# A Preliminary Assessment Petition

*PUBLIC PETITION FOR PRELIMINARY ASSESSMENT*

Elin Miller, Regional Administrator
Michelle Pirzadeh, Acting Regional Administrator
United States Environmental Protection Agency, Region X
1200 Sixth Avenue, Suite 900
Seattle, WA 98101

February 3, 2009

Fax: 206-553-1809
206-553-1234

Under the authority of CERCLA Section 105 (d), as amended, the petitioner,

(Name) : Dvija Michael Bertish, Rosemere Neighborhood Association, Columbia Riverkeeper

(Address) : Box 61471, Vancouver WA, 98666

We hereby request that Region X of the United States Environmental Protection Agency conduct a preliminary assessment of the known and suspected release of a hazardous substances, pollutants, or contaminants at the following location:

Camp Bonneville, Former US Military Installation, Clark County, WA (just outside Vancouver, WA)

Petitioners are affected by the [release (or) threatened release] because: Camp Bonneville, a surplus military property, is the subject of a dirty transfer from the US Dept. of Defense (DoD), to Clark County Government, via a non-profit "nature conservancy" known as the Bonneville Conservation, Restoration and Renewal Team (BCRRT). The property is currently under a cleanup program with supervision by Washington State Dept. of Ecology. EPA Region X staff are very familiar with the issues (both known and unknown) at the site. EPA was formerly involved with the clean-up project, but in an extremely rare occurrence, EPA opted out of the project in July 2003 citing a lack of adequate site assessment and a lack of collaboration on the US Army's part. Given various circumstances that have occurred since 2003, members of the public firmly believe that this project requires EPA to re-engage and list this site on the National Priorities List to achieve a higher level of oversight and to ensure public health and safety. As a former member of the Camp Bonneville Restoration Advisory Board, the petitioner is very concerned about ongoing groundwater contamination that has not been successfully mitigated. Landfill 4 was evacuated – military ordnance and great amounts of soil were removed and clean fill replaced. Ecology stated clearly that post evacuation increases in groundwater contaminant levels would indicate additional (unidentified) sources. Ammonium perchlorate concentrations have increased to above 500 ppb, and there are additional concerns with TCE, and RDX. RDX has a 100 year lifespan in the environment. The groundwater contamination plume abuts and flows toward Lacamas Creek, a salmon bearing stream that feeds into Lacamas Lake, and then into the Columbia River. Lacamas Creek flows through the heart of Camp Bonneville, including the Central Valley Floor where new pollutant discoveries have been made since the project ensued. The surrounding residents all use well water as their potable water supply, however the water on site is unsafe for human consumption. The site exists within the EPA designated Troutdale Sole Source Aquifer System, and petitioners are concerned that federal dollars being expended on this project are not being used to sufficiently protect against further damage to the vulnerable aquifer system and offsite migration of contamination. Since there is a direct federal funding nexus to the project, the petitioners request EPA to invoke its jurisdiction citing Sole Source Aquifer designation in order to evaluate these concerns, as there appears to have been insufficient containment and monitoring (placement of monitoring wells).

Faulty site characterization has long been a problem on this project, and since clean-up activity began, there have been at least 9+ new Area's of Concern (AOC) identified. The new AOCs include new firing points, burial

pits and practice ranges. Despite public comments regarding the probability of 155 mm Howitzer's being armed and fired on site, officials denied this concern, only to discover and detonate a Howitzer in the Central Target Impact Area in May of 2007. The find was near existing residential neighborhoods that were apparently built directly over the firing fans for this kind of projectile. Petitioners understand that the Army Corps of Engineers and/or the Dept. of Defense advised neighboring residences on the periphery of the site not to dig a pond or drive stakes into the ground on their own properties, however, there has been no additional planning to evaluate this public safety concern. In a January 12, 2009 letter from Baker Engineering & Energy (subcontractor) to BCRRT, Ecology's comments on the Draft Cleanup Action Plan include: "It is apparent from MEC data collected at the CVF [Central Valley Floor] that MEC types and distributions as well as their corresponding Explosive Hazard Rankings developed for Maneuver and Training areas need to be re-evaluated. The findings completely discredit the prevailing concept in the RI/FS that maneuver areas have negligible explosion hazard risks." Ecology also states: "Based on current available field data it is obvious that the selected cleanup actions for Maneuver areas, especially within the Regional Park, fall short of protectiveness in terms oflong-term effectiveness. A more protective action should take into account surface contamination, and in some areas, subsurface contamination as well." In response to Ecology's concerns, BCRRT staff seems to indicate that risk from new anomalies is "unlikey," and that more empirical data is required to determine if the threat is real. The public insists that the project is well beyond the need to prove whether the threat is real or valid. Various parties of record were denied the opportunity to offer scoping comments on the supplemental RI/FS. To date, the public has not seen a supplemental RI/FS to offer public comment, even though cleanup activity is presumably still underway. Petitioners voiced concern through the RI/FS process that the site was inadequately characterized, and that such data gaps would elevate risk assessment for the intended re-use of the site as a public park and overnight campground, but these concerns were ignored or rebuffed by officials running the project.

In a January 31, 2009 Columbian Article [Army Contests Camp Bonneville Costs; Contractor defends dubious expenses, including large bar tabs], the BCRRT contractor, Mike Gage, states that BCRRT "[has]found several things on-site that we believe are Army-retained conditions that they did not disclose to us." It has now been publicly acknowledged by the contractor that the federal funds budgeted to this project are insufficient to achieve cleanup standards necessary for the intended re-use, and the contractor will be seeking additional federal funding to cover the data gaps that were pointed out by EPA and the public prior to the inception of this project. The Columbian article continues with descriptions of misappropriated federal funds from the project expense records, a lack of oversight between Clark County and the contractor, and the contractor claiming that the project is a private contract that allows him to spend federal cleanup dollars as he so chooses without oversight. In published responses to the Columbian Article, the public perceives these developments as project mismanagement, collusion, and greed.

It is important for EPA to list this site on the National Priorities List simply because the public needs better federal oversight to ensure that the clean-up standards are achieved for optimum risk assessment to protect the public health and safety on this project. Superfund listing would provide additional oversight and would require de-listing prior to release of the site for re-use implementation. The petitioners firmly believe this layer of protection is necessary due to unmitigated circumstances at the site. Clark County officials have openly stated that conditions on this site allow for an "acceptable risk" for the intended re-use as a public park, a position that many people from the public vehemently oppose. Institutional controls call for MEC to remain on site in perpetuity, to be cordoned off by a three strand barbed wire fence adjacent to planned public recreation facilities. Many members of the public have argued that Camp Bonneville is unsuitable for a public park and that they would never bring their children to the site. This public perception is detrimental to the public's interest in this project, especially in light of financial shortfalls currently forecast. The EPA would be better suited to manage additional federal resources and what's left of the current operating budget since financial

oversight and accountability are lacking. It appears that Ecology is in need of assistance to bring clean-up standards to bear under CERCLA and MTCA regulations given the new discoveries.

