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Tennant Farm Herd Health Investigation
Cattle Team Report

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EPA/DuPont Cattle Team

December 23, 1999

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TABLE OF CONTENTS

Section		Page
1.0.	SUMMARY	4
1.1.	Signatures	5
2.0.	INTRODUCTION	6
3.0.	METHODS	6
3.1.	Cattle Team	6
3.1.1.	members	7
3.1.2.	meetings	7
3.2.	Animal Data	7
3.2.1.	videotapes	8
3.2.2.	diagnostic pathology reports	8
3.2.3.	April 1999 site visit data	11
3.2.4.	miscellaneous data	12
3.2.5.	wildlife	
		12
4.0.	RESULTS	12
4.1.	Cattle	12
4.1.1.	videotapes	14
4.1.2.	diagnostic pathology reports	15
4.1.3.	April 1999 site visit data	15
	a. herd history (4/8/99 interview)	16
	b. physical examination of cattle (4/7/99)	16
	- age, pregnancy status	16
	- body condition scores, girth	16
	- clinical signs	16
	c. clinical pathology	16
	- hematology	16
	- clinical chemistry	17
	- special chemistry	17
	- serology	18
	- parasitology	18
	d. hay and grain analysis	
		19
4.2.	Miscellaneous Data	19
4.3.	Wildlife	19
4.3.1.	videotapes	19
4.3.2.	small mammal data	19
4.3.3.	deer studies	
		20
5.0.	DISCUSSION	20
	- endophyte toxicity	22
	- pinkeye	23
	- malnutrition	

TABLE OF CONTENTS (continued)

Section		Page
5.0.	DISCUSSION (continued)	
	- copper deficiency	23
	- toxicology issues	24
6.0.	RECOMMENDATIONS	24
7.0	CONCLUSION	26
8.0	REFERENCES	26
9.0	GRAPHS	29
	Graph 1: Individual Prolactin Values	30
10.0	FIGURES	31
	Figures 1 and 2: Faceflies	32
	Figure 3: Corneal opacity	33
	Figure 4: Delayed shedding	33
	Figures 5 and 6: Coronitis	34
	Figures 7 and 8: Cattle standing in water	35
11.0	TABLES	36
	Table 1: Review of Tennant Farm Videotapes	37
	Table 2: Individual Animal Data: Clinical Signs	44
	Table 3: Individual Animal Data: Hematology (erythron, platelets)	46
	Table 4: Individual Animal Data: Hematology (leukon), and Special Chemistry	48
	Table 5: Individual Animal Data: Clinical Chemistry	50
	Table 6: Individual Animal Data: Serology and Fecal Exam	52
	Table 7: Tennant Farm Grain and Hay: Nutritional Analysis	54
12.0	APPENDICES	55
	Appendix A: Abbreviated Curriculum Vitae of Cattle Team Members	56
	Appendix B: Diagnostic Pathology Reports (Ohio Dept. Agric.: #4977-97; Michigan Animal Health Diagnostic Lab.: #1792571; Univ. Penn. Lab. of Large Animal Pathol. and Toxicol.: #UP9902702, #9901437)	58
	Appendix C: Dry Run Safety Plan	70
	Appendix D: Figures 1-42 : Photographs of the 42 adult cattle Figures 43-66 : Miscellaneous photographs of the Tennant Farm and cattle.	71
	Appendix E: Herd Health History (April 8, 1999 interview)	106
	Appendix F: Diet Analysis: Computer Software Simulation	109

1.0 SUMMARY

Introduction: The objective of this investigation was to evaluate the health status of Mr. Earl Tennant's cattle herd and determine possible causes of any problems. The investigation included an examination of relevant historical data as well as the collection and evaluation of new data. The investigation terminated in the production of this report, which outlines study findings and makes recommendations to improve herd health.

Methods: The Tennant farm herd health investigation was conducted by a team of six veterinarians with collective experience in bovine diseases, herd health management, toxicology, pathology, and wildlife diseases. In addition to numerous meetings and discussions, the cattle team visited the Tennant Farm on April 7-8, 1999 in order to collect relevant data. The cattle team reviewed historical data (e.g., videotapes, diagnostic laboratory reports) and contemporary data (e.g., clinical examinations, blood tests). Diagnoses and recommendations were based upon the data collected.

Results: The multifaceted disease investigation of the adult cattle in the Tennant beef herd revealed health problems that were related to endophyte toxicity, infectious keratoconjunctivitis (pinkeye), malnutrition, and copper deficiency. Clinical and historical data, with prolactin values of some animals, were consistent with endophyte mycotoxicosis. An examination of videotapes made during the summer months and clinical examinations of previously affected adult animals during the herd visit indicated prolonged severe enzootics of facefly (*Musca autumnalis*) infestation and concomitant pinkeye. Hay analysis, cattle body condition scoring, and an evaluation of the mineral and grain rations fed were consistent with protein-energy malnutrition and macromineral/trace nutrient deficiencies. Earlier laboratory data, clinical signs, and serum testing at the time of the herd visit were indicative of severe copper deficiency in the cattle.

Conclusion: There was conclusive evidence that the Tennant cattle herd was, and continues to be, suffering from four major disease entities, some of which were potentially interrelated: endophyte toxicity (fescue mycotoxicosis), pinkeye, malnutrition, and copper deficiency. As substantiated by the clinical and laboratory findings, and historical data, these four conditions readily account for the chronic herd health problems on the Tennant farm.

The herd health investigation revealed deficiencies in herd management, including poor nutrition, inadequate veterinary care, and lack of fly control. The lack of vaccination and internal parasite control programs did not appear to have a substantial impact on this relatively isolated herd.

Despite an exhaustive review of historical and contemporary herd data, there was no evidence of toxicity associated with chemical contamination of the environment.

1.1 Signatures

Perry L. Habecker
Perry L. Habecker, VMD, Dipl. ACVP

12/23/99
Date

Lisa A. Davis-Heller
Lisa A. Davis-Heller, DVM

12/30/99
Date

Peter G. Moisan
Peter G. Moisan, DVM, Dipl. ACVP, ABVP

12/26/99
Date

Robert J. Munson
Robert J. Munson, VMD

1/3/00
Date

Robert H. Poppenga
Robert H. Poppenga, DVM, PhD, Dipl. ABVT

1-3-00
Date

Greg P. Sykes
Greg P. Sykes, VMD, Dipl. ACVP, ABT

12-23-99
Date

2.0 INTRODUCTION

The objective of this investigation was to evaluate the health status of Mr. Earl Tennant's cattle herd and determine possible causes of any problems. The investigation included an examination of relevant historical data as well as the collection and evaluation of new data. The investigation terminated in the production of this report, which outlines study findings and makes recommendations to improve herd health.

3.0 METHODS

3.1. Cattle Team

3.1.1. Members

The Tennant Farm Herd Health Investigation was assigned to a team of six veterinarians ("cattle team"). The team was constituted to include expertise in bovine diseases, herd health management, toxicology, pathology, and wildlife diseases. Representatives of the DuPont Company (DuPont) selected three members (Drs. Sykes, Davis-Heller, Moisan); representatives of the United States Environmental Protection Agency (EPA) selected three members (Drs. Habecker, Poppenga, Munson). Abbreviated *Curriculum Vitae* of the cattle team members are included in this report (Appendix A).

Cattle Team

Members	Associations
Perry Habecker, VMD, Dipl. ACVP	Chief, Large Animal Pathology, Laboratory of Pathology and Toxicology, Univ. of Penn. School of Veterinary Medicine, New Bolton Center, Kennett Square, PA.
Lisa Davis-Heller, DVM	Private Practitioner, St. Mary's Veterinary Clinic, St. Mary's, WV.
Peter Moisan, DVM, Dipl. ACVP, Dipl. ABVP	Veterinary Pathologist, Rollins Animal Disease Diagnostic Laboratory (state laboratory), Raleigh, NC.
Robert Munson, VMD	Field Investigator, Center for Animal Health and Productivity, Univ. of Penn. School of Veterinary Medicine, Kennett Square, PA.
Robert Poppenga, DVM, PhD, Dipl. ABVT	Chief, Toxicology, Laboratory of Pathology and Toxicology, Univ. of Penn. School of Veterinary Medicine, New Bolton Center, Kennett Square, PA.
Greg Sykes, VMD, Dipl. ACVP, Dipl. ABT	Pathologist, Safety Assessment, DuPont Pharmaceuticals Company, Stine Research Center, Newark, DE.

DVM, VMD = Doctor of Veterinary Medicine

Dipl. ACVP = Diplomate, American College of Veterinary Pathologists

Dipl. ABVP = Diplomate, American Board of Veterinary Practice (Food Animal and Beef Cattle Specialist)

Dipl. ACVT = Diplomate, American College of Veterinary Toxicologists

Dipl. ABT = Diplomate, American Board of Toxicology

At the first meeting of the cattle team (March 9, 1999), Perry Habecker was elected Scientific Leader (i.e., chairman) and Greg Sykes was elected Coordinator. The

chairman and coordinator were instructed to communicate with the "steering committee" leaders, Drs. Sarah Caspar (EPA, Region III) and Ralph Stahl (DuPont Corporate Remediation Group), as needed. This "steering committee" included Drs. Caspar, Stahl, Mike Horne (USFWS), Mark Sprenger (EPA-OERR), and Rudy Valentine (DuPont - Specialities Chemicals toxicologist).

3.1.2. Cattle Team Meetings

The cattle team met formally on four occasions, including the Tennant Farm site visit.

Cattle Team Meetings

Date	Location
March 9, 1999	New Bolton Center, Kennett Square, PA
March 23, 1999	New Bolton Center, Kennett Square, PA
April 7-8, 1999	Tennant Farm, Wood County, WV*
July 28-29, 1999	New Bolton Center, Kennett Square, PA

* including pre-meeting planning session at Holiday Inn, Parkersburg, WV

In addition, several in-person discussions took place at New Bolton Center between and among Drs. Habecker, Munson, Poppenga, and Sykes between March 1999 and the issuance of this report. All cattle team members utilized the telephone, internet email, and US postal systems for pair and group discussions and information sharing.

3.2. Animal Data

3.2.1. Videotapes

Two videotapes were supplied to the cattle team by the steering committee. Each of the tapes was a collection of videotapes made, and narrated, by Mr. Earl Tennant on his farm and the adjacent landfill area. Although the tapes were edited and include material from different seasons, it appeared that these tapes were all produced between 1995 and 1997.

Tennant Farm Videotapes

Tape	Title	Animal Case Numbers
#1	"Tennant Farm: New England, Wood County, WVa - January and February, 1997"	1 - 18
#2	"Dry Run: Harris PC, Wood Co.; Off North Fork of Lee Creek, New England, WVa"	19 - 60

Both of these tapes were viewed, in their entirety, by the cattle team members individually. They were also reviewed at a cattle team meeting on July 28th (Dr. Davis-Heller not present). A total of 60 animal cases, ranging from a dead crayfish to groups of sick cows, were evaluated. Items on the tapes that were not animal related (e.g., water treatment) were noted but not evaluated. Table 1 is a compilation of the relevant animal health data derived from these tapes. This table does not include many assertions and

interpretations, made by the narrator in the tapes, which the team members considered to be incomplete or erroneous.

3.2.2. Diagnostic Pathology Reports

Two pathology reports (Appendix B) were supplied to the cattle team by the steering committee. Both were issued by state animal diagnostic laboratories in response to the submission of dead animals or tissues from the Tennant Farm. These reports were reviewed by the cattle team.

A third pathology report (Appendix B) was produced subsequent to the elective sacrifice of one animal (# 37) on June 10, 1999. The cattle committee decided, at a meeting on May 28, 1999, that it would be informative to have a toxicology screen on tissues from one or two older cows. Mr. Tennant was asked to select one or two of the cattle that he considered to be in the worst condition. He chose to sacrifice cow # 37, a 7-year old red cow that had freshened a few months earlier. This animal was euthanized by gunshot by Mr. Tennant on the farm on June 10, 1999. Mr. Tennant performed the dissection in the presence of Dr. Davis-Heller. Tissues were collected (Dr. Davis-Heller) for histopathology and analytical toxicology.

Individual Animal Pathology Reports

Pathology Report Date	Name of Diagnostic Laboratory	Case Material (case number)
March 10, 1997	Animal Disease Diagnostic Laboratory, Ohio Department of Agriculture, Reynoldsburg, OH	dead 6-month-old bull calf (#4977-97)
March 12, 1997	Animal Health Diagnostic Laboratory, College of Veterinary Medicine, Michigan State University, Lansing MI	tissues 4-year-old Holstein cow (#1792571) tissues 9-year-old Holstein cow (#1792571)
July 5, 1999	Laboratory of Large Animal Pathology and Toxicology, New Bolton Center, University of Pennsylvania, Kennett Square, PA	tissues 7-year-old cow (#UP9902702; UP9901437)

3.2.3. April 1999 Site Visit Data

The cattle team visited the Tennant Farm and adjacent Dry Run landfill site on April 7 and 8, 1999 in order to collect data and biological samples relevant to the herd health investigation. Before proceeding to the site on April 7th, a brief safety meeting was held at the Parkersburg Holiday Inn during which the Dry Run Safety Plan (Appendix C) was reviewed. The 6 cattle team members, 2 of the steering committee members (Caspar, Horne) and 2 USFWS employees were present.

April 7, 1999

The cattle team had planned to inspect the farm and adjacent landfill, view the herd grazing, and interview Mr. Tennant on the afternoon of Wednesday April 7th. However,

due to a misunderstanding. Mr. Tennant had corralled his entire herd on Wednesday morning. When the cattle team and EPA/USFWS personnel arrived at approximately 3:15 PM, the herd had been contained in a small enclosure, without food or water, for several hours. The team therefore elected to conduct the individual animal examinations and specimen collections immediately. A new head-hold restraint device had been installed next to the enclosure to facilitate animal handling. Mr. Earl Tennant and his brother were very helpful in handling the cattle and moving them into the restraint device.

The 41 adult cattle were individually run into the chute, secured with the head hold and a halter, and examined. Each adult (38 cows, 2 bulls, and 1 steer) was given a general physical examination including observation of gross abnormalities, grading of body condition, and estimation of age based on the incisors. Blood was collected by jugular venipuncture (2 red top, 1 green top, and 1 lavender top tubes) from each cow and fecal samples were rectally collected from each adult. Cows were rectally palpated to determine their pregnancy status. All examined adult animals received two ear tags, one with an identification number and one with an impregnated insecticide. One Hereford cow (i.e., the 39th cow, 42nd adult) escaped the chute prior to examination, aging, uterine palpation, blood collection, and ear tagging.

Each adult bovine was individually photographed and identified (Appendix D, photographs 1-42).

Only 1 cow (animal #22) received treatment – a mass, most consistent with a dermoid cyst, was incised and drained (Appendix D, photographs 49-51).

Additional photographs of the farm (Appendix D, photographs 43, 54-58), individual animal "lesions" observed on April 7, 1999 (Appendix D, photographs 44, 48, 52, 53), photographs supplied to the team by Mr. Tennant (Appendix D, photographs 60-65), and a photograph of cattle team and steering committee members (Appendix D, photograph 66) are also included in this report.

Adult Cattle Procedures

physical examination	fecal sample collection
body condition scored	blood collection
age estimation	ear tagged: animal identification
rectal pregnancy examination	ear tagged: insecticide
girth measurement	photographed

Twelve calves were examined as a group. The smaller seven received insecticidal ear tags; the larger five received no ear tags as Mr. Tennant indicated that they were to be sold in the very near future.

Although the cattle team was prepared to do a post-mortem examination on one or more cattle, the team decided that there was no animal sufficiently ill to justify euthanasia and necropsy at the time of the visit.

All animal biological samples (blood and feces) were taken back to New Bolton Center by Dr. Habecker. Blood samples were subjected to hematology, serum chemistry, and serology. Randomly selected fecal samples were subjected to fecal flotation.

The following clinical pathology parameters were evaluated:

Hematology

leukocyte (total and differential) count	*hematocrit
erythrocyte count	*mean corpuscular hemoglobin
hemoglobin concentration	*mean corpuscular hemoglobin concentration
mean corpuscular volume	*red cell distribution width
platelet count	*platelet distribution width
mean platelet volume	

*These parameters were calculated using the measured data.

Serum Chemistry

aspartate aminotransferase	potassium
gamma glutamyl transferase	calcium
creatine kinase	chloride
blood urea nitrogen	magnesium
creatinine	phosphorus
total protein	copper
albumin	selenium
*globulin	pepsinogen
sodium	**prolactin

* globulin was calculated from the measured albumin and total protein data.

** prolactin was measured from blood plasma derived from EDTA tubes (lavender top).

Serology

bovine leukemia virus (e)	epizootic hemorrhagic disease of deer (agid)
bovine virus diarrhea virus (sn)	<i>Mycobacterium paratuberculosis</i> (Johne's) (e)
bovine virus diarrhea virus (mp)	leptospirosis (sn)
blue tongue virus (agid)	brucellosis (sn)

(e) = elisa test; (sn) = serum neutralization test; (mp) = microplate assay; (agid) = agarose gel immunodiffusion test

April 8, 1999

Three members of the cattle team (Drs. Moisan, Munson, and Davis-Heller) met with Mr. Earl Tennant and recorded his recollection of the 1998-1999 herd health history (Appendix E).

Drs. Caspar and Horne gave all of the cattle team members a driving tour of the property between the Tennant barn and the Dry Run landfill, including a drive within the landfill. During those two trips, the team members were able to see the connecting pastures.

adjacent creeks, neighboring cattle grazing, and wildlife. The landfill was open and being utilized at the time of the site visit.

While on site, the cattle team made general observations regarding the environment, including the flora, fauna, and man-made structures. Core samples of three large round hay bales were collected (3 samples/bale) from bales in the barn yard. Mr. Tennant gave the team some receipts (dates ranged from 2/98 to 12/98) from complete, mixed feed, and mineral supplement he had purchased.

All plant biological samples (baled hay core samples and grain sample) were subjected to nutritional analysis by the Forage Testing Laboratory of the North Carolina Department of Agriculture (Table 7). These data were used in an Excel spreadsheet program (CNCPS v 3.1) from Cornell University to evaluate the diets in two cow models under two feeding situations (Appendix F, models 1-4).

The following nutritional parameters were evaluated:

Hay and Grain Analysis

dry matter	magnesium
crude protein	sulphur
unavailable protein	potassium
adjusted crude protein	copper
acid detergent fiber	iron
total digestible nitrogen	manganese
NE (lactation)	zinc
calcium	nitrate ion
phosphorus	selenium
sodium	

3.2.4. Miscellaneous Data

During the site visit in April, Mr. Tennant was asked to notify Dr. Lisa Davis-Heller or Dr. Sarah Caspar if there were any future signs of disease problems in his herd. The team wished to collect whatever data might be relevant to their assessment of the health status of the Tennant herd.

Between April 8 and December 23, 1999, Mr. Tennant consulted twice with Dr. Davis-Heller. Subsequent to notifying Dr. Caspar of a newborn calf which was born with a "cloudy eye", Mr. Tennant brought the calf to Dr. Davis-Heller's clinic (April 21, 1999). Dr. Davis-Heller examined the calf and made a diagnosis. Mr. Tennant left with the calf. On May 26, 1999, Dr. Davis-Heller examined cow #30 for a lump under the right mandible.

3.2.5. Wildlife

EPA and DuPont each sponsored environmental studies that included the trapping of small mammals in the grazing fields of Mr. Tennant's cattle. These reports were supplied to the cattle team by the steering committee. The data included in these reports, as it relates to small mammal pathology, were evaluated by the cattle team.

Small Mammal Studies

Report Date	Report Title	Animal Data Section
November, 1997 (draft)	Dry Run Creek: Washington, Wood County, West Virginia. USEPA Environmental Response Team	Table 39: Results of Histopathology for the Meadow Vole
December 3, 1998 (letter)	Small Mammal Trapping Effort; Dry Run Landfill, Washington, WV (URS Greiner Woodward Clyde study)	Table 1: Data Summary, Small Mammal Investigation

The cattle team was also made aware of periodic deer reproduction surveys conducted by Dr. Crum and associates of the West Virginia Department of Natural Resources (WV DNR) in the Dry Run area, however no reports were available.

4.0 RESULTS

4.1. Cattle

4.1.1. Videotapes (Table 1)

Two videotapes of several hours duration were reviewed. Forty cattle scenes and 20 wildlife scenes were presented, depicting numerous lesions. The individual scenes (i.e., cases), along with the cattle team's diagnosis/comment, are presented in Table 1 in the order in which they were presented in the videotapes. The herd health problems identified in these videos were summarized as follows:

1. Keratitis: Corneal ulcers, scars and opacities, as well as blepharospasm, were observed in many cattle. These were all considered to be manifestations of "pinkeye", an infectious keratoconjunctivitis caused by bacteria such as *Moraxella bovis*. The facefly (*Musca autumnalis*) problem observed in these videos and the lack of effective fly control were consistent with the diagnosis of severe "pinkeye" in these cattle. Affected young and adult cattle were observed to have 2-3 to 25-50 or more faceflies feeding at the medial canthus of each eye and on the lacrimal secretions. Figures 1 and 2 are prints from videotape #2, illustrating the facefly problem on a calf and her dam, respectively. Both of these animals were blind from chronic keratoconjunctivitis. Figure 3 (videotape #2) demonstrates an early central corneal ulcer on the left eye of a calf; faceflies are seen by the lower eyelid.

2. Hair loss, neck and tail: The cervical alopecia was most consistent with a lice problem. The alopecia observed on the tails of some cattle (e.g., loss of "switch") may also have been due to lice, or may have been related to fescue mycotoxicity.
3. Poor shedding of hair coats: This clinical sign, most prominent in the late spring and summer segments of the videotapes, is consistent with multiple nutritional deficiencies as well as fescue mycotoxicosis. Figure 4 demonstrates a cow from videotape #2 that was described by Mr. Tennant as having delayed shedding of the winter coat.
4. Hair depigmentation: The discoloration of the cattle hair coats is a change most often associated with a nutritional deficiency, and is especially common in cases of copper deficiency.
5. Coronitis: Alopecia and erythema above the coronary band may be seen with fescue mycotoxicosis, mechanical trauma, or as a non-specific dermatitis. Figures 5 and 6 (videotape #2) are representative of the erythematous foot lesions observed by Mr. Tennant in many of his cattle. Figures 7 and 8 (videotape #2) demonstrate the cattle's preference for standing in the water when these lesions were present. Fescue mycotoxicosis ("fescue foot") was considered the most likely diagnosis of this condition.
6. "Hunched up" or painful stance: This is a clinical sign often associated with abdominal or foot pain, but has been specifically described as a manifestation of the fescue endophyte toxicity complex.
7. Thin body condition: Poor body condition is a non-specific finding and the cases presented most likely represented different etiologies. The emaciated dead calf with serous atrophy appears to have starved while others appear to have had diarrhea or mastication problems. Considering the other findings in this herd (e.g., feed analysis), nutritional insufficiency (protein-energy malnutrition) was also a likely contributing factor to poor body condition.

Some findings described in these tapes were difficult to evaluate by video although they probably were real. For example, the described "lumps" in a cow udder (case # 54) was difficult to see but would be considered an incidental finding in any case. A few cattle were described as "hunched-up" or "humped-up" (cases # 1, 5, 17) – these may have been related to lameness, hardware disease (traumatic reticulopericarditis), fescue mycotoxicosis, or other condition. An individual cow that was slobbering, losing cud, and urinating (case # 13) may also have had hardware disease, although the diagnosis was not clear. Another individual cow (case # 45) which was panting was consistent with fescue mycotoxicosis (i.e., "summer fescue" hyperthermia), although this presentation was certainly non-specific.

4.1.2. Diagnostic Pathology Reports (Appendix B)

Only four of Mr. Tennant's cattle were submitted for post-mortem diagnostic evaluation of some type. The most significant finding was moderate to marked copper deficiency in the three cows analyzed for heavy metals. Keratitis was observed in the only animal that was formally necropsied. This 6-month old bull calf apparently died from winter starvation (i.e., negative energy balance or protein-energy malnutrition) complicated by untreated intestinal coccidiosis. These reports are included in Appendix B; summaries are presented below:

- a. Dead 6-month old bull calf submitted to the Animal Disease Diagnostic Laboratory, Ohio Department of Agriculture, Reynoldsburg, OH on 2/27/97; Laboratory report dated 3-10-97 (Appendix B)

History:	6-month old bull calf; underweight; diarrhea for one month; received no medication; corneal opacities; died.
Gross diagnosis:	Emaciation with serous atrophy of fat Intestinal parasitism (trichuriasis)
Histopathologic diagnosis:	Enteric coccidiosis Keratitis, moderate, chronic, focally extensive

- b. Tissues from a 4-year old Holstein cow submitted to the Animal Health Diagnostic Laboratory, College of Veterinary Medicine, Michigan State University, Lansing MI on 3/4/97; Laboratory report dated 3-12-97 (Appendix B)

History:	4-year old Holstein cow; died 2-18-97; dissected by owner; tissues submitted by EPA
Heavy metal screen:	Copper deficiency in liver (1.9 ppm vs. 25-150 reference range) and kidney (2.37 ppm vs. 4 - 6 ppm reference range). Manganese was marginally low in liver; cadmium was slightly increased in the kidney. No heavy metals found in urine (urine fluoride was 6.6 ug/ml)[reference range: toxic if ≥ 14 $\mu\text{g/mL}$]

- c. Tissues from a 9-year old Holstein cow submitted to the Animal Health Diagnostic Laboratory, College of Veterinary Medicine, Michigan State University, Lansing MI on 3/4/97; Laboratory report dated 3-12-97 (Appendix B)

History:	9-year old Holstein cow; died 3-2-97; dissected by owner; tissues submitted by EPA
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Histopathologic diagnosis: (only heart, liver, and kidneys submitted: autolysis and freeze/thaw artifact)
Myocardial sarcocysts

Heavy metal screen: Copper deficiency in liver (2.03 ppm vs. 25-150 reference range) and kidney (2.33 ppm vs. 4 – 6 ppm reference range).
Manganese was marginally low in liver; iron was elevated in the liver; cadmium was slightly increased in the kidney.
Urine heavy metals were normal (urine fluoride was 5.55 ug/ml)[reference range: toxic if $\geq 14 \mu\text{g/mL}$]

Clinical pathology: No significant findings

d. Tissues from a 7-year old red cow (euthanized on 6/10/99 and dissected by Mr. Tennant) submitted to the Laboratory of Large Animal Pathology and Toxicology, School of Veterinary Medicine, University of Pennsylvania, Kennett Square, PA on 6/27/99; Laboratory report dated 7-5-99 (Appendix B)

History: 7-year old red cow; euthanized 6-10-99; dissected by owner; tissues submitted by Dr. Davis-Heller.

Histopathologic diagnosis: Enteric lesions of minimal significance (forestomach abscesses; intestinal coccidiosis; myocardial sarcocysts).

Heavy metal screen: Copper deficiency in liver (7.71 ppm vs. 25-150 reference range).

4.1.3. April 1999 Site Visit Data

a. Herd History (Appendix E)

The herd history (Appendix E) was based on Mr. Tennant's recollections during the interview on April 8, 1999. A written record of herd health was conspicuously absent. Much of this can be attributed to the lack of outside intervention. There is no record of veterinary care or consultation with an animal nutritionist. Minimal medications have been used on these animals, and there has been no use of vaccines or modern dewormers. Except for the few animals noted in this document (see Diagnostic Pathology Reports, above), no diagnostic laboratory tests were done on dead animals. The level of cattle herd management has not changed since the installation of the landfill.

b. Physical Examination (Table 2)Age, Pregnancy Status

On April 7, 1999, the cattle team examined 41 animals, including 38 adult cows, 2 adult bulls, and 1 adult steer (Table 2). Estimated ages for the adult cows ranged from 4 to greater than 9 years. This is a herd of aged cattle; 32 of the 38 cows were estimated to be older than 9 years. Twenty-seven (27/38) cows were pregnant.

Body Condition Scores

Body condition scores (BCS) were based on a 1-9 scale. Scores ranged from 2 to 7; the average score was 3.5 (3=thin, 4=borderline, 5-7 is considered optimum).

Clinical Signs

Haircoat abnormalities were evident in 9 of the 41 cattle. One animal had an epidermal inclusion cyst that was lanced and emptied. Mammary gland lumps, consistent with chronic mastitis, were interpreted as abscesses or accumulations of fibrous connective (scar) tissue. Rectal examination of one cow suggested the presence of intra-abdominal fat necrosis.

c. Clinical Pathology (Tables 3 – 6; Graph 1)Hematology

Erythron (Table 3): Red blood cell indices were generally in the low-normal range. No animals were considered anemic.

Leukon (Table 4): The total white blood cell counts were within the normal range. Differential cell counts were considered invalid due to the 36 hour delay between collection and testing.

Clinical chemistry (Table 5)

Most electrolyte values were in the high-normal to slightly elevated range, consistent with mild dehydration. Since the cattle were penned during the daylight hours of April 7, which was unseasonably warm, and had no access to water, clinical dehydration was not unexpected. Dehydration is also the most likely explanation for the elevated creatinine in 40/41 cattle.

Most (27/41) of the cattle had elevated total protein, which also correlates highly with a diagnosis of dehydration (total protein = globulin fraction + albumin fraction). In all cattle (41/41) the globulin fraction was elevated while the albumin fraction was within the reference range.

Gamma glutamyltransferase (GGT), a sensitive indicator of active liver disease, was consistently within the normal reference range. Creatine kinase (CK), an indicator of muscle necrosis, was also normal in all of the cattle. However, aspartate aminotransferase (AST), a less sensitive indicator of liver and muscle degeneration, was minimally elevated in 33/41 cattle. This might be from leukocyte dissolution, the result of the 36 hour interval between blood collection and testing.

Special chemistry

Prolactin: Plasma prolactin levels (Table 4 and Graph 1) were significantly depressed. According to the testing laboratory (Dr. Neal Schrick, University of Tennessee), an average prolactin level for cattle on fescue-free pasture (for April) was 171.6 micrograms/liter (ng/mL) (i.e., reference mean = 171.6 ng/mL). The average of the 41 Tennant samples was 110.1 ng/mL and 36/41 of the Tennant cattle were below the reference mean (171.6 ng/mL). In contrast, an average prolactin level for cattle on endophyte-infected fescue (simulated by ergotamine tartrate administration) was 105.8 ng/mL (data from Dr. Schrick). This average was similar to the Tennant herd average (110.1 ng/mL) and 24/41 of the cattle were below this reference level (105.8 ng/mL). According to Dr. Schrick, these findings were highly supportive of endophyte toxicity in the Tennant herd.

Copper: Blood copper levels were in the deficient range for 26 of 41 animals; one copper assay was below the limit of detection.

Selenium: Blood selenium levels were normal for 41 of 41 cattle.

Pepsinogen: Pepsinogen, a blood enzyme indicator of parasite damage to the abomasum, was measured in 10 cows, one steer and one bull. All values were within the normal reference range. These data supported the conclusion that abomasal ostertagiasis was not a problem in adult cattle in this herd.

Serology (Table 6)

BLV (Bovine Leukemia Virus)	1/41 positive
Johne's (<i>Mycobacterium paratuberculosis</i> antigen)	1/14 positive
Brucella	0/41
BVD (Bovine Virus Diarrhea antigen)	2/41 positive
BVD Microplate Assay (viremia detection)	0/41
Bluetongue	0/41
Leptospira interrogans (5 subvarieties)	3/41 positive
EHD type 2 (Epizootic Hemorrhagic Disease of deer)	2/12 positive

None of the serology values suggested a herd-wide problem. Positive titers for BVD and Leptospira might reflect residual vaccination titers in purchased animals or natural exposure to these diseases. The discovery of two positive EHD titers was evidence that this disease has been in the local deer population.

Parasitology

Routine fecal flotation (Table 4) revealed parasite ova in 11 of 14 randomly selected fecal samples. The magnitude of ova shedding could be categorized as rare to moderate. Parasite groups included coccidia, tapeworms, and strongyle-type nematodes. Intestinal parasitism was not considered to be a major herd problem in the adult cattle. The shedding of small numbers of oocysts and helminth ova is expected of mature cattle.

d. Hay and Grain Analysis (Table 7)

During the cattle team's visit to the Tennant farm (4/8/99), Mr. Tennant was interviewed regarding herd feeding practices. Three large round bales of hay in the barnyard, identified as representative of the herd's forage, were visually inspected and core samples (3/bale) were collected for analysis. This forage (i.e., hay, grass/fescue) was fed *ad libitum*.

During the site visit, forage quality was subjectively evaluated as poor. The fiber level of the hay appeared to be high and forage analysis (Table 7) later substantiated that observation. Fiber levels of forage play an important role in determining how much of a feed can be consumed. Dry matter intake (DMI) is inversely related to fiber levels.

According to Mr. Tennant, mature animals, on the Tennant farm, were also fed five pounds per head per day of a grain mix composed of dry ear corn, soybean meal, and minerals (rate could not be validated, despite the existence of grain receipts). A sample of this feed was taken and analyzed.

An Excel spreadsheet program (CNCPS v 3.1) from Cornell University was used to evaluate the diets. Using the forage and grain nutritional analysis conducted by the Forage Testing Laboratory of the North Carolina Department of Agriculture (Table 7), two models for mature cows (early lactation and dry pregnant) were selected to examine the current feeding program (Appendix F).

According to the computer models, a cow in early lactation (model #1) in the spring of 1999 fed five pounds of this grain and free choice hay was in severe negative energy balance (72.5% of requirement) and less severe protein deficiency (90.9% of requirement). The limited nutrients available would have a negative impact on milk production, persistency of production, and calf growth. A cow under this feeding system would require 2.4 times the corn currently being fed to be isocaloric (model #2). Similarly, a dry pregnant cow (model #3) in the same feeding system would also be in negative energy balance (75.2% of requirement) but not deficient in protein (125%). The same dry pregnant cow maximizing dry matter intake (model #4) would still be in negative energy balance (87.7%).

The body condition scores (BCSs) of the herd were consistent with the energy deficit of the diets. The impact of the poor quality forage on this farm and subsequent energy deficits were considered to have chronic effects well after the cows return to adequate pasture.

4.2. Miscellaneous Data

Following the site visit, Mr. Tennant consulted with Dr. Davis-Heller regarding a suspected sick animal. Mr. Tennant brought a calf with a "cloudy eye" to Dr. Davis-Heller's clinic (April 21, 1999). Dr. Davis-Heller examined the calf and determined that there was nothing wrong with the eye, except for a slight mucoid exudate on the cornea which was easily wiped away.

On May 26, 1999, Dr. Davis-Heller examined cow #30 for a lump under the right mandible. The lesion was aspirated (pus) and subsequently lanced.

4.3. Wildlife

4.3.1. Videotapes (Table 1)

The 20 wildlife cases presented in the videotapes were all dead and, except for one case (case # 49), of no diagnostic value. These were all considered to be incidental deaths since there did not appear to be any consistency in the species, location, or timing of the deaths. In fact, these deaths appeared to be most consistent with the random wildlife carcasses which would be found in a healthy ecosystem. The individual dead deer (case # 49) which presented with hemorrhage from the nostrils may have died from epizootic hemorrhagic disease (EHD). This diagnosis would correspond with the known existence of this disease in local deer (personal communication: Dr. Crum to Dr. Sykes) and the finding of some EHD seropositive cattle in the Tennant herd.

4.3.2. Small Mammal Data

Two pathologists reviewed the liver and kidney histology from 45 small rodents (voles, shrews, and mice) captured on the Tennant property in 1997 (USEPA Environmental Response Team draft report: Dry Run Creek, Washington, Wood County, West Virginia; Table 39). No lesions characteristic of hepatotoxicity or nephrotoxicity were evident. Although several anomalies were identified, none were considered suggestive of toxic teratogenesis.

The 1998 small mammal trapping (URS Greiner Woodward Clyde study, December 3, 1998) observed no gross abnormalities in the captured animals (voles, shrews, and mice).

4.3.3. Deer Studies

The cattle team was made aware of the periodic deer reproduction surveys conducted by the West Virginia Department of Natural Resources (WV DNR) in the Dry Run area. Although the team reviewed some of the data sheets from these studies, no reports were available. One team member (Sykes) had a telephone conversation with Dr. Crum of the

WV DNR regarding deer herd health in the Dry Run area in order to acquire some additional information. From this conversation, it was the cattle team's understanding that:

- evidence of low fertility rates in young does was probably attributable to deer overpopulation;
- epizootic hemorrhagic disease (EHD) has been diagnosed clinically and serologically in dead and captured deer, respectively;
- bovine virus diarrhea (BVD) has been diagnosed serologically in deer not far from Dry Run;

In addition, the team has learned that outbreaks of EHD in West Virginia deer were reported between 1980 and 1989 [Southeastern Cooperative Wildlife Disease Study publication, Field Manual of Wildlife Diseases in the Southeastern U.S., 2nd ed.].

Since there was no evidence of an EHD or BVD outbreak in the Tennant herd, the deer population was not considered to be a contributing factor in the cattle herd health problems. Also, there was no evidence that the deer herd was a useful sentinel species for any of the disease entities identified in the Tennant herd.

5.0 DISCUSSION

The six veterinarians comprising the cattle team agreed that there was conclusive evidence that the Tennant herd was suffering from four major disease entities: endophyte toxicity, pinkeye, malnutrition, and copper deficiency. The clinical, laboratory, and historical data substantiate that these four conditions can readily account for the chronic herd health problems on the Tennant farm.

Endophyte toxicity

According to the history acquired on April 8, 1999, the herd has been fed a diet of KY31 fescue hay in the winter and pasture that approaches 100% KY31 fescue during the summer. There has been no supplemental pasture or other forage fed to these animals. The clinical signs in the Tennant herd that highly suggest endophyte toxicity (fescue mycotoxicosis) include:

- swelling and pain at the coronary band (coronitis) and above, with cattle that stand in the creek during hot weather (Figures 5-8);
- poor shedding of winter coats (Figure 4);
- patchy tail alopecia with loss of tail switch;
- birth of undersized calves;
- poor conception and calving rates;
- numerous vague diseases suggestive of immune dysfunction;

Other clinical signs that are consistent with endophyte toxicity include:

- fat necrosis, presumptive, as diagnosed by rectal palpation in cow #15;
- concomitant presence of copper deficiency;
- panting in cow #45, suggestive of hyperthermia;
- general failure of the cattle to thrive.

Vasoconstriction is seen as a result of ingestion of a number of ergot-like alkaloids. The endophyte fungus associated with fescue mycotoxicosis is *Acremonium coenophialum* which produces perloine, perlolidine, N-acetyl loline, and N-formyl loline (Stuedemann, et al., 1985). These alkaloids accumulate in the fescue grass seed during growth, acquiring the highest concentrations at the greatest maturity of the grass. Additionally, the alkaloids may be found in stored hay.

The coronitis problem observed in the videotapes (Figures 5 and 6) was typical of that produced by endophyte toxicity in the "fescue foot" syndrome. Signs of fescue foot generally start with reduced weight gain, or loss of weight, rough hair coat, arched back, and soreness in one or both rear limbs. Hyperemia of the coronary band occurs between the dewclaws and hooves and is generally accompanied by some swelling (Hemken, et al., 1984). Arching of the back was reported by the owner in the videotapes as "hunched" and "humped" posture in some cattle.

Peripheral vasoconstriction from these vasoactive alkaloids results in decreased ability to dissipate heat during hot weather. This phenomenon is known as "summer slump" (Osborne, et al., 1992). The panting and drooling by a red cow (#45) in videotape #2 was suggestive of the summer slump syndrome.

The birth of undersized calves to dams ingesting a diet high in endophyte-infested fescue has also been documented (Bolt, et al., 1986). This may be by a mechanism similar to the vasoconstriction caused by the ergot-like alkaloids. Vasoconstriction of the uterine blood vessels may result in decreased circulation to the growing fetus. The effect has been documented in mice that were exposed to the endophyte during gestation. Mouse pups from females fed the material during gestation were a lighter birth weight, were delayed in post-partum development, and grew slower than control mice (Varney, et al., 1991).

Evidence that endophyte toxicity in fescue grazing cattle may be responsible for the loss of the tail switch is largely anecdotal, from veterinary practitioners that have experience with similarly affected cattle. The most severe forms of endophyte-induced vasoconstriction result in dry gangrene of the tail and digits (Radostits, et al., 1994; Hemken, et al., 1984).

Reproductive effects from the ingestion of endophyte-infested fescue include incrementally depressed conception rates in cattle grazing infected pasture (Paterson, et al., 1995). In the Tennant herd, the grazing of pastures with 100% KY31 fescue could potentially play a major role in the unacceptable conception rate. A poor conception rate

could also be secondary to a lack of intensive breeding management at the Tennant farm, where breeding occurs year round. The advanced age of most animals in the breeding herd could also be expected to be a cause for depressed fertility and an extended calving interval. Likely, a combination of all three factors have contributed to suboptimal fertility.

The poor growth of the nursing calves could be multifactorial as well. The advanced age of the cows or a limited genetic potential in the herd could lead to poor milk production and poor calf growth. Similarly, lack of proper nutrition or a lack of a balanced diet among the brood cows could depress calf growth. The ingestion of endophyte-infested fescue could lead to depressed milk production due to prolactin inhibition (Hurley, et al., 1980; Paterson, et al., 1995). The mechanism is considered to be due to the dopaminergic effects of the endophyte ergopeptides on prolactin production in the bovine pituitary gland (Schultze, et al., 1999).

Endophyte intoxication is also considered to have an immunosuppressive effect by an apparently indirect route. Although anecdotal evidence exists to suggest that fescue intoxication is responsible for depressed immune function, there appears to be no apparent lack of immune response to vaccinations of cattle fed diets high in fescue (Rice, et al., 1997). Indirectly, however, there is a relationship between immune function, endophyte intoxication and copper status of cattle on a high fescue diet (Dennis, et al., 1998; Saker, et al., 1998). Steers grazing endophyte-infested tall fescue have lower serum copper concentrations than those not on a high-endophyte tall fescue diet, resulting in depressed monocyte-macrophage functions. This is apparently an effect of the decreased uptake of copper by the infected tall fescue plants. Another source has recorded depressed globulin levels in animals grazing infected pastures (Schultze, et al., 1999).

Fat necrosis is a herd problem of cattle grazing tall fescue with high endophyte levels. The necrotic fat accumulations are mostly within the omental and retroperitoneal fat depots, and consist of hard masses of partly mineralized fat. Cow #15 had palpable masses within the abdominal cavity that were identified during the herd exam on April 7, 1999. These masses were most suggestive of masses of necrotic fat. The biochemical reaction causing the fat necrosis is unclear, however, in affected animals that are on a diet high in N-formyl and N-acetyl loline, there is a consistent reduction of circulating levels of cholesterol (Stuedemann, et al., 1985). Animals with increased dietary levels of endophyte-infested fescue had decreased body condition and increased fat necrosis.

Pinkeye

Faceflies were a serious problem in the cattle in the videotaped recordings taken on the Tennant farm (Figures 1 and 2). Additionally, they have also been a problem in other years, according to the history provided by Mr. Tennant during the April 8, 1999 interview. Faceflies were seen in small numbers at the eyes of the cattle during the April 7, 1999 herd visit, representing an early spring infestation. The facefly, *Musca autumnalis*, is a vector for *Moraxella bovis*, the etiology of most bovine pinkeye. Control

of these insects is based on preventing the flies from feeding on the lacrimal secretions of the cattle. Insecticides and insecticidal ear tags, as applied during the visit, are effective controls. Secondly, the insecticides tend to limit the spread of *M. bovis* between susceptible cattle during outbreaks of pinkeye.

Severe facefly infestations can result in poor feed consumption and conversion among affected cattle. Some of the poor weight gain described in the history of the herd and the videos may be due to "fly worry". The manic stampeding of the cattle, that was described in one of the videotapes, was likely due to the large number of flies.

Malnutrition

Malnutrition was considered to be a significant problem in the Tennant herd. The owner had identified poor growth rates and infertility as specific problems among his cattle. This was considered a manifestation of protein-energy insufficiency and was reflected in the low body condition scores. Dietary requirements of beef cattle change dramatically during the life cycle of the animals and during the year, particularly with respect to such environmental and physiological stressors as fluctuating ambient temperatures and moisture conditions, lactation, growth, and breeding (Rice, 1991). The clinical impression of malnutrition that followed the visits of April 7 and 8 were confirmed by the results of the feed analysis of the hay and grain mix rations taken during the visits.

Copper deficiency

As indicated by the heavy metal analysis performed by two laboratories, on tissues from three animals, copper deficiency is a problem in the Tennant herd (Appendix B). In 1997, copper deficiency was diagnosed in a 4-year old Holstein cow and a 9-year old Holstein cow by the Animal Health Diagnostic Laboratory of Michigan State University in East Lansing, Michigan. In 1999, copper deficiency was revealed in tissues from a sacrificed 7-year old red cow by the Laboratory of Large Animal Pathology and Toxicology of the University of Pennsylvania, Kennett Square, Pennsylvania. Furthermore, serum samples taken from 41 adult animals at the farm on April 7, 1999 revealed that 26 of the 41 (63%) had serum copper levels below that considered deficient at the reference laboratory (Table 4).

Clinical signs of copper deficiency seen on the Tennant farm were lightening of the hair coats, poor quality hair on the cows, and overgrown hooves. This was reported by Mr. Tennant and shown in videotapes made of the herd.

The clinical effects of copper deficiency are multiple, and the clinical and physiological effects of such deficiency are well documented (NRC, 1996). The effects include immune deficiencies, poor quality hair coats, increased fragility of bone and sudden death in extreme cases. During disease, copper deficiency can result in depressed levels of tumor necrosis factor (a cytokine) with resulting abnormal temperature responses to infections and depressed feed intake (Gengelbach, et al., 1997).

Immune deficiencies related to copper deficiency are multiple and include depressed acute phase protein response and lymphocyte responsiveness to mitogen stimulation (Arthington, et al., 1996; Gengelbach, et al., 1997).

As there has been no documentation of any copper supplementation of the herd, the deficiency is expected to be present at this time and to continue. The relationship between high endophyte fescue grazing and copper status in the feed has been described (Dennis, et al., 1998). Copper deficiency is widespread throughout the United States (Dargatz, et al., 1999).

Toxicology issues

Based upon the draft report entitled Dry Run Creek, 1997 from the Environmental Response Team of the US EPA, carnivorous, piscivorous, omnivorous, insectivorous and herbivorous mammals in the Dry Run Creek study area are at increased health risk due to exposure to metals, fluoride and trichlorofluoromethane. At least with regard to metals of concern, diagnostic evaluation of tissue and fluids collected from three animals from the Tennant farm (two submitted to Michigan State University and one submitted to New Bolton Center) do not suggest elevated concentrations of any metal. In addition, urine (two samples submitted to Michigan State University) and bone (one sample submitted to Michigan State University from the cow evaluated at New Bolton Center) samples for fluoride analysis did not measure concentrations above expected or "background" values. The urinary fluoride values were 6.60 ppm and 5.55 ppm and one bone fluoride value was 1090 ppm (expressed on a fat free, dry weight basis). Urine and bone fluoride concentrations in adult cattle consistent with fluorosis are 15 to 20 ppm or greater and 3000 ppm or greater (expressed on a fat free, dry weight basis), respectively (Osweiler et al., 1985). In addition, there was no clinical evidence of chronic fluorosis in the Tennant herd.

Exposure to trichlorofluoromethane was considered to be a default risk factor based upon a lack of toxicologic benchmarks for this compound. However, available toxicity data derived from inhalation studies using common laboratory animals indicate that chlorofluorocarbons such as trichlorofluoromethane have low acute and chronic toxicity (Magda, 1999). Signs associated with acute toxicity are reversible effects on the central nervous system such as lethargy and incoordination. Chlorofluorocarbons are not developmental toxicants, do not affect reproductive performance and are not genotoxic.

6.0 RECOMMENDATIONS

The most important general recommendation from the cattle team, after completion of the herd visit and review of the investigatory data, would be for the owner of the Tennant herd to engage veterinary and nutritional consultants in the design of a herd health program.

Endophyte toxicity: With dietary forage that contains nearly 100% KY31 fescue, fed during all seasons, the immediate goal would be for the dilution of the endophyte in the diet by mixing the hay and pasture with either non-endophyte infested fescue or another different forage source. A short-term goal would be to reduce the content of endophyte-infested hay and pasture to 50% or less of the diet, primarily by supplementing the diet with higher quality forage. An acceptable long-term plan would be to replace the fescue pasture and hay fields with a non-endophyte-infested forage crop or crops over time, again with the goal of diluting the dietary endophyte consumption. Crop management should be attempted under the supervision of specialists in forage and grazing management.

Pinkeye: Prevention of pinkeye (keratoconjunctivitis) in the immediate future should be attempted by an approach that limits the spread of the infectious organism, *Moraxella bovis*, from carrier cattle to susceptible cattle. Effective fly control, through the use of insecticide-impregnated eartags or some other proven method, is perhaps the most effective control method that should be practiced during the warm months. The insecticide-laden eartags should be rotated every year in order to circumvent the development of insecticide resistance by the local facefly population. An additional long-term approach that may be employed is the breeding for cattle that have dark faces. By selecting for dark-faced cattle, the corneal damage that is caused by the ultraviolet light of the sun is minimized. However, while minimizing the damage to the corneas of the cattle may prevent overt lesions of keratoconjunctivitis, the loss of condition from severe fly infestations will not be avoided by selecting for face color in cattle. Thus regardless of the type of cattle in the herd, insecticide fly repellants should be used every year.

Malnutrition: Rations and pasture nutrition should be planned with the assistance of a specialist in beef cattle nutrition. In the Tennant herd, there was evidence of gross protein-energy malnutrition, as well as concerns about macromineral (calcium, phosphorus, and magnesium) nutrition. Trace mineral and vitamin deficiencies are common to many beef herds and should also be addressed. In the development of a ration for this herd, particular attention should be paid by the nutritionist to the local trace mineral and macromineral deficiencies.

Copper deficiency: Copper is a trace mineral that is crucial to the health of cattle yet is missing from the diet of cattle in many areas of the North America. As copper deficiency was suspected clinically and confirmed biochemically in the Tennant herd, the provision of a high copper trace mineral supplement, again under the supervision of a beef cattle nutritionist, should be a priority year round. This is especially critical considering the prevalence of endophyte-infested fescue on the Tennant farm.

7.0 CONCLUSION

There was conclusive evidence that the Tennant cattle herd was, and continues to be, suffering from four major disease entities, some of which were potentially interrelated: endophyte toxicity (fescue mycotoxicosis), pinkeye, malnutrition, and copper deficiency. As substantiated by the clinical and laboratory findings, and historical data, these four conditions readily account for the chronic herd health problems on the Tennant farm.

The herd health investigation revealed deficiencies in herd management, including poor nutrition, inadequate veterinary care, and lack of fly control. The lack of vaccination and internal parasite control programs did not appear to have a substantial impact on this relatively isolated herd.

Despite an exhaustive review of historical and contemporary herd data, there was no evidence of toxicity associated with chemical contamination of the environment.

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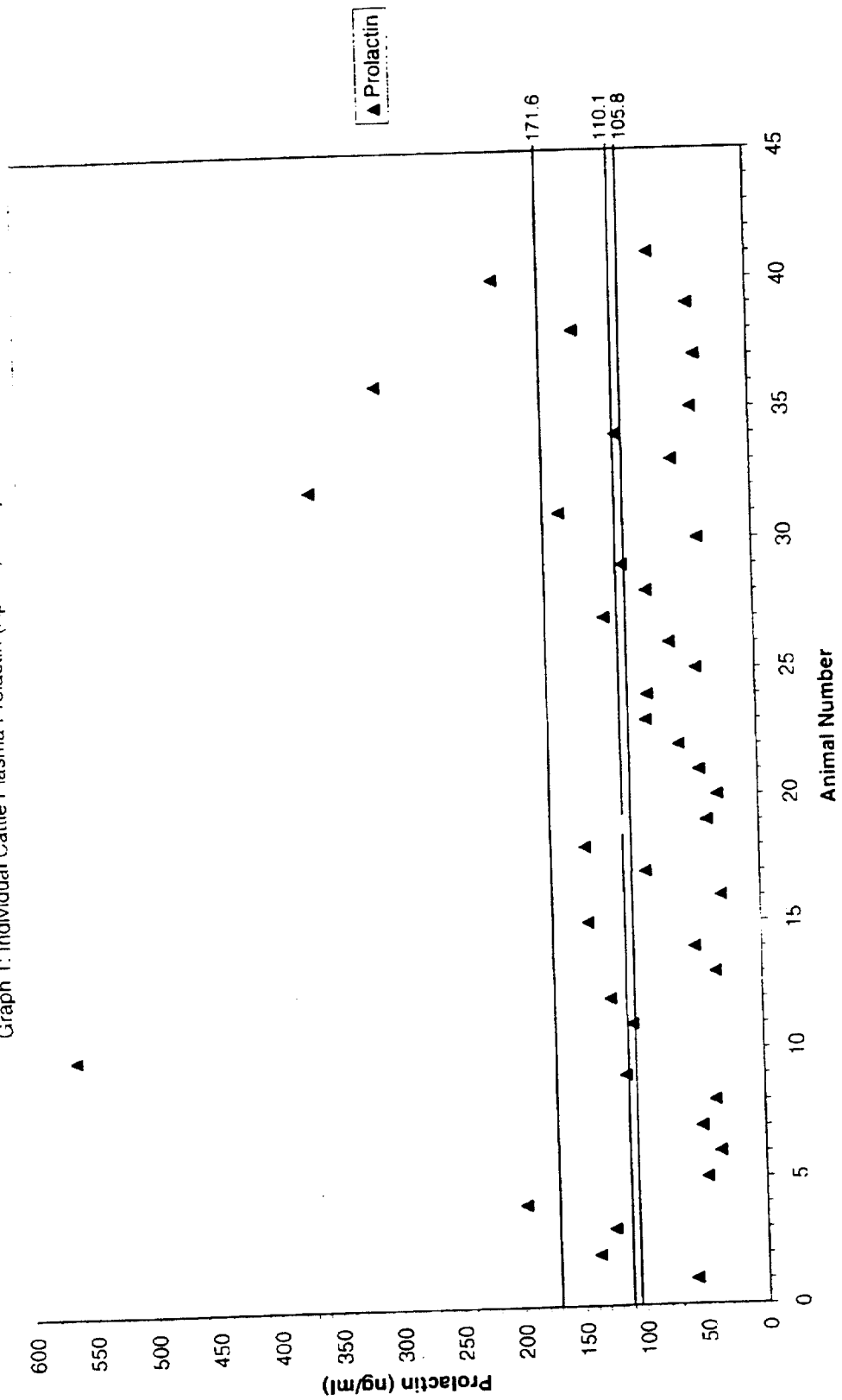
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9.0 GRAPHS

Graph 1: Individual Cattle Plasma Prolactin (April 7, 1999).

Heparinized blood samples taken from 41 adult cattle during the cattle team's visit to the Tennant farm were analyzed for the endophyte-responsive hormone, prolactin. Graph illustrates the laboratory's reference means for endophyte-free (171.6 ng/mL) and endophyte-infested (105.8 ng/mL) April pasture. The average plasma prolactin value for the Tennant herd (110.1 ng/mL) was similar to the endophyte-infested reference. These results were highly supportive of the diagnosis of endophyte mycotoxicosis in the Tennant herd. (Testing laboratory: Dr. Neil Schrick, University of Tennessee)

Graph 1: Individual Cattle Plasma Prolactin (April 7, 1999)



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10.0 FIGURES

Figure 1: Faceflies on the head of a calf.

Facefly (*Musca autumnalis*) infestation was considered to be a major disease problem on the Tennant farm. In addition to the constant harassment by flies, this calf had severe bilateral keratoconjunctivitis and appeared to be clinically blind on the videotape (photo was taken from Tennant videotape #2).

Figure 2: Faceflies on the head of a cow.

This cow was the dam of the calf in figure 1. Like her calf, she had severe bilateral keratoconjunctivitis. (photo was taken from Tennant videotape #2).

Figure 3: Left eye of a calf with faceflies and central corneal opacity.

Faceflies are a vector for the bacterial agents of pinkeye (keratoconjunctivitis) such as *Moraxella bovis*. Central corneal opacities may progress to diffuse corneal ulceration and clinical blindness. (photo was taken from Tennant videotape #2).

Figure 4: Delayed shedding of the winter coat on a beef cow.

The videotapes presented multiple cattle with delayed shedding of winter coats. This is a clinical sign often associated with endophyte toxicity as well as nutritional deficiencies. (photo was taken from Tennant videotape #2).

Figure 5: Alopecia and erythema above the coronary band (coronitis).

This lesion was present in several cattle in the videotapes. It is a common sign of endophyte toxicity and is generally referred to as "fescue foot". (photo was taken from Tennant videotape #2).

Figure 6: Alopecia and erythema above the coronary band (coronitis).

This example of "fescue foot" is similar to that presented in figure 5. (photo was taken from Tennant videotape #2).

Figure 7: Three cattle standing in the creek.

A unusual predilection for standing in water was described for the Tennant cattle in the summer. This behavior is known to be associated with endophyte toxicity as it provides some relief for both coronitis ("fescue foot") and hyperthermia ("summer fescue"). (photo was taken from Tennant videotape #2).

Figure 8: Two cattle standing in a puddle.

As described for figure 7, standing in water provides some clinical relief to cattle with coronitis. Although non-specific, a predilection for this behavior is associated with "fescue foot". (photo was taken from Tennant videotape #2).



Figure 1



Figure 2

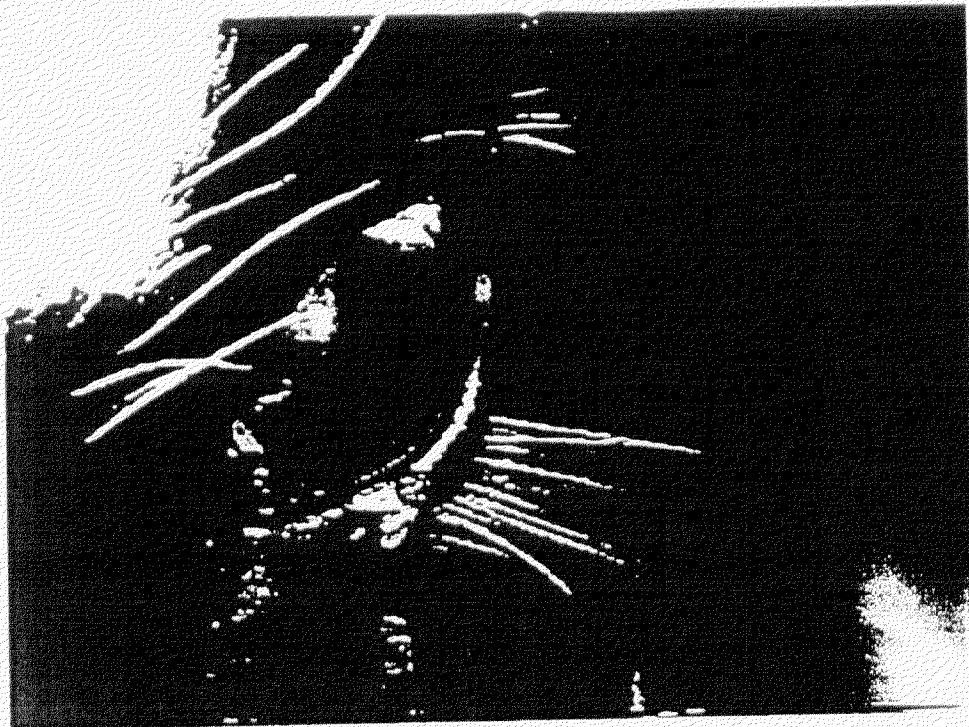


Figure 3

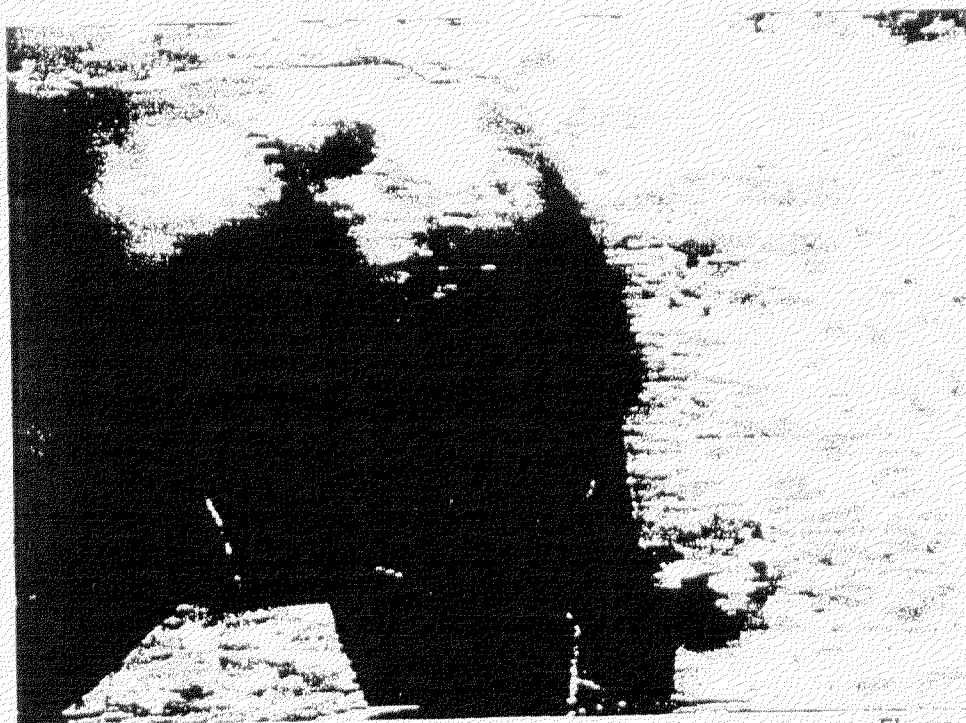


Figure 4



Figure 5

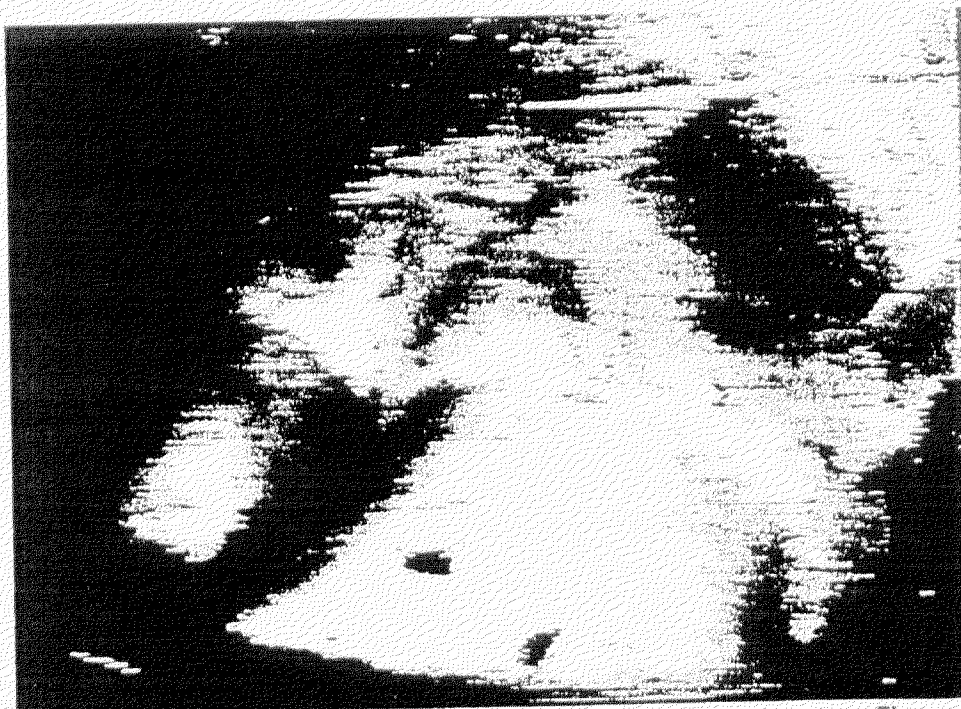


Figure 6



Figure 7

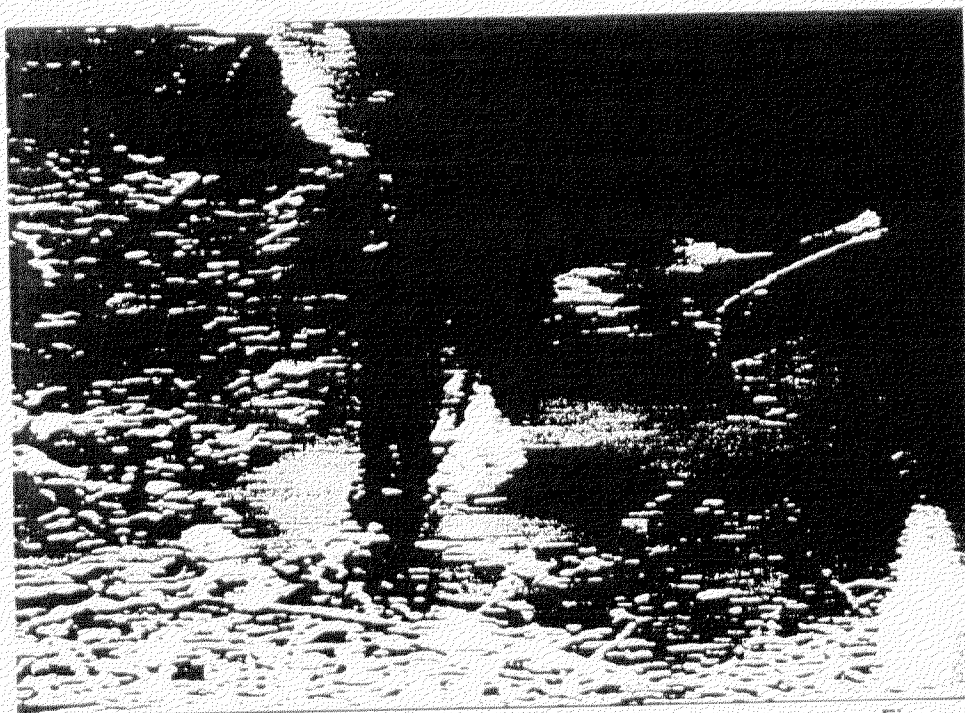


Figure 8

11.0 TABLES

Table 1: Review of Tennant Farm Videotapes

Table 2: Individual Animal Data: Clinical Signs

Table 3: Individual Animal Data: Hematology (erythron, platelets)

Table 4: Individual Animal Data: Hematology (leukon), and Special Chemistry

Table 5: Individual Animal Data: Clinical Chemistry

Table 6: Individual Animal Data: Serology and Fecal Exam

Table 7: Tennant Farm Grain and Hay: Nutritional Analysis

Table 1: Review of Tennant Farm Videotapes

Tape #1 (cases 1 – 18): Tennant Farm: New England, Wood Co., WV -
January & February, 1997

#	Subject Animal(s)	Presentation	Diagnosis/Comment
1	Cow, Hereford	- neck: alopecia, scaling, - described as "humped-up", (snowing)	- probable lice, "humped-up" difficult to appreciate on tape.
2	Cow, Hereford	- corneal opacity, (snowing)	corneal scar, probably secondary to pinkeye.
3	2 black bulls	- possible discoloration of hair (not clear), (snowing)	not clear from tape.
4	Cow, Hereford	- thin, - described as poor teeth, (snowing)	- very thin, probably due to decreased food consumption and mastication problem, although teeth not seen on video, - age unknown; cause of possible teeth problem unknown.
5	Cow, Hereford	- possible hunched back (not clear), (snowing)	not clear from tape.
6	Cow (tan)	- alopecia, tail switch, (snowing)	tail hair loss differential diagnosis would include mechanical, lice, fescue toxicosis, and selenium toxicosis.
7	Cow	- alopecia, tail switch, (snowing)	tail hair loss differential diagnosis would include mechanical, lice, fescue toxicosis, and selenium toxicosis.
8	Calf, black	- dead (dated 2/9/97) in snow, - overgrown hooves, - bilateral lens opacities, - black/brown teeth, - mucous on feces, - necropsy: no other lesions, - stated: had diarrhea	- hooves a little longer than normal, but not unusual, "cold cataracts" (post mortem), - teeth normal, - fecal mucous normal for stagnant feces in rectum, - necropsy: lack of fat; serous atrophy of fat: emaciation, probably due to starvation.

