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Consulting in Hydrogeology

Northwest Land & Water, Inc. • 6556 37th Avenue NE • Seattle, Washington 98115

May 6, 2014

Maggie Coon, President
Methow Valley Citizens' Council
Twisp, Washington

Re: Review of Okanogan County documents regarding water quantity and water quality

Dear Ms. Coon:

At the request of your organization, I have reviewed the Okanogan County documents that were provided to me and have summarized my opinions with regard to aquifer recharge areas, water quantity, and water quality in the attached document (Expert Testimony of Laura Strauss, Hydrogeologist). I have provided the scientific basis upon which I have made my opinions. I hope that my review helps you to better understand subject areas in which the Okanogan County documents need improvement in order to provide adequate information to achieve the objectives identified within the legal framework that requires the documents to be prepared.

Respectfully, **Northwest Land & Water, Inc.**

Laura J. Strauss LG, LHg Principal Hydrogeologist

State of Washington
Hydrogeologist
1002
Licensed Geologist
Laura J. Strauss

Expert Testimony of Laura Strauss, Hydrogeologist

1 Qualifications and Experience

I am a licensed hydrogeologist in Washington State (license #1002) and have been practicing as a consultant in hydrogeology since receiving my Master's degree in 1986 and in Washington since 1991. Much of the work I have done involves understanding and characterizing the hydrogeology of watersheds for the purpose of providing a scientific basis for planners and stakeholders to make decisions to work towards sustainable ground water supply while protecting surface water flows.

2 Materials Considered in Preparing this Expert Report

I reviewed the following Okanogan County documents:

- Comprehensive Plan of Okanogan County, Final Draft, 5/16/2013 (**Comp Plan**)
- Draft Environmental Impact Statement, Revisions to the Okanogan County Comprehensive Plan, 5/16/2013 (**DEIS**)
- Critical Areas Regulations, Draft 3/19/2012 (**CAO**)

In addition to these documents, I reviewed the following hydrological reports, specific to the Methow Valley, prepared by the United States Geological Survey (USGS), the Methow Basin Planning Unit, Aspect Consulting and Golder and Associates:

- Hydrogeology of the Unconsolidated Sediments, Water Quality, and Groundwater/Surface-water Exchanges in the Methow River Basin, Okanogan County, Washington (USGS, 2005)
- Methow Basin (WRIA 48) Watershed Plan (Methow Basin Planning Unit, 2005)
- Final Detailed Implementation Plan/Methow River Basin (WRIA 48), (MWC 2009)
- Water Withdrawal Study (Aspect, 2011a)
- Instream Flow Reservation Tracking Database (Aspect, 2011b)
- DRAFT MEMO, Evaluation of Reservation Quantities Established by Chapter 173-548 WAC under Current and Potential Future Build-out Scenarios (Aspect, 2011c)

In addition to these, I reviewed letters and comments responding to the County's documents. These include comments prepared by the Methow Valley Citizens' Council, the Department of Ecology, Futurewise, the Center for Environmental Law and Policy (CELP) and others.

The purpose of the following testimony is to offer my opinions regarding inaccuracies and omissions regarding groundwater resources in documents I reviewed. I was also asked to consider a series of questions put to me by the Methow Valley Citizens' Council regarding groundwater resources, aquifer recharge areas and the issue of groundwater quantity and quality in the Methow River basin of Okanogan County.

3 Summary of Expert Opinions

3.1 General comment on County documents

It is my opinion that the documents I reviewed (the proposed Comp Plan and CAO) fail to meet what I understand state mandated requirements to be, in terms of using best available science to identify and protect the quality and quantity of groundwater used for potable water. [1] This includes failure to identify or acknowledge in either the Comp Plan or CAO the known aquifers in the Methow Valley, which have been described and mapped by hydrogeologists in published documents. It also includes failure to acknowledge hydrologeologic studies conducted for the Methow Watershed Council that indicate there is not enough water in parts of the Methow Valley to support the planned growth and zoning.

3.2 Principal Sources of Potable Water in the Methow Valley

A large number of hydrogeological studies have been conducted in the Methow Valley. They indicate that the principal source of potable water in the Methow Valley is from aquifers located in lowland benches and valley bottoms within the basin. The aquifers are composed of highly permeable, unconsolidated materials deposited by rivers and glaciers over bedrock.

In general, the Methow Valley aquifers are unconfined, meaning there is no impermeable layer (aquitard) above them. Such aquifers are water table aquifers. Water table aquifers tend to be more susceptible to contamination than aquifers with a confining layer above because there is very little to intercept contamination. It is possible for contaminants from land use activities and septic discharge to move directly into the aquifer.

