

Stream Valley Alluvial Aquifers: Planning Document

Introduction

NAWQA needs an understanding of the spatial extent of alluvial aquifers and of the importance of alluvial aquifers for water use. The Principal Aquifers map (Miller, 2000; U.S. Geological Survey, 2003) provides the most complete National compilation of principal aquifers, and as such, has been used by NAWQA for planning and synthesis purposes. The only significant limitation of the Principal Aquifers map, for NAWQA planning and synthesis purposes, is that it does not attempt to describe and map at a National scale what are termed, “stream-valley aquifers” (Miller, 2000, p. A6). The omission from the Principal Aquifers map was intentional—individually, these aquifers are generally too small to be considered principal aquifers, and furthermore, their spatial extents were considered to be “too small to map accurately at the scale of the [Principal Aquifers map]” (Miller, 2000, p. A6). It may be, however, that many stream-valley aquifers could be considered together as components of a widespread aquifer system, and hence, treated as a principal aquifer. This approach could be similar to the approach that was taken with what are called, “sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains” (U.S. Geological Survey, 2003). Sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains were not mapped on the Principal Aquifers map in Miller (2000), but were subsequently added to the revised Principal Aquifers map (U.S. Geological Survey, 2003). General approaches to creating a stream-valley aquifers product are

discussed in this document, and some questions for the Alluvial Aquifers team follow at the end of this document.

Definition of Stream-valley Aquifers

Rosenshein (1988, p. 174) defines a type of alluvial aquifer, “alluvial-valley aquifers”, to be long but narrow aquifers that “are in hydraulic connection with associated streams”, and that “are of limited areal extent in comparison to most aquifer systems, [but] they are among the most intensively used.”

Heath (1984), in distinguishing between alluvial basins and alluvial valleys, defines alluvial valleys to be “thick sand and gravel deposits beneath floodplains and terraces of streams” (Heath, 1984, p. 58). Heath (1984, p. 59) adds:

“Three criteria are used to differentiate alluvial valleys from other valleys.

These criteria are as follows:

“1. The valleys contain sand and gravel deposits thick enough to supply water to wells at moderate to large rates. [Commonly, the water-transmitting capacity of the sand and gravel is at least 10 times larger than that of the adjacent (enclosing) rocks.]

“2. The sand and gravel deposits are in hydraulic contact with a perennial stream which serves as a source of recharge and whose flow normally far exceeds the demand from any typical well field.

“3. The sand and gravel deposit occurs in a clearly defined band (‘channel’) that normally does not extend beyond the floodplain and adjacent

terraces. (In other words, the width of the deposit is small or very small compared with its length.)”

Heath (1984, p. 59) further adds (and this will become important later in this document):

“According to these criteria, the valleys of streams that were not affected by glacial meltwater, such as those of the streams that originate in the southern Appalachian Mountains and flow to the Atlantic Ocean or the Gulf of Mexico, are not considered alluvial valleys. The floodplains in these valleys are commonly underlain only by thin deposits of fine-grained alluvium.”

Miller (2000, p. A6) describes stream-valley aquifers as follows:

“A fourth type [of unconsolidated sand and gravel aquifers], called stream-valley aquifers, is located beneath channels, floodplains, and terraces in the valleys of major streams. The stream-valley aquifers are not shown on [the Principal Aquifers map] because they are too small to map accurately at the scale of the figure. The most important stream-valley aquifers are mapped in the descriptive Atlas chapters.”

Because NAWQA relies heavily upon the material in the Ground Water Atlas of the United States for planning and synthesis purposes, NAWQA will retain the terminology (“stream-valley aquifers”) of Miller (2000), and his definition: “stream-valley aquifers are

unconsolidated sand and gravel aquifers located beneath channels, floodplains, and terraces in the valleys of major streams”.

Conceptual Workplan for Delineation of Stream-Valley Aquifers

The Principal Aquifers map (U.S. Geological Survey, 2003) does not have a “stream-valley aquifers” unit. However, in many instances, stream-valley aquifers are accounted for by being combined with other alluvial aquifers. A large part of the western conterminous U.S.—the region west of the Rocky Mountains and the Colorado Plateau, but extending as far east as the Rio Grande basin, and also including the Northern Rocky Mountains Intermontane Basins Aquifer System—contains numerous structural and erosional basins partially filled with alluvium. Stream-valley aquifers are abundant in this region, but generally are hydraulically connected with basin-fill aquifers and also generally not separable on a regional scale from basin-fill aquifers because of lithologic and hydraulic similarities.

