0014145

Enclosure

SUPPORTING DOCUMENT

1. Total Pages 73

2. Title Preliminary Site Evaluation Report for a Soil Column Disposal Site for the 242-A Evaporator and PUREX Plant Condensate Treatment Facility

3. Number WHC-SD-EN-EE-002

4. Rev. No. 0

5. Key Words

Preliminary Site Evaluation Report, Soil Column, Disposal Site, 242-A Evaporator, PUREX

6. Author

K. J. Koegler
Name (Type or Print)

K J Koegler
Signature

Env. Engineering/W1B6D
Organization/Charge Code

7. Abstract

The purpose of this preliminary site evaluation is to select the candidate sites for a soil column disposal site for the 242-A evaporator and PUREX plant condensate treatment facility. Three sites are recommended as candidate sites and were selected by the following process. First, site selection criteria were established. Next, preliminary candidate sites were developed by committee based upon the site selection criteria. Finally, each of the preliminary candidate sites was visited, evaluated, and points awarded for each criterion. These evaluations produced a ranking of the sites with the top three being those recommended as candidate sites. Candidate sites will be characterized and then evaluated in a site evaluation report which will include a cost/benefit analysis.

Koegler, K. J., 1990, Preliminary Site Evaluation Report for a Soil Column Disposal Site for the 242-A Evaporator and PUREX Plant Condensate Treatment Facility, WHC-SD-EN-EE-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPROVED FOR PUBLIC RELEASE 7/24/90 M.S.

8. ~~**PURPOSE AND USE OF DOCUMENT** – This document was prepared for use within the U.S. Department of Energy and its contractors. It is to be used only to perform, direct, or integrate work under U.S. Department of Energy contracts. This document is not approved for public release until reviewed.~~

~~**PATENT STATUS** – This document copy, since it is transmitted in advance of patent clearance, is made available in confidence solely for use in performance of work under contracts with the U.S. Department of Energy. This document is not to be published nor its contents otherwise disseminated or used for purposes other than specified above before patent approval for such release or use has been secured, upon request, from the U.S. Department of Energy, Patent Attorney, Richland Operations Office, Richland, WA.~~

9. Impact Level 2

10. R. P. Henckel
Authorized Manager's Name (Type or Print)

RPH
Authorized Manager's Signature

Specify Distribution Limit EXTERNAL

11. RELEASE STAMP

RELEASED

DISTRIBUTION LIMITS

☐ INTERNAL ONLY

☐ SPONSOR LIMITED

☒ EXTERNAL

DATE: JUL 24 1990

Sta. 21

A-6400-073 (04/90)

DISCLAIMER

Printed in the United States of America

DISCLM-2.CHP (2-89)

CONTENTS

APPENDICES

FIGURES

TABLES

1.0 INTRODUCTION

1.1 BACKGROUND

Past practice at the Hanford Site has been to discharge liquid effluents directly to the soil column. The favorable characteristics of the area including isolation, low precipitation, deep water table, and soil ion exchange properties had made this a reasonable and accepted method.

In March 1987, the U.S. Department of Energy, Richland Operations Office (DOE-RL) issued a document entitled *Plan and Schedule to Discontinue Disposal of Contaminated Liquids into the Soil Column at the Hanford Site*. This plan contains a strategy for implementing alternative treatment and disposal systems for major waste streams discharged to the soil column. Per this plan, the Plutonium Uranium Extraction (PUREX) Plant process condensate (PC) and ammonia scrubber distillate (ASD) and the 242-A Evaporator PC waste streams are identified for alternative treatment and disposal systems.

In April 1989, the 242-A Evaporator was placed in temporary standby because of a concern that past practices may have made the evaporator process condensate a listed waste. In addition, the PUREX Plant cannot operate until an alternate disposal site is made available. This is due to past waste generation practices suggesting potential past discharges of listed waste to the existing disposal site.

The operation of the 242-A Evaporator is vital to waste management and environmental operations at the Hanford Site. The 242-A Evaporator and the PUREX Plant Condensate Treatment Facility, Project C-018H, is being developed to provide a treatment system for the 242-A Evaporator PC and the PUREX Plant PC and ASD (hereinafter referred to as the treatment facility).

As identified in the functional design criteria (FDC) for the treatment facility (Flyckt and McCormack 1990), it is intended that the treated effluent from this facility will be discharged to the soil column at a state-approved land disposal site, per the Washington Administrative Code 173-216 (Ecology 1988).

1.2 PURPOSE

The purpose of this preliminary site evaluation report is to select the candidate sites for a new soil column disposal site in support of the treatment facility.

The use of any site herein identified is dependent on the acquisition of applicable regulatory permits.

1.3 SCOPE

This preliminary site evaluation report addresses the selection of candidate sites for a new soil column disposal site.

Following the approval of the candidate sites, each candidate site will be characterized in terms of geologic and hydrologic properties, as well as screened for any contamination present. A final site evaluation report will then be produced in which each site will be fully evaluated, including a cost/benefit evaluation.

The soil column disposal site will receive posttreatment effluents from the PUREX Plant PC and ASD and 242-A Evaporator PC waste streams. For the purposes of this report, it is assumed that the treated effluent will be delisted; however, it will contain tritium. Flow rate of treated effluent is 150 gal/min (Flyckt and McCormack 1990).

Effluent will be transported by pipeline to the disposal site from the treatment facility. According to the *Site Evaluation Report for the 200 Area Effluent Retention and Treatment Complex and 200 Area Treated Effluent Disposal Facility* (Trost 1989), the treatment facility is to be located at the northeast corner of the 200 East Area.

Siting and operations of this structure shall be accomplished in accordance with *Environmental Compliance* (WHC 1988).

2.0 SITE-SELECTION CRITERIA

2.1 BACKGROUND

The selection criteria presented in the following sections have been established for use in the evaluation of sites for a new soil column disposal site that will receive effluent from the treatment facility.

The selection criteria presented herein were developed primarily from guidelines established in DOE-RL Order 4320.2C, *Site Selection*, (1990) and DOE Order 6430.1A, *General Design Criteria* (1989, Section 200-1). Other criteria that have been determined applicable have also been included. The criteria have been broken down into two groups: determining criteria (i.e., go/no go) and engineering criteria. The latter of the two groups will be evaluated by weighting matrix.

Some site-selection criteria listed in the guidance documents were found to be common to all site options and/or not significant to this siting and are, therefore, not included.

2.2 DETERMINING CRITERIA

The following five criteria have been established as determining criteria (i.e., go/no go):

1. Sufficient land area for structure.

   The purpose of this criterion is to assure required area is available for structure. Required area is established by the following equation:

$$A = \frac{\dot{F}}{I}$$

   where:

   A = required area (ft^2)

   $\dot{F}$ = effluent rate of flow (gal/min)

   I = infiltration capacity [gal/min(ft^2)].

   The effluent rate of flow given in the FDC for the treatment facility is 150 gal/min. The infiltration capacities will be determined by field testing. Any site not having sufficient land area for the structure will be determined to be unacceptable.

2. Unacceptable impact on any site identified as a *Resource Conservation and Recovery Act of 1976* (RCRA) site or *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) site.

The purpose of this criterion is to assure that no existing contamination plume in the vadose zone or ground water will be adversely affected by the introduction of this effluent. Adverse effects would include the following: (1) intrusion of effluent into a contamination plume, significantly shortening the plume travel time to the Columbia River, or other source available to the public, or (2) unacceptable impact on the operation or remediation of an existing RCRA or CERCLA site.

Modeling will be accomplished to develop information about the effects on the ground water and vadose zone from the effluent. Required information on ground water travel times, stream lines, and changes in the water table will be developed from the Golder Associates, Inc. ground water package model, Aquifer Flow in Porous Media. Due to the large impact which B Pond has on the ground water conditions in the 200 areas and possible change in operations at B Pond, this information will be developed for the following two conditions: (1) Present conditions that include disposal of large quantities of effluent water to B Pond and (2) Possible future conditions of no discharge to B Pond. The resulting worst case of these two conditions will be used for each evaluation. Evaluation of the following specific criteria will be based on information obtained from this modeling:

- If it is determined that the introduction of this effluent to a particular site causes a known contamination plume to have a significantly shortened travel time to the Columbia River, or other source available to the public, then that site will be determined unacceptable.

- If it is determined that the introduction of this effluent to a particular site causes the ground water table to rise, remobilize contaminants that have been previously deposited in the vadose zone, and thereby provide for the travel of same contaminants toward the Columbia River, or other source available to the public, then that site will be determined unacceptable.

- If it is determined that the introduction of this effluent to a particular site causes a plume that interacts with a known contamination plume, and if the technical coordinator of the operable unit concerned identifies this interaction as unacceptable with regard to the operation or remediation of that operable unit, then that site will be determined unacceptable.

3. Unacceptable impact on cultural, historic, or archeological resources.

   The purpose of this criterion is to ensure preservation of cultural, historic, or archeological resources. Evaluation of this criterion will include field surveys by and the professional judgement of individuals qualified in this field. These evaluations will be made in accordance with the *Hanford Cultural Resources Management Plan* (Chatters 1989).

4. Unacceptable impact on endemic threatened or endangered plant or animal species.

   The purpose of this criterion is to ensure preservation of threatened or endangered plant or animal species. Individuals qualified in these fields will conduct surveys and use professional judgement in evaluation of this criterion.

5. Land use conflict.

   The purpose of this criterion is to ensure compliance with long-range land use plans at the Hanford Site. Any conflict with long-range land use plans for a site that cannot be resolved will make that site unacceptable.

2.3 ENGINEERING CRITERIA

The following categories of criteria will be used by means of a weighting matrix for the development and evaluation of preliminary candidate sites:

- Health and safety
- Environmental impact
- Operational impact
- Land use.

Each category of criteria has been assigned a comparative numerical value or weighting factor to signify its importance relative to the other categories of criteria. The comparative numerical values range from 1 to 5, with 5 being the most important and 1 being the least important. These values were established by the author to be in line with current requirements and guidance.

Each category of criteria is broken down into specific criteria. Under the process of evaluation, each candidate site will be rated on a scale of 1 to 10 against each specific criterion, 10 being the best score and 1 being the worst score. This raw score will be assigned by an evaluation team following a visit to the preliminary candidate site. The score assigned will be in compliance with objective parameters discussed in Section 4.0 of this report. For each site, the sum of the raw scores for all criteria under a category will be divided by the number of criteria in that category to provide an adjusted score by category. This score will be multiplied against the weighting factor for that category to obtain a final score for each site by category. The total points for each site will be the sum of all final category scores for that site.

2.3.1 Health and Safety (Weighting Factor 5)

The purpose of this category is to evaluate the variance between sites with regard to the health and safety of personnel.

The concept of reducing the exposure of workers to radiation and hazardous substances and conditions, known as "as low as reasonably achievable" (ALARA), is used in the following criteria to evaluate issues of health and safety of personnel (WHC 1989a). Specific criteria follow.

2.3.1.1 ALARA During Construction. The purpose of this criterion is to evaluate the risk involved with a site during the construction phase. A site with a lower risk will receive 10 points, while a site with a higher risk will receive 1 point.

2.3.1.2 ALARA During Operation. The purpose of this criterion is to evaluate the risk involved with a site during the operation phase. A site with a lower risk will receive 10 points, while a site with a higher risk will receive 1 point.

2.3.2 Environmental Impact (Weighting Factor 5)

Siting will be accomplished in compliance with applicable environmental laws and regulations. Environmental impact will be further reduced by considering sites with respect to geologic and hydrologic conditions. Specific criteria follow.

2.3.2.1 Tritium Travel Time in Ground Water to Columbia River. The purpose of this criterion is to evaluate sites with respect to ground water travel time and to give priority to sites that provide for longer decay of tritium before reaching the Columbia River. A site which provides for 10 half-lives will receive 10 points, while a site that provides for one half-life will receive 1 point.

2.3.2.2 Impact potential of Effluent Release. The purpose of this criterion is to evaluate the impact of an accidental release of effluent from the pipeline while enroute to the disposal site. A site which would cause a less serious impact will receive 10 points, while a site which would cause a more serious impact will receive 1 point.

2.3.3 Operational Impact (Weighting Factor 3)

The purpose of this category is to evaluate the impact to and/or from any existing operations located between the treatment facility site and the disposal site; this includes the disposal structure and supporting systems (e.g., pipelines). Consideration will be given to the impact on operations due to the physical siting as well as effects of the introduction of effluent to the soil column and its subsequent travel. Specific criteria follow.

2.3.3.1 Obstructions to or from Existing Operations. The purpose of this criterion is to evaluate obstructions to and/or from existing operations located between the treatment facility site and the disposal site, primarily during the construction phase. A site with few obstructions will receive 10 points, while a site with many obstructions will receive 1 point.

2.3.3.2 Interference with Existing Operations. The purpose of this criterion is to evaluate interference to and/or from existing operations located between the treatment facility site and the disposal site, primarily during the operation phase. A site causing low interference will receive 10 points, while a site causing high interference will receive 1 point.

2.3.4 Land Use (Weighting Factor 2)

The purpose of this category is to address the availability of land and to ensure compliance with long-range plans for the Hanford Site. Specific criteria follow.

2.3.4.1 Compatibility with Long-Range Use Plans. The purpose of this criterion is to ensure compatibility with long range use plans at the Hanford Site. A site which is fully compatible will receive 10 points, while a site that is less compatible will receive 1 point.

2.3.4.2 Adjacent Land Available for Use in Future Expansion. The purpose of this criterion is to evaluated the site for additional space available for use in future expansion. A site which provides for three times the required space will receive 10 points, while a site which has no extra space will receive 1 point.

3.0 PRELIMINARY CANDIDATE SITES SELECTION

The process by which preliminary candidate sites for the soil column disposal structure were selected follows. The site-selection criteria were established for use in developing and evaluating the sites. A panel was assembled consisting of representatives from the Environmental Engineering and the Geosciences groups and Waste Management Division. The panel placed a constraint that the site be in, or adjacent to, the 200 areas. Reasoning for this constraint was two-fold: (1) Though delisted, the treated effluent will contain tritium; therefore, it was considered prudent to maintain the effluent in areas adjacent to presently existing waste sites rather than to affect a new region; (2) Costs of transporting the effluent beyond the 200 areas was assumed to be prohibitive. Once this constraint was in place, the panel proceeded in open discussion applying the site-selection criteria.

The 200 areas were searched for unobstructed sites with a required minimum 30,000 ft^2; this amount was determined using the combined maximum flow rates of the waste streams, 205 gal/min and an average site infiltration rate of 10 gal/d/ft^2. Note that the rate of effluent from the treatment facility will be a maximum of 150 gal/min; this information was made available after the selection of preliminary candidate sites was made. Since the effluent rate of flow is less than the rate used in the selection, the required area will also be less; therefore, this change does not affect the selections as previously made. Those sections providing the required area were then screened against the site-selection criteria for elimination. Operable unit maps and charts showing contamination plumes were utilized to avoid known structures and contamination plumes (WHC 1989b). Per this process, the six best prospects were identified as preliminary candidate sites. A seventh preliminary candidate site emerged when the results from first-run modeling provided new information on ground water travel times. These preliminary candidate sites are identified below and shown in Figure 1.

- Site A: Hanford Coordinates N38000, W46000
- Site B: Hanford Coordinates N48500, W43000
- Site C: Hanford Coordinates N38500, W51000
- Site D: Hanford Coordinates N33000, W75000
- Site E: Hanford Coordinates N34500, W80500
- Site F: Hanford Coordinates N45500, W71500
- Site G: Hanford Coordinates N48000, W77000.

Detailed figures of preliminary candidate site locations are included in Appendix A.

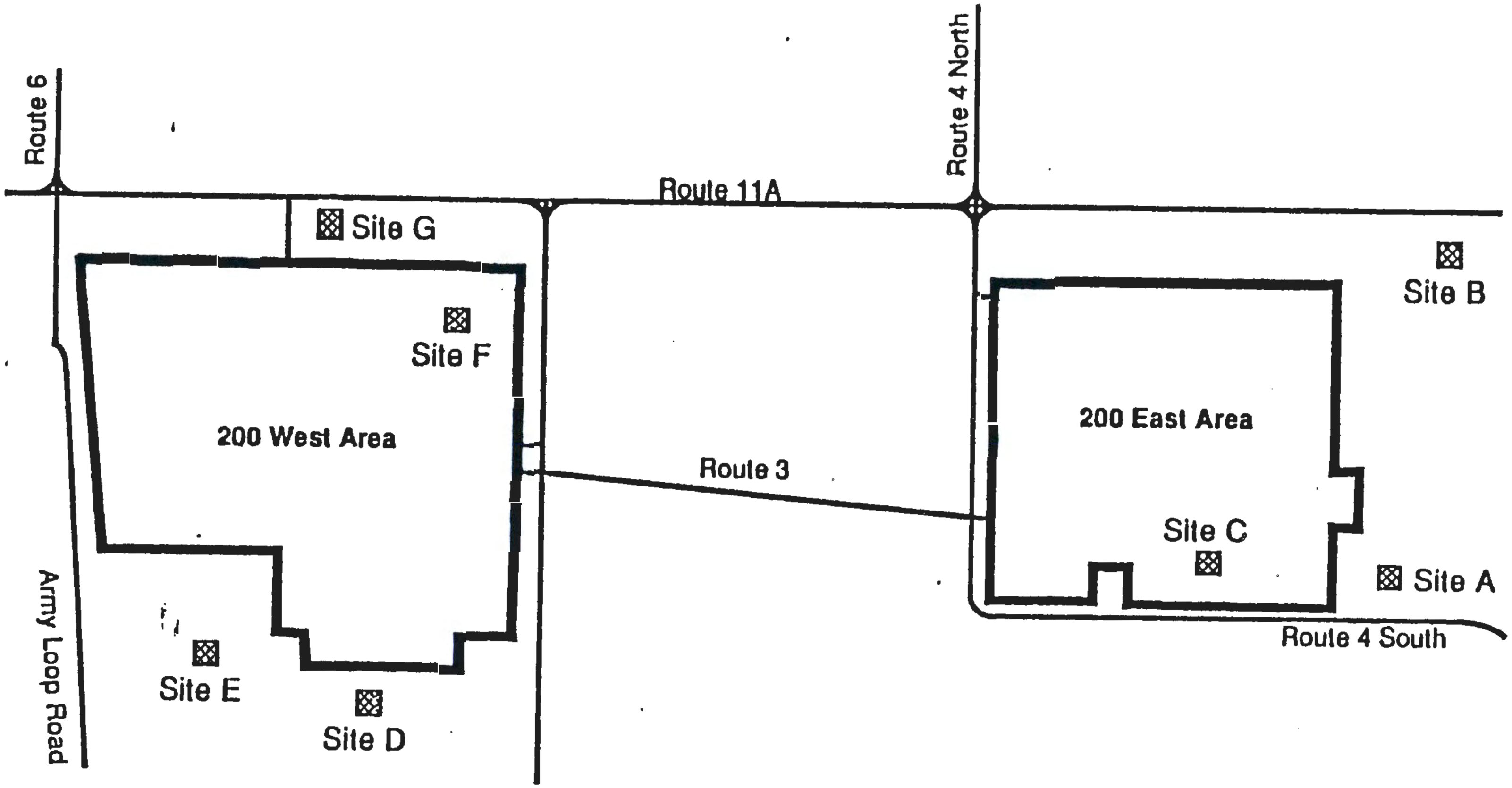


Figure 1. Preliminary Candidate Sites.

4.0 EVALUATION OF PRELIMINARY CANDIDATE SITES

4.1 BACKGROUND

The evaluation of preliminary candidate sites was performed by representatives from the Environmental Engineering Group and the Geosciences Group and was accomplished in the following manner.

Each preliminary candidate site received a preliminary evaluation against the determining criteria; this preliminary evaluation was based on best current information. A complete evaluation of candidate sites against the determining criteria will be accomplished once the candidate sites have been established and characterized. Each preliminary candidate site was then fully evaluated against the engineering criteria. Results of these evaluations are presented in the following sections.

4.2 DETERMINING CRITERIA

1. Sufficient land area for structure. Required area is established by the following equation:

   $$A = \frac{\dot{F}}{I}$$

   where:

   A = required area (ft^2)

   $\dot{F}$ = effluent rate of flow (gal/min)

   I = infiltration capacity [gal/min(ft^2)].

   Effluent rate of flow was determined using the combined maximum flow rates of the waste streams, 150 gal/min. The infiltration capacity numbers are pending field testing; a site average of 10 gal/d/ft^2 has been used in development of this evaluation to date. Using these values, 22,000 ft^2 was determined to be the minimum required area. All preliminary candidate sites fully meet this criterion.

