APPENDIX A

Historical Aerial Photograph Review

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1.0 INTRODUCTION

Table A-1 provides a summary description of the aerial photographs provided in this Appendix. Best efforts were used to identify visible changes to the facility from the aerial photographs. These changes are summarized in Table A-1 to the extent it was possible to make a reasonable interpretation of the photographic content. Figures A-1 through A-3 provide corresponding graphical representation of building changes over the operational period of the Hematite facility.

Table A-1

Summary Of Aerial Photographic Review 1954 - 1998

Photo Date	Description
A-1 Nov 13, 1954	Photo taken prior to plant construction, shows two existing barns in the northwest portion of the site with at least one residence. Areas north and south of the railway easement, south of State Road P, were cultivated.
A-2 Sept 24, 1957	Building 240 with an entrance drive and parking lot northwest of the structure are visible.
A-3 Aug 11, 1959	Building 240, Blue Room 240-4, Building 250, Building 255 and Building 235 are evident. Concrete or asphalt roadways exist between and around the structures. A liquid gas tank appears southwest of Building 240. The site pond is now in evidence indicating recent placement of the initial site dam.
A-4 Nov 3, 1960	Addition of Building 251 and a security fence around the existing site footprint. A footpath exists from the barns to the site parking lot. There is indication of an open burial due north of Building 244 inside the foliage boundary, which would now be in the northern corner of the Burial Pit area. This burial is thought to be one of the "undocumented burials" (i.e., was not intended to be a documented radiological burial – "Burial Pit" – under 10 CFR 20.304 [1964], since Burial Pits purportedly used under 10 CFR 20.304 [1964] did not begin until 1965).
A-5 Apr 7, 1962	This photo is relatively unchanged from the November 3, 1960 photo; however, there is more obvious scarring of the land due north of Building 255 supporting the possibility that the area included additional undocumented burials.
A-6 Sept 24, 1966	Shows addition of two site Evaporation Ponds along the railroad tracks southeast of Building 240. Building 252 now exists southeast of Buildings 250 and 251. An exposed Burial Pit filled with water is indicated due north of Building 255 in the same area as soil scarring in the two previous photos. This pit corresponds with Pit #5 in the Burial Pit logs. Note that Pit #5 immediately precedes Pit #6, where two waste pit fires occurred. Based on the evidence within the preceding photographs, a conclusion may be drawn that the area used for the pre-1965 undocumented burials became the area used for burial of Special Nuclear Material (SNM) waste purportedly under the governance of 10 CFR 20.304 (1964).

Table A-1 (continued) **Page 2 of 3**
Summary Of Aerial Photographic Review 1954 - 1998

Photo Date	Description
A-7 Mar 12, 1971	Scarring across the field now considered to be the Burial Pit area is evident. An open pit is evidenced in the same area shown in the September 24, 1966 photograph, lending credibility to interview statements claiming that some Burial Pits "ran into" previously used pits. There are indications of soil scarring up to the State Road P drainage ditch, and of foliage between the road and the soil scarring. A large outside storage area is visible southeast of Building 255 and directly northeast of Building 252. Another storage area is visible northeast of the new Oxide Building and loading dock, attached to Building 255. The new Building 110 is now in evidence northwest of Building 251.
A-8 Mar 15, 1973	The photo shows the same plant features as the March 12, 1971 photograph. Scarring in the Burial Pit area from the tree line along State Road P southeast to the train tracks is evident. A large open burial excavation exists in the southeast section of the Burial Pit area that is filled with water. Approximately 30 barrels are visible in this burial excavation. Note that this burial was not in evidence in the March 12, 1971 photograph; therefore, it was dug after November 4, 1970, when the AEC citation was issued to UNC for failure to adhere to AEC regulations concerning the quantity of material that could be buried on site. The plant site was being cleaned up in preparation for sale to CE at this time and it is possible that this burial was created to bury uncontaminated industrial refuse that was stored in areas around the facility. Outside storage appears to be expanded in the area southeast of Building 240 between the evaporation ponds, Building 240 and the liquid gas tank. A number of barrels are staged in this area. A UF_6 gas container laydown area is visible northeast of the Oxide Plant. Spacing rings for outside storage of SNM are visible in the large storage area northeast of Building 252. Limestone piles appear to be staged northeast and southeast of Building 255. Smaller storage areas are evident outside and directly alongside both Buildings 240 and 255.
A-9 May 4, 1973	The photograph appears to show the same plant features as the March 12, 1971 photograph. Vegetation can be seen advancing southwest across the Burial Pit area with some evidence of scarring still indicated in the southeast area. The open burial excavation seen in the March 15, 1973, photograph is still in evidence.

Table A-1 (continued) **Page 3 of 3**
Summary Of Aerial Photographic Review 1954 - 1998

Photo Date	Description
A-10 Jan 25, 1974	Photo is relatively unchanged from the May 4, 1973 photograph. Traces of the burial excavation in the southeast area are still visible. The spacing ring storage area appears to be significantly scaled back to a few rows along the northeast side of Building 252. A number of stored materials remain in the areas southeast of Building 240.
A-11 Apr 6, 1975	Photo shows the spacing ring storage area northeast of Building 252 is gone and the stored materials southeast of Building 240 are gone as well.
A-12 Feb 23, 1976	The site is unchanged from the April 6, 1975 photograph.
A-13 Dec 18, 1979	Photo is relatively unchanged from the February 23, 1976 photograph, with the exception of stored materials in evidence northeast of Building 252.
A-14 Apr 8, 1990	Buildings 250 and 251 have been replaced with Buildings 253 and 254. Building 256 with a loading dock is now in evidence. A roadway now wraps between Buildings 110 and 254, along the eastern side of the facilities, and the Building 256 loading dock. Another temporary roadway runs from State Road P to the Burial Pit area. Based on interviews with plant personnel, it is probable that building materials from construction activities were dumped in that area.
A-15 Apr 24, 1991	Photo shows the site relatively unchanged from the April 8, 1990 photograph, with the exception that significant amounts of limestone are stored in the southeast portion of the site as well as northeast of Building 255.
A-16 Apr 2, 1996	Photo shows completed Building 230 southwest of Building 240. A parking lot now exists southwest of Building 230 along with a large concrete storage area southeast of Building 230. The Sewage Treatment System can be seen southeast of Building 230. Evaporation tanks supporting the wet recovery process are visible along the southeast wall of Building 240. A number of materials are stored behind Building 240. A significant amount of activity is seen southeast of Building 255. A roadway is now in existence traversing the eastern perimeter of the site, over the Burial Pit area, and around the southeast portion of the site alongside the railroad tracks. The limestone storage facility is visible attached to the northeast side of Building 255. Building 115 is now in existence northeast of Building 110. The water tower and connecting road appear on the north side of State Road P.
A-17 Apr 2, 1998	Photo shows a complete Building 231 located southwest of Building 230. The outside storage areas described in the photograph dated April 2, 1996, remain in use.

