Available groundwater determination

Technical Memorandum

WWDC Green River Basin Water Plan II – Groundwater study
Level I (2007–2009)

August 2010

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This report was prepared under contract for the Wyoming Water Development Commission (WWDC)[3] by the Wyoming State Geological Survey (WSGS), United States Geological Survey (USGS), and Water Resources Data System (WRDS), in cooperation with the Wyoming State Engineer's Office (WSEO) and the Wyoming Oil and Gas Conservation Commission (WOGCC)

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Editor's preface

Continuous gravity groundwater flow through the pre-Laramide sediments in the area that is now Wyoming was interrupted and redirected, as a result of folding and faulting that accompanied the Sevier and Laramide orogenies, into the discontinuous, complex groundwater regime of today. Our basic human need for water and our use of water in productive activities require that we treat this groundwater as a resource; and our stewardship of this resource entails its measurement and characterization. The groundwater regime and basin subregimes being complex and our measurements being sparse and uneven in quality and distribution, we increase our knowledge of this resource only slowly over time.

Water is Wyoming's most important natural resource, more valuable over the long term than the fossil fuels that drive our state's economy at present, for water is essential to life, and water scarcity is an inevitable consequence of increasing population and changing climate. The study of our groundwater is necessary because we need to understand and predict the rate of use that would change our groundwater from a renewable to a non-renewable resource: when drawdown results in the lithologic compaction of an aquifer, the aquifer cannot be fully recharged. And, in practical terms, drawdown entails more and more costly production and treatment, so we are also gauging an economically renewable or non-renewable resource.

Our ultimate *objective* is a means of predicting the quality and quantity of groundwater that could be produced from a given hydrogeologic unit anywhere in Wyoming; our ultimate *goal* is the integration of the elements of this means, to protect the renewability of the resource. We approach our objective and goal along a continuum of cyclical effort [collect data, reduce data, process data to model parameters, visualize modeled parameters, refine model; collect data…]; and, for each area of the state, we describe our progress in steps, a series of reports, each report a compilation of the data available at its time of writing, each based on available methods of data analysis. Thus, this memorandum is a 2008 snapshot of our increasing ability to characterize the groundwater resource in the Greater Green River Basin.

In this memorandum we describe rocks in the GGRB as sequences of rock-stratigraphic units, geologic units, and hydrogeologic units.

Rock-stratigraphic units are the familiar formations, groups, members, and tongues that geologists have defined in the field, mapped locally, and attempted to correlate between local occurrences, over the last hundred years. They represent layers or outcrops with unique combinations of lithologic components.

Geologic units – discussed in Chapter 1 – represent reorganization of the lithologic components that characterize rock-stratigraphic units into lithologically consistent units appropriate in area to a given map scale. This reorganization of lithologic components follows from the way we use computers to reduce large sets of spatially defined data for visual presentation and interactive access. Computer flexibility allows geologic units to represent lithologic correlation variable in degree with respect to scale. Because lithologic components are thus reorganized, a geologic unit may coincide with a rock-stratigraphic unit, part of a rock-stratigraphic unit, or a grouping of rock-stratigraphic units or parts of rock-stratigraphic units.

Hydrogeologic units – discussed in chapters 3 and 5 – are rock layers or sequences of rock layers classified with respect to how they allow or retard the flow (actual or potential) of groundwater through them, and how much volume such flow represents. Most rock units in the GGRB are heterogeneous in lithology and in thickness – and in the thicknesses of constituent lithologies. The scale of heterogeneity determines how rock-stratigraphic units or geologic units are combined to form hydrogeologic units.

In this memorandum – as explained in Chapter 3 – for purposes of description, the whole stratigraphic column in the GGRB is divided into hydrogeologic units, arranged in four groups that correspond to the geologic eras. Certain sets of hydrogeologic units form *aquifer systems*, as defined in Chapter 3. Plate 1b shows the correlation of hydrogeologic units, aquifer systems, and corresponding rock-stratigraphic units. The relationship between rock-stratigraphic units, geologic units, and hydrogeologic units is not clear-cut; the relationships shown on Plate 1b are general and more or less equivocal. A cause of this uncertainty is the attempt to treat the basins composing the GGRB as one basin; for each "subbasin" has a unique tectonic and depositional history that determines its hydrogeologic character. Consequently, there is inconsistency in the use of these rock unit names among, and even within, the various chapters. A guide to entries for rock-stratigraphic units in the GGRB, at the very front of this memorandum, lists their locations in the various chapters. An entry in parentheses indicates a rock-stratigraphic unit described in Appendix 1 only as included in a geologic unit.

