VOLUME I

Technical Summary and 1984 Supplement
with Supporting Technical Memoranda

AN EVALUATION OF URANIUM DEVELOPMENT IN PITTSYLVANIA COUNTY, VIRGINIA
(October 15, 1983)

Prepared by Dravo Engineers, Inc.
For Marline/Umetco

September 1984

PREFACE

Pursuant to the Marline uranium discovery, the Virginia General Assembly in its 1981 session directed the Virginia Coal and Energy Commission to undertake a study on the issue of uranium development in the Commonwealth, and specifically in Pittsylvania County. The Coal and Energy Commission commenced its study in April 1981 and created a Uranium Subcommittee in late summer of that year.

After conducting several hearings on the advisability of uranium development within the Commonwealth, and undertaking a fact finding trip to uranium development areas in the western U.S., the Uranium Subcommittee recommended in 1982 that Virginia adopt a statute which would regulate the exploration of uranium ore. The recommendation was adopted through the passage of Virginia Senate Bill 179, which also prohibited any Virginia agency from accepting permit applications for uranium mining before July 1, 1983.

Following additional hearings, presentations and fact finding sessions by the Uranium Subcommittee, the Virginia Coal and Energy Commission recommended to the General Assembly in 1983 that additional studies be undertaken. The General Assembly accepted that recommendation and enacted Senate Bill 155, which was adopted on February 7, 1983.

Senate Bill 155 (SB 155) established the Uranium Administrative Group (UAG), which was charged with examining the issue of uranium development "at specific sites in Pittsylvania County", Virginia. Senate Bill 155 also provided the proponents of uranium development with the opportunity to conduct studies which address the various ramifications of uranium development and to submit reports of these studies to the UAG. The present document primarily is a summary of various reports developed by Marline and Umetco[1], which were consolidated into a nine-volume set and submitted to the UAG on October 15, 1983. This report also contains updated information based on continuing studies by Marline/Umetco and their consultants, which are summarized in the appended Technical Memoranda.

As stated in SB 155, the purpose of these studies is to aid in the assessment of the costs and benefits of allowing uranium mining and milling in the Commonwealth. The principle basis of that analysis is intended to be the studies which the proponents have been invited to submit, as well as all other information available to the UAG. As such, it is important to establish that the studies submitted to the UAG via the October 15 report as well as any supplemental studies at this stage, are not intended to support any licensing action, but rather are intended to achieve the specific purposes outlined in SB 155.

[1] Formerly the Metals Division of Union Carbide Corporation

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I. INTRODUCTION

A. OVERVIEW OF THE SWANSON PROJECT

The proponents of the Swanson Project, Marline Uranium Corporation and Union Carbide Corporation (Umetco) propose to develop an open pit uranium mine and ore processing facility, with associated tailings management area, in Pittsylvania County, Virginia. Specifically, the project is located six miles northeast of Chatham and will consist of approximately 1265 acres of project area.

The open pit mine will result in a nearly circular excavation approximately 2500 feet in diameter and up to 850 feet in depth. The mine is expected to produce around 30 million pounds of uranium concentrate or U_3O_8. The approximate volume of the pit will be 65 million cubic yards, resulting in a surface disturbance of 100 acres. Waste rock from mine development will be taken to a special storage area or used for tailings reclamation cover. Uranium-bearing ore removed from the mine pit will be trucked to the nearby mill for processing.

The overburden stockpiles and other disturbed areas will be regraded to stable configurations, covered with topsoil and revegetated, continuously through the 13-year operational life of the mine. During final reclamation, the pit slopes will be reduced in the upper pit wall areas, and the pit will be allowed to fill naturally with water, producing a 100-acre lake which will stabilize approximately 30 feet below the present land surface.

Metallurgical studies conducted to date indicate the ore is suitable for conventional agitation leaching. The final selection of either an acid or alkaline (carbonate) leaching method will be made upon completion of additional studies, but present indications are that a carbonate process is the most likely choice. Current plans call for a 3000 ton/day mill, which will accommodate the 13-year projected life of the mine.

The milling process will consist of ore crushing and grinding to liberate and expose the uranium bearing minerals, dissolution (or leaching) to extract the uranium and place it in solution, and a final concentration and recovery process. The final uranium product, normally a powdery substance called "yellowcake", will be packaged in steel drums and shipped for further processing into fuel for nuclear power plants.

Present indications are that the agitation leach process, whether acid or carbonate, can be designed to require a net demand of water from the mine dewatering system, thereby eliminating the need for any mill discharge to surface waters. Final process engineering will determine the exact composition and volumes of liquids and solids in the milling circuit.

Because the ore contains a small percentage of uranium, the milling process produces essentially the same weight of solid waste, or tailings, as the total input of ore to the mill. As such, the project will produce approximately 13.5 million tons of tailings over the life of the project.

Prior to placement in the management area, the tailings will be dewatered at a filtration plant located at the mill site. This plant will remove excess liquid from the tailings slurry and recycle the liquid to the mill process circuit. Trucks then will haul the moist tailings to the management area, located adjacent to the mine waste rock storage area.

A base pad of mine production waste rock will be placed over the management area, followed by a clay liner and earthen containment dike. The dewatered tailings then will be deposited in the facility and placed with conventional earthmoving equipment. Following deposition to the final thickness, a reclamation cap will be constructed over the tailings. Mine waste rock then will be placed over the reclamation cap to provide encapsulation of the tailings on all sides. The tailings management area will be engineered to meet all applicable safety and technical criteria.

The mining operation will employ 309 persons, the milling operation 144 persons, and the tailings management operation 11 persons. The Swanson Uranium Project will be designed to comply with existing regulations to ensure the safety to the public and mill employees. After the operating life of the facility, the mine, mill, and tailings management areas will be reclaimed according to applicable state and federal regulations.

B. THE PROPONENTS

Marline Uranium Corporation and Umetco are highly qualified to develop the Swanson Project, based on technical and financial considerations, and on past operating experience and practices. In addition, both companies have corporate philosophies which provide for environmental protection, public welfare, and worker health and safety in the conduct of operations.

Marline Uranium Corporation, headquartered in Danville, Virginia, is a subsidiary of Marline Oil Corporation of Houston, Texas, which is is a publically owned and traded U.S. Company with approximately 300 stockholders. Marline began uranium exploration activities in Virginia in July, 1977 as part of an exploration program extending through North America.

The late Alaster G. Swanson, for whom the project is named, was Marline's President and Chief Executive Officer at the time of the Pittsylvania County discovery. Mr. Swanson served as Director for Atomic Energy Canada, Ltd., and was instrumental in the development of the uranium industry in Canada. His leadership and foresight in minerals exploration ultimately led to the company's uranium discovery in Virginia.

Early in the evolution of the Swanson Project, Marline recognized the desirability of participation by an organization such as Umetco, which has the financial strength and industry experience required to fully develop the project. An agreement was signed between Marline and Umetco in December, 1982, whereby Umetco was designated to be the operator of a joint venture upon exercising its option to purchase the ore deposit. As operator, Umetco would assume all responsibilities for developing the project, including construction of the facilities, operation of the mine, processing of ores, reclamation and arrangements for marketing the uranium concentrate.

Umetco's parent organization, Union Carbide Corporation, is a broadly diversified international manufacturer of industrial and consumer products. It's major lines of business include commodity and speciality chemicals and plastics, industrial gases, carbons, metal, mining and milling, electronics, and a line of products sold directly to consumers. Union Carbide employs more than 103,000 persons at approximately 500 facilities in 38 countries. Approximately 130 international affiliates operate nearly 250 plants, mills, mines, and smelters.

Umetco mines uranium in 25 underground and open-pit mines in Colorado, Utah, and Wyoming and its uranium mills are located at Uravan, Colorado; Blanding, Utah; and Gas Hills, Wyoming. The company has extensive knowledge and experience in radiation protection, waste disposal, and management of mill tailings. Umetco strives not only to meet but to exceed all local, state, and federal environmental standards. The company has invested over $14,000,000 in pollution abatement equipment, and operates this equipment at an annual cost of $4,000,000.

C. PROPONENT'S OUTSIDE CONSULTANTS

Numerous consulting entities, both individuals and companies, assisted Marline and Umetco in the development and conduct of studies which formed the basis for several special reports filed with or presented to state agencies and committees, and also which culminated in the October 15, 1983 report submitted to the Uranium Administrative Group. Some of the studies were contracted directly with either Marline or Umetco, but the bulk of the work directly related to the preparation of the October 15 report was assigned to Dravo Engineers, Inc. of Denver, Colorado, who subcontracted a number of the specialized studies. In addition, Dravo provided overall project management and engineering services. Gibbs and Hill, Inc., also of Denver, provided the bulk of the environmental and radiological baseline studies, utilizing the services of Western Resource Development Corporation for ecological studies and Noel Savignac for radiological studies. Dravo subcontracted to Chen and Associates for geotechnical and soils investigations, Envirologic Systems for ground water hydrology and mine water treatability studies, and to Roman Pyrih and Associates for geochemistry.

The above consultants were chosen because of their knowledge of local physical characteristics or their expertise in certain specialized aspects, such as radiation effects. Also, they have considerable technical experience, along with credible professional reputations, in performing similar studies in previous uranium projects.

For a detailed presentation of the qualifications of the proponents and their consultants, refer to Volume 8, Appendix XIV in the October 15, 1983 report.

D. PURPOSE AND CONTEXT OF THE MAIN REPORT

The October 15, 1983 report consisted of nine volumes, and was designed to be responsive to the requirements of Virginia Senate Bill 155. That report was quite voluminous in representing information supplied by Marline and Umetco, as well as results of numerous studies conducted during 1983 by outside consultants. The purpose of the present "Technical Summary" document is to condense information contained in the nine-volume report, both for those readers who desire or require only an overview of the project and related technical issues, and also for those readers who do not have ready access to the nine-volume report. It is to be emphasized, however, that an examination of the nine-volume report is required to develop an appreciation for the magnitude of the effort which went into its preparation, and also to gain access to details required for a thorough analysis of issues and subjects.

The nine-volume report, in responding to Senate Bill 155, cannot be interpreted as a licensing type document. For licensing purposes, certain studies will have to be performed over longer periods of time and in more detail than was required for SB 155 purposes. However, Marline/Umetco firmly believe the October 15 report represents an extremely thorough analysis of planned uranium development activities in Pittsylvania County, to the extent required by SB 155. The companies furthermore believe the Commonwealth of Virginia can proceed toward enacting enabling legislation and subsequent development of a regulatory framework so that licensing activities can commence.

E. APPROACH TO THE SUMMARY

This summary does not follow the format of SB 155, as does the nine-volume report submitted to the UAG on October 15. Numerous questions and clarifications were necessary to fully understand the information submitted in that report, and many subsequent questions were raised by the state's consultants and interested citizens. To clarify certain critical issues, it was decided a more topical approach would be in order, thereby eliminating possible confusion of subjects and redundancies as found in the October 15 submittal.

Basically, this summary proceeds with a description of the project, which highlights mining, milling, and tailings management activities, as well as certain critical issues pertaining to the project water balance, monitoring programs, reclamation, worker health and safety, and manpower requirements.

Next, the site is discussed with respect to its overall suitability and descriptions of various aspects of the existing environment. A discussion of impacts follows, detailing radiological and non-radiological effects on air, water and ecological components; also discussed under this topic are issues pertaining to socioeconomics, cultural resources, traffic patterns, and effects of various types of accidents.

The summary also considers certain alternatives to the chosen actions, including such issues as the site, the milling process, and mining methods. Consistent with the main purpose of SB 155, the cost-benefit aspects of the project are addressed with respect to employment, economics, quality of life, and risks to public health and safety.

The summary is accompanied by several figures and tables to elucidate certain key areas discussed or described. However, it is emphasized that the main report contains numerous figures and tables which could not be included here due to space limitations. For those readers interested in data-level specifics regarding the various areas of investigation, it is imperative that the main report and its appendices be consulted. To assist the reader in this regard, extensive cross-referencing to the main report occurs within this summary.

During the Uranium Task Force efforts of early 1984, it was agreed that Marline/Umetco would provide technical clarifications and updates on the specific topics of water balance, clay volumes, geochemistry, seismicity, tailings design and implementation, radiological assessments and mine water impacts. These evaluations are appended to this report as a series of Technical Memoranda and are referred to throughout the text. In addition, updated and clarified information on the project water balance and waterborne radiological impacts appears in the text itself.

To allow an appreciation for the breadth of coverage and level of detail contained in the main report, its Table of Contents is included for reference at the end of this summary. The entire report can be found in the offices of numerous state agencies, as well as area universities, colleges, schools, and libraries. The report also can be examined in the Marline offices in Danville and Richmond.

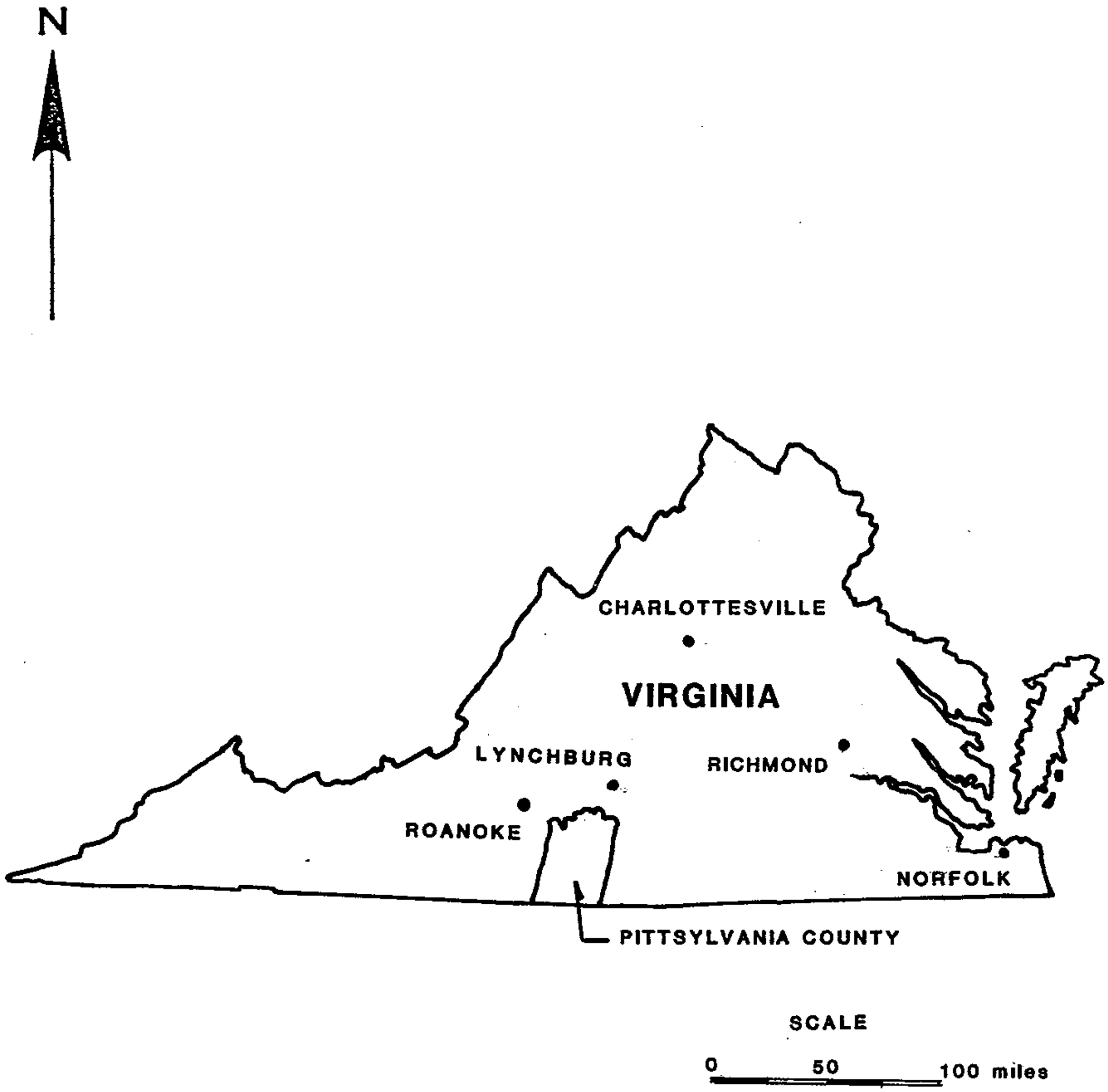
II. PROJECT DESCRIPTION

A. GENERAL DESCRIPTION AND PROJECT LOCATION

The Swanson Uranium Project will consist of a 3000-ton per day mill, an open pit mine, mine overburden storage areas, a uranium tailings management area, and appurtenant surface facilities. The project site is located in the Piedmont province of south-central Virginia within Pittsylvania County, approximately 20 miles north of Danville (Figures II-1 and II-2).

The ore deposit is adjacent to State Road 690, south of Cole's Hill (Figure II-3). The nearest town is Chatham, the county seat, which has a population of 1390 (1980) and is 6 miles southwest of the deposit. The next largest nearby community is Gretna, located 6.5 miles northwest of the Swanson Project area. The agricultural economy is based largely on tobacco, but includes beef cattle production and associated crops such as corn, wheat, and soybeans. Approximately half of the area has been cleared for agricultural purposes and homesites, with the remaining land in forest.

The general topography of the area is shown on Figure II-3, and is characterized by the rolling terrain typical of the Piedmont province. The mean elevation at the ore deposit is approximately 600 feet above sea level, with local relief of less than 150 feet. The area is drained by Mill and Whitethorn Creeks. Mill Creek enters Whitethorn 1.4 miles east of the deposit. Whitethorn Creek, which is joined by Georges Creek, flows two miles eastward to the Banister River, which is the major drainage feature of the area. The Banister then flows in

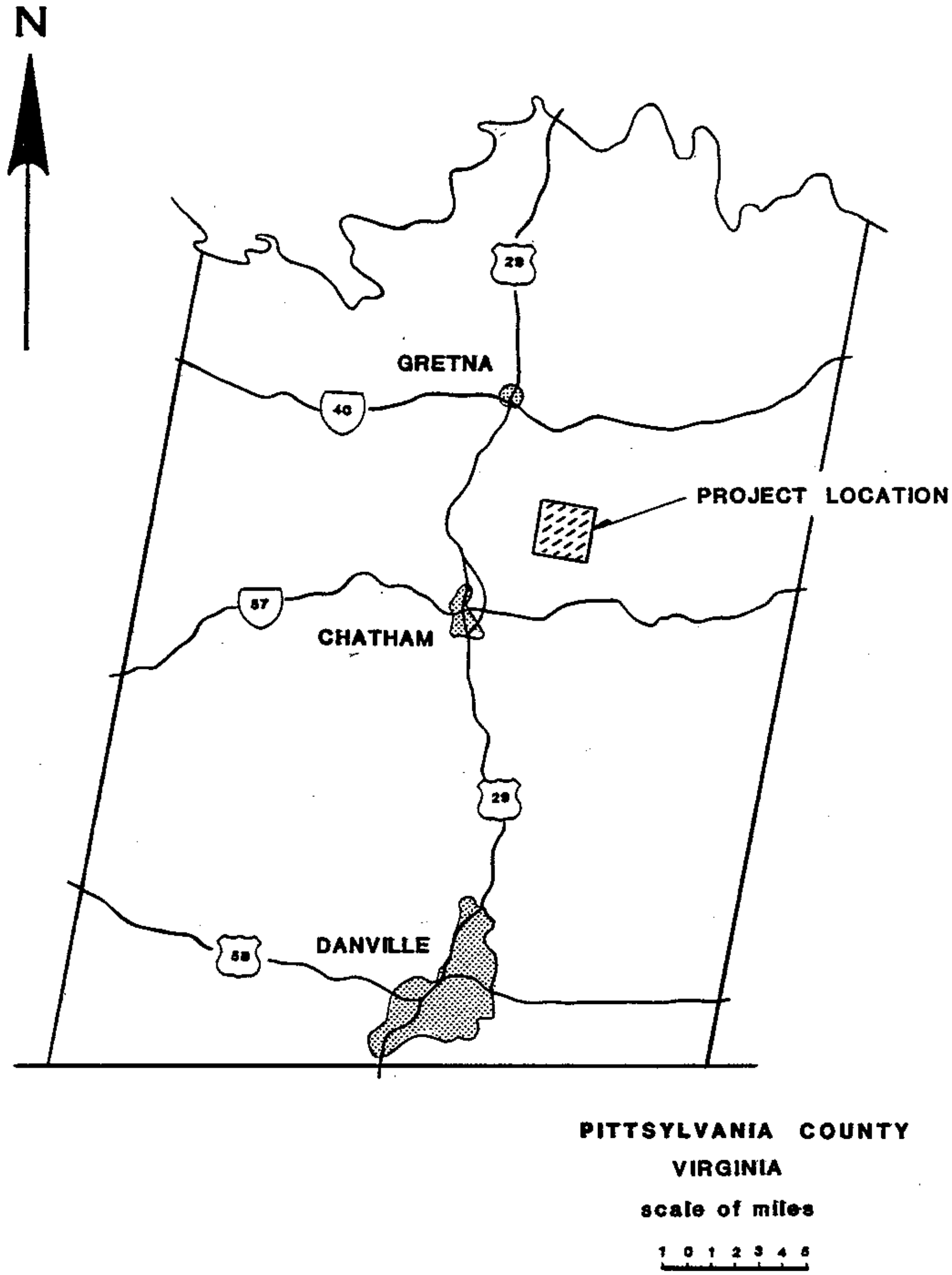


MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA

PROJECT REGION MAP
SWANSON URANIUM PROJECT

Dravo OCT/83

FIGURE II-1



MARLINE URANIUM CORPORATION

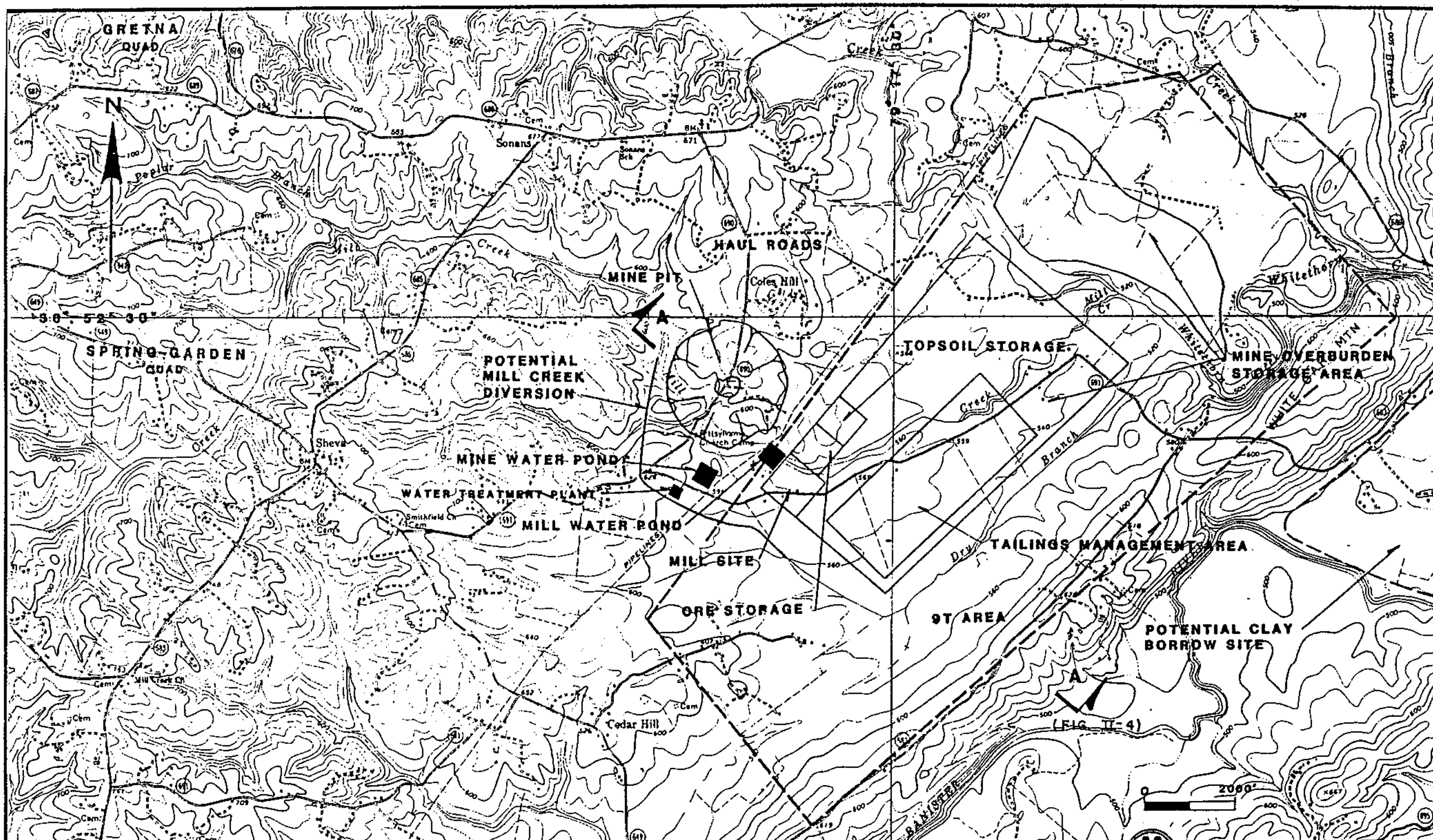
PITTSYLVANIA COUNTY, VIRGINIA

PROJECT LOCATION MAP

SWANSON URANIUM PROJECT

Dravo OCT/83

FIGURE II-2



MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA

SITE MAP

SWANSON URANIUM PROJECT

Dravo revised AUG/84

FIGURE II-3

a northeasterly direction before turning southeast and eventually discharging into the Kerr Reservoir in adjacent Halifax County.

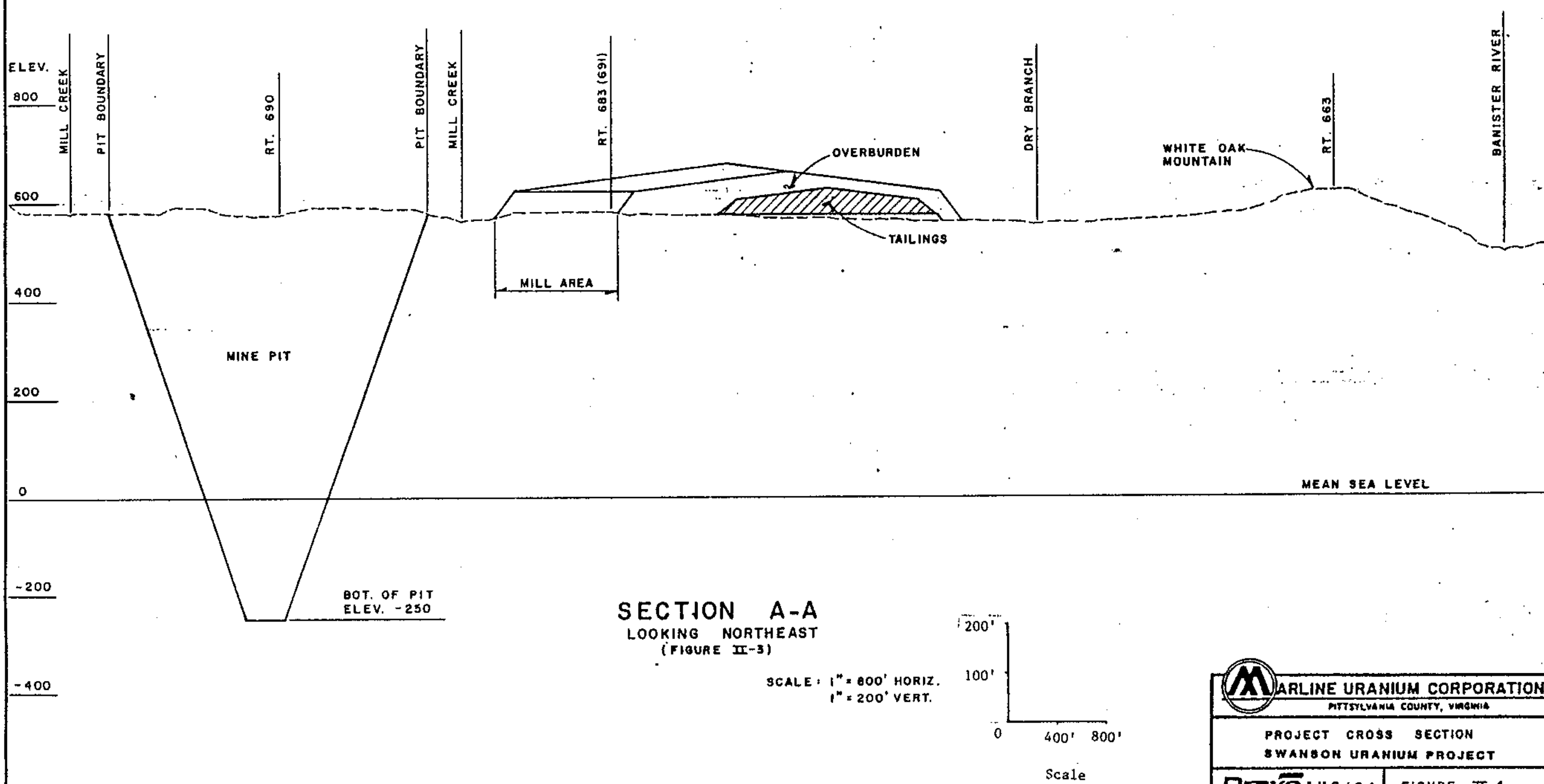
The following sections describe the various components that make up the Swanson Uranium Project.

B. MINING

1. Mining Method and Size

Based on studies conducted to date, the mine will employ the open pit method. This mining technique will utilize trucks and shovels to remove overburden, waste rock, and ore from the pit, resulting in an ore production rate of 4200 tons per day for a 250-day production year. The ore will be processed in the mill at the rate of 3000 tons per day for a 350-day production year. Upon completion of the 13-year mining process, the nearly circular excavation will be 2500 feet in diameter at the surface, 110 acres in area, and 850 feet deep at its maximum extent, and will yield 30 million pounds of uranium oxide (U_3O_8).

The approximate volume of the preliminary pit design is 65 million cubic yards. Figure II-3 shows the location of the mine pit in relation to local topography, and Figures II-4 and II-5 provide sectional views of the open pit in relation to the overall project site and local geology, respectively. Refer also to Volume 2, Section E.1 of the October 15, 1983 report, for a detailed discussion of the open pit mine. The following sections summarize that original information.



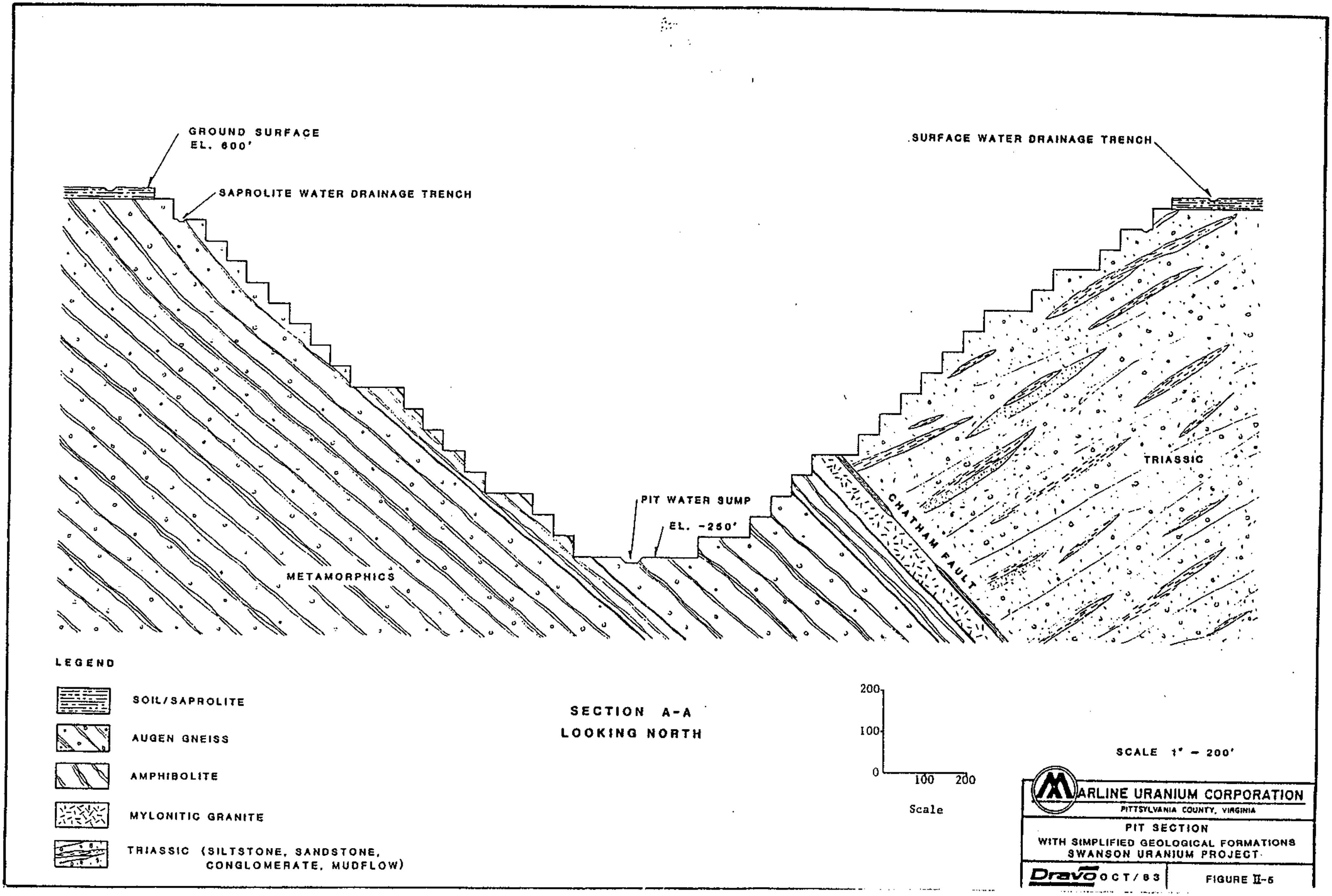
SECTION A-A
LOOKING NORTHEAST
(FIGURE II-3)

SCALE: 1" = 800' HORIZ.
1" = 200' VERT.

MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA

PROJECT CROSS SECTION
SWANSON URANIUM PROJECT

Dravo AUG/84 | FIGURE II-4


GROUND SURFACE
EL. 600'
SAPROLITE WATER DRAINAGE TRENCH
SURFACE WATER DRAINAGE TRENCH
TRIASSIC
CHATHAM FAULT
PIT WATER SUMP
EL. -250'
METAMORPHICS
LEGEND
SOIL/SAPROLITE
AUGEN GNEISS
AMPHIBOLITE
MYLONITIC GRANITE
TRIASSIC (SILTSTONE, SANDSTONE, CONGLOMERATE, MUDFLOW)
SECTION A-A
LOOKING NORTH
200
100
0
100
200
Scale
SCALE 1" = 200'
MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA
PIT SECTION
WITH SIMPLIFIED GEOLOGICAL FORMATIONS
SWANSON URANIUM PROJECT
Dravo OCT/83
FIGURE II-5

2. Geologic Description of Mine Site

The orebody is in the Piedmont geological province, an area underlain chiefly by Precambrian and Paleozoic igneous and metamorphic rocks. Within the Piedmont are Triassic age sedimentary rocks that were deposited in several basins. One of these, the Danville Triassic basin, is a narrow, elongated structural trough that extends from north-central North Carolina northeastward through Pittsylvania County, Virginia. The basin is approximately 110 miles long and ranges from 2 to 9 miles in width.