Figure A-1

Hematite Site Layouts 1956 To 1962

Figure A-2

Hematite Site Layouts 1968 To 1992

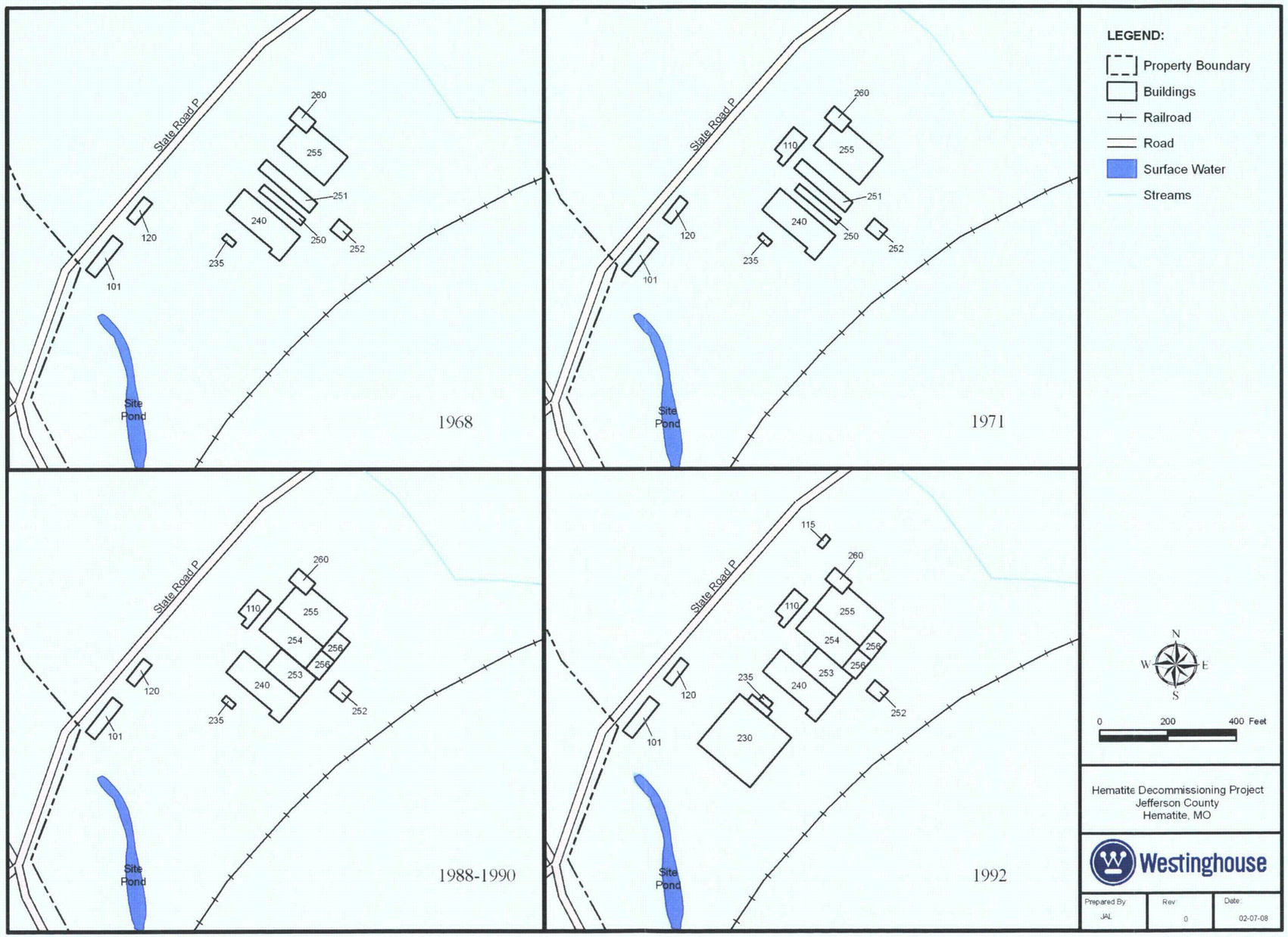


Figure A-3

Hematite Site Layout 1996-1999

Photograph A-1

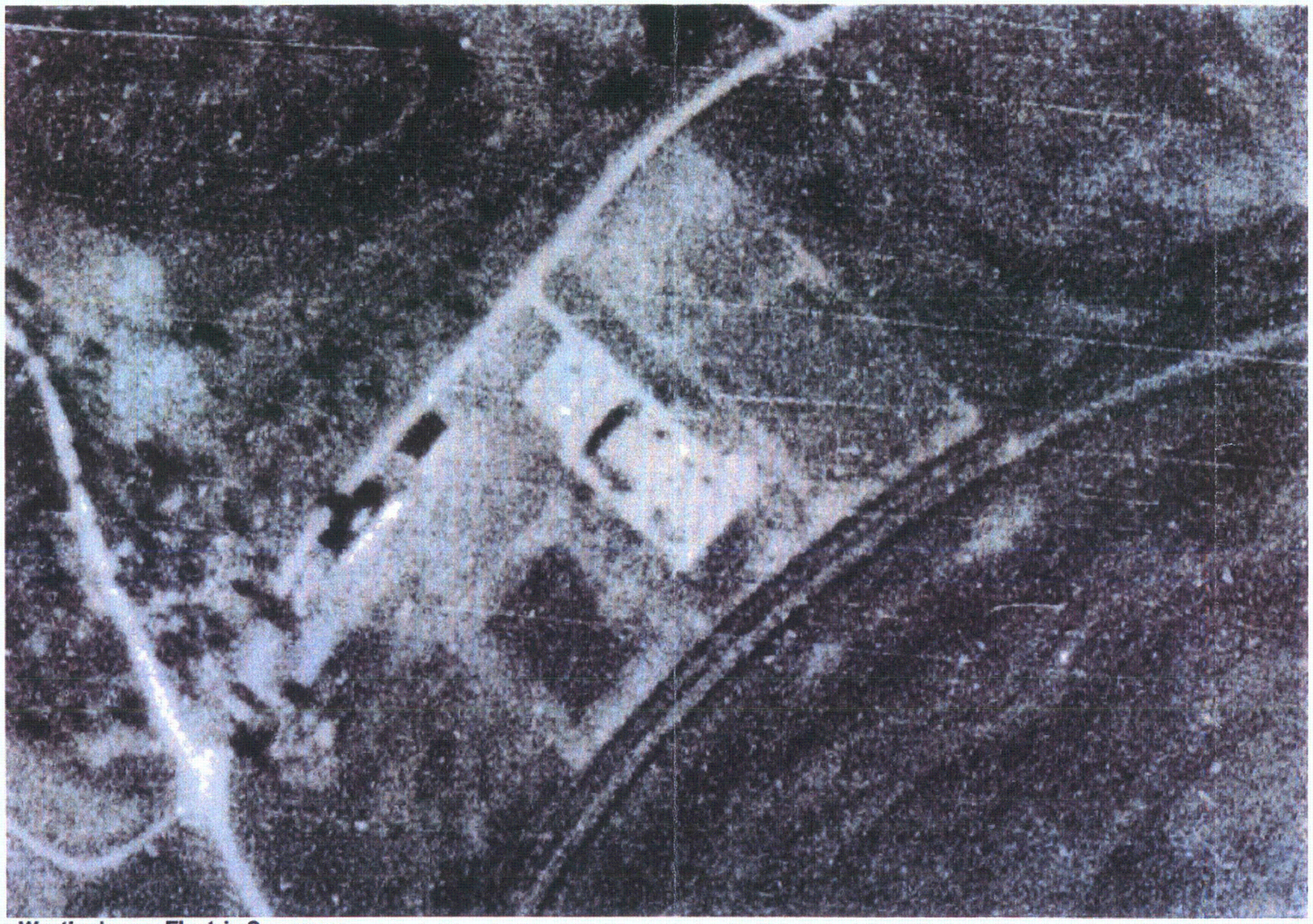
Hematite Site Aerial Photograph – 11/13/1954

Westinghouse Electric Company
Hematite Plant - Festus, MO
11/13/1954
Photo Source: National Archives

100 0 100 Feet

Photograph A-2

Hematite Site Aerial Photograph – 09/24/1957



Westinghouse Electric Company
Hematite Plant - Festus, MO
9/24/1957
Photo Source: National Archives

100 0 100 Feet

AERO-DATA CORP
ENVIRONMENTAL
AERIAL PHOTO ACQUISITION
INTERPRETATION and MAPPING

Photograph A-3

Hematite Site Aerial Photograph – 08/11/1959

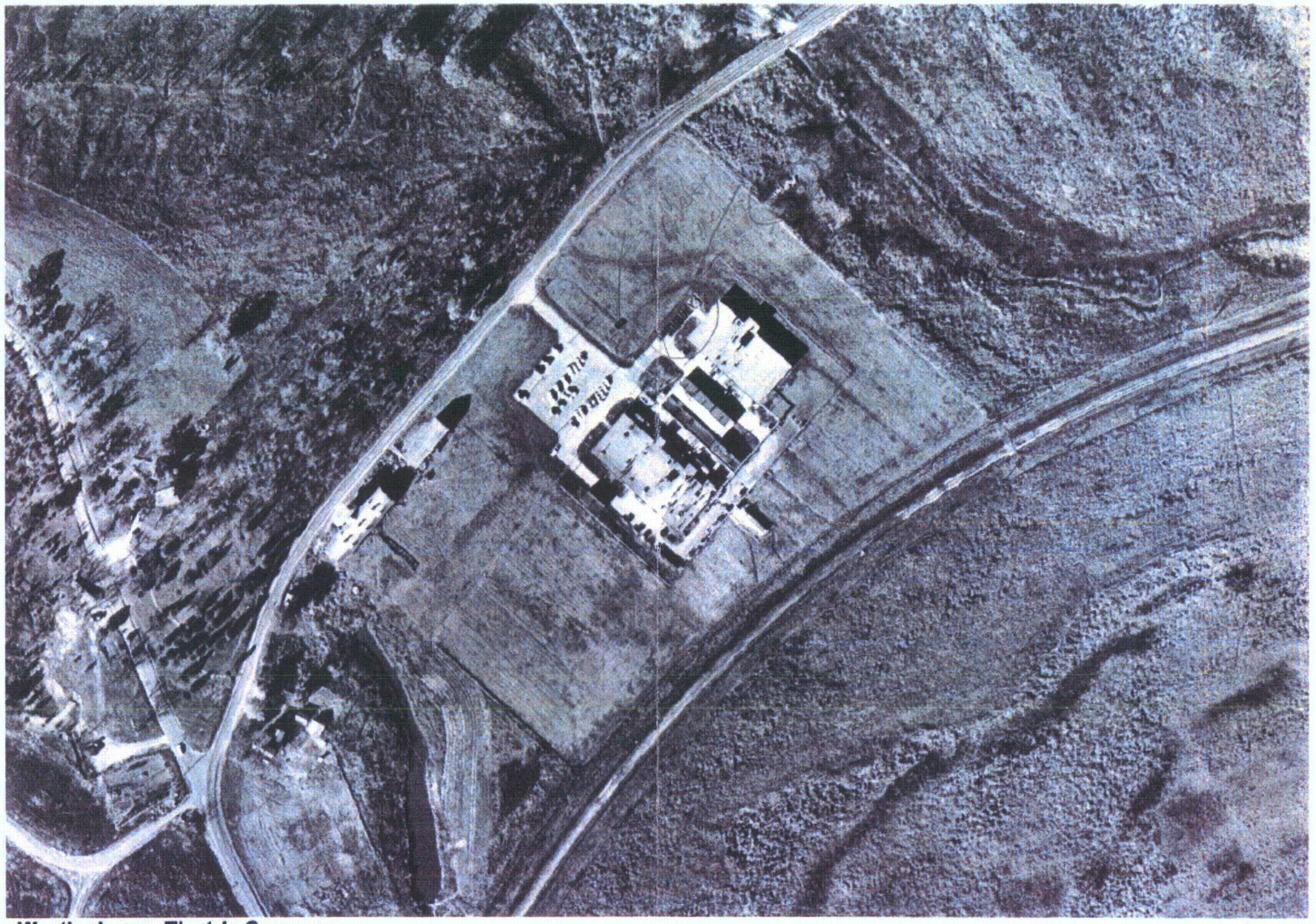
Westinghouse Electric Company
Hematite Plant - Festus, MO
8/11/1959
Photo Source: ASCS