Given that Camp Bonneville is a precedent setting project that sets an example for other military clean-ups of its kind, it is imperative that EPA help to establish improved protocols in order to protect other communities around the nation from experiencing the depth of confusion and largesse experienced on the ground in Clark County. The protocols noted in a Dept. of Defense/EPA document entitled "Management Principals for Implementing Response Actions at Closed, Transferring, or Transferred Ranges," clearly outline intended practices, including collaboration between EPA and DoD, that have been absent from Camp Bonneville's active clean-up. The petitioners hope that EPA can re-energize these much needed protocols and apply them with due diligence to Camp Bonneville's restoration efforts.

Type or characteristics of the substance(s) involved: Ammonium Perchlorate, Trichloroethane, Dichloroethene, Cyclotrimethylenetrinitramine (RDX), HMX, Lead, Chromium, Mercury and others. An extensive list of Militarized Ordnance including mortars, missiles, grenades, chemical warfare agents, and unknown contaminants located in new burial pits. Potential for radioactive materials.

Nature and history of any activities that have occurred regarding the release/threatened release: The sources of contamination are military landfills, target impact areas, firing ranges, burial pits and open burn pits, and documented groundwater contamination.

Federal, State and local authorities you have contacted about the release/threatened release and the response, if any: Washington State Dept. of Ecology , Barry Rogowski, Tim Nord, Ben Forson, Greg Johnson, Dawn Hooper; Martha Lentz, Sole Source Program, EPA Region X; Jonnie Hyde, Clark County Health Dept; Nancy Harney and Harry Craig, EPA Region X; Steve Stuart and Marc Boldt, Clark County Commissioners. Bill Barron, Clark County Administrator. Bill O'Donnell, US Dept. of Defense, Pentagon. Katherine Hanks, Environmental Health Scientist, Agency for Toxic Substances and Disease Registry; Jeroen Kok, Clark County Parks and Recreation; Pete Capell and Jerry Barnett, Clark County Public Works; Mike Gage, BCRRT Contractor; Taylor Aalvik and Nathan Reynolds, Cowlitz Tribe; Ed Marshman, FBI Portland, OR; Vancouver Fire Department District 5; Washington Department of Natural Resources; Camas/Washougal/Woodland Veterans of Foreign Wars and Veterans Administration Land Acquisitions, Willamette Cemetery Portland, OR; Gary Lucas, Clark County Sheriff; Department of Toxic Substances Bureau, San Francisco; Earl Blumenauer, Oregon Congressman; Brian Baird, Washington Congressman; Patty Murray and Maria Cantwell, Washington Senators; Governor Christine Gregoire, Washington.

# B Photographic Documentation

CAMP BONNEVILLE
Vancouver, Washington

TDD Number: 09-05-0003
Photographed by: Erin Lynch

Photo 1 Landfill 4 with wells in background.

*Direction: West* *Date: 8/26/09* *Time: 09:58*

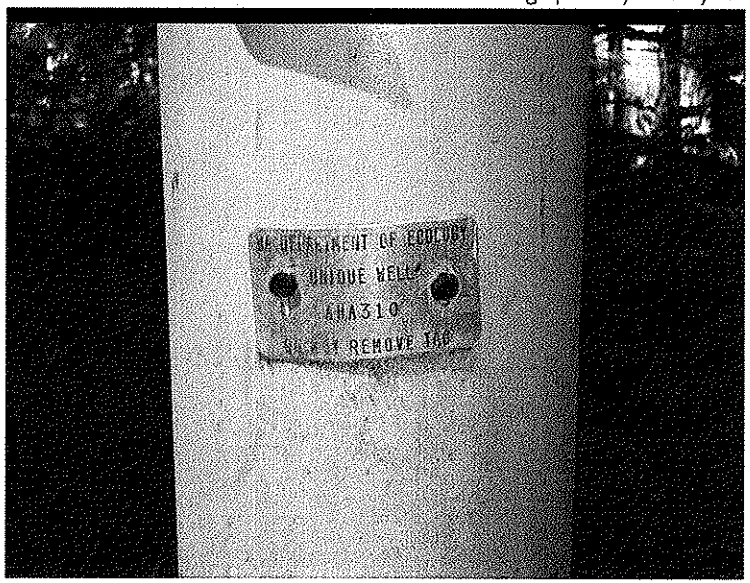


Photo 2 Monitoring wells south of landfill.

*Direction: West* *Date: 8/26/09* *Time: 10:01*

Photo 3 East lagoon.

*Direction: Northwest* *Date: 8/26/09* *Time: 10:19*

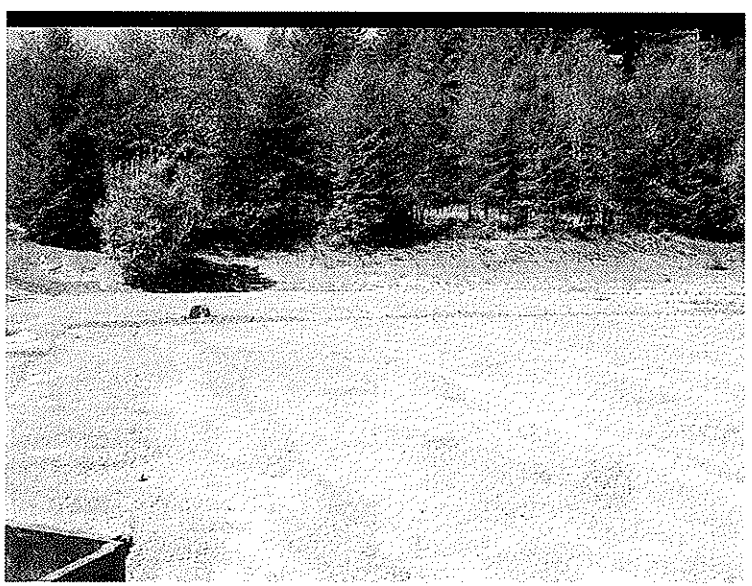

Photo 4 East lagoon.

*Direction: West* *Date: 8/26/09* *Time: 10:19*

Photo 5 Soil stockpile West lagoon.

*Direction: West* *Date: 8/26/09* *Time: 10:21*

Photo 6 Profile of shot crete in West Lagoon.

*Direction: West* *Date: 8/26/09* *Time: 10:22*

Photo 7 West lagoon.

*Direction: Northwest* *Date: 8/26/09* *Time: 10:22*

Photo 8 West lagoon with connection between lagoons.