2. Unacceptable impact on a RCRA or CERCLA site.

   Information to be used in evaluating this criterion is to be obtained at a later date through candidate site characterization and modeling. The proximity of each preliminary candidate site to RCRA or CERCLA sites and known geology and hydrology of these areas indicate that all preliminary candidate sites should meet this criterion.

3. Unacceptable impact on cultural, historic, or archeological resources.

Preliminary screening indicated all preliminary candidate sites should meet this criterion. Surveys were completed on the three highest-ranking sites per Section 4.3, with all three sites meeting this criterion.

4. Unacceptable impact on endemic threatened or endangered plant or animal species.

   Preliminary screening indicated all preliminary candidate sites should meet this criterion. Surveys were completed on the three highest-ranking sites per Section 4.3, with all three sites meeting this criterion.

5. Land use conflict.

   Per evaluation by Westinghouse Hanford Site Planning, all preliminary candidate sites meet this criterion.

4.3 ENGINEERING CRITERIA

The following is a description of the method used in awarding points against each of the engineering criteria, followed by the evaluation of each of the preliminary candidate sites by criterion.

4.3.1 Health and Safety

4.3.1.1 ALARA During Construction. A pristine site would have received a score of 10 points. As all sites are in or near the 200 areas, and considering the general nature of these areas, the maximum points awarded were 9. One point was subtracted for sites within boundary fences, because there is higher chance of unknown activities having occurred within these boundaries. One point was subtracted for sites within operable units, because there is a higher chance of encountering an unknown site or contamination plume. Points were subtracted for relative distance from existing waste structures, because there is a higher potential for encountering a contamination plume. Points were subtracted for sites where past practices in that section compels more concern.

Site A: This site is located outside the boundary fence for 200 East Area (no subtraction). It is outside any operable unit boundaries (no subtraction). This site was awarded 9 points.

Site B: This site is located outside the boundary fence for 200 East Area (no subtraction). It is outside any operable unit boundary (no subtraction). This site was awarded 9 points.

Site C: This site is located inside the boundary fence for 200 East Area (1 point subtracted). It is inside the 200-SS-1 operable unit boundary (1 point subtracted). It is located relatively near waste trenches (1 point subtracted). This site was awarded 6 points.

Site D: This site is located outside the boundary fence for 200 West Area (no subtraction). It is inside the 200-RO-1 operable unit boundary (1 point subtracted). It is located relatively near a waste ditch (1 point subtracted). This site has uncertain past practices (1 point subtracted). This site was awarded 6 points.

Site E: This site is located outside the boundary fence for 200 West Area (no subtraction). It is outside any operable unit boundaries (no subtraction). This site was awarded 9 points.

Site F: This site is located inside the boundary fence for 200 West Area (1 point subtracted). It is outside any operable unit boundaries (no subtraction). This site was awarded 8 points.

Site G: This site is located outside the boundary fence for 200 West Area (no subtraction). It is outside any operable unit boundaries (no subtraction). This site was awarded 9 points.

Summary:	Site A	Site B	Site C	Site D	Site E	Site F	Site G
	9 pts	9 pts	6 pts	6 pts	9 pts	8 pts	9 pts.

4.3.1.2 ALARA During Operation. One point was subtracted per 10,000 ft effluent is to be transported, because more distance introduces more opportunity for accidental release of effluent; two points were subtracted for sites requiring transport between 200 East and West areas (crossing personnel travel routes), because this would provide for greater exposure in the event of a release, and 1 point was subtracted for sites outside boundary fences, because this will provide easier access to uncleared/untrained individuals.

Site A: This site is located approximately 10,000 ft from the treatment facility site (1 point subtracted). It is outside the 200 East Area boundary fence (1 point subtracted). This site was awarded 8 points.

Site B: This site is adjacent to the treatment facility site (no subtraction). It is located outside the boundary fence for 200 East Area (1 point subtracted). This site was awarded 9 points.

Site C: This site is located approximately 14,500 ft from the treatment facility site (1 point subtracted). It is located inside the boundary fence for 200 East Area (no subtraction). This site was awarded 9 points.

Site D: This site is located approximately 44,000 ft from the treatment facility site (4 points subtracted). It requires transport from 200 East Area to 200 West Area (2 points subtracted). It is located outside the boundary fence for 200 West Area (1 point subtracted). This site was awarded 3 points.

Site E: This site is located approximately 48,000 ft from the treatment facility (5 points subtracted). It requires transport from 200 East Area to 200 West Area (2 points subtracted). It is located outside the boundary fence for 200 West Area (1 point subtracted). This site was awarded 2 points.

Site F: This site is located approximately 28,000 ft from the treatment facility site (3 points subtracted). It requires transport from 200 East Area to 200 West Area (2 points subtracted). It is located inside the boundary fence for 200 West Area (no subtraction). This site was awarded 5 points.

Site G: This site is located approximately 31,500 ft from the treatment facility site (3 points subtracted). It requires transport from 200 East Area to 200 West Area (2 points subtracted). It is located outside the boundary fence for 200 West Area (1 point subtracted). This site was awarded 4 points.

Summary:	Site A	Site B	Site C	Site D	Site E	Site F	Site G
	8 pts	9 pts	9 pts	3 pts	2 pts	5 pts	4 pts.

4.3.2 Environmental Impact

4.3.2.1 Travel Time for Tritium in Ground Water to Columbia River. A travel time of 10 half-lives would bring the tritium concentration down to drinking water standards; therefore, any site providing for a travel time of 10 or more half-lives for tritium was awarded the full 10 points. One point was subtracted for each half-life duration (approximately 12.5 yr) in travel time of less than 10 half-lives.

The ground water travel times used in this evaluation were taken from a report prepared by Golder Associates, Inc. (Appendix B). The information was developed through the Golder Associates, Inc. ground water package model, Aquifer Flow in Porous Media.

Site A: This site provides for a ground water travel time of approximately 20 yr, which is approximately 2 half-lives (8 points subtracted). This site was awarded 2 points.

Site B: This site provides for a ground water travel time of approximately 35 yr, which is approximately 3 half-lives (7 points subtracted). This site was awarded 3 points.

Site C: This site provides for a ground water travel time of approximately 16 yr, which is approximately 1 half-life (9 points subtracted). This site was awarded 1 point.

Site D: This site provides for a ground water travel time of approximately 56 yr, which is approximately 4 half-lives (6 points subtracted). This site was awarded 4 points.

Site E: This site provides for a ground water travel time of approximately 86 yr, which is approximately 7 half-lives (3 points subtracted). This site was awarded 7 points.

Site F: This site provides for a ground water travel time of approximately 75 yr, which is approximately 6 half-lives (4 points subtracted). This site was awarded 6 points.

Site G: This site provides for a ground water travel time of approximately 126 yr, which is approximately 10 half-lives (no subtraction). This site was awarded 10 points.

Summary:	Site A	Site B	Site C	Site D	Site E	Site F	Site G
	2 pts	3 pts	1 pt	4 pts	7 pts	6 pts	10 pts.

4.3.2.2 Impact Potential of Effluent Release. Up to 5 points were subtracted for travel time of ground water from point of release, because release point may provide for less decay of tritium before reaching the Columbia River; and points were subtracted for expected impact on locations of possible release, because release may affect travel time of an existing contamination plume to the Columbia River.

Site A: Release of effluent from transport piping to this site would provide for a possible travel time range of approximately 20 to 35 yr, depending on the point of release (4 points subtracted). If a release of effluent occurred, it could possibly be near a contamination plume (1 point subtracted). This site was awarded 5 points.

Site B: Release of effluent from transport piping to this site would provide for a travel time of approximately 35 yr (4 points subtracted). This site was awarded 6 points.

Site C: Release of effluent from transport piping to this site would provide for a possible travel time range of approximately 16 to 35 yr, depending on the point of release (4 points subtracted). If a release of effluent occurred, it could possibly be near a contamination plume (2 points subtracted). This site was awarded 4 points.

Site D: Release of effluent from transport piping to this site would provide for a possible travel time range of approximately 35 to 56 yr, depending on the point of release (4 points subtracted). If a release of effluent occurred, it could possibly be near a contamination plume (2 points subtracted). This site was awarded 4 points.

Site E: Release of effluent from transport piping to this site would provide for a possible travel time range of approximately 35 to 86 yr, depending on the point of release (3 points subtracted). If a release of effluent occurred, it could possibly be near a contamination plume (1 points subtracted). This site was awarded 6 points.

Site F: Release of effluent from transport piping to this site would provide for a possible travel time range of approximately 35 to 75 yr, depending on the point of release (3 points subtracted). This site was awarded 7 points.

Site G: Release of effluent from transport piping to this site would provide for a possible travel time range of approximately 35 to 126 yr, depending on the point of release (2 points subtracted). This site was awarded 8 points.

Summary:	Site A	Site B	Site C	Site D	Site E	Site F	Site G
	5 pts	6 pts	4 pts	4 pts	6 pts	7 pts	8 pts.

4.3.3 Operation Impact

4.3.3.1 Obstructions to or from Existing Operations. Points were subtracted for barriers between the preliminary candidate sites and the treatment facility site (e.g., fences, roads, transfer lines, other structures) which must be routed around or through during the construction of the effluent transport pipeline.

Site A: Barriers that exist between this site and the treatment facility site include B Pond and the Grout Site. Routing of the pipeline from the treatment facility to the disposal site could be accomplished around these barriers (1 point subtracted). This site was awarded 9 points.

Site B: This site is located adjacent to treatment facility site. One barrier exists, a rail line. Routing of the pipeline would be required through this barrier (1 point subtracted). This site was awarded 9 points.

Site C: Barriers that exist between this site and the treatment facility site include 200 East Area boundary fence and 200 East Area general. Pipeline from treatment facility to disposal site could be routed around some barriers and through others (3 points subtracted). This site was awarded 7 points.

Site D: Barriers that exist between this site and the treatment facility site include 200 East Area general, roads between 200 East and 200 West areas, and 200 West Area general. Pipeline from treatment facility to disposal site could be routed around some barriers and through others (5 points subtracted). This site was awarded 5 points.

Site E: Barriers that exist between this site and the treatment facility site include 200 East Area general, roads between 200 East and 200 West areas, and 200 West Area general. Pipeline from treatment facility to disposal site could be routed around some barriers and through others (6 points subtracted). This site was awarded 4 points.

Site F: Barriers that exist between this site and the treatment facility site include roads between 200 East and 200 West areas and 200 West Area boundary fence. Pipeline from treatment facility to disposal site could be routed around some barriers and through others (3 points subtracted). This site was awarded 7 points.

Site G: Barriers that exist between this site and the treatment facility site include roads between 200 East and 200 West areas and a rail line. Pipeline from treatment facility to disposal site could be routed around some barriers and through others (3 points subtracted). This site was awarded 7 points.

Summary:	Site A	Site B	Site C	Site D	Site E	Site F	Site G
	9 pts	9 pts	7 pts	5 pts	4 pts	7 pts	7 pts.

4.3.3.2 Interference with Existing Operations. Points were subtracted for anticipated functional impact to or from existing operations between the preliminary candidate sites and the treatment facility.

Site A: This site is located such that few operations and structures exist between it and the treatment facility site. Anticipated impact would be minimal (2 points subtracted). This site was awarded 8 points.

Site B: This site is located adjacent to treatment facility site, providing for virtually no interference. This site was awarded 10 points.

Site C: This site is located such that few operations and structures exist between it and the treatment facility site. Anticipated impact would be minor (3 points subtracted). This site was awarded 7 points.

Site D: This site is located such that a moderate number of operations and structures exist between it and the treatment facility site. Anticipated impact would be moderate (4 points subtracted). This site was awarded 6 points.

Site E: This site is located such that a moderate number of operations and structures exist between it and the treatment facility site. Anticipated impact would be moderate (5 points subtracted). This site was awarded 5 points.

Site F: This site is located such that few operations and structures exist between it and the treatment facility site. Anticipated impact would be minimal (2 points subtracted). This site was awarded 8 points.

Site G: This site is located such that few operations and structures exist between it and the treatment facility site. Anticipated impact would be minimal (2 points subtracted). This site was awarded 8 points.

Summary:	Site A	Site B	Site C	Site D	Site E	Site F	Site G
	8 pts	10 pts	7 pts	6 pts	5 pts	8 pts	8 pts.

4.3.4 Land Use

4.3.4.1 Compatibility with Long-Range Use Plans. Points were subtracted for adverse impact on long-range use plans.

Sites A & C: These sites are located in areas that are identified on long-range use plans for potential future production missions in the 200 areas (3 points subtracted).

All other sites are fully compatible with long-range use plans (no subtraction). All other sites were awarded 10 points.

Summary:	Site A	Site B	Site C	Site D	Site E	Site F	Site G
	7 pts	10 pts	7 pts	10 pts	10 pts	10 pts	10 pts.

4.3.4.2 Adjacent Land Available for Use in Future Expansion. Points were subtracted for sites of limited area.

All Sites: All sites have more than required additional space (no subtraction). All sites were awarded 10 points.

Summary:	Site A	Site B	Site C	Site D	Site E	Site F	Site G
	10 pts	10 pts	10 pts	10 pts	10 pts	10 pts	10 pts.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Evaluation results are tabulated for reference and included as follows. Table 1 represents the raw numbers from the evaluation of the site following the site visit. Table 2 represents these raw numbers condensed to category. This was accomplished by taking a simple average of all criteria under that category. Table 3 represents the weighting matrix; therein the adjusted raw numbers were multiplied by the weighting factor and totaled for each preliminary candidate site. These values are graphically represented as Figure 2.

Preliminary candidate sites G, B and F rank the highest in total points. These three sites also represent the best category totals of each of the major categories of criteria for this siting (i.e., health and safety and environmental impact). Also, though cost will be addressed in a future cost/benefit analysis, these sites represent the highest variance in cost for this project.

Per this evaluation, it is recommended that these same three highest ranked sites be identified as the candidate sites and be carried forward for characterization and full evaluation.

Table 1. Raw Numbers for Each Criterion.

	Site A	Site B	Site C	Site D	Site E	Site F	Site G
Health and Safety:							
ALARA during construction	9	9	6	6	9	8	9
ALARA during operation	8	9	9	3	2	5	4
Environmental Impact:							
Travel time of tritium to Columbia River	2	3	1	4	7	6	10
Impact Potential of effluent release	5	6	4	4	6	7	8
Operational Impact:							
Obstruction from existing structures	9	9	7	5	4	7	7
Interference with existing structures	8	10	7	6	5	8	8
Land Use:							
Compatibility with long range use plans	7	10	7	10	10	10	10
Land available for future expansion	10	10	10	10	10	10	10

Table 2. Raw Numbers Adjusted to Category (Average Points of All Criteria in that Category).

	Site A	Site B	Site C	Site D	Site E	Site F	Site G
Health and Safety	8.5	9	7.5	4.5	5.5	6.5	6.5
Environmental Impact	3.5	4.5	2.5	4	6.5	6.5	9
Operational Impact	8.5	9.5	7	5.5	4.5	7.5	7.5
Land Use	8.5	10	8.5	10	10	10	10

Table 3. Total Points Each Site, by Weighting Matrix (Sum of Raw Numbers times Weighting Values).

	Weighting Value	Site A	Site B	Site C	Site D	Site E	Site F	Site G
Health and Safety	5	42.5	45	37.5	22.5	27.5	32.5	32.5
Environmental Impact	5	17.5	22.5	12.5	20	32.5	32.5	45
Operational Impact	3	25.5	28.5	21	16.5	13.5	22.5	22.5
Land Use	2	17	20	17	20	20	20	20
Total Points		103	116	88	79	93.5	108	120

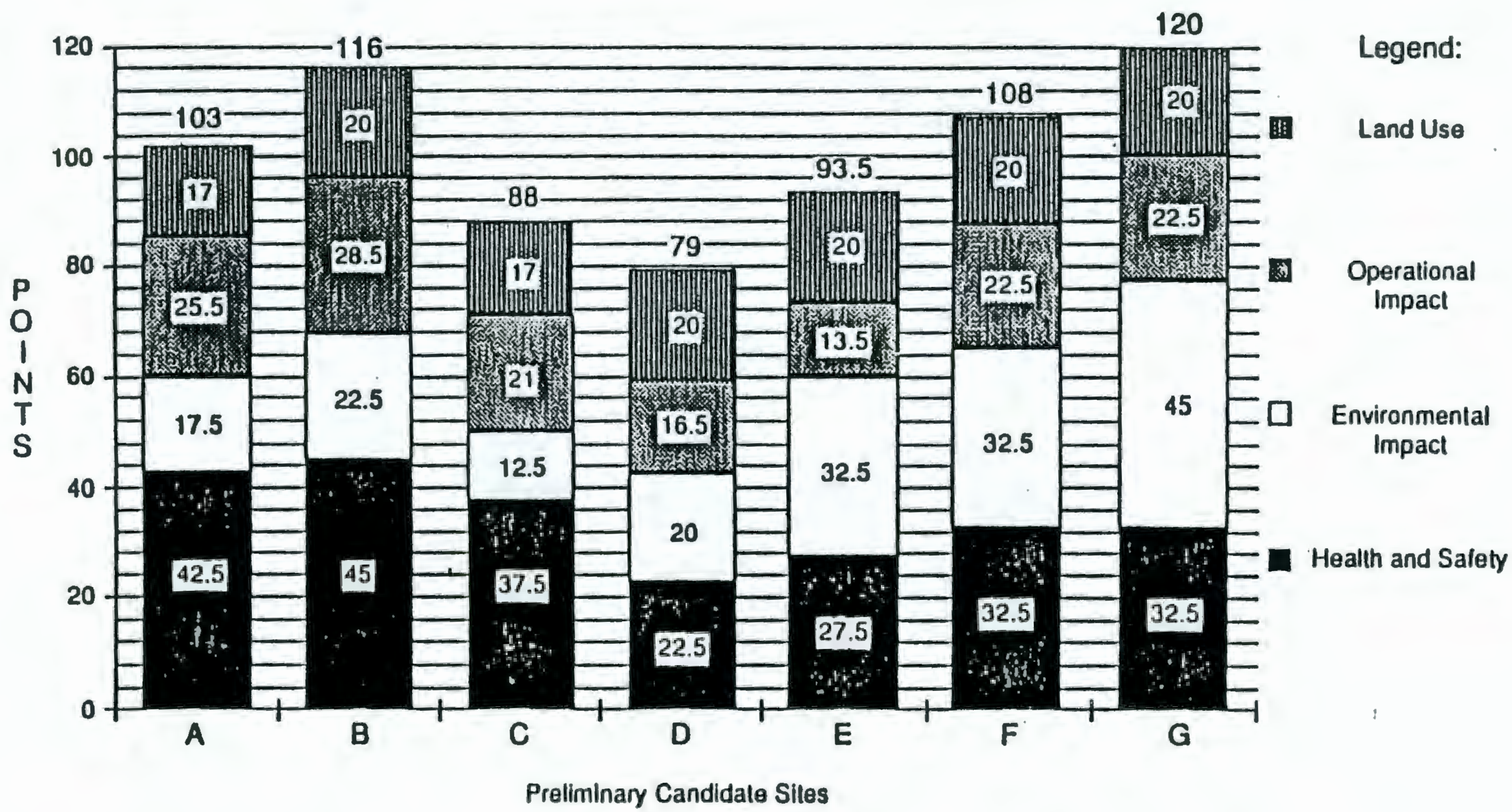


Figure 2. Total Points for Each Preliminary Candidate Site by Engineering Criteria.

6.0 REFERENCES

Chatters, J. C., 1989, *Hanford Cultural Resource Management Plan*, PNL 6942, Pacific Northwest Laboratory, Richland, Washington.

DOE, 1989, *General Design Criteria*, DOE Order 6430.1A, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1990, *Site Selection*, DOE Order 4320.2C, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1987, *Plan and Schedule to Discontinue Disposal of Contaminated Liquids into the Soil Column at the Hanford Site*, DOE 0065, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, 1988, State *Waste Discharge Permit Program*, Washington Administrative Code 173-216, Washington Department of Ecology, Olympia, Washington.

Flyckt, D. L. and R. L. McCormack, 1990, *242-A Evaporator and the PUREX Plant Condensate Treatment Facility*, WHC-SD-C018-FDC-001, Westinghouse Hanford Company, Richland, Washington.

Trost, E. T., 1989, *200 Area Effluent Retention and Treatment Complex (ERTC) and 200 Area TEDF*, WHC-SD-WM-SE-011, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988, *Environmental Compliance*, WHC-CM-7-5, Westinghouse Hanford Company, Richland, Washington.

