United States
Environmental Protection
Agency

Office of
Emergency and
Remedial Response

EPA/ROD/R10-91/033
September 1991

EPA

Superfund Record of Decision:

Bangor Naval Submarine Base, WA

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA/ROD/R10-91/033	2.	3. Recipient's Accession No.

4. Title and Subtitle SUPERFUND RECORD OF DECISION Bangor Naval Submarine Base, WA First Remedial Action	5. Report Date 09/19/91 6.
7. Author(s)	8. Performing Organization Rept. No.
9. Performing Orgainization Name and Address	10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address U.S. Environmental Protection Agency 401 M Street, S.W. Washington, D.C. 20460	13. Type of Report & Period Covered 800/000 14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

The Bangor Naval Submarine Base (SUBASE) is a former munitions handling, storage, and processing facility in Kitsap County, Washington. Land surrounding the SUBASE is generally undeveloped and supports limited residential use. The site overlies the surficial Shallow Aquifer and deeper aquifers, which are the principal water supplies for SUBASE Bangor and surrounding communities. Demilitarizing (demil) operations were conducted from 1940 until 1978, and included collecting condensate and solid explosive within a holding tank, followed by removal of the solid material from the wastewater before final discharge. Site F, a wastewater lagoon, was used between 1960 and 1971 for the disposal of final wastewater solution. Periodically, the lagoon was allowed to drain. Waste materials present in surficial sediment of the lagoon were burned off in place with waste oils, or transported to the onsite ordnance burning area for thermal destruction. Between 1972 and 1980, wastewater was collected into 55-gallon barrels and delivered to the SUBASE liquid-waste incinerator. Several onsite investigations of the distribution and transport of waste constituents at Site F have occurred since 1971. Based on data collected, it was confirmed that soil in the lagoon area is contaminated by ordnance constituents.

(See Attached Page)

17. Document Analysis a. Descriptors

Record of Decision - Bangor Naval Submarine Base, WA
First Remedial Action
Contaminated Medium: gw
Key Contaminants: organics (RDX, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, 1,3,5-TNB, 1,3,-DNB, N-nitrate, nitrobenzene)

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) None	21. No. of Pages 52
	20. Security Class (This Page) None	22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

Abstract (Continued)

In 1972, 500 cubic feet of soil was excavated from the top several feet of the lagoon and transported to the onsite ordnance burning area for burning. In 1980, the lagoon was filled in and covered with a low permeability asphalt cover. Ground water quality data collected at Site F during prior studies indicated that only the Shallow Aquifer has been impacted by Site F. This Record of Decision (ROD) is an interim remedial action addressing ground water contamination at Site F as Operable Unit 2 (OU2). The intent of this Remedy is to contain the contaminated ground water plume. A future ROD will address final remediation of both soil and ground water. The primary contaminants of concern affecting the ground water are organics including RDX; 2,4,6-TNT; 2,4-DNT; 2,6-DNT; 1,3,5-TNB; 1,3-DNB; N-nitrate; and nitrobenzene.

The selected remedial action for this site includes pumping and treatment of ground water from the Shallow Aquifer using UV-oxidation; reinjecting the treated ground water onsite into the Shallow Aquifer, or infiltrating it onsite using a recharge basin; ground water monitoring; and providing design information, as applicable, for the final remedy. If the UV-oxidation process cannot achieve the specified performance standards due to either technological or economic concerns, then carbon adsorption will be coupled with the UV-oxidation system to complete the treatment process prior to disposal. The estimated present worth cost for this remedial action is $2,515,000, which includes an O&M cost of $1,300,000 over 2 years.

PERFORMANCE STANDARDS OR GOALS: Chemical-specific ground water clean-up goals are based on MTCA clean-up standards and include RDX 5 ug/l, 2,4,6-TNT 3 ug/l, 2,4-DNT 0.1 ug/l, 2,6-DNT 0.1 ug/l, 1,3,5-TNB 0.8 ug/l, 1,3-DNB 2 ug/l, N-nitrate 10,000 ug/l, and nitrobenzene 8 ug/l.

Declaration of the Record of Decision, Decision Summary, Responsiveness Summary, and Administrative Record Index

for

Interim Remedial Action
Naval Submarine Base Bangor Site F
(Operable Unit 2)
Bangor, Washington

August 1991

DECLARATION OF
THE RECORD OF DECISION

SITE NAME AND LOCATION

Naval Submarine Base Bangor Site F (Operable Unit 2)
Bangor, Washington.

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected interim remedial action for Site F (Operable Unit 2) at the Naval Submarine Base, Bangor in Bangor, Washington, developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act, and, to the extent possible, the National Oil and Hazardous Substances Pollution Contingency Plan. This decision is based on the contents of the administrative record for the site.

The lead agency for this decision is the U.S. Navy. The U.S. Environmental Protection Agency (EPA) approves of this decision and, along with the State of Washington Department of Ecology (Ecology), has participated in the scoping of the site investigations and in the evaluation of interim remedial action alternatives. The State of Washington concurs with the selected remedy.

ASSESSMENT OF THE SITE

This interim remedial action will provide an opportunity to significantly reduce the mobility of the groundwater contamination, thereby reducing the potential risk to human health and the environment. Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment. It will also implement a cleanup strategy expected to be consistent with the final remediation and minimize additional remediation costs which would otherwise occur if no action were taken at this time.

DESCRIPTION OF SELECTED REMEDY

The selected remedy for interim remedial action for Site F at the Naval Submarine Base addresses the threat posed by the site by providing groundwater containment and on-site treatment with permanent reduction in the mobility, toxicity, and volume of contamination.

The elements of the preferred interim remedial action alternative include:

- Extract groundwater from the Shallow Aquifer using extraction wells to contain the contamination and thereby confine further contaminant movement in the aquifer;
- Treat the extracted groundwater using an Ultraviolet/Oxidation process to meet applicable federal and state regulations prior to disposal;
- Dispose of the treated groundwater on-base by recharge or injection into the Shallow Aquifer; and
- Monitor the effectiveness of the groundwater containment and groundwater treatment process throughout the interim action.

DECLARATION

This interim action is protective of human health and the environment, complies with Federal and State applicable or relevant and appropriate requirements for this limited-scope action, and is cost-effective. Although this interim action is not intended to fully address the statutory mandate for permanence and treatment to the maximum extent practicable, this interim action does utilize treatment and thus is in furtherance of that statutory mandate. Because this action does not constitute the final remedy for the operable unit, the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element, although partially addressed in this remedy, will be addressed by the final response action. Subsequent actions are planned to address fully the threats posed by the conditions at this operable unit.

Because this remedy will result in hazardous substances remaining on site above health-based levels, a review will be conducted to ensure that the remedy continues to provide adequate protection of human health and the environment within five years after commencement of the remedial action. Because this is an interim action Record of Decision, review of this operable unit and of this remedy will be ongoing as the Navy continues to develop remedial alternatives for the operable unit.

Lawrence Kramer — 4 Sept 1991

Captain Lawrence Kramer — Date
SUBASE, Bangor Commanding Officer
United States Navy

Dana A. Rasmussen — Sept 19, 1991

Dana A. Rasmussen — Date
Regional Administrator, Region 10
United States Environmental Protection Agency

Signature sheet for the foregoing SUBASE, Bangor - Site F, Interim Remedial Action, Record of Decision between the United States Navy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Carol L. Fleskes 8/26/91

Carol Fleskes, Program Manager — Date

Toxics Clean-up Program

Washington State Department of Ecology

CONTENTS

CONTENTS (Continued)

TABLES

CONTENTS (Continued)

FIGURES

DECISION SUMMARY

1.0 INTRODUCTION

Under the Defense Environmental Restoration Program, it is the U.S. Navy's policy to address contamination at Navy installations in a manner consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). In the case of Site F at Naval Submarine Base Bangor, the selected interim remedial action will comply with applicable or relevant and appropriate requirements (ARARs) promulgated by the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA).

This interim action is proposed to minimize the further spread of contamination during the completion period of the detailed remedial investigation and feasibility study (RI/FS). The RI/FS is necessary to determine the full nature and extent of on-site soil and groundwater contamination.

2.0 SITE NAME, LOCATION, AND DESCRIPTION

U.S. Naval Submarine Base (SUBASE) Bangor is located in Kitsap County, Washington, on Hood Canal approximately 10 miles north of Bremerton. Site F is located in the south-central portion of SUBASE Bangor, approximately 1.5 miles east of Hood Canal (Figure 1). Land surrounding SUBASE Bangor is generally undeveloped or supports limited residential use within the communities of Vinland (to the north), Olympic View and Bangor (to the west), and Silverdale (to the south).

Site F (defined as the former wastewater disposal lagoon) is located west of the SUBASE Segregation Facilities in a clearing surrounded by a large forested area. The site occurs in a generally closed basin which receives surface water inflow from adjacent drainages but no surface water drainage leaves the area. The ground elevation near the disposal lagoon is approximately 300 to 310 feet mean sea level (MSL) and increases to the west until it reaches a plateau ranging in elevation from 375 to 400 feet MSL. The former wastewater disposal site consisted of a 300-square-foot unlined evaporation lagoon and overflow area located adjacent to the Segregation Facility. Local features include a Naval Heli-pad located approximately 700 feet northwest of the site and barricaded sidings and rail line approximately 1,500 feet west. The only access road into the site is via the Segregation Facility, and it is secured. The access to the site is restricted to authorized personnel.

3.0 SITE HISTORY AND ENFORCEMENT ACTIONS

The concern over the environmental impact of ordnance operations at SUBASE Bangor originated from activities prior to its commissioning as a submarine base. From the early 1940s until 1971, the Bangor Naval complex served as a munitions handling, storage, and processing site. Limited demilitarization (demil) operations continued on a limited basis until about 1978. Site F, which represents a former wastewater lagoon and overflow area, was used between approximately 1960 and 1970 for the disposal of wastewater produced during the demilitarization of ordnance items in the adjacent Segregation Facility building. The Segregation Facility consisted of three primary segregation plants and several other smaller buildings. Figure 2 shows the historical features at the site including the location of the former wastewater lagoon and overflow channel.

Between approximately 1957 and 1978, the segregation facility's primary functions included the demil of Mk 6 and Mk 25 rocket warheads, Mk 6, Mk 8, and Mk 9 mines and depth charges, and 5-inch projectiles. These ordnance items contained primarily trinitrotoluene (TNT), Composition A, Composition B, and Amatol. Residues of TNT, hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and picric acid were identified within the building prior to its decontamination in 1980-81. Demiling activities reached a peak during 1966 to 1970 as a result of the Vietnam conflict.

The procedures used for the demiling of ordnance items included preliminary cutting or boring of large items using a mechanical tool, followed by steam cleaning; other items were demiled entirely through a steam melt-out process. During the steam-out process, steam was directed into the ordnance, and the resulting condensate and solid explosive were collected within a holding tank. Discharge from the holding tank was then directed into skimming and settling chambers, which removed much of the solid materials from the wastewater before final discharge.

Prior to 1972, the final wastewater solution was discharged through a drain line directly into the former wastewater lagoon. Beginning in 1972-73, wastewater was collected into 55-gallon barrels and delivered to the SUBASE, Bangor liquid-waste incinerator.

The quantity of ordnance demiled within the Segregation Facility is not well documented. Estimates range from as low as 500 pounds to up to 500,000 pounds, although a value well toward the lower estimate seems most plausible based on disposal records and interviews conducted with former workers.

Reportedly, ordnance recovered within the Demil Facility was flaked, boxed, and sent to magazines for future disposition. Some of these materials were apparently sold back to manufacturers such as DuPont, Atlas Powder, and Pacific Powder. The quantity of this "recycled" ordnance is not well documented. Ordnance not recycled was taken either to an ordnance burning area (Site A) located to the north on SUBASE, Bangor or off base for thermal destruction (such as Yakima, Washington, and Hawthorne, Nevada).

As stated above, during the period from 1960 to 1971, wastewater from the Demil Facility was directed to an infiltration and evaporation lagoon and overflow area. Periodically, the lagoon was allowed to drain. Waste materials present in surficial sediments of the lagoon were reportedly "burned-off" in place with waste oil during the 1960s, or transported to Site A for burning and disposal.