The water table aquifers in the Methow Valley are underlain by bedrock deposits, which are known to yield little water and are not considered a significant source of domestic water supply. This means residents in the Methow Valley have a high dependence on the water table aquifers.

A map showing aquifer recharge areas in the Methow Valley is included here (see Methow Basin Aquifer Recharge Areas, Figure 4A and 4B[2] in the attachments). The recharge areas indicated are coterminous with the water table aquifers.

3.3 Critical Aquifer Recharge Areas

Contrary to assertions made in County's proposed CAO , there is, in my opinion, sufficient scientific information available to identify aquifer recharge areas and to

[1] The Planning Enabling Act, under RCW 36.70.330 (1) states the following: "The land use element (of the Comprehensive Plan) shall also provide for the protection of the quality and quantity of groundwater used for public water supplies…"

[2] Methow Basin (WRIA 48) Watershed Plan page 31.

classify *critical* aquifer recharge areas.[3] Indeed, as noted above, aquifer recharge areas have already been identified in the Methow Valley.

Classifying critical recharge areas[4] involves identifying the following: 1) aquifers used or suitable for potable water and their associated recharge areas, 2) aquifer recharge areas *susceptible* to groundwater contamination based hydrogeological conditions, and 3) aquifer recharge areas *vulnerable* to contamination based on existing and proposed land uses. The combination of these factors is the basis for classifying critical aquifer recharge areas.

Based on the available science, in my opinion the County should consider the areal extent of the water table aquifers in the Methow Valley (the recharge areas shown in Figures 4A and 4A) as critical aquifer recharge areas. My opinion is based on the following: 1) the importance of the water table aquifers as a source of potable water, 2) the generally high contamination susceptibility of water table aquifers, and 3) the potential for groundwater-polluting development as planned in the County's proposed Comp Plan that directly overlies the primary aquifer and includes septic systems and other permitted uses in areas zoned for one acre lots.

Additional scientific investigation could be done to further delineate and evaluate critical aquifer recharge areas, and is advisable over the long term. But the aquifer information currently available and described here is sufficient to inform decisions made by the County regarding land use, zoning and critical area regulations.

3.4 Water Quantity

The County documents do not acknowledge the important findings of recent hydrological studies conducted by Aspect Consulting for the Methow Watershed Council.[5] Report findings indicate there is not enough groundwater to support additional further subdivision of land in what it outlines as the Lower Methow sub-basin. According to a report submitted to County by the Methow Watershed Council[6] and analysis of data included in the Aspect report[5], draft estimates indicate that without any further subdivision, there is not enough water for 1,092 existing lots to drill a well in the Lower Methow without threatening to exceed the 2 cfs reservation. If developed to its full zoned potential (which includes substantial areas of one acre zoning), the gap between water available and potential demand is

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[3] The Washington Administrative Code (WAC) Chapter 365-190 uses the following definition" "Areas with a critical recharging effect on aquifers used for potable water are areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water."

[4] Outlined in the Critical Aquifer Recharge Areas Guidance Document, published by the Department of Ecology.

[5] *Water Withdrawal Study* and the *Instream Flow Reservation Tracking Database WRIA 48*

[6] Methow Watershed Council. WRIA 48 Watershed Planning Information for the Okanogan County Planning Commission, July 9, 2013. (Included in the attachments.)

dramatic—with up to 24,313 lots not able to withdraw water without threatening to exceed the 2 cfs reservation.

The potential to exceed groundwater capacity is high in the Lower Methow. It would be reasonable for the County to modify zoning in order to reduce potential groundwater withdrawals in these areas. Salient information from the 2011 Aspect reports is described in later sections of this document to substantiate this opinion.

3.5 Water Quality

It should be a matter of concern that the proposed Comp Plan could allow extensive development that relies on septic systems on small lots where the Methow Valley aquifers are located and primary recharge occurs. High-density septic systems on small lots, especially in the one-acre range, have been shown to be a significant source of groundwater contamination in similar hydrogeologic settings. They pose an even greater threat where aquifers, such as the water table aquifers in the Methow, tend to have high hydrogeologic susceptibility. Groundwater contamination from anthropogenic sources has already been documented in the Methow Valley (Konrad, 2003).

3.6 Steps the County Could Take

The Methow Valley's aquifers and principal sources of public water supplies have been identified. Its recharge areas have been mapped. We know that the aquifers generally have a high susceptibility to contamination. The County needs only to identify potential sources of contamination, which should include areas where septic systems are concentrated.

