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**Environmental Resource Document for the
Idaho National Engineering Laboratory**

Volume 2

**John S. Irving
Principal Investigator**

*Work performed under
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**John S. Irving
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Published July 1993

**Idaho National Engineering Laboratory
EG&G Idaho, Inc.
Idaho Falls, Idaho 83415**

MASTER

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Appendix A
Land Resources

Richard P. Smith

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ACRONYMS

ATR	Advanced Test Reactor
AVZ	axial volcanic zone
B&R	basin and range
CTB	central tectonic belt
ESRP	Eastern Snake River Plain
H-EB	Howe-East Butte
INEL	Idaho National Engineering Laboratory
ISB	intermountain seismic belt
LR-HHA	Lava Ridge-Hell's Half Acre
MRE	most recent event
NPR	New Production Reactor
SRP	Snake River Plain
USGS	U.S. Geological Survey
VRZ	volcanic rift zone

A.1 Summary of the Results and Conclusions of the 1990-1992 Geoscience Investigations for the NPR Program

Following curtailment of New Production Reactor (NPR) geoscience field investigation in late 1991, efforts have been made to finalize the results of several in-progress investigations in the form of final reports from various subcontractors. In addition, an effort has been made to summarize all subcontractor reports in this summary document. The following summary of each of the 15 tasks, which make up the NPR geoscience program, includes a description of final results, a discussion of the implications and conclusions that can be made from the final results in light of the existing body of geoscience knowledge for the INEL area, and recommendations for future work necessary to complete the investigations. Important conclusion supported by information in this summary include:

1. In situ shear wave velocity measurements on both basalts and interbedded sediments, and laboratory dynamic property tests on undisturbed sediment samples are badly needed for improving site specific ground motion calculations.
2. Paleoseismic information is needed from the Lost River, Beaverhead, and Rexburg faults for probabilistic seismic hazards assessment.
3. Understanding the processes of volcanic rift zones VRZs and the axial volcanic zone are critically important for both probabilistic and deterministic seismic hazards assessment because these seismic sources are closest to the NPR site. Deep drilling, improved age determination methods, subsurface correlation, and geophysical/geological modeling are all critical to development of the understanding.
4. The INEL seismic network upgrade is now completely operational and has the potential to greatly improve our understanding of seismotectonic and volcanic processes in the INEL area.
5. Detailed investigations of tectonic geomorphology of the transition zones from the Lost River and Lemhi faults into the Arco and Lava Ridge-Hells Half Acre VRZs has a high potential of defining the southern extent of these fault zones.
6. The 1905 earthquake probably had its epicenter in northwestern Utah instead of near Shoshone, Idaho.
7. Resolution of heat flow variations on the Eastern Snake River Plain (ESRP) will enable improved understanding of the thermal structure of the crust and will help to test various mechanisms for tectonic activity in the area.
8. First order leveling surveys have a high potential of constraining contemporary vertical crustal deformation.

9. In situ stress determinations are vital for assessment of the maximum magnitude of random (floating) earthquakes within the ESRP and for constraining the volcano-tectonic processes operating beneath the Idaho National Engineering Laboratory (INEL).
10. In situ and laboratory density and magnetic property determinations are essential for modeling observed gravity and magnetic anomalies on the ESRP.

This summary and discussion is based on final reports of subcontractors, on publications by EG&G Idaho geoscience personnel, and on regulatory guidelines relating to nuclear reactor safety. A list of references is found in Section A.5. This summary considers each of the 15 tasks in sequence and also includes at the end a discussion of the deterministic and probabilistic seismic hazards assessment performed by Woodward-Clyde Consultants (1992a). This assessment was not one of the original 15 tasks, but it makes use of information from all of them and highlights the extreme sensitivity of seismic hazards assessments to the results of those tasks.

A.1.1 Task 1 - Site Specific Geotechnical Investigations

A.1.1.1 In situ Measurements. Cross-hole seismic surveys have given a good picture of the P- and S-wave velocities (and the variations thereof) in the basalt lava flows at the NPR site. Since the basalts at the NPR site are typical of ESRP basalts in general, the velocities should be applicable elsewhere on INEL where no data exist. The range of V_p and V_s determined by the surveys ($V_p = 1,524\text{--}3,962$ m/s; $V_s = 762\text{--}1,828$ m/s) are very low compared to velocities determined in the laboratory for small samples ($V_p = 5,090$ m/s) and compared to velocities determined by borehole sonic logging at depths of several hundred to several thousand feet in other INEL drill holes [$V_p = 4,693\text{--}5,456$ m/s at 122 to 244 m (400 to 800 ft) in Corehole 2-2A and $V_p = 4,877\text{--}6,401$ m/s at 518 to 610 m (1,700 to 2,000 ft) in drillhole INEL-1]. This rapid increase in V_p with depth is observed in other basalt terrains and is related to rapid closure of fractures with increasing lithologic loads. Most fractures are closed within the first few hundred feet of burial, so that the velocities increase rapidly at first. Below those depths, not much additional fracture closure occurs and velocities increase much more slowly.

Since the interbeds are so thin at the NPR site, their P- and S-wave velocities may not be well determined. The cross hole seismic work suggest that $V_p = 610\text{--}1,067$ m/s and $V_s = 305\text{--}610$ m/s, but since the interbeds are so thin, these values may be affected by refractions through the adjacent higher velocity basalts. The problem of measuring accurate velocities of thin sedimentary interbeds could be resolved by a couple of methods:

1. Reduce the drill hole spacing for cross-hole surveys to 3 m (10 ft). The 6-m (20-ft) spacing that was used at the NPR site was designed by Weston and the Construction Engineering and General Atomics Consortium before drilling began, without knowledge of the true interbed thickness. Reducing the hole spacing is an expensive option because it would require drilling additional 91 m (300 ft) drill holes and completing them with appropriate casings and grouts.

2. Perform a detailed surface to drill hole seismic survey (downhole survey) using knowledge of interbed positions to place a geophone string in the drill hole. By having geophones placed at critical interfaces and by using a shear wave source at the surface, the S-wave velocities of the sedimentary interbeds may be determined.

The surface-to-borehole seismic survey done by Weston did not produce P- and S-wave velocities of the sediments because their downhole string of geophones was not operable, forcing them to use one geophone placed at various depths while multiple seismic sources were activated at the surface. This does not produce adequate detail for determining the velocities of the interbeds due to variability in the wave forms and propagation characteristics from one source event to the next. Their survey gave an average velocity consistent with velocities determined by the cross-hole survey for the stratigraphic section but did not give detailed velocities of specific layers.

A.1.1.2 Laboratory Tests To Determine Static Mechanical And Physical Properties.

Soil and rock core tests are shown in Tables A-1 and A-2, respectively.

A.1.1.3 Dynamic Property Tests. The response of soils and interbeds to cyclic loading are critical for ground motion and soil-structure interaction analyses. Undisturbed sampling was planned for the geotechnical drill holes but only one or two were obtained because of unfavorable conditions. Very thin interbeds and presence of gravels and basalt clasts in the sediment made it impossible to obtain sufficient undisturbed material for cyclic loading or resonant column tests. A very high priority should be placed on future drilling in the area to obtain acceptable undisturbed samples for these tests.

The very good core recovery of interbed material in the deep drill hole (WO-2) gave hope that properly preserved intervals could be used for these tests. Interbeds in the interval from 183 to 244 m (600 to 800 ft) were sealed in lexan tubes and representative samples from deeper interbeds were wrapped in aluminum foil and dipped into molten paraffin to seal against moisture loss. However, at the January 9, 1992 meeting of the Senior External Events Review Group, it was decided that the coring process most likely disturbed the samples to some extent, so that results of tests done on them would always be open to question and therefore that it not be wise to spend the time and effort necessary to perform dynamic tests on these samples.

A.1.2 Tasks 2, 3, and 4 - Fault Investigations

Excavation, logging, and age determinations of a fourth trench on the southern Lemhi fault suggests that the previous segmentation model should be re-interpreted. The Howe and Fallert Springs segments do not behave independently. Instead, the southernmost segment of the Lemhi fault may extend from the Howe point area to Coyote Springs (about 75% of the combined length of the Howe and Fallert Springs segments). However, the most likely scenario does not involve faulting of this entire length in single earthquake events. Offset segments or steps in the fault geometry determined from detailed bedrock mapping of the fault support this rupture scenario. According to this scenario, the maximum credible earthquake associated with the southern part of the Lemhi fault has a movement magnitude of 6.9.

Appendix A ♦ A-4

Table A-1. Geotechnical soils testing laboratory results for NPR.^a

Soil test	Conclusions
Grain Size Analysis (Gradation)	Gravel sized material is rare to uncommon in interbeds beneath the NPR site. Most sediments are silt/clay (eolian) and sand (alluvial).
Plasticity (Atterberg Limits)	Liquid limits range from 22 to 42. Plastic limits range from 13 to 22. Plasticity indices range from 7 to 28.
Moisture content	Natural moisture contents range from 13.4 to 36.4%.
Unit Weight	Dry densities range from 75.2 to 110.3 pcf.
Specific Gravity	Specific gravity ranges from 2.63 to 2.79. Only three samples were measured.
Consolidated Drained Triaxial Shear Strength	Maximum deviatoric stress varies from 72.0 to 280.3 psi at effective confining pressures ranging from 25 to 75 psi. The lower deviatoric stresses correspond to tests done under lower confining pressures.

a. Golder Associates, November 18, 1991.

Rational arguments can be made for placing the southern terminus of the seismically active part of the Lemhi fault just north of the highway near Howe Point. This is based on the observed pattern of cross faulting and splay faulting which is consistent with fault termination structures in other settings. Also a detailed gravity survey of the area near Howe Point suggests the presence of an E-W trending graben structure, supporting the inferred fault terminus.

Detailed mapping was begun on the southern Lost River fault. Scarp heights and tectonic displacements have been determined for the southern part of the fault.^a These suggest that the faulting may extend south of Arco into the northern end of the Arco VRZ.

a. Letter report from Ron Bruhn, December 27, 1991.

Table A-2. Geotechnical rock core testing for NPR.^a

Rock core test	Conclusions
Direct Shear Strength	The best-fit line through the data for failure of 25 tested natural fractures (mostly contraction joints), is defined by the following equation: $\tau(\text{Shear stress}) = 1.225 \times \sigma(\text{Normal stress})$. Depending on depth of the sample in corehole, the normal stresses at which tests were run ranged from about 11 psi to 450 psi. The higher normal stresses correspond to deeper samples. Depths ranged from 8 feet to 217 feet.
Elastic Moduli	Poisson's Ratio is not well behaved in some NPR basalt cores. In well behaved samples the ratio is relatively stable for different axial loads and falls in the range of 0.2 to 0.4. For most samples the ratio varies over a much wider range (i.e., for one sample the range is 0.08 to 0.71). Most samples fall between these extremes. The unusual response of many samples is probably caused by the fact that most samples are extremely vesicular, some with large vesicles compared to size of the sample. 75 samples were tested.
Uniaxial Compressive Strength	Unconfined uniaxial compressive strengths range from 3500 to 17,000 psi. Strength generally increases with increasing Bulk Unit Weight (decreasing vesicularity). 75 samples were tested.
Brazilian Tensile Strength	Tensile strengths as determined by the Brazilian test for 20 samples range from 207 to 851 psi and generally increase with increasing Bulk Unit Weight (decreasing vesicularity).
Point Load Tests	Index strength values range from 171 to 1097 psi for 56 samples tested. Sample diameters ranged from 2 to 2.7 inches.
Specific Gravity	Bulk densities range from 2.40 to 2.86. Grain densities range from 3.03 to 3.11.

a. Golder Associates, December 1991.

A field excursion to the southern end of the Lost River fault to select paleoseismic trench sites was done in November, 1991. This effort shows that several excavations that already exist along the fault can be used as is or modified somewhat to reveal fault history in the Arco segment. Additional excavations may be desirable in the Pass Creek segment, but good trench sites were not found.^b

A.1.3 Task 5 - Volcanic Rift Zone Investigations

Surface deformational structures that result from VRZ processes on the ESRP are fissures, monoclines, and faults resulting from dike injection processes. They almost universally trend northwest, perpendicular to the inferred direction of regional extension. Measurements of structures in ESRP VRZs have shown that displacement magnitudes [up to about 10 m (33 ft) vertical displacement and several meters dilation] and mapped extent of structures [individual fissure/fault structures up to 8 km (5 mi) long occurring in zones up to 90 km (56 mi) long and 10 km (6 mi) wide] are consistent with those resulting from dike injection into active VRZs in Iceland and Hawaii. Because of similarities in tectonic regime (dike injection in an area of regional extension), Iceland serves as a better analogy to ESRP VRZ activity than does Hawaii.

Since individual dike injection events in Iceland produce faults with vertical displacements of up to 1 m (3.3 ft), the 10 m (33 ft) of vertical offset observed in some Arco VRZ structures must be a result of multiple dike injection events. This is consistent with geomorphic arguments that the displacements must be the result of small multiple events in order for the Big Lost River erosion to keep pace in the Box Canyon area. In Iceland, vertical displacements as large as 40 m (131 ft) result from multiple dike injection events.

Preservation of vertical displacements of several meters in the Arco VRZ (and in Icelandic VRZs) is consistent with a high proportion of dike intrusion to lava extrusion. Otherwise, the structures would be buried (resurfaced) by young lava flows, concealing/covering the large vertical displacements. In Hawaiian VRZs where effusion rates are higher, faults with several-meter vertical displacements are rarely observed. The Great Rift VRZ may be atypical of ESRP VRZs because there have been several dike intrusion events in Holocene time, but no large vertical displacements are preserved at the surface due to burial by high lava effusion rates in the Craters of the Moon and Wapi/Kings Bowl lava fields.

Surficial measurements of VRZ structures on the ESRP (magnitudes of vertical displacements, fissure dilation, fissure length and areal distribution of structures) are not sufficient to constrain the geometry of subsurface dikes responsible for the deformation. This is because a spectrum of dike geometries can produce the same deformational features. The mechanical models capable of constraining subsurface dike geometry require input of geodetic measurements before and after dike injection events. Obviously, we do not have that information because there have been no historic dike injection events on the ESRP. If seismic network monitoring ever

b. Letter report from Woodward-Clyde Consultants, December 9, 1991.

indicates rise of magma into upper crustal parts of an ESRP VRZ, every effort should be made to quickly perform appropriate detailed geodetic surveys across the rift zone before dike intrusion or volcanism occurs. This would give a baseline to which post-dike-emplacement surveys could be compared to constrain subsurface dike geometry.

Maximum surface areas of dike-induced faults and maximum displacements constrain the magnitudes of volcanically induced earthquakes to about 5.5 or less. Similar maximum magnitudes are indicated by analogy to recorded seismicity associated with dike injection in Iceland.

Comparison of the magnitude of Holocene extension in the adjacent basin-and-range (B&R) province to that from Holocene dike intrusion on the ESRP shows that extension on the plain reasonably is accommodated by dike injection rather than normal faulting. Intrusion of dikes perpendicular to the direction of regional extension reduces deviatoric stresses beneath the ESRP because magma pressure against the dike walls counteracts the tendency of regional extension to decrease the magnitude of minimum principal stress. This suppresses B&R-style normal faulting and leads to the relative aseismicity of the ESRP.

In the northern end of the Arco VRZ, progress has been made in determining minimum ages of structures. A set of river terraces estimated to have formed between 20,000 and 30,000 years ago are not offset by the rift zone structures, indicating that rift zone structures are at least as old as the latest movement on the Arco segment of the Lost River fault. Many of the northernmost structures are filled by and buried by thick loess and eolian sand deposits, suggesting that they are at least as old as early Pinedale (~30,000 years ago). The relationship of rift structures to deposits formed by a glacial outburst paleoflood, tentatively dated at 19,000 years ago, suggest also a pre-Pinedale age for the rift zone structures. Also, fissures in the middle part of the rift zone are covered by a lava flow that erupted about 100,000 years ago.

More subsurface information from deep drilling and geophysical modeling are required in order to reduce uncertainties about the spatial persistence of rift zones through time and about the existence of the hypothesized Howe-East Butte VRZ. The degree of spatial persistence through time determines whether migration of rift zones or creation of new rift zones should be considered in seismic and volcanic hazards assessments. The existence of the hypothesized Howe-East Butte VRZ has been identified as a major problem, because, if it exists, it lies very close to the NPR site and could be the controlling seismic source.

Development of ways to determine the minimum age of VRZ structures (fissures, monoclines, faults, grabens) is also critical. Even if the Howe-East Butte rift zone does exist, it may be so old that it is no longer considered capable of producing either volcanic or seismic activity. We do not yet have a means to make the assessment of minimum age of the fissures that are partially responsible for hypothesizing the rift zone.

A.1.4 Task 6 - Broadband Teleseismic Network

Stanford University personnel deployed one broadband instrument during the summer and fall of 1991, recording teleseismic events until November. At least 25 teleseismic events of magnitude greater than 5.5 were recorded and should provide an adequate data base for analysis of deep crustal and upper mantle structure. Analysis of data is underway by Stanford University without necessity of NPR funding. Results will be made available to us when the analysis is complete.

A.1.5 Task 7 - Upgrade INEL Seismic Network

The upgraded network is operational except for telemetry problems at two stations north of the ESRP. All of the stations on the ESRP have been placed in drill holes to reduce surface noise caused by wind.

Existing network coverage was insufficient to determine accurate epicenters and focal mechanisms for normal faulting earthquakes in the Basin and Range north of INEL and for microseisms and possible VRZ earthquakes on the ESRP. The expanded network is designed to remove those deficiencies.

A.1.6 Task 8 - Regional Geomorphologic Investigations

A regional geomorphologic report and maps have been completed. All of southeastern Idaho has been investigated by interpretation of small scale air photographs (1:80,000 scale), landsat (1:250,000) and spot images (1:125,000), and side looking airborne radar (1:250,000) for evidence of Quaternary faults. Field checks of ambiguous features have been completed. The resulting final geomorphologic report has been completed by Golder Associates (New Production Reactor Site Characterization Regional Geomorphic Study, Task 4, February 25, 1992).

Most lineaments on the ESRP are of nontectonic and nonvolcanic origin (fire scars, modified fire scars, eolian processes, color anomalies due to vegetative differences, and alignment of stream channels along lava flow edges). No previously unrecognized Quaternary faulting was found. Many features formerly suspected to be of tectonic origin have been shown to have other origins. Four lineaments have been identified that require further field investigations to ascertain their origin. These are (a) a 6.4-km (4-mi) long northeast trending lineament between the railroad and US-20 in the western part of INEL, (b) a 3.2-km (2-mi) long north trending lineament between Quaking Aspen Butte and Big Southern Butte, (c) a 3.2-km (2-mi) long ENE trending lineament along the west INEL boundary near the junction of US-20 and State Route 22, and (d) east-trending VRZ features (just north of Dubois) associated with the west end of the Spencer-High Point VRZ.

In the Box Canyon area of the Big Lost River, the use of geomorphic surfaces to constrain ages and rates of uplift related to the Arco Rift Zone is complicated by the effects of the late Pleistocene glacial-outburst flood that scoured the area and by a band of Holocene alluvium that

crosses the rift zone just south of Arco. Some river terraces just southeast of Arco may be useful. Other approaches that should be explored for dating rift zone events in this area include (a) excavations into sediment filled fissures to search for datable materials (organics for radiocarbon dating, silts for thermoluminescence dating) and (b) dating of rock surfaces exposed during fissuring with cosmogenic radionuclides.

Field examinations of faint north-northwest trending lineaments in the Big Lost River Sinks area south of Howe Point have shown that the lineaments are not directly related to tectonic activity but may be developed over buried faults or fissures.^b Standard and shallow high resolution reflection seismic surveys are needed to resolve the issue. A standard survey has been completed and processing of the data is done. Analysis of the resulting cross sections for faulting has not been completed and deserves high priority for future funding. If the standard reflection seismic survey indicates faulting, then high-resolution shallow seismic reflection surveys should be done to ascertain how close the faults approach the surface. This should give some idea of the youth of sediments faulted and suggest areas that could be trenched to see the effects of any faults on near-surface sediments.

A.1.7 Task 9 - Location Of The 1905 Earthquake

A search of historical records (letters, journals, diaries, church and weather records, and newspapers) in Idaho, Utah, Nevada, Oregon, Wyoming, Montana, Colorado, California, and Washington, D.C. has been completed. The data strongly suggest but do not prove that the epicenter for the earthquake was near Snowville in northern Utah. Although isoseismals drawn using the existing data center on the Snowville area, the data are so sparse in southern Idaho and northeastern Nevada that other interpretations are permissible. The earthquake is likely to have been centered in northern Utah because several B&R-style earthquakes of about the same magnitude have occurred there in the period since 1905.

A search for seismograph records was made but none were found. Logbooks which describe two seismograms of the earthquake were found in Vancouver, British Columbia and Toronto, Ontario. These descriptions allow estimations of magnitude to be made, assuming the location was somewhere in southern Idaho or Northern Utah. The surface wave magnitude estimates are 4.7 and 5.3 with an average of 4.9.

A.1.8 Task 10 - Heat Flow Determinations And Modeling

The objectives for the 1991/1992 heat flow investigations include the following:

Objective 1. Better determination of sub-aquifer heat flow in the ESRP and along its boundaries with the Basin-and-Range province. Heat flow determinations are particularly difficult in the ESRP because of the Snake River Plain (SRP) aquifer, which intercepts crustal heat and

b. Letter report from Woodward-Clyde Consultants, December 9, 1991.

prevents it from reaching the surface. Drill holes that penetrate beneath the aquifer are required to make the determinations. With the drilling of corehole WO-2 in the summer of 1991, an additional subaquifer drill hole is available. A detailed temperature log was made of the hole a few days after drilling stopped. Although it was not an equilibrium temperature log, the bottom hole temperature is higher than the temperature at equivalent depth [1,524 m (5,000 ft)] in INEL-1 (Blackwell 1990). This suggests a slightly higher heat flow for the two holes, but a relog of temperature after final equilibrium conditions are obtained, and determinations of thermal conductivities from core samples are required before that conclusion is totally justified.

A relog of temperature in INEL-1, using today's precise temperature measurement logging instruments, confirms earlier estimates of heat flow in that drill hole of 107 mWm^{-2} . This increases the confidence that the heat flow from the ESRP crust is about 25-30% higher than that from the adjacent B&R crust and that the ESRP should be considered a province separate from the B&R.

Objective 2. Evaluation of alternate models of the thermal structure of the crust beneath the ESRP. In the model of Brott and Blackwell (1981), the heat source associated with the Yellowstone mantle plume was assumed to be contained within the crustal column directly beneath the surface expression of the ESRP (i.e., it was not broader at depth than the width of the ESRP). This type of model best fits the observed heat flow information and known crustal structure but it does not allow the parabolic distribution of seismicity and late Quaternary faulting around the ESRP to be genetically related to hotspot heating because the model shows that heating effects do not extend far enough outside the ESRP margins to have any spatial relationship to the seismicity parabola. The 1991 NPR work evaluated various additional models in which the hotspot heat source extends up to 50 km (31 mi) outside the ESRP margins at depths of 15 to 20 km (9 to 12 mi). Although considerable uncertainty exists in the configuration of these models, they are allowed by uncertainties in crustal structure inferred from the 1982 ESRP seismic profiling experiment and in the available heat flow data from the ESRP and surrounding regions.

The results of these various models suggest a way to use heat flow information to evaluate whether or not the heat source extends beyond the ESRP boundaries. In all models in which the heat source extends beyond the ESRP boundaries, the heat flow predicted for the margins of the plain is not significantly different from that predicted for the axis of the plain. Only the models with the heat source confined within the ESRP boundaries predict significantly lower heat flow at the margins than along the axis. Existing subaquifer heat flow determinations are all located about equidistant from the northwest margin of the Plain and thus do not supply the observational data necessary for the test. Every effort should be made to obtain a subaquifer heat flow determination at a location near the axis of the ESRP so that it can be compared to existing data from locations near the northwest margin. Resolution of this problem has major implications for Objective 3, below.

Objective 3. Evaluation of the potential for variations in heat flow to account for the parabolic distribution of seismicity about the Yellowstone Plateau and the ESRP. It is difficult to

explain the parabolic distribution of seismicity around the ESRP in terms of temperature, even if the crustal heat source related to the passage of the Yellowstone mantle plume extends significantly beyond the margins of the ESRP. Upward conduction of heat into the lower crust from high temperature rocks in the upper mantle are required to produce seismicity and faulting at such great distances from the ESRP margin (Blackwell et al. 1993).

Objective 4. Determination of whether the proposed dike injection mechanism of crustal extension in the ESRP is consistent with observed heat flow. Injection of basalt dikes into the upper crust to accommodate regional extension during the past 5 million years can be expected to contribute some amount to the total heat flow of the ESRP. Using thermal models to predict the magnitude of that contribution and comparing the results to observed heat flow is a way to test the adequacy of the dike injection mechanism of strain accommodation. The dike injection rate necessary to accommodate extension determined by paleoseismology in the adjacent B&R is about one 1-m-thick dike every 2,000 to 3,000 years. This dike injection rate would add about 5 mWm^{-2} to the heat flow of the ESRP, an amount undetectable given the variability of heat flow on and around the ESRP.

A.1.9 Task 11 - Leveling Surveys

Comparisons of two existing first-order level line pairs indicate significant [30–40 mm (1.2–1.6 in.)] subsidence of parts of the ESRP with respect to its margins. Some or all of this may be related to groundwater withdrawal by large irrigation wells, but the results are encouraging in that they show that first-order leveling has the potential for establishing reliable vertical crustal movement rates to constrain tectonic models over relatively short time periods. Also, comparison of the new leveling with the old second-order lines has a high probability of yielding valuable crustal deformation information.

A new first-order leveling survey across the INEL was completed in 1992 by other INEL organizations interested in having first-order leveling accuracy for water well surveys. The surveys were conducted by the National Geodetic Service. The first-order lines follow the old second-order lines from Blackfoot to Arco via the railroad, from Arco to Howe, and from Howe to I-15 via Mud Lake and Terreton. In addition, several lines were surveyed across parts of the INEL. These surveys will furnish a good baseline for comparison to future levelings to determine crustal movements. Comparison of these first-order surveys to existing second-order surveys is in progress.

A.1.10 Task 12 - Reoccupy INEL GPS Network

A baseline network consisting of 32 stations distributed across the ESRP and surrounding B&R province was established in 1990. Reoccupations of stations in the network in future years will furnish information about horizontal crustal deformations.

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A.1.11 Task 13 - In situ Stress Determinations

A borehole televiewer log of INEL-1 to search for borehole breakouts as indicators of principal horizontal stress orientations was done in 1990. Absence of borehole breakouts indicates low deviatoric stresses beneath the plain. Hydrofrac tests in one or more deep drill holes are required in order to determine orientation and magnitudes of principal stresses. Hydrofrac is still possible in WO-2 by one of two options: (a) free the N rods in the hole and drill it deeper to find competent rock zones; (b) If the rods cannot be freed, drill the hole deeper with B rods to competent rock. Hydrofrac tests in other holes (INEL-1 or future new deep holes) may be preferable to WO-2.

Plans to determine compressive strength of deep core samples from INEL-1 and WO-2 were stopped when NPR shutdown was announced. This would have provided information that would have allowed realistic design of a hydrofrac program and would have placed limits on the stress differential existing at depth beneath the ESRP.

A.1.12 Task 14 - Geophysical Investigations And Modeling

Preliminary modeling shows that dike swarms are capable of generating observed gravity anomalies on the ESRP. Other geometries and structures may also be capable of generating observed anomalies. Gravity anomalies reflect deep structure (at least down to mid-crustal levels) beneath the ESRP. Magnetic anomalies reflect near-surface rock bodies [< 1 km (0.6 ft) deep]; therefore, they may not be good indicators of deep dike swarms beneath rift zones or of other deep structures. For these reasons, use of gravity and magnetic anomalies to help define VRZs gives inconsistent results. We have so little knowledge of the in situ physical properties of ESRP rocks that geophysical modeling is unconstrained. Therefore, obtaining densities, P- and S-wave velocities, and magnetic susceptibilities of basalts, interbeds, and rhyolitic rocks is a high priority for future work. The extreme gravity gradients mapped in the Hells Half Acre lava field area are due to processing errors.^c Therefore, there is no need to postulate large mass anomalies to explain them. A subsurface fault is recognized in one of the processed Sierra Geophysics lines south of Arco (between Arco and the north end of exposed Arco Rift Zone structures). More seismic lines recently completed in this area and at the south end of the Lemhi fault may help to further define the extent of faulting in these areas.

Five hundred new gravity stations have been surveyed to fill in the ESRP gravity map with approximately 5-km (3-mi) station spacing. All gravity data (published or proprietary) for the ESRP has been recompiled with consistent correction factors at scales of 1:250,000 and 1:100,000. Original flight line data for a 9,000-ft-elevation, 1-mi line spacing aeromagnetic survey of the INEL area was obtained from the U.S. Geographical Survey (USGS) and has been compiled into an aeromag map at a scale of 1:100,000. These surveys and recompilements furnish a consistent

c. John Karlo, Thesis, State University of New York.

regional data base, but modeling of anomalies will be difficult without in situ physical property determinations of ESRP rocks.

Analysis of aeromagnetic anomaly gradients on the aeromagnetic maps indicates that the observed anomalies reflect variations in magnetic properties of rocks in the upper 1–2 km of crust only. Correlation of new and recompiled geophysical data with geology and subsurface information from ESRP seismic profiling experiment will be useful in developing understanding of subsurface structures.

A.1.13 Task 15 - Site Specific Ground Motion Assessment

The stratigraphic column beneath the NPR site as determined by examination of core from the new deep hole (WO-2) contains sedimentary interbeds which may reduce ground motion at the site. Previous assessments conservatively assumed no interbeds below 183 m (600 ft) because no information was available. The large interval of unwelded, poorly welded, and fractured rhyolitic ash flows beneath the basalt section may also be influential in attenuating ground motion at the site.

Representative samples of all major interbeds in WO-2 have been preserved for laboratory testing of physical properties. The judgement of members of the Senior External Events Review Group and Walt Silva is that the core samples of interbeds are not appropriate for dynamic tests since they were not collected by undisturbed sampling methods.

The necessity to leave drill rods in the WO-2 to keep the hole open has destroyed plans to obtain borehole sonic velocity logs of the hole. Vertical seismic profiling to obtain seismic velocities of interbeds and basalts in WO-2 and other existing drill holes may be a way of obtaining some in situ shear wave velocity measurements.

The Deterministic Seismic Hazards report by Woodward-Clyde Consultants (1992a) contains ground motion estimates based on the new information from WO-2 but still contains uncertainties due to lack of shear wave velocity data and dynamic test results.

In the Deterministic and Probabilistic Seismic Hazards Reports, extensive use is made of the information gained from the field investigations described above, especially the paleoseismic investigations of the Lemhi fault, the segmentation studies of the Lemhi fault, the mapping of VRZs, the deep stratigraphy determined from WO-2, the cross-hole seismic surveys, and the borehole televiewer log of drill hole INEL-1. The paleoseismic and fault segmentation information allow determination of earthquake maximum magnitudes and source-to-site distance to a much higher degree of confidence than ever before for the Lemhi fault.

The VRZ mapping has furnished information that allows determination of source-to-site distance to nearest rift zone structures exposed on the surface. Analogy to active VRZs worldwide and estimation of the surface area of rift zone faults limits the maximum magnitudes of

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volcanism-induced earthquakes to 5.5. This allows the rift zones to be treated with confidence in both deterministic and probabilistic contexts.

The major issues for both deterministic and probabilistic assessments are (a) lack of knowledge about the subsurface distribution of VRZs and uncertainty about the existence of the proposed Howe-East Butte VRZ, (b) uncertainties in the minimum ages of fissures and other structures related to VRZ activity, and (c) uncertainties and differing viewpoints on how to treat a "floating" earthquake on the ESRP.

The Howe-East Butte rift zone was originally hypothesized by Kuntz (1978). That speculation was based on the presence of three volcanic vents (AEC Butte, State Butte, and Horseshoe Butte) south of Howe and west of the Big Lost River. Since their craters have northwest elongation it was thought that they could line up with some vents in the East Butte area and represent a VRZ. In maps published after 1978, Kuntz removed that rift zone because the evidence for its existence was too meager (personal communication, 1990). In 1984-85, an east trending fissure was found about a mile north of the Naval Reactors Facility and Golder's mapping in the summer of 1991 revealed a second fissure about a mile north of the Naval Reactors Facility fissure. These two fissures increase the evidence for a rift zone's existence in the area but the indications are still meager in part because the fissures cannot be confidently tied to any of the volcanic vents nearby. If such a rift zone exists, it is very old (AEC Butte and State Butte are estimated to be about 600,000 years old) and the vents are mostly buried by lava flows that are more than 400,000 years old. The fissures, however, cut the same lava flows that are more than 400,000 years old. This whole problem is a reflection of a more fundamental problem, namely, the persistence of VRZs in space and time.

Development of a way to determine the minimum age of the fissures described above and those in the Arco and Lava Ridge-Hells Half Acre VRZs is important for the seismic hazards assessment of the NPR site. If it could be established that they formed several hundred thousand years ago, their influence on the hazards assessments would be minimal.

The final issue is the concept of a floating earthquake on the ESRP. Some reviewers of the Deterministic and Probabilistic reports insist on the most conservative viewpoint, that a floating earthquake of magnitude 6 should be used for the ESRP because that is the largest earthquake in the B&R for which no surface fracturing is expected. One way to ultimately counter that assertion is to determine in situ stress conditions in deep drill holes beneath the plain and demonstrate that deviatoric stress is significantly less than that outside the Plain. This is predicted by the dike injection mechanism of extension accommodation but no independent evidence for it exists.

A.2 Seismicity and Seismic Hazards

A.2.1 Regional Seismotectonic Setting

The ESRP is defined as the eastern portion of the SRP, extending from the Yellowstone Plateau to the Great Rift (Figure A-1)^d. The relatively aseismic ESRP is surrounded by the seismically active Intermountain seismic and Centennial Tectonic belts. The Intermountain seismic belt (ISB) is a zone of concentrated seismicity that extends from northwestern Montana through eastern Idaho and central Utah into southern Nevada (Sbar and Barazangi 1970; Smith and Sbar 1970; Smith and Sbar 1974; Arabasz and Smith 1981; Smith and Arabasz 1991). It is divided into three parts, referred to as the northern (Montana), central (Idaho), and southern (Nevada and Utah) ISB (Smith and Arabasz 1991). North of the ESRP seismicity extends from Hebgen Lake, Montana westward into central Idaho and has been characterized as an independent zone of earthquake activity referred to as the Centennial tectonic belt (CTB) (Stickney and Bartholomew 1987). Smith and Arabasz (1991) consider the CTB (formerly called the Idaho Seismic Zone) as a part of the central ISB which "wraps around" the ESRP. In the following discussions, this zone of seismicity will be referred to as the CTB to distinguish it from the north-trending zone of seismicity within the central ISB.

A.2.2 Earthquake Data

Figure A-1 shows the locations of earthquakes with magnitudes greater than 2.0 between 1884 and 1989 (years indicate locations of earthquakes with magnitude greater than 5.5). These data were compiled by Woodward-Clyde Consultants (1992a) from the following sources:

Agency	Dates
INEL	1986-1989
United States Geological Survey (USGS)	1986-1989
Montana Bureau of Mines and Geology	1986-1989
United States Bureau of Reclamation	1986-1989
University of Utah Seismograph Stations	1986-1989
Engdahl and Rinehart (1988; 1991)	1884-1985

Jackson (1993) lists the earthquake location parameters (date, location, depth, magnitude, data source, etc.) for earthquakes greater than magnitude 3.0 for a 322-km (200-mi) radius around

d. Epicentral data were compiled from the INEL, University of Utah, Montana Bureau of Mines and Geology, U.S. Bureau of Reclamation and the Decade of North American Geology (Engdahl and Rinehart, 1988) seismicity catalogs. Seismicity of the Intermountain Seismic Belt (north-trending zone extending from northern Utah through the Yellowstone Plateau and into southern Montana) and CTB (east-west zone extending from Yellowstone Plateau to the Lost River fault) form a parabolic distribution of epicenters around the ESRP. Also shown are Quaternary normal faults (dashed where approximately located and dotted where concealed) and the Great Rift VRZ, as compiled from Witkind (1975), Bond (1978), Anderson and Miller (1979), Stickney and Bartholomew (1983), and Hecker (1991).

Figure A-1. Southeastern Idaho and adjacent states, including locations and magnitudes of earthquake epicenters between 1884 and 1989.

the ATR site. It does not include the entire listing of earthquakes within the B&R, Northern Rocky Mountain, and Central Rockies tectonic provinces, only events within these provinces that fall within the 322-km (200-mi) radius shown in Figure A-1.

For the central ISB, the earthquake record extends back to November 10, 1884, the date of the first documented earthquake (with a magnitude of 6.3 on the Richter scale), which occurred near Paris, Idaho. Prior to the 1960s, seismographic coverage of the ESRP and surrounding B&R was relatively poor, with only earthquakes larger than magnitude 5.0 recorded by seismographs worldwide. The detection of earthquakes prior to this time was based on felt and damage reports made by local residents. Such epicentral locations may be in error by 100 km (62 mi) or more (Woodward-Clyde Consultants 1992a). Over 90% of the earthquakes shown in Figure A-1 have occurred between 1970 and 1989. The epicenters have been determined from localized seismic networks within the intermountain region. Epicentral errors for this time period could range from 1 to >20 km (0.6 to >12.4 mi), depending on the number and spatial distribution of the seismic stations recording the event.

In the early 1960s, seismographs were installed in the intermountain area by the University of Utah Seismograph Stations and, in 1971, on the ESRP by the INEL. The USGS installed and operated a seismic network at Yellowstone National Park from 1970–1981 and, the University of Utah Seismograph Stations, from 1983 to present. Seismic stations were installed near Teton Dam, Idaho (currently operated by Ricks College) beginning in 1980, in southwestern Montana (by the Montana Bureau of Mines and Geology) starting in 1981, and in western Wyoming near Jackson Lake (by the United States Bureau of Reclamation) during 1986. With additional seismic stations, smaller magnitude earthquakes could be detected. Based on the number of seismic stations operating over specific time intervals, periods of completeness can be established for various magnitudes. The periods of completeness are the time periods over which independent earthquakes (excluding aftershocks) can be considered to be completely detected (Woodward-Clyde Consultants 1992a). Table A-3 shows the periods of completeness for various magnitudes of the earthquake data shown in Figure A-1 (Youngs et al. 1987; Geomatrix Consultants 1989; Engdahl and Rinehart 1988; Woodward-Clyde Consultants 1992a). The completeness periods indicate that, for historic times, the data base for larger magnitude earthquakes is more complete than for smaller magnitude events.

A.2.3 Moderate to Large Earthquakes

Moderate to large earthquakes of magnitude ≥ 5.5 have occurred within a 322-km (200-mi) radius of the INEL. For these events, Table A-4 lists the largest magnitude computed, moment magnitude if computed, and Modified Mercalli intensities which are based on damage at the epicenter. Since earthquakes ($M \geq 2.5$) occur at distances greater than 50 km (19.3 mi) from the Advanced Test Reactor (ATR), only events of $M \geq 5.5$ are listed in Table A-4. Figure A-2 shows their locations relative to B&R normal faults and the ESRP. Also shown are locations of Quaternary and Holocene normal faults in the Basin and Range province, and volcanic-rift zones of the ESRP.

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Table A-3. Time periods of earthquake data completeness.^a

Magnitude interval	Completeness
2.0-4.0	1975-1989
4.0-5.0	1963-1989
5.0-5.5	1950-1989
5.5-6.0	1925-1989
6.0-6.5	1900-1989
6.5-7.0	1875-1989
7.0 +	1850-1989

a. Woodward-Clyde Consultants 1992a.

The largest earthquake with surface-wave magnitude (M_s) 7.5, occurred within the ISB on August 17, 1959 at Hebgen Lake, Montana (Figure A-2) (Doser 1985b). It was located 190 km (118 mi) northeast of ATR. Although the earthquake was felt at the INEL, it caused no damage at ATR or other INEL facilities (Gorman and Guenzler 1983).

The M_s 7.3, Borah Peak, Idaho earthquake occurred on October 28, 1983 in the CTB near the INEL (Doser and Smith 1985). The earthquake resulted from normal faulting along the Lost River fault (Crone et al. 1987). The epicenter for this event was located in the Thousand Springs valley near the western flank of Borah Peak (Richins et al. 1987). Substantial damage occurred to masonry structures in the local communities of Mackay and Challis, Idaho near the epicentral area (Stover 1985).

The INEL was located in Modified Mercalli Intensity zone VI during the earthquake (see Figure A-3; Stover 1985). Inspections following the earthquake revealed no apparent structural or component damage that would compromise structural integrity of INEL facilities (Gorman and Guenzler 1983).

Currently, the INEL operates 22 strong motion accelerographs. They are located at various levels (i.e., basement, first floor, roof tops) within critical facilities and at free-field sites (not within buildings). Instruments within facilities record the response of the building to the earthquake ground shaking and, at free-field sites, the level of earthquake ground motions at the earth's surface. At the time of the Borah Peak earthquake, the INEL had 15 strong motion accelerographs in operation. Peak horizontal accelerations recorded at INEL ranged from 0.022-0.078 g for basement and free-field sites (Jackson 1985; Jackson et al. 1991b).

Table A-4. Earthquakes with magnitudes greater than 5.5 within 322 km (200 mi) of the INEL.

Earthquake Date and Time (Hr:Mn - UTC) ^a	Magnitude ^b	Modified Mercalli Intensity ^c	Geographical Location ^d	Radial Distance (km) ^e	References ^g
1884 November 10 08:50	6.3 M _I	VIII	Bear Lake, Utah	225	1
1905 November 11 21:26	5.5 M _L	VII	Shoshone, Idaho	164	2
1909 October 6 02:50	6.3 M _I	VIII	Hansel Valley, Utah	216	1
1914 May 13 17:15	5.7 M _I	VII	Ogden, Utah	283	1
1925 July 10 14:45	6.8 M 6.6 M _w	VI	Clarkston, Montana	201	3,4,5
1930 June 12 09:15	5.8 M _L	VI	E of Soda Springs, Idaho	190	5
1934 March 12 15:05	6.6 M _L 6.6 M _w	IX	Hansel Valley, Utah	222	1,3,6
1934 March 12 18:20	6.2 M _L 5.9 M _w	VII	Hansel Valley, Utah ^g	222	1,3,6
1934 April 14 21:26	5.6 M _L	VII	Hansel Valley, Utah ^g	245	1
1934 May 06 08:09	5.6 M _L	VI	Hansel Valley, Utah ^g	222	1
1944 July 12 19:30	6.1 M _b	VII	N of Stanley, Idaho	235	7
1945 February 14 03:01	6.0 M _L	VI	N of Stanley, Idaho	235	7
1947 December 17 12:38	6.3 M 6.1 M _w	ND	Virginia City, Montana	225	3,4
1959 August 18 ^h 06:37	7.5 M _s 6.3, 7.3 M _w	X	Hebgen Lake, Montana	187	3,8,9,10
1959 August 18 07:56	6.5 M	ND	Hebgen Lake, Montana ⁱ	208	3
1959 August 18 08:41	6.0 M	ND	Hebgen Lake, Montana ⁱ	208	3
1959 August 18 11:03	5.6 M	ND	Hebgen Lake, Montana ⁱ	182	3
1959 August 18 15:26	6.5 M _b ; 6.3 M _w	ND	Hebgen Lake, Montana ⁱ	209	10
1959 August 19 04:04	5.9 M _s ; 6.0 M _w	ND	Hebgen Lake, Montana ⁱ	209	4,10
1962 August 30 13:35	5.7 M _s ; 5.9 M _w	VII	Cache Valley, Utah	208	1,3,11
1964 October 21 07:38	5.8 M _b ; 5.6 M _w	ND	Hebgen Lake, Montana ⁱ	154	3,4
1975 March 28 02:31	6.1 M _b ; 6.2 M _w	VIII	Pocatello Valley, Utah	183	3,12
1975 June 30 18:54	6.1 M _L	VII	Yellowstone Park, Wyoming	209	3,13
1976 December 8 14:40	5.5 M _b	ND	Yellowstone Park, Wyoming	198	5
1983 October 28 14:06	7.3 M _s ; 6.8 M _w	IX	N W of Mackay, Idaho	93	3,8,9,14
1983 October 28 19:51	5.8 M _L ; 5.4 M _w	ND	N W of Mackay, Idaho ^j	98	3,15
1983 October 29 23:29	5.8 M _L ; 5.5 M _w	ND	N W of Mackay, Idaho ^j	121	3,15
1984 August 22 09:46	5.8 M _L 5.6 M _w	ND	Challis, Idaho ^j	127	3,15

a. Universal time coordinated (Greenwich mean time).

b. Highest magnitude value is reported in this table. Moment magnitudes are included, if calculated. Magnitude scales: M_I = Conversion from Intensity; M_L = Local or Richter; M = magnitude type not specified; M_w = Moment; M_b = Body-wave; M_s = Surface-wave.

c. Modified Mercalli intensity based on Wood and Neumann (1931).

d. Latitude and longitude coordinates are listed in Appendix 2-A.

e. Radial distances based on coordinates 43° 42.0', 112° 48.0'.

f. References: (1) Richins 1979; (2) Oaks 1992; (3) Doser and Smith 1989; (4) Doser, 1989a; (5) National Earthquake Information Center, unpublished data; (6) Doser 1989b; (7) Stover et al. 1986; (8) Doser 1985a; (9) Stover 1985; (10) Doser 1985b; (11) Westaway and Smith 1989; (12) Arabasz et al. 1979; (13) Pitt et al. 1979; (14) Doser and Smith 1985; (15) Richins et al. 1987.

g. Aftershock following the M_L = 6.6, 1934 Hansel Valley, Utah earthquake.

h. Hebgen Lake usually referred to as M_s 7.5, but is actually two events having magnitudes of M_w 6.3 and 7.3 (Doser 1985).

i. Aftershock following the M_s = 7.5, 1959 Hebgen Lake, Montana earthquake.

j. Aftershock following the M_s = 7.3, 1983 Borah Peak, Idaho earthquake.

Figure A-2. Locations, dates, and magnitudes of observed earthquakes with $M > 5.5$ in the INEL area.

Figure A-3. Isoseismal-contour map for the M_s 7.3, 1983 Borah Peak, Idaho earthquake (Stover 1985).

A.2.4 Geologic Structures and Tectonic Activity

A.2.4.1 Tectonic Provinces. The tectonic provinces of most concern for seismic and volcanic hazards at INEL are the ESRP and the northern B&R province (Figure 2-1). Other provinces that are sufficiently close to INEL that may need to be considered, especially for probabilistic seismic hazards assessments, are the Yellowstone Plateau and the Idaho Batholith.

The ESRP is distinguished from the surrounding provinces by subdued topography, lower elevations, absence of B&R faults and mountain ranges (Figure 2-2), and historic aseismicity (Anders et al. 1989). In addition, it is associated with regional high gravity (Bankey et al. 1985), positive aeromagnetic (Zeitz et al. 1978), and high seismic velocity (Sparlin et al. 1982) reflecting zones of dense, magnetic mafic rocks in the mid-crust beneath the Plain. This zone of mafic material in the mid-crust is believed to represent the zone of accumulation and solidification of mafic magmas that were generated by the Yellowstone hotspot as it passed beneath the ESRP.

The northern Basin and Range province is distinguished by north-northwestern trending block fault mountain ranges that formed in response to east-northeastern directed extension. Normal faults bounding these ranges have accumulated 1 to 2 km (0.6 to 1.2 mi) of vertical displacement during Late Tertiary and Quaternary time (Pierce and Morgan 1992). Seismicity and Holocene paleoseismicity along these faults are concentrated in a parabolic zone that passes through the Yellowstone Plateau and flanks both sides of the ESRP (Figure A-4) (Anders et al. 1989).

The Yellowstone Plateau is distinguished by Quaternary and continuing crustal response to rapid uplift over the Yellowstone hotspot in close proximity to areas (northeastern ESRP) that are rapidly subsiding. This results in development of large faults with high slip rates (Pierce and Morgan 1992) and with trends inconsistent with the direction of regional extension (for example, the Centennial, Teton, and Hebgen/Red Canyon faults) (Figure A-4) (Doser 1985b; Eddington et al. 1987; Peyton et al. 1991). In addition, the Yellowstone Plateau has much greater levels of seismicity than either the ESRP or the northeastern B&R province (Smith and Arabasz 1991), a situation resulting from interaction of regional extension with rapid local vertical crustal movements. Occurrence of voluminous Quaternary explosive silicic volcanism (Christiansen 1984) and significant delays in teleseismic P-waves beneath the caldera area suggest extremely high temperatures and presence of magma in the crust and upper mantle (Iyer et al. 1981; Evans 1982).

The Idaho Batholith is distinguished by high, rugged topography, sparsity of B&R faults, and absence of late Tertiary and Quaternary volcanism (Figures 2-1 and 2-2). Seismicity is much less intense than that associated with the Basin and Range (Smith and Arabasz 1991), with maximum magnitude of about 5. Nevertheless, the seismicity in the Idaho batholith is considered in seismic hazards assessment for INEL. The batholith appears to have been relatively unaffected by regional extension, perhaps because the granitic rocks are stronger or more coherent than rocks in the B&R province to the east and southwest.

Figure A-4. Major physiographic, geologic, and seismotectonic elements of the INEL region.

A.2.4.2 Faults. Faults of several ages and origins occur in the INEL region. Some of them are old and inactive, presenting no earthquake threat, whereas others are capable of generating earthquakes that could affect INEL facilities. Detailed correlation of faults with earthquakes is presented in Section A.2.5.

Mesozoic thrust faults occur in the mountain ranges bordering the ESRP (Figure A-4) (Skipp and Hait 1977; Link et al. 1988). They formed during a period of east-directed thrusting related to the Sevier orogeny. They are gently westward-dipping structures that separate major Paleozoic thrust sheets. These faults are mostly inactive at the present time because the compressional forces that created them is no longer in existence. However, it is possible that parts of some of the thrust faults have been reactivated by basin-and-range normal faults in Late Tertiary to Recent times (Smith and Bruhn 1984).

Eocene to Oligocene normal faults trend northward across the Lost River, Lemhi, and Beaverhead ranges north of the ESRP (Janacke 1992). Although these faults have several kilometers of accumulated displacement, their orientation with respect to the present stress field is such that they have no tendency for movement. Therefore they are not active today and pose no threat for earthquake hazards.

Basin-and-Range normal faults (Figure A-4) of Miocene to Recent age bound the present northwest trending mountain ranges north and south of the ESRP (Scott et al. 1985). These faults have accumulated 1 to 3 km (0.6 to 1.9 mi) of displacement in the past 4 to 7 million years and are still active today as evidenced by fault scarps cutting latest Quaternary and Holocene alluvial fan deposits and by the occurrence of the 1983 Borah Peak earthquake. Table A-5 summarizes the important characteristics of most Basin-and-Range normal faults around the ESRP.

The closest of these faults to INEL facilities, the Lost River, Lemhi, and Beaverhead faults (Figure A-4) each bound the southwest side of a mountain range, producing typical B&R half graben. These are large normal faults that extend from the northern margin of the ESRP northwards to the Salmon River. Based on seismic and paleoseismic investigations, they are capable of generating earthquakes of magnitude 7 (Doser and Smith 1985; Woodward Clyde Consultants 1992b). Because of their size, activity, and proximity to many INEL facilities, they control much of the INEL seismic hazard. New facilities must be designed to withstand ground motions that would be generated by earthquakes on these faults.

Detailed paleoseismic and structural investigations have been performed on the southern Lemhi fault (Woodward-Clyde Consultants 1992b and Bruhn et al. 1992). Results are:

1. Segmentation of the southern Lemhi fault is redefined based on timing of paleoseismic events and on detailed mapping of the structure of the fault in bedrock and surficial deposits (Figure A-5).

Table A-5. Basin and range faults around the ESRP.

FAULT	REFERENCE	IMPORTANT POINTS
Sawtooth, White Cloud Peaks area	Dewey (1987), Jackson and Zollweg (1988), Smith et al (1985).	Contemporary earthquake swarms, maximum magnitude = 6.1, several mapped normal faults.
Lost River Fault	Pierce (1985, 1988), Scott et al (1985), Crone et al (1987), Schwartz (1988), Malde (1987), Piety et al (1986)	Arco Segment - MRE~30 Ka, trenching, D~2-3 m, L~10 km, SR~0.12 mm/y, RI~30-40 Ka. Pass Creek Segment - MRE~30-50 Ka, scarp morphology, ND, L~30 km, RI~30-50 Ka? Mackay Segment - MRE~4.3-6.8 Ka, trenching, ND, L~22 km, SR~0.3 mm/yr, RI~4-7 Ka. Thousand Springs Segment - MRE=1983, trenching/earthquake, D=2.7 m, L=36 km, SR=0.3 mm/yr, RI=6-7Ka. Warm Spring Segment - MRE~5.5-6.2 Ka, trenching, ND, L~15 km, SR=0.3 mm/yr, RI<15 Ka. North Segment - MRE>Late Quaternary, scarp morphology, ND, L~20 km., ND, ND, low structural relief.
Lemhi Fault	Woodward-Clyde Consultants (1992, 1992a), Knuepfer (1989), Turko (1988), Baltzer et al. (1989), Malde (1987), Haller (1988), Scott et al (1985), Bruhn and others (1992)	Southern Segments (Howe and Fallert Springs segments) - MRE~15-24Ka, trenching/scarp morphology, D~2-3 m, L~25km, SR~0.1mm/yr, RI=3.3Ka(ave.) Sawmill Gulch Segment - MRE<10Ka, trenching, D=1.7 m, L=43 km, ND, ND. Goldburg Segment - MRE~10-15 Ka, scarp morphology, ND, L=12 km, ND, ND. Patterson Segment - MRE<10 Ka?, scarp morphology, ND, L~23 km, ND, ND. May Segment - MRE~15-30 Ka?, scarp morphology, ND, L~23 km, ND, ND.
Beaverhead Fault	Haller (1988), Stickney and Bartholomew (1987).	Blue Dome Segment - MRE>30 Ka, scarp morphology, ND, L~25 km, ND, ND. Nicholia Segment - MRE~10-15 Ka, scarp morphology, ND, L~42 km, ND, ND. Baldy Mountain Segment - MRE>30 Ka, scarp morphology, ND, L~21 km, ND, ND. Leadore Segment - MRE<10 Ka, scarp morphology, ND, L~23 km, ND, ND. Mollie Gulch Segment - MRE~10-15 Ka?, scarp morphology, ND, L~20 km, ND, ND. Lemhi Segment - MRE>30 Ka, scarp morphology, ND, L~20 km, ND, ND.

Note: For each segment or fault, the information under the Important Points column is presented as follows: most recent event (MRE) in thousands of years (Ka), type of study, displacement per last event (D), length (L), slip rate (SR), and recurrence interval (RI). ND = no data available.

Table A-5. (continued).

Red Rock Fault	Haller (1988), Stickney and Bartholomew (1987).	Sheep Creek Segment - MRE<10 Ka, scarp morphology, ND, L~16 km, ND, ND. Timber Butte Segment - MRE~10-15 Ka, scarp morphology, ND, L~11 km, ND, ND.
Centennial Fault	Stickney and Bartholomew (1987), Johnson (1981).	Western Centennial Valley Segment - MRE<10 Ka, scarp morphology, ND, L~23 km, ND, ND. Red Rocks Lake Segment - MRE>20 Ka?, scarp morphology, ND, L~24 km, ND, ND. Henrys Lake Segment - MRE<10 Ka, scarp morphology, ND, L~1 km, ND, ND.
Madison Fault	Stickney and Bartholomew (1987), Schneider (1985)	Madison Canyon Segment - MRE~Late Holocene (1947?, 1959?), scarp morphology, ND, L~34 km (total fault length = 117 km). Additional scarps exist but no segments have been delineated (a short segment of this fault ruptured in 1959).
Hebgen Fault and Red Canyon Fault	Stickney and Bartholomew (1987), Doser (1985b).	Hebgen Fault - MRE=1959, scarp morphology, D=6.7m, L~13 km (+ 14 km on R.C.Fault), ND, ND. Red Canyon Fault - MRE=1959, scarp morphology, D=6.7m, L~45 km, SR~1.2-1.5 mm/yr (pre-1959), RI=4.3 Ka.
Yellowstone area	Pitt et al (1979), U.S. Geological Survey (1972), Doser (1984).	Numerous north-trending normal faults around Yellowstone Caldera with Quaternary movement. Contemporary seismicity, maximum magnitude = 6.1. RI = 700-750 years for M7 earthquakes based on seismic moment rates.
Teton Fault	Piety and others (1986), Smith and others (1990), Byrd and others (1988), Susong and others (1987), Gilbert and others (1983)	South Segment - MRE~7Ka, trenching and scarp morphology, D=4.1m, L~24 km, SR~1.7-2.2 mm/yr, RI~1.4-2.3Ka. Middle Segment - MRE<11-14Ka, scarp morph., D~3m, L~20 km, SR~1.7-2.2 mm/yr, RI~1.4-2.3Ka. North Segment - MRE<11-14Ka, scarp morph., D~3m, L~20 km, SR~1.7-2.2 mm/yr, RI~1.4-2.3Ka.
Grand Valley Fault	Anders and others (1989), Piety and others (1986).	Grand Valley Fault - MRE>15-30 Ka, scarp morphology, ND, L~72 km, SR~0.02-0.04 mm/yr, ND.
Snake River Fault	Anders and others (1989), Piety and others (1986).	Snake River Fault - MRE>15-30 Ka, scarp morphology, ND, L~50 km, SR~0.001 mm/yr, ND
Star Valley Fault	Anders and others (1989), Piety and others (1986), McCalpin and others (1990).	Northern Segment - MRE<9Ka, scarp morphology, D~3.6-6.3, L~30 km, SR~0.8-1.2mm/yr, RI~5-7Ka. Southern Segment - MRE<9Ka, trenching and scarp morphology, D~5.0-6.3 m, L~28 km, SR~0.6-1.1 mm/yr, RI~5-7 Ka.
Northern Wasatch Fault Segments	Schwartz (1988), Machette et al. (1992), Swan and others (1980), Piety and others (1986).	Collinston Segment - MRE>13 Ka, scarp morphology, ND, L~25 km, ND, ND. Brigham City Segment - MRE=3400 yrs, trenching, ND, L~40 km, ND, ND. Weber Segment - MRE~500 years, 1.7-3.7 m, trenching, D~1.7-3.7m, L~50 km, SR~1.2-2.8 mm/yr, RI~1Ka?

A = Preferred scenario based on most reasonable interpretation of paleoseismic data.

B = Less-preferred scenario, which allows for rupture from just south of the Coyote Springs trench to the southern end of the range.

C = Least-preferred scenario, which allows for the slight possibility of rupture of the entire lengths of both the Fallert Springs and Howe segments.

Figure A-5. Possible rupture scenarios for the southern Lemhi fault (Woodward-Clyde Consultants 1992b).

2. The most recent earthquake events on the various segments ranges from 15,000 to 25,000 years ago (Figure A-6).
3. There is evidence for temporal clustering of earthquake events (i.e., clusters of several events over a few thousand years separated by long intervals (10s of thousands of years) of quiescence.
4. Maximum magnitude of earthquakes in the southern part of the fault is about M7 (Woodward Clyde Consultants 1992a).
5. Bedrock structural features of the southern part of the fault suggest that Quaternary displacement dies out at the south end of the Lemhi Range and that significant seismogenic fault movements do not extend onto the ESRP (Figure A-7).

From a seismic hazard point of view, the Lost River fault is about equal to the Lemhi. It is slightly farther away from most INEL facilities (hence Lemhi was studied first) but its threat is similar. However, state-of-the-art paleoseismic and structural studies have not yet been done, and we have only equivocal ideas about segmentation, most recent earthquake, recurrence intervals, and maximum magnitudes.

Although considerably farther from INEL than the Lemhi and Lost River faults, earthquakes from the Beaverhead fault will contribute significantly to the probabilistic hazard assessment. Therefore, additional paleoseismic and structural studies should be done for this fault.

Although the Grand Valley-Star Valley fault is located at great distance from the INEL area it will also contribute to the probabilistic hazard. Field investigations by Anders et al. (1989), Piety et al. (1986), and McCalpin et al. (1990) have shown that the northern part of this fault system was very active from about 4 to 2 million years ago, but since then has been inactive. The southern end of the fault, in the Alpine and Star Valley area, however, has experienced late Pleistocene and Holocene earthquake activity.

An additional point of interest for this fault is the interpretation by some authors that it extends onto the ESRP as far as the town of Rexburg (Williams and Embree 1980). If this interpretation is true, and if the associated displacement is late Pleistocene or Holocene, then the fault could have considerable significance from a tectonic perspective.

The northwest boundary of the ESRP has been considered as a possible seismic source (EG&G Idaho 1985). While it is true that a NE-trending fault or faults may exist at depth (Pankratz and Ackermann 1982), the only evidence for active faulting consists of the presence of a small NE-trending topographic scarp on an alluvial fan on the SE side of the Arco Hills (Scott 1982). That scarp was trenched in 1989 by the Idaho Geological Survey under contract to EG&G Idaho. The resulting trench logging showed that no faulting occurs there and that the scarp is due to some surficial processes such as eolian modification of a fire scar (Breckenridge and Othberg 1991). See Section A.2.6.4 for more information.

PALEOSEISMIC RESULTS: SOUTHERN LEMHI FAULT

Summary of earthquake events deduced from 4 trenches logged in 1990 and 1991. The data suggest that proposed segment boundaries (solid arrowheads) do not terminate earthquake ruptures. Instead, single events (E2, etc) may extend from Coyote Springs south to the end of the range (open arrowheads). Resulting rupture lengths of 34-35 km and corresponding $M_w=6.9$ establish the MCE for the southern Lemhi fault.

Figure A-6. Summary diagram of earthquake chronology for the southern Lemhi fault.

Figure A-7. The southern Lemhi fault, including bedrock structure and Quaternary fault scarps (Ronald Bruhn, written communication, 1991).

Nontectonic lineaments on and near INEL can be observed from the air, on aerial photographs, and on satellite images. One of the most pronounced of these lineaments, the Principal Lineament, has been studied extensively and shown to be caused by colian modifications to a large fire scar (Morin-Jansen 1987). This process produces many lineaments and perhaps even small topographic scarps on the ESRP. Other lineaments are caused by unmodified fire scars, linear stream drainages, alignments of vegetative or soil contrast with unknown causes, fluvial (stream, river) deposits, paleoflood deposits, and eolian deposits (dunes) (Golder Associates 1992; Breckenridge and Othberg 1991).

Late Tertiary caldera boundary faults are postulated to exist in the silicic volcanic rocks beneath the Snake River Group. There are several bases for this postulation:

1. Calderas like those that exist on the Yellowstone Plateau today must have been associated with the late- Tertiary silicic volcanic fields occurring along the margins of the ESRP.
2. In some areas (southern ends of the Lemhi and Beaverhead Ranges near INEL, and northern ends of the Caribou and Snake River Ranges near Rexburg) structures interpreted to be caldera boundary structures have been recognized (Morgan 1988).
3. The great thicknesses of silicic volcanic rocks observed in INEL deep exploration holes, INEL-1 and WO-2 (Figure 2-9), indicate that they were emplaced into an intra-caldera setting.

The exact sizes, shapes, and locations of the buried calderas is uncertain, but interpretations have been made (Figure A-4) on the basis of geophysical anomalies, positions of volcanic fields, flow-direction indicators in ash flow sheets, and paleomagnetic data (Morgan 1988). Several general observations are possible, however. Caldera size is such that some of them are likely to span the entire width of the ESRP. Caldera shape, and thus the configuration of associated caldera boundary faults, are generally circular to oval. Given the tendency for calderas to overlap each other (Figure A-4), it is likely that most of the ESRP boundary is characterized by caldera boundary faults buried beneath the edges of the Snake River Group. Caldera boundary faults can explain, in a manner consistent with data and concepts, Pankratz and Ackermann's (1982) interpreted buried fault along the northwest margin of the ESRP.

Several lines of evidence, summarized in Section 2.1.4, show that the calderas are no longer active because the causative heat source has moved to a new position beneath Yellowstone. The possibility of reactivation of the faults due to contemporary tectonism should be considered, but does not seem to be a cause for concern for two reasons: (a) Since the faults have a circular to oval configuration, they are not likely have long sections oriented properly for movement in contemporary stress fields; (b) No late-Pleistocene or Holocene faulting that could be related to reactivation of these faults is observed on the ESRP (Golder Associates 1992).

A.2.4.3 Volcanic Rift Zones and Axial Volcanic Zone. Volcanic vents on the ESRP are concentrated in NW-trending and NE-trending linear belts (Figure 2-21 and 2-22). The

NW-trending belts have associated ground deformation features and are referred to as VRZs (VRZs). The ground deformation features are fissures, faults, grabens, and monoclines that form due to dilational stresses above the tops of basalt dikes as magma moves from depth to the surface. Three VRZs occur in the INEL region of the ESRP, the Great Rift VRZ (which extends southeastward from Craters of the Moon National Monument), the Arco VRZ (which extends SE from Arco across the southwestern corner of the INEL), and the Lava Ridge-Hells Half Acre VRZ (which extends from the south end of the Lemhi Range to the Hells Half Acre lava field) (Figure 2-22).

By analogy with active VRZs in other parts of the world (Iceland and Hawaii), it can be inferred that VRZs are sources of earthquakes during periods of volcanic activity (see Section 2.1.4). Even though the magnitudes of VRZ earthquakes are smaller ($M < 5.5$) than those of the B&R faults ($M > 7.0$) (see Section A.2.6), their closer proximity to INEL facilities indicates that they can be significant contributors to both deterministic and probabilistic seismic hazards (Woodward-Clyde Consultants 1992a).

Some volcanic vents on the ESRP are concentrated in a northeast-trending zone along the axis of the ESRP (Figure 2-21 and 2-22). This is called the Axial Volcanic Zone (AVZ) to distinguish it from VRZs. It is important to make this distinction because the AVZ does not contain northeast-trending ground deformation features that would qualify it to be a VRZ. The few ground deformation features that do occur in the AVZ are NW-trending fissures. This indicates that the volcanic vents in the AVZ are fed by NW trending dikes and that, even though it is not a VRZ, seismicity can be associated with volcanism there. Thus it also plays an important role in deterministic and probabilistic seismic hazards assessment (Woodward-Clyde consultants 1992a).

The VRZs and the northeast-trending Axial Volcanic Zone have remained as highlands throughout much of the development of the ESRP and thus do not receive as much sediment as the basins between. This results in large scale heterogeneities in seismic energy transmission properties and in aquifer properties.

A.2.5 Correlation of Earthquake Activity with Geologic Structures or Tectonic Provinces

Figure A-8 shows a compilation of the minimum principal stress directions for the ESRP region derived from focal mechanisms, geologic indicators, and borehole breakouts (Jackson et al. 1993; Pierce and Morgan 1992; Peyton et al. 1991; Zoback and Zoback 1989). The minimum principal stress directions indicate northeast-trending extension northwest of the ESRP and more east-trending direction south of the ESRP. Although a rotation in the stress field may occur somewhere within the ESRP, the ESRP appears to be subjected to the same extensional stress field as the surrounding region (Jackson et al. 1993). Strain rates have been compiled by Eddington et al. (1987) for the ESRP region (Figure A-9). Strain rates for the region around the ESRP range between 1.1×10^{-15} per sec for Yellowstone Plateau to 3.8×10^{-17} per sec for the ISB. Preliminary estimates for the ESRP are 1×10^{-16} per sec based on the amount of extension measured within the ESRP rift zones for the Holocene and is similar to strain rates outside the

As compiled by Zoback and Zoback (1989), and from the 1989 ESRP composite microearthquake focal mechanisms of Jackson et al. (1993). Letters near T-axes denote stress-indicator types: F, focal mechanism; G, fault-slip data; B, borehole breakouts; V, alignment of rift-zone features. Quality rankings (a through d) are from Zoback and Zoback (1989). Borehole-televviewer log of well INEL-1 showed no borehole breakouts, implying low deviatoric stresses within the ESRP (Moos et al. 1990). Faults are from Witkind (1975), Bond (1978), Anderson and Miller (1979), Stickney and Bartholomew (1983), and Hecker (1991). Volcanic-fissure sets are from Smith et al. (1989) and Kuntz et al. (1992).

Figure A-8. Map of southern Idaho, showing the distribution of minimum-principal-stress orientations.

Figure A-9. Strain-rate map of southern Idaho (Eddington et al. 1987).

measured within the ESRP rift zones for the Holocene and is similar to strain rates outside the ESRP (Hackett et al. 1991).

Table A-6 lists earthquakes $M \geq 5.5$ that have occurred within a 322-km (200-mi) region around the INEL and that can be correlated with tectonic structures. This table includes the seismic moments, focal mechanisms, focal depths, rupture lengths, and horizontal and vertical displacements computed by various seismological methods for these earthquakes (see references in the table for more details). The following discussion of earthquakes and their relationships to geologic structures or provinces is separated into areas based on tectonic provinces.

A.2.5.1 ESRP Province.

A.2.5.1.1 Seismicity—Stover et al. (1986) noted 14 historic earthquakes that may have possible locations within the SRP (Stover et al. 1986). Figure A-10 shows their locations and Table A-7 lists their dates of occurrence, intensities, magnitudes (if reported), and location uncertainties. Earthquakes listed in Table A-7 occurring between 1905 and 1937 have locations based on felt reports and, therefore, large location errors. The earthquakes listed for 1954, 1964, and 1969 have instrumentally determined locations, but due to the lack of local seismic networks prior to 1970, they also have large location errors.

In compiling earthquake data (pre-1970) into the Decade of North American Geology catalog for the western United States, Engdahl and Rinehart (1988; 1991) selected only large magnitude earthquakes to represent earthquake source zones. Source zones were defined by using instrumentally located epicenters (post-1970) to determine seismically active areas. Within these areas, only large magnitude earthquakes (pre-1970) would be retained in the catalog. Thus, Figure A-1 excludes the epicenters for eight of the possible SRP events due to their low intensities (hence, low magnitudes) and large location errors, and includes only the epicenters for the 1905 (M_L 5.5) Shoshone, 1928 (M_L 5.2) and 1937 (M_L 5.4) events. Although, the epicenters for the 1928 and 1937 events are outside of the SRP boundaries as shown in Figure A-1 (located near the Idaho-Nevada border), Woodward-Clyde Consultants (1992a) included it within the SRP since Smith and Arabasz (1991) extend the SRP boundary to Idaho-Nevada border based on distribution of rhyolitic volcanic rocks. More commonly, as shown in Figure A-1, the SRP boundaries are defined by topographic features which separate the flat, low-lying SRP region from the surrounding mountainous region (B&R province).

Figure A-1 shows that from 1884 through 1989, the 1905 earthquake near Shoshone, Idaho is the only event located within the SRP. The November 11, 1905 Shoshone earthquake occurred before there was instrumental monitoring in Idaho and, since its location was based on felt reports, it may have an error of 100 km or more. This earthquake is significant to assessing seismic hazards at INEL, since it may have originated within the SRP.

A.2.5.1.2 1905 Shoshone Earthquake—Recently, Oaks (1992) conducted a comprehensive investigation of historical records throughout an eight-state region to determine the magnitude and epicenter of the Shoshone earthquake. For the investigation, historical

Table A-6. Earthquakes within 322 km (200 mi) that have occurred on tectonic structures.

Earthquake Date & Time (Hr:Mn - UTC) ^a	Seismic Moment ^b ($\times 10^{25}$ dyne-cm)	Focal Mechanism Strike/Dip/Rake ^c (Degrees)	Tectonic Structure, Source Parameters and Dimensions, and References ^d
1925 July 10 14:45	10 ± 2 B	30 80 -175 FM 250 56 - 38 BW	Associated with a fault oriented in an oblique manner north of the Clarkston Valley Fault north of Bozeman, Montana. Z=9 $\pm$ 5 km (LP); RL=25 $\pm$ 5 km (BW), 59 $\pm$ 5 km (SF); SD=2.0 $\pm$ 1.0 m (v). (1,2)
1934 March 12 15:05	0.95 G 8.6 ± 2 B	7 80 - 70 FM 40 87 - 11 BW 0 73 -110 SF	Caused a fault scarp along an unnamed fault in Hansel Valley, Utah. Z= 8 $\pm$ 2 km (LP); RL=11 $\pm$ 3 km (BW), 6 $\pm$ 2 km (SF); BWD= -2.1 $\pm$ 0.1 m (h), 0.2 $\pm$ 0.05 m (v); SD= -0.2 (h), 2.0 $\pm$ 1.0 m (v); GD= 0.4 $\pm$ 0.1 m (v). (1,3)
1934 March 12 18:20	0.77 ± 0.3 B	25 85 - 20 BW	Aftershock to March 12, 1934 earthquake. Z= 8 $\pm$ 7 km (LP); RL=7 $\pm$ 3 km (BW); BWD= -0.5 $\pm$ 0.1 m (h). (1,4)
1947 December 17 12:38	1.8 ± 0.5 B	120 60 -120 FM 104 48 -170 BW	Possibly associated with the Madison Fault northwest of Hebgen Lake, Montana. Z= 8 $\pm$ 2 km (LP); RL=9 $\pm$ 2 km (BW); BWD= -0.7 $\pm$ 0.2 m (h). (1,2,5)
1959 August 18 06:37 (M _s 7.5)	41 G 150 L 120 S	102 60 - 90 SW 120 70 - 90 SF 132 45 - 90 GE	Caused a fault scarp along the Hebgen and Red Canyon faults near Hebgen Lake, Montana. No distinction between subevents: Z= 11 $\pm$ 2 km (LP); RL=24 $\pm$ 4 km (SF), 40 $\pm$ 4 km (GE); SD= 4.4 m (v); GD= 7.4 $\pm$ 0.4 m (v). (1,6)
1959 August 18 06:37 (M _w 6.3)	2.8 B	102 60 - 90 FM 95 42 - 90 BW	Subevent 1: Z= 10 $\pm$ 2 km (LP); RL=7 $\pm$ 1 km (BW); BWD= 0.95 m (v). (1,6)
1959 August 18 06:37 (M _w 7.3)	92 B	100 54 - 90 FM 95 42 - 90 BW	Subevent 2: Z= 15 $\pm$ 3 km (LP); RL=21 $\pm$ 5 km (BW); BWD= 6.8 m (v). (1,6)

Table A-6. (continued).

Earthquake Date & Time (Hr:Mn - UTC) ^a	Seismic Moment ^b ($\times 10^{25}$ dyne-cm)	Focal Mechanism Strike/Dip/Rake ^c (Degrees)	Tectonic Structure, Source Parameters and Dimensions, and References ^d
1959 August 18 07:56	nd	70 55 - 45 FM	Aftershock to August 18, 1959 earthquake. nd. (1)
1959 August 18 08:41	nd	70 65 - 15 FM	Aftershock to August 18, 1959 earthquake. nd. (1)
1959 August 18 11:03	nd	50 64 31 FM	Aftershock to August 18, 1959 earthquake. nd. (1)
1959 August 18 15:26	3.10 B 5.5 S	90 60 - 70 FM 83 50 - 90 BW	Aftershock to August 18, 1959 earthquake. Z= 10 ± 2 km (LP); RL= 9 ± 1 km (BW). (1)
1959 August 19 04:04	1.1 ± 0.3 B 4.8 S	60 75 -155 FM 57 80 -161 BW	Aftershock to August 18, 1959 earthquake. Z= 8 ± 2 km (LP); RL= 11 ± 2 km (BW). (1)
1962 August 30 13:35	0.52 ± 0.2 B	185 58 - 85 FM 201 49 -108 BW	Associated with the Temple Ridge fault, Cache Valley, Utah. Z= 12 ± 2 km (LP); RL= 3 ± 1 km (BW); BWD= 0.55 ± 0.2 m (h). (1,7)
1964 October 21 07:38	1.10 ± 0.3 B	310 60 18 FM 307 56 14 BW	Aftershock to August 18, 1959 earthquake. RL= 3 ± 1 km (BW). (1)
1975 March 28 02:31	1.23 ± 0.6 B 2.4 L 1.2 S	225 39 - 53 FM 200 38 - 70 BW 210 60 - 90 GE	Associated with an unnamed fault in Pocatello Valley, Utah. Z= 9 ± 2 km (LP), 5 ± 2 km (SP), 12 km (GE); RL= 12 ± 2 km (BW), 18 ± 2 km (GE); BWD= 0.75 ± 0.25 m (v); GD= 0.50 m (v). (1,8,9)
1975 June 30 18:54	0.75 S	302 71 -129 FM	Associated with an unnamed fault near the north-central boundary of the Yellowstone Caldera, Wyoming. Z= 6 ± 1 km (SP); GD= 0.12 m (v). (1,9,10)

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Table A-6. (continued).

Earthquake Date & Time (Hr:Mn - UTC) ^a	Seismic Moment ^b ($\times 10^{25}$ dyne-cm)	Focal Mechanism Strike/Dip/Rake ^c (Degrees)	Tectonic Structure, Source Parameters and Dimensions, and References ^d
1983 October 28 14:06	28 G 21 B 29 L	138 45 - 60 FM 155 50 - 65 BW 160 70 - 70 SF 152 49 nd GE	Caused a fault scarp along the Thousand Springs segment of the Lost River Fault in central Idaho. Z= 16 $\pm$ 4 km (LP), 12 $\pm$ 2 km (SP), 14 km (GE); RL= 21 $\pm$ 2 km (BW), 19 $\pm$ 2 km (SF), 20 $\pm$ 2 km (GE); BWD= -0.20 m (h), 1.30 m (v); SD= -0.30 m (h), 1.50 m (v); GD= 2.10 m (v). (1,11)
1983 October 28 19:51	0.13 B 0.24 S	287 58 -165 FM 282 48 -159 BW 286 70 -155 SF	Aftershock to October 28, 1983 earthquake. Z= 10 km (LP), 10 km (SP), 10 km (GE); RL= 6 $\pm$ 2 km (BW). (1)
1983 October 29 23:29	0.20 B	309 51 - 65 FM 317 45 - 90 BW	Aftershock to October 28, 1983 earthquake. Z= 19 $\pm$ 9 km (LP), 10 km (SP); RL= 8 $\pm$ 1 km (BW). (1)
1984 August 22 09:46	0.24 B	170 70 - 5 FM 348 85 -160 BW	Aftershock to October 28, 1983 earthquake. Associated with the Challis segment of the Lost River fault and possibly caused slip (M 5.0) on an antithetic fault, the Lone Pine fault, central Idaho. Z= 10 km (LP), 10 km (SP); RL= 7 $\pm$ 1 km (BW). (1,12)

a - UTC - Universal Time Coordinated (Greenwich Mean Time).

b - Seismic moments based on: G - geology; B - body-wave analysis; L - Geodetic observations; S surface-wave analysis from Doser and Smith, 1989.

c - Focal mechanisms based on: FM - first motions; BW - body-wave analysis; SF - surface-wave analysis; SF - surface faulting; GE - geodetic observations from Doser and Smith, 1989.

d - Earthquake source parameters and dimensions: Z - focal depth from long-period waves (LP), short period waves (SP), and geodetic observations (GE); RL - rupture length from body waves (BW), surface faulting (SF), and geodetic observations (GE); BWD - body-wave displacement, SD - surface displacement, and GD - geodetic displacement for horizontal (h) and vertical (v) orientations. Numbers in parentheses corresponds to references listed below. For obtaining original references see Doser and Smith, 1989.

References: (1) Doser and Smith, 1989; (2) Doser, 1989a; (3) Shenon, 1936; (4) Doser, 1989b; (5) Dewey et al., 1973; (6) Doser, 1985b; (7) Westaway and Smith, 1989; (8) Cook and Nye, 1979; (9) Bache et al., 1980; (10) Pitt et al., 1979; (11) Crone et al., 1987; (12) Jackson et al., 1991a.

Figure A-10. Historic earthquakes on the ESRP (Stover et al. 1986).

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Table A-7. Historical earthquakes possibly located within the ESRP.^a

Date	Origin Time (UTC) ^b	Intensity ^c	Magnitude	Location Error (km) ^d
11 November 1905	22:29 ^e	MM VII	M _L 5.5 ^f	± 100-200
20 February 1909	01:nd	MM II	nd	± 50-100
6 December 1925	16:16	Felt	nd	± 50-100
7 August 1927	nd	Felt	nd	± 50-100
5 September 1928	05:36	Felt	M _L 5.2 ^g	≥ ± 100
6 June 1932	11:00	MM II	nd	± 50-100
21 December 1932	08:00	MM II	nd	± 50-100
28 April 1934	09:30	MM IV	nd	± 100-200
28 April 1934	10:00	MM III	nd	± 100-200
29 April 1934	06:10	MM III	nd	± 100-200
18 November 1937	23:50	nd	M _L 5.4 ^h	nd
1 February 1954	03:33:19. ⁱ	nd	nd	± 50-100
20 January 1964	10:09:39.7 ⁱ	nd	nd	± 22-56
28 February 1969	15:30:24.4 ⁱ	nd	nd	± 22-56

a - Modified from Woodward-Clyde Consultants (1992a).

b - Origin time shown as hour:minute:second for Universal Time Coordinated (UTC), as reported in Stover et al. (1986).

c - MM = Modified Mercalli Intensity (Wood and Neumann, 1931). Felt = Earthquake felt but no intensity assigned.

d - Estimated from Stover et al. (1986).

e - According to Oaks (1992) Shoshone earthquake occurred at 22:29 and not 21:29 as reported by Stover et al. (1986).

f - Richter magnitude (M_L) calculated by Oaks (1992).

g - Magnitude obtained from Slemmons et al. (1965).

h - Information obtained from Engdahl and Rinehart (1988).

i - Instrumentally computed location.

nd - No data.

documents were sought from Nevada, Oregon, Idaho, Utah, Wyoming, Montana, California, Colorado, and Washington, D.C. Primary sources included original field notes of the Department of Agriculture weather observers reports, daily and monthly journal notations by U.S. Army Surgeons and other scientific and military personnel at U.S. Army Command posts, personal diaries, and church records. Secondary sources, those transcribed from primary sources for use in another document, included newspapers, journal articles, books, maps, reports, and earthquake catalogs.

From a compilation of damage reports, Oaks (1992) determined the Modified Mercalli intensity for towns in Idaho, Utah, Nevada, and Oregon. Figure A-11 shows the contours for intensities IV and V, and the possible location of the epicenter near the Idaho-Utah border. Both Shoshone, Idaho and Elko, Nevada reported damage which correspond to intensity VI. It is noted that for other earthquakes (see Figure A-3 and A-12) these towns report higher intensities than surrounding towns (Stover 1985). A magnitude of $M_L 5.5 \pm 0.5$ was estimated for the Shoshone earthquake based on notes of seismic-wave amplitudes observed on a seismogram recorded by a station in Canada and measurements of the area within of the intensity V contour. Comparison of the intensity contours for the 1905 earthquake with earthquakes occurring near the Idaho-Utah border in 1934 ($M_L 6.6$), 1962 ($M_L 5.7$), and 1975 ($M_L 6.0$) also provides further support for an origin outside the SRP. Even though this study suggests the earthquake may be located outside the SRP, recent seismic hazards assessments at INEL estimated the level of ground motions from an earthquake similar in size to Shoshone occurring within the ESRP near the INEL.

A.2.5.1.3 INEL Seismic Monitoring. Local seismic monitoring within the ESRP began in December 1971 when a seismic station was installed at INEL (King et al. 1987). By 1979, this network included six stations located within and near the boundaries of the ESRP. Seismic stations were added to the network beginning in 1986. Currently, the INEL seismic network consists of 24 seismic stations (Figure A-13).

Earthquake data have been compiled by the INEL seismic network for a 19-year period from 1972–1990, primarily covering the ESRP (Figure A-13). During this period, approximately 19 microearthquakes have been located within or near the boundary of the ESRP, indicating that infrequent, small-magnitude earthquakes ($M \leq 1.5$) may be characteristic of ESRP seismicity (Jackson et al. 1990; Pelton et al. 1990; Jackson et al. 1993). Although 13 of these microearthquakes have occurred near or within the INEL boundary, Jackson et al. (1993) indicate that the INEL area of the ESRP is not more microseismically active than other areas, but rather that the INEL seismic network has an adequate detection threshold ($M = 0$) to record these small events.

Figure A-1 shows that 1884–1989 earthquakes ($M_L \geq 2.0$) were located in the ISB and CTB, but not within the ESRP. Also, earthquakes are located closest to the margins of the ESRP near the Yellowstone Plateau and farthest [up to 70 km (43.5 mi) away] from the ESRP margins near the Great Rift and Pocatello. From similar compilations of earthquake data, several investigators have concluded that the ESRP is aseismic (Smith and Sbar 1974; Smith 1978; Smith et al. 1985;

Figure A-11. Isoseismal-contour map for the 1905 Shoshone, Idaho earthquake (Oaks 1992).

Figure A-12. Isoseismal-contour map for the M_b 6.1, 1975 Pocatello Valley, Idaho earthquake (Cook and Nye 1979).

Figure A-13. Earthquake epicenters and magnitudes, as located by the INEL seismic network between 1972 and 1990. Only earthquakes of $M_c < 1.5$ have been located within the ESRP. Earthquakes northwest of Mackay are largely associated with the 1983 Borah Peak mainshock-aftershock sequence. Dashed lines show approximate boundary of the ESRP. Lines indicate basin-and-range normal faults from Anders et al. (1989), Stickney and Bartholomew (1987), and Scott et al. (1985). Triangles show locations of stations in the INEL seismic network.

Smith and Arabasz 1991). Contemporary seismic monitoring of the ESRP (1970–1991) suggests that only infrequent small-magnitude earthquakes (19 events over 19 years of $M_L \leq 1.5$) occur within the ESRP as compared to the 1000s of events of similar and larger size that occur within the surrounding region. Although it is recognized that historic earthquakes may have occurred within the ESRP, their large location uncertainties do not support origins within the ESRP, particularly when other geologic and geophysical data are considered.

A.2.5.1.4 Hypotheses for Aseismic Nature of ESRP—Earthquakes up to M_s 7.5 associated with basin-and-range faults have occurred within the ISB, but only small magnitude earthquakes ($M_L \leq 1.5$) have been detected instrumentally within the ESRP. Several investigators have attempted to explain the lower seismicity within the ESRP compared to the CTB and ISB. Their analyses have considered the distribution of instrumental seismicity and active faults, topography (surficial geologic features), the historical geologic record (formation of the ESRP and B&R province), tectonic stress patterns, crustal heat flow, and crustal- and upper-mantle compositions and properties. Earthquakes in the CTB and ISB indicate that the region around the ESRP is subjected to a tectonic extensional stress field that actively extends the crust by normal faulting which over millions of years produces mountains and valleys. The ESRP is also subjected to this same stress field and possibly similar strain rates (Figures A-8 and A-9), but crustal normal faults of this nature are not present within the ESRP, leading investigators to propose alternative mechanisms for extensional deformation:

1. **Aseismic Creep.** Smith and Sbar (1974) and Brott et al. (1981) suggest that deformation occurs by creep in response to high crustal temperatures beneath the ESRP. Comparisons of heat flow data in and outside the ESRP suggests that temperatures are higher beneath the ESRP (Brott et al. 1981; Blackwell 1989; 1992). Unlike the Basin and Range where brittle deformation (rock fracture) occurs in the form of earthquakes to raise the mountains and lower the valleys, the ESRP would experience ductile deformation (aseismic creep) because high temperatures near the mid-crust would allow rocks to flow rather than fracture.
2. **Crustal Strength.** Anders et al. (1989) suggest that the ESRP and the adjacent region near its boundary or "collapse shadow" region have increased integrated-lithospheric strength. They propose that the presence of a mid-crustal mafic intrusion (see Figure 2-8) strengthens the crust so that it is too strong to fracture. Smith and Arabasz (1991) also suggested that the mid-crustal mafic body beneath the ESRP may act to increase crustal strength and thereby, reduce the seismic capability of the ESRP.
3. **Dike-Injection.** Parsons and Thompson (1991) proposed that magma overpressure through dike injection suppresses normal faulting and associated seismicity by altering the local tectonic stress field. This process also provides a way for the ESRP to extend and keep pace with extension occurring in the surrounding Basin and Range province or ISB (Rodgers et al. 1990; Hackett and Smith 1992). As dikes are injected, they push a part the surrounding rocks and the net effect is to extend the crust.

4. **Crustal Strain Rates.** Anders and Sleep (1992) proposed a model of magmatism and extension to explain the lower rates of seismicity and latest Quaternary faulting within the "collapse shadow" region. They suggest that the introduction of mantle-derived mafic magmas into the mid-crust beneath the ESRP affects the crustal structure and properties, which in-turn influence the strain rates (causes accelerated faulting and subsequent fault-quiescence) during and after the passage of the Yellowstone hotspot.

A.2.5.1.5 Causes of ESRP Microearthquakes—Investigators have also suggested possible mechanisms for microearthquakes that occur within the ESRP. Because the ESRP is a volcanic province, magmatic processes have been considered as a possible mechanism for the low-level microearthquakes. Brott et al. (1981) suggested that microearthquakes may be a result of subsidence due to cooling and contraction of the ESRP following the passage of the hotspot. Pelton et al. (1990) suggested association with dike-injection or mass loading of the crust by the rhyolite domes located near the axis of the ESRP. Jackson et al. (1993) observed that the microearthquakes which have occurred in the ESRP from 1972–1990 do not have the distinct spatial or temporal patterns observed during contemporary dike-injection events at Kilauea, Hawaii or Krafla, Iceland (Brandsdottir and Einarsson 1979; Einarsson and Brandsdottir 1980; Klein et al. 1987) and therefore are not due to volcanism. Although no detailed analyses of mass loading and its role in producing microearthquakes within the ESRP has been performed, Jackson et al. (1993) attribute the occurrence of microearthquakes ($M \leq 1.5$) to small-scale faulting in the shallow crust, in response to the regional extensional tectonic stress field.

A.2.5.1.6 Volcanic Seismicity—There are small dike-induced normal faults located within the VRZs (see Section 2.1.4). Seismic studies at active VRZs, such as in Hawaii and Iceland, and theoretical and physical models of the resulting surficial deformation features indicate that dike-injection can produce small normal faults which extend to or slightly below the top of the dike [2–4 km (1.2–2.5 mi)] (Mastin and Pollard 1988; Ryan 1987; Rubin and Pollard 1987; 1988; Rubin 1990, 1992). Since a dike-injection event has not been observed within an ESRP rift zone, active analogs are used to estimate the maximum magnitude of earthquakes that would accompany future ESRP volcanism (Table A-8). Small magnitude earthquakes, commonly less than 4.5, usually accompany basalt dike injection, although magnitude 5.5 earthquakes have been observed (Hackett et al. in press; Woodward-Clyde Consultants 1992a). Rubin (1992) suggests that some small normal faults form aseismically through multiple offsets as dike-injection occurs. Bjornsson et al. (1977) observed offsets of 1–2 m (3.3–6.6 ft) along normal faults during intrusion into a Krafla rift zone where the largest magnitude of the associated seismicity was 3.8.

In addition to observed seismicity during active dike-injection events, the empirically based relationship of fault-area vs. moment magnitude (M_w) developed by Wells and Coppersmith (in press) is used to estimate the upper bound for the maximum magnitude of seismicity associated with dike-injection in ESRP VRZs. Table A-9 shows the range of magnitudes, $3.3 \leq M_w \leq 5.3$, derived from the fault area vs. moment magnitude relationship for normal fault lengths within the Arco and Lava Ridge-Hells Half Acre VRZs. These values are somewhat similar to the observational values shown in Table A-8. Using the fault-area versus maximum magnitude relationship to estimate the maximum magnitude, the result is in an upper bound for several

Table A-8. Maximum magnitudes of earthquakes associated with dike injection in VRZs.^a

LOCATION ^b	RIFTING EVENT ^c (Year)	MAXIMUM MAGNITUDE ^d	REFERENCES
Iceland			
Krafla	1975-76	5.0 ^e	1,2
Krafla	1977	3.8 ^e	3
Krafla	1978	4.1 ^e	4
Hawaii, USA			
Kilauea Rift Zones			
East	1965	4.4(M _L)	5
East	1968, Aug.	3.3	6
East	1968, Oct.	3.1	6
East	1969	4.7	7
Southwest	1975	3.0	8
East	1976-77	4.0	8
East	1980, Aug.	3.0(M _C) ^f	9
East	1980, Nov.	3.1(M _C) ^f	9
Southwest	1981	3.4(M _C) ^f	9
East	1982	3.0(M _C) ^f	9
Japan			
Izu Peninsula	1989	5.5(M _{JMA})	10,11,12
Africa			
Asal, Afar	1978	5.3(M _b)	13,14
New Zealand			
Taupo Volcanic Zone ^g	1964-65	4.6	15
Taupo Volcanic Zone ^g	1983	4.3	15
California, USA			
Mono Craters ^h	1325 ± 20	> 6.5(M _S)	16
Mean and 1-sigma/n=18ⁱ			
		4.1 ± 1.0	17

a - Modified from Hackett et al., in press.

b - Worldwide dike-injection events associated with mafic magma; composition of magma for Japan and New Zealand episodes are unknown.

c - An episode of dike-injection and associated seismicity having a beginning and end.

d - Maximum magnitude reported for the dike-injection event. Magnitudes: M_L - Local or Richter; M_C - Coda; M_{JMA} - Japan Meteorological Agency; M_b - Body-wave; M_S - Surface-wave.

e - Einarsson (1991) reports earthquakes of magnitude ≥ 5.0 are usually associated with caldera deflation events and magnitude ≤ 4.0 with dike injection at Krafla.

f - Coda magnitudes greater than amplitude magnitudes for these events (Nakata et al., 1981; Tanigawa et al., 1980, 1983).

g - Possibly associated with tectonic subsidence of the basin or triggered by dike injection (14).

h - Minimum estimate of the largest of five historic earthquakes based on liquefaction deposits as per (16). These earthquakes may be associated with movements along tectonic faults.

i - Mean and one standard deviation computed based on magnitudes as presented.

nd - No data obtained.

References: (1) Einarsson & Bjornsson, 1979; (2) Bjornsson et al., 1977; (3) Brandsdottir and Einarsson, 1979; (4) Einarsson and Brandsdottir, 1980; (5) Bosher and Duennebier, 1985; (6) Jackson et al., 1975; (7) Swanson et al., 1976b; (8) Dzurisin et al., 1980; (9) Karpin and Thurber, 1987; (10) Okada and Yamamoto, 1991; (11) Takeo, 1992; (12) Oura et al., 1992; (13) Abdallah et al., 1979; (14) Lepine and Hirn, 1992; (15) Grindley and Hull, 1986; (16) Sieh and Bursik, 1986; (17) Hackett et al., in press.

Table A-9. Calculated moment magnitudes from fault area for normal faults in ESRP VRZs.

Rift Zone	Normal Fault	Length ^a (km)	Depth Extent ^b (km)	Fault Area ^c (km ²)	Moment Magnitude ^d
Arco, ESRP ^e	Railroad Monocline	5	4	20	5.32
	Jaylin Monocline	1.3	1.3	1.69	4.25
	Box Canyon-NE	1.3	1.3	1.69	4.25
	Box Canyon-SW	3	3	9	4.97
	East-West	0.65	0.65	1.2	4.13
	Section 6	0.50	0.50	1.0	3.62
	Sect. 11	0.20	0.20	0.4	3.62
	Sect. 3	0.10	0.10	0.20	3.32
	Sect. 8	0.30	0.30	0.60	3.80
	Sect. 17	0.50	0.50	1.00	4.02
	Sect. 7	0.30	0.30	0.60	3.80
LR-HHA, ESRP ^e	Lapoint Monocline	1.4	1.4	2.8	4.47
Mean +1-sigma (N=12)					4.13 ± 0.58

- a - Maximum normal fault length observed at the surface in the volcanic rift zone having vertical offset and produced by dike-injection.
- b - Maximum downdip width of the normal fault is based on depth for the level of neutral buoyancy, 4 km (Ryan, 1987). In cases where lengths are less than 4 km, the downdip width is assumed to be equivalent to its length. The intent is to estimate the maximum area possible.
- c - Surface length x downdip width.
- d - Calculated using: $M_w = 4.01 + 1.0 \times \log_{10}(A)$; where A = fault-area and M_w = moment magnitude (Wells and Coppersmith, in press). The relationship is independent of the sense of slip.
- e - Smith et al., 1989; Golder Associates, 1992; Kuntz et al., 1992.

reasons (Hackett et al. in press): (a) deformation can occur aseismically and seismic moment release may be small compared to total moment released through inelastic deformation (Filson et al. 1973; Stein et al. 1991; Rubin 1992), (b) faults move in small increments due to slow dike propagation resulting in short, discontinuous segments with variations in amounts of displacement, (c) dike-induced normal faults have shallow downdip widths resulting in small areas for rupture (Daz and Scholtz 1983), (d) using magnitude-fault area relationships assumes rupture along the entire length, but observations indicate that the faults move in small increments or even aseismically, and (e) the relationship of moment magnitude to fault area assumes a crustal value for rigidity (3×10^{11} dyne/cm²), which may be lower for near-surface volcanic rocks to appropriately describe volume changes ($\sim 0.5\text{--}1.8 \times 10^{11}$ dyne/cm²; Filson et al. 1973; Mori et al. 1989; Stein et al. 1991).

Recurrence intervals of the dike-induced seismicity within the ESRP VRZs are based on the volcanic rock record. For the current probabilistic assessments, the maximum magnitude earthquake is assumed to occur during each dike-injection episode (see Section 2.1.4). Observational seismicity during dike-injection events at Krafla and Hawaii suggest that some proportion of the episodes of dike injection are not accompanied by magnitude 5.5 earthquakes.

A.2.5.2 Northern Basin and Range.

A.2.5.2.1 CTB—The 1983 M_s 7.3 Borah Peak, Idaho earthquake is the largest event to occur in the CTB (Figures A-1 and A-2). Figure A-3 shows a map of intensity distributions (Stover 1985). It originated at a depth of 16 ± 4 km (10 ± 2.5 mi), near the base of the seismogenic crust (Doser and Smith 1985). It ruptured to the northwest producing 36 km (22.4 mi) of surface faulting along the Thousand Springs and a portion of the Warm Springs segments of the Lost River fault. It also produced a surface scarp with a maximum of 2.7 m (89 ft) vertical displacement (Crone et al. 1987). The Borah Peak mainshock and aftershocks define a normal fault dipping 40 to 50 degrees to the southwest which is consistent with dips determined from first motions, body-wave analysis, and geodetic observations (Table A-6) (Richins et al. 1987). The stress drop determined from seismic moment is 17 bars and from geologic data, 12 bars. Even considering the possible sources of error in the calculations, the stress drop probably did not exceed 75 bars suggesting that the Borah Peak earthquake was a low stress-drop event when compared to other normal faulting earthquakes in the same magnitude range (Doser and Smith 1985).

A.2.5.2.2 ISB—Several moderate to large magnitude earthquakes that can be correlated to tectonic structures, have occurred within the central part of the ISB near the ESRP (Figure A-2):

1. **Hansel Valley.** The March 12, 1934, M_L 6.6, Hansel Valley Utah earthquake was felt over an area of 440,000 km² and reached Modified Mercalli intensity VIII (Smith and Arabasz 1991). Shenon (1936) mapped north-trending subparallel fractures displacing salt flats and unconsolidated late Quaternary sediments in the southwestern part of Hansel Valley over an area 6 km (3.7 mi) wide and 12 km (7.5 mi) long. Up to 50 cm (20 in.) of vertical

displacement and 25 cm (10 in.) horizontal offset were reported by dePolo et al. (1989). The focal mechanism from seismic wave-form modeling by Doser (1989b) indicates that the mainshock occurred along a strike-slip fault with left-lateral slip on a northeast-trending structure. The event originated at focal depth of 8–10 km (5–6.2 mi) and had a subsurface rupture length of 11 km (6.8 mi) (Doser 1989b).

2. Cache Valley. Re-analysis of seismograms for the August 30, 1962, M_b 5.7, Cache Valley earthquake indicates that it may be associated with the Temple Ridge fault, a less prominent feature with only 500 m (1,640 ft) of Neogene throw located east of the East Cache fault (Westaway and Smith 1989). Focal depth is estimated to be 10 ± 2 km (6.2 ± 1.2 mi) and focal mechanisms from first motions and body wave analysis suggest a dip of 49 and 58 degrees, respectively, to the west (Table A-6). Woodward-Clyde Consultants (1992a) estimated Brune and RMS stress drops of 25.2 ± 5.2 bars and 45.4 bars, respectively.
3. Pocatello Valley. The March 28, 1975, M_b 6.1, Pocatello Valley earthquake occurred along a northeast-trending structure with a large left-lateral component of slip (Bache et al. 1980). Figure A-12 shows the Modified Mercalli intensity distribution (Cook and Nye 1979). Studies of the aftershock sequence were consistent with a fault dip of 39 degrees to the northwest (Arabasz et al. 1979). The event originated at a focal depth of about 9 km (5.6 mi) (Table A-6) and has an inferred stress drop of about 50 bars for initial faulting (Bache et al. 1980).

A.2.5.3 Yellowstone Plateau.

A.2.5.3.1 Hebgen Lake—The August 18, 1959, M_b 7.5, Hebgen Lake earthquake is the largest event to occur in the ISB region. Figure A-14 shows the Modified Mercalli intensity distribution from (Eppley and Cloud 1961). Seismic waveform analysis by Doser (1985b) indicates that the mainshock was a double event consisting of subevent one, an M_b 6.3 followed 5 sec later by subevent two, an M_b 7.0. Her analysis also suggests that the rupture occurred along one or more fault planes with east-west strike orientations (Table A-6) slightly discordant with the trace of surface faulting along the Hebgen and Red Canyon faults. Maximum vertical displacements of 6.7 m (22 ft) over a surface scarp length of 23 km (14.3 mi) and 6.1 m (20 ft) over 14.5 km (9.0 mi) were observed along the Red Canyon and Hebgen faults (Myers and Hamilton 1964; Witkind 1964). A 1-m (3.3-ft) scarp was observed along a 3-km (1.9-mi) segment of a fault adjacent to Madison Canyon, but it was difficult to determine whether it was related to coseismic movement associated with the Hebgen Lake earthquake (Myers and Hamilton 1964).

Focal mechanisms derived from first motions and body-wave analysis for the subevents indicates fault dips ranging between 40–60 degrees to the southwest. Subevent 1 initiated at a focal depth of 10 km (6.2 mi) and subevent 2, 15 km (9.3 mi). The estimated stress drop for the mainshock is 115 bars (Doser 1985b).

A.2.5.3.2 Yellowstone Caldera—The June 30, 1975, M_L 6.1, Yellowstone Park earthquake occurred near the northern rim of the Yellowstone caldera. Figure A-15 shows the

Figure A-14. Iseseismal-contour map for the M_s 7.5, 1959 Hebgen Lake, Montana earthquake (Eppley and Cloud 1961).

Figure A-15. Isoseismal-contour map for the M_L 6.1, 1975 Yellowstone, Montana earthquake (Pitt et al. 1979).

Modified Mercalli intensity distribution from (Pitt et al. 1979). The focal depth of this event was shallow, 6 km (3.7 mi). Aftershock studies and first motions suggest normal faulting along a northwest-trending structure dipping about 70 degrees to the northeast (Pitt et al. 1979; Bache et al. 1980).

A.2.5.4 Northern Rockies.

A.2.5.4.1 Clarkston Valley—The July 10, 1925, M 6.8, Clarkston, Montana earthquake was felt over an 800,000 km² area and reached a Modified Mercalli intensity of VIII in the epicentral area (Smith and Arabasz 1991). Although this earthquake was large, it produced no surface scarp, but some ground cracks were observed (Pardee 1926). Seismic wave analysis indicates a focal depth of 9 km (5.6 mi), a rupture length of 25 km (15.5 mi), and oblique normal slip on a northwesterly-dipping plane trending north-south (Table A-6) (Doser 1989a).

A.2.5.4.2 Virginia City—The November 23, 1947, M 6.3, Virginia City earthquake may be associated with rupture along a portion of the northwest-trending Madison Canyon fault based on first motions (Dewey et al. 1973). Re-analysis using seismic waveforms by Doser (1989a) suggests right-lateral slip along a fault striking east-west. She suggests that fault motion at depth in this part of the Hebgen Lake/Madison region occurs along structures striking nearly east-west and that the northwest-strike of surface faulting may reflect the trend of preexisting weaknesses that the earthquake ruptures exploited as they propagated to the surface. The event originated at a focal depth of about 8 km (5 mi) (Doser 1989a).

A.2.6 Maximum Earthquake Potential

Patterns of seismicity and locations of mapped faults have been used to assess potential sources of future earthquakes for estimating ground shaking at INEL. The sources and maximum magnitudes of earthquakes which could produce the maximum levels of ground motions at INEL facilities include the following (Figure A-16): (a) a magnitude 7.0 earthquake at the southern end of the Lemhi fault along the Howe and Fallert Springs segments, (b) a magnitude 7.0 earthquake at the southern end of the Lost River fault along the Arco segment, (c) a magnitude 5.5 earthquake associated with dike-injection in either the Arco or Lava Ridge-Hell's Half Acre VRZs and the axial volcanic zone, and (d) a "random" magnitude 5.5 earthquake occurring within the ESRP (Woodward-Clyde Consultants 1992a). Ground motion contributions from other sources such as the postulated ESRP boundary fault, northern Basin and Range province, Yellowstone Plateau, and Idaho Batholith are significantly smaller due to their distant locations or lower maximum magnitudes.

A.2.6.1 Lemhi Fault - Howe and Fallert Springs Segments. The Howe and Fallert Springs segments are located at the southern end of the Lemhi segment and the Howe segment is closest to INEL (Figure A-16). The most recent event (MRE) occurred between 15,000 and 24,000 years ago (Woodward-Clyde Consultants 1992b). The lengths of the Howe and Fallert Springs segments are approximately 15–20 km (9.3–12.4 mi) and 25–30 km (15.5–18.6 mi), respectively (Turko 1988; Baltzer et al. 1989; Haller 1988). Recent paleoseismic investigations

Figure A-16. Locations of VRZs on the ESRP and Quaternary normal faults of the surrounding B&R province (southern segments of faults near INEL are shown as bold lines).

(four trenches excavated across the fault segments) by Woodward-Clyde Consultants (1992a; 1992b) indicate that the MRE could have ruptured portions of both the Howe and Fallert Springs segments resulting in a total length of 35 km (22 mi). For the MRE, maximum and average displacements are 2.5 m (8 ft) and 1.5 m (5 ft), respectively (Woodward-Clyde Consultants 1992b). The maximum magnitude estimated for the MRE is 7.0 based on empirical data from Wells and Coopersmith (in press) using the following: (a) surface rupture length, (b) subsurface rupture length, (c) rupture area [length $\times$ downdip extent; 31×21 km (20×13 mi); Figure A-17], (d) maximum displacement, and (e) average displacement (Woodward-Clyde Consultants 1992a). The slip rate of 0.1 mm/yr for both the Howe and Fallert Springs segments is lower than 0.3 mm/yr for the Thousand Springs segment of the Lost River fault indicating that the Howe segment is less active (Crone et al. 1987).

A.2.6.2 Lost River Fault - Arco Segment. The Arco segment is located at the southern-most end of the Lost River fault and is the closest part of the fault to INEL (Figure A-16). Reconnaissance paleoseismic studies conducted by Malde (1987) and Pierce (1985, 1988) along the Arco segment suggest that the MRE occurred about 30,000 years ago. The length of the fault segment is about 10 km (6.2 mi) and MRE caused about 2–3 m (6.6–9.8 ft) of displacement (Pierce 1985; Crone et al. 1987). The maximum magnitude estimated for the MRE is 7.0 by analogy to paleoseismic studies of the Howe and Fallert Springs segments of the Lemhi fault since no detailed studies have been performed for the southern Lost River fault. The analogy is supported by conclusions that faults northwest of the INEL are undergoing similar deformational processes (Crone et al. 1987; Woodward-Clyde Consultants 1992a). The slip rate of 0.12 mm/yr for the Arco segment is lower than 0.3 mm/yr for the Thousand Springs segment (Borah Peak earthquake) indicating that the Arco segment is less active (Crone et al. 1987).

A.2.6.3 Beaverhead Fault - Blue Dome Segment. The Blue Dome segment is located at the southern-most end of the Beaverhead fault (Figure A-16). Based on scarp morphology, the MRE occurred more than 30,000 years ago (Stickney and Bartholomew 1987), and recent unpublished mapping in the area suggests that it has not been active for several hundred thousand years (G. Embree, personal communication). The length of the segment is estimated to be about 25 km (15.5 mi) (Haller 1988). Since no detailed paleoseismic investigations have been conducted along this segment and faults northwest of INEL are undergoing similar deformational processes, Woodward-Clyde Consultants (1992a) estimates a maximum magnitude of 7.0 for an earthquake on along the Blue Dome fault. No data are available to quantitatively estimate a slip rate, but several investigators suggest that this segment has an activity rate similar to the southern segments of the Lemhi and Lost River faults (Crone et al. 1987; Anders et al. 1989).

A.2.6.4 ESRP Boundary Faults. Deep seismic refraction profiling across the northwest boundary of the ESRP near the INEL suggests the presence of a buried northeast-trending fault parallel to the ESRP boundary (Pankratz and Ackerman 1982). Scott (1982) suggested that a northeast-trending topographic scarp observed on an alluvial fan along the southeast side of the Arco Hills may be a result of past movement on a boundary fault. Breckenridge and Othberg (1991) excavated a trench across the scarp. Their trench logs indicate that no fault offset is

Figure A-17. Comparison of fault dimensions, fault orientations, and calculated moment magnitudes for dike-induced faults on the ESRP and normal faults of the surrounding B&R tectonic province.

present within the alluvial fan deposits. They conclude that the scarp may have developed from a buildup of eolian sediments along an old fire scar.

Other investigations have been conducted on northeast-trending faults at the southern terminations of the Lemhi Range and Beaverhead Mountains near the margins of the ESRP (Rodgers and Zentner 1988; Zentner 1989; Bruhn et al. 1992). Results of their studies indicate that these faults were active more than 2 million years ago. Based on the following lines of evidence these faults are not considered significant seismogenic sources: (a) their northeast trend is not consistent with the direction of the active northwest-trending normal faults which are produced by regional extensional stress field, (b) they do not displace sediments and volcanic rocks younger than 2 million years old, and (c) their lengths are small, generally less than 10 km (6.2 mi), and they have small total displacements. Furthermore, even if they were active, these faults would be capable of producing earthquakes of magnitude 5.0 based on their fault lengths and small displacements. This magnitude does not exceed the magnitudes of earthquakes that could occur in the Arco VRZ or randomly on the ESRP at equal or closer distances (Woodward-Clyde Consultants 1992a).

A.2.6.5 ESRP Volcanic Zones.

A.2.6.5.1 Arco Volcanic Rift Zone—The Arco VRZ extends from the southern end of the Lost River Range across the southwestern tip of the INEL (Figure A-16). The rift zone is about 6 km (3.7 mi) wide and 20 km (12.4 mi) long (Kuntz et al. 1990, 1992; Smith et al. 1989). Small normal faults within the rift zone are 5–6 km (3.1–3.7 mi) in length, have cumulative vertical offsets of about 12 m (39.5 ft) (multiple offsets) and are postulated to extend to a depth of 2 km (1.2 mi) below the surface (Mastin and Pollard 1988; Smith et al. 1989; Kuntz et al. 1990; Woodward-Clyde Consultants 1992a). A set of fissures in the Box Canyon graben area is colinear with the small normal faults [5 km (3 mi) long] (Table A-9) bounding the graben which results in a total length of 8 km (5 mi). Based on the compilation of earthquake data for active rift zones (Table A-8) a maximum magnitude of 5.5 is assumed possible for future dike-injection events within the rift zone. This is consistent with a magnitude of 5.2 based on the assumption that an earthquake associated with dike injection ruptures a fault area of 16 km^2 [length $\times$ depth; $8 \times 2 \text{ km}$ ($5 \times 1.2 \text{ mi}$)] (Figure A-17) (Woodward-Clyde Consultants 1992a). The most recent volcanic activity within the rift zone appears to have been about 95,000 years ago (Kuntz et al. 1990; Smith et al. 1989; Forman et al. in press).

A.2.6.5.2 Lava Ridge-Hell's Half Acre Volcanic Rift Zone—The Lava Ridge-Hell's Half Acre (LR-HHA) VRZ extends from the southern end of the Lemhi range across the INEL to the southeastern corner (Figure A-16). The rift zone is 3–6 km (1.9–3.7 mi) wide and 50 km (31 mi) long. At the southern end of the rift zone, two sets of fissures, which may or may not be associated with small normal faults [1.4 km (0.9 mi) in Table A-9], are about 4 km (2.5 mi) long (Golder et al. 1992). Since portions of the fissures are covered by younger lava flows, the fissure sets could extend 11 km (6.8 mi) farther south. A maximum magnitude of 5.5 was assumed possible for earthquakes associated with future dike-injection events within the LR-HHA rift zone based on the compilation of earthquake data shown in Table A-8. This is consistent with a

magnitude of 5.5 which was estimated using fault area ($15 \times 3 \text{ km} = 30 \text{ km}^2$) and assuming rupture along the entire fissure lengths (Woodward-Clyde Consultants 1992a). The most recent volcanic activity within the LR-HHA rift zone occurred about 5,200 years ago (Kuntz et al. 1990).

A.2.6.5.3 Howe-East Butte Volcanic Rift Zone—The postulated Howe-East Butte (H-EB) VRZ extends across the central portion of the INEL from the range-front south of Howe to East Butte (Figure A-16). It is poorly expressed surficially and is mostly covered by younger lava flows and fluvial and lacustrine sediment (Kuntz et al. 1990) (see Section 2.1.4). Woodward-Clyde Consultants (1992a) considered the maximum magnitude for the H-EB to be 5.5 similar to the Arco and LR-HHA VRZs. Volcanic vents in the H-EB VRZ are estimated to be 580,000 to 641,000 years old (Kuntz et al. 1990) and a conservative minimum age for the VRZ is established by its being overlain by a dated lava flow 230,000 years old.

A.2.6.5.4 Axial Volcanic Zone—The Axial Volcanic Zone (AVZ) is located along the ESRP axis and crosses southeastern portions of the INEL. Dike-induced features are located near the intersections of the Arco and LR-HHA VRZs with the AVZ. Thus, a maximum magnitude of 5.5 is assumed possible based on the close proximity of the AVZ to these VRZs. The most recent volcanic activity 5,000 years ago (Kuntz et al. 1988).

A.2.6.6 ESRP Province. Although instrumental seismicity indicates that the ESRP is relatively aseismic, an earthquake similar in size to the 1905 Shoshone event is considered possible within the ESRP. For estimating ground motions at INEL, an earthquake of maximum magnitude 5.5 is postulated to occur anywhere within a 25-km (15.5-mi) radius of each facility. This is referred to as a "random earthquake" and is commonly used for design of commercial nuclear reactors to assess effects from earthquakes that may occur on unknown faults (those without surface exposures).

A.2.6.7 Northern Basin and Range Province. The northern Basin and Range source region surrounds the ESRP. Excluding known normal faults which are capable of generating magnitude 7.0 events, an earthquake with a maximum magnitude of 6.75 is postulated to occur anywhere within this source region on an unknown subsurface structure (Woodward-Clyde Consultants 1992a). Doser (1985a) suggests that earthquakes of magnitude 6.0–6.75 could occur in the ISB without producing fault scarps for evidence of their past occurrence. An example of this phenomena is the 1975 M_L 6.0 Pocatello Valley earthquake near the Idaho-Utah border. This event occurred on a "blind" (not evident in surface geology) cross-fault which trended transverse to the trend of nearby B&R normal faults (Arabasz et al. 1981).

A.2.6.8 Idaho Batholith Province. The Idaho Batholith is seismically quiet region and its boundaries are defined by the extent of granitic rocks associated with the batholith. No extensive or well-defined Quaternary faults are mapped within the Idaho Batholith (Woodward-Clyde Consultants 1992a). Although seismographic coverage is poor (a detection threshold of $M \geq 3$), it appears to have a low seismic potential (Smith and Arabasz 1991). Woodward-Clyde Consultants (1992a) estimated the maximum magnitude to be M_w 5.5.

A.2.6.9 Yellowstone Plateau Province. The Yellowstone Plateau province includes the faults associated with the 1959 Hebgen Lake event, largest earthquake in the ISB. Thus, the maximum magnitude is M_s 7.5 based on this event (Woodward-Clyde Consultants 1992a).

A.2.7 Seismic Wave Transmission Characteristics

A.2.7.1 Regional Attenuation. For the ground motion modeling studies, regional attenuation was characterized by a frequency-dependent quality factor, $Q(f)$. Singh and Herrman (1983) determined a regional crustal coda Q_0 of 450 and η of 0.2 for $Q(f)$ in the B&R northwest of the ESRP. Braile et al. (1982) observed high attenuation in the 1978 ESRP seismic refraction experiment within the ESRP for the P-wave quality factor Q_p . They attributed it to low Q values in the volcanic rocks (Q_p 20 to 200) and throughout the crust (Q_p 160 to 300). Woodward-Clyde Consultants (1992a) used the model parameters of Q_0 and η from Singh and Herrman (1983) in their 1990 deterministic analysis. They also suggest that the relatively short source-to-site distance of 20 km (12.4 mi) [less than 30 km (18.6 mi)] does not significantly attenuate earthquake ground motions.

A.2.7.2 Near-surface Geological Attenuation. Woodward-Clyde Consultants (1990) indicate that near-surface geology [0–5 km (0–3.1 mi) depth] has a significant influence on earthquake ground motions at a site, in addition to amplification resulting from soil overlying bedrock. The INEL resides upon the ESRP which is covered with basalt lava flows and sediments (see Section 2.1.2). Boreholes located throughout the INEL site indicate the basalt is interbedded with sedimentary layers; in some areas, the percentage of interbeds is as great as 50%.

This unique stratigraphy has the affect of deamplifying or decreasing the level of earthquake ground motions because seismic waves travel through a sequence of alternating high (basalt) and low (sediments) velocity zones which tend to scatter the seismic energy. Also, seismic energy is intrinsically dampened by the sedimentary interbeds. The net effect of the interbedded basalt is to reduce the level of earthquake ground motions when compared to a homogeneous basalt (no interbeds) (Woodward-Clyde Consultants 1990). The amount of deamplification is dependent on the difference between the velocities for the basalt and sedimentary layers, and the thickness of the sedimentary layers.

As an example, Figures A-18 and A-19 show the shear-wave velocity (V_s) profiles (actual and smoothed models) determined to estimate earthquake ground motions at ATR (Woodward-Clyde Consultants 1992a). The velocity model was derived from using well and borehole logs located near the Test Reactor Area. Since the velocity model has large contrasts (basalt vs sediment), the velocity profiles were smoothed to taper the large effects of scattering which resulted in low-amplitude spectra. Regional earthquakes were digitally recorded near two boreholes at the Test Reactor Area. These data were used to estimate the near-surface attenuation, κ , and to determine the amount of smoothing in the velocity profiles.

A.2.8 Ground Motion Studies

Seismic hazards assessments to evaluate potential earthquake ground motions have been conducted at INEL since the early 1970s for establishing seismic design criteria. Since that time, ground motion seismology and federal regulations have continued to evolve, and geoscience investigations have continued at INEL. To keep pace with these changes, a deterministic (worst-case scenario) earthquake hazard assessment was conducted recently for all facilities at INEL using new geologic data and state-of-the-art ground motion modeling techniques (Woodward-Clyde Consultants 1990). Deterministic and probabilistic hazards assessments were conducted for the proposed NPR site at INEL, which evaluated ground motion contributions from the "random" ESRP earthquake (Woodward-Clyde Consultants 1992a). Also, an INEL probabilistic seismic hazard assessment is currently underway to assess the contributions from all earthquake sources on the levels of ground motions and their return periods. This study includes an evaluation for ATR.

A.2.8.1 1990 INEL Deterministic Evaluation. The 1990 deterministic study estimated peak ground accelerations based on the largest earthquake (M 7) that could occur along the Lemhi fault (Woodward-Clyde Consultants 1990). This evaluation incorporated all available results from geoscience investigations pertaining to the earthquake source and subsurface stratigraphy beneath the ESRP (crustal structure) and INEL facilities (near-surface stratigraphy). Woodward-Clyde Consultants (1990) used site-specific geologic profiles beneath INEL facilities to assess the nature of seismic-wave propagation from the Howe fault. The geologic profiles were used with the band-limited-white-noise ground motion model to determine site-specific accelerations for anticipated levels of earthquake ground motions. Sensitivity analyses were performed on the results which indicated that the size of the earthquake (stress drop) and near-surface geology (κ) had the most significant affects on the levels of earthquake ground motions. Peak horizontal and vertical accelerations and response spectra were estimated for the 50th and 84th percentiles based on the range of uncertainties in the geologic input.

A.2.8.2 1993 INEL Probabilistic Evaluation. A probabilistic seismic hazard study for INEL facilities will be completed in April 1993. This evaluation will provide seismic hazard curves (peak ground accelerations vs return periods) and response spectra. The geologic input will be similar to the input used in the NPR probabilistic evaluation with minor exceptions (Woodward-Clyde Consultants 1992a). Geologic profiles were refined from those in the 1990 deterministic evaluation based on new borehole information and additional estimates of V_s . The band-limited-white-noise ground motion model will be used along with empirical relationships. Sensitivity analyses will be performed to determine the seismic sources contributing to the hazard.

A.3 Surface Faulting

Surface faulting, defined as the rupture of the earth's surface due to tectonic or magmatic activity, is of concern in some areas of INEL. Surface faulting related to tectonic activity could occur near the southern tip of the Lemhi fault (Figures A-4 and A-5). Such surface faulting would be associated with an earthquake on the Howe and Fallert Springs segments and could extend into the INEL for a distance of several kilometers in the area just east of the Big Lost River Sinks. The age of most recent earthquake activity on the southern Lemhi fault is given in Sections A.2.4.2 and A.2.6.1.

Other areas in which surface faulting is of concern are in VRZs (see Section 2.1.4). Areas in and near the Arco and the Lava Ridge-Hells Half Acre VRZs (Figure 2-21) have the greatest potential for such dike-induced surface faulting (see Section 2.1.4 for a description of the surface deformation process). Also, the fissures north of the Naval Reactors Facility (Figure 2-20) appear to be dike-induced fissures. The potential recurrence of such fissuring is tied closely to periods of volcanic activity in VRZs and is quantified in Section 2.1.4.

A.4 Description of Soil Classification and Mapping Information Available About the INEL—Summary

The Soil Conservation Service has mapped portions of the INEL in Jefferson and Bonneville Counties, which comprises about 25% of the reservation. This portion of the INEL has not been significant for waste management or environmental restoration activities to date. There are no developments or facilities on these sections. The Soil Conservation Service did not penetrate the INEL boundary in the published Bingham and Butte County surveys. Revised, more detailed soil surveys will be published for Bingham and Butte Counties, however, information is not available at this time. Special soil surveys were written for Butte and Bonneville counties. These show the types of soil present and classify their irrigability (Chugg et al. 1968a, 1968b).

There are two maps of the INEL that delineate soils on the INEL, but neither have been verified for accuracy, and both are seemingly inaccurate. McBride et al. (1978) published a soil map of the INEL, which was compiled from various sources including the draft Jefferson County Soil Survey, Butte County Special Soil Survey (Chugg et al. 1968a), and the Bonneville County Special Soil Survey (Chugg et al. 1968b). Mapping units were not uniformly defined in the original documentation, and the lines around the units do not correlate at the boundaries. McBride et al. (1978) interpolated the boundaries, but did not explain the rationale for doing so, and they also made interpretations of the mapping units in order to define a new set of common units. The new units are related to the irrigability of soils, which has limited benefit for most land use planning at the DOE reservation.

