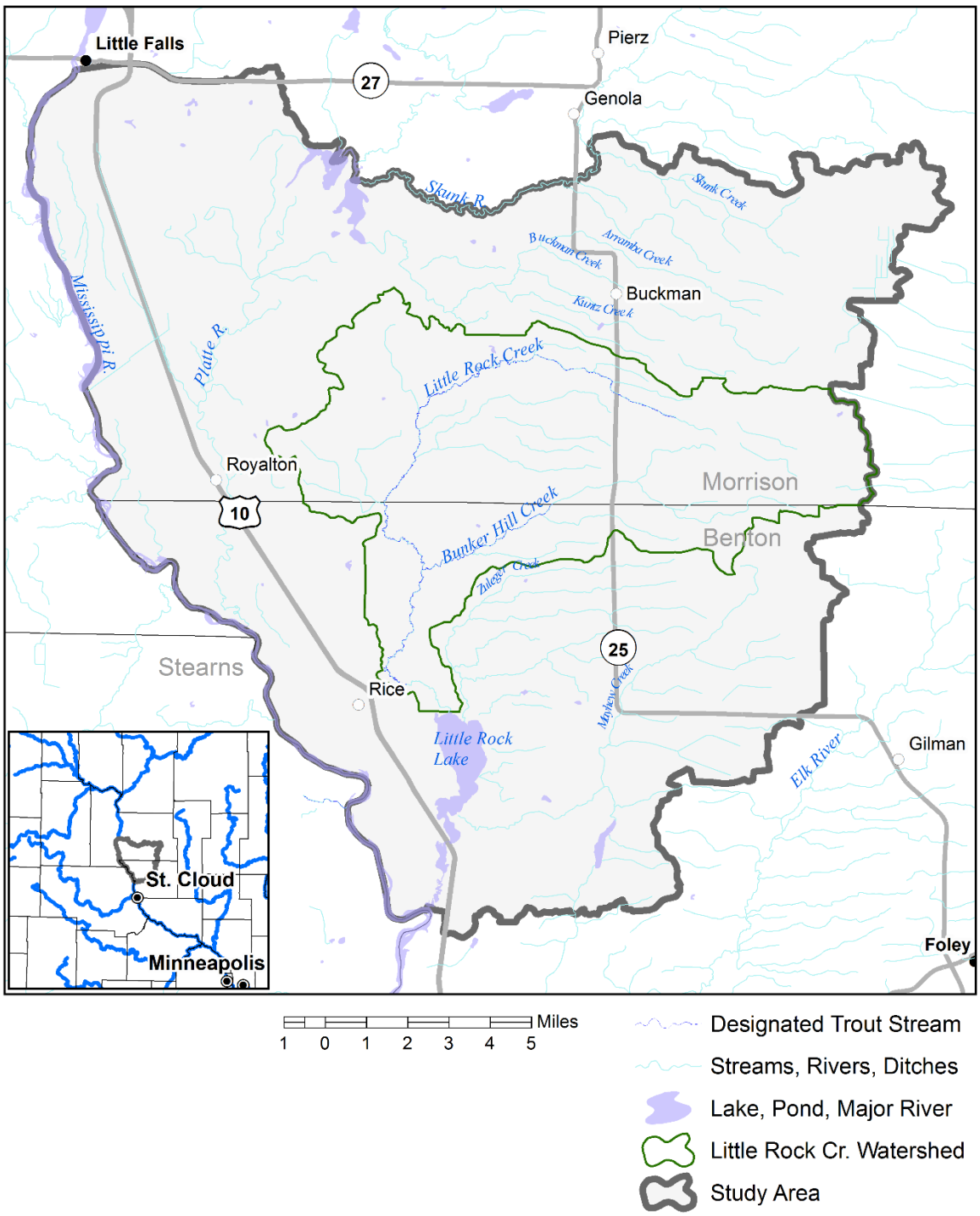

Figure 1 Location of the Little Rock Creek study area.

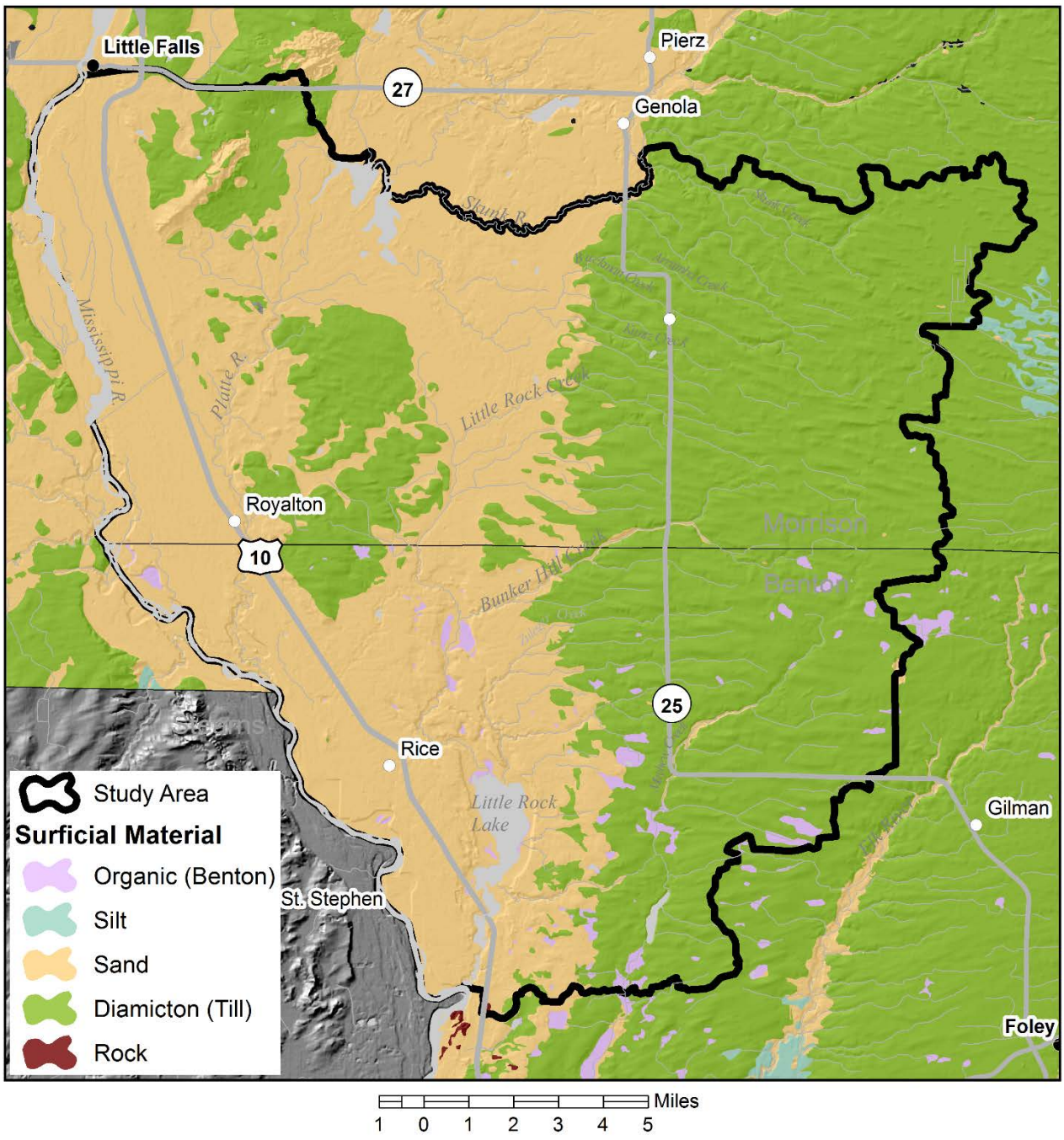

Figure 2 Surficial geology simplified from Setterholm (2010) for Benton County and Lusardi (2014) for Morrison County.

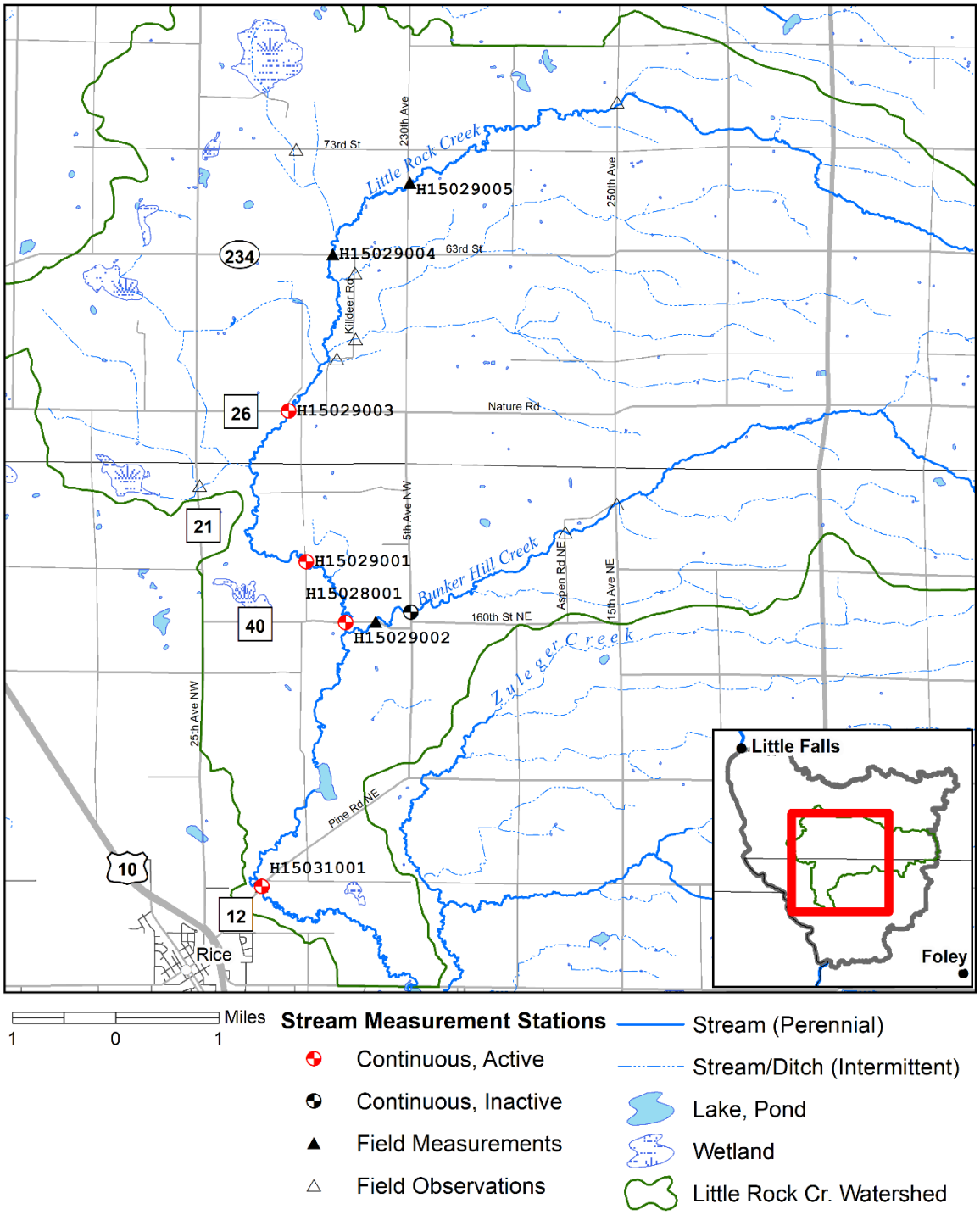

Figure 3 Stream gaging stations on the Little Rock Creek stream network.

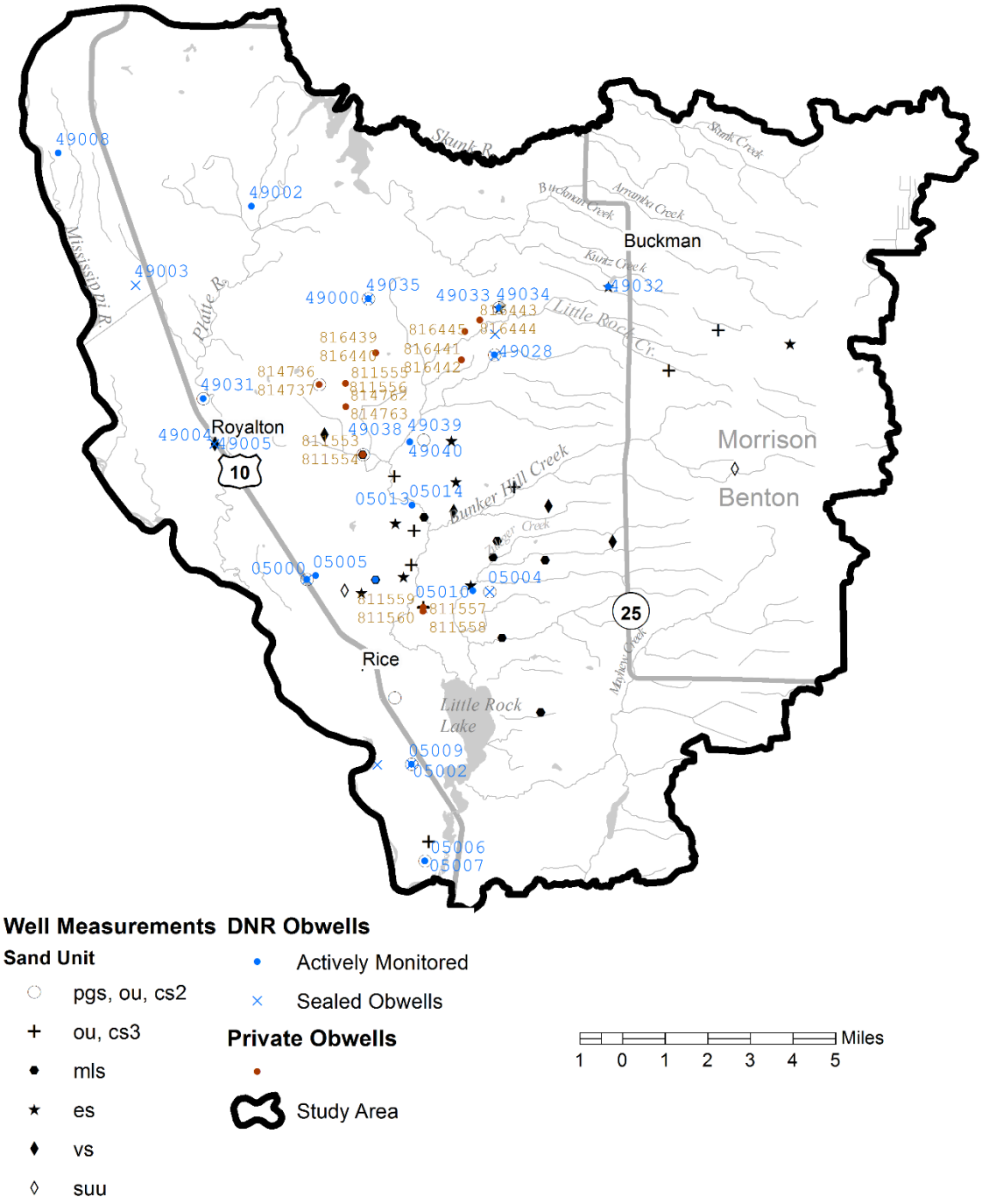

Figure 4 DNR observation wells and other measured wells.

DNR observation well (obwell) numbers are labeled by obwell number. Private obwells are labeled by Unique No. Private water wells measured during synoptic events and/or for county atlases (black symbols) are not labeled. See Figure 7 for sand unit/aquifer stratigraphy. Stratigraphic units are grouped according to model layering. DNR obwells 49035, 49038, 49039, 49040, 05009, 05010, 05011, 05013, and 05014 and all of the private obwells were installed after the history-matching period ending in September 2014.

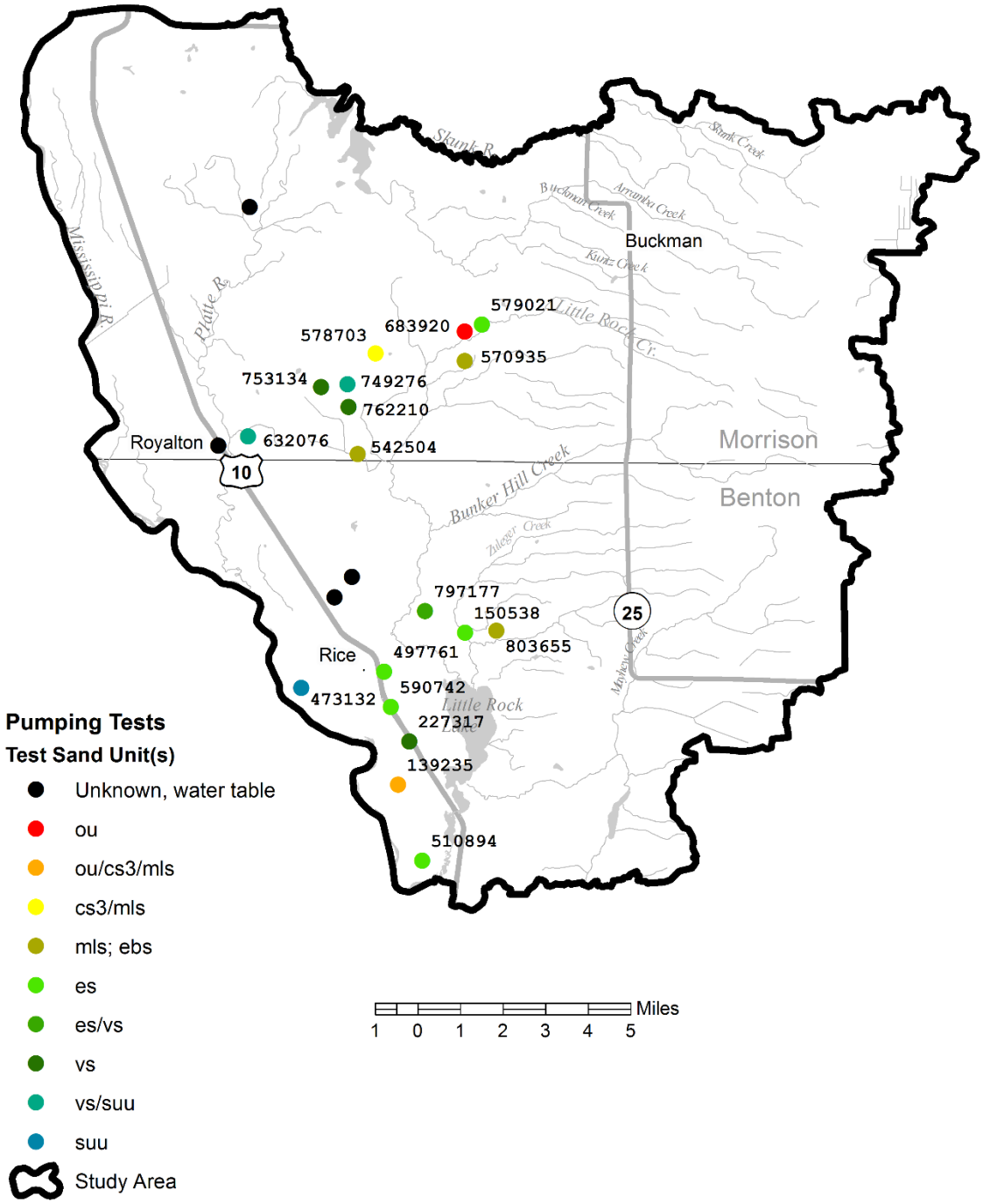

Figure 5 Locations of pumping wells for aquifer tests.

Color coding is for contiguous/stacked aquifer units corresponding to well screens. See Figure 7 for sand unit/aquifer stratigraphy. Labels are unique numbers, if known.

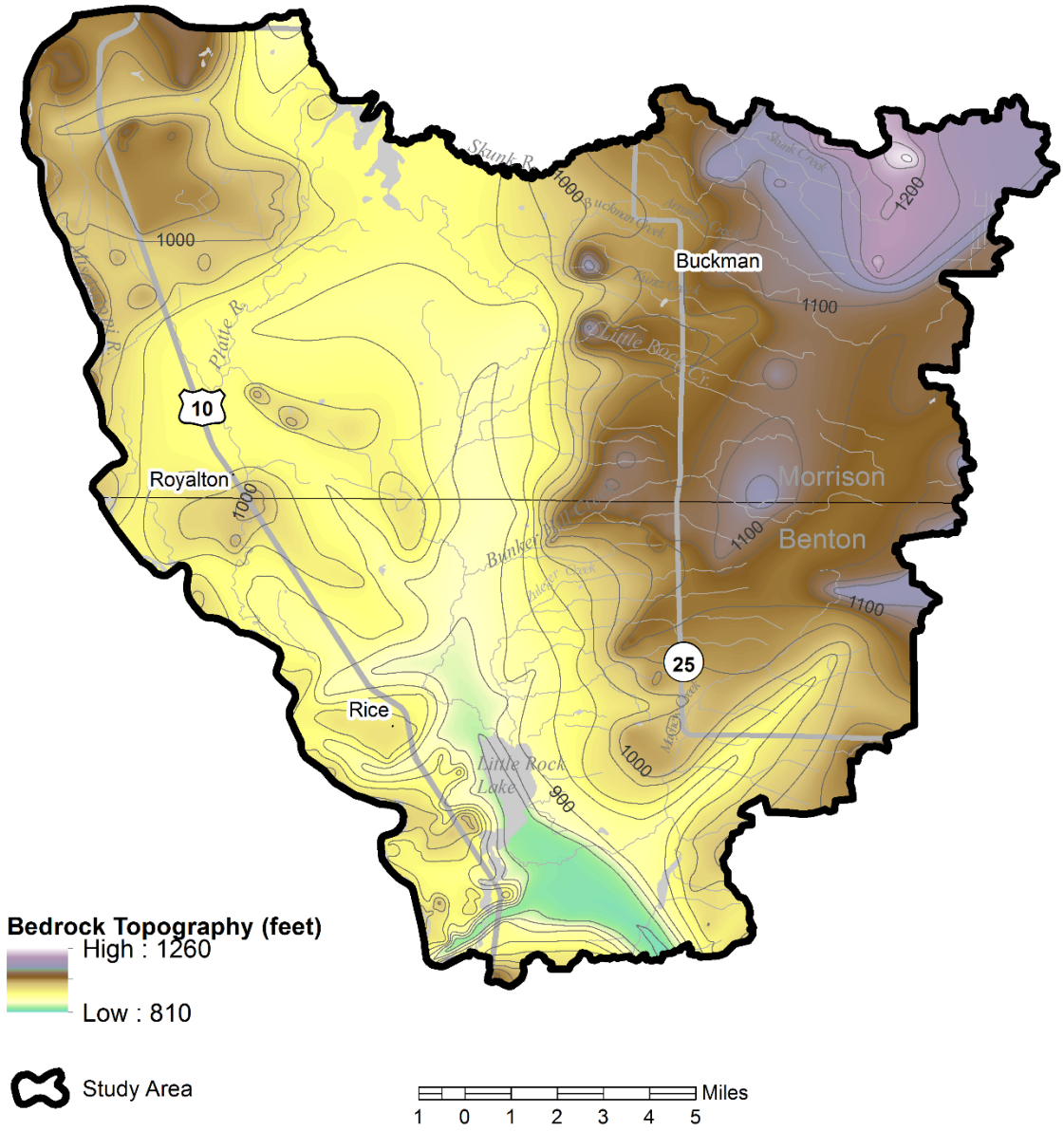

Figure 6 Bedrock topography in feet above mean sea level. Contour interval is 25 ft.

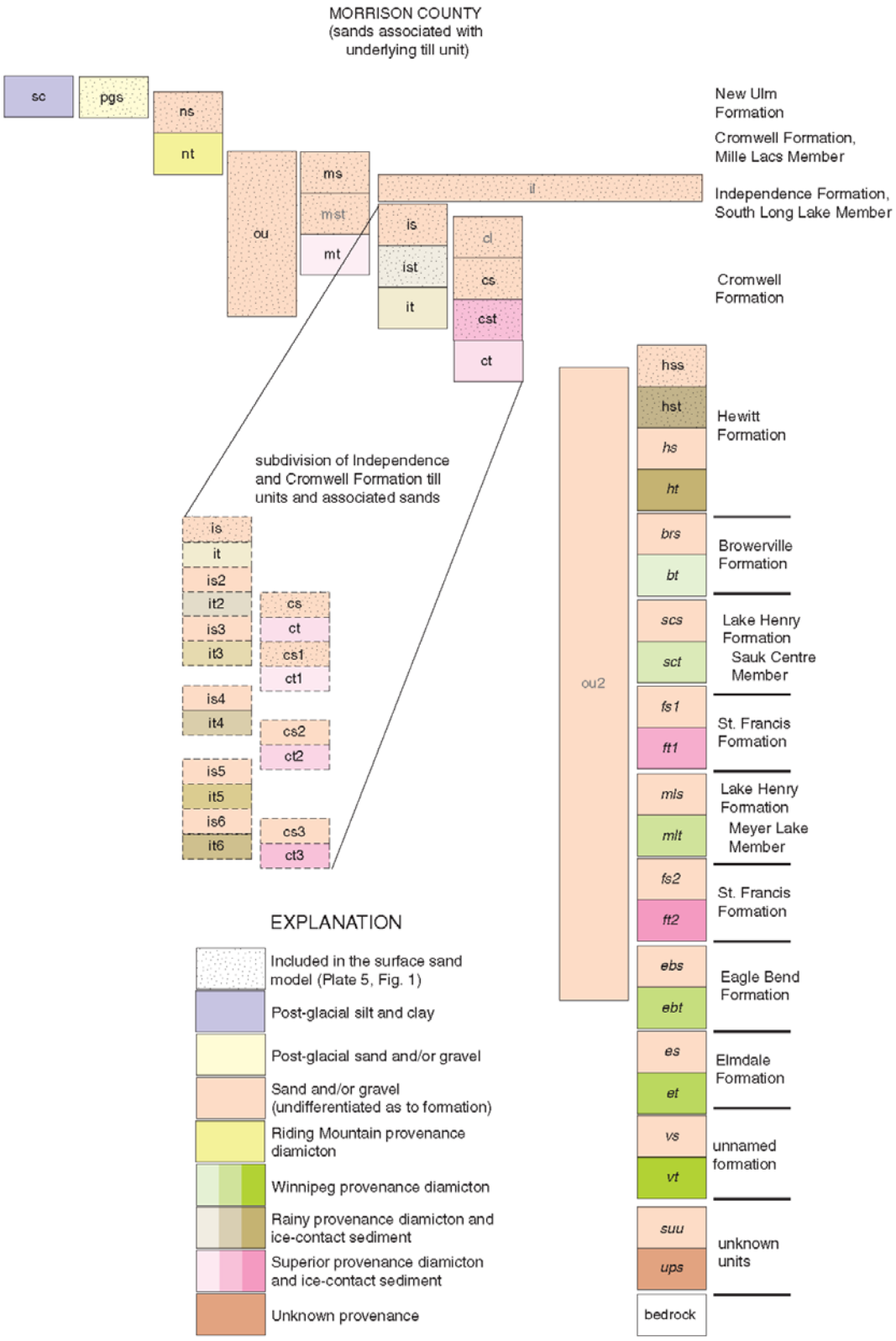

Figure 7 Stratigraphic position of Quaternary units, Figure 5 Plate 4 from Lusardi (2014).

