ENVIRONMENTAL IMPACT APPRAISAL

of the

NUCLEAR FUEL SERVICES, INC. ERWIN PLANT
ERWIN, TENNESSEE

JANUARY 1978

Regulatory Docket File

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
DIVISION OF FUEL CYCLE AND MATERIAL SAFETY
WASHINGTON, D.C.

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1. INTRODUCTION

Nuclear Fuel Services, Inc. has submitted an application for renewal of Special Nuclear Material License No. SNM-124, covering operations of the plant at Erwin, Tennessee. In connection with the application for license renewal, the applicant submitted an environmental information report (EIR), titled *Environmental Information Report on the Nuclear Fuel Services, Inc., Operation at Erwin, Tennessee, January 1976*. In response to Nuclear Regulatory Commission (NRC) staff questions and requests for additional information, revisions were made October 20, 1976, and May 31, 1977. In addition, the applicant submitted *Proposed Conditions: Special Nuclear Materials License SNM-124* (August 30, 1976), with appendices.

In connection with such license renewals, Title 10, Part 51 of the *Code of Federal Regulations* (10 CFR 51) requires that an environmental impact appraisal be performed to determine whether an environmental impact statement or a negative declaration will be prepared. Part 51 further states that the determination shall be guided by the President's Council on Environmental Quality (CEQ) guidelines (40 CFR 1500.6). In accordance with these regulations, the staff of NRC's Division of Fuel Cycle and Material Safety initiated an assessment of the environmental impact of the proposed licensing action. Upon completion of the environmental impact assessment and evaluation of the findings, the staff independently prepared this appraisal on environmental considerations associated with the proposed license renewal in accordance with 10 CFR Part 51, implementing the requirements of the National Environmental Policy Act of 1969 (NEPA) and the CEQ guidelines.

Because this is an operating facility and actual plant releases have been measured and documented, the staff in conducting this appraisal has used the information provided in the documents and has addressed all of the significant environmental factors. These factors include land use, demography, geology, hydrology, meteorology, ecology, effluent controls, environmental monitoring, and accident potential.

1.1 DESCRIPTION OF THE PROPOSED ACTION

The proposed action for which this environmental impact appraisal is performed is the routine renewal of Nuclear Fuel Services' license for continuing operation. Licensed activities include production of fuel containing highly or slightly enriched uranium; conversion of uranium hexafluoride to oxide, tetrafluoride, or metal; fabrication of thorium materials; recovery of uranium or thorium from scrap materials; and storage of plutonium. [Source materials (natural and depleted uranium and thorium) are licensed and controlled by the State of Tennessee]. The processes used at the site are numerous and change from time to time in response to the changing needs of the nuclear industry. According to the applicant, the activities that will continue under the authorization resulting from renewal of the present license have been in progress since 1958 with no adverse environmental effects. A new liquid-waste treatment facility has been installed, which will reduce the releases even further. Liquid and airborne discharges of radioactive and other hazardous materials must meet Federal and State standards.

1.2 FACILITIES

The facility is located in the mountainous region of east Tennessee on the southwest border of Erwin, along the east border of the Nolichucky River, and adjacent to the Clinchfield Railroad. Of 57.8 acres owned, 21.2 are enclosed by a security fence (Fig. 1.1). The land outside the security fence includes facility parking space, burial grounds, and undisturbed forest land. The facility is designed and managed so that the manufacture, packaging, and ultimate disposal of the resulting products and wastes create a minimum effect on the environment (Fig. 1.1).

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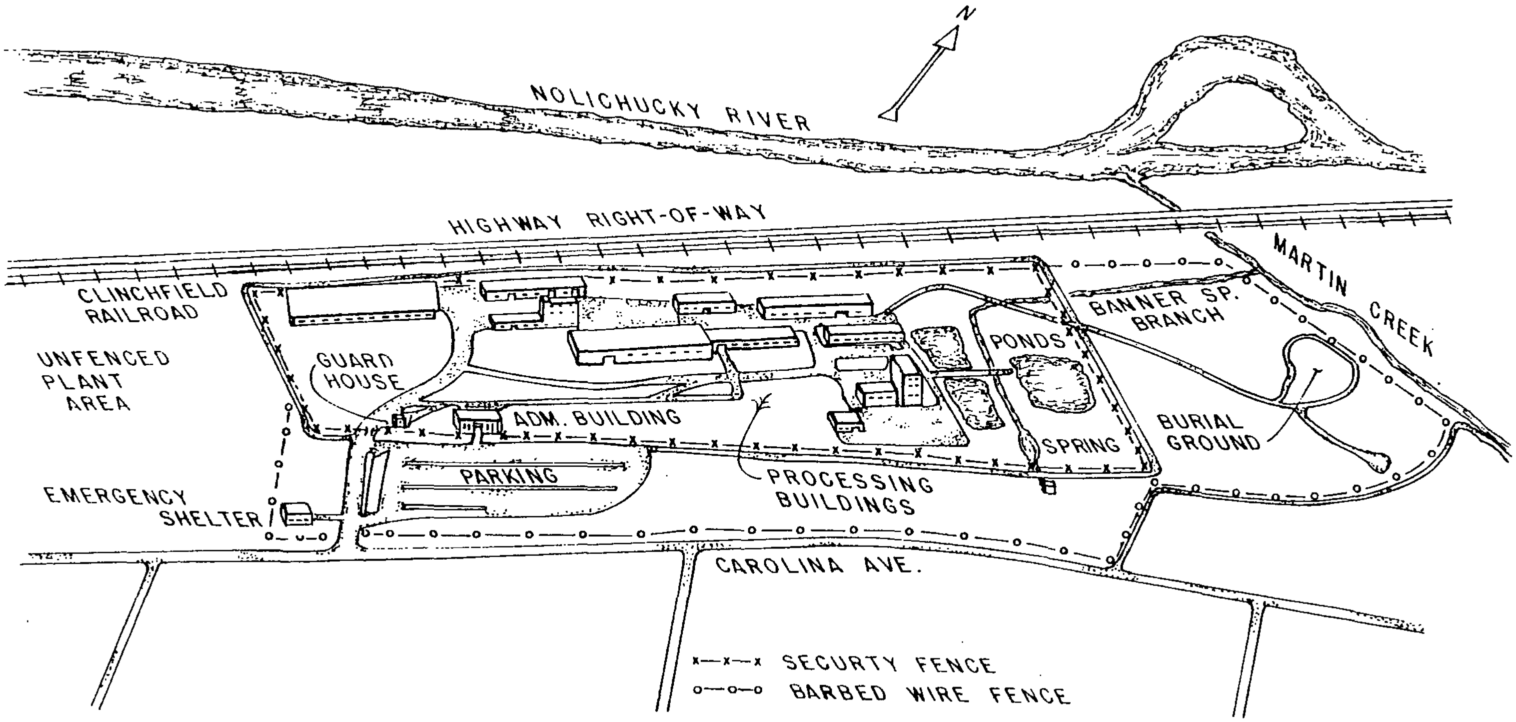

Fig. 1.1. Site of Nuclear Fuel Services, Inc., Erwin plant.

2. DESCRIPTION OF SITE ENVIRONMENT

This section provides basic information about the physical, biological and cultural environments surrounding the Nuclear Fuel Services (NFS) plant at Erwin.

2.1 SITE LOCATION

The NFS plant at Erwin is located in Unicoi County in northeast Tennessee. As shown in Fig. 2.1, the NFS Erwin site is approximately 0.5 mile southwest of the city limits of Erwin and is immediately west of the unincorporated community of Banner Hill.

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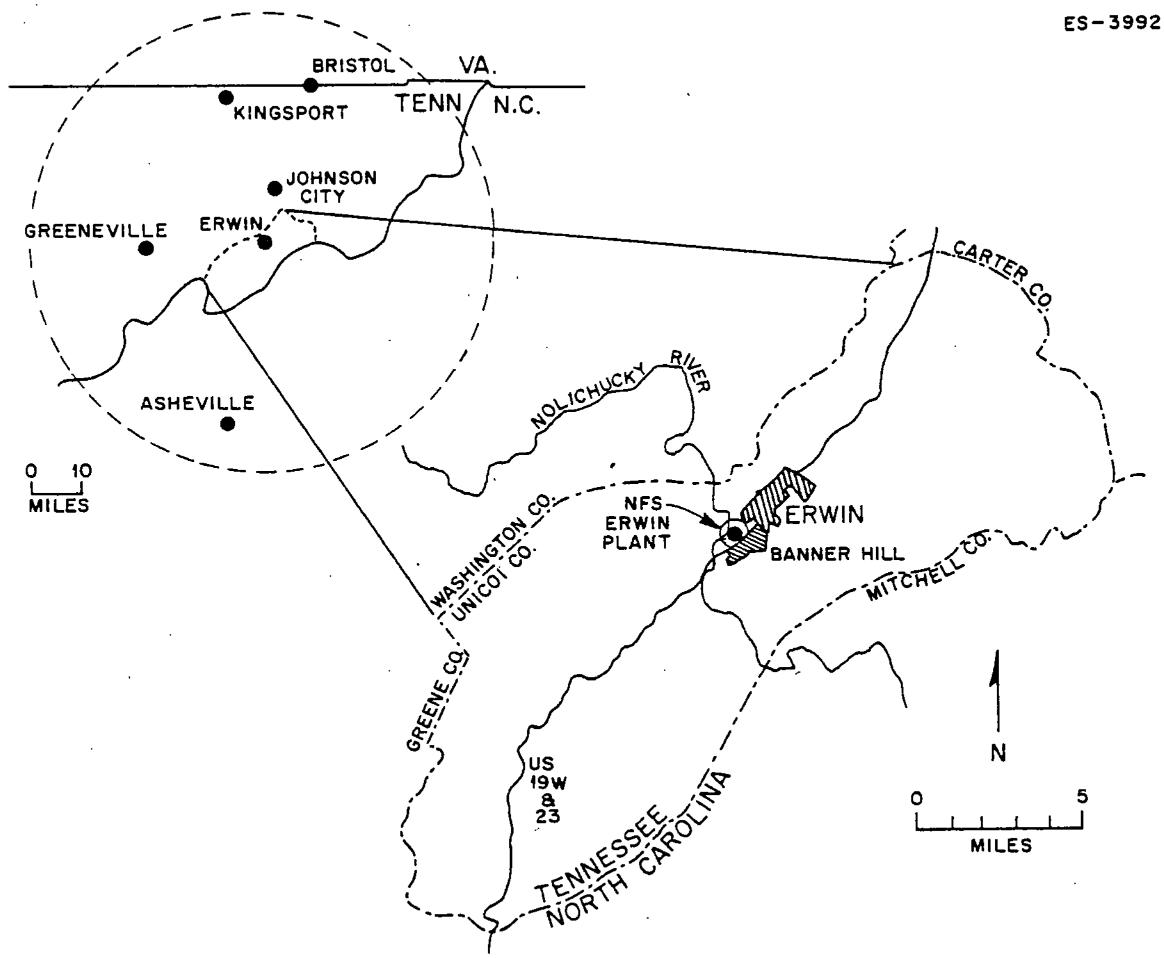

Fig. 2.1. Location map of the Nuclear Fuel Services plant at Erwin, Tennessee.

The site consists of a 57.8-acre tract, surrounded for the greatest part by privately owned property. Carolina Avenue runs parallel to the site on the southeast, and the Clinchfield Railroad right-of-way parallels the site boundary on the northwest. The restricted area containing the plant facilities occupies approximately 15 acres within the site boundary.

Situated in a narrow valley almost entirely surrounded by rugged mountains, the site occupies a relatively level area some 50 to 100 ft above the Nolichucky River. To the north, east, and south, the mountains rise to elevations of 3500 to 5000 ft within a few miles of the site.

2.2 DEMOGRAPHY

Population distributions within a 50-mile radius of the NFS Erwin plant were determined by using a computer program and 1970 census data.[1] A detailed breakdown of the 1970 population densities witin a 50-mile radius of the plant is presented in Table 2.1.

Table 2.1. Population distribution within a 50-mile radius of the Nuclear Fuel Services Erwin Plant, Erwin, Tennessee[a]

Sector	Distance (miles)									
	0–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
N						1,429	22,861	25,056	17,320	6,163
NNE							45,588	13,892	53,207	13,067
NE		1817	1694			2,994	16,860	8,711	4,797	9,460
ENE	1204					1,417	2,795	3,483	4,168	7,971
E							2,075	6,094	7,396	15,516
ESE			813			926	2,343	5,769	1,530	20,001
SE	2341						2,055	6,970	16,598	18,701
SSE						326	3,757	2,726	5,894	6,534
S	176						3,193	3,920	48,365	23,150
SSW							2,232	10,301	48,670	35,721
SW					1374	1,280	0	2,869	2,793	9,256
WSW							1,523	2,689	5,126	16,309
W							6,420	20,475	5,824	34,340
WNW						928	3,667	5,120	11,391	6,578
NW						596	3,461	4,000	7,402	5,318
NNW					1058	1,230	4,980	25,187	36,252	6,940
Total	3721	1817	2507	0	2432	11,126	123,810	147,262	276,733	235,025

[a] Based on 1970 U.S. Census data.

Some 3,700 persons reside within a 1-mile radius of the plant, with the distribution reflecting the proximity of the Erwin and Banner Hill communities to the east. The nearest residences are located ESE of the plant, approximately at about 350 m from the center of the site. Future population projections by the economic research staff of the Tennessee Valley Authority (TVA) indicate that the combined Erwin and Banner Hill 1970 population of 7,232 will increase to 9,300 by 1980, and to 14,300 by the year 2000 (EIR, Table 133.5-5).

Approximately 800,000 persons (1970 census data) live within a 50-mile radius of the plant. As shown in the inset map in Fig. 2.1, the 50-mile radius includes parts of three States: Tennessee, Virginia, and North Carolina.

2.3 LAND USE

The NFS Erwin facilities are located in the mountainous region of east Tennessee in which three-fourths or more of the land is forested.[2] The mountains have steep slopes and sharp crests, and are dissected by deep narrow valleys. The city of Erwin and the NFS plant lie in a valley traversing the region southwest to northeast.

Figure 2.2 illustrates the general land use within a 3-mile radius of the NFS plant. Generally, the areas to the east and northeast of the site are used for residential, commercial, and industrial purposes. In the narrowing river valley to the southwest of the plant, small farms and suburban residences prevail. There are also a few small farms northwest of the plant.

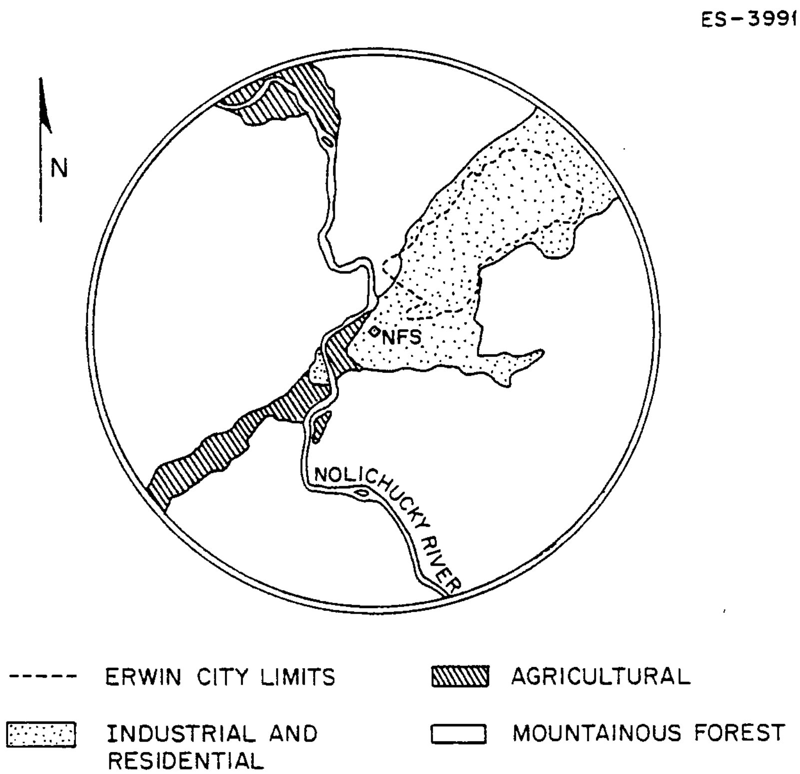

Fig. 2.2. Land-use diagram within a 3-mile radius of the Nuclear Fuel Services plant. Source: Nuclear Fuel Services, Inc., *Responses to Environmental Information Report: NRC Questions of April 15, 1977*, Erwin, Tenn., May 31, 1977.

Forest land occurs in every direction from the site (see Sect. 2.8.1 for description of composition of forest land).

Nearly 74% of the land within a 3-mile radius of the NFS plant is mountainous forest land (Table 2.2). Residential, commercial, and industrial lands constitute 19% of the area, and only 7% is covered by farms and suburban homes (Table 2.2).

Approximately 38% (44,600 acres) of Unicoi County has been classified as commercial forest, producing crops of industrial wood and generally capable of producing at least 20 ft^3 of annual growth per acre.[3] About 16% of the commercial forest lands in Unicoi County are grazed by domestic livestock.[3]

The U.S. Soil Conservation Service estimates that there are approximately 325 acres of prime and unique farmland within a 3-mile radius of the plant.[4] Tobacco, hay, and corn are the primary crops within the area, with a few acres of commercial strawberries approximately 1 mile south of the plant. The nearest forage crop (corn) is approximately 0.25 mile from the plant in an easterly direction. Beef and swine production in the area is low, and generally is limited to personal use by farm occupants. Presently, no *dairy herds exist within Unicoi County.*

The *National Register of Historic Places* lists one historic site in Unicoi County: the Clarksville Iron Furnace southwest of Erwin, founded in 1833, and located off State Highway 107 in the Cherokee National Forest. Production ended in 1844, when the millrace of the waterwheel collapsed, flooding the furnace and chilling the charge in the smelting process. The site is now owned by the U.S. Forest Service.[5]

Table 2.2. Land use within a 3-mile radius of the Nuclear Fuel Services plant

Land use	Percent of total area (18,100 acres)
Residential	13.8
Commercial	1.1
Industrial	4.4
Farms, suburban homes	7.2
Mountainous forest land	73.5
Total	100.0

Source: Nuclear Fuel Services, Inc., *Responses to Environmental Information Report NRC Questions of April 15, 1977,* Erwin, Tenn., May 31, 1977, Question 9.

2.4 GEOLOGY

This section presents information on the surface and subsurface environments in the vicinity of the Erwin site of the NFS plant.

2.4.1 Physiography

The NFS Erwin facility is located near the southeastern edge of the Valley and Ridge Province in eastern Tennessee. The boundary with the Blue Ridge Province lies 10 km (6 miles) to the southeast of the town of Erwin.

There are several major topographic features worthy of note. The town of Erwin and the NFS site lie on a flood plain formed by North Indian Creek and South Indian Creek (Fig. 2.3) which flow parallel (northeast to southwest) to the strike of stratigraphic and structural units of the region. The Nolichucky River generally cuts across the grain of the structure except where it is joined by the two creeks. Because the Nolichucky River cuts across erosion-resistant strata southeast of the Buffalo Mountain fault, its flood plain is narrow and poorly developed. Strata immediately adjacent to the fault, however, are easily eroded, accounting for the broad flood plain there. The valley of Indian Creek is paralleled by a series of ridges in sharp relief. Most of the terrain is in steep slope, maximum relief in the region being approximately 1500 m (5000 ft).

2.4.2 Structure and stratigraphy

The Erwin region is underlain by the Buffalo Mountain thrust sheet (Fig. 2.3) which has been separated by two minor thrust faults into three imbricate thrust blocks.[6] Cambrian and Precambrian(?) rocks in the Buffalo Mountain thrust sheet consist of the Unicoi (Ꞓu), Hampton (Ꞓh), and Erwin (ꞒE) formations of the Chilhowee Group and of the Shady Dolomite (Ꞓs). Younger Cambrian-Ordovician rocks lie *beneath* the thrust sheet. *The footwall strata include the* Rome Formation (Ꞓr), Honaker Limestone (Ꞓhk), Nolichucky Shale (Ꞓn), Knox Dolomite (OꞒk), and Athens Shale (Oa). The Hampton Formation (Ꞓh) is believed to be the detachment zone between the thrust sheets and the younger strata lying beneath them. Locally, along subsidiary thrusts, the Rome Formation also serves as a detachment zone. The complete lower Paleozoic section of northeastern Tennessee is described in Table 2.3.

Strata in the vicinity of Erwin dip 30° or more to the northwest. Locally, strata are near vertical or overturned, especially in the vicinity of faults.

During or following the thrusting, all the rocks in the area were folded into a northeast trending synclinorium. Slices of rock have been broken off and dragged along the surfaces of the thrusts. Rock cleavage (fractures) and low-rank metamorphism are present. Deformation probably occurred in late Paleozoic time during the Appalachian orogeny. Although there is some seismic activity in the southern Appalachian region today (Sect. 2.4.4), none of it is related to the deformation produced during the Appalachian orogeny. No movement has taken place on these faults for a 100 million years.

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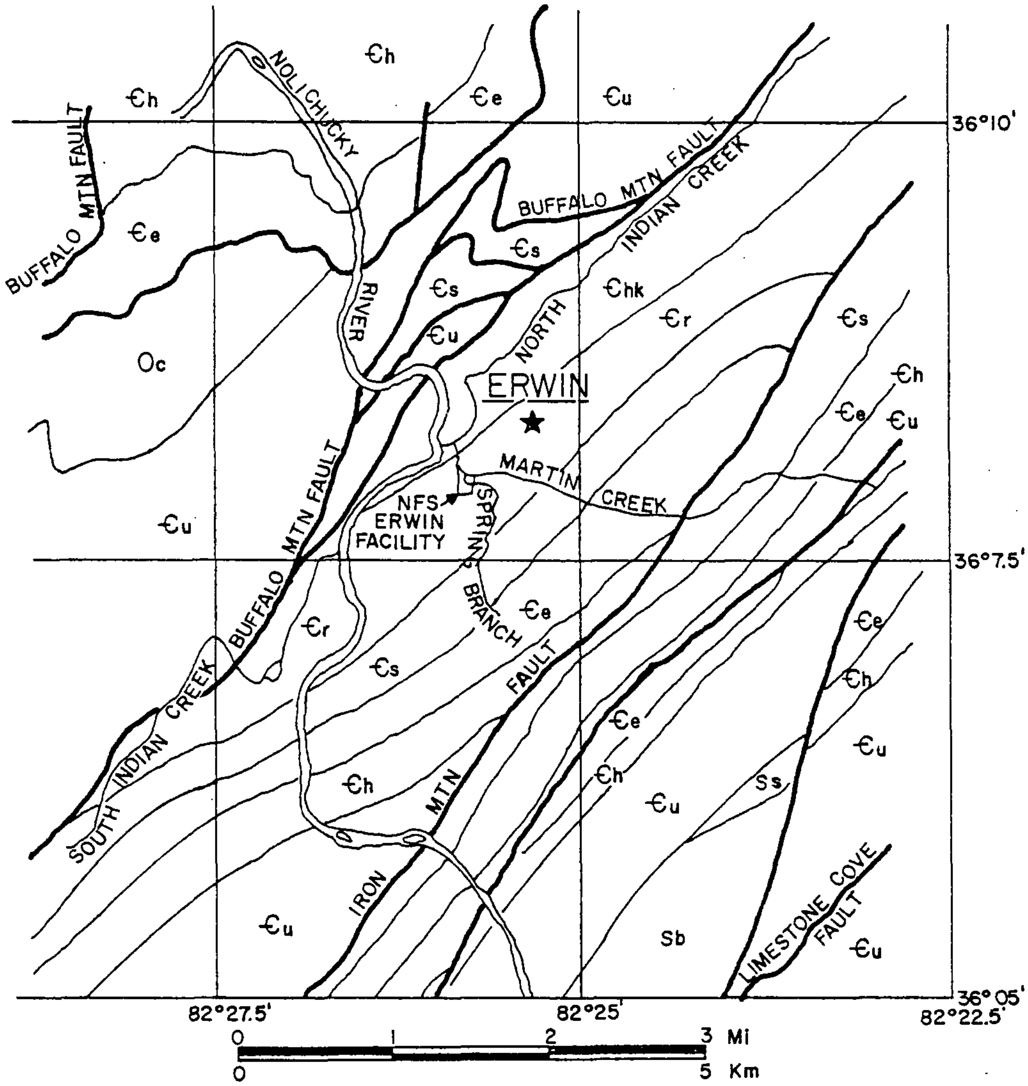

PRECAMBRIAN	(pꞒ)	CAMBRIAN	(Ꞓ)
OCOEE GROUP	Oc	HONAKER DOLOMITE	Ꞓhk
SANDSUCK SHALE	Ss	ROME FORMATION	Ꞓr
SNOWBIRD FORMATION	Sb	SHADY DOLOMITE	Ꞓs
		ERWIN FORMATION	Ꞓe
		HAMPTON FORMATION	Ꞓh
		UNICOI FORMATION	Ꞓu

Fig. 2.3. Geologic map of the Erwin region. Source: J. Rodgers, Compiler, *Geologic Map of East Tennessee,* Open File Sheet 199, Tennessee Division of Geology, Knoxville, Tenn.

Table 2.3. Generalized section of lower Paleozoic formations in northeastern Tennessee

Age	Formation (Map symbol)		Lithology	Thickness meters	Thickness feet
Lower Ordovician	Athens Shale Oa		Gray to black shale, calcareous below, sandy above	300–1500	1000–5000
Lower Ordovician / Upper Cambrian	Knox Dolomite OꞒk		Gray to blue-gray limestone and dolomite, in part cherty; argillaceous seams in lower part	1200	4000
Upper Cambrian	Nolichucky Shale Ꞓn		Green calcareous and dolomitic shale, and shaly dolomite	30	100
Upper Cambrian / Middle Cambrian	Honaker Dolomite Ꞓhk		Gray to blue-gray dolomite and limestone, with many silty and shaly laminae	600	2000
Middle Cambrian / Lower Cambrian	Rome Formation Ꞓr		Red shale and siltstone, some green shale, and some dolomite; residual clay contains some manganese deposits	360–550	1200–1800
Lower Cambrian	Shady Dolomite Ꞓs		Blue-gray dolomite, white dolomite, ribboned dolomite and limestone; residual clay contains many manganese deposits	270–360	900–1200
Lower Cambrian	Chilhowee Group	Erwin Formation Ꞓe	White quartzite, greenish sandy shale and siltstone	360–460	1200–1500
Lower Cambrian	Chilhowee Group	Hampton Formation Ꞓh	Dark-greenish argillaceous shale, sandy shale, and siltstone; some beds of arkosic quartzite	360–460	1200–1500
Lower Cambrian	Chilhowee Group	Unicoi Formation Ꞓu	Arkosic quartzite, conglomerate, arkosic sandy shale and siltstone; some beds of amygdaloidal basalt	600–1500	2000–5000

[a]The Ocoee Group (Oc), conformably underlies the Chilhowee Group and it, as well as lowermost Chilhowee strata, are tentatively considered to be Precambrian age. The Sandsuck (Ss) and Snowbird (Sb) formations are members of the Ocoee Group, the Snowbird being the oldest and resting unconformably on Precambrian crystalline rocks. The correlation of Ocoee Group rocks in the Erwin area is uncertain with respect to similarly named units found further to the south.

Source: Modified after R. J. Ordway, *Geology of the Buffalo Mountain-Cherokee Mountain Area, Northeastern Tennessee,* Tennessee Department of Conservation and Commerce, Division of Geology, Report of Investigation No. 9, Nashville, Tenn., 1959.

Three stratigraphic units will be described in detail because of their relationship to the NFS site (Fig. 2.3). These are the Rome Formation (Ꞓr), which underlies the site, and the Shady Dolomite (Ꞓs) and Honaker Dolomite (Ꞓhk) which lie to either side of the Rome Formation. The dolomite units are also important because they are aquifers, providing Erwin's public water supply. Groundwater is discussed in detail in Sect. 2.5.

The NFS site is underlain by the Rome Formation which occupies a valley broken by low hills to the northeast of Erwin. The Rome Formation is chiefly composed of red to maroon or brown shale, silty and well consolidated. Some beds are fine-grained sandstones that underlie higher ground owing to their resistance to erosion. There are thin (about two feet thick) interbeds of dolomite in the shale units in places.

Soils weathered from the Rome Formation are thin (a few inches to a foot thick), charged with shale chips, and are acidic. Near the Nolichucky River, deposits of alluvial materials have accumulated above the bedrock. These deposits are bouldery, to cobbly, to sand and silt-sized unconsolidated materials. The detritus is largely composed of quartzitic fragments from the adjacent higher ridges and mountains.

The Rome Formation in the area of the plant site dips northwest at an angle of approximately 30°, but locally the angles of inclination are steeper. The Rome outcrop is some 3700 ft wide in the horizontal plane.

Southeast of the Rome Formation, along the axis of Banner Hill and Hulen Hollow, the Shady Dolomite crops out below the Rome. The contact is poorly exposed but is conformable.

The Shady Dolomite is a blue-gray magnesian limestone that is generally weathered to a thick, yellowish, plastic clay. Weathering may be as deep as 100 ft or more.

The Honaker Dolomite is similar to the Shady in its lithology. Beds crop out along the southeast side of the Buffalo Mountain fault and are vertical to overturned in position throughout much of their area of outcrop.

