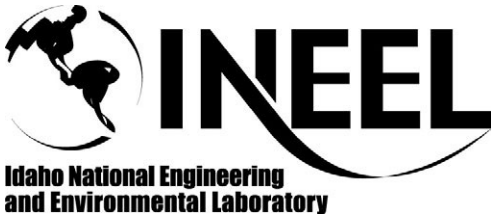

INEEL/CON-02-00777
PREPRINT

A Source Water Assessment Of The Idaho National Engineering And Environmental Laboratory: Conjunctive Delineation Of A Large Scale Area

Gerald Sehlke
Bradley D. Andersen

January 19, 2003

2003 AWWA Source Water Protection Symposium

A Source Water Assessment of the Idaho National Engineering and Environmental Laboratory: Conjunctive Delineation of a Large Scale Area

Gerald Sehlke and Bradley D. Andersen[1]

Overview

The Idaho National Engineering and Environmental Laboratory (INEEL) includes a government- owned reservation (the Site), in the southeastern portion of Idaho, approximately 25 miles west of Idaho Falls, Idaho (Figure 1) and a number of support and administrative facilities located in Idaho Falls. It was established in 1949 as the National Reactor Testing Station for the construction and testing of various kinds of nuclear reactors, primarily to demonstrate reactor safety. Of the 52 reactors built at the INEEL, only one is still active. Non-reactor research activities included testing of irradiated fuels; the recovery of uranium from spent fuels, reactor training, and storage, treatment and/or disposal of high-level, low-level and transuranic (TRU) wastes. The INEEL's present mission is centered on environmental cleanup and the development, demonstration and deployment of advanced science and engineering technology and information to the private sector.

The Site covers approximately 890 mi^2, extending a maximum 39 miles from north to south and 36 miles from east to west. Operations at the INEEL are concentrated in nine "major" operational areas and a number of "miscellaneous" facilities (Figure 2). Each major facility has its own source(s) of drinking water and/or production water. The miscellaneous facilities may or may not have their own on-site source of water, depending on its purpose, use and status (e.g., active or inactive).

Presently, the INEEL operates and monitors 12 Public Water Systems that pump water from 22 wells for at the Site (Table 1). The source of water for each of these facilities is the eastern Snake River Plain aquifer. Because the INEEL operates Public Water Systems, it is required to conduct source water assessments for those facilities and to develop a Source Water Management Program.

In 1994, the INEEL began developing a comprehensive Wellhead Protection Program for the site within the INEEL Groundwater Protection Management Plan (DOE-ID 10274, 1994), in accordance with the recommendations of the State of Idaho's draft Ground Water Quality Plan. The INEEL began delineating and evaluating wellhead protection areas because it provided a very practical and logical framework and process for evaluating and protecting its drinking water sources. During this period, a number of groundwater flow and contaminant assessments were completed for this and numerous other projects. This information was used as the basis for removing some sources of potential contamination from wellhead protection areas, as a tool for siting new facilities, and for screening various activities to determine their potential impacts on the INEEL's water supplies. In 2001, the INEEL began to develop a source water assessment of its facilities in accordance with the Safe Drinking Water Act's new "Source

1. Advisory Scientist/Engineer and Staff Scientist/Engineer, Integrated Environmental Analysis Department/Environmental Compliance, Idaho National Engineering and Environmental Laboratory, PO Box 1625, Idaho Falls, Idaho, 83415-2213, Gerald (Jerry) at 208.526.7362 or gse@inel.gov, Bradley (Brad) at 208.526.2711 or bda@inel.gov.