100 0 100 Feet

AERO-DATA CORP
ENVIRONMENTAL
REMOTE SENSING CONSULTING SERVICES
AERIAL PHOTO ACQUISITION
INTERPRETATION and MAPPING

Photograph A-4

Hematite Site Aerial Photograph – 11/03/1960



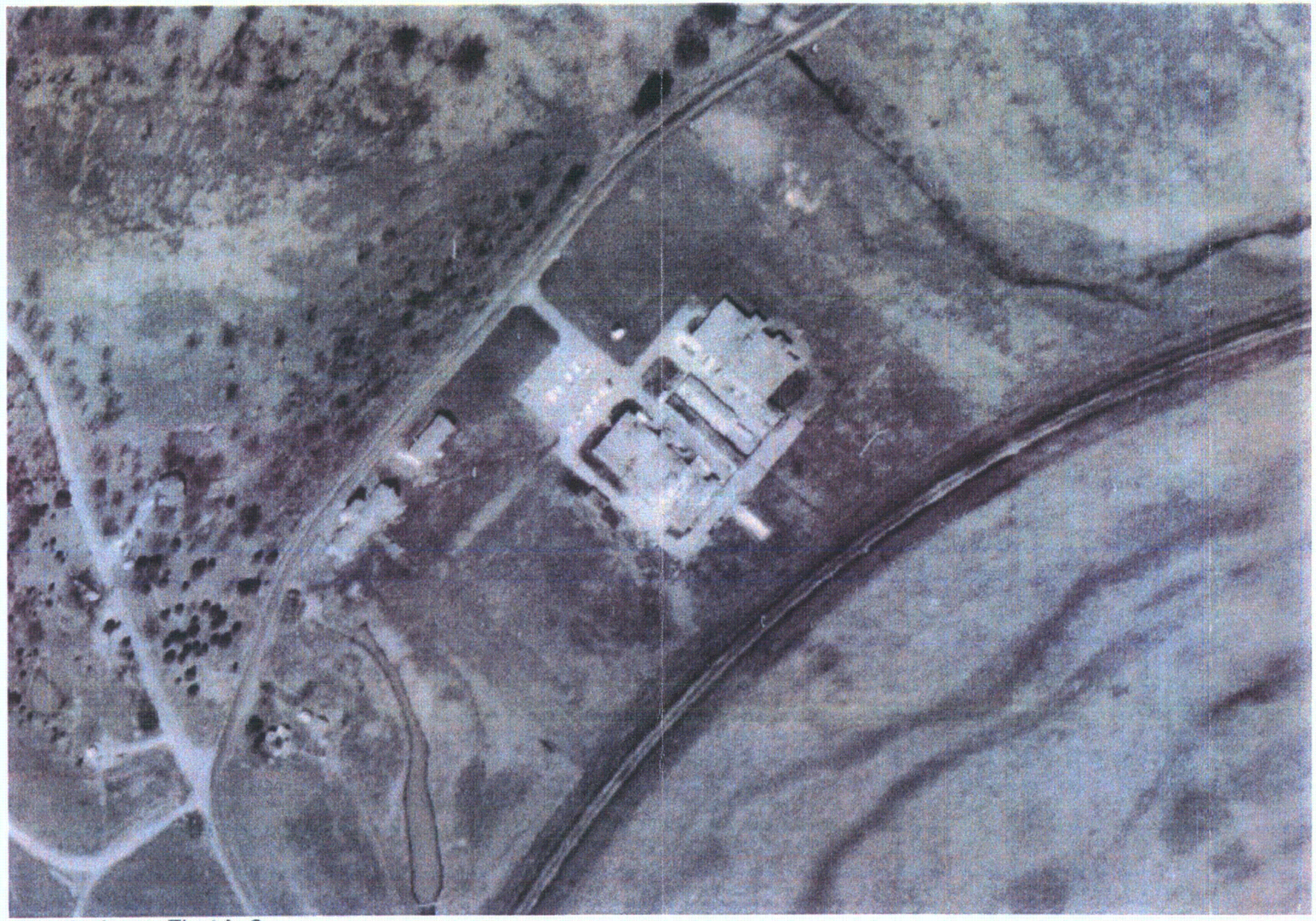
Westinghouse Electric Company
Hematite Plant - Festus, MO
11/3/1960
Photo Source: Missouri DOTD

100 0 100 Feet

AERO-DATA CORP
ENVIRONMENTAL
REMOTE SENSING CONSULTING SERVICES
AERIAL PHOTO ACQUISITION
INTERPRETATION and MAPPING

Photograph A-5

Hematite Site Aerial Photograph – 04/07/1962



Westinghouse Electric Company
Hematite Plant - Festus, MO
4/7/1962
Photo Source: USGS

N W E S 100 0 100 Feet

AERO-DATA CORP
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REMOTE SENSING CONSULTING SERVICES
AERIAL PHOTO ACQUISITION
INTERPRETATION and MAPPING

Photograph A-6

Hematite Site Aerial Photograph – 09/24/1966

Westinghouse Electric Company
Hematite Plant - Festus, MO
9/24/1966
Photo Source: ASCS

100 0 100 Feet

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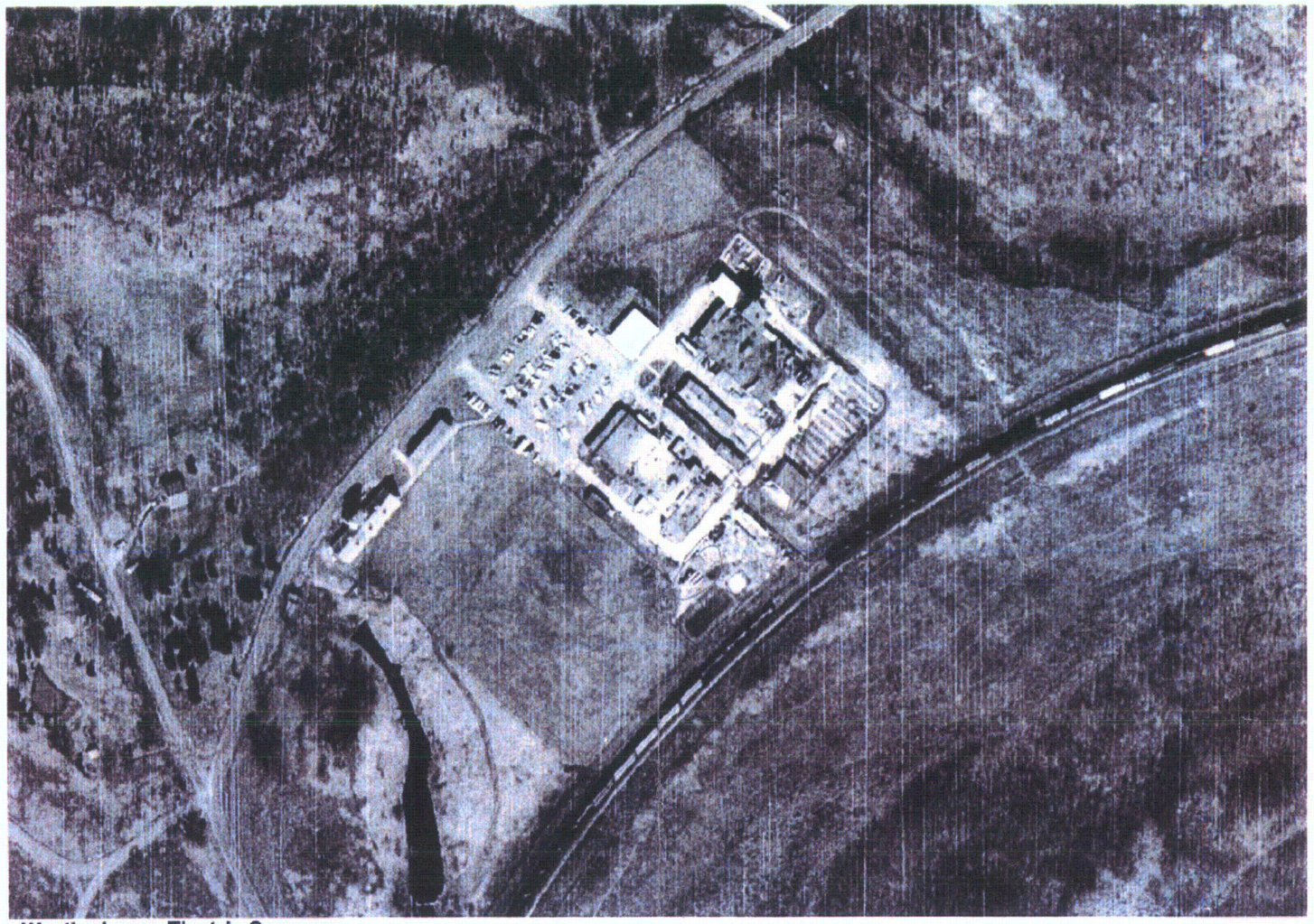
INTERPRETATION and MAPPING

Hematite Site Aerial Photograph – 03/12/1971



Westinghouse Electric Company
Hematite Plant - Festus, MO
3/12/1971
Photo Source: Surdex Corp.