Chapter 1 introduces the memorandum with discussions of rock units, sources of data and funding, and previous work; and acknowledgments.

Chapter 2 describes the geographic setting of the GGRB; the structural features within the GGRB; and the rock units, as rock-stratigraphic units or geologic units, that constitute the basin. These rock units correspond to those charted on Plate 1a, listed in Plate 7 and Appendix 1, and mapped on Plate 2.

Chapter 3 groups the hydrogeologic units by geologic era and describes the aquifer systems within them, as used in this memorandum to encompass the entire hydrogeologic regime of the GGRB and as charted on Plate 1b, and briefly introduces their hydrologic qualities. This chapter includes definitions of terms used throughout the memorandum, and shows how the terms are used to describe the hydrologic regime.

Chapter 4 evaluates certain groundwater balance parameters – recharge, discharge, and storage – in the GGRB. The context of the available storage estimate is a hypothetical volume 1,000 feet deep by the area delineated by Tertiary geologic unit outcrops, representing the domain of available groundwater in the Tertiary hydrogeologic units. Storage, in particular, is difficult to estimate, except very locally; and so these estimates for the whole GGRB are imprecise, as discussed in Chapter 8.

Chapter 5 defines and delineates the hydrogeologic units – aquifers and confining units – in the GGRB, as charted on Plate 1b, in terms of the rock-stratigraphic units that compose them, describing their physical and hydrologic properties in detail. Summaries of well yield, spring discharge, and hydraulic properties of GGRB rock-stratigraphic units are tabulated on Plates 4, 5, and 6.

Chapter 6 discusses the quality of groundwater in the rock-stratigraphic units in the GGRB in comparison with national and Wyoming standards for drinking water and various water uses: domestic, agricultural, and livestock. Water quality data are plotted in Appendices 2 and 3 and tabulated statistically in Appendices 4 and 5.

Chapter 7 estimates groundwater use in the GGRB, on the basis of maximum production as permitted by the Wyoming State Engineer's Office. Neither actual use from the permitted wells nor use from unpermitted wells is known; thus, use is the parameter to which accurate estimation of the groundwater balance in the GGRB is most sensitive.

Chapter 8 offers tentative conclusions about the groundwater balance in the GGRB.

The groundwater deficit of 7,000 to 15,000 acre-feet per year proposed in Chapter 8 is probably unrealistically high: the local changes implicit in the average deficit would have been noted long ago. A far smaller annual deficit is probable. This editor believes that we do have an average annual deficit rather than a long-term steady-state balance of recharge with discharge. Thus these editorial comments: We seem to have sufficient groundwater storage and flow that wet or dry periods won't make a difference in the overall groundwater balance, although they may impact local water use. Monitoring has shown occurrences of overdraft in Wyoming: local groundwater levels have declined due to concentrated groundwater production during energy development. In CBNG production, drawdown of confined aquifers is required; and if reinjection of coproduced groundwater is proposed, the impacts of that artificial recharge are understood only in terms of more-or-less analogous processes: secondary recovery in oil fields and the creation of freshwater barriers to seawater intrusion.

In Wyoming, we've experienced how the depletion of an oil and gas resource may be buffered by the introduction of more efficient exploration and production methods or by the discovery of a "new" accumulation – such buffering has unforeseen physical and economic limits that go unrecognized until delayed scarcity both demands sudden drastic changes in patterns of use and causes economic hardship and legal conflict. Just so, the depletion of Wyoming's groundwater resources may be buffered by hydrogeologic changes (for example, local drawdown causing increased head in an aquifer, which induces increased groundwater flow, which entails increased drainage of groundwater from the recharge areas, increasing accommodation and thus increasing recharge to the aquifer: depletion is buffered by increased recharge, and is not recognized) or by the discovery of "new" local aquifers (depletion is buffered by increased estimated available stored groundwater volume, and is not recognized). This buffering has unforeseen physical and economic limits that will go unnoticed until delayed scarcity demands sudden drastic changes in patterns of use, inconvenient (no more lawns, no more golf) to debilitating (curtailed stock watering, no more local agriculture, imported food and feed), and causes practically irresolvable legal disputes with our neighboring states.

This editor believes that we are currently depleting our overall groundwater storage in the GGRB, albeit at a slow rate; that such depletion is currently buffered and has not been recognized; and therefore that any decision to commit groundwater resources that we may now have in seeming surplus to out-of-state use should be carefully weighed against a critical absolute deficit that is highly probable in the near future and inevitable in the far future.

–David Copeland