Review of Research from 2009 to the Present about Miocene Aquifers in the Moscow-Pullman Area and Basic Facts about the Aquifers

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2022

INTRODUCTION

In 2007 the major entities of the Palouse Basin Aquifer Committee (PBAC) voted to increase their support of research on the Miocene aquifers of the Moscow-Pullman area. Discoveries and conclusions from these subsequent projects have greatly increased the knowledge and changed some of the concepts about the ground water resources of the area. In addition, two major State of Washington funded studies facilitated by PBAC greatly added to the knowledge base that has accumulated since 2009.

Over fifty publications and theses were completed on various aspects of the aquifer system. Most of these were by University of Idaho and Washington State University faculty and students. In addition to aiding in local research both universities benefited from the support of PBAC. The research products are tabulated by year in Table 1 and their results are summarized herein.

My review of the recent research revealed a problem that is common in any area of continued research studies. That problem is that changes in concepts are often overlooked or forgotten as time passes. Sometimes a few reports become the basis for myths or untruths that slow the progress of understanding. Knowledge and facts get lost and myths dominate. Asking someone to read and understand the thousands of papers on the rocks and aquifers of the Columbia River Basalt Group and associated sediment aquifers is not reasonable. It is quite a task even to read the hundreds of reports on the Palouse Basin. This report provides a brief overview of research since 2009; it also provides ten facts each on the upper and lower aquifers, iron pollution, and historical notes to help interested parties get a foundation in where we are today in our understanding of our water resources.

Table 1. Major research projects on the aquifer systems of the Palouse basin, 2009–present

Researchers	Title	Product
	2009	
Brad Bennett and Jim Osiensky	Strategically Designed Pumping to Maximize Induced Ground Water Recharge to the Wanapum Aquifer System in the Moscow, Idaho Area	poster
Bradley Bennett	Recharge Implications of Strategic Pumping of the Wanapum Aquifer System in the Moscow Sub-basin	M.S. thesis

Table 1 (cont.)

Researchers	Title	Product
	2009	
Brad Bennett	Recharge Implications of Strategic Pumping of the Wanapum Aquifer System in the Moscow Sub-basin	PDF slide show presentation
Lauren Carey and Jim Osiensky	Using Tritium Concentrations to Age Date Groundwater in the Palouse Basin	poster
Aaren Fiedler	Well Interference Effects in the Grande Ronde Aquifer System in the Moscow-Pullman Area of Idaho and Washington	PDF slide show presentation
Aaren Fiedler	Well Interference Effects in the Grande Ronde Aquifer System in the Moscow-Pullman Area of Idaho and Washington	M.S. thesis
Katie Moran	Long-Term, Basin-Wide Grande Ronde Aquifer Test	poster
Matthew Reeves	Estimating Recharge Uncertainty using Bayesian Model Averaging and Expert Elicitation with Social Implications	M.S. thesis
Kirk Sinclair and James Kardouni	Surface-water/Groundwater Interactions and Near-stream Groundwater Quality along the Palouse River, South Fork Palouse River, and Paradise Creek	publication
	2010	
Lauren Carey	Relative Age Dating of Groundwater in the Palouse Aquifer and Moscow Subbasin using Tritium and 0-18 Concentrations	Powerpoint slide show presentation
R. M. Conrey and J. A. Wolff	Basalt lava stratigraphy beneath Pullman and Moscow: implications for the flow of groundwater	poster
	2011	
Allyson Beall, Fritz Fiedler, Jan Boll and Barbara Cosens	Sustainable Water Resource Management and Participatory System Dynamics. Case Study: Developing the Palouse Basin Participatory Model	publication
Lauren R. Carey	Evaluation of Oxygen and Hydrogen Isotopes in Groundwater of the Palouse Basin and Moscow Sub-basin	M.S. thesis
Roel Dijksma, Erin S. Brooks and Jan Boll	Groundwater Recharge in Pleistocene Sediments Overlying Basalt Aquifers in the Palouse Basin, USA: Modeling of Distributed Recharge Potential and Identification of Water Pathways	publication and M.S. thesis
Attila J.B. Folnagy, Kenneth F. Sprenke and James L. Osiensky	Aquifer Storage Properties from Groundwater Fluctuations induced by Seismic Rayleigh Waves	poster
George Grader	Miocene Latah Formation and Subsurface Geology Along the Moscow Subbasin Margin: "Recharge from the East" Revisited	report to PBAC
Kathryn Moran	Interpretation of Long-Term Grande Ronde Aquifer Testing in the Palouse Basin of Idaho and Washington	M.S. thesis
Kathryn Moran	Evaluation of the Relationship Between Pumping and Water Level Declines in the Grande Ronde Aquifer of the Palouse Basin	report to PBAC
TerraGraphics Environmental Engineering, Inc., and Ralston Hydrologic Services	Palouse Ground Water Basin Framework Project Final Report	report to PBAC