Still farther southeast is the high, rugged topography of the Unaka Mountains. These mountains are held up by the tough, resistant Chilhowee Group rocks (Erwin Quartzite, Hampton Shale, and Unicoi Formation). These rocks are sandstones, siltstones, and conglomerates of great thickness, thoroughly indurated and very resistant to erosion.

Due to the faulting in Paleozoic time (over 300 million years ago), masses of the Chilhowee Series also crop out in Buffalo Mountain northeast of Erwin. The masses of ancient sandstones and conglomerates are in fault contact with younger strata that form the valley in which Erwin is located. The transit of the Nolichucky River and of Tennessee Highway 81 through them is via a deep gorge.[7]

2.4.3 Engineering geology

At the NFS site, bedrock strata are highly indurated (consolidated), making firm foundations for buildings that rest directly on the strata or that are supported by column footings. Structures on spread footings are supported by unconsolidated alluvium from the flood plain and terraces of the Nolichucky River. Structures supported by alluvium are subject to differential settlement, depending upon the character of the distribution of the load, and the inhomogeneity of the sediments bearing the load.

The NFS site is not likely to experience slope failure. Such failures are common in the mountainous terrain surrounding the site, but not on the flood plain where slopes are gentle.

2.4.4 Seismicity

According to Algermissen,[8] the Appalachian region is one of moderate seismic risk (Zone 2 in Fig. 2.4). Moderate damage is the maximum credible event for the region. Most earthquakes can be expected to cause minor damage or none at all.

There is a 90% probability that horizontal acceleration (a_h) will not exceed 7% ($a_h \leq 7\%$) of gravity over a 50-year period in the southern Appalachian region (Fig. 2.5). This horizontal acceleration is comparable to that expected for western Ohio but is less than that of the Central Mississippi Valley seismic region ($a_h \leq 19\%$) and the South Carolina seismic region ($a_h \leq 11\%$). As a basis for comparison, the more dangerous seismic regions of western United States have much higher expected horizontal accelerations ($40\% \leq a_h \leq 80\%$). A horizontal acceleration of 20% is considered to be on the threshold for causing extensive damage. Therefore, an earthquake is not expected to cause extensive damage anywhere within the southern Appalachian region within a 50-year period.[9]

Table 2.4 lists recurrence intervals and maximum credible earthquakes for the southern Appalachian and adjacent seismic regions.[9] The San Andreas fault zone is also listed for comparative purposes. Earthquakes originating from the New Madrid area (in 1811-1812) of the central Mississippi Valley seismic region and at Charleston (August 1886) in the South Carolina seismic region have been felt in east Tennessee,[7] but no local damage was caused by them.

Although damaging earthquakes are not expected anywhere within the southern Appalachian region over a 50-year period, Table 2.4 suggests that the region is by no means aseismic. It is expected that a modified Mercalli Scale V earthquake will occur somewhere within the southern Appalachians about once every two years. Even though such earthquakes are felt by nearly everyone in the vicinity, damage is negligible. Although recurrence intervals for Modified Mercalli Scale VIII earthquakes are not available due to the limited data base, the occurrence of such an earthquake somewhere within the southern Appalachian region is not beyond the realm of possibility.[9]

Table 2.5 describes earthquake conditions as outlined in the Modified Mercalli Intensity Scale of 1931.[8] Algermissen and Perkins[9] have compiled a statistical analysis based on the earthquake data available for the region.

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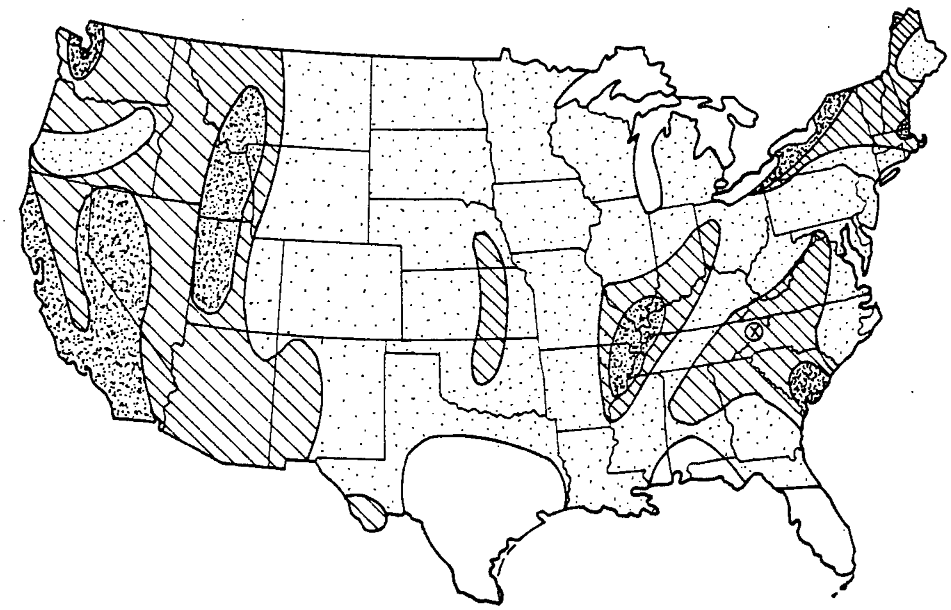

ZONE DEFINITION

0 — No Reasonable Expectation Of Earthquake Damage

1 — Expected Minor Damage

2 — Expected Moderate Damage

3 — Major Destructive Earthquakes May Occur

⊗ — NFS Nuclear Fuel Services, Inc. – Erwin Plant

Fig. 2.4. Seismic-risk map of the United States. Source: S. T. Algermissen, *United States Earthquakes*, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C., 1968.

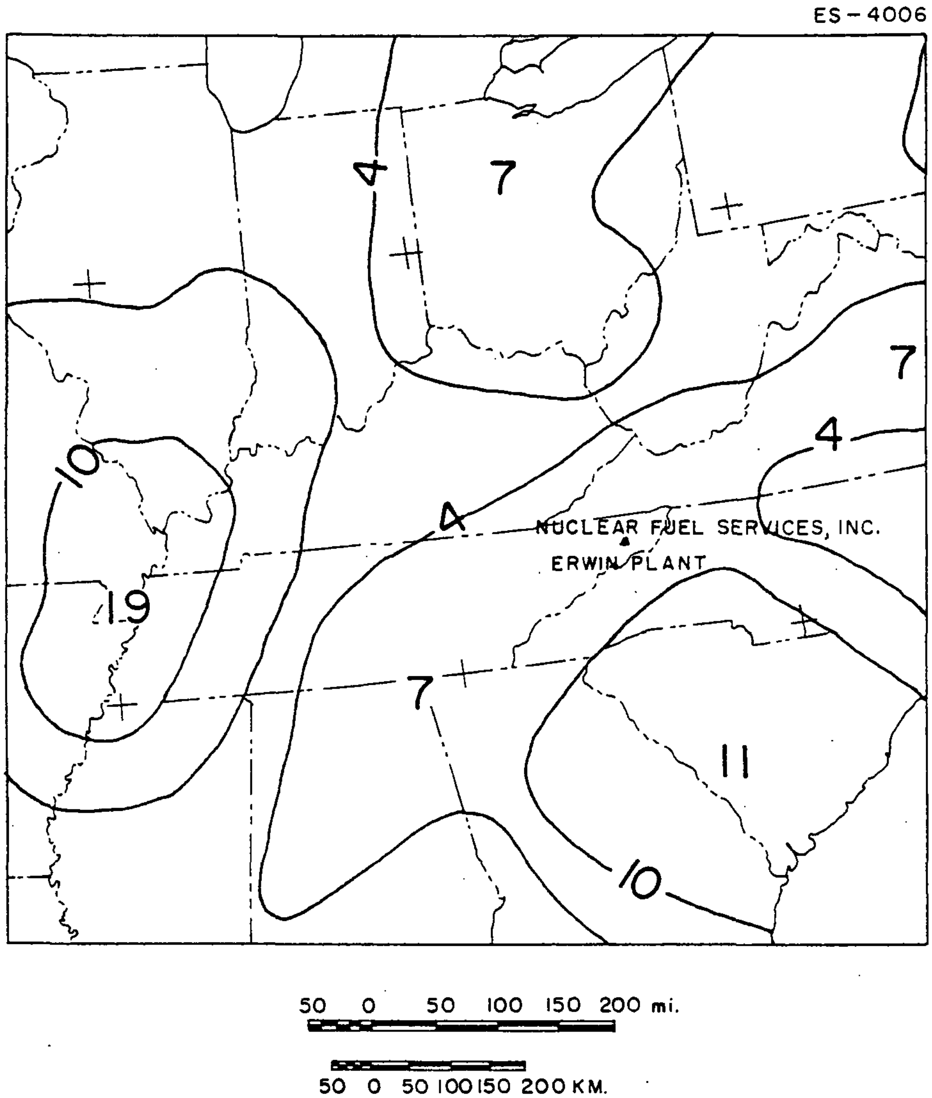

Fig. 2.5. Preliminary maps of horizontal acceleration (expressed as percent of gravity) in rock with 90% probability of not being exceeded in 50 year. Source: S. T. Algermissen and D. M. Perkins, *A Probabilities Estimate of Maximum Acceleration in Rock in the Contiguous United States*, U.S.G.S. Open File Report 76-416, Denver, Colo., 1976.

Table 2.4. Maximum credible earthquakes for selected seismic regions in the United States

Seismic region	Number of Modified Mercalli V earthquakes per 100-year period	Maximum credible intensity	Maximum credible magnitude
Central Mississippi Valley	84.5	X	7.3
South Carolina	19.9	X	7.3
Western Ohio	22.0	VIII[a]	6.1
Southern Appalachian	54.4	VIII[a]	6.1
San Andreas	110.0	XII	8.5

[a]Horizontal acceleration equal to 20% gravity is roughly equivalent to a Modified Mercalli Scale intensity of VIII. This is considered to be the threshold of extensive damage.

Source: S. T. Algermissen and D. M. Perkins, *A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States,* U.S. Department of the Interior, U.S.G.S. Open File Report 76-416, Denver, Colo., 1976.

Table 2.5. Modified Mercalli (MM) Intensity Scale of 1931[a]

Intensity class	Effects of earthquake
V	Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken. A few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate damage in well-built ordinary structures; considerable damage in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving motorcars.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings, with partial collapse; great damage in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great damage in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
XI	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

[a]Scale abridged to show data on earthquakes of sufficient intensity to cause significant damage.

Source: S. T. Algermissen, *United States Earthquakes,* U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C., 1968.

2.5 HYDROLOGY

2.5.1 Surface water

Figure 2.6 shows the three natural surface-water bodies at the NFS Erwin site: Banner Spring Branch, Martin Creek, and the Nolichucky River.

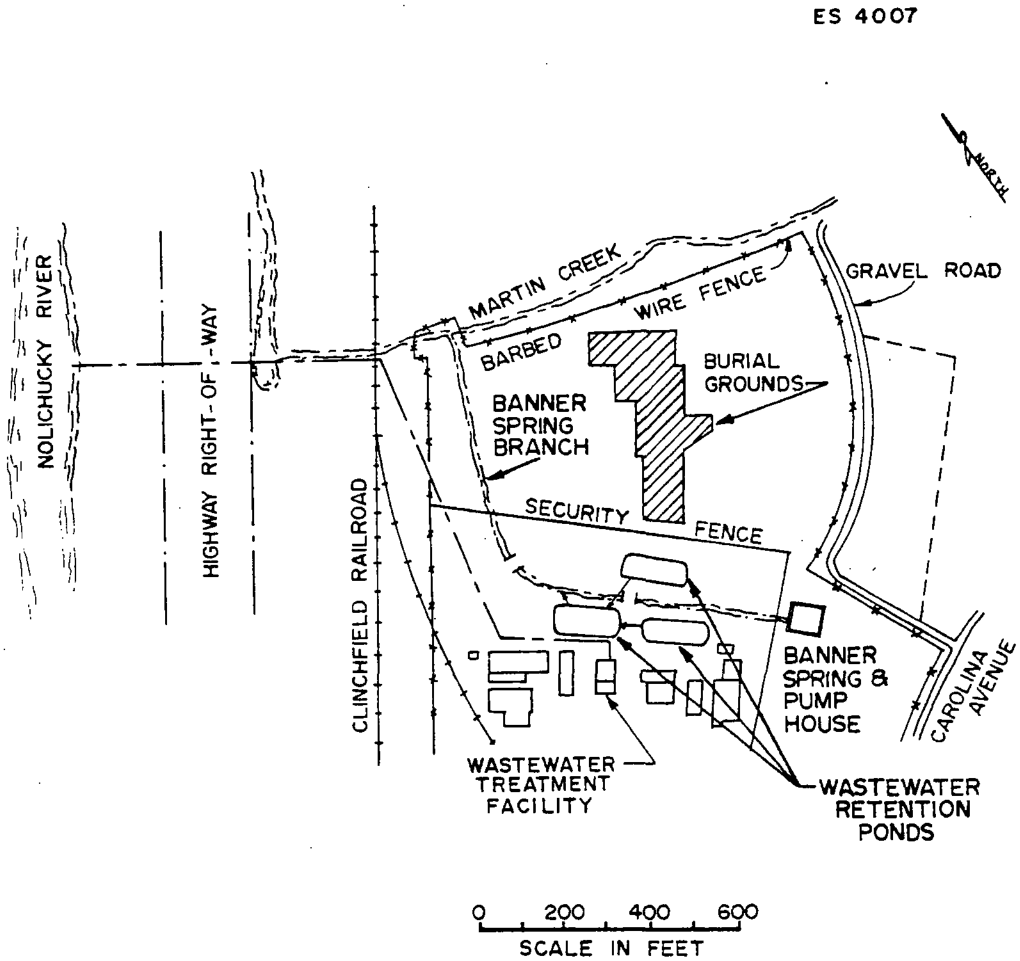

Fig. 2.6. Banner Spring Branch, Martin Creek, and the Nolichucky River in relation to the NFS Erwin plant site. Source: Nuclear Fuel Services, Inc., *Responses to NRC Questions Related to NFS Erwin Environmental Information Report, May 31, 1977*, Erwin, Tenn., May 31, 1977.

Banner Spring Branch is a small (1.5 to 3 ft wide) spring-fed stream lying entirely within NFS Erwin plant boundaries.[4] (However, it is not totally owned by NFS). The spring branch originates to the south and flows at a rate of 200 to 300 gal/min (0.45 to 0.67 cfs) into Martin Creek at the north corner of the NFS Erwin site about 1200 ft from its source.[4] Table 2.6 provides an accounting of daily average, high, and low stream flows.

Martin Creek, fed by mountain springs, rain, and snow-water drainage from Martin Creek Hollow, runs nearly parallel to the northern property line of the site, crossing the property for just a few yards at the north corner of the site where the creek is joined by Banner Spring Branch (Fig. 2.6). The lower course of Martin Creek is now different from that shown in the EIR. It runs parallel to the fill for a new highway [paralleling the Nolichucky River (Fig. 2.6)] and

Table 2.6. Flow rates for Banner Spring Branch, Martin Creek, and the Nolichucky River

Daily flow level	Flow rate (ft^3/sec)		
	Banner Spring Branch[a]	Martin Creek[a]	Nolichucky River[b]
Average	6.68×10^{-1}	6.68	1,347 (1919 to 1976)[c]
High	7.70×10^{-1}	11.14	30,700 (1940)[c]
Low	5.57×10^{-1}	2.23	88 (1924)[c]

[a]The period of time over which the measurements were made is unknown.

[b]Measurements taken at Embreeville Station gage two miles downstream from the mouth of Martin Creek.

[c]Time period during which measurements were made on the Nolichucky River.

Source: Nuclear Fuel Services, Inc., *Environmental Information Report on the Nuclear Fuel Services, Inc. Operation at Erwin, Tennessee,* January 1976; U.S. Department of the Interior, *Water Resources Data for Tennessee Water Year 1975,* USGS Water Data Report TN-75-1, Washington, D.C., 1975.

enters North Indian Creek to the north, which in turn enters the Nolichucky River to the west (Fig. 2.3). The width of Martin Creek varies from 8 to 15 ft, and depth varies from a few inches to pools of three or four feet.[4] The flow rate varies seasonally from 1000 to 5000 gal/min [2.23 to 11.14 cfs (Table 2.6)].

As shown in Fig. 2.7, the Nolichucky River is formed by the North Toe and Cane rivers in Yancey and Mitchell counties, North Carolina (110.7 river miles above the Nolichucky's confluence with the French Broad River), and flows westwardly from North Carolina and southwestwardly through Tennessee to join the French Broad River at mile 69.1 (French Broad river mile). The Nolichucky belongs to the upper Tennessee River basin, forming a part of the French Broad River watershed. The French Broad River in turn joins the Holston River to make up the Tennessee River at mile 652.1 (Tennessee river mile). The Nolichucky River basin in Tennessee includes practically all of Greene and Unicoi counties, and parts of Hawkins, Hamblen, Jefferson, Washington, and Cocke counties. The entire drainage area totals 1756 sq miles, of which approximately 1126 sq miles are in Tennessee. The remaining 630 sq miles are in North Carolina. Approximately 101 miles of this river are in Tennessee.[10]

The Nolichucky River averages from 100 to 200 ft wide in the area of the NFS Erwin site.[10] It has an average flow rate of 1347 cfs, measured 3 miles northwest of the site at Embreeville (river mile 89.0), as calculated over a 57-year period between 1919 and 1976. The average low flow statistically expected to occur for a duration of ten days in any seven-year period (7 day 10) is 247 cfs, and for a duration of 20 days in any three-year period (3 day 20) is 197 cfs.[11] These values were determined for the portion of the Nolichucky at river mile 95.9, at a point 2 miles southwest (upstream) of Erwin (Fig. 2.8). The minimum and maximum flows of record are 85 cfs (September 8-9, 1925) and 120,000 cfs (May 21, 1901) respectively.[11] Table 2.6 shows the daily average, high, and low flows measured by the U.S. Geological Survey (USGS) at the Embreeville gage. Figure 2.9 shows the seasonal variation at the same gaging station between October 1954 and June 1959, during which time the Tennessee Stream Pollution Control Board conducted biological surveys of the Nolichucky River (Sect. 2.7.2.2). Although the river was recently rechanneled in the Erwin area during the construction of a new highway (June–July 1976), the applicant has stated that the flows have remained the same.[12] The only consideration affected by the rechanneling is a significant reduction in the probability of backwater flooding of the plant.[12]

2.5.2 Groundwater

Groundwater is present as the main water table and as separate perched water tables. The water table lies at the same elevation as the Nolichucky River at the NFS Erwin site and is below the alluvial material in the Rome Formation (Sect. 2.4.2). The perched water tables are formed by rainfall which saturates the thin topsoil layer but which fails to penetrate the underlying impermeable Rome Formation. Dug wells tap the perched water tables, but not the main water table beneath the Rome Formation. The yield from the dug wells is often sufficient for domestic use,[13] unlike the yield from those tapping the Rome Formation, which only yield 3 gal/min (6.68×10^{-3} cfs) or less. In general, perched water from higher elevations moves to the southwest through the alluvium into Martin Creek, into Banner Spring Branch, and into the Nolichucky River. However, groundwater motion in bedrock aquifers is unknown because there are few wells that tap bedrock aquifers. Groundwater flow in the Ervin area is probably complex due to the structural deformation in this area (Sect. 2.4.2). At present, no perched water between the site and the surface streams is tapped.

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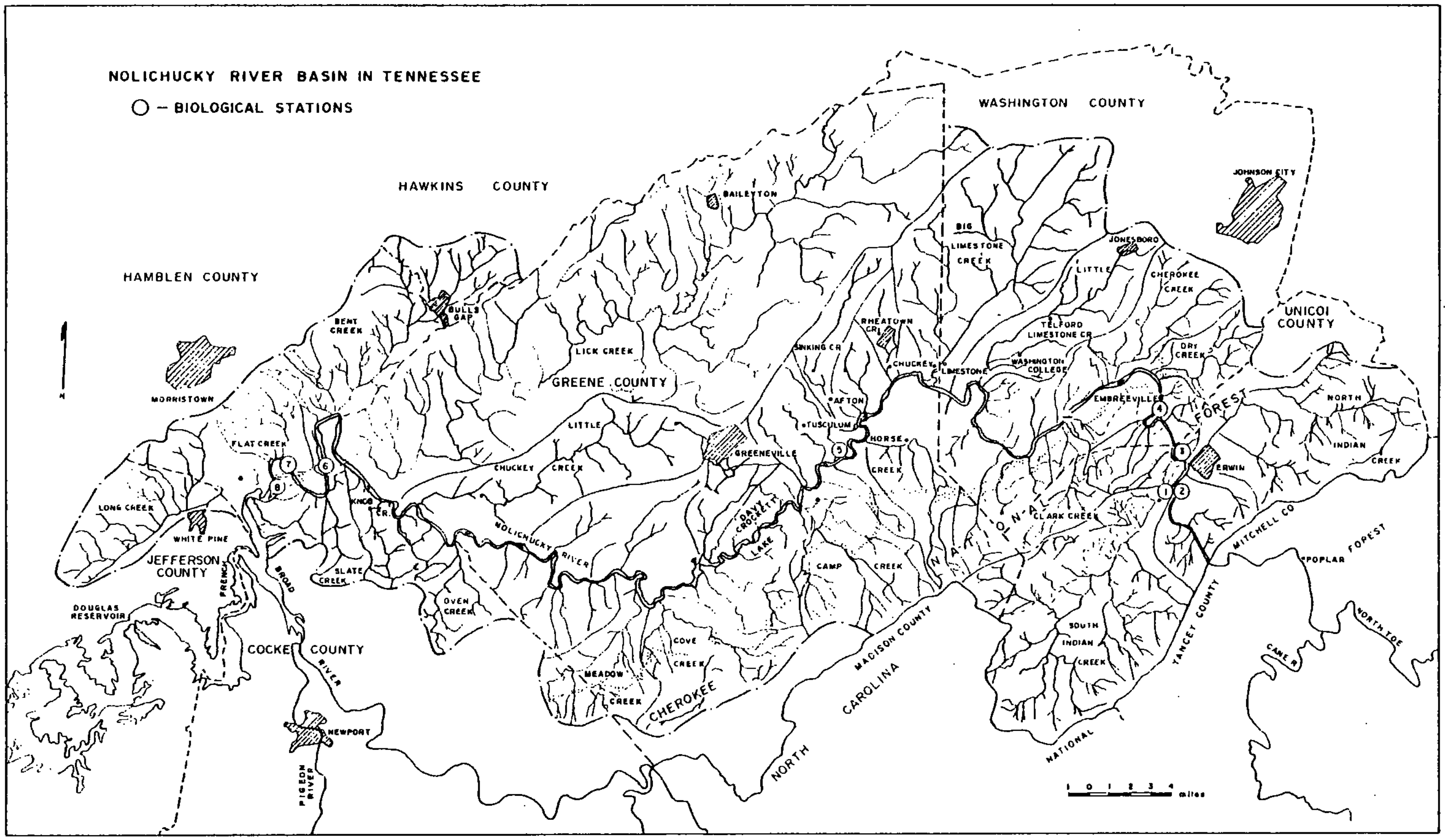

Fig. 2.7. Nolichucky River basin in Tennessee. Source: Tennessee State Highway Department.

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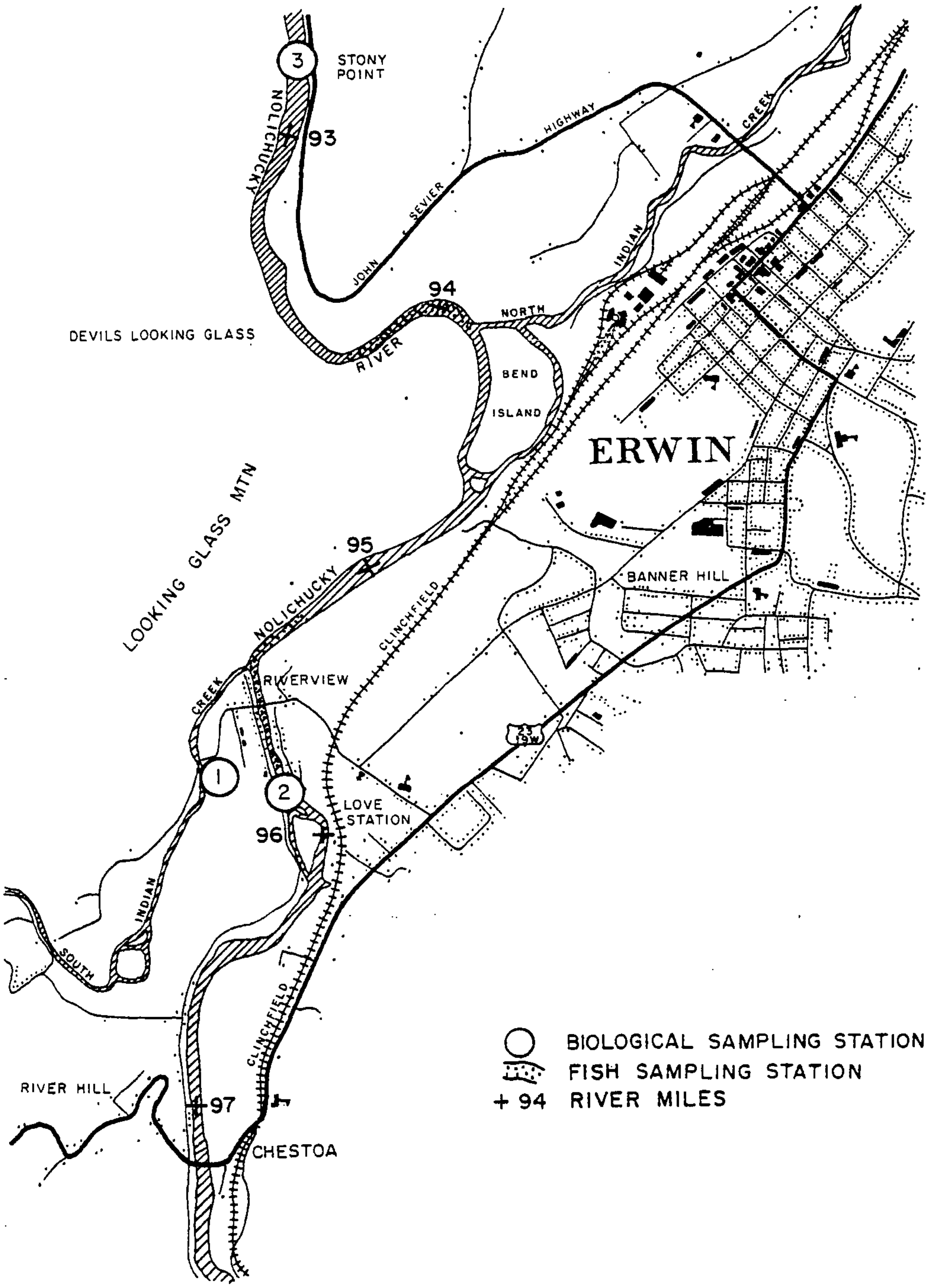

Fig. 2.8. Erwin site showing biological sampling locations.

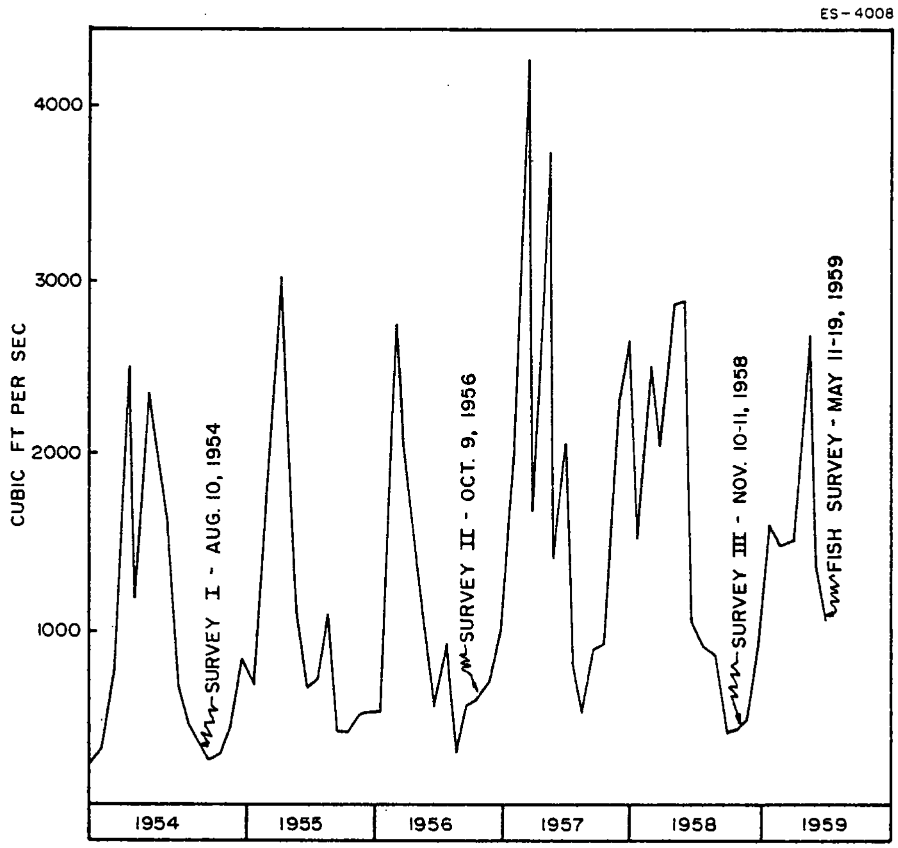

Fig. 2.9. Seasonal variation in Nolichucky River flow rate, showing dates of biological surveys conducted by the Tennessee Stream Pollution Control Board. Source: H. Mullican, R. M. Sinclair, and B. G. Isom, *Aquatic Biota of the Nolichucky River,* Tennessee Pollution Control Board, Tennessee Department of Public Health, Nashville, Tenn., 1973.

