INTRODUCTION

The Moscow-Pullman basin is filled with Miocene-age lava flows of the Columbia River Basalt Group (CRBG) and associated sediments of the Latah Formation that have a composite thickness greater than 2,700 ft (823 m). Domestic and municipal water supplies have been obtained from both the sediment and basalt units. Decades of continued water-level declines have prompted numerous hydrological studies, but accurate flow models have been difficult to construct due to the complexity of the subsurface architecture. Basalt units encountered in the subsurface were placed into a regional stratigraphic framework, and three geologic cross sections (Plates 1–3) were constructed to better understand the relationship between the sediments and individual basalt members and to assist in the interpretation of existing and future hydrological data.

SUBSURFACE GEOLOGY

The stratigraphic sequence and correlations of CRBG units were determined primarily from geochemical analyses of rock-chip cuttings collected from ten deep (700–2,250 ft [213–686 m]) wells (Bush and others, in press) and seven Washington Department of Ecology (DOE) test wells (Conrey and others, 2013). These determinations required comparisons to the regional stratigraphy as outlined by Reidel and others (2013a, b). Bush and others (2018) provided the geochemical data for the ten deep wells, discussed stratigraphic interpretations, and noted contributions by previous workers. Correlations to wells lacking whole-rock geochemical data were made using flow contacts and sediment horizons noted on drillers' reports. Sixteen members of the CRBG, made up of an estimated 25–30 lava flows, are illustrated and placed into three geologic formations; from base upward, they are the Grande Ronde, Wanapum, and Saddle Mountains Basalts. More than 90 percent of this basalt sequence belongs to the Grande Ronde Basalt which has been divided, from base upward, into the R1, N1, R2, and N2 magnetostratigraphic units (MSUs) (Swanson and others, 1980). The Latah Formation has been divided, from base upward, into the sediments of Moscow, the Vantage Member, and the sediments of Bovill (Bush and others, 1998).

Subdivision of the R1 and lower N1 MSUs into members is based only on samples from WSU well 7, and the position shown for the R1–N1 boundary should be considered tentative. The stratigraphic sequence upward from the top of the N1 is consistent from well to well. Correlations of the uppermost members of the Grande Ronde Basalt, the Vantage Member of the Latah Formation, and the Roza and Priest Rapids Members of the Wanapum Basalt were verified by comparisons to numerous drillers' reports and rare outcrops. Subsurface samples of the Latah Formation and descriptions are typically poor, and correlations of lithologies from well to well should be considered tentative.

The geologic cross section from about 4 mi (6 km) west of Pullman, Washington, to about 2 mi (3 km) east of Moscow, Idaho, (Plate 1) illustrates the nature of the subsurface dominated by slightly deformed CRBG lava flows in the western part and Latah Formation sediments in the eastern part. Most of the flows entered the basin from the west and pinch out and (or) thin near the state boundary. The folds in the Pullman area plunge to the northwest. They began to form at least as early as the R2 MSU of the Grande Ronde Basalt and, at times, acted as a barrier to lava emplacement into the basin. The Roza Member, in the western part of Plate 1, is the best example of a flow pinching out against the anticline.

The geologic cross sections in Plates 2 and 3 illustrate north-south relationships. They are more interpretive due to lack of subsurface data. Plate 2 shows the near-horizontal nature of the sequence in the central part of the basin, while Plate 3 portrays gentle folding beneath Pullman.

Hydrological Implications

The two primary groundwater systems in the Moscow-Pullman basin have been referred to as the upper and lower aquifers. The lower aquifer occurs entirely within the Grande Ronde Basalt and interbedded Latah Formation sediments, whereas the upper aquifer occurs primarily in the Vantage sediments (Latah Formation) and overlying basalt of Lolo (Wanapum Basalt). Some relationships between the subsurface geology and the aquifer systems are discussed briefly below.