In my opinion there is sufficient information to designate critical aquifer recharge areas in the Methow Valley. I would further say, based on Department of Ecology guidelines, that the alluvial deposits which coincide with the recharge areas shown on Figures 4A and 4B, could be considered critical recharge areas.

The Lower Methow sub-basin deserves special attention, due to indications the sub-basin is over-allocated. The potential for concentrations of septic systems and a wide range of commercial and industrial uses, which are allowed under both current and proposed zoning, also poses a higher threat of contamination from multiple sources than elsewhere in the valley. Further subdivision should be limited here, new guidelines for septic drainfield construction to reduce nitrates considered, and special regulation of commercial and industrial development instituted in this area.

4 Detailed Discussion of Expert Opinions

The following provides further discussion and substantiation of opinions presented in the above section as summary statements.

4.1 Recharge areas

A significant body of work has been done on the hydrogeology of the Methow Valley. In my opinion, this work is sufficient to identify aquifer recharge areas and classify critical recharge areas for the purposes of land use planning. This section presents the relevant studies, briefly describes the hydrogeology and aquifers, the criteria for classifying critical recharge areas, and outlines how the County could classify critical recharge areas in the Methow River valley.

4.1.1 Hydrogeologic Studies

A comprehensive list of relevant documents for the Methow Valley is available online through the Methow Watershed Council's website and included in the bibliography and reference sections of the series of studies produced by the Council and Aspect Consulting. None of this work has been cited or used in the critical aquifer recharge area section of the County's proposed Comp Plan or CAO. Two reports are particularly important and relevant to understanding recharge areas in the Methow River Basin and are described below and used in subsequent sections:

1. Hydrogeology of the Unconsolidated Sediments, Water Quality, and Groundwater/Surface-Water Exchanges in the Methow River Basin, Okanogan County, Washington, by *Christopher P. Konrad, Brian W. Drost, and Richard J. Wagner, USGS Water Resources Investigation Report* 03-4244, August 4 2005

2. Methow Basin (WRIA 48) Watershed Plan (Methow Basin Planning Unit, June 20 2005)

The above referenced USGS report describes the hydrogeology in the Methow basin. The study reviewed well logs for thousands of wells and compiled well log data for 488 wells. The report describes:

- the occurrence of aquifers,
- groundwater and surface water quality, and
- the relationship between surface water and groundwater.

The USGS report described the spatial extent, depth, and lithology of the unconsolidated sediments that form the hydrogeologic framework for the shallow groundwater system, which is the primary groundwater resource in the Methow basin.

The USGS report indicates that the majority of groundwater wells are completed in the shallow unconsolidated deposits aquifer. More specifically, *"the unconsolidated sediments directly beneath the main Methow River valley form the most productive aquifers where the ground water is closely connected to the flow in the Methow River. The median value for static depth to ground water in 184 wells from June through August 2001 was 27 ft below land surface, with a range from 1.2 to 218 ft."*(Konrad, 2005, pg 14)

These are the principal aquifers from which existing potable supplies are drawn (Konrad, 2005 pg 2); they are underlain by bedrock deposits that are known to yield little water and are not considered to provide substantial yield to wells. The extent of the unconsolidated aquifers is reflected on the figures included in the attachments, Methow Basin Aquifer Recharge Areas, Figure 4A and 4B.

4.1.2 Summary of Aquifer Description

The principal potable water supply in the Methow Valley is from aquifers located in lowland benches and valley bottoms within the basin. The aquifers comprise highly permeable sand and gravel deposited by rivers and glaciers – referred to as alluvium and glacial outwash deposits on the surficial geology map (Stoffel, et al, 1991). In general, the groundwater in these aquifers is unconfined and the aquifers are characterized as water table aquifers. While locally the aquifers may be semi-confined (where layers of limited extent, fine-grained sediment occur between land surface and groundwater), regionally Methow Valley aquifers may be considered to be largely unconfined. Such unconfined aquifers are, by definition, water table aquifers. Water table aquifers tend to have a higher susceptibility to contamination due to the fact that there is very little to intercept contamination from land-use activities. Water table aquifers that occur at shallow depths are more susceptible to contamination than deeper water table aquifers.

The recharge areas shown on Figures 4A and 4B are coterminous with the shallow alluvial aquifers. Precipitation incident on these areas recharges the underlying aquifers. In addition the aquifers are recharged by infiltration from surface water sources including the Methow and Twisp rivers and underflow from adjacent bedrock. While the bedrock is not a viable water supply for wells, regionally it may provide water to the shallow alluvial aquifers. The volume of water contained in the aquifers is a function of volume of the alluvial deposits comprising the aquifer, the porosity, and the groundwater elevation.

