November 1977 Report

Sub. 1010 Amendment No. 8

Introduction

An amendment to source material license SUB-1010, approved by the USNRC May 4, 1977, authorized test distribution of neutralized, barium treated, solvent extraction raffinate on approximately 160 acres of Kerr-McGee owned land located south of the Sequoyah Facility. This report describes the work conducted, observations, and preliminary results of the 1977 application program. Analytical results of sampling and a detailed evaluation of the 1977 test program will be reported to the NRC when completed.

I. Physical Area

The following work was initiated prior to the first raffinate application to the test area:

(1) A surveyor established the sampling grid at 300 ft. intervals.

(2) Construction of a runoff control dike and perimeter diversion ditch.

(3) Placement of sorption cups and tensiometers at designated sampling locations.

(4) Coring and drilling of five groundwater monitoring wells.

The location of these monitoring stations and control structures are indicated on Figure 1.

Timber clearing and windrowing was conducted in area 1 and 2, while area 3 (light timber) had pathways (12 ft. wide at 80 ft. intervals) cleared to allow sprayer equipment access (Fig. 1). Timber removal allowed access to approximately 20 additional acres of the test area. Following preparation, cleared areas were sprigged with Bermuda grass (summer) and subsequently seeded with rye and fescue (fall).

II. Baseline Inventory

Soils

The soil inventory allowed for the production of a detailed soils morphology map of the treatment area. This map, when used in conjunction with results of chemical and physical analyses provides a detailed baseline inventory and will also be used in describing soil moisture flow characteristics, and element sorption values obtained from subsequent analyses.

Description of Soil Units

The soils of the raffinate treatment area are of two major land resource areas. One is the easternmost part of the Cherokee Prairie, which includes mostly deep, darker colored soils, with varying degrees of permeability and drainage. The other group of soils are of the Ouachita Highlands and are generally sandy and loamy, light colored, shallow and moderately deep soils with varying degrees of permeability and moderately to well drained.

The specific soil units are listed and described below:

(HeF) HECTOR-LINKER-ENDERS

The mapping unit Hector-Linker-Enders complex, 5-40% slopes was identified. The soils in this complex range from stony and very shallow to deep. Hector and Linker soils make up about 75% of the total area. The soils characteristics are:

HECTOR. This soil consists of very shallow to shallow, rapidly permeable, excessively drained soils on uplands. They have a fine sandy loam surface layer that is grayish-brown in the upper part and yellowish-brown in the lower part. Below this is fine sandy loam mixed with sandstone. Sandstone bedrock occurs from 8 to 20 inches.

LINKER. This soil consists of moderately deep to deep, moderately permeable, well drained soils on uplands. They have a loam surface layer that is light yellowish-brown. The combined thickness of the surface is 6-12 inches. The upper part of the subsoil is reddish-yellow loam or light clay loam. The lower subsoil is light clay loam mottled with brownish-yellow, gray and red. Depth to sandstone is 20-48 inches.

ENDERS. This soil consists of deep, slowly permeable, moderately well-drained soil on sloping uplands. The soil has a fine sandy loam surface that is grayish-brown in the upper part and very pale brown in the lower part with a combined thickness of 10 inches. The subsoil is red clay that is mottled in the lower part. Shale depth ranges from 30-55 inches.

(LoD3) LINKER AND STIGLER SOILS

LINKER SERIES

See description under section HeF.

STIGLER SERIES

The Stigler series consists of deep very slowly permeable, somewhat poorly drained soils on uplands. The soils typically have a surface layer with the upper part a lt. brownish-gray silt loam about 10 inches thick and the lower part a very pale brown silt loam to 18-20 inches. The subsoil is a very pale brown silty clay loam that grades to a brownish-yellow mottled silty clay loam or clay at 45-60 inches.