Note that several units were not mapped in the Little Rock Creek study area (See Table 2). Localized, unmapped patches of the Eagle Bend, St. Francis, and Hewitt Fm. may be present within the study area.

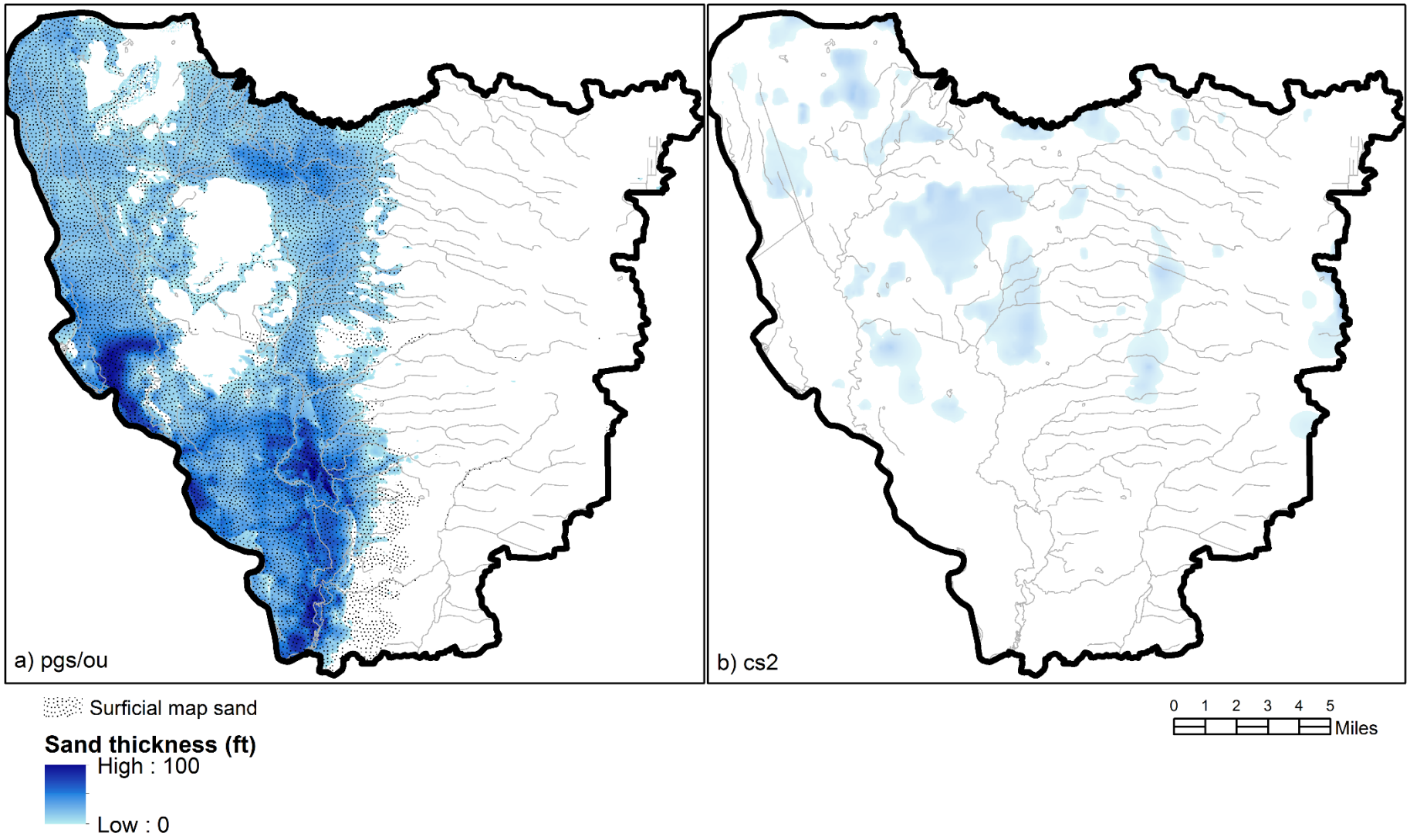

Figure 8 Sand thickness maps

a) surficial sand units pgs and ou (note that some areas with thin sand mapped at the surface were not included in the stratigraphic model) and b) cs2.

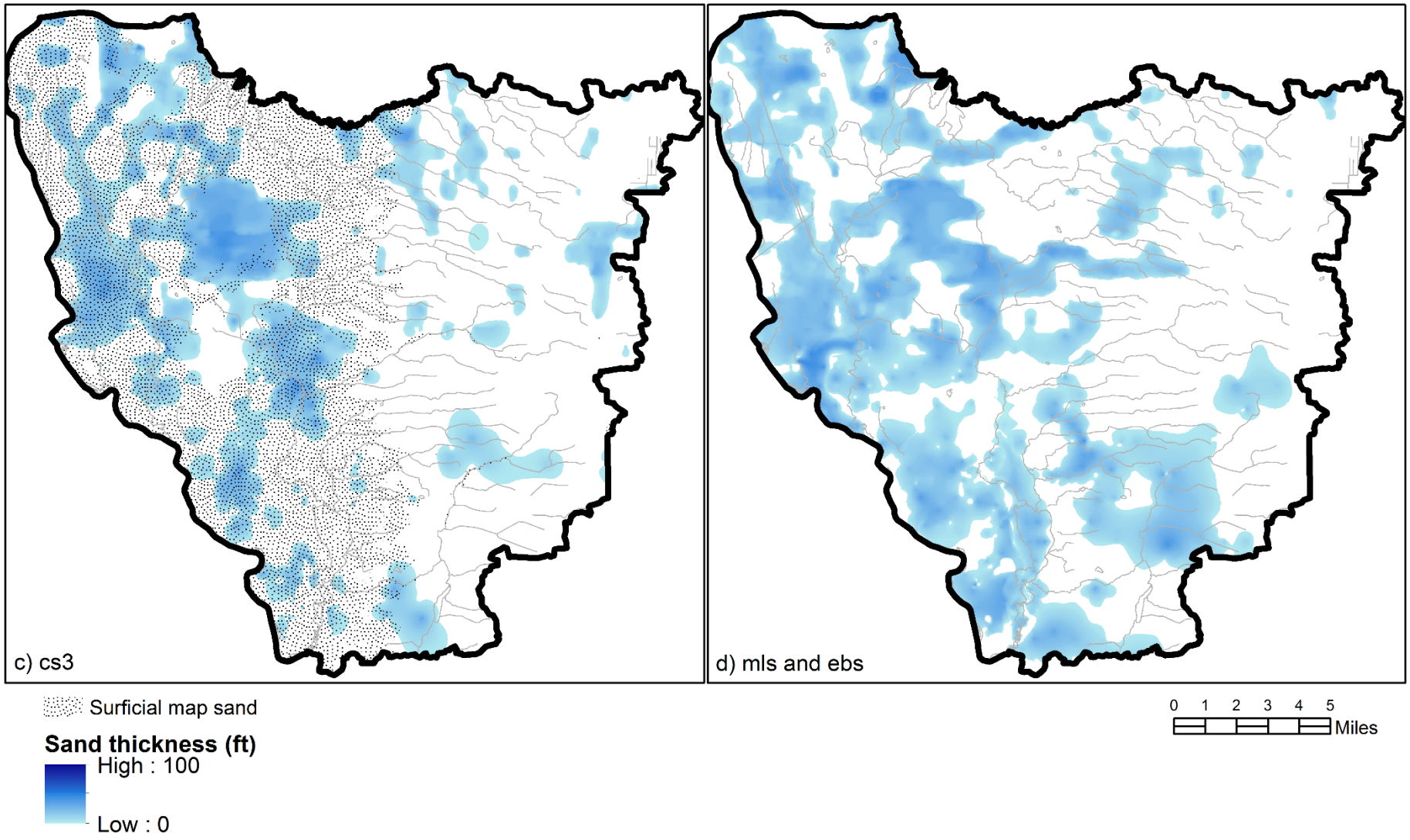

Figure 8 (continued)

Thickness of sand units c) cs3 and d) mls.

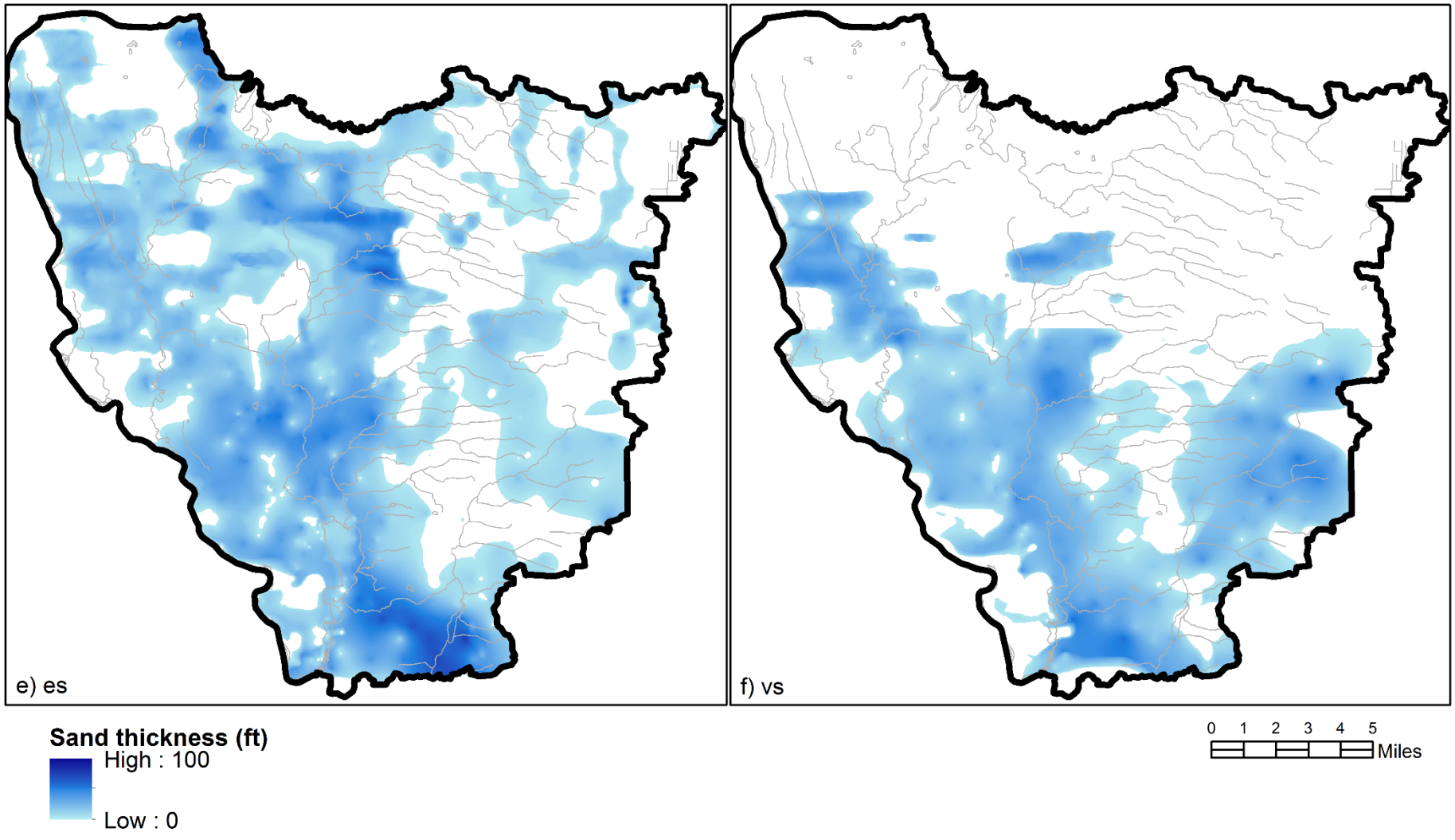

Figure 8 (continued)

Thickness of sand units e) es and f) vs.

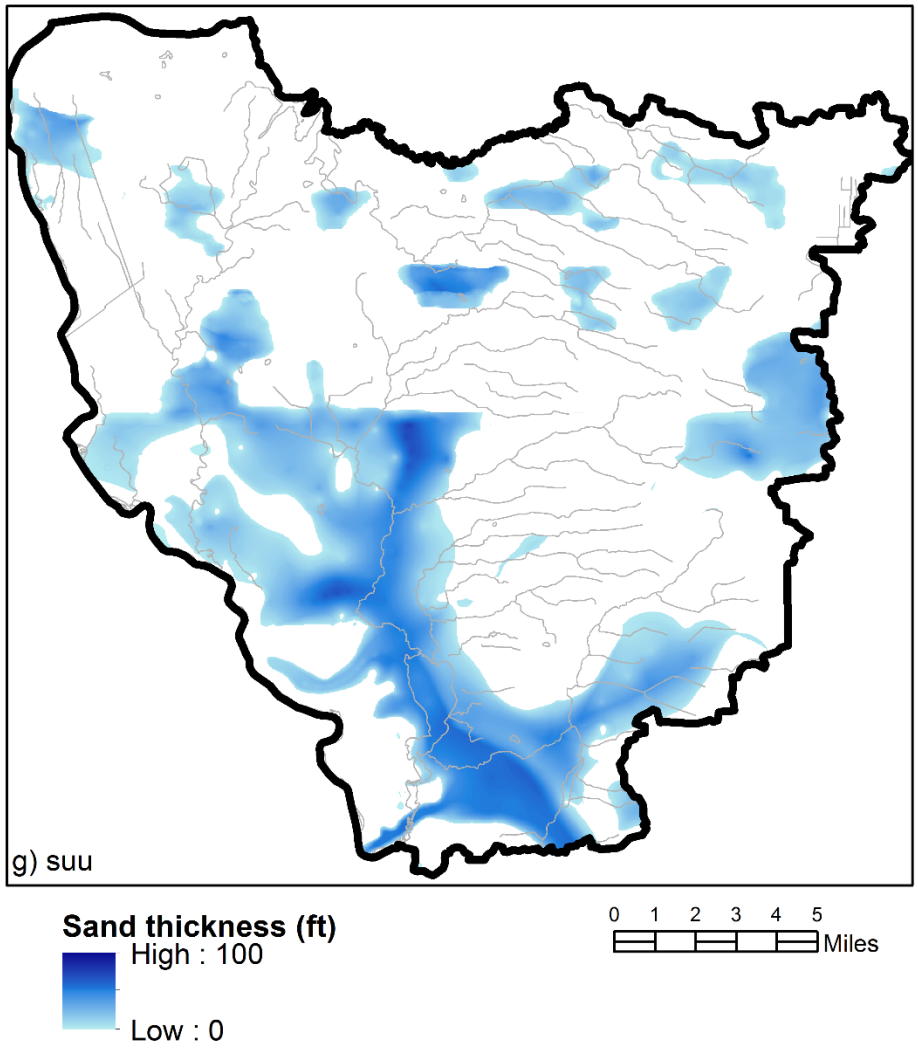

Figure 8 (continued)

g) Thickness of sand unit suu.

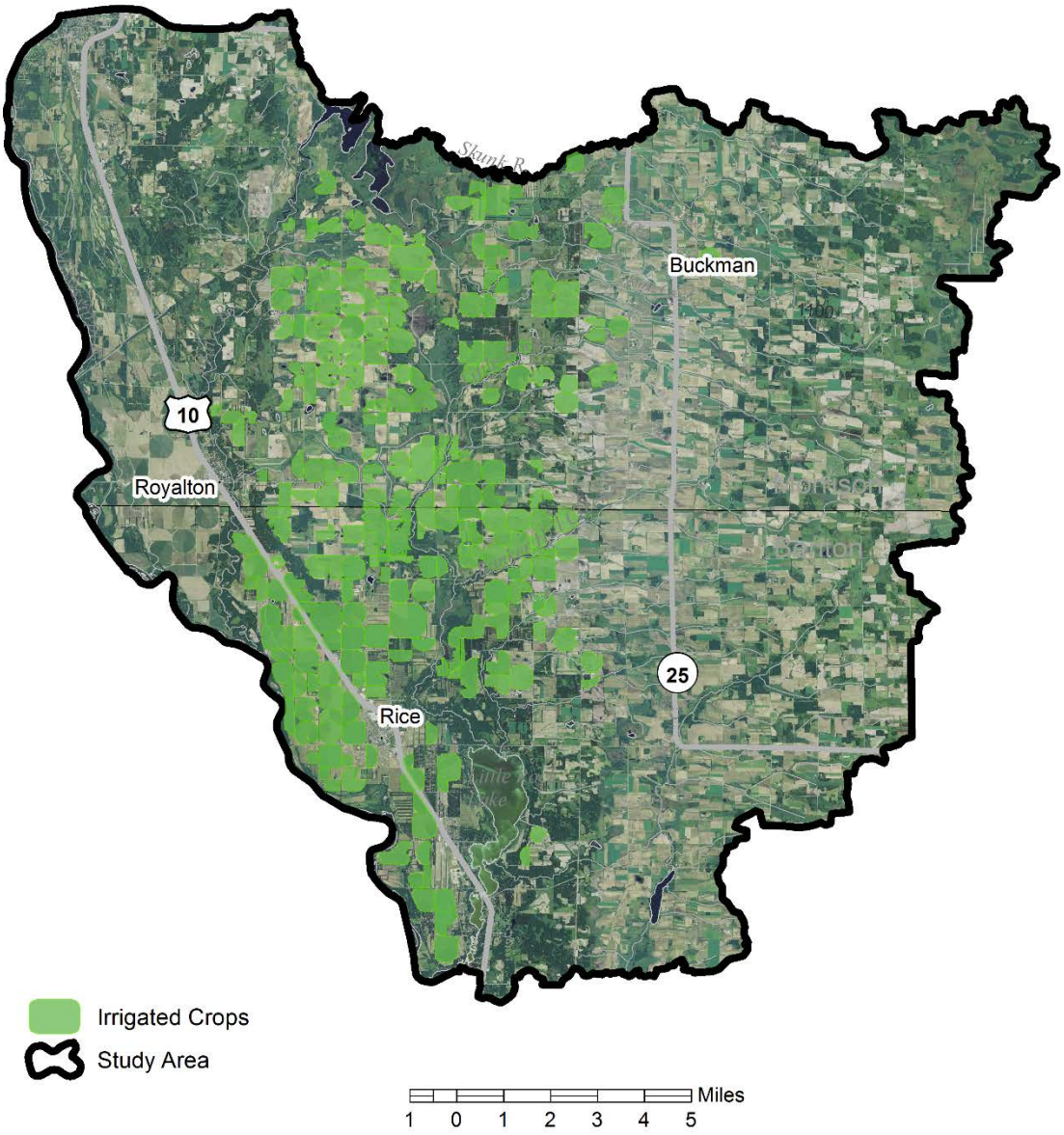

Figure 9 Irrigated crop areas east of the Platte River delineated in 2016.

Base is USDA NAIP imagery from July 2013.

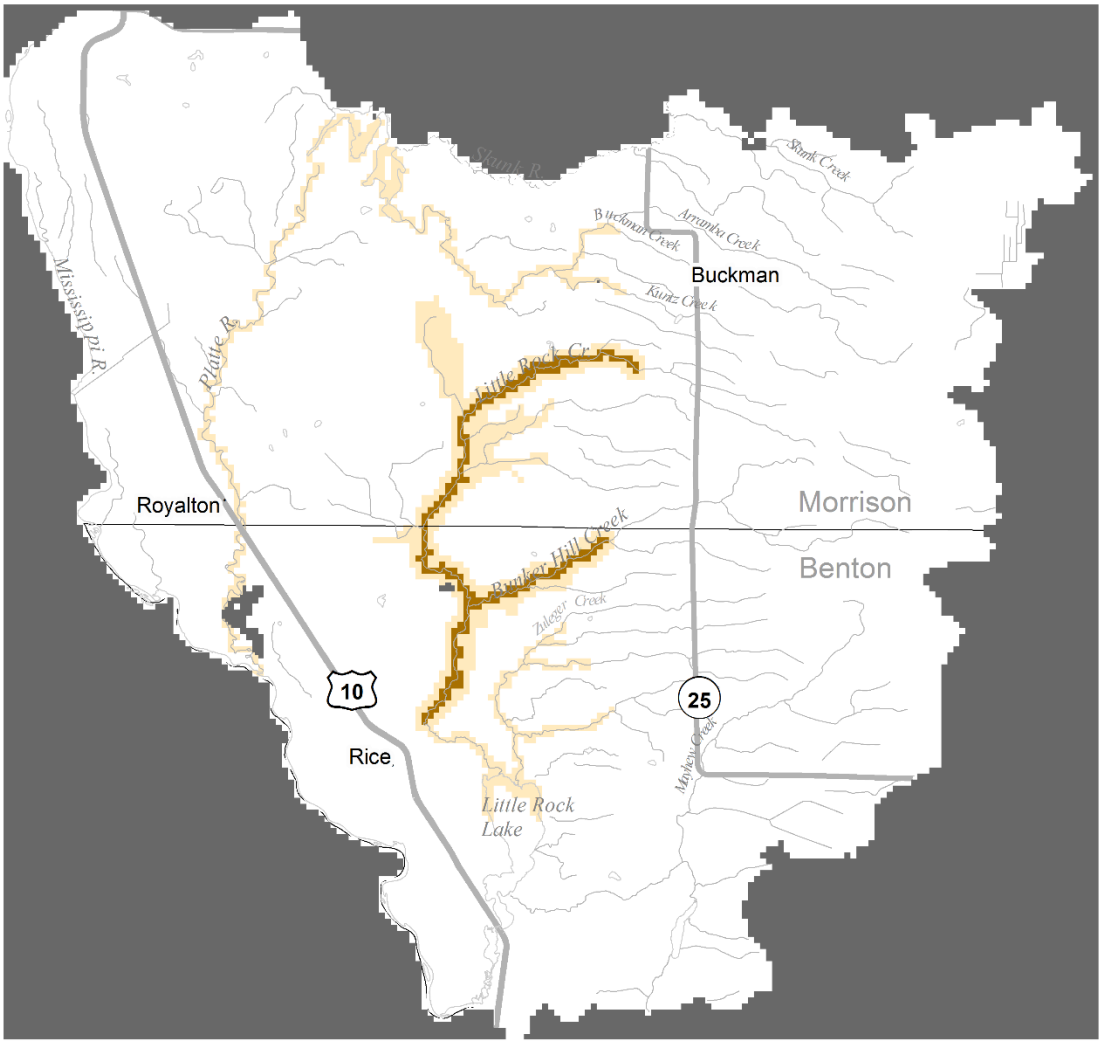

Figure 10 Distribution of cell sizes in the quadtree grid used in the MODFLOW model.

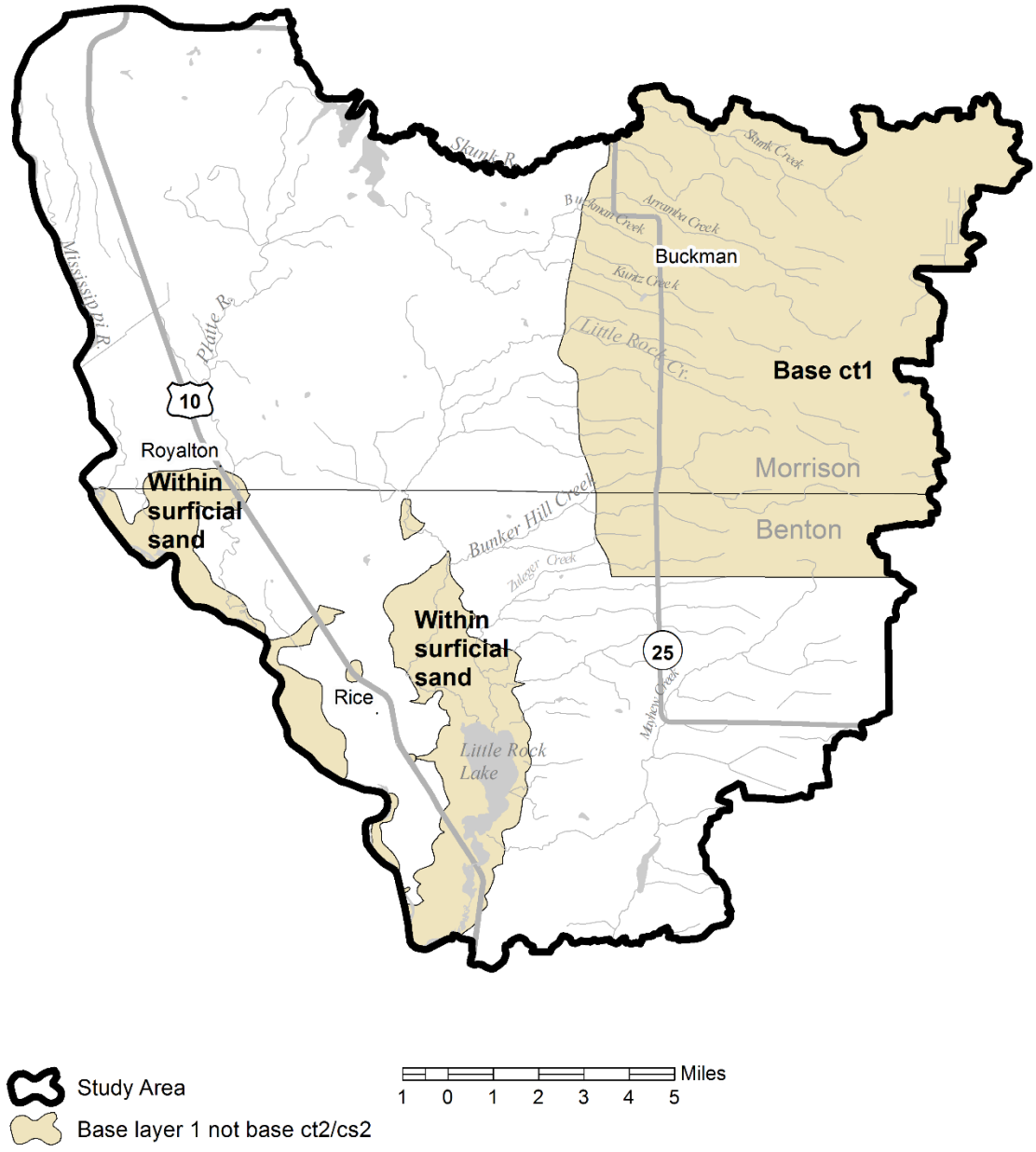

Figure 11 Areas where the base of layer 1 was not set to the base of unit ct2/cs2.