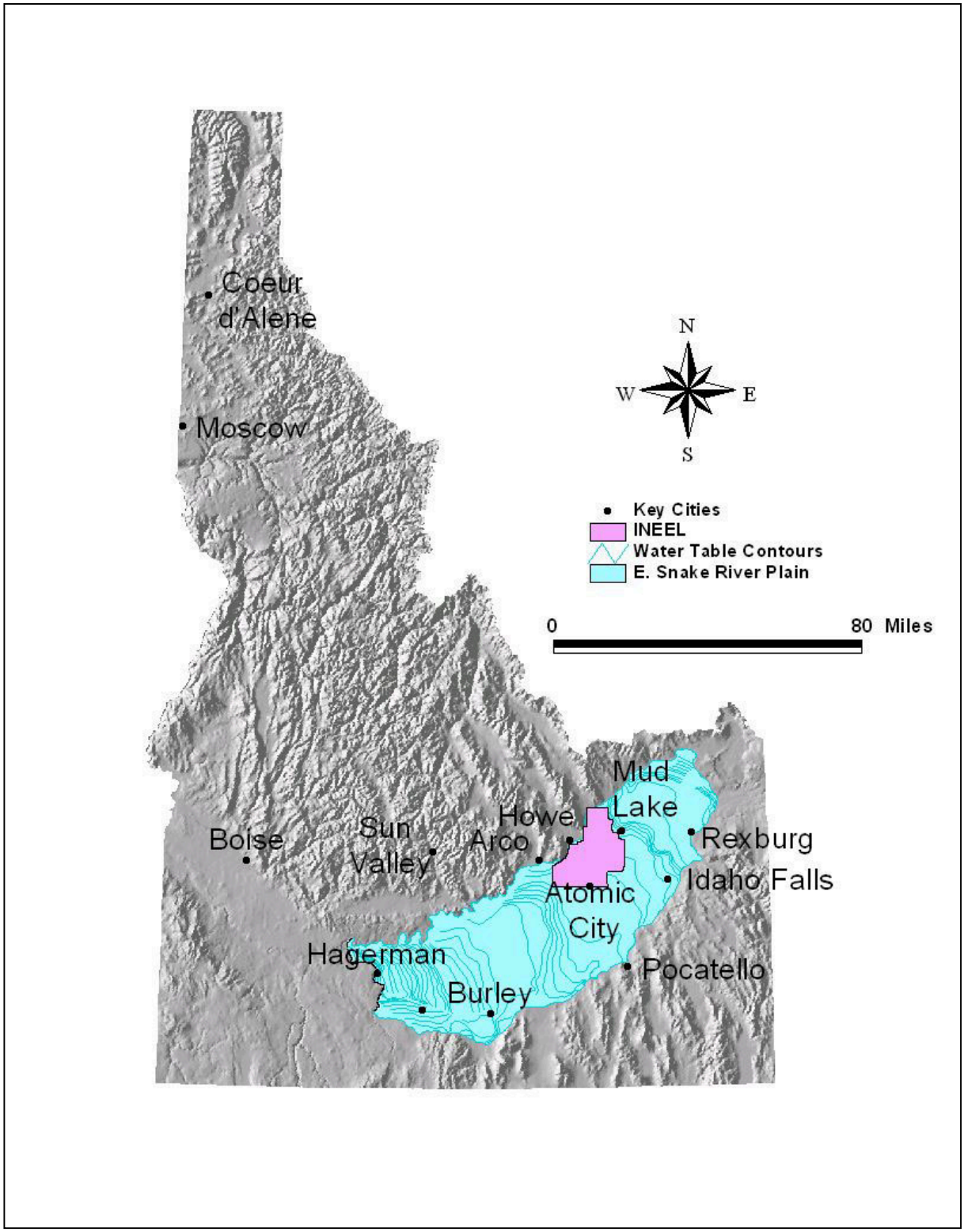

Figure 1. Location of the Idaho National Engineering and Environmental Laboratory (INEEL).