The mapping unit (LoD3) Linker and Stigler soils, 2-8% slopes, severely eroded. The soils are typical of the two series as described. Areas may be dominated by either soil or mixtures of the two described with inclusions of associated soils in other mapping units. Sheet erosion, and numerous gullies are present.

(Ma) MASON SERIES

The Mason Series consists of deep, moderately permeable, well-drained soils on bottomlands. The series typically has a surface layer of brown silt loam or loam about 12 inches thick. The subsoil is brown silty clay loam extending to 72 inches +.

The mapping unit (Ma) Mason Silt Loam, 0-2% slopes is typical of the series.

(PcB, PcC, PcC2) PICKWICK SERIES

The Pickwick soils are deep moderately permeable well-drained soils on the

uplands. The soils have a loam surface layer that is light grayish-brown in the upper part and very pale brown in the lower part. The combined thickness of the surface layers range from 10-16 inches. The subsoil is reddish-yellow clay loam that is mottled in the lower part. The depth to bedrock ranges from 48-72 inches.

The mapping units (PcB, PcC & PcC2) were identified. The units PcB and PcC are both similar to the described series with PcB occurring on 1-3% slopes and PcC occurring on 3-5% slopes. The PcC2 mapping unit occurs on 2-5% slopes and the surface layer has been thinned by erosion and gullies are common. Small areas of Linker loam are included.

(Ru) ROSEBLOOM SERIES

The Rosebloom series consists of deep, very slowly permeable, poorly drained soils on the bottomlands. These soils have a light brownish-gray silt loam surface 10-12 inches thick. The subsoil is a gray silty clay loam to 60+ inches. The soil is mottled throughout.

ENNIS SERIES

The Ennis series consists of deep, moderately permeable, well-drained soils on bottom lands. The series has a pale brown silt loam surface layer 12 inches thick and a subsoil of lt. yellowish-brown heavy silty loam or silty clay loam extending to six feet or more. The subsoil is mottled with gray at varying depths below 30 inches.

The mapping unit (Ru) Rosebloom and Ennis soils, broken was used in this survey. The unit is a mixture of the two previously described soils on slopes from 0-10%. Any given area may be dominantly Rosebloom or dominantly Ennis, or both soils may occur with soils included in the mapping. The unit is often strongly dissected by stream channels and frequently flooded.

(SnC) SPIRO SERIES

The Spiro series consists of moderately deep to deep, moderately permeable, well-drained soils on uplands. The soil typically has a grayish-brown silt loam surface layer 10 inches thick and a transitional subsurface layer of brown heavy silt loam to 14 inches. The subsoil is light yellowish-brown silty clay loam. Sandstone bedrock occurs at 40-50 inches. The mapping unit (SnC) Spiro silt loam, 2-5% slopes was identified.

(VaB, VaC) VIAN SERIES

The Vian series consists of deep, moderately slowly permeable and moderately well-drained soils on uplands. The soils have a silt loam surface layer that is grayish-brown in the upper part and light gray in the lower part. The combined thickness of the surface layers range from 16-26 inches. The uppermost part of the subsoil is a pale brown heavy silt loam. Below this is brownish-yellow silty clay loam that becomes coarsely mottled with light gray pale brown and yellow at about 48 inches. This material extends to over 72 inches.

Two mapping units (VaB and VaC) Vian silt loam, 1-3% and 3-5% slopes, have been identified in the project area. Both units include small areas of Stigler and Spiro soils on slopes from 1-5%.