LOWER AQUIFER

In Pullman, municipal water wells (Pullman 5, 7, 8; WSU 6, 8) were completed just above, in, and below sediments that separate the Cold Spring Ridge Member (CSRM) of the N1 MSU from the R2 MSU of the Grande Ronde Basalt. Primary production comes from this interval which contains gravel, hyaloclastite, sand, silt, and clay deposited by a stream system that existed in the Pullman area at the end of the N1 MSU (Bush and others, in press). Additional production comes from contacts between lava flows and flow-units of the overlying R2 MSU. All these producing zones are part of the lower aquifer. WSU well 7 was designed to obtain water from the lower aquifer (to a depth of 1,000 ft [305 m]) and then was extended to a depth of 2,225 ft (678 m) for research and exploration purposes. It subsequently was backfilled and grouted to a depth of 1,814 ft (553 m) (Wyatt-Jaykim Engineers and Ralston, 1987). Analytical modeling has indicated that, in Pullman, the lower aquifer is separated into upper and lower compartments with vertical leakage between the two (Moran, 2011; Folnagy, 2012). The lower compartment is believed to be primarily related to the sediment interbeds between the N1 and R2 MSUs and the upper compartment to flow contacts within the R2 sequence.

In Moscow, sediments dominate, flow contacts are not common, and the major production zones in the lower aquifer are not as consistent as they are in Pullman. Moscow city wells 9 and 10 and UI well 3 produce from the coarse-grained portions of the clay-rich sediments and the interlayered R2 basalts. In addition, Moscow city well 9 was also designed to obtain water from the base of the CSRM and the top of the underlying sediments. UI well 3 was also designed to produce water at various intervals within the CSRM and underlying sediments including weathered sands above granitic rocks. Thus, Moscow city well 9 and UI well 3 are composite wells in the sense that they obtain water from different stratigraphic horizons within the Grande Ronde Basalt and Latah Formation. Moscow city wells 6 and 8 were cased to the top of the CSRM and produce primarily from the underlying Latah sediments and to a much lesser extent from the CSRM. The CSRM is the most extensive CRBG member that can be correlated from well to well, and it ranges from 275 ft (84 m) beneath Pullman to 325 ft (99 m) below Moscow before terminating near the eastern end of the basin. At the DOE Pullman Test and Observation well, the CSRM top is a very dense basalt with rare vesicles. Beneath Moscow, where drill data and (or) well chips are available, the basalt is generally dense, not only at the top but throughout the unit, and the CSRM is considered an invasive unit in the eastern part of the basin. We believe the CSRM is a leaky aquitard throughout much of the basin. Folnagy (2012) and Fiedler (2009) determined that Moscow city wells 6 and 8 were hydrologically separated from the other Moscow city wells based on aquifer tests. In Pullman, Wyatt-Jaykim Engineers and Ralston (1987) noted that water-bearing zones below 1,000 ft (305 m) in depth in WSU well 7 likely were not as prolific as those intercepted above. Recognition of the CSRM as an aquitard is significant and should be considered in any hydrological model of the Moscow-Pullman basin.

UPPER AQUIFER

Domestic and municipal water supplies are obtained from the upper aquifer, but production varies from less than 1 gallon per minute (gpm) to more than 1,000 gpm. The variations of thicknesses and lithology of the Vantage Member of the Latah Formation are considered the primary controls on supply (Bush and others, 2016). For example, in the central part of the basin, the Vantage is thin and consists primarily of clay, thus wells are generally only capable of very low yields. Large-production wells have been developed in the Vantage Member where it is thick (> 200 ft [61 m]) by both the City of Moscow and the University of Idaho. The Vantage is clay rich, but zones of coarse-grained materials provide the necessary permeability for the high-production wells. These high-yield wells follow a north-south trend through the western part of Moscow along ancient stream channels responsible for the deposition of the Vantage Member (Bush and others, 2016, in press). These streams existed east of the pinchouts of the N2 and upper R2 MSUs of the Grande Ronde Basalt, as noted in Plate 1.