Table 1 (cont.)

Researchers	Title	Product
	2012	
Attila Jonathan Bela Folnagy	Long-Term Grande Ronde Aquifer Stress Testing to Delineate Aquifer Compartmentalization and Water Level Responses in the Palouse Groundwater Basin	M.S. thesis
Nathan Moxley	Stable Isotope Analysis of Surface Water and Precipitation in the Palouse Basin: Hydrologic Tracers of Aquifer Recharge	M.S. thesis
TerraGraphics Environmental Engineering, Inc., and Ralston Hydrologic Services	Well Siting for Proposed Washington Department of Ecology Monitoring Wells in the Palouse Basin	report to PBAC
Andrew Spencer	Modeling Semi-Permeable Boundaries in the Palouse Groundwater Basin	Senior thesis
	2013	
Rick Conrey, Chris Beard and John Wolff	Geology of the Palouse Basin DOE test wells	PDF slide show presentation
Richard Conrey, Chris Beard and John Wolff	Columbia River Basalt Flow Stratigraphy in the Palouse Basin Department of Ecology Test Wells	report to PBAC
Attila J.B. Folnagy, James L. Osiensky, Daisuke Kobayashi and Kenneth F. Sprenke	Specific Storage from Sparse Records of Groundwater Response to Seismic Waves	publication
Dale Ralston, Robin Nimmer, and Chris Beard	WDOE Monitoring Well Installation Results	PDF slide show presentation
TerraGraphics Environmental Engineering, Inc., and Ralston Hydrologic Services	Draft Palouse Basin Monitor Well Construction Program	report to PBAC
	2014	
Erin Brooks, Jasper Candel, Roel Dijksma, Ricardo Sánchez-Murillo, Todd Anderson and Craig Woodruff	Identifying Hydrologic Recharge Connections in the Moscow Sub-basin Using Isotopic and Caffeine Tracers	progress report to PBAC
Jasper Candel	Identifying Hydrologic Recharge Connections in the Moscow Sub-basin	M.S. thesis
Rick Conrey and Kyler Crow	Basalt Stratigraphy of the Moscow #9 and UI #4 wells; Evidence for the Moscow Fault	PDF slide show presentation
Kyler Crow and Rick Conrey	The Clear Creek Fault at Glenwood Springs, WA	Powerpoint slide show presentation
Bryan J. Donaldson	Seasonal Evolution of Hydrologic Connectivity in a Tile-drained Agricultural Catchment; An Environmental Tracer Study	M.S. thesis

Table 1 (cont.)