In February 1972, 500 cubic feet of soils were excavated from the top several feet of the former lagoon area and delivered to Site A for burning. In an effort to further reduce potential waste constituent transport from Site F, in 1980 the former lagoon area was filled in and covered with asphalt.

Also in 1980, demil operations at the Bangor Segregation Facility were transferred to the Indian Island Annex. The buildings were subsequently decontaminated and converted to storage.

A considerable number of on-site investigations of the distribution and transport of waste constituents at Site F have occurred since 1971. One of the conclusions reached during the earlier studies was that at least 4,300 kg of TNT and 140 kg of RDX were present, in 1974, within soils directly below the former disposal area.

In 1978, the Navy began an Assessment and Control of Installation Pollutants (ACIP) program to evaluate waste disposal sites at SUBASE Bangor, including Site F. Work at Site F continued in 1981 as part of an Initial Assessment Study (IAS) and in 1986 as part of a Characterization Study, both under the Navy Assessment and Control of Installation Pollutants (NACIP) program. In the latter year, Congress enacted the Superfund Amendments and Reauthorization Act (SARA) which required federal facilities to comply with the EPA's procedures at inactive waste sites. As a result, the Navy suspended further NACIP program activities and phased into the EPA Remedial Investigation/Feasibility Study (RI/FS) program.

On July 14, 1989, the EPA proposed SUBASE Bangor, including Site F, for listing on the National Priorities List (NPL) of Hazardous Waste Sites. On August 30, 1990, SUBASE Bangor was officially listed on the NPL. The RI/FS investigation at Site F is currently ongoing.

4.0 COMMUNITY RELATIONS

The overall Navy Community Relations Plan for the NPL sites at SUBASE, Bangor is presented in the Site F Management Plan, available for review in the information repositories. The specific requirements for public participation pursuant to CERCLA section 117(a), as amended by SARA, include releasing the Proposed Plan to the public. This was done in February 1991. The Proposed Plan was placed in the administrative record and information repositories. Attachment B presents the Administrative Record Index.

The information repositories are located at Kitsap regional libraries:

Bangor Branch (206) 779-9724
Naval Submarine Base Bangor
Silverdale, Washington 98315-5000

Main Branch (206) 377-7601
1301 Sylvan Way
Bremerton, Washington 98310

The Administrative Record is on file at:

Engineering Field Activity, Northwest
Naval Facilities Engineering Command
3505 N.W. Anderson Hill Road
Silverdale, Washington 98383-9130
(206) 476-5775

Notice of the availability of the proposed plan, plus notice of a public meeting on the proposed plan and public comment period was published in the Silverdale Reporter (February 20, 1991) and the Bremerton Sun (February 18, 1991). A public comment period was held from February 18, 1991, to March 20, 1991. A public meeting was held on February 28, 1991, with presentations given by the Navy, EPA, and Ecology. A total of 51 people attended the public meeting.

A total of seventeen comments were received by the Navy concerning the Proposed Plan. Twelve written comments were submitted and discussed at the public meeting. In addition, five comment letters were submitted to the Navy during the comment period. The public comments are summarized and responses presented in the Responsiveness Summary (Attachment A) portion of this document.

Community relations activities have established communication between the citizens living near the site, the Navy, and EPA. Discussion between the different groups for information purposes and suggestions on the project has been open. The actions taken to satisfy the requirements of the federal law have also provided a forum for citizen involvement and input to the interim remedial action decision.

The community relations activities at the site include the following:

- Technical Review Committee (TRC) meetings with representatives from surrounding communities;

- Issuance of one fact sheet for the Site F RI/FS. Additional fact sheets will be issued to provide updates on the work being performed and major findings at Site F and the other operable units;

- Coordination with other citizens groups which may form in response to site investigations of concern to the community; and

- Future public meetings to present information related to the Site F RI/FS.

5.0 SCOPE AND ROLE OF OPERABLE UNITS

Site F (Operable Unit 2) is one of seven operable units comprising 21 known and/or suspected hazardous waste sites located at SUBASE Bangor. Site F is geographically separate from the other operable units that comprise the Bangor NPL Site.

The Interim Remedial Action is a measure to prevent the spread of ordnance constituents, reduce the potential risk of impact to existing and future groundwater users located downgradient from the site, and initiate a strategy expected to be consistent with the final remedy. This action is limited to addressing groundwater contamination, whereas the final remedy will consider both groundwater and soil cleanup. The proposed interim action which includes groundwater extraction to contain the contaminants in the aquifer, groundwater treatment, and disposal will likely become a major component of the final remediation at the site.

6.0 SUMMARY OF SITE CHARACTERISTICS

This section presents a summary of site conditions including a discussion of the hydrogeologic characteristics and site waste constituents. The principal exposure pathway of concern to human health and the environment is the transport of site contaminants in the groundwater beneath the site. Contaminated soils do exist on site. However, the majority of these soils are capped with asphalt, thereby reducing the potential for exposure.

There are no critical habitat areas (including those of threatened or endangered species), wetlands, floodplains, or historical preservation sites in the area covered or affected by the interim action. Accordingly, there are no identified environmental concerns as defined under the National Environmental Protection Act (NEPA), associated with the operable unit or the area affected by the interim action at Site F.

Data being collected during the ongoing Site F Remedial Investigation will be used to refine and update our understanding of site conditions. Nevertheless, sufficient information is currently available to undertake this interim remedial action. Additional data, as available, will be incorporated into the existing database for the interim action design.

6.1 Site Hydrogeologic Conditions

There are three hydrogeologic units that have significance for the Interim Remedial Action at Site F. The units are:

- Vashon Till (Qvt);
- Shallow Aquifer (Vashon Advance Outwash, which is subdivided into two members: Qva_1 and Qva_2); and
- Vashon Proglacial Aquitard (Qvp).

Subsurface explorations at Site F and other locations on SUBASE Bangor indicate that this vertical sequence of units is regionally consistent.

Regionally, the Sea Level Aquifer and deeper aquifers underlie the Vashon Proglacial Aquitard. These aquifers provide the principal water supply for SUBASE Bangor and surrounding communities. However, available data indicate that only the Shallow Aquifer has been impacted by Site F, i.e., no contaminants associated with Site F have been detected in the Sea Level Aquifer or in deeper aquifers. These data and data from the on-going RI/FS indicate that the Vashon Proglacial Aquitard is both continuous across the site area and competent enough to impede the downward migration of groundwater through it.

Figure 3 shows the location of monitoring wells located at Site F which were used to assess geologic conditions beneath the site (during drilling) and provide an effective monitoring network to assess groundwater quality. The hydrogeologic units beneath Site F are illustrated on Figure 4, which is oriented east to west (cross section location is shown on Figure 3). Each of the three hydrogeologic units is described below.

Vashon Till (Qvt). The Vashon Till consists of a dense, unsorted gravelly, silty sand. The till forms a low permeability veneer over the site which limits the rate of infiltration to the underlying Shallow Aquifer. The thickness of the till ranges from approximately 25 to 45 feet across the site area. In the immediate area of the former wastewater lagoon, the till is approximately 25 feet thick.

Lenses of silt and sand also occur within the till, but they are laterally and vertically discontinuous. Although the isolated sand lenses become seasonally saturated, they do not constitute a perched aquifer system because of their lack of interconnection.

Shallow Aquifer (Qva_2). The Shallow Aquifer is an unconfined (water table) aquifer occurring within a thick sequence of Vashon Advance Outwash sand, which directly underlies the Vashon Till. Depth to water in the Shallow Aquifer ranges from approximately 50 feet near the former wastewater lagoon to more than 150 feet in topographically higher areas to the west. Locally, the aquifer is extensive, with a saturated thickness ranging from 60 to 100 feet.

The advance outwash deposits comprising the aquifer become finer grained with depth, grading from gravelly, coarse to medium sand downward into very silty, fine sand. The lower very silty portion of the outwash (Qva_1) is differentiated from the rest of the outwash (Qva_2) because of its unique fine-grained nature. Field observations during drilling and confirmatory grain size analyses suggest that the Qva_1 does not readily transmit water, and therefore effectively forms the bottom of the Shallow Aquifer. The Shallow Aquifer is exceptionally uniform across the area, and is highly permeable, with an average horizontal hydraulic conductivity estimated from pumping test and slug test data on the order of 10^{-2} cm/sec.

The Shallow Aquifer water table slopes gently toward the west-northwest, with a horizontal gradient of approximately 0.003 (3 foot drop for 1,000 feet horizontally). Accordingly, the groundwater flow is generally in a northwesterly direction, as shown on Figure 5. The average linear groundwater flow rate is approximately 120 to 140 feet per year.

Vertical hydraulic gradients also exist within the Shallow Aquifer, which appear to affect constituent migration within the aquifer. Downward gradients occur near the former lagoon area, resulting in a downward migration of waste constituents from the source area. The vertical gradient reverses to an upward direction in the area of monitoring wells F-MW25, F-MW18, and F-MW36, and becomes downward again at the location of F-MW41 (see Figure 3 for well locations). The vertical gradients appear to change as the groundwater flows up and over a ridge in the underlying silt aquitard, as discussed below (see Figure 4).

The Shallow Aquifer receives recharge from precipitation and discharges in the direction of flow (northwest) to on-base springs which feed tributaries flowing to Hood Canal, and possibly directly to Hood Canal. There are no on-base water supply wells completed in the Shallow Aquifer; however, such wells exist in the surrounding communities. The nearest water supply wells located toward Hood Canal (west of the site) and screened within the Shallow Aquifer are located off base approximately 6,000 feet west within the community of Olympic View, and approximately 10,000 feet west-northwest in the Town of Bangor.

Water quality data collected from on-site monitoring wells indicate that RDX has been transported in the Shallow Aquifer up to 3,000 feet to the northwest of the former disposal lagoon. RDX is the most mobile in groundwater of the ordnance constituents identified at the site. The extent of RDX contamination in the aquifer can be used to define the maximum extent of ordnance contamination. Consequently, RDX is being used as an indicator parameter to define the interim action groundwater containment boundary since it has migrated the furthest from the former disposal lagoon.

Figure 6 shows a contour map of RDX concentrations in the Shallow Aquifer. The extent of RDX at the 500 micrograms per liter (μg/L) and 80 μg/L concentrations are depicted. This figure also shows the distribution of TNT in the aquifer. Compared with RDX, TNT is less mobile in groundwater and moves at a slower rate through the aquifer. The distribution of TNT concentrations in the groundwater indicates that it has not migrated far from the source area. Detectable concentrations of TNT are contained within the 80 μg/L RDX boundary. This condition is also representative of other ordnance constituents such as dinitrotoluenes and nitrobenzene.

Contaminated groundwater occurs principally near the water table at the source area and moves deeper into the aquifer as it moves downgradient. No waste constituents have been detected east of the site.

Vashon Proglacial Aquitard (Qvp). The Vashon Proglacial Aquitard is a thick low permeability unit which separates the Shallow Aquifer from deeper aquifer systems in the area. In the Site F area the aquitard is approximately 60 to 80 feet thick based on geologic data from existing SUBASE, Bangor monitoring wells, and consists of clayey silt with occasional interbedded silty sand and gravel layers. The geometric mean of 7 laboratory measurements of vertical hydraulic conductivity of the aquitard material is approximately 10^{-7} cm/sec, which is approximately 100,000 times lower than the overlying Shallow Aquifer.

6.2 Site Waste Constituents

6.2.1 Soils

Soil quality data were collected during well drilling activities by the USGS in 1974, SUBASE, Bangor in 1981, and Hart Crowser in 1990. Approximately fifty percent of the soil samples were collected within the former wastewater lagoon area and overflow channel, with the remainder collected from downgradient locations away from the lagoon. No surficial soil samples were collected from the original lagoon area. However, surficial soils of the lagoon were removed off site in 1972 and replaced with clean fill. Because of the presence of fill materials and the asphalt cover which overlies the former lagoon, potential direct contact with such soils is presently minimal.