4.1.3 Guidance document for classifying critical recharge

The Department of Ecology's Critical Recharge Area Guidance Document indicates that best available science should be used to identify critical recharge areas and describes the methods to identify Critical Aquifer Recharge Areas (Section 4, p 26). Basic steps involved are the following:

1) identify the principle aquifers used for potable water supplies,
2) analyze susceptibility of aquifers to contamination, based on hydrogeologic characteristics, and
3) identify existing and potential sources of aquifer contamination.

The combination of susceptibility and contamination potential are used to classify the relative vulnerability of the aquifer which forms the basis for identifying "critical" recharge areas.

4.1.4 The County Should Classify Critical Recharge Areas

It is evident from the USGS report and Figures 4A and 4B that science is available to identify recharge areas. The County should use available studies to identify critical aquifer recharge areas, using the methods described Ecology's guidance document.

The first step in this process has been essentially completed for the Methow Valley. The aquifers that are principal sources of potable water and aquifer recharge areas have been identified. With nominal additional research and mapping, there is sufficient information to identify relative hydrogeologic sensitivity.

Step 2 of the basic steps, is to identify aquifers used for water supplies that are highly susceptible to contamination. Susceptibility is a function of factors outlined in both the Critical Areas Assistance Handbook and the Critical Aquifer Recharge Areas Guidance Document, published by the Department of Ecology.

Based on these guidelines and on my review of the available science, I believe it is reasonable for the County to consider the aquifer recharge areas identified on Figures 4A and 4B in the attachments as having a high potential susceptibility to contamination due to the relatively shallow depth to the water table and the very permeable subsurface material that would transport contaminants from the surface or near-surface directly to the aquifer.

Due to the susceptibility of the aquifer and the crucial nature of its groundwater supply, it would be reasonable for the recharge areas shown in Figures 4a and 4b to represent critical aquifer recharge areas. Alternatively, the County could use Figures 4a and 4b to identify and rank sub-areas within the recharge areas that have the greatest hydrologic susceptibility and would be the most critical to protect. For example, these might include areas where water table levels are the shallowest and areas within proximity of surface waters and Class A public water supply wells.

4.2 Water Quantity

This section presents a brief discussion of the regulations governing streamflow in the Methow River, a brief description of the relationship between groundwater water and streamflow, a summary of work done to quantify groundwater withdrawal and associated concerns, and steps the County could take to address water quantity concerns.

4.2.1 State Regulations on Streamflow in the Methow River

The Instream Flow Rule (Rule) for the Methow River was established in 1976 as Chapter 173-548 of the Washington Administrative Code (WAC). The Rule established a reservation of 2 cubic feet per second (cfs) of water in each of seven reaches of the Methow River watershed for future single domestic and stock water uses. The 2 cfs reservation in each reach is expressed as a reduction in stream flow associated with the consumptive use of aggregate instantaneous withdrawals authorized under the rule.

4.2.2 Groundwater Withdrawal and Associated Concerns

The hydrogeological firm, Aspect Consulting, was contracted by Methow Watershed Council to do a series of reports, funded by the Department of Ecology, on water use and water withdrawal in the Methow watershed. Results of these studies indicate a need for concern regarding over-allocation of groundwater.

4.2.2.1 Groundwater Withdrawal Studies

Reports done by Aspect in 2011, *Water Withdrawal Study* and the *Instream Flow Reservation Tracking Database WRIA 48*, indicate that if full build-out of current zoning (which in many areas allows division of land into one acre lots) occurs, water use from exempt wells in the Lower Methow would dramatically exceed the 2 cfs per sub-basin reserved for domestic or stock water use, especially during low flow when daily pumping reflects maximum water use.[7] Salient information from the 2011 Aspect reports is described below:

Aspect Consulting conducted a series of rigorous studies in the Methow Valley that quantified the existing number of exempt wells in each sub-basin, estimated pumping rate for exempt wells and water consumption use for domestic use. Aspect defined the boundaries of each sub-basin,

[7] The Instream Flow Rule (Rule) for the Methow River was established in 1976 as Chapter 173-548 of the Washington Administrative Code (WAC). The Rule established a reservation of 2 cubic feet per second (cfs) of water in each of seven reaches of the Methow River watershed for future single domestic and stock water uses. The 2 cfs reservation in each reach is expressed as a reduction in stream flow associated with the consumptive use of aggregate instantaneous withdrawals authorized under the rule.

and then, compiling data from many sources, counted developed parcels for each sub-basin and assumed an exempt well in each parcel that was designated developed and not served by a public system. Studies also estimated the maximum number of exempt wells that would occur at full build-out on existing lots and full build-out on lots that could be created under existing zoning regulations.

