ENVIRONMENTAL IMPACT STATEMENT

DAWN MINING COMPANY

TAILINGS DISPOSAL FACILITY EXPANSION

PROJECT

JULY 30, 1979

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1. INTRODUCTION

1.1 GENERAL INTRODUCTION

1.1.1 Proposal Location, Nature, and Sponsor

Dawn Mining Company, operators of a uranium milling operation near Ford, Washington, have requested permission to expand their existing mill tailings disposal facility by construction of a 28 acre membrane-lined, sub-grade impoundment contiguous with their existing disposal facility.

1.1.2 Lead Agency

The governmental agency responsible for the proposed action is the Washington State Department of Social and Health Services, Radiation Control Unit. (DSHS)

1.1.3 Authors

This document has been prepared by Dawn Mining Company personnel at the request of the DSHS. The principal author is Norman J. Lehrman, Chief Geologist for the Company. Important contributors to the project include: Jack E. Thompson, Resident Manager, Walter R. Lawrence, Mill Superintendant, Robert E. Nelson, Radiation Control Officer, and Phillip A Heninger, Geologist.

1.2 LIST OF ALL KNOWN LICENSES REQUIRED

Washington State Department of Ecology Waste Discharge Permit (granted Nov. 7, 1975)

Washington State Radioactive Materials License (expires Aug. 31, 1979 - renewal application submitted)

Washington State Permit to Appropriate Public Waters (granted Oct. 3, 1956)

1.3 SUMMARY OF CONTENTS

1.3.1 Proposal and Objectives

In order to provide additional storage capacity for mill tailings produced by their uranium milling operation near Ford, Washington, Dawn Mining Company has proposed a state-of-the-art, 28 acre, membrane lined, subgrade disposal facility. The proposal is designed to meet foreseeable capacity needs with the best available technology for hazardous materials storage and environmental protection. Implementation of the proposal is necessary for continued operations at the Dawn mill but will not affect either the process or rate of milling.

1.3.2 Potential Impacts

1. Mitigation of present seepage problems leading to increase in groundwater quality.
2. Mitigation of long-term land surface disfiguration.
3. Reinforcement of existing impoundment dikes.
4. Restricted land usage options, in perpetuity.
5. Incentive for reductions in water usage by milling operation.
6. Potential seepage from liner leaks leading to continued groundwater degradation.

1.3.3 Alternatives Considered

Four principal alternatives were studied:

1. Vertical additions to present impoundment dikes
(rejected: less secure long-term isolation of tailings; would not halt seepage recharge; would not provide reclamation materials)
2. Construction of new above-grade dike impoundment
(rejected: Less secure long-term isolation of tailings: greater surface area requirements per unit volume capacity; would not provide reclamation materials)
3. Construction of a lined subgrade storage pit
(selected: more costly, but halts seepage recharge; provides secure long-term isolation; produces needed reclamation materials without additional excavation; minimizes disrupted surface area per unit capacity)
4. "No action" alternative
(rejected: equal volume borrow pit still required for reclamation materials, but no means of restoration of that pit exists; Serious socioeconomic impacts through job loss without significant offsetting environmental gains; loss of approx. 2% of nation's uranium production in time of need).

1.3.4 Measures to Mitigate Impacts

No reasonable, economically feasible alternative is known to exist that could attain the proposed objective at lower environmental cost. The selected alternative is significantly more environmentally attractive than even the "no action" alternative due to the irreversible features of previously deposited tailings.

1.3.5 Remaining Unavoidable Adverse Impacts

The 28 acre disposal site will be added irreversibly to the existing area that will require perpetual usage restrictions, surveillance, and care to prevent dispersal of tailings materials.

2. DESCRIPTION OF THE PROPOSAL

2.1 INTRODUCTION

2.3.1 Lead Agency and Project Title

In compliance with the state environmental policy act of 1971 (SEPA), Dawn Mining Company has been instructed by the Washington State Department of Social and Health Services (DSHS), Radiation Control unit, to prepare and submit the following environmental impact statement for a project collectively referred to as the DAWN TAILINGS DISPOSAL FACILITY EXPANSION.

2.1.2 Location

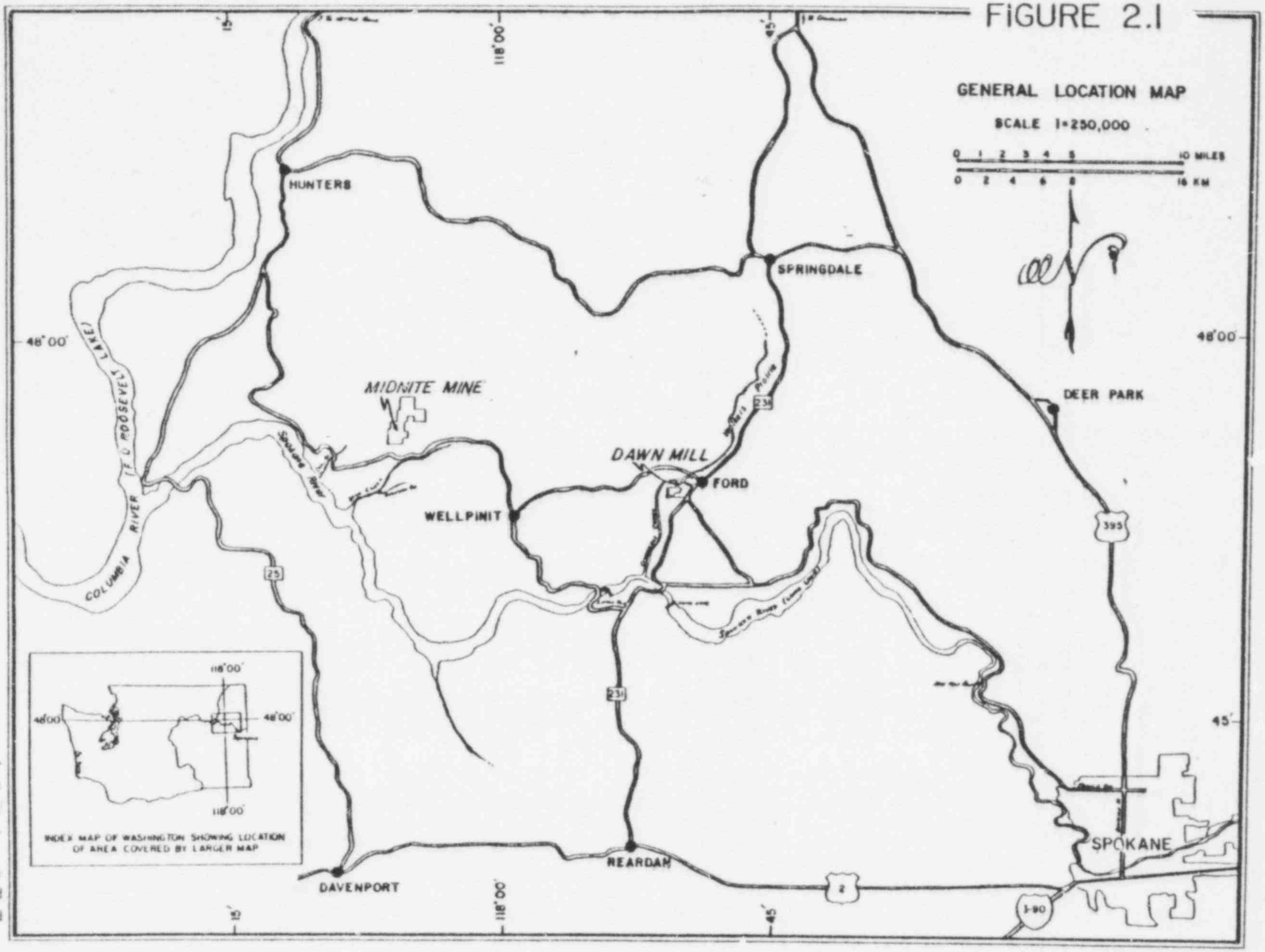
The project site is located near Ford, Wa., about 25 miles northwest of Spokane. The accompanying general location map (figure 2.1) illustrates the location of the Dawn Mining Company Millsite and the associated project area.

2.1.3 Scope of Present Study

Since the present proposal involves a relatively minor addition to an extensive pre-existing uranium milling and tailings disposal facility, ambiguities exist concerning the specific scope of this document. The following comments should help to focus the attention of concerned agencies, groups, and individuals to the specific project here considered.

1. The proposal for which approval is sought is an addition to existing tailings disposal facilities consisting of a membrane-lined, sub-grade excavation to provide permanent storage of solid wastes and temporary storage of liquid wastes generated by the on-going Dawn Mining Company uranium milling operation near Ford, WA.,
2. The existing environmental conditions studied include both traditional base-line conditions and features related to the past and present uranium milling operations.
3. The potential impacts discussed are those related to the present proposal only. Past and present impacts related to the on-going operations, actual or potential, are discussed only insofar as they are affected by the present proposal.
4. The potential impacts discussed emphasize those directly related to the proposed tailings disposal facility expansion project. However, since the project is part of a larger uranium mining and milling operation, the major aspects of these related operations are discussed as well.
   The proposed project, or some equivalent alternative, is necessary for continued milling operations. The project will not affect either the process or rate of on-going operations if implemented.
5. The overall mining and milling operations are subject to periodic review and licensing requirements falling outside the scope of this document. However, much of the data here presented are relevant to mill licensing considerations, and much is present in Dawn's current application for license renewal that is relevant to this document. Where gaps or omissions are apparent in either document, the concerned reader is asked to review pertinent sections of the companion compilation.

FIGURE 2.1


GENERAL LOCATION MAP
SCALE 1=250,000
0 1 2 3 4 5 10 MILES
0 2 4 6 8 16 KM
HUNTERS
SPRINGDALE
DEER PARK
MIDNITE MINE
DAWN MILL
FORD
WELLPINIT
REARDAN
DAVENPORT
SPOKANE
COLUMBIA RIVER (F.D. ROOSEVELT LAKE)
Spokane River
395
231
25
2
I-90
48°00'
118°00'
45'
15'
INDEX MAP OF WASHINGTON SHOWING LOCATION OF AREA COVERED BY LARGER MAP

2.2 MAJOR PHYSICAL AND ENGINEERING ASPECTS OF THE PROPOSAL

2.2.1 General Project Description

In response to the company's imminent requirement for an increase in tailings disposal capacity, a state-of-the-art, fully lined, subgrade disposal system has been designed.

A pit will be excavated into sand and gravel deposits south of and contiguous to the present tailings impoundment. The surface area at natural ground level will be 1,224,800 square feet (28.12 acres). The structure would be 65 feet deep, below grade, with inslopes at 1 vertical on 3 horizontal. Some of the excavated materials will be used to construct a 35-foot high dike/stockpile around the new structure, and the remainder will be strategically stockpiled around the periphery of the existing impoundment. The stockpiled material will later be used to cap the entire disposal facility after final termination of milling operations.

The excavation will be lined with 30-mil, fabric reinforced, synthetic rubber (Hypalon) to a height of five feet above ground level and covered with a one to two foot layer of stabilized sand. An under-drain system will be installed above the floor liner to facilitate dewatering of the tailings at the time of final decommissioning.

The total volume available for tailings storage to ground level will be 2.05 million cubic yards, which is adequate for approximately thirteen years of mill production at the present rate of 160,000 tons per year. The five vertical foot lined area above ground level may be used for temporary solution storage during the final stages of pond life.

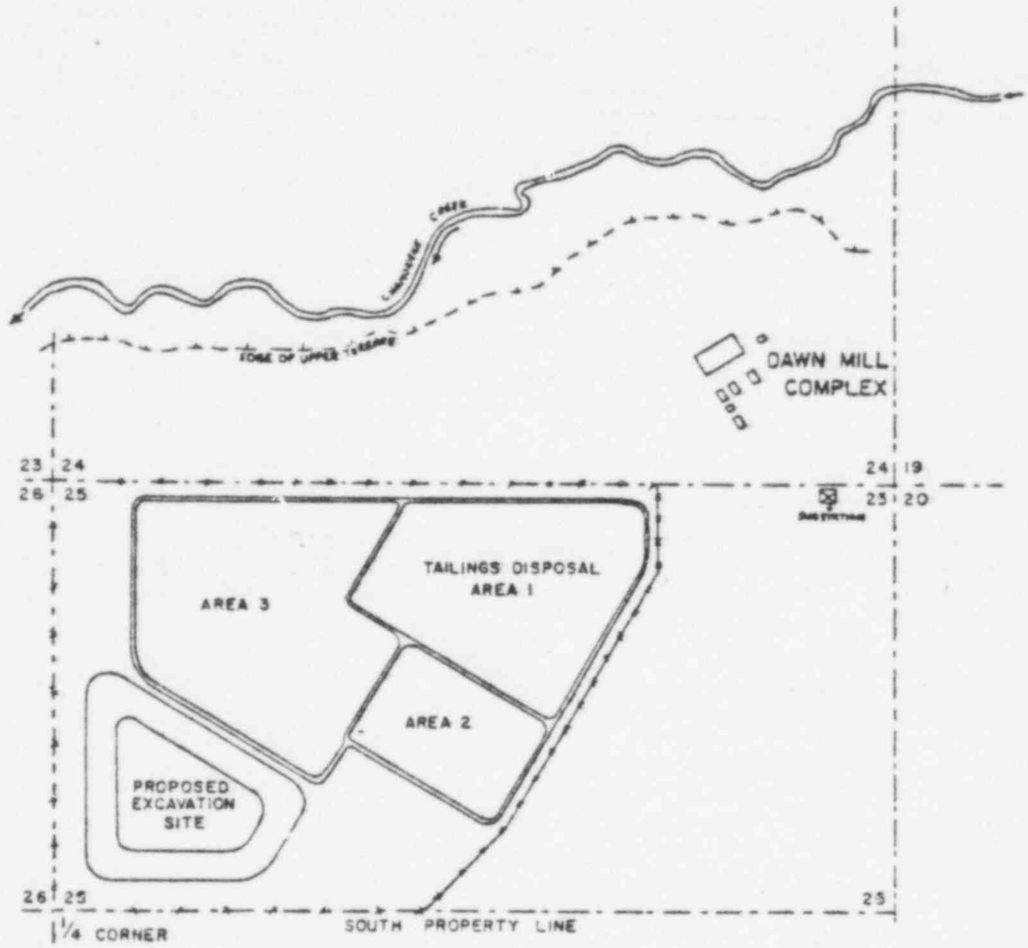
A tentative reclamation and long-term stabilization plan has been formulated, pending promulgation of final regulations addressing the subject. As presently outlined, the company will cap the total disposal facility with a two foot thick compacted clay member, overlain by a further eight foot layer of sands and gravels derived from the present project excavations. Outslopes on existing dikes will be moderated to one vertical on five horizontal. The entire disturbed zone will be revegetated, insofar as is possible, with native species.

After reclamation, stabilization, and revegetation work is completed, the Company will comply with the provisions of the Washington State "Mill Licensing and Perpetual Care Act of 1979" sections 3.1(b), 2(b), 6, 7, and 8, or the current laws in effect at the time of the event.

2.2.1.1 Subgrade Excavation Design

The site of the proposed excavation is immediately adjacent to the southwestern corner of the existing tailings impoundment complex. (See Figure 2.2) It lies fully within the present fenced restricted area.

The excavation will principally encounter sands and gravels deposited by glacial meltwaters and may reach the surface of deeply weathered basalt bedrock in the westernmost part of the pit floor. Figures 2.3 and 2.4 are a plan view and cross section of the proposed excavation illustrating the overall pit configuration and the geological materials that will be encountered.



PLAN MAP
DAWN MINING COMPANY
MILL & TAILINGS POND AREA
FORD, WA.

1" = 1200'

FIGURE 2.2

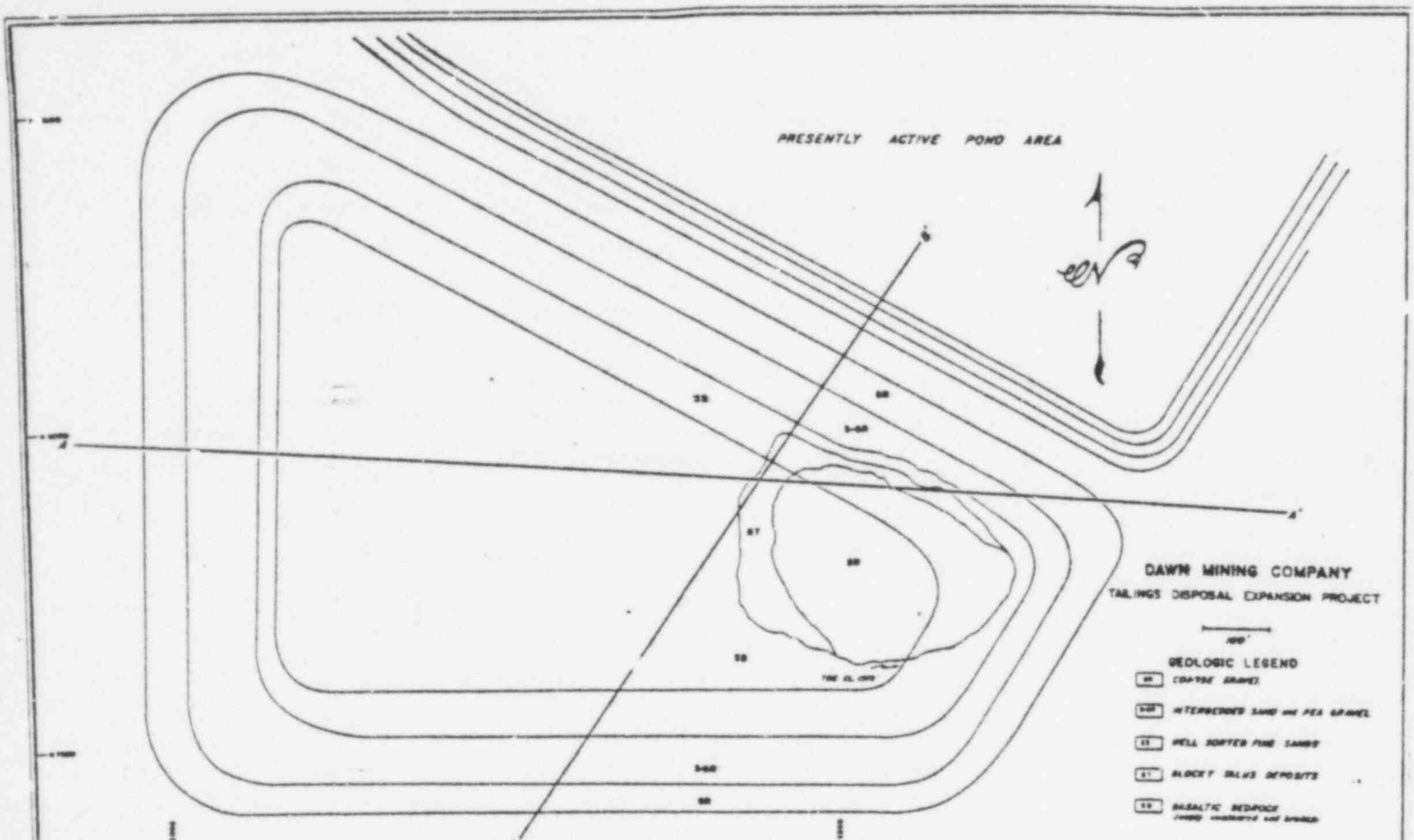

PRESENTLY ACTIVE POND AREA
A
A'
B
DAWN MINING COMPANY
TAILINGS DISPOSAL EXPANSION PROJECT
100'
GEOLOGIC LEGEND
COARSE GRAVEL
INTERBEDDED SAND AND PEA GRAVEL
WELL SORTED FINE SANDS
BLOCKY TALUS DEPOSITS
BASALTIC BEDROCK

FIGURE 2.3

POOR ORIGINAL

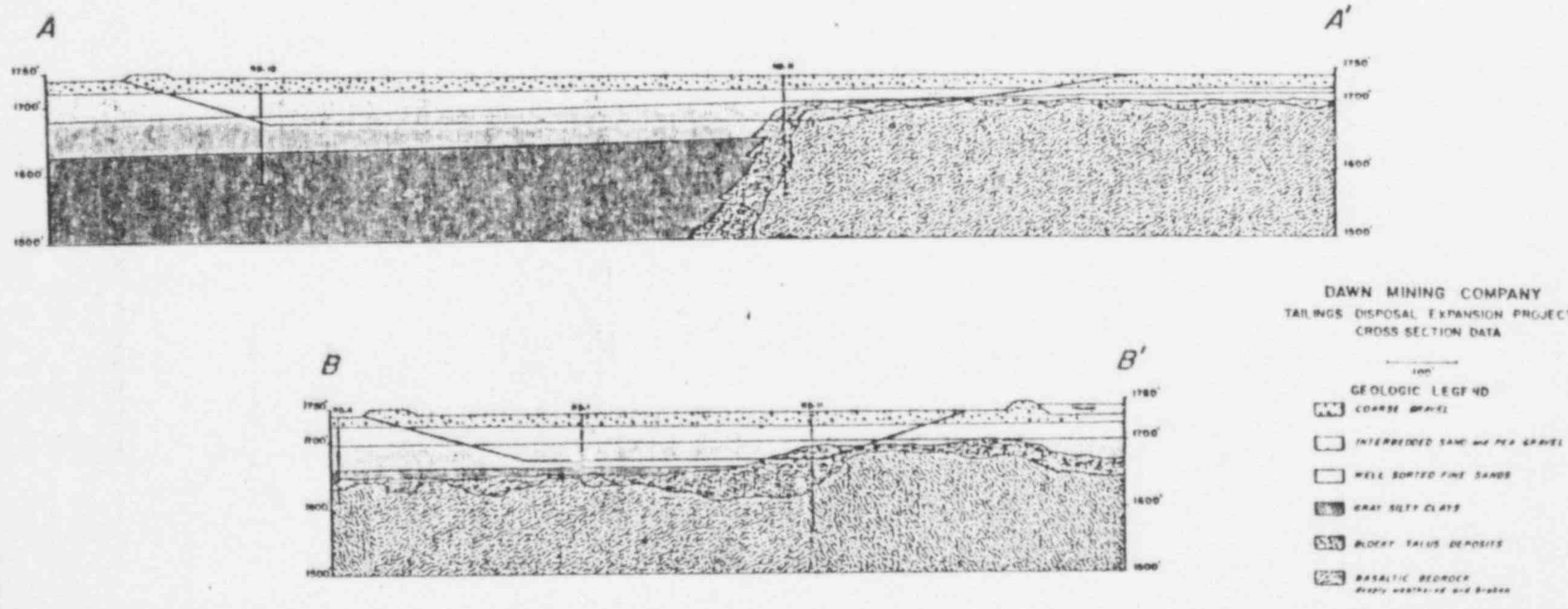


FIGURE 2.4

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Where the proposed excavation adjoins the existing dike impoundment, a fifty foot wide bench will be preserved at the downstream toe of the dike to assure structural integrity of the dam foundation while pit excavation is underway.

Pit inslopes will be maintained at 3 horizontal on 1 vertical. If sharp or irregular geologic units are encountered by the excavation, they will be blanketed with fine sands to provide a smooth base for liner installation.

Ingress and egress ramps for the excavation work will be located at the northern and eastern extremes of the pit area.

General requirements for rigorous structural engineering design for the excavation are minimal. Since impoundment failure is precluded by the subgrade design, the only significant engineering concerns are those that could effect the integrity of the liner system. Three key considerations relative to liner performance are:

1. slumpage of the excavation inslope,
2. differential compaction of the foundation materials,
3. slumpage of the membrane cover layer.

2.2.1.1.1 Inslope Stability

Natural angles of repose for the unconsolidated sands and gravels are from 38 to 42 degrees (1.28 h to 1v; 1.11 to 1,respectively), as measured along stream cutbanks. Slopes of 1.5:1 have been maintained without problem along portions of the existing dike impoundments.

From these observations, it is clear that the safety factor of the design inslopes at 3h to 1v is adequate.

2.2.1.1.2 Differential Compaction Potential

The only expected discontinuity in the pit floor is the interface between the basalt bedrock foundation which may be encountered in the eastern floor of the excavation and the thick glaciofluvial section to the west. Differences in compaction behavior are to be expected. However, since the materials excavated are comparable in weight to the materials being introduced into the facility (tailings), the foundation is essentially pre-stressed. In addition to these natural compactive processes, the operation of heavy construction equipment on the pit floor will enhance existing levels of compaction to the point that tailings-induced differential compaction will be negligable.

2.2.1.1.3 Membrane Cover Slumpage Potential

The synthetic membrane liner will be covered with one to two feet of chemically stabilized sands. 'early, the smooth membrane surface forms a slick, pervasive discontinuity plane.

The design inslope of 3:1 is premised on the experience of the contractor that installed the membrane liner on a similar installation for the nearby Western Nuclear Sherwood Project (N.A. Degerstrom Inc., Spokane). That installation utilized inslopes of 2.75h to 1v and a cover layer identical to that here proposed.

According to discussions with Western Nuclear personnel, the cover has shown excellent stability characteristics to date.

The gentler 3h to 1v slope proposed by Dawn should further assure cover stability.

2.2.1.2 Above-ground Dike Design

The five foot, membrane lined portion of the above ground dike mentioned in section 2.2.1 may be used for solution storage when the pit is nearly full. A typical section of the overall dike/stockpile is shown in figure 2.5. Material to be used for dike construction will be taken from the upper layer of sands and gravels from which all previous dikes have been constructed at Dawn. Maximum rock dimension is less than 4 inches. Each lift during construction will be 12" thick and will be compacted by use of a minimum 25,000 pound vibratory compactor. This will allow compaction levels in excess of Department of Ecology requirements. Moisture content will be maintained so as to insure proper compaction. The original safety berm and dam construction removed most of the topsoil from the area; what remains will be excavated. The previous dams constructed at the site have shown good bonding between embankment and foundations. The upstream side of the dike will be lined by the same method as the subgrade portion of the tailings impoundment. Residual freeboard will be maintained greatly in excess of 5 feet. Side slopes on the dike will be 3h:1v upstream and 2h:1v downstream. Top width will be 30 to 35 feet, double the Department of Ecology requirement of 15 feet for this height of dam.

It should be noted that the upper portion of this dike is basically a reclamation material stockpile, under no foreseen circumstances to be used as an impoundment dike beyond a level five feet above ground surface. This portion will be lined and utilized only for temporary solution storage.

2.2.1.3 Pond Liner

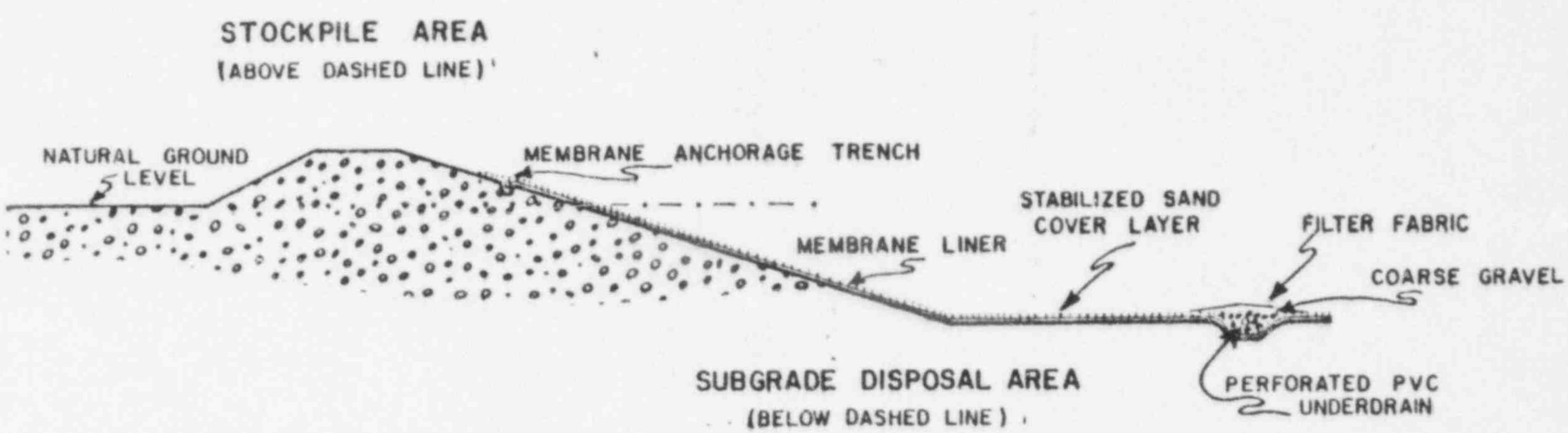
The entire pit floor and side slope surface will be lined with a fabric-reinforced 30-mil synthetic rubber (Hypalon) liner. The liner membrane will be carried up the dike inslope to a level five vertical feet above the original ground surface elevation in order to permit the lower part of the above-grade area to be utilized for solution storage during the final stages of pond life.