The constituents analyzed in the soil samplings prior to the Hart Crowser sampling in 1990 were largely limited to TNT and RDX. All but one of the soil samples collected within the disposal area contained detectable levels of TNT and RDX. Conversely, only two soil samples collected outside the lagoon and overflow ditch area exhibited detectable ordnance concentrations. Furthermore, these two detections were from samples collected at the water table, suggesting that the presence of the ordnance was likely due to groundwater transport.

Based on more recent data collected by Hart Crowser, RDX and TNT are confirmed as the primary ordnance constituents identified in soils in the disposal area. The other ordnance constituents detected at lower concentrations in the disposal area soils include 1,3,5-trinitrobenzene (TNB), 1,3-dinitrobenzene (DNB), 2,4- and 2,6- dinitrotoluene (DNT), nitrobenzene, picric and picramic acid, and tetryl. Low levels of various metals were also detected in the soils.

The waste constituents disposed of at Site F were found to be transported through the soil matrix with infiltration into the underlying water table. Termination of discharge and capping of the disposal area in 1980 likely limited water infiltration below the lagoon and reduced further leaching.

6.2.2 Groundwater

Groundwater quality data have been collected at Site F during prior studies beginning in 1974, during development of the Current Situation Report in 1986/1987, and as part of the ongoing RI/FS. Groundwater samples have been collected from approximately 35 on-site wells completed in the Shallow Aquifer. The database includes groundwater sampling data collected by the USGS, SUBASE, Bangor, and most recently Hart Crowser.

The lateral and vertical distributions of site waste constituents within the Shallow Aquifer are fairly well known. The ordnance waste constituents detected have included TNT, RDX, DNT, TNB, and nitrobenzene. Nitrate and low levels of various metals and organic chemicals were also detected. A summary of the maximum concentrations detected in groundwater at Site F is presented in Table 1.

Based on the Table 1 summary, the ordnance constituents detected at the highest concentrations in the Shallow Aquifer were RDX and TNT. As discussed previously, RDX is more mobile than TNT and the other ordnance constituents, and has migrated the furthest downgradient from the disposal area. Based on existing data, the bulk of the TNT in the groundwater has not migrated far from the former wastewater lagoon area.

In an effort to examine the possibility of existing impacts to water supply wells completed in the Shallow Aquifer within downgradient communities from Site F, SUBASE (in conjunction with the Kitsap County Health District) conducted an annual monitoring program of selected off-site water supply wells from 1984 to 1987. The sampling sites included twelve (12) off-base domestic supplies east and west of Site F, which obtained water from both the Shallow and Sea Level Aquifers. Eight SUBASE Bangor water supply wells completed within the Sea Level Aquifer or deeper aquifers have also been monitored.

No ordnance-related constituents were detected in any of the off-site water samples collected during this monitoring program.

The contaminated groundwater at Site F is not regulated under the Resource Conservation and Recovery Act (RCRA) as a RCRA waste since this does not involve a listed process nor does the contaminated groundwater represent a characteristic hazardous waste.

7.0 SUMMARY OF SITE RISKS

Elevated levels of ordnance constituents are present in the soils around the former wastewater lagoon and in the groundwater beneath the site. Remedial measures which included paving the site have reduced further migration of ordnance to the groundwater from the former lagoon. The paving also has minimized the potential health risk associated with direct contact and potential dust emission exposures to contaminated soil.

Ordnance constituents are also present in the groundwater beneath the site and are migrating in a northwesterly direction away from the former wastewater lagoon area. The continued transport of ordnance in groundwater, with its associated potential for impacts to future drinking water supplies downgradient of Site F, poses the most significant health risk at the site. The proposed interim action is designed to reduce the potential for future groundwater exposures to site contaminants by minimizing further migration.

A quantitative health risk assessment for Site F will be conducted as part of the RI/FS, but has not been completed. However, a recent (1991) Superfund Directive clarifying the use of "default" risk assessment methodologies was used as a basis for calculating the risk threshold at this site. The risk levels derived from this directive are presented in Table 1 for individual contaminants detected at Site F, and are based on the assumption of (future) drinking water use of the aquifer. Cleanup is generally warranted under Superfund whenever site concentrations exceed these threshold action levels. More stringent cleanup requirements may be determined as a result of the final RI/FS, though these evaluations are not yet available.

The waste constituents detected in the Shallow Aquifer at concentrations above the calculated risk levels include RDX, TNT, DNT, TNB, DNB, nitrobenzene, nitrate, and mercury (Table 1). The highest concentrations of all of these chemicals have consistently been observed at locations immediately adjacent to the former wastewater lagoon area. As discussed above, concentrations of most waste constituents in the groundwater decrease rapidly with increasing distance from the former lagoon. Recent (screening-level) results of groundwater sampling at the site suggest that only RDX is present at detectable levels more than 3,000 feet from the lagoon. However, the concentration of RDX at this distance was below the calculated risk level. Additional data is being collected to more precisely determine the extent of RDX contamination in the Shallow Aquifer.

The degree and extent of aquifer contamination provides the basis for the interim remedial action. The goal of the interim action is to prevent the spread of the contamination in a manner which will be consistent with the yet to be determined final remedy.

The clean-up goals for the disposal of the treated groundwater which apply to those alternatives involving groundwater extraction and treatment are, in this case, different from the threshold action levels presented in Table 1. Treatment standards are based on applicable or relevant and appropriate requirements (ARARs). Because this is an interim action, chemical specific ARARs are applicable only as they relate to the disposal of the treated groundwater.

8.0 DESCRIPTION OF ALTERNATIVES

Four alternatives were evaluated as possible interim remedial actions at Site F.

8.1 Alternative 1: No Action

Under the no action alternative, ordnance compounds present in the groundwater will continue to migrate until a final remedy is selected, designed, and implemented. The schedule for the Site F RI/FS, as specified in the Federal Facilities Agreement, SUBASE Bangor, dated January 29, 1990, includes submittal of the draft RI/FS by July 1992 and the final RI/FS by December 1992.

Evaluation of alternatives for the final remedy (Proposed Plan) and selection of the final remedy (Record of Decision) is scheduled to occur by September 1993. Consequently, the final remedy may not be implemented until late 1994 or early 1995 depending on the final remedy selected and the time period required for design. The no action alternative will therefore result in additional migration of the groundwater contamination and possibly lead to a higher cost of the final remedy.

There is no time constraint associated with this alternative. The no action alternative could be implemented immediately upon finalization and adoption of a Record of Decision.

8.2 Alternative 2: Contaminant Migration Containment by Groundwater Extraction and Treatment by Ultraviolet/Oxidation

This alternative involves extracting groundwater from the contaminated aquifer, treating it by ultraviolet light and oxidation (UV/oxidation) to meet water quality criteria necessary for disposal, and disposal of the treated water back into the aquifer. Groundwater from the Shallow Aquifer would be pumped from an extraction well network designed to capture the groundwater with an RDX concentration greater than or equal to 80 ppb. A pumping rate of 150 to 200 gallons per minute (gpm) is expected to be sufficient to prevent further contaminant migration and thereby contain the groundwater contamination.

The pumped water would be treated in an above-ground ultraviolet (UV) light and oxidation treatment system which will break apart the complex ordnance chemicals and convert them into components such as carbon dioxide, water, and nitrate. This breakdown is accomplished by exposing the contaminants to a combination of ultraviolet light and a chemical oxidant such as hydrogen peroxide in a controlled chamber.

The UV/oxidation system is an innovative technology which has been used successfully in pilot-scale and small field-scale applications to treat ordnance-contaminated wastewater. Although relatively minor quantities of ordnance by-products can be formed under some UV/oxidation treatment conditions (e.g., formic acid), the treatment system can generally be optimized to prevent the formation of potential toxicants. The application at Site F will require treatment of very low levels of ordnance at a relatively high flow rate. Existing case studies were conducted at lower flow rates than those anticipated at Site F, and the treatment criteria in these case studies were not as stringent as that required for Site F.

Because UV/oxidation is an innovative technology, additional laboratory and pilot scale studies are necessary to tailor the technology to a particular site groundwater. Treatability studies using UV/oxidation are currently being performed to verify that the treatment system is effective in removing all potential constituents in Site F groundwaters. The available information suggests that a UV/oxidation system can be designed which will achieve the required treatment levels for groundwater disposal. No air emissions are anticipated under this alternative.

If the groundwater treatment criteria are not achieved with the UV/oxidation system due to either technological or economic reasons, then additional treatment technologies (polishing treatment) will be incorporated into the treatment design to achieve the treatment criteria.

The treated groundwater will be disposed of back into Shallow Aquifer on base by groundwater injection into wells or by infiltration using a recharge basin. The injector wells or recharge basin would be located outside the identified zone of aquifer contamination. The groundwater disposal will likely be located upgradient of the site to hydraulically enhance containment, if practicable, and will not impact the effectiveness of this interim action.

This alternative can be commenced within a 15-month period after Record of Decision signature predicated on completion and findings of the treatability study.

8.3 Alternative 3: Contaminant Migration Containment by Groundwater Extraction and Treatment by Carbon Adsorption

This alternative includes the same procedure of groundwater extraction and disposal after treatment as Alternative 2. However, the water treatment process is different and involves the filtering of the contaminated groundwater through a carbon filter. This process involves removal of the contaminants by adsorption and concentration on granular activated carbon. Carbon treatment is a proven, conventional technology which can attain all cleanup criteria. This alternative will generate spent carbon waste requiring transport and off-site disposal by incineration. Although no air emissions are anticipated under this alternative, off-site releases can occur during final incineration and treatment of the spent carbon.

This alternative can be commenced within a 15-month period after Record of Decision signature.

8.4 Alternative 4: Upgradient Subsurface Barrier to Divert Regional Groundwater Flow around the Contamination

This alternative involves controlling further migration of ordnance compounds by installing a barrier to divert the groundwater flow around the contaminated groundwater. A subsurface barrier would be constructed across a portion of the Shallow Aquifer to restrict incoming groundwater. This alternative does not include groundwater treatment, but prevents additional groundwater from becoming contaminated.

This alternative may take longer to commence than a 15-month period after Record of Decision signature due to an anticipated lengthy design phase.

9.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

The four cleanup alternatives were evaluated based on the nine criteria established by EPA guidelines. The no action alternative was included as a baseline comparison. The following section evaluates the alternatives by the nine applicable criteria.

9.1 Protection of Human Health and the Environment

Based on the preliminary findings, groundwater contamination by ordnance at Site F appears to be restricted to the Shallow Aquifer which is not presently used for on-base drinking supply. However, future risks to possible downgradient groundwater users may occur if groundwater contaminants continued to migrate off site. For this reason, protection of human health and the environment was assessed relative to the ability of the interim action alternative to contain contaminated groundwater.

Alternatives 2 and 3 are protective of human health and the environment. Both prevent further migration of ordnance constituents in groundwater and are protective of future groundwater uses. Alternative 2, however, also provides final on-site treatment of ordnance compounds, whereas Alternative 3 involves final off-site treatment or disposal of spent carbon. Alternative 4 (subsurface barrier) would also effect a control on the further spread of contaminant. Under Alternative 1 (no action) the migration and spread of the groundwater contamination would continue until the final remedy is implemented.

With each of the alternatives, except no action, there is some measure of uncertainty in terms of effectiveness. The effectiveness of the groundwater extraction and disposal components of Alternatives 2 and 3 can be fairly well controlled and monitored during operation. The uncertainty in the laboratory analysis of RDX concentrations does effect the accuracy of the boundary of containment. The uncertainty in the effectiveness of the UV/oxidation system with any necessary polishing treatment and activated carbon system should be controlled through regular treatment effluent monitoring. Alternative 4 has the highest level of uncertainty related to the ability to construct an effective barrier to prevent further groundwater flow.

9.2 Compliance with ARARs

The purpose of the Interim Remedial Action is to contain or isolate contaminated groundwater in the Shallow Aquifer so as to minimize further migration of contaminants from the site until the final remedy if implemented. This interim action is neither intended to restore the aquifer to drinking water conditions nor to attain all federal and state applicable or relevant and appropriate requirements (ARARs) relating to cleanup of the aquifer. The Navy, EPA, and Ecology expect that such ARARs will be met by the final remedy to be selected for the site.