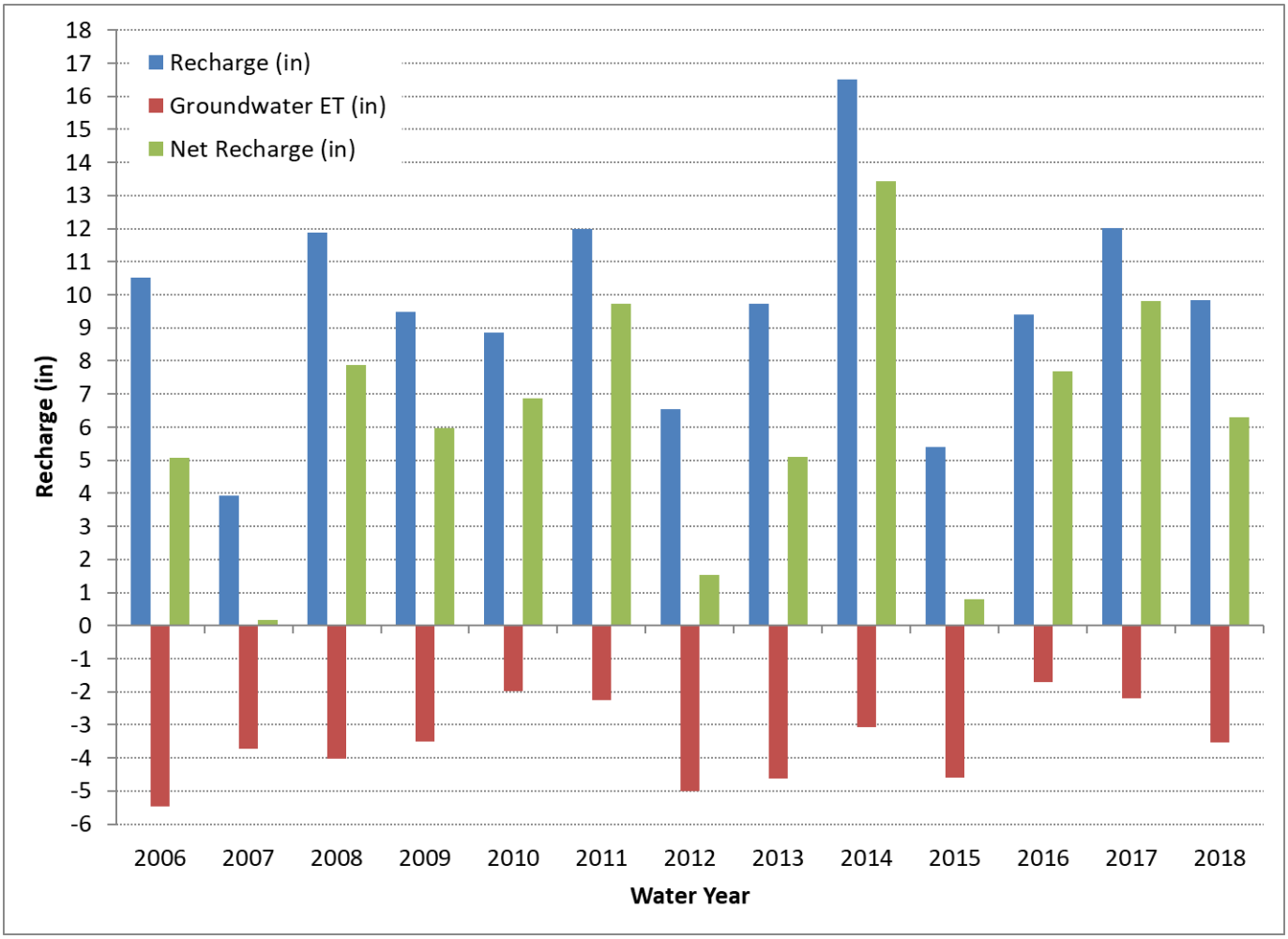

Figure 12 Computed recharge and groundwater evapotranspiration (ET) over the model domain for water years (October through September) 2006 through 2018.

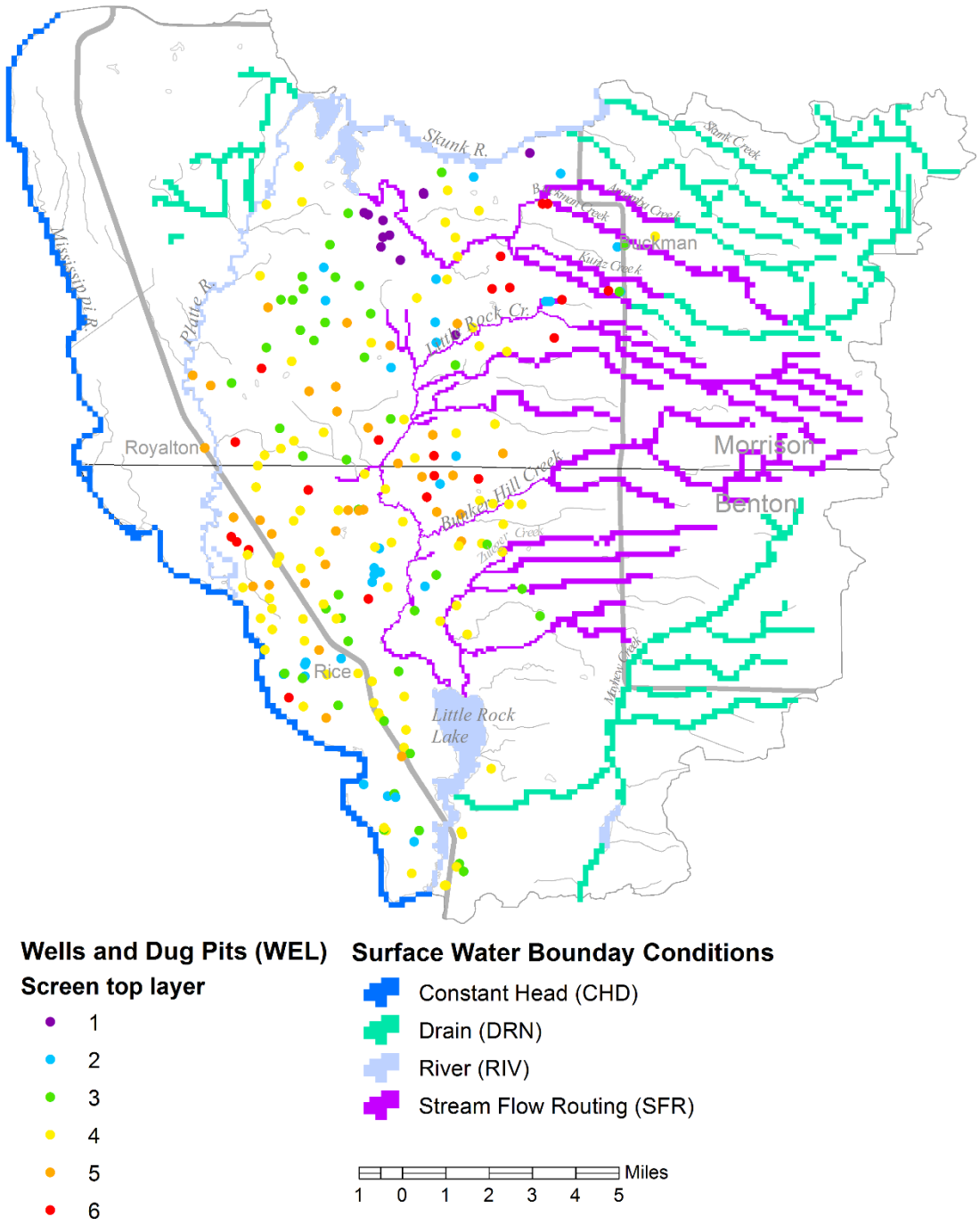

Figure 13 Surface-water and water withdrawal (wells and dug pits) boundary conditions through water year 2014 (several wells were added for the additional model period of water years 2015 through 2018).

Note that the entire cell containing a surface-water boundary condition is colored.

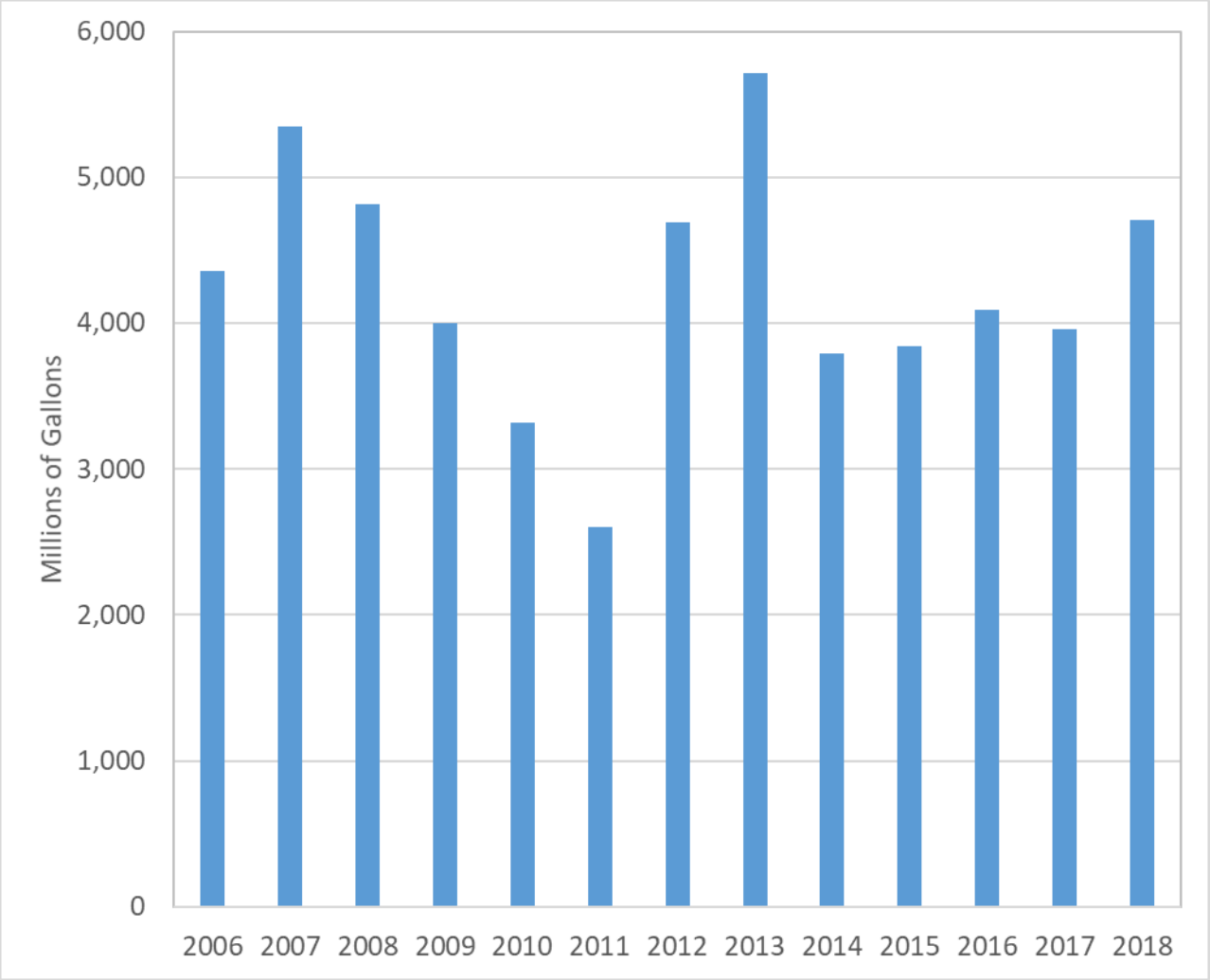

Figure 14 Annual (calendar year) groundwater withdrawals from permitted wells and dug pits included in the model in million gallons per year (MGY).

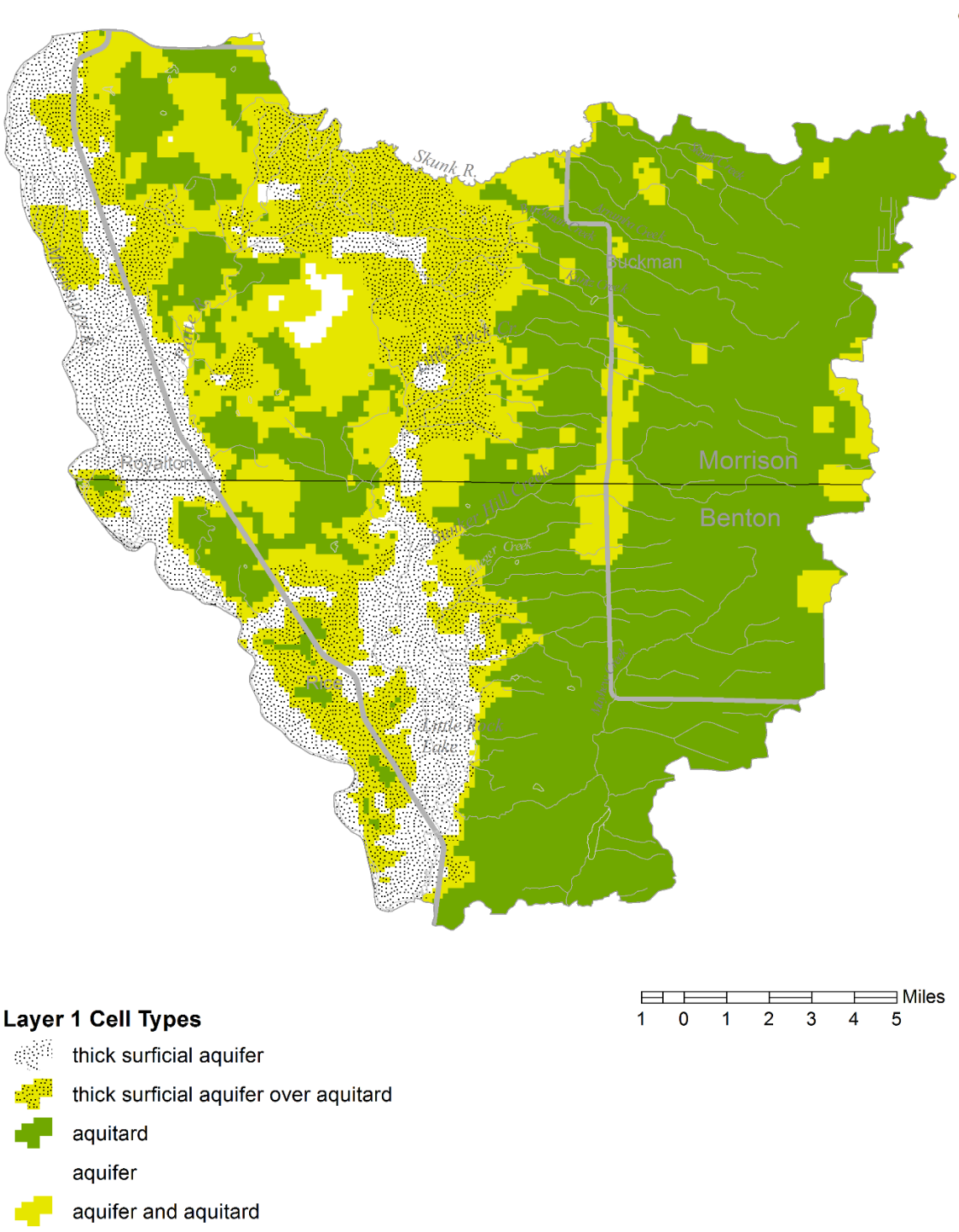

Figure 15 Hydraulic property cell types in each of layers 1 through 6.

a) layer 1 (includes all or parts of stratigraphic units pgs, ou, ct1, cs2, and ct2)

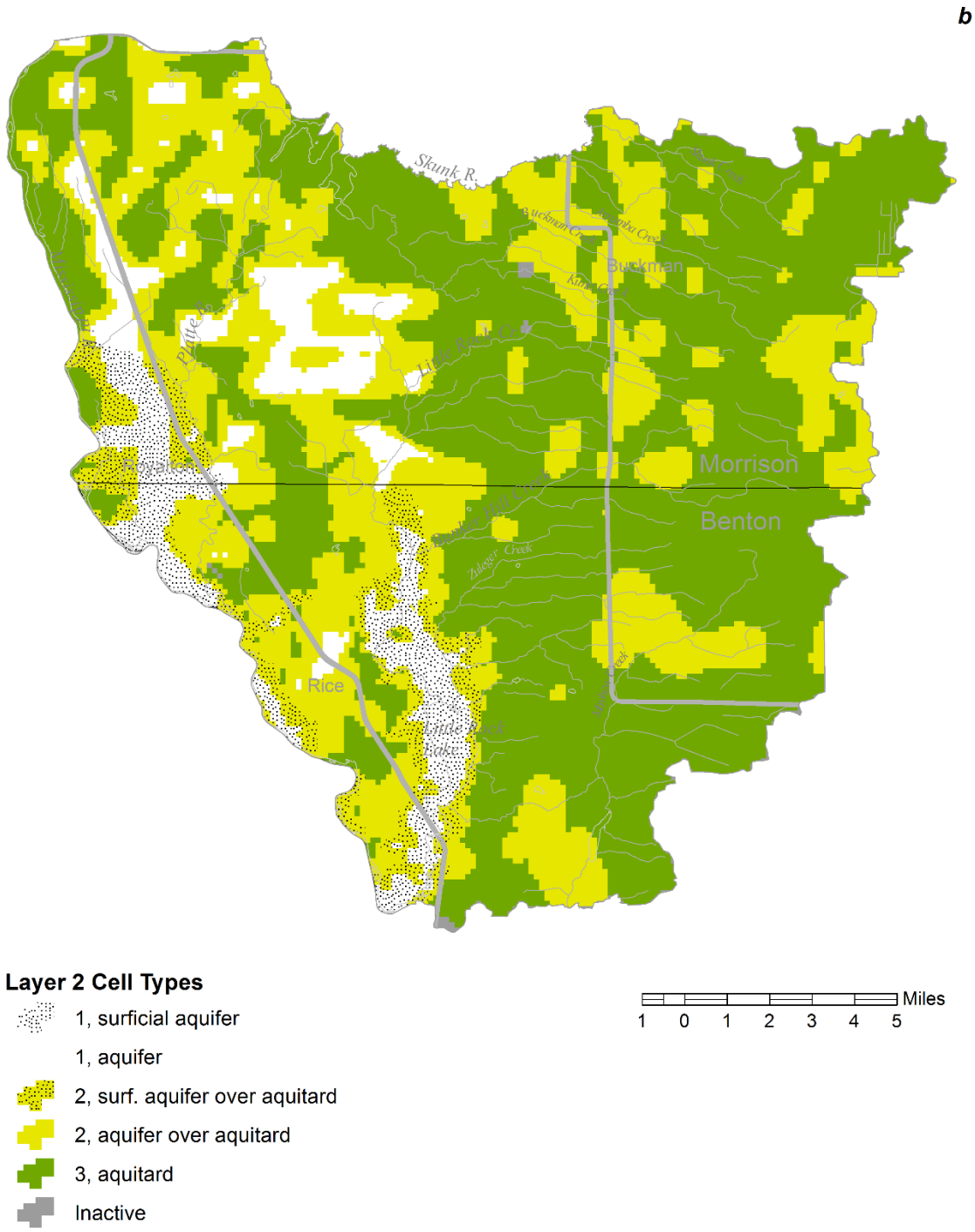

Figure 15 (continued)

b) layer 2 (includes part of stratigraphic units ou and ct2 and all of units cs3, and ct3)

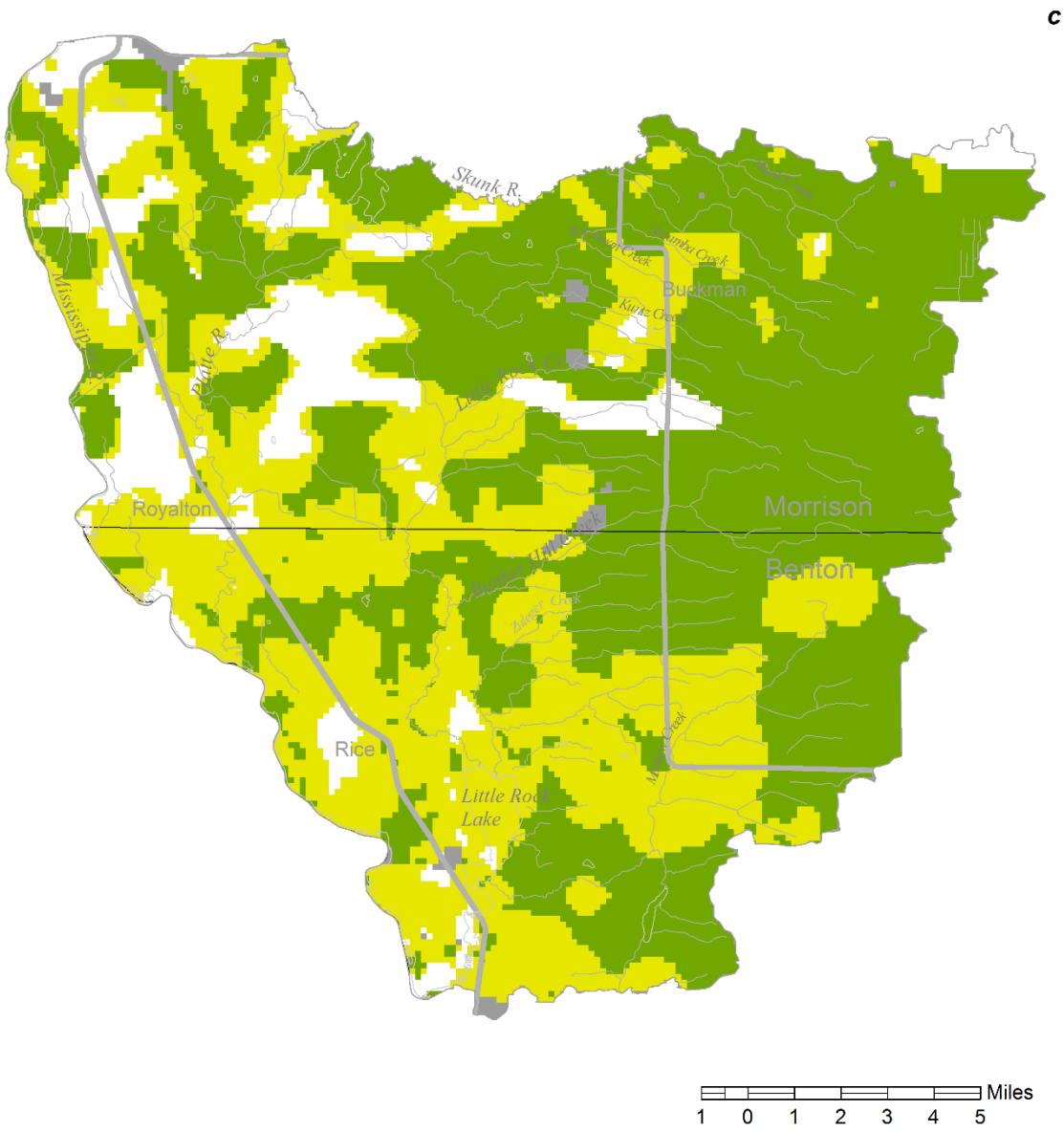

Figure 15 (continued)

b) layer 3 (includes stratigraphic units mls, mlt, ebs, and ebt)

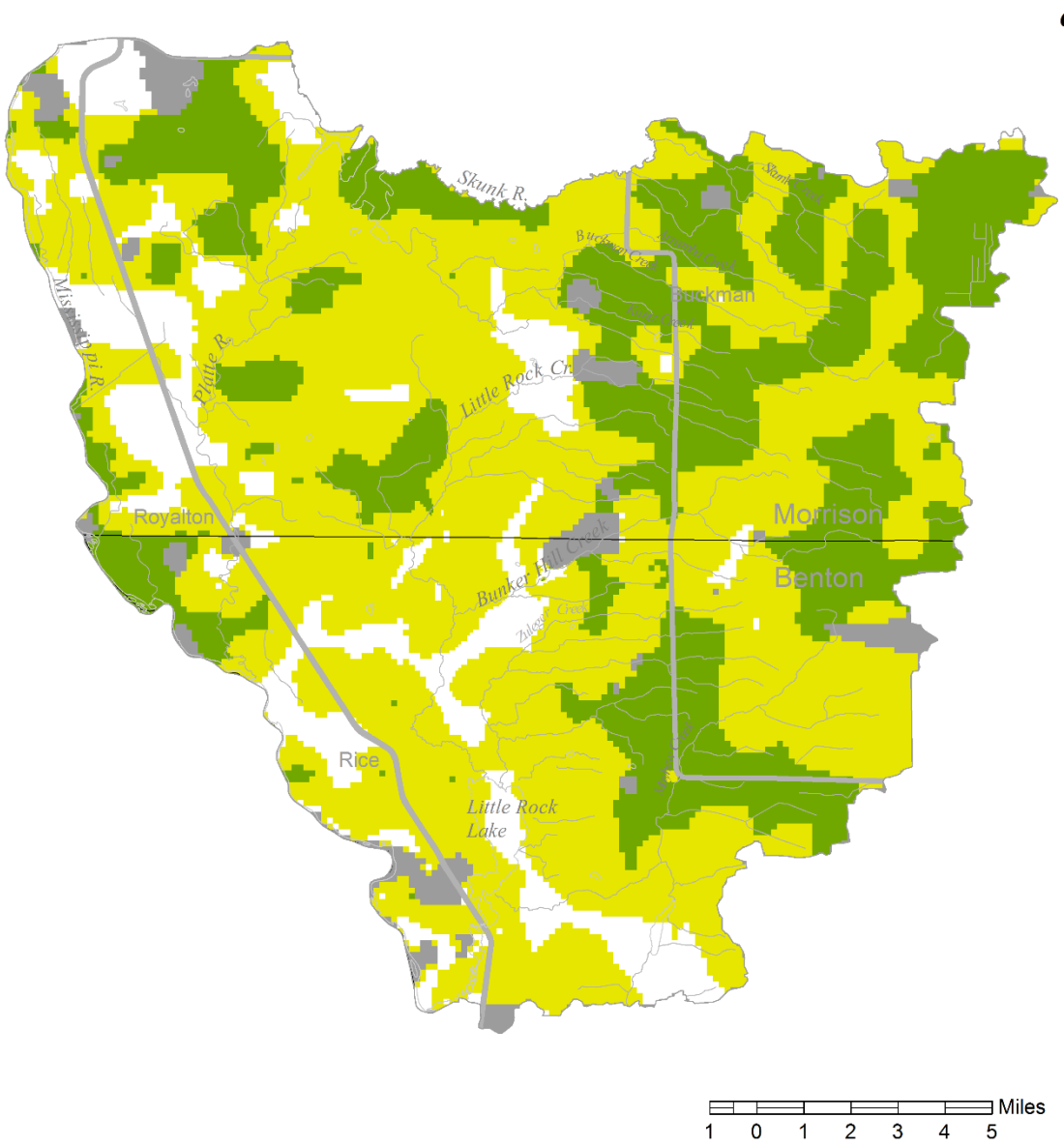

Figure 15 (continued)

b) layer 4 (includes stratigraphic units es and et)