Researchers	**Title**	**Product**
	2014	
Scott Ducar	Properties of the Grande Ronde Aquifer in the vicinity of Moscow, Idaho from the Synthesis of Aquifer Test Results with Seismic Groundwater Response	Senior thesis
Attila J.B. Folnagy, Kenneth F. Sprenke, James L. Osiensky and Daisuke Kobayashi	Generating Aquifer Specific Storage Properties from Groundwater Responses to Seismic Rayleigh Waves	poster
Mark W. Piersol and Kenneth F. Sprenke	Grande Ronde Basalt across the Kamiak Gap: the Gravity Model Revisited using Constraints from the DOE Butte Gap Monitoring Well	report to PBAC
	2015	
Mark W. Piersol and Kenneth F. Sprenke	A Columbia River Basalt Group Aquifer in Sustained Drought: Insight from Geophysical Methods [Revised May 2016]	publication
	2016	
E.S. Brooks, J. Candel, E. Verhoeff, M. Dobre, R. Sanchez-Murillo, G.W. Grader and R. Dijksma	Identifying Groundwater Recharge Pathways in the Moscow Sub-basin	PDF slide show presentation
John H. Bush, Dean L. Garwood and Pamela Dunlap	Geology and Geologic History of the Moscow-Pullman Basin, Idaho and Washington, from Late Grande Ronde to Late Saddle Mountains Time	publication
Jasper Candel, Erin Brooks, Ricardo Sánchez-Murillo, George Grader and Roel Dijksma	Identifying Groundwater Recharge Connections in the Moscow (USA) Sub-basin Using Isotopic Tracers and a Soil Moisture Routing Model	publication
	2018	
John H. Bush and Pamela Dunlap	Structure Contours on the Top of the Grande Ronde Basalt in the Moscow-Pullman Basin and Vicinity, Idaho and Washington	publication
John H. Bush, Pamela Dunlap, Stephen P. Reidel, and Daisuke Kobayashi	Geologic Cross Sections Across the Moscow-Pullman Basin, Idaho and Washington	publication
John H. Bush, Pamela Dunlap and Stephen P. Reidel	Miocene Evolution of the Moscow-Pullman Basin, Idaho and Washington	publication
John H. Bush and Pamela Dunlap	Geologic Interpretations of Wells and Important Rock Outcrops in the Moscow-Pullman Basin and Vicinity, Idaho and Washington	publication
	2019	
Kyle A. Duckett	Isotopic Discrimination of Aquifer Recharge Sources, Subsystem Connectivity and Flow Patterns in the South Fork Palouse River Basin, Idaho and Washington, USA	M.S. thesis

Table 1 (cont.)

Researchers	Title	Product
	2019	
Kyle A. Duckett, Jeff B. Langman, John H. Bush, Erin S. Brooks, Pamela Dunlap and Jeffrey M. Welker	Isotopic Discrimination of Aquifer Recharge Sources, Subsystem Connectivity and Flow Patterns in the South Fork Palouse River Basin, Idaho and Washington, USA	publication
Kyle A. Duckett, Jeff B. Langman, John H. Bush, Erin S. Brooks, Pamela Dunlap and Jessica R. Stanley	Noble Gases, Dead Carbon, and Reinterpretation of Groundwater Ages and Travel Time in Local Aquifers of the Columbia River Basalt Group	publication
John H. Bush, Pamela Dunlap, and Daisuke Kobayashi	A Collection of Geologic Maps, Cross Sections, and Schematic Diagrams that Illustrate the Subsurface Geology of the Moscow-Pullman Basin and Vicinity	report to PBAC
	2021	
Giacomo Medici, Nicholas B. Engdahl and Jeffery B. Langman	A Basin-Scale Groundwater Flow Model of the Columbia Plateau Regional Aquifer System in the Palouse (USA): Insights for Aquifer Vulnerability Assessment	publication
David Behrens	Tracing $\delta^{18}O$ and $\delta^{2}H$ in Source Waters and Recharge Pathways of a Fractured-Basalt and Interbedded-Sediment Aquifer, Columbia River Flood Basalt Province	M.S. thesis
David Behrens, Jeff B. Langman, Erin S. Brooks, Jan Boll, Kristopher Waynant, James G. Moberly, Jennifer K. Dodd and John W. Dodd	Tracing $\delta^{18}O$ and $\delta^{2}H$ in Source Waters and Recharge Pathways of a Fractured-Basalt and Interbedded-Sediment Aquifer, Columbia River Flood Basalt Province	publication
	2022	
John H. Bush, Steve Robischon, and Pamela Dunlap	Boundaries of the "Palouse Basin" Aquifer System in the Moscow-Pullman Area, Idaho and Washington	report to PBAC
Nicholas B. Engdahl	Critical Assessment and Recommendations for Future Research from the 2021 Moscow-Pullman Basin Aquifer Groundwater Model	report to PBAC
	2022, in progress	
Quinn Buzzard, Jeff B. Langman, David Behrens, Timothy C. Bartholomaus, and James G. Moberly	Monitoring the Ambient Seismic Field to Track Groundwater at a Mountain-Front Recharge Zone in the Columbia River Basalt Province	in progress for publication and M.S. thesis