Table 1: Review of Tennant Farm Videotapes

Table 1 (continued): Review of Tennant Farm Videotapes

Tape #1 (cases 1 – 18): Tennant Farm: New England, Wood Co., WV -
January & February, 1997

#	Subject Animal(s)	Presentation	Diagnosis/Comment
9	Calf, black/white face	- neck: alopecia, - diarrhea, - lens or corneal opacities	- probable lice, - cause of diarrhea unknown, - probable corneal scar (hard to tell).
10	Cow, Hereford	- thin, - corneal opacity, - above hooves: alopecia and hyperemia, - diarrhea	- corneal opacity probably secondary to pinkeye, - differential diagnosis of hoof lesions include mechanical dermatitis, fescue toxicosis, and moist dermatitis due to unknown - cause of diarrhea and thinning unknown,
11	Cow, black	neck: alopecia	probable lice.
12	Cow, red	neck: alopecia	probable lice.
13	Cow, red	- slobbering, losing cud (on ground), - urinating, - tail switch alopecia	- slobbering/urinating differential diagnosis includes hardware and cholinesterase inhibition (less likely due to individual cow affected), - alopecia differential diagnosis includes mechanical, lice, and fescue or selenium toxicosis.
14	Cow, red	- neck: alopecia, - tail switch: short hair	- neck: probable lice, - tail hair differential diagnosis includes mechanical, lice, and fescue or selenium toxicosis.
15	Cow, red	neck: alopecia	probable lice.
16	Cow, red	odd chewing behavior	not clear from tape.
17	Cow, Hereford	possible hunched back	not clear from tape; differential diagnosis includes hardware disease (traumatic reticulopericarditis).

Table 1 (continued): Review of Tennant Farm Videotapes

Tape #1 (cases 1 – 18): Tennant Farm: New England, Wood Co., WV -
January & February, 1997

#	Subject Animal(s)	Presentation	Diagnosis/Comment
18	Cow, red (same as #13)	• dead in barn, • corneal opacity, • necropsy: no other lesions	• (is this the 9-year-old cow submitted to Michigan?), • corneal opacity may be postmortem artifact, • necropsy: serous atrophy of fat, • noted: normal postmortem changes include moderate to severe autolysis, pseudomelanosis of intestines, interlobular emphysema (agonal), • also noted: normal front teeth • large gallbladder suggests period of anorexia, • cause of death unknown.

Table 1 (continued): Review of Tennant Farm Videotapes

Tape #2 (cases 19 – 60): Dry Run Harris PC. Wood Co. - Off North Fork of Lee Creek, New England, WVA

#	Subject Animal(s)	Presentation	Diagnosis/Comments
19	Calves, multiple	• corneal opacities of varying severity; some with exudate and/or blepharospasm, • fly problem (summer), • some with poorly shedded and/or light-colored coats	• fly problem with secondary pinkeye, • hair coat shedding and coloring probably due to a nutritional problem.
20	Fish (sucker?)	• dead	• incidental death: no diagnosis possible.
21	Small mammal (raccoon?)	• skeleton	• incidental death: no diagnosis possible.
22	Cow	• corneal opacity	• corneal scar secondary to pinkeye.
23	Calf	• corneal opacities, • possible head tilt (not clear)	• corneal scar secondary to pinkeye, • head tilt not clear on tape.
24	Calf	• corneal opacities, • flies	• corneal scar secondary to pinkeye.
25	Calf	• dead (~1 month-old), • corneal opacity, • (burning carcass)	• cause of death unknown, • corneal scar secondary to pinkeye.
26	Snake	• dead	• incidental death: no diagnosis possible.
27	Calf	• corneal opacities, • fly problem	• fly problem with secondary pinkeye.
28	Fish	• dead	• incidental death: no diagnosis possible.
29	Calf	• corneal opacity	• corneal scar secondary to pinkeye.
30	Calf	• corneal opacity	• corneal scar secondary to pinkeye.

Table 1: Review of Tennant Farm Videotapes

Table 1 (continued): Review of Tennant Farm Videotapes

Tape #2 (cases 19 – 60): Dry Run Harris PC. Wood Co. - Off North Fork of Lee Creek, New England, WVA

#	Subject Animal(s)	Presentation	Diagnosis/Comments
31	Cow	• dead, • worn incisors, • diarrhea, • emaciated, sunken eyes (dehydrated?), serous atrophy of fat (heart), • agonal lung emphysema	• cause of diarrhea, emaciation and death unknown, • worn incisors may be age or feed related, • lung emphysema was agonal and insignificant.
32	Crow	• dead	• incidental death: no diagnosis possible.
33	Crow	• dead	• incidental death: no diagnosis possible.
34	Calves, multiple	• corneal opacity	• corneal scar secondary to pinkeye.
35	Cow	• corneal opacity, • thin	• corneal scar secondary to pinkeye, • diagnosis of the cause of thin condition not possible.
36	Fish	• dying	• incidental death: no diagnosis possible.
37	Crayfish	• dead	• incidental death: no diagnosis possible.
38	Salamander	• dead	• incidental death: no diagnosis possible.
39	Toad	• dead	• incidental death: no diagnosis possible.
40	Newborn calf	• contracted tendons, • big hocks	• difficult to evaluate from tape; may be congenital contracted tendons.
41	Deer	• dead	• incidental death: no diagnosis possible.
42	Cow	• dead (rotten)	• no diagnosis possible.
43	Deer	• rotten carcass	• incidental death: no diagnosis possible.
44	Deer	• bones	• incidental death: no diagnosis possible.

Table 1: Review of Tennant Farm Videotapes

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Table 1 (continued): Review of Tennant Farm Videotapes

Tape #2 (cases 19 – 60): Dry Run Harris PC. Wood Co. - Off North Fork of Lee Creek, New England, WVA

#	Subject Animal(s)	Presentation	Diagnosis/Comments
45	Cow	panting; increased respiration	- differential diagnosis includes hyperthermia due to summer fescue toxicosis, - diagnosis uncertain.
46	Cow	diarrhea	cause of diarrhea unknown.
47	Raccoon	skull	incidental death: no diagnosis possible.
48	Deer	skeleton	incidental death: no diagnosis possible.
49	Deer	- dead (fresh), - bloody nose	death possibly due to epizootic hemorrhagic disease of deer (EHD).
50	Rabbit	dead	incidental death: no diagnosis possible.
51	Turkey	dead	incidental death: no diagnosis possible.
52	Hawk	dead	incidental death: no diagnosis possible.
53	Fish	dead	incidental death: no diagnosis possible.
54	Cow	lumpy udder	unclear from videotape.
55	Cows, multiple	- above hooves: alopecia, possibly erythema, - overgrown hooves	- differential diagnosis includes mechanical dermatitis, fescue toxicosis, and moist dermatitis due to unknown, - hoof length not significant.
56	Bull, cows, multiple	- corneal opacities, - alopecia and erythema above hooves	- corneal scar secondary to pinkeye, - hoof differential diagnosis includes mechanical dermatitis, fescue toxicosis, and moist dermatitis due to unknown.
57	Cow	lumpy udder	unclear from videotape.

Table 1: Review of Tennant Farm Videotapes

42

Table 1 (continued): Review of Tennant Farm Videotapes

Tape #2 (cases 19 – 60): Dry Run Harris PC. Wood Co. - Off North Fork of Lee Creek, New England, WVA

#	Subject Animal(s)	Presentation	Diagnosis/Comments
58	Cows, multiple	- above hooves: alopecia, possibly erythema, - poor shedding of coat in some animals	- hoof differential diagnosis includes mechanical dermatitis, fescue toxicosis, and moist dermatitis due to unknown, - poor hair coat shedding suggests nutritional problem or fescue mycotoxicosis.
59	Cow (tan)	unusual gait	lame due to unknown cause.
60	Cows, heifers, multiple	- thin, - delayed shedding	definitive diagnosis not possible from tape – probably a nutritional deficiency.

Note: This table excludes many of the clinical signs and pathological conditions that were proposed by the videotapes' narrator but were considered by the cattle team to be inaccurate. For example, the team did not agree with the narrator's assertion that blackened teeth or patchy melanosis were abnormal. Also numerous speculative comments regarding normal organs, during the dissections shown in the videotapes, were not included in this table.

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 2: Clinical Signs

Animal Number	Age	Preg. Status	Description	Body Condition Score (1 - 10)		Clinical Signs		Photo #
				Girth (in.)	BCS (1-10)			
1	>9	4 m	yellow	-	3	possible lice		1
2	>9	open	red, white face	-	3	lice, corneal scar (r)		2
3	>9	open	yellow, white face	-	3	(large uterus)		3
4	>9	7 m	red, white face	70	4	lice		4
5	>9	6 m	red, white face	75	4	corneal scar (l)		5
6	>9	3 m	red, white face	-	4	-		6
7	>9	6 m	red, white face	71	4	hair loss (switch)		7
8	>9	open	red, white face	-	4			8
9	>9	open	red, white face	70	4	(muzzle: melanin considered normal)		9
10	>9	term	red, white face	70	3	-		10
11	>9	8.5 m	red, white face	-	3	-		11
12	>9	term	red, white face	72	3	light coat color; small corneal scar (r)		12
13	>9	open	red, white face	66	2	slight corneal scar (l),		13
14	>9	calf	red, white face	78	4	alopecia (brisket)		14
15	>9	open	yellow	71	2	palpation difficult (fat necrosis?)		15
16	6	open	black	68	3	-		16
17	>9	4 m	red, white face	78	7	-		17
18	>9	4 m	red, white face	78	7	mammary gland lumps (right front)(abscesses?)		18, 53
19	>9	Calf	red, brockleface	68	3	slight corneal scars (l and r)		19
20	>9	6 m	red, white face	74	3	-		20
21	>9	5 m	red, white face	69	3	small corneal scar (l)(5 mm)		21
22	>9	5 m	red, brockleface	76	4	mass (12 cm) prescap. neck (r) - lanced; brown serum + hair		22, 49-51
23	-	bull	black	-	4	-		23
24	>9	6 m	red, white face	78	4	hair loss (neck)		24

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 2: Clinical Signs (continued)

Animal Number	Age	Preg. Status	Description	Body Condition Score (1 - 10)		Clinical Signs		Photo #
				years		Girth (in.)	BCS (1-10)	
25	4	5 m	black			72	4	
26	6	bull	black			-	5	corneal scar (l)
27	>9	8 m	red, brockleface			64	3	corneal opacity (l)
28	7	8 m	black, white face			74	4	-
29	>9	term	red, brockleface			77	2	mammary gland lumps (left rear) (abscesses?)
30	>9	8 m	red, white face			72	3	lice, hair loss (abd.), extra teat, corneal opacity (l=3mm; r=5mm)
31	8	6 m	red, white face			77	5	corneal scar (r) (2 mm); (tongue: melanin considered normal)
32	>9	6 m	black, white face			70	3	lice
33	>9	8 m	red, white face			72	3	-
34	>9	8 m	red, brockleface			73	2	-
35	>9	5 m	red, white face			72	3	-
36	>9	8 m	red, white face			75	3	corneal scar (l), severe
37	7	calf	red, brockleface			77	4	corneal scar (r) (1 cm)
38	>9	7 m	red, white face			73	4	-
39	>9	calf	red, white face			68	2	-
40	4	6 m	black			75	4	light hair color, corneal opacity (l) (2mm)
41	4	steer	black, white face			71	-	lame (lr), corneal opacity (r) severe; phthysical eye (l)
1 cow	-	-	red, whiteface			-	-	cow escaped run before being tagged or examined
calves	< 6 m	-	12 misc. calves			-	-	5 bigger calves not tagged; 7 smaller calves tagged

Cattle examinations conducted on April 7, 1999. Age determined by teeth examination (Dr. Moisan); Pregnancy Status determined by rectal palpation (Dr. Munson); Girth measured by tape (Dr. Habecker); BCS assigned by Drs. Moisan and Munson; Clinical Signs identified by cattle team (Drs. Davis-Heller, Habecker, Moisan, Munson, Poppenga, Sykes); Photos taken by Dr. Sykes.

Cow #22: Gross diagnosis (no histology) of skin lesion: epidermal inclusion cyst (incidental lesion of no significance).

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 3: Hematology (Erythron, Platelets)

Animal Number	Age	Preg. Status	RBC	Hgb	Hct	MCV	MCH	MCHC	RDW	PLT	MPV	PCT	PDW
	years		$\times 10^9/\text{ul}$	g/dl	%	fL	pg	g/dl	%	$\times 10^9/\text{ul}$	fL		%
		Reference Range:	5-10	8-15	24-46	40-60							
1	4	4 m	5.85	9.91	28.8	49.3	16.9	34.4	18.3	378	7.04	.266	15.9
2	3	open	4.68	8.82	26.0	55.6	18.8	33.8	19.5	186	9.10	.170	19.0
3	>9	open	6.22	12.0	34.8	55.9	19.3	34.6	17.8	233	8.50	.198	18.9
4	>9	7 m	5.81	10.4	29.7	51.1	17.9	35.1	19.3	259	8.08	.209	18.4
5	>9	6 m	5.86	9.87	29.2	49.8	16.9	33.8	18.6	142	8.82	.126	19.7
6	>9	3 m	5.21	10.1	28.8	55.2	19.4	35.1	19.3	201	8.98	.180	18.7
7	>9	6 m	5.06	10.6	29.3	58.0	21.0	36.1	17.8	378	6.49	.246	16.9
8	>9	open	4.44	9.58	26.6	59.9	21.6	36.0	19.2	448	6.42	.287	17.2
9	>9	open	4.48	8.66	25.2	56.3	19.3	34.3	20.2	184	13.1	.240	23.4
10	>9	term	5.23	10.5	29.7	56.9	20.1	35.3	17.1	369	8.02	.296	18.1
11	>9	8.5 m	4.81	9.84	28.2	58.6	20.4	34.9	17.8	142	-	-	-
12	>9	term	4.99	9.41	27.9	55.9	18.9	33.7	19.0	113	10.9	.123	21.8
13	>9	open	4.29	8.62	23.7	55.2	20.1	36.4	20.4	595	6.73	.400	17.7
14	>9	calf	6.04	12.0	33.7	55.8	19.9	35.7	18.8	361	8.91	.321	19.2
15	>9	pregn.	4.65	8.41	24.9	53.6	18.1	33.7	20.6	238	7.73	.184	19.2
16	6	open	5.47	9.58	28.2	51.5	17.5	34.0	20.0	284	8.27	.235	18.3
17	>9	4 m	6.16	13.1	37.7	61.1	21.2	34.7	19.2	87.4	-	-	-
18	>9	4 m	6.30	12.5	35.2	55.9	19.9	35.6	19.4	368	7.71	.283	17.2
19	>9	calf	4.92	9.98	29.1	59.2	20.3	34.3	17.3	317	5.75	.182	16.1
20	>9	6 m	4.85	9.51	28.0	57.7	19.6	34.0	18.0	275	7.55	.207	18.6
21	>9	5 m	5.80	10.7	30.9	53.2	18.5	34.8	19.0	320	8.30	.266	19.4
22	>9	5 m	5.55	10.5	30.3	54.7	18.9	34.6	19.1	391	7.24	.283	18.2
23	-	bull	6.13	12.4	34.8	56.7	20.3	35.7	19.0	283	8.74	.248	20.9
24	>9	6 m	6.02	11.8	33.5	55.7	19.6	35.2	21.8	270	8.23	.222	17.9

Data Tables

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 3: Hematology (Erythron, Platelets) (continued)

Animal Number	Age	Prep. Status	RBC	Hgb	Hct	MCV	MCH	MCHC	RDW	PLT	MPV	PCT	PDW
	years		x10 ⁶ /ul	g/dl	%	f	pg	g/dl	%	x10 ³ /ul	f		%
		Reference Range:	5-10	8-15	24-46	40-60							
25	4	5 m	6.93	12.5	35.9	51.8	18.0	34.8	18.8	231	8.33	.193	18.1
26	6	bull	6.13	11.4	33.1	54.0	18.5	34.3	18.4	278	7.71	.215	18.2
27	>9	8 m	4.90	9.88	28.3	57.8	20.1	34.9	18.3	406	7.05	.286	17.8
28	7	8 m	6.12	11.7	34.1	55.7	19.2	34.4	17.8	180	7.18	.129	17.6
29	>9	term	5.37	9.93	28.7	53.4	18.5	34.6	19.2	220	9.57	.211	24.4
30	>9	8 m	5.08	10.2	28.6	56.3	20.0	35.6	20.1	407	7.09	.288	16.9
31	8	6 m	6.03	12.6	36.0	59.7	20.9	35.1	19.5	217	8.07	.175	18.2
32	>9	6 m	6.17	11.3	32.4	52.5	18.2	34.7	19.2	138	7.33	.101	19.5
33	>9	8 m	5.42	10.1	30.1	55.5	18.7	33.6	17.8	186	7.77	.145	20.2
34	>9	8 m	5.41	11.6	33.0	60.9	21.4	35.1	18.2	361	7.20	.260	17.8
35	>9	5 m	5.86	11.1	32.2	55.0	19.0	34.6	21.2	246	6.33	.156	16.8
36	>9	8 m	4.34	9.44	26.3	60.6	21.7	35.9	18.1	315	8.00	.252	18.0
37	7	calv	5.48	10.9	30.9	56.4	19.8	35.1	18.8	363	8.56	.310	19.5
38	>9	7 m	5.88	11.5	32.2	54.8	19.6	35.7	18.3	397	5.82	.231	16.7
39	>9	calv	4.68	8.34	24.5	52.4	17.8	34.1	18.5	345	6.28	.217	16.4
40	4	6 m	6.94	12.4	34.4	49.6	17.9	36.1	19.1	449	6.65	.298	17.4
41	4	steer	6.78	12.2	34.7	51.1	18.0	35.2	20.0	298	6.94	.207	17.6

Blood collected by jugular venipuncture during examination while cattle restrained in a head-hold device. Blood refrigerated for approximately 36 hours before hematology was run on an Abbott Cell-Dyne 3500. Reference values are for cattle (New Bolton Center), but not from the Cell-Dyne 3500.

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 4: Hematology (leukon), Special Chemistry, and Fecal Exam

Animal Number	Age	Preg-Status	WBC	Neut	Lymph	Mchc	Eos	Baso	Prolactin	serum		Peps	Fecal Exam
										plasma	blood		
	years	Reference Range:	x10 ³ /ul	%	%	%	%	%	ng/ml	ppm	ppm	odu	
			4-12	15-45	45-75	2-7	2-20	0-2	171.6 (mean)	0.6-1.20	> 0.080	0.0-0.3	
1	4	4 m	8.74	35.9	28.7	7.48	27.9	.016	58.70	.282	.121	-	t; s (f)
2	3	open	8.46	32.0	44.2	9.36	14.4	.037	137.60	.305	.091	.276	-
3	>9	open	7.10	63.6	5.39	10.0	21.0	.024	124.68	.518	.120	-	neg.
4	>9	7 m	6.32	42.5	28.9	7.39	21.1	.109	197.19	.593	.121	-	-
5	>9	6 m	6.69	31.6	29.4	7.41	31.6	0.00	48.34	.693	.091	-	c(r); t
6	>9	3 m	8.48	35.6	25.1	7.07	32.3	0.00	37.01	.667	.110	-	-
7	>9	6 m	6.80	58.9	6.15	7.42	27.5	.029	51.61	.473	.138	-	-
8	>9	open	7.38	53.7	16.3	2.07	29.8	0.00	40.21	.633	.105	-	-
9	>9	open	4.81	43.9	33.6	9.93	12.6	.054	113.08	.518	.105	-	-
10	>9	term	6.54	62.2	15.3	10.5	11.8	.113	562.10	.525	.105	-	-
11	>9	8.5 m	6.25	34.8	35.8	9.72	19.6	.061	106.50	.344	.102	-	-
12	>9	term	6.13	45.7	33.0	7.75	13.5	.037	124.43	.462	.104	-	-
13	>9	open	5.37	61.4	18.0	10.0	10.4	.151	38.18	.586	.100	.304	s (f)
14	>9	calf	5.21	31.2	41.9	8.25	18.5	.137	54.40	.549	.128	-	-
15	>9	pregn.	4.29	56.5	25.0	12.1	5.89	.428	141.36	.244	.115	.302	s (f)
16	6	open	7.38	49.7	33.7	10.7	5.76	.240	32.04	.487	.101	-	s (f)
17	>9	4 m	6.83	44.8	27.6	10.2	17.5	0.00	92.87	.838	.156	.334	s (f)
18	>9	4 m	8.44	45.1	23.7	5.23	26.0	0.00	142.25	.773	.174	.390	-
19	>9	calf	5.28	57.2	19.4	11.3	11.9	.058	42.28	.414	.091	-	-
20	>9	6 m	3.59	53.4	19.2	8.19	19.2	0.00	33.35	.205	.134	-	c(r);s(f)
21	>9	5 m	7.90	32.0	22.6	4.68	40.7	0.00	47.37	.623	.135	-	-
22	>9	5 m	5.58	44.6	14.3	12.1	28.9	.167	62.95	.415	.151	-	-
23	-	bull	6.02	59.1	21.2	7.31	12.4	0.00	89.60	.437	.121	-	c(r);s(m)
24	>9	6 m	5.84	42.5	25.5	10.6	21.4	.028	87.94	.649	.135	-	-

Data Tables

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 4: Hematology (leukon), Special Chemistry, and Fecal Exam (continued)

Animal Number	Age	Preg. Status	WBC	Neut	Lymph	Mono	Eos	Baso	Prolactin	Cu	Se-AA	Peps	Fecal exam
	years		$\times 10^3/\mu\text{l}$	%	%	%	%	%	ng/ml	ppm	ppm	serum	
		Reference Range:	4-12	15-45	45-75	2-7	2-20	0-2					
25	4	5 m	8.98	54.8	6.61	7.76	30.8	0.26	47.76	.643	.161	-	-
26	6	bull	6.09	64.6	17.4	6.87	10.9	.168	68.95	.778	.142	.184	s (m)
27	>9	8 m	5.69	56.4	16.2	8.79	18.4	.160	122.27	.443	.116	-	-
28	7	8 m	5.92	69.9	19.1	5.25	10.5	0.00	86.90	.396	.114	-	-
29	>9	term	5.49	53.5	13.7	7.72	25.1	0.00	106.37	<0.20	.146	.224	neg.
30	>9	8 m	3.58	64.8	14.5	5.79	15.0	0.00	44.53	.289	.114	-	-
31	8	6 m	5.41	59.2	18.2	3.61	19.0	0.00	157.00	.683	.139	.098	-
32	>9	6 m	6.86	59.0	19.8	3.36	17.8	0.00	361.97	.488	.132	-	neg.
33	>9	8 m	6.76	70.4	4.69	6.72	18.2	.026	64.19	.533	.105	-	-
34	>9	8 m	5.19	57.6	19.5	9.81	13.0	.056	109.60	.434	.161	.324	-
35	>9	5 m	5.40	38.0	24.0	12.8	25.1	.055	47.45	.679	.140	-	-
36	>9	8 m	4.39	57.1	17.5	13.5	11.9	0.00	306.10	.596	.101	-	s (f)
37	7	calf	5.89	54.0	14.4	10.2	21.3	.090	43.89	.732	.142	-	-
38	>9	7 m	6.49	53.8	10.7	9.62	25.9	.022	143.13	.681	.124	-	-
39	>9	calf	4.72	35.5	35.5	7.47	21.5	0.00	48.70	.762	.109	qns	-
40	4	6 m	9.05	26.7	29.7	12.6	30.9	.055	207.43	.607	.146	-	s (f)
41	4	steer	9.57	52.3	31.3	2.73	13.7	0.00	80.12	.582	.143	.304	-

Blood collected by jugular venipuncture during examination while cattle restrained in a head-hold device. Blood refrigerated for approximately 36 hours before hematology was run on an Abbott Cell-Dyne 3500. WBC (WIC values) considered valid; WBC differential (neutrophils, lymphocytes, monocytes, eosinophils, basophils) considered invalid due to 36-hour storage of blood.

Hematology reference values are for cattle (New Bolton Center), but not from the Cell-Dyne 3500.

Selenium values of 0.050 ppm are considered marginal; below 0.050 ppm are selenium deficient.

Prolactin (heparin tubes)(Dr. N. Schrick, Univ. of Tenn., Dept. An. Sci.). Ref. means: April non-fescue (171.6) and ergotamine tartrate (105.8 ng/ml).

Cu = copper; Se-AA = selenium. (New Bolton Center)

Peps = serum pepsinogen; odu = optical density units (Texas Veterinary Diagnostic Laboratory, College Station, TX)

Fecal exam: c = coccidia oocysts; s = strongyle eggs; t = Monezia tapeworm eggs; (r) = rare; (f) = few; (m) = moderate. (New Bolton Center).

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 5: Clinical Chemistry

Animal Number	Age	Preg. Status	BUN	Creat	Na+	K+	Cl-	Ca	Mg	Phos	Tot Prot	Alb	Glob	AST	CK	GGT
	years		mg/dl	mg/dl	mmol/l	mmol/l	mmol/l	mg/dl	mg/dl	mg/dl	g/dl	g/dl	g/dl	U/L	U/L	U/L
		Reference Range:	6 - 22	0.5 - 1.1	134 - 144	4.0 - 5.7	96 - 104	8.2 - 10	2.0 - 2.8	4.7 - 9.0	5.8 - 7.5	2.4 - 3.5	3.0 - 3.5	58 - 100		22 - 64
1	4	4 m	14.7	1.68	145	5.14	102	9.8	2.3	5.73	7.2	2.79	4.41	126	89	40
2	3	open	10.5	1.23	143	4.95	106	8.75	1.9	7.02	7.6	2.70	4.90	98	77	36
3	>9	open	11.5	2.00	144	6.00	105	9.42	2.2	5.80	7.8	3.20	4.60	138	110	32
4	>9	7 m	10.8	1.59	144	4.78	106	9.21	2.1	7.24	7.3	2.92	4.38	84	57	29
5	>9	6 m	7.9	1.82	146	5.06	107	7.71	2.0	9.31	7.8	2.96	4.84	98	71	45
6	>9	3 m	8.1	1.73	145	4.55	107	9.87	2.2	5.09	7.6	3.17	4.43	126	181	37
7	>9	6 m	13.5	2.30	143	6.27	102	9.00	1.7	6.66	7.6	3.15	4.45	109	155	30
8	>9	open	10.0	1.47	145	6.13	106	9.58	1.9	5.30	8.0	3.03	4.97	141	187	49
9	>9	open	8.5	1.49	145	5.60	104	9.39	2.1	5.35	7.6	2.85	4.75	111	83	34
10	>9	term	17.0	2.15	150	4.91	109	9.93	2.2	6.11	7.0	3.04	3.96	99	49	35
11	>9	8.5 m	11.6	1.86	149	4.81	111	10.24	2.3	5.02	7.1	2.86	4.24	101	105	27
12	>9	term	21.0	1.62	146	4.64	109	9.56	1.7	4.76	7.6	2.86	4.74	97	76	37
13	>9	open	15.9	1.06	145	5.52	105	9.10	1.8	5.20	7.8	2.74	5.06	141	97	42
14	>9	calf	19.6	1.72	146	5.55	103	9.83	1.8	7.35	7.9	3.30	4.60	127	86	35
15	>9	pregn.	21.2	1.83	144	5.02	104	8.42	2.0	6.37	7.0	2.46	4.54	106	52	34
16	6	open	17.8	1.78	140	5.44	101	9.44	2.1	5.49	6.8	2.82	3.98	96	85	30
17	>9	4 m	12.0	1.87	151	6.46	109	10.29	2.1	5.31	8.3	3.35	4.95	109	87	31
18	>9	4 m	8.2	1.73	144	4.85	102	9.52	2.0	6.76	7.9	3.42	4.48	141	298	39
19	>9	calf	14.3	1.69	147	4.72	105	9.34	2.0	5.07	7.1	3.01	4.09	126	79	28
20	>9	6 m	11.3	2.09	146	5.36	107	10.32	2.1	5.95	8.1	3.07	5.03	113	92	35
21	>9	5 m	17.4	1.47	146	4.77	105	10.25	2.3	6.07	7.9	3.06	4.84	103	96	30
22	>9	5 m	15.6	2.09	145	5.42	108	10.40	2.2	4.93	7.8	3.25	4.55	101	90	34
23	-	bull	8.5	2.55	143	4.55	102	9.42	2.2	5.55	7.6	3.08	4.52	109	97	33
24	>9	6 m	9.6	1.98	148	4.67	110	8.19	2.1	7.03	7.5	3.03	4.47	109	116	37

Data Tables

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 5: Clinical Chemistry (continued)

Animal Number	Age	Preg. Status	BUN	Creat	Na ⁺	K ⁺	Cl ⁻	Ca	Mg	Phos	Tot Prot	Alb	Glob	AST	CK	GGT
	years		mg/dl	mg/dl	mmol/l	mmol/l	mmol/l	mg/dl	mg/dl	mg/dl	g/dl	g/dl	g/dl	U/L	U/L	U/L
		Reference	6 - 22	0.5 -	134 -	4.0 -	96 -	8.2 -	2.0 -	4.7 -	5.8 -	2.4 -	3.0 -	58 -		22 -
		Range:		1.1	144	5.7	104	10	2.8	9.0	7.5	3.5	3.5	100		64
25	4	5 m	10.0	1.99	149	4.93	108	9.90	2.4	7.12	7.7	3.34	4.36	122	138	29
26	6	bull	7.6	2.08	147	4.69	107	9.72	2.2	5.31	7.7	3.13	4.57	139	150	54
27	>9	8 m	14.3	1.72	149	4.97	113	10.18	1.8	3.67	7.4	2.94	4.46	138	133	39
28	7	8 m	14.7	2.07	147	5.44	110	9.83	2.4	5.04	7.6	3.20	4.40	102	123	33
29	>9	term	12.9	2.16	146	5.26	109	10.19	2.2	5.35	7.3	2.83	4.47	98	50	37
30	>9	8 m	14.1	1.64	143	5.42	103	8.80	2.3	6.77	7.5	2.99	4.51	132	90	35
31	8	6 m	11.3	1.66	148	4.55	109	10.33	2.2	5.24	7.3	3.25	4.05	111	99	29
32	>9	6 m	18.8	1.72	143	4.36	106	9.80	2.2	4.72	7.3	2.98	4.32	89	126	43
33	>9	8 m	13.0	1.95	152	4.50	112	9.61	1.4	7.14	7.9	3.14	4.76	150	137	38
34	>9	8 m	19.6	2.56	149	6.27	110	10.79	2.5	6.75	7.9	3.52	4.38	139	99	35
35	>9	5 m	7.9	1.81	148	5.77	107	9.82	2.3	5.30	8.0	3.27	4.73	120	106	30
36	>9	8 m	15.1	2.09	147	5.56	110	9.50	2.3	5.43	7.7	3.05	4.65	112	92	29
37	7	calf	9.8	1.92	146	5.55	106	9.43	2.0	4.12	8.2	3.43	4.77	119	94	36
38	>9	7 m	13.0	1.97	149	4.35	112	9.65	2.1	5.34	8.2	3.47	4.73	206	173	39
39	>9	calf	6.4	2.03	145	4.90	102	9.44	1.9	5.31	8.1	3.01	5.09	135	79	33
40	4	6 m	15.0	1.94	147	5.05	108	10.20	2.2	6.28	7.6	3.12	4.48	147	79	37
41	4	steer	8.3	1.72	143	6.37	106	9.95	2.3	6.99	7.4	3.10	4.30	110	192	26

Blood collected by jugular venipuncture during examination while cattle restrained in a head-hold device. Blood refrigerated for approximately 36 hours before serum chemistry was run on a Kodak Ektachem.

Cattle were corralled for several hours on a warm day, without water, before blood samples were collected.

Reference values are for cattle (New Bolton Center, Kodak Ektachem), except for globulin (Duncan and Prasse).

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 6: Serology

Animal Number	Age	Preg. Status	BLV	John's	Brucella	BVD	BVD	Blue Tongue	Lepto	EHD (type 2)
serum samples		serum test:	elisa	elisa	sn	sn	microplate	AGID	sn	AGID
		Reference Range:								
1	4	4 m	neg	neg	neg	neg	neg	neg	neg	neg
2	3	open	neg	neg	neg	neg	neg	neg	neg	neg
3	>9	open	neg	neg	neg	neg	neg	neg	neg	-
4	>9	7 m	neg	neg	neg	neg	neg	neg	neg	-
5	>9	6 m	neg	neg	neg	neg	neg	neg	neg	-
6	>9	3 m	neg	neg	neg	neg	neg	neg	neg	-
7	>9	6 m	neg	neg	neg	neg	neg	neg	neg	-
8	>9	open	neg	neg	neg	neg	neg	neg	neg	-
9	>9	open	neg	neg	neg	neg	neg	neg	neg	-
10	>9	term	neg	neg	neg	neg	neg	neg	neg	-
11	>9	8.5 m	neg	neg	neg	neg	neg	neg	neg	-
12	>9	term	neg	neg	neg	neg	neg	neg	neg	-
13	>9	open	neg	neg	neg	neg	neg	neg	neg	neg
14	>9	calf	neg	neg	neg	neg	neg	neg	neg	-
15	>9	pregn.	neg	neg	neg	1:512	neg	neg	neg	>1:80
16	6	open	neg	neg	neg	neg	neg	neg	neg	-
17	>9	4 m	neg	neg	neg	neg	neg	neg	neg	neg
18	>9	4 m	neg	neg	neg	neg	neg	neg	neg	neg
19	>9	calf	neg	neg	neg	neg	neg	neg	neg	-
20	>9	6 m	neg	neg	neg	neg	neg	neg	1:100	-
21	>9	5 m	neg	neg	neg	neg	neg	neg	neg	-
22	>9	5 m	neg	neg	neg	neg	neg	neg	neg	-
23	-	bull	neg	neg	neg	neg	neg	neg	neg	-
24	>9	6 m	neg	neg	neg	neg	neg	neg	neg	-

Individual Animal Data: Cattle from Tennant Farm (Washington, West Virginia)

Table 6: Serology (continued)

Animal Number	Age	Preg. Status	BLV	John's	Brucella	BVD	BVD	Blue Tongue	Lepto	EHD (type 2)
(Yrs)			elisa	elisa	sn	sn	microplate	AGID	sn	AGID
serum samples		serum test:	elisa		sn					
		Reference Range:								
25	4	5 m	neg	(neg) ¹	neg	neg	neg	neg	neg	-
26	6	bull	neg	neg	neg	neg	neg	neg	neg	neg
27	>9	8 m	POS	neg	1:256	neg	neg	neg	neg	-
28	7	8 m	neg	neg	neg	neg	neg	neg	neg	-
29	>9	term	neg	neg	neg	neg	neg	neg	1:100	>1:80
30	>9	8 m	neg	neg	neg	neg	neg	neg	neg	-
31	8	6 m	neg	neg	neg	neg	neg	neg	neg	neg
32	>9	6 m	neg	neg	neg	neg	neg	neg	neg	-
33	>9	8 m	neg	neg	neg	neg	neg	neg	1:100	-
34	>9	8 m	neg	neg	neg	neg	neg	neg	neg	neg
35	>9	5 m	neg	neg	neg	neg	neg	neg	neg	-
36	>9	8 m	neg	neg	neg	neg	neg	neg	neg	-
37	7	calf	neg	neg	neg	neg	neg	neg	neg	-
38	>9	7 m	neg	neg	neg	neg	neg	neg	neg	-
39	>9	calf	neg	neg	neg	neg	neg	neg	neg	neg
40	4	6 m	neg	POS	neg	neg	neg	neg	neg	-
41	4	steer	neg	neg	neg	neg	neg	neg	neg	neg

BLV = bovine leukemia virus antibody

John's = *Mycobacterium paratuberculosis* antibody (technique has a 1% false positive error rate)Brucella = *Brucella abortus* antibodyLepto = antibody to *Leptospira* spp. (*L. pomona*, *L. icterohemorrhagiae*, *L. hardjo*, *L. grippityphosa*, *L. canicola*).

BLV, John's, Brucella, and Lepto assays conducted by the Animal Diagnostic Laboratory, Penn. State Univ., University Park, PA.

EHD = 2 of 12 tested cattle were "positive" for EHD-type 2 (Alberta strain); (Texas Veterinary Diagnostic Laboratory, College Station, TX).

Tennant Farm (Washington, West Virginia): Grain and Hay Analysis

Table 7: Nutritional Analysis

Analyte	units	Hay		Grain	
		as sampled basis	dry matter basis	as sampled basis	dry matter basis
Dry Matter	%	86.34	-	89.66	-
Crude Protein	%	6.77	7.84	10.21	11.39
Unavailable Protein	%	1.90	2.20	-	-
Adj. Crude Protein	%	5.55	6.42	-	-
Acid Detergent Fiber	%	40.44	46.84	7.59	8.46
TDN	%	47.67	55.21	69.35	77.35
NE (Lactation)	Mcal/lb	0.33	0.38	0.72	0.81
Calcium	ppm	0.40	0.46	0.95	1.07
Phosphorus	ppm	0.10	0.12	0.30	0.33
Sodium	%	0.02	0.02	0.37	0.48
Magnesium	%	0.13	0.15	0.30	0.34
Sulfur	%	0.18	0.21	0.13	0.14
Potassium	%	0.87	1.01	0.60	0.67
Copper	ppm	5	6	6	7
Iron	ppm	206	239	305	340
Manganese	ppm	331	384	22	24
Zinc	ppm	43	50	39	43
Nitrate Ion	%	0.00	0.00		
Selenium	ppm		0.12		0.19
Hay and grain feed analysis performed by NC Dept. Agric., Food and Drug Protection Division, Forage Testing Laboratory, 4000 Reedy Creek Rd, Raleigh, NC 27607.					
Hay and grain samples collected by cattle team during April 1999 site visit to Tennant Farm. Hay sample consisted of 3 core samples each from 3 large round bales of 1998 cut hay.					

Data Tables

12.0 APPENDICES

Appendix A: Abbreviated Curriculum Vitae of Cattle Team Members

Appendix B: Diagnostic Pathology Reports

Ohio Department of Agriculture: #4977-97

Michigan Animal Health Diagnostic Laboratory: #1792571

University of Pennsylvania Laboratory of Large Animal Pathology
and Toxicology: #UP9902702, #9901437

Appendix C: Dry Run Safety Plan

Appendix D: Figures 1-42 : Photographs of the 42 adult cattle;

Figures 43-66 : Miscellaneous photographs of the Tennant Farm
and cattle

Appendix E: Herd Health History (April 8, 1999 interview)

Appendix F: Diet Analysis: Computer Software Modelling

Appendix A: Abbreviated *Curriculum Vitae* of the Cattle Team Members

Name:	Dr. Perry L. Habecker
Degrees,	
Certifications:	VMD, Diplomate ACVP
Employment:	Chief, Large Animal Pathology, Laboratory of Pathology and Toxicology, Univ. of Penn. School of Veterinary Medicine, New Bolton Center, Kennett Square, PA.
Education:	Juniata College (BS, 1972-1976) University of Pennsylvania, School of Veterinary Medicine (VMD 1969-1973) University of Pennsylvania, School of Veterinary Medicine (resident, 1989-1992)
Affiliations:	American College of Veterinary Pathologists Pennsylvania Veterinary Medical Association American Association of Veterinary Laboratory Diagnosticians
Name:	Dr. Lisa Davis-Heller
Degrees,	
Certifications:	DVM
Employment:	Private Practitioner, St. Mary's Veterinary Clinic, St. Mary's, WV.
Education:	Ohio State University Ohio State University, College of Veterinary Medicine (DVM, 1979-1983)
Affiliations:	American Veterinary Medical Association Ohio Veterinary Medical Association West Virginia Veterinary Medical Association International Veterinary Acupuncture Society Holistic Veterinary Society
Name:	Dr. Peter G. Moisan
Degrees,	DVM, Diplomate ACVP., Diplomate ABVP (food animal specialist: beef cattle
Certifications:	specialist)
Employment:	Veterinary Pathologist and Field Investigator, Rollins Animal Disease Diagnostic Laboratory, North Carolina Department of Agriculture, Raleigh, NC.
Education:	Cleveland State Community College (AS, 1974) East Tennessee State University (BS, Microbiology, 1975) East Tennessee State University (MS, Microbiology, 1978) University of Tennessee, College of Veterinary Medicine (DVM, 1981) Michigan State University (Resident, Veterinary Pathology, 1995) Kansas State University (Research, Veterinary Pathology, 1995-1998)
Affiliations:	American Board of Veterinary Practitioners American College of Veterinary Pathologists American Association of Bovine Practitioners American Association of Swine Practitioners Academy of Veterinary Consultants American Veterinary Medical Association American Association of Veterinary Laboratory Diagnosticians

Name: Dr. Robert J. Munson

Degrees,**Certifications:** VMD**Employment:** Field Investigator, Center for Animal Health and Productivity, Univ. of Penn.
School of Veterinary Medicine, Kennett Square, PA.**Education:** Dickinson College (BS, 1963-1967)

University of Pennsylvania School of Veterinary Medicine (VMD 1969-1973)

Affiliations: American Veterinary Medical Association

American Association of Bovine Practitioners

American Dairy Science Association

Name: Dr. Robert H. Poppenga

Degrees,**Certifications:** DVM, PhD, Diplomate, ABVT**Employment:** Chief, Toxicology, Laboratory of Pathology and Toxicology, Univ. of Penn.
School of Veterinary Medicine, New Bolton Center, Kennett Square, PA.**Education:** Western Illinois University (biological sciences, pre-vet medicine, 1971-1974)

University of Illinois, College of Veterinary Medicine (DVM, 1974-1978)

University of Illinois, College of Veterinary Medicine (PhD, 1983-1987)

Affiliations: American Veterinary Medical Association

Pennsylvania Veterinary Medical Association

American Academy of Veterinary and Comparative Toxicology

American Academy of Clinical Toxicology

Society of Environmental Toxicology and Chemistry

Society of Toxicologic Pathologists

Society of Toxicology

American Association of Veterinary Laboratory Diagnosticians

Name: Dr. Greg P. Sykes

Degrees,**Certifications:** VMD, Diplomate ACVP, Diplomate ABT**Employment:** Pathologist, Safety Assessment, DuPont Pharmaceuticals Company (wholly-owned subsidiary of the DuPont Co.), Stine Research Center, Newark, DE.**Education:** Cornell University: (biological sciences; 1968-1971);

University of Pennsylvania School of Veterinary Medicine (VMD 1971-1975)

Cornell University, NYS College of Vet Medicine (resident/fellow, 1979-1983)

Affiliations: American Veterinary Medical Association

American College of Veterinary Pathologists

International Academy of Pathology

C.L. Davis Foundation for the Advancement of Veterinary Pathology

Royal Microscopical Society

American Board of Toxicology

American Association of Laboratory Animal Science

Association of Wildlife Veterinarians

REPORT OF LABORATORY EXAMINATION

FINAL

PAGE 1 OF 5 (1)

ANIMAL HEALTH DIAGNOSTIC LABORATORY
P.O. Box 30076
Lansing, MI, 48909
Phone (517) 353-5275

PRIVILEGED INFORMATION
NOT FOR PUBLICATION



GROSS NECROPSY

Case Number: 1792571
Reported : 03/12/97
Received : 03/04/97
Pathologist: JSP
Case Origin: NECROPSY

Client Account: 258989

Clinic:

CASPAR, SARAH
U.S. EPA REG. 3
841 CHESTNUT BUILDING
PHILADELPHIA PA 19107

HISTORY : Many cattle on one farm (over 150 out of 200) have died over the past year. Clinical signs include blackened teeth, patchy hair loss and graying of the hair coat, loss of hair in the tail, overgrowth of the hooves, and weight loss. Necropsy findings included patchy, black discoloration of the ruminal mucosa and possible abnormalities in the kidneys. Clinical signs and necropsy findings were described in a video tape which was submitted with the tissues. Tissues from a 4-year-old cow (AHDL 1792571-1) which died on 2/18/97 and tissues from a 9-year-old cow (AHDL 1792571-2) which died on 3/2/97 were submitted. Exposure to an environmental contaminant is suspected.

Anim. #: 1 Name: 2/18 Age: 4y
Breed: HOLSTEIN Sex: FEMALE

LABORATORY FINDINGS

TOXICOLOGY RESULTS AND COMMENTS

SPECIMEN: LIVER

Test: TISSUE MINERAL ANALYSIS (values in ppm)

B (<1.00)	Ba (<0.100)	Ca (51.7)	Cu (1.90)
Co (<0.100)	Fe (170)	Mg (156)	Mn (1.53)
Mo (0.886)	P (2850)	Zn (43.2)	Sb (<1.00)
As (<0.500)	Cr (<0.200)	Cd (0.130)	Hg (<2.00)
Pb (<0.500)	Se (<2.00)	Tl (<2.50)	Na (1360)
K (2070)			

Test Comment:

Copper is within deficient range. Copper deficiency causes acute death and discoloration of hair. Manganese is marginally low. Other tissue element concentrations are within expected ranges.

WKR 03/07/97

58

*DENOTES ADDITIONAL TEST RESULTS
MSU IS AN AFFIRMATIVE ACTION/EQUAL OPPORTUNITY INSTITUTION

EID151739

000061

RGS000942

Case Number: 1792571

SPECIMEN: KIDNEY

Test: TISSUE MINERAL ANALYSIS (values in ppm)

B (<1.00)	Ba (0.281)	Ca (93.5)	Cu (2.37)
Co (<0.100)	Fe (118)	Mg (169)	Mn (0.605)
Mo (0.334)	P (2230)	Zn (19.8)	Sb (<1.00)
As (<0.500)	Cr (<0.200)	Cd (0.838)	Hg (<2.00)
Pb (<0.500)	Se (<2.00)	Tl (<2.50)	Na (1850)
K (2040)			

Test Comment:

Copper is below normal range (4-6 ppm) and cadmium is above normal range (<0.5 ppm).

WKR 03/07/97

SPECIMEN: URINE

Test: TISSUE MINERAL ANALYSIS (values in ppm)

B (2.97)	Ba (0.956)	Ca (409)	Cu (0.0650)
Co (<0.0500)	Fe (0.523)	Mg (428)	Mn (<0.0250)
Mo (<0.100)	P (76.2)	Zn (0.636)	Sb (<0.500)
As (<0.250)	Cr (<0.100)	Cd (<0.0500)	Hg (<1.00)
Pb (<0.250)	Se (<1.00)	Tl (<1.25)	Na (240)
K (6430)			

Test Comment:

No heavy metal found in the urine at the reported detection limits.

WKR 03/07/97

Both livers and kidneys had low copper. This is the major finding so far. Reported adequate liver mineral ranges for cattle are: calcium 30 to 200 ppm; copper, 25 to 150 ppm; iron, 45 to 300 ppm; magnesium, 100 to 200 ppm; manganese, 2.5 to 4.0 ppm; molybdenum, 0.14 to 1.40 ppm; phosphorus, 1500 to 4100 ppm; zinc, 25 to 200 ppm; sodium, 600 to 1900 ppm; and potassium, 1200 to 3300 ppm.

Toxicant screen by GC/MS on the liver is in progress and will be reported out in a supplemental report when available.

Nutritional examination: Urine fluoride concentration was 6.6 ug/ml.

Anim. #: 2 Name: 3/2
Breed: HOLSTEIN

Age: 9y
Sex: FEMALE

59

*DENOTES ADDITIONAL TEST RESULTS

EID151740

000062

RGS000943

Case Number: 1792571

SPECIMEN: FIXED TISSUES

HISTOPATHOLOGIC EXAMINATION

Sections of heart, liver, and kidney were examined. In sections of liver, there was advanced postmortem autolysis, with freeze/thaw artifacts in one section. Most hepatocytes contained single, small, round, clear, intracytoplasmic vacuoles, indicating mild, diffuse hepatic lipidosis. In sections of kidney, most glomeruli contained slightly increased quantities of eosinophilic mesangial matrix. The significance of this finding is unknown, and it may be a postmortem artifact. In sections of heart, small numbers of myofibers contained Sarcocystis cysts.

LABORATORY FINDINGS

TOXICOLOGY RESULTS AND COMMENTS

SPECIMEN: LIVER

Test: TISSUE MINERAL ANALYSIS (values in ppm)

B (<1.00)	Ba (<0.100)	Ca (32.7)	Cu (2.03)
Co (0.141)	Fe (356)	Mg (149)	Mn (1.76)
Mo (0.758)	P (2810)	Zn (88.6)	Sb (<1.00)
As (<0.500)	Cr (<0.200)	Cd (0.219)	Hg (<2.00)
Pb (<0.500)	Se (<2.00)	Tl (<2.50)	Na (1040)
K (2670)			

Test Comment:

Copper is within deficient range. The following element(s) is/are below normal range(s): manganese. The following element(s) is/are above normal range(s): Iron.

WKR 03/07/97

SPECIMEN: KIDNEY

Test: TISSUE MINERAL ANALYSIS (values in ppm)

B (<1.00)	Ba (0.327)	Ca (63.7)	Cu (2.33)
Co (<0.100)	Fe (71.5)	Mg (126)	Mn (0.595)
Mo (0.388)	P (1880)	Zn (26.5)	Sb (<1.00)
As (<0.500)	Cr (<0.200)	Cd (1.76)	Hg (<2.00)
Pb (<0.500)	Se (<2.00)	Tl (<2.50)	Na (2020)
K (2100)			

60

Case Number: 1792571

SPECIMEN: HAIR

Test: GENERAL MINERAL ANALYSIS (values in ppm)

B (<4.00)	Ba (9.37)	Ca (1740)	Cu (7.23)
Co (0.517)	Fe (263)	Mg (1090)	Mn (29.9)
Mo (<0.800)	P (288)	Zn (71.8)	Sb (<4.00)
As (<2.00)	Cr (<0.800)	Cd (<0.400)	Hg (<8.00)
Pb (<2.00)	Se (<8.00)	Tl (<10.0)	Na (68.4)
K (973)			

SPECIMEN: URINE

Test: FLUID MINERAL ANALYSIS (values in ppm)

B (2.70)	Ba (0.328)	Ca (18.2)	Cu (<0.0250)
Co (<0.0500)	Fe (<0.250)	Mg (188)	Mn (<0.0250)
Mo (<0.100)	P (131)	Zn (0.101)	Sb (<0.500)
As (<0.250)	Cr (<0.100)	Cd (<0.0500)	Hg (<1.00)
Pb (<0.250)	Se (<1.00)	Tl (<1.25)	Na (231)
K (8400)			

Both livers and kidneys had low copper. This is the major finding so far. Reported adequate liver mineral ranges for cattle are: calcium 30 to 200 ppm; copper, 25 to 150 ppm; iron, 45 to 300 ppm; magnesium, 100 to 200 ppm; manganese, 2.5 to 4.0 ppm; molybdenum, 0.14 to 1.40 ppm; phosphorus, 1500 to 4100 ppm; zinc, 25 to 200 ppm; sodium, 600 to 1900 ppm; and potassium, 1200 to 3300 ppm.

Toxicant screen by GC/MS on the liver is in progress and results will be reported in a supplemental report when available.

Nutritional examination: Urine fluoride concentration was 5.55 ug/ml.

SPECIMEN: SERUM

CLINICAL PATHOLOGY

Serum chemistry profile was run on a sample submitted from cow #2. Abnormalities included slightly low sodium concentration (137.6 mmol/L; reference range = 139-145), slightly low sodium to potassium ratio (24; reference range = 25-35), low serum albumin concentration (2.9 g/dl; reference range = 3.5-5.0), slightly low albumin to globulin ratio (0.81; reference range = 1.01-3.39), slightly elevated total bilirubin (0.4 mg/dl; reference range = <0.3), slightly elevated creatinine (1.7 mg/dl; reference range = 0.6-1.3), low calcium concentration (6.5 mg/dl; reference range = 7.9-10.7), slightly low sorbitol dehydrogenase activity (8.6 UL; reference range = 13.4-70.7), slightly elevated serum iron concentration (138 ug/dl; reference range = 40-136), and slightly low osmolality (283 mOsm/kg; reference range = 286-302).

61

FINAL

PAGE 5 OF 5 (1)

Case Number: 1792571

COMMENTS:

No significant pathologic findings.

[Toxicologic analyses are in progress and a supplemental report will be sent when results are available. R. Puls in "Mineral Levels in Animal Health" gives the normal levels of fluoride in cattle urine as 0.7 to 5.0 ppm, the high levels as 5.0 to 15.0 ppm, and the toxic levels as 14.0 - 120.0 ppm.]

Jon S. Patterson
Pathologist

(517) 353-5275

jms

62

*DENOTES ADDITIONAL TEST RESULTS
MSU IS AN AFFIRMATIVE ACTION/EQUAL OPPORTUNITY INSTITUTION

EID151743

000065

RGS000946

FROM : BELFRE ANIMAL CLINIC

PHONE NO. : 614 423 1758

3K17-2230-46 p22
3R17-2230-46

Animal Disease Diagnostic Laboratory

Accession: 4977-97
Report date: 3-10-97/SG
Owner: Custer, Kevin () 887-8135
Coordinator: Dr. Sheila Grimes

Ohio Department of Agriculture
8995 East Main St.
Reynoldsburg, OH 43068
614-728-8220
FAX: 728-8310

[REDACTED]
BELFRE, OH 45714

**SUBMISSION
SUMMARY**

Taken: not given
Received: 2-28-97

Species	Animals	Tests	Completed
Bovine	1	8	8

**** ADDENDED REPORT ****

PATHOLOGY

ANIMAL ID: 1: (not provided), Bovine, Mixed Breed Beef

Sample: Dead Animal

NECROPSY & HISTOPATHOLOGY 2-27-97/11:24a

Necropsy:

History: 6 MO

A dead, six-month-old bull calf was submitted. The calf is underweight and has had diarrhea for one month. According to the history, the calf has not been dewormed and has not received any medication. The eyes of the cow were observed to have cloudy centers.

Gross examination:

The male calf was presented dead. The carcass weighed 150 lbs. The nutritional state was poor. Minimal body fat was present on the carcass and serous atrophy of fat was present around the heart and kidneys. The state of hydration was fair. A few *Trichuris* were present in the cecum. Hay, but no grain was present in the forestomach. Formed fecal balls were present in the rectum. Feces were matted around the anus. Matted foam was present in the trachea. No additional gross lesions were observed.

Morphologic diagnosis:

Emaciation with serous atrophy of fat
Intestinal parasitism (trichuriasis)

Comments:

The calf was in an extremely poor nutritional state. During inclement weather conditions (i.e., cold associated with winter) nutritional requirements of animals increase and it is extremely important to increase the feed intake of the animals. Hay, but no grain, was observed in the forestomach. Supplementation of the hay with additional feed sources may be beneficial. Additionally, several parasite ova were observed in the feces and whipworms were observed in the cecum. A parasitic burden reduces the nutritional intake of the animal, compounding the

63

EID151744

000066

RGS000947

FROM : BELPRE ANIMAL CLINIC

PHONE NO. : 614 423 1758

F01

Accession: 4877-87 · Veterinarian: Alloway, Clyde H. Jr. Owner: Custer, Kevin
(continued)

Page: 2

NECROPSY & HISTOPATHOLOGY 3-27-87/11:24s (Continued)

previously poor nutritional state. Histopathologic, bacteriologic and virologic examinations are currently in progress. Lesions observed in the bull's eyes may have been a result of the cold, but a histopathologic examination of the eyes is currently in progress.

Sheila Grimes, DVM, PhD, Diplomate, ACVP
Veterinary Pathologist
Pathology Section
Histopathologic examination:

Sections of cerebrum, cerebellum, brainstem, lung, lymph node, liver, kidney, adrenal, duodenum, jejunum, ileum, colon, heart and skeletal muscle were examined. Moderate to severe postmortem autolysis was present in the sections of intestine. Several coccidial schizonts, ranging in size from 200 to 500 microns in diameter, were present in the small intestinal mucosa. Within the section of colon, various stages of coccidia, including coccidial oocyst, gametes and gametes, were present within crypt epithelial cells. Crypt abscesses were present within some of the crypts. The crypts were atrophic and lined by attenuated epithelium. The section of liver had mild to moderate, diffuse microvesicular vacuolation of hepatocytes. Hepatocytes contained multiple, poorly delineated vacuoles within their cytoplasm.

Etiologic diagnosis:

Enteric coccidiosis

*Crypts = dip. in
in intestinal mucosa*

Sheila Grimes, DVM, PhD, Diplomate, ACVP
Veterinary Pathologist
Pathology Section

Histopathologic examination:

Two sections of eye were examined. The eye had a chronic keratitis (corneal scar) characterized by the presence of a focally extensive area of fibroplasia consisting of relatively loosely arranged fibroblasts admixed with a few lymphocytes and plasma cells in the cornea. Mild vascularization and edema was present in the areas of fibrosis. The corneal epithelium overlying the area of fibrosis was hyperplastic and undergoing epidermal metaplasia with the formation of rete ridges. Descemet's membrane was cut and retracted (coiled).

Morphologic diagnosis:

Moderate, chronic, focally extensive fibroplastic keratitis.

Sheila Grimes, DVM, PhD, Diplomate, ACVP
Veterinary Pathologist
Pathology Section

64

EID151745

000067

RGS000948

FROM : BELPRE ANIMAL CLINIC

PHONE NO. : 614 423 1758

P82

Accession: 4877-87

Veterinarian: Alloway, Clyde H. Jr.

Owner: Custer, Kevin

Page: 3

(continued)

FECAL FLOTATION 2-27-87/11:24a (Continued)

FECAL FLOTATION 2-27-87/11:24a

Results:

Numerous strongyle type eggs, moderate numbers of oocidial oocysts and a few whipworm eggs were observed.

MICROBIOLOGY

ANIMAL ID: 1: (not provided), Bovine, Mixed Breed Beef

Sample: Pooled Tissue Culture

SALMONELLA CULTURE 3-3-87/11:24a

Results:

Negative

DIAGNOSTIC VIROLOGY

ANIMAL ID: 1: (not provided), Bovine, Mixed Breed Beef

Sample: Intestine

FA-CORONA VIRUS 2-27-87/4:51p

Results:

Negative

ANIMAL ID: 1: (not provided), Bovine, Mixed Breed Beef

Sample: Ileum

FA-CORONA VIRUS 2-27-87/4:51p

Results:

Negative

FA-GIARDIA 2-27-87/4:51p

Results:

Negative

FA-CRYPTOSPORIDIA 2-27-87/4:51p

Results:

Negative

65

EID151746

000068

RGS000949

FROM : BELPHE ANIMAL CLINIC

PHONE NO. : 614 423 1758

Accession: 4877-87

Veterinarian: Alloway, Clyde H. Jr.

Owner: Custer, Kevin

Page: 4

FINAL DIAGNOSIS & COMMENTS 3-4-87/5:40p (Continued)

PATHOLOGY

ANIMAL ID: 1: (not provided), Bovine, Mixed Breed Beef

Sample: Dead Animal

FINAL DIAGNOSIS & COMMENTS 3-4-87/5:40p

DIAGNOSIS

Emaciation

Atrophy, Serous

Coccidiosis, Enteric

Trichuriasis

Keratitis

Comments:

Please refer to the previous comments. The scour observed in the animal was probably a result of enteric coccidiosis. Histopathologic examination of the eye is currently in progress and results will be reported in an addendum.

Shella Grimes, DVM, PhD, Diplomate, ACVP
Veterinary Pathologist
Pathology Section

Addendum:

Please refer to the histopathologic description of the eye. Lesions in the eye were indicative of a prior corneal injury. Corneal injury may result from physical or chemical trauma, microbial agents, increased ocular pressure and rarely, inborn errors of metabolism. The exact cause of the keratitis or corneal wound in this case was not determined. Lesions in the eye were suggestive of those associated with trauma, but a traumatic injury in both eyes would be unusual. The ulcerating and suppurative keratitis associated with *Moraxella* was not observed in this case. However, fibrosis may occur with healing subsequent to the infection.

Shella Grimes, DVM, PhD, Diplomate, ACVP
Veterinary Pathologist
Pathology Section



NEW BOLTON CENTER

University of Pennsylvania, New Bolton Center
Laboratory of Large Animal Pathology and
Toxicology
382 W. Street Road
Kennett Square, PA 19348
Phone: (610) 444-5800 Fax: (610) 925-8110

FINAL REPORT

Accession No.: UP 9902707

Pg #: 1

Submitter: Dr. Perry Habecker

Report Address:

Dry Run Investigation Team

Case Tracking #: N o.p.

Case Coordinator: Perry L. Habecker, VMD

Date Submitted: 6/27/99

Report Date: 7/5/99 TA(D): 8

Species: Bovine	Production type:	Date obtained:	Reference Lab:
Breed:	Sex: F	Age:7 y m w d	☒ Adult ☐ Fetus ☐ Juvenile ☐ Unknown
Animal I.D. #37			
Sample:14..... Fixed Tissue			

HISTORY SUMMARY:

Killed and necropsied for Dr. Lisa Heller on June 10, 1999. Tissues also submitted to toxicology. (ADDENDUM: tissues for toxicologic assay were received 7/28 and accessioned as 9903263.)

DIAGNOSIS:

Enteric lesions of minimal significance.

COMMENTS:

The gastrointestinal eosinophilia is attributed to previous and current bouts of endoparasitism. Epithelial abscessation in the forestomachs is associated with acidosis due to excessive carbohydrate ingestion.

LABORATORY FINDINGS:

HISTOPATHOLOGY EXAMINATION:

- 1) Heart, 2 pieces: Minimal, focal lymphocytic myocarditis; focal Sarcocyst spp..
- 2) Lung, 2 pieces: Normal
- 3) Liver, 2 pieces: Normal
- 4) Spleen: Normal
- 5) Kidney: Normal
- 6) Test: Normal
- 7) Adrenal, 2 pieces: Normal
- 8) Lymph node, 2 pieces: Normal
- 9&10) Small intestine, 4 pieces: Mucosa--moderately severe, diffuse eosinophilia; focal coccidian parasite.
- 11) Abomasum, 2 pieces: Mucosa--mild, multifocal eosinophilia.
- 12) Omasum: Epithelium--abscesses, moderately severe, acute, multifocal.
- 13) Reticulum: Epithelium--abscesses, mild, acute, multifocal; tunica muscularis--granuloma, minimal, focal with intralesional plant foreign body.
- 14) Thymus: Normal

Perry L. Habecker, VMD

PLH

67

EID151748

000070

RGS000951



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FINAL REPORT

Accession No.: UP 9903263

Pg #: 1

Vet: Dr. Lisa Davis-Heller
Submitter: Dr. Perry Habecker

Report Address: Dry Run Investigation

Case Tracking #: Toxicology
Case Coordinator: Robert H. Poppenga, DVM, PhD
Date Submitted: 7/29/99
Report Date: 8/19/99 TA(D): 21

Species: Bovine	Production type: Beef	Date obtained:	Reference Lab:
Breed:	Sex: F	Age:7 y	m w d ☒ Adult ☐ Fetus ☐ Juvenile ☐ Unknown
Animal I.D. #37			
Sample:6..... Frozen Tissue			

HISTORY SUMMARY:

Killed and necropsied for Dr. Lisa Heller on June 10, 1999. Tissues also submitted to histology (see 9902707).

DIAGNOSIS:

Copper deficiency.

COMMENTS:

The following bovine liver mineral ranges can be utilized for the interpretation of the analytical results contained in this report. The indicated ranges are only guidelines and the results need to be interpreted in conjunction with management, dietary, and clinical variables. Herd evaluations should be based upon analysis of samples from an adequate number of animals.