DISCUSSION

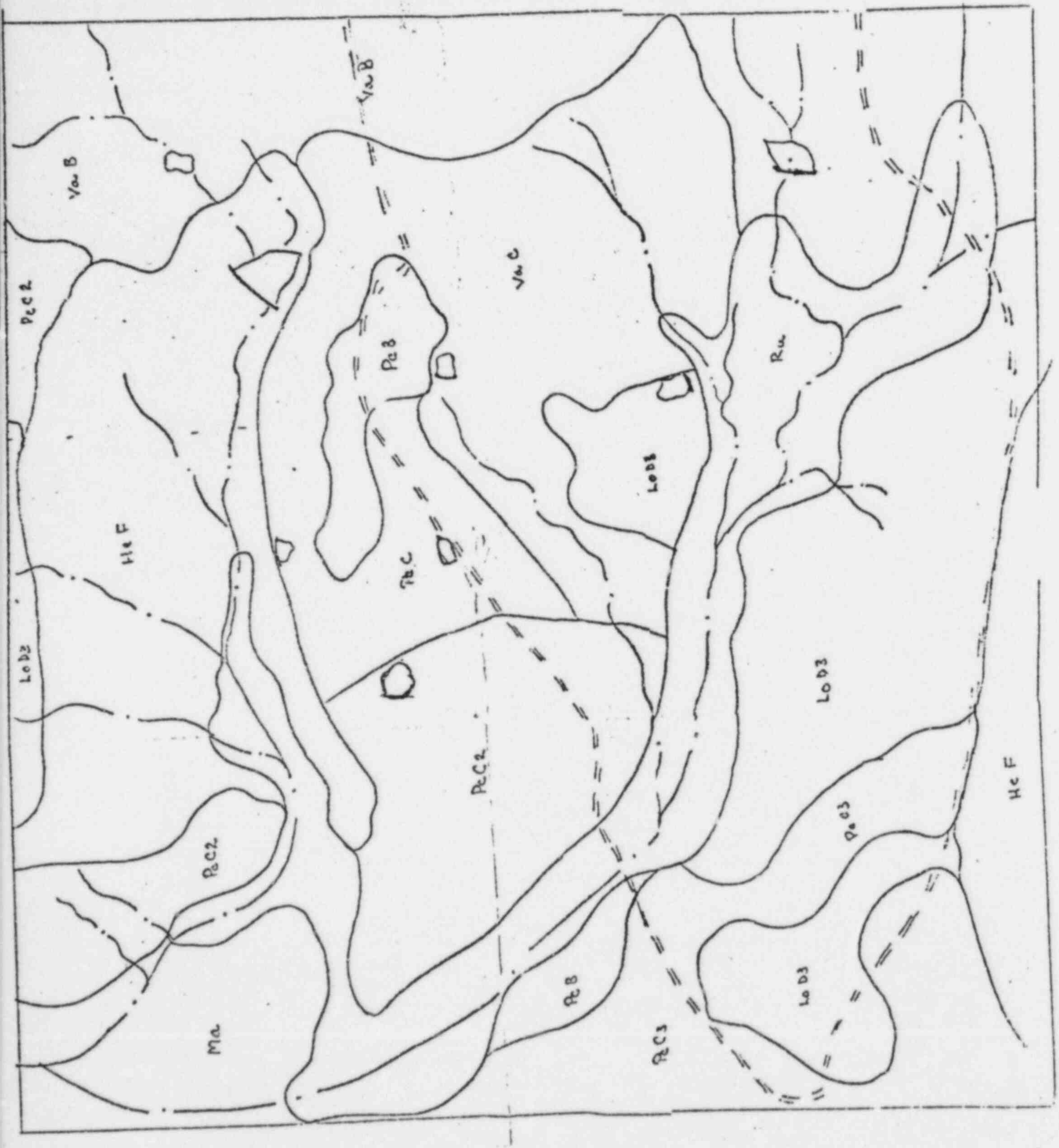
The majority of the soils within the confines of the treatment area of the surveyed portion of land are well suited for raffinate disposal. They are basically deep, loamy soils with very few having layers that would restrict water movement or root growth. The major portion of the marginal land (primarily the timbered upland) are restrictive because of excessive slope and very shallow and shallow soils.