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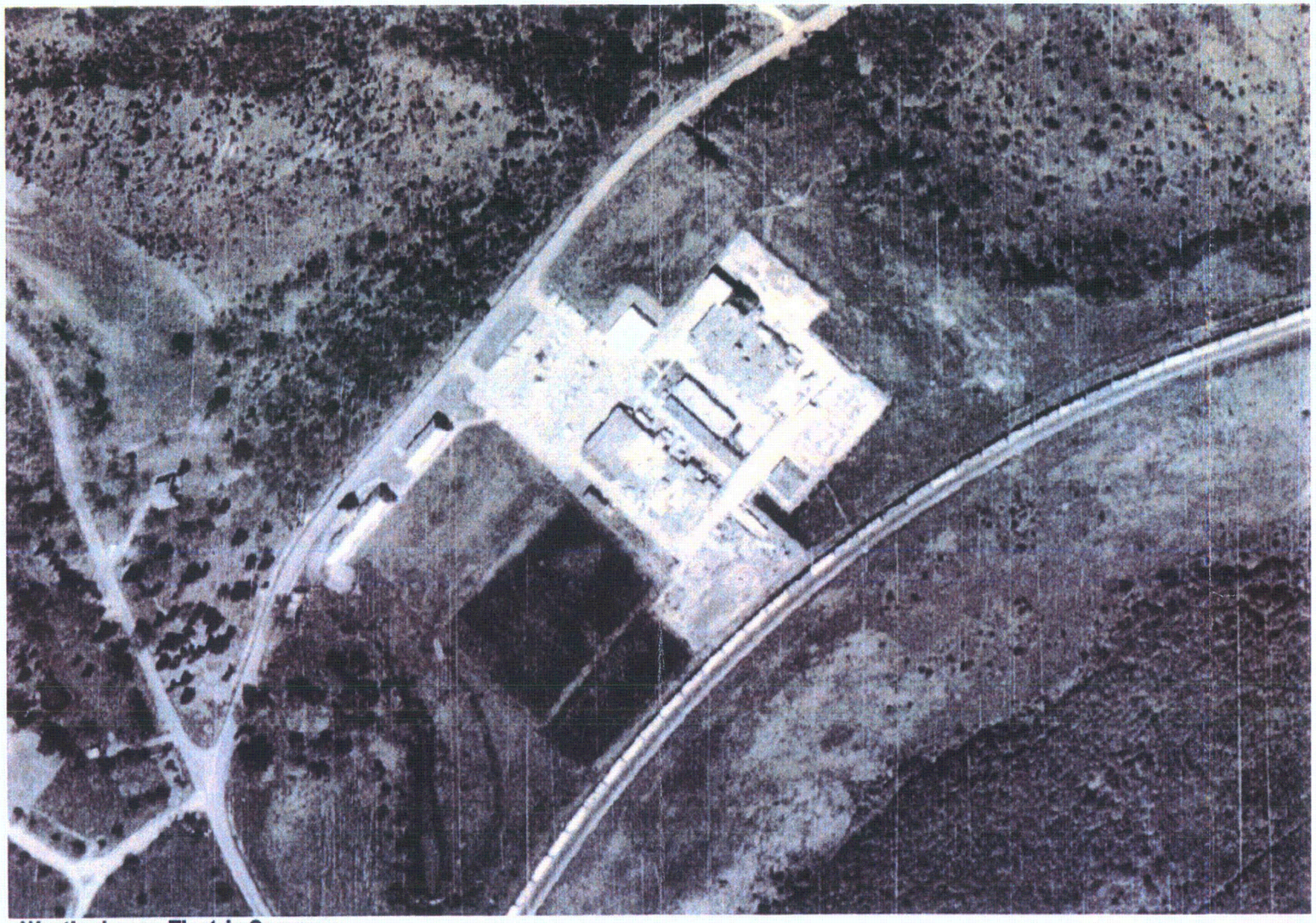
Photograph A-8

Hematite Site Aerial Photograph – 05/04/1973



Westinghouse Electric Company
Hematite Plant - Festus, MO
5/4/1973
Photo Source: Surdex Corp.

N W E S 100 0 100 Feet

AERO-DATA CORP
ENVIRONMENTAL
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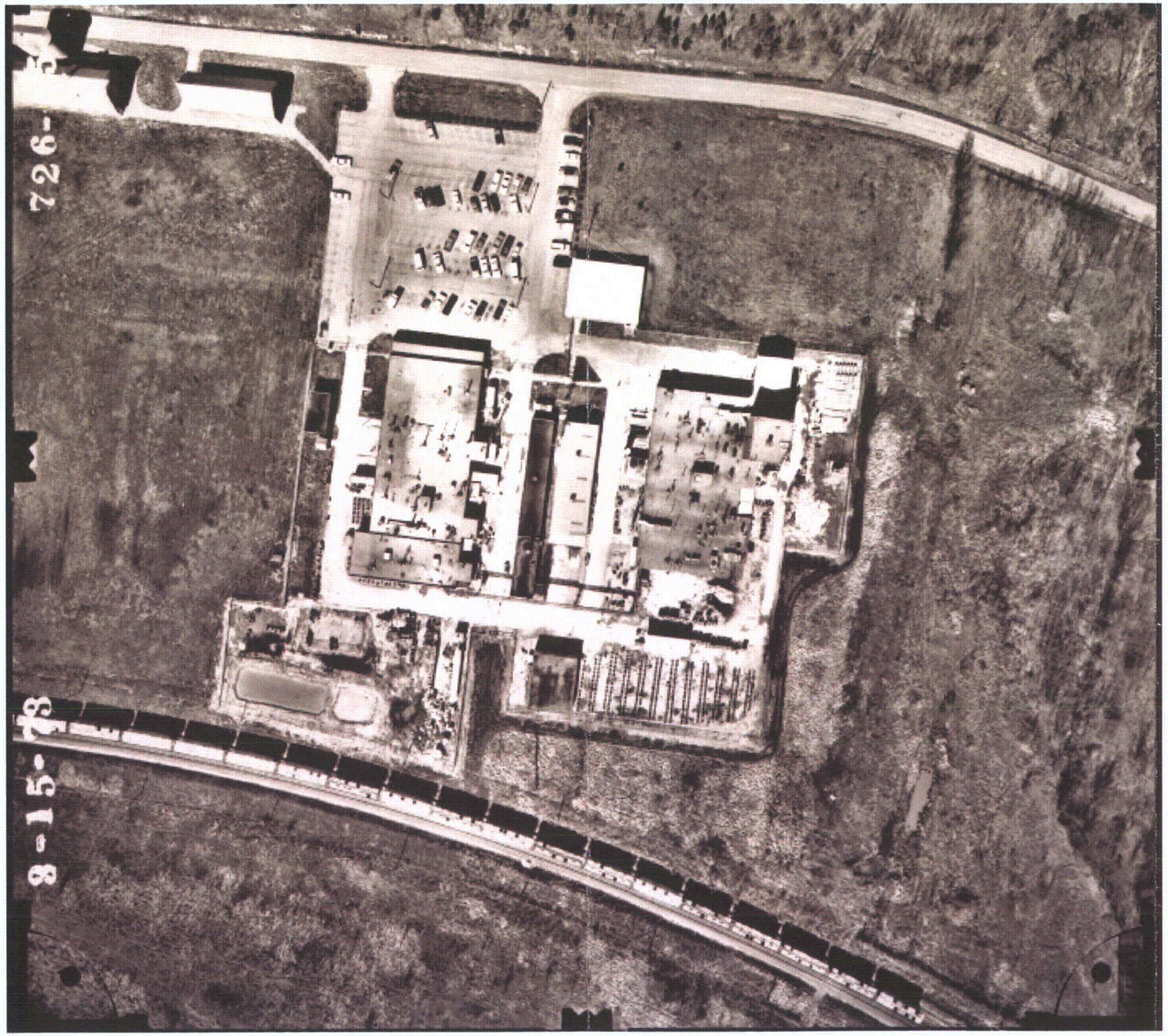
AERIAL PHOTO ACQUISITION
INTERPRETATION and MAPPING