Mineral	Deficient	Marginal	Adequate
Calcium	< 40 ppm		30 to 200 ppm
Cobalt	< 0.005 ppm	0.005 to 0.017 ppm	0.020 to 0.085 ppm
Copper	< 25 ppm		25 to 150 ppm
Iron	< 30 ppm		45 to 300 ppm
Magnesium			100 to 200 ppm
Manganese	< 1.00 ppm	1.50 to 3.00 ppm	
Molybdenum			0.14 to 1.40 ppm
Selenium	0.02 to 0.17 ppm	0.12 to 0.25 ppm	0.25 to 0.50 ppm
Zinc	< 20 ppm	25 to 40 ppm	25 to 200 ppm

Ranges obtained from Puls' Mineral Levels in Animal Health.

LABORATORY FINDINGS:

TOXICOLOGY RESULTS:

Sample: Liver and kidney

Test: Complete Metal Screen

Liver Kidney

Arsenic < 0.50 < 0.50

68

EID151749

000071

RGS000952



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382 W. Street Road
Kennett Square, PA 19348
Phone: (610) 444-5800 Fax: (610) 925-8110

FINAL REPORT

Accession No.: UP 9903263

Pg #: 2

Vet: Dr. Lisa Davis-Heller
Submitter: Dr. Perry Habecker

Cadmium	< 0.10	0.555
Chromium	< 0.20	< 0.20
Mercury	< 1.00	< 1.00
Lead	< 0.50	< 0.50
Selenium	< 1.00	< 1.00
Thallium	< 2.00	< 2.00
Calcium	42.4	70.9
Cobalt	< 0.10	< 0.10
Copper	7.71	4.29
Iron	67.0	93.9
Magnesium	178	148
Manganese	4.97	1.66
Molybdenum	1.09	< 0.30
Selenium	0.236	
Zinc	39.4	19.0
Beryllium	< 0.02	< 0.02
Nickel	< 0.30	< 0.30
Vanadium	< 0.30	< 0.30

All metal results are reported as ppm on a tissue wet weight basis.

Beryllium, vanadium and nickel are pending.

Sample: Liver and fat

Test: Organic Chemical Screen by GC/MS

No toxic compounds were detected in the submitted sample by our gas chromatography - mass spectroscopy organic chemical screen. Both conventional extraction and SPME were used on the liver and fat samples.

Sample: Rib Bone

Test: Fluoride

Fluoride was detected in the submitted bone sample at 1009 ppm (expressed on a fat free, dry bone basis).

Robert H. Poppenga, DVM, PhD

69

EID151750

000072

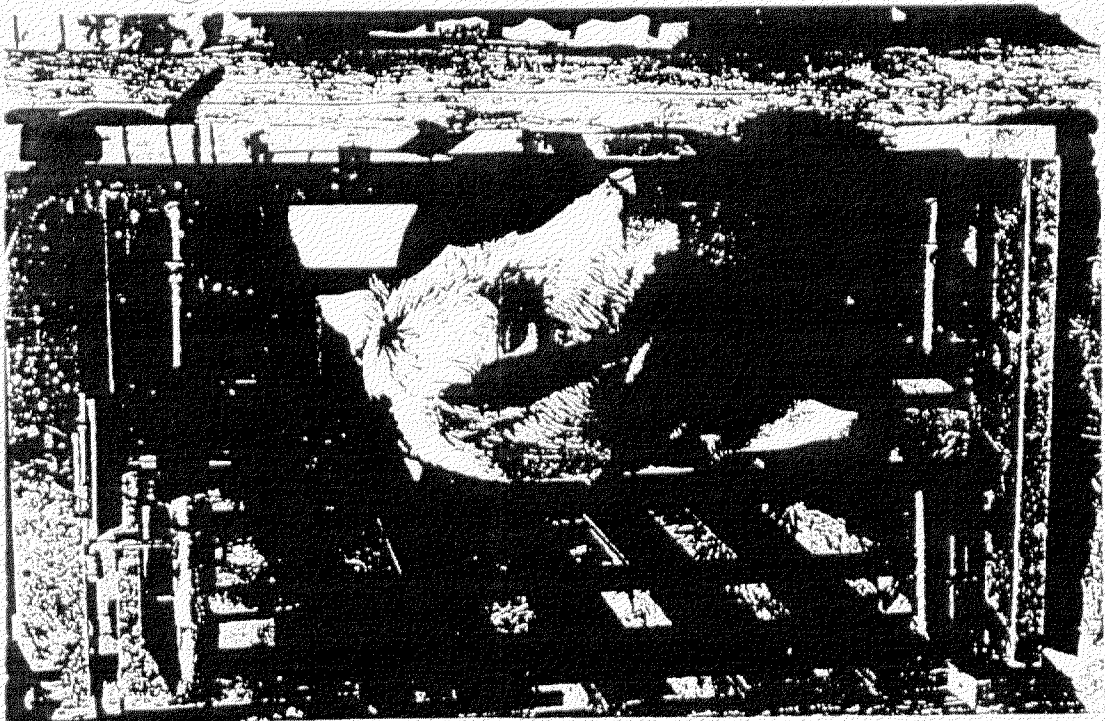
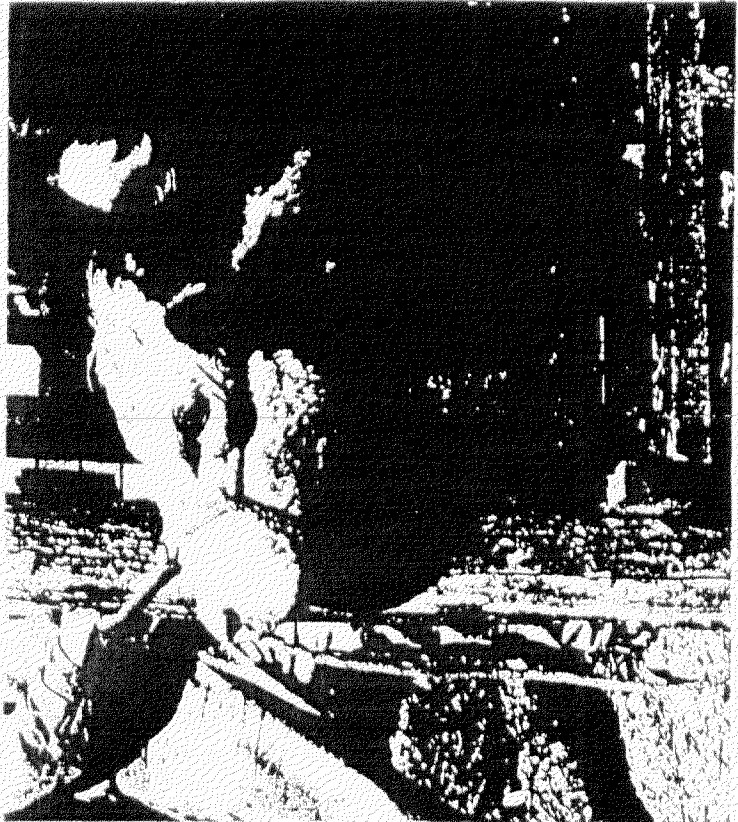
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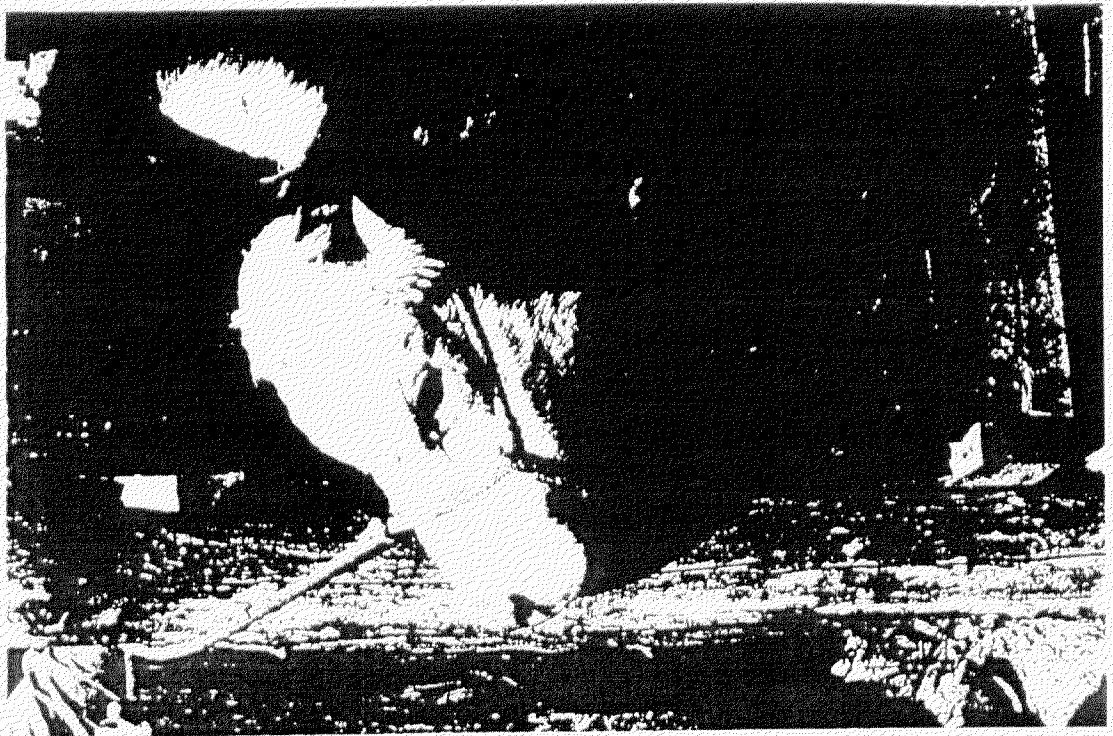
Dry Run Safety Plan

Hazard	Plan
1. Physical injury from cattle	- The team will follow the direction of the 3 most experienced cattle handlers (Bob M., Lisa, and Pete). - Mr. Tennant and his brother will help with the handling of the cattle (<i>note: added during 4/7/99 safety meeting</i>). - Rectal palpations will be performed only by veterinarians. - All members of the cattle team will be responsible for their personal safety, the safety of the team, and the safety of other personnel in the animal handling area. - All persons in the animal-handling area will be expected to abide by these safe practices. - Physical restraint devices (corral, headgate, halters) will be examined for adequacy before use. - Chemical restraint (e.g., sedatives) will be used on individual cattle if needed.
2. Physical injury from devices (e.g., knives, needles)	- All members of the cattle team are experienced in the handling of veterinary tools. Necropsies, phlebotomies, ear tagging, and similar procedures will be conducted only by the veterinarians. - Disposable sharps (e.g., blades, needles) will be placed in an approved sharps container and returned to New Bolton Center.
3. Biological safety	- The cattle team will be appropriately dressed (coveralls and boots) when working with the livestock. - Soapy water, scrub brush, and paper towels will be available. - Rectal sleeves will be used for rectal palpations. - Latex gloves will be used for necropsies and when otherwise considered appropriate. (For the biosafety of the cattle, "single use" collection devices will be used.) - If clinical signs warrant, the cattle team may implement additional biological safety measures.
4. Chemical safety	Formalin will be used as a preservative during the collection of necropsy tissues. All personnel will avoid skin contact with formalin.
Notes: This <i>Safety Plan</i> will be reviewed by all members of the cattle team prior to their arrival at Mr. Tennant's Farm in the Dry Run area. (<i>note: plan was reviewed and accepted during safety meeting on 4/7/98 at the Parkersburg Holiday Inn. Cattle team and 4 EPA/USFWS persons present</i>) The cattle team consists of six veterinarians: Drs. Lisa Davis-Heller, Perry Habecker, Peter Moisan, Bob Munson, Bob Poppenga, and Greg Sykes.	

Photo #	Photograph Legend
1 - 41	Cattle 1 - 41, respectively. Each photo number corresponds to the ear tag number (placed following examination) of the cow, bull, or steer and the animal number in Table 1 of this report.
42	Cow # 42: The individual cow which escaped the run and was therefore not ear tagged or examined.
43	Livestock in corral. The 42 adult cattle (39 cows, 2 bulls, 1 steer) and 12 calves were held in this corral for several hours prior to examination in the late afternoon of April 7, 1999.
44	Cow # 25: Corneal scar
45	Cow # 26: Corneal opacity
46	Cow # 30: Corneal opacity
47	Cow # 37: Corneal scar
48	Cow # 40: Corneal opacity
49	Cow # 22: Mass (12 cm diameter), prescapular, subcutaneous, neck, right.
50	Cow # 22: Scalpel puncture and drainage of mass during examination. Brown-red fluid contents drained.
51	Cow # 22: Manual exploration of cystic cavity revealed a large mass of red hair within the cyst. Diagnosis was "epidermal inclusion cyst" of spontaneous origin which was of no significance to herd health.
52	Cow # 31: Tongue with spotty melanosis. This was an incidental finding of no pathological significance. Melanosis of epidermal tissues, as seen here, is normal.
53	Cow # 18: Mammary gland lump adjacent to teat. This was considered to most likely be an abscess.
54	Group of cattle, owned by a neighbor of Mr. Tennant, grazing on an adjacent property.
55	Deer carcass on Tennant property. One of three deer carcasses observed by Mr. Tennant and Dr. Sykes, within 500 feet of the Tennant barn on April 8, 1999. All three appeared to have died in the past few months.
56	Tennant barn and barnyard adjacent to the corral where the cattle examinations were conducted.
57	Grazing pasture along the Dry Run Creek between the landfill site and the Tennant barn.
58	Grazing pasture along the Dry Run Creek between the landfill site and the Tennant barn.
59	Group of 16 cow skulls (photo supplied by Mr. Tennant)
60	Worn incisors of an unidentified cow, bull, or steer (photo supplied by Mr. Tennant).

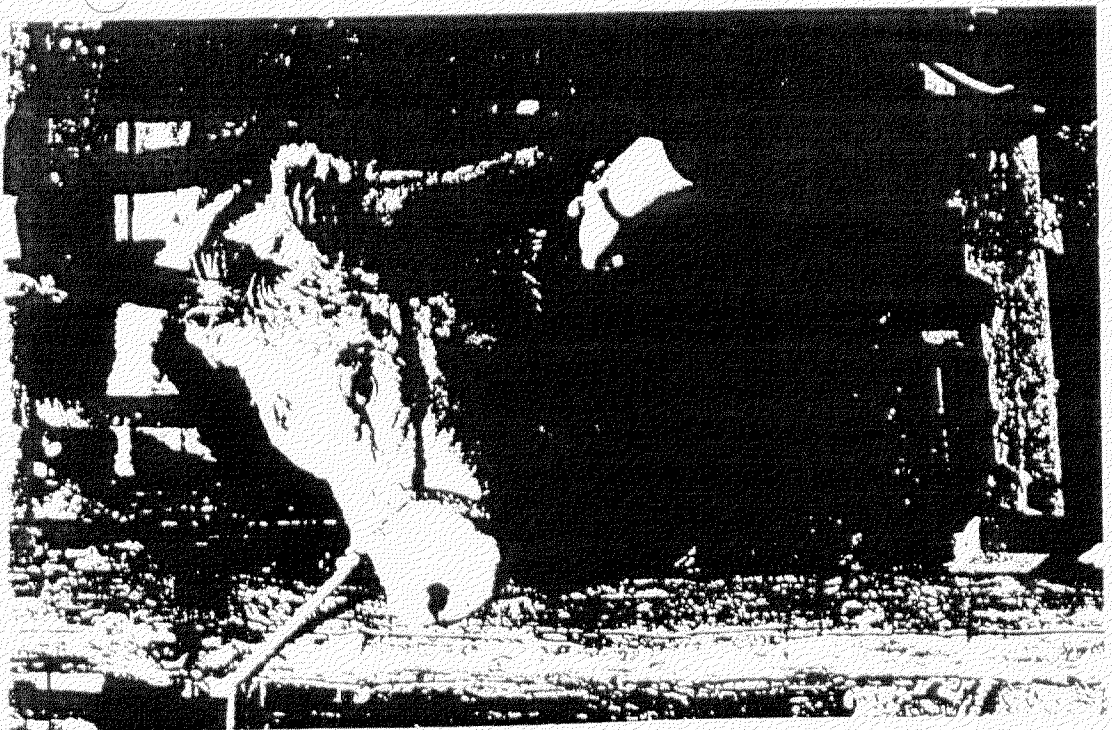
Photo #	Photograph Legend (continued)
61	Neck alopecia in an unidentified animal (photo supplied by Mr. Tennant). The cattle team considered this most likely due to lice.
62	Neck alopecia in an unidentified animal (photo supplied by Mr. Tennant). The cattle team considered this most likely due to lice.
63	Nose with spotty melanosis (photo supplied by Mr. Tennant). The cattle team considered this pigmentation to be normal.
64	Nose with diffuse melanosis (photo supplied by Mr. Tennant). The cattle team considered this pigmentation to be normal.
65	Hard palate with spotty melanosis (photo supplied by Mr. Tennant). The cattle team considered this pigmentation to be normal.
66	Cattle team (CT) and steering committee (SC) members at the Tennant Farm during the April 7-8 1999 site visit. From left to right: Dr. Robert Poppenga (CT: veterinary toxicologist), Dr. Robert Munson (CT: veterinary clinician); Dr. Peter Moisan (CT: veterinary clinician/pathologist), Sarah Caspar (SC: EPA On-Scene Coordinator), Dr. Perry Habecker (CT: veterinary pathologist), Dr. Lisa Davis-Heller (CT: veterinary clinician), Dr. Michael Horne (SC: USFWS, Environmental Response Team). Not shown: Dr. Greg Sykes (CT: veterinary pathologist/toxicologist; taking picture); Dr. Ralph Stahl (SC: DuPont biologist; not present) and Dr. Rudolph Valentine (SC: DuPont toxicologist; not present).





4

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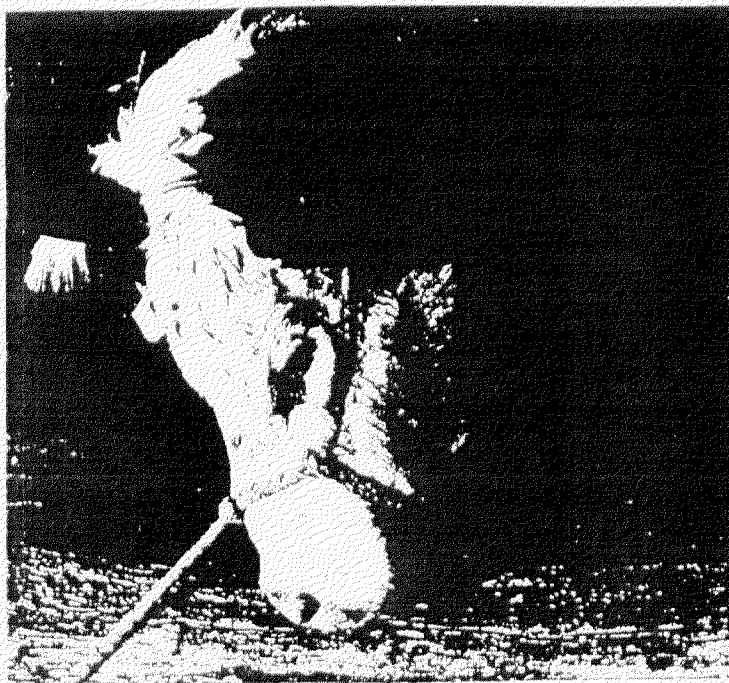


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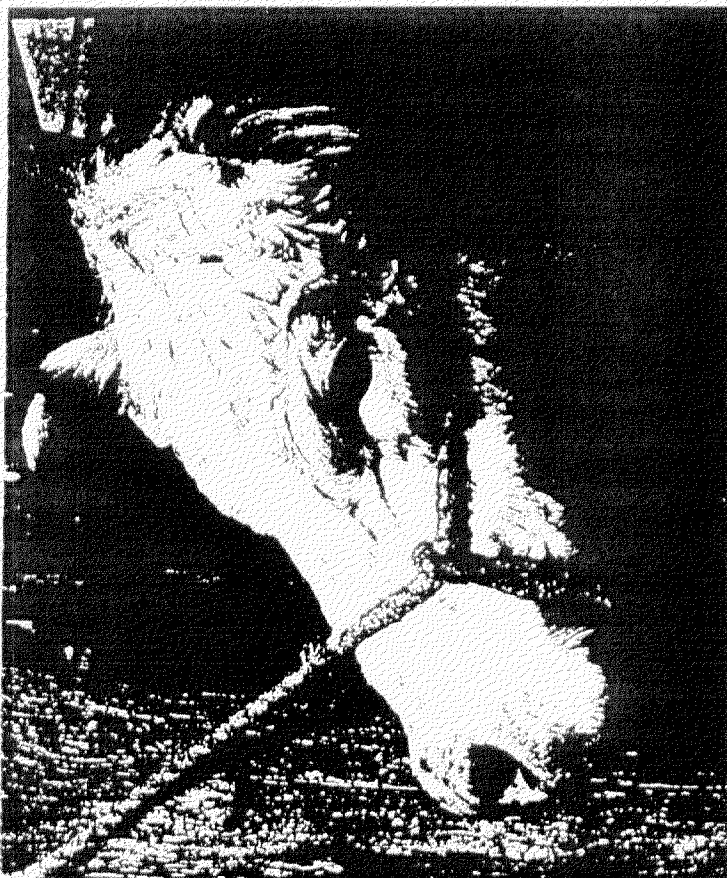
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RGS000958



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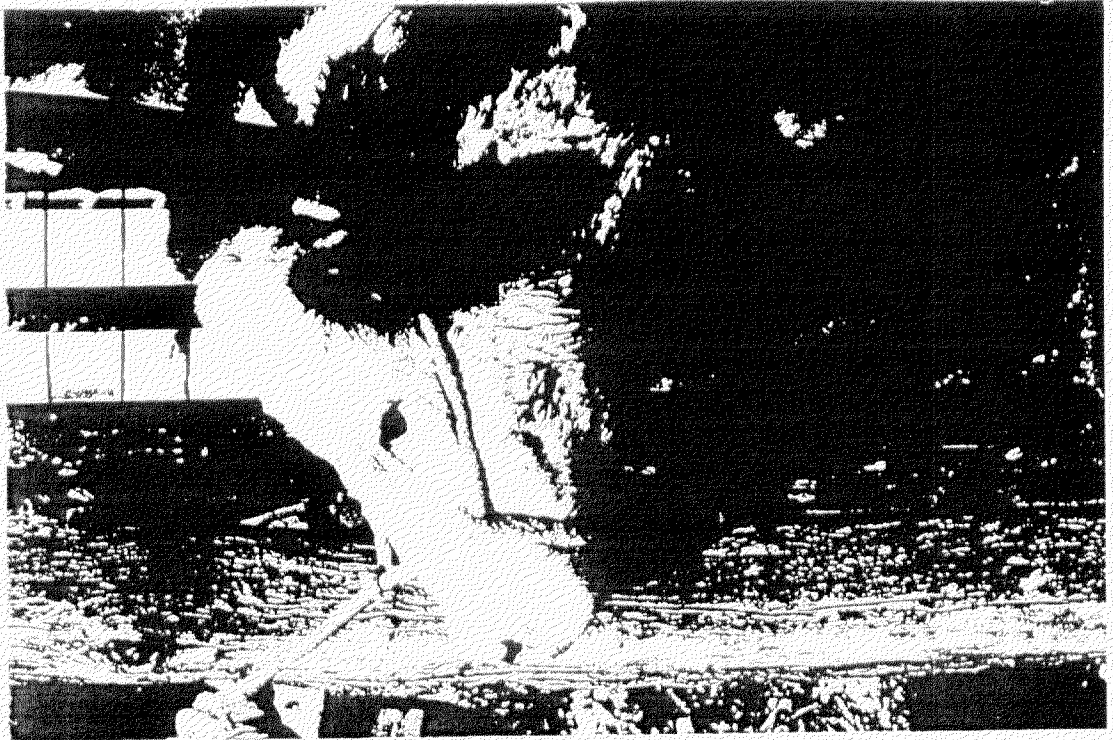
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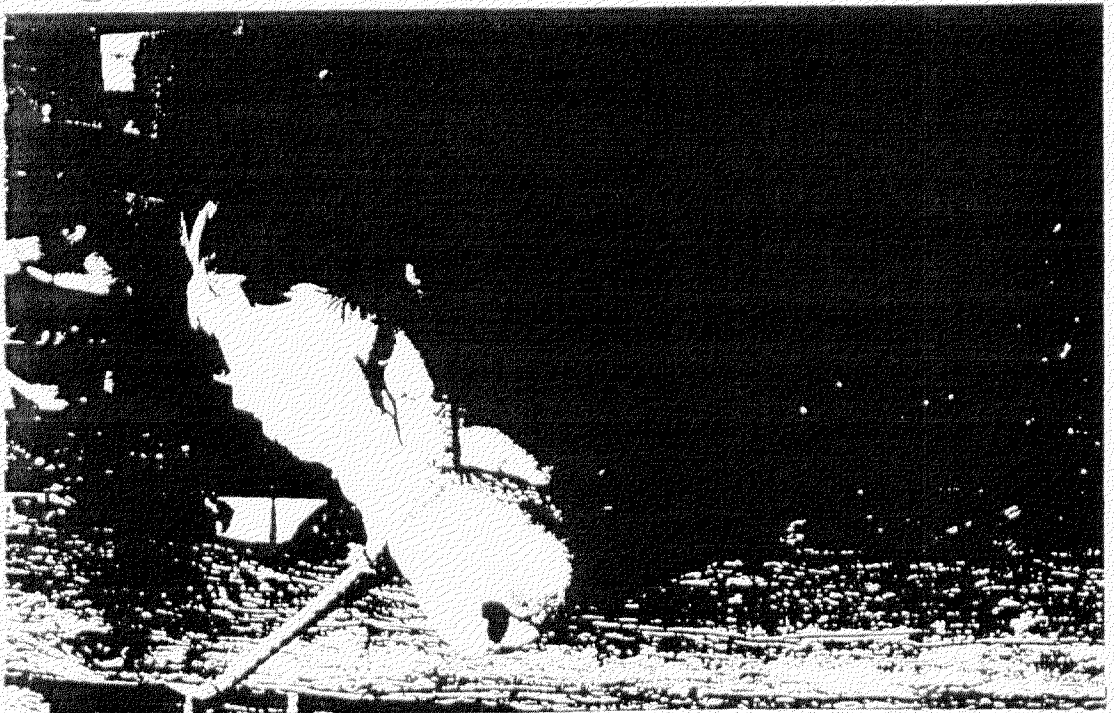
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RGS000959



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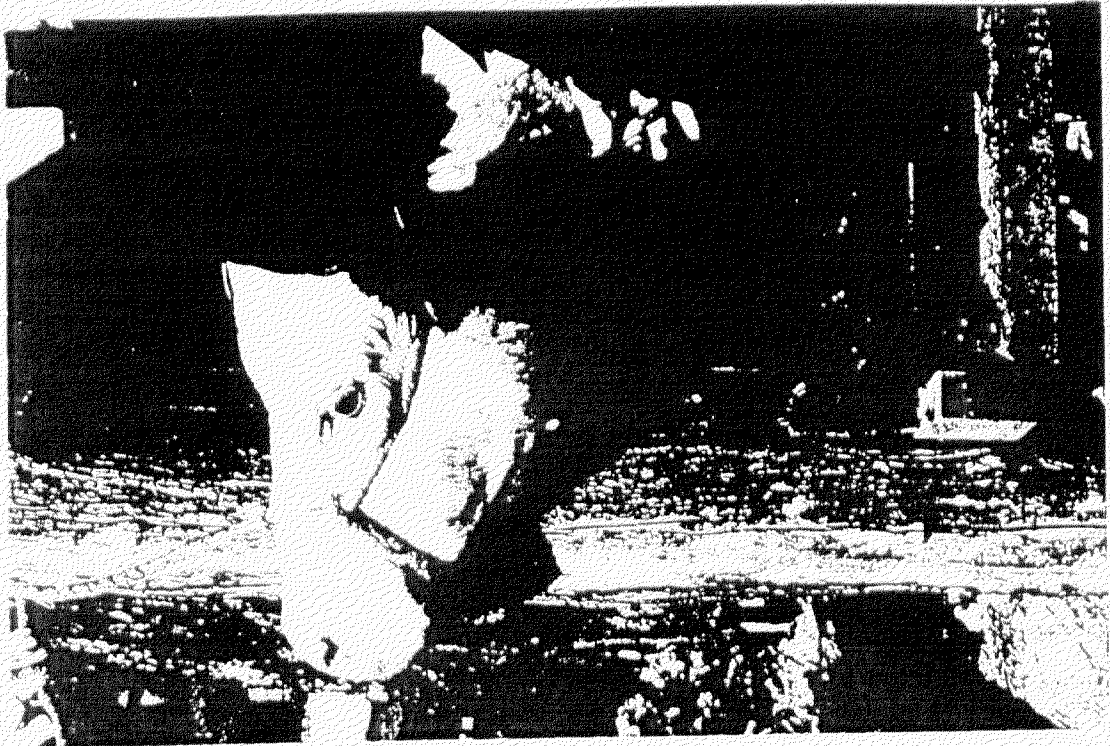


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EID151757

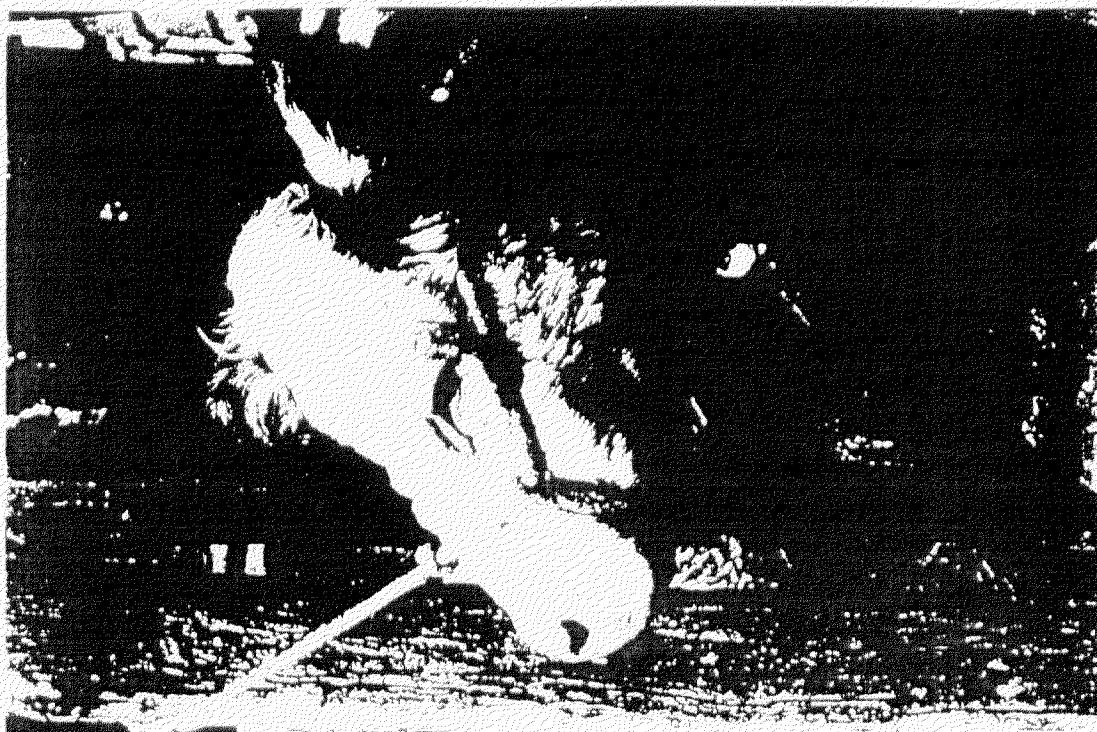
RGS000960



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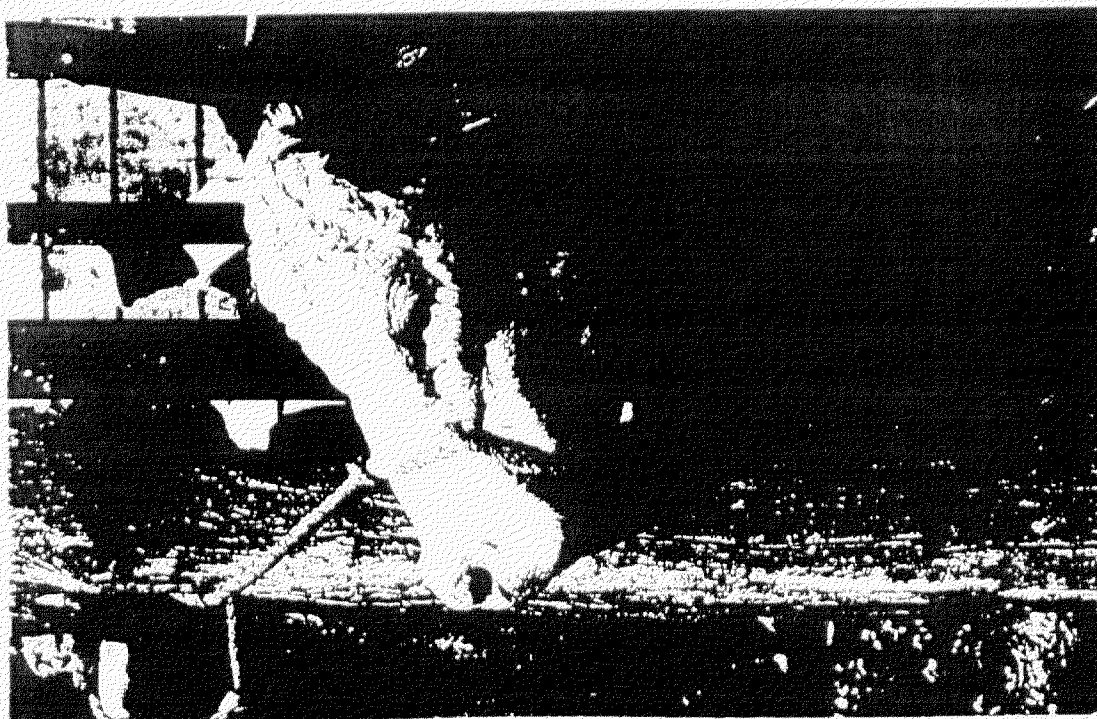


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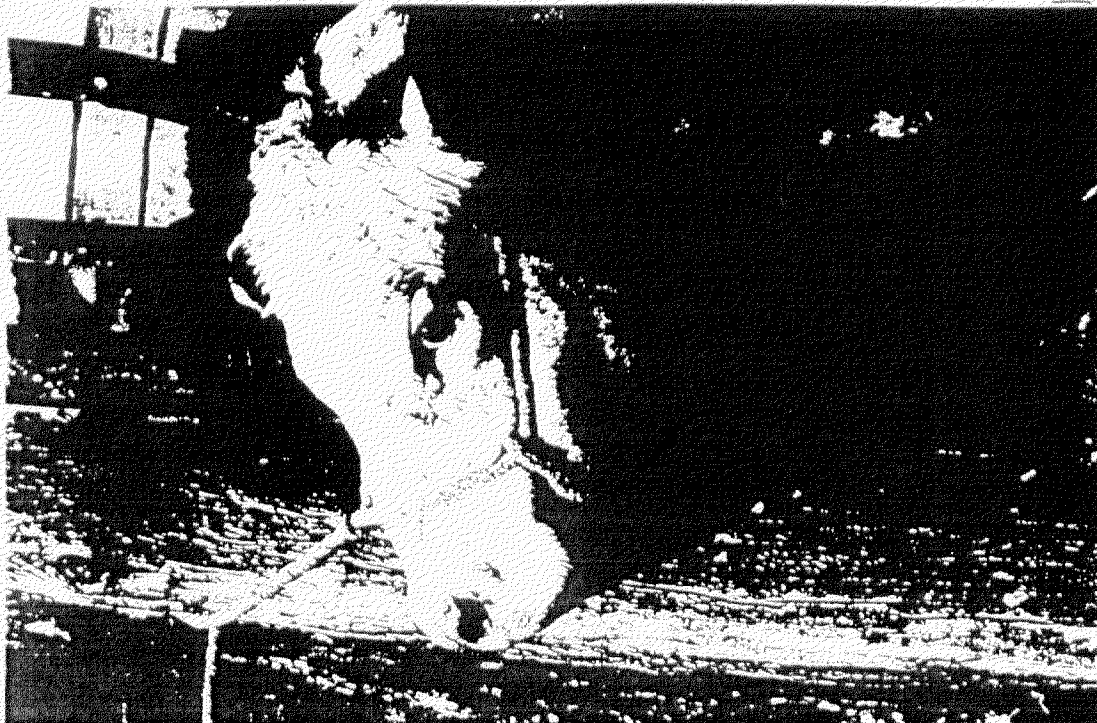


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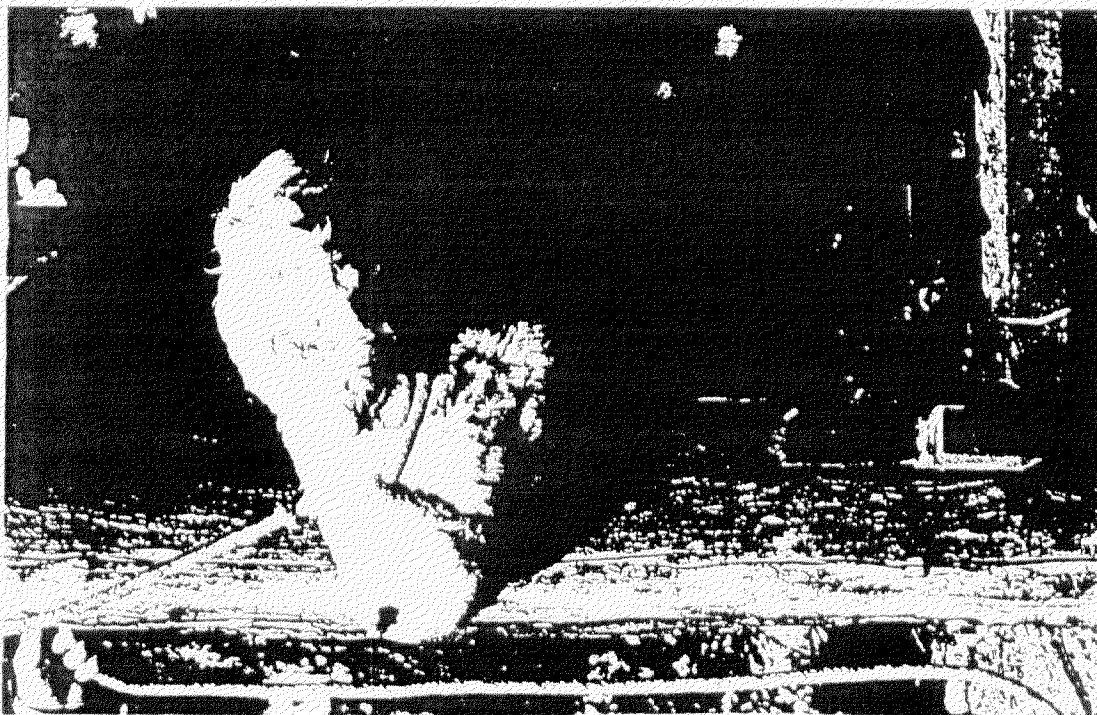
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RGS000962



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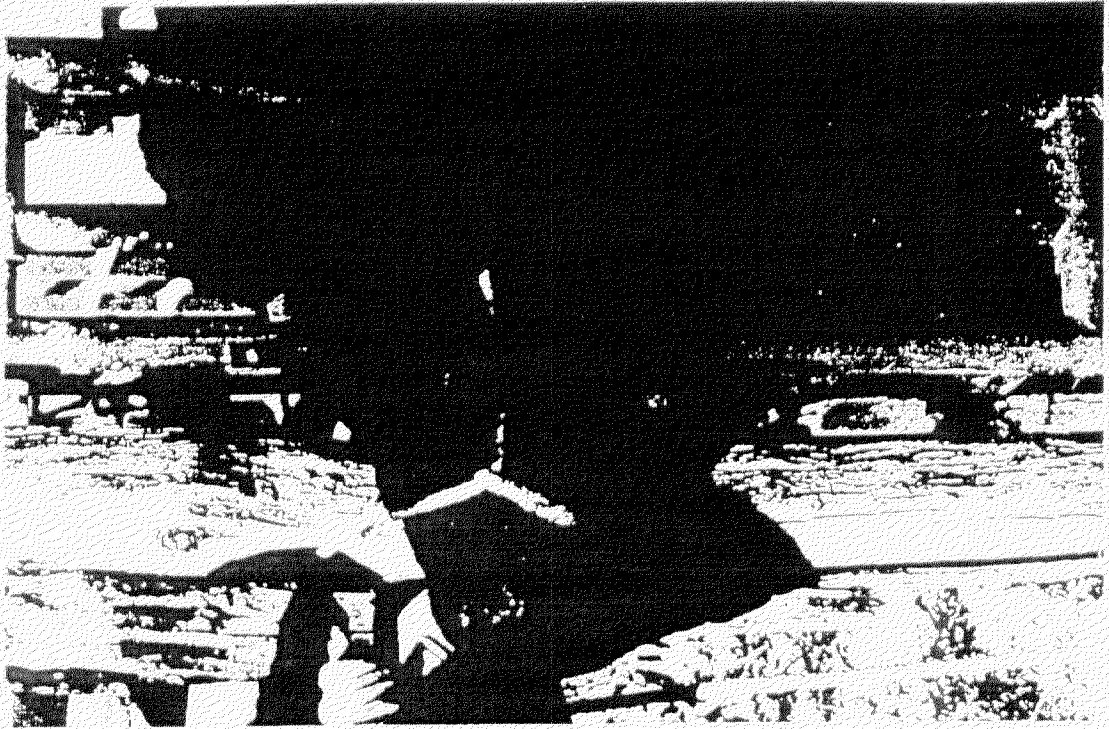


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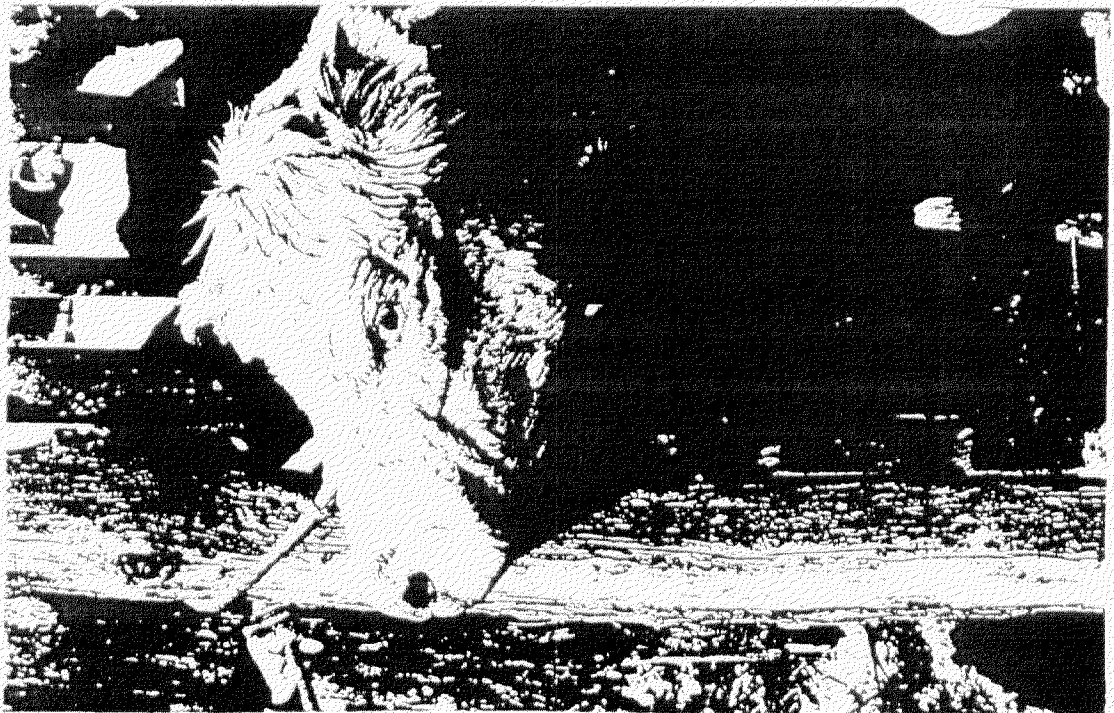
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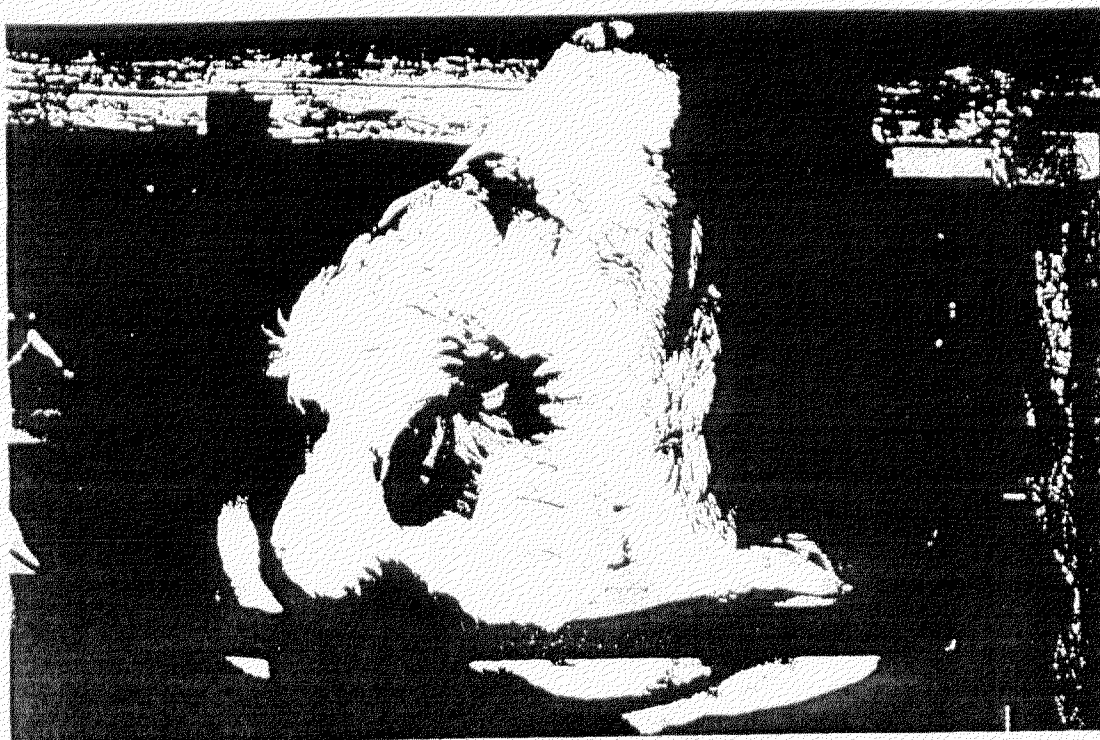


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RGS000964



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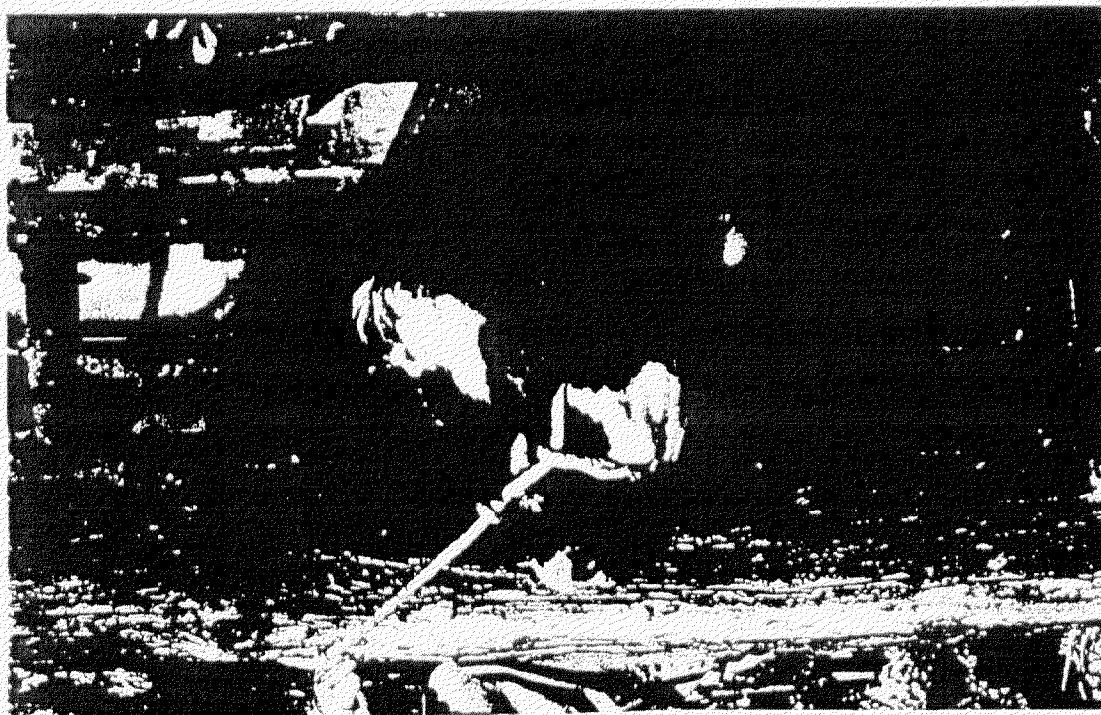
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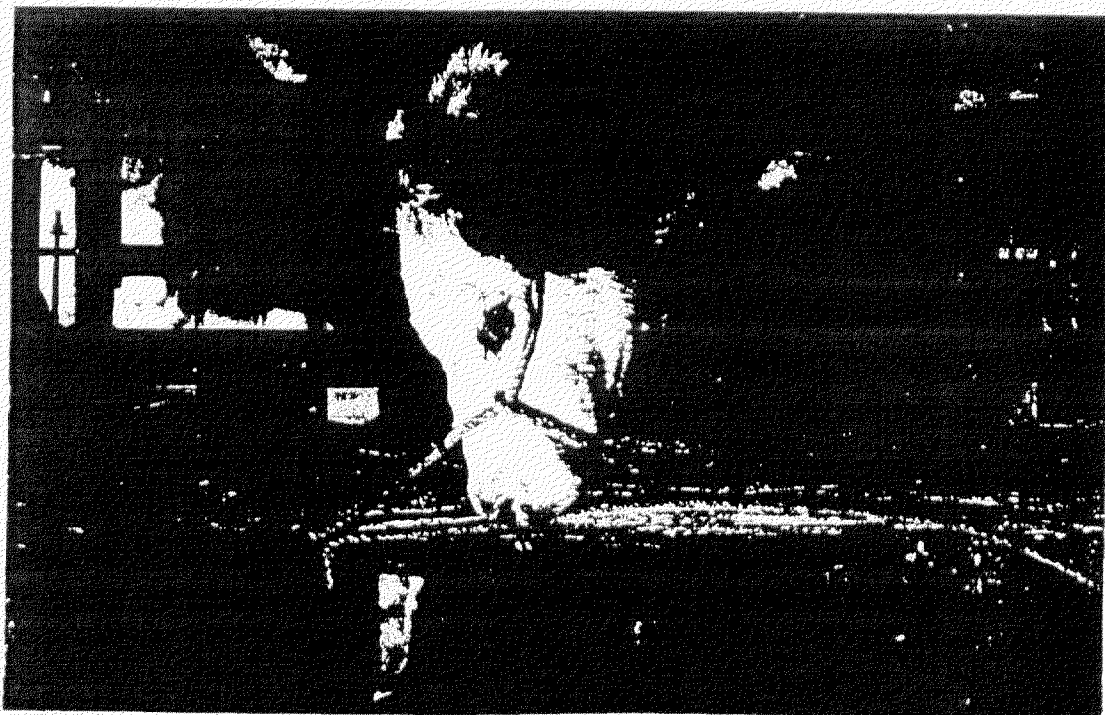
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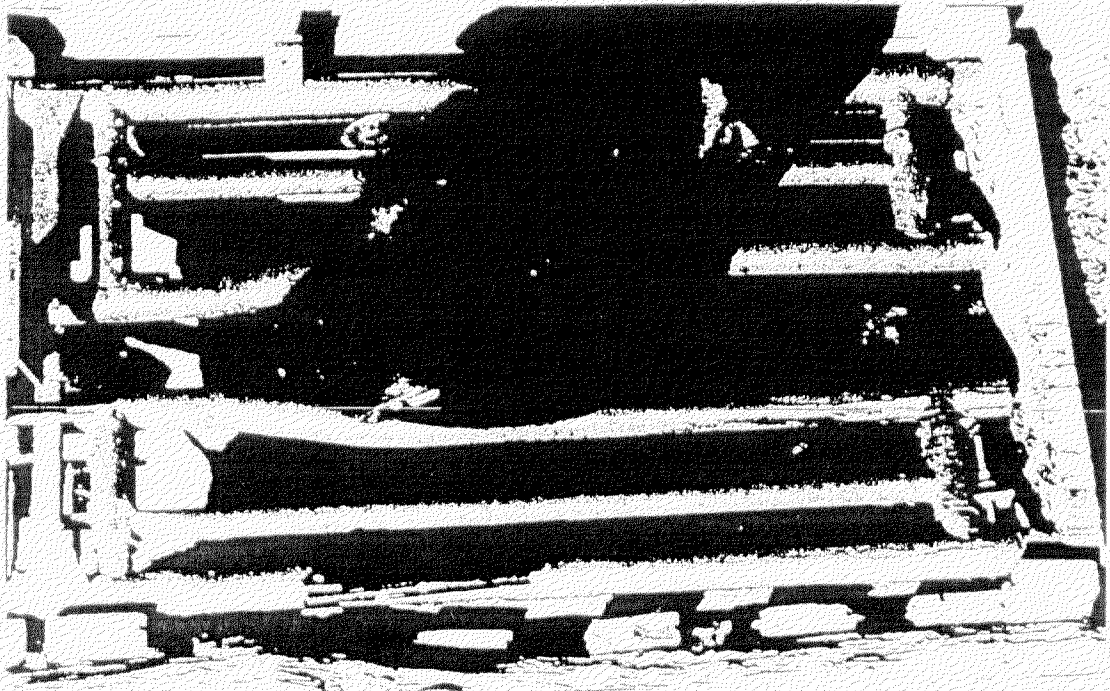


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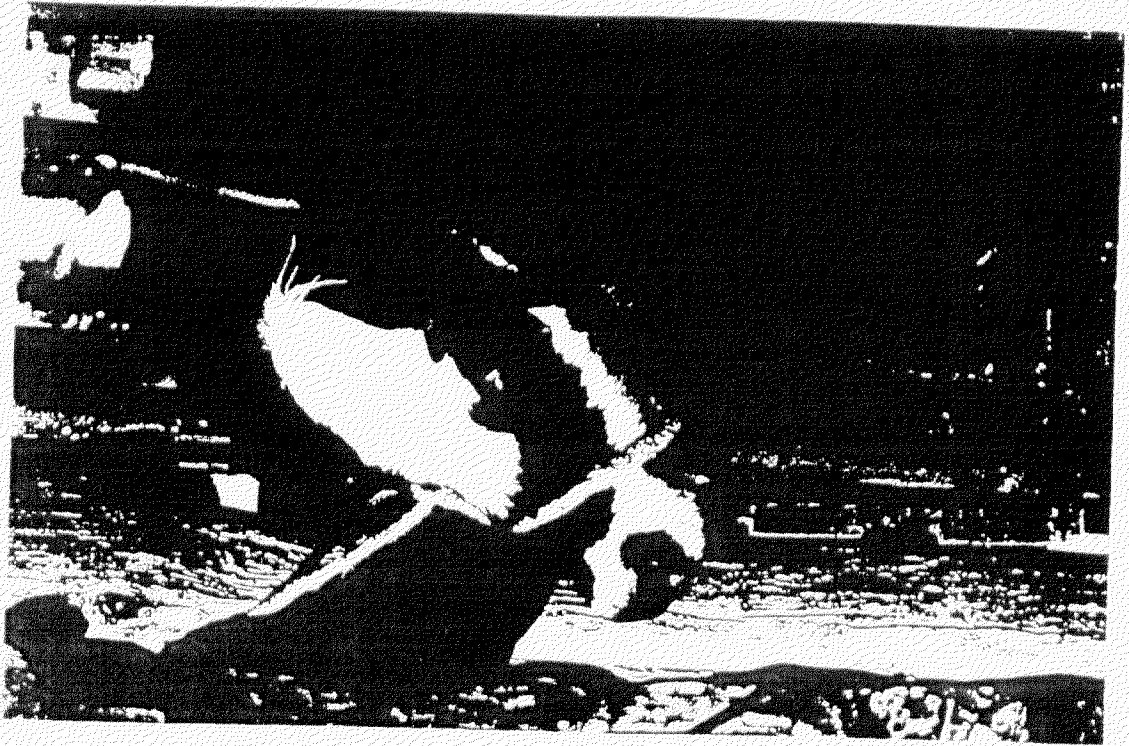


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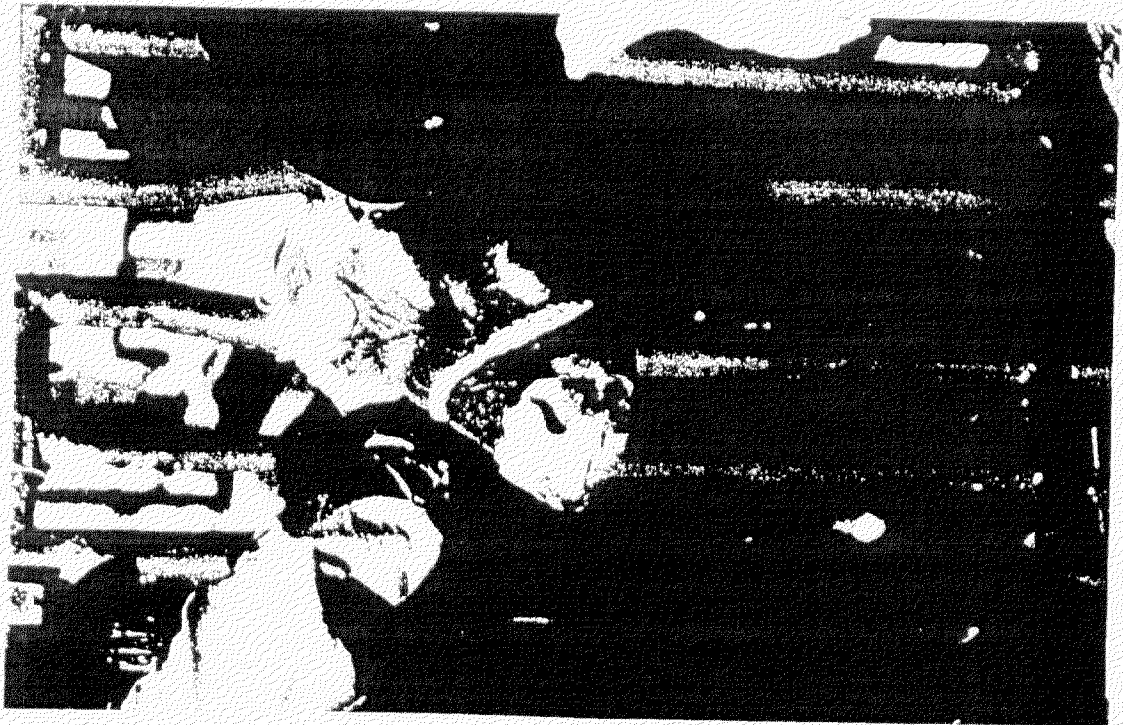
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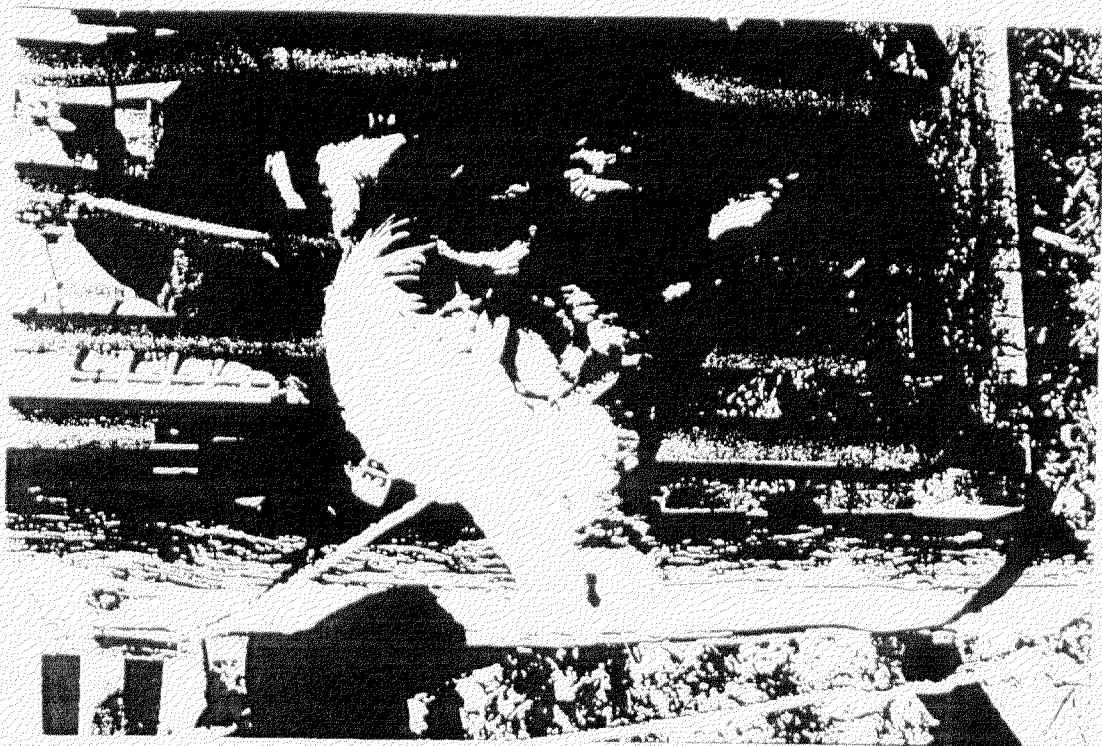
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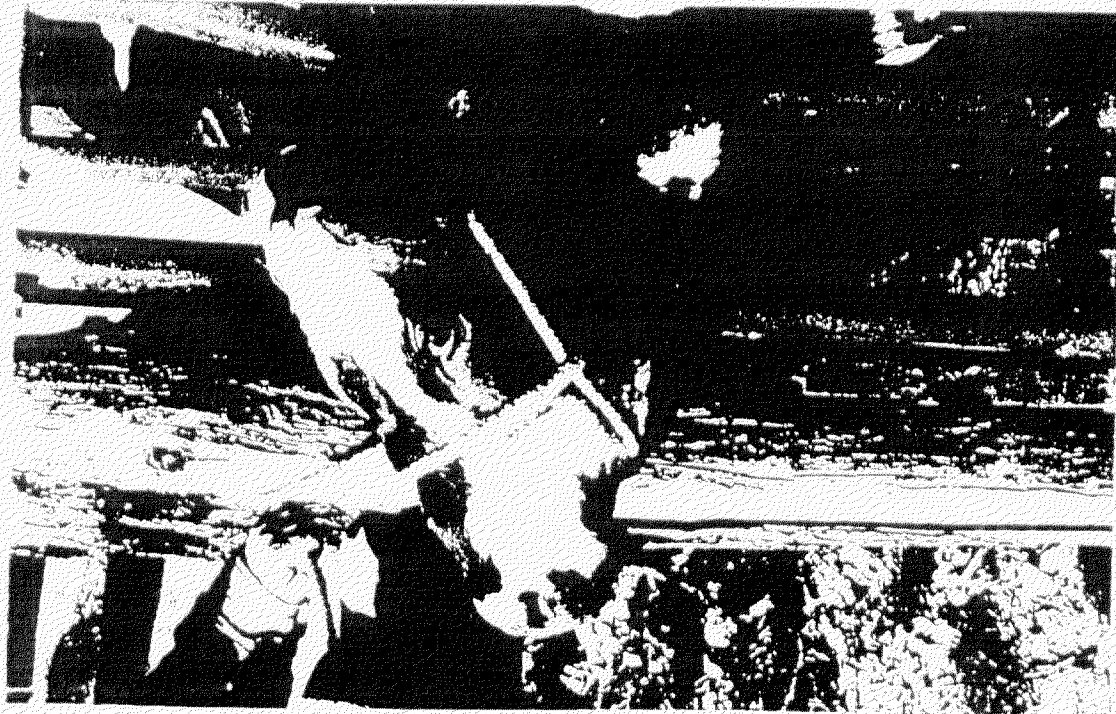
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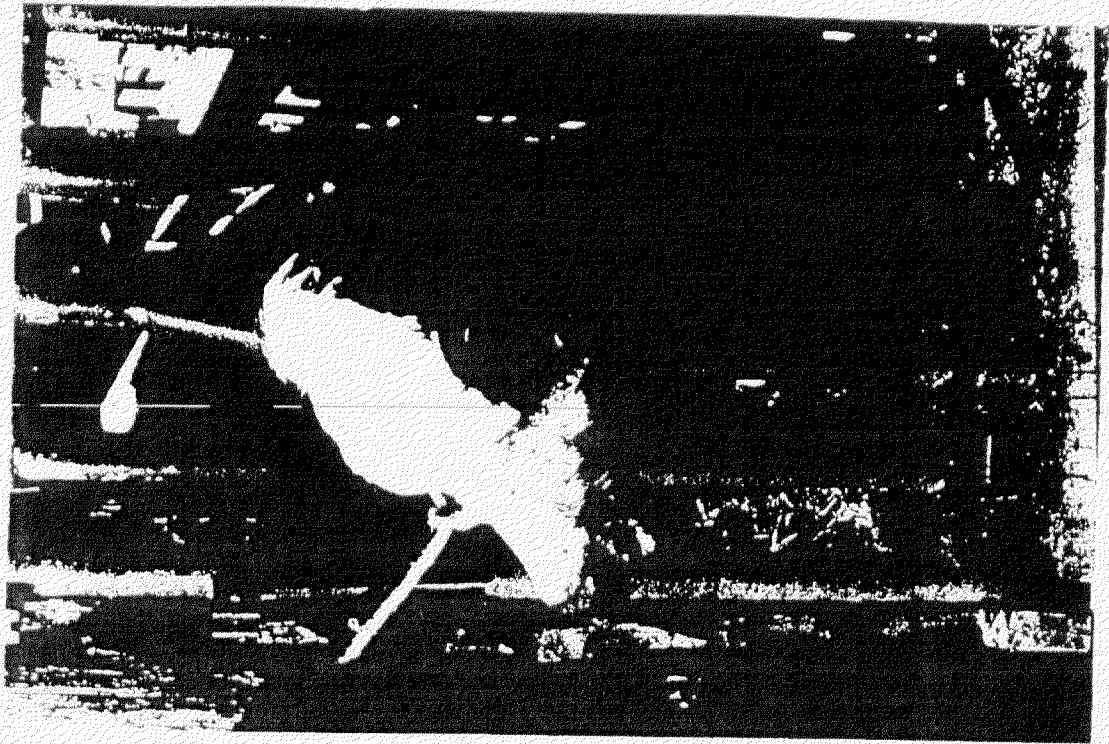