SOME FACTORS FOR RAFFINATE DISPOSAL

Soil	Slope	Permeability of Least Permeable Layer in/hr	Depth to Layer	Other Features
Hector	5-40%	5.0	0-10"	Shallow, strong slope
Linker	5-40%	0.8	12-18"	Shallow, strong slope
Enders	5-40%	0.05	7-14"	Strong slopes
Stigler	2-8%	0.05	18-24"	Slope
Mason	0-2%	0.2	12-20"	
Pickwick	1-3%	0.8	18-25"	
	3-5%	0.8	15-20"	
	2-5%	0.8	5-10"	
Rosebloom	0-10%	<0.05	20-25"	Flooding, water table
Ennis	0-10%	0.8	30-40"	Flooding
Spiro	2-5%	0.8	12-18"	
Vian	1-3%	0.2	25-30"	
	3-5%	0.2	18-25"	

SOIL MAP LEDGEND

Map Symbol	Mapping Unit
HeF	Hector, Linker-Enders complex, 5-40% slopes
LoD3	Linker & Stigler Soils, 2-8% slope, severely eroded
Ma	Mason Silt Loam
PcB	Pickwick Loam, 1-3% slopes
PcC	Pickwick Loam, 3-5% slopes
PcC2	Pickwick Loam, 2-5% slopes, eroded
Ru	Rosebloom and Ennis Soils, broken
SnC	Spiro Silt Loam, 2-5% slopes
VaB	Vian Silt Loam, 1-3% slopes
VaC	Vian Silt Loam, 3-5% slopes



Preliminary Soil Map - Raffinate Treatment Area.

The better soils should handle very large quantities of raffinate without causing losses either due to runoff or percolation through the soil. Any accumulation of nitrates or other material applied with the raffinate should be observed at or near the surface of the soil and extending into the least permeable layer for one foot or less.

Vegetation

Following initial field observations of the application area by Dr. Tucker, OSU, the original plan of establishing five permanent subplots in each province was modified. Due to the diversity of vegetation in certain provinces (i.e. 3 and 4a), five subplots would not be adequate to measure vegetation composition. In open areas (i.e. 4 and 5), bermudagrass was dominant and areas were relatively homogeneous. Because one of the major objectives of the vegetation study was to ascertain the effects of raffinate treatment on floral composition, seven permanent plots were established on selected sites which would encompass swards of the predominate species of the study area (see Figure 1). Six of the permanent plots were 65 x 65 feet and one was a 20 x 20 feet persimmon grove. The principal vegetation in each permanent plot was identified and counts made by use of a modified point frame. These counts were checked by dividing the plots into eight equal portions and the percentage of each species estimated. Groundcover was based upon a visual rating after several measurements from one square yard areas within subplots were made. The preinventory vegetation sampling was conducted during June and post-inventory completed September 29, 1977.

Species composition (both pre and post inventory) from the seven permanent flora sites are given below:

FLORA SITE 1 - PROVINCE 1

Basically Fescue - lespedeza with invasion of broomsedge and bermudagrass.

Basal ground cover: 90% 80%

Composition Specie	Preinventory % of Sward	Post-inventory % of Sward
Fescue	33	10
Sericea lespedeza	25	--
Broomseage	15	10
Lanceleaf Ragweed	10	20
Silverleaf Nightshade	5	--
Bermudagrass	5	30
Leadplant	2	--
Foxtail	2	13
Johnsongrass	1	17
Others	2	--

FLORA SITE 2 - PROVINCE 4a

Basically an open area of a previously cultivated field allowed to return to native species after having been sprigged to bermudagrass.