2.5.3 Water use

2.5.3.1 Surface water

Banner Spring Branch

Banner Spring Branch is not used for industrial purposes or as a potable water supply. There is no recreational use because the spring branch originates and terminates on restricted NFS Erwin property.[4] On the other hand, the spring water is used as a source of industrial water by the NFS Erwin facility for cooling (∿100,000 gal/day),[14] for inplant fire protection (∿500 gal/year), and for sanitary and washing water by the Clinchfield Railroad (∿15,000 gal/day).[14] Five fire hydrants are located on the NFS Erwin site and are routinely used for 5 to 10 sec once per year during flow-pressure testing. The pressure head for the hydrants is provided by an elevated reservoir consisting of two 50,000-gal water tanks on a nearby hill, known locally as Little Mountain. The Clinchfield Railroad uses the same reservoir for its supply of Banner Spring water.

Martin Creek

Approximately 200 yd upstream of the NFS Erwin site along Martin Creek is a State-operated fish hatchery (Erwin Trout Rearing Station) located on Love Spring Branch. Love Spring, which feeds Love Spring Branch, serves as the hatchery water supply (∿1,411,000 gal/day).[14] Martin Creek itself, however, is used only for recreational fishing. Fishing in the vicinity of the NFS Erwin site is infrequent because this short length of creek is not readily accessible to the public due to limited access roads.[4] The creek is not classified as a trout stream by the State of Tennessee Fish and Wildlife Commission,[4] nor is it used as a potable water source.

The Nolichucky River

The nearest municipal user of water (∿800,000 gal/day) from the Nolichucky River is the city of Jonesboro,[14] 8 miles downstream (river mile 86.9). The only known crop irrigation occurs approximately 10 to 15 miles downstream from the NFS Erwin plant discharge to the Nolichucky River.[4] Because the annual average rainfall in the area is generally adequate (∿45 in.), irrigation is not usually required. However, during the late part of the growing season, some farmers use overhead sprinkler irrigation to reduce frost damage to tomatoes and to extend the growing season.[4] The same overhead irrigation technique is used in late spring to prevent frost damage to strawberry crops in that area.[4] In addition, late summer irrigation is used to prevent cracking of the tomato crop caused by inflexibility of the tomato skin due to a lack of moisture.[4]

The Nolichucky River is used recreationally in a limited way for swimming, rafting, boating and canoeing, picnicking, and for similar activities in the 94 miles from its origin to its mouth at Douglas Lake (a TVA reservoir shown in Fig. 2.7). In the vicinity of the NFS Erwin plant (10 to 15 miles downstream), the primary recreational activities are canoeing and rafting.[4] There are no developed recreational facilities in this area, such as picnic tables and parks.[4] Some fishing occurs, largely for warm-water fish such as bass, walleye, and catfish.[4] The river is not classified as a trout stream by the State of Tennessee Fish and Wildlife Commission.[4] Conditions in the Nolichucky River are not generally suitable for a population of desirable game fish.[4,15]

2.5.3.2 Groundwater

The groundwater supplies within a 5-mile radius of the NFS Erwin site are shown in Fig. 2.10, and uses are indicated in the last column of Table 2.7. The Erwin municipal water supply is provided by four springs.[14] In 1970, the average daily use was 1,113,000 gal/day.[14] The Temple Hill Utility District in Unicoi County also relies on the groundwater system for its water supply, which in 1970 averaged 55,000 gal/day.[14] Other groundwater users in Unicoi County are the Flag Pond Elementary School, supplied by a spring (5000 gal/day); Limestone Cove Campground, supplied by a well (280 gal/day); Rock Creek Recreation Area, supplied by two wells (4700 gal/day); Temple Hill Elementary School, supplied by a well (4400 gal/day); Morrill Motors of Tennessee, supplied by a well (2000 gal/day); the Erwin Trout Rearing Station (Sect. 2.5.3.1), supplied by springs (1,411,000 gal/day), and a U.S. Department of the Interior trout hatchery, supplied by two springs (1,440,000 gal/day).

2.6 METEOROLOGY AND CLIMATOLOGY

2.6.1 Winds, tornadoes, and storms

The maximum sustained wind at the nearest airport (Tri-City Airport, near Kingsport, Tennessee) was 42 mph (18.8 m/sec) in August 1962. No tornadoes have been recorded in the area since it was colonized 200 years ago.

The Tennessee Valley Authority's Division of Water Control Planning has estimated the frequencies at which the Nolichucky River will achieve pertinent elevations at the Erwin plant. From these estimates it can be expected that a power failure could occur due to flooding once every 600 years, and water damage to the plant could occur once every 1000 years.

2.6.2 Atmospheric dispersion

The meteorological data for wind speed and direction were obtained on site from a Weather Measurement Corporation indicator and were recorded manually each hour by security guards. In order to more accurately represent the wind conditions at the site, Ratner's method[16] of correcting the wind roses was employed. The wind rose shown in Fig. 2.11 has been corrected by use of this method. For the use of wind speeds in the dispersion calculations, the calms were evenly distributed among the sectors and were added to the lowest wind-speed class in the proper sector.

Equipment is not available at the NFS Erwin site to determine atmospheric stability. Stability measurements are available from the STAR computer program outputs for the Tri-City Airport (near Bristol, Tennessee) and McGhee Tyson Airport (near Knoxville, Tennessee). However, the wind roses for the locations did not show good correlation with the observed wind directions on site, presumably due to the differences in topography. Because there is no accepted method to distribute the observed wind speeds and directions into stability categories, the available data were not usable. In the absence of site-specific stability conditions, Class D stability (neutral) for all wind and calm percentages was assumed. For the nearest residence site 350 m ESE of the plant emissions, a χ/Q value of 4.96×10^{-6} sec/m^3 was calculated for assessing the maximum individual dose. The χ/Q values for other distances at the 16 compass directions are shown in Table 2.8.

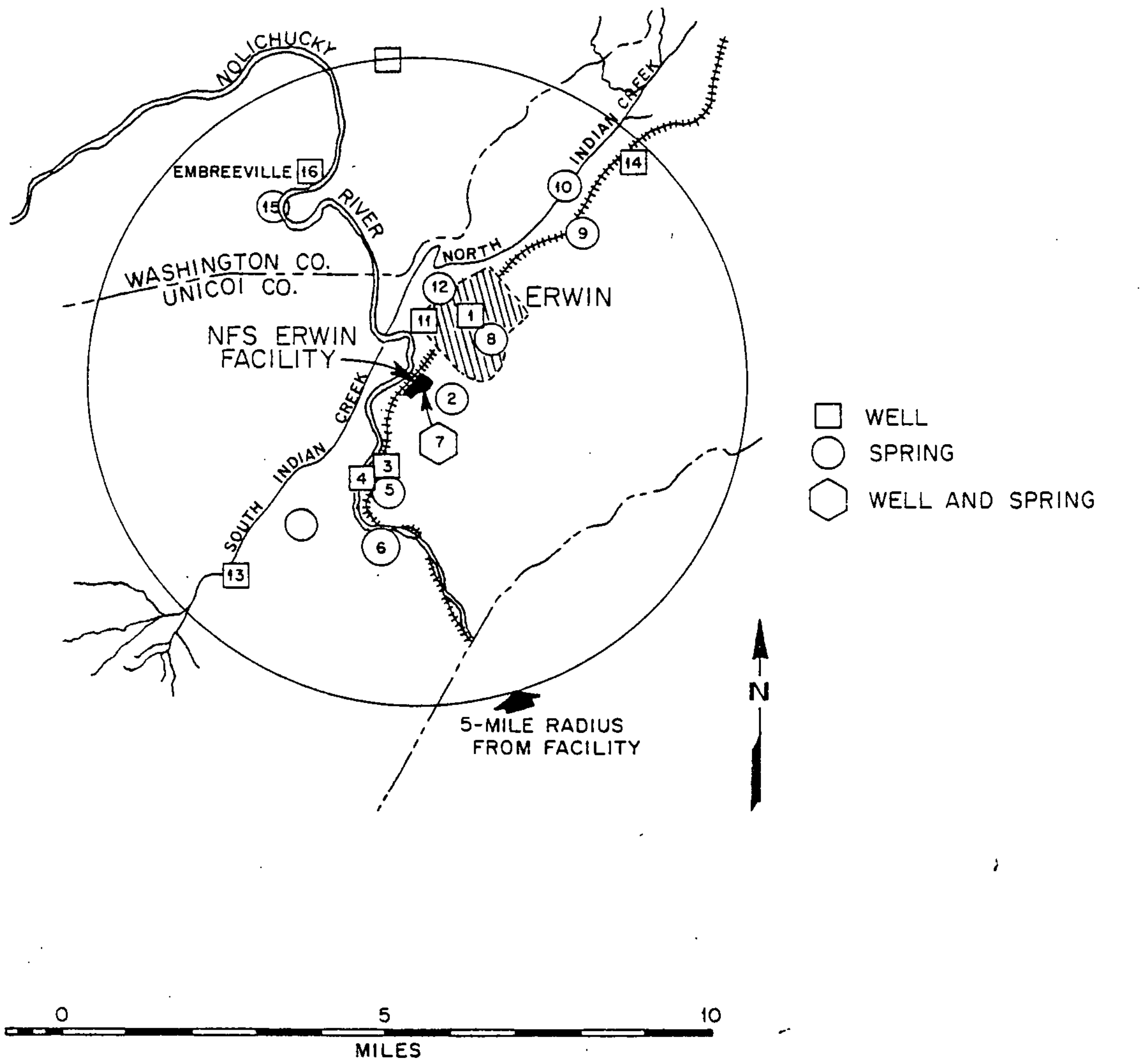

Fig. 2.10. Springs and wells within a 5-mile radius of the NFS Erwin plant. Numbered locations indicate sampling sites (See Tables 2.7 and 2.12 for physical characteristics and sampling data). Unnumbered wells and springs were not sampled.

Because suitable site-specific information was not available, a generic, or average, meteorology to assess the population doses to persons living within a 50-mile radius of the Erwin plant was used. The generic meteorology is based on the average meteorological conditions of 18 sites in the United States.[17]

2.7 BACKGROUND CHARACTERISTICS

2.7.1 Radiological characteristics

The background radiological characteristics presented in this section were developed from selected data from published reports and from the plant environmental monitoring program.

Table 2.7. Surveyed wells and springs within a 5-mile radius of the Nuclear Fuel Services, Inc. Erwin facility

Well or spring number[a] (w = well; s = spring)	Owner or name of spring or well	Topographic situation[b]	Altitude above sea level (ft)	Well depth (ft)	Probable water-bearing beds: Character of material	Probable water-bearing beds: Geologic horizon[c]	Yield (gallons per minute)	Use of water supply
1-w	Crystal Ice, Coal and Laundry Co.	V	1680	135	Dolomite	Ꞓhk	75	Industrial
2-s	Love Spring	V	1700		Dolomite	Ꞓs	500	
3-w	Grady Ledford	V	1760	122	Sandstone	Ꞓe	Not measured	Domestic
4-w	Sam Tipton	S	1720	80	Sandstone	Ꞓe	Not measured	Domestic
5-s	E. L. Lewis	S	1920		Sandstone	Ꞓe	5	Domestic
6-s	Unaka Springs	S	1720		Sandstone	Ꞓu	Not measured	Domestic
7-s	Banner Hill Spring	V	1640		Shale	Ꞓr	300	
8-s	Erwin Water Department	S	1730		Dolomite	Ꞓs	640	Public supply
9-s	U.S. Dept. of the Interior Fish Hatchery	V	1760		Dolomite	Ꞓhk	916	Industrial
10-s	Erwin Water Department	S	1760		Dolomite	Ꞓhk	450	Public supply
11-w	Fess Radford	V	1340	30	Residual dolomite	Ꞓhk	Not measured	Domestic
12-s	Birchfield Spring	V	1650		Dolomite	Ꞓs	2000	
13-w	Kelley Rice	V	1780	24	Residual dolomite	Ꞓs	Not measured	Domestic
14-w	Charles Erwin	S	1900	323	Dolomite	Ꞓhk	Not measured	Domestic[d]
15-s	Yates Spring	V	1620		Sandstone	Ꞓu	10	Domestic
16-w	W. B. Walker	V	1590	Not measured	Shale	Ꞓh	3	Domestic

[a]Numbers of wells and springs correspond to locations shown in Fig 2.10.
[b]V = valley; S = slope.
[c]Ꞓhk = Honaker Dolomite; Ꞓs = Shady Dolomite; Ꞓe = Erwin Formation; Ꞓu = Unicoi Formation; Ꞓr = Rome Formation; Ꞓh = Hampton Formation.
[d]Well supplies two houses.
Source: Table 9-2, EIR.

2.7.1.1 Total-body dose rates

Based on data from *Natural Radiation Exposure in the United States*,[18] the total-body dose rate from natural background radiation in the vicinity of Erwin, Tennessee, is expected, in general, to be on the same order as that of the State: 100 millirems/year (43 millirems/year from cosmic rays, 39 millirems/year from terrestrial radiation, and 18 millirems/year from internal emitters).

2.7.1.2 Soil, vegetation, and water

Upstream sampling of water and sediment in the Nolichucky River and of soil and vegetation at a distant location from the plant is routinely performed to establish background levels. The measured background alpha activity is 5.0×10^{-7} μCi/ml for water and 3.1×10^{-6} μCi/g for sediment in the Nolichucky River upstream from plant effluents.

Background samples for soil and vegetation taken 5 miles south of Erwin on the Asheville Highway were measured as follows:[7]

Radionuclide	Soil (pCi/g)	Vegetation (pCi/g)
U-234	0.19	0.00
U-235	0.00	0.00
U-238	0.13	0.00
Pu-238	0.14	0.00
Pu-239	0.00	0.00
Th-228	0.25	0.00
Th-230	0.16	0.04
Th-232	0.23	0.00

2.7.2 Nonradiological characteristics

2.7.2.1. Atmospheric effluents

Ambient concentrations of atmospheric nonradiological pollutants near the NFS site are not known. Fluorides and ammonia are the primary atmospheric chemicals discharged from the plant operations. Knowledge of background concentration of ammonia in the plant vicinity is not necessary because approximately 99.9% of the atmosphere's ammonia concentration is produced by

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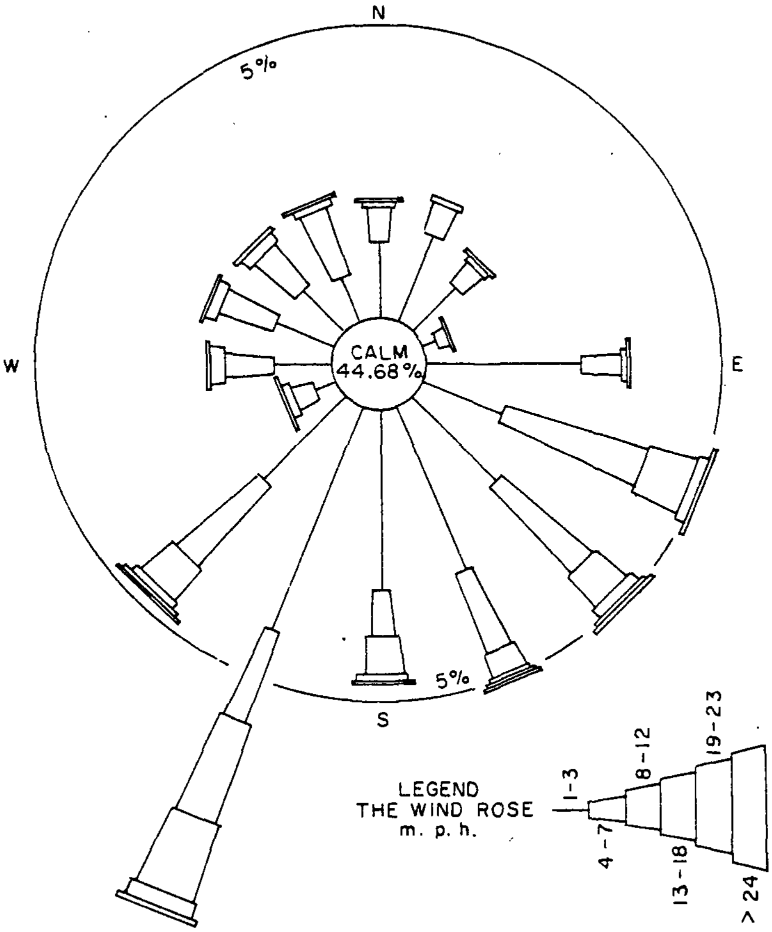

Fig. 2.11. Composite wind rose diagram.

natural biological processes.[19] Fluorides from the NFS facility are the main nonradiological effluent of concern. Generally, in rural areas free of industrial contamination, the concentration of fluoride in air is below detectable levels.[20] The maximum concentration detected by the National Air Pollution Control Administration in a nonurban area was 0.16 μg/m^3, whereas samples from urban areas[20] were as high as 1.89 μg/m^3.

Fluoride accumulation in the soil and vegetation offsite is quite low. A soil sample taken 5 miles south of the plant had a fluoride concentration of 0.09 μg/g of dry soil. Fluoride concentration in the vegetation at this baseline site was <0.01 μg/g of dry weight.

2.7.2.2 Surface water

Banner Spring Branch

An NRC inspection of the NFS Erwin facilities was conducted February 1 and 2, 1976. At that time, an investigation of the water quality analyses of process wastewater routinely discharged to Banner Spring Branch during the period of January through December 1975 revealed the following:[21]

Table 2.8. NFS Erwin plant χ/Q values (sec/m^3)[a] at various distances for the 16 compass directions

Wind toward (direction)	Distance from plant effluents (m)															
	200	275	300	350	400	750	1305	2414	4023	5632	7240	12,068	24,135	40,234	56,327	72,420
N	8.25E−6[b]	9.97E−6	9.87E−6	9.24E−6	8.37E−6	3.77E−6	1.50E−6	5.00E−7	1.98E−7	1.06E−7	6.52E−8	2.27E−8	4.48E−9	1.13E−9	4.13E−10	1.84E−10
NNW	8.57E−6	1.04E−5	1.03E−5	9.61E−6	8.70E−6	3.93E−6	1.57E−6	5.23E−7	2.07E−7	1.11E−7	6.88E−8	2.41E−8	4.82E−9	1.24E−9	4.59E−10	2.08E−10
NW	8.26E−6	9.99E−6	9.89E−6	9.26E−6	8.39E−6	3.79E−6	1.52E−6	5.10E−7	2.03E−7	1.10E−7	6.80E−8	2.41E−8	4.95E−9	1.32E−9	5.07E−10	2.38E−10
WNW	8.01E−6	9.69E−6	9.59E−6	8.99E−6	8.15E−6	3.69E−6	1.48E−6	5.00E−7	2.00E−7	1.09E−7	6.77E−8	2.42E−8	5.09E−9	1.38E−9	5.39E−10	2.55E−10
W	6.37E−6	7.69E−6	7.62E−6	7.13E−6	6.45E−6	2.90E−6	1.15E−6	3.82E−7	1.50E−7	8.02E−8	4.92E−8	1.69E−8	3.23E−9	7.75E−10	2.67E−10	1.12E−10
WSW	1.89E−6	2.28E−6	2.26E−6	2.11E−6	1.91E−6	8.62E−7	3.44E−7	1.14E−7	4.52E−8	2.42E−8	1.49E−8	5.18E−9	1.01E−9	2.50E−10	8.83E−11	3.78E−11
SW	3.65E−6	4.42E−6	4.37E−6	4.09E−6	3.71E−6	1.67E−6	6.66E−7	2.22E−7	8.78E−8	4.71E−8	2.90E−8	1.01E−8	2.00E−9	5.01E−10	1.81E−10	7.95E−11
SSW	4.53E−6	5.48E−6	5.42E−6	5.07E−6	4.59E−6	2.07E−6	8.23E−7	2.74E−7	1.08E−7	5.77E−8	3.55E−8	1.22E−8	2.37E−9	5.74E−10	1.99E−10	8.36E−11
S	4.50E−6	5.44E−6	5.39E−6	5.04E−6	4.56E−6	2.05E−6	8.18E−7	2.72E−7	1.08E−7	5.76E−8	3.54E−8	1.23E−8	2.40E−9	5.92E−10	2.10E−10	9.06E−11
SSE	4.29E−6	5.19E−6	5.14E−6	4.81E−6	4.36E−6	1.97E−6	7.90E−7	2.65E−7	1.06E−7	5.71E−8	3.54E−8	1.25E−8	2.56E−9	6.70E−10	2.51E−10	1.14E−10
SE	4.36E−6	5.27E−6	5.22E−6	4.88E−6	4.42E−6	2.00E−6	7.97E−7	2.66E−7	1.06E−7	5.68E−8	3.51E−8	1.23E−8	2.46E−9	6.26E−10	2.29E−10	1.02E−10
ESE	4.43E−6	5.35E−6	5.30E−6	4.96E−6[c]	4.49E−6	2.03E−6	8.10E−7	2.71E−7	1.08E−7	5.79E−8	3.58E−8	1.25E−8	2.52E−9	6.44E−10	2.37E−10	1.06E−10
E	4.29E−6	5.18E−6	5.13E−6	4.80E−6	4.35E−6[d]	1.96E−6	7.83E−7	2.62E−7	1.04E−7	5.57E−8	3.44E−8	1.20E−8	2.40E−9	6.09E−10	2.23E−10	9.94E−11
ENE	3.18E−6	3.85E−6	3.81E−6	3.56E−6	3.23E−6	1.45E−6	5.76E−7	1.91E−7	7.51E−8	4.01E−8	2.46E−8	8.47E−9	1.64E−9	4.05E−10	1.45E−10	6.38E−11
NE	8.12E−6	9.82E−6	9.72E−6	9.10E−6	8.25E−6	3.73E−6	1.49E−6	5.00E−7	1.99E−7	1.07E−7	6.65E−8	2.35E−8	4.82E−9	1.27E−9	4.86E−10	2.27E−10
NNE[e]	9.65E−6[f]	1.17E−5[g]	1.16E−5[h]	1.09E−5	9.90E−6	4.56E−6	1.87E−6	6.49E−7	2.69E−7	1.51E−7	9.62E−8	3.69E−8	8.89E−9	2.77E−9	1.20E−9	6.20E−10

[a] Based on an assumed Pasquill stability class D.
[b] To be read as 8.25×10^{-6}.
[c] At the nearest residence.
[d] At the nearest forage crop.
[e] Direction of prevailing winds. (See Table 4.11 for effluents, release points, and average effluent concentrations.)
[f] At the plant boundary nearest to hydrogen fluoride release point.
[g] At the plant boundary nearest to ammonia release point.
[h] At the plant boundary nearest to NO_x release point.

1. A range of ph values from 1.44 to 3.6 were frequently recorded. Values in excess of 9.0 appeared less frequently. [Limits later assigned by the National Pollutant Discharge Elimination System (NPDES) permit to wastewater discharged to the Nolichucky River ranged from pH 6 to 9.]

2. Fluoride concentrations as high as 240 mg/liter were recorded. [Tennessee water quality standards (Temporary Permit 76-89) which were to apply following expiration (12/31/76) of Temporary Permit 75-28 specified an upper limit of 30 mg/liter for wastewater discharged to the Nolichucky River.]

3. Mercury concetrations as high as 0.408 mg/liter were recorded. (Both the limits specified by the NPDES permit and the limits later imposed by State Temporary Permit 76-89 specified a maximum limit of 0.005 mg/liter for wastewater discharged to the Nolichucky River.)

4. Biological oxygen demand (BOD) maxima as high as 795 mg/liter were recorded. (State Temporary Permit 76-89 established a maximum limit of 15 mg/liter in wastewater discharged to the Nolichucky River.)

5. NO_3- and NH_3-nitrogen as high as 380 mg/liter and 539 mg/liter respectively were recorded. [The State established a maximum daily average limit for the combined concentration of NO_3- and NH_3- nitrogen of 15 mg/liter for wastewater discharged to the Nolichucky River (Temporary Permi76-89); this limit was to have taken effect by December 31, 1976.]

These findings were discussed by NRC inspectors with applicant representatives in February 1976.[21] However, no limitations restricting water quality criteria were in effect because Temporary Permit 75-28, which applied at that time, stated no discharge limits. The permit merely required that the quality of the wastewater represent the maximum efficiency of existing wastewater treatment. However, the permit did hold the applicant liable for any damage incurred to the State of Tennessee as a result of plant operation. The NRC staff is not aware of any reported damage.

Measurements of the upstream and downstream temperatures in Banner Spring Branch were made during a five-month period from April to September 1975. The results are summarized in Table 2.9, according to which the NPDES permit condition of 100°F (68°C) was not exceeded.

Table 2.9. Thermal measurements in °C: April—September 1975

Location	Number of samples	Average[a] temperature	Minimum temperature	Maximum temperature	Estimated[b] winter months temperature
Banner Spring Branch					
Upstream	21	16.6	10.6	19.4	10.0
Downstream	21	16.7	10.6	18.9	10.0
Increase		0.1			
Martin Creek					
Upstream	21	16.7	8.3	20.0	8.3
Downstream	21	16.8	10.6	20.0	8.3
Increase		0.1			
Nolichucky River					
Upstream	4	18.1	7.8	24.4	7.8
Downstream	4	17.8	7.8	24.4	7.8
Decrease		0.3			

[a]Spring and summer.

[b]Estimated temperatures are based on records of fish hatchery located upstream on Martin Creek.

Source: Nuclear Fuel Services, Inc., *Environmental Information Report on the Nuclear Fuel Services, Inc. Operation at Erwin, Tennessee*, January 1976.

Water temperature increases were also in compliance with the condition of State Temporary Permit 75-167 for the discharge of uncontaminated cooling water to Banner Spring Branch.

Table 2.10 provides data addressed in the NPDES permit on the concentration of water quality parameters measured in the wastewater discharged to Banner Spring Branch in 1974 and 1975. The high and low values from which the average values were calculated are also given. Table 2.10 shows that the highest values recorded in 1974 and 1975 for some of the water quality parameters are considerably higher than the high values reported by NRC inspectors. For example, the highest recorded value for mercury is a full order of magnitude higher; the highest fluoride value is more than one and one-half times as high; and the BOD value shown is nearly twice as high as that reported by NRC inspectors.

Table 2.10. Chemical water quality of the wastewater discharged from the wastewater retention ponds in 1974 and 1975, and the calculated increase of these chemical parameters in Banner Spring Branch, Martin Creek, and the Nolichucky River

Constituent	Concentration in discharge from wastewater retention ponds (mg/liter)			Calculated increase Banner Spring Branch (mg/liter)	Calculated increase in Martin Creek (mg/liter)	Calculated increase in the Nolichucky River (mg/liter)
	Low	Average	High			
Suspended solids	1.0	56.7	284.0	6.55	1.97	4.37×10^{-3}
Settleable solids	<0.01	0.1	84.0	0.01	3.47×10^{-3}	7.71×10^{-6}
Biological oxygen demand (BOD_5)	0.6	346.0	1475.0	40.02	12.01	2.67×10^{-2}
Ammonia (as nitrogen)	2.9	202.0	795.0	23.36	7.01	1.56×10^{-2}
Nitrate (as nitrogen)	1.0	116.0	500.0	13.42	4.03	8.94×10^{-3}
Fluoride	0.1	57.5	390.0	6.65	2.00	4.43×10^{-3}
Mercury	1×10^{-4}	0.026	4.08	3.01×10^{-3}	9.02×10^{-4}	2.00×10^{-6}
pH	1.3	6.95	11.7			

Source: Nuclear Fuel Services, Inc., *Environmental Information Report*, January 1976; and *Responses to NRC Questions Related to NFS Erwin Environmental Information Report, May 31, 1977*, Erwin, Tenn., May 31, 1977.

Martin Creek

Prior to the startup of the new waste treatment facility in April 1977, Martin Creek carried wastewater from Banner Spring Branch to the Nolichucky River.[13] Approximately 200 yd of the creek were involved.[13] Baseline water quality parameters in upstream Martin Creek were not monitored between May 1973 and May 1977. In May 1977, a site survey was conducted by biologists from East Tennessee State University (ETSU) to supply information for this environmental impact assessment.[4]

According to this survey, Martin Creek was characterized as typical of creeks found in east Tennessee. The pH was 5.8, which is within the range for water used by the fish hatchery upstream (Sect. 2.5.3.1). The water had a fishy odor, as was somewhat expected because most of it had passed through the fish-rearing troughs which contain a dense trout population. Water temperature was 60°F (15.5°C). No other chemical or physical determinations were made. It was noted that there was some pollution from the septic tanks of upstream houses, but that this had no noticeable influence on the character of the water.[11]

Presently, the NFS Erwin plant discharges only cooling water [uncontaminated, <60 gal/min (0.134 cfs)] to Martin Creek via Banner Spring Branch.[4] Measurements of upstream and downstream temperatures made during a five-month period from April to September 1975 are summarized in Table 2.9. Although the increase in temperature relative to the reference point was acceptable, the maximum temperature achieved during this five-month period was equal to the maximum allowable for Banner Spring Branch as specified in State Temporary Permit 76-167.