The Danville Basin is bounded on the northwest by the Chatham fault zone, which is a 40° to 70° southeast-dipping fault, and in places, a system of faults. The maximum depth of the Triassic basin near the Chatham fault zone has not been determined; however, it is probably greater than several thousand feet.

The Chatham fault zone's average strike of N25°E to N35°E is parallel to the long axis of the basin and the strike of the Triassic strata within it. The fault has apparently been subjected to repeated movement over geologic time, although geologic field relationships indicate that major movement has not occurred during the last 163 million years.

The Triassic sedimentary rocks in the basin are well-cemented, low permeability red, reddish-gray, gray, and black deposits consisting of interbedded conglomerates, sandstones, mudstones, and shales. These beds dip approximately 30° toward the northwest at the orebody location.

The crystalline terrain typical of the Piedmont lies to the northwest and is separated from the Danville Triassic Basin by the Chatham fault zone. The Swanson deposit lies within the sheared Precambrian gneissic and granitic rocks adjacent to and beneath the steeply dipping Chatham fault.

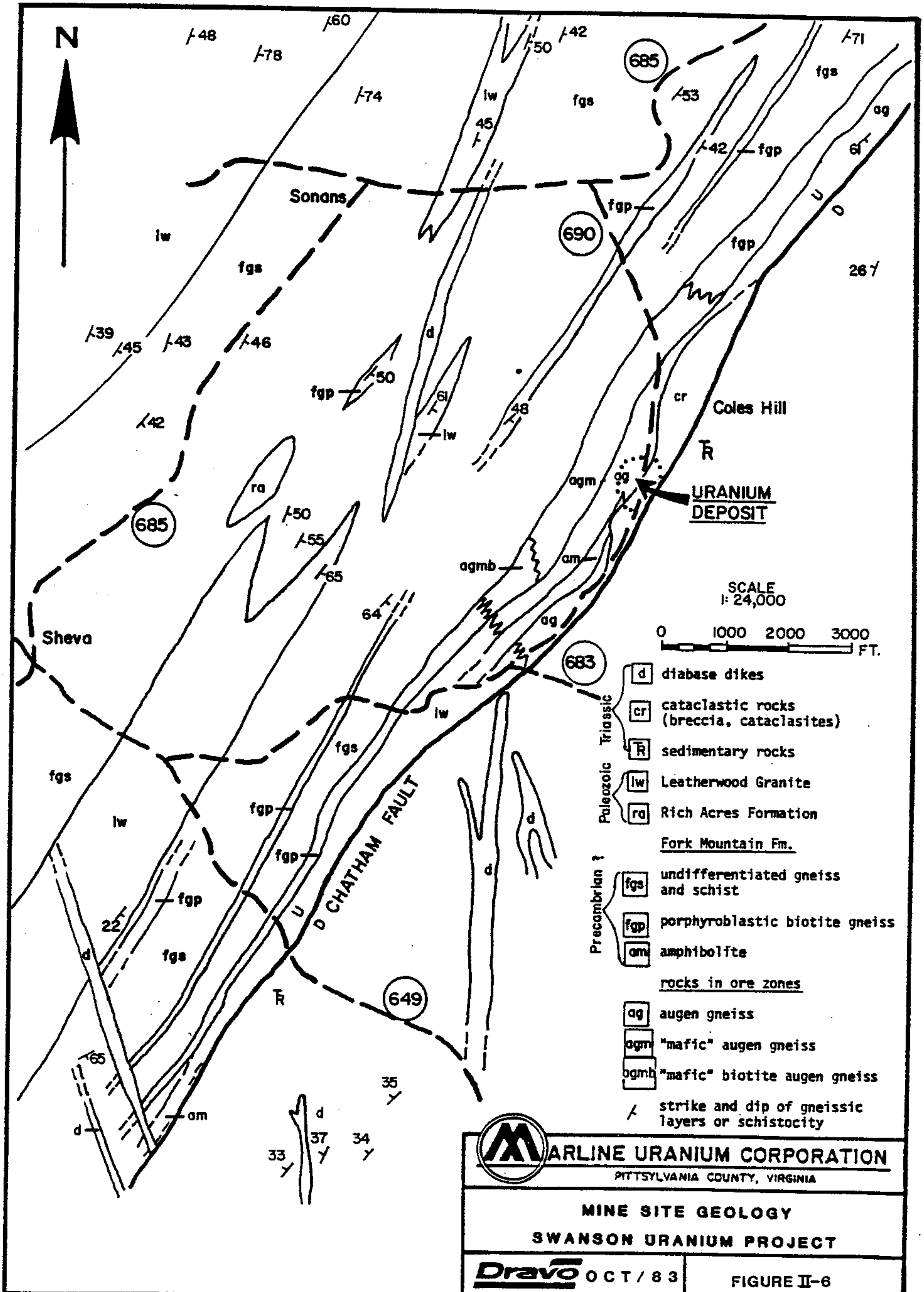
The surficial deposits covering bedrock in the mine area consist primarily of (1) relatively deep saprolite in the crystalline terrain, (2) relatively thin residual soils in the Triassic basin, and (3) alluvium along the valleys of the principal tributaries. Soil development has altered the surficial deposits to varying degrees near the ground surface. Saprolite is a highly weathered rock which still retains its original rock structure but has been altered to the consistency of a soil. The saprolite gradually changes with depth into weathered rock which then turns into unweathered rock. Saprolite depths range to 30 feet near the mine site.

In the Triassic basin, only thin residual soils cover the sedimentary rock, and rock outcrops are more prevalent in this area than they are in the crystalline terrain. Drilling has indicated the residual soils near the fault average about 20 feet thick; the residual soils encountered further to the southeast of the fault zone average about three feet thick.

Site geology is summarized in Figure II-6, which was prepared using information from outcrops, drill holes, and ground magnetometer surveys. Figure II-5, an east-west cross section through the proposed pit looking to the north, indicates the relationship between the fault, the Triassic Basin to the east and the metamorphic rocks of the crystalline terrain to the west. As shown on the cross section, the Chatham fault zone dips approximately 45° through the pit and exits the pit approximately 650 feet below the original ground surface.

3. Mine Development

The proposed ore production rate of 4200 tons per day for a 250-day production year will result in 1,050,000 tons per year. To achieve this production, it is estimated an average 8,400,000 tons (3,889,000 cubic yards) of rock will be removed annually. The schedule of mining operations for ore and waste rock is currently estimated at:


N
Sonans
Sheva
Coles Hill
URANIUM DEPOSIT
CHATHAM FAULT
685
690
683
649
SCALE
1: 24,000
0 1000 2000 3000 FT.
Triassic
d diabase dikes
cr cataclastic rocks (breccia, cataclasites)
TR sedimentary rocks
Paleozoic
lw Leatherwood Granite
ra Rich Acres Formation
Fork Mountain Fm.
Precambrian ?
fgs undifferentiated gneiss and schist
fgp porphyroblastic biotite gneiss
am amphibolite
rocks in ore zones
ag augen gneiss
agm "mafic" augen gneiss
agmb "mafic" biotite augen gneiss
strike and dip of gneissic layers or schistocity
MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA
MINE SITE GEOLOGY
SWANSON URANIUM PROJECT
Dravo OCT/83
FIGURE II-6

- Ore extraction: 2 shifts per day, 5 days per week.
- Rock removal: 3 shifts per day, 7 days per week.

Mine development is based on the following design criteria:

- Pit wall angle	45°
- Bench height in overburden	40 ft
- Bench height in ore and associated waste	20 ft
- Pit road width (including ditch, road, and berm)	85 ft
- Pit road maximum grade	8%
- Average surface elevation	600 ft
- Area of pit at surface	110 acres
- Maximum depth of pit	850 ft

After permit authorization for the mine has been obtained, but prior to actual ore production from the Swanson mine, the following preproduction activities will take place:

- Building of access roads.
- Installation of utilities for mine service.
- Construction of office building, change house, warehouse, maintenance shop and other ancillary facilities.
- Construction of substation and power lines for supply and distribution of electrical power.
- Procuring major mine construction and operational equipment.
- Locating and marking the pit perimeter.
- Removal and stockpiling of topsoil from the pit area, waste rock storage areas, and other areas of construction.
- Construction of sedimentation control ponds.

- Construction of main haul roads.
- Relocation of State Roads 690 and 683.
- Relocation of Mill Creek. The preliminary route of this diversion is indicated on Figure II-3. Additional engineering studies may modify this location. The economics of other diversion routes will be weighed against the advantages of protecting the pit and tailings areas from flood flows.
- Relocation of gas pipelines. Located 200 feet from the currently projected pit limit are high pressure natural gas lines owned by the Transcontinental Gas Pipeline Corporation (TRANSCO). Special operating techniques such as controlled blasting will be employed to protect the gas lines. In the event final mine plan studies produce a mine design that will impact the gas lines, the lines will be relocated with the full cooperation of TRANSCO.
- Initial benching and removal of the required overburden to expose sufficient ore to maintain a regular production rate thereafter.

Upon completion of the preproduction phase, the following production activities will take place:

- Drilling and blasting will be necessary to remove both the overburden and the ore. It is estimated that over 18,000 holes per year will be drilled for overburden, and 2900 holes per year for the ore itself. A mixture of ammonium nitrate and fuel oil (ANFO) will be used as a blasting agent, resulting in approximately 2030 tons per year of ANFO consumption. This is equivalent to two truckloads of ammonium nitrate delivered to the mine per week. Overburden removal operations will be conducted by two electric shovels (10 to 12 cubic yard buckets) loading the shot rock into a fleet of eleven 85-ton end dump trucks for transport to the overburden storage areas.
- Blasted ore will be excavated by two 3 to 5 cubic yard hydraulic power shovels loading into five 35-ton end dump trucks for transport to the mill.

- Waste rock will be transported by the 85-ton rear dump trucks over a system of mine haul roads to the overburden storage areas. These roads generally will be 85 feet wide, and also will carry the traffic of loaded ore haulage trucks to the mill. The roads will be constructed of naturally occurring local materials and will be watered to provide dust suppression as necessary.

Table II-1 provides a summary of the major mining equipment anticipated at the Swanson Uranium Project.

Current assumptions indicate that up to 1265 acres over and near the orebody will be required as follows:

- Mine pit and surrounding affected area 135 acres
- Overburden and waste storage, including topsoil 930 acres storage and tailings management facility
- Appurtenant facilities (mill, ore stockpile 200 acres haul roads, and other construction)

These acreages are estimates based on mining experience and current knowledge of the project.

4. Ore and Waste Rock Characteristics

a. <u>Ore Characteristics</u>

A substantial amount of test work has been performed on the Swanson ores. Composite samples representative of the entire orebody were made by combining drill core samples taken from various locations and depths within the orebody. The composite samples were subjected to mineralogical and chemical analyses and hardness testing.

These studies indicated that the host rocks contain the following minerals associated with the ore: plagioclase (about 70 percent), chlorite (11 percent), quartz (9 percent), calcite (3 percent), apatite (3 percent), and minor to trace amounts of sphene, amphibole, microcline, biotite, anatase, zircon, pyrite, barite, galena, zeolites, hematite, chalcopyrite, and zunyite. Results of chemical and x-ray fluorescence analyses of the composite are shown on Tables II-2 and II-3. The ranges in numerical value of various elements are due to different analytical techniques employed by the laboratories and differences in sample compositing and selection.

These analyses show that the Swanson ore does not contain high concentrations of heavy metals typical of uranium ores of the western United States. In addition, in 1984 a representative suite of ore samples were composited with oversight by the Virginia Division of Mineral Resources which indicated a close comparison with previous analyses.The reported Bond Work Index (BWI) of 13 indicates an ore of moderate hardness similar to porphyry copper ores, but much harder than the uranium-bearing sandstone ores of the southwest, which typically have a BWI of about 5.

b. Waste Rock Characteristics

The waste rock generated by the mining of the Swanson uranium ore will be one of three types of materials:

(1) Triassic rock - the sedimentary rocks east of the Chatham fault that are barren, i.e., contain no significant uranium mineralization; total tonnage equals 48.6 million tons.

(2) Barren Precambrian rock.

(3) Mineralized Precambrian rock - material that may have up to 0.05 percent U_3O_8. When combined with the rest of the Precambrian rock, the total tonnage of Precambrian material is 67.7 million tons at an average grade of 0.01 percent U_3O_8.

Subsequent to the submittal of the October 15 report to the UAG, additional analyses of the ore and associated waste rock from the

TABLE II-2

CHEMICAL ANALYSIS OF SWANSON PROJECT
COMPOSITE ORE SAMPLE

BASED ON STUDIES BY COLORADO SCHOOL OF MINES RESEARCH INSTITUTE (1982)

CONSTITUENT	ANALYTICAL RESULTS %	PPM
U_3O_8	0.104	1040
Al	8.4	84,000
Fe	2.6	26,000
Mg	0.72	7,200
Ca	2.8	28,000
CO_2	1.0	10,000
F	0.14	1,400
S(Total)	0.05	500
SO_4	0.1	1,000
PO_4	2.3	23,000
Mo	0.0004	4
As	0.001	10
B	0.002	20
V	0.0105	105
Zr	0.0200	200
Th	0.0050	50

BASED ON STUDIES BY UMETCO (1983) [(1)]

CONSTITUENT	%	PPM
U_3O_8	.095	950
Al_2O_3	16.5	165,000
Fe_2O_3	4.35	43,500
MgO	1.35	13,500
CaO	4.21	42,100
CO_2	3.19	31,900
F	0.14	1,400

(TABLE II-2, Continued)

CONSTITUENT	ANALYLITICAL RESULTS %	PPM
S	0.04	400
P_2O_5	1.85	18,000
Mo	.002	20
As	.00022	2.2
B	.001	10
V	.0102	102
Zr	.0065	65
Th	.0017	17 (2)
TiO_2	.587	5,870
MnO	.0682	682
Na_2O	8.04	80,000
K_2O	.73	7,300
SiO_2	60.2	602,000
Be	.000197	1.97
Cd	.0001	1
Cr	.0039	39
Co	.0015	15
Cu	.00971	97.1
Ni	.0008	8
Ba	.0733	733
Sn	.0003	3
Sr	.0427	427
Zn	.0030	30
Ag	.0005	5

(1) Analyses performed by Barringer Magenta Corp. Composite sample same as CSMRI except:

a. Some samples were used by CSMRI and thus were not available to Barringer;

b. CSMRI did not use samples weighing less than one pound, while Barringer did.

(2) Confirmed by Umetco x-ray fluorescence at 16 ppm.

TABLE II-3

FLUORESCENT X-RAY SPECTROGRAPHIC ANALYSIS
SWANSON URANIUM ORE[1]

ELEMENT	%	ELEMENT	%
Copper	0.012	Zirconium	0.046
Silver		Hafnium	
Gold		Thorium	
Zinc	0.023	Vanadium	
Cadmium		Columbium	
Mercury		Tantalum	
Gallium		Chromium	
Indium		Molybdenum	0.010
Thallium		Tungsten	
Germanium		Uranium	0.25
Tin	0.003	Manganese	0.029
Lead	0.025	Lanthanum	
Arsenic		Cerium	
Antimony		Praseodymium	
Bismuth		Neodymium	
Selenium		Samarium	
Tellurium		Europium	
Bromine		Gadolinium	
Iodine		Terbium	
Iron	1.9	Dysprosium	
Colbalt		Holmium	
Nickel		Erbium	
Cesium		Thulium	
Rubidium		Ytterbium	
Barium	0.11	Lutetium	
Strontium	0.073	Yttrium	0.002
Titanium			

(1) Source: Hazen Research, Inc. (1981)

Note: Elements left blank were not found in the analyses.

proposed mine pit were conducted by the State of Virginia and Marline (May 1984). The results of these analyses may be found in Technical Memorandum No. 9 attached to this report.

5. Mine Waste Rock Handling

One of the unique features of the Swanson Uranium Project is the final geometry of the mine waste rock storage piles in relation to the mill tailings management area. The present concept calls for encapsulating the tailings pile with mine waste to provide long-term stability of the tailings mass and to minimize total project land disturbance. This feature of the project will be developed in further detail subsequent to final mine and tailings engineering studies. However, the concept as presented in the October 15 submittal has the following features:

- All mineralized Precambrian waste rock (averaging 0.01 percent U_3O_8), will be covered by the barren Triassic sedimentary overburden. The average final depth of stockpiled Triassic overburden over the total available overburden storage area of 930 acres is more than 20 feet. In this configuration, mineralized rock will not be exposed after being covered by Triassic material. However, radiological dose calculations in the October 15 report assumed 10 percent (90 acres) of the mineralized waste exposed at any time during the operations prior to final reclamation.

- The average depth of Precambrian waste rock over the 930 acres overburden storage area ranges from 40 feet over the mill tailings area to 80 feet over those areas not containing tailings.

- The total height of stored materials in the overburden storage areas, including the 200-acre tailings management area, is approximately 100 feet. Refer to Figures II-4 and II-10 for a cross sectional view of the overburden storage and tailings management areas.

The above described configuration of mine overburden will necessarily require some intermediate temporary stockpiling of various materials to arrive at the final cross section. The size and location of these stockpiles have not yet been determined, and are dependent upon the relative timing of the removal of the different materials from the pit. Current information indicates that sufficient area exists to stage the placement of the mine overburden and arrive at the conceptually described configuration. Final mine plan engineering will be coordinated with tailings management design to determine the material handling details. However, final design cannot proceed in the absence of enabling legislation to develop a regulatory program for licensing.

C. MILLING

1. General Facility Description

Testwork conducted to date on actual Swanson uranium ore has indicated that the ore is suitable for agitation leaching, which is a hydro-metallurgical technique used to extract and recover the uranium mineral from the parent ore. Agitation leaching was chosen for the Swanson ores primarily because the fine nature of the uranium dispersed in the ore requires grinding to allow access by leaching agents to the disseminated minerals.

The two basic types of leaching solutions used in agitation leaching, acid and carbonate, have been tested under laboratory conditions. Results have shown that uranium recoveries greater than 90 percent may be obtained through the acid leaching process, while recoveries between 80 and 90 percent result from carbonate leaching.

Several factors enter into the selection of one process over another, foremost which are environmental and economic considerations. Marline and Umetco are favoring the carbonate leach process over the acid leach, based on laboratory tests conducted to date. The following summary focuses on the carbonate process, while characteristics of the acid process are addressed in Section V, Alternatives. Refer also to

Volume 2, Section E.2 of the October 15 report for an in-depth discussion of both process alternatives.

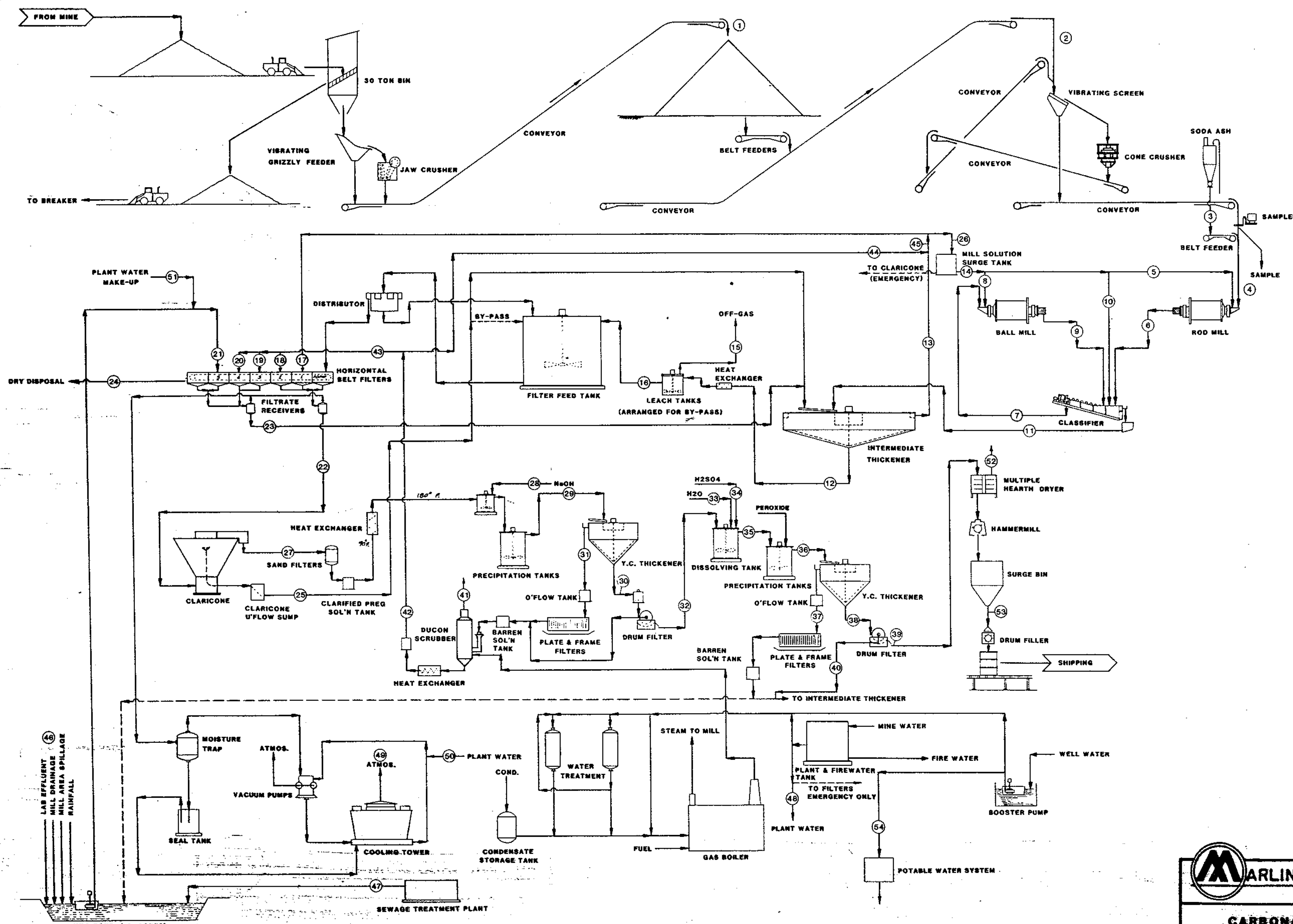
2. Carbonate Leach Process Description

The following discussion references the preliminary carbonate process flowsheet, Figure II-7. Table II-4 provides the associated material balance quantities and Figure II-8 shows a typical site plan for an agitation leach mill. The detailed site plan of the Swanson Project mill will be prepared following final process engineering.

It should be noted that revisions to the project water balance discussed in Section E of this document are not reflected in Figure II-7 and Table II-4, the carbonate process flow sheet. Project water balance adjustments would modify the waterflows in streams 46 and 51, per details found in Section E.

Broken ore is transported from the mine to the mill site by trucks and dumped onto a stockpile. Ore is then removed to a 30-ton bin by a frontend loader. The 30-ton bin is equipped with a heavy screen (called a "grizzly") made of rails with openings of about 36 inches square. The front-end loader dumps broken ore onto the grizzly and removes any rock that does not pass the screen. This oversize rock is first stockpiled, then later fed to a rock breaker and returned to the bin. The bin undersize (rock which passes through the grizzly) then moves over a second vibrating grizzly which sizes the ore at six inches. Rock larger than six inches in diameter is delivered to a jaw crusher where it is crushed to less than six inches and passes through the second grizzly, and is deposited on the same conveyor. The conveyor deposits the six-inch ore on a coarse ore stockpile.

Ore is withdrawn from the coarse stockpile at the rate of 125 tons per hours (3000 tons per day) by a belt feeder and is deposited on a conveyor, which transports the material to second-stage crushing (line



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PITTSYLVANIA COUNTY, VIRGINIA

CARBONATE PROCESS FLOWSHEET
SWANSON URANIUM PROJECT

Dravo OCT/83

FIGURE II-7

Table II-4

MARLINE
SWANSON PROJECT
MATERIAL BALANCE
Carbonate Leach Circuit

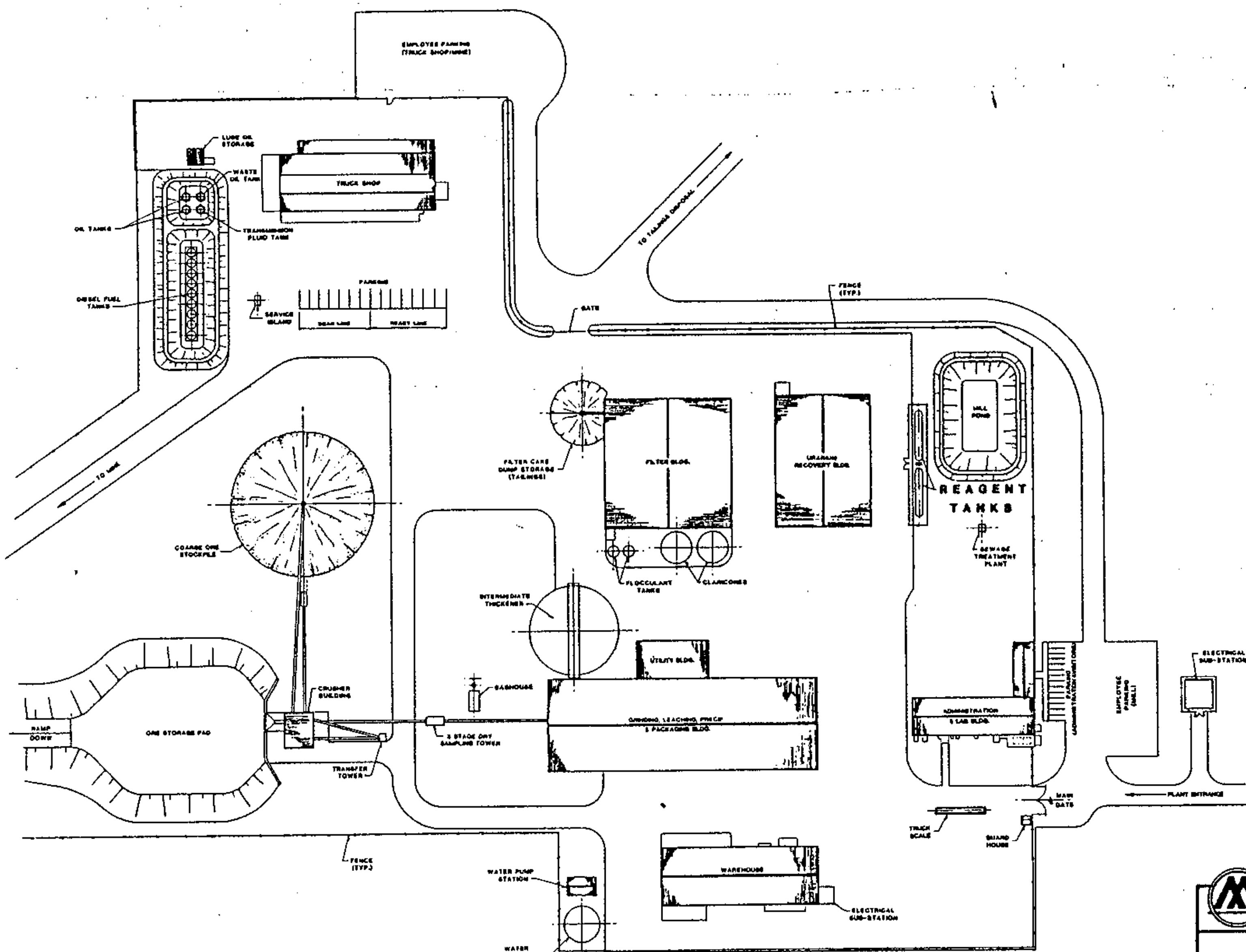
STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TPH SOLIDS	215	125	0.625	125.6	—	125.6	416.7	—	416.7	—	125.0	125.0	—	—	—	125
TPH LIQUIDS	23.8	13.8	—	13.8	53.5	67.3	139.1	86.6	224.4	221.5	375.0	125.0	375.1	381.3	0.3	116.7
WT. % SOLIDS	90.0	90.0	100	90.1	—	65.1	75.0	—	65.0	—	25.0	50.0	—	—	—	51.7
S.G. SLURRY	2.252	2.252	—	2.254	—	1.712	1.896	—	1.710	—	1.203	1.404	—	1.15	1.00	1.507
GPM SLURRY	—	—	—	—	—	429.7	1132.5	—	1432.3	—	1437.5	629.2	—	—	—	596.2
GPM LIQUID	82.6	47.9	—	47.9	188.8	233.8	479.7	299.8	779.5	789.2	1302.8	434.2	1300.6	1254.8	33.0	401.2
lbs/hr U3O8	—	288.0	—	—	—	—	—	—	—	—	325.7	93.4	279.6	—	—	283.9
g/l U3O8	—	—	—	—	—	—	—	—	—	—	0.50	0.43	0.43	—	—	1.415

STREAM NO.	17	18	19	20	21 **	22	23	24	25	26	27	28	29	30	31	32
TPH SOLIDS	—	—	—	—	—	—	—	125.0	.014	—	—	—	0.12	0.12	—	0.12
TPH LIQUIDS	41.7	41.7	41.7	41.7	36.08	157.0	125.1	36.7	0.13	300.6	157.0	3.1	160.1	0.28	159.82	0.12
WT. % SOLIDS	—	—	—	—	—	—	—	75.0	9.7	—	—	—	0.07	30.0	—	50.0
S.G. SLURRY	1.15	1.15	1.15	1.15	1.00	1.15	1.15	1.835	1.084	—	1.15	1.25	1.151	1.359	1.15	1.749
GPM SLURRY	—	—	—	—	—	—	—	339.9	0.53	—	—	—	565.7	1.06	—	0.51
GPM LIQUID	144.0	144.0	144.0	144.0	144.0	546.2	432.0	144.0	0.51	1250.6	544.7	10.0	565.7	0.97	564.14	0.41
lbs/hr U3O8	28.8	—	—	—	—	312.7	46.0	13.2	0.29	282.2	312.4	—	312.4	251.9	50.5	251.9
g/l U3O8	0.41	—	—	—	—	1.147	0.213	—	1.147	0.41	1.147	—	0.20	0.20	0.183	—

STREAM NO.	33	34	35	36	37	38	39	40	41	42	43	44	45	46 *	47 *	48
TPH SOLIDS	—	—	—	0.12	—	0.12	0.12	—	—	—	—	—	—	—	—	—
TPH LIQUIDS	0.28	0.25	0.56	0.44	0.16	0.28	0.12	0.16	7.51	152.3	125.1	27.2	402.3	0.1	0.2	33.0
WT. % SOLIDS	—	—	—	21.4	—	30.0	50.0	—	—	—	—	—	—	—	—	—
S.G. SLURRY	—	—	—	1.236	—	1.359	1.749	—	—	—	—	—	—	—	—	—
GPM SLURRY	—	—	—	2.13	—	1.21	0.51	—	—	—	—	—	—	—	—	—
GPM LIQUID	1.12	0.5	2.13	1.94	0.77	1.12	0.41	0.70	30.0	534.1	432.0	102.1	1402.8	32.3	0.7	131.7
lbs/hr U3O8	—	—	251.8	251.8	—	251.8	251.8	—	—	50.6	40.2	10.4	290.0	—	—	—
g/l U3O8	—	—	—	—	—	—	—	—	—	0.204	0.20	0.204	0.41	—	—	—

STREAM NO.	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
TPH SOLIDS	—	—	—	—	0.126	—										
TPH LIQUIDS	4.0	4.0	27.1	0.12	—	0.2										
WT. % SOLIDS	—	—	—	—	—	—										
S.G. SLURRY	—	—	—	—	—	—										
GPM SLURRY	—	—	—	—	—	—										
GPM LIQUID	20.0	20.0	108.4	0.41	—	0.7										
lbs/hr U3O8	—	—	—	—	251.8	—										
g/l U3O8	—	—	—	—	—	—										

* 365 Day Year
** 350 Day Operating Year



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TYPICAL MILL SITE
SWANSON URANIUM PROJECT

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FIGURE II-8

2 in Figure II-7). Again the ore is fed to a vibrating screen, this one with openings of 1/2 inch. The oversize material is passed through a cone crusher for a size reduction to 1/2 inch and is returned to the screen by conveyor belts. Undersize (rock which passes through the screen) is transported to a rod mill by conveyor belt. On the way, the ore passes through a sampler which obtains a portion for analysis and mill control.

At the rod mill, soda ash (sodium carbonate) is added (line 3) to the ore. As the primary leaching agent in this circuit, soda ash is partially consumed in the leach process, so more must be added to replace the loss. Mill solution also is added (line 5) at this point to give a slurry (mix of water and ore) (line 4) which contains about 60 percent solids. This slurry is fed into the rod mill, which reduces the solids size from 1/2 inch to about 20 mesh ("mesh" refers to the number of openings per square inch of the screen), and then passes into the classifier (line 6).

Coarse particles (larger than about 50 mesh) settle to the bottom of the tank and are transported to the upper discharge end of the classifier by a screw mechanism. Fine solids are suspended by the water flow, and overflow the lower end of the tank to the next step in the process. More mill solution (line 10) is added to the classifier to assist in washing the fine particles away from the coarser particles. The coarse particles (called classifier sands) are discharged into the ball mill (line 7), along with more mill solution (line 8), for further grinding; the ball mill discharges back into a classifier (line 9). In this manner, all the incoming 1/2-inch ore is reduced in size to less than 100 to 200 mesh. The grinding size obtained is controlled by the amount of water added to the classifier: the higher the flow rate, the coarser the particle that is carried over the overflow weir.

Slurry (now called pulp) overflowing the classifier (line 11) has a relatively low solids content (about 25 percent), which does not allow for efficient leaching. The solids content is increased by flowing the pulp into a thickener. The incoming pulp is allowed to settle in this tank, and the thickened solids (about 50 to 60 percent solids) are withdrawn from the conical bottom by a pump (line 12). Water released from the settled solids overflows the thickener top and is returned to the grinding circuit (line 13) via a mill solution tank.

Soda ash is added to the grinding circuit along with the mill solution (which also contains some soda ash), and leaching of the uranium begins in this part of the circuit. About 10 to 20 percent of the contained uranium oxide will be dissolved in this part of the process.

Since the leaching of uranium in the carbonate circuit is relatively slow at ambient temperatures, the thickener overflow pulp is passed through a steam-charged heat exchanger to warm the pulp from ambient temperature to about 180°F to 190°F. The heated pulp then enters a series of tanks (typically 8 to 12) arranged in a down-hill or cascade manner so that the pulp flows from one tank to the next by gravity. Oxidation of the uranium oxide is provided by small amounts of air blown into the pulp. The tanks are covered to minimize loss of water by evaporation, but because air is introduced, they are vented to the atmosphere through a common manifold (line 15). This procedure also prevents the build-up of radon in the mill working environment. During the time in leach, up to 95 percent of the uranium oxide remaining in the ore is dissolved.

Pulp from leaching (line 16) is pumped first to a large surge tank (filter feed tank) and subsequently pumped to filters, where the solids, now mostly barren of uranium, are separated from the uranium-bearing liquor by means of vacuum filtration. The pulp is dewatered (form stage) and then washed, first (line 17) with medium-strength, uranium-bearing mill solution (first stage line), then with 3 washes (lines 18, 19, 20) of low-strength, uranium-barren solution (stages 3, 4, 5) from the precipitation circuit, and finally with fresh water (line 21) to complete the recovery of mill solution and any remaining uranium. The solids, or tailings, are removed from the filter and transported to the tailings management area by trucks. The mill solution contains soda ash which is recovered as completely as possible and reused.

The liquor coming from the cake form and stages 1 and 2 on the filter (now called "pregnant liquor") are combined and sent forward to further processing (line 22). Liquor from stages 3, 4, 5 and from the drying stage are combined and returned to the mill solution tank (line 23). This separation of liquors is made so that the pregnant liquor is not diluted anymore than absolutely required; the more dilute the liquor becomes, the more difficult it is to precipitate the uranium oxide from it.