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RGS000971



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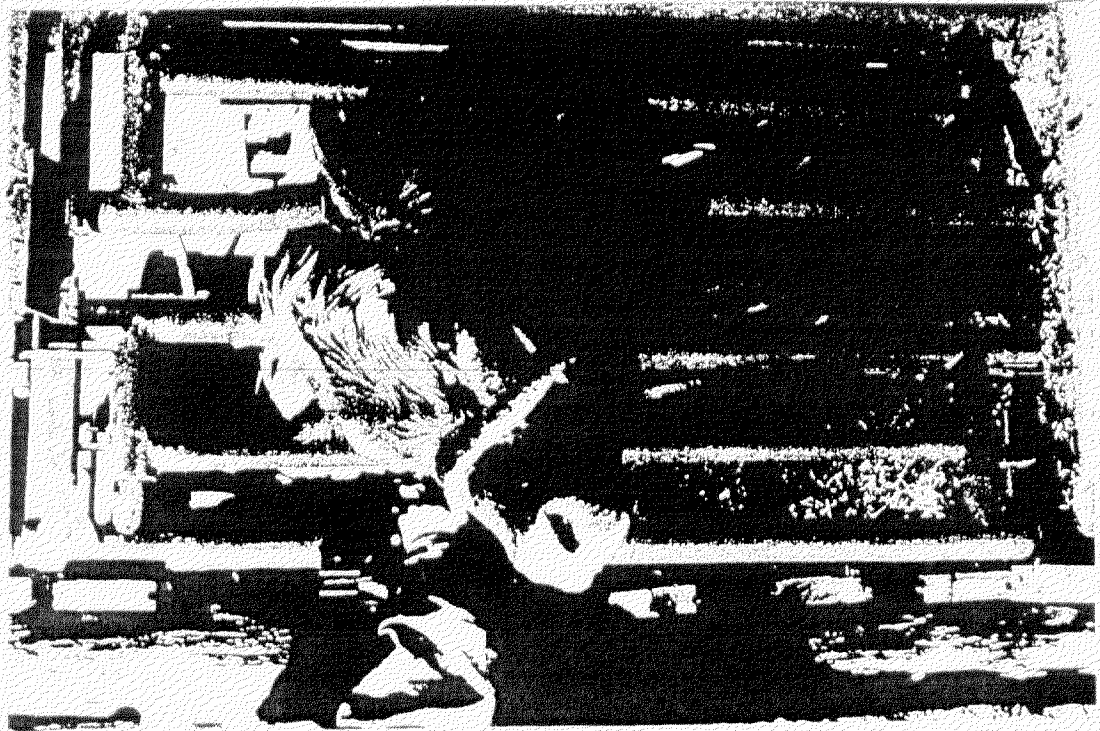
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EID151769

RGS000972



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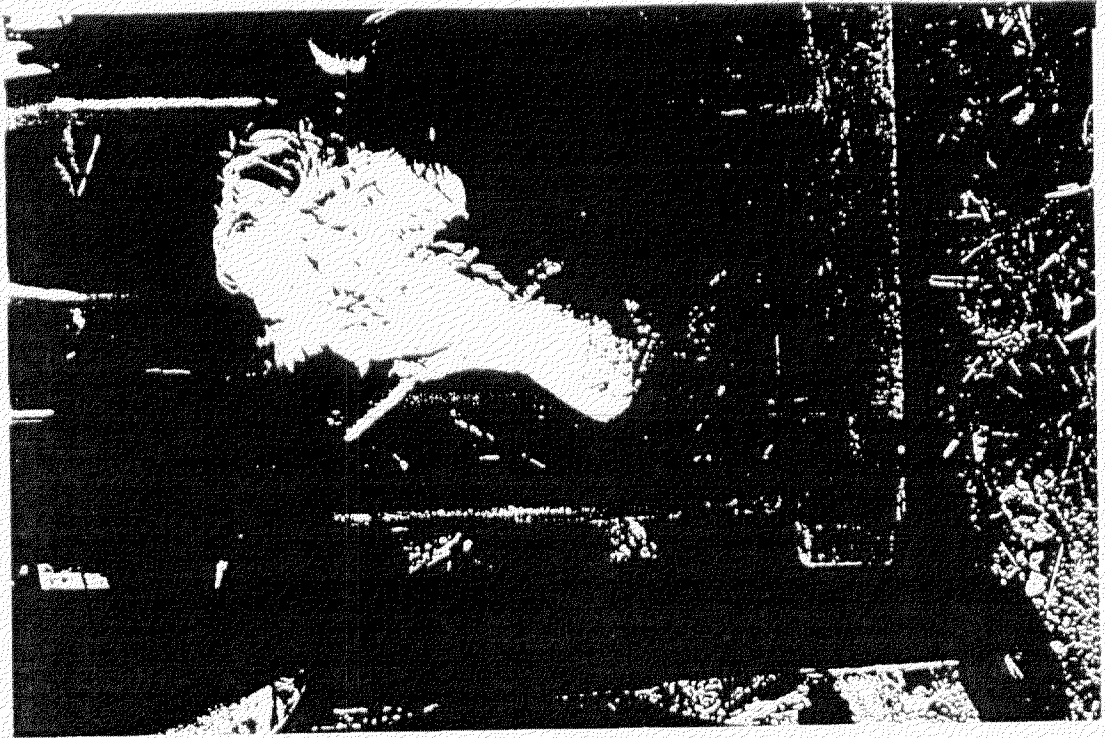


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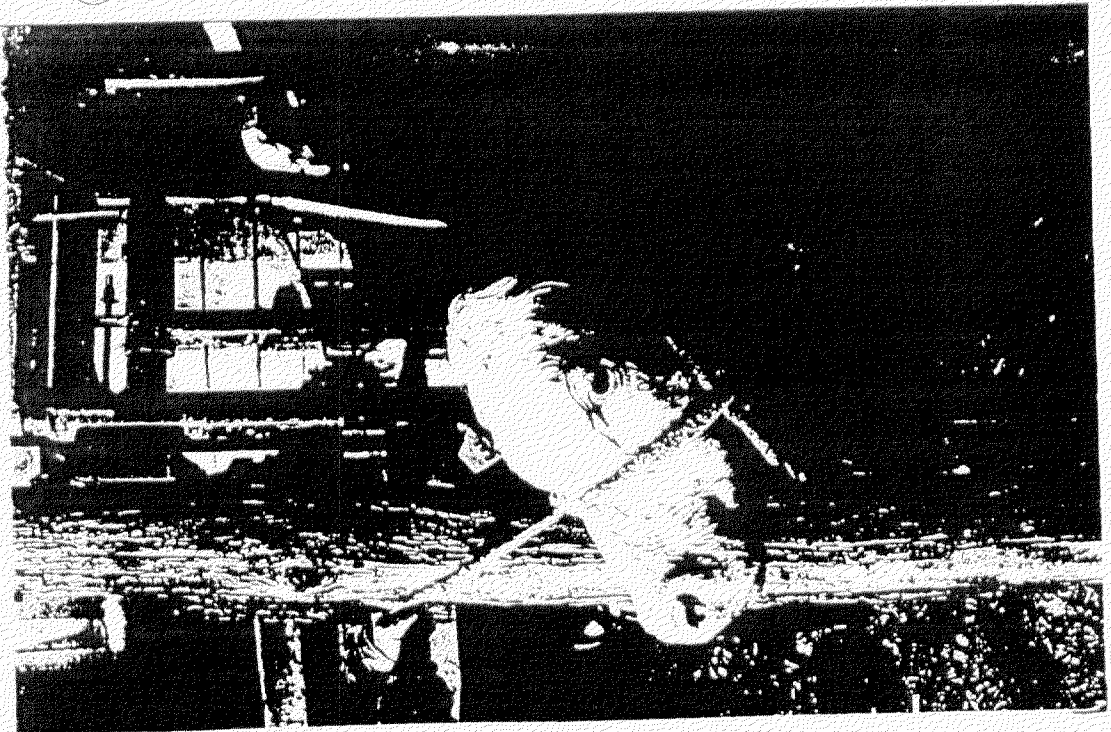
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RGS000973



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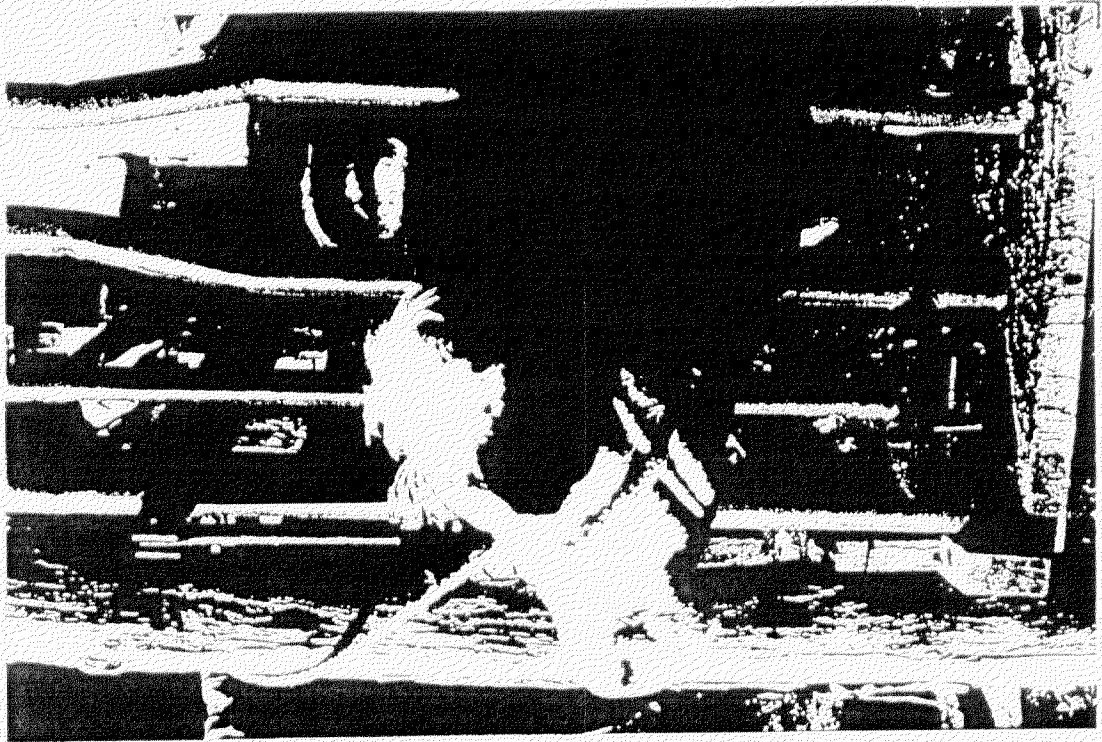


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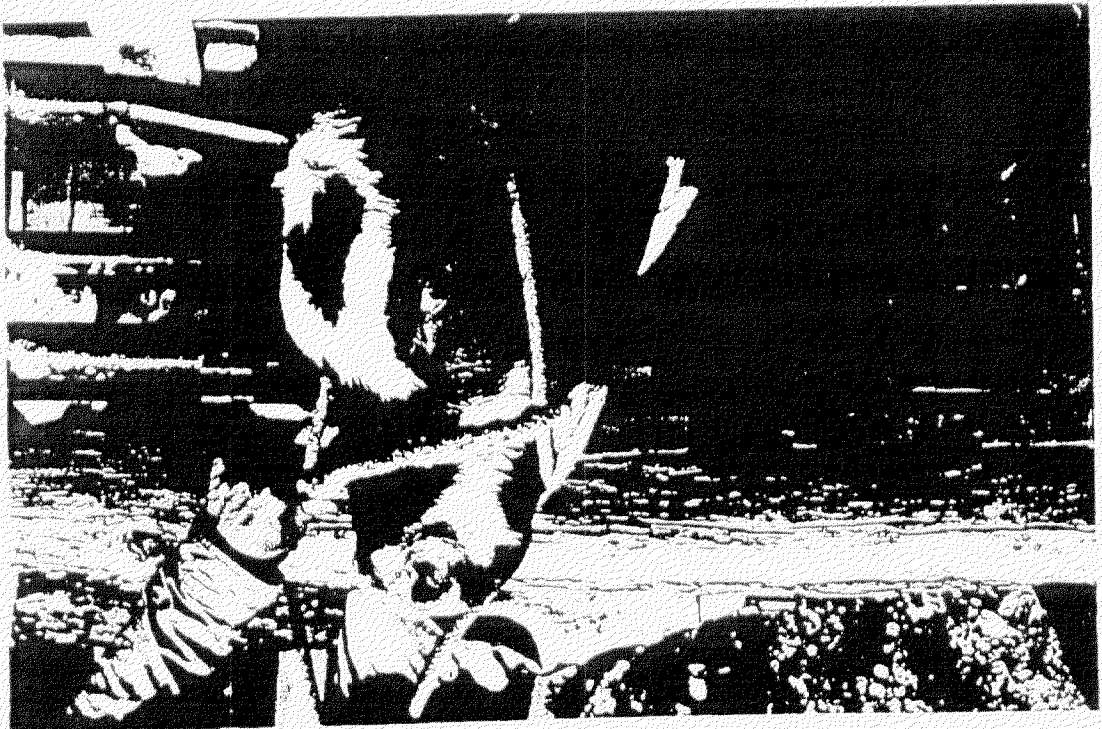
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RGS000974



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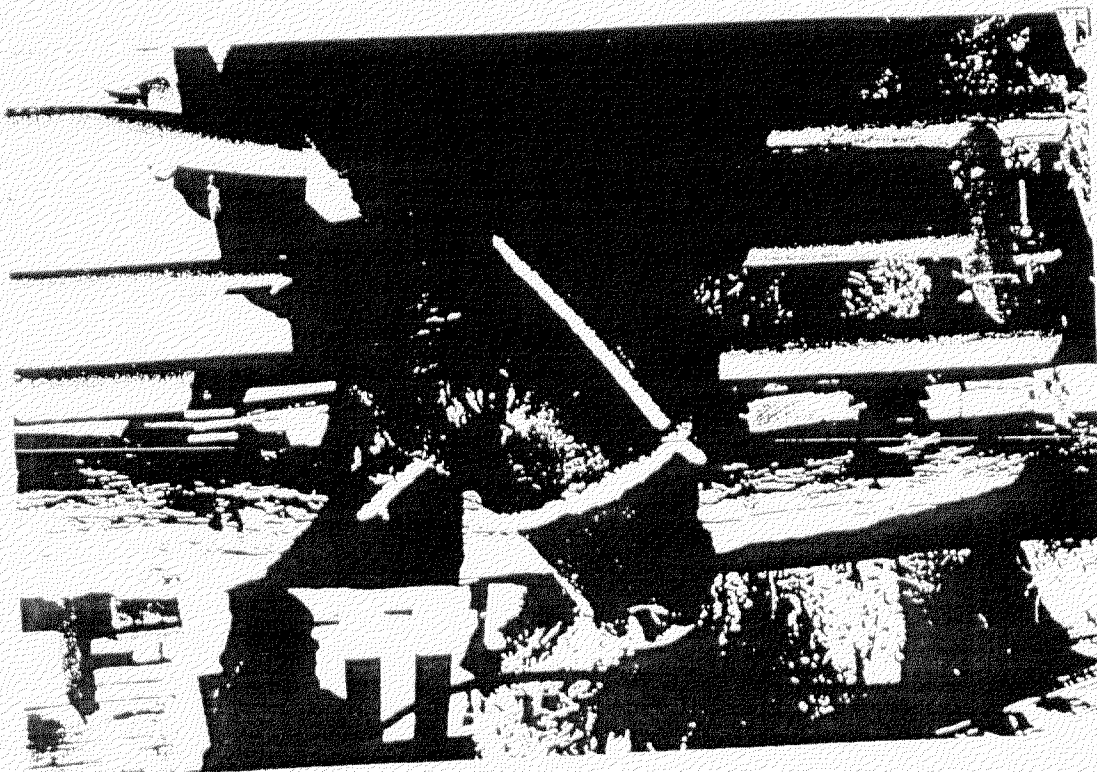


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EID151772

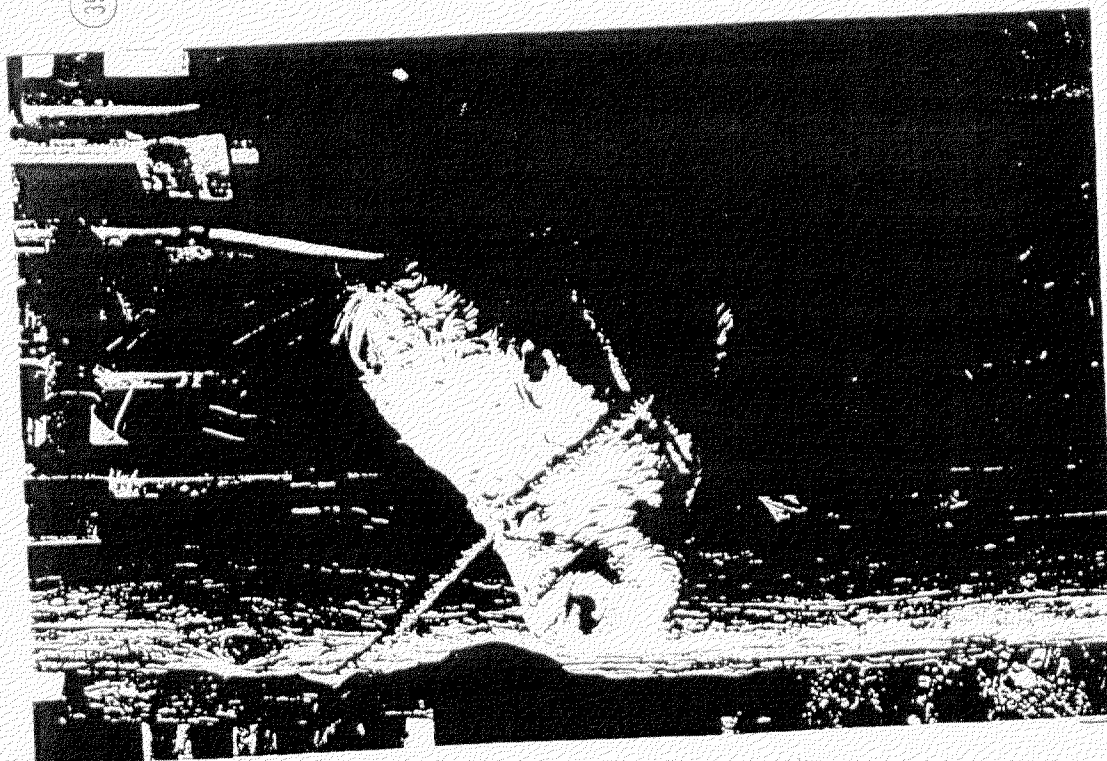
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RGS000975



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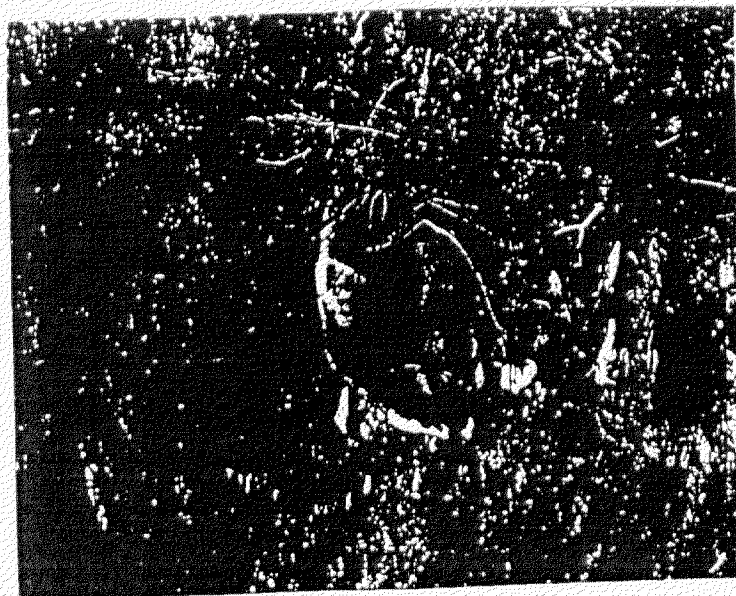


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EID151773

RGS000976



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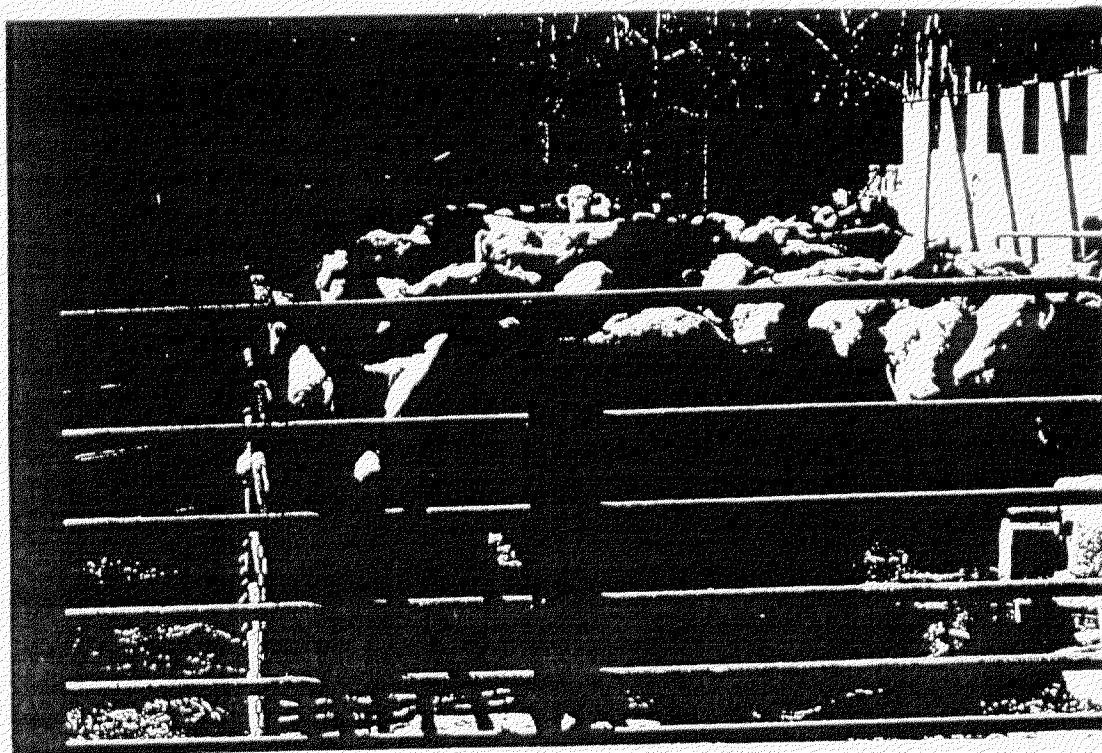


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EID151774

RGS000977



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RGS000978



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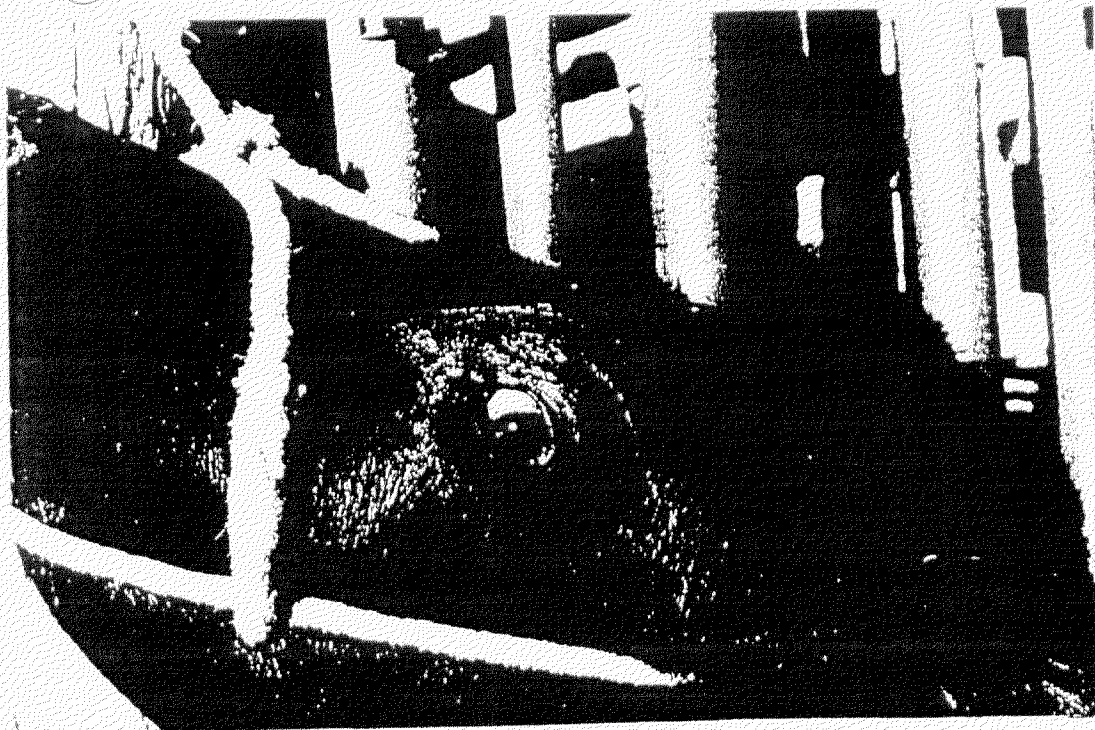
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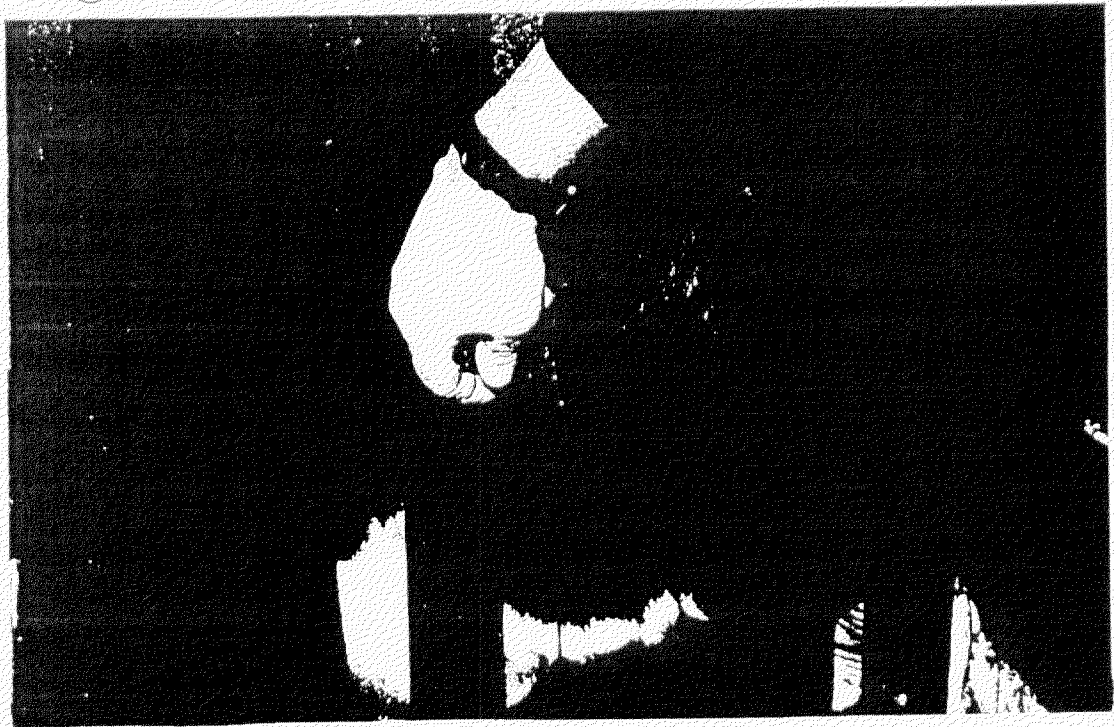
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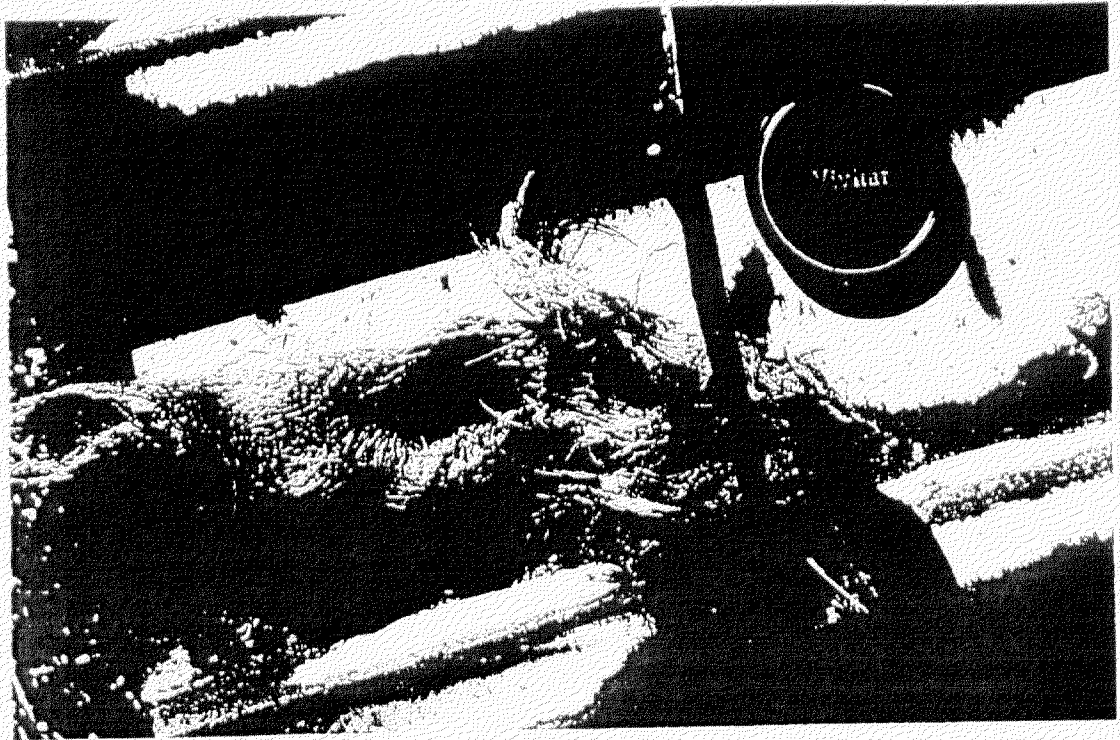


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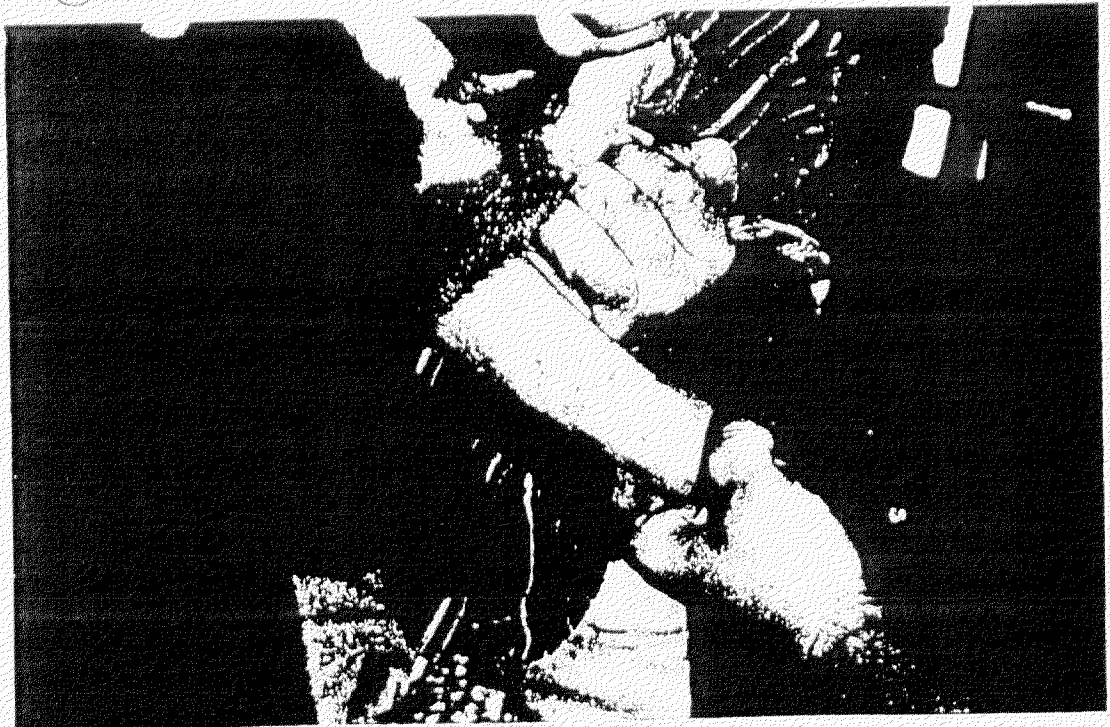
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RGS000981



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EID151779

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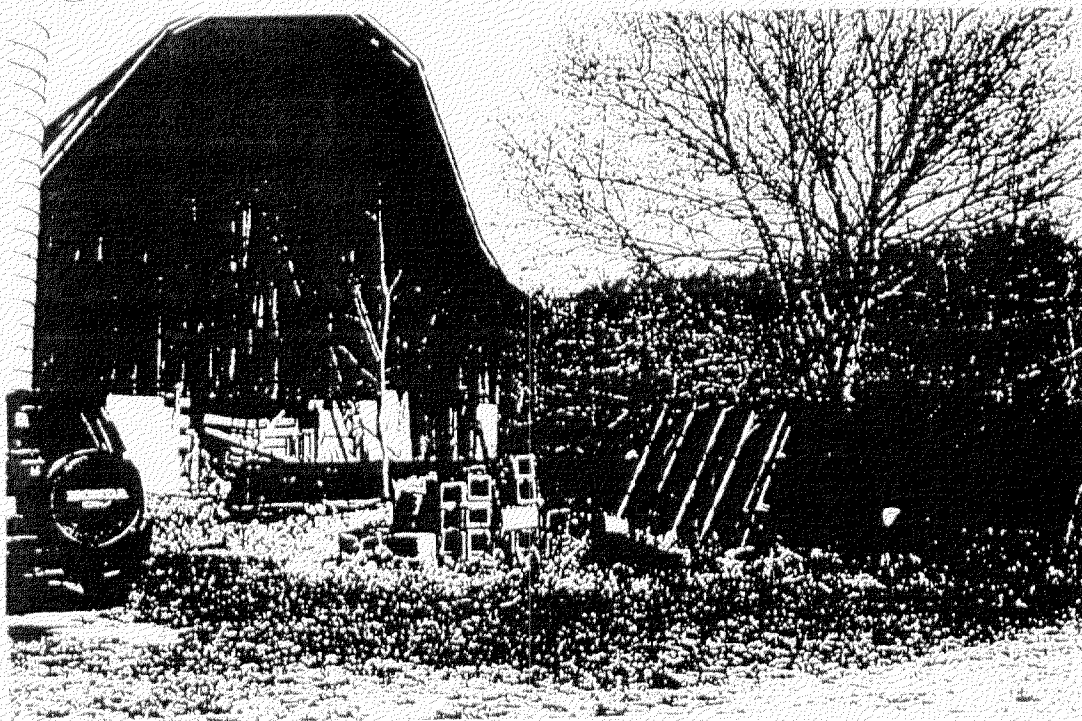
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RGS000983



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EID151781

RGS000984



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EID151782

RGS000985



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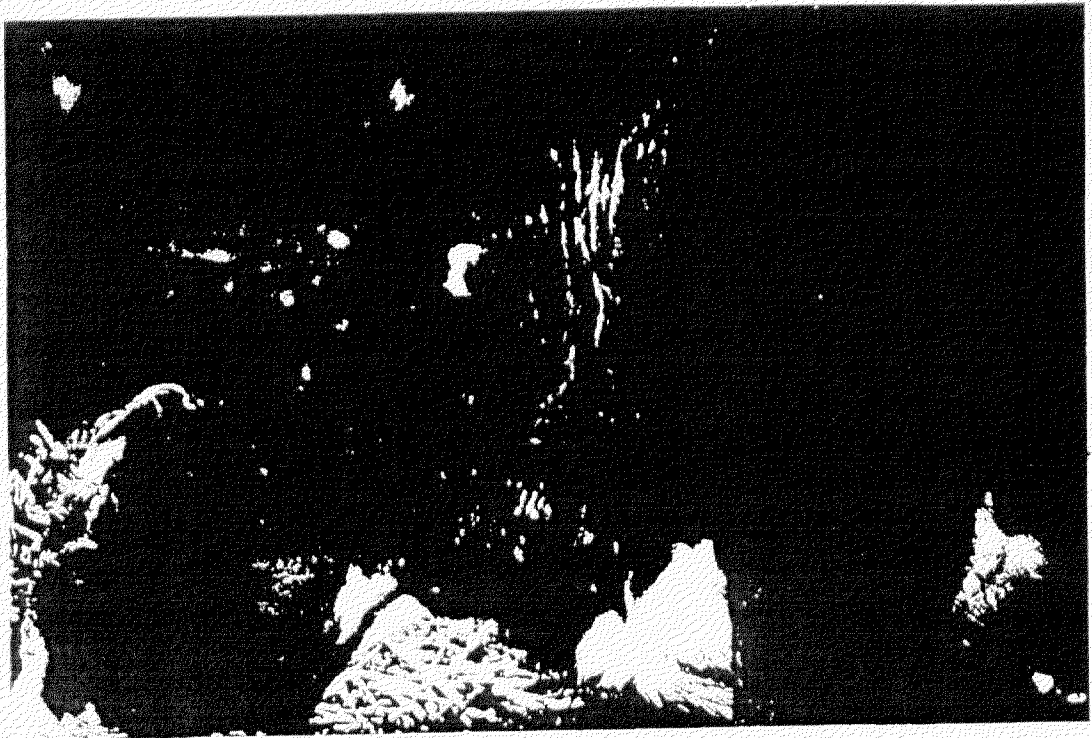


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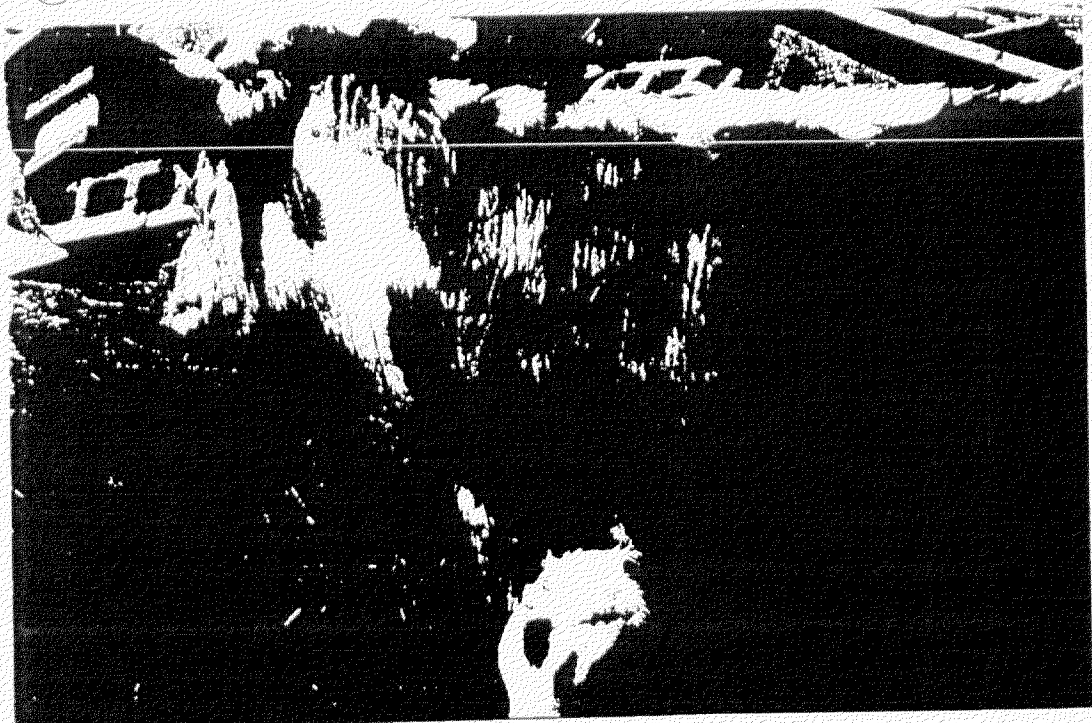
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RGS000986



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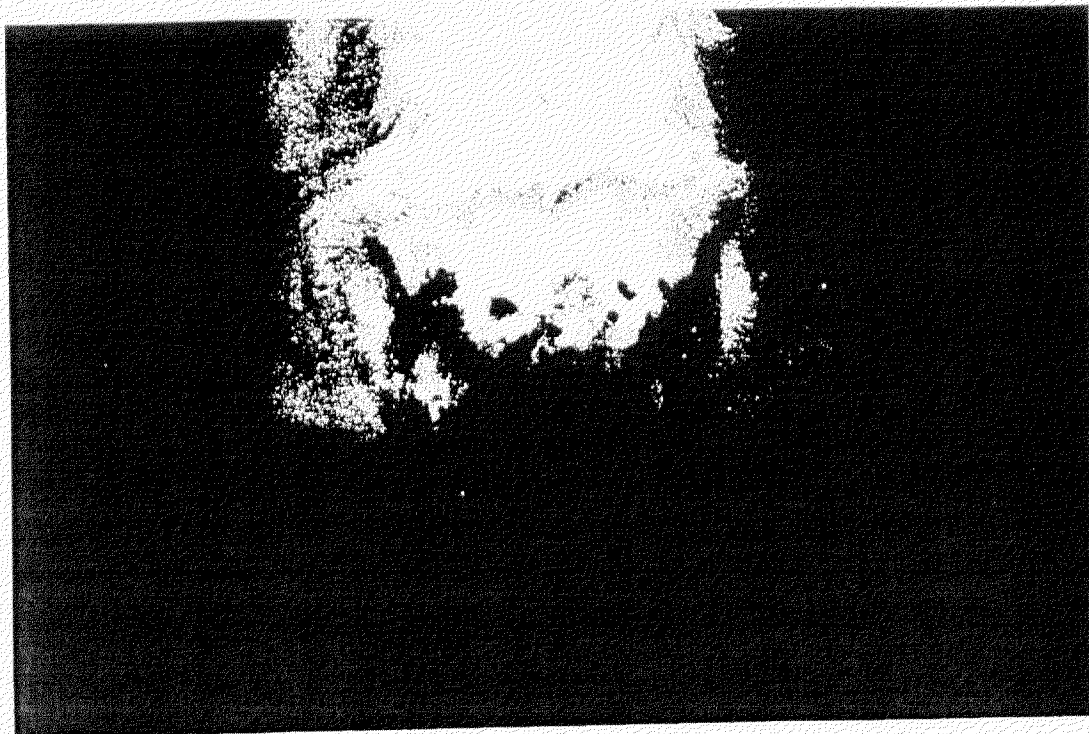


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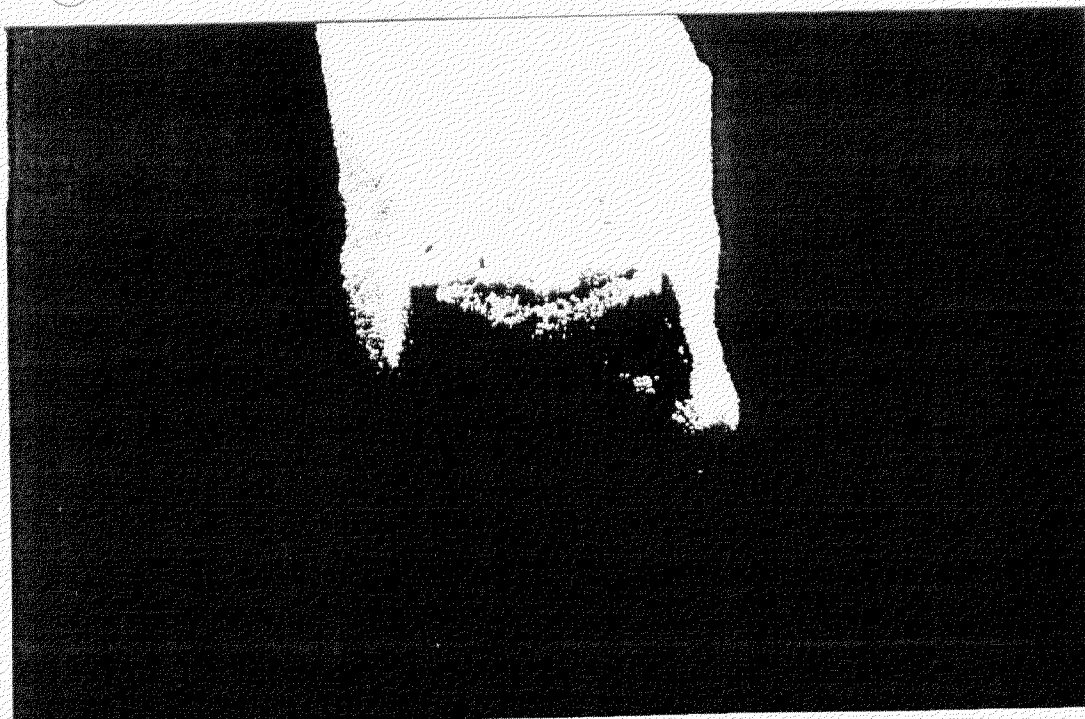
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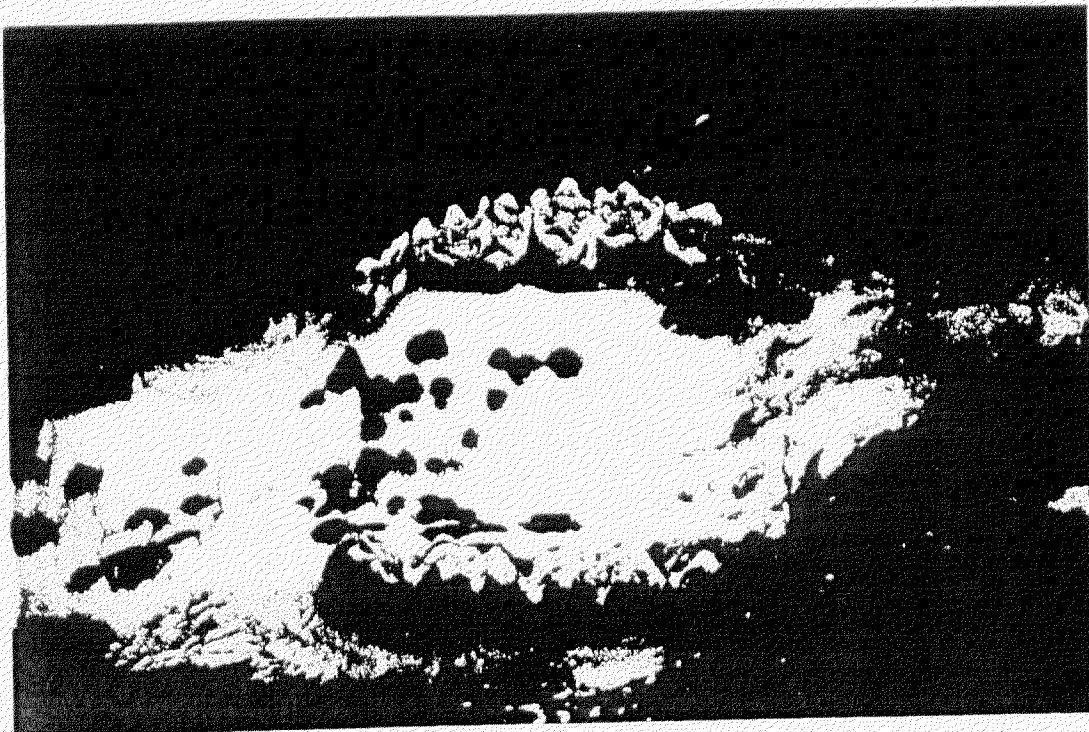


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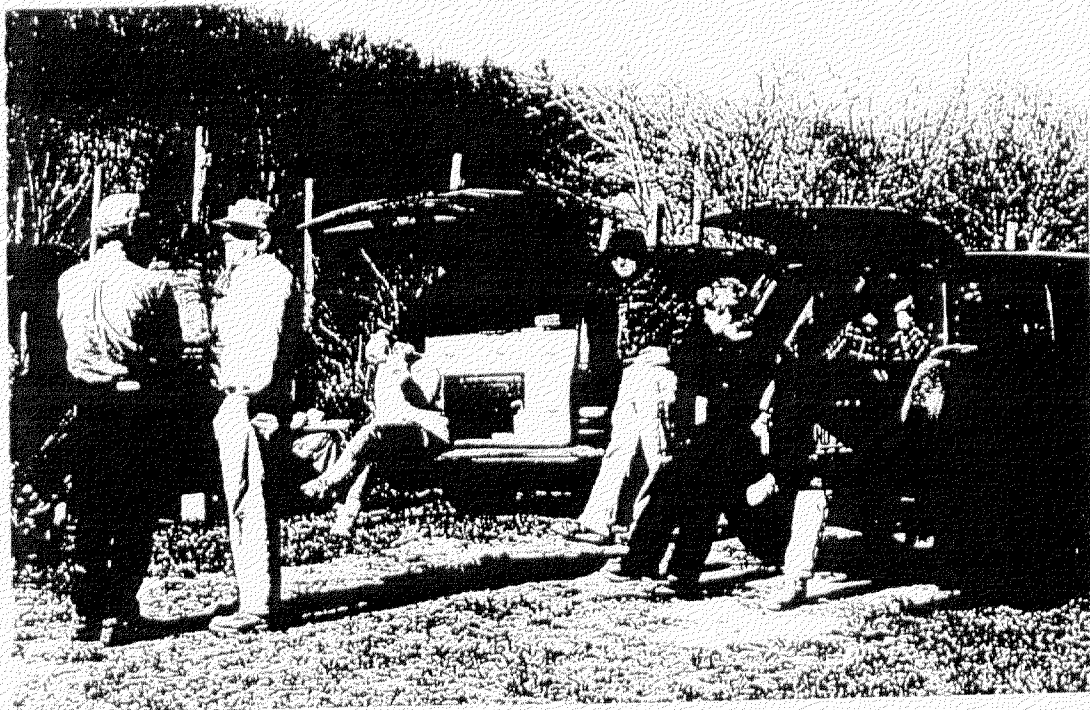
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EID151786

RGS000989

Herd Investigation – Beef Cattle – Date: April 8, 1999
Name: Wilbur Earl Tennant
Address: Route 3 Box 17, Washington, WV 26181

[Derived from interview of Mr. Earl Tennant by Drs. Peter Moisan, Lisa Heller, and Robert Munson on 4/8/99]

PART I: 1998

A. History from last calving season

Months during which cows calved: All year, 1998.
Number of cows in herd, 1998 calving season: 40 . Number of calves born: 35
live.
Number of cows calved 35 or 87.5 % of cows exposed.
Abortions/Stillborn in 1998: 5 – 6 . Other calving problems in 1998: None .
Sick calves in 1998: Scours: About 6 (No deaths) . Weak calves in 1998: Several
were weak and had enlarged joints.
Other illness in unweaned calves in 1998: Most calves were slow-growing and
underweight during nursing period. Birth weight was low in the calves
born in 1998 .
Age at weaning in 1998: 5 mos. . Number of calves weaned: 30 or % of cows
exposed: 75% .
Illness in weaned calves in 1998: All calves were sold at weaning time. A few
calves (5), born in 1998 (fall) are still nursing the cows.

B. Cows

Illness in cows in 1998: 1 cow disappeared in 1998.
Ocular disease: Some cattle have darker eyes when put in the hollow during the
summer. The darker eyes resolve when they are kept away from the
creek.
Skin disease: Some with lesions around the coronary bands. Thought to be "mild".
Diarrhea: A few cows had diarrhea when calves were 3 – 4 weeks old.
Lameness: Cows seem lame in cold damp weather (arthritis?).
Respiratory disease: 3 cows had a transient epistaxis in 1998.
Other disease in 1998: Cows and calves seem more healthy than in earlier years.
Treatments for disease in 1998: Alum to cows for calf scours. Treated cows with
ground garlic for worms.
Vaccinations in herd in 1998: None. Brucellosis vaccinations are not done in WV.
Diagnostic work performed in herd in 1998: Include necropsy or blood sampling:
None. (4 years ago, 12 blood samples were taken and paired serology was
inconclusive for brucellosis and leptospirosis).
Estimated body condition score (BCS range 1-9) of cows in 1998 calving season:
Same as 1999. May have been slightly better BCS than 1999.

C. Feeding History

Feed to cows during calving season 1998 (Include minerals): Corn silage. Ground corn with supplement. Orchard grass/timothy/brome/KY31 fescue hay. Fairly high percentage fescue. 5 pounds of grain per cow per day, with slightly more during cold weather.

Feed to cows in winter before calving season in 1998 (Include minerals): Same as during calving season with higher mineral. 5 pounds of grain per cow per day, with slightly more during cold weather.

Feed to nursing cows during grazing season 1998 (Include minerals): Trace mineral salt (TDN salt).

Feed Test Results for 1998: None.

D. Other

Other comments for 1998: Since the problems first started in 1988, the acreage grazed has decreased from 514 acres in 1988 to 196 acres now. In 1988 there were 200 cows. Silage was fed to these cows in the winter. Since 1988 there have been 176 dead cows and about 200 calves. The first to die appeared to have pneumonia, with shivering, fever, and foaming from the mouth. Other cows (15-20) were circling, then died.

PART II: 1999*A. History from current calving season*

First calving: About March 1, 1999.

Length of breeding season 1998: year long, 1998.

Anticipated last calving date in 1999: About October 1999 or later.

Number of cows in herd, 1999 calving season: 39. Number of calves born so far: 7.

Number of cows calved so far: 7 or 18 % of cows exposed.

Abortions/stillbirths so far in 1999: 1 ± Other calving problems in 1999: 1 stillborn in 1999 and 1 placenta found without a dead calf.

Sick calves in 1999: Scours None. Weak calves in 1999: None.

Other illness in unweaned calves in 1999: A few of last fall's calves, still nursing cows on pasture; are loose. Birth weights are around 35 pounds and appear lower than normal. Calves are fairly thin but otherwise healthy in 1999.

B. Cows

Illness in cows in 1999: None.

Ocular disease: _____.

Skin disease: _____.

Diarrhea: _____.

Lameness: _____.

Respiratory disease: None .

Other disease in 1999: Cows are healthy in 1999, so far. Owner notices that the cows are fairly thin .

Treatments for disease in 1999: None .

Vaccinations in herd in 1999: None .

Diagnostic work performed in herd in 1999: Include necropsy or blood sampling: None .

Owner estimated body condition score (BCS-range 1-9) of cows in 1998 breeding season: .

Clinical BCS of cows (average) on day of herd visit: 3 – 3.5 (Range BCS 2 – 7) .

C. Feeding History

Feed to cows during calving season 1999 (Include minerals): Hay and ground feed as in 1998. No silage .

Feed to cows in winter before calving season 1999 (Include minerals): Ground feed, same as in 1998, with higher mineral mix .

Feed to cows during grazing season 1999 (Include minerals): .

Feed Test Results for 1999: None .

D. Other

Other comments for 1999 to date: It seems that problems with cows and calves have decreased by 75 – 80% since the water from the landfill was hauled away for treatment. No new cows have been purchased in past 5 years. Bulls were purchased in 1996, estimated, but could have been in 1995. Bulls haven't been sick or poor breeders. There are reports of 2 neighbors with premature calves born, for total of 6 calves .

Results for:

Tennant

Lactating beef

12/15/99

MODEL 1

<u>Ration Nutrients Supplied and Required</u>						
	ME Avail Mcal/d	ME Req'd Mcal/d	Difference Mcal/d	MP Avail g/d	MP Req'd g/d	Difference g/d
Totals	16	23	-6	639	702	-64
Percent difference			72.5%			90.9%
Maintenance	16	15.1	1	639	318	320
Pregnancy	1	0	1	320	0	320
Lactation	1	7	-6	320	363	-43
Gain	-6	0	-6	-43	21	-64
Reserves	0	6	-6	0	64	-64
<u>Intake and Performance Predictions</u>						
DMI predicted		23.3 lbs/d				
DMI entered-% predicted: 66%		15.3 lbs/d		Pred. Max Forage Intake	12.0 lbs/d	
Relative DMI		100%		Entered Forage Intake	12.0 lbs/d	
Target ADG w/conceptus		0.24 lbs/d				
ME Allowable Gain		0.11 lbs/d		ME Allowable Milk	13.7 lbs/d	
MP Allowable Gain		-0.17 lbs/d		MP Allowable Milk	11.3 lbs/d	
AA Allowable Gain		0.02 lbs/d		AA Allowable Milk	13.9 lbs/d	
				Days to lose 1 CS	43	
<u>Diet Concentrations and Rumen Balances</u>						
Effective NDF required		3.1 lbs/d		MP from bacteria	467 g/d	
Effective NDF supplied		8.7 lbs/d		MP from undeg feed	172 g/d	
NDF in ration		61% DM		Diet CP	8.6% DM	
Diet ME		1.07 MCAL/LB DM		DIP	61% CP	
Diet NEI		0.69 MCAL/LB DM		Soluble Protein	23% CP	
Diet NEM		0.67 MCAL/LB DM		Total NFC in ration	18% DM	
Diet NEg		0.41 MCAL/LB DM		Fat in ration (total):	4.7% DM	
Pred. Ruminant pH		6.46		Total N balance	0 g/d	
		<u>g/d % of requirements</u>		Predicted MUN		
Ruminal N Balance	-26	79%		Urea cost	0.00 Mcal/d	
Pept Bal.	22	177%		% Forage in ration	71% DM	
First limiting AA: MET	1.19	109%		Ration DM	90%	
2nd limiting AA: LYS	2.29	106%		DMI/Maint DMI	1.1 X Maint.	
<u>Predicted Excretion</u>						
				N excretion: Fecal	0.2 lbs/hd/d	
				Urinary	0.1 lbs/hd/d	
				Total	0.3 lbs/hd/d	
				P excretion: Fecal	37.2 g/hd/d	
				Urinary	0.9 g/hd/d	
				Total	38.1 g/hd/d	
<u>Ration Costs</u>						
Cost/day		0.17 \$/day		Cost/cwt. ME allow. milk	1.27 \$/cwt	
Cost/cwt. milk production		1.27 \$/cwt		Cost/cwt. MP allow. milk	1.54 \$/cwt	
				Cost/cwt. AA allow. milk	1.25 \$/cwt	

Appendix F

109

EID151790

000112

RGS000993

Ration for Tennant Lactating beef cow

Enter amt. fed in blue cells:	As-fed Lbs	Forage	Pasture	Home grown	Rel DMI *	Pounds as fed	% of ration As-fed
Fescue, K31	12.00	y	n	y	12.00	12.00	70.6%
Corn Dry	4.20	n	n	y	4.20	4.20	24.7%
Soybean	0.30	n	n	n	0.30	.30	1.8%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Dry Cow Min	0.50	n	n	n	0.50	.50	2.9%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Total	17.00				17.00	17.00	100%

DMI Predicted	23.28	DMI Entered:	15.30
Entered DM - Predicted	-7.98		
Relative DMI %	100.0%		

MP Balance	-63.8 g/d	91%	Pred DMI	23.3 lbs/d
ME Balance	-6.2 mcal/d	73%	Actual DMI	15.3 lbs/d
Rumen N Balance	-26.5 g/d	-21%	Effective NDF Balance	5.6 lbs/d
Peptide Balance	21.7 g/d	77%	Days to lose 1 CS	43
			Cost : \$./day	\$ 0.17

110

General Factors

Farm Name:	Tennant
Diet	Lactating beef cow
Number in group:	1
Days to feed	365
NDF capacity	1 % of BW
Units	1 English
Feed Entry Basis LB/Head/Day	1 As-Fed
Milk Price	\$ - /cwt
Feed Losses	0% % dry matter
File Name	C:\casestudy\test

Animal Factors

Grade	5 Enter 1 to FALSE
Animal Type	0 Lactating beef cow (predicted milk)
Age	70 Months
Sex	4 Cow
Body Weight	900 Lb
Breed Type	1 Beef Maturity
Mature Weight	900 Lb
Condition Score	3 1=v.thin - 9=v.fleshy
Breeding System	2 2way cross
Dam breed	17 #N/A Hereford
Dam's maternal	1 1 Angus
Dam's paternal	17 17 Hereford
	18
	18
Days Pregnant	0 Days
Days Since Calving	30 Days DLW 0
Lactation #	4 0=dry or heifer
Rolling Herd Average (dairy)	0 Lb Predicted values
Milk Production (dairy)	0.00 Lb 7.0
Milk Fat (dairy)	0.00 % 3.6
Milk Protein (dairy) assume CP	0 % 3.8
Relative Milk Prod'n (beef)	2 1-9 16.53
Expected Calf Birth Weight	45 Lb 73.8

Management Factors

Additive	1 none
Grazing Unit Size	0.00 Acres
Daily pasture allowance	0 DM lb/PDMI
Initial pasture mass	1847 lb DM/acre
Selection-Pressure for growth/milk	0 1-5 Scale
Feeding Frequency	2 # of Times Fed Daily
Feeding Method	2 1=forage&grain separate,2=TMR
Calf Implanted	1 1=no,2=yes

Environmental Factors

Wind Speed	5 mph
Previous Temperature	40 Degrees F
Previous RH	30 %
Current Temperature	40 Degrees F

Current RH	30	%
Storm Exposure	1	1=no,2=yes
Night Cooling	1	1=none,2=with night cooling
Hair Depth	1	in
Hide	2	1=thin,2=avg,3=thick
Hair Coat	1	1=no mud,2=some mud on lower b
Cattle Panting (Heat Stress)	1	1=no,2=rapid shallow,3=open mout
DMI Scaler	1	% (110=+10%; 90= -10%)
In summer, cattle are exposed to:	12	1=No direct sunlight, 2=direct sunlig
Rectal Temperature (optional)	101.5	Degrees F
Animal Activity Functions	0	
Time spent standing	18	hrs per day
Number of body position changes	6	(lying down and standing again)
Distance walked	6562	feet/d
Flat		feet/d
Sloped		
Mud Depth	0	inches
Feedbunk Characteristics		
Bunk level	6	inches (distance between cow floor
Bunk Surface	1	see codes----->
Target Growth		
Age at 1st calving	24	months
Herd Calving Interval	16	months

Results for:

Tennant

Lactating beef

12/15/99

MODEL 2

<u>Ration Nutrients Supplied and Required</u>						
	ME Avail Mcal/d	ME Req'd Mcal/d	Difference Mcal/d	MP Avail g/d	MP Req'd g/d	Difference g/d
Totals	23	23	0	883	759	123
Percent difference			100.2%			116.3%
Maintenance	23	15.0	8	883	375	508
Pregnancy	8	0	8	508	0	507
Lactation	8	7	0	507	363	144
Gain	0	0	0	144	21	123
Reserves	0	0	0	123	0	123
<u>Intake and Performance Predictions</u>						
DMI predicted		23.9 lbs/d				
DMI entered-% predicted: 85%		20.3 lbs/d		Pred. Max Forage Intake	12.0 lbs/d	
Relative DMI		100%		Entered Forage Intake	12.0 lbs/d	
Target ADG w/conceptus		1.26 lbs/d				
ME Allowable Gain		0.11 lbs/d		ME Allowable Milk	13.7 lbs/d	
MP Allowable Gain		0.65 lbs/d		MP Allowable Milk	18.3 lbs/d	
AA Allowable Gain		0.02 lbs/d		AA Allowable Milk	22.8 lbs/d	
				Days to gain 1 CS	7586	
<u>Diet Concentrations and Rumen Balances</u>						
Effective NDF required		4.1 lbs/d		MP from bacteria	636 g/d	
Effective NDF supplied		9.5 lbs/d		MP from undeg feed	246 g/d	
NDF in ration		54% DM		Diet CP	8.7% DM	
Diet ME		1.11 MCAL/LB DM		DIP	60% CP	
Diet NEI		0.72 MCAL/LB DM		Soluble Protein	21% CP	
Diet NEm		0.71 MCAL/LB DM		Total NFC in ration	28% DM	
Diet NEg		0.44 MCAL/LB DM		Fat in ration (total):	4.4% DM	
Pred. Ruminant pH		6.46		Total N balance	20 g/d	
		<u>g/d % of requirements</u>		Predicted MUN		
Ruminal N Balance	-40	76%		Urea cost	0.22 Mcal/d	
Pept Bal.	13	124%		% Forage in ration	53% DM	
First limiting AA: MET	5.45	139%		Ration DM	89%	
2nd limiting AA: LYS	13.80	131%		DMI/Maint DMI	1.5 X Maint.	
<u>Predicted Excretion</u>						
				N excretion: Fecal	0.2 lbs/hd/d	
				Urinary	0.1 lbs/hd/d	
				Total	0.4 lbs/hd/d	
				P excretion: Fecal	43.2 g/hd/d	
				Urinary	0.9 g/hd/d	
				Total	44.2 g/hd/d	
<u>Ration Costs</u>						
Cost/day		0.17 \$/day		Cost/cwt. ME allow. milk	1.27 \$/cwt	
Cost/cwt. milk production		1.27 \$/cwt		Cost/cwt. MP allow. milk	0.95 \$/cwt	
				Cost/cwt. AA allow. milk	0.76 \$/cwt	

Appendix F

Ration for Tennant Lactating beef cow

Enter amt. fed in blue cells:	As-fed Lbs	Forage	Pasture	Home grown	Rel DMI *	Pounds as fed	% of ration As-fed
Fescue, K31	12.00	y	n	y	12.00	12.00	52.6%
Corn Dry	10.00	n	n	y	10.00	10.00	43.9%
Soybean	0.30	n	n	n	0.30	.30	1.3%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Dry Cow Min	0.50	n	n	n	0.50	.50	2.2%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Total	22.80			n	22.80	22.80	100%

DMI Predicted	23.86	DMI Entered:	20.29
Entered DM - Predicted	-3.57		
Relative DMI %	100.0%		
MP Balance	123.5 g/d	Pred DMI	23.9 lbs/d
ME Balance	0.0 mcal/d	Actual DMI	20.3 lbs/d
Rumen N Balance	-39.9 g/d	Effective NDF Balance	5.5 lbs/d
Peptide Balance	12.6 g/d	Days to gain 1 CS	7586
		Cost : \$/day	\$ 0.17

114

Results for:

Tennant

Dry pregnant

12/15/99

MODEL 3

USING MAXIMUM FORAGE
PREDICTION EQUATION**Ration Nutrients Supplied and Required**

	ME Avail Mcal/d	ME Req'd Mcal/d	Difference Mcal/d	MP Avail g/d	MP Req'd g/d	Difference g/d
Totals	16	22	-5	639	526	113
Percent difference			75.2%			121.4%
Maintenance	16	15.3	1	639	318	320
Pregnancy	1	3	-1	320	85	235
Lactation	-1	0	-1	235	0	235
Gain	-1	4	-5	235	122	113
Reserves	0	5	-5	113	0	113

Intake and Performance Predictions

DMI predicted	18.5 lbs/d	DMI predicted (Chase)	
DMI entered-% predicted: 83%	15.3 lbs/d	Pred. Max Forage Intake	12.0 lbs/d
Relative DMI	100%	Entered Forage Intake	12.0 lbs/d
Target ADG w/conceptus	0.24 lbs/d		
ME Allowable Gain	1.23 lbs/d	ME Allowable Milk	0.0 lbs/d
MP Allowable Gain	1.82 lbs/d	MP Allowable Milk	0.0 lbs/d
AA Allowable Gain	0.58 lbs/d	AA Allowable Milk	0.0 lbs/d
ADGpreg	0.58 lbs/day	Days to lose 1 CS	49
Conceptus Weight & Tissue	43.86 lbs		

Diet Concentrations and Rumen Balances

Effective NDF required	3.1 lbs/d	MP from bacteria	467 g/d
Effective NDF supplied	8.7 lbs/d	MP from undeg feed	172 g/d
NDF in ration	61% DM	Diet CP	8.6% DM
Diet ME	1.07 MCAL/LB DM	DIP	61% CP
Diet NEI	0.69 MCAL/LB DM	Soluble Protein	23% CP
Diet NEM	0.67 MCAL/LB DM	Total NFC in ration	18% DM
Diet NEg	0.41 MCAL/LB DM	Fat in ration (total):	4.7% DM
Pred. Ruminant pH	6.46	Total N balance	18 g/d
	<u>g/d % of requirements</u>	Predicted MUN	
Ruminal N Balance	-26 79%	Urea cost	0.20 Mcal/d
Pept Bal.	22 177%	% Forage in ration	71% DM
First limiting AA: MET	4.59 149%	Ration DM	90%
2nd limiting AA: LYS	12.59 142%	DMI/Maint DMI	1.1 X Maint.