Table 2.10 (column 5) provides data included in the NPDES permit on the calculated increases in water quality parameters which were expected to have occurred in Martin Creek in 1974 and 1975. However, absence of baseline measurements of these parameters in the creek prevents knowledge of the total ambient concentrations.

Nolichucky River

The Nolichucky River is highly turbid, which is believed to be due to large inputs of silt from mica and feldspar mining near Spruce Pine, North Carolina.[4] As early as 1956, just two years prior to the start of the NFS Erwin plant operation, the Nolichucky River at Riverview (about 1 mile upstream of the plantsite) was described as "milky and turbid."[15] In contrast, an observer at the turn of the century noted that the river was very clear.[15] Additional silt enters the river via North Indian Creek (see Fig. 2.7) from Vulcan Materials, Inc., a sand and gravel company, and via primary-treated sewage from the city of Erwin [∿2,340 P.E. (population equivalents)].[15] Above Erwin and for approximately 34 miles downstream, the river banks are lined with deposits of silt and mica.[15] In addition to the effect of heavy rainfall and runoff, the river picks up settled material and redeposits it further downstream, making this 34-mile stretch uninhabitable for benthic invertebrates and unsuitable for fish spawning.[15] Much of the load of particulate matter is dropped by the river in Davy Crockett Lake (Fig. 2.7) which acts as a settling basin.[15]

Although large quantities of particulate material settle out on the stream bed and banks, the material of colloidal size remains in suspension as a result of agitation by the current; it is this phenomenon which is primarily responsible for the constant milky appearance of the river.[11]

The following Secchi disc readings[14] were obtained by the Tennessee Game and Fish Commission from biological sampling stations on the Nolichucky River and from the control station on South Indian Creek in May 1959 (see Figs. 2.7 and 2.8 for locations of biological sampling stations):

Station No.	Location	Secchi depth (in.)
1 (Control)	South Indian Creek	50
2	Above mouth of North Indian Creek	7
3	Below mouth of North Indian Creek	6
4	Embreeville bridge	8

Table 2.10 (column 6) provides data on the calculated increases in the NPDES permit water quality parameters which were expected to occur in the river as a result of wastewater discharge from 1974 to 1975. Table 2.11 provides water quality data collected between 1964 and 1974 approximately 4 miles upstream from the NFS Erwin site for the parameters considered in the NPDES permit.

2.7.2.3 Groundwater

Pertinent data collected in 1948 and 1949 concerning the water quality of groundwater supplies within a 5-mile radius of the NFS Erwin site are shown in Table 2.12. The locations of the wells and springs listed in this table are shown in Fig. 2.10.

2.8 ECOLOGY

2.8.1 Terrestrial biota

2.8.1.1 Flora

The potential natural vegetation of the area is classified by Küchler[22] as Appalachian oak forest. Such vegetation forms a tall, broadleaf, deciduous forest dominated by white oak (*Quercus alba*) and northern red oak (*Q. rubra*). Other species would include red maple (*Acer rubrum*), sugar maple (*A. saccharum*), sweet birch (*Betula lenta*), three hickory species (*Carya cordiformis, C. glabra, C. tomentosa*), American chestnut (*Castanea dentata*), beech (*Fagus grandifolia*), tulip poplar (*Liriodendron tulipifera*), white pine (*Pinus strobus*), hemlock (*Tsuga canadensis*), and several oak species (*Quercus coccinea, Q. ilicifolia, Q. muhlenbergii, Q. prinus, Q. velutina*). Presently, the U.S. Forest Service[2] describes two major forest types in Unicoi County. The northwest half of the county consists of an oak-pine forest in which 50% or more of the stand is hardwood, usually upland oak, and in which southern pines make up 25 to 49%. Common associates include gum (*Liquidambar styraciflua*) and hickory (*Carya* sp.). The southeastern half of the county is oak-hickory forest in which 50% or more of the stand is upland oak and hickory, singly or in combination, and in which southern pines or red cedar make up less than 25%. Common associates are gum, tulip poplar, elm (*Ulmus* sp.), and maple (*Acer* sp.).

Table 2.11. Water quality of the Nolichucky River[a]

Constituent	Number of samples	Concentration (mg/liter) May 1964 to September 1965	September 1965 to December 1974	August 1972 to December 1974
Total residue	36, 31	185.0	80.0	
Nonfilterable residue	36, 31	145.0	44.0	
Dissolved oxygen	21		9.6	
Biological oxygen demand	22		1.13	
Total alkalinity ($CaCO_3$)	23		12.7	
Total hardness ($CaCO_3$)	23		19.3	
Calcium ($CaCO_3$)	23		10.8	
Magnesium ($CaCO_3$)	23		8.5	
Sodium	23		2.9	
Potassium	23		1.3	
Total nitrogen	31		0.28	
Iron	23		2.1	
Magnesium	23		4.8	
Chloride	25			2.75
Phosphorous	25			0.16
Sulfate	25			7.17
Mercury	5			0.27
Temperature, °C	20		14.2	
Turbidity, Jackson turbidity units (JTU)	36, 30	38.9	23.0	
pH	22		7.5	

[a]Samples taken at 98.5 river miles above the confluence of the Nolichucky and French Broad rivers.

Source: Tennessee Department of Public Health data; EIR, Table 6.1.

Very little natural vegetation occurs on the NFS property, primarily due to the compact nature of the plant. The NFS facilities, located immediately adjacent to the southwest city limits of Erwin, are on 57.8 acres of land, of which 21.2 acres are enclosed by a security fence. The area within the security fence contains primarily urban ornamental vegetation. However, a wetland habitat of cattail and willow occurs on the northeast end of the property along Banner Spring Branch, a drainage area for a natural spring located just outside the east corner of the security fence. The land outside the security fence includes facility parking space, burial grounds, and undisturbed forest. There are no critical habitats on the site known to be unique or important to endangered or threatened fauna.

2.8.1.2 Fauna

Very little site-specific information exists. Fauna surveys in the immediate vicinity of the plant have never been conducted.[4] In May 1977, biologists from ETSU performed a field survey for NFS on the plant site and concluded that "the NFS site contains nothing of unique biotic value."[4] Observations by the NRC staff on the site visit are in agreement with these findings. It is doubtful that the site is of critical importance to any endangered or economically important species. Birds and mammals whose territories might include the NFS site could include the cardinal (*Richmondena cardinalis*), titmice and chickadees (*Parus* sp.), woodpeckers (Picidae), English sparrow (*Passer domesticus*), mourning dove (*Zenaidura macroura carolinensis*), red-winged blackbird (*Agelaius phoeniceus*), house mouse (*Mus musculus*), white-footed mouse (*Peromyscus leucopus*), gray squirrel (*Sciurus carolinensis*), opossum (*Didelphis marsupialis virginiana*), and white-tailed deer (*Odocoileus virginianus*). Other animals associated with the riparian habitat in the vicinity (Banner Spring Branch, Martin Creek, Nolichucky River) might include some species of ducks (Anseriformes), yellow throat (*Geothlypis trichas*), shrews (*Sorex* and *Blarina*), muskrat (*Ondatra zibethicus*), raccoon (*Procyon lotor*), and a number of species of water snakes, salamanders, and frogs.

The potential for habitats for game species in Unicoi County is high. The Tennessee Game and Fish Commission[23] estimates that 91% of the land within the county is potential deer habitat; 88% is potential forest game habitat (for squirrel, raccoon, grouse); and 9% of the land is potential farm game habitat (for quail, rabbit, and dove).

Table 2.12. Analyses of water samples from wells and springs within a 5-mile radius of the Nuclear Fuel Services Erwin plant

Well or spring number[b]	Owner or name of spring or well[c]	Geologic horizon[d]	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na & K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C)
1-w	Crystal Ice, Coal and Laundry Co.	Ꞓhk	12/23/47	11.0	15	4.3	4.0	0	62	3	5.5	2.8	90	55	119
2-s	Love Spring	Ꞓs	12/23/47	18.0	17	7.5	4.0	0	86	4	5.0	0.5	103	73	148
3-w	Grady Ledford	Ꞓe	3/9/48	10.0	22	11.0	6.6	0	130	3	3.0	0.8	124	100	206
4-s	Sam Tipton	Ꞓe	3/9/48	8.0	15	5.7	7.3	0	68	3	7.0	10.0	108	61	153
5-s	E. L. Lewis	Ꞓo	3/9/48	9.8			4.5	0	8	2	5.0	0.2		6	26
6-s	Unaka Springs	Ꞓu	3/8/48	28.0	16	7.1	5.2	0	70	18	3.0	0.2	145	69	168
7-s	Banner Hill Spring	Ꞓr	3/8/48	14.0	16	8.6	0.6	0	78	5	3.0	4.0	109	75	156
8-s	Erwin Water Department	Ꞓs	3/8/48	9.2	15	8.4	3.0	0	86	2	3.0	2.2	93	72	150
9-s	U.S. Dept. of the Interior fish hatchery	Ꞓhk	3/10/48	14.0	18	9.5	2.2	8	80	4	3.0	1.8	108	84	165
10-s	Erwin Water Department	Ꞓhk	3/8/48	16.0	16	8.8	2.9	0	86	4	4.0	2.8	108	76	154
11-w	Fess Radford	Ꞓhk	3/8/48	18.0			5.8	0	14	7	4.0	4.0		15	65
12-s	Birchfield Spring	Ꞓs	3/8/48	18.0	19	9.0	0.6	8	78	3	2.0	3.2	110	84	169

[a]Concentrations are in parts per million (mg/liter).
[b]Well and spring numbers correspond to locations shown on map in Fig. 2.10.
[c]All sampling locations are in Unicoi County.
[d]Geologic horizon: Ꞓhk – Honaker Dolomite; Ꞓs – Shady Dolomite; Ꞓe – Erwin Formation; Ꞓu – Unicoi Formation; Ꞓr – Rome Formation; Ꞓh – Hampton Formation.
Source: Nuclear Fuel Services, Inc., *Environmental Information Report on the Nuclear Fuel Services, Inc Operation at Erwin, Tennessee,* January, 1976.

2.8.1.3 Threatened and endangered species

There are 27 endangered plant species whose ranges include Tennessee.[24] Habitat requirements for all but one of these species indicate that the species could potentially be in the vicinity of the site, but none have been reported. A cursory field survey of the site by biologists from ETSU revealed no endangered species or critical habitats for endangered species. Also, it is quite unlikely that any of these species would occur within the security-fenced area due to the plant-related disturbances. A somewhat greater potential for occurrence of the endangered species exists on the applicant's undisturbed forest land outside the security fence.

Threatened[25] and endangered[26] animal species whose ranges include Tennessee are listed in Table 2.13. The southern bald eagle, whose nesting habitat includes western Tennessee, may be expected to be seen occasionally in the Erwin area but has not been reported by the applicant. The Arctic peregrine falcon occurs only as a migrant in Tennessee. Because the number of specialized nesting sites is limited, the red-cockaded woodpecker is not likely to be found in the area. Bachman's warbler is so infrequently seen that little is known about its present breeding or wintering distribution. It is possible, but not very likely, for this species to be found in the river-bottom forested habitat near the site. The Indiana bat has a fairly restricted geographic range because it is associated with major cavernous limestone areas.[25] In the winter, the bats show a high degree of aggregation; over 90% of the estimated bat population is found in only four caves.[25] Therefore, it is unlikely for this endangered species to appear in the Erwin area. The Virginia big-eared bat, which is very intolerant of human disturbance,[25] is not expected to be found on site. The eastern cougar, formerly regarded as extinct, has been sighted by reliable observers hundreds of times in recent years from eastern Canada to the Carolinas. Very recently, the eastern cougar was sighted on the Department of Energy (DOE) reservation at Oak Ridge, Tennessee, which is located approximately 120 miles southeast of Erwin. Due to the abundance of habitat for prey species in Unicoi County (Sect. 2.8.1.2), it is possible for the eastern cougar to be found in this heavily forested, mountainous region of the State.

Table 2.13. Threatened and endangered animal species whose ranges include Tennessee

Common name	Scientific name	Status
	Birds	
Southern bald eagle	*Haliaeetus leucocephalus leucocephalus*	Endangered
Arctic peregrine falcon	*Falco peregrinus tundrius*	Endangered
Red-cockaded woodpecker	*Dendrocopos borealis*	Endangered
Bachman's warbler	*Vermivora bachmanii*	Endangered
	Mammals	
Indiana bat	*Myotis sodalis*	Endangered
Virginia big-eared bat	*Plecotus townsendii virginianus*	Threatened
Eastern cougar	*Felis concolor cougar*	Endangered

[a]U.S. Department of the Interior, Fish and Wildlife Service, *Threatened Wildlife of the United States*, Resource Publication 114, U.S. Government Printing Office, Washington, D.C., 1973.

[b]U.S. Department of the Interior, "Endangered and Threatened Wildlife and Plants," *Fed. Regist.* 41 (208): 47180-47198, 1976.

2.8.2 Aquatic ecology

2.8.2.1 Banner Spring Branch

At the time of the site survey conducted in May 1977 by biologists from ETSU, the major faunal forms within the spring were the immature of the following insect orders: *Diptera* (flies), *Ephemeroptera* (mayflies) and *Trichoptera* (caddis flies). Aquatic or semiaquatic adults observed flying over the stream or on the vegetation immediately adjacent to the water were members of the following orders: *Ephemeroptera*, *Mecoptera* (scorpion flies), *Odonata* (ruby-winged damsel flies) and *Plecoptera* (stone-flies). Only a very sparse growth of diatoms was seen; collections for microscopic study were not taken. Vertebrates, mollusks, and crustaceans were absent.[4]

Abundance and diversity of aquatic biota were low. This was attributed to the small size of the stream (1.5 to 3 ft wide and 1200 ft long), the lack of microhabitat diversity (all sandy bottom with only a few small stones), and the lack of organic material. The lack of organic material is attributed to the distance of the stream from woody vegetation and to the fast flow of the water.[4]

2.8.2.2 Martin Creek

The ETSU survey also included Martin Creek, in which the vertebrates observed consisted of amphibians, fish, and one pair of mallard ducks with chicks. One of the fish was a rainbow trout, believed to have been an escapee from the fish hatchery located 200 yd upstream from where it was captured. The invertebrates were represented by five orders of insects, numerous crayfish, and one mollusk (a periwinkle snail). Aquatic plants consisted of green algae, blue-green algae, and diatoms. Martin Creek was judged typical of creeks in east Tennessee, possessing the usual and anticipated kinds of flora and fauna. The stream bed is composed of sand, pebbles, and rocks mixed with some organic material, such as leaves and branches from dead trees.

2.8.2.3 Nolichucky River

Three separate biological surveys (Fig. 2.7) were made on the Nolichucky River by the Tennessee Stream Pollution Control Board: Survey I — August 10, 1954 (stations 6, 7 & 8); Survey II — October 9, 1956 (stations 1 & 2); and Survey III — November 10-11, 1958 (stations 1–8).[15] The following are the results of these surveys at three of the stations (2, 3, and 4), one located just above and two located below the NFS Erwin site (Figs. 2.7 and 2.8).[15]

Station 2 (Riverview)

Station 2 was sampled in 1956 and 1958. The station lies in Unicoi County (Chestoa quadrangle, No. 199 southwest), 95.9 river miles above the confluence of the French Broad River (Fig. 2.11). The turbidity principally consisted of mica and sand particles. The current was swift to moderate, and the water temperature was 10°C. The stream bed contained boulders ranging in size from approximately 6 ft in diameter to very small stones with heavy deposits of sand and mica. There were also mica and sand deposits about 3 ft deep along the left bank.

No aquatic plants were noted in the main stream. There were dense growths of river weed (*Podostemon)* and filamentous green algae on stones near the bank. Although the river weed at this station was not abundant in 1956, it was very abundant in 1958. River weed provides good insect habitat, which could account for the 500% increase in genera and for the 780% increase in the total number of insects observed in 1958. Dipterans and oligochaetes, two species absent in 1956, made up a large part of the faunal population in 1958.

Station 3 (Stony Point)

Station 3 was sampled only in 1958. The station lies at the Unicoi and Washington county line on Tennessee Highway 81 (Erwin quadrangle, No. 199 northwest), 92.5 river miles above the confluence of the French Broad River (Fig. 2.11). The water at this station was milky to muddy; the current was swift; and the water temperature was 10°C. Large mud flats were noted. The principal materials in the stream bed were large boulders and stones, mica, mud, and sand. River weed was common. A few filamentous green algae, dragonflies, caddis flies (hydropsychid type) and pleurocerid snails were observed. Of a total of 335 individuals representing 24 genera, 279 were oligochaetes or annelid worms, which are often found in abundance in areas of undesirable water quality (e.g., low dissolved oxygen, organic enrichment, etc.). Mayflies and caddis flies were few, whereas *Physa* and *Ferrissia* (pulmonate snails) were a dominant part of the fauna. Both the faunal analysis and physical appearance of the river indicated a degraded condition caused by organic pollution and high turbidity. Among the 16 species of flora found were *Beggiatoa* and *Thioploca*. Both of these genera are represented by species in fresh and marine waters only when hydrogen sulfide is present. Hydrogen sulfide is a by-product of sulfur-metabolizing bacteria, usually existing under anaerobic conditions. *Sphaerotilus*, the so-called sewage fungus,[27] was also found. The flora at this station were considered typical of other stations along the Nolichucky.

Station 4 (bridge on State Highway 81 at Embreeville)

Station 4 was sampled only in 1958. The station lies in Washington County (Erwin quadrangle, No. 199 northwest), 89.0 river miles above the confluence of the French Broad River (Fig. 2.7). The water at this station was milky to muddy, the current swift to moderate, and the water temperature 10°C. The stream bed consisted of boulders and rocks compacted with mica and sand. Common vegetation consisted of river weed, which was in poor condition, and filamentous green algae. Dragonflies, damselflies, planorbid snails and pleurocerid snails were few. The dominant faunal species was *Physa*; of the 96 animals collected, 56 were pulmonate snails, 42 of which were *Physa*. This snail can live in areas of septicity due to a lung system that enables it to obtain atmospheric oxygen at the surface. Of these individuals, 20 were insects, representing ten genera. Fourteen species of flora were found at this station. One of these was *Leptomitus lacteus*, which is often associated with organic pollutants.

2.8.2.4 Discussion of Nolichucky River aquatic environment

The biological surveys conducted by the Tennessee Stream Pollution Control Board revealed the flora and fauna of the Nolichucky River to be seriously handicapped by the shifting bottom and by the exclusion of light by the suspended material. The surveys showed phytoplankton at all stations to be practically nonexistent, with a total count of 20 to 120 cells per liter. Only 9 species were found at Station 2, whereas 21 species were found at Station 1 (control station) on South Indian Creek. The smallest total number of cells was found at Station 4.

The benthic fauna of the river were largely restricted to riffle areas. This was attributed to extremely limited production of phytoplankton and an unfavorable habitat caused by a virtually sterile, shifting bottom. The stream bed in pools was found to be blanketed by a layer of particulate matter. Even in riffle areas, the rocks were compacted with particulate matter. Increased light penetration in the shallow riffles enhanced the growth of herbaceous plants such as river weed, bryophytes, and filamentous green and blue-green algae. In turn, the plants provided shelter and attachment for the associated faunal community, as well as furnished food for the herbivores. These factors allowed a food web to be established, providing the necessary community structure for a limited group of tolerant organisms.

The Nolichucky River at one time supported a desirable population of game fish. A map showing distribution of major game fish in Tennessee indicates spotted, largemouth, and smallmouth bass occurring in the river. Out of the six stations on the Nolichucky sampled in May 1959 by the Tennessee Game and Fish Commission, only 20 individuals of the above three bass species were collected. The total weight was a little over 5 lb. While reproduction of game fish has proven unsuccessful in this part of the Nolichucky, reproduction of channel catfish, on the other hand, has been successful. Because catfish are tolerant of turbid waters, turbidity has been suggested as the primary factor preventing game fish reproduction.

Table 2.14 lists the fish species that were collected in the Nolichucky River in May 1959 during cooperative sampling by the Tennessee Stream Pollution Control Board and the Tennessee Game and Fish Commission.

2.8.2.5 Rare, threatened, and endangered species

The *Endangered Species Technical Bulletin*[28] lists about 20 freshwater snails which the Department of the Interior has proposed for endangered or threatened status. Twelve of these are found in Tennessee. One of these proposed for the threatened list is Anthony's river snail (*Athearnia anthonyi*) which has recently been discovered living in the Nolichucky River. However, Anthony's river snail is not known to exist in the section of the Nolichucky between the North Carolina border and Davy Crockett Lake, about 15 miles west of Erwin, although this may be a reflection of the lack of study devoted to snails in this part of the river.

Another species of snail inhabiting the Nolichucky River, the spiny river snail (*Io fluvialis*), has been proposed by TVA for endangered species classification on the Federal list. According to TVA biologists, a fish species called the sharphead darter (*Etheostoma acuticeps*) should be added to the list because of its rare status. Neither of these species is known to inhabit the portion of the Nolichucky River between the NFS Erwin site and Davy Crockett Lake. Biologists from ETSU found no rare, threatened, or endangered species during their recent survey of Banner Spring Branch and Martin Creek.[4]

Table 2.14. Comparative fish species sampling on the Nolichucky River

Common Name	Number	Weight (lb)
Mouth of South Indian Creek		
Channel catfish	99	43.7
Flathead catfish	5	1.1
Golden redhorse	44	31.8
Shorthead redhorse	8	3.3
Highfin sucker	2	2.3
Gizzard shad	148	6.9
Mooneye	12	2.7
Spotted bass	2	0.4
Rock bass	2	
Bluegill	4	0.4
Rainbow trout	1	0.4
Hog sucker	3	0.9
Longnose	1	1.6
Minnows	24	
Total number of fish, 355		
Total weight of fish, 95.5 lb		
Weight of game fish, 1.2 lb		
Below the mouth of North Indian Creek		
Channel catfish	102	87.6
Flathead catfish	1	8.6
River redhorse	2	3.8
Golden redhorse	4	3.5
Shorthead redhorse	2	1.2
Highfin sucker	7	9.7
Gizzard shad	192	8.0
Mooneye	1	0.2
Walleye	1	10.3
Bluegill	1	
Minnows	26	
Total number of fish, 339		
Total weight of fish, 132.9 lb		
Weight of game fish, 10.3 lb		

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26. U.S. Department of the Interior, "Endangered and Threatened Wildlife and Plant," *Fed. Regist.* 41 (208): 47180-47198, 1976.

27. H. B. N. Hynes, *The Biology of Polluted Waters,* University of Toronto Press, Toronto, Canada, 1974.

28. U.S. Department of the Interior, *Endangered Sp. Tech. Bull.,* 2 (2), 1977.

3. THE FACILITY

3.1 GENERAL DESCRIPTION

The facility consists of numerous small buildings located within a chain-link security fence. The administration building and the guard house are made of local brick; the process buildings are predominantly cement block, painted white. Metal "Butler" buildings are used for storage of material. Retention ponds, formerly used for liquid wastes, are also located within the security fence. The burial grounds for low-radioactivity solid wastes are outside the security fence but inside a barbed-wire fence (Fig. 1.1).

The average employment on day shift (Monday through Friday) is 203 persons, and the average evening, midnight, and weekend shift employment is 62 persons per shift.

Process work includes production of nonirradiated nuclear fuel components and other products from uranium. Some work done in the past with thorium and plutonium is briefly described here, but principal attention in the following sections is given to currently licensed processes, especially the four which are in actual use in 1977.

3.2 SUMMARY OF PROCESSES

Processing buildings and most other buildings have been designated with numbers and names which are shown in Fig. 3.1. The processes are associated with the names of the buildings in which they are performed.

3.2.1 Warehouse facilities

The warehouse facilities and shops include buildings 120, 300, 310, 304, 135 (also called the calcium building), and various Butler buildings. No stable or radioactive chemicals are stored in these buildings if release to the environs is probable. Double containment is provided for storage of radioactive materials. The only waste from these buildings is sanitary sewage and some solid waste. The sewage is sampled through a port in the main sewer pipe prior to release to the city sewer. Solid wastes are packaged for offsite burial or are incinerated and buried on site as described in Sect. 3.2.11.

3.2.2 Plutonium fuel fabrication, Building 234

Reactor fuel elements containing uranium and plutonium have been fabricated on site. The plutonium fuel element fabrication operations have not been performed for some time. These operations are now shut down, and decommissioning plans will be requested at the time of license renewal. The process was performed in two sections of Building 234. Uranium-233 was reclaimed from scrap materials in the other section of the same building.

3.2.3 High-enriched uranium scrap recovery, Building 233

Highly enriched uranium fuel that does not meet specifications and various scrap materials generated in the fabrication of highly enriched uranium fuel are processed in Building 233 to reclaim the uranium. The scrap processed in this facility may be generated in other buildings or received from off site. The final product may be recycled to fabrication facilities on site or shipped off site.

[redacted]

Liquid effluents generated in the recovery process are sampled for uranium prior to transfer to the waste treatment system. Gaseous effluents from the process are treated by dual high-efficiency particulate air (HEPA) filtration or by scrubbing (Fig. 3.3) and are discharged through either of two stacks.

Fig. 3.1. Applicant's facilities. Source: EIR, Fig. 2-1, p. 2-2.

Fig. 3.2. High-enriched-uranium scrap recovery, Building 233.

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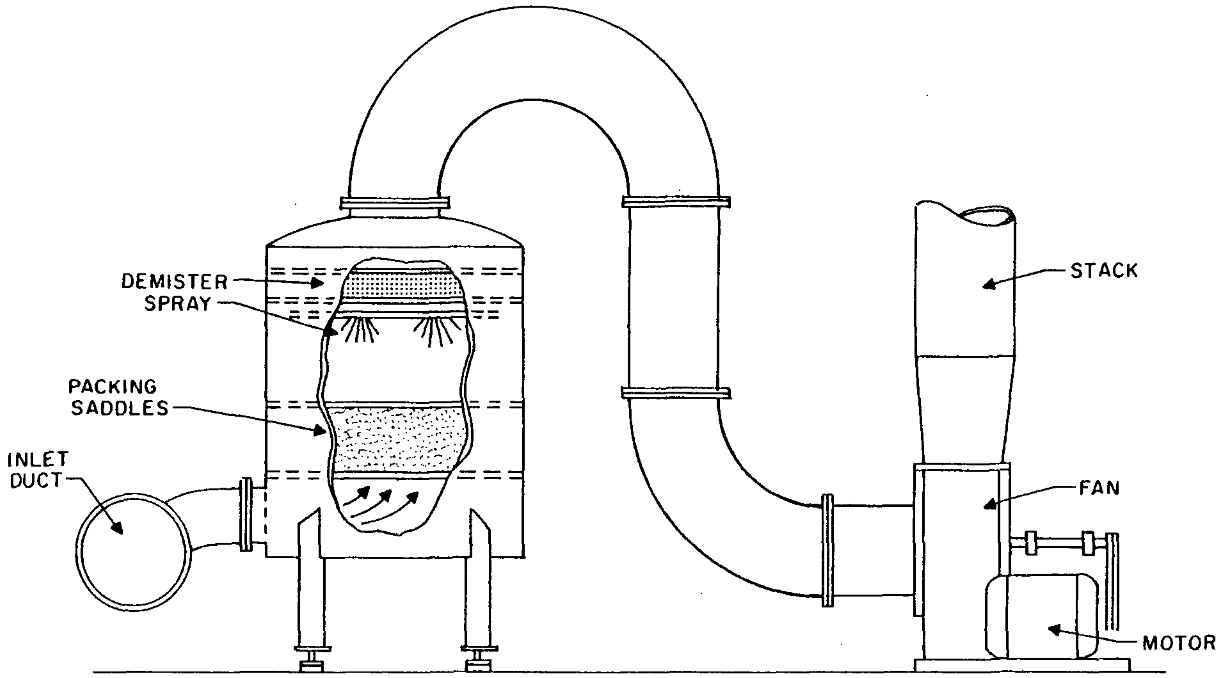

Fig. 3.3. Typical scrubber (on stack 219, Building 233).

3.2.4 Service building, Building 100

Building 100 contains change rooms, lunch rooms, and laundry facilities. There are no gaseous effluents other than normal building air, which is sampled routinely for worker protection, and dryer exhaust vents. The only liquid effluents are laundry waste and sanitary sewage. Sanitary sewage is discharged into the main sewer pipe where it is sampled. Laundry waste may be processed in the waste treatment system or discharged to the municipal sewage system. Daily flows average 2700 gal (10,200 liters) and contain about 15 lb (7 kg) of detergent.

3.2.5 Ceramics building, Building 110

The ceramics building contains a processing facility and an analytical laboratory. The processing facility can be used to fabricate enriched uranium, thorium, or thorium and uranium blend fuel rods. The process primarily involves dry materials. The only liquid is a solution used for ultrasonic wash. The used solution may be solidified or processed as scrap in another building. There are no liquid effluents from the fabrication processes.

The analytical laboratory may generate a small amount of liquid waste. Because past laboratory operations included the analysis of small quantities of plutonium as well as uranium-233, all laboratory wastes are solidified for burial at a licensed site. All building air is filtered through single or double HEPA filters.

3.2.6 Chemical building, Building 111

Three process lines have operated in the chemical building. The one for low-enriched-uranium (LEU) scrap is illustrated in Fig. 3.4. Scrap material containing enriched uranium is processed to recover the uranium. Thorium dioxide powder and thorium metal pellets were also produced in the facility. Certain equipment is common to these processes, including the two scrubbers on stacks 278 and 287. The scrubber on stack 278 is a wet-venturi type, while the scrubber on stack 287 is a packed-bed type.