*Direction: Northwest* *Date: 8/26/09* *Time: 10:22*

CAMP BONNEVILLE
Vancouver, Washington

TDD Number: 09-05-0003
Photographed by: Erin Lynch

Photo 9 State listed Stemmed Checker Mallow.

*Direction: Down* *Date: 8/26/09* *Time: 10:27*

Photo 10 State listed Stemmed Checker Mallow.

*Direction: Down* *Date: 8/26/09* *Time: 10:27*

CAMP BONNEVILLE
Vancouver, Washington

TDD Number: 09-05-0003
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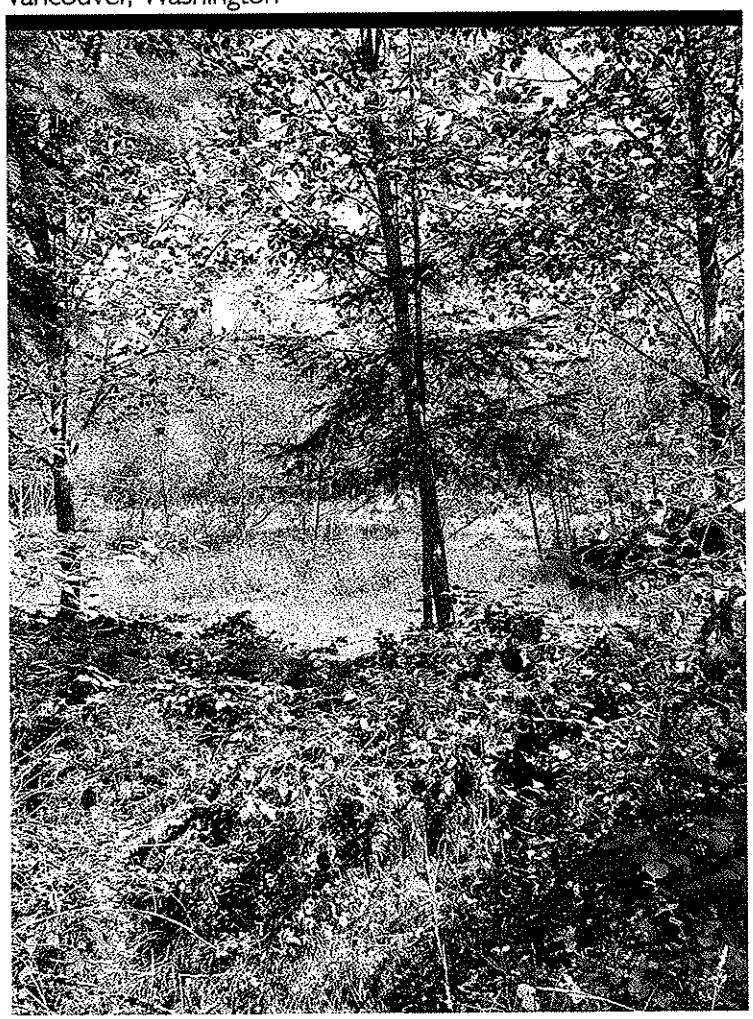

Photo 11 Davis (?) Creek dammed by beavers.

*Direction: Northeast* *Date: 8/26/09* *Time: 10:45*

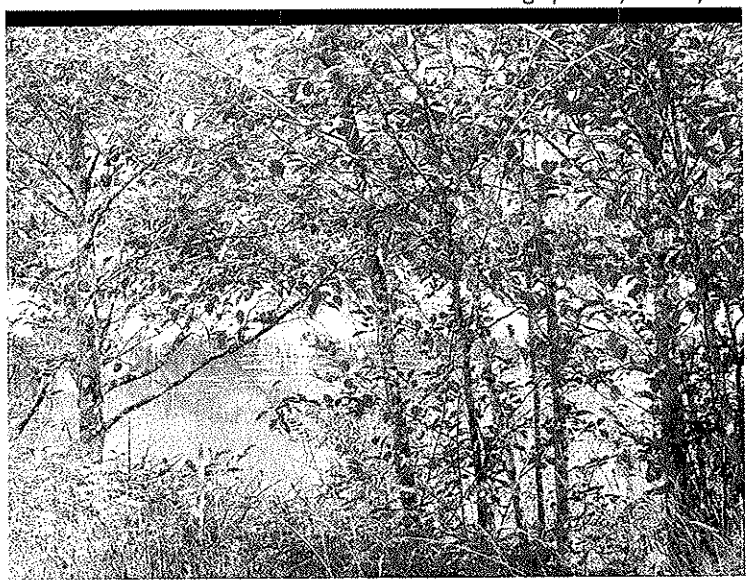

Photo 12 Borrow pit flooded by beaver dam.

*Direction: Northeast* *Date: 8/26/09* *Time: 10:46*

Photo 13 Small arms firing range.

*Direction: West* *Date: 8/26/09* *Time: 10:46*

CAMP BONNEVILLE
Vancouver, Washington

TDD Number: 09-05-0003
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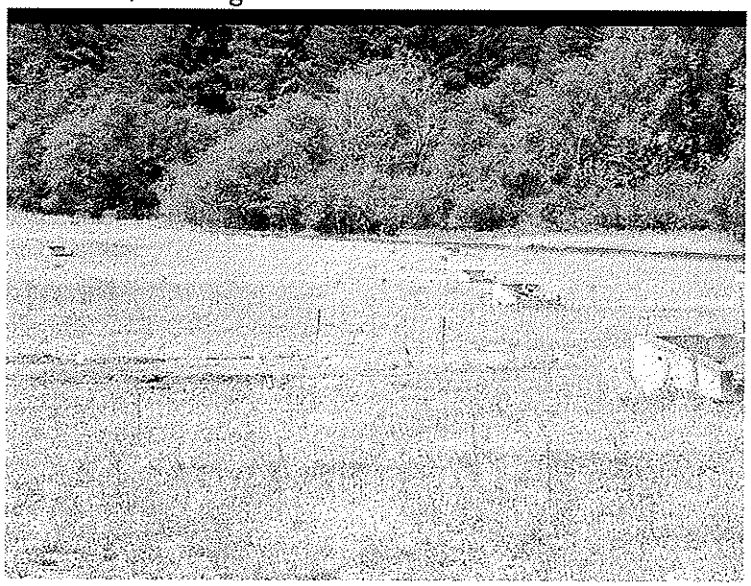

Photo 14 Flagged sampling area for lead.