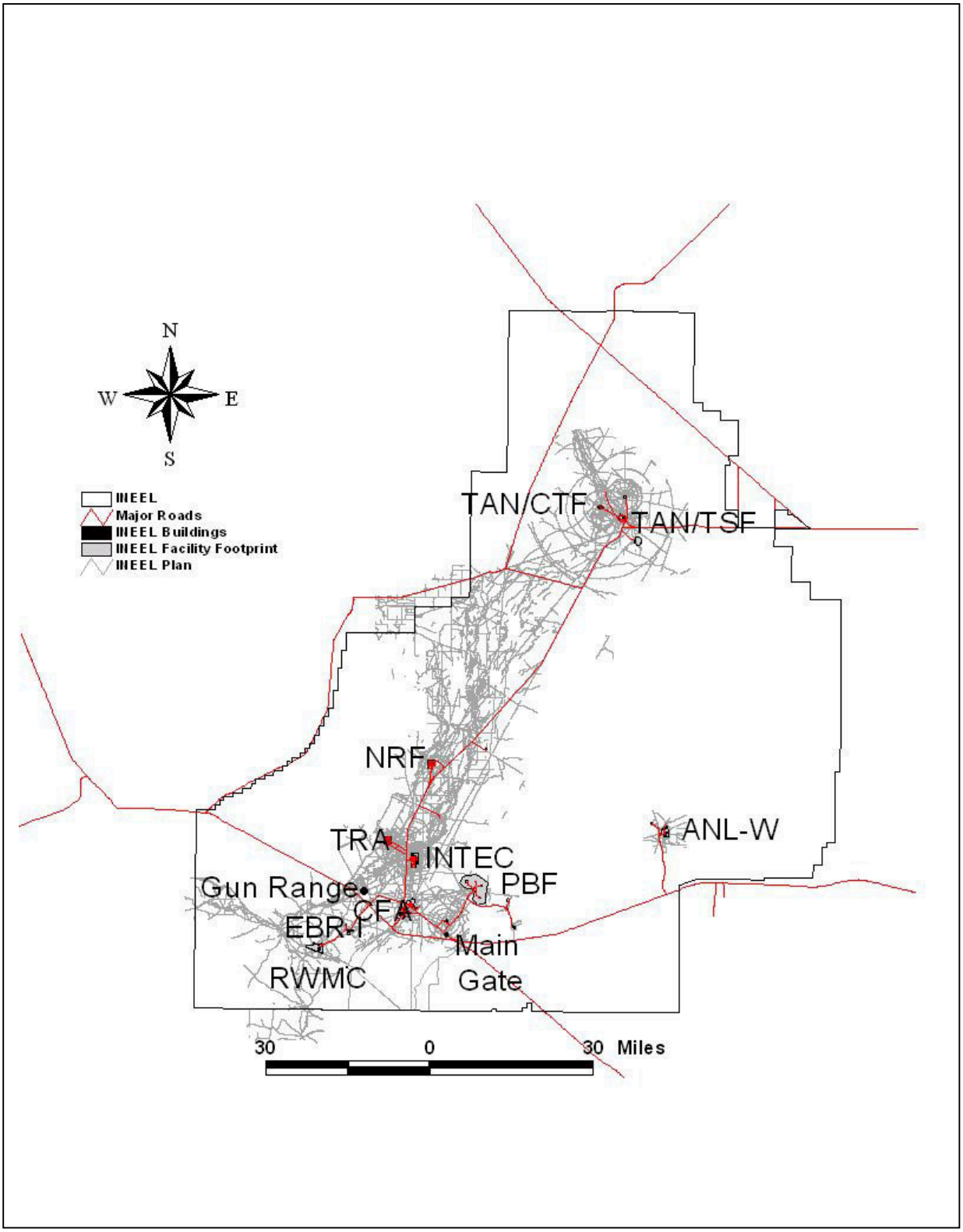

Figure 2. Selected INEEL operational areas and facilities.

Water Assessment Program" (P.L.104-182). The information collected and the activities undertaken under that Wellhead Protection Program provided the underpinnings for the INEEL's present Source Water Assessment Program.

Surface Water Delineations

One of the major differences between the state's earlier Wellhead Protection Program and the Source Water Assessment Program (DEQ, 1999) is that the earlier program only required ground water sources to be evaluated. The Source Water Assessment Program requires an evaluation of all sources of water that can potentially contaminate a Public Drinking Water Supply. No Public Drinking Water Systems at

Table 1. Public Drinking Water Systems at the INEEL Site.

Facility Name	PWS Number	System Type	Wells
Argonne National Laboratory- West (ANL-W)	6060036	nontransient, noncommunity	EBR-II #1
			EBR-II #2
Central Facilities Area (CFA)	6120008	nontransient, noncommunity	CFA-1
			CFA-2
Experimental Breeder Reactor-I (EBR-I)	6120009	transient, noncommunity	EBR-1
Gun Range	6120025	transient, noncommunity	Rifle Range Well
Idaho Nuclear Technology and Engineering Center (INTEC)	6120012	nontransient, noncommunity	CPP-4
			CPP-5[8]
Main Gate	6120015	transient, noncommunity	Main Gate Well (Badging Facility Well)
Naval Reactors Facility (NRF)	6120016	nontransient, noncommunity	NRF-1
			NRF-2
			NRF-3
Power Burst Facility (PBF)	6120019	nontransient, noncommunity	PBF-1 (SPERT-1)
			PBF-2 (SPERT-2)
Radioactive Waste Management Complex (RWMC)	6120018	nontransient, noncommunity	RWMC Production
Test Area North/Contained Test Facility (TAN/CTF)	6120013	nontransient, noncommunity	CTF-1 (FET-1)
			CTF-2 (FET-2)
Test Area North/Technical Support Facility (TAN/TSF)	6120021	nontransient, noncommunity	TSF 1 (well)
			TSF 2 (well)
Test Reactor Area (TRA).	6120020	nontransient, noncommunity	TRA-1
			TRA-3
			TRA-4

the INEEL use surface water as their drinking water supply. However, there are several wells at the INEEL that are located very close to streams that are at least hydraulically connected. Therefore, the INEEL delineated all watersheds that could potentially impact the ground water supplies to the INEEL's Public Drinking Water Systems and conducted at least a reconnaissance-level evaluation of each.

Using the USGS' surface water classification scheme, portions of six "watersheds" (USGS Cataloging Units) either drain surface water from the INEEL or recharge surface water to the INEEL. These watersheds include: American Falls (17040206), Big Lost (17040218), Birch Creek (17040216), Idaho Falls (17040201), Little Lost (17040217), and Medicine Lodge (17040215) watersheds (Table 2 and Figure 3). Combined, these watersheds are sometimes referred to locally as the "Pioneer Basins". The Big Lost River, Birch Creek and Little Lost River all flow near or onto the INEEL where they terminate either by being lost via seepage to underlying local aquifer(s) or the regional eastern Snake River Plain aquifer, or lost via evapotranspiration. American Falls and Idaho Falls watersheds drain towards the Snake River, however, neither of these watersheds have permanent streams on or near the INEEL.