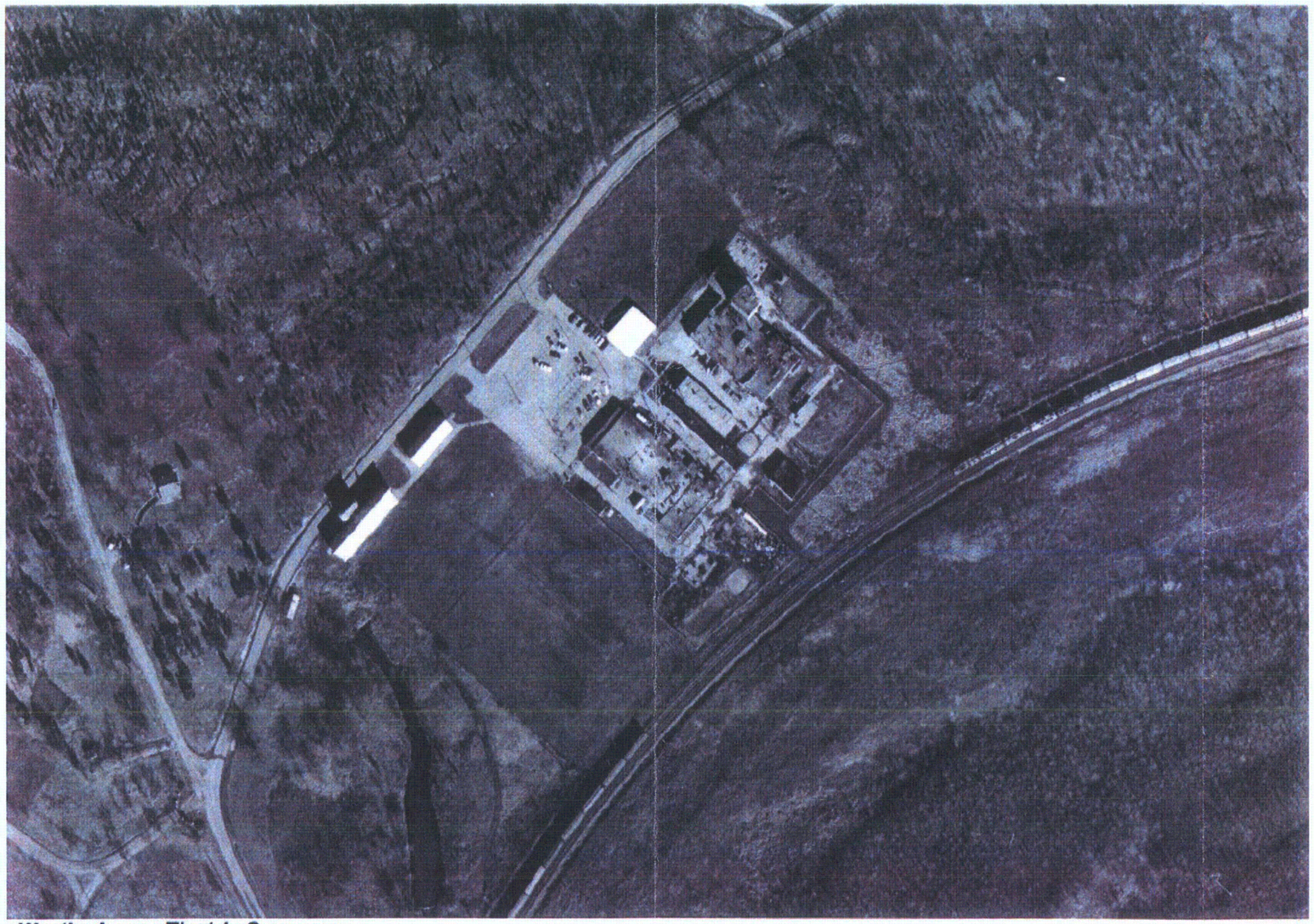
Photograph A-9

Hematite Site Aerial Photograph – 08/15/1973



Photograph A-10

Hematite Site Aerial Photograph – 01/25/1974



Westinghouse Electric Company
Hematite Plant - Festus, MO
1/25/1974
Photo Source: Missouri DOTD

100 0 100 Feet

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Photograph A-11

Hematite Site Aerial Photograph – 04/06/1975

Westinghouse Electric Company
Hematite Plant - Festus, MO
4/6/1975
Photo Source: Surdex Corp.

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100 0 100 Feet

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INTERPRETATION and MAPPING

Photograph A-12

Hematite Site Aerial Photograph – 02/23/1976

Westinghouse Electric Company
Hematite Plant - Festus, MO
2/23/1976
Photo Source: USGS

100 0 100 Feet

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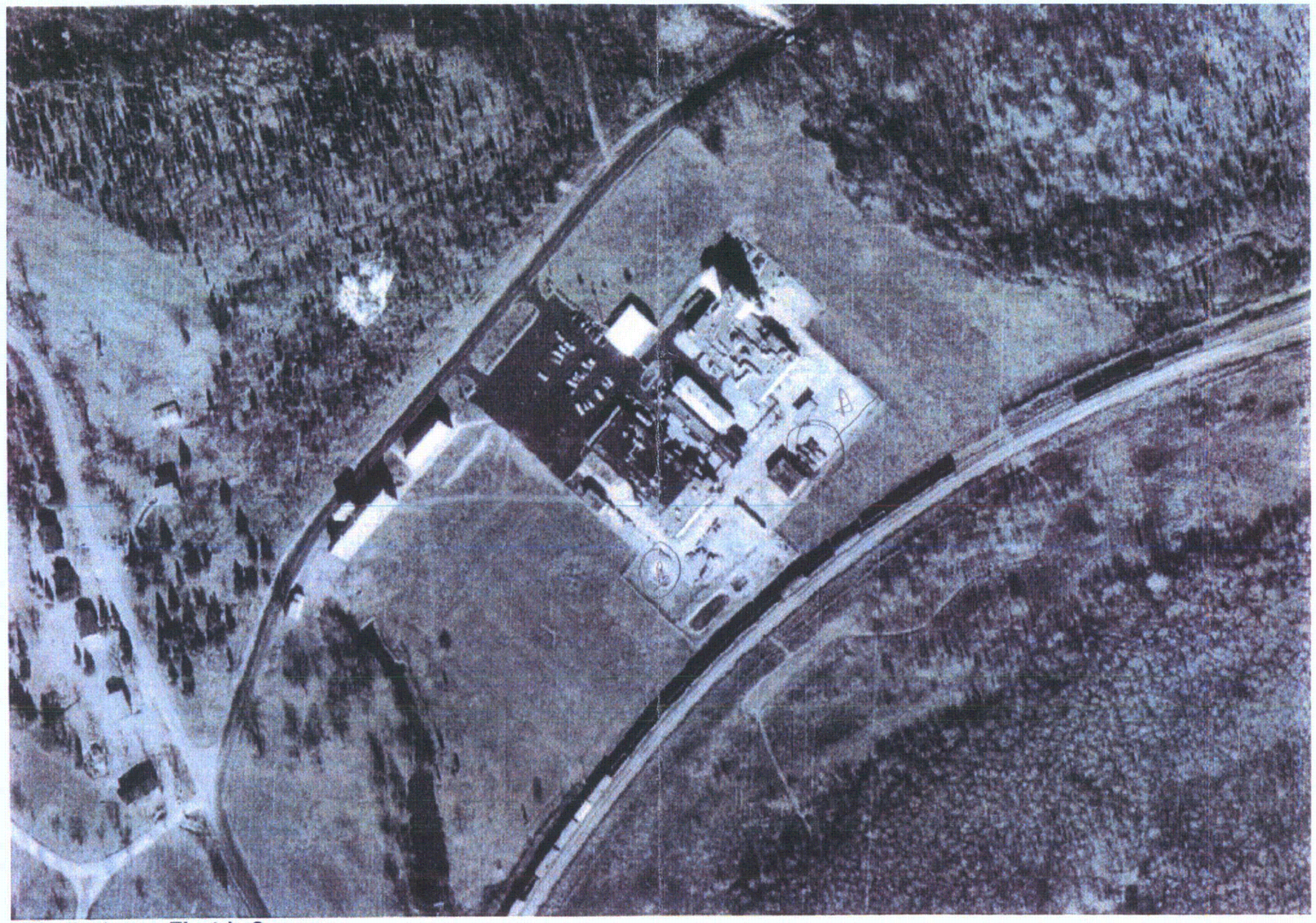
AERIAL PHOTO ACQUISITION
INTERPRETATION and MAPPING

Photograph A-13

Hematite Site Aerial Photograph – 12/18/1979



Westinghouse Electric Company
Hematite Plant - Festus, MO
12/18/1979
Photo Source: Surdex Corp.

N W E S 100 0 100 Feet

AERO-DATA CORP
ENVIRONMENTAL
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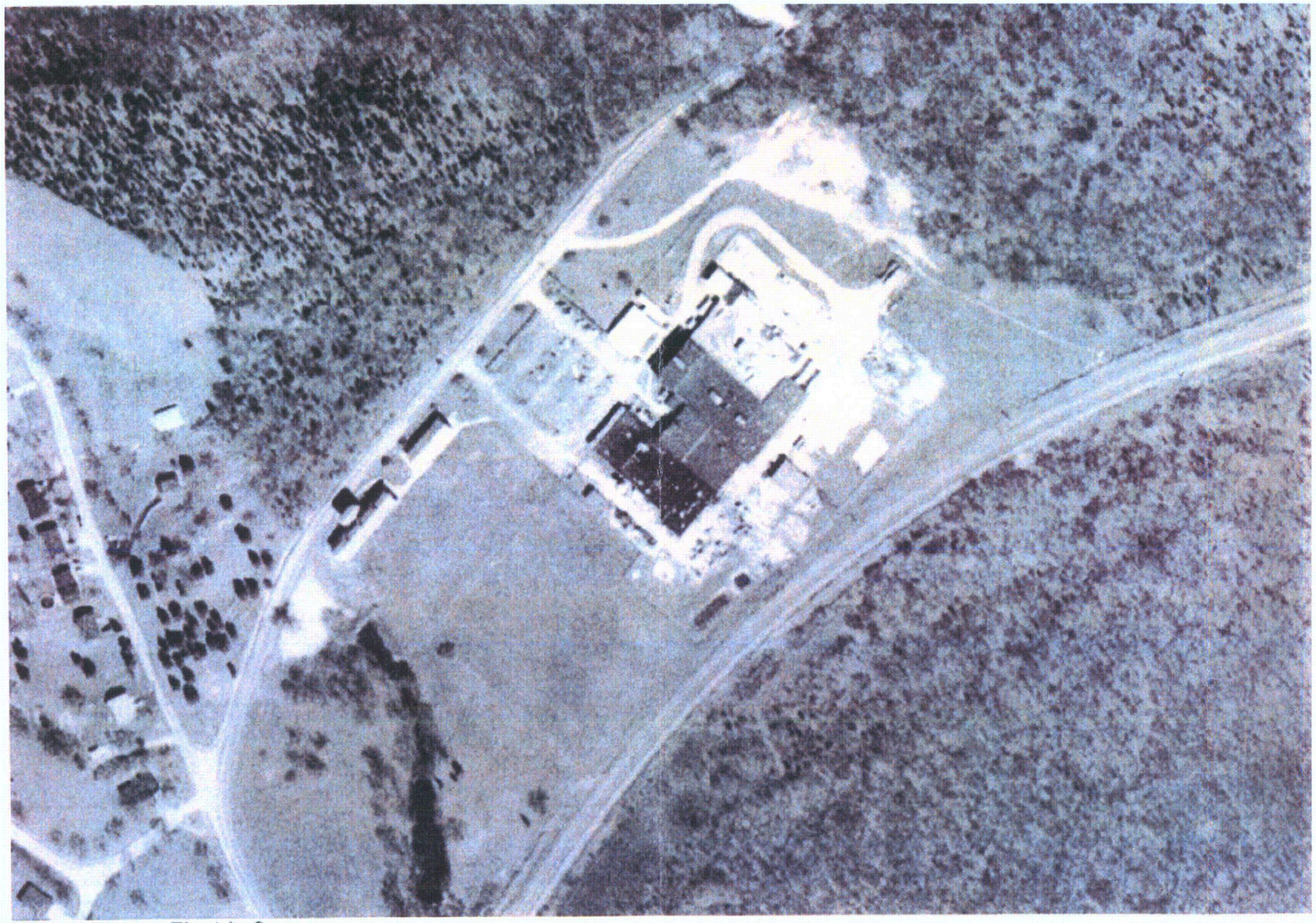
INTERPRETATION and MAPPING

Photograph A-14

Hematite Site Aerial Photograph – 04/08/1990



Westinghouse Electric Company
Hematite Plant - Festus, MO
4/8/1990
Photo Source: USGS

N W E S

100 0 100 Feet

AERO-DATA CORP
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REMOTE SENSING CONSULTING SERVICES
AERIAL PHOTO ACQUISITION
INTERPRETATION and MAPPING

Photograph A-15

Hematite Site Aerial Photograph – 04/24/1991

Westinghouse Electric Company
Hematite Plant - Festus, MO
4/24/1991
Photo Source: Surdex Corp.