Stream-valley aquifers also are numerous in the region north of the limit of Quaternary continental glaciation and east of the Rocky Mountains. Stream-valley aquifers here are essentially reworked glacial materials, and generally are hydraulically connected with glacial aquifers and generally not separable from them on a regional scale.

Stream-valley aquifers in the remainder of the U.S. often are less well represented on the Principal Aquifers map (U.S. Geological Survey, 2003). However, many stream-valley aquifers are mapped in the sub-regional chapters of the Ground Water Atlas of the United States (Miller, 2000). A summary of the means by which stream-valley aquifers are represented in the Ground Water Atlas of the United States sub-regions (Miller, 2000) is provided in Table 1. This analysis was derived from evaluation of the extent and relative completeness of coverage of alluvial

aquifers in the sub-regions, comparison of the extents of alluvial aquifers with locations of major streams and rivers and with the extents of Quaternary alluvial deposits shown on sub-regional geologic maps in Miller (2000), and through study of selected, additional geologic maps. The result is an approximate appraisal of the strengths and weaknesses of our current understanding of regionally and nationally important stream-valley aquifers. A more thorough analysis could, and probably should, be done, but is beyond the scope of the present analysis.

Table 1. Stream-valley aquifers in the Ground Water Atlas of the United States (Miller, 2000), by sub-region.

[AA, alluvial aquifer; ACP, Atlantic Coastal Plain; CSA, central and southern Appalachians]

Chapter	Sub-region	How stream-valley aquifers are represented at chapter level
B	CA, NV	In other AAs
C	AZ,CO,NM,UT	In other AAs, and as separate aquifers
D	KS,MO,NE	In other AAs, and as separate aquifers ⁽¹⁾
E	OK,TX	In other AAs, in ACP, and as separate aquifers, but incomplete on ACP
F	AR,LA,MS	In other AAs, in ACP, and as separate aquifers, but incomplete on ACP
G	AL,FL,GA,SC	In other AAs, and ACP, but incomplete on ACP, absent CSA ⁽²⁾
H	ID,OR,WA	In other AAs
I	MT,ND,SD,WY	In other AAs, and as separate aquifers ⁽¹⁾
J	IA,MI,MN,WI	As separate aquifers ⁽¹⁾
K	IL,IN,KY,OH,TN	In other AAs, in ACP, and as separate aquifers ⁽¹⁾ , but incomplete on ACP and CSA ⁽²⁾
L	DE,MD,NC,NJ,PA,VA,WV	In ACP, and as separate aquifers ⁽¹⁾ , but incomplete on ACP and CSA ⁽²⁾
M	CT,MA,ME,NH,NY,RI,VT	As separate aquifers ^{(1) (3)}
N	AK,HI, PR, Virgin Islands	In other AAs, and as separate aquifers

⁽¹⁾ In that part of the country where “sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains” are found (U.S. Geological Survey, 2003), stream-valley aquifers are grouped with glacial aquifers and considered to be one aquifer system, separate from other aquifers and aquifer systems.

⁽²⁾ Central and southern Appalachians refers to the Appalachian region south of the limit of Quaternary continental glaciation, and include parts of the following physiographic provinces: Appalachian Plateaus, Blue Ridge, Interior Low Plateaus, Piedmont, and Valley and Ridge.

⁽³⁾ This sub-region contains a small part of the central/southern Appalachians (in NY)(see footnote 2). In this chapter, stream-valley aquifers are mapped for that one small part of the central/southern Appalachians. This sub-region also contains a small piece of the Atlantic Coastal Plain (part of Long Island), which is not expected to contain any significant stream-valley aquifers.

It should be evident from the summary shown in Table 1 that many stream-valley aquifers are accounted for in the Ground Water Atlas of the United States (Miller, 2000), either directly (in regional chapters) or indirectly (where stream-valley aquifers are part of a larger

aquifer or aquifer system). The chapter-level data will make the job of accounting for stream-valley aquifers much easier than would be the case if NAWQA were to use only the aquifers shown on the Principal Aquifers map (U.S. Geological Survey, 2003). However, because many stream-valley aquifers are considered to be part of larger aquifers or aquifer systems in the Ground Water Atlas of the United States (Miller, 2000), and because stream-valley aquifers often cannot be consistently identified from underlying sediments, NAWQA will not be able to group all stream-valley aquifers. For example, in the sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains, stream-valley aquifers probably cannot be separated from glacial-deposit aquifers.