A surficial geology map was published by Scott (1982), but the information is limited to the geological setting (e.g., fan alluvium, discontinuous loess, dune deposits) and does not provide any soil characteristics information, which is necessary for interpreting the suitability of the soils for various land uses.

Other maps of INEL soils provide small islands of information, and lack the overall context that would be provided by a site-wide map. Breckenridge and McGrath (1989) published soils maps of the two NPR sites. This report is frequently cited in INEL reports that describe INEL soils, however, the NPR mapping covered only two 2.6-km² (1-mi²) patches within the INEL's 2,300-km² (890-mi²) area, and may not be representative of the INEL soils in general. Moreover, the specific boundaries and locations of the square mile patches are not well documented in the report. Martin et al. (1992) published some information and maps of soil types around some of the EG&G Idaho-managed facilities, but the mapping units have not been correlated, and the mapping only covers four isolated areas at the INEL, and does not include areas in or around the Radioactive Waste Management Complex, Argonne National Laboratory-West, the Idaho Chemical Processing Plant, and the Naval Reactors Facility.

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- Woodward-Clyde Consultants, 1992a, Earthquake strong ground motion evaluations for the proposed New Production Reactor at the Idaho National Engineering Laboratory, Volume I: Deterministic Evaluation and Volume II: Probabilistic Evaluation, EG&G Idaho, Inc., EGG-GEO-10304.
- Woodward-Clyde Consultants, 1992b, Paleoseismic investigations of the southern Lemhi Fault, Idaho, EG&G Idaho, Inc., EGG-GEO-10178, 32 p.
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A.6 Annotated Bibliography for Geoscience Investigations, New Production Reactors Program, and Other INEL Programs^e

1. Ansley, S. L.; Smith, R. P.; Tullis, J. A., and Zeisloft, J. A., 1992, *Summary Report: NPR 1991 Geotechnical Drilling*, EG&G Idaho, Inc., Idaho Falls, ID.

Final documentation of purpose, procedures, and results of the 1991 NPR drilling program. contains a 29 page text summary of the program, technical specifications for drilling, health and safety plan, inventory of photographs of drill core, geophysical logs of drill holes, inventory of downhole video records, grout logs, field point load tests, daily drilling reports, geologic logs, "as built" well diagrams, and lessons learned.

Subject: NPR drilling program report
Keywords: HEALTH & SAFETY / DRILL CORE / LOAD TEST / LOGS
Location: R.P. Smith Files; S.L. Ansley Files; INEL Well File Repository

2. Blackwell, D. D., 1990, *Temperatures and Heat Flow in INEL- G51, and WO-2 Boreholes, Snake River Plain, Idaho*, EG&G Idaho, Inc., EGG-NPR-10690, Idaho Falls, ID.

High resolution temperature logs and recalculation of heat flow from the deepest drill hole on the INEL.

Subject: Temperature and heat flow in INEL-G51
Keywords: INEL-GT1 / TEMPERATURE / HEAT FLOW
Location: R.P. Smith Files; W.R. Hackett Files; S.M. Jackson Files

3. Blackwell, D. D.; Kelley, S., and Steele, J. L., 1992, *Heat Flow Modeling of the Snake River Plain, Idaho*, EG&G Idaho, Inc., EGG-NPR-10790, Idaho Falls, ID.

Summary of new temperature logs of drill holes in southeastern Idaho and modeling of the temperature structure of the crust beneath the ESRP and adjacent basin and range province.

Subject: Heat flow modeling
Keywords: LOGS / TEMPERATURE / ESRP / CRUST / MODELING
Location: R.P. Smith Files; W.R. Hackett Files; S.M. Jackson Files

4. Breckenridge, R. M., and Othberg, K. L., 1991, *Geologic Interpretation of a Trench Excavation near Arco Hills on the Northwest Margin of the INEL, srp, Idaho*, EG&G Idaho, Inc., Idaho Geological Survey Technical Report 91-2, Idaho Falls, ID.

e. Not all references are annotated. Those not annotated are provided for your information.

Documentation of logging of a trench across a possible northeast-trending boundary fault to the ESRP near the west border of the INEL. Concludes that no fault exists and the scarp results from surficial processes.

Subject: Trench excavation near the Arco Hills
Keywords: NORTHEAST-TRENDING / BOUNDARY FAULTS / TRENCH
EXCAVATION / ARCO HILLS
Location: Idaho Geological Survey

5. Breckenridge, R. P., and McGrath, C. L., 1989, *Soil classification of proposed NPR sites at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-CEMA-8510, Idaho Falls, ID, May, 1989.

Two areas at the INEL were selected for possible location of the proposed NPR. This report describes the soils at those two sites. The sites were located west of the Idaho Chemical Processing Plant, and were each about one square mile. Soils are described and mapped to the soil series (i.e., very detailed) level.

Location: INEL Technical Library

6. Bruhn, R. L., 1992, *Final Report on Structure of the Southern Lemhi and Arco Fault Zones*, Idaho, EG&G Idaho, Inc., EGG-NPR-10680, Idaho Falls, ID.

Describes results of field work in 1990 and 1991 which documents the segmentation of the southern Lemhi fault and shows that it terminates at the northern margin of the ESRP.

Subject: Structure of Lemhi & Arco faults
Keywords: LEMHI FAULT / ARCO FAULT / ESRP
Location: R.P. Smith Files; W.R. Hackett Files; S.M. Jackson Files

7. Chugg, J. C.; Jorgensen, W., and Fosberg, M. A., 1968, *Special soil survey Butte County, Idaho*, Idaho Water Resources Board, No. 5, September 1968.

An inventory of soils, approximate distribution, acreage and irrigability interpretations. The report covers only Butte County, which accounts for about 60 percent of the INEL. Soil characteristics data are tabulated, including: surface depth and texture, subsoil depth and texture, restrictive layers (if any), underlying material (e.g., sand and gravel, basalt), slope (%), available water holding capacity to 48 in., soil limitations (e.g., permeability, alkali), and irrigable class (1-6). For each mapping unit, the geomorphologic and general soil information is provided. Information on the irrigability of the soils is somewhat useful for land use planning, since irrigability is related to soil depth, permeability, slope, infiltration and water holding capacity.

Location: INEL Technical Library

8. Chugg, J. C.; Webb, V. S., and Fosberg, M. A., 1968, *Special soil survey Bonneville County, Idaho*, Idaho Water Resources Board, No. 7, September 1968.

A small section in the southeast corner of the INEL is in Bonneville County. This report preceded the SCS's Bonneville County Soil Survey, and lacks the detail and refinement found in that report (there is one mapping unit for the Bonneville County section of the INEL). McBride et al. (1978) used this map in compiling the soil map of the INEL. Mapping units contain complexes of soil series, and they do not correlate with the mapping units from the Butte County report by the same authors.

Location: INEL Technical Library

9. Fishel, M., 1992, *Geology and Petrology of Uplifted Mafic Lavas on Big Southern Butte, Eastern Snake River Plain, Idaho*, Masters Thesis, Idaho State University, Pocatello, ID.

Describes the 1 km thick block of basaltic lava flows uplifted by the Big Southern Butte rhyolite dome and correlates lava flows in the block to surface and subsurface lava flows in the southern INEL area.

Subject: Uplifted mafic lavas on Big Southern Butte

Keywords: BIG SOUTHERN BUTTE / UPLIFT MAFIC LAVA

Location: Idaho State University Library

10. Forman, S. L.; Smith, R. P.; Hackett, W. R., and Tullis, J. A., In Press, "Stratigraphic and chronologic constraints on late Pleistocene loess deposition on the Snake River Plain, Idaho", *Quaternary Research*.

Location: Published Article

11. Geomatrix Consultants, Woodward-Clyde Consultants, and Pacific Engineering and Analysis, 1992, *Earthquake Ground Motion Evaluations for the Proposed NPR at the INEL, Volume II: Probabilistic Evaluation*, EG&G Idaho, Inc., EGG-GEO-10304, Idaho Falls, ID.

Probabilistic seismic hazard assessment for NPR based on newest information resulting from the 1990-1991 field investigations for NPR. Considers all earthquake sources; Lemhi fault, Lost River fault, Beaverhead fault, volcanic rift zones, axial volcanic zone, and random (floating) earthquake.

Subject: Earthquake hazard assessment

Keywords: EARTHQUAKE / NPR / SEISMIC HAZARD / LEMHI FAULT / LOST RIVER FAULT / BEAVERHEAD FAULT

Location: INEL Technical Library

12. **Geotrace, Inc.**, 1991, *Reprocessing of Sierra Geophysics Reflection Lines at South Ends of Lost River and Lemhi Faults.*

State-of-the-art computer processing of the reflection seismic lines run by Sierra Geophysics at the south ends of the Lost River and Lemhi faults in 1984 for the NPR program. Shows possible fault displacement on some layers at depths of several hundred feet near the southern termini of the faults.

Subject: Reflection seismic lines

Keywords: REFLECTION LINES / LOST RIVER FAULT / LEMHI FAULT / NPR

Location: R.P. Smith Files; G.S. Carpenter Files

13. **Geotrace, Inc.**, 1992, *Processing of EG&G Idaho Seismic Reflection Lines at the South Ends of the Lost River and Lemhi Faults.*

State-of-the-art computer processing of reflection seismic lines run by EG&G Idaho Geosciences in December of 1991. The seismic sections have not yet been analyzed for presence or absence of faults.

Subject: Reflection seismic lines

Keywords: REFLECTION SEISMIC LINES / LEMHI FAULT / LOST RIVER FAULT

Location: R.P. Smith Files; G.S. Carpenter Files

14. **Golder Associates**, 1991, *Geotechnical Soil Testing Laboratory Results for the NPR, Final Report, Volume 1*, EGG-NPR-10688.

Documentation of determinations of physical and mechanical properties of subsurface (sedimentary interbeds) and surface soils collected during the 1991 drilling program at the NPR site.

Subject: Soils testing

Keywords: SEDIMENTARY INTERBED / SURFACE SOIL / NPR

Location: R.P. Smith Files; W.R. Hackett

15. **Golder Associates**, 1991, *NPR project, Idaho, Laboratory test results, final rock core test report, 3 volumes. Volume 1: Results of direct shear testing; Volume 2: Results of elastic moduli testing; and Volume 3: Results of uniaxial compression testing, Brazilian tensile testing, point load testing, and specific gravity determination.*

Documentation of determinations of physical and mechanical properties of subsurface basalt rock cores collected during the 1991 drilling program at the NPR site.

Location: Files of R.P. Smith & W.R. Hackett

16. **Golder Associates**, 1992, *New Production Reactor site characterization*, EG&G Idaho, Inc., EGG-NPR-10625, Volume 1-3, Idaho Falls, ID.

Documents results of regional geomorphic investigations of southeastern Idaho by analysis of remote sensing imagery and field checks of all features (lineaments) that may have tectonic or volcanic origin. Concludes that no previously unknown tectonic structure exist in the area, but that several lineaments on the near ESRP deserve field investigation.

Location: Files of R.P. Smith & W.R. Hackett

17. **Hackett, W. R., and Smith, R. P.**, 1992, "Quaternary volcanism, tectonics, and sedimentation in the Idaho National Engineering Laboratory Area", *Utah Geological Survey Miscellaneous Publication*, 92(3):1-18.

Location: Published Article

18. **Hackett, W. R.; Smith, R. P., and Josten, N. E.**, In Preparation, "Interaction of Quaternary Volcanic and Tectonic Processes, Eastern Snake River Plain, Idaho," *GSA Cordilleran Section Symposium, Volcanic Hazards and Cenozoic Volcanism in the Cordillera*, March 1991.

19. **Hayden, K.**, 1992, *Geology and petrology of Cedar Butte eruptive center*, M.S. Thesis, Idaho State University, Pocatello, ID.

Describes and interprets the volcanic history and origin of lavas at Cedar Butte. Correlates Cedar Butte lavas to surface and subsurface lavas in the area of the southern INEL.

Location: Idaho State University, Pocatello, ID

20. **Hironaka, M.; Fosberg, M. A., and Winward, A. H.**, 1983, *Sagebrush-grass habitat types of southern Idaho*, University of Idaho, Bulletin Number 35, Moscow, ID, May 1983.

This report provides a good overview of the habitat types in southern Idaho. Included with the descriptions of the habitat types is a description of the associated soils. Many of the habitat types described in the document occur on the INEL.

Location: INEL Technical Library

21. **Jackson, S. M.; King, J. J.; Anderson, D. M.; Carpenter, G. S., and Adams, H. J.**, 1991, *Strong ground motion data recorded at the INEL during the 1983 Borah Peak, Idaho earthquake*, EG&G Idaho, Inc., EGG-BG-9249, Idaho Falls, ID.

Documents recordings of strong motion accelerographs at INEL facilities due to the 1983 earthquake and absence of structural or safety-related damage to INEL facilities.

22. Kuntz, M. A.; Skip, B.; Lanphere, M. A.; Scott, W. E.; Pierce, K. L.; Dalrymple, G. B.; Morgan, L. A.; Champion, D. E.; Embree, G. F.; Smith, R. p.; Hackett, W. R., and Rodgers, D. W., 1990, *Revised geologic map of the Idaho National Engineering Laboratory and adjoining areas, eastern Idaho*, EG&G Idaho, Inc., U.S. Geol. Survey Open File Report, 90-333, Idaho Falls, ID.
23. Martin, K. L.; Barnard, C. J.; Freeman, A. L.; Groh, M. R.; Kissel, K. T.; Lord, S. J.; Olson, G. L.; Randolph, P. D., and Wilhelmsen, R. N., 1992, *Preliminary assessment of surface soils at active EG&G Idaho facilities data document*, EG&G Idaho, Inc., EGG-ESQ-9225, Revision 1, Idaho Falls, ID, May 1992.

More than 300 samples were collected from EG&G Idaho facilities at the INEL, and analyzed for metals (by ICP, and FAA for mercury) and for radionuclides (gamma spectral, gross alpha, and some alpha spectral analyses). Results are presented in this report. Also included in the report is a discussion of the soil types around each of the facilities (Test Reactor Area, Test Area North, Central Facilities Area, and Power Burst Facility area), with soil maps showing the different soil series present.

Location: INEL Technical Library

24. McBride, R.; French, N. R.; Dahl, A. H., and Detmer, J. E., 1978, *Vegetation types and surface soils of the Idaho National Engineering Laboratory Site*, DOE, IDO-12084, Idaho Falls, ID.

This document provides a soil map of the INEL. Mapping units are distinguished on the basis of their "arability" class. Information was compiled from: Chugg et al. 1968; Salzmann 1973; and the draft Jefferson County Soil Survey 1976). Classification of soils was not the same in all the original reports, therefore, an attempt was made to use the Butte County classification for the INEL soil map.

Location: INEL Technical Library

25. Moos, D., and Barton, C. A., 1990, *In situ stress and natural fracturing at the INEL site, Idaho*, EG&G Idaho, Inc., EDF #NPR- MHTGR-0333, Idaho Falls, ID.

Results and conclusions of the borehole televiwer logging of drill holes INEL-1, USGS-7, USGS Site 17, and No-Name. Absence of borehole breakouts interpreted to suggest low deviatoric stresses beneath the INEL area.

Location: EG&G Idaho NPR Department

26. Moos, D.; Barton, C. A., and Smith, R. P., 1990, "Results of borehole televiewer logging to 3 km depth in the Snake River Plain - In situ stress and natural fracturing", *Abstract, EOS*, 71(43):1622.

27. Nace, R. L.; Deutsch, M., and Voegeli, P. T., 1972, *Physical environment of the National Reactor Testing Station, Idaho*, USGS, USGS Geological Survey Professional Paper 725-A.

Discusses the geographic setting of the INEL, and explains the parent materials from which the soils were formed (e.g., alluvial features, lake floors, eolian features, etc.) and some of the soil forming factors specific to the area (e.g., freezing and thawing, wind, torrential rain).

Location: INEL Technical Library

28. Nace, R. L.; Voegeli, P. T.; Jones, J. R., and Deutsch, M., 1975, *Generalized geologic framework of the National Reactor Testing Station, Idaho*, USGS, USGS Geological Survey Professional Paper 725-B.

Discusses the characteristics of the geologic materials on the INEL, including the basalt, Big Lost River alluvium, loess, and the Birch Creek playa sediments. Grain size and some chemical composition information is provided for some sediments, including information on clay types. A hypothesis is presented on the formation of earth cracks in the Birch Creek playa, and the authors also discuss some of the constraints associated with constructing or dumping materials in that type of material.

Location: INEL Technical Library

29. National Geodetic Survey, 1991, *Crustal motion survey, Eastern Snake River Plain, Idaho*, EDF #NPR-MHTGR-0327.

Final report on establishment of the INEL global position system network. Describes procedures and precision/accuracy of station location and shows station locations on a map of southeastern Idaho.

Location: EG&G Idaho NPR Department

30. Oaks, S. D., 1992, *Historical seismicity investigation for the November 11, 1905 earthquake*, EG&G Idaho, Inc., EGG-GEO- 10203, Idaho Falls, ID.

Documentation of the search of historical records of the 1905 earthquake and resulting isoseismal map which suggests that the epicenter for the earthquake was in northwestern Utah.

Location: Files of S.M. Jackson

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31. **Oaks, S. D. Jackson, S. M.**, 63, "An investigation of the 11 November 1905 Shoshone, Idaho earthquake: Implications for seismic hazards within the Eastern Snake River Plain", *Seismological Research Letters*, 1(22)

32. **Parsons, T., and Thompson, G. A.**, 1991, "The role of magma overpressure in suppressing earthquakes and topography: world wide examples", *Science*, 253:1339-1402.

Location: Published Article

33. **Pelton, J. R.**, 1991, *Analysis of geodetic leveling data in the vicinity of INEL; EDF # NPR-MHTGR-0332, 4 Volumes. Volume 1: Main report plus Appendices 1, 2, and 3; Volume 2: Appendix 4, part 1 (lines 60134 through L16681); Volume 3: Appendix 4, part 2 (lines L16994 through L18004. Volume 4: Appendix 4, part 3 (lines L21136 through L24756), EG&G Idaho, Inc., EGG-NPR-10691.*

Results of analysis of errors and accuracy of previous geodetic levelling surveys in the INEL. Shows that ESR has subsided by measurable amounts in the area north and just southwest of Idaho Falls along I-15. .

Location: EG&G Idaho NPR Department

34. **Scott, W. E.**, 1982, *Surficial geologic map of Eastern Snake River Plain and adjacent areas, 111 degrees to 115 degrees W., Idaho and Wyoming*, Department of the Interior, United States Geological Survey, Miscellaneous Investigations Series, Map I- 1372.

This is a geologic map, with descriptions of the geologic events pertinent to the ESRP, including the INEL. Categories for the mapping units include: deposits of modern flood plain, deposits of cut terraces, fan alluvium, moderately thick loess over basalt, etc. No specific soils information is provided with this publication; some inferences can be made about the properties of the soils within the mapping units.

Location: INEL Technical Library

35. **Smith, R. P.; Hackett, W. R., and Jackson, S. M.**, 1991, "Geoscience investigations for seismic and volcanic hazards assessment at the INEL," *Proceedings of the Third DOE Natural Phenomena Hazards Mitigation Conference*.

36. **Smith, R. P.; Hackett, W. R., and Rodgers, D. W.**, 1989, "Relationship of volcanic rift zones to seismic and volcanic hazards at the Idaho National Engineering Laboratory," *Proceedings of the 31st Annual Symposium, Idaho Falls, ID, April*.

Location: Published Article

37. Smith, R. P.; Hackett, W. R., and Rodgers, D. W., 1989, "Surface deformation in the Arco Rift Zone, Eastern Snake River Plain, Idaho", *Geol. Soc. Am., Abstracts with Programs*, 21(5): 146.
38. Smith, R. P.; Hackett, W. R.; Wong, I. G., and Jackson, S. M., 1990, "Geologic hazards assessment at the Idaho National Engineering Laboratory, Southeastern Idaho," *Circum-Pacific Energy and Mineral Resource*, July.
39. TerraSense, Inc., 1991, *Map compilation of 1964 airborne magnetic survey of INEL; 12 p. plus plates*, TerraSense.

Detailed map of aeromagnetic anomalies recorded in the 1964 survey. Compilation of original flight data resulted in much more detailed map than previously available.

Location: Files of Smith, R.P. and Carpenter, G.S.

40. Thompson, G. A.; Parsons, T., and Smith, R. P., 1990, "Examples of magma overpressure suppressing normal faulting and inhibiting seismicity: Snake River Plain, Idaho", *Abstracts, EOS*, 71(43):1622.
41. UNC Geotech, 1988, *An informal data report on the results of the helium soil-gas survey.*

Results of an attempt to use helium content of soil gas to locate faults and fissures in the Arco volcanic rift zone and the south of the Lost River fault.

Location: File of R.P. Smith

42. UNC Geotech, 1989, *Analysis of possible fault scarps in the Arco-Butte City area, Idaho.*

Geomorphic analysis of scarps in the northern part of the Arco volcanic rift zones are interpreted to be river terraces based on elevations with respect to terraces along the west side of the Big Lost river.

Location: Files of R.P. Smith

43. United States Department of Agriculture Soil Conservation Service, 1979, *Soil survey of Jefferson County, Idaho.*

This soil survey contains taxonomic classes, descriptions, and characteristics for soils in Jefferson County, including the portion of the county occupied by the INEL. The survey is very useful, but covers only Jefferson County.

Location: Idaho Falls Public Library

44. United States Department of Agriculture Soil Conservation Service, 1981, *Soil survey of Bonneville County Area, Idaho*.

A small portion of the INEL is in Bonneville County. This soil survey provides soil classification information to the soil series level, which is very detailed and provides information about the engineering and chemical properties of the soils (see Jefferson County Soil Survey categories).

Location: USDA Soil Conservation Service Bonneville County Office

45. U.S. Department of Interior Bureau of Land Management, 1984, *Medicine Lodge resource management plan, Environmental Impact Statement, Idaho Falls District, Draft 1984*, U.S. BLM, Idaho Falls, ID.

This document contains a soils map for BLM's Medicine Lodge resource area, which includes the part of the INEL which lies in Jefferson County. The soil map was compiled from the Jefferson County Soil Survey and some original mapping done by the BLM in Bingham County.

Location: BLM Idaho Falls Office

46. U.S. Geological Survey, 1989, *Mineralogy and grain size of surficial sediment from the Big Lost River Drainage and vicinity, with chemical and physical characteristics of geologic materials from selected sites at the Idaho National Engineering Laboratory, Idaho*, USGS, Open-File Report 89-384.

The authors report specific characteristics of the surficial sediments on the INEL's Big Lost River drainage, demonstrating that Big Lost River channel deposits are coarser than other types of deposits. Laboratory analysis was performed on a variety of Big Lost River sediments (downstream, overbank, INEL spreading areas, sink and playa, etc.). ISU ran X-ray diffraction on 27 samples to arrive at qualitative estimates of the abundance of clay minerals in the samples. The report also summarizes findings of clay mineralogy from other reports.

Location: USGS Office at the INEL

47. U.S. Geological Survey, 1989, *Mineralogy and grain size of surficial sediment from the Little Lost River and Birch Creek drainages, Idaho National Engineering Laboratory, Idaho*, USGS, Open-File Report 89-385.

Grain size analysis was performed on samples from 13 sites. Samples were sieved for the larger particles size analysis, and the pipette method was used for analysis of clay and silt size fractions. X-ray diffraction analysis was used to determine bulk mineralogy of all particles in a sample less than 0.5 mm, and clay mineralogy of particles less than 0.004 mm

in diameter. Semiquantitative analysis was used to determine the relative abundance of minerals in the samples.

Location: USGS Office at the INEL

48. **Volcanism Working Group** (D.H. Chung, D.W. Carpenter, B.M. Crowe, G.F. Embree, W.R. Hackett, S.M. Jackson, M.A. Kuntz, W.P. Lee, H.L. McKague, and R.P. Smith, 1990, *Assessment of potential volcanic hazards for New Production Reactor site at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-NPR- 10624, Idaho Falls, ID.

Summarizes the geologic setting, characteristics of volcanism, an assessment hazard from each type of volcanism, and a preliminary probabilistic volcanic hazard assessment. Concludes that the hazard from volcanic activity is 10×10^{-5} /year or less. .

Location: Files of R.P. Smith and W.R. Hackett

49. **Weston Geophysical Corporation and Purdue University**, 1991, *Final gravity map of the SRP (1:250,000 scale) and INEL area (1: 100,000 scale), 2 map sheets.*

Final maps of gravity anomalies in the ESRP and INEL areas from recompilation of data from all available sources and on new gravity data collected during 1991 field investigations for NPR.

Location: Files of R.P. Smith and G.S. Carpenter

50. **Weston Geophysical Corporation**, 1991, *Geophysical investigation, New Production Reactor Complex, Idaho National Engineering Laboratory*, EGG-NPR-10689.

Summary of borehole geophysical logging done during the 1991 NPR drilling program. Also includes the results of cross-hole determinations of P- and S-wave seismic velocities through the basalts and interbeds.

51. **Wong, I. G.**, 1990, "Normal faulting earthquake in southeastern Idaho," *Proceedings of the Fourth DOE Natural Phenomena Hazards Mitigation Conference.*

52. **Wong, I. G.**, 1992, "Addressing earthquake strong motion issues at the INEL," *Proceedings of the Third DOE Natural Phenomena Hazards Mitigation Conference.*

53. **Wong, I. G. , et al.** 1992, "Modeling strong ground motions in the near-field of a Basin-and Range", *Seismological Research Letters*, 63(1):33.

54. **Wong, I. G.; Silva, W. J.; Jackson, S. M., and Smith, R. P.**, 1989, "Earthquake strong ground motions studies at the Idaho National Engineering Laboratory," *Proceedings of the 2nd*

Department of Energy Phenomena Hazards Mitigation Conference, Knoxville, TN, October 1989.

55. Woodward-Clyde Consultants, 1990, *Earthquake strong ground motion estimates for the Idaho National Engineering Laboratory*, Woodward-Clyde Consultants, EGG-BG-9350, 3 volumes.

Models deterministic ground motion for each INEL facility but uses only the Lemhi fault as an earthquake source.

56. Woodward-Clyde Consultants, 1991, *Lost River fault trip report, 12-14 November 1991*, EG&G Idaho, Inc., Letter Report, Idaho Falls, ID.

57. Woodward-Clyde Consultants, 1992a, *Earthquake ground motion evaluations for the proposed NPR at the INEL, Volume : Deterministic Evaluation*, EGG-GEO-10304.

Deterministic seismic hazard assessment for NPR based on newest information resulting from 1990-1991 field investigations for NPR. Considered all earthquake sources; Lemhi fault, Lost River fault, Beaverhead faults, volcanic rift zone, axial volcanic zone, and random (floating) earthquake.

58. Woodward-Clyde Consultants, 1992b, *Paleoseismic investigations of the southern Lemhi fault, Idaho*, EG&G Idaho, Inc., EGG-GEO-10178, Idaho Falls, ID.

Final report summarizing findings and conclusions from logging of four new trenches across the southern Lemhi fault and from mapping of surficial deposits in the area of the trenches. Documents late Pleistocene earthquake history of the southern part of the fault; earthquake magnitude, recurrence intervals, most recent events, and ages of events.

Appendix B
Air Resources

Patrick R. Leonard

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B.1 Annotated Bibliography for Air Resources	B-1
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B.1 Annotated Bibliography for Air Resources^a

1. **Abbott, M. L.; Brooks, J. M., and Martin, K. L.**, 1991, *NPR Environmental Impacts at the INEL: Air Quality, Cooling Towers, and Noise*, EG&G Idaho, Inc., NPRD-90-059, Rev. A, Idaho Falls, ID, March 1991.

This document assesses the NPR environmental impacts relating to air quality, cooling towers, and noise at the INEL. For air quality, emission inventories of criteria and NPR toxic air pollutants were developed for existing (baseline) INEL sources, NPR construction source, and new NPR operational sources. Wet cooling tower impacts were qualitatively assessed for plume visibility, fogging, icing, and drift deposition.

Subject: NPR Impacts

Keywords: AIR QUALITY / STATIONARY SOURCES / MOBILE SOURCES /
COOLING TOWER / NOISE / NEW PRODUCTION REACTOR

Location: INEL Technical Library

2. **Briggs, G. A.**, 1969, *Plume Rise*, USAEC, TID-25075, Washington, D.C.

The mechanism of plume rise and dispersion is described in qualitative terms with emphasis on possible aerodynamic, meteorological, and topographical effects. Plume rise observations and formulas in the literature are reviewed, and a relatively simple theoretical model is developed and compared with other models.

Subject: Plume dispersion

Keywords: PLUME RISE / MOMENTUM / THERMAL / AERODYNAMICS /
METEOROLOGY / TOPOGRAPHY / DISPERSION

Location: INEL Technical Library

3. **Clements, W. E.**, 1979, *Experimental Design and Data of the April, 1977 Multitracer atmospheric Experiment at the Idaho National Engineering Laboratory*, Los Alamos Scientific Laboratory, LA-7795-MS, Los Alamos, NM.

A multitracer atmospheric transport and diffusion experiment was conducted during April 1977, at the INEL. SF₆, C₈F₁₆, C₆F₁₂, C₇F₁₄, 13CD₄, and 12CD₄ were released simultaneously in a well-defined and monitored meteorological situation and sampled at various downwind distances. This report describes the details of this experiment, presents a compilation of data collected, discusses the performance of the various tracers and sampling techniques used, and outlines some recent progress and plans.

Subject: atmospheric transport, dispersion, and diffusion

a. Not all references are annotated. Those not annotated are provided for your information.

Keywords: atmospheric TRANSPORT / DIFFUSION / TRACER / SAMPLING /
METEOROLOGY

Location: INEL Technical Library

4. Coats, D. W., and Murray, R. C., 1985, *National Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for Department of Energy Sites*, Lawrence Livermore National Laboratory, UCRL-53526, Rev. 1, Livermore, CA.

This work is part of a three-phase effort aimed at establishing uniform building design criteria for seismic and wind hazards at DOE sites throughout the U.S. This report summarizes the final wind/tornado hazard models recommended for each site and the methodology used to develop these models.

Subject: Tornados

Keywords: WIND / HAZARDS / TORNADO / MODELS

Location: INEL Technical Library

5. DeMarrais, G. A., 1958, *The Climatology of the National Reactor Testing Station*, U.S. Weather Bureau, Department of Commerce, IDO-12003.

This is the first in a series of three climatological reports on the National Reactor Testing Station, now the INEL. This report is concerned with the general climatology of the areas with particular emphasis on temperature, relative humidity, precipitation, snowfall, winds, pressure, and special phenomena. The reasons for any significant variations in the observed meteorological parameters are discussed.

Subject: Climatology and meteorology

Keywords: CLIMATOGRAPHY / METEOROLOGY / TEMPERATURE /
RELATIVE HUMIDITY / PRECIPITATION / WIND

Location: INEL Technical Library

6. DeMarrais, G. A., 1958, *The Engineering Climatology of the National Reactor Testing Station*, U.S. Weather Bureau, Department of Commerce, IDO-12004.

This is the second in a series of three climatological reports on the National Reactor Testing Station, now the INEL. This report presents, in a form useful to designers and engineers, data on the following subjects: temperature, moisture content of the air, precipitation, wind, state of the ground, dust, and human comfort.

Subject: Climatology and meteorology

Keywords: ENGINEERING CLIMATOGRAPHY / METEOROLOGY /
MOISTURE / TEMPERATURE / DUST

Location: INEL Technical Library

7. DeMarrais, G. A., and Islitzer N.F., 1960, *Diffusion Climatology of the National Reactor Testing Station*, U.S. Weather Bureau, Department of Commerce, IDO-12015.

This report presents the results of the observational program conducted by the Weather Bureau at the National Reactor Testing Station (now the INEL) that are pertinent to the study of atmospheric diffusion. The following elements as they affect diffusion are qualitatively and quantitatively summarized: topography, lapse rate and winds, turbulence parameters, solar and terrestrial radiation, and precipitation. In addition, the specialized diffusion investigation conducted at the National Reactor Testing Station are described in a large appendix. This includes data on both diffusion climatology and diffusion measurements using radioactive and non radioactive tracers.

Subject: Atmospheric transport, dispersion, and diffusion
Keywords: METEOROLOGY / atmospheric DIFFUSION / CLIMATOGRAPHY
Location: INEL Technical Library

8. Dickson, C. R.; Start, G. E., and Markee, E. H., Jr., 1969, "Aerodynamic Effects of the EBR-II Reactor Complex on Effluent Concentration", *Nuclear Safety*, 10:228.

This is a description of experimental releases of a tracer, uranin dye, at EBR-II. The purpose of the test was to quantify turbulent mixing and dilution of a contaminant downwind of a large building.

Subject: Building wake dispersion
Keywords: atmospheric DISPERSION / TURBULENCE / BUILDING EFFECT / DILUTION / EBR-II/ DIFFUSION / DISPERSION / TRACER
Location: INEL Technical Library

9. Dickson, C. R., and Angell, J. K., 1968, "Eddy Velocities in the Planetary Boundary Layer as Obtained from Tetroon Flights at Idaho Falls", *J. Appl. Meteorology*, 7:986-993.

10. EG&G Idaho, Inc., 1985, *INEL Characterization Report*, Idaho Falls, ID, EGG-NPR-6688, Rev. 1.

This three-volume (Volume I: Summary; Volumes II and III: Appendices) environmental characterization report contains general information on environmental aspects of the INEL, and specific information on two areas within the INEL which were tentatively selected for NPR siting. The report presents environmental information but not environmental impacts of the proposed NPR.

Subject: Environmental Characteristics
Keywords: SITE CHARACTERIZATION / GEOGRAPHY / ECOLOGY / CLIMATOGRAPHY / HYDROLOGY / CULTURAL RESOURCES /

ENVIRONMENT / ENVIRONMENTAL MONITORING / NEW
PRODUCTION REACTOR

Location: INEL Technical Library

11. **EG&G Idaho, Inc.**, 1989, *Site Transportation Plan for the New Production Reactor at the INEL, Part 1: Existing Facilities and Activities, Draft*, NPR-DEIS-SR-0026, Idaho Falls, ID.

This draft document describes the INEL transportation system, including roadways, railroads, equipment, and other facilities. Data are provided on current and recent shipment and traffic activity.

Subject: INEL Transportation System

Keywords: TRANSPORTATION / RAILROADS / HIGHWAYS / TRAFFIC /
RADIOLOGICAL RISK / TRAILS

Location: INEL Technical Library

12. **EG&G Idaho, Inc.**, 1991, *Formal Documentation Showing the origins, Path, and Methods Underlying the Creation of Some of the CAP-88-Readable Wind Files in Use by the EMA Unit, Engineering Design File*, EDF CAP-PROT-91-005, Idaho Falls, ID, March 1991.

This technical report details the methods used by EG&G air dispersion modelers to create CAP-88 wind files starting with joint frequency distributions (JFD) provided by the NOAA. JFD's are tabular listings of the hours that the wind blows in each of the 16 compass directions, at each of a set of wind speed classes, and for a set of stability categories. JFDs for facilities at the INEL are converted to wind files usable by the EPA CAP-88 code.

Subject: Wind data

Keywords: WIND FILES / WIND DATA / METEOROLOGY / CAP-88 / JFD

Location: Unit Files, Subsurface and Environmental Modeling Unit, EG&G

13. **EG&G Idaho, Inc.**, 1992, *Formal Documentation of 1987-1991 INEL Wind Files Used in CAP-88, Engineering Design File*, EDF CAP-PROT-91-011, Idaho Falls, ID, February 12, 1992.

This EDF is similar to EG&G, 1991; this report contains INEL wind data from 1987 through 1991. Less detail on methods is contained in this report.

Subject: Wind data

Keywords: WIND FILES / WIND DATA / METEOROLOGY / CAP-88 / JFD

Location: Unit files, Subsurface and Environmental Modeling Unit

14. Environmental Protection Agency, 1985, *Compilation of Air Pollutant Emission Factors*, AP-42, Fourth Edition, PB86-124906, September 1985.

Emission data obtained from source tests, material balance studies, engineering estimates, etc. have been compiled for use by individuals and groups responsible for conducting air pollution emission inventories. Emission factors given in this two-volume document cover most of the common stationary, area, and mobile source emission categories: fuel combustion, combustion of solid wastes, evaporation of fuels, solvents, and other volatile substances, various industrial processes, vehicle exhausts, and misc. sources.

Subject: Air pollutant emissions
Keywords: EMISSIONS / STATIONARY SOURCES / AREA SOURCES /
MOBILE SOURCES / FUEL COMBUSTION / EMISSION
INVENTORIES / EXHAUST EMISSIONS / COMBUSTION /
EVAPORATION
Location: INEL Technical Library

15. Environmental Protection Agency, 1989, *User's Guide to MOBILE4 (Mobile Source Emission Factor Model)*, EPA-AA-TEB-89-01, February 1989.

MOBILE4 is a computer program that calculates emission factors for hydrocarbon (HC), carbon monoxide (CO), and oxides of nitrogen (NOx) from gasoline-fueled and diesel highway motor vehicles. The program uses the calculation procedures and emission factors presented in Compilation of Air Pollutant Emission Factors: Highway Mobile Source (AP-42, Fourth Edition, September 1985). MOBILE4 calculates emission factors for eight individual vehicle types in 48 regions of the country. MOBILE4 emission estimates depend on various conditions such as ambient temperature, speed, and mileage accrual rates.

Subject: Air Pollutant Emissions
Keywords: HYDROCARBONS / CARBON MONOXIDE / NITROGEN OXIDES /
MOTOR VEHICLES / REGULATIONS / COMPUTER PROGRAMS /
AIR POLLUTION / EXHAUST EMISSIONS
Location: INEL Technical Library

16. Fuguay, J. J.; Simpson, C. L., and Hinds, W. T., 1963, *Prediction of Environmental Exposures from Sources Near the Ground, Based on Hanford Experimental Data*, Hanford Atomic Products Operation, General Electric Co., Richland, WA.

This report presents experimental data on plume lateral growth in air. The lateral growth is expressed as a function of travel time and the product of the standard deviation of the wind direction and the mean wind speed near the release height. A method of obtaining cross-wind prediction solely from low-level wind and temperature data is proposed and demonstrated for a set of ten independent field tests.

Appendix B ♦ B-6

Subject: Plume dispersion
Keywords: atmospheric DISPERSION / DIFFUSION / WIND DIRECTION /
WINDSPEED / RICHARDSON NUMBER / GROUND RELEASE
Location: Idaho Falls NOAA Office

17. Hilsmeier, W. F., and Gifford, F. A., Jr., 1962, *Graphs for Estimating atmospheric Dispersion*, U.S. AEC Report, ORO-545, Oak Ridge, TN, July 1962.

This is a short description of a method for determining χ/Q values using graphs. The graphs give the dispersion parameter versus distance and χ/Q versus distance for the six stability categories A through F.

Subject: Dispersion parameters and stability categories
Keywords: STABILITY CATEGORY / atmospheric DISPERSION / DISPERSION
COEFFICIENTS / STANDARD DEVIATIONS / SPECIFIC
CONCENTRATION
Location: INEL Technical Library

18. Holtzworth, G. C., 1967, "Mixing Depths, Wind Speeds and Air Pollution Potential for Selected Locations in the United States", *Journal of Applied Meteorology*, 6(6):1039-1044.

Daily estimates of morning and afternoon mixing depths and average wind speeds through the mixing layers are calculated and summarized for seven locations in several climatic regions of the contiguous U.S. Monthly averages of morning and afternoon mixing depth and wind speed are presented graphically.

Subject: Mixing depth variation
Keywords: MIXING DEPTH / LID / MIXING LAYERS / WINDSPEED /
DIFFUSION / POLLUTANT / CONCENTRATION
Location: Idaho Falls NOAA Office

19. Holzworth, G. C., 1972, *Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States*, EPA, Pub. No. AP-101, Research Triangle Park, NC.

20. Humphrey, P. A.; Wilkins, E. M., and Morgan, D. M., 1953, *Atmospheric Dust at the National Reactor Testing Station, Final Report*, U.S. Department of Commerce, Weather Bureau Office, Idaho Falls, ID.

21. Idaho Air Quality Bureau, 1989, *Rules and Regulations for the Control of Air Pollution in Idaho*, IDAPA 16.01, June 15, 1989.

This set of Idaho State Regulations pertaining to air pollution contains detailed limits on specified pollutants; most are identical to the National Ambient Air Quality Standards (NAAQS).

Subject: Idaho State Air Quality Regulations
Keywords: IDAHO STATE REGULATIONS / AIR QUALITY / POLLUTION / POLLUTANT / IDAPA / OCCUPATIONAL EXPOSURE LEVEL / THRESHOLD LIMIT VALUE / AMBIENT AIR / NAAQS
Location: INEL Technical Library

22. Islitzer, N. F., 1961, "Short-Range atmospheric-Dispersion Measurements from an Elevated Source", *Journal of Meteorology*, 18(4 (August 1961)):443-450.

Dispersion measurements of a tracer, uranin dye in solution, were made out to two miles from the release point in unstable atmospheres. The tracer was released from the top of a 150-foot tower and sampled at ground level by 100 high-volume air samplers.

Subject: atmospheric transport, dispersion, and diffusion
Keywords: atmospheric DISPERSION / DIFFUSION / TRACER / TOWER RELEASE / CONCENTRATION / TURBULENCE
Location: Idaho Falls NOAA Office

23. Islitzer, N. F., 1965, *Aerodynamic Effects of Large Reactor Complexes Upon atmospheric Turbulence and Diffusion*, U.S. AEC, U.S. Weather Bureau, IDO-12041, Idaho Falls, ID.

The additional turbulence immediately downwind of a large reactor complex (MTR-ETR) due to aerodynamic effects from the buildings was measured. Wind stations employing anemometers and bivanes were used, as well as sampling stations that directly measured diffusion of a tracer, uranin dye.

Subject: Building wake dispersion
Keywords: atmospheric DISPERSION / TRACER / TURBULENCE / DISPERSION / DIFFUSION / BUILDING EFFECT
Location: INEL Technical Library

24. Islitzer, N. F., and Dumbauld, R. K., 1963, "atmospheric Diffusion-Deposition Studies Over Flat Terrain", *International Journal of Air and Water Pollution*, 7:999-1022.

This report evaluates measurements of particle dispersion from a ground-level source out to two miles. This is done in terms of wind-direction statistics from time-averaged data. The tests were carried out with uranin dye as a tracer.

Subject: atmospheric transport, dispersion, and diffusion
Keywords: atmospheric DISPERSION / DIFFUSION / DEPOSITION / TRACER /
CONCENTRATION / POLLUTANT
Location: Idaho Falls NOAA Office

25. Johnson, O. J., and Dickson, C. R., 1962, *An Eight Year Summary of the Temperature Gradient Below 250 feet at the National Reactor Testing Station*, U.S. Weather Bureau, Department of Commerce, IDO-12025, May 1962.

This technical report gives a monthly breakdown of an eight year period (1953-1960) of temperature gradient data below 250 feet. The data are compiled in tabular form showing the time of formation, duration, maximum intensity, and dissipation of inversions for each month.

Subject: Near surface temperature data
Keywords: TEMPERATURE / INVERSION / LAPSE RATE / LOCAL CLIMATE /
METEOROLOGY
Location: INEL Technical Library

26. Markee, E. H., Jr., 1963, "Methods of Estimating Air Pollutant Dispersion Over Relatively Smooth Terrain from Routine Meteorological Observations," *219th National Meeting of the American Meteorological Society, Palo Alto, CA, June 20, 1963.*

This is a report on techniques used to compute dispersion of an atmospheric pollutant for 1-hour sampling times out to 3200 meters over desert-type terrain. The techniques were derived from diffusion experiments carried out at the INEL.

Subject: atmospheric transport, dispersion, and diffusion
Keywords: atmospheric DISPERSION / POLLUTANT / DIFFUSION / STABILITY
CATEGORY
Location: Idaho Falls NOAA Office

27. Markee, E. H., Jr.; Beckerly, J. G., and Sanders, K. E., 1974, *Technical Basis for Interim Regional Tornado Criteria*, USAEC, WASH-1300.

The objective of this study was to determine from available information a regionalized design basis tornado for the contiguous U.S. From an analysis of tornado classification data from the National Weather Service Offices for 1971 and 1972 and tornado occurrence data, it was concluded that three general regions with associated tornado severity and frequency of occurrence could be determined. Probable windspeeds were calculated, and corresponding pressure drops and rates of pressure drop were determined from the cyclostrophic equation.

Subject: Tornadoes

Keywords: TORNADO / WINDSPEED / OCCURRENCE / PRESSURE DROP /
DESIGN BASIS / SEVERITY / GEOGRAPHICAL REGIONS
Location: INEL Technical Library

28. Nace, R. L.; Voegeli, P. T.; Jones, J. R., and Deutsch, M., 1975, *Generalized Geologic Framework of the National Reactor Testing Station, Idaho*, USGS, USGS Prof. Paper 725-B, Washington, D.C.

29. Pasquill, F., 1961, "The Estimation of the Dispersion of Windborne Material", *Meteorology Magazine*, 90:33-459.

Diffusion experiments using fluorescent particles are described and data on travel and horizontal spread over distances of 10-80 miles are summarized.

Subject: atmospheric transport, dispersion, and diffusion
Keywords: atmospheric DIFFUSION / HORIZONTAL SPREAD / TURBULENCE /
VERTICAL SHEAR / TRACER
Location: Idaho Falls NOAA Office

30. Sagendorf, J. F., and Dickson, C. R., 1974, *Diffusion under Low Windspeed Inversion Condition*, NOAA Technical Memorandum, ERL ARL-52, December 1974.

A series of diffusion tests conducted under stable conditions with windspeeds less than 2 m/sec is described.

Subject: Low windspeed diffusion
Keywords: atmospheric DIFFUSION / DISPERSION / LIGHT WINDS / LOW
WINDSPEED / INVERSION / LAPSE RATE / TRACER
Location: Idaho Falls NOAA Office

31. Sagendorf, J. F.; Ricks, N. R.; Start, G. E., and Dickson, C. R., 1980, *Diffusion Near Building as Determined from atmospheric Tracer Experiments*, NOAA Technical Memorandum, ERL ARL-84, September 1980.

Data from the innermost arcs and roof top samplers of the Rancho Seco and EOCR field studies were used to examine diffusion close to a building. The minimum length plume paths were determined from each release location to each sampler position at the two test sites.

Subject: Building wake dispersion
Keywords: atmospheric DISPERSION / DIFFUSION / TRACER / RANCHO SECO
/ BUILDING WAKE / TURBULENCE
Location: Idaho Falls NOAA Office

32. Slade, D. H., 1968, *Meteorology and Atomic Energy*, USAEC, TID-24190, July 1968.

This volume is a combination of guide, handbook, textbook, and research report on subjects relating to the distribution of pollutants in the atmosphere. .

Subject: atmospheric transport, dispersion, and diffusion
Keywords: atmospheric TRANSPORT / DIFFUSION / INSTRUMENTS /
WEATHER / WIND / CLIMATOGRAPHY / METEOROLOGY /
DEPOSITION / SCAVENGING / WASHOUT / BUILDING EFFECT /
PLUME / CLOUD / DOSE/ SAFETY
Location: INEL Technical Library

33. Solar Energy Research Institute, 1981, *Solar Radiation Energy Resource Atlas of the United States*, Solar Energy Research Institute, SERI/SP-642-1037, Washington, D.C.

34. Stan, G. E.; Hukari, N. F.; Sagendorf, J. F.; Cate, J. H., and Dickson, C. R., 1980, *EOCR Building Wake Effects on Atmospheric Diffusion*, U.S. Dept. of Commerce, NOAA, Env. Res. Lab., Air Res. Lab., Technical Memorandum ERL/ARL-91, Idaho Falls, ID.

35. Stan, G. E.; Cate, J. H.; Sagendorf, J. F.; Ackermann, G. R.; Dickson, C. R.; Hukari, N. H., and Thorngren, L. G., 1985, *Comparisons of Trajectories, Tracer Concentration Patterns and MESODIF Model Calculations: Idaho Field Experiment 1981, Vol. III*, U.S. Dept. of Commerce, NOAA, Env. Res. Lab., Air Res. Lab., , NUREG/CR-3488, Idaho Falls, ID.

36. Start, G. E.; Cate, J. H.; Sagendorf, J. F.; Ackerman, G. R.; Dickson, C. R.; Hukari, N. H., and Thorngren, L. G., 1985, *Idaho Field Experiment 1981, Volume 3: Comparison of Trajectories, Tracer Concentration Patterns, and MESODIF Model Calculations*, NUREG/CR-3488, February 1985.

Release of sulfur hexafluoride tracer gas were made for 8-hour from 46 m above ground. Tracer was sampled hourly, for 12 sequential hours, at 100 locations.

Subject: Aerial dispersion data
Keywords: atmospheric DISPERSION / MESODIF / TRACER
Location: INEL Technical Library

37. Start, G. E.; Dickson, C. R.; Sagendorf, J. F.; Ackerman, G. R.; Clawson, K. L.; Johnson, R. C., and Hukari, N. F., 1989, *Atmospheric Diffusion for Airflows in the Vicinity of the James Forrestal Campus, Final Report*, Princeton University, May 1989.

A field measurement program was conducted to directly evaluate atmospheric diffusion condition in the vicinity of the Princeton Plasma Physics Laboratory. Gaseous tracer releases were made from selected locations. A site-specific diffusion climatography was developed for PPPL.

Subject: Building wake dispersion
Keywords: atmospheric DIFFUSION / TRACER / PRINCETON PLASMA
PHYSICS LABORATORY / STABILITY CATEGORY / BUILDING
WAKE / TURBULENCE
Location: Idaho Falls NOAA Office

38. Start, G. E.; Hukari, N. F.; Sagendorf, J. F.; Cate, J. H., and Dickson, C. R., 1980, *EOCR Building Wake Effects on atmospheric Diffusion*, NOAA Technical Memorandum, ERL ARL-91, November 1980.

A series of 22 simultaneous releases of three gaseous tracers was conducted around the EOCR test reactor building at the INEL. Hourly averaged tracer concentrations were sampled on several concentric sampling arcs and at limited number of elevated locations.

Subject: Building wake dispersion
Keywords: atmospheric DIFFUSION / BUILDING EFFECT / BUILDING WAKE /
TRACER / VERTICAL DIFFUSION
Location: Idaho Falls NOAA Office

39. Start, G. E., and Wendell, L. L., 1974, *Regional Effluent Dispersion Calculations Considering Spatial and Temporal Meteorological Variations*, NOAA Technical Memorandum, ERL ARL-44, May 1974.

An objective regional trajectory analysis scheme has been combined with a Gaussian diffusion model to yield a technique called MESODIF - mesoscale diffusion. The trajectory analysis scheme utilized wind data from a network of tower-mounted wind sensors to consider the effects of spatial variabilities of horizontal wind flow near the surface, incorporated time changes in rates of diffusion, and used an upper level lid to vertical mixing.

Subject: MESODIF model development
Keywords: atmospheric DIFFUSION / MESODIF / TRAJECTORY ANALYSIS /
CONCENTRATION
Location: Idaho Falls NOAA Office

40. Start G.E.,ed., 1984, *Climatology of the Idaho National Engineering Laboratory*, IDO-12048A and B, Idaho Falls, ID.
41. Sutton, O. G., 1955, *Micrometeorology*, New York, NY, McGraw-Hill Book Co.
42. Turner, D. B., 1970, *Workbook of Atmospheric Dispersions Estimates, Revised*, EPA, Research Triangle Park, NC.

43. U.S. Department of Energy, 1982, *INEL Architectural-Engineering Standards for the U.S. Department of Energy, Revision 3*.
44. U.S. Department of Energy, 1989, *Climatology of the Idaho National Engineering Laboratory, 2nd Edition*, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Air Resources Laboratory, Field Research Division, DOE/ID-12118, Idaho Falls, ID.
45. U.S. Department of Energy, 1989, *INEL Environmental Characterization Report, Volume 1*, EG&G Idaho, Inc., EGG-NPR-6688, Idaho Falls, ID.
46. U.S. Department of Energy, 1990, *NPR Environmental Impacts at the INEL: Air Quality, Cooling Towers, and Noise, New Production Reactor MHTGR*, NPRD-90-059, Idaho Falls, ID.
47. U.S. Department of Energy, 1992, *The Idaho National Engineering Laboratory Site Environmental Report*, Department of Energy, DOE/ID-12082, Idaho Falls, ID.

This report, issued periodically, contains information relative to environmental surveillance at the INEL. The 1992 issue presents data for CY 1991. The report describes the surveillance program, the collection of foodstuffs at the INEL boundary and distant locations, and the collection of air and water samples at onsite locations and offsite boundary and distant locations. The report also compares and evaluates the sample results and discusses implications, if any. Non radioactive and radioactive effluent monitoring at the Site, and the USGS ground-water monitoring program are also summarized.

Subject: Environmental surveillance
Keywords: ENVIRONMENTAL SURVEILLANCE / REGULATIONS /
MONITORING / RADIOACTIVE / NON RADIOACTIVE / GROUND
WATER / SAMPLING / CERCLA / NESHAP / RCRA / SDWA / NEPA
/ CAA / TSCA
Location: INEL Technical Library

48. U.S. Nuclear Regulatory Commission, 1972, *Onsite Meteorological Programs*, NRC, Regulatory Guide 1.23, Washington, D.C.
49. Wendell, L. L., 1972, "Mesoscale Wind Fields and Transport Estimates Determined from a Network of Wind Towers", *Monthly Weather Review*, 100:565-578.

Techniques are developed to use wind data from a network of stations to study mesoscale flow patterns and transport in the lower planetary boundary layer. The data sample for this study is hourly averaged wind data for the year 1969 from 21 stations over the Upper Snake River Plain.

Subject: Wind data
Keywords: atmospheric DISPERSION / MESOSCALE / WIND FIELDS /
TRANSPORT / FLOW PATTERNS
Location: Idaho Falls NOAA Office

50. Yanskey, G. R.; Markee, E. H., Jr., and Richter, A. P., 1966, *Climatology of the National Reactor Testing Station*, Environmental Science Services Administration, Department of Commerce, IDO-12048, January 1966.

This is the first edition of a general climatology report of the reserve that was once known as the National Reactor Testing Station, now the INEL. It contains data up to 1964. In addition to the subjects mentioned under clawson et al., 1989, it contains a discussion of modifications to the basic diffusion equation and persistence data for wind speed and direction.

Subject: Climatology and meteorology
Keywords: CLIMATOGRAPHY / METEOROLOGY / NATIONAL reactor
TESTING STATION / atmospheric TRANSPORT / DIFFUSION
Location: INEL Technical Library

B.2 Keyword List^b

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b. Numbers refer to numbered references in Section B.1, Annotated Bibliography for Air Resources.

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32, 50

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Appendix C
Water Resources

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ACRONYMS

CFA	Central Facilities Area
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ICPP	Idaho Chemical Processing Plant
INEL	Idaho National Engineering Laboratory
NRF	Naval Reactors Facility
RWMC	Radioactive Waste Management Complex
SRPA	Snake River Plain Aquifer
TAN	Test Area North
TRA	Test Reactor Area

C.1 Perched Water Data

C.1.1 Water Quality

The location and hydrology of perched water beneath the Idaho National Engineering Laboratory (INEL) has been discussed in Section 4.2.1, Vadose Zone Hydrology. Because the source for most of the perched water beneath the INEL is waste from INEL facilities, these water bodies may frequently have elevated contaminant concentrations. However, the concentrations of contaminants in all of these perched waters have not yet been measured.

C.1.2 Test Reactor Area

Elevated tritium, cobalt-60, chromium, and sulfate concentrations have been observed in the deep perched water near the Test Reactor Area (TRA). Tritium concentrations in the deep perched water increased from $757,000 \pm 3,000$ pCi/L in 1981 to $1,770,000 \pm 30,000$ pCi/L in 1985. Sulfate concentrations increased from 12 to 2,700 mg/L in 1981, to 63 to 3,400 mg/L in 1984 (Pittman et al. 1988). The highest chromium concentration measured in the deep perched water during 1985 was 0.14 mg/L. These concentrations, like those in the Snake River Plain Aquifer (SRPA), have probably decreased since 1985 due to decreased release. The concentration of cobalt-60 in the deep perched water near TRA decreased from 800 ± 90 to 360 ± 50 pCi/L between 1981 and 1985.

C.1.3 Radioactive Waste Management Area

A monitoring well drilled into the deep perched water near the Radioactive Waste Management Complex (RWMC) showed elevated concentrations of carbon tetrachloride (1.2 mg/L in 1987 and 1.4 mg/L in 1988), chloroform (0.65 mg/L in 1987 and 0.95 mg/L in 1988), 1,1,1-trichloroethane (0.14 mg/L in 1987 and 0.25 mg/L in 1988), trichloroethylene (0.86 mg/L in 1987 and 1.1 mg/L in 1988), tetrachloroethylene (0.11 mg/L in 1987 and 0.12 mg/L in 1988), 1,1-dichloroethylene (0.013 mg/L in 1987 and 0.022 mg/L in 1988) (Mann and Knobel 1987; Mann 1990). The concentration of these organic contaminants appears to have increased between 1987 and 1988. Elevated tritium concentrations have been detected in the shallow perched water near the RWMC (Humphrey and Tingey 1978; Bargelt, et al., 1992).

C.1.4 Idaho Chemical Processing Plant

Elevated strontium-90 concentrations (9.8 pCi/L) have recently been observed in perched water near the Idaho Chemical Processing Plant (ICPP). Although water from this well was also analyzed for cobalt-60 and cesium, neither compound was detected (Norrell 1993).

C.2 Groundwater Quality Data

Figures C-1, C-2, C-3, and C-4 show the spacial distribution of temperature, total dissolved solids, calcium, and sodium, respectively, in the SRPA beneath the INEL.

In addition to the naturally occurring compounds found in the SRPA beneath the INEL, U.S. Department of Energy (DOE)/INEL activities have introduced radioactive compounds, nonradioactive metals, inorganic salts, and organic compounds into the subsurface materials and groundwater.

Radionuclides released and observed in the soils and groundwater of the INEL include tritium, strontium-90, iodine-129, cobalt-60, cesium-137, plutonium-238, plutonium-239, -240 (undivided), and americium-241. Radionuclide concentrations in the SRPA beneath the INEL have generally decreased since the middle 1980s. These reduced concentrations have resulted from changes in INEL disposal practices, radioactive decay, adsorption of the radionuclides to the surfaces of rocks and minerals within the aquifer, and dilution by natural surface and ground waters entering the SRPA (Pittman et al. 1988; Orr and Cecil 1991).

Figures C-5a through C-5d show the spacial distribution of tritium in the SRPA beneath the INEL for the years 1961, 1968, 1985, and 1988, respectively. The size of the tritium plume increased to a maximum area of 132 km² (51 mi²) by 1985, and extended just south of the INEL boundary. The tritium concentrations within the small portion of the plume that extended outside of the INEL boundary were less than the maximum contaminant level of 60,900 pCi/L set by the Environmental Protection Agency (EPA) (56 FR 3350, 1991). Natural concentrations of tritium occurring in the SRPA generally range from 75 to 150 pCi/L (Orr and Cecil 1991).

Figures C-6a through C-6d show the distribution of strontium-90 in the SRPA for the years 1964, 1970, 1985, and 1988, respectively. Unlike tritium, strontium adsorbs to rock and mineral surfaces and has not migrated through the SRPA to the extent of tritium. In 1985, the area of the strontium-90 plume reached 5.2 km² (2 mi²), from which it declined to 2.1 km² (0.8 mi²) by 1988. The highest strontium-90 concentration observed in 1988 was 48±3.3 pCi/L (Pittman et al. 1988; Orr and Cecil 1991). Strontium-90 does not naturally occur in groundwater.

The maximum iodine-129 concentrations observed in the SRPA were 27±1 pCi/L in 1977, 41±2 pCi/L in 1981, and 3.6±0.4 pCi/L in 1986. The plume area has decreased from 2.1 km² (0.8 mi²) exceeding 5 pCi/L in 1981 to 1.0 km² (0.4 mi²) exceeding 3 pCi/L in 1986 (Mann et al. 1988). However, Mann^a has recently observed iodine-129 at concentrations slightly higher than natural (but much less than the maximum contaminant level) 9.7 km (6 mi) outside of the INEL. Natural concentrations of iodine-129 in the SRPA range from 0 to 0.05 pCi/L (Orr and Cecil 1991).

Measurable cobalt-60 concentrations were observed in well 65 near the TRA through 1985. Cobalt has not been detected in this well since 1986. A cobalt-60 concentration of 890±9 pCi/L was observed in the Test Area North (TAN) disposal well in 1987 (Pittman et al. 1988).

a. Private communication with L. J. Mann, 1993.

Figure C-1. Spatial distribution of temperature in the SRPA beneath the INEL.

Figure C-2. Spatial distribution of dissolved solids in the SRPA beneath the INEL.

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J93 0033

Figure C-6b. Spacial distribution of strontium-90 in the SRPA for 1970.

Figure C-6c. Spatial distribution of strontium-90 in the SRPA for 1985.

Figure C-6d. Spatial distribution of strontium-90 in the SRPA for 1988.

Cesium-137 was detected in two wells near the ICPP between 1982 and 1985. The maximum concentration observed was 237 ± 34 pCi/L. Cesium has not been detected in these wells after 1985. A cesium-137 concentration of $3,800 \pm 160$ pCi/L was observed in the TAN disposal well in 1986. A total of $3,060 \pm 120$ pCi/L of cesium-137 were observed in the TAN well in 1988. Although cesium-137 was also released at the TRA, it has never been observed in monitoring wells near the TRA (Pittman et al. 1988; Orr and Cecil 1991).

Measurable plutonium-238 concentrations were observed in two wells near the ICPP prior to 1986. The highest concentration observed was 0.5 ± 0.06 pCi/L in 1983. No plutonium-238 has been detected in these wells since 1986. A plutonium-239, -240 concentration of 5.5 ± 0.4 pCi/L was detected in one of these wells in 1987. Plutonium-239, -240 has not been detected in either well since 1987. The plutonium-238 concentration in the TAN disposal well was 1.22 ± 0.09 pCi/L in 1987 and 0.19 ± 0.05 pCi/L in 1988. The plutonium-239, -240 concentration in the TAN disposal well was 5 ± 0.02 pCi/L in 1987 and 0.96 ± 0.08 pCi/L in 1988. A plutonium-238 concentration of 0.11 ± 0.03 pCi/L was observed in a well near the Central Facilities Area in 1987. No plutonium-238 has been detected in the well since 1987 (Pittman et al. 1988; Orr and Cecil 1991).

Americium-241 is a decay product of plutonium-241. Measurable americium-241 was observed in four wells near the RWMC from 1972 through 1982. The highest americium-241 concentration observed was 5 ± 1 pCi/L. No americium-241 has been detected in any of these wells since 1982. Also, 2.1 ± 0.04 and 1 ± 0.03 pCi/L were observed in the TAN disposal well in 1987 and 1988, respectively (Pittman et al. 1988; Orr and Cecil 1991).

The nonradioactive metals, sodium, chromium, mercury, and lead have been released into the subsurface by human activities at the INEL. Of these metals, sodium was released in greatest quantity. It is estimated that a total of 25,410 kg (55,979 lb) of chromium, 154 kg (340 lb) of lead, and 68 kg (150 lb) of mercury were discharged at the INEL prior to 1984. None of these metals have been discharged by INEL facilities since 1984. Approximately 1.5 million kg (3.2 million lb) of sodium were discharged at the INEL between 1986 and 1988 (Orr and Cecil 1991).

A plume of elevated sodium concentration in the northeastern portion of the INEL is evident. This plume may be due to infiltration of irrigation water in the Mud Lake region northeast of the INEL. Sodium concentrations greater than 10 mg/L have been observed in several wells near the RWMC. The maximum sodium concentration measured in a well near the RWMC was 52 mg/L. The maximum sodium concentration observed in wells near the Navel Reactors Facility (NRF) during 1988 was 114 mg/L. Sodium disposal from the NRF decreased from about 39,010 kg (86,000 lb) in 1986 to about 6,350 kg (14,000 lb) in 1988 (Pittman et al. 1988; Orr and Cecil 1991).

Figures C-7a through C-7c show the distribution of chromium in the SRPA beneath the INEL in 1966, 1967, and 1970, respectively. Although chromium has been discharged at the TRA, NRF, Experimental Breeder Reactor II, ICPP, and Power Burst Facility (PBF) at various times measurable chromium concentrations have only been observed near the TRA. The highest

J93 0044

Figure C-7a. Spacial distribution of chromium in the SRPA beneath the INEL for 1966.

J93 0034

Figure C-7b. Spatial distribution of chromium in the SRPA beneath the INEL for 1967.

J93 0038

Figure C-7c. Spatial distribution of chromium in the SRPA beneath the INEL for 1970.

chromium concentration observed in the SRPA beneath the INEL was 5 mg/L. This observation was made in 1970 at a well near the TRA. In 1988, the highest chromium concentration observed at this same well was 0.21 mg/L, and was well beneath the drinking water standard (Mann and Knobel 1988; Pittman et al. 1988; Orr and Cecil 1991).

Relatively small amounts of lead and mercury were released from the ICPP prior to 1984. Neither lead nor mercury have been released from INEL facilities since 1986. The highest lead and mercury concentrations measured in the SRPA beneath the INEL in 1987 were 0.007 and 0.004 mg/L, respectively, well beneath the drinking water standards (Mann and Knobel 1988; Pittman et al. 1988; Orr and Cecil 1991).

Various inorganic salts containing chloride, sulfate, and nitrate have been released into the subsurface by human activities at the INEL. Of these three, sulfate and chloride have been released in greatest abundance. The average annual discharge of sulfate and nitrate from the INEL between 1982 and 1985 was approximately 0.9 million and 124,000 kg (1.9 million and 273,300 lb), respectively. The annual average discharge of these compounds has been reduced by approximately 45% since 1985. Approximately 0.6 million kg (1.32 million lb) of chloride were discharged from the INEL annually between 1986 and 1988 (Pittman et al. 1988; Cecil and Orr 1991).

Measurable concentrations of 19 organic compounds have been observed in the SRPA beneath the INEL. The most frequently observed compounds are carbon tetrachloride, 1,1,1-trichloroethane, and trichloroethylene. Chloroform, tetrachloroethylene, dichlorodifluoromethane, toluene, 1,1-dichloroethane, 1,1-dichloroethylene, 1,2-dichloroethane, 1,2-trans-dichloroethylene, 1,1,2-trichloroethane, benzene, bromoform, methylene chloride, 1,4-dichlorobenzene, xylene, trichlorofluoromethane, 1,2-dichloropropane, ethylbenzene, 1,2-dichlorobenzene and vinyl chloride also were detected in some ground water samples (Leenheer and Bagby 1982; Mann and Knobel 1987; Mann 1990). Concentrations of the most frequently observed organic compounds measured in monitoring wells during 1987 to 1989 are presented in Table C-1. The location of the sample wells are presented in Figures C-8 and C-9.

Concentrations of most of these compounds were less than 0.002 mg/L. An isolated observation of a carbon tetrachloride concentration (0.0066 mg/L) slightly above the federal drinking water standard of 0.005 mg/L was made at a well near the RWMC during 1987. The carbon tetrachloride concentrations observed in this well during 1988 and 1989 ranged from 0.001 to 0.0041 mg/L (Mann and Knobel 1987; Mann 1990).

The TAN disposal well exhibited elevated concentrations of trichloroethylene (35 mg/L in 1987 to 24 mg/L in 1989), tetrachloroethylene (0.17 mg/L in 1987 to 0.1 mg/L in 1988), 1,1-dichloroethylene (0.049 mg/L in 1987 to 0.025 in 1989), 1,2-dichloroethylene (22 mg/L in 1987 to 13 mg/L in 1988), and vinyl chloride (0.027 mg/L in 1989). Vinyl chloride frequently results from the degradation of organic compounds such as those observed in the TAN well. Slightly elevated concentrations of trichloroethylene were also observed in monitoring wells near TAN (Mann and Knobel 1987; Mann 1990). The federal drinking water standards for these organic compounds are listed in Table C-2.

Table C-1. Concentrations of selected organic compounds in groundwater.

Well ID	Date Sampled	Carbon tetra-chloride	Chloro-form	1,1,1-Tri-Chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Dichloro-difluoro-methane	Toluene	1,1-Di-chloro-ethane	1,1-Di-chloro-ethylene	Remarks
9	07-30-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	
	10-05-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
37	10-05-87	<0.2	<0.2	0.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
40	10-13-87	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
43	10-05-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
47	10-26-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
51	10-13-87	<0.2	<0.2	0.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
57	10-09-87	<0.2	<0.2	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
58	10-08-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
59	10-06-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
65	10-14-87	<0.2	<0.2	1.1	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
67	10-06-87	<0.2	<0.2	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	
76	10-08-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
82	10-06-87	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
83	10-14-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
86	08-04-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-06-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
87	06-03-87	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	
	08-11-87	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	09-23-87	0.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	

Table C-1. (continued).

Well ID	Date Sampled	Carbon tetra-chloride	Chloro-form	1,1,1-Tri-Chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Dichloro-di-fluoro-methane	Toluene	1,1-Di-chloro-ethane	1,1-Di-chloro-ethylene	Remarks
88	06-03-87	6.6	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
	07-08-87	2.7	<0.2	0.6	1.1	0.2	0.3	<0.2	<0.2	<0.2	40 minutes of pumping
		3.2	<0.2	0.7	1.2	0.2	<0.2	<0.2	<0.2	<0.2	1 hour of pumping
		3.1	<0.2	0.7	1.2	0.2	<0.2	<0.2	<0.2	<0.2	2 hours of pumping
		2.9	<0.2	0.6	1.2	0.2	<0.2	<0.2	<0.2	<0.2	3 hours of pumping
		2.8	<0.2	0.6	1.2	0.2	<0.2	<0.2	<0.2	<0.2	4 hours of pumping
	07-15-87	4.4	1.0	0.9	1.4	<0.2	<0.2	<0.2	<0.2	<0.2	
	08-11-87	2.1	0.4	0.4	1.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	09-22-87	2.9	0.7	0.5	1.1	<0.2	<0.2	<0.2	<0.2	<0.2	
89	06-03-87	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
	08-12-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	09-22-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	
90	06-03-87	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
	08-11-87	0.6	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	09-23-87	0.8	<0.2	0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	
92	10-23-87	1,200	650	140	860	110	<0.2	<0.2	13	0.8	1,1,2,2-Tetrachloroethane, 1.0 μ g/L
	10-22-87	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1,2-Dichloropropane, 5.9 μ g/L Equipment blank for well 92; styrene, 0.5 μ g/L
97	10-14-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
98	10-14-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
99	10-14-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
100	10-20-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
101	10-27-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
103	09-2-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
104	09-24-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
105	07-30-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	09-28-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	QA Replicate
106	10-06-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	QA Replicate
107	10-09-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
108	09-28-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
109	07-31-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.7	<0.2	<0.2	
	09-28-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.0	<0.2	<0.2	

Table C-1. (continued).

Well ID	Date Sampled	Carbon tetra-chloride	Chloro-form	1,1,1-Tri-Chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Dichloro-difluoro-methane	Toluene	1,1-Di-chloro-ethane	1,1-Di-chloro-ethylene	Remarks
110	10-09-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
111	09-25-87	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
112	09-25-87	<0.2	<0.2	0.6	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	
113	10-02-87	<0.2	<0.2	0.8	<0.2	<0.2	0.4	<0.2	<0.2	<0.2	
114	10-09-87	<0.2	<0.2	1.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Benzene, 0.3 µ g/L
115	10-09-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
116	10-28-87	<0.2	<0.2	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
117	10-19-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	
		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	<0.2	<0.2	QA Replicate
	11-05-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
119	11-06-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.2	<0.2	<0.2	
		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.0	<0.2	<0.2	QA Replicate
120	11-18-87	1.5	<0.2	0.5	0.5	<0.2	<0.2	0.3	<0.2	<0.2	
		1.4	<0.2	0.4	0.4	<0.2	<0.2	0.3	<0.2	<0.2	QA Replicate
ANP-6	10-28-87	<0.2	<0.2	<0.2	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	
ANP-8	10-25-87	<0.2	<0.2	<0.2	7.5	4.2	<0.2	<0.2	<0.2	<0.2	
ARA-2	10-28-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.7	<0.2	<0.2	
ARA-3	10-28-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Atomic City	10-29-87	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	
Bedding Facility	10-24-87	<0.2	<0.2	1.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
CFA-1	10-15-87	<0.2	<0.2	0.8	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	
CFA-2	10-14-87	<0.2	<0.2	0.7	0.7	<0.2	<0.2	<0.2	<0.2	0.2	
EBR-I	10-14-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
EBR-II-1	10-15-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
EBR-II-2	10-15-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Fire Station 2	11-03-87	<0.2	<0.2	2.6	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Highway 3	10-29-87	<0.2	<0.2	<0.2	0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
ICPP-1	10-22-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
ICPP-2	10-22-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
ICPP-4	10-22-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
IET-1	10-27-87	<0.2	0.2	<0.2	1.3	1.2	<0.2	<0.2	<0.2	<0.2	1,2-Dichlorobenzene, 1.9 µ g/L

Table C-1. (continued).

Well ID	Date Sampled	Carbon tetra-chloride	Chloro-form	1,1,1-Tri-Chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Dichloro-di-fluoro-methane	Toluene	1,1-Di-chloro-ethane	1,1-Di-chloro-ethylene	Remarks
INEL-IWS	10-26-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-25-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
LOFT-1											
LOFT-2	10-26-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
MTR Test	10-07-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
NPR Test	10-15-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.8	<0.2	<0.2	QA Replicate
	10-15-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-15-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
NRF-1	10-29-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
NRF-2	10-29-87	<0.2	<0.2	<0.2	1.3	<0.2	<0.2	<0.2	<0.2	<0.2	1,2-trans-Dichloroethylene, 0.3 µ g/L
NRF-3	10-29-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
OMRE	10-30-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2.2	<0.2	<0.2	
P&W-2	10-16-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-23-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
RWMC	06-03-87	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
	08-11-87	1.0	<0.2	0.2	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	
	09-23-87	1.3	<0.2	0.3	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-14-87	1.5	<0.2	0.5	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	
Site 4	11-03-87	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Site 14	10-14-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Site 19	10-07-87	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
SPERT-1	10-24-87	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
SPERT-2	10-24-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
TAN-1	10-23-87	<0.2	<0.2	<0.2	7.7	0.2	<0.2	<0.2	<0.2	<0.2	
TAN-2	10-23-87	<0.2	<0.2	<0.2	5.4	1.1	<0.2	<0.2	<0.2	<0.2	
TAN	10-27-87	<20	20	20	35,000	170	<20	<20	<20	49	1,2-trans-Dichloroethylene, 22,000 µ g/L
Disposal											
TRA-1	10-30-87	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
TRA-3	10-27-87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
TRA-4	10-30-87	<0.2	<0.2	<0.2	6.7	<0.2	<0.2	3.4	<0.2	<0.2	
TRA	10-28-87	<0.2	<0.2	<0.2	4.0	<0.2	<0.2	0.5	<0.2	<0.2	
Disopal											
Blank	10-07-87	<0.2	0.5	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	Trichlorofluoromethane, 0.5 µ g/L
	10-15-87	<0.2	0.5	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Trichlorofluoromethane, 14 µ g/L

Table C-1. (continued).

Well ID	Date Sampled	Carbon tetra-chloride	Chloro-form	1,1,1-Tri-Chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Dichloro-difluoro-methane	Toluene	1,1-Di-chloro-ethane	1,1-Di-chloro-ethylene	Remarks
11	09-13-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.7	<0.2	<0.2	
14	09-24-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.0	<0.2	<0.2	
		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.9	<0.2	<0.2	Replicate
17	12-14-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
24	01-14-88	<0.2	1.3	24	1,600	120	<0.2	<0.2	2.1	11	1,2-Dichloroethane, 0.8; 1,2-trans-Dichloroethylene, 48
	02-28-89	<0.2	1.0	12	1,400	64	<0.2	<0.2	1.5	9	1,2-Dichloroethane, 0.5; 1,2-trans-Dichloroethylene, 11; 1,1,2-Trichloroethane, 0.3
27	07-20-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.9	<0.2	<0.2	Total xylene, 0.5
		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Equipment blank (portable pump)
43	06-21-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
47	09-30-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
86	06-22-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
87	04-06-88	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	06-22-88	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-18-88	0.6	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	01-04-89	0.7	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-05-89	0.6	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	07-11-89	0.8	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-26-89	0.8	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Benzene, 0.2
88	04-05-88	2.5	0.5	0.6	1.1	0.2	0.4	<0.2	<0.2	<0.2	
		2.3	0.5	0.6	1.0	<0.2	0.4	<0.2	<0.2	<0.2	Replicate
	06-24-88	4.1	0.6	0.8	1.2	0.2	<0.2	<0.2	<0.2	<0.2	
		4.1	0.6	0.8	1.2	0.2	<0.2	<0.2	1.0	<0.2	Replicate: Bromoform, 1.0
	09-29-88	1.9	0.4	0.4	0.9	<0.2	0.2	<0.2	<0.2	<0.2	
	01-04-89	2.3	0.4	0.4	1.0	<0.2	0.3	<0.2	<0.2	<0.2	
	04-04-89	2.2	0.4	0.4	1.0	<0.2	<0.2	<0.2	<0.2	<0.2	
	07-12-89	1.0	0.4	0.2	0.5	<0.2	1.0	<0.2	<0.2	<0.2	
		1.1	0.4	0.2	0.6	0.2	1.1	<0.2	<0.2	<0.2	Replicate

Table C-1. (continued).

Well ID	Date Sampled	Carbon tetra-chloride	Chloro-form	1,1,1-Tri-Chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Dichloro-difluoro-methane	Toluene	1,1-Di-chloro-ethane	1,1-Di-chloro-ethylene	Remarks
89	02-01-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.8	<0.2	
	04-05-88	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	
	06-24-88	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	
	10-18-88	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	<0.2	<0.2	<0.2	
	01-04-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Replicate
	04-04-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
90	04-06-88	0.7	<0.2	<0.2	0.3	<0.2	0.3	<0.2	<0.2	<0.2	
	06-22-88	1.0	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-18-88	0.7	<0.2	0.2	0.3	<0.2	1.6	<0.2	<0.2	<0.2	
		0.8	<0.2	0.2	0.3	<0.2	1.1	<0.2	<0.2	<0.2	Replicate
	01-18-89	0.9	<0.2	0.2	0.4	<0.2	0.2	<0.2	<0.2	<0.2	
		0.9	<0.2	0.2	0.4	<0.2	0.3	<0.2	<0.2	<0.2	Replicate
	04-05-89	0.8	<0.2	0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	
92	07-11-89	1.0	<0.2	0.3	0.4	<0.2	0.4	<0.2	<0.2	<0.2	
	04-06-88	1,400	940	250	1,100	120	0.3	0.3	22	2.6	Thief sample from perched ground-water zone. 1,2-Dichloroethane, 1.6; Benzene 0.2; Trichlorofluoromethane, 0.4; 1,2-Dichloropropane, 12; 1,2-trans-Dichloroethylene, 1.7
97	09-26-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	11-30-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
98	11-29-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
99	11-30-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
108	09-05-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
112	09-28-88	<0.2	<0.2	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
		<0.2	<0.2	0.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Replicate
117	02-01-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-05-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	06-27-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Methylene chloride, 1.7
	10-17-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	01-12-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-03-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	

Table C-1. (continued).

Well ID	Date Sampled	Carbon tetra-chloride	Chloro-form	1,1,1-Tri-Chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Dichloro-difluoro-methane	Toluene	1,1-Di-chloro-ethane	1,1-Di-chloro-ethylene	Remarks
119	02-01-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-05-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	06-27-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-17-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	01-12-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-03-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
120	02-01-88	1.9	0.2	<0.2	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-05-88	1.5	<0.2	0.4	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	
	06-27-88	2.1	0.2	0.5	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	Bromoform, 1.0
	10-18-88	1.1	<0.2	0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	
	01-12-89	0.7	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-04-89	0.8	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	07-12-89	1.0	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
ANP-8	12-13-89	<0.2	<0.2	<0.2	6.4	3.7	<0.2	<0.2	<0.2	<0.2	
Arbor Test	02-15-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Atomic City	05-18-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
EBR 1	10-28-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-28-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Replicate
Highway 3	05-18-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	5.2	<0.2	<0.2	
	11-01-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
IET 1	03-01-89	<0.2	<0.2	<0.2	0.3	0.7	<0.2	<0.2	<0.2	<0.2	1,4-Dichlorobenzene, 0.8
NRF-1	12-19-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
NRF-2	05-23-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	
	12-21-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Total xylene, 0.5
NRF-3	12-19-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
NRF-4	12-19-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
NRF-5	12-21-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Thief sample

Table C-1. (continued).

Well ID	Date Sampled	Carbon tetra-chloride	Chloro-form	1,1,1-Tri-Chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Dichloro-di-fluoro-methane	Toluene	1,1-Di-chloro-ethane	1,1-Di-chloro-ethylene	Remarks
RWMC	02-18-88	1.2	<0.2	0.3	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	
		1.1	<0.2	0.3	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-06-88	1.1	<0.2	0.4	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	
	07-21-88	1.4	<0.2	0.4	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-28-88	1.0	<0.2	<0.2	0.5	0.2	<0.2	<0.2	<0.2	<0.2	
	11-28-88	1.1	<0.2	0.3	0.5	0.2	<0.2	<0.2	<0.2	<0.2	
	12-28-88	1.5	<0.2	0.4	0.7	0.2	<0.2	<0.2	<0.2	<0.2	
	01-18-89	1.5	<0.2	0.3	0.7	<0.2	<0.2	<0.2	<0.2	<0.2	
	02-16-89	1.5	<0.2	0.4	0.7	<0.2	<0.2	<0.2	<0.2	<0.2	
	03-23-89	1.4	<0.2	0.3	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-25-89	1.3	<0.2	0.3	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	
	05-24-89	1.3	<0.2	0.3	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	
	06-20-89	1.3	<0.2	0.3		<0.2	<0.2	<0.2	<0.2	<0.2	
	07-11-89	1.5	<0.2	0.3	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	
	08-29-89	1.3	<0.2	0.3	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	
	09-28-89	1.4	<0.2	0.3	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-26-89	1.6	<0.2	0.4	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	
TAN Disposal	01-11-88	<0.2	0.3	0.7	26,000	100	<0.2	1.0	1.7	25	Pumped at 20 gal/min; 1,2-trans-Dichloroethylene, 15,000 1,2-Dichloroethane, 0.4; Benzene, 0.5; Ethylbenzene, 0.4; 1,2-Dichlorobenzene, 4.6; 1,4-Dichlorobenzene, 0.4;
		<0.2	0.4	1.3	29,000	120	<0.2	1.1	1.8	25	Vinyl chloride, 26; Total xylene, 2.0 Pumped at 37 gal/min; 1,2-trans-Dichloroethylene, 13,000 1,2-Dichloroethane, 0.5; Benzene, 0.6 Ethylbenzene, 0.5; 1,2-Dichlorobenzene 5.1; 1,4-Dichlorobenzene, 0.6;
	03-07-89	<100	<100	<100	24,000	<100	<100	<100	<100	<100	Vinyl chloride, 27; Total xylene, 2.4 1,2-trans-Dichloroethylen, 13,000

Table C-1. (continued).

Well ID	Date Sampled	Carbon tetra-chloride	Chloro-form	1,1,1-Tri-Chloro-ethane	Tri-chloro-ethylene	Tetra-chloro-ethylene	Dichloro-di-fluoro-methane	Toluene	1,1-Di-chloro-ethane	1,1-Di-chloro-ethylene	Remarks
TTD-1	03-02-89	<0.2	<0.2	0.3	44	9.2	<0.2	<0.2	0.3	<0.2	1,2-trans-Dichloroethylene, 0.9
TDD-2	03-06-89	<0.2	0.4	0.3	180	11	<0.2	<0.2	<0.2	<0.2	1,2-trans-Dichloroethylene, 1.2
TDD-3	12-13-89	<0.2	<0.2	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Pumped sample
	12-13-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	Bailer sample; Total xylene, 0.3
INEL-1WS	12-14-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Blank	01-05-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.6	<0.2	<0.2	Total xylene, 0.2
	02-01-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.4	<0.2	<0.2	
	02-18-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	04-07-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	05-18-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	Methylene chloride, 1.4; Total xylene, 0.9 1,2-Dichloroethane, 0.8; Bromoform, 2.8; Dibromochloromethane, 0.3
	06-24-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.3	<0.2	<0.2	
	06-29-88	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
	10-03-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	
Equipment Blank (garden hose)	12-14-89	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.7	<0.2	<0.2	Benzene, 0.2; Ethylbenzene, 0.3; Methylene chloride, 0.3; Total styrene, 0.2; Total xylene, 4.3

Figure C-8. Location of wells sampled for purgeable organic compounds during 1987.

Figure C-9. Location of wells sampled for purgeable organic compounds during 1988 and 1989.

Table C-2. Federal drinking water standards for organic compounds.

Compound	MCL (mg/L)	Proposed MCL (mg/L)	Secondary MCL (mg/L)
Acrylamide ^a	TT	none	none
Alachlor ^a	0.002	none	none
Aldicarb ^d	0.003	none	none
Aldicarb sulfoxide ^d	0.004	none	none
Aldicarb sulfone ^d	0.002	none	none
Atrazine ^a	0.003	none	none
Benzene ^a	0.005	none	none
Benzopyrene ^c	none	0.0002	none
Benzoanthracene ^c	none	0.0001	none
Benzofluoranthene ^c	none	0.0002	none
Butylbenzylphthalate ^c	none	0.1	none
Carbofuran ^a	0.04	none	none
Carbon tetrachloride ^a	0.005	none	none
Chlordane ^a	0.002	none	none
1,2-Dibromochloro-3-propane (DBCP) ^a	0.0002	none	none
Chrysene ^c	none	0.0002	none
Dalapon ^c	none	0.2	none
Dibenzoanthracene ^c	none	0.0003	none
o-Dichlorobenzene ^a	0.6	none	none
1,3-Dichlorobenzene ^c	none	0.6	none
p-Dichlorobenzene ^a	0.075	none	none
1,2-Dichloroethane ^a	0.005	none	none
1,1-Dichloroethylene ^a	0.007	none	none
cis-1,2-Dichloroethylene ^a	0.07	none	none
trans-1,2-Dichloroethylene ^a	0.1	none	none
Dichloromethane (methylene chloride) ^c	none	0.005	none
1,2-Dichloropropane ^a	0.005	none	none
2,4-D ^a	0.07	none	none
Dinoseb ^c	none	0.007	none
Di(ethylexyl) adipates ^c	none	0.5	none
Di(ethylexyl) phthalate ^c	none	0.004	none
Diguan ^c	none	0.1	none
Endothall ^c	none	0.1	none
Endrin	0.0002 ^b	0.002 ^c	none
Epichlorohydrin ^a	TT	none	none
Ethylbenzene ^a	0.7	none	none
Ethylene dibromide ^a	0.00005	none	none

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Table C-2. (continued).

Compound	MCL (mg/L)	Proposed MCL (mg/L)	Secondary MCL (mg/L)
Glyphosate ^c	none	0.7	none
Heptachlor ^a	0.0004	none	none
Heptachlor epoxide ^a	0.0002	none	none
Hexachlorobenzene ^c	none	0.001	none
Hexachlorocyclopentadiene ^c	none	0.05	0.008
Indeno(1,2,3-c,d) pyrene ^c	none	0.0004	none
Lindane ^a	0.0002	none	none
Methoxychlor ^a	0.04	none	none
Monochlorobenzene ^a	0.1	none	none
Oxamyl (vydate) ^c	none	0.2	none
PCBs (as decachlorophenyl) ^a	0.0005	none	none
Pentachlorophenol ^d	0.001	none	none
Pichloram ^c	none	0.5	none
Simazine ^c	none	0.001	none
Styrene ^a	0.1	none	none
Tetrachloroethylene ^a	0.005	none	none
Toluene ^a	1.0	none	none
total trihalomethanes ^{b,c}	0.1	none	none
Toxaphene ^a	0.003	none	none
1,2,4-Trichlorobenzene ^c	none	0.009	none
1,1,2-Trichloroethane ^c	none	0.005	none
Trichloroethylene ^a	0.005	none	none
1,1,1-Trichloroethane ^b	0.2	none	none
2,3,7,8-TCDD (dioxin) ^c	none	5 x 10 ⁻⁸	none
2,4,5-TP (Silvex) ^a	0.05	none	none
Vinyl chloride ^a	0.002	none	none
Xylenes (total) ^a	10.0	none	none

TT = treatment technique.

a. 56 Federal Register 3593, 3594, 3597, and 3614, Jan. 30, 1991.

b. 240 CFR 141 and 143, July 1, 1990.

c. EPA OSWER memorandum, April 11, 1991, Update to Numeric Action Levels for Contaminated Drinking Water Sites, from Stephen D. Luftig to Superfund Branch Chiefs and OHM Coordinators, Regions I-X. For sources of proposed MCLs, the memo cites 55 Federal Register 30370-30448, July 25, 1990.

d. 456 Federal Register 30280, July 1, 1991. Note that there is a typo in the Federal Register on p. 30280:: the MCL for aldicarb sulfone is 0.002, not 0.003 (ref.: p. 30270 of the Federal Register and the EPA Safe Drinking Water Hotline).

e. Total trihalomethanes is the sum of the concentrations of bromodichloromethane, dibromochloromethane, trichloromethane (bromoform), and trichloromethane (chloroform).

f. Proposed standards are shown for comparison only; they are not regulatory standards unless/until they are adopted by EPA as final.

Tritium and iodine-129, the only contaminants detected outside the INEL boundaries, were found in extremely low concentrations slightly beyond the southern INEL boundary. Tritium was observed past the boundary in 1985, but the plume has since receded and decreased in size and is now contained within the INEL Site (Pittman et al. 1988; Orr and Cecil 1991; Orr et al. 1991). Iodine-129 concentrations much below the EPA maximum contaminant levels have recently been measured in two wells approximately 6.4 and 12.8 km (4 and 8 mi) south of the INEL boundary.^b

b. Private communication with L. J. Mann, April 1993.

C.3 References

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- Mann, L. J., and Knobel, L. L., 1988, *Concentrations of Nine Trace Metals in Ground Water at the Idaho National Engineering Laboratory*, USGS, Open File Report 88-332, DOE/ID-22075.
- Mann, L. J.; Chew, E. W.; Morton, J. S., and Randolph, R. B., 1988, *Iodine-129 in the Snake River Plain Aquifer at the INEL, Idaho*, USGS, Water Resources Investigations Report 88-4165, DOE/ID-22076.
- Norrell, G., 1993, EG&G, Idaho, Inc., Personal Communication, February 19, 1993.
- Orr, B. L.; Cecil, L. D., and Knobel, L. L., 1991, *Background Concentrations of Selected Radionuclides, Organic Compounds, and Chemical constituents in Ground Water in the Vicinity of the Idaho National Engineering Laboratory*, USGS, Water Resources Investigation Report 91-4015, DOE/ID-22094.
- Orr, B. R., and Cecil, L. D., 1991, *Hydrologic Conditions and Distribution of Selected Chemical Constituents in Water, Snake River Plain Aquifer, Idaho National Engineering Laboratory, Idaho 1986 to 1988*, USGS, Water Resources Investigations Report 91- 4047, IDO-22096.
- Pittman, J. R.; Jensen, R. G., and Fischer, P. R., 1988, *Hydrologic Conditions at the Idaho National Engineering Laboratory 1982 to 1985*, USGS, Water Resources Investigation Report 89-4008, DOE/ID-22078.

C.4 Annotated Bibliography for Water Resources^c

1. Ackerman, D. J., 1991, *Transmissivity of the Snake River Plain Aquifer at the Idaho National Engineering Laboratory, Idaho*, DOE, DOE/ID-22097, Idaho Falls, ID.

Aquifer test data of 183 single-well tests at 94 wells in the ESRP aquifer were analyzed to estimate values of transmissivity. Estimates of transmissivity for individual wells ranged from 1.1 to 7.6×10^{-5} feet squared per day. These data were determined in consistent manner and are useful for describing the distribution of transmissivity at the INEL.

Subject: Aquifer testing at the INEL
Keywords: TRANSMISSIVITY / ESRP AQUIFER / BASALT
Location: Arnett Files, Sondrup Files

2. Ackerman, D. J., 1991, *Transmissivity of Perched Aquifers at the Idaho National Engineering Laboratory, Idaho*, DOE, DOE/ID-22099, Idaho Falls, ID.

Aquifer test data from twenty-two perched water wells was analyzed to determine transmissivity. Data and discussion are presented.

Subject: Aquifer testing at the INEL
Keywords: TRANSMISSIVITY / PERCHED GROUNDWATER / BASALT
Location: Sondrup

3. Adamic, M. L.; Burr, J. K. and McManus, G. J., 1984, *Baseline Levels of Controlled Pollutants in the Vicinity of ICPP Processes*, WINCO, WINCO-1018, Idaho Falls, ID.

Baseline levels of controlled pollutants at the ICPP were determined. Pollutants included in this study were: hydrogen sulfide, sulfur dioxide, nonmethane hydrocarbons, particulates, mercury, and cadmium.

Subject: Background levels at the INEL
Keywords: ICPP / CONTAMINANT / BACKGROUND / MERCURY / CADMIUM
Location: INEL Technical Library

4. Adams, L. E.; Janke, D. H., and Dickman, P. T., 1979, *Annual Report-1978 Environmental Surveillance Report for the Idaho National Engineering Laboratory Radioactive Waste Management Complex*, EG&G Idaho, Inc., TREE-1357, Idaho Falls, ID.

This document is the 1978 annual environmental surveillance report for the RWMC of the INEL. Included are tabulated data from and discussions about routine radiological monitoring of atmospheric, hydrologic, geologic, and biotic environments of the RWMC.

c. Not all references are annotated. Those not annotated are provided for your information.

Subject: Environmental surveillance at the INEL
Keywords: ENVIRONMENTAL MONITORING / RWMC / GROUNDWATER /
WASTE MANAGEMENT
Location: WAG 10 Files

5. **Anderson, B. C., and Schletter, R. M., 1979, *A History of the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory*, PR-W-79-038.**

This report presents information on the site selection and development of the RWMC. It discusses waste burial and management as well as the environmental surveillance.

Subject: RWMC History
Keywords: RWMC / WASTE MANAGEMENT / GROUNDWATER /
ENVIRONMENTAL
Location: WAG 10 Files

6. **Anderson, S. R., 1991, *Stratigraphy of the Unsaturated Zone and Uppermost Part of the Snake River Plain Aquifer at the Idaho National Engineering Laboratory*, Idaho, USGS, WRIR 91-4010, DOE/ID-22095.**

Stratigraphic data are presented for basalt flows and sedimentary interbeds underlying the ICPP and TRA at the INEL in eastern Idaho. Data includes flow dating, petrographical and mineralogical analysis. Stratigraphic data was gathered from core samples, geophysical logs, lithologic logs, and laboratory analysis.

Subject: Characterization of INEL basalts
Keywords: STRATIGRAPHY / BASALT / ESRP AQUIFER / UNSATURATED
ZONE
Location: C.W. Bishop Files

7. **Anderson, S. R., and Lewis, B. D., 1989, *Stratigraphy of the Unsaturated Zone at the Radioactive Waste Management Complex*, Idaho National Engineering Laboratory, Idaho, U.S. Geological Survey, WRIR 89-4065, IDO-22080.**

Stratigraphic data are presented for the layered basalt flows, cinders, and sediment underlies the RWMC. Wells drilled to 700 feet penetrate a sequence of 10 basalt-flow groups and 7 major sedimentary interbeds that range in age from about 100,000 to 600,000 years old. The 10 flow groups consist of 22 separate lava flows and flow-units.

Subject: Characterization of INEL basalts
Keywords: STRATIGRAPHY / LAYERED BASALT / CINDERS / SEDIMENT /
RWMC
Location: C.W. Bishop Files

8. **Ansley, S. L.**, 1990, *Sampling and Analysis Plan for the Hydrogeologic Characterization of the Interbed Soil Beneath CFA Landfills II and III*, EG&G Idaho, Inc., EGG-ER-8721, Rev. 2, Idaho Falls, ID.

This sampling and analysis plan is part of an investigation in response to requirements of 40 CFR 265.90 Subpart F (regulations for groundwater monitoring at landfills) and is governed by hazardous waste regulations promulgated under the RCRA. This plan includes the sampling objectives, project organization and responsibility, sampling strategy and procedures, sample control and document management, equipment, analytical procedures, data management, quality assurance, and safety and training.

Subject: CFA landfills
Keywords: SAMPLE AND ANALYSIS PLAN / CFA LANDFILL / SAMPLING
Location: S.L. Ansley Files

9. **Ansley, S. L.**, 1990, *Technical Work Plan for the Hydrogeologic Characterization of CFA Landfills II and III*, EG&G Idaho, Inc., EGG-WM-9119, Idaho Falls, ID.

The purpose of the document is to establish and document the methods and procedures that will be used to accomplish the drilling and completion of wells.

Subject: Wells at the INEL
Keywords: DRILLING / COMPLETION OF WELL / SAMPLING / CFA
LANDFILL / DECONTAMINANT / DOCUMENTATION
Location: S.L. Ansley Files

10. **Ansley, S. L.; Hull, L. C., and Burns, S. M.**, 1988, *Shallow Drilling Report for CFA Landfills II and III -FY-1988*, EG&G Idaho, Inc., EGG-ER-8291, Idaho Falls, ID.

A shallow drilling program was implemented at CFA Landfills II and III to define the geologic and hydrologic characteristics of the shallow surficial sediments at the landfills, to quantify the amounts and rates of water movement into and through the sediments, and to sample the sediments and soil gas for contaminants. Results of infiltration studies are presented.

Subject: Wells at the INEL
Keywords: SHALLOW DRILLING / CFA LANDFILL / HYDRAULIC
PROPERTIES / INSTRUMENTATION
Location: S.L. Ansley Files

11. **Armstrong, A. L.; Leeman, W. P., and Malde, H. E., 1975, "Dating of Quaternary and Neocene Volcanic Rocks of the Snake River Plain, Idaho", *American Journal of Science*, 275:225-231.**

Snake River Plain basalts are stratigraphically correlated and age dated.

Subject: Characterization of INEL basalts
Keywords: AGE DATING / BASALT / SNAKE RIVER PLAIN / STRATIGRAPHY
Location: Published Article

12. **Arnett, R. C.; Estey, S. A., and Aichele, D. R., 1986, *Verification and Benchmarking of the MAGNUM-3D Groundwater Flow Code*, Rockwell Hanford Operation, RHO-BW-ST-69P, Richland, WA.**

This document reports the verification and benchmarking of MAGNUM-3D. Included is a software summary, mathematical model, numerical methods, users manuals, code assessment and support, and continuing documentation and code listing.

Subject: Benchmarking and verification
Keywords: MAGNUM-3D / BENCHMARKING / VERIFICATION /
GROUNDWATER
Location: R.C. Arnett Files

13. **Arnett, R. C., and Martineau, 1990, *Preliminary Numerical Model of Contaminant Transport in the Snake River Plain Aquifer Near the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-WM-8820, Idaho Falls, ID.**

Two-dimensional groundwater flow and transport models were used to simulate past transport and predict future movement of selected contaminants in the aquifer in and near the INEL. Modeling for Tritium, strontium-90, and iodine-129 plumes are reported.

Subject: Contaminant modeling at the INEL
Keywords: CONTAMINANT TRANSPORT / ESRP AQUIFER / MODELING /
BASALT / TRITIUM / STRONTIUM / IODINE
Location: C.W. Bishop Files

14. **Baca, R. G., and Hubbell, J. M., 1987, *Modeling Moisture Transport through the Vadose Zone of the Radioactive Waste Management Complex*, EG&G Idaho, Inc., Idaho Falls, ID.**

This report documents a preliminary study of the problem of modeling the patterns and rates of soil-moisture transport through the vadose zone beneath the RWMC. Also included in the report is a discussion of the relevant hydrologic scenarios that will be considered in future modeling studies.

Subject: Vadose zone properties
Keywords: CONTAMINANT TRANSPORT / ESRP AQUIFER / MODELING /
BASALT / VADOSE ZONE / RWMC
Location: Sondrup Files

15. Baca, R. G.; Magnuson, S. O.; Nguyen, H. D., and Martin, P., 1992, *A Modeling Study of Water Flow in the Vadose Zone Beneath the Radioactive Waste Management Complex*, EG&G Idaho, Inc., EGG-GEO-10068, Idaho Falls, ID.

A numerical modeling study was conducted to investigate; 1) relationship between meteorologic conditions and net infiltration, 2) water movements after floods, and 3) water travel time in the vadose zone. The processes modeled include precipitation, evaporation, infiltration, and soil-moisture redistribution. The time periods covered are 1955-1964 and 1984-1990. Using a Monte Carlo simulation approach, the statistical distribution of water travel time exhibits a log-normal trend with a geometric mean travel time of 610 years. Simulation models used are: UNSAT-H, FLASH, PORFLOW, and FLOWMC.

Subject: Groundwater modeling at the INEL
Keywords: MODELING / VADOSE ZONE / RWMC / STREAMFLOW
Location: C.W. Bishop Files

16. Baca, R. G., and Walton, J. C., 1988, *Preliminary Conceptual Models of Contaminant Migration at the RWMC*, EG&G Idaho, Inc., EGG-WM-8023, Idaho Falls, ID.

This report presents the conceptual models that have been formulated to explain the migration of radiological and nonradiological contaminants at the RWMC.

Subject: Contaminant modeling at the INEL
Keywords: CONTAMINANT TRANSPORT / MODELING / RWMC /
RADIOLOGICAL / NON-RADIOACTIVE
Location: INEL Technical Library

17. Baca, R. G.; Walton, J. C., and Arnett, R. C., 1989, *Preliminary Monitoring Plan for the Vapor Vacuum Extraction Demonstration Project*, EG&G Idaho, Inc., EGG-WM-8422, Idaho Falls, ID.

This report presents a study that was conducted to formulate a technical plan for the VVE demonstration. The study consists of: 1) computer modeling of the VVE demonstration, 2) detailed specifications of the data that will be collected before, during, and after the demonstration, and 3) an evaluation of four alternative demonstration strategies.

Subject: VVE demonstration at RWMC
Keywords: VAPOR VACUUM EXTRACTION / ORGANIC COMPOUNDS /
RWMC

Location: INEL Technical Library

18. Baca, R. G.; Walton, J. C.; Rood, A. S., and Otis, M. D., 1988, *Organic Contaminant Released from a Mixed Waste Disposal Site: A Computer Simulation Study of Transport Through the Vadose Zone and Site Remediation*, CONF-880839.

Analysis of soil gas samples and ground water samples indicate that organic vapors are being emitted from disposal pits in the Subsurface Disposal Area of the RWMC. The primary source of the organic vapor is organic waste disposed at the site in the mid 1960's. This paper describes the technical approach and preliminary results from an ongoing computer modeling study of the organic vapor releases from the RWMC.

Subject: Contaminant modeling at the INEL

Keywords: CONTAMINANT / TRANSPORT / ORGANIC COMPOUNDS /
GROUNDWATER / ORGANIC VAPOR / DISPOSAL PIT / RWMC

Location: C.W. Bishop Files

19. Bagby, J. C.; Ghering, G. E.; Jensen, R. G., and Barraclough, J. T., 1981, *A Wind-Powered, Ground Water Monitoring Installation at a Radioactive Waste Management Site in Idaho*, U.S. Geological Survey/Water Resources, Open File Report 81-493, IDO-22059-USGS.

This document reports drilling and installation of and monitoring systems installed in four wells drilled outside the RWMC in 1971.

Subject: Wells at the INEL

Keywords: RWMC / MONITORING / INSTALLATION / GROUNDWATER /
RADIOACTIVE WASTE

Location: INEL Technical Library

20. Bagby, J. C.; White, L. J.; Barraclough, J. T., and Jensen, R. G., 1984, *Ground Water Site Inventory Data for Selected Wells on or near the Idaho National Engineering Laboratory, 1949 through 1982*, USGS, Open-File Report 84-231, DOE/ID-22064.

This report includes a tabulation of construction and completion data for water-table wells on and near the INEL. The majority of the data are reported for 1949 through 1982. Maps showing the location of the wells are included as well as a reference list of reports which interpret the data.

Subject: Wells at the INEL

Keywords: WELL / CONSTRUCTION / COMPLETION OF WELL

Location: J.T. Barraclough Files

21. Bagby, J. C.; White, L. J., and Jensen, R. G., 1984, *Water-Level Data for Selected Wells on or near the Idaho National Engineering Laboratory, 1949 through 1982*, USGS, Open File Report 84-239, IDO-22065-USGS.
22. Bagby, J. C.; White, L. J., and Jensen, R. G., 1985, *Water-Quality Data for Selected Wells on or near the Idaho National Engineering Laboratory, 1949 through 1982*, USGS, Open-File Report 84-714, DOE/ID-22068.

Because radionuclide and chemical wastes have been disposed to the Snake River Plain aquifer for the past 34 years of INEL operations, water quality is monitored. During 1949 to 1982, several thousand water samples have been collected from an observation well network on the INEL. These data have been assembled on magnetic computer tape and this report is a listing, in tabular form, of the water quality data available on magnetic tape. Included are water quality data for water table wells, on and near the INEL for 1949 through 1982. Maps are included.

Subject: Groundwater properties at the INEL
Keywords: GROUNDWATER QUALITY / SAMPLING / WELL NETWORK /
RADIONUCLIDES / CHEMICAL
Location: J.T. Barraclough Files

23. Bargelt, R. J.; Dicke, C. A.; Hubbell, J. M.; Paarmann, M.; Ryan, D.; Smith, R. W., and Wood, T. R., 1992, *Summary of RWMC Investigations Report*, EG&G Idaho, Inc., EGG-WM-9708.
24. Barraclough, J. T., 1974, "Geohydrology of the Idaho National Engineering Laboratory," *Proceeding of the National Environmental Research Park Symposium*.

This paper presents information of the surface water at the INEL and regional and site specific hydraulic information of the aquifer. It shows contaminant plumes for tritium, cobalt-60, and chromium-51.

Subject: Groundwater monitoring at the INEL
Keywords: GROUNDWATER / ESRP AQUIFER / RADIONUCLIDES /
CONTAMINANT
Location: WAG 10 Files

25. Barraclough, J. T.; Bagby, J. C., and White, L. J. / J. R. G., 1984, *Water-Level data for selected wells on or near the Idaho National Engineering Laboratory, 1949 through 1982*, USGS, Open-File Report 84-239, DOE/ID 22065.

This report is a tabulation of the water-level data available on magnetic tape and includes water-level data for wells on or near the INEL which penetrate the Snake River Plain Aquifer.

Subject: Wells at the INEL
Keywords: WATER TABLES / GROUNDWATER / ESRP AQUIFER
Location: INEL Tech. Library

26. Barraclough, J. T., and Jensen, R. G., 1976, *Hydrologic Data for the Idaho National Engineering Laboratory Site, Idaho*, USGS, Open-File Report IDO-22055-USGS.

Groundwater samples were collected to determine the migration and the concentration of radioactive wastes in the subsurface. Water altitude fluctuations within both the regional and perched water systems were monitored and mapped. Recharge from the Big Lost River and other streams to the north of INEL caused the water table in the aquifer to rise to record highs in 1972 or 1973 over much of the INEL. Infiltration from TRA ponds has formed a large perched water body in the basalt. ICPP discharges low-level radioactive waste and chemical waste directly into the SRP Aquifer through a 600-foot disposal well. The average yearly discharge was about 300 million gallons.

Subject: Hydraulic properties at the INEL
Keywords: GROUNDWATER / SAMPLING / CONTAMINANT / PERCHED
GROUNDWATER / AQUIFER RECHARGE / DISCHARGE / ESRP
AQUIFER
Location: J.T. Barraclough Files

27. Barraclough, J. T.; Lewis, B. D., and Jensen, R. G., 1981, *Hydrologic Conditions at the Idaho National Engineering Laboratory, Idaho Emphasis: 1974-1978*, USGS / Water Resource, Open-File Report 81-526, IDO-22060-USGS.

During the period of record, 1974 through 1978, the regional water table has declined. Recharge from surface water has been minimal or non-existent during the latter part of this period. A large perched water body has formed in the basalt under TRA disposal ponds. Chemical components of the perched water and contaminant plumes for the water table are presented.

Subject: Hydraulic properties at the INEL
Keywords: HYDROLOGY / ESRP AQUIFER / GROUNDWATER / AQUIFER
RECHARGE / CONTAMINANT / PLUMES / PERCHED
GROUNDWATER
Location: J.T. Barraclough Files

28. Barraclough, J. T.; Lewis, B. D., and Jensen, R. G., 1982, *Hydrologic Conditions at the Idaho National Engineering Laboratory, Idaho, Emphasis: 1974-1978*, USGS, Water-Supply Paper, 2191-USGS.

From 1974-1978 the water table beneath the INEL has declined, a perched water body has formed beneath the TRA waste disposal ponds which contains radioactive ions, the ICPP

well ejected low concentration radioactive material into the aquifer resulting in formation of waste plumes. Radioactive plume size and concentrations are controlled by aquifer flow conditions, the quantity discharged, radioactive decay, sorption, dilution by dispersion, and other chemical reactions.

Subject: Geology and hydrology at the INEL
Keywords: GROUNDWATER / PERCHED GROUNDWATER / CONTAMINANT
 PLUMES / RADIONUCLIDES
Location: J.T. Barraclough Files

29. Barraclough, J. T.; Robertson, J. B., and Janzer, V. J., 1976, *Hydrology of the Solid Waste Burial Ground, As Related to the Potential Migration of Radionuclides, Idaho National Engineering Laboratory, with a Section on Drilling and Sample Analysis*, by L. G. Saindon, USGS, Open-File Report 76-471, IDO-22056-USGS.

Work at the RWMC was conducted to (1) evaluate the hydrologic, radiologic and geochemical variables that control the potential for subsurface migration of waste radionuclides from the burial trenches to the SRP Aquifer; (2) to determine the extent of radionuclide migration and, (3) to construct monitoring wells into the aquifer. Wells were drilled and basalt and interbed samples collected and analyzed.

Subject: Hydraulic properties at the INEL
Keywords: RADIONUCLIDES / RWMC / DRILLING / ESRP AQUIFER /
 GROUNDWATER / GEOCHEMISTRY
Location: J.T. Barraclough Files

30. Barraclough, J. T.; Robertson, J. B.; Janzer, V. J.; Carter, M. W.; Moghissi, A. A., and Kahn, B., 1979, *Geohydraulic Study of a Burial Site for Solid Low-Level radioactive Wastes at the Idaho National Engineering Laboratory*, Elmsford, NY, Pergamon Press.
31. Barraclough, J. T.; Teasdale, W. E., and Jensen, R. G., 1967, *Hydrology of the National Reactor Testing Station Area, Idaho: Annual Progress Report 1965*, USGS, Open-File Report IDO-22049.

This annual report discusses investigations at the INEL during 1965. Effects of radioactive waste disposal, floods, infiltration, pumpage on the groundwater and the aquifer are evaluated.

Subject: Geology and hydrology at the INEL
Keywords: ESRP AQUIFER / GROUNDWATER / ESRP AQUIFER /
 HYDROLOGY / SPREADING AREAS
Location: J.T. Barraclough Files

32. Barracclough, J. T.; Teasdale, W. E.; Robertson, J. B., and Jensen, R. G., 1967, *Hydrology of the National Reactor Testing Station Idaho 1966*, USGS, Open-File Report IDO-22049.

The report describes on-going studies to determine the hydrologic effects of disposal of radioactive waste to the ground at the NRTS. Water sample analysis, groundwater maps, recharge effects, perched water bodies, and contamination plumes are discussed.

Subject: Geology and hydrology at the INEL
Keywords: HYDROLOGY / WASTE DISPOSAL / RADIONUCLIDES / GAS
INJECTION / AIR-FLOW IN BASALT
Location: J.T. Barracclough Files

33. Barracclough, J. T.; Teasdale, W. E., and Jensen, R. G., 1965, *Hydrology of the National Reactor Testing Station, Idaho—Annual Progress Report*, USGS, Open File Report, IDO-22048.
34. Barracclough, J. T.; Teasdale, W. E.; Robertson, J. B., and Jensen, R. G., 1966, *Hydrology of the National Reactor Testing Station, Idaho: 1966*, USGS, Open File Report, IDO-22049.
35. Barracclough, J. T.; Teasdale, W. E., and Jensen, R. G., 1967, *Hydrology of the National Reactor Testing Station, Idaho: 1965*, USGS, Open File Report, IDO-22048.
36. Bartholomay, R. C., 1990, *Digitized Geophysical Logs for Selected Wells on or near the Idaho National Engineering Laboratory, Idaho*, USGS, Open-File Report 90-366, DOE/ID-22088.

This report contains digitized geophysical logs from wells, at the INEL logged prior to August 1989. Data sheets with information on the wells are presented along with selected neutron, gamma-gamma, gamma, and caliper logs.

Subject: Wells at the INEL
Keywords: LOGS / GAMMA ACTIVITY
Location: INEL Technical Library, Norrell Files

37. Bartholomay, R. C., 1990, *Mineralogical correlation of surficial sediment from area drainages with selected sedimentary interbeds at the INEL, Idaho*, USGS, WRIR 90-4147, DOE/ID-22092.

Mineralogical data are used to Correlate surficial sediment samples from the Big Lost River, Little Lost River, and Birch Creek drainages with selected sedimentary interbed core samples taken from test holes at the RWMC, TRA, ICPP, and TAN. Correlating the mineralogy of a particular present-day drainage area with a particular sedimentary interbed provides information on historical source of sediment interbeds in and near the INEL. This document describes the regional geology, stratigraphy, sediments, mineralogy, fractures, and

hydrology of the RWMC area, as well as a brief description of the operation of the diversion ponds.

Subject: Mineralogy of surficial sediments
Keywords: MINERALOGY / SURFICIAL SEDIMENTS / SEDIMENTARY
INTERBED
Location: INEL Technical Library

38. Bartholomay, R. C., 1990, *Mineralogy, Petrology, and Grain Size of Surficial Sediment from the Big Lost River, Little Lost River, and Birch Creek Drainages, Idaho National Engineering Laboratory*, Masters Thesis, Idaho State University, Pocatello, ID.
39. Bartholomay, R. C., and Knobel, L. L., 1989, *Mineralogy and Grain Size of Surficial Sediment from the Little Lost River and Birch Creek Drainages, Idaho National Engineering Laboratory, Idaho*, USGS, Open-File Report 89-385, DOE/ID 22082.

Thirteen samples of surficial sediment from the Little Lost River and Birch Creek drainages were collected for grain size distribution, bulk mineralogy, and clay mineralogy. Samples were collected from the Little Lost River and Birch Creek.

Subject: Mineralogy of surficial sediments
Keywords: MINERALOGY / SEDIMENT / SURFICIAL SEDIMENTS / X-RAY
DIFFRACTION / LITTLE LOST RIVER / BIRCH CREEK
Location: INEL Technical Library

40. Bartholomay, R. C.; Knobel, L. L., and Davis, L. C., 1989, *Mineralogy and Grain Size of Surficial Sediment from the Big Lost River Drainage and Vicinity, with Chemical and Physical Characteristics of Geologic Materials from Selected Sites at the Idaho National Engineering Laboratory, Idaho*, USGS, Open-File Report 89-384, DOE/ID-22081.

Samples of surficial sediment from the Big Lost River drainage and vicinity were collected for analysis of grain size distribution, bulk mineralogy, and clay mineralogy. Twenty-five core samples from eight wells were analyzed for bulk and clay mineralogy. These included basalt flows, vesical and fracture fillings, and sedimentary interbeds. Data distributed include cation exchange capacity, bulk chemistry, specific gravity, bulk mineralogy, silt and clay mineralogy, and grain size analyses.

Subject: Mineralogy of surficial sediments
Keywords: MINERALOGY / SEDIMENT / BIG LOST RIVER / SEDIMENT /
SEDIMENTARY INTERBED
Location: INEL Technical Library

41. Beard, K. V., and Kaminsky, J. F., 1991, *INEL Well Inspection and Surveying Project*, EG&G Idaho, Inc., EGG-WM-9890, Idaho Falls, ID.

This document describes methods, procedures, quality assurance measures, and health and safety precautions that will be used during the INEL well inspection and surveying project.

Subject: Wells at the INEL
Keywords: WELL SURVEY / PROCEDURES / QUALITY ASSURANCE / SAFETY
Location: J.F. Kaminsky Files

42. Bennett, C. M., 1986, *Capacity of the diversion channel below the flood-control dam on the Big Lost River at the INEL, Idaho*, USGS / Water Resource, Investigation Report 86-4204, DOE/ID-22071.

Stage-discharge relations were computed for two selected cross sections of a diversion channel at the INEL for discharges between 2,000 and 7,200 cfs. The channel diverts water from the Big Lost River into four spreading areas. Computed water-surface profiles, based on channel conditions in the summer of 1985, indicate that the diversion channel will carry a maximum discharge of 7,200 cfs from the Big Lost River into the first spreading areas. An additional 2,100 cfs will pass through two low swales west of the main channel for a combined maximum diversion capacity of 9,300 cfs.

Subject: Flood Control at the INEL
Keywords: FLOODING / BIG LOST RIVER / WATER DIVERSION
Location: INEL Technical Library

43. Bennett, C. M., 1990, *Streamflow losses and groundwater level changes along the Big Lost River at the INEL, Idaho*, USGS / Water Resources, Investigation Report 86-4204, DOE/ID-22091.

Streamflow from the Big Lost River infiltrates the bed of the river channel, the spreading areas and playas located at the terminus of the river. Average annual streamflow for 1965-1987 for the Big Lost River are presented. Infiltration and evaporation losses are discussed. Water levels in the area immediately southwest of the RWMC and the area between the NRF and playas 1 and 2 were substantially affected by recharge from the Big Lost River.

Subject: Streamflow losses
Keywords: STREAMFLOW / GROUNDWATER / BIG LOST RIVER / SPREADING AREAS
Location: INEL Technical Library

44. Binda, R. E., 1981, *Evaluation of Final Surface Cover Proposal for the INEL Subsurface Disposal Area*, Internal Technical Report, WM-F1-81-007.

This document presents a closure proposal for the INEL subsurface Disposal area. It calls for a minimum of 1.5 m of compacted soil over buried waste, which would be covered with 0.2 m of topsoil, and planted with a shallow-rooting perennial grass species. The document also addresses potential problems arising from plant root penetration of soils and what can be done to prevent penetration of buried waste.

Subject: Closure plans
Keywords: RWMC / WASTE DISPOSAL / CLOSURE PLANS / SOIL
Location: INEL Technical Library

45. Bishop, C. W., 1991, *Abbreviated Sampling and Analysis Plan Test Reactor Area Perched Water Zone Testing to Determine Aquifer Properties*, EG&G Idaho, Inc., EGG-WM-9718, Idaho Falls, ID.

The sampling and analysis plan provides guidelines and procedures for conducting aquifer tests including pumping and slug tests in TRA perched water.

Subject: Aquifer testing at the INEL
Keywords: AQUIFER TEST / SLUG TEST / PUMPING TEST / TEST REACTOR AREA / PERCHED GROUNDWATER
Location: C.W. Bishop Files

46. Bishop, C. W., 1991, *Hydraulic Properties of Vesicular Basalt*, Masters Thesis, University of Arizona, Tucson, AZ.

A large block of vesicular basalt from the RWMC was transported to the University of Arizona, Department of Hydrology and Water Resources, and subsampled. Samples were tested to determine matrix hydraulic properties of vesicular basalt. Data obtained included bulk density, skeletal density, effective porosity, saturated hydraulic conductivity, moisture characteristic curves some showing hysteresis, unsaturated fitting parameters which were used to calculate unsaturated hydraulic conductivity and diffusivity. Inhibition curves were also developed for a large block of vesicular basalt.

Subject: Hydraulic properties at the INEL
Keywords: HYDRAULIC PROPERTIES / BASALT / MATRIX SUCTION
Location: C.W. Bishop Files

47. **Bishop, C. W.; Wylie, A. H., and Mattick, J. L., 1992, *Results of Perched Water Aquifer Testing at the Test Reactor Area, Idaho National Engineering Laboratory, Idaho*, EG&G Idaho, Inc., EGG-WM-10014, Idaho Falls, ID.**

This report describes testing procedures and presents and interprets field data concerning tests performed on monitoring wells in the deep perched groundwater at the TRA. TRA wells were tested to estimate hydraulic conductivity, transmissivity and storativity. A 24-hr pumping test was conducted in well PW-8.

Subject: Aquifer testing at the INEL
Keywords: PUMPING TEST / SLUG TEST / TEST REACTOR AREA / PERCHED
GROUNDWATER
Location: C.W. Bishop Files

48. **Blanchfield, L. A., and Hoffman, L. G., 1984, *Annual Report 1983 Environmental Surveillance for the Idaho National Engineering Laboratory, Radioactive Waste Management Complex and Other Areas*, EG&G Idaho, Inc., EGG-2312, Idaho Falls, ID.**

This report describes the air, water, soil, and ambient radiation monitoring activities performed at the RWMC, the WERF, two surplus facilities, and background control locations during 1983. The report presents and evaluates results of these activities.

Subject: Environmental monitoring at the INEL
Keywords: AIR QUALITY / ENVIRONMENTAL MONITORING /
GROUNDWATER / RWMC
Location: WAG 10 Files

49. **Borghese, J. B., 1991, *Hydraulic Characteristics of Soil Cover Subsurface Disposal Area Idaho National Engineering Laboratory*, Masters Thesis, Department of Geology, University of Idaho, Moscow, ID.**

The characteristics of 14 samples from the soil cover of the subsurface disposal area INEL were examined for saturated conductivity (K), grain size distribution, dry bulk density, and porosity. The range of saturated vertical hydraulic conductivity of the samples tested is 7.7×10^{-6} to 8.4×10^{-2} centimeters per second. The analysis of grain sizes indicates that the samples are predominantly silt size, dry bulk densities range from 1 to 1.5 grams per cubic centimeter. Porosity ranged from 25% to 38%.

Subject: Hydraulic properties at the INEL
Keywords: HYDRAULIC PROPERTIES / SEDIMENT / SEDIMENT /
PROPERTIES / RWMC
Location: C.W. Bishop Files, Hubbell Files

50. Bowman, A. L.; Downs, W. F.; Moor, K. S., and Russell, B. F., 1984, *INEL Environmental Characterization Report Volume I and II*, EG&G Idaho, Inc., EGG-NPR-6688, Idaho Falls, ID.

This environmental characterization report contains general information on environmental aspects of the INEL, and specific information on two areas within the INEL which have been tentatively selected for NPR siting. The objective of this report is to present environmental information, but not assess environmental impacts. Topics addressed include geography, physiography, and demography of the INEL; ecology; climatology overview; geology and seismology; hydrology; cultural resources assessment; baseline socioeconomic data; description of INEL facilities; effluent and environmental measurements and monitoring programs; exposure pathways; and environmental laws and regulations. The hydrology section contains a general overview of the surface water that impacts the site (Big Lost River, Little Lost River, and Birch Creek), the regional aquifer, and water quality. Recharge to the aquifer is discussed qualitatively.

Subject: Environmental characterization at the INEL
Keywords: GEOGRAPHY / PHYSIOGRAPHY / DEMOGRAPHY / ECOLOGY /
CLIMATE / GEOLOGY / HYDROLOGY / ENVIRONMENTAL LAW /
REGULATIONS / CONTAMINANT PATHWAYS
Location: J.T. Barraclough Files

51. Bowman, A. L.; Downs, W. F.; Moor, K. S., and Russell, B. F., 1984, *INEL Environmental Characterization Report Volume III: Appendix C*, EG&G Idaho, Inc., EGG-NPR-6888, Vol 3, Idaho Falls, ID.