WHC, 1989a, *ALARA Program Manual*, WHC-CM-4-11, Westinghouse Hanford Company, Richland, Washington.

WHC, 1989b, *Preliminary Operable Units Designation Project*, WHC-EP-0216, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

PRELIMINARY CANDIDATE SITE LOCATIONS

APPENDIX A

PRELIMINARY CANDIDATE SITE LOCATIONS

Figures A-1 to A-7 show the preliminary candidate site locations for the 242-A Evaporator and the Plutonium Uranium Extraction Plant Condensate Treatment Facility.

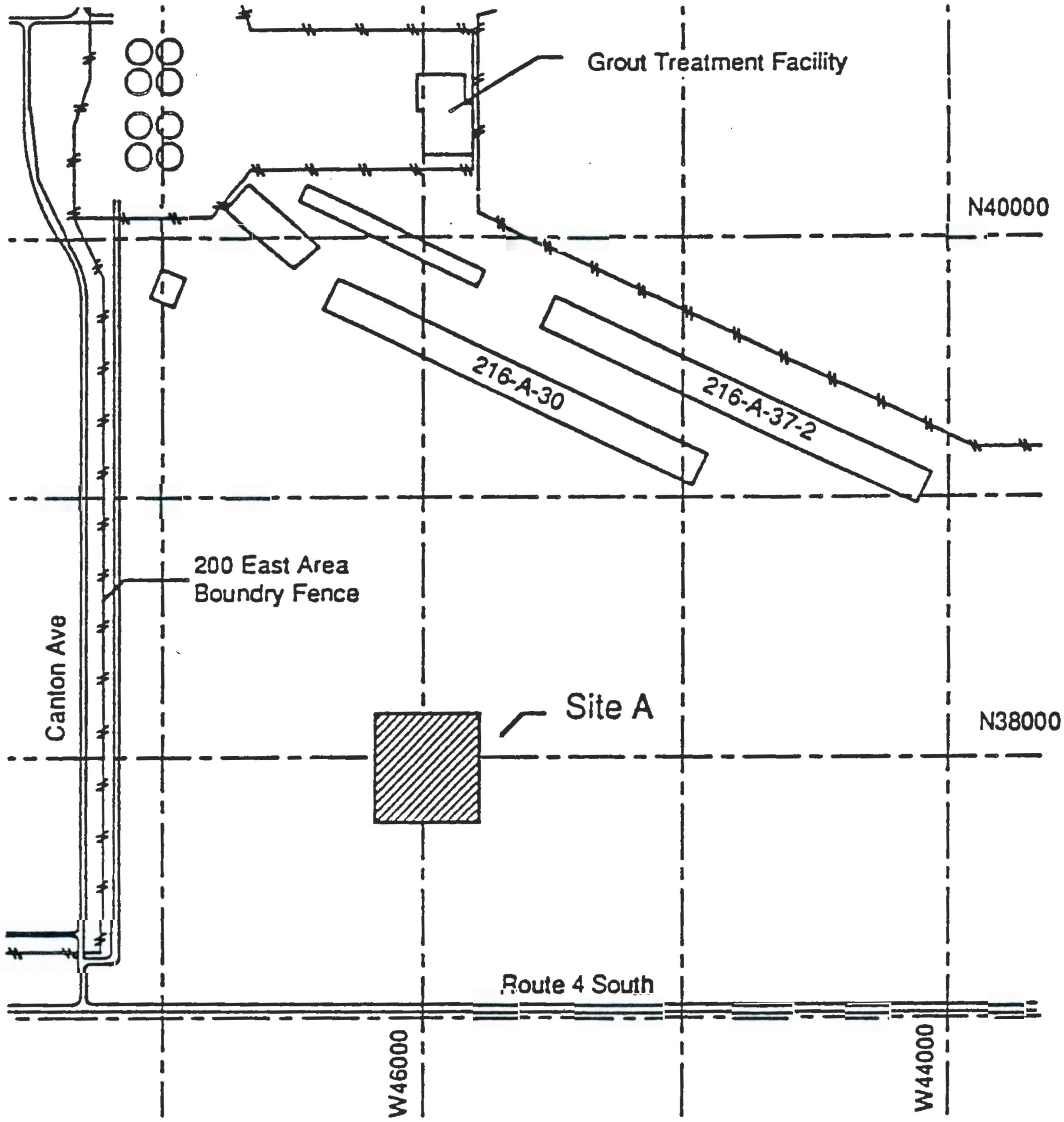


Figure A-1. Preliminary Candidate Site A.

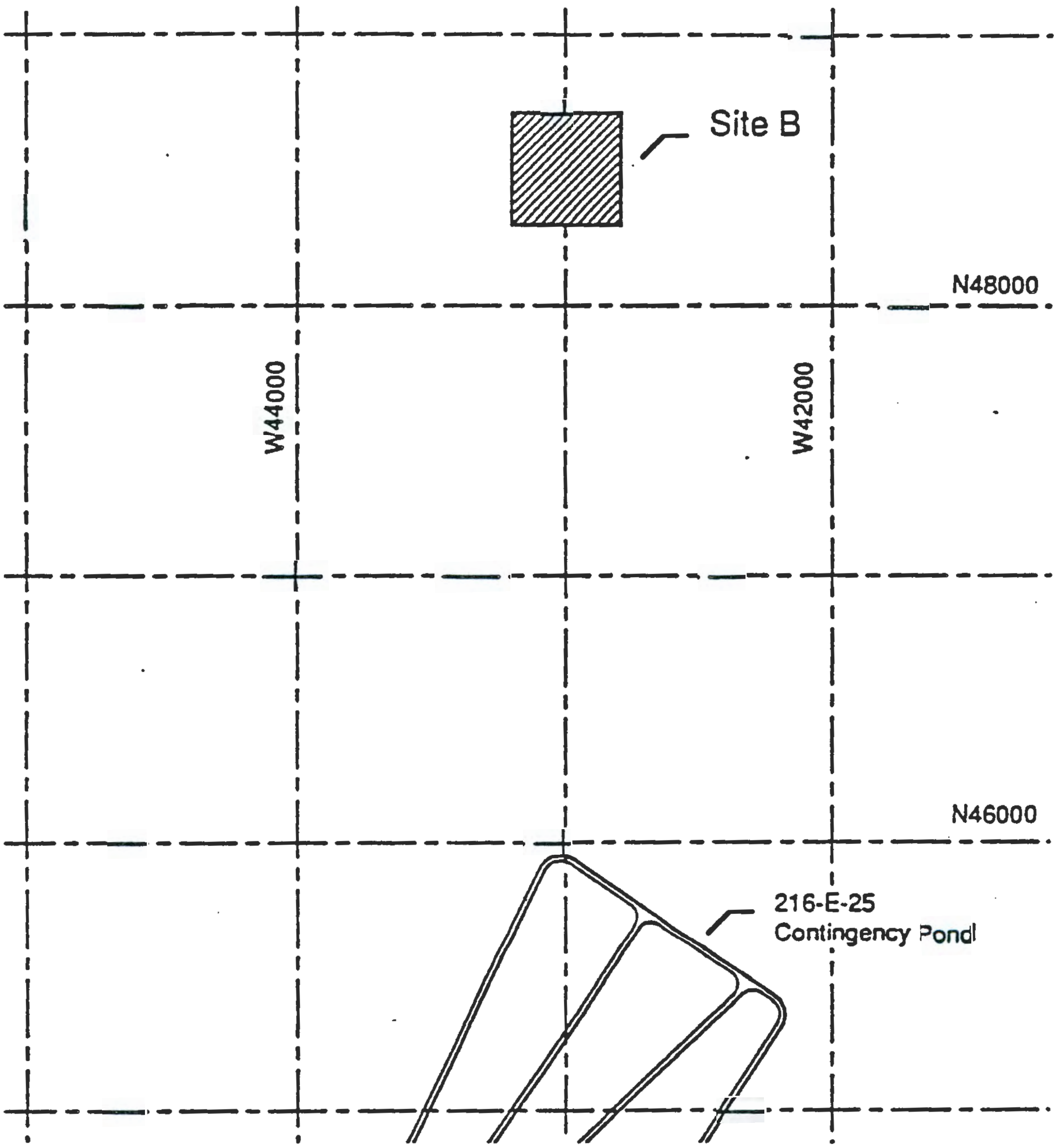


Figure A-2. Preliminary Candidate Site B.

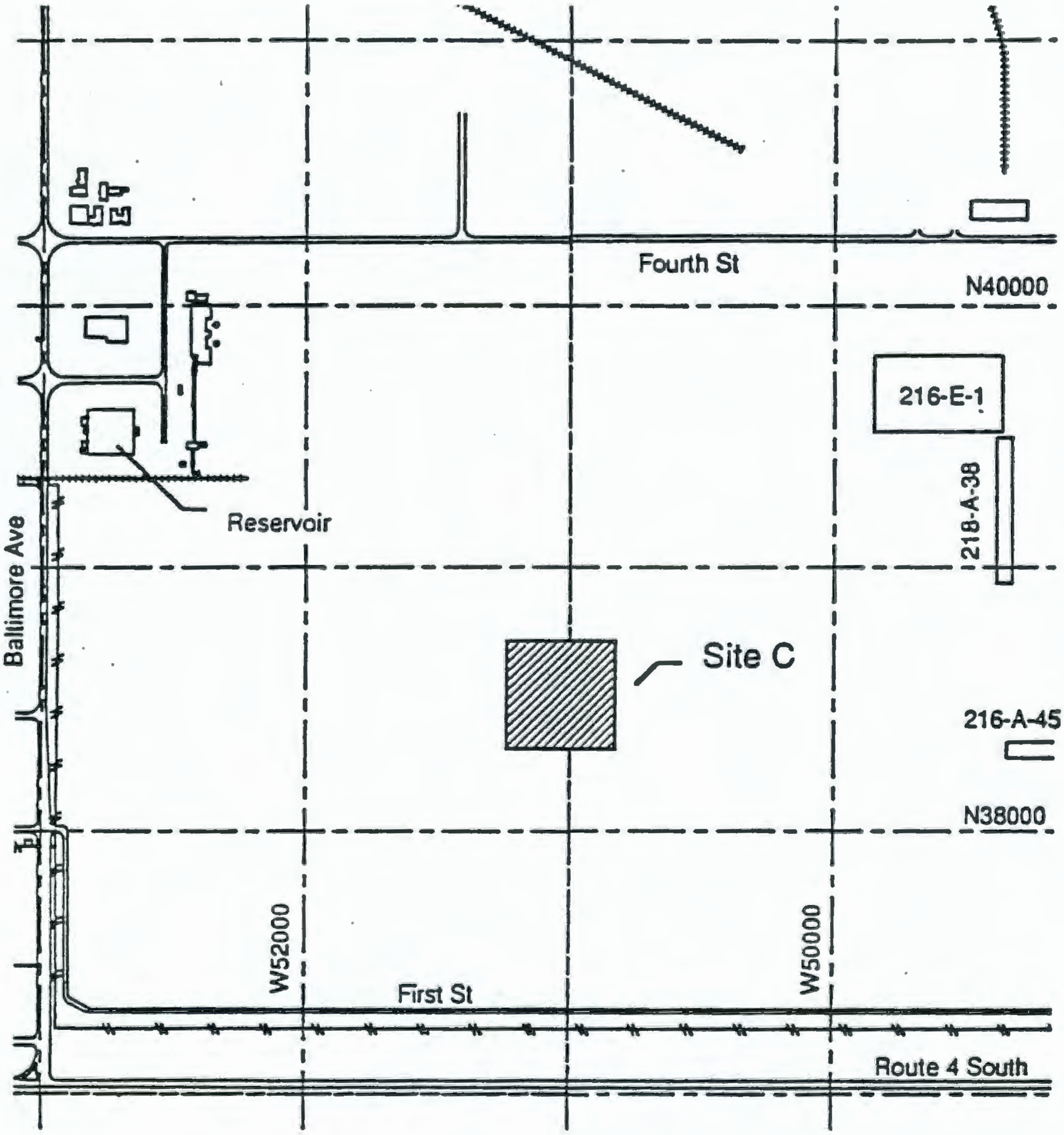


Figure A-3. Preliminary Candidate Site C.

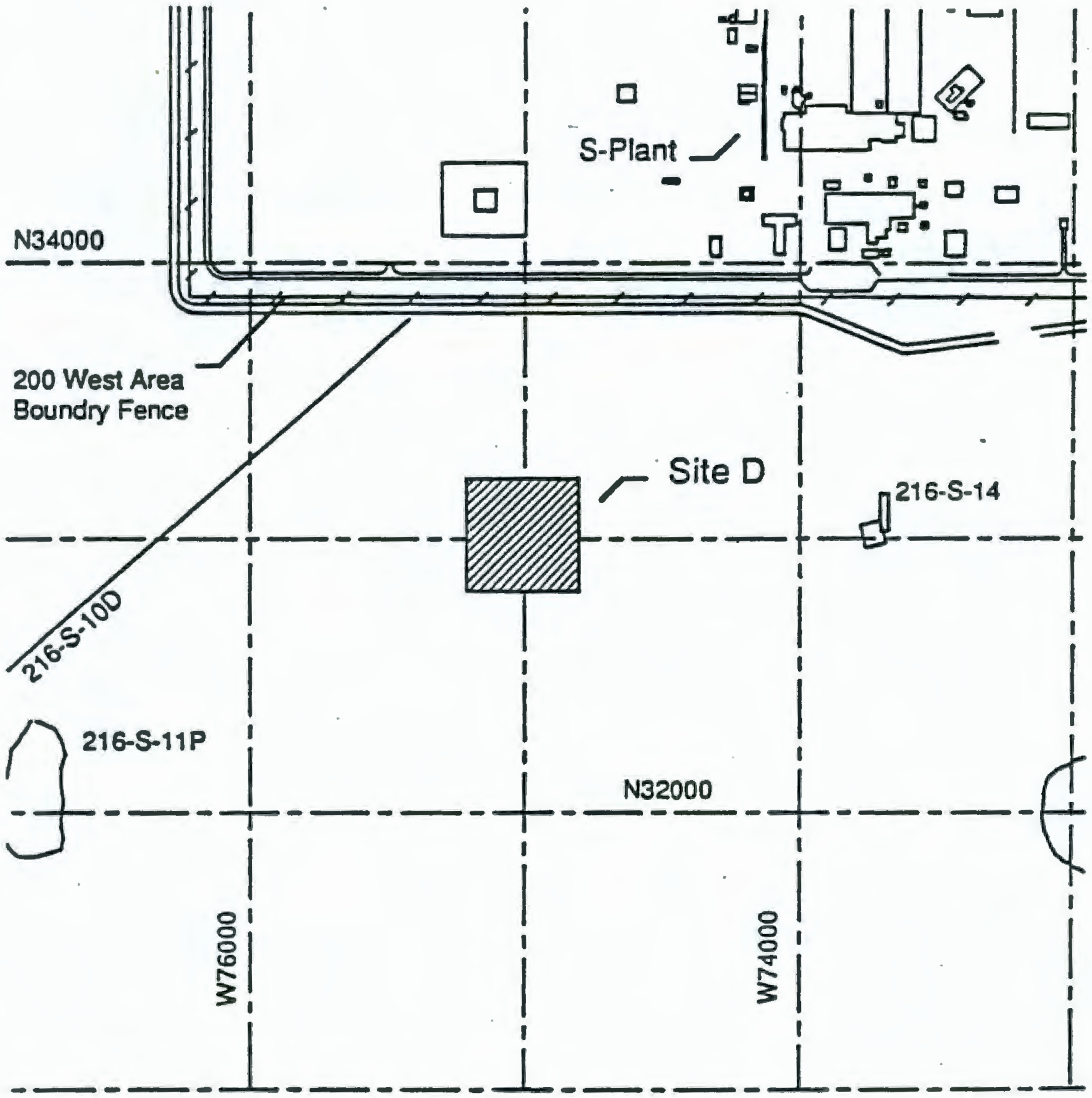


Figure A-4. Preliminary Candidate Site D.

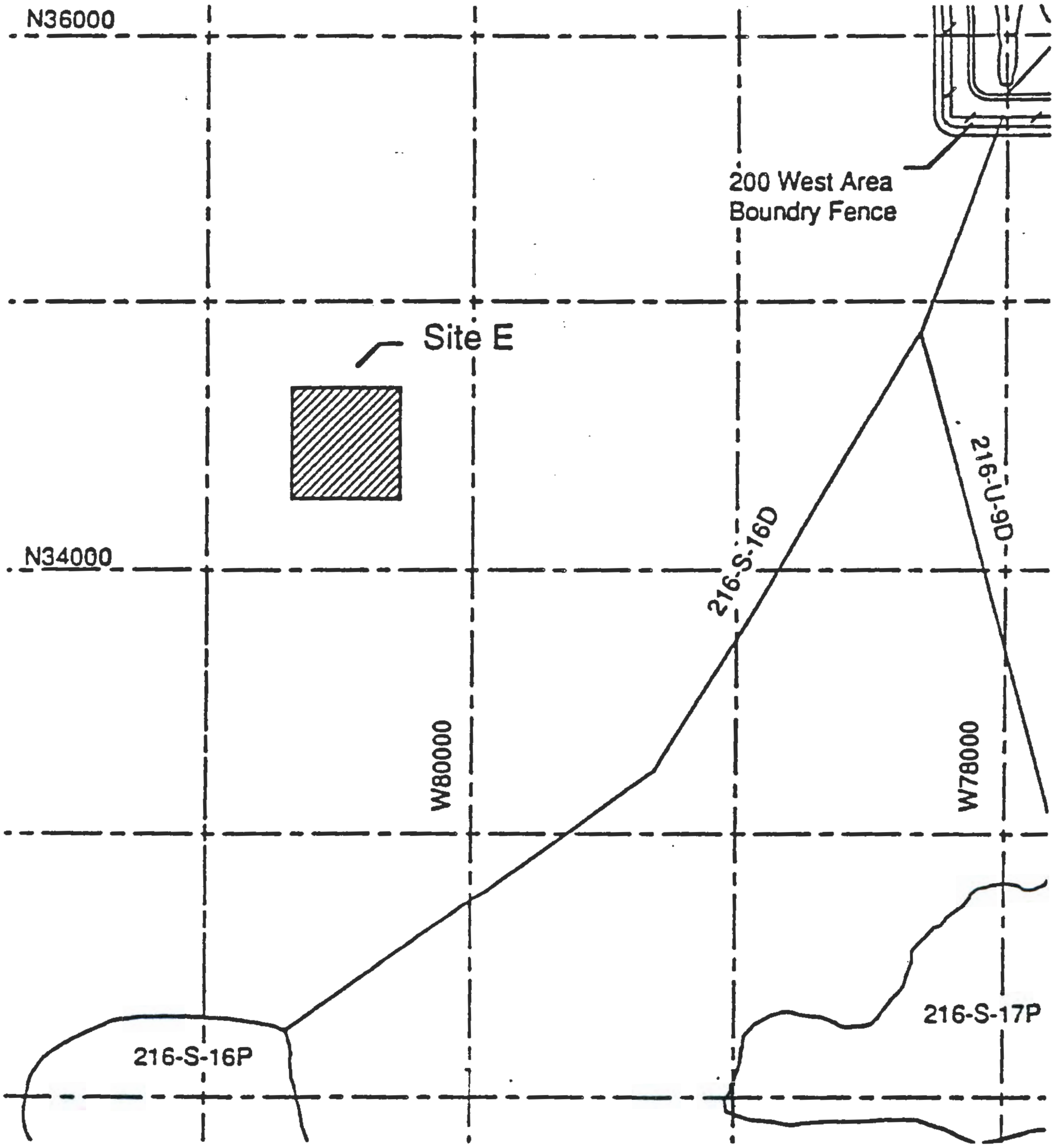


Figure A-5. Preliminary Candidate Site E.