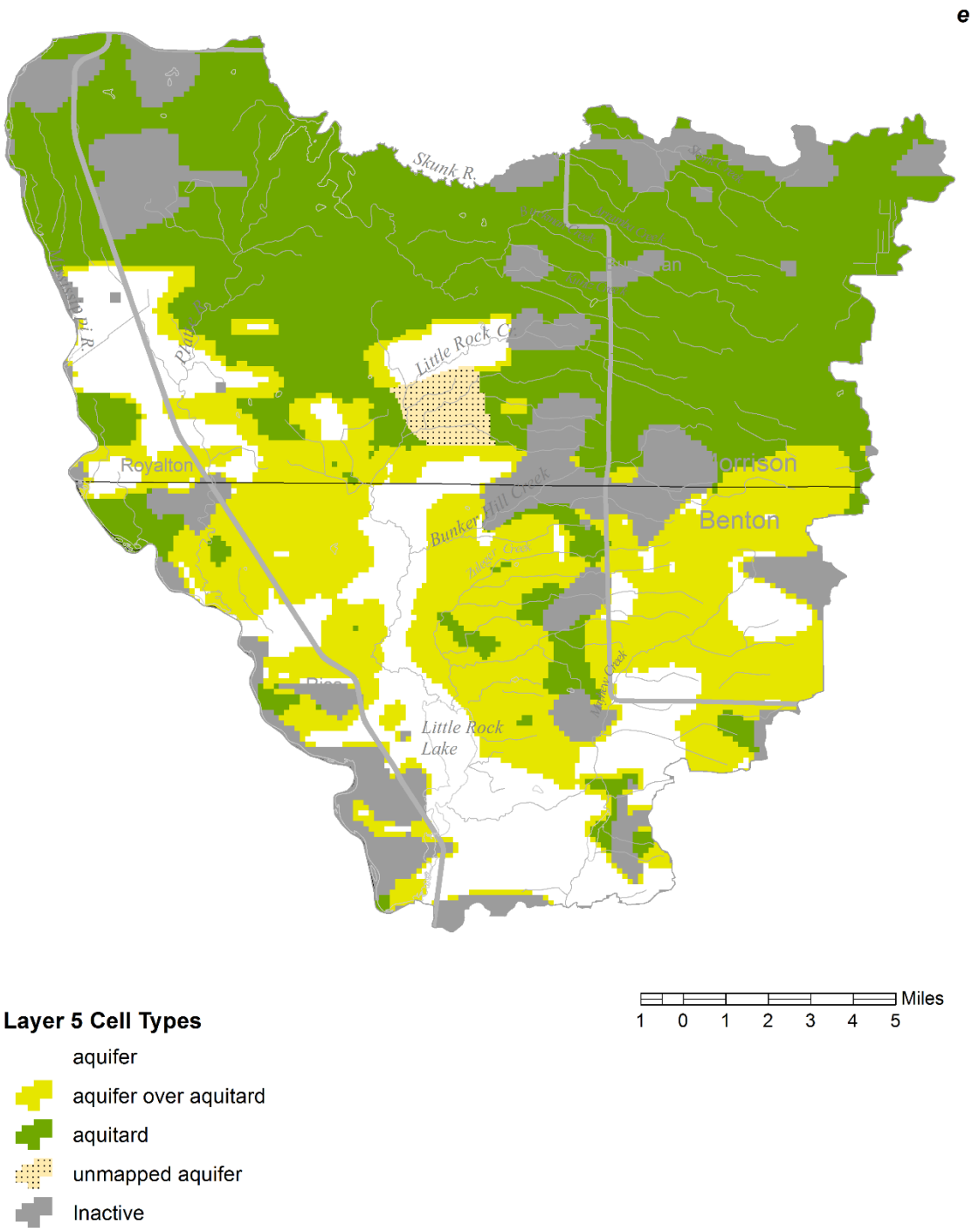

Figure 15 (continued)

b) layer 5 ((includes all stratigraphic units vs and vt)

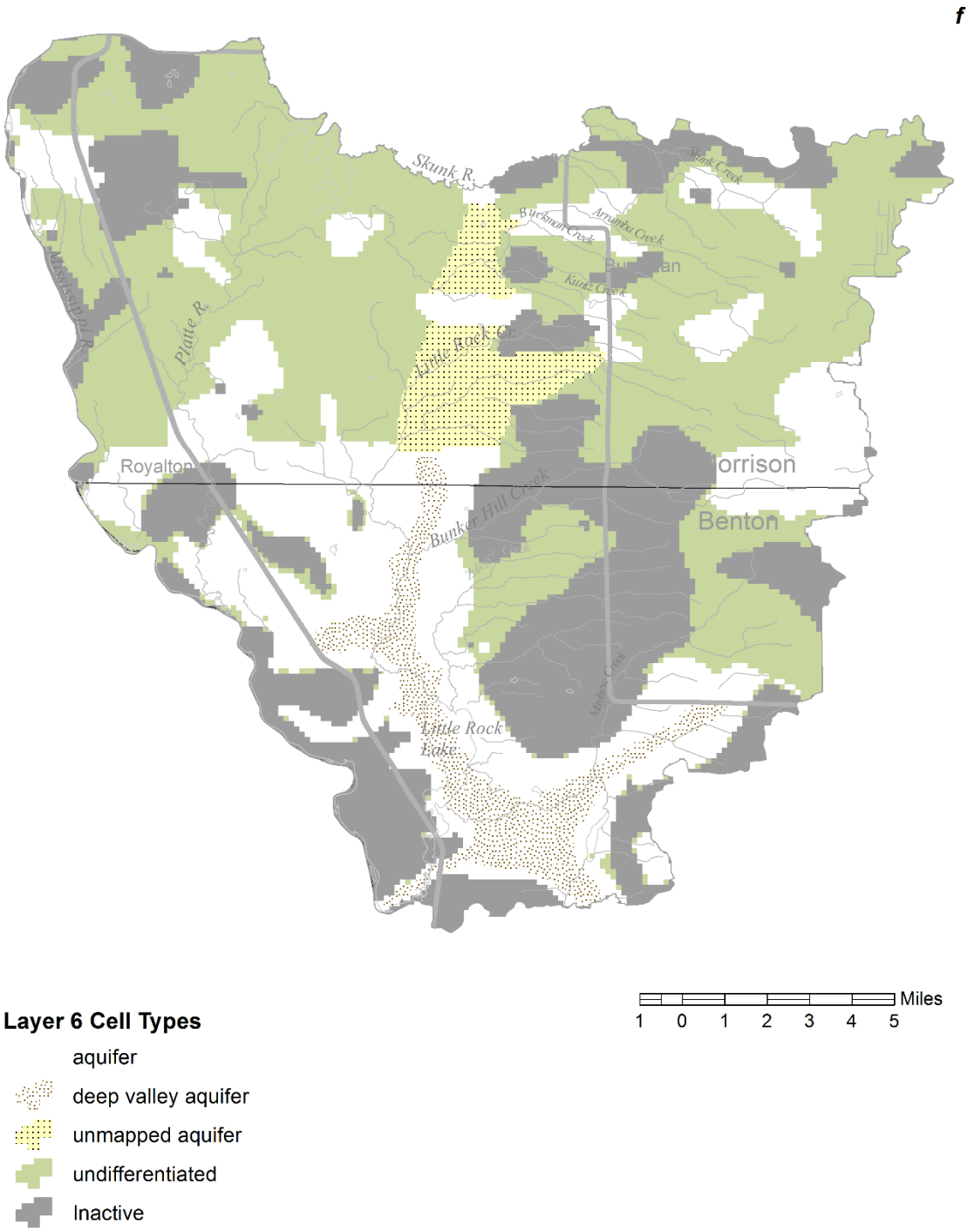

Figure 15 (continued)

b) layer 6 (includes stratigraphic units suu and ups)

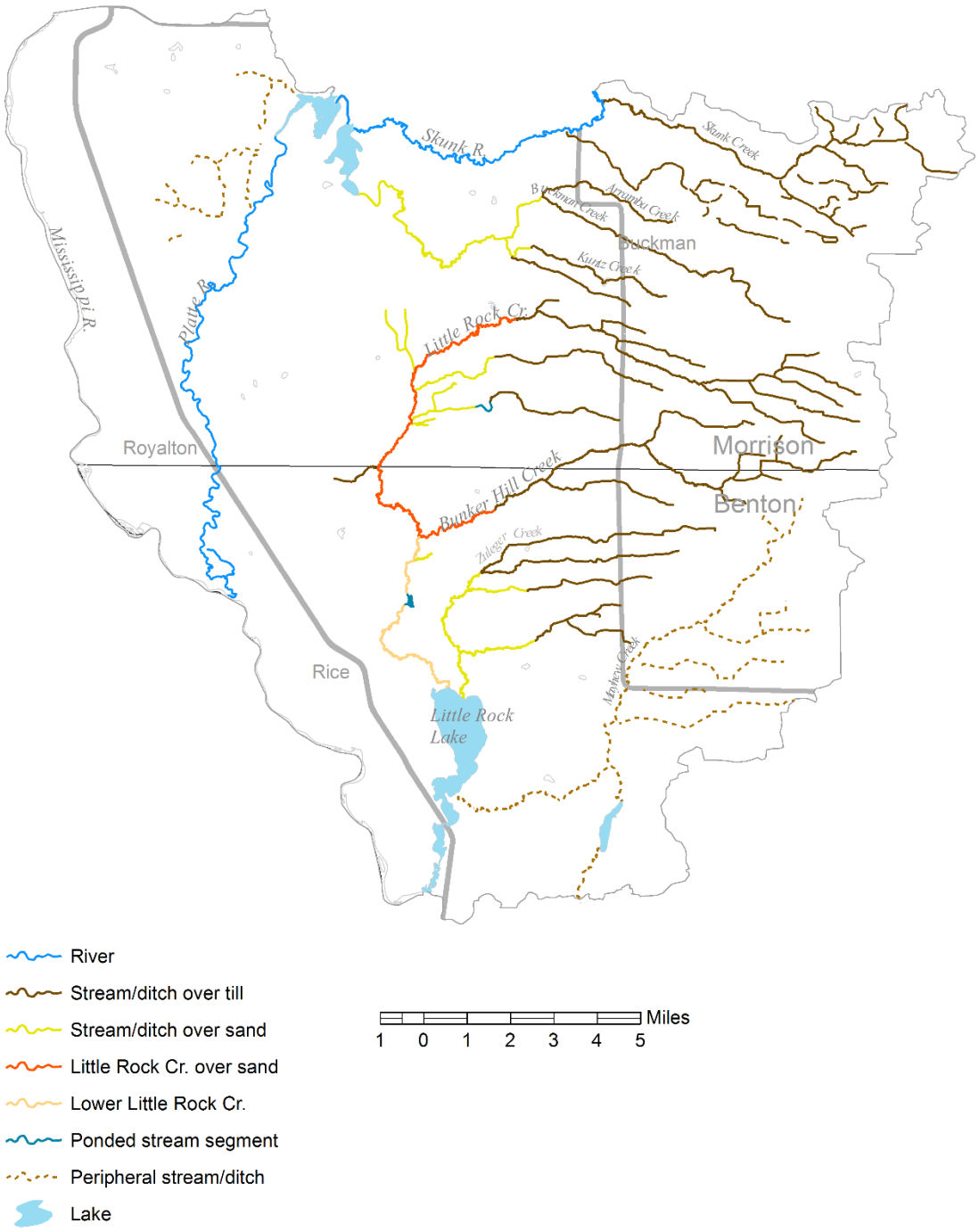

Figure 16 Surface-water leakance groups

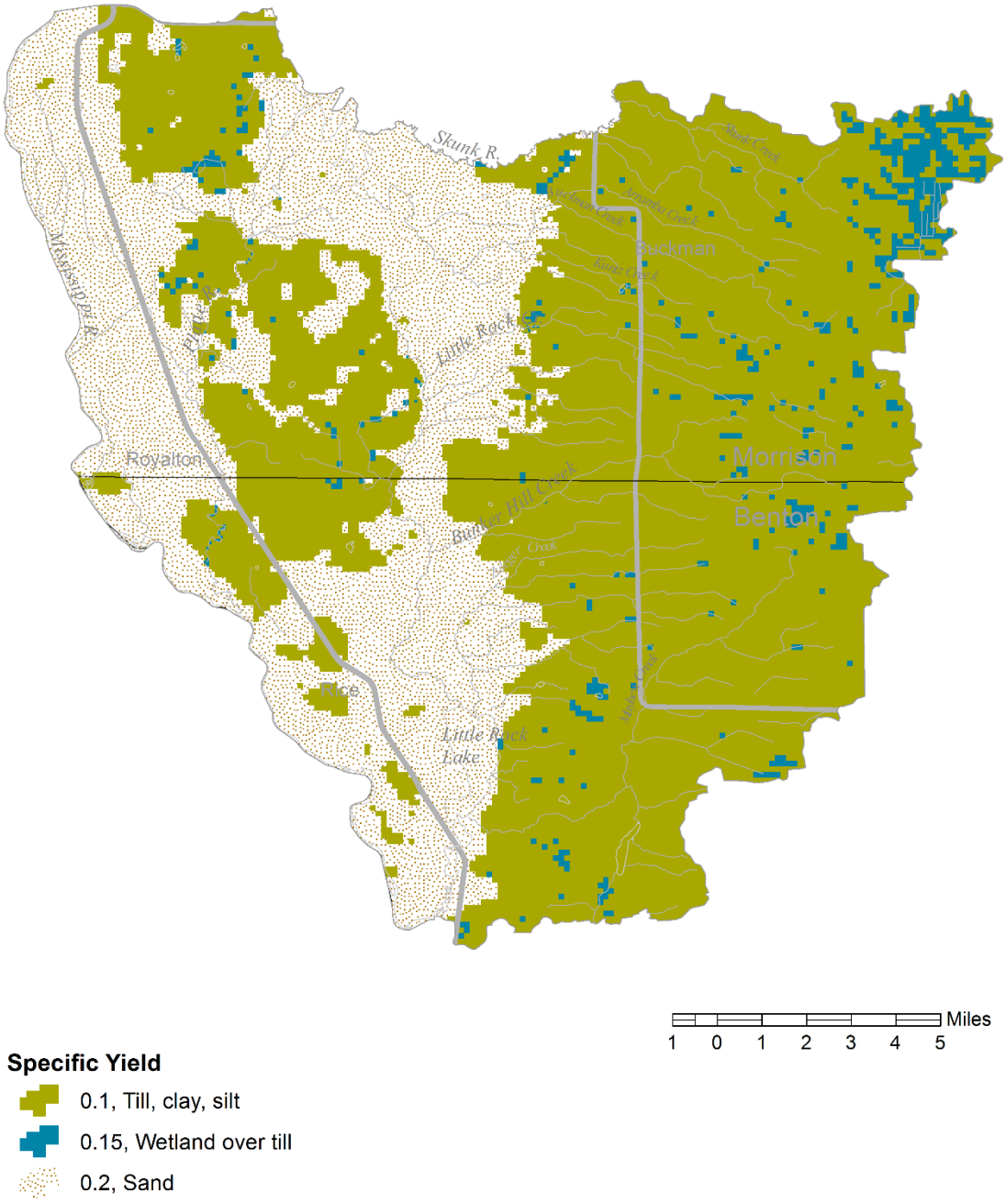

Figure 17 Specific yield zones based on material type at the water table.

Note that in some areas the surficial material shown in Figure 2 differs from the material at the water table.

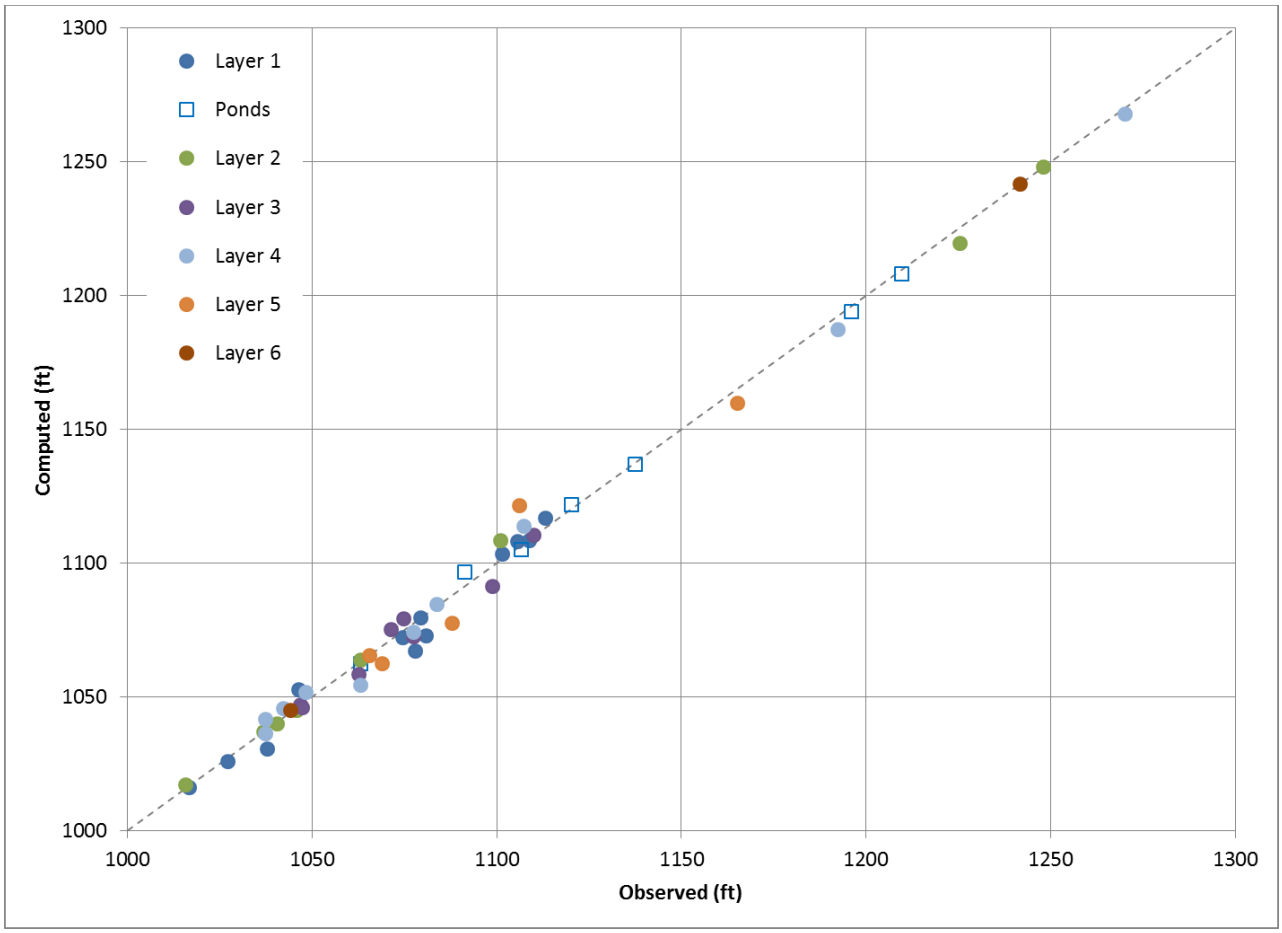

Figure 18 Computed versus observed groundwater heads for the steady-state model representing average 2008-2012 conditions.

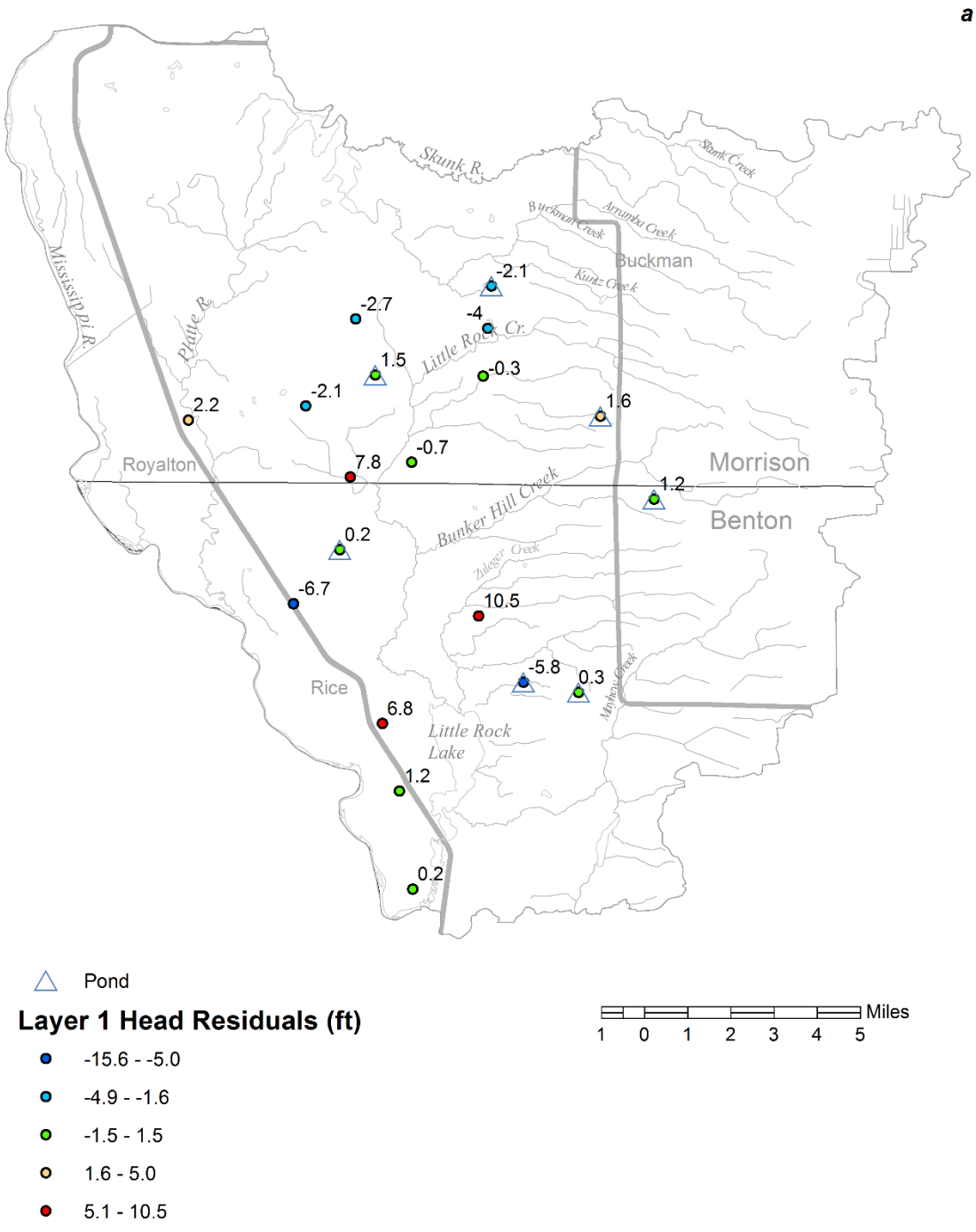

Figure 19 Head residuals for well and pond observations for the steady-state model representing average 2008-12 conditions

Residuals were calculated as observed minus simulated. a) layer 1.