*Direction: West* *Date: 8/26/09* *Time: 10:47*

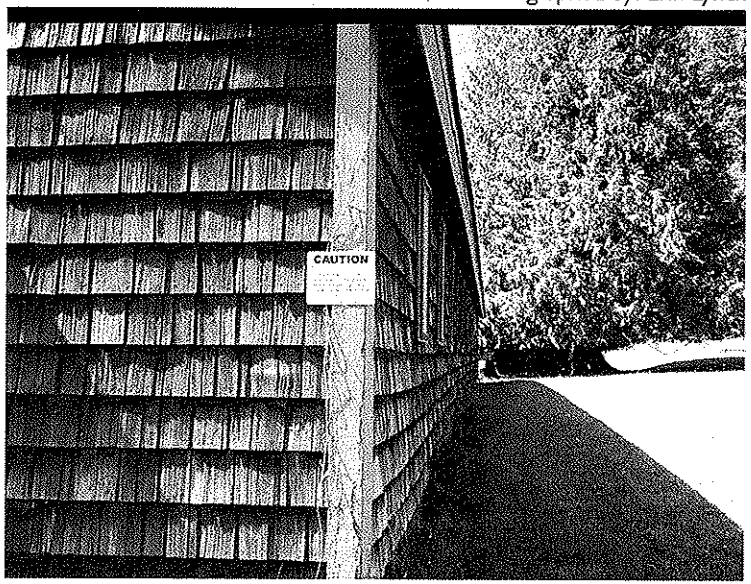


Photo 15 Sign barracks close up.

*Direction: West* *Date: 8/26/09* *Time: 11:01*

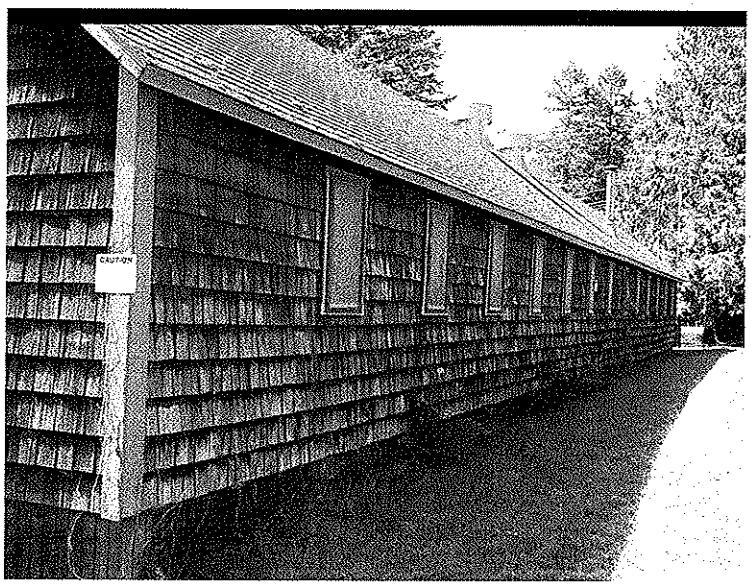

Photo 16 Signs on two sides of barracks.

*Direction: Southwest* *Date: 8/26/09* *Time: 11:01*

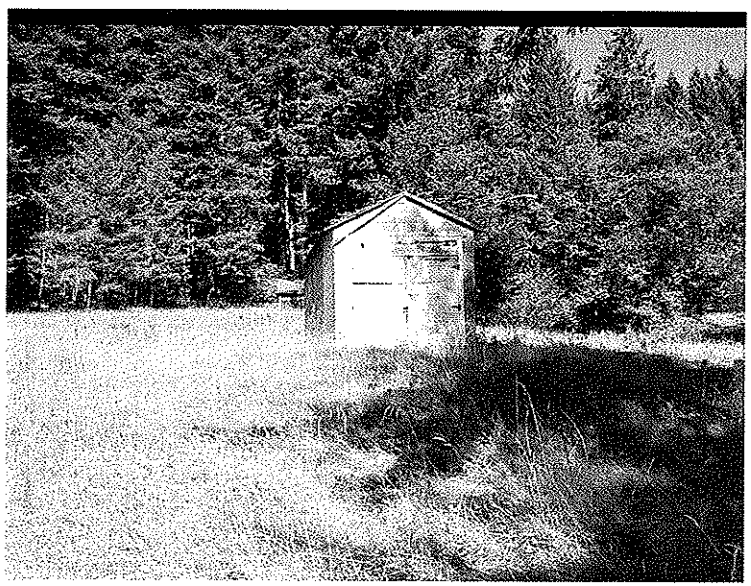

Photo 17 Pesticide storage building.

*Direction: West* *Date: 8/26/09* *Time: 11:02*

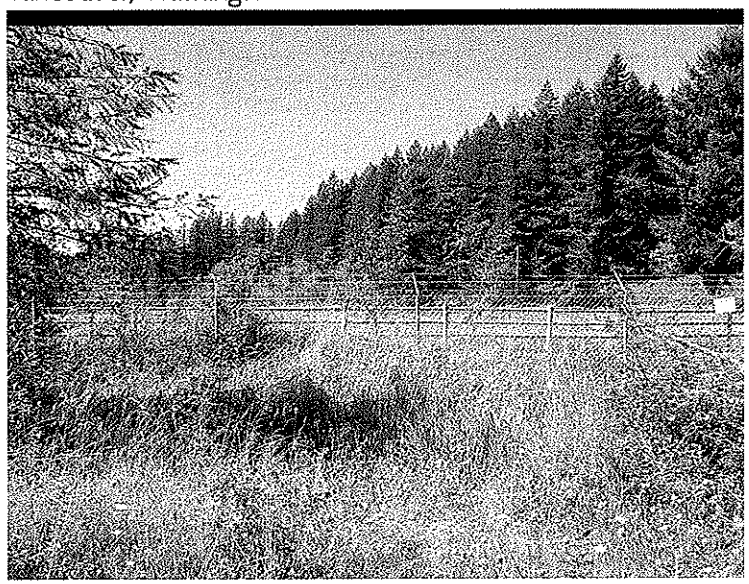

Photo 18 Ranch to southwest corner adjacent to Camp Bonneville.

*Direction: Southwest* *Date: 8/26/09* *Time: 11:13*

Photo 19 Suspected Demolition Area 3.

*Direction: Down* *Date: 8/26/09* *Time: 11:20*

Photo 20 Suspected Demolition Area 3.

*Direction: Down* *Date: 8/26/09* *Time: 11:20*

Photo 21 Gas pipeline corridor through site.