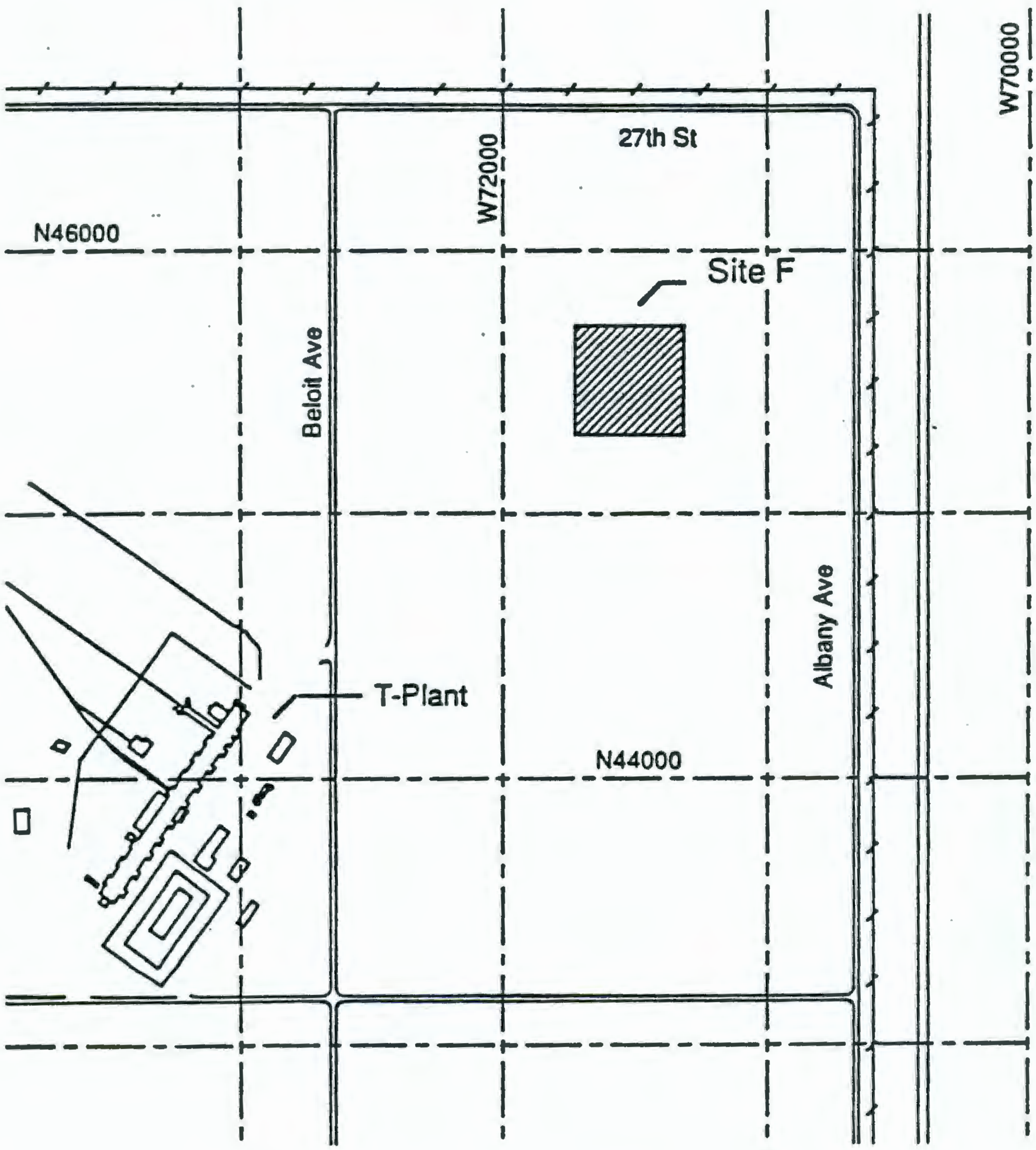


Figure A-6. Preliminary Candidate Site F.

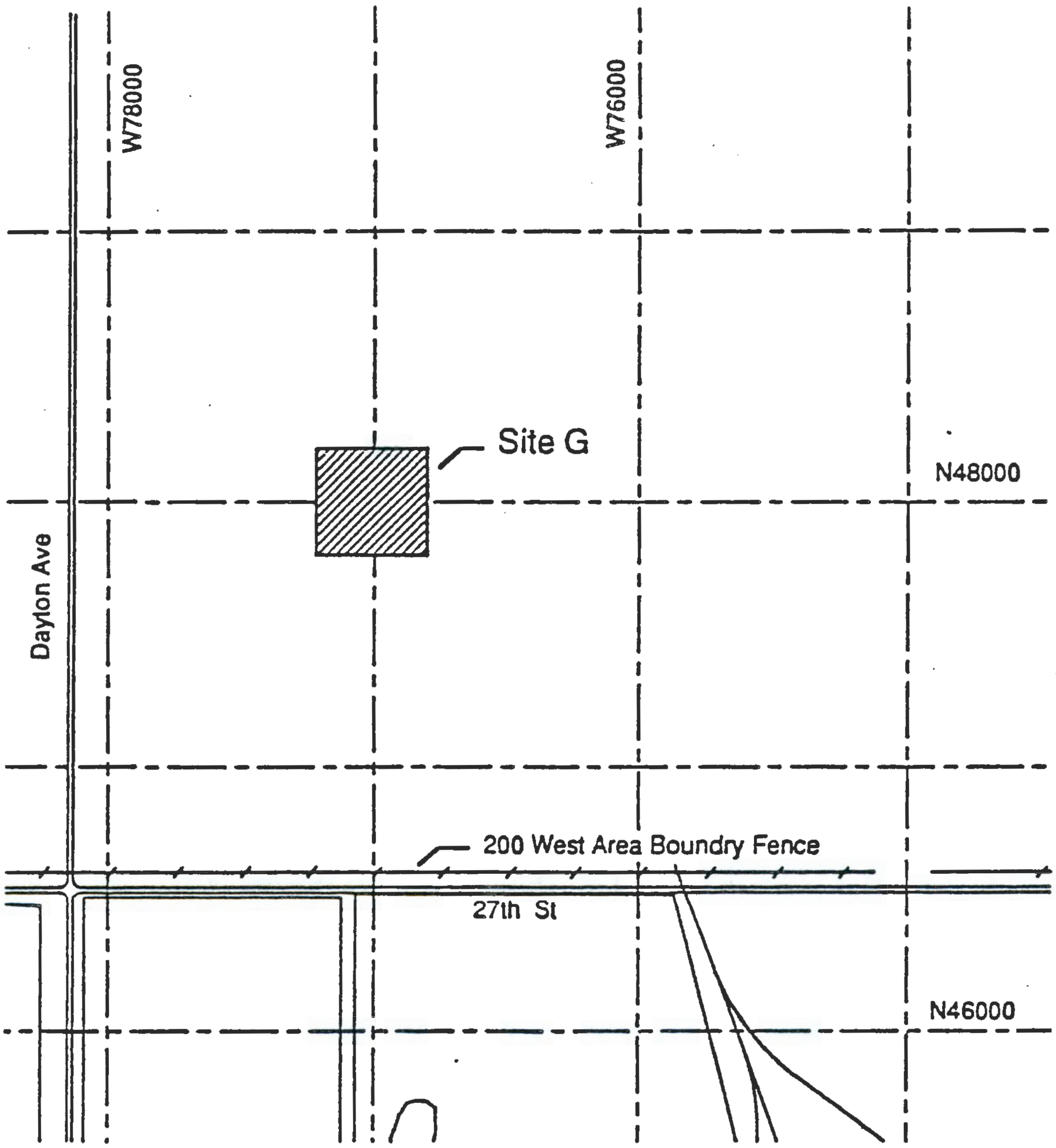


Figure A-7. Preliminary Candidate Site G.

APPENDIX B

TRAVEL TIME ESTIMATES FOR ALTERNATIVE TRITIUM CRIB LOCATIONS HANFORD SITE, WASHINGTON

Golder Associates Inc.
CONSULTING ENGINEERS

FINAL REPORT TO WESTINGHOUSE HANFORD COMPANY

TRAVEL TIME ESTIMATES FOR ALTERNATIVE TRITIUM CRIB LOCATIONS HANFORD SITE, WASHINGTON

Prepared by:

Golder Associates Inc.

Charles R. Wilson

Charles R. Wilson
Associate

March 30, 1990 893-1433

GOLDER ASSOCIATES INC. • 4104 - 148TH AVENUE N.E., REDMOND (SEATTLE), WASHINGTON, U.S.A. 98052 • TEL. (206) 883-0777 • FACSIMILE (206) 882-5498 • TELEX 5106002944

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

This report provides estimates of groundwater travel times to the Columbia River from eight alternative tritium crib locations on the Hanford Site. The estimates were made using a two-dimensional, finite element model of the uppermost aquifer at the Hanford Site. This model was prepared by Golder Associates to support an earlier investigation of alternative soil column disposal locations for process waste streams from the 200 Areas. This earlier investigation is summarized in Appendix H of the report "200 Area Treated Effluent Disposal Study" (Engineering-Science, Inc., 1989), and has been included for reference as Appendix A to this report.

This report is presented in four sections. Following this introduction, a discussion of the groundwater model is presented in Section 2. The input parameters for this study and the results obtained are discussed in Section 3, and conclusions and recommendations are presented in Section 4.

2. HANFORD SITE GROUNDWATER MODEL

The Hanford Site groundwater model used in this study was developed using Golder Associate's Golder Groundwater Package. This modeling package contains state-of-the-art finite element computer programs for simulation of groundwater flow and contaminant transport, as well as graphics programs for presenting results. For this study, the program AFPM (Aquifer Flow in Porous Media) was used in its two-dimensional form. The program accommodates variable aquifer properties, a changing phreatic surface, transient boundary conditions, and other characteristics useful for groundwater modeling at the Hanford Site.

Development and calibration of the groundwater model is discussed in detail in Appendix A, and will only be summarized here. The modeled region and finite element mesh are shown in Figure 1, and were determined based upon the principal geologic heterogeneities, groundwater flow patterns, and boundary conditions at the Hanford Site. The model contains 976 nodes and 920 elements. Most of the elements are square with side lengths of 3,275 ft.

Boundary conditions were defined as explained in Appendix A and shown in Figure 1. The base of the aquifer was estimated from Plate III-2 in Gephart et al. (1979). The thickness of the aquifer and therefore the transmissivity varied within regions of constant hydraulic conductivity. Initial hydraulic conductivity values were estimated from Plate III-5 in Gephart et al. (1979). These conductivities were then modified in a series of calibration runs until reasonably close comparisons were obtained for both 1944 and 1979 phreatic surfaces. The final hydraulic conductivities used in the model are shown in Figure 2. Effective porosities were determined using the model-generated flowpaths and the actual travel times of known tritium plumes on the Hanford Site. This process is also described in Appendix A. Effective porosities were found to be correlated with hydraulic conductivity, and are estimated to range from 0.15 to 0.25 as shown in Figure 2. The hydrogeologic properties and boundary conditions used in this study are the same as those developed for the aforementioned 200 Area study (Engineering-Science, Inc., 1989).

3. ALTERNATIVE CRIB ANALYSIS AND RESULTS

3.1 Model Parameters

Travel time analyses were made for hydrologic conditions on the Hanford Site with B-Pond in operation (Case 1), and without B-Pond in operation (Case 2). Both cases were studied using hydrologic boundary conditions developed for the aforementioned 1979 model calibration. In both cases, natural groundwater recharge was assumed to be provided only from subsurface inflow from Cold Creek and Dry Creek Valleys; no recharge was assumed from infiltration of direct precipitation. In the Case 1 study, additional artificial recharge was assumed only from B-Pond, and in the Case 2 study no additional source of artificial recharge was assumed. The results are therefore intended to represent near-future conditions when artificial recharge from all major facilities (except B-Pond in Case 1) has ceased and the underlying groundwater mounds have dissipated.

The hydraulic head contours for the uppermost aquifer under Case 1 conditions (with B-Pond) are shown in Figure 3. The groundwater mound beneath B-Pond is evident in the central part of the model area. The steady-state B-Pond inflow was assumed to be 16.5 million gallons per day (2.2×10^6 ft^3/day), based on information provided by Westinghouse Hanford Company (WHC).

The hydraulic head contours for the uppermost aquifer under Case 2 conditions (without B-Pond) are shown in Figure 4. This is the same as Figure H-7 of Appendix A.

3.2 Travel Time Results

Travel times were estimated for the eight crib locations A through H shown in Figures 5 and 6. Locations A through F were described in the initial WHC Task Order, and locations G and H were added from subsequent discussions with the WHC technical liaison. Inflow into the tritium cribs was assumed to be the same at each location, and equal to 11,300 ft^3/day. This inflow rate is sufficiently small that no mounding beneath any of the cribs could be discerned from the hydraulic head contour maps. The crib discharges were therefore assumed to have no influence on groundwater flow rates and directions.

The crib inflow is equal to the combined average flow of the effluent waste streams from PUREX Process Condensate (8,000 ft^3/day) and from the 242-A Evaporator Process Condensate (3,300 ft^3/day)(Engineering-Science, Inc., 1989, Table 2.1). These two waste streams have the highest average tritium concentrations and when combined account for approximately 88 percent of the total tritium release from the PUREX and 242-A Evaporator facilities (Engineering-Science, Inc., 1989, Table A.1).

Tritium travel time is expected to be the same as groundwater travel time because the tritium molecule is very similar to the natural water molecule and is non-sorbing. Estimated travel times are shown in Figure 5 for Case 1 with B-Pond, and in Figure 6 for Case 2 without B-Pond. All travel time results are summarized in Table 1. All travel times are expressed to the nearest whole year, without further rounding, to indicate the relative differences for the various crib locations; however, this should not be taken as an indication of the accuracy of the estimates. Although the actual accuracy of the estimates is not known, based upon a comparison of simulated results with observed plume travel times, the error may be approximated to be about plus or minus 30 percent.

Tritium travel times were found to range from 20 to over 130 years for the various crib locations and hydrologic conditions. In general, travel times without B-Pond are longer than with B-Pond because of the increased hydraulic gradients caused by the B-Pond mound. As would be expected, these differences are greatest for the locations near B-Pond. Exceptions occur only at crib locations A and H: the path length from crib A to the river is shorter without B-Pond and requires less travel time; and the path from crib H to the river passes through higher conductivity materials without B-Pond and requires less travel time.

Tritium crib H is of potentially greatest interest because of its estimated travel time in excess of 100 years. The travel time from this crib is large because of the long flow path within the zone of lowest hydraulic conductivity in the model, shown in Figure 2. About 70 percent of the travel time from crib H occurs within this low conductivity zone, and its influence on the results is therefore significant.

4. CONCLUSIONS AND RECOMMENDATIONS

Based upon the results obtained, the longest estimated travel time and therefore the most attractive location for a tritium disposal crib is at point H on Figures 5 and 6. Considering that the half-life of tritium is about 12.3 years, a travel time of 130 years would consume more than 10 half lives. The residual tritium concentration upon release to the river would be about 0.1 percent of the original concentration discharged to the crib.

Before making a final selection of crib location, a relatively simple sensitivity study of the model to the various uncertainties in input parameters is recommended. Of particular importance would be a thorough review of available hydraulic conductivity data and an evaluation of the effect of small amounts of groundwater recharge from direct precipitation on the calibrated hydraulic conductivity values. The uncertainties related to the primary mechanisms of groundwater recharge assumed in the model are discussed in Appendix A. The average rate of recharge on the Hanford Site from natural precipitation is currently the subject of extensive research by WHC and Pacific Northwest Laboratory personnel, and highly variable results have been obtained based on ground surface conditions (Gee, 1987, p. 5.1). The calibrated hydraulic conductivity values may change if recharge from direct precipitation is considered, and, as has been seen, the estimated travel time is relatively sensitive to hydraulic conductivity.

REFERENCES

Engineering-Science, Inc., 1989. 200 Area Treated Effluent Disposal Study. Prepared for Westinghouse Hanford Company, Richland, Washington, by Engineering-Science, Inc., Denver, Colorado, under contract to Golder Associates Inc., Redmond, Washington, April.

Gee, G.W., 1987. Recharge at the Hanford Site: Status Report. Pacific Northwest Laboratory Report PNL-6403, Richland, Washington, November.

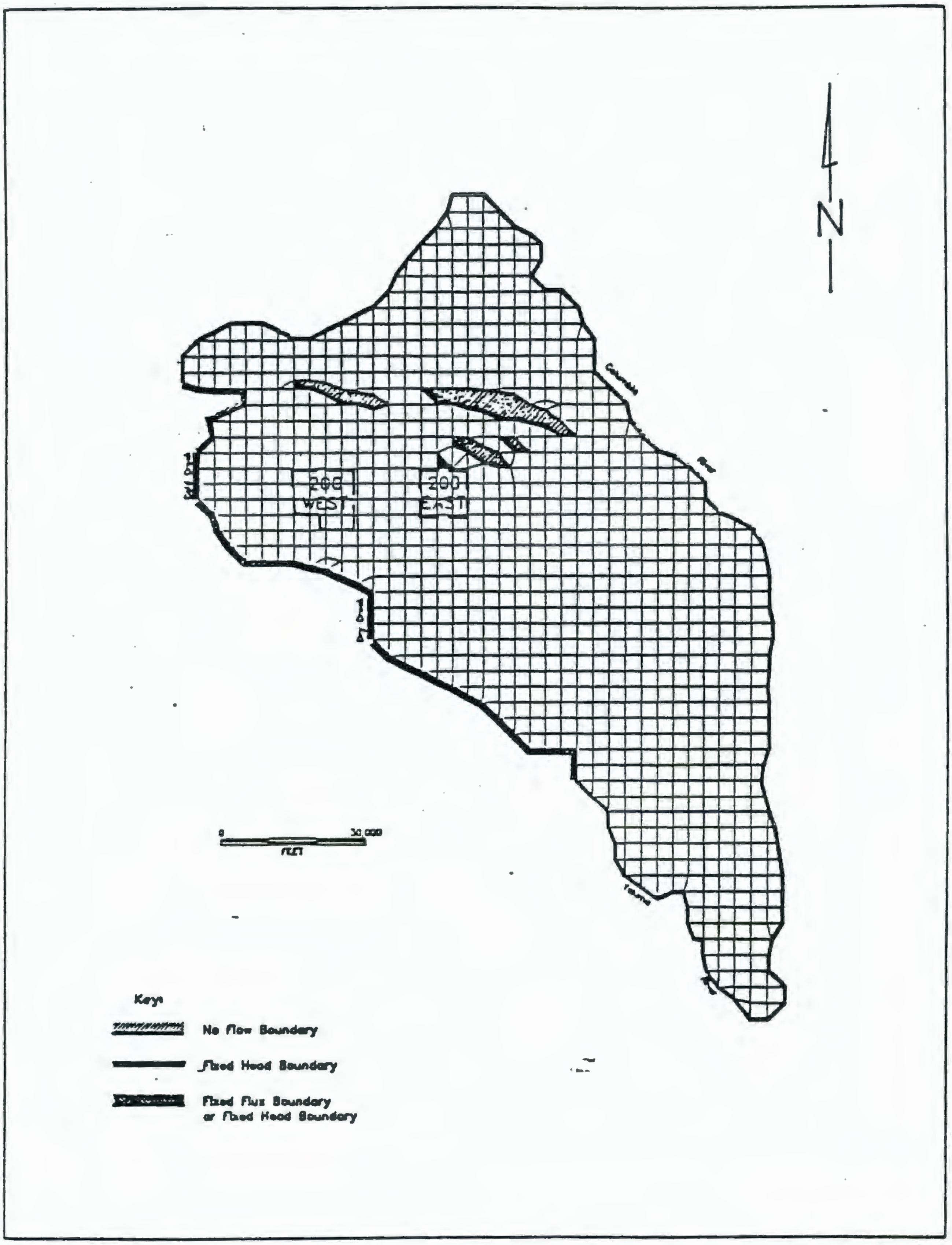
Gephart, R.E., R.C. Arnett, R.G. Baca, L.S. Leonhart, and F.A. Spane, Jr., 1979. Hydrologic Studies within the Columbia Plateau, Washington: An Integration of Current Knowledge. Rockwell Hanford Operations Report RHO-BWI-ST-5, Richland, Washington.