Appendices C and E through H are: Site Specific climatology summary. Appendix C is a discussion on precipitation for the candidate sites for the NPR. Included is precipitation data for selected hourly and daily time periods and snowfall amounts and depths, snow occurrence.

Subject: Environmental characterization at the INEL
Keywords: GEOGRAPHY / PHYSIOGRAPHY / DEMOGRAPHY / ECOLOGY /
CLIMATE / GEOLOGY / HYDROLOGY / ENVIRONMENTAL LAW /
REGULATIONS / CONTAMINANT PATHWAYS
Location: J.W. Barraclough Files

52. Brooks, J. M.; Matzen, T. A.; Spry, M. J.; Burns, S. M.; Ludi, K. M., and Stanisich, S. N., 1990, *Sampling and Analysis Plan for the Auxiliary Reactor Area-III Facility*, EG&G Idaho, Inc., EGG-WM-9003, Idaho Falls, ID.

This report outlines a sampling and analysis plan for assessing the extent of site contamination at the ARA III. The document reviews site specific information about surface and subsurface geology, mineralogy, cation exchange capacity, KD (sorption

coefficient) and soiles. It reviews site hydrology, and includes a list of sample handling techniques, radionuclide half lives, and detection limits.

Subject: Sampling and Analysis Plan
Keywords: SAMPLING / GROUNDWATER / TRANSPORT / DATA QUALITY /
ARA
Location: INEL Technical Library

53. **Burgus, W. H., and Macstas, S. E., 1976, *The 1975 RWMC Core Drilling Program; A Further Investigation of Subsurface Radioactivity at the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, IDO-10065, Idaho Falls, ID.***

Samples of materials taken from cores of three wells drilled in 1975 at the TWMC at INEL were radiochemically analyzed for the presence of radioactive waste nuclides. None of the results of the sample analysis were statistically positive indicating no detectable downward migration to and retention in either of two major sedimentary beds underlying the areas at depths of about 110 and 240 ft.

Subject: RWMC drilling program
Keywords: RWMC / DRILLING / SUBSURFACE RADIOACTIVITY / SAMPLING
/ RADIONUCLIDES
Location: INEL Technical Library

54. **Burns, S. M.; Stanisich, S. N. / S. M. J., and Shoop, D. S., 1990, *Closure Plan for the Test Reactor Chemical Waste Pond (COCA Unit TRA-06), EG&G Idaho, Inc., EGG-WM-9193, Idaho Falls, ID.***

The document describes the proposed plans for closure of the TRA Chemical Waste Pond (TRA-06) in accordance with the Consent Order and Compliance Agreement. A cost estimate and tentative schedule are presented.

Subject: Closure plans
Keywords: CLOSURE PLANS / WASTE POND / TEST REACTOR AREA
Location: INEL Technical Library

55. **Burr, J. R.; McManus, G. J.; Hohorst, F. A.; Duce, F. A.; Peterson, G. L., and Fernandez, S. J., 1983, *Determination of Baseline Levels of Toxic Non-Radioactive Substances at the ICPP, ENICO-1136.***

This report documents the concentrations of nonradioactive hazardous materials in off-gas, precipitation, and soil at the ICPP. Also, methods of collection and analysis were evaluated for boron, cadmium, fluoride, and mercury in ICPP off-gas and for mercury and cadmium in ICPP soil.

Subject: Background levels at the INEL
Keywords: NON-RADIOACTIVE / MERCURY/ CADMIUM / BORON /
FLUORIDE / ICPP
Location: INEL Technical Library

56. Carrigan, P. H. Jr., 1972, *Probability of exceeding capacity of flood-control system at the NRTS, Idaho*, USGS, IDO-22052.

Flood-control at the NRTS consists of earth-fill embankments which partially dam flow in the Big Lost River, near the southwest corner of the station, and which confine the flow diverted at the dam to four spreading grounds. Analyses of historical streamflow information indicate that floods in the Big Lost River would overtop the flood-control diversion dam about once every 55 years on the average; if the culverts in the dam are completely plugged, overtopping of the dam would occur about once every 16 years. Snowmelt flood analyses indicate that the diversion dam will not be overtopped by a 300-year flood if the capacity of the diversion to the spreading grounds is doubled.

Subject: Flood Control at the INEL
Keywords: FLOODING / NRTS
Location: INEL Technical Library

57. Cassidy, G. B., 1982, *Radioactive Waste Management Information 1981 Summary and Record-To-Date*, EG&G Idaho, Inc., IDO-10054(81), Idaho Falls, ID.

This document summarizes radioactive waste data records for the INEL compiled since 1952. Updated annually, the report includes information on volume, radioactivity, isotopic identity, origin, and decay status. The radioactive waste data presented was obtained from the INEL Waste Management System.

Subject: RWMC data summary
Keywords: RWMC / LIQUID WASTE / AIRBORNE WASTE
Location: INEL Technical Library

58. Cecil, D. L.; Beasley, T. M.; Pittman, J. R.; Michel, R. L.; Kubik, P. W., and Sjarma, P., 1992, *Water Infiltration Rates in the Unsaturated Zone at the Idaho National Engineering Laboratory Estimated from Chlorine-36 and Tritium Profiles, and Neutron Logging, Water-Rock Interaction*, Balkema, Rotterdam.

Environmental tracers (chlorine-36 and tritium) were used at the RWMC to estimate natural water infiltration rates in the unsaturated zone near buried nuclear waste. Chlorine-36 and tritium were measured in the soil column to determine the depth of the maximum concentration of these radionuclides produced by atmospheric testing of nuclear devices in the late 1950's and early 1960's.

Subject: ENVIRONMENTAL SURVEILLANCE AT THE INEL
Keywords: TRITIUM / CHLORINE / INFILTRATION / RWMC / VADOSE ZONE
Location: C.W. Bishop Files

59. Cecil, D. L.; Knobel, L. L., and Wegner, S. J., 1989, *Evaluation of Field Sampling and Preservation Methods for Strontium-90 in Ground Water at the Idaho National Engineering Laboratory, Idaho*, IDO-22046-USGS, Idaho Falls, Idaho.

Water from four wells completed in the SRP aquifer was sampled to determine concentrations of Strontium-90 in the INEL groundwater. Sampling and analytical procedures are presented.

Subject: Radionuclide studies at the INEL
Keywords: STRONTIUM / GROUNDWATER
Location: INEL Technical Library

60. Cecil, D. L.; Orr, B. R.; Norton, T., and Anderson, S. R., 1991, *Formation of Perched Ground-water Zones and Concentrations of Selected Chemical Constituents in Water, Idaho National Engineering Laboratory, Idaho, 1986-88*, USGS, WRIR 91-4166, DOE/ID-22100.

this document discussed formation of perched water and features controlling its formation, i.e., contrasts in vertical hydraulic conductivity, baked-zone alterations, unfractured basalt, and fracture filling. Concentrations of chemical and radionuclide contaminants present in the perched water are reported.

Subject: Perched water and contaminants at the INEL
Keywords: PERCHED GROUNDWATER / ESRP AQUIFER / RADIONUCLIDES / BASALT / SEDIMENTARY INTERBED / TRITIUM / STRONTIUM / SODIUM / CHLORIDE / CESIUM / CHROMIUM / COBALT
Location: T.R. Wood Files

61. Chase, G. H.; Teasdale, W. E.; Ralston, D. A., and Jansen, R. G., 1984, *Completion Report for Observation Wells 1 through 49, 51, 54, 55, 56, 80, and 81 at the National Reactor Testing Station, Idaho*, USGS, IDO-22045-USGS.

This report presents lithologic and geophysical logs and construction data for NRTS research observation wells 1 through 49 and for wells 51, 54, 55, 56, 80, and 81.

Subject: Lithology description
Keywords: LITHOLOGY / LOGS / GEOPHYSICAL / NRTS
Location: INEL Technical Library

62. Chaves, A., 1988, *Special Core Analysis of Basalt Samples*, TerraTek Core Services, TR 89-27.

This report presents results from testing four basalt cores for porosity, permeability and other properties.

Subject: Characterization of INEL basalts
Keywords: BASALT / POROSITY / PERMEABILITY
Location: C.W. Bishop Files

63. Clawson, K. L.; Start, G. E., and Ricks, N. R., 1989, *Climatography of the Idaho National Engineering Laboratory*, DOE/ID-12118.

64. Colwell, F. S., 1988, *Microbial Examination of RWMC Surface and Subsurface Soils and Biodegradation of Low Molecular Weight Hydrocarbons Using Microorganisms Indigenous to RWMC*, EG&G Idaho, Inc., Internal Technical Report, ST-BEG-03-88, Idaho Falls, ID.

This report documents microbial investigations performed on surface sediments and subsurface interbeds. The findings provide important basic information regarding the utilization of bacteria indigenous to the RWMC to degrade hazardous low molecular weight halocarbons.

Subject: RWMC microorganism
Keywords: RWMC / BACTERIA / SEDIMENT / SEDIMENTARY INTERBED / CONTAMINANT DEGRADATION
Location: C.W. Bishop Files

65. Copeland, D. F., and Spry, M. J., 1991, *Closure Plan for the Test Reactor Area North Sulfuric Acid Spill Area (COCA Unit LOFT-10)*, EG&G Idaho, Inc., EGG-WM-9255, Idaho Falls, ID.

This document presents the proposed plans for closure of the TAN Sulfuric Acid Spill Area at the INEL in accordance with RCRA Interim Status Closure Guidelines.

Subject: Closure plans
Keywords: TEST AREA NORTH / CLOSURE PLANS / CONTAMINANT
Location: INEL Technical Library

66. Davis, L. C., and Pittman, J. R., 1990, *Hydrological, Meteorological, and Geohydrological Data for an Unsaturated Zone Study near the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho--1987*, USGS, Open-File Report 90-114, DOE/ID-22086.

Data including hydrological, soil temperature, capillary pressure, soil moisture content, meteorological, air temperature, relative humidity, and wind speed and direction, precipitation, grain size distribution, carbonate content, color, particle roundness and sphericity, mineralogic and clastic constituents were collected in 1987 from the test trench area. Data are presented and discussed.

Subject: Climatic conditions at the INEL
Keywords: HYDROLOGY / METEOROLOGY / GEOHYDROLOGY /
UNSATURATED ZONE / RWMC
Location: Sondrup Files

67. Del Debbio, J. A., and Thomas, T. R., 1989, *Transport Properties of Radionuclides and Hazardous Chemical Species in Soils at the Idaho Chemical Processing Plant*, WINCO, WINCO-1068, Idaho Falls, ID.

Laboratory studies have been completed to provide transport parameters for transport modeling. Retardation factors and dispersion coefficients for Tc-99 (technetium, as pertechnetate ion) and Se-79 (selenium, as selenate ion) were measured in water-saturated soil columns of surficial and interbed sediments and crushed basalt. A retardation factor was also determined for selenite ion in basalt.

Subject: Transport parameters
Keywords: TRANSPORT MODELING / SOIL COLUMNS / BASALT /
RETARDATION FACTORS
Location: INEL Technical Library

68. Deutsch, M. W. M. C., and West, S. W., 1952, *Geology of Site 14 and vicinity National Reactor Testing Station, Idaho*, IDO-22019-USGS.

The report summarizes geology and geohydrology of Site 14, which is an areas containing about 12 square miles of NRTS. It is located about 16 miles northeast of the CFA and 6 miles east of the Big Lost River.

Subject: Site 14 description
Keywords: NRTS / GEOLOGY / GEOHYDROLOGY / GROUNDWATER
Location: INEL Technical Library

69. Deutsch, M. W. M. C.; Nace, R. L., and Shuter, E., 1954, *Geology and Groundwater Resources of a Part of Western Jefferson County Adjacent to the NRTS, Idaho*, IDO-22028-USGS, Idaho Falls, ID.

This report is a quantitative evaluation of the potential perennial supply of groundwater that is available in an area adjacent to the northeastern part of the NRTS, south of the Mud Lake Basin, Idaho. Included are data on the chemical quality of the groundwater that is present in the area and a discussion of the direction of groundwater flow.

Subject: Groundwater properties at the INEL
Keywords: GROUNDWATER / NRTS / CHEMICAL / STREAMFLOW /
JEFFERSON COUNTY
Location: INEL Technical Library

70. Deutsch, M.; Nace, R. L., and Voegeli, P. T., 1952, *Geology, Ground Water, and Waste-Disposal at the Aircraft Nuclear Propulsion Project Site, National Reactor Testing Station, Idaho*, USGS, IDO-22023-USGS.

A summary of the principal results of a detailed ground water and geologic study of the proposed Aircraft Nuclear Propulsion Project Site is presented. Geologic details, the source and occurrence of ground water, the directions of ground-water movement, and the hydraulic properties of water-bearing materials are considered in relation to the special nature of the ANP facility.

Subject: Waste management and disposal at the INEL
Keywords: GEOLOGY / GROUNDWATER / WASTE DISPOSAL
Location: INEL Technical Library

71. Deutsch, M.; Voegeli, P. T.; Nace, R. L., and Jones, J. R., 1952, *Geology and Ground Water in the Northeastern Part of the National Reactor Testing Station, Idaho*, USGS, IDO-22022-USGS.

A summary of the principal results of a detailed study of the ground water and geology of the Northeastern Part of the NRTS is presented. The investigations emphasize evaluation, development, conservation, and protection of ground water resources. Emphasis is on the rocks, soils, and sediments present at the land surface, their types, surficial distribution, and probable subsurface extensions.

Subject: Groundwater properties at the INEL
Keywords: GROUNDWATER / NRTS / GEOLOGY
Location:

72. Dolenc, M. R., and Janke, D. H., 1977, *Environmental Surveillance Report for the Idaho National Engineering Laboratory Radioactive Waste Management Complex Annual Report—1976*, TREE-1078.

This report describes the environmental surveillance activities during 1976 at the two solid waste facilities on the INEL. The monitoring program encompasses periodic and random sampling of air, water, soil within and adjacent to the RWMC and SL-1 Burial Ground.

Subject: ENVIRONMENTAL surveillance AT THE INEL
Keywords: AIR QUALITY / RWMC / SL-1 / BURIAL GROUND /
RADIOACTIVE WASTE / GROUNDWATER
Location: WAG 10 Files

73. Domenico, P. A., and Schwartz, F. W., 1990, *Physical and Chemical Hydrogeology*, Hamilton Printing Company.
74. Doornbos, M. H.; Mattick, J. L.; McElroy, D. L.; Street, L. V.; Blackmore, C. S., and Dicke, C. A., 1991, *Environmental Characterization Report for the Test Reactor Area, Vol. I*, EGG-WM-9690.
75. Druffel, L.; Stiltner, G. J., and Keefer, T. N., 1979, *Probable Hydrologic Effects of a Hypothetical Failure of Mackay Dam on the Big Lost River Valley from Mackay, Idaho to the INEL*, USGS, WRI 79-99, IDO-22058-USGS.

Mackay Dam is an irrigation reservoir on the Big Lost River, Idaho, approx. 7.2 km northwest of Mackay, Idaho. Consequences of possible rupture of the dam have concerned management of waste disposal facilities on the INEL. The objective of this report is to calculate and route the flood wave resulting from the hypothetical failure of Mackay Dam downstream to the INEL. Both a full and a 50% partial breach of this dam are investigated.

Subject: Flood control at the INEL
Keywords: MACKAY DAM / FLOODING / BIG LOST RIVER
Location:

76. Edwards, D. D.; Bartholomay, R. C., and Bennett, C. M., 1990, *Nutrients, Pesticides, Surfactants, and Trace Metals in Ground Water from the Howe and Mud Lake Areas Upgradient from the Idaho National Engineering Laboratory, Idaho*, USGS, Open-File Report 90-565, DOE/ID 22093.

Samples from wells and one canal upgradient of the INEL were analyzed for nutrients, herbicides, insecticides, polychlorinated compounds, surfactants, and heavy metals. Analytical concentrations are reported.

Subject: Background levels at the INEL
 Keywords: TRACE METALS / SURFACTANTS / GROUNDWATER /
 NUTRIENTS / PESTICIDES / MUD LAKE / HOWE
 Location: J.T. Barraclough Files

77. EG&G Idaho, Inc., 1979, *Radioactive Waste Management Information 1978 Summary and Record-To-Date*, EG&G Idaho, Inc., IDO-10054(78), Idaho Falls, ID.

This document summarizes radioactive waste data records for the INEL compiled since 1952. Kinds of information include volume, radioactivity, isotopic identity, origin, and decay status of waste.

Subject: Waste management and disposal at the INEL
 Keywords: RWMC / RADIOACTIVE WASTE / CHEMISTRY / RADIONUCLIDES
 Location: INEL Technical Library

78. EG&G Idaho, Inc., 1984, *INEL Environmental Characterization Report Volume II: Appendices A-C*, EG&G Idaho, Inc., EGG-NPR-6688, Vol. 2, Idaho Falls, ID.

The socioeconomic data base is a compilation of relevant socioeconomic data for that part of southeast Idaho which would be impacted by the proposed expansion of the INEL to accommodate the NPR.

Subject: Environmental characterization at the INEL
 Keywords: ENVIRONMENTAL CHARACTERIZATION / SOCIOECONOMIC
 Location: J.T. Barraclough Files, Hubbell Files

79. EG&G Idaho, Inc., 1984, *INEL Environmental Characterization Report Volume VI: Appendices D-H*, EG&G Idaho, Inc., EGG-NPR-688, Vol. 4, Idaho Falls, ID.

As part of the INEL characterization some special geologic studies were conducted. These studies are summarized in or included as Appendices D1 through D7.

Subject: Environmental characterization at the INEL
 Keywords: ENVIRONMENTAL CHARACTERIZATION / GEOLOGY /
 HYDROLOGY
 Location: J.T. Barraclough Files, Hubbell Files

80. EG&G Idaho, Inc., 1984, *INEL Environmental Characterization Report Vol I, Summaries*, EG&G Idaho, Inc., EGG-NPR-6688, Idaho Falls, ID.

81. EG&G Idaho, Inc, 1988, *Radioactive Waste Management Complex Subsurface Investigations Program Peer Review Report*, EG&G Idaho, Inc., EGG-BEG-8071, Idaho Falls, ID.

The Subsurface Investigations Program, established in 1983 for the RWMC at the INEL, was subjected to a peer review March 7-11, 1988. The panel reviewed the program's progress and plans for future work. This report presents the results of that review.

Subject: Subsurface investigation
Keywords: SUBSURFACE INVESTIGATIONS / RWMC / DRILLING /
CHARACTERIZATION / HYDRAULIC PROPERTIES / FLUX /
TRANSPORT / ORGANIC COMPOUNDS
Location: Sondrup Files

82. EG&G Idaho, Inc., 1989, *Closure Plan for the Test Area North Technical Support Facility Disposal Pond (COCA Unit TSF-07)*, EG&G Idaho, Inc., EGG-8405-R1, Idaho Falls, ID.

83. EG&G Idaho, Inc., 1990, *Sampling and Analysis Plan/Quality Assurance Project Plan for Groundwater Sampling at CFA Landfills II and III*, EG&G Idaho, Inc., EGG-ER-8807, Idaho Falls, ID.

This document pertains to the environmental data collection, evaluation, and review of activities specific to the groundwater sampling conducted at CFA Landfills II and III.

Subject: Sampling and Analysis Plan
Keywords: GROUNDWATER / SAMPLING / CFA LANDFILL / QUALITY
ASSURANCE
Location: INEL Technical Library

84. EG&G Idaho, Inc., 1991, *Closure Plan for the Technical Support Facility Heat Transfer Reactor Experiment III Mercury Spill Area (COCA Unit TSF-08)*, EG&G Idaho, Inc., EGG-WM-9355, Idaho Falls, ID.

85. EG&G Idaho, Inc., 1991, *Closure Plan for the TSF Paint Shop Floor Drain Leach Field (COCA Unit TSF-27)*, EG&G Idaho, Inc., Idaho Falls, ID.

86. EG&G Idaho, Inc., 1991, *Inorganic TRA Warm Waste Pond Data 1988 Sampling Effort*, EG&G Idaho, Inc., RDG-15-91, Idaho Falls, ID.

This report summarizes the results of analytical data for metals, total organic carbon, sulfide, and cyanide in soil samples taken from the TRA Warm Waste Pond.

Subject: TRA warm waste ponds

Keywords: TEST REACTOR AREA / WARM WASTE PONDS / SAMPLING /
INORGANIC COMPOUNDS

Location:

87. EG&G Idaho, Inc., 1991, *Validation Inorganic Data from TRA Warm Waste Pond 1988 Sampling Effort*, EG&G Idaho, Inc., RDG-16-91, Idaho Falls, ID.

This report contains the validation data for the inorganic analysis for several soil samples. These soil samples were taken at the TRA warm waste leaching pond area in 1988.

Subject: TRA warm waste ponds

Keywords: TEST REACTOR AREA / WARM WASTE PONDS / SAMPLING /
INORGANIC COMPOUNDS

Location:

88. EG&G Idaho, Inc., 1991, *Validation of Radiological Data From TRA Warm Waste Leaching Pond*, EG&G Idaho, Inc., DAA-05-91, Idaho Falls, ID.

Soil and water samples, taken from in and around the TRA Warm Waste Ponds at the INEL, were analyzed for radiochemical constituents at the EG&G Idaho, Radiation Measurements Laboratory. This report presents interpretation of the data, the quality levels achieved by the reported sample results, conclusions that can be drawn from the data, and sample results tables.

Subject: Radionuclide studies at the INEL

Keywords: RADIOLOGICAL / TEST REACTOR AREA / WARM WASTE
PONDS / QUALITY ASSURANCE

Location:

89. EG&G Idaho Inc., 1991, *Validation of Semi-Volatile Organic Data from the 1988 TRA Warm Waste Pond Project*, EG&G Idaho, Inc., RDG-07-91, Idaho Falls, ID.

Several soil samples were taken from in and around the TRA Warm Waste Ponds at the INEL. These samples were analyzed for semi-volatile organics. The results of the validation process is presented and the reason for the qualification.

Subject: Organic compounds

Keywords: ORGANIC COMPOUNDS / TEST REACTOR AREA / WARM WASTE
PONDS / QUALITY ASSURANCE

Location:

90. EG&G Idaho, Inc., 1991, *Validation of Volatile Organic Data from the 1988 TRA Warm Waste Pond Project-SDG-TRA0388001*, EG&G Idaho, Inc., RDG-09-91, Idaho Falls, ID.

This report contains the validation of volatile organic data from the 1988 TRA warm waste pond project. The samples were analyzed for volatile organics. The samples were tested for the compounds acetone and acrylonitrile. The results of these tests were provided with the validation process used.

Subject: Organic compounds

Keywords: ORGANIC COMPOUNDS / TEST REACTOR AREA / WARM WASTE PONDS / QUALITY ASSURANCE

Location:

91. EG&G Idaho, I., 1992, *Sitewide Groundwater Monitoring Plan Vol. I, II, and III*, EG&G Idaho, ID, EGG-WMO-10383, Idaho Falls, ID.

The three volumes present the sitewide groundwater monitoring plan for the INEL. An overview is given, followed by specific site descriptions. For each site past and current operations, physical setting, water quality, groundwater hazard assessment and finally groundwater monitoring programs are discussed.

Subject: Groundwater monitoring at the INEL

Keywords: GROUNDWATER / ESRP AQUIFER / QUALITY ASSURANCE / MONITORING / HAZARD / SURFACE WATER / BASALT / COMPLIANCE / CONTAMINANT / PERCHED GROUNDWATER / RISK / STREAMFLOW

Location: T.R. Wood Files, Honeycutt Files

92. Freeze, R. A., and Cherry, J. A., 1979, *Groundwater*, Englewood Cliffs, NJ, Prentice-Hall.

93. Garabedian, S. P., 1986, *Application of a Parameter-Estimation Technique to Modeling the Regional Aquifer Underlying the Eastern Snake River Plain, Idaho*, USGS, Paper 2278, USGS-86-2278.

A nonlinear, least-squares regression technique for the estimation of ground-water flow model parameters was applied to the regional aquifer underlying the eastern Snake River Plain, Idaho. The technique uses a computer program to simulate two-dimensional, steady-state ground-water flow. Hydrologic data for the 1980 water year were used to calculate recharge rates, boundary fluxes, and spring discharges.

Subject: Groundwater modeling at the INEL

Keywords: MODELING / ESRP AQUIFER / GROUNDWATER

Location: WAG 10 Files

94. Garabedian, S. P., 1989, *Hydrology and Digital Simulation of the Regional Aquifer System, Eastern Snake River Plain, Idaho*, USGS, Open-File Report 87-237.

This report primarily discusses the groundwater flow for the entire SRP aquifer. Not much attention is paid specifically to the INEL site and it's related drainages. Regional groundwater flow is generally from northeast to southwest, from areas of recharge to areas of discharge. The flow was simulated with numerical groundwater models.

Subject: ESRP aquifer
Keywords: ESRP AQUIFER / SIMULATION / WATER TABLES
Location:

95. Golder Associates, Inc., 1990, *Final Well Completion Report for Wells #121, #122, and #123 at the Idaho Chemical Processing Plant*, Golder Associates, Inc., GOLDER-90-01.

Subject: Groundwater monitoring at the INEL
Keywords: INSTALLATION / WELL MONITORING / COMPLETION OF WELL
Location:

96. Golder Associates, Inc., 1991, *Geohydraulic and Petrographic Analyses of Samples from Well #121 and #123*, Golder Associates, Inc., GOLDER-91-01.

This report describes the testing methods and presents the results of geohydraulic and petrographic analyses of nine samples, selected from soil and rock core collected while drilling monitoring wells, 121 and 123.

Subject: Geohydraulic and petrographic analyses
Keywords: ICPP / GEOHYDROLOGY / PETROGRAPHIC / SAMPLING
Location:

97. Golder Associates, Inc., 1991, *Report for the Idaho Chemical Processing Plant Drilling and Sampling Program at Land Disposal Units CPP-39*, Golder Associates, Inc., Golder 893-1195.310.

The objectives of the environmental investigation at land disposal units (LDU, CPP-39) were to determine the nature and extent of any hazardous constituents released to a containment vault and dry well as a result of hydrofluoric acid storage and disposal. This work was performed in accordance with "The Technical Work Plan for the ICPP. The hazardous constituents detected (PAH) and (BEHP) cannot be attributable to disposal of listed hazardous wastes at LDU CPP-39.

Subject: Wells at the INEL
Keywords: DRILLING / SAMPLING / LAND DISPOSAL UNIT / ICPP
Location:

98. Golder Associates, Inc., 1991, *Report for the Idaho Chemical Processing Plant Drilling and Sampling Program at Land Disposal Unit CPP-59*, Golder Associates, Inc., Golder-91-002.

Eleven boreholes were drilled and sampled for chemical analysis at LDU CPP-59. Samples were analyzed for volatile organic compounds and total petroleum hydrocarbons (TPH). The results of the sampling analysis show that total petroleum hydrocarbons indicative of the spilled kerosene were detected at the site. The volatile components of kerosene of primary toxicological concern, benzene, toluene and ethylbenzene were not detected. Although LDU CPP-59 has been the site of reported kerosene spills, further RCRA closing activities are not recommended for the site because kerosene is not a RCRA hazardous waste. Recommendations for further work on LDU CPP-59 are included.

Subject: Wells at the INEL
Keywords: DRILLING / SAMPLING / LAND DISPOSAL UNIT / ICPP
Location:

99. Golder Associates, Inc., 1991, *Report for the Chemical Processing Plant Drilling and Sampling Program at Land Disposal Unit CPP-59*, Golder Associates, Inc., Ref: C86-131159, Task 6, Mod 4..

100. Golder Associates, Inc., 1991, *Report for the Chemical Processing Plant Drilling and Sampling Program at Solid Waste Management Unit CPP-51*, Golder Associates, Inc., Ref: C86-131159, Task 6, Mod 4..

101. Golder Associates, Inc., 1991, *Report for the Chemical Processing Plant Drilling and Sampling Program at Solid Waste Management Unit CPP-54*, Golder Associates, Inc., Ref: C86-131159, Task 6, Mod 4..

102. Goldstein, F. J., and Weight, W. D., 1982, *Subsurface Information from Eight Wells Drilled at the Idaho National Engineering Laboratory, Southeastern Idaho*, USGS, Open-File Report 82-0644, IDO-22063-USGS.

Six wells were drilled and two existing wells were deepened at the INEL from 1969 through 1974. Water levels in three wells near the Big Lost River respond to changes in recharge to the Snake River Plain aquifer from the Big Lost River. Measured water levels in multiple piezometers in one well indicate increasing pressure heads with depth. A marked decline in water levels in the well since 1977 is attributed to lack of recharge to the Snake River Plain Aquifer.

Subject: Wells at the INEL
Keywords: HYDROLOGY / ESRP AQUIFER / INSTRUMENTATION
Location: J.T. Barraclough Files

103. Hackett, B.; Pelton, J., and Brockway, C., 1986, DOE/ID.

The pamphlet describes the hydrogeologic environment at the INEL and ESRP aquifer. It deals with recharge, discharge, water movement within the aquifer, and volcanism and seismicity of the SRP.

Subject: Hydraulic properties at the INEL
Keywords: ESRP / VOLCANISM / HYDROLOGY / AQUIFER RECHARGE /
DISCHARGE / SEISMOLOGY
Location: C.W. Bishop Files

104. Hackett, W. R., and Smith R.P., 1992, "Quaternary Volcanism, Tectonics, and Sedimentation in the Idaho National Engineering Laboratory Area," *Rocky Mountain Section Meeting, Geological Society of America and Utah Geological Survey.*

105. Hardy, C. E., and Brower, J. H., 1985, *Conceptual Design Report for the TRA Radioactive Liquid Waste Cleanup System Phase III*, PR-T-80-014 (rev. 6).

Modifications are presented to Phase III of the TRA Radioactive Liquid Waste Cleanup System and extends the capabilities of Phases I and II to provide zero discharge of radioactive liquid to the aquifer.

Subject: Waste management and disposal at the INEL
Keywords: TEST REACTOR AREA / RADIOACTIVE WASTE / WATER
TREATMENT / DISPOSAL POND
Location: INEL Technical Library

106. Hardy, C. K., and Stanisich, S. N., 1990, *Closure Plan for the ARA-I Chemical Evaporation Pond (COCA Unit ARA-1)*, EG&G Idaho, Inc., EGG-WM-9114, Idaho Falls, ID.

107. Harness, J. L., and Passmore, R. W., 1976, *Onsite Environmental Surveillance Report for the Idaho National Engineering Laboratory, Radioactive Waste Management Complex Annual Report—1974*, TREE-1014.

This report indicated that operation of the RWMC during 1974 had little impact upon the environment. The most measurable effect was increased radiation levels at the perimeter of the RWMC.

Subject: Environmental surveillance at the INEL
Keywords: AIR QUALITY / ENVIRONMENTAL / RWMC / RADIONUCLIDES /
BURIED WASTE / GROUNDWATER
Location: WAG 10 Files

108. **Harness, J. L., and Passmore, R. W., 1976, *Onsite Environmental Surveillance Report for the Idaho National Engineering Laboratory, Radioactive Waste Management Complex Annual Report—1975*, TREE-1013.**

This report documents the continuing INEL RWMC environmental surveillance program. The 1975 monitoring program results indicate that operation of the RWMC continues to have minimal impact on the environment.

Subject: RWMC operational impact to the environment
Keywords: AIR QUALITY / ENVIRONMENTAL / RWMC / BURIED WASTE /
RADIONUCLIDES / SURVEILLANCE
Location: WAG 10 Files

109. **Hawkins, D. B., and Foster, D. C., 1963, *A Comparison of Two Methods of Sampling Gravel for the Evaluation of a Ground-Disposal Site for Radioactive Liquid Waste*, IDO-12027.**

This document compares two methods for sampling alluvium and their ability to provide accurate estimates of total fine-grained material.

Subject: Sampling and analysis plan
Keywords: GRAVEL / RADIOACTIVE WASTE / GROUND DISPOSAL
Location: INEL Technical Library, Microfiche, WAG 10 Files

110. **Hawkins, D. B., and Schmalz, B. L., 1965, *Environmental Tritium Studies at the National Reactor Testing Station*, IDO-12043.**

Information on the concentration of tritium in waste, precipitation, surface and ground water at the NRTS and surrounding areas is presented. These data have been gathered to determine the effect of NRTS operations on the surrounding region and to elucidate the hydrology of ground water at the NRTS.

Subject: Radionuclide studies at the INEL
Keywords: TRITIUM / NRTS / GROUNDWATER
Location: INEL Technical Library

111. **Hawkins, D. B., and Shorttle, H. L., 1965, *Equations for the Sorption of Cesium and Strontium on Soil and Clinoptilolite*, IDO-12046.**

Four equations have been developed which permit the calculation of the distribution coefficient for the sorption of cesium and Strontium on soil and clinoptilolite. These equations hold over the following concentration ranges of the solution phase: calcium 5 to 500 ppm, magnesium 1 to 125 ppm, cesium 0.05 to 5 ppm, phosphate 0.1 to 10 ppm, and pH 4 to 9.

Subject: Radionuclide studies at the INEL
 Keywords: DISTRIBUTION COEFFICIENT / CESIUM / STRONTIUM / SOIL
 contaminantION / RETARDATION FACTORS
 Location: INEL Technical Library

112. Hedahl, T. G., and Janke, D. H., 1977, *Environmental Surveillance Report for the Idaho National Engineering Laboratory Radioactive Waste Management Complex Annual Report—1977*, TREE-1251.

This annual report describes the environmental surveillance (routine and random sampling of air, water, and soil) activities, conducted through 1977, at the RWMC.

Subject: ENVIRONMENTAL surveillance AT THE INEL
 Keywords: AIR QUALITY / ENVIRONMENTAL / MONITORING /
 GROUNDWATER / SOIL contaminantION / RWMC
 Location: WAG 10 Files

113. Hoff, D. L.; Chew, E. W., and Rope, S. R., 1987, *1986 Environmental Monitoring Program Report for the Idaho National Engineering Laboratory Site*, DOE, DOE/ID-12082, Idaho Falls, ID.

114. Hoff, D. L.; Mitchell, R. G.; Bowman, G. C., and Moore, R., 1989, *The Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1989*, DOE/ID-12082(89).

A summary of the environmental surveillance program at the INEL is given. Results from the various monitoring programs for 1989 are presented. The environmental monitoring programs include air, water, foodstuff, and soil sampling, environmental radiation measurement and big game species, radioactive effluent, and groundwater.

Subject: Environmental report for the INEL
 Keywords: ENVIRONMENTAL / RADIOLOGICAL / GROUNDWATER /
 MONITORING
 Location: INEL Technical Library

115. Hubbell, J. M., 1990, "Monitoring and Sampling Perched Ground Water in a Basaltic Terrain," *Fourth National Outdoor Conference on Aquifer Restoration, Groundwater Monitoring and Geophysical Methods*.

This paper describes the distribution and characteristics of perched groundwater at the RWMC at the INEL. It discusses perched water below the surficial sediments in wells at the RWMC, the characteristics of chemical contaminant transport in the unsaturated zone of water, and the lateral extent of perched water.

Subject: Perched water and contaminants at the INEL
Keywords: SAMPLING / MONITORING / PERCHED GROUNDWATER /
BASALT
Location: J.M. Hubbell Files

116. Hubbell, J. M., 1990, *Perched Ground Water at the Radioactive Waste Management Complex of the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-ER-8779, Idaho Falls, ID.

This report is an assessment of the presence, extent, source and quality of perched ground water at the RWMC. It was written to aid in the overall understanding of the hydrogeologic environment of the unsaturated zone at the RWMC.

Subject: Perched water and contaminants at the INEL
Keywords: PERCHED GROUNDWATER / RWMC / BASALT / UNSATURATED
ZONE
Location: J.M. Hubbell Files

117. Hubbell, J. M., 1991, *Evaluation of Vapor Monitoring and Testing Sites at the RWMC*, EG&G Idaho, Inc., Engineering Design File, ERP-VVED-065, Idaho Falls, ID.

This report presents a study undertaken at the RWMC to evaluate potential sites for vapor vacuum extraction. These sites include open wells, neutron access tubes, groundwater wells, subpit sampling wells, monitoring ports, and suction lysimeters.

Subject: Vacuum extraction sampling
Keywords: VAPOR VACUUM EXTRACTION / SAMPLING / VADOSE ZONE /
RWMC / ESRP AQUIFER
Location: J.M. Hubbell Files

118. Hubbell, J. M.; Hull, L. C.; Humphery, T. G.; Russell, B. F.; Pittman, J. R., and Cannon, K. M., 1985, *Annual Progress Report: FY-1985 Subsurface Investigations Program at the Radioactive Waste Management Complex of the Idaho National Engineering Laboratory*, DOE/ID-10136, Idaho Falls, Idaho.

This report describes work conducted in FY-85 in support of the Subsurface Investigations Program at the RWMC of the INEL. The objective of the work is to define and predict radionuclide migration from the buried waste. Work includes drilling to evaluate radionuclide content in the surficial sediments and characterize the hydrogeologic environment.

Subject: Subsurface investigation
Keywords: SUBSURFACE INVESTIGATIONS / GROUNDWATER / BASALT /
HYDROLOGY / RWMC

Location: J.T. Barraclough Files

119. Hubbell, J. M.; Hull, L. C.; Humphery, T. G.; Russell, B. F.; Pittman, J. R., and Fisher, P. R., 1987, *Annual Progress Report: FY-1986 Subsurface Investigations Program at the Radioactive Waste Management Complex of the Idaho National Engineering Laboratory*, DOE/ID-10153, Idaho Falls, ID.

This report summarizes the work performed in support of the Subsurface Investigations Program during FY-1986. The work is part of a continuing effort to define and predict radionuclide migration from buried waste. Work included shallow augering and deep drilling. Some holes were instrumented with lysimeters, tensiometers, dissipation sensors and psychrometers. Instrument readings were taken on a monthly basis. Pore water, core, and weighing lysimeter samples were collected and analyzed.

Subject: Subsurface investigation

Keywords: SUBSURFACE INVESTIGATIONS / RWMC / CHARACTERIZATION / GROUNDWATER / VADOSE ZONE

Location: J.T. Barraclough Files

120. Hubbell, J. M., and Wood, T. R., 1991, *A Hydrologic Evaluation of the RWMC Production Well and USGS Well 90*, EG&G Idaho, Inc., EGG-WM-10123, Idaho Falls, ID.

This report presents test methods for pumping tests that were run at the RWMC in Nov. 1974 and 1990. It also presents hydraulic data, data analyses, and makes recommendations for subsequent pumping tests.

Subject: Pump tests at the INEL

Keywords: PUMPING TEST / RWMC / ESRP AQUIFER

Location: J.M. Hubbell Files

121. Hull, L. C., 1987, *Hydrogeologic Assessment of Land Disposal Unit, CPP-37 ICPP Gravel Pit #2*, EG&G Idaho, Inc., EGG-87-01, Idaho Falls, ID.

this report describes the geology and hydrology of the Land Disposal Unit CPP-37, which consists of Gravel Pit #2 in the northeast corner of the ICPP compound at the INEL. Extensive work over the past 30 years provides a very good picture of the geologic and hydrologic characteristics of the INEL.

Subject: Waste management and disposal at the INEL

Keywords: HYDROLOGY / GEOLOGY / ICPP

Location:

122. Hull, L. C., 1989, *Conceptual Model and Description of the Affected Environment for the TRA Warm Waste Pond (Waste Management Unit TRA-03)*, EG&G Idaho, Inc., EGG-ER-8644, Idaho Falls, ID.

This report discusses the development of a conceptual model of the movement of water and contaminants associated with the TRA warm waste pond based on an analysis of existing data. The conceptual model is a verbal description of the processes which are important for contaminant migration.

Subject: Contaminant modeling at the INEL
Keywords: MODELING / CONTAMINANT / WARM WASTE PONDS
Location: C.W. Bishop Files

123. Hull, L. C., and Wood, T. R., 1989, *Groundwater Monitoring Plan for the Test Reactor Area Paint Shop Ditch, Revision 1*, EG&G Idaho, Inc., Informal Report, EGG-ER-8554, Idaho Falls, ID.

This document presents the groundwater monitoring plan for the Paint Shop Ditch at the TRA of the INEL.

Subject: Groundwater monitoring at the INEL
Keywords: GROUNDWATER / SITE CHARACTERIZATION / ESRP AQUIFER / TEST REACTOR AREA
Location: T.R. Wood Files

124. Humphrey, T. G.; Smith, T. H., and Pope, M. C., 1982, "Projected subsurface migration of radionuclides from the buried Idaho National Engineering Laboratory Transuranic Waste", *Nuclear Technology*, 58:136-149.

This article reports on computer migration projections based on three alternative isolation methods of wastes buried at the RWMC at the INEL.

Subject: Radionuclide studies at the INEL
Keywords: RADIONUCLIDE / MIGRATION / BURIED WASTE / SNAKE RIVER PLAIN AQUIFER / MODELING
Location: INEL Technical Library

125. Humphrey, T. G., 1980, *Subsurface Migration of Radionuclides at the Radioactive Waste Management Complex 1978*, EG&G Idaho, Inc., DOE-EGG-2026, Idaho Falls, ID.

An investigation conducted by EG&G Idaho to determine the extent of radionuclide migration from waste buried at the RWMC. It is described in a series of investigations conducted with the same objectives.

Subject: Radionuclide studies at the INEL
 Keywords: RADIONUCLIDES / MIGRATION / BURIED WASTE / RWMC /
 DRILLING / SAMPLING
 Location: J.T. Barraclough Files

126. Humphrey, T. G., and Reno, H. W., 1981, *1979 Subsurface Investigation at the Radioactive Waste Management Complex of the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-2083, Idaho Falls, ID.

This report describes the 1979 subsurface investigation of radionuclide movement beneath the RWMC of the INEL. Three wells were drilled in the area. Analytical results from these efforts are compared with previous results.

Subject: Subsurface investigation
 Keywords: RWMC / GROUNDWATER / BURIED WASTE / RADIONUCLIDES /
 MIGRATION
 Location: WAG 10 Files

127. Humphrey, T. G., and Tingey, F. H., 1978, *The Subsurface Migration of Radionuclides at the Radioactive Waste Management Complex 1976-1977*, EG&G Idaho, Inc., TREE-1171, Idaho Falls, ID.

Samples of subsurface material from the RWMC at the INEL were collected and radiochemically analyzed. The purpose of this study was to determine the extent of radionuclide migration from buried waste. The material came from eight core drilled wells and from four sample trenches excavated beneath buried waste. One well provided deeper samples from directly under buried waste. It is concluded from this study that radionuclide migration will not be a future hazard to the Snake River Plain aquifer under present climatic conditions.

Subject: Radionuclide studies at the INEL
 Keywords: RADIONUCLIDES / MIGRATION / RWMC / SUBSURFACE
 RADIOACTIVITY / ESRP AQUIFER
 Location: J.T. Barraclough Files

128. Idaho Department of Health and Welfare and EG&G Idaho, Inc., 1990, *INEL's Test Reactor Area (TRA) Evaporation Pond ---Prevention of Significant Deterioration (PSD) Application for a Permit to Construct (PTC)—Response Package*, Department of Environmental Quality, DEQ-90-01, Boise, ID.

This is number 1 of a three volume set that contains information about an application for an evaporation pond at the TRA at INEL. They include the application, Correspondence, and a record of public comment. Since the pond will be lined, the radionuclide Tritium will be released into the air, so a permit is necessary. These documents contain some data on

quantity and quality of the waste stream from TRA as well as a calculation of potential dosage from the site.

Subject: TRA data

Keywords: TEST REACTOR AREA / EVAPORATION POND / TRITIUM /
WASTE STREAM / GROUNDWATER

Location:

129. Idaho Department of Health and Welfare and EG&G Idaho, Inc., 1990, *INEL's Test Reactor Area (TRA) Evaporation Pond ---Prevention of Significant Deterioration (PSD) Application for a Permit to Construct (PTC)—Public Comment Package*, Department of Environmental Quality, DEQ-90-02, Boise, ID.

This is number 2 of a three volume set that contains information about an application for an evaporation pond at the TRA at INEL. They include the application, Correspondence, and a record of public comment. Since the pond will be lined, the radionuclide Tritium will be released into the air, so a permit is necessary. These documents contain some data on quantity and quality of the waste stream from TRA as well as a calculation of potential dosage from the site.

Subject: TRA data

Keywords: TEST REACTOR AREA / EVAPORATION POND / TRITIUM /
WASTE STREAM / GROUNDWATER

Location:

130. Idaho Department of Health and Welfare and EG&G Idaho, Inc., 1990, *INEL's Test Reactor Area (TRA) Evaporation Pond ---Prevention of Significant Deterioration (PSD) Application for a Permit to Construct (PTC)—Public Comment Package Addendum*, Department of Environmental Quality, DEQ-90-03, Boise, ID.

This is number 3 of a three volume set that contains information about an application for an evaporation pond at the TRA at INEL. They include the application, Correspondence, and a record of public comment. Since the pond will be lined, the radionuclide Tritium will be released into the air, so a permit is necessary. These documents contain some data on quantity and quality of the waste stream from TRA as well as a calculation of potential dosage from the site.

Subject: TRA data

Keywords: TEST REACTOR AREA / EVAPORATION POND / TRITIUM /
WASTE STREAM / GROUNDWATER

Location:

131. Janke, D. H., 1983, *Environmental Surveillance for the Idaho National Engineering Laboratory Radioactive Waste Management Complex and other Areas*, EG&G Idaho, Inc., EGG-2256, Idaho Falls, ID.

This report presents analytical results for air and water monitoring during 1982. Results indicate that RWMC operations produced minimal impact on the environment.

Subject: RWMC operational impact to the environment
Keywords: AIR QUALITY / RWMC / WASTE DISPOSAL / RADIONUCLIDES / GROUNDWATER
Location: WAG 10 Files

132. Janke, D. H.; Reno, H. W., and Wickham, L. E., 1980, *Environmental Surveillance for the Idaho National Engineering Laboratory Radioactive Waste Management Complex—1980*, EG&G Idaho, Inc., EGG-2128, Idaho Falls, ID.

The 1980 environmental surveillance report for RWMC of the INEL contains data and discussions about routine radiological monitoring of the atmospheric, hydrologic, and geologic environments of the RWMC.

Subject: Environmental monitoring at the INEL
Keywords: AIR QUALITY / ENVIRONMENTAL / MONITORING / HYDROLOGY
Location: WAG 10 Files

133. Janke, D. H., and Zahn, T. P., 1982, *Annual Report 1981 Environmental Surveillance for the Idaho National Engineering Laboratory Radioactive Waste Management Complex*, EG&G Idaho, Inc., EGG-2209, Idaho Falls, ID.

The 1981 environmental surveillance report for the RWMC of the INEL contains data and discussions about routine radiological monitoring of the atmospheric, hydrologic, and geologic environments of the RWMC.

Subject: Environmental monitoring at the INEL
Keywords: AIR QUALITY / ENVIRONMENTAL / MONITORING / HYDROLOGY
Location: WAG 10 Files

134. Jones, J. R.; Deutsch, M., and Vogeli, P. T., 1951, *Geology and Ground Water at Site 3, Reactor Testing Station, Idaho*, USGS, IDO-22002-USGS, Idaho Falls, ID.

A summary of the principal results of a detailed study of the ground water and geology of Site 3 (NRF) on the NRTS is presented. The investigations emphasize evaluation, development, conservation, and protection of ground water resources. Emphasis is on the

rocks, soils and sediments present at the land surface, their types, surficial distribution, and probable subsurface extensions.

Subject: Groundwater properties at the INEL
Keywords: NRTS / GROUNDWATER / SITE 3 / GEOLOGY
Location: TBD

135. Jones, J. R., and Jones, S. L., 1951, *Memorandum Report on Compiled Logs of AEC Wells STR-2 and CPP-2*, USGS, IDO-22014-USGS, Idaho Falls, ID.

This document presents a description of lithology encountered in drill holes STR-2 and CPP-2.

Subject: Lithology description
Keywords: LOGS / LITHOLOGY / CPP-2 / STR-2
Location: INEL Technical Library

136. Jones, J. R., and Jones, S. L., 1952, *Logs of Test Holes in the Central Snake River Plain, Idaho*, USGS, IDO-22015-USGS, Idaho Falls, ID.

The preliminary drillers logs of 11 test holes, three abandoned holes, and two production wells is presented. The logs are strictly factual descriptions of the materials and conditions encountered during drilling.

Subject: Wells at the INEL
Keywords: LOGS
Location: INEL Technical Library

137. Jones, J. R., and Voegcli, P. T., 1951, *Geology and Ground Water at Site 2A, Reactor Testing Station, Idaho*, USGS, IDO-22001-USGS, idid.

A summary of the principal results of a detailed study of the ground water and geology of Site 2A (MTR) on the NRTS is presented. The investigations emphasize evaluation, development, conservation, and protection of ground water resources. Emphasis is on the rocks, soils and sediments present at the land surface, their types, surficial distribution, and probable subsurface extensions.

Subject: Groundwater properties at the INEL
Keywords: GROUNDWATER / NRTS / SITE 2A
Location: INEL Technical Library

138. Jones, P. H., 1961, *Hydrology of Waste Disposal National Reactor Testing Station, Idaho*, USGS, IDO-22042-USGS, Idaho Falls, ID.

First year summary of advanced research on the hydrology of waste disposal at the NRTS is presented. The purpose of the research is to provide detailed and accurate information on the occurrence, movement, quality, and geologic environment of water beneath the land surface.

Subject: Geology and hydrology at the INEL
Keywords: NRTS / HYDROLOGY / WASTE DISPOSAL / GROUNDWATER / ESRP AQUIFER
Location: J.T. Barraclough Files, INEL Technical Library

139. Jones, P. H., 1961, *Hydrology of Radioactive Waste Disposal at the Idaho Chemical Processing Plant National Reactor Testing Station, Idaho*, USGS, IDO-22041-USGS, Idaho Falls, ID.

This report briefly describes work completed and in progress to determine the capacity of the Snake River Plain aquifer in the vicinity of the ICPP to receive and attenuate radioactive waste.

Subject: Geology and hydrology at the INEL
Keywords: HYDROLOGY / WASTE DISPOSAL / NRTS / ICPP
Location:

140. Kaminsky, J. F., 1991, *Experimental Test Plan for Laboratory analysis of Drilling Additives proposed to be used during Drilling Operations at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-WM-9733, Idaho Falls, ID.

The report presents a proposed test to determine if drilling additives have adverse effects on groundwater quality.

Subject: Wells at the INEL
Keywords: DRILLING ADDITIVES / LABORATORY / GROUNDWATER
Location: J.F. Kaminsky Files

141. Kaminsky, J. F., 1991, *In Situ Characterization of Unsaturated Hydraulic Properties of Surficial Sediments Adjacent to the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho*, Idaho State University, ISU-91-000, Pocatello, ID.

In situ estimates of hydraulic properties of surficial sediments adjacent to the RWMC were obtained from a field infiltration/ drainage test instrumented with tensiometers and two neutron probe access tubes which was flooded for 24 hours, then covered and allowed to drain.

Appendix C ♦ C-74

Subject: Hydraulic properties at the INEL
Keywords: HYDRAULIC PROPERTIES / SEDIMENT / RWMC
Location: Geoscience Files

142. Kaminsky, J. F., 1991, *In Situ Characterization of Unsaturated Hydraulic Properties of Surficial Sediments Adjacent to the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho*, Masters Thesis, Idaho State University, Pocatello, ID.
143. Key, W. S., 1963, *Drilling, Casing and Cementing Observation Wells at the National Reactor Testing Station, Idaho*, IDO-12022, Idaho Falls, ID.

This report summarizes the costs, drilling, casing, experience, and results of drilling 27 wells at the NRTS.

Subject: Wells at the INEL
Keywords: NRTS / DRILLING / COMPLETION OF WELL / GROUNDWATER
Location: WAG 10 Files

144. Knobel, L. L.; Bartholomay, R. C.; Cecil, L. D.; Tucker, B. J., and Wegner, S. J., 1992, *Chemical Constituents in the Dissolved and Suspended Fractions of Ground Water from Selected Sites, Idaho National Engineering Laboratory and vicinity, Idaho, 1989*, USGS, Open File Report 92-51, DOE/ID-22101.
145. Knobel, L. L., and Mann, L. J., 1988, *Radionuclides in Ground Water at the Idaho National Engineering Laboratory, Idaho*, USGS, Open-File Report 88-731, DOE/ID-22077.

During November 1987, 80 wells completed in the Snake River Plain aquifer and one in a perched water body were sampled and analyzed for radionuclides. Sampling procedures and analyses results are reported.

Subject: Radionuclide studies at the INEL
Keywords: GROUNDWATER / RADIONUCLIDES / ESRP AQUIFER /
PERCHED GROUNDWATER / SAMPLING
Location: C.W. Bishop Files

146. Knutson, C. F.; Harrison, W. E., and Smith, R. P., 1989, "Petrophysical Characterization of Vadose Zone Basalt, Idaho National Engineering Laboratory, Eastern Snake River Plain," *Proceedings of 3rd International Symposium on Borehole Geophysics, October 2-5, 1989*.

Vadose zone basalts have been characterized by measuring bulk densities, porosities, permeabilities. Variability between individual flows have been established.

Subject: Characterization of INEL basalts

Keywords: BASALT / BULK DENSITY / POROSITY / PERMEABILITY /
STREAMFLOW

Location: C.F. Knutson Files

147. Knutson, C. F.; McCormick, S. R. P.; Hackett, W. R.; O'Brien, J. P., and Crocker, J. C., 1989, *FY 89 Report RWMC Vadose Zone Basalt Characterization*, EG&G Idaho, Inc., EGG-WM-8949, Idaho Falls, ID.

This report summarizes the petrological information developed as an initial step in the characterization of basalt in the vadose zone beneath the RWMC. A petrologic study, including lithologic logging of the core and representative samples of basalt, was performed. Petrophysical studies were performed measuring porosity, permeability, grain density, equilibrium water saturation, and pore-size distribution of flow groups. Thin cylindrical slices were cut from petrophysical plugs, and petrographic studies analyzing texture and mineralogy were accomplished using a petrographic microscope.

Subject: Vadose zone properties

Keywords: BASALT / RWMC / VADOSE ZONE / HYDRAULIC PROPERTIES /
PROPERTIES / CORE

Location: R.P. Smith Files

148. Knutson, C. F.; McCormick, K. A.; Crocker, J. C.; Glenn, M. A.; Fishel, M. L., and Whitaker, C. A., 1992, *3D RWMC Vadose Zone Modeling*, EG&G Idaho, Inc., EGG-ERD-10246, Idaho Falls, ID.

Modeling and geostatistical studies reported provided a summary of the RWMC vadose zone basalt characterization, a view of a prototype 3D stochastic geological model of the subsurface, and suggestions for additional work.

Subject: Vadose zone properties

Keywords: RWMC / BASALT / STATISTICAL MODELING

Location: C.F. Knutson Files

149. Koeppen, L. D.; Casey, C.; McBride, D. W., and Gehrke, R. J., 1988, *Gamma-Ray Analysis of TRA Warm Waste Leaching Pond Soil and Water Samples for the Consent Order and Compliance Agreement (COCA) Sampling Program*, ST-CS-039-88.

this report contains the results from the gamma-ray analysis of soil and water samples from the TRA warm waste leaching ponds. Soil samples from boreholes at the leaching pond site were counted/analyzed using Ge gamma-ray spectrometry.

Subject: TRA warm waste ponds

Keywords: WASTE / TEST REACTOR AREA / GAMMA-RAY ANALYSIS / SOIL
CONTAMINATION / SEDIMENT

Appendix C ♦ C-76

Location: INEL Technical Library

150. Koslow, K. N., and Van Haaften, D. H., 1986, *Flood Routing Analysis for Failure of Mackay Dam*, EG&G Idaho, Inc., EGG-EP-7184, Idaho Falls, ID.

DAMBRK, the National Weather Service computer code, was used to provide information necessary to establish the appropriate level of protection for the INEL facilities from possible flooding of the Big Lost River due to failure of Mackay Dam. The results of this study provided the basis for assessing and developing a flood protection system for the INEL.

Subject: Flood Control at the INEL

Keywords: FLOODING / MACKAY DAM / BIG LOST RIVER

Location: Keck Files

151. Krivanek, K. R., 1988, *ICPP Environmental Monitoring report CY-1987*, WINCO, WINCO-1055, Idaho Falls, ID.

Summarized in this report are the data collected through environmental monitoring programs conducted at the ICPP.

Subject: Environmental monitoring at the INEL

Keywords: AIRBORNE WASTE / RELEASES / SEWAGE / INJECTION

Location: INEL Technical Library

152. Lamke, R. D., 1969, *Stage-Discharge Relations on Big Lost River within NRTS, Idaho*, USGS, Open-File Report, IDO-22050-USGS, Idaho Falls, ID.

Theoretical stage-discharge relations (ratings curves) were computed for 11 selected sites on the Big Lost River system within the NRTS and are given in this report. These ratings curves were computed by various techniques, which are dependent upon the hydraulic characteristics of each site. The rating curves apply only for the stated conditions and for the physical and hydraulic characteristics existing in April 1988.

Subject: Big Lost River Drainage basin data

Keywords: BIG LOST RIVER / WATER DIVERSION / PLAYAS

Location: INEL Technical Library

153. Laney, P. T.; Minkin, S. C.; Baca, R. G.; McElroy, D. L.; Hubbell, J. M.; Hull, L. C.; Russell, B. F.; Stormberg, G. J., and Pitman, J. T., 1988, *Annual Progress Report FY-1987 Subsurface Investigations Program at the Radioactive Waste Management Complex of the Idaho National Engineering Laboratory*, DOE/ID-10183, Idaho Falls, ID.

This document reports the progress made in FY 87 toward the goals of field calibrating a model to predict long-term radionuclide migration and measurement of the actual migration to date at the RWMC.

Subject: Subsurface investigation
 Keywords: SUBSURFACE RADIOACTIVITY / RADIONUCLIDES / CHEMICAL / RADIOACTIVE WASTE / GROUNDWATER / RWMC
 Location: J.T. Barraclough Files

154. Langford, J. E., 1971, *TRA Retention Basin Study*, Idaho Nuclear Corporation.

155. Lee, C. B., 1990, Interoffice Correspondence.

156. Leenheer, J. A., and Bagby, J. C., 1982, *Organic Solutes in Groundwater at the Idaho National Engineering Laboratory*, USGS, USGS Water Resources Investigation 82-15, IDO-22061-USGS, Idaho Falls, ID.

A summary of the results of a reconnaissance survey of organic solutes in drinking water sources, ground-water monitoring wells, perched water table monitoring wells, and in select waste streams at the INEL is presented. Dissolved organic carbon (DOC), insecticides and herbicides, volatile and semivolatile organic compounds were analyzed for in samples collected from numerous wells. Results are presented.

Subject: Organic compounds
 Keywords: ORGANIC COMPOUNDS / GROUNDWATER / SAMPLING / HYDROLOGY
 Location: Sondrup Files, INEL Technical Library

157. Lewis, B. D.; Eagleton, J. M., and Jensch, R. G., 1985, *Aqueous Radioactive and Industrial-Waste Disposal at the Idaho National Engineering Laboratory through 1982*, USGS, Open-File Report 84-636, DOE/ID-22069.

Aqueous waste disposal data, plus related and pertinent hydrologic and ground water quality data, have been assembled on magnetic computer tape and are now available for comparison and evaluation of various digital ground water solute transport models.

Subject: Waste management and disposal at the INEL
 Keywords: RADIOACTIVE WASTE / CHEMICAL / AQUEOUS WASTE / GROUNDWATER

Location: INEL Technical Library

158. Lewis, B. D., and Goldstein, F. J., 1982, *Evaluation of a Predictive Ground-Water Solute-Transport Model at the Idaho National Engineering Laboratory, Idaho*, USGS, Water Resources Investigations 82-25, IDO-22062-USGS.

Eight wells were drilled during the summer of 1980 near the southern boundary to fill existing gaps in the INEL hydrogeological data base, to delineate the leading edge of the waste plumes, and to monitor for first arrivals of aqueous wastes at the exiting boundary of the INEL. The data from the eight wells were used to evaluate the accuracy of the predictive model, and the assumptions used. Data interpretation from the drilling program indicates that the subsurface geology in the southwestern INEL vicinity is dominated by thin basalt flows interbedded with layers of sediment. The Arco volcanic rift zone was found to have a marked effect on the regional ground water flow regimen, and perhaps, on water quality.

Subject: Wells at the INEL

Keywords: HYDRAULIC PROPERTIES / CHARACTERIZATION / AQUEOUS WASTE / SOUTHERN BOUNDARY

Location: J.T. Barraclough Files

159. Lewis, B. D., and Jensen, R. G., 1983, *Hydrologic Conditions at the Idaho National Engineering Laboratory, Idaho: 1979-1981 Update*, USGS, Hydrologic Investigations Atlas, HA-674.

Contains maps with explanation. Reports constituents in Snake River Plain Aquifer and describes the continuing effects of the disposal of liquid radioactive and chemical wastes on the quality of the water in the Snake River Plain aquifer at the INEL with an emphasis on 1979-81.

Subject: Hydraulic properties at the INEL

Keywords: HYDRAULIC PROPERTIES / CHEMICAL / RADIONUCLIDES / LIQUID WASTE / QUALITY ASSURANCE

Location: J.T. Barraclough Files

160. Lewis, B. D., and Jensen, R. G., 1984, *Hydrologic Conditions at the Idaho National Engineering Laboratory, Idaho*, USGS, Open-File Report 84-230, DOE/ID 22066.

Studies from 1979 through 1981 have shown the perpetuation of a perched ground water zone in the basalt underlying the waste disposal ponds at the TRA and of the ICPP. The perched zone contains tritium, Cr-51, Co-60, Sr-90, and several nonradioactive chemicals. Tritiated waste water has formed the largest plume south of the ICPP, and accounts for 99 percent of the total radioactivity disposed of through the ICPP disposal well. Waste plumes with similar configurations and flow paths contain sodium, chloride, nitrate, and I-129.

Sr-90 and Cs-137 are also discharged through the well but they are sorbed from solution as they move through the aquifer.

Subject: Hydrologic investigation at the INEL
 Keywords: HYDROLOGY / PERCHED GROUNDWATER / RADIONUCLIDES /
 CONTAMINANT PLUMES
 Location: Sondrup Files

161. Lindholm, G. F., n.d., *The Basalt Aquifer System Underlying the Eastern Snake River Plain in Idaho and Hydrologic Changes Due to 100 Years of Irrigation*, USGS, Unpublished.

162. Lindholm, G. F., and Goodell, S. A., 1986, *Irrigated Acreage and Other Land Uses on the Snake River Plain, Idaho and Eastern Oregon*, USGS, Hydrologic Investigations Atlas, Atlas Ha-691.

163. Luni, K. M.; Burns, S. M.; Hardy, C. K.; Fugate, M., and Stanisich, S. N., 1990, *Closure Plan for the Power Burst Facility Corrosive Waste Sump and the Power Burst Facility Evaporation Pond (COCA Units PBF-08 and PBF-10)*, EG&G Idaho, Inc., EGG-WM-8996, Idaho Falls, ID.

164. MacLean, S. C.; Coles, D. G., and Weed, H. C., 1978, *Measurement of Sorption Ratios for Selected Radionuclides on Various Geologic Media*, UCID-17928.

This report documents distribution coefficient measurements made on a variety of rock types. Measurements for basalt from the Sentinel Gap formation are of interest in INEL activities. Values for Sr (45+-3 ml/g), Cs (290+-24 ml/g), and Pu (580+-2.1 ml/g) were calculated based on experiments conducted at several laboratories. The use of a simulated brine groundwater altered the Kd significantly. Distribution coefficients for Sr and Cs were dramatically reduced while Pu values were elevated.

Subject: Characterization of INEL basalts
 Keywords: RETARDATION FACTORS / RADIONUCLIDES / MOBILITY /
 DISTRIBUTION COEFFICIENT / STRONTIUM / CESIUM /
 PLUTONIUM
 Location: WAG-10 Data Repository

165. Mann, L. J., 1986, *Hydraulic Properties of Rock Units and Chemical Quality of Water for INEL-1-A 10,365-foot Deep Test Hole Drilled at the Idaho National Engineering Laboratory, Idaho*, USGS, Water Resources Investigation Report 86-4020, DOE/ID-22070,

A deep borehole has been drilled at the INEL. Aquifer testing shows that the hydraulic conductivity decrease with depth and is much lower for the rock underlying the Snake River Plain Aquifer. The base of the SRP Aquifer is estimated to be between 840 and 1,220 feet below land surface at the borehole.

Appendix C ♦ C-80

Subject: Hydraulic properties at the INEL
Keywords: ESRP AQUIFER / GROUNDWATER / HYDROLOGY / HYDRAULIC PROPERTIES
Location: WAG-10 Data Repository

166. Mann, L. J., 1989, *Tritium Concentrations in Flow from Selected Springs that Discharge to the Snake River, Twin Falls-Hagerman Area, Idaho*, USGS, Water Resources Investigation Report 89-4156, DOE/ID-22084.

Summary of spring sampling conducted in fall of 1988 and spring of 1989 in the Twin Falls-Hagerman Area of Idaho. Report indicates that INEL site activities have not impacted the groundwater in the Twin Falls-Hagerman area in regard to tritium.

Subject: Radionuclide studies at the INEL
Keywords: TRITIUM / SPRINGS / ESRP AQUIFER / GROUNDWATER / QUALITY ASSURANCE
Location: WAG-10 Data Repository

167. Mann, L. J., 1990, *Purgeable Organic compounds in Groundwater at the Idaho National Engineering Laboratory, Idaho 1988 and 1989*, USGS, Open-File Report 90-367, IDO-22089.

Ground water samples from 38 wells at the INEL were analyzed for 36 purgeable organic compounds. analyses of water from 22 wells indicated that the aquifer locally contained detectable concentrations of at least 1 of 19 purgeable organic compounds. Except for five wells, the maximum concentration of a specific compound in ground water was 6.4 micrograms per liter or less; the concentration of most compounds were less than 0.2 micrograms per liter. Water from a well that obtains water from a discontinuous perched groundwater zone at the RWMC contained significant concentrations of carbon tetrachloride, chloroform, 1,1,1-trichloroethane, and trichloroethylene.

Subject: Organic compounds
Keywords: GROUNDWATER / QUALITY ASSURANCE / WATER CHEMISTRY / GEOCHEMISTRY / ORGANIC COMPOUNDS
Location: WAG-10 Data Repository

168. Mann, L. J., and Cecil, L. D., 1990, *Tritium in Ground Water at the Idaho National Engineering Laboratory, Idaho*, USGS, Water Resources Investigation Report 90-4090, DOE/ID-22090.

From 1952 to 1988, approximately 30,900 curies of tritium were contained in waste water generated by the ICPP and TRA at the INEL. The waste water at the ICPP was discharged directly to the Snake River Plain Aquifer through a disposal well until Feb. 9, 1984, when routine use of the well was discontinued and unlined infiltration ponds were put to use.

Waste water disposal at the TRA has been discharged to some to three infiltration ponds since 1952. The average annual concentration of tritium in water from 26 selected well at the INEL decreased from 250 pCi/ml in 1961 to 18 pCi/Ml in 1988. Four factors are responsible for this decrease in tritium concentration: (1) a decrease in the amount of tritium disposed annually to ponds and wells from 1961 to 1988; (2) the change from the use of a disposal well to infiltration ponds at the ICPP; (3) radioactive decay; and (4) dilution from recharge.

Subject: Radionuclide studies at the INEL

Keywords: BIG LOST RIVER / DISCHARGE / LIQUID WASTE /
RADIONUCLIDES / VOLUME / HYDROGEN (H-3) / QUALITY
ASSURANCE / INJECTION / INFILTRATION / QUALITY
ASSURANCE

Location:

169. Mann, L. J.; Chew, E. W.; Morton, J. S., and Randolph, R. B., 1988, *Iodine-129 in the Snake River Plain Aquifer at the INEL, Idaho*, USGS, Water Resources Investigations Report 88-4165, DOE/ID-22076.

From 1953 to 1984 iodine-129 wastewater generated by the ICPP at the INEL was directly discharged to the Snake River Plain Aquifer through a deep disposal well. The well was discontinued and replaced by unlined infiltration ponds. The average concentration of iodine-129 in water from 18 wells that were sampled in 1977, 1981, and 1986 was 4.0, 6.7, and 1.3 pCi/L, respectively. The marked decrease in the iodine-129 concentrations from 1981 to 1986 was the result of three factors: (1) the amount of iodine-129 disposed annually, (2) a change from the routine use of the disposal well to the infiltration ponds; and (3) dilution of the iodine-129 in the aquifer by an increase in recharge from the Big Lost River at Lincoln Boulevard from 1980 to 1986. To determine what effect dilution had on the concentration of iodine-129, the amount of recharge to the aquifer was estimated using the number of days during which flow occurred and the infiltration rate of water from the channel.

Subject: Radionuclide studies at the INEL

Keywords: GROUNDWATER / IODINE / ICPP / INJECTION / INFILTRATION /
RECHARGE

Location:

170. Mann, L. J., and Knobcl, L. L., 1987, *Purgeable Organic Compounds in Ground Water at the Idaho National Engineering Laboratory*, USGS, Open File Report 87-766, DOE/ID-22074.

Summary of sampling activities during the summer and fall of 1987 for purgeable organic compounds at the INEL. Twelve compounds were detected in the groundwater. Very high

levels of organics were detected in a well previously used for contaminant injection and in a discontinuously perched aquifer zone.

Subject: Organic compounds
Keywords: CARBON TETRACHLORIDE / 1,1,1-TRICHLOROETHANE /
TRICHLOROETHYLENE / TETRACHLOROETHYLENE /
TOLUENE / ORGANIC COMPOUNDS / GROUNDWATER /
QUALITY ASSURANCE
Location: WAG-10 Repository

171. Mann, L. J., and Knobcl, L. L., 1988, *Concentrations of Nine Trace Metals in Ground Water at the Idaho National Engineering Laboratory*, USGS, Open File Report 88-332, DOE/ID-22075.

Groundwater samples from 81 wells in the Snake River Plain Aquifer were collected and analyzed for arsenic, barium, beryllium, cadmium, chromium, lead, mercury, selenium, and silver. Collection and sample preservation techniques are discussed.

Subject: ESRP aquifer
Keywords: ESRP AQUIFER / GROUNDWATER / GEOCHEMISTRY / QUALITY
ASSURANCE / METALS / ARSENIC / BARIUM / BERYLLIUM /
CADMIUM / CHROMIUM / LEAD / MERCURY / SELENIUM /
SILVER
Location: WAG-10 Repository

172. Mann, L. J., and Knobcl, L. L., 1990, *Radionuclides, Metals, and Organic Compounds in Water, Eastern Part of A & B Irrigation District, Minidoka County, Idaho*, USGS, Open File Report 90-191, DOE/ID-22087.

Summary of groundwater analyses for radionuclides, metals, and organic compounds for wells in the Snake River Plain Aquifer. Contains sample collection and analytic results for all contaminant types mentioned in the keyword section.

Subject: Background levels at the INEL
Keywords: TRITIUM / RADIONUCLIDES / URANIUM / RADIUM / RADON /
STRONTIUM / TRACE METALS / ORGANIC COMPOUNDS /
NUTRIENTS / PESTICIDES / GROUNDWATER / ESRP AQUIFER
Location: WAG-10 Repository

173. Markham, O. D., 1987, *Summaries of the Idaho National Engineering Laboratory Radioecology and Ecology Program Research Projects*, U.S. Department of Energy, DOE/ID-12111, Idaho Falls, ID.

This report summarizes vegetation and animal studies conducted at the INEL to determine the relationship between plant life on waste disposal and the relationship between waste disposal and the animal population at the INEL.

Subject: Ecological and soil resources of the INEL
 Keywords: VEGETATION / PLANT ROOTS / PLANT ROOTS / MAMMALS /
 RAPTORS / BIBLIOGRAPHY
 Location: WAG-10 Repository

174. Martin, K. L.; Barnard, C. J.; Freeman, A. L.; Groh, M. R.; Kissel, K. T.; Lord, S. J.; Olsen, G. L.; Randolph, P. D., and Wilhelmson, R. N., 1992, *Preliminary Assessment of Surface Soils at Active EG&G Idaho Facilities*, EG&G Idaho, Inc., EGG-ESQ-9225, Rev. 1, Idaho Falls, ID.

This report provides a comprehensive reference document on the properties, metals, and radioactive content of surface soils at active nonwaste management EG&G facilities. Results of sample analysis indicated that most soils for systematic sample locations did not have concentrations of metals or radionuclides above the concentrations in background samples. However, systematic sample areas at TAN were contaminated with radionuclides at concentrations well above background. Evaluation of metal concentrations in soils indicate that the soil type will have an impact on the concentration of metals detected. No Correlation between soil type and radionuclide concentration was noted. The specific sites studied include the CFA, PBF, TAN, TRA, and Radioactive Mixed Waste Storage Facility (SPERT-IV).

Subject: Radionuclide studies at the INEL
 Keywords: SOIL CONTAMINATION / PH / CATION EXCHANGE CAPACITY /
 METALS / RADIONUCLIDES / BACKGROUND / CFA / PBF / TEST
 AREA NORTH / TEST REACTOR AREA / MIXED WASTE
 Location:

175. Marts, S. T.; Wood, T. R., and Bishop, C. W., 1991, *Evaluation of Devices for Sampling Volatile Organic Compounds from Deep Groundwater Wells at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-WM-9787, Idaho Falls, ID.

A series of tests were conducted using gas piston, centrifugal, bailer, and bladder pumps to determine the pumping method that provides the most representative results for VOCs.

Subject: Pump tests at the INEL

Appendix C ♦ C-84

Keywords: ORGANIC COMPOUNDS / GAS PISTON PUMP / CENTRIFUGAL PUMP / BAILER / BLADDER PUMP

Location: WAG-10 Repository

176. Marusich, M. E., 1981, *Conceptual Design Report—Subsurface Disposal Area Drainage Improvements*, EG&G Idaho, Inc., Internal Technical Report, WM-F1-81-005, Idaho Falls, ID.

This report outlines the design of drainage system to prevent flooding of the RWMC during high precipitation events.

Subject: Flood control at the INEL

Keywords: RWMC / DRAINAGE BASIN / PRECIPITATION / SDA

Location: WAG-10 Repository

177. Mattick, J. L., and Doornbos, M. H., 1990, *Evaluation of Wells Installed from 1949 to 1986 at the Test Reactor Area of the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., Informal Report EGG-WM-9100, Idaho Falls, ID.

This study was conducted to assist in the determination of whether the existing wells at TRA are suitable for use during the Warm Waste Pond Remediation Investigation. The report includes a brief description of the hydrogeology of the operable unit, an evaluation of the existing wells based on construction details and well locations, and proposed recommendations.

Subject: TRA data

Keywords: TEST REACTOR AREA / WELL CONSTRUCTION /
HYDROGEOLOGY / WELL LOCATION / GEOLOGY /
GROUNDWATER

Location: WAG-10 Repository

178. McBride, R.; French, N. R.; Dahl, A. H., and Detmer, J. E., 1978, *Vegetation Types and Surface Soils of the Idaho National Engineering Laboratory Site*, Radiological and Environmental Sciences Lab., EG&G Idaho, Inc., IDO-12084, Idaho Falls, ID.

Provides vegetation type map and description of the different vegetation types located at the INEL site. A preliminary soil type map is also included based on the vegetation type map.

Subject: Ecological and soil resources of the INEL

Keywords: SOIL TYPES / VEGETATION / MAPS

Location: WAG-10 Repository

179. McCaslin, J. W., and Savignac, B. F., 1969, *Operations of the Naval Reactor Testing Site Burial Ground*, Idaho Nuclear Corporation Report, Idaho Falls, ID.

The handling of "routine" and "no-routine" waste to be sent to the burial ground are described. The primary means of containment is cardboard boxes. No liquid waste is allowed in this type of disposal.

Subject: Waste management and disposal at the INEL
Keywords: WASTE DISPOSAL / ROUTINE WASTE / NON-ROUTINE WASTE /
PITS / TRENCHES
Location: WAG-10 Repository

180. McElroy, D. L., 1990, *Vadose Zone Monitoring at the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory 1985-1989*, EG&G Idaho, Inc., Informal Report EGG-WM-9299, Idaho Falls, ID.

Summary of data from instrumentation of the RWMC surficial sediments and interbeds from psychrometers, heat-dissipation sensors, gypsum blocks, tensiometers, and neutron logs is presented. Snowmelt is major source of infiltration water. Lithologic contacts may partially control moisture distribution in the surficial sediments and sedimentary interbeds. Some downward movement of moisture in the interbeds is indicated.

Subject: Vadose zone properties
Keywords: RWMC / VADOSE ZONE / SOIL MOISTURE / PSYCHROMETERS /
GYPSUM BLOCKS / TENSIMETERS / NEUTRON PROBES /
MATRIX POTENTIAL / INFILTRATION / SEDIMENTARY
INTERBED
Location: WAG-10 Repository

181. McElroy, D. L., and Hubbell, J. M., 1989, "Vadose Zone Monitoring at the Radioactive Waste Management Complex, Idaho National Engineering Laboratory," *Focus '89, Nuclear Waste Isolation in the Unsaturated Zone Conference Proceedings*, Las Vegas, NV.

A network of vadose zone instruments was installed in sediments at the RWMC at the INEL to measure capillary pressure and monitor water movement in an effort to develop an understanding of the hydrogeologic and contaminant transport process at the RWMC. Instruments were installed at depths up to 70 m below land surface in sediments which overlie and are intercalated with basalt flows. An array of instruments, which included psychrometers, gypsum blocks, heat-dissipation sensors, and tensiometers, porous-cup lysimeters, and neutron access tubes, were installed. This paper presents preliminary results pertaining to water movement in the surficial sediments and interbeds at the RWMC, as inferred by collected data. Capillary pressures range and trends in the surficial sediments and interbeds are discussed. Hydraulic gradients are presented for selected boreholes.

Subject: Vadose zone properties
Keywords: STRATIGRAPHY / SURFICIAL SEDIMENTS / CAPILLARY PRESSURE / HYDRAULIC PROPERTIES / SEDIMENTARY INTERBED / PSYCHROMETERS / GYPSUM BLOCKS / HEAT-DISSIPATION SENSORS / TENSIMETERS / LYSIMETERS / NEUTRON ACCESS TUBES / VADOSE ZONE
Location: WAG-10 Repository

182. McElroy, D. L., and Hubbell, J. M., 1990, *Hydrologic and Physical Properties of Sediments at the Radioactive Waste Management Complex*, EG&G Idaho, Inc., EGG-BG-9147, Idaho Falls, ID.

Sediment samples from RWMC were analyzed for hydrologic and physical properties pertinent to contaminant migration at the RWMC. These sediments overlie and are intercalated with fractured basalts at the RWMC. Grain size distributions and particle density are representative of in situ combinations for all of the samples. The long storage time of the samples prior to analysis yielded in situ moisture contents which may be less than the in situ field values. Some of the saturated hydraulic conductivities from these recent analyses were compared to previous hydraulic conductivity determined for the same samples. The results prior to storage and after two years of storage agreed within two orders of magnitude. Due to the long shelf life and sample compaction, some of the dry bulk density, moisture characteristics, saturated and unsaturated hydraulic conductivity and air permeability results have limited value and caution should be used in applying the data.

Subject: Hydrologic investigation at the INEL
Keywords: SEDIMENT / BULK DENSITY / POROSITY / PARTICLE SPECIFIC GRAVITY / SOIL MOISTURE / UNSATURATED HYDRAULIC PROPERTIES / AIR PERMEABILITY
Location: WAG-10 Repository

183. McElroy, D. L.; Porro, I.; Bishop, C. W.; Keck, K. N., and Kaminsky, J. F., 1992, *RWMC SDA Engineered-Barrier Test Plan*, EG&G Idaho, Inc., Draft Report EGG-WMO-10284, Idaho Falls, ID.

Provides experimental design for hydrologic performance testing of two engineered-barrier designs. Focus was on developing water budgets for the two designs.

Subject: Engineered barriers at the RWMC
Keywords: ENGINEERED BARRIER / WATER BUDGET / EVAPORATION / PRECIPITATION / RUN-OFF / WATER STORAGE / VEGETATION / MONITORING
Location: WAG-10 Repository

184. McElroy, D. L.; Rawson, S. A.; Hubbell, J. M.; Minkin, S. C.; Baca, R. G.; Vigil, M. J.; Bonzon, C. J.; Landon, J. L., and Laney, P. T., 1989, *Annual Progress Report: FY-1988, Site Characterization Program at the Radioactive Waste Management Complex of the Idaho National Engineering Laboratory*, U.S. Department of Energy & EG&G Idaho, Inc., DOE/ID-10233(88), Idaho Falls, ID.

A variety of studies were conducted in an effort to further characterize the vadose zone at the INEL. Stratigraphy, hydraulic properties of sediments and the 240 foot interbed sediments at the SDA did not confirm the presence of radionuclide. Analyses of subsurface air and groundwater samples identified five volatile organic compounds of concern: carbon tetrachloride, trichloroethylene, 1,1,1-trichloroethane, chloroform, and tetrachloroethylene. Data from vadose zone instrumentation suggests that occurrence of downward movement of soil water for large portions of the year. Preliminary solute transport modeling under unsaturated flow conditions is in general agreement with observed radionuclide migration and subsurface water contents. These modeling results suggest that fractures may play an important role in unsaturated flow and solute transport.

Subject: Environmental characterization at the INEL
Keywords: LITHOLOGY / STRATIGRAPHY / VADOSE ZONE / LOGS /
HYDRAULIC PROPERTIES / TEMPERATURE / SURFICIAL
SEDIMENTS / RADIONUCLIDES / GROUNDWATER QUALITY /
GROUNDWATER / MODELING
Location: WAG-10 Repository

185. McKinley, K. B., and McKinney, J. D., 1978, *Early Waste Retrieval Interim Report*, EG&G Idaho, Inc., TREE-1265, Idaho Falls, ID.

This report discusses the results of the Early Waste Retrieval Interim Program for Fiscal Year 1977. Estimate of contaminant failures are given for drums and discussion of waste types found in pits and trenches is provided.

Subject: Waste management and disposal at the INEL
Keywords: RWMC / WASTE RETRIEVAL / WASTE DRUMS / SOIL
contaminantION / TRANSURANIC WASTE
Location: WAG-10 Repository

186. McKinley, K. B., and McKinney, J. D., 1978, *Initial Drum Retrieval Final Report*, EG&G Idaho, Inc., TREE-1286, Idaho Falls, ID.

Report summarizes the activities of the Initial Drum Retrieval Program. Operations and results are discussed along with costs of the program.

Subject: Waste management and disposal at the INEL

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Keywords: BURIED WASTE / WASTE DRUMS / RADIONUCLIDES / WASTE DRUMS

Location: WAG-10 Repository

187. McKinney, J. D., 1985, *Big Lost River 1983-1984 Flood Threat*, EG&G Idaho, Inc., PPD-FPB-002, Idaho Falls, ID.

This report documents the flooding events that occurred at the INEL Big Lost River diversion system. The report is historical in nature and looks at the Big Lost River flow records, INEL diversion system, 1983 Mount Borah Earthquake, record low temperatures in December 1983, and the resulting ice jam on the diversion system which forced the river to pond next to and nearly overtop Dike 1.

Subject: Flood Control at the INEL

Keywords: RWMC / BIG LOST RIVER / WATER DIVERSION / FLOODING / ICE JAM / STREAMFLOW / DIKE / EARTHQUAKE / CLIMATE

Location: WAG-10 Repository

188. Morris, D.; Nace, R. L., and Voegeli, P. T., 1952, *Geology, Ground Water, and Waste-Disposal at the Aircraft Nuclear Propulsion Project Site, National Reactor Testing Station, Idaho*, USGS Water Resources Division Ground Water Branch, IDO-22023-USGS.

189. Morris, D. A.; Barraclough, J. T.; Chase, G. H.; Teasdale, W. E., and Jensen, R. G., 1965, *Hydrology of Waste Disposal National Reactor Testing Station Idaho Annual Progress Report 1964*, USGS, IDO-22047-USGS, Idaho Falls, ID.

Summary of research on the hydrology of waste disposal at the NRTS. Describes on-going efforts to provide detailed and accurate information on the occurrence, movement, quality, and geologic environment of water beneath the land surface. The report discusses the use of aeroradioactivity survey in conjunction with characterizing the geologic structure of the NRTS, geochemical study of the groundwater, gas-injection tests, study of the TRA waste disposal pond area, the effect of the Alaskan earthquake on groundwater levels, study of regional hydrology, air flow in basalt, relationship of disposal pond levels to region and perched water levels, and the site wide drilling, geophysical and water level measurement program.

Subject: Environmental characterization at the INEL

Keywords: INFILTRATION / WELL HYDROGRAPH / STREAMFLOW / LITHOLOGY / LOGS / WELL PUMPAGE / BASALT / MINERALOGY / SURFICIAL SEDIMENTS / SOIL MOISTURE / SPECIFIC GRAVITY / BULK DENSITY / SPECIFIC RETENTION / POROSITY / SPECIFIC YIELD / HYDRAULIC PROPERTIES / SEDIMENT / QUALITY ASSURANCE / SPECIFIC CONDUCTANCE /

RADIOACTIVITY / RADIONUCLIDES / METALS / PERCHED
GROUNDWATER / TEST REACTOR AREA

Location: WAG-10 Repository

190. Morris, D. A.; Hogenson, G. M.; Teasdale, W. E., and Shuter, E., 1963, *Hydrology of Waste Disposal National Reactor Testing Station Idaho Annual Progress Report 1962*, USGS, IDO-22044-USGS, Idaho Falls, ID.

The purpose of the study of the hydrology of subsurface waste disposal at the NRTS is to determine the concentration of any increment of aqueous waste disposed to the environment and to define it qualitatively in time and place. This requires a knowledge of the travel path and velocity of the hot water, an estimate of the volume of water moving through the environment, the amount of transverse and longitudinal dispersion of radionuclides in groundwater, and specific information on the chemical and physical effects of the geologic and hydrologic environment upon the adsorption and ion-exchange characteristics of the dissolved isotopes. The current report sketches in brief form the progress made by hydrologic investigations during the year 1962.

Subject: Hydrologic investigation at the INEL

Keywords: WELL HYDROGRAPH / INFILTRATION / BAROMETRIC
EFFICIENCY / SURFICIAL SEDIMENTS / STRATIGRAPHY /
LITHOLOGY / LOGS / SEDIMENT / SPECIFIC GRAVITY / BULK
DENSITY / SOIL MOISTURE / SPECIFIC RETENTION / POROSITY /
SPECIFIC YIELD / HYDRAULIC PROPERTIES / QUALITY
ASSURANCE / RADIOACTIVITY / HYDROGEN (H-3) / SPECIFIC
CONDUCTANCE / RADIONUCLIDES / PERCHED
GROUNDWATER / GROUNDWATER / TEST REACTOR AREA /
ICPP / BASALT

Location:

191. Morris, D. A.; Teasdale, W. E.; Chase, G. H.; Barraclough, J. T.; Ralston, D. A.; Jensen, R. G., and Shuter, E., 1964, *Hydrology of Subsurface Waste Disposal National Reactor Testing Station Annual Progress Report*, USGS, Idaho Falls, ID.

The emphasis of this report is directed towards the investigation of regional geohydrology of the INEL. A preliminary study of physical and chemical quality of ground water throughout the INEL is provided. This report indicates additional progress in interpretation of the geology of the area on the basis of preliminary gravity and magnetic surveys and sketches the progress made in the operational phases of the study of the hydrology of waste disposal. Results from microscopic studies of the geohydrology of waste disposal at NRF and ICPP are presented along with data from the site wide drilling program.

Subject: Geology and hydrology at the INEL

Keywords: QUALITY ASSURANCE / WATER CHEMISTRY / METALS /
RADIONUCLIDES / SPECIFIC CONDUCTANCE / RADIOACTIVITY
/ BASALT / ICPP / NRF / SEDIMENT / STRATIGRAPHY / LOGS /
SOIL MOISTURE / LOFT / SEDIMENT / SPECIFIC GRAVITY /
BULK DENSITY / SOIL MOISTURE / SPECIFIC RETENTION /
POROSITY / SPECIFIC YIELD / HYDRAULIC PROPERTIES /
PERCHED GROUNDWATER / TEST REACTOR AREA

Location:

192. Mudra, P. J., and Schmalz, B. L., 1965, *An Appraisal of Gaseous Waste Disposal into the Lithosphere at the National Reactor Testing Station, Idaho*, IDO-12024, Idaho Falls, ID.

Reports results of gaseous waste injection into the lithosphere to determine storage capacity of the lithosphere, direction and velocity of migration of the injected gas, dilution and dispersion effects on the initial concentration of the gas, and pressures required for injection. Injection was done at a maximum of 400 feet below surface with He. Injection was viewed as feasible for volumes up to 6 million cubic feet.

Subject: Gaseous injection of waste
Keywords: GASEOUS WASTE / INJECTION / HELIUM
Location: WAG-10 Repository

193. Nace, R. L., 1949, *Memorandum Report on Pumping Test of Arco Reactor Testing Station Production Test Well No. 1, with Recommendations for Well-Finishing*, USGS, IDO-22005-USGS.

Data are presented from pump testing at well number 1 at the INEL.

Subject: Pump tests at the INEL
Keywords: HYDROLOGY / PUMPING TEST / DISCHARGE / DRAWDOWN /
WATER TABLES
Location: WAG-10 Repository

194. Nace, R. L., 1952, *Water Supply and Waste Disposal at Proposed ANPR Site, National Reactor Testing Station, Idaho*, USGS, IDO-22021-USGS.

Summary of groundwater availability and waste disposal options at the ANPR Site. The analysis rules out surface ponds for waste disposal.

Subject: Waste management and disposal at the INEL
Keywords: GROUNDWATER / WASTE DISPOSAL / LOGS / DISPOSAL POND
Location:

195. Nacc, R. L., 1953, *Altitude and Configuration of the Water Table Beneath the National Reactor Testing Station, Idaho*, USGS, IDO-22024-USGS.

Initial report on the water table levels of the Snake River Plain Aquifer at the INEL.

Subject: Groundwater monitoring at the INEL
 Keywords: GROUNDWATER / HYDROLOGY / WATER TABLES / ESRP
 AQUIFER
 Location: WAG-10 Repository

196. Nacc, R. L., 1955, *Water Supply and Waste Disposal for Proposed Engineering Test Reactor, Large Ship Reactor, and Organic-Moderator Reactor Experiment, National Reactor Testing Station, Idaho*, USGS, IDO-22031-USGS.

Discusses water supply and waste disposal requirements at the reactor sites. Recommendations for water supply and waste disposal are presented. Water quality from existing well are reportedly held by the U.S. Atomic Energy Commission.

Subject: Waste management and disposal at the INEL
 Keywords: WATER SUPPLY / GROUNDWATER / WASTE DISPOSAL /
 QUALITY ASSURANCE
 Location:

197. Nacc, R. L., 1959, *Geography, Geology, and Water Resources of the National Reactor Testing Station, Idaho; Part 1, Purpose, History, and Scope of Investigations*, USGS, IDO-22033-USGS.

Provides information on the types of facilities at the site to day (1959) with basics of activities being conducted at each facility. Contains surface and groundwater information on hydrology of basalt, geochemical parameters, well construction and geophysical surveys.

Subject: Geology and hydrology at the INEL
 Keywords: GROUNDWATER / SURFACE WATER / HYDROLOGY /
 GEOLOGY / GEOCHEMISTRY
 Location: WAG-10 Repository

198. Nacc, R. L., 1964, *Geography, Geology, and Water Resources of the National Reactor Testing Station, Idaho; Part 4, Geologic and Hydrologic Aspects of Waste Management*, USGS, IDO-22035-USGS,

Focuses on the relationship of radioactive waste management with the geology and hydrology of the INEL site. Summarizes data pertinent to furthering the understanding of radioactive waste and the interactions with its environment.

Subject: Waste management and disposal at the INEL

Keywords: HYDROLOGY / GEOLOGY / RADIONUCLIDES

Location: WAG-10 Repository

199. Nace, R. L., and Barraclough, J. T., 1952, *Groundwater Recharge from the Big Lost River Below Arco, Idaho*, USGS, IDO-22016-USGS.

The Big Lost River rises from tributaries on the northeast slopes of the Pioneer and Boulder mountains. The river channel ends in the northern part of the NRTS, where the river is intermittent. Unseasonable high runoff in the Big Lost River during the latter half of 1951 permitted useful information to be collected about groundwater increments and seepage losses from the river. Relevant data concern the volume and rate of flow of the river, seepage losses (infiltration rates) in various segments and reaches, channel form and capacity, and fluctuations of the water table (from recharge).

Subject: Groundwater properties at the INEL

Keywords: PRECIPITATION / BIG LOST RIVER / DISCHARGE /
INFILTRATION / AQUIFER RECHARGE / STREAMFLOW

Location:

200. Nace, R. L.; Deutsch, M., and Vogtcli, P. T., 1956, *Geography, Geology, and Water Resources of the National Reactor Testing Station, Idaho, Part 2*, USGS, IDO-22033-USGS.

Geologic factors in the physical environment of the NRTS control the amount and availability of the water supply, the methods and efficiency of obtaining water, and the behavior of waste materials that are disposed on the ground or beneath the land surface. These factors also effect construction and operation. For those reasons, areal and subsurface geologic study and mapping were a major part of investigations on the NRTS.

Subject: Geology and hydrology at the INEL

Keywords: GEOLOGY / HYDROLOGY / GROUNDWATER / QUALITY
ASSURANCE / WATER SUPPLY / SOIL MOISTURE / LITHOLOGY /
LOGS / BASALT / MINERALOGY / ALLUVIAL SEDIMENT /
SEDIMENT / CLAY / BEARING CAPACITY / COMPACTION /
ATTERBERG LIMITS

Location:

201. Nace, R. L.; Jones, J. H.; Vogtcli, P. T., and Deutsch, M., 1951, *Geology and Ground Water in the Central Construction Area, Reactor Testing Station, Idaho*, USGS, IDO-22044-USGS.

Summary of the principal results of a detailed study of the groundwater and geology of the CFA on the INEL. The investigations emphasize evaluation, development, conservation, and protection of ground water resources. The geologic information gathered is useful in engineering planning and design, well construction, liquid waste disposal, drainage, road

construction, and excavation. Emphasis is on the rocks, soils, and sediments present at the land surface, their types, surficial distribution, and probable subsurface extension.

Subject: Geology and hydrology at the INEL
 Keywords: SEDIMENT / NEAR SURFACE STRATIGRAPHY / SUBSURFACE
 BASALT CONTOUR / FENCE DIAGRAM / DISCHARGE / QUALITY
 ASSURANCE / WATER CHEMISTRY / LOGS
 Location:

202. Nace, R. L., and Jones, J. R., 1950, *Reconnaissance of the Geology in the Atomic Reactor-testing Station, Idaho*, IDO-22012-USGS.

Outlines general geologic features of the Snake River Plain in the vicinity of the INEL. Report includes principal rock types and surficial sediments.

Subject: Geology and hydrology at the INEL
 Keywords: GEOLOGY / SEDIMENT
 Location: WAG-10 Data Repository

203. Nace, R. L.; Stewart, J. W., and Walton, W. C., et. al, 1959, *Geography, Geology, and Water Resources of the National Reactor Testing Station, Idaho, Part 3*, USGS, Hydrology and Water Resources, Open File Report, IDO-22034-USGS.

The report describes the hydrology and evaluates the water resources of the INEL, sets these in their regional perspective, and forecasts conditions and effects during future years. Surface and groundwater studies are summarized as well as structural and hydrologic properties of the basalts comprising the Snake River Plain Aquifer.

Subject: Geology and hydrology at the INEL
 Keywords: BASALT / HYDROLOGY / GROUNDWATER / SURFACE WATER /
 GEOCHEMISTRY
 Location: WAG-10 Data Repository

204. Nace, R. L.; Vogeli, P. T.; Jones, J. R., and Deutsch, M., 1975, *Generalized Geologic Framework of the National Reactor Testing Station, Idaho*, USGS, USGS Professional Paper 725-B.

Provides a general overview of the site geology covering geologic events, rock structures, materials distribution including: volcanic rock with compositions, and sediments. Also discusses some test drilling, electrical-resistivity and seismic surveying, ion exchange and desiccation cracking of surficial sediments. Relates geology to construction concerns (e.g., earthquake, volcanism, excavation).

Subject: Geology and hydrology at the INEL

Appendix C ♦ C-94

Keywords: GEOLOGY / SEISMOLOGY / GEOCHEMISTRY / BASALT /
SEDIMENT / CONSTRUCTION

Location: WAG-10 Data Repository

205. Nace, R. L., and Vocgili, P. T., 1951, *Geology and Ground Water at the Site 1 and an Adjacent Areas to the East, Reactor Testing Station*, USGS, IDO-22003-USGS.

Summary of the principal results of a study of the ground water and geology of Site 1 (EBR) and an adjoining areas of four and one-half sections to the east utilization of ground water, location and arrangement of reactor plants and facilities, and management of liquid waste disposal. The report describes the types of rocks, soils, and sediments present at the land surface, their surficial distribution, and their probable subsurface extensions.

Subject: Groundwater properties at the INEL

Keywords: SEDIMENT / DISCHARGE / LOGS / LIQUID WASTE / FACILITIES
DESCRIPTION

Location:

206. National Oceanic and Atmospheric Administration (NOAA), 1991, *Meteorological Information for FWMC Flood Potential Studies*, August 14, 1991.

207. Niccum, M. R., 1973, *Flooding Potential at the Idaho Chemical Processing Plant*, Internal Report, Construction Engineering Division.

208. Nichols, W. D., 1987, *Geohydrology of the Unsaturated Zone at the Burial Site for Low-Level Radioactive Waste Near Beatty, Nye County, Nevada*, USGS, USGS-87-2312.

Low-level radioactive solid waste has been buried in trenches at a site near Beatty, Nevada. The geohydrology of the waste burial site has been studied to unsaturated zone beneath the waste burial trenches. The site is underlain by poorly stratified deposits of gravelly or silty sand and sandy gravel and thick beds of clay sediments. Evaporation studies over a two year period were used to calibrate a numerical procedure for analyzing long-term precipitation data and estimating annual water budgets. This analysis demonstrated that a potential exists for deep percolation (greater than two meters) and provided predictions of the time of year and the antecedent conditions that enhance the probability of deep percolation. Soil moisture profiles demonstrate that deep percolation does occur.

Subject: Subsurface investigation

Keywords: HYDROLOGY / SURFICIAL SEDIMENTS / INFILTRATION /
EVAPORATION / SOIL MOISTURE / HYDRAULIC PROPERTIES

Location:

209. Northing Engineering and Testing, Inc., 1988, *Final Report Geohydrologic Investigation of Industrial Waste Pond at Argonne National Laboratory-West, Idaho Falls, Idaho*, Northern Engineering and Testing, Inc., NE497.HG, Idaho Falls, ID.

This report summarizes ground water investigations and associated water quality analyses. The primary objectives of this investigation were to characterize the geology and hydrogeology of the area adjacent to the industrial wastewater pond and document the water quality of the uppermost aquifer. The targeted sedimentary interbed occurring at an approximate depth of 40 to 50 feet below the ground surface is not aerially extensive and is noticeably absent west of the industrial waste quality. Several factors combine to account for the absence of a perched water body (1) relatively low discharge volume of waste water, (2) grain size of interbed does not limit vertical flow significantly, and (3) interbeds are not really extensive or thick.

Subject: Perched water and contaminants at the INEL

Keywords: BOREHOLE / LOGS / LITHOLOGY / QUALITY ASSURANCE /
SEDIMENTARY INTERBED

Location:

210. Norton, T. J., 1990, *Development of Perched Water Zones Associated with the Idaho Chemical Processing Plants Unlined Aqueous Waste Infiltration Ponds*, Washington State University, Pullman, WA.

Discharge of chemical radioactive waste from the ICPP has led to the development of several perched water zones. Using geophysical neutron logs taken in three consecutive years for two wells in close proximity to the infiltration ponds, development of perched water zones at 30 to 100, 150 and 330 feet below the ground surface can be delineated. Three dimensional numerical simulations have been conducted using available data.

Subject: Perched water and contaminants at the INEL

Keywords: BOREHOLE / LOGS / HYDRAULIC PROPERTIES / LITHOLOGY /
LOGS

Location:

211. Olmsted, F. H., 1962, *Chemical and Physical Character of Ground Water in the National Reactor Testing Station, Idaho*, USGS, IDO-22043-USGS.

This report describes the chemical and physical properties of the ground water beneath the NRTS. The chemical properties described are chiefly the concentration and proportions of the dissolved constituents. The physical properties include temperature, specific conductance, density, and viscosity.

Subject: Groundwater properties at the INEL

Keywords: AQUIFER RECHARGE / BASALT / MINERALOGY / QUALITY ASSURANCE / TEMPERATURE / SPECIFIC CONDUCTANCE / TEMPERATURE

Location:

212. Orr, B. L.; Cecil, L. D., and Knobel, L. L., 1991, *Background Concentrations of Selected Radionuclides, Organic Compounds, and Chemical constituents in Ground Water in the Vicinity of the Idaho National Engineering Laboratory*, USGS, Water Resources Investigation Report 91-4015, DOE/ID-22094.

This report addresses background concentrations of radionuclides, organic compounds, and chemical constituents in the Snake River Plain Aquifer. Concentrations of metals, radionuclides, and organic compounds in ground water have been increased by site activities.

Subject: Background levels at the INEL

Keywords: GROUNDWATER / RADIONUCLIDES / METALS / ORGANIC COMPOUNDS / HYDROLOGY / GEOCHEMISTRY

Location: WAG-10 Data Repository

213. Orr, B. R., and Cecil, L. D., 1991, *Hydrologic Conditions and Distribution of Selected Chemical Constituents in Water, Snake River Plain Aquifer, Idaho National Engineering Laboratory, Idaho 1986 to 1988*, USGS, Water Resources Investigations Report 91-4047, IDO-22096.

This report presents an analysis of water level and water quality data collected from the Snake River Plain Aquifer during 1986-1988 as part of the continuing hydrogeologic investigation at the INEL. Detectable concentrations of radionuclide and chemical waste constituents in water from the Snake River Plain Aquifer at INEL decreased during 1986-1988. Decreased radionuclide concentrations are attributed to reduced rates of radionuclide waste disposal, sorption processes, radioactive decay, dilution from recharge, and changes in waste disposal practices.

Subject: Groundwater properties at the INEL

Keywords: ESRP AQUIFER / QUALITY ASSURANCE / BIG LOST RIVER / WATER TABLES / LIQUID WASTE / SOLID WASTE / TRITIUM / STRONTIUM / COBALT / CESIUM / PLUTONIUM / PLUTONIUM / AMERICIUM / CHROMIUM / SODIUM / CHLORIDE / NITRATE / LEAD / MERCURY / SPECIFIC CONDUCTANCE

Location: WAG-10 Data Repository

214. Osloond, J. H., 1970, *Waste Disposal Data for the National Reactor Testing Station Idaho*, Atomic Energy Commission, Idaho Operations Office, IDO-12074, Idaho Falls, ID.

A total liquid waste volume of 2.82E9 liters and a gross activity quantity of 4,180 curies were discharged to the NRTS lithosphere during 1969. About 72% was composed of radionuclides having a half-life of less than 30 days and tritium comprised 21%. The total radioactivity released to the atmosphere during 1969 was 76,400 curies. The total radioactivity released to the atmosphere during 1969 was 76,400 curies. Ninety-eight percent in the form of noble gases. The noble gas radionuclides identified were Ar-41, Kr-88-89, and Xe-137-138 which have half-lives of two hours or less. During 1969 a total of 972,000 curies in 410,000 cf of solid waste was deposited in the NRTS burial ground. Approx. 242,000 cf contaminated with 36,000 curies originated at the Rocky Flats establishment. This waste was contaminated with plutonium isotopes and Am-241. The specific activity was about 0.2 curies per cf. The primary contaminant in the on-site generated waste was Co-60. The specific activity of the on-site waste was approximately 5.6 curies per cf.

Subject: Waste management and disposal at the INEL
Keywords: LIQUID WASTE / RADIONUCLIDES / VOLUME / SETTLEABLE SOLIDS / BOD / CHLORINATION RESIDUAL / MEAN DISCHARGE / AIRBORNE WASTE / SOLID WASTE / CONTAINER TYPE / RWMC / EBR-II STORAGE AREA

Location:

215. Paige, B. E.; Siedenstrang, F. A., and Niccum, M. R., 1972, *Evaluation of Hazards and Corrosion of Buried Waste Lines in NRTS Soils*, Allied Chemical Corporation, Idaho Chemical Programs, Operations Office, ICP-1013.

The purpose of this study was to locate and categorize buried wastelines and to establish corrosion control and monitoring program for potentially hazardous underground piping systems. Primary attention was given to the study of lines transferring radioactive waste. Evaluation of the degree of hazard from waste lines was based on composition and activity of the waste handled. The potential for contaminantion of the environment was based on the construction of lines, frequency of use, and existing methods of monitoring the lines. Because external corrosion can be significant on buried lines, the NRTS soils were reviewed for soil profile, hydraulic conductivity, and moisture content.

Subject: Buried pipelines at the INEL
Keywords: SURFICIAL SEDIMENTS / RESISTIVITY / SOIL MOISTURE / PH / CARBONATE / BICARBONATE / CHLORIDE / SULFATE / HARDNESS / STRATIGRAPHY / SEDIMENT / HYDRAULIC PROPERTIES / INFILTRATION

Location:

216. **Peckham, A. E.**, 1959, *Investigation of Underground Waste Disposal, Chemical Processing Plant Area, National Reactor Testing station, Idaho*, USGS, IDO-22039-USGS.

This report describes the progress made in observations of the rate and direction of movement of liquid waste discharged through the disposal well at the ICPP. The report contains tabulated data and tentative conclusions based on explorations through March 1958.

Subject: Wells at the INEL
Keywords: STORAGE COEFFICIENT / STREAMFLOW / QUALITY ASSURANCE
Location:

217. **Pickett, S. L., and Spry, M. J.**, 1991, *Closure Plan for the ARA-III, ARA-740 Sanitary Sewer Leach Field (COCA Unit ARA-13)*, EG&G Idaho, Inc., Informal Report EGG-WM-9471, Idaho Falls, ID.

This report describes the closure plan for the ARA Sanitary Sewer Leach Field in accordance with COCA. The location and physical characteristics of the site are described, and the results of sampling and analysis are discussed. Some removal of waste is required due to concentrations of contaminants in the distribution box and septic tank. No removal is required for the leach field.

Subject: Closure plans
Keywords: TEST REACTOR AREA / PAINT SHOP DITCH / GEOLOGY / HYDROLOGY / CLIMATE / CONTAMINANT / METALS / ORGANIC COMPOUNDS
Location: WAG-10 Data Repository

218. **Pickett, S. L., and Stanisich, S. N.**, 1990, *Closure Plan for the Test Reactor Area Paint Shop Ditch (COCA Unit TRA-02)*, EG&G Idaho, Inc., Informal Report EGG-WM-9212, Idaho Falls, ID.

This report describes the closure plan for the TRA Paint Shop Ditch in accordance with COCA. The location and physical characteristics of the site are described, and the results of sampling and analysis are discussed. Contaminants were found to be near background or below cleanup regulatory limits.

Subject: Closure plans
Keywords: TEST REACTOR AREA / PAINT SHOP DITCH / GEOLOGY / HYDROLOGY / CLIMATE / CONTAMINANT / METALS / ORGANIC COMPOUNDS
Location: WAG-10 Data Repository

219. Pierce, K. L.; Fosberg, M. A.; Scott, W. E.; Lewis, G. C., and Colman, S. M., 1982, *Loess Deposits of Southern Idaho: Age and Correlation of the Upper Two Loess Units*, Idaho Bureau of Mines and Geology, USGS Report.

Reconstruction of loess deposition is reconstructed for loess units A and B (back to approx. 150,000 years b.p.). correlations are drawn from relationships to major geologic events such as Wisconsin and Pinedale Glaciations and Bonneville Flood. The bulk of the loess deposits are suggested to have been deposited during glacial times on flood plains of large streams and the active alluvial fans on and adjacent to the Snake River Plain.

Subject: Ecological and soil resources of the INEL
Keywords: LOESS / GLACIATION / FLOODING / ESRP / ALLUVIAL FAN /
RADIOMETRIC DATING
Location: WAG-10 Data Repository

220. Piggot, W., 1989, *Monitoring, Analysis, and Test Plan, TRA-36-ETR Cooling Tower*, EG&G Idaho, Inc., Informal Report EGG-ER-8544, Idaho Falls, ID.

This report states the objectives of the test plan, gives a brief history of the area, addresses the geological conditions at the INEL, and addresses proposed sampling and analysis plans.

Subject: TRA data
Keywords: TEST REACTOR AREA / ETR / GEOLOGY / BASALT / ALLUVIAL
SEDIMENT / MINERALOGY / SEDIMENT
Location: WAG-10 Data Repository

221. Pittman, J. R., 1989, *Hydrological and Meteorological Data for an Unsaturated Zone Study near the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho—1985-86*, USGS, Open File Report 89-74, IDO-22079.

Presents the progress of a study to obtain a reliable estimate of the amount of water that infiltrates the surficial sediment and eventually recharges the aquifer by quantifying ET rates, soil moisture content and variability, soil-moisture flux, hydraulic conductivities, soil moisture velocities, and soil temperatures. Two test trenches were installed in the surficial sediment adjacent to the RWMC burial ground to collect hydrologic data from undisturbed and disturbed soil.

Subject: Subsurface investigation
Keywords: TEST TRENCH / CAPILLARY PRESSURE / BULK DENSITY / SOIL
MOISTURE / TOTAL SOLAR RADIATION / REFLECTED SOLAR
RADIATION / WIND SPEED / RELATIVE HUMIDITY / AIR
TEMPERATURE / PRECIPITATION
Location: WAG-10 Data Repository

222. Pittman, J. R.; Jensen, R. G., and Fischer, P. R., 1988, *Hydrologic Conditions at the Idaho National Engineering Laboratory 1982 to 1985*, USGS, Water Resources Investigation Report 89-4008, DOE/ID-22078.

Aqueous chemical and radioactive wastes discharged since 1952 to unlined ponds and wells at the INEL have affected water quality in perched ground water zones and in the Snake River Plain Aquifer. Routine waste water disposal has changed from a deep injection well to ponds at the ICPP in 1984. During 1982-85, tritium concentrations increased in perched groundwater zones under disposal ponds, but Co-60 concentrations decreased. During 1982-85, tritium concentrations in water in the Snake River Plain Aquifer decreased as much as 80 pCi/ml near the ICPP. Tritium was detected in groundwater near the southern boundary of the INEL 9 miles south of the ICPP and TRA. Sr-90 concentrations in groundwater generally were smaller than 1981 concentrations. Sodium and chloride concentrations generally decreased during 1982-1985. Nitrate concentrations increased near TRA and NRF and decreased near the ICPP.

Subject: Waste management and disposal at the INEL
Keywords: BIG LOST RIVER / WATER TABLES / WELL HYDROGRAPH /
LIQUID WASTE / RADIONUCLIDES / TRITIUM / SULFATE /
SODIUM / CHLORIDE / STRONTIUM / COBALT / CESIUM /
PLUTONIUM / PLUTONIUM / PERCHED GROUNDWATER /
AREAL EXTENT / CHROMIUM / NITRATE / TEMPERATURE /
QUALITY ASSURANCE / LEAD / MERCURY / SPECIFIC
CONDUCTANCE
Location: WAG-10 Data Repository

223. Polzer, W. L.; Percival, D. R., and Barraclough, J. T., 1976, *Special Analyses for Plutonium and Americium in Water from the Snake River Plain Aquifer*, Idaho National Engineering Laboratory Report IDO-12081, Idaho Falls, ID.

Analyses for plutonium and americium were made for samples from five wells in the Snake River Plain Aquifer near the INEL. No samples were found to exceed the "background" level for these radionuclides.

Subject: Radionuclide studies at the INEL
Keywords: PLUTONIUM / AMERICIUM / GROUNDWATER / ESRP AQUIFER /
RWMC
Location: WAG-10 Data Repository

224. Prestwich, S. M., and Bowman, J. A., et. al., 1980, *Completion and Testing Report; INEL Geothermal Exploratory Well One (INEL-1)*, DOE, IDO-10096, Idaho Falls, ID.

Discusses the drilling of a geothermal test well for potential use at the ICPP. The well was drilled to a total depth of 10,333 ft with no significant production or high temperatures.

Rock cores, geophysical logs, and hydrologic tests of the well indicate that no useful geothermal resource exists at this location.

Subject: Geothermal Drilling at the INEL
 Keywords: GEOTHERMAL / DRILLING / LOGS / ROCK CORES /
 HYDROLOGY / ICPP
 Location: WAG-10 Data Repository

225. Rasco, R. D., and Spry, M. J., 1991, *Closure Plan for the Central Facilities Area French Drains (COCA Unit CA-07)*, EG&G Idaho, Inc., Informal Report EGG-WM-9494, Idaho Falls, ID.

This document describes the proposed plans for closure of the CFA French Drain in accordance with COCA. The location and physical characteristics of the site are described. The site has not been characterized in regard to the presence or extent of hazardous waste. Characterization activities are described.

Subject: Closure plans
 Keywords: CFA / FRENCH DRAIN / GEOLOGY / GROUNDWATER / CLIMATE
 / SOIL
 Location: WAG-10 Data Repository

226. Rasco, R. D., and Spry, M. J., 1991, *Closure Plan for the Central Facilities Area French Drains (COCA Unit CA-12)*, EG&G Idaho, Inc., Informal Report, EGG-WM-9495, Idaho Falls, ID.

This document describes the proposed plans for closure of the CFA French Drain in accordance with COCA. The location and physical characteristics of the site are described. The site has not been characterized in regard to the presence or extent of hazardous waste. Characterization activities are described.

Subject: Closure plans
 Keywords: CFA / FRENCH DRAIN / GEOLOGY / GROUNDWATER / CLIMATE
 / SOIL
 Location: WAG-10 Data Repository

227. Rawson, S. A., and Hubbell, J. M., 1989, "Geochemical Controls on the Composition of Soil Pore Waters Beneath a Mixed Waste Disposal Site in the Unsaturated Zone," *Proceedings of the Nuclear Waste Isolation in the Unsaturated Zone, Focus 1989*.

Paper summarizes results of analysis and geochemical modeling activities of surficial and interbed pore water sampling. It is suggested that the use of silica flour in the installation of the suction lysimeters may impact the chemistry of the pore fluid collected. This is based on equilibrium geochemical calculations made on the sample results.

Subject: Subsurface investigation
Keywords: LYSIMETER / RWMC / SUBSURFACE DISPOSAL AREA /
GEOCHEMISTRY / RADIONUCLIDES / SEDIMENTARY
INTERBED / SURFICIAL SEDIMENTS
Location: WAG-10 Data Repository

228. Rawson, S. A.; Walton, J. C., and Baca, R. G., 1989, "Modeling Potential Migration of Petroleum Hydrocarbons from a Mixed-Waste Disposal Site in the Vadose Zone," *Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection and Restoration*.

A one-dimensional model was used to estimate the vertical distribution of vapor phase, aqueous phase, and immiscible free liquid of machine oil contaminated with radionuclides in the vadose zone. Simulations indicate that the oil may migrate to significant depths.

Subject: Radionuclide studies at the INEL
Keywords: VAPOR PHASE TRANSPORT / AQUEOUS PHASE TRANSPORT /
TRANSURANIC WASTE / MACHINE OIL / TRANSPORT
MODELING
Location: WAG-10 Data Repository

229. Rehak, E. M., 1989, *Statistical Analysis of TRA Warm Waste Pond Chemical Data*, EG&G Idaho, Inc., EGG-SARE-8712, Idaho Falls, ID.

This report contains the results of the statistical analysis of the chemical data from the Remedial Investigation sampling performed in the TRA Warm Waste Pond in May, June, and July of 1988. The objects of this investigation were to identify the principle locations of hazardous constituents identified in the Preliminary Investigation and determine the spatial distribution of these contaminants. In order to assess the extent of the contamination, sampling was done across the three ponds.

Subject: TRA warm waste ponds
Keywords: BOREHOLE / SURFICIAL SEDIMENTS / ACETONE /
ACRYLONITRILE / BIS(2-ETHYLHEXYL) PHTHALATE /
DI-N-BUTYLPHTHALATE / DI-N-OCTYLPHTHALATE /
PENTACHLOROPHENOL / ARSENIC / BERYLLIUM / CADMIUM /
CHROMIUM / COPPER / CYANIDE / HEXAVALENT CHROMIUM /
MERCURY / SILVER / SULFIDE / TOC / ZINC
Location:

230. Reyes, B. D.; Case, M. J., and Wilhelmsen, R. N., 1986, *Annual Report 1985, Environmental Surveillance for the EG&G Idaho Radioactive Waste Management Complex at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-2451, Idaho Falls, ID.

Describes monitoring activities at the RWMC facilities during 1984. Report compares monitoring results with past histories for trend analysis.

Subject: Environmental monitoring at the INEL
Keywords: AIR QUALITY / RWMC / ENVIRONMENTAL MONITORING /
RADIONUCLIDES
Location: WAG-10 Data Repository

231. Reyes, B. D.; Case, M. J., and Zahn, T. P., 1985, *Annual Report 1984, Environmental Surveillance for the Idaho National Engineering Laboratory rnc and other Areas*, EG&G Idaho, Inc., EGG-2386, Idaho Falls, ID.

Describes monitoring activities at RWMC facilities during 1984. Report compares monitoring results with past histories for trend analysis.

Subject: Environmental monitoring at the INEL
Keywords: AIR QUALITY / RWMC / ENVIRONMENTAL MONITORING /
RADIONUCLIDES
Location: WAG-10 Data Repository

232. Reyes, B. D.; Tkachyk, J. W., and Ritter, P. D., 1987, *Environmental Surveillance for the EG&G Idaho Radioactive Waste Management Complex at the Idaho National Engineering Laboratory, Annual Report 1986*, EG&G Idaho, Inc., EGG-2502, Idaho Falls, ID.

Describes monitoring activities at RWMC facilities during 1986. Report compares monitoring results with past histories for trend analysis.

Subject: Environmental monitoring at the INEL
Keywords: AIR QUALITY / RWMC / ENVIRONMENTAL MONITORING /
RADIONUCLIDES
Location: WAG-10 Data Repository

233. Rightmire, C. T., 1984, *Description and Hydrologic Implications of Cored Sedimentary Material from the 1975 Drilling Program at the Radioactive Waste Management Complex, Idaho*, USGS, IDO-22067, Idaho Falls, ID.

Samples of sedimentary material from interbeds between basalt flows and from fractures in the flows, from beneath the RWMC were analyzed for (1) particle size distribution, (2) bulk mineralogy, (3) clay mineralogy, (4) cation exchange capacity, and (5) carbonate content. Thin sections of selected sedimentary interbed material were made for petrographic

examination. The results of these analyses are interpreted as a first step in characterizing the paths and rates of movement of radionuclides transported by infiltrating water. Preliminary interpretations indicate that (1) it may be possible to distinguish the various sedimentary interbeds on the basis of their mineralogy, (2) the presence of carbonate horizons in sedimentary interbeds may be utilized to approximate the time of and orientation of fracture-filling material may be utilized to determine the mechanism by which fractures were filled.

Subject: RWMC drilling program
Keywords: SEDIMENTARY INTERBED / HYDROLOGY / VADOSE ZONE /
SEDIMENT / SPECIFIC GRAVITY / BULK MINERALOGY /
QUARTZ / K-SPAR / PLAGIOCLASE / CALCITE / PYROXEDNE /
CLAY / CHORITE / ILLITE / MONTMORILLONTE / KOAOLINITE /
CARBONATE / LITHOLOGY / LOGS
Location: WAG-10 Data Repository

234. Rightmire, C. T., and Lewis, B. D., 1987, *Geologic Data Collected and Analytical Procedures Used During a Geochemical Investigation of the Unsaturated Zone, Radioactive Waste Management Complex Idaho National Engineering Laboratory, Idaho*, USGS, Open File Report 87-246, DOE/ID-22072.

Describes the cored material and subpit sedimentary samples, and documents the sample preparation and analytical techniques used to characterize the hydrologic and geochemical environment of the unsaturated zone at the RWMC. This characterization is needed to develop a conceptual model of the hydrogeochemical environment of the shallow unsaturated zone, and to determine how changes in that environment may influence the mobility and migration of waste radionuclides buried in pits and trenches at the RWMC between the early 1950's and early 1970's. Visual and optical inspections of cored material collected from 8 well drilled during a 1976-1977 drilling program, along with subpit sedimentary samples, provided the needed hydrogeologic data.

Subject: Geochemical data for the RWMC
Keywords: GEOCHEMISTRY / CORE DESCRIPTION / THIN SECTIONS /
UNSATURATED ZONE / RWMC / GEOLOGY
Location: WAG-10 Data Repository

235. Rightmire, C. T., and Lewis, B. D., 1987, *Hydrogeology and Geochemistry of the Unsaturated Zone, Radioactive Waste Management Complex (RWMC), Idaho National Engineering Laboratory, Idaho*, USGS, Water Resources Investigation Report 87-4198, DOE/ID-22073.

Stable isotope and chemical data suggest that the perched water observed beneath the RWMC is not due to vertical infiltration through the ground surface at the RWMC, but is due to lateral flow of water that infiltrated through the diversion ponds. It is hypothesized

that the water accumulates as a perched mound on the thick, laterally continuous sedimentary interbed at a depth of 73 meters (m) and then moves about 1.5 kilometers to the northeast through sedimentary material and open fractures, at least to the interbed at a depth of 73 m.

Subject: Perched water and contaminants at the INEL
 Keywords: SURFICIAL SEDIMENTS / SEDIMENT / MINERALOGY / STABLE ISOTOPES / CLAY / CATION EXCHANGE CAPACITY / CARBONATE / X-RAY DIFFRACTION / SEDIMENTARY INTERBED / BASALT / BIG LOST RIVER / GROUNDWATER / WATER TABLES / PERCHED GROUNDWATER / ALKALINITY / PH / TEMPERATURE / STABLE ISOTOPES / POROSITY / HYDRAULIC PROPERTIES / INFILTRATION / AQUIFER RECHARGE / PRECIPITATION / PH / SPECIFIC CONDUCTANCE / DEUTERIUM / OXYGEN (O-18) / QUALITY ASSURANCE
 Location: WAG-10 Data Repository

236. Robertson, J. B., 1969, *Behavior of Xenon-133 Gas after Injection Underground: Molecular Diffusion, Materials Balance, and Barometric Pressure Effects*, USGS, IDO-22051.

Nine hundred and eight-seven curies of radioactive Xenon-133 gas were injected rapidly under pressure to 1.5 to 1.65 psig with one million cubic feet of air into permeable basalt strata. A capping layer of fine-grained playa sediments confined the gas underground. Underground distribution patterns after injection pressure had dissipated were evaluated by materials-balance analysis. The results indicated that most of the Xenon-133 gas remained underground and decayed radioactively. Molecular diffusion rates of Xenon-133 from the ground were estimated using a simplified numerical model.

Subject: Gaseous injection of waste
 Keywords: GAS INJECTION / XENEON / POROSITY / EFFECTIVE POROSITY / DIFFUSION COEFFICIENT / SOIL MOISTURE / DIFFUSION RATE / PERMEABILITY / BAROMETRIC FLUX RATE
 Location:

237. Robertson, J. B., 1974, *Digital Modeling of Radioactive and Chemical Waste Transport in the Snake River Plain Aquifer at the National Reactor Testing Station, Idaho*, USGS, IDO-22054.