A one foot thick cover layer of stabilized sand will be placed over the membrane to prevent aerodynamic wind billowing and to shield the membrane from ultraviolet rays for longer life. Membrane anchorage will be achieved by means of peripheral trench burial in accordance with recommended practice.

2.2.1.4 Reclamation Material Stockpiles

The subgrade pit excavation will generate sufficient volumes of sand and gravel to provide for anticipated long-term site reclamation needs for the entire tailings disposal area. To facilitate utilization of these materials for reclamation purposes in the future, Dawn intends to stockpile the sands and gravels in piles surrounding existing tailings ponds. This plan will have the additional benefit of reinforcing existing dikes. Figure 2.6 illustrates the intended stockpile areas. An interrim vegetative cover will be established on the stockpiles to reduce wind and sheet-wash erosion.

DIKE/STOCKPILE & SUBGRADE DISPOSAL FACILITY



ENGINEERING SECTION

FIGURE 2.5

2.2.1.5 Underdrain System

Since the proposed facility will be fully lined, normal dewatering by means of seepage into the substratum is precluded. It is therefore necessary to provide a system capable of aiding in the dry-out phase of reclamation and long-term stabilization.

Engineering studies are still in progress to determine the optimum configuration for the drainage duct system. Generally, the system envisioned would include an underdrain grid of French or pipe drains feeding into a combined French/perforated PVC pipe collection sump where solutions can be pumped to the surface for disposal by evaporation. It will likely be necessary to cover the drain system with a polyester filter fabric to prevent clogging of the drainage ducts with tailings fines.

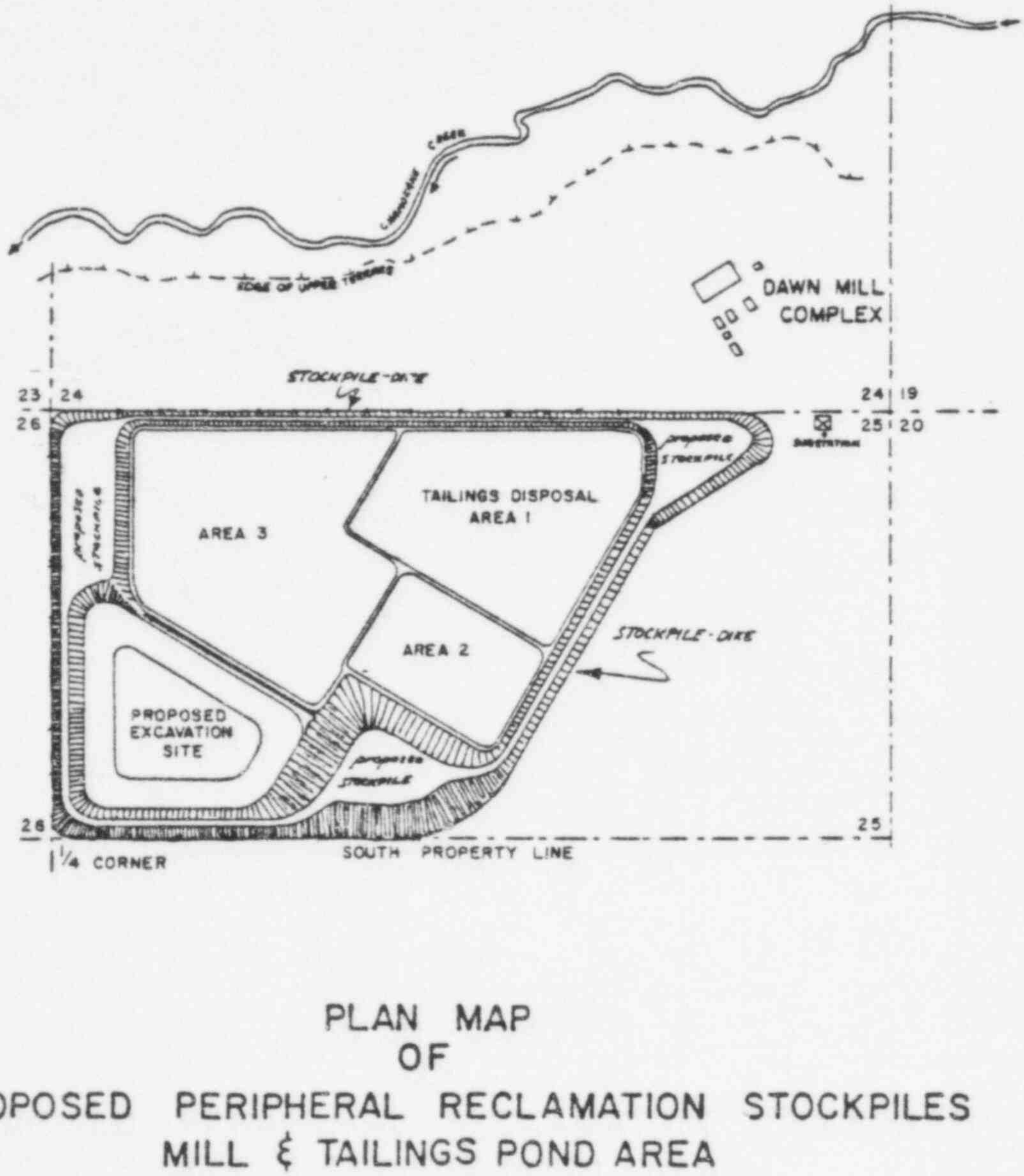
The potential for inducing liquid migration towards underdrain lines by electro-kinetic densification proceedures developed by the Bureau of Mines (Sprute and Kelsh, 1974) is being researched, and may be incorporated into the dewatering plan if feasable.

2.2.1.6 Reclamation and Long-Term Stabilization

Pursuant to the Washington State "Mill Licensing and Perpetual Care Act of 1979" and based on the guidelines presented in NUREG - 0511, Draft Generic Environmental Statement, Dawn has developed the following planned program for reclamation and long-term stabilization of the tailings disposal facility. This plan may be modified upon promulgation of final regulations or in accordance with those in effect at the time of the event.

The following steps will be taken to stabilize the tailings pond:

1. The tailings will be allowed to dewater for a period of 1 - 3 years to allow heavy equipment to work on the tailings surface. Interim dust control measures (sprinkling or wood chip cover) will be taken to control wind dispersion of tailings.
2. Tailings surface will be graded to enhance drainage.
3. A layer of clay 2 ft. thick will be placed and compacted over the tailings surface.
4. An additional layer of fill 8 ft. thick consisting of sands and gravels will be placed overlying the clay.
5. No topsoil will be added to this cover since the area surrounding the project site has minimal natural "A" horizon soil development.
6. The cover over the tailings will be graded and contoured so as to eliminate the possibility of ponding of precipitation over the area. In addition, the out-slopes of the cap layer will be reduced to a slope of 5 horizontal to 1 vertical by the addition of fill material along the peripheries.
7. The entire area will be seeded and fertilized to stabilize the cover. Natural reforestation will ensue fairly rapidly as evidenced by 20 ft. plus trees presently growing on the abandoned tailings berm around areas #1 and 2.
8. The revegetation effort will be monitored for success and remedial measures will be taken to insure coverage of the area.



PLAN MAP
OF
PROPOSED PERIPHERAL RECLAMATION STOCKPILES
MILL & TAILINGS POND AREA

1" = 1200'

FIGURE 2.6

With respect to the final disposition of the facility, Dawn Mining Company will comply with the provisions of the Washington State "Mill Licensing and Perpetual Care Act of 1979" sections 3.1(b), 2(b), 6, 7, and 8, or the current laws in effect at the time of the event.

2.2.2 Timing of Phased Operations

2.2.2.1 Construction Phase

The detailed steps involved in the construction phase and their approximate timing are summarized in Table 2.1. It should be specifically pointed out that Dawn's existing tailings disposal ponds will be filled by mid-1980, by which time new pond areas must be available. To comply with this scheduling requirement, construction work on the proposed facility will need to begin no later than January, 1980.

2.2.2.2 Operations Phase

Beginning in mid-1980, the new facility will be utilized as a disposal site for tailings solids and solutions generated by the uranium milling process. If utilized to full design capacity, the solids will fill the pit to original ground level by mid-1993, at which time the area would be taken out of service.

2.2.2.3 Post-Operations Phase

After useage is halted, a 1 to 3 year dry-out period will ensue. Interrim dust control measures will be implemented as necessary. After the surface of the tailings material has dried sufficiently for heavy equipment access, the reclamation and stabilization measures described in section 2.2.1.6 will be initiated. The process should be complete and vegetative cover well established by 1999 or 2000.

2.3 OTHER OPERATIONS RELATED TO PROJECT

2.3.1 Introduction

The proposed project is part of a uranium mining and milling operation. While the project will result in no changes in either the processes or rates of mining or milling, construction of the facility is necessary to permit present operations to continue. In order to better provide an understanding of the overall context of the project, the nature of the mining and milling operation is here summarized.

2.3.2 Mining

Uranium ore fed to process at the Dawn mill is obtained from the Midnite Mine, located 13 miles airline WNW of the millsite. The mine is on the Spokane Indian Reservation, on land leased by Dawn from the Spokane Tribe of Indians.

The deposit consists of relatively compact, high-grade orebodies distributed along the contact between a 70 million year old quartz monzonite intrusive and 1.2 billion year old metasediments of the Togo formation. The orebodies are typically mineralized breccias occuring within pyritic, carbonaceous facies of the Togo. Principal ore minerals are pitchblende (uranium dioxide) and autunite (hydrous calcium-uranium phosphate). Average ore grades over the life of the mine have fluctuated between 0.10% and 0.25% U_3O_8.

POOR ORIGINAL

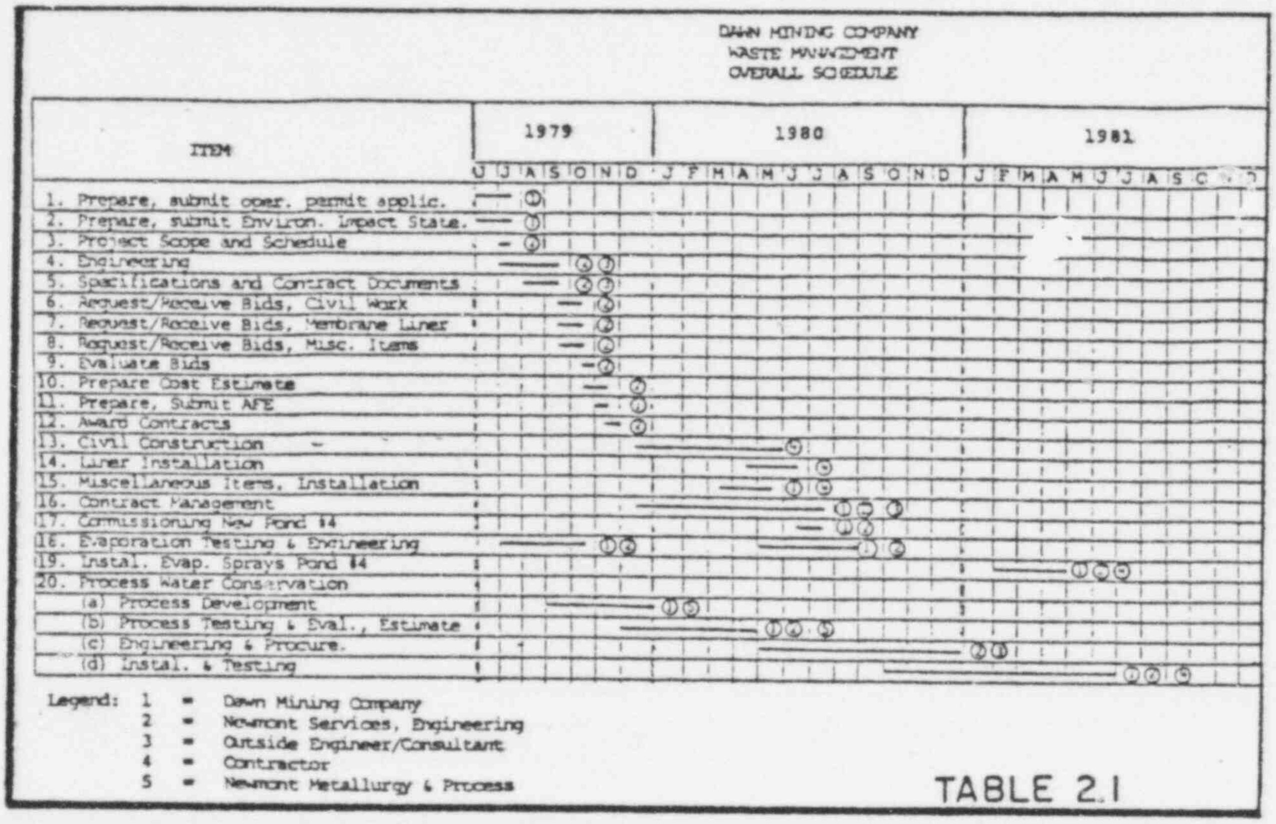


TABLE 2.1

The deposit was discovered in 1954 and has been operated by Dawn Mining Company until the present time. To date, over 10 million pounds of U_3O_8 have been recovered from about 2.2 million tons of ore averaging 0.225% U_3O_8.

The deposit is mined exclusively by open pit methods. Production has been from eight essentially separate pits, all but three of which have been backfilled with waste from subsequent mining. Waste to ore ratios have gradually increased over the years from about 2:1 to nearly 30:1 today. Maximum depths of excavation have also increased from about 100 feet to depths of over 500 feet.

Total mine life expectancy remains open-ended. Exploratory drilling is continuing to increase proven reserves and delineate favorable targets. Dawn has announced reserves totaling 937,000 tons averaging 0.143% U_3O_8 (as of year end, 1978). These reserves are sufficient to provide mill feed for nearly six years. Potential for the development of proven mineable reserves in addition to this amount is considered excellent.

All mining operations (and eventual reclamation work) are conducted under plans approved by the Department of Interior Bureau of Indian Affairs and the U.S. Geological Survey.

2.3.3 Ore Hauling

Ore is trucked from the Midnite Mine to the Dawn mill at Ford by means of contracted 25 ton truck-trailer rigs. A company-owned and maintained haulage road connects the minesite with a paved county highway which extends to Ford. The trucks then follow state highway 231 about one-fourth mile west to the mill access roadway. Total one-way distance from mine to mill is 18 miles. During winter and spring periods when road conditions become hazardous, ore haulage is interrupted and the mill is fed from stockpiles maintained at the millsite.

2.3.4 Milling

From millsite ore stockpiles, ore is delivered to the primary crusher system by a rubber-tired front-end loader.

Primary crushing operations are conducted on a one-shift per day basis by means of a jaw crusher and a three foot Symons cone. After screening, the material passing 5/8ths inch is mechanically sampled and conveyed to one of a series of five fine ore bins. Crushed ore from the bins is blended to yield a constant grade mill feed (currently 0.13 to 0.15% U_3O_8) and fed into a ball mill circuit producing a ground product passing 28-mesh.

The ground ore is then introduced into a series of sulfuric acid leach agitators. Acid content of the leach solutions is held at about 20 gm/l. Steam is injected to bring the system to a temperature of 40 degrees Centigrade, and manganese oxide is added as an oxidant to aid in dissolution of the uranium. This stage results in extraction of about 92% of the uranium contained in the ground ore.

The solution/pulp mixture is then pumped into a counter-current decantation circuit for separation of pregnant solutions from the leached sands and slimes. Seperan Ma 200 is added as a flocculant. Outflow from this circuit is filtered through a coal bed for final clarification of the solutions before being injected into the ion-exchange circuit.

The clarified pregnant solutions are then passed through a series of three pressure tanks containing ion-exchange resins. Uranium, along with several other chemical species, is adsorbed onto the resin beads. After an ion-exchange cell is loaded to capacity, the resin bed is eluted by means of an ammonium nitrate rinse.

This eluate is then introduced into a series of pachukas where the pH is gradually raised by addition of anhydrous ammonia and lime. At a pH of 3.8, calcium sulfate and iron oxide precipitate and are removed from the solution by drum filtration. The filter cake is returned to the primary leach circuit, while the filtered solutions are fully neutralized by further additions of anhydrous ammonia. At this point, the uranium precipitates as ammonium diurannate. A flocculant is added to speed settling, and the product is separated from the remaining solutions by further drum filtration.

The resultant wet "yellowcake" is then extruded into a dryer where excess moisture and ammonia are driven off. The yellowcake is finally loaded into steel drums, sampled, weighed and prepared for shipment.

Tailings leave the mill as a 30 to 50% solids slurry and are pumped through a six-inch PVC pipeline one-half mile to the tailings disposal facility. Tailings components are derived from several points in the mill circuit, but the principal exit point for leached solid residues is from the number 4 thickener underflow (CCD circuit). Other fractions of the tailings composite include:

1. High-nitrate barren from the I-X circuit,

2. Wash solutions derived from the resin regeneration and wash cycle, and

3. Low-nitrate barren periodically bled to tails to prevent silica build-up.

2.4 CONSISTENCY OF PROJECT WITH EXISTING COMPREHENSIVE LAND USE PLANS FOR AREA

A formal comprehensive land use plan has not been formulated for the Walkers Prairie region of Stevens county. However, by merit of the provisions of the Washington State Mill Licensing and Perpetual Care Act of 1979, uranium mill tailings disposal sites will be deeded to the state at the time of permanent cessation of milling for purposes of perpetual care. All area involved with the present proposal would already come under the provisions of that act; in effect, the project area has been committed to perpetual uranium mill tailings storage by merit of its immediate proximity to pre-existing disposal facilities.

3. EXISTING ENVIRONMENTAL CONDITIONS

3.1 ELEMENTS OF THE PHYSICAL ENVIRONMENT

3.1.1 Earth

3.1.1.1 Regional and Site Geology

Since long-term site stability is an important consideration in the present proposal, the geologic history of this region is discussed in detail in Appendix A. The area surrounding the Dawn millsite has a long and varied history, characterized by the following sequence:

1. Exceptionally stable pre-Cambrian conditions of shallow marine deposition lasting over 1 billion years (2 billion to 600 million yrs. B.P.);

2. Progressive marine transgression and gentle structural deformation during the Paleozoic (600 million to 225 million yrs., B.P.);

3. Acceleration of structural deformation leading to a major mountain building episode and widespread granitic intrusions during the Mesozoic (225 million to 65 million yrs. B.P.);

4. Non-marine deposition, scattered volcanic and intrusive activity, and major block faulting during the early Tertiary (65 million through about 27 million yrs. B.P.);

5. Mid-Tertiary outpourings of flood basalts on an extensive scale; and,

6. A complex period of continental glaciation and glacier-related major flooding during early Quaternary times (1 million to about 20,000 yrs. B.P.)

Since the final recession of the great continental glaciers about 20,000 years ago, the region has been geologically "quiet". The historic perspective presented as Appendix A should help the concerned reader to evaluate the present geologic stability of the region.

In the last hundred years, there has been a scattering of minor earthquakes likel related to glacial unloading, with epicenters located less than 100 miles from the Dawn millsite; however, none of these have been significantly destructive. A few of the most severe quakes with epicenters from 100 to 400 miles away from the project area have produced significant local ground movement, but none in recorded history have extensively damaged structures in the Spokane area. Appendix B includes available seismic data for the region.

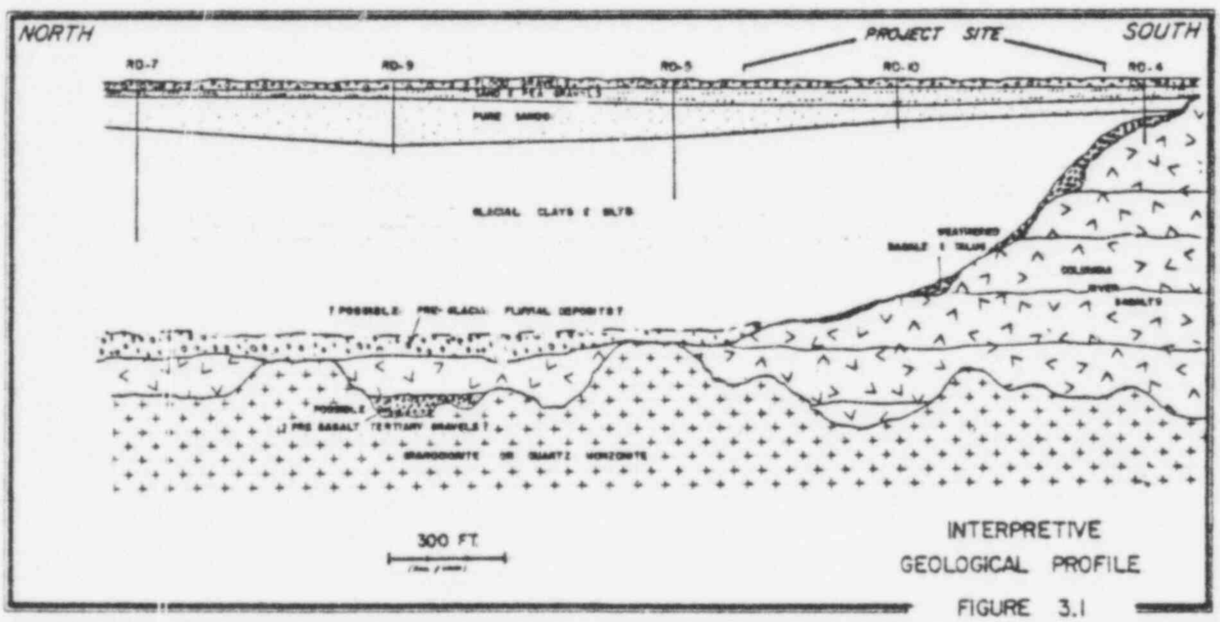
Walkers Prairie, site of the Dawn operation, is believed to be an erosional feature free of potential seismic structures. The mill area is underlain by a granitic basement buried beneath thin remnants of Columbia River Basalt and a thick accumulation of glacio-fluvial clays, sands and bouldery gravels. Figure 3.1 is an interpretive geologic profile of the materials underlying and adjacent to the millsite. A detailed measured section of the glacio-fluvial deposits which will be encountered by the sub-grade excavation is presented in Figure 3.2.

From Figures 3.1 and 3.2, it is apparent that the significant aspects of the geology with regards to the proposed project are:

1. Most of the excavation will involve gravels anc fine sands. The latter will greatly facilitate installation of a synthetic liner.

2. Deep.y weathered basalt bedrock may be encountered in the eastern part of the pit floor.

3. A dense glacio-lacustrine clay underlies most of the project site and provides a base for any vertically infiltrating seepage solutions. As discussed in Section 3.1.3.6, it is clear that this "main lower clay" unit is influencing seepage patterns from the present ponds. Figure 3.3A depicts the configuration of the upper surface of this clay. A more graphic presentation of the main lower clay configuration is to be seen in Figure 3.3b.



INTERPRETIVE GEOLOGICAL PROFILE
FIGURE 3.1

3.1.1.2 Soils

Soils of the project area, are in general, excessively drained, gravelly loamy sands derived from glacial outwash deposits. Little or no organic rich "A" horizon soils have developed on any of the units present.

According to soils mapping done by the USDA Soil Conservation Service, the principal unit directly affected by the project is the "Springdale Gravelly Sandy Loam", a stony phase of the Springdale series. A 6" surface layer of pale brown extremely stony sandy loam gives way to very gravelly loamy coarse

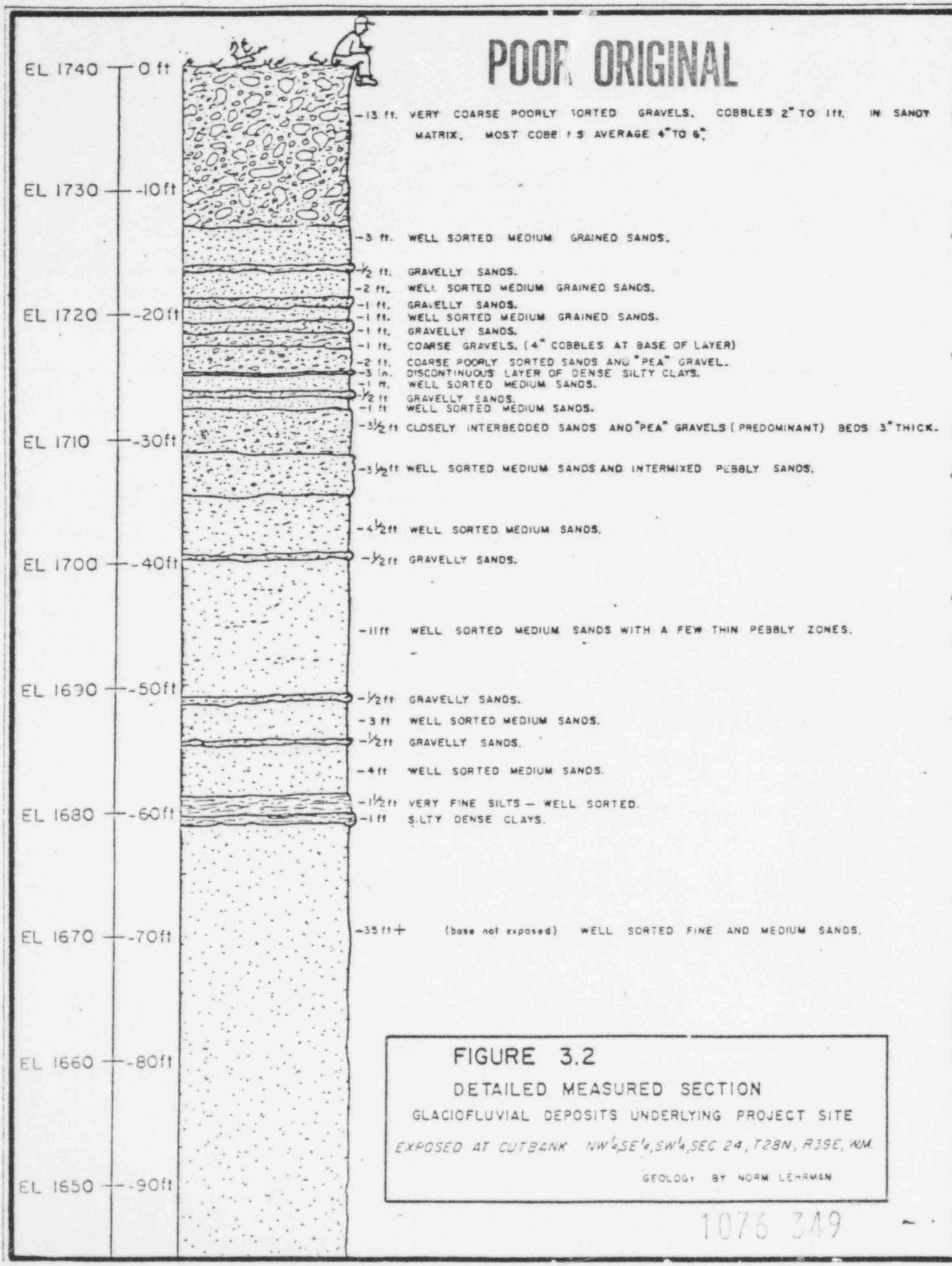


FIGURE 3.2

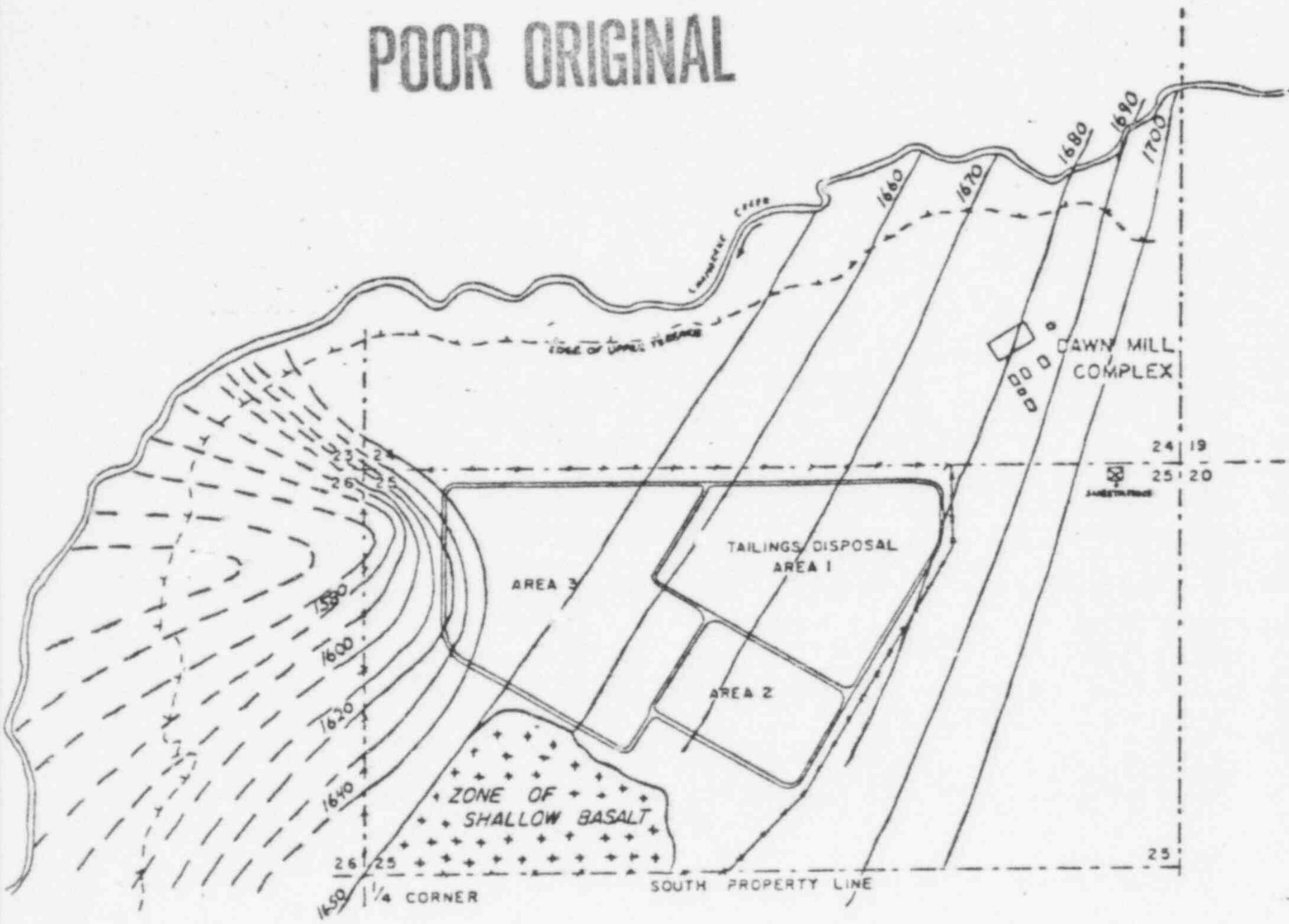
DETAILED MEASURED SECTION

GLACIOFLUVIAL DEPOSITS UNDERLYING PROJECT SITE

EXPOSED AT CUTBANK NW¼,SE¼,SW¼,SEC 24, T28N, R39E, W.M.