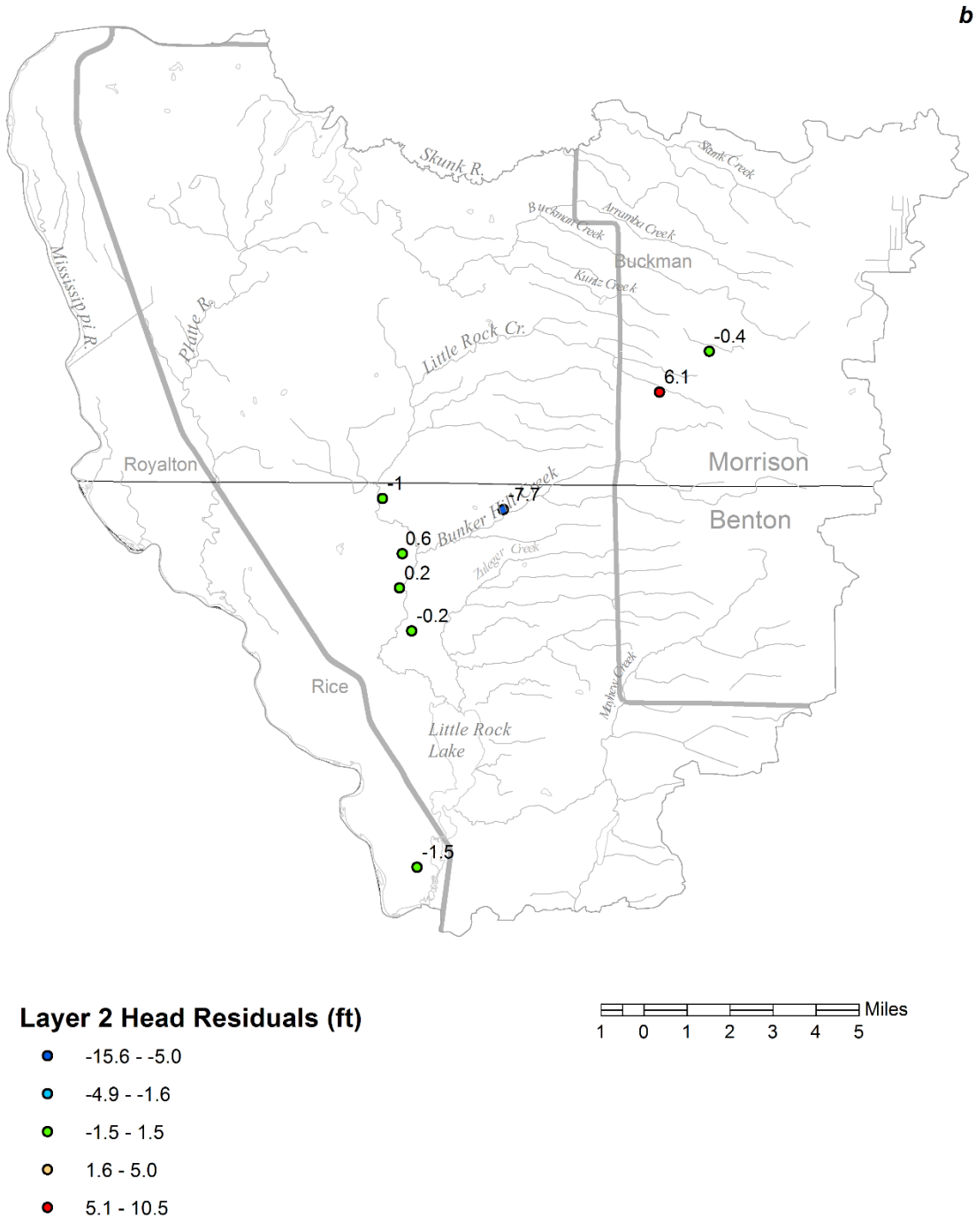

Figure 19 (continued)

b) layer 2

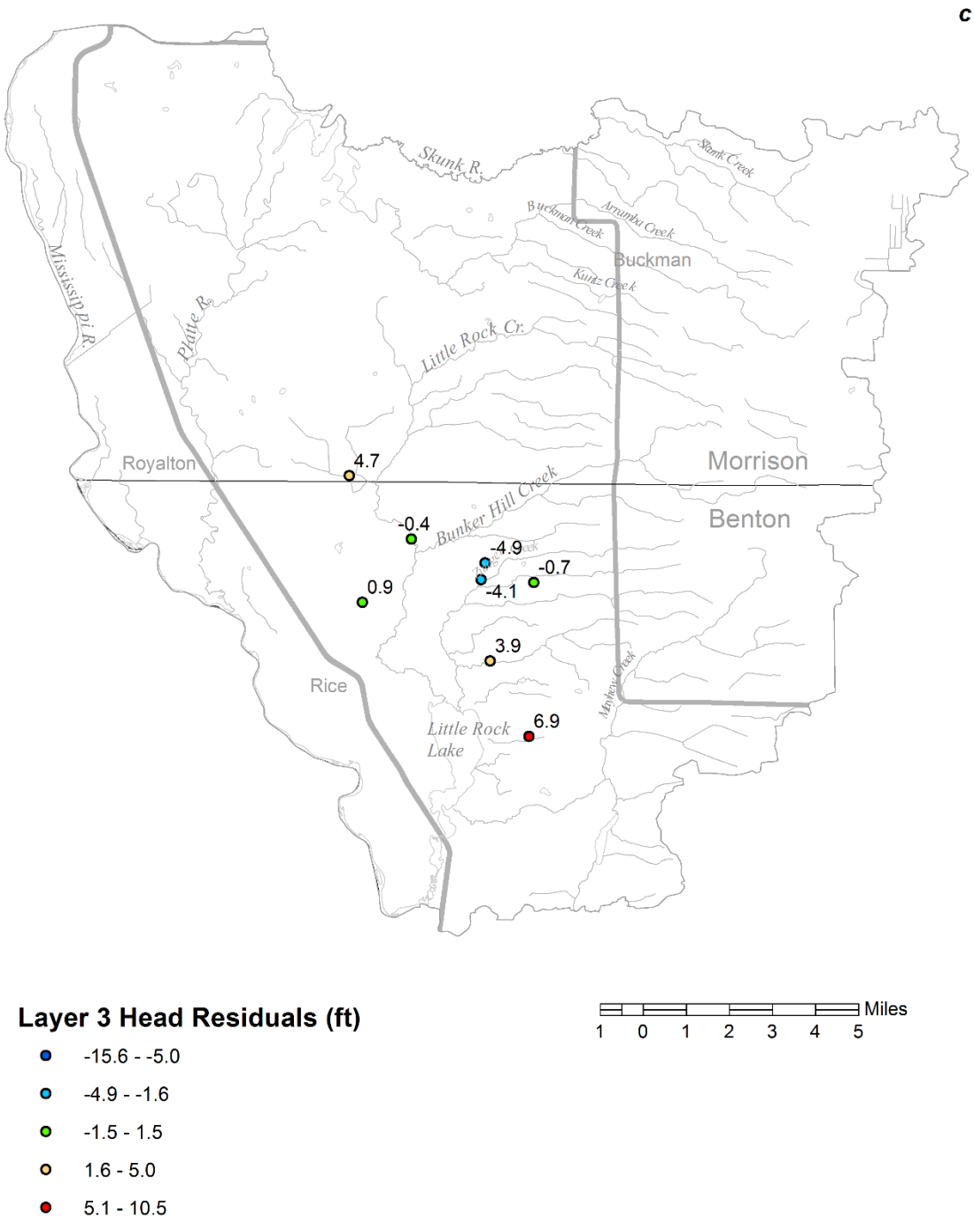

Figure 19 (continued)

c) layer 3

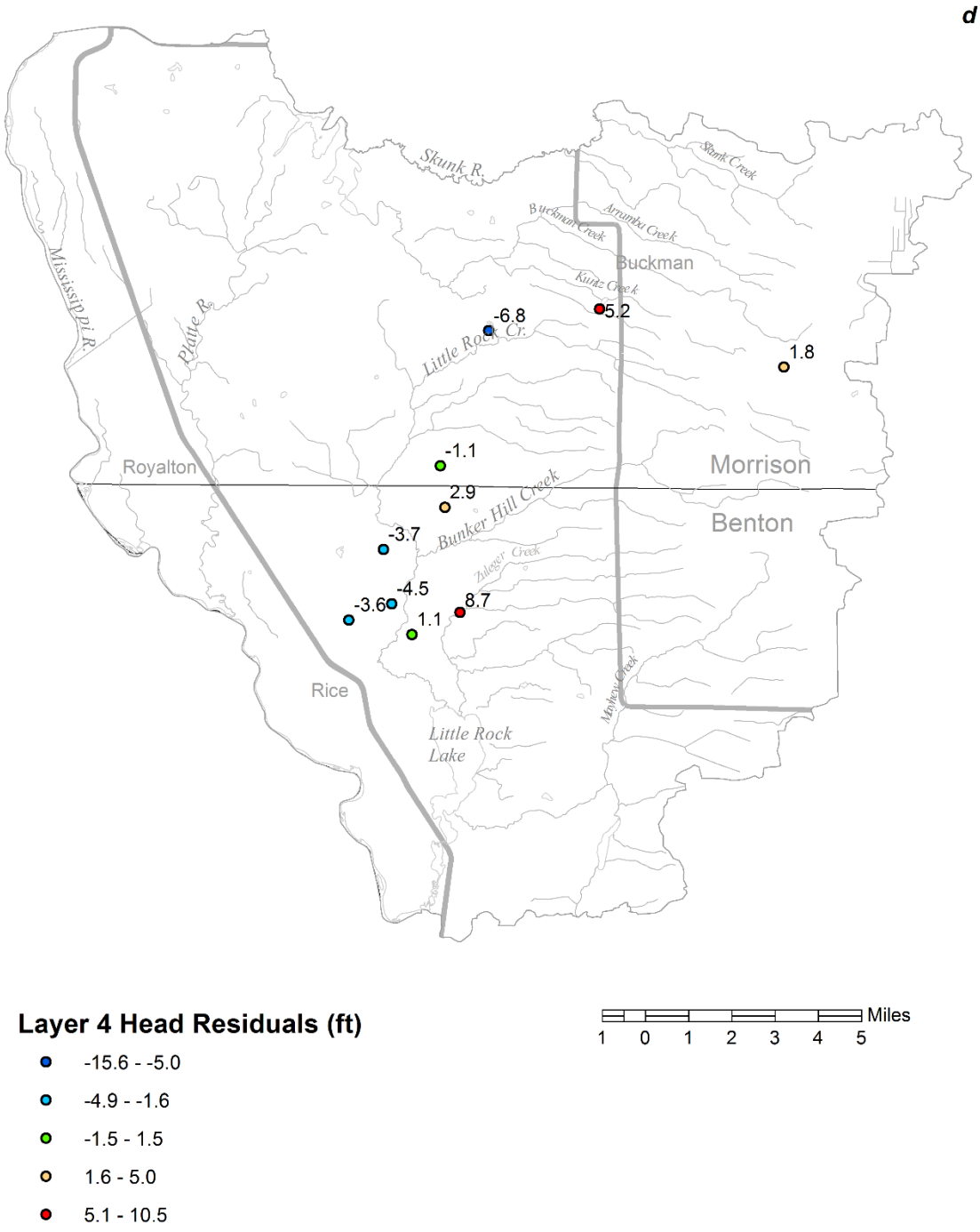

Figure 19 (continued)

d) layer 4

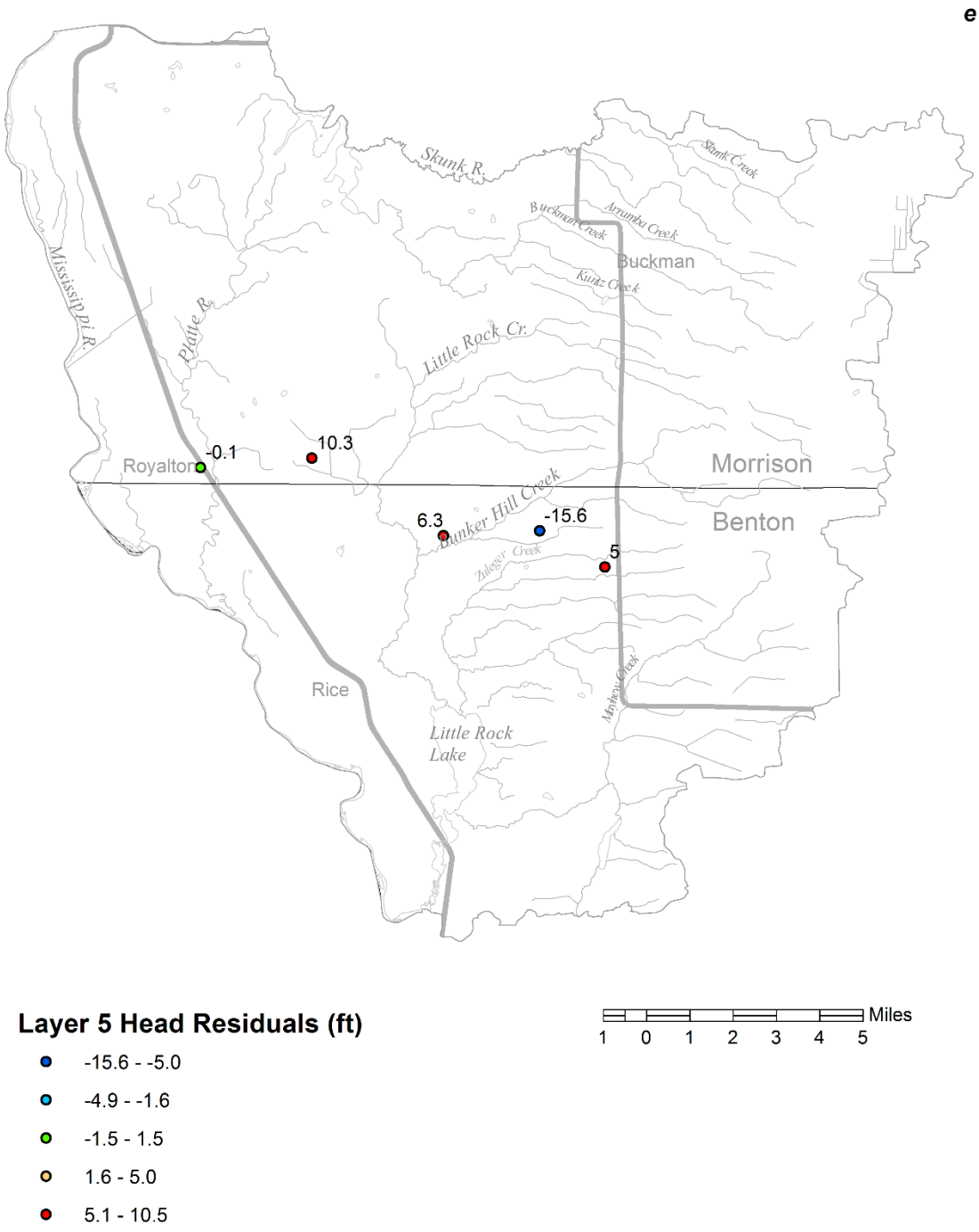

Figure 19 (continued)

e) layer 5

f

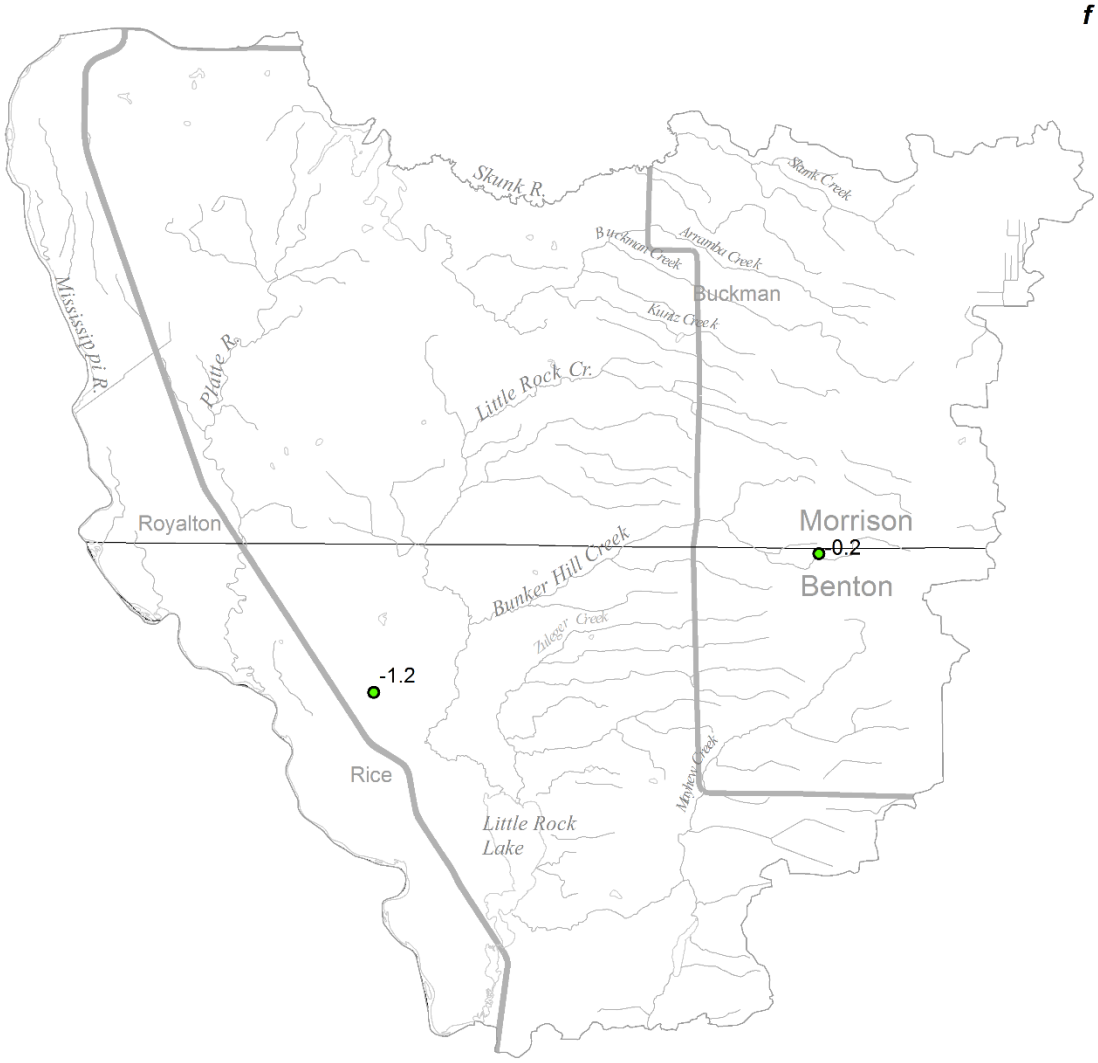

Figure 19 (continued)

f) layer 6

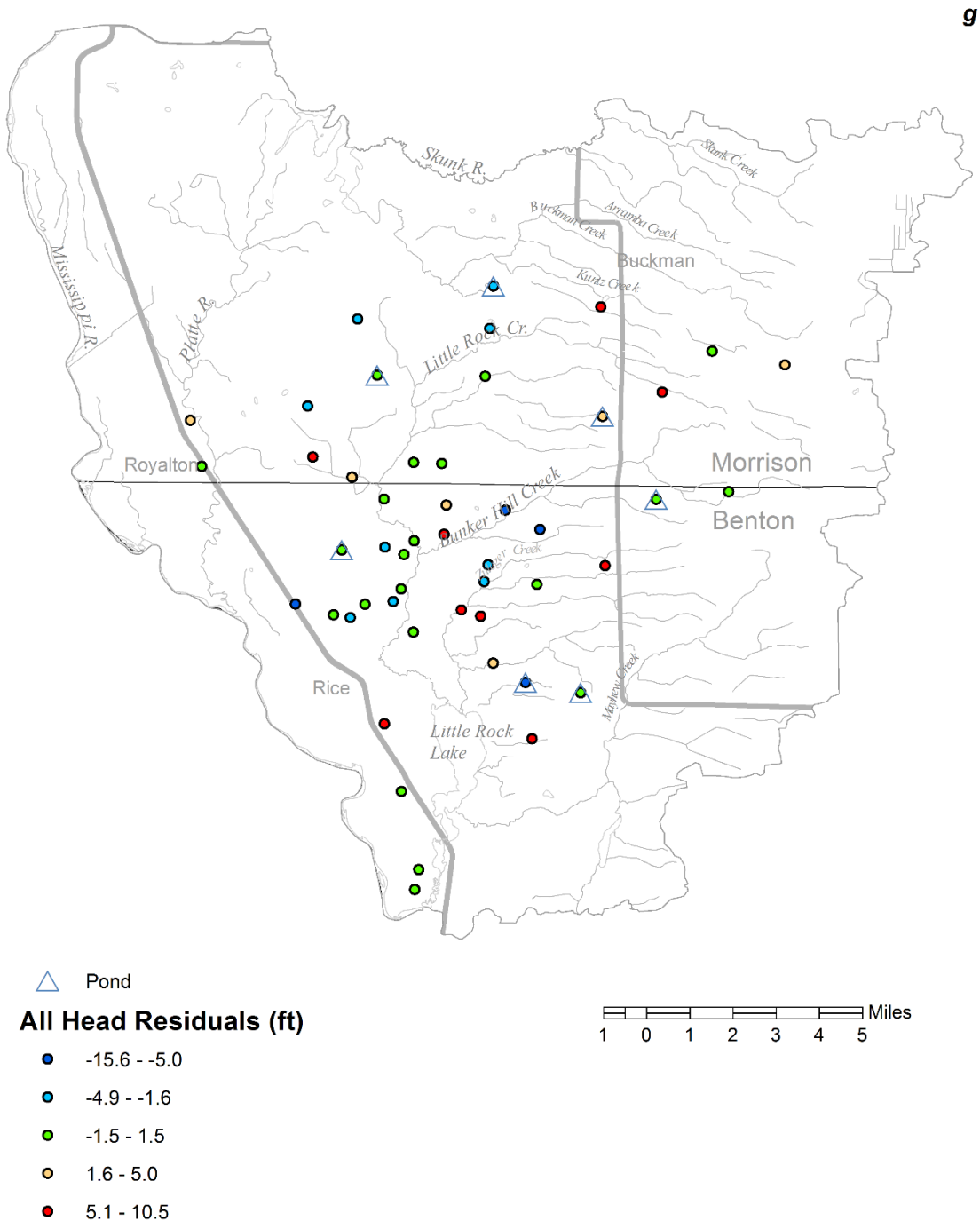

Figure 19 (continued)

g) all layers

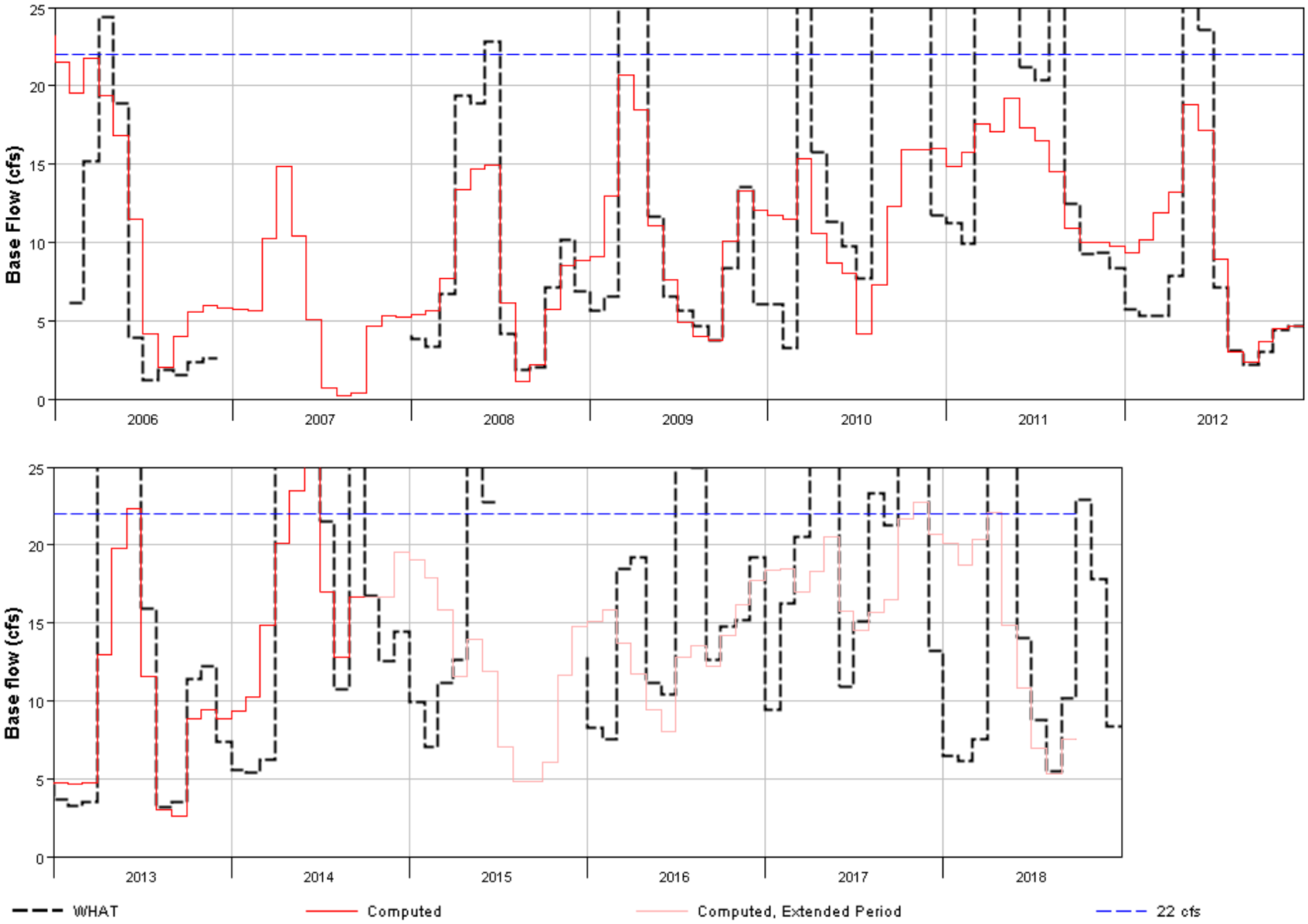

Figure 20 Monthly average WHAT and model-computed base flow for station 15029001 on Little Rock Creek

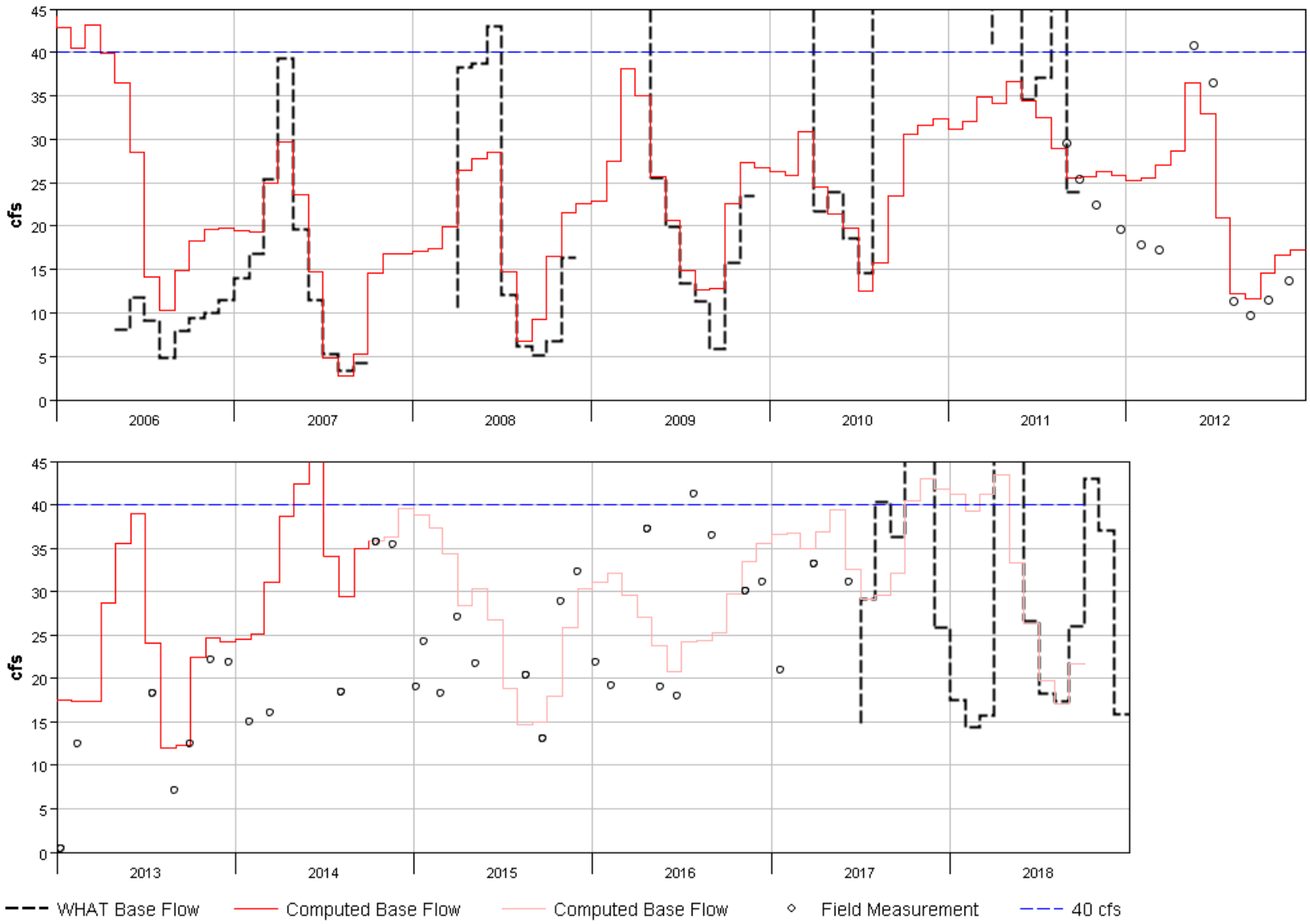

Figure 21 Monthly average WHAT and model-computed base flow for station 15031001 on Little Rock Creek. Field Measurements of streamflow are also shown for the period without continuous data.