*Direction: East* *Date: 8/26/09* *Time: 11:22*

CAMP BONNEVILLE
Vancouver, Washington

TDD Number: 09-05-0003
Photographed by: Erin Lynch

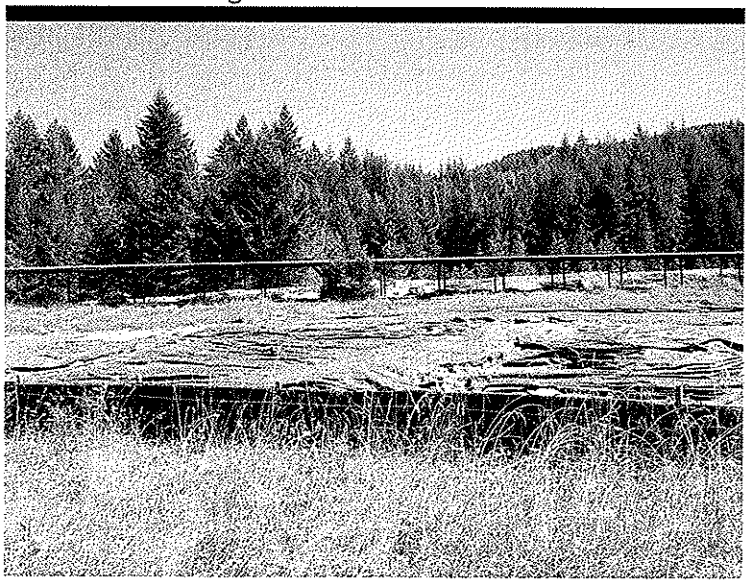

Photo 22 Stockpiled soil (800 tons)/Machine gun range.

*Direction: North* *Date: 8/26/09* *Time: 11:29*

Photo 23 Stockpiled soil (800 tons)/Machine gun range.

*Direction: North* *Date: 8/26/09* *Time: 11:29*

Photo 24 Lead contaminated area adjacent to Lacamas Creek at weir.

*Direction: Southeast* *Date: 8/26/09* *Time: 11:33*

Photo 25 Lead contaminated area adjacent to Lacamas Creek at weir.

*Direction: Southeast* *Date: 8/26/09* *Time: 11:33*

CAMP BONNEVILLE
Vancouver, Washington

TDD Number: 09-05-0003
Photographed by: Erin Lynch

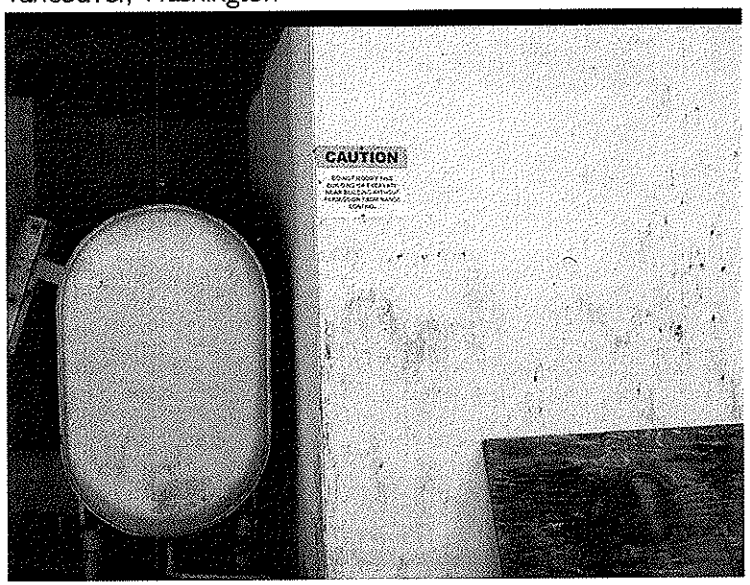


Photo 26 Sign on fuel contaminated building.

*Direction: North* *Date: 8/26/09* *Time: 11:41*

# C

# Fate and Transport Modeling Review

ecology and environment, inc.
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**MEMORANDUM**

DATE: February 24, 2010

TO: Monica Tonel, EPA Task Monitor, Seattle, WA Mail Stop ECL-112

FROM: Erin A. Lynch, START-3 Senior Hydrogeologist, E & E, Portland, OR

SUBJECT: Contaminant Fate and Transport Modeling Review for RAU2C (Landfill 4/ Demolition Area 1), Camp Bonneville Site, Clark County, Washington
EPA Site ID Number WAN001002030

REFERENCE: Contract Number: EP-S7-06-02
Technical Direction Document Number: 09-05-0001

cc: Renee Nordeen, E & E Project Manager, Seattle, WA

The United States Environmental Protection Agency (EPA) has tasked Ecology and Environment, Inc. (E & E) under Superfund Technical Assessment and Response Team (START)-3 Contract Number EP-S7-06-02, Technical Direction Document Number 09-05-0001, to provide technical support for completion of a Preliminary Assessment (PA) for the Camp Bonneville Site. The subject model review of contaminant fate and transport modeling of RAU2C (Landfill 4/ Demolition Area 1) is intended to support this work. All modeling reviewed in this document was completed by contractors to the Washington Department of Ecology (Ecology).

The following documents were reviewed for this technical memorandum:

- DRAFT Remedial Investigation/Feasibility Study RI/FS for Site-Wide Groundwater Remedial Action Unit 2C, Camp Bonneville Military Reservation, 2301 Northeast Pluss Road, Vancouver, WA 98682 (Bonneville Conservation Restoration & Renewal Team, August 2009); and
- DRAFT Perchlorate Evaluation Landfill 4/Demolition Area 1 (RAU 2C), Camp Bonneville Military Reservation, 2301 Northeast Pluss Road, Vancouver, WA 98682 (Bonneville Conservation Restoration & Renewal Team, February 2008).

## Site Location and Layout

Camp Bonneville is located in Clark County, approximately 12 miles northeast of Vancouver, Washington (Figure 2-1). Camp Bonneville consists of approximately 3,840 acres of land that was historically used by the United States Department of Defense (DOD) to provide training for active Army, Army Reserve, National Guard, Marine Corps Reserve, Navy Reserve, Coast Guard Reserve units, and other DOD personnel. The installation consists of two cantonment areas (Bonneville Cantonment and Killpack Cantonment), 25 firing ranges, and several known or suspected disposal areas; including Landfill 4/Demolition Area 1 (Woodward Clyde Federal Services 1997).

On February 4, 2003 Enforcement Order 03TCPHQ-5286 was issued for Camp Bonneville. The enforcement order divided the site into three remedial action units (RAUs). The RAUs and their status are described below.

- **RAU 1:** This RAU consists of the 20 acres where hazardous substances other than military munitions have been located.
- **RAU 2:** This RAU consists of the areas where hazardous substances have been located, but not addressed through remedial actions. This RAU has been further subdivided into three subunits.
  - **RAU2A:** This RAU consists of the 21 small arms range areas.
  - **RAU2B:** This RAU consists of Demolition Areas 2 and 3.
  - **RAU2C:** This RAU consists of the Landfill 4 area.
- **RAU 3:** This RAU consists of any area where military munitions may have come to be located.

This technical memorandum focuses on contaminant fate and transport modeling completed for RAU2C Landfill 4/Demolition Area 1.