3.2.7 Administration and laboratory, Building 105

This building primarily houses offices and computer facilities that generate no effluents other than sanitary sewage and wastepaper which is disposed of on site. Some laboratory facilities are also located in this building. Liquid wastes from the laboratories are processed in the waste treatment system.

3.2.8 Metals, Building 130

Except for UF_6 cylinder cleaning, the metals building has not operated since 1973. In the past, it was used to produce uranium metal, uranium tetrafluoride, or thorium metal. A new process to wash UF_6 cylinders has been installed. [redacted] The only liquid effluent from the metals building is the scrubber solution resulting from the cylinder wash process, which is recycled and then disposed of in the waste treatment system.

The new UF_6 cylinder wash process is illustrated in Fig. 3.5. Cylinders which have been used to transport LEU hexafluoride are washed free of uranium and are air dried. The UF_6 is hydrolized with water. Gaseous exhaust from this process is passed through a packed-bed scrubber. Water is removed from the cylinder by a vacuum transfer system in which a steam ejector is used to create the vacuum. The water which is removed from the cylinders is sampled and is transferred to the scrap recovery facility in Building 111. Condensate from the steam ejector is transferred to the waste treatment system. The cylinders are emptied and refilled several times until the wash solution contains 5.0 g/liter or less of uranium. The cylinders are then air dried and shipped off site.

3.2.9 Pilot plant, Building 131

The pilot plant has been used for process development but not for actual production work. [redacted] No plutonium has been used in this facility. Exhaust air is filtered through HEPA filters before discharge. Liquid effluents are sent to the waste treatment system.

Fig. 3.4. Low-enriched-uranium scrap recovery, Building 111.

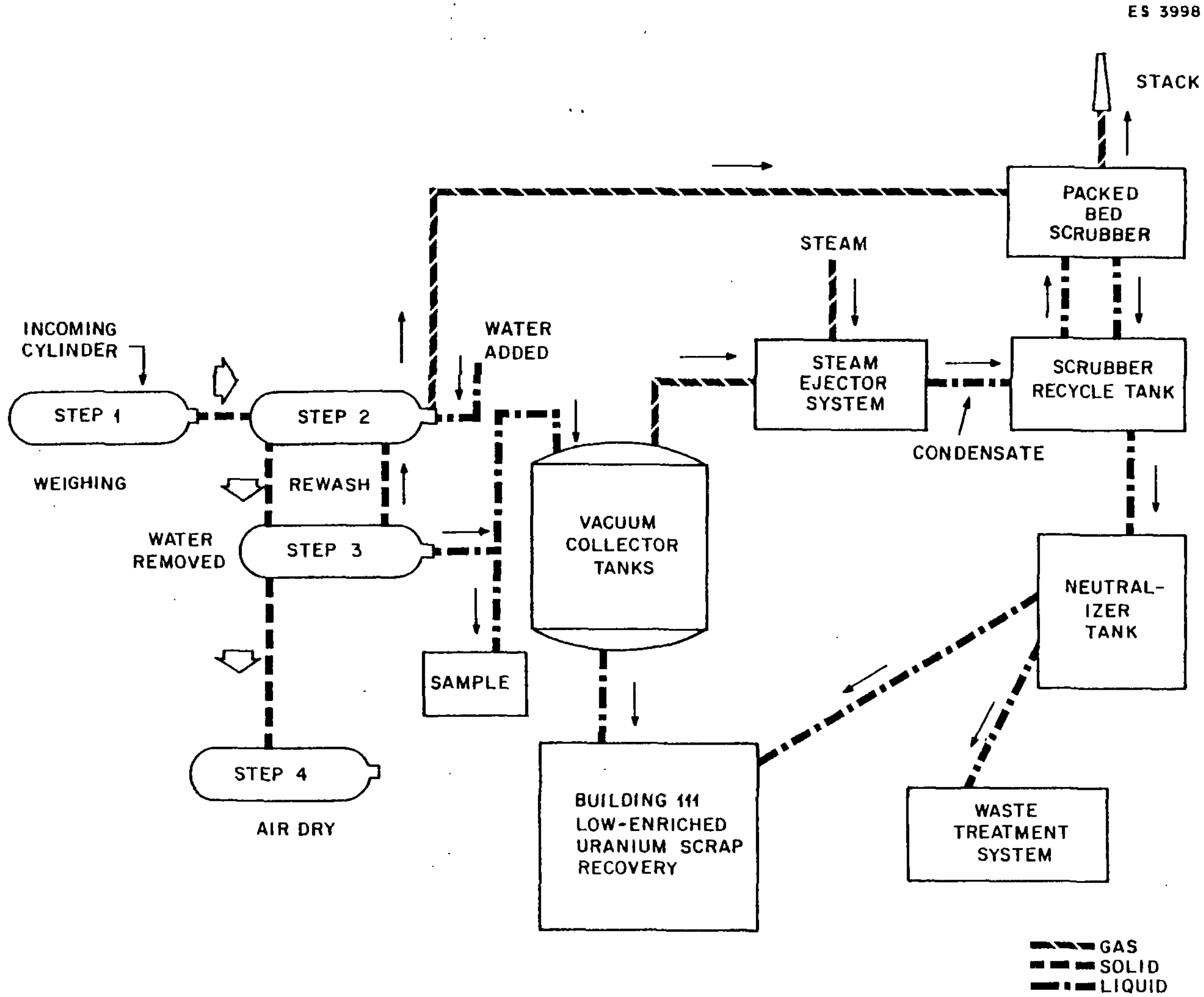

Fig. 3.5. Uranium hexafluoride cylinder wash, Building 130.

3.2.10 High-enriched uranium fuel fabrication, Buildings 302 and 303

The finished product line uses highly enriched uranium [redacted] to produce a classified product. The process is vented through a single large scrubber on the roof of the building. In addition, certain process steps have individual control devices. [redacted] are vented through a venturi scrubber of the same design as the one on stack 278. Where ammonia and fluoride may be present, an ammonia fume scrubber is used. Ordinarily, there is no UF_6 in the effluent; however, the scrubber provides added control should a malfunction occur in the vaporization process. In addition to being scrubbed, certain processes in which there is a high dust potential are vented to the main exhaust system through HEPA filters.

All these process effluents are vented through a single packed-bed scrubber which has the same design as the scrubber on stack 219, but has a larger capacity. This scrubber is illustrated in Fig. 3.3. Building air is filtered through Cambridge particulate filters and is exhausted through ducts on the roof. The purpose of these filters is to provide environmental protection against the unlikely occurrence of an accident inside the facility.

3.2.11 Auxiliary facilities

In addition to effluents generated by the processing facilities, certain support equipment also generates gaseous and liquid effluents. Gaseous effluents are generated from incinerators for clean and contaminated solid wastes, building heaters, boilers, and emergency generators. Liquid effluents are generated from laundry of potentially contaminated clothing, restrooms and showers, and stormwater runoff. The generation, treatment, and disposal of the effluents from these sources are described in the following sections and in Sect. 3.3.

Incinerator for office and lunchroom wastes

Solid nonradioactive wastes are incinerated in a commercial-type incinerator with a natural gas afterburner. Administrative controls and frequent inspections ensure that no contaminated waste from processing or laboratory operations is disposed of in the incinerator.

The incinerator ash is buried on site. Gaseous effluents from the incinerator are expected to contain small quantities of particulates, oxides of sulfur and nitrogen, and carbon monoxide. The gaseous effluent is discharged from a 15-ft stack.

Incinerator for contaminated wastes

Process or laboratory wastes are incinerated in the newly installed Combustall Waste Incinerator, which has been modified to greatly reduce particulate emissions which might contain small quantities of uranium. Batch loading and ash cleanout after each incineration preclude any possibility of criticality. Complete combustion is assured by the use of a gas-fired afterburner. Soluble products of combustion are removed by the venturi scrubber along with particulates before the effluent is discharged from stack 317.

Ash is removed from the incinerator by a suction system and is transferred to a container where it is weighed and assayed prior to transfer to either Building 233 or 111 for scrap recovery. Exhausts from the transfer operation are also passed through the scrubber and out through stack 317.

The incinerator has been in operation only a short time; so release data are limited. Preliminary data show the average effluent concentration to be 1.31×10^{-12} μCi/ml, or 1.9% of the maximum permissible concentration (MPC). This is MPC_a for controlled areas, the most restrictive value with respect to solubility. The design flow rate is 16.7 ft^3/sec (0.5 m^3/sec).

Emergency generators

Three diesel-powered emergency generators are available to operate critical alarm and ventilation equipment during power outages. These generators operate only infrequently during power outages and during testing. Although generator emissions can be expected to contain small quantities of particulates, carbon monoxide, oxides of sulfur and nitrogen, and hydrocarbons, they are not expected to adversely affect the air quality in the area.

Building and process heat

Process steam is provided by three boilers that are fired using either natural gas or No. 2 diesel oil. Measurements of emission have not been made, but total emissions can be computed from fuel consumption and average emission factors for similar equipment which have been published by the Environmental Protection Agency.[1] The estimate is, however, complicated by the fact that both No. 2 diesel oil and natural gas are used in the boiler. In addition, building heat is provided by small oil- or gas-fired units in the processing buildings.

It is assumed that the diesel building heaters have the same emission factors as those of a small boiler; the emissions in Table 3.1 are predicted from estimated usages of oil or gas.

Table 3.1. Emission from heating plant

Contaminant	Emission rate (lb/year)[a]	Emission rate (kg/year)[a]	Concentration $\mu g/m^3$[b]
With oil			
Particulates	3,015	1368	6,707
Sulfur dioxide	5,708	2589	12,698
Sulfur trioxide	80	36	178
Carbon monoxide	40.2	18.2	89
Hydrocarbons	603	274	1,341
Oxides of nitrogen	16,080	7294	35,771
Aldehydes (as HCHO)	402	182	894
With natural gas			
Particulates	450	204	8.1
Carbon monoxide	15	6.8	0.3
Oxides of sulfur (as SO_2)	10	5	0.2
Hydrocarbons (as CH_4)	100	45	1.8
Oxides of nitrogen (as NO_2)	300	140	5.4
Aldehydes (as HCHO)	8	140	0.1
Organics	18	8	0.3

[a]Based on 210,000 gal (790,000 liters) oil or 25,200 MCF (700,000 m^3) gas.
[b]Concentrations in micrograms per square meter are based on estimated volumes of combustion air required.

3.3 WASTE CONFINEMENT AND EFFLUENT CONTROL

Release data for each facility which were summarized by the applicant[2] are based on analysis of gaseous and liquid effluents. This section summarizes the nature of the effluents, and methods and principles for their control. Locations of releases of gaseous and liquid effluents are those shown in Fig. 3.6, plus a direct line from the waste treatment facility (Building 330) to the Nolichucky River.

3.3.1 Gaseous effluents

Various control devices used to remove radioactive particulates and chemicals from gaseous effluents are described here briefly. Although specific efficiency values are not provided for all such control devices, the plant personnel measure effluent concentrations after treatment. The total airborne alpha activity release rate[2] for a typical period was 9.9×10^{-4} µCi/sec. The characteristics of the stacks and vents are given in Table 3.2, and the discharge from the buildings emitting essentially all the radioactivity are included in Tables 3.3 through 3.5.

Cambridge filters are used for building air ventilation on buildings 302 and 303. They have been determined by the manufacturer to have an 83% removal efficiency for 0.3-µm-diam particles.

High-efficiency particulate air filters are in use throughout the facility. They are at least 99.97% efficient for removal of 0.3-µm-diam dioctyl phthalate particles. In some cases, two or three HEPA filters are connected in series. This arrangement provides increased removal efficiency and is environmentally beneficial as a contingency against releases which may occur during filter change or from accidental damage to one filter. The HEPA filters are tested by the manufacturer and certified as to their efficiency.

Table 3.2. Physical characteristics of Nuclear Fuel Services process stacks and building vents

Stack No.	Building	Effective diameter (m)	Height (m)	Gas exit velocity (m/sec)[a]
27	234	0.38 X 0.46	4.6	17.74
28	234	0.69 X 0.48	4.6	7.87
29	234	0.30 X 0.18	7.6	2.92
35	234	0.30 X 0.38	11.9	3.72
51	234	0.25	12.2	4.51
224	234	0.18 X 0.30	9.1	2.57
219	233	0.61	12.0	5.57
233	233	0.20	6.1	5.04
No number	220	0.51	18.9	38.44
103	110	0.34 X 0.41	1.5	9.22
104	110	0.34 X 0.41	1.5	10.87
211	110	0.27 X 0.30	2.4	7.93
212	110	0.23 X 0.27	7.6	4.06
278	111	0.20	7.0	6.35
287	111	0.19	12.2	5.97
283	130	0.22 X 0.22	10.6	16.76
284	130	0.10	4.57	26.44
285	130	0.10	9.1	26.44
184	131	0.09 X 0.15	4.6	2.44
185	131	0.30 X 0.38	4.6	1.09
299	105	0.20	6.0	9.72
300	105	0.25	5.5	2.64
207	308	0.76	15.8	7.18
317	302	0.30	9.4	11.85
159	301	0.64 X 0.56	15.2	3.27
197	301	0.28 X 0.28	15.2	5.74
198	301	0.10 X 0.10	15.2	28.45
292	301	0.25 X 0.25	2.4	10.58
320	130	0.20	1.32	9.0
No number	330	0.61	9.1	64.0
HS 1[b]	303	0.76	8.7	6.93
HS 2	303	0.76	6.7	10.04
HS 3	303	0.76	6.7	10.28
HS 4	303	0.76	6.7	11.00
HS 5	303	0.61	6.7	7.29
HS 6	302	0.61	6.7	11.71
HS 7	302	0.76	6.7	12.91
HS 8	302	0.76	6.7	14.10
HS 9	302	0.76	6.7	10.16
HS 10	302	0.76	4.5	6.83
HS 11	233	0.76	4.1	9.20
HS 12	233	0.76	4.1	8.96
HS 13	233	0.61	12.2	8.72

[a] All at approximately 22°C.
[b] Room air vent designated HS.

Venturi scrubbers are also in use throughout the facility. These scrubbers impart kinetic energy to the gaseous-effluent stream and to a fine water mist, causing particulate matter from the gas stream to become impacted in the water droplets and to be subsequently removed by a "cyclone" separator.

Packed-bed scrubbers are used in several buildings where water, potassium hydroxide, aluminum nitrate, or ammonium hydroxide is used as the scrubbing solution.

The average release of gaseous ammonia,[2] largely from the wastewater treatment facility, is estimated to be 1.84 g/sec. Gaseous fluoride release, almost entirely from stack 207, is 3668 μg/sec. Emissions from the heating plant are given in Table 3.1.

3.3.2 Liquid waste retention

There are three underground waste retention tanks; two have a 6000-gal (23,000-liter) capacity, and one has a 140-gal (430-liter) capacity.

The 140-gal emergency collection tank is made of stainless steel and is filled with borosilicate raschig rings. This tank is buried within Building 233 on the east side, and serves as an emergency collection system in case of a spill or rupture in any of the [redacted] columns located within the building. If the tank were used as the result of an accident, it would be emptied and the contents would be reprocessed as soon as practicable.

Table 3.3. Gaseous effluents from the chemical building, Building 111

Release point, stack	Control devices	Efficiency of control devices	Operational checks	Potential contaminant	Flow rate (ft³/sec; m³/sec)	Concentration (μCi/ml) and percent of MPC[a]		Emission rate, (μCi/sec)	Release height (m)
						Avg.	Max.		
278	Wet scrubber	Unknown	Fan and pump checked daily; sample analyzed daily	Uranium Oxalic acid[c] HNO_3[c]	8.3 (0.23)	11.31×10^{-12}[b] (11.31%)	749.7×10^{-12}	2.66×10^{-6}	7
287	Wet scrubber	Unknown	Fan and pump checked daily; sample analyzed daily	Insoluble low-enriched uranium	283 (8.01)	0.28×10^{-12} (0.28%)	0.46×10^{-12}	2.24×10^{-6}	12.2
				Soluble low-enriched uranium		66.92×10^{-12} (13.38%)	78.31×10^{-12}	5.36×10^{-4}	
West wall fan No. 1	None		Room air monitored continuously	Low-enriched uranium	71.7 (2.03)	0.64×10^{-12}	2.55×10^{-12}	1.30×10^{-6}	4.5
West wall fan No. 2	None		Room air monitored continuously	Low-enriched uranium	71.7 (2.03)	0.64×10^{-12}	2.55×10^{-12}	1.30×10^{-6}	4.5
North wall fan	None		Room air monitored continuously	Low-enriched uranium	38.3 (1.08)	0.64×10^{-12}	2.55×10^{-12}	6.94×10^{-7}	4.5
South wall fan	None		Room air monitored continuously	Low-enriched uranium	1.5 (0.04)	0.64×10^{-12}	2.55×10^{-12}	2.72×10^{-8}	3.0
Micronizer stack[d]									

[a] MPC_a for controlled areas. Most restrictive value with respect to the radionuclide and solubility has been used.
[b] 1973 to February 1975 data.
[c] The process using these materials has not operated since this ventilation system was installed.
[d] This is out of service. It is to be rerouted to Stack 287.
Source: EIR, Table 2.4, p. 2-22.

The two other underground collection tanks are located adjacent to buildings 105 and 303. These 6000-gal (23,000-liter) fiberglass tanks are used to collect uranium-bearing process wastes for sampling before release or reprocessing. They are used to route the process wastes to the waste treatment facility. In order to detect leakage of liquid from the tanks, the applicant is required to set up a monitoring program to detect potential leakage from the tanks.

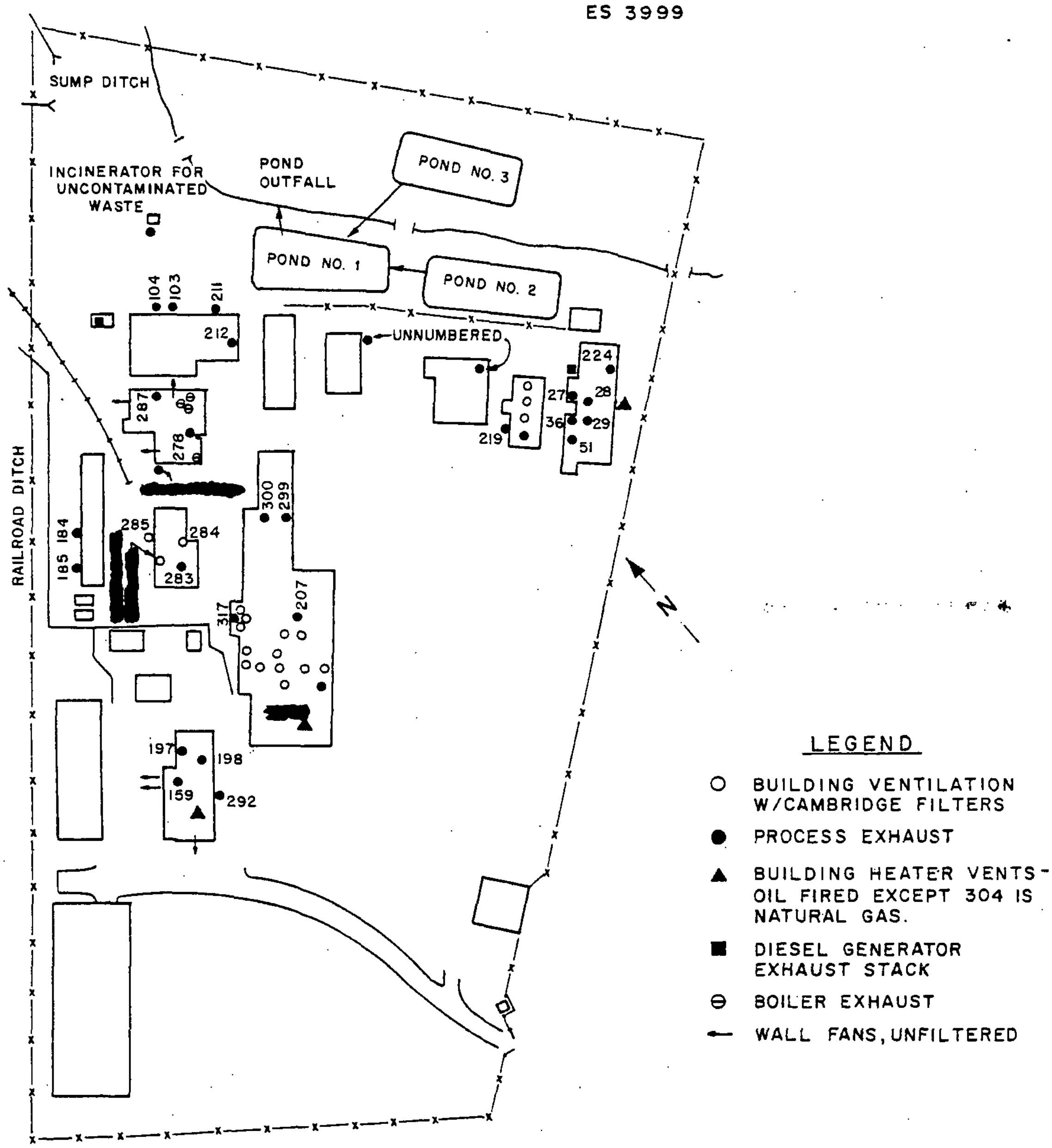

Fig. 3.6. Effluent release locations.

Table 3.4. Gaseous effluents from finished product fabrication, Building 302–3

Release point, stack	Control devices	Efficiency of control devices (%)	Operational checks	Potential contaminant	Flow rate, (ft^3/sec)	Concentration (μCi/ml X 10^{-12}) and percent of MPC[a]		Emission rate, (μCi/sec)[b]	Release height (m)
						Avg	Max		
207	HEPA filter	99.97	Fan and pump checked daily; sample analyzed daily	High-enriched insoluble uranium	317	2.67[c] 0.17	83.18	2.00 X 10^{-6}	15.8
	Venturi and packed-bed wet scrubber	Unknown		High-enriched soluble uranium		65.44 84[d]	850.00	1.00 X 10^{-4}	
				[redacted]		[redacted]		[redacted]	
				Particulates				0.003 lb/hr	
				Fluorides		<0.5 ppm			
Roof vents	Cambridge filter	83 for 0.3-μ particle	Breathing air monitored continuously; effluent sampled periodically	High-enriched uranium	628.3 total				6.7

[a]MPA$_a$ for controlled areas. Most restrictive value with respect to the radionuclide and solubility has been used.
[b]Emission rate is in microcuries per second unless otherwise noted.
[c]Data in 1974.
[d]Soluble uranium in stack 207 effluents averaged 210 X 10^{-12} μCi/ml in 1973 due to a demister problem which has since been corrected. The 1974 data is expected to be representative of current and future operations.
Source: EIR, Table 2-8, p. 2-33.

Table 3.5. Gaseous effluents from high-enriched scrap recovery, Building 233

Release point, stack	Control devices	Efficiency of control devices (%)	Operational checks	Potential contaminant	Flow rate (ft^3/sec)	Concentration (μCi/ml X 10^{-12}) and percent of MPC[a]		Emission rate, (μCi/sec)	Release height (m)
						Avg	Max		
219	Packed-bed wet scrubber	Unknown	Fan, spray and motor checked daily; samples analyzed daily	High-enriched insoluble uranium	91.7	1.31[b] 2.2	70.4	2.84 X 10^{-7}	12
				High-enriched soluble uranium		55.34 79.0	99.58	1.20 X 10^{-5}	
				Nitric acid					
				Hydrofluoric acid					
				Tributyl phosphate					
253	2 HEPA filters in series	99.999	Samples analyzed daily	High-enriched uranium	20.0	0.99[c] 17.0	26.00	4.67 X 10^{-8}	6.1

[a]MPC$_a$ for controlled areas. Most restrictive value with respect to the radionuclide and solubility has been used.
[b]Measurements made from 1973 to February 1975.
[c]Measurements made from 1972 to February 1975.
Source: EIR, Table 2-2, p. 2-12.

3.3.3 Liquid effluents

The bulk of aqueous process wastes, including laundry wastes, are disposed to the waste treatment system. This volume averages less than 50,000 gal (190,000 liters) per day.

Former waste treatment consisted of pH adjustment and settling in unlined ponds. Discharge was to Banner Spring Branch, which flows into Martin Creek and then to the Nolichucky River. When this treatment method was used, the effluent met existing and proposed water quality criteria with respect to radiological contaminants. It did not, however, meet future water quality restrictions with respect to ammonia, nitrates, fluorides, and biological oxygen demand (BOD). For this reason, a wastewater treatment facility (Building 330) was recently put into service, and the use of the ponds was discontinued. Discharge to Banner Spring Branch will continue.

The applicant plans to maintain the ponds by keeping sediment wet and replacing water lost through evaporation or seepage in order to prevent the spread of radioactivity by blowing dust. Monitoring for radioactivity (and occasional chemical parameters) will be continued downstream in Banner Spring Branch and Martin Creek. The applicant expects this monitoring to detect any seepage due to the general groundwater structure in the area, based on local geological information.[2] The analytical data that were obtained since pond use was discontinued are insufficient to be indicative of normal operating levels. No plans presently exist for disposal of active sediment.

The general process of the wastewater treatment facility involves adjustment of the pH of wastewater on a batch basis with caustic soda (sodium hydroxide) precipitation and removal of fluoride ions through the addition of lime slurry [$Ca(OH)_2$]. Normally, dissolved ammonia is subsequently removed by air stripping when the ambient air temperature is above ~40°F, and by the addition of elemental chlorine for breakpoint chlorination when the ambient temperature is below ~40°F and when air removal of ammonia is inefficient. After the removal of ammonia, the pH is adjusted to discharge values (6 to 9), and the water is discharged to the Nolichucky River. The process flow diagram for this facility is shown in Fig. 3.7.

During the operation of the wastewater treatment facility, each batch is analyzed for gross alpha and gross beta radioactivity prior to discharge. A monthly composite sample is analyzed for isotopes of uranium. The chemical parameters prescribed in the NPDES and State of Tennessee permits are also analyzed at least on the frequency specified in the permits. During startup of the facility, more frequent sampling and analyses have been performed. Samples of the treated wastewater have been collected from the final neutralization tank prior to discharge. Water quality parameters for this discharge are given in Table 3.6.

Sanitary wastes are generated from showers and restrooms throughout the facility. These wastes are collected in one main pipe for discharge to the Erwin municipal sewage treatment facility. Daily samples are analyzed for alpha contamination to ensure that contaminated wastes are being properly disposed of by all personnel.

Analyses of 125 sewage samples collected between December 1974 and May 1975 showed an average of 2.4×10^{-6} μCi/ml total alpha contamination (8% of MPC_w based on uranium for unrestricted area). This value should be viewed within the perspective of the counting error which approached ±100% of the measured value for these samples.

Stormwater runoff is controlled by two drainage channels, as shown in Fig. 3.6. The sump ditch collects all storm drains and empties directly into Martin Creek. The discharge is allowed under the NPDES permit issued by EPA.

Because there is a possibility for LEU contamination outside the buildings during transport of contaminated material to burial, through dispersion by people, and through fallout from gaseous effluents, runoff is sampled. Samples are collected at the northwest corner of the plant perimeter. An average total alpha contamination of samples collected between December 1973 and March 1975 was 2.78×10^{-6} μCi/ml (9% of MPC_w for uranium). The range was 1.14×10^{-6} to 6.01×10^{-6}. Because other nuclides, such as plutonium and thorium, could also be contaminated, the staff recommends that the applicant analyze on a quarterly basis the uranium, plutonium, and thorium on composite samples collected weekly from the sewage and stormwater runoff.

3.3.4 Solid waste retention: burial grounds

All uranium-contaminated solid wastes are either buried on site, if the total annual quantity is less than 120 μCi of uranium plus thorium, or else they are packaged for offsite burial at a licensed waste disposal site. No plutonium wastes were ever buried on site.

The location of the burial ground is shown in Fig. 2.6. Burial operations use two types of pits. Small pits contain packaged, LEU- or thorium-contaminated wastes; larger pits contain unpackaged, clean or very LEU- or thorium-contaminated wastes. Wastes in the small pits are packaged in plastic-lined buckets or plastic bottles. The quantity of uranium in the pits (used before the regulation changed in May 1970) was limited to 50 mCi of uranium-235 per pit. The estimated quantities of uranium in each pit are shown in Table 3.7. Pits used after May 1970 contain 10 μCi or less of uranium-235 per pit.

Waste in the large pits consists mainly of shipping containers which are free of contamination, ash from the clean incinerator, very LEU-contaminated laboratory waste, and other miscellaneous items. Covered burial sites are marked on all four corners with 6-in.-square, reinforced concrete posts with metal end plates stamped for identification.