The pregnant liquor from the filters usually contains some solids (100 to 200 parts per million, ppm) which must be removed prior to precipitation. This is accomplished by passing the liquor through a claricone (a specially modified thickener) and then (line 27) through a second set of sand filters for polishing. Underflow from the claricone (line 25) is returned to the intermediate thickener so that no uranium oxide is lost. The pregnant liquor is then heated and sodium hydroxide (NaOH) is added (line 28) to precipitate the uranium oxide. Since this reaction is slow, retention time is provided in a series of precipitation tanks, arranged in a manner similar to the leach tanks. The slurry of precipitated uranium oxide and liquor is passed to the yellowcake thickener where the solids are settled. Liquor overflowing the thickener will contain 100 to 500 ppm uranium-bearing solids, which are filtered (line 31) by plate and frame filters. The solids accumulating in the filters are periodically removed and added to the dissolving tank. Filtrate from the plate and frame filters is pumped to the barren solution tank.

Uranium-bearing solids from the thickener are pumped to a drum filter (line 30) for further removal of liquor from the solids. Filtrate from the drum filter is sent to the barren solution tank.

In the process of precipitation of uranium oxide with sodium hydroxide some sodium carbonate is broken down in the barren liquor. This degenerated solution is regenerated in a Ducon scrubber by contact with carbon dioxide gas from the boiler. The excess sodium hydroxide is converted to sodium carbonate in the same manner. Part of the regenerated barren solution is used for filter wash (line 43); the remainder is returned to the mill solution tank for reuse (line 44).

Filter cake from the drum filter still contains some sodium-bearing mill solution. Since yellowcake containing large amounts of sodium is unacceptable to refiners, the sodium must be removed. In order to remove the sodium, the filter cake (line 32) is mixed with deionized water (line 33) to lower the solids content from 60 percent to about 10 percent, and sulfuric acid (line 34) is added. This dissolves the uranium-bearing solids, and the solution (line 35) is re-precipitated by the addition of peroxide. The resulting slurry is thickened and filtered in a manner similar to that performed earlier. The now largely sodium-free yellowcake is transported (line 39) to a dryer where the water is removed.

The dry yellowcake tends to clump in the dryer, so it is sent to a hammer mill where it is crushed. The yellowcake is stored in the surge bin until it is finally packaged (line 53) in steel drums for shipment. The yellowcake filtering, drying, and packaging operations are conducted under negative pressure in enclosed areas of the mill and are restricted to all but authorized operators. Exhaust air from these areas is released only after passing through special venturi wet-scrubbing systems.

The entire mill site is curbed and bermed so that rain water falling on the site and buildings, as well as plant spills, can be contained. This drainage goes to the mill pond (line 46) and is used as a source of process make-up water. This water source does not satisfy the total mill demand, however, and the remaining requirement is made up from the plant water tank (line 48) which will contain water from the mine, or from an alternative source during dry periods when mine water may not be available.

D. TAILINGS MANAGEMENT

1. General Tailings Management Description

The carbonate milling process essentially produces the same weight of solid waste, or tailings, as the total ore input to the mill. The Swanson Project will produce approximately 13.5 million tons of tailings solids over the project life.

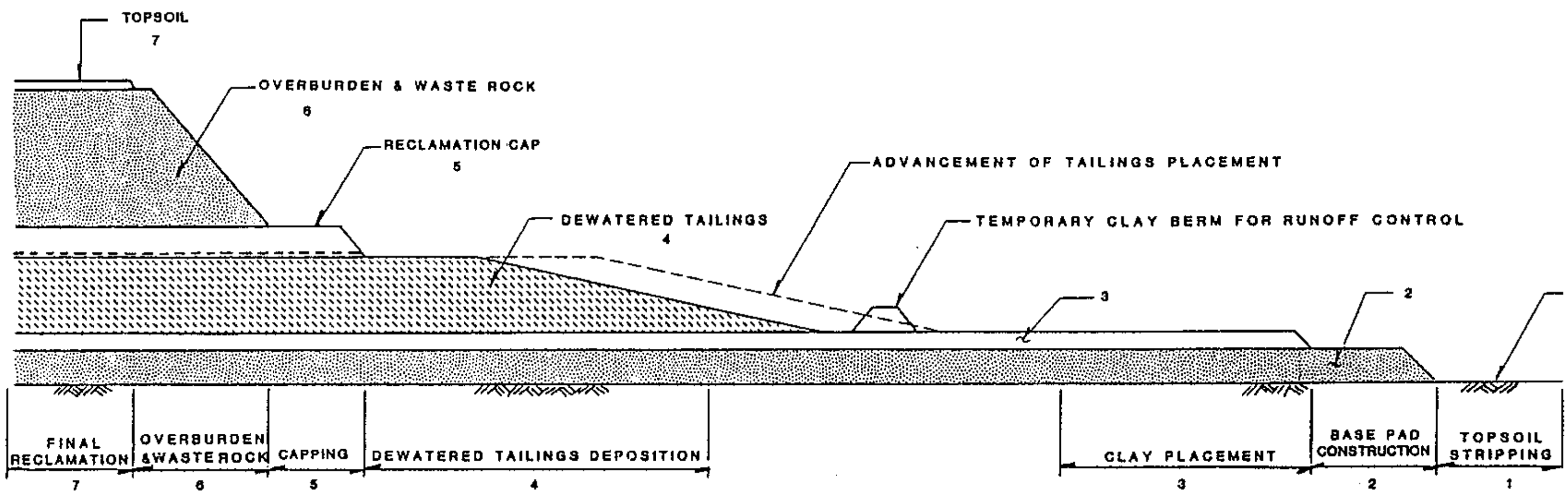
The conceptual tailings management program begins with the tailings slurry filtration plant located at the mill site (see flowsheet, Figure II-7). This plant will wash the tailings with water (line 21, Figure II-7), remove excess liquid from the tailings slurry and recycle the liquid back to the mill process circuit (line 23). Filtration will produce "dewatered" tailings consisting of a moist sand (25% water by weight) that will be loaded onto dump trucks for transportation to the tailings management area (see Figure II-3). This area, located within the larger mine waste rock storage area, will be approximately 200 acres, resulting in an average thickness of 33 feet of dewatered tailings upon project completion. The management area will be lined with natural clay to minimize seepage and provide a geochemical cleansing action to reduce the level of contaminants in any potential seepage.

The sequence of operations for construction and operation of the tailings management area are as follows (refer to Figure II-9). Topsoil and any areas of deep residual soils will be removed and stockpiled. A base pad of mine production waste rock will be placed in advance of liner construction and tailings deposition to provide a working surface and capillary break from ground water. Following the construction of an earthen containment dike and the clay liner, the dewatered tailings will be trucked and dumped in the facility and graded with conventional earthmoving equipment. As the tailings reach final depths and grades, a clay reclamation cap and drainage blanket will be placed over the tailings. Mine waste rock then will be graded over the reclamation cap to provide final encapsulation of the tailings on all sides. Finally, a soil cover will be place on the mine waste rock to provide a medium for revegetation with grasses.

The most significant feature of the tailings management concept is the final encapsulation of the tailings mass with mine overburden waste rock. This feature will provide long-term stability, while minimizing the total project land disturbance. Figures II-9 and II-10 provide cross sections showing the final tailings management geometry and the unit operations involved in facility construction. Figure II-11 shows the arrangement of the various components in the conceptual cross section. Section E.3 in Volume 2 of the main report contains a complete description of the tailings management facility.

2. Tailings Management Area Site Conditions

The proposed location of the tailings management area is in the area known as the "Meadows" along and between Mill Creek and Dry Branch, and in the area extending across Mill Creek to the north. The area crosses both the existing State Road 683 and Mill Creek. State Road 683, therefore, will either be re-routed or abandoned in accordance with state requirements. Mill Creek will be re-routed from a point upstream from the proposed mine location, possibly to the southeast



SEQUENCE OF OPERATIONS

NOTE:
FOR CROSS SECTION SHOWING FINAL CONFIGURATION, SEE FIGURE II-11

MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA
TAILINGS MANAGEMENT OPERATIONS
SWANSON URANIUM PROJECT
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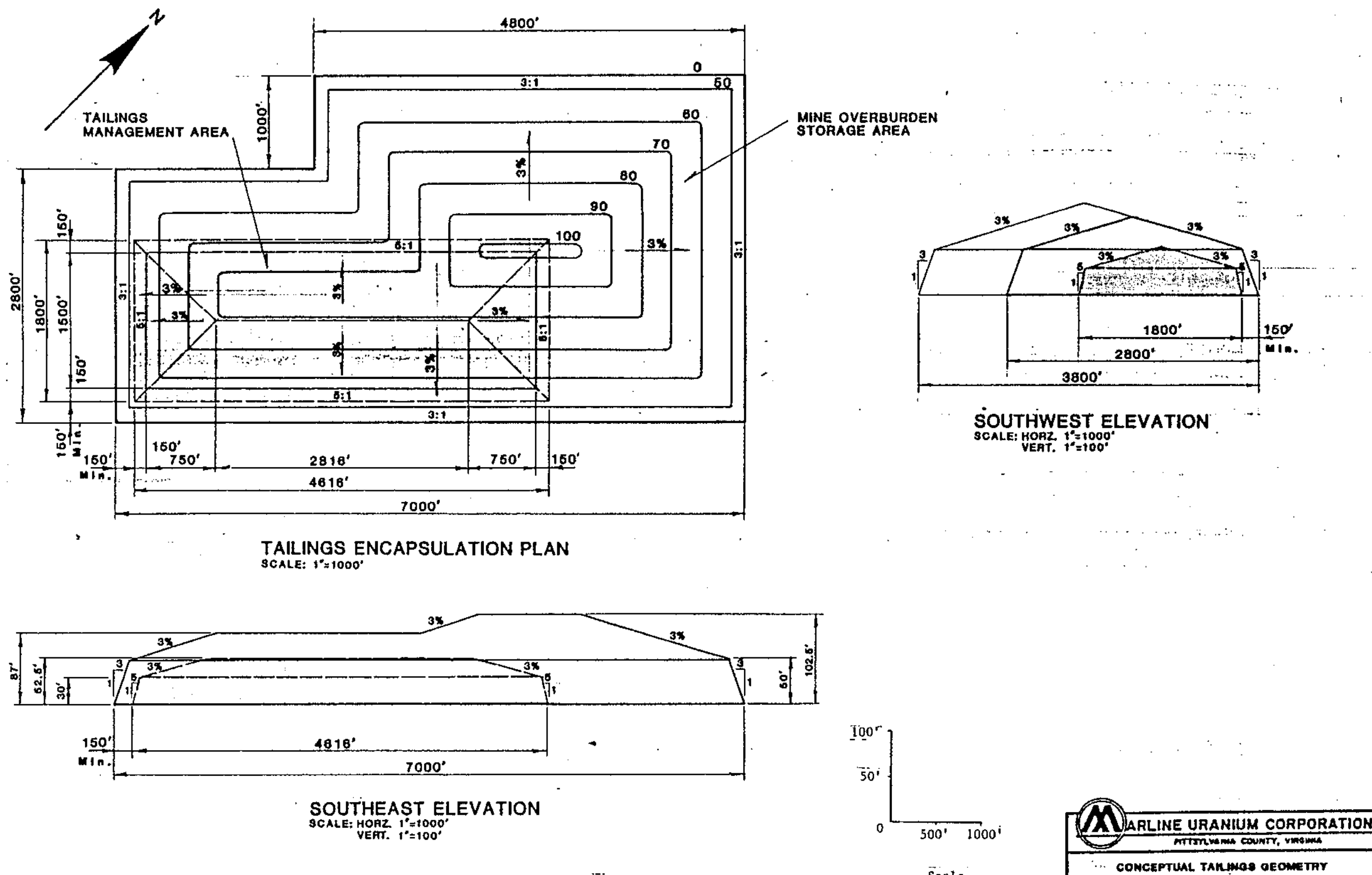
FIGURE II-9



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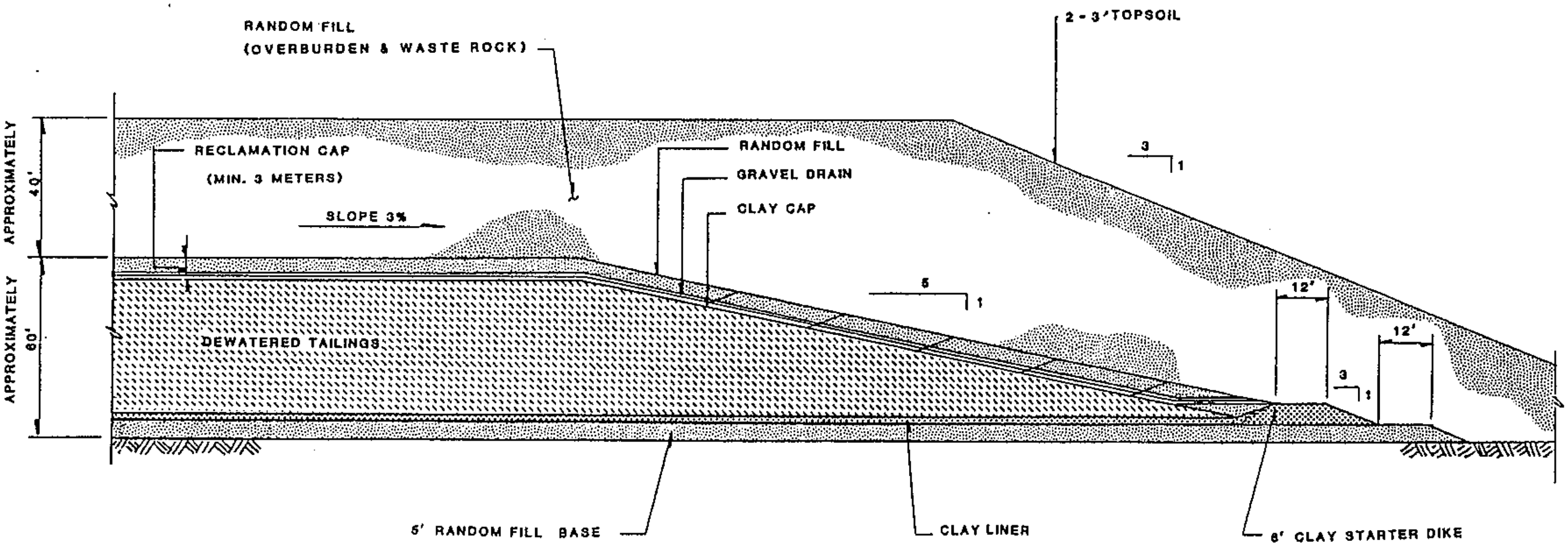
CONCEPTUAL TAILINGS GEOMETRY
SWANSON URANIUM PROJECT

Dravo AUG/84 FIGURE II-10



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PITTSYLVANIA COUNTY, VIRGINIA

CONCEPTUAL CROSS SECTION
TAILINGS MANAGEMENT AREA
SWANSON URANIUM PROJECT

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FIGURE II-11

into the Dry Branch drainage basin, to the northeast into Whitethorn Creek, or to the south into the Banister River.

The site is characterized by a relatively flat surface with stream drainage to the northeast in Dry Branch and in Mill Creek. Both of these streams are tributary to Whitethorn Creek, which in turn is tributary to the Banister River. The slopes within the site typically range from one-half to one percent. The current use of the land for the proposed site is approximately equally divided between pastureland or feed crop cultivation and forestation.

Geologically, the site lies to the southeast of the Chatham fault zone and is within the Danville Triassic Basin, which is characterized by rocks of sedimentary origin. The residual soils in this area are shallow, ranging in depth from zero to approximately five feet, averaging three feet. Bedrock permeabilities measured in the Triassic Basin by downhole packer permeability tests indicate the weathered bedrock (average thickness 16 feet) has an average estimated permeability of 83 feet per year, while the unweathered bedrock average permeability is estimated to be 28 feet per year.

3. Seepage Management and Ground Water Protection

In addition to physically containing the tailings, the primary goals of the tailings management area design are to isolate the tailings from water, minimize the quantity of seepage and minimize the potential impacts of the dissolved constituents in any seepage that may occur. Table II-5 summarizes the composition of three possible tailings solutions prepared in the laboratory from Swanson ores. These solutions were synthesized by applying the processes likely to be employed at the mill, although the actual concentrations of various parameters will change upon final process design. At this time, Marline and Umetco are favoring the carbonate process (column C in Table II-5).

TABLE II-5

Chemical and Radiochemical Profile of Undiluted Tailings Solution
Typical of Swanson Project Ore

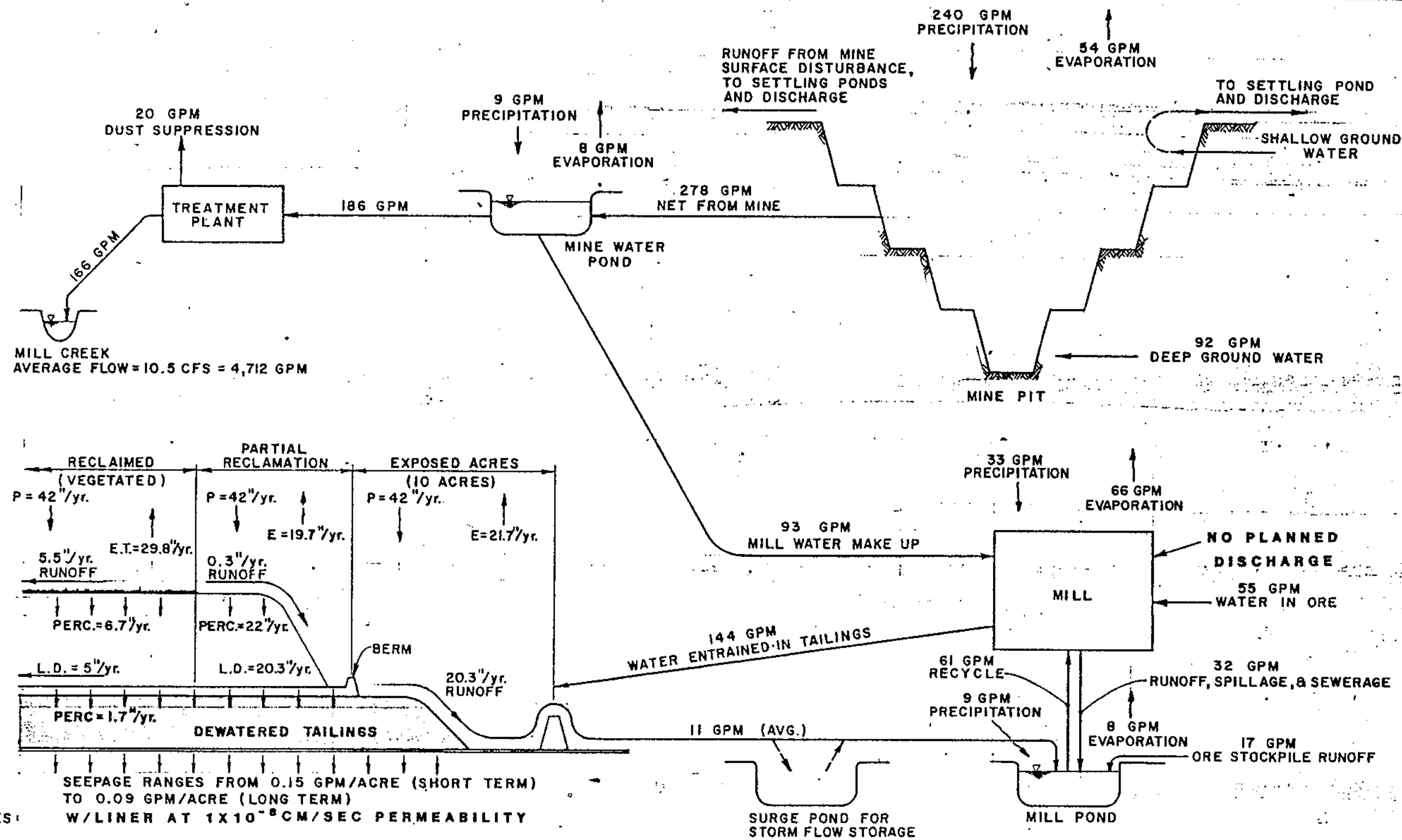
TAILINGS SOLUTION PROCESS DESCRIPTION	A Acid Leach	B Acid Leach (pH Neutralized)	C Carbonate Leach
General Parameters:			
TDS (in g/l)	28.9	13.1	7.34
pH	1.9	4.2	9.8
EMF (in mv)	+360	+315	+100
Chemical Profile:		Concentration, mg/l	
SO_4 (in g/l)	20.3	9.38	1.20
HCO_3	<5.	<5.	446.
CO_3	<1.	<1.	2370.
Cl	251.	165.	396.
F	54.	2.0	11.6
Na	424.	322.	2700.
Ca	396.	436.	9.0
Mg	1650.	1300.	17.
As	0.18	<0.01	0.08
Ba	0.1	0.1	<0.1
Cd	0.18	0.03	0.01
Cr	1.17	0.01	<0.01
Cu	4.66	0.07	0.17
Fe	1700.	220.	0.51
Hg	0.0021	0.0004	<0.0003
Mo	0.5	0.1	2.2
Pb	4.3	0.4	4.9
Se	<0.01	<0.01	<0.01
V	19.3	<0.1	0.5
Zn	40.	2.6	0.02
PO_4-P	0.01	<0.01	1.09
NH_3-N	1.16	413.	1.61
NO_3-N	0.1	0.3	<0.1
NO_2-N	0.04	<0.01	0.01
Radiochemical Profile:		Concentration, pCi/l	
U_3O_8 (in mg/l)	44.	0.7	35.
Gross α	14117±382	391±40	19817±280
Gross β	28085±319	531±33	7719±124
Th 230	6681±1569	502±33	162±88
Ra 226	105±6	14±2	22±2
Pb 210	23±14	2.9±1.3	6.7±1.1
Po 210	833±25	0.2+0.2	0.8±0.4

In the net precipitation environment of Virginia, water may enter the tailings due to direct precipitation, surface runoff from adjacent areas or a rise in the ground water level. In addition to these water inputs, the moisture already contained within the dewatered tailings after filtration (25% by weight) also must be controlled. The design features provided to minimize water inputs into the tailings and thereby minimize seepage are surface water diversions, the low permeability reclamation cap, and the low permeability clay liner.

The site selected for the tailings management area will undergo detailed engineering tests to confirm the physical stability of the underlying foundation. The prepared surface will meet specific engineering criteria before grading to provide drainage away from the tailings. Also, diversion ditches will be placed where necessary around the area to divert and thereby eliminate any surface flows into the tailings management area. Proper diversion design, construction, and maintenance will eliminate surface water as a possible source of inflow and consequent outflow from the tailings, leaving only direct precipitation, ground water, and the tailings solution itself to be controlled.

During the operational phase of tailings management, when trucks are placing dewatered tailings in the facility, the critical seepage control feature will be the low permeability liner. Regarding the liner:

- Locally available clays will be placed under a strict quality control program to specified density, moisture content, and permeability.
- As with all materials, this liner will have some finite permeability and will therefore transmit some amount of water. Estimates conducted in 1983 based on a permeability of 1×10^{-8} cm/sec and a 30-foot driving force, assuming complete saturation of the overlying tailings, resulted in a rate of 0.15 gallons per minute per acre of liner (Figure II-12). Additional analyses conducted in 1984 on an assumed 1×10^{-7} cm/sec liner indicate initial seepage rates may



SEEPAGE RANGES FROM 0.15 GPM/ACRE (SHORT TERM)
TO 0.09 GPM/ACRE (LONG TERM)

NOTES: W/LINER AT 1X10^{-8} CM/SEC PERMEABILITY

P PRECIPITATION
E EVAPORATION
E.T. EVAPOTRANSPIRATION
PERC. PERCOLATION
L.D. LATERAL DRAINAGE
1 CUBIC FOOT PER SECOND (CFS) = 448.8 GALLONS PER MINUTE (GPM)

MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA

PRELIMINARY PROJECT WATER BALANCE
(CARBONATE)
SWANSON URANIUM PROJECT

Dravo revised AUG/84

FIGURE II-12

be as high was 1.025 gpm per acre, but the seepage rate declines relatively rapidly after the tailings are covered due to the faster reduction in hydraulic driving force on the more permeable liner.

- Due to the natural ability of clay materials to heal cracks and resist sudden perforation-type failures, the clay liner system is structurally superior to a synthetic membrane. Conversely, synthetic membranes typically have lower permeabilites as long as their structural integrity is maintained.

- Perhaps the most important feature of properly designed and tested natural clay liners is their documented ability to geochemically remove significant portions of contaminants from seepage over a long period of time. This geochemical aspect of the clay liner is discussed in depth in Section E.3.6 and Appendix V of the October 15 submittal, and is further addressed in the Technical Memorandum No. 2 attached to this summary.

To protect against the intrusion of water into the tailings mass during seasons of high ground water, a five foot thick compacted base pad of mine production rock will be placed prior to the construction of the clay liner. This thickness of base material is adequate to provide a suitable structural platform for the tailings facility, while serving as a physical barrier and capillary break between ground water and the clay liner.

During placement of the tailings, and prior to capping and final encapsulation with mine waste rock, the dewatered tailings will be exposed to direct precipitation. In wet seasons, the infiltration from this precipitation could saturate the exposed tailings due to their initial moisture content of 25 percent from the mill. This likely saturation in wet weather is the basis for assuming an average 30-foot hydraulic head in the tailings to calculate the short-term seepage rate of 0.15 gpm per acre for the 1 X 10^{-8} cm/sec liner. Therefore, a primary goal of tailings management will be the rapid covering and revegetation of the tailings area to minimize infiltration of intercepted precipitation. It is currently estimated that only 10 acres of tailings area will be exposed at any one time, equivalent to over seven months of mill production. The remaining area will be covered either by a low permeability clay cap or mine overburden graded to provide drainage from the facility.

Unlike the operational phase, where the key component of seepage control is liner permeability, post-reclamation long-term seepage control is provided by the clay cap and overlying drainage blanket. In the humid climatic conditions of Virginia, the clay cap and associated drainage layer will be designed to inhibit additional moisture inputs from infiltrating water at the surface of the reclaimed facility.

It is currently estimated that once final revegetation is well established, the mine waste, gravel drain and clay cap will prevent all but 1.7 inches of the intercepted precipitation from penetrating the tailings mass. This long-term percolation rate is equivalent to 0.09 gpm per acre. During this post-reclamation phase, the seepage through the bottom of the facility will remain in equilibrium with the climatic input and therefore will eventually equilibrate to the 0.09 gpm per acre entering through the cap. This long-term equilibrium rate will be reached regardless of the liner permeability, with the difference between various liners being the period of time for equilibrium to occur.

4. Operational Aspects of Tailings Management

Figure II-9 is an idealized cross section of the tailings management area that summarizes the various operations. The numbers referenced in the following discussion correlate with the locations on the cross section. After the initial clearing and grubbing of existing vegetation, local topsoils will be stripped and stockpiled for future site reclamation (1). At this time, any areas of deep residual unconsolidated soils will be excavated to bedrock. Based on the initial drilling investigations conducted on the site, bedrock is shallow, averaging three feet, and therefore deep zones are not anticipated.

After initial clearing and topsoil stripping, a base pad of mine waste rock will be constructed to a nominal depth of five feet (2). This depth will vary according to local topography, and will provide a suitable construction surface and capillary break. This base will be constructed to predetermined geotechnical specifications to ensure overall facility stability.

Clay liner construction (3) follows these operations. Suitable clay materials may be obtained during development of the mine site, tailings management area, and mine overburden storage area, plus off-site sources as required, and will be placed to a final thickness of at least 18 inches on the rock base pad. The critical construction phase will require strict quality control techniques to achieve consistent moisture content and density (at least 95 percent Standard Proctor) of the liner material, and will be supervised on-site by qualified geotechnical engineering personnel.

To minimize the possibility of clay desiccation (drying) and therefore ensure liner integrity, the liner construction will be staged with tailings deposition in a fashion that will eliminate exposing the liner to drying for long periods of time prior to tailings placement. It is likely that intermediate soil covers and wetting will be employed to keep the liner moist in dry weather. These liner covers also will protect against erosion in wet weather and freezing and thawing during the winter season. Refer to the attached Technical Memoranda Nos. 1, 2, and 6 for a summary of potential clay sources, clay volumes and, geotechnical and geochemical properties of local clay materials.

Once liner construction is initiated, starter dikes will be constructed on three sides of the rectangular tailings management area to provide containment for the dewatered tailings. As currently conceptualized, these dikes will be six feet in height and constructed of clay materials. They will be integrally connected to the underlying clay liner to ensure a continuous hydraulic barrier to tailings seepage.

Tailings placement (4) will commence once a confined area is available within the starter dikes. This operation will consist of dump trucks transporting the dewatered tailings from the mill and depositing them within the facility. Additional grading will be performed by conventional earthmoving equipment located in the management area.

The fourth side of the rectangular facility will be a temporary clay berm that will intermittently advance as the final tailings geometry is achieved within the confined area. The purpose of this berm is to contain any seepage that may occur from the tailings deposited on top of the liner, or any surface runoff from precipitation on contaminated ares. Liquids collected by this berm will be evacuated by gravity flow or pumping to a tailings surge pond, and eventually will be recycled to the mill.

Figure II-10 shows a cross sectional view of the final tailings geometry. The present conceptual design consists of a 5:1 tailings slope from the confining berms to a tailings height of 30 feet, where the slope will decrease to three percent. This configuration will result in a symmetrical prism with rectangular base dimensions of 4616 feet by 1800 feet (191 acres), a maximum depth of 52.5 feet at the centerline crest and an average depth at the base of 32 feet.

Once the deposited tailings are graded to the final geometry, a reclamation cap will be constructed (5). The cap will consist of a nominal 12 inches of compacted clay, an overlying eight inch gravel drain, and a zone of random fill material, resulting in a total cover depth of nearly ten feet (three meters). The cover will have three primary functions:

- The clay zone will inhibit the passage of percolating water due to infiltrating precipitation;
- the gravel drainage blanket will laterally transmit intercepted percolation off the facility;
- the entire capping system will attenuate radon gas emanation from the tailings surface to required levels.

Additional engineering studies required to be conducted prior to final tailings design include the determination of the actual radon attentuation characteristics of local construction materials and the consolidation characteristics of the tailings. If the consolidation analysis indicates that settlement of the tailings mass could affect the structural integrity of the reclamation cap, an alternative approach would be to gradually add mine overburden waste rock to the tailings. This technique would accelerate consolidation and provide a stable base for reclamation cover construction.

After the reclamation cover construction, the tailings management facility will be encapsulated by mine waste rock (6). The final geometry of the mine waste rock in relation to the tailings facility is shown in cross section on Figures II-4 and II-10. The encapsulation will start with a 3:1 slope at the original ground surface up to a height of 50 feet, where the slope will decrease to 3 percent. The configuration will provide a cover over the tailings ranging in depth from 25 feet to over 40 feet.

The final operation in the construction of the tailings management area will be the redistribution of topsoil and revegetation (7). The present concept is based on a soil depth on the order of two or three feet and revegetation with grasses. The goal of this final reclamation will be the establishment of a well-rooted vegetation cover that will maximize evapotranspiration, and therefore minimize the volume of water to be laterally transported by the gravel drain overlying the clay cap.

E. PROJECT WATER BALANCE

1. General

In contrast with the typically arid or semi-arid areas of the southwestern U.S. uranium industry, the Swanson Uranium Project is located in a humid climatic area, with annual precipitation (42 inches) exceeding annual evaporation (38 inches).

The goal of the preliminary project water balance presented in the October 15 submittal was to provide a reasonable estimate of the volume of water requiring treatment under normal operating conditions. As future engineering studies develop detailed mine plans, final mill process flow sheets and the general arrangement of all surface facilities, the water balance will be calculated for different periods in the project's life, such as during wet and dry weather periods and on a monthly basis. Also, the results of extreme rainfall events will be assessed in greater detail, with adequate surge capacity engineered into the water containment system.

A mill water balance calculated with reasonable assumptions at this early stage of project development can provide the basis for the worst-case environmental impact. As past discussions with state officials and the UAG consultants have indicated, the primary concern in the net-precipitation environment of Virginia is that of a project water surplus that would require a discharge from the mill to surface waters. In accordance with federal regulations, the mill will be designed to function as a zero-discharge facility. EPA's New Source Performance Standards (40 CFR 440.34) prohibit discharges from new mills except for the amount by which precipitation may exceed evaporation as measured over the area of the treatment facility. Any discharged water must satisfy concentration standards corresponding to use of the best available demonstrated treatment (BADT) technology. In addition, specific limits are established under these standards for discharges of zinc, radium-226 (dissolved and total), uranium and total suspended solids. In the net precipitation environment of Virginia, the approximately four inches of precipitation excess is equivalent to 0.21 gpm per acres of treatment facility area. Conversely, it is quite possible that the project may experience a process water deficit under certain conditions. If this occurs, the overall environmental impact of the project would be reduced; instead of a required discharge to surface waters, additional water supplies to the system would have to be developed. Alternative sources of water during such periods would be ground water from wells, saprolite water (i.e., shallow ground water) intercepted by the mining operation, or a surface intake from a local stream.

Considering the current stage of engineering design relative to the overall goal of assessing possible adverse environmental impacts, a project water balance was calculated and presented in Section E.2.5 of the October 15 report. The following discussion reflects some revisions to this water balance which is depicted in Figure II-12. Additional technical concerns raised subsequent to the October 15 submittal are addressed in the attached Technical Memoranda Nos. 5, 11, and 12.

2. Water Inflows to the Swanson Project

The possible water inflows to the the mine, mill, mine overburden and tailings management area complex include:

- mine pit ground water inflows
- precipitation and runoff
- fresh water mill make-up

a. Mine Pit Ground Water

As summarized in Section E.1.6.2 and discussed in depth in Volume 5, Appendix IV, Report B of the main report, a high estimate of ground water inflows into the mine pit is made up of the following components:

Chatham Fault Zone	10 gpm
Triassic Rocks (east wall)	14 gpm
Crystalline Rocks (north, south and west walls)	68 gpm
TOTAL	92 gpm

The contribution from the Chatham fault zone was based on a pump test conducted at a depth of 168 feet in a 197-foot well. Although the total depth of the proposed pit is 850 feet, the pump test of the Chatham fault zone was conducted at the shallower depth due to the tendency of the fractures in fractured crystalline rock to "heal" as a result of overburden pressure. Experience has shown that 200 feet is a reasonable maximum depth for open fractures in this type of geology. Also, drilling at the mine site has indicated that the Chatham fault zone thins with depth.

The calculation of the ground water inflow from the fault zone was based on extrapolating the results of the pump test down to the elevation where the fault exits the pit at 650 below the surface. In this way, the relatively high permeability of the upper 200 feet of fault zone was assumed to exist for the full depth of the fault, and therefore the estimated flow rate is considered high. Likewise, the estimated inflows from the Precambrian rock and Triassic rock were based on a pit depth of 850 feet, while using the higher permeability found at shallower depths.

During the pump test conducted at the mine site, it became clear that the overlying soils, or saprolite, provided the water that recharged the fractures in the upper zone of the bedrock. Once the soils are stripped from the mine site, and the excavation continues into bedrock, a berm and collection ditch system will intercept this ground water contribution and prevent it from entering the pit. It is currently estimated that an average 140 gallons per minute (gpm) would be intercepted in this fashion.

This water will be diverted to a surface drainage or used as mill make-up water, if needed. Samples taken of this shallow ground water indicate radionuclide and chemical content are not high enough to require treatment prior to release.

b. Precipitation and Runoff

The water balance portrayed in Figure II-12 shows the average flows resulting from the 42-inch average annual precipitation falling on potentially contaminated areas. The 240 gpm inflow into the mine pit (42 inches on 110 acres per year) assumes the pit is at its greatest areal extent and that no rainfall into the pit is isolated from mineralized areas or free water.