GEOLOGY BY NORM LEHRMAN

STRUCTURE CONTOURS ON SURFACE OF MAIN LOWER CLAY

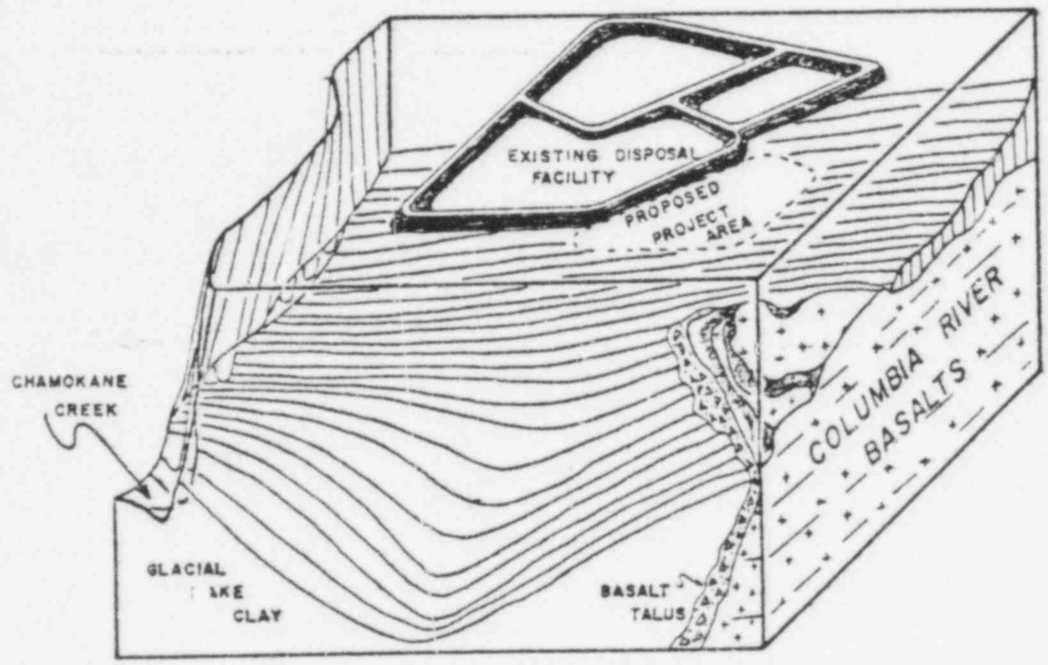


PLAN MAP
DAWN MINING COMPANY
MILL & TAILINGS POND AREA
FORD, WA.

1" = 1200'

FIGURE 3.3A

POOR ORIGINAL



CONFIGURATION OF MAIN LOWER CLAY UNIT

FIGURE 3.3b

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sands and very cobbly gravelly coarse sands below. The soil is best suited for woodland, grazed woodland, or dryland crop use.

Locally, the glacial deposits have been reworked by wind, generating a soil type referred to as the "Marble Loamy Sand". Often covered by an organic forest-floor duff layer, the thin surficial layers of brown loamy sand rapidly give way to a thick zone of well sorted fine sands. Again, this excessively drained unit is considered best used for woodland or grazed woodland applications.

Along very steep terrace breaks, a unit known as the "Spens Extremely Gravelly Loamy Sand" is developed adjacent to the project area. This is an extremely gravelly unit similar to the "Springdale Gravelly Sandy Loam" but lacking the loamy surface layer.

A few areas west of the project site in the stream bottomlands have local developments of moderately well drained to somewhat poorly drained loam soils classified as the "Narcisse Silt Loam" and the "Chamokane Loam". In both of these units, loamy surface layers may extend to depths of several feet and are somewhat better suited for dryland crops than either of the terrace top soils.

3.1.1.3 Topography

Walkers Prairie, the site of the Dawn mill complex, is a northeast trending valley about two miles wide and 15 miles long. It is bordered along the northwest by rimrock cliffs of plateau basalts and along the southeast by rounded granitic hills. A few erosional remnants of basalt veneer the flanks of the granitic terrain.

The valley floor is a flat plain of glacial out-wash and flood deposits cut by the meandering channel of Chamokane Creek. At the millsite, valley floor elevations range from 1740 to 1760 feet above sea level, while Chamokane Creek has incised its channel to an elevation about 100 feet below the Dawn mill level. Intervening cut banks between stream level and the main valley floor terrace above are very steep but in most areas are stabilized by fir/pine vegetation.

3.1.1.4 Unique Physical Features

No unusual or unique physical features are recognized in the project area. Downstream about three miles though, Chamokane Creek cascades over a series of scenic small falls, dropping about 50 feet in a span of 500 feet. This cascade, known as Chamokane Falls, is the only physical feature of special interest in Walkers Prairie. It will in no way be affected by the project here considered.

3.1.1.5 Accretion/Avulsion

Because of the moderate climate, low precipitation, and flat topography of Walkers Prairie, the only significant accretionary/avulsionary force operant in the area is the flowing water of Chamokane Creek.

Chamokane Creek is actively downcutting, working its way through the 500 to 600 feet of glacial outwash materials that fill its ancient channel. Since the uppermost glacial flood deposits were laid down about 20,000 years ago, and stream action has cut a channel 3000 feet wide and 100 feet deep through this material, the rate of down-cutting may be computed. In the past 20,000 years, the stream has deepened its meander zone an average of 0.005 feet per year. It has laterally widened its meander zone at a rate of 0.149 feet per year. If the full volume eroded is compared with overall Prairie width (10,000 ft.) the average rate of material removal is 0.00015 feet per year.

3.1.2.1 Air Quality and Odor

While no ambient air quality measurements have been made in the project area, air quality is subjectively evaluated by local residents as excellent. No significant sources of air pollutants exist in the local air flow regime except for intermittant burning of logging slash or agricultural fields.

The only detectable aromatic components of the Ford airflow are those from local agricultural or livestock operations, smoke from logging and agricultural burns, and flowery infusions from major wildflower blooms. The Dawn mill contributes no noticeable odors to the local atmosphere, and implementation of the present proposal will not induce any change in either rates or quality of gaseous emissions.

3.1.2.2 Climate

3.1.2.2.1 Areal Climatology

The Dawn millsite is located at the juncture between the broad flatlands of the Columbia Basin to the west, and the abruptly rising foothills of the Rocky Mountains to the east. Most of the air masses which reach the area consist of maritime Polar air brought in by the prevailing westerly and southwesterly circulations. This warm, moist system is stripped of much of its moisture as it is lofted across the Coast and Cascade Mountain ranges, producing a dryer "rain shadow" to the east. Less frequently, the area is over-ridden by dry continental Polar air masses from the northeast, resulting in high temperature/low humidity periods in the summer or sub-zero temperatures in winter.

Complete meteorologic records relevant to the project area are available from Spokane (25 miles to the SE), Wellpinit (10 miles to the WSW), and Chewelah (35 miles to the NNE). Climatological summaries for these stations are included as Appendix C to this report.

3.1.2.2.2 Precipitation

Annual precipitation for the area is 20 inches. About 70% of this total falls between the first of October and the end of March. During the October-March period, about half of the precipitation falls as snow.

3.1.2.2.3 Temperature

Mean annual temperatures for the area are about 47°F. The mean winter month temperature is about 28°, while the summer months average 66°.

Annual extreme highs of 100° +/- 3°F. have been consistently recorded at the Dawn millsite. Temperatures in excess of 80° commonly persist for about 8 to 10 weeks during June, July and August. Temperatures in excess of 90° are recorded for 2 to 4 week periods.

Annual extreme lows are bimodal. During years when local weather patterns are dominated by southwesterly circulation, the maritime Polar air brings lows of -7° +/- 5°F. However, during about half of the ten years that records have been kept at the millsite, 1 to 2 week periods of temperatures in the -20° to -40°F range have been noted, likely due to spill- overs of modified continental Polar air crossing the Rockies from the east or northeast.

3.1.2.2.4 Wind

Surface wind roses for various Washington stations are presented in Figure 3.4. Records from Spokane and from Western Nuclear's Sherwood mine site indicate prevailing winds blowing out of the southwest or west-southwest at an average of 8.5 mph. During winter months the air flow is commonly reversed, with winds out of the northeast.

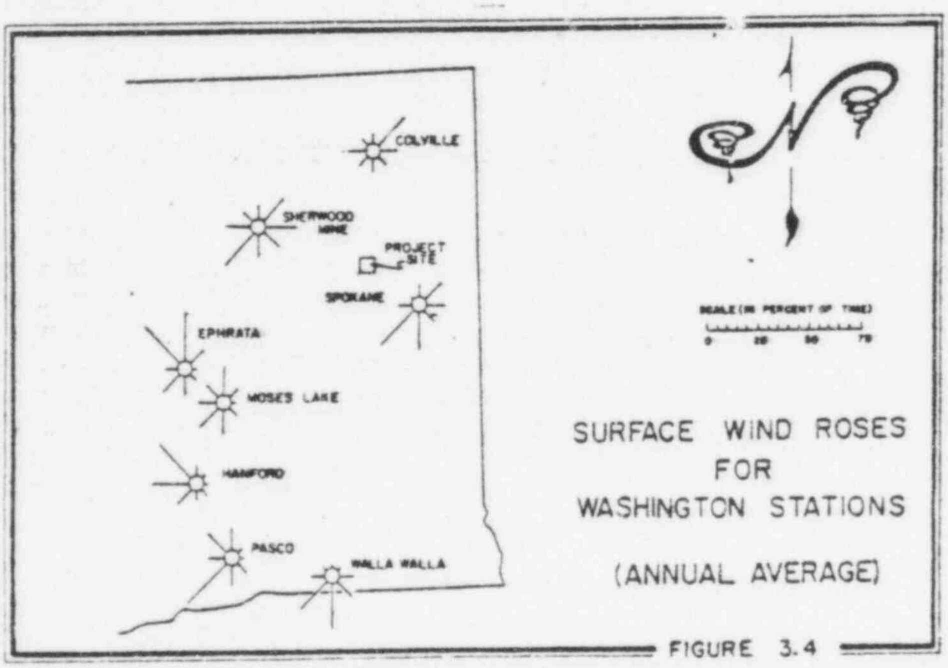


FIGURE 3.4

This prevailing regional southwest/northeast circulation is enhanced in the Dawn millsite area due to a similar trend to Walkers Prairie, providing a channel for surface winds of that orientation.

3.1.2.2.5 Evaporation

Mean annual lake evaporation for this area is about 38" per year (Harbeck and others, 1958). Class A pan evaporation is about 53"/yr. If mean annual lake evaporation rates above are adjusted to include the effects of precipitation, the net annual evaporation that can be expected is about 18" per year, equivalent to 11.1 gallons/ft^2/yr.

Mean annual relative humidity for the Spokane station is about 65%. Average January vapor pressures are on the order of 0.17", while midsummer (July) values are about 0.30".

3.1.2.2.6 Inversions

Low-level temperature inversions occur commonly in northeastern Washington, active up to 20-30 percent of the time during fall and winter months and increasing to 50-65 percent in summer and fall (Hosler, 1961)

Periodic upper-level inversions during the winter months can result in stagnant surface air conditions for extended periods. During such periods, under conditions of low wind speeds and low mixing heights, effective dispersion of atmospheric pollutants is at a minimum (U. S. EPA, 1972).

3.1.3 Water

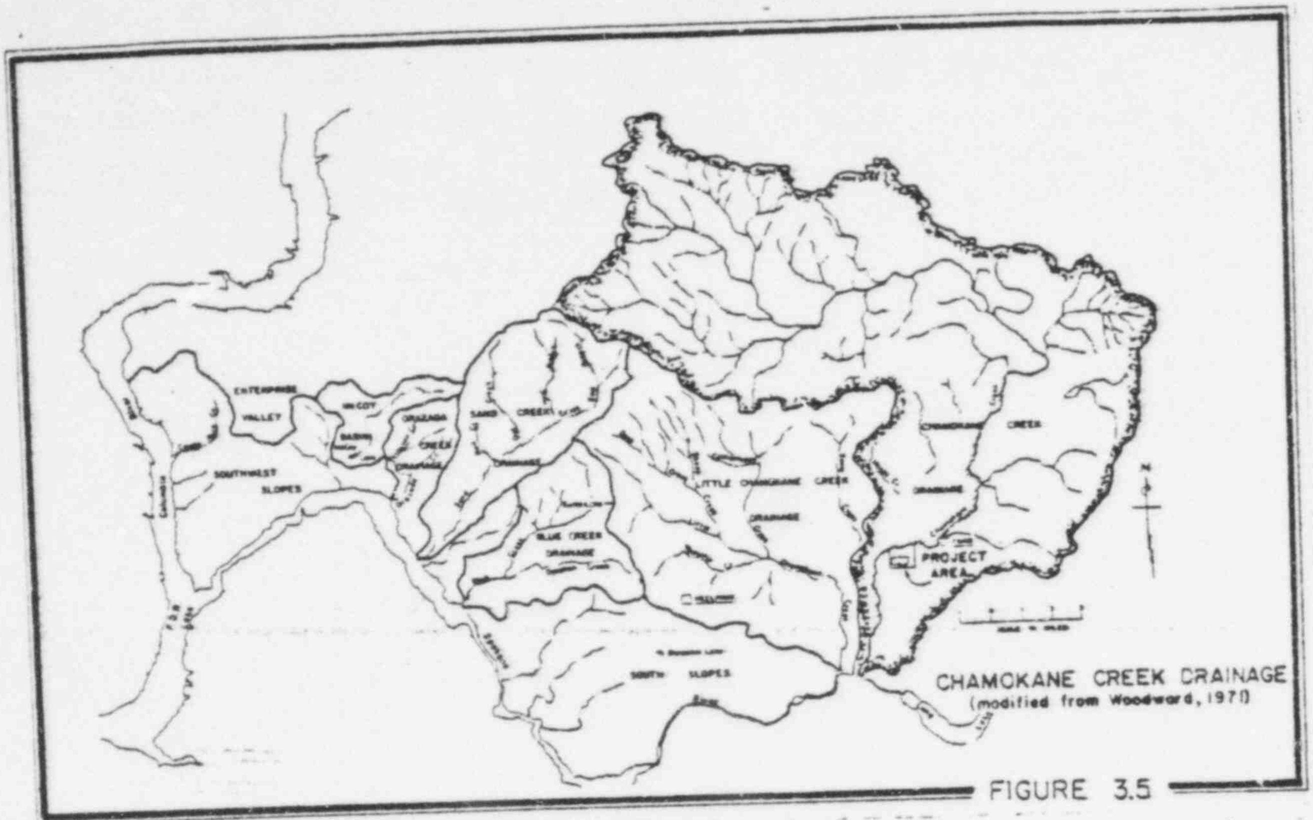
3.1.3.1 Surface Water

The Dawn millsite lies within the drainage basin of Chamokane Creek, the principal surface stream of Walkers Prairie. Extending the full length of Walkers Prairie, the creek flows southwestward, entering the Spokane River between Long Lake and Little Falls Dams. Chamokane Creek has its headwaters in the Huckleberry Mountains north of the Spokane Indian Reservation. Its watershed includes nearly 180 square miles, yielding a mean discharge of 53 cubic feet per second near its mouth about 6 miles below the project area. Figure 3.5 illustrates the Chamokane Creek watershed.

Although the creek has continuous flow in the mountainous headwater portion of its basin, the flow becomes subterranean and the surface stream intermittant upon entering the gravel-filled floor of Walkers Prairie near Springdale. Several miles downstream, in the vicinity of Ford and the Dawn mill, a series of massive springs emerge, restoring continuous flow to the surface channel from there to its mouth.

Because of the high permeabilities of the glacial sands and gravels composing the millsite terrace, there are no other surface stream courses in the area immediately surrounding the mill tailings pond. Virtually all precipitation is absorbed into the ground without surface runoff.

Chamokane creek does not have a history of serious flooding, and in any event, potential flooding would not involve the present project area since the stream occupies a wide meander flats about 100 feet below the project terrace.



CHAMOKANE CREEK DRAINAGE
(modified from Woodward, 1971)

FIGURE 3.5

3.1.3.2 Surface Water Quality

In a study for the Spokane Tribe of Indians, Woodward (1971) states: "Natural contamination as well as stock and agricultural pollution in the entire watershed of the Chamokane Creek render the surface flowing water, as in the case of all streams, impotable without disinfection and possibly treatment."

Results of analyses on water samples collected by Dawn Mining Company are shown in Table 3.1. Figure 3.6 depicts sampling locations. Other analyses are reported in Woodward (1971).

	SAMPLE STATION	T.D.S.	SO_4	NO_3	Zn	Mn	As	Pb	Cr	Cu	U
Upstream	SP-15	124	5	0.71	.002	.08	<.001	.003	-	.002	.001
	TCU	173	5	-	-	.015	.001	-	.02	.002	.002
	SP-11	257	15	0.70	.004	.08	.001	.002	-	.002	.001
Seepage influx zone											
Downstream	SP-12	300	25	2.92	.003	.07	.006	.001	-	.001	.002
	TCL	356	40	-	-	.015	.001	-	.01	.002	.005
	SP-13	262	20	3.56	.003	.04	.002	.001	-	.002	.002
	Spokane River	68	5	0.03	.095	.06	<.001	.004	-	.002	.001

(All values reported as mg/L (*ppm))

TABLE 3.1 SURFACE WATER ANALYSES

See Figure 3.6 for sampling locations

POOR ORIGINAL

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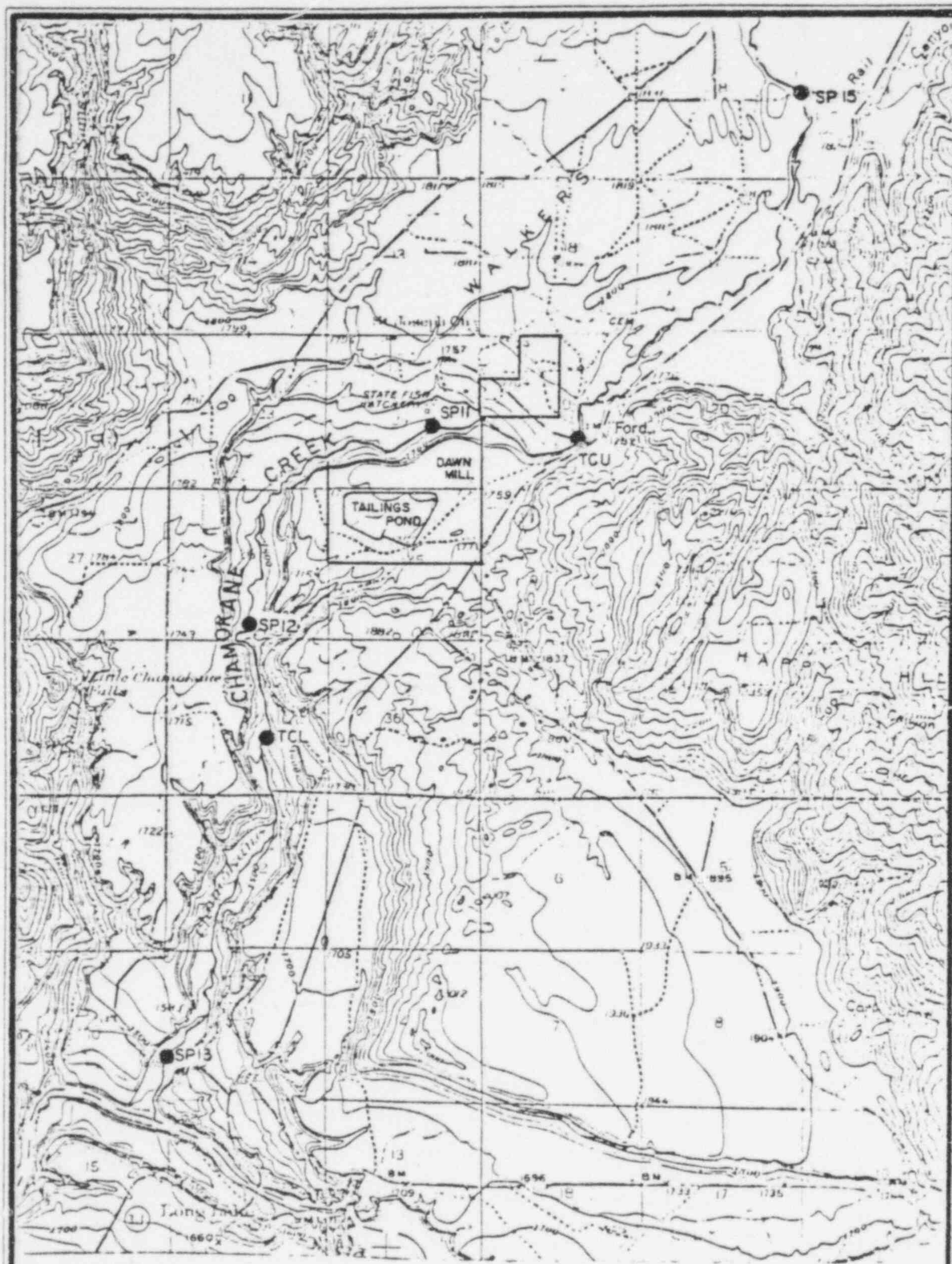


FIGURE 3.6

SAMPLING LOCATION
SURFACE WATERS

An apparent increase in total dissolved solids, Sulfate, Nitrate and to a lesser extent, trace arsenic and trace uranium is evident for stations progressively further downstream. Zinc and copper are essentially constant at all stations, while both lead and manganese decrease downstream.

Of the parameters tested, all stations meet the EPA criteria for livestock consumption, while manganese alone is slightly in excess of the recommended limit for human consumption.

3.1.3.3 Ground Water

The ground water/surface water relationship in Walkers Prairie is complex. As has been noted in Section 3.1.3.1, a substantial segment of the Chamokane Creek water flow through Walkers Prairie is subterranean, moving through the highly permeable glacial sands and gravels of the valley floor. Emergence of this subterranean flow at large springs in the Ford area maintains a consistant flow rate of over 25 c.f.s. in the lower portion of the channel. As a further consequence of the high permeability of the overburden gravels, no lesser tributaries to Chamokane Creek are developed in the Prairie area; essentially all precipitation and runoff from adjacent highlands infiltrates the gravels.

It is clear that both surface waters and precipitation recharge the glaciofluvial materials in Walkers Prairie. The uppermost mantle of coarse gravels serves as temporary storage for recharge of underlying less transmissible materials. The effective storage capacity of the glacial materials of Walkers Prairie has been estimated at about 15,000 acre-feet (Woodward, 1971).

Several significant geohydrologic horizons exist in the Ford area. The unconsolidated valley fill materials consist of a thick relatively constant section of glaciofluvial materials deposited by glacial melt and flood-waters. This sequence of gravels, sands, and silty clays overlies a basalt-rimmed paleochannel incised into granitic basement rocks. (see Figure 3.1) The shallow aquifers within the glaciofluvial section are quite well understood; however, considerably less is known about inferred or surmised aquifers associated with the bedrock units.

Within the unconsolidated section, significant ground water flows have been noted in essentially three zones. The uppermost zone occurs within and at the base of the highly permeable gravel/sand section usually composing the uppermost 100 feet of the valley fill. This unit is floored on a dense silty blue-gray clay which serves as a base for vertical infiltration. The clay surface dips gently westward, inducing groundwater migration in that direction. Flows at this interface are generally very modest, ranging from saturated sands to a few gallons per minute. (See Figure 3.3a and 3.3b)

The blue-gray clay unit locally contains thin stringers of water-bearing sand under slight artesian pressures. Flow rates of up to 10 gpm were recorded from this horizon in Dawn monitor wells.

To the south of the present mill tailings pond, the clay laps against a deeply weathered basalt rimrock, completely buried by later glaciofluvial deposits. One well encountered a sand/gravel layer beneath the lip of the clay which yielded up

1076 358

to 70 gpm. Elsewhere similar material was encountered at elevations above the surface of the clay unit, and no water flow was observed. Where confined beneath the clay, this horizon should be considered a significant potential aquifer.