TABLE 1

TRITIUM TRAVEL TIME RESULTS

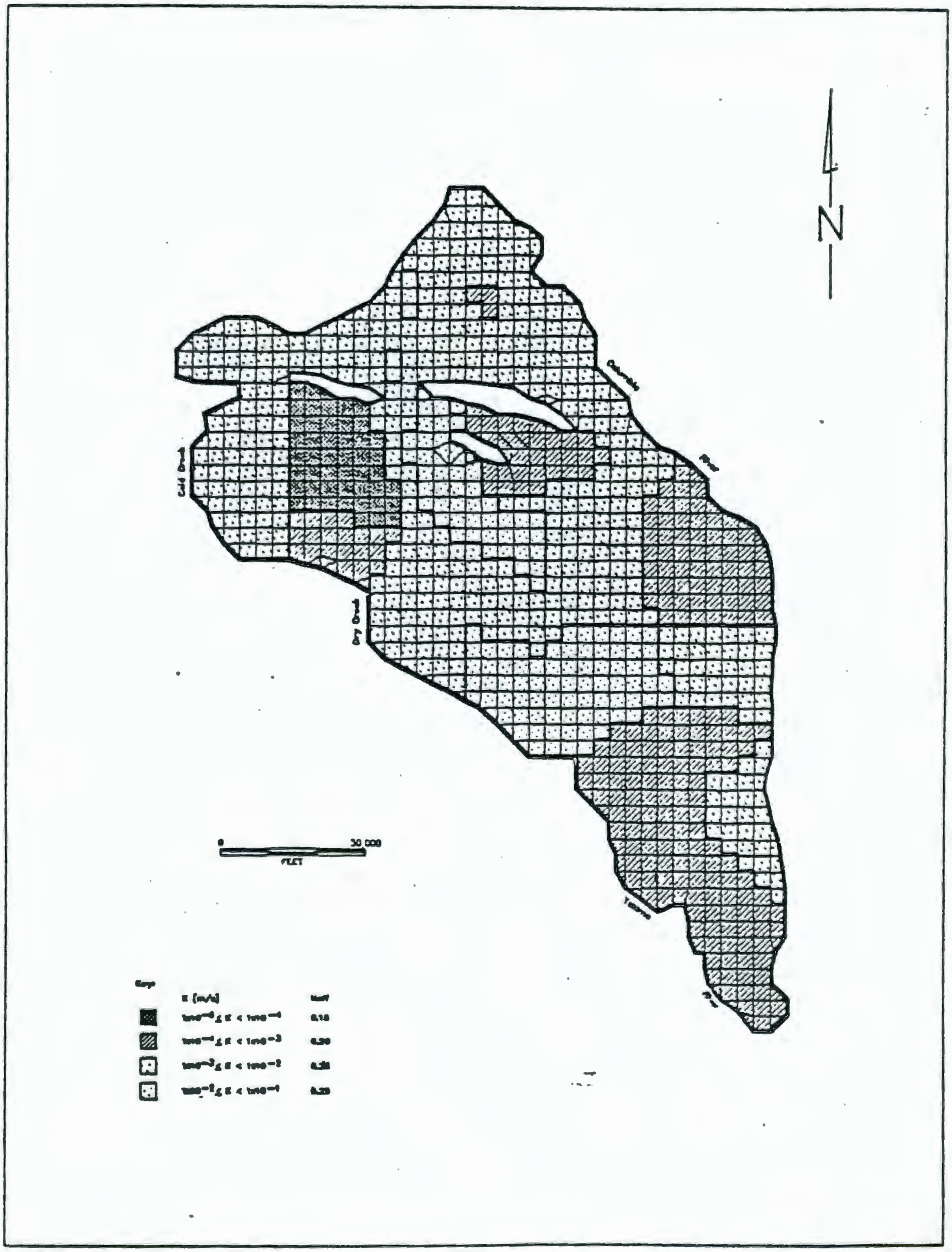
Tritium Crib	Estimated Travel Time*	
	With B-Pond (years)	Without B-Pond (years)
A	22	20
B	35	54
C	16	48
D	56	72
E	86	87
F	64	69
G	75	80
H	134	126

* Estimated standard error is plus or minus 20 percent.



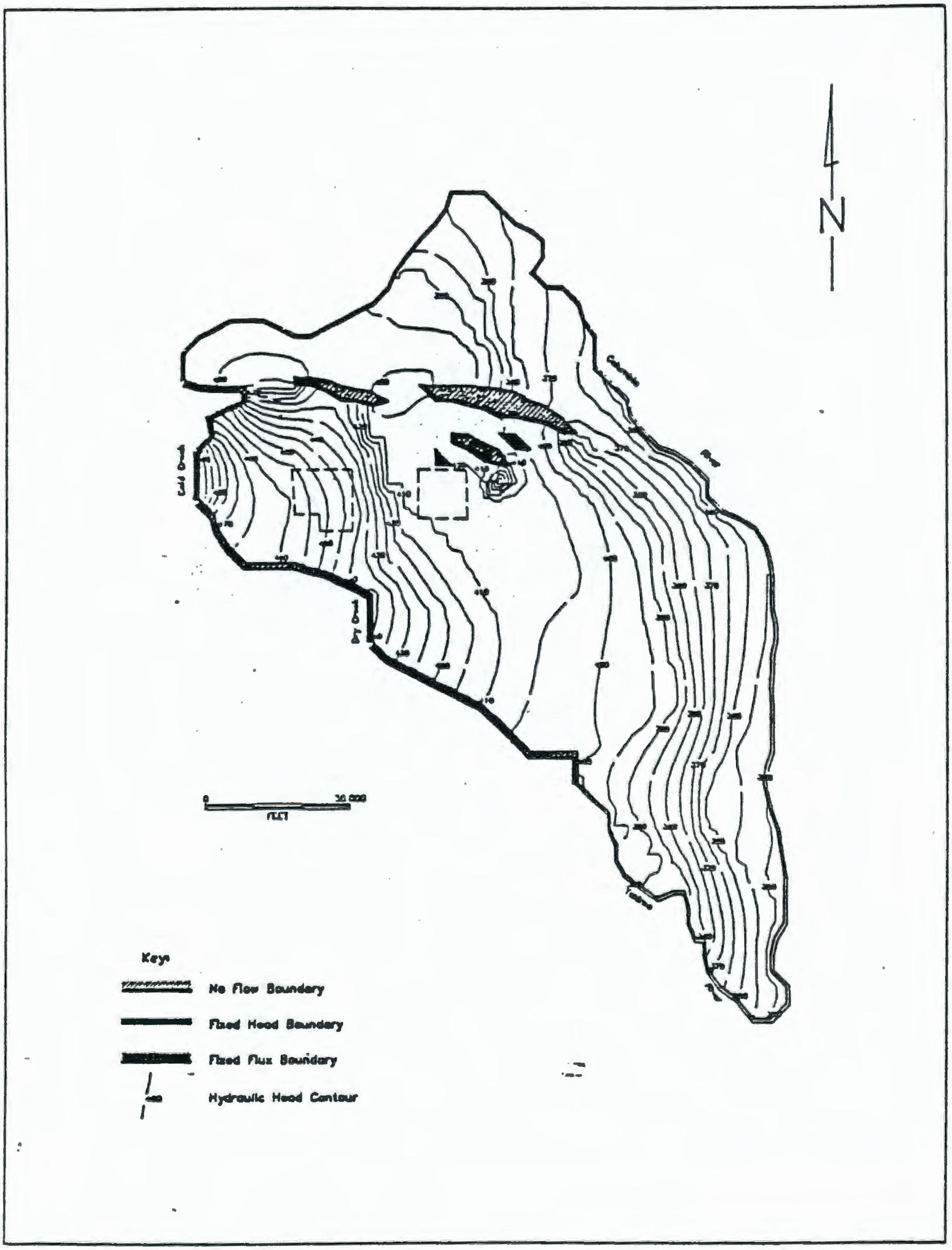
8931433\33568

Figure 1. Finite Element Grid.



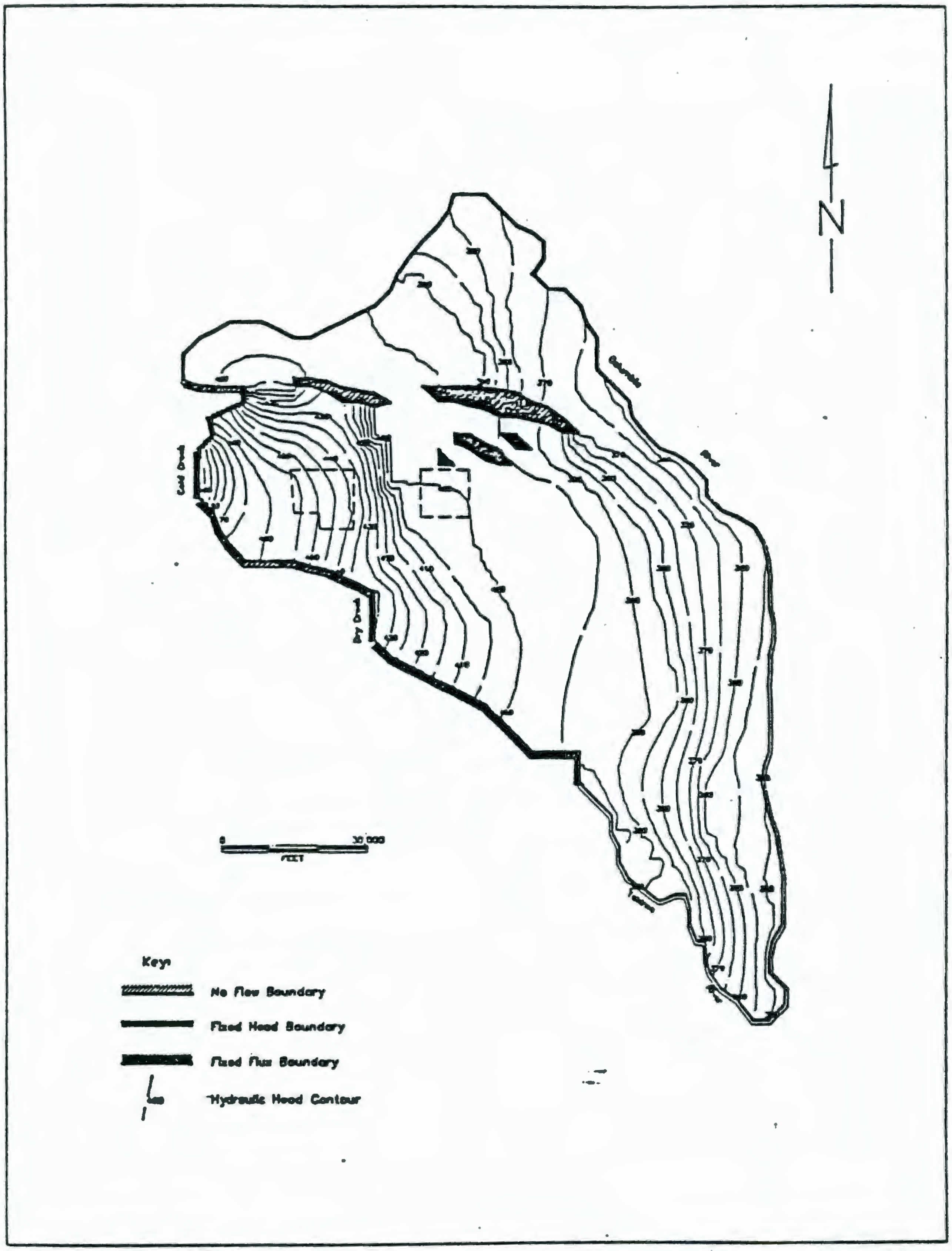
8931433\33569

Figure 2. Model Hydraulic Conductivities.



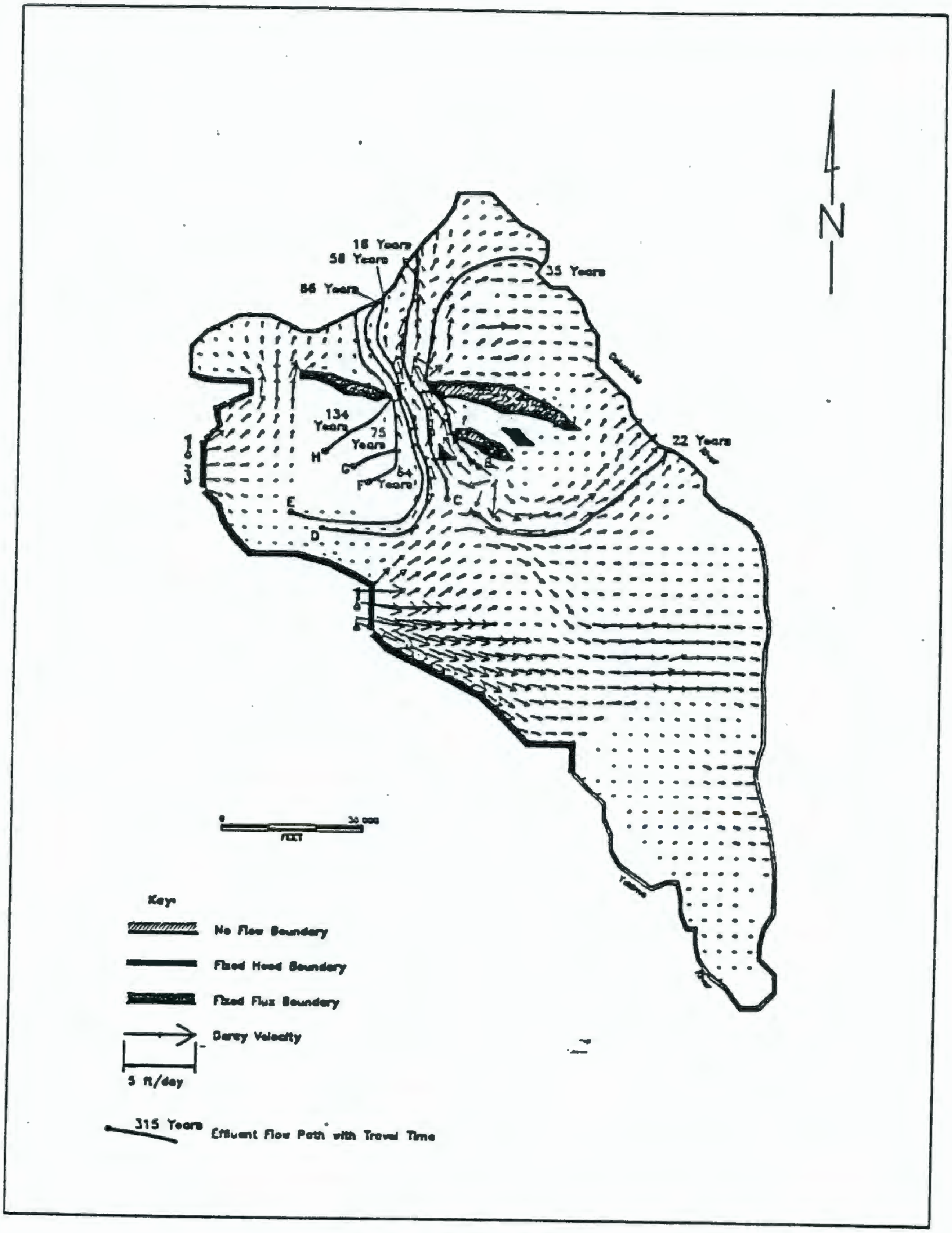
8931433\33570

Figure 3. Hydraulic Head Contours.
Case 1: With B-Pond Operating.



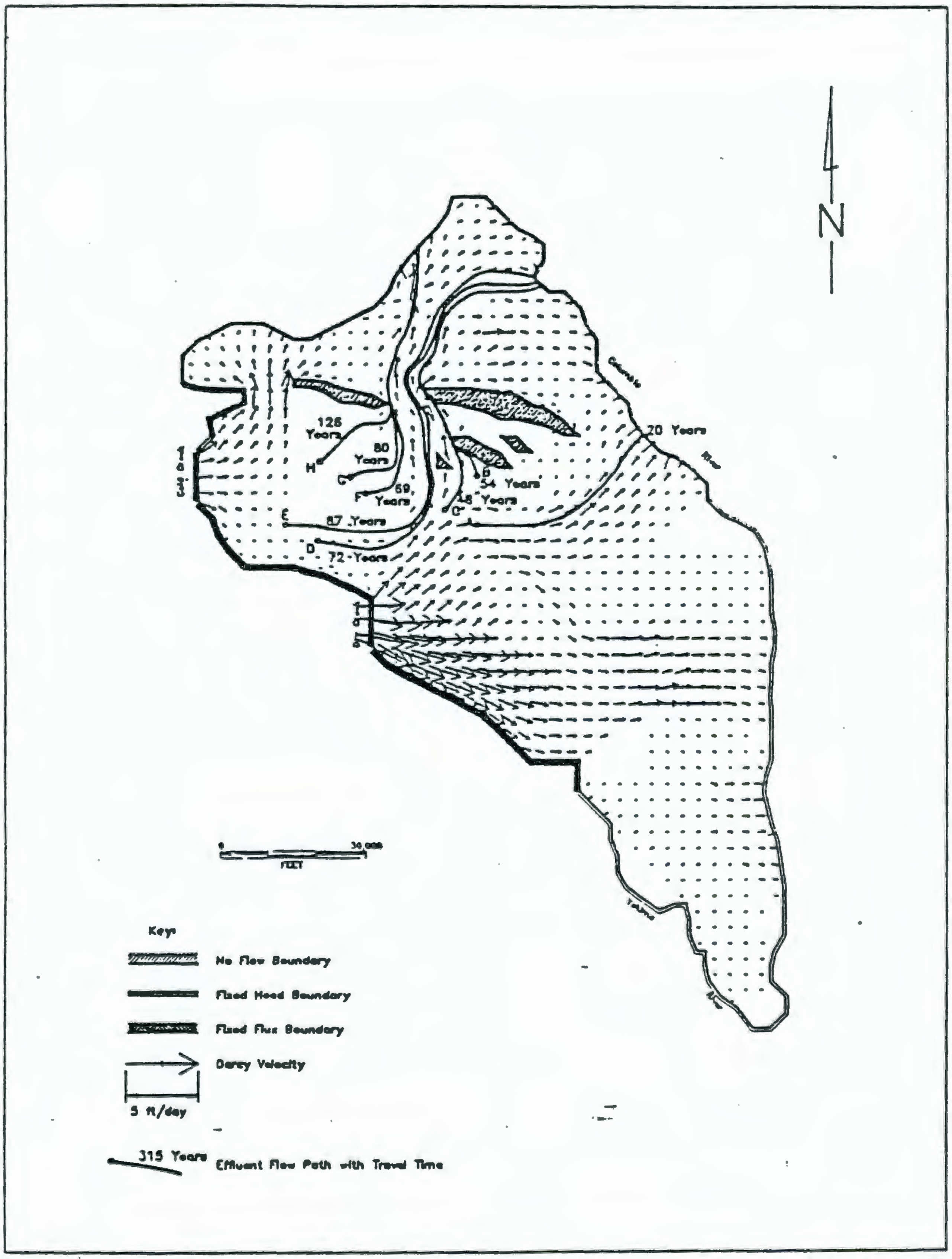
8931433\33571

Figure 4. Hydraulic Head Contours.
Case 2: Without B-Pond Operating.



8931433\33572

Figure 5. Alternative Tritium Crib Locations and Flowpaths.
Case 1: With B-Pond Operating.



8931433'.33573

Figure 6. Alternative Tritium Crib Locations and Flowpaths. Case 2: Without B-Pond Operating.

APPENDIX A

NUMERICAL GROUNDWATER MODELING

APPENDIX A

NUMERICAL GROUNDWATER MODELING

PURPOSE

Groundwater modeling was performed to support consideration of the soil column disposal option. Specific objectives of the modeling effort included:

1) Demonstrate how groundwater flow patterns would be impacted by various disposal schemes.

2) Provide estimates of travel time under various disposal schemes.

3) Investigate whether it is possible to dispose of the necessary volumes of effluent to the subsurface without causing groundwater mounding which would impact existing soil contamination.

4) Estimate the dilution due to dispersion during subsurface flow to the Columbia River from various disposal sites.

THE COMPUTER CODE

The computer codes used for this modeling effort are primarily parts of the Golder Groundwater Package. The Package includes state-of-the-art finite element computer programs for simulation of groundwater flow and contaminant transport, as well as graphics programs for presentation of the results. Golder Associates Inc. (GAI) has developed the package to simulate a variety of two- and three-dimensional systems. For the purposes of this modeling effort the program AFPM (Aquifer Flow in Porous Media) was utilized. AFPM is designed to simulate groundwater flow through a system of interconnected aquifers, although only one layer was used in this work. The program accommodates variable aquifer properties, a changing phreatic surface, transient boundary conditions, and other characteristics useful for groundwater modeling at the Hanford Site.

DEVELOPMENT OF THE CONCEPTUAL MODEL

The initial stage of conceptual model development was to define a domain and discretize that domain into a finite element grid. For purposes of modeling large-scale groundwater flow at the Hanford Site, a two-dimensional grid was defined between the basalt ridges on the west side, and the Columbia and Yakima Rivers on the north, east, and south sides of the modeled region. Locations of the basalt ridge boundaries were determined using maps from Gephart et al. (1979) and Serkowski et al. (1988); the river boundaries were located using the United States Geological Survey (USGS) 7.5' topographic quadrangles. Arbitrary boundaries were defined across Cold Creek and Dry Creek Valleys. The modeled domain along with the nodes and elements comprising the grid are shown in Figure H.1. 976 nodes and 920 elements were used to discretize the domain. Most of the elements were square with side lengths of 3275 feet.