The ARARs for this interim remedy relate to the disposal of groundwater that is extracted and treated during implementation of the interim remedial action. Alternatives 2 and 3 include discharge of treated groundwater back into the aquifer that currently supplies a portion of the water supplies in the communities of Olympic View and Old Bangor.

If the treated groundwater is returned to the aquifer, the groundwater cleanup standards established under the Model Toxics Control Act, WAC 173-340-720, are relevant and appropriate chemical-specific treatment standards for water to be discharged. Requirements of the State Underground Injection Control Program, WAC 173-218, are applicable action-specific ARARs for the design of the injection wells.

The substantive provisions of Sec. 402 of the Federal Clean Water Act, as codified in 40 CFR 122, will be applicable treatment standards for the effluent discharging into surface waters.

The treatment technology for the extracted groundwater under Alternatives 2 and 3 will meet these ARARs. There are not ARARs identified for Alternatives 1 and 4 since no treatment is involved.

9.3 Reduction of Toxicity, Mobility, or Volume by Treatment

Alternatives 2 and 3 both reduce mobility by removing and treating groundwater contaminants. Alternatives 2 and 3 differ in the method used to reduce the toxicity and volume of contaminants. Alternative 2 (UV/oxidation treatment) would provide final treatment and thus primary reduction in toxicity and volume of contaminants. Alternative 3 (carbon adsorption treatment) would provide removal of contaminants from the groundwater to the carbon, thus effecting a reduction in toxicity and volume of contaminants in the groundwater. The carbon would then require final off-site treatment by incineration. Alternative 4 would reduce the further spreading of contaminants (mobility) and thereby reduce the volume of groundwater needing treatment under the final remedy, but it would not reduce the toxicity. Alternative 4 does not include a treatment process. The no action alternative does not achieve any of these goals.

9.4 Short-Term Effectiveness

Alternatives 2 and 3 can be implemented within a 15-month period after Record of Decision signature; however, the implementation schedule for alternative 2 is predicated on the UV/oxidation treatability study. Groundwater containment can be effected within a short period of time following initiation of pumping. The construction required during implementation of Alternatives 2 and 3 should only cause minor disturbance at the site which will not increase the current site risk to workers or the surrounding communities nor result in adverse impact to the environment. No impact to surrounding communities is anticipated due to noise during construction given the large distance (approximately 1.5 miles) to the nearest off-base community and the nature of the construction involved in implementing either of these alternatives.

Alternative 4 would require a long construction period to implement and consequently would not be effective in the short-term. This alternative is not a treatment process. Impacts due to noise from construction are anticipated in the vicinity of the site but not to surrounding communities given the distance.

9.5 Long-Term Effectiveness and Permanence

This criteria does not apply to interim actions and consequently was not a major consideration in the selection of the remedy.

Although implemented under an Interim Remedial Action, Alternatives 2 and 3 would permanently decrease the mobility, toxicity, and volume of groundwater contamination. Alternative 2 would provide permanent on-site treatment of groundwater contaminants.

The final groundwater remedy for the site may require groundwater cleanup to levels below the interim action groundwater containment level under alternatives 2 and 3. The interim action containment level however does encompass the bulk of the mass of contamination. The residual risk associated with the groundwaters with RDX concentrations below 80 $\mu g/L$ is low, given the distance from current drinking water receptors and the travel time of the contaminants.

Alternatives 2 and 3 include disposal of the treated groundwater back into the aquifer. However, the groundwater will be treated to meet ARARs and the residual risk of the re-injected water will be less than the most restrictive risk threshold of 10^{-6} established under the NCP. The effectiveness of the treatment will be monitored during operation to minimize the potential for disposal of water out of compliance with treatment criteria.

Alternative 4 will require a major construction phase to install the subsurface barrier prior to controlling further contaminant migration and its effectiveness is highly dependent upon knowing the site conditions, which are still under study, and the quality of construction. The effectiveness of Alternative 4 would be limited by leakage, especially at the bottom of the barrier.

9.6 Implementability

Alternatives 2 and 3 could be implemented from a technical standpoint without difficulty following further analysis to determine the optimum placement and operation of groundwater extraction wells. One extraction well is currently in place. The system can also be expanded and utilized as part of the final remedy for the site, if selected.

Groundwater treatment and disposal are required for Alternatives 2 and 3. Of the two treatment options, UV/oxidation (Alternative 2) is the most implementable since treatment by activated carbon is presently limited by the facilities which handle disposal of the spent carbon. The water disposal will involve injection into the aquifer by wells or infiltration. Injection wells are easier to construct and implement than an infiltration basin at the site.

Alternative 4 would be difficult to implement because it would require a subsurface barrier to be constructed at an unusually great depth (to 150 feet below ground surface). Therefore, it would require a detailed engineering analysis to design the subsurface barrier prior to implementation.

9.7 Cost

Alternative 1 is the least expensive alternative in the short term but is more costly in the long term, since groundwater contamination will continue to spread over a larger area, which will likely require treatment by the final remedy. Alternatives 2 and 3 have approximately the same estimated present worth costs of $2,500,000. The UV/oxidation system (Alterative 2) is anticipated to have a higher capital cost but lower operations and maintenance (O&M) costs. Carbon adsorption has lower capital cost but requires incineration of the spent carbon. Alternative 4 ($8,000,000) is the most expensive, particularly if the long-term costs of ultimately treating residual groundwater remaining on the site are considered.

Tables 3, 4, and 5 present the basis of comparative cost estimates for interim remedial action alternatives. These costs were based on 1991 dollar figures. A discount rate was not applied since the estimated duration for the interim action is only 2 years. The cost estimates provide an accuracy of +50 percent to -30 percent in accordance with EPA guidelines.

9.8 State Acceptance

The State concurs with the selected interim remedial action at Site F and comments received from Ecology have been incorporated into this Record of Decision.

9.9 Community Acceptance

Based on comments received during the public review period and at the public meeting, the public generally accepts the proposed plan as described in the attached Responsiveness Summary. The major issue raised by the public was the impact of groundwater extraction on groundwater supplies from a quantity standpoint. The disposal option preferred by the public was placement of the treated water back into the Shallow Aquifer. This method of disposal was selected based on public preference, implementability, and cost.

10.0 THE SELECTED REMEDY

The selected interim remedial action for this site is **Alternative 2: Contaminant Migration Containment by Groundwater Extraction and Treatment by Ultraviolet/ Oxidation.** This alternative is preferred because it best achieves the goals of the evaluation criteria in comparison to the other alternatives. This alternative was selected over Alternative 3, which differs only in the treatment method, because it employs an innovative technology and provides on-site treatment with permanent reduction in the toxicity and volume of the groundwater contaminant.

The elements of the preferred interim remedial action alternative include:

- Extracting groundwater from the Shallow Aquifer to minimize further migration of ordnance constituents;

- Treating the extracted groundwater by Ultraviolet/Oxidation process below federal and state groundwater quality standards;

- Disposing of the treated groundwater back into the Shallow Aquifer on base by groundwater injection into wells or by infiltration using a recharge basin. The injection wells or recharge basin would be located outside the identified zone of aquifer contamination and will likely be located upgradient of the site to hydraulically enhance containment; and

- Monitoring of the effectiveness of the interim remedial action (groundwater containment and treatment) and provide design information,as applicable, for the final remedy;

The components of the selected interim remedial action are discussed in more detail below.

10.1 Feasibility of Groundwater Extraction

A groundwater flow model was used to evaluate groundwater extraction rates and the effectiveness of the extraction system for containing groundwater with RDX concentrations greater than or equal to 80 μg/L. The model used was Flowpath, which is a two-dimensional, steady state finite difference groundwater flow model. The model was used to simulate the capture zone (the portion of the aquifer contributing flow to the extraction system) based on site-specific hydrogeologic data collected during the on-going RI/FS for Site F. The assumed hydrogeologic parameters used for the modeling were:

- Unconfined (water table) aquifer conditions;
- Hydraulic conductivity of 10^{-2} cm/sec, based on average values obtained from *in situ* hydraulic conductivity testing and grain size analyses;
- Horizontal hydraulic gradient of 0.003, based on water table contour maps produced from monthly data; and
- Effective porosity of 0.25, taken from literature values for medium sand.

A variable elevation for the bottom of the aquifer (i.e., top of the underlying aquitard) was input to the model, based on a contour map of the aquitard surface produced from the RI/FS drilling data.

Model Results. The groundwater modeling results indicate that extraction of groundwater from the Shallow Aquifer is feasible. The results indicate that an extraction system pumping a total of 150 to 200 gpm will contain all groundwater with RDX concentrations at or above 80 μg/L. Figure 6 shows the distribution of RDX in the Shallow Aquifer including the 80 μg/L contour which encompasses the groundwater having a concentration at or above 80 μg/L. The concentration contours of TNT are also shown on Figure 6. The TNT distribution is representative of the other ordnance constituents in terms of relative mobility in the groundwater. The RDX containment zone of 80 μg/L encompasses the TNT and the other ordnance constituents. The model indicates that three wells pumping at variable rates totaling approximately 175 gpm will affect the necessary containment, which is generally consistent with results obtained previously from a different groundwater model (RESSQ).

Figure 7 presents the RDX concentration contour map and estimated groundwater capture zone induced by extraction well pumping.

The model results (i.e., number of wells and pumping rates) presented herein are preliminary and do not represent final design for an extraction system. Additional hydrogeologic data will be collected and more detailed groundwater flow analysis performed during the ongoing RI/FS. Additional field data include results of aquifer pumping tests which included extensive monitoring of response in wells completed in varying zones of the aquifer. Further analysis will include development of a more detailed predictive model of the groundwater flow system which will be used to assess contaminant movement and groundwater flow conditions under varying extraction and injection scenarios. These data together with the additional groundwater quality data collected at the site will be integrated with existing data to optimize a groundwater extraction system during the design phase of the Interim Remedial Action.

The interim action design will also be based on the findings of a currently on-going ordnance treatability study. This study is designed to verify the effectiveness of using

UV/oxidation system to treat low-level contamination of groundwater by ordnance compounds and to tailor a treatment system for use at Site F. The study includes both laboratory-scale and field-scale components.

10.2 Containment Level of RDX in Groundwater

This interim action is designed to minimize further migration of groundwater contamination. Since this interim action should also be consistent with the final remedy to be selected for the site, the containment level needs to consider minimum (threshold) action levels as outlined in applicable Superfund Directives (Table 1).

The containment level is the concentration of RDX in groundwater which will be prevented from further migration. It does not represent an ARAR. Considering the range of potential risk goals addressed under the state and federal programs (e.g., 10^{-4} to 10^{-6} potential lifetime cancer risks due to drinking water consumption), the corresponding cleanup standards for RDX in groundwater range from 80 μg/L to 0.8 μg/L. The containment level based on a risk of 10^{-4}, calculated in accordance with OSWER Directive 9285.6-03, is approximately 80 μg/L (Table 1).

It is important to note that the calculated risk level for RDX has changed during the course of interim remedial action development, from 30 μg/L to 80 μg/L. The containment level for RDX of 30 μg/L was in effect at the time of issuance of the final Proposed Plan for Interim Remedial Action and the comment period which occurred in February 1991. The RDX containment level was based on Region 10 exposure factors which were contained in the EPA Region 10 Statement of Work for RI/FS Risk Assessment. The revised RDX containment level of 80 μg/L is based on exposure factors adopted by EPA Region 10 consistent with the OSWER Directive 9285.6-03.

Since containment at the 80 μg/L (upper-bound) level would address most of the mass and risk associated with all chemical releases from Site F, a lower containment value was not considered appropriate for an interim action. The 80 μg/L meets the 10^{-4} risk goal and also would not preclude the development of other cleanup remedies for any future remedial action to be taken at the site.

Because this is an interim action, chemical specific ARARs are only invoked as they relate to the disposal of the extracted groundwater after treatment. Consequently all groundwater extracted during this Interim Remedial Action will be treated to a cleanup level which complies with these ARARs. The water treatment levels (ARARs) are presented in Table 2.