OVERVIEW OF RECENT RESEARCH

1. Bennet (2009); Carey (2011)—These two University of Idaho theses added to and summarized earlier work on the upper aquifer in Moscow. The upper aquifer consists primarily of two parts the uppermost basalt of Lolo and the underlying Vantage sediments. These two portions are separated by a leaky aquitard consisting of the dense center of the basalt. Vertical recharge does occur from stream loss, overlying sediments of Bovill and soil percolation, but most of this water does not reach the lower aquifer. The upper aquifer recharges annually and is capable of being a renewable resource. The sediments are the primary producers which, by process of elimination, must receive significant lateral recharge.

2. Fiedler (2009); Moran (2011); Folnagy (2012)—These three University of Idaho theses used long term pump tests to determine several conclusions about the lower aquifer. Resources are compartmentalized but interconnected throughout the Palouse Basin on a long-term basis. Each study determined that significant recharge was occurring on an annual basis. There is not a major connection of this aquifer system with the Colfax area. Two authors believed that the lower aquifer in the City of Palouse area was connected to the Moscow-Pullman area while one questioned that connection. The aquifer system beneath Moscow is primarily a sediment, rather than a basalt, aquifer.

3. Conrey et al. (2010–2014)—Conrey (WSU GeoAnalytical Lab), with co-authors, made several presentations to PBAC. In addition to providing new and accurate well data they noted possible small, NW-trending faults and verified the existence of an up fold west of Pullman.

4. TerraGraphics and Ralston Hydrologic Services (2011, 2013)—These two reports provided a wealth of information and summaries of previous work. Their 2013 report showed the interconnection of the lower aquifer into the Union Flat Creek and City of Palouse area. The continued monitoring of water levels in wells that they established has provided crucial information on the rate of water decline.

5. Moxley (2012); Sinclair and Kardouni (2009); Piersol and Sprenke (2015 [2016])—The work by these researchers overlap and point to recharge in the lower aquifer in the Pullman area. In particular, recharge was noted along the South Fork River Palouse from Pullman to Albion. The reason for the recharge is the fact that the South Fork is located at the base of the basalt of Lolo and in the upper part of the Grande Ronde Basalt.

6. Grader (2011); Dijksma et al. (2011); Candel el al. (2016)—Grader discovered that geologic maps along the slopes of the western flanks of the southern Palouse Range are in error and many areas originally mapped as granite are, in fact, sediments and weathered granite. Erin Brooks (University of Idaho) with students from the Netherlands published articles reporting recharge into those sediments and weathered granites.

7. Bush et al. (2016–2022)—Five publications included a database of water well logs, a detailed geologic cross-section between Moscow and Pullman and a subsurface map illustrating geologic structures. Paleogeographic reconstructions show that the Palouse River, which once flowed north to south, reversed direction to flow north toward the City of Palouse via the Butte Gap area. Two reports to PBAC provided numerous illustrations on the geologic architecture of the subsurface and discussed the boundaries of the Palouse Basin.