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EXPLANATION

Columbia River Basalt Group

- Saddle Mountains Basalt
  - Weissenfels Ridge Member(?)
- Wanapum Basalt
- Grande Ronde Basalt
  - N_2 Magnetostratigraphic Unit (MSU)
  - R_2 MSU
  - N_1 MSU
  - R_1 MSU

Latah Formation

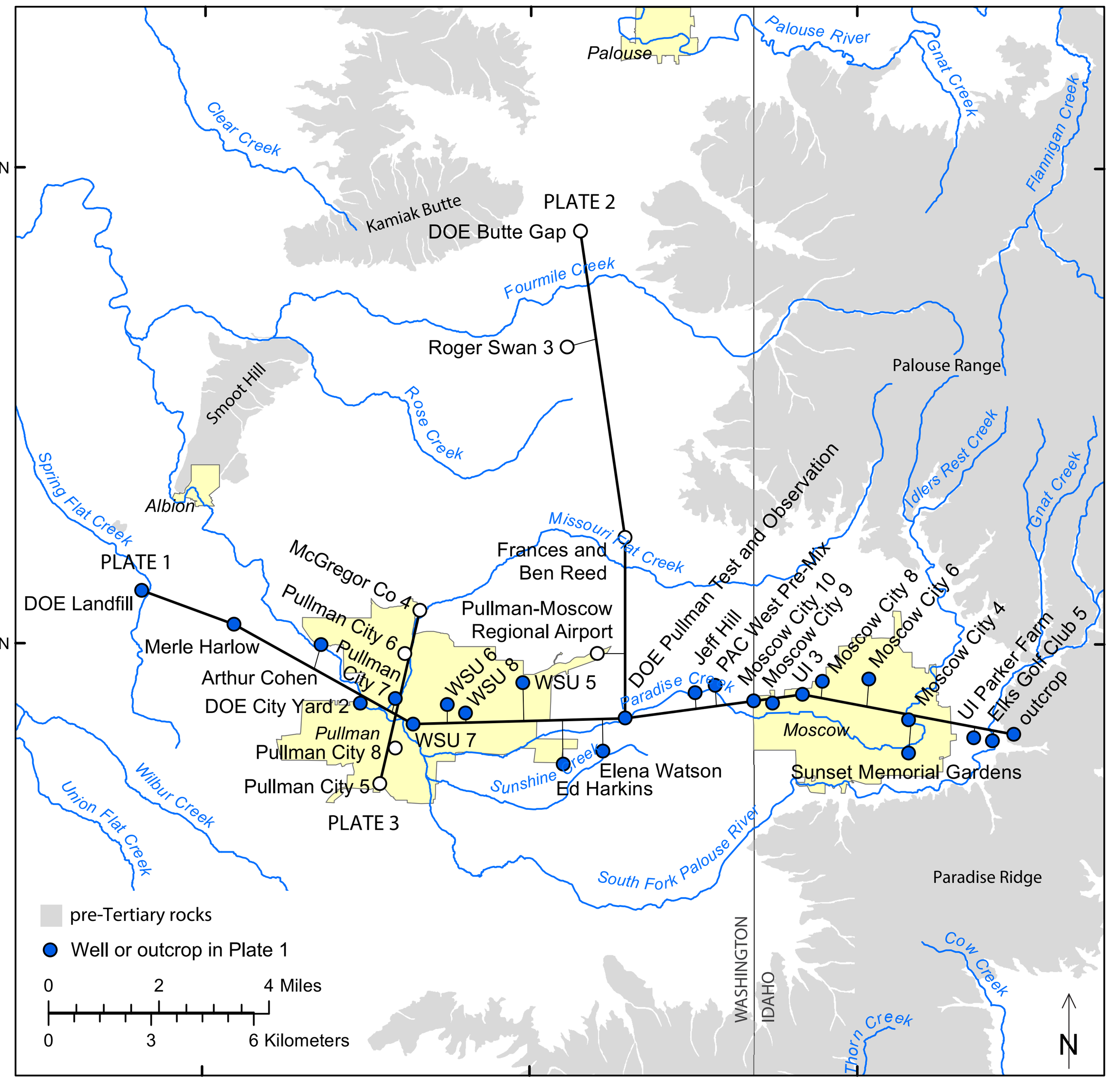
- Grain size unknown
- Gravel
- Sand
- Silt and clay
- Clay
- Palagonite