One scenario for improving upon the Principal Aquifers map (Miller, 2000; U.S. Geological Survey, 2003) would be to retain the 63 principal aquifers shown on the Principal Aquifers map (U.S. Geological Survey, 2003) (62 numbered principal aquifers, plus the unnumbered aquifer system, “sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains”), and add a 64th principal aquifer, “stream-valley aquifers not represented in other principal aquifers”. This aquifer system would be composed, in part, of stream-valley aquifers mapped at the chapter level in Ground Water Atlas of the United States (Miller, 2000): p. C7, first three aquifer systems listed in the hydrogeologic explanation; p. D3, aquifer system south of “sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains”; p. E6; p. F4, aquifer systems along Red, Ouachita, Saline, and Arkansas Rivers; p. I3, aquifer systems east of “northern Rocky Mountains Intermontane Basins aquifer system” and south of “sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains”; p. K3, aquifer systems south of “sand and gravel aquifers north of the limit of

Quaternary continental glaciation and east of the Rocky Mountains”; p. L3, aquifer systems south of “sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains”; p. M4, aquifer systems south of “sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains” (small area in NY), and those stream-valley aquifers shown on pp. N7, N24, and N25 that are not shown on the Principal Aquifers Map (U.S. Geological Survey, 2003). To these, other regionally important stream-valley aquifers that are not available in Miller (2000) would be added; as can be seen in Table 1, the two significant areas where representation of stream-valley aquifers may be lacking are stream-valley aquifers on Atlantic Coastal Plain aquifers (actually, stream-valley aquifers are accounted for here by inclusion in the Atlantic Coastal Plain aquifers which house the stream-valley aquifers, but the combination of stream-valley aquifers with Atlantic Coastal Plain aquifers results in lumping of unconsolidated aquifers with semiconsolidated aquifers—a scenario that would be nice to avoid if possible), and stream-valley aquifers in the Appalachian Region south of the limit of Quaternary continental glaciation. Just as stream-valley aquifers generally cannot be separated from glacial-deposit aquifers in sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains, it may not be possible to separate stream-valley aquifers from Atlantic Coastal Plain aquifers, and it would appear that efforts to delineate hitherto unmapped stream-valley aquifers should initially be directed at the Appalachian Region south of the limit of Quaternary continental glaciation. Even for the Appalachian Region south of the limit of Quaternary continental glaciation, the importance of stream-valley aquifers is ill-defined. Recall from earlier in this document that Heath (1984, p. 59) considered stream-valley aquifers in the southern Appalachian Mountains to be unimportant because that alluvium was thought to be thin and fine-grained. Yet for such a

large region, it would be difficult for NAWQA to dismiss this resource without further investigation.

Thus, the proposed approach involves creating a new principal aquifer, stream-valley aquifers not represented in other principal aquifers. This new principal aquifer will be composed of stream-valley aquifers shown in chapters of the Ground Water Atlas of the United States (Miller, 2000), and to that, other stream-valley aquifers will be added. The first area of focus will be the Appalachian Region south of the limit of Quaternary continental glaciation. Subsequent efforts should focus on (1) separating stream-valley aquifers from Atlantic Coastal Plain aquifers, if possible, and (2) doing a more thorough evaluation of the degree to which stream-valley aquifers are adequately represented as parts of the basin-fill aquifers of the region west of the Rocky Mountains and the Colorado Plateau, but extending as far east as the Rio Grande basin, and also including the Northern Rocky Mountains Intermontane Basins Aquifer System.

This approach of compiling the proposed principal aquifer, “stream-valley aquifers not represented in other principal aquifers”, has some limitations. One, a compilation of ground water use for all stream-valley aquifers may not be achievable. As discussed above, stream-valley aquifers often cannot be laterally separated from adjacent aquifers in many regions. Also, even if such separation could be achieved, the depth of the contact between stream-valley aquifers and underlying aquifers often is poorly constrained. Ultimately, stream-valley aquifer water use will, in many locations, be lumped in with water use of associated aquifer systems (e.g. stream-valley aquifers and glacial-deposit aquifers).