## Hydrogeology and Contamination

Details of the regional and site geologic setting and aquifer system are contained in Section 3.1 of the PA report for the Camp Bonneville Site (E & E 2010). This section briefly summarizes the hydrogeology at Landfill 4/Demolition Area 1. The following hydrogeologic units are present in order from shallowest to deepest: Recent Alluvial Sediments, Lower (Conglomerate) member of the Troutdale Formation, and Basaltic Andesite of the Elkhorn Mountain (see attached USGS map of surficial deposits). Recent alluvium and landslide deposits are present along Lacamas Creek. The alluvial deposits consist of unconsolidated silt, sand, and gravel. Well-rounded quartzite pebbles from the Troutdale Formation are present in these deposits. The Troutdale Conglomerate is present along the west – southwest portion of Camp Bonneville and a remnant is present at Landfill 4/Demolition Area 1 (Figure 2-2, RI/FS RAU2C). The remnant of the Troutdale Conglomerate is not connected to the conglomerate located along the west – southwest portion of the Camp Bonneville. At Landfill 4/Demolition Area 1 the Troutdale Conglomerate reaches a maximum depth of 15 ft and is located above the water table. The Troutdale Aquifer is considered an excellent water-bearing aquifer and in the Camp Bonneville area it has been designated a sole source aquifer. Groundwater occurs in the heavily weathered Basaltic Andesite. This weathered basalt grades to increasingly larger grain sizes with depth. Zones are described as saturated sandy, silty, or clayey (angular) gravels. The Basaltic Andesite generally does not act as an aquifer since it has little capacity to store or transmit water. Fractures have been identified in the Andesite and are reported to be oriented nearly horizontal.

Groundwater flow regionally and at Camp Bonneville is thought to follow topography with Lacamas Creek serving as a discharge location for groundwater during most of the year. Where groundwater doesn't discharge to Lacamas Creek, it is thought to follow surface water flow to the south – southwest. Groundwater contours for the site are shown in Figure 2-3 from the RI/FS for RAU2C which is attached to this memorandum.

Perchlorate and Royal Demolition Explosive (RDX) have been identified in soil and groundwater at the Landfill 4/Demolition Area 1. The perchlorate is thought to be present from

disposal of fireworks at the site in the 1960's (BCCRT 2009). Three pits were identified that had apparently been used for burning fireworks. The pits were dug well into the heavy clay soil and one pit was completed into the saturated zone. Based on site observations, it appears that excess fireworks were placed in the pits and soaked with diesel oil prior to ignition. Not all fireworks were combusted; intact fireworks were recovered during a removal action. Because the landfill area is not thought to have significant infiltration, the contamination of groundwater by perchlorate is thought to be the result of fireworks that were placed in the pit that encountered the saturated zone. An Interim Removal Action in which contaminated soils were removed was completed at Landfill 4/Demolition Area 1 however; some impacted soils containing residual perchlorate were left in place. Quarterly monitoring indicates perchlorate concentrations in groundwater samples from monitoring wells at and downgradient of the Landfill 4/Demolition Area 1 have been variable. As presented in the 4$^{th}$ Quarter groundwater sampling and analysis report from 2006 (PBS 2007) and in the draft RI/FS report for RAU2 - Landfill 4/Demolition Area 1 (BCRRT 2000) perchlorate concentrations appear to show both seasonal and longer term fluctuations. Monitoring well locations are indicated in Figure 3.8 from the RI/FS for RAU2C which is attached to this memorandum. Note monitoring well LF4-MW02 is considered to be hydraulically downgradient of the area where the highest perchlorate concentrations were found in soil. Quarterly groundwater sampling results for perchlorate are shown in an attachment (Appendix A, BCRRT 2008) to this memorandum. Perchlorate concentrations in groundwater from monitoring wells L4-MW 2A (shallow) and LF4-MW 2B (deep) are the highest of all of Landfill 4/Demolition Area 1 monitoring wells, fluctuate seasonally, and show a slightly increasing overall trend. All concentrations are greater than the 15 microgram per liter (ug/L) EPA Preliminary Remediation Goal (PRG) for tap water (EPA 2009).

Surface water samples were collected from the North Fork Lacamas Creek in 2009 from the following locations:

- Upstream/northwest of MW-4A;
- Directly across/west of LF4-MW2A&B pair; and
- Downstream/south where the creek goes through two 90 degree bends and the mapped remnant Troutdale conglomerate pinches out.

All samples resulted in nondetects for perchlorate.

## Contaminant Fate and Transport Modeling

Two types of models have been used to evaluate the fate and transport of perchlorate and RDX in the vadose zone and in groundwater in Landfill 4/ Demolition Area 1 at Camp Bonneville. Model input and output for vadose zone modeling are contained in Appendix D (not provided for review) and groundwater mass transport modeling are contained in Appendix E of the RI/FS for RAU2C.

### *Vadose Zone Modeling*

VLEACH was utilized for contaminant fate and transport modeling within the vadose zone at RAU2C (Ravi and Johnson 1997). VLEACH is a one-dimensional finite difference, vadose zone leaching model. The model is used to estimate impact on groundwater due to the mobilization and migration of organic contaminants located in the overlying vadose zone. VLEACH describes the movement of an organic contaminant within and between three different phases: as

a solute dissolved in water, as a gas in the vapor phase, and as an adsorbed compound in the solid phase. The vadose zone is modeled by a series of polygons with input parameters that describe site conditions (e.g., area, height, recharge rate, effective porosity etc.). Distribution coefficients for the contaminant being modeled are defined by the modeler based on published data and are used by VLEACH to calculate the equilibration distribution of the contaminant between the phases.

Results of modeling with VLEACH are commonly used as a preliminary assessment of potential impacts to groundwater because a number of major assumptions are employed. The following assumptions are made in VLEACH:

- Linear isotherms describe the partitioning of the pollutant between the liquid, vapor and soil phases. Local or instantaneous equilibrium between these phases is assumed within each cell.
- The vadose zone is assumed to be in a steady-state condition with respect to water movement. More specifically, the moisture content profile within the vadose zone is assumed to be constant. This assumption will rarely occur in the field. Although moisture gradients cannot be simulated, the user can estimate the impact of various moisture contents by comparing results from several simulations that cover the common or possible ranges in soil moisture conditions.
- Liquid phase dispersion is neglected. Hence, the migration of the contaminant will be simulated as a plug. This assumption causes higher dissolved concentrations and lower travel time predictions than would occur in reality.
- The contaminant is not subjected to in-situ production or degradation. Since organic contaminants, especially hydrocarbons, generally undergo some degree of degradation in the vadose zone, this assumption results in conservative concentration values.
- Homogeneous soil conditions are assumed to occur within a particular polygon. This condition will rarely occur in the field. Although spatial gradients cannot be simulated, the user can estimate the impact of non-uniform soils by comparing results from several simulations covering the range of soil properties present at the site. However, initial contaminant concentrations in the soil phase can vary between cells.
- Volatilization from the soil boundaries is assumed to be either completely unimpeded or completely restricted. This assumption may be significant depending upon the depth of investigation and the soil type. In particular, after a depth of 1 meter volatilization to the atmosphere will decrease significantly.