The assumption that all of the intercepted rainfall will be available as free water results in a high estimate of water yield from the pit. In reality, some of this water will remain entrained in the overburden and ore, and will be trucked out of the mine. Assuming the moisture content of the blasted material is increased by two percent due to intercepted precipitation results in 90 gpm leaving the pit with this solid material. However, to maximize the estimate of free water from the mine requiring treatment, this flow was not included in this preliminary analysis.

Eleven gallons per minute inflow from the ten acres of exposed tailings is indicated on Figure II-12. This figure is based on an estimated 52% evaporative loss. Ten acres represents 10 divided by 200, or approximately five percent of the total tailings management area, equating to over seven months of tailings production. Additional engineering to be performed during the later design phases of the project will provide the details of operational water control plans at the tailings management area. The basic principle to be applied will be separating all runoff from contaminated areas from combining with uncontaminated runoff, thereby keeping the volume of water requiring treatment to a minimum. A system of berms and ditches will be constructed to provide this function.

The water balance diagram in the main report (Figure E.2-7) originally indicated that tailings runoff would be routed to the mine water treatment pond.

Due to the potential for contamination by residual mill process reagents, this has been revised in Figure II-12 to show the 11 gpm routed to the mill pond for eventual recycle to the mill process.Runoff from the 15-acre ore stockpile area is estimated to average 17 gpm, and would be routed through a small sedimentation control pond to settle out solids and used to supplement mill water make-up demands.

c. Fresh Water Mill Make-Up

Based on the current level of process engineering, it is believed that under normal conditions the mill water demand can be met by the water generated by mining and intercepted precipitation. No free liquid waste stream will be discharged. Figure II-12 shows the mill water balance for the carbonate leach process. (Marline and Umetco are currently favoring the carbonate process over the acid process; the required mill water demands are similar for both.) As shown in the figures, the net water demand is as follows:

Water input to mill:

-	Site precipitation	33 gpm
-	Water contained in ore	55 gpm
-	Water available from mill pond	61 gpm
	TOTAL WATER INPUT	149 gpm

Water losses from mill:

-	Site runoff, spillage, sewerage	32 gpm
-	Water remaining in tailings after filtration	144 gpm
-	Process evaporation	66 gpm
	TOTAL WATER LOSSES	242 gpm

Net water demand:

-	Total water losses	242 gpm
-	Total water input	149 gpm
	NET DEMAND	93 gpm

The above calculations indicate that the primary water loss from the mill is the liquid entrained in the filtered tailings.

As shown in Figure II-12, the mill make-up water demand will be supplied by the mine water treatment pond. In calculating the volume of excess mine water eventually requiring treatment and discharge, the water content of the mill ore feed was considered to be quite high (11%), thereby reducing the mill water make-up demand and increasing the excess mine water volume. During periods of dry weather, the ore will not contain this relatively high amount of water, and the mill demand would increase accordingly.

3. Water Outflow From the Swanson Project

The possible outflows of water from the Swanson Project include:

- Seepage
- Runoff
- Evapotranspiration
- Dust Suppression
- Direct discharge from treatment plant

a. <u>Seepage</u>

Seepage of water into the ground potentially can occur at the mine, tailings management area, and overburden storage area. Seepage at the mine is considered negligible, however, due to the low permeability of the associated rock formations.

Seepage through a tailings management area bottom liner with a permeability of 1×10^{-8} cm/sec is estimated to range from 0.15 gpm per acre over the short-term to a long-term rate of 0.09 gpm per acre. The short-term rate was calculated assuming a 30-foot depth of saturated tailings. The long term rate is equivalent to 1.7 inches of precipitation per year passing through the tailings reclamation cap into the tailings mass, and ultimately through the bottom liner. Based on a 200-acre tailings management facility, the rate of seepage through such a tailings liner will range from 18 to 30 gpm. In the case of a 1×10^{-7} cm/sec liner, the initial seepage rate would increase to 1.085 gpm per acre, which would decrease to the long-term rate of 0.09 gpm per acre of the operational life.

Seepage from overburden storage areas will occur once the material is sufficiently wetted by intercepted precipitation to exceed the water-holding capacity of the finer fraction of overburden. The overburden mass will be made up of predominately large rock fragments, with some fine particles created by material blasting, loading, and final placement. During active operations (prior to final reclamation and revegetation), the initial overall permeability of the overburden mass will be high, although locally variable due to the natural segregation of coarse material from the finer material during the placement process. Calculations indicate that the seepage rate will be 1.14 gallons per minute per acre during operation.

After final reclamation and proper revegetation, evapotranspiration will reduce the amount of infiltrating water available for infiltration into the overburden mass. The long-term seepage rate from areas not overlying tailings is estimated to be 0.32 gallons per minute per acre. Refer to Technical Memoranda Nos. 5, 11, and 12 for further details on the estimation of seepage rates.

b. Runoff

Another source of water outflow is surface runoff into adjacent water courses. As described in the preceding Section E.1, potentially contaminated runoff from the mill area and exposed tailings area will be contained for recycle to the mill. However, runoff from reclaimed tailings management and overburden storage areas will exit the project site without treatment, while runoff from partially reclaimed (unvegetated) areas will be collected by a system of ditches and routed to settling ponds prior to final discharge.

An additional source of potential surface water flow from the site is the lateral seepage that exists from the tailings management area reclamation cap drain. As described in Section II.D, Tailings Management, a gravel drain will be placed on the impermeable clay cap overlying the dewatered tailings. Current estimates indicate that of approximately 6.7 inches of water percolating through the mine overburden mass each year, all but 1.7 inches will be carried by the drainage blanket off the tailings site. Over the entire 200-acre tailings management area, this five-inch difference is equivalent to an annual average of 52 gpm distributed over the area perimeter of 12,800 feet. This rate is equivalent to 0.004 gpm per foot, and is not of sufficient magnitude to cause erosion at the exit point of the drain. Refer to the cross section of the tailings management area (Figure II-10) for an understanding of final slopes and drainage patterns.

c. Evapotranspiration

A significant source of water loss from the Swanson Project will be in the form of water vapor due to natural evaporation from water and land surfaces, and evapotranspiration from reclaimed (vegetated) areas. Evaporation from the mine pit will be a combination of water losses from the temporary ponds within the pit located on mine benches, and also evaporation from the wetted pit walls, floor and material stockpiles. An estimated 54 gpm is projected as the average total evaporative loss from the mine, which is equivalent to the losses from a 27-acre lake.

Lake evaporation at the project site is 38 inches per year. With annual precipitation averaging 42 inches, the net 4-inch input over project pond surfaces is equivalent to 0.21 gpm per acre of water surface.

A significant evaporative water loss from the site is evapotranspiration from reclaimed areas. Current estimates indicate that an established stand of grass on a 2.5-foot-deep soil cover will transpire nearly 30 inches of water annually at the project site. Refer to Technical Memoranda Nos. 5 and 11 for details on the water balance calculations used to estimate evapotranspiration.

d. Dust Suppression

Another outflow from the system is that of dust suppression water applied to haul roads both inside and outside of the mine pit. This uncontaminated water ultimately will be lost due to evaporation. The present estimate of 20 gpm (30,000 gallons per day) for average dust suppression needs is considered to be low in an attempt to maximize the estimate of mine water requiring treatment. In practice, this flow easily could increase ten-fold during dry weather. It is conceivable that other sources of water in addition to that from the mine, such as local streams or shallow ground water, would be developed to augment dust suppression water supplies during dry weather.

e. Direct Discharge from Treatment Plant

As summarized in Section E.1.7.4 of the October 15 report, and described in detail in Volume 5, Appendix IV, Part 3 of that document, a mine water treatability study was conducted to verify that potentially contaminated water from the pit could be treated for safe discharge to the local surface water system.

By sampling ground water within the orebody, an attempt was made to obtain a sample representative of the most heavily contaminated water that could be generated from the mining operations. Using this water source as the basis for study, a series of bench-scale tests was conducted in the field. Two fundamental water treatment techniques formed the basis for the series of experiments: barium-radium sulfate co-precipitation (a process that removes radium in solution by causing a reaction that solidifies and settles out the radium), and radium and uranium specific ion exchange and adsorption (mechanisms that remove radium and uranium by molecular attraction).

The conclusions of the testing were as follows:

- The barium chloride addition treatment method is effective in reducing the dissolved radium levels in the mine drainage. Such treatment produces a 97+ percent reduction in dissolved radium.

- Use of commercially available chemical additives significantly improves the solid/liquid separation processes required to remove the barium radium sulfate co-precipitate crystals produced during the barium chloride treatment process. The co-precipitate must settle from the treated mine water to insure compliance with discharge requirements for total radium.

- The Swanson Project mine waters are amenable to radium removal treatment with ion exchange and/or absorption resins. Used independently or in conjunction with barium chloride treatment, these materials will produce treated drainage waters suitable for surface discharge.

- The mine drainage water will contain insufficient amounts of sulfate for the barium chloride treatment method to succeed without supplemental sulfate addition, which can be achieved using sodium sulfate.

- The mine drainage waters are amenable to dissolved uranium removal treatment using ion exchange resins. Removal rates of greater than 90 percent were demonstrated, yielding treated discharge concentrations significantly lower than 2 mg/1 (below NPDES limits).

As indicated on Figure II-12, the estimated average flow rate to be discharged from the treatment plant is 166 gpm. Under wet weather conditions, this rate could be higher depending on system storage capacity. However, the dilution provided by the additional water under such conditions would lower contaminant concentrations entering the plant. It is possible that during some wet periods the natural dilution of mine water by precipitation would make treatment of mine water unnecessary prior to discharge. Conversely, during dry weather, the only source of water inflow to the pit would be ground water. Current estimates of this component at 92 gpm are considered high, and in any case, insufficient to provide the required mill water make-up. Discharge from the mine water treatment plant could be eliminated during such a period and the mill would rely on supplemental water sources.

4. Water Control During Extreme Precipitation Events

The Probable Maximum Flood (PMF) has been considered in the conceptual design of the tailings facility. This event is the flow resulting from the Probable Maximum Precipitation (PMP), which is the theoretically greatest depth of precipitation for a given duration that is physically possible over a given area at a given time. At the Swanson Project site, the PMP is 29 inches of rainfall in 6 hours.

Because the PMF theoretically has no return period (such as the "50-year" flood or the "100-year" flood), it is not possible to directly evaluate the risk of such an extreme event. However, in recent applications of the PMF it has arbitrarily been assigned a return period of 10,000 years. Based on this arbitrary and conservative return period, the probability that a PMF will occur at least once during the proposed 13-year operation of the project is 0.13 percent.

The conceptual design of the tailings management area, as indicated in the preceding Section II.D., Tailings Management, includes a temporary dike preceding the advancing area of tailings deposition. The purpose of this dike is twofold: to contain tailings seepage that may collect on top of the clay liner during operations, and to contain and route the runoff from exposed tailings areas due to the PMP and lesser storms. All liquids collected by the dike ultimately will be transported to the mill pond either by gravity flow or pumping. As tailings deposition advances, additional dikes will be constructed to contain contaminated runoff. A system of berms and ditches will be constructed to direct and control water from uncontaminated areas off the project site, thereby minimizing the volume of water to be stored.

As indicated on the water balance diagram of Figure II-12, a surge pond will be incorporated into the drainage control system to temporarily store the intermittent runoff volumes associated with heavy rainfall events, and thereby keep the active tailings deposition area sufficiently dry for work to progress. The water collected in the surge pond will be used to supplement mill make-up water from the mine pond. For example, the volume of water from the exposed tailings area due to the 5.3 inch 10-year, 24-hour storm, which has as a 75 percent probability of occurring at least once over the 13-year project life, is approximately 1,440,000 gallons. This volume is equivalent to less than 9 days of mill operation. In the unlikely event of the PMP, all storage areas would be used to contain the 7.9 million gallon storm volume from the 10-acre tailings area (equivalent to 48 days of mill water consumption). The catastrophic PMP would suspend mining operations due to the collection of 266 acre-feet (86.6 million gallons) in the pit. This extreme dilution would make treatment of this water before discharge unnecessary.

F. RECLAMATION AND DECOMMISSIONING

The entire Section F, Vol. 2 of the main report is devoted to the subject of reclamation and decommissioning; that exhaustive treatment is only summarized here.

1. Mine

During the active mining phase of operations, topsoil will be removed from the mine pit area, as well as from other construction areas, and stockpiled for use during reclamation. A 15-acre area will serve as the topsoil storage area, and the storage piles may reach 30 feet in height. The topsoil storage pile will be temporarily revegetated to minimize erosion.

Waste rock and overburden storage areas will be graded to stable configurations, and topsoil will be distributed over the areas and vegetated with and approved grass species. Erosion control systems, incorporating surface runoff diversions and sedimentation ponds, will remain in place until surface runoff from reclaimed areas meets prevailing standards.

These areas will be reclaimed in a manner that allows unrestricted use after closure of the operation. It is anticipated that the 42-inch average annual precipitation at the Swanson Project site, combined with proper site preparation and maintenance, will ensure rapid and successful revegetation.

Ancillary buildings and other structures related to the mining project will be dismantled and the associated surface disturbance will be regraded, covered with topsoil, and revegetated. Upon final treatment of the water remaining in the mine water treatment pond, the remaining solids will be loaded and transported to the tailings management area for final disposal.

Because no plans for additional open-pit operations in the area are being considered, it will not be possible to backfill the proposed pit. Thus, the pit will be left in its mined-out condition and be allowed to fill with water from natural sources. Water inflow will be from the bedrock ground water (around 100 gpm), from the shallow weathered rock or saprolite (140 gpm), and precipitation (293 gpm). By subtracting the average water loss due to evaporation, the average net rate of inflow into the pit will be 410 gpm, which translates to 660 acre-feet per year. At this rate it would require approximately 60 years for the pit to fill with water to a level of approximately 30 feet below the present land surface.

The rate of pit filling can be dramatically increased by diverting all or a portion of the flow from Mill Creek into the pit. For example, by diverting 50 percent of the stream flow from Mill Creek, or 3840 acre-feet per year, the pit filling time can be reduced to nine years. By diverting 100 percent of the flow from Mill Creek into the pit, the estimated time to fill would be less than five years. The feasibility of such a diversion is currently being contemplated.

Once the lake fills to the local ground water level, outflow will occur either by ground water seepage or by a surface outlet, depending on whether Mill Creek is serving as a source of inflow. Based on current knowledge of the local ground water system, the re-established water table will approximate original conditions where circulation is limited to the upper portions of the saturated zone of the saprolite and weathered rock zone. The Chatham fault zone and deeper bedrock units are not anticipated to circulate significant quantities of ground water.

Calculations were performed to project final pit lake water quality on a worst-case basis, assuming there would be no input and dilution from Mill Creek. Certain indicator parameters were estimated to be present in the following concentrations:

Parameter	Concentration (mg/1)
TDS	40
HCO_3	19
SO_4	5
Mn	0.02
Ra-226	1.5 (pCi/1)

These estimates indicate the quality of pit lake water will be good, and would tend to improve over time in the case of continuous influx of fresh water from Mill Creek.

2. Mill

The mill site area will be decontaminated to levels of radioactivity which allow complete and unrestricted use. Salvageable equipment and structures will be decontaminated and transported to other sites for use, and unsalvageable items will be placed in the tailings management area prior to final reclamation of that site.

The U.S. Nuclear Regulatory Commission has published guidelines for decontamination of facilities and equipment prior to release for unrestricted use, and the U.S. Environmental Protection Agency also has standards for clean-up of land and buildings contaminated with residual radioactive materials. These, or similar state standards and regulations, will be applied at the time of actual reclamation to assure the highest degree of protection of the public health and safety.

Compared to reclamation activities at the mine and tailings management areas, reclamation and decommissioning of a mill site is a simple and routine matter.

3. Tailings Management Area

The objective of the tailings management area reclamation program is to isolate the tailings from the environment both during operations and over the long term. The tailings management and reclamation program were selected from several alternatives in a procedure designed to identify the optimum combination of siting and disposal technique in fulfilling the objective of the program.

The encapsulation and reclamation of the dewatered tailings, carried out concurrently with mining operations, will minimize the amount of tailings directly exposed to the environment during operations. The large amount of cover and the construction of the liners, berms and cap, all will provide the necessary protection for the long term without ongoing active maintenance.

The reclamation plan for the Swanson Project is an integral part of the mining, milling, and tailings management sequence. To minimize the area of tailings exposed to the environment, the management system was designed to employ gradual construction of an encapsulation containment. Dry tailings will be trucked to the area and placed on the clay liner, and then a low pressure, tracked vehicle will spread the tailings in about 1-foot lifts. When the tailings reach final depths and grades, a minimum of three meters of reclamation cap, plus a large quantity of mine overburden (25 to 40 feet) will be placed on top. This thickness of reclamation cover will effectively reduce direct gamma radiation from the tailings.

Radon emanation from the tailings also will be reduced by the reclamation cap and overburden covering to achieve safe levels required by regulatory standards. With the thick overburden cover above the three-meter-thick reclamation cap, the completed tailings management area will represent an earth and rock structure capable of withstanding erosional forces over the long term.

Seepage control will be accomplished by the use of a highly impermeable clay liner. Geotechnical tests have shown that this material can be compacted to a very low permeability. Additionally, seepage from the tailings management area will be minimized by reducing the infiltration of rainfall. Design and construction specifications of the reclamation cap and a controlled placement of mine overburden above the cap, coupled with a vegetation cover, will reduce the volume of rainfall entering the tailings mass to an estimated 1.7 inches per year. Migration of ground water into the tailings facility will be prevented by a granular construction pad which will effectively block any upward capillary movement of ground water.

The reclaimed, encapsulated and revegetated tailings area will be fenced and monitored after decommissioning. There will be no potential for access to or use of the tailings. However, with the huge amount of cover over the reclaimed filtered tailings, and resultant isolation from the environment, it is anticipated the tailings management could be returned to some compatible and beneficial use, provided such would be allowed by regulation.

G. MONITORING PROGRAMS AND ENVIRONMENTAL CONTROL

All licensed uranium processing facilities are required to conduct selfmonitoring programs to determine levels of contaminants and effluents in the surrounding environment. In addition, it is required that results of monitoring programs be submitted regularly to the licensing agency for determination of compliance with regulations and license conditions, and also to ascertain whether contaminants are increasing significantly over baseline levels.

In the absence of Virginia-based regulatory guidance, the proposed monitoring program is designed around the procedures outlined in U.S. NRC Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills". It also assumes certain requirements related to specific permits for the overall operation.

Should there be a discharge from the project operation, monitoring will be conducted at each discharge point in compliance with NPDES permit requirements. It is anticipated that the monitoring will, at a minimum, include natural uranium, radium-226, zinc, COD, pH, and total suspended solids.

Surveillance monitoring will include measurements of meteorology, ambient air, surface water, ground water, vegetation, food, fish, soils, sediment, and direct radiation. The purpose of the surveillance monitoring program is to determine the potential effect of mine and mill operations on ambient levels of radionuclides and chemicals.

The entire anticipated monitoring program is outlined in Table II-6. By the time the Swanson Project is licensed, it is possible that regulatory guidelines regarding monitoring could change, and additional requirements may be imposed by the Commonwealth of Virginia. Any such changes in the regulatory requirements will be incorporated into the monitoring program prior to licensing. Likewise, any changes made to the monitoring program after licensing will have the full concurrence of the licensing entity, and will be formalized in a licensed amendment.

Section C, Volume 1a of the October 15 report is devoted entirely to the discussion of operational monitoring.

TABLE II-6

OPERATIONAL MONITORING PROGRAM[1]

TYPE OF SAMPLE	LOCATION	FREQUENCY
	(EFFLUENT)	
Air Particulates	Yellowcake Dryer	Quarterly
Air Particulates	Other Stacks	Semi-Annually
	(ENVIRONMENTAL)	
Surface Water[2]	Mill Site	Continuous
Air Particulates	Several, including nearest residence and control	Weekly filter change
Radon	Same as air particulates	Continuous, quarterly, composite
Ground Water[3]	Tailings area, existing wells, mine area, control	Quarterly
Surface Water[4]	Project area, upstream and downstream	Quarterly
Vegetation, Food, Fish[5]	Area of influence	Grab, as appropriate
Soil	Same as air particulate	Annually
Sediments	Same as surface water	Annually
Direct Radiation	Same as air particulates	Continuous, quarterly change of dosimeters

Notes
1. Most analyses include uranium, Th-230, Ra-226, Pb-210 and PO-210; heavy metals requirement to be determined.
2. Includes Zinc, COD, pH, TDS, and flow.
3. Some samples include a battery of chemical/physical parameters.
4. (Same as 3)
5. Includes tobacco, livestock, and dairy products.

H. WORKER HEALTH AND SAFETY

A radiological safety program has been designed to be responsive to U.S. NRC Regulatory Guide 8.3, "Health Physics Surveys in Uranium Mills". Radiation safety programs are necessarily tied to the design and operation of the mill complex. As such, the program reflects the presently anticipated project engineering design, but will be modified as appropriate to incorporate any changes in the final design. A basic tenet of the worker health safety program is to learn from operating experience and to improve procedures as the life of the operation progresses; such is especially beneficial during the first two years of operation.

Health concerns during the operation of a typical uranium mill relate primarily to various forms of airborne radioactivity. This radioactivity may be in the form of dust created by grinding and crushing of ore, and also from the drying and packaging area for the uranium concentrate. In addition, radon-222, which is an inert radioactive gas emanating from radium-bearing ore, can create potential health hazards if present in high concentrations.

Therefore, one of the primary objectives of a radiological safety program is to minimize releases of airborne radioactive materials; if releases do occur, either routinely or accidentally, to minimize the exposure of workers to these potentially hazardous materials. Aerosols and dust are routinely controlled by mist eliminators, scrubbers, or baghouse filters.

To minimize the inhalation or ingestion of yellowcake dust by workers, the drying/packaging section of the mill requires careful dust control via hoods, dust collectors, and scrubbers. The entire drying section typically is contained within a separate enclosure with its own dust control system.

An integral part of the radiation safety program is effective personnel training and proper practices and procedures. All mill employees, including administrative and clerical, will be subjected to appropriate levels of training to ensure they understand the potential hazards associated with their particular tasks. Periodic refresher training also is part of the program. The mill radiation safety officer, qualified by virtue of his training and experience, is responsible for the employee training program and for implementing and enforcing the overall radiation safety program.

The radiological monitoring program is divided into restricted area and personnel monitoring. Areas where external radiation, airborne particulates (radionuclides), and radon can be generated, and where the unprotected worker could be exposed, are referred to as restricted areas. In a more general sense the entire mill area often is referred to as a restricted area.

Gamma radiation surveys will be performed semi-annually throughout the mill at locations representative of where workers are exposed. If the survey reveals any areas accessible to personnel where the exposure rate is high enough that a major portion of the body of an individual could receive a dose in excess of 5 millirems (mrem) in any one hour, or a does in excess of 100 mrem in any five consecutive days, the area will be designated a "radiation area".

Airborne particulate sampling will be conducted for natural uranium in dust within specified areas. The data collected will be used to estimate personnel exposure to these airborne contaminants. Routine breathing zone air samples will be collected for precipitation and crusher operators. Non-routine breathing zone air samples will be collected on workers performing tasks that may result in exposures approaching regulatory limits. Airborne particulate sampling also will occur during nonscheduled maintenance activity, especially when associated with the yellowcake filter, drying and packaging areas. Respirators will be required if the radiation safety officer deems that levels of radioactive material may be present in an amount that could cause a significant increase in exposure.

Above-background concentrations of radon-222 and its daughter products may occur near ore storage bins, crushing and grinding circuits, or any location where large quantities of ore are found, particularly dry ore. Radon daughter concentrations, rather than radon gas, are measured to provide the best indicator of worker dose. These measurements are routinely made on a monthly basis, except in areas where elevated concentrations are detected, in which case measurements are made weekly until concentrations return to acceptable levels.

Certain mill workers, by virtue of the direct radiation levels in locations where they work, will be required to wear personnel radiation dosimeters, which typically contain thermoluminescent detectors, referred to as TLD's.

Individuals working in the yellowcake processing and ore crushing sections of the mill will be required to participate in a bioassay program which includes urinalysis and whole body counting. Urinalysis will determine the concentration of the more soluble components of yellowcake and uranium ore components in body fluids, while whole-body counting assesses the quantity of insoluble yellowcake in the lungs. In addition, urinalysis will be conducted on an as-needed basis for those individuals involved in nonscheduled maintenance requiring the use of a respirator.

Yellowcake or ore dust lying on surfaces can become re-suspended and contribute to the intake of radionuclides. In ore handling areas, surface contamination generally is not a significant problem because of the very low specific activity of the ore. If clean-up is deemed necessary by the radiation safety officer, hosing down the area with water or using a vacuum system will prevent resuspension of the dust. In the precipitation circuit and in the yellowcake drying and packaging areas, surface contamination can be a problem because of the concentrated nature of the yellowcake. To aid in visual surveys of such areas, surfaces where yellowcake may accumulate will be painted in contrasting colors. Visible yellowcake will be removed promptly, especially where contamination could be resuspended or scattered to other areas.

In areas where uranium concentrate is not produced, such as eating rooms, change rooms, control rooms and offices, a lower level of surface contamination must be maintained. These areas will be spot checked weekly for removable surface contamination using smear tests. The areas will be promptly cleaned if surface contamination exceeds permissible levels.

Contamination of skin and personal clothing will be controlled to prevent the spread of contamination to unrestricted areas. Alpha radiation emanating from such radioactive material is not a direct hazard due to the low penetration of alpha particles. Rather, such radionuclides are primarily a hazard if they are inhaled or swallowed. Therefore, workers will be required to refrain from eating and drinking in work areas, wash their hands before eating, and will not wear street clothes while working with yellowcake in the mill. Prior to leaving the restricted area, anyone who has worked with yellowcake during the day either will shower or undergo monitoring after changing clothes. An alpha survey instrument will be available at the exit of the employee change room, or at the mill area exit.

Any equipment leaving the restricted area will be surveyed to determine levels of radioactive contamination. If contamination above permissible limits is detected, the equipment will be decontaminated to acceptable levels before leaving the mill area.

Worker health and safety is discussed in more detail in Section E.2.7, Volume 2, of the main report.

III. THE PROJECT SITE

A. OVERALL SUITABILITY

The project area was evaluated based on plans which call for an open pit mine, conventional mill, and tailings management area. The site suitability assessment included descriptions of environmental and socioeconomic characteristics of the local area and project region. Conclusions and salient points included the following:

- Permeability in the underlying crystalline and sedimentary rocks is low, thereby restricting ground water flow, the spread of contamination and the depletion of ground water resources.

- Net precipitation in the region will facilitate reclamation, and minimize dust and radon emanation.

- The location of the project in rural Pittsylvania County minimizes the number of people in the project influence area.

- Numerous studies were conducted to assess suitability of the selected tailings management site in conjunction with management/reclamation techniques; all of the findings demonstrated overall suitability of the site as a tailings management area.

- Archaelogical, meteorological, surface water, ground water, biological, demographic, and land use studies all indicated the intended use of the selected site is compatible with these environmental and social components.

- There is an adequate local labor pool from which the project can be staffed.

- There exists sufficient excess capacity in local social services to accommodate additional people and a new industry.

- No endangered plant or animal species were located in the study area.

B. CHARACTERISTICS OF THE EXISTING ENVIRONMENT

1. Climatology

In the project region, January is the coldest month of the year, when mean temperatures range from 35-38°F (2-3°C). July is the warmest month of the year, with a mean temperature of 75-78°F (24-26°C). Mean annual precipitation in the general region varies from 39.4 to 45.0 inches. During most winters, all of the snowfall in this region occurs during November through March, and varies from 11.4 inches to 16.5 inches.

In early morning, there is a high frequency of surface inversions during all seasons of the year, with a maximum occurrence in the fall. The majority of late afternoon inversion base heights occurs above the surface. Surface-based inversions are observed most often in fall and less frequently in summer. Inversions with bases from the earth's surface to approximately 10,000 feet were most frequently observed during winter and least often noted in summer.

The large scale wind configuration over Virginia in the winter is generally disorganized, though there is evidence of a synoptic scale westerly or northwesterly wind pattern over the state. During the spring and summer, there is a large scale southerly flow. In the fall, the flow is ill-defined, though weak northerly or northeasterly winds predominate. On an annual basis, southwesterly flow predominates in this region.

Data for Danville show a tri-modal wind distribution for the annual period. The primary maximum occurs with winds from the southwest, while northeast and northwest winds constitute secondary maxima. Average wind speed at Danville is 7.1 mph.

Two meterological monitoring stations were established to collect site specific data from August 1 through September 8, 1983. One station was located 500 feet south-southeast of the intersection of State

Roads 690 and 683, and the other one-half mile east of State Road 914, 500 feet northeast of State Road 686. The northern site has been discontinued while the southern site continues to operate as part of the ongoing Umetco baseline program.

The southern station contains instruments to measure wind speed, wind direction, atmospheric stability, temperature, relative humidity, and precipitation. Comparison of data from this station with historical records is difficult due to the short interval over which measurements have been made. Climatology is discussed in great detail in Volume 1, Sections A.5.2, A.5.3, A.5.5, A.5.6; and Volume 1a, Section B.3.1 of the October 15, 1983 report.

2. Air Quality

The criteria pollutants regulated by the State of Virginia are sulfur dioxide (SO_2), total suspended particulates (TSP), carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2) and lead (Pb). Of these, only TSP is measured by the state in Virginia Air Quality Control Region (VAQCR) III, which includes the project region.

These data show that neither the primary nor secondary annual, or 24-hour, TSP standards were violated in VAQCR III during the first quarter of 1983, or for the preceding 12 months. The highest annual (geometric mean) concentration was 44 micrograms per cubic meter (ug/m^3). The lowest annual value, 27 ug/m^3, was observed in Farmville. The highest 24-hour value was 99 ug/m^3, noted in Lynchburg. Farmville recorded the lowest 24-hour concentration of 11 ug/m^3.

Though no data on the other criteria pollutants are available in VAQCR III, it can be inferred that CO, NO_x, O_3, SO_2 and Pb values are very low due to the absence of major industry and the rural nature of the region.

A high-volume air sampler was placed at the southern meterological station to collect site-specific TSP data during August 1 - September 15, 1983, and the sampler continues to operate to the present time. Data taken during that period show the following:

Period	TSP Concentration (ug/m^3)
August (mean)	48.7
August (maximum)	58.3
September (mean)	54.6
September (maximum)	75.8

The Virginia 24-hour ambient TSP standard is 160 ug/m^3. For more discussion on regional and site-specific air quality, see Sections A.5.4, A.5.7 (Vol.1) and B.3.1 (Vol. 1a) of the main report.

3. Geology

a. Geomorphology

The Swanson Uranium Project is located in the Piedmont province, which is typified by rolling terrain made up of broad-crested, concordant ridges which form the interfluves between shallow, alluvial-floored valleys. The major landscape features in the project are influenced largely by the underlying bedrock. In the area to the northwest of the Chatham fault zone, the landscape is underlain by Precambrian and Paleozoic age crystalline rocks, and the topography is typical of that commonly found throughout the Piedmont. Bedrock in the Danville Triassic basin to the southeast of the Chatham fault zone is made-up of sedimentary rock, and the topography is considerably different from that of the crystalline terrain to the northwest.

b. Bedrock Stratigraphy

Regional geologic mapping for the project area indicates that Late Precambrian and Early Paleozoic age crystalline rock are present to the northwest of the Chatham fault zone, and that Triassic sedimentary rocks are present in the Danville basin, which lies to the southeast of the fault zone. North-trending diabase dikes of Jurassic and Late Triassic age cut both the older crystalline rock and the Triassic sedimentary rock.

c. Structure

The principal structural feature in the project area is the Chatham fault zone which separates the Triassic basin from the crystalline terrain. The geologic structure in the crystalline terrain to the northwest of the Chatham fault zone is very complex as a result of past events which have involved folding, large scale over-thrusting and metamorphism. In comparison, the structure of the Danville Triassic basin to the southeast of the Chatham fault zone is somewhat less complicated.

d. Surficial Deposits

Rock outcrops in the project area are rare and usually are present only within the drainage channels. The surficial deposits covering bedrock in the project area consist primarily of relatively deep saprolite in the crystalline terrain, relatively thin residual soils in the Triassic basin, and alluvium along the Banister River valley floor and along the valleys of the principal tributaries. Pedologic soil development has altered the surficial deposits to varying degrees near the ground surface.

e. Seismic Exposure

Relative to other areas in the United States, south central Virginia is considered to have a moderate potential for seismic activity. The largest earthquakes recorded in the region have had Modified Mercalli intensities of VIII in their epicentral areas. Only two such earthquakes have been reported in the region since 1737.

The project site is located in Source Zone 099 which has had comparatively low seismic activity. Source Zone 099 covers much of the Piedmont and Coastal Plain adjacent to the Atlantic coast. A few small earthquakes have occurred in Seismic Zone 099, within 200 miles of the Swanson Project site; however, none of these earthquakes had epicentral intensities greater than MM V.

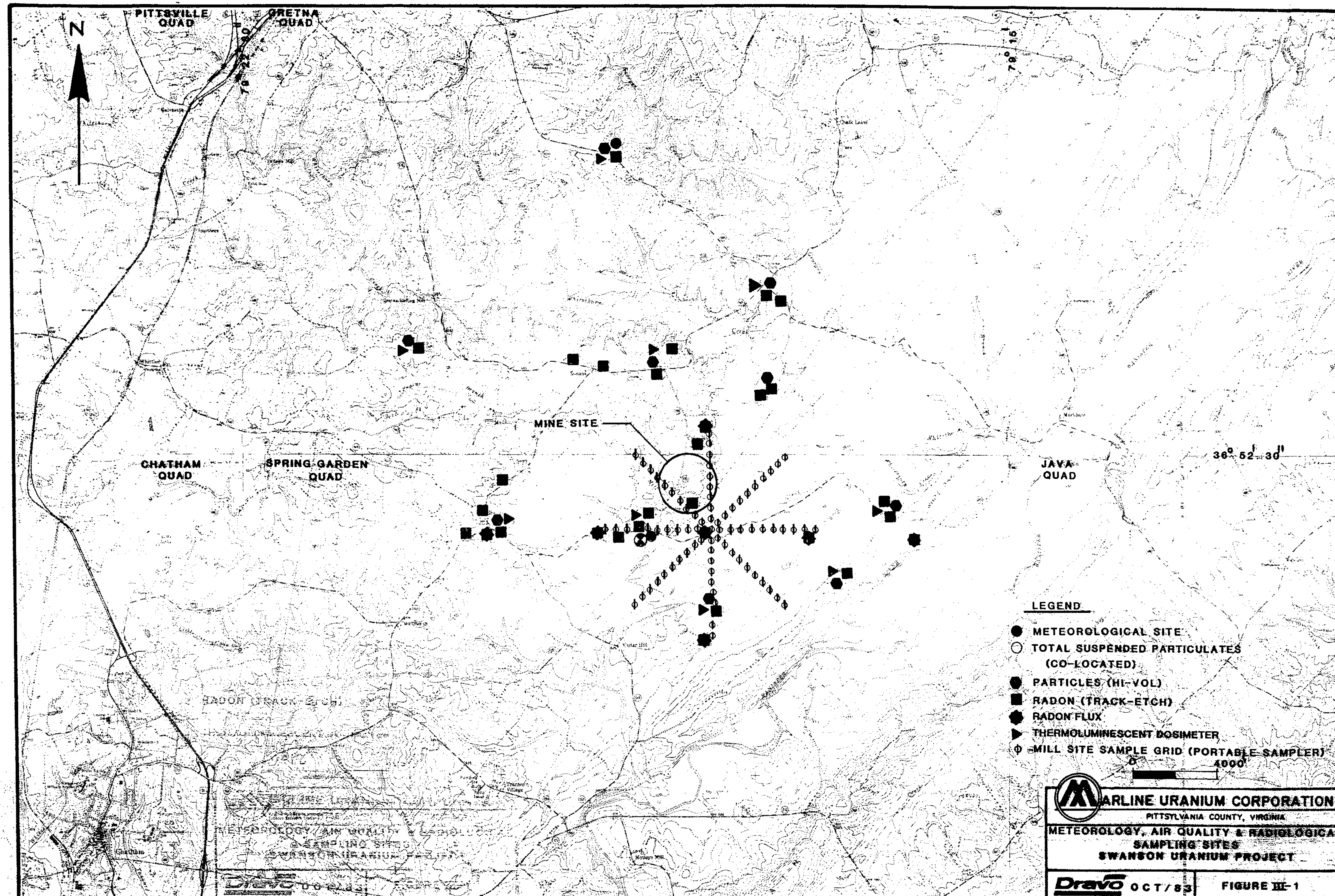
Historic seismic activity in the region does not appear to be associated with the Chatham fault zone, and geologic field relationships indicate that major movement has not occurred on the fault during the last 163 million years. These observations suggest that the fault zone is not a capable fault according to current Nuclear Regulatory Commission criteria. Refer to Technical Memorandum No. 3 attached to this summary for additional discussion of site seismicity.