The *Water Withdrawal Study WRIA 48* (Aspect, 2011a, page 4) reports that average annual consumptive use for exempt wells was calculated to be 205 gpd and maximum consumptive use was calculated to be 725 gpd per residence served by an exempt well.

The *Instream Flow Reservation Tracking Database WRIA 48* (Aspect, 2011b) summarizes in Table 8 the estimated number of exempt wells in each sub-basin subject to the instream flow rule assuming full build-out; Table 9 summarizes Estimated Exempt Well Parcels Subject to the Instream Flow Rule at Build-out with Current Parcel Size (Reduced Build-out); and Table 10 summarizes Estimated Exempt Well Parcels Subject to the Instream Flow Rule at Full Build-out - Assuming No Additional Development within Closed Basins.

<u>Comparison of exempt well water use to instream flow appropriation</u>
The appropriation for exempt wells of 2 cubic feet per second (cfs) per sub-basin is equivalent to 1,292,544 gallons per day (gpd) for the combined 7 sub-basins that comprise the Methow watershed. Assuming the average annual consumptive use of 205 gpd, 6,305 exempt wells would use the equivalent of 2 cfs; assuming the maximum consumptive use of 725 gpd, 1783 exempt wells would use the equivalent of 2 cfs.

Table 8 (Aspect, 2011) indicates that 25,834 exempt wells could occur in the Lower Methow sub-basin if full build-out occurs, assuming the zoning as of 2011(which is the current zoning). Full build-out represents the upper limit for the maximum number of exempt wells. While it is unlikely that full build-out will occur, it is clear from these estimates that water use from exempt wells in the Lower Methow would exceed the 2 cfs appropriated for exempt wells.

Table 1, prepared for this letter, summarizes the water use for the estimated number of exempt wells summarized in Tables 7, 8, 9, and 10 in the Instream Flow Reservation Tracking Database report (Aspect, 2011) for the four different exempt well water use estimates reported in the Water Withdrawal Study (Aspect, 2011). Table 1 shows the effect of the different assumptions for per well water use on the total exempt-well water use for each sub-basin. Table 1 indicates that the Lower Methow sub-basin would be over-allocated with respect to the instream flow reservation of 2 cfs for all conditions of build-out and assumptions for water use except for full build-out under existing parcel size configuration for which over-allocation would occur for the maximum annual pumping and maximum consumptive water use but would not occur for the lower estimates of water withdrawal and consumptive use. Similarly, the Upper Methow sub-basin would be over-allocated for conditions of full build-out assuming current zoning and the larger estimate for water withdrawal and consumptive use.

4.2.2.2 Concern regarding water quantity

Draft estimates indicate that even without further subdivision of current parcels in the Lower Methow sub-basin 1092 lots would not be able to draw water from the aquifers without threatening to exceed the 2 cfs reservation for exempt wells that is identified for each sub-basin in the instream flow rule for the Methow River (Letter from Methow Watershed Council, 2011). Water use by sub-basin, summarized in Table 1, indicates in red the build-out conditions for which water withdrawal would exceed the 2 cfs reservation. These data support the statement made in the Methow Watershed Council letter (2011) regarding 1092 lots with respect to full buildout under *current parcel size*; Table 1 also indicates that if full buildout occurred under current zoning (current parcels subdivided according to current zoning rules) 24,313 lots in the Lower Methow sub-basin would not be able to draw groundwater without threatening to exceed the 2 cfs reservation (assuming 710 gpd consumptive use). Exceedance of 2 cfs from any of the sub-basins could reduce streamflow in the Methow river below the minimum required under chapter 173-548 WAC (Methow Watershed Council, 2013). Maintaining minimum streamflow is necessary to sustain anadromous fish populations.

4.2.3 Steps the County Could Take to Address Water Quantity Concerns

In my opinion, the County Comp Plan should include steps it will take to manage future growth in the face of increasing demands on limited water resources.

4.2.3.1 Identify specific areas of concern

The Upper and Lower Methow sub-basins of the Methow basin are clearly areas of greater concern because the likelihood that exempt well withdrawal will exceed the 2 cfs reservation is greatest within these sub-basins (Table 1). Based on studies by Aspect Consulting for the Methow Watershed Council, possibly the Upper Methow and most certainly the Lower 1Methow reaches are over-allocated for water with respect to WAC 173-548. (Hatcher, 2011)

Development in the Lower Methow deserves special attention. The alluvial deposits within this sub-basin should be designated a critical aquifer recharge area (Figure 4B) If, as indicated in recent studies by Aspect Consulting, there is not enough water in the aquifers to supply the number of lots that *currently exist*, further subdivision of land would be unwise until a plan to resolve the forecast water shortages has been developed.