10.3 Effectiveness of Treatment Technology

Ultraviolet/Oxidation (UV/Oxidation) is the proposed treatment technology for treatment of the ordnance contaminated groundwater at Site F. It is an innovative technology which has been shown to be successful in treating complex organic compounds including ordnance compounds (e.g., RDX and TNT).

Combined use of UV with strong oxidants such as ozone and hydrogen peroxide has developed into a successful technology for treating refractory organics in industrial wastewater. UV-catalyzed oxidation, or UV/oxidation has also been applied to treatment of groundwater contaminants including ordnance compounds.

The basis of enhanced oxidation is the use of UV light and an oxidant source such as ozone or hydrogen peroxide to generate the hydroxyl radical. This hydroxyl radical will aggressively attack and breakdown complex organic compounds (such as ordnance) by initiating a series of oxidative reactions and converts them into components such as carbon dioxide, water, and nitrate. Although relatively minor quantities of ordnance by-products can be formed under some UV/oxidation treatment conditions (e.g., formic acid), the treatment system can generally be optimized to prevent the formation of potential toxicants.

The technology has been shown to be effective on munitions; however, the application at Site F may require treatment of very low levels of ordnance at a relatively high flow rate. Existing case studies identified were conducted at lower flow rates than those anticipated at Site F, in addition the level of treatment was not as stringent as that planned for Site F. A treatability study is currently on-going to verify that the treatment system is effective in meeting the low-level treatment and high flow rate requirements of this interim action at Site F.

If the UV/oxidation process cannot achieve treatment levels down to the desired criteria due to either technological or economic reasons then an on-site polishing (e.g., activated carbon) treatment will be coupled with the UV/oxidation system to complete the treatment process prior to disposal.

10.4 Disposal of Treated Groundwater

The preferred alternative presented in the Proposed Plan for Interim Remedial Action at Site F presented several options for disposal of treated groundwater. The treated groundwater will meet ARARs prior to disposal. The disposal options initially considered as part of this interim action included discharge to sewer, discharge to surface water, or infiltration through a recharge basin. These options were presented to the public at the

Public Meeting. A majority of comments expressed concern for impacts to the availability of groundwater due to groundwater extraction and support for disposal of treated groundwater back into the Shallow Aquifer.

In response to the public preference and based on comparison of each of the disposal options, recharge back into the Shallow Aquifer on base via one of two methods has been selected as the preferred disposal option. The two methods being considered include injection of the treated groundwater through specially designed wells or infiltration through a recharge basin. Both would occur on base and would be located outside the identified zone of groundwater contamination. The injection or recharge area may be located upgradient of the groundwater contamination and could be used to enhance containment.

The benefits to this disposal method include facilitating on-base disposal and minimizing concern for depletion of the groundwater resource. Groundwater recharge could be designed to assist in preventing contaminant migration and accelerate contaminant removal. This method of disposal would be more cost-effective than discharge to a sanitary sewer or piping to a surface water discharge point.

If disposal directly to the Shallow Aquifer is found to have limitations during the design phase then the contingency method will be discharge to an existing on-base upland surface water feature. This disposal will in effect provide recharge to the Shallow Aquifer.

11.0 STATUTORY DETERMINATION

The Navy's and EPA's primary responsibility, under their legal CERCLA authorities, is to ensure that interim remedial actions will protect human health and the environment from the exposure pathways or threat it is addressing and the waste material being managed. Additionally, Section 121 of CERCLA, as amended by SARA, establishes several other statutory requirements and preferences. These specify that, when complete, the selected remedial action must comply with applicable or relevant and appropriate environmental standards established under federal and state environmental laws unless a statutory waiver is justified.

The selected remedy also must be cost-effective and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. The remedy should represent the best balance of tradeoffs among alternatives with respect to pertinent criteria, given the limited scope of the action. Finally, the statute includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as their principal element.

The selected interim remedial action for Site F at SUBASE Bangor meets the statutory requirements for the extraction, treatment and disposal of contaminated groundwater. The goal of the interim remedial action is to minimize the further spread of ordnance contaminated groundwater. Overall remediation goals for groundwater cleanup will be addressed in the selected final remedial action.

11.1 Protection of Human Health and the Environment

The selected Interim Remedial Action will protect human health and the environment through minimizing the further spread of contaminants in the groundwater, thereby reducing the threat to drinking water supplies located beyond the current contamination boundaries. The treatment of the extracted contaminated groundwater will be to a level protective of human health and the environment. The contaminants (2,4,6-TNT, RDX, nitrobenzene, 2,4- and 2,6-DNT, 1,3,5-TNB, 1,3-DNB, and other minor waste constituents) will be permanently removed from the groundwater through the treatment process which includes destruction by ultraviolet light and oxidation. As necessary, the effluent from this treatment process will be further treated by a polishing treatment to assure that the disposed water does not constitute an unacceptable potential risk to human health and the environment.

11.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy of drawing in contaminated groundwater at a rate sufficient to minimize the further spread of significant levels of contamination and the subsequent on-site treatment, and discharge of the treated groundwater will comply with all applicable or relevant and appropriate chemical-, action-, and location-specific requirements (ARARs). The ARARs are presented below.

11.2.1 Action-Specific ARARs

- Requirements of the State of Washington for water well construction as set forth in Chapter 18.104 RCW (Water Well Construction) and codified in Chapter 173-160 WAC (Minimum Standards for Construction and Maintenance of Wells), establishes criteria for the construction of the extraction wells.

- Requirements of the State Underground Injection Control Program (Chapter 173-218 WAC) as approved under the Safe Drinking Water Act, establishes design standards for injection wells.

- State of Washington requirements for hazardous waste operations conducted at uncontrolled hazardous waste sites as set forth in WAC 296-62 (Part P), establish safe operating procedures.

- Federal Clean Water requirements for discharge of treatment system effluent to the waters of the United States as set forth in 40 CFR 122, establish design standards for wastewater treatment units.

- Water Pollution Control Act (Chapter 90.48 RCW) and Water Resources Act of 1971 (Chapter 90.54 RCW) require the use of all known available and reasonable methods (AKARMs) for controlling discharges to surface water and groundwater.

- State of Washington Hazardous Waste Management Act (Chapter 70.105 RCW) requirements for dangerous waste and extremely hazardous waste as codified in Chapter 173-303 WAC may apply depending upon any treatment residuals created. No dangerous wastes have been identified to date.

11.2.2 Chemical-Specific ARARs

Groundwater extraction/treatment activities will meet the following chemical-specific ARARs:

- Since the treated water will be returned to the aquifer that currently supplies part of the water supply to the communities of Olympic View and Old Bangor, the cleanup standards established under the Model Toxics Control Act, as codified in WAC 173-340-720, are relevant and appropriate for treatment of the extracted water.

- Clean Water Act Section 402 (40 CFR Parts 121-125) for effluent discharge may be applicable if it is necessary to use an alternative to the injection well disposal of the treated water.

11.2.3 Location-Specific ARARs

There are no location-specific ARARs for this interim action.

11.2.4 Land Disposal Restrictions

The selected remedy will not involve the placement of RCRA hazardous wastes on site. This being the case, the Land Disposal Restrictions would not apply.

11.2.5 Other Criteria, Advisories, or Guidance To-Be-Considered (TBC)

No other criteria, advisory, or guidance are considered necessary for implementation of this interim remedial action.

11.3 Cost Effectiveness

The selected Interim Remedial Action is cost-effective because it is protective of human health and the environment and attains ARARs, and its effectiveness in meeting the objectives of the selected remedial action is proportional to its cost. The selected remedy is comparable in cost to Alternative 3; however, it employs the use of an innovative treatment technology and will result in the on-site destruction of contaminants and recharge of the extracted and treated groundwater to replenish groundwater supplies. The selected remedy can be implemented in the short-term and provides a groundwater extraction, treatment, and disposal system which could be incorporated into the final remedy for groundwater cleanup. The use of granular activated carbon would require off-site treatment where the efficiency of the destruction process could not be assured. The selected remedy assures a much higher degree of certainty that the remedy will be effective in the long-term due to the significant reduction in toxicity, mobility, and volume of wastes through the treatment process.

11.4 Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

Although the selected interim remedial action has certain features of a permanent solution due to its use of a treatment technology, this is a limited scope action and is not intended to provide a final remedy for this site. The minimization of further significant contaminant spread in the groundwater through the extraction and treatment of contaminated groundwater will permanently reduce the toxicity, volume, and mobility of contaminants by achieving significant destruction of the contaminants in the groundwater through ultraviolet light and oxidation. The treatment process for the extracted groundwater will be designed to meet or exceed state and federal standards for the protection of human health and the environment prior to recharge.

11.5 Preference for Treatment as Principal Element

While this interim action remedy does employ a treatment technology which addresses the threat of future ingestion/inhalation of contaminants in the extracted groundwater, this action is being undertaken primarily to limit the spread of the contaminants within the shallow aquifer. The statutory preference for remedies employing treatments which permanently and significantly reduce the toxicity, mobility or volume of the hazardous substances, pollutants, or contaminants as a principal element will be addressed fully in the final decision document for this operable unit.

12.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The selected interim remedial action is the preferred alternative presented in the Proposed Plan. There are no significant changes to the components of the preferred alternative except for the containment level of RDX in the groundwater.

The containment level is the concentration of RDX in the groundwater which will be prevented from further migration. The containment level was based on a risk goal of 10^{-4} (potential lifetime cancer risk due to drinking water consumption) consistent with OSWER Directive 9285.6-03.

The calculated 10^{-4} risk level for RDX has changed during the course of interim remedial action development, from 30 μg/L to 80 μg/L. The calculated containment level for RDX was 30 μg/L at the time of issuance of the final Proposed Plan for Interim Remedial Action and the comment period which occurred in February 1991. The RDX containment level was initially based on Region 10 exposure factors in effect at the time of the proposed plan. The revised RDX containment level of 80 μg/L is based on national exposure factors consistent with the OSWER Directive 9285.6-03. There has, however, been no change in the risk threshold target of 10^{-4}.

RECORD.rod

Table 1. Comparison of Maximum Concentrations of Chemicals Detected at Site F with EPA-Superfund Calculated Risk Levels for Remedial Action (a)

Chemical	Maximum Site F Groundwater Concentration in ug/L (b)	EPA-Superfund Calculated Risk Level in ug/L (a)
METALS AND INORGANICS:		
Barium	44.0	1,000.0 c
Cadmium	3.0 B	10.0 c
Chromium	11.0 B	50.0 c
Copper	41.0	1,000.0 c
Lead	13.0	15.0 c
Mercury	4.0	2.0 c
Nickel	22.0	730.0 d
Nitrate-N	81,000.0	10,000.0 c
Silver	8.0 B	50.0 c
Zinc	190.0 B	5,000.0 c
ORDNANCE:		
2,4,6-Trinitrotoluene	58,000.0	18.0 d
2,4-Dinitrotoluene	290.0	13.0 e
2,6-Dinitrotoluene	30.0	13.0 e
1,3,5-Trinitrobenzene	987.0	1.8 d
1,3-Dinitrobenzene	1,200.0	3.7 d
Nitrobenzene	1,030.0	18.0 d
RDX	28,500.0	83.0 e
OTHER ORGANICS:		
Acetone	150.0 BN	1,800.0 d
Bis(2-ethylhexyl)phthalate	610.0 BN	650.0 e
Di-n-butyl phthalate	2.0 E	3,650.0 d
Di-n-octyl phthalate	18.0	3,650.0 d
Endrin	0.1	0.2 c
Heptachlor	0.1	2.0 e
Heptachlor epoxide	0.1	No Data
Methylene Chloride	610.0 BN	610.0 e
2,4,5-TP (Silvex)	0.7	10.0 c

NOTES:

a. From EPA-OSWER Directives 9285.6-03 (March 1991).
b. From Current Situation Report, SUBASE Bangor (Hart Crowser, 1989).
c. Based on Drinking Water Maximum Contaminant Levels
d. Based on prevention on non-cancer risk at a Hazard Quotient of 1.
e. Based on a threshold cancer risk of 1 in 10,000.