Two, this approach does not account for regolith. Regolith is assumed to be a minor aquifer because in general, regolith does not have the high hydraulic conductivity and stream-connectedness that stream-valley aquifers typically have. Regolith also would be difficult to map

because, unlike stream-valley aquifers which often are mapped as a separate “Holocene Alluvium” or more generally, “Quaternary Alluvium” geologic unit, regolith generally is mapped as part of the bedrock unit from which it was formed. Thus, for reasons of presumed minor importance and elusive boundaries, regolith is not considered in our analysis.

Three, there is the problem of alluvium versus alluvial aquifers. Some Ground Water Atlas of the United States chapters show what appear to be stream-valley aquifers (e.g. Oklahoma and Texas: “Alluvial aquifers along major streams”; Miller, 2000, p. E6), whereas other chapters show what may be *potential* stream-valley aquifers (e.g. Utah, Colorado, New Mexico, Arizona: “Alluvial or eolian deposits are present in many parts of Segment 2. Where saturated, these deposits comprise surficial aquifers and can yield large volumes of water to wells.” Miller, 2000, p. C7). Are the “alluvial aquifers along major streams” for Oklahoma and Texas truly aquifers, though, or are they the mapped extents of Holocene (or Quaternary) alluvium that are assumed to be saturated? And how much of the mapped extent of “alluvial or eolian deposits” of Utah, Colorado, New Mexico, Arizona are aquifers versus unsaturated sediments? One of the assumptions that might have been made in previous regional work, and which we may have to make in our analysis, is that the mapped extents of certain types of alluvium along major streams are representative of the areal extents of stream-valley aquifers.

Four, any national coverage of stream-valley aquifers will inevitably lose some detail that may be important at local scales. For example, alluvial deposits (presumably stream-valley aquifers) in the UCOL study unit are mapped as being more extensive at the study unit scale (Apodaca and Bails, 2000, p. 5) than the presumably same aquifers at the Ground Water Atlas of the United States chapter scale (Miller, 2000, p. C7). Such generalization at the National scale probably is necessary.

In spite of these limitations, the proposed product can be obtained. And, on a positive note, the process of obtaining a coverage of stream-valley aquifers not represented in other principal aquifers probably will be easier than was the task of separating aquifers from low permeability units in the sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains, as the latter involved separating relatively permeable sediments from relatively impermeable sediments within a framework of glacial sediments that may often appear to be of similar origin and geologic age.

This overall approach, while not capable of directly capturing all stream-valley aquifers, nor of capturing all alluvial aquifers of local importance, will increase the overall network of important alluvial aquifers. As a test of the degree to which this approach will meet NAWQA needs, consider the list of Cycle II Study Units that have planned studies in alluvial aquifers. Of the planned studies in alluvial aquifers, those that are not in one of the sixteen principal aquifers (based upon water use) are listed in Table 2. Some of these studies are in principal aquifers, but in principal aquifers that are not in the list of the top sixteen. Of the others, some already are represented by chapter-level stream-valley aquifers (Miller, 2000). The studies that are not represented by a principal aquifer and are not represented by chapter-level stream-valley aquifers (Miller, 2000) are in the MOBL and TENN study units. Those alluvial aquifers from the MOBL and TENN that are in stream-valley aquifers would be captured by the delineation of unmapped stream-valley aquifers in the Appalachian Region south of the limit of Quaternary continental glaciation. One of the two TENN studies, though, lies in regolith, and would not be captured.

Table 2. List of NAWQA Cycle II Study Units that have planned studies in alluvial aquifers that are not one of the current list of sixteen principal aquifers.

[PA, principal aquifer]

NAWQA Study Unit	PA (U.S. Geological Survey, 2003), or chapter-level stream-valley aquifers in Miller (2000)
MOBL	Stream-valley aquifers missing
PUGT	PA: Puget Sound Aquifer System
RIOG	PA: Rio Grande Aquifer System
SPLT	Stream-valley aquifers are shown on p. C7
TENN	Stream-valley aquifers missing
UCOL	Stream-valley aquifers are shown on p. C7
USNK	PA: Snake River Plain Basin-Fill Aquifers
WILL	PA: Willamette Basin Fill Aquifers
YELL	Stream-valley aquifers are shown on p. I3

Quantification of Water Use

Water use, for public water supply and for domestic use, can be determined through analysis of WY2000 water use data. Records of county-level water use by aquifer probably are available, although for some areas the data may be incomplete and in need of some additional work. By compiling these data, NAWQA will be able to answer some basic questions about public water supply and domestic water use for important groups of the Nation's principal aquifers, including the proposed, new principal aquifer: stream-valley aquifers not represented in other principal aquifers. With this information, a re-ordering of principal aquifers by public water supply and domestic water use could be created, and could include a potentially useful, broad alluvial and glacial aquifers category composed of basin-fill aquifers, blanket sand and gravel aquifers, glacial-deposit aquifers, and stream-valley aquifers not represented in other principal aquifers.