Other geologically inferred zones may constitute deeper conduits for ground water migration. Blocky talus materials bordering the buried rimrock channel would constitute a high permeability material confined laterally by rock to the SE and the dense clay unit to the NW. Stream deposited gravels which may remain in the paleochannel bottom beneath the glacial silts and clays could be modeled as a potential aquifer. Seismic work reported by Woodward (1971) indicates a paleochannel depth of about 600 feet below the present valley floor. Finally, unpredictable fracture conduits within the bedrock units would comprise another class of aquifers likely to exist within the project area.

Since the major blue-gray clay unit acts as a base for downward infiltration of solutions in the project area, the uppermost aquifer level discussed is of the greatest relevence to the present proposal. The net of monitor wells established by Dawn Mining Company around the periphery of the tailings disposal area is being modified to sample this zone. (See Section 3.1.3.5)

The information summarized in this section was gained from an extensive drilling program, seismic refraction and reflection studies, electrical resistivity surveys, and geological examinations.

Support data for these studies is located in Company files and is available for inspection by authorized parties.

3.1.3.4 Ground Water Quality

Data here presented are based on analyses of samples taken from the most significant of the Ford area natural springs, several of which flow at rates of over 1,000 gpm. Tabulated results appear on Table 3.2, while sample locations are indicated on Figure 3.7. Additional analyses may be found in Woodward (1971).

SAMPLE STATION	T.D.S.	SO_4	NO_3	Zn	Mn	As	Pb	Cr	Cu	U	Cd	Mo	pH	NH_3	Cl
1	143	5	2.1	-	.10	-	-	-	-	.005	.001	.004	7.7	-	-
2	195	5	.1	-	.10	-	-	-	-	.003	.001	.003	8.1	-	-
5	334	50	<.05	-	.15	-	-	-	-	.005	.001	.003	7.4	-	-
6	320	15	1.2	-	.15	-	-	-	-	.018	.001	.006	8.9	-	-
16	232	5	.72	.002	.08	.001	.001	-	.002	.002	-	-	8.2	<.1	-
17	222	5	.14	.004	.020	.001	-	.02	.004	.001	-	-	-	-	5.0
18	200	5	1.09	.003	.015	.001	-	.02	.002	.001	-	-	-	-	1.0
19	209	5	.16	.002	.015	.001	-	.01	.002	.001	-	-	-	-	0.5
20	160	5	.11	.005	.010	.001	-	.08	.002	.002	-	-	-	-	2.0
21	203	5	2.22	.009	.020	.001	-	.06	.004	.002	-	-	-	-	2.0
AVERAGE	221.8	10.5	0.789	.0042	.066	.001	.001	.038	.0027	.004	.001	.004	8.06	<.1	2.1

(All values reported as mg/L (=ppm))

TABLE 3.2 GROUND WATER (Natural Spring) ANALYSES

See Figure 3.7 for sampling locations

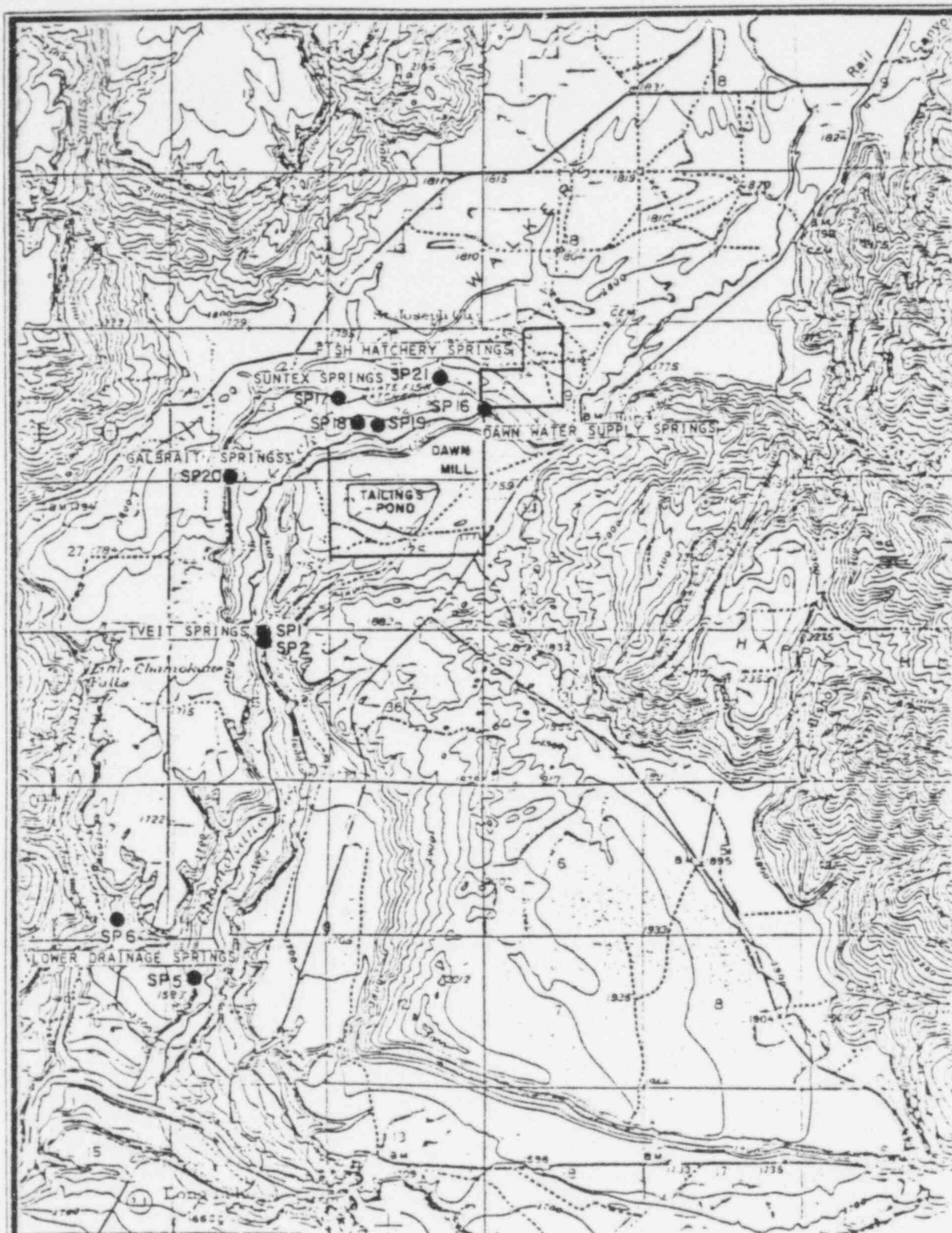


FIGURE 3.7

SAMPLING LOCATION
GROUNDWATER (SPRINGS)

Such waters are typically somewhat alkaline and moderately high in manganese, sulfate, nitrate and chromium. All fall within EPA limitations for consumption by both livestock and humans, although manganese locally is slightly above recommended limits for human use.

3.1.3.5 Dawn Monitor Wells

In order to obtain subsurface geological information and to establish a groundwater monitoring network, a series of eleven 6" rotaty holes were drilled during 1978 and 1979. Of these, 5 wells were cased to varying depths as permanent monitoring stations.

Table 3.3 presents analyses received to date together with water level elevation data. Figure 3.8 shows the monitor well locations.

SAMPLE STATION	CASED DEPTH	STANDING WATER LEVEL EL.	U	SO_4	NH_3	TDS	Zn	Cd	pH	Ra226 diss*	TOTAL ALPHA*	Mn	MO	NO_3
Well 5	220'	1644	.004	90.	3.31	188.	.013	.001	8.3	0.3	2.1	.15	.005	.60
Well 6	133'	1682	.0035	15.	3.24	100.	.10	.001	7.6	0.2	0.3	.20	.002	.60
Well 7	356'	1663	.002	30	-	102	.001	.001	7.8	0.3	2.2	.05	.006	.48
Well 8	152'	1676	.002	35	-	140	.001	.001	7.6	0.3	3.2	.15	.013	.31
Well 9	177'	1652	.002	60	-	162	.001	.001	9.3	0.3	2.2	.05	.008	.46

(All values reported as ppm (=mg/L) except *pCi/L)

Values given are means of 1 to 5 determinations (all available analyses)

TABLE 3.3 MONITOR WELL ANALYSES

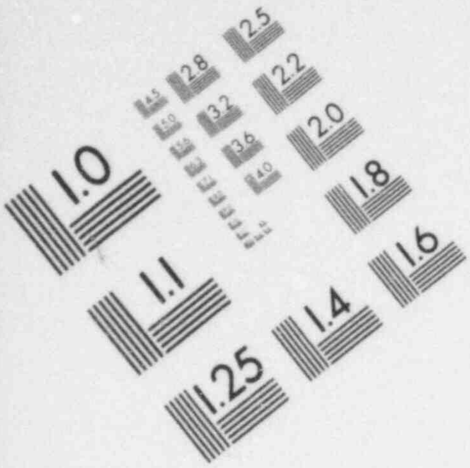
See Figure 3.8 for well locations

In view of the recently discovered seepage emergence zone located one-half mile west of the present pond area (discussed in Section 3.1.3.6, following) it is distressing that the monitor wells failed to clearly define this flow. The problem is likely due to upper (contaminated?) flows being scaled off by casing that extends to greater depths. Dawn proposes to re-enter the wells and perforate the casing just above the main lower clay surface (see section 3.1.3.3) in order to obtain more meaningful samples.

Comparison of Tables 3.2 (Ground Water analyses) and 3.3 (Monitor well analyses) shows essentially background levels of Uranium, Radium, Total Dissolved Solids, Nitrate, Cadmium, Manganese, and Molybdenum in the monitor well waters. Above background concentrations in sulfate, ammonium ion, and zinc are apparent in several wells, and this is probably a weak indication of seepage contamination. It appears that sulfate may be the best seepage indicator for future monitoring activities.

Observed standing water levels range between an elevation of 1644 and 1682 feet. In the immediate project area, the position of the water table is

7



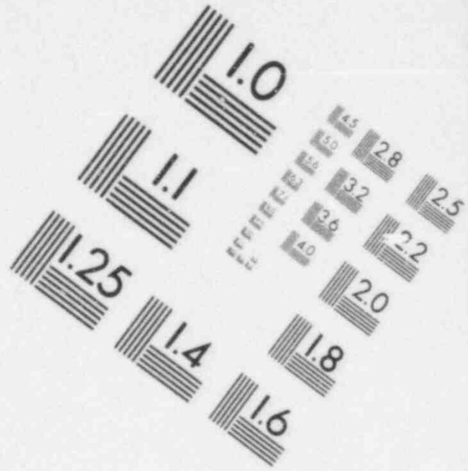
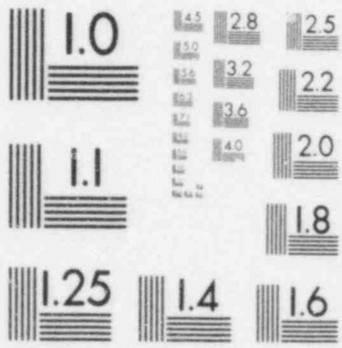
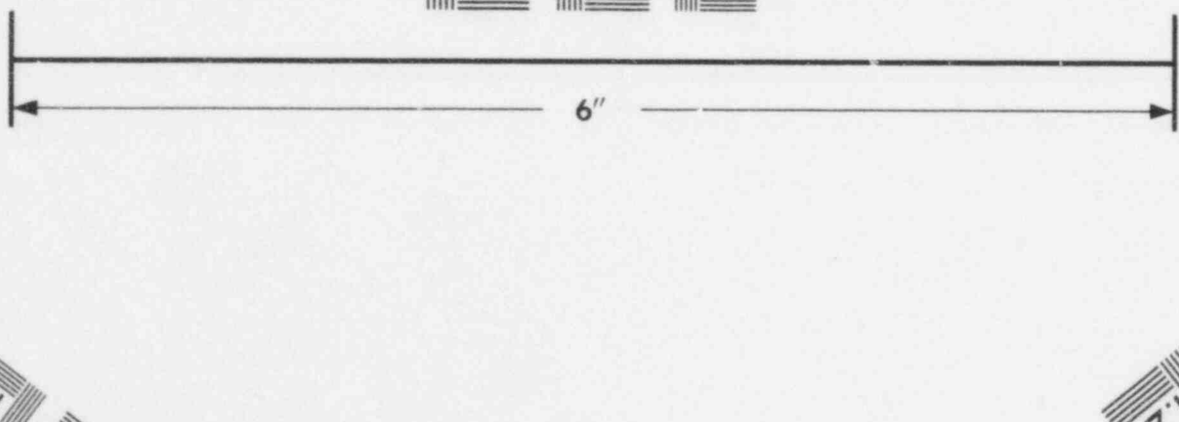
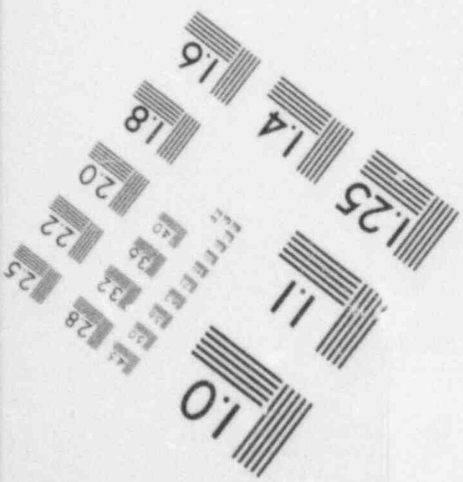
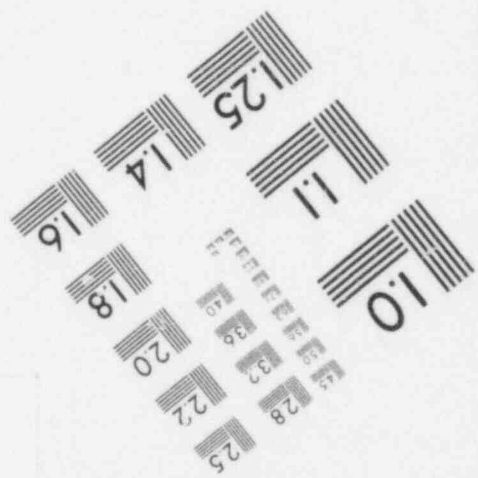


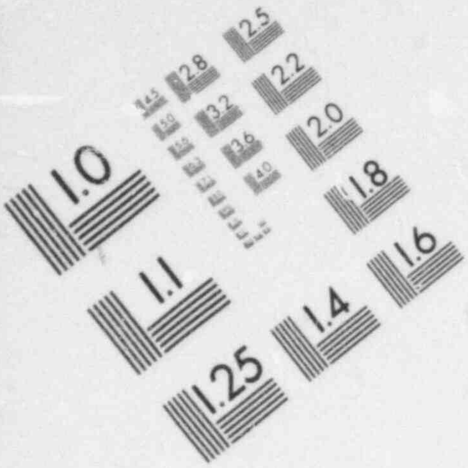
IMAGE EVALUATION TEST TARGET (MT-3)











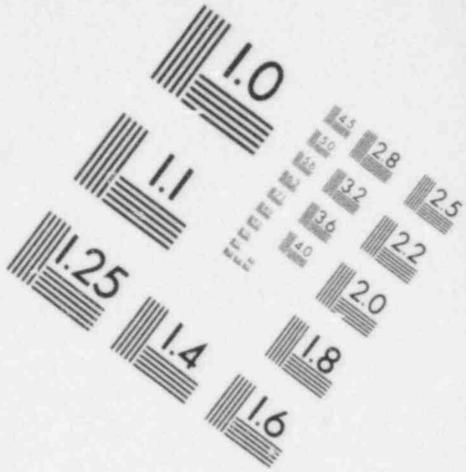
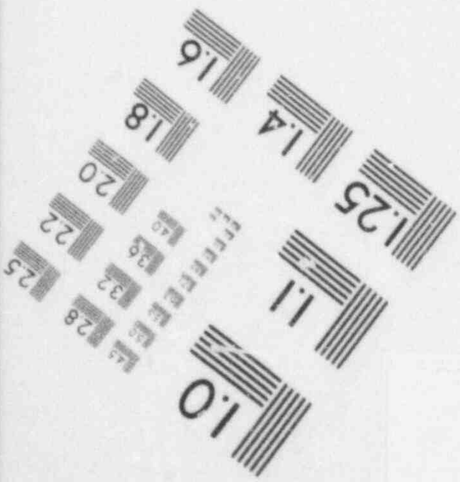
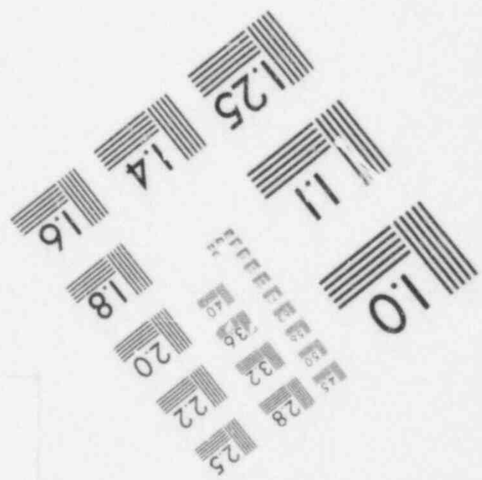
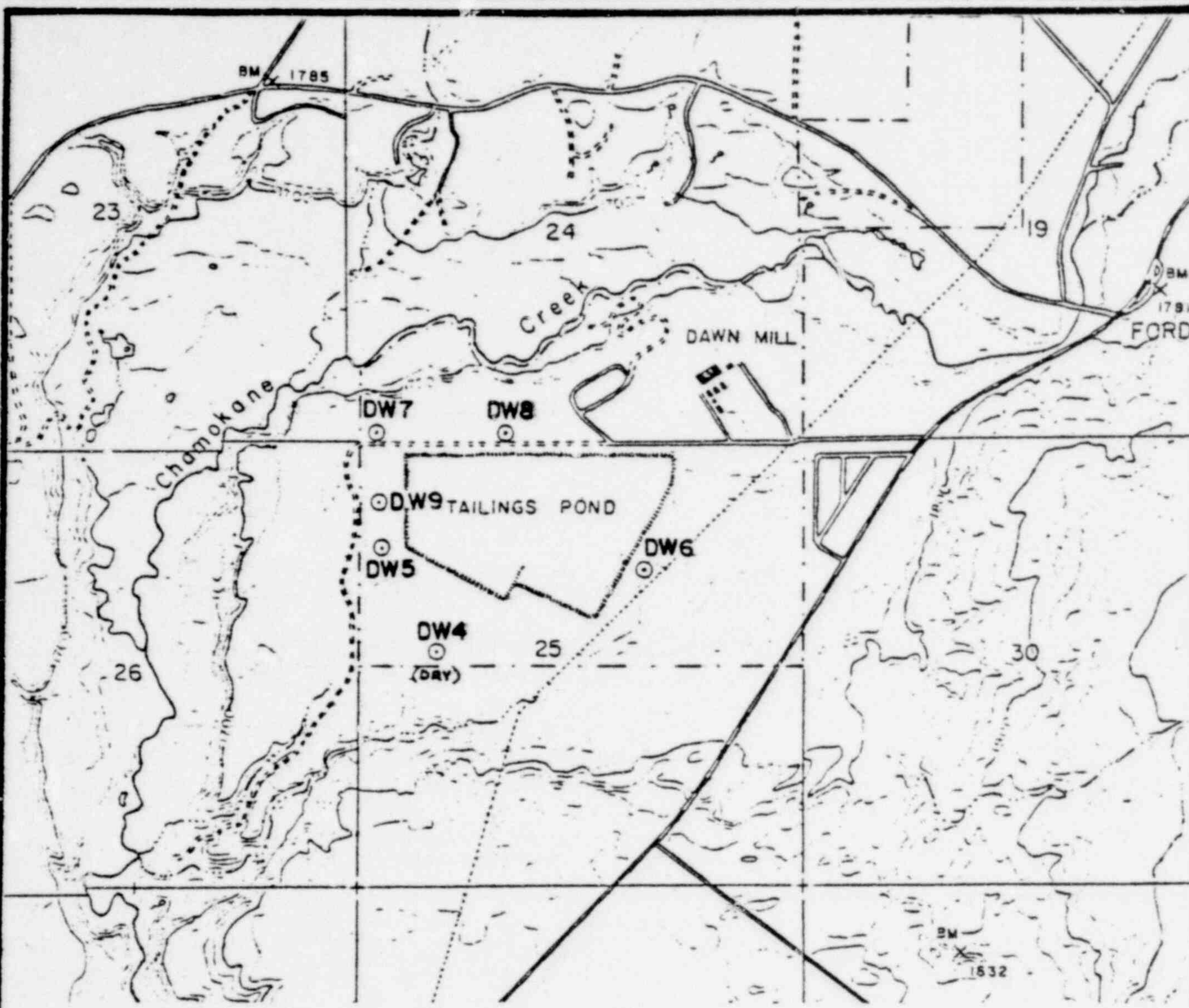


IMAGE EVALUATION TEST TARGET (MT-3)







POOR ORIGINAL

FIGURE 3.8

SAMPLING LOCATION

DAWN MONITOR WELLS

1077.001

about 1650 ft. The elevation of the proposed excavation floor is planned for 1680 ft., leaving a comfortable buffer zone between ground waters and the base of the disposal facility.

3.1.3.6 Tailings Solution Seepage

As a part of the studies preliminary to the formulation of the proposed project, detailed evaporation and water balance calculations were made. The results of this study can be summarized as follows:

	TAILS @ 30% SOLIDS	TAILS @ 50% SOLIDS
Solution inflow to pond ————	185 gpm	83 gpm
Net evaporation from pond ———	23 gpm	23 gpm
Solution entrainment in tails ——	3 gpm	3 gpm
Implied seepage outflow ————	159 gpm	57 gpm

Subsequent mass balance studies of Chamokane Creek upstream and downstream from the mill, based on conductivity and total dissolved solids, suggested a similar rate of inflow to the stream. A detailed follow-up sampling program led to the discovery of a high-conductivity seep entering Chamokane Creek approximately one half mile west of the present pond. The location of this seep corresponds with the projected position of a trough in the surface of the glacial clay stratum that underlies the tailings pond. (See Figure 3.3a and 3.3b) Figure 3.9 shows the position of the inferred seepage plume and seepage emergence zone.

Table 3.4 presents all available analyses from the seepage emergence zone, depicted on Figure 3.9a.

Evidence that this seepage has not significantly degraded the quality of Chamokane Creek can be seen by a comparison of analyses of stream waters collected above and below the seepage emergence area (see Table 3.1 and Figure 3.6). In general, total dissolved solids and nitrate show increases of about five times background, while sulfate, conductivity, uranium, and arsenic are elevated to about double background levels. Note however, that no significantly elevated arsenic was detected in seepage samples (Table 3.4), implying that the increase in this parameter is not due to the seepage influx.

Table 3.5 depicts the ratio of tailings solution concentrations to seepage solution concentrations for key parameters. Note the major increases in water quality observed in every measured parameter.

SAMPLE STATION	TDS	COND.*	SO_4	NO_3	U	Zn	Mn	pH	Mo	Pb	As	Ca	Ra^{226} (diss.)**	Total Alpha**
SP 3-1	2857	2030	1500	81	.07	.011	.05	7.1	.003	-	-	-	0.4	1.2
SP 4-1	3512	2970	1800	105	.10	.010	.40	7.0	.002	-	-	-	0.5	1.3
SP 7-1	5836	3200	5250	2	.09	.021	2.55	7.5	-	.005	.001	260	-	-
SP 8-1	1466	1300	800	8	.03	.005	.08	7.9	.002	.007	.002	125	-	-
SP 9-1	1571	2000	1600	.09	.02	.004	.05	7.9	.003	.002	.001	145	-	-
SP 10-1	2726	2000	3500	11.7	.24	.006	.07	8.1	.008	.004	.002	150	-	-
AVERAGE	2995	2250	2575	34.6	.06	.010	.53	7.45	.003	.0045	.0015	170	0.45	1.25

(All parameters in mg/L except - * mhos/cm^2 **pCi/L)

TABLE 3.4 SEEPAGE ANALYSES

See Figure 3.9 for sampling locations

	SP 3-1	SP 4-1	SP 7-1
Co	-	-	.02
Ni	-	-	.03
Cd	.001	.001	-
Cr	-	-	.01
Ag	-	-	.005
Fe	-	-	213
Hg	-	-	.042
NH_3	-	-	.1
Th	-	-	.001
V	-	-	.01
Cl	-	-	5.85
Si	-	-	.025
Mg	-	-	290
Na	-	-	51.5
K	-	-	12.5
PO_4	-	-	.001
Alkalinity***	-	-	1150
Hardness****	-	-	3220

(All parameters in mg/L except - ***mg HCO_3/L ****mg $CaCO_3$/L)

TABLE 3.4 Cont. SEEPAGE ANALYSES

See Figure 3.9 for sampling locations

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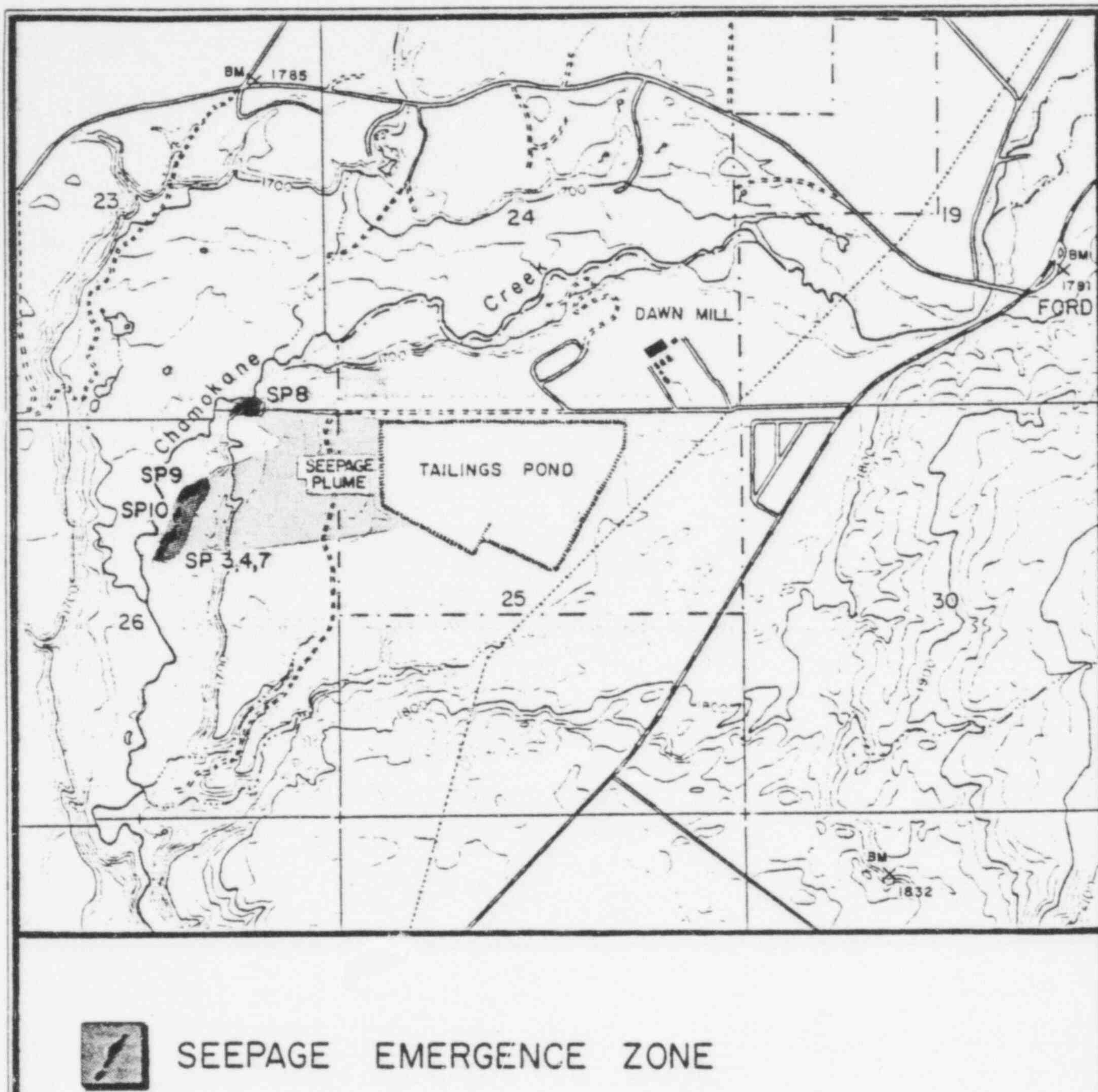
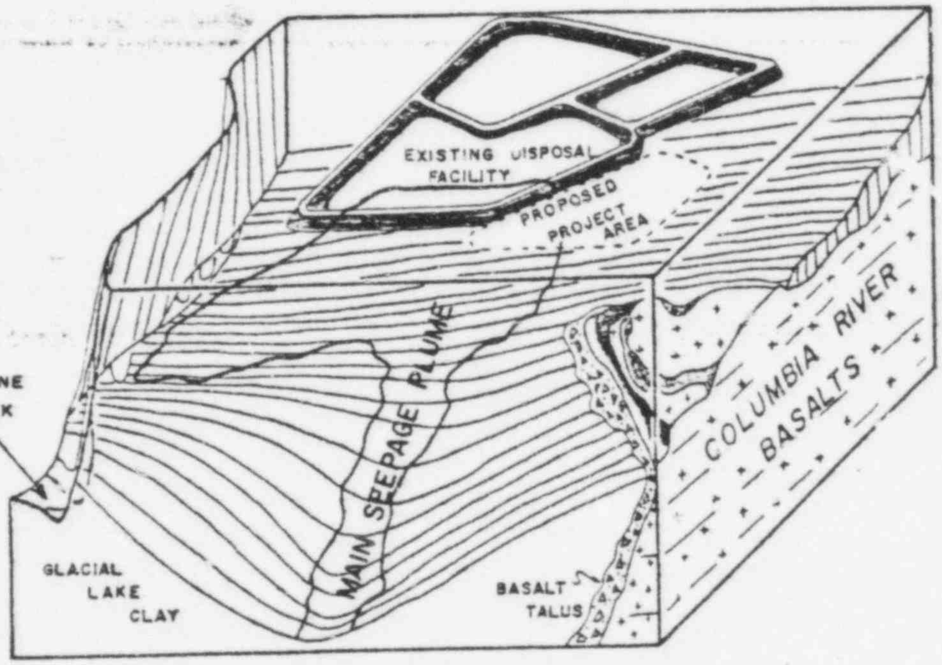


FIGURE 3.9A

SEEPAGE EMERGENCE ZONE

POOR ORIGINAL



SEEPAGE PLUME

Vs.