Data Qualifiers:

B Chemical also detected in laboratory blanks.
E Estimated concentration.
N Compound not detected during resampling.

Table 2 - Summary of Water Treatment Objectives - ARARs - for Bangor Site F
Proposed Interim Action

Summary of Water Treatment Objectives for Pumped Groundwater

Compound	Concentrations in µg/L		
	MTCA (a) Method B Water Cleanup Standard		Proposed Treatment Objectives
	Groundwater	Surface Water	
Nitrate-N	10,000	10,000	10,000
2,4,6-Trinitrotoluene	3	10	3
2,4-Dinitrotoluene	0.1	1	0.1
2,6-Dinitrotoluene	0.1	1	0.1
1,3,5-Trinitrobenzene	0.8	10	0.8
1,3-Dinitrobenzene	2	20	2
Nitrobenzene	8	110	8
RDX	0.815 (c)	12	5 (b)

NOTES:

(a) Model Toxics Control Act (MTCA), Cleanup Regulations, Chapter 173-340 WAC, February 28, 1991.

(b) The current practical quantitation limit for RDX is 5 µg/L, which defines the compliance cleanup concentration for potential drinking water exposure conditions in accordance with MTCA.

(c) ARARs = Applicable or Relevant and Appropriate Requirements.

Toxicity and Bioconcentration Data Used to Compute Cleanup Standards

Chemical	Oral Reference Dose in mg/kg-day	Source	EPA Oral Cancer Group	Oral Potency Slope in $(mg/kg\text{-}day)^{-1}$	Source	BCF (b)	Source (c)
Nitrate-N	1.0	IRIS (a)	D			1	Estimated
2,4,6-Trinitrotoluene	5×10^{-4}	IRIS	C	3×10^{-2}	IRIS	21	Table 5-7
2,4-Dinitrotoluene	ND		B2	6.8×10^{-1}	IRIS	25	Table 5-7
2,6-Dinitrotoluene	ND		B2	6.8×10^{-1}	IRIS	13	Table 5-7
1,3,5-Trinitrobenzene	5×10^{-5}	IRIS	D			21	Estimated
1,3-Dinitrobenzene	1×10^{-4}	IRIS	D			21	Estimated
Nitrobenzene	5×10^{-4}	IRIS	D			21	Estimated
RDX	3×10^{-3}	IRIS	C	1.1×10^{-1}	IRIS	5	Table 5-7

(a) EPA (1988). Integrated Risk Information System (IRIS). Office of Research and Development, Environmental Criteria and Assessment Office.

(b) Bioconcentration Factor.

(c) Current Situation Report for Sites C, D, E, F. Naval Submarine Base, Bangor, Washington, prepared by Hart Crowser, 1989.

ND - Not Determined.

POOR QUALITY ORIGINAL

Table 3 – Cost Estimate for Alternative 2: Groundwater Extraction and Treatment by UV/Oxidation

TASK	Qty	Unit	Unit Cost	Cost	Reference
CAPITAL COSTS					
Groundwater Extraction					
Recovery Wells	3	EA	30,000	90,000	1
Recovery Pumps and Piping	3	EA	5,000	15,000	1
Injection Wells	3	EA	30,000	90,000	1
SUBTOTAL				195,000	
Groundwater Treatment					
Lab Testing	1	LS	20,000	20,000	2
Holding Tanks	4	EA	50,000	200,000	1
Pumps and Piping	1	EA	50,000	50,000	1
UV/Ox System, 200 gpm	1	EA	600,000	600,000	2
Design Level Exploration	1	EA	50,000	50,000	1
Design, Remediation Mgmt.	1	EA	100,000	100,000	1
SUBTOTAL				1,020,000	
OPERATION AND MAINTENANCE (Based on 2 years of operation)					
Groundwater Extraction	1	EA	100,000	100,000	1
Groundwater Treatment					
UV/Ox System inputs and maintenance	200,000	Tgal	5	1,000,000	2
Discharge Monitoring	1	EA	100,000	100,000	1
Design, Remediation Mgmt.	1	EA	100,000	100,000	1
SUBTOTAL				1,300,000	
TOTAL ESTIMATED COST:				2,515,000	

REFERENCES USED IN COST TABLES:

1. Previous Experience.

2. Reed, D., 1990b. Personal Communication from Doug Reed of Solarchem, Inc., to Ravi Bhatia of Hart Crowser, Inc. November 21, 1990.

14631901.wk1

POOR QUALITY ORIGINAL

Table 4 – Cost Estimate for Alternative 3: Groundwater Extraction and Treatment by Carbon Adsorption

TASK	Qty	Unit	Unit Cost	Cost	Reference
CAPITAL COSTS					
Groundwater Extraction					
Recovery Wells	3	EA	30,000	90,000	1
Recovery Pumps and Piping	3	EA	5,000	15,000	1
Injection Wells	3	EA	30,000	90,000	1
SUBTOTAL				195,000	
Groundwater Treatment					
Lab Testing	1	LS	10,000	10,000	3
Holding Tanks	4	EA	50,000	200,000	1
Pumps and Piping	1	EA	50,000	50,000	1
Carbon System, 200 gpm	1	EA	300,000	300,000	3
Design Level Exploration	1	EA	50,000	50,000	1
Design, Remediation Mgmt.	1	EA	100,000	100,000	1
SUBTOTAL				710,000	
OPERATION AND MAINTENANCE (Based on 2 years of operation)					
Groundwater Extraction	1	EA	100,000	100,000	1
Groundwater Treatment					
Carbon Disposal and Replacement	2	EA	600,000	1,200,000	3
Maintenance	1	EA	200,000	200,000	1
Discharge Monitoring	1	EA	100,000	100,000	1
Design, Remediation Mgmt.	1	EA	100,000	100,000	1
SUBTOTAL				1,600,000	
TOTAL ESTIMATED COST:				2,505,000	

REFERENCES USED IN COST TABLES:

1. Previous Experience.

2. Reed, D., 1990b. Personal Communication from Doug Reed of Solarchem, Inc., to Ravi Bhatia of Hart Crowser, Inc. November 21, 1990.

3. Hanson, R., 1990. Personal Communication from Robert Hanson of Cameron-Yakima, Inc., to Ravi Bhatia of Hart Crowser, Inc. July 5, 1990. This facility is not currently able to accept ordnance for disposal, however, these costs were provided for purposes of cost comparison.

146319ct.wk1

Table 5 – Cost Estimate for Alternative 4: Slurry Wall

TASK	Qty	Unit	Unit Cost	Cost	Reference
CAPITAL COSTS					
Groundwater Extraction					
Slurry Wall, Design, and Mgmt.	1,000,000	EA	8	8,000,000	1
SUBTOTAL				8,000,000	
OPERATION AND MAINTENANCE (Based on 2 years of operation)				0	
TOTAL ESTIMATED COST:				8,000,000	

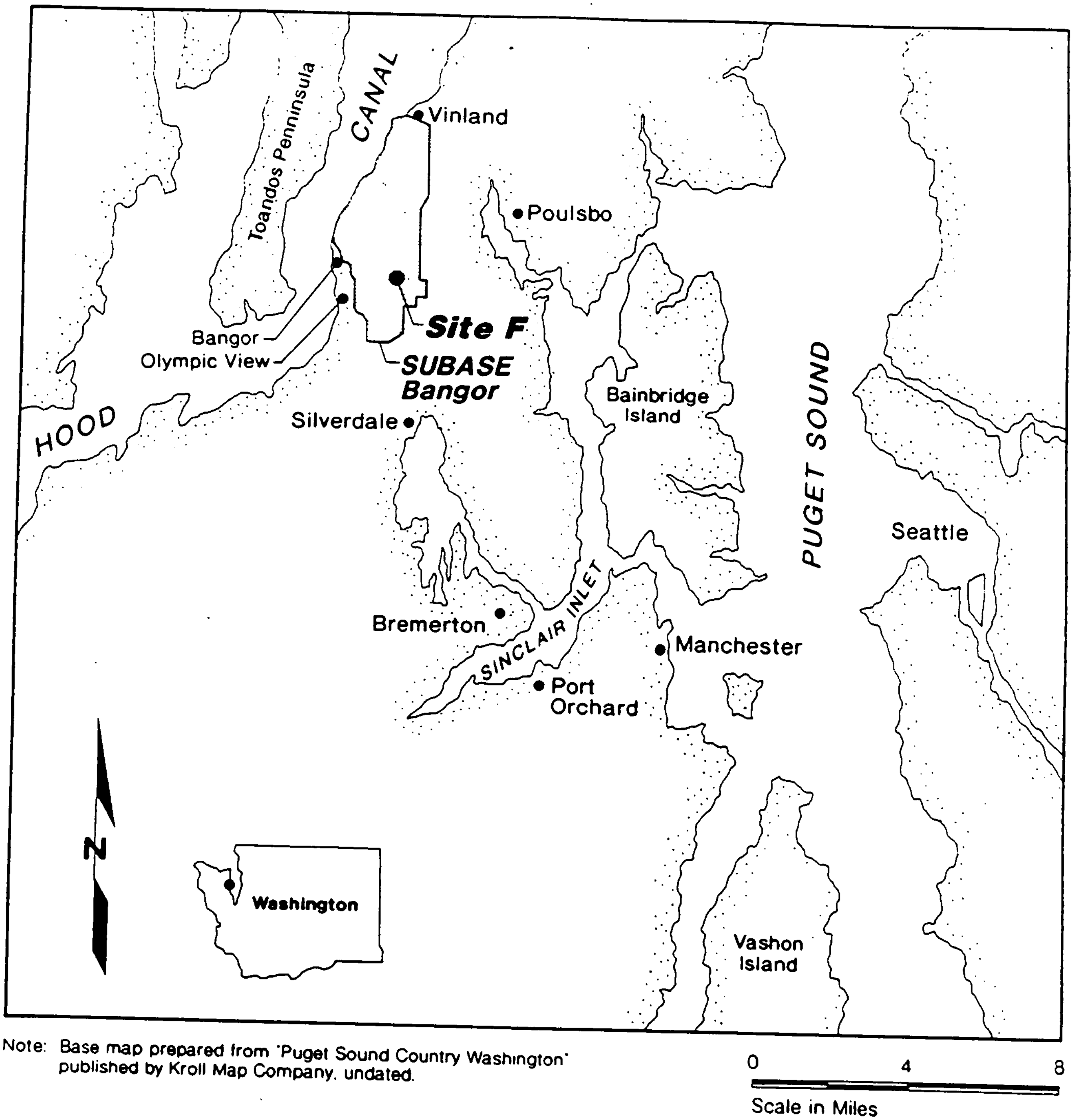
REFERENCES USED IN COST TABLES:

1. EPA, 1987. "Compendium of Costs of Remedial Technologies at Hazardous Wastes Sites," EPA/600/2-87/087, Hazardous Waste Engineering Research Laboratory, USEPA, Cincinnati, Ohio.