4.2.3.2 Modify zoning regulations

Allowing continued subdivision of land under the current zoning would exacerbate the problem. An estimated potential of 24,313 lots could be created if all property is subdivided to its zoned potential, but would not be able to drill a well.

The County could modify the zoning rules to prevent or minimize subdivision of existing parcels to reduce the potential number of exempt wells and thus reduce impact on groundwater resources and stream flow.

4.2.3.3 Concentrate development in areas served by municipal supply

Concentrating future residential, commercial and industrial growth in areas where water is supplied by municipal wells with limited water rights while simultaneously allowing low-density residential and agricultural uses in lowland areas of the valley where aquifers are located, would provide stronger safeguards to groundwater resources than the proposed Comp Plan offers.

4.2.3.4 Other steps

Limiting development density over aquifers may not be enough to protect groundwater resources, nor is it the only means to do so. Water conservation and regulatory measures to prevent contamination from residential, commercial, industrial and agricultural sources may be necessary over the long run.

4.3 Water Quality

In my opinion, it is a matter of concern that the proposed Plan could allow extensive development that relies on septic systems on small lots (in the one acre range) where the aquifers are located and primary recharge occurs. High-density septic systems (on small lots) have been shown to be a significant source of groundwater contamination and pose an even greater threat where aquifers, such as the water table aquifers in the Methow, tend to have high hydrogeologic susceptibility.

It is my opinion, based on the USGS report of water quality in the Methow Basin (Konrad, 2003) and the many USGS reports regarding nitrate contamination (in shallow groundwater in the vicinity of La Pine, Oregon), the County documents do not adequately address potential concerns of water quality.

This section presents a summary of the risk of nitrate contamination from septic systems in similar water table aquifers, the hydrogeology that is relevant to water quality concern, relevant reports on the hydrogeology, and steps that the County could take to address concern for groundwater and surface water quality.

4.3.1 Risk of nitrate contamination from septic discharge

Increased residential development outside of municipal service areas (sewered) would not only increase exempt wells and affect issues of water quantity, but the associated increase in septic system density could impact groundwater quality. The strong hydraulic continuity with the Methow River indicates that groundwater contamination from septic discharge could also impact surface water quality. Nitrate is the primary contaminant of concern from septic discharge. Ideally, the nitrate released into septic drainfields is taken up by plants and removed from the water. However, in practice, the nitrate commonly infiltrates below the root zone to the underlying water table before the nitrate is removed or sufficiently reduced.

Not only is elevated nitrate in groundwater harmful to those who drink it, when it discharges to surface water it impacts riparian habitat. Elevated nitrate can cause increased algae growth which results in decreased dissolved oxygen which is harmful to most animals and disruptive to an aquatic ecosystem.

4.3.2 Hydrogeology

The alluvial aquifer in the Methow River valley is susceptible to contamination from surface activities and septic discharge because the depth to the water table is shallow, the subsurface deposits are permeable and allow relatively fast travel time to the groundwater. These conditions provide much less opportunity for contaminants to be removed by adsorption to sediment.

4.3.3 Relevant reports

The USGS report (Konrad, 2005) indicates that the majority of groundwater wells are completed in the shallow unconsolidated deposit aquifers (or water table aquifers.) More specifically*, the unconsolidated sediments directly beneath the main Methow River valley form the most productive aquifers where the ground water is closely connected to the flow in the Methow River. The median value for static depth to ground water in 184 wells from June through August 2001 was 27 ft below land surface, with a range from 1.2 to 218 ft.*)

The report also finds evidence of groundwater contamination: "*nitrate concentrations were greater than 3 mg/L in five groundwater samples and may be an indicator of anthropogenic sources of contamination."* This indicates there is a legitimate concern for contamination from a high density of septic systems. (Konrad, 2005 pg 25)

Elevated concentration of nitrate in groundwater in La Pine, Oregon from septic discharge is well documented and studied (Williams, et al, 2007). La Pine, Oregon, is in the Deschutes basin, east of the Cascade Mountains and has a similar climate as parts of Okanogan County. Groundwater from a shallow unconsolidated deposit aquifer supplies water to the residents of La Pine and discharges to the Deschutes River or tributaries to the Deschutes. Elevated nitrate concentration in shallow groundwater from septic drain fields has been discharging into the aquifer for decades but has taken a while to show up in many wells because of slow groundwater flow rate. The USGS reports indicate that 58% of lots are less than 1 acre and 82 % are less than 2 acres.[8]