Basal ground cover: 70% 95%

Composition Specie	Preinventory % of Sward	Post-inventory % of Sward
Bermudagrass	25	97
Korean lespedeza	10	--
Iron Weed	10	--
Winter annual grass (Cheat-grass, Little Barley, Brome)	20	--
Persimmon sprouts	5	1
Western Ragweed	5	--
Bracted Plankton	3	--
Others	22	2

FLORA SITE 3 - PROVINCE 3

Native Grass - Winged Elm - Blackberry

Basal ground cover:	80%	80%
Composition:	Preinventory	Post-inventory
Specie	% of Sward	% of Sward
Native grasses (Big & Little Bluestem, Indiangrass, Switchgrass)	70	70
Blackberry	5	10
Winged Elm 20 small seedling, clump of 4 Winged elms, 1 holly in NE corner	1C	10
Dallasgrass	5	5
Others (no bermudagrass present)	10	5

FLORA SITE 4 - PROVINCE 3

Native Grass - Green Briar

Basal ground cover:	70%	
Composition:	Preinventory	Post-inventory
Specie	% of Sward	% of Sward
Green Briars (15 x 20" Briar patch) Composition within patch 50%	30	31
Bluestems Within subpatch 30%	50	54
Blackberries	5	4
Winged Elm	2	3
Others (1 persimmon 5 ft. tall)	8	8

FLORA SITE 5 - PROVINCE 3

Persimmon clump (20 x 20')

32 trees over 1" in diameter (20 - 25' tall)

Basal ground cover:	60%	100%
Composition beneath trees:	Preinventory	Post-inventory
Specie	% of Sward	% of Sward
Sericea lespedeza	30	30
Bermudagrass	30	10*
Bluestem	30	50
Others	10	10

4 reference trees were marked.

*Note: Bermuda decreased due to increased competition from bluestem.

FLORA SITE 6 - PROVINCE 4

Open area - Basically bermudagrass native grass pasture (once cultivated).

Basal ground cover:	65%	100%
Composition:	Preinventory	Post-inventory
Specie	% of Sward	% of Sward
Bermudagrass	40	97
Winter annual grasses (Bromes, cheatgrass)	30	--
Lanceleaf ragweed	10	--
Korean lespedeza	5	--
Big Bluestem	3	--
Dallasgrass	3	--
Foxtail	2	1
Silver leaf Nightshade	2	--
Crabgrass	1	1
Others (Iron Weed, Leadplant, Bracted Plankton)	4	1

FLORA SITE 7 - PROVINCE 5

A cultivated field with invaded common bermudagrass -
Had been plowed in early spring and seeded to NK-37 bermudagrass.

Basal ground cover:	June 2, 15%	Sept. 29, 100%
Composition:	Preinventory	Post-inventory
Specie	% of Sward	% of Sward
Bermudagrass	96	100
Crabgrass	2	--
Others (Nightshade, Nettles)	2	--

In addition to the permanent flora sites, certain trees representing key species were permanently marked for ascertaining effects of treatment on growth and chemical composition.

Species marked included:

Reference trees	Trunk Circumference*	Estimated Heights (feet)
Persimmon #1	16	15
Persimmon #2	12	15
Winged Elm	18½	22
Post Oak	49	40
Water Oak #1	31	40
Water Oak #2	29	40
Walnut	45	30
Eastern Red Cedar	18	15
Black Locust #1	14	20
Black Locust #2	12	15
Honey Locust	7	15
Hickory	22	30
American Elm	40	45

*Measured by 4½ feet above ground level on uphill side.

The permanent flora plots and reference trees will give the change in sward composition due to treatment and the effects of treatment on individual trees. Uptake of various elements can also be obtained. A lack of control trees (without treatment) within the area will not allow for direct comparisons of treated and untreated species but it is felt that the baseline test samples can be used for that purpose.

III. Treatment

Prior to the first raffinate treatment, soil samples were collected and tests conducted to determine amounts of limestone, phosphate, and potash required. Ra-226, thorium (results not yet available), and uranium addition from these commercial nutrient sources were also determined.

Following equipment maintenance, storage and sampling, applications of treated raffinate began on June 7, 1977. The schedule of treated raffinate applications to the test area and total gallons applied during each period is provided in Table 1.