In addition, the model does not account for non-aqueous phase liquids or any flow conditions derived from variable density.

Model inputs include :

- *Number of Polygons.* The number of polygons used to conceptualize the site. Each polygon has a unique set of parameter data. For RAU2C, the vadose zone was modeled using three laterally distributed polygons for perchlorate and RDX impacted soil as indicated in the RI/FS for RAU2C. Polygon inputs include:
  - Area and height,
  - Recharge rate for groundwater through the vadose zone,
  - Dry bulk density of soil,

- Effective porosity of the soil,
- Water content in soil,
- Organic content of soil,
- Contaminant concentration in recharge water,
- Contaminant concentration in the atmosphere above the soil surface,
- Contaminant concentration in groundwater at the base of the vadose zone, and
- Initial contaminant concentration.

- *Model Timestep.* A model timestep given in years.
- *Simulation Time.* The simulation time is the total time length for model simulation in years.
- *Organic Carbon Distribution Coefficient ($K_{oc}$).* Organic carbon distribution coefficients were used for perchlorate and RDX.
- *Henry's Constant ($K_h$).* The Henry's constants were used for perchlorate and RDX.
- *Water Solubility.* Water solubilities were used for perchlorate and RDX.
- *Free Air Diffusion Coefficient.* The free air diffusion coefficients were used for perchlorate and RDX.

Site specific model inputs are indicated in model result summary sheets for both perchlorate and RDX simulating post-Interim Removal Action (post-excavation) attached to the RI/FS for RAU2C. However, these input values were not available for this review and therefore were not reviewed for this memorandum. Three laterally distributed polygons were modeled separately utilizing VLEACH.

Results of vadose zone modeling at Landfill 4/Demonstration Area 1 indicate for post-excavation that perchlorate in leachate would take over 100 years to reach concentrations less than 1 ug/L and that the peak concentration of RDX leaching to groundwater would occur 24 years after excavation.

***Groundwater Modeling***

For contaminant fate and transport modeling in groundwater at RAU2C, the Domenico analytical solute transport model (Domenico 1987) was utilized. The Domenico model is a commonly used analytical solution to the advection-dispersion partial-differential equation of organic transport processes in groundwater for a continuous release source.

The model is based on the advection-dispersion partial-differential equation for organic contaminant transport processes in groundwater. Model inputs include hydrogeologic data (seepage velocity, hydraulic conductivity, hydraulic gradient, effective porosity), source data (source thickness, width, and concentration), dispersivity data (longitudinal, transverse, and vertical dispersivity and estimated plume length), adsorption data (retardation factor, soil bulk density, organic carbon partition coefficient ($K_{oc}$), fraction organic carbon (foc)), biodegradation data (e.g., first-order decay coefficient, dissolved plume solute half-life, etc.).

The use of the analytical model requires contaminant temporal concentration data at a minimum of one source and one downgradient monitoring well. The model is calibrated by adjusting four model-input parameters to fit the pattern of groundwater temporal concentration distribution at the downgradient monitoring well. Once the model is calibrated, it can be used to estimate travel

time to a receptor along the contaminant plume centerline given distance, for dissolved organic contaminants in groundwater.

Model assumptions include:
- Transient conditions,
- A continuous release source,
- Homogenous aquifer properties,
- One-dimensional groundwater flow,
- No change in groundwater flow direction or velocity,
- First order degradation rate,
- Contaminant concentration estimated at the centerline of the plume,
- Molecular diffusion based on concentration gradient is neglected, and
- Adsorption in transport process is neglected.

Site specific model inputs are indicated in model result summary sheets (attached) for both perchlorate and RDX simulating post-Interim Removal Action (post-excavation).

Modeling results indicate that perchlorate and RDX should have reached Lacamas Creek within 11.3 years of the disposal of explosives and fireworks in the late 1960's, if no dispersion or retardation had occurred. However, none has been detected in surface water as of the recent sampling. BCRRT attributes these results to another attenuation mechanism such as biodegradation in creek sediments and/or in the root zones of flora along the creek.

## Summary and Recommendations

The existing vadose zone contaminant fate and transport model for Landfill 4/Demolition Area 1 at Camp Bonneville is a good screening-level tool. Vadose zone modeling indicates that both perchlorate and RDX will continue to be a source of groundwater contamination at Landfill 4/Demolition Area 4, in the case of perchlorate, for over 100 years.

The existing groundwater contaminant fate and transport model for Landfill 4/Demolition Area 1 at Camp Bonneville is also a good screening-level tool. At the source area, groundwater is within the deeply weathered basaltic andesite. Contaminant fate and transport modeling indicates that perchlorate and RDX should have reached North Fork Lacamas Creek since the burial of explosives and fireworks in Landfill 4/Demolition Area 1 in the late 1960's. However, neither perchlorate nor RDX was detected in surface water samples collected from North Fork Lacamas Creek, adjacent to Landfill 4/Demolition Area 1. This may be due to underestimation of contaminant travel times by the model, dilution by surface water to non-detectable concentrations once contaminants reach Lacamas Creek, or no discharge of contaminated groundwater to Lacamas Creek in the sampled area.

In general, both perchlorate and RDX tend to be persistent in the environment. Perchlorate biodegradation requires anaerobic conditions, the presence of sufficient carbon, and an active perchlorate degrading microbial population (Tipton, et al 2003 and Urbansky and Brown 2003). It is unlikely that biodegradation is occurring at this site. However if biodegradation is occurring, it could be demonstrated by the presence of intermediates of perchlorate degradation.

Adsorption is not a significant attenuation process for RDX since it has a low adsorption coefficient. In addition, anaerobic biodegradation of RDX has been observed to occur more readily and more completely than aerobic biodegradation. (Brannon and Pennington 2002)

The Domenico (1987) model for contaminant fate and transport in groundwater is limited in that it assumes homogeneous aquifer properties, one-dimensional groundwater flow, among other assumptions. Contaminated groundwater from the landfill initially flows within the weathered andesitic basalt as it migrates toward North Fork Lacamas Creek, it likely flows through alluvial sediments. These alluvial sediments would have different hydraulic and organic carbon properties.

In addition, monitoring wells LF4-MW02A&B, located downgradient of Landfill 4/Demolition Area 1, show slightly increasing concentrations of perchlorate even after excavation of contaminated soils. This indicates that perchlorate is still migrating from the area.

To better understand the fate and transport of perchlorate and RDX from Landfill 4/Demolition Area 1, additional plume delineation may be required. This could be accomplished through additional borings and installation of a monitoring well pair between LF4-MW02A&B and the North Fork Lacamas Creek, closer to the creek, and collection of water level and water quality data. A better understanding of groundwater flow, particularly vertical groundwater gradients, could be accomplished through the addition of a paired shallow and deeper monitoring well near the creek.