MAIN LOWER CLAY CONFIGURATION

FIGURE 3.9b

Parameter	Ratio Pond/Seep
Ammonium	2050
Zinc	1[illegible]90
Arsenic	827
Uranium	471
Manganese	429
Lead	137
Copper	101
Nitrate	36
Conductivity	13
Sulfate	9.4
Total diss. solids	9.3

TABLE 3.5 Pond/seep concentration ratios illustrating magnitude of increase in water quality after seepage.

Clearly, as the result of chemical reactions and dilution during seepage migration through about one half mile of glacial deposits, most parameters show drastic reductions in concentration. Examination of the conductivity, sulfate, and total dissolved solids ratios suggests an approximate ten-fold dilution of the seepage by natural groundwaters. The extreme drop in other measured concentrations requires explanation beyond that of simple dilution.

It is apparent that tailings solution acidity (pH = 1.6) is swiftly neutralized as it infiltrates the substratum, since all monitor wells and seeps show alkaline pH. This neutralization is responsible for the precipitation and immobilization of most of the heavy metals present in the initial tailings solutions.

The radionuclides, Radium 226 and Thorium 230, because of their well-documented slow migration due to adsorption onto soil mineral particles, are not present at levels above normal background in the seepage solutions.

Under the terms of State of Washington, Department of Ecology Waste Discharge Permit No. 5230, disposal of process waters by seepage is authorized. In no tested parameter are EPA uranium mill effluent guidelines exceeded. Nevertheless, the presence of the seepage is considered undesireable by Dawn Mining Company, underscoring the urgency for rapid approval of the membrane-lined tailings disposal facility here proposed. Such a system should be seepage free, and its utilization at the earliest possible date would halt the inflow of further solutions into the present unlined pond area.

From the analytical work to date it is apparent that the emerging seepage solutions are relatively innocuous, exceeding the EPA maximum permissible concentrations for drinking water only in nitrate, which is present in the seeps at levels about three and one-half times the M.P.C. specified. Observed nitrate concentrations are well within the limits specified for livestock utilization.

Sulfate, manganese, and total dissolved solids occur in excess of the EPA "recommended" limit for drinking water, but none of these parameters are considered toxic; rather, recommended limits have been set due to taste and laxative properties. All parameters show immediate dilution to near-background levels upon mixing with creek waters. Observed concentrations of toxicants in the receiving stream are sufficiently low that they will not interfere with beneficial downstream water uses.

No pollutant concentrations have been observed in the receiving stream (Chamokane Creek) that are expected to affect biological community diversity, productivity, or stability. Further, no effects on the rates of eutrophication or inorganic or organic sedimentation should be expected.

3.1.4 Flora

The project area occurs within the Ponderosa Pine Vegetation Zone and is dominated by Pinus ponderosa, the sole significant tree species directly affected by the project.

The well-developed open mature pine forest environment characterizing the Dawn millsite area hosts a simple understory floral community consisting of Columbia hawthorn (Crataegus columbiana), a variety of forb species dominated by Arrowleaf balsamroot (Balsamorhiza sagittata) and velvet lupine (Lupinus leucophyllus), and perennial grasses including Idaho fescue (Festuca idahoensis), needle-and-thread grass (Stipa comata), and bluebunch wheatgrass (Agropyron spicatum). Local patches of snowberry (Symphoricarpos albus), tufted phlox (Phlox caespitosa), yarrow (Achillea millefolium), and wild strawberry (Fragaria virginiana) were identified. Along roadways, sweet-clover (Melilotus sp.) flourishes.

Adjacent to the project area, along the breaks and bottom-lands of Chamokane Creek, there is an abrupt change in floral populations. There, Douglas fir (Pseudotsuga menziesii) is the dominant conifer. Ponderosa Pine is sparsely scattered throughout the area, and a few lodgepole pine (Pinus contorta) have been observed.

A vigorous deciduous community exists along the creek bottom lands, dominated by Mountain Alder (Alnus incana), Black Cottonwood (Populus trichocarpa), quaking Aspen (Populus tremuloides), Western Paper Birch (Betula papyrifera commutata), and Willow (several Salix sp.). Mock Orange (Philadelphus lewisii), Chokecherry (Prunus virginiana), and Elderberry (Sambucus cerulea) are also common understory bushes.

Heavy undergrowth consists of Pearhip rose (Rosa woodsii), Mallow ninebark (Physocarpus malvaceus), Snowberry (Symphocarpos albus), Nettle (Urtica dioica), Russian Thistle (Salsola kali), Burdock (Arctium minus), Oregon grape (Berberis aquifolium), Mullein (Verbascum thapsus), Nightshade (Solanum dulcamara), Jointgrass (Equisetum sp.), Camas (variety not determined) and numerous lesser grasses and forbs. Marshes and swamps typically support heavy Cattail (Typha latifolia) populations.

All species identified in the project area and adjacent bottomlands are of widespread distribution in equivalent regional environments. No unique, rare, threatened, or endangered species are known to occur in the general area of the project. This determination is made with great confidence with regard to the classic open pine forest zone that will alone be directly affected by the proposed project.

The two main communities identified represent relatively mature ecosystems that have evenly populated their respective environments. Zone boundaries coincide with topographic breaks; thus, the Chamokane Creek channel is, in nature, a corridor for the lush Douglas fir/Mountain Alder community. The proposed project is located entirely within the Ponderosa Pine community of the drier terrace-top area and will in no way influence the configuration of existing vegetative corridors or barriers. Only members of the Ponderosa Pine Community will be directly affected by the project.

Alfalfa, and to a lesser extent, grains, are the principal agricultural crops raised in the Walkers Prairie area. No cultivated lands will be affected by the proposed project.

3.1.5 Fauna

3.1.5.1 Mamals

The immediate area affected by the proposal is intermittantly frequented by White-tailed deer (Odocoileus virginianus), Coyotes (Canus latrans), Porcupines (Erithizon dorsatum), and more rarely by badgers (Taxides taxus), bobcats (Felis rufus), and long-tailed weasels (Mustela frenata). On an exceedingly rare basis, the area may be crossed by transcient black bears (Ursus americanus) or mountain lions (Felis concolor) although neither have been observed during the 20+ years of mill operation.

A number of small mammals are known to reside in the proposal area, including ground squirrels (Spermophilus washingtoni), yellow pine chipmunks (Eutamias amoenus), northern pocket gophers (Thermomys talpoides), and red squirrels (Tamiasciurus hudsonieus). Small bats of indeterminate species overfly the area. The varied mouse and vole population includes Deer mice (Peromyscus maniculatus) and montane voles (Microtus montanus). Common house mice (Mus musculus) have been observed in the mill complex. Shrew populations have not been studied in detail.

The Chamokane creek bottomlands offer better habitat and cover, supporting a population that includes all of the above species plus the following:

Cottontail rabbit	(Silvilagus floridanus)
Striped Skunk	(Mephitis mephitis)
Raccoon	(Procyon lotor)
Beaver	(Castor canadensis)
Muskrat	(Ondatra zibethicus)
Mink	(Mustela vison)

No rare, threatened, or endangered mammalian species are known to frequent the project area. It is probable that most individuals present will be simply displaced to extensive equivalent habitat nearby. It is possible that a limited number of the rodents living within the project site may be accidentally destroyed by construction equipment.

3.1.5.2 Birds

A complete listing of the wide variety of species of small songbirds that intermittantly use the project area is beyond the scope of the present study. The most common of the smaller summer residents include:

Western bluebird	(Sialia mexicana)
Eastern Kingbird	(Tyrannus tyrannus)
American Robin	(Turdus migratorius)
Bank swallow	(Riparia riparia)
Song sparrow	(Melospize melodia)
White-crowned sparrow	(Zonotrichia leucophrys)
Mountain chickadee	(Parus gambeli)
Yellow-rumped warbler	(Dendroica coronata)

Of the larger birds observed in the project area, the population is best characterized by the following:

Black-billed Magpie	(Pica pica)
Western Meadowlark	(Sturnella neglecta)
Common crow	(Corvus brachyrhynchos)
Common Raven	(Corvus corax)
Common Flicker	(Colaptes auratus)
Killdeer	(Charadrius vociferus)
Mourning Dove	(Zenaida macroura)
Downy Woodpecker	(Dendrocopos pubescens)
Red-tailed Hawk*	(Buteo jamaicensis)
Great Horned Owl	(Bubo virginianus)
Cooper's Hawk	(Accipiter cooperii)

*two pairs of Red-tailed hawks were observed nesting along the breaks of Chamokane creek adjacent to the project area during the spring of 1979.

The stream bottomlands adjacent to the project area provide habitat for a variety of additional large species. Some of the more significant include:

Great Blue Heron	(Ardea herodias)
Ruffed Grouse	(Bonasa umbellus)
Ring-necked Pheasant	(Phasianus colchicus)
Mallard	(Anas platyrhyncos)
Western grebe	(Aechmophorus occidentalis)
Common Merganser	(Mergus merganser)
Canada goose	(Branta canadensis)
American widgeon	(Mareca americana)
California quail	(Lophortyx californicus)
Belted Kingfisher	(Megaceryle alcyon)
Steller's Jay	(Cyanocitta stelleri)

Of the observed bird population, virtually all are common, widespread species. None are known to inhabit the area that are considered threatened or endangered. It is unlikely that any individuals will be directly affected by the project, since no nests have been observed in affected areas.

3.1.5.3 Reptiles and Amphibians

A limited variety of reptilian species have been observed in the project area and adjacent Chamokane Creek bottomlands including the following species:

Gopher (Bull) Snake	(Pituophis melanoleucus)
Garter Snake	(Thamnophis sp.)
Blue Racer	(Coluber constrictor)
Rubber Boa	(Charina bottae)
Western Skink	(Eumeces skiltonianus)
Painted Turtle	(Chrysemys picta)

Observed amphibians include:

Leopard Frog	(Rana pipiens)
Pacific Treefrog	(Hyla regilla)
Western Toad	(Bufo boreas)
Tiger Salamander	(Ambystome tigrinum)

All absorved species are common throughout the region. The immediate area affected by the proposed project would displace no more than a few individuals, essentially limited to Pacific Treefrogs and Western Skinks. No sizeable populations of any of the listed species inhabit the immediate project area. None of the known reptilian fauna present are rare, threatened, or endangered.

3.1.5.4 Arthropods

As with other faunal groups present in very large numbers and widely varied species, no effort is here made to catalog every individual genus that resides in or migrates through the project area; rather, a few of the dominant populations characterizing the locale are listed:

The most evident of the arthropod residents of the project area during summer months are the following:

Orthoptera (grasshoppers and crickets): Field crickets (Acheta sp.), camel crickets (Ceuthophilus sp.), and short-horned grasshoppers of the family Acrididae.

Homoptera (cicadas): Annual cicadas of undetermined species.

Coleoptera (beetles): Diverse population present represented by click beetles (Elateridae), Metallic wood-boring beetles (Buprestidae), Ground beetles (Carabidae), and Tiger beetles (Cincindelidae).

Lepidoptera (butterflies and moths): Also is a very diverse population, this insect order is locally climaxed by Swallowtails (Papilionidae) including (Papilio eurymedon) and (P. rutulus). Whites (Pieris spp.) and sulphurs (Colias spp.) are very common. Sara's Orange Tip (Anthocaris sara), numerous small Lycaenid species, and Nymphalids including several of the Tortoiseshells, Anglewings, and the Mourning Cloak (Nymphalis antiopa) emerge early in the spring.Later, several varieties of Fritillaries, Nymphs, and Skippers become dominant.

No rare, unique, threatened, or endangered, species have yet been identified in the project region. Major geographical features such as high mountain ridges and large river systems are the most common barriers to the spreading of such species; corridors are formed by the generally extensive intervening life zones. All of these features occur at a scale not affected by the present project. No unique environments are affected by the proposed work, so the potential for disrupting a small, highly localized population of unrecognized rarities is considered very small.

3.1.5.5 Fish

The surface waters of Chamokane Creek, which skirt the project area on the northern and western sides, provide habitat for moderate populations of a variety of gamefish, including (in descending order of abundance) the following:

1.	German brown trout	(Salmo trutta)
2.	Rainbow trout	(Salmo gairdnerii)
3.	Eastern Brook (Char)	(Salvelinus fontinalis)
4.	Cutthroat trout	(Salmo clarkii)

Non-game species in the project area include:

Common dace	(Rhinichtys sp.)
Redside shiner	(Richardsonius balteatus)
Sculpin	(Cottus sp.)

Below Chamokane falls, in the waters of the stream mouth and short distances upstream, a variety of Spokane River species locally invade the creek. As well as the above listed species, these include:

Yellow perch	(Perce flavescens)
Northern squawfish	(Ptychocheilus oregonensis)
Carp	(Cyprinus carpio)
Largemouth bass	(Micropterus salmoides)
Brown bullhead	(Ictalurus nebulosus)
Black crappie	(Pomoxis nigromaculatus)

None of the fish known to inhabit Chamokane Creek are threatened or endangered species; further, no individuals will be directly affected by the proposal, as any related changes in stream chemistry or sedimentation patterns will be both gradual and trivial.

3.1.6 Noise

The project site is located in a low population density rural area that may be characterized as quiet and serene. Operation of the present Dawn mill generally produces no sounds perceptible beyond the limits of the controlled area. The largest source of noise in the Ford vicinity is vehicular activity along the paved roadways. The mature pine forest intervening between the project site and the nearest residences rapidly attenuates low level noise.

3.1.7 Light and Glare

The present Dawn millsite is well lighted at night, but due to its location within a mature pine forest environment, it is not visible to surrounding roadways or residences.

3.1.8 Land Use

Dominant land use patterns of Walkers Prairie center around agricultural pursuits, princip the cultivation of alfalfa and grain. The uncultivated areas near the Dawn mill are used as cattle rangeland. This proposed project would involve only lands falling within the present confines of the controlled area reserved for uranium milling activities since 1956.

3.1.9 Natural Resources

3.1.9.1 Rate of Use

Natural resources utilized by the present uranium milling operation are tabulated in Table 3.6.

Implementation of the proposed project would not alter either the materials utilized or their rates of consumption.

3.1.9.2 Nonrenewable Resourses

It will be noted that most elements of the above listing (section 3.1.9.1) are mineral products and hence "nonrenewable". Again, there is no reason to believe that implementation of the proposal would influence existing patterns of consumption.

3.1.10 Risk of Hazardous Emissions

The system of tailings disposal utilized since the beginning of operations (disposal in unlined, above grade diked impoundments) involves several possible emission risks:

1. Dike failure and escape of liquified tails materials

2. Solution seepage

3. Wind erosion and transport of tailings particles

4. Radioactive emissions

3.1.10.1 Dike Failure

The potential for dike failure and escape of hazardous materials has recently been examined by an outside investigator on behalf of Newmont Mining Corporation, Dawn's parent firm. It was there concluded:

"The possibility of failure of this tailings system appears to be relatively unlikely. However, if failure should occur, damage should be limited to

Material	Annual Consumption	
Ammonia	143,000	lbs.
Ammonium Nitrate	846,000	lbs.
Caustic Soda	135,500	lbs.
Diesel Oil	18,500	gal.
Flocculant	26,500	lbs.
Fuel Oil	350,000	gal.
Gasoline	20,000	gal.
Grinding Balls	197,000	lbs.
Lime	1,054,000	lbs.
Manganese	308,000	lbs.
Resin	150	cu. ft.
Steel Drums	605	ea.
Sulfuric Acid	20,232,000	lbs.

TABLE 3.6 Supplies consumed by milling operation

the Dawn Mining Company property. With the limited amount of water presently stored in the tailings pond, it would be unlikely that even effluent water would flow off of the property." (Toland, 1979)

In the 25 year period since the existing system was commissioned, there have been no instances of dike failure or slumpage and no cases where overflow has been noted.

3.1.10.2 Seepage of Tailings Solutions

As detailed in Section 3.1.3.6, seepage of tailings solutions has been recently documented; however, chemical evolution of the solution by dilution and reactions in the course of migration through about one-half mile of glacio-fluvial deposits has rendered the solutions relatively innocuous at their emergence point. This must, nonetheless, be viewed as an undesireable aspect of the present environment.

3.1.10.3 Wind Erosion of Tailings Solids

Since 1977, escape of hazardous materials by wind erosion and transport from the present disposal facility has been precluded by:

1. Application of a heavy layer of wood chips over dried portions of the tails, and,

2. Maintainance of moisture saturation in exposed tails.

Prior to that time, moisture saturation was the exclusive means of dust control. Locally, some dusting did occur and is the principal mechanism responsible for the observed areas of elevated radiation.

3.1.10.4 Radioactive Emissions

Parts 1, 2, and 3 of this sub-subsection deal with the principal potential pathways for radionuclide (and associated chemical species) escape from the existing tailings disposal complex. Under the present heading are presented the observed radiologic characteristics of the pond area.

No direct data exist concerning radioactivity in the millsite area prior to the initiation of operations. Background gamma radiation for the Spokane area is considered to be about 91 mrem/yr (R. E. Nelson, pers. comm. 1979). Values currently observed in presumably uncontaminated areas near the mill range from 77 to 177mrem/yr. and are taken as the approximate natural background range. Background radioactivity is a composite of radiation from several natural sources together with widely dispersed radiogens of human-related origin, including:

1. Primary and secondary cosmic radiation

2. Terrestrial radiation, principally from radionuclides in the U-238 and Th-232 decay series and K-40

3. Industrial and military sources

Figure 3.10 illustrates the total radioactivity measured at various points around the present Dawn tailings disposal facility by means of thermoluminescent dosimeters. Measurements were made during three month periods in the fall of 1978 and again in the spring of 1979. Observed radioactivity would include elements of the normal background with local additions chiefly related to wind-borne particulates that moved prior to application of the present wood-chip cover.

While highly localized elevations in radioactivity may be observed in the immediate vicinity of the pipeline and wind-blown tailings fines, it is gratifying to see that these elevated values do not persist more than a hundred feet or so from the source. Note also that radiation levels measured at the Ford store (one mile NE of the present pond) and at Bailey's Feed store (one half mile E) are in the low background range.

Hence, although past operations have been characterized by considerably looser controls on potentially hazardous emissions than will be built into the proposed project, impacts are not of consequence outside of the restricted access zone.

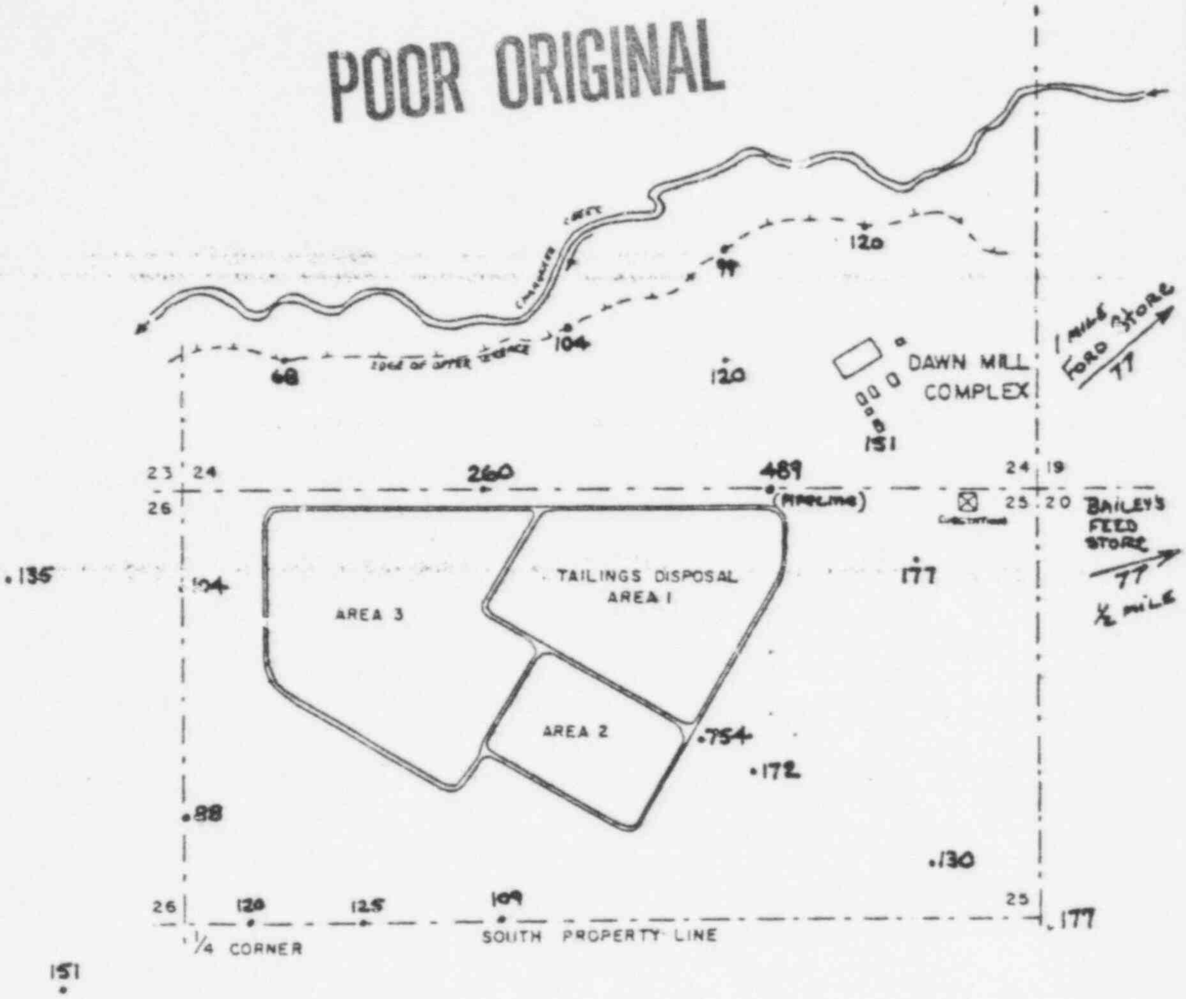
3.1.10.5 Erosional Enchroachment on Existing Tailings

In section 3.1.1.5, data are presented indicating a widening of the Chamokane Creek channel of 0.149 ft./yr. This is equivalent to an average yearly advance of each bank totaling 0.075 ft.

At its closest point, the terrace edge lies 850 ft. from the existing tailings facility. Barring human intervention, at the average calculated rate of channel widening, the disposal facility could be breached by erosion in about 11,300 years.

Preventive measures such as rip-rap stabilization or stream diversions can easily eliminate this eventuality. However, such efforts can be much more efficiently focused in the distant future when actual encroachment patterns become well defined. If measures were to be implemented at present to foreclose this danger, the approach would have to be so broad that prohibitive environmental costs would be incurred.

The proposal site lies on the far side of existing facilities relative to the point of maximum present encroachment. Hence, it will not be significantly related to this existing potential mode of hazardous material release.



PRESENT RADIOLOGIC CHARACTERISTICS

DAWN MILL & TAILINGS POND AREA

1" = 1200'

ALL MEASUREMENTS REPORTED AS MREMS/YEAR

(Based on 1978 and 1979 TLD Surveys)

FIGURE 3.10

3.2 HUMAN ENVIRONMENT

3.2.1 Introduction

As has been previously noted, implementation of the proposed action would simply permit continuation of operations that have been on-going for many years. No new demands or influences on the elements of the human environment as a result of this work are to be expected. Hence, the following sections are discussed only briefly but are included so that the concerned reader may better evaluate the potential impacts of a "no action" alternative, which could force closure of the mill and a consequent loss of about 130 directly related jobs.

3.2.2 Population

According to Carl Bade, Ford, WA., postmaster, the Ford Post Office serves about 225 families, representing a local population of approximately 700 to 800 individuals. This population resides within a geographic area of 50 to 70 sq. miles, indicating population densities of 10 to 15 individuals (3 - 4 families) per square mile.

3.2.3 Housing

Virtually all available housing in the Walkers Prairie area is presently occupied.

3.2.4 Transportation/Circulation

Paved State highway 231 running from Reardan, WA., to Springdale, Wa., and a paved county road extending from Ford, WA., to Wellpinit and Hunters, WA., intersect at Ford near the Dawn Millsite and project area. (See General Location map, figure 21). Ore haulage trucks reach the Dawn Millsite via the county highway while supplies arrive by truck on Highway 231.

The nearest railheads are at Springdale, WA., and Reardan, WA. Yellowcake shipments originating at the Dawn Mill move by truck to Reardan where they are transferred to railroad cars for long distance transport.

Traffic on both roadways is light, and no traffic flow problems have been evident during the past years of Dawn Mill operations.

Both highways are travelled by school buses during ongoing school terms.

3.2.5 Public Services

An eleven man volunteer fire department consisting of one pump truck and a tanker w/ 200 and 1600 gallon capacities respectively, is located at Ford. Police services to the off-reservation area are provided by the Stevens County Sheriffs department and the Washington State Patrol. Tribal police patrol the Spokane Reservation.

Public schools exist in Reardan, Wellpinit, and Springdale. Children from the Ford area are transported by bus to their respective schools. A variety of parks and recreational facilities service the region, chiefly located along the Spokane River or the lakes formed thereon by the several local dams.

3.2.6 Energy

The present Dawn Mill operation requires about 7 million KWH of electrical energy per year which is supplied by nearby Washington Water Power Co. hydroelectric operations.

3.2.7 Utilities

Electrical energy for the area is provided by Washington Water Power Co. Pacific Northwest Bell provides telephone service to the region. No centralized water, sewer, or storm water disposal systems have yet been installed in the Ford area. To date, population densities have not warranted such expenditures. An open dump for solid waste disposal is maintained about 2 miles SW of Ford.