Provinces were treated in sequence during each application period and this allowed vegetation to recover prior to receiving subsequent treatment. Difficulty was encountered with contract sprayer equipment malfunctions and a second sprayer unit (K-M owned) was placed in operation July 25. As two vehicles were in operation after this date, this accounts for the overlapping of application number 3 and 4 during August.

Nitrogen content of treated raffinate averaged higher (50.4 g.N/l) than in previous test programs and only five treatments were necessary to provide the prescribed amounts. As the fifth (final) application was completed prior to the end of the growing season, this insured uptake of nutrients by plants prior to the winter dormancy period.

Table 1. SCHEDULE OF TREATED RAFFINATE APPLICATIONS TO THE TEST AREA. - 1977

Period	Application #	Total Gallons Applied
6/7 - 6/29	1	75,000
6/29 - 7/13	2	94,000
8/3 - 8/17	3	73,000
8/15 - 8/26	4	67,000
8/31 - 9/16	5	64,000
		373,000

Provinces 1 and 2 received one raffinate application following timber clearing in preparation for bermuda sprigging and one application in preparation for subsequent seeding to rye and fescue. Windrowed timber (piled debris) in these areas received three applications of treated raffinate to enhance breakdown of accumulated organic matter.

Final test area configuration, amounts of commercial fertilizers and treated raffinate applied, and results of radionuclide analyses are summarized in Table 2. Radionuclide addition to the test area from combined commercical fertilizer sources (limestone, phosphate, and potash), were 285 times greater for Radium and 13 times greater for Uranium than additions from treated raffinate.

IV. Monitoring

Raffinate Testing

The average composition of treated raffinate applied to the test area is presented in Table 3. Values represent averages of bulk storage tank analyses (10,000 gal). In addition, composite samples from every third sprayer tank (1000 gal) were collected for each of the five treatments to the test area (Table 3).

Vegetation-Soils

Vegetation samples were collected from each province in June and September 1977. Samples of the major species were collected for chemical analyses and results will be reported in the completion report. For the post-inventory, pasture grasses were collected from three - one sq. yard locations in provinces 4a, 4 and 5. Blackberry and bramble samples were collected near permanent flora site 3. Leaves from the upper and outer branches of the permanently marked reference trees were obtained. These included Persimmon, winged elm, American elm, post oak, walnut, Pecan, Black Locust, Hickory and Eastern Red Cedar.

Table 2. SUMMARY OF 1977 TEST PROGRAM

DESCRIPTION	Province #1	Province #2	Province #3	Province #4	Province #4a	Province #5	TOTALS
Type Ground Cover	Cleared Timber	Cleared Timber	Woodland	Grassland	Grassland	Grassland	12% Cleared 27% Timber 61% Grass
Area in Acres	11.3	6.2	41.0	52.2	11.2	27.1	149.0 A
Fraction of Total Acres (%)	7.6	4.2	27.5	35.0	7.5	18.2	100.0 %
Total Limestone, 70% $CaCO_3$ (tons)	48.6	26.7	82.0	104.4	22.2	89.4	373.3 tons
Total Phosphate/Potash, 36% P_2O_5/60% K_2O	0.98/0.45	0.54/0.25	3.57/3.40	4.54/4.33	0.97/0.93	2.36/2.25	13.0/11.6 tons
Nitrogen Proposed lbs/Acre	1000	1000	1000	1000	1000	1500	----
Total (tons) N_2/Province	5.6	3.1	20.5	26.1	5.6	20.3	81.2 tons
Nitrogen Applied lbs/Acre	508	502	994	1028	1181	1561	----
Total N_2 tons/Province	2.9	1.6	16.4	26.3	6.5	21.2	74.8 tons
Vol. of Raff., (Thous. Gals.)	14.0	7.5	94.0	126.0	32.0	99.5	373.0
Ra-226/Limestone/ Province (μCi)	22.1	15.5	42.2	53.6	11.5	32.0	176.9 μCi
Ra-226/Phos.-Potash Province (μCi)	6.7	4.7	30.2	38.3	8.2	20.0	108.1 μCi
Ra-226/Raffinate/ Province (μCi)	0.036	0.019	0.248	0.462	0.040	0.214	0.999 μCi
Ra-226/Total/Province (μCi)	28.8	20.2	72.7	92.4	19.7	52.2	286.0 μCi
Uranium/Limestone Province (grams)	5.9	4.1	11.2	14.2	3.0	12.2	50.3 grams