A two-dimensional model was developed to simulate contaminant movement in the Snake River Plain Aquifer. The modeling results indicate that hydraulic dispersion is a much more significant influence than previously suggested by earlier studies. The model is used to estimate future waste migration patterns for varied assumed hydrological and waste conditions up through the year 2000. The hydraulic effects of recharge from the Big Lost River have an important influence on the simulated future migration patterns.

Subject: Contaminant modeling at the INEL
Keywords: LIQUID WASTE / RADIONUCLIDES / TRITIUM / SULFURIC ACID / SODIUM HYDROXIDE / CHLORIDE / DISSOLVED SOLIDS / QUALITY ASSURANCE / CHLORIDE / TRITIUM / STORAGE COEFFICIENT / TRANSMISSIVITY / POROSITY / DISPERSIVITY / DISTRIBUTION COEFFICIENT
Location: WAG-10 Data Repository

238. Robertson, J. B., 1977, *Numerical Modeling of Subsurface Radioactive Solute Transport from Waste-Seepage Ponds at the Idaho National Engineering Laboratory*, USGS, IDO-22057.

Keywords: STRATIGRAPHY / POROSITY / HYDRAULIC PROPERTIES / LIQUID WASTE / SULFURIC ACID / SODIUM HYDROXIDE / SODIUM CHORIDE / QUALITY ASSURANCE / PERCHED GROUNDWATER / RADIONUCLIDES

239. Robertson, J. B.; Schoen, R., and Barraclough, J. T., 1974, *The Influence of Liquid Waste Disposal on the Geochemistry of Water at the National Reactor Testing Station, Idaho: 1952-1970*, USGS, IDO-22053.

This report presents a summarized evaluation of the geology, hydrology, and water geochemistry of the NRTS and the associated influences of subsurface liquid waste products discharged from the NRTS facilities. The progressive buildup, distribution, and changes of both radioactive and chemical wastes are analyzed for the total disposal period —1952-70. Of principal concern is the fate of wastes discharged from the NRTS in the Snake River Plain Aquifer.

Subject: Groundwater properties at the INEL
Keywords: WELL HYDROGRAPH / BIG LOST RIVER / INFILTRATION / AQUIFER RECHARGE / STRATIGRAPHY / DISTRIBUTION COEFFICIENT / TRANSMISSIVITY / STREAMFLOW / QUALITY ASSURANCE / WATER CHEMISTRY / TEMPERATURE / COLOR / PH / SPECIFIC CONDUCTANCE / TOTAL DISSOLVED SOLIDS / HARDNESS / PERCHED GROUNDWATER / ICPP / TEST REACTOR AREA / NRF / WELL HYDROGRAPH / LIQUID WASTE / RADIONUCLIDES
Location: WAG-10 Data Repository

240. Rood, A. S., 1992, *ground water SCREEN: A Semi Analytical Model for Assessment of the Ground Water Pathway From Surface or Varied contaminantion: Theory and Users Manual*, EG&G Idaho, Inc., Informal Report, EGG-GEO-10158, Idaho Falls, ID.

ground water SCREEN was developed for assessment of the groundwater pathway for leaching of radioactive and nonradioactive substances from surface or buried sources. The

code was designed for implementation in the track 1 and track 2 assessment of comprehensive environmental resource, compensation and liability act (CERCLA). The code uses a mass conservation approach to model three processes; Contaminant release from source volume, contaminant transport in the unsaturated zone and contaminant transport in the saturated zone. The source model considers adsorptive properties and solubility of the contaminant. Transport in the unsaturated zone is described by a plugged flow model. Transport in the saturated zone is calculated with a semi analytical solution to the advective dispersion equation for transient mass flux input.

Subject: Contaminant modeling at the INEL
Keywords: PATHWAY ANALYSIS / MODELING / GROUNDWATER /
CONTAMINANT
Location: WAG-10 Data Repository

241. Rood, A. S.; Arnett, R. C., and Barraclough, J. T., 1989, *Contaminant Transport in the Snake River Plain Aquifer; Phase I, Simple Analytical Model of Individual Plumes*, EG&G Idaho, Inc., Informal Report, EGG-ER-8623, Idaho Falls, ID.

Preliminary screening calculations for transport of several contaminants found at the INEL based on a simple analytical groundwater model. Model matches current plume configurations reasonably well. Predictions show that CCl-4 and I-129 may need further evaluation because they reach the site boundary at or near the groundwater regulatory guidelines.

Subject: Contaminant modeling at the INEL
Keywords: RADIONUCLIDES / ORGANIC COMPOUNDS / ICPP / TEST
REACTOR AREA / RWMC / DISPOSAL POND / INJECTION /
CONTAMINANT TRANSPORT / GROUNDWATER MODEL /
GROUNDWATER
Location: WAG-10 Data Repository

242. Rope, S. K.; Arthur, W. J.; Craig, T. H., and Craig, E. H., 1988, *Nutrient and Trace Elements in Soil and Desert Vegetation of Southern Idaho*, DOE, RESL-88-002, Idaho Falls, ID.

Concentrations of 30 elements were measured in strong acid extracts of soil, sagebrush, (Artemisia tridentata SSP), leaves and perennial grass from the INEL and two reference sites in southern Idaho. A bicarbonate-chelating extract of soil was used to estimate plant-available concentrations. The results provide baseline data prior to start up of a coal fired steam generator facility on the INEL and other developments in the region. In addition, existing impact from effluents from 30 years of a nuclear fuel processing facility on the INEL was evaluated. Based on the spatial distribution of element concentrations, as well as comparison with reference sites, we conclude that concentrations of zinc, and perhaps nickel, cadmium and vanadium are currently elevated around the fuel processing facility.

Subject: Radionuclide studies at the INEL
Keywords: SURFICIAL SEDIMENTS / PH / ORGANIC COMPOUNDS / CATION
EXCHANGE CAPACITY / TEXTURE / QUALITY ASSURANCE /
WATER CHEMISTRY

Location:

243. Russell, B. F.; Hubbell, J. M., and Humphrey, T. G., 1987, *Waste Management '87*.

Provides a summary of activities of the Subsurface Investigations Program at the RWMC. This includes shallow and deep drilling activities complete with instrumentations and results of radionuclides analyses of pore fluids from the unsaturated zone.

Subject: Wells at the INEL
Keywords: RWMC / SHALLOW DRILLING / DEEP DRILLING / SUBSURFACE
INVESTIGATIONS / LYSIMETER / RADIONUCLIDES /
PLUTONIUM / AMERICIUM / STRONTIUM / CERIUM / CESIUM /
COBALT

Location: WAG-10 Data Repository

244. Sagendorf, J., 1991, *Meteorological Information for RWMC Flood Potential Studies*, U.S. Dept. of Commerce, NOAA, Environmental Research Laboratories, Air Resources Laboratory Field Research Division, Idaho Falls, ID.

This report addresses meteorological information related to modeling the potential for floods at the RWMC. Descriptive data and statistics such as estimates of 25 and 100 year return periods for maximum 24 hour precipitation amounts and also 25 and 100 year maximum snow depths are provided. The results are to assist in development of a design basis storm.

Subject: Flood control at the INEL
Keywords: RWMC / FLOODING / METEOROLOGY / PRECIPITATION
Location: WAG-10 Data Repository

245. Schmalz, B. L., 1968, *Liquid Waste at the National Reactor Testing Station, Idaho*, U.S. Atomic Energy Commission, Idaho Operations Office, IDO-12066.

Briefly describes the systems which dispose of liquid waste to the lithosphere. It is organized on the basis of three categories, sanitary sewage, radioactive, and industrial wastes and summarizes the volumes and contaminants involved.

Subject: Waste management and disposal at the INEL
Keywords: SEWAGE / LIQUID WASTE / RADIONUCLIDES / SLIMICIDE /
QUALITY ASSURANCE / WATER CHEMISTRY

Location:

246. Schmalz, B. L., 1972, *Radionuclide Distribution in Soil Mantle of the Lithosphere as a Consequence of Waste Disposal at the National Reactor Testing Station*, U.S. Atomic Energy Commission, Idaho Operations Office, IDO-10049.

this report is a study of the distribution of radionuclides in the soil resulting from disposal of liquid and solid waste at the NRTS. The situation involving liquid waste is appraised by: (1) mathematical models using parameters determined in the laboratory, (2) physical models using soil samples and simulated waste solutions, and (3) sampling of soil and water where waste is being discharged. Leaching of waste and the migration of some fission products as well as plutonium isotopes and daughter products is shown to have occurred to a very limited extent.

Subject: Waste management and disposal at the INEL
Keywords: DISTRIBUTION COEFFICIENT / STRONTIUM / CESIUM / COBALT / CERIUM / URANIUM / AMERICIUM / TRITIUM / LEACHING / SURFICIAL SEDIMENTS / QUALITY ASSURANCE / GEOCHEMISTRY / BURIED WASTE
Location: WAG-10 Data Repository

247. Schmalz, B. L., and Polzer, W. L., 1969, "Tritiated Water Distribution in Unsaturated Soil", *Soil Science*, 108:43-47.

Soil water samples were collected and analyzed for tritium content from locations on the INEL to aid in the determination of water movement in the unsaturated zone.

Subject: Groundwater properties at the INEL
Keywords: TRITIUM / UNSATURATED ZONE / WATER MOVEMENT
Location: WAG-10 Data Repository

248. Shuman, R. D.; Case, M. J., and Rope, S. K., 1985, *Documentation of a Simple Environmental Pathways Model of the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-WM-6916, Idaho Falls, ID.

This report documents the search and modification of a simulation code for modeling applications at the RWMC. The conceptual model, mathematical description and results for the waste site are given.

Subject: Contaminant modeling at the INEL
Keywords: GROUNDWATER TRANSPORT / MODELING / RWMC / RADIONUCLIDES
Location: WAG-10 Data Repository

249. Shuter, E., and Brandvold, G. E., 1952, *Water Levels in Wells in Bingham, Bonneville, Butte and Jefferson Counties, Idaho*, USGS, IDO-22017-USGS.

The report summarizes investigations relating to the occurrence, sources, quality, utilization, and conservation of ground water in the Snake River Plain. More specialized studies including: performance of production wells, hydraulic properties of the aquifer, physical characteristics of the geologic materials, and sources of ground water recharge are given for the INEL.

Subject: Groundwater monitoring at the INEL
Keywords: GROUNDWATER / WATER TABLES / ESRP AQUIFER / GEOLOGY / RECHARGE
Location: WAG-10 Data Repository

250. Sisson, J. B., and Ellis, G. C., 1990, *Summary Report of Results of the Vapor Vacuum Extraction Test at the RWMC*, EG&G Idaho, Inc., EGG-WM-9301, Idaho Falls, ID.

A test scale vapor vacuum extraction system was operated for four months at the RWMC. The extraction system removed more than 65 million cubic feet of soil gas containing 429 Kg of carbon tetrachloride and 164 Kg of trichloroethylene. Hydraulic properties of the basalts were estimated and input into a numerical transport model. The model simulations indicated that a rubble zone at 190 ft dominated the soil gas flow pattern.

Subject: Vacuum extraction sampling
Keywords: SOIL GAS / VACUUM VS. FLOW RATE / BOREHOLE / HYDRAULIC PROPERTIES / CARBON TETRACHLORIDE / CONCENTRATION PROFILE
Location: WAG-10 Data Repository

251. Sisson, J. B.; Walton, J. C., 1989, Idaho Falls, ID.

252. Smith, C. J., 1984, *A History of the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., Waste Management Report WM-F1-81-003, rev. 2, Idaho Falls, ID.

Report summarizes major waste management developments, decisions, and practices at the RWMC in the following categories; early disposal (1952-59), interim burial ground (1960-63), mid to late 60s (1964-1969), and 1970-1984. Terminology changes and Arconyms are listed. Information is drawn from available documentation.

Subject: Waste management and disposal at the INEL
Keywords: RWMC / WASTE MANAGEMENT / EARLY DISPOSAL / BURIAL GROUND
Location: WAG-10 Data Repository

253. Stewart, J. W., 1951, *Results of Tests on Wells at Sites 3 and 7, NRTS, Idaho*, USGS, IDO-22011.

This memorandum summarizes and reviews the results of artificial recharge, discharge-drawdown, and pumping tests by the USGS at ICPP and STR. The purpose of the tests was to obtain information about the water-bearing properties of the aquifers, build-up of the water level in intake wells, the local effect of this build-up on the water table, the lateral extent of the cones of elevation and depression, and the minimum desirable spacing of production and waste disposal wells.

Subject: Wells at the INEL
Keywords: DISCHARGE / DRAWDOWN / TRANSMISSIVITY / STORATIVITY / LOGS / RECHARGE
Location:

254. Stewart, J. W.; Nace, R. L.; Fowler, K. H.; Peckham, A. E., and Vogeli, P. T., 1960, *Geography, Geology, and Water Resources of the NRTS, Appendix 2, Basic Hydrological Data*, USGS, IDO-22034-USGS.

Report contains data on altitude and fluctuations of water table, discharge of Big Lost River, aquifer testing at various INEL site facilities.

Subject: Geology and hydrology at the INEL
Keywords: GEOLOGY / HYDROLOGY / AQUIFER TEST / WATER TABLES
Location: WAG-10 Data Repository

255. Teasdale, W. E., and Pemberton, R. R., 1990, *Experimental Suction Drilling in Basalts at the Idaho National Engineering Laboratory, Idaho*, USGS, Water Resources Investigation Report 90-4206.

256. Thomas, T. R., 1988, *Modeling Hypothetical Groundwater Transport of Nitrates, Chromium, and Cadmium at the Idaho Chemical Processing Plant, WINCO, Inc., WINCO-1060*, Idaho Falls, ID.

This report provides information that will ultimately result in a decision on waste disposal of materials generated at ICPP. Also models transport of three contaminants from calcine due to rainwater recharge.

Subject: Waste management and disposal at the INEL
Keywords: ICPP / CALCINE / TRANSPORT MODELING / NITRATE / CHROMIUM / CADMIUM / GROUNDWATER
Location: WAG-10 Data Repository

257. Thompson, R. J., 1972, *Solid Radioactive Waste Retrieval Test*, Allied Chemical Corporation, ACI-120.

Report summarizes the solid waste retrieval test conducted to determine if Rocky Flats waste disposal at the INEL could be safely exhumed and handled.

Subject: Rocky Flats waste retrieval
Keywords: ROCKY FLATS / RADIOACTIVE WASTE / TRANSURANIC WASTE / WASTE RETRIEVAL
Location: WAG-10 Data Repository

258. Tkackyk, J. W.; Ritter, P. D., and Wilhelmsen, R. N., 1988, *Annual Report—1987 Environmental Surveillance for the EG&G Idaho Radioactive Waste Management Areas at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-2550, Idaho Falls, ID.

Describes monitoring activities at RWMC facilities during 1987. Report compares monitoring results with past histories for trend analysis.

Subject: Environmental monitoring at the INEL
Keywords: AIR QUALITY / RWMC / ENVIRONMENTAL MONITORING / RADIONUCLIDES
Location: WAG-10 Data Repository

259. Tkackyk, J. W.; Wright, K. C.; Ritter, P. D.; Wilhelmsen, R. N., and Heileson, W. M., 1989, *Annual Report—1988 Environmental Monitoring for EG&G Idaho Facilities at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-2564, Idaho Falls, ID.

This report describes the 1988 environmental monitoring activities at EG&G operated facilities at the INEL. Additional monitoring activities are also discussed, including preliminary radiological characterization of other facilities, drinking water monitoring, non-radiological liquid effluent monitoring, subsurface investigation, and data management.

Subject: Environmental modeling at the INEL
Keywords: AIR QUALITY / QUALITY ASSURANCE / SPECIFIC CONDUCTANCE / SOIL contaminantION / RADIONUCLIDES / ORGANIC COMPOUNDS
Location: WAG-10 Data Repository

260. Tkackyk, J. W.; Wright, K. C., and Wilhelmsen, R. N., 1990, *Annual Report—1989 Environmental Monitoring for EG&G Idaho Facilities at the Idaho National Engineering Laboratory*, EG&G Idaho, Inc., EGG-2612, Idaho Falls, ID.

This report describes the 1989 environmental monitoring activities at EG&G operated facilities at INEL. Additional monitoring activities are also discussed, including drinking water monitoring, non radiological liquid effluent monitoring, as well as data management. The primary purposes of monitoring are to evaluate environmental conditions and to provide information, in compliance with applicable regulations and interpreted as necessary, for insuring protection of personnel, the public and the environment.

Subject: Environmental monitoring at the INEL
Keywords: AIR QUALITY / MAMMALS / QUALITY ASSURANCE / SPECIFIC CONDUCTANCE / RADIONUCLIDES / ORGANIC COMPOUNDS / METALS
Location: WAG-10 Data Repository

261. Travis, W. L., 1954, *Progress Report on Operations of Stream-Gaging Station, Big Lost River Near Arco, Idaho, Water Year 1953*, USGS, IDO-22029-USGS.

Reports Arco gaging station data for the year 1953.

Subject: Big Lost River Drainage Basin data
Keywords: BIG LOST RIVER / DRAINAGE BASIN / STREAMFLOW / HYDROLOGY
Location: WAG-10 Data Repository

262. Travis, W. L., 1955, *Progress Report on Operations of Stream-Gaging Station, Big Lost River Near Arco, Idaho, Water Year 1954*, USGS, IDO-22030-USGS.

This report outlines the general relationship of the Arco gaging station to the hydrology of the Big Lost River drainage basin.

Subject: Big Lost River Drainage Basin data
Keywords: BIG LOST RIVER / DRAINAGE BASIN / STREAMFLOW / HYDROLOGY
Location: WAG-10 Data Repository

263. U. S. Geological Survey, 1989, *Water Quality Data—USGS Wells 1 to 120; Wells, ponds, rivers, springs, (1980-1988)*, USGS.

264. U.S. Bureau of Reclamation (USBR), 1977, *Design of Small Dams, Chapter III*, Government Printing Office, Revised Reprint.

265. U.S. Department of Energy, 1980, *1979 Environmental Monitoring Program Report for Idaho National Engineering Laboratory Site*, DOE, IDO-12082(79), Idaho Falls, ID.

266. U.S. Department of Energy, 1981, *1980 Environmental Monitoring Program Report for Idaho National Engineering Laboratory Site*, DOE, IDO-12082(80), Idaho Falls, ID.

267. U.S. Department of Energy, 1984, *Collection and Radiochemical Analyses of Sedimentary Interbed Samples from the Radioactive Waste Management Complex, Idaho National Engineering Laboratory: 1979*, EG&G Idaho, Inc., EGG-2083, Idaho Falls, ID.

268. U.S. Department of Energy, 1984, *Environmental and Other Evaluations of Low-level Waste at the Radioactive Waste Management Complex*, EG&G Idaho, Inc., EGG-WM-6523, Idaho Falls, ID.

This report presents a detailed technical environmental evaluation of the low-level radioactive waste buried at the RWMC of the INEL. It discusses the existing environment at and around the RWMC; the quantity and nature of the activities. It compares the monitoring results with ambient concentrations of naturally occurring and fallout radionuclides. It presents the effects of current operations and conditions, and projects the effects from future operations and conditions.

Subject: Environmental characterization at the INEL
Keywords: RWMC / ENVIRONMENTAL / GROUNDWATER / BURIED WASTE / RADIONUCLIDES
Location: WAG 10 Files

269. U.S. Department of Energy, 1991, *INEL Site Environmental Surveillance Data for the First Quarter*, DOE, DOE-91-01, Idaho Falls, ID.

This report summarizes data from sample analyses collected at INEL Site locations during the first quarter of calendar year 1991. Data were obtained from analyses of air and from analyses of well and surface water samples.

Subject: Environmental surveillance AT THE INEL
Keywords: ENVIRONMENTAL / SURVEILLANCE / AIR QUALITY / WATER
Location: INEL Technical Library

270. U.S. Department of Energy, 1991, *INEL Site Environmental Surveillance Data for the Fourth Quarter, 1990*, DOE, DOE-90-04, Idaho Falls, ID.

This report summarizes data from analyses of samples collected at INEL Site locations during the fourth quarter of calendar year 1990. Data were obtained from analyses of air and from analyses of well and surface water samples, and from direct radiation measurements.

Subject: Environmental surveillance AT THE INEL
Keywords: ENVIRONMENTAL / SURVEILLANCE / AIR QUALITY / WATER
CHEMISTRY
Location: INEL Technical Library

271. U.S. Department of Energy, 1991, *INEL Site Environmental Surveillance Data for the First Quarter, 1991*, DOE, DOE-91-01.

This report summarizes data from analyses of samples collected at INEL Site locations during the first quarter of calendar year 1991. Data were obtained from analyses of air and from analyses of well and surface water samples.

Subject: Environmental monitoring at the INEL
Keywords: MONITORING / WATER TABLES / PERCHED GROUNDWATER /
AIR QUALITY / QUALITY ASSURANCE / SPECIFIC
CONDUCTANCE / ORGANIC COMPOUNDS / METALS /
RADIONUCLIDES
Location:

272. U.S. Department of Energy, 1991, *INEL Site Environmental Surveillance Data for the First Quarter, 1991*, DOE, DOE-91-01.

This report summarizes data from analyses of samples collected at INEL Site locations during the first quarter of calendar year 1991. Data were obtained from analyses of air and from analyses of well and surface water samples.

Subject: Environmental monitoring at the INEL
Keywords: MONITORING / WATER TABLES / PERCHED GROUNDWATER /
AIR QUALITY / QUALITY ASSURANCE / SPECIFIC
CONDUCTANCE / ORGANIC COMPOUNDS / METALS /
RADIONUCLIDES
Location:

273. U.S. Department of Energy, 1991, *INEL Site Environmental Surveillance Data for the Fourth Quarter, 1990*, DOE, DOE-90-04.

This report summarizes data from analyses of samples collected at INEL Site locations during the fourth quarter of calendar year 1990. Data were obtained from analyses of air and from analyses of well and surface water samples, and from direct radiation measurements.

Subject: Environmental Monitoring at the INEL
Keywords: MONITORING / WATER TABLES / PERCHED GROUNDWATER /
AIR QUALITY / QUALITY ASSURANCE / SPECIFIC

**CONDUCTANCE / RADIONUCLIDES / METALS / ORGANIC
COMPOUNDS**

Location:

- 274. U.S. Environmental Protection Agency, 1990, *Support Document for Designation of the Eastern Snake River Plain Aquifer as a Sole Source Aquifer*, EPA, Region 10, Office of Groundwater, EPA 910/9-90-020.**

This document summarizes readily available information about the eastern Snake River Plain, and served as the technical basis for the EPA designation of the ESRP aquifer as a sole source aquifer.

Subject: ESRP AQUIFER

Keywords: ESRP AQUIFER / SOLE SOURCE AQUIFER / GROUNDWATER /
CONTAMINANT / BOUNDARIES / GEOLOGY

Location: C.W. Bishop Files

- 275. U.S. Geological Survey, 1962, *Hydrology of Waste Disposal National Reactor Testing Station, Idaho, Annual Progress Report, 1962*, U.S. Department of Interior, IDO-22044-USGS.**

The purpose of this investigation is to determine the effect of underground disposal of liquid radioactive waste upon the regional groundwater resource. This requires a knowledge of the travel path, velocity and volume of the host water, the nature and volume of the waste, and the extent to which ion exchange, decay, and dispersion reduce any hazard from the waste.

Subject: Radionuclide studies at the INEL

Keywords: GROUNDWATER / ESRP AQUIFER / BASALT / RADIONUCLIDES /
WASTE DISPOSAL

Location: Wag 10 Files

- 276. U.S. Geological Survey, 1962, *Hydrology of Waste Disposal at the National Reactor Testing Station, Idaho; Annual Progress Report 1962*, USGS, IDO-22044-USGS.**

Tritium artificially induced into the ground water has been used to determine the direction of velocity of the ground water flow and the amount of dispersion or dilution that takes place. Rates of ground water movement based on "first arrival" ranged from 19 to 140 feet per day and averaged 60 feet per day. However, analysis of the tracer by center of mass, or maximum tritium concentration, indicate average ground water velocity is 10 to 13 feet per day. MTR pond study is described (perching).

Subject: Groundwater properties at the INEL

Keywords: QUALITY ASSURANCE / TRITIUM / PH / SPECIFIC
CONDUCTANCE / GAMMA ACTIVITY / LITHOLOGY / SEDIMENT

/ INFILTRATION / LOGS / WATER TABLES / AQUIFER
RECHARGE / BIG LOST RIVER

Location: WAG-10 Data Repository

277. U.S. Geological Survey, 1988, *Routine Sampling for Wells Near the Radioactive Waste Management Complex*, USGS.

278. Van Deusen, L., and Trout, b., 1990, *Phase I Remedial Investigation/Feasibility Study Work Plan and Addendums for the Warm Waste Pond Operable Unit at the Test Reactor Area of the Idaho National Engineering Laboratory (Volume I and II)*, EG&G Idaho, Inc., EGG-WM-8814, Idaho Falls, ID.

The purpose of the RI/FS for the TRA warm waste pond operable unit at the Idaho National Engineering Laboratory is determine the means of remedial action. In connection with the study, this work plan will include site background, initial evaluation, data quality objectives, RI/FS tasks, costs, and schedule. The site background includes meteorology and air quality monitoring, regional and local geology, hydrogeology, vegetation and wildlife, waste descriptions and existing characterization data.

Subject: TRA warm waste ponds

Keywords: AIR QUALITY / PRECIPITATION / LITHOLOGY / GEOLOGIC
CROSS SECTION / WATER TABLES / SPECIFIC CONDUCTANCE /
LITHOLOGY / LOGS / BIG LOST RIVER / QUALITY ASSURANCE /
GEOLOGY / BASALT / SEDIMENTARY INTERBED / BOREHOLE /
POROSITY / TRANSMISSIVITY / SEDIMENT / STORAGE
COEFFICIENT / AQUIFER THICKNESS / CONTAMINANT PLUMES
/ PERCHED GROUNDWATER / VEGETATION / SMALL ANIMALS
/ BIG GAME / LIQUID WASTE / RADIONUCLIDES / SURFICIAL
SEDIMENTS / ORGANIC COMPOUNDS

Location:

279. Van Haaften, D. H.; Koslow, K. N., and Naretto, C. J., 1984, *Hydrologic analysis of a Mackay Dam Failure During a Probable Maximum Flood on the Big Lost River, Idaho*, EG&G Idaho, Inc., Internal Technical Report No. SE-A-84-018, May 1984.

280. Vernon, D., and DeMartinis, K., 1991, *Scope of Work Perched Water System RI/FS, Test Reactor Area, Idaho National Engineering Laboratory*.

281. Vigil, M. J., 1989, *Subsurface Disposal Area (SDA) Waste Identification (1952-1970 Emphasis)*, EG&G Idaho, Inc., EGG-WM-8727, rev. 2, Idaho Falls, ID.

Summary of available information concerning the general identification of hazardous and radioactive contaminated waste disposed in the SDA. Data was obtained from shipping records, data bases, logbooks, research, and interviews with SDA operations personnel.

Subject: SDA waste identification
Keywords: SUBSURFACE DISPOSAL AREA / RWMC / LOW-LEVEL WASTE /
TRANSURANIC WASTE / ROCKY FLATS
Location: WAG-10 Data Repository

282. Voegeli, P. T., and Deutson, M., 1953, *Geology, Water Supply, and Waste Disposal at Sites II and IIa, Burial Ground D and Vicinity, National Reactor Testing Station, Idaho*, USGS, IDO-22027-USGS.

This report summarizes geology, water-supply, and waste disposal data for actual and potential construction sites at the INEL.

Subject: Facility siting
Keywords: GEOLOGY / HYDROLOGY / WASTE DISPOSAL / WATER SUPPLY
/ WELL CONSTRUCTION / DRAINAGE BASIN
Location: WAG-10 Data Repository

283. Walker, E. H., 1960, *Analysis of Aquifer Test, January 1958—June 1959, at the National Reactor Testing Station, Idaho*, USGS, IDO-22040-USGS.

This report summarizes the aquifer tests that were conducted on the INEL in 1958 and midyear 1959. Data collected provided specific capacity and transmissivity values for the wells. Water level measurements, well discharge, and atmospheric pressure measurements were made for each of the pump tests.

Subject: Pump tests at the INEL
Keywords: GROUNDWATER / HYDROLOGY / PUMPING TEST / ESRP
AQUIFER / DRAWDOWN / BASALT / TRANSMISSIVITY /
STORATIVITY
Location: WAG-10 Data Repository

284. Walton, J. C.; Rood, A. S.; Baca, R. G., and Otis, M. D., 1988, "Model for Estimation of Chlorinated Solvent Release from Waste Disposal Sites", *Journal of Hazardous Materials*, 21:15-34.

A mathematical model was developed to estimate the release and transport of chlorinate solvents from hazardous waste sites located in the vadose zone. The model formulation accounts for container degradation, interphase mass transfer, waste decomposition, soil temperature effects on physical and chemical properties of the waste, and mass transport through geologic media. Aqueous, nonaqueous, and vapor transport were considered. Calculations indicate the dominant transport mechanism is vapor diffusion to the surface and vadose zone.

Subject: Contaminant modeling at the INEL

Keywords: SURFICIAL SEDIMENTS / CARBON TETRACHLORIDE /
MACHINE OIL / TETRACHLOROETHYLENE /
TETRACHLOROETHYLENE / CHLOROFORM, 1,
1,1-TRICHLOROETHANE

Location: WAG-10 Data Repository

285. Walton, W. C., 1958, *Analysis of Aquifer Tests at the National Reactor Testing Station, Idaho, 1949-1957*, USGS, IDO-22034.

Report provides a summary of 49 pump tests conducted on INEL wells from 1949 to 1957. Determination of specific capacities and transmissivities and storativities are made. Range of hydraulic characteristics of the basalt are given.

Subject: Aquifer testing at the INEL

Keywords: GROUNDWATER / HYDROLOGY / PUMPING TEST /
DRAWDOWN / TRANSMISSIVITY/ STORATIVITY / BASALT

Location: WAG-10 Data Repository

286. Weeks, E. P., 1977, *Field Determination of Vertical Permeability to Air in the Unsaturated Zone*, USGS, Open File Report 77-346.

287. Weeks, E. P., 1978, *Field Determination of Vertical Permeability to Air in the Unsaturated Zone*, USGS, Professional Paper 1051.

288. Wegner, S. T., 1989, *Selected Quality Assurance Data for Water Samples Collected by the U.S. Geological Survey, Idaho National Engineering Laboratory, 1980 to 1988*, DOE, DOE/ID-22085,

Water sample analyses were conducted at six different laboratories between 1980 and 1988 to investigate agreement using descriptive statistics. The laboratory results showed a median agreement of 95 percent between all usable data pairs. Some samples could not be compared because analytical uncertainties were not consistently reported.

Subject: Groundwater properties at the INEL

Keywords: GEOCHEMISTRY / GROUNDWATER QUALITY /
RADIONUCLIDES / ORGANIC COMPOUNDS / TRACE METALS /
SPECIFIC CONDUCTANCE

Location: WAG-10 Data Repository

289. Westinghouse Idaho Nuclear Co., 1991, *CPP-66/06 Sampling and analysis Data Package*, WINCO and Golder and Associates, WINCO-91-01.

This is a collection of soil and water sample data from the area around the ICPP.

Subject: Groundwater properties at the INEL

Keywords: PERCHED GROUNDWATER / RADIONUCLIDES / GAMMA SCAN /
SEDIMENTARY INTERBED / BASALT / BIOXINS / FURANS /
HERBICIDES / METALS / PESTICIDES / PCB / ORGANIC
COMPOUNDS / SPECIFIC CONDUCTANCE / PH / TEMPERATURE /
TURBIDITY / ORGANIC COMPOUNDS / HYDROCARBONS /
SURFICIAL SEDIMENTS

Location:

290. Wickham, L. E., and Janke, D. H., 1980, *Annual Report—1979 Environmental Surveillance for the Idaho National Engineering Laboratory, Radioactive Waste Management Complex*, EG&G Idaho, Inc., EGG-2042, Idaho Falls, ID.

This report contains the monitoring data for 1979 for the RWMC. Atmospheric, hydrologic, geologic, and biotic environmental monitoring results are included. Non radiologic contaminants are also discussed.

Subject: Environmental monitoring at the INEL

Keywords: RWMC / ENVIRONMENTAL MONITORING / GROUNDWATER /
GEOLOGY / AIR QUALITY / BIOTIC / RADIONUCLIDES /
METALS

Location: WAG-10 Data Repository

291. Wood, T. R., 1989, *Preliminary Assessment of the Hydrology at the Radioactive Waste Management Complex, Idaho National Engineering Laboratory*, EG&G Idaho, Inc., Informal Report, EGG-WM-8694, Idaho Falls, ID.

This report provides a preliminary assessment of the hydrogeology at the RWMC. The data was used to evaluate the amount of effort and data required to adequately characterize the aquifer in the vicinity of the RWMC.

Subject: Geology and hydrology at the INEL

Keywords: RWMC / HYDROLOGY / GEOLOGY / GROUNDWATER
MOVEMENT

Location: WAG-10 Data Repository

292. Wood, T. R., 1989, *Test Area North Pumping Tests 1953-1987*, EG&G Idaho, Inc., EGG-WM-9668, Idaho Falls, ID.

This report provides an interpretation of the 1987 TAN pumping tests and summarizes the 1950's pumping tests. The 1950's tests of the TAN wells are discussed in a number of USGS documents.

Subject: Pump tests at the INEL

Keywords: GROUNDWATER / WATER TABLES / PUMPING TEST

Location: WAG-10 Data Repository

293. Wood, T. R., 1990, "Impact of Surface Water Recharge on the Design of a Groundwater Monitoring System for the Radioactive Waste Management Complex, Idaho National Engineering Laboratory," *Proceedings of the 1990 Annual Symposium on Engineering Geology & Geotechnical Engineering, Idaho State University.*

Characterization of the water levels in wells near the RWMC indicate that the flow direction changes with time. This is attributed to the diversion of water from the Big Lost River during high flow periods to the spreading area. The diverted water infiltrates and creates a groundwater mound changing the flow direction from south-southwest to east.

Subject: Groundwater properties at the INEL
Keywords: GROUNDWATER / HYDROLOGY / WATER TABLES
Location: WAG-10 Data Repository

294. Wood, T. R., 1991, *Ground Water Characterization Plan for the Subsurface Disposal Area, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Informal Report EGG-WM-9668, Idaho Falls, ID.*

Data from monitoring wells at the RWMC indicate ground water movement is dynamic, and the rate and direction of ground water flow is strongly influenced by diversion of water from the Big Lost River to spreading areas to the east and southwest of the facility. The regional ground water flow is from the north to the south-southwest. However, near the RWMC, a recharge mound from seepage from the INEL diversion area causes a change in the flow direction to south-southwest to east.

Subject: Groundwater properties at the INEL
Keywords: GROUNDWATER / AQUIFER RECHARGE / WATER TABLES / WATER DIVERSION
Location: WAG-10 Data Repository

295. Wood, T. R., 1991, *Impact of Surface Water Recharge on the Design of a Groundwater Monitoring System for the RWMC, INEL, EG&G Idaho, Inc., EGG-M-9016, Idaho Falls, ID.*

Measured water levels in wells penetrating the Snake River Plain Aquifer near the RWMC and the corresponding direction of flow show change over time. this change is related to water table mounding caused by recharge from excess water diverted from the Big Lost River for flood protection during high flows. Water levels in most wells near the RWMC rise on the order of 10 ft in response to recharge, with water in one well rising over 60 ft. Recharge changes the normal south-southwest direction of flow to the east.

Subject: Groundwater monitoring at the INEL

Keywords: GROUNDWATER / AQUIFER RECHARGE / WATER TABLES /
WELL HYDROGRAPH / WATER DIVERSION

Location: WAG-10 Data Repository

296. Wood, T. R.; Hull, L. C., and Doornbos, M. H., 1989, *Groundwater Monitoring Plan and Interim Status Report for Central Facilities Landfill III*, EG&G Idaho, Inc., Informal Report EGG-ER-8521, Idaho Falls, ID.

Provides a description of work completed and planned for Landfill III at CFA. The document contains: facility description, physiography, climatology, regional geology, groundwater hydrology, and drilling program.

Subject: CFA landfills

Keywords: GROUNDWATER / GEOLOGY / HYDROLOGY / DRILLING /
MONITORING / ESRP AQUIFER / WELL CONSTRUCTION

Location: WAG-10 Data Repository

297. Wood, T. R.; Hull, L. C., and Doornbos, M. H., 1989, *Groundwater Monitoring Plan and Interim Status Report for Central Facilities Landfill II*, EG&G Idaho, Inc., EGG-ER-8496, Idaho Falls, ID.

This document reports activities concerning the Groundwater Monitoring Plan for CFA Landfill II. This document provides description of Landfill II, and describes the work that has been conducted to date, the work which is planned to characterize the hydrogeology at the site. Selecting a post-closure option for Landfill II requires the implementation of a detection ground water monitoring system.

Subject: CFA landfills

Keywords: BOREHOLE / SOLID WASTE / CLIMATE / PHYSIOGRAPHY /
GEOLOGY / ESRP AQUIFER / TRANSMISSIVITY / STORAGE
COEFFICIENT / CONTAMINANT PLUMES / SPECIFIC
CONDUCTANCE / CHLORIDE / MONITORING / QUALITY
ASSURANCE / SURFICIAL SEDIMENTS / ORGANIC COMPOUNDS
/ ORGANIC COMPOUNDS / PCB / PAH / METALS

Location:

298. Wood, W. W., and Low, W. H., 1988, *Solute Geochemistry of the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon*, USGS Professional Paper 1408-D, USGS.

Four geochemical approaches were used to determine chemical reactions controlling solute concentrations in the Snake River Plain Regional Aquifer system: (1) calculations of a solute balance within the aquifer, (2) identification of weathered products in the aquifer framework, (3) comparison of thermodynamic mineral saturation indices with plausible solute reactions, and (4) comparison of stable-isotope ratios of the solutes with those in the

aquifer framework. Solutes in the geothermal groundwater system underlying the main aquifer were examined by calculating thermodynamic mineral saturation indices, stable-isotope ratios, geothermometry, and radiocarbon dating.

Subject: ESRP aquifer
Keywords: GEOCHEMISTRY / ESRP AQUIFER / WEATHERING /
SATURATION INDICES / STABLE ISOTOPES / GEOTHERMAL
Location: WAG-10 Data Repository

299. Yanskey, G. R.; Markee, E. G. Jr., and Richter, A. P., 1966, *Climatology of the National Reactor Testing Station*, AEC, IDO-12048.

Report contains information on site topography, climatology, calculations of atmospheric dispersion from site sources, persistence and extreme values of climatological parameters, and atmospheric transport.

Subject: Climatic conditions at the INEL
Keywords: CLIMATE / TOPOGRAPHY / AIR TEMPERATURE /
PRECIPITATION / WIND SPEED
Location: WAG-10 Data Repository

C.5 Keyword List^d

1,1,1-TRICHLOROETHANE: 170	ARA: 52
ACETONE: 229	AREAL EXTENT: 222
ACRYLONITRILE: 229	ARSENIC: 171, 229
AGE DATING: 11	ATTERBERG LIMITS: 200
AIR PERMEABILITY: 182	BACKGROUND: 3, 174
AIR QUALITY: 48, 72, 107, 108, 112, 131, 132, 133, 230, 231, 232, 258, 259, 260, 269, 270, 271, 272, 273, 278, 290	BACTERIA: 64
AIR TEMPERATURE: 221, 299	BAILER: 175
AIRBORNE WASTE: 57, 151, 214	BARIUM: 171
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Appendix D
Ecological Resources

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a. Parts of this appendix are being completed by EG&G Idaho and will be included in the next revision, which will provide more information on the ecology of the INEL and a section on wetlands.

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ACRONYMS

COE	U.S. Army Corps of Engineers
DOE	U.S. Department of Energy
EPA	Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service
GIS	geographical information system
GPS	global positioning system
INEL	Idaho National Engineering Laboratory
NWI	National Wetlands Inventory
RWMC	Radioactive Waste Management Complex

Appendix D

Ecological Resources

Section D.1 discusses the ecological characteristics at the Idaho National Engineering Laboratory (INEL) and provides a bioassessment of ecological conditions. Information on the flora and fauna are presented. Section D.2 presents a discussion of the habitat relationships between vegetative communities and animal species on the INEL.

Flora references in this appendix are generally made using scientific names since common names of plant species are not always available. For fauna references, the reverse is generally the case, with common names preceding the scientific names, which are in parentheses.

D.1 Ecological Setting

The INEL is a facility managed by the U.S. Department of Energy (DOE) and was originally established in 1949 as the National Reactor Testing Station. The INEL is one of five national environmental research parks established to provide protected lands for research and education in environmental sciences and to study the environmental impacts of energy development.

The INEL occupies approximately 2,305 km² (890 mi²) of the northwestern portion of the Eastern Snake River Plain in southeast Idaho. It is nearly 63 km (39 mi) long from north to south and about 58 km (36 mi) wide in its broadest southern portion (Figure 5-1). The INEL is bounded on the northwest by three major mountain ranges: Lost River, Lemhi, and Bitterroot. The remainder of the INEL is bounded by the Eastern Snake River Plain.

The surface of the INEL is a relatively flat, semiarid, sagebrush steppe desert, with some volcanic buttes and basalt flows. The average elevation of the INEL is 1,526 m, (5,000 ft) above sea level. A broad topographic ridge, which extends northward, effectively separates the drainage of mountain ranges northwest of the INEL from the Snake River. INEL soils are derived from silicic volcanic and Paleozoic rocks from nearby mountains and buttes and are underlain by basalt. In the southern part of the INEL, soils are gravelly to rocky and generally shallow; the northern portion is covered by lake and eolian deposits, mostly composed of unconsolidated clay, silt, and sand.

The continental climate of the area is characterized by large diurnal and seasonal temperature fluctuations. Winters are cold, with 2 to 3 months having mean temperatures below freezing. Topsoils usually remain frozen from mid-to-late November through mid-February or early March. Snow cover typically persists for two to three months or more. In summer, low humidities and clear skies result in a high temperature from 30 to 35°C (86 to 95°F) and high evaporative demand during the day and low temperatures at night. The average annual temperature is 5.4°C (41.7°F), and the frost-free period is about 90 days.

The area lies in the rain shadow of the numerous mountain ranges of south-central Idaho. Mean annual precipitation is 224 mm (8.74 in.). On average, over one-third of the precipitation falls early in the growing season during April, May, and June. Melting snow and spring rains account for virtually all of the annual recharge of moisture in the soil profile (Anderson et al. 1987).

Some areas within the boundaries of INEL are relatively undisturbed and provide important habitat for species native to the region. Several nuclear production facilities are located on the Site, and 60% of the Site is grazed by sheep and cattle (McBride et al. 1978).

D.1.1 Flora and Plant Communities

The INEL is within a cool desert ecosystem characterized by shrub-steppe communities. Sagebrush communities occupy the greater part of the INEL, but communities dominated by juniper, crested wheatgrass, and Indian ricegrass are also present.

Most of the natural vegetation at the INEL consists of a shrub overstory with an understory of perennial grasses and forbs. The most common shrub is Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) may dominate or be co-dominant with Wyoming big sagebrush on sites having deep soils or sand accumulations (Shumar and Anderson 1986). Communities dominated by big sagebrush occupy most of the central portions of the INEL. Green rabbitbrush (*Chrysothamnus viscidiflorus*) is the next most abundant shrub. Other common shrubs include winterfat (*Ceratoides lanata*), spiny hopsage [*Atriplex spinosa* (*Grayia spinosa*)], prickly phlox (*Leptodactylon pungens*), and gray rabbitbrush (*Chrysothamnus nauseosus*). Communities dominated by Utah juniper (*Juniperus osteosperma*), threetip sagebrush (*Artemisia tripartita*), and/or black sagebrush (*Artemisia nova*) are found along the periphery of the INEL on slopes of the buttes and foothills of adjacent mountain ranges.

At the lowest elevations, the rhizomatous thick-spiked wheatgrass (*Agropyron dasystachyum*) is the most abundant graminoid; bottlebrush squirreltail (*Sitanion hystrix*), Indian ricegrass (*Oryzopsis hymenoides*), and needle-and-thread (*Stipa comata*) are common bunchgrasses. Patches of creeping wildrye (*Elymus triticoides*) and western wheatgrass (*Agropyron smithii*) are locally abundant. Communities dominated by Great Basin wildrye (*Elymus cinereus*) are found in scattered depressions between lava ridges and in other areas having deep soils. Bluebunch wheatgrass (*Agropyron spicatum*) is quite rare at the lowest elevations but common on slightly higher elevations in the southwest and east of the INEL.

Unlike much of the sagebrush steppe region, which has a long history of livestock grazing, the INEL supports a high diversity of forbs. Because of the richness of native forbs and protection from grazing by domestic livestock, the INEL is an important reservoir of the genetic diversity of sagebrush steppe ecosystems, which occupy some 45 million ha of the Intermountain West (West 1983).

Flora and plant communities of the INEL have been studied and described by several researchers (see the Bibliography in Section D.4). Plant species for the INEL are listed on Table D-1. Substantial data and information for INEL flora exist. Vegetative communities of the INEL have been defined and were recently mapped and classified using LANDSAT Thematic Mapper imagery and field measurements from INEL vegetation plots (Rope et al. in press; Kramber et al. 1992; Anderson 1991).

An extensive survey for rare and endangered plant species was conducted by Cholewa and Henderson (1983, 1984) from 1980 to 1982. With the exception of vegetation communities associated with wetlands (see Section D.2.5.1), no additional surveys were conducted for rare and endangered species for this environmental impact statement. Current work being conducted by Idaho State University will provide additional information on the INEL communities and the status sensitive plant species.

D.1.1.1 Vegetation Mapping. Vegetation maps depicting major vegetation types at the INEL were prepared by Harniss and West (1973) and McBride et al. (1978). These maps are too general to adequately describe the spatial distribution of the INEL plant communities. Furthermore, no accuracy assessment of the maps is available, and some communities at the INEL may have changed significantly since the maps were produced (Anderson and Inouye 1988).

In 1990, a vegetation map was developed for the INEL to support environmental assessments, monitoring, and restoration activities (Rope et al. in press; Anderson 1991). The information provided by the map can be used to assess vegetation community characteristics, distributions, and habitat use. The methodology included principal component analysis of a multitemporal Landsat Thematic Mapper scene, and an unsupervised classification procedure (Kramber et al. 1992). Two to four field sample sites from each vegetation class were selected for field characterization. The field sample site coordinates were determined using a global positioning system (GPS) receiver.

The use of satellite imagery to map vegetation is based on the assumption that vegetation communities have unique spectral properties. In arid regions where vegetation is sparse, however, the spectral signature of an area may depend largely on the spectral characteristics of the soil surface and/or the shadows cast by individual trees or shrubs (Tueller 1987; Smith and Nowak 1990). To the extent that soil spectral properties and vegetation are not related, we can expect limits on the ability to map vegetation using satellite imagery.

D.1.1.2 INEL Vegetation Communities Classification. Twenty-two vegetation communities were recognized as a result of the field work to support the 1990 vegetation mapping effort (Anderson 1991); some were represented by a single sample plot and may not be representative of a recognizable plant community type. The 15 vegetation cover classes that were recognized as a result of the vegetation mapping effort are discussed below (Table D-2). Some vegetation cover classes consist of several similar plant communities. Combining these communities was necessary because they have similar spectral signatures and could not be differentiated using the satellite data available.

Appendix D ♦ D-4

Table D-1. Plant species of the INEL.

Family

Genus species, Common Name

Aceraceae, Maple Family

Acer glabrum Torr., Rocky Mountain Maple
Acer negundo L., Box Elder

Alismaceae, Water Plantain Family

Alisma gramineum Gmel., Water Plantain

Amaranthaceae, Amaranth Family

Amaranthus albus L., White Pigweed
Amaranthus californicus (Moq.) Wats., California Amaranth
Amaranthus hybridus L., Pigweed
Amaranthus retroflexus L., Redroot

Anacardiaceae, Sumac Family

Rhus trilobata Nutt., Squawbush, Skunkbush

Apocynaceae, Dogbane Family

Apocynum cannabinum L., Dogbane

Asclepiadaceae, Milkweed Family

Asclepias speciosa Torr., Showy Milkweed, Greekweed

Betulaceae, Birch Family

Betula occidentalis Hook., Western Water Birch

Boraginaceae, Borage Family

Amsinckia menziesii (Lehm.) Nels. and Macb., Small-flowered Fiddleneck
Asperugo procumbens L., Catchweed, Madwort
Cryptantha ambigua (Gray) Greene, Obscure Cryptantha
Cryptantha circumsicissa (H. and A.) Johnst., Matted Cryptantha
Cryptantha fendleri (Gray) Greene, Fendler's Cryptantha
Cryptantha interrupta (Greene) Pays., Bristly Cryptantha
Cryptantha kelseyana Greene, Kelsey's Cryptantha
Cryptantha scoparia Nels, Desert Cryptantha
Cryptantha watsoni, Watson's Cryptantha
Hackelia jessicae (McGregor) Brand, Blue Stickseed, Wild Forget-Mc-Not
Lappula echinata Gilib., Stick-tights, Beggar Ticks
Lappula redowskii (Hornem.) Greene, Western Stickseed, Beggar's Ticks

Table D-1. (continued).

Family

Genus species, Common Name

Boraginaceae, Borage Family (cont.)

Lithospermum ruderale Dougl., Gromwell, Western Gromwell, Columbia Puccoon
Mertensia oblongifolia (Nutt.) G. Don, Leafy Bluebells
Myosotis laxa Lehm., Small-flowered Forget-Me-Not

Cactaceae, Cactus Family

Opuntia polyacantha Haw., Starvation Cactus, Prickly Pear

Capparidaceae, Caper Family

Cleome lutea Hook., Yellow Bee Plant

Caprifoliaceae, Honeysuckle Family

Sambucus cerulea Raf., Elderberry
Symphoricarpos oreophilus Gray., Snowberry

Caryophyllaceae, Pink Family

Arenaria congesta Nutt., Capitulate Sandwort, Ballhead Sandwort
Arenaria franklinii Dougl., Franklin's Sandwort
Arenaria kingii M. E. Jones, King's Sandwort
Arenaria nuttallii Pax., Nuttall's Sandwort
Lychnis apetala L., Catchfly, Campion
Silene douglasii Hook., Catchfly, Wild Pink
Silene menziesii Hook., Catchfly, Wild Pink

Chenopodiaceae, Goosefoot Family

Atriplex canescens (Pursh) Nutt., Wingscale
Atriplex confertifolia, Shadscale, Spiny Saltbush
Atriplex nuttallii, Saltsage, Moundscale
Atriplex rosea, Red Orache
Atriplex spinosa (Hook.) Collotzi, Spiny Hopsage
Chenopodium album L., White Goosefoot, Lamb's Quarter, White Pigweed
Chenopodium fremontii Wats., Fremont's Goosefoot
Chenopodium leptophyllum (Mog.) Wats., Slimleaf Goosefoot, Lamb's Quarter
Chenopodium rubrum L., Red Goosefoot
Eurotia lanata (Pursh) Mog., Winterfat, White Sage, Winter Sage
Halogeton glomeratus C. A. Meyer, Halogeton
Kochia scoparia (L.) Schrad., Summer Cypress, Red Belvedere
Monolepis nuttalliana (Schultes) Greene, Povertyweed, Prostrate Monolepis
Salsola kali L., Windwitch, Tumbleweed, Russian Thistle
Sarcobatus vermiculatus (Hook.) Torr., Greasewood, Chico

Table D-1. (continued).

Family

Genus species, Common Name

Asteraceae, Composite or Sunflower Family

Achillea millefolium L., Common Yarrow
Agoseris glauca (Pursh) Raf., False Dandelion
Agoseris retrorsa (Benth.) Greene, Spear-leaved Agoseris
Ambrosia artemisiifolia L., Ragweed
Antennaria dimorpha, Dwarf Pussy-toes, Low Pussy-toes
Antennaria microphylla Rydb., Rosy Pussy-toes
Arctium minus (Hill) Bernh., Common Burdock
Arnica cordifolia hook, Heart-leaved Arnica
Artemisia arbuscula Nutt., Low Sage, Dwarf Sage
Artemisia biennis Willd., Biennial Wormwood
Artemisia drancunculus L., Dragon Sage
Artemisia frigida Willd., Pasture Sagebrush, Fringed Sagebrush
Artemisia ludoviciana Nutt., Silver Sage, Prairie Sage
Artemisia spinescens Eat., Spiny Sage
Artemisia tridentata Nutt., Big Sage
Artemisia tripartita Rydb., Threetip Sage
Aster scopulorum Gray, Crag Aster, Lava Aster
Balsamorhiza hookeri Nutt., Hooker's Balsamroot
Balsamorhiza sagittata (Pursh) Nutt., Arrowleaf Balsamroot
Bidens cernua L., Nodding Beggar-ticks
Carduus nutans L., Musk Thistle, Milk Thistle
Centaurea maculosa Lam., Spotted Knapweed
Centaurea repens L., Russian Knapweed
Chaenactis douglasii (Hook.) H. and A., Hoary False-yarrow
Chrysothamnus nauseosus (Pall.) Britt., Gray Rabbit brush
Chrysothamnus vicidiflorus (Hook.) Nutt., Green Rabbit-brush
Cirsium arvense (L.) Scop., Canada Thistle, Creeping Thistle
Cirsium magnificum (A. Nels.) Petrah., Showy Thistle
Cirsium subniveum Rydb., Jackson's Hole Thistle
Cirsium utahense Petr., Utah Thistle
Cirsium vulgare (Savi) Airy-Shaw, Bull-Thistle
Conyza canadensis (L.) Cronq., Horseweed, Canada Fleabane
Conyza floribunda H. B. K. Nov., Horseweed
Crepis acuminata Nutt., Longleaved Hawksbeard
Crepis atrabarba Heller, Slender Hawksbeard
Crepis barbigera Leib., Bearded Hawksbeard
Crepis modocensis Greene, Low Hawksbeard
Crepis occidentalis Nutt., Western Hawksbeard
Erigeron caespitosus Nutt., Tufted Fleabane, Gray Daisy
Erigeron corymbosus Nutt., Longleaf Fleabane
Erigeron gabellus Nutt. - Fleabane Daisy
Erigeron pumilus Nutt. - Shaggy Fleabane
Gnaphalium palustre Nutt. - Lowland Cudweed, Everlasting
Grindelia squarrosa (Pursh) Dunal - Gumweed, Resin-Weed

Table D-1. (continued).

Family

Genus species, Common Name

Asteraceae, Composite or Sunflower Family (cont.)

Gutierrezia sarothrae (Pursh) Britt. and Rusby, Matchbrush, Broom Shrub, Snakeweed
Haplopappus resinosus (Nutt.) Gray, Columbia Goldenweed
Haplopappus acaulis (Nutt.) Gray, Stemless Goldenweed, Strawflower
Helenium autumnale L., Sneezeweed
Helianthus annuus L., Annual Sunflower, Common Sunflower
Helianthus petiolaris Nutt., Prairie Sunflower
Hymenopappus filifolius Hook., Hymenopappus
Iva axillaris Pursh, Poverty Weed
Iva xanthifolia Nutt., Tall Marsh Elder
Lactuca pulchellus (Pursh) D. C., Blue Lettuce
Lactuca serriola L., Prickly Wild Lettuce
Lygodesmia grandiflora (Nutt.) T. and G., Skeleton Weed, Rush Pink
Lygodesmia spinosa Nutt., Spiny Skeleton Weed
Machaeranthera canescens (Pursh) Gray, Hoary Aster
Matricaria maritima L., Scentless May-Weed
Scenecio canus Hook., Woolly Groundsel
Scenecio integrimus Nutt., Western Groundsel, One-stemmed Butterweed
Senecio serra Hook., Tall Butterweed
Senecio vulgaris L., Common Groundsel
Solidago canadensis L., Canada Goldenrod, Meadow Goldenrod
Solidago occidentalis (Nutt.) T. and G., Goldenrod, Western Goldenrod
Sonchus asper (L.) Hill, Prickly Sow Thistle
Stephanomeria exigua Nutt., Small Wirelettuce
Stephanomeria tenuifolia (Torr.) Hall, Narrow-leaved Skeletonweed, Wirelettuce
Tanacetum vulgare L., Tansey, Common Tansey
Taraxacum officinale Webber, Common Dandelion
Tetradymia canescens D. D., Gray Horsebrush
Tetradymia spinosa H. and A., Spiny Horsebrush
Townsendia florifer (Hook.) Gray, Showy Townsendia
Tragopogon dubius Scop., Goat's Beard, Yellow Salsify
Xanthium strumarium L., Common Cocklebur

Brassicaceae, Mustard Family

Alyssum desertorum Stapf., Desert Alyssum
Arabis cobrensis Jones, Cobre Rockcress
Arabis holboellii Hornem., Holboell's Rockcress
Arabis lignifera A. Nels., Rockcress, Woody-branched Rockcress
Arabis microphylla Nutt., Littleleaf Rockcress
Arabis nuttallii Robin, Rockcress, Nuttall's Rockcress
Bassica juncea (L.) Coss., Chinese Mustard
Capsella bursa-pastoris (L.) Medic, Shepherd's Purse
Chorispora tenella (Pall.) D. C., Purple Carpet, Purple Mustard, Blue Mustard

Appendix D ♦ D-8

Table D-1. (continued).

Family

Genus species, Common Name

Brassicaceae, Mustard Family (cont.)

Descurainia pinnata (Walt.) Britt., Western Tansey Mustard
Descurainia sophia (L.) Webb., Tansey-mustard, Flixweed
Draba obligosperma Hook. var. *oligosperma*, Whitlow Grass
Erysimum inconspicuum (Wats.) McMillan, Wallflower, Small Wallflower
Lepidium densiflorum Schard., Peppergrass, Common Peppergrass
Lepidium perfoliatum L., Pepperweed, Claspig Peppergrass
Lepidium virginicum L., Peppergrass, Tall Peppergrass
Lesquerella ludoviciana (Nutt.) Watts., Silvery Bladderpod
Phoenicaulis cheiranthoides Nutt., Daggerpod
Rorippa curvisiliqua (Hook.) Bessey, Yellow watercress, Marsh Yellowcress
Rorippa islandica (Oed.) Borbas, Yellow watercress, Marsh Yellowcress
Rorippa obtusa (Nutt.) Britt., Yellow Watercress, Blunt-leaved Yellowcress
Schoenocrambe linifolia (Nutt.) Greene, Perennial Mustard, Flaxleaved Plains Mustard
Sisymbrium altissimum L., Jim Hill Mustard, Tumbleweed Mustard
Sisymbrium loeselii L., Loesel Tumbleweed
Stanleya viridiflora Nutt., Prince's Plume, Perennial Stanleya
Thelypodium laciniatum (Hook.) Endl., Thick-leaved Thelypody
Thlaspi arvense L., Penny-cress, Fanweed

Convolvulaceae, Morning Glory Family

Convolvulus arvensis L., Field Morning Glory, Small Bindweed

Cornaceae, Dogwood Family

Cornus stolonifera Michx., Red-stemmed Dogwood, Red-osier Dogwood

Crassulaceae, Stonecrop Family

Sedum stenopetalum Pursh, Wormleaf Stonecrop

Cupressaceae, Cypress Family

Juniperus osteosperma (Torr.) Little, Utah Juniper
Juniperus scopulorum Sarg., Rocky Mountain Juniper

Cyperaceae, Sedge Family

Carex douglasii, Douglas Sedge
Eleocharis palustris (L.) R. and S., Spikerush, Common Spikerush, Creeping Spikerush
Scirpus acutus Muhl., Hardstem Bulrush
Scirpus maritimus L., Seacoast Bulrush

Table D-1. (continued).

Family

Genus species, Common Name

Euphorbiaceae, Spurge Family

Euphorbia esula L., Esula spurge*Euphorbia glyptosperma* Engelm., Corrugate-seeded Spurge

Gentianaceae, Gentian Family

Fraseria albicaulis Dougl., White-stemmed Fraseria

Poaceae, Grass Family

Agropyron x Elymus, Wheatgrass/Ryegrass Cross*Agropyron caninum* (L.) Beauv., Awned Wheatgrass, Bearded Wheatgrass*Agropyron cristatum* (L.) Gaerth., Crested Wheatgrass*Agropyron dasystachyum* (Hook.) Scribn., Thickspike Wheatgrass*Agropyron smithii* Rydb., Western Wheatgrass*Agropyron spicatum* (Pursh) Scribn. and Smith, Bluebunch Wheatgrass*Agrostis alba* L., Bentgrass*Alopecurus aequalis* Sobol., Shortawn Foxtail, Little Meadow-Foxtail*Aristida fendleriana* Stend., Three-awn*Beckmannia syzigachne* (Steud.) Fern., Slough Grass*Bromus carinatus* Hook. and Arn., California Bromegrass*Bromus inermis* Leys., Smooth Bromegrass*Bromus tectorum* L., Cheatgrass, Downy Chess, June Grass*Dactylis glomerata* L., Orchard Grass*Distichlis stricta* (Torr.) Rydb., Desert Saltgrass*Echinochloa crusgalli* (L.) Beauv., Barnyard Grass*Elymus ambiguus* Vasey and Scribn., Ryegrass*Elymus cinereus* Scribn. and Merrill, Giant Wildrye*Elymus flavescens* Scribn. and Smith, Golden Wildrye*Elymus triticoides* Buckl., Creeping Wildrye, Beardless Wildrye*Festuca idahoensis* Elmer, Idaho Fescue*Festuca octoflora* Walt., Six-weeks fescue*Glyceria grandis* Wats., American Mannagrass*Hesperochloa kingii* (Wats.) Rydb., Spike Fescue*Hordeum jubatum* L., Foxtail Barley*Koeleria cristata* Pers., Prairie June Grass*Melica bulbosa* Geyer, Oniongrass*Oryzopsis hymenoides* (R. and S.) Ricker, Indian Ricegrass*Panicum capillare* L., Witchgrass, Panic grass*Phalaris arundinacea* L., Reed Canary Grass*Phleum pratense* L., Timothy, Common Timothy

Appendix D ♦ D-10

Table D-1. (continued).

Family

Genus species, Common Name

Poaceae, Grass Family (cont.)

Poa bulbosa L., Bulbous Bluegrass
Poa fendleriana (Steud.) Vasey, Muttongrass
Poa nevadensis Vasey, Nevada Bluegrass
Poa pratensis L., Kentucky Bluegrass
Poa sandbergii Vasey, Sandberg's Bluegrass
Poa scabrella (Thurb.) Benth., Pine Bluegrass
Setaria viridis (L.) Breauv., Green Bristle-grass
Sitanion hystrix (Nutt.) J. G. Smith, Bottlebrush, Squirreltail
Sporobolus cryptandrus (Torr.) Gray, Western Dropseed
Stipa commata Trin. and Rupr., Needle-and Thread Grass
Stipa occidentalis Thurb., Western Needlegrass
Stipa thurberiana Piper, Thurber's Needlegrass
Triticum aestivum L., Common Wheat

Grossulariaceae, Currant or Gooseberry Family

Ribes aureum Pursh., Golden Current
Ribes cereum Dougl., Squaw Currant
Ribes setosum Lindl., Gooseberry, Missouri Gooseberry

Hydrophyllaceae, Waterleaf Family

Hesperochiron californicus (Benth.) Wats., California Hesperochiron
Hesperochiron pumilus (Griseb.) Porter, Dwarf Hesperochiron
Phacelia glandifera Piper, Glandular Phacelia
Phacelia glandulosa Nutt., Silky Phacelia
Phacelia hastata Dougl., Silverleaf Phacelia
Phacelia humilis T. and G., Low Phacelia

Iridaceae, Iris Family

Sisyrinchium angustifolium Mill, Blue-eyed-grass, Blue star

Juncaceae, Rush Family

Juncus balticus Willd., Baltic Rush

Labiatae, Mint Family

Agastache cusikii (Greene) Heller, Horsemint
Agastache urticifolia (Benth.) Kuntze, Giant Hyssop
Mentha arvensis L., Field Mint

Table D-1. (continued).

Family

Genus species, Common Name

Leguminosae, Pea Family

Astragalus agrestis Dougl., Purple Milkvetch
Astragalus calycosa Torr., Matted Milkvetch
Astragalus canadensis L., Canada Milkvetch
Astragalus ceramicus Sheld., Painted Milkvetch
Astragalus cibarius Sheld., Browse Milk-vetch
Astragalus convallarius Greene, Lesser Rushy Milkvetch
Astragalus curvicaupus (A. Hell.) Macbr., Curvepod Milkvetch
Astragalus filipes Torr., Basalt Milkvetch, Threadstock Milkvetch
Astragalus lentiginosus Dougl., Freckled Milkvetch
Astragalus miser Dougl., Weedy Milkvetch
Astragalus purshii Dougl., Loco Weed, Woolly-pod Milkvetch
Astragalus terminales Wats., Railhead Milkvetch
Glycyrrhiza lepidota Pursh., Licorice, Licorice-root
Hedysarum occidentale Nutt., Western Hedysarum
Lupinus argenteus Pursh, Silvery Lupine
Lupinus pusillus Pursh, Tiny Peavine
Lupinus sericeus, Silky Lupine
Lupinus wyethii Wats., Wyeth's Lupine
Medicago lupulina L., Black Medic, Hop Clover
Medicago sativa L., Alalfa
Melilotus alba Desr., White Sweet Clover
Melilotus officinalis (L.) Lam., Common Yellow Sweet Clover
Oxytropis lagopus Nutt., Rabbit-foot Crazyweed
Oxytropis sericea Nutt., Silky Crazyweed
Petalostemum ornatum Dougl., Western Prairie Clover
Psoralea lanceolata Pursh., Lance-leaved Scurf-pea
Thermopsis montana Nutt., Mountain Thermopsis, False-Lupine, Buck-bean
Trifolium pratense L., Red Clover
Trifolium repens L., White Clover, Dutch Clover
Vicia sativa L., Common Vetch

Liliaceae, Lily Family

Allium acuminatum Hook., Hooker's Onion
Allium geyeri Wats., Geyer's Onion
Allium textile Nels. and Macbr., Textile Onion
Calochortus brueaunis Nels. and Macbr., Mariposa Lily
Calochortus macrocarpus Dougl., Sagebrush Mariposa, Green-banded Star-Tulip
Fritillaria atropurpurea Nutt., Leopard Lily
Fritillaria pudica (Pursh.) Spreng., Yellowbell, Fritillary
Smilacina stellata (L.) Desf., False Solomon's Seal
Zigadenus paniculatus (Nutt.) Wats., Foothills Death-Camas
Zigadenus venenosus Wats., Death-Camas, Meadow Death-Camas

Appendix D ♦ D-12

Table D-1. (continued).

Family

Genus species, Common Name

Loasaceae, Blazing-Star Family

Mentzelia albicaulis Dougl., White-Stemmed Mentzelia, Little Blazing-Star
Mentzelia laevicaulis (Dougl.) T. and G., Blazing-Star

Malvaceae, Mallow Family

Sphaeralcea munroana (Dougl.) Spach., White-stemmed Globemallow

Marsileaceae, Pepperwort Family

Marsilea vestita Hook and Grev., Pepperwort, Clover-fern

Nyctaginaceae, Four-o'clock Family

Abronia mellifera Dougl., Sand Verbena, White Sand Verbena

Onagraceae, Evening-primrose Family

Epilobium angustifolium L., Fireweed, Blooming Sally
Epilobium paniculatum Nutt., Autumn Willow-Herb, Tall Annual Willow-Herb
Epilobium watsonii Barbey, Watson's Willow-Herb
Gayophytum nuttallii T. and G., Nuttall's Gayophytum
Gayophytum racemosum T. and G., Racemed Groundsmoke
Gayophytum ramosissimum Nutt., Hairstem Gayophytum
Oenothera andina Nutt., Obscure Evening Primrose
Oenothera biennis L., Common Evening Primrose
Oenothera caespitosa Nutt., Evening Primrose
Oenothera minor (A. Nels) Munz, Small Flowered Evening Primrose
Oenothera pallida Lindl., White-stemmed Evening Primrose
Oenothera scapoidea Nutt., Naked-stemmed Evening Primrose

Orchidaceae, Orchid Family

Corallorhiza maculata Raf., Spotted Coral-Root

Orobanchaceae, Broomrape Family

Orobanche californica Cham. and Schlecht., California Broomrape
Orobanche fasciculata Nutt., Clustered Broomrape

Pinaceae, Pine Family

Pinus contorta Dougl., Lodgepole Pine
Pinus flexilis James, Limber Pine
Pseudotsuga menziesii (Mirbel.) Franco, Douglas Fir

Table D-1. (continued).

Family

Genus species, Common Name

Plantaginaceae, Plantain Family

Plantago major L., Common Plantain*Plantago patagonica* Jacq., Desert Plantain, India-wheat

Polemoniaceae, Phlox Family

Collomia linearis Nutt., Narrow-leaf Collomia*Eriastrum sparsiflorum* (Eastw.) Mason, Few-Flowered Eriastrum*Gilia aggregata* (Pursh) Spreng., Scarlet Gilia*Gilia congesta* Hook., Many-flowered Gilia*Gilia leptomeria* Gray, Great Basin Gilia*Gilia minutiflora* Benth., Small Flowered Gilia*Gilia sinuata* Doug. 1, Sinuate Gilia*Gymnosteris nudicaulis* (H. and A.) Greene, Large Flowered Gymnosteris*Gymnosteris parvula* (Rydb.) Heller, Small-flowered Gymnosteris*Langloisia setosissima* (T. and G.) Greene, Bristly Langloisia*Leptodactylon pungens* (Torr.) Nutt., Prickly Phlox*Leptodactylon watsoni* (Gray) Rydb., Watson's Prickly Phlox*Linanthus septentrionalis* Mason, Northern Linanthus*Phlox aculeata* A. Nels., Prickly-Leaved Phlox*Phlox hoodii* Rich., Hood's Phlox*Phlox longifolia* Nutt., Longleaf Phlox

Polygonaceae, Buckwheat Family

Eriogonum caespitosum Nutt., Mat Buckwheat*Eriogonum cernuum* Nutt., Nodding Buckwheat*Eriogonum heracleoides* Nutt., Parsnip-flowered Buckwheat*Eriogonum mancum* Rydb., Imperfect Buckwheat*Eriogonum marifolium* T. and G., Slender Bush Buckwheat*Eriogonum microthecum* Nutt., Shrubby Buckwheat*Eriogonum ovalifolium* Nutt., Cushion Buckwheat*Eriogonum umbellatum* Torr., Sulfurflower Buckwheat*Oxytheca dendroidea* Nutt., Oxytheca*Polygonum aviculare* L., Doorweed, Prostrate Knotweed*Polygonum persicaria* L., Heartweed, Spotted Ladysthumb*Polygonum ramosissimum* Michx., Yellow Flowered Knotweed*Rumex crispus* L., Curley Dock*Rumex salicifolius* Weinm., Willow-leaved Dock*Rumex maritimus* L., Seaside Dock*Rumex venosus*, Wild Begonia

Polypodiaceae, Common Fern Family

Woodsia oregana D. C. Eat., Woodsia (Fern)

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Table D-1. (continued).

Family

Genus species, Common Name

Ranunculaceae, Buttercup Family

Aquilegia formosa Fisch., Red Columbine
Clematis ligusticifolia Nutt., Virgin's Bower
Delphinium andersonii Gray, Desert Larkspur
Delphinium nuttallianum Pritz., Upland Larkspur
Ranunculus andersonii Gray, Anderson Buttercup
Ranunculus aquatilis L., Water Crowfoot
Ranunculus cymbalaria Pursh, Shore Buttercup
Ranunculus glaberrimus Hook., Sagebrush Buttercup
Ranunculus macounii Britt., Macoun's Buttercup
Ranunculus testiculatus Crantz., Bur Buttercup

Rhamnaceae, Buckthorn Family

Ceanothus velutinus L., Snowbrush, Mountain Laurel

Rosaceae, Rose Family

Amelanchier alnifolia Nutt., Western Serviceberry
Cercocarpus ledifolius Nutt., Mountain Mahogany
Chamaebatiaria millefolium (Torr.) Maxim., Fernbrush, Tanseybush
Geum macrophyllum Willd., Large-leaved Avens
Holodiscus dumosus (Hook.) Heller, Ocean Spray
Physocarpus alternans (M. E. Jones) J. T. Howell, Ninebark
Potentilla anserina L., Common Silverweed
Potentilla biennis Greene, Biennial Cinquefoil
Potentilla norvegica L., Norwegian Cinquefoil
Prunus virginiana L., Common Chokecherry
Purshia tridentata (Pursh) D. C., Bitterbrush, Antelope-brush
Rosa woodsii Lindl., Wood's Rose
Rubus ideaus L., Red Raspberry

Rubiaceae, Madder Family

Galium bifolium Wats., Thin-leaved Bedstraw
Galium multiflorum Kell., Shrubby Bedstraw

Salicaceae, Willow Family

Populus angustifolia James, Narrow-leaved Cottonwood
Populus tremuloides Michx., Quaking Aspen
Salix exigua Nutt., Western Sandbar Willow
Salix lasiandra Benth., Whiplash Willow
Salix phylicifolia L., Tea-leaved Willow
Salix scouleriana Barratt, Scouler's Willow

Table D-1. (continued).

Family

Genus species, Common Name

Santalaceae, Sandalwood Family

Comandra umbellata (L.) Nutt., False Toadflax

Saxifragaceae, Saxifrage Family

Heuchera parvifolia Nutt., Common Alumroot*Lithophragma bulbifera* Rydb., Star Flower*Lithophragma parviflora* (Hook.) Nutt., Star Flower

Scrophulariaceae, Figwort Family

Castilleja angustifolia (Nutt.) G. Don., Desert Paintbrush*Castilleja longispica* A. Nels., White Paintbrush*Collinsia parviflora* Lindl., Blue-eyed Mary*Cordylanthus ramosus* Nutt., Bushy Birdbeak*Limosella aquatica* L., Mudwort*Linaria dalmatica* (L.) Mill., Dalmation Toadflax*Linaria vulgaris* Hill, Butter-and-eggs*Purshia tridentata* (Pursh) D. C., Bitterbrush, Antelope-brush*Mimulus breviflorus* Piper, Short Flowered Monkey Flower*Minulus nanus* H. and A., Purple Monkey Flower*Penstemon cyaneus* Pennell, Dark-blue Penstemon*Penstemon deustus* Dougl., Hot-rock Penstemon*Penstemon humilis* Nutt., Lowly Penstemon*Penstemon pumilus* Nutt., Dwarf Penstemon*Penstemon radicosus* A. Nels, Matroot Penstemon*Verbascum thapsus* L., Common Mullein, Hairy Mullein*Veronica americana* Schewin., American Brookline, Speedwell*Veronica anagallis-aquatica* L., Water Speedwell

Solanaceae, Nightshade Family

Hyoscyamus niger L., Black Henbane*Nicotiana attenuata* Torr., Coyote Tobacco*Solanum dulcamara* L., Bittersweet

Typhaceae, Cattail Family

Typha latifolia L., Common Cattail

Umbelliferae, Parsley Family

Cymopterus acaulis (Pursh) Raf., Biscuit-Root*Cymopterus terebinthinus* (Hook.) T. and G., Turpentine Cymopterus

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Table D-1. (continued).

Family

Genus species, Common Name

Umbelliferae, Parsley Family

Lomatium dissectum (Nutt.) Math. and Const., Fern-leaved Desert Parsley

Lomatium foeniculaceum (Nutt.) Coult. and Rose, Fennel-leaved Desert Parsley

Lomatium triternatum (Pursh) Coult. and Rose, Nine-leaf Lomatium

Osmorhiza chilensis H. and A., Sweet Cicely

Urticaceae, Nettle Family

Urtica dioica L., Stinging Nettle

Verbenaceae, Verbena Family

Purshia tridentata (Pursh) D. C., Bitterbrush, Antelope-brush

Verbena bracteata Lag. and Rodg., Bracted Verbena

Violaceae, Violet Family

Viola nuttallii Pursh., Yellow Violet

Table D-2. Description of vegetative covers on the INEL.

Name	Description
Juniper Woodlands	<p><i>Juniperus osteosperma</i> (Utah juniper) typically dominate this cover class; however, some areas containing junipers are dominated by <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> and <i>Artemisia nova</i>. Even when not dominant, these two species were also very abundant on other juniper stands. The areas used to characterize this community indicate that there is not a single species association characterized by the presence of juniper.</p> <p>The "Lava" and the "Sagebrush/Low Sagebrush/Rabbitbrush on Lava" cover classes may occasionally have juniper trees associated with them. These individual or sparsely associated trees provide nesting sites for raptors and can be important habitat for other organisms.</p>
Native Grasslands Communities	
Great Basin Wildrye	<p>This cover class includes nearly pure stands of <i>Elymus cinereus</i> (Great Basin wildrye) that occur on low lying areas between lava ridges where deep soils accumulate. <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> and <i>Chrysothamnus viscidiflorus</i> or <i>Chrysothamnus nauseosus</i> are typically present. <i>Descurainia sophia</i> is common in the understory. Some other native grasslands will occasionally be confused with this class on the vegetation map (see next 2 groups).</p>
Steppe (bunchgrass)	<p>This cover class includes areas dominated by native bunchgrasses such as <i>Sitanion hystrix</i> or <i>Stipa comata</i>. The annuals <i>Bromus tectorum</i> and <i>Sisymbrium altissimum</i> are common and codominants in some areas.</p>
Grassland	<p>This cover class is dominated by rhizomatous species (e.g. <i>Agropyron dasystachyum</i> and <i>Carex douglasii</i>). They are characterized by the abundance of native graminoids and a sparse cover of shrubs. Common dominants include <i>Agropyron dasystachyum</i>, <i>Carex douglasii</i>. The annuals <i>Bromus tectorum</i>, <i>Lappula redowski</i>, <i>Descurainia pinnata</i>, and <i>Sisymbrium altissimum</i> are common in some areas.</p>
Big Sagebrush Communities	
Sagebrush-Steppe off Lava	<p>This cover class is similar to the Sagebrush-Steppe on Lava class described below except that the communities are located off the lava flow that covers the central area of the INEL. These areas typically have deeper soils and are associated with the flood plain, alluvium deposits, sand dunes, or deposition zones for wind blown materials.</p>

Table D-2. (continued).

Name	Description
Sagebrush-Steppe on Lava	This cover class is characterized by the dominance of <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> (Wyoming big sagebrush) and <i>Artemisia tridentata</i> ssp. <i>tridentata</i> (basin big sagebrush) and are located on the large lava flow that covers much of the INEL. The two primary communities addressed by this cover class are described below.
Basin Big Sagebrush Steppe	This community is characterized by the dominance of <i>Artemisia tridentata</i> ssp. <i>tridentata</i> (basin big sagebrush). The differential distributions of <i>Artemisia tridentata</i> ssp. <i>tridentata</i> and <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> at the INEL are related to gradients of soil texture (Shumar and Anderson 1986). <i>Artemisia tridentata</i> ssp. <i>tridentata</i> occurs on sandy soils that are often deep and well drained, whereas <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> is dominant on fine-textured, shallower soils having limited depths of water penetration. At the INEL, pockets of <i>Artemisia tridentata</i> ssp. <i>tridentata</i> within extensive stands of <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> occur on the lee sides of lava ridges where sand accumulates; additionally, extensive patches of <i>Artemisia tridentata</i> ssp. <i>tridentata</i> as large as 65 km ² occur, mostly on the eastern half of the area (Shumar 1983). Aside from the dominance of <i>Artemisia tridentata</i> ssp. <i>tridentata</i> , these communities do not have a unique species composition. Rather, they share the suite of subordinate species found in the other big sagebrush communities. Transitional stands co-dominated by both subspecies of big sagebrush are common between stands dominated by one subspecies or the other. It appears unlikely that it will be possible to separate communities dominated by the two the subspecies of <i>Artemisia tridentata</i> using Landsat imagery.
Wyoming Sagebrush Steppe	This community is characterized by the dominance of <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> (Wyoming big sagebrush). It is similar to the Basin Big Sagebrush Steppe community described above, except that native perennial bunchgrasses are much more abundant in these areas. <i>Bromus tectorum</i> was rare or absent, in contrast to the Basin Big Sagebrush Steppe community. <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> and <i>Chrysothamnus viscidiflorus</i> were dominants, but the combined cover of perennial bunchgrasses was similar to that of the shrubs.

Table D-2. (continued).

Name	Description
Sagebrush-Winterfat	Most of these areas are dominated by <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> ; <i>Ceratoides lanata</i> is present on these areas and often abundant. It is dominant or co-dominant on a few areas. <i>Chrysothamnus viscidiflorus</i> is common, as are members of the suite of native perennial grasses, especially <i>Oryzopsis hymenoides</i> . Native forbs are abundant. <i>Bromus tectorum</i> was not recorded on any of these areas. Most of these areas appear to be intermediate between the Salt Desert Shrub and Sagebrush/Rabbitbrush communities. This may reflect a gradient from upland loess soils to the more halomorphic lacustrine soils of prehistoric Lake Terretion. Native grasses are abundant at some areas.
Salt Desert Shrub	This cover class consists of several communities; three are described below:
Nuttall Saltbush	This community is dominated by suffrutescent shrubs, <i>Atriplex nuttallii</i> (Nuttall saltbush) and <i>Eriogonum microthecum</i> (shrubby buckwheat) and <i>Ceratoides lanata</i> (winterfat).
Shadscale	This community is dominated by <i>Atriplex confertifolia</i> (shadscale). <i>Chrysothamnus viscidiflorus</i> (green rabbitbrush) and <i>Ceratoides lanata</i> were common shrubs. <i>Atriplex nuttallii</i> is also present.
Winterfat	This community is dominated by <i>Ceratoides lanata</i> , but <i>Atriplex canescens</i> (four-wing saltbush) is also common. No perennial grasses and only two forbs were recorded on the sample site (only four species were found at the plot).
	Most of the salt desert shrub communities have a high percentage of bare ground, so it is likely that areas supporting such communities will be classified as "Salt Desert Shrub" or "Playa-Bare Ground" depending on the spectral properties of the soil and percent cover of the vegetation.
Sagebrush/Rabbitbrush	This cover class includes areas that are dominated by <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> and/or <i>Chrysothamnus viscidiflorus</i> . Most of these areas have a fairly rich understory of native perennial grasses and forbs. <i>Bromus tectorum</i> was observed in these areas and was moderately to very abundant on most. This cover class occurs both on and off of lava flows.
Sagebrush/Low Sagebrush/ Rabbitbrush on Lava	These areas are characterized by the presence of <i>Artemisia nova</i> (black sagebrush), though generally it is not dominant. <i>Chrysothamnus viscidiflorus</i> and <i>Gutierrezia sarothrae</i> are common. <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> and <i>Ceratoides lanata</i> are also present in some areas. Generally, native grasses and forbs are abundant.

Table D-2. (continued).

Name	Description
Wetlands	<p>These areas on the vegetation map are south of the Big Lost River Sinks, in locations that are periodically flooded. <i>Eleocharis palustris</i> (common spike-rush) was dominant. Some locations had been a cattail (<i>Typha latifolia</i>) marsh in the early to mid 1980's; it is likely that this is a recurring marsh during periods of above average precipitation. <i>Agropyron smithii</i> was also common in some areas. Species diversity is very low.</p> <p>The wetlands delineated by the FWS include the wetlands on the vegetation map, however there are other areas that may be classified as bare ground/playas that are also considered wetlands by the FWS.</p>
Playa/Bare ground	<p>This cover class includes areas that are primarily barren and have high reflectance soils. The map may potentially confused these areas with the "Salt Desert Shrub" and "Old Fields, Disturbed Communities, and Seedings" (see below) cover classes. Some of these areas have been mapped by the FWS as wetlands.</p>
Lava	<p>This class is dominated by exposed lava outcrops and rubble. The vegetation in this class is dominated by <i>Artemisia tridentata</i> ssp. <i>tridentata</i>. <i>Chamaebatiaria millefolia</i> (fern-bush) and <i>Chrysothamnus nauseosus</i> is common. <i>Chamaebatiaria millefolia</i> is common on lava flows and along desert canyon walls, but is rare over most of the INEL. Only four vascular plant species were recorded at the sample plots used for characterizing this cover class.</p> <p>This cover class occasionally has junipers associated with it. The cracks, crevices, and cliffs also provide habitat for raptors, small and large mammals, and reptiles. There is also a greater probability for archaeological finds in these areas.</p>
Old Fields, Disturbed Communities, and Seedings	<p>These areas typically have exposed soils consistent with disturbed areas and playas. Recent seedings and/or those that still have a significant amount of bare ground fall into this classification. There will be some confusion between this class, bunchgrass communities, and bare ground classes on the vegetation map.</p>
Summer Cypress	<p>Some areas are dominated by the exotic annual, <i>Kochia scoparia</i>. <i>Verbena bracteata</i> and <i>Iva axillaris</i> (poverty-weed) occurred at these sites. <i>Salsola kali</i> (Russian thistle) was common at other locations. No perennial shrubs or grasses were recorded at these sites.</p> <p>Another area in this class is dominated by <i>Salsola kali</i>. <i>Kochia scoparia</i> and <i>Iva axillaris</i> are common, as is the native shrub, <i>Atriplex canescens</i>. <i>Agrophyron dasystachyum</i> is present.</p>
Saltbush-Grass	<p>This cover class has not been adequately characterized at present. It occurs primarily in association with the grassland, sagebrush-winterfat, and sagebrush-steppe off lava vegetation cover classes.</p>

Cover classes that are potentially ecologically important include juniper woodlands, lava, sagebrush/low-sagebrush/rabbitbrush on lava, wetlands, and the grassland communities (Great Basin wildrye, steppe, grassland). Playa areas also present features that could be important during wet periods by collecting and holding water longer than surrounding areas. The importance of these communities is discussed further in Section D.1.6.

Table D-3 summarizes the 15 cover classes and associated areal extent on the INEL. Relative abundances of common species for these cover classes are summarized on Table D-3.

The classification presented is not hierarchical, nor are the groups equally distinct. Some classes were readily recognized and quite distinct from most or all other classes (e.g., wetlands, new lava, saltbush desert communities, disturbance communities, Great Basin wildrye). Others were either quite heterogeneous (e.g., juniper woodlands, native grassland) or they overlapped considerably and the distinctions are very arbitrary (e.g., the five big sagebrush communities). In almost all cases, communities that are intermediate in species composition occur between classes that, by themselves, are quite distinct from each other. For example Wyoming sagebrush/winterfat communities appear to be transitional between other sagebrush classes and the saltbush desert communities.

It is clearly evident that the vegetation at the INEL forms a continuum (Anderson 1991). The data emphasize that vegetation is a continuously varying phenomenon, a consequence of the distribution and proportional abundance of individual species, rather than a mosaic of discrete "types" (e.g., Whittaker 1975; Miles 1979). For the most part, plant species are distributed independently, each according to its own requirements, characteristics, and interactions with other species in a particular locale.

Cover classes that are potentially ecologically unique include juniper woodlands, lava, sagebrush/low-sagebrush/rabbitbrush on lava, wetlands, and the grassland communities (Great Basin wildrye, steppe, grassland). Playa areas also present features that could be important during wet periods by collecting and holding water longer than surrounding areas. The importance of these communities is discussed further in Section D.2.

D.1.2 Fauna

Numerous animal species have been observed on the INEL including one amphibian, nine reptile, 184 bird, and 37 mammal species. Withdrawn from public domain since 1949, public access has been restricted, and some areas remain relatively undisturbed. Although lists provided here are as current as available, because of the size and diversity of INEL habitats, less commonly occurring species may have been overlooked by some surveys (Reynolds et al. 1986).

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Table D-3. Vegetation cover classes for the INEL.

Cover class description	Dominant species	Area (ha)	% Area	Comments (based on limited information)
Juniper woodlands		11,620	0.88	Unique habitat on INEL; important raptor and other bird nesting/perching habitat, provides cover for elk & deer
Great Basin wildrye		4,366	0.33	Relatively unique habitat; associated with basins, playas, and deeper soils
Steppe (bunchgrass)		24,510	1.86	Common, but not abundant; provides forage
Grassland		88,051	6.67	Common, but not abundant; provides forage
Sagebrush-steppe off lava		366,689	27.79	Very abundant community
Sagebrush-steppe on lava		313,225	23.74	Most abundant community on INEL
Sagebrush-winterfat		46,732	3.54	Common, not abundant; more in north part of INEL; Winterfat is important forage
Salt desert shrub		54,741	4.15	Common, not abundant; more in north part of INEL
Sagebrush/rabbitbrush		59,490	4.51	Common, not abundant; more in north part of INEL
Sagebrush/low sagebrush rabbitbrush on lava		7,301	0.55	Unique; associated with lava outcrops, may provide habitat for rodents, raptors, and rabbits; These areas may also have juniper trees associated with them; Greater potential for archeological finds
Wetlands ^a		3,322	0.25	Unique; Big Lost River and spreading areas are mapped by FWS as wetlands; Big Lost River has significant vegetation (tree and shrub) and lava outcrops.
Playa/bare ground		12,738	0.97	Unique; playas may be associated with temporary flooding and, therefore, ephemeral wetlands; Area surrounding playa may include good forage habitat
Lava		24,028	1.82	Unique; lava outcrops provide good habitat for small and large mammals, raptors, and reptiles; Also, good potential for archaeological sites; these areas may also have juniper trees associated with them
Old fields, disturbed areas and seedings		20,757	1.57	Potential for establishment and spread of exotic plant species
Saltbush-grass		8,083	0.61	Not adequately characterized yet; Associated with the grassland, sagebrush-winterfat, and sagebrush-steppe off lava cover classes

a. Described and discussed separately in Section D.2.5.1.

D.1.2.1 Mammals. Thirty-seven species of mammals have been recorded on the INEL and are listed on Table D-4. Fourteen of these species are rodents; four are lagomorphs; six are chiropterans (bats); six are carnivores; and one, Merriam's shrew, belongs to the Insectivora. The INEL supports resident populations of mule deer, elk, and pronghorn. Moose, mountain sheep, and mountain lion have been reported, but are species that are not generally found on the INEL (Reynolds et al. 1986). Mule deer are considered uncommon and are generally concentrated in the southern and central portion of the INEL. They exist in greater numbers on the buttes and mountains surrounding the INEL. At least two herds of elk resided on the INEL in 1990 (update this with current management results). Home ranges for the INEL elk herds encompass lands surrounding the INEL. Pronghorn are found throughout the INEL and are considered abundant. Most pronghorn in southeastern Idaho are migratory. This species has been the subject of a number of studies on the INEL (generate table from bibliography). The Townsend's ground squirrel, least chipmunk, Great Basin pocket mouse, Ord's kangaroo rat, western harvest mouse, deer mouse, bushy-tailed wood rat, and montane vole are the most common small mammals on the INEL. Four species of leporids occur on the INEL and all but the white-tailed jackrabbit are considered abundant or common (Reynolds et al. 1986).

The number of black-tailed jackrabbits on the INEL varies dramatically and periodically from less than 0.5 to more than 142 animals/km² (Stoddart 1983). Seven furbearing species have been recorded on the INEL (Reynolds et al. 1986). The muskrat and beaver are confined to areas near water and are considered rare or vary local in distribution. The coyote and long-tailed weasel are considered common species, while the bobcat and badger are considered uncommon. Bobcats and coyotes have both been studied at the INEL, and the abundance of these species depends, in part, on the abundance of jackrabbits (Knick 1990; MacCracken and Hansen 1987). The spotted skunk is listed as a rare species on the INEL (Reynolds et al. 1986). The pygmy rabbit and Townsend's big-eared bat are Federally listed as Category 2 (C2) species, and the Western pipstrelle (bat), which may exist on the INEL (Reynolds et al. 1986), is listed as a species of special concern for the State of Idaho.

D.1.2.2 Birds. A total of 164 avian species were recorded for the INEL in 1986 (Reynolds et al. 1986). Since then, 21 additional species have been recorded.^b A list of bird species recorded on the INEL is given on Table D-5. Additional species may be present on the INEL because over 216 avian species have been reported in southeastern Idaho in habitats similar to those found on the INEL (Trost et al. 1977). Breeding bird surveys have been conducted through the Radiological and Environmental Sciences Laboratory. Thirty-two species of game birds have been recorded on the INEL. Twenty-six of these are waterfowl (including American coot and common snipe). Six upland game birds have been recorded on the INEL. Eighty-two species of passerines have been recorded on the INEL (Reynolds et al. 1986). The most common species are the horned lark, black-billed magpie, robin, sage thrasher, Brewer's sparrow, sage sparrow, and western meadowlark.

b. Private communication with T. D. Reynolds, 1990.

Table D-4. Mammals recorded on the INEL (Reynolds et al. 1986).

Taxa	Distribution and Habitat	Abundance ^a
INSECTIVORA		
Soricidae		
Merriam Shrew, <i>Sorex merriami</i>	Site-wide; sagebrush-steppe	Uncommon
CHIROPTERA		
Vespertilionidae		
Little Brown Myotis, <i>Myotis lucifugus</i>	Site-wide; roosts in buildings	Common
Small-footed Myotis, <i>M. leibii</i>	Site-wide; rocky outcrops and lava	Abundant
Long-eared Myotis, <i>M. evotis</i>	SE INEL; junipers	Common
Big-brown Bat, <i>Eptesicus fuscus</i>	Site-wide; roosts in buildings and caves	Common
Hoary Bat, <i>Lasiurus cinereus</i>	Patchy; riparian and junipers	Uncommon
Townsend's Big-eared Bat, <i>Plecotus townsendii</i>	Site-wide; caves and lava tubes	Abundant
LAGOMORPHA		
Leporidae		
White-tailed Jackrabbit, <i>Lepus townsendii</i>	Site-wide; sagebrush-steppe	Occasional
Black-tailed Jackrabbit, <i>L. californicus</i>	Site-wide; sagebrush-steppe	Abundant-occasional (cyclic)
Nuttall's Cottontail, <i>Sylvilagus nuttallii</i>	Site-wide; sagebrush-steppe facilities	Common
Pygmy Rabbit, <i>S. idahoensis</i>	Patchy; sagebrush-steppe and rocky outcrops	Common

Table D-4. (continued).

Taxa	Distribution and Habitat	Abundance ^a
RODENTIA		
Sciuridae		
Least Chipmunk, <i>Tamias minimus</i>	Site-wide; sagebrush-steppe	Abundant
Yellow-bellied Marmot, <i>Marmota flaviventris</i>	Site-wide; rocky outcrops	Uncommon
Townsend's Ground Squirrel, <i>Spermophilus townsendii</i>	Site-wide; sagebrush-steppe facilities	Common
Geomyidae		
Northern Pocket Gopher, <i>Thomomys talpoides</i>	Patchy; sagebrush-steppe	Occasional
Heteromyidae		
Great Basin Pocket Mouse, <i>Perognathus parvus</i>	Site-wide; sagebrush-steppe	Uncommon
Ord's Kangaroo Rat, <i>Dipodomys ordii</i>	Site-wide; sagebrush-steppe and grassland	Common
Castoridae		
Beaver, <i>Castor canadensis</i>	Patchy; Big Lost River	Local
Cricetidae		
Western Harvest Mouse, <i>Reithrodontomys megalotis</i>	Site-wide; sagebrush-steppe and grassland	Common
Deer Mouse, <i>Peromyscus maniculatus</i>	Site-wide; all habitats	Abundant
Northern Grasshopper Mouse, <i>Onychomys leucogaster</i>	Site-wide; sagebrush-steppe	Occasional
Bushy-tailed Woodrat, <i>Neotoma cinerea</i>	Site-wide; rocky outcrops	Common

Table D-4. (continued).

Taxa	Distribution and Habitat	Abundance ^a
Cricetidae (cont.)		
Montane Vole, <i>Microtus montanus</i>	Site-wide; grassland and facilities	Abundant-occasional
Sagebrush Vole, <i>Lagurus curtatus</i>	Patchy; sagebrush-steppe	Uncommon
Muskrat, <i>Ondatra zibethicus</i>	Patchy; aquatic	Rare (cyclic)
Muridae		
Norway Rat, <i>Rattus norvegicus</i>	NW and NE INEL; near agricultural areas	Rare
House Mouse, <i>Mus musculus</i>	Patchy; facilities	Rare
Erethizontidae		
Porcupine, <i>Erethizon dorsatum</i>	Patchy; riparian and juniper	Uncommon
CARNIVORA		
Canidae		
Coyote, <i>Canis latrans</i>	Site-wide; all habitats	Common
Mustelidae		
Long-tailed Weasel, <i>Mustela frenata</i>	Site-wide; sagebrush-steppe	Common
Badger, <i>Taxidea taxus</i>	Site-wide; all habitats	Uncommon
Western Spotted Skunk, <i>Spilogale gracilis</i>	Site-wide; rocky outcrops	Rare
Felidae		
Mountain Lion, <i>Felis concolor</i>	Site-wide; transient	Vagrant
Bobcat, <i>F. rufus</i>	Site-wide; sagebrush-steppe, juniper	Uncommon

Table D-4. (continued).

Taxa	Distribution and Habitat	Abundance ^a
ARTIODACTYLA		
Cervidae		
Wapiti, <i>Cervus elaphus</i>	Site-wide; transient	Vagrant
Mule Deer, <i>Odocoileus hemionus</i>	Site-wide; sagebrush-steppe, grassland	Uncommon
Moose, <i>Alces alces</i>	Site-wide; transient	Vagrant
Antilocapridae		
Pronghorn, <i>Antilocapra americana</i>	Site-wide; sagebrush-steppe, facilities	Abundant
Bovidae		
Mountain Sheep, <i>Ovis canadensis</i>	North INEL; transient	Vagrant

a. See Table D-5 for definition of abundance terms.

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Table D-5. Avifauna recorded on the INEL (updated from Reynolds et al. 1986).

Taxa	Abundance, ^a Season, and Breeding Status ^b	Habitat
GAVIIFORMES		
Gaviidae		
Common Loon, <i>Gavia immer</i> ^d		M5w
PODICIPEDIFORMES		
Podicipedidae		
Pied-billed Grebe, <i>Podilymbus podiceps</i>	S5, M5	w
Horned Grebe, <i>Podiceps auritus</i>	M5	w
Eared Grebe, <i>P. nigricollis</i>	B5, M3, W3	w
Western Grebe, <i>Aechmophorus occidentalis</i>	S5, M5	w
PELECANIFORMES		
Pelecanidae		
American White Pelican, <i>Pelecanus erythrorhynchos</i> ^d	M5	w
Phalacrocoracidae		
Double-crested Cormorant, <i>Phalacrocorax auritus</i>	U6	w
CICONIIFORMES		
Ardidae		
American Bittern, <i>Botaurus lentiginosus</i>	S5, M5	w
Great Blue Heron, <i>Ardea herodias</i>	S5, M5	w
Snowy Egret, <i>Egretta thula</i>	U6	w
Great Egret, <i>Casmerodius albus</i> ^d	S5, M5	w
Cattle Egret, <i>Bubulcus ibis</i>	U6	w
Green-backed Heron, <i>Butorides striatus</i>	S6, M6	w
Threskiornithidae		
White-faced Ibis, <i>Plegadis chihi</i> ^d	S5, M5	w
ANSERIFORMES		
Anatidae		
Tundra Swan, <i>Cygnus columbianus</i>	M5	w
Trumpeter Swan, <i>C. buccinator</i> ^d	U6	w

Table D-5. (continued).

Taxa	Abundance, ^a Season, and Breeding Status ^b	Habitat
ANSERIFORMES Anatidae (cont.)		
Snow Goose, <i>Chen caerulescens</i>	M5	w
Ross' Goose, <i>Chen rossii</i>	U6	w
Canada Goose, <i>Branta canadensis</i>	S3, M3	w
White-fronted Goose, <i>Anser albifrons</i>	U6	w
Wood Duck, <i>Aix sponsa</i>	S6, M5	w
Green-winged Teal, <i>Anas crecca</i>	S5, M5	w
Mallard, <i>A. platyrhynchos</i>	B2, M2, W3	w
Northern Pintail, <i>A. acuta</i>	S3, M3	w
Blue-winged Teal, <i>A. discors</i>	B2, M3	w
Cinnamon Teal, <i>A. cyanoptera</i>	B3, M3	w
Northern Shoveler, <i>A. clypeata</i>	B3, M3	w
Gadwall, <i>A. strepera</i>	S3, M3	w
American Wigeon, <i>A. americana</i>	S3, M3	w
Canvasback, <i>Aythya valisineria</i>	B5, M5	w
Redhead, <i>A. americana</i>	S5, M5, W5	w
Ring-necked Duck, <i>A. collaris</i>	S5, M5	w
Lesser Scaup, <i>A. affinis</i>	S5, M3, W3	w
Common Goldeneye, <i>Bucephala clangula</i>	S5, M3, W3	w
Barrow's Goldeneye, <i>B. islandica</i>	S6, M5	w
Bufflehead, <i>B. albeola</i>	S5, M3	w
Surf Scoter, <i>Melanitta perspicillata</i>	U6	w
Common Merganser, <i>Mergus merganser</i>	S3, M5	w
Hooded Merganser, <i>Lophodytes cucullatus</i>	U6	w
Anatidae		
Ruddy Duck, <i>Oxyura jamaicensis</i>	B5, M3	w
FALCONIFORMES		
Cathartidae		
Turkey Vulture, <i>Cathartes aura</i>	S3, M3, W6	w
Accipitridae		
Osprey, <i>Pandion haliaetus</i>	M5	w
Bald Eagle, <i>Haliaeetus leucocephalus</i> ^c	M5, W3	sw
Northern Harrier, <i>Circus cyaneus</i>	R2	sw
Sharp-shinned Hawk, <i>Accipiter striatus</i>	S5, M5, W5	sw
Cooper's Hawk, <i>A. cooperii</i>	S3, M5, W5	sw
Northern Goshawk, <i>A. gentilis</i>	S5, M5, W5	sw
Swainson's Hawk, <i>Buteo swainsoni</i>	B3, M3, W5	sw
Red-tailed Hawk, <i>B. jamaicensis</i>	B3, M3, W5	sw
Ferruginous Hawk, <i>B. regalis</i> ^d	B3, M3, W5	sw

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Table D-5. (continued).

Taxa	Abundance, ^a Season, and Breeding Status ^b	Habitat
FALCONIFORMES Accipitridae (cont.)		
Rough-legged Hawk, <i>B. lagopus</i>	S6, M2, W2	sw
Golden Eagle, <i>Aquila chrysaetos</i>	B3, M4, W2	sw
Falconidae		
American Kestrel, <i>Falco sparverius</i>	B2, M2, W3	sw
Merlin, <i>F. columbarius</i> ^d	R5	sw
Peregrine Falcon, <i>F. peregrinus</i> ^e	S5, M5, W5	sw
Gyr Falcon, <i>F. rusticolus</i>	M6	sw
Prairie Falcon, <i>F. mexicanus</i>	R3	sw
GALLIFORMES		
Phasianidae		
Gray Partridge, <i>Perdix perdix</i>	R3	g, ss, f
Chukar, <i>Alectoris chukar</i>	R3	g, ss
Ring-necked Pheasant, <i>Phasianus colchicus</i>	R3	g, ss
Blue Grouse, <i>Dendragapus obscurus</i>	S6	f
Sage Grouse, <i>Centrocercus urophasianus</i>	R2	ss, g, f
GRUIFORMES		
Gruidae		
Sandhill Crane, <i>Grus canadensis</i>	U6	U
Rallidae		
Sora, <i>Porzana carolina</i>	B5, M5	w, f
American Coot, <i>Fulica americana</i>	R3	w
CHARADRIIFORMES		
Charadriidae		
Killdeer, <i>Charadrius vociferus</i>	B2, M2	sw
Semipalmated Plover, <i>C. semipalmatus</i>	U6	w
Mountain Plover, <i>Eupoda montana</i>	U6	U

Table D-5. (continued).

Taxa	Abundance, ^a Season, and Breeding Status ^b	Habitat
CHARADRIFORMES (cont.)		
Recurvirostridae		
American Avocet, <i>Recurvirostra americana</i>	S2, M3	w
Black-necked stilt, <i>Himantopus mexicanus</i>	U6	w
Scolopacidae		
Greater Yellowlegs, <i>Tringa melanoleuca</i>	M5	w
Lesser Yellowlegs, <i>T. flavipes</i>	S5, M5	w
Solitary Sandpiper, <i>T. solitaria</i>	S5, M3	w
Willet, <i>Catoptrophorus semipalmatus</i>	S3, M3	w, ss
Spotted Sandpiper, <i>Actitis macularia</i>	S3, M3	w
Long-billed Curlew, <i>Numenius americanus</i> ^d	S3, M3	w, ss
Marbled Godwit, <i>Limosa fedoa</i>	S3, M5	w
Least Sandpiper, <i>Calidris minutilla</i>	S5, M5	w
Long-billed Dowitcher, <i>Limnodromus scolopaceus</i>	M5	w
Western Sandpiper, <i>Ereunetes mauri</i>	U6	w
Baird's Sandpiper, <i>Erolia bairdii</i>	U6	w
Common Snipe, <i>Gallinago</i>	S5, M5	w
Wilson's Phalarope, <i>Phalaropus tricolor</i>	S3, M3	w
Red-necked Phalarope, <i>P. lobatus</i>	M5	w
Laridae		
Franklin's Gull, <i>Larus pipixcan</i>	S3, M3	w, ss
Bonaparte's Gull, <i>L. philadelphia</i>	M5	w
Ring-billed Gull, <i>L. delawarensis</i>	S3, M3	w, ss, g
California Gull, <i>L. californicus</i>	S5, M3	w, ss
Herring Gull, <i>L. argentatus</i>	S3, M3	w, ss, g
Black-legged Kittiwake, <i>Rissa tridactyla</i>	W6	w
Caspian Tern, <i>Sterna caspia</i>	M5	w
Forster's Tern, <i>S. forsteri</i>	S5	w
Black Tern, <i>Chidonias niger</i>	S5, M5	w
COLUMBIFORMES		
Columbidae		
Rock Dove, <i>Columba livia</i>	R2	sw
Mourning Dove, <i>Zenaida macroura</i>	B1, M3, W5	sw

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Table D-5. (continued).

Taxa	Abundance, ^a Season, and Breeding Status ^b	Habitat
STRIGIFORMES		
Strigidae		
Great Horned Owl, <i>Bubo virginianus</i>	R3	sw
Snowy Owl, <i>Nyctea scandiaca</i>	W5	sw
Burrowing Owl, <i>Athene cunicularia</i>	B3, M3, W6	ss, g
Long-eared Owl, <i>Asio otus</i>	B4, M4	d
Short-eared Owl, <i>A. flammeus</i>	B3, M3	ss, g
Northern Saw-whet Owl, <i>Aegolius acadicus</i>	S6, M6, W6	sw
CAPRIMULGIFORMES		
Caprimulgidae		
Common Nighthawk, <i>Chordeiles minor</i>	B2, M3	sw
Common Poor-will, <i>Phalaenoptilus nuttallii</i>	U6	j
APODIFORMES		
Apodidae		
White-throated Swift, <i>Aeronautes saxatalis</i>	S5	d
Trochilidae		
Rufous Hummingbird, <i>Selasphorus rufus</i>	S3, M3	d
CORACIIFORMES		
Alcedinidae		
Belted Kingfisher, <i>Ceryle alcyon</i>	S3, M3	w
PICIFORMES		
Picidae		
Downy Woodpecker, <i>Picoides pubescens</i>	B5, M5	d
Northern Flicker, <i>Colaptes auratus</i>	B3, M3	d
Lewis' Woodpecker, <i>Asyndesmus lewis</i>	U6	U
Red-naped Sapsucker, <i>Sphyrapicus nuchalis</i>	U6	U

Table D-5. (continued).

Taxa	Abundance, ^a Season, and Breeding Status ^b	Habitat
PASSERIFORMES		
Tyrannidae		
Olive-sided Flycatcher, <i>Contopus borealis</i>	S5, M5	d
Western Flycatcher, <i>Empidonax difficilis</i>	S5	d
Say's Phoebe, <i>Sayornis saya</i>	B3, M3	ss,d,f,j
Ash-throated Flycatcher, <i>Myiarchus cinerascens</i>	S5	d
Western Kingbird, <i>Tyrannus verticalis</i>	B3, M3	f,d,j
Eastern Kingbird, <i>T. tyrannus</i>	B3, M3	f,d,j
Alaudidae		
Horned Lark, <i>Eremophila alpestris</i>	R2	g,ss
Hirundinidae		
Tree Swallow, <i>Tachycineta bicolor</i>	B3, M3	d,j
Violet-green Swallow, <i>T. thalassina</i>	B4, M4	d,j
Northern Rough-winged Swallow, <i>Stelgidopteryx serripennis</i>	B3, M3	d,j
Bank Swallow, <i>Riparia riparia</i>	B5, M3	d,j
Cliff Swallow, <i>Hirundo pyrrhonota</i>	B2, M2	d,j
Barn Swallow, <i>H. rustica</i>	B2, M3	d,j
Corvidae		
Blue Jay, <i>Cyanocitta cristata</i>	U6	U
Clark's Nutcracker, <i>Nucifraga columbiana</i>	S4, M4, W5	j
Black-billed Magpie, <i>Pica pica</i>	R2	sw
American Crow, <i>Corvus brachyrhynchos</i>	R3	sw
Common Raven, <i>C. corax</i>	R3	sw
Troglodytidae		
Rock Wren, <i>Salpinctes obsoletus</i>	B3, M3	ss
Canyon Wren, <i>Catherpes mexicanus</i>	S5, M5	ss
House Wren, <i>Troglodytes aedon</i>	R3	d
Muscicapidae		
Ruby-crowned Kinglet, <i>Regulus calendula</i>	M3, W6	d
Western Bluebird, <i>Sialia mexicana</i>	S5, M5	ss
Mountain Bluebird, <i>S. currucoides</i>	S3, M3	ss
Townsend's Solitaire, <i>Myadestes townsendi</i>	S5, M5	d
American Robin, <i>Turdus migratorius</i>	B2, M2	sw
Varied Thrush, <i>Ixoreus naevius</i>	W6	ss

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Table D-5. (continued).

Taxa	Abundance, ^a Season, and Breeding Status ^b	Habitat
PASSERIFORMES Muscicapidae (cont.)		
Swainson's Thrush, <i>Hylocichla ustulata</i>	U6	U
Mimidae		
Northern Mockingbird, <i>Mimus polyglottos</i>	S6	j
Sage Thrasher, <i>Oreoscoptes montanus</i>	B2, M2	ss
Poliophtilidae		
Blue-gray Gnatcatcher, <i>Poliophtila caerulea</i>	U6	U
Motacillidae		
Water Pipit, <i>Anthus spinoletta</i>	M5	ss
Bombycillidae		
Bohemian Waxwing, <i>Bombycilla garrulus</i>	S3, M2, W3	f,d
Cedar Waxwing, <i>B. cedrorum</i>	S5, M3, W5	f,d
Laniidae		
Northern Shrike, <i>Lanius excubitor</i>	M3, W5	sw
Loggerhead Shrike, <i>L. ludovicianus</i>	B3	ss
Sturnidae		
European Starling, <i>Sturnus vulgaris</i>	R3	sw
Virconidae		
Warbling Vireo, <i>Vireo gilvus</i>	S5, M5	d
Emberizidae		
Black-and-White Warbler, <i>Mniotilta varia</i>	U6	U
Yellow Warbler, <i>Dendroica petechia</i>	B5, M3	d
Yellow-rumped Warbler, <i>D. coronata</i>	S3, M3	d
Townsend's Warbler, <i>D. townsendi</i>	M5	d
American Redstart, <i>Setophaga ruticilla</i>	M6	f
Common Yellowthroat, <i>Geothlypis trichas</i>	S5	d
Wilson's Warbler, <i>Wilsonia pusilla</i>	S5, M5	d
Orange-crowned Warbler, <i>Bermivora celata</i>	U6	U
Yellow-breasted Chat, <i>Icteria virens</i>	S5	d

Table D-5. (continued).

Taxa	Abundance, ^a Season, and Breeding Status ^b	Habitat
PASSERIFORMES Emberizidae (cont.)		
MacGillivray's Warbler, <i>Oporornis tolmiei</i>	U6	U
Western Tanager, <i>Piranga ludoviciana</i>		S3, M3d
Black-headed Grosbeak, <i>Pheucticus melanocephalus</i>	S5, M5	sw
Lazuli Bunting, <i>Passerina amoena</i>	S5, M5	d
Green-tailed Towhee, <i>Pipilo chlorurus</i>	S3, M3	ss
Rufous-sided Towhee, <i>P. erythrophthalmus</i>	S3, M3	sw
Chipping Sparrow, <i>Spizella passerina</i>		M5f,d,ss
Brewer's Sparrow, <i>S. breweri</i>	B2, M2	ss
Vesper Sparrow, <i>Pooecetes gramineus</i>	B3, M3	g, ss
Lark Sparrow, <i>Chondestes grammacus</i>	S3, M5	sw
Black-throated Sparrow, <i>Amphispiza bilineata</i>	S5, M5	ss
Sage Sparrow, <i>A. belli</i>	B2, M2	ss
Lark Bunting, <i>Calamospiza melanocorys</i>	S5, M5	ss
Savannah Sparrow, <i>Passerculus sandwichensis</i>	S5, M3	d,g
Song Sparrow, <i>Melospiza melodia</i>	S5, M3	d
White-crowned Sparrow, <i>Zonotrichia leucophrys</i>	M4	ss
Dark-eyed Junco, <i>Junco hyemalis</i>	M3	sw
Snow Bunting, <i>Plectrophenax nivalis</i>	W5	g,ss
Red-winged Blackbird, <i>Agelaius phoeniceus</i>	B3, M3	w, ss
Western Meadowlark, <i>Sturnella neglecta</i>	B2, M2, W3	g,ss
Yellow-headed Blackbird, <i>Xanthocephalus</i>	B4, M3	w,d
Icteridae		
Brewer's Blackbird, <i>Euphagus cyanocephalus</i>	B2, M2, W5	sw
Brown-headed Cowbird, <i>Molothrus ater</i>	B3, M3	ss
Northern Oriole, <i>Icterus galbula</i>	S3, M3	d
Orchard Oriole, <i>Icterus spuris</i>	U6	U
Fringillidae		
Rosy Finch, <i>Leucosticte arctoa</i>	M5, W5	ss
House Finch, <i>Carpodacus mexicanus</i>	S3, M3	f,d
Pine Siskin, <i>Carduelis pinus</i>	S5, M3	f,d
American Goldfinch, <i>C. tristis</i>	M5	d,ss
Brewer's Blackbird, <i>Euphagus</i>	??	
Evening Grosbeak, <i>Coccothraustes vespertinus</i>	S5, M3	d
Passeridae		
House Sparrow, <i>Passer domesticus</i>	B2, M1, W3	f,d

Table D-5. (continued).

a. Abundance code (all abundance classes assume a qualified biologist exerted a reasonable effort to search or sample the proper habitat at the appropriate time of year):

1. Abundant: very numerous and certain to be seen or sampled.
2. Common: likely but not certain to be observed or sampled.
3. Uncommon: found in limited numbers, not likely to be sampled or observed.
4. Occasional or local: a species that is not always present or is restricted in distribution.
5. Rare: a species that has a range including all or part of the INEL, but has been documented $\leq$ seven times on the INEL.
6. Vagrant or accidental: a species that is not expected to occur on the INEL, but has been recorded there.

b. Breeding and seasonal code:

R = Breeder and year-round resident
B = Summer breeder
M = Migrant
W = Winter visitor
S = Summer visitor: no breeding records
U = Unknown

In descending order of preference):

w = On or near water
ss = Shrub-steppe
d = Deciduous or riparian
j = Juniper woodland
g = Grassland
sw = Site-wide
f = Facility complexes.
U = Unknown

d. Candidate species for list of threatened or endangered species (white-faced ibis; ferruginous hawk; long-billed curlew) or Idaho State species of special concern (Moseley and Groves 1990).

e. Endangered.

The INEL is an important nesting and wintering area for raptors. Twenty-two species of hawks, falcons, owls, or vultures have been observed on the INEL (Reynolds et al. 1986). Ten species nest on or near the INEL. The most abundant breeding species are American kestrels and long-eared owl. American rough-legged hawks, American kestrels, prairie falcons, and golden eagles are the most abundant raptors observed during the nonbreeding season. As many as 108 golden eagles and 15 bald eagles have been observed on the INEL in a single day (Watson 1984). The numbers of some wintering raptors are closely tied to fluctuation in black-tailed jackrabbit abundance, while others are closely tied to the population of small rodents. Two species, the bald eagle and the peregrine falcon, are Federally listed endangered species. Six additional species are listed as Idaho special species of concern and/or sensitive by the Bureau of Land Management or the U.S. Forest Service.

D.1.2.3 Amphibians and Reptiles. One amphibian and 10 reptilian species have been recorded on the INEL and are listed on Table D-6 (Reynolds et al. 1986). Of these, five species are considered common or abundant. There is only one confirmed record for the rubber boa on the INEL. The western racer was only recently recorded on the INEL. The only amphibian recorded, the Great Basin spadefoot toad, is typically associated with the Big Lost River, the Big Lost River Sinks, and the spreading areas near the Radioactive Waste Management Complex (RWMC) (Reynolds et al. 1986) and because of drought, has not bred on the INEL for some time. Published ranges indicate that an additional four reptile species could possibly be found on the INEL (Nussbaum et al. 1983); however, of these, it is likely that only the night snake exists on the Site.^c The night snake and the ringnecked snakes are listed as sensitive species by the Bureau of Land Management and are discussed in Section D.1.3.

D.1.2.4 Fish. Six species of fish have been identified during the Big Lost River Salmonid Surveys (Overton 1977) in that portion of the Big Lost River that flows onto the INEL and are listed on Table D-7 (Reynolds et al. 1986). Four of these were game species (salmonids) and two were nongame species. Additional game and nongame species may have been present but were not observed or are present only during some years of normal stream flow. Not since October 1986 has there been sufficient water in the Big Lost River to reach the INEL. That year, water flowed as far as the Big Lost Sinks. Since that time, low runoff, combined with upstream diversions, has prevented sustained flow and hence aquatic biota in the Big Lost River on the INEL.

D.1.2.5 Invertebrates. A total of 740 insect species have been collected on the INEL. A significant portion of these (226) have not been identified beyond the family level. The majority of the abundant species are Hymenoptera (wasps and ants), Diptera (flies), including parasitic and predatory forms, and Coleoptera (beetles) (Stafford 1983, 1987; Stafford et al. 1986; Youdie 1986). A diverse insect community is associated with the sagebrush and great basin wildrye communities on the INEL, and these insects play an important role in the food chains of INEL ecosystems (Stafford 1983, 1987; Youdie 1986). A prominent feature of the area is harvester ant

c. Private communication with Peterson, 1990.

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Table D-6. Reptiles recorded on the INEL (Reynolds et al. 1986).

Taxa	Distribution and Habitat	Abundance
ANURA		
Pelobatidae		
Great Basin Spadefoot Toad, <i>Spea intermontana</i> ^b	Big Lost River and sinks	Common
SQUAMATA		
Iguanidae		
Leopard Lizard, <i>Gambelia wislizenii</i> ^c	NE INEL; sandy areas	Local
Short-horned Lizard, <i>Phrynosoma douglassi</i>	Site-wide; shrub-steppe	Abundant
Sagebrush Lizard, <i>Sceloporus graciosus</i>	Site-wide; shrub-steppe	Abundant
Scincidae		
Western Skink, <i>Eumeces skiltonianus</i>	South INEL	Rare
Boidae		
Rubber Boa, <i>Charina bottae</i>	Unknown	Accidental
Colubridae		
Desert Striped Whipsnake, <i>Masticophis taeniatus</i>	NE INEL; shrub-steppe	Uncommon
Gopher Snake, <i>Pituophis melanoleucus</i>	Site-wide; shrub-steppe	Common
Western Garter Snake, <i>Thamnophis elegans</i>	Site-wide; all habitats	Uncommon
Western Racer, <i>Coluber constrictor</i>	Unknown	Accidental
Viperidae		
Western Rattlesnake, <i>Crotalus viridis</i>	Site-wide; shrub-steppe	Common

a. This is listed as *Scaphiophus intermontanus*.

b. This is placed in the genus *Crotaphytus*.

See Table D-5 for definition of abundance terms.

Table D-7. Fish recorded on the INEL (Reynolds et al. 1986).

Taxa	Distribution	Abundance ^a
SALMONIFORMES		
Salmonidae		
Kokanee Salmon, <i>Oncorhynchus nerka</i>	Big Lost River	Uncommon
Rainbow Trout, <i>Salmo gairdneri</i>	Big Lost River	Common
Brook Trout, <i>Salvelinus fontinalis</i>	Big Lost River	Uncommon
Mountain Whitefish, <i>Prosopium williamsoni</i>	Big Lost River	Common
CYPRINIFORMES		
Cyprinidae		
Speckled Dace, <i>Rhinichthys osculus</i>	Big Lost River	Uncommon
PERCIFORMES		
Cottidae		
Shorthead Sculpin, <i>Cottus confusus</i>	Big Lost River	Common

a. See Table D-1 for definitions of abundance terms.

mounds, which are visible on aerial photographs. Ants of the INEL have been the subject of a number of recent studies (Clark and Blom 1988, 1991; Clark and Blom in press), as have honeybees. No sensitive insect species have been identified on the INEL.

D.1.3 Threatened, Endangered, and Sensitive Species

National concern for the loss of plant and animal species in the United States culminated in 1973 with the passage of Public Law 93-205, the Endangered Species Act, which is administered by the U.S. Fish and Wildlife Service (FWS). As amended, this Act provides Federal protection for certain species of plants and animals and their critical habitats, and authorizes the secretary of the interior to develop and implement recovery plans for each listed species. These species and subspecies are listed in 50 CFR 17.11 and 17.12 as either endangered or threatened. By law, all

Federal agencies are required to consider in their management plans those plant and animal species considered to be endangered, threatened, or proposed for such status (candidate species).

Listed endangered species are defined as those taxa in danger of extinction throughout all or a significant portion of their range. Listed threatened species are defined as taxa likely to be classified as endangered within the foreseeable future throughout all or a significant portion of their range. Candidate species for endangered and threatened status are defined as taxa for which the FWS currently has substantial information on hand to support the biological appropriateness of proposing to list as endangered or threatened; taxa for which information now in possession of the FWS indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability and threat are not currently available to support proposed rules; and taxa that were once being considered for listing as endangered and threatened, but are no longer receiving such consideration.

The Idaho Department of Fish and Game is mandated under Idaho Code Section 36-103 to preserve, protect, perpetuate, and manage all wildlife. A law protecting native wildflowers in Idaho was enacted in 1967 (Idaho Code Section 18-3913), that gives the Idaho Department of Parks and Recreation the authority to establish and amend a list of plants in need of protection because they may become extinct or they may affect the scenic beauty of public roads or public land.

Certain species (found on the INEL) are protected by Idaho law and cannot be hunted, taken, or possessed except under special circumstances. Those species include all threatened or endangered wildlife including peregrine falcons and bald eagles; all protected nongame species such as chipmunks, all hawks, owls, eagles, and vultures; and all nongame birds except the starling, English sparrow, and feral pigeon.

A comprehensive list of plant and animal species from Federal and/or state threatened, endangered, and sensitive lists is presented on Table D-8. Although species of special concern and sensitive species do not receive legal protection, they are included here because of their regional importance.

D.1.3.1 Plants. An extensive survey for rare and endangered plant species was conducted by Cholewa and Henderson (1983, 1984) from 1980 to 1982. With the exception of vegetation communities associated with wetlands (see Section D.2.5.1), no additional surveys were conducted for rare and endangered species for this environmental impact statement. Current work being conducted by Idaho State University will provide additional information on the INEL communities and the status sensitive plant species. Rare and sensitive plant species found on the INEL are discussed in Section D.1.1.5.

No plant species at the INEL are currently considered Federally threatened or endangered (50 CFR 17.11, 17.12). Several species known to exist at the INEL are on State of Idaho special species of concern, Bureau of Land Management (BLM), and U.S. Forest Service (USFS) lists (see Table D-8). Ten plants appear on the state rare plant list including Lemhi milkvetch, plains

Table D-8. Threatened and endangered species, special species of concern, and sensitive species that may be found on the INEL.