Extensive discussions on area geology can be found in the October 15 report in Sections A.3 (Vol. 1) and E.1.2 (Vol. 2).

4. Radiological Characteristics

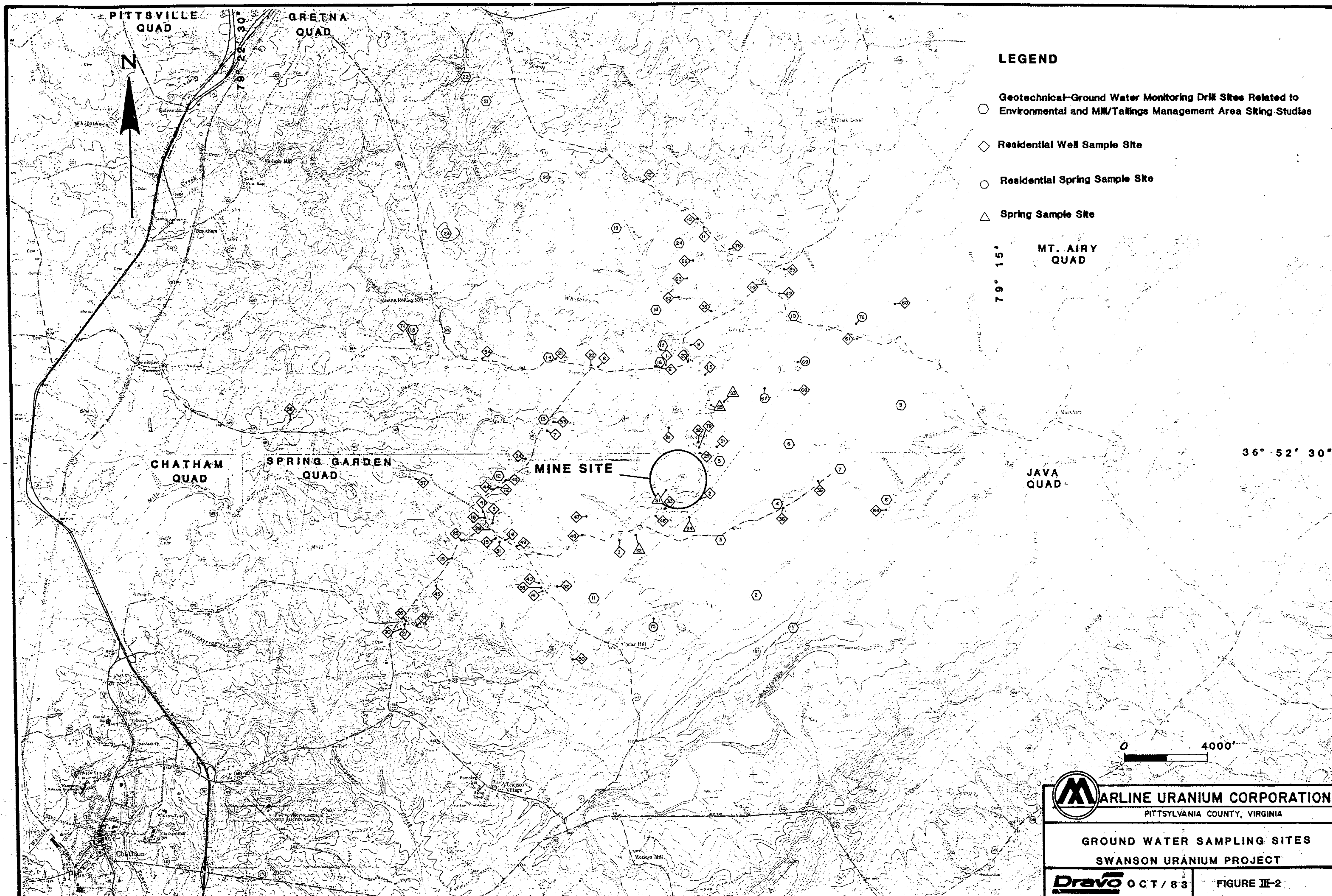
All sampling locations for the radiological, as well as for the non-radiological, monitoring programs are shown on Figures III-1 through III-4. A synopsis of all radiological data is presented in Table III-1. In addition, the October 15 report should be consulted for details regarding the radiological sampling program (see Sections A.6.3, Vol.1; A.9.3, Vol. 1; B.3.2,Vol. 1a; and Appendix VIII, Vol. 6).

The radiological data presented herein were collected during the summer and fall of 1983. A radiological monitoring program based on Regulatory Guide 4.14 will continue through September 1984.

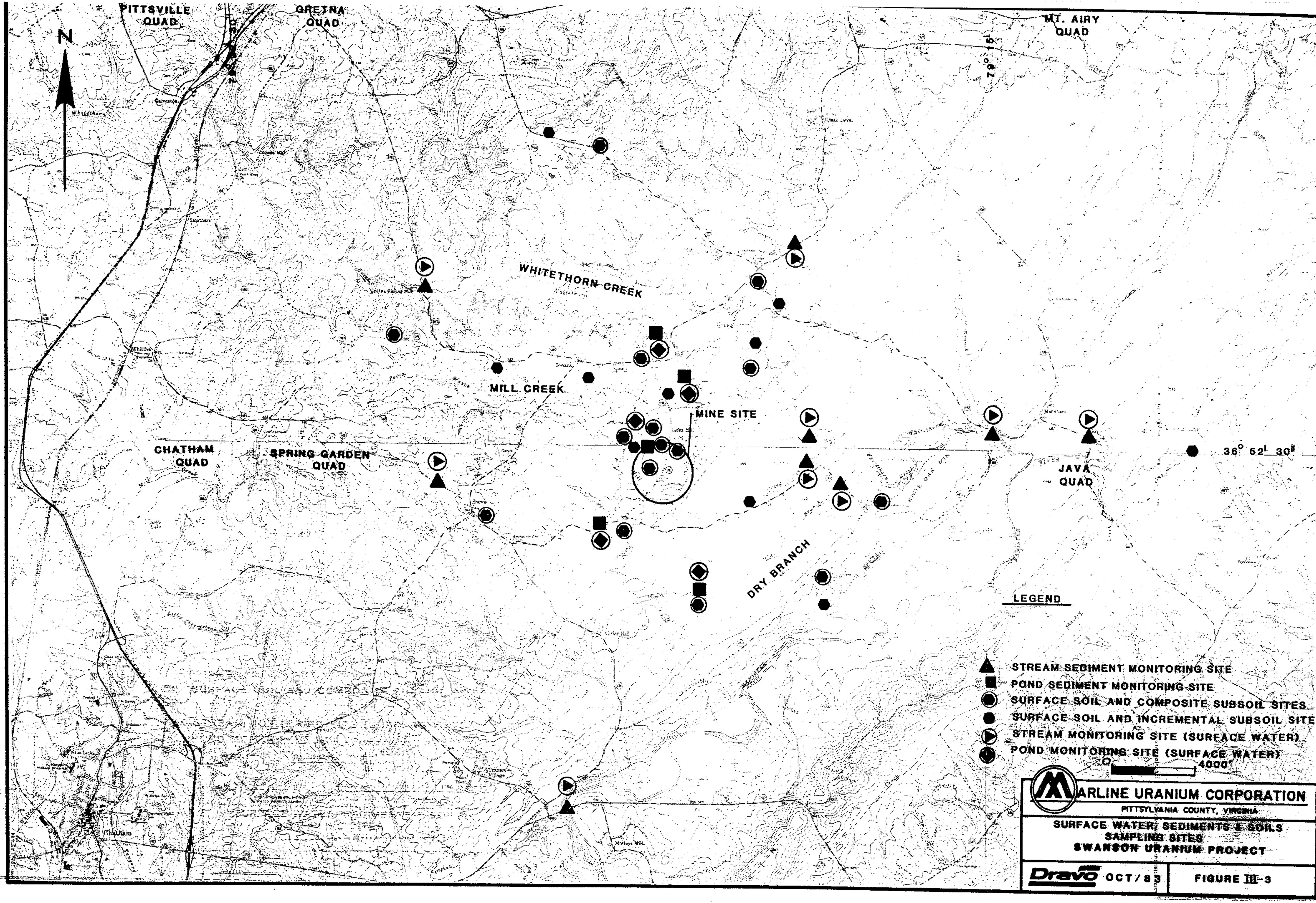


METEOROLOGY, AIR QUALITY & RADIOLOGICAL SAMPLING SITES
SWANSON URANIUM PROJECT

FIGURE III-1



PITTSVILLE QUAD
GRETNA QUAD
79° 22' 30"
N
LEGEND
Geotechnical-Ground Water Monitoring Drill Sites Related to Environmental and Mill/Tailings Management Area Siting Studies
Residential Well Sample Site
Residential Spring Sample Site
Spring Sample Site
79° 15'
MT. AIRY QUAD
CHATHAM QUAD
SPRING GARDEN QUAD
MINE SITE
36° 52' 30"
JAVA QUAD
0
4000'
MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA
GROUND WATER SAMPLING SITES
SWANSON URANIUM PROJECT
Dravo
OCT/83
FIGURE III-2


N
PITTSVILLE QUAD
GRETNA QUAD
MT. AIRY QUAD
79° 15'
WHITETHORN CREEK
MILL CREEK
MINE SITE
CHATHAM QUAD
SPRING GARDEN QUAD
JAVA QUAD
36° 52' 30"
DRY BRANCH
LEGEND
STREAM SEDIMENT MONITORING SITE
POND SEDIMENT MONITORING SITE
SURFACE SOIL AND COMPOSITE SUBSOIL SITES
SURFACE SOIL AND INCREMENTAL SUBSOIL SITE
STREAM MONITORING SITE (SURFACE WATER)
POND MONITORING SITE (SURFACE WATER)
0
4000'
MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA
SURFACE WATER, SEDIMENTS & SOILS
SAMPLING SITES
SWANSON URANIUM PROJECT
Dravo
OCT/83
FIGURE III-3

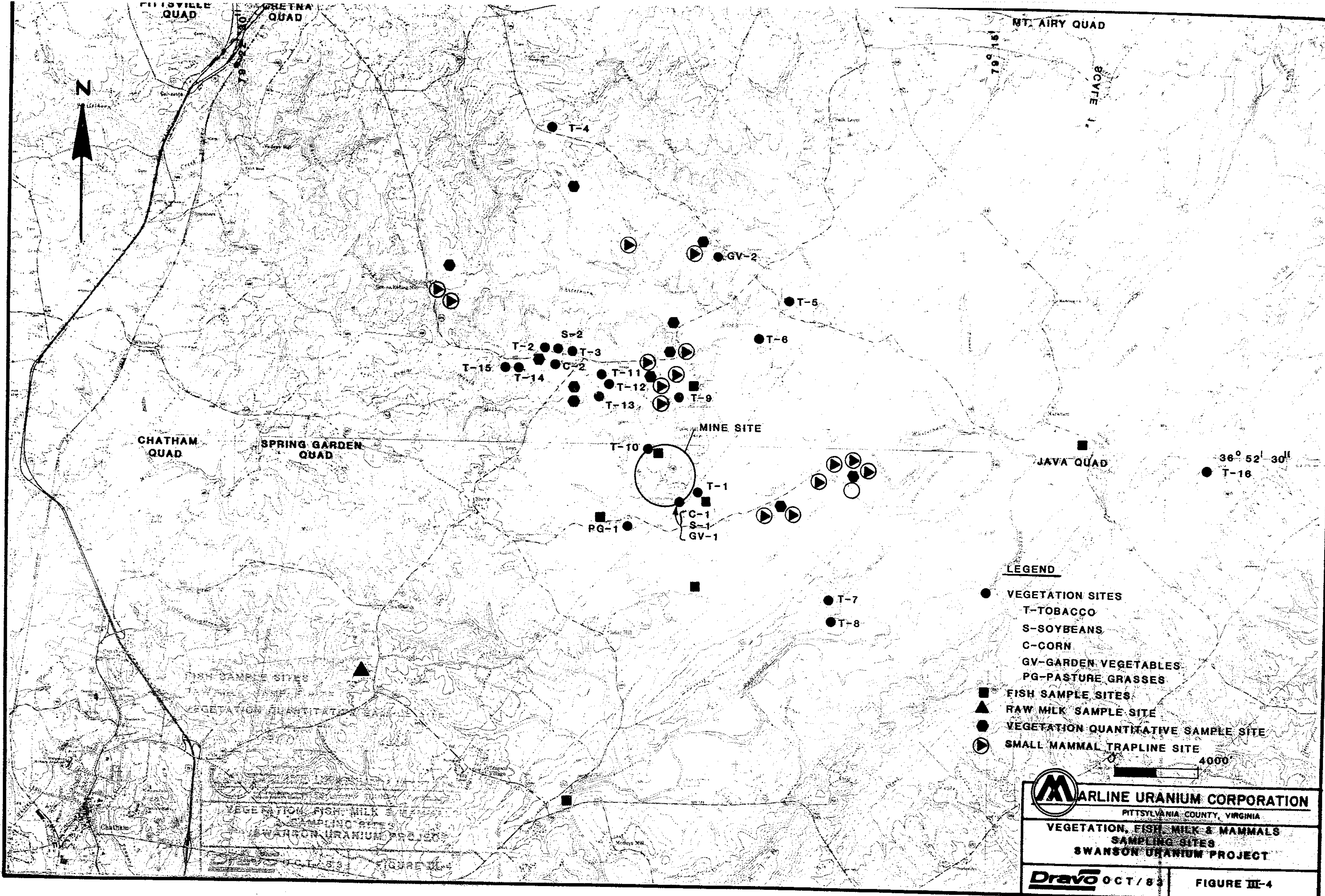

PITTSVILLE QUAD
GRETNA QUAD
MT. AIRY QUAD
79° 22' 30"
79° 15'
SCALE 1:
N
T-4
GV-2
T-5
T-6
S-2
T-2
T-3
C-2
T-15
T-14
T-11
T-12
T-13
T-9
MINE SITE
T-10
T-1
C-1
S-1
GV-1
PG-1
CHATHAM QUAD
SPRING GARDEN QUAD
JAVA QUAD
36° 52' 30"
T-16
T-7
T-8
LEGEND
VEGETATION SITES
T-TOBACCO
S-SOYBEANS
C-CORN
GV-GARDEN VEGETABLES
PG-PASTURE GRASSES
FISH SAMPLE SITES
RAW MILK SAMPLE SITE
VEGETATION QUANTITATIVE SAMPLE SITE
SMALL MAMMAL TRAPLINE SITE
0
4000'
MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA
VEGETATION, FISH, MILK & MAMMALS
SAMPLING SITES
SWANSON URANIUM PROJECT
Dravo
OCT/83
FIGURE III-4

TABLE III-1

SUMMARY OF RADIOLOGICAL DATA[1]

Type of Sample	U-nat	Th-230	Ra-226	Pb-210	Po-210
Air Particulates (uCi/ml x 10^{-17})	5.1 - 23.0	9.4 - 34	0.9 - 4.8	13 - 583.0	1.1 - 136.0
Surface Water[2] (Whitethorn Creek)	<0.0005 - 0.0009 (mg/l)	0.1 - 0.4	0 - 0.39	0 - 0.07	0.1 - 1.0
Surface Water (Mill Creek)	<0.0005 - 0.0008 (mg/l)	0.1 - 1.3	0.2 - 0.34	0.3 - 1.3	0.1 - 0.5
Surface Water (Banister River)	<0.0005 - 0.0004 (mg/l)	0.1 - 0.5	0.1 - 0.4	1.1[3]	0.1[4]
Surface Water (Ponds)	<0.0005 - 0.0013 (mg/l)	0 - 3.1	0 - 0.26	0.2 - 0.7	0 - 0.6
Ground Water	0.0003 - 0.0028 (mg/l)	0 - 0.3	0 - 1.3	(no data)	0 - 0.1
Soils (pCi/g)	0.6 - 28.3 (ug/g)	0.3 - 16.0	0.08 - 9.6	0.1 - 11.0	0 - 9.3
Sediments (pCi/g)	0.8 - 1.2 (ug/g)	0.7 - 1.2	0.4 - 0.8	0 - 0.9	0 - 1.9
Tobacco (pCi/kg)	1.0 - 44.5	9.5 - 93.0	1.0 - 125.0	22.0 - 223.0	0.5 - 55.0
Fish (wet basis; pCi/kg)	0.02 - 19.0	0.4 - 17.6	0.04 - 10.3	0.7 - 28.7	0 - 34.0

Direct Radiation (TLD's)	1.49 - 2.09 mrem/week
Radon Concentration (environmental)	0.32 - 0.86 pCi/l
Radon Concentration (indoors)	0.45 - 8.5 pCi/l
Radon Flux	0.37 - 1.80 pCi/m^2sec

NOTES

(1) Data are expressed as ranges of all measurements; in liquid media, values represent total concentration, i.e., suspended plus dissolved.
(2) Surface and ground water radionuclides in pCi/l.
(3) Only one sample.
(4) Two samples, both the same.

a. Airborne Radioactivity

The monitoring program for airborne radioactivity included sampling for airborne particulates, radon gas, and radon flux. High-volume (hi-vol) samplers were located in areas of probable maximum downwind impact, at nearest residences, at boundary sites, and at a control location. Radon and direct radiation were monitored at each of the high-volume sampling locations. Direct radiation and radon flux were measured along sampling routes which reflected the location of the mill site.

Particulates

The baseline study included nine continuous high-volume sampling sites for monitoring airborne radioactive particulates. Following is a summary of average airborne particulate radioactivity levels:

Natural Uranium	14.2×10^{-17} uCi/ml
Th-230	15.3×10^{-17} uCi/ml
Ra-226	4.1×10^{-17} uCi/ml
Pb-210	96.3×10^{-17} uCi/ml
Po-210	30.9×10^{-17} uCi/ml

Radon

Radon was monitored continuously at ten locations, plus indoors in three types of residential structures. Track-etch detectors were exposed for 43 to 58 days during this program; readings ranged from 0.32 to 0.86 pCi/l outdoors and 0.45 to 8.50 pCi/l indoors.

Radon Flux

Radon flux measurements were made at the center of the milling area and at locations 750 and 1500 meters from the center of this area, in each of the four primary compass directions. The data indicate that radon emanation ranges from 0.37 to 1.80 pCi/m^{2}sec, with an average value of 0.98 pCi/m^{2}sec.

b. Direct Radiation

Direct radiation measurements were made at each of the 10 high-volume sampler site locations, utilizing thermoluminescent dosimeters (TLD). In addition, measurements of direct radiation were made on two occasions utilizing a portable gamma exposure rate meter.

There was very little variation in direct radiation measurements among sites. The average weekly dosimeter reading at all sites was 1.69 mrem/wk.

This translates to an annual dose rate of 88 mrem/yr, which compares to national background radiation levels of 95-165 mrem/yr.

An instantaneous gamma radiation survey was conducted around the proposed mine site. Background gamma levels generally were 20 uR/hr or less. The highest instantaneous readings were observed on uranium deposit outcrop areas, with levels recorded as high as 100-150 uR/hr.

A gamma survey was conducted about the selected mill site. Here also, background levels were 20 uR/hr or less. The maximum reading of 70 uR/hr was recorded approximately 1500 meters north of the mill site in a uranium deposit outcrop area.

c. Waterborne Radioactivity

The surface water monitoring program for radionuclides utilized samples from ten streams and five ponds in the project area. These samples were analyzed for natural uranium, thorium-230, radium-226, radium-228, lead-210, polonium-210, gross alpha, and gross beta. All samples were analyzed for suspended and dissolved constituents. The highest observed gross alpha value from the stream stations was 1 pCi/1 (suspended and dissolved combined). This value was found at several of the stations. The highest observed gross alpha value from the pond stations was 4 pCi/1. The highest observed concentration of combined radium-226 and radium-228 at the stream stations was 1.43

pCi/1. The highest observed concentration of combined radium in ponds as 2.6 pCi/1.

The ground water program included the sampling of 86 existing potable water supply wells and springs in the project area, plus the drilling and installing of 24 water wells for additional sampling. The radiological parameters analyzed on a suspended and dissolved basis were natural uranium, radium-226, radium-228, thorium-230, lead 210, polonium-210, gross alpha and gross beta. The data indicate that elevated radionuclide concentrations occur only in the immediate area of the uranium orebody.

d. Soils and Sediment

Surficial and sub-surface soils samples were collected at 25 locations throughout the study area, and were analyzed for uranium, Ra-226, Th-230, Pb-210, and Po-210. The highest radionuclide concentrations were found in the area of the mineralized outcrop.

Bottom sediment samples were collected at all surface water monitoring stations, including ten stream sites and five pond sites. All samples were analyzed for uranium, Ra-226, Th-230, Pb-210, and Po-210. The data reveal a slight increase in the concentration of uranium at the downstream sites. This increase is very slight and is equal to the uranium values found in the surrounding soils. No increase was noted for other radionuclides at the downstream sites.

Pond sediments showed concentrations slightly higher than stream sediments and were comparable to surface and sub-surface soils. A pond directly downstream of the orebody outcrop had the highest concentration of radionuclides.

e. Vegetation

Tobacco leaf samples were collected in conjunction with soil samples at 13 sites in the study area. The samples, which represented leaf composites from approximately 15 individual plants at each site, were analyzed for Po-210, Pb-210, Ra-226, Th-230 and uranium.

Tobacco samples did not show a relationship between radioisotope concentrations and proximity to the orebody. Total uranium in the tobacco leaves generally varied from the lower limit of detection (1.0 pCi/Kg dry weight) to 49.5 pCi/Kg dry weight. Th-230 in the tobacco samples varied from 9.5 to 93.0 pCi/Kg; the two highest values came from a field in the western portion of the study area. Two of the highest values for Ra-226 also came from this site. These high values in samples located well away from he orebody suggest the possibility that they result from the use of phospate fertilizers. Overall, Ra-226 varied from the lower limit of detection of 1.0 pCi/Kg to 160 pCi/Kg.

Pb-210 in the tobacco tissues ranged from 26 to 223 pCi/Kg dry weight. Po-210 values ranged from the lower limit of detection of 0.5 pCi/Kg up to 55.0 pCi/Kg. Generally, the highest levels of Po-210 and Pb-210 were from samples in the Triassic area northeast and southeast of the orebody.

f. Fish

Samples of herbivores (carp and suckers) and predators (bass, sunfish, crappie, pickerel) were collected at two sites on the Banister River and five farm ponds in the project vicinity. Fish collected at each sample site were analyzed for whole body and edible portion (fillet) concentrations of natural uranium, Th-230, Ra-226, Pb-210, and Po-210.

Data for the two Banister River sites were similar overall, with some notable differences. Rather consistent values were found for Po-210 which was present at the lowest levels in the herbivore whole bodies, at intermediate levels in the predator whole bodies, and at the highest levels in the herbivore fillets. Results for the other radionuclides were quite varied, underscoring the apparent masking effect of sample exigencies such as age, diet, and movement patterns.

As with the two Banister River sites, the five farm ponds showed varied results. The two farm ponds located a short distance down--drainage from the uranium orebody did not show consistently elevated levels of any radionuclides, although Po-210 in one herbivore fillet sample was substantially higher than other values recorded for that radionuclide.

5. Heavy Metals

Several studies were undertaken to define levels of heavy metals present in the various environmental components. Table III-2 presents a summary of data derived from these investigations.

The values reported in Table III-2 reflect ranges over which the observations fell. Occasional anomolous or aberrant values were included for the sake of accuracy, but the vast majority of observations were well below the upper limits when a wide range of values existed. The entire data report on heavy metals can be found in the main report (Section B.3.5, Vol. 1a; and Appendix VIII, Vol. 6) in the event it is desired to examine individual data.

6. Ground Water

Ground water of the Pittsylvania County region originates from precipitation which falls on the land surface and infiltrates through rocks to fill voids below the water table. Ground water discharge from the zone of saturation supports the base flow of regional streams between precipitation events. Two major interrelated water-bearing units exist within the Pittsylvania County area. The lower of these consists of the consolidated bedrock, which yields variable quantities of water by means of open fractures within the rocks ("secondary"

TABLE III-2

SUMMARY OF METALS ANALYSES(1)
(ppm, total)

Metal	Soils	Sediments	Tobacco(2)	Fish(3)	Surface Water	Ground Water
Iron	6260 - 89500	4400 - 69000	33 - 417	20 - 292	0.24 - 3.6	0 - 0.81
Manganese	55 - 3100	29 - 1400	4607 - 289	2.19 - 40.2	0.01 - 0.35	0 - 0.37
Lead	14 - 190	3.8 - 1000	0.78 - 6.44	0.51 - 3.1	0(4)	0(4)
Zinc	11 - 118	7 - 93	7.9 - 41.4	3.7 - 88.9	0 - 0.009	0 - 0.04
Copper	3.8 - 18.8	3.8 - 7.8	2.04 - 12.4	0.58 - 1.11	0 - 0.01	0(4)
Cadmium	0.33 - 1.5	0.25 - 1.2	0.12 - 8.99	0.06 - 0.18	0 - 0.01	0(4)
Arsenic	0 - 55	0 - 29	0 - 0.2	0 - 0.46	0(4)	0(4)
Mercury	0 - 0.58	0 - 0.05	0.03 - 0.18	0.01 - 0.04	0(4)	0(4)
Selenium	0 - 0.05	0(4)	0 - 0.09	0.01 - 0.4	0 - 0.005	0(4)
Silver	0 - 1.5	0 - 0.58	0.25 - 0.65	0.07 - 0.85	0(4)	0(4)
Chromium	13 - 230	37 - 150	0.35 - 4.99	0.3 - 3.15	0 - 0.01	0(4)
Barium	41 - 670	14 - 230	3.9 - 31.1	0.9 - 5.6	0(4)	0(4)
Aluminum	6800 - 72800	2500 - 24000	391 - 1273	6.6 - 1235	0 - 1.5	0 - 2.3
Cobalt	0 - 91	1 - 22	0.34 - 2.18	0.4 - 1	0(4)	0(4)
Molybdenum	0 - 4	0 - 0.25	0 - 0.83	0 - 0.26	0(4)	0(4)
Nickel	2.3 - 78	3 - 38	1.23 - 3.48	0.3 - 0.9	0 - 0.02	0(4)
Vanadium	4 - 920	5 - 63	0 - 1.42	0 - 0.8	0 - 0.1	0(4)
Magnesium	(no data)	(no data)	1117 - 6682	51 - 633	0.78 - 2.7	0.62 - 160

NOTES

(1) Ranges of values found in the analyses
(2) Dry Weight basis
(3) Wet Weight basis
(4) All samples below level of detection

permeability). The rock itself has little in the way of "primary" permeability, i.e., permeability between individual grains within the rock units.

Ground water in the Pittsylvania County area generally occurs under "water table" conditions, in which the upper surface of the zone of saturation is at atmospheric pressure, and is not confined under impermeable geologic strata. The water table surface generally follows that of the land topographic surface. The water table intersects surface streams in the valleys, and is deeper under upland regions. Flow paths of ground water thus are quite short, generally from the crest of the ridge land to the adjacent stream valley. There are no "underground rivers" within the Pittsylvania County area, but rather the ground water occurs as a continuous saturated zone throughout the area. The yield of wells is highly variable, however, due to the variation in permeability of the saprolite (the weathered rock on top of bedrock) and the relative abundance of fractures in the underlying consolidated rock aquifer.

The saprolite overlying the consolidated bedrock is significantly more permeable than either the Triassic or Precambrian rocks. Ground water within the saprolite is generally somewhat acidic and contains water with very low concentrations of dissolved constituents. Depth to water table within the mine site is approximately 10 meters, decreasing to the south toward Mill Creek. Minor perched springs are located throughout the mine site area.

Depths to water throughout the Triassic basin area generally are less than in other portions of the study area due to decreased topographic variation observed in the Triassic basin rocks. Water table surfaces still mimic the topography, and depths to the water table commonly are two meters or less, especially in valley areas.

The saprolite aquifer is quite extensive throughout the crystalline rock area, with saprolite thicknesses of 30 meters or more not uncommon. Depth to water throughout the Precambrian region is highly variable depending on topographic conditions. Depth to water under ridges is commonly 20 meters, while the water table in the alluvium of valley areas is at or near the land surface. The saprolite generally yields usable quantities of ground water to individual bored wells by means of both fracture permeability and intergranular ground water movement.

Crystalline rocks within the Precambrian - Early Paleozic terrain have highly variable permeability depending on the abundance of fractures. The crystalline rocks generally yield excellent quality water, although it is usually somewhat higher in dissolved constituents than water in the overlying saprolite.

In general, there are interconnections between the crystalline rock units and the saprolite derived from them. Depth to the ground water (or piezometric) surface is generally greatest on the ridge lines, and least in the valley areas, which is typical of recharge and discharge portions of the ground water flow regime. Thus, infiltrating precipitation first recharges the saprolite aquifer on ridge lines, and then moves downward into the underlying crystalline rock. In the case of stream valleys, the crystalline rock units serve to supply water to the overlying saprolite aquifer, which in turn discharges to the stream.

Samples were taken from of 60 existing wells and springs in the project vicinity, and were analyzed for numerous water quality constituents, including pH, conductivity, temperature, major ions, metals, and nutrients.

This water proved generally to be of high quality, except for occasional wells which contained elevated levels of iron, manganese, and nitrates.

Numerous monitor wells were constructed or converted from geotechnical borings to provide water quality and quantity information. The series of wells included deep and shallow wells located both near and away from the proposed mine area, and also aquifer test wells. Prior to pumping these wells for samples, depth to water level was determined; these measurements then were translated into a piezometric surface contour map of the study area (see Figure B.3.4-3 of the October 15 report).

Samples from the monitor wells reinforced conclusions drawn from the study of existing wells and springs. The water quality is good except in selected areas of the Triassic basin where more saline waters are encountered. Water quality data are summarized in Table III-3, according to the geologic medium from which samples were taken.

There appeared to be a slight variation in water quality as a function of depth between the saprolite and consolidated rock aquifers in the Precambrian and Chatham fault area. Saprolite water has lower pH (slightly acid) and lower concentrations of dissolved solids.

Two separate aquifer tests were performed. The first was in the orebody and designed to provide information on the permeability of the Chatham fault zone and associated features. Permeability values of approximately 1×10^{-5} cm/sec were calculated from this test, which was completed successfully at low flow rates. The second aquifer tests was conducted in Precambrian rock north of the orebody, utilizing monitor wells along "fracture traces". This test revealed permeabilities of 1.2×10^{-3} cm/sec.

Ground water and aquifer tests are discussed in more detail in the October 15 report (Section A.4.2, Vol. 1; B.3.4, Vol. 1a; E.1.7, Vol. 2; and Appendix IV, Vol. 5).

TABLE III-3

RANGES OF GROUND WATER QUALITY PARAMETERS FOR GEOLOGIC MEDIUM (mg/l)

PARAMETER	SAPROLITE	PRECAMBRIAN	FAULT ZONE	TRIASSIC
TDS	30 - 140	66 - 190	88 - 140	140 - 1535
Bicarbonate	10 - 130	20 - 140	36 - 130	100 - 499
Sulfate	5	5 - 16	5 - 10	5 - 781
Chloride	3	3 - 6	3	4 - 17
Sodium	2 - 10	1.5 - 7.9	6 - 17	9 - 99
Potassium	0.4 - 3	0.4 - 3.4	0.4 - 1.8	2.8 - 22
Calcium	1 - 23	3.5 - 23	1.3 - 25	20 - 120
Magnesium	0.3 - 5.5	0.6 - 12	0.6 - 3.1	5 - 160
Iron	0.01	0.01 - 0.09	0.01 - 0.09	0.01 - 0.02
Manganese	0.005 - 0.37	0.01 - 0.28	0.005 - 0.45	0.01 - 0.072
Zinc	0.005	0.005 - 0.009	0.005 - 0.057	0.005 - 0.01
Nitrate	0.08 - 0.94	0.17 - 0.96	0.07 - 1.2	0.05 - 1.3

7. Surface Water

In the Precambrian crystalline terrain northwest of the Chatham fault zone, the drainage pattern is highly branched. The principal streams in this area meander through relatively flat alluvial valleys in which the floor width varies from 300 to 1500 feet. In the Triassic basin, drainage channels have not incised significantly below adjacent terrain, except where the streams cross hogback ridges that parallel the northeast strike of the sedimentary beds. Here, a trellis drainage pattern characterizes this broad, flat area of the Triassic basin.

The principal streams that drain the project area are Dry Branch, Mill Creek, and Whitethorn Creek. These channels flow generally in a southeast direction. Dry Branch and Mill Creek are tributaries to Whitethorn Creek, which joins the Banister River about three miles downstream from the project site. The Banister River follows the Triassic basin northeast for about seven miles and then resumes a drainage course southeast to John H. Kerr Reservoir, where it joins the Roanoke River.

Ground water and surface water resources in the project area are closely interconnected. Peak stream flows occur as result of surface runoff during precipitation events. Ground water is discharged continuously and gradually to surface streams. Hence, the baseflows of waterways in the project area are maintained by ground water inflow. On an average annual basis, approximately six inches of the 42 inch annual rainfall appears as direct runoff in the project area. Since the average annual amount of streamflow leaving the project area is about 14 inches, the remaining 8 inches is supplied by ground water baseflow.

The annual average flow in the project area is about 1 cubic foot per second (cfs) per square mile of watershed area. On a monthly basis, however, the average streamflows exhibit typical seasonal fluctuations with peaks in early spring and low flows observed in late summer. Flood flows occur during intense rainfall events. Low flows in the project area are influenced by drainage area, geology, and streamflow regulation by reservoirs, mills, and irrigation practices.

It is estimated that the six-hour probable maximum precipitation (PMP) at the project site is 29 inches of rainfall. Preliminary analysis of flooding potential indicates that the probable maximum flood (PMF) will approach 5000 cfs per square mile in the project area. The probability that a PMF will occur during the proposed 13-year operation of the project is 0.13 percent.

The U.S. Geological Survey (USGS) operates two surface water quality monitoring stations in the project area. One of these stations is located on the Dan River near Paces, and the other one is on the Roanoke River near Altavista. Between the months of October, 1980 and September, 1981, seven samples were collected on the Dan River, and eight samples were collected on the Roanoke River. Total dissolved solids and pH are within the standards for public drinking water supply. There are no state standards for the other parameters, but these parameters are well within the limits necessary to produce high quality water.