3.2.8 Human Health

Major medical services to the region are provided by the Spokane hospitals about 25 miles airline SE of Ford. Clinics located in Wellpinit and Springdale accomodate routine health services.

3.2.9 Aesthetics

The Walkers Prairie area is one of gentle, moderate scenery, rolling forested hills and tableland basalt plateaus. Fertile valley floors checkerboarded with agricultural crops and meandering brushy stream coarses complete the rather pastoral scene. The Dawn Mill complex is located within an open, mature pine forest that completely shields it from the view of incidental passers-by as well as local residents.

3.2.10 Recreation

Many of the local summer-month recreational opportunities are water-related, taking advantage of the lakes, rivers, and streams that are the dominant features of the region. An excellent Walleye Pike fishery exists in the lower Spokane River, while a variety of species of trout, bass, and other game fish populate regional streams and lakes.

The area affords good hunting opportunities, with White-tailed Deer, Ringed-necked pheasants, grouse, doves and migratory waterfowl being the principal objects of pursuit.

During winter months, area residents are avid snowmobilers and many travel to the major ski resorts on Mt. Spokane and Chewelah Peak.

4. IMPACT OF PROPOSAL ON THE ENVIRONMENT

4.1 IMPACT OF PROPOSAL ON THE PHYSICAL ENVIRONMENT

4.1.1 Earth

4.1.1.1 Construction Phase

Implementation of the proposal will necessarily result in modifications to or disruptions of the geology, soils, topography, and accretionary/avulsionary processes characteristic of the area. However, none of these impacts is considered significant.

Construction work will disrupt or modify about 50 acres that are not presently disturbed. However, long-term stabilization and reclamation requirements (such as the probable requirement for 5h : 1v or gentler outsloping of existing dikes) would result in equivalent land disturbance at some future time. In the long-term perspective, this impact will be necessary even if the present proposal is not implemented.

Stockpiled reclamation materials will be subject to increased sheet wash erosion until interrim stabilization vegetation is established. Due to the high permeability of surface gravels, silt-laden runoff will not reach surface drainages in the area, so no impacts to drainage systems would be expected.

4.1.1.2 Operations Phase

During operation of the lined, sub-grade disposal system here proposed, no further impacts to elements of the geology, soils, topography, unique physical features, or accretionary/avulsionary processes are anticipated.

4.1.1.3 Post Operations Phase

Upon termination of utilization of the disposal site and implementation of the long-term reclamation plan, the site will be returned to a condition quite similar to the initial state : topographic form will be gently mounded, planting of stabilization vegetation will rapidly generate soils comparable to those initially present, and aggradational/degredational processes will be operant at their usual slow pace. The geologic pattern will be permanently modified, although this might well be viewed as a "neutral" change rather than either a beneficial or deleterious impact.

4.1.2 Air

4.1.2.1 Construction Phase

The only potential impact anticipated during construction operations is dusting. rinkling by means of a water truck will be utilized as needed to control this potential impact on air quality.

4.1.2.2 Operations Phase

The subgrade disposal system here proposed will be essentially free of dusting

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3.2.11 Archaeological/Historical

No evidence of earl, human occupation has been disclosed in the project area, but the valley was used intermittantly in prehistoric and early historic times by the lower Spokane band of the Spokane Tribe of Indians. About 1 mile northwest of the Dawn Millsite, the Tshimakain Presbyterian Mission was founded by Reverends Eels and Walker in 1838. Nothing remains of this historic site save a commemorative granite monument. Since the local tribes centered their activities around the salmon runs of the pre-Grand Coulee Dam Spokane River, most significant cultural remains are located along the maj waterways rather than inland valleys.

potential due to a rapid build up of solutions that will either cover or saturate the tailings solids. No discernable odors or other air impacts are anticipated.

4.1.2.3 Post-Operations Phase

After placement of a stabilization cap and establishment of vegetation, there should be no further potential for air quality degradation.

4.1.3 Water

4.1.3.1 Construction Phase

No changes in any water quality or quantity parameter is expected during the construction phase of the proposed project.

4.1.3.2 Operations Phase

Utilization of the membrane-lined sub-grade disposal system will have important beneficial impacts on ground water quality. Solution seepage is a serious negative feature of the present disposal facility. The proposed system will provide an essentially seepage-free alternative, permitting termination of utilization of the present system. It is probable that contaminated seepage will continue to emerge for a period of several years, but once the influx of solutions has stopped, flow rates will slow and dilution effects increase.

There is a potential negative impact related to possible leaks in the proposed membrane liner system. However, at worst, such leaks would be of much lesser magnitude than the seepage from the present unlined pond. The concerned reader is here urged to re-examine the nature of actual seepage solutions observed to date. (Section 3.1.3.6) It is encouraging to note that the actual nature and effect of such seepage have not been extreme, even in a case of totally uncontrolled seepage. Given a potential of much more limited leaks, at worst, from the proposed system, there is valid reason to argue that the resultant impacts would be barely discernable.

Installation of the impermeable liner system will result in a loss of 28 acres of precipitation infiltration surface, resulting in a slight decrease in ground water quantity derived from this source area.

No surface waters will be affected by operations, and conversely, no surface waters are in a position to affect the operation. Major flooding will not encroach upon the project area as the stream channel lies in a wide meander valley, a full 100 feet below the project elevation.

4.1.3.3 Post Operations Phase

Stabilization and reclamation plans will result in decreased infiltration rates for an indefinite period due to the imperveous membrane and the low permeability clay cap which will ultimately cover the disposal site. The impacts of this on the overall hydrology should be negligible.

No other long-term impacts to surface or ground water movement, quantity, or quality is anticipated.

4.1.4 Flora

4.1.4.1 Construction Phase

Construction work will directly result in destruction of 50 acres of open pine forest ecosystem consisting of mature Ponderosa Pine, scattered Columbia Hawthorn shrubs, numerous clumps of Arrowleaf Balsam root, velvet Lupine and grasses.

Disrupted areas do not differ in any known significant respect from adjacent populations, so neither species diversity nor overall population densities are expected to suffer. Vegetative assemblages are nearly homogeneous throughout the project area. No pioneering species have been observed encroaching upon the area; it is consequently believed that the project will neither affect nor become a barrier or corridor for dispersal of species. (See also Section 3.1.4)

4.1.4.2 Operations Phase

Same as above.

4.1.4.3 Post Operations Phase

Native species will be re-established on the reclaimed area, essentially returning it to its baseline levels of productivity and diversity.

4.1.5 Fauna

4.1.5.1 Construction Phase

While about 50 acres of open pine forest habitat will be destroyed by operations, the specific areas involved are close enough to existing operations that they are very infrequently utilized by the larger game species, such as white-tailed deer. The principal species directly affected by operations will include the various small rodents residing in the area and insects. All other species are likely to be displaced into similar adjacent habitats. The effects of the project on the various faunal groups is discussed in more detail in Section 3.1.5.

4.1.5.2 Operations Phase

The disposal facility itself will be barren of vegetation, and will therefore not serve as habitat for any of the local fauna. The vegetation-stabilized reclamation material stockpile will provide good habitat for smaller species during operations.

4.1.5.3 Post-Operations Phase

After reclamation and revegetation, all local species are expected to return, equivalent in diversity and population density to baseline conditions.

4.1.6 Noise

4.1.6.1 Construction Phase

For a period of 3 to 4 months, the operation of heavy equipment will increase noise levels in the immediate project area. Table 4.1 cites expected noise output levels for equipment likely to be utilized. Noise should not be objectionable at the nearest dwellings. Once a pit has been excavated, most noises will be effectively blocked. No explosives will be required for expected operations.

4.1.6.2 Operations Phase

Utulization of the facility will be essentially silent.

4.1.6.3 Post Operations Phase

After termination of the utilization of the facilities, noise levels will be at baseline conditions.

4.1.7 Light/Glare

No phase of the project will result in increased light or glare. The existing operation is fully shielded from view, day or night, by the surrounding pine forest.

4.1.8 Land Use

All lands involved in the proposal fall within presently restricted areas permanently dedicated to tailings disposal. The present project will remove 28 acres of additional area from potential long-term alternative usage.

A significant beneficial impact on land use patterns is a special strength of the proposal. If future tailings disposal were by means of continued vertical or lateral expansion of the diked impoundment system now in use, when it comes time for final reclamation and stabilization, a major source of cover materials would be needed. To meet this need, a very large borrow pit would have to be excavated, probably in the current mill/stockpile area, significantly disrupting another large block of land. In short, a hole the size here proposed will eventually have to be dug whether or not it can serve a double purpose and be used for tailings disposal as well. The excavation required for the subgrade proposal is specifically designed to offset the known requirements of materials for reclamation and stabilization of the entire disposal facility. The proposed excavation will be filled with tailings such that no subgrade structure will remain after reclamation.

By this line of reasoning, implementation of the proposal will result in one half the amount of land disruption that would be incurred by continued use of dike impoundments. Because of the reclamation material requirements, even if operations were now halted and no further tailings generated, the same sized pit would have to be excavated, but no means of reclaiming that pit would exist. We believe that the present proposal results in the most efficient land use alternative available, even if the "no action" alternative is considered.

Equipment	Noise Level (dba) at 50 ft.
Scrapers, Graders	80-92
Tractors	76-96
Compacters	72-74
Trucks	82-93
Front Loaders	72-84

TABLE 4.1 Construction Equipment Noise Ranges

(Adapted from "Noise from Construction Equipment" as quoted in Draft Environmental Impact Statement Relative to The Proposed Administrative Action of The Washington State Department of Ecology for the Proposed Northwest Alloys Magnesium Plant, Addy, Washington, May 1973)

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4.1.9 Impact of Proposal on Natural Resources

4.1.9.1 Rate of Use

Implementation of the proposal will permit continuation of operations at their current rate and will not effect the present pattern of resource utilization.

4.1.9.2 Non-renewable Resources

Same as 4.1.9.1

4.1.10 Impact of Proposal on Risk of Hazardous Emissions

Significant beneficial impacts of the proposal have been identified in several areas:

1. The reclamation materials stockpiles will bolster the strength of existing impoundment dikes, reducing the risks of dike failure and escape of liquified tailings.

2. Termination of use of the present disposal facility will permit dust control measures (wood chip cover or sprinkling) and possible reclamation work, to be undertaken through-out that area.

   The proposed facility is designed to eliminate dusting potential by the rapid build-up in tailings liquids that will saturate and soon cover all tailings solids introduced into the system.

3. Halting the use of the present facility will stop the recharge of seepage solutions into the substrate and will decrease the hydraulic head and phreatic mounding that drives the seepage laterally into the groundwater regime. This decrease in the driving force behind seepage migration will permit a more gradual rate of influx of seepage into the groundwater, increasing dilution effects and maximizing the time for chemical reactions.

   Slow-moving radionuclides presently in the zone of vertial infiltration will be stranded in the dried vadose zone once seepage recharge has halted, permitting the extended time periods needed for radioactive decay. Even chemical species whose migration fronts have now reached the regime of phreatic mound-induced lateral flow will be largely stranded by interruption of their transport mechanism. Only species whose migration fronts have now reached the natural groundwater transport regime will continue to migrate towards eventual emergence at a significant rate. See section 3.1.3.6 for a complete analysis of seepage features.

   Since tailings solids may retain up to 70% of the total radioactivity of the raw ore, commissioning of a new disposal facility will result in a direct change in the distribution of radiation emitters on the mill property block. However, due to the subgrade design and the peripheral 35 ft (+) stockpiles, complete shielding of adjacent areas from increased radioactivity is expected. There should be no detectable change in radiation levels measured at the external boundary fence.

No consequential negative impacts on the risk of hazardous emissions have been identified. The key potentials of such a facility are related to:

1. escape of toxic chemical species,

2. escape of radionuclides, and

3. direct radioactive emissions.

The company believes that design features eliminate these potential concerns.

The escape modes of potential significance include:

1. dike failure (precluded by subgrade design)

2. wind erosion (precluded by solution ponding)

3. gaseous emanations (reduced to minimal levels by solution cover)

4. solution seepage (precluded by synthetic membrane liner)

5. direct radioactive emissions (eliminated horizontally by stockpile/ dike; vertically by solution cover)

From a "worst case" perspective, membrane failure is the only significant possibility, and at worst, the impacts of such an event would be no worse than those observed in connection with the uncontrolled seepage characteristic of the present facility (see 3.1.3.6) which is undesireable, but clearly not catastrophic.

4.2 IMPACT OF PROPOSAL ON ELEMENTS OF THE HUMAN ENVIRONMENT

Implementation of the proposal will simply permit a continuation of existing patterns. New jobs will be created only during the short-lived construction phase and are expected to be filled by present employees of the selected project contractor.

Since virtually no changes in the human status quo will result from the project, the impacts under every heading of the existing human environment (section 3.2) are nil. For this reason, individual headings are not further reviewed.

Only the "no action" alternative would result in alterations to the local human status quo. In this case (discussed in section 8.3) about 130 present jobs would be lost. This represents a highly significant impact of that alternative to the area.

Similarly, such features of the human environment as Aesthetics, Recreational opportunities, and Archaeological/Historical resources will not be affected by the project. The site is fully shielded from public view and will therefore not affect the aesthetic values of the area. Restricted access (already in effect) precludes utilization of the site for recreational purposes, and no features of either archaeological or historical importance have been identified, despite the extensive work previously undertaken in the project vicinity.

4.3 SUMMARY OF IDENTIFIED IMPACTS

Because of the narrowly restricted nature of the actual proposal, the potential areas of impact are few. After intensive review, costing tens of thousands of dollars and over 6 months time, no major adverse impacts have been identified. On the contrary, the most significant impacts expected are beneficial. Following is a brief compilation of the significant or potentially significant impacts identified in the previous headings of this section.

4.3.1 Known Significant Beneficial Impacts

4.3.1.1 Mitigation of Present Seepage Problems

Implementation of the proposal will permit immediate termination of the use of the existing, freely seeping tailings disposal complex. This will result in interruption of seepage recharge, diminution of hydraulic head, and dissipation of the phreatic mound. Radionuclide species now slowly migrating will be effectively stranded in the dried vadose zone. Rapid up-grading of seepage-contaminated groundwaters is expected to ensue.

4.3.1.2 Mitigation of Long-term Land Surface Disfigurations

The proposal will simultaneously satisfy two requirements:

1. Increased tailings storage capacity.
2. Production of reclamation and stabilization materials.

The second requirement is an inescapable feature of all alternatives, including the "no action" option. In that case, a pit of equal size must still be excavated, but no mechanism for restoration of that pit would exist. Under the proposal, the excavation that generates required reclamation materials will be backfilled with mill tailings, thereby resulting in less long-term land disfiguration than any other option.

4.3.1.3 Reinforcement of Existing Impoundment dikes

While existing impoundment dikes are considered both safe and stable, it is nonetheless a significant beneficial consequence of proposal implementation that the existing dikes will be greatly reinforced by the reclamation material stockpiles that will be placed in dike-like configuration around the peripheries of existing dikes.

4.3.1.4 Environmentally Sound Continuation of Milling Operations

While other alternatives exist which could provide the increased tailings storage capacities required for continued operation of the uranium milling facility, the proposal incorporates state-of-the art technologies that result in a high degree of environmental soundness. No other economically feasable alternative provides a comparable degree of impoundment stability and freedom from adverse impacts.

Even the "no action" alternative has signigicantly greater negative impacts than the proposal in that (1) operations would necessarily be halted resulting in the loss of approximately 130 direct jobs, and (2) reclamation material requirements would still remain, resulting in the excavation of a borrow pit for which no environmentally attractive restoration exists comparable with that offered by the proposal.

4.3.2 Known Significant Adverse Impacts

4.3.2.1 Foreclosure of Future Land-use Options For the Site

Proposal implementation will directly result in a 28 acre increase in the land surface area now covered with uranium mill tailings. This area will be removed from alternate usage in perpetuity unless the tailings are reclaimed and reprocessed for recovery of other elements at some future time. Note, however, that under the terms of the Washington State Mill Licensing and Perpetual Care Act of 1979, much if not all of the project site will be perpetually removed from alternate usage regardless of project implementation by merit of its immediate proximity to a tailings disposal facility. Hence, the actual magnitude of this impact is small.

4.3.3 Potential Significant Beneficial Impacts

4.3.3.1 Incentive For Reduction in Water Use and Liquid Discharge to Tails

Because of seepage outflow of tailings liquids from the present disposal facility, there has been no liquid build up requiring additional disposal system design or reduction of liquid discharge to tailings.

Implementation of the proposal will eliminate seepage discharge from tailings, resulting in a gradual build-up in liquids in the disposal facility. The proposed system is capable of storage of all solids and liquids generated for several years. However, to derive full utilization of solids storage capactiy, the company must devise either (1) a supplemental system for liquid disposal, or (2) a means of recycling process liquids to reduce discharge rates to a level that can be accommodated by direct pond evaporation.

This problem is currently being studied in detail by the company. It is probable that systems will be devised to recycle a significant fraction of the process liquids, which will have the potential significant impact of reducing fresh water requirements for milling operations.

4.3.4 Potential Significant Adverse Impacts

4.3.4.1 Potential Seepage from Liner Leaks

While theoretically the proposal is a zero-seepage facility, the potential for liner leakage certainly must be recognized. However, since such leaks would be of many orders of magnitude less than the volume of seepage presently generated by the unlined dike impoundments, expected impacts of such seepage would also be correspondingly reduced.

Since the actual environmental impacts of presently observed seepage are quite slight, the amount of seepage expected from potential liner leaks should produce wholly negligable results.

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4.4 POTENTIAL FOR SIGNIFICANT CUMULATIVE EFFECTS

Virtually no cumulative or interrelating environmental effects that could generate a significant overall effect have been identified.

One cumulative effect considered is the following: If seepage influx into the receiving stream is halted, and utilization of fresh waters by the mill is diminished, resulting in a corresponding increase in spring flow into Chamokane Creek, might the freshening of downstream waters be of sufficient magnitude to effect the existing biologic communities?

In view of the relatively slight impacts of both seepage water and spring waters on the over-all chemistry of Chamokane Creek, the changes induced by a reduction in seepage and an increase in spring flow would be slight. Discussions with Washington State Game biologist, Ray Duff, indicate that the principal species populating Chamokane Creek show wide tolerances for the chemical species studied. The chief risk to biota is in sudden changes in chemistry; gradual changes of large magnitude can be readily tolerated.

In the instance under discussion, overall changes will be both slight and gradual, in that seepage emergence can not be suddenly halted, but flow through with ever increasing levels of dilution by groundwater is expected to persist for months to years. It is therefore concluded that no significant impacts on the bio-community are to be expected as a result of this cumulative effect.

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5. RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

5.1 POTENTIAL TRADE-OFFS, SHORT-TERM VS. LONG-TERM

5.1.1 Land Use and Aesthetics

The local, short-term effects of continued milling are those associated with the operation of any comparable-sized ore milling facility. The short-term disruption of the landscape during mill operations will not adversely affect long-term aesthetics if reclamation efforts are successful as planned. The millsite will be returned to its prior uses without restriction, except for the tailings disposal area, which will require perpetual restrictions against digging or other forms of intrusion that could expose the buried tailings. Proposed reclamation measures should permit otherwise unrestricted access and land use in the long-term.

5.1.2 Water

Since all water requirements for the continuing operation are satisfied by natural springs, no long-term effects on groundwater availability are expected. Although local groundwater quality has been affected by seepage from existing tailings impoundments, implementation of the proposal should prevent any further seepage influx into the aquifer. Dilution, diffusion, and chemical attenuation by soil reactions will render presently affected groundwaters non-toxic within short periods, eliminating long-term degradation of water quality.

5.1.3 Mineral Resources

The mining and milling of uranium ores does not preclude extracting other substances of future economic importance should the demand arise. The uranium-mill tailings could be easily reworked.

5.1.4 Biota

Milling activities to date have reduced or eliminated the viability of about 220 acres of open Pine forest vegetation and wildlife habitat. Implementation of the proposal will result in the disturbance of an additional 5 to 10 acres that would not otherwise be disturbed. However, final reclamation plans call for re-establishment of native vegetation after cessation of operations which should be immediately followed by the return of native faunal species. Long-term productivity and diversity of both faunal and floral communities should rapidly return to a state approximating undisturbed surrounding areas.

5.1.5 Radiological Environment

Reclamation plans for the millsite complex are designed to return all areas to near background alpha, beta, and gamma radioactivity. Capping and burial of tailings will be undertaken to meet radon release standards, rendering the disposal site non-hazardous so long as the cover layer is properly maintained. Both funding and responsibility for perpetual care have been established by the Washington State Mill Licensing and Perpetual Care Act of 1979.

5.1.6 Summary

No significant long-term trade-offs have been identified other than the permanent restriction on digging or otherwise breeching the cap over the buried tailings. These restrictions are a necessary consequence of the substantial amount of tailings already in place. The incremental additions related to continued operations afforded by the proposed action should not constitute a large long-term cost.

5.2 EFFECT OF RESERVING PROPOSAL FOR SOME FUTURE TIME

There is a considerable advantage, both in terms of economics and resource utilization, to permit uninterrupted operations throughout the full life of the milling facility. If the proposal were reserved until some future time, essentially two options would be open to the company: (a) mine remaining ore and have it processed at another licensed mill, or (b) interrupt all operations.

The only other licensed milling facility within economic ore transportation distance is Western Nuclear's Sherwood project mill, located about 8 miles from the Midnite Mine. However, the Sherwood Mill is operating at capacity and facilities there have been designed to balance the anticipated production of the associated Sherwood Mine. Processing of Midnite ores at Sherwood would therefore require enlargements to existing facilities there similar to the proposal. Under this option, the Dawn Mill at Ford would be permanently closed and all associated employment terminated, but an equivalent proposal would still be required.

Interruption of all operations would also result in prohibitively high costs without compensating gains. The Dawn operation was interrupted from 1965 through 1970 due to market conditions. Rehabilitation of the facility after that period required virtual replacement of the mill. The costs of maintaining a continuing operation are very low in comparison to mill replacement costs, and considerable needless energy and resource consumption would be required during the rehabilitation phase. Interrupted operations would also generate costly socioeconomic impacts through job loss, emigration from the area, reduction in existing supportive services, followed by reconstruction with its reversed conditions. In general, it is obvious that uninterrupted continuity of operations is more efficient and yields fewer overall impacts than the interrupted operations that would be a necessary consequence of proposal deferral.

In view of present national energy supply and demand, it is imperative that energy production resources be generated in a timely fashion. This is particularly true in the case of nuclear power generation in that the huge funding commitments and lead time requirements for the construction of a nuclear power facility necessitate an assured fuel supply. If nuclear power is to contribute its projected share to the nation's goal of energy self-sufficiency, then sufficient levels of uranium production need to be maintained to allow utilities to proceed with reactor construction with assurance of adequate fuel availability.

Undelayed growth of nuclear and coal-based electrical energy production is desirable in that this would decrease our dependence on (and consumption of) other fossil fuels already in very short supply in the U. S. At present, uranium is less expensive on a thermal unit basis than any other fuel used to produce electrical power.

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In recent years, the Dawn operation has produced 2 to 3% of the nation's uranium production, and is capable of maintaining this status for many years to come.

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6. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

6.1 LAND AND MINERAL

6.1.1 Land

A restriction on digging or other forms of intrusion may indefinitely prevent the the development of the lands containing buried tailings. This is considered an irreversible commitment of resources.

6.1.2 Mineral

The extraction, processing, and eventual use of the ammonium diuranate produced by the mill are considered irreversible and irretrievable. Other than the uranium resource itself, several million gallons of fuel oil and other fuels consumed to generate the electrical power utilized in the mining and milling operations, no irreversible or irretrievable commitment of mineral resources are anticipated.

6.2 WATER AND AIR

6.2.1 Water

Because of the large volume of groundwater available in the alluvial aquifer and its large recharge capacity, the use of this groundwater for the mill's water supply is not considered to represent an irreversible or irretrievable commitment of this resource.

6.2.2 Air

Because the atmosphere is self-cleaning of pollutants at the low concentration anticipated, no irreversible nor irretrievable commitments of the area's air quality are expected.

6.3 BIOTA

6.3.1 Terrestrial

The area of the tailings pile will not be available for any activity that will result in the incorporation of the tailings into the upper strata of the soil or in any way damage the seal over the tailings. The possible effects of breaching of the soil and clay materials by burrowing animals is not known.

6.3.2 Aquatic

The presence of certain heavy metals, radionuclides, and other toxic chemical byproducts of mill operation may exceed background concentrations in the receiving stream. Implementation of the proposal will halt fresh influx of solutions to the substrate. Subsequent diffusion, dilution, and attenuation by soil reactions will eventually erase the areas of excessive concentrations of these substances.

6.4 MATERIAL RESOURCES

Chemicals and reagents (see Table 3.6) required by the milling process will be consumptively used, and therefore are considered irretrievable and irreversible commitments of these resources. Use of these materials, however, is considered a minor impact, because, in the volumes consumed, the materials are readily available.

(Section adapted from U. S. NRC NUREG-0505, 1978)

7. ADVERSE IMPACTS WHICH CAN BE MITIGATED OR ELIMINATED

Of the direct impacts of the actual proposal discussed in Section 4 of this document, only one was deemed a "known significant adverse impact", and that consisted of foreclosure of future land-use options for the immediate site (4.3.2.1). Mitigation of this effect as much as possible was a stated goal of the disposal option designed. Since the facility will be excavated to the maximum depth permitted by the position of the water table, its capacity relative to surface area is at a practical maximum.

The only disposal alternative that would avoid incremental increase in the foreclosed-usage surface area would be a lift of about 20 vertical feet around the entire above-ground dike system now in use. While this approach would mitigate the land-use foreclosure problem, it would sustain the more serious solution seepage aspect of the present system. Also, it would place the tailings in a considerably more vulnerable position for erosional breeching of the cover layer in the long-term.

Solution seepage, the key "known significant adverse impact" of the present tailings disposal system, would be greatly mitigated by implementation of the proposed fully-lined facility.

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8. ALTERNATIVE METHODS FOR TAILINGS MANAGEMENT

8.1 INTRODUCTION

For the purposes of the section, "tailings management" is defined as the disposition of the tailings and waste leach solutions following extraction (separation) of the uranium. In the case of the Dawn Mill, the number of alternatives for tailings management is constrained by the fact that the mill has been operating for about 20 years and considerable tailings have already accumulated.

The alternative tailings management plans considered by the Company have been evaluated against the following set of performance objectives, developed by the NRC (see Scarano and Linehan, 1978), and designed to ensure th potential public health hazards which otherwise could occur in the operation of the project are avoided or minimized:

Siting and Design

1. Locate the tailings isolation area remote from people such that population exposures would be reduced to the maximum extent reasonably achievable.

2. Locate the tailings isolation area such that disruption and dispersion by natural forces is eliminated or reduced to the maxium extent reasonably achievable.

3. Design the isolation area such that seepage of toxic materials into the groundwater system would be eliminated or reduced to the maximum extent reasonably achievable.

During Operations

4. Eliminate the blowing of tailings to unrestricted area during normal operating conditions.

Post-reclamation

5. Reduce direct gamma radiation from the impoundment area to essentially background level.

6. Reduce the radon emanation rate from the impoundment area to about twice the emanation rate in the surrounding environs.

7. Eliminate the need for an ongoing monitoring and maintenance program following successful reclamation.

8. Provide surety arrangements to assure that sufficient funds are available to complete the full reclamation plan.

8.2 ALTERNATIVES CONSIDERED

8.2.1 Siting

After considering the existing tailings disposal area relative to the NRC performance objectives, no significant reasons were found for seeking an alternate disposal site location. Since the present disposal site is already irreversibly contaminated, it makes better sense to confine future disposal to the same site than to contaminate any other area without strong cause. This approach will retain important benefits in terms of the cost of perpetual monitoring and maintenance. Further, it would be exceedingly difficult to either define or find a more acceptable site than that already in use.