Predicted Excretion

N excretion: Fecal	0.2 lbs/hd/d
Urinary	0.1 lbs/hd/d
Total	0.3 lbs/hd/d
P excretion: Fecal	30.3 g/hd/d
Urinary	0.8 g/hd/d
Total	31.1 g/hd/d

Ration Costs

Cost/day	0.17 \$/day	Cost/cwt. ME allow. milk	#N/A	\$/cwt
Cost/cwt. milk production	#N/A \$/cwt	Cost/cwt. MP allow. milk	#N/A	\$/cwt
		Cost/cwt. AA allow. milk	#N/A	\$/cwt

Appendix F

115

000118

EID151796

RGS000998.01

Ration for Tennant Dry pregnant cow

Enter amt. fed in blue cells:	As-fed Lbs	Forage	Pasture	Home grown	Rel DMI * As-fed	Pounds as fed	% of ration As-fed
Fescue, K31	12.00	y	n	y	12.00	12.00	70.6%
Corn Dry	4.20	n	n	y	4.20	4.20	24.7%
Soybean	0.30	n	n	n	0.30	.30	1.8%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Dry Cow Min	0.50	n	n	n	0.50	.50	2.9%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Total	17.00			n	17.00	17.00	100%

DMI Predicted	18.46	DMI Entered:	15.30
Entered DM - Predicted	-3.16		
Relative DMI %	100.0%		
MP Balance	112.7 g/d	121% Pred DMI	18.5 lbs/d
ME Balance	-5.4 mcal/d	75% Actual DMI	15.3 lbs/d
Rumen N Balance	-26.5 g/d	-21% Effective NDF Balance	5.6 lbs/d
Peptide Balance	21.7 g/d	77% Days to lose 1 CS	49
		Cost : \$./day	\$ 0.17

116

000119

EID151797

RGS000999

General Factors

Farm Name: Tennant
 Diet Dry pregnant cow
 Number in group: 1
 Days to feed 365
 NDF capacity 1 % of BW
 Units 1 English
 Feed Entry Basis LB/Head/Day 1 As-Fed
 Milk Price \$ /cwt
 Feed Losses 0% % dry matter
 File Name C:\casestudy\test

USING MAXIMUM
 FORAGE PREDICTION
 EQUATION

Animal Factors

Grade 5 Enter 1 to FALSE
 Animal Type 3 Dry Cow
 Age 70 Months
 Sex 4 Cow
 Body Weight 900 Lb
 Breed Type 1 Beef Maturity
 Mature Weight 900 Lb
 Condition Score 3 1=v.thin - 9=v.fleshy
 Breeding System 2 2way cross
 Dam breed 17 #N/A Hereford
 Dam's maternal 1 1 Angus
 Dam's paternal 17 17 Hereford

18
 18
 Days Pregnant 240 Days
 Days Since Calving 360 Days DLW 0
 Lactation # 4 0=dry or heifer
 Rolling Herd Average (dairy) 0 Lb Predicted values
 Milk Production (dairy) 45.40 Lb 1.2
 Milk Fat (dairy) 3.70 % 6.8
 Milk Protein (dairy) assume CP 3 % 4.5
 Relative Milk Prod'n (beef) 1 1-9 16.53
 Expected Calf Birth Weight 45 Lb 73.8

Management Factors

0
 Additive 1 none
 Grazing Unit Size 0.00 Acres
 Daily pasture allowance 0 DM lb/PDMI
 Initial pasture mass 1847 lb DM/acre
 Selection-Pressure for growth/milk 0 1-5 Scale
 Feeding Frequency 2 # of Times Fed Daily
 Feeding Method 2 1=forage&grain separate.2=TMR
 Calf Implanted 1 1=no,2=yes

Environmental Factors

0
 Wind Speed 5 mph
 Previous Temperature 40 Degrees F
 Previous RH 30 %
 Current Temperature 40 Degrees F

Current RH	30	%
Storm Exposure	1	1=no,2=yes
Night Cooling	1	1=none,2=with night cooling
Hair Depth	1	in
Hide	2	1=thin,2=avg,3=thick
Hair Coat	1	1=no mud,2=some mud on lower b
Cattle Panting (Heat Stress)	1	1=no,2=rapid shallow,3=open mout
DMI Scaler	1	% (110=+10%; 90= -10%)
In summer, cattle are exposed to:	12	1=No direct sunlight, 2=direct sunlig
Rectal Temperature (optional)	101.5	Degrees F
Animal Activity Functions	0	
Time spent standing	18	hrs per day
Number of body position changes	6	(lying down and standing again)
Distance walked	6562	feet/d
Flat		feet/d
Sloped		
Mud Depth	0	inches
Feedbunk Characteristics		
Bunk level	6	inches (distance between cow floor
Bunk Surface	1	see codes----->
Target Growth		
Age at 1st calving	24	months
Herd Calving Interval	16	months

Results for:

Tennant

Dry pregnant

12/15/99

MODEL 4

USING MAXIMUM DRY MATTER
INTAKE (DMI)

<u>Ration Nutrients Supplied and Required</u>						
	ME Avail Mcal/d	ME Req'd Mcal/d	Difference Mcal/d	MP Avail g/d	MP Req'd g/d	Difference g/d
Totals	19	22	-3	762	584	177
Percent difference			87.7%			130.3%
Maintenance	19	15.5	4	762	377	385
Pregnancy	4	3	1	385	85	300
Lactation	1	0	1	300	0	300
Gain	1	4	-3	300	122	177
Reserves	0	3	-3	177	0	177
<u>Intake and Performance Predictions</u>						
DMI predicted		18.5 lbs/d		DMI predicted (Chase)		
DMI entered-% predicted: 100%		18.5 lbs/d		Pred. Max Forage Intake	12.0 lbs/d	
Relative DMI		100%		Entered Forage Intake	15.5 lbs/d	
Target ADG w/conceptus		0.68 lbs/d				
ME Allowable Gain		1.23 lbs/d		ME Allowable Milk	0.0 lbs/d	
MP Allowable Gain		2.17 lbs/d		MP Allowable Milk	0.0 lbs/d	
AA Allowable Gain		0.58 lbs/d		AA Allowable Milk	0.0 lbs/d	
ADGpreg		0.58 lbs/day		Days to lose 1 CS	97	
Conceptus Weight & Tissue		43.86 lbs				
<u>Diet Concentrations and Rumen Balances</u>						
Effective NDF required		3.7 lbs/d		MP from bacteria	548 g/d	
Effective NDF supplied		11.0 lbs/d		MP from undeg feed	214 g/d	
NDF in ration		63% DM		Diet CP	8.4% DM	
Diet ME		1.05 MCAL/LB DM		DIP	30% CP	
Diet NEI		0.68 MCAL/LB DM		Soluble Protein	23% CP	
Diet NE _m		0.65 MCAL/LB DM		Total NFC in ration	16% DM	
Diet NE _g		0.39 MCAL/LB DM		Fat in ration (total):	4.8% DM	
Pred. Ruminant pH		6.46		Total N balance	28 g/d	
		<u>g/d % of requirements</u>		Predicted MUN		
Ruminal N Balance	-31	79%		Urea cost	0.32 Mcal/d	
Pept Bal.	27	190%		% Forage in ration	76% DM	
First limiting AA: MET	5.90	156%		Ration DM	90%	
2nd limiting AA: LYS	16.66	149%		DMI/Maint DMI	1.3 X Maint.	
<u>Predicted Excretion</u>						
				N excretion: Fecal	0.2 lbs/hd/d	
				Urinary	0.1 lbs/hd/d	
				Total	0.3 lbs/hd/d	
				P excretion: Fecal	32.2 g/hd/d	
				Urinary	0.8 g/hd/d	
				Total	33.0 g/hd/d	
<u>Ration Costs</u>						
Cost/day		0.17 \$/day		Cost/cwt. ME allow. milk	#N/A	\$/cwt
Cost/cwt. milk production	#N/A	\$/cwt		Cost/cwt. MP allow. milk	#N/A	\$/cwt
				Cost/cwt. AA allow. milk	#N/A	\$/cwt

Appendix F

119

EID151800

000122

RGS001002

Ration for Tennant Dry pregnant cow

Enter amt. fed in blue cells:	As-fed		Home grown	Rel DMI *		% of ration	
	Lbs	Forage		Pasture	As-fed	Pounds as fed	As-fed
Fescue, K31	15.50	y	n	n	15.50	15.50	75.6%
Corn Dry	4.20	n	n	n	4.20	4.20	20.5%
Soybean	0.30	n	n	n	0.30	.30	1.5%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Dry Cow Min	0.50	n	n	n	0.50	.50	2.4%
Blank	0.00	n	n	n	0.00	.00	0.0%
Blank	0.00	n	n	n	0.00	.00	0.0%
Total	20.50				20.50	20.50	100%
DMI Predicted	18.46						
Entered DM - Predicted	0.02				DMI Entered:	18.49	
Relative DMI %	100.0%						
MP Balance	177.2 g/d	130%		Pred DMI	18.5 lbs/d		
ME Balance	-2.7 mcal/d	88%		Actual DMI	18.5 lbs/d		
Rumen N Balance	-30.5 g/d	-21%		Effective NDF Balance	7.3 lbs/d		
Peptide Balance	27.2 g/d	90%		Days to lose 1 CS		97	
				Cost : \$./day	\$	0.17	

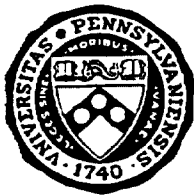
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EID151801

RGS001003

000123

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NEW BOLTON CENTER

University of Pennsylvania, New Bolton Center
Laboratory of Large Animal Pathology and
Toxicology
382 W. Street Road
Kennett Square, PA 19348
Phone: (610) 444-5800 Fax: (610) 925-8110

FINAL REPORT

Accession No.: UP 9902707

Pg #: 1

Submitter: Dr. Perry Habecker

Report Address:

Dry Run Investigation Team

Case Tracking #: N o.p.

Case Coordinator: Perry L. Habecker, VMD

Date Submitted: 6/27/99

Report Date: 7/5/99 TA(D): 8

Species: Bovine	Production type:	Date obtained:	Reference Lab:
Breed:	Sex: F	Age:7.y	m w d ☒ Adult ☐ Fetus ☐ Juvenile ☐ Unknown
Animal I.D. #37			

Sample:14..... Fixed Tissue

HISTORY SUMMARY:

Filed and necropsied for Dr. Lisa Heller on June 10, 1999. Tissues also submitted to toxicology.

DIAGNOSIS:

Enteric lesions of minimal significance.

COMMENTS:

The gastrointestinal eosinophilia is attributed to previous and current bouts of endoparasitism. Epithelial abscessation in the forestomachs is associated with acidosis due to excessive carbohydrate ingestion.

LABORATORY FINDINGS:

HISTOPATHOLOGY EXAMINATION:

- 1) Heart, 2 pieces: Minimal, focal lymphocytic myocarditis; focal Sarcocyst spp..
- 2) Lung, 2 pieces: Normal
- 3) Liver, 2 pieces Normal
- 4) Spleen: Normal
- 5) Kidney: Normal
- 6) Test: Normal
- 7) Adrenal, 2 pieces: Normal
- 8) Lymph node, 2 pieces: Normal
- 9&10) Small intestine, 4 pieces: Mucosa--moderately severe, diffuse eosinophilia; focal coccidian parasite.
- 11) Abomasum, 2 pieces: Mucosa--mild, multifocal eosinophilia.
- 12) Omasum: Epithelium--abscesses, moderately severe, acute, multifocal.
- 13) Reticulum: Epithelium--abscesses, mild, acute, multifocal; tunica muscularis--granuloma, minimal, focal with intralesional plant foreign body.
- 14) Thymus: Normal

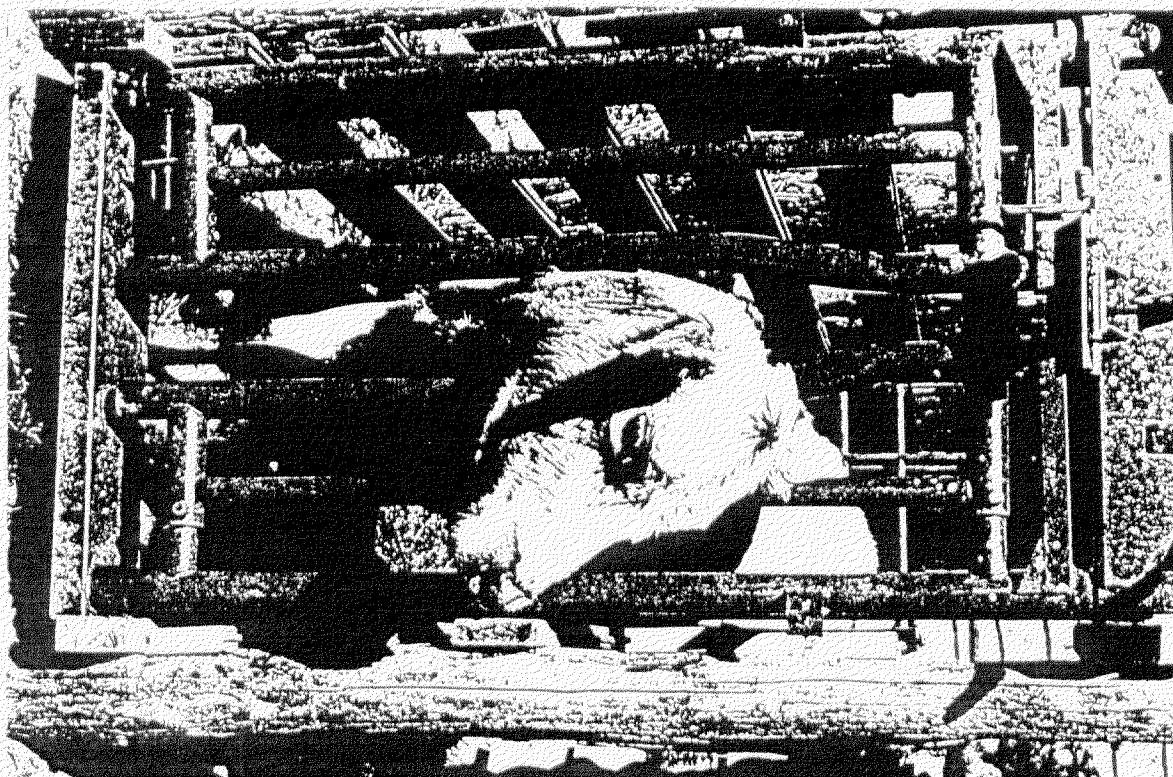
Perry L. Habecker, VMD

000125

DUP 004

Photo #	Photograph Legend
1 - 41	Cattle 1 - 41, respectively. Each photo number corresponds to the ear tag number (placed following examination) of the cow, bull, or steer and the animal number in Table 1 of this report.
42	Cow # 42: The individual cow which escaped the run and was therefore not ear tagged or examined.
43	Livestock in corral. The 42 adult cattle (39 cows, 2 bulls, 1 steer) and 12 calves were held in this corral for several hours prior to examination in the late afternoon of April 7, 1999.
44	Cow # 25: Corneal scar
45	Cow # 26: Corneal opacity
46	Cow # 30: Corneal opacity
47	Cow # 37: Corneal scar
48	Cow # 40: Corneal opacity
49	Cow # 22: Mass (12 cm diameter), prescapular, subcutaneous, neck, right.
50	Cow # 22: Scalpel puncture and drainage of mass during examination. Brown-red fluid contents drained.
51	Cow # 22: Manual exploration of cystic cavity revealed a large mass of red hair within the cyst. Diagnosis was "epidermal inclusion cyst" of spontaneous origin which was of no significance to herd health.
52	Cow # 31: Tongue with spotty melanosis. This was an incidental finding of no pathological significance. Melanosis of epidermal tissues, as seen here, is normal.
53	Cow # 18: Mammary gland lump adjacent to teat. This was considered to most likely be an abscess.
54	Group of cattle, owned by a neighbor of Mr. Tennant, grazing on an adjacent property.
55	Deer carcass on Tennant property. One of three deer carcasses observed by Mr. Tennant and Dr. Sykes, within 500 feet of the Tennant barn on April 8, 1999. All three appeared to have died in the past few months.
56	Tennant barn and barnyard adjacent to the corral where the cattle examinations were conducted.
57	Grazing pasture along the Dry Run Creek between the landfill site and the Tennant barn.
58	Grazing pasture along the Dry Run Creek between the landfill site and the Tennant barn.
59	Group of 16 cow skulls (photo supplied by Mr. Tennant)
60	Worn incisors of an unidentified cow, bull, or steer (photo supplied by Mr. Tennant).

Photo #	Photograph Legend (continued)
61	Neck alopecia in an unidentified animal (photo supplied by Mr. Tennant). The cattle team considered this most likely due to lice.
62	Neck alopecia in an unidentified animal (photo supplied by Mr. Tennant). The cattle team considered this most likely due to lice.
63	Nose with spotty melanosis (photo supplied by Mr. Tennant). The cattle team considered this pigmentation to be normal.
64	Nose with diffuse melanosis (photo supplied by Mr. Tennant). The cattle team considered this pigmentation to be normal.
65	Hard palate with spotty melanosis (photo supplied by Mr. Tennant). The cattle team considered this pigmentation to be normal.
66	Cattle team (CT) and steering committee (SC) members at the Tennant Farm during the April 7-8 1999 site visit. From left to right: Dr. Robert Poppenga (CT: veterinary toxicologist), Dr. Robert Munson (CT: veterinary clinician); Dr. Peter Moisan (CT: veterinary clinician/pathologist), Sarah Caspar (SC: EPA On-Scene Coordinator), Dr. Perry Habecker (CT: veterinary pathologist), Dr. Lisa Davis-Heller (CT: veterinary clinician), Dr. Michael Horne (SC: USFWS, Environmental Response Team). Not shown: Dr. Greg Sykes (CT: veterinary pathologist/toxicologist; taking picture); Dr. Ralph Stahl (SC: DuPont biologist; not present) and Dr. Rudolph Valentine (SC: DuPont toxicologist; not present).



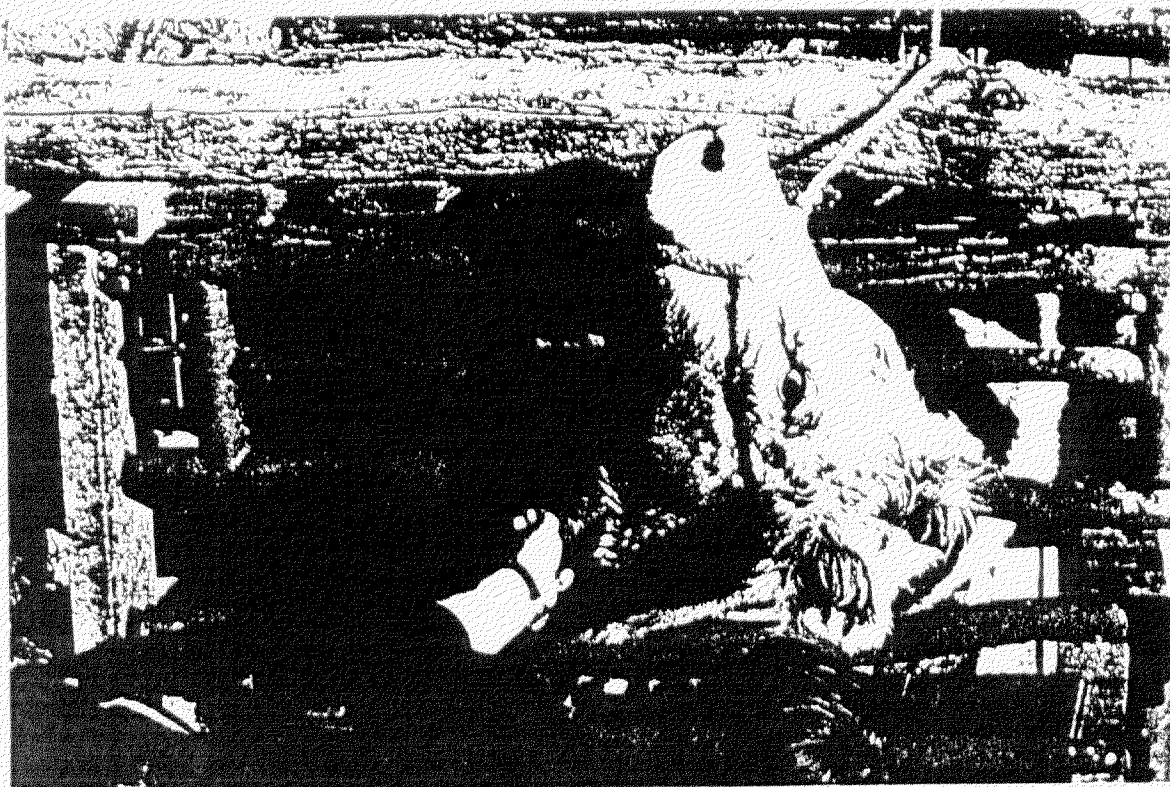
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DUP 030



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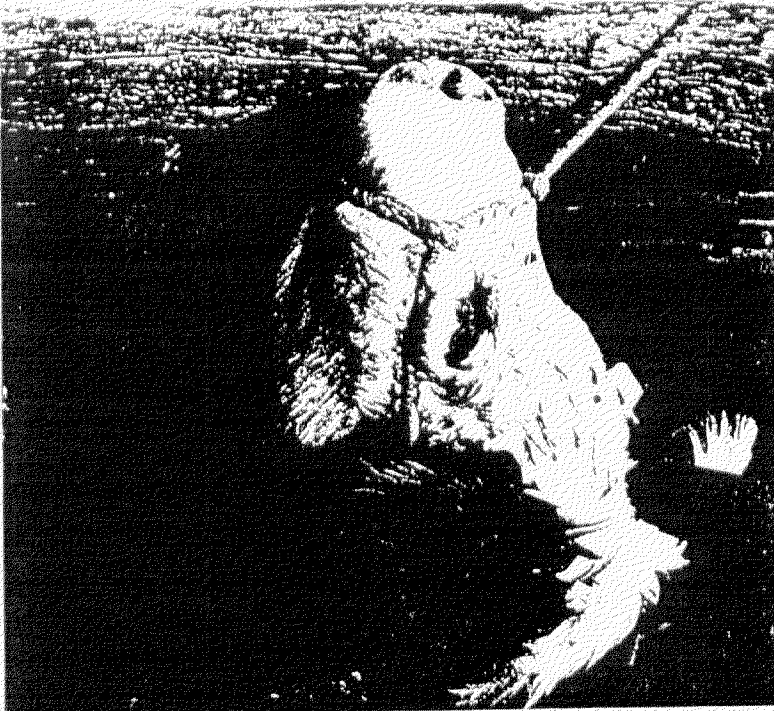
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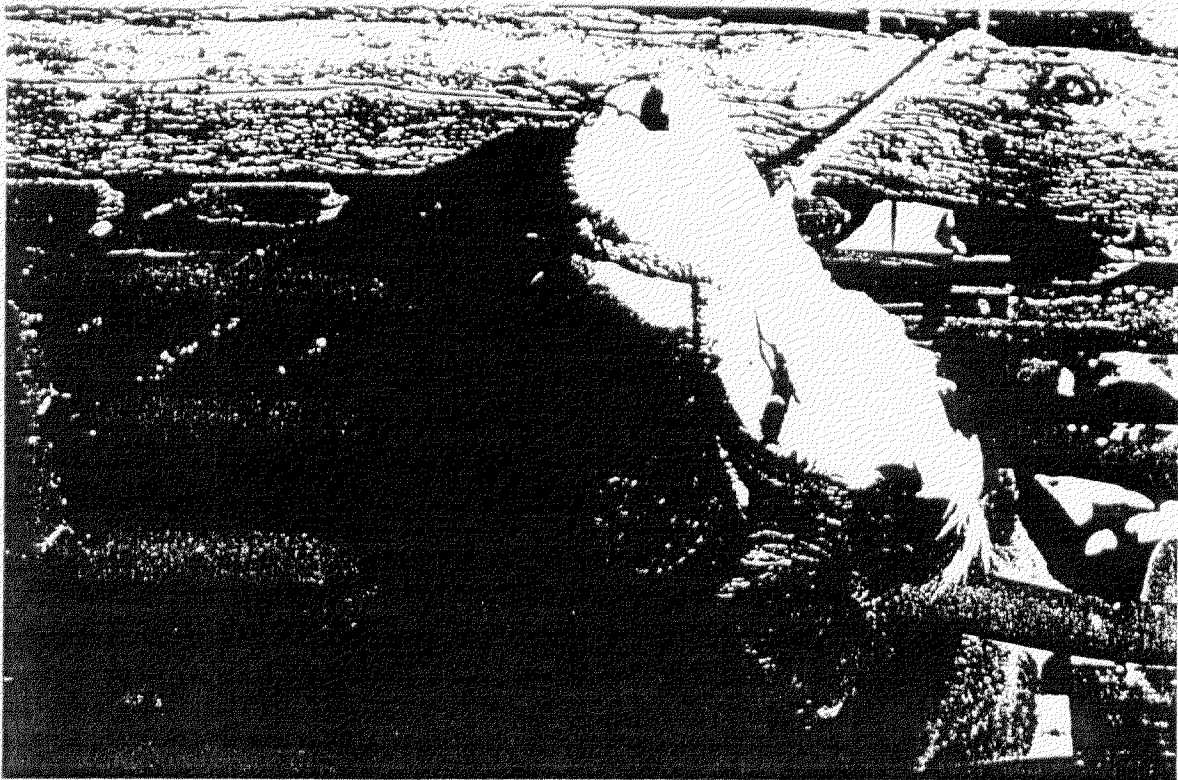
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DUP 033



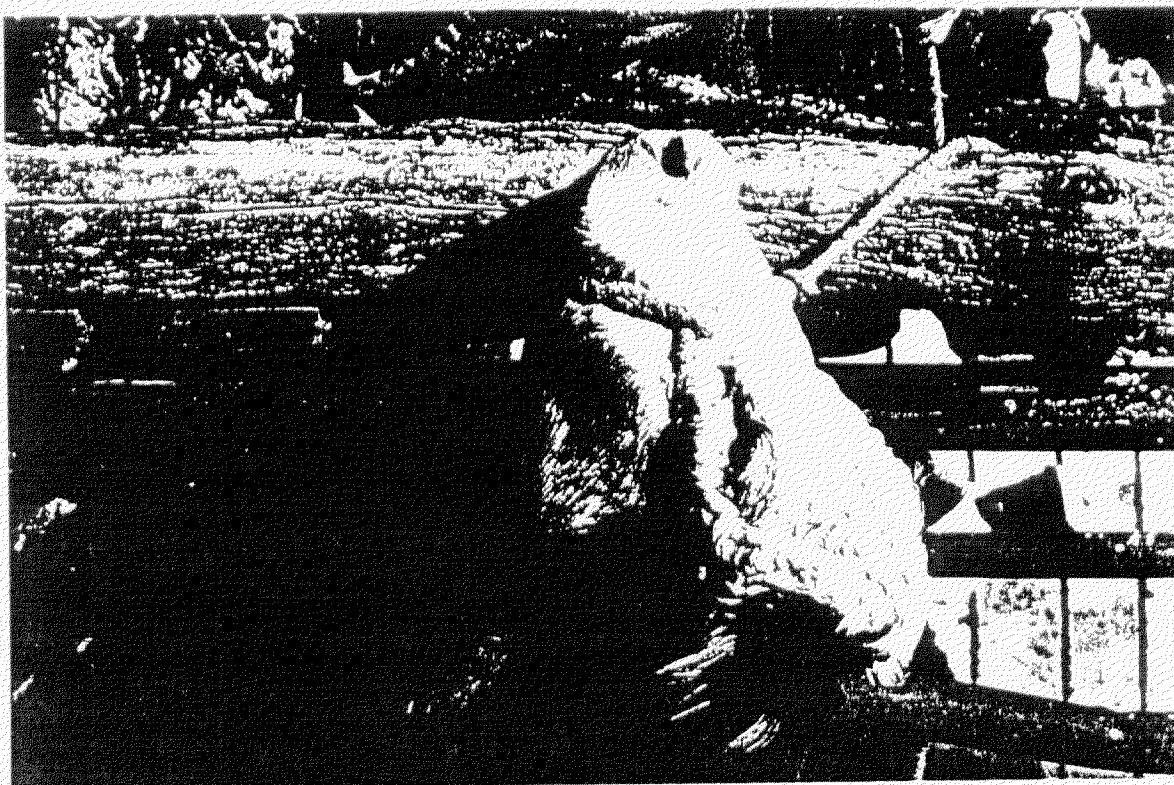
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DUP 034



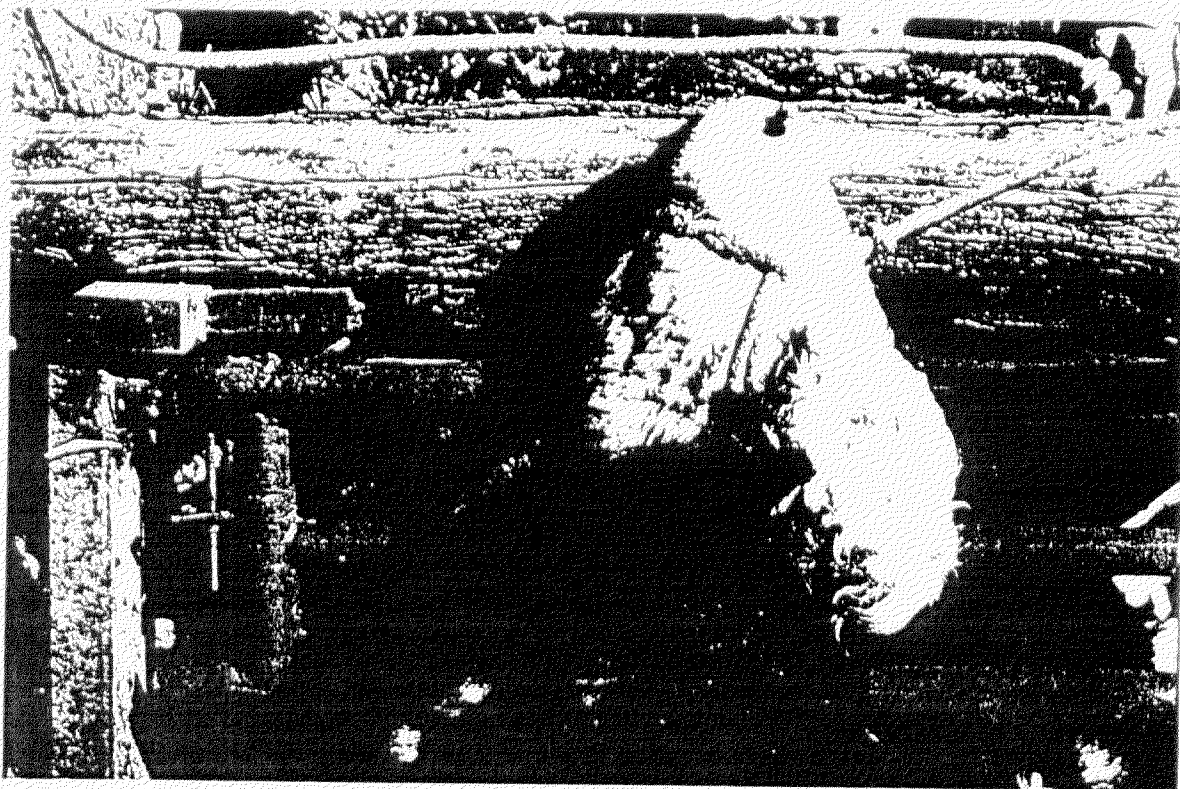
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DUP 035



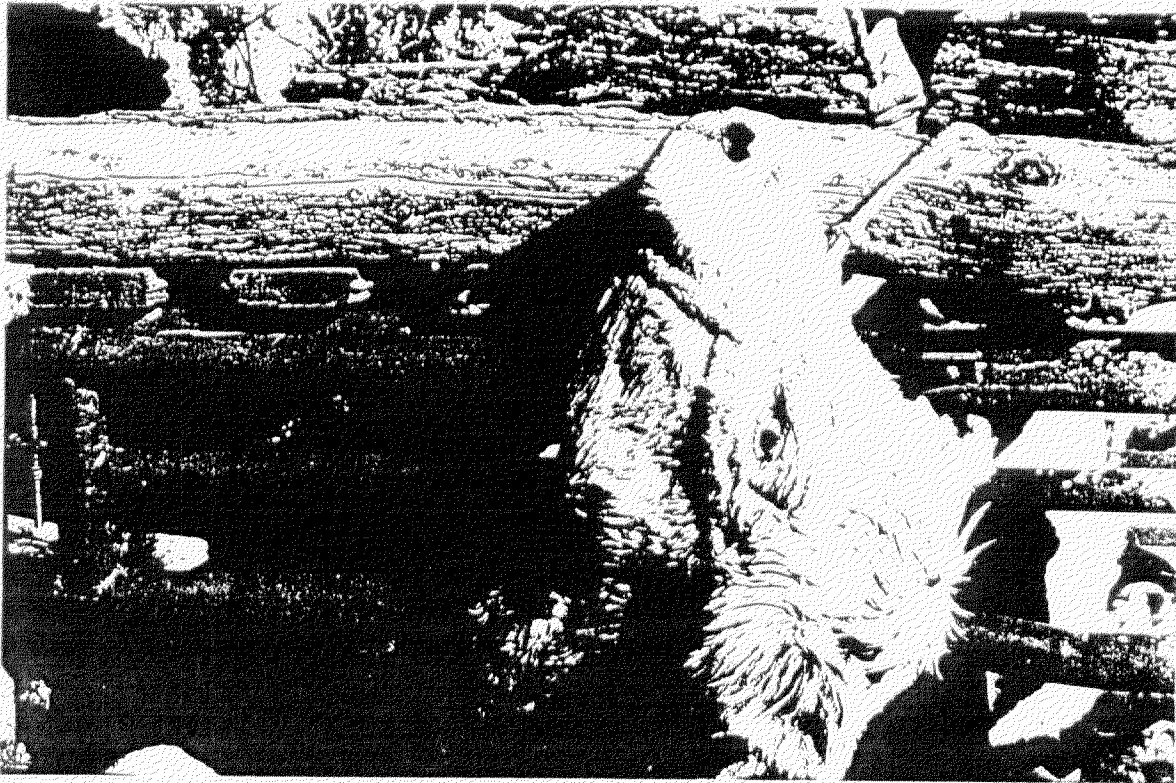
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DUP 036



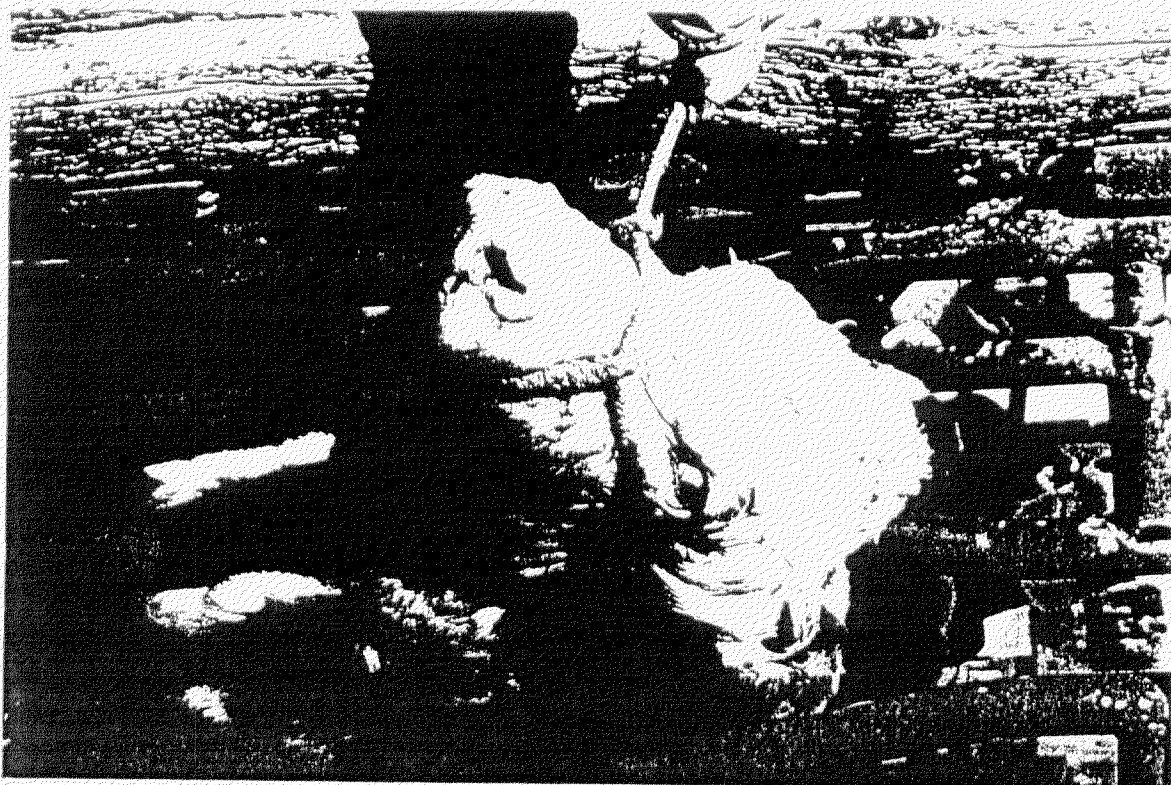
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DUP 037



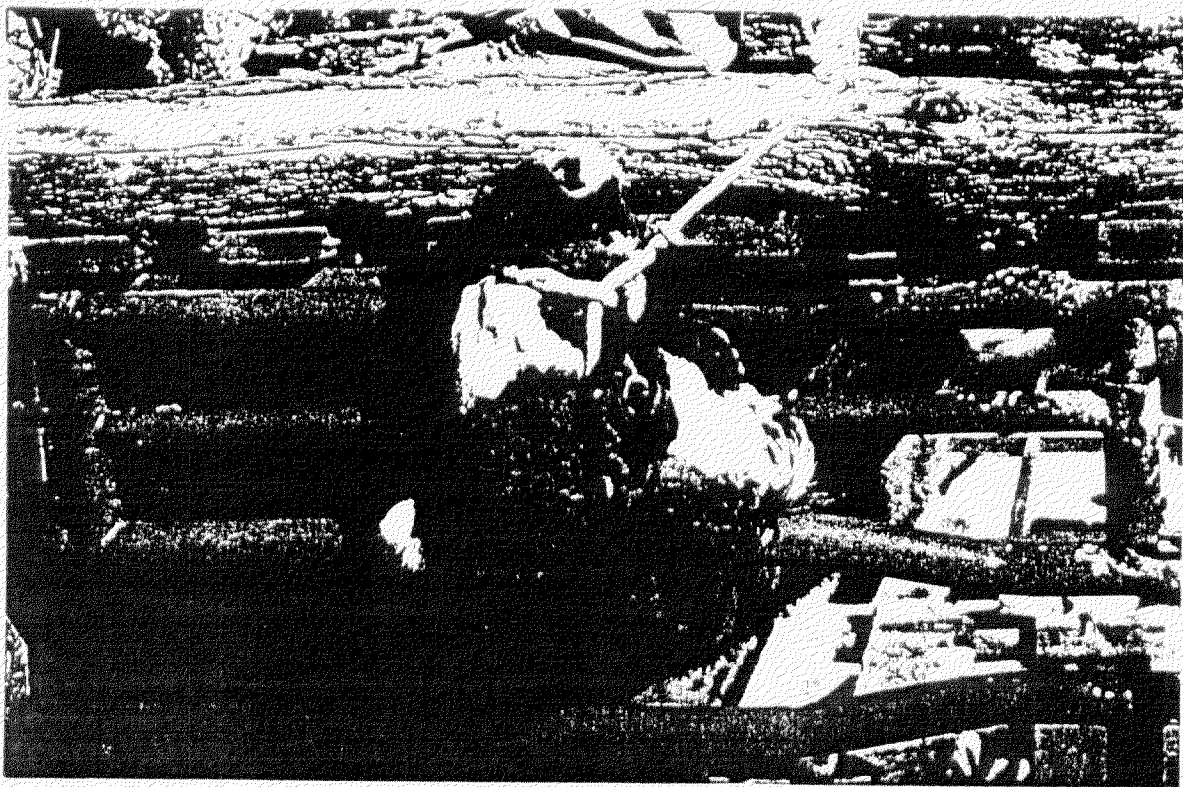
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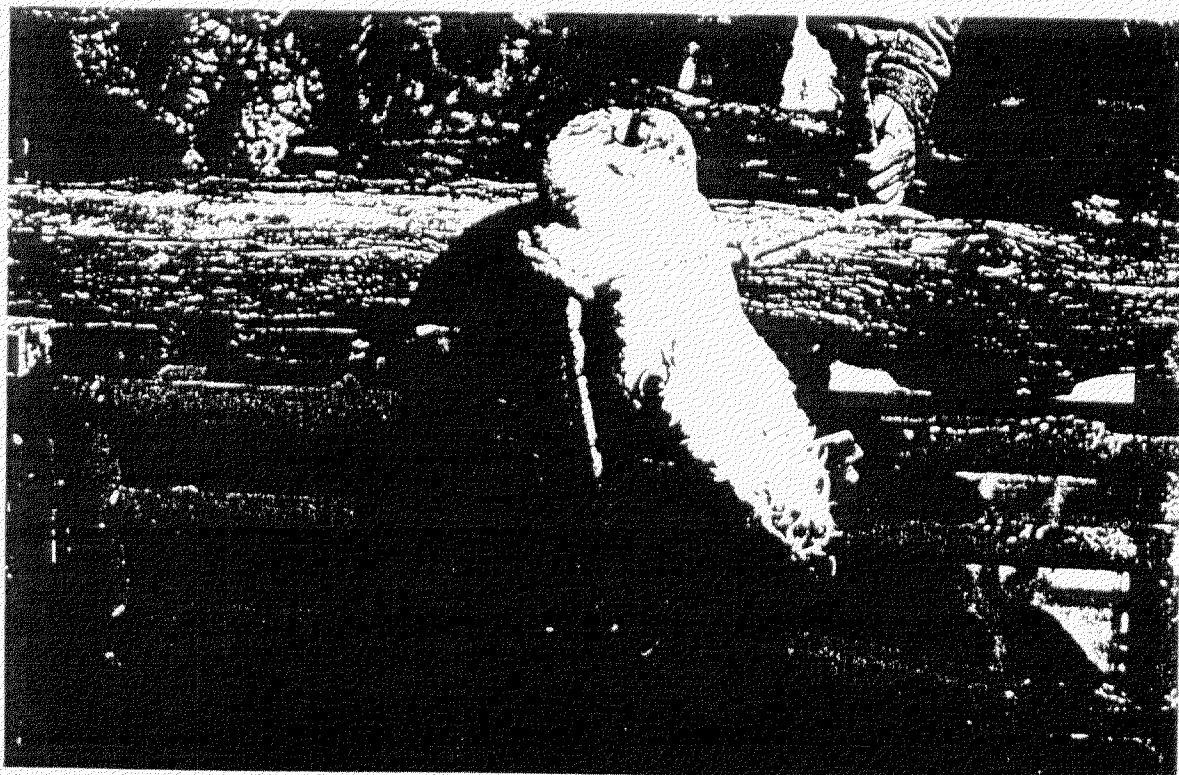
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DUP 038



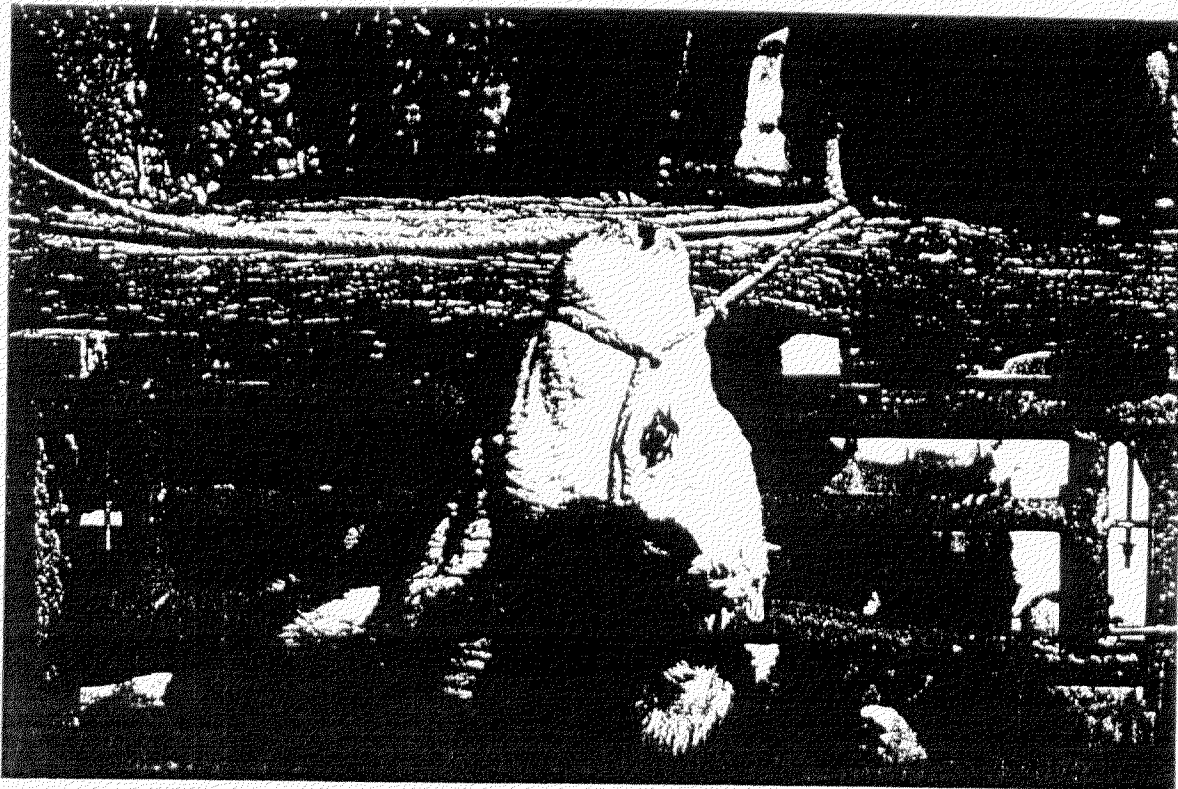
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DUP 039



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DUP 040



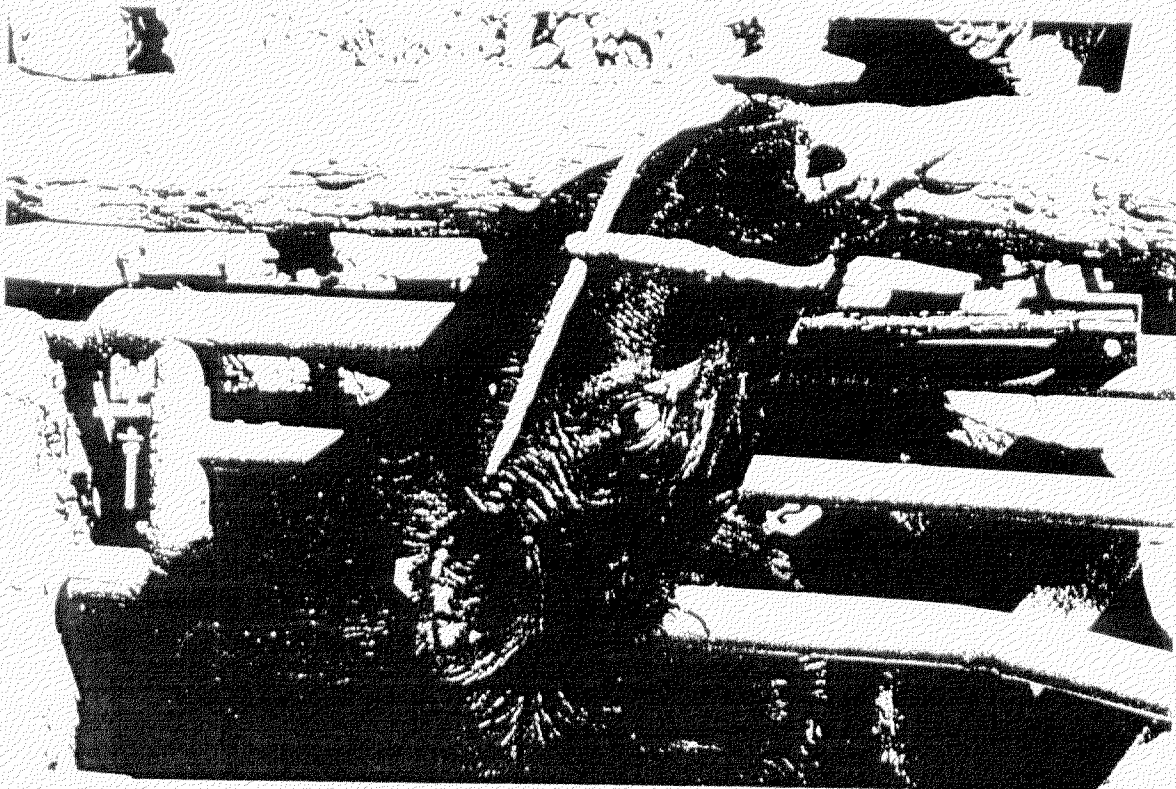
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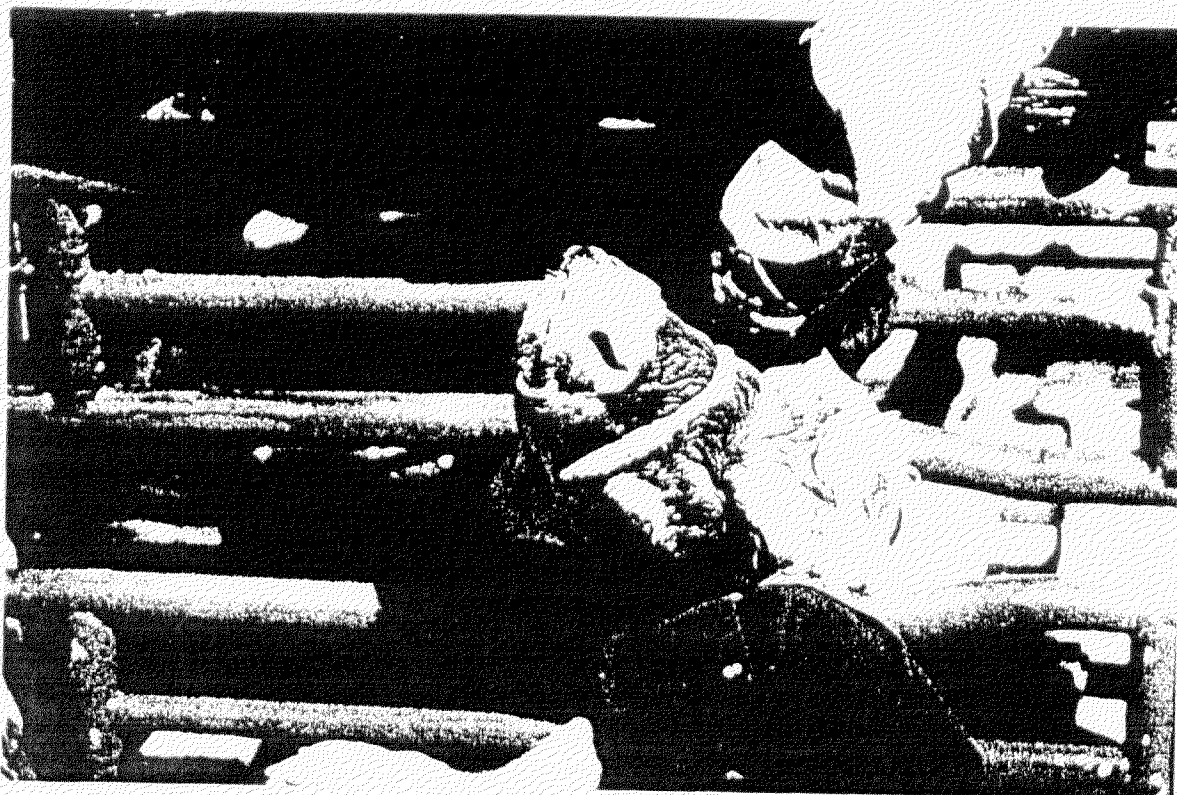


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DUP 044



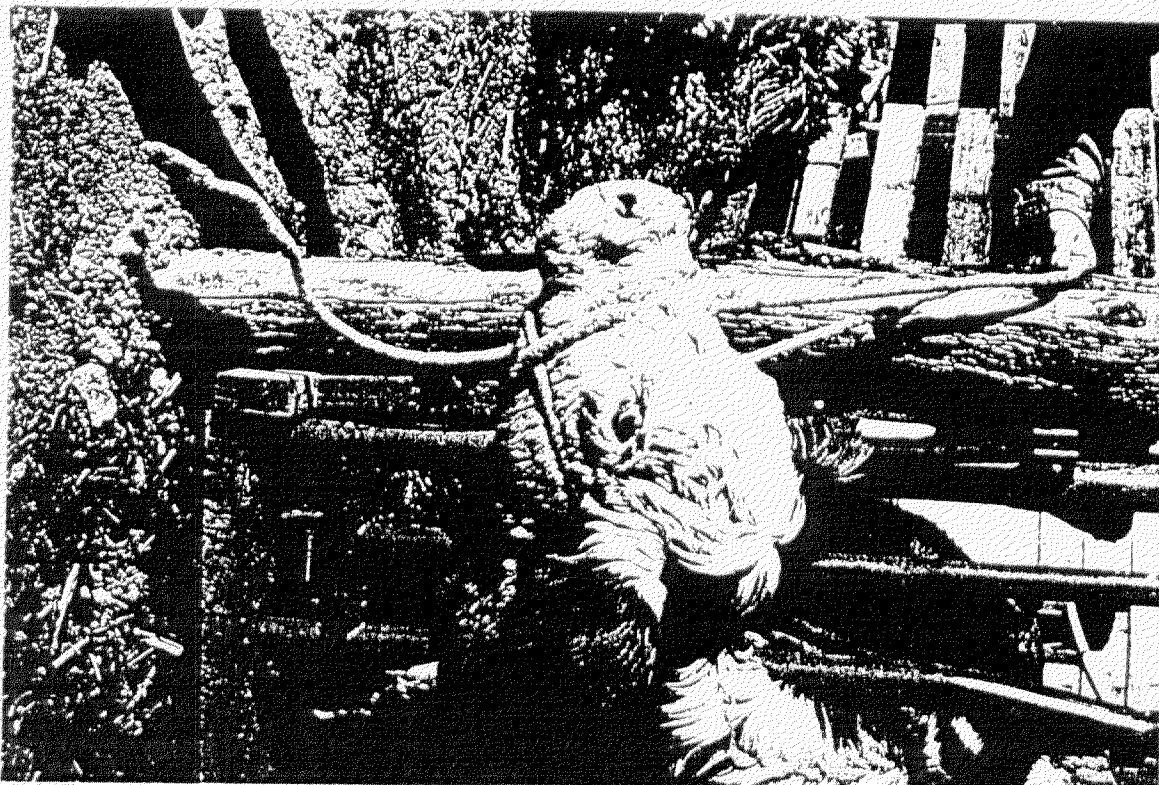
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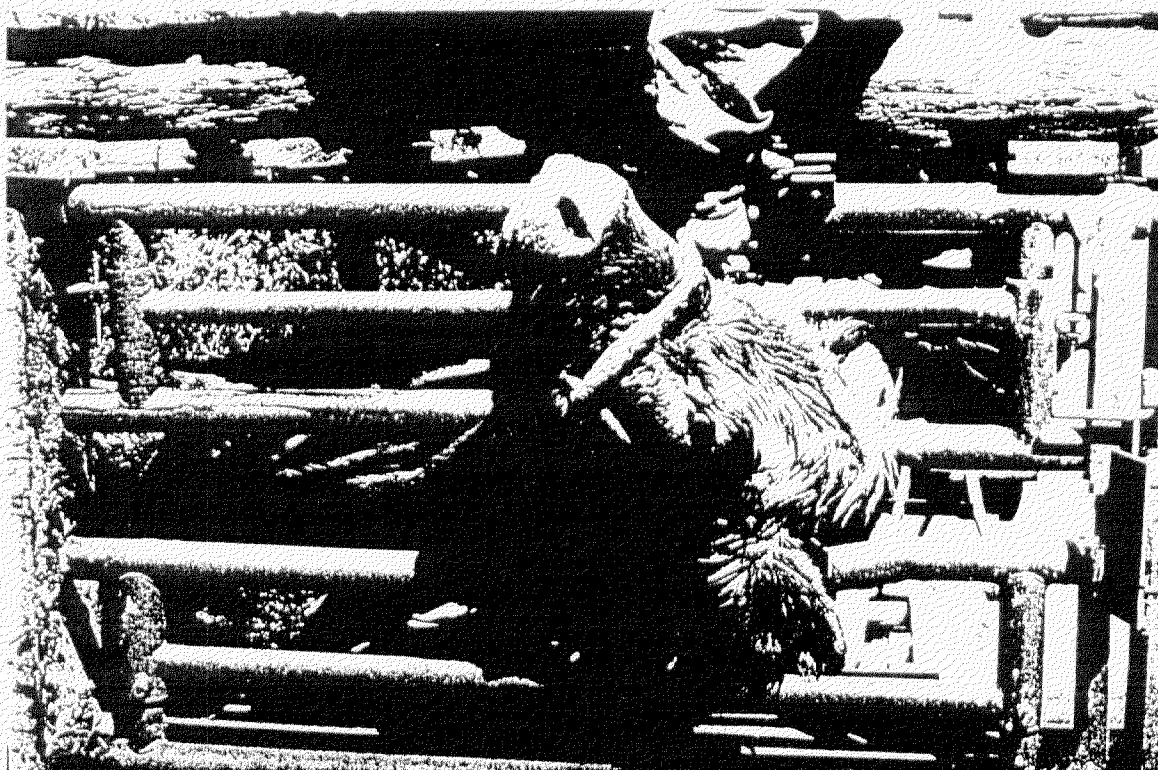
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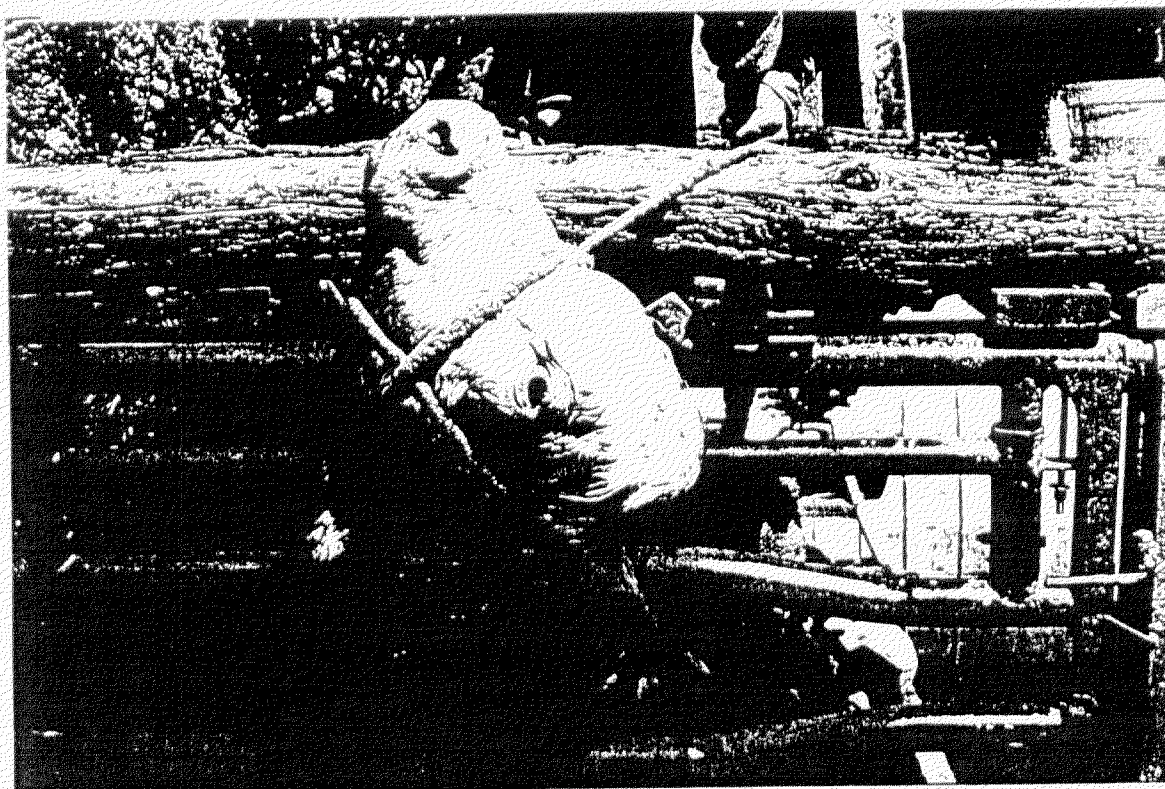