x Approximate location of basalt sample analyzed for chemistry

Uncased, perforated, or screened intervals for some wells

* Well projected onto cross section

Note: Surface shown is the first Tertiary rocks encountered after drilling through the Palouse Formation (loess). The boundary between Palouse Formation and sediments of Bovill was estimated.



LOCATION MAP

Geologic Cross Section Through Pullman and Moscow

Geologic Cross Sections Across the Moscow-Pullman Basin, Idaho and Washington

By

John H. Bush[1], Pamela Dunlap[2], Stephen P. Reidel[3], and Daisuke Kobayashi[4]

2018

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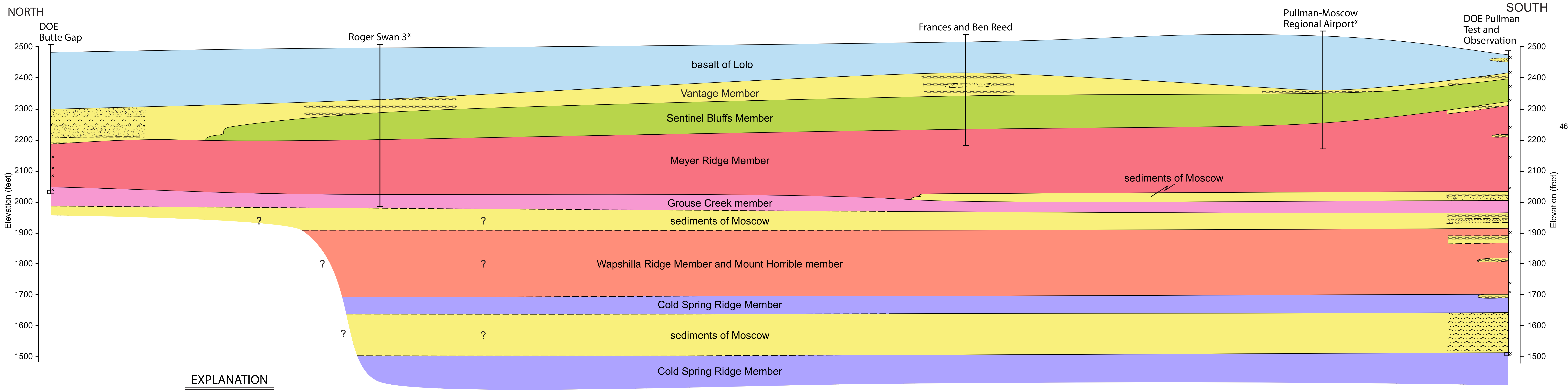