8.2.2 Design

Several facility design alternatives were evaluated, including:

1. Vertical additions to present impoundment dikes.

2. Construction of a new dike impoundment adjacent to existing facilities.

3. Excavation of a subgrade storage pit.

The above-grade impoundment options were rejected because:

1. Isolation of the tailings in the long term is less assured than with the subgrade option;

2. The large reclamation material requirements would have to be derived from some other area. With the subgrade option, needed sands and gravels for reclamation would be a by-product of facility construction;

3. The Company was anxious to conform to designs considered the best available technology in order to facilitate aquisition of necessary permits. Time constraints on the approval and construction process are very tight;

4. The disrupted surface area per unit capacity would be greater.

The lined subgrade facility proposed is believed to be a state-of-the-art system. No reasonable alternative is known to exist that could attain the proposal objective at a lower environmental cost.

8.2.3 Liner Alternatives

Both synthetic membrane liners and compacted natural clays were investigated. Hypalon synthetic rubber (30 mil) reinforced with a 10 by 10 polyster scrim was selected, although clay liners appear very similar in favorability. The rejection of the clay option is based on the wider range of uncertainties, both in engineering characteristics and economics of acquisition and placement, associated with utilization of natural clays.

Synthetic membrane investigated include Polyvinyl Chloride (PVC), Chlorinated Polyethylene (CPE) and Synthetic Rubber (Hypalon). Of the group, Hypalon is most expensive but has excellent, proven performance characteristics under the anticipated conditions. Hypalon is the principal liner material specified by both industry and government for this application.

8.2.4 Wind Erosion Control

The subgrade design promotes saturation and liquid covering of tailings solids precluding wind erosion problems within the proposed facility.

The use of wood chip cover on existing disposal facilities was predicated on ready availability and effectiveness. No reason for investigation of other options has arisen.

8.2.5 Reclamation and Stabilization

The proposed long-term reclamation plan was based on NRC preferences outlined in the Generic Environmental Impact Statement (GEIS, NUREG - 0511) recently published. Other options have not been investigated as formal regulations prescribing reclamation requirements are expected as an outgrowth of the GEIS. Hence, the Company has tentatively proposed a plan consistent with present objectives and considers it futile to speculate on other options until final promulgation of related rule-making.

8.3 THE "NO ACTION" ALTERNATIVE

It is a peculiar feature of the proposed system, that the "no action" alternative--that is, non-issuance of permit, resulting in termination of mill operations--generates greater impacts to the physical environment than would implementation of the proposal. The key consideration in this context is the source of the considerable volumes of borrow materials required for the reclamation and stabilization of existing (and any new) tailings disposal facilities.

The proposed excavation will generate an amount of sands and gravels adequate to cap all facilities and moderate outslopes as outlined in section 2.2.1.6. Utilization of this pit for tailings disposal will effectively restore the topographic form of the excavation.

If the "no action" alternative were pursued, a borrow pit exactly equivalent in volume to that of the present proposal would still have to be excavated to obtain reclamation materials for existing facilities, but no means for restoration of that pit would exist.

Hence, even ignoring the more obvious adverse socioeconomic impacts of mill closure and job losses, the "no action" alternative does not result in environmental benefits. Virtually all expected impacts of the proposal already exist and cannot be avoided by the "no action" alternative.

9. UNAVOIDABLE ADVERSE IMPACTS

9.1 DISCUSSION

The only unavoidable adverse impact of the proposed tailings management system is the generation of an additional 28 acre area that will require usage restrictions, surveillance, and care in perpetuity, due to the placement of hazardous materials within that area.

All other adverse environmental effects of proposal implementation will be indiscernable in the long-term.

It should be emphasized that the single unavoidable adverse impact of the proposal is but an incremental increase to an identical, existing impact involving a much larger acreage.

9.2 COST-BENEFIT ANALYSIS

In return for the single unavoidable adverse impact discussed in 9.1 above, milling operations at the Dawn facility will be able to continue, ultimately preserving over 130 jobs for a period of 6 to 10 or more years. During that period 2.5 to over 4 million pounds of yellowcake will be produced, significantly contributing to the nation's electrical energy production in a time of widespread shortages and pointed attempts to achieve national self-sufficiency in energy resources.

APPENDIX A REGIONAL GEOLOGIC HISTORY

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APPENDIX A REGIONAL GEOLOGIC HISTORY

Since long term site stability is an important consideration in the present proposal, the geologic history of this region is here discussed in detail. The area surrounding the Dawn millsite has a long and varied history, ranging from the monotony of a full billion years of conditions as stable as any part of the world has ever seen, to major episodes of mountain building, Plutonism, earthquakes, volcanism, glaciation, and flooding. The following historic perspective should help the concerned reader to evaluate the present geologic stability of the region.

The oldest preserved rocks of the NE Washington area are slates, argillites, and quartzites of the preCambrian Belt Supergroup. Muds and fine sands of this unit were deposited in shallow salty waters occupying a slowly deepening trough at the edge of a broad, flat continental plain. Deposition of the Belt Supergroup began nearly 2 billion years before present (B.P.) and continued uneventfully for a billion years. Nearly fifty thousand feet of sediments accumulated.

The overlying Huckleberry conglomerate and volcanics of Late preCambrian age record the abrupt close of this long sequence of stable conditions. The slow compressional stresses that caused the downwarping of the Belt depositional basin finally exceeded the plastic limit of the underlying crustal plate, and sudden violent rupture resulted. The continental side of the break rebounded, lifting the Belt rocks of Idaho and Montana high above sea level. Rapid erosional downwasting of this uplifted highlands contributed the coarse cobbles of the Huckleberry conglomerate into the down-dropped NE Washington basin. Magmas found their way into the ruptured zone and fed submarine volcanism indicated by the Huckleberry volcanics.

Continued compressional stresses were relieved by underthrusting of the oceanward plate beneath the lip of the continental plate. Frictional drag between the plates slowly downwarped the continental plate, leading to the deposition of a deepening water succession of sediments. The basal Camgrian deposits are sands of the Addy Quartzite formation, overlain by offshore muds of the Maitlen Phyllite, topped by the deep water parts of the midCambrian Metalline Limestone. However, during the last half of Metalline Limestone depostion , a broad upward bulge began to grow in the continental plate.

Increasing restriction of the seaway was recorded in Ordovician times by the accumulation of organic black muds of the Ledbetter Slat formation. The very stagnant conditions required for this type of sedim tion indicate very poor circulation of the marine waters—clearly not an open-ocean feature.

Small coral reef deposits of very limited geographic extent were formed during late Paleozoic times, further documenting the greatly restricted seaways. By this time, the broad upward bulge had multiplied into a series of wave-like folds, and slender tongues of marine water were restricted to the troughs of the synclinal folds.

Continued compressional folding and underthrusting finally lifted the continental plate above sealevel about 300 million years B.P. A period of mountain building ensued, culminated by the intrusion of large granitic plutons about 100 million years ago.

To the west, in the area of the major subductive underthrust (near the present course of the Columbia River), a melange of deep sea deposits carried continentward by the diving plate were scraped off on the lip of the continental crust. Landslides of continental detritus cascaded into the trench, accumulating in a structurally complex pile of jumbled deep sea and continental deposits.

Intrusion of the Cretaceous granites "healed" the underthrust zone, welding the two plates together again. As unrelenting compressional stresses built up, a new downwarp was initiated west of the present Cascade Mountains. The entire sequence began to repeat itself at that locality, while in northeastern Washington, stresses greatly relaxed.

Release of the compressional forces that both built and maintained the lofty folded and thrust-faulted landforms, resulted in large scale collapse structures in several areas. The Metaline, Republic and Methow grabens formed as large fault-bounded blocks dropped downwards as much as 10,000 feet.

At about this time, widespread volcanic eruptions commenced, blanketing much of northeastern Washington with rhyodacitic tuffs and flows of the Sanpoil Volcanics. Simultaneously, the younger (50 million years B.P.) intrusive units of the Loon Lake batholith were rising into place.

Relatively stable conditions and deep erosion prevailed over the following 20 million years, etching deeply into even the youngest intrusive units.

About 30 million years ago, great rifts opened in central and southwestern Washington and flood basalts poured out, fluidly filling the lowlands like vast rivers of lava. For the next 20 million years flow after flow poured out, building thicknesses of up to 10,000 feet. A few of the uppermost flows lapped into the highland valleys in the vicinity of the Dawn millsite.

Again, a period of quiescence and erosion intervened. Very little tectonic activity occured in the NE Washington region, but to the west, the Cascade volcanoes were growing. As a result of the Cascade rain-shadow, weather in the eastern part of the state became increasingly arid.

Climaxing the local geological history, the great continental glaciers began their southward march about 1 million years ago. Several times the ice advanced, then receded, stagnating somewhat north of the present city of Spokane. Meltwaters carried huge loads of rock flour, sands, and gravels southwestwards across the basalt plateau. Winds picked up the fine particles and blew them back again, forming the dune-like fertile soils of the Palouse.

The final advance of the Purcell lobe of the glacier dammed the Clark Fork River, backing up waters to form glacial Lake Missoula. Eventual failure of the ice dam sent a wall of water across the Spokane (and Ford) area estimated to have carried a flow of water for a brief period that equaled ten times the flow of all the major rivers of earth combined. This raging torrent scoured its way across the plateau producing Washington's channeled scablands. In the Ford area, a twenty foot layer of coarse gravel was deposited by the waning stages of the "Great Spokane Flood". This spectacular event took place about 20,000 years ago.

Since the final recession of the glaciers, the region has been geologically "quiet". In the last hundred years, there has been a scattering of minor earthquakes, probably related to glacial unloading, with epicenters located less than 100 miles from the Dawn millsite; however, none of these have been significantly destructive. A few of the most severe quakes with epicenters from 100 to 400 miles away from the project area have produced significant local ground movement, but none in recorded history have extensively damaged structures in the Spokane area. Appendix B includes available seismic data for the region.

Walkers Prairie, the site of the Dawn operation, is believed to be an erosional feature free of potential seismic structures. The Dawn mill area near Ford, Wa. is underlain by a granitis basement buried under thin remnants of Columbia River Basalts and a thick accumulation of glaciofluvial clays, sands, and bouldery gravels. Figure 3.1 is an interpretive geologic profile of the materials underlying and adjacent to the millsite. A detailed measured section of the glaciofluvial deposits which will be encountered by the sub-grade excavation is presented in Figure 3.2.

APPENDIX B REGIONAL SEISMOLOGY

From "Draft Environmental Statement, Sherwood Uranium Project, Spokane Indian Reservation," Appendix E, U.S. Department of the Interior Bureau of Indian Affairs, Portland, April, 1976.

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TABLE B-1

PRIMARY SOURCES OF EARTHQUAKE DATA

Reference	Geographic Area	Time Period
Townley and Allen (1939)	Washington, Oregon, Idaho	18[illegible]-1928
Coombs (1953)	Washington	1930-1951
Rasmussen (1967)	Washington	1840-1965
Coffman and von Hake (1973)	Washington/Oregon, Western Mountain Region	1841-1970
U.S. Earthquakes	Washington/Oregon, Western Mountain Region	1928-1971
U.S. Coast and Geodetic Survey (1930-1970)		
U.S. National Ocean Survey (1971)		
U.S. Environmental Data Service (1972, 1973)		
Milne (1956)	Western Canada	1841-1951
Milne et al (1953, 1961-1964, 1966)	Western Canada	1951-1963
Smith and Milne (1969, 1970)	Western Canada	1964-1965
Stevens et al (1972)	Western Canada	1966

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POOR ORIGINAL

TABLE B 2

RECORDED EARTHQUAKES LOCATED WITHIN 100 MILES OF THE PROJECT [a]

Sheet 1 of 2

Year	Date	Location	Assigned Latitude/ Longitude	Intensity/ Magnitude [b]
1897	Dec 15	Lakeside	47.8 N, 120.1 W	"Severe Shock"
1898	Jan 11	Lakeside	47.8 N, 120.1 W	Felt
1898	June 3	Lakeside	47.8 N, 120.1 W	Felt
1906	Jan 2	N.E. Wash.	48.5 N, 118.0 W	VI
1906	Nov 2	Colville	48.5 N, 117.9 W	V
1909	May 24	47.6 N, 120.0 W	47.6 N, 120.0 W	Felt
1914	Feb 1	Lakeside	47.8 N, 120.1 W	Felt
1914	Aug 8	Lakeside	47.8 N, 120.1 W	Felt
1915	Mar 1	Lakeside	47.8 N, 120.1 W	III
1915	Mar 5	Lakeside	47.8 N, 120.1 W	IV
1915	Jul 18	Lakeside	47.8 N, 120.1 W	IV
1915	Dec 10	Spokane	47.7 N, 117.4 W	IV
1918	Mar 11	48.0 N, 116.7 W	48.0 N, 116.7 W	V
1917	Apr 18	White Bluffs Prairie	47.7 N, 117.6 W	IV
1918	Nov 1	Corfu	46.7 N, 119.5 W	V-VI
1920	Nov 28	Spokane	47.7 N, 117.4 W	Felt
1920	Nov 29	Spokane	47.7 N, 117.4 W	Felt
1922	Jan 31	Tonasket	48.7 N, 119.5 W	III(?)
1922	Jan 31	Republic	48.7 N, 118.7 W	II(?)
1922	June 1	Spokane	47.7 N, 117.4 W	IV
1926	Nov 28	47.5 N, 116.0 W	47.5 N, 116.0 W	V
1926	Dec 30	Chelan/East-Central Wash.	47.8 N, 120.1 W	VI
1930	Sept 3	47.3 N, 117.8 W	47.3 N, 117.8 W	V
1931	Sept 18	Lakeside/ Chelan Falls	47.8 N, 120.0 W	Felt
1932	Aug 15	Chelan	47.8 N, 120.0 W	-III
1932	Sept 5	Lakeside	47.8 N, 120.1 W	III
1933	Apr 29	Chelan/Pateros	47.8 N, 120.1 W	III
1933	May 29	Chelan	47.8 N, 120.0 W	III
1933	May 31	Chelan	47.8 N, 120.0 W	IV
1934	Jan 11	48.0 N, 117.0 W	48.0 N, 117.0 W	(?)
1934	Mar 9	Lakeside	47.8 N, 120.1 W	IV
1934	Mar 10	Chelan Falls	47.8 N, 120.0 W	III
1934	Mar 18	Waterville	47.7 N, 120.0 W	III
1935	July 9	47.7 N, 120.0 W	47.7 N, 120.0 W	V
1935	Oct 12	Entiat	47.7 N, 120.2 W	IV-V
1937	Aug 11	Spokane	47.7 N, 117.4 W	Felt
1939	Nov 29	Chelan Falls	47.8 N, 120.0 W	Felt
1939	Nov 30	Chelan Falls	47.8 N, 120.0 W	Felt
1940	Jan 6	Ephrata	47.3 N, 119.6 W	Felt
1941	Jan 3	Pullman	46.7 N, 117.3 W	Felt
1941	Apr 7	Republic	48.7 N, 118.7 W	Felt
1941	Apr 7	48.3 N, 119.6 W	48.3 N, 119.6 W	VI
1941	Apr 12	Waterville	47.7 N, 120.0 W	Felt
1941	Jul 29	Spokane	47.7 N, 117.4 W	Felt
1942	Feb 23	Wenatchee/ Chelan Falls	47.6 N, 120.1 W	V

(a) Compiled from references cited in Table B-1.
(b) Intensity = modified Mercalli Scale; magnitude = Richter Magnitude Scale.

POOR ORIGINAL

TABLE B-2

Year	Date	Location	Assigned Latitude/ Longitude	Intensity/ Magnitude
1942	Nov 1	48.0 N, 116.7 W	48.0 N, 116.7 W	VI
1942	Dec 1	Entiat	47.7 N, 120.2 W	Felt
1943	June 13	Entiat	47.7 N, 120.2 W	Felt
1943	Sept 23	Coulee Dam	48.0 N, 119.0 W	Felt
1943	Oct 9	Waterville	47.7 N, 120.0 W	Felt
1943	Oct 27	Okanogan	48.4 N, 119.6 W	Felt
1944	Jan 29	Chelan Falls	47.8 N, 120.0 W	Felt
1944	Oct 7	Chelan Falls	47.8 N, 120.0 W	III
1944	Dec 25	Entiat	47.7 N, 120.2 W	IV
1945	Jan 4	Entiat	47.7 N, 120.2 W	V
1945	Feb 27	Winthrop	48.[illegible] N, 120.2 W	IV
1945	Mar 2	Entiat	47 [illegible], 120.2 W	IV
1946	Feb 5	Chelan/ Ardenvoir	47.[illegible] N, 120.2 W	IV
1947	Dec 22	Entiat	47.7 N, 120.2 W	IV
1948	Jan 13	Lucerne/ Waterville	47.7 N, 120.0 W	V
1948	Aug 28	Deer Park	47.8 N, 117.5 W	IV
1948	Oct 25	Chelan	47.8 N, 120.0 W	IV
1949	Apr 14	Pullman	46.7 N, 117.2 W	Felt
1950	Mar 8	Entiat	47.7 N, 120.2 W	IV
1950	June 25	Cheney	47.5 N, 117.5 W	IV
1951	Jan 4	Chelan/ Waterville	47.75 N, 120.0 W	V
1952	Mar 4	Spokane	47.7 N, 117.4 W	V
1954	May 22	Twisp	48.3 N, 120.1 W	V
1954	June 8	47.5 N, 116.0 W	47.5 N, 116.0 W	V
1955	Feb 6	Grand Coulee Dam	48.0 N, 119.0 W	IV
1955	Jul 15/19	Soap Lake	47.4 N, 119.5 W	IV
1955	Dec 19	48.5 N, 116.3 W	48.5 N, 116.3 W	3.1
1956	Feb 24	Electric City	47.95 N, 119.0 W	V
1957	Dec 18	Wallace, Idaho	47.5 N, 116.0 W	VI
1958	Apr 12	48 N, 120 W	48.0 N, 120.0 W	VI
1959	July 11	Deep Lake	47.7 N, 119.5 W	Felt
1959	Aug 6	--	47.8 N, 120.0 W	VI
1959	Aug 18	Chelan	47.8 N, 120.0 W	Felt
1961	Apr 22	49.0 N, 119.7 W	49.0 N, 119.7 W	3.3
1961	May 22	47.6 N, 120.2 W	47.6 N, 120.2 W	IV
1961	Oct 31	48.4 N, 120.0 W	48.4 N, 120.0 W	V
1961	Nov 7	Spokane	47.7 N, 117.4 W	Felt
1962	Jan 15		47.83 N, 120.22 W	V
1963	Dec 22		48.5 N, 119.3 W	V/4.4
1965	Apr 28		48.6 N, 116.9 W	V
1966	Jul 23		47.2 N, 119.5 W	4.3
1966	Nov 6		47.9 N, 119.1 W	(?)
1966	Nov 13		48.5 N, 119.0 W	3.2
1966	Dec 8		48.3 N, 120.0 W	3.8
1967	June 6		48.2 N, 119.1 W	3.9
1968	Apr 12		48.8 N, 116.3 W	(?)
1968	Aug 9		47.52 N, 116.0 W	(?)
1969	May 10		49.1 N, 118.72 W	3.4
1971	Jan 26		46.91 N, 119.57 W	2.3
1971	Oct 25		46.7 N, 119.5 W	3.2
1973	Dec 20		46.94 N, 119.25 W	4.8

TABLE B-3

MODIFIED MERCALLI INTENSITY (DAMAGE) SCALE OF 1931 (Abridged)

Intensity	Description
I	Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale.)
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale.)
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel Scale.)
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel Scale.)
V	Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale.)
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale.)
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel Scale.)
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX Rossi-Forel Scale.)
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale.)
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale.)
IX	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown upward into the air.

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APPENDIX C CLIMATOLOGICAL SUMMARIES

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U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU IN COOPERATION WITH
THE WASHINGTON STATE DEPARTMENT OF COMMERCE AND ECONOMIC DEVELOPMENT
CLIMATOGRAPHY OF THE UNITED STATES 20-45

LATITUDE 47° 37'N
LONGITUDE 117° 31'W
ELEV (GROUND) 2357 ft.

CLIMATOLOGICAL SUMMARY

STATION SPOKANE, WASH.
Spokane International Airport

NORMALS, MEANS, AND EXTREMES

Month	Temperature – Normal – Daily maximum	Temperature – Normal – Daily minimum	Temperature – Normal – Monthly	Temperature – Extremes – Record highest	Year	Temperature – Extremes – Record lowest	Year	Normal degree days
(a)	(b)	(b)	(b)	15		15		(b)
J	31.4	19.2	25.3	52	1959	-24	1950	1251
F	37.4	22.5	30.0	61	1958	-12	1950	980
M	47.0	28.1	38.1	71	1960	-3	1955	834
A	58.6	35.8	47.3	84	1952	21	1951	531
M	68.3	43.1	55.7	92	1958	24	1954	278
J	73.5	49.3	61.4	96	1958+	35	1954	147
J	83.6	55.4	69.5	102	1960+	39	1962	19
A	81.0	53.8	67.5	98	1958+	40	1962	34
S	72.7	47.0	59.9	96	1950	30	1958+	189
O	58.1	38.0	48.6	80	1958+	20	1949	508
N	41.2	29.5	35.2	61	1953	-11	1955	894
D	34.9	24.2	29.6	54	1957	-9	1951	1097
Yr	57.5	37.2	47.3	102	Jul 1960	-24	Jan 1950	6762

Month	Precipitation – Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs	Year	Snow, Sleet – Mean total	Snow, Sleet – Maximum monthly	Year	Snow, Sleet – Maximum in 24 hrs	Year
(a)	(b)	15		15		15		15	15		15	
J	2.44	4.96	1959	.50	1949	1.48	1954	20.2	56.9	1950	13.0	1950
F	1.86	3.94	1961	1.07	1953	.96	1961	10.1	20.6	1959	8.0	1951
M	1.50	3.75	1960	.45	1948	.91	1950	5.3	12.4	1951	5.1	1950
A	.91	3.08	1948	.08	1956	.89	1962+	.2	1.4	1957	1.4	1957
M	1.21	5.71	1948	.58	1956	1.67	1948	T	.2	1950	.2	1950
J	1.49	2.84	1950	.16	1960	1.52	1957	T	T	1954	T	1954
J	.38	1.29	1948	T	1960+	.79	1955					
A	.41	1.41	1956	T	1955	1.09	1955					
S	.75	2.05	1959	.06	1950	.92	1948					
O	1.57	4.05	1950	.11	1952	.88	1955	.8	6.1	1957	6.1	1957
N	2.24	4.64	1960	.34	1956	1.41	1960	6.0	24.7	1955	6.6	1955
D	2.43	4.35	1951	1.21	1959	1.60	1951	15.6	39.4	1951	12.1	1951
Yr	17.19	5.71	May 1948	T	Jul 1960+	1.67	May 1948	58.0	56.9	Jan 1950	13.0	Jan 1950

Month	Relative humidity – 4:00 A. PST	10:00 A. PST	4:00 P. PST	10:00 P. PST	Wind – Mean hourly speed	Wind – Prevailing direction	Wind – Fastest mile – Speed	Direction	Year	Pct of poss sunshine	Average sky cover sunrise to sunset
(a)	13	13	13	13	14	13	15	15		14	14
J	84	81	79	84	7.9	NE	50	SW	1951	26	8.1
F	84	77	71	81	8.9	SSW	54	SW	1949	36	8.1
M	80	65	56	75	9.1	SSW	54	SW	1955	52	7.5
A	75	53	45	63	9.1	SSW	50	SW	1962	62	7.0
M	72	51	41	64	8.2	SSW	49	W	1957	62	6.6
J	76	48	38	59	8.4	SSW	39	SW	1949	67	6.0
J	64	34	26	43	7.7	SW	37	W	1959	82	3.2
A	67	42	28	46	7.6	SW	38	SW	1950	78	4.2
S	69	47	34	54	7.6	NE	38	SW	1961+	71	4.9
O	82	67	55	74	7.5	SSW	56	SW	1950	51	6.6
N	86	78	74	83	7.6	NE	54	SW	1949	33	7.6
D	88	87	83	87	8.4	NE	51	SW	1956	22	8.6
Yr	77	61	52	68	8.2	SSW	56	SW	Oct 1950	57	6.5

Month	Mean number of days – Sunrise to sunset – Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Sleet 1.0 inch or more	Thunderstorms	Heavy fog	Max. temp. 90° and above	Max. temp. 32° and below	Min. temp. 32° and below	Min. temp. 0° and below
(a)	14	14	14	14	14	14	14	13	13	13	13
J	4	4	23	16	6	0	9	0	15	28	5
F	3	5	20	13	4	0	6	0	6	25	1
M	4	8	19	12	3	*	3	0	2	24	*
A	5	8	17	8	*	1	1	0	0	10	0
M	6	10	15	10	0	1	1	*	0	1	0
J	7	11	12	8	0	3	1	1	0	0	0
J	19	8	4	4	0	2	*	9	0	0	0
A	16	8	7	5	0	2	*	5	0	0	0
S	12	9	9	6	0	1	*	1	0	1	0
O	7	8	16	9	*	*	5	0	0	7	0
N	4	6	20	12	2	*	8	0	3	20	*
D	2	4	25	16	5	0	12	0	12	27	1
Yr	89	89	187	118	19	11	46	16	39	142	7

(a) Length of record, years.
(b) Normal values are based on the period 1931-60 and are means adjusted to represent observations taken at the present standard location. Means and extremes in the above table are from the existing location. Annual extremes have been exceeded at prior locations as follows: highest temperature 108 in July 1928; lowest temperature -30 in January 1888; maximum monthly precipitation 5.85 in November 1897; minimum monthly precipitation 0.00 in July 1885; maximum precipitation in 24 hours 2.22 in June 1888.

NARRATIVE CLIMATOLOGICAL SUMMARY

Spokane lies on the eastern edge of the broad Columbia Basin area of Washington which is bounded by the Cascade Range on the west and the Rocky Mountains on the east. The elevations in eastern Washington vary from less than 400 feet above sea level near Pasco where the Columbia River flows out of Washington to over 5000 feet in the mountain areas of the extreme eastern edge of the State. Spokane is located on the upper plateau area where the long gradual slope from the Columbia River meets the sharp rise of the Rocky Mountain Ranges.

Much of the urban area of Spokane lies along both sides of the Spokane River at an elevation of approximately 2000 feet, but the residential areas have spread to the crests of the plateaus on either side of the river with elevations up to 2500 feet above sea level. Spokane International Airport is situated on the plateau area six miles west-southwest and some 400 feet higher than the downtown business district.

Spokane's climate combines some of the characteristics of damp coastal type weather and arid interior conditions. Most of the air masses which reach Spokane are brought in by the prevailing westerly and southwesterly circulations. Frequently much of the moisture in the storms that move eastward and southeastward from the Gulf of Alaska and the eastern Pacific Ocean is precipitated out as the storms are lifted across the Coast and Cascade Ranges. Annual precipitation totals in the Spokane area are generally less than twenty inches and less than 50 percent of the amounts received west of the Cascades. However, the precipitation and total cloudiness in the Spokane vicinity is greater than that of the desert areas of south-central Washington. The lifting action on the air masses as they move up the east slope of the Columbia Basin frequently produces the cooling and condensation necessary for formation of clouds and precipitation.

Infrequently the Spokane area comes under the influence of dry continental air masses from the north or east. On occasions when these air masses penetrate into eastern Washington, the result is high temperatures and very low humidity in the summer and subzero temperatures in the winter. In the winter, most of the severe arctic outbursts of cold air move southward on the east side of the Continental Divide and do not affect Spokane.

In general, Spokane weather has the characteristics of a mild, arid climate during the summer months and a cold, coastal type in the winter. Approximately 70 percent of the total annual precipitation falls between the first of October and the end of March and about half of that falls as snow. The growing season usually extends over nearly six months from mid-April to mid-October. Irrigation is required for all crops except dryland type grains. The summer weather is ideal for full enjoyment of the many mountain and lake recreational areas in the immediate vicinity. Winter weather includes many cloudy or foggy days and below freezing temperatures with occasional snowfall of several inches in depth. Subzero temperatures and traffic-stopping snowfalls are infrequent. The nearby winter sports areas have a season of four to five months with plenty of facilities for skiing and other winter outdoor activities.