Table 2. SUMMARY OF 1977 TEST PROGRAM (cont'd)

DESCRIPTION	Province #1	Province #2	Province #3	Province #4	Province #4a	Province #5	TOTALS
Uranium/Phos.-Potash/ Province (grams)	160.8	117.4	759.5	965.5	20.73	561.5	2772 grams
Uranium/Raffinate/ Province (grams)	4.1	2.4	42.1	93.7	17.0	56.0	215.3 grams
Uranium/Total/ Province (grams)	170.7	123.9	812.8	1073.4	227.4	629.7	3037.8 grams

Table 3. AVERAGE COMPOSITION OF TREATED RAFFINATE APPLIED TO THE TEST AREA - 1977.

	Parameter							
	Radium ^{226}Ra pCi/l	Uranium U μgs/l	Boron B mg/l	Copper Cu mg/l	Molybdenum Mo mg/l	Nickel Ni mg/l	total N (NO_3+NH_3) g/l	pH
Average of Bulk Storage Tanks (10,000 gal)	.698	145.7	3.2	6.3	56.6	21.5	50.4	7.1
Average of Sprayer Tanks (1000 gal)	.961	160.2	2.9	5.4	48.1	20.3	50.4	7.1

For pasture grasses, total production was obtained by combining the three-one sq. yard samples and drying in a forced air oven at 140°F until constant weight was achieved. Vegetation samples were ground to pass a 100 mesh stainless sieve in a Wiley micro-mill and submitted for analyses.

Soil samples were also collected during June and September for chemical analyses. Soil samples were collected from provinces 1, 3, 4, 4a and 5. For post-inventory, one surface sample composite (0-6") was obtained by collecting 50 cores at random throughout the province. This sample will be representative of the entire province and will reflect fertility status of the province. Samples at 6 inch increments were taken from an area representing the most predominate soil of the province. These samples will show accumulation, if any, of chemical elements in the soil profile to a depth of 42 inches. Each 6 inch increment was separated for analyses. After air drying to equilibrium in an oven at 100°F, soil samples were rolled to break clods and sieved to remove pebbles and large vegetative material. They were then passed through a mechanical divider and submitted for analysis.

Water

Soil Water

Due to extremely dry conditions during the early part of the 1977 growing season, soil moisture samples from sorption cups could not be obtained. Following heavy rainfall periods in July, the sampling schedule was resumed and enough soil moisture obtained to conduct limited chemical analyses.

Groundwater monitor wells were sampled during application periods and samples collected from 7-17 days following commencement of each raffinate treatment.

Surface Runoff

Heavy rains and a leak around the drain pipe in the runoff contol dam resulted

in failure to the structure on June 28. Water remaining in the retention pond was sampled and found within limits specified in the NRC submittal (<.2 mg/l NO_3-N; <.2 mg/l NH_3-N; .364 pCi/l Ra-226). Application of treated raffinate was suspended and repairs to the runoff control dam completed on July 3.

A 2.5 inch rain on July 25, produced considerable runoff and the retention pond and control dam filled to about 50% capacity and retained all runoff water. Nitrate levels in this runoff water were 1.8 mg/l N or 70% of the NPDES average limit and .446 pCi/l Ra-226.

A 1.5 inch rain July 30, produced little additional runoff and the control dam continued to function properly. However, runoff produced from a 1.5 inch rain received August 23, contained 29 mg/l NO_3-N; 1.001 pCi/l Ra-226. Irrigation piping was laid from the runoff control pond and water recycled to Area 5. A two inch rain on August 28, yielded runoff water with an average of 30 mg/l NO_3-N. This runoff water was also recycled to Area 5.