The Sole Source Troutdale Aquifer along the western edge of Camp Bonneville is of concern with respect to the potential for contamination from Camp Bonneville. The Landfill 4/Demolition Area 1 is several 1,000 feet to the northeast of the Troutdale Aquifer. A more robust model of groundwater flow and contaminant fate and transport could be used to determine if perchlorate and RDX could reach the Troutdale Aquifer. If a more robust model of groundwater flow and contaminant fate and transport at the Camp Bonneville Military Reservation and adjacent Troutdale Sole Source Aquifer is required, a groundwater flow model based on the program MODFLOW is recommended. MODFLOW is a finite-difference model that models groundwater flow in three dimensions (USGS 1983). MODFLOW allows the user to simulate multiple aquifers, incorporate aquifer heterogeneities, and allows for water sources and sinks. If this type of modeling were to be developed for Camp Bonneville, it could be based on the existing USGS groundwater flow model of the Portland Basin (USGS 1996). This model could be refined in the Camp Bonneville area and include layers for the basaltic andesite, the weathered basaltic andesite, the Troutdale Conglomerate, and the alluvial deposits along Lacamas Creek. Such a model could indicate if and where water may be discharging to Lacamas Creek and also if any water is moving under the creek.

In addition, if MODFLOW were to be used for the site, the model MT3D is also recommended for simulating both the perchlorate and RDX fate and transport in groundwater from the Landfill 4/Demolition Area 1. MT3D is a three-dimensional contaminant fate and transport modeling software package that can be used to simulate advection, anisotropic dispersion, first-order decay and product reactions, and linear and nonlinear sorption. Although many of these contaminant properties are modeled in Domenico 1987 based models, MT3D in combination with

MODFLOW provides a more robust solution in part because they can account for more system variables.

***Attachments:***

PA Report
Figure 2-1 – Site Vicinity Map, Camp Bonneville Preliminary Assessment.

BCCRT (2009)
Figure 2-2 – Site Geology Map
Figure 2-3 – Groundwater Contours
Figure 3.8 – Landfill 4/Demolition Area 1 (RAU 2C), Monitoring Well Locations, Geology Map
Appendix E Results of contaminant fate and transport modeling in groundwater using Domenico 1987 for perchlorate and RDX (post-excavation)

BCCRT (2008)
Appendix A - Plot of Landfill 4 Perchlorate Results

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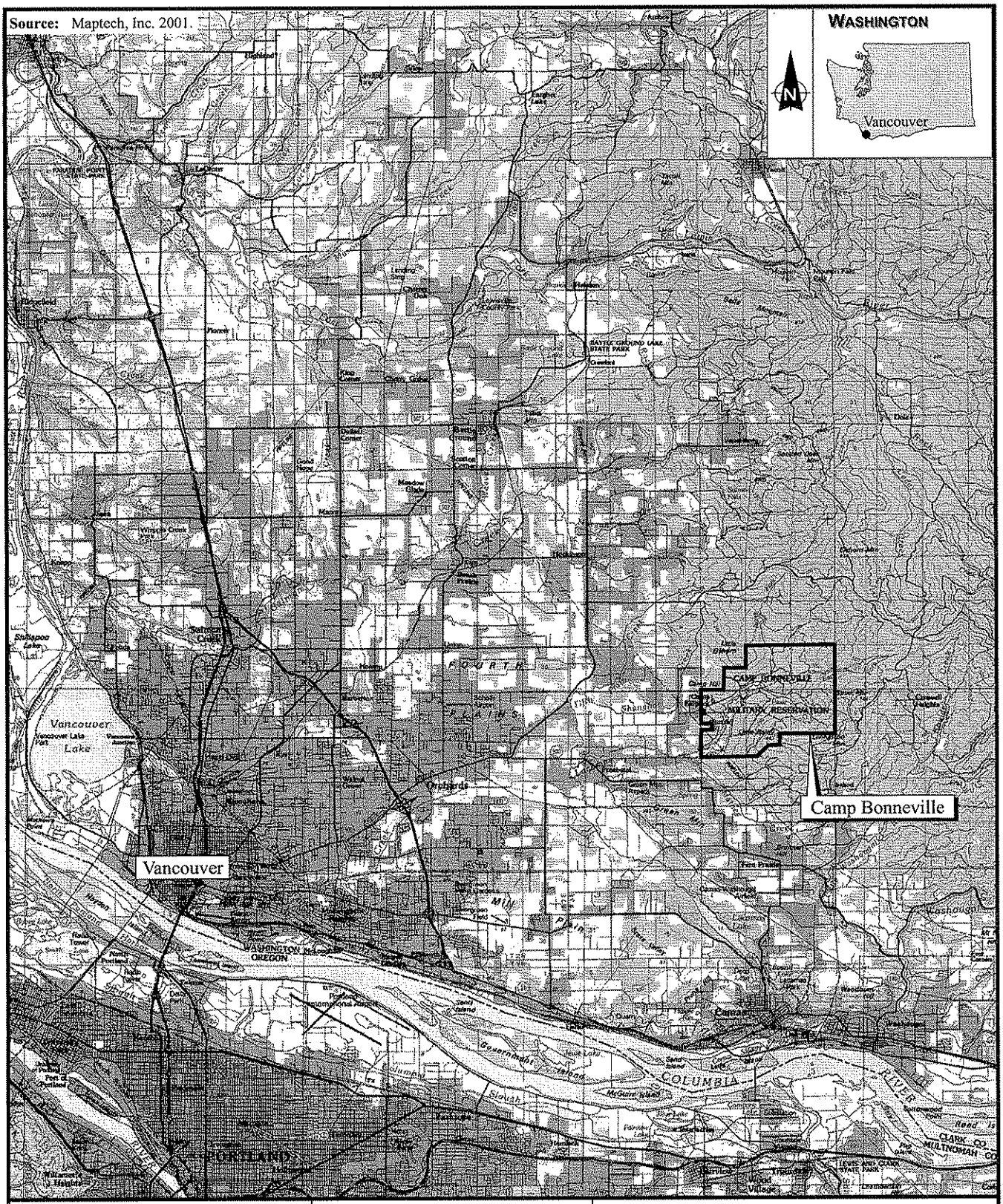


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| **ecology and environment, inc.**<br>International Specialists in the Environment<br>Seattle, Washington | CAMP BONNEVILLE<br>Vancouver, Washington | Figure 2-1<br>SITE VICINITY MAP | | |
| | 0 1.5 3<br>Approximate Scale in Miles | Date:<br>11-18-09 | Drawn by:<br>AES | 10:START-3\09050003\fig 2-1 |