Since 1972, the State Water Control Board (SWCB) has had three water quality monitoring stations on the Banister River, two of which ceased operation in 1979. Water samples from these stations have been analyzed for metals, residues (solids), nutrients, bacteria, and field measurements (pH, dissolved oxygen, conductivity, temperature). Most of the metals were below detection limits, although some lead, iron and manganese were present in low concentrations. No measureable levels of organic parameters were recorded.

A surface water sampling program was initiated in the project area in July, 1983 to define existing water quality and flow characteristics. Stream monitoring locations were above and below all potential disturbance areas for each drainage, and downstream of the mineralized outcrop. Overall there were ten stream sites and five pond sites, each sampled during July and August; results are presented in Table III-4.

Total dissolved solids were low at all sites, although ponds had higher levels than streams; most metals were at or below the level of detection. The major anion is bicarbonate (HCO_3^-) and 90 percent of the cations are represented by calcium, magnesium, and sodium.

No laboratory analyses revealed water quality parameters that exceeded the National Interim Primary Drinking Water Standards. However, iron, manganese, and phenols exceeded the Virginia standards at several sites.

The summer of 1983 was unusally dry in the project region, and stream flows were low. The flow of Whitethorn prior to its confluence with Mill Creek was measured at 6.12 cfs. The seven-day, ten-year low flow ($Q_{7,10}$) of Whitethorn is estimated to be 6.0 cfs. Because of these low flow conditions, most water quality components were assumed to be at their highest natural concentrations.

More detail on surface water aspects can be found in the main report in Sections A.4.3 (Vol. 1), B.3.3. (Vol. 1a), E.1.6 (Vol. 2), E.3.7 (Vol. 2), and Appendix VIII (Vol. 6).

8. Soils

Most of the soils in Pittsylvania County located on slopes of less than seven percent are classified as prime farmland, although they are considered to have low fertility because of acid parent rock material and many years of intensive crop production. Pittsylvania County and many of the surrounding counties are considered to have an erosion problem, with an average annual soil loss of 16 tons/acre. This high erosion rate is caused by the predominance of row crops, which do not

TABLE III-4

RANGES OF VALUES OF KEY CONSTITUENTS AND PARAMETERS MEASURED AT SURFACE WATER MONITORING SITES
(mg/l unless otherwise indicated)

Field pH	6.9 - 9.6
Conductivity (umhos/cm @ 25°C)	64 - 81
Total Dissolved Solids	12 - 64
Alkalinity	11 - 43
Hardness	7 - 25
Bicarbonate	12 - 45
Calcium	1.4 - 6.3
Magnesium	0.045 - 2.7
Manganese (soluble)	0.005 - 0.082
Sodium	2.0 - 5.5

provide enough vegetation cover to protect the soil from wind and rain. In areas with adequate vegetation cover (i.e., pastures, forests), high erosion rates are not encountered.

All the upland soils in the county are residual, being formed from the underlying parent material. Most of the country is underlain by Precambrian and Paleozic granite, gneiss, and schist. A thin bank of Triassic sedimentary rock extends through the county and passes through the project area.

Soil series found in Pittsylvania County are the Cecil, Louisa, Durham, Appling, Davidson, Iredell, Wilkes, Granville, Penn, Lehigh, Wadesboro, and White Store. The four major soil series in the project area are the Cecil fine sandy loam, Cecil gravelly-fine sandy loam, Penn loam, and Lehigh silt loam, all of which are common through the country. The Cecil series in the project area includes two types: fine sandy loam and gravelly-fine sandy loam. The Lehigh silt loam occurs in the Triassic belt and is derived from sandstones and shales. More detail on project area soils is found in Section A.9 (Vol.1) of the main report.

9. Ecology

The following discussions are extracted from exhaustive treatments of the subjects found in the main report (see Vol. 1, Section A.6; Vol. 1a, Section B.3.6; Vol. 6, Appendix IX; and Vol. 7, Appendix X).

a. Vegetation

Historical land use has been a dominant factor in shaping existing patterns of vegetation in the study area. Intensive agricultural activities in the past 300 years have resulted in the loss of native climax plant communities and the recurring disturbance of recovering types. Much of the original clearing was done to allow for the cultivation of tobacco. As the original plantings depleted the soil, new areas of native vegetation were cleared; the old tobacco fields were abandoned and left to the natural progression commonly called "old-field succession."

At present, a substantial portion of the upland areas with low slope gradients is under cultivation. Prevalent crops are tobacco, soybeans, corn and wheat, plus smaller amounts of sorghum and vegetables. Other areas have been planted for pasture or are lying fallow.

The natural vegetation of the area has been variously described as oakhickory-pine forest, oak-hickory association, oak-hickory forest, and the Atlantic Slope section of oak-pine forest. Native vegetation of the study area is typical of the region. Successional processes are evident throughout, resulting in variable dominating species depending on the time elapsed since the last disturbance.

During the first few years following abandonment, old-fields are dominated by annual herbaceous species, conspicuous among which are horseweed, common ragweed, and beggarstick. Later, the area comes to be thoroughly dominated by broomsedge. Virginia pine and, in lesser numbers, shortleaf pine colonize the broomsedge fields and develop into pine forest which persists for 75-100 years before significant replacement of the pines by deciduous tree species occurs.

On well-drained sites, the deciduous forest is dominated by white oak, red oak, scarlet oak, and red maple. Occasional associates in the overstory are persimmon, yellow poplar, Virginia pine, shortleaf pine, Spanish oak, blackjack oak, and swamp chestnut oak.

Along drainages with additional moisture, a slightly different deciduous forest is found which is dominated by red maple, yellow poplar, and mockernut hickory. Occasional associated species in the overstory are bitternut hickory, pumpkin ash, white oak, and red oak. In addition to naturally forested areas, there are some acreages that have been planted with loblolly pine in evenly spaced rows for eventual harvest as sawtimber or pulpwood.

Three species which are under review by the U.S. Fish and Wildlife Service for possible proposal as threatened or endangered are known to occur in Pittsylvania County: Lewis heartleaf, Virginia quillwort, and nestronia. These species were not located during the study.

b. Wildlife

The terrestrial vertebrate fauna of the study area is typical of the Piedmont region. In general, wildlife species present are representative of three major habitat groupings: deciduous or mixed coniferous-deciduous forest, various stages of early old-field succession, and farmland. Also present in lesser degrees are plantation pine forests, small rural communities, and rural residences.

The only large mammal present in the area is the white-tail deer. Common smaller mammals observed in the area during early August 1983 were the red fox, raccoon, striped skunk, opossum, eastern cottontail, woodchuck, eastern gray squirrel, hispid cotton rat, and white-footed mouse.

Raptors commonly observed were the broad-winged hawk, turkey vulture, and black vulture. Northern bobwhites and mourning doves were abundant, but no waterfowl or other game bird species were observed. The small bird community was diverse; the most numerous and widespread species in native habitats were the indigo bunting, Carolina wren, Carolina chickadee, northern cardinal, song sparrow, and field sparrow.

Eastern box turtles and eastern painted turtles were the most abundant--or at least the most conspicuous--reptiles. Other common reptiles in the area include the eastern fence lizard, six-line racerunner, black racer, rat snake, and rough green snake. Prominent amphibians included the bullfrog, northern chorus frog, and American toad.

The overall terrestrial habitat quality is good, with no signs of existing environmental stress other than the encroachment of agriculture into native types. The interspersion of mature forests with old-fields and pastures--and the rather extensive edge (ecotone) between the types--is preferred by several of the larger and wider-ranging species, such as deer, foxes, quail, and many birds of prey.

The mature forest types probably are not extensive enough for especially furtive species, like the mountain lion or black bear, but they are capable of supporting wild turkeys and sizable populations of eastern gray squirrels.

Results of the August 1983 field survey indicate that the study area is not inhabited by terrestrial vertebrates federally listed as threatened or endangered. Species present that are of state-level concern are the American kestrel, eastern bluebird, grasshopper sparrow, and red-shouldered hawk. The little blue heron, another species of special concern in Virginia, also was present, but probably as a straggler rather than a breeder. River otters are potentially present in the Banister River system.

c. Aquatic Ecology

The Roanoke River system contains the richest and most diverse ichthyofaunal (fish populations) of the Atlantic Slope drainage. It has been reported that there are 84 primary freshwater native species in the basin. Of these, six are endemic and two are possible introductions. Twenty-one non-native species were reported in the basin.

Because the Banister River system lies entirely within the Piedmont province, its ichthyofauna is less diverse and rich than the Roanoke

River system as a whole. Species not expected in the Banister River system are primarily montane and coastal forms. Nevertheless, the limited historical data and the present study revealed a rather diverse ichthyofauna. Historically, 39 species, including five probable introductions, have been reported in the Banister River system.

The middle reaches of the Banister River system support warm-water fish communities characteristic of the Lower Piedmont. The creek communities normally had fewer species and were dominated by characteristic creek forms, such as bluehead chub and mountain redbelly dace. River communities contained most of the common creek forms plus typical fluvial species, and were therefore more diverse than creek assemblages.

Minnows dominated most communities. Game fish and large suckers were not common at any site in the study area. Game fish species collected from streams in the study included the bluegill, redbreast sunfish, largemouth bass, and chain pickerel. A paucity of suitable deep pool habitat at several sites and low sampling efficiency in deep, debris-clogged pools contributed to their apparent low numbers. For these reasons, abundance of both groups probably is greater than reported in this study.

Qualitative macroinvertebrate samples revealed a strong correlation between substrate heterogeneity and macroinvertebrate biomass. In sand-bottom reaches, macroinvertebrates were uncommon. Most fishes collected are insectivorous for at least part of their life spans and the low diversity and abundance of fish probably was due in part to the low macroinvertebrate production.

The five farm ponds sampled in conjunction with the radiological program yielded highly variable results. Some contained primarily carp or suckers, while others produced various mixes of sunfish or "bream", black crappie, largemouth bass, and chain pickerel.

10. Cultural Resources

There are only two designated cultural/historic landmarks within the study area. However, within a 16 kilometer (10 mile) radius of the study area, there are numerous designated cultural/historic landmarks and one scenic/management area, the White Oak Mountain Wildlife Management Area.

Hargraves House and Coles Hill are the only two historic structures within the study area which are listed on the Virginia Historic Landmarks Commission's Inventory of Historic Places. For more information, see Sections A.8 (Vol. 1), B.3.7 (Vol. 1a), and Appendix II (Vol. 4) of the October 15 report.

11. Land Use

The study area contains a total of approximately 1.17 million acres, of which more than 98 percent is agricultural or forest lands. Concentrated (urban and suburban) residential, commercial, and industrial uses together account for approximately 2 percent of the total land area.

In Pittsylvania County, 37 percent of the land is devoted to agriculture, and another 60 percent is forest lands; the county is distinctly rural in character. Most development is concentrated within and around the Danville city limits, and in the towns of Chatham, Gretna, and Hurt. In Halifax County, growth has been largely limited to the area around South Boston and the town of Halifax.

In 1970, about 55 percent of Pittsylvania County's population resided in areas characterized as rural, with the remainder in concentrated residential (urban/suburban) areas. Recent development has been almost wholly limited to suburban extensions of Danville; the towns of Chatham, Gretna, and Hurt; and the smaller communities of Cascade, Dry Fork, Motley, Mt. Cross, and Ringgold.

Commercial uses are concentrated in urban areas, with Chatham and Gretna having central business districts. A more recent trend is the growth of commercial strip development along the highways radiating from Danville, particularly at various points along U.S. Highways 29 and 58.

In Pittsylvania County, industrial activity accounts for only 0.14 percent of all land use. Historically, industrial development in the region has not required large amounts of land. The recent industrial growth has taken place just outside of Danville, where large suitable tracts of land have been available and in close proximity to infrastructure and labor. There are some existing industries in Chatham, Gretna, and just west of Hurt. In addition, there is a new industrial park located south of Chatham at Tightsqueeze.

Lands designated as public or semi-public account for 2400 of Pittsylvania County's 647,680 total acres. These include 26 public schools, two private school campuses in Chatham, churches, government buildings, Danville Municipal Airport, and two detention facilities.

Pittsylvania County has no county-operated parks. Its major recreational resources include the 2710-acre White Oak Mountain Wildlife Management Area; the Pittsylvania Wayside Park near Hurt; the recreational facilities associated with the 26 schools; numerous privately owned campgrounds, marinas, and golf courses; and the Smith Mountain Lake recreational area in the northwest corner of the County.

For more detail, see the October 15 report, Section A.7.3 (Vol.1).

12. Socioeconomics

The regional study area has been defined as a two-county region, including Pittsylvania and Halifax Counties, together with their associated municipalities of Danville and South Boston. The entire Section I (Vol. 3) of the main report has been devoted to socio-economics of the study area; discussions also are found in Section A.7 (Vol.1).

a. Transportation

The study area is served by two primary U.S. highways: Highway 29 which bisects Pittsylvania County in a north-south direction; and Highway 58, which traverses the southern portions of both counties, connecting Danville and South Boston. Other important roads are U.S. Highway 360, connecting Danville and the town of Halifax; U.S. Highway 501, linking South Boston and Halifax with Lynchburg to the north, and with Roxboro, North Carolina, to the south; and State Highway 40, which links Gretna to Rocky Mount and U.S. Highway 220 in Franklin County to the west. Interstate Highway I-81 is located to the north-west and I-85 and I-40 to the south and east.

The main line of the Norfolk/Southern Railway runs through the area, roughly parallel to U.S. Highway 29, and provides rail connections to the rest of the nation.

b. Population

The population of the regional study area is 149,481 persons according to the 1980 census. Pittsylvania County's population was 66,147 in 1980, while Danville's population was 45,642.

Slightly more than 30 percent of the population in the regional study area in 1980 was 19 years or younger, while 18 percent was 60 years or older. School-aged children, five through 17 years old, represented 22.3 percent of the total population in 1980.

Pittsylvania County contained 22,147 households in 1980 and Danville contained 17,511 households, for a total of 39,658 in the Pittsylvania/Danville area. With a combined population of 111,789 in 1980, the average household size was 2.78 persons.

c. Housing

In 1980, there were 42,660 housing units in the Pittsylvania/Danville area, and 14,666 in the Halifax/South Boston area for a total of 56,826 units in the study area. Of the total 56,826 units in the study area, 52,456 (92.3%) were occupied.

d. Industry

Manufacturing is the major force in the regional economy and accounts for about 49.4 percent of labor and proprietor's income in the study area. Most of the other industries in the profile, including construction, trade, finance, transportation, services, and management usually serve local markets within the region. These non-manufacturing activities employ about 30,000 persons in the study area. The construction industry provided 3101 jobs in 1981, and accounted for $341 million in earnings. The Pittsylvania/Danville area had most of these jobs.

A basic industry of considerable importance to the economy of the study area is agriculture. This industry produced $68.4 million in earnings and proprietor's income in 1981, and employed 6950 persons, 5500 as proprietors and 1450 as laborers.

e. Labor Force

The civilian labor force consists of persons 16 years and older. In June 1983, the civilian labor force in the regional study area totaled 76,959 persons, or about 50 percent of the population. The unemployment rate in the regional study area ranged between 8.1 and 15 percent during a recent 18-month period, peaking in January 1983; by June 1983, the rate had declined to 8.1 percent. The most common occupations in the area are equipment operators, craftsmen, foremen, and clerical workers.

In 1980, Pittsylvania County had over 28,000 employed members of the labor force, 36 percent of whom worked in the county, with most of the rest working in Danville. Danville in 1980 had over 20,000 employed members of the labor force, almost all of whom worked in the city; only 1700 worked in the county.

Halifax County had a population of 30,599, with an employed labor force of 7748 (non-agricultural) in 1979, and 6320 individuals deriving their income from agriculture.

In Pittsylvania County, manufacturing consistently pays the highest wages, followed by transportation, communication, and utilities. Agriculture and service industries pay the lowest wages. In Danville, the transportation, communications, and utilities pay the highest wages, followed by construction and manufacturing. The lowest wages are earned in Danville's trade section.

f. <u>Local Government</u>

Pittsylvania County government provides general administration, legal, public safety, education, solid waste, library, and other public services to the county. Water and sewer service is provided by municipalities.

The County budgeted expenditures in fiscal 1983-84 of $35.2 million. The public school systems accounted for $27.4 million, or 78 percent of the total. General County operations and other operating costs were budgeted at $7.1 million. Capital outlays, including debt service, were budgeted at $0.7 million.

County revenues of 1983-84 were projected at $35.2 million. Local sources accounted for $9.2 million, or 26 percent of the total. State sources (mainly school assistance) and federal aid were budgeted at $25.3 million.

The major component of local revenue is the real property tax which is estimated to yield $6.4 million in revenue in 1983-84. Other local sources, including the local share of the state sales tax and motor vehicle licenses and permits, are projected to provide $2.8 million.

The City of Danville provides public education, water, sewer, and general government services. The city budgeted expenditures in 1982-83 of $27.5 million. The public school system accounted for $7.6 million, or 27 percent of the total. The major source of local revenue is the property tax, which provided $6.2 million. Other local taxes, mainly the local share of the sales tax, yielded $5.2 million.

Halifax County government provides public education and general government services. Projected expenditures in 1983-84 are $19.5 million, with 78.6 percent allocated to public schools. Revenues of $19.5 million include $0.6 million from prior years' surplus.

g. Schools

Pittsylvania County administers 26 public schools with a total enrollment in the 1982-83 school year of 12,606 students. Of the 26 schools, 20 are grade schools, two are junior high schools, and four are high schools. Currently, 7493 students are enrolled in kindergarten through seventh grades, 4824 students are in eighth through twelfth grades, and 289 are in special programs for the handicapped.

In addition to these regular schools, Pittsylvania County recently opened a Vocational Technical Center (VOTECH) facility south of Chatham, near Dry Fork with a capacity of 500 students. The current number of students is 386. Eight private schools and parochial schools also are located in Pittsylvania County, including two preparatory institutions, Hargrave Military Academy and Chatham Hall, both near Chatham. Their combined enrollments in 1983 was 1797.

The City of Danville administers 14 public schools with a total enrollment of 7494 students for the 1982-83 school year. Included are 11 grade schools, two junior high schools, and one high school. The students are distributed as follows: 2711 in kindergarten, 1478 in junior high, and 1757 in high school. The private schools are located in the city.

h. Medical Facilities

The study area is served by two major hospitals: the 506-bed Memorial Hospital in Danville, and the 192-bed Halifax-South Boston Community Hospital. Memorial Hospital has an estimated service area of 135,000 people; its market share is 95 percent of admissions in Danville and nearly 70 percent in the county. In the northern part of the county about 40 percent of referrals are to Lynchburg General Hospital in Lynchburg, with 60 percent going to Memorial. Halifax-South Boston Community Hospital captures 80 percent of admissions in its own county/city areas.

There are several public clinics run by both counties and city health departments, including those in Chatham and Gretna. Currently, 112 physicians and surgeons have offices in Danville, along with three clinical psychologists, three chiropractors, seven physical therapists, and 40 dentists. The town of Chatham is served by five physicians and five dentists.

i. Public Safety

Danville city employs 70 uniformed policemen, for a rate of 1.15 per 1000 population. The towns of Chatham, Gretna, and Hurt each have their own independent police departments. The total number of police officers in the county is about 75, a ratio of just over one per 1000 population.

Pittsylvania County is served by 18 volunteer fire companies linked by radio with the sheriff's department. In addition, there are four rescue squads. In these two services, there are a total of approximately 500 volunteers, for a service ratio of 7.6 emergency volunteers per 1000 population.

j. Infrastructure

Water Supply

The city of Danville and the towns of Chatham and Gretna operate their own municipal water systems. Danville's water service area is the city itself and a few adjacent areas of Pittsylvania County; the estimated service population is about 53,000 persons. Per capital consumption is 155 gallons per day (gpd) overall, and about 181 gpd for each residental unit. Raw water is obtained from the Dan River, which has an average daily flow of 1.6 billion gpd. The treatment plant currently treats approximately 8.4 million gallons of water per day. The reserve treatment capacity thus is 6.62 million gpd. The system's storage capacity totals 11.1 million gallons.

The town of Chatham obtains its raw water from Cherrystone Creek. Approximately 33,000 gallons of water per day are treated at the Chatham treatment plant. The plant operates at about 45 percent of capacity, leaving a reserve of 390,000 gpd.

The town of Gretna obtains its raw water from a reservoir on Georges Creek. Approximately 192,000 gallons of water is used daily, leaving a reserve of 96,000 gpd. Total storage capacity is 345,000 gallons.

Six separate water systems which obtain water from wells serve sub-division areas at West Fork, Washington Acres, Ridgecrest, Mt. Zion, Robin Court, and Wayside Acres. The other residents of Pittsylvania County obtain their water from individual wells or springs.

Sewage Treatment

The study area's sewage treatment facilities are found generally in the same urbanized areas as the public water supply systems. The city of Danville has two sewage treatment plants with a combined design capacity of 31.5 million gallons per day (mgd). The design population is 116,000 persons. At present, only the Northside plant (capacity 24 mgd) is in operation. The average demand is 15.6 mgd, about 65 percent of the Northside plant's capacity.

The town of Chatham maintains a central sewage system with a capacity of 540,000 gallons per day. It provides primary treatment only, and is operating at about 50 percent of its capacity.

The town of Gretna treats its sewage in a 3.81 acre raw sewage stabilization pond with a treatment capacity of 153,000 gpd. Current usage is 145,000 gpd, with a surplus capacity of only 8,000 gpd.

Several other sewage treatment plants exist throughout the county, serving localized areas. In the rest of Pittsylvania County, sewage is disposed of in individual septic tanks.

Solid Waste Disposal

It is estimated that the total tonnage of solid waste collected in Pittsylvania County is about 25,000 tons per year. In the county, garbage is collected in 660 "dumpsters" located throughout the county. In addition, there are two mini-compaction sites in the Danville suburbs area. Approximately 60-80 tons of solid waste is collected by compactor trucks, most of which is deposited at a state approved, 92-acre landfill near Dry Fork. Danville, Chatham and Gretna have their own municipal refuse collection systems. On a daily basis, about 150 tons of waste are disposed of in Danville's 75-acre landfill.

Electric and Gas Utilities

The Appalachian Power Company (APCO) and the Virginia Electric and Power Company (VEPCO) are the major producers of electrical power in the region. Pittsylvania County's electric power is provided by VEPCO. APCO provides 95 percent of Danville's electric power, with the remainder supplied by the city's own hydro-electric plant.

Natural gas in the study area is supplied by Transcontinental Pipeline Company, whose main pipeline runs through the Swanson Project site. The distribution companies serving the area are the City of Danville's gas department, Citizen's Gas Company, Lynchburg Gas Company, and Virginia Pipeline Company.

IV. IMPACTS AND MITIGATIVE MEASURES

A. RADIATION EXPOSURE PATHWAYS

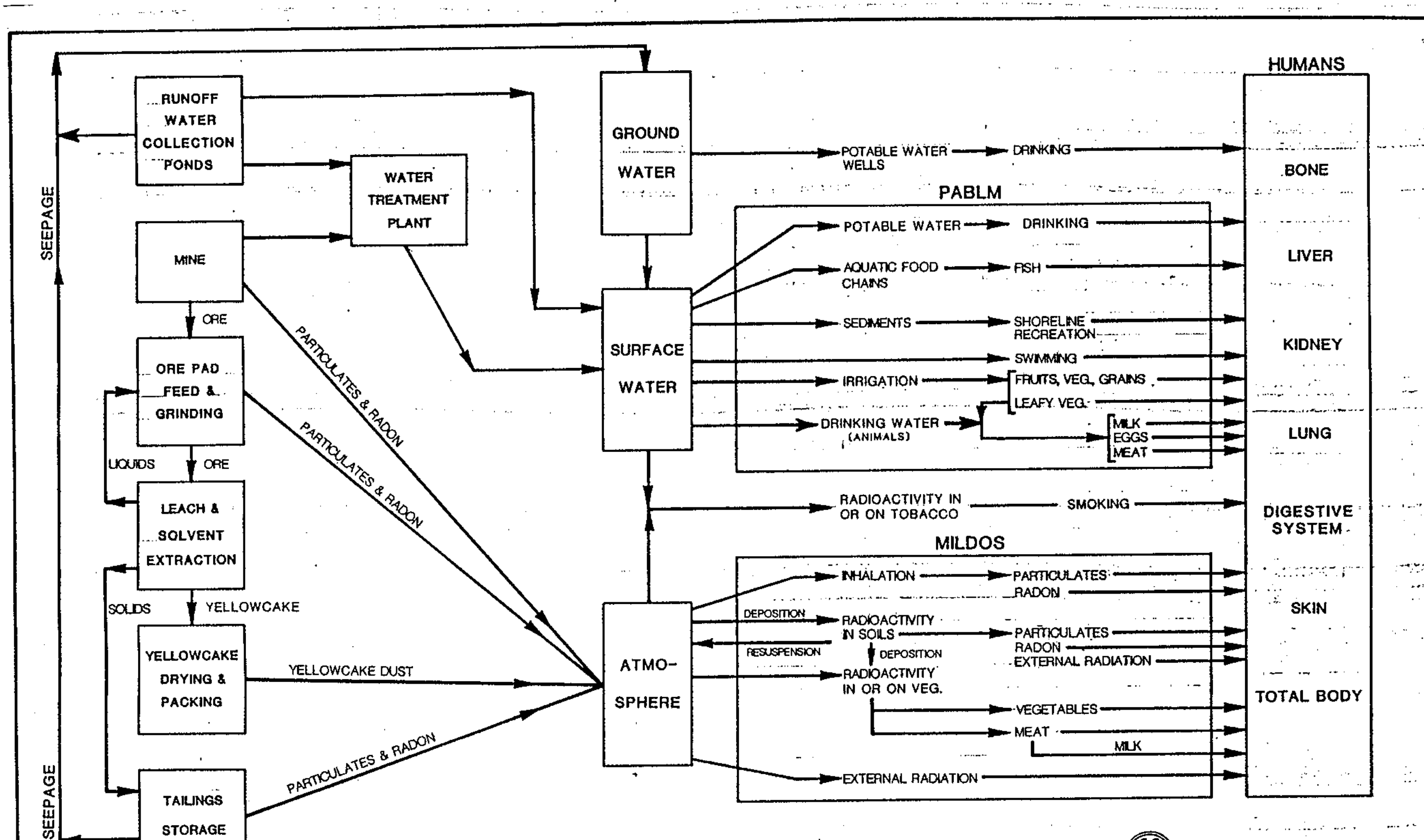
Development and operation of the Swanson Project could result in certain radionuclides being added to those already present in the environment and to which the human population is now, and will continue to be, exposed via several natural pathways. Exposure pathways characteristic of the Swanson Project are illustrated in Figure IV-1 which shows sources of radioactive contamination from the mine, mill, and tailings via ground water, surface water, and atmospheric routes.

Computer modeling was employed to assist in the assessment of conveyance of contaminants via surface water (PABLM) and air (MILDOS). These programs not only elucidate the transport of contamination, but also calculate resultant doses to receptor members of the public, and also to certain critical body organs and tissues.

1. Surface Water Pathways

The computer program PABLM calculates radiation doses from radionuclides in humans from the intake of radionuclides in water that is directly consumed by humans, in water that is used to irrigate crops consumed by humans, and water used to raise animals and animal products consumed by humans. In addition, PABLM calculates the radiation dose to people working in fields containing radionuclides in irrigation water.

As an explanatory note, the PABLM model was written by Battelle Pacific Northwest Laboratories (Publication PNL-3209-VC-70) for the



MARLINE URANIUM CORPORATION
PITTSYLVANIA COUNTY, VIRGINIA

URANIUM MINING AND MILLING
POTENTIAL EXPOSURE PATHWAYS

Dravo OCT/83 FIGURE IV-1

Office of Nuclear Waste Isolation, under contract with the U.S. Department of Energy. The program uses aquatic food parameters adapted from the computer programs ARRRG and FOOD and other parameters from NRC Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I". The entire Appendix XI of the main report (Vol. 7) is devoted to description of the model and presentation of detailed output from the computer run of the program.

For the most realistic evaluation of radiation doses to man by the PABLM computer program the annual-average receiving stream flow rates, Q_{avg}, can be used to determine dilution of the annual-average effluent flow rates. However, to be conservative, a lower receiving stream flow rate, $Q_{90,10}$ was used, i.e., the minimum 90-day average flow rate that would occur on the average once every 10 years. Use of the $Q_{90,10}$ flow rates as opposed to Q_{avg} flow rates result in a lower calculated radiation dose and consequently a safety factor of at least two.[(1)] For calculation purposes only, the radiation doses presented in Appendix XI of the main report (Vol. 7) were based on $Q_{7,10}$ values which are the minimum 7-day average flow rates that would occur on the average once every 10 years. Those doses were converted to $Q_{90,10}$ values as described in the appendix.

a. Mine Discharge

Surface runoff, incident precipitation, and ground water inflow will be collected in the mine pit and in surface runoff holding ponds. If the collected surface runoff water exceeds the requirements for mill process water, the excess will be treated and discharged to Mill Creek. The water treatment plant will be designed to remove uranium, radium and other constituents to comply with U.S. Environmental Protection Agency release limits. For the PABLM analysis, maximum

(1) The ratios of Q_{avg}: $Q_{90,10}$ are 2.3 for Whitethorn Creek, 3 for Mill Creek, and 4.6 for the Banister River.

allowable 30-day averages were assumed to be the concentrations present in the discharge, i.e., 2 mg/l uranium and 10 pCi/l radium-226.

Mill Creek may be diverted south of its present course into Dry Branch, which then discharges into Whitethorn Creek, and thence to the Banister River. The $Q_{90,10}$ flow assumed in Mill Creek is 3.5 cfs. For calculating radiological dose to persons drinking water supplied from the Halifax Water Treatment Plant on the Banister River, which is the nearest downstream water treatment plant, a $Q_{90,10}$ of 120 cfs was used.

Further assumptions in the calculations are: (1) the individual maximally exposed from the release of treated mine and surface waters is assured to reside 2500 meters south of Coles Hill, near but not adjacent to the Mill Creek Diversion; (2) the individual sprinkler irrigates his crops with water from the diversion at a rate of one foot of water every three months; (3) half of his dietary consumption is from irrigated plants and animals that consume water from the diversion; (4) his gamma exposure results solely from standing in a field after irrigating with contaminated water; and (5) no drinking water is consumed directly from the diversion.

Residents of Halifax drink treated water obtained from the Banister River, which receives water from Mill Creek. In addition, each resident is assumed to consume annually two kilograms of fish taken from the Banister River.

b. Seepage

Some liquids associated with the tailings management area may seep through the liner and flow as ground water in a northeasterly direction toward Whitethorn Creek. All such seepage is assumed to flow immediately and directly into Whitethorn Creek once it has penetrated the liner under the deposited tailings, and there is no subsequent improvement in seepage quality. In reality, the ability of natural soils and substrates to geochemically trap contaminants would improve the water quality; however, this reduction in radionuclide content of the seepage was not included in the calculated dose. The net discharge calculated from tailings seepage in this scenario is 0.025 cfs. Based on column percolation tests using soils and clays characteristic of the project site, the seepage will contain 0.7 mg/l uranium and 1.0 pCi/l radium-226. The $Q_{90,10}$ for Whitethorn Creek if 13.0 cfs.

The individual maximally exposed due to release of tailing seepage into Whitethorn Creek is assumed to reside three kilometers east-southeast of Coles Hill and is near, but not adjacent to Whitethorn Creek. Other assumptions are the same as for the Mill Creek scenario above.

c. Accidental Release

In case of inadequacy of water management practices, resulting in accumulation and subsequent release of impounded water, a pond breach scenario could result. Such an event is assumed to release the contents of an impoundment into Whitethorn Creek, causing an average flow of 2.02 cfs over a 24-hour period. This is equivalent to the volume of the mean annual precipitation event (3.5 inches in 24 hours) over 14 acres, or 4 acre-ft. The quality of the liquids released assumes a 50 percent dilution of the tailings liquids with surface water runoff that collects in the tailings area. Thus, the liquids are assumed to contain 1650 pCi/l uranium and 125 pCi/l radium-226.

For the "pond breach" scenario, average flow rates for Whitethorn Creek and the Banister River were used because such an event is more likely to occur under average, or even high-flow conditions, than under low-flow conditions. In other words, the event would most likely occur due to accumulation of water following a heavy precipitation event, which also would tend to increase flows in the streams. Therefore, Whitethorn Creek was assumed to be flowing at the Q_{avg}

rate of 30 cfs at its confluence with Mill Creek, and the Banister River at the Q_{avg} rate of 550 cfs.

The maximally affected individual is assumed to reside three kilometers east-southeast of Coles Hill, and is near but not adjacent to Whitethorn Creek, and that: (1) his gamma radiation dose from released radionuclides is negligible because he is not living on the banks of Whitethorn Creek; (2) he sprinkler irrigates his crops during the 24-hour pond breach release, and harvests his crops and slaughters his animals immediately after the break; (3) half of his dietary consumption is from the irrigated crops and watered animals; and, (4) he does not drink water from Whitethorn Creek.

Halifax residents are assumed to drink treated water from the Banister River during a 24-hour period while water from the pond breach passes by the treatment plant. No fish are caught and eaten from the Banister River during this 24-hour period.

2. Radiological Doses (PABLM)

The radiological doses calculated from each of the above three scenarios are presented in Tables IV-1 through IV-4. In these tables, doses to the total body, bone, and lower large intestine are presented. These components were selected because they receive the largest dose from ingested radionuclides, in part because uranium and radium tend to concentrate in bone tissue. Doses to other organs such as the lung or thyroid are not presented because they are insignificant in relation to the doses from the three components listed above.

The total doses presented in Table IV-4 can be compared to the estimated 25 mrem/yr received by the average person due to consumption and/or intake of water, food, and air. The doses calculated for the combination of routine operations and a postulated pond breach that impact a maximally exposed individual are less than five percent of

TABLE IV-1

CALCULATED RADIOLOGICAL DOSES
DUE TO MINE WATER RELEASE
(PABLM 1983)

RECEPTOR	TOTAL BODY	BONE	GI-LLI (1)
Maximal Individual (2)	10.08	17.47	0.46
Halifax Resident (2)	3.03	5.27	0.09
Halifax Population (3)	3.63	6.32	0.11

NOTES

(1) gastrointestinal - lower large intestine
(2) mrem/yr
(3) man-rem/yr

TABLE IV-2

CALCULATED RADIOLOGICAL DOSES DUE TO TAILINGS SEEPAGE
(PABLM 1983)

Receptor	Total Body	Bone	GI-LLI [1]
Maximal Individual [2]	0.016	0.013	0.0001
Halifax Resident [2]	0.07	0.07	0.003
Halifax Population [3]	0.083	0.082	0.003

NOTES

(1) gastrointestinal - lower large intestine
(2) mrem/yr
(3) man-rem/yr

TABLE IV-3

CALCULATED RADIOLOGICAL DOSES DUE TO
POSTULATED POND BREACH
(PABLM 1983)

Receptor	Total Body	Bone	GI-LLI[1]
Maximal Individual[2]	0.48	0.74	0.01
Halifax Resident[2]	0.03	0.06	0.01
Halifax Population[3]	0.04	0.06	0.001

NOTES

(1) gastrointestinal - lower large intestine
(2) mrem/yr
(3) man-rem/yr

TABLE IV-4

SUMMARY OF WATERBORNE RADIOLOGICAL DOSES
(PABLM 1983)

Source	Total Body	Bone	GI-LLI[1]
Individual Doses (mrem/yr) at Halifax[2]			
Mine Water	3.03	5.27	0.09
Tailings Seepage	0.07	0.07	0.003
Pond Breach	0.03	0.06	0.01
TOTAL	3.13	5.40	0.10
Individual Doses (mrem/yr) at Whitethorn Creek			
Tailings Seepage	0.016	0.013	0.0001
Pond Breach	0.48	0.74	0.01
TOTAL	0.50	0.75	0.01

NOTES

(1) gastrointestinal - lower large intestine
(2) table B.2.2-7 of the main report contained typographical errors in Halifax values which have been corrected in this table.

the doses received naturally through the same pathways, and less than one percent of the 88 mrem/yr direct radiation dose actually measured at the project site.