N

100 0 100 Feet

AERO-DATA CORP
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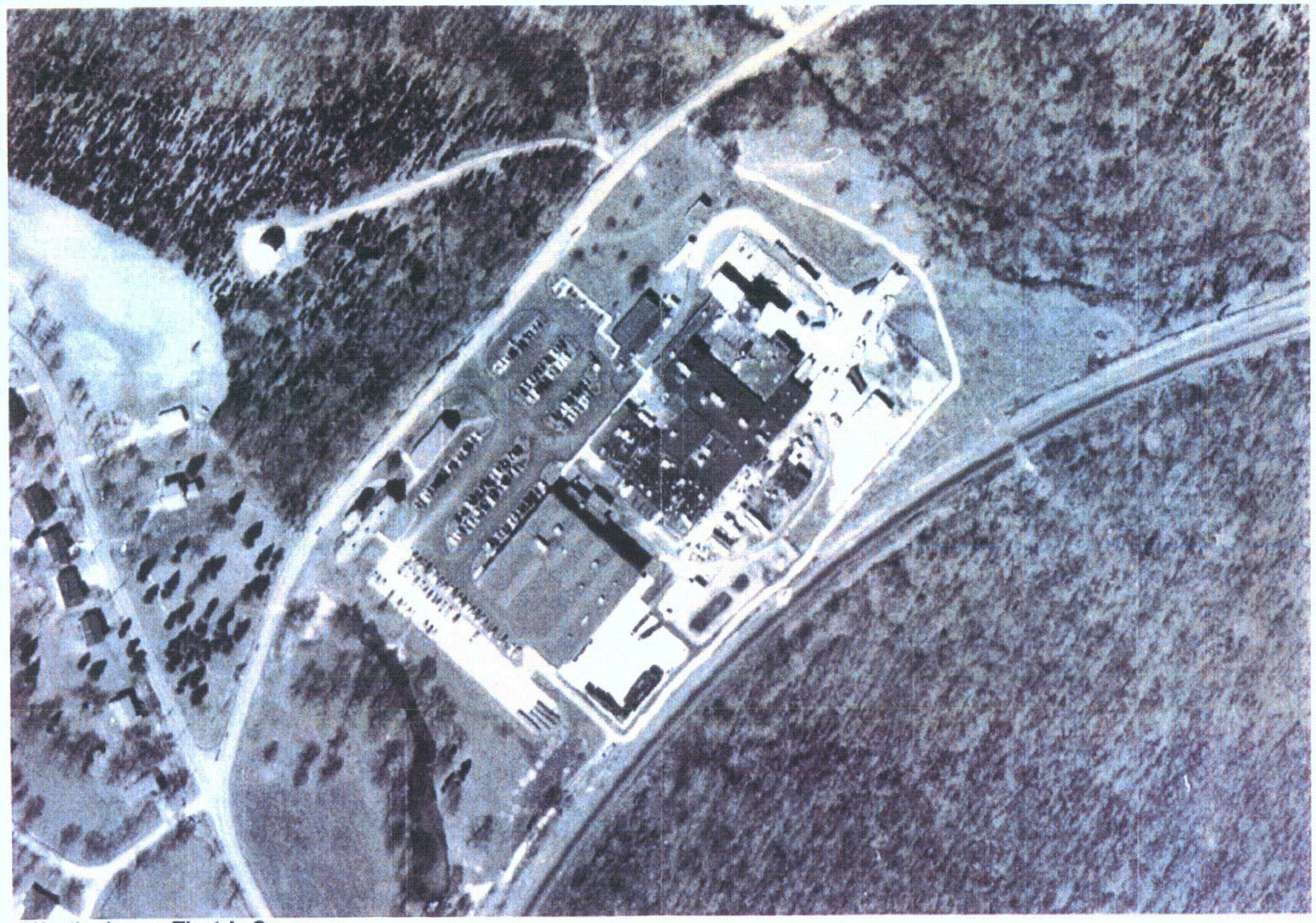
REMOTE SENSING CONSULTING SERVICES
AERIAL PHOTO ACQUISITION
INTERPRETATION and MAPPING

Photograph A-16

Hematite Site Aerial Photograph – 04/02/1996



Photograph A-17

Hematite Site Aerial Photograph – 04/02/1998

Westinghouse Electric Company
Hematite Plant - Festus, MO
4/2/1998
Photo Source: Surdex Corp.

N W E S 100 0 100 Feet

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APPENDIX B

Historical Summaries

TABLE OF CONTENTS

1.0 INTRODUCTION

With consideration for the numerous changes in facility ownership and site activities/operations, the content of this appendix represents the "best efforts" to reconstruct previous site activities in the areas of: site operations, on-site waste burials and Evaporation Pond use. The information herein was used to identify historical activities which had the potential to impact site areas and to identify radiological and hazardous materials used at the site.

2.0 HEMATITE OPERATIONAL HISTORY

2.1 HIGH ENRICHED ERA

The focus of operations during this era was Uranium fuel research and production of fuels for various government applications. Research reactor fuels, United States Navy/Army reactor fuels and some commercial nuclear reactor fuels were produced during this era.

2.1.1 TIME PERIOD: 1956-1963

In the ABB memorandum, "The Hematite Burial Grounds," from J. Rode to W. Sharkey dated March 5, 1996 (Reference B-1), Mr. Rode stated:

> *The original Hematite facility was more of an R&D facility than a production plant. Our goal was analogous to much of the Mallinckrodt main plant, i.e., the facility was devoted to providing custom products requested by a variety of government and government-aided labs. We produced Uranium compounds ranging from crystalline particles of UO_2 to uranyl sulfate dueterate, Uranium nitride, Uranium carbide, etc. We were involved in work on the Army package power reactor, the aircraft nuclear propulsion program, the homogeneous reactor program, SL-1, N.S. Savannah, etc. Near the end of the 50s we finally began something that resembled real production as we won the contract to supply pellets for Yankee Rowe Core 1 (1960) and Oxide for Dresden 1 Core 1 (1960).*

This observation is further born out in the following documents recovered from the NRC ADAMS website:

Letter from Mallinckrodt to the Atomic Energy Commission (AEC) Licensing Division dated January 21, 1957 (Reference B-2), requesting License No. SNM-33 be revised to permit receipt and possession of Uranium enriched in the U-235 isotope for use in making uranyl sulfate. Mallinckrodt was in negotiations with Japanese and Danish Governments for the conversion of 20 percent UF_6 to uranyl sulfate, for reactors they were purchasing from the Atomics International Division of North American Aviation.

AEC Compliance Inspection Report dated February 10, 1960 (Reference B-3) indicated the source material license under C-4495 was a limited research program, which involved the receipt by the licensee on October 10, 1959, of 1720 lbs. of natural UF_6 for studies on preparation of reactor fuel elements. The program was said to have been completed with the shipment of 245 lbs. of UO_2 to General Electric Company.

In an AEC letter dated June 17, 1963 (Reference B-4), it was noted that the program under SNM-230 involved research involving a process for direct conversion of UF_6 to UF_4. One order of 20 lbs. of Uranium enriched to about 20 percent, and two orders of 40 lbs. of Uranium at 20 percent enrichment were received, used in the research program and then processed to a

Hematite final product and shipped to licensed receivers. The direct conversion process was indicated to be part of the overall Hematite plant process under License No. SNM-33, and no further work was to have been done under License No. SNM-230.

In the same AEC letter (Reference B-4), the AEC stated that the Applicant (Hematite) requested a license amendment to manufacture 20 percent enriched anhydrous UO_2 SO_4 D_2O, and that the UO_2SO_4 has been produced in the high enrichment area (Red Room) of the plant. The letter indicated the Hematite application stated that the six liters of heavy water, to be used in this operation, was to be stored in the Degassing and Loading Station dry box.

2.1.2 TIME PERIOD: 1964-1973

Hematite support of U.S. Government operations during this period included subcontracts to Westinghouse and General Electric, primary contractors to the U.S. Navy. High enriched (93 to 98 percent) Uranium was supplied for the U.S. Navy's nuclear propulsion program. Examples of other U.S. Government projects supplied by Hematite during this time include Uranium metal for nuclear submarines and a D1G destroyer reactor, oxides for test reactors utilized by the U.S. Navy, Uranium-zirconium pellets for Bettis Laboratory, and high enriched oxides for General Atomics' support of the NERVA nuclear rocket project. Hematite also contracted directly with the Oak Ridge AEC office for the recovery of Uranium from scrap materials. Scrap recovery projects at Hematite included the recovery of Uranium from scrap generated by a variety of Navy projects and CUNO filter scrap generated by the Aircraft Nuclear Propulsion program.