8. Duckett (2019); Duckett et al. (2019); Behrens (2021); Behrens et al. (2021); Buzzard et al. (in progress)—These studies, lead by students of Jeff Langman (University of Idaho), reported on movement of ground water. Most important was the tracing of snowmelt waters from the southern Palouse Range to Pullman and the identification of dead carbon in lower aquifer wells which verified that the reported dates of carbon-14 for the groundwater are too old.

9. Medici et al. (2021); Engdahl (2022)—One publication and one report discussed numerical modeling of the Palouse Basin and noted the difficulty in predicting groundwater decline. The lack of data outside of the pumping centers was a major problem.

10. The continued reporting on monitoring wells and water-level trends by Steve Robischon (PBAC, 2009–2022) has been important to the understanding of the aquifer system. The most recent example is the comparison of the City of Palouse water-level decline trends to those recorded at the DOE Butte Gap well. The nearly perfect match of those trends verifies the groundwater connection between the two areas.

THE UPPER AQUIFER (WANAPUM AQUIFER), MOSCOW-PULLMAN—TEN FACTS

1. The upper aquifer is very compartmentalized, has variable water levels, and its pumping capacity ranges from <1 gpm to >1,300 gpm.

2. Upper aquifer waters are obtained from fractures in the basalt of Lolo and coarse-grained sediments in the Vantage Member in the Moscow-Pullman and City of Palouse areas.

3. Major municipal supplies are only obtainable from the upper aquifer in Moscow where the Vantage is thick and is recharged annually.

4. The basalt of Lolo averages 160 ft in thickness and extends over much of the Moscow-Pullman and surrounding areas. It has a dense, nearly impermeable center at most localities which prohibits significant vertical recharge.

5. The Vantage also extends over much of the area but is missing or is very thin (<5 ft) at some localities and can become very thick (> 250 ft) at others.

6. Most wells that penetrate only basalt produce low-yield domestic supplies.

7. The high-yield wells in Moscow are not connected to all wells in Moscow. Municipal pumping does not appear to affect upper aquifer wells in the Pullman area.

8. The thick Vantage beneath the Moscow area thins and consists mostly of clay west of the state line. The thin Vantage dominated by clays are in part the cause of upper aquifer low yield wells between Moscow and Pullman.

9. Recharge to the upper part of the basalt of Lolo in Moscow has been documented but most of these waters do not reach the base of the basalt.

10. West of Pullman in the Union Flat Creek area the upper aquifer consists of three basalt flows named from base upward as the Roza, the basalt of Lolo, and the Asotin. Interbeds are generally thin and the aquifer has produced domestic supplies only.

THE LOWER AQUIFER (GRANDE RONDE AQUIFER), MOSCOW-PULLMAN—TEN FACTS

1. Lower aquifer wells in Moscow and Pullman are some of the largest producers in the Columbia River Plateau.

2. Nearly all the municipal and university supplies are derived from the lower aquifer with water levels up to 150 ft below levels in the upper aquifer.

3. Water levels are similar from well to well but supplies are compartmentalized and not all wells are affected by other wells on a short-term basis.

4. Most new domestic wells between Moscow and Pullman obtain their waters from the lower aquifer.

5. The lower aquifer is connected to the Palouse city area and to the Union Flat Creek area west of Pullman. However, the nature of those connections are not well known.

6. In Pullman, the lower aquifer rocks consist mostly of basalt and are over 2,100 ft thick. However, the lower 1,100 ft does not contain the same prolific water producing zones as the upper 1,000 ft.

7. In Moscow, the lower aquifer rocks consist of mostly sediment and are about 800 ft in thickness. Basalt aquifers are thin and sediments are believed to be delivering waters to those aquifers.

8. The western slopes of the southern Palouse Range and streams in the Pullman area have been identified as areas of recharge.