After discretizing the domain, the boundary conditions were defined. Fixed-head conditions were established along the river boundaries using values of head from the June 1987 water table map in Serkowski et al. (1988). For calibration purposes, fixed head conditions were also used across the Cold Creek and Dry Creek Valleys. The head values across these boundaries were fixed according to the observed heads reported on the respective calibration standards discussed in the following paragraphs. Along boundaries defined by basalt extending above the water table the model assumed zero flux conditions across the boundary. Zero flux conditions were also assumed along the base of the aquifer. The validity of these boundary conditions will be discussed in the next section.

Initial hydraulic conductivity values were estimated from Plate III-5 in Gephart et al. (1979). The domain was divided up into 27 regions, each of which was assigned a value for hydraulic conductivity, storativity and specific yield. Storativity and specific yield were only important for transient simulations. Although some transient flow modeling was conducted the results were not found to be relevant to the objectives of the study and are not presented.

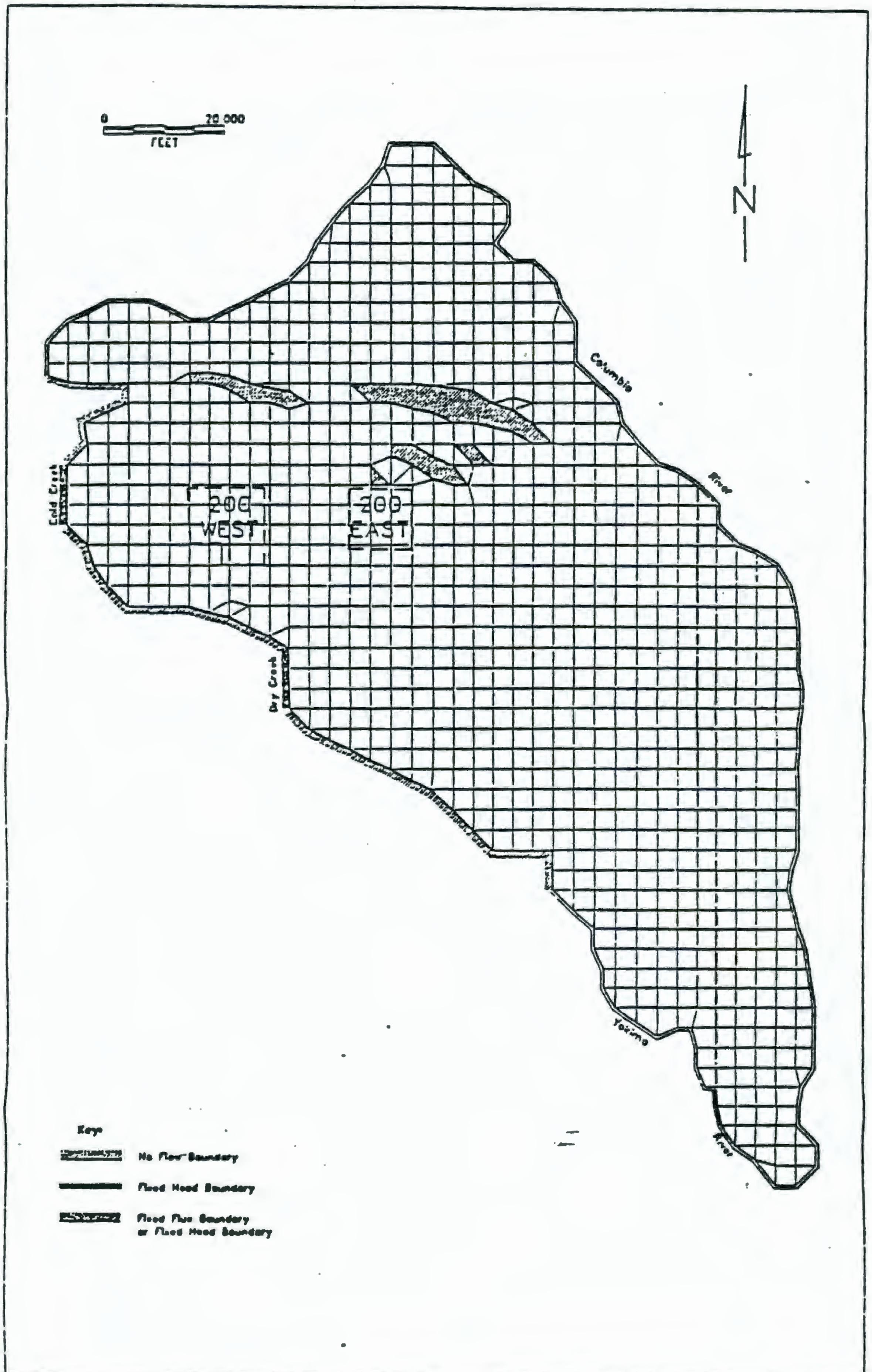


Figure II-1. Finite Element Grid

For the first calibration analysis a contour map of 1979 water levels was used as a standard (Plate III-4 in Gephart et al. (1979)). By 1979 the major disposal facilities, B-Pond, Gable Mountain Pond and U-Pond, had been operating for several decades, and groundwater elevations were probably close to steady state levels. The assumed distribution and rates of artificial recharge used for this calibration were estimated from data summarized in Zimmerman et al. (1986); the location and rates of artificial recharge are shown on Figure H.2. Hydraulic conductivities were adjusted until the steady state solution visually approximated the observed 1979 head contours to within about five vertical feet.

To help confirm the estimated hydraulic conductivities a second calibration analysis was performed using a contour map of 1944 water table elevations from Gephart et al. (1979) as a standard. Since effluent discharge was not significant until the mid to late 1940's no artificial recharge was applied to the simulation region. Hydraulic conductivities were adjusted until reasonably close results were obtained for both the 1944 and 1979 calibration standards. When calibration was complete the hydraulic conductivities ranged from 20 to 15000 feet/day. These values are similar to the range of 9 to 10000 feet/day reported by Graham et al. (1981) for the middle Ringold and Hanford units. The hydraulic head contours and Darcy velocity fields for the calibration runs are shown in Figures H.2 through H.5.

During calibration runs fixed head conditions were used across Cold Creek and Dry Creek Valleys. In order to model the various effluent disposal schemes it was necessary to allow the head elevations to change along these sections of boundary. Consequently, these boundaries were changed from fixed head to fixed flux boundaries. The amount of flux across the Cold Creek and Dry Creek boundaries for simulation of future disposal schemes was fixed at the rate which occurred in the 1979 calibration run. These fluxes are as much as ten times larger than those calculated by others (Graham et al. (1981)). Implications of these discrepancies are discussed in the following section.

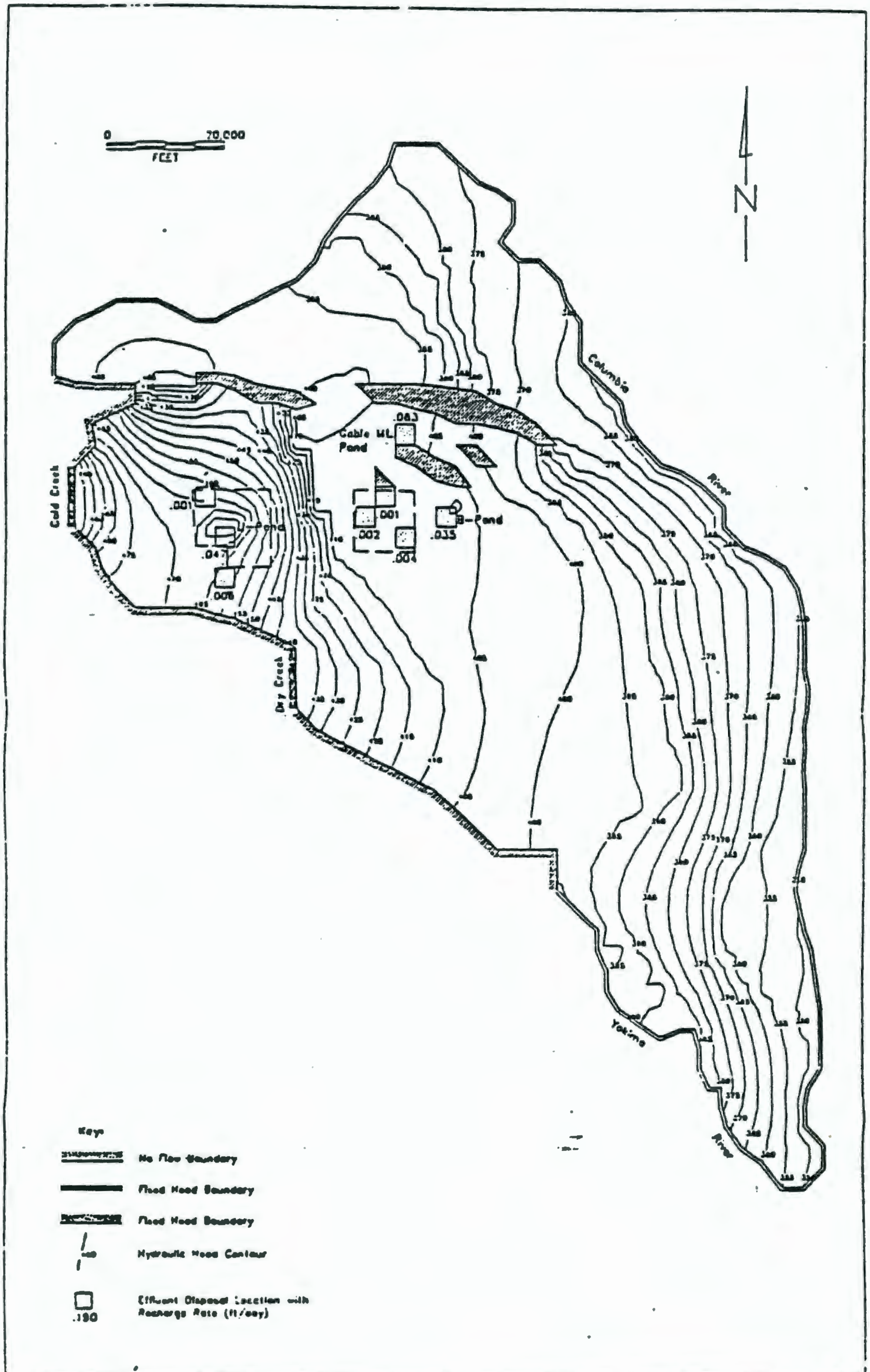
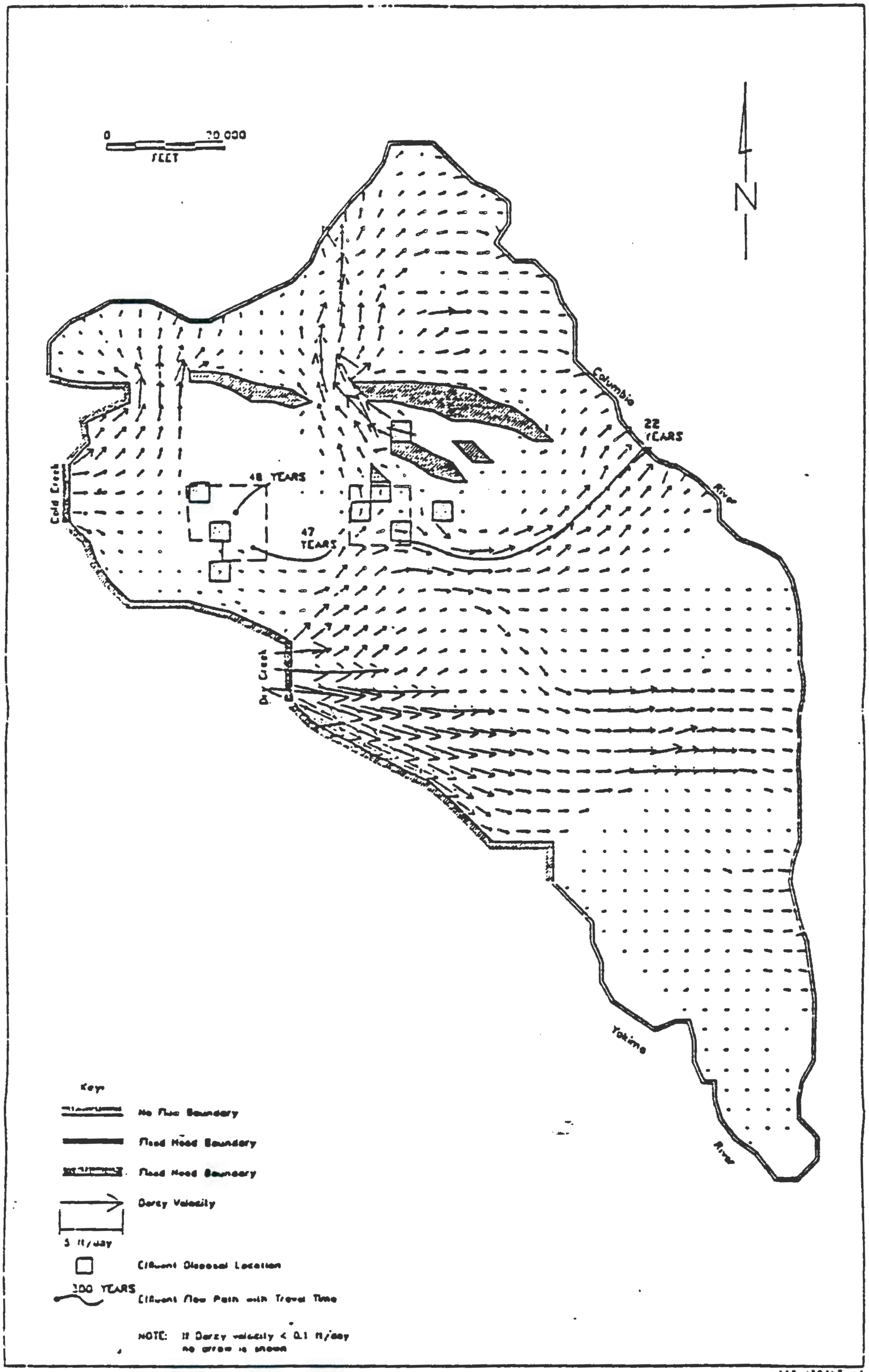
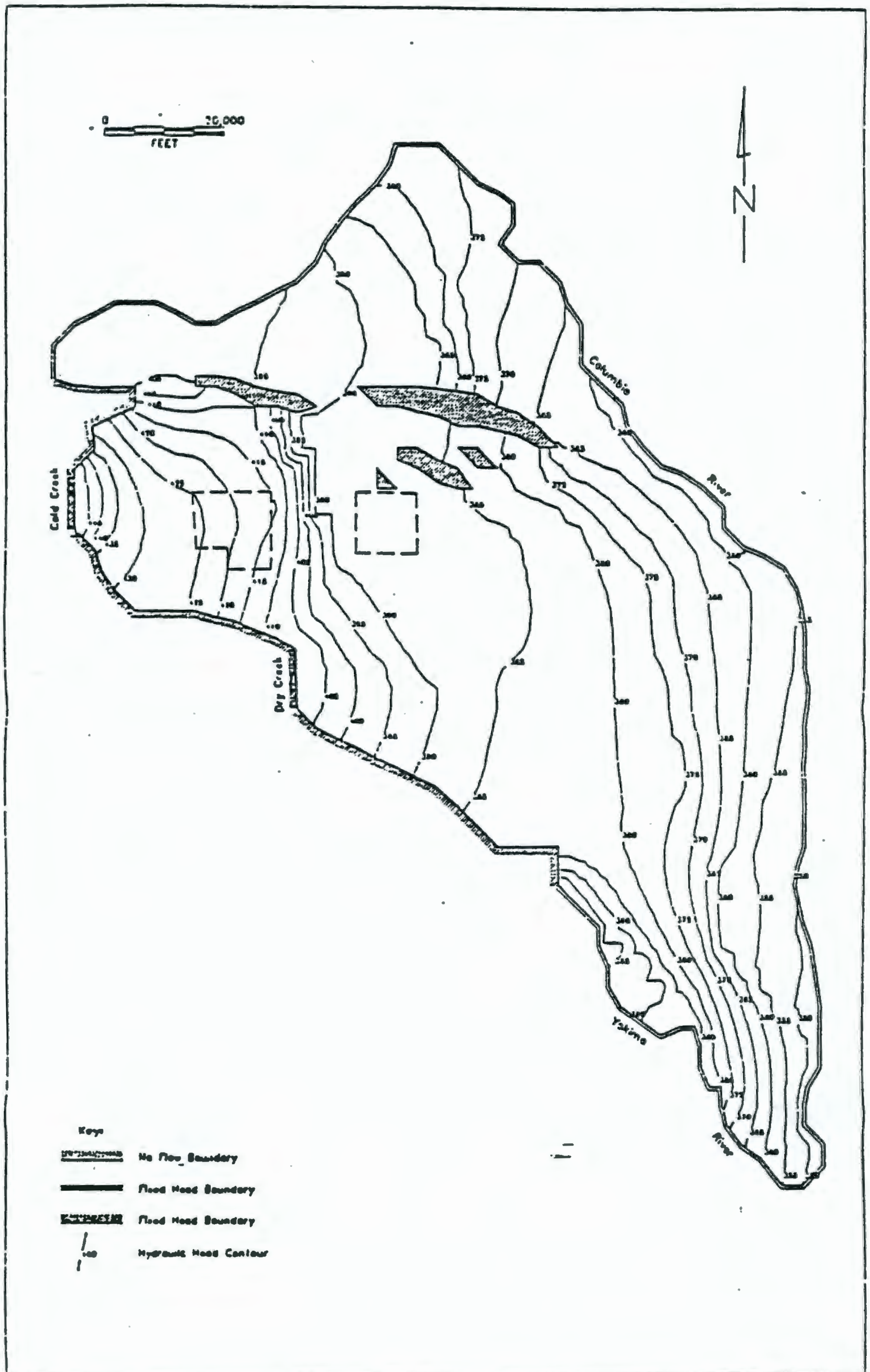


Figure II-2. 1979 Calibration Results Hydraulic Head Contours



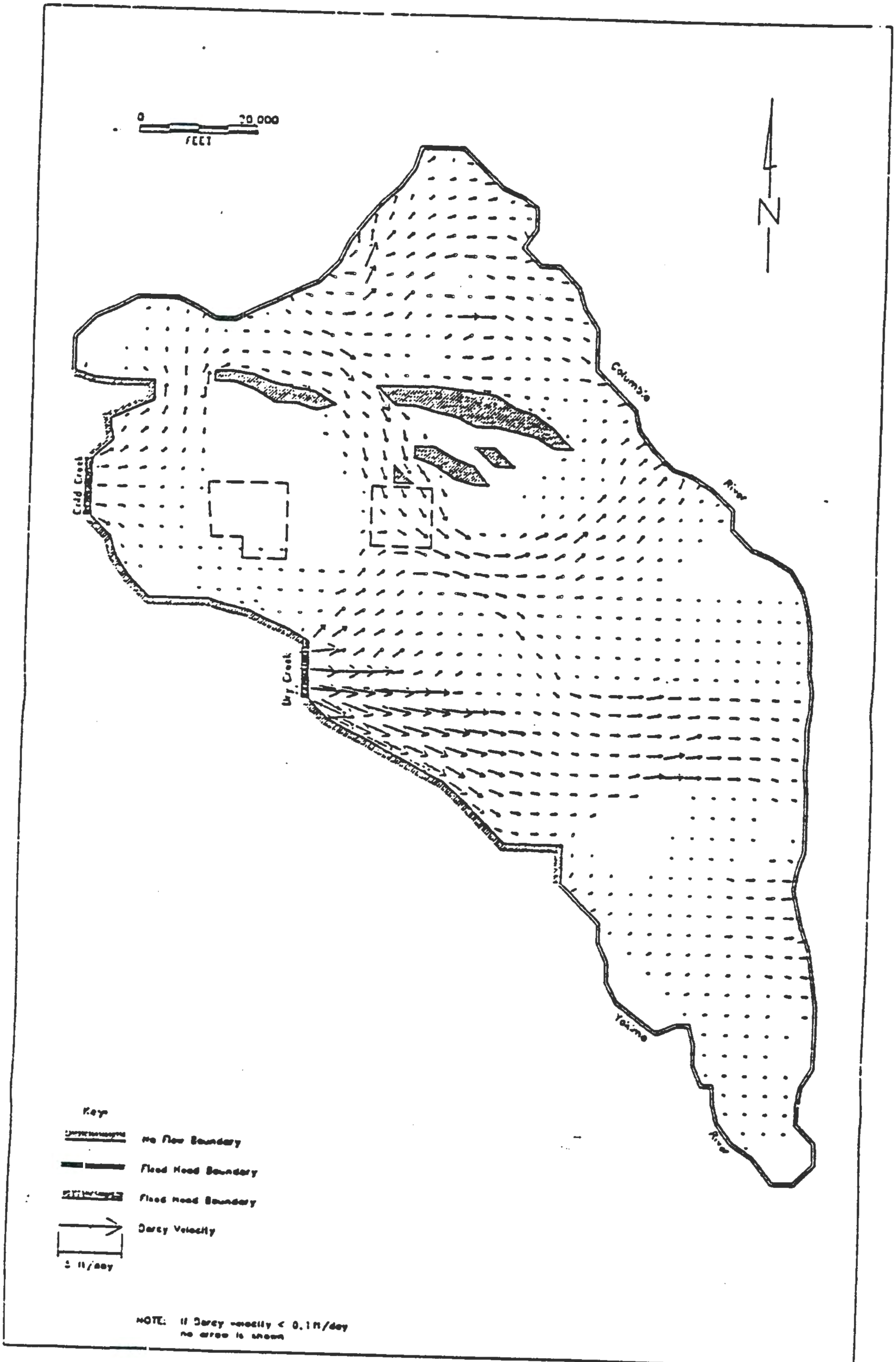
883-1708/7446

Figure II-3. 1979 Calibration Results Darcy Velocity Vectors



883-1708/2453

Figure II-4. 1944 Calibration Results
Hydraulic Head Contours



883-1708/7434

Figure II-5. 1944 Calibration Results
Velocity Vectors

ASSUMPTIONS AND LIMITATIONS

Any modeling of groundwater processes requires some assumptions. An explanation of the rational for the assumptions is helpful for assessing the uncertainty of the results. The assumptions used in this modeling effort are discussed below.