The application of the PABLM model and calculation of doses is treated in more detail in the October 15 report (Section B.2.2 Vol. 1a).

3. Airborne Pathways

The computer program MILDOS was used to assess the radiological impacts of airborne emissions from routine mine, mill, and tailings operation. MILDOS was developed by Battelle Pacific Northwest laboratories under contract with the NRC. The program was adapted from the Argonne National Laboratory computer program UDAD. The model uses straight-line Gaussian plume atmospheric dispersion modeling from point and area sources to calculate dust concentration at many receptor locations.

Knowing the specific radioactivity of the dust, the biological transport mechanisms of inhaled dust and the radiation dose conversion factors, the radiation dose to man due to dust inhalation can be calculated by MILDOS. In addition, by calculating dust deposition on food crops or forage, the radiological dose due to consumption of potentially contaminated foods can be determined.

MILDOS requires the input of radionuclide sources and physical characteristics of the tailings disposal area, meteorological data, food production data, population distribution data, identification of receptor locations, and operational schedules for the project. Assumptions include the following: (1) the overburden storage area contains 0.01 percent U_3O_8, which is equivalent to 29 pCi/g of U-238 and each of its daughter products; (2) radon emanation from the storage area was assumed to be similar to that of low grade mill tailings; (3) the mine pit contained 0.106 percent U_3O_8, which is equivalent to 300 pCi/g of U-238 and each of its daughter products; (4) overburden adjacent to the tailings contained 0.01 percent U_3O_8, which is equivalent to 29 pCi/g of U-238 and each of its daughter products; (5) exposed tailings contained 15 pCi/g U_3O_8 and 300 pCi/g of U-238 and each of its daughter products; (6) the ore storage pad contained 300 pCi/g U-238 and each of its daughter products; (7) the yellowcake stack releases 7.72×10^{-2} Ci U-238/yr, 3.86×10^{-4} Ci/yr Th-230/yr, and 7.72×10^{-5} Ci/yr each of Ra-226, Pb-210, and Po-210 at a linear flow rate of 17 meters^3/sec; and (8) total emissions from the ore crusher were equivalent to 2.64×10^{-4} Ci/yr for U-238 and each of its daughter products.

Radon emanation rates from the various components described above were estimated or calculated from U.S. Nuclear Regulatory Commission publications, NUREG-0706 and NUREG-0757.

Further assumptions in the MILDOS input, and sources of information, are:

(1) <u>Meteorlogical Data</u> (Annual average frequency occurrence of wind speed, wind direction, and atmospheric stability)	Historical data for Danville, Virginia January, 1950 - December, 1954; average daily mixing height, 975 m
(2) <u>Food Production</u>	
(USNRC-NUREG-0597)	
Vegetables	1.7206×10^3 kg/yr/km^2
Meat	3.638×10^3 kg/yr/km^2
Milk	7.3441×10^3 kg/yr/km^2
(3) <u>Population Distribution</u>	Oak Ridge National Laboratory (1983); adjusted for the known population distribution within 5 km of the project site; total population within 80 km, 789,112

(4) Receptor Locations (Appendix XII and Figure B.2.3, Main Report)	Includes nearest residence; a tobacco growing area; the now private residence, formerly serving as Sonan's School; a grazing area; a northeastern residence; Cedar Hill Hunt Club; Chatham, Gretna, and Danville; four locations directly over or immediately adjacent to the mine site; and one location directly over the exposed tailings.
(5) Operational Schedule	13-year operational life, followed by two-year reclamation period.

4. MILDOS Output

MILDOS calculates radiation dose to the whole body, as well as to bone and lung tissue, at numerous receptor locations. The results obtained then are compared to applicable regulatory limits. For example, the 25 mrem standard of 40 CFR 190 provides that no member of the public shall receive a dose in excess of 25 mrem/yr due to uranium milling activities; the standard specifically excludes contributions from radon and its daughter products. If radon is included in the overall dose estimation, from the mine and other sources, then a different standard is referenced. When radon is considered, the standard of 10 CFR 20, which limits the whole-body radiation exposure of the general public to 500 mrem/yr, is applicable.

The MILDOS runs included in Appendix XII of the main report (Vol. 7) constitute a voluminous package, and represent several variations in accommodating project components and different age groups of receptor subjects.

However, for conciseness in this summary, information is presented on (1) radiological doses due to routine operation of the mill and tailings facility, excluding the contribution of radon and its daughter products; (2) doses from the mine, mill, and tailings area, including the contribution of radon and its daughter products; and (3) total annual dose with and without radon and its daughter products by exposure pathway, to allow determination of which airborne pathway produces the greatest dose to which organs. Data are presented in Tables IV-5 through IV-8 to illustrate the above. Only averages or ranges are discussed in Tables IV-5 and IV-6, and the reader is encouraged to consult Section B.2.2.1.2 (Vol. 1a) of the main report for more detailed information on anticipated doses at each of the receptor locations.

The airborne radiological doses presented in Table IV-5 are from the mill and tailings area and do not include the doses from radon and its daughter products. All the locations specified are where people currently live or could possibly live. Locations such as over the tailings or mining area are restricted areas that exclude human residences. The Table IV-5 values are presented to demonstrate compliance with the EPA's 25 mrem/yr maximum dose to humans under the restrictions noted above for the EPA regulations.

The airborne radiological doses presented in Table IV-6 are from the mine, mill, and tailings areas and include radon and its daughter products. All sources and all radionuclides are included for the airborne pathway. The values in Table IV-6 are for unrestricted areas except the last line of the table which are for restricted areas. Comparison of the values in Table IV-6 with the regulatory limits in the footnotes indicate compliance with the NRC limitations on dose specified in 10 CFR 20.

5. Summary of Annual Radiation Doses

Table IV-7 presents a summary of the total radiation dose at three locations where the highest radiation doses from both the air and water pathways are anticipated. The table indicates that at the Mill Creek location doses from the water pathway generally exceed the doses from the air pathway. At the Cedar Hill Hunt Club, the doses from the air pathway exceed those from the water pathway. At the nearest residence, only the air pathway is of importance. None of the combined

TABLE IV-5

AIRBORNE RADIOLOGICAL DOSES FROM MILL AND TAILINGS, EXCLUDING RADON AND ITS DAUGHTER PRODUCTS (MILDOS, mrem/yr) [1]

Location	Whole Body	Bone	Avarge Lung
Nearest Residence	0.27	3.57	12.2
Other Residences	0.04 - 0.18	0.52 - 2.34	1.26 - 3.59
Others within 4 km [2]	0.04 - 1.84	0.52 - 12.8	0.85 - 13.7
Sheva	0.02	0.25	0.85
Chatham	0.01	0.07	0.16
Gretna	0.01	0.03	0.05
Danville	0.002	0.01	0.02

NOTES

(1) values are comparable with the 25 mrem/yr limitation specified in 40 CFR 190.
(2) these sites are not at existing residences and are not located over the proposed tailings or mine area.

TABLE IV-6

AIRBORNE RADIOLOGICAL DOSES FROM MINE, MILL, AND TAILINGS INCLUDING RADON AND ITS DAUGHTER PRODUCTS (MILDOS, mrem/yr)[1]

Location	Whole Body	Bone	Average Lung
Nearest Residence	16.4	94.5	41.0
Other Residences	0.84 - 3.50	3.62 - 14.0	2.68 - 8.58
Others within 4 km[2]	1.08 - 14.1[2]	3.0 - 80.7[2]	1.55 - 36.6[2]
Sheva	0.54	1.61	1.51
Chatham	0.20	0.50	0.41
Gretna	0.09	0.22	0.16
Danville	0.04	0.10	0.06
Restricted Area[3]	8.76 - 61.9	49.9 - 373	24.5 - 119

NOTES

(1) these values do not assume any dust control at the mine and are comparable to the 500 mrem/yr limitations specified in 10 CFR 20 for unrestricted areas. See exception in Note (3).
(2) these sites are not at existing residences and are not located over the proposed tailings or mine area.
(3) these sites are over tailings, or in or immediately adjacent to the mine and are restricted areas comparable with the 500 mrem/yr limitation in 10 CFR 20.

pathway doses exceed the 500 mrem/yr maximum specified by the NRC for doses that include radon and its daughter products.

Table IV-7 presents the combined dose from the air and water pathways excluding radon, radon daughter products, and radionuclides from the mine. The values in Table IV-8 are comparable with the 25 mrem/yr limitation from the EPA with all of its restrictions. None of the predicted doses in Table IV-8 exceeded the 25 mrem/yr limitation for the combined air and water pathways.

6. PABLM Assessment - 1984

a. Basis and Input Parameters

Subsequent review of the 1983 PABLM predictions, plus continuing refinements in the engineering design of the project and more detailed water balance analyses, promoted a more detailed assessment in 1984 of the radiological doses from the project's liquid effluents. The analysis is only summarized here, and can be found in its entirety as Technical Memorandum No. 13. The results of the 1984 assessment were combined with the 1983 (MILDOS) analysis of mine, mill, and tailings facility operational impacts of airborne radionuclide releases, both including and excluding radon, to establish the total projected dose above background to humans.

The 1984 PABLM analysis took into account the following:

- The ongoing refinement of the design of the proposed facility.
- The assumed increase in clay liner permeability from 1×10^{-8} to 1×10^{-7} cm/sec, as suggested by the state's consultants.
- The results of a field survey of local residents regarding food and water consumption habits.
- An update of the calculation models used in the PABLM code.
- The results of leaching tests on site-specific ores and waste rock (CSMRI).

TABLE IV-7

LOCATIONS RECEIVING THE GREATEST RADIOLOGICAL DOSES FROM WATER AND AIR, INCLUDING RADON AND ITS DAUGHTER PRODUCTS (PABLM 1983 + MILDOS, mrem/yr) (1)

Pathway	Total Body	Bone	GI	Average Lung
Receptor Location: Mill Creek				
Water	10.08	17.47	0.46	0.0
Air	1.08	4.46	N/A	4.42
TOTAL	11.16	21.93	0.46	4.42
Receptor Location: Cedar Hill Hunt Club - Whitethorn Creek				
Water	0.50	0.75	0.01	0.0
Air	1.53	5.39	N/A	4.17
TOTAL	2.03	6.14	0.01	4.17
Receptor Location: Nearest Resident				
Water	0.0	0.0	0.0	0.0
Air	16.4	94.5	N/A	41.0
TOTAL	16.4	94.5	0.0	41.0

(1) reference 500 mrem/yr standard, 10 CFR 20

TABLE IV-8

LOCATIONS RECEIVING THE GREATEST RADIOLOGICAL DOSES FROM WATER AND AIR, EXCLUDING RADON, RADON DAUGHTER PRODUCTS AND MINES EMISSIONS (PABLM 1984 + MILDOS, MREM/YR) [1]

Pathway	Total Body	Bone	GI	Average Lung
Receptor Location: Mill Creek				
Water	10.08	17.47	0.46	0.00
Air	0.14	1.77	N/A	3.11
TOTAL	10.22	19.24	0.46	3.11
Receptor Location: Cedar Hill Hunt Club - Whitethorn Creek				
Water	0.50	0.75	0.01	0.0
Air	0.18	2.04	N/A	2.39
TOTAL	0.68	2.79	0.01	2.39
Receptor Location: Nearest Resident				
Water	0.0	0.0	0.0	0.0
Air	0.27	3.57	N/A	12.2
TOTAL	0.27	3.57	0.0	12.2

(1) reference 25 mrem/yr standard, 40 CFR 190

- Deletion of the Mill Creek receptor location because that location will be within the active mining area with restrictions on any private water use.

- The consideration of all possible sources of waterborne contaminants including mine water, unattenuated and attenuated akaline tailings seepage, overburden seepage, runoff from the site area and a postulated pond breach (mill site).

- The use of average flow rates to better address the chronic nature of annual radiological doses.

Table IV-9 provides a summary of the key input parameters to the 1984 PABLM run. (See also Technical Memorandum No. 5 for a more detailed treatment of PABLM input parameters) The input includes radionuclide content based on laboratory leaching studies to characterize the discharged water. Dissolved Ra-226 levels are based on EPA's maximum allowable 30-day average concentrations, which mine water treatability studies show can be met. The input also includes average annual flow rates for the receiving streams and receptor locations (Cedar Hill Hunt Club - maximally impacted residence(2); Halifax - closest downstream municipality). Finally, the input includes a summary of the modeled pathway-to-man scenarios for each source including vegetable, water, and meat consumption, as well as the effects of using irrigation water. These pathway inputs were derived in large part of the results of a field survey regarding local eating and drinking habits. (See Technical Memorandum No. 5)

Two types of tailings seepage were considered. Unattenuated seepage represents alkaline tailings liquid that retains its full complement of radionuclides as postulated seepage occurs through the clay liner beneath the tailings. Attenuated seepage is reduced in radionuclide content by the various physico-chemical (e.g., absorption, adsorption) processes as the tailings liquid seeps through the clay liner. The attenuated seepage is considered an optimistic representation of

(2) Also referred to as the Whitethorn Creek receptor.

TABLE IV-9
SUMMARY OF PABLM INPUT PARAMETERS (1984)

Source	Quality	Quantity	Receiving Stream	Receptors	Pathway(1)
1) Treated Mine Water	U-nat - 0.5 mg/l Th-230 - 0.4 pCi/l Ra-226 - 3.0 pCi/l Pb-210 - 0.1 pCi/l Po-210 - 0.9 pCi/l	0.37 CFS	A. Mill Creek 10.5 CFS Whitethorn 30.0 CFS TOTAL 40.5 CFS	A. Cedar Hill Hunt Club	A. Vegetable Irrigation at 0.6 ac-ft/yr Fish at 2.2 kg/yr Water at 1 liter/yr Local Consumption = 50% of total
			B. Banister River 550. CFS	B. Halifax 1200 people	B. Fish at 2.2 kg/yr Water--all drinking water
2) Tailings Seepage-Unattenuated	U-nat - 35 mg/l Th-230 - 162 pCi/l Ra-226 - 22 pCi/l Pb-210 - 7 pCi/l Po-210 - 1 pCi/l	0.203 CFS	A. Mill Creek 10.5 CFS Whitethorn 30.0 CFS TOTAL 40.5 CFS	A. Cedar Hill Hunt Club	A. Vegetable Irrigation at 0.6 ac-ft/yr Fish at 2.2 kg/yr Local Consumption = 50% of total
			B. Banister River 550. CFS	B. Halifax 1200 people	B. Fish at 2.2 kg/yr All drinking water from Banister
3) Tailings Seepage-Attenuated	U-nat - 0.7 mg/l Th-230 - 1.0 pCi/l Ra-226 - 1.0 pCi/l Pb-210 - 2.0 pCi/l Po-210 - 1.0 pCi/l	0.203 CFS	Same as A. above	Same as A. above	Same as A. above
			Same as B. above	Same as B. above	Same as B. above
4) Overburden Seepage	U-nat - 0.028 mg/l Th-230 - 0.203 pCi/l Ra-226 - 9.01 pCi/l Pb-210 - 0.187 pCi/l Po-210 - 0.116 pCi/l	Nonvegetated Overburden: 0.274 CFS +Vegetated overburden: 0.540 CFS TOTAL: 0.814 CFS	Same as A. above	Same as A. above	Same as A. above
			Same as B. above	Same as B. above	Same as B. above
5) Runoff	U-nat - 0.014 mg/l Th-210 - 0.102 pCi/l Ra-226 - 4.505 pCi/l Pb-210 - 0.094 pCi/l Po-210 - 0.058 pCi/l	Nonvegetated Overburden: 0.002 CFS	Same as A. above	Same as A. above	Same as A. above
			Same as B. above	Same as B. above	Same as B. above
6) Pond Breach	U-nat - 7.4 mg/l Th-210 - 10 p Ci/l Ra-226 - 50 pCi/l Pb-210 - 40 pCi/l Po-210 - 10 pCi/l	2.02 CFS in 24 hours	Same as A. above	Cedar Hill Hunt Club	Vegetable-1 day's intake. No fish Local Consumption = 50% of total
			Same as B. above	Halifax	No fish Water--drinking 1 day's intake

(1) Numerical values derived in large part from a survey of local food production characteristics and local food and water habits.

actual conditions to be encountered at the site, and the unattenuated seepage represents a more pessimistic set of assumptions. Further detailed studies during licensing will closely approximate actual operating conditions. The actual tailings seepage concentrations will most likely lie between these two bounds.

Background or naturally occurring radionuclide concentrations were not included in the PABLM/MILDOS assessments to better assess the incremental impacts of project operations over background conditions. This approach is identical to that taken in typical environmental impact analyses of other nuclear facilities. At the Swanson Site, the background external radiation level is 88 mrem/yr, as measured during the summer of 1983. In addition, ambient radon contributes approximately 130 mrem/yr,[3] for a total of 218 mrem/yr background radiation dose at the site.

The model runs were structured to allow maximum flexibility in assessing the impact of the various project components including:

- What source of liquid effluent contributes the greatest radiological dose to people, i.e., is mine water, seepage, runoff, or a pond breach the most important?
- What is the maximal dose to the nearest resident who could use water containing liquid effluents from the project?
- Which radionuclides, organs, or food pathways are the most important?
- What is the radiological dose over 50 years?

To assess the effects of the Swanson Project over the long term, a radiological dose over 50 years was considered for two sets of exposure times. The first was the dose over 50 years due strictly to the operational mode from 13 years of treated mine water releases to streams potentially used at the Cedar Hill Hunt Club (maximally

[3] Estimate provided by Senes Consultants.

impacted receptor via the water pathway). After 13 years of operation, the project is scheduled to be closed and the mine water releases will cease. A second set of doses were calculated to simulate a full 50 years of tailing seepage, overburden seepage, and runoff to the Cedar Hill Hunt Club location.

b. Results

Tables IV-10 through IV-14 present the radiological doses from the six project sources for both the Cedar Hill Hunt Club and the Halifax residents. These results indicate that the Cedar Hill Hunt Club doses are higher than the Halifax doses, and the doses to the bone are higher than the doses to the whole body or to the gastrointestinal tract. The largest dose from all the sources to the bone at Cedar Hill Hunt Club is 3.4 mrem/year (Table IV-11) and is attributable to the contribution of unattenuated seepage. Mine water, attenuated seepage, overburden seepage, and pond breach contribute lesser doses (overburden runoff the least at 0.00007 mrem/year).

Table IV-15 provides the total waterborne radiological dose summarized from Tables IV-10 through IV-14. (See also Technical Memorandum No. 13.) The maximum individual dose from Table IV-15 is 3.6 mrem/year (assuming the contribution from unattenuated tailings seepage) to the bone of a person residing at the Cedar Hill Hunt Club, and results from the food and water consumption habits specified in Table IV-9. The contribution of each modeled exposure pathways to the percentage contribution of each modeled radionuclide to the maximum waterborne dose of 3.6 mrem/year is presented in Table IV-16. Leafy vegetables, and milk are the main source of radiological dose, and uranium-234 and uranium-238 are the main contributors to the bone dose for a Cedar Hill Hunt Club resident.

Table IV-17, for example, presents the long-term, 50-year, radiological dose assessment for both unattenuated and attenuated seepage conditions. In each case, the dose over 50 years for 13 years' mine water release was added to the dose over 50 years from 50 years of tailings seepage, overburden seepage, and runoff. The highest total

TABLE IV-10

CALCULATED RADIOLOGICAL DOSES DUE TO MINE WATER RELEASES
(PABLM 1984)

Receptor	Total Body	Bone	GI-LLI (1)
Cedar Hill Hunt Club (2)	0.012	0.096	0.041
Halifax Resident (3)	0.003	0.026	0.011
Halifax Population (4)	0.004	0.031	0.013

NOTES

(1) gastrointestinal -- lower large intestine
(2) mrem/yr
(3) mrem/yr (obtained by multiplying the population dose in man-rem/yr by 1000 to convert rem to mrem, and then dividing by 1200 people)
(4) man-rem/yr

TABLE IV-11

CALCULATED RADIOLOGICAL DOSES DUE TO TAILINGS SEEPAGE
(PABLM 1984)

Receptor	Total Body	Bone	GI-LLI (1)
	Unattenuated Seepage		
Cedar Hill Hunt Club (2)	0.41	3.4	1.4
Halifax Resident (3)	0.11	0.92	0.38
Halifax Population (4)	0.13	1.1	0.46
	Attenuated Seepage		
Cedar Hill Hunt Club (2)	0.009	0.074	0.03
Halifax Resident (3)	0.002	0.019	0.008
Halifax Population (4)	0.003	0.023	0.009

NOTES

(1) gastrointestinal - lower large intestine
(2) mrem/yr
(3) mrem/yr (obtained by multiplying the population dose in man-rem/yr by 1000 to convert rem to mrem, and then dividing by 1200 people)
(4) man-rem/yr

TABLE IV-12

CALCULATED RADIOLOGICAL DOSES DUE TO OVERBURDEN SEEPAGE
(PABLM 1984)

Receptor	Total Body	Bone	GI-LLI[1]
Cedar Hill Hunt Club[2]	0.013	0.059	0.036
Halifax Resident[3]	0.001	0.013	0.007
Halifax Population[4]	0.002	0.016	0.009

NOTES

(1) gastrointestinal - lower large intestine
(2) mrem/yr
(3) mrem/yr (obtained by multiplying the population dose in man-rem/yr by 1000 to convert rem to mrem, and then dividing by 1200 people)
(4) man-rem/yr

TABLE IV-13

CALCULATED RADIOLOGICAL DOSES DUE TO OVERBURDEN RUNOFF (PABLM 1984)

Receptor	Total Body	Bone	GI-LLI[1]
Cedar Hill Hunt Club[2]	0.00001	0.00007	0.00004
Halifax Resident[3]	0.000002	0.00002	0.00001
Halifax Population[4]	0.000002	0.00002	0.00001

NOTES

(1) gastrointestinal - lower large intestine
(2) mrem/yr
(3) mrem/yr (obtained by multiplying the population dose in man-rem/yr by 1000 to convert rem to mrem, and then dividing by 1200 people)
(4) man-rem/yr

TABLE IV-14

CALCULATED RADIOLOGICAL DOSES DUE TO POSTULATED POND BREACH
(PABLM 1984)

Receptor	Total Body	Bone	GI-LLI(1)
Cedar Hill Hunt Club(2)	0.006	0.047	0.019
Halifax Resident(3)	0.0007	0.0058	0.0023
Halifax Population(4)	0.0008	0.0070	0.0028

NOTES

(1) gastrointestinal — lower large intestine
(2) mrem/yr
(3) mrem/yr (obtained by multiplying the population dose in man-rem/yr by 1000 to convert rem to mrem, and then dividing by 1200 people)
(4) man-rem/yr

TABLE IV-15

TOTAL WATERBORNE RADIOLOGICAL DOSES (1)

(PABLM 1984)

Receptor	Total Body	Bone	GI-LLI (2)
Unattenuated Tailings Seepage, Mine Water, Overburden Seepage, Runoff and Pond Breach			
Cedar Hill Hunt Club	0.4	3.6	1.5
Halifax Resident	0.1	1.0	0.4
Halifax Population (3)	0.1	1.1	0.5
Attenuated Tailings Seepage, Mine Water, Overburden Seepage, Runoff and Pond Breach			
Cedar Hill Hunt Club	<0.1	0.3	0.1
Halifax Resident	<0.1	<0.1	<0.1
Halifax Population (3)	<0.1	0.1	<0.1

NOTES

(1) mrem/yr
(2) gastrointestinal -- lower large intestine
(3) man-rem/yr

TABLE IV-16

CALCULATED RADIOLOGICAL DOSE TO THE BONE OF A CEDAR HILL HUNT CLUB RESIDENT BY EXPOSURE PATHWAY AND BY RADIONUCLIDE

UNATTENUATED SEEPAGE[1]

(1984 PABLM)

Exposure Pathway	Bone
Leafy vegetables	0.98
Other above ground vegetables	0.21
Other root vegetables	0.30
Orchard fruit	0.32
Grains	0.79
Eggs	0.059
Milk	0.52
Beef	0.26
Pork	0.0027
Poultry	0.00005
Irrigated field exposure	0.014
Fish	0.13
Drinking water	0.014
TOTAL	3.6

Radionuclide	Bone	Percent of Total Dose[2]
U-234	1.8	51
U-235	0.075	2
U-238	1.6	43
Ra-226	0.069	1
Th-230, Pb-210, Po-210	0.018	1

NOTES

(1) mrem/yr
(2) percentages do not total 100 due to rounding.

TABLE IV-17

LONG-TERM, 50-YEAR RADIOLOGICAL DOSE TO RESIDENTS AT CEDAR HILL HUNT CLUB[1]

(PABLM 1984)

Source	Whole Body	Bone	GI-LLI[2]
	Unattenuated Tailings Seepage		
13 Years Mine Water, 50-Year Dose	0.07	6.8	0.73
50 Years of Tailings Seepage, Overburden Seepage and Runoff	78.	740.	110.
TOTAL	78.	747.	111.
	Attenuated Tailings Seepage		
13 Years Mine Water 50-Year Dose	0.07	6.8	0.73
50 Years of Tailings Seepage, Overburden Seepage and Runoff	26.	120.	22.
TOTAL	26.	127.	23.

NOTES

(1) mrem/yr
(2) gastrointestinal - lower large intestine

dose is 747 mrem to the bone over 50 years. That value can be compared to a 50-year dose of 1250 mrem which represents EPA's maximum allowable annual dose (25 mrem) over 50 years.

Table IV-18 presents a summary of the total radiation dose (assuming <u>unattenuated</u> seepage) to maximally exposed individuals from the water pathway (PABLM), air pathway (MILDOS) including radon contributions from the mining and milling activities, and from both pathways acting together. The table indicates that at Cedar Hill Hunt Club (Whitethorn Creek) the doses from the air pathway slightly exceed those from the water pathway to give a total bone dose of 9.0 mrem/year. Doses from combined air and water pathways to other organs range from 1.5 to 4.2 mrem/yr.

At the nearest residence (0.2 km N.E. of the mine) the air pathway is the most important because the house is located up-stream of the project. The nearest resident was assumed to eat 2.2 kg/yr of fish caught from Whitethorn Creek near the Cedar Hill Hunt Club. There the highest dose is 94.5 mrem to the bone, which is the highest of all calculated doses in the table, but still only 19% of the ICRP maximum of 500 mrem/year (whole body) for doses that include radon and its daughter products. In this case, radon and its daughter products contribute 96% of the 94.6 mrem/yr dose.[4] The doses at Halifax are due only to the water pathway because Halifax is far enough away from the project to reduce the airborne contribution to less than 0.1 mrem/yr to the bone. This is the same dose calculated for Danville, which is in one of the three primary wind directions from the project site, but close than Halifax.

[4] The quality and quantity of some liquid effluents differed between the 1983 and 1984 PABLM assessment as shown below.

TABLE IV-18

TOTAL RADIATION EXPOSURE TO MAXIMALLY EXPOSED INDIVIDUALS FROM WATER AND AIR PATHWAYS, INCLUDING RADON AND ITS DAUGHTER PRODUCTS

(PABLM 1984 + MILDOS, mrem/yr)

Pathway	Total Body	Bone	GI	Average Lung
Receptor Location: Halifax				
Water (unattenuated tailings seepage)	0.2	0.9	0.4	0.0
Air	0.0	0.0	N/A	0.0
TOTAL	0.2	0.9	0.4	0.0
Receptor Location: Cedar Hill Hunt Club - Whitethorn Creek				
Water (unattenuated tailings seepage)	0.4	3.6	1.5	0.0
Air	1.5	5.4	N/A	4.2
TOTAL	1.9	9.0	1.5	4.2
Receptor Location: Nearest Resident (1)				
Water (2)	0.0	0.1	0.1	0.0
Air	16.4	94.5	N/A	41.0
TOTAL	16.4	94.6	0.1	41.0

NOTES

(1) Coles Hill, adjacent to mine pit.
(2) assumes the nearest resident eats fish caught from Whitethorn Creek near the Cedar Hill Hunt Club.

Table IV-19 presents the combined dose from air and water pathways, excluding radon, radon daughters, and radionuclides from the mine. These values are comparable with the EPA 25 mrem/year limitation. None of the predicted doses in Table IV-19 exceed the 25 mrem/year limitation for the combined air and water pathways.

c. Comparison of 1983 and 1984 PABLM Assessments

The significant differences between the 1983 and 1984 PABLM analyses are presented below:

1) The Mill Creek receptor location in the 1983 PABLM assessment was assumed to be a location where people could use the water from Mill Creek diversion for irrigation purposes. The 1984 PABLM assessment did not include

2) The Whitethorn Creek receptor location in the 1983 PABLM assessment is referred to, and is the same location as, the Cedar Hill Hunt Club receptor in the 1984 PABLM assessment.

3) The 1983 PABLM assessment contained three sources of radionuclides released as liquids to surface waters. The 1984 PABLM assessment contained six possible sources as indicated below:

1983 PABLM Sources	1984 PABLM Sources
Treated Mine Water	Treated Mine Water
Attenuated Tailings Seepage	Unattenuated Tailings Seepage or
Pond Breach	Attenuated Tailings Seepage
	Overburden Seepage
	Overburden Runoff
	Pond Breach

4) The quality and quantity of some liquid effluents differed between the 1983 and 1984 PABLM assessments as shown below:

TABLE IV-19

TOTAL RADIATION EXPOSURE TO MAXIMALLY EXPOSED INDIVIDUALS
FROM WATER AND AIR PATHWAYS, EXCLUDING RADON, RADON
DAUGHTER PRODUCTS AND MINE EMISSIONS
(PABLM 1984 + MILDOS, mrem/yr)

Pathway	Total Body	Bone	GI	Average Lung
Receptor Location: Halifax				
Water (unattenuated tailings seepage)	0.2	0.9	0.43	0.0
Air	0.0	0.0	N/A	0.0
TOTAL	0.2	0.9	0.4	0.0
Receptor Location: Cedar Hill Hunt Club - Whitethorn Creek				
Water (unattenuated tailings seepage)	0.4	3.6	1.5	0.0
Air	0.2	2.0	N/A	2.4
TOTAL	0.6	5.6	1.5	2.4
Receptor Location: Nearest Resident(1)				
Water(2)	0.0	0.1	0.1	0.0
Air	0.3	3.6	N/A	12.2
TOTAL	0.3	3.7	0.1	12.2

NOTES

(1) Coles Hill, adjacent to mine pit.
(2) assumes the nearest resident eats fish caught from Whitethorn Creek near the Cedar Hill Hunt Club

		1983 PABLM	1984 PABLM(5)
Mine Water (with Ra-226 treatment)	U-nat	2 mg/l	0.5 mg/l
	Th-230	----------	0.4 pCi/l
	Ra-226	10 pCi/l	3.0 pCi/l
	Pb-210	----------	0.1 pCi/l
	Po-210	----------	0.9 pCi/l
	Flow	0.37 CFS	0.37 CFS
Unattenuated Seepage	U-nat	----------	35. mg/l
	Th-230	----------	162. pCi/l
	Ra-226	----------	22. pCi/l
	Pb-210	----------	7. pCi/l
	Po-210	----------	1. pCi/l
Attenuated Seepage	U-nat	0.7 mg/l	0.7 mg/l
	Th-230	----------	1.0 pCi/l
	Ra-226	1.0 pCi/l	1.0 pCi/l
	Pb-210	----------	2.0 pCi/l
	Po-210	----------	1.0 pCi/l
	Flow	0.025 CFS	0.203 CFS
Overburden Seepage	U-nat	----------	0.028 mg/l
	Th-230	----------	0.203 pCi/l
	Ra-210	----------	9.01 pCi/l
	Pb-210	----------	0.187 pCi/l
	Po-210	----------	0.116 pCi/l
	Flow	----------	0.814 CFS
Runoff	U-nat	----------	0.014 mg/l
	Th-230	----------	0.102 pCi/l
	Ra-226	----------	4.505 pCi/l
	Pb-210	----------	0.094 pCi/l
	Po-210	----------	0.058 pCi/l
	Flow	----------	0.002 CFS
Mill Pond Breach	U-nat	2.4 mg/l (1650. pCi/l)	7.4 mg/l (5000. pCi/l)
	Th-230	----------	10. pCi/l
	Ra-226	125. pCi/l	50. pCi/l
	Pb-210	----------	40. pCi/l
	Po-210	----------	10. pCi/l
	Flow	2.02 CFS	2.02 CFS

(5) Values derived after completion of mine waste rock leaching studies conducted by CSMRI with specific analytical data for each parameter, as agreed to by the State's consultant.

5) Receiving water volumetric flow rates differed between the 1983 and 1984 PABLM assessments, as agreed to by the State's consultants:

	1983 PABLM[6]	1984 PABLM[7]
Mill Creek	3.5 CFS	10.5 CFS
Whitethorn Creek	13.0 CFS	30.0 CFS
Banister River	120.0 CFS	550.0 CFS

6) Sprinkler irrigation water applications rates differed per the June, 1984 survey:

1983 PABLM	1984 PABLM
1.0 ac-ft/yr	0.6 ac-ft/yr

7) Food and water consumption pathways varied per the June, 1984 survey as follows:

Location	Pathway	1983 PABLM	1984 PABLM
Whitethorn Creek	Fish	----------	2.2 kg/yr
	Water	----------	1.0 liter/yr
	% local consumption	50	50
Halifax	Fish	2 kg/yr	2.2 kg/yr
	Drinking Water	All	All

8) Dose calculational models varied between the assessments as follows:

	1983 PABLM	1984 PABLM
Model	ICRP 2	ICRP 10a

(6) The lowest 90-day average flow rate expected to occur on average once in a 10-year period ($Q_{90,10}$).

(7) Average annual flow rate (Q_{avg}).

The final calculated radiological doses from the two PABLM assessments were as follows:

Receptor Location	1983 PABLM	1984 PABLM[8]
Mill Creek		
Total Body	10.1 mrem/yr	----------
Bone	17.4	----------
GI	0.5	----------
Whitethorn Creek		
Total Body	0.50	0.4
Bone	0.70	3.6
GI	<0.1	1.5
Halifax		
Total Body	3.1	0.1
Bone	5.4	1.0
GI	0.1	0.4

7. Ground Water Pathway

As stated under the discussion of the PABLM analysis, seepage from the tailings area eventually expresses itself as surface water, and thus was factored into dose estimates pertaining to the use and/or consumption of water from Whitethorn Creek and the Banister River. It is possible, as the pathways diagram presented as Figure IV-1 suggests, that contamination of ground water which eventually expresses itself in potable water wells could constitute a pathway; however, there will be no potential for such wells in the influence area due to the control of this property by the operator. In other words, there will be no residents using potable water from wells in areas where ground water could be contaminated due to the influence of the project. For this reason, a detailed analysis regarding the ground water pathways, other than that which expresses itself as surface water, was not included in the October 15 report.

(8) Assumes unattenuated seepage.

B. ENVIRONMENTAL ASPECTS

The following sections provide a summary of the short and long-term impacts associated with the construction and operation of the Swanson Uranium Project. More lengthy discussions are found in the main report, Section G and H (Vol. 2) and I.4 (Vol.3).

1. Air

Surrounding air quality due to the construction and preoperational phases of the proposed project will result primarily from fugitive dust and, to a lesser degree, gaseous emissions from construction machinery and vehicles. Air quality impacts during these phases will be of a short-term nature and will terminate at the conclusion of construction.

Fugitive dust emissions are expected to vary with the different phases of activity. In winter, dust loading should be less due to the more prolonged nature of rains, less evaporation, and occasional snow cover. During the spring and summer, when construction activity is high, fugitive dust emissions will be at a maximum and will be minimized through measures such as watering of roads and vehicle speed control. However, depending upon the degree of activity, even with control measures in effect, construction activities could cause occasional increases in the concentration of particulates within or near the construction area.