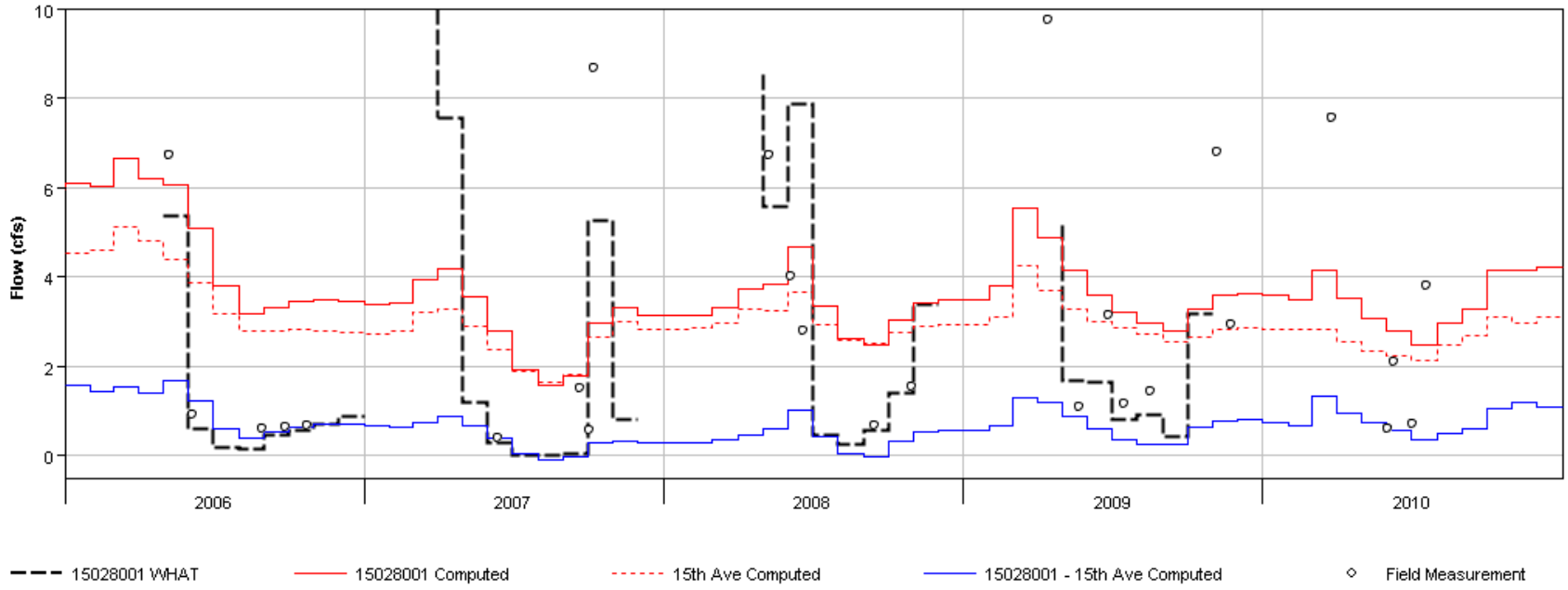

Figure 22 Monthly average WHAT and model-computed base flow and field measurements of streamflow for station 15028001 on Bunker Hill Creek. Also shown are computed base flow at 15th Ave and the computed change in base flow from 15th Ave to the station (15028001 – 15th Ave).

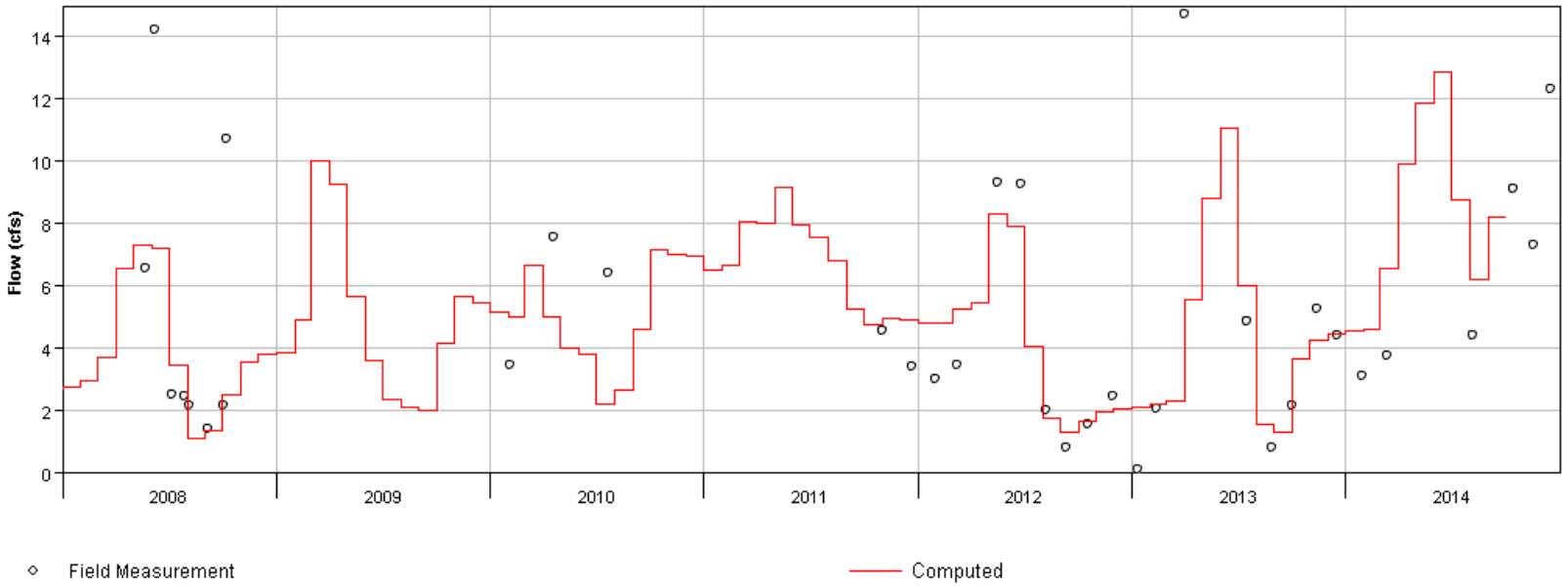

Figure 23 Field measurements of streamflow and model-computed, monthly average base flow at station 15029005 on Little Rock Creek.

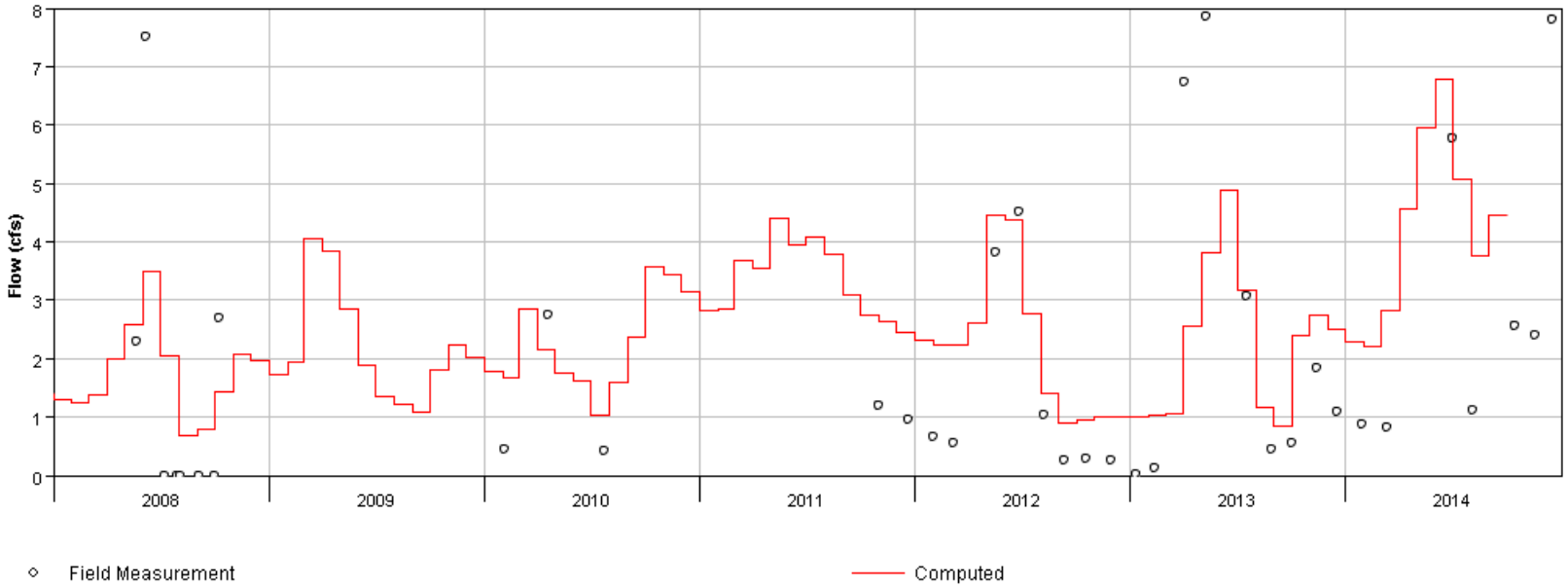

Figure 24 Field measurements of streamflow and model-computed, monthly average base flow at station 15029004 on Little Rock Creek

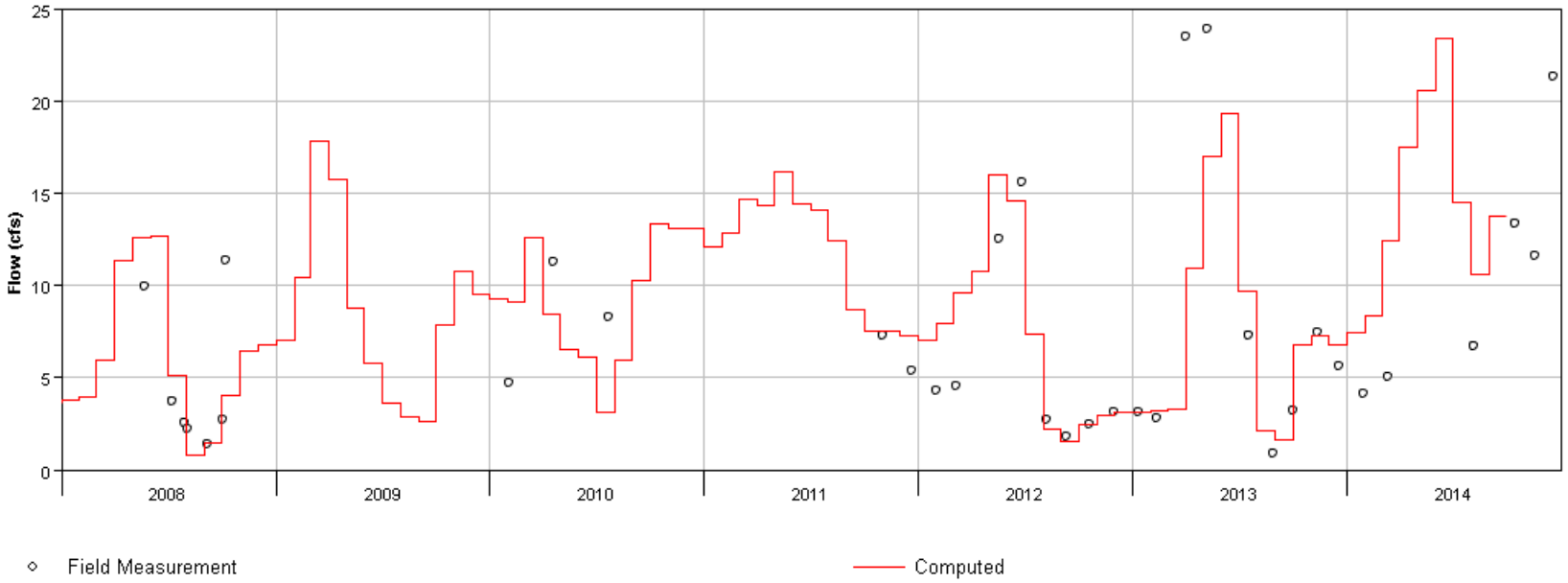

Figure 25 Field measurements of streamflow and model-computed, monthly average base flow at station 15029003 on Little Rock Creek

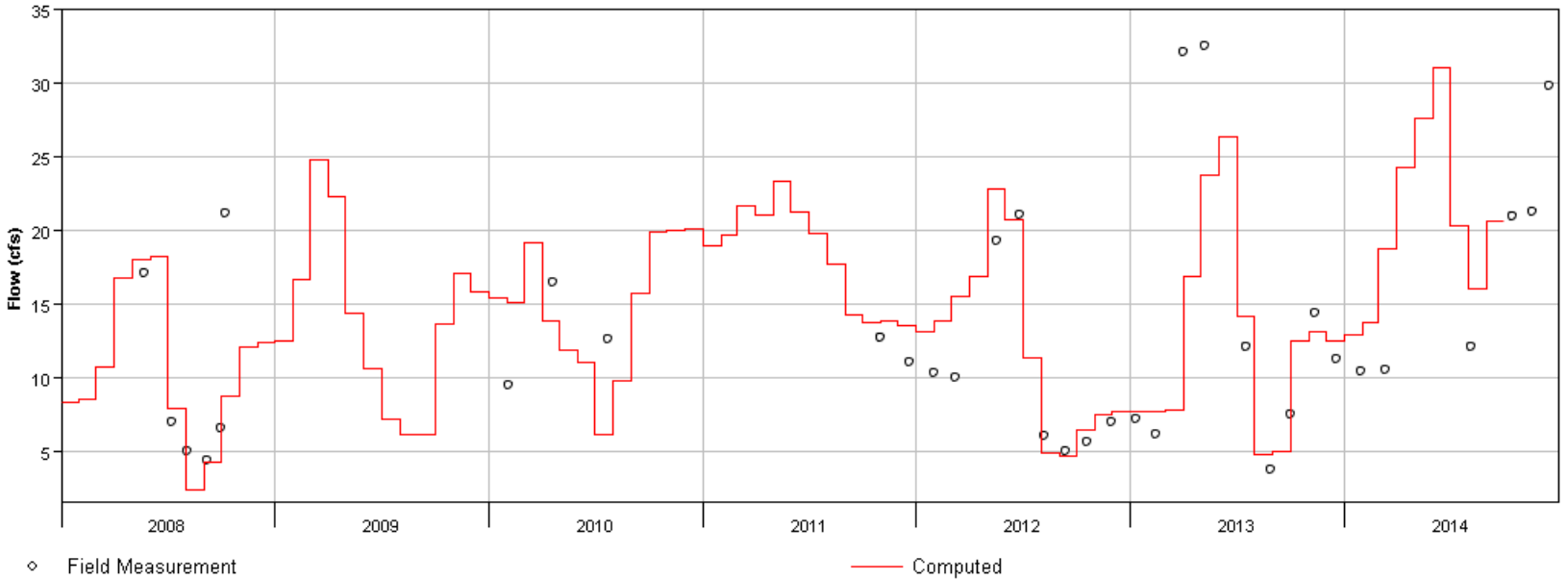

Figure 26 Field measurements of streamflow and model-computed, monthly average base flow at station 15029002 on Little Rock Creek

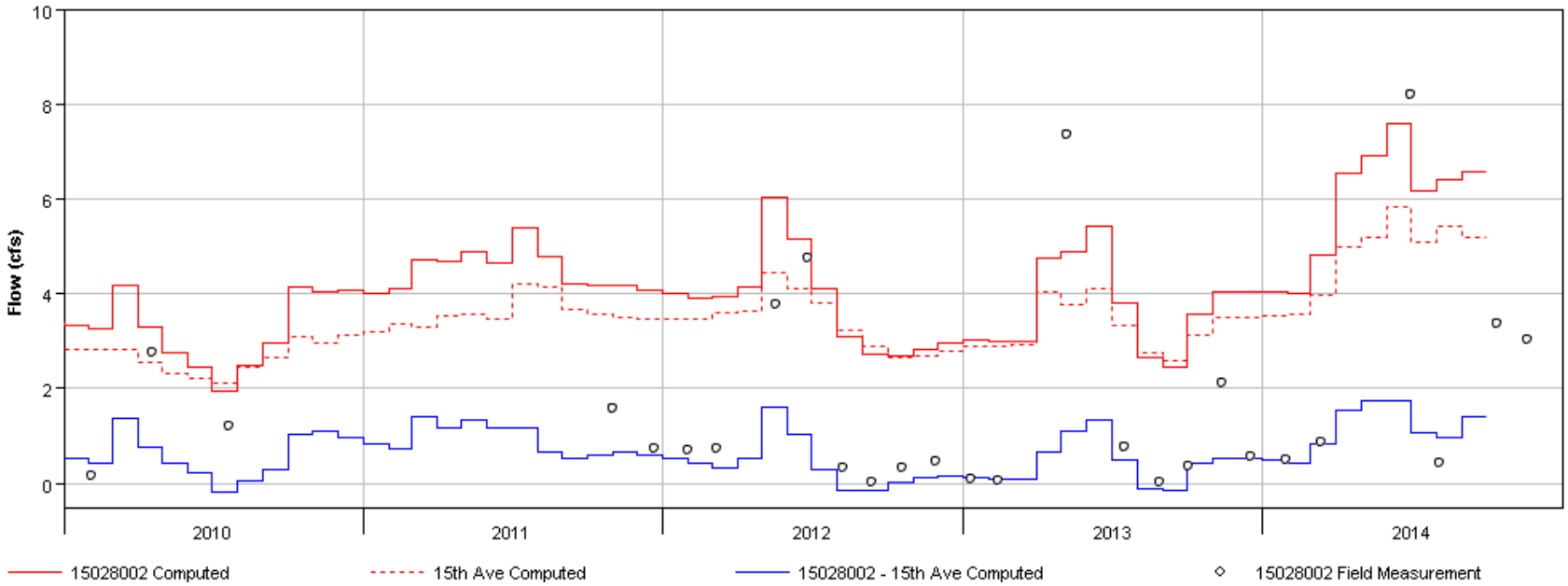

Figure 27 Field measurements of streamflow and model-computed base flow for station 15028002 on Bunker Hill Creek. Also shown are computed base flow at 15th Ave and the computed change in base flow from 15th Ave to the station (15028002 – 15th Ave).

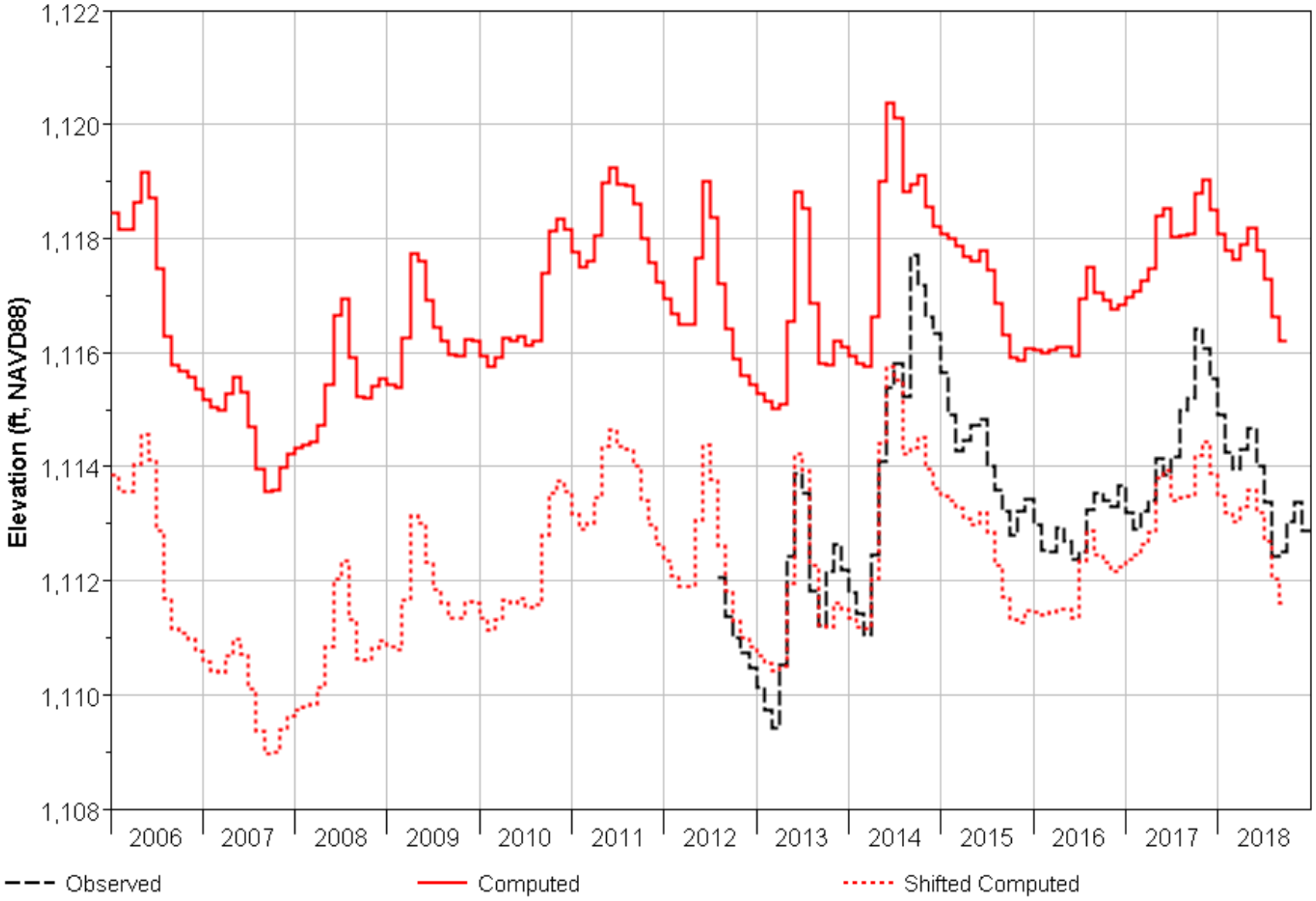

Figure 28 Monthly averaged heads at observation well 49034 (Unique No. 783245), layer 1 (ou), includes extended model period (Oct 2014 – Sep 2018)