1) Fixed head boundary conditions were used along the Columbia and Yakima Rivers. As explained above, the values of head were fixed at elevations reported in a map of 1987 water levels. If a low permeability layer exists along the base of the river a fixed head boundary condition may not be the most appropriate. Since the nature of any low permeability layer is presently unknown, we decided to use fixed head conditions. Furthermore, any fluctuation in the stage of the river may cause transient changes in groundwater flow not accounted for in this conceptual model. These effects should be confined to the region near the river and were not important to the objectives of this modeling effort.

2) Zero flux conditions were assumed along the basalt ridge boundaries and the base of the aquifer. Although flow probably occurs across these boundaries, quantifying this flow is virtually impossible given the current state of knowledge.

3) Natural recharge due to infiltration of precipitation was assumed to equal zero. Lysimeter studies discussed in Gee and Heller (1985) and Gee (1987) have indicated that evapotranspiration removes all precipitation from the soil column if the surface is vegetated. It has also been observed, however, that significant recharge may occur in gravelly surfaces with no vegetation (Gee (1987)). Observations of the Hanford site indicate that vegetation covers most of the surface, suggesting that natural recharge would be insignificant.

   As mentioned in the previous section, our model estimates of fluxes out of Cold Creek and Dry Creek Valleys are considerably higher than those estimated by others. If some natural recharge across the Hanford Site were allowed, due to precipitation or due to flux across no-flow basalt boundaries, the amount of flow from Cold Creek and Dry Creek Valleys required for proper calibration would be lower. In order to achieve this lower flow in the model the hydraulic conductivities near these valleys would have to be reduced; reduction of hydraulic conductivities near these boundaries might impact hydraulic conductivities, groundwater flow patterns, and calculated travel times over the entire site. Because of the calibration approach used in this study, however, the possible changes in site-wide conductivities would not be expected to be large. The reason for this is that the heights of the groundwater mounds and the fluxes that created these mounds were used in the 1979 calibration run to establish the values of conductivity near the mounds. Because the relative values of conductivity were known over the entire simulation region from calibration to head data, knowing the conductivity at the mounds permitted the remaining conductivity values to be quantitatively determined.

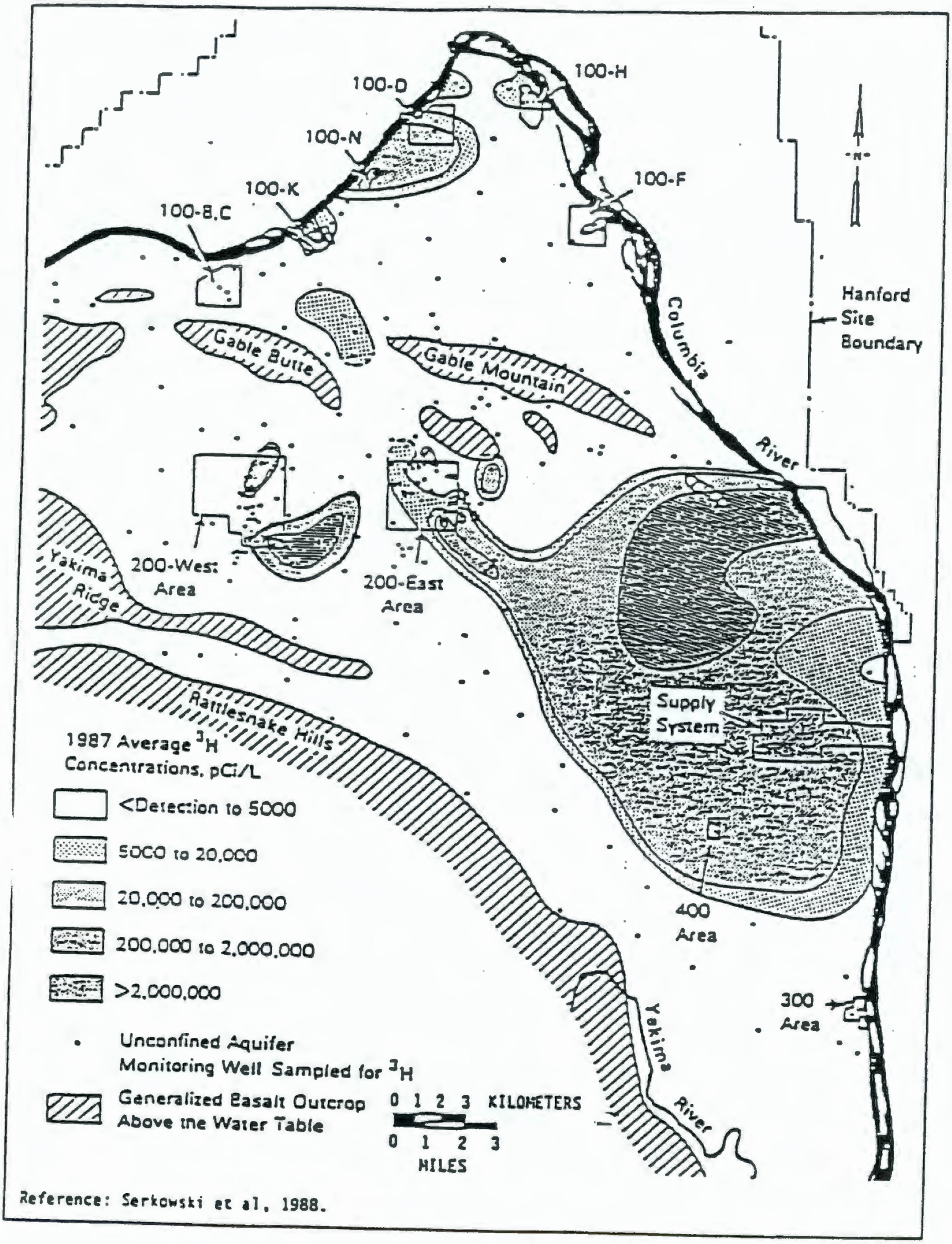
4) The thickness of the aquifer was estimated from Plate III-2 in Gephart et al. (1979). Although the base of the aquifer is defined as the top of the uppermost basalt flow over most of the simulation region, the lower Ringold is defined as the base of the aquifer where it is present. The lower Ringold is a low permeability layer which only occurs in the western part of the modeled region (Tallman et al. (1979)). A high conductivity layer, the basal Ringold, is present beneath the lower Ringold. It is possible that flow through the lower Ringold into the basal Ringold may impact groundwater flow dynamics above the lower Ringold. Although the Golder Groundwater Package is capable of modeling multi-layered aquifers, the general objectives of this modeling effort did not warrant the additional time and expense of modeling a second layer.

5) The fundamental flow equations used by the AFPM program are derived using standard assumptions for two-dimensional flow modeling, including no vertical flow, vertical averaging of hydraulic conductivity, and deterministic approximation of the flow parameters. These assumptions, plus the assumption of an isotropic medium, were used in the model. Furthermore, the aquifer was modeled as a phreatic aquifer with variable saturated thickness.

RELIABILITY OF THE MODEL

Given the assumptions discussed in the previous section the reliability of the results is difficult to assess. Rigorous quantification of uncertainty would require extensive sensitivity analysis and/or a stochastic approach which were not warranted considering the objectives of this study. A simple method to evaluate the validity of a model is to compare observed travel times with those predicted by the model. A map of the Hanford Site showing tritium concentrations is presented in Figure H.6. At least three tritium plumes originate from sources in the separations area. One of these plumes originates from the 200 East Area and the other two from the 200 West Area.

The plume from the southeast corner of the 200 East Area includes an elevated pulse of tritium which reached the Columbia River in the mid-1980's (Law and Allen (1984); Serkowski et al. (1988)). Tritium is contained in effluent from the PUREX plant which commenced major disposal to cribs in the southeast corner of the 200 East area in the late 1950's (Zimmerman et al. (1986)). Assuming that the main plume of tritium reached the Columbia between 1983 and 1987, the observed travel time to the Columbia River would be approximately 25 years. In a review of travel time estimates, Freshley et al. (1988) concluded that travel times from the 200 East Area could range from 13-23 years. Using the 1979 calibration results, and a porosity of 0.25, the travel time from the southeast corner of the 200 East area is estimated at 22.5 years. The modeled travel path is shown on Figure H.3. Since travel time varies linearly with the value of porosity used in the calculation, and



883-1708/ 9299

Figure H-6. Tritium Plume Map for the Hanford Site, 1987 porosity for high permeability materials could range from 0.2 to 0.3, the estimated travel time is probably between 18 and 27 years. This is in agreement with the observed travel time of 25 years.

Two tritium plumes with sources in the 200 West Area are also apparent in Figure H.6. Assuming that both plumes have been produced since effluent disposal began in the late 1940's, they are approximately 40 years old. Travel paths and travel times using the 1979 simulated flowfield are shown on Figure H.3 for transport similar to the observed plumes. Using a porosity of 0.15, the travel times predicted by the model are 47 to 48 years. For the lower permeability materials in the western part of the Hanford Site porosity could vary from 0.1 to 0.2, suggesting a range in travel time from 32 to 63 years. The observed travel time of 40 years is well within this range. The accuracy of the model predictions of travel time lends confidence to the validity of the model.

STEADY STATE RESULTS

Three steady state simulations are presented below. In all three simulations the flux out of Cold Creek and Dry Creek Valleys is fixed at the rate which occurred in the 1979 calibration run.

Simulation 1 is for the case when no effluent is disposed to the groundwater. The resulting water table map and velocity vectors are shown in Figures H.7 and H.8. As expected, the mounding beneath the 200 West Area and beneath B-Pond has dissipated. The results differ from the 1944 calibration run because the flux out of Cold Creek and Dry Creek Valleys has increased significantly, presumably due to increased irrigation in these valleys.

The other two simulations are for effluent disposal to the subsurface at two different sites. These sites are labeled as the "Primary Disposal Site" on Figures H.9 through H.12. Since one criterion for a subsurface disposal site was to avoid impacting existing vadose zone soil contamination, the locations were chosen to lie well outside known solid or liquid waste disposal sites. In addition, the locations were within the high transmissivity zone running through the

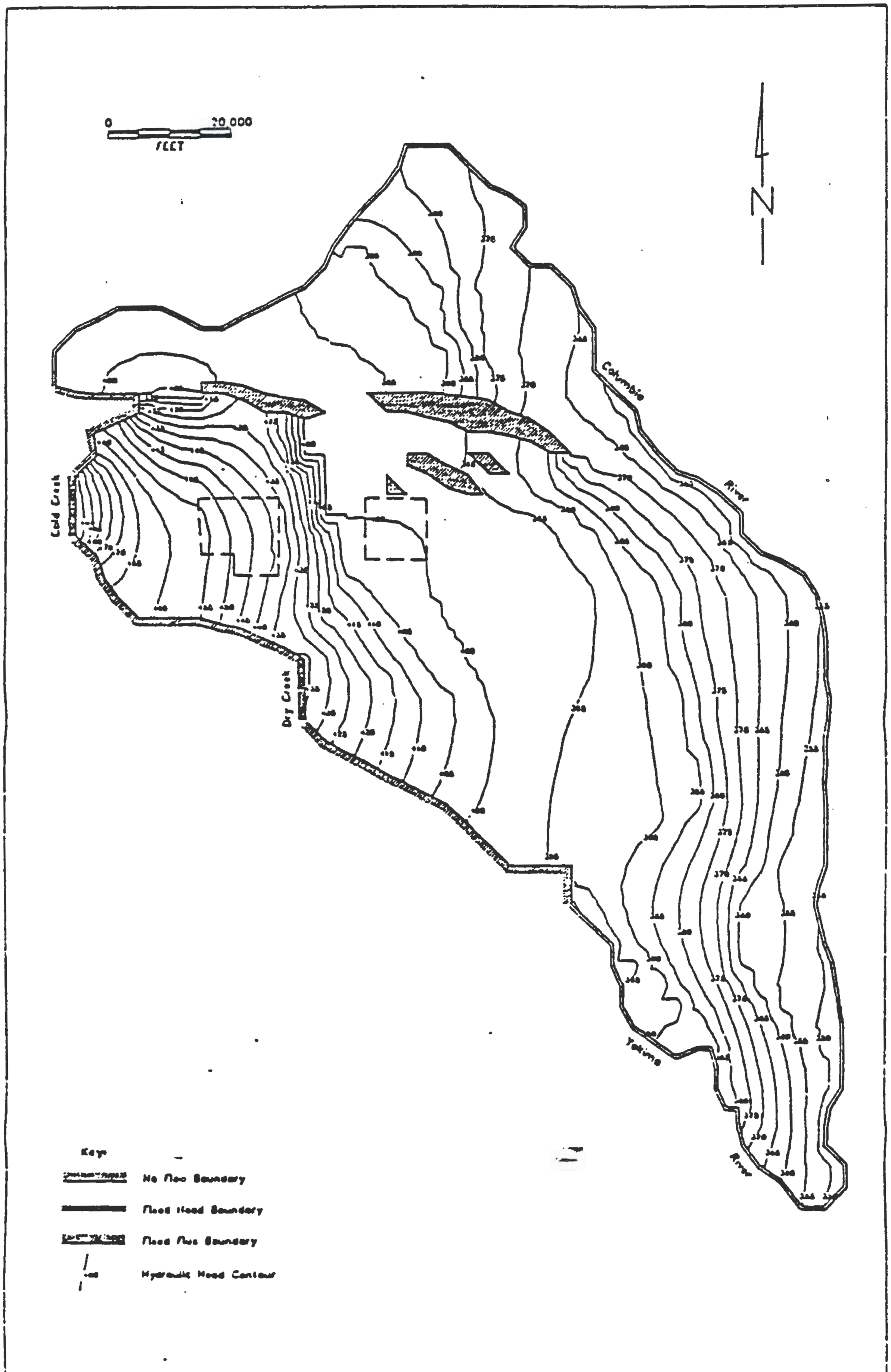
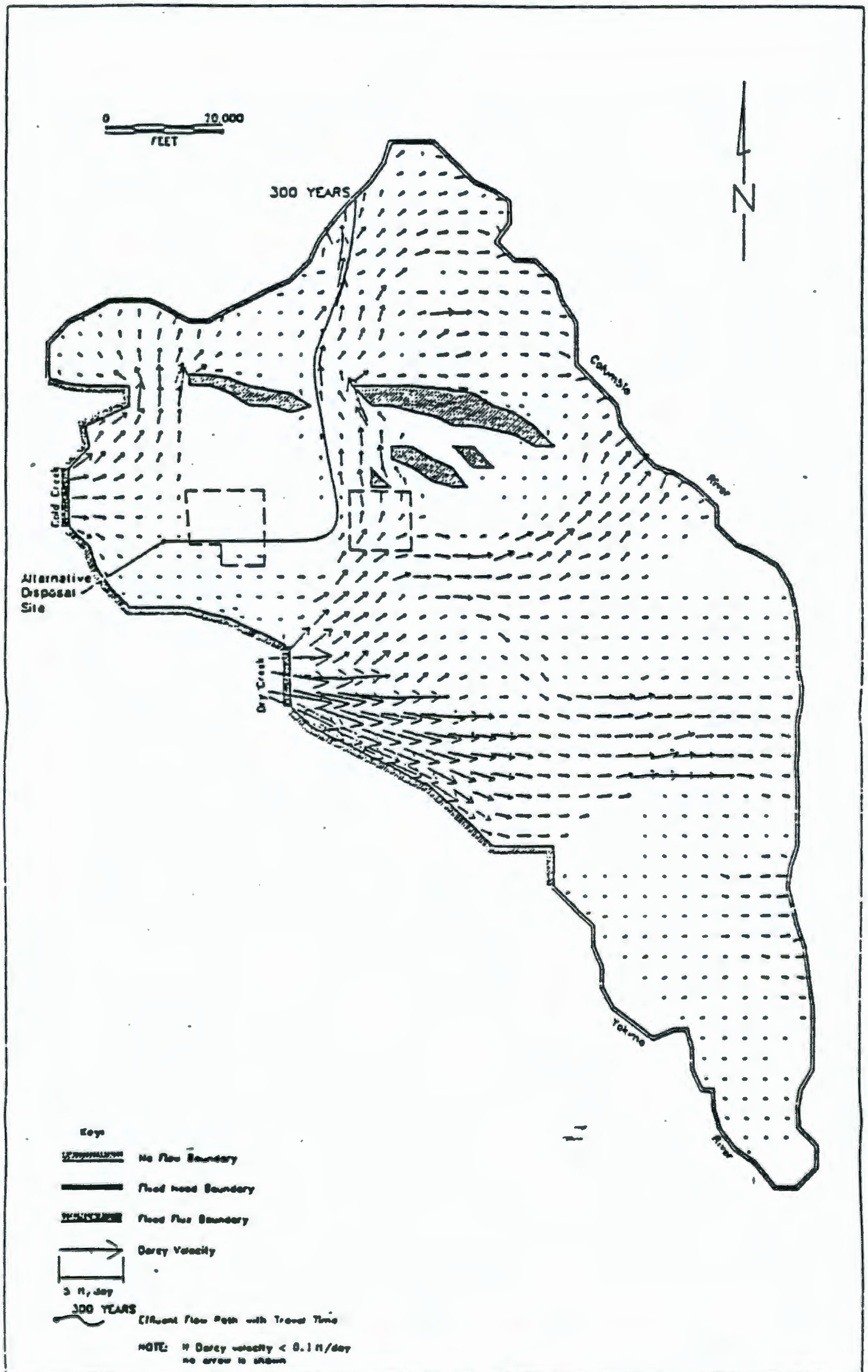