Gaseous emissions from vehicles and other internal combustion construction equipment potentially will affect local air quality. However, the contribution to the overall impact of pre-operational activity is expected to be negligible, and specific mitigation measures will not be warranted. Good maintenance, speed control, and other procedural measures will be used to minimize these impacts.

During operation the project primarily will be a source of fugitive dust emissions, but also will be a minor source of other contaminants such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and hydrocarbons (HC).

Operation of the mine and mill complex will not result in violations of federal (NAAQS) or state ambient air quality standards. In addition, the facility will not be subject to Prevention of Significant Deterioration (PSD) regulations, based on current project design alternatives.

Maximum predicted 24-hour SO_2 concentrations will be less than 1 ug/m^3, while concentrations of gaseous pollutants on an annual basis will be negligible. Total suspended particulates (TSP) concentrations due to process and fugitive dust emissions will be a maximum of 4.5 ug/m^3 on an annual basis. These concentrations occur to the northeast of the facility in line with the prevailing winds.

Minor emissions of kerosene, ammonia, and sulfuric acid are possible. However, the use of standard abatement technology will assure that no odor or safety problems arise due to these emissions.

The small amounts of asbestiform mineral discovered in the mine overburden material, with even less in the ore zone, are not expected to create any airborne health or environmental hazards. However, evaluation of the quantity and distribution of these asbestos-like fibers is continuing.

2. Water Resources

The construction of the mine will result in a localized cone of depression in the saprolite aquifer, with an associated decline in water levels in immediately adjacent wells. Only three potable water wells will be affected by mine development. Two of these private wells are either within the proposed pit boundry or within 200 feet of the perimeter. The remaining residential well is within 400 yards of the pit perimeter and may not be significantly affected.

The development of the mine will cause deep ground water to move into the pit. This water will be collected, and if not required as process water, will be treated and discharged. It is anticipated that water treatment will require the addition of sulfate ions to allow the co-precipitation of barium sulfate and radium sulfate. Treatment will be designed to meet National Pollutant Discharge Elimination System (NPDES) discharge standards, but discharged water will be slightly higher in total dissolved solids (TDS) than in its ambient state. Sediment control structures will be constructed to prevent abnormally high increases of suspended solids in discharges to streams.

The mill site will be bermed and ditched to prevent runoff into existing streams. The holding pond in the mill area will be lined to prevent the contamination of ground water due to seepage. The mill will be designed as a zero discharge facility.

A potential environmental impact from the tailings management area is the radiological and chemical contamination of ground water due to seepage. Initial studies of the project area indicate that suitable liner materials are available to provide the necessary environmental safeguards to protect the ground water resources.

The possibility exists for nutrient (nitrate) contamination of mine effluent water due to undetonated and residual blasting agent (ANFO, ammonium nitrate and fuel oil) being picked up by coincident water in the pit. However, control of this potential contaminant can be accomplished by proper handling of the material and proper disposal of packages and containers. Moreover, as explained in the attached Technical Memorandum No. 7, it would require enormous amounts of fugitive ANFO to create significant nitrate concentrations in downstream locations.

The location of the tailings and waste rock storage areas will be confined to the drainage basins of Whitethorn Creek and Mill Creek. There will be no potential for impacts on Georges Creek from surface runoff, and it is unlikely that there will be any effects on Georges Creek due to seepage or any other type of project-related disturbance. Ground water flow patterns in the project area essentially parallel surface water drainage basins.

3. Mineral Resources

No other mineral resources have been found on the project site in sufficient quantity to warrant serious economic consideration. Therefore, no other mineral development options will be precluded due to uranium development in the area.

4. Soils

Approximately 850 acres of surface will be disturbed during site preparation and construction. Before these activities began, all soils will be stripped and stockpiled for use in final reclamation. Erosion of stockpiles will be controlled by minimizing the slope and length of the pile and establishing vegetation. During final reclamation, the soil will be used as the top layer on the tailings structure and be replaced over the decommissioned mill site.

Runoff from stockpiles and reclaimed areas will pass through sediment control structures before being discharged. Erosion rates will be temporarily increased at the stockpiles and reclaimed areas, but will return to acceptable levels once a vegetation cover is established. Little or no additional soils will be disturbed during the operational phase of the project.

5. Ecology

a. Vegetation

As a result of project construction activities, native vegetation and agricultural lands in the affected areas will be lost temporarily. Trees of merchantable size will be salvaged, but most of the forest is of submerchantable size. The value of lost agricultural lands is mainly in the production of crops such as corn, soybeans, wheat, and hay. Some of the lands lost would normally be used in tobacco production or pasture.

b. Wildlife

The major impact on wildlife associated with site preparation/construction will be loss of habitat. The overall result of this habitat loss will be reduced numbers for most of the terrestrial vertebrate populations. In addition to the actual physical removal of vegetation cover, habitat loss also results from the fact that wildlife tend to avoid areas of intensive human activity.

The loss of wildlife through direct mortality can be expected to fall into three general categories. First, small species, especially small mammals, reptiles, and amphibians are subject to being killed by the operation of heavy equipment. Second, increased traffic on area roads is likely to result in higher roadkill rates for species such as deer, rabbits, and smaller species. Third, large birds such as raptors are subject to increased mortality from wirestrikes and electrocution along distribution lines providing electricity to the mining and milling facilities. The latter is expected to represent a relatively minor impact because suitable natural perches are plentiful in the area and safe ("raptor-proof") electrical pole configurations are available.

c. Aquatic Biota

The greatest adverse impact on aquatic biota would result from the proposed diversion of Mill Creek from a point upstream of the orebody to Dry Branch. The diversion essentially would leave Mill Creek a dry course from its confluence with Whitethorn Creek upstream for about 5 km. It is expected that most fishes presently inhabiting the affected portion of Mill Creek would die, and some would migrate to Whitethorn Creek and/or the Banister River.

The passage of Mill Creek water through a newly excavated channel could result in the transport of increased sediment load to Whitethorn Creek and the Banister River. The downstream manifestation of the increased sediment load would be influenced by discharge volume, stability of excavated reaches, additional erosion, and season. Until the excavated reach attains some bank and substrate stability, and sediment transport subsides, Dry Branch will not support many fish. Within Whitethorn Creek and the Banister River, sediment deposition would have localized effects on invertebrate production, fish spawning success, and fish vitality.

6. Land Use

Land use impacts will be limited to the immediate vicinity of the project site itself, and to the effects of additional automobile and truck traffic. Basically, changes will occur in the present land use of the 1265 acres required for the mine, mill, overburden, and associated uses. Land uses surrounding the project site are not expected to change.

7. Aesthetics

Construction of the project will introduce certain landscape alterations and reduce the overall native scenic aspects of the project area. The rolling landscape will be broken by the open pit form of the mine. The color of the open pit, overburden storage area, haul roads, and related facilities will contrast with the color of the surrounding environs. The mine, roads, and powerlines will introduce additional straight-line effects into a landscape with natural curving lines.

The construction of the uranium mill and ancillary support facilities also will result in impacts to the form, lines, and color of the existing environment. Buildings, tanks, the mill, and other structures would introduce rectangular, oblong, and circular forms into the topography. As with the mine, the area could be seen from existing roads; however, the towns of Gretna and Chatham would not suffer any visual disruption or degradation of scenic view.

The construction of the tailings management area would reduce the overall scenic quality of the area on a localized basis. The construction of an embankment with its sloping sides rising above the existing terrain would result in an obvious land form change. The construction of haul roads and stockpiling of construction topsoil material would further alter the existing terrain.

Reclamation will remove many of the features creating contrasting line forms and colors. However, the mine pit will remain and be allowed to fill with water, and the reclaimed tailings area will remain as a mounded structure.

8. Cultural Resources

Impacts on cultural resources, if any, will occur primarily during the construction phase. The feature identified during the cultural resource inventory are not presently considered significant and are not afforded regulatory protection. However, appropriate mitigative measures will be instituted as significance is attached to sites per discussion with regulatory and advisory groups.

9. Noise

Noise generated during the construction phase is difficult to estimate and is highly dependent on equipment used, work schedule, and duration. All construction activities will be in compliance with federal Mine Safety and Health Administration (MSHA) standards. For this reason, and also because of the short duration relative to the project lifetime, construction noise will not have a significant environmental impact away from the immediate project area.

The impact of blasting is expected to carry off site and contribute to noise impact. There is insufficient information at this time on charge placement and size to quantify this component, but blasting noise is expected to rate low as an adverse impact.

The major operational noise source at the mill probably will be the ore crushers and screens; however, crushing and screening do not generate sufficient noise to carry off site, and no mitigation is necessary. Actual sound levels are not available for analysis, but initial data indicate that untreated noise levels from the mill would appear not to have a deleterious impact away from the project site.

10. Socioeconomics

a. Economic Impacts

Total non-labor capital cost during construction will be $82.4 million for mill process equipment, open pit mining equipment, materials and supplies for buildings, excavation, concrete, electrical equipment, mine and mill site preparation, and indirect costs such as engineering. Local non-labor purchases in the regional study area are expected to amount to $37.1 million, or 45 percent of the non-labor total. Total labor cost for the regional study area is $5.1 million for 457.5 person-years of construction labor, provided by an average work force of 305 persons over a peak construction period of 18 months. During project construction, direct expenditures of $5.1 million in mine-mill construction payroll plus additional purchases of non-labor items will generate an additional $7.2 million in earnings to other local residents.

Annual labor expenditures during operations are estimated to be $5.9 million in 1981 dollars for 453 project employees. In addition, labor, local annual expenditures during operations will include $8.8 million for electricity, natural gas, wholesale trade (diesel fuel, maintenance and repair parts), and real estate (leases and rental of offices, royalties and lease payments to landowners). During project operations, annual expenditures of $8.8 million will generate an additional $2.2 million in earnings in the community.

b. Employment Impacts

The total construction force is estimated to average 305, which includes 20 salaried employees (supervisory and management). It is assumed that all of the wage-earning employees in the construction phase will be hired locally. Of the salaried employees, about half will be managers or professionals with specialized experience in the uranium industry who will be hired from outside of the area. During the 18 months of construction, the mine-mill portion of the project will generate another 441 person-years of labor in other sectors of the economy. When these figures are adjusted to reflect the site development for the tailings management area, and annualized, the economic impact is over 700 jobs in the construction year, which will reduce unemployment in the area by over 10 percent.

During the thirteen years of operation, the project will generate 453 direct jobs, and 596 total jobs in the regional study area. If the project is not built, the labor force (in a typical year - 1990) will include 80,000 people, employment will be 73,600, and 6,400 people will be unemployed. If the project is built, the labor force will be slightly higher due to in-migration, but employment will be substantially higher. Unemployment will be reduced from 6,400 to 5,860, lowering the unemployment rate from 8.0 percent to 7.3 percent.

c. Population Impacts

About ten managers or professionals with specialized experience in the uranium industry will relocate to the region for the construction phase of the project. They and their families will total 30 persons, including nine school-age children. About 45 managers, professionals, technicians, and foremen with mining experience will migrate to the area for operations. Their families will include 136 persons, 41 of whom will be school-age children.

The most likely areas to be chosen by the 45 in-migrants for establishing their residences will be in the newer, high-growth areas, already or soon to be served by municipal water and sewer systems, and within approximately 30 minutes driving time of the project site, i.e., the growth areas around Chatham, Gretna, and Danville suburbs (particularly Mr. Hermon, Westover Hills, and Glenwood). A small percentage may opt for locations towards Hurt/Altavista, Halifax, or even Lynchburg.

d. Housing Impacts

A few of the ten in-migrant households may choose to purchase homes during the construction phase, even for the 24-month duration. At most, this would amount to 6-8 homes, a demand which could be met easily.

Of the 45 operations-phase in-migrant households, seven are assumed to be single person households and the remainder family households. At least some of the single person households will choose to rent rather than purchase new homes.

The remaining 38 households are assumed to be families likely to purchase housing. The projected number of new homes required, by location, is as follows: Danville City - 2, Pittsylvania County and Danville Suburbs - 25, Chatham and Gretna - 11.

e. Impacts on Schools

During the construction phase, school children added to the County schools will not exceed seven pupils in the Danville suburbs area, and four in the Chatham area.

In the operations phase peak year (1990), it is estimated that the number of added pupils will be 26 in the Danville suburbs, 12 in the Chatham area, and three in Danville city. Because of the projected excess classroom capacity, the addition of this number of pupils--representing 0.31 percent of baseline demand in the County and 0.05 percent in the City--will require no additional facilities.

f. Impacts on Infrastructure

Project-generated impacts on community facilities and infrastructure will be minimal. The total population increment of 136 will be geographically dispersed, and represents a very small proportion of total study area population. The in-migrant population is not anticipated to require any additional personnel or facilities in the areas of health, public safety, social services, cultural facilities, or solid waste disposal. Projected water supply and treatment capacities are ample to meet anticipated demand in 1990.

During plant operation, direct tax revenues are estimated at $417,350 per year, almost all of which will be paid to Pittsylvania County. Project real estate is estimated to be assessed at $71.6 million which under projected tax rates will yield $250,600 per year. The total of all tax revenues received by Pittsylvania County is estimated at $372,460 per year. In addition, $44,890 in sales tax will be received by Danville and Halifax County. Secondary revenues are estimated at $53,700. The $8.0 million in earnings will yield $4.0 million in retail sales, which will return $40,000 to jurisdictions in the region.

The project will generate in-migration of 45 households for direct jobs at the plant. These families will pay about $13,700 in real estate taxes to the communities they live in. Most will pay user charges for water and sewer services to the providers of these public services.

The net fiscal impact in the Regional Study Area is positive. Additional annual revenues will exceed additional costs by about $419,689. Most of the benefits, $355,899 per year, will be to Pittsylvania County. The other $63,970 in annual net benefits will be distributed to the city of Danville and Halifax County.

C. EFFECTS OF ACCIDENTS

Accidents discussed under this topic are those having ramifications regarding the health and safety of the general public. These include such things as unplanned releases of radioactive materials, transportation accidents, pipeline ruptures, etc. Occupational safety matters are outside the scope of this discussion, and in reality are no different with respect to uranium mining and milling than for other minerals-related industrial activities. Radiation safety and contingency matters are discussed in another section of this report.

1. Mine Related Accidents

a. <u>Pipeline Rupture</u>

A potential mining related accident involves the rupture of any or all of three parallel, 30-inch, high pressure natural gas pipe-lines belonging to the Transcontinental Gas Pipeline Corp. (TRANSCO) and passing within approximately 150 feet of the edge of the open pit.

TRANSCO has been contacted about this matter and has agreed to provide guidance for blasting and transportation activity in the vicinity of the pipeline. A cooperative effort between the operator and TRANSCO will assure that safe blasting practices are instituted and protection is afforded the pipelines with respect to vehicle crossings. Rupture contingency plans will be developed to follow those currently maintained by TRANSCO, and which have been approved by federal and state regulatory authorities.

b. Explosive Detonation

Accidental detonation of explosives stored in the explosives magazine could occur in such magnitude so as to result in area vibrations and pressure shock waves. Federal and state safety regulations regarding the storage and use of explosives will be followed, and the magazine usually will contain only an amount of explosives necessary for one week's operation.

2. Mill and Tailings Related Accidents

a. Minor Accidents

Various types of trivial accidents can result in small releases of radioactivity to the environment. Pipelines may rupture within the mill area and release reagents and liquids bearing radioactive materials. However, these substances are always contained within the mill area by protective berms and sumps, and do not result in releases to the environment. However, small releases of radioactive materials and chemicals can result due to various types of explosions and failures in effluent control mechanisms, especially in areas where yellowcake is handled. For example, if the yellowcake dryer scrubber and its alarm system fail and is undetected for an entire shirt, a release of 25 pounds of insoluble uranium could result. In such case, an individual living two kilometers directly downwind of the mill could receive a radiological dose of up to 90 mrem to the lungs, roughly equivalent to the background dose in the area. Moreover, such an event is unlikely because of the frequent checks made on yellowcake scrubbers and the electrical interlocks which prevent yellowcake dryer operation should there be a pressure drop in the scrubber.

In the event of a fire and resultant dumping of the material in the solvent extraction circuit, an individual living two kilometers directly downwind could receive a dose of approximately 103 mrem to the bone. Although a significant fire hazard exists in the solvent extraction area of the mill, strict safety measures have prevented fires from being a frequent occurrence in uranium mills. Only two major solvent extraction fires have occurred in 570 mill-years of operation in the United States.

High winds, leaks or ruptures in tanks or piping have the potential for dispersion of small amounts of radioactive and other substances into the environment; however, proper design and operation result in virtual 100% containment of these materials on site. High winds sufficient to cause dusting of dry tailings do not occur frequenting in Pittsylvania County, usually are of short duration, and are associated with rain. Therefore, the potential for significant environmental impact due to transport of dry tailings by wind is not great. Contrasted with the western U.S. scenario, this aspect of accidental transport of radioactive tailings is less serious in a moist environment. Moreover, the routine operational procedure of keeping most of the tailings covered and the exposed area minimal will further reduce the potential for dusting due to high wind.

b. Accidents Resulting in Large Releases to the Environment

Tornadoes

Tornadoes, with their fierce winds, can do extensive damage to mill facilities, as well as to other similarly constructed buildings. However, the tailings facility probably would not be seriously affected due to its nature and its large mass. Furthermore, there is an extremely low probability that a tornado would strike a tailings impoundment, with the probability set at one such event in 3268 years at the Swanson site.

If a tornado should strike the mill site, it has been calculated that the nearest downwind resident would receive an incremental radiation dose on the order 10^{-4} mrem, which is extremely small compared to the 88 mrem per year natural background dose.

Tailings Impoundment Failure

In the case of the Swanson project, which produces filtered tailings, the radiological impact of a dike failure would be small compared to a similar failure where slurried materials are released. The probability of a dike failure at the Swanson project has been calculated to be 0.03, equivalent to one dam failure every 35 years. The Swanson tailings facility has a projected life of 13 years.

3. Transportation Accidents

Transportation of materials into and out of the project vicinity will be by truck. Trucks will transport chemicals and reagents to the mill site, ore from the mine to the mill, yellowcake product from the facility, and tailings to the tailings management area. The NRC has calculated the incidence of truck accidents to be approximately 1.3 x 10^{-6} per km traveled (NUREG-0706).

Truck accidents involving the spillage of reagent liquids can be serious with respect to both personal injury and the environment. For example, a truck hauling reagents to the mill could release chemicals onto the land surface and possibly into a creek or river. Such releases into a stream could be detrimental to local biota, and probably would result in localized fish kills. Potable water supplies might be temporarily interrupted until chemicals entering a stream flow pass the treatment plant intake. Reagent spills on site would not have serious environmental consequences, as the material could be cleaned up, and contaminated soil placed in the tailings management facility.

Yellowcake product will be packaged in 55-gallon drums, each containing approximately 950 pounds of material. This material will be hauled by truck to a uranium hexaflouride conversion plant, the nearest of which is approximately 1500 miles away. An average truck shipment will contain 40 drums, resulting in approximately 65 shipments annually. There is a 20 percent chance that a truck carrying yellowcake will have an accident of some type during any one-year period. A truck accident involving complete loss of the yellowcake shipment, that is, each drum being ruptured and contents released, would result in a population exposure of 200 man-rem.

It is possible that the postulated accident could occur on a bridge, such that the containers could be spilled into the water below. A reasonably high estimate states that over the life of the project a total of 160 kilometers of bridges would be traversed by trucks hauling yellowcake enroute to the conversion plant. A worst case suggests that the truck and all of its containers would be immersed, and 45 percent of the containers would be ruptured and release their contents into the water. The probability of the yellowcake becoming immersed is around 8.7×10^{-10} per vehicle/km.

If yellowcake is spilled on the ground, the material would be cleaned up immediately to prevent spread of contamination. The greatest danger in such an event would be inhalation of airborne yellowcake dust, in which case health effects due to the chemical toxicity of uranium as a metal could result. However, due to rapid response in isolating and cleaning up the material, no ill effects have been observed in individuals in the vicinity of the spills. Truck drivers will be trained to deal properly with any yellowcake spills.

Tailings will be hauled from the mill to the management area over a distance of 1.6 km. Due to the short distance and lower truck speed, the probability of a truck accident in this scenario should be less than that stated above for general truck traffic. Tailings have a low specific radioactivity and any spill between the mill and tailings management would have minimal environmental consequences, due both to the low level of radioactivity and the quick response in cleaning up the material.

As part of licensing and operating the mill, all potential accidents will have associated contingency plans for clean up and remedial action. These contingency plans will be updated periodically and kept on file for inspection. They also will be used in appropriate training programs for those individuals whose job assignments involve remedial action pertaining to specific accidents.

4. Post-Closure Accidents

The risk of accidents occurring during reclamation will be no greater than those postulated in the above discussion, and will be controlled by the same procedures for accident avoidance as were used during operation. After the mill is closed, the tailings area will be reclaimed according to NRC and Virginia Regulations in force at that time. The NRC currently requires that each licensee establish financial surety arrangements prior to the commencement of operation to assure that sufficient funds will be available to carry out the decontamination and decommissioning of the mill and tailings facilities. Prior to license termination and release of the surety, the licensee must pay a fee to ensure adequate long-term monitoring and maintenance of the tailings management area.

V. EVALUATION OF ALTERNATIVES

A. ALTERNATIVE SITES

The only site possible for the mine is the location of the deposit, and therefore, no alternative siting considerations are possible for the mine.

Alternatives are available and were considered in the siting of the mill and tailings management area. Ideally, with all other environmental, economic, and sociological factors being favorable, it generally is preferred that the mill be located as closely as possible to the mine site, and the tailings management area situated in close proximity to the mill. Such arrangement minimizes total area disturbance and length of haul roads, optimizes operational logistics and economics, and makes the overall project more manageable. However, locating mill facilities near the mine operation cannot be given priority unless a suitable mill site and tailings management area can be identified, considering all environmental, geochemical, and geotechnical factors.

In the case of the Swanson Project, highly suitable sites were located in the vicinity of the mine for tailings management and mill facilities. The process of selecting these sites is outlined in detail in Volume 4, Appendix I of the main report.

Initially, eleven candidate sites were identified for tailings management, and all but three were eliminated due to environmental and economic factors. Field investigations subsequently were performed on the three preferred sites to collect information on ground water, geologic, geotechnical, geochemical, and cultural resource conditions.

As a result of these investigations, all three locations proved favorable as tailings management sites.

Only after the selection of an above grade encapsulation of belt filtered tailings as the tailings management system did one of the sites prove more favorable than the other two. The site selected for tailings management, referred to at 9T, is located in the wide, relatively flat, lower area of the Triassic Basin near the mine site. The general 9T area also will contain the mill site and mine overburden storage area.

B. PROCESS ALTERNATIVES

As discussed in Section II the Swanson uranium ore is suitable for agitation leaching, a hydro-metallurgical technique that is used to extract and recover uranium from the parent ore. The two alternatives for the agitation leaching process are acid and carbonate, both of which have been tested under laboratory conditions using actual Swanson ore. Although more detailed analyses are yet to be made, Marline and Umetco are favoring the carbonate leach process over the acid leach. Uranium recovery is slightly lower in the carbonate process, but economic and environmental advantages make it the favored process.

Because the carbonate process is summarized in Section II, the following discussion highlights only the acid leach alternative. For a detailed discussion of the acid leach process, refer to Volume 2, Section E.2.3.1.3 of the October 15, 1983 submittal.

Ore preparation (crushing, grinding, and sorting) in the acid circuit is similar to that of the carbonate circuit. The uranium dissolution is based on leaching the ground ore with sulfuric acid (pH=1.5) which results in over 90 percent extraction of uranium from the ore; acid consumption is relatively high at over 300 pounds per ton of ore. By comparison, uranium recovery in the carbonate process is less than 90 percent, with a reagent consumption of 6 to 8 pounds sodium carbonate per ton of ore. After dissolution, the uranium-bearing liquid is processed further to concentrate and eventually remove the uranium product.

The most significant difference between the acid and carbonate process is the significantly higher levels of dissolved elements in the acid raffinate (the uranium-barren waste solution). Dissolved solids levels in the undiluted acid solution are nearly four times greater than the undiluted carbonate tailings solution. To prevent a build-up of dissolved contaminates in the system, the acid raffinate is chemically neutralized by the addition of hydrated lime. The result of this reaction is the precipitation, or settling out, of a waste sludge containing the lime and other dissolved constituents.

The resulting neutralized solution is used to wash the tailings before disposal, thus minimizing the contaminant levels in the residual tailings fluids that occupy the voids among the sand-like tailings particles. The sludge generated by the neutralization process is managed with the dewatered tailings, and would increase the tonnage of material at the tailings management area by 21 percent over the carbonate leach process. If the acid leach process tailings were placed at the same average height as the carbonate tailings (33 feet), an additional 42 acres would be required for tailings management.

Thus, the primary differences between the acid and carbonate process alternatives are the nature of the chemically stronger acid reagent and the effects it has on the tailings washing procedures, disposal volumes, and reagent consumption rates. Further pilot-plant scale testing and process engineering will be conducted to confirm the initial carbonate process selection prior to licensing.

C. MINING METHOD ALTERNATIVES

The basic alternatives for mining the Swanson ore deposit are surface mining, underground mining, or a combination of the two. The selection of one alternative over the others is a complex decision involving the physical characteristics of the orebody, economic forecasting and environmental considerations.

The Swanson ore body currently is proposed to be mined by the open pit technique. This choice is based on the current understanding of the distribution and continuity of the ore within the host rock. The open pit method will allow greater recovery of the overall ore deposit than would the underground technique. However, as surface mines increase in depth, the volume of waste to be removed for every ton of ore mined increases until the stage is reached beyond which surface mining becomes uneconomical. It is conceivable that as surface mining progresses, knowledge gained about the ore body would be sufficient to allow underground mining.

Although it is necessary as an initial step to generate long-term mining plans, it reality these usually change over time to reflect the effects of a changing economy, increased knowledge of the orebody, and improvements in mining technology. The mine will commence as a open pit mining operation; however, at later stages of the project, some underground mining could be considered. The preliminary open pit design discussed in Volume 2, Section E.1 of the October 15, 1983 report will be developed in much greater detail during a future pre-licensing stage of the project.

VI. COST-BENEFIT EVALUATION

A. BENEFITS

Benefits of uranium activities in Pittsylvania County include increased employment opportunities, increased regional income, increased tax revenues, and increased knowledge of the local environment and natural resources as a result of associated research and monitoring.

Additional benefits to be derived from operation of the proposed Swanson Uranium Project include the production of uranium oxide (U_3O_8), the subsequent generation of electricity from that uranium production, reduction of domestic reliance on imported fossil fuels, the creation of a new source for uranium in the United States, and the strengthening of the overall U.S. fuel supply.

The estimated 30 million pounds of uranium oxide to be produced from the contemplated Swanson Project translates to approximately 65 percent of the total annual residential electrical demand in the U.S., and approximately 22 percent of the entire annual U.S. demand for electricity, which is the equivalent of 850 million barrels of oil. During 1983, nuclear generating stations supplied 41 percent of the electrical power generated by the Virginia Electric and Power Company (VEPCO), or about one-third of all electricity used by Virginians. In 1982, VEPCO required approximately 1.9 million pounds of uranium oxide to meet their uranium fuel needs, and nearly one-half of this material was obtained from foreign sources. Thus, it is clear that development of the Swanson Uranium Project, which represents one of the largest uranium deposits in the country, will help ensure the energy independence of the United States.

Throughout the construction and operational phases of the Swanson Project, revenues will be generated that will benefit a variety of local, state, and federal revenue systems. Although the bulk of the economic benefit from the new industry will accrue to the regional study area, some economic benefits also will be apparent in surrounding counties, the entire Commonwealth, and the nation.

The total project capital cost is estimated at $200 million. The construction period will result in payroll costs of $16.3 million, of which over 98 percent will be allocated to local residents. These figures translate to a 10 percent reduction of unemployment in the area. Operating expenditures during the 13-year life of the project will be $30.8 million per year. These expenditures will generate about $9 million in annual earnings for area residents, supporting about 600 additional jobs.

It can be seen that the project will have a positive direct fiscal impact on local and state budgets. Pittsylvania County will receive a net fiscal benefit of $356,000 per year, mainly through property taxes. The Commonwealth of Virginia will receive a net fiscal benefit of $1.1 million per year.

Some property values may increase as a result of the project, due in part to the fact that land upon which the project will be constructed is being purchased at prices in excess of fair market value. Also, the increased demand for land brought about by the arrival of new workers into the area, as well as the increased prosperity of the local citizens, will have a beneficial effect on land values in general. There also will be increases in land values because of the additional mineral exploration activity prompted by the development of more detailed geologic information. There is no evidence to suggest that uranium development in the area will have an adverse effect on adjacent agricultural uses and associated land values.

B. COSTS

The costs resulting from the development of the Swanson Project are primarily in the realm of environmental and social impacts. Monetary costs to the proponents also are a factor, with the estimated capital cost of the project totaling $200 million.

The impact of the proposed project on surface water will be slight. The diversion of Mill Creek upstream of the mine pit will be necessary. The discharge of treated effluent water from the mine water treatment plant, although meeting discharge limitations, will cause the levels of total dissolved solids in Mill Creek to increase slightly. This effluent will not violate drinking water standards, including the standard for radionuclides, nor will it significantly increase nutrient levels in the stream.

Because ground water recharge in the area essentially follows the surface water drainage basins, impacts from the proposed open pit would be limited to the small basins specifically disturbed. The potential for ground water contamination is slight due to the lack of wide ranging ground water conduits in linear fractures or faults. Field testing has indicated that the Chatham fault, which passes through the proposed mine pit, will not provide a mechanism for ground water contamination.

The implementation of the project would result in the disturbance of approximately 1265 acres. This disturbance will result in the displacement of localized plant and animal populations, but no general effect in this regard is anticipated. No unusual, threatened, or endangered plant or animal species are known to exist in the area.

The primary air pollutants which will be emitted from the project are particulate matter and small amounts of process vapors and mists. These emissions will remain under applicable regulatory and license limits. Radionuclide emissions will be extremely small.

Certain noises will be perceptible from the project development due to traffic, blasting, and process and crushing equipment. Impacts in this regard will decrease with distance from the site, and also as the mine pit deepens. Immediately adjacent to the site, it is possible that noise could create minor interferences with work, sleep, or hearing.

Route 690 will be closed, as will a portion of Route 683. However, alternative access routes exist in both cases and will result in only minor inconveniences. The primary access route to the site will need to be improved to handle the increased traffic and truck loads anticipated. During construction, projected traffic generated by the project is 146 passenger cars at peak hours in each direction and 20 trucks over an average 24-hour period. During operation, predicted peak hour passenger car volume is 190 cars in each direction, and a maximum of 31 trucks during a typical 24-hour period.

Visual impacts will result from the alteration of the natural landscape, producing a contrast with the surrounding geography. However, project features will not be visible at great distances from the site. Activity at the site, therefore, will not affect the scenic views from the nearest towns of Chatham and Gretna.

Typically, the greatest socioeconomic costs resulting from development of projects such as this are in the area of public and social services, and also in the internal cost of the project. The local population probably will increase by approximately 136 people. Due to an excess capacity in the local school system of 5733 places, an expected increase of 40 students could easily be accommodated.

The water treatment facilities in the area can accommodate the increased demand for domestic water; overall capacity utilization would be increased from 45 percent to 48 percent. Sanitary waste treatment systems and solid waste disposal systems, likewise, are capable of handling the increased demand.

The addition of 136 persons to the area would not significantly change the current physician-to-patient ratio of approximately 1:900. Police and fire protection personnel would not need to be increased. It is estimated that 15 new houses will be needed in the Chatham area and that 30 new houses will be needed in the Danville suburbs.

Electric utility and natural gas service lines will need to be extended to the project site from the nearest available sources. Utility requirements of the mine/mill complex will not adversely affect the rates or service capabilities of local utility companies.

C. COST - BENEFIT COMPARISONS

Because some of the benefits and costs described above are quantifiable, they are relatively easily to compare. For example, it is not difficult to estimate the value of the uranium, the tax revenues, the new salaries, and the increases in income, and then to contrast the sum of those benefits with the costs of the increased demand for public services and capital costs associated with the project. Such "hard" benefit to "hard" cost comparison clearly demonstrates that the benefits involved with the development of the project far outweight the costs.

However, certain intangible benefits and costs also must be considered. The benefits of decreasing U.S. dependence on fossil fuel, enhancing the dependability of domestic energy supplies, increased job opportunities, and an increased knowledge of the local environment must be weighed against the intangible costs of the impacts on the social and natural environments. Such values are not quantifiable in the empirical sense.

Only those who are likely to receive the benefits or bear the costs can assign values to subjective judgments. Public opinion surveys conducted for the proponents by an independent polling firm in 1981 and 1982 indicate that a clear majority of people in the regional study area favor development of the proposed project.

For a more detailed discussion of the costs and benefits associated with the Swanson Project, refer to Volume 3, Section J, in the October 15, 1983 report.

VII. CONCLUSION

Marline and Umetco believe the report submitted to the Uranium Administrative Group on October 15, 1983 was responsive to the mandate of Senate Bill 155. The report structure was consistent with the format of SB 155 and addressed the subjects contained therein on a point-by-point basis. Furthermore, as stated in the preceding section, the proponents firmly believe the benefits of the proposed uranium development far outweigh the costs involved, whether on a "hard" or judgmental basis.

The major concern which appears to have surfaced in discussions involving the Swanson project is the impact of the operation on water resources of the area. Studies within the October 15, 1983 report show that:

- the mining operation will not reduce yields of water wells beyond 400 yards from the perimeter of the pit.
- no potable water wells will be adversely affected by seepage from the tailings management area.
- all controlled discharges from the facility will meet applicable water quality standards.
- the project will not alter the Banister River as a quality drinking water source.
- column percolation tests demonstrated that local clays to be used as liner material have excellent qualities for geochemically trapping radiological and chemical contamination due to seepage.

No other environmental or socioeconomic impacts have been identified which should preclude the development of the uranium resource in Pittsylvania County.

Various comments have been made regarding the applicability of technologies used in the western U.S. uranium producing areas to the net precipitation environment of Virginia. Upon examination, it can be concluded that most of the environmental ramifications of uranium development are of less consequence in the net precipitation environment than in the arid west. For example, (1) radon emanation will be significantly reduced due to higher moisture content of materials which contain radium, (2) there is less wind and higher humidity which results in significant natural dust suppression and inhibition of radioactive materials becoming airborne, (3) process water is readily available so as not to stress local water supplies, and (4) revegetation potential is greatly enhanced. In the event excess water needs to be discharged, treatment technologies exist to ensure that effluents from the project will not degrade the quality of receiving waters, nor would they affect downstream uses of the water resources.

Marline and Umetco believe it is possible for the Commonwealth of Virginia to move toward the development of enabling legislation to provide a framework for regulating the uranium industry in Virginia. All parties recognize that project planning and associated development of engineering details cannot progress until such regulatory framework is in place.

Once regulations are developed, whether NRC or state-based or a combination thereof, a greater level of project detail can be provided and more intensive monitoring programs developed to augment a licensing process for the Swanson Project. However, sufficient information is available at the present time to enable the Uranium Administrative Group to conduct, in accordance with the mandate of SB 155, a cost benefit evaluation of uranium development in Pittsylvania County.

VIII. CONTENTS OF THE OCTOBER 15, 1983 REPORT TO THE URANIUM ADMINISTRATIVE GROUP

The following pages contain the Table of Contents copied directly from the October 15, 1983 report to the UAG. These contents are included here to facilitate cross referencing and to give an appreciation for the level of detail and thoroughness of the larger report. The contents also demonstrate the responsiveness of the report to the format and requirements of Senate Bill 155.

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