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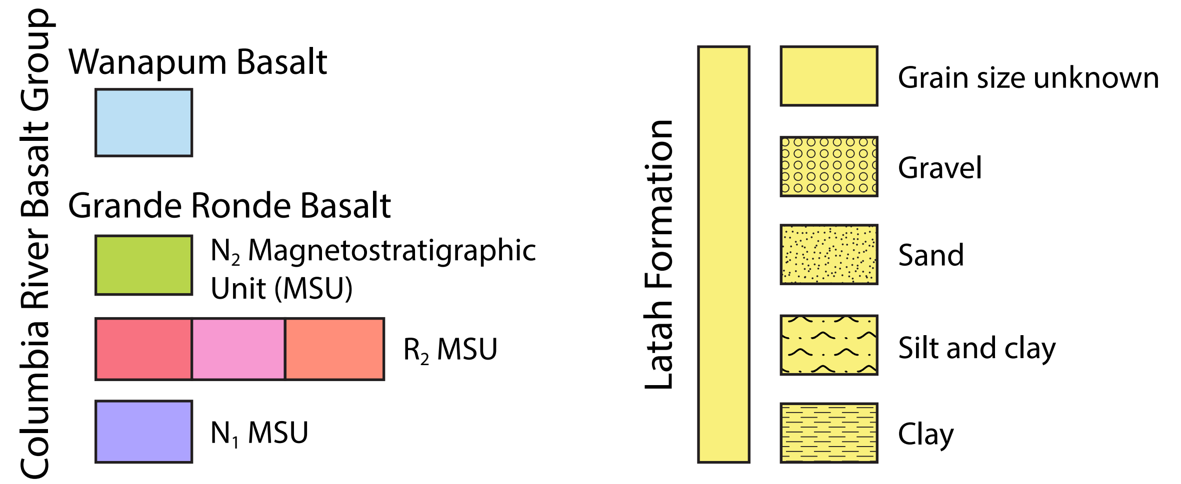