Figure II-7. Simulation 1 - No Discharge Hydraulic Head Contours



883-1708/7429

Figure II-8. Simulation 1 - No Discharge Velocity Vectors

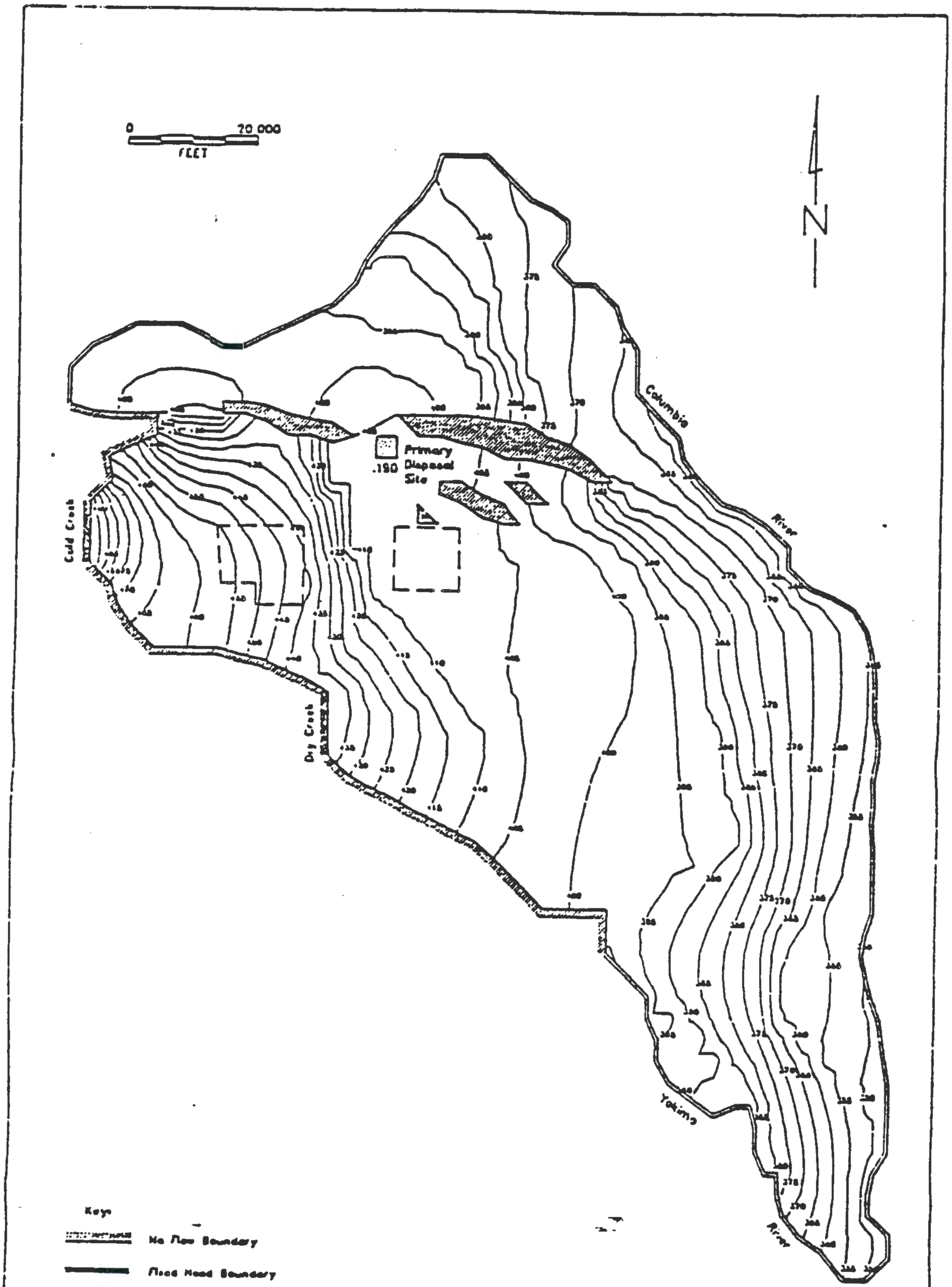
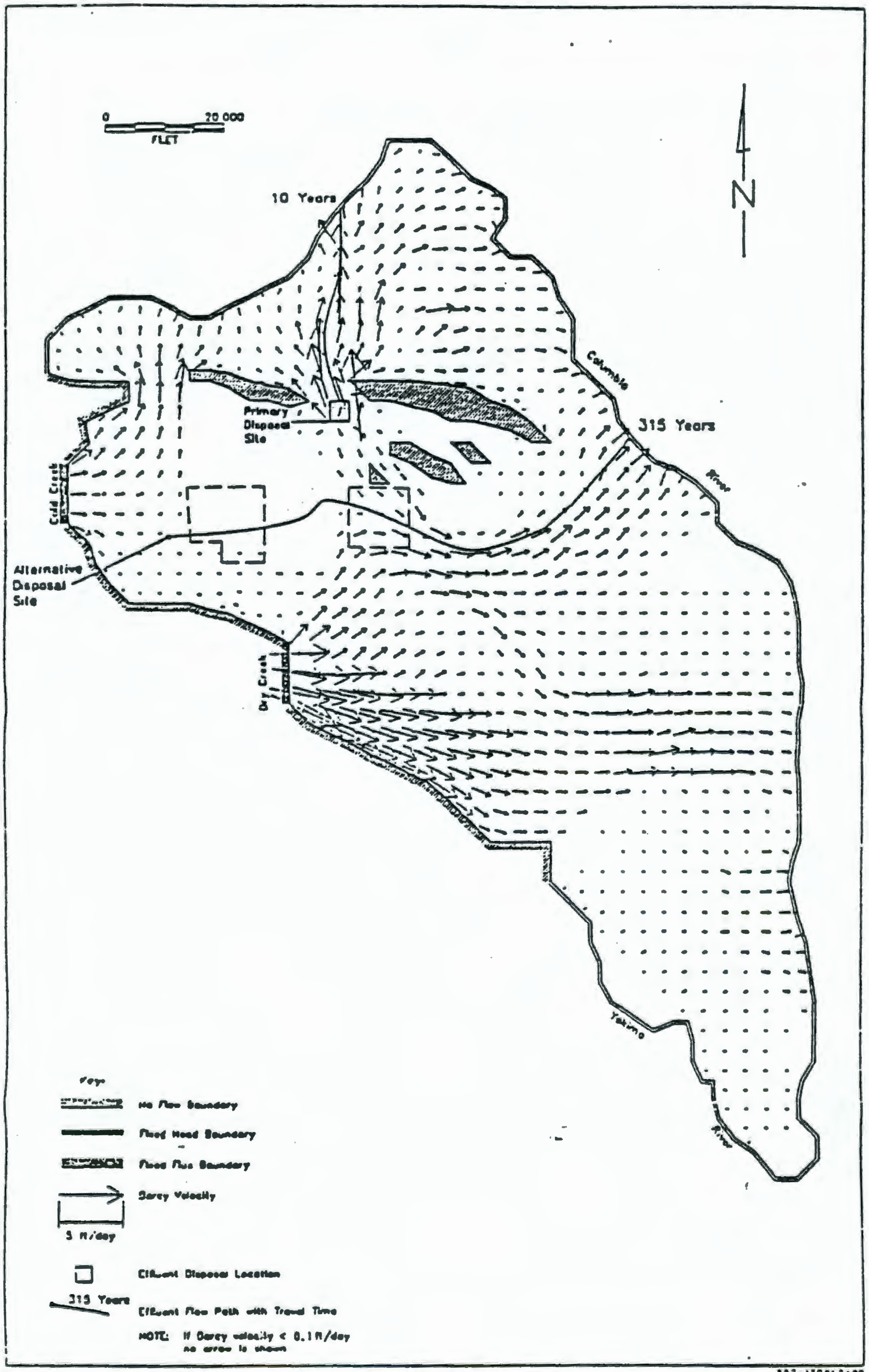


Figure II-9. Simulation 2
Hydraulic Head Contours



883-1708/7422

Figure II-10. Simulation 2 Velocity Vectors

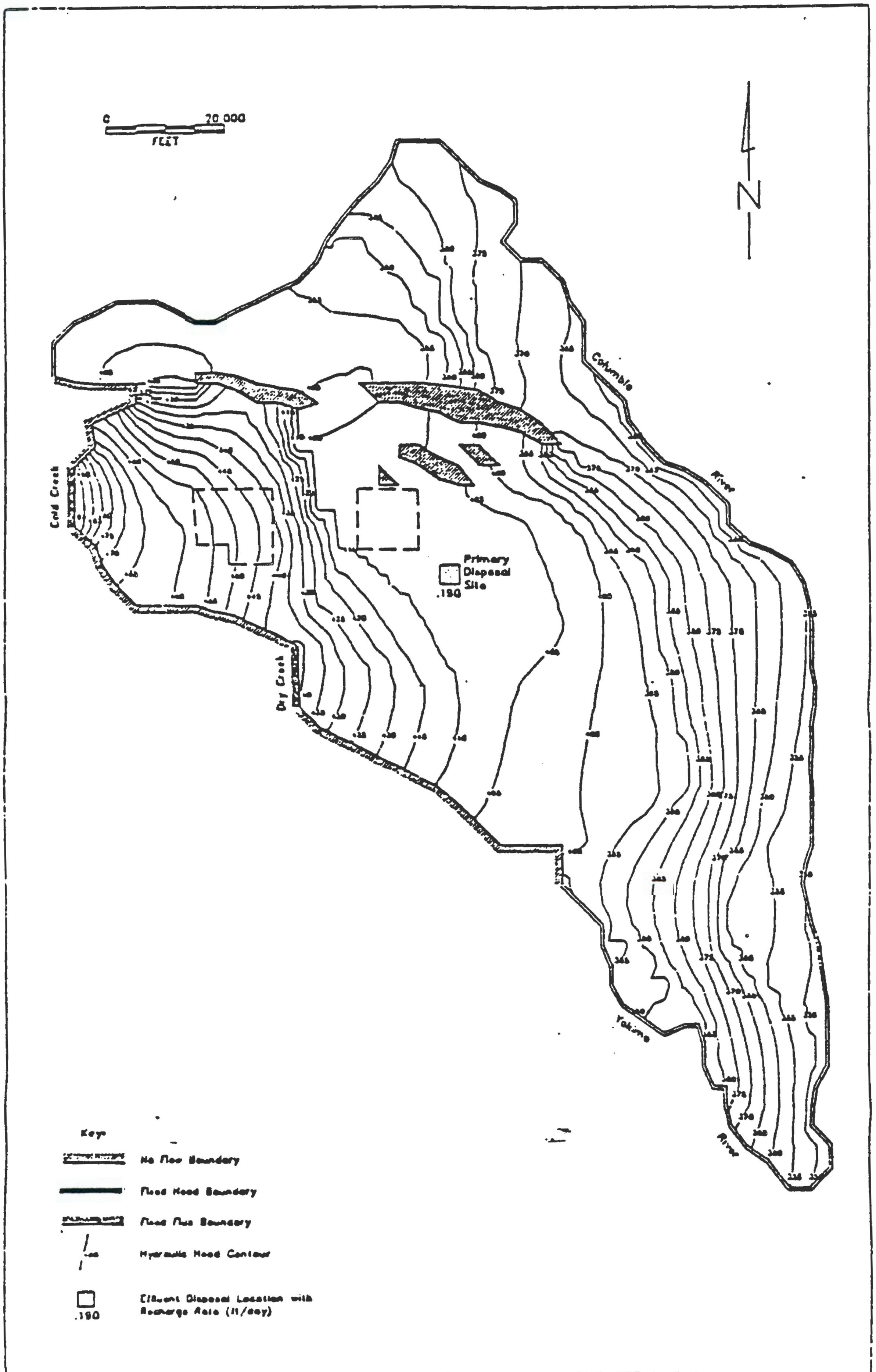
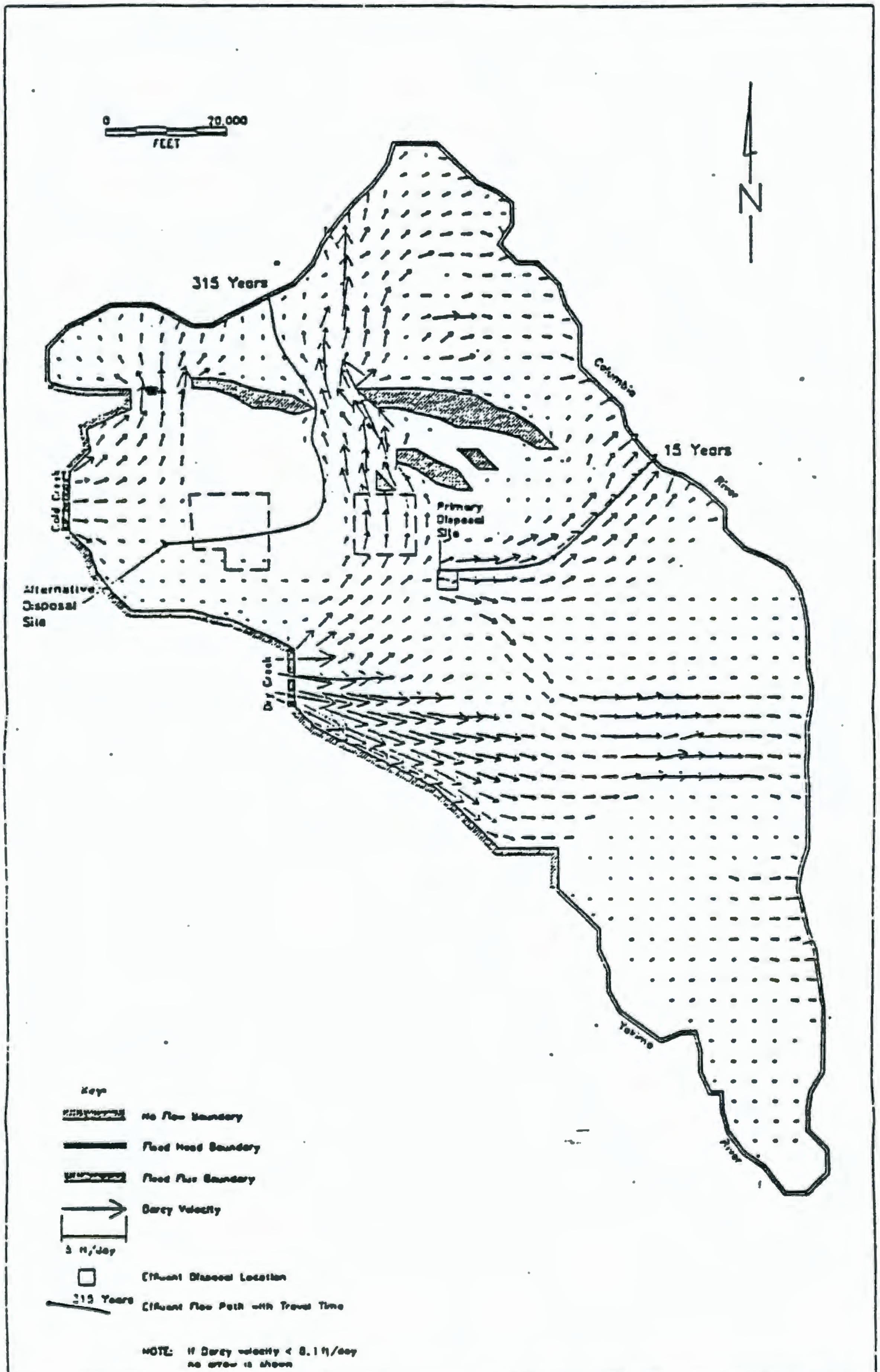


Figure II-11. Simulation 3
Hydraulic Head Contours



883-1706/7430

Figure II-12. Simulation 3

200 East Area to minimize the height of mounding. In both simulations mounding was less than five feet and would not be expected to impact any existing soil contamination. The amount of effluent released in the simulations was 2 million cubic feet per day, approximately equal to the total effluent presently produced at both the 200 East and 200 West areas. As shown in the figures, the recharge has been uniformly distributed over one grid element at a rate of 0.19 feet/day.

Simulation 2 is for a disposal facility located near Gable Mountain Gap, approximately four miles northwest of the proposed retention area at B-Pond. The results are shown in Figures H.9 and H.10. Using a porosity of 0.25, the shortest travel time to the Columbia River from the disposal site is estimated at 10 years. A major disadvantage of this site is that it is located very close to an erosional window through the Rattlesnake Ridge Basalt Flow to the uppermost interbed aquifer (Graham et al. (1984)). Due to the potential for contamination, it would be undesirable to induce flow from the suprabasalt aquifer to a basalt interbed aquifer.

Simulation 3 is for a discharge facility about two miles south of B-Pond. Results are shown in Figures H.11 and H.12. Assuming a porosity of 0.25, the shortest travel time to the Columbia River is estimated at 15 years. This location appears to be better suited than the Gable Mountain location because it is closer to the proposed retention area and it is not close to any erosional windows to the interbed aquifers.

Inspection of the velocity vectors for the three simulations indicates that groundwater flow patterns would be significantly impacted by different effluent disposal schemes. For example, comparison of Figures H.10 and H.12 show that in Simulation 3 the groundwater flow direction across the 200 East Area is completely reversed from that in Simulation 2. Since changes in groundwater flow patterns would affect the movement of any existing contamination plumes, the location of the disposal facility may require re-evaluation of groundwater monitoring networks for regulatory compliance.

ALTERNATIVE DISPOSAL SITE FOR TRITIUM STREAMS

One objective of this study was to investigate the possibility of disposing tritium-contaminated streams in a low conductivity area with a long travel time to the Columbia River. Based upon the flow patterns observed in these simulations an example site was chosen west of the 200 West Area which maximized travel time to the Columbia River. The location is labeled as the "Alternative Disposal Site" on Figures H.8, H.10 and H.12. Since the tritium-contaminated effluent streams are low volume they would not noticeably alter general flow patterns. For transport through the low-conductivity regions near the 200 West Area a porosity of 0.15 was used. A porosity of 0.25 was used for transport through the higher conductivity regions in the central and eastern parts of the Hanford Site. The pathway and travel time from the alternative tritium disposal site for each of the three steady-state simulations presented in the previous section are shown on Figures H.8, H.10, and H.12. For the case when no effluent is disposed to groundwater (Simulation 1) the travel time is about 300 years. The other two simulations, when all the effluent is disposed to groundwater, both have travel times of approximately 315 years. These results suggest that disposal of effluent to groundwater, instead of directly to the river, creates a partial barrier which may slightly retard the movement of upstream plumes.

Given the comparison of observed versus modeled travel times discussed earlier in this appendix, it is conservative to assume that travel times from a low-volume effluent disposal site just west of the 200 West Area are greater than 150 years and less that 400 years. Additional study would be necessary to refine this estimate.

DILUTION FACTORS

Dilution of effluent due to dispersion in groundwater will reduce the concentration of chemical compounds before they reach the Columbia River. The amount of dilution will be affected by a variety of factors, including the amount of wastewater being released, the amount of spreading in the unsaturated zone, the velocity of the groundwater beneath the source, the dispersivity of the soil medium, and the distance from the source to the river. Two approaches have been used to estimate the dilution factor, which is defined as follows:

$$\text{Dilution Factor} = C/CO$$

where C equals the concentration at the river and CO equals the initial concentration.

The first approach is to use empirical evidence from the behavior of existing contaminant plumes to determine the dilution factor. As shown in Figure H.6, the highest concentrations of tritium entering the river from the 200 East Area are between 0.2 and 2.0 microcuries/liter. The source of this tritium is the PUREX Process Condensate stream, which is reported in Appendix A to have a concentration of 30 microcuries/liter. Allowing for 25 years of decay would reduce concentrations by 75 percent to 7.5 microcuries/liter. Assuming a maximum concentration at the river of about 1.0 microcuries/liter the dilution factor is estimated as 0.13.

The second approach is to use an analytical transport model. The model used has been described by Domenico and Robbins (1985). It assumes a strip source of constant concentration, a uniform flow field, constant longitudinal and transverse dispersivity, and zero vertical dispersivity. The dilution factors reported here are intended to approximate steady state conditions at the distances of interest. The necessary parameters include the width of the source, longitudinal and transverse dispersivity, and distance. From a review by Gelhar et al. (1985) of many field scale dispersivity measurements a longitudinal dispersivity of 50 feet and a transverse dispersivity of 5 feet was used. Based upon the dimensions of the plume near the southeast corner of the 200 East Area shown in Figure H.6, the width of the source was set equal to 1000 feet. For the primary disposal sites used in Simulations 2 and 3 the dilution factor is about 0.5. Due to the greater travel distance, the dilution factor for the alternative disposal site is reduced to about 0.35. This analysis indicates that between the primary disposal site and the alternative disposal site the dilution factor is reduced by about one-third.

The dilution factors obtained from the analytical model simulations are higher than those estimated from the empirical evidence. The modeled results are quite sensitive to the width of the source and transverse dispersivity, neither of which are known with much certainty. Furthermore, if vertical dispersion were accounted for in the analytical model the dilution factors would be decreased. Given the uncertainty of the model it is probably advisable to rely more upon the empirically based results.

SUMMARY

To support investigations of the soil disposal option a numerical groundwater model was developed. The model was used to simulate large-scale flow at the Hanford Site. This modeling, supported by field observations and simple analytical modeling, resulted in the following conclusions:

1) Travel times to the Columbia River from two potential disposal sites located in the vicinity of B-Pond was 10 to 15 years. Travel times from an alternative site near the 200 West Area for tritium-bearing streams could range from 150 to 400 years.

2) The dilution factor from proposed disposal sites near the 200 East Area was estimated to be about 0.1 to 0.5. Analytical model results suggest that from the alternative disposal site (west of the 200 West Area) the dilution factor was approximated one-third less than at the primary disposal site (near the 200 East Area).

3) Disposal of proposed effluent streams to the high-transmissivity region running beneath the 200 East Area would probably not create groundwater mounding up into contaminated soil regions.

4) Different disposal schemes will significantly impact groundwater flow patterns and movement of existing contamination plumes.