Common names	Scientific name	Federal status ^a	State status ^a	BLM status ^a	USFS status ^a	INPS status ^a
Plants						
Lemhi milkvetch	<i>Astragalus aquilonius</i>	—	—	S	S	2
Painted milkvetch	<i>Astragalus ceramicus</i> var. <i>apus</i>	3c	—	—	—	M
Plains milkvetch	<i>Astragalus gilviflorus</i>	NL	—	S	S	1
Thistle milkvetch	<i>Astragalus kentrophyta</i> var. <i>jessiae</i>	NL	—	S	—	S
Winged-seed evening primrose	<i>Camissonia pterosperma</i>	NL	—	S	—	S
Nipple cactus	<i>Coryphantha missouriensis</i>	NL	—	—	—	M
Large-flowered gymnosteris	<i>Gymnosteris nudicaulis</i>	NL	—	S	—	M
Spreading gilia	<i>Ipomopsis</i> (<i>Gilia</i>) <i>polycladon</i>	NL	—	S	—	2
King's bladderpod	<i>Lesquerella kingii</i> var. <i>cobrensis</i>	—	—	—	—	M
Oxytheca	<i>Oxytheca dendroidea</i>	NL	—	S	—	S
Birds						
Peregrine falcon	<i>Falco peregrinus</i>	LE	E	—	—	—
Merlin	<i>Falco columbarius</i>	NL	—	S	—	—
Gyr falcon	<i>Falco rusticolus</i>	NL	SSC	S	—	—
Bald eagle	<i>Haliaeetus leucocophalus</i>	LE	E	—	—	—
Ferruginous hawk	<i>Buteo regalis</i>	C2	SSC	S	—	—
Black Tern	<i>Chlidonias niger</i>	—	—	—	—	—
Northern pygmy owl ^b	<i>Glaucidium gnoma</i>	—	—	—	—	—
Burrowing owl	<i>Athene cucularia</i>	NL	—	S	—	—
Common loon	<i>Gavia immer</i>	—	SSC	—	—	—
American white pelican	<i>Pelicanus erythrorhynchos</i>	—	SSC	—	—	—
Great egret	<i>Casmerodius albus</i>	—	SSC	—	—	—
White-faced Ibis	<i>Plegadis chihi</i>	C2	—	—	—	—
Long-billed curlew	<i>Numenius americanus</i>	3c	—	S	—	—
Loggerhead shrike	<i>Lanius ludovicianus</i>	C2	NL	—	—	—
Northern goshawk	<i>Accipiter gentilis</i>	C2	S	—	S4	—
Swainson's hawk	<i>Buteo swainsoni</i>	—	—	S	—	—
Mammals						
Pygmy rabbit	<i>Brachylagus</i> (<i>Sylvilagus</i>) <i>idahoensis</i>	C2	NL	—	—	—
Townsend's western big-eared bat	<i>Plecotus townsendii</i>	C2	SSC	—	S2	—
Western pipistrelle ^b	<i>Pipistrellus hesperus</i>	NL	SSC	S	—	—
Fringed myotis ^b	<i>Myotis thysanodes</i>	—	SSC	—	—	—
California Myotis	<i>Myotis californicus</i>	—	SSC	—	—	—
Reptiles and amphibians						
Spotted frog ^b	<i>Rana pretiosa</i>	C2	—	—	—	—
Mojave Black-collared lizard ^b	<i>Crotophytus bicinctores</i>	—	SSC	—	—	—
Ringneck snake ^b	<i>Diadophis punctatus</i>	NL	SSC	S	—	—
Night snake ^b	<i>Hypsiglena torquata</i>	—	—	S	—	—

a. Status Codes: C2 = Category 2 species; 3c = no longer considered for listing; E = endangered species; NL = not listed; SSC = species of special concern; T = threatened species; S=sensitive; S4=Sensitive, USFS Region 4; INPS=Idaho Native Plant Society, M=state monitor species, 1 = State Priority 1, 2=State Priority 2, S=Sensitive. This list was from USFS (letter dated December 21, 1992) and was cross-checked and incorporated with the Idaho Department of Fish and Game Conservation Data Center threatened, endangered, and sensitive species list for the State of Idaho (Moseley and Groves 1992).

milkvetch, thistle milkvetch, winged-seed evening primrose, nipple cactus, large-flowered gymnosteris, spreading gilia, King's bladderpod, Oxytheca, and painted milkvetch (recently removed from C2 status). Habitat and distribution information for these species is given in Section D.2.4.1.

D.1.3.2 Animals. The only species at the INEL currently recognized as threatened or endangered under the Endangered Species Act are the bald eagle, a winter visitor, and the peregrine falcon. Several species that are candidates for the Federal list are known to exist at the INEL. They are the ferruginous hawk, white-faced ibis, black tern, northern goshawk, pygmy rabbit, and the Townsend's big-eared bat (Arthur et al. 1984). These candidate species are those for which the FWS has information suggesting that a change in status to threatened or endangered may possibly be appropriate, but for which conclusive data are not available. The long-billed curlew is currently considered to be more widespread than previously believed, or is not subject to identifiable threats and has been designated 3C (removed from C2 status) (Moseley and Groves 1992).

The State of Idaho recognizes two separate classes of rare fauna: species of special concern and threatened and endangered wildlife. Species of special concern known to exist at the INEL include the common loon, American white pelican, ferruginous hawk, Northern pygmy owl, California myotis, merlin, and great egret (Moseley and Groves 1992).

D.1.4 Unique or Special Habitats and Communities

This section addresses INEL ecological communities and habitats with unique or special characteristics. For this assessment, wetlands (including riparian and aquatic communities), caves, buttes, man-made structure and facilities, and soil microflora are included.

D.1.4.1 Wetlands. Over 130 areas within the boundaries of the INEL have been assigned wetland status as part of the FWS National Wetlands Inventory (NWI). The geographic coverage of the INEL includes 30 7.5-ft U.S. Geological Survey topographic quadrangles. Finalized NWI maps have been generated for 23 of these quadrangles.

To support this environmental impact statement, a survey of a sample of these wetlands was conducted in fall of 1992. As part of this survey, designated wetlands from the completed NWI inventory maps were digitized and entered into a geographical information system (GIS) at the INEL. A map of INEL wetlands was created and combined with other coverages already available in the GIS database. The survey methodology and results are described in detail elsewhere (Hampton et al. 1993). Habitat and ecological associations for INEL wetlands are presented in Section D.2.5.1.

The NWI maps for the INEL were finalized prior to FWS adoption of 1989 manual and technical criteria to be applied in assessing vegetation, soils, and hydrology are not specified under 10 CFR 1022.11(c) (DOE 1992). Consequently, technical criteria drawn from the 1989 Federal manual were used to develop data collection requirements and field methodology for this survey.

NWI wetlands maps, U.S. Geological Survey 7.5-ft topographic maps and 1991 aerial photographs (1:40,000) were the primary sources of information for the survey.

It is unclear whether the DOE definition requires application of mandatory technical criteria conforming to the Environmental Protection Agency (EPA)/U.S. Army Corps of Engineers (COE) definitions or those of the FWS. The NWI sites for which wetland vegetation and/or wetland hydrologic criteria were confirmed satisfy the FWS single criteria requirement. However, no verification with regard to the EPA/COE three-criteria requirement can be made for these sites without confirmation of hydric soils. Collection of soil data was beyond the scope of the preliminary survey.

Since the completion of the INEL preliminary wetlands survey in November 1992, proposed revisions to the 1989 manual (EPA 1991) have been challenged. Pending resolution of questions regarding wetland delineation criteria, the EPA and COE have adopted the COE Wetlands Delineation Manual (COE 1987). It is unclear whether the FWS will also use the 1987 manual.

D.1.4.1.1 Survey Summary—Sixteen separate NWI FWS classifications are represented by approximately 130 wetland sites within INEL boundaries. These NWI classifications are denoted by a descriptive acronym assigned by the FWS and are defined (and summarized) on Table D-9. Two additional classes were created for the INEL preliminary wetlands survey to include investigation of (a) potential wetlands that exist in the seven quadrangles not yet mapped by the FWS NWI (UNMAP) and (b) areas within the mapped quadrangles that have characteristics similar to mapped wetlands, but were not classified as wetlands (UNCLASS).

NWI mapped wetlands and sites investigated during the survey are shown on Figure D-1. Field descriptions were completed for 105 sites in 16 NWI and two special categories. In addition, 20 sites were inspected as part of the verification of grouped wetland sites. The information collected as part of the survey is summarized on Table D-10. Plant species identified during the survey are listed on Table D-11. Wetland classes across the INEL have geographic or characteristic similarities that facilitate grouping into six categories and are discussed in the following sections. Further details of the survey methodology and results are discussed in the formal survey documentation (Hampton et al. 1993).

Conditions associated with extended drought and the season in which field investigations were conducted limited the collection of important vegetative and hydrological information, and other information such as wildlife use is not available. This relative ranking procedure can only be considered a subjective estimate of potential importance of each wetland relative to the conditions present during the survey.

D.1.4.1.2 PUSJ Classified Wetlands—About 70% of the individual NWI wetlands within INEL boundaries are classified as PUSJ. The distribution of surveyed PUSJ sites is shown on Figure D-2. Total area encompassed by PUSJ wetlands is just under 20 ha (50 acres). The smallest PUSJ site is approximately 0.04 ha (0.1 acre), and the largest is about 3 ha (7 acres).

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Table D-9. Definitions of wetlands survey site classifications.

Wetland Acronym	Wetland Classification Description	Total Mapped Wetlands on the INEL	Number of Wetlands Surveyed
NWI Classifications:			
PAB4Hx	Palustrine, Aquatic Bed, Floating Vascular, Permanently Flooded, Excavated	1	1
PEM1A	Palustrine, Emergent (Vegetation, Persistent, Temporarily Flooded	3	1
PEM1C	Palustrine, Emergent (Vegetation), Persistent, Seasonally Flooded	2	2
PEM1J	Palustrine, Emergent (Vegetation), Persistent, Intermittently Flooded	2	2
PEMJ	Palustrine, Emergent (Vegetation), Intermittently Flooded	2	2
POWHx	Palustrine, Open Water, Permanently Flooded, Excavated	14	11
PUSC	Palustrine, Unconsolidated Shore, Seasonally Flooded	1	1
PUSCrX	Palustrine, Unconsolidated Shore, Seasonally Flooded, Artificial Substrate, Excavated	2	2
PUSCx	Palustrine, Unconsolidated Shore, Seasonally Flooded, Excavated	1	1
PUSJ	Palustrine, Unconsolidated Shore, Intermittently Flooded	88	45
L2USJ	Lacustrine, Littoral, Unconsolidated Shore, Intermittently Flooded	6	4
R20WHx	Riverine, Lower Perennial, Open Water, Permanently Flooded, Excavated	1	1
R4SBA	Riverine, Intermittent, Streambed, Temporarily Flooded	1	1
R4SBC	Riverine, Intermittent, Streambed, Seasonally Flooded	2	1
R4SBJ	Riverine, Intermittent, Streambed, Intermittently Flooded	3	1
R4SBJx	Riverine, Intermittent, Streambed, Intermittently Flooded, Excavated	2	2
TOTAL NWI CLASSIFICATION		131	78
Special Classifications:			
UNCLASS	Areas not classified as a wetland by NWI	Unknown	29
UNMAP	NWI maps not complete	Unknown	14
TOTAL		131	121

Figure D-1. NWI-mapped wetlands and sites investigated during the wetlands survey.

Table D-10. INEL wetlands survey data (incomplete information).

Class	Site Name ^a	Approximate Dimensions	Vegetation Site	Vegetation Area	1991 INEL Vegetation Map Classification	Wildlife ^b	Archaeology ^b	Rank ^c	Comments
1	PUSJ		None	Sage / Halogeton		H	L	1	
2			Halogeton	Halogeton / Sitanion		H	F/L	1	Series of connected
3			Halogeton	Halogeton / Sage		H	F/H	1	playas, 2 associated sites
4			Salsola	Salsola / Dead		M	F/M	2	Wildlife / Archaeology
				Shrubs / Grasses					
5	ATMCIT1		Saltbush	Sage		L	F/M	3	Artificial Impoundment
6	CIRBUSE1		None	Low sage / Elymus		L	None	3	
7	CIRBUSE3		None	Sage / Elymus		M	F/H	2	
8	CIRBUSE4		Halogeton	Sage / Grass		L	F/L	3	
9	KETBU2		Salsola / Elymus	Elymus		H	None	1	Unique Vegetation
10	KETBU3		Halogeton	Elymus / Sage		M	None	2	
				Halogeton					
11	LITBUNW1		None	Sage / Greasewood		H	None	1	
12	LITBUNW2		None	Sage / Rabbitbrush		L	F/L	3	
13	LITBUNW3		None	Sage / Winterfat		H	None	1	2 Adjacent sites
14	LITBUNW4		Halogeton	Sage / Winterfat		H	None	1	1 Adjacent site
15	LITBUNW5		Halogeton	Sage / Halogeton		H	A/L	1	7 Total sites in area
16	LITBUNW6		None	Sage / Horsebush		H	None	1	See also LITBUNW5
17	LITBUNW7		None	Halogeton / Sage		H	F/L	1	1 Adjacent site
18	LITBUNW8		Halogeton	Sage / Halogeton		H	M	1	
19	LITBUNW9		None	Sage / Halogeton		H	None	1	2 Adjacent sites
20	LITBUNWA	None	Sage / Halogeton			H	None	1	1 Adjacent site
21	LITBUNWB		Sage / Grass	Sage / Grass		L	L	3	Disturbed borrow pit
22	LITBUNWC		Halogeton	Sage / Winterfat		H	None	2	
23	LITBUNWD	Elymus	Elymus			L	None	3	
24	LITBUNWE		Elymus	Elymus / Grass		H	None	1	Large basin
25	LITBUNWF		Elymus	Sage		L	None	2	
26	LITBUSW1		Halogeton	Sage / Grass		L	None	3	
27	LITBUSW3		None	Sage		M	F/M	2	
28	LITBUSW5		Halogeton	Halogeton / Sage		L	None	3	
29	LITBUSW6		Halogeton	Sage / Rabbitbrush		L	None	3	
30	PAB4Hx		Dock / Thistle	Sage		L	None	3	
31	PEM1A		Grass / Salsola	Grass / Sage		M	None	1	Sinks, Heavily disturbed
32	PEM1C		Grass	Grass		L	None	1	Visit in wet years

Table D-10. (continued).

Class	Site Name ^a	Approximate Dimensions	Vegetation Site	Vegetation Area	1991 INEL Vegetation Map Classification	Wildlife ^b	Archaeology ^b	Rank ^c	Comments
33			Bulrush	Sage		M	None	2	Outflow channel
34	PEM1J		Grass	Sage		L	None	1	Sinks - Visit in wet years
35			Weedy annuals	Sage		L	None	1	Visit in wet years
36	PEMJ		Elymus / Grass	Sage		L	None	3	
37			Lupine / Grass	Sage		M	F/H, A/M	3	Heavily disturbed
38	PUSC		Crested wheat	Sage		L	None	3	Seeding in borrow pit
39	PUSCr _x		Rabbitbrush	Sage		L	None	3	Excavated
40			Crested wheat	Sage		L	None	3	Old waste area
			Willow						
41	PUSC _x		Weedy annuals	Sage		L	None	3	Lined waste pond
42	POWH _x		Weedy annuals	Sage		L	None	3	Waste pond, 1 adjacent site
43			Weedy annuals	Sage		L	None	4	Covered Waste Pond
44			Weedy annuals	Sage		L	None	3	See CIRBUNWC
45			Weedy annuals	Sage		L	None	4	Rubble pit
46			None	Sage		L	None	4	Manganese: pile
47			Sage	Sage		L	None	4	Firing range
48			Dock /Thistle	Sage		L	None	3	Waste pond
49			None	Sage		L	None	3	Waste pond / Gravel pit
50			Cattail / Bulrush	Sage		M	None	2	Outflow area
51			Weedy annuals	Sage		L	None	3	Waste pond
52			Weedy annuals	Sage		L	None	3	Waste pond
53	L2USJ		Grass / Weeds	Sage		L	None	2	Spreading area
54			Grass / Weeds	Sage		L	None	2	Spreading area
55			Milkvetch	Sage		L	F/H, A/L	2	Revisit in wet years
56			Grass / Weeds	Sage		M	F/L	2	Revisit in wet years
57	R20WH _x		Cattails / Bulrush	Sage		L	None	2	Outflow channel
58	R4SBA		Sparse	Willow / Rose		L	None	2	River - visit in wet years
59	R4SBC		Weedy annuals	Sage		L	None	2	Visit in wet years
60	R4SBJ		Weedy annuals	Grass / Weedy annuals		L	None	2	Visit in wet years
61	R4SBJ _x		Weedy annuals	Sage		L	None	3	Visit in wet years
62			Weedy annuals	Sage		L	None	3	Visit in wet years
63	UNMAP		Elymus	Sage		M	F/H, A/M	1	Visit in wet years
64			Elymus	Sage		L	F/L	2	

Table D-10. (continued).

Class	Site Name ^a	Approximate Dimensions	Vegetation Site	Vegetation Area	1991 INEL Vegetation Map Classification	Wildlife ^b	Archaeology ^b	Rank ^c	Comments
65	UNMAP	ARCHIL3	Elymus	Sage		L	F/L	2	
66		ARCHIL4	Elymus	Sage		L	F/L	3	
67		ARCHIL5	None	Sage		L	F/L	3	
68		ARCHIL6	None	Sage		L	F/L	3	
69		ARCHIL7	Weedy annuals	Cottonwood		L	None	3	Visit in wet years
70		ARCHIL8	Weedy annuals	Sage		L	None	3	Visit in wet years
71		BUTCIT1	Sage / Weeds	Chokecherry		L	None	2	River - visit in wet years
72		BUTCIT2	Sage / Weeds	Rose		L	None	2	River - visit in wet years
73		BUTCIT3	Sage / Weeds	Currant		L	None	2	River - visit in wet years
74		BUTCIT4	Sage / Weeds	Sage		L	None	2	River - visit in wet years
75		HOWPK1	Elymus	Sage		L	A/L	3	
76		HOWPK2	Elymus	Sage		L	F/L	3	
77	UNC	ANTBU5	Salsola	Sage		M	F/L	3	
78		BIGLOST7	None	Saltbush		L	None	3	
79		CIRBU1	None	Rabbitbrush / Sage / Winterfat		L	None	3	
80		CIRBUNE1	None	Sage / Grass		L	None	3	
81		CIRBUNE2	None	Sage / Halogeton		M	F/M	2	
82		CIRBUNE3	None	Rabbitbrush		M	F/M, A/L	2	
83		CIRBUNE4	None	Sage / Horsebrush		L	F/M	3	
84		CIRBUNE5	Salsola / Sage	Sage		L	None	3	
85		CIRBUNW1	None	Elymus / Greasewood		M	F/M	2	
86		CIRBUN2	None	Sage		L	None	3	
87		CIRBUNW3	Saltbush	Sage / Elymus		L	F/L, A/M	3	
88		CIRBUNW4	None	Sage / Saltbush		L	None	3	
89		CIRBUNW5	None	Sage / Grass		L	A/L	3	
90		CIRBUSE2	None	Low Sage		L	None	3	
91		CIRBUSE5	Halogeton	Sage / Grass		M	F/M	3	Man-made catchment
92		CIRBUSW4	Sedge / Rush Weeds	Sage		M	None	2	TRA outflow
93		CIRBUSN	Dock	Sage		L	None	3	CPP waste pond
94		KETBU1	Saltbush / Grass	Sage		H	None	2	Elymus stand nearby
95		LITBUNE1	Elymus	Elymus / Sage		H	A/L	1	Visit in wet years
96		LITBUNE2	Halogeton	Elymus / Sage		H	F/H	2	
97		LITBUNE3	Halogeton	Sage / Grass		L	None	3	

Table D-10. (continued).

Class	Site Name ^a	Approximate Dimensions	Vegetation Site	Vegetation Area	1991 INEL Vegetation Map Classification	Wildlife ^b	Archaeology ^b	Rank ^c	Comments
98	UNC		LITBUSW2	None	Grass / Sage	M	F/L	3	
99			LITBUSW4	Halogeton	Elymus / Grass / Sage	L	F/L	3	
100			LITBUSW7	Elymus	Elymus / Sage	L	F/L	3	
101			LITBUSW8	Halogeton	Sage / Grass	M	None	3	
102			RICHBUT1	Elymus / Birch Willow / Rose	Sage	L	None	2	Visit in wet years
103			RICHBUT	Cottonwood / Elymus / Currant	Sage	L	None	2	Visit in wet years
104			RICHBUT3	Elymus / Rose	Sage	L	None	2	Visit in wet years
105			RICHBUT4	Sage / Elymus / Rose	Sage	M	None	2	Visit in wet years

a. Each site was assigned an identifier comprised of the abbreviated quadrangle in which they were located and an ascending number representing the order in which the sites within the quadrangle were visited. Identifiers were limited to 8 characters. For numbering past 9, alpha characters were used, for example CIRBUNW3 represents the third site visited in the Circular Butte 3 NW quadrangle and LITBUNWA the tenth site visited in the Little Butte NW quadrangle.

b. H = High; M = Moderate; L = Low; F = Flakes; A = Artifacts.

- c.
- 1 = Wetland having high potential for ecological importance
 - 2 = Wetland having moderate potential for ecological importance
 - 3 = Wetland having lower potential for ecological importance
 - 4 = No apparent wetlands characteristics

Appendix D ♦ D-50

Table D-11. INEL wetlands survey—plant species list.

Scientific Name	Common Name
<i>Achillea millefolium</i> L.	Common Yarrow
<i>Agropyron caninum</i> (L.) Beauv.	Bearded Wheatgrass
<i>Agropyron cristatum</i> (L.) Gaerth.	Crested Wheatgrass
<i>Agropyron dasystachyum</i> (Hook.) Scribn.	Thickspike Wheatgrass
<i>Agropyron spicatum</i> (Pursh) Scribn. & Smith	Bluebunch Wheatgrass
<i>Arctium minus</i> (Hill) Bernh.	Common Burdock
<i>Artemisia dracunculus</i> L.	Dragon Sage
<i>Artemisia ludoviciana</i> Nutt.	Silver Sage
<i>Artemisia nova</i> A. Nels.	Low Sagebrush
<i>Artemisia tridentata</i> Nutt. ssp. <i>tridentata</i>	Basin Big Sagebrush
<i>Artemisia tridentata</i> Nutt. ssp. <i>wyomingensis</i> Beetle & Young	Wyoming Big Sagebrush
<i>Artemisia tripartita</i> Rydb.	Threetip Sage
<i>Asclepias speciosa</i> Torr.	Showy Milkweed
<i>Astragalus calycosus</i> Torr.	Matted Milkvetch
<i>Astragalus lentiginosus</i> Dougl.	Freckled Milkvetch
<i>Atriplex canescens</i> (Pursh) Nutt.	Fourwing Saltbush
<i>Atriplex nuttallii</i> Wats.	Saltsage
<i>Betula occidentalis</i> Hook.	Water Birch
<i>Bromus japonicus</i> Thunb.	Japanese Brome
<i>Bromus tectorum</i> L.	Cheatgrass
<i>Carex</i> spp.	Sedge
<i>Chaenactis douglasii</i> (Hook.) H. & A.	Desert Dusty Maiden
<i>Chenopodium fremontii</i> Wats.	Fremont's Goosefoot
<i>Chrysothamnus nauseosus</i> (Pall.) Britt.	Gray Rabbitbrush
<i>Chrysothamnus viscidiflorus</i> (Hook.) Nutt.	Green Rabbitbrush
<i>Cirsium arvense</i> (L.) Scop.	Canada Thistle
<i>Cryptantha interrupta</i> (Greene) Pays.	Bristly Cryptantha
<i>Descurainia pinnata</i> (Walt.) Britt.	Western Tansy Mustard
<i>Distichlis stricta</i> (Torr.) Rydb.	Desert Saltgrass
<i>Echinochloa crusgalli</i> (L.) Beauv.	Barnyard Grass
<i>Elymus cinereus</i> Scribn. & Merr.	Great Basin Wildrye
<i>Erigeron pumilus</i> Nutt.	Shaggy Fleabane
<i>Eriogonum microthecum</i> Nutt.	Shrubby Buckwheat
<i>Euphorbia glyptosperma</i> Engelm.	Corrugate-seeded Spurge
<i>Gutierrezia sarothrae</i> (Pursh) Britt. & Rusby	Matchbrush
<i>Halogeton glomeratus</i> Meyer	Halogeton
<i>Hordeum jubatum</i> L.	Foxtail Barley
<i>Hyocymus niger</i> L.	Black Henbane
<i>Iva axillaris</i> Pursh	Poverty weed

Table D-11. (continued).

Scientific Name	Common Name
<i>Juncus</i> spp.	Rush
<i>Kochia scoparia</i> (L.) Schrad.	Kochia
<i>Lupinus argenteus</i> Pursh	Silvery Lupine
<i>Lygodesmia spinosa</i> Nutt.	Kpiny Skeleton Weed
<i>Machaeranthera canescens</i> (Pursh) Gray	Hoary Aster
<i>Medicago lupulina</i> L.	Black Medic
<i>Medicago sativa</i> L.	Alfalfa
<i>Melilotus officinalis</i> (L.) Lam.	Yellow Sweet-clover
<i>Oenothera caespitosa</i> Nutt.	Desert Evening Primrose
<i>Oenothera tanacetifolia</i> T. & G.	Tansy-ld Evening Primrose
<i>Opuntia polyacantha</i> Haw.	Prickly Pear
<i>Orobanche fasciculata</i> Nutt.	Clustered Broomrape
<i>Oryzopsis hymenoides</i> (R. & S.) Ricker	Indian Ricegrass
<i>Phlox hoodii</i> Rich.	Hood's Phlox
<i>Poa nevadensis</i> Vasey	Nevada Bluegrass
<i>Poa sandbergii</i> Vasey	Sandberg's Bluegrass
<i>Polygonum aviculare</i> L.	Doorweed
<i>Polygonum douglasii</i> Greene	Douglas' Knotweed
<i>Populus angustifolia</i> James	Narrow-leaved Cottonwood
<i>Populus trichocarpa</i> T. & G.	Black Cottonwood
<i>Prunus virginiana</i> L.	Common Chokecherry
<i>Ribes aureum</i> Pursh	Golden Currant
<i>Rosa woodsii</i> Lindl.	Wood's Rose
<i>Rumex crispus</i> L.	Curly Dock
<i>Salix exigua</i> Nutt.	Gray Sandbar Willow
<i>Salsola kali</i> L.	Russian Thistle
<i>Scirpus acutus</i> Muhl.	Hardstem Bulrush
<i>Scirpus</i> spp.	Bulrush
<i>Sisymbrium altissimum</i> L.	Jim Hill Mustard
<i>Sitanion hystrix</i> (Nutt.) Smith	Bottlebrush Squirreltail
<i>Solanum triflorum</i> Nutt.	Cut-leaved Nightshade
<i>Solidago canadensis</i> L.	Canada Goldenrod
<i>Sphaeralcea munroana</i> (Dougl.) Spach.	Orange Globemallow
<i>Stipa comata</i> Trin. & Rupr.	Needle-and-thread Grass
<i>Typha latifolia</i> L.	Common Cattail
<i>Urtica dioica</i> L.	Stinging Nettle

Figure D-2. Distribution of survey PUSJ sites.

Thirty-seven of the 44 surveyed PUSJ wetlands are dry, bare playas with scattered halogeton (*Halogeton glomeratus*) plants established in mud cracks. Four sites are basins containing primarily basin wildrye (*Elymus cinereus*). Other established vegetation at PUSJ sites was rare. Nearly all sites are surrounded by sagebrush (*Artemisia* spp.) in some combination with other species including weeds, grasses, greasewood (*Sarcobatus vermiculatus*), rabbitbrush (*Chrysothamnus* spp.), or winterfat (*Ceratoides lanata*).

Although no water was present at any PUSJ site during the fall survey, their characteristics indicate that water is present during some parts of the year. No obligate or facultative wetland vegetation was observed. Playa soil texture was generally fine (silty clay or silty clay loam) and compacted, with surfaces broken by mud cracks. Many of the sites were surrounded by large areas of dead and dying sagebrush (*Artemisia* spp.). Evidence of wildlife was present at all PUSJ sites, and nearly one third of the sites had signs of heavy use. No rare or endangered species were observed.

D.1.4.1.3 L2USJ, PEM1A, PEM1C, PEM1J, and PEMJ Classified

Wetlands—Lacustrine (L2USJ) and palustrine (PEMJ, PEM1J, PEM1A, and PEM1C) classifications cover large portions of the Big Lost River spreading areas and the outflow areas from the Big Lost River Sinks. The distribution of these wetlands and location of surveyed sites are shown Figure D-3. The largest single area encompassed by L2USJ wetlands is approximately 325 ha (800 acres). Area totals for PEMJ, PEM1J, PEM1A, and PEM1C wetlands are between 160 ha (400 acres) and 290 ha (700 acres). INEL wetlands included in these classifications cover a total of approximately 1,417 ha (3,500 acres).

Wetlands for these five classifications are expansive, with large areas of bare ground and perennial weed cover. Most areas are heavily grazed by cattle. Native perennials are present in small numbers for both PEM1J sites, and some native grasses were found among many weed species at the PEM1A site. Communities dominated by sagebrush (*Artemisia* spp.) surround both lacustrine and palustrine wetlands for all five classifications.

Remains of obligate wetland vegetation [bulrush (*Scirpus acutus*)] were observed at an outflow area north of Naval Reactors Facility (PEM1C), and remains of cattails (*Typha latifolia*) were found in areas of the Big Lost Sinks (PEM1C). However, a combination of extended drought, upstream water diversion, and heavy cattle grazing have reduced vegetation in the Big Lost Sinks to bare ground and weed cover. Gray sandbar willow (*Salix exigua*), an obligate wetland species, was identified in the L2USJ areas east of the Big Lost Sinks, and several facultative wetland species such as curly dock (*Rumex crispus*), doorweed (*Polygonum aviculare*), and desert saltgrass (*Distichlis stricta*) were also identified at L2USJ and PEM1A sites. Soils were generally loose, disturbed, and fine (sandy silt). Low to moderate evidence of wildlife use was observed for all 11 of these sites. No rare or endangered species were observed. The northernmost PEM1A site located in the Big Lost Sinks is the only INEL wetland that has been ground-truthed by the FWS for the NWI.

Figure D-3. Surveyed palustrine and lacustrine wetlands of the INEL.

D.1.4.1.4 Manmade Wetlands—Manmade wetlands on the INEL include industrial waste or sewage treatment ponds (PAB4Hx, POWHx, PUSC_x, PUSC_{rx}) and borrow or gravel pits (PUSC) associated with INEL facilities. The distribution of the sites visited during this survey is shown in Figure D-4. With the exception of several POWHx ponds, these wetlands are generally less than 0.8 ha (2 acres) in size and are indistinguishable at the scale shown on Figure D-4.

Most waste ponds are surrounded by gravel berms and some are lined. Water sources for these sites are sustained as part of facility operations. Most have only weed species growing around the edges, except the industrial waste pond northwest of Argonne, where water flow maintained by facility operations supports obligate wetland vegetation including bulrush (*Scirpus acutus*) and cattails (*Typha latifolia*). The obligate wetland species, gray sandbar willow (*Salix exigua*), was observed at the waste area south of Auxiliary Reactor Area (PUSC_{rx}). The single PUSC site is an excavated borrow pit with weeds and crested wheatgrass (*Agropyron cristatum*). Minor facultative wetland components observed at POWHx and PAB4Hx include barnyard grass (*Echinochloa crusgalli*), doorweed (*Polygonum aviculare*), and curly dock (*Rumex crispus*).

The only standing or running water observed at INEL wetlands during this survey was contained in industrial waste ponds or outflow channels associated with facility operations [POWHx and R2OWHx (see Section D.1.4.1.5)]. Evidence of wildlife use for these wetlands was low; however, the open water may be of importance to waterfowl in spring and fall. No archaeological evidence was observed at any of these surveyed sites, probably due to the high degree of localized ground disturbance. No threatened or endangered species were observed. Although these areas rank lower in potential ecological importance, they retain importance in relation to facility planning and operations.

D.1.4.1.5 Riverine Wetlands—Riverine classifications (R4SBJ_x, R4SBA, R4SBC, R4SBJ, R2OWHx) represent channel features associated with the Big Lost River. The main river channel is mapped as a single R4SBA feature. The distribution of these wetlands and the location of surveyed sites are shown on Figure D-5.

The river channel features classified as R4SBC, R4SBJ, and R4SBJ_x are generally scattered with weeds. Extended drought conditions have allowed establishment of sparse vegetation, including perennials from the riparian and upland vegetation, along the Big Lost River (R4SBA). Cottonwood (*Populus angustifolia*), rose (*Rosa woodsii*), willow (*Salix exigua*), chokecherry (*Prunus virginiana*), and sagebrush (*Artemisia tridentata*) riparian habitats are common along the southern half of the Big Lost River.

All surveyed riverine wetlands were dry with the exception of the R2OWHx site. This site is one of three areas surveyed on the INEL that supports obligate wetlands vegetation. Bulrush (*Scirpus acutus*) and cattails (*Typha latifolia*) are maintained at this site by water flow from Naval Reactors Facility operations. Gray sandbar willow (*Salix exigua*) was the only additional obligate wetland species identified in the main Big Lost River channel (R4SBA). Light to moderate evidence of wildlife was observed, and in some sections of the river, raptor nests and owls were observed. No threatened or endangered species were observed.

Figure D-4. Surveyed manmade wetlands of the INEL.

Figure D-5. Surveyed riverine wetlands of the INEL.

D.1.4.1.6 Wetland Areas in UNMAPPED Quadrangles—The 14 unmapped sites (UNMAP) included in this survey are located in seven quadrangles for which NWI maps have not been completed by the FWS (see Figure D-6). These maps cover the westernmost areas of the INEL, and the sites visited include riverine classifications along the Big Lost River, as well as sites that are similar to the PUSJ sites that were investigated in other areas of the INEL. Unmapped riverine sites were similar to the R4SBA sites described in Section D.1.4.1.5. The remaining sites were similar in most respects to PUSJ sites described in Section D.1.4.1.2, except that playa areas dominated by basin wildrye (*Elymus cinereus*) were more common. The unmapped sites visited for the survey are included on Figure D-6.

D.1.4.1.7 UNCLASSIFIED Areas—Twenty-nine unclassified areas (UNCLASS) on the INEL were included as part of this survey. Non-riverine sites in this classification were similar in all respects to those classified as PUSJ (Section D.1.4.1.2). Most sites were bare playas or basins dominated by basin wildrye (*Elymus spp.*); however, disturbed areas with numerous weedy species were also included. Some unclassified areas had substantial signs of wildlife use and archaeological evidence. All areas appeared to retain water for some duration during normal precipitation years. A number of these areas are represented as intermittent water (blue) on the U.S. Geological Survey 7.5-ft topographical maps covered by the NWI; however, they were not selected for NWI classification. The unclassified sites surveyed are included on Figure D-6.

The only unclassified riverine area included for this survey was the Birch Creek drainage. The creek system contains areas with important riparian communities including of cottonwoods (*Populus spp.*), willow (*Salix spp.*), birch (*Betula spp.*), chokecherry (*Prunus virginiana*) and rose (*Rosa woodsii*).

D.1.4.1.8 Riparian Areas—These areas are generally included in the discussion for riverine, unmapped, and unclassified wetlands. They include the Big Lost River and Birch Creek drainages.

D.1.4.2 Caves. This section will be completed as part of GIS analysis.

D.1.4.3 Manmade Structures and Facilities. This section will be completed as part of GIS analysis.

D.1.4.4 Soil Microflora. Given the magnitude of mass and energy that cycles through microbial biomass and the pivotal nature of their associations with plant species, the impact of site development and environmental restoration activities on microbial communities should not be ignored. The ecological significance of soil microorganisms, their distribution in the environment, and recent work describing the role of microorganisms in disturbed and restored environments is cited below. The microbiology of shrub-steppe ecosystems is not well understood. At the INEL, detailed Site-wide data are not available describing the distribution and activities of soil microorganisms. Limited microbiology data exist for several subsurface basalt/sediments cored during 1988 and 1990 and from the Snake River Plain Aquifer sampled at discrete well locations.

Figure D-6. Surveied unmapped and unclassified areas on the INEL.

Soil microorganisms influence the success or failure of plant growth by regulating the quantity and form of nutrients and toxicants. In addition, microorganisms synthesize vitamins, amino acids, growth factors, auxins, and allelopathic substances. In the immediate vicinity of the plant's rhizosphere, there are increased numbers of microorganisms; this enhancement is known as the rhizosphere effect. Many of the microorganisms that reside in the rhizosphere are involved in some type of mutualistic relationship with the host plant species. Some of these relationships are loosely defined such as the increased bioavailability of nutrients in exchange for labile carbon from root exudates. Symbiotic relationships between plants and nitrogen-fixing bacteria and associations with mycorrhizae fungi necessitate physical integration of these species into the plant structure. All of these interactions may contain nuances in the mechanisms of material exchange and the presence of elaborate feedback signals. Soil microorganisms further modify the plant's environment by contributing to soil particle structure, both with their living biomass and extracellular polymer production.

Microorganisms mediate transformations of nearly all inorganic and organic substances. Collectively, they share the primary responsibility for material recycling in all ecosystems. Their ability to make a local impact (nutrient bioavailability) or a global impact (climate change) is a direct function of their large numbers (for bacteria alone: ca. 10^9 /g soil and 10^6 /mL water). The role of soil microorganisms in terrestrial ecosystems is particularly critical as the upper soil horizons function as reservoirs containing organic matter and inorganic nutrients in these systems.

The biogeochemical cycles of C, O, and H are heavily influenced by microbes. Soil microorganisms, especially bacteria and fungi, are largely responsible for the decomposition of organic matter (to CO_2 , water, and simple inorganic molecules) in terrestrial systems. These organic substrates include those considered as contaminants such as hydrocarbons and xenobiotics. They also incorporate inorganic (and organic) carbon into biomass and provide a food source for higher heterotrophic organisms such as grazers. The consumption of oxygen during the metabolism of aerobic microorganisms often determines the level of O_2 in the soil atmosphere. Due to the enormous physiological diversity of microorganisms, significant numbers of species are involved in metabolic transformations which consume or evolve H_2 , altering the flow of electrons in the environment.

All of the major, minor, and trace nutrients are directly or indirectly influenced by the activity of soil microorganisms. These elements are used not only as nutrients, but as energy sources and alternate terminal electron acceptors by varying segments of the microbial community. Nitrogen is one the most actively cycled elements in the soil and is often limiting to plant productivity. Organic N can be mineralized or assimilated. Inorganic nitrogen can be oxidized or reduced. These biologically-catalyzed reactions result in conversion of N to any one of its oxidation states and may partition the N into any phase. These transformations affect the mobility and bioavailability of N in the environment with the extreme case being a loss of N from the system (e.g., denitrification, leaching of NO_3^-) or a gain (e.g., N_2 fixation). Iron and sulfur are cycled as intensively and along many of the same routes as nitrogen. Phosphorous is less actively cycled, mostly between organic and inorganic forms. The bioavailability of many elements

essential for life such as Mn, Ca, Si, Cu, and Zn are influenced by the activities of the soil microflora.

The speciation of nearly all trace metals, and therefore form, mobility, bioavailability, and toxicity, may be altered by microorganisms. These alterations may be direct, e.g., reduction of a metal as a terminal electron acceptor, oxidation as an energy source, methylation or assimilation of that metal. Immobilization of the metal may involve sorption processes at the cell surface, or these transformations may be more indirect. The metabolism of microorganisms can result in gradients in redox potential or pH; both affect sorption phenomena and mineral solubility. Microorganisms produce extracellular organic compounds, which function as simple ligands or multidentate chelators for metals. These compounds include enzymes, extracellular polysaccharide polymers, siderophores, and incompletely oxidized organic substrates. These organic compounds can profoundly alter the speciation, solubility, bioavailability, and partitioning of metals in the environment.

As a group, microorganisms respond to a multitude of environmental variables that determine their distribution and activity. Among bacteria and fungi, species may respond differently to these factors and exhibit quite a range of tolerances and optima. Within species, there is variability attributable to the individual. In general, microorganisms are uniquely qualified to react to trace quantities of a chemical in the environment. The physical, chemical, and biological variables that microorganisms respond to are present in the environment in concentration gradients that vary in length scale from submicron to kilometers. The large number of influential variables and their varying length scales combine to ensure that microorganisms will be heterogeneously distributed in time and space. Certainly, the presence of plant species will affect the distribution of microbes in soils. Key variables that affect microbial activity are temperature, moisture, quantity, and quality of organic carbon, nutrients, and electron acceptors, such as oxygen, nitrate, and sulfate.

The soil microbial community and its functions are affected by disturbance—whether introduction of contaminants such as hydrocarbons (Atlas et al. 1991) or pesticides (Duah-Yentumi and Johnson 1986) or by excavation and stockpiling (Johnson et al. 1988). The ability of contaminated, remediated, or restored soil to support revegetation with the original complement of flora is uncertain. Further, the impact of remedial operations (if necessary) on the soil microflora is undefined. Anticipated alterations due to remedial actions might include changes in the native microbial community structure and function and concomitant effects in carbon and nutrient flow and storage (Fender 1992). Impact on bacteria involved in mutualistic associations with vegetation may translate to decreased plant growth or inability to reestablish native vegetation. Effects at higher trophic levels would be expected.

Research has indicated that recolonization of soils by the appropriate microbial communities is critical to the success of land reclamation efforts (Shubert and Starks 1985). Maxwell (1991) reported the requirement of a diverse autotrophic soil microflora community for long-term revegetation of reclaimed metal-contaminated lands. Williamson and Johnson (1991) showed that restored soils at open-cast coal sites have lower nitrogen bioavailability than undisturbed soils.

This decrease in bioavailable N is due to complex changes in the relative abundances of microbial guilds in response to the availability of terminal electron acceptors. Nitrogen is lost from the system by leaching and denitrification and immobilized by microbial assimilation (Johnson et al. 1988). Lack of bioavailable N causes increased competition between soil microorganisms and plants for N with a consequence of lower plant production. Decreased biomass and a lower percentage of active biomass (Harris and Birch 1989) occur in restored soils relative to undisturbed soils. Williamson and Johnson (1991) have demonstrated low soil-biomass-C:soil-C ratios and increasing C:N ratios of soil organic matter 3 years after soil restoration at open-cast coal sites, which indicates long-term implications for soil fertility.

It has always been assumed that microbes are ubiquitous and that they appear spontaneously with the correct blend of physiologies—by immigration, mutation, or transfer of genetic material. This may not be a sound assumption. Microorganisms have evolved over geological time (e.g., millions of years). Anthropogenic disturbances have occurred over much shorter time periods. While it is true that short generation times, high mutation rates, and horizontal gene transfer among microbial populations confer tremendous selective advantage to bacteria and allow them to rapidly adapt to changing conditions, critical microbial niches may go unoccupied. It has been shown that disturbed environments may exhibit long-term deviations in the processing of energy and materials relative to undisturbed locations. Manipulation of microbial populations via bioaugmentation or biostimulation or by controlling environmental variables during site remediation may be required for successful restoration of disturbed sites, particularly where revegetation is a criteria. When appropriate microbial populations are deficient in the rhizosphere, plant growth is inhibited (Campbell 1985). This conclusion is due to the general role of soil microorganisms in maintaining soil fertility through materials cycling and their effect on soil structure and by specific roles provided by microorganisms that engage in mutualistic associations with plant species.

D.2 Habitat Analyses and Ecological Associations (Biological Assessment)

This section describes the methods and the strategy employed to establish a habitat relationship between vegetative communities and animal species for the INEL. By identifying wildlife habitat associations and by utilizing the INEL vegetation map (Section D.1.1.1), mapping (GIS) analyses can be applied to analyze potential impacts at the community level.

D.2.1 Vegetation Communities

D.2.1.1 Fragmentation. This section will be completed as part of GIS analysis.

D.2.1.2 Exotic Species. This section will be completed as part of GIS analysis.

D.2.1.3 Ecological Importance. This section will be completed as part of GIS analysis.

D.2.1.4 Vegetation Community Stratification. Because community and individual data for INEL flora and fauna are incomplete for the INEL, a habitat model approach was applied to develop a baseline structure for INEL plant and wildlife communities. Ecological studies for the INEL were compiled, reviewed, and evaluated to extract data that were appropriate for GIS and mapping assessments and to support the development of habitat profiles for individual species.

Short and Burnham (1982) have developed a wildlife habitat evaluation model based on the vertical structure of vegetation communities that has been used to assess impacts to rangeland habitats (see also Short 1982, 1986). The relationship between the number of species and the number of vegetation layers in a community has been shown to be significant, especially for birds and reptiles (Short 1982, 1986; Jones 1986). The model is based on the assumption that greater vertical and horizontal diversity in desert habitats results in greater niche diversity and a more diverse wildlife association (Short 1986; Jones 1986; Anderson 1991). This vertical stratification approach was applied to allow a coarse scale association of wildlife groups and individual species with vertical habitat "layers" within INEL vegetation communities.

Dominant specie life forms for each of the 14 INEL vegetation communities were used to determine a maximum plant canopy height. Each of the communities were stratified by vertical habitat structure according to the criteria suggested by Short and Burnham (1982) and defined on Table D-12. The resultant vertical stratification for INEL communities is illustrated on Table D-13.

Community associations for individual plant and animal species were drawn through development of habitat profiles or "models" (FWS 1981; Short 1986) to allow linkage to strata within one or more INEL vegetation communities.

Table D-12. Criteria for vertical stratification of INEL vegetation communities (Short 1986).

Layer	Criteria
Tree canopy or overstory	Vegetation structure is 8 m (25 ft) or more above the terrestrial or aquatic surface and provides at least 5% cover when projected to the surface (500 m ² /ha or 2,200 ft ² /a).
Tree bole	Tree trunks have a dbh 20 cm (8 in.) and occur at a density 12/ha (5/a).
Shrub midstory	Vegetation height from 50 cm (20 in.) up to 8 m (25 ft), which provides at least 5% cover when projected to the surface (500 m ² /ha or 2,200 ft ² /a).
Terrestrial surface	Layer extends from 10 cm (4 in.) below the apparent surface up to, but not including 50 cm (20 in.) above the apparent surface and provides at least 5% cover when projected to the surface 500 m ² /ha or 2,200 ft ² /a).
Terrestrial subsurface	Extends from more than 10 cm (4 in.) below the apparent surface down.
Surface water layer	Land surface-water interface and shallow water interface up to 25 cm (10 in.) deep.

Table D-13. Summary of vertical stratification for INEL vegetation communities.

This table is being completed.

D.2.2 Habitat and Ecological Associations—Flora

Plant site profiles were developed from INEL ecological studies and other associated literature. Only profiles for threatened, endangered, and sensitive species were compiled. Several habitat components were used to correlate individual plant species with INEL vegetation communities including:

- Dominant species within the community or communities in which the plant has been located and with which it is generally associated
- Soil type and characteristics
- Specific landforms with which the plant may be associated.

Only profiles for sensitive plant species were compiled for this assessment to allow association of individual species with the INEL mapped vegetation communities discussed in Section D.1.1.2. An example of the profile developed for Thistle milkvetch (*Astragalus kentrophyta* var. *jessiae*) is shown on Table D-14. Other habitat ecological associations for sensitive plant species are presented in Section D.1.4.

Section D.2.2 to be completed as part of GIS analysis.

D.2.3 Habitat and Ecological Associations—Fauna

Data on the relative abundance, habitat use, and seasonal occurrence of species of fish, amphibians, reptiles, birds, and mammals recorded on the INEL were updated in 1986 (Reynolds et al. 1986). Previous ecological studies conducted on the INEL and correspondence with INEL researchers and personnel provided the basis for the analyses and data reported in this appendix. See Section D.4 for an annotated bibliography of INEL ecological studies.

Habitat profiles were developed for individual animal species of interest, including threatened, endangered, and sensitive species. The profiles were constructed around 18 components of desert ecosystems considered to be critical to desert wildlife and presented on Table D-15 (Jones 1986). INEL vegetation, soil, and geologic studies were evaluated to compile information on how these habitat components are distributed. Ecological research and other literature was reviewed to obtain information about how individual species utilize habitat components on the INEL. In addition, the FWS has developed habitat suitability index models in support of their Habitat Evaluation Program (FWS 1981). These models were used to construct habitat profiles for several species including the pronghorn (*Antilocapra americana*) and the ferruginous hawk (*Buteo regalis*) (Table D-16) (Jasikoff 1982).

The resulting profiles were used to associate individual species with the appropriate vertical strata using breeding and feeding loci as demonstrated by Short (1982, 1986). This prevented evaluation of communities unrepresentative of the species vertical niche. The verbal profiles were then used to identify vegetation community association through the process of elimination.

Table D-14. Site profile—*Astragalus kentrophyta* var. *jessiae* (Cholewa and Henderson 1984).

INEL Vegetation Community ^a	Dominant Species	Soil	Landform Associations	Comments
Juniper Woodlands	<i>Juniperus osteosperma</i> Associates: <i>Eriogonum ovalifolium</i> <i>Arenia franklinii</i> <i>Agropyron spicatum</i> <i>Aristida purpurea</i> var. <i>longicita</i>	Deep sand	Gullywashes	Occur in grazed areas on the INEL Habitat vulnerable to erosion

a. Preliminary association pending completion of GIS analysis.

The impacts may then be evaluated on a community basis by recompiling the species profiles into guilds and mapping all INEL vegetation communities with which the guild is associated. Disturbance layers are then overlaid and GIS calculations completed on the percent disturbed for each impact. Patch boundary analyses may then be applied to further define associations for both plant and animal communities.

D.2.3.1 Mammals. This section will be completed as part of GIS analysis.

D.2.3.2 Birds. This section will be completed as part of GIS analysis.

D.2.4 Habitat and Ecological Associations—Threatened and Endangered Species

D.2.4.1 Flora. This section will be completed as part of GIS analysis.

D.2.4.2 Fauna. This section explains the habitat and ecological associations of raptors (bald eagle, peregrine falcon, merlin, ferruginous hawk, and northern goshawk), other birds (long-billed curlew, loggerhead shrike, and common loon and pelican), and mammals (Townsend's western big-eared bat, western pipistrelle, and pygmy rabbit).

D.2.4.2.1 Raptors—A raptor survey was conducted by automobile during the winters of 1974–1975 and 1975–1976. A total of 32 surveys were conducted over a 187-km (116-mi) covering the western two-thirds of the INEL Site (Craig 1979). Surveys were conducted in the same area again during the winter of 1981–1982 (Craig et al. 1984) and from January through May in 1992 (Flake and Hansen 1992).

Table D-15. Important components of desert habitats (Jones 1986).

Components	Description	Variables / Factors
<u>Microhabitat Components</u>		
Water (lotic)	Rivers and streams	Riffle/run/pool ratios, water temperatures, turbidity, DO, organic content, siltation, pollutants
Water (permanent)	Ponds, marshes, lakes, reservoirs, natural catchments, agricultural run-off, potholes, manmade, etc.	Water temperature, DO, organic content, siltation, pollutants, emergent vegetation, logs and other litter, substrate
Water (temporary lentic)	Temporary rain pools, irrigation ditches	DO, water temperatures, siltation, pollutants, duration, frequency, emergent vegetation, substrate
Rock	Talus slopes, cliffs, boulders, substrate	Rock size, heterogeneity, interfaces, origin, vertical and horizontal structure
Soil	Surface and subsurface soil types	Types, depth, heterogeneity, horizontal and vertical structure, interfaces with other habitat components
Vegetation - litter/debris	Leaves, logs, limbs	Litter size, depth, heterogeneity, horizontal structure, type, moisture retention, temperature
Vegetation - dead	Standing vegetation, roots	Size, interface with other habitats, heterogeneity, vertical and horizontal structure, soils (roots only)
Vegetation - live	All vegetation including roots	Horizontal and vertical structure, interfaces with abiotic components, heterogeneity
Vegetation - plant species	Individual plant species	Individual plant species abundance and occurrence
Animal -created		
Manmade Structures (other than water and agriculture)		

Table D-15. (continued).

Components	Description	Variables / Factors
<u>Macrohabitat Components</u>		
Slope	Percent angle of area from horizontal	Percent slope, moisture availability, thermal regimes, vegetation structure
Aspect	South, north, east, and west facing	Direction, moisture availability, temperature regimes, vegetation structure
Elevation	Vertical, above or below sea level	Vertical distance, moisture availability, thermal regimes, vegetation structure
Precipitation	All forms	Quantity, type, duration, frequency, moisture availability, thermal regimes, vegetation structure
Ecotones / habitat juxtaposition	Habitat interfaces and locations	Heterogeneity, interface size, and cumulative numbers, position of habitats
Geographic Location	Major geographic boundaries and barriers	Size, location and frequency, habitat size and disjunction
<u>Human Influences</u>		

Bald Eagle—The bald eagle exists only in North America, is our national symbol, and has cultural significance for native Americans (Green 1985). It is listed as an endangered species by FWS and as an endangered species by the Idaho Department of Fish and Game (Moseley and Groves 1992).

Bald eagles were observed on the INEL Site during the 1976 raptor survey and are periodically reported during the winter months on the northern portion of the INEL (Craig 1979). Their existence Site-wide is considered uncommon to rare; however, sightings increased from one sighting during the 1974–1976 survey to 79 sightings in 1981–1982 (Craig et al. 1984). Only one bald eagle was sighted in the 1992 survey (Flake and Hansen 1992).

The primary food source for bald eagles is fish, waterfowl, and seabirds. Nearly 100% of their nests are found within 2 mi of a coastal area, lake, river, or other body of water. Wintering sites are usually associated with water but may be in areas without open water if food sources such as rabbit and deer are abundant. Night roost sites in tall trees are a major characteristic of winter habitat (Green 1985).

Table D-16. Example species habitat profile for the ferruginous hawk (Jones 1986).

Habitat Component	Defense	Escape Cover	Food or Prey	Feeding Substrate	Nest or Birthing Substrate	Physio-logical	Repro-duction	Resting Substrate	Thermo-regulatory substrate	Comments
Water (lotic)										
Water (permanent lentic)										
Water (temporary lentic)							•			
Rock				•			•			
Soil										
Vegetation-litter / Debris										
Vegetation - dead				•	•		•			
Vegetation - live					•		•			Juniper
Vegetation - Plant species										
Animal - Created										
Manmade Structures							•			
Slope										
Aspect							•			
Elevation										
Precipitation										
Ecotones / Habitat Juxtaposition										
Geographic Location										
Human influences					•					Manmade Structure

Peregrine Falcon—The peregrine falcon migrates over the INEL (Craig 1979). Sightings on the INEL have been rare but have occurred in both summer and winter (Arthur et al. 1984). The peregrine falcon is listed by FWS as an endangered species (Moseley and Groves 1992) due to the population decline in the 1950s and 1960s (Craig 1986). Efforts to reintroduce the species into Idaho were begun in the early 1980s (Craig 1986).

There is no record of peregrine falcons breeding on the INEL; however, the known breeding range extends along the rocky mountains from the arctic to Mexico (Craig 1986). Breeding occurs primarily in March and April, and eggs are laid in scrapes on high escarpments or sometimes on ledges of tall, man-made structures (Craig 1986).

Peregrine falcons feed primarily on shore birds, other birds (Craig 1986), and small mammals, reptiles, and insects (Craig 1979). Marshes and riparian areas are important for their foraging (Craig 1986). Because they are at the apex of the food chain, small perturbations in the system have dramatic effects on them. DDT and chlorinated hydrocarbons are considered to be one of the primary causes of their decline (Craig 1986).

Merlin—The merlin is a species of special concern for the state of Idaho and a sensitive species for the Bureau of Land Management (Moseley and Groves 1992).

The merlin is a Site-wide resident but its existence is rare (Arthur et al. 1984). Only one merlin was sighted on the INEL during the winter 1992 survey (Flake and Hansen 1992).

The distribution of the merlins is from the northwestern corner of Oregon, up through northern Washington and Idaho, and back down through Montana, Wyoming, and Eastern Idaho. They winter throughout the region and breed primarily in the prairie-parkland, rarely breeding in juniper. Two nestings of merlin close to the INEL have been recorded (Craig and Renn 1977).

Ferruginous Hawk—The ferruginous hawk is a candidate species (C2) for the FWS and listed as a species of special concern by the Idaho Department of Fish and Game (Moseley and Groves 1992). It is a migrant species, arriving on the INEL Site in mid-March and leaving in September. It has been seen Site-wide but is considered uncommon and rarely seen in the winter (Arthur et al. 1984).

During the 1974–1976 raptor survey (Craig 1979), three areas on the Site were determined to be breeding sites for ferruginous hawks. Evidence of at least 35 older nesting sites (Craig 1984) were found, which led the researchers to conclude that ferruginous hawks were declining in the area as they are throughout much of their territory (Harlow and Bloom 1987). Powers and Craig (1976) describe the INEL as a part of the most concentrated Ferruginous hawk nesting area in southeastern Idaho.

Ferruginous hawks are commonly found in grassland, sagebrush, and pinion-juniper habitats. A versatile nester, the ferruginous hawk nests in trees, cliffs, buttes, and even manmade structures (Jasikoff 1982). Their decline is generally attributed to human disturbance and the conversion of

grassland to agricultural lands, not to the loss of breeding sites (Harlow and Bloom 1987). Researchers of the INEL have attributed their decline on the Site to the reduced blacktail jackrabbit population at the time of the survey (Craig 1979) and reported that ferruginous hawks were regularly seen during the winter of 1981–1982 when jackrabbit populations were increasing (Craig et al. 1984). Ferruginous hawks were sighted 41 times during the 1992 survey (Flake and Hansen 1992).

Northern Goshawk—The northern goshawk is listed by the FWS as C2, taxa for which information indicates that endangered or threatened status may be appropriate but for which conclusive data on vulnerability are not available. Also, it is listed by Region 4 of the U.S. Forest Service as a sensitive species (Moseley and Groves 1992).

The northern goshawk is a migratory species that is rare at the INEL; however, some have been sighted in the spring and fall near Big Southern Butte or along the edge of the mountains to the northwest, and in the winter along the Big Lost River.

Northern goshawks are associated with woodlands and forests. Their rounded wings and long tail are adapted for flight agility in dense vegetation (Reynolds 1987). Their preferred breeding habitat is older, tall forests, but wintering habitat can be in more open scrublands and woodlands. Typical prey are quail, jay, American robin, snowshoe hare, tree squirrel, and ground squirrel.

D.2.4.2.2 Other Birds—This section covers the long-billed curlew, the loggerhead shrike, and the common loon and pelican.

Long-Billed Curlew—The long-billed curlew is listed as 3C by FWS, a species more widespread or abundant than previously believed or not subject to identifiable threats (Moseley and Groves 1992) but is listed by the Bureau of Land Management as a sensitive species. The species has been declining in the Great Basin region and throughout the West (Arthur et al. 1984).

The long-billed curlew is the largest of the North American shorebirds (Ryser 1985). It has been sighted on the INEL near water and in sagebrush-steppe communities (Arthur et al. 1984). It is a migratory bird that is not known to breed on the INEL. Long-billed curlews usually breed in grassy areas near marshes but have been known to breed in dry upland areas and even in alkali flats (Arthur et al. 1984). Insects and other invertebrates are their primary food source.

Loggerhead Shrike—The loggerhead shrike is listed by the FWS as C2, taxa for which information indicates that endangered or threatened status may be appropriate but for which conclusive data on vulnerability are not available.

They are not common to the INEL, but some breed there. They generally are found in open areas with shrubs and small trees for nesting sites. The loggerhead shrike is declining

throughout the United States, but are most prevalent in the brushlands and deserts of the southwest. They eat a wide variety of small mammals, birds, reptiles, and insects.

Common Loon and Pelican—The common loon and pelican are both listed as special species of concern for the State of Idaho. Both species migrate over the INEL, but their existence on the Site is rare. Since the INEL has no extensive aquatic habitat, the activities there are not likely to affect these species.

D.2.4.2.3 Mammals—This section covers Townsend's western big-eared bat, the western pipistrelle, and the pygmy rabbit.

Townsend's Western Big-Eared Bat—Townsend's big-eared bat is listed by FWS as category C2, is listed as a sensitive species by Region 4 of the Forest Service, and is a species of concern for the State of Idaho (Moseley and Groves 1992).

In a study of hibernating bats in lava tubes, 177 Townsend's big-eared bats were counted (Genter 1986). Wackenhut reported Townsend's big-eared bats summering on the INEL and hibernating in caves in groups of 3 to 406 (Genter 1986). The species is seldom abundant, but is widespread, occupying a variety of habitats, but most typically in the arid western desert scrub, pinon-juniper, and pine forest regions. In arid regions, it uses caves rather than buildings for daytime roosts, but uses buildings for nighttime roosts. The main food source for Townsend's big-eared bat is lepidoptera.

Western Pipistrelle—The western pipistrelle is a species of special concern for the State of Idaho (Moseley and Groves 1992). This species has not been found on the INEL, but is a summer resident of the lava tubes and caves in Lincoln and Gooding counties (Wackenhut 1990).

Pygmy Rabbit—The pygmy rabbit is listed as C2, taxa for which information indicates that endangered or threatened status may be appropriate but for which conclusive data on vulnerability are not available (Moseley and Groves 1992).

The pygmy rabbit is a resident of the INEL and is abundant particularly in the southwestern section of the INEL (Fisher 1979). It is dependent upon the presence of dense stands of big sagebrush for defense, reproduction, and food (Wilde 1978). Pygmy rabbits apparently dwell only in big sagebrush habitats, but require some rock outcrops as well (Fisher 1979).

D.2.5 Unique or Special Habitats and Communities

D.2.5.1 Wetlands. This section will be completed as part of GIS analysis.

D.2.5.2 Caves. This section will be completed as part of GIS analysis.

D.2.5.3 Manmade Structures and Facilities. This section will be completed as part of GIS analysis.

D.2.5.4 Soil Microflora. This section will be completed as part of GIS analysis.

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D.4 Annotated Bibliography for Ecological Resources^d

1. Anderson, J. E., and Inouye, R., 1988, *Long-term dynamics of vegetation in a sagebrush steppe of southeastern Idaho*, Final Report, April 1988.

The vegetation in established long-term plots was identified and cover, density, and frequency calculated. Results are discussed along with observable trends in the grass, forb, and shrub cover since grazing was halted in this portion of the INEL. Also, status of the noxious weed cheatgrass on the INEL is discussed.

Subject: Vegetative studies on the INEL

Keywords: VEGETATION / SAGEBRUSH / CHEATGRASSES / GRAZING

2. Abbott, M. L., and Fraley, L. Jr., 1991, "A review: radiotracer methods to determine root distribution," *Experimental and Environmental Botany*, 31:1-10.

Summarized in Markham, 1991.

3. Abbott, M. L.; Fraley, L. J., and Reynolds, T. D., 1991, "Root profiles of selected cold desert shrubs and grasses in disturbed and undisturbed soils," *Environmental and Experimental Botany*, 31:165-178.

Summarized in Markham, 1991.

4. Anderson, J. E., 1986, "Development and structure of sagebrush steppe plant communities," In: Joss, P. J.; Lynch, P. W.; Williams, O. B., *Rangelands: A Resource Under Siege, Proceedings, 2nd International Rangeland Congress, Adelaide, Australia*.

Data spanning more than three decades indicate that succession on sagebrush dominated rangeland does not proceed in a deterministic, directional manner to some climax composition. The species present were stable but the variability in relative abundance provides widely differing community structure.

Subject: Sagebrush steppe plant communities

Keywords: SAGEBRUSH / PLANT COMMUNITIES / CLASSICAL SUCCESSION

Location: Published Article

d. Not all references are annotated. Those not annotated are provided for your information.

5. Anderson, J. E., 1991, *Final Report, Field Work to Support the NPR Environmental Impact Statement*, Idaho Falls, ID, May 1991.

A compilation of all the data collected during the vegetation studies in support of the NPR Environmental Impact Statement. This includes all vegetative species, wildlife, plot location and site information, and soil data collected at NPR plots, surrounding Long Term Vegetation plots, and other GIS plots supporting the INEL vegetation mapping. Copies of all data collected and results of analysis are included.

Subject: Vegetative studies on the INEL
Keywords: NPR / ENVIRONMENTAL IMPACT STATEMENT / VEGETATION / GIS / VEGETATION / SOIL / WILDLIFE & HABITAT
Location: Submitted report to EG&G Idaho

6. Anderson, J. E.; Nowak, R. S.; Ratzlaff, T. D., and Markham, O. D., 1991, *Managing Soil Moisture on Waste Burial Sites*, DOE/ ID-12123, Idaho Falls, ID.

Summarized in Markham, 1991.

7. Anderson, J. E., and Holte, K. E., 1981, "Vegetation development over 25 years without grazing on sagebrush dominated rangeland in southeastern Idaho," *J. Range Manage.*, 34:25-29.

A study conducted to determine what changes had taken place in the vegetation complex over the past 25 years on the INEL. Data from permanent vegetation transects established in 1950, were analyzed to determine what changes had taken place in the absence of grazing. Cover of shrubs and perennial grasses nearly doubled. No evidence of serial replacement, as predicted by classical succession, was found.

Subject: Vegetative studies on the INEL
Keywords: VEGETATION / SHRUB-STEPPE / GRASSES / FORBS / GRAZING / CLASSICAL SUCCESSION
Location: Published Material

8. Anderson, J. E., and Inouye, R., 1988, *Long-term dynamics of vegetation in a sagebrush steppe of southeastern Idaho*, Final Report, April 1988.

The vegetation in established long-term plots was identified and cover, density, and frequency calculated. results are discussed along with observable trends in the grass, forb, and shrub cover since grazing was halted in this portion of the INEL. Also, status of the noxious weed cheatgrass on the INEL is discussed.

Subject: Vegetative studies on the INEL
Keywords: VEGETATION / SAGEBRUSH / CHEATGRASSES / GRAZING

9. **Anderson, J. E., and Marlette, G. M., 1986, "Probabilities of seedling recruitment and the stability of crested wheatgrass stands," p. p. 97-105 In: Johnson, K. L., *In Crested Wheatgrass: Its Values, Problems, and Myths, Symposium Proceedings, Utah State University, Logan, UT,***

Presents the results of a study on the probabilities of seedling recruitment of native species into crested wheatgrass stands.

Subject: Vegetative studies on the INEL
Keywords: CRESTED WHEATGRASSES / NATIVE VEGETATION /
SEEDLINGS / REVEGETATION
Location: Utah State University

10. **Anderson, J. E., and Shumar, M. L., 1986, "Impacts of black- tailed jackrabbits at peak population densities on sagebrush- steppe vegetation," *J. Range Management*, 39:152-156.**

Reports on the results of a study of the impacts of peak population density of black-tailed jackrabbits on sagebrush- steppe vegetation. Total plant cover was reduced but no single species was irreparably impacted.

Subject: Black-tail jackrabbit and nuttall cottontail ecology
Keywords: JACKRABBIT / SAGEBRUSH / WINTERFAT / RABBITBRUSH /
SHRUB-STEPPE / GRASSES / FORBS
Location: Published Article

11. **Anderson, J. E.; Shumar, M. L.; Toft, N. L., and Nowak, R. S., 1987, "Control of the soil water balance by sagebrush and three perennial grasses in a cold-desert environment," *Arid Soil Res. and Rehabilitation*, 1:229-244.**

results of the comparison of evapotranspiration and soil water extraction by four species when grown in a monoculture to those of a natural sagebrush steppe community. The effective water storage capacity of the soil and the minimum depth of soil caps adequate to store the annual precipitation and preclude deep drainage were determined.

Subject: Soil water balance by sagebrush and grasses
Keywords: SOIL / EXTRACTABLE WATER / EVAPOTRANSPIRATION /
WATER BALANCE / WASTE MANAGEMENT
Location: Published Article

12. **Anderson, J. E., and Shumar, M. L., 1989, *Guidelines for revegetation of disturbed sites at the Idaho National Engineering Laboratory, DOE-ID, DOE/ID-12114, Idaho Falls, ID.***

This document covers important considerations for the revegetation of arid climates. Characteristics of plant species recommended for revegetation projects are presented. Specific communities, seeding waste management sites and roadsides, and establishing strips

of fire-resistant vegetation are included. Techniques for preparing seedbeds, seeding, and transplanting are discussed. Guidelines for evaluating the success of revegetation projects are given.

Subject: Revegetation projects in arid climates
Keywords: REVEGETATION / ARID ECOSYSTEM / SHRUB-STEPPE /
GRASSES / FORBS / WILDLIFE & HABITAT / SEEDLINGS /
TRANSPLANTING
Location: INEL Technical Library

13. Arthur, W. J., 1982, "Radionuclide concentrations in vegetation at a solid radioactive waste disposal area in southeastern Idaho," *J. Envir. Qual.*, 11:394-399.

*A report on a study conducted to determine radionuclide concentrations in vegetation at INEL. Concentrations of Pu-238, Pu-239,240, and Am-241 in crested wheatgrass (*Agropyron cristatum*) and Russian thistle (*Salsola kali*) samples collected from a solid radioactive waste disposal area at INEL were significantly greater than concentrations in control vegetation.*

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: RADIONUCLIDE / VEGETATION
Location: Published Material

14. Arthur, W. J.; Connelly, J. W.; Halford, D. K., and Reynolds, T. D., 1984, *Vertebrates of the Idaho National Engineering Laboratory*, DOE/ID-120999.

Abundance, habitat use, and seasonal occurrence are reported for the 5 fish, 1 amphibian, 9 reptile, 159 birds and 37 mammal species recorded on the INEL. An additional 45 species, for which site records are lacking, were listed as possibly occurring because portions of their documented range and habitat overlap the INEL. Species of special concern on the federal and state level are discussed. Data is qualitative.

Subject: Vertebrates on the INEL
Keywords: VERTEBRATE / FISH / AMPHIBIAN / REPTILE / AVIAN /
MAMMAL / ENDANGERED SPECIES / SPECIES OF CONCERN
Location: INEL Technical Library

15. Arthur, W. J., and Gates R.J., 1988, "Trace element intake via soil ingestion in pronghorn and in black-tailed jackrabbits," *J. Range Management*, 41:162-166.

Documents the soil ingestion rations in pronghorn and black- tailed jackrabbits. Estimates the importance of soil and vegetation pathways for trace, toxic, and radioactive elemental intake.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: JACKRABBIT / ENVIRONMENTAL CONTAMINANTS / NUTRITION
/ PRONGHORN / SOIL / TRACE ELEMENTS
Location: Published Article

16. Arthur, W. J., and Janke, D. H., 1986, "radionuclide concentrations in tissues of wildlife occurring at a solid radioactive waste disposal area," *Northwest Sci.*, 60:154-159.

A study to compare radionuclide concentrations in tissues of common vertebrae species. Of 18 mammalian species observed during a 24 month period at INEL, deer mice had the highest concentration of radionuclides. Background levels of radionuclides were detected in horned lark, mourning dove, and sage grouse. Coyote fecal samples from the disposal area had significantly greater concentrations of Am-241 than those from a control area.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: RADIONUCLIDE / WILDLIFE & HABITAT / SMALL MAMMAL /
AVIAN / INVERTEBRATE / REPTILE
Location: Radionuclides in wildlife

17. Arthur, W. J.; Markham, D. O.; Groves, C. R., and Keller, B. L., 1987, "Radionuclide export by deer mice at a solid radioactive waste disposal area in southeastern Idaho," *Health Physics*, 52:45-53.

Summarized in Markham 1991.

18. Arthur, W. J., and Markham, O. D., 1982, "Ecological vectors of radionuclide transport at a solid radioactive waste disposal facility in southeastern Idaho," p. 574-580 In: M.A. Feraday, *Proceedings of International Conference on Radioactive Waste Management, Winnipeg, Manitoba, Sept. 12-15, 1982.*

A brief description of research at the INEL to define and model the quantity of radionuclides transported by various ecosystem components and to determine the impact of subsurface disposal of radioactive wastes on biotic species in the area.

Subject: Radioecology & Ecology research projects at the INEL
Keywords: RADIONUCLIDE / ECOLOGICAL VECTORS / SMALL MAMMAL /
COYOTE / WHEATGRASSES / RUSSIAN THISTLE / SOIL /
BURROWING
Location: INEL Technical Library

19. Arthur, W. J., and Markham, O. D., 1982, "Radionuclide export and elimination by coyotes at two radioactive waste disposal areas in southeastern Idaho," *Health Physics*, 43:493-500.

Coyote feces were analyzed to determine the extent of any radionuclide Contamination spread by coyotes inhabiting the INEL. Concludes that coyotes are a mode of radionuclide transport from the two radioactive waste disposal areas, but doubtful that any significant environmental consequences occur as a result of this transport mechanism.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: COYOTE / RADIONUCLIDE / SCATS
Location: Published Material

20. Arthur, W. J., and Markham, O. D., 1983, "Small mammal soil burrowing as a radionuclide transport vector at a radioactive waste disposal area in southeastern Idaho," *J. Envir. Qual.*, 12: 117-122.

Reports on a study to estimate the mass of soil excavated to the surface by small mammals, to determine the radionuclide concentrations in these soils, and to estimate the total inventory of radionuclides brought to the soil surface by small mammal burrowing. The total amount of plutonium in excavated soils was only 0.05% of the amount estimated to occur in waste disposal area surface soils.

Subject: Small mammals and radioactive waste disposal sites
Keywords: SMALL MAMMAL / BURROWING / RADIONUCLIDE
Location: Published Material

21. Arthur, W. J., and Markham, O. D., 1984, "Polonium-210 concentrations in soil, vegetation and small mammals in southeastern Idaho," *Health Physics*, 46:793-799.

Reports on the determination of Polonium-210 concentrations for soil, vegetation and small mammal tissues collected at a solid radioactive waste disposal area, near a phosphate ore processing plant and at two rural areas in southeastern Idaho.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: POLONIUM-210 / SOIL / VEGETATION / SMALL MAMMAL
Location: Published Article

22. Arthur, W. J.; Markham, O. D.; Groves, C. R.; Keller, B. L., and Halford, D. K., 1986, "Radiation dose to small mammals inhabiting a solid radioactive waste disposal area," *J. Applied Ecology*, 23:13-26.

Radiation dose rates received by deer mice and Ord's kangaroo rats inhabiting a waste disposal area from surgically implanted thermoluminescent dosimeter to provide an indirect

method of measuring biological intrusion into soil covers over solid low- level radioactive waste disposal areas.

Subject: Small mammals and radioactive waste disposal sites
 Keywords: SMALL MAMMAL / DEER MICE / KANGAROO RAT / RADIATION
 DOSE / WASTE MANAGEMENT / THERMOLUMINESCENT
 DOSIMETER
 Location: Published Article

23. Autenrieth, R. E.; Copeland, G. L.; Connelly, J. W., and Reynolds, T. D., 1980, *Job Progress Report, Project W-160-R-7, Antelope-Sage Grouse Ecology*, Idaho Department of Fish and Game, Boise, ID.

Location: Idaho Department of Fish and Game, Boise, ID

24. Autenrieth, R. E.; Copeland, G. L., and Reynolds, T. D., 1981, "Capturing pronghorn antelope using a helicopter and etorphine hydrochloride," *Wildl. Soc. Bull.*, 9:314-319.

Location: Published Material

25. Bent, G. C., 1988, *Surface erosion and hydrology of earth covers used in shallow land burial of low-level radioactive waste*, M.S. Thesis, Utah State University, Logan, UT.

26. Bcst, L. B., and Petersen, K. L., 1982, "Effects of stage of the breeding cycle on sage sparrow detectability," *Auk*, 99:788- 791.

An evaluation of the effects of the stage of breeding cycle on bird detectability with consequences for the accuracy of bird census procedures. Compares the detectability of sage sparrows with field sparrows.

Subject: Sparrow ecology
 Keywords: SPARROW / FIELD SPARROW / DETECTABILITY / AVIAN /
 NESTING
 Location: Published Material

27. Bcst, L. B., and Peterson, K. L., 1985, "Seasonal changes in detectability of sage and brewer's sparrows," *Condor*, 87:556-558.

Determines the seasonal changes in the detectability of bird species in a shrubsteppe.

Subject: Sparrow ecology
 Keywords: SPARROW / SEASONAL DETECTABILITY / POPULATION
 PARAMETERS
 Location: Published Article

28. Blom, P. E., 1990, *Ecological characteristics and preferential edge use of small mammal populations inhabiting a radioactive waste disposal area*, M.S. Thesis, Idaho State University, Pocatello, ID.

Investigation of ecological characteristics of small mammals by live trapping and tracking with fluorescent pigments in a vegetative edge habitat near a radioactive waste disposal area.

Subject: Small mammal ecology
Keywords: SMALL MAMMAL / VEGETATION / EDGE / RADIOACTIVE
DISPOSAL AREA / COLLECTION TECHNIQUES
Location: Idaho State University

29. Blom, P. E.; Clark, W. H., and Johnson, J. B., 1991, "Colony Densities of the Seed Harvesting Ant *Pogonomymex salinus* (Hymenoptera: Formicidae) in Seven Plant Communities on the Idaho National Engineering Laboratory," *J. Idaho Academy Science*, 27:28-36.

Blom, P.E.; Clark, W.H.; Johnson, J.B.
Describes the variability of colony density of harvester ants over seven vegetation communities on the INEL. Suggests that soil characteristics may be a factor in colony densities.

Subject: Colony Density of Harvester Ant
Keywords: COLONY DENSITY
Location: Published Article

30. Blom, P. E.; Johnson, J. B., and Rope, S. K., 1991, "Concentrations of ¹³⁷Cs and ⁶⁰Co in Nests of the Harvester Ant, *Pogonomymex salinus*, and associated soils near nuclear reactor waste water disposal ponds," *American Midland Naturalist*, 126: 140-151.

Higher concentrations of Cs-137 and Co-60 in ant mounds near waste water disposal ponds. Levels were probably from exhumation of deeper soils during nest construction. Mounds and nearby soils and reference soils were studied.

Subject: Higher concentration of Cs and Co in ant mounds
Keywords: ANTS / ANT-MOUND CONSTRUCTION / LEACHING POND / CS-137 / CO-60 / TRA
Location: Published article

31. **Bright, R. C., and Davis, O. K., 1982, "Quaternary paleoecology of the Idaho National Engineering Laboratory, Snake River Plain, Idaho," *Amer. Midl. Natur.*, 108:21-33.**

Reports on the sampling of Quaternary sediments and fossils. The Holocene vegetation history has been one of sagebrush steppe that became increasingly similar to shadscale steppe. Radiocarbon dating show that Lake Terreton was filled as recently as 700 years ago.

Subject: Quaternary sediments and fossils on the INEL

Keywords: QUATERNARY / SEDIMENTS / FOSSILS / WOODRAT MIDDENS /
POLLEN / LAKE TERRETON

Location: Published Material

32. **Bromenshenk, J. J., "Regional monitoring of pollutants with honey bees," Wise, S. A.; Zeiser, R.; Goldstein, G. M., *Progress in Environmental Specimen Banking*, Special Publication 740, 156- 170, Nat. Bur. Stand..**

33. **Browers, H. Jr., 1981, "Dispersal of sage grouse from the Test Reactor Area of the Idaho National Engineering Laboratory," *Trans West. States Sage Grouse Workshop*.**

Location: Published Material

34. **Browers, H. W., 1983, *Dispersal and harvest of sage grouse utilizing the Test Reactor Area of the Idaho National Engineering Laboratory*, M.S. Thesis, South Dakota State University, Brookings, SD.**

Documents the radio telemetric study of sage grouse to determine habitat, home range, brood breakup, fall movements, and harvest of sage grouse in a desert ecosystem.

Subject: Avian ecology

Keywords: SAGE GROUSE / HOME RANGE / ACTIVITY PATTERNS / BROOD
BREAKUP

Location: INEL Technical Library

35. **Browers, H. W., and Connelly, J. W., 1986, "Capturing sage grouse with mist nets," *Prairie Natur.*, 18:185-188.**

This study compares the advantages of using a mist net to drive trapping in the capturing of grouse. Mist netting was easier to transport and assemble and produced a lower mortality rate.

Subject: Evaluation of trap types

Keywords: SAGE GROUSE / COLLECTION TECHNIQUES

Location: Published Article

36. Browsers, H. W., and Flake, L. D., 1985, "Breakup and sibling dispersal of two sage grouse broods," *Prairie Natur.*, 17:248-249.

Location: Published Article

37. Cholewa, A. F., and Henderson, D., 1983, "Noteworthy collections-Idaho: *Lesquerilla kingii* S. wats, var. *cobrenses* Roll. and Shaw, *Astragalus kentrophyta* Gray var. *jessiae* (Peck) Barneby, *Gilia polycladon* Torrey," *Madrono*, 30:63-64.

Documents the location of rare vascular plants found on the INEL. Map coordinates are given.

Subject: Rare plants on the INEL
Keywords: RARE VASCULAR PLANTS
Location: Published Material

38. Cholewa, A. F., and Henderson, D. M., 1984, "A survey and assessment of the rare vascular plants of the Idaho National Engineering Laboratory Site," *Great Basin Natur.*, 44:140-144.

Documents the abundance and distribution of all rare plant taxa occurring on the INEL, assesses subjectively current or potential threats to survival of the plants, and makes preliminary recommendations to the Department of Energy concerning the status and management of habitats supporting rare plant taxa.

Subject: Rare plants on the INEL
Keywords: RARE VASCULAR PLANTS / SURVEY / ASSESSMENT
Location: Published Article

39. Cholewa, A. F., and Henderson, D. M., 1984, *A survey and assessment of the rare vascular plants of the Idaho National Engineering Laboratory*, IDO-12100.

Location: National Technical Information Service, VA

40. Clark, W. H., and Blom, P. E., 1991, "Observations of Ants (Hymenoptera: Formicidae: Myrmicinae, Formicinae, Dolichoderinae) Utilizing Carrion," *Southwestern Naturalist*, 36:140-142.

Location: Summarized in Markham, 1991

41. Clark, W. H., and Blom, P., 1988, "Observations on the relationship between ants (Hymenoptera: Formicidae: Myrmicinae, Dorylinae) and *Araeoschizus* (Colcopter: Tenebrionidae)," *J. Idaho Acad. Sci.*, 24:34-37.

Location: Summarized in Markham 1991

42. Clark, W. H., and Blom, P. E., 1989, "A collection technique for mound-building ants (Hymenoptera: Formicidae)," *Ent. News*, 100:127-128.

A simple, fast, and inexpensive method for collecting relatively clean samples of mound-building ants. The method consists of creating a miniature pitfall trap in the mound with a collecting tube.

Subject: Evaluation of trap types

Keywords: ANT-MOUND CONSTRUCTION / COLLECTION TECHNIQUES

Location: Published Article

43. Cole, N. K., 1987, *The growth and water relations of Leymus cinereus following a prescribed burn*, Masters Thesis, Idaho State University, Pocatello, ID.

This study examined the fire ecology and water relations of Great Basin wildrye in the cold desert steppe of the Great Basin. results showed a vigorous response to burning and an increase in uptake of water which resulted in less water for other species.

Subject: Fire ecology and water relations of Great Basin wildrye

Keywords: WILDRYE / FIRE ECOLOGY / WATER BALANCE / SAGEBRUSH

Location: Idaho State University

44. Colwell, F. S., 1988, *Microbiological examination of RWMC surface and subsurface soils and biodegradation of low molecular weight hydrocarbons using microorganisms indigenous to RWMC*, EG&G Idaho, Inc., ST-BEG-03-88, Idaho Falls, ID, October 1988.

Final report on a study to determine whether microbes exist in the subsurface sediments below the RWMC of the INEL. Studies were conducted to determine whether microbial isolates from the RWMC are capable of degrading low molecular weight halocarbons.

Subject: Bacteria in deep subsurface soils

Keywords: MICROBIOTA / BACTERIA / HALOCARBONS / SOIL

Location: Published Article

45. Colwell, F. S., 1989, "Microbiological comparison of surface soil and unsaturated subsurface soil from a semiarid high desert," *Applied and Environmental Microbiology*, 55(9):2420-2423.

Compares the microbial community of surface and deep (70 m) subsurface soils at the RWMC at the INEL. The study provides evidence of microbial survival in a subsurface habitat different from those studied previously and highly relevant with regard to waste storage sites and future attempts at bioremediation.

Subject: Bacteria in deep subsurface soils
Keywords: MICROBIOTA / BACTERIA / SOIL
Location: Published Article

46. Connelly, J. W., 1979, *Ecology of sage grouse on the INEL site*, In: Antelope-Sage Grouse Ecology, Idaho Department of Fish and Game Job Progress Report, W-160R-6, pp. 43-49, Idaho Department of Fish and Game, Boise, ID.

47. Connelly, J. W., 1979, "A preliminary report on sage grouse studies on the Idaho National Engineering Laboratory," *Trans. West. States Sage Grouse Workshop*, 11:11-12.

Location: Published Material

48. Connelly, J. W., 1980, *Ecology of sage grouse on the INEL Site*, Idaho Department of Fish and Game, Boise, ID.

Location: Idaho Department of Fish and Game, Boise, ID

49. Connelly, J. W., 1981, "Winter flocking behavior and habitat use by sage grouse in southeastern Idaho," *Trans. West States Sage Grouse Workshop*.

Location: Published Material

50. Connelly, J. W., 1982, *An ecological study of sage grouse in southeastern Idaho*, Ph.D., Washington State University, Pullman, WA.

Reports on the seasonal movements, radionuclide concentrations, flocking characteristics, and habitat use of sage grouse in southeastern Idaho. Sage grouse did act as a transport mechanism for radionuclides, though the quantities removed per individual were small. To maintain sage grouse populations summer and winter ranges along the migration routes should be preserved.

Subject: Sage grouse ecology
Keywords: SAGE GROUSE / RADIONUCLIDE / HOME RANGE / WINTER RANGE / MOVEMENT PATTERNS
Location: INEL Technical Library

51. Connelly, J. W., 1983, "Whata you do with a grouse in yer face," *Idaho Wildlife*, 4:14-16.

Location: Published Material

52. Connelly, J. W.; Arthur, W. J., and Markham, O. D., 1981, "Sage grouse leks on recently disturbed sites," *J. Range Manage.*, 34:153-154.

A description of three sage grouse leks located on recently disturbed areas on the INEL. This species' acceptance of newly cleared sites for display area may have potential as a management tool.

Subject: Sage grouse ecology
Keywords: SAGE GROUSE / LEKS / DISTURBED AREAS
Location: Published Material

53. Connelly, J. W.; Browers, H. W., and Gates, R. J., 1988, "Seasonal movements of sage grouse in southeastern Idaho," *J. Wildlife Management*, 52:116-122.

Study of sage grouse wintering, breeding, and summer range looking at differences between males and females. Suggestions that populations should be defined on a temporal and geographic basis and protection of areas around leks may not be enough to ensure protection of year-long habitat requirements.

Subject: Avian ecology
Keywords: SAGE GROUSE / LEKS / RADIO-TELEMETRY / AVIAN / NESTING / AVIAN
Location: Published Article

54. Connelly, J. W., and Gates, R. J., 1981, "First record of a black-legged kittiwake in Idaho," *Condor*, 83:272-273.

Documents the first record of a Black-legged Kittiwake in Idaho and to review past records of the kittiwake in adjacent states.

Subject: Black-legged Kittiwake
Keywords: BLACK-LEGGED KITTIWAKE
Location: Published Material

55. Connelly, J. W.; Gates, R. J., and Browers, H. W., 1983, *Seasonal movements of sage grouse in southeastern Idaho*, Trans. West. States Sage Grouse Workshop 13.

56. Connelly, J. W., and Markham, O. D., 1983, "Movements and radionuclide concentrations of sage grouse in southeastern Idaho," *J. Wildlife Management*, 47(169-177)

*Movements and radionuclide concentrations of sage grouse (*Centrocercus urophasianus*) summering near nuclear facilities on the INEL were studied from 1977 through 1980. radionuclide concentrations were higher in sage grouse summering near a facility with liquid*

radioactive waste storage than in grouse summering near a solid radioactive waste disposal area.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: RADIONUCLIDE / RESIDENCE TIME / SAGE GROUSE /
MOVEMENT PATTERNS
Location: Published Material

57. Craig, E. H.; Craig, T. H., and Powers, L. R., 1988, "Activity patterns and home-range use of nesting longeared owls," *Wilson Bull.*, 100:204-213.

A study of two pairs of Long-eared owls during nesting season looking at activity patterns, movements, and home range use with the use of radio-telemetry.

Subject: Avian ecology
Keywords: OWLS / RADIO-TELEMETRY / AVIAN / NESTING / HOME RANGE
/ AVIAN
Location: Published Article

58. Craig, E. H.; Craig, T. H., and Powers, L. R., 1986, "Habitat use by wintering golden eagles and American rough-legged hawks in southeastern Idaho," *Raptor Research*, 20:69-71.

Location: Published Article

59. Craig, T. H., 1977, *Raptors of the Idaho National Engineering Laboratory Site*, M.S. Thesis, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

60. Craig, T. H., 1978, "A car survey for raptors in southeastern Idaho," *Raptors Res.*, 12:40-45.

Location: Published Material

61. Craig, T. H., 1979, *Raptors of the Idaho National Engineering Laboratory Site*, DOE, IDO-12089, Idaho Falls, ID.

62. Craig, T. H., 1986, "A day in the life of a raptor biologist," *Idaho Wildlife*, 5:11-14.

Location: Published Article

63. Craig, T. H., and Craig, E. H., 1984, "A large concentration of roosting eagles in southeastern Idaho," *Auk*, 101:610-613.

A description of a large concentration of nocturnally roosting Golden Eagles, some of which roosted communally on powerline structures.

Subject: Roosting of Golden Eagles on powerline structures
Keywords: EAGLE / COMMUNAL ROOST / POWERLINE STRUCTURES
Location: Published Article

64. Craig, T. H.; Craig, E. H., and Powers, L. R., 1984, "Recent changes in eagle and buteo abundance in southeastern Idaho," *Murrelet*, 65:91-93.

Reports on a study to determine changes in eagle and buteo population levels between 1974-1976 and 1981-1982. A large increase in eagles and buteos that winter and nest on the INEL occurred simultaneously with an increase in jackrabbit numbers.

Subject: Eagle and buteo abundance
Keywords: EAGLE / RAPTOR / AVIAN / NESTING / POPULATION PARAMETERS
Location: Published Article

65. Craig, T. H.; Craig, E. H., and Powers, L. R., 1985, "Food habits of long-eared owls (*Asio otus*) at a communal roost site during the nesting season," *Auk*, 102:193-195.

Documentation of a large communal roost of long-eared owls on the INEL and description of their food habits determined from castings found at the roost.

Subject: A communal roost of long-eared owls
Keywords: OWLS / COMMUNAL ROOST / DIET & FOOD HABITS / CASTING
Location: Published Article

66. Craig, T. H.; Halford, D. K., and Markham, O. D., 1979, "Radionuclide concentrations in nestling raptors near nuclear facilities," *Wilson Bull.*, 91:72-77.

Reports on a study conducted to determine the level of Contamination by gamma-emitting radionuclides in nestling raptors near 2 nuclear facilities at the INEL. Concluded that the influences of ICPP and TRA on radionuclide concentrations in nestling raptors were limited to a area within 3.5 km of the facility.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: RAPTOR / AMERICAN KESTRELS / OWLS / RAPTOR / RADIONUCLIDE
Location: Published Material

67. Craig, T. H., and Renn, F., 1977, "Recent nesting of the Merlin in Idaho," *Condor*, 57:392.

brief report of the sighting of a Merlin and a magpie nest containing Merlin eggs on the wester edge of the Snake River Plain.

Subject: Merlin nest in Idaho
Keywords: MERLIN / AVIAN / NESTING
Location: Published Material

68. Craig, T. H., and Trost, C. H., 1979, "The biology and nesting density of breeding American kestrels and long-eared owls on the Big Lost River, southeastern Idaho," *Wilson Bull.*, 91:50-61.

This study addresses some nesting parameters of American Kestrels and Long-eared owls in a desert environment. The percent biomass of prey items in the diet of these raptors was calculated.

Subject: Avian ecology
Keywords: AMERICAN KESTRELS / OWLS / PRODUCTIVITY / AVIAN / NESTING / DIET & FOOD HABITS / FLEDGLING
Location: Published Material

69. Cronn, R. C., 1991, *Determination of Cadmium toxicity and the Relationship Between Dose and Metallothionein Levels in the Honey Bee, Apis mellifera*, Master's thesis, University of Montana, Missoula, MT.

70. Culp, T., 1986, *Plutonium distribution and physiochemical characteristics in test reactor leaching ponds*, M.S. Thesis, Colorado State University, Ft. Collins, CO.

Location: Colorado State University, Ft. Collins, CO

71. Davis, O. K., 1981, *Vegetation migration in southern Idaho during the late-Quaternary and Holocene*, Ph.D. Dissertation, University of Minnesota, Minneapolis, MN.

Location: University of Minnesota, MN

72. Davis, O. K., 1984, "Multiple thermal maxima during the holocene," *Science*, 225:617-619.

Three different vegetation types in southern Idaho indicate thermal maxima at different times during the Holocene, depending on the climatic variable controlling each type.

Subject: Vegetative studies on the INEL
Keywords: HOLOCENE / THERMAL MAXIMA / VEGETATION
Location: Published Article

73. Davis, O. K.; Sheppard, J. C., and Robertson, S., 1986, "Contrasting climatic histories for the Snake River Plain, Idaho, resulting from multiple thermal maxima," *Quaternary Res.*, 26:321- 339.

Sediment cores and pollen grain collection from high and low elevation sites on the Snake River Plain show consistent differences in climatic histories.

Subject: Holocene climatic histories
Keywords: CLASSICAL SUCCESSION / SNAKE RIVER PLAIN / SEDIMENT CORES / POLLEN / HOLOCENE / SUMMER INSOLATION / FALL INSOLATION
Location: Published Article

74. Davison, R. P., 1980, *The effect of exploitation on some parameters of coyote populations*, Ph.D. Dissertation, Utah State University, Logan, UT.

Location: Utah State University, Logan, UT

75. Evenson, L. M., 1981, *Systemic effects of radiation exposure on rodents inhabiting liquid and solid waste disposal areas*, M.S. Thesis, University of Idaho, Moscow, ID.

results of a study to determine the possible physiological effects, chromosomal aberrations, changes in lymphocyte and erythrocyte counts and morphology, and changes in the incidence of tumors due to chronic irradiation of deer mice populations inhabiting both solid and liquid radioactive waste disposal areas. Deer mice received average dose equivalents of 160 mrem/ day.

Subject: Systematic effects of radiation exposure on rodents on the INEL
Keywords: DEER MICE / CHRONIC IRRADIATION / HEMATOPOIETIC SYSTEM / CHROMOSOMES
Location: INEL Technical Library

76. Fazio, J. R., 1980, *The conceptual design of interpretive exhibits for Idaho National Environmental Research Park*, Forest, Wildlife and Range Experiment Station, No. 192, Moscow, ID.

77. Filipovich, M. A., 1983, *Small mammal density, movement, and food habitat on the SL-1 radioactive-waste disposal area, Idaho National Engineering Laboratory*, M.S. Thesis, Idaho State University, Pocatello, ID.

Documents seasonal patterns of small mammal movements and to determine whether species composition and density of small mammal populations were similar among 3 areas of the INEL. Also assess the use of radiotelemetric methods for rodent studies.

Appendix D ♦ D-98

Subject: Small mammal ecology
Keywords: SMALL MAMMAL / RODENTS / MOVEMENT PATTERNS / DIET &
FOOD HABITS
Location: INEL Technical Library

78. Fisher, J. S., 1979, *Reproduction in the pygmy rabbit in southeastern Idaho*, M.S. Thesis, Idaho State University, Pocatello, ID.

79. Floyd, D. A., 1982, *A comparison of three methods used for estimating vegetal cover on a controlled burn site in southeastern Idaho*, M.S. Thesis, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

80. Floyd, D. A., and Anderson, J. E., 1982, "A new point interception frame for estimating cover of vegetation," *Vegetation*, 50:185-186.

The description of a simple, widely applicable point sighting frame that can be used to establish a dot grid on underlying vegetation or ground. The paper describes construction and use of the frame and presents a comparison of its cover estimates to those of the line interception.

Subject: Construction and use of a point interception
Keywords: POINT INTERCEPTION / CANOPY COVER / VEGETATION
Location: Published Material

81. Floyd, D. A., and Anderson, J. E., 1987, "A comparison of three methods for estimating plant cover," *J. Ecol.*, 75:221-228.

Documents the results of a comparison of line intercept, point intercept, and canopy coverage estimation for determining plant cover in a sagebrush steppe community.

Subject: Methods for determining plant cover
Keywords: PLANT COMMUNITIES / LINE INTERCEPTION / CANOPY COVER
/ SAGEBRUSH
Location: Published Article

82. Fraley, L. Jr.; Bowman, G. C., and Markham, O. D., 1982, "Iodine-129 in rabbit thyroids near a nuclear fuel reprocessing plant in Idaho," *Health Physics*, 43:251-258.

Reports on research to determine the I-129 and I-127 concentrations, and the ratios of the two isotopes in rabbit thyroids on the INEL. Concludes that it is unlikely that I-129 concentrations in rabbit thyroids would result in any detectable health hazard to the rabbits.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
 Keywords: RABBIT / THYROID / IODINE-129 / IODINE-127 / RADIONUCLIDE
 Location: Published Material

83. French, N. R., and Mitchell, J. E., 1984, *Long-term vegetation changes in permanent quadrants at the Idaho National Engineering Laboratory Site*, University of Idaho Forest Wildlife and Range Exper. Station, Bull. No 36, Moscow.

84. Fuller, R. K., 1981, *Habitat utilization, invertebrate consumption, and movement by salmonid fishes under fluctuating flow conditions in the Big Lost River, Idaho*, M.S. Thesis, Idaho State University, Pocatello, ID.

Investigates the habitat utilization by rainbow trout and mountain whitefish in an intermittent irrigation canal. Initial study undertaken to assess Big Lost River channel on INEL but it was dry during the time of study.

Subject: Salmonid populations on the INEL
 Keywords: SALMONID HABITAT / RAINBOW TROUT / MOUNTAIN WHITEFISH / INVERTEBRATE
 Location: INEL Technical Library

85. Gasser, K. W.; Cannamella, D. A., and Johnson, D. W., 1981, "Contributions to the life history of the shorthead sculpin, *Cottus confusus*, in the Big Lost River, Idaho: age, growth and fecundity," *Northwest Sci.*, 55:174-181.

Examines the age, growth, and fecundity of 513 shorthead sculpin collected from the Big Lost River, Idaho. Age determinations by otoliths revealed six age classes, with growth being fastest the first year and slower thereafter. Age class composition and condition varied with the habitat. Condition also fluctuated seasonally.

Subject: Sculpin ecology
 Keywords: SHORthead SCULPIN / AGE / GROWTH / POPULATION PARAMETERS
 Location: Published Material

86. Gates, R. J., 1981, "Summer use by sage grouse of irrigated agriculture in southeastern Idaho," *Trans. West. States Sage Grouse Workshop*.

Location: Published Material

87. **Gates, R. J.**, 1983, *Sage grouse, lagomorph and pronghorn use of sagebrush-grassland burn site on the Idaho National Engineering Laboratory*, M.S. Thesis, Montana State University, Bozeman, MT.

Relative use of a burn site on the INEL by 4 species was determined for 2 years before and 1 year after treatment. This thesis reports on the effects of a prescribed burn on pygmy rabbits but results of post-burn studies of vegetation, grouse, and pronghorn were not concluded.

Subject: Habitat use on the INEL
Keywords: FIRE ECOLOGY / PRONGHORN / JACKRABBIT / PYGMY RABBIT
/ SAGE GROUSE / VEGETATION
Location: INEL Technical Library

88. **Gates, R. J.**, 1985, "Observations on the formation of a sage grouse lek," *Wilson Bull.*, 97:219-221.

Documents the establishment of a sage grouse lek on a prescribed burn site on the INEL.

Subject: Sage grouse ecology
Keywords: SAGE GROUSE / LEKS / FIRE ECOLOGY
Location: Published Article

89. **Gates, R. L.**, 1983, *A preliminary interpretation of the effects of fire on sage grouse in an arid sagebrush grassland*, Trans. West. State Sage Grouse Workshop 13.

90. **Genter, D. L.**, 1986, "Wintering bats of the upper Snake River Plain: occurrence in lava-tube caves," *Great Basin Natur.*, 46:241-244.

Reports on the distribution and habitat selection of hibernating bats at the INEL and adjacent areas.

Subject: Bats in lava-tube caves
Keywords: BATS / LAVA-TUBE CAVES / HIBERNATION
Location: Published Article

91. **Genter, D. L.**, 1987, "Dolphins of the sky," *Idaho Wildlife Review*, 7:18-20.

92. **Gleason, R., and Craig, T. H.**, 1979, "Food habits of burrowing owls in southeastern Idaho," *Great Basin Natur.*, 39: 274-276.

Food habits of a population of the Burrowing Owl were studied. Invertebrates, largely insects, constituted 91 percent of the total prey item, but only 29 percent of the total biomass. The prey were mostly nocturnal species.

Subject: Avian diet and food habits
Keywords: OWLS / DIET & FOOD HABITS / FECAL PELLETS /
INVERTEBRATE / SMALL MAMMAL
Location: Published Material

93. Gleason, R. S., 1978, *Aspects of the breeding biology of burrowing owls in southeastern Idaho*, M.S. Thesis, University of Idaho, Moscow, ID.

Location: University of Idaho, Moscow, ID

94. Gleason, R. S., and Johnson, D. R., 1985, "Factors influencing nesting success of burrowing owls in southeastern Idaho," *Great Basin Natur.*, 45:81-84.

Discusses the effects of nest site and prey availability on the reproductive success of a burrowing owl population based on emerging broods.

Subject: Avian ecology
Keywords: OWLS / AVIAN / NESTING / PREDATOR-PREY / POPULATION
PARAMETERS
Location: Published Article

95. Goff, B. F., 1991, *Hydrologic and Erosion Response of a Disturbed Sagebrush Hillslope*, Dissertation, Utah State University, Logan, Ut.

96. Goodrich S.; Cholewa, A., and Henderson, D., 1983, "Noteworthy collections: Idaho, *Astragalus gilviflorus* Sheld," *Modrono*, 30:63.

Location: Published Material

97. Griffith, J. S., 1981, "Water bodies should be managed to maintain a balanced and indigenous community," *Proceedings, Fifth National Workshop on Entrainment and Impingement, San Francisco, CA, May 5-7, 1980.*

Location: Published Material

98. Groves, C. R., 1981, *The ecology of small mammals on the subsurface disposal area, Idaho National Engineering Laboratory Site*, M.S. Thesis, Idaho State University, Pocatello, ID.

Reports on a study of seasonal changes, species diversity, movements, and population density of small mammals on the INEL. The largest number of species and the highest species diversity was recorded for sagebrush habitat. Limited long-distance movement of small mammals occurred.

Subject: Small mammal ecology

Appendix D ♦ D-102

Keywords: SMALL MAMMAL / RODENTS / SPECIES COMPOSITION &
DIVERSITY / POPULATION PARAMETERS / SAGEBRUSH /
CRESTED WHEATGRASSES / RUSSIAN THISTLE

Location: INEL Technical Library

99. Groves, C. R., and Keller, B. L., 1983, "Ecological characteristics of small mammals on a radioactive waste disposal area in southeastern Idaho," *Amer. Midl. Natur.*, 109:253-265.

Species composition, diversity, biomass and densities of small mammal populations were examined in crested wheatgrass, Russian thistle, and sagebrush habitats. The peak small mammal biomass of 5000 g/ha in crested wheatgrass and sagebrush habitats was considerably higher than previously reported for similar habitats. Differences in diversity and biomass between the disposal area and surrounding native habitat are most likely related to differences in soil compaction and vegetation between these two areas.

Subject: Small mammal ecology

Keywords: SMALL MAMMAL / DEER MICE / KANGAROO RAT / VOLE /
CRESTED WHEATGRASSES / RUSSIAN THISTLE / SAGEBRUSH /
SPECIES COMPOSITION & DIVERSITY / BIODIVERSITY /
BIOMASS

Location: Published Material

100. Groves, C. R., and Anderson, J. E., 1981, "Allelopathic effects of *Artemisia tridentata* leaves on germination and growth of two grass species," *Amer. Midl. Natur.*, 106:73-79.

Location: Published Material

101. Groves, C. R.; Arthur, W. J.; Keller, B. L., and Markham, O. D., 1986, "Effects of surgically implanting thermoluminescent dosimeters in small mammals," *Health Physics*, 51:142-145.

The purpose of this study was to compare three populations statistics (mean survival, trappability and weight) between small mammals that were implanted with thermoluminescent dosimeter packets and those that were not.

Subject: Small mammal ecology

Keywords: SMALL MAMMAL / RADIATION DOSE / THERMOLUMINESCENT
DOSIMETER / SURGICAL TECHNIQUES

Location: Published Article

102. Groves, C. R., and Keller, B. L., 1984, "Hip glands in a natural population of montane voles (*Microtus montanus*)," *Great Basin Natur.*, 44:468-470.

A comparison of reproductive characteristics and weights of voles in which hip glands were present or absent. Suggests they may be important in behavioral changes that occur in fluctuating vole populations.

Subject: Hip glands in montane voles
Keywords: VOLE / HIB GLANDS
Location: Published Article

103. Groves, C. R., and Keller, B. L., 1986, "Movements by small mammals on a radioactive waste disposal area in southeastern Idaho," *Great Basin Natur.*, 46:404-410.

Subject: Small mammals and radioactive waste disposal sites
Location: Summarized in Markham 1991

104. Guyer, C., 1978, *Home range and homing ability in Sceloporus graciosus and Phrynosoma douglassi*, M.S. Thesis, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

105. Guyer, C., and Linder, A. D., 1985, "Growth and population structure of the short-horned lizard (*Phrynosoma douglassi*) and the sagebrush lizard (*Sceloporus graciosus*) in southeastern Idaho," *Northwest Sci.*, 59:294-303.

The major objective of this study was to collect data on selected ecological aspects of P. douglassi and S. graciosus near the northern limits of their ranges. Estimates of growth rates, population size, survivorship, and sex ratios are compared with predictions made by theories of reproductive strategies.

Subject: Lizard ecology
Keywords: LIZARD / GROWTH / POPULATION PARAMETERS /
SURVIVORSHIP / SEX RATIO
Location: Published Article

106. Guyer, C., and Linder, A. D., 1986, "thermal ecology and activity patterns of the short-horned lizard (*Phrynosoma douglassi*) and the sagebrush lizard (*Sceloporus graciosus*) in southeastern Idaho," *Great Basin Natur.*, 45:607-614.

A mark-recapture study of the short-horned lizard and the sagebrush lizard showing ecology, thermal ecology, and activity patterns in sagebrush steppe-communities.

Subject: Lizard ecology

Keywords: LIZARD / SAGEBRUSH / REPTILE / HERPTOFAUNA

Location: Published Article

107. Halford, D. K., 1981, "Repopulation and food habits of *Peromyscus maniculatus* on a burned sagebrush desert in southeastern Idaho," *Northwest Sci.*, 55:44-49.

This study was conducted to judge the effects of fire in a desert sagebrush community on rodent food habits. Although six species of rodents were trapped on the study area, deer mice constituted 87 percent of the total sample. The kangaroo rat was the only species which was more abundant in the burned areas than in the control areas. Studies on seasonal food habits are needed to explain the effects of fire on small mammal repopulation of a desert ecosystem.

Subject: Small mammal ecology

Keywords: SMALL MAMMAL / FIRE ECOLOGY / REPOPULATION / DESERT ECOSYSTEM

Location: Published Material

108. Halford, D. K., 1987, "Effect of cooking on radionuclide concentrations in waterfowl tissues," *J. Envir. Radioact.*, 5:229- 233.

Location: Summarized in Markham 1991

109. Halford, D. K., 1987, "Transuranic inventory in tissues of small mammals at a liquid radioactive waste disposal area," *Proc. of Sym. Environmental Research on Actinide Elements*, CONF- 86008713, Hilton Head, SC, November 7-11, 1983.

110. Halford, D. K., and Markham, O. D., 1984, "Iodine-129 concentrations in muscle from waterfowl using a liquid radioactive waste pond," *Health Physics*, 46:1259-1263.

Determination of the I-129/127 atom ratios and I-129 concentrations in waterfowl muscle and to determine the resultant whole-body dose to waterfowl and thyroid dose to man consuming these waterfowl were made. The lifetime thyroid dose commitment to man consuming a wild duck from the leaching ponds was 1.3×10^{-4} mrem.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL

Keywords: WATERFOWL / IODINE-129 / RADIONUCLIDE / DOSE TO HUMANS

Location: Published Article

111. Halford, D. K.; Arthur, W. J., and Markham, O. D., 1982, "Biotic transport of radioactive materials at the INEL site," *Trans. of the American Nuclear Society*, 41:63.

Reviews the research and monitoring programs that identify and model quantities of radionuclides transported through biotic pathways at the INEL site.

Subject: Radioecology & ecology research projects at the INEL
Keywords: BIOTA & RADIONUCLIDE / RADIONUCLIDE / PROGRAM
REVIEW
Location: Published Material

112. Halford, D. K., and Markham, O. D., 1978, "Radiation dosimetry of small mammals inhabiting a liquid radioactive waste disposal area," *Ecology*, 59:1047-1054.

An inventory of the terrestrial vertebrate fauna and the seasonal occurrence of each species was determined for a radioactive leaching pond complex. It appears that the TRA radioactive leaching pond complex is an important water source and provides habitat for some species of wildlife.

Subject: Man-made ponds and wildlife
Keywords: VERTEBRATE / LEACHING POND / SPECIES LIST
Location: Published Material

113. Halford, D. K.; Markham, O. D., and Dickson, R. L., 1982, "Radiation doses to waterfowl using a liquid radioactive waste disposal area," *J. Wildl. Manage.*, 46:905-914.

This study was conducted to determine the total combined radiation doses received by waterfowl from internal and external radiation sources at a liquid radioactive waste disposal area. Internal doses were highly variable, accounted for amount of time spend on ponds, differences in food habits and metabolism.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: WATERFOWL / RADIATION DOSE / LIQUID RADIOACTIVE
WASTE
Location: Published Material

114. Halford, D. K.; Markham, O. D., and White, G. C., 1983, "Biological elimination of radioisotopes by mallards CONTAMINANTed at a liquid radioactive waste disposal area," *Health Physics*, 45:745-756.

The biological elimination of radioisotopes was studied in mallards which were released onto liquid radioactive waste ponds. The ducks were removed from the CONTAMINANTed environment and place in metabolic cages after 68, 75, or 145 days. Indicates the dose to man consuming these ducks would be inconsequential.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: MALLARD / BIOLOGICAL ELIMINATION RATES /
RADIONUCLIDE / LIQUID RADIOACTIVE WASTE
Location: Published Material

115. Halford, D. K., and Millard, J. B., 1978, "Vertebrate fauna of a radioactive leaching pond complex in southeastern Idaho," *Great Basin Natur.*, 38:64-70.

Location: Published Material

116. Halford, D. K.; Millard, J. B., and Markham, O. D., 1981, "Radionuclide concentrations in waterfowl using a liquid radioactive waste disposal area and the potential radiation dose to man," *Health Physics*, 40:173-181.

A study conducted to determine (1) species and numbers of waterfowl using the waste ponds, (2) levels of radioactivity accumulated by waterfowl and the estimated extent of its removal, and (3) potential radiation dose commitment to a hunter consuming CONTAMINANTed waterfowl tissues. Over 3100 ducks, geese, swans and American coots were censused from 1974 to 1978. The potential whole-body and thyroid dose commitment to man from consuming one waterfowl that was CONTAMINANTed with the average radionuclide concentrations observed would be 12 and 7 mrem, respectively.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: WATERFOWL / RADIONUCLIDE / WHOLE-BODY DOSE /
THYROID
Location: Published Material

117. Harris, C. E., 1983, *Differential behavior of coyotes with regard to home range limits*, Ph.D. Dissertation, Utah State University, Logan, UT.

118. Hoskinson, R. L., 1977, *Migration behavior of pronghorn antelope and summer movements and fall migrations of pronghorn fawns in southeastern Idaho*, Ph.D. Dissertation, University of Minnesota, Minneapolis, MN.

Location: University of Minnesota, Minneapolis, NM

119. Hoskinson, R. L., and Tester J.R., 1980, "Migration behavior of pronghorn antelope in southeastern Idaho," *J. Wildl. Manage.*, 44:132-144.

Reports on the radio-collaring of pronghorns to provide detailed information on summer and winter home-ranges. The studies support the hypothesis tat pronghorn fall migrations are stimulated by changes in moisture content of vegetation. Snow cover affects the location of winter ranges, the start of spring migration, and the rate at which the pronghorn

migrate to summer ranges. Fall migration occurred without snow or storms and coincided with the shift down the valleys in the location of the most moist vegetation.

Subject: The migration patterns of radio-collared pronghorns
 Keywords: PRONGHORN / MOVEMENT PATTERNS / RADIO-TELEMETRY /
 SNOW COVER / MOISTURE IN VEGETATION
 Location: Published Material

120. Howe, F. P., 1986, *An ecological study of mourning doves in a cold desert ecosystem on the Idaho National Engineering Laboratory*, M.S. Thesis, South Dakota State University, Brookings, SD.

Study conducted to determine use of man-made ponds, daily movements around ponds, and nesting ecology of mourning doves on the INEL. Radiotelemetry techniques were used.

Subject: Avian ecology
 Keywords: MOURNING DOVE / MOVEMENT PATTERNS / AVIAN / NESTING
 Location: INEL Technical Library

121. Howe, F. P., and Flake, L. D., 1989, "Mourning dove use of mad-made ponds in a cold desert ecosystem in Idaho," *Great Basin Naturalist*, 49:627-631.

Use of man-made ponds by mourning doves for watering, feeding, gritting, loafing, and courting. Conclusions on the importance of these sources where water availability may limit productivity and abundance and use of arrival rates as a population index.

Subject: Man-made ponds and wildlife
 Keywords: MOURNING DOVE / LEACHING POND / POPULATION
 PARAMETERS / ARRIVAL RATE / AVIAN
 Location: Published Article

122. Howe, F. P., and Flake L.D., 1988, "Mourning dove movements during the reproductive season in southeastern Idaho," *J. Wildlife Management*, 52:477-480.

Determination of mourning dove movements in relation to man-made ponds using radiotelemetry. results indicate populations could be enhanced by establishing additional man-made watering sites. Also, minimal opportunities for transport of radionuclides exists.

Subject: Avian ecology
 Keywords: MOURNING DOVE / RADIO-TELEMETRY / RADIONUCLIDE /
 LEACHING POND / AVIAN / NESTING
 Location: Published Article

123. Howe, F. P., and Flake, L. D., 1989, "Nesting ecology of mourning doves in a cold desert ecosystem," *Wilson Bull.*, 101: 467-472.

A study of the nesting habits, nesting success, fledgling, survival, etc. of mourning doves. Distribution and observations are reported.

Subject: Avian ecology
Keywords: MOURNING DOVE / AVIAN / NESTING / FLEDGLING
Location: Published Article

124. Ibrahim, S., and Culp T., 1989, "Plutonium distribution and oxidation states in a reactor leaching ponds system," *Health Physics*, 57:607-614.

125. Jackson, B. D.; Kcegans, S. J.; Morgan, E. D.; Clark, W. H., and Blom, P. E., 1991, "Chemotaxonomic study of undescribed species of *Mymica* ant from Idaho," *J. Chem. Ecol.*, 17:335-342.

Location: Summarized in Markham 1991

126. Janke, D. H., and Arthur, J. W., 1985, "Radionuclide transport by cottontail rabbits at a radioactive waste disposal area," *Northwest Sci.*, 59:221-229.

Location: Published Article

127. Johnson, D. W.; Channamela, D. A., and Gasser, K. W., 1983, "Food habits of the shorthead sculpin (*Cottus confusus*) in the Big Lost River, Idaho," *Northwest Sci.*, 57:229-239.

*Feeding habits of the shorthead sculpin (*Cottus confusus*) were analyzed by size in both autumn and spring, and by habitat type in the spring. Trichoptera, Diptera, and Ephemeroptera larvae were the most important food items with some seasonal variation.*

Subject: Sculpin ecology
Keywords: SHORthead SCULPIN / DIET & FOOD HABITS / SALMONID
HABITAT / TRICHOPTERA / INVERTEBRATE /
BOTTOM-FEEDING
Location: Published Material

128. Johnson, J. B., and Stafford, M. P., 1986, "Adult Noctuidae feeding on aphid honeydew, and a discussion of honeydew feeding by adult Lepidoptera," *J. Lepidoptera Soc.*, 39:321-327.

*Documentation of the feeding of adult *Aseptis characta* and *Rhynchagrotis exertistigma* on the honeydew of *Zyxaphis canae* on basin big sagebrush. Means by which the moths could locate honeydew sources and the adaptive value of this ability in specific situations are considered.*

Subject: The feeding of Noctuidae on aphid honeydew
 Keywords: NOCTUIDAE / HOMOPTERA / INVERTEBRATE / APHIDS
 Location: Published Article

129. Johnson, M. K., 1978, *Food habits of coyotes in southcentral Idaho*, Ph.D. Dissertation, Colorado State University, Fort Collins, CO.

Location: Colorado State University, Fort Collins, CO

130. Johnson, M. K., 1978, "What do coyotes eat?," *Idaho Wildlife*, 1:25-26.

Location: Published Material

131. Johnson, M. K., 1979, "Foods of primary consumers on cold desert shrub-steppe of southcentral Idaho," *J. Range Manage.*, 32: 365-368.

Trophic relationships of rabbits, black-tailed jackrabbits, pronghorn, sheep, and cattle were examined on a cold desert shrub-steppe. Grasses were the most important foods of lagomorphs and livestock. Pronghorn depended mostly on basin big sagebrush.

Subject: Primary consumers on cold desert shrub-steppe
 Keywords: RABBIT / JACKRABBIT / PRONGHORN / SHEEP / CATTLE / GRASSES / SAGEBRUSH / PRIMARY CONSUMERS / DIET & FOOD HABITS / COMPETITION

Location: Published Material

132. Johnson, M. K., 1981, "Estimating coyote diet: a validation," *Amer. Midl. Natur.*, 106:399-400.

Validates the use of a method for estimating predator food intake. Scat analysis produced estimates of ingested biomass near to the biomass actually eaten for each prey.

Subject: Coyote diet, habitat, & home range
 Keywords: COYOTE / DIET & FOOD HABITS / DRY MATTER INTAKE / BIOMASS

Location: Published Material

133. Johnson, M. K., 1982, "Response of small mammals to livestock grazing in southcentral Idaho," *J. Range Manage.*, 35:51- 53.

Reports on conflicting conclusions of different studies which compare the effects of sheep grazing on vertebrate populations. This study concludes that small mammal abundance varies site specifically and that there is no proof that differences in small mammal abundance resulted from the land use practices. Recommends studies be conducted with

replication and strict controls before correlated data is accepted as indicators of cause and effect relationships.

Subject: Small mammal ecology
Keywords: SMALL MAMMAL / CATTLE / CAUSE AND EFFECT
RELATIONSHIPS / GRAZING
Location: Published Material

134. Johnson, M. K., and Hansen, R. M., 1977, "Comparison of point frame and hand separation of coyote scats," *J. Wildl. Manage.*, 41:319-320.

Estimated mean dry weights of insoluble fragments in coyote scat were not significantly different from dry weights determined by hand separation.

Subject: Methods for determining the mean dry weights of insoluble fragments for coyote scat
Keywords: COYOTE / INSOLUBLE FRAGMENTS / POINT INTERCEPTION
Location: Published Material

135. Johnson, M. K., and Hansen, R. M., 1978, "Estimating dry weight per occurrence for taxa in coyote scat," *J. Wildlife Manage.*, 42:913-915.

Reports on the use of a point frame to estimate dry weight fractions of sand, bone, plant, feather, hair etc. found in predator feces on the INEL.

Subject: Coyote diet, habitat, & home range
Keywords: COYOTE / SCATS / MACROFRAGMENTS / POINT INTERCEPTION
Location: Published Material

136. Johnson, M. K., and Hansen, R. M., 1979, "Coyote food habits on the Idaho National Engineering Laboratory," *J. Wildl. Manage.*, 43:951-956.

Describes the coyote food habits on the INEL during a period when black-tailed jackrabbits populations densities were extremely low. A comparison of the use of coyote control areas versus those areas where coyote control is prohibited. Supports the hypothesis that the coyote is highly selective rather than opportunistic. There was no evidence to suggest that coyotes are attracted to seasonally abundant livestock. The relative lack of rabbits in livestock-grazed areas may have been responsible for a low level of livestock predation compared to what might have occurred if livestock had been grazed in closer proximity to the coyote staple.

Subject: Coyote diet, habitat, & home range
Keywords: COYOTE / DIET & FOOD HABITS / CATTLE / PREDATOR-PREY / RABBIT

Location: Published Material

137. Johnson, M. K., and Hansen, R. M., 1979, "Estimating coyote food intake from undigested residues in scats," *Amer. Midl. Natur.*, 102:363-367.

Demonstrates how the food intake of a coyote population might be elucidated from knowledge of the contents of scats and the digestibility of prey.

Subject: Coyote diet, habitat, & home range

Keywords: COYOTE / SCATS / UNDIGESTED FRAGMENTS / DIGESTIBILITY INDEXES

Location: Published Material

138. Johnson, M. K., and Hansen, R. M., 1979, "Food habits of cottontails and woodrats in southcentral Idaho," *J. Mammal.*, 60: 213-215.

Reports on the trophic relationship between bushytail woodrats and Nuttall cottontails. Similarities in cottontail fecal compositions between dens and non-sen sties suggest that activities of woodrats have little influence on the food habits of cottontails that inhabit woodrat den sites.

Subject: Analysis of bushytail woodrats and Nuttall cottontails feces

Keywords: BUSHYTAILED WOODRATS / NUTTALL COTTONTAIL / SCATS / DIET & FOOD HABITS

Location: Published Material

139. Johnson, M. K., and MacCracken, J. G., 1978, "Similarity between pronghorn and mule deer fecal pellets," *Great Basin Natur.*, 38:222-224.

Reports on the differences of between pH values and botanical composition for mule deer and pronghorn fecal pellets. Concludes that pH analysis of fecal pellets can distinguish between the two species.

Subject: A method to distinguish fecal pellets of mule deer and pronghorn

Keywords: PRONGHORN / MULE DEER / FECAL PELLETS / PH ANALYSIS

Location: Published Material

140. Johnson, R. D., 1982, *Relationships of black-tailed jackrabbit diets to population density and vegetal components of habitat*, M.S. Thesis, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

141. Johnson, R. D., and Anderson, J. E., 1984, "Diets of black- tailed jack rabbits in relation to population density and vegetation," *J. Range Manage.*, 37:79-83.

The results of a study to compare the composition of vegetation among areas having different population densities of black-tailed jack rabbits and to compare diet with vegetal composition in these areas. Jack rabbits appeared to select open, grass- dominated habitats and then tended to eat whatever grasses were found there.

Subject: Black-tail jackrabbit and nuttall cottontail ecology
Keywords: JACKRABBIT / GRASSES / POPULATION PARAMETERS
Location: Published Article

142. Johnson, W. C., 1977, *Examination of censusing techniques for small mammals in a high desert ecosystem*, M.S. Thesis, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

143. Johnson, W. C., and Keller, B. L., 1983, "An examination of snap-trapping techniques for estimating rodent density in high desert," *Northwest Sci.*, 57:194-204.