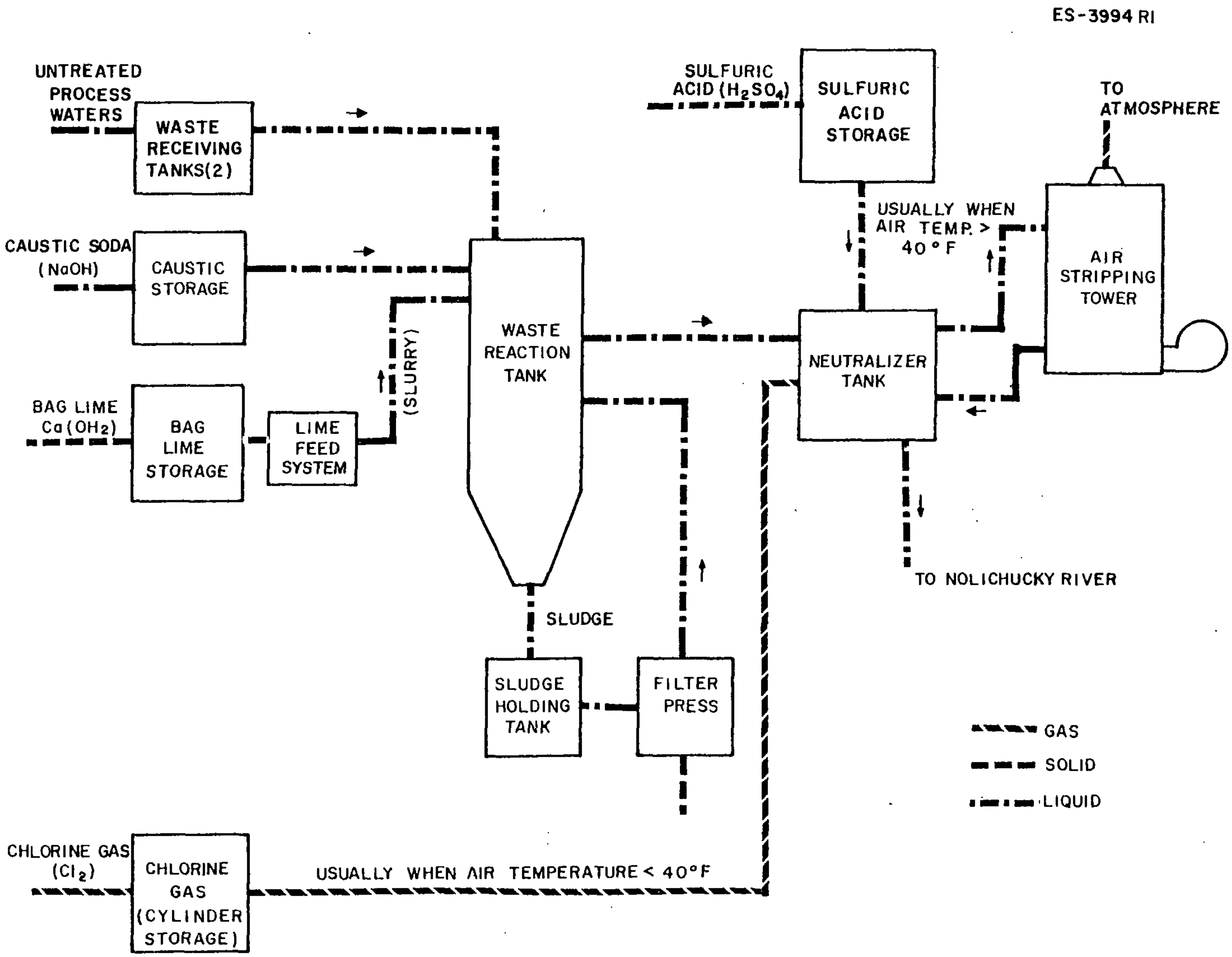

Fig. 3.7. Wastewater treatment, Building 330.

Table 3.6. Chemical water quality

Constituent	Maximum average concentration (mg/liter)	Maximum daily quantity (lb/day)	Maximum daily quantity (kg/day)	Anticipated average effluent concentration after treatment (mg/liter)
Suspended solids	40	36.7	16.6	≤40.0
Settleable solids	0.5			0.1
Biological oxygen demand (BOD)	30	27	12	≤30.0
Ammonia (as nitrogen)	20	18	8.2	≤20.0
Nitrate (as nitrogen)		656	298	≤1570.0
Fluoride	20	18	8.2	<5.0
Mercury	0.005			0.005
pH	6.0 to 9.0			6.0 to 9.0

Table 3.7. Estimated quantities of uranium in burial pits

Pit designation	Estimated total quantity of uranium and thorium (mCi)
66–1	65.4
67–1	68.44
68–1	35.44
69–1	0
69–2	0
69–3	30.0
69–4	98.0
69–5	0.04
69–6	2.5
[a]	
69–12	0.2
70–1	3.8
70–2	2.7
70–3	48.7
70–4	49.9
70–5	49.7
70–6	48.6
70–7	53.3
70–8	49.3
70–9	2.6×10^{-3}
70–10	76.3
70–11	87.0
71 & 72–1	0.3
73–1	1.7×10^{-3}[b]

[a]Pits 69–7 through 69–11 were not used in 1969 and were later renumbered to reflect the year of their use.

[b]To May 1975; pit still in use.

REFERENCES FOR SECTION 3

1. U.S. Environmental Protection Agency, *Compilation of Air Pollution Emission Factors*, PG209559, Feb. 1972.

2. Nuclear Fuel Services, Inc., *Environmental Information Report*, Erwin, Tenn., Jan. 1976.

4. ENVIRONMENTAL IMPACTS OF FACILITY OPERATIONS

4.1 RADIOLOGICAL IMPACTS

The radiological impacts of the NFS Erwin facility were assessed by calculating the maximum annual dose t (an individual living at the nearest residence. Except where specified, the term "dose" as referred to in this report is actually a 50-year dose commitment; that is, the total dose to the reference organ which will accrue from one year of intake of radionuclides during the remaining lifetime (50 years) of the individual. It is conservatively assumed that the individual spends all of his time at the reference location, and that all of the food consumed is produced at the site. The dose reflects the release of radionuclides from the combined stack effluents. Where possible, site-specific data are used for calculating dose.

4.1.1 Terrestrial dose measurements

Emissions from building exhaust stacks are monitored continuously, and the alpha activity is determined. Approximately 9.9×10^{-4} μCi/sec are released from all sources.[1] No isotopic analysis of the gaseous effluents is made. However, the average concentrations have been estimated based on known feed concentration and uranium enrichment. The composition of radionuclides presented in airborne effluents is shown as follows:[1]

Uranium (U), enriched	= 0.997899
Plutonium (Pu)	= 0.000198
Thorium (Th)	= 0.001914

It is assumed that all plutonium–uranium mixtures are plutonium and all thorium–uranium mixtures are thorium. It is conservatively assumed that 100% of the uranium present is uranium-234, all plutonium is plutonium-239, and all thorium is thorium-230. The annual release rate for these radionuclides thus calculated is shown in Table 4.1. The major routine releases accounting for more than 95% of the emissions of radioactive materials originate from buildings 111 and 303 (see Tables 3.3 and 3.4), which are approximately 350 m from the nearest residence.

Table 4.1. Annual release of radionuclides in the stack effluents of the Nuclear Fuel Services plant at Erwin

Radionuclide	Annual release[a] Ci/year
U-234	3.12×10^{-2}
Pu-239	6.18×10^{-6}
Th-230	5.97×10^{-5}

[a]Based on total release of 9.90×10^{-4} μCi/sec from all stack effluents.

After airborne particles reach the ground by deposition and washout, they may again enter the air by resuspension processes and be inhaled. There is currently no general model that can predict the levels of responded-air activity with regard to the geometrical configuration of the land surface; the particle characteristics of the deposited radioactive material; and the parameters of the host soil, vegetation cover, and meteorological conditions. These highly variable factors and others related to land use, such as disturbance of soil surfaces by human activities, must be considered in a precise estimate of resuspended radioactivity. Based on recent measurements,[2] a resuspension factor of 1×10^{-5} m^{-1} was selected for computational use. For estimating the intake via inhaling of resuspended radionuclides, the expression is

$$\text{Ci per year intake: Ci per } m^2 \times 10^{-5}/m \times 8395 m^3 \text{ of inhaled air per year.}$$

The dose from the resuspension of radionuclide particulates was based on a calculated ground deposition for the radionuclides from airborne emissions. A deposition velocity of 0.01 m/sec was used in calculating the soil concentration of deposited particulates.

4.1.1.1 Individual dose

The maximum annual doses to the individual living at the nearest residence to the site are shown in Table 4.2. The contributions of radionuclides released to the atmosphere in plant emissions are shown in Table 4.3.

Table 4.2. Maximum annual dose[a] to the individual living at the nearest residence[b] to the Nuclear Fuel Services, Inc., Erwin plant

Pathway	Dose rate (millirems)			
	Total body	Bone	Lungs	Kidneys
Inhalation (direct)[c]	6.7E–2[d]	1.3E0	2.3E0[e]	3.0E–1
Ingestion[f]	1.3E–1	2.1E0	1.3E–1	4.9E–1
Submersion in air[c]	1.2E–8	1.4E–8	5.1E–9	4.0E–9
Ground surface[g]	4.2E–2	4.9E–2	1.7E–2	1.4E–2
Resuspension (inhalation)[h]	4.8E–7	8.0E–6	1.9E–5	1.9E–6
Total	2.4E–1	3.4E0	2.4E0	8.0E–1

[a] Fifty-year dose commitment from one year of intake of radionuclides.
[b] The nearest residence is 350 m from building effluents, ESE of plant site.
[c] Air-inhalation rate of 23 m^3/day.
[d] To be read as 6.7×10^{-2}.
[e] The dose conversion factor used is essentially from the ICRP-II model. (The Task Group Lung Model may result in a higher dose, depending on the particle sizes and translocation classes of the material released, however even under conservative assumptions, the Task Group Lung Model will result in a lung dose rate less than 25 millirems/year).
[f] All food is conservatively assumed to be produced and consumed at the reference location. Daily intakes are 1 liter of milk, 0.25 kg of vegetables, and 0.3 kg of beef.
[g] Exposure for 100% of the time; no shielding.
[h] Based on a resuspension factor of 10^{-5}; air-inhalation rate of 23 m^3/day.

Table 4.3. Contribution of radionuclides to the maximum annual dose[a] to the individual living at the nearest residence[b] to the Nuclear Fuel Services, Inc., Erwin plant site

Radionuclide	Dose rate (millirems)			
	Total body	Bone	Lungs	Kidneys
U-234	2.3E–1[c]	2.9E0	2.3E0	7.0E–1
Pu-239	1.3E–3	5.3E–2	1.4E–3	5.5E–3
Th-230	1.2E–2	4.2E–1	5.1E–2	9.0E–2
Total	2.4E–1	3.4E0	2.4E0	8.0E–1

[a] Fifty-year dose commitment for radionuclide intake over a one-year period.
[b] Nearest residence is 350 m from the building effluents, ESE of the site.
[c] To be read as 2.3×10^{-1}.

The maximum annual total-body dose was 0.24 millirem. About 94% of the dose was due to uranium-234 via the ingestion (54%) and inhalation (29%) pathways.

The highest annual doses to the organs were 3.4 millirems to the bone, 2.4 millirems to the lungs, and 0.8 millirem to the kidneys. About 87% of the bone and kidney doses was due to thorium-230. Almost 98% of the lung dose was due to uranium-234.

4.1.1.2 Population dose

The doses (50-year dose commitment) from the airborne effluents to the population living within a 50-mile radius of the plant are shown in Table 4.4. The total-body population dose is 0.3 man-rem and may be compared to the population dose of 8.04×10^4 man-rems from the natural background in the area.[4] The highest population organ dose of 4.4 man-rems is to the bone.

4.1.1.3 Long-term assessments of routine airborne releases

Estimates[5] have been made of future potential radiation doses to individuals and populations after the NFS Erwin plant has ceased to operate using the assumption that the plant has operated 30 years at the 1975 rate of plant emissions and that the long-lived radionuclides are deposited on the land during this operating period. Conservative assumptions[5] are used in areas where deficiences of knowledge exist;[6] thus, the estimates are well above the probable effects. The amounts of long-lived radionuclides released during the 30-year lifetime of the plant are presented in Table 4.5. It has been assumed that the solid radionuclides are deposited evenly over 2.03×10^{10} m^2 within the 50-mile radius of the plant. The pathways of exposure considered are inhalation of resuspended radionuclides, ingestion, and exposure to contaminated ground.

The postoperational radiation dose to an individual residing within the uniformly contaminated area is estimated for the total body and for organs that are known to accumulate the long-lived radionuclides. Population doses are expressed in man-rems for the 1970 population within a 50-mile radius of the plant. No assumption for population changes are included. The doses are expressed in 50-year dose commitments; however, in assessing a situation where people are continually exposed over a long period of time and radionuclides have reached steady-state conditions, dose commitments approximate annual doses.

Table 4.4. Annual doses to the population from airborne effluents of the NFS Erwin plant[a,b]

Total body or organ	Population dose (man-rems)
Total body	3.0 E−1[c]
Bone	4.4 E0
Kidney	1.0 E0
Lung	3.0 E0

[a] Fifty-year dose commitment from exposure to one year of plant operation.

[b] Entire 1970 population within 50-mile radius of the plant facilities (8.04×10^5 persons); daily intakes are 300 ml of milk, 0.25 kg of vegetables, and 0.3 kg of beef. All food is produced and consumed at the reference locations.

[c] To be read as 3.0×10^{-1}.

Table 4.5. Long-term effects of long-lived radionuclides released during the lifetime of the NFS Erwin plant[a]

Radionuclides	Total release[b] during the 30-year plant life (Ci)	Radioactivity concentration[c] (Ci per m^2)
U-234	9.36E−1[d]	4.61E−11
Pu-239	1.85E−4	5.84E−14
Th-230	1.79E−3	8.82E−14

[a] A 30-year operating lifetime is assumed.

[b] Based on 1975 release rates, these values derived by using the calculation that $2.03 \times 10^{10}/m^2$ equals the assumed deposition rate.

[c] Deposition is assumed to occur uniformly out to a distance of 50 miles and to be dispersed over an area of $2.03 \times 10^{10}/m^2$.

[d] To be read as 9.36×10^{-1}.

Long-term individual total-body and organ doses

The annual average dose to individuals living within the 50-mile radius and the contributing radionuclides are shown in Table 4.6. The total-body dose of 2.5×10^{-5} millirems/year is due almost entirely to uranium-234. The highest organ dose, 8.1×10^{-5} millirems/year, is to the bone and, as with the other organ doses, is essentially all due to uranium-234. While the doses will vary considerably as a function of distance from the emissions source, calculations show that the doses for the actinides at 1 mile will be about 70 times the dose at the 50-mile distance. Thus, the highest exposure relatively close to the plant would be quite small.

Table 4.6. Maximum annual dose[a] to the population from radionuclides[b] after the NSF plant closes[c] until significant decay of all radionuclides occurs

Radionuclide	Dose (millirems per year)			
	Total body	Bone	Lungs	Kidneys
U-235	2.5E−5[d]	7.3E−5	3.3E−5	1.8E−5
Pu-239	8.6E−8	3.2E−6	8.9E−8	3.7E−7
Th-230	1.7E−7	4.3E−6	5.2E−7	1.8E−7
Total	2.5E−5	8.1E−5	3.4E−5	1.9E−5

[a] Fifty-year dose commitment from one year of intake.

[b] Assumes all radionuclides remain available for exposure to individual.

[c] A 30-year lifetime is assumed for the plant.

[d] To be read as 2.5×10^{-5}.

Long-term population doses

The annual population doses to the total body and organs (given in man-rems per 8.04×10^5 persons) are shown in Table 4.7. The total-body dose to the population of 2.0×10^{-2} man-rems is only 2.5×10^{-5}% of the similar population dose of 8.04×10^4 man-rems from natural background.[5] All population organ doses are well below 1 man-rem per year.

Table 4.7. Annual dose to the population[a] from radionuclides[b] released in airborne effluents after NSF plant closes[c] until significant decay of all radionuclides occurs

Radionuclide	Dose (man-rems per 8.04×10^5 persons)			
	Total body	Bone	Lungs	kidneys
U-234	2.0E−2[d]	5.9E−2	2.7E−2	1.4E−2
Pu-239	6.9E−5	2.6E−3	7.2E−5	3.0E−4
Th-230	1.4E−4	3.5E−3	4.2E−4	1.4E−4
Total	2.0E−2	6.5E−2	2.7E−2	1.4E−2

[a] Based on 1970 population; population growth not considered in calculations.
[b] All radionuclides are assumed to remain available for exposure to the population.
[c] A plant operating lifetime of 30 years is assumed.
[d] To be read as 2.0×10^{-2}.

4.1.2 Impacts from liquid effluents

The average concentrations of radionuclides at the point of discharge and after full mixing in the Nolichucky River are shown in Table 4.8. (Full mixing is expected to occur at a distance of about 10 times the width of the river; that is, 2000 ft downstream from the point of discharge.) The estimated maximum doses to the individual from use of the river at the point of full mixing are shown in Table 4.9.

Table 4.8. Average concentration of radionuclides at the point of discharge into the Nolichucky River and after dilution by the river

Radionuclide[a]	Average concentration (µCi/ml)			
	At discharge	Maximum permissible concentration (%)	In river after mixing	Maximum permissible concentration (%)
U-234–235	1×10^{-6}	3.7	2×10^{-11}	7×10^{-5}
U-238	5×10^{-8}	0.1	1×10^{-12}	2×10^{-6}
Th-230	3×10^{-9}	0.1	6×10^{-14}	3×10^{-6}
Pu-239	2×10^{-10}	4×10^{-3}	4×10^{-15}	8.0×10^{-8}

[a] Based on estimated average daily discharges as diluted by average daily flow of the river.

The doses resulting from these liquid effluents are quite low, all well below 1 millirem per year. The highest dose is to the bone and is only 0.009 millirem per year. Uranium-234 (95%) and uranium-238 (4%) contributed most of the dose (Table 4.10) via the pathway of drinking water.

4.2 NONRADIOLOGICAL IMPACTS

4.2.1 Terrestrial impacts

4.2.1.1 Construction

No major expansion of existing facilities is planned for the NFS plant. A new wastewater treatment facility, however, was recently designed and constructed in cooperation with the Tennessee Water Quality Control Division and the EPA to improve the quality of wastewater discharged to Nolichucky River. The construction involved approximately 33,500 ft^2 of unused site land within the security fence, and temporary disturbance of approximately 1,500 linear ft of industrial land to install a 6-in. pipeline to the Nolichucky River.[6] Because the construction effects were short-term and involved a previously committed site, the construction of the new wastewater treatment facility does not constitute a significant adverse impact.

Table 4.9. Estimated maximum annual dose from liquid effluents of the Erwin Nuclear Fuel Services plant based on water sampling data from the Nolichucky River[a]

Pathway	Dose[b] (millirems)		
	Total body	Bone	Kidney
Submersion in water[c]	1.0E−9[d]	1.2E−9	3.5E−10
Consumption of fish[e]	7.9E−5	1.3E−3	3.1E−4
Consumption of drinking water[f]	4.7E−4	7.7E−3	1.8E−3
Total	5.5E−4	9.0E−3	2.1E−3

[a]Based on estimated concentration of radionuclides in the Nolichucky River at the point of effluent discharge after full mixing occurs.
[b]Fifty-year dose commitment from one year's intake of radionuclides.
[c]Swimming in water 1% of year.
[d]Read as 1.0×10^{-9}.
[e]Daily intake of 20 g of fish.
[f]Daily intake of 1.2 liters of water.

Table 4.10. Contribution of major radionuclides to individual dose from liquid effluents in the Nolichucky River

Radionuclide	Dose (%)		
	Total body	Bone	Kidney
U-234	95.5	94.4	94.8
U-238	4.2	4.3	4.2
Pu-239	<0.1	0.1	<0.1
Th-230	0.4	0.9	1.0

4.2.1.2 Atmospheric effluents and resultant doses to biota

The primary potential impact of the NFS plant operation on terrestrial biotic communities will result from the release of gaseous effluents. The nonradiological gaseous effluents released from the NFS plant are presented in Table 4.11. The effluent concentrations are listed as averages, but in many instances represent only a single measurement. Maximum values were not reported, and according to the applicant the original records of the data are no longer available.[7] The nonradiological chemical effluents were measured in 1971 and 1972, but no measurements were made for the period from 1973 to the present.[7,8]

Fluorides and ammonia are the primary atmospheric chemicals discharged. Only minor quantities of nitrogen oxides (NO_x) are discharged. Assuming all processes are operating at the same time, the maximum discharge rates for these effluents are as follows: fluorides, 3668 μg/sec; ammonia, 1.841 g/sec; NO_x, 0.519 g/sec. The staff has calculated ground-level concentrations for these effluents at various critical distances from the sources. All calculations are based on annual average χ/Q values assuming a Pasquill class D (neutral) stability (see Table 2.8).

The maximum annual ground-level air concentration of fluorides downwind of the prevailing wind direction (NNE) at the plant boundary (200 m) is 0.035 μg/m^3. Comparable figures for ammonia concentrations (275 m from the source) and nitrogen oxide concentrations (300 m from the source) are 21.54 μg/m^3 and 6.02 μg/m^3 respectively. Maximum annual ground-level air concentrations for these effluents at the nearest residence (350 m ESE) are as follows: fluorides, 0.018 μg/m^3; ammonia, 9.13 μg/m^3, nitrogen oxides 2.57 μg/m^3. Maximum annual ground-level air concentration of fluorides at the nearest forage crop (400 m E) is 0.016 μg/m^3.

Table 4.11. Nonradiological gaseous effluents from the Nuclear Fuel Services, Inc. Erwin plant[a,b]

Process	Building number	Release stack point	Release rate (ft^3/sec)	Release height (m)	Average concentration (μg/liter)		
					Fluorides	Ammonia	Nitrogen oxides
Low-enriched uranium oxide facility	301	159[c]	53.3	15.2	0.78	3.81	
		197	15.0	15.2	0.52	12.90	
		198	9.7	15.2	3.69	3.47	
		292	36.7	2.4		1.82	
Finished product fabrication	302/303	207[d]	148.0	15.8	<0.3		
High-enriched uranium scrap recovery	233	219[e]	91.7	12.0			20.0
Wastewater treatment	330	Unnumbered	660.0	15.0		97.74	

[a]Does not include gaseous effluents from auxiliary facilities such as incinerator for office and lunchroom wastes, incinerator for contaminated wastes, emergency generators, and three boilers for building and process heat.

[b]Based on data presented in Tables 2-1 through 2-9 of the EIR.

[c]Particulate = 0.84 μg/liter.

[d]Hydrogen chloride = <5.0 μg/liter; chlorine = <0.09 μg/liter; chlorine dioxide = <0.09 μg/liter.

[e]Tributyl phosphate = trace only.

In addition to the effluents generated by the processing facilities, relatively small quantities of particulates, sulfur oxides, and nitrogen oxides, carbon monoxide, hydrocarbons, and organics are released by the auxiliary facilities.

4.2.1.3 Impacts on plants

Of the several oxides of nitrogen released to the atmosphere, the most toxic forms to vegetation are nitric oxide (NO) and nitrogen dioxide (NO_2).[9] Nitric oxide, although absorbed slowly by plants, is converted in the atmosphere to other forms, including NO_2 which may then be taken up more rapidly.[9] Both Federal[10] and State of Tennessee[11] air quality standards for NO_2 are set at 100 μg/m^3 on an annual basis. This concentration of NO_2 is expected to induce small chronic reduction in growth and production of very susceptible plants.[9] The expected annual concentration of nitrogen oxides at the plant boundary in the most prevalent downwind direction is only 6.02 μg/m^3 and at the nearest residence is even less, only 2.57 μg/m^3. Consequently, the staff concludes that the release of nitrogen oxides at the NFS plant will have no adverse impact on the vegetation in the vicinity.

Ammonia is a natural component of the atmosphere and is generally regarded as a nutrient for plant growth. The background concentration of ammonium compounds in the lower troposphere is about 6 μg/m^3 in the mid-latitudes and increases to 140 μg/m^3 near the equator.[12] Experimental evidence indicates that growing plants may be a natural sink for atmospheric ammonia; at concentrations of approximately 700 μg/m^3, 43% is absorbed by plants.[13] The lowest atmospheric concentration of ammonia known to affect plants is 1000 μg/m^3, which caused a 10% decrease in photosynthetic rates in several species.[14] The maximum annual concentration of ammonia to be expected at the plant boundary in the most prevalent downwind direction is 21.5 μg/m^3, and only 9.1 μg/m^3 at the nearest residence. The staff concludes that no adverse impacts will occur to the vegetation from the release of ammonia by the NFS plant.

The release of atmospheric fluorides from the NFS plant is of major concern because fluorides absorbed by leaves can be phytotoxic, and plants are damaged at lower concentrations of fluorides than they are by most other pollutants;[15] and the accumulation of relatively high fluoride concentrations by forage crops may be potentially hazardous to livestock.[16] Most experimental exposures of plants to hydrogen fluoride have been continuous exposures to relatively constant concentrations. Under these conditions, the accumulation of fluoride by foliage is related to both the concentration and the duration of exposure.[17] The maximum ground-level concentration at the nearest forage crop (corn at 400 m) is estimated to be 0.016 μg/m^3. This concentration is nearly 2 orders of magnitude less than that which is required to cause damage to the most susceptible species such as gladiolus, peach, and pepper; no visible damage should occur to corn.[17]

The distance between the low-enriched uranium oxide facility to the site boundary in the direction of the prevailing wind direction (NNE) is approximately 200 m (Fig. 3.1). The expected annual ground concentration of fluorides at this location is 0.035 μg/m^3. Annual fluoride concentration at the nearest residence is expected to be 0.018 μg/m^3. The primary ambient air quality standard for fluorides in the State of Washington (which has the most restrictive state standards) is 0.5 μg/m^3 on an annual basis.[18] Tennessee does not have an annual ambient air quality standard for fluorides. However, the standard is set at 1.2 μg/m^3 for a 30-day averaging interval.[11] Presently, the vegetation which exists at the plant boundary and immediate vicinity should not be adversely affected by the release of atmospheric fluorides from the NFS plant.

The concentration of fluorides in the soil west of Building 131 (the area most frequently downwind of the low-enriched uranium oxide facility) was 28.6 μg/g of dry soil as opposed to a baseline concentration of 0.09 μg/g. Soil samples at all other locations near the plant perimeter (Sect. 5.2.4.1) had fluoride concentrations ≤0.13 μg/g dry soil. Even though some accumulation of fluorides was found in the soil immediately downwind of the low-enriched uranium oxide facility, the concentration was still well within the range of naturally occurring fluoride in the soil.[19] The fluoride concentration in vegetation at the baseline site was <0.01 μg/g of dry weight as compared to ≤0.02 μg/g at all other locations.

4.2.1.4 Impacts on animals (including man)

No adverse effect of nitrogen oxides on animals or humans is expected to occur at the concentrations calculated for the NFS plant boundary (6.02 μg/m^3) and for the nearest residence (2.57 μg/m^3). Both Federal[10] and State of Tennessee[11] air quality standards for NO_2 are set at 100 μg/m^3. A summary of studies of toxicological effects in animals due to NO_2 exposure indicates that concentrations several orders of magnitude higher than those at the plant boundary are needed to produce adverse effects.[20]

The concentrations of ammonia found at the plant boundary (21.5 μg/m^3) and at the nearest residence (9.1 μg/m^3) are also expected to have no effect on the animals or humans in the vicinity. The lowest ammonia concentration found to affect experimental animals was 2,000 μg/m^3, and concentrations 2 orders of magnitude greater are generally required to produce measurable damage.[12] Ammonia concentrations of 280,000 to 490,000 μg/m^3 are needed to produce eye, nose, and throat irritations in humans.[12]

The threshold limiting value[21] for industrial exposure to airborne hydrogen fluoride is 2500 μg/m^3. The annual average concentration at the closest plant boundary in the prevalent wind direction (assuming D stability) is only 0.035 μg/m^3, and even less at the nearest residence, 0.018 μg/m^3. Tennessee's primary air quality standard[11] for fluorides over a 30-day interval is nearly two orders of magnitude higher, 1.2 μg/m^3. Direct inhalation of atmospheric fluorides from the NFS plant should have no adverse effects on animals or man. Atmospheric fluorides can have a significant indirect effect on grazing animals, however, if these fluorides accumulate sufficiently in the forage. Among the grazing animals that have been studied, cattle are the most susceptible to fluorosis (fluoride injury) from consumption of forage with a high fluoride content. Recommended safe levels of fluoride in the total ration of dairy cows ranges from 30 to 50 ppm, and 40 to 50 ppm for beef cattle.[19] Exposing alfalfa to a fluoride concentration of 0.3 μg/m^3 for a period of two months will produce plant fluoride concentrations of 40 ppm.[19] Assuming that corn has a similar coefficient of accumulation to alfalfa, a six-month exposure is expected to produce a plant fluoride concentration of only 7 ppm in the nearest forage crop. This is a conservative estimate because it ignores the decrease in the apparent accumulation coefficient with time and the decrease in fluoride content due to weathering losses. From this analysis, the staff concludes that no significant impact on livestock is expected to occur from the consumption of vegetation that has been exposed to atmospheric fluorides from the NFS plant. Dietary intake of fluorides by humans is not a problem because the consumption of contaminated plant and/or animal food in the vicinity is not likely to constitute large enough portions to cause adverse effects.[19]

4.2.1.5 Summary of impacts on terrestrial biota

No deleterious effects of nitrogen oxides or ammonia released from the NFS plant have been identified for either plants or animals. Although it is not known conclusively, it is unlikely that these effluents will have an adverse effect on threatened and endangered species which could potentially occur in the vicinity. Fluorides may affect the vegetation only under very unusual meteorological circumstances, and then affect only the most sensitive species. Therefore, it is unlikely for any threatened and endangered plant species which may occur in the area to be adversely affected. None of the threatened and endangered animal species which may occur in the vicinity are grazers, and should not be adversely affected by the small amounts of fluorides released by the NFS plant. No other significant impact of the NFS plant operation upon agricultural or natural biota is anticipated.