As timber clearing was completed July 22 in area 1 and 2, nitrate values in surface runoff waters after this date were due to loss of vegetation in these areas and application of treated raffinate for seedbed preparation and to windrows (piled debris). Raffinate treatment to windrows was terminated when elevated nitrate values were recorded in surface runoff water samples (8/23/77).

V Environmental Impacts

As expected, raffinate treatment to established grasslands (4, 4a and 5) effected gradual displacement of broad leaf annuals and summer annual grasses to bermudagrass. Bermudagrass dominated in these areas forming almost monotopic stands and achieved high rates of production. Broad leaf annuals like iron-

weed were severely burned back by initial raffinate treatments but produced sprouts later in the growing season. A portion of Area 5 which had been plowed prior to raffinate treatment exhibited an increase in basal groundcover from 15% in Jun to 100% in September. Area 5 received 1500 lbs N/acre and this dosage appeared to inhibit production somewhat toward the end of the treatment program. Areas 4 and 4a (1000 lbs N/acre) exhibited continued tolerance to this application rate throughout the treatment sequence.

Most cleared pathways (12 ft wide at 80 ft intervals) in Area 3 had groundcover well established by the end of the growing season. Light timber and shrub cover in Area 3 showed tolerance to raffinate treatments and tree and shrub foliage was damaged only at lower levels where fertilizer application actually wetted leaves.

Newly cleared areas developed good fall and winter cover (Rye and fescue) but had minimum of summer cover (bermudagrass). Timber clearing in areas 1 and 2 and subsequent application of treated raffinate for seedbed preparation and to windrows was undoubtedly responsible for nitrate levels present in surface runoff samples during August. This pattern is similar to other observations conducted on disturbed forest systems. In a series of watersheds in a New Hampshire forest, a balance sheet of input and outflow of materials in the system was developed. After a few years of undisturbed operation, one watershed was logged with as little disturbance as possible. Trees were cut but left on the forest floor and herbicide used to prevent revegetation. After two years, nitrate levels increased from .9 to 53 mg/l in surface runoff. Increased surface runoff rates (up 40%) and reduced root absorption caused by plant removal decreased the overall removal of minerals from materials leached and resulted in substantial loss of nitrate from the system.[1]

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[1] Bormann, F.H. and G.E. Likens, D.W. Fisher, and R.S. Pierce. 1968. Nutrient Loss Accelerated by Clear-cutting of Forest Ecosystem. Science 159: pp 882-84.

Additional surface runoff water sampling was conducted on the raffinate treatment area during November. A 1.54 inch rain received November 1, 1977, yielded 6.8 mg/l nitrate and <.2 mg/l ammonia in surface runoff waters at the dam retention pond. This reduction in nitrate levels in surface runoff from the treatment area was probably related to development of good fall groundcover (Rye and fescue) in timber cleared areas by early October coupled with termination of raffinate treatment well before the end of the growing season. This enabled additional nutrient uptake and storage in developing plant biomass and elminated excess nutrient output from the system.

Because of high nitrogen doses applied, timber clearing on the treatment area, and extremely dry conditions during the early part of the growing season followed by high intensity rainfall periods, the 1977 program illustrates impacts of raffinate fertilizer treatment under extreme conditions. Results indicated that application rates of 1000 lbs N/acre increased plant productivity and were well tolerated, while 1500 lbs N/acre (area 5) appeared to approach saturation dosage for bermudagrass pasture. Vegetation composition changes were greatest in open areas with established cover (4, 4a, 5) and less pronounced in the shrub-grassland type (area 3). Raffinate treatments to recently cleared timber areas resulted in elevated nitrate levels in surface runoff during August, but subsequent runoff water sampling in November indicated that nitrate levels had been reduced.

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