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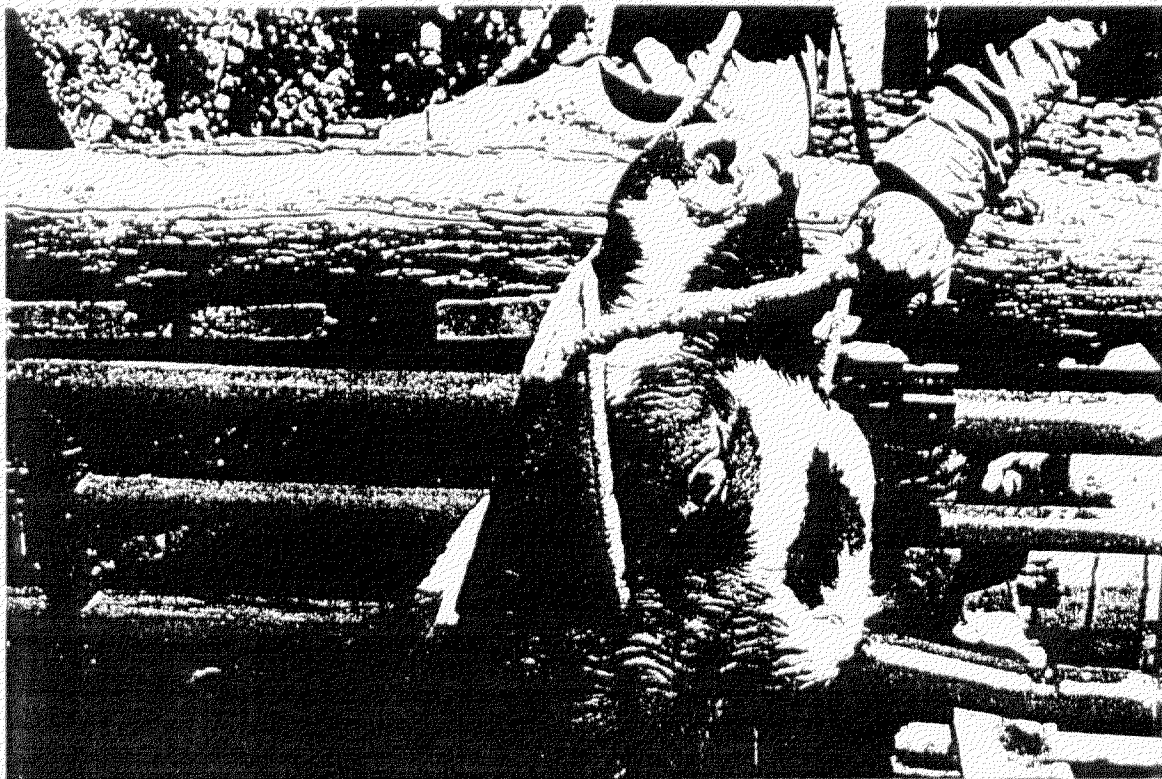
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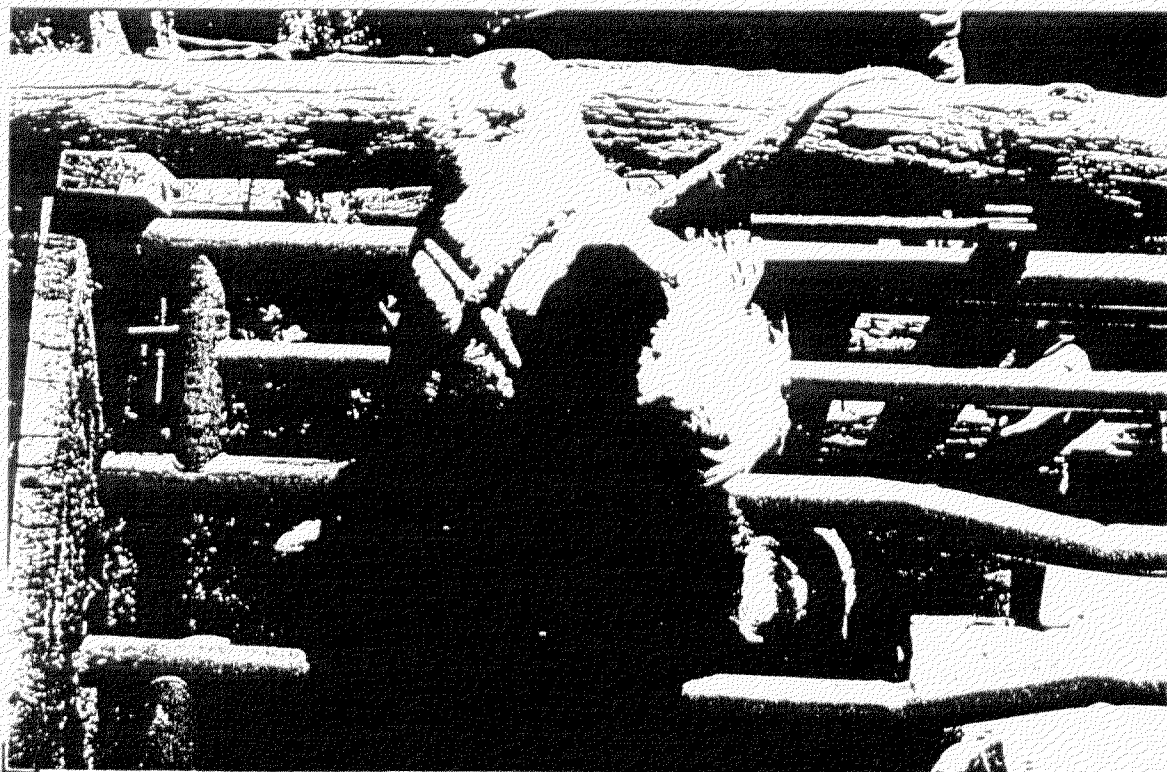
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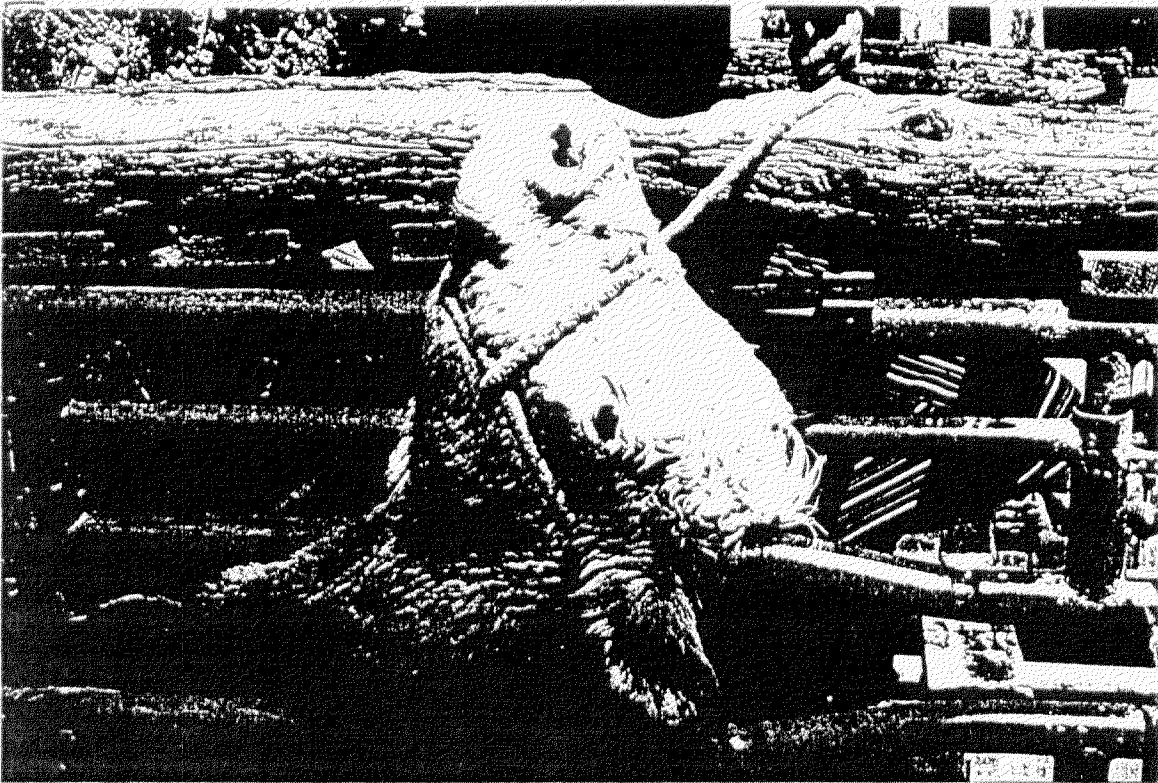
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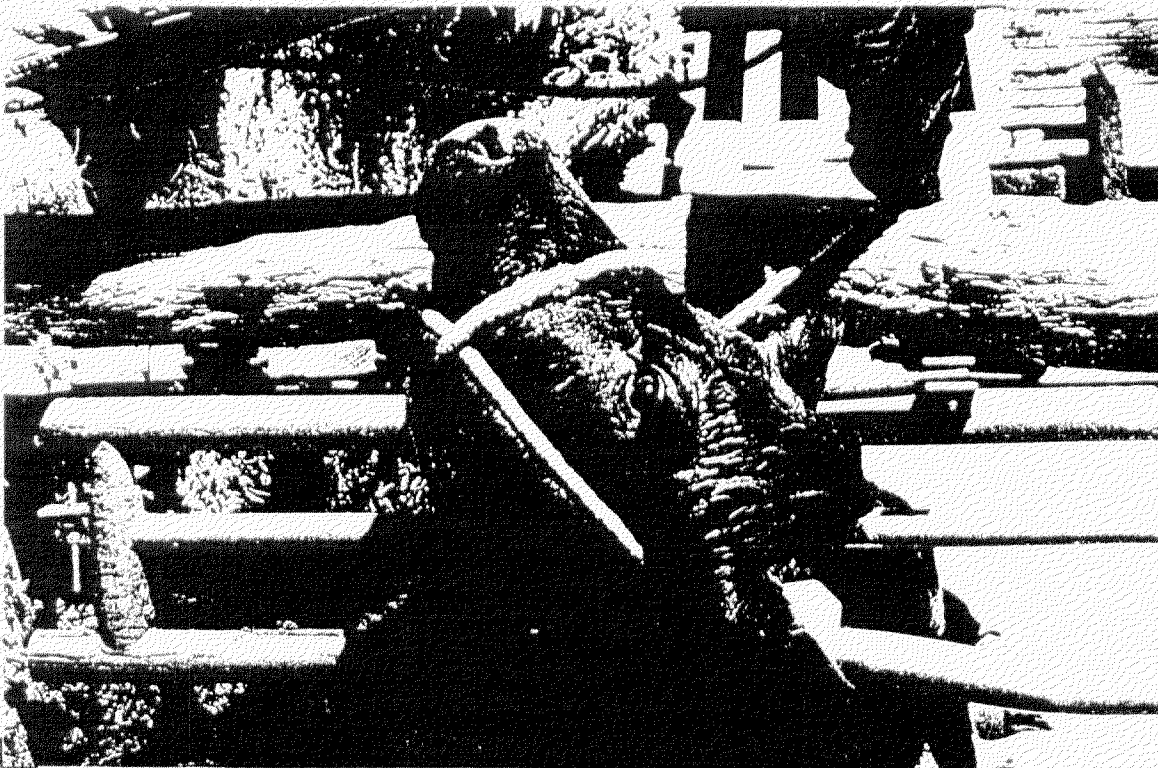
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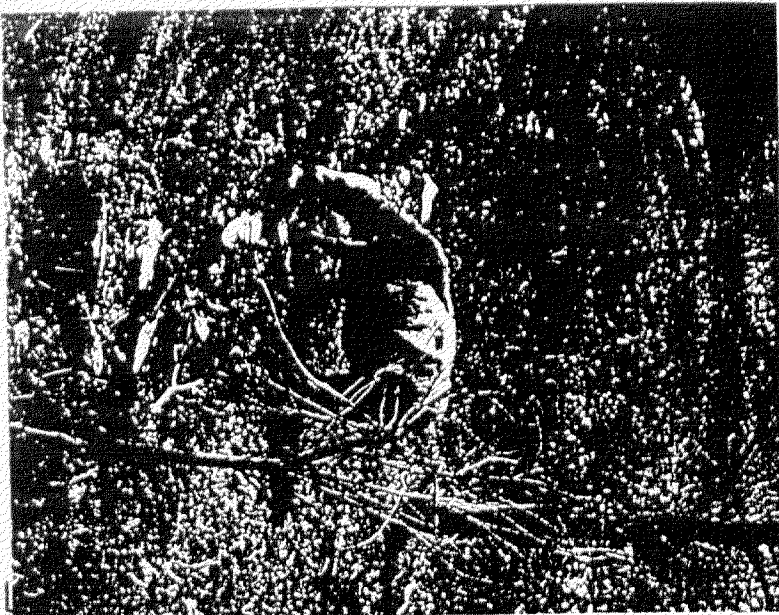
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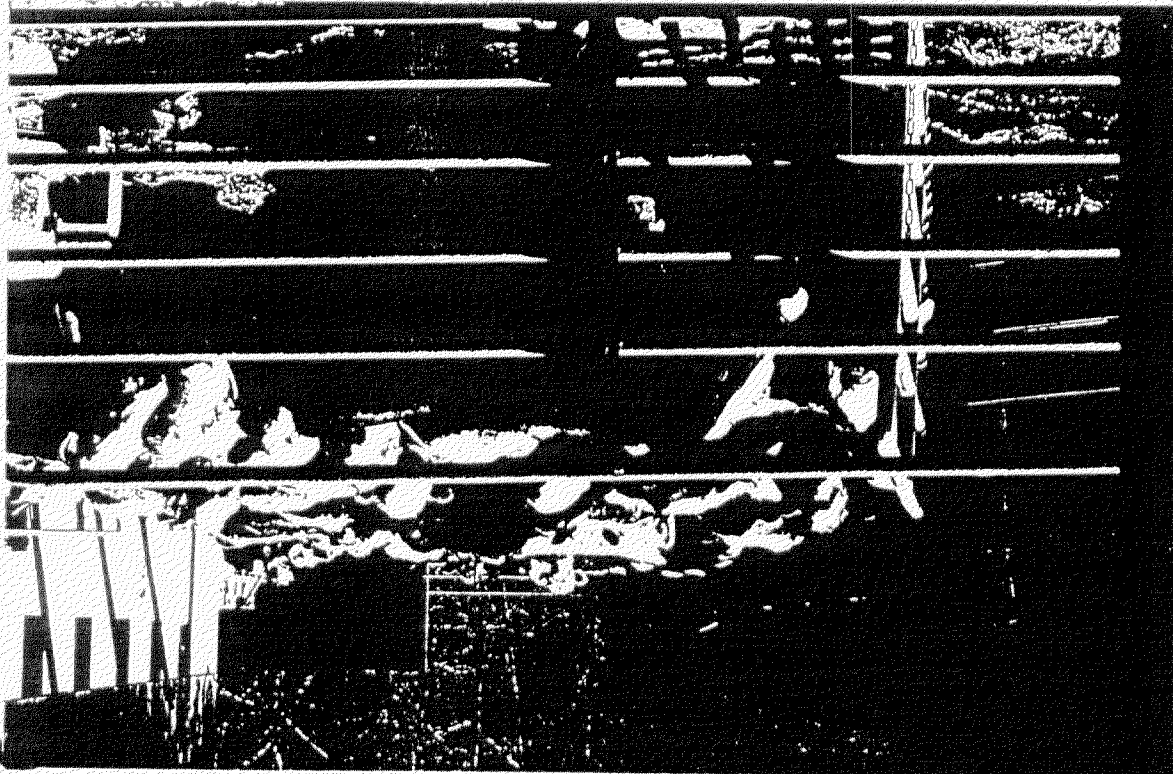
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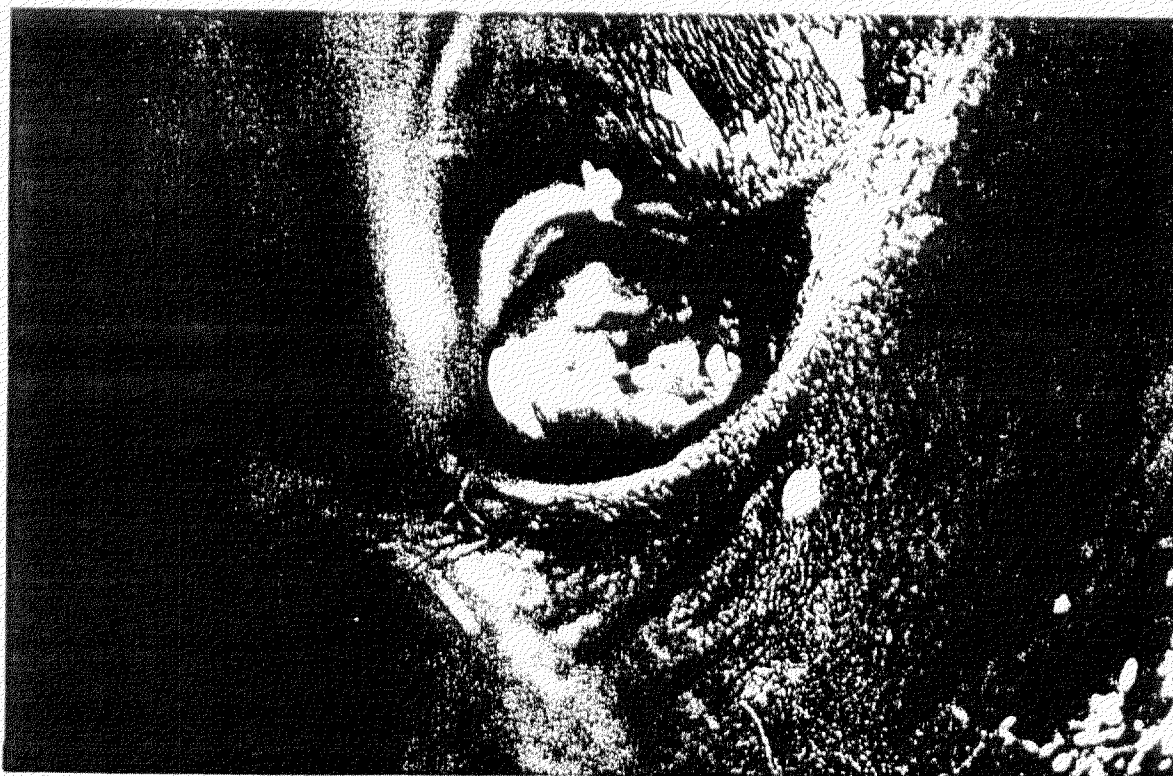
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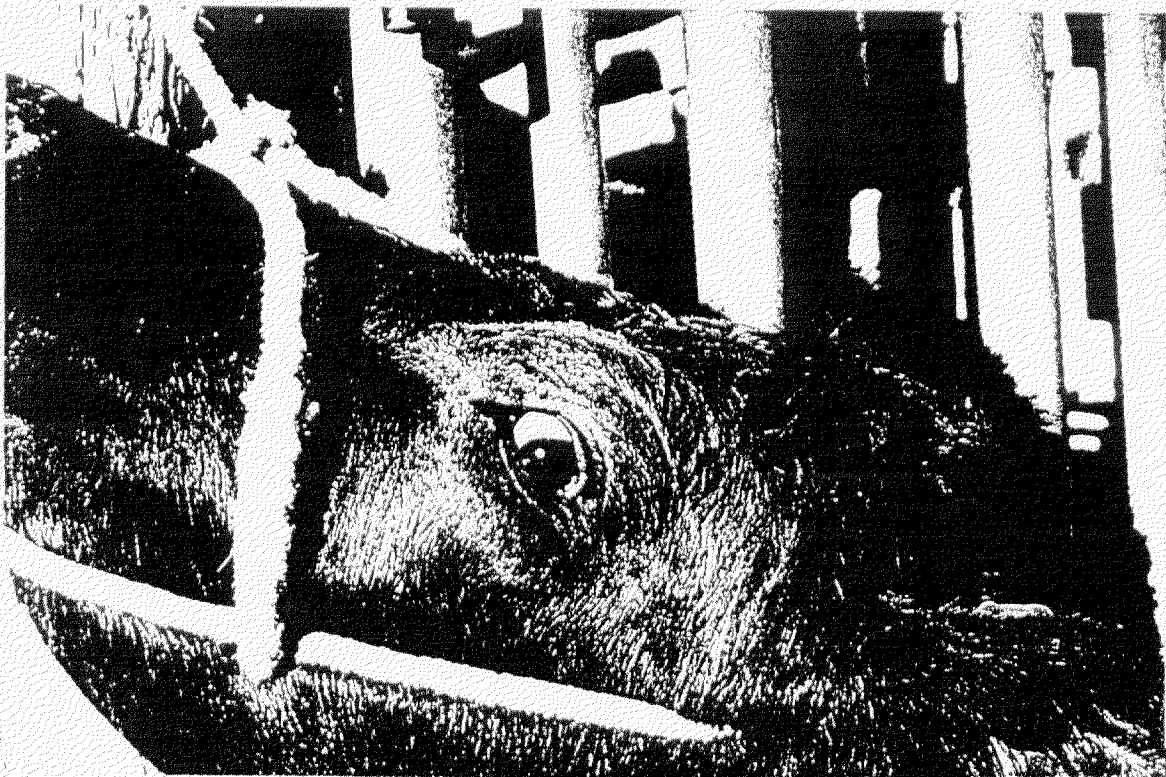


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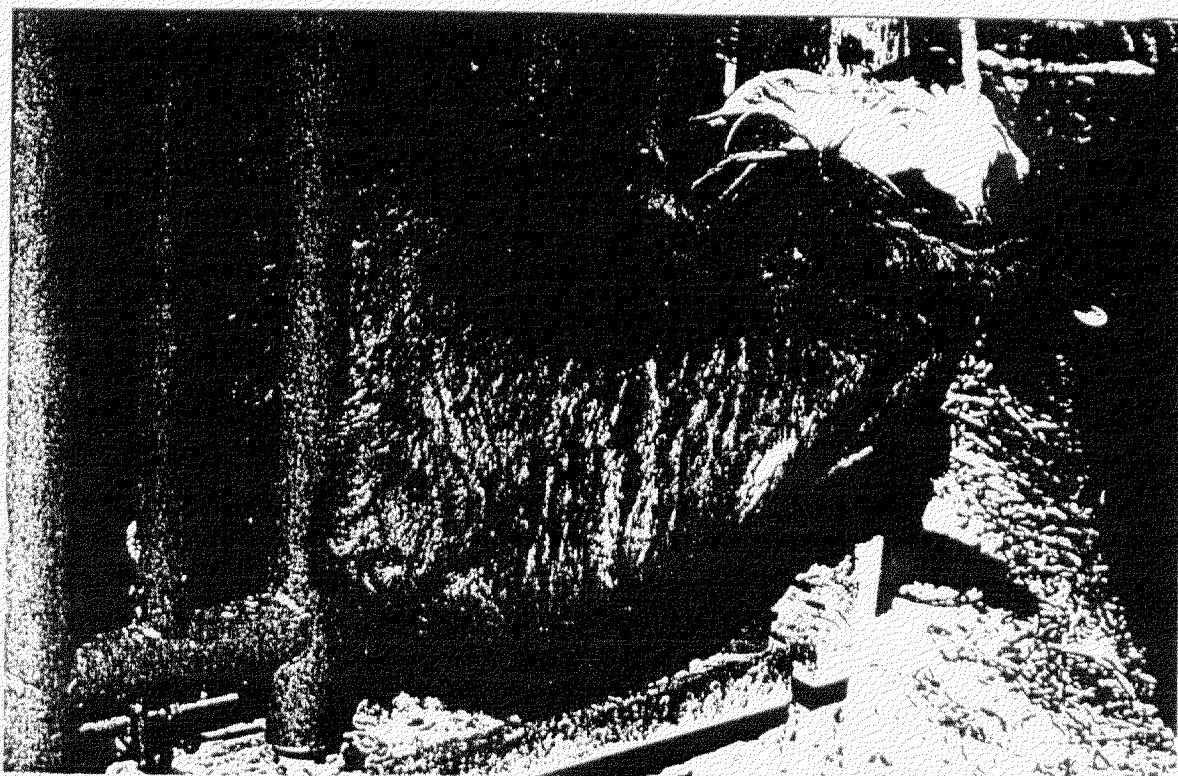
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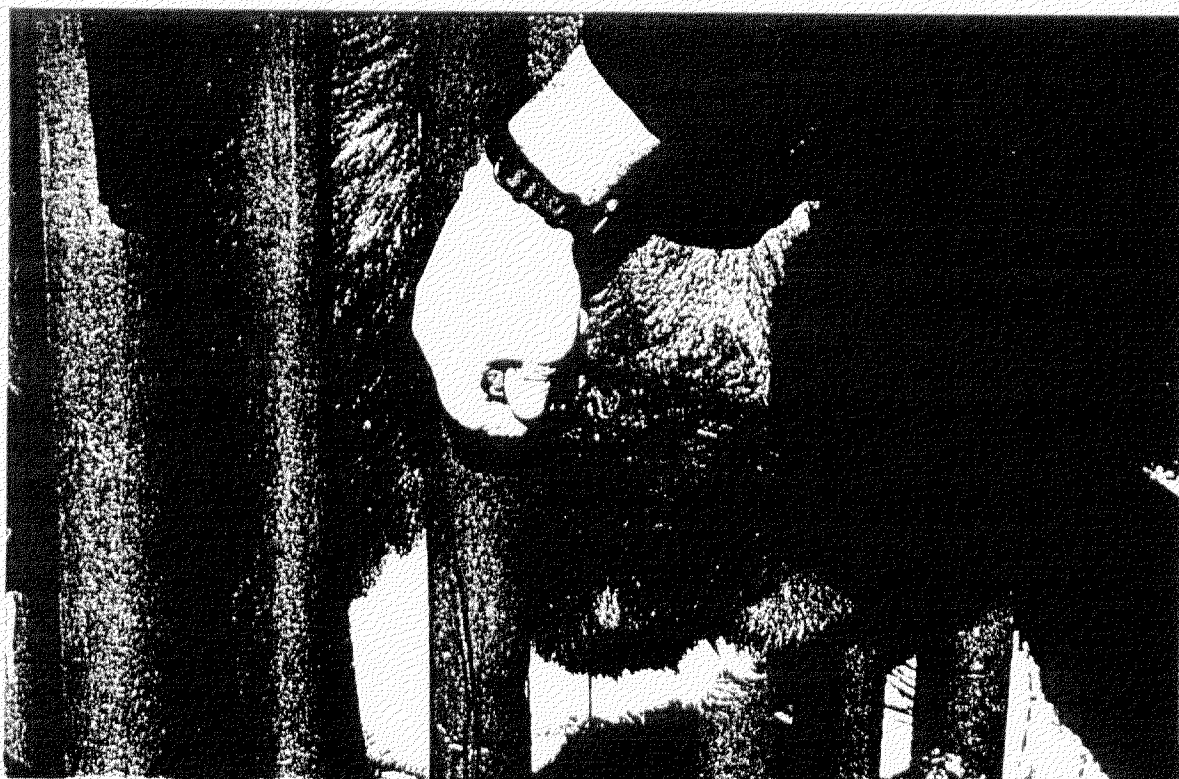
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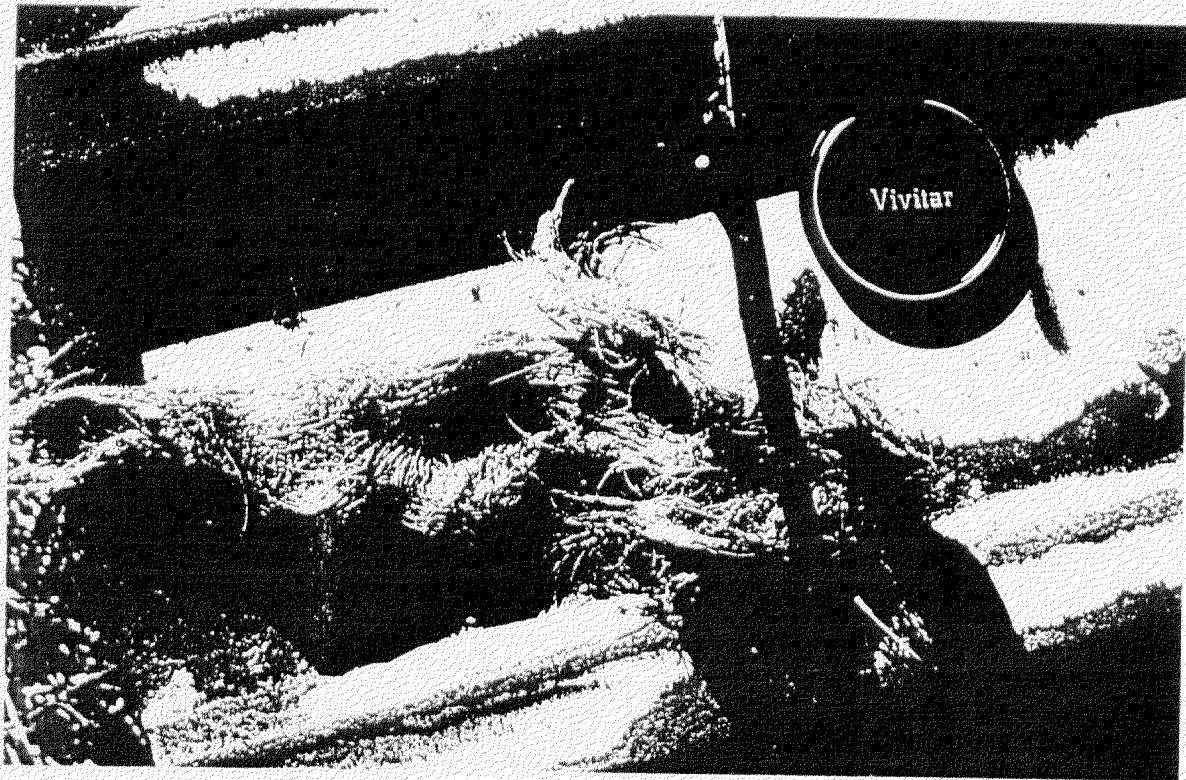
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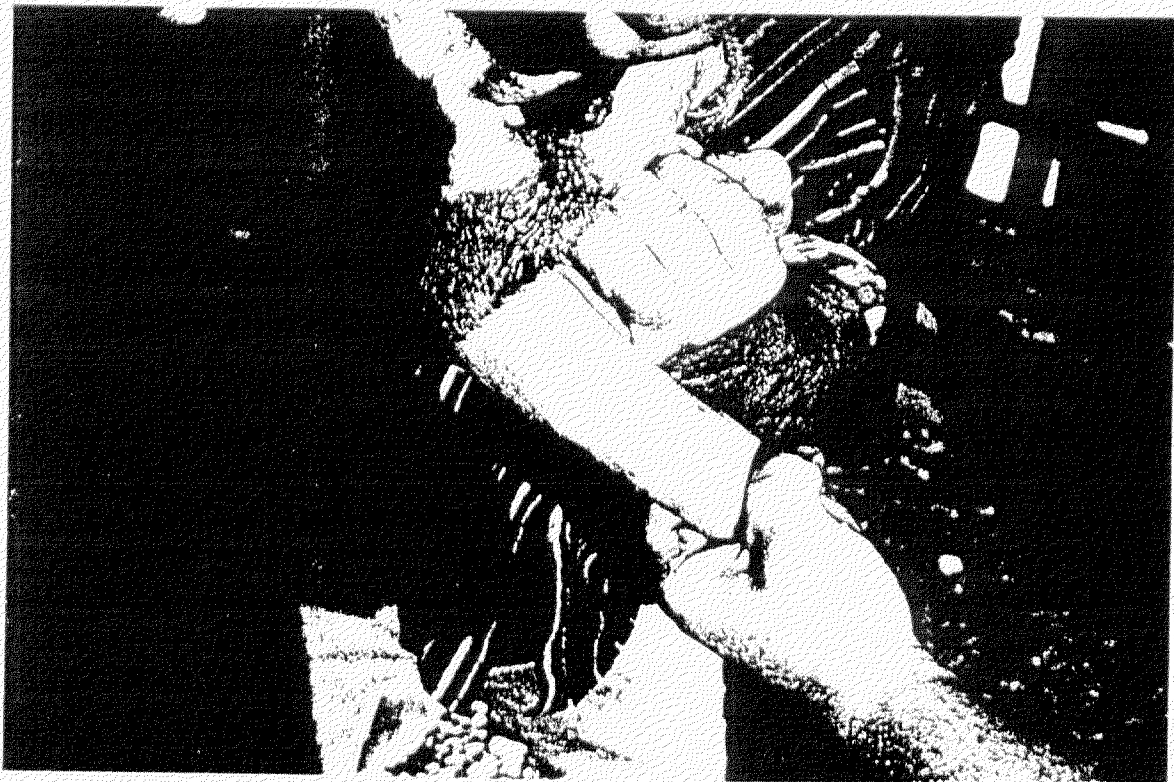
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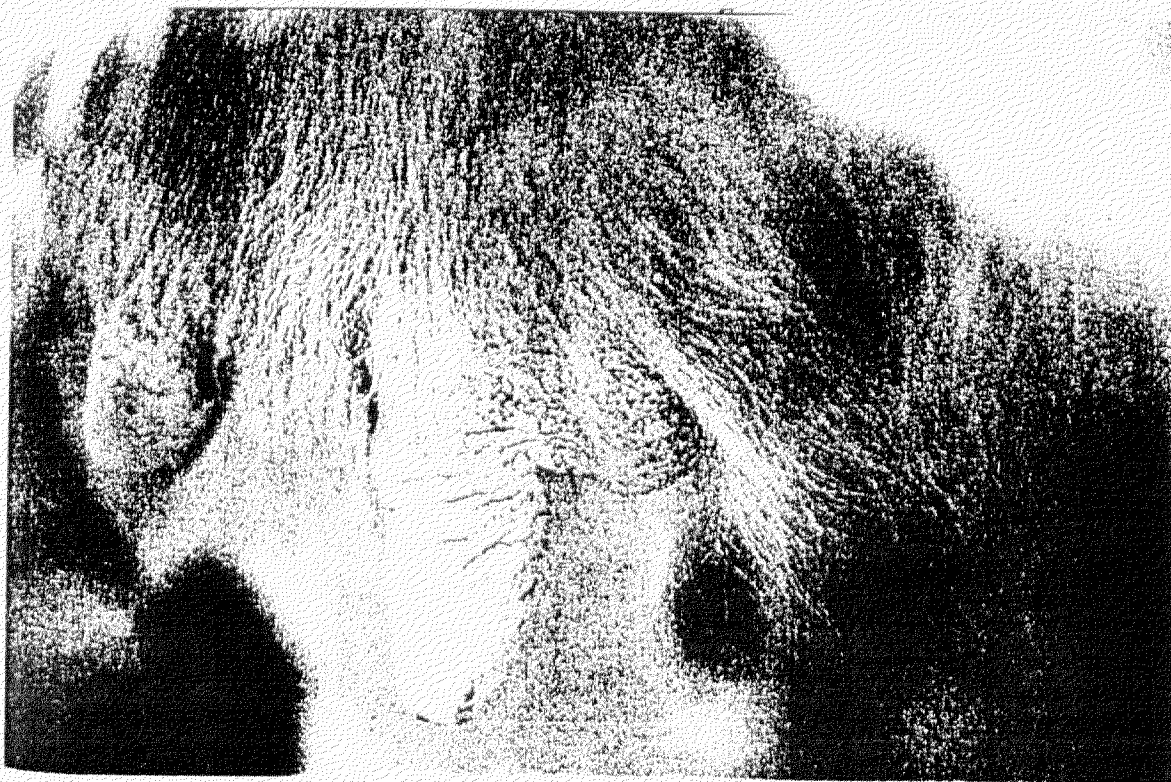
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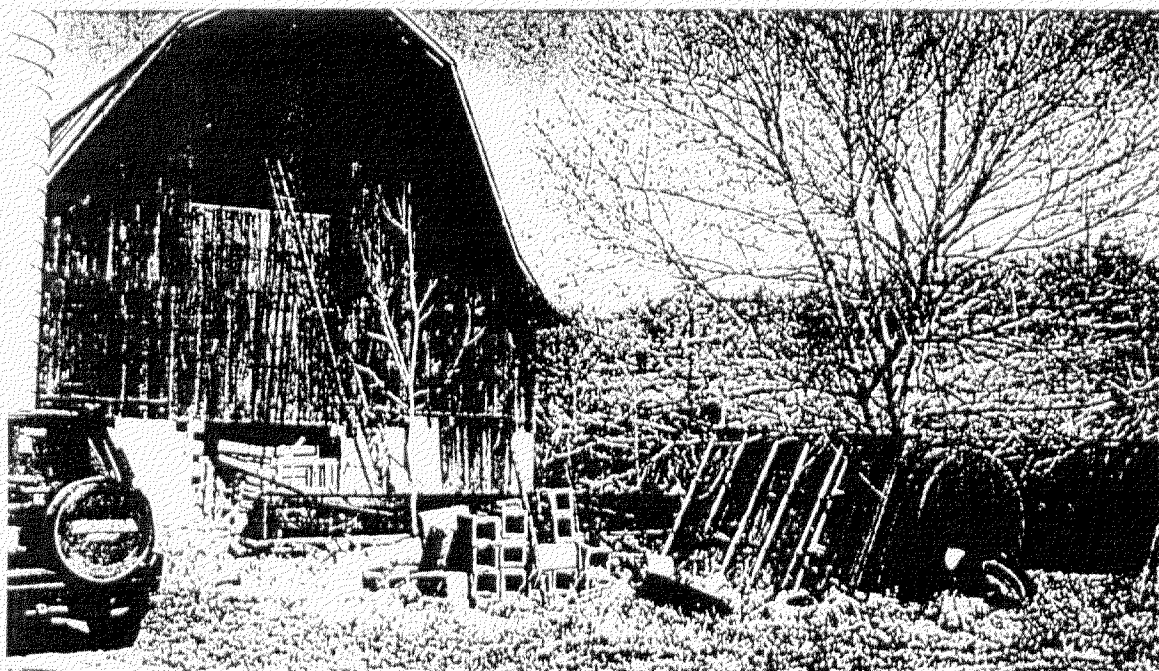
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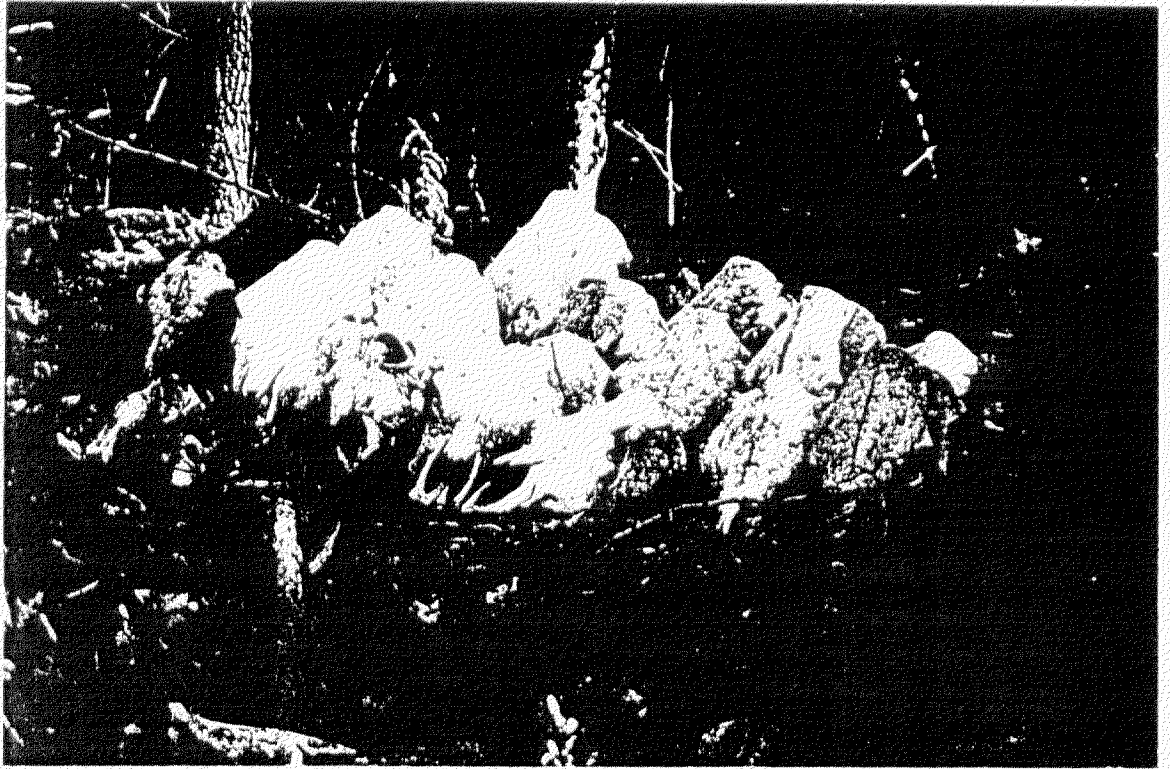
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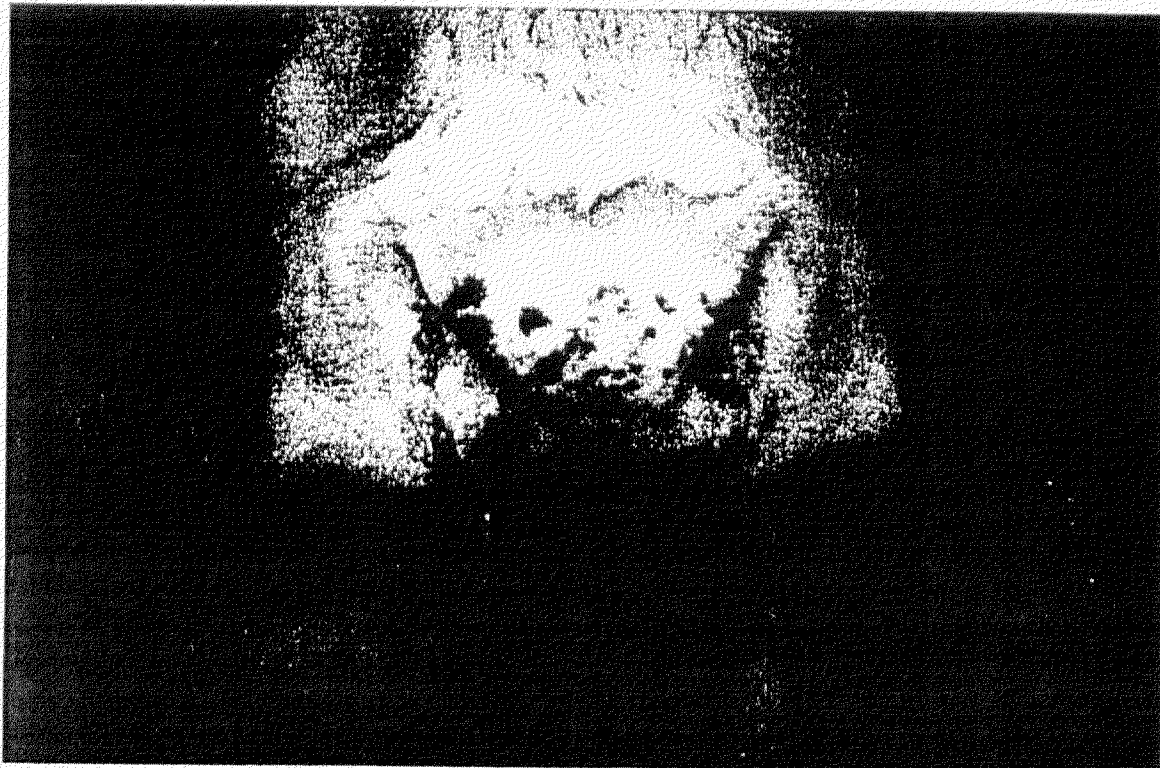
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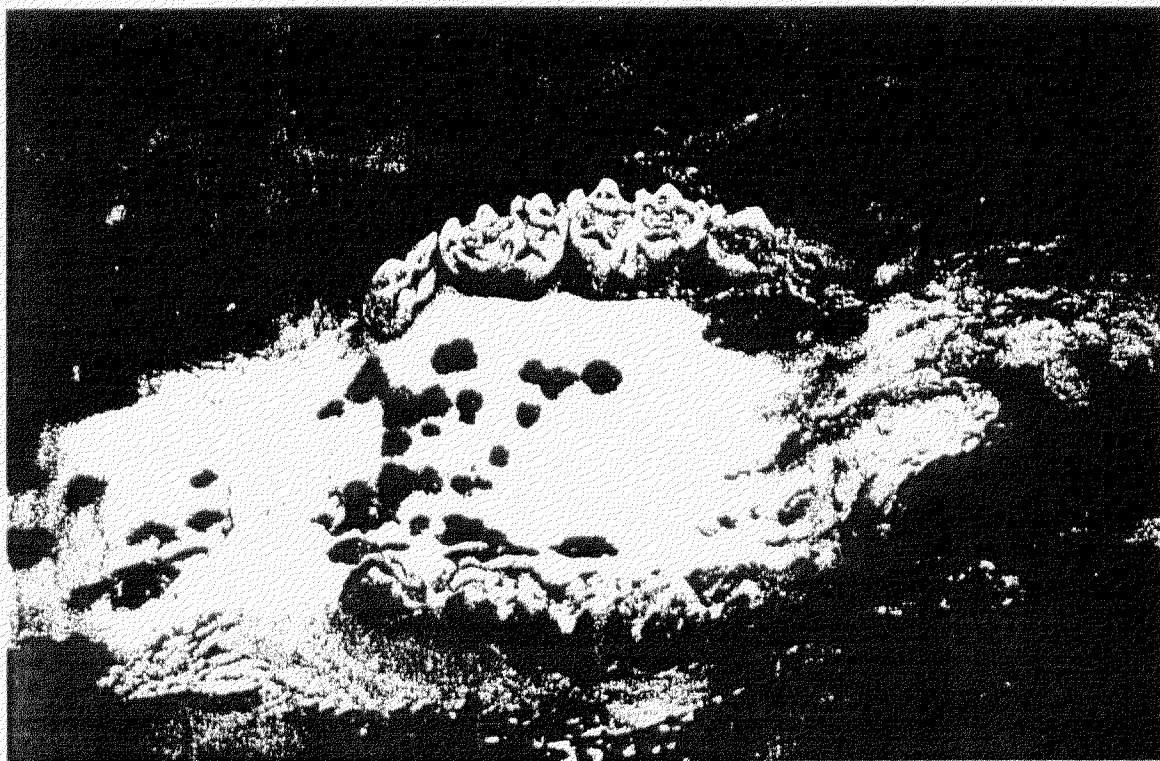
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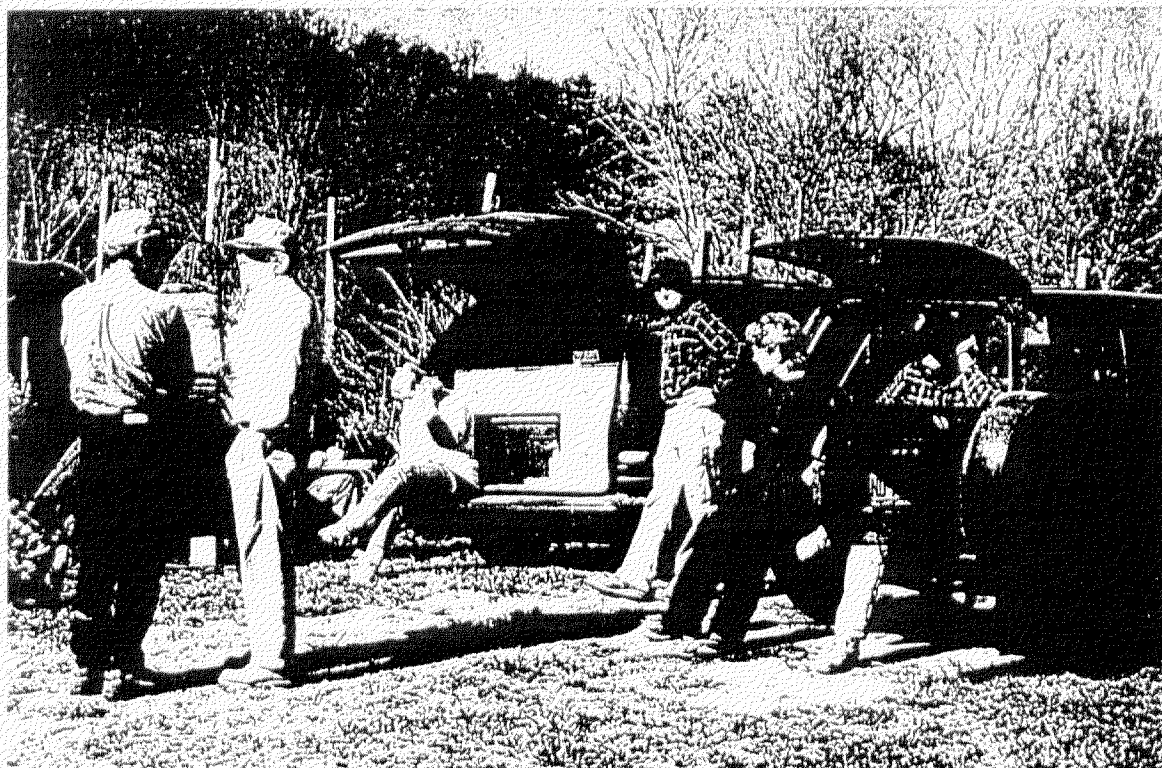
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DRAFT REPORT
DRY RUN CREEK
WASHINGTON, WOOD COUNTY, WEST VIRGINIA
NOVEMBER 1997



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TABLE OF CONTENTS

LIST OF TABLES	vi
LIST OF FIGURES	viii
SECTION I. TECHNICAL APPROACH, SUMMARY OF FIELD EFFORT RESULTS, AND PRELIMINARY RISK SCREEN	
1.0 INTRODUCTION	1
1.1 Objective	1
1.2 Site Background	1
2.0 METHODOLOGY	1
2.1 Soil Sampling	1
2.2 Sediment Sampling	2
2.3 Surface Water Sampling	2
2.4 Drinking Water Well Sampling	2
2.5 Biological Sampling	3
2.5.1 Small Mammal Study	3
2.5.2 Vegetation Sampling	3
2.5.3 Aquatic Macroinvertebrate Sampling	4
2.5.4 Fish Collection	4
2.6 Toxicity Testing	4
2.6.1 <i>Eisenia foetida</i> (Earthworm) Toxicity Tests	4
2.6.2 <i>Hyalella azteca</i> (Amphipod) Toxicity Tests	5
2.6.3 <i>Pimephales promelas</i> (Minnow) Toxicity Tests	5
2.7 Sampling Equipment Decontamination	5
2.8 Standard Operating Procedures	5
2.8.1 Documentation	5
2.8.2 Sample Packaging, Shipment, Storage, Preservation, and Handling	5
2.8.3 Field Sampling and Analytical Techniques	5
2.8.4 Health and Safety	6
3.0 RESULTS	6
3.1 Water, Soil, and Sediment Analysis	6
3.1.1 BNAs	6

	3.1.2	TAL Metals	7
	3.1.3	Pesticides/PCBs	8
	3.1.4	VOCs	8
	3.1.5	Total Fluoride	9
	3.1.6	Organofluorides	9
	3.1.7	Total Organic Carbon and Grain Size of Soil and Sediment	10
	3.1.8	Water Quality Parameters	10
	3.1.9	Bovine Fecal Samples	10
	3.2	Biotic Sampling and Tissue Analysis	10
	3.2.1	Benthic Macroinvertebrates	11
	3.2.2	Mammal	12
	3.2.3	Fish	13
	3.2.4	Earthworm	13
	3.2.5	Vegetation	14
	3.3	Histological assay of small mammal liver and kidney	14
	3.4	Toxicity Testing	14
4.0		SUMMARY OF PRELIMINARY ECOLOGICAL RISK ASSESSMENT SCREEN	15
5.0		DISCUSSION	15
SECTION II		ECOLOGICAL RISK ASSESSMENT	16
1.0		INTRODUCTION	16
	1.1	Objective	16
	1.2	Site Background	16
2.0		PROBLEM FORMULATION	16
	2.1	Ecological Risk Assessment	16
	2.2	Identification of the Contaminants of Concern	17
	2.3	Exposure Characterization	17
	2.4	Hazard Characterization/Toxicity Assessment	17
	2.4.1	Fluoride	17
	2.4.2	Organofluorides	18
	2.4.3	Aluminum	18
	2.4.4	Arsenic	18
	2.4.5	Beryllium	19

2.4.6	Chromium	19
2.4.7	Copper	20
2.4.8	Iron	21
2.4.9	Lead	21
2.4.10	Manganese	21
2.4.11	Nickel	22
2.4.12	Vanadium	23
2.4.13	Zinc	23
2.5	Selection of Assessment Endpoints	23
2.6	Production of Testable Hypotheses	24
2.7	Conceptual Model	25
2.8	Selection of Measurement Endpoints	26
2.9	Life History/Exposure Profile Information	29
2.9.1	The amphipod (<i>Hyalloa azteca</i>) as Representative of Benthic Invertebrates	29
2.9.2	Earthworm (<i>Eisenia foetida</i>) as Representative of Terrestrial Invertebrates	30
2.9.3	Fathead Minnow (<i>Pimephales promelas</i>) as Representative of Fish Community	31
2.9.4	American Robin (<i>Turdus migratorius</i>) as Representative of Worm-eating Birds	32
2.9.5	Red-tailed Hawk (<i>Buteo jamaicensis</i>) as Representative of Carnivorous Birds	33
2.9.6	Red Fox (<i>Vulpes vulpes</i>) as Representative of Carnivorous Mammals	34
2.9.7	Mink (<i>Mustela vison</i>) as Representative of Carnivorous Mammals	35
2.9.8	Raccoon (<i>Procyon lotor</i>) as Representative of Omnivorous Mammals	37
2.9.9	Short-tailed Shrew (<i>Blarina brevicauda</i>) as Representative of Insectivorous Mammals	38
2.9.10	Meadow Vole (<i>Microtus pennsylvanicus</i>) as Representative of Herbivorous Mammals	40
3.0	ASSUMPTIONS	42
4.0	EFFECTS PROFILE	43
4.1	Fluoride	43

4.2	Organofluorides	43
4.3	Aluminum	43
4.4	Arsenic	44
4.5	Beryllium	44
4.6	Chromium	44
4.7	Copper	45
4.8	Iron	45
4.9	Lead	45
4.10	Manganese	46
4.11	Nickel	46
4.12	Vanadium	46
4.13	Zinc	47
5.0	RISK CHARACTERIZATION	47
5.1	Benthic Invertebrate Community Structure and Function	47
5.2	Soil Invertebrate Community Structure and Function	48
5.3	Fish Communities	48
5.4	Worm-eating Birds	48
5.5	Carnivorous Birds	48
5.6	Carnivorous Mammals (Terrestrially feeding)	48
5.7	Piscivorous Mammals	48
5.8	Omnivorous Mammals	49
5.9	Insectivorous Mammals	49
5.10	Herbivorous Mammals	49
6.0	UNCERTAINTY ANALYSIS	49
7.0	CONCLUSIONS	50
7.1	Benthic Invertebrate Community Structure and Function	50
7.2	Soil Invertebrate Community Structure and Function	50
7.3	Fish Communities	51
7.4	Worm-eating Birds	51
7.5	Carnivorous Birds	51
7.6	Carnivorous Mammals	51
7.7	Piscivorous Mammals	51
7.8	Omnivorous Mammals	51

7.9	Insectivorous Mammals	52
7.10	Herbivorous Mammals	52
8.0	SUMMARY	52
LITERATURE CITED		53
APPENDIX A		
	Small Mammal Data Sheets	60
APPENDIX B		
	Analytical Reports	61
APPENDIX C		
	Toxicity Testing Reports	62
APPENDIX D		
	Field Notes	63
APPENDIX E		
	Statistical Analysis	64

000167

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USEPA 6866

LIST OF TABLES

<u>NUMBER</u>	<u>TITLE</u>
1	Concentration of BNA's in Water
2	Concentration of BNA's in Soil
3	Concentration of BNA's in Sediment
4	Concentrations of Metals in Water
5	Results of Concentrations of Metals in Soil
6	Results of Concentrations of Metals in Sediment
7	Results of the Analysis for Pesticide/PCB in Water
8	Results of the Analysis for Pesticide/PCB in Soil
9	Results of the Analysis for Pesticide/PCB in Sediment
10	VOA Concentrations in Water
11	VOA Concentrations in Soil
12	VOA Concentrations in Sediment
13	Concentrations of Fluoride in Water
14	Concentrations of Fluoride in Soil
15	Concentrations of Fluoride in Sediment
16	Results of the Organo-fluoride Analysis in Sediment
17	Concentrations of TOC in Soil
18	Results of the Analysis for Grain Size in Soil
19	Concentrations of TOC in Sediment
20	Results of the Analysis for Grain Size in Sediment
21	In Situ Water Quality Parameters
22	Concentrations of Bromide, Chloride, Nitrate, Phosphorus, and Sulfate in Water

23	Concentrations of BNA's in Fecal Samples
24	Concentrations of Metals in Fecal Samples
25	Concentrations of Fluoride in Fecal Samples
26	Frequency and Abundance of Benthic Macroinvertebrates
27	Concentrations of Metals in Small Mammals
28	Concentrations of Fluoride in Small Mammals
29	Lipid Concentrations in Mammal Tissue
30	Concentrations of Metals in Fish Tissue
31	Concentrations of Fluoride in Fish Tissue
32	Lipid Concentrations in Fish Tissue
33	Results of the Analysis for TAL Metals in Earthworm Tissue
34	Results of the Analysis for Fluoride in Earthworm Tissue
35	Lipid Concentrations in Earthworm Tissue
36	Concentrations of Metals in Vegetation
7	Concentrations of Fluoride in Vegetation
	Lipid Concentrations in Plant Tissue
	Results of Histopathology for the (Meadow Vole, Short-tail shrew, Meadow jumping mouse, and White-footed mouse)
	Summary of Toxicity Test Results
	Summary of Initial Risk Screen
	Risk Calculations Based on Wet Weight

LIST OF FIGURES

<u>NUMBER</u>	<u>TITLE</u>
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1	Sampling Site Map
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SECTION I. TECHNICAL APPROACH, SUMMARY OF FIELD EFFORT RESULTS, AND PRELIMINARY RISK SCREEN

1.0 INTRODUCTION

1.1 Objective

The objective of this project was to provide technical support to the U.S. Environmental Protection Agency Region III Removal Program in conducting an evaluation of ecological risks from alleged contamination of soil, sediment, and water at a working beef production farm located down gradient of a landfill. The effort resulted in the collection of soil, sediment, surface water, and biota samples for contaminant analyses and soil, sediment, and surface water for laboratory toxicity testing. The primary goals of the project were to: 1) identify contaminants present, 2) determine the extent of contamination, and 3) produce an ecological risk assessment based on the collected data.

1.2 Site Background

The site is a working beef production farm located in Washington, Wood County, WV. The owner of the farm has filed numerous complaints with the West Virginia Department of Natural Resources and the U. S. EPA alleging that contaminants are being discharged from an industrial landfill owned by the DuPont corporation, into Dry Run. Dry Run flows through the farmer's property and is a primary source of water for his cattle. The farmer maintains that numerous deaths, blindness, and other unusual illnesses observed in his herd are directly attributable to the contaminants that are discharged into Dry Run from the DuPont landfill. It has also been reported that fish and wildlife kills have also occurred in the area, which may be associated with the abnormalities observed in the cattle.

2.0 METHODOLOGY

The approach used in this document followed current U.S. EPA guidance for designing and conducting ecological risk assessments (U.S. EPA 1997). Based on the problem formulation phase of the risk assessment design, the following field study was conducted to provide data needed to complete the assessment. A screening-level ERA was conducted after the field investigation, as little data on site contamination was available prior to the effort. Numerous fish and wildlife kills, in addition to problems in the cattle, had been reported prior to this activation.

2.1 Soil Sampling

Surface soil samples were collected at 4 sample areas along Dry Run and in one reference sample area (Figure 1). Sample areas were selected based on distance from the landfill outfall in an attempt to identify a contaminant concentration gradient. Sampling was concentrated in the meadows along the stream bed. Three replicate samples were taken in each sampling area. Replicate sampling locations were determined by gridding the sampling area and randomly choosing three grid nodes for sampling through the use of a random numbers table. Sampling grid nodes were determined by using a random numbers table.

Surface soil samples were collected using a decontaminated stainless steel trowel or spoon from the top 6 inches of the soil according to ERTC/REAC Standard Operating Procedure (SOP) #2012, *Soil Sampling*. All soil samples were analyzed for total organic carbon (TOC); grain size; target analyte

list (TAL) metals; TCL pesticides/PCBs; TCL Base, Neutral, and Acid Extractable (BNAs) compounds; TCL volatile organic compounds (VOCs), total fluoride, and organofluoride compounds. Additional soil was collected from the sample node closest to the stream bed for use in an earthworm toxicity test. A vegetation sample was also taken at each of the soil sampling nodes.

2.2 Sediment Sampling

Sediment samples were collected at 5 sample areas on site in Dry Run, one reference sample area, and one area in Lee Creek. Sample areas were selected based on distance from the landfill outfall in an attempt to identify a contaminant concentration gradient. Sampling was concentrated in the depositional areas along the stream bed.

All sediment sampling was conducted according to ERTC/REAC SOP #2016, *Sediment Sampling*. At each sample station, sediment was collected from the top 6 inches using a decontaminated trowel. The sample was composited into a decontaminated 5-gallon stainless steel bucket, homogenized, and divided into the appropriate sample containers for chemical analyses. Additional sediment was collected in the reference area, Tributary A, Tributary B, Area II, and Area IV, for use in a *Hyalella azteca* whole sediment bioassay.

2.3 Surface Water Sampling

Surface water samples were collected at locations which corresponded to each of the seven sediment sample stations. Surface water samples were collected directly into two 1-liter polypropylene bottles for metals analyses and into 1-liter glass bottles for organic (i.e., BNAs, Pesticide/PCBs, VOCs) analyses as per ERTC/REAC SOP #2013, *Surface Water Sampling*. Water samples were collected prior to collecting sediment samples and upstream of any stream disturbances caused by the sampler. One sample at each location was filtered through a 0.45 micron (μm) filter in the field prior to TAL metals analysis; all the remaining TAL metals samples and all the organic samples were analyzed unfiltered. All samples analyzed for metals were preserved by adding 40 percent nitric acid until a pH of less than 2 in the sample was obtained. The filtered sample submitted for TAL metal analysis was preserved after the sample was filtered. All surface water samples were submitted for TAL metals, TCL BNAs, TCL Pesticide/PCBs, TCL VOCs, chloride, fluoride, bromide, nitrate, sulfate, and phosphate analyses. Additional sample was taken in the reference area, Tributary A, Tributary B, Area II, and Area IV, for use in a *Pimephales promelas* aqueous phase toxicity test.

Water quality parameters were measured using a Horiba™ water quality meter. The meter was used to measure temperature in degrees Celsius ($^{\circ}\text{C}$), pH, dissolved oxygen [milligrams per liter (mg/L)], conductivity [millimhos per centimeter (mmhos/cm)], oxidation reduction potential [volts (V)]. The meter was calibrated prior to and after data collection. In-situ water quality data was transcribed from the digital display of the Horiba™ into a field logbook at the time of collection. The Horiba™ was used in accordance the manufacturer's operating manual.

2.4 Drinking Water Well Sampling

Water was sampled from a drinking water well on the Tennant farm. Parameters were analyzed as outlined above. Samples to be analyzed were taken from a tap that was located directly on the pump head after the well had been purged for a period of approximately five minutes.

2.5 Biological Sampling

2.5.1 Small Mammal Study

Small mammals were collected from the site to determine body burden levels of TAL metals and total fluoride and to evaluate histopathological effects of exposure to site contaminants. Tissue burdens of small mammals trapped on site were compared to animals collected from the reference area. All field trapping activities were conducted in accordance with ERTC/REAC Draft Standard Operating Procedure SOP #2029, *Small Mammal Sampling and Processing*.

Four trapping areas were established on site in areas corresponding to the soil sampling locations. A fifth grid was established on a reference area located just to the north of Dry Run in similar meadow habitat as that observed along the stream corridor (Figure 1). The reference area was chosen because the habitat present was similar to that in the meadows near Dry Run, and because it was outside the area that could be directly influenced by surface water from Dry Run. The length of the trapping period and the trapping effort varied among each of the trap areas and was based on the length of time and effort required to capture a sufficient number of mammals for statistical evaluation. Sampling was performed using Museum Special snap traps set in grids. All traps were spaced 10 feet apart and baited with a rolled oats and peanut butter mixture. The traps were checked twice daily, once in the morning and once in the evening. During trap checks, traps were rebaited and reset as necessary. Recovered animals were labeled with the trap area, trap number, species, and date of capture while in the field and then were transferred in coolers to the staging area for processing.

For each animal, prior to performing the necropsy, data from the specimen label was transferred to a small mammal data sheet (Appendix A). Body metrics including total body weight, body length, tail length, ear length, liver weight, and kidney weight were measured and recorded on the data sheet. During the necropsy any abnormalities were noted and the contents of the gastrointestinal tract were removed from each specimen. Sections of the liver and kidney (approximately 0.5 g each) were removed for histopathological analyses. The sections were placed in a labeled 40-mL glass vial and preserved with 10 percent neutral buffered formalin. Preserved liver and kidney sections were submitted to Animal Reference Pathology (ARP) for histopathological evaluation. The remaining tissue was submitted for homogenization and TAL metal, total fluoride, percent moisture, and percent lipid analysis.

2.5.2 Vegetation Sampling

Vegetation was collected by hand for residue analysis per ERTC/REAC SOP #2038 *Vegetation Assessment Field Protocol*. The most abundant grass taxa observed at all sampling locations was targeted for residue analysis. Grass samples were taken in each area at the same grid nodes as the soil samples were taken. The above ground portion of plants from the immediate vicinity of the soil sampling node were collected by cutting the stems at the soil surface with a decontaminated knife. All samples were analyzed for TAL metals, total fluoride, percent moisture, and percent lipids.

2.5.3 Aquatic Macroinvertebrate Sampling

The infaunal macroinvertebrate community was sampled per Draft ERTC/REAC SOP #2032 *Benthic Macroinvertebrate Sampling* and U.S. EPA (1983, 1989, and 1990). Macroinvertebrate samples were collected for evaluation of community structure. In this investigation, macroinvertebrates were defined as organisms that impinged on a 0.5 millimeter (mm) sieve. A total of three replicates were collected from each of five sediment sampling locations (Figure 1).