Each of the above watersheds was first delineated using the State of Idaho's "Topographic Delineation Method" and then using the state's "Buffer Method". The Topographic Method requires that the entire watershed be identified and a reconnaissance-level assessment be made. The Buffer Method then allows the purveyor to refine the delineation by focusing on a 500 foot buffer area around the contributing stream(s) or lake(s) for the distance of four hours travel or 25 miles upstream from the drinking water intake, whichever is greatest. A more in-depth assessment can then be made on the smaller area. The INEEL implemented the 25 mile buffer option.

Ground Water Delineations

Each of the above watersheds are hydrologically interconnected with one or more of the five aquifers that flow near the INEEL: the Big Lost River Valley aquifer, Birch Creek Valley aquifer, Copper Basin aquifer, Little Lost River Valley aquifer, and the eastern Snake River Plain aquifer (Figure 3 and Table 2). Each of the tributary aquifers eventually discharge to the regional eastern Snake River Plain aquifer. The Birch Creek and Little Lost River aquifers discharge to the eastern Snake River Plain aquifer in the vicinity of the INEEL, however, the eastern Snake River Plain aquifer is the only aquifer that actually flows directly beneath INEEL facilities therefore, it was the only aquifer evaluated in detail.

Idaho's rules allow the purveyor to use an "Arbitrary Fixed Radius Method" to be used for "Transient, Non-Community" systems or a "Calculated Fixed Radius Method" or "Refined Analytical Method" that can be used for any type of system. Three of the INEEL's systems are "Transient, Non-Community" systems (EBR-I, the Gun Range and the Main Gate Facility) and the remainder are Non-transient, Non-Community systems. The INEEL chose to use the Refined Method for all delineations with the exception of the Main Gate Facility, which was not modeled during the initial modeling process. Since the Main Gate Facility had no known sources of contamination, is a long distance from facilities known to have released contaminants to the environment and is located outside of their flow paths, this system was delineated using the Calculated Fixed Radius Method.