146319ca.wk1

POOR QUALITY ORIGINAL

Generalized Regional Map

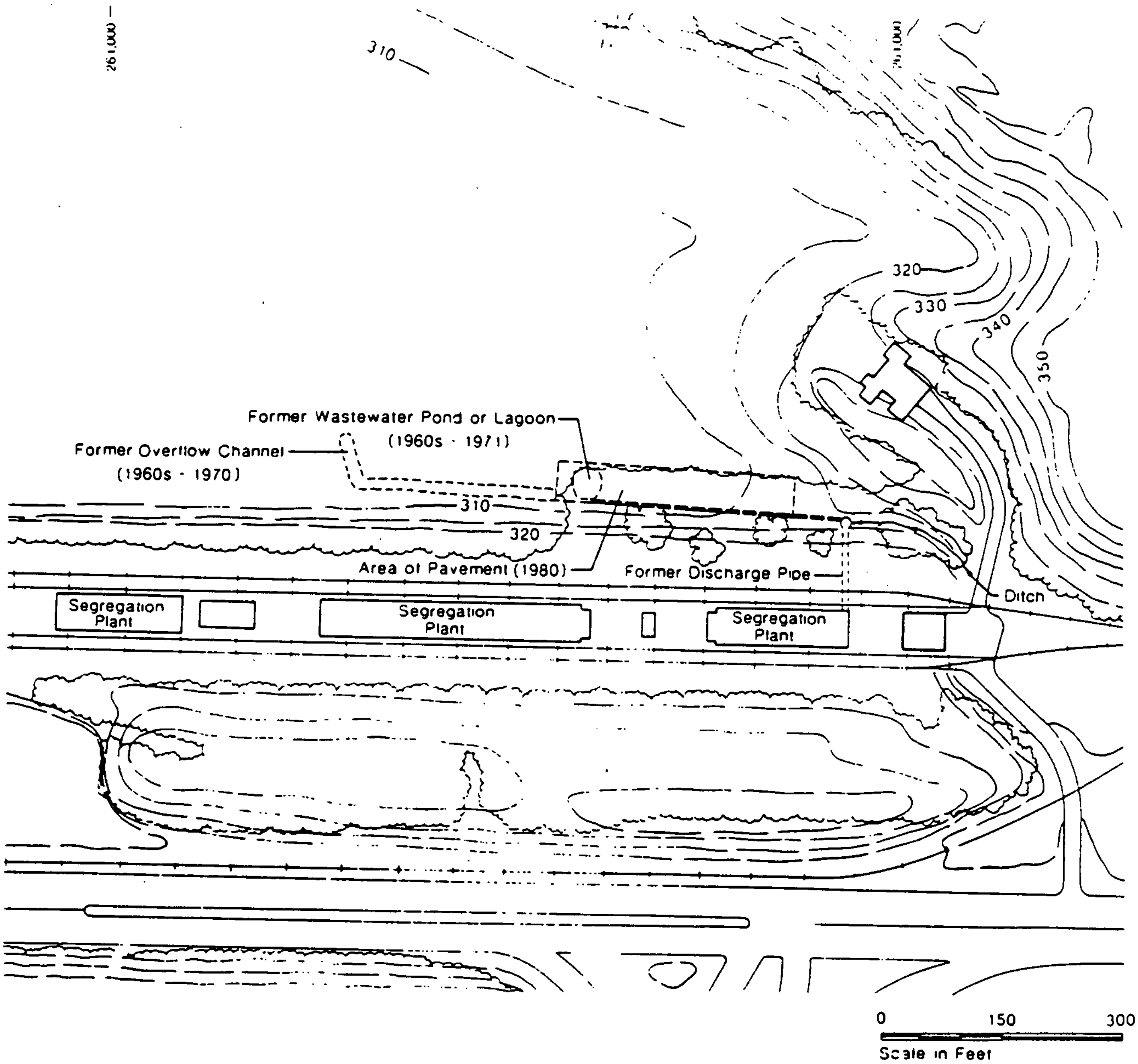


Note: Base map prepared from "Puget Sound Country Washington" published by Kroll Map Company, undated.

POOR QUALITY
ORIGINAL

HARTCROWSER
J-1463-19 4/91
Figure 1

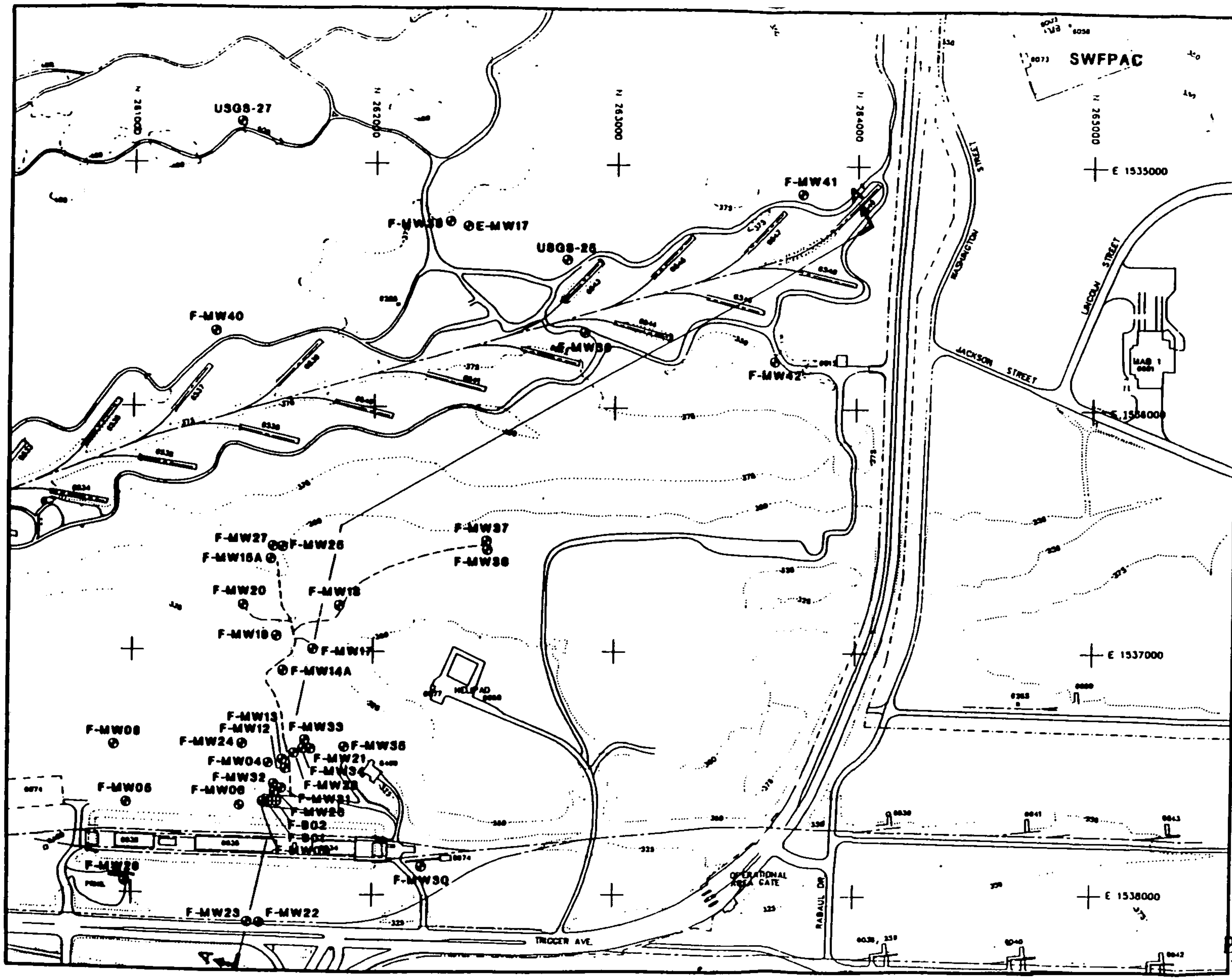
Site F Historical Features Map



HARTCROWSER
J-1463-19 4/91
Figure 2

POOR QUALITY
ORIGINAL

Well cation Plan



⊕F-MW29 Monitoring Well Location and Number

⊕F-B01 Soil Boring Location and Number

A A' Cross Section Location and Designation

N

0 400 800

Scale in Feet

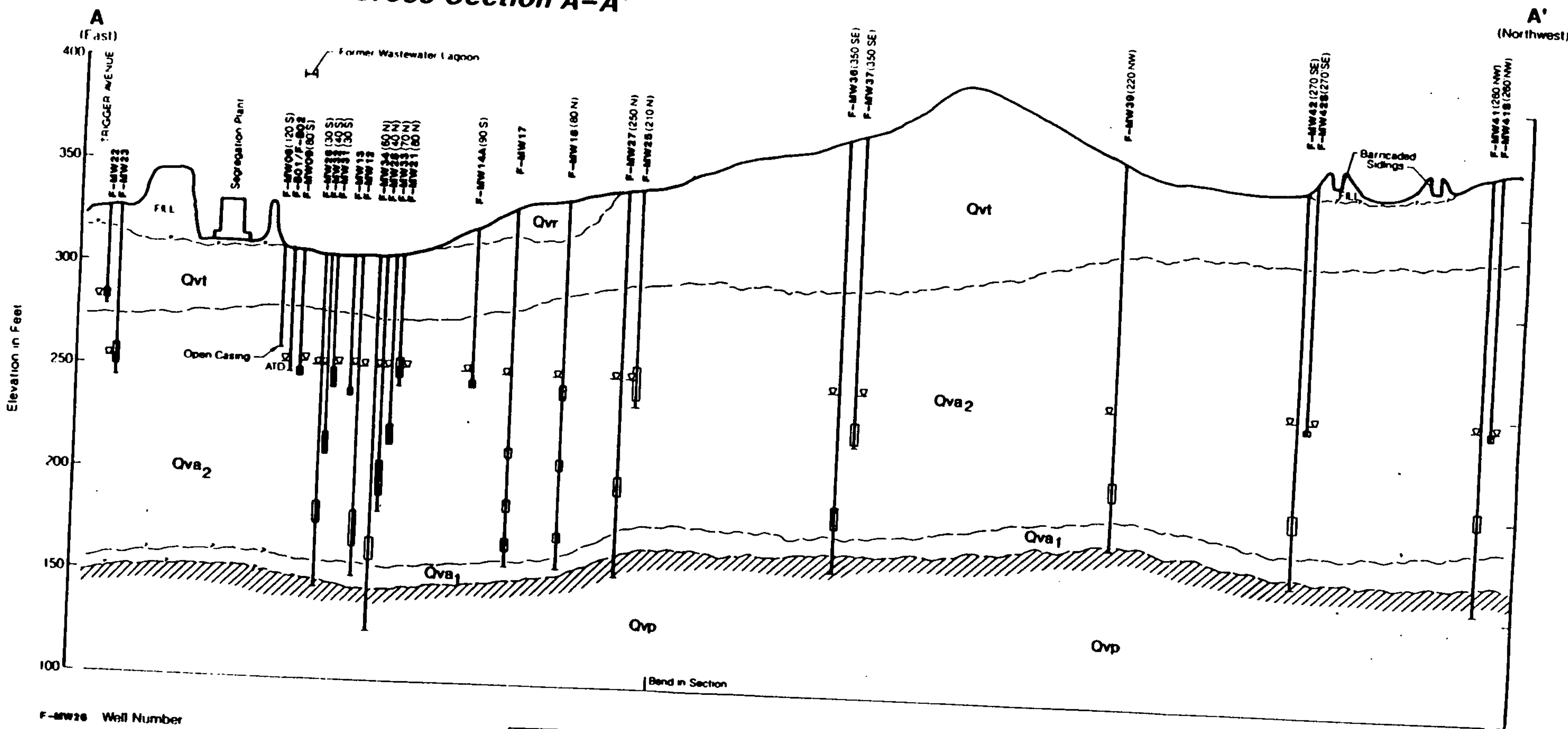
POOR QUALITY ORIGINAL

HARTCROWSER

J-1463-19 4/91

Figure 3

Generalized Subsurface Cross Section A–A'



F-MW26 Well Number

(30 S) Distance and Direction of Offset

Well Location

Water Level (Nov 1990)
(ATD=At Time of Drilling)

Recorded Screened Interval

Inferred Screened Interval

Qvr	Vashon Recessional Outwash
Qvt	Vashon Till
Qva_2	Vashon Advance Outwash 2
Qva_1	Vashon Advance Outwash 1
Qvp	Vashon Proglacial Deposits