9. Rubbly, fractured interflow zones and flow pinch outs in the lower Grande Ronde basalts are considered to be the mechanism by which waters move from the sediment areas on the east to the basalt areas on the west.

10. Lower aquifer waters do not flow toward the Snake River and the connection of the lower aquifer waters from Pullman to the Colfax area is not believed to be significant.

UPPER AQUIFER NATURAL IRON POLLUTION AND LATAH FORMATION SEDIMENTS, LATAH COUNTY, IDAHO—TEN FACTS

1. Many upper aquifer wells in Moscow and surrounding areas in Latah County produce waters that contain high amounts of iron and other elements. The water is often brown, smelly, and stains fixtures and containers.

2. Regionally, upper aquifer wells in basalt have higher concentrations of iron amounts than lower aquifer wells but not to the extent as those in Moscow.

3. The most contaminated wells have penetrated Latah sediments and are located close to higher elevation granitic basement rocks

4. Wells with excessive or high concentrations of iron west of Moscow in Washington are rare. Latah sediments are thin and/or are missing.

5. In the Palouse city area most domestic wells are in the base of the basalt of Lolo or in sands of the Vantage. Surrounding basement rocks are quartzitic rather than granitic. Excessive iron concentrations are rare.

6. In Moscow, iron in the upper aquifer is common despite continued recharge.

7. The upper Latah sediments are clay rich with layers, channels, and lenses of poorly-sorted iron-stained sand. Organic material and iron-cemented nodules are common throughout.

8. Weathered granitic rocks lack ferro-magnesium minerals common in non-weathered portions.

9. Weathering of the granitic rocks releases iron which precipitates as cement, stains and vesicle fillings. Where the iron comes in contact with organic material, iron bacteria form.

10. The iron, in general, does not reach the lower aquifer because of its removal (precipitation) out of the system.

TEN COMMON MYTHS ABOUT THE MOSCOW-PULLMAN AQUIFER SYSTEMS

1. MYTH: There is very little recharge. FACT: There are several research works in the past 13 years that documented significant recharge!

2. MYTH: Carbon-14 dates show that the groundwater is mostly old (Pleistocene). FACT: Reported dates are much too old and misleading!

3. MYTH: The aquifers are primarily basalt aquifers. FACT: Major aquifers are primarily sediments in Moscow and basalt and sediments in Pullman!

4. MYTH: The mountain slopes on the southern end of the Palouse Range (Moscow Mountain area) consist of granite underlying loess. FACT: Most of the area contains weathered granite or sediments overlying granite!

5. MYTH: The upper aquifer in Moscow dried up in the late 1950s. FACT: The upper aquifer was over pumped, not dried up, because it recharges 2–3 ft annually!

6. MYTH: If there is recharge to the lower aquifer it is vertical via the loess (or sediments of Bovill) and uppermost basalt flows. FACT: There is no significant vertical recharge over most of the central part of the Moscow-Pullman basin!

7. MYTH: All the aquifer rocks are horizontal. FACT: The rocks in western Pullman slope down to the west and northwest and are bent into upfolds and downfolds!

8. MYTH: Lower aquifer water in Pullman is not connected to Idaho. FACT: Snowmelt waters can be traced from the Moscow Mountain area to Pullman and from Moscow to Pullman!

9. MYTH: The rate of water decline is increasing each year. FACT: Water declines continue, but the rate of decline has been decreasing!

10. MYTH: The aquifers consist of subsurface lakes. FACT: The aquifers consist of saturated fractures and porous zones in basalt and sediment!

HISTORICAL NOTES ABOUT THE PALOUSE BASIN AQUIFERS

1. In the late 1800s and early 1900s, Moscow residents obtained their water from springs and shallow dug wells in the sediments of Bovill and the upper part of the basalt of Lolo. Water in the earliest basalt wells flowed out at the top into stream drainages. The city's first municipal well was hand dug into the sediments of Bovill and the upper part of basalt of Lolo.