An evaluation of various trapping techniques to establish a reliable method for estimating abundance of small mammals in desert communities. Recommends maximum rodent abundance be assessed in spring two Museum Special traps and one treadle rat trap per station be used, baited, unset snap-traps should be placed at each sample station for several days prior to snap trapping.

Subject: Evaluation of trap types
Keywords: SMALL MAMMAL / COLLECTION TECHNIQUES / POPULATION PARAMETERS / DESERT ECOSYSTEM
Location: Published Material

144. Johnson, W. C., and Keller, B. L., 1983, "Examination of the area of effect of snap-trap transects in Idaho desert," *Canadian J. Zool.*, 61:403-410.

The objective of this study was to determine the accuracy of snap trapping on rodent density and dispersion. The experiment established that all marked individuals were not equally susceptible to capture in a central snap-trap transect line and that no clear area of removal could be defined for any species enumerated.

Subject: Evaluation of trap types
Keywords: RODENTS / COLLECTION TECHNIQUES / POPULATION PARAMETERS
Location: Published Material

145. Keller, B. L.; Groves, C. R.; Pitcher, E. J., and Smolen, M. J., 1982, "A method to trap rodents in snow, sleet, or rain," *Can. J. Zool.*, 60:1104-1106.

Describes the construction and use of bucket shelters for live trapping of small mammals in winter.

Subject: Evaluation of trap types
Keywords: BUCKET SHELTERS / SMALL MAMMAL / COLLECTION
TECHNIQUES
Location: Published Material

146. Knick, S. T., 1987, *Ecology of bobcats in southeastern Idaho*, Ph.D. Dissertation, University of Montana, Missoula, MT.

A study of harvested and unharvested bobcat populations on and around the INEL. Reports on population parameters, social organization, home range dynamics, activity patterns and response to jack rabbit decline.

Subject: Bobcat ecology
Keywords: BOBCAT / PREDATOR-PREY / HOME RANGE / ACTIVITY
PATTERNS / RADIO-TELEMETRY / JACKRABBIT / POPULATION
PARAMETERS
Location: INEL Technical Library

147. Knick, S. T., 1987, "What do the bobcats do when the jackrabbits are gone?," *Idaho Wildlife*, 7:14-17.

148. Knick, S. T., 1990, "Ecology of bobcats relative to exploitation and a prey decline in southeastern Idaho," *Wildlife Monographs*, 108

Location: Published Article

149. Knick, S. T., and Bailey, T. N., 1986, "Long distance movements by two bobcats from southeastern Idaho," *Amer. Midl. Natur.*, 116:222-223.

A report of the longest reported movements of bobcats (182 and 158 km straight-line distances). this occurred after a decline in prey base population.

Subject: Bobcat ecology
Keywords: BOBCAT / MAMMAL / RADIO-TELEMETRY / EAR-TAGGED
Location: Published Article

150. Kochler, D. K., 1988, *Small mammal movement patterns around a radioactive waste disposal area in southeastern Idaho*, M.S. Thesis, University of Wyoming, Laramie, WY.

Location: Summarized in Markham 1991

151. Koehler, D. K., and Anderson, S. H., 1991, "Habitat use and food selection of small mammals near a sagebrush/crested wheatgrass interface in southeastern Idaho," *Great Basin Naturalist*, 51:249-255.

Habitat use and food selection data were collected for deer mice, montane voles, Ord's kangaroo rates, and Townsend's ground squirrels near a big sagebrush/crested wheatgrass interface in SE Idaho.

Subject: Small mammal ecology

Keywords: SMALL MAMMAL / DIET & FOOD HABITS / HABITAT / DEER MICE / VOLE / KANGAROO RAT / TOWNSEND'S GROUND SQUIRREL

Location: Journal Article

152. Kochler, D. K.; Reynolds, T. D., and Anderson, S. H., 1985, "Use of interperitoneal transmitter implants to monitor small mammal movements," *J. Colorado-Wyoming Acad. Sci.*, 17:38.

Location: Published Article

153. Kochler, D. K.; Reynolds, T. D., and Anderson, S. H., 1987, "Radio-transmitter implants in 4 species of small mammals," *J. Wildlife Management*, 51:105-108.

A simple surgical procedure was used to implant radio transmitters intraperitoneal in deer mice, montane voles, Ord's kangaroo rats, and Townsend's ground squirrels. The technique appeared to offer a viable method of fitting these semifossorial species with radio transmitters.

Subject: Radio-Telemetry in small mammals

Keywords: RADIO-TELEMETRY / SURGICAL TECHNIQUES / SMALL MAMMAL / DEER MICE / VOLE / KANGAROO RAT / TOWNSEND'S GROUND SQUIRREL

Location: Published Article

154. Kramber, W. J.; Rope, R. C.; Anderson, J.; Glennon, J., and Morse, A., 1992, "Producing a Vegetation Map of the Idaho National Engineering Lab Using LANDSAT Thematic Mapper Data," 1992 ASPRS/ACSM Annual Meeting and Convention, Albuquerque, NM, February 29 - March 5, 1992.

Producing a vegetation map of the INEL for use in Environmental Assessments, monitoring and restoration activities from LANDSAT images. Using spectral classes the community characteristics were identified, field work undertaken for verification, and final spectral

classes established for identified communities. Report discusses all aspects of the study with main emphasis on LANDSAT image manipulation.

Subject: LANDSAT images to produce vegetation maps
 Keywords: LANDSAT / VEGETATION / GIS / GPS / SPECTRAL CLASSES /
 ENVIRONMENTAL ASSESSMENT / MONITORING / RESTORATION
 / PLANT COMMUNITIES
 Location: Published

155. Kuzo, G. B.; Fraley, L. Jr.; Whicker, F. W., and Markham, O. D., 1987, "Comparative behavior and distribution of transuranium nuclides in selected components of Test Reactor Leaching Ponds," *Proc. of Sym. Environmental Research on Actinide Elements, CONF- 86008713, Hilton Head, SC, November 7-11, 1983.*

156. Landre, J. W., 1981, "Temporal variation in coyote vocalization rates," *J. Wildl. Manage.*, 45:767-769.

Documentation of seasonal and diel variation in coyote vocalization rates. Seasonal and diel variations were found. A recommendation was made for further study.

Subject: Seasonal and diel variation in coyote vocalization
 Keywords: COYOTE / VOCALIZATION RATE / TEMPORAL VARIATION
 Location: Published Material

157. Landre, J. W., and Keller, B. L., 1981, "Home-range use by coyotes in Idaho," *Anim. Behav.*, 29:449-461.

Documents a study to test the following null hypothesis (1) no significant relationship exist between how often an areas is used and the movement in that area, (2) patterns in spatial and behavioral use are not significantly altered on a daily or seasonal basis, and (3) their is no significant difference between the patterns of use for male and female coyotes. Utilization of the home range was found to vary spatially and behavioral.

Subject: Coyote diet, habitat & home range
 Keywords: COYOTE / HOME RANGE / TEMPORAL VARIATION / SPATIAL
 VARIATION
 Location: Published Material

158. Landre, J. W., and Keller, B. L., 1983, "Trappability of coyotes relative to home range boundaries," *Canadian J. Zool.*, 61:1932-1934.

Trappability of coyotes relative to location of the home range boundary was examined to determine whether animals were more susceptible to capture in an unfamiliar area. Susceptibility to trapping did not appear to increase on the edge or outside of home range

boundaries, but equal probability of capture in areas receiving different intensities of use still needs to be assessed.

Subject: Coyote diet, habitat, & home range
Keywords: COYOTE / COLLECTION TECHNIQUES / HOME RANGE
Location: Published Material

159. Landre, J. W.; Reynolds, T. D.; Knick, S. T., and Ball, I. J., 1987, "Accuracy of daily point relocations in assessing real movements of radio-marked animals," *J. Wildlife Management*, 51: 937-940.

Correlations between telemetry taken at 24-hour intervals and at more frequent times for differences between "real" and "perceived" distances travelled for pronghorns, coyotes, bobcats, and mallards showing daily relocation data may not be valid.

Subject: Radio-Telemetry in small mammals
Keywords: RADIO-TELEMETRY / PRONGHORN / COYOTE / BOBCAT / MALLARD / AVIAN
Location: Published Article

160. Landre, J. W., 1979, *A behavioral study of home range utilization by coyotes on the INEL site in southeastern Idaho*, Ph.D. Thesis, Idaho State University, Pocatello, ID.

161. Landre, J. W., 1989, "Burrows of least chipmunks in southeastern Idaho," *NW Naturalist*, 70:18-20.

Location: Summarized in Markham 1991

162. Landre, J. W., 1989, "Estimating soil bulk density with expanding polyurethane foam," *Soil Sci.*, 147:223-224.

Location: Summarized in Markham 1991

163. Landre, J. W., 1989, "Horizontal and vertical diameter of burrows of five small mammal species in southeastern Idaho," *Great Basin Naturalist*, 49:646-649.

Burrow cross-sections for Townsend's ground squirrel, Wyoming ground squirrel, Ord's kangaroo rat, montane vole, and deer mouse were examined. Burrows were compared with each animal and among animals. Relative sizes are reported and effect of soil bulk density and texture on burrow diameter for each species.

Subject: Small mammal ecology
Keywords: SMALL MAMMAL / SOIL / BURROWING
Location: Published Article

164. Laundre, J. W., 1990, *Assessment of CREAMS and ERHYM-II computer models for simulating soil water movement on the Idaho National Engineering Laboratory*, DOE-ID, DOE/ID-12116, Idaho Falls, ID.

Location: Summarized in Markham 1991

165. Laundre, J. W., 1990, "Calibration and sensitivity testing of CREAMS and ERHYM-II computer models for use in cold desert environment," *Arid Soil Research Rehabilitation*, 4:205-222.

Location: Summarized in Markham 1991

166. Laundre, J. W., 1990, "Soil moisture patterns below mounds of harvester ants," *J. Range Management*, 43:10-12.

Location: Summarized in Markham 1991

167. Laundre, J. W.; Davison, R.; Johnson, M. K.; Keller, B. L., and Wilde, D. B., 1978, "Coyote-prey assessment on a NERP site in southeastern Idaho," *Great Basin Natur.*, 38:55-67.

Location: Published Material

168. Laundre, J. W.; Davison, R.; Johnson, M. K.; Keller, B. L.; Stoddart, L. C., and Wilde, D. B., 1978, "Coyote-prey assessment on a National Environmental Research Park in southeastern Idaho," In: Ketching, J. T.; Tarr, N. E., *National Environmental Research Park Symposium: Natural Resource Inventory, Characterization and Analysis*, Oak Ridge National Laboratory, Oak Ridge, TN, *Outlines methods used to assess populations and behavior parameters of the coyote and the various prey species available to it. The methods outlined were employed in areas protected from predator management programs and in areas where these activities are prevalent.*

Subject: Coyote-prey dynamics

Keywords: COYOTE / LONG-TERM STUDIES / NERP

Location: Published Material

169. Laundre, J. W., and Keller, B. L., 1984, "Home range of coyotes - a critical review," *J. Wildlife Management*, 48:127-139.

A review of methods used to collect and analyze home-range data, presents uniform guidelines to assess the validity of existing data, and attempts to test current hypotheses concerning home-range size.

Subject: Coyote diet, habitat, & home range

Keywords: COYOTE / HOME RANGE

Location: Published Article

170. Laundre, J. W., and Wilkosz, R. J., 1991, "The use of cluster analysis to analyze habitat use by coyotes in an area of low vegetal heterogeneity," *Northwestern Naturalist*, 72:12-20.

Using cluster analysis to study vegetation data in areas used by coyotes for hunting or resting. Relationships between coyote activity and similar clustered plots for percent grass cover, percent ground litter, and percent rock and bare ground.

Subject: Coyote diet, habitat, & home range

Keywords: COYOTE / VEGETATION / CLUSTER ANALYSIS

Location: Published Article

171. Lennstrom, H. A., 1985, *Holocene vegetation history of the eastern Snake River Plain: An analysis of seventeen woodrat (Neotoma) middens*, M.S. Thesis, University of Minnesota, Minneapolis, MN.

Location: University of Minnesota, Minneapolis, MN

172. Linder, A. D., and Schman, R. W., 1977, "Heptofauna of the Idaho National Engineering Laboratory Site," *J. Idaho Acad. of Sci.*, 13(2):43-46.

A list of the reptiles and amphibians inhabiting the INEL. General descriptions and locations of habitat are included.

Subject: Amphibians and reptiles

Keywords: HERPTOFAUNA / REPTILE / AMPHIBIAN

Location: Published Material

173. Linder, A. D., and Schman, R. W., 1978, "The herptofauna of the Idaho National Engineering Laboratory Site," *J. Idaho Acad. Sci.*, 13:47-50.

Location: Published Material

174. MacCracken, J. G., 1980, *Feeding ecology of coyotes on the upper Snake River Plain, Idaho*, M.S. Thesis, Colorado State University, Fort Collins, CO.

Location: Colorado State University, Fort Collins, CO

175. MacCracken, J. G., and Hansen, R. M., 1982, "Herbaceous vegetation of habitat used by black-tailed jackrabbits and Nuttall cottontails in southeastern Idaho," *Amer. Midl. Nat.*, 107:180-184.

This paper presents data on biomass of herbaceous vegetation in habitat used by black-tail jackrabbits and nuttall cottontails, in southeastern Idaho. These leporids were most abundant where biomass of herbaceous vegetation was greatest, but abundance of black-tail jackrabbits and nuttall cottontails was related inversely.

Subject: Black-tail jackrabbit and nuttall cottontail ecology
Keywords: JACKRABBIT / NUTTALL COTTONTAIL / FECAL PELLETS /
VEGETATION / GRASSES / FORBS
Location: Published Material

176. MacCracken, J. G., and Hansen, R. M., 1982, "Seasonal foods of coyotes in southeastern Idaho: a multivariate analysis," *Great Basin Natur.*, 42:45-49.

A study in which seasonal foods of coyotes (Canis latrans) inhabiting the INEL site were examined using step-wise discriminant analysis. Significant differences (P less than or equal 0.001) were detected among seasons in food consumption by coyotes, where univariate statistical analysis failed to recognize differences. The role opportunistic behavior plays in coyote food selection on the study area is questioned.

Subject: Coyote diet, habitat, & home range
Keywords: COYOTE / DIET & FOOD HABITS / SMALL MAMMAL /
INVERTEBRATE
Location: Published Material

177. MacCracken, J. G., and Hansen, R. M., 1984, "Seasonal foods of black-tail jackrabbits and Nuttall cottontails in southeastern Idaho," *J. Range Management*, 37:256-259.

Study of the diets of black-tail jackrabbits and Nuttall cottontails. Distinct seasonal differences in diet were ascertained. The greatest diversity in diet occurred during the spring. Livestock grazing appeared to limit leporid population density rather than alter leporid food habits.

Subject: Black-tail jackrabbit and nuttall cottontail ecology
Keywords: JACKRABBIT / NUTTALL COTTONTAIL / DIET & FOOD HABITS /
CATTLE
Location: Published Article

178. MacCracken, J. G., and Hansen, R. M., 1986, "Energy and protein content of coyote prey in southeastern Idaho," *Great Basin Natur.*, 46:274-276.

Gross energy, digestible energy, crude protein, and digestible crude protein were estimated for two leporids and five rodents that were the primary prey of coyotes (Canis latrans) in southeastern Idaho.

Subject: Coyote diet, habitat, & home range
Keywords: COYOTE / ENERGY CONTENT / DIGESTIBLE PROTEIN / CRUDE PROTEIN / SMALL MAMMAL / INVERTEBRATE / RODENTS / DEER MICE / TOWNSEND'S GROUND SQUIRREL / KANGAROO RAT / LEAST CHIPMUNK / JACKRABBIT / NUTTALL COTTONTAIL / VOLE
Location: Published Article

179. MacCracken, J. G., and Hansen R.M., 1987, "Coyote feeding strategies in southeastern Idaho: optimal foraging by an opportunistic predator?," *Wildlife Management*, 51:278-285.

results of an examination of coyote food habits, abundance, and distribution in relation to changes in abundance of their major prey (leporids).

Subject: Coyote diet, habitat, & home range
Keywords: COYOTE / JACKRABBIT / DIET & FOOD HABITS / FEEDING STRATEGIES
Location: Published Article

180. Markham, O. D., 1973, *National Reactor Testing Station environmentally related publications*, U.S. Atomic Energy Commission, IDO-12078, Idaho Falls, ID.

181. Markham, O. D., 1974, "Environmental and radiological monitoring at the National Reactor Testing Station during FY- 1973," *Rad. Data and Reports*, 15:227-246.

Location: Published Material

182. Markham, O. D., 1974, "Radioecology of Idaho National Engineering Laboratory - radioecology and the ecology programs at Idaho National Engineering Laboratory," *Rad. Data and Reports*, 15:33-34.

Location: Published Material

183. Markham, O. D., 1978, *Activation and fission products in the environment near the Idaho National Engineering Laboratory Radioactive Waste Management Complex*, DOE, IDO-12085, Idaho Falls, ID.

184. Markham, O. D., 1985, *Summaries of Idaho National Engineering Laboratory Radioecology and Ecology Program's waste management related studies*, DOE/ID 12103.

Location: National Technical Information Service, VA

185. Markham, O. D., 1987, *Summaries of the Idaho National Engineering Laboratory Radioecology and Ecology Programs research projects*, DOE-ID, DOE/ID-12111, Idaho Falls, ID.

This report provides summaries of individual research projects conducted by the INEL Radioecology and Ecology Program. Summaries include projects that were published prior to 1987 to those that were just began during that year.

Subject: Radioecology & Ecology research projects at the INEL
 Keywords: VEGETATION / REVEGETATION / WILD PLANTS / SOIL / ROOT PROFILES / SHRUB-STEPPE / NATIVE VEGETATION / CRESTED WHEATGRASSES / WILD RYE / WATER BALANCE / MODELING / ANTS / APHIDS / INVERTEBRATE / HONEY BEE / TRACE ELEMENTS / LICHEN / RODENTS / SMALL MAMMAL / TOWNSEND'S GROUND SQUIRREL / JACKRABBIT / BOBCAT / SAGE GROUSE / PRONGHORN / BATS / RAPTOR / AVIAN / NESTING / MOURNING DOVE / WATERFOWL

Location: INEL Technical Library

186. Markham, O. D., 1991, *Summaries of Idaho National Engineering Laboratory Radioecology and Ecology Program Environmental Restoration and Waste Management Related Research*, DOE-ID, DOE/ID-12124, Idaho Falls, ID.

Documentation of waste management and environmental restoration related research projects being conducted or proposed by the INEL Radioecology and Ecology Program within the Radiological and Environmental Sciences Laboratory.

Subject: Radioecology & Ecology research projects at the INEL
 Keywords: ENVIRONMENTAL RESTORATION / WASTE MANAGEMENT / EVAPOTRANSPIRATION / SOIL / SMALL MAMMAL / BURROWING / ROOT PROFILES / REVEGETATION / WHEATGRASSES / ANTS / BIOBARRIER / HONEY BEE / TRANSURANICS / LICHEN / TRACE ELEMENTS / WILDLIFE & HABITAT / WATERFOWL

Location: INEL Technical Library

187. Markham, O. D. (ed.), 1976, *Progress report Idaho National Engineering Laboratory Site radioecology-ecology programs*, DOE, IDO-12080, Idaho Falls, ID.

Location: National Technical Information Service, Springfield, VA

188. Markham, O. D. (ed.), 1976, *Summaries of the Idaho National Engineering Laboratory Site Ecological Information Meeting July 10-11, 1975*, DOE, IDO-12079, Idaho Falls, ID.

Location: National Technical Information Service, Springfield, VA

189. Markham, O. D. (ed.), 1978, *Ecological studies on the Idaho National Engineering Laboratory Site, 1978 Progress Report*, DOE, IDO-12087, Idaho Falls, ID.

190. Markham, O. D. (.), 1983, *Idaho National Engineering Laboratory Radioecology and Ecology Program 1983 Progress Report*, DOE-ID, DOE/ID-12098, Idaho Falls, ID.

Summarizes 42 on-going and completed radioecology and ecology research projects at the INEL. Lists researchers, publications, and oral publications.

Subject: Radioecology & Ecology research projects at the INEL

Keywords: RADIONUCLIDE / IODINE-129 / BIOTA & RADIONUCLIDE / BIOLOGICAL INTRUSIONS / SOIL / RARE VASCULAR PLANTS / VEGETATION / CRESTED WHEATGRASSES / SAGEBRUSH / CONTROLLED BURN SITE / PRONGHORN / COYOTE / BOBCAT / RABBIT / JACKRABBIT / RODENTS / SMALL MAMMAL / WATERFOWL / RAPTOR / SAGE GROUSE / SPARROW

Location: INEL Technical Library

191. Markham, O. D., and Arthur, W. J., 1979, "Desert Island," *Idaho Wildl.*, 1:14-17.

192. Markham, O. D., and Arthur, W. J. (eds.), 1979, *Proceedings of the Symposium on the Idaho National Engineering Laboratory Ecology Programs, Grand Teton National Park, September 10-12, 1978*.

193. Markham, O. D.; Autenrieth, R., and Hoskinson, R., 1976, "Concentration of radionuclides in tissue of antelope on and near the Idaho National Engineering Laboratory Site," *Proceedings of the 7th Biennial Pronghorn Antelope Workshop, Twin Falls, ID*.

194. Markham, O. D.; Autenrieth, R. E., and Dickson, R. L., 1979, "Plutonium in pronghorn antelope lungs near a nuclear fuel reprocessing plant," *Health Physics*, 37:398-400.

195. Markham, O. D.; Hakonson, T. E.; Whicker, F. W., and Morton, J. S., 1983, "Iodine-129 in mule deer thyroids from Rocky Mountain States," *Health Physics*, 45:31-38.

Documentation of Iodine-129/Iodine-127 ratios in mule deer thyroids from portions from portions of the Rocky Mountain region. Although of no health consequences to the

animals, Iodine-129 in deer thyroids may be a sensitive indicator of contaminants for nuclear fuel reprocessing plants.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: MULE DEER / IODINE-129 / IODINE-127 / BIOINDICATOR /
THYROID
Location: Published Material

196. Markham, O. D.; Halford, D. K.; Bihl, D. E., and Authenrieth, R. E., 1980, "Iodine-131 concentrations in air, milk, and antelope thyroids in southeastern Idaho," *Health Physics*, 38:321-326.

A determination of I-131 concentrations in air, milk, and antelope thyroids resulting from atmospheric releases from INEL facilities and fallout from nuclear detonations. The relative sensitivities of the three media in detecting Iodine-131 in the environment are discussed. Iodine-131 concentrations increased after five above-ground nuclear weapon detonations were conducted by the People's Republic of China.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: IODINE-131 / MILK / PRONGHORN / THYROID / PEOPLE'S
REPUBLIC OF CHINA
Location: Published Material

197. Markham, O. D.; Halford, D. K., and Autenrieth, R. E., 1980, "Strontium-90 concentrations in pronghorn antelope bones near a nuclear fuel reprocessing plant," *Health Physics*, 38:811-816.

The analysis of pronghorn bones revealed an average radiation dose of 40 mrad/yr to endosteal cells and 20 mrad/yr to active bone marrow. The study concludes that the increase dose from INEL of strontium-90 would result in significant health problems for the antelope.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: PRONGHORN / STRONTIUM-90 / RADIONUCLIDE
Location: Published Material

198. Markham, O. D., and Halford, D. K., 1982, "Radionuclides in mourning doves near a nuclear facility complex in southeastern Idaho," *Wilson Bull.*, 94:185-197.

This study was conducted to determine the concentrations of radionuclides in mourning dove tissues, the consequent radiation dose to doves, the consequent of the transfer of radionuclides through the food chain, and to relate these concentrations to potential radiation doses to man.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: MOURNING DOVE / RADIONUCLIDE / RADIATION DOSE
Location: Published Material

199. Markham, O. D.; Halford, D. K.; Autenrieth, R. E., and Dickson, R. L., 1982, "Radionuclides in pronghorn resulting from nuclear fuel reprocessing and worldwide fallout," *J. Wildl. Manage.*, 46:30-42.

results of a study to (1) determine concentrations of radionuclides in tissues of pronghorn both on and off the INEL site, (2) assess possible radionuclide intake by sportsmen consuming pronghorn tissues; and (3) assess radiation doses received by pronghorn as a result of the various radionuclides in worldwide fallout and INEL atmospheric effluents. Radiation doses to pronghorn and to man eating the pronghorn are below current guidelines established for man. Pronghorn appear to be useful bioindicators of radionuclides in the environment.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: PRONGHORN / RADIONUCLIDE / BIOINDICATOR
Location: Published Material

200. Markham, O. D., and Halford, D. K., 1985, "Effects of decreased effluents from nuclear fuel reprocessing on Cs-137 concentrations in wildlife," *Northwest Sci.*, 59:180-184.

Presents the effects of additional filtering of atmospheric effluents on the radionuclide concentrations in edible tissues of game animals on the INEL and to estimate the subsequent potential radiation dose to man consuming tissues of wildlife.

Subject: Effect of additional filtering of atmospheric at the ICPP on wildlife
Keywords: WILDLIFE & HABITAT / CESIUM / HEPA FILTERS /
RADIONUCLIDE
Location: Published Article

201. Markham, O. D.; Halford, D. K.; Rope, S. K., and Kuzo, G. B., 1988, "Plutonium, Am, Cm and Sr in ducks maintained on radioactive leaching ponds in southeast Idaho," *Health Physics*, 55:517-524.

Location: Summarized in Markham 1991

202. Markham, O. D.; Puphal, K. W., and Filer, T. D., 1978, "Plutonium and americium CONTAMINANTion near a transuranic storage area in southeastern Idaho," *J. Environ. Qual.*

Reports on a study conducted to determine concentrations of PU- 238, PU-239, Am-241 in the soil and small mammals on the INEL. The data indicate the radionuclides may have different transport mechanisms in the terrestrial environment.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: RADIONUCLIDE / SMALL MAMMAL
Location: Published Material

203. Markham, O. D.; Reynolds, T. D., and Rope, S. K., 1985, *Descriptions of the Idaho National Environmental Research Park*, p. 13-20, *IN: Department of Energy National Environmental Research Parks*, DOE/ER-0246.

A description of the INEL Research Park. Includes name, size, location, principle biome, research summaries, site activities, existing data bases.

Subject: INEL's National Environmental Research Park
Keywords: NERP
Location: INEL Technical Library

204. Markham, O. D., and Reynolds, T. D., 1991, *Publications of the Idaho National Engineering Laboratory Radioecology and Ecology Program: 1974-1991*, DOE-ID, DOE/ID-12125, Idaho Falls, ID.

A list of 300 publications that have resulted from research conducted by the INEL Radioecology and Ecology Program during the years 1974 - 1991.

Subject: Radioecology & Ecology research projects at the INEL
Keywords: RADIOECOLOGY / AVIAN / CONTAMINANT TRANSPORT AND DISTRIBUTION / DIET & FOOD HABITS / FISH / HABITAT / ICPP / INVERTEBRATE / LICHEN / MAMMAL / PALEOECOLOGY / PHYSIOLOGY / RWMC / REPTILE / AMPHIBIAN / SOIL / SPECIES LIST / TECHNIQUES
Location: INEL Technical Library

205. Markham, O. D., and Trost, C. H., 1986, "Summer foods of mourning doves in southeastern Idaho," *Murrelet*, 67:60-62.

Food habitats of Mourning doves inhabiting sagebrush dominated areas which have previously not been reported in the literature.

Subject: Avian diet and food habits
Keywords: MOURNING DOVE / SAGEBRUSH / AVIAN
Location: Published Article

206. Marlette, G. M., 1982, *Stability and succession in crested wheatgrass seedings on the Idaho National Engineering Laboratory Site*, M.S. Thesis, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

207. Marlette, G. M., and Anderson, J. E., 1986, "Seed banks and propagule dispersal in crested-wheatgrass stands," *J. Applied Ecol.*, 23:161-175.

Documents the results of a study which found a lack of native propagules in crested wheatgrass stands on the INEL. Crested wheatgrass stands retarded the development of a diverse plant community.

Subject: Vegetative studies on the INEL
Keywords: CRESTED WHEATGRASSES / SEMI-ARID PLANT COMMUNITIES /
NATIVE VEGETATION / REVEGETATION
Location: Published Article

208. McBride, R.; French, N. R.; Dahl, A. H., and Detmer, J. E., 1978, *Vegetation types and surface soils of the Idaho National Engineering Laboratory Site*, DOE, IDO-12084, Idaho Falls, ID.

Location: National Technical Information Service, Springfield, VA

209. McGiff, T. J., 1985, *Determination of I-129 and I-127 in vegetation at the Idaho National Engineering Laboratory*, M.S. Thesis, Colorado State University, Ft. Collins, CO.

Documents the results of a study of Iodine-129 in the vegetation on the INEL. The data was used to calculate an estimated dose to humans from milk, beef, and antelope meat.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: VEGETATION / IODINE-129 / DOSE TO HUMANS / MILK / BEEF /
PRONGHORN
Location: INEL Technical Library

210. Millard, G. C.; Fraley, L. Jr., and Markham, O. D., 1983, "Deposition and retention of Ce-141 and Cs-134 aerosols on cool desert vegetation," *Health Physics*, 44:349-358.

Deposition velocities and retention times were obtained for submicron aerosols of Cerium-141 and Cesium-134 on sagebrush and grass in a major ecosystem - the sagebrush

steppes of western North America. This study indicates that species differences in vegetation are the major factors affecting deposition and retention of fine particles.

Subject: Aerosols on sagebrush and grass in sagebrush steppes
Keywords: SUBMICRON AEROSOLS / CE-134 / CS-141 / SAGEBRUSH /
GRASSES / DEPOSITION VELOCITIES
Location: Published Material

211. Millard, G. E., 1986, *The deposition and retention of radioactive aerosols on desert vegetation*, Ph.D. Dissertation, Colorado State University, Ft. Collins, CO.

Research conducted to (1) estimate deposition velocities and retention times for submicron aerosols of Ce-141 and Cs-134, (2) compare deposition and retention on desert species, (3) determine if any seasonal factors affect deposition or retention. Data indicate that species differences in vegetation are the major factors affecting deposition and retention of fine particles. Hairy leaved shrubs appeared more effective in trapping fine particles.

Subject: submicron aerosol deposition on desert species
Keywords: CS-134 / CE-141 / DESERT ECOSYSTEM / SAGEBRUSH / GRASSES /
SEASONAL DEPOSITION RATES
Location: INEL Technical Library

212. Millard, J. B.; Craig, T. H., and Markham, O. D., 1978, "Cannibalism in adult great-horned owls," *Wilson Bull.*, 90:449.

Reports the observation of cannibalism in great horned owls.

Subject: Avian diet and food habits
Keywords: OWLS
Location: Published Material

213. Millard, J. B.; Whicker, F. W., and Markham, O. D., 1990, "Radionuclide uptake and growth of barn swallows nesting by radioactive leaching ponds," *Health Physics*, 58:429-439.

Uptake of radionuclides by nesting barn swallows near a radioactive leaching pond was studied. Higher concentrations were determined in immature and adult birds. The growth rates of young were examined and compared with birds from other locations. Differences were seen but all rates were within the normal range reported in the literature.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: RADIONUCLIDE / SWALLOW / LEACHING POND / TRA /
NESTING / AVIAN
Location: Published Article

214. Moritz, W. E., 1988, *Wildlife use of fire-disturbed areas in sagebrush steppe on the Idaho National Engineering Laboratory*, M.S. Thesis, Montana State University, Bozeman, MT.

Investigates the long-term impact of fire in a sagebrush steppe community by examining wildlife use of 9 fire-disturbed areas (fire scars) ranging from 0 to 75 years old, on the INEL. Indicates that wildfire has a long-term influence on the flora and fauna of the INEL. Community and animal density influence use of a fire scar.

Subject: Revegetation of burn areas and wildlife use of fire scars
Keywords: FIRE ECOLOGY / VEGETATION / SAGE GROUSE / PRONGHORN
/ ELK / SMALL MAMMAL / SAGEBRUSH / CHEATGRASSES /
RABBITBRUSH
Location: INEL Technical Library

215. Morton, J. S.; Halford, D. K., and Parker, D., 1980, "A confinement device for the determination of radionuclide concentrations in live ducks," *Health Physics*, 38:234-236.

Details the construction and use of a confinement device for whole-body counts of live ducks.

Subject: Radionuclide concentration and transport in flora & fauna of the INEL
Keywords: DUCKS / COLLECTION TECHNIQUES / RADIONUCLIDE /
WHOLE- BODY DOSE
Location: Published Material

216. Morton, J. S.; Halford, D. K., and Parker, D., 1980, "A confinement device for the determination of radionuclide concentrations in live ducks," *Health Physics*, 38:234-236.

Location: Published Material

217. Mullican, T. R., 1985, *Ecology of the sagebrush vole (Lemmyscus curtatus) in southeastern Idaho*, M.S. Thesis, Idaho State University, Pocatello, ID.

The population ecology and life history of Lemmyscus curtatus was studied in sagebrush steppe of southeastern Idaho on the INEL. Details trapping techniques required to catch Lemmyscus. Sagebrush voles in the study were not colonial during the summer months.

Subject: Vole ecology
Keywords: VOLE / COLLECTION TECHNIQUES / BEHAVIOR
Location: INEL Technical Library

218. Mullican, T. R., 1986, "Additional records of *Sorex merriami* from Idaho," *Murrelet*, 67:19-20.

*Reports on the collections of Merriam's shrew (*Sorex merriami*) at the INEL.*

Subject: Merriam's shrew
Keywords: MERRIAM'S SHREW / MAMMAL
Location: Published Article

219. Mullican, T. R., and Keller, B. L., 1986, "Ecology of the sagebrush vole (*Lemmys curtatus*) in southeastern Idaho," *Canadian J. Zool.*, 64:1218-1223.

Study of sagebrush vole on dispersion, food, and reproduction.

Subject: Vole ecology
Keywords: VOLE / SAGEBRUSH
Location: Published Article

220. Nowak, R. S.; Anderson, J. E., and Toft, N. L., 1988, "Gas exchange of *Agropyron desertorum*: diurnal patterns and responses to water vapor gradient and temperature," *Oecologia*, 77:289-295.

Location: Summarized in Markham 1991

221. Nowak, R. S.; Nowak, C. L.; DeRocher, T.; Jones, M. A., and Cole, N., 1990, "Prevalence of *Oryzopsis hymenoides* near harvester ant mounds: Indirect facilitation by ants," *Oikos*, 58:190-198.

Location: Summarized in Markham 1991

222. Overton, C. K.; Cannamela, D. A., and Johnson, D. W., 1978, "Assessing environmental effects of river fluctuations on the INEL National Environmental Research Park," *Wilson Bull.*, 90:68- 82.

Location: Published Material

223. Overton, C. K., 1977, *Description, distribution, and density of Big Lost River salmonid populations*, M.S. Thesis, Idaho State University, Pocatello, ID.

results of a study of salmonid populations in the Big Lost River on the INEL. Salmonid populations fluctuated with waterflow fluctuations resulting from man's activities.

Subject: Salmonid populations on the INEL
Location: Idaho State University, Pocatello, ID

224. Parmenter, R. A., 1985, *Food and energy intake of coyotes determined from turnover of tritiated water and sodium-22*, M.S. Thesis, Colorado State University, Ft. Collins, CO.

Location: Colorado State University, Ft. Collins, CO

225. Pearson, L. C., and Rope, S. K., 1987, *Lichens of the Idaho National Engineering Laboratory*, DOE-ID, DOE/ID-12110, Idaho Falls, ID.

Provides a species list and species abundance of lichen at the INEL. Includes a brief presentation on lichen morphology and identification. gives genera description and includes some photographs of lichen at the INEL.

Subject: Lichen
Keywords: LICHEN
Location: INEL Technical Library

226. Petersen, K. L., 1982, *Breeding ecology of passerine birds in a sagebrush-dominated community*, M.S. Thesis, Iowa State University, Ames, IO.

A description of a nongame bird community on the INEL and sage sparrow, Brewer's sparrow, and sage thrasher breeding biology. The second part of the thesis details nest-site characteristics and preferences of sage and Brewer's sparrow, and sage thrasher.

Subject: Nongame bird communities
Keywords: SPARROW / SAGE THRASHER / AVIAN / NESTING
Location: INEL Technical Library

227. Petersen, K. L., and Best, L. B., 1985, "Brewer's sparrow nest-site characteristics in a sagebrush community," *J. Field Ornithol.*, 56:23-27.

Reports on a study to further the understanding of nest-site selection by Brewer's sparrow. Nest-site characteristics were measured and nest-site preferences assessed.

Subject: Avian ecology
Keywords: SPARROW / AVIAN / NESTING / SAGEBRUSH
Location: Published Article

228. Petersen, K. L., and Best, L. B., 1985, "Nest-site selection by sage sparrows," *Condor*, 87:217-221.

A comprehensive measurement of nest-site selection by Sage Sparrows occupying a sagebrush community.

Subject: Avian ecology
Keywords: SPARROW / AVIAN / NESTING
Location: Published Article

229. Petersen, K. L., and Best, L. B., 1986, "Diets of nestling Sage sparrows and Brewer's sparrows in an Idaho sagebrush community," *J. Field Ornithol.*, 37:283-294.

Sage and Brewer's sparrow nestling diets and factors influencing them in a sagebrush dominated community.

Subject: Avian diet and food habits
Keywords: SPARROW / AVIAN / SAGEBRUSH
Location: Published Article

230. Petersen, K. L., and Best, L. B., 1987, "Effects of prescribed burning on nongame birds in a sagebrush community," *Wildlife Society Bulletin*, 15:317-329.

231. Peterson, K. L., 1986, *Avian ecological studies in a sagebrush community: Bird responses to fire and territory dynamics in a sparrow population*, Ph.D. Dissertation, Iowa State University, Ames, IO.

The response of nongame birds to a prescribed fire in southeastern Idaho. After the fire, burned plots consistently supported 1 more species than control plots. Total bird densities declined moderately the year after fire, but by the fourth postburn season, total densities on experimental plots were greater than those on controls. Also reports on a study of territory dynamics in a sage sparrow population.

Subject: Nongame bird communities
Keywords: SPARROW / HABITAT / AVIAN / NESTING
Location: INEL Technical Library

232. Peterson, K. L., and Best, L. B., 1987, "Territory dynamics in a sage sparrow population: Are shifts in site use adaptive?," *Behav. Ecol. and Sociobiol.*, 21:351-358.

Sage Sparrow populations were studied to evaluate the hypothesis that territory shifts represent adaptive adjustments in site use. Territory shifting seems to be adaptive behavior aimed primarily at increasing territory size.

Subject: Avian ecology
Keywords: SPARROW / HABITAT / AVIAN
Location: Published Article

233. Peterson, K. L., and Best, L. B., 1991, "Nest-site selection by sage thrasher in southeastern Idaho," *Great Basin Naturalist*, 51:261-266.

Nest sites selected by Sage Thrashers in SE Idaho were characterized and compared with available habitat. Vegetation, directional exposure, and shrub characteristics were related to nest placement.

Subject: Avian ecology
Keywords: SAGE THRASHER / SAGEBRUSH / SHRUB-STEPPE / AVIAN /
NESTING
Location: Published Article

234. Peterson, K. L.; Best, L. B., and Winter, B. M., 1986, "Growth of nesting sage sparrows and Brewer's sparrow," *Wilson Bull.*, 98:535-546.

Characterizes Sage sparrow and Brewer's sparrow nestling growth and evaluated proximate factors potentially influencing growth in a shrub steppe community. Effects could be correlated with factors in Sage sparrows, but in Brewer's sparrows little variation was explained by the variables measured.

Subject: Sparrow ecology
Keywords: SPARROW / AVIAN / SAGEBRUSH
Location: Published Article

235. Powers, L. R., and Craig, T. H., 1976, "Notes on the status of nesting ferruginous hawks (*Buteo regalis*) in Little Lost River Valley and vicinity, southeastern Idaho," *Murrelet*, 57:46.

Location: Published Material

236. Powers, L. R., and Wheeler, M. J., 1987, "Brewer's blackbird feeding on a barn swallow," *Wilson Bull.*, 99:294-295.

Observation of a Brewer's Blackbird feeding on a dead barn swallow.

Subject: Avian diet and food habits
Keywords: BLACKBIRD / SWALLOW / DIET & FOOD HABITS / AVIAN
Location: Published Article

237. Reynolds, T. D., 1978, *The response of native vertebrate populations to different land management practices on the Idaho National Engineering Laboratory Site*, Ph.D. Thesis, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

238. Reynolds, T. D., 1979, "The impact of loggerhead shrikes on nesting birds in a sagebrush environment," *Auk*, 96:798-800.

Location: Published Material

239. Reynolds, T. D., 1979, "Response of the reptile populations to different land management practices on the Idaho National Engineering Laboratory Site," *Great Basin Natur.*, 39:255-262.

Evaluates the response of reptile populations to different land management practices on the INEL. The sagebrush lizard was most abundant in the native, ungrazed, sagebrush habitat, and the short-horned lizard was most plentiful in the sheep-grazed area dominated by big sagebrush.

Subject: Amphibians and reptiles
Keywords: REPTILE / LIZARD / GRAZING
Location: Published Material

240. Reynolds, T. D., 1980, "The effects of some different land management practices on small mammal populations," *J. Mammal.*, 61:558-561.

Compares the relative densities and species diversities of small mammals among four areas subjected to different land management practices. Different land management practices on the INEL site resulted in changes in the distribution and abundance of small mammals.

Subject: Small mammal ecology
Keywords: SMALL MAMMAL / LAND MANAGEMENT PRACTICES
Location: Published Material

241. Reynolds, T. D., 1980, "Save some sage," *Idaho Wildlife*, 2: 10-13.

242. Reynolds, T. D., 1980, "Seasonal ranges and migration of antelope in southeastern Idaho, p. 13," *Job Progress Report, Antelope-Sage Grouse Ecology*, pp. p. 9-13, Boise, Idaho, Idaho Department of Fish and Game, Job Progress Report, Federal Aid Project W-160-R-7.

243. Reynolds, T. D., 1983, "Nesting of the sage thrasher, sage sparrow, and Brewer's sparrow in southeastern Idaho," *Condor*, (61-64)

Location: Published Material

244. Reynolds, T. D., 1983, "Pronghorn response to hunting coyotes," *Great Basin Natur.*, 43:88-92.

Observation of pronghorns attacking coyotes. Six different events are described, one including the joint pursuit by a Short-eared owl.

Subject: The pursuit of coyotes by pronghorns
Keywords: PRONGHORN / COYOTE / OWLS / PREDATOR-PREY
Location: Published Material

245. Reynolds, T. D., 1984, "Daily summer movement, activity patterns, and home range of pronghorn," *Northwest Sci.*, 58:300- 311.

Daily movements, activity patterns, and spatial and behavioral use of summer home ranges of pronghorn (Antilocapra americana) were examined by radiotelemetry in southeastern Idaho from June through August 1980. total daily summer movements in excess of 15 km were not uncommon for pronghorns. None of the study animals moved to and used open water during any of the 24-hour sampling periods.

Subject: Migration patterns of radio-collared pronghorns
Keywords: PRONGHORN / DAILY ACTIVITY PATTERNS / HOME RANGE /
RADIOTELEMETRY
Location: Published Article

246. Reynolds, T. D., 1988, "Seasonal abundance and distribution of pronghorn on the Idaho National Environmental Research Park," In: Hess, M., *Proceedings, 12th Biennial Pronghorn Antelope Workshop, Special Publication, Reno, NV, March 11-13, 1986.*

247. Reynolds, T. D., 1990, "Effectiveness of three natural biobarriers in reducing root intrusion by four semi-arid plant species," *Health Physics*, 59:849-852.

Location: Summarized in Markham 1991

248. Reynolds, T. D., 1990, "Root mass and vertical root distribution of five species of semi-arid land plants," *Health Physics*, 58:191-197.

Experimental results of root mass and vertical distribution studies of five semi-arid plants transplanted to containers.

Subject: Vegetative studies on the INEL
Keywords: ROOT PROFILES / ROOT DISTRIBUTION / SAGEBRUSH /
WILDRYE / RUSSIAN THISTLE / WHEATGRASSES / CRESTED
WHEATGRASSES
Location: Published Article, Summarized in Markham 1991

249. Reynolds, T. D., 1991, "Movement of gravel by the Owyhee harvester ant, *Pogonomyrmex salinus* (Hymenoptera: Formicidae)," *Entomological News*, 102:118-124.

Colored aquarium gravel was used in a study to determine the source of small fossil and modern zoological and archaeological specimens accumulated in the mounds of harvester ants. results suggest that mature colonies of harvester ants collect, rather than excavate, most of the materials used to reconstruct mounds.

Subject: Harvester ant mound construction

Keywords: ANTS / ANT-MOUND CONSTRUCTION / ARCHAEOLOGY /
FOSSILS

Location: Published Article

250. Reynolds, T. D., and Autennieth, R. E., 1980, "Dexamethasone and its effect on the natality of preparturiant pronghorn antelope does," *J. Am. Vetr. Med. Assoc.*, 177:943-945.

Location: Published Material

251. Reynolds, T. D.; Connelly, J. W.; Halford, D. K., and Arthur, W. J., 1986, "Vertebrate fauna of the Idaho National Environmental Research Park," *Great Basin Natur.*, 46:513-527.

The relative abundance, habitat use, and seasonal occurrence are report for the 6 fish, 1 amphibian, reptile, 164 bird, and 39 mammal species recorded on the INEL.

Subject: Vertebrates on the INEL

Keywords: FISH / AMPHIBIAN / REPTILE / HERPTOFAUNA / AVIAN /
MAMMAL / VERTEBRATE

Location: Published Article

252. Reynolds, T. D., and Fralcy, L. J., 1989, "Root profiles of some native and exotic plant species in southeastern Idaho," *Environ. & Expt. Bot.*, 29:241-241.

Location: Published Article

253. Reynolds, T. D., and Laundre, J. W., 1988, "Vertical distribution of soil removed by four species of burrowing rodents in disturbed and undisturbed soils," *Health Physics*, 54:445-450.

Documents the results of the measurement of burrow volumes of rodents in disturbed and undisturbed soil on the INEL.

Subject: Burrow volumes of rodents in disturbed and undisturbed soil

Keywords: BURROWING / RODENTS / SOIL / VOLE / DEER MICE /
TOWNSEND'S GROUND SQUIRREL / KANGAROO RAT

Location: Published Article

254. Reynolds, T. D., and Laundre, J. W., 1990, "Time intervals for estimating pronghorn and coyote home ranges and daily movements," *J. Wildlife Management*, 54:316-322.

Compares estimates of home range and daily movement of coyotes and pronghorns based on subsamples of data collected at short intervals. Relationships suggest that restricting sampling effort sacrifices biologically significant information.

Subject: Migration patterns of radio-collared pronghorns
Keywords: PRONGHORN / COYOTE / HOME RANGE / DAILY ACTIVITY
PATTERNS / RADIO-TELEMETRY
Location: Published Article

255. Reynolds, T. D., and Markham, O. D., 1987, *Publications of the Idaho National Engineering Laboratory Radioecology and Ecology Program: 1974-1986*, DOE-ID, DOE/ID-12109, Idaho Falls, ID.

A list of publications of the Idaho National Engineering Laboratory Radioecology and Ecology Program from the years 1974 to 1986. Publications are cross-referenced under key words.

Subject: Radioecology & Ecology research projects at the INEL
Keywords: AVIAN / CONTAMINANT TRANSPORT AND DISTRIBUTION /
DIET & FOOD HABITS / FISH / HABITAT / ICPP / INVERTEBRATE
/ MAMMAL / PALEOECOLOGY / PHYSIOLOGY / RWMC /
REPTILE / AMPHIBIAN / SOIL / SPECIES LIST / TECHNIQUES /
TRA / VEGETATION
Location: INEL Technical Library

256. Reynolds, T. D., and Rich, T. D., 1978, "reproductive ecology of the sage thrasher (*Oreoscoptes montanus*) on the Snake River Plain in southcentral Idaho," *Auk*, 95:580-582.

Thirty-four sage thrasher nests were located and followed closely until fledgling. Nest success, egg success, hatching rate, and fledgling success were reported.

Subject: Avian ecology
Keywords: SAGE THRASHER / AVIAN / NESTING
Location: Published Material

257. Reynolds, T. D.; sheppard R.B.; Landre, J. W., and Winter, C. L., 1987, "Calibrating resistance-type soil moisture units in a high clay content soil," *Soil Sci.*, 144:237-241.

Location: Summarized in Markham 1991

258. Reynolds, T. D., and Shorey, D. P., 1983, "Unusual behavior of the horned lark," *Western Birds*, 14:209-210.

Documentation of postmortem mate fidelity of a horned lark, a passerine species that, at the most, forms a pair bond for only one breeding season.

Subject: Horned lark behavior

Keywords: HORNED LARK / AVIAN / BEHAVIOR
Location: Published Material

259. Reynolds, T. D., and Trost, C. H., 1978, "vertebrate population levels correlated with different land use practices on the INEL National Environmental Research Park," In: Ketching, J. T.; Tarr, N. E., *National Environmental Research Park Symposium: Natural Resource Inventory, Characterization and Analysis*, Oak Ridge National Laboratory, Oak Ridge, TN.
260. Reynolds, T. D., and Trost, C. H., 1979, "The effect of crested wheatgrass plantings on wildlife on the Idaho National Engineering Laboratory Site.," *The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats*.
261. Reynolds, T. D., and Trost, C. H., 1980, "The response of native vertebrate populations to crested wheatgrass plantings and grazing by sheep," *J. Range Manage.*, 33:122-125.

A study conducted to determine the species diversity and relative density of birds, mammals, and reptiles in grazed and ungrazed habitats dominated by big sagebrush and crested wheatgrass. In sagebrush, grazing did not significantly alter the species diversity or the density of reptiles or nesting birds. Both the diversity and the relative density of small mammals were significantly reduced. Crested wheatgrass supported fewer nesting bird species and a lower density and a lower of birds, mammals, and reptiles.

Keywords: AVIAN / NESTING / REPTILE / SMALL MAMMAL / SAGEBRUSH /
CRESTED WHEATGRASSES / GRAZING / BIODIVERSITY
Location: Published Material

262. Reynolds, T. D., and Trost, C. H., 1981, "Grazing, crested wheatgrass, and bird populations in southeastern Idaho," *Northwest Sci.*, 55:225-234.

Location: Published Material

263. Reynolds, T. D., and Wakkinen, W., 1987, "Characteristics of the burrows of rodents in undisturbed southeastern Idaho soils," *Amer. Midl. Natur.*, 118:245-250.

Dimensions and depth characteristics of burrows of Townsend's ground squirrels, Ord's kangaroo rats, montane voles, and deer mice in undisturbed soils.

Subject: Small mammal ecology
Keywords: SMALL MAMMAL / TOWNSEND'S GROUND SQUIRREL /
KANGAROO RAT / VOLE / DEER MICE / BURROWING
Location: Published Article

264. Ropc, S. K.; Arthur, W. J.; Craig, T. H., and Craig, E. H., 1988, "Nutrient and trace elements in soil and desert vegetation of southern Idaho," *Environ. Monit. and Assess.*, 10:1-24.

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Location: Summarized in Markham 1991

265. Rope, S. K.; Jornitz, R. S., and Schre, D. T., 1987, *Availability of trace elements in solid waste from fluidized bed combustion of coal*, DOE-ID, DOE/ID-12112, Idaho Falls, ID.

Location: Summarized in Markham 1991

266. Rope, S. K., and Pearson, L. C., 1990, "Lichens as air pollution biomonitors in a semiarid environment in Idaho," *The Bryologist*, 93:50-61.

Location: Published Article, Summarized in Markham 1991

267. Rucker, R. L., "The home range of the coyote on the Idaho National Engineering Laboratory," *In National Environmental Research Park Symposium, Idaho Falls, ID.*

268. Seal, U. S., and Hoskinson, R. L., 1978, "Metabolic indicators of habitat condition and capture stress in pronghorn," *J. Wildl. Manage.*, 42:755-763.

Blood samples were collected from pronghorn antelope for hematology and metabolic and hormonal parameters as possible indices of herd condition and range condition. The blood chemistry showed differences between the populations indicative of differences in the nutritional history, in stress at the time of blood sample collection, age, and sex.

Subject: Blood chemistry in pronghorn

Keywords: PRONGHORN / BLOOD CHEMISTRY / NUTRITION / STRESS

Location: Published Material

269. Seelcy, R. R., and Reynolds, T. D., 1989, "The effects of indomethacin-treated wheat on a wild population of montane voles," *Great Basin Naturalist*, 49:556-561.

Use of Indomethacin-treated wheat to control pregnancy in wild populations of montane voles for populations control. After the experiment all categories of the control was unchanged while they were significantly lower in the experimental group.

Subject: Vole ecology

Keywords: IDOMETHACIN / TREATED WHEAT / VOLE / POPULATION
PARAMETERS / SMALL MAMMAL

Location: Published Article

270. Schman, R. W., 1977, *Hibernaculum dynamics of the great basin rattlesnake (Crotalus viridis lutosus)*, M.S. Thesis, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

271. Sheman, R. W., and Lindcr, A. D., 1978, *Amphibian and reptilian fauna of the Idaho National Engineering Laboratory Site*, DOE, IDO-12086, Idaho Falls, ID.

Location: National Technical Information Service, Springfield, VA

272. Shumar, M. L., 1983, *Factors affecting the distribution of two subspecies of big sagebrush*, M.S. Thesis, Idaho State University, Pocatello, ID.

Extensive pure and mixed stands of two Artemisia tridentata subspecies were investigated to describe vegetation, soils, and dominance-diversity relationships. Distributions of the sagebrush subspecies were consistently associated with gradients in soil texture.

Subject: Distribution of two subspecies of sagebrush

Keywords: SAGEBRUSH / SOIL / VEGETATION / DOMINANCE-DIVERSITY
RELATIONSHIP

Location: INEL Technical Library

273. Shumar, M. L.; Anderson, J. E., and Reynolds, T. D., 1982, "Identification of subspecies of big sagebrush by ultraviolet spectrophotometry," *J. Range Manage.*, 35:60-62.

Describes a technique for distinguishing three subspecies of big sagebrush (Artemisia tridentata) by UV spectrophotometry. Alcohol leaf extracts of the three subspecies produce relative absorbance graphs that differ markedly from one another between 230 and 280 nm.

Subject: The identification of subspecies of big sagebrush by UV spectrophotometry

Keywords: SAGEBRUSH / IDENTIFICATION OF SUBSPECIES /
ULTRAVIOLET SPECTROPHOTOMETRY

Location: Published Material

274. Shumar, M. L., and Anderson, J. E., 1986, "Gradient analysis of vegetation dominated by two subspecies of big sagebrush," *J. Range Management*, 39:156-160.

Detrended correspondence analysis and correlation were used to elucidate potential relationships between vegetation patterns and soil factors along a gradient from stands having only the subspecies tridentata to stands having only the subspecies wyomingensis. Distribution of the subspecies were consistently associated with changes in soil texture rather than actual amounts of sand, silt, or clay.

Subject: Vegetative studies on the INEL

Keywords: SAGEBRUSH / SOIL

Location: Published Article

275. Shumar, M. L., and Anderson, J. E., 1986, "Water Relations of two subspecies of big sagebrush on sand dunes in southeastern Idaho," *Northwest Sci.*, 60:179-185.

Compares plant and soil water potentials among dune tops, dune margins, and adjacent slacks. Two subspecies of sagebrush (tridentata and wyomingensis) were found to have no difference in plant water potential when growing together on the dune margins.

Subject: Vegetative studies on the INEL
Keywords: SAGEBRUSH / SAND DUNES / WATER BALANCE
Location: Published Article

276. Shumar, M. L., and Anderson, J. E., 1987, "Transplanting seedlings in small revegetation projects," *Arid Soil Res. and Rehabilit.*, 1:253-256.

Results of the transplanting of natural vegetation from the vicinity to revegetate small severely disturbed sites at the INEL. Survival was high for all species, ranging from about 80% for Artemisa tridentata and Chrysothamnus viscidiflorus to nearly 100% for Agrophyron.

Subject: Vegetative studies on the INEL
Keywords: REVEGETATION / TRANSPLANTING / SEEDLINGS
Location: Published Article

277. Sime, C. A., 1991, *Sage grouse use of burned, non-burned, and seeded vegetation communities on the Idaho National Engineering Laboratory, Idaho*, M.S. Thesis, Montana State University, Bozeman, MT.

This study was designed to describe sage grouse distribution and movement patterns in and around vegetation communities altered by fire and an artificial seeding of crested wheatgrass. Field work was conducted from mid-March to early-September in 1988 and 1989. On this study area, alteration of the sagebrush community did not appear to discourage sage grouse use.

Subject: Sage grouse ecology
Keywords: SAGE GROUSE / FIRE ECOLOGY / CRESTED WHEATGRASSES / MOVEMENT PATTERNS / RADIO-TELEMTRY
Location: INEL Technical Library

278. Sirotnak, J. M., 1990, *Interspecific and intraspecific competition in Leymus cinereus and Chrysothamnus nauseosus in a cold-desert environment*, M.S. Thesis, Idaho State University, Pocatello, ID.

This study examined intraspecific competition among Great Basin wildrye and interspecific competition between Great Basin Wildrye and Gray Rabbitbrush in a sagebrush steppe

ecosystem. results show rabbitbrush has little effect on wildrye but wildrye has effects on rabbitbrush and other wildrye plants.

Subject: Vegetative studies on the INEL
Keywords: VEGETATION / WILDRYE / RABBITBRUSH / COMPETITION /
SAGEBRUSH
Location: Idaho State University

279. Smith, S. D., and Nowak, R. S., 1990, "Ecophysiology of plants in the intermountain lowlands," In: Osmond, C. B.; Pitelka, L. F.; Hidy, G. M., *Ecological Studies*.

Location: Published Article

280. Stafford, M. P., 1983, *Surface-dwelling Coleoptera inhabiting sagebrush communities in southeastern Idaho*, M.S. Thesis, University of Idaho, Moscow, ID.

A study of the surface-dwelling Coleoptera in two sagebrush habitats located on the INEL was conducted in the summers of 1981 and 1982. The objectives of this study were to document the taxonomic composition, seasonal occurrence, and relative abundance of this beetle fauna.

Subject: Coleoptera of the INEL
Keywords: INVERTEBRATE / SAGEBRUSH
Location: INEL Technical Library

281. Stafford, M. P., 1987, *Insect interactions with four species of sagebrush (Artemisia) in a southeastern Idaho high desert rangeland*, Ph.D. Dissertation, University of Idaho, Moscow, ID.

282. Stafford, M. P.; Barr, W. F., and Johnson, J. B., 1986, "Coleoptera of the Idaho National Engineering Laboratory Site: An annotated checklist," *Great Basin Natur.*, 46:287-293.

An annotated list of coleoptera of the INEL. Gives information on abundance, method of collection and dates of adult occurrence.

Subject: Colcoptera of the INEL
Keywords: INVERTEBRATE
Location: Published Article

283. Stafford, M. P., and Johnson, J. B., 1986, *Phytophagous insects of green rabbitbrush in southeastern Idaho*, p. 211-214. *In*: McArthur, E.D. and Welch, B.L. (Compilers), Intermtn Forest and Range Exp. Stat., USDA Gen. Tech. Rep. INT-200, Ogden UT.

Insects associated with green rabbitbrush were surveyed throughout the summers of 1981-82 in southeastern Idaho. Results indicated that a diverse insect fauna is associated with green rabbitbrush and nearly all plant parts are attacked. The impact of these insects on the host has not been well documented and is in need of further study.

Subject: Insects which feed on the various parts of green rabbitbrush
Keywords: INVERTEBRATE / RABBITBRUSH / ROOT BORER /
DEFOLIATORS / GALL-FORMERS / FLOWER & FLUID FEEDERS
Location: Intermountain Forest & Range Exp. Sta., Ogden, UT

284. Staley, C. S., and Case, M. J., 1987, "An Evaluation of IN SITU microcosms for validating aquatic fate and transport models," *Environmental Monitoring and Assessment*, 8:103-112.

The fates of two compounds, 2,4-DBEE and 1,4-DCB, were examined in IN SITU.

Subject: Validating aquatic fate and transport models with IN SITU microcosms
Keywords: 2,4-DBE / 1,4-DCB / IN SITU MICROCOSMS / DECAY RATES /
AQUATIC FATE / TRANSPORT MODELS / LEACHING POND
Location: microcosms placed in a pond and compared with the pond itself. results of decay rates were compared with predictions and models

285. Stauber, E. H.; Autenrieth, R. E., and Markham, O. D., 1980, "A seroepidemiologic survey of three southeastern Idaho pronghorn populations, 1975-1977," *J. Wildl. Dis.*, 16:109-115.

this study was conducted to test antelope sera for antibodies against Brucella abortus and viruses which were suspected of contributing to weak calf syndrome. There were no reactors to brucellosis, bluetongue, or epizootic hemorrhagic disease. The prevalence of reactors varied considerable for different locations and for different years.

Subject: Weak calf syndrome
Keywords: SEROEPIDEMIOLOGIC SURVEY / PRONGHORN / BRUCELLA
ABORTUS / WEAK CALF SYNDROME / CATTLE
Location: Published Material

286. Toft, N., and Anderson, J. E., 1989, *Water and nitrogen processes in sagebrush steppe communities*, DOE-ID. Progress Report for the Idaho National Engineering Laboratory, Radioecology and Ecology Programs, Idaho Falls, ID, February 1989.

This report on a study to assess the extent to which the photosynthetic capacity of cold desert species was limited by the availabilities of water and nitrogen. The effects of water

and nitrogen availabilities on water use were also studied. The studies revealed a number of differences among species within this sagebrush-grass steppe community.

Subject: The effects of the availability of water and nitrogen on cold desert plant species
 Keywords: SAGEBRUSH / NITROGEN / WATER BALANCE / SAGEBRUSH / WINTERFAT / WHEATGRASSES / GRASSES
 Location: INEL Radioecology and Ecology Program

287. Toft, N. L.; Anderson, J. E., and Nowak, R. S., 1989, "Water use efficiency and carbon isotope composition of plants in a cold desert environment," *Oecologia*, 80:11-18.

Documents the experimental results of four treatments of water and nitrogen on water use efficiency of plants. Water use efficiency and carbon isotope composition of four species of plants in a natural sagebrush steppe community were studied.

Subject: Water use efficiency of plants in a sagebrush community
 Keywords: CARBON ISOTOPE COMPOSITION / PHOTOSYNTHESIS / WATER BALANCE / NITROGEN
 Location: Published Article

288. U.S. Department of Energy, 1982, "Idaho National Engineering Laboratory, Hanford Site and Los Alamos National Laboratory," *Symposium on Radioecology and Ecology*, IDO-12095, Grand Teton National Park, Aug. 24-27, 1982.

Papers presented to the Symposium on Radioecology and Ecology. Includes 28 papers on research at the INEL.

Subject: Radioecology & Ecology research projects at the INEL
 Keywords: SOIL / TRACE ELEMENTS / RADIONUCLIDE / CONTROLLED BURN SITE / BASELINE VEGETATION / PLANT COMMUNITIES / SAGEBRUSH / PLANT COMMUNITIES / FORAGING ECOLOGY / PRONGHORN / BOBCAT / COYOTE-RABBIT RELATIONSHIP / COYOTE / RABBIT / JACKRABBIT / RODENTS / SAGE GROUSE / SPARROW / RAPTOR / OWLS / WATERFOWL / INVERTEBRATE / IODINE-129
 Location: INEL Technical Library

289. Veith, R. D., 1983, *Dispersal, relative density, and speed of carrion location of the burying beetle, Nicrophorus heacate Bland (Coleoptera:Silphidae) in southeastern Idaho*, M.S. Thesis, Idaho State University, Pocatello, ID.

Documents the results of a study in which carrion beetles were found to disperse 2 km from the release point to carrion-baited traps. concludes that carrion beetles are capable of

transporting radionuclides received from contaminated small mammal carcasses found on radioactive disposal sites.

Subject: Carrion beetles and radioactive waste disposal sites
Keywords: INVERTEBRATE / RADIONUCLIDE / VECTORS
Location: INEL Technical Library

290. Wackenhut, M. C., 1990, *Bat species overwintering in lava-tube caves in Lincoln, Gooding, Blaine, Bingham, and Butte Counties, Idaho with special reference to annual return of banded Plecotus townsendii*, M.S. Thesis, Idaho State University, Pocatello, ID.

A study of bat populations in lava tube caves with species identified, population numbers, and data on banded bat returns.

Subject: Bats in lava-tube caves
Keywords: MAMMAL / BATS / LAVA-TUBE CAVES
Location: Idaho State University

291. Watson, J. W., 1984, *Rough-legged hawk winter ecology in southeastern Idaho*, M.S. Thesis, Montana State University, Bozeman, MT.

Ecology of the American rough-legged hawk was investigated. Transmission lines were found to influence range shape and size and were used extensively as hunting and roosting substrates. Other aspects of social behavior, hunting success, roosting behavior and food habits were reported.

Subject: Raptor ecology
Keywords: RAPTOR / WINTER ECOLOGY / POPULATION PARAMETERS
Location: INEL Technical Library

292. Watson, J. W., 1985, "Trapping, marking and radio-monitoring American rough-legged hawks," *North American Bird Bander*, 10:9- 10.

Location: Published Article

293. Watson, J. W., 1986, "Range use by wintering American rough-legged hawks in southeastern Idaho," *Condor*, 88:256-258.

Information on the winter ecology of rough-legged hawks looking at home range, range use and fidelity, and migration in a sagebrush steppe community.

Subject: Raptor ecology
Keywords: RAPTOR / SAGEBRUSH / RADIO-TELEMETRY / HOME RANGE / MOVEMENT PATTERNS

Location: Published Article

294. Watson, J. W., 1986, "Temporal fluctuations of rough-legged hawks during carrion abundance," *Raptor Research*, 20:42-43.

Location: Published Article

295. White, J. A.; McDonald, H. G.; Anderson, E., and Soiset, J. M., 1984, "Lava blisters as carnivore traps," *Carnegie Special Publ.*, 8:241-256.

Location: Published Article

296. Wilde, D. B., 1978, *A population analysis of the pygmy rabbit (Sylvilagus idahoensis) on the INEL Site*, Ph.D. Dissertation, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

297. Wilde, D. B., 1981, "Pygmy rabbit reproduction: possible modification by drought conditions," *Proceedings of the World Lagomorph Conference, Guelph, Ontario*.

Location: Published Material

298. Wilkosz, R. J., 1980, *Coyote habitat preferences on the Idaho National Engineering Laboratory Site in southeastern Idaho*, M.S. Thesis, Idaho State University, Pocatello, ID.

Habitat characteristics from known coyote hunting and resting areas were studied to determine if a relationship existed between coyote activity and features of vegetation or topography. Data was gathered from the home ranges of four adult coyotes, two males and two females. Habitat features examined included % cover of all perennial plant species, average shrub height, texture of surface soil, and topographic configuration and contour.

Subject: Coyote diet, habitat, & home range

Keywords: COYOTE / HABITAT / VEGETATION / HOME RANGE

Location: INEL Technical Library

299. Winter, B. M., 1984, *Effects of prescribed burning on avian foraging ecology and arthropod abundance in sagebrush grassland*, M.S. Thesis, Iowa State University, Ames, IO.

Location: Iowa State University, Ames, IO

300. Winter, B. M., and Best, L. B., 1985, "Effect of prescribed burning on placement of sage sparrow nests," *Condor*, 87:294-295.

A report on the placement of Sage sparrow nests in a sagebrush- grassland before and after prescribed burning.

Subject: Avian ecology
Keywords: SPARROW / AVIAN / NESTING / SAGEBRUSH / FIRE ECOLOGY
Location: Published Article

301. Woodruff, R. A., 1977, *Annual dispersal, daily activity pattern and home range of Canis latrans on the Idaho National Engineering Laboratory Site*, M.S. Thesis, Idaho State University, Pocatello, ID.

Location: Idaho State University, Pocatello, ID

302. Woodruff, R. A., and Keller, B. L., 1982, "Dispersal daily activity, and home range of coyotes in southeastern Idaho," *Northwest Sci.*, 56:199-207.

This study, the third in a series of coyote home range investigations on the INEL was designed to study coyote movements in southeastern Idaho. Analysis of 15 minute interval fixes obtained over a 24-hour period suggested that some areas within the home range received more intensive use than others, particularly areas around resting points.

Subject: Coyote diet, habitat, & home range
Keywords: COYOTE / HOME RANGE / ACTIVITY PATTERNS
Location: Published Material

303. Youtic, B. A., 1986, *The insect fauna associated with Great Basin wildrye in southern Idaho*, M.S. Thesis, University of Idaho, Moscow, ID.

Location: University of Idaho, Moscow, ID

304. Youtic, B. A.; Stafford, M. P., and Johnson, J. B., 1987, "Herbivorous and parasitic insect guilds associated with Great Basin wildrye (*Elymus cinereus*) in southern Idaho," *Great Basin Natur.*, 47:644-651.

Reports on the insects inhabiting Great Basin wildrye (Elymus cinereus) at two sites on the Snake River Plain in southern Idaho during 1982 and 1983. Forty-six species of phytophagous insects were observed. Life stage, abundance, plant part utilized, and the study site were recorded for each insect species collected.

Subject: Insects inhabiting Great Basin wildrye
Keywords: WILDRYE / INVERTEBRATE / INSECT GUILDS
Location: Published Article

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Appendix E

Socioeconomic Characteristics

Ecology and Environment, Inc.^a

a. This section was written by Ecology and Environment, Inc. for the U.S. Department of Energy under DOE Idaho Operations Office Contract DE-AC07-91ID12919.

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ACRONYMS

ANL-W	Argonne National Laboratory-West
B&W	Babcock & Wilcox
DOD	Department of Defense
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
EIS	Environmental Impact Statement
ER&WM	Environmental Restoration and Waste Management
FY	fiscal year
INEL	Idaho National Engineering Laboratory
MK-FIC	Morrison/Knudson-Ferguson of Idaho Company
NRC	Nuclear Regulatory Commission
NRF	Naval Reactors Facility
PTI	Protection Technology, Inc.
WEC	Westinghouse Electric Corporation
WINCO	Westinghouse Idaho Nuclear Company, Inc.

Appendix E

Socioeconomic Characteristics

This appendix provides supplemental information on the social and economic characteristics of the counties and communities surrounding the INEL. Detailed data on demographic characteristics, employment, the housing market, public school districts, public revenues, and community services and facilities are discussed. In addition, data on INEL's historical and future work force and budgets are included.

Some of the tables included in this appendix have been referred to in the main body of the text. Other tables will include statistics that will support general statements made in Section 6.

This appendix is divided into 10 sections corresponding with the 10 sections in Section 6. These sections include information on demographic characteristics; economy, employment, and income; housing; school services; taxes; INEL; fire protection and emergency services; security services; nonhazardous and nonradioactive solid waste disposal; and health care delivery services.

E.1 Demographic Characteristics

Tables E-1, E-2, and E-3 show demographic data for the seven-county region. The population of all counties, cities, and unincorporated areas in the seven-county region between 1940 and 1990 is shown on Table E-1. Table E-2 displays the percent change in population by decade (1940-1990) for counties, cities, and unincorporated areas in the seven-county region. The range of population densities found in the seven-county region and in the State of Idaho is illustrated on Table E-3.

As shown on Table E-1, population densities in the region range from a high of 59.39 persons per square mile in Bannock County to only 0.43 persons per square mile in Clark County. Also, the character of the counties in the study area varies between urban and rural. According to the U.S. Bureau of the Census, Bannock and Bonneville Counties are defined as being 83.6% and 78.2% urban, respectively. In contrast, Clark and Butte counties have no urban population (see Table E-3).

Appendix E ♦ E-2

Table E-1. Population for all counties, cities, unincorporated areas in the seven-county region from 1940 to 1990.^a

County, city, or unincorporated area	Population					
	1940	1950	1960	1970	1980	1990
Bannock	34,759	41,745	49,342	52,200	65,421	66,026
Arimo City	291	337	303	252	388	311
Chubbuck City	—	120	1,590	2,924	7,052	7,791
Downey City	673	748	726	586	645	626
Fort Hall ^b	—	—	—	—	—	1,535
Inkom City	—	434	528	522	830	769
Lava Hot Springs City	647	591	593	516	467	420
McCammon City	489	578	557	623	770	722
Pocatello City ^c	18,133	26,131	28,534	40,036	46,340	46,027
Unincorporated Areas	14,526	12,806	16,511	6,741	8,929	7,990
Bingham	21,044	23,271	28,218	29,167	36,489	37,583
Aberdeen City	1,016	1,486	1,484	1,542	1,528	1,406
Atomic City	—	—	141	24	34	25
Basalt City	252	227	275	349	414	407
Blackfoot City	3,681	5,180	7,378	8,716	10,065	9,646
Firth City	242	293	322	362	460	429
Fort Hall ^b	—	—	—	—	—	2,625
Shelley City	1,751	1,856	2,612	2,614	3,300	3,536
Unincorporated Areas	14,102	14,229	16,006	15,560	20,688	20,823
Bonneville	25,697	30,210	46,906	52,457	65,980	72,207
Ammon City	363	447	1,882	2,545	4,669	5,002
Idaho Falls City	15,024	19,218	33,161	35,776	39,590	43,929
Iona City	518	502	702	890	1,072	1,049
Irwin City	—	147	330	228	113	108
Ririe City ^d	—	—	—	47	60	74
Swan Valley City	—	203	217	235	135	141
Ucon City	449	356	532	664	833	895
Unincorporated Areas	9,343	9,337	10,082	12,072	19,508	21,009
Butte	1,877	2,722	3,498	2,925	3,342	2,918
Arco City	548	961	1,562	1,244	1,241	1,016
Moore City	—	256	358	156	210	190
Unincorporated Areas	1,329	1,505	1,474	1,483	1,798	1,653

Table E-1. (continued).

County, city, and unincorporated area	Population					
	1940	1950	1960	1970	1980	1990
Clark	1,005	918	915	741	798	762
Dubois City	332	430	447	400	413	420
Spencer City	—	70	100	45	29	11
Unincorporated Areas	673	418	368	296	356	331
Hamer City	—	—	144	81	93	79
Lewisville City	371	402	385	468	502	471
Menan City	432	430	496	545	605	601
Jefferson	10,762	10,495	11,672	11,740	15,304	16,543
Mud Lake City	—	—	187	194	243	179
Rigby City	1,978	1,826	2,281	2,324	2,624	2,681
Ririe City	493	527	560	528	495	522
Roberts City	319	341	422	393	466	557
Unincorporated Areas	7,169	6,969	7,197	7,207	10,276	11,453
Madison	9,816	9,156	9,417	13,452	19,480	23,674
Rexburg City	3,437	4,253	4,767	8,272	11,559	14,302
Sugar City	697	684	584	617	1,022	1,275
Unincorporated Areas	5,682	4,219	4,066	4,563	6,899	8,097

a. U.S. Bureau of the Census 1982; 1992.

b. Fort Hall Indian Reservation is located in Bannock, Bingham, Caribou, and Power counties. An additional 903 residents who are not shown on this table live on the reservation in Power County.

c. Pocatello is located in both Bannock and Power counties.

d. Ririe is located in both Bonneville and Jefferson counties.

Appendix E ♦ E-4

Table E-2. Percent change by decade (1940–1990) for counties, cities, and unincorporated areas in the seven-county region.^a

County, city, and unincorporated areas	Percent change by decade				
	1940–1950	1950–1960	1960–1970	1970–1980	1980–1990
Bannock	20.1	18.2	5.8	25.3	0.9
Arimo City	15.8	-10.1	-16.8	54.0	-19.8
Chubbuck City		1225.0	83.9	141.2	10.5
Downey City	11.1	-2.9	-19.3	10.1	-2.9
Fort Hall ^b	NA ^c	NA	NA	NA	NA
Inkom City	NA	21.7	-1.1	59.0	-7.3
Lava Hot Springs City	-8.7	0.3	-13.0	-9.5	-10.1
McCammon City	18.2	-3.6	11.8	23.6	-6.2
Pocatello City ^d	44.1	9.2	40.3	15.7	-0.7
Unincorporated Areas	-11.8	28.9	-59.2	32.5	-10.5
Bingham	10.6	21.3	3.4	25.1	3.0
Aberdeen City	46.3	-0.1	3.9	-0.9	-8.0
Atomic City	NA	NA	-83.0	41.7	-26.5
Basalt City	-9.9	21.1	26.9	18.6	-1.7
Blackfoot City	40.7	42.4	18.1	15.5	-4.2
Firth City	21.1	9.9	12.4	27.1	-6.7
Fort Hall	NA	NA	NA	NA	NA
Shelley City	6.0	40.7	0.1	26.2	7.2
Unincorporated Areas	0.9	12.5	-2.8	33.0	0.7
Bonneville	17.6	55.3	11.8	25.8	9.4
Ammon City	23.1	321.0	35.2	83.5	7.1
Idaho Falls City	27.9	72.6	7.9	10.7	11.0
Iona City	-3.1	39.8	26.8	20.4	-2.1
Irwin City	NA	124.5	-30.9	-50.4	-4.4
Ririe City ^c	NA	NA	NA	27.7	23.3
Swan Valley City	NA	6.9	8.3	-42.6	4.4
Ucon City	-20.7	49.4	24.8	25.5	7.4
Unincorporated Areas	-0.1	8.0	19.7	61.6	7.7
Butte	45.0	28.5	-16.4	14.3	-12.7
Arco City	75.4	62.5	-20.4	-0.2	-18.1
Butte City	NA	NA	-59.6	121.4	-36.6
Moore City	NA	39.8	-56.4	34.6	-9.5
Unincorporated Areas	13.2	-2.1	0.6	21.2	-8.1

Table E-2. (continued).

County, city, and unincorporated areas	Percent change by decade				
	1940-1950	1950-1960	1960-1970	1970-1980	1980-1990
Clark	-8.7	-0.3	-19.0	7.7	-4.5
Dubois City	29.5	4.0	-10.5	3.3	1.7
Spencer City	NA	42.9	-55.0	-35.6	-62.1
Unincorporated Areas	-37.9	-12.0	-19.6	20.3	-7.0
Jefferson	-2.5	11.2	0.6	30.4	8.1
Hamer City	NA	NA	-43.8	14.8	-15.1
Lewisville City	8.4	-4.2	21.6	7.3	-6.2
Menan City	-0.5	15.3	9.9	11.0	-0.7
Mud Lake City	NA	NA	3.7	25.3	-26.3
Rigby City	-7.7	24.9	1.9	12.9	2.2
Ririe City	6.9	6.3	-5.7	-6.3	5.5
Unincorporated Areas	-2.8	3.3	0.1	42.6	11.5
Madison	-6.7	2.9	42.8	44.8	21.5
Rexburg City	23.7	12.1	73.5	39.7	23.7
Sugar City	-1.9	-14.6	5.7	65.6	24.8
Unincorporated Areas	-25.7	-3.6	12.2	51.2	17.4

a. U.S. Bureau of the Census 1982; 1992.

b. Not available.

c. Fort Hall Indian Reservation is located in Bannock, Bingham, Power, and Caribou counties.

d. Pocatello is located in Bannock and Power counties.

e. Ririe is located in Bonneville and Jefferson counties.

Appendix E ♦ E-6

Table E-3. 1990 population densities for the seven-county region and the State of Idaho.^a

Geographic area	Land area (mi ²)	1990 total population	Population density (persons/mi ²)	% Urban
Bannock County	1,112	66,026	59.38	83.6
Bingham County	2,096	37,583	17.93	38.9
Bonneville County	1,840	72,207	39.24	78.2
Butte County	2,236	2,918	1.31	0.0
Clark County	1,763	762	0.43	0.0
Jefferson County	1,093	16,543	15.14	16.2
Madison County	468	23,674	50.59	60.4
Seven-County Region	10,608	219,713	20.71	65.2
Idaho	82,413	1,006,749	12.22	57.4

a. U.S. Bureau of the Census 1992.

E.2 Economy, Employment, and Income

This section provides additional data on the economy of the seven-county region. As shown on Table E-4, farming, ranching, food processing, higher education, and INEL technology transfer are all industries important to the regional economy. This table lists major industries and businesses located in the seven-county region. The vast majority of businesses in the region are directly related to agriculture, food processing, or the INEL.

Table E-5 lists the percentage of employed persons in each county by type of industry. In 1989, 6.9% of the total work force in the seven-county region was employed in agriculture, forestry, and fisheries industries. This percentage, when compared with the national average of 2.7% for these industries, shows the importance of this employment sector to the regional economy. Approximately 6.6% of the 1989 employed workforce in the seven-county region was employed in the construction industry. This number is slightly larger than the state-wide average of 6.5% and the national average of 6.2%. Approximately 8% of the workforce in the seven-county region is employed in the manufacture of nondurable goods. Food processing is the most significant type of manufacturing that occurs in the region. The manufacture of durable goods is considerably less important to employment in the region than in the nation as a whole. The percentage of the workforce that is employed in wholesale and retail trade (5.3% and 17.6%, respectively) in the area is slightly greater than the state and national averages. Financial, business, health, and personal services in the region employ a slightly smaller percentage of the workforce than the percentages employed by these services in Idaho or the United States (see Table E-5).

Educational services provide 11.4% of the region's employment. Approximately one quarter of Madison County's 1989 employment was related to education, underscoring the importance of Ricks College to the county's economy. Approximately 1.3% of the employed workforce in the seven-county region works in the entertainment and recreation industries, which include hotels/motels, eating and drinking establishments, and other recreational providers. Many of the services utilized by tourists are included in this category. Finally, a significantly higher percentage of workers are employed in other professional and related industries in the seven-county region (10.2%) than in the state (6.5%) or the nation (6.6%). INEL contractors are the primary cause for the greater than average employment levels in other professional and related industries in the seven-county region (10.2%) than in the state (6.5%) or the nation (6.6%). INEL contractors are the primary cause for the greater than average employment levels in other professional and related industries. Nearly 17% of the employed residents of Bonneville County work for other professional and related industries (see Table E-5).

Median household income levels and per capita income levels during 1979 are shown on Table E-6. In addition, these measurements have been inflated to 1989 dollars so that they can be directly comparable to 1989 income levels shown on Table 6-6 in the main text. Median household income levels varied significantly throughout the seven-county region during 1979. Clark County recorded the lowest median family income of \$11,463 while Bingham County enjoyed the highest median household income during the same time period.

Appendix E ♦ E-8

Table E-4. Major industries and businesses in the seven-county region.^a

County	Major Industries	Major Businesses
Bannock County	Phosphate processing, food processing, manufacturing, higher education	J. R. Simplot Co. FMC Corp. Union Pacific Railroad Ore-Ida Foods AMI Semiconductors Bannock Paving Co. Idaho State University
Bingham County	Crop farming, food processing	Idaho Potato Packers Corp. Pillsbury American Potato Idaho Supreme
Bonneville County	INEL technology transfer, agricultural services, crop farming	EG&G Idaho Westinghouse Corp. Amcor, Inc. King B. Jerky Logan Farm Equipment Co. Melaleuca, Inc. Scientech Busch Agricultural Resources, Inc.
Butte County	Cattle ranching, tourism	Idaho Gold Corp.
Clark County	Farming, ranching, opal mining	Not available
Jefferson County	Crop farming, cattle ranching, food processing	Golden Valley Packers, Inc. Idaho Fresh-Pak, Inc. Pro-Idaho Foods, Inc.
Madison County	Crop farming, food production, printing, higher education	American Potato Artco Stylart Manufacturing and Distributing Ricks College

a. Stapilus 1992.

Per capita income figures also showed significant variations throughout the region. Per capita income levels were the lowest in Madison County, reflecting the low median household income levels. Despite its lower median household income, Bannock County enjoyed the highest 1979 per capita income level in the region (see Table E-6).

Table E-5. Percent of workforce by type of industry for the seven-county region, the state, and the U.S. in 1989.^a

Geographic region	Type of Industry					
	Agriculture, forestry, & fisheries (%)	Mining (%)	Construction (%)	Manufacture Nondurable goods (%)	Manufacture Durable goods (%)	Transportation (%)
Bannock	2.6	0.7	5.8	7.3	5.5	7.6
Bingham	12.2	0.7	6.2	13.0	3.8	3.1
Bonneville	4.1	0.1	7.5	6.6	3.2	2.9
Butte	22.5	4.2	9.2	4.2	1.0	2.8
Clark	46.4	0.7	7.2	2.2	0.7	2.6
Jefferson	15.4	0.2	8.6	8.4	2.1	5.4
Madison	11.3	0.0	4.1	8.1	2.3	2.4
Seven County Region	6.9	0.4	6.6	8.0	3.8	4.5
Idaho	9.0	0.6	6.5	6.4	8.3	3.9
U.S.	2.7	0.6	6.2	7.0	10.7	4.4
Geographic region	Communication public utilities (%)	Wholesale trade (%)	Retail trade (%)	Finance, insurance & real estate (%)	Business & repair services (%)	Personal service (%)
Bannock	2.0	4.9	19.5	5.9	3.7	2.4
Bingham	2.8	7.2	14.7	3.2	2.85	2.2
Bonneville	3.0	4.9	17.9	4.8	4.2	2.2
Butte	3.8	3.8	10.7	2.1	1.8	2.1
Clark	2.4	0.7	10.8	2.4	0.0	2.4
Jefferson	1.9	7.1	14.7	3.3	2.7	1.5
Madison	1.6	3.6	18.7	3.4	2.5	3.0
Seven County Region	2.5	5.3	17.6	4.6	3.5	2.3
Idaho	2.2	4.8	17.3	5.0	3.9	3.0
U.S.	2.7	4.4	16.8	6.9	4.8	3.2
Geographic region	Entertainment & recreation	Health services	Educational services	Other professional & related services	Public administration	
Bannock	1.5	7.5	12.7	6.2	4.1	
Bingham	0.5	5.7	9.3	8.2	4.5	
Bonneville	1.3	6.7	7.7	16.7	6.0	
Butte	2.3	3.6	10.4	11.8	3.8	
Clark	0.2	0.2	8.9	3.1	8.9	
Jefferson	0.6	3.6	10.7	8.6	5.2	
Madison	2.1	4.3	24.6	4.7	3.1	
Seven County Region	1.3	6.3	11.4	10.2	4.8	
Idaho	1.3	6.7	9.2	6.5	5.2	
U.S.	1.4	8.4	8.3	6.6	4.8	

a. U.S. Bureau of the Census 1992.

Appendix E ♦ E-10

Table E-6. Median household income and per capita income in the seven-county region and in the State of Idaho in 1979.^a

County	Median house- hold income (in 1979 \$)	Median house- hold income (in 1989 \$)	Per capita income (in 1979 \$)	Per capita income (in 1989 \$)
Bannock	17,458	29,817	6,692	11,429
Bingham	18,167	31,027	6,568	11,217
Bonneville	15,357	26,228	5,155	8,804
Butte	13,590	23,210	5,484	9,366
Clark	11,463	19,578	4,591	7,841
Jefferson	14,176	24,211	4,577	7,817
Madison	13,039	22,269	4,098	6,999
Seven-County Region	NA	NA	NA	NA
Idaho	15,285	26,105	6,248	10,671

a. U.S. Bureau of the Census 1982. All incomes are listed in 1979 dollars.

E.3 Housing

Between 1980 and 1990, the regional housing supply enjoyed moderate growth, with an increase of 11,063 units. Table E-7 displays the total number of housing units that existed in 1990 in each county and indicates the decade in which these units were built. Growth in the housing stock in the seven-county region has remained relatively constant since 1940, increasing by 1,100 to 1,200 units annually. With the exception of the slow housing growth in the 1940s due to World War II and the rapid expansion that occurred in the 1970s, the trend has remained relatively constant since the 1930s.

Table E-8 shows the number of occupied housing units, and vacancy rates, for the six cities in the seven-county region that had populations greater than 5,000 residents in 1990 and their corresponding counties.

Vacancy rates for owner-occupied housing units in the cities are similar to the rates found in the counties as a whole. The cities of Pocatello and Rexburg had vacancy rates for owner-occupied housing units that are slightly greater than total rates for their respective counties. The cities of Blackfoot, Chubbuck, and Ammon had vacancy rates that are slightly less than their county totals while the vacancy rate in Idaho Falls matched Bonneville County's rate. However, the vacancy rates in all these cities do not vary more than one percentage point from the county rates (see Table E-8).

With the exception of the cities of Blackfoot and Chubbuck, vacancy rates on rental units are approximately one percentage point less in the cities than in the counties as a whole. During 1990, the City of Chubbuck had a rental vacancy rate of 14.6% compared to Bannock County's rate of 10.3%, (see Table E-8).

Three basic programs provide affordable housing on the Fort Hall Indian Reservation: the mutual help program, a rental program, and an elderly housing complex. The mutual help program provides home ownership opportunities to qualified residents. The home buyer is required to make monthly payments that are based on 15% of his or her adjusted monthly income. Currently, 133 homes have been built under this program and 41 are under construction (Tribal Health and Human Services Department n.d.). The rental program provides rental housing to low-income families. Participants in this program pay 30% of their adjusted monthly income as rent. Presently, there are 75 rental units on the Fort Hall Indian Reservation. Finally, an elderly housing complex consisting of 19 units provides housing to elderly and handicapped persons.

Appendix E ♦ E-12

Table E-7. Building trends since 1930 for the seven-county region and the State of Idaho.^a

Geographic area	Total units in 1990	Percentage of housing units built ^a					1980 to March 1990 (%)
		Before 1940 (%)	1940–1949 (%)	1950–1959 (%)	1960–1969 (%)	1970–1979 (%)	
Bannock	25,694	15.4	11.1	15.8	13.8	30.8	13.1
Bingham	12,664	16.2	8.5	13.1	14.3	34.6	13.4
Bonneville	26,049	12.1	7.8	18.1	17.8	29.6	14.6
Butte	1,265	19.4	9.3	23.0	13.6	20.2	14.4
Clark	502	25.3	13.9	11.0	14.7	23.7	11.4
Jefferson	5,353	19.5	8.1	10.8	12.3	32.4	16.8
Madison	6,133	10.2	4.0	10.0	11.9	46.9	17.0
Seven-County Region	77,660	14.4	8.8	15.4	14.9	32.2	14.3
Idaho	413,327	15.9	8.5	12.1	13.1	32.4	18.0

a. U.S. Bureau of the Census 1992.

b. Percentages may not equal 100 because of rounding.

Table E-8. Number of owner-occupied and renter-occupied housing units and vacancy rates for selected cities in the seven-county region in 1990.^a

City/County	Owner-occupied housing units		Renter-occupied housing units	
	Number of occupied units	Vacancy rates (%)	Number of occupied units	Vacancy rates (%)
Bannock County	16,082	2.4	7,330	10.3
Pocatello ^b	10,900	2.7	6,193	9.8
Chubbuck	1,790	1.6	633	14.6
Bingham County	8,830	2.0	2,683	9.2
Blackfoot	2,181	3.0	1,127	11.3
Bonneville County	17,371	1.9	6,918	6.2
Idaho Falls	10,381	1.9	5,636	5.7
Ammon	1,083	1.2	218	3.1
Madison County	3,476	1.3	2,325	2.8
Rexburg	1,382	1.5	2,036	2.5

a. U.S. Bureau of the Census 1992. Includes all cities in the seven-county region that had more than 5,000 residents in 1990.

b. The City of Pocatello is located in Bannock and Power counties.

E.4 School Services

Table E-9 presents the 1990–1991 total enrollment, student-teacher ratio, revenues, and revenues per pupil for each public school district in the seven-county region. Total fiscal year (FY) 1992 impact aid entitlements for each school district are shown on Table E-10. Pocatello School District No. 25 receives the largest amount of impact aid of any district in the seven-county region (\$396,190). However, less than 4% of this funding is related to civilian INEL employment. Similarly, Blackfoot School District No. 55 received \$336,867 in impact aid during FY 1992. However, only 5% of this aid was provided as a result of INEL dependents. The majority of the aid received by these two districts is due to the large number of American Indian students who attend these school districts. In contrast, Idaho Falls School District No. 91, which received \$340,000 in impact aid during FY 1992, and Arco School District No. 111, which received \$35,506 in impact aid during FY 1992, were almost entirely funded because of INEL employment. Total public school district expenditures during the 1990–1991 academic year are shown on Table E-11 for each school district in the seven-county region.

E.5 Taxes

The total amount of revenues collected by the State of Idaho by source during fiscal years 1990 and 1991 are shown on Table E-12. The largest single revenue source for the State of Idaho was personal income tax payments. The state received \$436,429,000 from individual income tax during fiscal year 1991. The 5% sales and use tax was the next largest revenue generator, followed by the motor fuel tax and the corporate income tax. All major taxes levied by the State of Idaho during fiscal year 1990 and 1991 are included on Table E-12.

The State of Idaho has a progressive personal income tax structure with rates ranging from 2% to 8.2% and a corporate income tax rate of 8%. These taxes are imposed on all taxable income received in the State of Idaho. A sales and use tax of 5% is levied on all retail sales of tangible personal property as well as hotel and motel accommodations, admissions fees, and fees for recreation (Idaho State Tax Commission 1991).

The State of Idaho also assesses a gasoline and special fuels tax on motor vehicle fuels. Gasoline and diesel fuel are taxed at \$0.21/gal, gasohol at \$0.17/gal, and propane at \$0.152/gal. All civilian aviation fuel is taxed at \$0.055/gal; a \$0.045/gal tax is levied on jet fuel; and natural gas is taxed at \$0.165 per therm of natural gas (Idaho State Tax Commission 1991).

Financial information for the county governments of the seven-county region are discussed on Tables E-13 and E-14. Total revenues by source for fiscal year 1991 are shown on Table E-13. This table details the percent of revenue that each county government collected through taxes; licenses, permits, fees, fines, charges, and forfeitures; intergovernmental revenue; investment income; and other income sources.

The total annual expenditures of county governments are shown on Table E-14. These expenditures were also divided into categories labeled as general government, public safety, health and welfare, sanitation/public works, trust remittances, roads, debt service, and other expenses.

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Table E-9. Enrollment and revenue statistics for public schools in the seven-county region during the 1990-1991 academic year.^a

County	Total Enrollment	Revenues (\$)	Total Per Pupil (\$)	Number of Students/Teacher
Bannock County				
Marsh Valley, No. 21	1,623	6,021,094	3,710	18.95
Pocatello, No. 25	13,832	41,988,268	3,036	
Non-Public	340			NA
Bingham County				
Snake River, No. 52	2,415	7,577,416	3,138	22.1
Blackfoot, No. 55	4,592	14,417,478	3,140	20.7
Aberdeen, No. 58	858	3,142,163	3,662	17.9
Firth, No. 59	1,043	3,460,444	3,318	22.2
Shelley, No. 66	2,403	8,133,424	3,385	21.9
Non-Public	93			NA
Bonneville County				
Idaho Falls, No. 91	10,249	49,593,747	4,849	21.7
Swan Valley, No. 92	90	516,853	5,743	30.0
Bonneville, No. 93	7,557	34,685,714	4,590	21.2
Non-Public	361			NA
Butte County				
Arco, No. 111	765	2,804,908	3,677	19.8
Clark County				
Clark, No. 161	166	929,167	5,597	13.8
Jefferson County				
Jefferson, No. 251	3,875	11,373,686	2,935	21.7
Ririe, No. 252	690	2,574,708	3,731	21.2
West Jefferson, No. 253	774	2,940,416	3,799	19.7
Madison County				
Madison, No. 321	4,452	13,668,650	4,078	23.5
Sugar-Salem, No. 322	1,515	5,012,229	3,308	19.3

a. Idaho Department of Education 1991a, 1991b, n.d.

Table E-10. Prorated impact aid entitlements and estimated entitlements related to INEL dependents for school districts during fiscal year 1992.^a

School district	Total prorated impact aid entitlement	Estimated prorated entitlement related to INEL dependents ^b
Bannock County		
Pocatello, No. 25	\$396,190	\$13,333
Bingham County		
Snake River, No. 52	33,674	25,256
Blackfoot, No. 55	336,867	17,790
Shelley, No. 66	10,119	9,411
Bonneville County		
Idaho Falls, No. 91	340,000	306,249
Bonneville Joint, No. 93	264,639	220,891
Butte County		
Arco, No. 111	35,506	35,506
Clark County		
Clark County, No. 161	23,290	644
Jefferson County		
Ririe, No. 252	1,781	1,414
West Jefferson, No. 253	NA	NA
Madison County		
Sugar-Salem, No. 322	1,684	1,323

a. Private communication from K. L. Shelly, Ecology and Environment, Inc., Lancaster, New York, to Marilyn Galvin, U.S. Department of Education, Impact Aid Program, December 2 and 31, 1992.

b. These estimates assume that all INEL-related dependents were "B" students. Also, where the average daily attendance of INEL-related dependents was not known, it was assumed to be 95% of the total number of INEL-related dependents claimed for impact aid purposes.

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Table E-11. Public school district expenditures in the seven-county region during the 1990–1991 academic year.^a

District	Total (\$)	Per pupil (\$)
Bannock County		
Marsh Valley No. 21	5,991,859	3,692
Pocatello, No. 25	43,250,394	3,127
Bingham County		
Snake River, No. 52	7,788,025	3,225
Blackfoot, No. 55	14,220,819	3,097
Aberdeen, No. 58	3,080,312	3,590
Firth, No. 59	3,508,495	3,364
Shelley, No. 60	12,375,963	5,150
Bonneville County		
Idaho Falls, No. 91	47,096,722	4,595
Swan Valley, No. 92	743,812	8,265
Bonneville, No. 93	26,537,081	3,512
Butte County		
Arco, No. 111	2,742,290	3,585
Clark County		
Clark No. 161	881,998	5,313
Jefferson County		
Jefferson, No. 251	10,918,915	2,818
Ririe, No. 252	2,286,650	3,314
W. Jefferson, No. 253	3,029,769	3,914
Madison County		
Madison, No. 321	14,003,603	4,178
Sugar-Salem, No. 322	4,971,517	3,282

a. Idaho Department of Education 1991b, n.d.

Table E-12. Total revenues collected by the State of Idaho during fiscal years 1990 and 1991.^a

Source	FY 1990 Revenue	FY 1991 Revenue
Individual Income Tax	\$402,146,000	\$436,429,000
Sales and Use Tax	381,432,000	400,743,000
Motor Fuel Taxes	105,188,000	115,214,000
Corporate Income Tax	72,721,000	60,269,000
Cigarette Tax	12,620,000	14,681,000
Beer Tax	3,302,000	3,410,000
Travel and Convention Tax	2,435,000	2,662,000
Tobacco Tax	1,775,000	1,885,000
Estate Tax	1,744,000	2,065,000
Electricity (Kilowatt Hour)	1,677,000	1,783,000
Unclaimed Property	1,253,000	1,691,000
Boise Auditorium District Hotel/Motel Tax	1,178,000	1,193,000
Wine Tax	876,000	852,000
Mine License Tax	253,000	471,000
Illegal Drug Tax	114,000	157,000
Railroad Car Company Property Tax	105,000	100,000
Miscellaneous	66,000	79,000
Total	\$988,885,000	\$1,043,684,000

a. Idaho State Tax Commission 1991. These figures represent amounts remaining after refunds were paid from the accounts.

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Table E-13. Total revenues by source for county governments in the seven-county region during FY 1991.^a

County	Taxes (%)	Licenses, permits, fees, fines, charges, and forfeitures (%)	Inter- government revenues (%)	Investment income (%)	Other (%)	Total revenue (\$)
Bannock	44	19	29	5	3	16,232,274
Bingham	42	12	35	4	7	11,434,200
Bonneville ^b	16	3	70	2	9	50,186,650
Butte	33	1	51	2	13	1,417,684
Clark	27	1	56	10	6	1,236,849
Jefferson	36	12	36	5	11	4,408,236
Madison	35	25	28	2	10	5,249,432
Seven-County Region ^c	41	16	33	4	6	39,978,675

a. Ghan 1992; Bingham County n.d.; McFadden n.d.; Swager & Swager 1992a, 1992b; Draney, Searle & Associates 1992; Schwendiman and Sutton, P.A. 1992.

b. Bonneville County's financial data are not directly comparable to that of other counties in the region. Bonneville County's financial statements and total revenue data include special accounts for schools, cities, cemeteries, fire districts, ambulance districts, and other special accounts not found in other county budgets. The majority of intergovernmental revenue is funding for these accounts.

c. Bonneville County revenue sources have been excluded from the totals for the seven-county region.

Table E-14. Total expenditures by source for county governments in the seven-county region during FY 1991.^a

County	General Government (%)	Public Safety (%)	Health & Welfare (%)	Sanitation/ Public Works (%)	Trust Remittance (%)	Roads (%)	Debt Service (%)	Other (%)	Total (\$)
Bannock	25	22	21	0	0	15	0	17	14,216,708
Bingham	26	12	16	4	4	29	3	6	10,708,011
Bonneville ^b	12	6	6	1	65	9	0	1	51,850,100
Butte	34	9	15	38	0	0	0	4	1,397,012
Clark	40	12	5	29	0	0	1	13	1,086,379
Jefferson	29	10	14	6	10	28	0	3	4,566,074
Madison	27	13	10	34	0	0	11	5	5,662,080
Seven-County Region ^c	27	16	16	9	2	18	3	9	37,596,264

a. Ghan 1992; Bingham County n.d.; McFadden n.d.; Swager & Swager 1992a, 1992b; Draney, Searle & Associates 1992; Schwendiman & Sutton, P.A. 1992.

b. Bonneville County financial statements and total expenditures include special accounts for schools, cities, cemeteries, fire districts, and other special accounts not found in other county budgets. The majority of the expenditures for trust remittances are related to the transfer of funds to these accounts.

c. Bonneville County expenditures have been excluded from the seven-county regions's total expenditure patterns.

E.6 Idaho National Engineering Laboratory

EG&G Idaho was the largest operating contractor at the INEL in January 1992, with 5,265 employees, and Westinghouse Idaho Nuclear Company, Inc. (WINCO) was the second largest operating contractor, with 1,796 personnel. During the same time period, WEC and ANL-W had 980 and 858 personnel, respectively (see Table 4-11).

As total employment at the INEL increased from 1989 to 1992, the distribution of employees changed. EG&G Idaho received the largest benefit from the increase in employment, with an addition of 1,534 workers. Employment at architectural, engineering, and construction firms increased by 741 employees, or 235%, in the four years. The U.S. Department of Energy Idaho Operations Office (DOE-ID) also enjoyed significant growth during that time, with staffing of the field office increasing by more than 45% (see Table E-15). Rockwell-INEL employment was completely curtailed in 1991, when DOE-ID did not renew their contract. By January 1992, no Rockwell-INEL employees were working at the facility. Babcock & Wilcox (B&W) received the contract to operate the former Rockwell-INEL projects. Employment at WEC declined slightly from 1,002 employees in 1989 to 980 employees in 1992 (see Table 4-11).

The total INEL workforce is expected to decline by nearly 1,000 workers over the next 10 years. This reduction will be primarily due to reductions in employment at EG&G Idaho, WINCO, and Naval Reactors Facility (NRF). From FY 1993 to 2002, the total subcontractor workforce is expected to fluctuate considerably. The remaining employees are projected to maintain a near constant staffing level through the next decade.

These projections do not take into account the decision made by DOE-ID to consolidate its operations at the INEL and employ only one basic contractor by 1994. This consolidation is expected to further reduce the INEL work force.

DOE-ID employment levels rose steadily between FY 1982 and FY 1991 despite some annual fluctuations. Employment declined in FY 1992, and this decline is projected to continue through the end of the century.

The total INEL funding levels for FY 1989 to 1992 are shown on Table E-16. The facility received a total of \$1,147.9 million to operate DOE-ID, NRF, and ANL-W programs. DOE-ID was appropriated \$967.3 million for onsite programs, NRF was appropriated \$102 million, and ANL-W was appropriated \$78.6 million. Table E-16 illustrates INEL funding sources by program sponsors for FY 1989 to 1992.

The Assistant Secretary for Environmental Restoration and Waste Management (ER&WM) was the single largest sponsor of DOE-ID programs; in 1992 DOE-ID received approximately \$340 million (35% of its entire funding) from the Assistant Secretary for ER&WM. The next largest sponsor was the Assistant Secretary for Defense Programs, which supplied approximately \$265 million. The other two significant funding sources for the DOE-ID were the Assistant

Table E-15. Projected INEL headcount by contractor for FY 1993 to 2002.^a

Employer	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
PTI	402	400	400	400	400	400	400	400	400	400
EG&G Idaho	5080	5050	4950	4852	4757	5663	4572	4572	4572	4572
WINCO	1750	1730	1700	1680	1660	1650	1640	1630	1615	1600
ANL-W	840	840	840	840	840	840	840	840	840	840
B&W	436	438	438	438	438	438	438	438	438	438
MK-FIC	158	158	158	158	158	158	158	158	158	158
NRF ^b	1975	1650	1675	1625	1675	1900	1650	1625	1625	1625
DOE-ID	529	529	529	529	529	529	529	529	529	529
Other Federal employees ^c	58	40	40	40	40	40	40	40	40	40
Subcontractors	<u>645</u>	<u>675</u>	<u>685</u>	<u>835</u>	<u>860</u>	<u>855</u>	<u>715</u>	<u>485</u>	<u>485</u>	<u>685</u>
Total	11,875	11,510	11,415	11,397	11,357	11,473	10,982	10,717	10,702	10,887

a. Memorandum (Transmittal of Funding Data for INEL Environmental Impact Statement) from William G. Lloyd, DOE-ID, to Robert Rothman, November 10, 1992; Private communication with Vicki Johnson, DOE-ID, Idaho Falls, Idaho, 1993.

b. Includes Westinghouse, U.S. Navy, and subcontractor personnel.

c. Excludes West Valley personnel.

Secretary for Nuclear Energy (\$108 million) and the funding derived from work done for other DOE offices or laboratories and other Federal agencies (\$97 million) (see Table E-16).

The remaining DOE-ID funds were derived from the Office of New Production Reactors (6.1%); the Assistant Secretary for Conservation and Renewable Energy (4.2%); the Office of Civilian Radioactive Waste Management (0.8%); the Assistant Secretary for Management and Administration (1.5%); the Assistant Secretary for Fossil Energy (0.3%); the Office of Energy Research (2.0%); the Assistant Secretary for Environment, Safety, and Health (0.8%); and the Office of Intelligence (0.2%) (see Table E-16).

Funding from the Assistant Secretary for ER&WM showed the largest change, increasing by \$218.4 million. Funding from the Assistant Secretary for Defense Programs and the Office of New Production Reactors had increases of \$70.6 million and \$45.5 million, respectively. In contrast, funding for work done for other Federal agencies declined by \$84.1 million.

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Table E-16. INEL funding for FY 1989 to 1992 by program sponsor (in \$ millions).^a

Program Sponsor	FY 1989	FY 1990	FY 1991	FY 1992
Assistant Secretary for ER&WM	123.7	218.8	356.6	342.1
Assistant Secretary for Defense Programs	192.6	207.7	217.5	263.2
Assistant Secretary for Nuclear Energy	76.1	79.6	94.4	108.7
Office of New Production Reactors	14.3	45.4	78.1	59.8
Assistant Secretary for Conservation and Renewable Energy	7.8	59.8	45.0	41.4
Office of Energy Research	19.5	22.6	30.5	14.7
Assistant Secretary for Management and Administration	17.2	16.9	17.1	20.0
Office of Civilian Radioactive Waste Management	24.5	15.5	15.0	8.2
Assistant Secretary for Environment, Safety, and Health	14.9	17.4	9.1	7.6
Assistant Secretary for Fossil Energy	4.5	2.9	4.5	2.7
Office of Intelligence	0.0	0.0	1.7	1.6
Office of Nuclear Safety	0.0	0.0	0.0	0.2
Work for Others	181.2	184.6	109.2	97.1
Total DOE-ID Funding ^b	726.3	871.2	978.7	967.3
Naval Reactors Facility	92.0	102.0	92.0	102.0
Argonne National Laboratory-West	60.0	66.0	73.0	78.6
Total INEL Funding	878.3	1,039.2	1,143.7	1,147.9

a. U.S. Department of Energy 1993.

b. Total Idaho Operations Office funding excludes funding for West Valley, Grand Junction, and Mountain States Environmental.

INEL financial planning projections by program sponsors to the year 2002 are displayed on Table E-17.

These planning projections have been broken down by program sponsor and include funding only for programs located directly at the INEL. Funding at the INEL is expected to remain relatively constant through 2002. NRF and ANL-W financial planning projections are expected to increase throughout the next decade. DOE-ID financial planning projections are also expected to increase through the decade, declining only after FY 2001. Almost the entire increase in DOE-ID planned funding will be directly related to the ER&WM programs (see Table E-17).

Table E-18 converts INEL financial planning projections into constant 1992 dollars. As shown on the table, ER&WM funding will almost double in real terms between FY 1992 and FY

Table E-17. INEL financial planning projections by program sponsors for FY 1993 through 2002.^a

Program Sponsor	Millions of dollars									
	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
Assistant Secretary for Environmental Restoration and Waste Mgmt.	537.4	576.7	582.4	619.3	654.7	590.0	710.6	817.4	910.1	881.8
Assistant Secretary for Defense Programs	26.0	21.8	22.1	22.2	22.8	23.4	23.9	23.2	24.4	24.7
Assistant Secretary for Nuclear Energy	102.9	93.8	102.5	112.6	113.6	110.0	112.9	114.6	117.6	120.7
Office of New Production Reactors	24.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Assistant Secretary for Conservation and Renewable Energy	30.4	30.2	43.4	41.9	42.8	43.9	46.1	46.3	46.5	46.7
Office of Civilian Radioactive Radioactive Waste Mgmt.	8.3	8.6	17.3	15.3	19.5	6.9	5.6	3.9	3.9	4.0
Assistant Secretary for Mgmt. and Administration	26.0	28.1	28.7	28.6	28.7	29.6	30.7	32.0	33.1	34.5
Assistant Secretary for Fossil Energy	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Office of Energy Research	18.1	27.7	31.8	36.9	39.0	39.6	39.0	39.7	40.1	40.4
Assistant Secretary for Environment, Safety, and Health	9.3	9.5	9.5	9.6	9.7	9.9	10.1	10.1	10.1	10.1
Office of Intelligence	1.4	1.7	2.0	2.2	2.7	2.9	3.4	3.5	3.6	3.7
Work for Others	61.0	84.3	97.2	96.1	96.5	97.0	98.8	100.1	101.3	102.6
Office of Nuclear Safety	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Onsite Idaho Operations Office	847.3	884.4	938.9	986.7	1,032.0	1,055.2	1,083.1	1,192.81	1,292.7	1,271.2
Argonne National Laboratory-West	89.5	95.3	96.2	96.8	96.2	96.6	96.6	96.6	96.6	96.6
Naval Reactors Facility	115.0	95.0	105.0	115.0	145.0	150.0	135.0	140.0	145.0	150.0
Total INEL Planning Numbers	1,051.8	1,074.7	1,140.1	1,198.5	1,273.2	1,301.8	1,314.7	1,429.4	1,534.3	1,517.8

a. U.S. Department of Energy 1993; Private communication with Vicki Johnson, DOE-ID, Idaho Falls, Idaho, concerning NRF (1992) and ANL-W (1993). Support services provided by DOE-ID to NRF and ANL-W may be double-counted in these totals.

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Table E-18. INEL financial planning projections by program sponsors for FY 1996 to 2002 in constant 1992 dollars.^a

	FY in 1992 Million Dollars							
	1992	1996	1997	1998	1999	2000	2001	2002
Assistant Secretary for Environmental Restoration and Waste Management	342.1	550.2	564.7	577.9	577.8	645.3	697.5	656.1
Assistant Secretary for Defense Programs	263.2	19.7	19.7	19.6	19.4	18.3	18.7	18.4
Assistant Secretary for Nuclear Energy	108.7	100.0	98.0	92.1	91.8	90.5	90.1	89.8
Office of New Production Reactors	59.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Assistant Secretary for Conservation and Renewable Energy	41.4	37.2	36.9	36.8	37.5	36.5	35.6	34.7
Office of Civilian Radioactive Waste Management	14.7	13.6	16.8	5.8	4.6	3.1	3.0	3.0
Assistant Secretary for Management and Administration	20.0	25.4	24.8	24.8	25.0	25.3	25.4	25.7
Assistant Secretary for Fossil Energy	8.2	1.8	1.7	1.7	1.6	1.6	1.5	1.5
Office of Energy Research	7.6	32.8	33.6	33.2	31.7	31.3	30.7	30.1
Assistant Secretary for Environmental, Safety, and Health	2.7	8.5	8.4	8.3	8.2	8.0	7.7	7.5
Office of Intelligence	1.6	2.0	2.3	2.4	2.8	2.8	2.8	2.8
Work for Others	97.1	85.4	83.2	81.2	80.3	79.0	77.6	76.3
Office of Nuclear Safety	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Argonne National Laboratory-West	78.6	86.0	83.0	80.9	78.5	76.3	74.0	71.9
Naval Reactors Facility	102.0	102.2	125.1	125.6	109.8	110.5	111.1	111.6
Total INEL Planning Numbers	1,147.9	1,064.9	1,098.3	1,090.2	1,069.0	1,128.4	1,175.9	1,129.4

a. Private communication with B. Lloyd, Chief of Budget Branch, DOE-ID, Idaho Falls, ID, 1993.

2002. Total INEL funding will be less than FY 1992 levels for all years between FY 1996 and 2002 except FY 2001.

The Department of Defense (DOD) and the Nuclear Regulatory Commission (NRC) are the largest beneficiaries of work performed by the DOE-ID for other federal agencies. During FY 1992, the DOD programs had budgets of approximately \$70 million. This level of expenditure is projected to be significantly reduced in FY 1993 and then gradually increased through FY 2002. The NRC had programs performed by the DOE-ID that accounted for approximately \$22 million in FY 1992. This funding level is also predicted to remain at nearly \$23 million annually to the year 2002. The EPA, the National Aeronautical and Space Administration (NASA), and the U.S. Department of Transportation are the other major beneficiaries of the DOE-ID's work. Since FY 1989, the dollar value of the work performed by the DOE-ID for the DOD has almost halved. Work for the NRC has remained relatively constant, and work for the EPA has diminished significantly (see Tables E-19 and E-20). DOE-ID funding by contractor for FY 1989 to FY 1992 is depicted on Table E-21.

E.7 Fire Protection and Emergency Services

Detailed information on the facilities, personnel, and equipment of local fire districts in the seven-county region are shown on Table E-22. This table lists the number of fire stations located within each county, the number of paid and volunteer firefighters assigned to these stations, the number of firefighting vehicles utilized, and the names of each fire district located within the county.

E.8 Security Services

As illustrated on Table E-23, in 1991, there were between 1.3 and 2.5 law enforcement personnel per 1,000 residents in most counties in the study area. Clark County is the one exception; during 1991, there were an average of 6.3 law enforcement personnel per 1,000 residents (see Table E-23).

E.9 Nonhazardous and Nonradioactive Solid Waste Disposal

Landfills located in the seven-county region are listed on Table E-24. The expected useful lifespan of the landfills and any information on their compliance status with EPA standards are also included on this table.

E.10 Health Care Delivery Services

The eight hospitals that serve the seven-county region are listed on Table E-25. In addition, the total number of licensed beds, the number of patient days, the annual occupancy rate, and a listing of available services by each hospital are provided.

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Table E-19. Work performed by DOE-ID for other Federal agencies and other DOE offices and laboratories during FY 1989 to 1992.^a

Federal Agency	Millions of dollars			
	FY 1989	FY 1990	FY 1991	FY 1992
Department of Defense	150.4	153.5	73.7	69.9
Nuclear Regulatory Commission	25.1	25.5	23.7	22.2
Environmental Protection Agency	0.2	0.2	3.7	0.1
Department of the Interior	4.2	4.0	4.1	2.2
National Aeronautics and Space Administration	0.4	0.0	0.0	0.0
Other DOE Offices and Laboratories	0.0	0.0	0.7	0.2
All other Federal Administration	0.9	1.4	3.3	2.5
Total ^b	181.2	184.6	109.2	97.1

a. U.S. Department of Energy 1993.

b. Total excludes West Valley, Grand Junction, Mountain State Environmental, NRF, and ANL-W.

Table E-20. Projected work load performed by DOE-ID for other Federal agencies and other DOE offices and laboratories during FY 1993 to 2003.^a

Agency	Millions of dollars									
	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
Department of Defense	30.6	52.8	65.5	63.8	64.1	63.8	78.2	78.2	78.2	78.2
Nuclear Regulatory Commission	22.1	22.2	22.2	22.7	22.7	22.7	22.7	22.7	22.7	22.7
Department of Transportation	1.3	2.3	2.3	3.2	3.3	3.5	3.5	3.5	3.5	3.5
Department of the Interior	3.0	3.0	3.0	4.0	4.0	4.5	5.0	5.0	5.0	5.0
NASA	0.6	0.6	0.6	0.1	0.1	0.1	0.5	0.5	0.5	0.5
Other DOE Offices and Laboratories	0.4	0.4	0.5	0.5	0.5	0.5	0.8	0.8	0.8	0.8
All Other Federal Agencies	<u>3.0</u>	<u>3.0</u>	<u>3.1</u>	<u>1.8</u>	<u>1.8</u>	<u>1.9</u>	<u>1.6</u>	<u>1.6</u>	<u>1.6</u>	<u>1.6</u>
Total ^b	61.0	84.3	97.2	96.1	96.5	97.0	112.3	112.3	112.3	112.3

a. U.S. Department of Energy 1993.

b. Totals exclude West Valley, ANL-W, and NRF.

Table E-21. DOE Idaho Operations Office onsite funding by contractor for FY 1989 to 1992.^a

Contractor ^b	(in \$ millions)			
	FY 1989	FY 1990	FY 1991	FY 1992
EG&G Idaho	389.0	457.9	513.7	437.5
WINCO	144.2	182.1	219.7	284.9
Rockwell	59.5	82.7	42.0	0.0
Babcock & Wilcox	—	—	—	52.1
MK-FIC	49.3	52.6	86.7	77.0
DOE-ID	84.3	95.8	116.7	115.8
Total ^c	726.3	871.1	978.8	967.3

a. U.S. Department of Energy 1993.

b. PTI funding has not been identified because these costs have been spread among all site contractors and are therefore included in the contract totals.

c. The table excludes Westinghouse funding. These data are presently unavailable.

Table E-22. Fire protection services in the seven-county region in 1992.^a

County ^b	Fire stations	Firefighters		Firefighting vehicles ^c	Fire districts
		Paid	Volunteer		
Bannock	9	71	95	37	Chubbuck, Downey, Inkom, Lava Hot Springs, McCammon, and Pocatello
Bingham	7	20	76	25	Aberdeen, Blackfoot, Shelley, and Shelley-Firth
Bonneville	6	81	40	24	Ammon, Idaho Falls, and Ucon
Butte	2	0	15	3	Arco
Clark	1	0	7	1	Dubois
Jefferson	4	1	62	11	Jefferson County and Rigby
Madison	1	6	18	6	Rexburg

a. Statistics provided by representatives of each fire protection district.

b. Fire district boundaries do not necessarily coincide with county boundaries; county totals therefore include fire districts based within the counties.

c. Totals include pumpers, tankers, rescue trucks, and hazardous materials vehicles.

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Table E-23. Law enforcement staffing levels in the seven-county region.

County ^b	Law enforcement personnel in 1991 ^a		
	Sworn officers	Civilians	Total personnel (per 1000 population)
Bannock	151	25	2.5
Bingham	65	18	2.0
Bonneville	143	26	2.2
Butte	4	0	1.3
Clark	2	3	6.3
Jefferson	18	8	1.6
Madison	43	6	1.9
State Police	53	14	NA

a. Personnel statistics from the Idaho Department of Law Enforcement n.d.

b. County totals include sheriffs' offices and police departments located within the county.

c. Not applicable.

Table E-24. County landfill capacity in the seven-county region in 1992.^a

County	Expected lifespan	Comments
Bannock		
Fort Hall Mine Landfill	30 years	Landfill is being redesigned to meet EPA standards.
McCammon Landfill	None	Being closed due to noncompliance with EPA standards.
Bingham		
Aberdeen Landfill	1 year	May close due to noncompliance with EPA standards.
Bingham County Sanitary Landfill	3 years +	Lifespan could increase depending on the amount of bulky waste that can be diverted.
Blackfoot Landfill	5-6 years	Accepts mainly bulky waste.
Bonneville		
Bonneville County Sanitary Landfill	October 1993	Will be closing due to noncompliance with EPA standards. New landfill will then open with an expected lifespan of 50 years.
Butte		
Arco Landfill	30 years	
Howe Landfill	30 years	
Clark		
Clark County Landfill	August 1993	Will be closed due to noncompliance with EPA standards.
Jefferson		
Mud Lake Landfill	2 years	Capacity could be expanded in adjacent area.
Rigby Landfill	None	Being closed due to noncompliance with EPA standards.
Madison		
Madison County Landfill	July 1993	Will be closed due to noncompliance with EPA standards.

a. Data provided by representatives of each of the county governments.

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Table E-25. Hospital statistics for all hospitals in the seven-county region, October 1, 1989 to September 30, 1990.^a

Hospital	Licensed beds	Patient days	Occupancy rate	Services provided
Bannock County				
Aspen Crest Hospital in Pocatello	60	7,019	32.1%	Psychiatric and substance abuse
Bannock Regional Medical Center in Pocatello	139	19,768	39.0%	General acute care services
Pocatello Regional Medical Center in Pocatello	110	15,210	37.9%	General acute care services; rehabilitation and substance abuse care; no obstetrical or pediatric care
Bingham County				
Blackfoot Memorial Hospital in Blackfoot	54	5,075	25.7%	General acute care services except no pediatric care
State Hospital South in Blackfoot	184	9,764	89.2%	Psychiatric care
Bonneville County				
Eastern Idaho Regional Medical Center in Idaho Falls	311	53,539	49.8%	General acute services plus psychiatric and rehabilitation care
Butte County				
Lost Rivers Hospital in Arco	4	321	22.0%	Medical/surgical care only
Madison County				
Madison Memorial Hospital in Rexburg	52	9,519	50.2%	General acute care services

a. Statistics from Idaho Department of Health and Welfare n.d.

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Appendix F
Cultural Resources

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ACRONYMS

ACHP	Advisory Council on Historic Preservation
AHPA	Archaeological and Historical Preservation Act
AIRFA	American Indian Religious Freedom Act
ARPA	Archaeological Resources Protection Act
CFR	Code of Federal Regulations
CRM	cultural resource management
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy Head Quarters
DOE-ID	U.S. Department of Energy Idaho Operations Office
E.O.	Executive Order
EIS	Environmental Impact Statement
FR	Federal Register
GIS	Geographic Information System
HABS	Historic American Building Survey
HAER	Historic American Engineering Record
HHS	Historic Sites Survey
INEL	Idaho National Engineering Laboratory
MOA	Memorandum of Agreement
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NHPA	National Historic Preservation Act
NRHP	National Register of Historic Places
PA	programmatic agreements
PL	Public Law
SHPO	State Historic Preservation Office
USC	U.S. Code

F.1 Summary of Federal and State Guidelines Related to Cultural Resources on the INEL

F.1.1 Federal Law

The following summary of federal statutes and guidelines is organized chronologically to give a sense of the development of national thought on historic protection. Several of the earlier acts have been strengthened or superseded by later legislation. Although all laws listed apply, those listed below are the leading and most relevant to the daily routine of the Idaho National Engineering Laboratory (INEL) and long range planning by the Cultural Resource Management (CRM) Office.