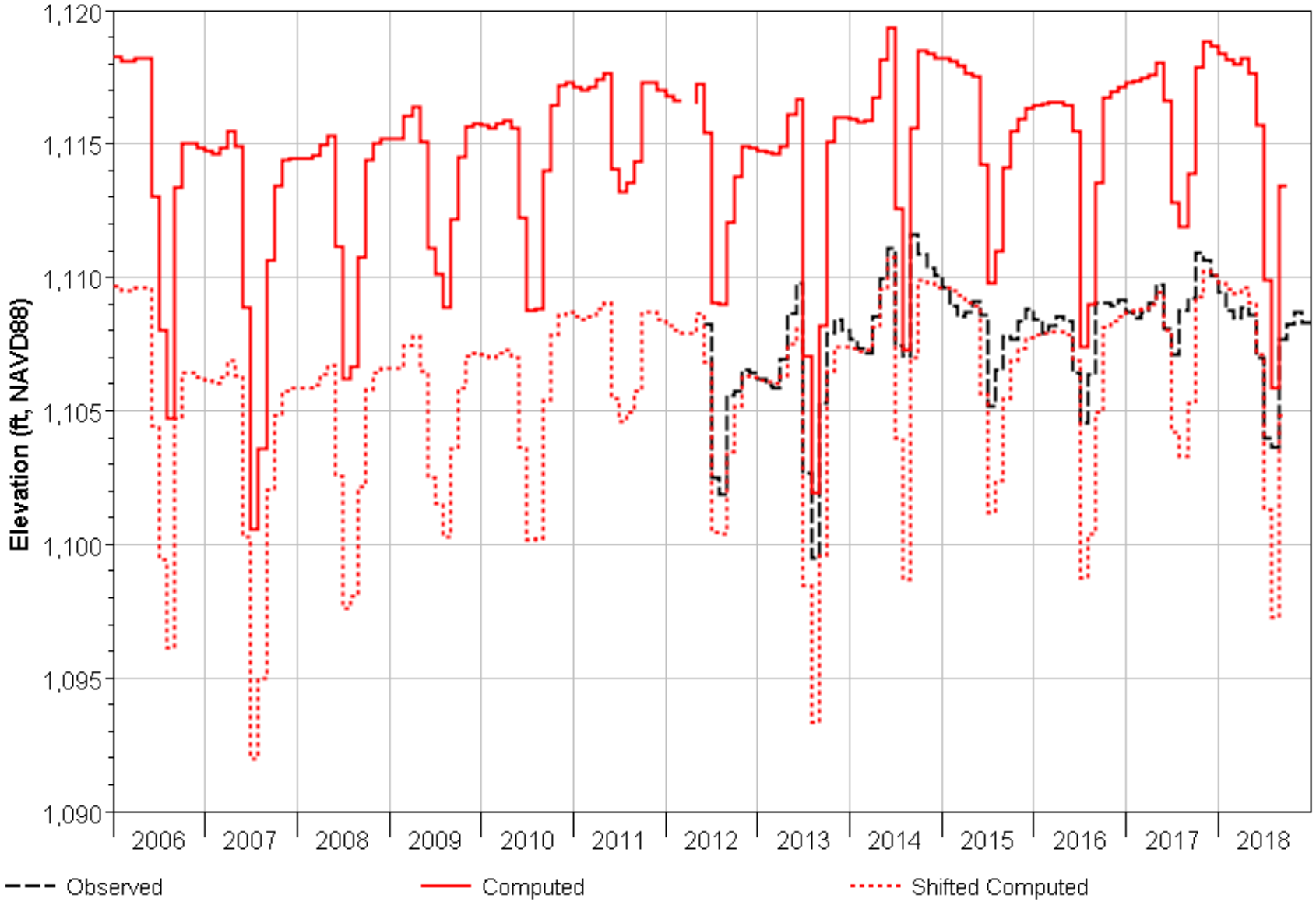

Figure 29 Monthly averaged heads at observation well 49033 (Unique No. 789964), layer 4 (es), includes extended model period (Oct 2014 – Sep 2018)

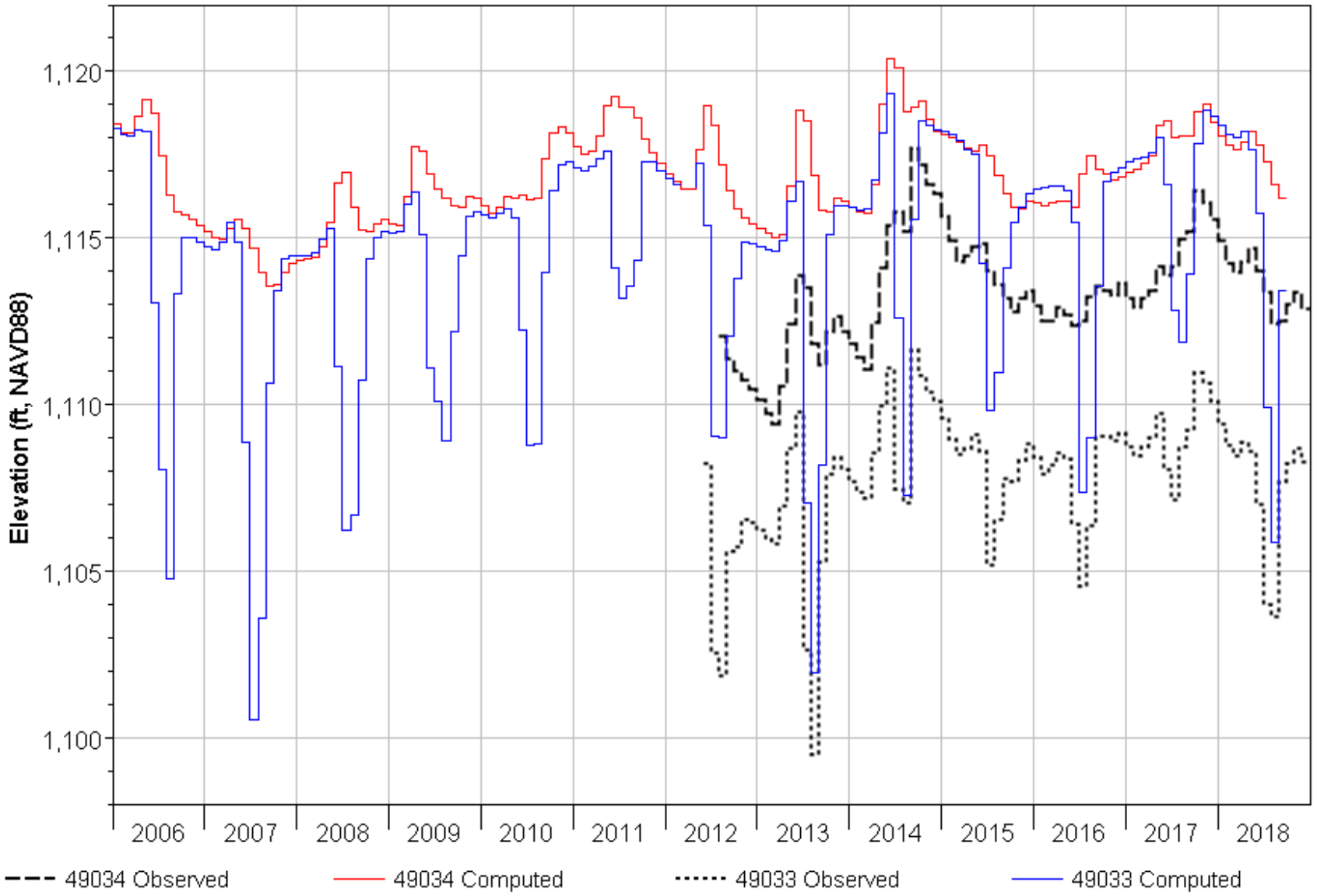

Figure 30 Observed and computed monthly averaged heads at nested observation wells 49034 (Unique No. 783245) and 49033 (Unique No. 789964), includes extended model period (Oct 2014 – Sep 2018)

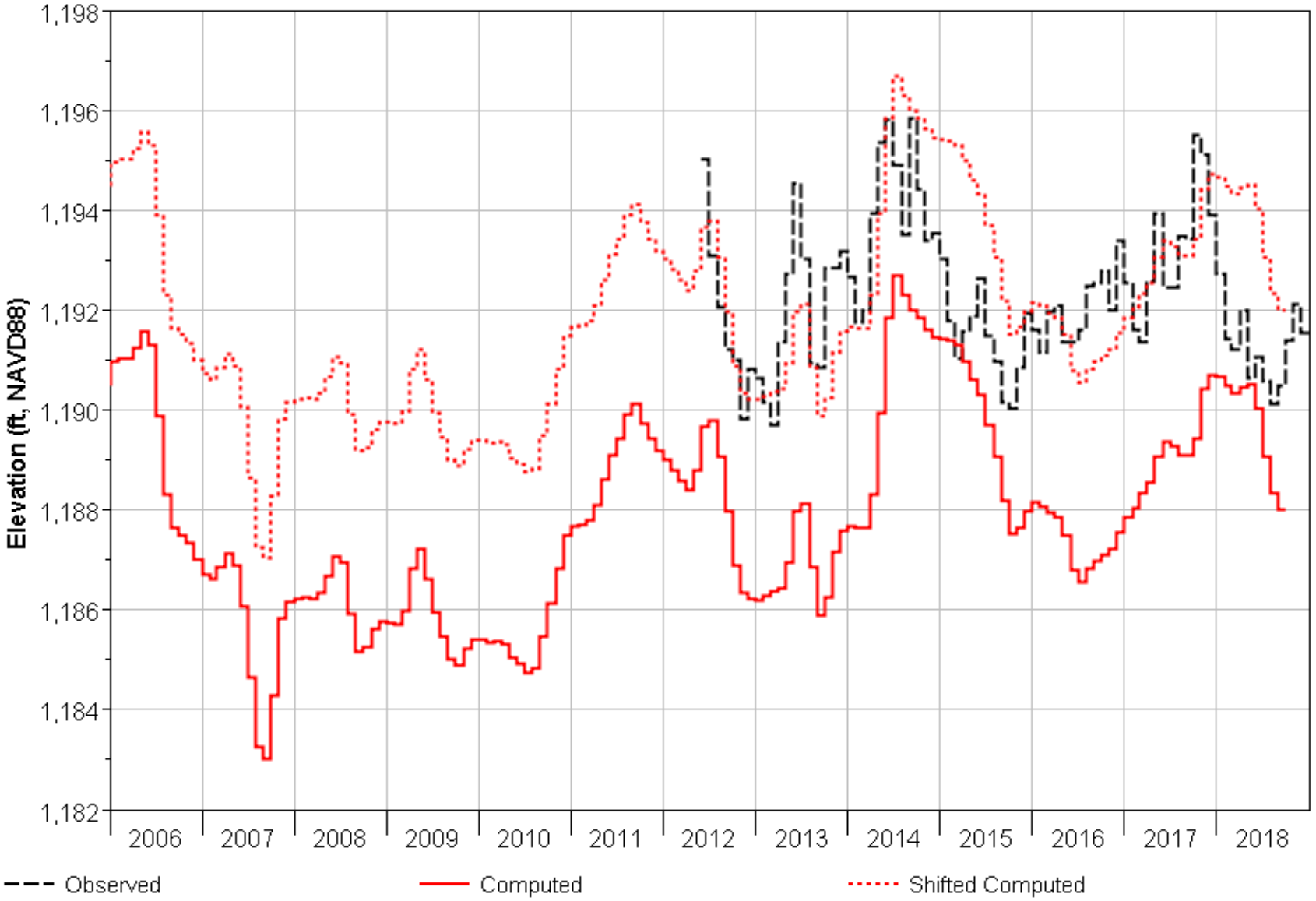

Figure 31 Observed and computed Monthly averaged heads at observation well 49032 (Unique No. 789965), layer 4 (es), includes extended model period (Oct 2014 – Sep 2018)

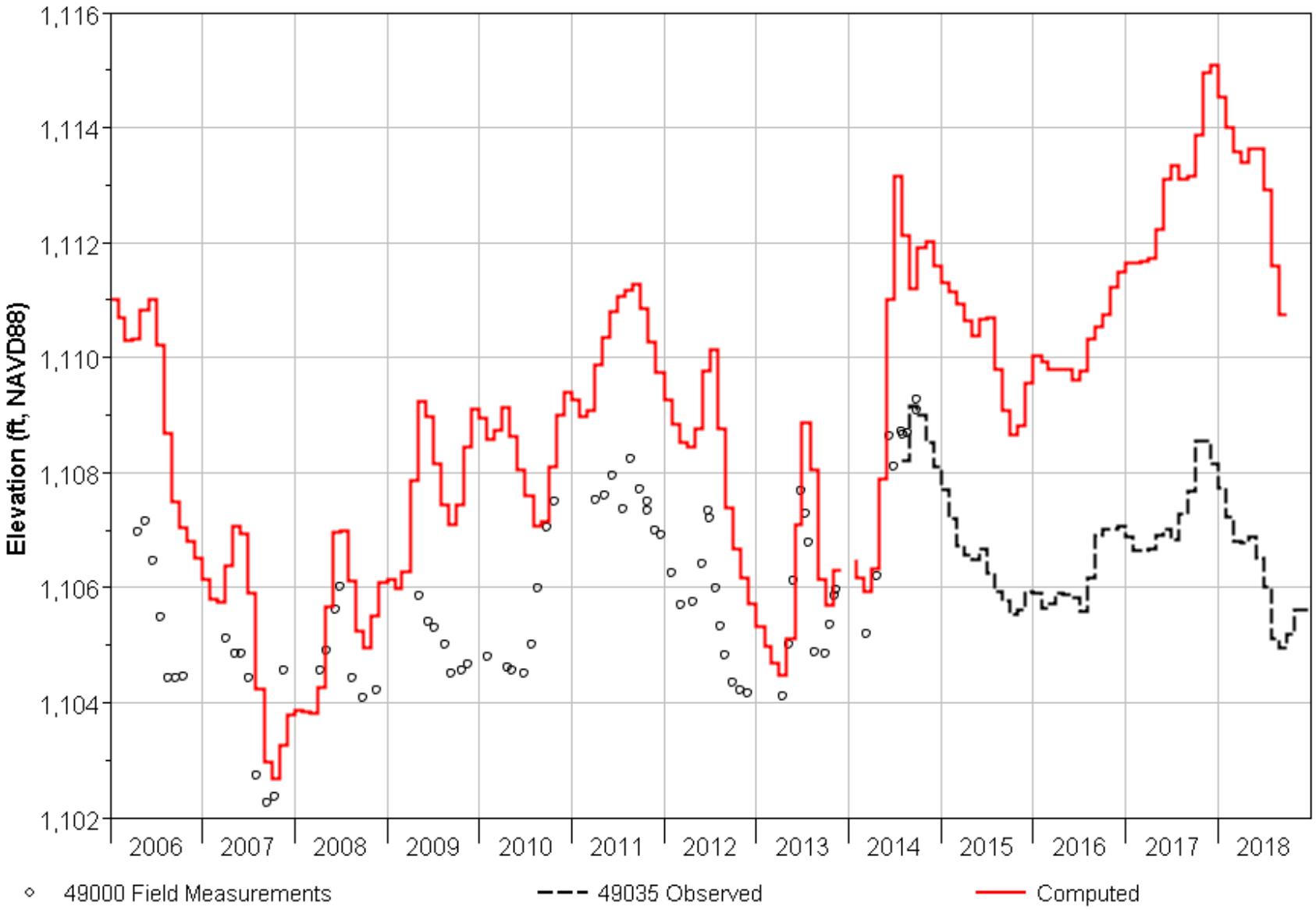

Figure 32 Field measurements and computed monthly averaged heads at observation well 49000 (Unique No. 243996) and its adjacent replacement observation well 49035 (Unique No. 792505), layer 1 (cs2), includes extended model period (Oct 2014 – Sep 2018)

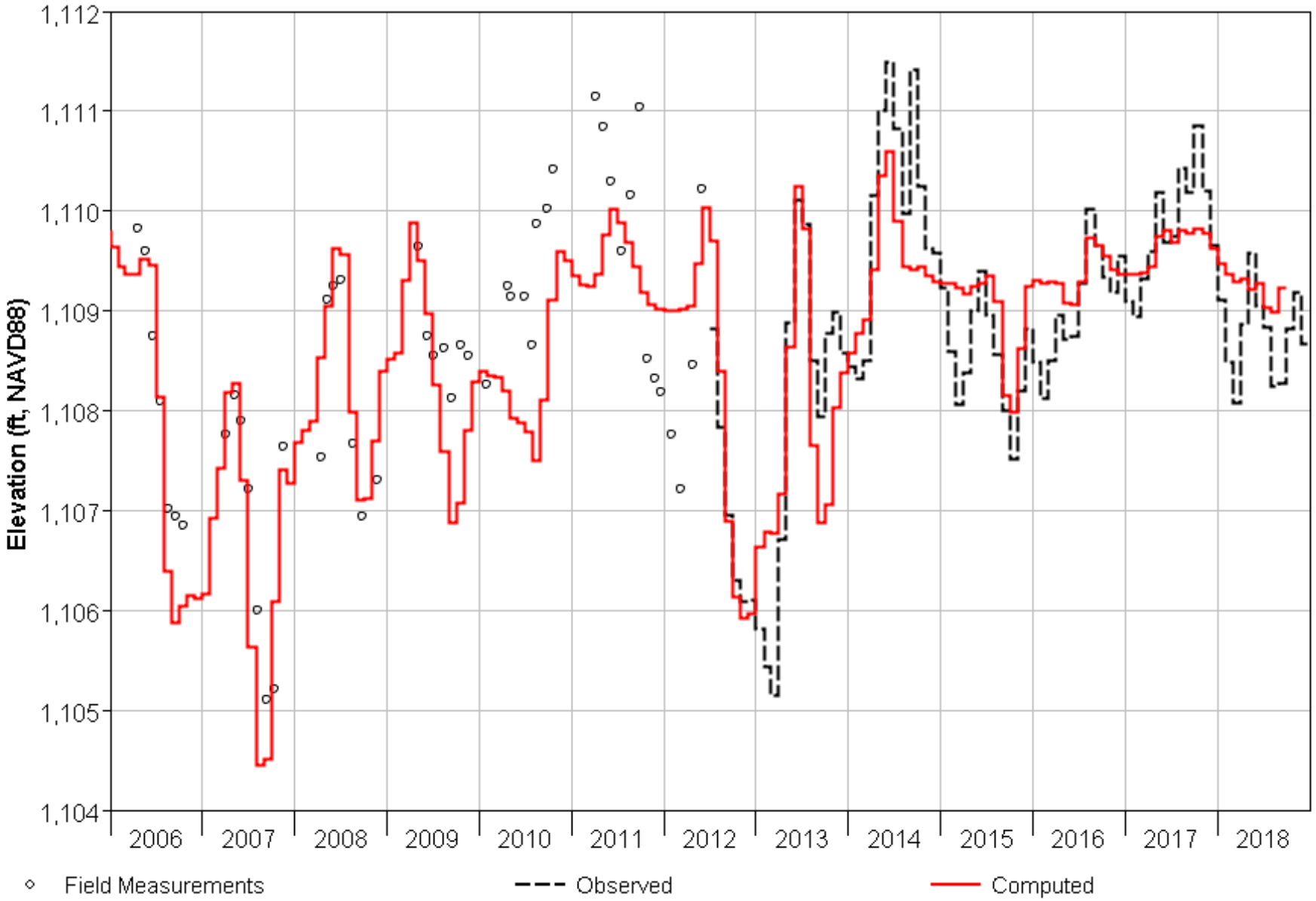

Figure 33 Observed and computed monthly averaged heads at observation well 49028 (Unique No. 431178), layer 1 (ou), includes extended model period (Oct 2014 – Sep 2018)

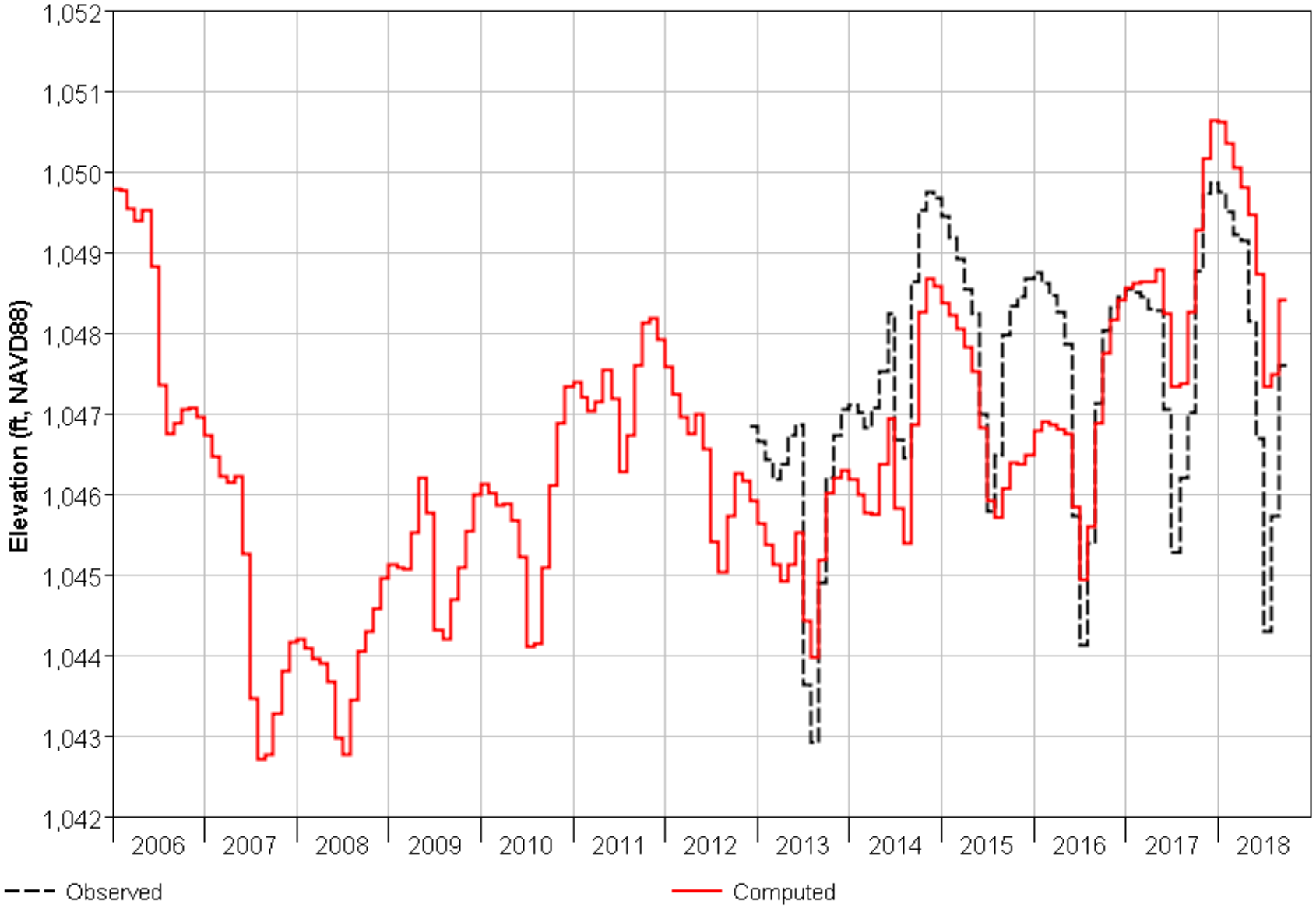

Figure 34 Observed and computed monthly averaged heads at observation well 05008 (Unique No. 789911), layer 3 (mls), includes extended model period (Oct 2014 – Sep 2018)

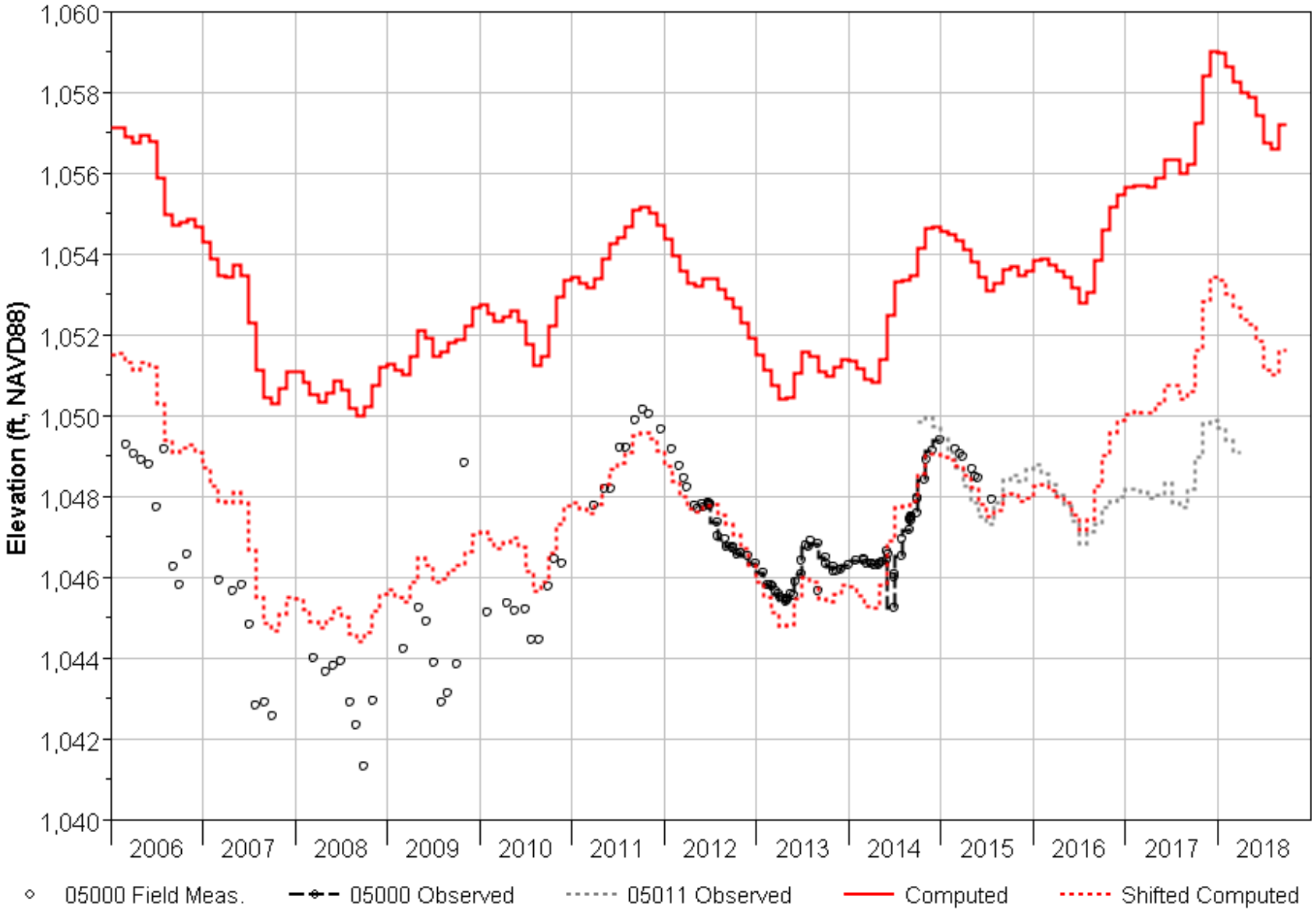

Figure 35 Observed and computed monthly averaged heads at observation observation well 05000 (Unique No. 243625), and its adjacent replacement observation well 05011 (Unique No. 792513), bottom, layer 1 (ou), includes extended model period (Oct 2014 – Sep 2018)