Questions

Is the assumption that stream-valley alluvial aquifers generally cannot be separately identified from Atlantic Coastal Plain aquifers reasonable or erroneous? In other words, does the near-absence of separately identified stream-valley aquifers in Ground Water Atlas of the United States chapters (Miller, 2000) reflect the difficulty of separating unconsolidated sediment in stream-valley alluvium from semiconsolidated sediment in Atlantic Coastal Plain aquifers, in the same manner that stream-valley aquifers were not separated from sand and gravel aquifers north of the limit of Quaternary continental glaciation and east of the Rocky Mountains? Or, are stream-valley aquifers in Atlantic Coastal Plain aquifers separable?

At the first Alluvial Aquifers conference call, the consensus was to pilot an alluvial aquifers assessment in a region that included the RIOG study unit. While prioritization of water use efforts towards a “western alluvial basins” group that includes the RIOG study unit may be warranted, the results of the analysis above suggest that stream-valley aquifers for many alluvial systems such as that of the RIOG already have been largely accounted for in the larger alluvial aquifers that hold the stream-valley aquifers. At the same time, before a national appraisal of alluvial aquifers water use can be compiled, any large areas of stream-valley aquifers (Appalachian Region south of the limit of Quaternary continental glaciation?) that are currently not represented in our principal aquifers groups need to be evaluated. Thus, will a general approach of using existing coverages of stream-valley aquifers from Ground Water Atlas of the United States chapters (Miller, 2000), in combination with a new compilation effort on the Appalachian Region south of the limit of Quaternary continental glaciation, best serve the needs of NAWQA for alluvial aquifers identification and mapping purposes? Or, would efforts better

be put into more carefully evaluating the extent to which current principal aquifers coverages of western alluvial basins fail to capture important stream-valley aquifers?

If we decide to work first on the Appalachian Region south of the limit of Quaternary continental glaciation, how do we best approach the task of mapping the areal extents of stream-valley aquifers in the Appalachian Region south of the limit of Quaternary continental glaciation? One possibility would be to use three approaches: (1) sum water-use data for stream-valley aquifers in the Appalachian Region south of the limit of Quaternary continental glaciation, to quantify the importance (or lack thereof) of these aquifers, (2) query District Ground Water Specialists in the Appalachian Region south of the limit of Quaternary continental glaciation about the importance of stream-valley aquifers in the Appalachian Region south of the limit of Quaternary continental glaciation and obtain key USGS publications describing these aquifers, and (3) assemble coverages of Quaternary (or perhaps just Holocene) alluvium from State geologic maps of the Appalachian Region south of the limit of Quaternary continental glaciation. Information from these sources could be compared and synthesized. Would this work, or does the task require a different kind of approach?

Literature Cited

Apodaca, L.E., and J.B. Bails, 2000, Water quality in alluvial aquifers of the Southern Rocky

Mountains physiographic province, Upper Colorado River Basin, Colorado, U.S.

Geological Survey Water-Resources Investigations Report 99-4222, 68 p.

Heath, R.C., 1984, Ground-water regions of the United States, U.S. Geological Survey Water-Supply Paper 2242, 78 p.

Miller, J.A., (ed.), 2000, Ground water atlas of the United States, U.S. Geological Survey, Reston, Virginia, variously paged.

Rosenshein, J.S., 1988, Chapter 21: Region 18, Alluvial valleys, in Back, W., Rosenshein, J.S., and Seaber, P.R., eds., The geology of North America, Volume O-2, Hydrogeology, The Geological Society of America, Boulder, Colorado, 524 pp.

U.S. Geological Survey, 2003, Principal aquifers, U.S. Geological Survey, Reston, Virginia (map, Rev. 2003) (URL: <http://nationalatlas.gov/>)