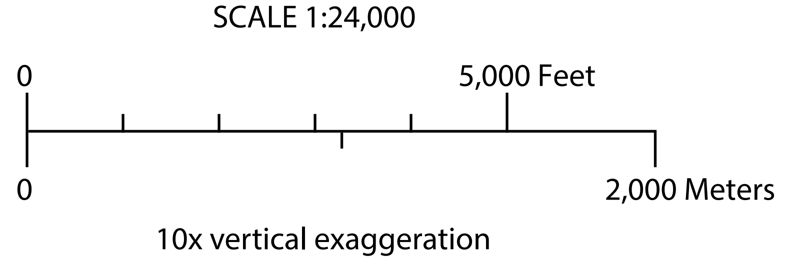

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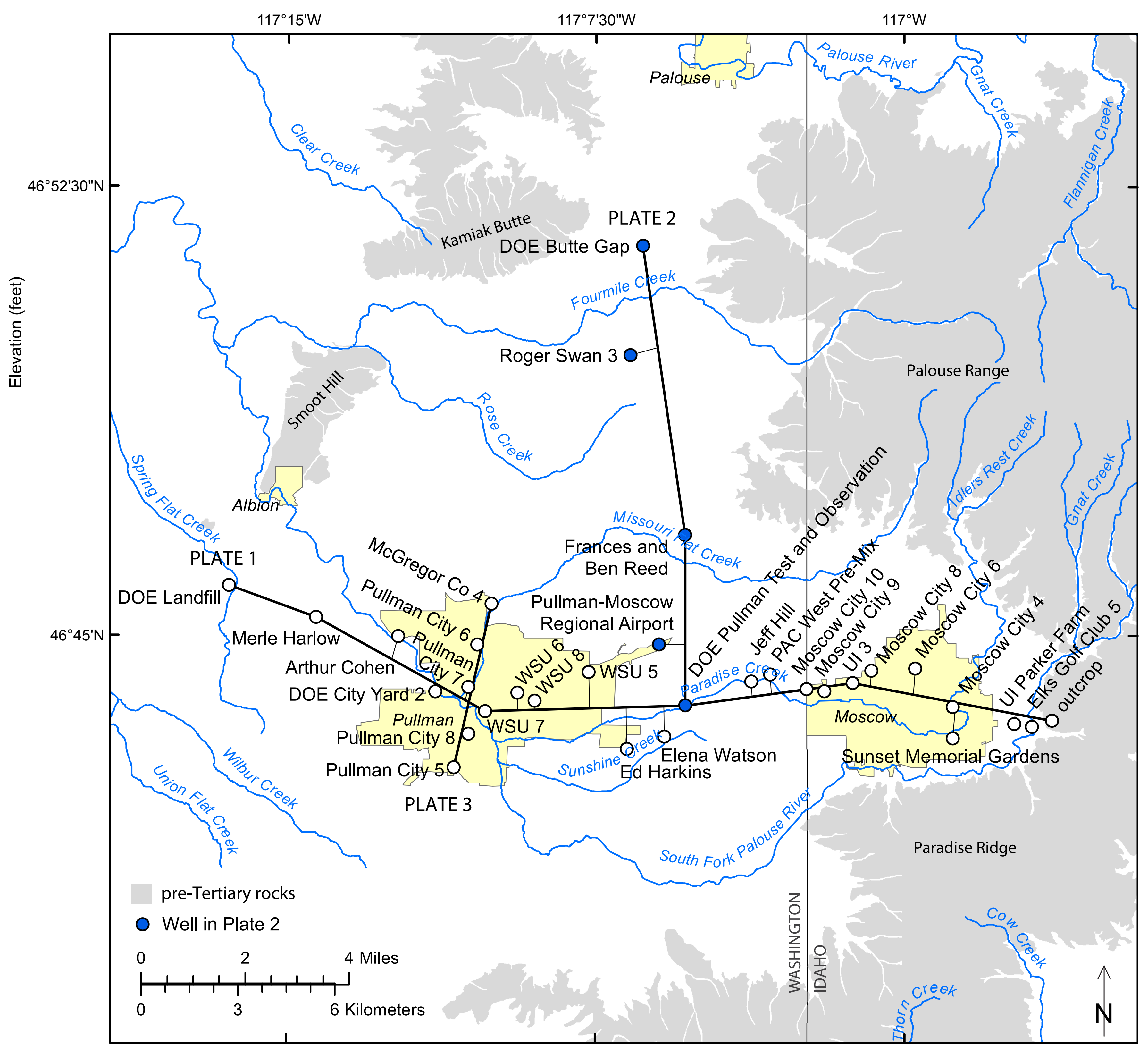

LOCATION MAP

Geologic Cross Section Across the Central Part of the Moscow-Pullman Basin

Geologic Cross Sections Across the Moscow-Pullman Basin, Idaho and Washington

By

John H. Bush[1], Pamela Dunlap[2], Stephen P. Reidel[3], and Daisuke Kobayashi[4]

2018

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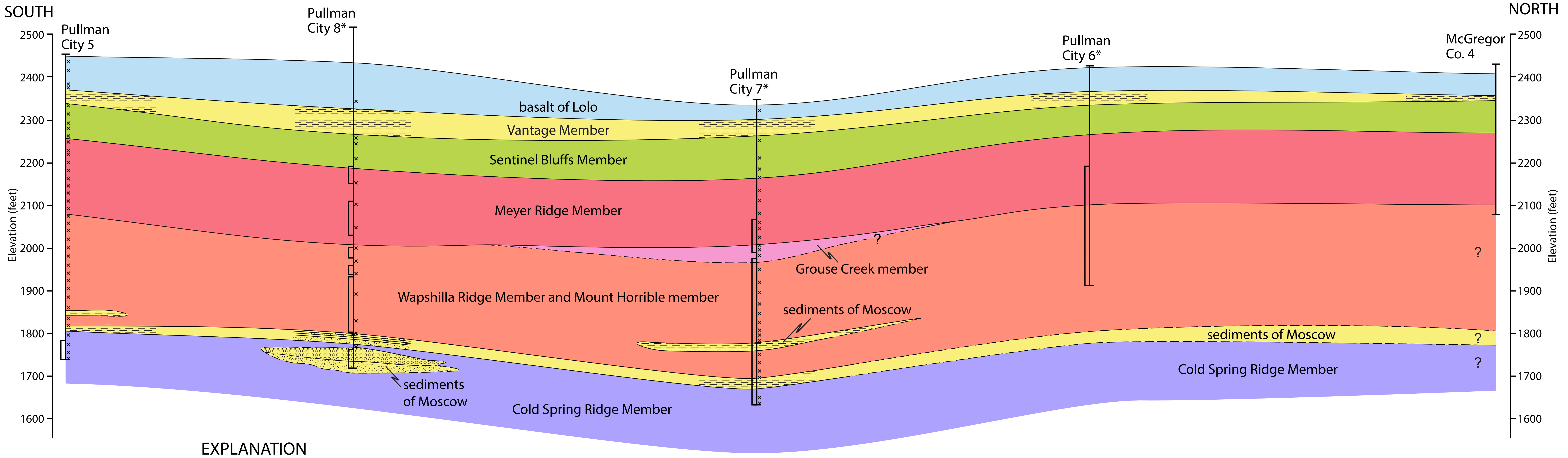