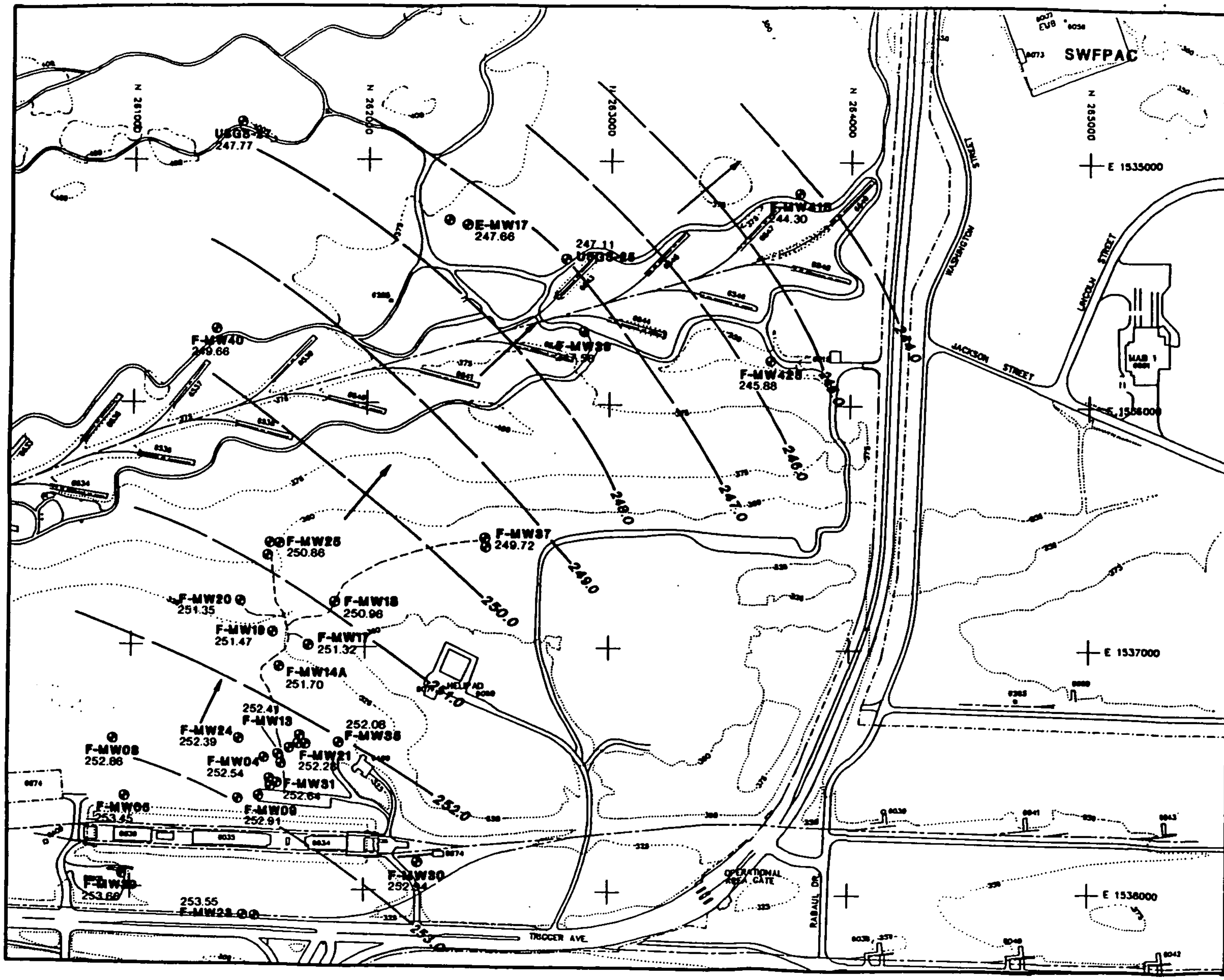
Horizontal Scale in Feet
0 300 600
0 50 100
Vertical Scale in Feet
Vertical Exaggeration x 6

POOR QUALITY ORIGINAL

HARTCROWSER
J-1463-19 4/91
Figure 4

Shallow Aquifer Water Table Elevation Contour Map

January, 1991



⊗ F-MW18	Monitoring Well Location and Number
244.30	Spot Water Table Elevation in Feet
-244.0-	Water Table Elevation Contour in Feet (Contour Interval = 1.0 Foot)
——→	Generalized Groundwater Flow Direction

Note: Depth to water measurements collected on 1/9/91.

POOR QUALITY ORIGINAL

N

0 400 800

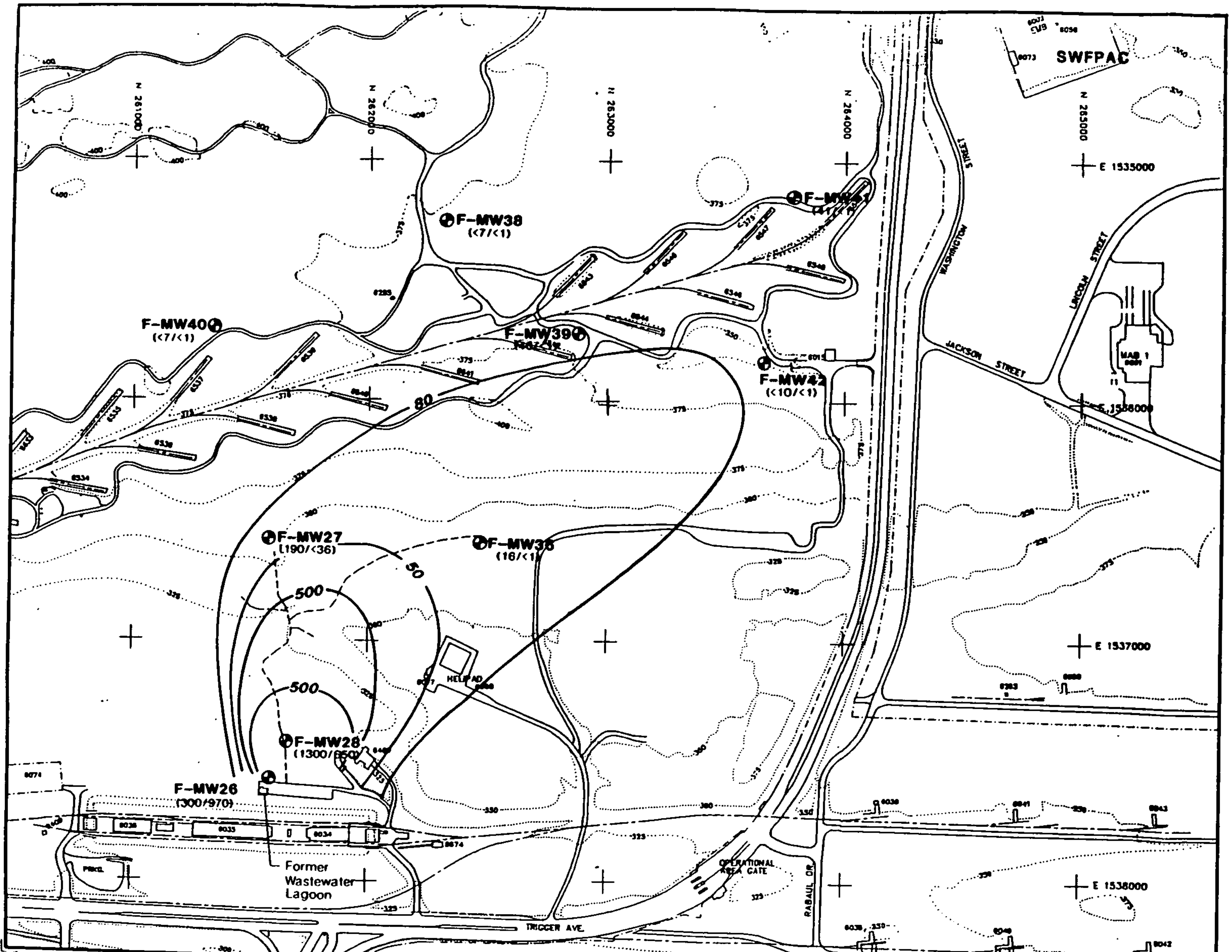
Scale in Feet

HARTCROWSER

J-1463-19 4/91

Figure 5

RDX and TNT Concentration Contour Map



Monitoring Well Location and Number (F-MW26)

(300/970) RDX/TNT Concentration in µg/L Based on Screening Level Data

— 80 — RDX Concentration Contour in µg/L

— 50 — TNT Concentration Contour in µg/L

POOR QUALITY ORIGINAL

N

0 400 800

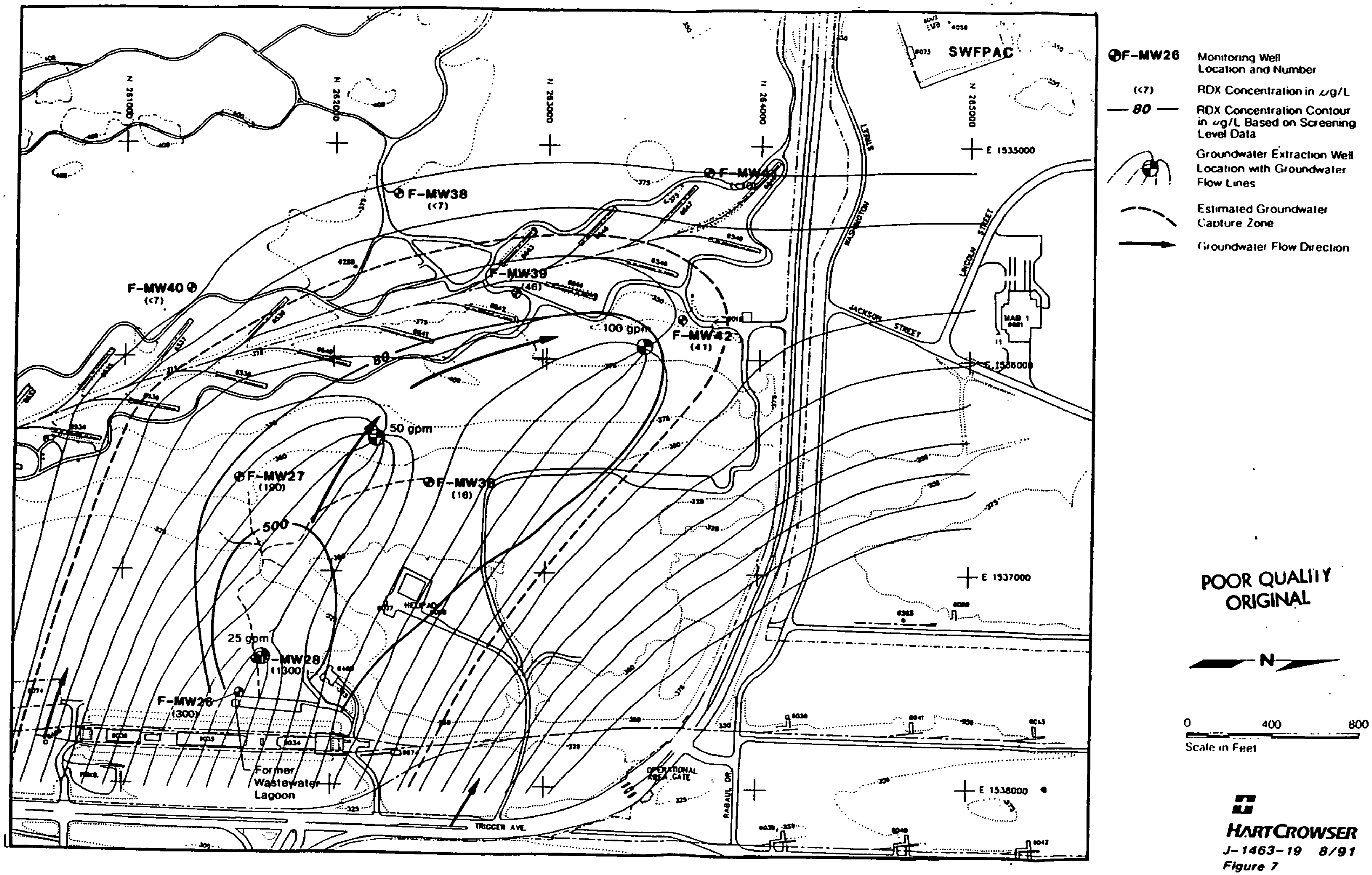
Scale in Feet

HARTCROWSER

J-1463-19 8/91

Figure 6

R oncentration Contour Map and Estimated G dwater Capture Zone



POOR QUALITY ORIGINAL