In a letter from UNC to AEC Licensing and Regulation dated July 15, 1964 (Reference B-5), UNC requested an amendment to License No. SNM-33 to include "item" plant and permit processing of fully enriched Uranium in this location. The Item Plant became Building 255-3. This area was designated solely for high enriched fuel operations in support of the U.S. Navy fuel contract.

ABB memorandum, "The Hematite Burial Grounds," from J. Rode to W. Sharkey dated March 5, 1996 (Reference B-1), states, "Development work took a dramatic turn at this point with emphasis on the high enriched market. A new process for producing high enriched UF_4, Uranium metal and UO_2 was developed, which immediately made us the low cost supplier in this market; and, major resources were devoted to qualifying as suppliers of two new fuel materials - one for the NERVA Rocket program and the other for the nuclear navy. An extraction system for the recovery of Uranium from high enriched scrap was installed and UNC began bidding aggressively on scrap recovery contracts for the U.S. Government."

The March 5, 1996, memorandum (Reference B-1) continued, "We won the navy contract, high enriched operations, all of which were financed by the AEC, accounted for 90% of our work. This continued to be the case until 1968 when we completed the construction of the semi-works oxide and pellet plant and began producing pellets for CE's Palisade's reactor (1971)."

The following historical documents indicate the existence of thorium and zirconium on site:

Letter from UNC to AEC Licensing and Regulation dated March 31, 1964 (Reference B-6), Amendment request to License No. SNM-33 to permit blending fully enriched UO_2 with natural ThO_2 in the pellet plant.

Letter from UNC to AEC Licensing and Regulation dated June 20, 1964 (Reference B-7), "We have been awarded a contract for the production of fully enriched UO_2-ZrO_2 pellets for the LPR criticality facility...."

In a letter from AEC Licensing and Regulation to UNC dated June 8, 1970, License Amendment No. 59 was granted to include the following changes: increased capacity for UF_6 cylinders, a second UF_6 vaporizer station, increased capacity of existing UO_2 in process storage silos, reduced volume of the granulator in the agglomeration station, installation of an additional final blender, installation of two vacuum systems for collection of press feed fines from the pressing operations and addition of a UF_6 heel removal station. The facility was steadily transforming from batch operation processes to automated processes in support of fuel fabrication throughput (Reference B-8).

Fuel fabrication operations supporting the commercial nuclear power industry starting in 1968 were centralized around contracts to supply CE reactors, the first being Palisades. This relationship with Hematite led to CE's purchase of Hematite, in order to vertically integrate their business as they manufactured fuel for their own plants, thereby reducing fuel supply costs.

2.1.3 FUEL FABRICATION OPERATIONS 1956-1968

Batch type operations dominated the production of Uranium fuels during this era. The following excerpt from an AEC Inspection letter (Reference B-9) describes production:

> *Processing Uranium dioxide (UO_2) was from normal and enriched grade Uranium hexafluoride (UF_6) through an intermediate diuranate step. The process consisted of the hydrolysis of UF_6 with a dilute ammonia solution to yield a precipitate of ammonium diuranate that is then filtered, washed and dried. The dried powder is then pyrohydrolized with steam at the same time the ADU is converted to black oxide (U_3O_8), which is an intermediate that is used for preparing other Uranium compounds. The U_3O_8 is then reduced to UO_2 with hydrogen or cracked ammonia. If the UO_2 was to be pressed into pellets for use in fuel elements, it was blended, pelleted and sintered at high temperature. UO_2 high-fired crystals and ceramic grade UO_2 were also produced following the blending step or converted to UF_4 for use in preparing Uranium metal.*

By 1960, this process was modified by replacing the Ammonium Diuranate (ADU) step with a direct conversion process in which the UF_6 was reduced by an organic reductant to UF_4. This was then filtered through a stainless steel filter onto 1-in. deep trays and converted. Process

scrap, which included such items as filter bags, clean-up scrap, rejected pellets, destructive test samples, and analytical scrap were dissolved in acid. Then Uranium was extracted in solvent and put into a purified uranyl nitrate solution that could then be converted to ADU.

Most of the liquid waste generated during this time consisted of Ammonium Diuranate (ADU). This solution was treated with lime to precipitate the Uranium and fluoride. The resulting slurry was brought to its boiling point to release ammonia, while the precipitate was filtered to remove the calcium fluoride and Uranium content. The resulting filter cake was stored for future processing and the filtrate, which was water, was released to the process waste sewer line.

Ammonium fluoride solution analyses showed that the maximum Uranium contents were 50 parts per million with average values between 5 and 25 parts per million. Ninety-nine percent of Ammonium Fluoride liquors were produced in the Green Room area of the plant. (It was noted that, since Uranium content was so low, Mallinckrodt proposed to stop the lime treatment and transport the untreated Ammonium Fluoride by truck to the main Mallinckrodt plant in St. Louis, where the material was used in another process.)

Liquid effluent monitoring of Hematite plant discharge was conducted at several locations. All process wastes were discharged west from the main building through a sewer that emptied into the Site Creek running south through the property. From there it flowed several hundred feet and discharged into the Joachim Creek.

Samples were obtained from the process sewer, the process filtrate, the Site Creek and at several points in Joachim Creek, both below and above the entry point of the stream. The highest concentration reported at the Mallinckrodt's property was detected in Joachim Creek just below Mallinckrodt's point of entry. This was detected on July 27, 1957, with a concentration of 1.84×10^{-7} μCi/ml of alpha activity (Reference B-3).

By the following AEC inspection conducted in 1960, the site creek was dammed below the point of entry for the storm water drain, such that a site pond, fed by a natural spring, was formed. The dam gave Mallinckrodt better control of discharges and sampling locations for liquid effluent (Reference B-3).

In a letter to the AEC dated April 14, 1960, Mallinckrodt requested an extension to License No. SNM-33 that included substantial equipment changes and modifications to the recovery process. The request allowed larger volumetric throughput that contained the following steps: (1) dissolving the scrap material in nitric acid; (2) extracting Uranium content from the acid solution; (3) precipitating extracted Uranium; and (4) filtering the precipitate. Details of the processing equipment were included in the request (Reference B-10).

By letter to the AEC dated October 6, 1960, Mallinckrodt requested approval to incinerate contaminated trash such as filters, rags, paper and floor mop water to concentrate Uranium prior to chemical recovery in Building 240 (Reference B-11).

In an AEC letter dated June 17, 1963, the AEC discussed UNC's request to manufacture 20 percent enriched UO_2SO_4 D_2O in Area 240-2 (Red Room) for the LPR critical facility (Reference B-4).

In a March 31, 1964, letter UNC requested an amendment to License No. SNM-33 permitting blending fully enriched UO_2 with natural thorium (ThO_2) in the Pellet Plant (Area 255-2) (Reference B-6).

In a July 15, 1964, letter to the AEC, UNC requested an amendment to License No. SNM-33 to permit processing fully enriched Uranium in Area 255-3 (the Item Plant) (Reference B-5).

In an October 26, 1968, letter to the AEC, UNC discussed fabrication of Uranium-aluminum ceramic cores, although it is uncertain how much if any of this activity was proposed to be performed at the Hematite facility (Reference B-12).

A November 27, 1968 UNC request for renewal of License No. SNM-33 included UNC procedures that were being used to perform activities at the Hematite Site. A review of these procedures indicates that batch-type operations still predominated site activities. Detailed descriptions were provided for Red Room and Green Room operations. Some issues of interest were found within these procedures that shed light on Burial Pit log entries made during that time (Reference B-13).

In UNC procedure entitled Chemical Operation 800, issued on October 31, 1968, the Red Room process for converting UF_4 into Uranium metal was described as a thermite reaction with calcium metal and a small amount of additive. This process was carried out using an induction furnace that held a metal shell measuring 6.125 X 13 inches and was referred to as a "bomb shell." Within this shell, 8,600 grams of UF_4 was changed into a 6.5 Kg metal biscuit. The biscuits were chemically treated in a "pickling hood" using acetic acid. This explains the terms "pickling solution" and "bomb casings/shells" that are referenced in the Burial Pit logs (Reference B-14).

Another reference in the Burial Pit logs found in the Chemical Operation 800 procedure are balls from milling operations, a type of grinder used in grinding (or mixing) materials like ores, chemicals, ceramic, raw material and paints. Ball mills rotate around a horizontal axis, partially filled with the material to be ground plus the grinding medium. An internal cascading effect reduces the material to a fine powder.

2.1.4 FUEL FABRICATION OPERATIONS 1968-1974

In 1968, the Oxide Building and loading dock were added to the northeast side of Building 255. The receipt and storage areas for UF_6 cylinders were modified. The Building housed three chemical reactors, increasing the throughput capability of UF_6 to UO_2 conversion. The conversion process using chemical reactors is described below.

Uranium hexafluoride (UF_6) feed material, enriched up to five weight percent in U-235 was received from suppliers (e.g., Paducah) in 2.5-ton, 30-inch diameter cylinders. These cylinders were off-loaded onto the UF_6 dock and stored outside on 4 X 4 ft. wooden chocks. To initiate the conversion process, UF_6 cylinders were brought inside and heated in steam chambers to vaporize UF_6 into gas. Ammonium bicarbonate was used to wash the cylinders prior to transport back to DOE. The resulting wash water went into the wet recovery cycle described below.