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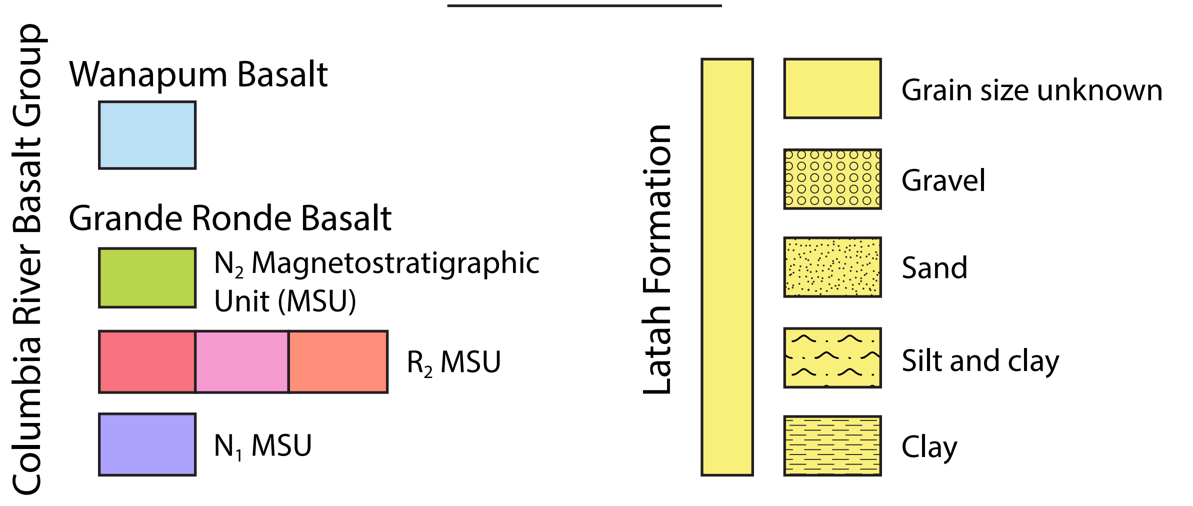