4.2.2 Aquatic impacts

4.2.2.1 Compliance with Federal and State water quality regulations

The applicant has been issued a series of wastewater discharge permits for nonradiological effluents, including an NPDES permit and four temporary permits from the State Department of Public Health's Division of Water Quality Control. The requirements of each are set forth as follows:

1. The NPDES Permit TN-0002038 issued by EPA specifies effluent limitations in wastewater discharged to both Banner Spring Branch and the Nolichucky River. The permit was issued December 31, 1976, and will remain effective until June 28, 1979, allowing discharges to Banner Spring Branch until completion and operation of an approved wastewater treatment facility in order to meet the effluent limitations and conditions specified. Construction was required to have begun December 31, 1975. The permit further requires that a construction progress report was to be made by March 31, 1976, and that the facility be completed and in operation by December 31, 1976. On November 7, 1975, the applicant was issued a notice of violation by EPA for failure to obtain from EPA a final plan approval for the wastewater treatment facility by October 31, 1975. At the time of an NRC health and safety inspection on February 1-2, 1976, an applicant representative stated that NFS continued to be in violation of the permit since such approval had not yet been granted as required by the permit. On March 31, 1976, a formal request was made to EPA for a change of the December 31, 1976 deadline to April 30, 1977 for beginning of operation of the wastewater treatment facility. The EPA subsequently extended the operation date to June 30, 1977. According to the most recent NPDES Discharge Monitoring Report (March 1977), NFS Erwin is not in compliance with respect to biological oxygen demand (BOD), total dissolved solids (TDS), ammonia (as N), nitrates (as N), fluoride, mercury, and settleable solids (Table 2.10).

2. Tennessee Permit 75-167 was issued March 13, 1975, and expired March 13, 1977. The permit allowed the discharge to Banner Spring Branch of uncontaminated cooling water only. The quality of the cooling water discharged was required to be essentially the same as the quality of water prior to its use, except in regard to temperature. The permit also restricted temperature change to 3°C in the receiving water relative to an upstream control point. The maximum rate of temperature change in the receiving stream was limited to $2°C/hr^{-1}$, and the stream temperature could not exceed 30.5°C. The applicant does not appear to have been in violation of the conditions of this permit (Sect. 2.7.2.2). This permit has not been renewed, although it is the responsibility of the State and not NFS Erwin to initiate renewal.

3. Temporary Permit 75-28 was also issued by the State on March 13, 1975, and also expired on December 31, 1976. This permit allowed the discharge of treated industrial and other wastes into Banner Spring Branch. However, it placed no discharge restrictions nor effluent limitations on such wastes, specifying only that the applicant's existing wastewater treatment facilities should be operated at maximum efficiency. The permit also required that the applicant construct and operate a State-approved wastewater treatment facility to assure that all State water quality criteria and conditions be met. Prior to April 1977, the wastewater treatment system consisted of wastewater neutralizers and settling ponds. On January 23, 1976, the State approved a revision to the permit which required the applicant to initiate construction on or prior to March 31, 1976, and to complete and operate the approved treatment facility on or prior to April 30, 1977. The original permit requirements assigned a completion date of December 31, 1976.

4. Temporary Permit 76-89 was issued by the State on October 26, 1976, with an expiration date of January 1, 1978. This permit incorporated two revisions of Temporary Permit 75-89 which it replaced: first, it extended the date for completion and operation of the new wastewater treatment facility until June 30, 1977; second, it deleted discharge limitations pertaining to Banner Spring Branch because NFS Erwin had selected the permanent option of discharging to the Nolichucky River following completion of the new waste treatment facility. Discharge to Banner Spring Branch or the Nolichucky River was optional in Permit 75-28, and separate criteria applied in each case. However, the limitations for discharge to the Nolichucky River specified in Temporary Permit 76-89 were the same as those specified in Temporary Permit 75-28.

   Although a new temporary permit has been issued, NFS Erwin is not in compliance with the guidelines of the previous permit (76-89). Settleable solids are twice the maximum concentration allowable (i.e., 1.0 mg/liter vs 0.5 mg/liter). Consequently, the Water Quality Control Division of the State Department of Public Health is currently issuing a new temporary permit which will allow settleable solids to remain at their present concentration until such time as the more stringent limit can be met. The new temporary permit also outlines a monitoring program for investigating potential past contamination of underlying groundwater. Because a new law that became effective June 28, 1977, abolishes temporary permits and requires that State permits resemble the NPDES permit in being permanent and in providing a schedule for coming into compliance with various requirements, it is not clear how this latest temporary permit is to be negotiated.

4.2.2.2 Impacts of aquatic effluents on surface water

There are no known historical ecological impacts to Banner Spring Branch, Martin Creek, or the Nolichucky River resulting from routine discharges or from violations of the various wastewater discharge permits discussed in Sect. 4.2.2.1. The recent ecological survey of Banner Spring Branch and of Martin Creek conducted by biologists from ETSU (Sects. 2.8.2.1 and 2.8.2.2) did not reveal any impacts attributable to NFS Erwin operations or other sources.

Banner Spring Branch and Martin Creek

Because all wastewater is now discharged directly to the Nolichucky River, the only potential for future impact to Banner Spring Branch and to Martin Creek is from thermal loading due to the release of uncontaminated cooling water to Banner Spring Branch (Sect. 4.2.2.1). The most recent NPDES Discharge Monitoring Report (March 1977) shows the water temperature of Banner Spring Branch to be within the established limits (Table 4.12). Given the background ecological conditions of Banner Spring Branch and Martin Creek (see Sect. 2.8), temperature increases allowed by the NPDES permit should not pose any threat of potential impact to either Banner Spring Branch or Martin Creek.

Table 4.12. NPDES Discharge Monitoring Report data[a] on cooling water discharged to Banner Spring Branch

	Temperature (°C)		
	Minimum	Average	Maximum
Reported	62	75	92
Permit condition	None	95	100

[a] Report issued in March 1977.

Nolichucky River

Table 4.13 shows the values for water quality parameters addressed in the NPDES permit; these values were obtained from two samples collected in 1977 at two locations downstream of the NFS Erwin wastewater discharge to the Nolichucky River. These values are compared with those obtained from a control sample collected upstream of the discharge. The table indicates that sufficient mixing and dilution have occurred by the time the wastewater has traveled 0.5 mile downstream to return the concentrations to background levels, except for nitrate (as N) which is approximately double the upstream concentration. However, compared with the upstream concentration, this increased concentration may not be a result of NFS Erwin discharge.

Table 4.14 presents NPDES-regulated water quality values which have been calculated to theoretically occur in the Nolichucky River under conditions of low river flow and through use of maximum reported values for the water quality in the wastewater discharged to the Nolichucky. These values were calculated using the following formula:

$$C_c = \frac{cf + CF}{f + F} ,$$

where

C_c = the calculated concentration of the particular water quality parameter in the Nolichucky River;

c = the maximum concentration of the same water quality parameter in the wastewater discharged to the Nolichucky River and reported in the March 1977 NPDES Discharge Monitoring Report (Table 4.15);

Table 4.13. Nolichucky River water quality data for 1977[a]

Constituent	Concentration		
	Upstream (0.5 mile)	Downstream (50 ft)	Downstream (0.5 mile)
Ammonia (as N) (mg/liter)	<0.1	0.45	0.2
Nitrate (as N) (mg/liter)	0.42	2.20	0.58
Fluoride (mg/liter)	0.26	0.97	0.24
BOD_5 (mg/liter)	4.0	6.0	2.0
Mercury (μg/liter)	7.0	5.0	7.0
Cadmium (μg/liter)	<0.2	<0.2	<0.2
Total suspended solids (mg/liter)	55	63	71[b]
Settleable solids (mg/liter)	<0.1	<0.1	<0.1
pH	6.55	6.30	6.50
Residual chlorine (mg/liter)	<0.1	<0.1	<0.1

[a]Single sample collected in April 1977, approximately 0.5 mile downstream from discharge point (30 min after discharge). The point of discharge is located on the east side of the Nolichucky River approximately 94.1 river miles from its confluence with the French Broad River. The 6-in. discharge pipe is located approximately 3 ft above the river surface at normal flow.

[b]The suspended solids concentration in the Nolichucky River is quite variable; most is due to mining operations upriver near Spruce Pine, North Carolina.

Table 4.14. Comparison of incremental and total concentrations of nonradiological water quality parameters contributed by wastewater discharges to the Nolichucky River to EPA water quality criteria for the protection of aquatic biota

Constituent (Biological oxygen demand)	Wastewater concentration	Nolichucky background concentration plus wastewater addition[a]	Incremental additional concentration to Nolichicky by wastewater	Water quality criteria for aquatic biota[b]
	(mg/liter)			
(BOD_5)	1014.54	4.05766	0.50766	No criterion
Total suspended solids	385.45	55.01885	0.01885	Not to reduce depth of compensation for photosynthesis by 10%
Ammonia (as N)	141.82	0.10809	0.00809	0.02 mg/liter (as un-ionized) NH_3)[c]
Nitrate (as N)	8383.64	0.89488	0.47488	Levels of nitrate nitrogen at or below 90 mg/liter have no effects on warm-water fish
Fluoride	36.36	0.26206	0.00206	No criterion. New York state limit is 1.5 mg/liter[d]
Mercury	0.016	0.00070	<0.00001	0.05 μg/liter (0.00005 mg/liter)
Settleable solids	1.10	0.10006[e]	0.00006	Same as total suspended solids
Chlorine residual	0.60	0.10003[e]	0.00003	10 μg/liter (0.01 mg/liter) for non-salmonid fishes and other aquatic organisms

[a]0.1 mg/liter used as the Nolichucky River background concentration.

[b]Water quality criteria are from *Quality Criteria for Water,* Environmental Protection Agency.

[c]A portion of the ammonia released will be ionized, reducing the concentration of un-ionized ammonia in the Nolichucky River to a lower concentration than shown in the table.

[d]Water supplies are commonly fluoridated to 1 mg/liter with no adverse effects on aquatic life from discharges.

[e]Calculations based on lowest flow calculated to last for 20 days for any 3-year period, and using the maximum concentration for each water quality parameter and the lowest wastewater flow reported on the March 1977 NPDES Permit Discharge Monitoring Report.

Table 4.15. Wastewater-quality data from the National Pollutant Discharge Elimination System Discharge Monitoring Report for March 1977

Parameter	Quantity (kg/day^{-1})[a]			Concentration		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Biological oxygen demand (BOD_5)						
Reported	3.6	17.5	27.9			
Permit condition	None	4.0	4.0			
Total suspended solids						
Reported	0.6	4.6	10.6			
Permit condition	None	17.0	17.0			
Ammonia (as N)						
Reported	0.8	1.8	3.9			
Permit condition	None	8.0	8.0			
Nitrates (as N)						
Reported	25.0	106.0	228.9			
Permit condition	None	297.5	297.5			
Fluoride						
Reported	0.2	0.7	1.0			
Permit condition	None	8.0	8.0			
Mercury (mg/liter)						
Reported				0.00001	0.0033	0.0016
Permit condition				None	0.005	0.005
Settleable solids (ml/liter)						
Reported				<0.1	0.5	1.1
Permit condition				None	0.5	0.5
Chlorine residual (mg/liter)						
Reported				<0.1	0.2	0.6
Permit condition				0.5	None	2.0

[a] Flow: minimum, 27.5; average, 48.0; maximum, 54.8.

f = the lowest wastewater discharge flow reported in the March 1977 NPDES Discharge Monitoring Report (27.9 m^3/day);

C = the upstream concentration of the same water quality parameter in the Nolichucky River (value obtained from first data column of Table 4.13); and

F = the lowest average flow of the Nolichucky River statistically expected to last for 20 days in any three-year period (197 ft^3/sec).

A comparison of the last two columns of Table 4.14 shows that incremental increases of contaminants in the Nolichucky River contributed by NFS Erwin wastewater do not exceed EPA criteria which have been established for the protection of aquatic life. (These calculations assume complete mixing and do not take into account local concentration of these materials in the vicinity of the outfall, or such phenomena as chelation, adsorption, or sedimentation.) Incremental increases of these contaminants would be expected to be even lower during average flow conditions (1,347 vs 197 cfs) and average contaminant concentrations in the wastewater.

The second data column of Table 4.14 shows the final river concentrations of the NPDES permit water quality parameters following the discharge of NFS Erwin wastewater. Even here, however, there are no values in excess of EPA criteria for any of the water quality parameters.

Un-ionized ammonia, for which an EPA criterion applies, should not be confused with ammonia as N, which is the ammonia concentration presented in Table 4.14. Only un-ionized ammonia is toxic. The higher the temperature and pH, the greater the un-ionized fraction of the total ammonia concentration. For example, at a temperature of 30°C and a pH of 10, a total ammonia concentration of only 0.022 mg/liter would be required to yield 0.02 mg/liter (EPA criterion) in the un-ionized form, whereas at 5°C and at a pH of 6, 160 mg/liter total ammonia would be necessary to yield 0.02 mg/liter in the un-ionized form.[22] Choosing representative Nolichucky River conditions of pH = 6.5 (Table 4.13) and 10°C (Sect. 2.8.2.3), 0.02 mg/liter of un-ionized ammonia would not be reached until the total ammonia (as N) concentration reached 34.0 mg/liter. This is approximately 2 orders of magnitude higher than the combined background-wastewater concentration calculated for low-flow conditions and calculated the highest wastewater concentration of ammonia (as N) reported in the March 1977 NPDES Discharge Monitoring Report (Table 4.15).

Although the nitrate (as N) concentration in the river has approximately doubled, ostensibly as a result of inputs from the NFS Erwin wastewater, it is nevertheless approximately 2 orders of magnitude lower than the EPA criterion established for the protection of warm-water fish (Table 4.14). The effect of increased nitrate levels in stimulating undesirable algal growth is not anticipated in this river system because of its extremely high turbidity (Sect. 2.8.2.3). Conceivably, most of the nitrate entering the river is transported to Davy Crockett Lake (Fig. 2.7) due to the low primary production — hence low nitrate utilization — occurring in the river (Sect. 2.8.2.3).

According to Table 4.13, the natural concentration of mercury in the Nolichucky River is extremely high. In contrast to the 7.0 μg/liter reported for the Nolichucky River (Table 4.13), the mercury content of unpolluted rivers from 31 states where natural mercury deposits are unknown is less than 0.1 μg/liter. The staff does not consider that the NSF Erwin plant discharge contributes measurably to this problem. Such a high concentration in the Nolichucky is probably a result of the extensive mica and feldspar mining activities carried out in North Carolina.

Although the concentration of residual chlorine in the upstream sample of the Nolichucky River appears high (Table 4.13), the value shown in the table is given as less than 0.1 μg/liter; therefore, the actual concentration may be *considerably less* than 0.1 μg/liter. The staff has found no evidence that the NFS Erwin plant discharge adds significantly to the residual chlorine concentration in the river.

4.2.3 Impacts of liquid effluents on groundwater supplies

Until June 30, 1977, the applicant's waste treatment process consisted primarily of pH adjustment and settling in retention ponds. The waste retention ponds are located immediately north of the manufacturing area (Fig. 2.6). The ponds are constructed with earthen dikes and are unlined. Pond structures are located on the Rome Formation, an outcropping of shale under the NFS Erwin site (Sect. 2.4.2). When the ponds were used as the main wastewater treatment facility, the approximate total capacity was 1.6 million gal. The volume of aqueous process waste released to the ponds was nominally 50,000 gal/day.

At the time of an NRC inspection during February 1-2, 1976, the applicant had no data concerning migration and seepage of potential contaminants from the ponds.[23] Although seepage into the Rome Formation is considered extremely unlikely, seepage through the sides of the ponds which are constructed of compacted alluvial material would be expected if the ponds were filled above the alluvial-Rome interface.[24] Applicant representatives stated that geological studies of the area about the plant indicated that the shale formation underlying the plant has an angle of inclination and low transmissivity characteristics such that any seepage reaching the formation would probably flow along the surface of the formation in the general direction of Martin Creek and the Nolichucky River. Therefore, any seepage would eventually be detected in surface water monitoring (Sect. 5.2.3). However, applicant representatives also pointed out that it would be difficult, if not impossible, to distinguish between contamination resulting from seepage and migration from the ponds and from that resulting from planned releases from the waste treatment system.

The latest State temporary permit (T. P. 76-89) for wastewater discharge outlines a monitoring program for investigating potential contamination of groundwater resulting from former use of the retention ponds (Sect. 4.2.2.1). At present, however, there is no known impact to groundwater supplies resulting from either discharge or from seepage and migration of liquid effluents.

4.2.4 Impacts of solid waste

Solid nonradioactive wastes from the offices and lunchroom are incinerated in a commercial-type incinerator with a natural-gas afterburner (Sect. 3.2.11). The incinerated wastes are buried on site. Toxic solid-chemical wastes are disposed of in licensed offsite burial sites. Nontoxic chemical wastes are buried on site. Sanitary wastes generated from showers and restrooms are discharged to the Erwin municipal sewage treatment facility. The disposal of solid nonradioactive wastes from the NFS plant is expected to have no significant adverse effects on biota or people in the vicinity of the site.

4.2.5 Impacts of noise on biota

During the site visit, the staff could hear very little noise coming from the NFS plant when in the applicant's parking lot. The noise level of the wastewater treatment facility (Building 330) was quite loud next to the operating facilities, but the staff concludes that noise from the normal operation of the NFS plant should cause no significant adverse impacts on biota or people living near the site.

4.2.6 Appearance: visual impact

The general impression of the plant is industrial; there are numerous small buildings and considerable clutter, especially discarded equipment northwest of the ponds. From Carolina Avenue, approximately 400 ft southeast of the nearest processing facility, the most visible structures are the guard house and administration building in the foreground and the processing facilities in the background. The administration building and guard house are constructed of local brick, and the process buildings are predominantly cement block, painted white. Metal "Butler" buildings are used for material storage, but are not visible to the public. The facility grounds are landscaped with lawn and shrubs; the area outside the security fence is primarily grassy and forested.

REFERENCES FOR SECTION 4

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5. ENVIRONMENTAL MONITORING PROGRAM

5.1 RADIOLOGICAL MONITORING

A summary of the offsite environmental monitoring program is presented in Table 5.1.

5.1.1 Air monitoring

The gaseous effluent of each release point that may contain radionuclides is sampled with a particulate filter and sample pump that operate continuously during facility use. Filters are changed and analyzed daily, or five to seven days per week, according to potential significant release of radionuclides. The effluent and building air samples are routinely counted for alpha activity.

Environmental air sampling is conducted continuously at seven boundary site locations (Fig. 5.1). The filters are exchanged weekly and are counted for alpha radioactivity. In addition to the boundary locations, three offsite locations are sampled. These sample locations are 2000 ft northeast, 500 ft southeast, and 5 miles southwest of the plant site.

5.1.2 Water monitoring

Water samples are taken daily from Banner Spring Branch and Martin Creek at the locations shown in Fig. 5.2. This frequency may be reduced from daily to weekly after the new water treatment system is in operation. Samples are analyzed for gross alpha and gross beta counts. An aliquot from each sample is composited monthly and sent to an offsite laboratory for analysis of plutonium, uranium, and thorium as well as gross alpha and gross beta counts. The frequency of composites may be adjusted to quarterly after baseline data on the waste treatment system has been firmly established.

Water from the Nolichucky River is sampled both upstream and downstream (Fig. 5.2) of the facility once per month. Samples are analyzed for gross alpha and gross beta counts.

5.1.3 Sediment sampling

Sediment samples are taken once per month from Banner Spring Branch, Martin Creek, and the Nolichucky River both upstream and downstream of the locations where plant effluents are introduced. Frequency of the sampling may be reduced to once per year when the water treatment facility is completed. Sediment from the top one-quarter inch of a square foot of stream bed is analyzed for gross alpha and gross beta counts.

5.1.4 Soil and vegetation sampling

Soil and vegetation samples are taken at five locations near the plant perimeter (Fig. 5.3). Because the prevailing wind is out of the south, most of the sample locations were chosen north of the release point. An additional sampling site is located 5 miles south of Erwin and is considered to represent the background for the area. Samples are analyzed for uranium-238, uranium-234, uranium-235, plutonium-239, thorium-228, thorium-230, and thorium-232.

5.1.5 Conclusions

With the additional monitoring as recommended in Sects. 3.3.2 and 3.3.3, the monitoring program for sampling the air, water, soil, and vegetation at the NFS Erwin plant appears adequate to measure the impacts of the radionuclides released from all plant effluents in the environment during routine operations and appears adequate to monitor for potential accident situations.

Table 5.1. Summary of environmental monitoring programs off site[a]

Sample type — media	Minimum number sampling stations	Collection frequency	Sample type	Type of analysis performed	Sampling/analytical procedure
Air	3	Weekly	Continuous	Alpha, beta	Constant air pump Radiometric counting
Water[b]	5	1 daily[c] 4 monthly	Reprocessed grab	Alpha, beta Isotopic (1/month) pH (daily) BOD (1/month) Total suspended solids (1/month) Ammonia (1/month) Nitrates (1/month) Fluorides (1/month) Boron (1/month) Cadmium (1/quarter) Mercury (1/quarter) Settleable solids (1/quarter) Residual chlorine (when required)	Dip sample • Radiometric counting and alpha spectroscopy • Chemical characteristics are analyzed by standard methods accepted by EPA.
Soil	3	Monthly	Grab	Alpha, beta	Scoop sample of top ½ in. Acid leach — radiometric counting
Vegetation	3	Monthly	Grab	Alpha, beta	Reprocessed vegetation — acid leach — radiometric counting
Bottom sediments	4	Monthly	Grab	Alpha, beta	Scoop sample — acid leach — radiometric counting

[a]Test results and data are summarized, reviewed by the Health and Safety manager, and distributed periodically to plant management.
[b]Reflects operation of wastewater treatment facility.
[c]By discharge batch.

ES 4002

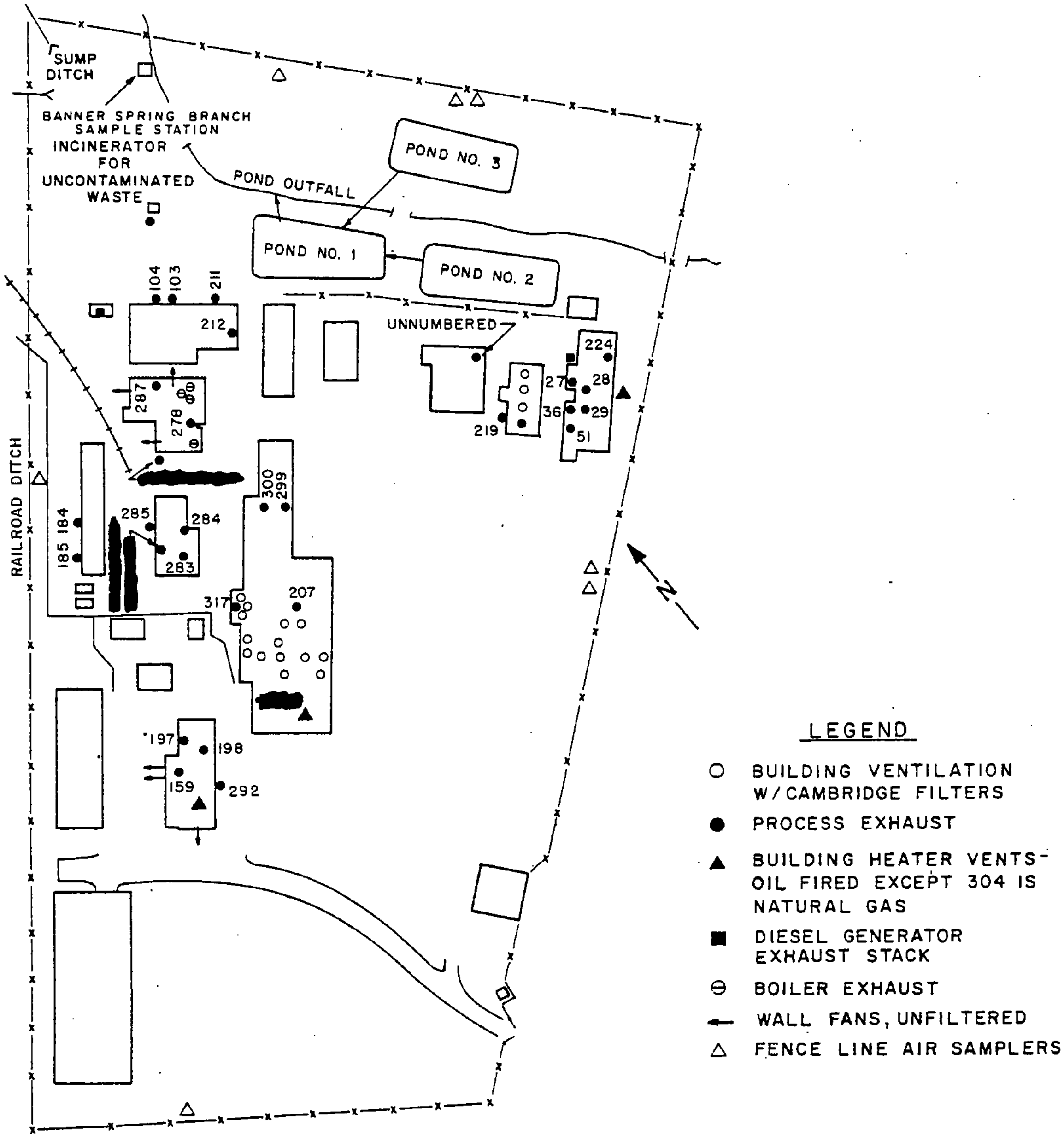

Fig. 5.1. Air sampling stations.

5.2 NONRADIOLOGICAL MONITORING

5.2.1 Atmospheric monitoring

The NFS Erwin plant does not routinely monitor its stacks for release of gaseous effluents. The applicant states that measurements are made periodically (no time period given) and are made following process- or control-equipment modifications. However, no measurements were made for the period from 1973 to the present.[1] The environmental offsite monitoring program proposed by the applicant does not include the monitoring of nonradiological gases in the air.[1]

ES 4001

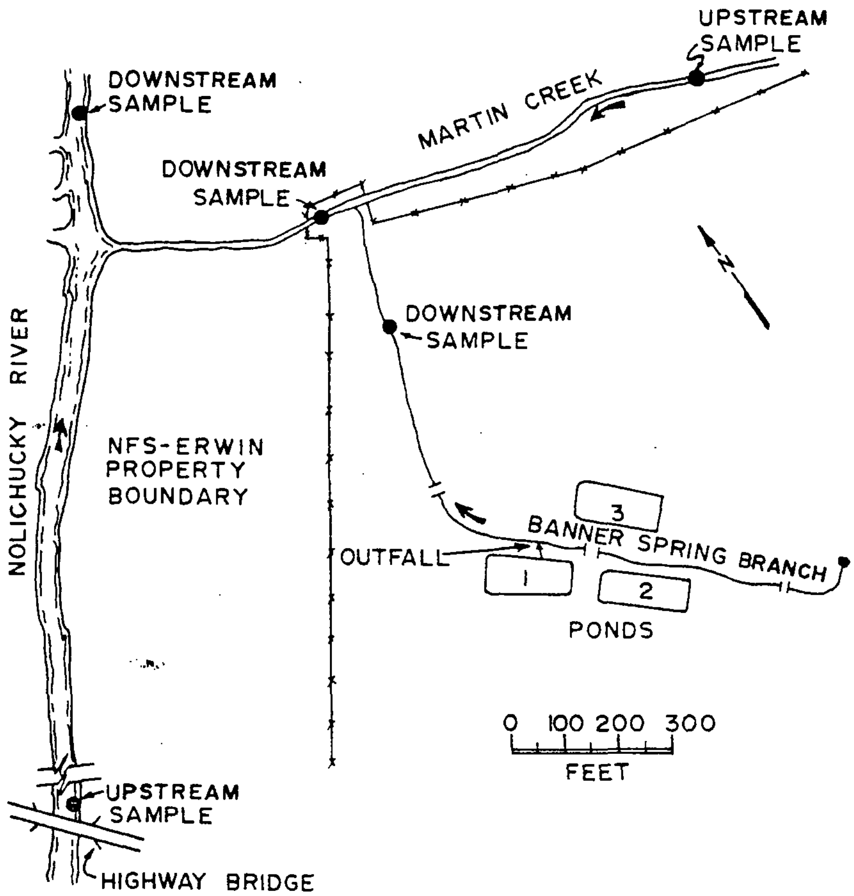

Fig. 5.2. Water sampling stations.

5.2.2 Monitoring of surface waters

5.2.2.1 Banner Spring Branch and Martin Creek

Beginning sometime in the spring of 1977, Banner Spring Branch and Martin Creek have been monitored on a weekly basis for the water quality parameters listed in the NPDES permit. The monitoring program was begun in response to an NRC inspection conducted February 1-2, 1976. Until that time, the most recent baseline water quality data on Banner Spring Branch and Martin Creek were obtained in May of 1973, although quarterly water quality surveillance is accepted practice for maintaining current baseline data.[2]

5.2.2.2 Nolichucky River

Currently, there is no monitoring program for the Nolichucky River. Except for the one-time sampling conducted in April 1977 (see Table 4.13), the most recent baseline water quality data on the Nolichucky River were obtained in May of 1973.[2] Although monitoring has been resumed for Banner Spring Branch and Martin Creek, no such program has been established for the Nolichucky River.