A long-handled, D-frame kick net, measuring approximately 45 centimeters wide and 20 centimeters tall, with 0.5 mm mesh was used. The net was used to disturb submerged vegetation and debris and collect dislodged invertebrates. Each replicate collection was performed over a uniform area at each sampling location. Benthic invertebrate samples were transferred to 500 ml polyethylene jars and preserved with a 70 percent 2-propanol solution.

In the laboratory, the sample was rinsed in clean water and placed in a white 12 x 18-inch polyethylene pan with just enough water added to allow complete dispersion of the material within the pan. Large debris, stones, and other extraneous materials were removed from the tray and inspected for attached or clinging organisms. All organisms picked from the pan were identified to the lowest positively identified taxonomic level, enumerated, and recorded on a laboratory bench sheet. The size and life history stage of the organisms and state of taxonomic knowledge of the group determined the level of identification. The organisms were identified using appropriate taxonomic references and a representative subsample were identified by a second individual to meet the Quality Assurance/Quality Control (QA/QC) requirements of the taxonomic analysis.

2.5.4 Fish Collection

Fish were collected from Dry Run to determine body burden levels of TAL metals and total fluoride. A Coffelt™ battery powered backpack electroshocker was used and operated as per the manufacturer's instructions. The sampling team consisted of one individual operating the electroshocker and one individual collecting stunned fish with a dip net. Stunned fish were placed in a 5-gallon bucket filled with site water. Following collection, fish were identified to the lowest taxonomic level possible in the field and live specimens were released. Voucher and dead specimens were preserved with a dilute formaldehyde solution and returned to the ERT/REAC biological laboratory for confirmation of field taxonomic analyses. Fish tissue was homogenized and submitted to the laboratory for TAL metal, total fluoride, % lipid and % moisture analysis.

2.6 Toxicity Testing

2.6.1 *Eisenia foetida* (Earthworm) Toxicity Tests

Five soil samples were taken for evaluation in an earthworm toxicity test. Four of the samples were taken in the meadow sampling areas along Dry Run and one in the reference meadow area as outlined above. The test was run for a period of 28 days, at which time mortality and growth in each of the test soils was enumerated. Earthworm tissue resulting from each of the treatments was submitted for TAL metals, total fluoride, % lipid, and % moisture analysis. Figure 1 details the earthworm toxicity test soil sampling locations.

2.6.2 *Hyalella azteca* (Amphipod) Toxicity Tests

USEPA 6873

Five sediment samples were taken for evaluation in an amphipod toxicity test. Four of the samples were taken in Dry Run and one in a reference area stream. The test was run for a period of 10 days, at which time mortality and growth in each of the test sediments was enumerated. Figure 1 details the amphipod toxicity test sediment sampling locations.

2.6.3 *Pimephales promelas* (Minnow) Toxicity Tests

Five surface water samples were taken for evaluation in a fathead minnow toxicity test. Four of the samples were taken in Dry Run and one in a reference area stream. The test was run for a period of 7 days, at which time mortality and growth in each of the test waters was enumerated. Figure 1 details the fathead minnow toxicity test water sampling locations.

2.7 Sampling Equipment Decontamination

The following sampling equipment decontamination procedure was employed prior to and subsequent to sampling in the following numerical sequence:

1. physical removal
2. nonphosphate detergent wash
3. potable water rinse
4. 10 percent nitric acid rinse
5. distilled water rinse
6. solvent rinse [acetone]
7. air dry

2.8 Standard Operating Procedures

2.8.1 Documentation

Documentation was conducted in accordance with the following SOPs:

- ERTC/REAC SOP #2002, *Sample Documentation*
- ERTC/REAC SOP #4001, *Logbook Documentation*
- ERTC/REAC SOP #4005, *Chain of Custody Procedures*

2.8.2 Sample Packaging, Shipment, Storage, Preservation, and Handling

Sample packaging, shipment, storage, preservation and handling were conducted in accordance with the following SOPs:

- ERTC/REAC SOP #2003, *Sample Storage, Preservation and Handling*
- ERTC/REAC SOP #2004, *Sample Packaging and Shipment*

2.8.3 Field Sampling and Analytical Techniques

Field sampling activities and field analytics were conducted in accordance with the following SOPs:

- ERTC/REAC SOP #2001, *General Field Sampling Guidelines*

USEPA 6874

000175

- ERTC/REAC SOP #2005, *Quality Assurance/Quality Control Samples*
- ERTC/REAC SOP #2006, *Sampling Equipment Decontamination*
- ERTC/REAC SOP #2012, *Soil Sampling*
- ERTC/REAC SOP #2013, *Surface Water Sampling*
- ERTC/REAC SOP #2016, *Sediment Sampling*
- REAC SOP #2029, *Small Mammal Trapping and Processing*
- REAC SOP #2032, *Benthic Sampling*

2.8.4 Health and Safety

Health and Safety was conducted in accordance with the following SOPs:

- ERTC/REAC SOP #3001, *REAC Health and Safety Program Policy and Implementation*
- ERTC/REAC SOP #3012, *REAC Health and Safety Guidelines at Hazardous Waste Sites*
- ERTC/REAC SOP #3020, *Inclement Weather, Heat Stress and Cold Stress*

3.0 RESULTS

3.1 Water, Soil, and Sediment Analysis

3.1.1 BNAs

Surface Water

Analysis of the surface water samples from Dry Run, the reference stream, and Lee Creek produced only one detection on the standard BNA scan. A sample taken in the Upper Tributary B location contained an estimated concentration of 2 ug/L of Bis(2-Ethylhexyl)phthalate. In addition, numerous Tentatively Identified Compounds (TICs) including unknown alkane and alkene compounds were found in the surface water samples. Results for the BNA analysis of surface water samples taken in Dry Run are presented in Table 1 and in Appendix B.

Well Water

The sample taken at the Tennant Farm well produced no detections from the standard BNA list. Several TICs were identified, however only one of the detected compounds could be tentatively characterized and identified as an alkene. Results for the BNA analysis of the well water sample taken at the Tennant farm is presented in Table 1 and in Appendix B.

Soil

Analysis of the surface soil samples from the meadows adjacent to the streambed and the reference meadow area produced a few isolated hits from the standard BNA list. Fluoranthene was detected at an estimated concentration of 23 ug/Kg in one of the three reference samples. Carbazole was detected at an estimated concentration of 41 ug/Kg in one of the three Area I soils. Di-n-butylphthalate was detected at concentrations of 22, 27, 26, and 30 ug/kg in one sample from area II, one sample from area three, and two of the three samples from area IV, respectively. Bis(2-Ethylhexyl)phthalate was detected at estimated concentrations of 27 and 62 ug/Kg in one sample from Area III and one sample

from Area IV. Di-n-octylphthalate was detected at an estimated concentration of 180 ug/kg in one of the samples from area IV. In addition, numerous TICs including unknown alkane, cycloalkane, alkene, aldehyde, sterols, alcohols, PAH, acid, and other organic compounds were found in the surface soil samples. Results for the BNA analysis of soil samples is presented in Table 2 and in Appendix B.

Sediment

Analysis of the sediment samples from the five site and two off-site stream locations produced only a few isolated detections of BNA compounds. Di-n-butylphthalate was detected in the Area IV sediment sample at an estimated concentration of 30 ug/Kg. Bis(2-Ethylhexyl)phthalate was detected in the Area III sediment sample at an estimated concentration of 52 ug/Kg. No other standard list compounds were found in any of the Lee Creek, reference stream, or Dry Run sediment samples. Numerous TICs including unknown alkane, cycloalkane, alkene, aldehyde, sterols, alcohols, PAH, acid, and other organic compounds were found in the Dry Run, Lee Creek, and reference sediment samples. Results for the BNA analysis of sediment samples is presented in Table 3 and in Appendix B.

3.1.2 TAL Metals

Surface Water

Analysis of the surface water samples from Dry Run, the reference stream, and Lee Creek included both filtered and unfiltered samples for TAL metals analysis. Antimony, arsenic, beryllium, cadmium, cobalt, mercury, nickel, selenium, silver, thallium, and vanadium were not detected in any of the filtered or unfiltered water samples.

Aluminum, barium, calcium, copper, iron, magnesium, manganese, potassium, sodium, and zinc were detected in the filtered water samples. Of the list of detected metals in the filtered samples, it appears that aluminum, copper, and zinc are found in higher concentrations in the Dry Run Creek drainage, including the reference stream, than in Lee Creek.

Aluminum, barium, calcium, copper, iron, magnesium, manganese, potassium, sodium, and zinc were detected in the unfiltered samples. Of the list of detected metals in the unfiltered samples, concentrations of aluminum, iron, and zinc appear to be higher in Dry Run than those measured in Lee Creek.

Detailed results of the TAL metals analysis in filtered and unfiltered water samples are presented in Table 4 and in Appendix B.

Well Water

Well water sampled from the well on the Tennant farm was analyzed as an unfiltered sample. Antimony, arsenic, beryllium, cadmium, chromium, cobalt, mercury, nickel, selenium, silver, thallium, and vanadium were not detected in the well sample. Concentrations measured for the remaining list of TAL metals are presented in Table 4 and in Appendix B.

Soil

Three replicate surface soil samples from the four Dry Run meadow areas and the reference meadow area were analyzed for TAL metals. Antimony, cadmium, mercury, selenium, silver, and thallium were not detected in any of the soil samples. One-way analysis of variance determined that soil manganese concentrations were significantly higher in Area II compared to the reference area, but the same as those noted in areas I, III, and IV ($p=0.094$). Area II had the highest mean manganese concentration with mean concentrations from the other areas ranging from 680 to 1310 mg/kg. Further results of the TAL metals analysis of site and reference soil samples are presented in Table 5 and Appendix B.

Sediment

Seven sediment samples were submitted for TAL metals analysis. Five of the samples were taken in the streambed of Dry Run, one was taken in Lee Creek, and one was taken in the reference stream. Antimony, cadmium, mercury, selenium, silver, and thallium were not detected in any of the sediment samples. In comparison to the levels measured in the Lee Creek sample, it appears the Dry Run Creek reach may be enriched in aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. Based on the results of the aluminum, barium, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, and zinc analysis, there also appears to be a general trend that metal concentrations decrease with increasing distance from the landfill. Further results of the TAL metals analysis of site and reference sediment samples are presented in Table 6 and Appendix B.

3.1.3 Pesticides/PCBs

Water

No pesticides or PCBs were detected in the Dry Run samples, the Lee Creek sample, or in the reference stream sample (Table 7; Appendix B).

Soil

No pesticides or PCBs were detected in the Dry Run meadow samples, or in the reference meadow samples (Table 8; Appendix B).

Sediment

No pesticides or PCBs were detected in the Dry Run samples, the Lee Creek sample, or in the reference stream sample (Table 9, Appendix B).

3.1.4 VOCs

Water

No volatile organic carbon compounds were detected in the Dry Run samples, the Lee Creek sample, or in the reference stream sample (Table 10; Appendix B).

Soil

Trichlorofluoromethane was detected in every soil sample taken in the meadows adjacent to Dry Run at concentrations ranging from 0.9 to 3.6 ug/Kg. In addition, tetrachloroethene was detected in one replicate Area III soil sample at a concentration of 4.4 ug/Kg. No other volatile organic carbon compounds were detected in the Dry Run samples, the Lee Creek sample, or in the reference stream sample. Results of the VOC analysis of site and reference soil samples are presented in Table 11 and Appendix B.

Sediment

Acetone was detected in the Area IV sample at a concentration of 7.2 ug/Kg. Chloroform was detected at a concentration of 0.5 ug/kg in the Area III sample. No other volatile organic carbon compounds were detected in the Dry Run samples, the Lee Creek sample, or in the reference stream sample. Results of the VOC analysis of site and reference sediment samples are presented in Table 12 and Appendix B.

3.1.5 Total Fluoride

Water / Well Water

Fluoride was not detected in the Dry Run samples, the Lee Creek sample, the reference stream sample, or in the well sample taken on the Tennant farm (Table 13; Appendix B).

Soil

Fluoride was detected in the Dry Run meadow and in the reference meadow samples. Soil fluoride concentrations ranged from a low of 180 mg/kg in Area IV to a high of 370 mg/kg in Area III. There appear to be no statistically significant differences in total soil fluoride concentration. Results of the soil fluoride analysis are presented in Table 14 and Appendix B.

Sediment

Fluoride was detected in the Dry Run creekbed and in the reference creekbed samples, but not in Lee Creek. Fluoride concentrations ranged from a low of 290 mg/kg in the Area IV sampling area to a high of 450 mg/kg in the Upper Tributary A sampling area. Fluoride was not detected in Lee Creek. Overall, fluoride concentrations tend to decrease with increasing distance from the landfill. Sediments sampled in the Dry Run Creek reach appear to be enriched with fluoride, which is not found in Lee Creek. Results of the sediment fluoride analysis are presented in Table 15 and in Appendix B.

3.1.6 Organofluorides

USEPA 6878

Sediment

Because of methodology problems, specifically in obtaining appropriate standards, and the high volatility of some standards, only a limited suite of organofluoride compounds could be scanned for in the sediment samples. These compounds are presented in Table 16. Of the list that was analyzed for (Tetrafluoroethylene, hexafluoropropylene,

000179

chlorodifluoromethane, perfluorocyclobutane, 1-Chloro-1,1,2,2, tetrafluoroethane, 2-Chloro-1,1,1,2,3,3, hexafluoropropane, and Perfluoroisobutylene), none of the organofluoride compounds were detected in site sediments. Results of the organofluoride analysis is reported in Table 16 and in Appendix B.

3.1.7 Total Organic Carbon and Grain Size of Soil and Sediment

Summaries of total organic carbon and grain size analysis are presented in Tables 17-20 and in Appendix B. TOC in the soil ranged from an average low of 5.6% in Area III soils to an average high of 9.2 in Area IV soils. Soil grain size determinations are summarized in Table 18. TOC in the sediment ranged from a low of 1.9% in Lee Creek to a high of 4.5 % in Area IV. Sediment grain size determination is presented in Table 20.

3.1.8 Water Quality Parameters

Water quality parameters including pH, conductivity, turbidity, dissolved oxygen, temperature, bromide, chloride, nitrate, phosphate, and sulfate was measured in the Dry Run Creek reach, the reference stream, and in Lee Creek. The most notable observations were that conductivity and sulfate concentration decreased with increasing distance from the landfill. Other parameters appeared to be in the expected range. Results of these measurements and analyses are presented in Tables 21 and 22.

3.1.9 Bovine Fecal Samples

Six fecal samples were taken to determine if environmental contaminants were showing up in the digestive products of the affected cattle.

BNAs

Phenol was detected in all six fecal samples at concentrations ranging from 2.6 to 8.0 mg/kg. Additionally, 4-methylphenol was detected in all six samples in concentrations ranging from 45 to 110 mg/kg. Benzoic acid was detected in two of the samples at a concentration of 30 mg/kg. Additional information is presented in Table 23 and in Appendix B.

TAL Metals

Aluminum, barium, calcium, copper, iron, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc were detected in the fecal samples. Additional information presented in Table 24 and in Appendix B.

Fluoride

Fluoride was not detected in any of the fecal samples (Table 25; Appendix B).

3.2 Biotic Sampling and Tissue Analysis

3.2.1 Benthic Macroinvertebrates

A total of 27 taxonomic groups were collected from the 5 locations sampled (Table 26). Of these, there was 1 Oligochaete, 1 Mollusc, 1 Turbellarian, 3 Crustaceans, and 21 Insect taxa. Of the latter, the dominant group, in terms of taxonomic diversity, were the Coleoptera which were represented by 7 taxa. The Diptera were represented by 4 taxa and the Ephemeroptera were represented by 3 taxa. The Plecoptera, Hemiptera, Tricoptera, and Megaloptera were the least diverse groups and were represented by one or two taxa. The greatest taxonomic diversity was observed at the reference location, where 19 taxa were collected. Fewer taxa were observed at locations I through IV, and the lowest diversity was observed at location IV where 11 taxa were collected. The difference in taxonomic diversity between the reference location and locations I, II, III, and IV was primarily due to the presence of a greater number of rare taxa at the former location.

The number of individuals collected per replicate ranged from 203 at the reference location (replicate A) to 24 at location IV (replicate C). The observed density of individuals throughout the study area is primarily the result of the numerical abundance of only several taxa (Table 26). The numerically dominant taxa collected from the study area includes *Leucrocuta* and *Asellidae*. When present, these taxa were typically the most numerically abundant organisms and were represented by 221 and 391 individuals, respectively. Other taxa, including *Perlida*, *Chironomidae*, *Hyalina*, the Turbellaria, and to a lesser extent, *Leptophlebia*, *Baetis*, and *Pseudolimnophila*, were present at most locations in consistently significant proportions. In general, most taxa collected were relatively rare and were represented by five or fewer individuals at most locations. For example, of the 129 total taxonomic observations, 54 were represented by one individual, 36 were represented by two to five individuals, 11 by six to 10 individuals, 15 by 11 to 20 individuals, and 13 by greater than 21 individuals.

Several taxa were collected from all locations sampled including *Leucotrichia*, *Perlesta*, *Chironomidae*, and *Asellidae* (Table 26). Several taxa were not collected from all locations but were broadly represented throughout the drainage including *Leptophlebia*, *Agabus*, *Hyalina*, and Turbellaria. Of the nine taxa observed at only one location, four, including Elmidae, Scirtidae, *Pseudolimnophila*, and Stratiomyidae were collected only from the reference location. The most common distribution observed was one where a taxa was collected in relatively low numbers, and at few locations. For example, Elmidae, *Hydropsyche*, Limnophilidae, *Nigronia*, and Ceratoponidae were collected infrequently and in low numbers. Similarly, *Lipogomphus*, Dytiscidae, Curculidae, Elmidae, Scirtidae, Histeridae, *Pseudolimnophila*, Stratiomyidae, and *Physa* were collected in low numbers at only one location.

Five functional feeding groups were collected from the Dry Run drainage (Table 26). Resulting from the presence of *Asellidae* and *Hyalina*, omnivores were the dominant functional group at most locations. Although less dominant, collector-gatherers and scrapers were consistently collected from all locations in the study area and included the mayflies *Leucrocuta* and *Leptophlebia*. The dominant scraper was the mayfly *Leucrocuta*. Predators were dominant at locations II and III and were represented primarily by the stonefly *Perlesta*.

The overall assessment of ecological condition first focuses on the evaluation of habitat quality, and secondly on the analysis of biological components in light of habitat. Habitat,

as the principal determinant of biological potential, sets the stage for interpreting biosurvey data and can be used as a general predictor of biological condition. High quality habitat will support high quality biological communities and responses to minor alterations will be subtle and of little consequence. However, as a habitat declines in quality, discernable biological impairment results. When habitat and biological data are systematically collected together, empirical relationships can be quantified and subsequently used for screening impact and discriminating water quality effects from habitat degradation. The watershed that drains the Dry Run study area has been modified as a result of past and present land use, particularly with respect to cattle grazing and other agricultural practices, as well as the siting of commercial and industrial facilities. The loss of riparian vegetation, through replacement by species resistant or adapted to grazing, or elimination by grazing has several consequences that should be considered when evaluating the distribution of benthic macroinvertebrates and macroinvertebrates in the current study.

The attainable biological potential of a stream or river is primarily determined by the quality of the habitat at a particular location. The Dry Run study area is situated in a rural area utilized primarily for grazing cattle and, although historic indications of grazing are evident, significant portions of the riparian area remain vegetated, and there are few areas with a completely open canopy and exposed soil. Portions of the Dry Run drainage, though somewhat degraded, support a surprisingly diverse and apparently robust aquatic community. The taxonomic diversity and numerical abundance of the macroinvertebrate was relatively high at the reference area. In contrast, the diversity and abundance at locations I, II, III, and IV was reduced substantially. Since habitat considerations at all locations in Dry Run are similar, the presence of contamination at the latter locations may be significant.

3.2.2 Mammal

Four species of small mammals (meadow voles, short-tailed shrews, white-footed mice, and meadow jumping mice) were caught during the trapping effort. Whole bodies were submitted for lipid, TAL metal and total fluoride analysis.

The trapping effort revealed at least one important field observation, which was there was extremely low trapping success in Area I, the area nearest the landfill outfall, as compared to the other areas. This is highly irregular given the similar habitats present site-wide, and may indicate an ecological threat. Field necropsies identified several significant problems with the small mammals collected in the meadow areas adjacent to Dry Run. Short-tail shrews sampled from all areas showed blackened and degenerating teeth. Shrews commonly have what is known as chestnut tipped teeth, where the extreme points of the dentitia are a light brown color. The black, mottled, and degenerating teeth observed in this study are not normally observed in shrews. One meadow vole sampled from the area was missing the left kidney, and another appeared to have an extra kidney or an extra lobe on the right kidney, independent of the adrenals.

Sufficient numbers of meadow voles were caught from the Reference Area, Area II, Area III, and Area IV for statistical comparisons of tissue concentrations. Lipid concentration of meadow voles was significantly depressed in the Reference Area, Area II, and Area III, compared to that observed in Area IV ($p < 0.001$). Barium concentration was significantly lower in the Reference Area, Area II, and Area III, compared to that observed in Area IV

($p=0.067$).

Sufficient numbers of short-tail shrews were caught from the Reference Area and Area III for statistical comparisons. There were no differences in body concentration of lipid, TAL metals, and fluoride in shrews taken from these two areas.

Results of the trapping success, TAL metals, and fluoride analysis are presented in Tables 27-29, and in Appendix B. Results are presented by species and trapping location.

3.2.3 Fish

Four species of fish were collected from Dry Run in Areas II, III, and IV. No fish were observed in Area I or the Reference Area. Creek chubs and fantail darters were collected in Area IV. Creek chubs and river chubs were collected in area III. Creek chubs, river chubs, fantail darters, central stone rollers, and black-nose dace were collected in Area II. Fish sampled during the electrofishing effort in Dry Run were submitted for whole body lipid, TAL metal and fluoride analysis. A composite sample that was taken during a historical fish kill in Dry Run was also analyzed.

Since creek chubs were the only species common to all three sampling locations, statistical analysis concentrated on differentiating between tissue concentrations in this species. Aluminum, arsenic, barium, beryllium, cobalt, iron, lead, manganese, thallium, and vanadium were significantly higher in creek chubs from area II than those sample in Areas III and IV. Likewise, concentrations of these metals in Area III creek chubs were higher than those in Area IV. Conversely, cadmium and silver concentrations showed the reverse trend, with tissue concentrations in Area IV significantly higher than those measure in Areas II or III. In spite of this result, it is clear that fish inhabiting upper reaches of Dry Run, nearer to the landfill are being dosed with a significantly higher amount of metals than those in the lower reaches. There were no difference in lipid or fluoride concentration.

Results of the chemical analyses are presented in Tables 30-32 and in Appendix B.

3.2.4 Earthworm

Three replicate earthworm samples were produced from each of the earthworm toxicity test soil samples. One-way analysis of variance was used to look for significant differences in tissue concentrations between earthworms exposed to each of the five soil treatments. Cadmium and thallium concentrations in the earthworm tissue was significantly higher in the Area I exposures than those in Areas II, III, IV, or the Reference soils. Cobalt levels were lower in worms taken from the reference area, but tended to increase with increasing distance from the landfill. Copper and nickel concentrations were higher in worms taken from the reference soils than those observed in worm taken from the other soil area exposures.

Further results of the earthworm tissue analyses for lipid, TAL metals and fluoride concentration are presented in Tables 33-35 and in Appendix B.

3.2.5 Vegetation

USEPA 6882

fluoride, aluminum, calcium, magnesium, nickel, potassium, and sodium. Further, there were strong negative associations between the growth endpoint and chromium, copper, lead, and zinc concentrations, although the relationships were not significant at the 0.10 level. Further results of the amphipod toxicity test are presented in Table 40 and in Appendix C.

4.0 SUMMARY OF PRELIMINARY ECOLOGICAL RISK ASSESSMENT SCREEN

Sediment, soil and water concentrations were compared against Region III BTAG screening values (U.S. EPA 1995). Hazard quotients were generated by dividing the maximum site concentration measured in each matrix by the corresponding Region III benchmark values. All contaminants for which maximum concentrations exceeded benchmarks for sediment, soil, and water in the initial screening-level risk assessment are listed in the following sections. Contaminants that failed the initial screening process will be further evaluated in a final risk assessment for the site.

Sediment

Table 1 lists maximum concentrations, screening criteria, and quality criteria factors for sediment contaminants. The maximum concentration recorded at the site exceeded the benchmark values for the following compounds: arsenic, chromium, copper, manganese, and nickel. Because of the lack of a screening benchmark, the following compounds are still considered as risk factors as well: fluoride, aluminum, barium, beryllium, cobalt, iron, and vanadium.

Water

Table 1 lists maximum concentrations, benchmarks, and quality criteria factors for water contaminants. The maximum concentration recorded at the site exceeded the benchmark values for the following compounds: aluminum, copper, and iron. Because of the lack of a screening benchmark, fluoride is considered to be a potential risk factor.

Soil

Table 1 lists maximum concentrations, screening criteria, and quality criteria factors for soil contaminants. The maximum concentration recorded at the site exceeded the benchmark values for the following compounds: aluminum, beryllium, chromium, copper, iron, lead, manganese, vanadium, and zinc. Because of the lack of a screening benchmark, the following compounds are still considered as risk factors as well: fluoride and trichlorofluoromethane.

5.0 DISCUSSION

The data generated during the field effort suggests that there are potential problems associated with conditions at the Dry Run Creek site. Minimally, the results of the sediment and water toxicity tests suggest potential problems in the stream. Some metals appear in higher tissue concentrations in biota sampled nearest the outfall of the landfill, with those levels progressively dropping with increasing distance from the landfill area. Likewise, sediments sampled in Dry Run near the landfill outfall appear to have higher fluoride and metals concentrations than those sampled further downstream. A preliminary screen of potential risk factors suggests that other problems, specifically elevated levels of fluorides, organofluorides, and some metals, may be present as well. Data gathered during the field effort will be further analyzed through a base-line ecological risk assessment for the Dry Run Creek site

USEPA 6884

Three replicate samples of meadow grass were taken in each of the five soil sampling locations. One way analysis of variance was used to look for differences in plant tissue concentrations across the five sampling areas. Barium concentration was significantly higher in the Area I vegetation than in the Area III and IV vegetation, but similar to that observed in plants taken in the Reference and in Area II. Manganese concentration was significantly higher in the Area I and reference vegetation than in the Area II, III and IV vegetation. Cobalt was significantly higher in Area IV vegetation than that taken in any of the other areas. There was no difference in the fluoride or lipid concentration.

Results of the TAL metals and fluoride analysis are presented in Tables 36-38 and in Appendix B.

3.3 Histological assay of small mammal liver and kidney

Histological analysis of liver and kidney sections of meadow voles, short-tail shrews, meadow jumping mice, and white-footed mice trapped in each of the five trapping areas concluded that there were no substantive changes in liver or kidney morphology. The absence of a kidney in one animal, and the presence of an extra lobe on the right kidney of another provide anecdotal evidence of an effect, however we are unable to ascertain the importance of these observations. Full summaries of the histopathological work are presented in Table 39 and in Appendix B.

3.4 Toxicity Testing

Earthworm

Based on the toxicity evaluation of soils, there is no evidence for growth or survival effects on earthworms tested in any of the soil samples collected at the Dry Run Creek site. Survival was 100% in all treatment replicates and growth ranged from 32.4 to 54.3%. Further results of the earthworm toxicity test are presented in Table 40 and in Appendix C.

Fathead minnow

Based on the toxicity evaluation of surface water samples to the fathead minnow, it appears that surface water taken in the Upper Tributary A location induced significant mortality. Survival in the Upper Tributary A sample was 58% while survival in all other samples, including the reference location, ranged from 87 to 100%. There appear to be no growth related effects water, on the minnows in any of the water samples taken from Dry Run Creek. Survival was negatively correlated potassium concentrations, however these correlations are not statistically significant at the 0.10 level. There was a significant positive correlation between fathead survival and iron concentrations in the filtered water samples. Further results of the fathead minnow toxicity test are presented in Table 40 and in Appendix C.

Amphipod

Based on the results of the 10 day solid phase whole sediment toxicity test with the amphipod, *Hyalella azteca*, growth of the organisms was inhibited in the sediment samples taken at the Upper Tributary A, and Area II locations. There were no effects observed on survival in any of the samples taken. The observed negative growth effect was significantly negatively correlated with

SECTION II

ECOLOGICAL RISK ASSESSMENT

1.0 INTRODUCTION

1.1 Objective

The objective of this risk assessment was to provide technical support to the U.S. Environmental Protection Agency Region III in conducting an evaluation of potential ecological threat due to existing contaminant levels in soil, sediment, and water at a working beef production farm located down gradient of a landfill. Soil, sediment, surface water, and biota samples were collected for contaminant analyses and soil, sediment, and surface water were collected for laboratory toxicity testing. The information gathered during this field effort was incorporated into an ecological risk assessment for the Dry Run Creek site.

1.2 Site Background

The site is a working beef production farm located in Washington, Wood County, WV. The owner of the farm has filed numerous complaints with the West Virginia Department of Natural Resources and the U. S. EPA alleging that contaminants are being discharged from an industrial landfill owned by the Dupont corporation, into Dry Run. Dry Run flows through the farmer's property and is a primary source of water for his cattle. The farmer maintains that numerous deaths, blindness, and other unusual illnesses observed in his herd are directly attributable to the contaminants that are discharged into Dry Run from the Dupont landfill. In addition to these abnormalities, numerous fish and wildlife kills have also been reported in Dry Run since the construction of the landfill.

2.0 PROBLEM FORMULATION

This risk assessment was designed to evaluate the potential threats to ecological receptors from exposure to site contaminants. During the preliminary risk assessment, the problem formulation process included the identification of COCs and a comparison of the maximum concentration of COCs with accepted benchmarks. This information was then used to identify complete exposure pathways of compounds exceeding benchmarks to ecological receptors and their appropriate measurement endpoints.

The first step of the preliminary risk assessment process compared all chemicals analyzed in soil, sediment, and water during the field with established toxicological benchmarks. Benchmarks for sediment and soil were used to identify potential contaminants of concern for the protection of aquatic biota (U.S. EPA 1995, Long and Morgan 1990, Long et al. 1995, Persuad et al. 1992, U.S. EPA 1992, Suter and Mabrey 1994). Compounds exceeding benchmarks were retained for further evaluation using ingestion-based exposure models for higher vertebrates, and direct exposure assays for fish, benthic and terrestrial invertebrates.

2.1 Ecological Risk Assessment

This ecological risk assessment was written to determine the risk associated with the exposure of biota to site-related contaminants. The following steps were completed for this preliminary risk assessment:

- (1) A literature search was conducted to locate life history information for selected indicator species, to determine ecotoxicological effects of site contaminants, and to locate bioconcentration factors for site contaminants.
- (2) An evaluation of ecological receptors was prepared. This consisted of the following:
 - Exposure scenarios were determined based on site contaminant levels, the extent and magnitude of contamination, and the toxicological mechanisms of the

contaminants.

- Indicator species were selected based on species present and/or potentially present on site, the availability of toxicity information from the literature, and the potential for exposure to site contaminants based on habitat use or behavior.
- Exposure pathway(s) were determined for each indicator species.
- Exposure and effect profiles were written for each indicator species and each site contaminant.
- A risk characterization was conducted which involved the calculation of hazard quotients (HQs) for each species for a range of exposure scenarios.

Based on the results of this evaluation, the COCs identified in the initial screen were further evaluated through the use of conservative risk models.

2.2 Identification of the Contaminants of Concern

The contaminants of potential concern were identified using the initial contaminant screen. The COCs for this site that were retained through the preliminary screen include metals, fluoride, and organofluoride compounds.

2.3 Exposure Characterization

The objective of the exposure assessment is to determine the pathways and media through which receptors may be exposed to site contaminants. Potential exposure pathways are dependant on habitats and receptors present on site, extent and magnitude of contamination, and environmental fate and transport of COCs. In this base-line ecological risk assessment, it will be concluded that "a potential risk" exists if the HQ calculated from the maximum site concentration and the No Observed Apparent Effect Level (NOAEL) equals or exceeds 1.

Exposure to COCs present in forage and prey species via ingestion could cause toxicity in higher trophic level organisms. In addition to exposure via consumption of contaminated forage, ecological receptors may also be exposed through ingestion of water and incidental ingestion of soil/sediment. The exposure of benthic invertebrates, terrestrial invertebrates, and fish was determined by examining results of the toxicity tests.

2.4 Hazard Characterization/Toxicity Assessment

To determine the effects of contaminants on biota, it is necessary to understand the mechanisms of toxicity of the chemicals and the systems that they affect. Knowledge of the fate, effects, and mode of action of the COCs allows for the selection of appropriate assessment endpoints. Next is a review of the general toxicological information for the COCs identified in Section 2.4.

2.4.1 Fluoride

Inorganic fluoride compounds are ubiquitous in nature. However, industrial processes such as manufacturing and mining have contributed to the environmental load of fluoride, primarily through atmospheric deposition. In low doses, it is accepted that fluoride is

protective of teeth in humans as well as other animals. However in higher levels it is generally accepted that fluoride can be toxic to both plant and animal life. Dental and skeletal lesions, lameness, stiffness of gait, appetite impairment, decreased weight gain, decreased milk production, posture abnormalities, tremors, stillbirths, overgrowth of hooves, severe diarrhea, and death have been associated with mammalian fluoride toxicity (Suttie, 1977; Shupe et al, 1992). In addition to the effects known in mammals, birds are also susceptible to fluoride toxicity. Mortality, decreased growth rates, depressed appetite, and decreased eggshell quality have been reported as toxicological endpoints of fluoride exposure in birds (Fleming and Schuler 1988; Fleming et al. 1987; Guenter and Hahn 1986).

2.4.2 Organofluorides

Organofluorides are used in a variety of industrial processes including the production of Teflon™, propellants, and refrigerants. Available toxicological data generally concentrates on inhalation exposure and dermal absorption. Acute (10 day) exposure of rats to chlorodifluoromethane produced decreased maternal and fetal weights, as well as an increased frequency of anophthalmia and subsequent blindness in newborn fetuses (IARC 1986). Hexafluoropropene exposure induced an increased incidence of hamster ovary cell aberrations and increased frequency grossly abnormal cells (HSDB 1997).

2.4.3 Aluminum

Because of its strong reactivity, aluminum (Al) is not found as a free metal in nature. Aluminum has only one oxidation state (+3), thus its behavior in the environment depends on its ordination chemistry and the surrounding conditions. In soils, a low pH generally results in an increase in aluminum mobility. In water, an equilibrium with a solid phase is established that controls the extent of aluminum dissolution (ATSDR 1990).

Plants vary in their ability to remove aluminum from soils, although bioconcentration factors for plants are generally less than one. Biomagnification of aluminum in terrestrial food chains does not appear to occur. There is no data on the biomagnification of aluminum in aquatic food chains (ATSDR 1990).

The nervous system may be a target area for aluminum. Aluminum accumulates in neurofibrillary tangles in humans with Alzheimer's disease. Aluminum may also interact with neuronal DNA to alter gene expression and protein formation. Mammalian studies do not indicate that aluminum affects reproduction although some developmental effects have been reported in mammals (ATSDR 1990). Aluminum is known to interfere with gill transport of oxygen and carbon dioxide in fish, and has also been identified in ionoregulatory disruption.

2.4.4 Arsenic

Several review articles are available which discuss the toxic effects of As (Eisler 1988a, Nriagu 1994). Arsenic tends to be widespread in the environment (Woolson 1975) and is constantly being oxidized, reduced, or mobilized (Eisler 1988a). Physical processes are important in determining As bioavailability in aquatic environments. For example, arsenates are readily adsorbed onto sediments with high organic matter, and arsenates are more strongly adsorbed onto sediments than other As forms. However, absorption depends on the As concentration, sediment characteristics, pH, and ionic concentration of other compounds

(Eisler 1988a; U.S. EPA 1981). The U.S. EPA (1981) noted that arsenate (pentavalent) is the predominant As form in oxygenated water and that arsenite (trivalent) is the predominant As form in anaerobic conditions.

Arsenic is not significantly concentrated in aquatic invertebrates; whole body concentration factors for invertebrates range from 3 to 17 for exposure to arsenic trioxide (trivalent) and from 0 to 7 for arsenic pentoxide (pentavalent). Arsenic may be bioconcentrated by organisms at the bottom of the food chain; however, data do not indicate that significant biomagnification occurs (U.S. EPA 1985).

2.4.5 Beryllium

The majority of the beryllium (Be) in the environment is the result of coal and oil combustion. Beryllium naturally enters waterways through the weathering of rock and soil, and through deposition of atmospheric beryllium. Upon reaching water and soil, beryllium is most likely retained as an insoluble form that is generally immobile. However, beryllium chloride, fluoride, nitrate, phosphate, and sulfate (tetrahydrate) are all water-soluble forms (ATSDR 1993a).

Due to its geochemical similarity to aluminum, beryllium may be expected to adsorb onto clay surfaces at low pHs, and it may remain precipitated as insoluble complexes at higher pHs. Therefore, beryllium is expected to have limited mobility in soil (ATSDR 1993a).

Beryllium is not expected to bioconcentrate in aquatic animals and no evidence for significant biomagnification within food chains has been found. Beryllium is extremely toxic to warmwater fish in soft water. The degree of toxicity decreases with increasing hardness (ATSDR 1993a).

Major exposure routes for aquatic ecological receptors include ingestion of contaminated soil and sediment. Although several studies point out the negative effects of beryllium in mammalian systems, no studies that evaluated the relationship between sediment beryllium concentration and observed toxicity to benthic organisms could be found (ATSDR 1993a).

2.4.6 Chromium

Chromium (Cr) can exist in oxidation states ranging from -2 to +6, but is most frequently converted to the relatively stable trivalent (+3) and hexavalent (+6) oxidation states (Eisler 1986a). In both freshwater and marine systems, hydrolysis and precipitation are the most important processes that determine the fate and effects of Cr, whereas adsorption and bioaccumulation are relatively minor. Precipitated Cr^{+3} hydroxides remain in sediments under aerobic conditions. However, under anoxic and low pH conditions, Cr^{+3} hydroxides may solubilize and remain as ionic Cr^{+3} unless oxidized to Cr^{+6} through mixing and aeration (Eisler 1986a). In soils, the solubility and bioavailability of Cr are governed by soil pH and organic complexing substances, although organic complexes play a more significant role (James and Bartlett 1983a; James and Bartlett 1983b).

The trivalent state is the form usually found in biological materials. This form functions as an essential element in mammals by maintaining efficient glucose, lipid, and protein metabolism (Stevens et al. 1976). Chromium is beneficial but not essential to higher plants (Eisler 1986a). The biomagnification and toxicity of Cr^{+3} is low relative to Cr^{+6} because of

its low membrane permeability and its noncorrosivity. However, a large degree of accumulation by aquatic and terrestrial plants and animals in the lower trophic levels has been documented (Eisler 1986a), although, the mechanism of accumulation remains largely unknown.

Chromium is mutagenic, carcinogenic, and teratogenic, with Cr^{6+} exhibiting the greatest toxicity; relatively less is known about the toxicity of Cr^{3+} . At high concentrations, Cr^{6+} is associated with abnormal enzyme activity, altered blood chemistry, lowered resistance to pathogenic organisms, behavioral modifications, disrupted feeding, histopathology, osmoregulatory upset, alterations in population structure, and inhibition of photosynthesis.

Rabbits fed dietary Cr accumulated hyaluronates, chondroitin sulfates, and neutral mucopolysaccharides in the soft tissues, causing pericapillary sclerosis (Kucher and Shabanov 1967). This accumulation blocked blood tissue barriers, which are permeable under normal conditions, preventing the normal transport of metabolites. One manifestation of this condition was the inhibition of insulin production in the pancreatic islets due to damage to the beta-cells contained therein.

Chromium also leads to nephron damage via swelling and loss of microvilli, the formation of intracellular vacuoles, mitochondrial swelling, and cytoplasmic liquefaction and loss of cells lining the nephron surface (Evan and Dail 1974).

The preliminary step in Cr-induced respiratory cancer is speculated to be the scarring of alveolar tissue, followed by the elicitation of inflammatory reactions in lung tissue leading to bronchopneumonia, alveolar epithelial changes, atrophy, and benign tumor formation. Direct skin contact with highly corrosive chromic acid and its anhydride produces skin ulcers and necrosis by a mechanism independent of any allergic response (Steven et al. 1976).

2.4.7 Copper

Copper (Cu) does not appear to have mutagenic properties (IRIS 1990), but it is a teratogen (RTECS 1991) and a possible carcinogen (Venugopal and Luckey 1978). Copper is caustic, and acute toxicity is primarily related to this property (Hatch 1978).

Copper is an essential element for animals and is a component of many metalloenzymes and respiratory pigments (Demayo et al. 1982). It is also essential to iron (Fe) utilization and functions in enzymes for energy production, connective tissue formation, and pigmentation (Venugopal and Luckey 1978). Excess Cu ingestion leads to accumulation in tissues, especially in the liver. High levels of Cu modify hepatic metabolism (Brooks 1988), which may lead to inability of the liver to store and excrete additional Cu. When liver concentration exceeds a certain level, the metal is released into the blood, causing hemolysis and jaundice. High Cu levels also inhibit essential metabolic enzymes (Demayo et al. 1982). Toxic symptoms appear when the liver accumulates 3 to 15 times the normal level of Cu (Demayo et al. 1982).

Although the exact mechanism of toxicity is not known, the following mechanisms have been proposed: formation of stable inhibitory complexes with cytochrome P-450 (Wiebel et al. 1971); impairment of function of NADPH-cytochrome c reductase and alteration of mixed function oxidations (Reiners et al. 1986); and inhibition of heme biosynthesis (Martell 1981). Intracellular inclusions may act as a detoxifying mechanism where Cu is complexed by

protein ligands, protecting cytoplasmic organelles (Demayo et al. 1982).

Ruminants are the most sensitive mammal species to Cu toxicosis. Young animals retain more dietary Cu than older animals and are more sensitive to Cu toxicity (Venugopal and Luckey 1978).

2.4.8 Iron

Iron (Fe) is commonly detected in concentrations of 5 percent or more in soil. It is used primarily in the production of steel and other alloys as well as a major source of hydrogen. Iron is a constituent of hemoglobin and is essential to plant and animal life as well as being an important component in cellular oxidative processes. The disposition of ingested iron is regulated by a complex mechanism to maintain homeostasis. Therefore, bioconcentration in biota is not expected to be a significant process for iron. Generally, about 2 to 15 percent of ingested iron is absorbed from the gastrointestinal tract, and elimination is approximately 0.01 percent of the body burden per day. Adverse effects of iron toxicity may include renal failure and hepatic cirrhosis. The mechanism of toxicity begins with acute mucosal cell damage and absorption of ferrous ions directly into circulation, resulting in capillary endothelial cell damage to the liver (Shacklette and Boermgen 1984).

2.4.9 Lead

Lead does not biomagnify to a great extent in food chains, although accumulation by plants and animals has been extensively documented (Wixson and Davis 1993, Eisler 1988b). Older organisms typically contain the highest tissue Pb concentrations, with the majority of the accumulation in the bony tissue of vertebrates (Eisler 1988b).

Predicting the accumulation and toxicity of Pb is difficult since its effects are influenced to a very large degree, relative to other metals, by interactions among physical, chemical, and biological variables. In general, organolead compounds are more toxic than inorganic Pb compounds, and young, immature organisms are most susceptible to its effects (Eisler 1988b). In plants, Pb inhibits growth by reducing photosynthetic activity, mitosis, and water absorption. The mechanism by which photosynthetic activity is reduced is attributed to the blocking of sulfhydryl groups, inhibiting the conversion of coproporphyrinogen to protoporphyrinogen (Holl and Hampp 1975).

The toxic effects of Pb on aquatic and terrestrial organisms are extremely varied and include mortality, reduced growth and reproductive output, blood chemistry alterations, lesions, and behavioral changes. However, many effects exhibit general trends in their toxic mechanism. Generally, Pb inhibits the formation of heme, adversely affects blood chemistry, and accumulates at hematopoietic organs (Eisler 1988b). At high concentrations near levels causing mortality, marked changes to the central nervous system occur prior to death (Eisler 1988b).

Plants can uptake Pb through surface deposition in rain, dust, and soil, or by uptake through the roots. The ability of a plant to uptake Pb from soils is inversely related to soil pH and organic matter content. Lead can inhibit photosynthesis, plant growth, water absorption.

2.4.10 Manganese

soluble pentavalent form. The mobility of vanadium in soil is affected by pH, redox potential, and the presence of particulates. Relative to other minerals, vanadium is mobile in neutral or alkaline soils and its mobility decreases in acidic soils (ATSDR 1991; Van Zinderen Bakker and Jaworski 1980).

In the terrestrial systems, bioconcentration is more common in lower plant species. In addition, vanadium concentrations in plants are dependent on the amount of water-soluble vanadium, pH, and growing conditions. Vanadium appears to be present in all terrestrial mammals but the concentrations are usually below the detection limits. The highest concentration of vanadium is usually found in the liver and skeletal tissues (ATSDR 1991).

Vanadium is very poorly absorbed into the gastrointestinal tract and the toxic mechanism of vanadium on the respiratory system is similar to other metals (Castronova et al. 1984). Vanadium damages the alveolar macrophages by decreasing the macrophage membrane integrity. Damaged macrophages inhibit the ability of the respiratory system to clear itself of other particles. In vitro experiments indicate that the mechanism of toxicity of vanadium is by inhibiting sodium-potassium ATPase activity, which inhibits the sodium-potassium pump. This pump is necessary for the transport of material across cell membranes (Nechay and Saunders 1978).

2.4.13 Zinc

Zinc (Zn) is essential for normal growth and reproduction in plants and animals and is regulated by metallothioneins. Metallothioneins act as temporary Zn storage sites and aid in reducing the toxicity of Zn to both vertebrates and invertebrates (Olsson et al. 1989). Zinc is not known to bioaccumulate in food chains, because it is regulated by the body and excess Zn is eliminated.

Zinc has its primary metabolic effect on Zn-dependant enzymes that regulate the biosynthesis and catabolic rate of ribonucleic (RNA) acid and deoxyribonucleic acid (DNA). High levels of Zn induce Cu deficiency and interfere with metabolism of calcium (Ca) and Fe (Goyer 1986). The pancreas and bone seem to be the primary targets of Zn toxicity in birds and mammals. Pancreatic effects include cytoplasmic vacuolation, cellular atrophy, and cell death (Lu and Combs 1988, Kazacos and Van Vleet 1989). Zinc preferentially accumulates in bone, and induces osteomalacia (a softening of bone caused by a deficiency of Ca, phosphorus and other minerals) (Kaji et al. 1988). Gill epithelium is the primary target site in fish. Zinc toxicosis results in destruction of gill epithelium and tissue hypoxia (Spear 1981).

2.5 Selection of Assessment Endpoints

The information gathered during a site reconnaissance and during the field work, and subsequent discussions with the U.S. EPA on-scene coordinator and the Region III Biological Technical Assistance Group, allowed for the selection of assessment endpoints that corresponded to the habitat types present at the Dry Run Creek site. The site is composed of a variety of habitats including forested and old-field uplands, grassy meadows, the creek, and associated riparian areas. A variety of birds, mammals, and fish may use the site for feeding and nesting. Likewise, terrestrial and benthic invertebrates are key elements in the functions of these systems. Therefore, the assessment endpoints focused toward these faunal groups. Viability of terrestrial, avian, and aquatic populations and organism survivability were selected as assessment endpoints for this risk assessment. Listed next are

Manganese (Mn) does not occur as a free metal in the environment but is a component of numerous minerals. Elemental manganese and inorganic manganese compounds have negligible vapor pressures, but may exist in air as suspended particulate matter derived from industrial emissions or the erosion of soil. Removal from the atmosphere is mostly through gravitational settling. The transport and partitioning of manganese in water is controlled by the solubility of the specific chemical form present. The metal may exist in water in any of four oxidation states (2+, 3+, 4+, or 7+). Divalent manganese (Mn+2) predominates in most waters (pH 4 to 7), but may become oxidized at a pH greater than 8 or 9. Manganese is often transported in moving water as suspended sediments. The tendency of soluble manganese compounds to adsorb to soils and sediments depends mainly on the cation exchange capacity and the organic composition of the soil. Manganese in water may be significantly bioconcentrated at lower trophic levels. However, biomagnification in the food chain may not be significant (ATSDR 1990).

The amount of manganese absorbed across the gastrointestinal tract is variable. There does not appear to be a marked difference between manganese ingested in food or in water. One of the key determinants of absorption appears to be dietary iron intake, with low iron levels leading to increased manganese absorption. This is probably because both iron and manganese are absorbed by the same transport system in the gut (ATSDR 1990).

2.4.11 Nickel

Pure nickel (Ni) is a hard, white metal that is usually used in the formation of alloys (such as stainless steel) and Ni combined with other elements is found in all soils. Nickel is the 24th most abundant element and is found in the environment as oxides or sulfides. Nickel may be released into the environment through mining, oil-burning power plants, coal-burning power plants, and incinerators. Nickel will attach to soil or sediment particles, especially those containing Fe or manganese (Mn). Under acidic conditions, Ni may become more mobile and seep into the groundwater. The typical Ni concentration reported in soils is from 4 - 80 milligrams per kilograms (mg/kg). The speciation and physicochemical state of Ni is important in considering its behavior in the environment and its availability to biota.

The most probable exposure routes of Ni are through dermal contact, inhalation of dust, and ingestion of Ni-contaminated soil. The respiratory system is the primary target of Ni exposure following inhalation. Manifestations such as inflammation of the lungs, fibrosis, macrophage hyperplasia, and increased lung weight have been noted in animals exposed to Ni. Animals exposed to Ni through oral exposure were noted to have lethargy, ataxia, irregular breathing, salivation, and squinting (ATSDR 1996).

2.4.12 Vanadium

Elemental vanadium does not occur naturally but it can exist in 50 different ores and fossil fuels. Other anthropogenic sources include acid-mine leachate, sewage sludge, and fertilizers. The principal use of vanadium is as an alloy constituent, especially in steel. The addition of vanadium to steel removes oxygen and nitrogen, which improves the strength. The average concentration of vanadium in the earth's crust is 150 mg/kg and in the U.S. soils are 200 mg/kg (Byernum et al. 1974).

The release of vanadium to water and soil occurs as a result of the weathering of rocks and from soil erosion. This process usually converts the less-soluble trivalent form to the more-

on the site?

Are levels of site contaminants sufficient to cause negative impacts on growth, survival, and reproductive success of carnivorous birds due to the ingestion of contaminated forage, soil, and water on the site?

Are levels of site contaminants sufficient to cause negative impacts on growth, survival, and reproductive success of carnivorous mammals due to the ingestion of contaminated forage, soil, and water on the site?

Are levels of site contaminants sufficient to cause negative impacts on growth, survival, and reproductive success of piscivorous mammals due to the ingestion of contaminated forage, soil, and water on the site?

Are levels of site contaminants sufficient to cause negative impacts on growth, survival, and reproductive success of omnivorous mammals due to the ingestion of contaminated forage, soil, and water on the site?

Are levels of site contaminants sufficient to cause negative impacts on growth, survival, and reproductive success of insectivorous mammals due to the ingestion of contaminated forage, soil, and water on the site?

Are levels of site contaminants sufficient to cause negative impacts on growth, survival, and reproductive success of herbivorous mammals due to the ingestion of contaminated forage, soil, and water on the site?

2.7 Conceptual Model

The conceptual model relies on contaminant and habitat characteristics to identify critical exposure pathways to the selected measurement endpoints. At the Dry Run Creek site, contaminants in the soil may come in contact with subsurface (earthworms) and above-ground terrestrial receptors (small mammals) inhabiting the wooded, wetland, and open field areas of the site. Subsurface terrestrial receptors in these areas may be exposed to site contaminants through direct contact with the soil, and in some cases, the intentional ingestion of soil. Above-ground terrestrial receptors may be exposed to contaminants through direct contact with the soil, the ingestion of subsurface terrestrial organisms, the ingestion of other above-ground terrestrial receptors, the incidental ingestion of soil adhered to food items, and the intentional ingestion of surface water from any of the on-site surface drainages.

The wooded areas, riparian area, and meadow areas provide distinct habitat types that may support a variety of terrestrial and avian receptors. For example, a small omnivorous mammal may occupy one or all the habitat types, whereas, an individual carnivorous mammal may regularly traverse all three habitats daily in search of food items. Avian piscivores and carnivores may be exposed to site contaminants in much the same way as an above-ground terrestrial receptor. The consumption of contaminated prey, the incidental ingestion of soil/sediment, and the consumption of surface water may transfer contaminants to these receptors.

The conceptual model relies on contaminant and habitat characteristics to identify critical exposure pathways to the selected measurement endpoints. The preliminary risk screen identified metals, fluoride, and trichlorofluoromethane as the primary contaminants exceeding benchmarks in site sediment, soil, and water. Benthic macroinvertebrates, fish, and terrestrial invertebrates may be

the specific assessment endpoints selected for this ecological risk assessment.

Ten assessment endpoints were chosen to evaluate the risk of contaminants at the Dry Run Creek site:

- 1) protection of benthic invertebrate community structure and function
- 2) protection of soil invertebrate community structure and function
- 3) protection of fish communities to ensure that direct exposure to contaminants does not have a potential negative impact on growth, survival, or reproductive success.
- 4) protection of worm-eating birds to ensure that ingestion of contaminants in forage does not have a potential negative impact on growth, survival, or reproductive success.
- 5) protection of carnivorous birds to ensure that ingestion of contaminants in forage does not have a potential negative impact on growth, survival, or reproductive success.
- 6) protection of carnivorous mammals to ensure that ingestion of contaminants in forage does not have a potential negative impact on growth, survival, or reproductive success.
- 7) protection of piscivorous mammals to ensure that ingestion of contaminants in forage does not have a potential negative impact on growth, survival, and reproductive success.
- 8) protection of omnivorous mammals to ensure that ingestion of contaminants in forage does not have a potential negative impact on growth, survival, and reproductive success.
- 9) protection of insectivorous mammals to ensure that ingestion of contaminants in forage does not have a negative impact on growth, survival, and reproductive success.
- 10) protection of herbivorous mammals to ensure that ingestion of contaminants in forage does not have a negative impact on growth, survival, and reproductive success.

2.6 Production of Testable Hypotheses

The testable hypotheses are specific risk questions that are based on the assessment endpoints. Based on the mechanism of contaminant toxicity, the number of exposure pathways that may exist for an assessment endpoint, or other factors, there may be more than one question for each assessment endpoint.

Are levels of site contaminants sufficient to have negative effects on benthic invertebrate community structure and function?

Are levels of site contaminants sufficient to have negative effects on soil invertebrate community structure and function?

Are levels of site contaminants sufficient to cause direct toxicity to fish growth, survival, and reproductive success?

Are levels of site contaminants sufficient to cause negative impacts on growth, survival, or reproductive success of worm-eating birds due to the ingestion of contaminated forage, soil, and water

- a) Ingestion of vegetation
- b) Incidental ingestion of sediment
- c) Incidental ingestion of water

2.8 Selection of Measurement Endpoints

Measurement endpoints are measurable ecological characteristics that are related to the valued characteristics selected as assessment endpoints. Measurement endpoints should be linked to the assessment endpoints by the mechanism of toxicity and the route of exposure. Measurement endpoints are used to derive a quantitative estimate of potential effects, and form a basis for extrapolation to the assessment endpoints.

Measurement endpoints were selected on the basis of potential presence of receptors on site, and the potential for exposure to contaminants of concern. The availability of the appropriate toxicity information on which risk calculations could be based was also an important consideration. Endpoints selected were determined to be representative of exposure pathways and assessment endpoints identified for the site.

Next is a list of specific measurement endpoints that correspond to the assessment endpoints identified in Section 2.5.

Measurement endpoints for assessment endpoint:

- protection of benthic invertebrate communities structure and function

To evaluate the structure and function of the benthic community, benthic macroinvertebrates were collected from five locations in Dry Run. Existing community structure was evaluated at each of the five locations by determining taxonomic diversity and through an evaluation of functional feeding groups.

Sediment was also collected in each of the five areas for toxicity testing using the amphipod, *Hyalella azteca*. The endpoints of these tests were survival and growth. Collocated sediment samples were also collected and analyzed for target analyte list (TAL) metals, BNA's, Pest/PCBs, VOCs, fluoride, grain size, and total organic carbon (TOC). The chemistry results were then correlated with observed adverse biotic responses in the toxicity tests in order to determine risk potential.

Measurement endpoints for assessment endpoint:

- protection of soil invertebrate community structure and function

To evaluate the structure and function of the benthic community, soil was collected from each of the meadow locations and tested using the earthworm, *Eisenia foetida* in toxicity tests. The endpoints of these tests were survival and growth. Collocated soil samples were also collected and analyzed for target analyte list (TAL) metals, BNA's, Pest/PCBs, VOCs, fluoride, grain size, and total organic carbon (TOC).

Measurement endpoints for assessment endpoint:

- protection of fish communities to ensure that direct exposure to contaminants does not have a negative impact on growth, survival, and reproductive success.

exposed to contaminated sediment, water, or soil through direct toxicity. For the purposes of this risk assessment, the concentration of the contaminants of concern found in the sediment, water, or soil were correlated with toxicity levels identified in the corresponding toxicity tests to determine if benthic invertebrates fish, or terrestrial invertebrates may be at risk. Terrestrial receptors may be exposed to contaminants by feeding on organisms which have accumulated COCs in their tissues. Higher trophic level receptors may also be exposed to contaminants from food ingestion and via incidental ingestion of soil/sediment and water. The pathway to the reference area meadow is unknown, however the pathway to the reference area stream may involve groundwater transport. The following pathways were evaluated in this risk assessment:

- I. Benthic invertebrates
 - a) Direct exposure to sediment
- II. Soil invertebrates
 - a) Direct exposure to soil
- III. Fish
 - a) Direct exposure to water
- IV. Worm-eating bird
 - a) Ingestion of earthworms
 - b) Incidental ingestion of soil
 - c) Incidental ingestion of water
- V. Carnivorous bird
 - a) Ingestion of small mammals
 - b) Incidental ingestion of soil
 - c) Incidental ingestion of water
- VI. Carnivorous mammal
 - a) Ingestion of small mammals
 - b) Incidental ingestion of soil
 - c) Incidental ingestion of water
- VII. Piscivorous mammal
 - a) Ingestion of forage fish
 - b) Incidental ingestion of sediment
 - c) Incidental ingestion of water
- VIII. Omnivorous mammal
 - a) Ingestion of forage fish
 - b) Incidental ingestion of sediment
 - c) Incidental ingestion of water
- IX. Insectivorous mammal
 - a) Ingestion of earthworms
 - b) Incidental ingestion of sediment
 - c) Incidental ingestion of water
- X. Herbivorous mammal

- Protection of omnivorous mammals to ensure that ingestion of contaminants in forage does not have a negative impact on growth, survival, and reproductive success.

Food chain accumulation studies were selected to evaluate risk to mammalian species which utilize the site and adjacent areas. The selected measurement endpoint receptor species is the raccoon, *Procyon lotor*, as a model for omnivorous mammalian species. Appropriate forage species (fish) were identified for the above receptors and the dietary exposure of receptors to contaminants was quantified.

Measurement endpoints for assessment endpoint:

- Protection of insectivorous mammals to ensure that ingestion of contaminants in forage does not have a negative impact on growth, survival, and reproductive success

Food chain accumulation studies were selected to evaluate risk to mammalian species which utilize the site and adjacent areas. The selected measurement endpoint receptor species is the short-tail shrew, *Blarina brevicauda*, as a model for insectivorous mammalian species. Appropriate forage species (earthworms) were identified for the above receptors and the dietary exposure of receptors to contaminants was quantified.

Measurement endpoints for assessment endpoint:

- Protection of herbivorous mammals to ensure that ingestion of contaminants in forage does not have a negative impact on growth, survival, and reproductive success

Food chain accumulation studies were selected to evaluate risk to mammalian species which utilize the site and adjacent areas. The selected measurement endpoint receptor species is the meadow vole, *Microtus pennsylvanicus*, as a model for herbivorous mammalian species. Appropriate forage species (vegetation) was identified for the above receptors and the dietary exposure of receptors to contaminants was quantified.

2.9 Life History/Exposure Profile Information

Receptor species were selected from several trophic levels. Organisms which were likely to be exposed to contaminants because of specific behaviors, patterns of habitat use, or feeding habits were selected for evaluation in this risk assessment. The availability of appropriate toxicity information on which risk calculations could be based was also an important consideration. The terrestrial invertebrate receptor selected for this assessment is the earthworm. The terrestrial vertebrate receptor species selected for this risk assessment are: meadow vole, short-tail shrew, raccoon, mink, and red fox. The avian receptor species selected for this risk assessment are: American robin and red-tailed hawk. The aquatic vertebrate receptor species for this risk assessment is the fathead minnow. The aquatic invertebrate receptor is *H. azteca*.

2.9.1 The amphipod (*Hyallela azteca*) as Representative of Benthic Invertebrates

Justification

Hyallela azteca was selected as representative of benthic invertebrates due to their direct contact with sediment for a significant portion of their life cycle, ubiquitous distribution in aquatic systems, importance as a food item for aquatic-invertebrate consumers, and ease of

Fathead minnow, *Pimephales promelas*, toxicity tests were used to determine the toxicity of the water in Dry Run. The endpoints of these tests were survival and growth. Collocated water samples were also collected and analyzed for target analyte list (TAL) metals, BNA's, Pest/PCBs, VOCs, fluoride, grain size, and total organic carbon (TOC). The chemistry results were then correlated with observed adverse biotic responses in the toxicity tests in order to determine risk potential.

Measurement endpoints for assessment endpoint:

- Protection of worm-eating birds to ensure that ingestion of contaminants in forage does not have a negative impact on growth, survival, and reproductive success.

Food chain accumulation studies were selected to evaluate risk to avian species which utilize the site as a feeding area. The selected measurement endpoint receptor species is the American robin, *Turdus migratorius*. Appropriate forage species (earthworms) were identified for the above receptor, and the dietary exposure of receptors to contaminants was quantified and compared to existing toxicity data for these, or other closely related species.

Measurement endpoints for assessment endpoint:

- Protection of carnivorous birds to ensure that ingestion of contaminants in forage does not have a negative impact on growth, survival, and reproductive success.

Food chain accumulation studies were selected to evaluate risk to avian species which utilize the site as a feeding area. The selected measurement endpoint receptor species is the red-tailed hawk, *Buteo jamaicensis*. Appropriate forage species (small mammals) were identified for the above receptor, and the dietary exposure of receptors to contaminants was quantified and compared to existing toxicity data for these, or other closely related species.

Measurement endpoints for assessment endpoint:

- Protection of carnivorous mammals to ensure that ingestion of contaminants in forage does not have a negative impact on growth, survival, and reproductive success.

Food chain accumulation studies were selected to evaluate risk to mammalian species which utilize the site and adjacent areas. The selected measurement endpoint receptor species is the red fox, *Vulpes vulpes*. Appropriate forage species (small mammals) were identified for the above receptors and the dietary exposure of receptors to contaminants was quantified.

Measurement endpoints for assessment endpoint:

- Protection of piscivorous mammals to ensure that ingestion of contaminants in forage does not have a negative impact on growth, survival, and reproductive success.

Food chain accumulation studies were selected to evaluate risk to mammalian species which utilize the site and adjacent areas. The selected measurement endpoint receptor species are the mink, *Mustela vison*. Appropriate forage species (fish) were identified for the above receptors and the dietary exposure of receptors to contaminants was quantified.

Measurement endpoints for assessment endpoint:

earthworms were observed in both the wooded and open field areas of the Dry Run Creek site.

Life History

Earthworms feed on dead and decaying plant and animal remains and on free-living soil microflora and microfauna. Their primary source of food is dead plant material, especially plant litter. Next to food, their most important requirement is adequate moisture. Water conservation mechanisms are poorly developed; respiration depends on diffusion of gases through the body wall which must be kept moist. Earthworms are generally absent or rare in soils with very coarse texture, in soils with high clay content in regions of high rainfall, and in soils with a pH of less than 4 (Lee 1985).

Earthworms are hermaphroditic and most species reproduce by cross-fertilization, although many species can also produce cocoons parthenogenetically. Sexual reproduction cannot occur without a clitellum, ovaries, oviducts, and possibly the ovisacs, but male organs are not essential. The population of an earthworm species at any one time consists of young immature, well-grown immature (adolescent), mature, and senescent individuals (Edwards and Lofty 1977).

Earthworms have several ways of surviving adverse environmental conditions such as soil desiccation and ambient cold and heat. In terms of population survival, the cocoons can resist desiccation and temperature extremes much more easily than mature individuals. Worms may also migrate to deeper soil or undergo states of inactivity until environmental conditions become favorable once again (Edwards and Lofty 1977).

Some species of worms grow throughout their lives by continually adding segments proliferated from a growing zone located just in front of the anus. Other species, such as *E. foetida*, possess the adult number of segments upon hatching and increase in size without increasing the number of segments. The life span of *Eisenia foetida* was reported to be approximately 4.5 years under laboratory conditions (Edwards and Lofty 1977).

Exposure Profile

Direct contact with contaminated soil is the primary route of exposure for earthworms in this risk assessment. Survival and growth endpoints following exposure to site soils will be used to evaluate risk to these organisms. Tissue residue analysis will also be conducted on the worms to determine exposure to higher trophic level organisms.

2.9.3 Fathead Minnow (*Pimephales promelas*) as Representative of Fish Community

Justification

The fathead minnow was selected as representative of omnivorous fish due to its dietary composition, direct contact with water throughout the life cycle, ubiquitous distribution in aquatic systems, importance as a food item for fish-eating consumers, and ease of use in laboratory toxicity evaluations.

Life History

USEPA 6900

use in laboratory toxicity evaluations. These species are also likely to occur in the surface sediment at the Dry Run Creek site.