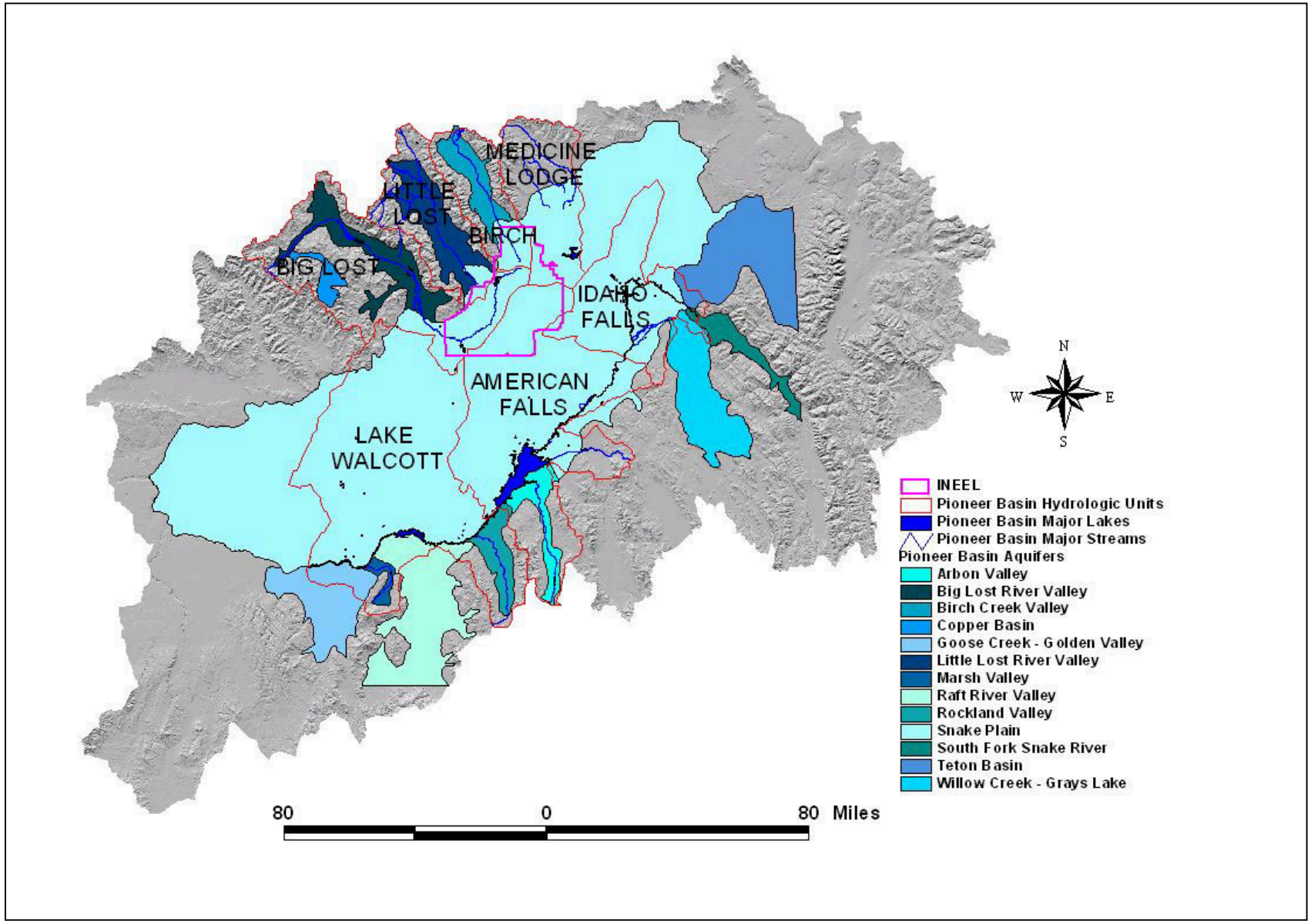

Figure 3. INEEL-Related Watersheds and Aquifers

Table 2. Watersheds and Aquifers that Directly Affect the INEEL.			
Aquifer #	**Aquifer Name**	**Watershed #**	**Watershed Name**
39	Snake Plain	17040201	Idaho Falls
		17040206	American Falls
		17040209	Lake Walcott
		17040215	Medicine Lodge
		17040216	Birch
		17040217	Little Lost
		17040218	Big Lost
62	Birch Creek Valley	17040216	Birch
64	Little Lost River Valley	17040217	Little Lost
66	Big Lost River Valley	17040218	Big Lost
67	Copper Basin	17040218	Big Lost
Aquifer names and numbers after Graham and Campbell, 1981; watershed names and numbers after Seber et al. 1987.			

The original capture zone delineations were modeled using the RESSQC module of the EPA's Well Head Protection Area (WHPA) computer software program. The initial modeling assumptions and results were checked by running several scenarios using USGS' Modflow model. Because ground water hydrology at the INEEL has been well studied, typically there are sufficient data available for populating models. The transmissivity values used in the model generally represent an average of values from one or more wells in the vicinity of each facility, including the drinking water wells where possible. Where facility-specific transmissivity values were not available, the widely- quoted value of 173,000 ft^2/day was used (Robertson et al., 1974). The values of 250 feet for aquifer thickness and 0.1 for porosity are widely accepted as typical for the INEEL, and are assumed for all of the capture zone maps. Flow angles and gradients were measured from water table elevation maps. Most pumping rates were based on annualized pumping volumes, and information on well location and construction came from the INEEL's Comprehensive Well Survey (Sehlke et al., 1993).

Modifications to the Initial Wellhead Protection Zone Delineation's

Based on a number of changes in criteria, review comments and concerns about whether the initial delineations were sufficient for protecting the INEEL's systems, several significant modifications were made to the original capture zone maps. For example, the original capture zones were delineated in 1995 under the State's former Wellhead Protection Program generated capture zone maps for 2- and 5-year times of travel for each of the wells. Idaho's Source Water Assessment Program now requires capture zones for 3-, 6-, and 10-year travel times. The INEEL Groundwater Committee also questioned whether the modeling assumptions were sufficiently protective considering the data uncertainties and ranges of values used; noting that the WHPA code assumes no lateral migration of contaminants through the vadose zone. Faced with three options (1) adopt much larger protection areas via the use of one of the Fixed or Calculated Radius Methods, (2) embark on an expensive mission to remodel the capture zones using a more complex code, or (3) modify the existing capture zone maps; the latter was chosen.

Based on the recommendations and assistance from the INEEL Water Resources Committee, the capture zone maps were modified in a number of ways (Figure 4). First, the protection areas were lengthened by linearly extrapolating the 2- and 5-year time of travel capture zones to 3-, 6-, and 10-year times of travel. Second, the protection areas were widened by adopting flow angle "ranges", rather than the single, dominant flow angle used in the original capture zone maps. Based on information in the INEL Groundwater Monitoring Plan (Sehlke, Bickford and Golder Assoc., 1993a) it is known that all INEEL facilities exhibit variation or uncertainty in aquifer flow angle ranging from 20 degrees to 90 degrees. Adopting these flow angle ranges as bounding guidelines in establishing the lateral boundaries of the protection areas, the resultant protection areas resemble a pie-shaped wedge. Third, the protection areas were augmented with a circular zone surrounding the wellhead to account for uncertainties associated with a heterogeneous aquifer, a thick vadose zone, and the potential for lateral migration of contaminants near the wellhead prior to their entry to the aquifer. Finally, as recommended by DEQ (1999), in situations where the mapped protection areas of multiple wells intersect, the protection areas are combined and the wells are treated as a single well field. This has resulted in a single wellhead protection area for each of the INEEL facilities within which drinking water or production wells are located.

In total, 12 wellhead protection areas were delineated covering a total area of approximately 73 mi^2 Table 3 and Figure 5 provide an overview of the INEEL's wellhead protection areas.