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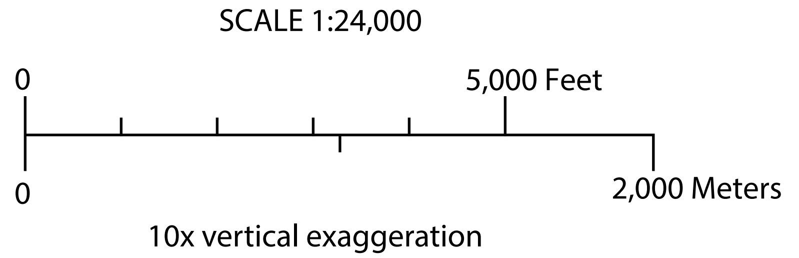
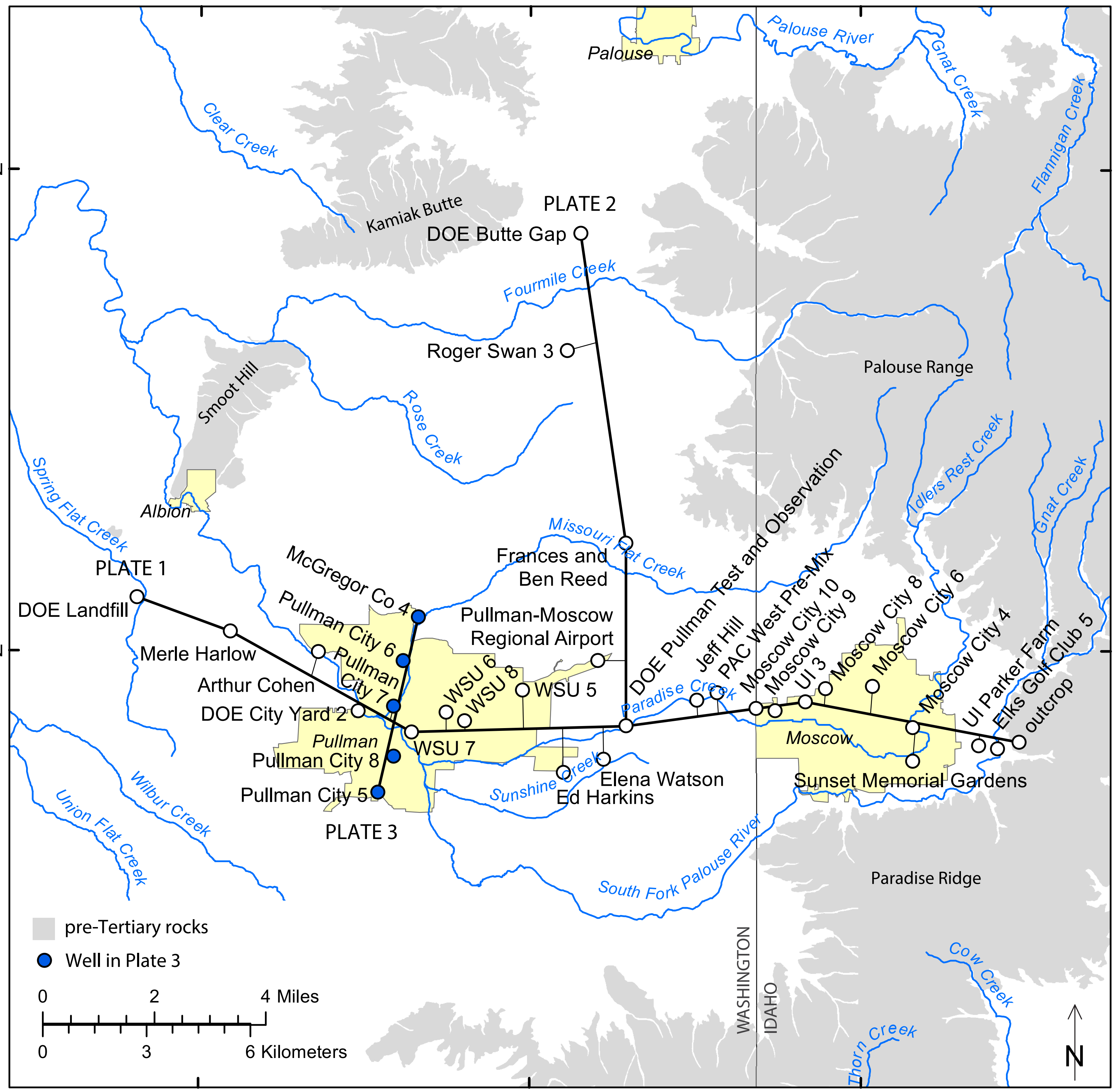


Geologic Cross Section Through Pullman



LOCATION MAP

Geologic Cross Sections Across the Moscow-Pullman Basin, Idaho and Washington

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2018

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