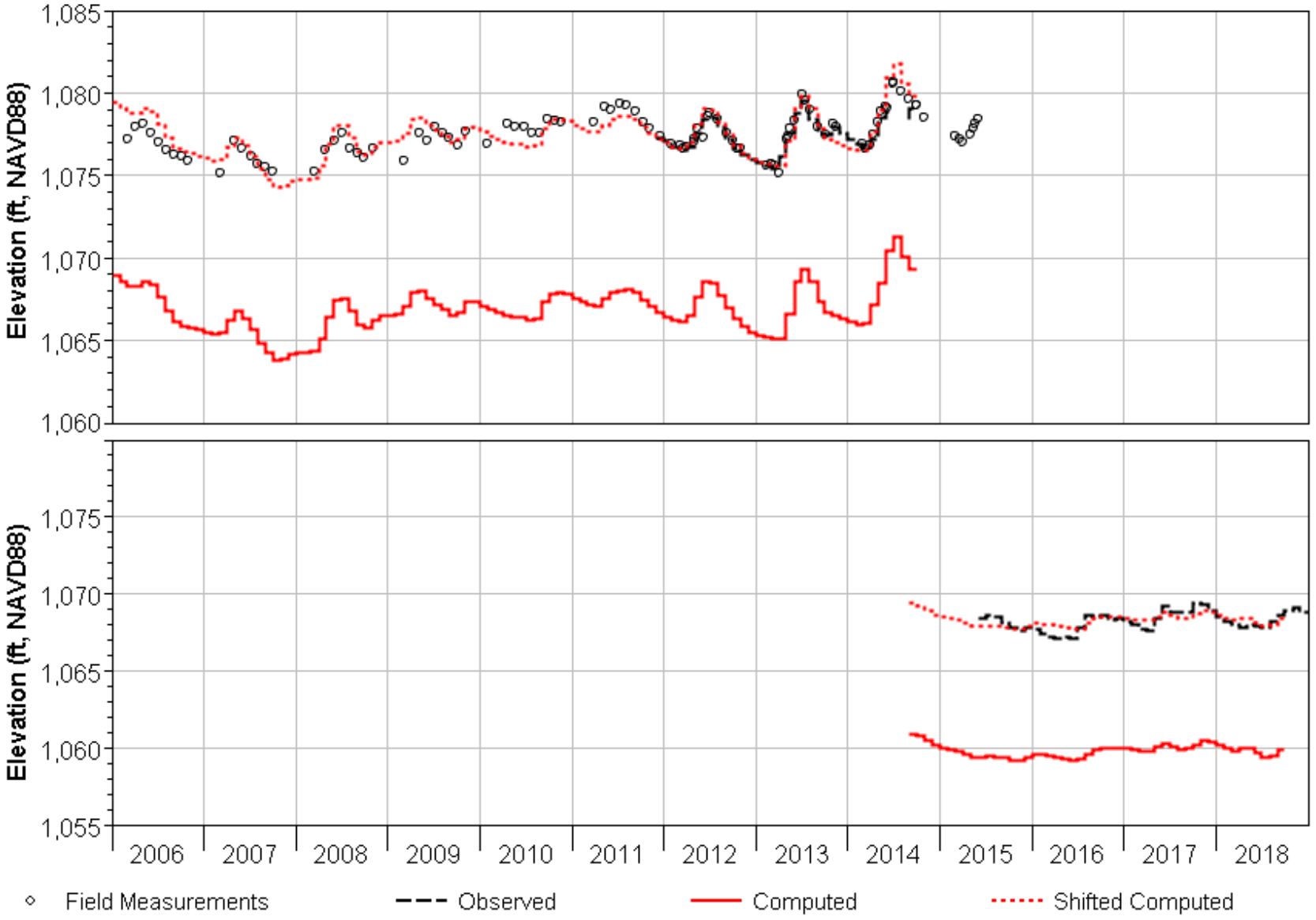

Figure 36 Observed and computed monthly averaged heads at observation well 05004 (Unique No. 243629, sealed), top, and nearby replacement observation well 05010 (Unique No. 792512), bottom, layer 1 (ou),), includes extended model period (Oct 2014 – Sep 2018)

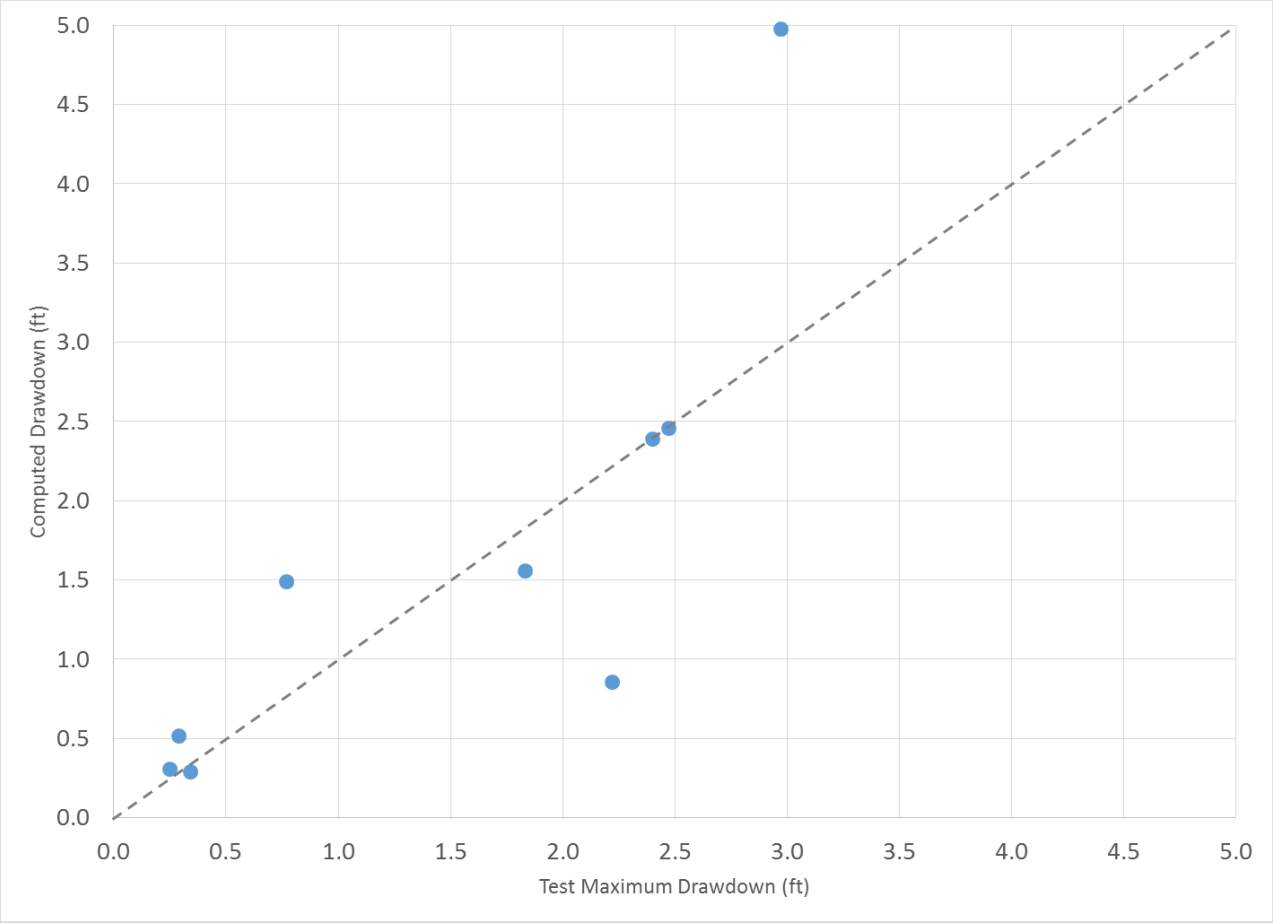

Figure 37 Computed versus observed maximum drawdown at "distant" observation wells measured during five aquifer tests.

The following wells were pumped during these tests: Unique Nos. 542504, 570935, 579021, 753134, and 762210. See Appendix C for information on these aquifer tests.

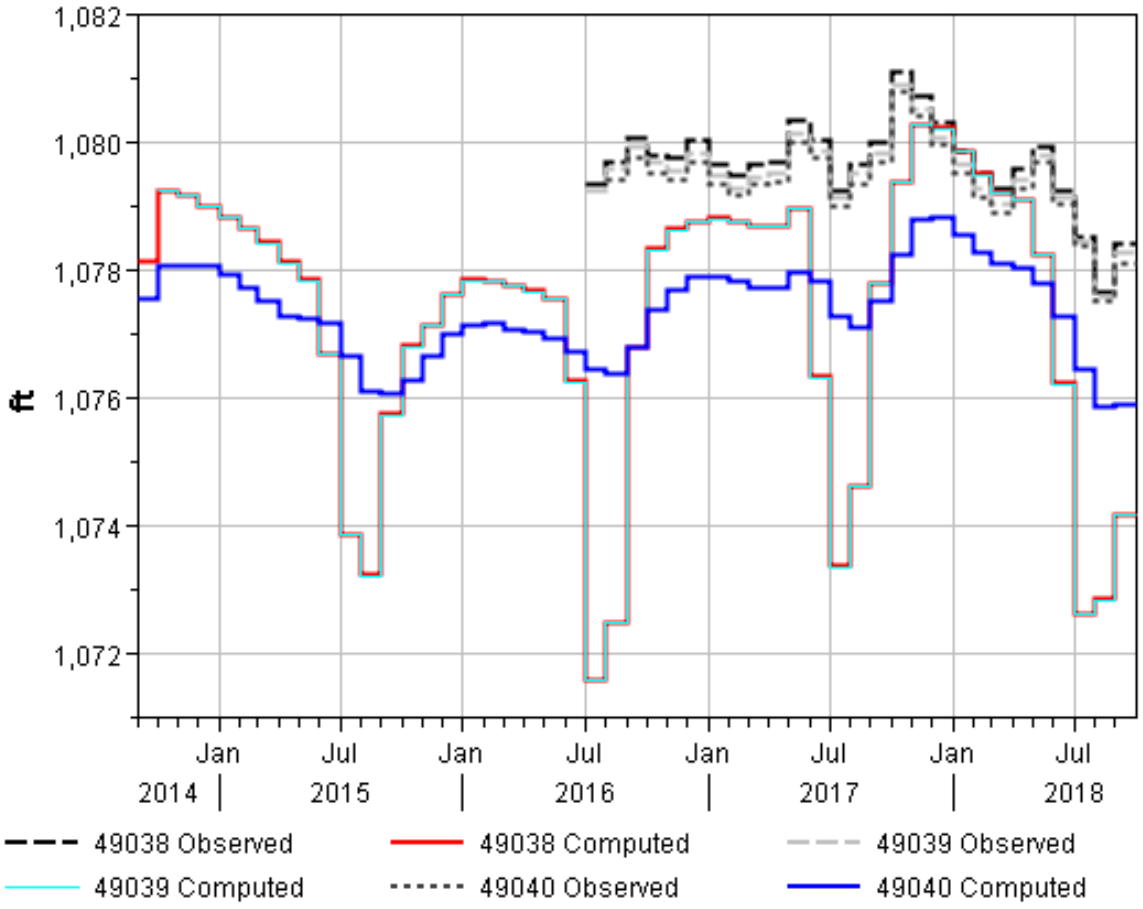

Figure 38 Monthly averaged heads (NAVD 88) at nested observation wells 49040 (Unique No. 816911), layer 1 (water table); 49039 (Unique No. 819503), layer 5 (vs); and 49038 (Unique No. 819502), layer 6 (suu).

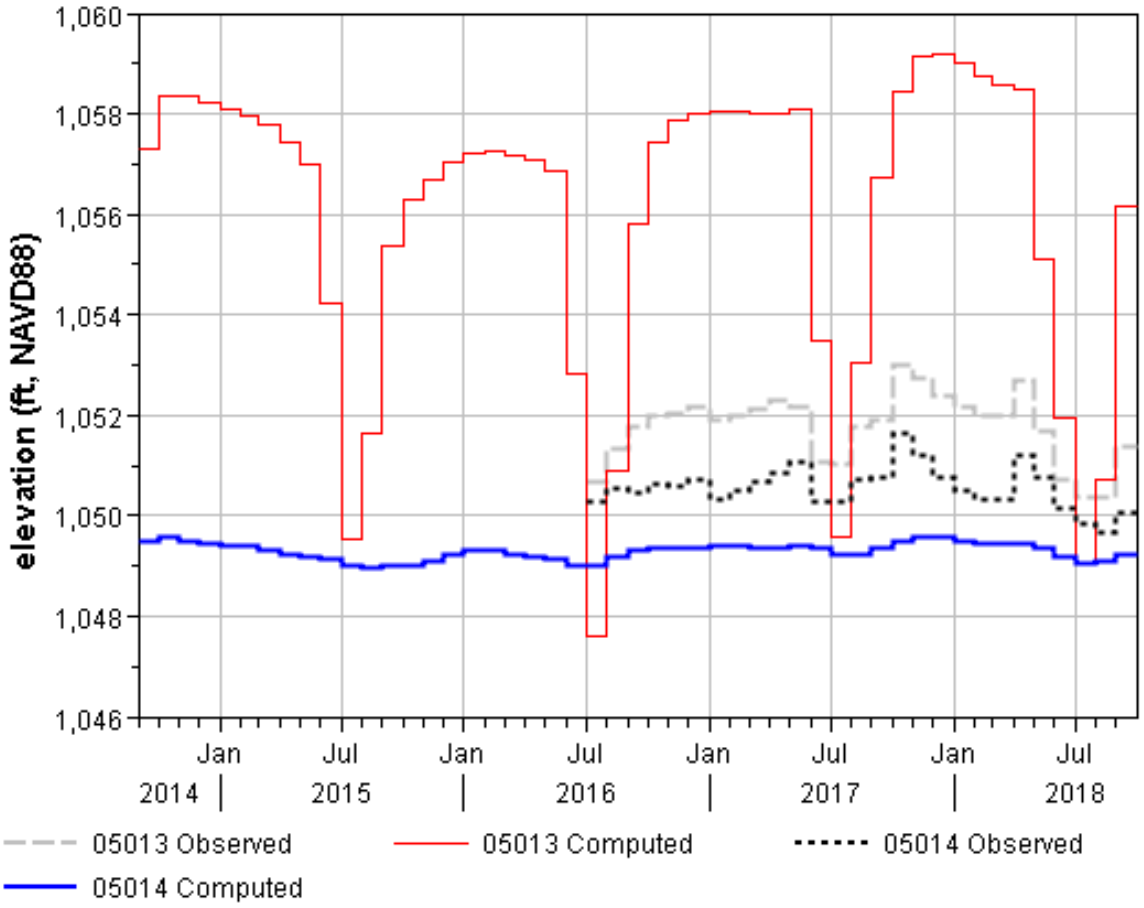

Figure 39 Monthly averaged heads at nested observation wells 05014 (Unique No. 816910), layer 2 (water table) and 05013 (Unique No. 819501), layer 5 (vs)

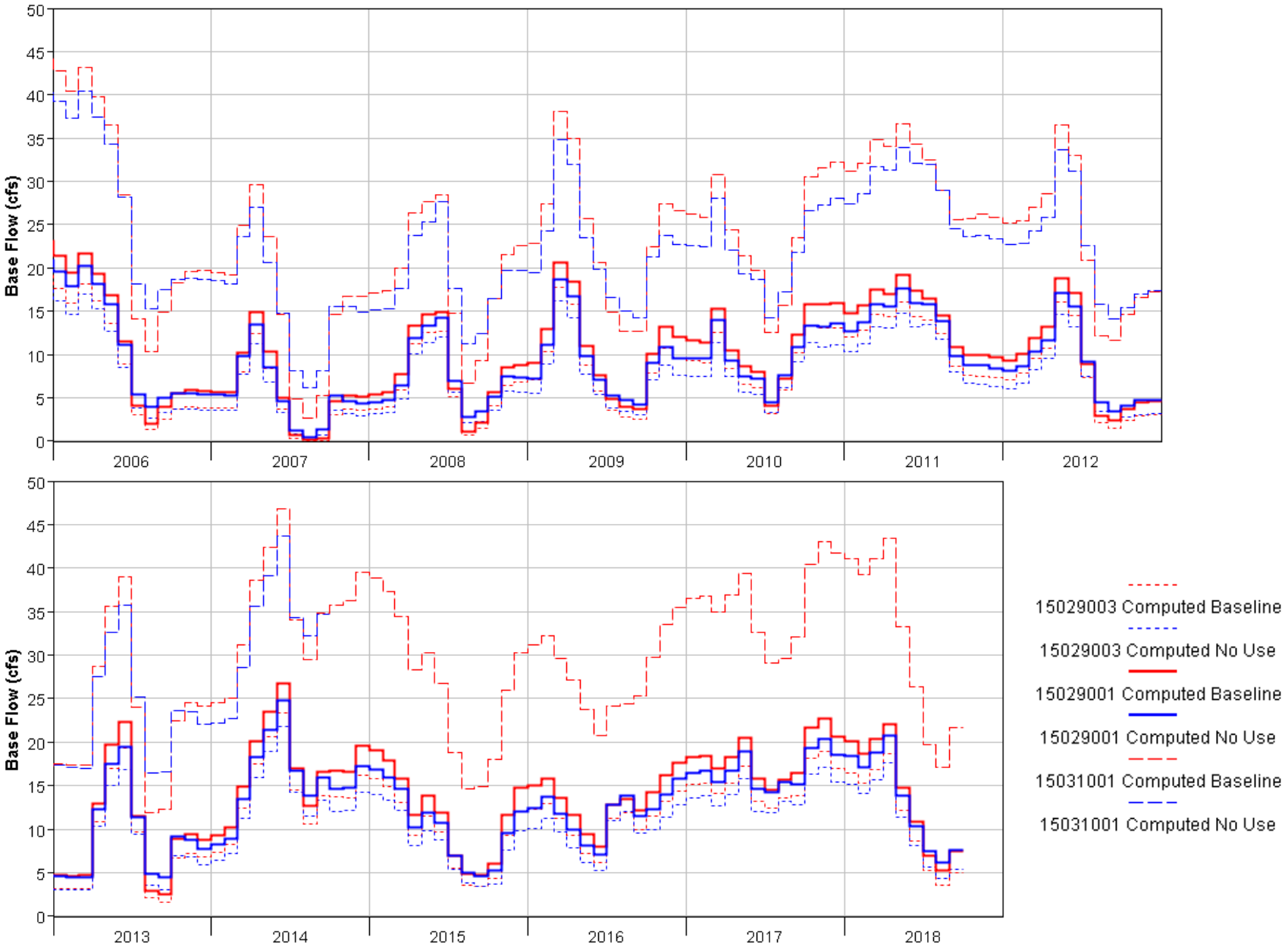

Figure 40 Computed base flow for the baseline and no-use scenarios at stations 15029003, 15029001, and 15031001 on Little Rock Creek..

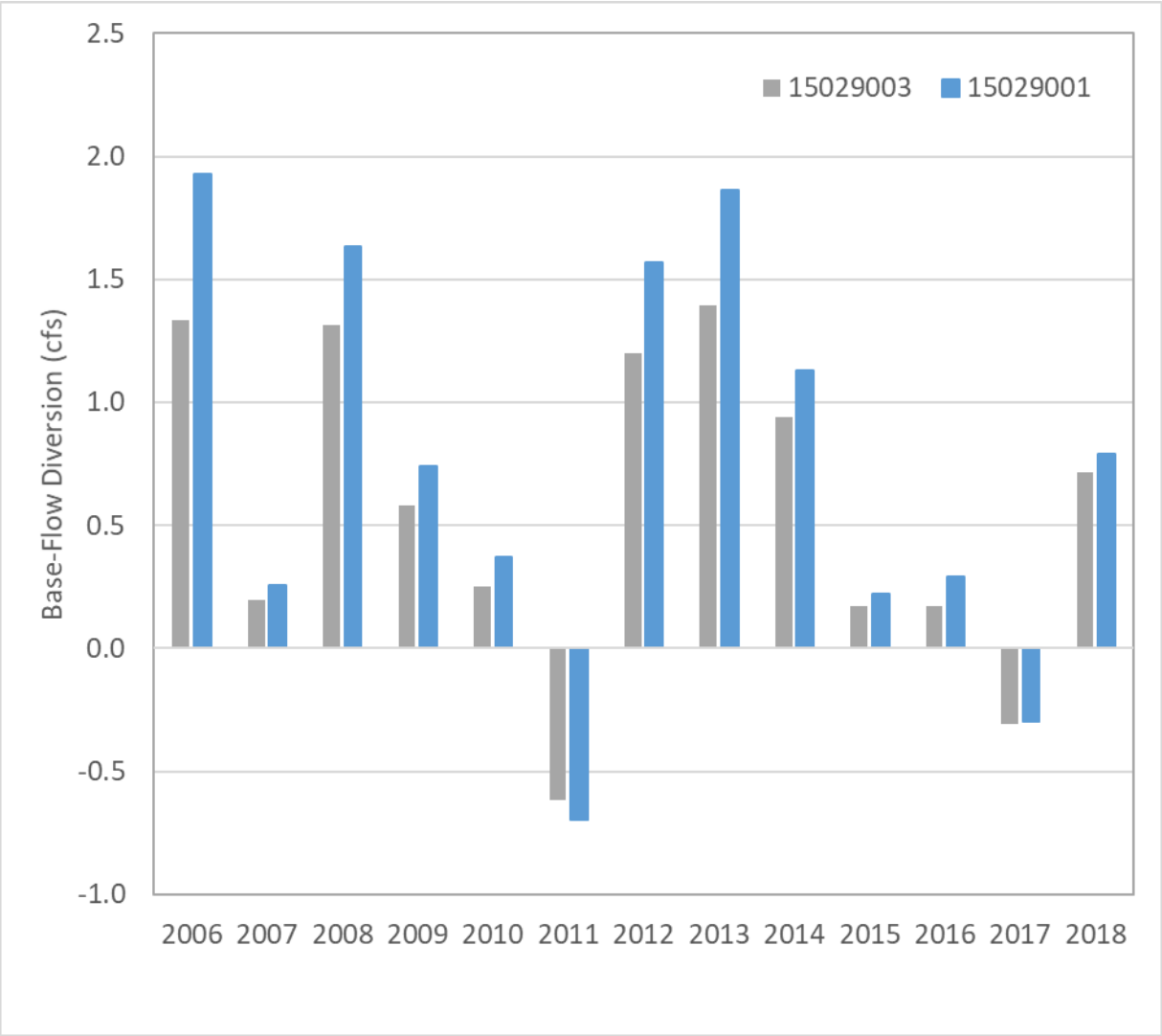

Figure 41 Calculated August, monthly-average base-flow diversions (no use minus baseline) at stations 15029003 and 15029001 on Little Rock Creek.

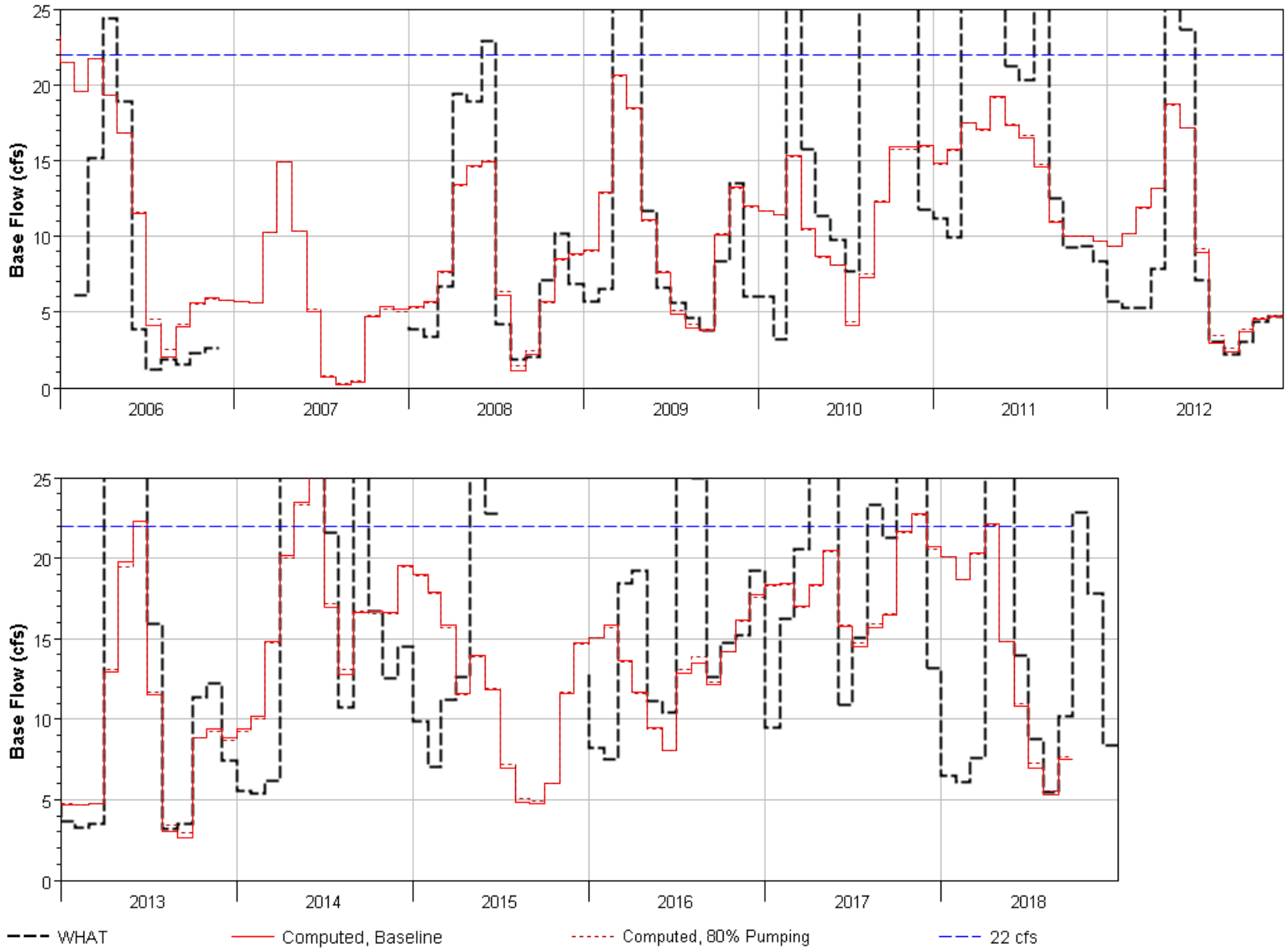

Figure 42 Monthly average WHAT and computed base flow for the baseline and 80% pumping scenarios at station 15029001 on Little Rock Creek