Table 3. Wellhead Protection Area Summary

Facility	Acres	$Miles^2$
ANL-W	1,845.7	2.8
CFA	988.2	1.5
EBR-I	18.0	0.0
Gun Range	2,558.2	3.9
INTEC	28,752.7	43.7
LOFT	40.9	0.1
Main Gate	5,556.4	8.4
NRF	6,311.5	9.6
PBF	187.6	0.3
RWMC	288.5	0.4
TRA	1,121.0	1.7
TSF	119.6	0.2
TOTAL	47,788.3	72.6

As expected, there is a large variation in protection area size when comparing one facility to another. This is largely the result of the variation in transmissivity values (which dictates protection area length) and groundwater flow angle range values (which dictates protection area width) across the site. Close observation of this figure also points out an apparent discrepancy; NRF and INTEC portray similar wellhead protection area characteristics, but TRA has a protection area that differs significantly in size and orientation, even though it overlaps that of INTEC. This is probably caused by facility-specific data being extrapolated to a larger region (Local hydrologic conditions vary greatly in fractured basalt; when these localized conditions are projected over a larger area, subtle differences in the data become magnified). Or, it may be indicative the effect of Big Lost River flows on the individual facilities (i.e., surface water recharge may cause the appearance of a much greater aquifer transmissivity at INTEC than TRA since INTEC's wells are located much closer to the Big Lost River. These differences do not necessarily indicate an error in the development of the protection area for TRA, but more likely reflect the

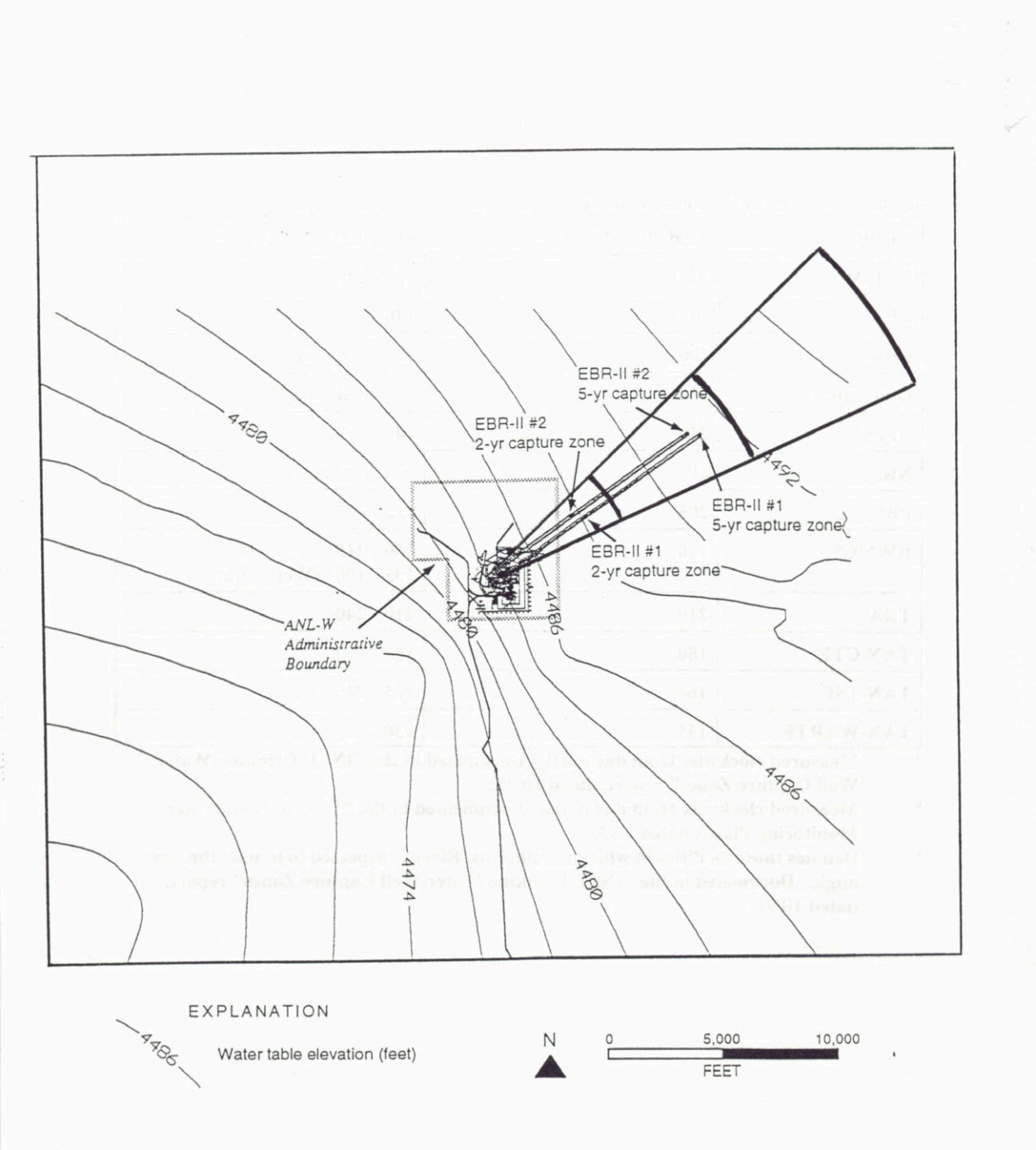

Figure 4. Example of Initial Well Head Protection Area (WHPA) Modeling Modifications.