- American Indian Religious Freedom Act (AIRFA) of 1978, Section F.1.1.12
- Archaeological and Historic Preservation Act of 1974, Section F.1.1.8
- Archaeological Resources Protection Act (ARPA) of 1979, Section F.1.1.13
- Curation of Federally-Owned and Administered Archaeological Collections, Section F.1.1.15
- Destruction of Government Property, Malicious Mischief, Section F.1.1.11
- U.S. Department of Energy Idaho Operations Office (DOE-ID) Directive: Management of Cultural Resources on the INEL (A. A. Pitrolo, 10/12/90), Section F.1.2.3
- Embezzlement and Theft Act of 1875, Section F.1.1.10
- Federal Cave Resources Protection Act of 1988, Section F.1.1.14
- National Environmental Policy Act (NEPA) of 1969, Section F.1.1.6
- National Historic Preservation Act (NHPA) of 1966, Section F.1.1.4
- Native American Grave Protection and Repatriation Act of 1990, Section F.1.1.16
- U.S. DOE Memorandum EH-231: Management of Cultural Resources at Department of Energy Facilities, Section F.1.2.2
- U.S. DOE Order 1324.7: Departmental History Program, Section F.1.2.1.

F.1.1.1 Antiquities Act of 1906 [Public Law (PL) 59-209; 16 U.S. Code (USC) 431-433]. This was the first statute to protect antiquities on federal lands. It states that objects of antiquity (including paleontological resources) are to be preserved, restored and maintained, and disturbed only under excavation permits issued by the federal government. The law also provides criminal sanctions for unauthorized disturbance and clarifies that all artifacts and associated documents amassed under permit are to be cared for in public museums. Requirements of the Antiquities Act, including the permitting process, have been expanded, strengthened, and superseded by the Archaeological Resources Protection Act. However, the recent statute does not include paleontological remains in the revised definition of antiquities or cultural resources.

F.1.1.2 Historic Sites, Buildings, and Antiquities Act of 1935, as amended (PL 74-292; 16 USC 461-467; 49 Statute 666). This act expands the basic principles of preservation set forth in the Antiquities Act and sets a national policy of preserving historic sites, buildings, and objects of national significance. It provides the Secretary of Interior with the power to restore and maintain such sites through the National Historic Landmarks Program and also establishes the National Survey of Historic Sites and Buildings (now the National Register of Historic Places), the Historic Sites Survey (HSS), the Historic American Buildings Survey (HABS), and the Historic American Engineering Record (HAER). This was the first act that officially recognized that the federal government has a responsibility to alleviate impacts that it regularly causes to cultural resources and authorizes the expenditure of funds for archaeological studies on major land modification projects.

F.1.1.3 The Reservoir Salvage Act of 1960 (PL 86-523; 16 USC 469). This statute provides for salvage and preservation of historic and archaeological data that might otherwise be destroyed or harmed as a result of federal dam and reservoir construction. The law is extensively amended by the Archaeological and Historical Preservation Act of 1974.

F.1.1.4 National Historic Preservation Act (NHPA) of 1966, as amended [PL 89-665; PL 96-515; 16 USC 470; 36 Code of Federal Regulations (CFR) 60, 61, 63, 64, 65, 67, 68, 800; 48 FR 44716-44742]. This act furthers the principles of the Historic Sites, Buildings and Antiquities Act of 1935 by explicitly outlining the leadership role of the federal government in preservation of prehistoric and historic resources and promoting a policy of cooperation between federal agencies, Indian tribes, and other nations, states, and local governments. It directs federal agencies to assume responsibility for considering cultural resources in their activities and provides a process by which historically and scientifically important properties must be recognized and protected. The act establishes the National Register of Historic Places (NRHP), State Historic Preservation Office (SHPO), state historic preservation plans, procedures for forming approved state and local government historic preservation programs, and also provides further guidance for the National Historic Landmarks Program. It also creates the independent National Advisory Council on Historic Preservation (ACHP) to serve as counsel on preservation issues to the President, Congress, and federal and state agencies.

The following are sections of NHPA that are especially important to the relationship between cultural resources protection and activities on federal land:

F.1.1.4.1 NHPA Section 106—The ACHP, created by the NHPA, is responsible for implementation of Section 106. This important section requires that federal agencies consider the potential impact of their activities on properties on or eligible to the National Register and give the ACHP sufficient information and time to comment on federal activities. It provides a process to be followed to meet this requirement and maintain compliance with federal law. Federal agencies can comply with Section 106 by following procedures for individual projects or by developing programmatic agreements (PA) for large, long-term, or complicated projects. PAs are developed in consultation with the SHPO, ACHP, Native Americans, and other interested groups. Federal agencies can also develop their own regulations (subject to approval by the ACHP) and/or follow a state review system, approved by ACHP and the state, which substitutes for the federal process.

Basic compliance with Section 106 of the NHPA involves the following steps: (a) identification and evaluation of historic properties within the project area, (b) assessment of the effects of the project on those properties, (c) consultation with the SHPO and other interested parties on ways to avoid or minimize adverse effects [e.g., developing a PA, Memorandum of Agreement (MOA), and/or mitigation plan], (d) providing an opportunity for the SHPO and ACHP to comment on the plan or the MOA, and (e) making a final agency decision on whether or how to proceed (implementation).

F.1.1.4.2 NHPA Section 110—This section directs federal agencies to establish programs to locate, evaluate, and nominate all eligible cultural properties under their jurisdiction to the National Register. This requirement is important because it stresses that federal agencies must take an active role in the preservation and management of all significant cultural resources under their jurisdiction and not only those that happen to fall within the path of construction. Compliance with Section 110 also implies monitoring of known resources and when necessary the taking of action to prevent any loss of information. Guidelines for large scale inventory and monitoring programs such as this have been proposed by the National Park Service (53 FR 4727).

Federal agencies are also responsible for historic properties previously unidentified, which may be discovered during project implementation, even after completion of the Section 106 review process and/or implementation of a mitigation plan. Compliance can be met for this rule and the applicable laws by (a) incorporating the treatment protocol for unexpected discoveries in the project plan, (b) complying with Section 36 CFR 800.6 when discoveries are made, (c) restarting the 106 process, or (d) notifying the Secretary of the Interior under PL 93-291.

F.1.1.4.3 NHPA Section 304— This section addresses confidentiality by directing federal agencies, after consultation with the Secretary of the Interior, to "withhold from disclosure to the public, information relating to the location or character of historic resources whenever the head of the agency or the Secretary determines that the disclosure of such information may create a substantial risk of harm, theft, or destruction to such resources or to the area or place where

such resources are located." This section is also used to protect sensitive information related to religious or sacred properties that is provided by traditional cultural leaders.

F.1.1.5 Federal Collections Act of 1966 (PL 89-508; 80 Stat. 309; 4 CFR 2). Historic and prehistoric sites have been clearly defined as resources under many legislative acts and, as such, their deliberate or inadvertent destruction or disturbance constitutes damage to public property. This act requires that agencies attempt to collect for damages arising from activities on federal land, including cases that address unauthorized/illegal damage or destruction to cultural resources. In these situations, professional archaeological appraisal is required to translate site damage into monetary terms and evidential requirements for court cases.

F.1.1.6 National Environmental Policy Act (NEPA) of 1969 [PL 91-190; 42 USC 4321-4361; 40 CFR 1500-1508; 10 CFR 1021; Executive Order (E.O.) 11514; E.O. 11991]. This important act outlines a federal policy of general environmental protection by forcing information-gathering, planning, and assessment in advance of projects or actions that occur on federal land or are federally licensed or funded. It requires the use of natural and social sciences in planning and decision-making with regard to project impacts on all aspects of the environment, including cultural resources. Federal agencies must prepare detailed environmental impact statements (EISs) outlining the scope, environmental effects of, and alternatives to the action planned and must also allow for and incorporate public, scientific, and legal comment. Because EISs must address the environmental consequences of a project to cultural resources, NEPA forces the involvement of archaeologists early in project planning stages. This results in detailed inventories of cultural resources for project areas as well as evaluations of potential impacts on them, alternative actions, and programs of appropriate mitigation if the project or one of its alternatives is slated to proceed. It is also important to note that categorical exclusions under NEPA (45 FR 20694, 47 FR 7976 for DOE) do not eliminate the need to comply with Section 106 of the NHPA, requiring the identification and evaluation of cultural resources in the path of construction projects.

F.1.1.7 Executive Order 11593 of 1971 (36 CFR 8921). This directive formally designates the federal government as leader in "preserving, restoring, and maintaining the historic and cultural environment of the Nation." It gives federal agencies the responsibility for locating, inventorying, and nominating to the National Register those sites that qualify and urges caution to ensure that eligible properties are not transferred or altered during the process of this inventory and nomination. The primary philosophy and requirements of E.O. 11593 were incorporated into 1980 amendments to the NHPA.

F.1.1.8 Archaeological and Historic Preservation Act (AHPA) of 1974 (PL 86-523; PL 93-291; 42 CFR 5375; 42 FR 5374; 16 USC 469). Also known as the "Archaeological Recovery Act" and the "Reservoir Salvage Act," this law was written to preserve archaeological data threatened by any federal ground-disturbing program or activity, or project requiring a federal license. More importantly, the act provides that up to 1% of the total project appropriation may be dedicated to cultural resources data recovery. (The NHPA also authorizes project and project planning funds to be used in this manner). PL 96-515 defines this 1% for site

identification, surveys, and evaluations as part of planning, not mitigating, budgets. This limitation can be waived with the concurrence of the Secretary of the Interior and review by the National Park Service's consulting archaeologist.

F.1.1.9 Department of Transportation Act of 1976 (PL 89-670; 49 USC 4321-4361). This law states that no Federal Highway Administration, Federal Aviation Administration, Urban Mass Transit Administration, or U.S. Coast Guard project may be undertaken if it requires the use of land from cultural resources of national, state, or local significance unless there is no feasible alternative and unless the program includes planning to minimize harm to the properties.

F.1.1.10 Embezzlement and Theft Act of 1875, as amended (PL 93-203; PL 93-567; 18 USC 641). This act describes acts of theft and embezzlement against the federal government and prescribes fines and punishments. Together with the malicious mischief statute, this legislation may be used in coordination with the ARPA to establish the liability of individuals who loot cultural resources as well as their connected commercial agents or dealers in artifacts.

F.1.1.11 Destruction of Government Property, Malicious Mischief (18 USC 1361). This law provides penalties for willful destruction of federal government property. When applied to litigation against looters and vandals, the penalties of this statute may be applied to partial site destruction or to destruction or removal of smaller non-replaceable artifacts such as pots, stone tools, and perishable materials.

F.1.1.12 American Indian Religious Freedom Act (AIRFA) of 1978 (PL 95-341; 42 USC 1996; 43 CFR 7; 25 CFR 262; 55 FR 2580-2583). This act reaffirms Native American religious freedom rights under the First Amendment and sets U.S. policy to protect and preserve the inherent and constitutional right of American Indians to believe, express, and exercise their traditional religions. The act requires that federal actions avoid interfering with access to sacred locations and traditional resources that are integral to the practice of religions. Although not specifically mandated in AIRFA, a subsequent court ruling states that consultation by agencies with interested Native American groups and leaders during the project decision-making process will satisfy compliance with the act. (Section 10a of the ARPA requires consideration of AIRFA in developing regulations.)

F.1.1.13 Archaeological Resources Protection Act (ARPA) of 1979, as amended (PL 96-95; PL 100-555; PL 100-588; 16 USC 470; 43 CFR 7; 36 CFR 296; 18 CFR 1312; 32 CFR 229). This is the primary archaeological protection law for federal and tribal lands. It defines archaeological resources and ensures the confidentiality of locational information. The law specifically prohibits unauthorized excavation or removal of materials from archaeological resources on federal lands as well as the buying and selling of antiquities. Protection measures are also extended to resources defined as sacred by Native American groups. For those who would disregard these sanctions, ARPA provides strict criminal and civil penalties. Implementing regulations outline procedures for the legal excavation and removal of archaeological resources (which remain the property of the federal government or Indian tribe), including necessary permitting. Recent amendments complement Section 110 of the NHPA by requiring that federal

agencies develop plans for surveying lands not immediately scheduled for development. Agencies are also tasked with developing and implementing systems for reporting and recording violations of the act and with developing public awareness programs.

F.1.1.14 Federal Cave Resources Protection Act of 1988 (PL 100-691). The stated purposes of this act are "...to secure, protect, and preserve significant caves on Federal lands for the perpetual use, enjoyment, and benefit of all people...to foster increased cooperation and exchange of information between governmental authorities and those who utilize caves located on Federal lands for scientific, education, or recreational purposes..." Much like ARPA, this act addresses confidentiality of locational information, collecting, permitting, and civil and criminal penalties for violations.

F.1.1.15 Curation of Federally-Owned and Administered Archaeological Collections (36 CFR 79). This statute provides standards and guidelines to be followed by federal agencies to preserve artifacts and associated records recovered in conjunction with federal projects.

F.1.1.16 Native American Grave Protection and Repatriation Act of 1990 (PL 101-601). This law directs the Secretary of Interior to guide responsibilities in repatriation of federal archaeological collections and collections held by museums receiving federal funding. It is expected that major actions under this new law will be undertaken within the year for the Secretary by the Departmental Consulting Archaeologist and the Archaeological Assistance Division of the National Park Service. Important actions ordered under this act include: (a) establishing a review committee with monitoring and policy-making responsibilities; (b) developing regulations for repatriation, including procedures for identifying lineal descent or cultural affiliation needed for claims; (c) oversight of museum programs designed to meet the inventory requirements and deadlines of this law; and (d) developing procedures to handle unexpected discoveries of graves and/or grave goods during activities on federal or tribal lands.

F.1.2 Department of Energy Directives

Within recent years, DOE has exhibited a heightened awareness of compliance with federal and state antiquities legislation. The following directives have been issued as a result of this increased attention.

F.1.2.1 U.S. DOE Order 1324.7: Departmental History Program (10/21/88). This directive states that "...it is Departmental (DOE) policy to establish a history program to write the official history of the Department and its predecessor agencies, create and maintain the Department's historical archives, and provide institutional memory for the Department, its laboratories, and contractors. The objectives of the history program are to record the Department's official history and to create and maintain historical archives useful for decision-makers who must evaluate current and proposed policies within a framework of Departmental precedent." The document provides references, defines responsibilities, and describes the types of archival information that are to be managed by all DOE elements, offices, divisions and contractors.

F.1.2.2 U.S. DOE Memorandum EH-231: Management of Cultural Resources at Department of Energy Facilities (R. F. Pelletier, 2/23/90). The stated intent of this document is "...to inform all Department of Energy (DOE) facilities and programs of the requirements for complying with the various executive orders, statutes and implementing regulations governing the management of cultural resources..." To this end, the memo describes applicable regulations and mandates the development of specific programs for the identification, evaluation, protection and mitigation of cultural resources located on DOE-owned or leased facilities.

F.1.2.3 DOE-ID Directive: Management of Cultural Resources on the INEL (A. A. Pitrolo, 10/12/90). This directive outlines the DOE-ID response to the DOE Headquarters (DOE-HQ) memorandum directing all DOE facilities to comply with cultural resources legislation. It commits to rigorous compliance and advises cooperation between INEL contractors in the development and implementation of a CRM plan for the INEL.

F.1.2.4 U.S. DOE Report ER-0246: DOE National Environmental Research Parks (8/1/85). The DOE National Environmental Research Park (NERP) Program was established for the purpose of utilizing the often large landholdings of DOE facilities as outdoor laboratories for research in environmental sciences and energy technology options. The INEL is the second largest in land area of six DOE NERPs. Research at the NERPs includes basic natural history and baseline data-gathering, wetlands, soils, climate, biodiversity, bioremediation, and ecosystem dynamics. Archaeology and paleontology fit into NERP programs both conceptually (human and non-human environmental characterization, past and present ecological adaptations, climatic modeling) and practically (baseline studies, need to maintain the integrity of the Parks for scientific research, environmental compliance requirements).

F.1.3 Idaho State Laws

On the INEL, as on other federal reserves, federal statutes usually supersede existing state legislation pertaining to cultural resources. However, both sets of statutes are complementary in their message of preservation.

F.1.3.1 Idaho Antiquities Act, Idaho Code, Chapter 41. This statute establishes protection of archaeological and vertebrate paleontological resources on public (state) lands in Idaho. Like its federal counterpart, the Idaho Act provides for the permitting of qualified individuals or institutions to excavate, and establishes penalties for violation of the code. However, the Idaho Act is superseded by federal law on the INEL.

F.1.3.2 Idaho Burial Act, Idaho Code, Chapter 5, Title 27 and Chapter 70, Title 18.

This act prohibits the desecration of human burials on public (state) lands in Idaho. Penalties are established for unlawful removal of human remains and associated grave goods. The statute also defines permitted activities and establishes guidelines for the legal removal of human remains. These guidelines require that excavation be conducted by a qualified archaeologist under consultation and with written permission of the appropriate Indian tribe and that human remains and associated items be reinterred in an area approved by the tribe.

F.1.3.3 Idaho Cave Protection Act, Idaho Code, Chapter 70, Title 18, Section 7035.

This state law makes it unlawful to damage caves or their features or contents through vandalism or unauthorized removal of materials. The law applies to caves on federal, state, or private land. Violation of the act is considered a trespass and malicious injury to property misdemeanor.

F.2 Comprehensive Catalog of INEL CRM Projects

Table F-1. Cultural resource surveys on the INEL, July 1984 to July 1992.

SURVEY NUMBER	PROJECT NAME	ACREAGE	IFs	SITES	MAP NUMBERS ^a
SJM-1	INEL Boundary (Miller 1984a, 1985)	3083.0 acres	51	43	1, 2, 4, 5, 6, 7, 14, 15, 16, 17, 18, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
SJM-2	Grazing Boundary (Miller 1984a, 1985)	1949.0 acres	61	41	3, 5, 6, 9, 10, 11, 12, 13, 15, 18, 19, 20, 21, 26, 28
SJM-3	Diversion Area (Miller 1985)	undetermined	26	41	3, 6
SJM-5	1984 New Production Reactor Surveys (Miller 1983, 1984b)	undetermined	32	55	12, 13
SJM-9	INEL Seismic Studies (Miller 1985)	undetermined	12	34	5
ISU-84-1	CFA Power Intertie (Reed et al. 1987b:159)	7.5 acres	0	0	13
ISU-84-2	WERF Perimeter (Reed et al. 1987b:266)	25.0 acres	2	2	12
ISU-84-3	CFA/EBR I Powerline (Reed et al. 1987b:497)	65.0 acres	0	1	13
ISU-84-4	TRA Security Upgrade (Reed et al. 1987b:174)	5.0 acres	0	0	13
ISU-84-5	RWMC Monitor Wells (Reed et al. 1987a:177)	60.0 acres	0	2	6
ISU-85-2	Borax V D&D (Reed et al. 1987b:221)	5.0 acres	1	0	3
ISU-85-3	TAN/TSF Fuel Tank (Reed et al. 1987b:257)	1.0 acre	0	0	8
ISU-85-7	Weapons Range (Reed et al. 1987b:330)	2400.0 acres	111	67	3, 13
ISU-85-8	TRU-Waste (Reed et al. 1987b:214)	50.0 acres	2	1	3
ISU-85-9	Reynolds Drill Pad (Reed et al. 1987b:230)	1.0 acre	0	0	13
ISU-85-10	TAN/IET D&D (Reed et al. 1987b:262)	25.0 acres	3	0	8
ISU-85-11.1	TRA Perimeter (Reed et al. 1987b:174)	96.0 acres	0	0	13
ISU-85-11.2	CFA Perimeter (Reed et al. 1987b:161-2)	225.0 acres	10	7	13
ISU-85-11.21	CFA Gravel Pits/Landfill (Reed et al. 1987b:172)	340.0 acres	0	0	13

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SURVEY NUMBER	PROJECT NAME	ACREAGE	IFs	SITES	MAP NUMBERS ^a
ISU-85-11.3	TAN/TSF Perimeter (Reed et al. 1987b:257)	79.0 acres	0	0	8
ISU-85-11.31	LOFT Perimeter (Reed et al. 1987b:258-9)	55.0 acres	1	1	8
ISU-85-11.32	WRRTF Perimeter (Reed et al. 1987b:262)	49.0 acres	0	0	8
ISU-85-11.4	RWMC Office Area (Reed et al. 1987b:177)	24.0 acres	0	0	3
ISU-85-11.41	RWMC Borrow Area (Reed et al. 1987b:181)	770.0 acres	35	22	6
ISU-85-11.5	Borax V Gravel Pit (Reed et al. 1987b:221)	88.0 acres	1	2	3
ISU-85-11.6	PBF/SPERT Administrative Area (Reed et al. 1987b:266)	1133.0 acres	36	48	12, 13
ISU-85-11.7	EOCR Perimeter (Reed et al. 1987b:325)	44.0 acres	0	0	13
ISU-85-11.81	Fiber Optics-TAN/ANL (Reed et al. 1987b:547)	269.0 acres	6	8	8, 20, 21
ISU-85-11.84	Fiber Optics-CFA/PPP/TRA/NRF/TAN (Reed et al. 1987b:537)	456.0 acres	5	8	5, 8, 10, 11, 13
ISU-85-11.85	Fiber Optics-135kV Line from CFA/ANL (Reed et al. 1987b:429)	520.0 acres	20	19	12, 13, 21
ISU-85-11.87	Fiber Optics-EOCR/PBF (Reed et al. 1987b:559)	91.0 acres	1	3	12, 13
ISU-85-11.9	Fiber Optics-Lincoln Blvd. (Reed et al. 1987b:497)	1155.0 acres	28	20	5, 8, 10, 11, 13
ISU-85-11.91	Fiber Optics-T-24 Road (Reed et al. 1987b:461)	659.0 acres	10	17	12, 13, 21
ISU-85-12	NRF Perimeter (Reed and Ringe 1986)	275.0 acres	7	12	11
ISU-85-13	INEL Helicopter Pads (Reed et al. 1987b:327)	3.0 acres	1	0	3, 8, 21
ISU-85-14	W. Portland Exit Ramp (Reed et al. 1987b:172)	20.0 acres	0	0	13
ISU-86-2	ICPP Perimeter (Reed et al. 1987a:47)	440.0 acres	3	0	13
ISU-86-5	CFA Substation (Reed et al. 1987a:45)	25.0 acres	2	0	13
ISU-86-6	CFA/NRF/TAN Gravel Pits (Ross et al. 1986)	495.0 acres	9	12	8, 9, 10, 13

SURVEY NUMBER	PROJECT NAME	ACREAGE	IFs	SITES	MAP NUMBERS ^a
ISU-86-7	CFA Landfill Expansion (Reed et al. 1987a:25)	15.0 acres	0	0	13
ISU-86-8	Fiber Optics-ANL/IF (Reed et al. 1987a:102)	247.0 acres	2	1	17, 18, 21, 31, 32
ISU-86-12	NRF Topsoil Pit (Reed et al. 1987a:62)	1.0 acre	0	0	11
ISU-86-17	NODA (Reed et al. 1987a:54)	10.0 acres	0	0	13
ISU-86-20	ARVFS (Reed et al. 1987a:52)	3.0 acres	0	0	10
ISU-87-3	Borax V Access Road (Reed et al. 1987a:99)	5.0 acres	0	0	13
ISU-87-6	TRA Drill Pad (Ringe and Reed 1987)	6.0 acres	0	0	13
ISU-87-7	TAN Fire Station (Ringe and Reed 1987)	3.0 acres	0	0	8
ISU-87-8	RWMC Bore (Ringe and Reed 1987)	0.5 acres	0	0	3
ISU-87-9	W. Portland/Weapons Range Powerline (Ringe and Reed 1987)	14.0 acres	0	0	13
ISU-87-12	SSC (Ringe et al. 1987)	600.0 acres	31	16	1, 5, 8, 10, 18, 19
ISU-87-14	Weapons Range Helipad (Reed 1987a)	10.0 acres	0	0	13
ISU-87-15	Ant Study Plots (Wright and Holmer 1987)	104.0 acres	5	3	3, 10, 13
ISU-87-16	Highway Information Signs (Reed and Holmer 1987)	4.0 acres	0	0	5, 8, 9, 24, 27, 29,
ISU-87-20	Perimeter Sign Maintenance (Reed and Holmer 1987)	254.0 acres	11	18	3, 4, 5, 7, 12, 13, 17, 18, 21, 22
ISU-87-22	FOC-ANL/Highway 20 (Reed 1987b)	17.0 acres	2	0	21
ISU-88-1	NRF Waste Ditch (Ringe 1988a)	1000.0 acres	32	32	11
ISU-88-3	ICPP Gravel Pit (Ross 1988)	2.5 acres	1	0	13
ISU-88-5	Fiber Optics-TRA/ Lincoln Blvd. (Wright 1988a)	46.0	2	0	13
ISU-88-7	Gravel Haul Road (Wright 1988b)	37.5	3	1	13
ISU-88-9	ANL-W Administrative Boundary (Ringe 1988b)	600.0 acres	21	13	21
ISU-88-12	T-12 Borrow Pit (Ringe 1988c)	10.0 acres	0	0	3
ISU-88-13	RWMC Wind Gap (Ringe 1988d)	60.0 acres	1	3	3
ISU-88-14	RWMC Inactive Borrow Area (Ringe 1988e)	53.0 acres	1	2	6
ISU-88-16	EBR I Display Area (Ringe 1988f)	2.5 acres	0	0	13

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SURVEY NUMBER	PROJECT NAME	ACREAGE	IFs	SITES	MAP NUMBERS ^a
ISU-89-1	CPP/TRA Gravel Pit (Ringe 1989a)	35.0 acres	0	1	13
ISU-89-2	Hunting Boundary (Wright and Holmer 1990)	675.0 acres	18	27	1, 5, 9, 11, 15, 22, 24, 29, 30
ISU-89-3	Lost River Fault Trench (Ringe 1989b)	4.0 acres	1	0	15
ISU-89-4	NPR Seismic Stations (Ringe 1989c)	5.0 acres	1	1	5, 12, 19
ISU-89-5	1990 Testing of 10 sites and Misc. survey projects in NPR Area E (Ringe 1990d)	240.0 acres	25	18	12, 13
ISU-89-6	Fast Attack Vehicles (Wright et al. 1989)	915.0 acres	30	33	13
ISU-89-8	Fenceline and Demonstration Area (Henrikson and Holmer 1990a)	45.0 acres	2	0	12
ISU-90-2	RWMC/Section 18 (Sammons-Lohse and Holmer 1990)	400.0 acres	17	13	3, 6
ISU-90-4	NPR Sample Survey (Henrikson and Holmer 1990b)	1200.0 acres	38	40	11, 12, 13
ISU-91-1	PBF/NPR Access Road (Henrikson et al. 1990)	64.0 acres	1	3	12
ISU-91-2	1991 Testing of 41 sites and Misc. survey projects in NPR Area E (Henrikson and Holmer 1991)	1105.0 acres	18	16	12, 13
EGG-90-1	ICPP Percolation Pond (Ringe 1990e)	54.0 acres	3	0	13
EGG-90-2	CFA Groundwater Monitoring Wells (Ringe 1990f)	2.5 acres	1	0	13
EGG-90-3	RWMC Sewage Lagoon (Lowrey 1990a)	12.0 acres	0	0	3
EGG-90-4	RWMC Bore Holes (Lowrey 1990b)	3.0 acres	0	0	3, 6
EGG-90-5	TAN Core Drilling (Ringe 1990g)	5.0 acres	0	0	8
EGG-90-6	RWMC Administrative Expansion (Marler 1990a)	1.0 acre	0	0	3
EGG-90-7	TRA Warm Water Waste Pond (Marler 1990b)	1.0 acre	0	0	13
EGG-90-8	INEL Sewer Upgrade (Ringe 1990e)	225.0 acres	25	4	8, 13
EGG-90-9	ICPP/NPR Access Road Upgrade (Ringe 1990f)	84.0 acres	1	3	13
EGG-90-10	Cinder Butte Rattlesnake Study (Ringe 1990c)	1.0 acre	0	1	5, 8

SURVEY NUMBER	PROJECT NAME	ACREAGE	IFs	SITES	MAP NUMBERS ^a
EGG-90-11	RWMC/CFA Powerline (Ringe 1990g)	220.0 acres	6	8	3, 13
EGG-90-13	T-12 Gravel Pit Expansion (Marler 1990c)	5.0 acres	0	0	3
EGG-90-14	Teakettle Butte Spring Development (Ringe 1990b)	1.0 acre	0	0	25
EGG-90-15	Soil Coring Near PBF (Ringe 1990a)	1.0 acre	1	0	12, 13
EGG-91-7	Final Alignment of PBF/NPR Road (Ringe 1991b)	20.0 acres	2	2	13
EGG-91-12	NRF Bore Holes (Ringe 1991c)	38.0 acres	2	1	11
EGG-91-14	NPR Thermoluminescence Plots (Miller 1991)	5.0 acres	0	0	Off INEL
EGG-91-22	WAG 7/RWMC Wells (Miller 1992a)	93.0 acres	3	4	3,6
EGG-91-24	Off site Deep Wells (Ringe 1991a)	2.0 acres	1	0	4, 7, 18, 21
EGG-92-1	Elk Capture and Relocation (Lowrey 1991)	Undetermined	0	1	20
EGG-92-19	NRF Railroad Spur (Ringe 1992a)	34.0 acres	0	0	11
EGG-92-20	TAN Monitoring Wells (Miller 1992b)	5.0 acres	0	0	8
EGG-92-30	RWMC Powerline Rebuild	15 acres	3	5	3, 13
EGG-92-34	SNTP Tank Farm (Ringe 1992b)	39 acres	0	1	8
EGG-93-9	INEL Central Connector (Marler 1992)	25 acres	3	1	13
TOTALS	103 Survey Projects	23,677.0 acres	790	737s	

a. Numbers correspond to maps in Section F.6.

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Table F-2. Cultural resource testing projects on the INEL, July 1984 to July 1992.

PROJECT NUMBER	PROJECT NAME	TOTAL SITES	SIGNIFICANT SITES	NONSIGNIFICANT SITES	TESTING METHODS	C ₁₄ DATES
ISU-88-4	Testing of Three Sites Near the INEL Weapons Range (Wright 1988a)	3	0	3		None
ISU-88-6	Testing of Ten Sites Along the 135 kV Line (Ringe 1988g)	10	6	4	Shovel probes and 1 x 2 m test units on 10 cm levels	10BT1043, hearth, 1350±70 BP; 10BT1052, hearth, 310±80 BP
ISU-89-5	Archaeological Investigations at New Production Reactor Area E on the INEL (Ringe 1990d)	10	10	0	1x2m test units in 10 cm levels	None
ISU-91-1	Archaeological Investigations at New Productions Reactor Area E (Henrikson and Holmer 1991)	41	23	18	Shovel probes and 1x2m test units in 10 cm levels	None
ISU-91-6	Subsurface Archaeological Investigations at New Production Reactor Area E on the INEL (Thompson 1992)	17	2	15	Shovel probes and 1x2m test units in 10 cm levels	10BT395, hearth, 1500±60 BP
EGG-92-15	RWMC Expansion: Pit Nine Administrative Area (Ringe 1992d)	1	0	1	Shovel probes	None
EGG-92-17	RWMC Expansion: Operations Control Building, Roadway, and Powerline (Ringe 1992e)	1	0	1	Shovel probes	None
EGG-92-30	RWMC Expansion: Sewage Lagoon (Ringe 1992c)	1	0	1	Shovel Probes	None
TOTALS	8 Projects	84 Total Sites	43	43		

F.3 Useful Plants Found on the INEL

Table F-3. Edible, medicinal, and practical plants growing on the INEL.

Scientific Name	Common Name	Use and Reference
<i>Agropyron spp.</i>	Wheatgrass	Seeds eaten (Chamberlin 1974: 360; Steward 1938:21) and used as coffee substitute (Harrington 1967:301; Ross 1976:4); roots eaten and used for kidney disorders (Ross 1976:4).
<i>Allium spp.</i>	Wild Onion	Roots and greens eaten, used as flavoring in other foods, skin used for dye (Craighead et al. 1963:16; Harrington 1967: 345; Nickerson 1966; Ross 1976:6; Steward 1938:21).
<i>Artemisia spp.</i>	Sagebrush	Leaves made into tea for fever, leaves used as covering over other foods in storage caches Chamberlin 194:363); leaves used for dye (Craighead et al. 1963: 193); seeds eaten, wood used for fires, bark used for bags and clothing, plant boiled and used for fevers, colds and sore eyes (Steward 1938:33, 310).
<i>Astragalus spp.</i>	Milkvetch	Some species poisonous; roots, pods, peas eaten (Craighead et al. 1963:97; Harrington 1967:20); used for horse medicines (Chamberlin 1974:363).
<i>Atriplex spp.</i>	Shadscale	Seeds eaten (Steward 1938: 22), greens eaten when young, plant used as flavoring in other foods or as dye (Harrington 1967:20; Nickerson 1966:47; Ross 1976:3).
<i>Balsamorhiza spp.</i>	Arrowroot	Greens boiled and eaten, seeds eaten, plant mashed and applied to fresh wounds (Chamberlin 1974:363); roots, greens, young shoots, seeds and stems eaten (Craighead et al. 1963:196; Ross 1976; Steward 1938:22).
<i>Carex spp.</i>	Sedge	Greens, shoots eaten when young, larger plants used for bedding (Chamberlin 1974: 365; Craighead et al. 1963:8).
<i>Cardus spp.</i> or <i>Cirsium spp.</i>	Thistle	Roots, stems, young shoots eaten (Craighead et al. 1963: 203; Harrington 1967:166; Steward 1938:22).
<i>Castilleja spp.</i>	Indian Paintbrush	Blossoms used for dye (Nickerson 1967:50).
<i>Chaenactis spp.</i>	Yarrow	Leaves, roots boiled and used for diarrhea (Steward 1938:310); plant mashed and applied to sore limbs (Chamberlin 1974:365); plant made into tea for slowing heartbeat (Nickerson 1966:50).
<i>Chenopodium spp.</i>	Goosefoot	Seeds and shoots eaten, leaves used as tea (Chamberlin 1974:366; Harrington 1967:71; Steward 1938:23).
<i>Chrysothamnus spp.</i>	Rabbitbrush	Plant used for rubber (Ross 1976:5); roots used as chewing gum, roots made into salve for colds, measles and smallpox (Steward 1938:23, 311).
<i>Crepis spp.</i>	Hawksbeard	Leaves eaten (Chamberlin 1974:367; Steward 1938:24).
<i>Delphinium spp.</i>	Desert larkspur	Blossoms used for dye (Nickerson 1966:47).

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Table F-3. (continued).

Scientific Name	Common Name	Use and Reference
<i>Elymus spp.</i>	Great Basin wild rye	Seeds eaten (Chamberlin eaten and plant used as drug (Ross 1976:4); seeds eaten and plant used for thatch and bedding (Steward 1938).
<i>Erigonum spp.</i>	Buckwheat	Flowers boiled and used for stomach disorders (Steward 1938:311); plant used for eye disorders, stomach aches and burns (Chamberlin 1974:368).
<i>Erigeron spp.</i>	Fleabane	Roots used for arrow poison (Chamberlin 1974:368); plant used as medicine during childbirth (Ross 1976:5).
<i>Erysimum spp.</i>	Wallflower	Seeds used as flavoring in other foods (Craighead et al. 1963:5).
<i>Erotia spp.</i>	Winterfat	Used for intermittent fever (Chamberlin 1974:369).
<i>Gilia spp.</i>	Many Flowered Gilia	Mashed and applied to Flowered wounds and bruises (Chamberlin 1974:370); blossoms dried, powdered and applied to relieve pain, whole plant used for blood disease (Nickerson 1966:49).
<i>Helianthus spp.</i>	Sunflower	Seeds eaten and processed for oil (Chamberlin 1974: 371); seeds eaten and processed for oil, stems used for fiber, flowers used for dye (Craighead et al. 1963: 218); seeds eaten, processed for oil and used as coffee substitute, flowers boiled and eaten (Harrington 1967:314); seeds eaten, roots boiled and used as physic and emetic (Steward 1938).
<i>Heracleum spp.</i>	Cow Parsnip	Stems peeled and eaten (Chamberlin 1974:371; Craighead et. al. 1963:126; Harrington 1967:132); roots, leaves and stems eaten, used as salt substitute, used in treatment of rheumatism, fainting or convulsions, made into poultice for boils, intestinal pain, and as a physic (Ross 1976:2).
<i>Lactuca spp.</i>	Prickly Wild Lettuce	Leaves and young shoots eaten (Craighead et al. 1963 221), roots used as chewing gum (Ross 1976:2); leaves eaten (Steward 1938:25)
<i>Lappula spp.</i>	Stickweed	Seeds eaten (Steward 1938: 25).
<i>Lomatium spp.</i>	Desert Parsley	Roots eaten (Craighead et al. 1963:127; Ross 1976:1).
<i>Lygodesmia spp.</i>	Skeleton Weed	Used as horse medicine (Chamberlin 1974:374); leaves boiled with meat (Craighead et al. 1963:222); hardened juice used as chewing gum (Ross 1976:5).
<i>Menuha spp.</i>	Mint	Leaves boiled to make tea (Steward 1938:26; Chamberlin 1974:374); leaves boiled to make tea, used in medicines, flavoring agents and perfumes (Craighead et al. 1963:161); tea made and consumed for indigestion (Nickerson 1966:50).
<i>Oenothera spp.</i>	Primrose	Seeds eaten, roots used as medicine (Chamberlin 1974: 375; Craighead et al. 1963: 121; Harrington 1967:82; Steward 1938).
<i>Opuntia spp.</i>	Prickly Pear Fruit	Fruit eaten and made into candy, used as emergency water source (Craighead et al.
	Cactus	1963:120); fruit and pulp eaten, used as emergency water source (Steward 1938: 26; Harrington 1967: 248).

Table F-3. (continued).

Scientific Name	Common Name	Use and Reference
<i>Oryzopsis spp.</i>	Indian Ricegrass	Seeds eaten (Craighead et al. 1963:120; Harrington 1967: 248; Ross 1976:3; Steward 1938:26).
<i>Phacelia spp.</i>	Phacelia	Leaves eaten (Craighead et al. 1963:152).
<i>Poa spp.</i>	Bluegrass	Seeds eaten (Steward 1938: 28; Chamberlin 1974:377).
<i>Rumex spp.</i>	Dock	Root used as blood medicine and for severe constipation (Craighead et al. 1963:44; Chamberlin 1974:380); leaves, seeds and stems eaten, used as flavoring in other foods, and to tan hides, seeds used as tobacco (Harrington 1967:145; Ross 1976:3); seeds eaten, plant made into tea, roots mashed and applied to swellings, cuts and sores (Steward 1938:29).
<i>Salsola spp.</i>	Tumbleweed	Seeds and young shoots eaten (Harrington 1967:93).
<i>Sarcobatus spp.</i>	Greasewood	Wood used for arrow shafts and digging sticks (Steward 1938:312).
<i>Sisymbrium spp.</i>	Tumble Mustard	Seeds and greens eaten, used as flavoring in other foods (Steward 1938:30; Harrington 1967:62, 95; Chamberlin 1974:382).
<i>Sitanion spp.</i>	Squirreltail Grass	Seeds eaten (Steward 1938: 30)
<i>Sonchus spp.</i>	Sow Thistle	Leaves eaten (Craighead et al. 1963:277; Harrington 1967:149; Chamberlin 1974:382; Ross 1976:2).
<i>Sphaeralcea spp.</i>	Globemallow	Plant boiled and mixed with potters' clay (Steward 1938: 312; Chamberlin 1974:382).
<i>Stipa spp.</i>	Needle and Thread Grass	Seeds eaten (Steward 1938:30)
<i>Taraxacum spp.</i>	Dandelion	Leaves, stems and roots eaten, root used as tonic, diuretic or laxative, flowers made into wine (Craighead et al. 1963:227); leaves, stems and roots eaten, flowers made into wine, seeds dried and used as coffee substitute, leaves used as tea (Harrington 1967:99); leaves and flowers eaten (Ross 1976:3).
<i>Tragopogon spp.</i>	Goatsbeard	Roots boiled and used for indigestion (Craighead et al. 1963: 231); leaves eaten, juice used as chewing gum (Ross 1976:5).
<i>Trifolium spp.</i>	Clover	Leaves, greens and seeds eaten (Steward 1938:30; Craighead et al. 1963:104).

F.4 Programmatic Priorities

The ongoing management of INEL cultural resources is guided by the "INEL Management Plan for Cultural Resources" (Miller 1992b), now in draft form and being reviewed by DOE-ID and INEL contractors. The stated purposes of this document are the following: (a) respond to DOE directives and memoranda issued in regard to cultural resources, (b) serve as a handbook for DOE-ID and its contractors for environmental planning and cultural resource compliance activities in regard to land-use decisions on the INEL, (c) direct the compliance and research commitments of the INEL-CRM Office, (d) summarize the philosophical and legal background of cultural resource protection on federal land, and (e) define the nature and extend of INEL cultural resources (prehistory, history, paleontology, ethnography). Sections F.4.1 through F.4.7 below identify the outstanding requirements/needs that are integral for successful implementation of this document.

F.4.1 Programmatic Agreements

Agreements between the DOE-SHPO-ACHP, DOE-Shoshone/Bannock Tribes, and DOE-Curation Facility are needed immediately. These agreements will streamline communications between all offices and agencies with cultural resource interests on the INEL, and will set standards and procedures for cultural resource compliance activities.

F.4.2 Communication Between INEL Programs/Managers and the INEL-CRM Office

The methods by which the INEL-CRM Office is notified about impending projects needs to be formalized and streamlined to prevent possible construction delays. Maintenance of up-to-date survey and resource files is essential for responsible management of INEL cultural resources. Survey files are regularly updated as a result of NEPA and NHPA-driven compliance activities. However, computerized archaeological site registrations are currently backlogged for the years 1984 through 1988. Integration of INEL-CRM data with the INEL Geographical Information System (GIS) would also facilitate project planning.

F.4.3 NHPA Section 110 Compliance

Section 110 of the National Historic Preservation Act requires federal land managers, like DOE-ID, to actively manage all potentially significant cultural resources on lands under their jurisdiction. Current efforts are only focussed on resources in danger of impact by INEL construction projects. A system should be established to inventory all important resources on the INEL. This must be guided by a comprehensive research design and predictive model. A system for monitoring the condition of known sites that are currently in high impact areas or subject to vandalism, erosion, and other forms of adverse impact must also be established.

F.4.4 Law Enforcement

Violations of the Archaeological Resource Protection Act in the form of vandalism to pictographs (indian rock paintings), illegal artifact collection, unauthorized excavation, uncontrolled off-road vehicle travel, and other activities are known to occur on the INEL. Currently, no mechanisms exist to discourage these activities and training programs must be established.

F.4.5 INEL Cave Resource Management Plan

Caves are among the most significant resources located on the INEL, for their cultural as well as biological aspects. Over 25 caves are known to exist within INEL boundaries but few have been examined and appropriately documented. Many are also subject to adverse impact in the form of graffiti, unauthorized excavation, unauthorized camping, and erosion, among others. A comprehensive inventory and management plan must be developed for these unique resources.

F.4.6 INEL Paleontological Management Plan

The INEL contains many paleontological localities that contain important taxonomic, phylogenetic, ecologic, taphonomic, temporal, climatic, and stratigraphic data. Measures to inventory and manage these resources are currently nonexistent, and must be developed.

F.4.7 INEL History

The INEL has a rich and varied history as a nuclear research laboratory and many of its facilities are eligible for nomination to the National Register of Historic Places. Because no program exists to assemble this important information, a great deal is being lost as a result of facility decontamination/decommissioning, and even through employee retirement. To remain in compliance with the National Historic Preservation Act, a program to collect and archive this important information is required.

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F.6 INEL Archaeological Survey Maps

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12.	ATOMIC CITY, IDAHO QUADRANGLE	F-40
13.	ARCO HILLS, IDAHO QUADRANGLE	F-41
14.	SCOVILLE, IDAHO QUADRANGLE	F-42
15.	KETTLE BUTTE SW, IDAHO QUADRANGLE	F-43
16.	KETTLE BUTTE NW, IDAHO QUADRANGLE	F-44
17.	LITTLE BUTTE, IDAHO QUADRANGLE	F-45
18.	QUAKING ASPEN BUTTE, IDAHO QUADRANGLE	F-46
19.	SCOTT BUTTE, IDAHO QUADRANGLE	F-47
20.	BUTTE CITY, IDAHO QUADRANGLE	F-48
21.	HOWE PEAK, IDAHO QUADRANGLE	F-49
22.	LITTLE BUTTE NW, IDAHO QUADRANGLE	F-50
23.	LITTLE BUTTE NE, IDAHO QUADRANGLE	F-51
24.	TERRETON, IDAHO QUADRANGLE	F-52
25.	ANTELOPE BUTTE, IDAHO QUADRANGLE	F-53
26.	BIG LOST RIVER SINKS, IDAHO QUADRANGLE	F-54
27.	RICHARD BUTTE, IDAHO QUADRANGLE	F-55
28.	SNAKY CANYON, IDAHO QUADRANGLE	F-56
29.	CIRCULAR BUTTE NW, IDAHO QUADRANGLE	F-57
30.	LITTLE LOST RIVER SINKS, IDAHO QUADRANGLE	F-58

a. Numbers refer to the Map Numbers shown on Table F-1 in Section F.2 (see pages F-9 through F-13).

Map No. 1 Appendix F ♦ F-29

Appendix F ♦ F-30 Map No. 2

CIRCULAR BUTTE, IDAHO

1000

Appendix F ♦ F-32 Map No. 4

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

BIG SOUTHERN BUTTE QUADRANGLE
IDAHO-BUTTE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
1:250,000

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CIRCULAR BUTTE 3 NE QUADRANGLE
IDAHO-BUTTE CO
7.5 MINUTE SERIES (TOPOGRAPHIC)

DEPRESSION

GRAZING ECOMONY SURVEY
8 SIGNIFICANT RESOURCES
(ON THIS MAP)

LINCOLN BLVD. SURVEY
8 SIGNIFICANT RESOURCES
(ON THIS MAP)

NAT. ENGINEERING LABORATORY

NIP GRAVE PIT SURVEY
8 SIGNIFICANT RESOURCES

ARVPS SURVEY AREA
8 SIGNIFICANT RESOURCES

NIP SURVEY QUADRANTS
8 SIGNIFICANT RESOURCES

NIP SURVEY QUADRANTS
8 SIGNIFICANT RESOURCES
(ON THIS MAP)

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Scale 1:250,000

Projection: UTM
Datum: NAD 83
Units: Meters

Map Classification
Scale: 1:250,000
Projection: UTM
Datum: NAD 83
Units: Meters

CIRCULAR BUTTE 3 NE, IDAHO
7.5 MINUTE SERIES

Appendix F ♦ F-36 Map No. 8

Map No. 9 Appendix F ♦ F-37

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

MIDDLE BUTTE QUADRANGLE
IDAHO-BENHAM CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

REL. BOUNDARY SURVEY & BOUNDARY RESOURCES (ON THIS MAP)

SCALE 1:40,000

CONTOUR INTERVAL 10 FEET

NATIONAL GEODETIC SURVEY, 1911-1912

ROAD CLASSIFICATION

MIDDLE BUTTE, IDAHO

[illegible]

[illegible]

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ARCO HILLS QUADRANGLE
IDAHO-BUTTE CO
7.5 MINUTE SERIES (TOPOGRAPHIC)

Map scale: 1 inch = 24,000 feet

Legend:

- Primary highways
- Light duty road
- Dark duty road
- Secondary highways
- Light duty road
- Dark duty road
- Intermittent road
- U.S. Route
- State Route

REL BOUNDARY SURVEY
SIGNIFICANT RESOURCES
(ON THIS MAP)

SCALE: 1 inch = 24,000 feet

CONTOUR INTERVAL: 20 FEET

ORIGINAL BENCH MARK: 100

ARCO HILLS, IDAHO
1972

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SCOVILLE QUADRANGLE
IDAHO
7.5 MINUTE SERIES (TOPOGRAPHIC)

NATIONAL ENGINEERING LABORATORY

GRAZING BOUNDARY SURVEY
SIGNIFICANT RESOURCES
(ON THIS MAP)

MIL BOUNDARY SURVEY
SIGNIFICANT RESOURCES
(ON THIS MAP)

SCALE 1:24,000

CONTOUR INTERVAL, 20 FEET

ROAD CLASSIFICATION

Primary highways
Secondary highways
Unimproved roads
Private roads

Light duty roads
Medium duty roads
Heavy duty roads

SCOVILLE, IDAHO
1973

KETTLE BUTTE SW QUADRANGLE
IDAHO-BONNEVILLE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

Appendix F ♦ F-44 Map No. 16

LITTLE BUTTE QUADRANGLE
IDAHO
7.5 MINUTE SERIES (TOPOGRAPHIC)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

QUAKING ASPEN BUTTE QUADRANGLE
IDAHO-BUTTE CO
7.5 MINUTE SERIES (TOPOGRAPHIC)

NATIONAL REACTOR TESTING STATION

MIL SOIL SURVEY & SIGNIFICANT RESOURCES (ON THIS MAP)

SCALE 1:24,000

CONTOUR INTERVAL 20 FEET

ROAD CLASSIFICATION

Primary highway Light duty road none
Highway Improved surface
Secondary highway Unimproved road
None surface U.S. Route State Route

THIS MAP COMPLETES THE NATIONAL MAP ACCURACY STANDARD
FOR SALE BY U.S. GEOLOGICAL SURVEY BANNER CO. ORDER NO. 10071 OR 10072
A VALUE ACCORDING TO THE NATIONAL MAP ACCURACY STANDARD

QUAKING ASPEN BUTTE, IDAHO
845225-011071-13
1972

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SCOTT BUTTE QUADRANGLE
IDAHO-CLARK CO
7.5 MINUTE SERIES (TOPOGRAPHIC)

117° 37' 30" W 117° 30' W 117° 22' 30" W 117° 15' 30" W 117° 8' 30" W 117° 1' 30" W 116° 54' 30" W 116° 47' 30" W 116° 40' 30" W 116° 33' 30" W 116° 26' 30" W 116° 19' 30" W 116° 12' 30" W 116° 5' 30" W 116° 0' 30" W 115° 53' 30" W 115° 46' 30" W 115° 39' 30" W 115° 32' 30" W 115° 25' 30" W 115° 18' 30" W 115° 11' 30" W 115° 4' 30" W 115° 0' 30" W 114° 53' 30" W 114° 46' 30" W 114° 39' 30" W 114° 32' 30" W 114° 25' 30" W 114° 18' 30" W 114° 11' 30" W 114° 4' 30" W 114° 0' 30" W 113° 53' 30" W 113° 46' 30" W 113° 39' 30" W 113° 32' 30" W 113° 25' 30" W 113° 18' 30" W 113° 11' 30" W 113° 4' 30" W 113° 0' 30" W 112° 53' 30" W 112° 46' 30" W 112° 39' 30" W 112° 32' 30" W 112° 25' 30" W 112° 18' 30" W 112° 11' 30" W 112° 4' 30" W 112° 0' 30" W 111° 53' 30" W 111° 46' 30" W 111° 39' 30" W 111° 32' 30" W 111° 25' 30" W 111° 18' 30" W 111° 11' 30" W 111° 4' 30" W 111° 0' 30" W 110° 53' 30" W 110° 46' 30" W 110° 39' 30" W 110° 32' 30" W 110° 25' 30" W 110° 18' 30" W 110° 11' 30" W 110° 4' 30" W 110° 0' 30" W 109° 53' 30" W 109° 46' 30" W 109° 39' 30" W 109° 32' 30" W 109° 25' 30" W 109° 18' 30" W 109° 11' 30" W 109° 4' 30" W 109° 0' 30" W 108° 53' 30" W 108° 46' 30" W 108° 39' 30" W 108° 32' 30" W 108° 25' 30" W 108° 18' 30" W 108° 11' 30" W 108° 4' 30" W 108° 0' 30" W 107° 53' 30" W 107° 46' 30" W 107° 39' 30" W 107° 32' 30" W 107° 25' 30" W 107° 18' 30" W 107° 11' 30" W 107° 4' 30" W 107° 0' 30" W 106° 53' 30" W 106° 46' 30" W 106° 39' 30" W 106° 32' 30" W 106° 25' 30" W 106° 18' 30" W 106° 11' 30" W 106° 4' 30" W 106° 0' 30" W 105° 53' 30" W 105° 46' 30" W 105° 39' 30" W 105° 32' 30" W 105° 25' 30" W 105° 18' 30" W 105° 11' 30" W 105° 4' 30" W 105° 0' 30" W 104° 53' 30" W 104° 46' 30" W 104° 39' 30" W 104° 32' 30" W 104° 25' 30" W 104° 18' 30" W 104° 11' 30" W 104° 4' 30" W 104° 0' 30" W 103° 53' 30" W 103° 46' 30" W 103° 39' 30" W 103° 32' 30" W 103° 25' 30" W 103° 18' 30" W 103° 11' 30" W 103° 4' 30" W 103° 0' 30" W 102° 53' 30" W 102° 46' 30" W 102° 39' 30" W 102° 32' 30" W 102° 25' 30" W 102° 18' 30" W 102° 11' 30" W 102° 4' 30" W 102° 0' 30" W 101° 53' 30" W 101° 46' 30" W 101° 39' 30" W 101° 32' 30" W 101° 25' 30" W 101° 18' 30" W 101° 11' 30" W 101° 4' 30" W 101° 0' 30" W 100° 53' 30" W 100° 46' 30" W 100° 39' 30" W 100° 32' 30" W 100° 25' 30" W 100° 18' 30" W 100° 11' 30" W 100° 4' 30" W 100° 0' 30" W 99° 53' 30" W 99° 46' 30" W 99° 39' 30" W 99° 32' 30" W 99° 25' 30" W 99° 18' 30" W 99° 11' 30" W 99° 4' 30" W 99° 0' 30" W 98° 53' 30" W 98° 46' 30" W 98° 39' 30" W 98° 32' 30" W 98° 25' 30" W 98° 18' 30" W 98° 11' 30" W 98° 4' 30" W 98° 0' 30" W 97° 53' 30" W 97° 46' 30" W 97° 39' 30" W 97° 32' 30" W 97° 25' 30" W 97° 18' 30" W 97° 11' 30" W 97° 4' 30" W 97° 0' 30" W 96° 53' 30" W 96° 46' 30" W 96° 39' 30" W 96° 32' 30" W 96° 25' 30" W 96° 18' 30" W 96° 11' 30" W 96° 4' 30" W 96° 0' 30" W 95° 53' 30" W 95° 46' 30" W 95° 39' 30" W 95° 32' 30" W 95° 25' 30" W 95° 18' 30" W 95° 11' 30" W 95° 4' 30" W 95° 0' 30" W 94° 53' 30" W 94° 46' 30" W 94° 39' 30" W 94° 32' 30" W 94° 25' 30" W 94° 18' 30" W 94° 11' 30" W 94° 4' 30" W 94° 0' 30" W 93° 53' 30" W 93° 46' 30" W 93° 39' 30" W 93° 32' 30" W 93° 25' 30" W 93° 18' 30" W 93° 11' 30" W 93° 4' 30" W 93° 0' 30" W 92° 53' 30" W 92° 46' 30" W 92° 39' 30" W 92° 32' 30" W 92° 25' 30" W 92° 18' 30" W 92° 11' 30" W 92° 4' 30" W 92° 0' 30" W 91° 53' 30" W 91° 46' 30" W 91° 39' 30" W 91° 32' 30" W 91° 25' 30" W 91° 18' 30" W 91° 11' 30" W 91° 4' 30" W 91° 0' 30" W 90° 53' 30" W 90° 46' 30" W 90° 39' 30" W 90° 32' 30" W 90° 25' 30" W 90° 18' 30" W 90° 11' 30" W 90° 4' 30" W 90° 0' 30" W 89° 53' 30" W 89° 46' 30" W 89° 39' 30" W 89° 32' 30" W 89° 25' 30" W 89° 18' 30" W 89° 11' 30" W 89° 4' 30" W 89° 0' 30" W 88° 53' 30" W 88° 46' 30" W 88° 39' 30" W 88° 32' 30" W 88° 25' 30" W 88° 18' 30" W 88° 11' 30" W 88° 4' 30" W 88° 0' 30" W 87° 53' 30" W 87° 46' 30" W 87° 39' 30" W 87° 32' 30" W 87° 25' 30" W 87° 18' 30" W 87° 11' 30" W 87° 4' 30" W 87° 0' 30" W 86° 53' 30" W 86° 46' 30" W 86° 39' 30" W 86° 32' 30" W 86° 25' 30" W 86° 18' 30" W 86° 11' 30" W 86° 4' 30" W 86° 0' 30" W 85° 53' 30" W 85° 46' 30" W 85° 39' 30" W 85° 32' 30" W 85° 25' 30" W 85° 18' 30" W 85° 11' 30" W 85° 4' 30" W 85° 0' 30" W 84° 53' 30" W 84° 46' 30" W 84° 39' 30" W 84° 32' 30" W 84° 25' 30" W 84° 18' 30" W 84

Appendix F ♦ F-48 Map No. 20

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HOWE PEAK QUADRANGLE
IDaho-BUTTE CO
7.5 MINUTE SERIES (TOPOGRAPHIC)

Appendix F ♦ F-50 Map No. 22

LITTLE BUTTE NE QUADRANGLE
IDAHO
7.5 MINUTE SERIES (TOPOGRAPHIC)

Appendix F ♦ F-52 Map No. 24

Map No. 25 Appendix F ♦ F-53

[illegible]

Map No. 27 Appendix F ♦ F-55

Appendix F ♦ F-56 Map No. 28

Map No. 29 Appendix F ♦ F-57

**UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY**

**LITTLE LOST RIVER SINKS QUADRANGLE
IDAHO-BUTTE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)**

LITTLE LOST RIVER VALLEY

DEPRESSION

**NATIONAL HUNTING BOUNDARY SURVEY
(ON THIS MAP)**

REACTOR TESTING STATION

SCALE 1 IN 60,000

CONTOUR INTERVAL 30 FEET

**DOTTED LINES REPRESENT 5 FOOT CONTOURS
BASED ON MEAN SEA LEVEL**

ROAD CLASSIFICATION

Primary highway	Light-duty road	Road or
Secondary highway	Unimproved road	
Terrace road	U.S. Road	Road Road

LITTLE LOST RIVER SINKS, IDAHO
64348—611882, 6/73

F.7 Annotated Bibliography for Cultural Resources^b

1. **Advisory Council on Historic Preservation, 1980, *Treatment of Archaeological Properties: A Handbook*, Washington D.C., November 1980.**

General guidance on the principles, procedures and methods of dealing with archaeological resources in the context of historic preservation law and in specific compliance with the National Historic Preservation Act and 36 CFR Part 800.

Subject: Archaeological research for compliance purposes
Keywords: ARCHAEOLOGICAL RESEARCH / CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / MITIGATION / EXCAVATION / ARCHAEOLOGICAL SURVEY
Location: INEL CRM Library

2. **Advisory Council on Historic Preservation, 1986, 36 CFR 800, "Protection of Historic Properties: Regulations of the Advisory Council on Historic Preservation Governing the Section 106 Review Process," Washington, D.C., October 1986.**

General guidance on compliance with the National Historic Preservation Act, particularly Section 106, which requires federal agencies to consult with state and federal preservation agencies after the identification and evaluation of historic properties in danger of impact by federal actions.

Subject: Compliance with the National Historic Preservation Act
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / NATIONAL HISTORIC PRESERVATION ACT
Location: INEL CRM Library

3. **Advisory Council on Historic Preservation and National Park Service, 1988, *Identification of Historic Properties: A Decision-Making Guide for Managers*, Washington, D.C., September 1988.**

Outline of basic principles and approaches for identifying and considering historic properties in the planning and implementation of land use and development projects on federal lands. General discussion of how to apply these principles in varying circumstances while remaining in compliance with Section 106 of the National Historic Preservation Act.

Subject: Identification of cultural resources
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / COMPLIANCE / ARCHAEOLOGICAL SURVEY /

b. Not all references are annotated. Those not annotated are provided for your information.

**ARCHITECTURAL SURVEY / NATIONAL HISTORIC
PRESERVATION ACT**

Location: INEL CRM Library

4. **Advisory Council on Historic Preservation, 1989, *Preparing Agreement Documents: How to Write Determinations of No Adverse Effect, Memoranda of Agreement, and Programmatic Agreements under 36 CFR Part 800*, Washington, D.C., September 1989.**

General guidance on the preparation of formal documentation of compliance with the National Historic Preservation Act when it is determined that an action will have some effect on significant or potentially significant cultural properties.

Subject: Preparation of agreement documents

Keywords: CULTURAL RESOURCES / MOA'S / PA'S MITIGATION / HISTORIC
PRESERVATION / COMPLIANCE / NATIONAL HISTORIC
PRESERVATION ACT

Location: INEL CRM Library

5. **Advisory Council on Historic Preservation and National Park Service, 1989, *The Section 110 Guidelines: Annotated Guidelines for Federal Agency Responsibilities Under Section 110 of the National Historic Preservation Act*, Washington, D.C., November 1989.**

General guidance on implementing Section 110 of the National Historic Preservation Act which ensures that historic preservation is fully integrated into the ongoing programs and missions of Federal agencies.

Subject: Compliance with the National Historic Preservation Act

Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
PRESERVATION / NATIONAL HISTORIC PRESERVATION ACT

Location: INEL CRM Library

6. **Advisory Council on Historic Preservation, 1991, *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities*, Washington, D.C.**

Outline and discussion of basic principles and approaches for margin historic preservation needs with the management and operation of highly technical/scientific facilities (i.e., nuclear reactors).

Subject: Historic preservation of facilities

Keywords: CULTURAL RESOURCES / COMPLIANCE / NUCLEAR HISTORY /
SCIENTIFIC SIGNIFICANCE

Location: INEL CRM Library

7. American Nuclear Society, 1992, *Controlled Nuclear Chain Reaction: The First 50 Years*, American Nuclear Society, LaGrange, IL.

8. Antevs, E., 1948, "The Great Basin, With Emphasis on Glacial and Post-Glacial Times: Climatic Changes and Pre-White Man," *University of Utah Bulletin*, 33(20):168-191.

Generalized sequence of climatic change for the Great Basin also appropriate for comparison with more detailed local (INEL region) reconstructions.

Subject: Large scale climate change
Keywords: PALYNOLOGY / PALEOECOLOGY / PALEOCLIMATE /
ALTITHERMAL / ANATHERMAL / MEDITHERMAL / ICE AGE
Location: INEL CRM Library

9. Arthur, W. J.; Connelly, J. W.; Halford, D. K., and Reynolds, T. D., 1984, *Vertebrates of the Idaho National Engineering Laboratory*, DOE/ID-120999.

Abundance, habitat use, and seasonal occurrence are reported for the 5 fish, 1 amphibian, 9 reptile, 159 birds and 37 mammal species recorded on the INEL. An additional 45 species, for which site records are lacking, were listed as possibly occurring because portions of their documented range and habitat overlap the INEL. Species of special concern on the federal and state level are discussed. Data is qualitative.

Subject: Vertebrates on the Idaho National Engineering Laboratory
Keywords: VERTEBRATES / FISH / AMPHIBIANS / REPTILES / BIRDS /
MAMMALS / ENDANGERED SPECIES / SPECIES OF CONCERN
Location: INEL Technical Library

10. Atwood, N. D., 1970, "Flora of the National Reactor Testing Station," *Brigham Young University Science Bulletin, Biological Series*, 11:1-46.

Listing of plants currently present in the INEL region useful for comparison with studies of Native American plant use to develop hypotheses about prehistoric use of the area.

Subject: Vegetation patterns on the INEL
Keywords: PLANTS LIST / MODERN VEGETATION / SAGEBRUSH
GRASSLAND
Location: INEL CRM Library

11. Beal, M. D., 1942, *A History of Southeastern Idaho*, Caldwell, Id, Caxton Printers, Ltd.

Historic overview for southeastern Idaho.

Subject: Idaho history

Appendix F ♦ F-62

Keywords: IDAHO HISTORY / AGRICULTURE / MINING / FUR TRADE /
SHOSHONE INDIANS
Location: Idaho Falls Public Library

12. Benedict, James B., 1979, "Getting Away From It All: A Study of Man, Mountains, and the Two-Drought Altithermal," *Southwestern Lore*, 54(3):11-12.
13. Bonnichsen, B., and Breckenridge, R. M., 1982, "Cenozoic Geology of Idaho," (editors), Idaho Bureau of Mines and Geology Bulletin, No. 26, Moscow, ID.

A collection of reports on regional geology covering various topics. Of special interest are the following chapters: General Features of the Snake River Plain, Volcanic Rocks, Rhyolitic Volcanism, Basalt Volcanism, Stratigraphy and Structural Relationships, Stratigraphy of Lacustrine Sediments, Stratigraphy and Paleontology, Pleistocene Lava Dams, Mountain Glaciation, Pleistocene Flood Deposits and Gravels, Pleistocene Episodes of Alluvial-Gravel Deposition, and Loess Deposits.

Subject: Idaho Geology
Keywords: PLEISTOCENE / VOLCANISM / GLACIATION / STRATIGRAPHY /
PALEONTOLOGY / SNAKE RIVER BASIN
Location: INEL CRM Library

14. Bottolfsen, C. A., 1926, "Little Bits of Lost River History," Arco Advertiser, Arco, Idaho.

Newspaper article on Idaho History.

Subject: Idaho history
Keywords: BIG LOST RIVER / IDAHO HISTORY / CULTURAL RESOURCES
Location: Idaho Falls Public Library

15. Bottolfsen, C. A., 1926, "Pioneer Lore," Blackfoot Daily Bulletin, Blackfoot, Idaho. January 18, 1926.

Newspaper article on Idaho history.

Subject: Idaho history
Keywords: IDAHO HISTORY / CULTURAL RESOURCES
Location: Idaho Falls Public Library

16. Bright, R. C., 1966, "Pollen and Seed Stratigraphy of Swan Lake, Southeastern Idaho: Its Relation to Regional Vegetational History and to Lake Bonneville History," *Tebiwa*, 9(2):1-47.

Analyses of fossil pollen, spores, and seeds from a core of Swan Lake sediments are compared with modern pollen rani samples to reveal the vegetational history of the area during the past 12,090 years.

Subject: Vegetation patterns on the INEL
Keywords: PALYNOLOGY / PALEOECOLOGY / PALEOCLIMATE / LAKE BONNEVILLE / SWAN LAKE / PLEISTOCENE
Location: INEL CRM Library

17. Bright, R. C., and Davis, O. K., 1982, "Quaternary Palcoecology of the Idaho National Engineering Laboratory, Snake River Plain, Idaho," *American Midland Naturalist*, 108(1):21-23.

Plant and animal fossils from several depositional contexts are analyzed to document the Holocene vegetation history of the INEL region. Results show the continued presence of sagebrush/ shadscale steppe throughout the period with a brief time of increased moisture at 700 B.P. when a portion of the Lake Terreton basin is suspected of being filled.

Subject: Paleoecology of the INEL
Keywords: PALYNOLOGY / PALEOECOLOGY / PALEOCLIMATE / LAVA TUBES / MIDDLE BUTTE CAVE / RATTLESNAKE CAVE / QUATERNARY / LAKE TERRETON / PACKRAT MIDDENS
Location: INEL CRM Library

18. Brosnan, C. J., 1948, *History of the State of Idaho*, New York, NY, Charles Scribner's Sons.

A detailed history of Idaho from pre-European contact to 1935. Covers: Lewis and Clark, Indians, the fur trade, missionaries, mining, agriculture, ranching, pioneers, statehood, geology, etc.

Subject: Idaho history
Keywords: HISTORY / FUR TRADE / AGRICULTURE / PIONEERS / STATEHOOD / INDIANS
Location: Idaho Falls Public Library

19. Butler, B. R., 1968, "An Introduction to Archacological Investigations in the Pioneer Basin Locality of Eastern Idaho," *Tebiwa*, 11(1):1-36.

Preliminary description of research conduced from 1965-1967 at the Wasden site/Owl Cave on the northeastern Snake River Plain near the INEL.

Subject: Archaeological excavation of the Wasden Site
Keywords: CULTURAL RESOURCES / ARCHAEOLOGICAL EXCAVATION /
WASDEN SITE / OWL CAVE / LAVA TUBES / CLIMATE /
ECOLOGY / PIONEER BASIN / PREHISTORY / PIONEER BASIN
Location: INEL CRM Library

20. Butler, B. R., 1970, "A Report on the 1967-69 Archaeological Survey of the National Reactor Testing Station, Idaho," *Tebiwa*, 13(1):58-75.

Documentation of the first archaeological surveys conducted on the INEL. Over the three year span of this intuitively-based examination of the area, 41 prehistoric sites were recorded. Although the data are difficult to work with (largely due to vague locational information), they do document the human occupation of the INEL region for at least 12,000 years and clearly show that much of the area is archaeologically sensitive.

Subject: Intuitive archaeological survey of the INEL
Keywords: CULTURAL RESOURCES / INTUITIVE ARCHAEOLOGICAL
SURVEY / PREHISTORY / PIONEER BASIN / LAKE TERRETON
Location: INEL CRM Library

21. Butler, B. R., 1978, "A Guide to Understanding Idaho Archaeology: The Upper Snake and Salmon river Country," Special Publication of the Idaho Museum of Natural History, Pocatello, ID.

A broad, non-technical overview of the prehistory of Southeastern Idaho with discussions on the history of archaeological research in the region, environmental change, cultural chronology, and prehistoric lifeways. The proposed cultural sequence includes an Early Big Game Hunting tradition followed by an extensive Archaic tradition and brief Equestrian tradition. Although these traditions are interpreted as being related to similar manifestations in the Great Basin, a greater reliance on the hunting of big game (bison and mountain sheep) is interpreted for southeastern Idaho.

Subject: Prehistory of southeastern Idaho
Keywords: ARCHAEOLOGICAL EXCAVATION / WILSON BUTTE CAVE /
BIRCH CREEK VALLEY / PREHISTORY / WASDEN SITE /
CULTURAL RESOURCES / PREHISTORIC RESOURCES /
PIONEER BASIN / LAKE TERRETON / BIG GAME HUNTING /
CULTURAL CHRONOLOGY
Location: INEL CRM Library

22. Butler, B. R., 1981, "Little Lost River Cave No. 1, the Birch Creek Project and the Antiquity of the Northern Shoshone," Occasional Papers of the Idaho Museum of Natural History, No. 32, Pocatello, ID.

Brief presentation of the results of archaeological excavations conducted in 1954 at Little Lost River No. 1, located north of the INEL. Meager notes and records indicate that excavation revealed three stratigraphic levels probably dating from 150 to 3000 B.P. Fragments of basketry recovered from the excavation are classified as Fremont in affiliation and are key in the construction of an argument for the persistence of the Fremont Culture in southeastern Idaho, long after its apparent collapse in Utah. The article concludes with a discussion of Numic expansion and the antiquity of Northern Shoshonean occupation in the region.

Subject: Archaeological excavation of Little Lost River Cave No. 1
Keywords: CULTURAL RESOURCES / PREHISTORIC RESOURCES / CAVE /
ARCHAEOLOGICAL EXCAVATION / BASKETRY / FREMONT
CULTURE / SHOSHONE INDIANS / BITTERROOT CULTURE /
NUMIC EXPANSION
Location: INEL CRM Library

23. Butler, B. R., 1986, "Prehistory of the Snake and Salmon River Area," D'Azevedo, W. L., (editor), *Great Basin*, Vol. 11, pp. 127-134.

A discussion on the prehistory of southeastern Idaho covering the Early Big Game Hunting Period (12,500-5,800 B.C.), the Archaic Period 5800 B.C.-A.D. 500), and the Late Period (A.D. 500-1805).

Subject: Idaho Prehistory
Keywords: CULTURAL RESOURCES / PREHISTORY / SNAKE RIVER BASIN /
WASDEN SITE / BIRCH CREEK VALLEY / JAGUAR CAVE /
CULTURAL CHRONOLOGY
Location: INEL CRM Library

24. Butler, William B., 1987, "Significance and Other Frustrations in the CRM Process," *American Antiquity*, 52(4):820-829.

25. Carnett, C., 1991, *Legal Background of Archaeological Resources Protection*, USDI National Service Cultural Resources Technical Brief No. 11, Washington, D.C.

26. Chamberlin, R. V., 1974, "The Ethno-Botany of the Gosiute Indians of Utah," *American Anthropological Association Report*, 2(5):331-405.

A discussion of various native plants that were utilized by the Gosiute Indians for food, medicine, dyes, and various materials.

Subject: Ethnobotany
Keywords: NATIVE PLANTS / ETHNOBOTANY / PLANT FOODS / PLANT
DYES / PLANT MEDICINE / USEFUL PLANTS
Location: INEL CRM Library

27. **Clark, S. F.**, 1986, *Nineteenth Century Shoshone-Bannock Riparian Adaptation*, Master's Thesis, Idaho State University, Pocatello, ID.

28. **Clements, L. J.**, n.d., *A Collection of Upper Snake River Valley History Plus a Complete Biography of Andrew Henry*, Rexburg, ID, Upper Snake River Valley Historical Society.

A collection of short histories and stories of pioneering and trapping in the Snake River Valley including campfire tales of eastern Idaho and the biography of Andrew Henry, the earliest confirmed trapper in the valley.

Subject: Idaho history
Keywords: ANDREW HENRY / FUR TRADE / BIOGRAPHY / HISTORY /
SNAKE RIVER BASIN
Location: Idaho Falls Public Library

29. **Coale, G. L.**, 1963, "A Study of Shoshonean Pottery," *Tebiwa*, 6(2):1-11.

Type description for Shoshonean pottery commonly found on the INEL (also known as Intermountain Ware). Pots were constructed by coiling or modeling and were generally cone or flower-pot in shape with flat bottoms. Temper consists of grit or sand and firing was uneven and of variable temperature.

Subject: Prehistoric ceramics of southeastern Idaho
Keywords: POTTERY / CERAMICS / SHOSHONE INDIANS /
INTERMOUNTAIN WARE / LATE PREHISTORIC
Location: INEL CRM Library

30. **Coloff, S.**, 1965, "The High and Dry Navy: World War II," *Philtron*, October.

31. **Conley, C.**, 1982, *Idaho For the Curious: A Guide*, Cambridge, ID, Backeddy Books.

A descriptive and complete road/travel guide to historic sites and other places of interest throughout Idaho, including mention of EBR I on the INEL.

Subject: Idaho Travel Guide
Keywords: HISTORY / PLACES OF INTEREST / GUIDE BOOK / EBR I
Location: Idaho Falls Public Library

32. Crabtree, D. E., 1982, "An Introduction to Flintworking," occasional Papers of the Idaho Museum of Natural History, No. 28, Pocatello, ID.

Discussion of methods of prehistoric stone tool manufacture (flintknapping or flintworking). Includes extensive glossary and list of terms with informative illustrations.

Subject: Methods of stone tool manufacture
Keywords: FLINTWORKING / STONE TOOLS / ARTIFACTS
Location: INEL CRM Library

33. Craighead, J. J., and Craighead, F. C. Jr., 1963, *A Field Guide to Rocky Mountain Wildflowers*, Boston, MA, Houghton and Mifflin Co.
34. Crowder, D. L., 1981, *Tales of Eastern Idaho*, Idaho Falls, ID, Curtiss Press, Inc.
35. Currey, D. R., and James, S. R., 1982, "Paleoenvironments of the Northeastern Great Basin and Northeastern Basin Rim Region: A Review of Geological and Biological Evidence," Madsen, D. B.; O'Connell, J. F., *Man and Environment in the Great Basin*, Society For American Archaeology Papers No. 2, Washington, D.C.
36. Davis, O. K.; Sheppard, J. C., and Robertson, S., 1986, "Contrasting Climatic Histories for the Snake River Plain, Idaho, Resulting from Multiple Thermal Maxima," *Quaternary Research*, 26: 321-339.

Documentation of Late Pleistocene vegetation changes and associated climatic regimes for the INEL region based on pollen and macrofossil analyses at Middle Butte and Rattlesnake Caves, located on the INEL, and Lake Cleveland, located near the southern edge of the Snake River Plain. Differences between the climatic histories documented at these sites are attributed to the autecology of the plants involved and the changing seasonal climate.

Subject: Paleoecology of the Eastern Snake River Plain
Keywords: PALYNOLOGY / PALEOECOLOGY / PALEOCLIMATE / LAVA TUBES / MIDDLE BUTTE CAVE / RATTLESNAKE CAVE / PLEISTOCENE
Location: INEL CRM Library

37. Davis, O. K., and Bright, R. C., 1983, *Late Pleistocene Vegetation History of the Idaho National Engineering Laboratory*, edited by O.D. Markham, pp. 162-171, DOE/ID-12098.

38. Dort, W., Jr., and Miller, S. J., 1977, *Archaeological Geology of Birch Creek Valley and the Eastern Snake River Plain, Idaho, Field Guide, First Annual Field Trip*, Idaho Falls, ID, Division of Archaeological Geology, Geology Society of America.

Informative guide to the archaeology and geology of the northeastern Snake River Plain and the Birch Creek Valley with emphasis on the Wasden Site/Owl Cave and Jaguar Cave.

Subject: Field guide to archaeology and geology of Birch Creek Valley and northeastern Snake River Plain
Keywords: CULTURAL RESOURCES / GEOMORPHOLOGY / GEOLOGY / WASDEN SITE / OWL CAVE / JAGUAR CAVE / ARCHAEOLOGICAL EXCAVATION / PALEOCLIMATE
Location: INEL CRM Library

39. Dort, Wakefield Jr., 1975, "Archaeo-Geology of Jaguar Cave, Upper Birch Creek Valley, Idaho," *Tebiwa*, 17(2):33-58.

Description of the sediments, fauna, and cultural debris found during the excavation of Jaguar Cave, a frost-fractured limestone concavity north of the INEL. Human occupation of the cave (including a very early record of domesticated dog) occurred between 12,000 and 9,000 B.P. after which the void became sealed.

Subject: Pleistocene human occupation of southeastern Idaho
Keywords: CULTURAL RESOURCES / CAVE / PLEISTOCENE / DOMESTIC DOG / MOUNTAIN SHEEP HUNTING / ARCHAEOLOGICAL EXCAVATION
Location: INEL CRM Library

40. Druss, M., and Reale, S., In Press, "Springtime on the Lava Plateau: Ephemeral Lakes and subsistence-Settlement in South-Central Idaho," *Idaho Archaeologist*.

Brief discussion of the association between prehistoric archaeological sites and ephemeral lakes, or playas, on the Snake River Plain and the resource potential of these seasonal features.

Subject: Settlement and subsistence on the Snake River Plain
Keywords: CULTURAL RESOURCES / PREHISTORY / PLAYAS
Location: INEL CRM Library

41. Duncan, F., 1990, *Rickover and the Nuclear Navy*, Annapolis, MD, Naval Institute Press.

A history of how Admiral Hyman G. Rickover, the "father of the nuclear navy," developed atomic energy for ship propulsion and the politics of developing the nuclear navy.

Subject: History of the Nuclear Navy
Keywords: U.S. NAVY / NUCLEAR HISTORY / H.G. RICKOVER / SUBMARINE / NRF
Location: INEL CRM Library

42. Dykes, F. W., 1985, *A View of Idaho History As Seen From Big Butte*, Pocatello, ID, F.W. Dykes.

Narrative discussion and maps of various points of interest on the northeastern Snake River Plain compiled by the author from casual interviews, correspondence, and archival research. Many of the areas mentioned are on or near the INEL including: Pioneer / Powell community, Webb Spring, Frenchman's Cabin, Big Butte Stage Station, Cerro Grande Siding, Frank Ferguson Homestead, Taber Community, Goodale's Cutoff, Atomic city, CCC Powder Bunkers, INEL, Big Butte, and several miscellaneous cabins and stage roads.

Subject: Idaho history
Keywords: CULTURAL RESOURCES / IDAHO HISTORY / BIG SOUTHERN BUTTE / STAGE ROUTES & STATIONS / STAGE ROUTES & STATIONS / HOMESTEADS / PIONEER TOWN'SITES / PIONEER TOWNSITES / GOODALES CUTOFF
Location: INEL CRM Library

43. Dykes, F. W., 1989, *Jeffery's Cutoff: Idaho's Forgotten Oregon Trail Route*, Pocatello, ID, F.W. Dykes.

A description of travel and places visited by the Ebey wagon train on the Jeffery/Goodale Cutoff, July-August 1854. Based on documentation by twelve of the train emigrants.

Subject: Goodales Cutoff
Keywords: CULTURAL RESOURCES / IDAHO HISTORY / BIG SOUTHERN BUTTE / STAGE ROUTES & STATIONS / STAGE ROUTES & STATIONS / PIONEERS / JEFFERY CUTOFF / GOODALES CUTOFF

Location: Idaho Falls Public Library

44. Edelman, H., n.d., *Reminiscences: Manuscript #8*, Idaho State University Archives, Eli M. Obler Library, Pocatello, ID.

45. Ellen, R., 1982, *Environment, Subsistence and System: The Ecology of Small-Scale Social Formations*, New York, NY, Cambridge University Press.

46. Ferris, W. A., 1940, "Life in the Rocky Mountains," Phillips, P. C., (editor), Denver, CO, O.H. West Publishing Co.,

A story told by W.A. Ferris, of his travels in the Rocky Mountains, including descriptions of camping on the Big Lost River and on Birch Creek. He also tells of camping by one of the three buttes and seeing several hundred Indians traveling across the Snake River Plain.

Subject: Fur trapping in the Rocky Mountains
Keywords: IDAHO HISTORY / INDIANS / BIRCH CREEK VALLEY / BIG LOST RIVER / BIG SOUTHERN BUTTE / MIDDLE BUTTE / EAST BUTTE / AMERICAN FUR COMPANY / FUR TRADE
Location: Idaho Falls Public Library

47. Fowler, D. D., 1982, *Cultural Resources Management, Advances in Archaeological Method and Theory, Volume 5*, edited by M.B. Schiffer, New York, NY, Academic Press.

48. Franzen, J. G., 1980, *Class II Cultural Resource Inventory of Areas in and Adjacent to the big Desert Planning Unit, Idaho*, Commonwealth Associates Inc., Technical Report No. R-2182.

Documentation of intensive archaeological survey of a 10% stratified random sample of 46,400 acres on Bureau of Land Management lands surrounding the INEL. Buttes and playas exhibited high site densities during this project while park-kipukas and lava tubes exhibited low densities. A scarcity of Paleoindian (ca. 12,000-8,000 B.P.) material and preponderance of Late Archaic (ca. 3,600-150 B.P.) were also observed.

Subject: Intensive archaeological survey of the INEL
Keywords: CULTURAL RESOURCES / HISTORIC PRESERVATION / COMPLIANCE / INTENSIVE ARCHAEOLOGICAL SURVEYS / PREHISTORY / HISTORY / ARCHAEOLOGICAL SENSITIVITY
Location: INEL CRM Archives

49. Franzen, J. G., 1980, *A Cultural Resource Survey of the Teton Replacement Farmland, Jefferson Co.*, Commonwealth Associates, Inc., Technical Report No. R-21XX.

Documentation of an intensive archaeological survey of 3200 acres adjoining the INEL (Teton Replacement Farmland) resulting in the recording of 81 previously unidentified cultural resources. Three sites were also subject to limited testing.

Subject: Intensive archaeological survey of the INEL
Keywords: CULTURAL RESOURCES / HISTORIC PRESERVATION / COMPLIANCE / INTENSIVE ARCHAEOLOGICAL SURVEYS / PREHISTORY / HISTORY / TEST EXCAVATION
Location: INEL CRM Library

50. **Franzen, J. G.**, 1981, *Southeastern Idaho Cultural Resources Overview, Burley and Idaho Falls Districts*, Commonwealth Associates, Inc., Technical Report No. R-2196.

Broad descriptive synthesis of information pertaining to prehistoric and historic human use of the INEL region. Discussion of prehistory focusses on changes in settlement patterns, land use, land tenure, cultural systems, and environment, and how they might be interrelated. Processes of Euroamerican settlement are also examined with emphasis on the fur trade, emigrant trails, mineral exploitation, transportation ranching, and agriculture.

Subject: Overview of historic and prehistoric human use of the Eastern Snake River Plain
Keywords: CULTURAL RESOURCES / BLM / CULTURAL CHRONOLOGY / PREHISTORY / HISTORY
Location: INEL CRM Library

51. **Fredlund, G. G., and Dort, W. Jr.**, 1986, "Phytolith and Pollen Evidence for Early Holocene Vegetation Change, Owl Cave, Wasden site, Eastern Snake River Plain, Idaho," *Fifty-first Annual Meeting of the Society for American Archaeology, New Orleans, LA.*
52. **Frison, G. G.**, 1978, *Prehistoric Hunters of the High Plains*, New York, NY, Academic Press.

Overview of archaeological investigations in the Northwestern Plains (Montana, Wyoming, Idaho) with special emphasis on cultural chronology, hunting practices, and overall subsistence strategies. Some Northwestern Plains traits are observed in the INEL region.

Subject: Prehistory of the Northwestern Plains
Keywords: CULTURAL RESOURCES / CULTURAL CHRONOLOGY / NORTHWESTERN PLAINS / BIG GAME HUNTING / PROJECTILE POINTS
Location: INEL CRM Library

53. **Gerard, H. C.**, 1982, *Wild Horse Jack*, Harry Clay Gerard.

A collection of short stories by Wild Horse Jack covering much of the Lost River Valley, the Big Southern Butte area and Howe from 1913 to 1917.

Subject: History of the Lost River Valley
Keywords: BIG SOUTHERN BUTTE / CATTLE RANCHING / FRENCHMAN'S SPRING / HOWE / ARCO / LOST RIVER VALLEY
Location: Idaho Falls Public Library

54. **Greeley, R.**, 1982, "The Style of Basaltic Volcanism in the Eastern Snake River Plain, Idaho," **Bonnichsen, B.; Breckenridge, R. M.**, *Cenozoic Geology of Idaho*, pp. 407-422, Idaho Bureau of Mines and Geology Bulletin No. 26, Moscow, ID.

55. Greenwood, A. P., 1934, *We Sagebrush Folks*, Moscow, ID, The University of Idaho Press.

An in depth description of the daily lives of a young farming community in southern Idaho in the early 1900's.

Subject: Idaho history
Keywords: HISTORY / CAREY LAND ACT / HOMESTEADS / AGRICULTURE / IRRIGATION
Location: Idaho Falls Public Library

56. Greiser, Sally T., 1984, "Projectile Point Chronologies of Southwestern Montana," *Archaeology in Montana*, 25(1):35-51.

57. Gruhn, R., 1961, "The Archaeology of Wilson Butte Cave, South-Central Idaho," occasional Papers of the Idaho State College Museum, No. 6, Pocatello, ID.

Detailed report on the excavation of Wilson Butte Cave, a lava tube on the Snake River Plain in south-central Idaho. The deposits at Wilson Butte Cave spanned at least 12,000 years with some evidence of an even earlier occupation at 14-15,000 B.P. Six assemblages were defined and designated as Wilson Butte I through VI. the Wilson Butte I and II assemblages are associated with now-extinct forms of megafauna including horse, camel, ground sloth, and bison and may represent one of the earliest human occupations yet known in North America. The Wilson Butte VI assemblage is further designated as the Dietrich Phase and is associated with Shoshone Indians between 700 and 150 years B.P.

Subject: Archaeological excavation of Wilson Butte Cave
Keywords: CULTURAL RESOURCES / ARCHAEOLOGICAL EXCAVATION / LAVA TUBES / CULTURAL CHRONOLOGY / SHOSHONE INDIANS / PALEOINDIAN
Location: INEL CRM Library

58. Gruhn, R., 1965, "Two Early Radiocarbon Dates From the Lower Levels of Wilson Butte Cave, Southcentral Idaho," *Tebiwa*, 8(2): 57.

Brief mention of two very early radiocarbon dates (ca. 15,000 B.P.) taken from two different strata at Wilson Butte Cave, distinguishing the cave as one of the earliest archaeological sites in North America.

Subject: Wilson Butte Cave radiocarbon dates
Keywords: WILSON BUTTE CAVE / RADIOCARBON DATES / CULTURAL CHRONOLOGY / LAVA TUBES
Location: INEL CRM Library

59. Guilday, J. E., and Adams, E. K., 1967, "Small Mammal Remains from Jaguar Cave, Lemhi County, Idaho," *Tebiwa*, 10(1):26-36.
60. Hackett, W. R., and Morgan, L. A., 1988, "Explosive Basaltic and Rhyolitic Volcanism of the Eastern Snake River Plain, Idaho," Link, P. K.; Hackett, W. R., *Guidebook to the Geology of Central and Southern Idaho*, pp. 283-304, Idaho Geologic Survey Bulletin No. 27, Moscow, ID.
61. Haines, A. L. , (ed.), 1969, *Osborne Russell's Journal of a Trapper (1834-1843)*, Lincoln, NE, University of Nebraska Press.

Osborne Russell's journal covering nine years of daily life, trapping and exploring in the southeastern Idaho/Yellowstone/ Northern Utah area and including descriptions of the trading post at Fort Hall and several encounters with Indian tribes of the area.

Subject: History of southeast Idaho
Keywords: FUR TRADE / INDIANS / FORT HALL / JIM BRIDGER / CAPT. B.S. BONNEVILLE / HISTORY / YELLOWSTONE
Location: Idaho Falls Public Library

62. Hammer, C. G., 1967, "Lost Gold of the Lavas," *True West*, 15(2)

63. Harniss, R. O., and West, E., 1973, "Vegetation Patterns on the National Reactor Testing Station, Southeastern Idaho," *Northwest Science*, 47:30-43.

Listing of plants currently present in the INEL region useful for comparison with studies of Native American plant use to develop hypotheses about prehistoric use of the area.

Subject: Vegetation patterns on the INEL
Keywords: PLANTS LISTS / MODERN VEGETATION / SAGEBRUSH GRASSLAND
Location: INEL CRM Library

64. Harrington, H. P., 1967, *Edible Native Plants of the Rocky Mountains*, Albuquerque, NM, University of New Mexico Press.

65. Henrikson, L. S., 1991, *Bobcat Cave: Evidence of Cold Storage on the Eastern Snake River Plain*, Master's thesis, Idaho State University, Pocatello, ID.

Documentation of archaeological investigations at Bobcat Cave, a lava tube ice cave on the northeastern Snake River Plain. Used as a meat storage facility or ice procurement locality is suggested by the results of subsurface testing and by numerous ground stone fragments and elk antler tines ("hammers and chisels") found on the lower chamber of this cave.

Subject: Archaeological excavation of a Lava Tube Ice Cave
Keywords: CULTURAL RESOURCES / PREHISTORY / ALTITHERMAL /
ARCHAEOLOGICAL EXCAVATION / ELK / ICE CAVE / LAVA
TUBES / PICTOGRAPHS
Location: INEL CRM Library

66. Henrikson, L. S., and Holmer, R. N., 1990, *The New Production Reactor Archaeological Sample Survey 1990*, Northern Intermountain Quaternary Institute Reports of Investigations, No. 90-4, Pocatello, ID.

Documentation of a cultural resource inventory of thirty randomly selected forty-acre quadrants within the lava flows surrounding the NPR Area E where 78 previously unknown cultural resources were located.

Subject: Intensive archaeological survey of the INEL
Keywords: ARCHAEOLOGICAL SURVEY / CULTURAL RESOURCES / NPR /
COMPLIANCE / HISTORIC PRESERVATION / PREHISTORY /
ARCHAEOLOGICAL SENSITIVITY
Location: INEL CRM Archives

67. Henrikson, L. S., and Holmer, R. N., 1990, *The New Production Reactor Archaeological Sample Survey*, Northern Intermountain Quaternary Institute Reports of Investigations, No. 91-2, Pocatello, ID.

Documentation of a cultural resource inventory of thirty randomly selected forty-acre quadrants within the lava flows surrounding the NPR Area E where 78 previously unknown cultural resources were located.

Subject: Intensive archaeological survey on the INEL
Location: INEL CRM Archives

68. Henrikson, L. S., and Holmer, R. N., 1991, *Archaeological Investigations at NPR Area E*, Northern Intermountain Quaternary Institute Reports of Investigations, No. 91-2.

Documentation of the results of a intensive cultural resource inventory and testing of previously recorded cultural resources within the NPR area E on the INEL, by personnel from the Northern Intermountain Quaternary Institute, where 36 previously unknown cultural resources were recorded and 41 archaeological resources were tested.

Subject: Intensive archaeological survey and small-scale testing on the INEL
Keywords: COMPLIANCE / CULTURAL RESOURCES / HISTORY /
PREHISTORY / NPR / ARCHAEOLOGICAL SURVEY / TEST
EXCAVATION / PREHISTORY
Location: INEL CRM Library

69. **Henrikson, N. D.; Henrikson, L. S., and Holmer, R. N., 1990, *Archaeological Survey of the PBF/NPR Area E Road Corridor*, Northern Intermountain Quaternary Institute Reports of Investigations, No. 91-1, Pocatello, ID.**

70. **Hewlett, R. G., and Anderson O. Jr., 1990, *The New World: A History of the U.S. Atomic Energy Commission, Vol 1, 1939-1946*, Berkeley, CA, University of California Press.**

A history of the discovery of fission, federal support for nuclear research, military support for atomic weapons, isotope separation plants, the development of the atomic bomb, and how various DOE facilities were involved in the development of nuclear research.

Subject: History of the Atomic Energy Commission

Keywords: ATOMIC WEAPONS / ATOMIC WEAPONS / ISOTOPE
SEPARATION PLANTS / NUCLEAR RESEARCH / FISSION/
HISTORY

Location: INEL CRM Library

71. **Hewlett, R. G., and Duncan, F., 1990, *The New World: A History of the U.S. Atomic Energy Commission, Vol 2, 1947-1952*, Berkeley, CA, University of California Press.**

A history of the Atomic Energy Commission from 1947-1952 covering the following topics: weapons research and production, reactor development, accelerators research, raw materials procurement, aircraft and naval propulsion, international control and the United Nation, plutonium, thermonuclear development, industry and civilian power development, impacts of the Korean war on research and development, DOE facilities.

Subject: History of the Atomic Energy Commission

Keywords: ATOMIC WEAPONS / NUCLEAR RESEARCH / CANCER
RESEARCH / HISTORY / ATOMIC WEAPONS

Location: INEL CRM Library

72. **Hewlett, R. G., and Holl, J. M., 1989, *Atoms for Peace and War, 1953-1961: Eisenhower and the Atomic Energy Commission*, Berkeley, CA, University of California Press.**

A history of atomic research from 1953-1961 covering the following topics: the Atomic Energy Bill, the Nevada Proving Grounds, nuclear weapons, nuclear power, nuclear technology and its role in U.S. politics and economics.

Subject: History of atomic research

Keywords: NUCLEAR ATOMIC WEAPONS / NUCLEAR RESEARCH /
HISTORY

Location: INEL CRM Library

Appendix F ♦ F-76

73. Holmer, R. N., and Ringe, B. L., 1986, *Numic Occupation of the Upper Snake River Basin*, In: Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations: 85-16, Pocatello, ID.
74. Holmer, R. N., 1986, "Common Projectile Points of the Intermountain West," Condie, C. J.; Fowler, D. D., (editors), *Anthropology of the Desert West: Essays in Honor of Jesse D. Jennings*, University of Utah Anthropological Papers, No. 110, pp. 89-115, Salt Lake City, UT.

Discussion of changes in projectile point style through time with emphasis on material from the Great Basin. Useful for use in the analysis of artifacts from the INEL region.

Subject: Prehistoric projectile point classification
Keywords: CULTURAL RESOURCES / CULTURAL CHRONOLOGY /
PROJECTILE POINTS / GREAT BASIN / PREHISTORY
Location: Eli M. Obler Library, Pocatello, ID

75. Holmer, R. N., 1986, *Shoshone-Bannock Cultural History*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 85-16, Pocatello, ID.

Detailed report on two seasons of archaeological excavation at the Wahmuza site, a prehistoric winter village located near bottomlands along the Snake River on the Fort Hall Indian Reservation.

Subject: Archaeological excavation at the Wahmuza site at Fort Hall
Keywords: ETHNOHISTORY / ETHNOARCHAEOLOGY / ARCHAEOLOGICAL
EXCAVATION / CULTURAL RESOURCES / SHOSHONE-BANNOCK
INDIAN CULTURE / SNAKE RIVER BASIN / WAHMUZA SITE
Location: INEL CRM Library

76. Hoskinson, R. L., and Tester, J. R., 1980, "Migration Behavior of Pronghorn Antelope in Southeastern Idaho," *Journal of Wildlife Management*, 44:132-144.

77. Idaho National Engineering Laboratory, n.d., "Public Relations Brochures," INEL CRM Office, Idaho National Engineering Laboratory, Idaho Falls, ID.

Large file containing a variety of public relations brochures describing the INEL.

Subject: INEL facts, figures, and history
Keywords: CULTURAL RESOURCES / INEL HISTORY / SNAKE RIVER BASIN
Location: INEL CRM Library

78. Idaho State Historical Society, n.d., "Goodales Cutoff," Reference Series, No. 51.

79. **Idaho State Journal**, 1989, "INEL's 40th Anniversary Celebration," Idaho State Journal, Pocatello, ID, May, 15, 1989.

Newspaper article focussing on INEL history.

Subject: INEL facts, figures, and history
Keywords: INEL HISTORY / NUCLEAR HISTORY / CULTURAL RESOURCES
Location: Idaho Falls Public Library

80. **Intermountain Antiquities Computer**, 1989, *IMACS Users Guide*, University of Utah, U.S. Bureau of Land Management, U.S. Forest Service, Salt Lake City, UT.

Directions and codes for using the IMACS system of recording cultural resources. This system is utilized by the INEL CRM Office as required by the Idaho State Historic Preservation Office.

Subject: Cultural Resource recording system
Keywords: IMACS / SITE RECORDING FORMS / ARCHAEOLOGICAL
DATABASE
Location: INEL CRM Library

81. **Jimenez, J.**, 1986, *the Ahvish Phase at Wahmuza and the Numic Affiliation of the Dietrich and Lemhi Phases of Southern Idaho*, Master's thesis, Idaho State University, Pocatello, ID.

82. **Kelly, R.**, 1988, "Hunter-Gatherer Ecology in the Western Great Basin: Hunting Patterns and the Use of Marshes," *Twenty-First Great Basin Anthropological Conference, Park City, UT, October 1988*.

83. **Kingsbury, L. A.**, 1977, *Final Report on 1976 Cultural Resource Inventory of the Little Lost-Birch Creek Planning Unit*, Idaho Museum of Natural History Archaeological Reports, No. 10, Pocatello, ID

Documentation of archaeological reconnaissance in the valleys located north of the INEL resulting in the recording of 126 previously unidentified cultural resources and the re-recording of 30 previously examined resources.

Subject: Archaeological reconnaissance in the vicinity of the INEL
Keywords: CULTURAL RESOURCES / ARCHAEOLOGICAL SURVEY /
PREHISTORY / HISTORY
Location: INEL CRM Library

84. **Knoll, K. M.**, 1977, "Chronology of Alpine Glacier Stillstands, East-Central Lemhi Range, Idaho," Special Publication of the Idaho Museum of Natural History.

Documentation of investigations conducted from 1970-1972 on glacial and periglacial deposits and landforms in four canyons of the east-central Lemhi Range, Idaho.

Subject: History of Idaho glacial deposits and landforms
Keywords: PERIGLACIAL / GEOLOGY / LEMHI RANGE / GLACIATION /
BULL LAKE / LAND FORMATIONS
Location: Idaho glacial history

85. **Knudson, R., and Pfaff, P.**, 1980, *Heritage Resources and Known Geothermal Resource Areas (KGRAs) in Idaho: A Preliminary Evaluation*, University of Idaho Anthropological Research Manuscript Series No. 49, Laboratory of Anthropology, University of Idaho, Moscow, ID.

86. **Knudson, R.**, 1986, "Contemporary Cultural Resource Management," *American Archaeology Past and Future: A Celebration of the Society for American Archaeology 1935-1985*, pp. 395-414, Washington, D.C., Smithsonian Institution Press.

87. **M. A. Kuntz; B. Skipp; M. A. Lanphere; W. E. Scott; K. L. Pierce; G. B. Dalrymple; L. A. Morgan; D. E. Champion; G. F. Embree; R. P. Smith; W. R. Hackett; D. W. Rodgers, and W. R. Page**, n.d., Revised Geologic Map of the Idaho National Engineering Laboratory and Adjoining Areas, Eastern Idaho, U.S. Geological Survey, Open File Report, 90-333.

Map and brief text depicting the geology of the INEL and contiguous parts of the eastern Snake River Plain as well as the geology and structure of the southernmost parts of the Lost River, Lemhi, and Beaverhead Ranges, Useful in the reconstruction of prehistoric settlement and subsistence patterns.

Subject: INEL Geology
Keywords: CULTURAL RESOURCES / SNAKE RIVER BASIN / VOLCANISM /
AEOLIAN SEDIMENT / MOUNTAINS
Location: INEL CRM Library

88. **Kuntz, Mel A.; Spiker, E. C.; Rubin, M.; Champion, D. E., and Lefebvre, R. H.**, 1986, "Radiocarbon Studies of Latest Pleistocene and Holocene Lava Flows of the Snake River Plain, Idaho: Data, Lessons, Interpretations," *Quaternary Research*, 25(2):163-176.

89. Kurten, B., and Anderson, E., 1972, "The Sediments and Fauna of Jaguar Cave II: The Fauna," *Tebiwa*, 15(1):21-45.

Detailed examination of the faunal remains from the excavation of Jaguar Cave located north of the INEL.

Subject: Archaeological excavation of Jaguar Cave
Keywords: EXCAVATION / CULTURAL RESOURCES / DOMESTIC DOG / BIG GAME HUNTING / PREHISTORY
Location: INEL CRM Library

90. Lewis, B. D., and Jensen, R. G., 1984, *Hydrologic Conditions at the Idaho National Engineering Laboratory, Idaho: 1979-1981*, USGS, U.S. Geologic Survey Open File Report 84-230, Denver, CO.

91. Liljebblad, S., 1957, *Indian Peoples in Idaho*, Master's thesis, Idaho State University, Pocatello, ID.

92. Link, P. K., and Hackett, W. R. (eds.), 1988, "Guidebook to the Geology of Central and Southern Idaho," Idaho Geologic Survey Bulletin, No. 27.

Detailed examination of regional geology. Of particular interest are articles on volcanism of the Snake River Plain in Chapters 4 and 5.

Subject: Geology of the Snake River Plain
Keywords: VOLCANISM / OBSIDIAN / LAND FORMATIONS / SNAKE RIVER BASIN
Location: INEL CRM Library

93. Lohse, E. S., 1989, "Aviator's Cave," *Idaho Archaeologist*, 12(2)

Brief report on the archaeological test excavation of Aviators Cave on the INEL. This undisturbed lava tube contains three occupation zones spanning the past 1000 years and yielded a remarkable assemblage of perishable remains.

Subject: Archaeological excavation of a lava tube on the INEL
Keywords: CULTURAL RESOURCES / LATE PREHISTORIC / LAVA TUBES / TEST EXCAVATION / SHOSHONE INDIANS / PERISHABLE REMAINS
Location: INEL CRM Archives

94. Lowrey, Dino L., 1990, Letter, J.L. Mayberry, "Archaeological Clearance Recommendation for Construction of a Sewage Line and Lagoon Northeast of RWMC Facilities," DLL-01-90, 1/17/90, INEL Archaeological Research Center, Idaho Falls, ID,

95. **Lowrey, Dino L.**, 1990, Letter, J.J. Jessmore, "Archaeological Clearance Recommendation for Excavation of Three Bores Associated with RWMC ERP Site Characterization," DLL-02-90, 3/29/90, INEL Archaeological Research Center, Idaho Falls, ID,
96. **Lowrey, D. L.**, 1991, Letter, T.D. Reynolds, "Archaeological Survey and Recommendations for the Proposed Elk Capture and Relocation Project," DLL-17-91, INEL Archaeological Research Center, Idaho Falls, ID,
97. **Mabey, D. R.**, 1982, *Geophysics and Tectonics of the Snake River Plain, Idaho*, In: Cenezoic Geology of Idaho, edited by B. Bonnicksen and R.M. Breckenridge, pp. 139-153, Idaho Bureau of Mines and Geology Bulletin No. 26, Moscow, ID.
98. **Madsen, D. B., and O'Connell, F. O. (eds.)**, 1982, "Man and Environment in the Great Basin," Society for American Archaeology Papers, No. 2, Washington, D.C.

Volume summarizing the status of archaeological research in the Great Basin in the early 1880's. Thirteen articles touch on four major themes: past environments, cultural chronology, subsistence and settlement, and cultural history. Great Basin traits are common in prehistoric assemblages from the INEL.

Subject: Prehistoric Overview of the Great Basin
Keywords: CULTURAL RESOURCES / PREHISTORY / CULTURAL
CHRONOLOGY / PALEOENVIRONMENT / GREAT BASIN /
SUBSISTENCE AND SETTLEMENT
Location: INEL CRM Library

99. **Marler, C. F.**, 1992, Letter, R. L. Twitchell, "INEL Central Connector Archaeological Survey," CFM-22-92, INEL Archaeological Research Center, Idaho Falls, ID,
100. **Marler, Clayton F.**, 1990, Letter, J.B. Taylor, "Archaeological Clearance Recommendation for Northern Expansion of RWMC Administrative Facilities," CFM-03-90, 1/24/90, INEL Archaeological Research Center, Idaho Falls, ID,
101. **Marler, Clayton F.**, 1990, Letter, J.L. Mattick, "Archaeological Clearance Recommendation for TRA Warm Waste Pond RI/FS," CFM-18-90, 6/14/90, INEL Archaeological Research Center, Idaho Falls, ID,
102. **Marler, Clayton F.**, 1990, Letter, J.J. Reidesel, "Archaeological Report and Clearance Recommendation-T-12 Borrow Pit Expansion Phase II," CFM-22-90, 11/8/90, INEL Archaeological Research Center, Idaho Falls, ID,

103. McBride, R.; French, N. R.; Dahl, A. H., and Detmer, J. E., 1978, *Vegetation Types and Surface Soils of the Idaho National Engineering Laboratory Site*, Idaho National Engineering Laboratory, IDO-12084, Idaho Falls, ID.

Discussion of surface geology and associated vegetation on the INEL important in the reconstruction of prehistoric use patterns of the area.

Subject: Natural environment of the INEL
Keywords: CULTURAL RESOURCES / LAND FORMATIONS / MODERN
VEGETATION / SOILS
Location: INEL Technical Library

104. McCallum, W. M., 1981, *Further analysis of 22 Prehistoric Sites within the Teton Replacement Farmland, Snake River Plain, Jefferson County, Idaho*, Archaeological Services, Laramie, WY.

Documentation of intensive surface collection and mapping at 22 prehistoric sites located on lands surrounding the INEL (Teton Replacement Farmland). Most of the resources included in this study are located in the shifting sand dunes that have formed in the basin of Lake Terreton.

Subject: Artifact collections from the eastern margin of the INEL
Keywords: CULTURAL RESOURCES / PREHISTORY / ARTIFACTS
Location: CRM Archives

105. McDonald, J. G., and Anderson, E., 1975, "A Late Pleistocene Vertebrate Fauna from Southeastern Idaho," *Tebiwa*, 18(1):1-8.

106. Merrill, I. R., 1990, "Tim Goodale and His Cutoff: A Major Trail Segment During and After the Four Emigration Wave," *Overland Journal*, 8(3):9-16.

107. Merrill, I. R. (ed.), 1988, *Bound for Idaho, the 1864 Trail Journal of Julius Merrill*, Moscow, ID, University of Idaho Press,

A journal of Julius Merrill's travels by wagon train from when he left Milwaukee on April 28, 1864 until he arrived in Boise, ID September 1864. He gives details about camping at the base of Big Southern Butte and traveling over what now is the INEL.

Subject: Idaho history
Keywords: HISTORY / BIG SOUTHERN BUTTE / EAST BUTTE / MIDDLE
BUTTE / BIG LOST RIVER / WAGON TRAINS
Location: Idaho Falls Public Library

108. Miller, S. J., 1972, *Weston Canyon Rockshelter: Big Game Hunting in Southeastern Idaho*, Unpublished Master's Thesis, Department of Anthropology, Idaho State University, Pocatello, ID.

109. Miller, S. J., 1982, "The Archaeology and Geology of an Extinct Megafauna/Fluted Point Association at Owl Cave, the Wasden Site, Idaho," Ericson, J. E.; Taylor, R. E.; Berger, R., ((eds.)), *Peopling of the New World*, Los Altos, CA, Ballena Press.

Archaeological excavation of the Wasden site/Owl Cave, an important lava tube near the INEL on the northeast Snake River Plain. Emphasis is on 12,000 year old associations between extinct megafauna (i.e. bison, camel, mammoth) and fluted projectile point fragments.

Subject: Archaeological excavation of the Wasden site/Owl Cave
Keywords: ARCHAEOLOGICAL EXCAVATION / LAVA TUBES / CULTURAL RESOURCES / BIG GAME HUNTING / CULTURAL CHRONOLOGY
Location: INEL CRM Library

110. Miller, S. J., 1983, *Preliminary Cultural Resources Assessment of Two Study Areas on the Idaho National Engineering Laboratory, Southeastern Idaho*, EG&G Idaho, Inc., Idaho Falls, ID.

General overview of paleontology, prehistoric and historic archaeology of the INEL, Snake River Plain and the results of a preliminary archaeological reconnaissance of NPR study areas "A" and "E".

Subject: Archaeological reconnaissance of proposed NPR construction areas
Keywords: PALEONTOLOGY / PALEOECOLOGY / PREHISTORY / HISTORY / CULTURAL RESOURCES / ARCHAEOLOGICAL SURVEY / SNAKE RIVER BASIN / COMPLIANCE / HISTORIC PRESERVATION
Location: INEL CRM Archives

111. Miller, S. J., 1984, *A Cultural Resources Inventory of the Perimeter Boundary, Grazing Boundary, and 1984 Project Areas, Idaho National Engineering Laboratory, Southeastern Idaho*, EG&G Idaho, Inc., Archaeological Research Center, Idaho Falls, ID.

Documentation of surveys conducted in 1984 along the INEL grazing boundary, INEL perimeter, and other areas where 208 cultural resources were recorded.

Subject: Archaeological reconnaissance on the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / ARCHAEOLOGICAL SURVEY / PREHISTORY / GRAZING BOUNDARY / HISTORIC PRESERVATION / INEL BOUNDARY
Location: INEL CRM Archives

112. Miller, S. J., 1984, *A Cultural Resources Inventory of the NPR Study Area E, Idaho National Engineering Laboratory, Southeastern Idaho*, EG&G Idaho, Inc., Archaeological Research Center, Idaho Falls, ID.

Documentation of intuitive and systematic archaeological reconnaissance in NPR Area E (approximately 900 acres) resulting in the identification of 87 previously unrecorded cultural resources.

Subject: Archaeological reconnaissance for the NPR
Keywords: CULTURAL RESOURCES / COMPLIANCE / PREHISTORY /
ARCHAEOLOGICAL SURVEY / HISTORIC PRESERVATION / NPR
Location: INEL CRM Archives

113. Miller, S. J., 1985, *Archaeological Clearance Surveys and Cultural Resource Inventories on the Idaho National Engineering Laboratory, Southeastern Idaho*, INEL Archaeological Research Center, Idaho Fall, ID.

114. Miller, S. J., 1990, "Characteristics of Mammoth Bone Reduction at Owl Cave, The Wasden Site, Idaho," Bonnichsen, R.; Sorg M.H., ((eds.)), *Bone Modification, Center for the Study of the First Americans*, Orono, ME, Institute for Quaternary Studies, University of Maine.

Analysis of faunal remains from archaeological excavations at the Wasden Site/Owl Cave with emphasis on mammoth bone which appears to have been intentionally reduced by prehistoric people in order to extract marrow and obtain raw material for bone artifact production.

Subject: Faunal inventory
Keywords: FAUNAL REMAINS / BONE TOOLS / MAMMOTH / TAPHONOMY
Location: INEL CRM Library

115. Miller, S. J., 1991, Letter, J.A. Tullis, "Archaeological Clearance Survey for Nine Thermoluminescence Dating Sites on the Eastern Snake River Plain," SJM-44-91, 7/11/91, INEL Archaeological Research Laboratory, Idaho Falls, ID,
116. Miller, S. J., 1992, Letter, B.D. Higgs, "INEL Archaeological Clearance Survey, WAG-7 Wells, RWMC Vicinity, INEL," SJM-25-92, 4/21/92, INEL Archaeological Research Laboratory, Idaho Falls, ID,
117. Miller, S. J., 1992, Letter, "Archaeological Survey for Additional Wells, in the Test Area North (TAN) Vicinity, Idaho National Engineering Laboratory (INEL)," SJM-27-92, 5/4/92, INEL Archaeological Research Laboratory, Idaho Falls, ID,

118. Miller, S. J., 1992, *Idaho National Engineering Laboratory Management Plan for Cultural Resources (Draft)*, Department of Energy, DOE/ID-10361, Idaho Falls, ID, March 1992.

Important handbook for all aspects of cultural resource management on the INEL including extensive overviews of previous survey and testing projects, known resources on the INEL, legal mandates, INEL CRM procedures, and data needs.

Subject: INEL cultural resource management
Keywords: CULTURAL RESOURCES / HISTORIC PRESERVATION / COMPLIANCE
Location: INEL CRM Library

119. Miller, S. J., and Dort, W. Jr., 1978, *Early Man at Owl Cave: Current Investigations at the Wasden Site, Eastern Snake River Plain, Idaho*, Occasional Papers of the University of Alberta Department of Anthropology, No. 1, Edmonton, Alberta, Canada.

Preliminary description of archaeological investigations at the Wasden site/Owl Cave located on the northeastern Snake River Plain near the INEL.

Subject: Archaeological excavation of Wasden Site
Keywords: CULTURAL RESOURCES / LAVA TUBES / WASDEN SITE / CULTURAL CHRONOLOGY / BIG GAME HUNTING
Location: INEL CRM Library

120. Miss, C. J., 1978, *A Functional Analysis of Lithic Endscrapers from Idaho Archaeological Collections*, Master's thesis, Idaho State University, Pocatello, ID.

Morpho-functional analysis of endscrapers including specimens recovered from the INEL and indicating that most items were used to process soft material such as hide.

Subject: Prehistoric artifact analysis
Keywords: CULTURAL RESOURCES / PREHISTORY / ENDSCRAPPERS / HIDE WORKING / USEWEAR ANALYSIS
Location: Eli M. Obler Library, Pocatello, ID

121. Murphy, R. F., and Murphy, Y., 1960, "Shoshone-Bannock Subsistence and Society," *University of California Anthropological Records*, 16(7):293-333.

Discussion of the settlement and subsistence practices of local Native Americans as augmented by adoption of the horse. Contains useful information on seasonal rounds that may have included the INEL region.

Subject: Shoshone-Bannock culture, settlement, and subsistence

Keywords: CULTURAL RESOURCES / SHOSHONE INDIANS / BANNOCK INDIANS / HUNTING AND GATHERING / SEASONAL ROUNDS
Location: Eli M. Obler Library, Pocatello, ID

122. Murphy, R. F., and Murphy, Y., 1986, "Northern Shoshone and Bannock," D'Azevedo, W. L., ((ed.)), *Handbook of North American Indians, Great Basin*, Vol. 11, pp. 284-307.

A description of local Native American groups, the Northern Shoshone and Bannock, covering the following topics: Language, Prehistory, History, Environment, External Relations, Territory, Population, and other aspects of their culture.

Subject: Shoshone and Bannock Indians
Keywords: IDAHO INDIANS / PREHISTORY / HISTORY / SHOSHONE/ BANNOCK INDIANS / HUNTING AND GATHERING / SEASONAL ROUNDS
Location: INEL CRM Library

123. Nace, R. L.; Voegli, P. T.; Jones, J. R., and Deutsch, M., 1975, *Generalized Geologic Framework of the National Reactor Testing Station, Idaho*, USGS, Professional Paper, 725-B, Washington, D.C.

Discussion of surface geology on the INEL important for reconstructing patterns of prehistoric use.

Subject: INEL Geology
Keywords: SURFACE GEOLOGY / LAND FORMATIONS / CULTURAL RESOURCES / PIONEER BASIN / LAKE TERRETON
Location: INEL Technical Library

124. Nace, R. L.; Deutsch, M., and Voegli, P. T., 1972, *Physical Environment of the National Reactor Testing Station, Idaho: A Summary*, USGS, Professional Paper, 725-A.

Discussion of surface geology on the INEL important for reconstructing patterns of prehistoric use.

Subject: INEL Geology
Keywords: SURFACE GEOLOGY / LAND FORMATIONS / CULTURAL RESOURCES / PIONEER BASIN / LAKE TERRETON
Location: INEL Technical Library

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125. Nickerson, G. S., 1966, "Some Data on Plains and Great Basin Indian Uses of Certain Native Plants," *Tebiwa*, 9(1):45-51.

A list of useful plants compiled by interviews with Native Americans on usage for food, medicine, dye, weaving material, etc.

Subject: Ethnobotany
Keywords: NATIVE PLANTS / ETHNOBOTANY / PLANT FOODS / PLANT DYES / PLANT MEDICINE / USEFUL PLANTS
Location: INEL CRM Library

126. Oberg, P. M., 1970, *Between These Mountains: History of Birch Creek Valley, Idaho*, New York, NY, Exposition Press.

An in-depth History covering: Indians, fur traders, first settlers, Mormons, Fort Lemhi, mining, ghost towns, recreation, and daily life within the Birch Creek Valley.

Subject: History of Birch Creek Valley
Keywords: BIRCH CREEK VALLEY / FORT LEMHI / GILMORE / MINING / HISTORY / MORMONS / FISHING
Location: Idaho Falls Public Library

127. Olsen, G. P., 1978, "Mackay's Yesterdays," Arco Advertiser, Arco, ID.

A history of the Big Lost River Valley including reference to the first stage route between Blackfoot and Challis with histories of the towns and stops along the way.

Subject: Idaho history
Keywords: IDAHO HISTORY / CULTURAL RESOURCES / BIG LOST RIVER / STAGE ROUTES & STATIONS / TRANSPORTATION / MACKAY / PIONEER TOWNSITES
Location: Idaho Falls Public Library

128. Pettite, W. S., 1977, *Memories of market Lake, Volume II*, Wm. Stibal Pettite.

129. Pettite, W. S., 1983, *Memories of Market Lake, Volume III*, Wm. Stibal Pettite.

130. Pierce, K. L., and Scott, W. E., 1982, *Pleistocene Episodes of Alluvial-Gravel Deposition, Southeastern Idaho*, In: *Cenozoic Geology of Idaho*, edited by B. Bonnicksen and R.M. Breckenridge, Idaho Bureau of Mines and Geology Bulletin No. 26, Moscow, ID.

131. Plastino, B. J., 1991, *Idaho Falls: City of Destiny*, Idaho Falls, ID, Bonneville County Historical Society.

132. Plew, M. G.; Pavesic, M. G., and Davis, M. A., 1987, *Archaeological Investigations at Baker Caves I and III: A Late Archaic Component on the Eastern Snake River Plain*, Boise State University Archaeological Reports, No. 15, Boise, ID.

Documentation of archaeological excavations at Baker Caves (10-BN-153 and 10-BN-154), lava tube caves on the eastern Snake River Plain near Minidoka. The report provides a descriptive account of the excavations and ensuing analyses including a description of the locale, cave sediments, cultural features, faunal materials (including the remains of 17 bison), and material culture. The site is interpreted as an undisturbed Late Archaic (ca. 1300-150 B.P.) hunting campsite, probably affiliated with Shoshonean groups. This information is useful for comparison with information gathered from caves on the INEL.

Subject: Archaeological excavation of a lava tube on the Eastern Snake River Plain
Keywords: CULTURAL RESOURCES / ARCHAEOLOGICAL EXCAVATION / LATE PREHISTORIC / LATE ARCHAIC / SHOSHONE INDIANS / BISON
Location: INEL CRM Library

133. *The Post Register*, 1989, "INEL--The First 40 Years," The Post Register, Idaho Falls, ID May 5, 1989.

Newspaper article on the history of the INEL.

Subject: INEL facts, figures, and history
Keywords: HISTORY / INEL / NUCLEAR REACTOR TESTING / ATOMIC ENERGY COMMISSION
Location: Idaho Falls Public Library

134. Preston, R. N., 1978, "Early Idaho Atlas," 2nd, Portland, OR, Binford and Mort.

Useful compilation of historical maps of Idaho including stage and wagon routes across the present day INEL and stage stops, railroad sidings, and small townsites in the INEL region.

Subject: Idaho History
Keywords: IDAHO HISTORY / CULTURAL RESOURCES / TRAVEL / TRANSPORTATION / HISTORIC ATLAS / PIONEER TOWNSITES
Location: Idaho Falls Public Library

135. **Reed, W. G.**, 1986, *An Archaeological Survey of the Chemical Processing Plant Perimeter*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 86-2, Pocatello, ID.

Detailed report on intensive survey of 440 acres surrounding the Idaho Chemical Processing Plant on the INEL resulting in the identification of six cultural resources.

Subject: Intensive archaeological survey of the ICPP
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
PRESERVATION / ICPP
Location: INEL CRM Library

136. **Reed, W. G.**, 1987, *An Archaeological Survey of the Weapons Ranges Helipad and Access Road on the Idaho National Engineering Laboratory*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, 87-14, Pocatello, ID.

Report documenting intensive archaeological survey of 10 acres near the INEL Weapons Range. No cultural resources recorded.

Subject: Archaeological survey near the INEL Weapons Range
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
PRESERVATION / INTENSIVE ARCHAEOLOGICAL SURVEYS /
WEAPONS RANGE
Location: INEL CRM Library

137. **Reed, W. G.**, 1987, *An Archaeological Survey of an Alternate Route for a Fiber Optic Line from ANL-W to Highway 20*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 87-22, Pocatello, ID.

Report documenting intensive archaeological survey of a corridor between Highway 20 and ANL-W encompassing approximately 17 acres and resulting in the recording of two cultural resources.

Subject: Archaeological surveys near INEL boundary
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
PRESERVATION / INTENSIVE ARCHAEOLOGICAL SURVEYS /
PREHISTORY
Location: INEL CRM Library

138. Reed, W. G., and Ringe, B. L., 1986, *An Archaeological Survey of the Idaho National Engineering Laboratory: The Naval Reactor Facility*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 85-12, Pocatello, ID.

Detailed report on intensive survey of 275 acres surrounding the Naval Reactors Facility on the INEL resulting in the recording of 19 cultural resources.

Subject: Intensive archaeological survey of NRF
 Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
 PRESERVATION / INTENSIVE ARCHAEOLOGICAL SURVEYS /
 PREHISTORY / HISTORY / NRF
 Location: INEL CRM Archives

139. Reed, W. G.; Ross, J. W.; Ringe, B. L., and Holmer, R. N., 1987, *Annual Review of Archaeological Investigations on the INEL 1986-1987*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 87-2, Pocatello, ID.

Report on intensive archaeological survey projects completed in 1986 on the INEL. Nine projects and 29 resources are reported in the document along with an initial attempt to examine archaeological sensitivity on the INEL.

Subject: Intensive archaeological survey of the INEL
 Keyword: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
 PRESERVATION / INTENSIVE ARCHAEOLOGICAL SURVEYS /
 PREHISTORY / HISTORY
 Location: INEL CRM Archives

140. Reed, W. G.; Ross, J. W.; Ringe, B. L., and Holmer, R. N., 1987, *Archaeological Investigations on the Idaho National Engineering Laboratory: 1984-1985*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 87-1, Pocatello, ID.

Detailed report on intensive archaeological survey projects completed on the INEL from 1984-1985 for purposes of regulatory compliance. These projects resulted in the Inventory of 8950 acres and recording of 521 historic and prehistoric resources. Previous archaeological investigations on the INEL are also summarized.

Subject: Intensive archaeological survey of the INEL
 Keyword: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
 PRESERVATION / INTENSIVE ARCHAEOLOGICAL SURVEYS /
 PREHISTORY / HISTORY
 Location: INEL CRM Archives

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141. Reed, W. G., and Homer, R. N., 1987, *An Archaeological Survey for the Idaho National Engineering Laboratory Perimeter Sign Maintenance Project*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 87-20, Pocatello, ID.