4.3.4 Steps to address potential water quality concerns

4.3.4.1 Identify sources of aquifer contamination

Classification of critical aquifer recharge areas is an important step to protect groundwater quality. As discussed above, the guidelines outlined in the Critical Aquifer Recharge Areas Guidance Document published by the Department of Ecology describe the science necessary to identify critical aquifer recharge areas and were summarized in three basic steps:

1) identify the principle aquifers used for potable water supplies,
2) analyze susceptibility of aquifers to contamination, based on hydrogeologic characteristics,
3) identify existing and potential sources of aquifer contamination

As discussed in the section on critical recharge areas, step 1 has essentially been completed, and with nominal additional research and mapping, there is sufficient information to identify relative hydrogeologic sensitivity for step 2.

The County should complete the final task, which County planning staff would have the expertise to do—identify and map the risk of contamination from existing and potential future land uses.

4.3.4.2 Restrict parcel subdivision

Okanogan County has an opportunity to prevent impact to groundwater quality by learning from the LaPine study that suggests that zoning of 1-acre parcels may have allowed the density of septic discharge that resulted in nitrate contamination. Zoning regulations that restrict or minimize subdivision of current parcels would reduce risk to water quantity, as discussed above. It would also reduce septic system density and potential groundwater contamination from nitrate.

[8] USGS reports regarding nitrate contamination in aquifers in the vicinity of La Pine, Oregon are found at http://or.water.usgs.gov/proj/or186/new_site/reports.html

4.3.4.3 Concentrate development in sewered areas

Concentrating future residential, commercial and industrial growth in sewered areas (where water is supplied by municipal wells) while simultaneously allowing low-density residential and agricultural uses in lowland areas of the valley where aquifers are located, would reduce risk of contamination from septic drainfields .

4.3.4.4 Septic drainfield regulations and guidelines

The County could provide new guidelines and criteria for septic drainfield construction, installation, and maintenance to reduce nitrate input to the groundwater.

4.3.4.5 Zoning and regulations for other sources of contamination

Zoning regulations should specifically restrict and/or regulate development in critical recharge areas that would be a source for other potential contamination identified in step 3 (described above).

5 Reference Documents

Aspect Consulting, 2011. Water Withdrawal Study, Water Resources Inventory Area 48, Twisp, Washington, Project 080180-003 May 10, 2011 Draft

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Aspect Consulting, 2011. DRAFT of Reservation Quantities Established by Chapter 173-548 WAC under Current and Potential Future Build-out Scenarios.

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Konrad, C. P., B.W. Drost and R. J. Wagner, 2005. Hydrogeology of the Unconsolidated Sediments, Water Quality, and Groundwater/Surface-Water Exchanges in the Methow River Basin, Okanogan County, Washington, *USGS Water Resources Investigation Report* 03-4244.

Methow Watershed Council, 2009. Final Detailed Implementation Plan/Methow River Basin (WRIA 48).

Methow Watershed Council, 2011. Letter to Okanogan County Commission, June 14, 2011 signed by Greg Knott.

Methow Watershed Council, 2013. *WRIA 48 Water Planning Information for the Okanogan County Planning Commission*, July 9, 2013. Recommendations from the Methow Watershed Council Instream Flow Rule Revision Committee, Drafted by Hans Smith, Instream Flow Rule Revision Committee Chair

Stoffel, K. L., et al, 1991. Geologic Map of Washington – Northeast Quadrant. Washington Division of Geology and Earth Resources Geologic map G-39, Washington State Department of Natural Resources.

Williams, J.S., D.S. Morgan, S.R. Hinkle, 2007. Questions and Answers About the Effects of Septic Systems on Water Quality in the La Pine Area, Oregon. USGS Fact Sheet 2007-3103, prepared in cooperation with Deschutes County and Oregon Department of Environmental Quality.

6 Curriculum Vitae

Resume for Laura Strauss, PG, LG, LHg

Years of Experience: 26

Education:

M.S. Hydrology, 1986
University of Arizona

B.A. Geology / Environmental Studies, 1983
University of California, Santa Barbara

***Professional Registration**:*

Registered Geologist, Arizona

Licensed Geologist / Licensed Hydrogeologist, Washington

Major Areas of Expertise:

Aqueous geochemistry

Isotope sampling and analysis

Geochemical modeling

Groundwater flow modeling

Artificial recharge assessment

Database development

Aquifer test analysis

Environmental impact analysis

Geographic Information Systems

Laura Strauss has technical experience in many areas related to water resource planning and hydrologic impact analysis:

- Hydraulic continuity analysis
- Groundwater flow modeling
- Aquifer storage and recovery feasibility
- Groundwater recharge analysis
- Environmental isotope hydrogeochemistry
- Water quality analysis
- Water rights investigations
- Aquifer testing and analysis

Ms. Strauss skillfully identifies project goals, objectives, and key issues. She moves fluidly between the big picture and the details of technical analysis.