Life History (*Hyalalea azteca*)

The amphipod, *Hyalalea azteca*, is commonly found in freshwater lakes, streams, ponds, and rivers throughout North and South America. In preferred habitats, they are known to reach densities in excess of 10,000 per square meter. They may also be found in sloughs, marshes, and ditches, but generally in lower numbers (U.S. EPA 1994).

Hyalalea azteca are epibenthic detritivores that feed on coarse particulate organic material. They typically burrow into surface sediment, and avoid bright light. Because of their feeding and behavioral characteristics, they are ideal test organisms for toxicological evaluation of freshwater sediments. Avoidance of light by movement into the sediment keeps these organisms almost constantly in contact with sediment contaminants (U.S. EPA 1994).

Reproduction in this crustacean is sexual. Males are larger than females and have larger front gnathopods that are presumably used for holding the female during amplexus and copulation. During amplexus, the male and female feed together for a period of up to one week. The pair separates temporarily while the female goes through a molting period. Immediately after the molt, the two rejoin and copulation begins. During copulation, the male releases sperm near the female's marsupium. The female sweeps the sperm into her marsupium, and simultaneously releases eggs from her oviducts, into the marsupium, where fertilization takes place. The average brood size for female *Hyalalea azteca* is 18 eggs per brood, but this number can vary with environmental conditions and physiological stress (U.S. EPA 1994).

Developing embryos and hatched young are kept inside the female's marsupium until she undergoes a second molt. At that time, the juvenile *Hyalalea azteca* are released into the surrounding environment. Under favorable conditions, each female produces approximately one brood during every ten day time period (U.S. EPA 1994).

Hyalalea azteca have a minimum of 9 instars, with 5 to 8 pre-reproductive stages. The first five stages are juvenile stages; instars 6 and 7 form the adolescent stages; and stages 8 and higher are considered adult (fully reproductive) stages (U.S. EPA 1994).

Exposure Profile for *Hyalalea azteca*

Since direct contact with contaminated sediment in the toxicity evaluation is the primary route of exposure for *Hyalalea azteca* in this risk assessment, the results of the test will be used to indicate exposure.

2.9.2 Earthworm (*Eisenia foetida*) as Representative of Terrestrial Invertebrates

Justification

Earthworms were selected as representative of terrestrial invertebrates due to their feeding habits, ubiquitous distribution throughout many habitats and soil conditions, and importance in providing a food base for many small- to medium-sized predators. A diet of detritus, microflora, and microfauna, combined with direct contact with the surrounding soil, presents a potential link between soil contaminants and soil-invertebrate consumers. In addition,

Breeding territories are established by male robins. Most foraging occurs close to these territories during the breeding season; however, if densities of robins are high in a given area or if food resources are limited, adult robins will leave to temporarily forage elsewhere. Outside of the breeding period, robins typically return to the same foraging sites and roost within 1 to 3 kilometers (km) of these areas (U.S. EPA 1993).

Exposure Profile

Adult American robins are reported to weigh from 77.3 to 133.8 g (U.S. EPA 1993). Territory sizes vary from 0.3 to 1 acre, with foraging home ranges reported up to 2 acres (U.S. EPA 1993). The lowest reported body weight (77.3 g) and the smallest reported home range of (0.3 acres) were assumed for this risk assessment.

A food ingestion rate of 0.89 to 1.52 g/g BW/day and a water ingestion rate of 0.14 g/g BW/day are reported for this species (U.S. EPA 1993). Assuming a 77.3 g body weight, an American robin can be expected to consume 117.5 g/day of food and 10.8 g/day of water.

The diet of the American robin consists of seasonally variable proportions of invertebrates (e.g., earthworms, snails, beetles, caterpillars, spiders) and fruit (e.g., dogwood, cherry, sumac, hackberries, raspberries) (U.S. EPA 1993, Ehrlich et al. 1988). During spring, summer, and fall, the dietary composition is reported to change from 93 percent invertebrates and 7 percent fruit in the spring (nesting season) to 92 percent fruit and 8 percent invertebrates in fall (migratory season). The summer dietary proportion is reported as 68 percent fruit and 32 percent invertebrates (U.S. EPA 1993). For the purposes of this risk assessment, a diet of 100% earthworms will be assumed.

An incidental soil ingestion rate for the American robin could not be found in the literature. However, a soil ingestion rate of 10.4 percent of the diet reported for the American woodcock will be used as a substitute ingestion rate for the American robin (Beyer et al. 1994). Assuming a food ingestion rate of 117.5 g/day, the soil ingestion rate for the American robin is 12.2 g/day.

2.9.5 Red-tailed Hawk (*Buteo jamaciensis*) as Representative of Carnivorous Birds.

Justification

The red-tailed hawk was selected as representative of a carnivorous bird due to its dietary composition, relative abundant distribution, and likelihood of occurrence at the Dry Run Creek site. Its diet allows for the evaluation of contamination in site soils. In addition, the concentration of contaminants found in small mammal tissue will also provide an accurate dose to the red-tailed hawk which allows for the evaluation of contaminants in the food source.

Life History

Red-tailed hawks are the most common and widespread American *Buteo* (Bull and Farrand 1977). Their habitat is highly variable, but they are commonly found in wooded areas near open land. They also inhabit plains, prairie groves, and deserts in the western United States (NGS 1987). This species is absent, however, from tundra, and rare in extensive unbroken forest. An opportunistic feeder, the red-tailed hawk hunts from a perch or, on the wing for

The fathead minnow, *P. promelas*, is widely distributed in North America and is found in a variety of habitats such as small streams, ponds, and small lakes. It is uncommon or absent in streams of moderate and high gradients. It is tolerant of high temperature, high turbidity, and low oxygen concentrations (U.S. EPA 1985).

The fathead minnow is primarily omnivorous. Young typically feed on detritus, algae, and zooplankton. Adults feed on aquatic insects, worms, small crustaceans, and other animals. This species is considered an important food source for other fish and birds (U.S. EPA 1985).

Adult fathead minnows spawn in the spring and continue to spawn throughout most of the summer. The minimum spawning temperature appears to be approximately 16°C. The ovaries of the females contain eggs in all stages of development, and they spawn repeatedly as the eggs mature. The average number of eggs per spawn per female is 100 to 150. Larger females may lay 400 to 500 eggs per spawn. Hatching times depend on temperature and average about six days. In warm water with an ample food supply, spawning may occur as early as the first year. In cooler water with a moderate food supply, spawning usually occurs during the second year. Survival to the third year is relatively uncommon (U.S. EPA 1985).

Exposure Profile

Since direct contact with contaminated water in the toxicity evaluation is the primary route of exposure for fathead minnows in this risk assessment, the results of the test will be used to indicate exposure.

2.9.4 American Robin (*Turdus migratorius*) as Representative of Worm-eating Birds

Justification

The American robin was selected as representative of omnivorous and carnivorous birds because of its ubiquitous distribution and dietary composition. The preference for soil invertebrates in its omnivorous diet allows this species to be used as both an omnivorous and carnivorous receptor in this risk assessment. This species is also likely to occur at the Dry Run Creek site.

Life History

The American robin (*Turdus migratorius*) occurs throughout most of the continental U.S. and Canada, wintering in the southern half of the U.S., Mexico, and Central America. Given the increase in open habitat and lawns, the robin's breeding range has expanded in the recent times. Habitat requirements for breeding robins include access to fresh water, protected nesting sites, and productive foraging areas. These requirements are commonly met in moist forests, swamps, open woodlands, and other open areas. Non-breeding robins occupy similar habitats although proximity to fruit bearing trees is of more importance.

The primary foraging technique for robins is to hop along the ground in search of ground-dwelling invertebrates, although they commonly search for insects and fruit in tree branches as well. The robin's diet during the breeding season consists mainly of invertebrates and some fruit, but fruit is the primary food consumed outside of the breeding season. As robins exhibit a low digestive efficiency for fruit, they often consume more than their own body weight in fruit to meet their metabolic needs (U.S. EPA 1993).

dose to the red fox which allows for the evaluation of contaminants in the food source.

Life History

Red fox inhabit open meadows, ditch banks, field and wood edges, fencerows, stream and lake borders, and farmlands (Hoffmeister 1989; Jones and Birney 1988; Merritt 1987). With the exception of the breeding season, red fox have no permanent home but sleep on the ground (Schwartz and Schwartz 1981). A den, usually modified from an existing woodchuck or fox den, is dug during the breeding season and exceptionally cold winters (Barbour and Davis 1974). These scent-marked dens have multiple rooms, entrances, and trails leading to and from hunting areas (Schwartz and Schwartz 1981). In addition to their dens, both males and females will defend their scent-marked hunting territory from intruders (Jones and Birney 1988).

The red fox is primarily an opportunistic carnivore, consuming food items such as rabbits, opossums, muskrats, skunks, rodents, birds, eggs, carrion, invertebrates, snakes, and frogs (Barbour and Davis 1974; Merritt 1987). Some vegetable matter such as fruits and nuts are also consumed when in season (Jones and Birney 1988). During times of abundant food supply, the red fox will bury surplus food to return to for consumption at a later time (Schwartz and Schwartz 1981).

Male and female foxes pair for life, remaining together from midwinter to summer. Females bear one litter per year usually between March and April (Merritt 1987). Gestation periods last from about 49 to 56 days, with most averaging 53 days (Schwartz and Schwartz 1981). The pups are weaned at about 60 days, leave the den in the autumn, and are sexually mature by their first winter (Merritt 1987). Natural predators of the red fox are few but include large hawks and owls, and possibly coyotes (Merritt 1987; Schwartz and Schwartz 1981). Red fox may live from six to ten years in the wild (Schwartz and Schwartz 1981).

Exposure Profile

Adult red fox weigh from 2.7 to 7 kg (Barbour and Davis 1974; Jones and Birney 1988). Home ranges vary from 245 to 1,235 acres (Merritt 1987).

The food ingestion rates of the red fox range from 0.069 g/g BW/day for a nonbreeding adult to 0.16 g/g BW/day for a juvenile (U.S. EPA 1993). The water ingestion rate for an adult red fox is estimated to be approximately 0.086 g/g BW/day (U.S. EPA 1993). To express these values in units of g/day, the highest reported food ingestion rate of 0.16 g/g BW/day and the water ingestion rate of 0.086 g/g BW/day were multiplied by the lowest reported body weight of 2.7 kg (2,700 g) to yield a food ingestion rate of 432 g/day and a water ingestion rate of 232.2 g/day (232.2 mL/day). For the purposes of this risk assessment, a diet of 100% small mammals will be assumed.

A soil ingestion rate of 2.8 percent of the total diet has been reported (Beyer et al. 1994) for the red fox. To express this value in units of g/day, the soil ingestion rate of 2.8 percent was multiplied by the food ingestion rate of 432 g/day to yield a soil ingestion rate of 12.1 g/day.

2.9.7 Mink (*Mustela vison*) as Representative of Carnivorous Mammals

Justification

USEPA 6904

food items such as small mammals (e.g., mice, chipmunks, rabbits), birds (usually ground-dwelling species), reptiles, insects, and occasionally, prey species that are too heavy to lift off the ground (Burton 1989).

The breeding season starts with aerial courtship displays, commonly followed by mating on a perch and nest-building by both sexes. Nests are placed in tall trees, high rock ledges, or tall cacti and are often refurbished annually for use in consecutive years. Incubation of two to three eggs is carried out by both sexes and lasts for approximately 30 days. The young are able to feed themselves at 4 to 5 weeks and fledge in about 45 days (Bull and Farrand 1977; Burton 1989).

Exposure Profile

Adult male and female red-tailed hawks are reported to weigh 960 g and 1,235 g, respectively (DeGraaf and Rudis 1983; U.S. EPA 1993). Home ranges vary from 148.26 to 395.36 acres (Kirkwood 1980). The lowest reported body weight of 0.960 kg and the smallest reported home range of 148.26 acres were assumed for this risk assessment.

The diet of a red-tailed hawk consists of mammals, birds, reptiles, and insects which vary in importance with season and availability (U.S. EPA 1993). For the purposes of this risk assessment, the hawk will be assumed to consume 100% small mammals. Food ingestion rates are reported to range from 136 to 400 g/day (Kirkwood 1980). The highest reported food ingestion rate of 400 g/day was assumed for this risk assessment. A water ingestion rate of approximately 0.059 g/g BW/day has been estimated for this species (U.S. EPA 1993). To express this value in units of g/day, the water ingestion rate was multiplied by the lowest reported body weight of 960 g to yield a water ingestion rate of 56.64 g/day (56.64 mL/day).

A soil ingestion rate for the red-tailed hawk could not be found in the literature; therefore, the amount of soil predicted to be entrained in the digestive tract of a white-footed mouse was used to calculate this value. A soil ingestion rate of less than 2 percent of the total diet has been reported (Beyer et al. 1994) for the white-footed mouse. From this value, a conservative soil ingestion rate of 1.9 percent of the total diet was assumed for the white-footed mouse. To express this value in units of g/day, the soil ingestion rate of 1.9 percent was multiplied by the food ingestion rate of the white-footed mouse (4.50 g/day) (U.S. EPA 1993) to yield a soil ingestion rate of 0.09 g/day. This value was assumed to represent the amount of soil entrained in the digestive tract of the white-footed mouse that remains constant over time. To express 0.09 g in units of grams of soil per gram of mouse body weight, this value was divided by the lowest reported body weight (13 g) of the white-footed mouse (Merritt 1987) to yield a value of 0.007 g/g BW. This value was then multiplied by the food ingestion rate of the red-tailed hawk (400 g/day) to yield a soil ingestion rate of 2.8 g/day.

2.9.6 Red Fox (*Vulpes vulpes*) as Representative of Carnivorous Mammals

Justification

The red fox was selected as representative of a carnivorous mammal due to its dietary composition, relative abundant distribution, and likelihood of occurrence at the Dry Run Creek site. Its diet allows for the evaluation of contamination in site soils. In addition, the concentration of contaminants found in small mammal tissue will also provide an accurate

The mink was selected as representative of a carnivorous mammal due to its dietary composition, relative abundant distribution, and likelihood of occurrence at the Dry Run Creek site. Its diet allows for the evaluation of contamination in site soils. In addition, the concentration of contaminants found in clams and fish tissue will also provide an accurate dose to the mink which allows for the evaluation of contaminants in the food source.

Life History

Mink are distributed over much of boreal North America, southward throughout the eastern United States and in the west to California, New Mexico, and Texas (Jones and Birney 1988). They can be found in virtually any habitat containing permanent water thus, they are not commonly found in upland areas (Jones and Birney 1988). Although primarily nocturnal, their activity often extends into midday (Hoffmeister 1989).

Dens are always near water, and they are usually an old muskrat burrow or constructed by the mink itself (Jones and Birney 1988). Males tend to live in their own burrows which are less elaborate than ones occupied by females (Barbour and Davis 1974). Home ranges tend to be linear since mink often follow a shoreline (Jones and Birney 1988). Mink are solitary and mark their territories by spraying (Merritt 1987).

Seasonal food availability governs the dietary composition (Barbour and Davis 1974). Their diets may consist of crayfish, frogs, fish, snakes, rodents, rabbits, and plants among other items (Jones and Birney 1988; Schwartz and Schwartz 1981). Crayfish are a major portion of the summer diet in many regions of North America (Barbour and Davis 1981; Jones and Birney 1988; Merritt 1987).

Breeding occurs from January to early April with highly variable gestation periods ranging from 40 to 75 days (Merritt 1987; Schwartz and Schwartz 1981). A highly variable single litter of 1 to 17 young may be produced (Schwartz and Schwartz 1981). Average litter sizes vary among regions (Barbour and Davis 1974; Hoffmeister 1989; Jones and Birney 1988; Merritt 1987; Schwartz and Schwartz 1981). Young are weaned at about five to six weeks of age and are sexually mature by ten months (Merritt 1987; Schwartz and Schwartz 1981). Occasionally great horned owls, foxes, coyotes, bobcats, and dogs will prey on mink (Merritt 1987; Schwartz and Schwartz 1981). Although some individuals have lived up to six years, mink seldom exceed two years of age in the wild (Schwartz and Schwartz 1981).

Effects Profile

Adult mink weigh from 520 to 1,750 g (Merritt 1987; U.S. EPA 1993). Home ranges vary from 19 to 1,900 acres (U.S. EPA 1993).

A year-round food ingestion rate of 0.22 g/g BW/day has been estimated for both male and female mink (U.S. EPA 1993). To express this value in units of g/day, the food ingestion rate was multiplied by the lowest reported body weight (520 g) to yield a food ingestion rate of 114 g/day. An estimated water ingestion rate of 0.11 g/g BW/day was reported for farm-raised females (U.S. EPA 1993). To express this value in units of g/day, this water ingestion rate was multiplied by the lowest reported body weight of 520 g to yield a water ingestion rate of 57.2 g/day (57.2 mL/day). For the purposes of this risk assessment, a diet of 100% fish will be assumed.

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An incidental sediment ingestion rate was not available from the literature; therefore, a predicted incidental ingestion rate for sediment that may be entrained in the digestive system of the prey item (fish) was used for this risk assessment. Consumption of this prey item was assumed to be the primary mechanism by which mink may incidentally ingest sediment. The derivation of the predicted level of incidental sediment ingestion via consumption of fish is described next.

Life history information for the bluegill (*Lepomis macrochirus*) was used to predict the amount of sediment that may be ingested by mink via consumption of fish. Adult bluegills range in size from 100 to 230 mm (Pflieger 1975; Smith 1985). In keeping with the conservative approach of this risk assessment, the amount of sediment entrained in the lowest body size of 100 mm in length was predicted. The weight of a 100 mm bluegill was calculated to be 18.11 g based on the following algorithm relating length to weight (Hillman 1982):

$$\log \text{Weight (g)} = -5.374 + 3.316 \log \text{Length (mm)}$$

A daily food ingestion rate of 1.75 percent BW/day has been reported for the bluegill (Kolehmainen 1974). This provides a predicted intake rate of 0.32 g of food per day for a 18.11 g fish. A study evaluating the stomach contents of 153 bluegills reported an average content of detritus and sediment to be 9.6 percent of the total diet (Kolehmainen 1974). If a conservative assumption is made that 9.6 percent of the food ingested is entirely sediment, it can be predicted that a fish of this size may contain 0.03 g of sediment in its digestive system.

For the purpose of this model, it was assumed that the level of sediment contained in the digestive system of a fish remains constant over time. This value (0.03 g) was divided by the predicted fish body weight (18.11 g) to express sediment entrained in fish digestive systems in units of grams of sediment per gram of fish body weight. This provided a value of 0.0017 g sediment/g body weight. When this value is multiplied by the food ingestion rate of the mink (114 g/day), the predicted sediment ingestion rate for the mink through consumption of fish is 0.2 g/day.

2.9.8 Raccoon (*Procyon lotor*) as Representative of Omnivorous Mammals

Justification

The raccoon was selected as representative of a omnivorous mammal due to its dietary composition, relative abundant distribution, and likelihood of occurrence at the Dry Run Creek site. Its diet allows for the evaluation of contamination in site sediment. In addition, the concentration of contaminants found in forage fish tissue and clams will also provide an accurate dose to the raccoon which allows for the evaluation of contaminants in the food source.

Life History

Raccoons are medium-sized omnivores and are abundant throughout North America. Raccoons prefer aquatic habitats, particularly hardwood swamps, flood plains, freshwater wetlands, and salt marshes (Kaufmann 1982). Raccoons have also adapted well to residential areas and farmlands. Raccoons rely heavily on surface waters for foraging and as a source

of drinking water (Stuewer 1943). Raccoons are active primarily from dusk to dawn (Stuewer 1943) but will alter their activities to opportunistically feed on whatever is available (Sanderson 1987). For example, raccoons living near a salt marsh may become active during the day to take advantage of feeding opportunities during low tide (Ivey 1948). Raccoons feed primarily on fruits, nuts, acorns, grains, insects, frogs, crayfish, and eggs (Palmer and Fowler 1975).

Raccoons in the southern regions of the United States are active year round (Goldman 1950). Adult raccoons are normally solitary but will come together for short periods of time during mating (Kaufman 1982). Mating occurs from March to June in southern areas and each male may mate with several females during each season (Sanderson 1987; Kaufman 1982). Young males are normally not sexually mature in the first breeding season but mature later in the summer, while females mature in the first year (Sanderson 1951).

The home range of a raccoon depends on the animal's age, habitat, food resources, and season (Sanderson 1987). Home ranges are typically a few hundred hectares (ha) but ranges as large as a few thousand ha have been reported (Sanderson 1987). Population densities also depend strongly on the amount of resources in the area. Numbers of 0.1 to 0.2 animals per ha are common (Hoffman and Gottschang 1977).

Raccoons are found near every aquatic habitat. During the last 50 years raccoon populations have increased greatly (Sanderson 1987). In Alabama, adult male raccoons weighed up to 8.8 kilograms (kg) (mean 4.31 kg) while adult females can weigh up to 5.9 kg (mean 3.67 kg) (Johnson 1970). Adult raccoons weigh between 2 and 12 kg (Nowak 1991), and consume 0.5 kg of food per day (Newell et al. 1987).

Raccoons feed primarily on fruits, nuts, acorns, grains, insects, frogs, crayfish, eggs (Palmer and Fowler 1975). In a Maryland forested bottom land, the dietary composition of raccoons during the summer was principally made up of insects (39 percent), wild cherry (17 percent), blackberries (16 percent), crayfish (8 percent), snails (5 percent), herptiles (5 percent), fish (2 percent), rodents (2 percent), corn (1 percent), and trace amounts of *Smilax*, acorns and pokeberry (Llewellyn and Uhler 1952). At Washington state tidewater area raccoons displayed the following dietary composition: molluscs, mussels and oyster (44 percent), Crustacea, shrimp and crabs (25 percent), fish (9 percent), marine worms (20 percent), and Echiurida worms (1 percent) (Tyson 1950).

The home range of a raccoon depends on the animal's age, habitat, food resources, and season (Sanderson 1987). Home ranges are typically a few hundred hectares but ranges as large as a few thousand hectares have been reported (Sanderson 1987). The home range for adult male raccoon found in coastal Georgia raccoons is approximately 65 ha ($\pm$ 18 SE) while the home range for adult females in the same area is approximately 39 ha ($\pm$ 16 SE) (Lotze 1979). Population densities also depend strongly on the amount of resources in the area. Numbers of 0.1 to 0.2 animals per hectare is common (Hoffman and Gottschang 1977).

Exposure Profile

For the purposes of this risk assessment, a body weight of 2 kg, an ingestion rate of 0.5 kg/day, and a diet of 80 percent forage fish and 20 percent clams were assumed. A soil ingestion rate of 9.4 percent of the diet has been reported for raccoons (Beyer et al. 1991). Multiplying the ingestion rate by 9.4 percent yields a sediment ingestion rate of 0.047 kg/day.

A daily water ingestion rate of 0.18 Liters per day (L/day) was calculated using an allometric equation derived by Calder and Braun (1983). A diet of 100% fish will be assumed.

2.9.5 Short-tailed Shrew (*Blarina brevicauda*) as Representative of Insectivorous Mammals

Justification

The short-tailed shrew was selected as representative of insectivorous mammals because of its dietary composition, relative abundant distribution in both moist and dry habitats, and likelihood of occurrence at the Dry Run Creek site. Although their diets may consist of plants as well as insects, they tend to favor soil invertebrates when they are in abundance. Hence, by assuming that their dietary composition comprises solely invertebrates in this risk assessment, this species may represent an insectivorous mammal.

Life History

The short-tailed shrew is an extremely active, large, and heavy-bodied shrew common within its range (Jones and Birney 1988). It occupies a variety of moist and dry habitats such as marshes, bogs, moist forest floors with ample decaying matter, brushland, fencerows, weedfields, and pastures (Barbour and Davis 1974; Jones and Birney 1988). Short-tailed shrews are active both day and night throughout the year, although most of this activity is subnivian (Merritt 1987). During harsh winters, this species may undergo a period of torpor (Hoffmeister 1989).

The home range of this species varies with their dramatic population cycles. In peak years, animal density may be greater than 25 individuals per acre (Schwartz and Schwartz 1981). In other years, this species may have an animal density of one individual per acre (Merritt 1987).

Although short-tailed shrews strongly prefer animal matter, they are opportunistic omnivores and will voraciously consume whatever food items are in ample supply (Barbour and Davis 1974). These food items include earthworms, slugs, snails, insects, arthropods, fungi, vegetable matter, seeds, snakes, salamanders, small mammals, and young birds (Barbour and Davis 1974; Jones and Birney 1988; Schwartz and Schwartz 1981). Plant matter is generally consumed to a greater extent in winter (Schwartz and Schwartz 1981). In some regions, plant matter may constitute up to 20 percent of the shrew's diet (Barbour and Davis 1974). Submaxillary glands produce a venom that quickly immobilizes their prey (Merritt 1987). Prey items that are not consumed immediately are stored in a cache (Merritt 1987).

Using echolocation and scent-marking, short-tailed shrew rely heavily on their hearing and sense of smell to locate food and to move about (Hoffmeister 1989). An elaborate system of runways and tunnels are constructed usually just a few inches below the ground surface (Schwartz and Schwartz 1981). Two types of nests are built by this species, a breeding nest and a resting nest. Both nests are built underground beneath a log, rock, or other cover, and have multiple entrances. The breeding nest is typically larger than the resting nest (Merritt 1987).

Breeding appears to commence in early spring and extend into the fall, although in some regions, breeding may subside in early and midsummer but peak again in early fall (Hoffmeister 1989; Jones and Birney 1988). Gestation periods are approximately 21 to 22

days with litter sizes of approximately four to ten young (Jones and Birney 1988; Schwartz and Schwartz 1981). The young are fully mature from one to three months of age (Barbour and Davis 1974; Schwartz and Schwartz 1981). Both sexes may breed their first spring (Schwartz and Schwartz 1981).

Natural predators of the short-tailed shrew include fish, snakes, owls, hawks, shrikes, opossums, raccoons, foxes, weasels, bobcats, skunks, and feral cats, although most of these predators do not consume the shrew (or at least all of the shrew) because of their distasteful musk glands (Barbour and Davis 1974; Jones and Birney 1988; Merritt 1987; Schwartz and Schwartz 1981). The life expectancy of a short-tailed shrew in the wild is approximately one year (Schwartz and Schwartz 1981).

Exposure Profile

Adult short-tailed shrews weigh from 12 to 30 grams (g) (Jones and Birney 1988; Merritt 1987). Home ranges vary from 0.5 to 1 acre (Merritt 1987). Therefore, it was assumed that a short-tailed shrew could obtain 100 percent of its diet from the contaminated area (area use factor of 1), since the area comprising the on-site sampling locations was approximately 20 acres.

Food ingestion rates ranging from 0.49 to 0.62 gram per gram of body weight per day (g/g BW/day) have been reported (U.S. EPA 1993). An average food ingestion rate of 7.95 g/day has also been reported (U.S. EPA 1993). To express the former food ingestion rates in units of g/day for comparison to the latter ingestion rate, the former ingestion rates were multiplied by the lowest reported body weight of 12 grams to yield food ingestion rates of 5.88 to 7.44 g/day. Of these values, the highest food ingestion rate of 7.95 g/day will be used for the purposes of this risk assessment.

A water ingestion rate of 0.223 g/g BW/day has been reported (U.S. EPA 1993). To express this value in units of g/day, the water ingestion rate was multiplied by the lowest reported body weight of 12 g to yield a water ingestion rate of 2.7 g/day (2.7 milliliters per day [mL/day]).

A soil ingestion rate for the short-tailed shrew was not available from the literature, therefore, the soil ingestion rate of the opossum was used. The opossum's diet is similar to that of the short-tailed shrew since they are both opportunistic omnivores with a strong preference for animal matter (Schwartz and Schwartz 1981). A soil ingestion rate of 9.4 percent of the diet was reported for the opossum (Beyer et al. 1994). This value was multiplied by the highest food ingestion rate of the short-tailed shrew (7.95 g/day) to yield a soil ingestion rate of 0.74 g/day. For the purposes of the food chain model in this risk assessment, it was assumed that 100 percent of the diet of the short-tailed shrew was comprised of earthworms.

2.9.10 Meadow Vole (*Microtus pennsylvanicus*) as Representative of Herbivorous Mammals

Justification

The meadow vole was selected as representative of herbivorous mammals because of its dietary composition, abundance in North America, preference for moist areas, and likelihood of occurrence at the Dry Run Creek site.

Life History

The meadow vole is one of the largest and most abundant voles in North America (Jones and Birney 1988; Merritt 1987). Although they are more commonly found in habitats such as moist meadows, bogs, swamps, stream banks, and lakeshores, they have also been known to inhabit cultivated fields, roadside ditches, and fencerows (Barbour and Davis 1974; Jones and Birney 1988; Merritt 1987; Schwartz and Schwartz 1981). Dense vegetative cover appears to be one of the major prerequisites for habitation (Hoffmeister 1989; Jones and Birney 1988).

The home range of the meadow vole varies in size with season, habitat, and population size (Jones and Birney 1988). Populations tend to fluctuate drastically every two to five years, with peak population density levels exceeding 100 voles per acre (Barbour and Davis 1974; Jones and Birney 1988). Activity occurs during both day and night, and throughout the year, although it is greatest at dawn and dusk (Barbour and Davis 1974). Well-worn intersecting runways under vegetative cover are distinctive of meadow vole inhabitation (Jones and Birney 1988). Elaborate spherical nests are commonly built aboveground in the center of a tussock of grass, although underground nests are also built in drier areas (Barbour and Davis 1974; Jones and Birney 1988).

The meadow vole is herbivorous, feeding primarily on grasses, sedges, legumes, tubers, and roots (Merritt 1987); however, insectivory and cannibalism have been reported in some individuals (Barbour and Davis 1974; Hoffmeister 1989). Bluegrass (*Poa* sp.) is a major component of the diet in some regions (Jones and Birney 1988; Hoffmeister 1989). This species hoards food for the winter in above- and below-ground caches (Merritt 1987).

The meadow vole is one of the most prolific mammals, producing litter after litter in rapid succession (Barbour and Davis 1974). Breeding occurs during the warmer months of the year (Jones and Birney 1988). The gestation period is about 21 days with litter sizes ranging from 1 to 11 young (averaging four to seven) (Barbour and Davis 1974; Jones and Birney 1988). The helpless young mature rapidly and may breed by 25 days of age (Barbour and Davis 1974).

Meadow voles are preyed upon by nearly all species of predatory birds and mammals (Barbour and Davis 1974). These predators include owls, hawks, shrikes, bluejays, crows, foxes, weasels, mink, cats, raccoons, skunks, opossums, shrews, and snakes (Barbour and Davis 1974; Merritt 1987). Due to heavy predation, only a small proportion of the population exceeds sixty days of age (Schwartz and Schwartz 1981).

Exposure Profile

Adult meadow voles weigh from 20 to 65 grams (Merritt 1987; U.S. EPA 1993). The home range of this species varies from less than one acre to 3.2 acres (Merritt 1987). Therefore, it was assumed that a meadow vole could obtain 100 percent of its diet from the contaminated area (area use factor of 1), since the area comprising the on-site sampling locations was approximately 20 acres.

A food ingestion rate ranging from 0.30 to 0.35 g/g BW/day, and a mean water ingestion rate of 0.21 g/g BW/day is reported for this species (U.S. EPA 1993). To express these values in units of g/day, the highest reported food ingestion rate of 0.35 g/g BW/day and the water

ingestion rate of 0.21 g/g BW/day were multiplied by the lowest reported body weight of 20 g to yield a food ingestion rate of 7.0 g/day and a water ingestion rate of 4.2 g/day (4.2 ml/day).

A soil ingestion rate of 2.4 percent of the total diet has been reported (Beyer *et al.* 1994) for the meadow vole. To express this value in units of g/day, the soil ingestion rate of 2.4 percent was multiplied by the food ingestion rate of 7.0 g/day to yield a soil ingestion rate of 0.17 g/day.

For the purposes of the food chain model in this risk assessment, it was assumed that 100 percent of the diet was comprised of plants.

3.0 ASSUMPTIONS

This risk assessment evaluates exposure to contaminants through food and incidental sediment/soil ingestion. The following conservative assumptions were made to conduct this risk assessment in the absence of site-specific data:

- The maximum of the contaminant levels measured in sediment, soil, or water collected on site was used in risk calculations.
- The maximum concentrations of COCs reported in sediment, soil, water, and biota were assumed to be present site-wide.
- An area use factor (AUF) of 1 was assumed for all species using the site for feeding.
- Contaminants were assumed to be 100 percent bioavailable.
- Dietary composition information was obtained from the literature for the receptor species. However, simplifications of complex diets were performed for the receptors.
- A literature search was conducted to determine the chronic toxicity of the contaminants of concern when ingested by the indicator species. If no toxicity values could be located for the receptor species, values reported for a closely related species were used. All studies were critically reviewed to determine whether study design and methods were appropriate. When values for chronic toxicity were not available, LD₅₀ (median lethal dose) values were used. For purposes of this risk assessment, a factor of 100 was used to convert the reported LD₅₀ to a No Observed Apparent Effect Level (NOAEL). A factor of 10 was used to convert a reported Lowest Observed Adverse Effect Level (LOAEL) to a NOAEL, and a factor of 10 was used to convert a reported LD₅₀ to a LOAEL. If several toxicity values were reported for a receptor species, the most conservative value was used in the risk calculations regardless of toxic mechanism. Toxicity values obtained from long-term feeding studies were used in preference to those obtained from single dose oral studies. No other safety factors were incorporated into this risk assessment.
- In some cases, contaminant doses were reported as part per million contaminant in diet. These were converted to daily intake (in milligrams per kilogram body weight per day; mg/kg-day) by using the formula:

$$\text{Intake (mg/kg/day)} = \text{Contaminant Dose (mg/kg diet)} \times \text{Ingestion Rate (kg/day)} \times 1/\text{Bodyweight (kg)}$$

This conversion allows dietary toxicity levels cited for one species to be converted to a daily dose for a different species based on body weight. For the purposes of this risk assessment, incidental soil/sediment ingestion was also included in the calculation to determine the total daily intake for the receptor species. This daily dose may then be used to evaluate the risk to other species if no specific toxicity data are available for a target receptor.

- Some contaminants of concern (e.g. aluminum) are not food chain accumulators, but instead are direct toxins when ingested at the presented levels.

4.0 EFFECTS PROFILE

Many contaminants detected at the Dry Run Creek site do not have benchmarks. This excluded them from further consideration in this risk assessment, but does not exclude them as potential contaminants of concern. Based on the results of the preliminary risk assessment, the following compounds were considered COCs and their toxic effects are presented next: fluoride, trichlorofluoromethane, aluminum, arsenic, beryllium, chromium, copper, iron, lead, manganese, nickel, vanadium, and zinc. Based on the chemistry results, these compounds will be further evaluated using food chain accumulation models. Contaminants exceeding their respective benchmarks are assumed to be affecting receptor species and negatively impacting species, populations, and communities in the aquatic and terrestrial ecosystems at the Dry Run Creek site.

4.1 Fluoride

Maurer et al (1990) identified skeletal and dental abnormalities in rats that were exposed to sodium fluoride for a period of 99 weeks. The LOAEL identified in this study was 4 mg F/kg BW/day. A NOAEL was calculated from the LOAEL using an accepted conversion factor of 10. Based on these results, a LOAEL of 4mg/kg BW/day and an estimated NOAEL of 0.4/kg BW/day will be used to evaluate the risk posed by fluoride mammalian receptors

Fleming et al. (1987) found significant growth rate reduction in European starling fed a diet containing as low as 13 mg F/kg BW/day. No effects were observed at 10 mg F/kg BW/day. As such, this risk assessment will estimate fluoride related risk using a LOAEL of 13 mg/kg BW/day and a NOAEL of 10 mg/kg BW/day.

4.2 Organofluorides

No studies pertaining to the dietary toxicity of trichlorofluoromethane or any other fluorinated organic compound was found in the literature.

4.3 Aluminum

Dixon et al. (1979) conducted a study that evaluated the reproductive success of rats exposed to aluminum in drinking water for 90 days prior to breeding. The highest dose administered was 77.5 milligrams per kilogram body weight per day (mg/kg BW/day) and did not result in reproductive abnormalities. Lal et al. (1993) conducted a 180-day drinking water study in which rats were exposed to 55 mg/kg BW/day of aluminum. At this dose, behavioral effects were observed, including a significant reduction in spontaneous locomotor activity and significant deficits in acquisition and retention of learned responses. Based on these results, a LOAEL of 55 mg/kg BW/day and an estimated NOAEL of 5.5 mg/kg BW/day will be used to evaluate the risk posed by aluminum to mammalian receptors (Table 1).

No effects were observed when Japanese quail were fed a diet containing 0.05 percent (84 mg/kg BW/day) aluminum for four weeks (Hussein et al. 1988). When quail were fed a diet containing 0.1 percent (165 mg/kg BW/day) aluminum, a decrease in egg shell breaking strength was observed. Finally, when quail were fed a diet containing 0.15 percent (257 mg/kg BW/day) aluminum, a decrease in body weight, egg shell strength, and egg shell production was observed. A 48-day feeding study using chickens concluded that dietary levels of 28.4 mg/kg BW/day aluminum resulted in a decrease in weight gain, feed intake, and plasma inorganic phosphorus, as well as an increase in plasma calcium (Hussein 1990). However, only the altered metabolism of calcium and phosphorus could be attributed to the direct effects of aluminum. The associated NOAEL for this effect is 22.8 mg/kg BW/day. Because a range of concentrations were used and the endpoints were ecologically significant and related to the dose, the study by Hussein et al. (1988) was used to develop the NOAEL and LOAEL values. A NOAEL of 84 mg/kg BW/day and a LOAEL of 165 mg/kg BW/day will be used to evaluate the risk posed by aluminum to avian receptors (Table 1).

4.4 Arsenic

Several studies were located which determined the effects of As to mammals. A study conducted on cats indicated that a chronic oral toxicity dose was 1.5 mg/kg BW/day (Pershagen and Vahter 1979). In addition, National Resources Council of Canada (1978) states that mammals in general have oral LD₅₀s that range from 10 to 50 mg/kg of lead arsenate. A study conducted on mice indicated an oral dose LD₅₀ of 39.4 mg/kg BW/day and an oral dose LD₀ of 10.4 mg/kg BW/day after 96 hours (NAS 1977). For the purposes of this risk assessment, the chronic value for the cat was used to calculate HQs for mammals (1.5 mg/kg BW/day). This value was converted to a NOAEL by dividing by a factor of 10.

Eisler (1988a) reviewed several studies in which the toxicity of inorganic arsenicals were measured. Inorganic As is more mobile than organic As and may pose greater risk by leaching into surface water. Studies were also described in which organoarsenical compounds were measured. Studies indicate that sensitive species include the California quail (single oral dose LD₅₀ of 47.6 mg/kg BW/day) (Hudson et al. 1984) and chicken (single oral dose LD₅₀ of 33 mg/kg BW/day) (NAS 1977). For the purposes of this risk assessment, a value of 3.3 mg/kg BW/day was used to determine the HQ to birds. This value was converted to a NOAEL by dividing by a factor of 10.

4.5 Beryllium

Two separate chronic dietary exposure studies using rats reported similar musculoskeletal effects. Guyatt et al. (1933) fed large amounts of beryllium carbonate to rats at concentrations of 10, 20, 40, 80, 160, and 240 mg/kg BW/day. Rats from all exposure levels developed rickets, with the fragility of the bones varying directly with the exposure concentration. Similar results were reported by Jacobson (1933) who reported severely weakened bones in rats fed beryllium carbonate at dietary levels of 121 and 242 mg/kg BW/day.

For this risk assessment, a dietary exposure level of 10 mg/kg BW/day was used to estimate risk of beryllium to the short-tailed shrew. A NOAEL of 0.10 mg/kg BW/day was derived from this LOAEL using an accepted conversion factor of 10.

No studies pertaining to the dietary toxicity of beryllium to avian receptors were found in the literature.

4.6 Chromium

USEPA 6913

Heinz and Haseltine (1981) exposed 2- to 3-year old breeding pairs of black ducks (*Anas rubripes*) to a diet containing 0, 20, or 200 mg/kg, wet weight, (0, 2.77, or 27.77 mg/kg BW/day) of Cr^{+3} as chromium potassium sulfate [$\text{CrK}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$] for a period of approximately five months, until the onset of egg-laying by the females. Hatched ducklings were then fed a mash diet containing the same Cr concentrations that the parents were fed. Seven-day old chicks were tested for avoidance behavior in response to a fright stimulus. None of the Cr concentrations resulted in alteration of avoidance behavior.

However, Haseltine et al. (1985), in an unpublished study reported by Eisler (1986a) notes that black duck ducklings suffered reduced survival and altered growth patterns when exposed to 10 mg/kg and 50 mg/kg of an unspecified Cr^{+3} compound in their diets. The percent reduction in survival and a detailed explanation of the altered growth patterns were not available in this unpublished study.

For the purposes of this risk assessment, dietary levels of 10 mg/kg (1 mg/kg BW/day) of Cr in prey was used as a LOAEL for the avian species. However, due to the conflicting results, a NOAEL was derived from the same study in which the LOAEL was selected to maintain a degree of consistency regarding the Cr species evaluated. A NOAEL of 0.1 mg/kg BW/day was derived from the LOAEL using a conversion factor of 10.

A study conducted with dogs indicated that 2.5 mg/kg/day of Cr^{+6} ingested in the diet caused death (Steven et al. 1976). For the purposes of this risk assessment, a LOAEL of 0.25 and a NOAEL of 0.025 were used for the red fox, raccoon, and mink.

4.7 Copper

One study was located which determined the effects of ingestion of Cu to mammalia species. An oral dose of 100 mg/kg/day to a dog caused death (OHMD 1987). For the purposes of this risk assessment, a LOAEL of 10 mg/kg/day was used and a NOAEL of 1 mg/kg/day were used for the exposure of mammals.

Several studies were located which determined the effects of Cu on chickens. A dose of 350 mg/kg (61.3 mg/kg/day) caused a significant decrease in growth and food consumption (Smith 1969). Another study found that a dose of 325 mg/kg (23.5 mg/kg/day) caused respiratory problems (Hatch 1978). Assuming that respiratory problems are an acute effect, a LOAEL of 2.35 mg/kg/day and a NOAEL of 0.235 mg/kg/day were used to determine risk to avian species.

4.8 Iron

No studies pertaining to the dietary toxicity of iron to mammalian or avian receptors were found in the literature.

4.9 Lead

The gastric motility of adult male and female red-tailed hawks fed 0.82 and 1.64 mg Pb/kg BW/day in a single oral dose was evaluated through the use of surgically implanted transducers for a period of three weeks following the dose. Neither concentration had any effect on gastric contractions or egestion of undigested material pellets (Lawler et al. 1991).

A study conducted on red-tailed hawk found that 3 mg/kg/day of Pb caused the clinical symptoms of Pb poisoning (Reiser and Temple 1981). A similar study found that 3 mg/kg/day fed to starlings caused a reduction in muscle condition and altered their feeding activity (Osborne et al. 1983). For

the purposes of this risk assessment, a LOAEL of 3 mg/kg/day was used to determine risk to avian species and a NOAEL of 0.3 was used.

Several studies were located which determined the effects of Pb ingestion to mammals. A study conducted on mice indicated that 1.5 mg/kg/day of Pb caused a reduction in success of implanted ova (Clark 1979). Another study found that 2.2 mg/kg/day caused a reduction in the frequency of pregnancy when the dose was administered 3 to 5 days following mating (Clark 1979). For the purposes of this risk assessment, a NOAEL of 0.15 mg/kg/day and a LOAEL of 1.5 mg/kg/day were used to determine risk to mammals.

4.10 Manganese

The effects levels for manganese toxicity vary widely, most likely attributable to the form of manganese tested. Rats exposed to 13 mg/kg BW/day of manganese as $MnSO_4$ in their diet for 224 days exhibited reduced testosterone levels (Laskey et al. 1982). In mice, a dietary level of 140 mg/kg BW/day, also of $MnSO_4$ for 90 days resulted in decreased activity (Gray and Laskey 1980). A much higher exposure concentration of 2,300 mg/kg BW/day of manganese as $MnCl_2$ resulted in reduced dopamine levels (Gianutsos and Murray 1982).

In contrast, levels as high as 930 mg/kg BW/day of manganese as $MnSO_4$ for 103 weeks had no effect on the respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal, hepatic, renal, dermal, and ocular systems of mice (Hejmancik et al. 1987).

For this risk assessment, a dietary exposure level of 13 mg/kg BW/day will be used as a LOAEL to estimate risk of manganese to the selected mammalian receptor. A NOAEL of 1.3 mg/kg BW/day was derived from this LOAEL using an accepted conversion factor of 10.

No studies pertaining to the dietary toxicity of manganese to an avian receptor were found in the literature.

4.11 Nickel

Several studies were available which determined the effects of Ni ingestion to mammals. Wistar rats fed Ni sulfate indicated a NOAEL of 187.5 mg/kg/day to most systems except for body weight. This level of Ni sulfate caused a 27 to 29 percent decreased body weight (Ambrose et al. 1976). In a similar study with a beagle, a NOAEL of 62.5 mg/kg/day was noted (Ambrose et al. 1976). For the purposes of this risk assessment a NOAEL of 62.5 mg/kg/day was used to determine risk to mammals. This value was converted to a LOAEL of 625.0 mg/kg/day by multiplying the NOAEL by a factor of 10.

No studies were available that determined the dose of Ni to avian species. Therefore, the risk to avian species from ingested Ni will not be determined.

4.12 Vanadium

Gavage studies in mice have found an LC50 of 31 mg Vn/Kg diet (Schroeder and Balassa 1967). This dose was converted to a LOAEL of 3.1 mg/kg and a NOAEL of 0.31 using an accepted factor of 10 conversion. This food dose was converted to a daily dose by multiplying the LOAEL or NOAEL concentration by an ingestion rate commonly observed in mice (0.003 kg of food/day) and then by the inverse of the body weight (0.025 kg)(RTECS 1985). This calculation resulted in a LOAEL of 0.372

mg V/kg BW/day and a NOAEL of 0.0372 mg V/kg BW/day. These values will be used to estimate risk to mammalian receptors in this risk assessment.

Rosomer (1960) exposed chickens to varying concentrations of vanadium. The study involved feeding 4 replicates of 13 chickens varying concentrations of vanadium for a period of 21 days. The study found that a dietary level of 40 mg/kg in the diet resulted in a marked depression in weight gain and efficiency of food utilization. At levels of 200 mg/kg, mortality was noted in all test chickens. The authors reported that a dietary level of 20 mg/kg could be tolerated with no resultant toxic effects. This dietary level was converted to a daily dose as above by multiplying the dietary concentration by a representative chicken ingestion rate (0.140 kg/day) and then by the inverse of the body weight (0.800 kg) (RTECS 1985). This calculation resulted in LOAEL of 7 mg V/kg BW/day and a NOAEL of 3.5 mg V/kg BW/day. These values will be used to estimate risk to avian receptors.

4.13 Zinc

Several studies were available which determined the effects of ingested Zn to birds. A concentration of 144.5 mg/kg/day caused a decrease in growth and anemia in chickens (Stahl et al. 1989). In a similar study conducted on chickens, a concentration of 361 mg/kg/day caused a reduction in body weight (Dean et al. 1991). In a study conducted on Japanese quail, a concentration of 139 mg/kg/day caused 7 percent mortality in chicks and reduced food intake (Hill and Camardese 1986). For the purposes of this risk assessment, a LOAEL of 139 mg/kg/day was used to determine the effects to avian species. This value was converted to a NOAEL of 13.9 mg/kg/day by dividing the LOAEL by a factor of 10.

A study conducted on dogs, indicated that 1,000 mg/kg (25 mg/kg/day) caused no effects after one year (NAS 1979). For the purposes of this risk assessment, a LOAEL of 250 and a NOAEL of 25 were used to determine risk to the fox and the mouse. In a study conducted on ferrets, a dose of 370 mg/kg/day caused a decrease in food intake and weight loss. Because the ferret is similar to the mink, a LOAEL of 370 mg/kg/day was used and a NOAEL of 37 was used to determine risk to the mink.

5.0 RISK CHARACTERIZATION

The following method was used to calculate risk. To estimate the risk to wildlife in the model systems utilizing the Dry Run Creek site, implications of the exposure concentrations need to be determined. The HQ method (U.S. EPA 1989, Barnhouse et al. 1986) compares exposure concentrations to ecological endpoints such as reproductive failure or reduced growth. The comparisons are expressed as ratios of potential intake values to population effect levels, or:

$$\text{Hazard Quotient (HQ)} = \frac{\text{Mean Exposure Concentration}}{\text{No Observed Adverse Effect Level (NOAEL)}}$$

A HQ greater than one indicates that exposure to the contaminant has the potential to cause adverse effects in the organism. A HQ less than one does not indicate a lack of risk. The HQ should be interpreted based on the severity of the effect reported. The results of the risk characterization are presented next.

5.1 Benthic Invertebrate Community Structure and Function

The benthic invertebrate community in Dry Run appears to be at risk for two reasons. The benthic community survey showed a decrease in community taxonomic diversity and abundance in Dry Run as compared to the Reference stream. Since land use and available habitat are the same along both

streams, the decrease in diversity and abundance in Dry Run may be attributed to contamination present in sediments in Dry Run. In addition, the amphipod toxicity test clearly demonstrates that acute exposure sub-lethal effects can be produced in the benthic community, especially under conditions present in Tributary A and in Area II. The observed negative growth effect was significantly negatively correlated with fluoride, aluminum, calcium, magnesium, nickel, potassium, and sodium. Further, there were strong negative associations between the growth endpoint and chromium, copper, lead, and zinc concentrations, although the relationships were not significant at the 0.10 level. Since the sediments closer the landfill along the whole Dry Run reach appear to be enriched with metals, the observed toxicity may represent a significant threat.

5.2 Soil Invertebrate Community Structure and Function

The soil invertebrate community does not appear to be at risk based on current soil conditions at Dry Run. The earthworm toxicity test identified no problems with survival or growth.

5.3 Fish Communities

The fish community at Dry Run may be at risk. Results of the fathead minnow toxicity bioassay show that water conditions in Upper Tributary A induce mortality to larval fish. This mortality could not directly be associated with a suite of contaminants as in the amphipod test, but survival was negatively correlated with potassium concentrations, however this correlation was not statistically significant at the 0.10 level. There was a significant positive correlation between fathead survival and iron concentrations in the filtered water samples. Low species diversity and abundance observed during the electroshocking effort may be reflected by the results of the toxicity test.

5.4 Worm-eating Birds

A conservative risk assessment model based on wet-weight concentrations of contaminants for the Dry Run Creek site has determined that worm-eating birds may be at risk due to ingestion of contaminated forage, soil, and water. The model predicts that aluminum, chromium, copper, lead, vanadium, zinc, and fluoride are risk factors based on conservative inputs. By default, beryllium, iron, manganese, nickel, and trichlorofluoromethane are risk factors due to lack of toxicological benchmarks for these compounds. Food chain risk calculations and resultant hazard quotients are presented in Table 42.

5.5 Carnivorous Birds

A conservative risk assessment model based on wet-weight concentrations of contaminants for the Dry Run Creek site has determined that carnivorous birds may be at risk due to ingestion of contaminated forage, soil, and water. The model predicts that aluminum, chromium, copper, lead, zinc, and fluoride are risk factors based on conservative inputs. By default, beryllium, iron, manganese, nickel, vanadium, and trichlorofluoromethane are risk factors due to lack of toxicological benchmarks for these compounds. Food chain risk calculations and resultant hazard quotients are presented in Table 42.

5.6 Carnivorous Mammals (Terrestrially feeding)

A conservative risk assessment model based on wet-weight concentrations of contaminants for the Dry Run Creek site has determined that carnivorous mammals may be at risk due to ingestion of contaminated forage, soil, and water. The model predicts that aluminum, chromium, copper, lead,

manganese, vanadium, and fluoride are risk factors based on conservative inputs. By default, iron and trichlorofluoromethane are risk factors due to lack of toxicological benchmarks for these compounds. Food chain risk calculations and resultant hazard quotients are presented in Table 42.

5.7 Piscivorous Mammals

A conservative risk assessment model based on wet-weight concentrations of contaminants for the Dry Run Creek site has determined that piscivorous mammals may be at risk due to ingestion of contaminated forage, soil, and water. The model predicts that chromium, manganese, and fluoride are risk factors based on conservative inputs. Trichlorofluoromethane is not considered a risk factor because it was not detected in site sediments. Food chain risk calculations and resultant hazard quotients are presented in Table 42.

5.8 Omnivorous Mammals

A conservative risk assessment model based on wet-weight concentrations of contaminants for the Dry Run Creek site has determined that omnivorous mammals may be at risk due to ingestion of contaminated forage, soil, and water. The model predicts that arsenic, chromium, copper, manganese, vanadium, and fluoride are risk factors based on conservative inputs. Trichlorofluoromethane is not considered a risk factor because it was not detected in site sediments. Food chain risk calculations and resultant hazard quotients are presented in Table 42.

5.9 Insectivorous Mammals

A conservative risk assessment model based on wet-weight concentrations of contaminants for the Dry Run Creek site has determined that insectivorous mammals may be at risk due to ingestion of contaminated forage, soil, and water. The model predicts that aluminum, chromium, copper, lead, manganese, vanadium and fluoride are risk factors based on conservative inputs. By default, iron, and trichlorofluoromethane are considered risk factors due to lack of toxicological benchmarks for these compounds. Food chain risk calculations and resultant hazard quotients are presented in Table 42.

5.10 Herbivorous Mammals

A conservative risk assessment model based on wet-weight concentrations of contaminants for the Dry Run Creek site has determined that herbivorous mammals may be at risk due to ingestion of contaminated forage, soil, and water. The model predicts that aluminum, chromium, lead, manganese, and fluoride are risk factors based on conservative inputs. By default, iron, vanadium, and trichlorofluoromethane are considered risk factors due to lack of toxicological benchmarks for this compound. Food chain risk calculations and resultant hazard quotients are presented in Table 42.

6.0 UNCERTAINTY ANALYSIS

There are factors inherent in the risk assessment process which contribute to uncertainty and need to be considered when interpreting results. Major sources of uncertainty include natural variability, error, and insufficient knowledge.

Error can be introduced by use of invalid assumptions in the conceptual model. Conservative assumptions were made in light of the uncertainty associated with the risk assessment process. This was done to minimize the possibility of concluding that no risk is present when a threat actually does exist (e.g., elimination of false negatives). Whenever possible, risk calculations were based on conservative values. For example, NOAELs

used to calculate HQs were the lowest values found in the literature, regardless of toxic mechanism.

An important contributor to uncertainty is the incompleteness of the data or information upon which the risk assessment is based. Risk calculations are based on maximum COC levels in sediment, water, and soil samples.

Literature values for the toxicity of COCs were not available for all receptor species. An attempt was made to identify studies using closely related species to make risk estimates for the selected receptors. Species respond differently to exposure to toxins; responses to COCs by the indicator species may be different from species for which the toxicity data are reported. Methodological problems were also apparent in several of the studies from which NOAELs were obtained. Unfortunately, studies which were more suitable for this assessment were not found for some of the selected receptors.

A literature search was conducted to identify appropriate NOAELs and LOAELs for this risk assessment. The values used to calculate HQs were the lowest values found in the literature. In many of the studies reviewed, adverse effects were observed at the lowest exposure concentration. This made it impossible to identify appropriate NOAELs for some receptors. In these cases, a factor of 10 was used to convert the LOAEL to a NOAEL, which adds uncertainty to the NOAEL-based calculations.

Doses in toxicological studies can be reported in units of mg contaminant/kg diet, or in units of mg contaminant/kg body weight/day. All doses reported as mg/kg in diet were converted to units of mg/kg BW/day. If body weights were reported for the test animals in a given study, these values were used for making this conversion. Otherwise, the body weight and ingestion rate for the species reported in other literature sources were used.

Another source of uncertainty arises from the use of toxicity values reported in the literature which are derived from single-species, single-contaminant laboratory studies. Prediction of ecosystem effects from laboratory studies is difficult. Laboratory studies cannot take into account the effects of environmental factors which may add to the effects of contaminant stress. NOAELs were generally selected from studies using single contaminant exposure scenarios. Species utilizing the Dry Run Creek site are exposed to a variety of contaminants.

There is very little information available in the literature regarding the rates of incidental soil/sediment ingestion for wildlife species. In this risk assessment, most of these values were based on estimates reported for species similar to the indicator species.

Exposure concentrations were calculated for each target receptor species based on levels of contaminants detected in site media, daily food ingestion rates, incidental soil/sediment ingestion rates, and body weight reported in the literature.

This ecological risk assessment was conducted with the intent of completing a baseline risk assessment. In this risk evaluation it is concluded that a "potential ecological risk" exists if the HQ calculated from the maximum area concentration and the NOAEL equals or exceeds one. Within the calculation spreadsheets, alternate calculations were made using LOAEL toxicity benchmarks.

7.0 CONCLUSIONS

7.1 Benthic Invertebrate Community Structure and Function

Data from both the benthic survey and the toxicity tests indicate that fluoride and metal contamination may be a significant problem in Dry Run. Numerous fish kills historically reported in Dry Run also

provide evidence for potential effects on the benthic community.

7.2 Soil Invertebrate Community Structure and Function

The structure and function of the soil invertebrate community does not appear to be at risk under current conditions found at the Dry Run Creek site. However, since earthworms comprise a significant amount of the forage base of some organisms (e.g. American robins, short-tail shrews, etc.), food chain problems may result from contaminants being tied up in the earthworm tissue. Based on our food chain models, it appears that this may be the case.

7.3 Fish Communities

It was shown through the results of the fathead minnow bioassay, that larval fish were susceptible to contamination currently present near the landfill outfall at Dry Run. This finding is further supported by the results of the benthic invertebrate toxicity tests, where toxicity was observed at the same location. Negative effects of contaminants on the benthic community may directly affect fish communities, in that a portion of the fish food base in Dry Run (i.e. benthic invertebrates) may also be removed from the system. Reports of historical fish kills are also an important piece of evidence that suggests an ecological risk. In addition, high levels of metals were noted in the fish, which may present problems to upper level consumers due to dietary toxicity.

7.4 Worm-eating Birds

Results of the food chain model for worm-eating birds such as the American robin indicate a potential risk due to metals, fluoride, and trichlorofluoromethane. This risk is associated with these contaminants in the soil and/or in earthworm tissue. Reports of historical wildlife kills also suggest ecological risk to avian receptors.

7.5 Carnivorous Birds

Results of the food chain model for carnivorous birds such as the red-tail hawk indicate a potential risk due to metals, fluoride, and trichlorofluoromethane. This risk is associated with these contaminants in the soil and/or in small mammal tissue. Reports of historical wildlife kills also suggest ecological risk to avian receptors.

7.6 Carnivorous Mammals

Results of the food chain model for terrestrially feeding carnivorous mammals such as the red fox indicate a potential risk due to metals, fluoride, and trichlorofluoromethane. This risk is associated with these contaminants in the soil and/or in small mammal tissue. Reports of historical wildlife kills also suggest ecological risk to mammalian receptors.

7.7 Piscivorous Mammals

Results of the food chain model for piscivorous mammals such as the mink indicate a potential risk due to metals, fluoride, and trichlorofluoromethane. This risk is associated with these contaminants in the soil and/or in fish tissue. Reports of historical wildlife kills also suggest ecological risk to mammalian receptors.

7.8 Omnivorous Mammals

USEPA 6920

Results of the food chain model for omnivorous mammals such as the raccoon indicate a potential risk due to metals, fluoride, and trichlorofluoromethane. This risk is associated with these contaminants in the soil and/or in fish tissue. Reports of historical wildlife kills also suggest ecological risk to mammalian receptors.

7.9 Insectivorous Mammals

Results of the food chain model for insectivorous mammals such as the short-tail shrew indicate a potential risk due to metals, fluoride, and trichlorofluoromethane. This risk is associated with these contaminants in the soil and/or in earthworm tissue. Physiological abnormalities, specifically the tooth structure of the shrews taken on site, further suggest ecological risk. In addition to the direct potential risk for the shrews, some of these animals had high concentrations of metals and fluoride in their tissues. This could present problems to organisms that feed on shrews and other small mammals on the site due to dietary toxicity. Reports of historical wildlife kills also suggest ecological risk to mammalian receptors.

7.10 Herbivorous Mammals

Results of the food chain model for herbivorous mammals such as the meadow vole indicate a potential risk due to metals, fluoride, and trichlorofluoromethane. This risk is associated with these contaminants in the soil and/or in plant tissue. In addition to the direct potential risk for the voles, some of these animals had high concentrations of metals and fluoride in their tissues. This could present problems to organisms that feed on voles and other small mammals on the site due to dietary toxicity. Reports of historical wildlife kills also suggest ecological risk to mammalian receptors.

8.0 SUMMARY

During the past several years, a farmer who grazes his cattle along the reach of Dry Run Creek, has reported severe abnormalities in his herd. These abnormalities have included an increased incidence of stillborn calves, blindness in newborn and adult cattle, erratic behavior, stiffness of gait in adult cattle, abnormal posture, mottled teeth, and a high mortality rate across all age classes of his herd. In addition to problems with his herd, the farmer and others have also reported numerous fish kills in Dry Run, and wildlife kills (e.g. deer) for animals drinking from Dry Run. The results of this risk assessment support his assertion that effluent from the Dry Run Creek landfill may be having adverse effects on the ecological communities that inhabit the old field, deciduous forest, meadow, stream, and riparian habitats that are present on the site. These effects may be related to enriched levels of metals, fluoride, and trichlorofluoromethane that appear to be resultant of the landfill drainage. At a minimum, the symptoms manifest by the herd are characteristic of fluoride toxicity, and consistent with the conclusions of the risk assessment. In addition to the compounds that were studied in this risk assessment, numerous other compounds were present in Dry Run (specifically those identified as TICs or Tentatively Identified Compounds in the BNA scan) that could not be accurately identified. These compounds may also present a threat to the system, and certainly merit further investigation. The DuPont landfill that drains into Dry Run is the only apparent source of trichlorofluoromethane in soils adjacent to the stream.

USEPA 6921

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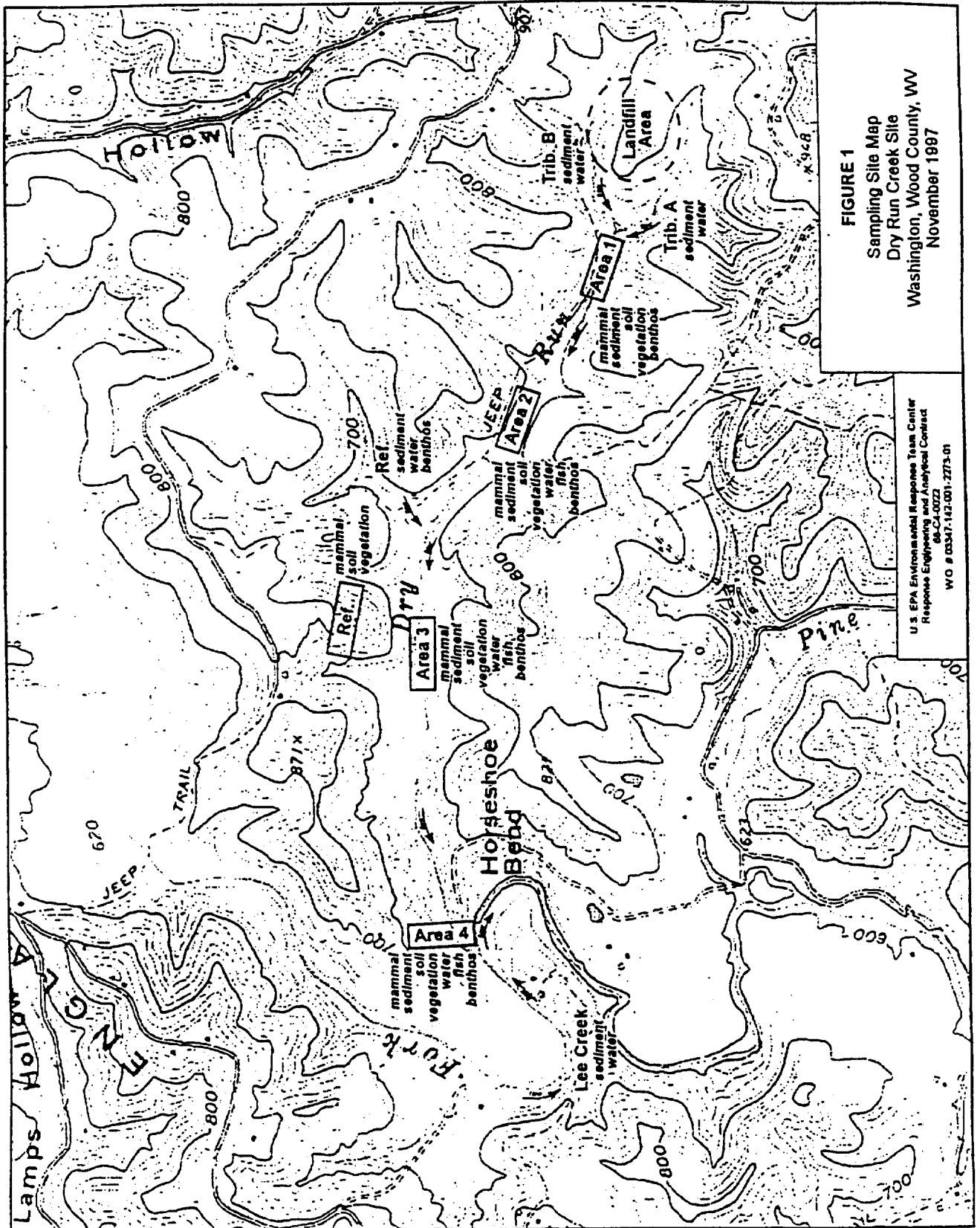


FIGURE 1
Sampling Site Map
 Dry Run Creek Site
 Washington, Wood County, WV
 November 1997

U.S. EPA Environmental Response Team Center
 Response Engineering and Analytical Contract
 #6-24-0073
 W.O. # 03347-142-001-2273-01

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