Report documenting intensive archaeological survey of several linear corridor segments on the INEL encompassing a total of 254 acres and resulting in the recording of 29 cultural resources.

Subject: Archaeological surveys near INEL boundary
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / INTENSIVE ARCHAEOLOGICAL SURVEYS / INEL BOUNDARY / PREHISTORY
Location: INEL CRM Library

142. Rees, J. E., 1918, *Idaho Chronology, Nomenclature, Bibliography*, Chicago, IL, W.B. Conkey, Co.

143. Reeves, B. O. K., 1983, *Cultural Change in the Northern Plains: 1000 B.C.-A.D. 1000*, In: Archaeological Survey of Alberta Occasional Papers No. 20, Edmonton, Alberta, Canada.

144. Reynolds, T. D.; Connelly, J. W.; Halford, D. K., and Arthur, W. J., 1986, "Vertebrate Fauna of the Idaho National Environmental Research Park," *Great Basin Naturalist*, 46:513-527.

Discussion of animals currently inhabiting the INEL region important in reconstructing possible patterns of prehistoric use, particularly in regard to hunting practices and preferences.

Subject: Faunal inventory
Keywords: CULTURAL RESOURCES / ANIMALS / VERTEBRATES / HUNTING AND GATHERING
Location: INEL CRM Library

145. Ringe, B. L., 1988, *Archaeological Investigations on the Idaho National Engineering Laboratory: The Naval Reactors Facility Industrial Waste Ditch*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 88-1, Pocatello, ID.

Report documenting the intensive archaeological survey of approximately 1000 acres northeast of NRF on the INEL and resulting in the recording of 64 cultural resources.

Subject: Intensive archaeological survey of NRF
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / INTENSIVE ARCHAEOLOGICAL SURVEYS / PREHISTORY / HISTORY

Location: INEL CRM Archives

146. Ringe, B. L., 1988, *Archaeological Investigations on the Idaho National Engineering Laboratory: The Argonne National Laboratory-West Administrative Boundary*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 88-9, Pocatello, ID.

Detailed report on the intensive archaeological survey of the 600 acre area surrounding ANL-W on the INEL. The project resulted in the recording of 34 cultural resources, which are documented in the report with recommendation for management.

Subject: Intensive archaeological survey of ANL-W on the INEL
Keywords: CULTURAL RESOURCES / HISTORIC PRESERVATION / COMPLIANCE / PREHISTORY / ANL-W
Location: INEL CRM Archives

147. Ringe, B. L., 1988, *Archaeological Investigations on the Idaho National Engineering Laboratory: The T-12 Borrow Pit*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 88-12, Pocatello, ID.

Report on the intensive archaeological survey of a 10-acre area surrounding an active borrow pit northeast of the RWMC on the INEL. No cultural resources recorded.

Subject: Intensive archaeological survey of the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / RWMC / INTENSIVE ARCHAEOLOGICAL SURVEYS
Location: INEL CRM Archives

148. Ringe, B. L., 1988, *Archaeological Investigations on the Idaho National Engineering Laboratory: The RWMC Wind Gap*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 88-13, Pocatello, ID.

Report on the intensive archaeological survey of 60 acres northeast of the RWMC on the INEL resulting in recording of four cultural resources.

Subject: Intensive Archaeological survey near the RWMC on the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / RWMC / INTENSIVE ARCHAEOLOGICAL SURVEYS / PREHISTORY
Location: INEL CRM Archives

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149. Ringe, B. L., 1988, *Archaeological Investigation on the Idaho National Engineering Laboratory: The Inactive Borrow Area Near the RWMC*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 88-14, Pocatello, ID.

Report on the intensive archaeological survey of 53 acres southwest of the RWMC on the INEL resulting in the recording of three cultural resources.

Subject: Intensive archaeological survey near the RWMC on the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / RWMC / INTENSIVE ARCHAEOLOGICAL SURVEYS / PREHISTORY
Location: INEL CRM Archives

150. Ringe, B. L., 1988, *Archaeological Investigations on the Idaho National Engineering Laboratory: The Experimental Breeder Reactor I HTRE Display Pad*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigation, No. 88-16, Pocatello, ID.

Report on the intensive archaeological survey of 10 acres north of EBR I on the INEL. No cultural resources recorded.

Subject: Intensive archaeological survey at EBR I on the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / EBR I / INTENSIVE ARCHAEOLOGICAL SURVEYS
Location: INEL CRM Archives

151. Ringe, B. L., 1988, *Test Excavation of Ten Sites Along the Powerline Between PBF and EBR II, Idaho National Engineering Laboratory, Draft*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 88-6, Pocatello, ID.

Draft report documenting the archaeological test excavation of ten prehistoric archaeological sites located beneath the powerline that extends between PBF and ANL-W on the INEL.

Subject: Archaeological test excavation
Keywords: CULTURAL RESOURCES / PREHISTORY / COMPLIANCE / HISTORIC PRESERVATION / TEST EXCAVATION
Location: INEL CRM Archives

152. Ringe, B. L., 1989, *Archaeological Investigations on the Idaho National Engineering Laboratory: The CPP/TRA Gravel Pit*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 89-1, Pocatello, ID.

Report on the intensive archaeological survey of 35 acres surrounding a gravel pit between TRA and ICPP on the INEL resulting in the recording of one cultural resource.

Subject: Intensive archaeological survey of the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / TRA / ICPP / INTENSIVE ARCHAEOLOGICAL SURVEYS
Location: INEL CRM Archives

153. Ringe, B. L., 1989, *Archaeological Investigations on the Idaho National Engineering Laboratory: The Lost River Fault Trench*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 89-3, Pocatello, ID.

Report documenting the intensive archaeological survey of a small 4-area in the northern portion of the INEL. One cultural resource was recorded during the survey.

Subject: Archaeological survey on the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / INTENSIVE ARCHAEOLOGICAL SURVEYS
Location: INEL CRM Archives

154. Ringe, B. L., 1989, *Archaeological Investigations on the Idaho National Engineering Laboratory: The NPR Seismic Study*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 89-4, Pocatello, Idaho.

Report documenting the intensive archaeological survey of several areas for construction of seismic station. Two cultural resources were recorded in the 5 acres examined.

Subject: Archaeological survey on the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / INTENSIVE ARCHAEOLOGICAL SURVEYS / LEMHI RANGE / PREHISTORY
Location: INEL CRM Archives

155. Ringe, B. L., 1990, Letter, T.D. Reynolds, "Archaeological Clearance Recommendation for Soil Coring Near PBF," BLR-27-90, 11/5/90, Idaho Falls, ID,

156. Ringe, B. L., 1990, Letter, T.D. Reynolds, "Archaeological Clearance Recommendations for Development of Well Near Teakettle Butte," BLR-25-90, 10/23/90, Idaho Falls, ID,

157. Ringe, B. L., 1990, Letter, C. Peterson, "Archaeological Clearance Recommendation for Drilling Near Cinder Butte on the Idaho National Engineering Laboratory," BLR-17,90, 9/19/90, Idaho Falls, ID,

158. Ringe, B. L., 1990, *Archaeological Investigations at New Production Reactor Area E on the Idaho National Engineering Laboratory*, EGG-NPR-9032, Idaho Falls, ID, June 1990.

During the summer of 1989, an extensive archaeological survey was conducted at the preferred site for construction of the New Production Reactor on the INEL. A total of 116 prehistoric cultural resources were relocated or newly recorded during this survey.

Subject: Archaeological survey on the INEL for the NPR
Keywords: CULTURAL RESOURCES / NPR / COMPLIANCE / PREHISTORY /
ARCHAEOLOGICAL SURVEY / HISTORIC PRESERVATION
Location: INEL CRM Archives

159. Ringe, B. L., 1990, *Archaeological Survey for the Idaho National Engineering Laboratory Sewer Upgrade*, EGG-CRM-90-8-2, Idaho Falls, ID, November 1990.

Report documenting the intensive archaeological survey of a large area near CFA and two smaller areas near TRA and TAN, all encompassing approximately 225 acres. As a result of the project, 29 resources were recorded.

Subject: Archaeological survey near CFA, NRF, TAN, and TRA
Keywords: CULTURAL RESOURCES / COMPLIANCE / PREHISTORY /
HISTORY / ARCHAEOLOGICAL SURVEY / HISTORIC
PRESERVATION
Location: INEL CRM Archives

160. Ringe, B. L., 1990, *Archaeological Survey of the Access Road Between the Idaho Chemical Processing Plant and New Production Reactor Area E on the Idaho National Engineering Laboratory*, EGG-CRM-90-9-1, Idaho Falls, ID, October 1990.

In September 1990, members of EG&G's Cultural Resource Management staff conducted an archaeological survey along the road that provides access to the NPR, Area E via the ICPP on the INEL. A total of four prehistoric archaeological resources were identified in the 84 acres of land examined during the survey.

Subject: Archaeological survey road between ICPP & NPR
Keywords: CULTURAL RESOURCES / ARCHAEOLOGICAL SURVEY /
HISTORIC PRESERVATION / NPR / ICPP / COMPLIANCE /
PREHISTORY
Location: INEL CRM Archives

161. Ringe, B. L., 1990, *Archaeological Survey of a Powerline Corridor Between Central Facilities and the Radioactive Waste Management Complex on the Idaho National Engineering Laboratory*, EGG-CRM-90-11-3, Idaho Falls, ID.

Report documenting the archaeological survey of a proposed powerline corridor near the existing line between CFA and the RWMC. In the 220 acres examined 14 resources were identified.

Subject: Archaeological survey between CFA and RWMC
Keywords: CULTURAL RESOURCES / INTENSIVE ARCHAEOLOGICAL SURVEYS / COMPLIANCE / HISTORIC PRESERVATION / CFA / RWMC / PREHISTORY
Location: INEL CRM Archives

162. Ringe, B. L., 1991, Letter, J.A. Tullis, "Archaeological Clearance Recommendation for Deep Coreholes on and Near the Idaho National Engineering Laboratory," BLR-43-91, Idaho Falls, ID,

163. Ringe, B. L., 1991, *Archaeological Survey of the Final Alignment for a Road Between PBF and NPR Area E on the Idaho National Engineering Laboratory*, NPRD-91-010, Idaho Falls, ID, April 1991.

Report documenting the intensive archaeological survey of a 60 m wide corridor (approx. 20 acres) stretching from PBF to the center of NPR Area E where 4 cultural resources were identified.

Subject: Archaeological survey between PBF and NPR Area E
Keywords: CULTURAL RESOURCES / INTENSIVE ARCHAEOLOGICAL SURVEYS / COMPLIANCE/ HISTORIC PRESERVATION / PBF / NPR / PREHISTORY
Location: INEL CRM Archives

164. Ringe, B. L., 1991, *Archaeological Investigations for the Naval Reactor Facility Sewage Pond, Draft*, EGG-CRM-91-12-1, Idaho Falls, ID.

Draft report documenting the intensive archaeological survey of 38 acres south of the NRF on the INEL and resulting in the recording of three cultural resources.

Subject: Archaeological survey near CFA, NRF, TAN, and TRA
Keywords: CULTURAL RESOURCES / INTENSIVE ARCHAEOLOGICAL SURVEYS / COMPLIANCE / HISTORIC PRESERVATION / NRF / PREHISTORY
Location: INEL CRM Archives

165. Ringe, B. L., 1992, Letter, K.D. Christianson, "Archaeological Survey of the Area Between the A1W and S5G Railroad Spurs Near the Naval Reactors Facility (NRF) on the Idaho National Engineering Laboratory (INEL)," BLR-14-92, Idaho Falls, ID,
166. Ringe, B. L., 1992, Letter, T.J. Hill, "Archaeological Survey for the SNTP Tank Farm Northeast of LOFT on the INEL," BLR-41-92, 10/5/92, Idaho Falls, ID,
167. Ringe, B. L., 1992, *Archaeological Test Excavation of 10-BT-1605*, EG&G Idaho, Inc., EGG-CS-10448, Idaho Falls, ID, September 1992.
168. Ringe, B. L., 1992, *Archaeological Test Excavation of 10-BT-1230*, EG&G Idaho, Inc., EGG-CS-10268, Idaho Falls, ID, May 1992.

This report describes archaeological test excavations conducted from April 20-28, 1992 at a prehistoric site (10-BT-1230) near the RWMC on the INEL. Excavation of 80 systematically placed shovel probes indicate that the site is restricted to a surface context and is unlikely to yield any additional information.

Subject: Archaeological Test Excavation
Location: INEL CRM Archives

169. Ringe, B. L., 1992, *Archaeological Test Excavation of 10-BT-1609*, EG&G Idaho, Inc., EGG-CS-10334, Idaho Falls, ID, July 1992.

This report describes archaeological test excavations conducted during the period April 28 through June 30, 1992, at a prehistoric site (10-BT-1609) near the RWMC on the INEL. Excavation of 204 systematically placed shovel probes indicates that the site contains only limited subsurface cultural materials that are not appreciably different from the materials currently exposed at the surface.

Subject: Archaeological Test Excavation
Location: INEL CRM Archives

170. Ringe, B. L., 1992, *Archaeological Reconnaissance for the Radioactive Waste Management Complex Power Upgrade*, EG&G Idaho, Inc., EGG-CS-10395, Idaho Falls, ID, August 1992.
171. Ringe, B. L., 1993, *Locational Analysis and Preliminary Predictive Model for Prehistoric Cultural Resources on the INEL*, EG&G Idaho, Inc., EGG-CS-10706, Idaho Falls, ID.

172. Ringe, B. L.; Holmer, R. N.; Miller, S. J.; Hearst, J., and Akersten, W., 1987, *Archaeological and Paleontological Survey of the Idaho National Engineering Laboratory for the Super Conducting Super Collider*, Idaho Museum of Natural History Reports of Investigations, No. 87-12, Pocatello, ID.

Preliminary predictive model for prehistoric cultural resources on the INEL based on intensive archaeological sample surveys conducted to gather information for assessing the probable effects of construction of the Super Conducting Super Collider on the INEL. The report describes 48 cultural resources recorded during these surveys and also provides a detailed description and preliminary predictive model for paleontological resources on the INEL.

Subject: Archaeological and Paleontological sensitivity on the INEL
 Keywords: CULTURAL RESOURCES / PALEONTOLOGY /
 ARCHAEOLOGICAL SURVEY / PREDICTIVE MODELLING /
 PREHISTORY / HISTORY / SSC
 Location: INEL CRM Archives

173. Ringe, B. L.; Holmer, R. N., and Reed, W. G., 1988, "Current Perspectives on the Prehistory of the Eastern Snake River Plain," *Twenty-First Great Basin anthropological Conference*, Park City, UT, October 1988.

Summary of research conducted in the INEL region and synthesis of a four-part cultural sequence as follows: Early Prehistoric Period (15,000–7500 B.P.), Middle Prehistoric Period (7500–1300 B.P.), Late Prehistoric Period (1300–15 B.P.), and Protohistoric Period (150–100 B.P.).

Subject: Cultural Chronology
 Keywords: CULTURAL CHRONOLOGY / PROJECTILE POINTS / CULTURAL
 RESOURCES / PREHISTORY
 Location: INEL CRM Library

174. Ringe, B. L.; Reed, W. G., 1987, Letter, N.E. Stanley, "Archaeological Clearance of TAN Fire Station, TRA Drill Pad, RWMC Borehole, and Weapons Range Powerline," 6/15/87, Idaho Falls, ID,

175. Ross, A., 1956, "The Fur Hunters of the Far West," Spaulding, K. A. (ed.), Norman, OK, University of Oklahoma Press.

176. Ross, J. W., 1988, *An Archaeological Survey of a Proposed Borrow Area Near the Chemical Processing Plant on the Idaho National Engineering Laboratory*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 88-3, Pocatello, ID.

Documentation of an intensive archaeological survey of a small area (2.5 acres) near ICPP here one cultural resource was recorded.

Subject: Archaeological survey near ICPP
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
PRESERVATION / ICPP
Location: INEL CRM Archives

177. Ross, J. W.; Ringe, B. L.; Reed, W. G., and Holmer, R. N., 1986, *Archaeological Surveys of Three INEL Gravel Pit Locations*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 86-6, Pocatello, ID.

Detailed report on archaeological surveys of existing gravel pits at TAN, CFA, and NRF on the INEL. In the course of these investigations, 21 cultural resources were recorded (11 AT tan, 9 CFA, and 1 at NRF).

Subject: Archaeological surveys at TAN, CFA, and NRF
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
PRESERVATION / CFA / NRF / TAN / INTENSIVE
ARCHAEOLOGICAL SURVEYS
Location: INEL CRM Archives

178. Ross, R. L., 1976, *Wild, Edible, and Medicinal Plants*, Montana State University Cooperative Extension Service, Circular No. 11183, Bozeman, MT.

Data gathered by interviewing Native Americans living in Montana, on useful/wild plants that were/are gathered for dyes, medicines, and foods, and how they were prepared for use.

Subject: Native American plant use
Keywords: ETHNOBOTANY / CULTURAL RESOURCES / USEFUL PLANTS /
PLANT DYES / PLANT MEDICINE / ETHNOGRAPHY
Location: INEL CRM Library

179. Sadck-Kooros, Hind, 1972, "The Sediments and Fauna of Jaguar Cave, I: The Sediments," *Tebiwa*, 15(1):1-21.

Description of the stratigraphy and faunal assemblage revealed during excavation of Jaguar Cave located north of the INEL.

Subject: Archaeological excavation of Jaguar Cave

Keywords: ARCHAEOLOGICAL EXCAVATION / CULTURAL RESOURCES /
CAVE / DOMESTIC DOG / JAGUAR CAVE / BIG GAME HUNTING
Location: INEL CRM Library

180. Sammons-Lohse, D., and Holmer, R. N., 1990, *Archaeological Survey of the Radioactive Waste Management Center Perimeter*, Northern Intermountain Quaternary Institute Reports of Investigations, No. 90-2, Pocatello, ID.

Report on the intensive archaeological survey of the 400 acre area surrounding the RWMC on the INEL (Section 18, T2N, R29E). The project resulted in the recording or rerecording of 36 prehistoric cultural resources, which are described and evaluated in the report.

Location: INEL CRM Archives

181. Sargeant, K. E., 1973, *The Haskett Tradition: A View from Redfish Overhang*, Master's thesis, Idaho State University, Pocatello, ID.

182. Schiffer, M. B., and Gumerman, G. J., 1977, *Conservation Archaeology: A Guide for Cultural Resource Management Studies*, New York, NY, Academic Press.

183. Schmalz, B. L., 1963, "Headgates and Headaches: The Powell Tract," *Idaho Yesterdays*, 9(4):22-25.

184. Schwantes, C. A., 1991, *In Mountain Shadows: A History of Idaho*, Lincoln, NE, University of Nebraska Press.

A general book of Idaho history covering early state history such as Indians and exploration, mining, Mormons, statehood, transportation, economy, education, politics, and the varying ethnic backgrounds throughout the state.

Subject: Idaho History
Keywords: HISTORY / LEWIS AND CLARK / MINING / INDIANS / CAREY
LAND ACT / INEL / ECONOMY / MORMONS / TRAPPING /
EXPLORATION
Location: Idaho Falls Public Library

185. Scott, P. L., 1983, *Idaho and the Carey Act, 1894-1930: Reclamation by the States*, Master's thesis, University of Utah, Salt Lake City, UT.

Discussion of the history and implementation of the Carey Land Act (1894) in Idaho. This legislation spurred much of the agricultural development in the vicinity of the INEL by offering free acreage to settlers who participated in State-sponsored reclamation projects.

Subject: History of Idaho agricultural

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Keywords: CAREY LAND ACT / RECLAMATION / AGRICULTURE /
PIONEERS / MORMONS

Location: INEL CRM Library

186. Sedgewick, M., n.d., *Manuscript*, Idaho State University Archives, Eli M. Obler Library, Pocatello, ID.
187. Sherfy, M., and Luce, W. R., n.d., *Guidelines for Evaluating and Nominating Properties That Have Achieved Significance Within the Last Fifty Years*, In: National Register Bulletin, No. 22, Washington, D.C.
188. Shimkin, D. B., 1947, "Wind River Shoshone Ethnogeography," *University of California Anthropological Records*, 5(4):245-288.
189. Simms, S. R., 1984, *Aboriginal Great Basin foraging Strategies: An Evolutionary Analysis*, Ph.D. Dissertation, Department of Anthropology, University of Utah, Salt Lake City, Utah.
190. Sneed, P. G., 1967, "An Archaeological Reconnaissance of the Craters of the Moon National Monument," *Tebiwa*, 10(1):37-52.

Documentation of an intuitive archaeological survey within Craters of the Moon National Monument during which 28 prehistoric sites were identified. This includes open sites, caves, rock structures, hunting blinds, and quarries (obsidian and basalt). Artifacts are also described in this short report which documents prehistoric use as opposed to avoidance of the rough volcanic region, although it is suggested that movement across the SRP was probably deflected to the north and/or south of the major lava formations.

Subject: Archaeological survey of the Craters of the Moon National Monument

Keywords: CULTURAL RESOURCES / INTUITIVE ARCHAEOLOGICAL
SURVEY / PREHISTORY / LAVA / CRATERS OF THE MOON
NATIONAL MONUMENT

Location: INEL CRM Library

191. Spcar, D. B., and King, J. S., 1986, *The Geology of Big Southern Butte, Idaho*, In: Cenezoic Geology of Idaho, edited by B. Bonnichsen and R.M. Breckenridge, pp. 395-403, Idaho Bureau of Mines and Geology Bulletin No. 26, Moscow, ID.
 192. Staley, Mildred, 1978, "Water: A History of the Mud Lake Area," *Snake River Echoes*, 7(1):11-12.
- A quarterly publication of miscellaneous articles focussing on Snake river Valley History (Vol. 3-21, 1974-1992).*

Subject: History of Southeast Idaho
Keywords: SNAKE RIVER BASIN / LOCAL HISTORY / PIONEERS /
CULTURAL RESOURCES
Location: INEL CRM Library

193. Steward, J. H., 1938, *Basin Plateau Aboriginal Sociopolitical Groups*, Bureau of American Ethnology Bulletin, No. 120, Washington, D.C.

Important ethnographic study of Shoshonean groups in Idaho and surrounding areas.

Subject: Shoshone-Bannock culture, settlement, and subsistence
Keywords: SHOSHONE INDIANS / BANNOCK INDIANS / ETHNOGRAPHY /
PREHISTORY / HUNTING AND GATHERING / SETTLEMENT AND
SUBSISTENCE / CULTURAL RESOURCES
Location: INEL CRM Library

194. Steward, J. H., 1943, "Culture Element Distributions XXIII: Northern and Gosiute Shoshoni," *University of California Anthropological Records*, 8(3):263-392.

Detailed description of select elements of Shoshonean culture (i.e., dwellings).

Subject: Shoshonean culture
Keywords: SHOSHONE INDIANS / LIFEWAY / ETHNOGRAPHY /
PREHISTORY / SETTLEMENT AND SUBSISTENCE / CULTURAL
RESOURCES
Location: Eli M. Obler Library, Pocatello, ID

195. Suid, L. H., 1990, *The Army's Nuclear Power Program: the Evolution of a Support Agency*, In: Contributions in Military Studies, No. 98, New York, NY.

196. Swanson, E. H., Jr., 1972, *Birch Creek: Human Ecology in the Cool Desert of the Northern Rocky Mountains 9000 B.C.-A.D. 1850*, Pocatello, ID, Idaho State University Press.

Prehistoric overview for the Birch Creek Valley based largely on excavations at Bison and Veratic rockshelters. The proposed five-phased chronological sequence is utilized in the INEL region and much of southern Idaho and is as follows: Birch Creek Phase-11,000-7200 B.P., Bitterroot Phase-7200-3450 B.P., Beaverhead Phase-3450-2950 B.P., Blue Dome Phase-2950-750 B.P., and the Lemhi Phase-750-150 B.P. Based on his research, Swanson defines the Bitterroot Culture, an 8000 year span of continual occupation of the Northern Rockies by ancestors of the Northern Shoshone.

Subject: Prehistory of Birch Creek Valley

Keywords: CULTURAL RESOURCES / PREHISTORY / CULTURAL
CHRONOLOGY / ROCKSHELTERS / BIRCH CREEK VALLEY /
BITTERROOT CULTURE / SHOSHONE INDIANS
Location: INEL CRM Library

197. Swanson, E. H., Jr., and Bryan, A. L., 1964, *Birch Creek Papers No. 1: An Archaeological Reconnaissance in the Birch Creek Valley of Eastern Idaho*, In: Occasional Papers of the Idaho State University Museum, No. 13, Pocatello, ID.

Documentation of an intuitive archaeological survey of the Birch Creek drainage. Based on results of the survey, it is suggested that the northern edge of the northeastern SRP (< 6000 ft. elevation) was abandoned by human populations from approx. 7000-3000 B.P. due to the onset of very dry climatic conditions and the desiccation of the Birch Creek/Lost River Sinks. The middle portion of the Birch Creek Valley shows no evidence of this lack of occupation and is interpreted as an upper limit to the effects of the dry climatic regime. Several sites recorded during this project are located on the INEL including: 10-BT-33, 10-BT-34, 10-BT-37, 10-BT-38, 10-BT-39, 10-BT-40, 10-JF-4, 10-JF-5, 10-JF-6, 10-JF-7, and 10-JF-8. All are significant for future research.

Subject: Prehistory of Birch Creek Valley
Keywords: CULTURAL RESOURCES / ALTITHERMAL / ARTIFACTS /
INTUITIVE ARCHAEOLOGICAL SURVEY / BIRCH CREEK
VALLEY / SINKS
Location: INEL CRM Library

198. Swanson, E. H., Jr.; Butler, B. R., and Bonnicksen, R., 1964, *Birch Creek Papers No. 2: Natural and Cultural Stratigraphy in the Birch Creek Valley of Eastern Idaho*, In: Occasional Papers of the Idaho State University Museum, No. 14, Pocatello, ID.

Brief reports on test excavations and artifact assemblages recovered from prehistoric sites in the Birch Creek Valley. Includes the following: Bar^z Ranch, Sawmill Canyon (10-BT-62), Uncle Ike Creek (10-BT-52), Coral Island, tipi ring Site (10-CL-4), Desert Zone Site (10-BT-51 on the INEL), Cottontail rockshelter (10-CL-23), Bobcat Rockshelter (10-CL-11), 10-CL-35, 10-CL-46, 10-CL-100, and Deer Skeleton Cave (10-CL-27). Evidence of alternating drier and moister conditions is preserved at each locality and the document ends with a discussion of the relationship between climatic change and human occupation.

Subject: Prehistory of Birch Creek Valley
Keywords: ARCHAEOLOGICAL EXCAVATION / CULTURAL RESOURCES /
PREHISTORY / BIRCH CREEK VALLEY / CLIMATE / CAVE
Location: INEL CRM Library

199. Swanson, E. H., Jr.; Tuohy, D. R., and Bryan, A. L., 1959, *Archaeological Explorations in Central and Southern Idaho, 1958: Types and Distributions of Site Features and Stone Tools*, In: Occasional Papers of the Idaho State College Museum, No. 2, Pocatello, ID.

Documentation of one of the earliest archaeological survey projects in southeastern Idaho. Report includes limited discussions of the sites identified and artifacts recovered during a large-scale intuitive survey of proposed reservoirs along the Snake and Salmon rivers. Survey methods are not discussed and discussion of site distributions are of limited value. Among the sites recorded during his early project, four are located on the INEL: 10-BT-3, 10-BT-19, 10-BT-29, and 10-BT-30. All of these are very significant resources.

Subject: Intuitive archaeological survey of southern Idaho
Keywords: CULTURAL RESOURCES / PREHISTORY / INTUITIVE
ARCHAEOLOGICAL SURVEY / ARTIFACTS / SNAKE RIVER /
SALMON RIVER
Location: INEL CRM Library

200. Thomas, David H., 1981, "How to Classify the Projectile Points from Monitor Valley, Nevada," *Journal of California and Great Basin Anthropology*, 3(1):7-43.

Discussion of a well-dated and well-documented projectile point sequence from the Great Basin useful for classification of artifacts from the INEL regions.

Subject: Cultural chronology
Keywords: CULTURAL CHRONOLOGY / PROJECTILE POINTS / GREAT
BASIN / ARTIFACTS
Location: INEL CRM Library

201. Thompson, R. W., 1991, *Subsurface Archaeological Investigations at New Production Reactor Area E on the Idaho National Engineering Laboratory*, In: Northern Intermountain Quaternary Institute archaeological Report, No. 91-6, Pocatello, ID.

Documentation of subsurface test excavations of 17 sites at NPR Area E conducted in the Fall of 1991.

Subject: Archaeological test excavation
Keywords: PREHISTORY / TEST EXCAVATION / COMPLIANCE / CULTURAL
RESOURCES / HISTORIC PRESERVATION / NPR
Location: INEL CRM Archives

202. Thompson, R. W., 1992, *Subsurface Archeological Investigations at New Production Reactor Area E on the Idaho National Engineering Laboratory*, North Intermountain Quaternary Institute Archaeological Reports, No. 91-6, Pocatello, ID.

203. Titmus, G. L., and Woods, J. C., 1991, "Fluted Points from the Snake River Plain," Bonnichsen, R.; Turnmire, K. L. (eds.), *Clovis Origins and Adaptations*, Oregon State University Center for the Study of the First Americans, Corvallis, OR.

Review of the morphology and technology of a collection of fluted points (12,000-9000 B.P.) recovered from several localities in southern Idaho. Detailed examination suggest that the Idaho specimens may share characteristics that distinguish them from other areas.

Subject: Prehistoric projectile point classification
Keywords: PROJECTILE POINTS / EARLY PREHISTORIC / PALEOINDIAN / CLOVIS FOLSOM / FLUTED POINTS
Location: INEL CRM Library

204. Trego, B., n.d., *Manuscript No. 142*, Idaho State University Archives, Eli M. Obler Library, Pocatello, ID.

205. Trego, B., 1928, "Pioneer Lore," Blackfoot Daily Bulletin, Blackfoot, ID. April, 5, 1928.

Newspaper article on Idaho history.

Subject: Idaho History
Location: Idaho Falls Public Library

206. Trego, B., 1935, "Pioneer Lore," Blackfoot Daily Bulletin, Blackfoot, ID. April 11, 1935.

Newspaper article on Idaho history.

Subject: Idaho history
Location: Idaho Falls Public Library

207. U.S. National Park Service, 1978, *The Archaeological Survey: Methods and Uses*, PB-284-061, Washington, D.C.

Nontechnical presentation of the basic methods and objectives of archaeological surveys including: background research, research design, and fieldwork, as conducted in the context of cultural resource management and regulatory compliance.

Subject: Methods and objectives of archaeological survey projects
Keywords: CULTURAL RESOURCES / HISTORIC PRESERVATION / COMPLIANCE / ARCHAEOLOGICAL SURVEY
Location: INEL CRM Library

208. Walker, D. W., 1982, *Indians of Idaho*, Moscow, ID, University of Idaho Press.

General survey of the aboriginal American Indian cultures of Idaho gleaned from historical and ethnographic writings and focussed on the Kutenai, Kalispel, Coeur d'Alene, Nez Pierce, Shoshone-Bannock, and Northern Paiute.

Subject: Native American groups in Idaho
Keywords: NATIVE AMERICAN GROUPS / SHOSHONE INDIANS / BANNOCK INDIANS / PREHISTORY / SETTLEMENT AND SUBSISTENCE / CULTURAL RESOURCES
Location: INEL CRM Library

209. Wentworth, E. C., 1948, *America's Sheep Trails*, Iowa State College Press.

210. White, J. A.; McDonald, H. G.; Anderson, E., and Soiset, J. M., 1984, "Lava Blisters as Carnivore Traps," Genoways, H. H.; Dawson, M. R. (eds.), *Contributions in Quaternary Vertebrate Paleontology: A Volume in Memorial to John E. Guilday*, Special Publication of the Carnegie Museum of Natural History, No. 8, Pittsburgh, PA.

Based on faunal analyses, study of carnivore behavior patterns, and examination of cave morphology, it is suggested that Middle Butte and Moonshiner Caves (both located on the INEL) operated over long periods of time as baited traps for carnivorous mammals such as wolves, coyotes, foxes, badgers, wolverines, martens, and weasels. At Moonshiner Cave, 30% (42% of biomass) is composed of carnivores and at Middle Cave, carnivores make up 42% (40% of biomass). In a "normal" fossil cave fauna from this region, carnivore remains usually make up only 2-5% of the total assemblage.

Subject: Paleontology of lava tubes
Keywords: PALEONTOLOGY / LAVA TUBES / CARNIVORES / MIDDLE BUTTE CAVE / MOONSHINER CAVE / FAUNAL TRAPS
Location: INEL CRM Library

211. Williams, M. H., 1970, *Special Report: the History of Development and Current Status of the Carey Act in Idaho*, Idaho Department of Water Resources, Boise, ID.

History, development and implementation of Carey Land Act sponsored agricultural pursuits in Idaho.

Subject: History of Idaho agricultural
Keywords: CAREY LAND ACT / AGRICULTURE / CULTURAL RESOURCES / RECLAMATION
Location: INEL CRM Library

212. Winterhalder, B., and Smith Eric Alden, 1981, *Hunter-Gatherer Foraging Strategies*, Chicago, IL, University of Chicago Press.

213. Work, J., 1923, "The Journal of John Work, a Chief Trader of the Hudson's Bay Company During His Expedition From Vancouver to the Flatheads and the Blackfeet of the Pacific Northwest," Lewis, W. S.; Phillips, P. C. (eds.), Cleveland, OH, Arthur H. Clark Co.

214. Wormington, H. M., 1954, *Ancient Man in North America*, Denver Museum of Natural History Popular Series No. 4.

Discussion of early prehistoric (Pleistocene) occupation of North America circa 12,000–10,000 B.P.

Subject: Pleistocene occupation of North America
Location: Eli M. Obler Library, Pocatello, ID

215. Wright, S., 1988, *An Archaeological Survey of a Proposed Underground Telephone Cable Route Between TRA and Lincoln Blvd, Idaho National Engineering Laboratory*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 88-5, Pocatello, ID.

Documentation of an intensive archaeological survey of 46 acres near TRA resulting in the documentation of two cultural resources.

Subject: Archaeological survey near CFA, NRF, TAN, and TRA
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / TRA / PREHISTORY
Location: INEL CRM Library

216. Wright, S., 1988, *An Archaeological Survey of a Proposed Gravel Haul Road Between Borrow Pits Near CFA and the Weapons Range at the Idaho National Engineering Laboratory*, Swanson/ Crabtree Anthropological Research Laboratory Reports of Investigations, No. 88-7, Pocatello, ID.

Documentation of an intensive archaeological survey of 38 acres near CFA resulting in the recording of 4 cultural resources.

Subject: Archaeological survey near CFA, NRF, TAN, TRA
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC PRESERVATION / CFA / PREHISTORY
Location: INEL CRM Archives

217. Wright, S.; Henrikson, N. D., and Homer, R. N., 1989, *Archaeological Survey of the Fast Attack Vehicle Off-road Training Area*, Northern Intermountain Quaternary Institute Reports of Investigations, No. 89-6, Pocatello, ID.

Documentation of the intensive survey of 915 acres southeast of CFA resulting in the identification of 63 previously unrecorded cultural resources.

Subject: Archaeological survey on the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
PRESERVATION / FAV / PREHISTORY / HISTORY
Location: INEL CRM Archives

218. Wright, S., and Holmer, R. N., 1987, *An Archaeological Survey of Three Ant Study Areas on the Idaho National Engineering Laboratory*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 87-15, Pocatello, ID.

Documentation of the intensive survey of three study plots totalling approx. 104 acres and resulting in the recording of eight cultural resources.

Subject: Archaeological survey near CFA, NRF, TAN, and TRA
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
PRESERVATION / CFA / PREHISTORY
Location: INEL CRM Archives

219. Wright, S., and Holmer, R. N., 1990, *Archaeological Investigation on the Idaho National Engineering Laboratory: The Hunting Boundary Signing Project*, Swanson/Crabtree Anthropological Research Laboratory Reports of Investigations, No. 90-2, Pocatello, ID.

Documentation of intensive archaeological surveys of linear corridors totalling approx. 675 acres near the INEL boundary. As a result of this survey, 45 previously unknown cultural resources were identified.

Subject: Archaeological survey on the INEL
Keywords: CULTURAL RESOURCES / COMPLIANCE / HISTORIC
PRESERVATION / INEL BOUNDARY / PREHISTORY / HISTORY
Location: INEL CRM Archives

220. Wyeth, N. J., 1899, "The Correspondence and Journals of Captain Nathaniel J. Wyeth, 1831-1836," *Sources of the History of Oregon*, No. 1, Eugene, OR.

F.8 Keyword List^c

AEOLIAN SEDIMENT: 87	ATOMIC ENERGY COMMISSION: 133
AGRICULTURE: 11, 18, 55, 185, 211	ATOMIC WEAPONS: 70, 71
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AMPHIBIANS: 9	BIG GAME HUNTING: 21, 52, 89, 109, 179
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c. Numbers refer to numbered references in Section F.7, Annotated Bibliography for Cultural Resources.

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Appendix G

**Environmental Resource Databases and
Geographic Information Systems**

Reed L. Hoskinson

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ACRONYMS

ARA	Auxiliary Reactor Area
ASCII	American Standard Code for Information Interchange
CBS	Community Base Station
CEMA	Center for Environmental Monitoring and Assessment
CRCS	Computer Registration and Computer Security
DBMS	database management system
DEC	Digital Equipment Corporation
DOE	U.S. Department of Energy
E&WMC	Environmental and Waste Management Computing
ERIS	Environmental Restoration Information System
GIS	Geographic Information Systems
GPS	Global Positioning System
GRASS	Geographical Resources Analysis Support System
IMACS	Intermountain Antiquities Computer System
INEL	Idaho National Engineering Laboratory
INWMIS	INEL nonradiological Waste Management Information System
ISC	INEL Supercomputing Center
NOAA	National Oceanic and Atmospheric Administration
NPR	New Production Reactor
PC	personal computer
RCO	Regulatory Compliance Office
RESL	Radiological and Environmental Sciences Laboratory
RWMC	Radioactive Waste Management Complex
RWMIS	Radioactive Waste Management Information System
SAIC	Science Applications International Corporation
TRA	Test Reactor Area
USGS	U.S. Geological Survey
WAG	Waste Area Group

Appendix G

Environmental Resource Databases and Geographic Information Systems

Section G.1 discusses environmental resource databases available at the Idaho National Engineering Laboratory (INEL). Section G.2 discusses geographic information systems (GIS) and their availability at the INEL.

G.1 Environmental Resource Databases

This section discusses environmental resource databases available at the INEL. Most of these databases are accessed through some database management system (DBMS) such as dBase or Oracle.^a The DBMS allows you to store and retrieve the information using the DBMS. Other "databases" discussed are simply computer files of data, most often in a word processing format, or in American Standard Code for Information Interchange (ASCII) format. The environmental resource databases discussed cover a broad range of data quality. Carefully review the data quality and the security of the data when using these resources. Table G-1 lists contacts and phone numbers for different databases. To access some databases, the you must have or obtain a registered user ID from Computer Registration and Computer Security (CRCS) at the INEL Supercomputing Center (ISC). The following are descriptions of environmental resource databases currently available at the INEL.

G.1.1 Wind

G.1.1.1 CAP-88. The Idaho Falls office of the National Oceanic and Atmospheric Administration (NOAA) supplied wind data from the 5-year period from 1987 through 1991 for seven INEL sites. These data were in the form of joint frequency distributions of hours distributed over 16 wind directions, eight wind-speed classes, and six atmospheric stability categories. These hourly data were put into the computer program BASIC, which converts the joint frequency distributions of hours into the parameters required by CAP-88. The infrequent hours for the highest wind-speed class [>22.58 m/sec (74.08 ft/sec)] were put into the seventh class [15.42–22.58 m/sec (50.59–74.08 ft/sec)] for this data conversion. Since CAP-88 requires data for seven stability categories, an array of zeros was added for Category G.

a. Mention of specific products of manufacturers in this document implies neither endorsement, preference, nor disapproval by the U.S. Government, any of its agencies, or EG&G Idaho, Inc., of the use of a specific product for any purpose.

Appendix G ♦ G-2

Table G-1. GIS, GPS, and environmental database contacts.

Database	Organization responsible (contact)	Telephone number
GIS/GPS Information		
To obtain registered user ID	Computer Registration and Computer Security	526-9949
GIS/GPS Technical Assistance	Center For Environmental Monitoring and Assessment	526-9491
Assistance with GRASS & KHOROS	Computational Services Visualization	526-9379
Coverages on DEC Arc/Info® System	Environmental and Waste Management Computing (E&WMC) Data Administrator	526-0680
Arc/Info® System	E&WMC Technical Leader	526-1036
Air		
CAP-88 code data	Subsurface and Environmental Modeling Unit	526-0788
GENII code	Subsurface and Environmental Modeling Unit	526-0788
NOAA	Radiological Environmental Science Laboratory	526-2311
Water		
Drinking Water Wells database	Environmental Technical Support Unit	526-2504
Hydraulic Bibliography database	Applied Geosciences	526-6782
Water Quality and Quantity database	Subsurface and Environmental Modeling Unit	526-8005
Geology and Seismology		
RWMC Bibliography Database	Geology and Seismology Unit	526-9896
NPR Bibliography database	Geology and Seismology Unit	526-9896
WAG 10 Well Repository	Geology and Seismology Unit	526-9896
NPR Geologic Database	Center For Environmental Monitoring and Assessment	526-9501

Table G-1. (continued).

Database	Organization responsible (contact)	Telephone number
Cultural and Socioeconomic Resources		
IMACS	Cultural Resources Management Unit	526-9748 or 526-5106
Predictive Model for Prehistoric Resources	Cultural Resources Management Unit	526-9748
Cultural Resource Archives	Cultural Resources Management Unit	526-9748 or 526-5106
Socioeconomic Databases	Environmental Assessment and Permitting Unit	525-5999
Environmental Restoration and Waste Management		
ERIS Database	E&WMC Technical Leader	526-1036
RWMIS Database	Environmental Technical Support Unit	526-2504
INWMIS Database	Environmental Technical Support Unit	526-2504
RCO Milestone Tracking System	Regulatory Compliance Office	526-1728
Site Facility		
INEL Boundary Distance Database	Subsurface and Environmental Modeling Unit	526-0788
Contaminated Soil Database	Planning and Inspection	526-1182

Two sets of wind files were created, one set with the calm hours included in the input and another set without the calm hours. When included, calm hours are incorporated into the first wind-speed class for each stability category in the same proportion as the hours for each direction have to the total hours in that first class. The resulting files were given characteristic names to identify them. These files are now stored on the Cray supercomputer at ISC, and are available to CAP-88 users.

G.1.1.2 GENII. The NOAA wind data from the five-year period from 1987 through 1991 for seven INEL sites were added to a spreadsheet. These data are distributed over 16 wind directions with eight wind-speed classes and six atmospheric stability categories. The spreadsheet calculates the fractions, in percent of total hours, represented by the number of hours the wind blows in a given direction at a given velocity for a specific stability category. The resulting computer files were given characteristic names to identify them.

G.1.1.3 NOAA. NOAA has weather data such as temperature, rainfall, and wind speed/direction since the 1950s.

G.1.2 Water

G.1.2.1 Hydraulic Bibliography. The Hydraulic database contains an annotated bibliography of reports and documents dealing with the hydrology at the INEL. Topics include surface water, vadose zone, perched water zones, and the saturated zone (Snake River Plain Aquifer). Some material is included as parts of other documents, such as site surveillance information, of which water monitoring is one section. Information includes historical data through current data. Besides the annotation, the data base includes the subject, keywords, and physical location of the document.

G.1.2.2 Drinking Water Wells. The Drinking Water Wells database contains validated water quality data from drinking water wells controlled by EG&G Idaho, Inc.

G.1.3 Geology, Seismology, and Volcanism

G.1.3.1 Radioactive Waste Management Complex (RWMC) Bibliography. The RWMC bibliographic database is a PC system using the Pro-Cite DBMS. It contains a listing of 183 references concerning geology, hydrology, and contaminant distribution at RWMC. Most references are specific to RWMC, but some are concerned with the INEL as a whole and with other INEL facilities.

G.1.3.2 New Production Reactor (NPR) Bibliography. The NPR bibliographic database is a WordPerfect-based PC system. It contains a bibliographic listing of several hundred references concerning regional and local geologic, geophysical, seismic, and volcanic information used for the NPR Safety Analysis Report.

G.1.3.3 WAG 10 Well File Repository. The well repository for Waste Area Group (WAG) 10 is a PC-based Pro-Cite DBMS. It is a comprehensive collection of INEL well log and geologic/hydrologic information designed to support the development of the comprehensive remedial investigation/feasibility study for the INEL. This repository is in development and will continue to grow.

G.1.3.4 NPR Geologic Database. The NPR Geologic Database runs on the IBM mainframe ADoCS software system. The database contains a bibliography, and some abstracts, of natural sciences, nuclear engineering, and waste management publications. ADoCS allows keyword search, sorting, and printed output.

G.1.4 Ecology, Cultural, and Socioeconomic Resources

G.1.4.1 Radiological and Environmental Sciences Laboratory (RESL). RESL maintains several data sets of ecological information collected at the INEL by them and other government agencies. These data sets include:

- Weather data (e.g., temperature, rainfall, wind speed/direction) since the 1950s
- Aerial photographs of the INEL dating back to 1949
- Permanent stream streamflow data from six stations since 1965
- Intermittent stream streamflow data from four stations since 1986
- Vegetation transect data since 1950
- Winter raptor survey since about 1982
- Breeding-bird survey since about 1983
- Pronghorn antelope production-survey since about 1983
- Radionuclides in air, soil, water, and foodstuffs since 1966.

G.1.4.2 Intermountain Antiquities Computer System (IMACS). The IMACS provides a standardized regional format for the recording of cultural resources. Many state and Federal agencies, universities, and private individuals in the region of Idaho, Nevada, Wyoming, and Utah subscribe to IMACS. In addition, the Idaho State Historic Preservation Office requires that all cultural resource site registrations in southern Idaho be submitted in IMACS format. To facilitate this process, the INEL Cultural Resource Management Office has set up ArcheoCompute, a commercial, PC-based database management program designed to accept and manipulate information in IMACS format. Currently, the INEL IMACS database includes detailed administrative, environmental, and descriptive information for over 500 cultural resources located on the INEL.

G.1.4.3 Predictive Model for Prehistoric Resources. Predictive modeling efforts on the INEL rely on two comparable databases. The first summarizes assemblage characteristics and environmental features for more than 700 prehistoric archaeological components identified on the INEL. The second is an environmental control sample that consists of environmental features recorded for 500 randomly-drawn points on the INEL. Variables measured for these databases include two administrative categories, four measures of variability within the archaeological assemblages (not included in the environmental control sample), and 14 environmental

characteristics including physiographic zone, aspect, elevation, three measures of local relief [100, 250, and 500 m (328, 820, and 1,640 ft) radii], and eight measures of distance to local features judged to have had some impact on prehistoric settlement choices (permanent water, intermittent water, sinks, Pleistocene Lake Terreton, foothills, buttes, lava margins, and recent lava margins).

G.1.4.4 Cultural Resource Archives. Results of all cultural resource inventories conducted on the INEL are summarized in several databases. The INEL Cultural Resource Project database includes the following: project identifiers, acreage, map location, number of isolates, and number of sites for over 150 intensive survey projects conducted on the INEL between 1980 and the present. It also includes bibliographic references for all projects completed on the INEL since the early 1950s. The INEL Site database includes project information and limited descriptive data for all cultural resources formally recorded on the INEL since the early 1950s.

G.1.4.5 Socioeconomic Database for Southeastern Idaho. The Socioeconomic database for Southeastern Idaho contains relevant socioeconomic data, and was developed to provide (a) the statistical data necessary for socioeconomic impact analysis for activities at the INEL and (b) data for risk assessments according to the standards of the U.S. Nuclear Regulatory Commission.

Data have been collected for two identifiable regions to satisfy these purposes. The first region (or primary socioeconomic impact area) consists of Bannock, Bingham, Bonneville, Butte, Jefferson, and Madison counties in Idaho. This region includes most of the population and economic activity expected to be affected by any INEL activity.

The second region, for Nuclear Regulatory Commission standards, encompasses a much larger geographic area. The Nuclear Regulatory Commission requires that human population, animal population, and land use within 80 km (50 mi) of a reactor facility be identified. The area covered by this 80-km (50-mi) radius includes part or all of the counties listed above and parts of Blaine, Clark, Custer, Fremont, Lemhi, Lincoln, Minidoka, and Power counties. This region is divided into concentric rings 16 km (10 mi) wide, and 16 22.5-degree sectors. The center of the 80-km (50-mi) radius circle is placed on a facility and data are reported for each of the 80 sections. Data in this format can be found in appropriate sections of the socioeconomic database.

The database consists primarily of 279 statistical tables with a little text and nine figures. The tables are organized into the following headings:

- Economic conditions (including employment, income/wage, and employers)
- Tax structure, revenue, and expenditures
- Health services
- Public safety
- Political and municipal systems
- Public welfare
- Housing

- Transportation systems
- Agriculture
- Tourism
- Utilities
- Water supply and delivery systems
- Demographics.

G.1.5 Environmental Restoration and Waste Management

G.1.5.1 Environmental Restoration Information System (ERIS). The ERIS, which is an Oracle DBMS application, consists of several high-quality databases of environmentally related information. ERIS is maintained by E&WMC for the Environmental Restoration and Waste Management Department in support of the U.S. Department of Energy Idaho Operations Office. All ERIS data sets reside in a controlled environment so that change is regulated and data quality is maintained. The data are protected from inadvertent loss with comprehensive backup and restore procedures and with a comprehensive security plan and procedures. The principal user of ERIS is the Environmental Restoration Program.

The main data set of interest is the Chemical Sampling database, which consists of about 300,000 records of chemical analytical samples collected during environmental remediation at the INEL. The sample intent ranges from characterization of Environmentally Controlled Areas to background sampling in noncontaminated areas. Almost all of the samples were collected and analyzed using U.S. Environmental Protection Agency Certified Lab Program techniques and procedures. A complete description of the related data structures can be found in the *Environmental Restoration Information System Chemical Relational Database Management System Design Document* (EGG-WM-ERIS-90-0005, June 1990).

The second most frequently used database within ERIS is the Comprehensive Wells Database, which is a highly qualified collection of information describing the well construction, stratigraphy, and geophysical log information for over 700 wells at the INEL. These data, which are the best available well data for the INEL at this time, are presently being evaluated by a third party for qualification by the Environmental Protection Agency. The third party will prepare a report describing the current fitness of each well for use in monitoring and remediation sampling. Results of this report are expected to become part of the Comprehensive Wells Database in the third quarter of FY-93. Data from the Comprehensive Wells Database are also accompanied by a PC-based set of tools for viewing well construction and geophysical log diagrams. Data structures can be found in the *ERIS Hydrology Database Management System Phase I Design Document* (EGG-WM-ERIS-90-004, May 1990).

Additional data sets available in ERIS include stratigraphy, lithology, and small rock property databases developed by INEL geologists for specific areas at the INEL. As well, the U.S. Geological Survey (USGS) Water Quality and Water Quantity data sets collected at the INEL from 1949 to present have been checked against original data records before entry into ERIS. These data consist of water-level measurements for a suite of ground-water and perched-water

wells at the INEL and immediate vicinity, and general water quality measurements (e.g., temperature, pH, dissolved oxygen) and chemical parameters (e.g., nitrate, chloride). The ERIS database system contains other data sets that are specific to particular projects or of limited general use.

G.1.5.2 Radioactive Waste Management Information System (RWMIS). The RWMIS serves as the official record for all radioactive effluent and solid radioactive waste at the INEL, with data from 1952 to present. Types of information include volume, radioactivity, isotopic identity, origin, and decay status.

G.1.5.3 INEL Nonradiological Waste Management Information System (INWMIS). The INWMIS is a centralized database for managing nonradioactive waste discharge data. Data can be segregated by the type of effluent released (i.e., liquid), and the database can be queried by release point, release volume, and the weight and concentration of the released substances.

G.1.5.4 Regulatory Compliance Office (RCO) Milestone Tracking System. Within the Environmental Restoration and Waste Management Department, the RCO manages the RCO Milestone Tracking System. This system is used to ensure that all RCO milestones are completed on schedule. The database stores information that is necessary for the completion of RCO milestones. Fields have been set up to include work package information, budget information, date due, person performing the work, and any comments that could provide meaningful information.

G.1.6 Site Facilities

G.1.6.1 INEL Boundary Distances. As input for various environmental computer models, the locations of INEL facilities and the minimum distances from these facilities to the INEL site boundary, in each of 16 compass directions, have been determined.

G.1.6.2 Contaminated Soils. The Planning and Inspection Unit in the Facility Engineering Group is developing a database for contaminated soils. This development is underway and scheduled for completion in July 1993. The database will map the boundaries of known locations of contaminated soils on the INEL. The database will provide general data on the location and its contaminants and will give references to other data sources or published documents where more specific information about the contamination is available. This information will be used by the Planning and Inspection Unit for new project planning, site analysis and location studies, and facility modification and expansion projects.

G.2 Geographic Information Systems

Geographic Information Systems (GISs) combine the data storage/retrieval capability of database technology with the spatial drawing capability of computer mapping, and have the added capability to do spatial analyses of the data. Spatial data sets contain attribute data and provide known geographic positions of features. An example of this would be the geographic data coordinates of a well location associated with attribute data (e.g., name, date, depth, size). The spatial features can have point, line, or area (polygon) characteristics. A GIS can store and manipulate these types of spatial data, along with the associated attributes data. It is this spatial analysis that sets GIS apart from previous Computer Aided Design and Computer Aided Mapping technologies.

There are two data structure technologies used to organize spatial data in a GIS: the raster data structure and the vector data structure. The raster data structure partitions the spatial area into a set of grid cells (usually square) in rows and columns. Each cell is assigned a code describing the feature contained within the cell. The cell size is constant for all cells and is usually a function of computer memory restrictions or of the resolution available or needed. Explicit (x,y) coordinates are not given to each cell because the cell location is implicit in its row and column location. Image processing systems, specifically those developed to manipulate remotely sensed digital data from satellites (such as Landsat or SPOT), have many functions that make them most suitable as raster systems. However, the cell-by-cell nature of the raster structure makes it difficult to retrieve information about linear features (such as the length of a river or road) or to traverse a network (such as a train route or a watershed).

Vector data structures use a series of (x,y) coordinates to describe point, line, and polygon features. The vector data structure also allows for storage of data for multiple features for the coordinates. In addition, the information about the connections and relationships among the features (the topology) is calculated and stored with the coordinates. This allows the user to derive relationships such as adjacency and connectivity. Although vector data structures are computationally more demanding than raster, they are more widely used because of the greater information inherent in the data.

Each GIS data set is normally limited to one thematic topic or data, and is commonly called a coverage or a layer. Examples of coverages are (a) well coverage (point) to define the location and characteristics of a set of wells, (b) stream coverage (line) to describe the hydrology of an area, and (c) soil coverage (polygon) to define the soil type map of an area.

The primary activity of a GIS is to apply spatial analysis tools to combinations of data categories to model and reach conclusions about problems. These tools are part of the GIS software, and allow (a) the spatial combining of data sets (overlying, intersecting, joining, etc.), (b) the creation of additional attributes based on logical and mathematical analyses of combinations of feature attributes, and (c) the calculation of distances, or areas, or volumes. Examples of these analyses might include:

- Create a composite map made by overlaying the vegetation coverage map and the soils coverage map to study the relationship of vegetation to soil type
- Overlay the U.S. Census Bureau's Topologically Integrated Geographic Encoding and Referencing files containing census data with the map of the agricultural farmlands to calculate the number of people affected directly by some agricultural practice
- Study the location of a proposed new facility by overlaying its location onto maps for the area's geology, hydrology and hydrography, local roads and highways, the electrical power distribution system, and local wind directions and velocities
- Compute the volume of a pit with known bottom contour.

Typically, a GIS has extensive output capabilities for the display of maps, charts, and graphs resulting from the analyses. However, the effective choice of color, pattern, shading, symbols, text fonts, and placement of text in an uncluttered but accurate way is one of the classical challenges of cartography.

G.2.1 GIS at the INEL

To access some GIS systems at the INEL, you must have or obtain a registered user ID from CRCS at the ISC.

The vector GIS most used at the INEL is Arc/Info, which is from the Environmental Systems Research Institute in Redlands, California. EG&G Idaho owns two licenses for Arc/Info. The Computational Services Unit in the Computer Operations and Data Processing Group within the Administration Department has a three-user license for Arc/Info on the Sun workstation environment. Their Arc/Info is used primarily for research and systems development. They also have the raster GIS ERDAS Imagine system, the vector Geographical Resources Analysis Support System (GRASS), and the KHOROS public domain software that interfaces with GIS.

The Center for Environmental Monitoring and Assessment (CEMA) has Atlas GIS, which is a vector PC GIS. In addition, CEMA has two raster GIS PC systems: MicroImage and IDRISI. CEMA can provide in-depth ecological and environmental analytical support to projects using their data and the coverages and Arc/Info in the Digital Equipment Corporation (DEC) environment. Table G-2 lists coverages presently under development by CEMA.

The E&WMC Unit in the Information Systems Group within the Administration Department administers a 10-user Arc/Info license for the DEC environment. They also have a PC GIS called MapInfo. E&WMC's Spatial Analysis Laboratory provides GIS production mapping support for the INEL. This DEC Arc/Info system is available for other INEL users, and is accessible through Ethernet. Table G-3 lists the coverages presently available on the DEC Arc/Info system.

Table G-2. GIS coverages and Landsat TM5 satellite images.

Coverage	Description
GIS coverages	Map of INEL vegetation communities and cover types Elk location and habitat use Bobcat locations and habitat use Sagegrouse leks Vegetation sampling locations Soil sampling locations U.S. Fish & Wildlife Service Wetlands Inventory Maps for the INEL Other INEL "wetlands)
Landsat TM5 satellite image data (dates)	July 1984 May 1987 October 1988 June 1989 July 1989 August 1989

G.2.2 Global Positioning System

The Global Positioning System (GPS) determines accurately the three-dimensional location of a point on the earth. GPS is operated by the U.S. Department of Defense and is based on signals received from a constellation of NAVSTAR satellites orbiting the earth. The commercially available GPS portable receiver is a small, electronic device that receives the signals from these satellites and calculates the receiver's position on the earth. It takes a minimum of four satellite signals to determine a three-dimensional position. Only three satellite signals are necessary if the elevation of the receiver is known. The calculation of the location is made based on the differences in time required for the time-synchronized signals from the different satellites to reach the receiver. By also collecting the signals simultaneously at another compatible receiver at a known location, a differential correction can later be made to improve the accuracy of the GPS location.

GPS accuracy varies with the satellite constellation configuration available at the time of data collection, with the satellite signals' quality, and with atmospheric and ionospheric conditions at the time. Additional factors are the quality and capabilities of the equipment used, and the distance from a Community Base Station (CBS) if differential correction is used. The CBS is a GPS receiver at a stationary, known (surveyed) location. In addition, the accuracy of GPS can purposefully be degraded by the Department of Defense using an operational mode called

selective availability, which is designed to deny hostile forces the tactical advantage of GPS positioning.

Manufacturers' specifications for accuracy of the GPS instruments currently available at the INEL range from ± 30 m (98 ft) for uncorrected and nonaveraged positions to ± 2 –5 m (6.6–16.4 ft) with differentially corrected and averaged positions. CEMA experience with GPS technology at the INEL suggests that accuracies better than ± 1 m (3.3 ft) can be obtained when the system is operating optimally. Accuracies of ± 3 m (9.8 ft) can be expected under normal circumstances with position averaging and differential correction. Without differential corrections, position inaccuracies may be recorded that are significantly greater than the manufacturers' specifications. Inaccuracies as high as 1,500 m (4,920 ft) have been observed. Typically, this is due to the Department of Defense initiating a selective-availability mode of operation on the satellite signals. Survey grade GPS receivers can attain accuracies better than ± 1 cm (0.39 in.). These systems are very expensive and currently unavailable at the INEL. The National Geodetic Survey and other organizations can be contracted to conduct work using these systems.

Determination of the location of points, using GPS technology, provides the necessary input data for detailed GIS mapping and analysis capabilities. By measuring the locations of multiple points, the points can also be used to define lines and polygons. These points, lines, and polygons can be used in a GIS for mapping points (well locations, sampling point locations, etc.), lines (roads, rivers, pipelines, etc.), or polygons (buildings, disposal sites, remediation sites, vegetation classifications, etc.).

CEMA maintains a CBS GPS receiver. The CBS antenna is located on the roof of the INEL Research Center at a surveyed, known location. This CBS is used to differentially correct field-collected GPS locations. CEMA also has a Trimble GPS Pathfinder Professional GPS portable receiver, a Magellan NAV1000 GPS, and GeoLink software system from GeoResearch, Inc. CEMA uses the GPS to obtain field location data for GIS applications. GeoLink allows for online, real-time mapping of GPS data as they are collected in the field. GeoLink outputs a GIS file.

E&WMC has a Trimble Pathfinder Basic Plus GPS portable receiver, and GeoLink. E&WMC uses the Trimble GPS for field validation, verification, and correction of GIS data points. Other organizations at the INEL have older Magellan GPS receivers. These receivers are not as technologically advanced as the Trimble systems.

Table G-3. DEC Arc/Info system coverages.

100-mi buffer	05/03/91	created from INEL border using arc command	100-mi buffer around the INEL
50-mi buffer	05/03/91	created from INEL border using arc command	50-mi buffer around the INEL
50-mi veg	06/14/91		Shows vegetation types for 50 mi around and including the INEL (does not include any part of Montana)
acidpit	01/30/92	unk	Outline of acid pit at RWMC
acidpitcon	01/28/92	unk	RWMC acid pit contours
acidpitgeo	01/29/92	unk	geophysical anomaly boundary
acover	07/09/91		Projected northarrow
acover1	07/09/91		Projected northarrow (transformed from acover coverage)
aeframe	08/15/91	Architectural Engineering	Standard EG&G layout for frame used for RWMC inventory map
aeromag	04/08/91	Aeromagnetic map of Idaho 1978	Aeromagnetic Map of Eastern Idaho
aerwmc	08/15/91	Aeromark fly-over data	RWMC fly-over data rotated 90' and appended to aeframe
aflow	02/04/91	Digitized from hand drawing	Shows top of a flow at RWMC
airmon	01/15/91	Points from Ron Rope	Air monitoring sites for the INEL
anl	07/17/91	Aeromark	ANL fly-over data
anl_50mi	04/20/92	US Census Bureau	population within 80 kilometers of ANL
anl_wells	06/03/91	SAIC	wells at Argonne National Lab
aqua	06/17/91	USGS open report	Snake River Plain Aquifer Boundary

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
aquifer	01/15/91	USGS Publication	Water Table Elevation of the Snake River Plain
aquifer_3d Snake	07/17/91	USGS Publication	3-Dimensional view of the River Plain Aquifer.
ara3	12/10/90	diskette from Tom Matzen	Portion of ARA III -used in demo-
ara3d	12/10/90	created from ara_samp using tin	3-Dimensional view of ARA III -used in demo-
ara_contour	12/10/90	digitized points from Tom Matzen	Contour drawing of spot elevations based on samples.
ara_contour	12/10/90	digitized points from Tom Matzen	-used in demo-
ara_points	12/10/90	digitized points from Tom Matzen	Points for spot elevations; no annotation -used in demo-
ara_samp	01/24/91	digitized points from Tom Matzen	Sample sites at ARA
aracoca	03/01/91	controlled drawing 171973	Coca sites for ARA
aradrape	12/10/90	digitized points from Tom Matzen	drape of ARA area created in tin -used in demo-
arapr03	01/25/91	controlled drawing 171973	Map of ARA
arr	12/05/90		northarrow
arr_drp	07/09/91		Drape of acover1 coverage (Northarrow)
arr_sp	7/12/91		northarrow
arvfs	07/10/91	Aeromark	ARVFS fly-over data
arvfs_storage	07/01/91	Aeromark	ARVFS Storage area fly-over data

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
banpop	05/07/92	US Census Bureau	Bannock county census blocks
bas_sat	04/10/91		Basalt saturation in the Snake River Plain
bas_thk	04/10/91		Map of the approximate thickness of quaternary
bas_thk	04/10/91		basalt (in feet) of the Snake River Plain.
bas_thk_3d	01/04/91	tin created from bas_thk	Tin created from bas_thk which is a map of the approx.
bas_thk_3d	01/04/91	tin created from bas_thk	thickness of quaternary basalt in the Snake River Plain.
base_a	02/04/91	Digitized from a hand drawing	Shows bottom of a flow in RWMC
bedrock berm	06/26/91 01/02/91	Map from Ron Rope Hopi Salomon	Basalt flows of the INEL Sample elevation points within the Warm Waste Ponds at TRA;
berm	01/02/91	Hopi Salomon	used for creating tins.
berml	01/02/91	Hopi Salomon	Sample elevation points for the outer edge of TRA Warm Water
berml	01/02/91	Hopi Salomon	Waste pond; used for creating tins.
bingpop	05-07-92	US Census Bureau	Bingham country census blocks
blainepop	05-07-92	US Census Bureau	Blaine county census blocks
bldg	12/10/90	unknown	RWMC buildings
bldg_clip	07/05/91	NPR project	NPR buildings
bldg_clip1	07/05/91	NPR Project	NPR buildings

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
bonnlpop	05/07/92	US Census Bureau	Bonneville County census blocks
borax1	11/06/90	controlled drawing 171974	Border of borax
bore1	05/10/91	controlled drawing 171970	Lower left quadrant of TRA; this coverage is used with
bore1	05/10/91	controlled drawing 171970	boreholes information.
bore2	5/10/91	controlled drawing 171970	with borehole information.
bore2	5/10/91	controlled drawing 171970	Lower left quadrant of TRA including Warm Waste Ponds; used
boreholes	05/09/91	Points from Hopi Salomon	Boreholes for lower left quadrant of TRA
boundary	12/10/90	unknown	boundary used in demo
boundary_inel	03/06/91	dxf file from K. Taylor	INEL boundary line
box1	07/10/91		NPR site outline
box2	07/10/91		NPR septic tank field outline
box2a	07/10/91		NPR septic tank field outline
brass	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	Map of Lesquerella Kingii (Brassicaceae) in the INEL
brass	01/15/91		Map of Lesquerella Kingii (Brassicaceae) in the INEL
brass		Survey and Assessment of Rare Vascular Plants of the INEL	Map of Lesquerella Kingii (Brassicaceae) in the INEL
brass			Map of Lesquerella Kingii

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
			(Brassicaceae) in the INEL
brass	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	
brass brass	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	
brass buf1	12/10/90	generated through analysis with Arc/Info	100 ft. buffer area around road in N.E. quadrant of RWMC.
buf2	12/10/90	generated through analysis with Arc/Info	Buffer area around road in N.E. quadrant of RWMC.
buf2	12/10/90	generated through analysis with Arc/Info	-used in demo-
buttepop cacta	04/24/92 01/15/91	US Census Bureau Survey and Assessment of Rare Vascular Plants of the INEL	Butte County census blocks Maps Coryphantha Missouriensis of the INEL
calderas	04/10/91		Calderas of Eastern Idaho and adjacent Yellowstone
cancer	06/21/91	Russ Brown of WINCO	Cancer mortality data for Idaho
cancer-3d	06/24/91	Russ Brown of Winco	3-Dimensional view of cancer mortality data in Idaho.
cancer-drp	06/24/91	Russ Brown of WINCO	Cancer coverage modified so that it can be draped

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
cariboupop ceram	05/07/92 01/15/91	US Census Bureau Survey and Assessment of Rare Vascular Plants of the INEL	Caribou County census blocks Map of Astragalus Ceramicus presence in the INEL
cfa cfa_50mi	05/28/91 04/20/92	Aeromark US Census Bureau	CFA fly-over data population within 80 kilometers of CFA
cfa_wells cfacoca	08/21/92 02/11/91	SAIC controlled drawing 171971	wells at CFA CFA coca sites
cfapr03	01/15/91	controlled drawing 171971	CFA border
clarkpop cldpit	05/07/92 11/27/91	US Census Bureau aerial flyover	Clark county census blocks topography features of RWMC cold test pit
clippond	04/11/91	generated in arc/info	Used to clip portions of TRA ponds for contouring purposes
coca_signs comp21_50mi	7/15/91 04/17/92	MK-Ferguson Survey US Census Bureau	Coca sites in the INEL population within 80 kilometers of complex 21
cookall	08/09/91		Piece of RWMC with outlines of pits 8, 9 & acidpit
corners	07/05/91		Corners at NPR study area; used to force map extent at NPR
corners counties	07/05/91 06/21/91		site County boundaries and names in Idaho
counties-drp	06/18/91		Counties of Idaho (counties coverage) modified so that
counties-drp	06/18/91		it can be draped.

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
cpp	03/01/91	controlled drawing from CPP	CPP drawing
cpp	03/01/91	Aeromark	CPP drawing
cpp	02/25/91	controlled drawing from CPP	CPP drawing
cpp	02/25/91	Aeromark	CPP drawing
cpp	03/01/91	controlled drawing from CPP	CPP flyover data
cpp	03/01/91	Aeromark	CPP flyover data
cpp	02/25/91	controlled drawing from CPP	CPP flyover data
cpp	02/25/91	Aeromark	CPP flyover data
cpp_50mi	04/17/92	US Census Bureau	population within 80 kilometers of CPP
cpp_cont	07/25/91	unknown	Contours at CPP made from sample elevation points
cpp_inter	04/17/92	US Census Bureau	census blocks within 50 mile radius of CPP
cpp_wells	07/23/91		Wells at CPP with annotation showing cable tools
cpp_wells	07/23/91	SAIC	Wells at CPP with annotation showing cable tools
cpp_wells	08/31/91		Wells at CPP with annotation showing cable tools
cpp_wells	08/31/91	SAIC	Wells at CPP with annotation showing cable tools
cpp_wells	07/23/91		wells at CPP
cpp_wells	07/23/91	SAIC	wells at CPP
cpp_wells	08/31/91		wells at CPP
cpp_wells	08/31/91	SAIC	wells at CPP
cppwells	04/08/91	SAIC data	Wells at CPP

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
cppwells1	08/06/91	unknown	Wells at CPP with annotation showing depth
custerpop demo_wells dikes	05/17/92 12/10/90 12/10/90	US Census Bureau SAIC controlled drawing	Custer county census blocksa RWMC wells -used in demo- Dikes in the RWMC area -used in demo-
doelogo dpwell1	02/05/91 06/20/91	Points from Hopi Salomon and MK Ferguson	NPR and DOE logos Perched wells in the TRA vicinity.
dpwell2	06/20/91	Points from Hopi Salomon and MK Ferguson	Aquifer wells in the TRA vicinity.
drillholes	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	Geologic section and location of drillholes
drillholes	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	used in section.
dumps	08/28/90	Points keyed in from Dump locations in Pit 9 data provided by RWMC analyst	
dumps1	09/05/90	Keyed in by hand from points provided by RWMC analyst	Outline for RWMC pit9
easttra	04/30/91	controlled drawing 171970	State plane coordinates.
easttra	04/30/91	controlled drawing 171970	Drawing of TRA that contains annotation and tics showing

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
easttral	04/30/91	controlled drawing 171970	TRA drawing containing annotation and tics showing state
easttral	04/30/91	controlled drawing 171970	plane coordinates; closer view than coverage easttra.
ebr	06/05/91	Aeromark	EBR fly-over data
ebr1	11/06/91	controlled drawing 171974	EBR1 border
ebrwells	10/11/90	SAIC	Wells at EBR facility
ecapolys	08/23/92	Marilyn Parrmann	environmentally controlled areas at the INEL
egg_logo	10/11/90		EG&G Logo with Idaho Inc. appearing underneath logo
egg_logol	02/04/91		Logo for EG&G
eis_logo	10/03/91	created by G. Heaton	logo of INEL Spatial Analysis Laboratory
eris_logo	10/11/90		ERIS Logo using text font 9
eris_logol	10/15/90		ERIS logo using text font 9 and thicker lines than eris_logo
eris_logo_p	04/04/91		ERIS Logo using text font 8
ewmc_logo	04/22/91		Logo for EWMC
fac5mile	12/24/91	aerial flyover	NPR site with a 5 mile buffer
facil	02/01/91	HPGL	NPR facilities; modified from faciltr02 coverage
facil_drp	02/11/91	HPGL	Modification of facil coverage; projected into 3-d
facilities	02/01/91	HPGL	NPR facilities
faciltr02	02/01/91	HPGL	NPR facilities transformed into feet

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
factbox	01/08/91		Clipbox used to clip NPR site
factop	01/08/91	HPGL	Tops of buildings at NPR facility; edited from facility coverage
factop	01/08/91	HPGL	NPR facilities in relation to overall NPR site
factop_ll	01/08/91	HPGL	
factop_line	01/08/91	HPGL	Tops of buildings at NPR facilities; edited version of
factop_line	01/08/91	HPGL	factop coverage
farms	07/01/91	Mylar(veg) IDWR interpr. of Landsat false color photos(irg)	Combination of irrigated lands (irg) and the agricultural
farms	07/01/91	Mylar(veg) IDWR interpr. of Landsat false color photos(irg)	zones in the panhandle from idaho-veg coverage
fence	12/10/90	controlled drawing	Fences in the RWMC area -used in demo-
fences	09/27/90		Fences at RWMC
flood	01/14/91	K. Koslow study using DAMBREAK computer code & hand calc.	Old map of INEL floodplain that is somewhat disputed
flynntra	04/20/92	Shannon Flynn	TRA operable units
format	03/22/91		Title block format
fremontpop	05/07/92	US CensusBureau	Fremont county census blocks
gamma2_cont	01/06/91	Generated in arc/info from points provided by Hopi Salomon	Contours for Warm Waste Ponds at TRA.
gamma_cont	01/09/91	Generated in arc/info from points provided by Hopi Salomon	Contours for Warm Waste Ponds at TRA

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
gaslines	08/09/91	Aeromark fly-over data	Topography of RWMC clipped and edited
gilvi	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	Mapping of Astragalus Gilviflorus in the INEL
gpsnet	04/10/91	Points from Ron Rope	Mapping of GPS Network Stations, where stations
gpsnet	04/10/91	Points from Ron Rope	appear as points and the INEL boundary is a line.
gravelpits	08/05/92	Steve Minkin	gravelpits at INEL
gravity	04/10/91		description not available
graze	01/15/91		INEL grazing areas
grouse	01/15/91		Sage Grouse Leks in the INEL
heatflow	01/15/91		Heat Flows
hopi_wells	12/13/90	points from Hopi Salomon	Re-defines wells at TRA into four categories.
hopitics	03/25/91	controlled drawing 171970	TRA line drawing with annotation and tic marks to show state
hopitics	03/25/91	controlled drawing 171970	plane coordinates
hopitra	03/25/91	controlled drawing 171970	TRA line drawing with annotation and tic marks showing state
hopitra	03/25/91	controlled drawing 171970	plane coordinates
hydrologic	04/04/91	1:100000 Mylars and 7 1/2 minute Quads	Hydrologic units of Idaho
id-maj-cities	02/22/91		Idaho cities having a population greater than 2500;

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
id-maj-cities	02/22/91		selected from idaho-cities coverage.
idaho	06/12/91		Idaho state boundary
idaho-cities	02/16/91		State data for town location points; towns with names.
idaho-rds	01/31/91	USGS map	Roads of Southern Idaho
idaho-veg	04/26/91	Vegetation 1950-1985	Vegetation types of Idaho
inel-maj-rds	05/30/91	USGS DLG's	Major roads of the INEL taken from coverage inel-rds
inel-mtt	01/15/91	USGS DLGs	Pipelines and Transmission Lines in the INEL
inel-rds	04/10/91	USGS DLGs	Roads of the INEL
inel-rds	04/10/91	IDWR	Roads of the INEL
inel-rds	01/04/91	USGS DLGs	Roads of the INEL
inel-rds	01/04/91	IDWR	Roads of the INEL
inel-rds	04/10/91	USGS DLGs	Roads of the INEL projected into Idaho Eastern State Plane
inel-rds	04/10/91	IDWR	Roads of the INEL projected into Idaho Eastern State Plane
inel-rds	01/04/91	USGS DLGs	Roads of the INEL projected into Idaho Eastern State Plane
inel-rds	01/04/91	IDWR	Roads of the INEL projected into Idaho Eastern State Plane
inel-riv	01/15/91	USGS DLGs	Rivers in the INEL
inel-rrt	01/15/91	USGS DLGs	Railroads in the INEL
inel-wells	01/04/91	EG&G	Well data for the INEL site (includes name and type)
inel3d	01/22/92	unk	WAGs at INEL
inel_aquifer	07/15/91	USGS publication	Clip taken from aquifer coverage to show the aquifer in the INEL site.
inel_aquifer	07/15/91	USGS publication	Logo for the INEL
inel_logo	10/11/90		

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
inelutm	12/12/90	controlled drawing converted to UTM coordinates in-house	Facilities and roads of the INEL in UTM coordinates (no
inelutm	12/12/90	controlled drawing converted to UTM coordinates in-house	boundary)
inelwells	06/18/91	SAIC	All INEL wells
inelwells	06/18/91	SAIC	All INEL wells
inelwells	06/18/91	SAIC	All INEL wells
inelwells	06/18/91	SAIC	All INEL wells
inelwells	06/18/91	SAIC	wells at INEL
inelwells	06/18/91	SAIC	wells at INEL
inelwells	06/18/91	SAIC	wells at INEL
inelwells	06/18/91	SAIC	wells at INEL
inelwellsutm	12/12/90	controlled drawing converted to UTM coordinates	Wells in the INEL
initial_coca	07/30/91	Initial Assesment of Coca sites provided by Fred Bickford	Results of initial assesments of coca sites provided by
initial_coca	07/30/91	Initial Assesment of Coca sites provided by Fred Bickford	Fred Bickford
irc	04/16/92	autocad drawing	INEL Research Center
irc_50mi	05/25/92	USCensus Bureau	population within 80 km of INEL Research Center
irg	06/26/91	IDWR interpreted from Landsat false color photos	Irrigated land in Idaho
isabel	06/05/92	unk	Boundary of RWMC
isabelwell	12/30/91	Isabel Anderson	existing and new wells at RWMC
isopac	02/22/91		Isopachs of Sediments
izzy384-2	03/31/92	Isabel Anderson	soil locations at RWMC
izzy_rwmc	03/27/92	unk	RWMC with defined waste types

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
jefferpop	03/07/92	US Census Bureau	Jefferson country census blocks
joedig	07/11/91	Digitized from NRTF 10 ft. contour maps	Features around RWMC
joepoly key	07/15/91 08/05/91	generated by hand	Drainage spaces around RWMC Keymap that shows sheets that went into making tan
kpotveg	05/02/91		Potential vegetation data for Idaho
latlontics	03/25/91	generated in arc/info	Tic marks in TRA vicinity showing latitude/longitude
latlontics	03/25/91	generated in arc/info	coordinates
legend	05/10/91		Part of the legend for RWMC inventory map (clipped from
legend legum	05/10/91 01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	rwmc7) Astragalus Purshii presence in the INEL
legumast	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	Astragalus Kentrophyta presence in the INEL
lemhipop	05/07/92	US Census Bureau	Lemhi county census blocks
lincolnpop	05/07/92	US Census Bureau	Lincoln county census blocks
loft_50mi	04/21/92	US Census Bureau	population within 80 kilometers of LOFT
logdep	01/15/91	Hydrologic Investigation	Selected drillers logs depth, in feet

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
logdep	01/15/91	Hydrologic Investigation	Log-dep ID: 1 400 - 999
logdep	01/15/91	Hydrologic Investigation	2 1000 - 2999
logdep	01/15/91	Hydrologic Investigation	3 3000 - 14000
logo_egg	03/27/91		EG&G logo; Idaho Inc. appears at end of logo
madisonpop	05/07/92	US Census Bureau	Madison county census blocks
minidokapop	05/07/92	US Census Bureau	Minidoka county census blocks
mk_boundary	07/01/92	MK Ferguson	INEL boundary
mka1uvwells	03/25/91	Points from MK Ferguson survey	Alluvial wells in the TRA vicinity
mkdeepwells	03/25/91	Points from MK Ferguson survey	Deep wells in the TRA vicinity
mkwells	03/25/91	Points from MK Ferguson survey	All wells on the INEL site
modinelsite	12/17/91	autocad drawing	boundary roads and facilities at INEL
myara	12/10/90	controlled drawing 171973	ARA III drawing. -used in demo-
new-boundary	05/03/91	From K. Taylor; updated with help from Dale Evans	INEL boundary that has had some revision in the southern
new-boundary	05/03/91	From K. Taylor; updated with help from Dale Evans	border. (This version is not used)
newanl	06/03/91	autocad drawing	ANL facility
newbox1	07/05/91		Polygon of NPR site outline
newcoca	10/01/91	bickford	COCA sites at ANL
newframe	02/05/91	Aeromark	Drawing frame for NPR flyover data

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
newframe1	03/29/91	Aeromark	Piece of frame for NPR flyover data
newframe2	05/06/91	Aeromark	Edited copy of newframe1 coverage
newp2	01/28/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
newp2	01/28/91	Points provided by Hopi Salomon	and/or sampling information
newrwmc_wells	12/10/90	SAIC	RWMC wells -used in demo-
newtanpr03	10/31/91	autocad drawing	TAN area for tanks
newtra	10/31/92	autocad drawing	TRA area for tanks
newwell_anno	12/10/90	SAIC	Annotation for RWMC wells -used in demo-
newwell_anno	12/10/90	SAIC	Annotation for RWMC wells -used in demo-
newwell_anno	10/03/90	SAIC	Annotation for RWMC wells -used in demo-
newwell_anno	10/03/90	SAIC	Annotation for RWMC wells -used in demo-
newwell_anno	12/10/90	SAIC	Annotation for wells in the INEL
newwell_anno	12/10/90	SAIC	Annotation for wells in the INEL
newwell_anno	10/03/90	SAIC	Annotation for wells in the INEL
newwell_anno	10/03/90	SAIC	Annotation for wells in the INEL
newwellspr02	03/12/91	SAIC	Wells at the INEL
north	03/14/91		Polygon coverage of drainage spaces around RWMC

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
north	03/14/91		Polygon coverage of drainage spaces around RWMC
north	03/14/91		Northarrow for RWMC inventory map (clipped from rwmc7)
north	03/14/91		Northarrow for RWMC inventory map (clipped from rwmc7)
northarrow npr1	01/29/91 06/26/91		Northarrow Tin view of NPR site topography
npr100x90 npr10ac	10/19/91 02/04/91	aerial flyover Mylars from Ron Rope (IDWR digt. for EG&G)	NPR proposed site plan 10 ft. contours at NPR; created to make a dxf file
npr1_3d	07/10/91		Tin of NPR site topography with NPR buildings clipped
npr3b	07/09/91	Generate file from autocad	3-D view of NPR buildings
npr3b3	07/10/91		3-D view of NPR buildings; edited from npr3b coverage
npr400	04/16/91	Aeromark fly-over data	NPR fly-over data in frame
npr50	02/02/91		Point coverage with point elevations for NPR
npr_11_drp	01/03/92	engineering drawing	proposed New Production Reactor play
npr_3d npr_50mi	07/10/91 04/20/92	US Census Bureau	Tin view of NPR populaiton within 80 kilometers of NPR

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
npr_bldg	07/02/91	NPR facility	NPR facilities coded with elevations for base and tops
npr_bldg	07/02/91	NPR facility	of buildings
npr_ll_drp	07/09/91	NPR facility	Drape of NPR facilities
npr_lines	07/09/91	NPR facility	NPR line features other than buildings
npr_lines_drp	07/09/91	NPR facility	Drape made from npr_lines of line features other than bldgs.
npr_logo	02/01/91		Logo for NPR
npr_roads.drp	01/04/91	Mylar with contours	nprrds cov.(rds. in NPR) modified so that it can be draped
npr_site	06/28/91	NPR facility	NPR facility
npr_work	01/10/91		Old version of NPR tin view with buildings
npr_z	06/26/91	Aeromark fly-over data	Topography for NPR - came from Autocad through a generate
npr_z	06/26/91	Aeromark fly-over data	file
npr_zer	07/05/91	Aeromark fly-over data	Topography for NPR with site erased
nprbou	01/15/91	Data received from Ron Rope	NPR Boundary
nprcont	01/04/91	Mylars from Ron Rope	Contour Lines of the NPR site.
nprcont1	01/04/91	Mylars from Ron Rope	Contour lines of the NPR site.
nprcont1_3d	01/04/91	Mylars from Ron Rope	3-Dimensional view of NPR site contour lines.
nprcont_3d	01/04/91	Mylars from Ron Rope	3-Dimensional view of NPR site contour lines
nprcont_anno	01/04/91	Mylars from Ron Rope	Annotation for nprcont coverage

Appendix G ♦ G-32**Table G-3.** (continued).

Coverage Name	Coverage Date	Data Source	Data Text
nprcontp	01/14/91	Mylars from Ron Rope; IDWR digitized for EG&G	2-ft contours at NPR
nprcontpr	02/04/91	Mylars from Ron Rope	10-ft contours at NPR
nprfinds	04/15/91	Mylars from Ron Rope.	Archeological finds at the NPR site.
nprframe	02/05/91		Drawing frame for NPR data
nprframe1	02/07/91		Piece of drawing frame for NPR data (edited from nprframe)
nprout3	06/28/91	Aeromark fly-over data	NPR fly-over data with NPR site clipped out
nprout4	06/28/91	Aeromark fly-over data	NPR fly-over data with NPR outline clipped
nprout5	06/28/91	Aeromark flyover data	NPR fly-over data (contours) with NPR facility clipped
nprpls	01/15/91	1:24000 quad sheets	Public Land Surveys for NPR
nprrds	01/15/91	Mylar with contours	Roads on NPR site
nprsite	04/10/91	mylar from Ron Rope	Archeological Sites within the NPR
nprsite.drp	01/04/91	mylar from Ron Rope	nprsite coverage (of archeological sites at NPR) modified
nprsite.drp	01/04/91	mylar from Ron Rope	so that it can be draped.
nprsoil	04/08/91	Blue line map (Ron Rope)	Soil types: 1 = Q1 Loess
nprsoil	04/08/91	Blue line map (Ron Rope)	2 = Qa1 Alluvium
nprsoil	04/08/91	Blue line map (Ron Rope)	3 = Qb Basalt
nprsoil	04/08/91	Blue line map (Ron Rope)	Soil types of the NPR site.

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
nprsoil	04/08/91	Blueline map (Ron Rope)	4 = Qp Playa
nprwell	01/15/91	GPS from Ron Rope	Well sites for the NPR site
nrf	05/14/91	autocad from NRF	NRF facility
nrf_50mi	04/21/92	US Census Bureau	population within 80 kilometers of NRF
nrfwells	05/11/92	Dennis Walker	wells at NRF
omre	06/04/91	Aeromark	OMRE fly-over data
onagr	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	Canissonia Pterosperma presence in the INEL
opunit12	01/28/91	Data provided by Hopi Salomon	Polygon depicting boundary of perched water zone operable
opunit12	01/28/91	Data provided by Hopi Salomon	unit 2-12 at TRA
ordnance	05/06/91		Locations of unexploded ordnances
ordnancel	05/06/91		Locations of unexploded ordnances. (edited from ordnance)
ordnance2	05/07/91		Locations of unexploded ordnances (fewer points than
ordnance2	05/07/91		previous coverages)
p1_3d	01/29/91	Generated in arc/info from points provided by Hopi Salomon	Perspective drawing of chemical samplings made from points
p1_3d	01/29/91	Generated in arc/info from points provided by Hopi Salomon	Provided by Hopi Salomon

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
plchempts	04/11/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
plchempts	04/11/91	Points provided by Hopi Salomon	and/or sampling information
plh_prof	01/28/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
plh_prof	01/28/91	Points provided by Hopi Salomon	and/or sampling information
plh_prof_pl	01/28/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
plh_prof_pl	01/28/91	Points provided by Hopi Salomon	and/or sampling information
plpts	01/02/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
plpts	01/02/91	Points provided by Hopi Salomon	and/or sampling information
plpts_a	01/02/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
plpts_a	01/02/91	Points provided by Hopi Salomon	and/or sampling information
plptsa	01/02/91	Points provided by Hopi Salomon	and/or sampling information
plptsa	01/02/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
plv_prof	01/28/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
plv_prof	01/28/91	Points provided by Hopi Salomon	and/or sampling information

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
plv_prof_p1	01/28/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
plv_prof_p1	01/28/91	Points provided by Hopi Salomon	and/or sampling information
p2_3d	01/29/91	Generated in arc/info from points provided by Hopi Salomon	provided by Hopi Salomon
p2_3d	01/29/91	Generated in arc/info from points provided by Hopi Salomon	Perspective drawing of chemical samplings made from points
p2chempts	04/11/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
p2chempts	04/11/91	Points provided by Hopi Salomon	and/or sampling information
p2pts	01/02/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
p2pts	01/02/91	Points provided by Hopi Salomon	and/or sampling information
p2pts	01/02/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
p2pts	01/02/91	Points provided by Hopi Salomon	and/or sampling information
p3_3d	01/29/91	Generated in arc/info from points provided by Hopi Salomon	Perspective drawing of chemical samplings made from points
p3_3d	01/29/91	Generated in arc/info from points provided by Hopi Salomon	Provided by Hopi Salomon

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
p3chempts	04/11/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
p3chempts	04/11/91	Points provided by Hopi Salomon	and/or sampling information
p3pts	01/02/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
p3pts	01/02/91	Points provided by Hopi Salomon	and/or sampling information
p3pts_a	01/29/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
p3pts_a	01/29/91	Points provided by Hopi Salomon	and/or sampling information
p3pts_a	01/02/91	Points provided by Hopi Salomon	Chemical analysis sampling points to be used for contours
p3pts_a	01/02/91	Points provided by Hopi Salomon	and/or sampling information
pbfarapr03	11/27/90	controlled drawing 171972	Border of PBF
pbfcoca	03/01/91	controlled drawing 171972	Coca sites for PBF
pit9	08/02/91	Aeromark	immediate area around RWMC Pit9; clipped from rwmc fly-over
pit9	08/02/91	Aeromark	data
pit9bnd	08/27/90		Outline for RWMC Pit9
pits	08/15/91		Line coverage showing pit outlines for all pits at RWMC
playa	07/16/92	Joe Zukauskas	Playa at TAN
pls	12/10/90	USGS 15 minute quad map. -used in demo-	Section grid for RWMC. -used in demo-

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
poap02	12/10/90	USGS map	Barrow pits and gaging stations around RWMC area. -used
poap02 polemgil	12/10/90 01/15/91	USGS map Survey and Assessment of Rare Vascular Plants of the INEL	in demo- Gilia Polycladen Torr in the INEL
polemgym	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	Gymnosteris Nudicaulis in the INEL
polycpp	03/01/91	controlled drawing from Chemical Processing Plant	Map of controlled areas at CPP
polyg	01/15/91	Survey and Assessment of Rare Vascular Plants of the INEL	Map of Oxytheca Dendroidea presence in the INEL
pond1	01/02/91	Data provided by Hopi Salomon	Upper warm waste pond at TRA
pond2	01/02/91	Data provided by Hopi Salomon	Middle warm waste pond at TRA
pond3	01/02/91	Data provided by Hopi Salomon	Lower warm waste pond at TRA
ponds	01/02/91	Data provided by Hopi Salomon	Upper, middle, and lower warm waste ponds at TRA
pondz	01/02/91	Points provided by Hopi Salomon	Sample coordinates for warm waste ponds at TRA
pop-3d	06/24/91		Tin of Idaho city populations (from cov. id_maj_cities)
powerpop	10/07/91	US Census Bureau	Power county census blocks

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
pr171974a	02/19/91	controlled drawing 171974a	Map of EBR1
pr171974b	02/27/91	controlled drawing 171974b	Map of Borax5
pts1990	04/11/91	Points provided by Hopi Salomon	1990 Chemical sampling points for the warm waste ponds at
pts1990	04/11/91	Points provided by Hopi Salomon	TRA
pts8890	02/14/91	Points provided by Hopi Salomon	1988-1990 Chemical sampling points for TRA warm waste ponds
quest_50mi	05/08/92	US Census Bureau	population within 50 miles of the Quest site
quest_inter	05/08/92	US Census Bureau	Census blocks within a 80 kilometer radius of the Quest site
rad_fence	04/04/91	controlled drawing 171970	Fence around warm waste ponds at TRA
rcas_logo	12/04/90	Digitized in-house	RCAS Logo
rcas_stations	12/04/90	NCAR import	Outline of states in the USA with military bases added as
rcas_stations	12/04/90	NCAR import	points
rcas_usa	11/21/90	NCAR import	Outline of states in the USA
rifts	04/02/91		Rift Zones
road_buf	12/10/90	generated through analysis with arc/info	Buffer around roads in RWMC area. -used in demo-
roads	12/10/90	digitized from USGS 15 minute quad maps	INEL roads -used in demo-
rpoly	03/25/91	RWMC	Piece of RWMC inventory map (clipped from rwmc)

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
rpolya	05/13/91		Subset of rpoly coverage (RWMC inventory map)
rreach	07/12/91	digitized data	Drainage information for RWMC
rsta	07/09/91	Aeromark	RSTA fly-over data
rwmc	06/17/91	Aeromark	RWMC fly-over data
rwmc-buf	04/30/91		Line buffer around RWMC fly-over data
rwmc1	05/31/91	RWMC	Piece of RWMC inventory map
rwmc5	03/26/91	RWMC	Piece of RWMC inventory map with legend
rwmc7	07/15/91	RWMC	Piece of RWMC inventory map without legend
rwmc_50mi	04/13/92	US Census Bureau	population within 80 kilometers of RWMC
rwmc_boring	12/10/90	Data from Hopi Solomon	Boring locations for test purposes along fence of RWMC.
rwmc_boring	12/10/90	Data from Hopi Solomon	-used in demo-
rwmc_d	07/15/91	Aeromark	Immediate area around RWMC clipped from rwmc fly-over data
rwmc_d	07/15/91	Aeromark	with contours removed
rwmc_wells	12/10/90	SAIC	RWMC wells -used in demo-
rwmc_wells	12/10/90		RWMC wells -used in demo-
rwmc_wells	03/08/91	SAIC	RWMC wells -used in demo-
rwmc_wells	08/08/91		RWMC wells -used in demo-
rwmc_wells	12/10/90	SAIC	Wells at RWMC derived from newwells coverage
rwmc_wells	12/10/90		Wells at RWMC derived from newwells coverage
rwmc_wells	08/08/91	SAIC	Wells at RWMC derived from newwells coverage

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
rwmc_wells	08/08/91		Wells at RWMC derived from newwells coverage
rwmcbuf	12/10/90	generated through analysis with Arc/Info	Buffer area around RWMC -used in demo-
rwmcinch	08/15/91	Aeromark fly-over data	RWMC fly-over data rotated 90' and scaled to inches
scs-soils	3/1991	Soil Conservation Service	Incomplete soil classifications from Soil Conservation Serv.
sda	05/09/91	Aeromark	Immediate area around Subsurface Disposal Area (SDA)
sda	05/09/91	Aeromark	clipped from rwmc fly-over data
shallow_wells	05/21/92	Dennis Walker	shallow wells at INEL
sipos	10/11/92	unk	INEL site roads
siposl	10/11/92	unk	INEL site boundary
soilgas	01/31/91		Soil gases in RWMC area. -used in demo-
soilgas	01/31/91	generated from text	Soil gases in RWMC area. -used in demo-
soilgas	12/10/90		Soil gases in RWMC area. -used in demo-
soilgas	12/10/90	generated from text	Soil gases in RWMC area. -used in demo-
soilgas	01/31/91		Soilgas survey points at RWMC
soilgas	01/31/91	generated from text	Soilgas survey points at RWMC
soilgas	12/10/90		Soilgas survey points at RWMC
soilgas	12/10/90	generated from text	Soilgas survey points at RWMC
soilgas3	12/10/90		Portion of soilgas samples in RWMC. -used in demo-

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
soiltype	04/04/91	INEL Soil Type Map (McBride)	Soil Types of the INEL
sresources	08/05/92	Steve Minkin	areas checked for archiological finds
srp-rds	01/19/91	USGS map	Clip taken from idaho-rds coverage
stbuf	12/10/90	generated through analysis using Arc/Info	Buffer zones around streams in RWMC area. -used in demo-
strakal streams	01/28/92 12/10/90	Dan Strakal USGS 15 minute quad map	soil types at INEL Streams in the RWMC area. -used in demo-
streams	12/10/90	IDWR	Streams in the RWMC area. -used in demo-
streams	05/23/91	USGS 15 minute quad map	Streams in the RWMC area. -used in demo-
streams	05/23/91	IDWR	Streams in the RWMC area. -used in demo-
streams	12/10/90	USGS 15 minute quad map	Streams in the INEL
streams streams	12/10/90 05/23/91	IDWR USGS 15 minute quad map	Streams in the INEL Streams in the INEL
streams streets	05/23/91 12/10/90	IDWR USGS 15 minute quad map	Streams in the INEL Streets in the RWMC area. -used in demo-
strms	05/23/91	USGS 15 minute quad map	Streams in the RWMC area
suitable	05/09/91		Sample coverage used for suitability demo

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
surfgeo	03/26/91	Surficial Geologic Map of Eastern Snake River Plain	Surficial Geology of the INEL
tan	10/02/91	controlled drawing 171967	Line drawing of TAN facility
tan	10/02/91	Aeromark	Line drawing of TAN facility
tan	06/18/91	controlled drawing 171967	Line drawing of TAN facility
tan	06/18/91	Aeromark	Line drawing of TAN facility
tan	10/02/91	controlled drawing 171967	TAN fly-over data
tan	10/02/91	Aeromark	TAN fly-over data
tan	06/18/91	controlled drawing 171967	TAN fly-over data
tan	06/18/91	Aeromark	TAN fly-over data
tan_50mi	04/17/92	US Census Bureau	population within 80 kilometers of TAN
tanpr03	10/02/90	controlled drawing 171967	Line drawing of TAN facility
tanwells	04/08/91	SAIC	Wells at TAN facility
tanwellsp	04/25/91	SAIC	Wells at the TAN facility
thrmisp	01/15/91		Thermal Springs in the Snake River Plain
tic-cover	03/07/91		Fence line at RWMC
tin-cities	06/12/91		tin made from coverage id-maj-cities
tn-mn	08/07/91	drawn freehand	Northarrow
tra	06/18/91	Aeromark	TRA fly-over data
tra5mileutm	12/12/90	generated in arc/info	5 mile boundary around TRA in UTM coordinates
tra_50mi	04/17/92	US Census Bureau	Population within 80 kilometers of TRA

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
tra_wells1	03/25/91	SAIC	Wells at TRA
tracoca	01/28/91	controlled drawing 171970	Coca sites at TRA
tracont	01/09/91	generated in arc/info from points provided by Hopi Salomon	TRA contours generated from sample points
tracont1	01/09/91	generated in arc/info from points provided by Hopi Salomon	TRA contours generated from sample points
tracont2	01/11/91	generated in arc/info from points provided by Hopi Salomon	TRA contours generated from sample points
tracwp_wells	03/25/91	Points provided by Hopi Salomon	Wells at TRA
traflynn	04/01/92	provided by engineering drawing	cleanup area around ponds at TRA
traiaag	01/28/91	modified TRA coca per Hopi Solomon	Inter-Agency Agreements(IAGs) at TRA
trans	01/15/91		Transmisivity of Snake River Plain
transport	12/10/90	USGS 15 minute quad maps	All transportation (highway, dirt roads, Rail Roads, ect) in
transport	12/10/90	USGS 15 minute quad maps	the RWMC area. -used in demo-
traoutline	06/13/91	modified from controlled document 171970	Outline of TRA facility

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
traperch	06/13/91	Points from SAIC, MK Ferguson, and Hopi Salomon	Perched wells at TRA
trapipes	05/03/91	controlled drawing 171970 w/ mod. by Blackmore & Salomon	Waste piping diagram of TRA facility with modifications by
trapipes	05/03/91	controlled drawing 171970 w/ mod. by Blackmore & Salomon	Carolyn Blackmore and Hopi Salomon
trarad	12/31/90	Points from Hopi Salomon	Radiation sample points from warm waste ponds at TRA
trarad1	12/31/90	Points from Hopi Salomon	Radiation sample points from warm waste ponds at TRA
trascp trashallow	11/24/92 3/26/91	Shannon Flynn Points received from SAIC, MK Ferguson, and Hopi Salomon	retention basis local area Aquifer and shallow wells at TRA
tratanks trautm	01/20/91 10/02/91	unk	Tanks around TRA 100 mile radius from ATR at TRA
tsf7	06/28/1991	Aeromark	Immediate area around tsf7 clipped from tan fly-over data
usa	12/10/90	unknown	Map of the United States. -used in demo-
usa	12/10/90	NCAR import	Map of the United States. -used in demo-
usa	06/18/91	unknown	Map of the United States. -used in demo-
usa	06/18/91	NCAR import	Map of the United States. -used in demo-
usa	12/10/90	unknown	Outline of states in USA

Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
usa	12/10/90	NCAR import	Outline of states in USA
usa	06/18/91	unknown	Outline of states in USA
usa	06/18/91	NCAR import	Outline of states in USA
usa-west	06/18/91	NCAR import	Outline of western states in the USA
vegtran	01/15/91	Long term vegetation transects (Ron Rope)	Vegetation Transects
vegtype	04/04/91	Vegetation Types & Surface Soils of the INEL (McBride)	Vegetation types for the INEL
wag10	02/19/91	controlled drawing	Entire INEL site less the facilities
wag10_wells	10/30/90	SAIC	Wells at WAG 10
wag10coca	02/19/91	Layne Butler	Coca sites not located in facilities
wag10wells	07/11/91	SAIC	Wells at WAG 10
wag2	10/12/90	controlled drawing 171970	Coca sites and wells at TRA
wag5wells	01/25/91	SAIC	Well data for PBF and ARA
wag7	04/23/91	input from digitizing and drawings	RWMC drawing
wasteponds	04/10/91	USGS 7 1/2 foot quads (Ron Rope)	Waste Ponds and INEL Boundary
water	05/23/91	Data from Hopi Salomon	Polygon showing water in warm waste ponds at TRA
water	05/23/91		Polygon showing water in warm waste ponds at TRA
water	01/06/91	Data from Hopi Salomon	Polygon showing water in warm waste ponds at TRA
water	01/06/91		Polygon showing water in warm waste ponds at TRA

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Table G-3. (continued).

Coverage Name	Coverage Date	Data Source	Data Text
water	05/23/91	Data from Hopi Salomon	Streams in the RWMC area
water	05/23/91		Streams in the RWMC area
water	01/06/91	Data from Hopi Salomon	Streams in the RWMC area
water	01/06/91		Streams in the RWMC area
water2	01/11/91	Data from Hopi Salomon	Polygon showing water in warm waste ponds at TRA
weather	01/04/91	Randy Johnson of NOAA	Weather telemetry station locations
well_anno	12/10/90	SAIC	annotation for RWMC wells
well_anno	12/10/90	SAIC	annotation for RWMC wells
well_anno	03/13/91	SAIC	annotation for RWMC wells
well_anno	03/13/91	SAIC	annotation for RWMC wells
well_anno	12/10/90	SAIC	Annotation for wells in TAN vicinity
well_anno	12/10/90	SAIC	Annotation for wells in TAN vicinity
well_anno	03/13/91	SAIC	Annotation for wells in TAN vicinity
well_anno	03/13/91	SAIC	Annotation for wells in TAN vicinity
wells	12/10/90	SAIC	Wells in the RWMC area
wellsanno	07/08/91	SAIC	Annotation for wells in the INEL
werf	07/09/91	Aeromark	WERF fly-over data
werf_50mi	04/20/92	US Census Bureau	population within 80 km of werf

Appendix H
Data Deficiencies and Needs

Albert L. Bowman
John S. Irving

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ACRONYMS

AR	Air Resources
CFR	Code of Federal Regulations
CR	Cultural Resources
DOE	Department of Energy
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ER	Ecological Resources
ER&WM	Environmental Restoration and Waste Management
ERD	Environmental Resource Document
INEL	Idaho National Engineering Laboratory
LR	Land Resources
NEPA	National Environmental Policy Act of 1969
NRC	Nuclear Regulatory Commission
RESL	Radiological and Environmental Sciences Laboratory
SAR	Safety Analysis Report
SE	Socioeconomic Resources
WR	Water Resources

Appendix H

Data Deficiencies and Needs

H.1 Data Deficiencies and Needs

The following tables have been prepared to provide a better understanding of the INEL environmental resources data deficiencies. These data could be useful in addressing impacts during environmental assessment on the INEL. Data needs have been identified using several sources of information. Many of the needs are based on regulatory compliance (i.e., needed to comply with Federal, state, or local laws and statutes. Sources include:

- Data Deficiencies Document
- Review comments from Ecology and Environment, Inc. on the Data Deficiencies Document
- Review comments on the draft Environmental Resource Document
- Rules and Regulations of the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the State of Idaho.

Each data deficiency has been numbered according to discipline (i.e., Land Resources, LR-1 or Ecological Resources, ER-5). It is expected that this list will change as new needs are identified and as data are gathered to satisfy identified needs. A computerized database will be kept current. Tables H-1 through H-6 describe the data deficiencies and needs and the justification for each of the following: land resources; water resources; ecological resources; socioeconomic resources, demography, and land use; cultural resources; and air resources.

Appendix H ♦ H-2

Table H-1. Land resources.

No.	Data deficiencies and needs	Justification
LR-1	Determine sedimentary stratigraphy for eolian deposits. Characterize geomorphology and quaternary history of sand dunes on and bordering the INEL.	DOE Draft Order 5820.2A requires erosion rate assessments and long-term land surface stability studies for siting of any new waste management facilities. 10 CFR 61 (61.50) requires long-term stability for surface erosion for waste management sites.
LR-2	Determine lava tube statistical parameters to include sizes and depths of directional tendencies.	Lava tube parameters are required for input to groundwater model. 10 CFR 61.30 (10) requires avoidance of areas that could affect the ability for disposal site to meet long term objectives. Previous scoping comments indicate public concerns relative to groundwater flow, especially pathways for rapid transport to aquifer.
LR-3	Prepare volcanic hazards map.	No volcanic hazards map exists for the INEL. NRC regulatory guide 1.7 (Rev. 4) and 10 CFR 60 and 61 require assessment of volcanic hazards for siting high- and low-level radioactive waste sites. Also covered in DOE 5480.23 (SAR).
LR-4	Prepare seismic hazards map and 200-mi radius seismicity map.	No probabilistic seismic hazards map or 200-mi radius seismicity map exist for the INEL as required by NRC Regulatory Guide 1.70, 10 CFR 100, Appendix A, DOE Order 6430.1A, and University of California Research Laboratories 15910 & 53588.
LR-5	Prepare INEL Site-wide soils map.	No Site-wide maps exist for classifying overall soils on the INEL. Soils information is needed for NEPA per 7 CFR 658 (Farmland Protection Policy Act), DOE Order 5400.XY. Fish and Wildlife Service, Bureau of Land Management, and Soil Conservation Service. No Site-wide baseline data for radionuclides and metals content exist.
LR-6	DOE Order 5820.2A requires erosion rate assessments.	Wind and water erosion are potential problems at the INEL. Erosion studies are required to support long-term siting studies for waste management facilities. Existing erosion models are unverified; DOE Order 5820.2, 10 CFR 61, 6430.1A.

Table H-1. (continued).

No.	Data deficiencies and needs	Justification
LR-7	Comprehensive fault maps near south and west border of INEL do not exist.	Seismic surveys of these areas were completed in December 1991. Analyses of the survey data has not been completed. This should be done to support NEPA, 10 CFR 100, and 10 CFR 61 siting studies. This is especially significant due to the proximity of the Radioactive Waste Management Complex to the Arco fault.
LR-8	Determine morphological features of patterned ground (mounds). Determine the effects of mounds on erosion or deposition of sediment.	Large areas of the land surface at the INEL are covered with earth mounds 3 to 8 m in diameter. United States Geological Survey studies indicate that these mounds may be potentially important in determining erosion or deposition of sediment.
LR-9	This effort will compile and assemble existing INEL soil data into a consistent format on a data base, and provide some initial validation assessment of the data. It will provide documentation for each data set used and provide data and documentation to the Environmental Restoration Information System program. Assess radionuclides and metals content of soils.	Soils data are important for siting facilities, environmental monitoring, and understanding INEL land form characteristics. Recent efforts supported by the New Production Reactor EIS and other baseline studies have provided several potentially useful data sets; however, much of the data have not been examined to determine their ability to clarify and/or validate existing soils maps. The INEL has not been entirely mapped by the Soil Conservation Service and consequently is lacking significant information.
LR-10	This effort will compile and document existing INEL boundary information, determine corners that still need to be accurately surveyed and set, survey and set these corners, and document the process. This boundary data will then be placed on the INEL Geographical Information System.	Accurate determination of the INEL Site boundary is imperative for cumulative and accident impact assessments to the public. The INEL boundary, especially at the north end of the Site, is known to be in error compared to the existing maps. This must be rectified.
LR-12	Produce consistent topography data set for the INEL at the resolution required for ecological, geological, and archaeological studies. Topography maps for the INEL that currently exists are inaccurate for 90 mi ² surface area. This makes accurate location of surficial features difficult or impossible.	7.5-ft United States Geological Survey quad map with contours at 10 ft is needed to support general observations for environmental resources. Registration and requirements dictates accurate location of surface features of the INEL. Geographical Information System is the only known method for determining accurate locations at a reasonable price.

Appendix H ♦ H-4

Table H-2. Water resources.

No.	Data deficiencies and needs	Justification
HR-1	Determine aquifer and vadose zone hydraulic and geochemical properties.	<p>Accurate determination of hydraulic and geochemical properties is needed to predict the possible migration of contaminants into and through the aquifer.</p> <p>EPA regulations affect the siting of low-level waste disposal facilities (40 CFR 193) if the Snake River Aquifer is declared a Class 1 aquifer (40 CFR 149).</p>
HR-2	Groundwater modeling studies to predict impacts for alternative actions.	<p>NRC regulatory guide 4.2 specifies needed information for groundwater systems and models.</p> <p>Additional requirements are found in:</p> <ul style="list-style-type: none">- 40 CFR 1502.14, Alternatives- 40 CFR 1502.16, Environmental Consequences- DOE Order 5440.1D, NEPA Compliance Program- DOE Order 5400.4, Comprehensive Environmental Response, Compensation, and Liability Act Compliance- Local Federal Facility Agreement and Consent Order and Resource Conservation and Recovery Act. <p>Public scoping hearings reveal strong interest in capability for present and future groundwater contamination.</p>
HR-3	Development of two-dimensional flood plain model.	<p>Currently, there are no one- or two-dimensional floodplain models adequate to simulate overland or sheet flow at INEL. This is flow caused by sudden and torrential rains that could affect local facilities. Model is required to generate floodplain maps.</p>
HR-4	Map 100-year and 500-year return period floods for the INEL.	<p>No accurate flood plain map exists for the INEL that can accurately predict the 100- and 500-year flood on the INEL.</p> <p>This deficiency was a tiger team finding (DOE/EH-0178 Finding (DOE/EH-1078 Finding SW/CF-10).</p> <p>Additional requirements are found in:</p> <ul style="list-style-type: none">- Executive Order 11988 (flood plain management).- 40 CFR 761.65(B)(1)(V) and- 40 CFR 264.18(B)(1)- 10 CFR 61 (Cannot site within 100-yr flood plain).- DOE 4320.1B.

Table H-2. (continued).

No.	Data deficiencies and needs	Justification
HR-5	Delineate the waters of the U.S. on the INEL.	Noted in Tiger Team findings and new EPA storm water permit requirements. Locations of "waters of the U.S." are defined in the Clean Water Act and must be identified for: <ul style="list-style-type: none"><li>- Development of facility specific plans<li>- Preparation of National Pollution Discharge Elimination System discharge permits.<li>- Obtaining coverage under the EPA's general storm water permit program.

Appendix H ♦ H-6

Table H-3. Ecological resources.

No.	Data deficiencies and needs	Justification
ER-1	Determine distribution of sensitive species/habitats at the INEL.	Assessments required by NEPA, Endangered Species Act, and State. Major topic of most EISs.
ER-2	Identify and characterize biota associated with wetlands at the INEL.	Required by NEPA, Presidents's comprehensive plan, and the Fish and Wildlife Service. Major concern for U.S. Army Corps of Engineers. Major topic of most EISs.
ER-3	No comprehensive wetlands map for INEL exists. No generic description material available.	Wetlands are to be protected (E.O. 11990). No waste disposal sites are to harm wetlands. 10 CFR 1022. Fish and Wildlife Service has delineated wetlands on the INEL, but no verification has taken place. No comprehensive data base exists with accurate locations of wetlands.
ER-4	Compile, qualify, and enter environmental data into the Geographical Information System.	Geographical Information System required by DOE 4320.1B Better quality assurance/quality control. Provides consistent qualified data base for multiple users. Most productive method for effective use of resources.
ER-5	This will be a report documenting the development and status of the new INEL vegetation map and associated data.	No formal DOE documentation exists for the production of this vegetation map. This map has already been useful for providing siting information for other facilities. Providing this documentation and information regarding how the map can be used will be valuable for siting facilities and/or restoring areas to natural conditions.
ER-6	Accuracy assessment of vegetation map for the INEL.	No overall comprehensive vegetation map exists for the INEL. An accuracy assessment of INEL vegetation is needed for the EIS. Verification and ground truthing is required to establish a basis for statistical accuracy.
ER-7	Compile existing INEL data on species/habitats that could be affected by INEL activities. No overall compilation exists for the INEL.	Significant amounts of ecological data have been collected for the INEL. However, the data resides at various locations within the INEL and at several universities which participated in study efforts over the years. No single comprehensive data base exists for INEL ecological data.

Table H-4. Socioeconomic resources, demography, and land use.

No.	Data deficiencies and needs	Justification
SE-1	Socioeconomic and Land Use data bases for vicinity of the INEL and regions of interest.	10 CFR 20, 100 6430.1A.

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Table H-5. Cultural resources.

No.	Data deficiencies and needs	Justification
CR-1	Characterize the INEL paleontology resources & develop predictive model.	<p>Paleontology information incorporated in many EISs</p> <p>Antiquities act requires consideration of paleontology resources in NEPA.</p> <p>Incorporates data into Cultural Resource Management and National Environmental Research Park philosophy at the INEL.</p>
CR-2	Develop predictive model for cultural resources.	<p>Provides Federal cultural resources compliance with the National Historical Preservation Act, Archaeological Resource Protection Act, & Executive Order 11593.</p> <p>Complies with DOE-HQ directives on management of cultural resources and land use and planning in accordance with the National Historic Preservation Act 7 CFR 43.</p>
CR-3	Develop historical overview of the INEL and potential eligibility to National Registry of Historic Places.	<p>The National Historic Preservation Act & NEPA require an assessment of historic resource potential & the affects of federal agency activities on those resources: 36 CFR 800.</p>
CR-4	Cave Resource Assessment.	<p>Federal Cave Resource Protection Act (11/88) requires protection of biological, paleontology, and cultural resources in cave environments.</p> <p>Cave resources never assessed on the INEL.</p> <p>Supports the National Historical Preservation Act, the American Indian Religious Freedom Act, the Native American Graves Protection and Repatriation Act, and the Endangered Species Act.</p>

Table H-6. Air resources.

No.	Data deficiencies and needs	Justification
AR-1	Dose and Risk Assessment Guide.	Radiological and nonradiological assessments are an integral part of EISs, EAs, SARs, demonstrating compliance with environmental regulations, and the siting of facilities. In addition, these assessments are under increasing scrutiny by the public and groups such as the INEL Oversight Program and the INEL Dose Evaluation and Risk Assessment Advisory Panel.
	Evaluate & select codes to be used to calculate environmental impacts.	
	V & V computer codes and correct deficiencies.	
	Maintain & update computer code configuration & configuration Management Plan.	
	Prepare Radiological and Non Radiological assessment protocol documents for the impact analyses.	
AR-2	Determine multiple point sources.	Accident assessments (both radiological and nonradiological) are an integral part of EISs, EAs, SARs, and the siting of facilities. In addition, these assessments are under increasing scrutiny by the public and groups such as the INEL Oversight Program and the INEL Dose Evaluation and Risk Assessment Advisory Panel.
	Pathways Analysis Document.	
	Determine exposure pathways at the INEL and data bases to describe pathways.	Provide consistency in determining Dose & Risk Assessments. Provide reference document for contractors.

H.2 Proposals and Corresponding Categories and Priority Rankings

Proposals have been developed in response to the needs described in the previous tables (Tables H-1 through H-6). These proposals address the short- and long-term needs of the INEL. Information from most of these proposals will be used to support the ER&WM EIS and other NEPA-related documents, safety analysis reports, and site selection documents. All proposals meet a need described in Tables H-1 through H-6. Proposals have been categorized by the following activities:

- ER&WM EIS (short-term)
- ER&WM EIS (long-term)
- Other NEPA documents (EAs & EISs)
- Safety Analysis Reports (SARs)
- Compliance
- Site selection documents
- Environmental Resource Document (ERD).

Short-term proposals are considered important for the ER&WM EIS or for mitigative measures associated with the EIS. These projects should be completed for inclusion in the draft ER&WM EIS. Long-term proposals or those satisfying other activities (SARs, compliance, etc.) would provide additional environmental data bases and knowledge of the INEL Site. Proposals may satisfy several activities (e.g., both ER&WM EIS and SARs). All proposals would provide information that could be included in the ERD.

Each proposal, and in some cases, phases of a proposal, have been ranked (1a, 1b, 1c, 2, or 3) in order of importance to the ER&WM EIS (Table H-7). A ranking of 1a means that the proposal can satisfy a direct need for the Draft ER&WM EIS. Proposals ranked 1a should be given high priority when and if funds become available for additional INEL environmental characterization. A ranking of 1b denotes a proposal of potential importance to the ER&WM EIS database, but not as critical. The tasks for 1b proposals could be performed to support issuance of the Draft or Final EIS. Proposals ranked 1c are tasks that ideally would be performed to support the EIS, but they are not as important to its support as 1a and 1b tasks. However, all proposals ranked 1a, 1b, and 1c should be undertaken in the near future, as soon as funds become available. Other rankings (2 or 3) are of a long-term nature or of lesser importance. Proposals receiving rankings of 2 or 3 may still address needs that would help, but are not critical, in evaluating impacts in the EIS.

Table H-7. Priority rankings.

Proposal No.	Title	Principal investigator(s)	Deficiency and data needs No.	Priority ranking
Priority category 1				
01	Soils Map, Generalized, Phase I	G. Olson	LR-5	1a
02	Cultural Resources Predictive Models, Phase I	B. Ringe	CR-2	1a
03	Wetlands Map	R. Rope & K. Moor	ER-2	1a
04	Update / Support Global Positioning System	R. Rope	ER-4	1a
05	INEL Vegetation Map Documentation and Digitization, Phase I	R. Rope	ER-5, ER-6	1a
12	Seismic Hazard Map and Seismicity Map, Phase I & II	R. Smith & S. Jackson	LR-4	1a
13	Volcanic Hazards Map and Report, Phase I	W. Hackett	LR-3	1a
14	Sediment Interbed Properties Map	R. Smith	LR-4, HR-2	1a
15	Statistical Parameter for Lava Tube Distribution & Geometry, Phase I & II	R. Smith	LR-2	1a
29	Land Use & Agricultural Data Acquisition, Phase I & II	?	SE-1	1a
31	Map Depth to Aquifer, Phase I & II	T. Wood & I. Porro	HR-1, HR-2	1a
40	Mapping of 100/500 yr. Floodplains for the INEL	S. Clapp & G. Sehlke	HR-3, HR-4	1a
23	Groundwater Model & Parameter Review & Code Testing	R. Arnett & S. Magnuson	HR-2	1b
24	Evaluate the Contaminant Transport Potential of Lava Tube Type Structures	R. Arnett & S. Magnuson	HR-2	1b
27	Establish a Normal Operation Radiological Assessment Protocol	S. Maheras & M. Abbott	AR-1, AR-2	1b
28	Establish Air Transport Modeling and Exposure Assessment Protocol for Evaluation of Potential Accidents Scenarios	S. Maheras & M. Abbott	AR-1, AR-2	1b
06	Eolian Stratigraphy	J. Tullis	LR-1	1c

Appendix H ♦ H-12

Table H-7. (continued).

Proposal No.	Title	Principal investigator(s)	Deficiency and data needs No.	Priority ranking
13	Volcanic Hazards Map, Detailed Map & Report, Phase II	W. Hackett	LR-3	1c
32	Determine Aquifer Hydraulic Properties	T. Wood & I. Porro	HR-1, HR-2	1c
33	Determine Aquifer and Vadose Zone Geochemical Properties, Phase I	T. Wood & I. Porro	HR-1, HR-2	1c
34	Determine Vadose Zone Hydraulic Properties, Phase I	T. Wood & I. Porro	HR-1, HR-2	1c
37	Two-Dimensional Floodplain Model	R. Martineau	HR-3, HR-4	1c
Priority category 2				
01	Soils Map, Detailed, Phase II	G. Olson	LR-5	2
02	Cultural Resources Statistical Prediction Model, Phase II	B. Ringe	CR-2	2
05	INEL Vegetation Map Documentation and Accuracy Assessment, Phase II	R. Rope	ER-5, ER-6	2
08	INEL 10' Contour Topography Map	R. Rope	LR-11	2
09	Erodibility of Soils	G. Olson	LR-6	2
18	Lost River Fault Paleoseismology	R. Smith, W. Hackett, & S. Jackson	ERD	2
19	Strength Tests and Thermal Conductivity Determinations	R. Smith & W. Hackett	LR-3, LR-4	2
25	Ecological Studies of Sensitive Species at the INEL	RESL	ER-1	2
26	Mapping INEL Boundary	R. Rope	LR-10, ERD	2
Priority category 3				
05	INEL Vegetation Map Documentation and Accuracy Assessment, Phase II	R. Rope	ER-5, ER-6	3
07	Earth Mounds	J. Tullis	LR-8	3

Table H-7. (continued).

Proposal No.	Title	Principal investigator(s)	Deficiency and data needs No.	Priority ranking
10	Cave Resources	D. Lowrey & S. Miller	CR-4	3
11	Paleontology & Paleoecology	S. Miller & D. Lowrey	CR-1	3
16	Synthesis of Results of Geoscience New Production Reactor Investigation	R. Smith & W. Hackett	ERD	3
17	Analysis of Seismic Sections at South ends of Major Faults	G. Carpenter	LR-7	3
20	Analysis of First Order Leveling Data	R. Smith	LR-3, LR-4	3
21	Field Mapping of Lineaments Identified During 1991 Geomorphic Analysis	R. Smith & W. Hackett	LR-3, LR-4	3
29	Land Use & Agricultural Data Acquisition, Regional Addition, Phase III	?	SE-2	3
30	Determine Aquifer Quality	T. Wood & I. Porro	HR-1, HR-2	3
33	Determine Aquifer and Vadose Zone Geochemical Properties; Phase II	T. Wood & I. Porro	HR-1, HR-2	3
34	Determine Vadose Zone Hydraulic Properties, Phase II	T. Wood & I. Porro	HR-1, HR-2	3
35	Determine Recharge to Aquifer	T. Wood & I. Porro	HR-1, HR-2	3
36	Determine Aquifer Limits	T. Wood & I. Porro	HR-1, HR-2	3
38	Compilation of INEL Ecological Data	R. Rope	ER-7	3
39	Compilation of Soil Analysis Data	G. Olson	LR-9	3

**DATE
FILMED**

6/3/94

END