2. In the 1920s, water levels dropped, and two new Moscow city wells were drilled in 1925 and the 1930s. The new wells penetrated the basalt and were completed in the Vantage Member. Prolific sources were obtained at the base of the Lolo and from the Vantage. These two wells provided the first evidence that the upper aquifer in Moscow consists of at least two major producing zones separated by a nearly impermeable center of the basalt of Lolo.

3. In the late 1800s and early 1900s, Pullman residents obtained their water from artesian wells (spouting up to 65 ft in height above ground) that were left flow into stream drainages. Those waters were derived from a zone that included the base of the basalt of Lolo, Vantage sediments and the uppermost Grande Ronde Basalt. Water level declines by the 1930s caused both the city and Washington State University to drill deeper into the Grande Ronde Basalts for additional supplies.

4. In the late 1940s, there was concern for water-level decline in the upper aquifer of Moscow. The general belief was that the aquifer was drying up but, in fact, the aquifer actually was being pumped beyond its annual recharge.

5. In 1955, deep wells into the lower aquifer were completed by the City of Moscow and the University of Idaho. Pumping from the city's upper aquifer wells was curtailed in the early 1960s after 35 years of continual use. A return to heavy pumping (<200 gallons/year) occurred in the early 1990's and ceased in 2017.

6. In the 1970s, there were several items of interest. Jones and Ross (1972) reported that the upper aquifer had not dried up and was recharging 2–3 ft each year. The Washington Department of Ecology drilled a test and observation well between Moscow and Pullman. Brown (1979) reported that the basalts were deformed in the Pullman area. Barker (1979) completed the first numerical model of the Moscow-Pullman area. He believed that there was a barrier to groundwater flow west of Pullman in the Union Flat Creek area. A committee made of individuals from both Washington and Idaho began to meet on a regular basis; this Moscow-Pullman Aquifer Committee later became PBAC.

7. In the 1980s: Klein et al. (1987) completed a geophysical survey of the Moscow-Pullman area. That study suggested the presence of a deep pre-basalt canyon and the possible existence of a subsurface high, possibly dikes, 5 miles southwest of Pullman. WSU well no. 7, a research-

production well completed to a depth of 2,205 ft, verified the presence of a deep pre-basalt canyon. The prolific water-bearing zones occurred above 1,000 ft in depth—in what was later determined to be in the R2 interval of the Grande Ronde Basalt.

8. In the 1990s: Lum et al. (1990) built a numerical model that suggested lowering of pumping would stabilize water decline. The two cities and universities went to considerable effort to reach those goals but water declines continued. One assumption in the model may have been the primary reason for its failure. The model assumed groundwater flow toward the Snake River canyon. Later studies showed that the basalts slope away from the canyon edges causing the water to flow to the northwest. Geologic mapping documented that loess in the Moscow area was underlain by thick Latah sediments (sediments of Bovill) on top of the basalt of Lolo. It was previously thought that thick loess covered both the basalt and granite beneath the City of Moscow. The Moscow-Pullman Aquifer Committee changed its name to the Palouse Basin Aquifer Committee. Moscow began annual pumping from the upper aquifer in the early 1990s.

9. In the early 2000s, a series of hearings and meetings occurred over a water-well permit for construction of a private well that could produce 3,000 gpm. The permit was eventually denied. The general belief developed from several research projects was that there was little or no modern recharge to the lower aquifer. That belief was later refuted.

10. In 2007, several government and university entities agreed to increase their annual fee to PBAC.

ACKNOWLEDGMENTS

I wish to thank Steve Robischon and Pamela Dunlap for their helpful insights. And, I very much appreciate the efforts of the Palouse Basin Aquifer Committee in supporting research into the Palouse basin aquifer systems and posting the research results on their website.

Report submitted to Palouse Basin Aquifer Committee, 5 October 2022