Earl L. Phillips
State Climatologist
U. S. Weather Bureau
Seattle, Washington
RSO-7 (Revised)

Average Temperature (°F)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept	Oct	Nov.	Dec.	Ann'l
1931	34.4	34.6	41.6	49.3	60.0	63.9	72.8	71.2	60.6	49.4	33.3	29.2	50.0
1932	26.1	29.7	38.2	50.0	55.7	66.4	69.1	69.6	61.2	49.2	42.0	26.9	48.7
1933	31.8	23.3	40.2	48.4	52.5	64.0	71.8	70.3	56.8	51.7	39.1	37.8	49.0
1934	37.4	39.4	47.2	56.5	61.2	65.4	71.3	71.0	57.6	51.4	43.6	32.9	52.9
1935	33.3	35.6	38.3	45.2	55.8	62.4	70.2	67.4	63.8	47.0	33.1	31.3	48.4
1936	31.8	17.4	38.7	52.2	62.0	65.5	72.8	71.0	59.1	52.2	37.3	33.0	49.0
1937	9.9	28.6	42.2	46.6	57.3	63.3	72.4	66.2	62.6	52.6	40.4	34.2	48.0
1938	31.5	33.6	41.1	49.8	56.8	66.8	75.0	67.8	67.8	51.2	35.1	32.8	50.9
1939	34.6	28.1	41.2	51.6	58.9	60.8	72.4	72.6	62.1	49.5	39.6	37.0	50.7
1940	30.0	35.9	45.3	50.6	60.5	68.3	77.8	70.6	64.6	53.0	32.2	33.5	51.5
1941	32.0	32.4	45.6	51.8	53.7	62.6	73.8	68.5	55.6	47.5	40.2	33.7	50.5
1942	22.6	31.0	39.6	49.8	53.0	55.6	71.2	70.4	61.8	50.4	35.0	32.4	48.1
1943	21.8	33.2	35.8	50.4	52.4	58.6	69.3	66.8	62.6	50.2	37.6	29.2	47.3
1944	30.2	32.5	37.0	47.9	56.8	62.6	69.7	66.8	61.6	54.2	36.8	28.4	48.7
1945	32.6	35.1	37.8	44.7	56.9	60.5	70.9	69.4	56.6	50.8	36.8	29.8	48.5
1946	30.9	35.2	41.1	48.0	57.0	60.5	69.4	68.6	58.8	44.2	34.6	32.6	48.4
1947	24.4	36.1	42.6	48.2	59.6	61.5	70.3	66.7	59.0	50.8	34.8	31.2	48.8
1948	27.5	29.0	36.2	43.5	52.8	65.4	65.1	65.2	58.1	47.3	34.8	21.5	45.5
1949	8.5	26.4	38.0	49.7	59.1	61.8	68.6	68.6	61.6	44.2	41.2	27.8	46.2
1950	9.0	29.8	35.7	43.9	52.2	61.0	69.1	70.2	62.0	46.7	36.2	33.6	45.8
1951	27.1	32.2	34.3	48.3	54.5	61.3	71.0	68.3	60.2	45.7	35.7	22.2	46.8
1952	23.5	30.2	36.7	49.8	56.5	61.0	70.1	68.4	63.8	54.5	32.7	30.3	48.1
1953	37.9	35.1	40.0	45.6	52.4	57.2	69.3	68.0	61.7	51.6	40.3	33.2	49.4
1954	26.9	33.1	36.3	43.5	55.4	57.2	67.5	64.5	57.5	46.2	41.5	30.2	46.6
1955	26.9	27.9	31.2	40.6	49.4	62.7	66.4	68.4	59.4	47.1	28.1	26.8	44.6
1956	28.9	22.6	36.1	49.9	58.1	58.9	71.6	67.6	60.7	46.3	32.7	30.7	47.0
1957	15.0	28.7	37.6	48.0	59.3	62.1	67.5	65.6	62.8	45.0	35.6	35.1	46.9
1958	32.0	39.8	38.9	44.9	62.7	65.6	73.0	73.7	58.7	50.2	35.7	32.4	50.7
1959	29.0	30.5	39.2	47.4	50.6	61.7	70.6	64.4	55.1	46.1	31.5	28.8	46.3
1960	20.5	30.6	38.2	45.9	51.2	62.2	75.1	65.1	60.3	48.6	35.2	26.6	46.6
1961	30.3	37.0	39.9	45.1	53.0	66.6	71.9	74.0	55.9	45.2	30.7	26.6	48.0
1962	22.6	32.4	34.6	49.8	50.9	61.1	68.2	65.4	60.7	47.6	37.9	33.1	47.0

PROBABILITY OF 32°, 28°, 24°, 20° AND 16° OCCURRING AS LATE IN THE SPRING OR AS EARLY IN THE FALL AS THE DATES LISTED IN THE FOLLOWING TABLE:

	PROBABILITY - SPRING				PROBABILITY - FALL			
	75%	50%	25%	10%	10%	25%	50%	75%
32°	Apr 7	Apr 20	May 3	May 15	Sep 19	Sep 30	Oct 12	Oct 24
28°	Mar 24	Apr 6	Apr 19	May 1	Oct 3	Oct 14	Oct 26	Nov 7
24°	Feb 28	Mar 14	Mar 27	Apr 8	Oct 18	Oct 29	Nov 10	Nov 22
20°	Feb 7	Feb 21	Mar 7	Mar 19	Oct 31	Nov 11	Nov 23	Dec 6
16°	Jan 26	Feb 11	Feb 26	Mar 10	Nov 13	Nov 24	Dec 8	Dec 26

In the above table, the 50% point is the same as the average for each freeze category.

From a statistical viewpoint based on past data, the probabilities could be considered as follows when converted into the number of occurrences to expect in a 40-year period:

75% - 30 years in 40

50% - 20 years in 40

25% - 10 years in 40

10% - 4 years in 40

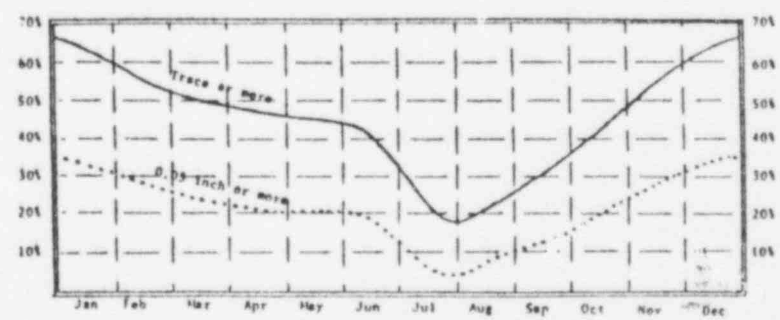
(More detailed local monthly and annual climatological data summaries are available from the U.S. Weather Bureau Office, Spokane, Wash.)

POOR ORIGINAL

Total Precipitation (Inches)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann'l
1931	1.50	.76	1.52	.53	.26	.87	T	.01	1.05	.82	2.41	3.89	13.61
1932	1.99	.82	2.69	.93	2.74	.28	.21	.27	.06	1.14	2.59	2.13	15.85
1933	1.16	.60	1.19	.28	.59	1.16	.17	.64	1.25	2.72	.80	4.35	14.91
1934	2.57	[illegible]	1.53	.34	.25	.84	T	.19	.98	3.45	2.01	1.50	13.93
1935	2.06	[illegible]	.78	.92	.06	.77	.68	.96	.05	.96	.90	1.78	10.51
1936	2.78	[illegible]	.58	.18	.57	2.33	.07	.23	1.64	.28	.08	2.39	12.70
1937	1.94	1.49	1.11	2.53	.23	3.13	.56	.61	.62	.87	3.05	2.76	18.90
1938	1.44	1.90	2.09	.35	.47	.83	.26	.29	.09	.83	.89	1.63	11.07
1939	1.55	[illegible]	1.20	.61	.30	.71	.40	.04	.23	.95	.28	2.83	11.47
1940	1.09	[illegible]	2.91	1.86	.64	.36	1.46	.01	2.12	2.47	2.37	2.59	23.50
1941	1.61	.83	.69	.32	3.18	2.55	.09	1.85	1.36	.85	1.63	2.78	17.74
1942	1.24	1.30	.48	.98	3.19	.93	.34	.08	.22	1.12	2.69	1.70	14.37
1943	1.25	1.15	1.60	1.33	1.19	1.42	.35	.98	.12	3.13	.60	.54	13.66
1944	.53	1.08	.57	1.40	.94	1.11	.21	1.02	.56	.45	1.64	1.14	10.65
1945	1.27	.95	2.46	1.12	2.20	1.37	T	.55	2.24	.79	2.41	2.00	17.36
1946	1.51	1.43	1.69	.98	1.43	1.08	.03	.07	1.76	1.38	3.16	.90	15.42
1947	1.24	.26	1.60	1.17	.31	1.98	.72	.83	1.57	5.41	1.67	1.80	18.56
1948	2.72	2.75	.45	3.08	5.71	2.17	1.29	.27	1.46	.66	2.38	3.13	26.07
1949	.50	3.08	2.17	.42	.90	.22	.07	.19	1.06	1.52	2.28	1.50	13.91
1950	4.13	1.93	3.75	.43	.72	2.84	.56	.41	.06	4.05	1.96	2.16	23.00
1951	3.16	1.61	1.72	.38	.66	1.04	.37	.40	.47	3.26	1.88	4.35	19.30
1952	2.41	1.33	1.14	.28	.63	2.44	.06	.18	.52	.11	.80	3.10	13.00
1953	4.56	1.07	1.77	1.48	1.59	.81	T	1.36	.50	.19	2.00	1.90	17.23
1954	4.90	1.19	.83	.53	.78	.75	.85	1.25	1.55	.77	1.42	1.44	16.26
1955	1.38	1.32	.79	1.83	.67	.80	1.28	T	1.13	2.84	3.92	3.82	19.78
1956	2.87	1.44	1.29	.08	.59	1.18	.50	1.41	.09	1.87	.34	1.22	12.88
1957	1.34	1.54	1.82	.81	3.74	2.74	.04	.30	.68	2.33	.82	1.93	18.09
1958	3.55	3.27	.84	1.72	.71	1.63	1.15	.13	.47	.79	3.72	2.93	20.91
1959	4.96	2.01	1.21	.57	2.26	.39	.05	1.24	2.05	1.32	2.30	1.21	19.57
1960	1.05	1.64	2.36	1.51	2.73	.16	T	.56	.72	.95	4.64	1.37	17.69
1961	1.61	3.94	1.75	.96	1.77	1.64	.37	.30	.17	1.05	1.83	3.91	19.30
1962	1.39	1.72	2.56	1.02	1.65	.78	.29	.63	.90	1.62	3.02	1.44	17.02

PROBABILITY OF PRECIPITATION OCCURRING ON ANY GIVEN DAY AT SPOKANE
(Based on 77 years of data ending with 1957)



Note: The probability of a trace or more of precipitation occurring on any day is indicated by the solid line. The probability of 0.05 of an inch is indicated by the dotted line

U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU IN COOPERATION WITH
THE WASHINGTON STATE DEPARTMENT OF COMMERCE AND ECONOMIC DEVELOPMENT
CLIMATOGRAPHY OF THE UNITED STATES 20-45

LATITUDE 48° 15'
LONGITUDE 117° 43'
ELEV (GROUND) 1635 Ft.

CLIMATOLOGICAL SUMMARY

STATION CHEWELAH, WASH.

MEANS AND EXTREMES FOR PERIOD 1931-1960

Month	Temperature (°F) Means: Daily maximum	Daily minimum	Monthly	Extremes: Record highest	Year	Record lowest	Year	Mean degree days **	Precipitation Totals (Inches): Mean	Greatest daily	Year	Snow, Sleet: Mean	Maximum monthly	Year	Greatest daily	Year	Mean number of days: Precip. .10 inch or more	Temperatures Max.: 90° and above	32° and below	Min.: 32° and below	0° and below	Month
(a)	30	30	30	30		30		30	30	30		30	30		30		30	30	30	30	30	
JAN	31.7	15.	23.3	55	1953	-38	1950	1293	2.52	1.40	1934	14.7	39.0	1937	9.0	1933	8	0	14	29	6	JAN
FEB	38.8	18.3	28.5	61	1958	-33	1933	1022	1.83	1.24	1958	9.4	39.5	1937	10.5	1937	6	0	5	26	3	FEB
MAR	49.4	27.1	38.2	74	1940	-12	1951	831	1.70	1.44	1945	2.3	14.0	1951	5.0	1956	5	0	*	25	*	MAR
APR	61.7	32.6	47.2	89	1934	12	1936	534	1.29	1.15	1932	.2	2.3	1945	2.3	1945	4	0	0	14	0	APR
MAY	71.3	39.2	55.2	96	1934	16	1954	313	1.67	1.29	1957						5	1	0	5	0	MAY
JUN	76.8	44.6	60.7	98	1955+	26	1952	150	1.58	1.19	1936						5	2	0	1	0	JUN
JUL	87.3	45.9	66.6	107	1941+	32	1960+	50	.64	1.70	1955						2	13	0	*	0	JUL
AUG	86.3	42.4	64.4	103	1958	28	1937	71	.59	1.11	1959						2	11	0	1	0	AUG
SEP	76.9	37.6	57.3	101	1938	16	1934	252	1.08	1.56	1940						3	3	0	8	0	SEP
OCT	61.7	31.7	46.7	88	1943+	2	1935	567	1.85	1.53	1938	.4	4.0	1939	4.0	1939	5	0	*	17	0	OCT
NOV	42.6	26.6	34.6	69	1949	-15	1955	912	2.34	1.38	1941	3.7	14.0	1956	8.0	1958	8	0	2	24	1	NOV
DEC	34.9	21.9	28.4	58	1956	-27	1951+	1135	2.73	1.23	1951	10.8	30.7	1948	10.5	1937	8	0	10	25	2	DEC
Year	59.9	31.9	45.9	107	1941+	-38	1950+	7130	19.82	1.56	1940	41.5	39.5	1937	10.5	1937+	61	30	31	178	12	Year

(a) Average length of record, years.

T Trace, an amount too small to measure.

** Base 65°F

\+ Also on earlier dates, months, or years.

* Less than one half.

NARRATIVE CLIMATOLOGICAL SUMMARY

Chewelah is located in the northeastern section of the State and near the southern edge of Stevens County. The city is in the Colville River valley. Within 5 to 10 miles of the river, north-south ranges of mountains reach elevations of 4,000 to 6,000 feet. The most important agricultural activities are the raising of livestock and the growing of hay and small grain crops. The higher elevations are State and National forest lands. Deposits of copper, silver and other minerals are found in the mountains. The Huckleberry Mountains on the west flank of the valley contain one of the largest magnesite deposits in the United States. A magnesite processing plant is located near the city. Winter ski areas are being developed along some of the mountain slopes.

Summers are warm, dry and sunny and winters are rather cold with considerable cloudiness. Some of the factors influencing the climate are terrain, distance and direction from the ocean and the prevailing westerly winds above the summits of the mountains. The Rocky Mountains protect this area from the more severe winter storms moving southward across Canada, however, the north-south valleys between ranges of mountains extending into British Columbia permit some of the cold air to reach the Inland Basin of eastern Washington. In a westerly direction, the Cascade Mountains form a barrier to the easterly movement of moist air from over the ocean.

On a typical summer's day, afternoon temperature is in the 80's with nighttime reading in the 40's. In midsummer, maximum temperatures exceed 90° on one day out of three, reaching 100° on a few afternoons. Even on the warmest days, temperatures drop rather quickly after sunset. The growing season is comparatively short and frost has occurred in midsummer months. The last freezing temperature in the spring usually occurs after the first of June and the first in the fall may occur during the latter half of August.

During the winter season, afternoon temperatures are near freezing and minimum temperatures range from 10° to 20° above zero. Maximum temperatures were below freezing on 60 days in one of the colder winters and on only 13 days in one of the warmer winters. Minimum temperatures are below freezing on almost every night from the latter half of October through March. Minimum temperatures can be expected to drop to -14° or lower on at least 4 nights in 7 out of 10 winters. During one of the coldest winters in recent years, 1949-50, minimum temperatures were below zero on 24 nights, -10° on 20 nights, -20° on 12 nights and -30° on 6 nights. The coldest weather generally occurs when cold air from Canada or east of the Rocky Mountains reaches this section of the State. During these cold outbreaks, the sky is frequently clear and the ground is covered with snow, thus a large amount of heat is lost by radiation at night.

Precipitation is light in summer, increasing in the fall, reaching a peak in winter, then decreasing in the spring with a slight increase in May and June followed by a sharp drop in July. Annual precipitation has ranged from 13 to 27 inches. During August, the driest month, the total precipitation is less than .01 inch in 1 summer out of 10; also, the total precipitation is more than 2 inches in 1 summer out of 10. Several thunderstorms and a few hail storms occur each summer.

Most of the precipitation between the latter half of November and the first of March falls as snow. In the higher elevations, snow can be expected after the middle of October and in the lower valleys before the first of December. A snow cover remains on the ground most of the time between the middle of December and the first of March. Snow reaches a depth of 15 to 20 inches almost every winter and 20 to 30 inches in the heavier snowfall seasons. In the higher elevations, snow can be expected to remain on the ground from the last of October until May or June. The few snow survey reports available for elevations above 4,000 or 5,000 feet indicate 6 to 8 feet of snow on the ground the first of April and 4 to 5 feet the first of May.

During the winter season, the loss of heat by radiation at night and moist air crossing the Cascades results in considerable cloudiness and fog. The number of clear or only partly cloudy days each month increases from approximately 6 in winter to 14 in spring and fall and to 25 in midsummer.

In this section of the State, the relative humidity in winter ranges from 75% in the afternoon to 90% at night, and in summer from 30% in the afternoon to 60% at night.

Earl L. Phillips
State Climatologist
U.S. Weather Bureau
Seattle, Washington

Total Precipitation (Inches)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l
1931	2.62	1.58	2.22	.38	.37	2.52	.19	T	1.71	1.99	3.19	5.03	21.90
1932	2.25	.73	3.21	2.95	2.61	.71	.31	.18	.32	1.51	3.18	3.35	21.31
1933	2.78	1.60	2.85	.38	1.25	.40	.13	.20	2.42	2.17	.87	6.59	21.64
1934	4.05	.25	1.34	.74	.86	.56	.36	.46	.69	3.52	3.35	2.91	19.10
1935	3.78	1.25	1.18	.24	1.07	.65	1.54	.48	.55	1.58	1.50	2.23	16.05
1936	3.42	1.17	.26	.58	1.15	2.36	.23	T	1.39	.39	.07	1.76	12.72
1937	2.26	3.12	1.79	2.78	.07	4.58	.88	.17	1.06	1.16	5.43	3.38	26.68
1938	2.79	3.60	3.20	.62	.48	.59	.03	.31	.67	2.47	1.22	1.99	17.97
1939	2.91	1.53	1.07	.54	.77	2.49	.22	T	.21	1.09	.63	5.03	16.49
1940	1.30	4.65	2.71	1.97	.63	.44	.24	.10	2.83	4.02	2.02	2.57	23.48
1941	2.26	.80	1.17	.72	4.34	1.80	.06	2.59	2.89	.77	2.62	4.63	24.65
1942	1.10	1.10	.50	1.03	3.35	1.62	1.27	.06	.10	.84	3.16	2.20	16.33
1943	.92	1.21	1.74	1.16	.96	1.18	.24	.80	.08	3.98	.73	1.04	14.04
1944	1.68	1.24	.38	1.90	.98	1.48	.52	.12	.67	.33	2.67	.97	13.09
1945	1.89	1.99	4.25	.75	2.44	1.27	T	.45	1.89	1.17	3.85	2.58	22.53
1946	2.01	2.45	1.38	1.52	.63	1.38	.10	.12	1.44	1.17	3.10	1.15	17.25
1947	1.80	1.87	.58	.97	.89	2.58	.73	.57	2.01	5.06	1.23	1.69	20.00
1948	2.54	2.46	.14	2.52	4.82	3.89	1.50	.10	.91	.73	3.51	2.38	26.10
1949	.49	2.68	2.14	.64	.79	.61	.19	.19	.93	1.48	1.91	1.21	13.26
1950	3.04	2.26	3.20	.50	.53	1.50	1.24	.32	.16	4.15	2.53	3.16	2[illegible].59
1951	3.01	1.53	1.80	.52	.65	.79	.31	.71	.85	4.14	2.72	5.02	22.05
1952	2.72	1.10	.90	.33	.71	2.33	.25	.66	.45	.14	.60	3.89	14.08
1953	3.83	1.09	2.17	2.05	1.82	2.09	.20	2.02	.13	.64	2.42	2.07	20.58
1954	3.92	2.06	1.10	1.12	1.96	1.47	1.06	1.97	1.06	.24	2.07	1.67	19.70
1955	1.60	.88	.84	3.82	1.40	2.21	3.72	0	1.50	2.44	2.19	4.48	25.08
1956	3.15	2.08	1.33	.82	1.17	1.16	1.45	1.27	.14	1.64	.49	1.08	15.78
1957	1.55	1.72	2.13	1.00	5.09	1.56	.28	.54	1.33	2.50	1.27	2.60	21.57
1958	3.31	4.17	1.89	3.42	.53	1.63	1.78	.38	.80	.87	3.51	2.08	24.37
1959	4.90	1.21	.50	.62	4.35	.76	.12	1.37	2.35	1.77	2.41	2.33	22.99
1960	1.79	1.43	2.87	2.02	3.29	.38	.01	.92	.75	1.31	5.42	.77	20.96
1961	1.24	3.58	1.19	1.11	3.41	.90	.80	.25	.46	1.92	1.86	3.95	20.67
1962	1.38	1.20	2.01	.93	2.26	.58	.03	.70	1.53	2.56	2.52	2.54	18.24
1963	.31	2.01	2.05	2.15	1.76	1.18	.71	.85	1.02	.73	3.36	1.59	17.72

STATION HISTORY

The first climatological station in this area was established at the residence of C.A. LaVigne located .2 of a mile northwest of the Post Office in Chewelah. Mr. LaVigne served as cooperative weather observer from 9/1/1925 to 6/1/1938. The elevation at this location was 1668 feet. The station was moved to the residence of Walter L. Goodman who served as cooperative weather observer from 6/1/1938 to 7/25/1940. During this period, the station was located .8 of a mile northwest of the Post Office and at an elevation of 1668 feet. The climatological station was moved to the present site at the Northwest Magnesite Company located 2 miles south of the Post Office on 7/26/1940. The present elevation of the station is 1635 feet.

Average Temperature (°F)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l
1931	31.2	31.2	[illegible]	46.6	57.6	61.2	67.2	64.9	56.3	45.6	31.8	25.3	46.2
1932	22.5	25.2	36.2	47.4	53.8	62.6	63.2	64.0	55.8	45.5	38.2	22.3	44.8
1933	26.5	17.8	37.0	45.2	50.5	59.5	64.4	64.6	53.0	46.8	37.2	35.3	41.5
1934	32.6	36.2	43.2	52.8	56.4	60.7	65.6	65.0	53.2	47.0	41.7	29.6	48.7
1935	24.4	29.8	37.2	43.4	52.1	57.6	65.2	62.6	57.6	44.1	31.2	30.1	41.6
1936	28.6	13.3	37.4	48.4	57.8	62.0	66.0	63.9	55.8	48.2	30.0	30.8	45.2
1937	4.6	23.8	39.6	45.8	54.4	59.2	67.4	61.2	57.6	49.0	38.2	30.9	44.3
1938	28.8	31.8	38.6	-	-	64.3	66.8	62.2	63.6	48.9	-	-	-
1939	30.3	23.6	38.4	48.5	54.8	56.4	66.0	65.8	58.2	46.2	35.4	33.0	46.4
1940	26.8	32.6	43.4	49.2	57.6	64.7	70.6	65.3	62.5	50.6	30.8	29.5	48.6
1941	28.6	35.6	44.2	50.6	54.8	61.8	70.6	65.5	54.2	45.5	37.7	31.0	48.4
1942	21.6	31.4	38.7	47.8	52.9	58.8	68.6	67.5	58.3	46.5	32.3	28.4	46.1
1943	18.2	29.3	34.3	49.6	52.0	58.3	66.9	63.2	56.4	46.9	36.6	27.2	45.1
1944	22.8	28.4	36.6	47.8	56.2	62.0	67.2	64.5	59.0	50.4	36.0	26.0	46.4
1945	30.0	33.4	38.3	44.3	56.6	59.8	67.6	65.9	54.6	48.2	33.5	27.6	46.7
1946	25.2	28.1	40.0	48.0	57.1	59.3	66.3	65.4	56.0	42.0	37.6	29.6	45.8
1947	21.4	34.2	42.0	47.0	57.6	60.0	66.1	63.4	57.4	49.1	[illegible].2	30.2	46.9
1948	22.4	27.8	37.2	44.9	55.6	65.8	63.9	64.5	56.9	45.0	34.4	17.2	44.6
1949	-0.4	19.2	38.2	48.9	58.3	60.3	65.8	64.4	58.9	43.0	40.8	26.3	43.7
1950	5.8	26.1	36.0	44.3	52.6	61.1	67.2	65.7	58.0	45.2	34.2	31.7	44.0
1951	24.[illegible]	29.4	32.8	47.4	54.7	59.7	66.8	65.0	57.3	46.7	33.3	19.3	44.9
1952	21.3	28.4	37.3	49.4	56.4	60.8	66.5	65.8	59.5	49.2	31.2	29.6	46.3
1953	36.8	35.9	40.6	46.5	53.4	58.2	65.7	65.1	57.8	48.8	38.8	32.6	49.4
1954	25.0	33.7	37.2	44.6	54.6	57.7	63.9	61.9	56.4	43.7	41.6	29.1	45.9
1955	26.7	26.0	31.5	41.9	51.1	61.7	65.4	62.8	56.8	47.1	28.3	23.9	43.5
1956	26.1	20.8	34.5	49.7	57.6	59.1	67.5	64.5	57.2	45.9	32.1	29.3	45.4
1957	10.7	25.4	36.4	47.6	60.2	62.1	64.0	61.5	59.5	46.3	34.5	32.6	45.3
1958	31.8	40.0	40.6	46.6	61.4	65.6	69.4	69.7	56.5	46.4	31.7	29.5	49.1
1959	26.3	27.3	38.7	47.7	50.5	59.9	66.0	62.3	54.8	45.3	30.2	28.7	44.8
1960	18.7	30.2	37.8	46.8	52.0	60.6	69.4	62.4	57.2	47.6	35.1	27.9	45.5
1961	29.3	36.6	39.9	46.1	54.6	65.8	68.3	69.9	53.2	44.3	29.0	23.7	46.7
1962	17.2	30.1	34.3	48.7	51.3	59.1	64.1	65.3	56.9	47.3	36.6	33.5	45.4
1963	20.8	34.8	40.6	45.5	53.5	61.1	63.9	65.5	61.9	48.2	36.2	24.9	46.4

PROBABILITY OF 32°, 28°, 24°, 20° AND 16° OCCURRING AS LATE IN THE SPRING OR AS EARLY IN THE FALL AS THE DATES LISTED IN THE FOLLOWING TABLE:

	PROBABILITY - SPRING				PROBABILITY - FALL			
	75%	50%	25%	10%	10%	25%	50%	75%
32°	May 21	Jun 4	Jun 18	Jun 30	Aug 2	Aug 12	Aug 25	Sep 6
28°	Apr 23	May 7	May 21	Jun 1	Aug 28	Sep 7	Sep 20	Oct 2
24°	Mar 26	Apr 9	Apr 22	May 5	Sep 7	Sep 18	Oct 1	Oct 12
20°	Mar 10	Mar 24	Apr 7	Apr 18	Oct 4	Oct 15	Oct 27	Nov 8
16°	Feb 18	Mar 3	Mar 17	Mar 28	Oct 19	Oct 30	Nov 11	Nov 23

In the above table, the 50% point is the same as the average for each freeze category.

From a statistical viewpoint based on past data, the probabilities could be considered as follows when converted into the number of occurrences to expect in a 10-year period:

[illegible]

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APPENDIX D REFERENCES CITED OR CONSULTED

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