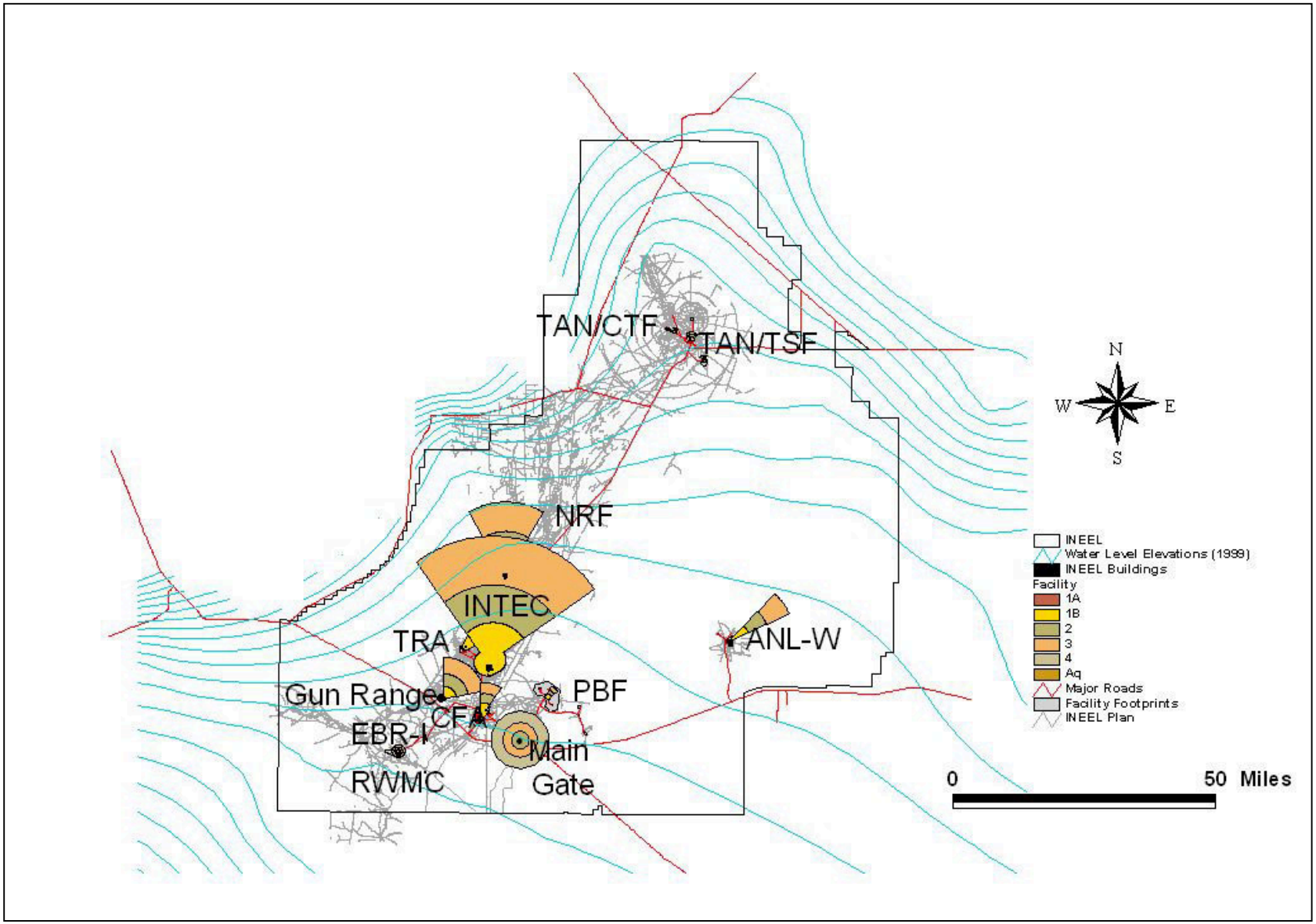

Figure 5. Final INEEL Wellhead Protection Areas.

degree of uncertainty associated with establishing the protection areas for NRF and INTEC. As a result, no efforts have been made to change the protection area maps to reflect "consistency".

Conjunctive Delineation

In areas where surface water and ground water sources are closely associated the purveyor must determine whether the surface water and ground water sources are "hydraulically connected" or if the ground water source is "directly influenced" by the surface water source. In both categories, the surface water and ground water resources are hydrologically connected. The distinction between them is whether protozoan microorganisms can migrate from the surface water source to the ground water source, potentially infecting the Public Water System (DEQ, 1999). If protozoa are likely to infect the system, the state of Idaho classifies the system as being "under the direct influence of surface water." If the ground water supply is "under the direct influence of surface water", the surface water sources must be evaluated and manage along with that portion of the aquifer that could impact their Public Water System (i.e., the wellhead protection areas).