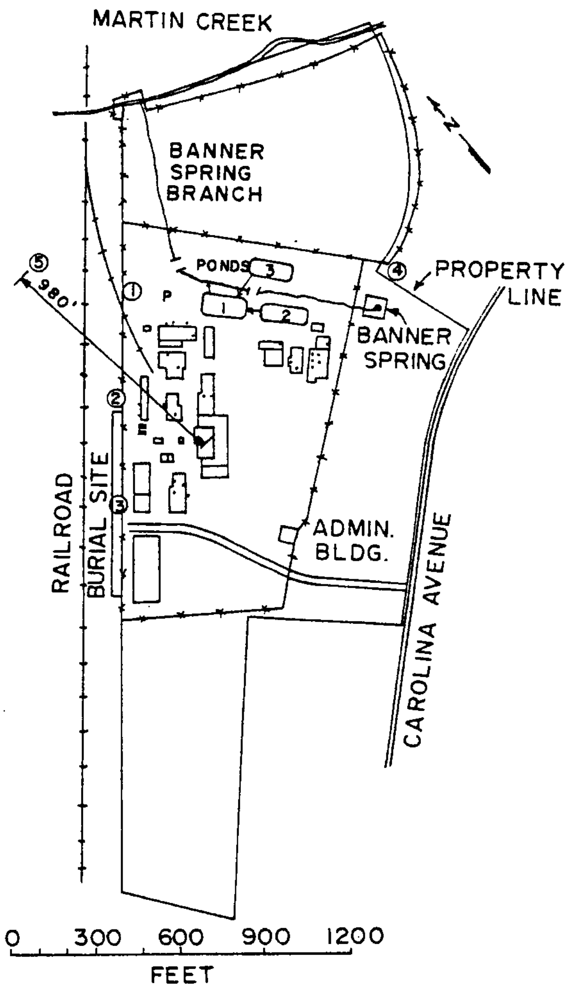

Fig. 5.3. Soil and vegetation sampling locations.

5.2.3 Groundwater monitoring

There is not now, nor has there ever been, a groundwater monitoring program at Erwin.

5.2.4 Monitoring of biota

5.2.4.1 Terrestrial biota

In late August 1975, a limited survey of fluoride accumulation in soil and vegetation was conducted at five locations near the plant perimeter, primarily in the prevalent downwind direction, and at one location 5 miles south of the plant, representing baseline conditions for the area (Fig. 5.3). Soil was sampled at a depth of 2 to 2.5 in., was composited, and was blended; a 1000 g sample was submitted for analysis by an outside laboratory. The vegetation collected at each site consisted of annual native grasses and weeds. The entire plant was collected including leaves and roots.[3] The environmental offsite monitoring program proposed by the applicant does not include the monitoring of nonradiological chemicals in the soil and vegetation.

According to biologists from ETSU, biota surveys in the immediate vicinity of the plant have never been conducted.[3] In May 1977, a limited field survey of the terrestrial biota on the NFS site was conducted. No further plans have been made to survey the biota of the NFS plant or vicinity.

5.2.4.2 Aquatic biota

There is not now, nor has there been in the past, a program for monitoring aquatic biota.

5.2.5 Staff recommendations for future nonradiological monitoring

5.2.5.1 Atmospheric monitoring

Nuclear Fuel Services has had a very nominal monitoring program for nonradiological gaseous effluents in the last six years (Sects. 4.2.1 and 5.2.1). In addition, a review of the applicant's records by an NRC inspector[4] indicated that the average values listed in the EIR may not necessarily be representative of what is being released at any given time because certain processes may be modified, the type of product may vary, or the process may not be operating at all as governed by the needs of a specific project or contract. The NFS effluent of major concern is hydrogen fluoride because it is toxic to plants at low concentrations and because it can cause fluorosis in cattle through accumulation of high fluoride levels in forage. The staff believes that it is important to have accurate records of how much hydrogen fluoride is released at the NFS site. Therefore, the staff recommends as a condition to license renewal that NFS propose a monitoring program, to be reviewed and accepted by NRC, to determine total hydrogen fluoride releases under normal operating conditions.

5.2.5.2 Surface waters

The staff concludes that the monitoring of temperature in Banner Spring Branch as outlined in State Permit 75-167 is adequate and should be continued. No monitoring of additional water quality parameters in Banner Spring Branch is considered necessary because discharges to Banner Spring Branch are restricted to uncontaminated cooling water. No monitoring of Martin Creek is considered necessary because Martin Creek receives no direct wastewater input, except for uncontaminated cooling water entering via Banner Spring Branch where monitoring is recommended. The staff concludes that routine monitoring of the Nolichucky River by NFS Erwin is not necessary. This is based on the staff's finding of little potential impact resulting from the wastewater currently discharged by NFS Erwin into the Nolichucky River both under normal conditions and under worst-case conditions (see Sect. 4.2.2.2).

5.2.5.3 Groundwater

The staff strongly recommends that the applicant investigate potential groundwater contamination by nonradiological contaminants present in the wastewater [ammonia (as N), nitrate (as N), fluoride, and mercury] in the vicinity of the formerly used wastewater retention ponds, and that the applicant carry out a program for eliminating the source of any further contamination if such is found to exist. This program might be effectively combined with the investigation of potential groundwater contamination by radiological contaminants as required in State Temporary Permit 77-75. It is the staff's opinion that possible groundwater contamination could have resulted from seepage and leakage from the formerly used wastewater retention ponds (Sect. 4.2.3). The monitoring of radiological and nonradiological parameters will be incorporated as license conditions.

REFERENCES FOR SECTION 5

1. Nuclear Fuel Services, Inc., *Summary of Responses to Comments and Questions Related to NFS-Erwin Environmental Information Report,* Erwin, Tenn., Nov. 1, 1976.
2. Nuclear Regulatory Commission, *Health & Safety Inspection Report,* IE Inspection Report 70-143/76-2, Feb. 2, 1976.
3. Nuclear Fuel Services, Inc., *Responses to Environmental Information Report NRC Questions of April 15, 1977,* Erwin, Tenn., May 31, 1977.
4. G. P. Coryell, *IE Inspection Report 70-143/76-2,* Docket No. 70-143, Mar. 29, 1976.

6. IMPACT OF ACCIDENTS

The applicant has identified a number of accident situations and has indicated qualitatively or quantitatively the potential environmental impact of typical ones.[1] With the exception of a criticality accident, accidents within the applicant's facilities are of comparable probability, nature, and magnitude with nonnuclear process operations using small quantities of chemicals. Because nonirradiated fuel is processed, it is "unlikely that any significant impact outside the confines of the plant would result from an accident."[2]

6.1 ACCIDENTS INVOLVING NONRADIOACTIVE MATERIAL

Plant accidents involving nonradioactive material have been divided into categories as follows:

Category 1	Expected to occur on site during plant life	Caused by pipe leaks, operator errors, exhaust-scrubber failure, minor spills, and utility outages
Category 2	Not expected to occur during plant life, but possible	Caused by breach of bulk-chemical storage container, severe earthquake, fire, flood, explosion
Category 3	Unexpected catastrophic natural events or combination of highly improbable (Category 2) events	Major earthquake, volcanic eruption, simultaneous failure of several independent systems

6.1.1 Category 1 events

An accident in this category would be typified by a minor leak in a process or chemical pipeline resulting in the release of a few gallons of the material from the pipeline. A leak of this type inside the manufacturing buildings would be detected quickly because it would be visible to workers. Corrective action (such as isolation of the leaking pipeline section) would be taken immediately. The spilled liquid(s) along with any necessary water used in cleanup would be recycled into the process or transferred to the waste treatment system. Therefore, no environmental release would occur.

Similarly, a leak of the above type in an exposed pipeline outside of the facility would be observed within an hour, and corrective actions would be taken quickly due to the location of such lines with respect to normal access points into the building and the frequent movement of NFS employees and security patrol through such points. Consequently, the amount of material lost would easily be held by the upper few inches of soil and could subsequently be removed.

Scrubber or filter failure could result in discharge of particulate matter. Such a failure is improbable due to an active maintenance program. Detection would occur within less than a day because effluents are monitored regularly. No significant release has occurred from this cause during the history of the plant.

6.1.1.1 Utility outages

Electrical failures have occurred and can be anticipated, especially during storms. Criticality alarms as well as ventilation and air samplers in areas containing hazardous materials are connected to diesel-powered generators. The absence of electrical power is not expected to exceed 10 min in these facilities. Processes that are not supplied with auxiliary power will be shut down immediately following an electrical failure. No significant environmental releases have been experienced as a result of electrical power outages.

Natural gas is supplied to the plant on an interruptable basis to cover peak loads. Liquid propane, bottled gas, and No. 2 diesel oil are stored at the site for substitution following notification of natural gas service interruption. No loss of operating time or environmental control has been attributed to the loss of natural gas service at the NFS Erwin site.

Water is supplied to the plant from two sources: Banner Spring Branch and the Erwin city water system. Banner Spring Branch supplies cooling water that is pumped from the spring and is returned to the creek. Routine maintenance of the pumping system reduces the probability of a cooling-water loss. However, failure of this system is considered possible. Consequently, temperature sensors have been installed in water-cooled processes. The sensors would trigger immediate action, including process shutdown if necessary, should cooling be lost. As a result, measurable release of chemicals and/or radionuclides is not anticipated.

Fire-protection water is also supplied from Banner Spring Branch by pumping to an elevated 500,000-gal tank (owned by Clinchfield Railroad) and is supplied to the plant through an underground 8-in.-diam pipe. Except for cooling- and fire-protection water, all other plant water is supplied from the Erwin sanitary water system. Failure of this supply without advance notice is improbable. However, this failure mode is considered here in order to allow evaluation of utility failures as a whole.

Certain operator errors could cause minor environmental releases. Anticipation of all such errors a worker could make is not feasible. However, effort has been made to eliminate situations where a single error could result in a significant environmental release or hazard to plant personnel. Where physical safeguards to negate the consequences of operator error have been impractical to use, extensive training and administrative safeguards are employed.

6.1.2 Category 2 events

Major leaks inside the buildings could not result in releases that would be of concern to the external environment for the reasons described under Category 1 events. Ruptures of indoor tanks might result in employee injury, and/or temporary shutdown of process operations, but are not expected to result in environmental degradation. External leaks of acids would be largely neutralized by the soil, or by addition of base. Liquid ammonia is transported, stored, and used, for example, in agriculture without serious risk.

The facility is located in seismic zone 2 on the seismic risk map of the United States (Fig. 2.4), indicating the maximum probable earthquake would correspond to intensity VII on the Modified Mercalli Scale. No earthquakes in excess of a magnitude of 4.5 to 5 on the Richter scale have been reported in the area. Some minor onsite damage to buildings or interruption of processes may result from the maximum probable earthquake, but environmental releases would be expected to be limited to process-piping leaks described in Sect. 6.1.1 as Category 1 events.

A study of floods on the Nolichucky River in the vicinity of Erwin was published in March 1967 by the Tennessee Valley Authority.[3] The greatest recorded flood (100-year period), regional flood, and maximum probable flood (1000-year period) are discussed in that report for the NFS Erwin property. The site buildings are above the level of the greatest recorded flood and of the regional flood, but are 3 to 6 ft below the maximum probable flood. The maximum flood would not wash through the property but would back up from the river below to cause water damage to some of the process facilities.

Were a washout of the ponds to occur during a flood at the magnitude of the 1901 flood, and were the entire solid and liquid contents of the pond to be released in a period of 30 min, the resulting radionuclide concentration in the flood water would be 0.004% of the MPC_w for uncontrolled areas. Such a release would not add perceptibly to the impact and consequences of the flood.

Hydrogen gas is used in various small [redacted] in the NFS Erwin facility. Because hydrogen is extremely flammable and presents an explosion hazard, administrative controls require that the furnaces be purged with inert gas prior to any exposure to air.

An inadequate purge might result in an explosion [redacted] The most violent postulated explosion could result if the largest [redacted] were filled with one-third oxygen and two-thirds hydrogen. The largest [redacted] has a capacity of 20 ft^3 and operates at 815°C (1500°F). The explosion could cause release of 300 k/cal (1200 Btu) of energy and would create an instantaneous pressure of 50 $lb/in.^2$ within the [redacted]. If the [redacted] did not contain this explosion, the resulting instantaneous room-pressure rise would be 3 in. of water that could cause a room temperature increase of 4.5°F.

Minor structural damage and no measurable environmental release would be expected from such an explosion.

6.1.3 Category 3 events

Events of this nature fall into two general categories. The first includes natural disasters such as mountain-raising earthquakes, unanticipated melting of the polar ice caps and volcanic eruption under the facility. All these events are of such environmental significance that the impact caused by distruction of NFS facilities could be quit inconsequential by comparison. The second category includes unanticipated combinations of improbable events such as an explosion in a [redacted], failure of the fire-protection system and simultaneous failure of the scrubber. In such calamities, environmental degradation is limited only by the quantity of stable and radioactive chemicals present in the facility (Table 6.1).

Table 6.1. Chemical storage and use

Type	Chemical	Average annual usage	Maximum quantity stored	Average shipment size	Approx. number of shipments per year	Environmental and toxicological data
Compressed gas	Helium		6	2		Nontoxic – inert
	Argon		8	2		Nontoxic – inert
	Oxygen		6	5		Nontoxic – accelerates combustion
	P-10 (90% argon 10% methane)		8	6		Will not support combustion
	Acetylene		4	1		Moderate explosion hazard
	Nitrogen		12	6		Nontoxic – inert
Liquified gas	Carbon dioxide		2,700 gal	925 gal		Nonflammable
	Argon		2,200 gal	1,400 gal		Nontoxic – inert
	Hydrogen		6,000 gal	4,300 gal		Explosive
	Nitrogen		12,000 gal	4,450 gal		Nontoxic
	Ammonia		10,000 gal	7,200 gal		TLV 400–700 ppm in air – 1-hr exposure causes no serious effect Recommended TLV in air 3-hr exposure 50 ppm[a]
Fuel	No. 2 diesel oil		40,000 gal	7,000 gal		Flammable – toxic
	Natural gas					Flammable – toxic
	Liquid propane		300 gal	150 gal		Explosive – toxic
	Lubricating oils		495 gal	1-55 gal drum		Flammable
Process chemicals	Nitric acid 67%		7,000 gal	3,800 gal		Acidity interferes with most water use. USPHS recommend limit for nitrates 45 mg/liter
	Hydrofluoric acid 70%		4,000 lb	4,000 lb		TLV in air for 8-hr day 3 ppm[b]
	Potassium hydroxide		5,000 gal	3,500 gal		Highly toxic unless neutralized (LD 50 rabbits 500 mg/kg)[c]
	Tributyl phosphate		1,800 lb	1,800 lb		LD 50 oral in rats 3 g/kg
	Amsco 125		1,000 gal	550 gal		Flammable – similar to kerosene
	Aluminum nitrate		2,000 lb	2,000 lb		Toxic to fish in tapwater at 0.55 mg/liter[d]
	Hydrochloric acid		10,000 lb	7,500 lb		TLV in air for 8-hr day of 5 ppm; toxic unless neutralized
	Ammonium hydroxide 25% solution		1,100 gal	1,100 gal		See ammonia, above
	Sodium hydroxide		1,000 lb	1,000 lb		Highly toxic unless neutralized (LD 50 rabbits 500 mg/kg)[c]
	Acetone		275 gal	55 gal		Highly flammable – toxic
	Hexanol		4,100 gal	4,125 gal		Flammable – toxic
	Methyl alcohol		275 gal	275 gal		Flammable, TLV 200 ppm in air[e]
	Detergent		1,000 lb	1,000 lb		Water pollutant
Radioactive chemicals	Low-enriched uranium		18,000 kg	700 kg		
	High-enriched uranium	Refers to classified product				
	Plutonium	0	6.6 kg	-	None	

[a] Manufacturing Chemists Association, *Data Sheet* SD-8.
[b] American Conference of Governmental Industrial Hygienists.
[c] *Merck Index*, 8th ed., 1968.
[d] B. G. Anderson, "The Apparent Thresholds of Toxicity of *Daphnia Magna* for Chlorides of Various Metals When Added to Lake Erie Water," *Trans. Amer. Fish. Soc.* 78,196 (1948), Water Pollution Abstracts 23 (December 1950).
[e] Irving N. Sax, *Dangerous Properties of Industrial Materials*, 3rd ed., Van Nostrand Reinhold Company, New York, 1968.

Although the probability and effect of this type of occurrence cannot be precisely estimated, it does not appear that the probability is significantly different from that at other industrial- or chemical-processing facilities.

Fire is an unlikely event because combustible materials are restricted, and electrical and heating equipment is carefully maintained. Plant personnel would notice an incipient fire visually or they would be alerted by a fire detector, and the fire would be extinguished according to plan.[1] As an example of such an improbable event, the applicant has postulated[4] a fire in a plutonium-contaminated glove box in Building 234, which is not in use. Less than 350 g of residual plutonium is thought to be fairly uniformly distributed over about 21,000 ft^2 of surface area. It is predicted that the fire would be of a slow-burning type, and might destroy the first absolute filter, but would not destroy the final bank. It is estimated that the short-term release of plutonium might increase a thousandfold, to about 10^{-5} μCi/sec, but the long-term average would change very little.

6.2 ACCIDENTS INVOLVING RADIOACTIVE MATERIAL

6.2.1 Spills of process material

Spills within buildings would be transferred to waste, while external spills would be absorbed by the soil. No significant release of solid material appears credible. In general, no offsite consequences are foreseen from in-plant spills.

6.2.2 Criticality

In calculating the consequences of an accidental criticality, it has been assumed that the accident occurs in an outdoor storage tank at the north end of Building 233, and that the accident results in a total of 1.4×10^{18} fissions. The source terms (amount of radionuclides released) at the point of release are presented in Table 6.2.

In the absence of site-specific meteorology, the conservative meteorological conditions of 1 m/sec wind speed and a Pasquill type F stability were used to estimate the atmospheric concentrations of radionuclides. A dry deposition of 0.01 m/sec for particulates was assumed. Due to the proximity of the storage tank to Building 233, a building wake dispersion factor of 0.33 was used in the calculation.[5]

Table 6.2. Source terms for a postulated criticality accident of 1.4×10^{18} fissions at the NFS Erwin plant

Radionuclide	Amount released (Ci)
Kr-83	3.64
Kr-85*m*	15.96
Kr-85	1.54×10^{-4}
Kr-87	1.68×10^{2}
Kr-88	64.96
Kr-89	4.06×10^{3}
Xe-131*m*	3.78×10^{-3}
Xe-133*m*	5.46×10^{-2}
Xe-133	12.88
Xe-135*m*	11.06
Xe-135	15.96
Xe-137	3.78×10^{3}
Xe-138	1.20×10^{3}
I-129	4.2×10^{-11}
I-131	1.82×10^{-1}
I-132	6.44×10^{-1}
I-133	3.50
I-134	47.60
I-134	12.04

6.2.2.1 Maximum dose to the nearest residence

The maximum doses from all sources to the nearest resident, who lives at a distance of 245 m south of the storage tank (Building 233), are shown in Table 6.3. The estimated maximum total-body dose is 7.9 rems. The gamma and neutron doses resulting from the prompt burst are based on data from Caldwell.[6] The doses from the airborne radionuclides were calculated using the AIRDOS-II computer code.[7] Most of the total-body dose (75%) is due to Kr-89 via the submersion-in-air pathway. The highest organ dose (28.6 rems) is to the thyroid (Table 6.3) as a result of the iodine-131 (36%) and iodine-133 (27%) inhaled. A criticality accident is an uncontrolled fission event similar to a reactor accident. The potential calculated doses may be compared with the equivalent time at occupational MPC in 10 CFR Part 20 (see Table 6.3). As shown in Table 6.3, the maximum doses received by the nearest resident would not result in any fatalities or serious injury.[8]

6.2.2.2 Population dose

The population dose is based on the airborne release of radionuclides within the most populous sector up to 80 km (50 miles) of the effluent. Dose calculations were made using the AIRDOS-II computer code[6] and are shown in Table 6.4. The population total-body dose is 0.85 man-rem, and the highest population organ dose is 1.6 man-rems to the thyroid. These doses may be compared to the dose from natural background radiation (based on State of Tennessee dose rates)[9] of 1.76×10^{4} man-rems to the 126,000 persons living in the designated sector.

Table 6.3 Summary of maximum offsite consequences[a] from a nuclear criticality incident at the NFS Erwin site with a prompt burst of 1.4×10^{18} fissions

Organ[b]	Dose from prompt burst (rems)		Dose from airborne release (rems)[d]	Total (rems)	Equivalent time at occupational MPC (months)
	Gamma[c]	Neutron[c]			
Total body	0.21	0.46	7.2	7.9	4.5
Thyroid	0.21	0.46	27.9	28.6	2.7

[a] Dose to nearest resident 245 m from location of incident.
[b] Dose to organs not shown is less than that of the total body.
[c] Based on equation from Sect. 3.34 of the *Nuclear Regulatory Guide.*
[d] Fifty-year dose commitment.

Table 6.4. Doses[a] to the population[b] from the airborne radionuclides released during a criticality accident (1.4 fissions)

Organ	Dose (man-rems)	Principal contributing radionuclides (%)
Total body	0.85	Kr-88 (65%); Xe-135*m* (14%); Kr-87 (8%); Xe-135 (8%)
GI tract	0.66	Kr-88 (68%); Xe-135*m* (13%); Kr-87 (8%); Xe-135 (6%)
Bone	0.98	Kr-88 (60%); Xe-135*m* (15%); Kr-87 (8%); Xe-135 (10%)
Thyroid	1.60	I-131 (26%); I-133 (18%); Kr-88 (32%); Xe-135*m* (8%)
Lung	0.81	Kr-88 (65%); Xe-135*m* (14%); Kr-87 (8%); Xe-135 (7%)
Kidneys	0.68	Kr-88 (64%); Xe-135*m* (16%); Kr-87 (8%); Xe-135 (7%)

[a] Fifty-year dose commitment based on one year of intake or exposure.
[b] Based on population in the single sector out to 80 km (50 miles) from the site which gives the highest population dose (126,000 persons).

Because there is a possibility of a serious accident at the facility due to the presence of hazardous materials, the applicant has established a plan to cope effectively with emergencies that might arise. The purpose of the plan is to protect the health of the employees and the public and to deal effectively with the emergency in a timely manner. Detailed procedures of the applicant's emergency plan can be found in the applicant's EIR.

6.3 TRANSPORTATION ACCIDENTS

The facility processed [redacted] tons of uranium in 1974. This required more than [redacted] shipments to and from the facility. Although the safety of uranium shipments is the responsibility of the shipper, for purposes of this report, incoming and outgoing shipments are both considered.

All radioactive shipments are regulated by the Department of Transportation (DOT) and the NRC, and must also conform to State and other Federal requirements.

The probability of an accident occurring in transportation is small, about 10^{-6} per vehicle mile, and decreases with increased severity of the accident to an extremely small probability of about 10^{-13} per vehicle mile for extremely severe accidents.[2]

The radioactive materials shipped to and from the plant are packaged in containers that are approved by NRC and DOT and are in full accordance with State and Federal regulations governing the safe shipment of hazardous materials (Type B requirements).

The shipping containers required for significant quantities of radioactive materials are of such integrity that they survive with no release of contents in all but the most severe and unusual of transportation accidents.

Shipments of enriched uranium from the facility are packaged so that accidental criticality under all but nearly incredible conditions is impossible. The facility receives high-enriched uranium in cylinders which meet the Type B requirements. A criticality incident from such a cylinder is considered remotely credible, although such an event has never occurred.

If a cylinder containing highly enriched uranium were to rupture so that the cylinder filled with water without losing its contents, a criticality could result. A small hole in a submersed cylinder would be plugged by the products of reaction between uranium hexafluoride and water, and the cylinder would not fill, preventing criticality. Larger holes would allow contents to leak out and, consequently, would prevent criticality.

In addition to the stringent performance standards for the shipping containers, administrative controls are imposed over the exclusive-use truck-transport vehicles for high-enriched uranium (10 CFR Part 73). The number, type, and contents of the packages loaded on each truck are controlled to ensure that all vehicles will remain nuclearly safe both under normal transport conditions and during accident situations.

There is a slight probability that in time some radioactive material being shipped to or from the plant will be involved in a traffic accident. The probability that the accident will be severe enough to release any of the material from the packaging containers is significantly more remote than the probability of an accident. Finally, the probability that such an accident would result in measurable radiation exposure to the general public or environmental contamination is extremely slight, almost nonexistent.

REFERENCES FOR SECTION 6

1. Nuclear Fuel Services, Inc., *Environmental Information Report,* Erwin, Tenn., January 1976; with revisions October 20, 1976, and May 31, 1977.

2. *Environmental Survey of the Uranium Fuel Cycle,* WASH-1248 Washington, D.C., (April 1974).

3. Tennessee Valley Authority Division of Water Control Planning, *Floods on Nolichucky River and North and South Indian Creeks in Vicinity of Erwin, Tennessee,* TVA, Knoxville, Tenn., 1967.

4. C. J. Michel, Nuclear Fuel Services, Inc., letter to W. T. Crow, Nuclear Regulatory Commission, Docket No. 70-143, Nov. 1, 1976.

5. U.S. Nuclear Regulatory Commission, "Regulatory Guide Assumptions used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Uranium Fuel Fabrication Plant," *U.S. Nuclear Regulatory Guide,* 3.34, p. 3.34-10, (April 1977).

6. Roger D. Caldwell, "The Effects of a Criticality Accident," *Environmental Data for License Renewal Application,* Babcock and Wilcox, Nuclear National Materials Division, SNM-145, Docket No. 70-135, Sept. 24, 1975.

7. R. E. Moore, *The AIRDOS-II Computer Code for Estimating Radiation Dose to Man from Airborne Radionuclides in Areas Surrounding Nuclear Facilities,* ORNL-5245, ESD Publication 974, Oak Ridge, Tenn., April 1977.

8. Atomic Energy Commission, *The Effects of Nuclear Weapons,* Samuel Glasstone, ed., U.S. Government Printing Office, Washington, D.C., April 1972, p. 592.

9. Environmental Protection Agency, *Radiological Quality of the Environment,* EPA-520/1-76-010, Washington, D.C., May 1976, pp. 17-35.

7. MATERIALS AND PLANT PROTECTION

7.1 PHYSICAL PROTECTION AND MATERIAL ACCOUNTING

Current safeguards are set forth in 10 CFR Parts 70 and 73. The regulations in Part 70 provide for material accounting and control requirements with respect to facility organization, material control arrangments, accountability measurements, statistical controls, inventory methods, shipping and receiving procedures, material storage practices, records and reports, and management control.

The Commission's current regulations in 10 CFR Part 73 provide requirements for the physical security and protection of fixed sites and for transportation involving strategic quantities of nuclear materials. Physical security requirements for protecting fixed sites include the establishment and training of a security organization (including armed guards), provision for physical barriers, and establishment of response plans.

The Commission's regulations in 10 CFR Parts 70 and 73, described here briefly, are applied in the reviews of individual license and permit applications. License conditions then are developed and imposed which translate the regulations into specific requirements and limitations that are tailored to fit the particular type of plant or facility involved.

The Nuclear Fuel Services operation is an existing licensed activity, and although experience and continuing study may indicate areas in which the Commission's regulations applicable to the NFS Erwin site should be revised, the Commission has determined that for the kind of installation under review, the safeguards framework of existing and proposed regulations discussed in its statements of November 14, 1975,[1] and January 27, 1977,[2] are adequate to enable the Commission to carry out its responsibilities to protect the public health and safety and the common defense and security. The applicant has an approved material control and accounting plan an approved physical security plan which meet safeguards-related activities have insignificant environmental impact.

REFERENCES FOR SECTION 7

1. "Mixed Oxide Fuel," *Fed. Regist.* 40 (221): 53056-53063, 1975.
2. *Fed. Regist.* 42 (18): 5150, 1977.

8. SUMMARY AND CONCLUSIONS OF ENVIRONMENTAL IMPACTS OF OPERATION

An analysis of nonradiological atmospheric emissions of fluorides, ammonia, and nitrogen oxides by the staff indicates that it is unlikely that there will be any significant offsite adverse impacts on local flora or fauna, agricultural, livestock, or humans.

An analysis of nonradiological effluents released to the aquatic environment shows that various contaminants occasionally have exceeded NPDES permit criteria. Further analysis of potential impact on the aquatic environment (Nolichucky River) indicates the improbability of any adverse impacts occurring, because EPA water quality criteria for the protection of aquatic biota have never been exceeded.

The maximum annual radiation dose (50-year dose commitment) received by individuals living at the nearest residence in the direction of prevailing winds was estimated to be 0.2 millirem to the total body. This dose rate is insignificant compared to the natural background dose rate of 140 millirems per year in the state of Tennessee. The total body dose to the population of 0.3 man-rem is only about 0.0004% of that received from natural background radiation to persons living within 50 miles of the plant.

The staff has concluded that the monitoring program for sampling air, water, soil, and vegetation is apparently adequate to measure the impacts of the radionuclides released from all plant effluents into the environment during routine plant operation, and for measuring impacts of potential accident situation.

Current monitoring of surface water for an analysis of the impact from nonradiological contaminants arising from plant effluents is also adequate. However, an investigation of potential groundwater contamination associated with the formerly used wastewater retention ponds is strongly recommended.