Ms. Strauss uses her proficiency in computer applications to seamlessly manage data, bringing it in and out of analytical computer applications, to convey results in a meaningful and useful way. She has used various models to conduct groundwater flow modeling: analytical element models (*GFlow2000*), and finite difference models for saturated (*MODFLOW*) and unsaturated (*VS2D*) groundwater conditions. She uses various geochemistry applications to characterize groundwater and to understand the geochemical reaction paths. She proficient with geographic information systems (GIS) and databases to manage and analyze large and varied water quality, hydrogeologic and land-use data sets. Through merging her *GIS*, *CAD*, and database skills, Laura has developed 3-D hydrogeologic models using *View-Log*, an application that manages, displays, and creates subsurface visualization images (e.g. cross-sections).

In addition, she specializes in the analysis of isotopic data. Laura has designed programs for sampling isotopes of carbon, hydrogen, and oxygen, and has used her knowledge to evaluate groundwater flow and recharge–discharge patterns. This expertise has often been an integral, cost-effective way to understand hydraulic relationships that were not apparent using traditional methods.

Representative Project Experience

West Plains (WRIA 54) & Lower Hangman Creek Watershed (WRIA 56) Hydrologeologic Characterization. This project was and extension of a hydrogeologic characterization conducted for the middle- and upper-Hangman Creek watershed. It involved construction of monitoring wells in the West Plains and Lower Hangman. A conceptual model of the West Plains was developed using hydro-

Summary of non-standard software commonly used to conduct analytical office work:

ArcGIS

MODFLOW

MODSURFACT

MODPATH

GFLOW2000

VS2D

Groundwater Vistas

AQTESOLV

AutoCAD

MS Access

ViewLog

NETPATH

PHREEQE

Rockware Suite

Summary of software and other equipment commonly used to conduct field work:

Pressure Transducers and dataloggers:

Geokon
Campbell Scientific
INW

geologic cross sections, analysis of groundwater geochemistry, age dates, water levels, and flow directions.

Hydrogeologic Framework for the Goldsborough Creek Sub-Basin & Johns Creek Vicinity. Developed a framework for a 90 square mile area. This work entailed constructing 33 working cross section from 385 well logs. Hydrogeologic unit layers were converted to model layers that are currently be used by Ecology to assist with water management decisions.

Spokane County Conservation District – Hangman Creek Watershed (WRIA 56) Hydrogeologic Study. Planned field testing and analyzed hydrogeologic, geochemical, and water level data for Columbia River Basalt Group aquifers and connected creeks to develop a conceptual model of the groundwater and surface water flow system. The conceptual model was developed using 100s of wells and constructed using 10s of cross sections in a visualization program called *Viewlog*. Geochemistry (stable isotopes) and age-dating (tritium, C14) were used to identify distinct aquifers and their connection to creeks. An exempt water use build-out analysis was also completed to identify areas of expected future water demand.

Upper Deschutes Basin Groundwater Modeling. Modeled the effects on the surface water and groundwater flow system in the upper Deschutes Basin, Oregon, due to pumping from a proposed destination resort. The study entailed using the MODFLOW model constructed for the basin by the USGS. The stratigraphy of the study area is dominated by basalt flows. The study included summarizing groundwater level data, evaluating ground-water level trends, and summarizing streamflow data.

WRIA 14 Hydrogeologic Characterization. Conducted a hydrogeologic characterization of a 60-square-mile study area using *Viewlog* to develop a three-dimensional conceptual model to construct cross-sections and to assist in selecting wells for a multi-aquifer monitoring network. The study included collecting samples for analysis of routine chemistry and stable isotopes; data was evaluated to better understand the dynamics of the groundwater flow system. This study resulted in data for water resource decisions in the watershed.

Groundwater Age / Flow Analysis. Analyzed radiocarbon, tritium, stable isotope, and major ion data collected for different projects in Washington. The data was used to constrain possible interpretations of the flow dynamics and develop a conceptual flow. This tool was used for groundwater flow systems in basalt aquifer systems in eastern Washington.