Using the state's definitions, the eastern Snake River Plain aquifer is "hydraulically connected" with the Big Lost River, Birch Creek and the Little Lost River in the vicinity of the INEEL's systems rather than "under the direct influence" of them (DEQ 1999). The Little Lost River is not an issue here because even though historically it flowed onto what is now a portion of the INEEL, since the beginning of irrigation in that valley no surface water has crossed the INEEL's boundary. In addition, no INEEL Public Water Systems are located in this watershed. Therefore, the only water flowing from the Little Lost River basin to the INEEL is ground water that will be monitored and evaluated as such. Both the Big Lost River and Birch Creek flow onto the INEEL intermittently. However, their stream channels are approximately 200 feet to 500 feet above the eastern Snake River Plain aquifer. Therefore, there is sufficient natural filtration by the soil column such that there is little chance of protozoan microorganisms being transported from those channels to the INEEL's drinking water wells. Other factors that ensure that there is an insignificant risk of protozoan microorganisms being transported to INEEL water wells include:

- each of the streams are relatively small and intermittent, typically only carrying small amounts of water that could recharge the aquifer near the INEEL;
- the thick vadose zone at the INEEL in most cases blocks or filters contaminants prior to reaching given well intakes;
- all drinking water wells near these streams are completed deep below the land surface (~ 300 – 700 feet) and are in general adequately cased and sealed in order to prevent easy migration between the surface and the depth of the intake; and
- INEEL's rigorous historical sampling does not indicate that there have been any significant sources of microbial contamination in any of the drinking water wells originating from surface water sources.

Based on the above evaluations, it was determined that the INEEL is only required to fully delineate and evaluate the eastern Snake River Plain aquifer in the vicinity of the INEEL. However, the INEEL decided that it was important to develop a better understanding of these water resources to fully protect them and to manage them in a more integrated manner. So, in addition to delineating the contributing

watersheds and aquifers, the INEEL conducted a preliminary evaluation of the watersheds and aquifers that contribute water to the eastern Snake River Plain aquifer in the vicinity of the INEEL. This preliminary evaluation helps the INEEL better understand potential sources of contaminants coming on site. In addition, it helps the INEEL meet DOE's obligations under the "Unified Federal Policy for Ensuring a Watershed Approach to Federal Land and Resource Management" (EPA 2000) and will help the INEEL in case of an emergency or threat situation.

Summary

Source water assessments were conducted for 12 Public Water Systems at the INEEL. Because of its size and location, six watersheds and five aquifers potentially affect the INEEL's drinking water sources. Although it was determined that none of these watersheds were required to undergo a detailed assessment in order to meet the regulatory needs, preliminary assessments were conducted to meet INEEL administrative needs. After an evaluation of the five aquifers in the area of the INEEL, it was determined that only the eastern Snake River Plain aquifer needed to be delineated to meet the INEEL's regulatory needs.

Well capture zones were originally estimated using the RESSQC module of the EPA's Well Head Protection Area (WHPA) program but capture zones were expanded to account for the uncertainties associated with changing ground water flow directions, a thick vadose zone and other data uncertainties. Finally, all well capture zones at a given facility were merged in order to have a single wellhead protection area at each facility. The results are, we believe, a very robust set of wellhead protection areas that will be protective of the INEEL's Public Water Systems without becoming so conservative as to inhibit carrying out the INEEL's missions. These results are now being used to conduct the INEEL's contaminant source inventory and assessments, which will be completed this fiscal year. A Source Water Management Plan will be developed for the INEEL in 2003 to establish the programs and institutional infrastructure necessary to implement a site-wide Source Water Management Program.

References

DOE-ID, 1993. *Idaho National Engineering Laboratory Groundwater Protection Management Program* (DOE-ID 10274). US Department of Energy, Idaho Operations Office, Idaho Falls, Idaho.

DEQ, 1999. *Idaho Source Water Assessment Plan*. Idaho Department of Environmental Quality, Boise, Idaho.

DEQ, 1997. *Idaho Wellhead Protection Plan*. Idaho Department of Environmental Quality, Boise, Idaho.

Roberston, J. B., 1974, *Digital Modeling of Radioactive and Chemical Waste Transport in the Snake River Plain Aquifer at the National Reactor Testing Station, Idaho,* U.S. Geological Survey National Reactor Testing Station Open-File Report, IDO-22054, May.

Sehlke, G., F. E. Bickford, and Golder Associates (1993). *INEL Groundwater Monitoring Plan* (DOE/ID-10441), Volumes 1 & 2, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho, and Golder Associates Inc., Redmond, Washington.

Sehlke, G., D. E. Davis, W. W. Tullock, J. A. Williams, and Golder Associates Inc. (1993*). Well Fitness Evaluation for the Idaho National Engineering Laboratory* (DOE/ID-10392), Volumes 1 - 6, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho, and Golder Associates Inc., Redmond, Washington.