The conversion of UF_6 to UO_2 was accomplished using three chemical reactor vessels (R-1, R-2 and R-3) connected in series. The chemical reactor vessels were fitted with electrically heated furnaces. The reactor system was designed to convert UF_6 to UO_2 granules through a fluidized bed conversion process. The UO_2F_2 was then pyrohydrolized in a reducing atmosphere of dissociated ammonia to remove residual fluoride and reduce the UO_2F_2 to UO_2 to granular form. The UF_6 gas was then reacted with steam to produce uranyl-fluoride (UO_2F_2) and hydrofluoric acid (HF).

$$\mathbf{UF_6(gas) + 3\ H_2O(gas) \rightarrow UO_2F_2\ (solid) + 4HF(gas) + H_2O\ (gas)}$$

The UO_2F_2 particles passed into the next reactor in series, where the UO_2F_2 reacted with hydrogen (obtained from cracked ammonia) to form UO_2.

$$\mathbf{UO_2F_2(solid) + H_2\ (gas) \rightarrow UO_2\ (solid) + 2HF\ (gas)}$$

The UO_2 granules exiting the R-3 reactor were cooled by a water-cooled heat exchanger. The granules of UO_2 powder were then passed through a dew point analyzer and deposited in a receiver. Dry scrubbers were used to reduce HF discharge to the plant stack. These dry scrubbers used calcium carbonate, which reacted with the fluorine to calcium fluoride (CaF_2 - spent limestone) that accumulated on site over time. This spent limestone was used as fill material on site as allowed per a Special Authorization of License No. SNM-33, providing that the average total Uranium alpha activity was less than 30 pCi/gm.

2.2 COMMERCIAL NUCLEAR POWER ERA

This period encompassed the production of fuel pellets using low-enriched Uranium (<5 percent) and fuel assemblies supplying various commercial nuclear power plants. Regulatory oversight during this era was conducted by the NRC.

2.2.1 AEC/DOE RECYCLED URANIUM

While this period predominantly focused on using low enriched Uranium, the characteristics of the UF_6 supplied to Hematite by the U.S. Department of Energy (DOE) introduced radioisotopes of concern. Due to the characteristics of recycled Uranium, as detailed in DOE Project Overview and Field Site Report, "A Preliminary Review of the Flow and Characteristics of Recycled Uranium throughout the DOE Complex 1952-1999" (Reference B-15), Tc-99 and some trace concentrations of U-236, Am-241, Pu-239/240 and Np-237 were introduced into Uranium provided by the U.S. Department of Energy to fuel fabrication facilities. Hematite was one of the fuel cycle facilities that received UF_6 from the DOE that was produced from recycled Uranium.

Because Tc-99 forms volatile and semi-volatile chemical compounds that tend to migrate toward the top of the gaseous diffusion cascade, Tc-99 was contained in the enriched Uranium product supplied to Hematite. Due to its higher relative atomic weight, Am-241 generally migrates toward the bottom of the gaseous diffusion cascade along with much of the U-238; and thus, is not believed to have been introduced into Hematite operations in any significant quantities.

Enriched Uranium, the primary contaminant of concern at the site, tends to favor the lower mass isotope (i.e., Tc-99) from the gaseous diffusion process as described above. As a result, Technetium is a significant contaminant of concern at the site, based on materials handled at the facility. Tc-99 is a low energy beta-emitter and is found in the environment primarily as the pertechnetate anion (TcO_4). This form is highly water soluble and mobile in soil and groundwater.

2.2.2 FUEL FABRICATION OPERATIONS

The main operations performed at Hematite during the commercial low enriched fuel operations were: (1) conversion of UF_6 to UO_2, (2) pellet fabrication, and (3) scrap recovery. When Building 230 was constructed in 1992, rod loading and fuel assembly operations were added to the facility processes.

Operating Sheet (O.S.) No. 604.15, "Dry Scrubber Operation," states that if the limestone is dispositioned as acceptable to dump by Health Physics, the hopper can be temporarily dumped in the designated intermediate storage area inside the fence until the accumulation warrants moving it to a storage location outside the fence. A permanent covered location for spent limestone was added to the northeast side of Building 255 in the early 1990s (Reference B-16).

Bulk storage and recycle hoppers were used to store the Uranium oxide. The bulk storage hopper was typically employed for transporting and storing the virgin UO_2 product. A recycle hopper was typically employed for storing and transporting UO_2 from the scrap recovery process. After filling and closing, the bulk storage hopper was transported out of the Oxide Room through the north corridor of Building 255 to the north end of Building 254. Powder transferred from the bulk storage and recycle hoppers was unloaded in hoods and fed to a micronizer by means of a vibratory feeder. The micronizer, which used a process of air grinding to work the coarse raw oxide into a fine oxide powder, was then vacuum-transferred to the oxide blender.

Note that in the late 1990s, erbium was introduced into this process during production of UO_2 pellets for CE reactors. Erbium is an element of the rare-earth group (atomic number 68) and functions in fuel as a burnable poison, used for reactivity control and for maximizing fuel loading. It is not radioactive and not considered toxic.

2.2.2.1 Pellet Fabrication

Blending process steps, through pellet pressing, were contained in a vertical column beginning with the blended UO_2 powder receiving hood on the third floor of Building 254. Various steps included use of a conical screw miter, slugging press, granulator and pellet press; the addition of a poreformer and press fines assisted in the fabrication of fuel pellets. The mixture was pressed into pellet form in a rotary pellet press. The pellets emerging from the rotary press were loaded into sintering "boats" for heat treatment (sintering); the pellets were de-waxed and sintered to obtain the required ceramic properties.

The sintering process, which used ammonia, increased the density of the UO_2 pellets by shrinking them. Heated ammonia yields H_2 and N_2 gases. The hydrogen created a reducing atmosphere that kept Uranium dioxide as UO_2 (prevented oxidation to U_3O_8 or black oxide) and the nitrogen purged the atmosphere. The sintered pellets were then transferred to a grinder feed system and ground under a stream of coolant to obtain a specific size. After grinding, the pellets were transferred by feeder to pans, and removed to an inspection area. The finished pellets were then packaged for shipment or stored for use on-site.

After construction of Building 230 in 1992, fuel pellets were taken to Building 230 where they were loaded into empty fuel rods, plugged, weighted and seal-welded. The sealed rods were inspected, leak tested and assembled into fuel bundles.

2.2.2.2 Scrap Recovery

Scrap materials and waste products bearing Uranium were treated in a wet recovery process, which included: oxidation, dissolution, filtration, precipitation, centrifuging and drying the UO_4 product. The UO_4 product was then converted back to UO_2 and returned to the feed process described above.

The wet recovery process was initiated when Uranium oxide (U_3O_8) or Uranium peruranate (UO_4) was first slurried with deionized water, to reduce Uranium losses from dusting and provide a uniform rate of reaction during dissolution. The U_3O_8 or UO_4 slurry was pumped into a dissolution vessel at a specified rate, where it was dissolved in a hot nitric acid (HNO_3) solution to produce uranyl nitrate.

Precipitation of UO_4 from the dilute $UO_2(NO_3)_2$ solution was the chemical purification step of the wet recovery process. During chemical purification, the Uranium was selectively precipitated from the $UO_2(NO_3)_2$. The UO_4 slurry was separated from the liquor containing impurities that were present in the solution. The uranyl nitrate solution was then transferred to a trough precipitator and discharged into a centrifuge feed vessel.

The precipitate cake exiting the centrifuge was dropped by gravity into a steam-heated screw conveyor dryer. After drying, the UO_4 was transferred to a safe volume container in a dry discharge hood. A recycle furnace was equipped with its own ventilation and scrubber system to clean effluent gasses prior to discharge to the atmosphere. The scrubber liquor for furnace No. 1 used aqueous ammonia (NH_4OH) to scrub the gases. Anhydrous ammonia (NH_3) was used to maintain pH. The scrubber liquor for furnaces No. 2 and 3 was either potassium hydroxide (KOH) or regenerated KOH. The scrubber liquor was regenerated using crushed limestone that was presumably disposed of pursuant to the guidelines discussed under O.S. No. 604.15, "Dry Scrubber Operation" (Reference B-16).

Filtrate from the centrifuge was pumped through a UO_4 polish filter for final clarification and then pumped to a liquid capacity filtrate holdup tank. It was sampled for Uranium concentration and transferred to a holding and evaporation tank complex located outside south of Building 240 for concentrating. The complex consisted of a hold tank and two steam-heated evaporation tanks used to concentrate liquids. All three tanks were within a diked area to contain any spills or overflows from the tanks. The pad included a sump pump for returning liquids to the outside holding tank. The holding tank stored excess liquids for evaporation and, in some cases, filtered recycle furnace scrubber potassium hydroxide (KOH) solution. A steam supply to the evaporation tanks heated filtrate in the tanks until evaporation began. Additional filtrate was pumped into the tanks until the holding tank emptied. Analyzing the concentration determined if the total Uranium was less than 350 grams. The liquid would be solidified and packaged for shipping. O.S. No. 801.14, "Outside Hold and Evaporation Tanks," was used during system operation (Reference B-17).

3.0 BURIAL PITS AND OTHER ON-SITE BURIAL HISTORY

Waste was buried at the Hematite Site during two distinct periods: (1) prior to July 16, 1965, and (2) between July 16, 1965 and 1973. Locations of those burials are in the northeast area of the central tract, and primarily in the area northeast of Building 255, southeast of State Road P, southwest of the north east site creek, and northwest of the railroad tracks.

3.1 WASTE BURIED PRIOR TO JULY 16, 1965

The following are excerpts from memorandum, "The Hematite Burial Grounds," from Jim Rode, previous Hematite Plant Manager, to Bill Sharkey, Hematite Licensing Manager, dated March 5, 1996 (Reference B-1):

> *The first on-site burial that I am aware of were [sic] instigated by then Plant Manager Ned North after the formation of United Nuclear II (when Saber-Pinion bought majority control and the production of Naval Fuel was initiated). That probably places it after 1961 and before 1964. ...burials then were limited to general trash, though it probably included some items which were lightly contaminated by current release standards including small tools, paint cans, etc. ...There was no burial of known Uranium bearing materials are [sic] major equipment that I am aware of. The burials were specifically designed to be placed in the path of future roadways between buildings on the site as the site expanded. These burials weren't documented as they were not considered to contain significant quantities of SNM. The placement was intended to avoid problems with foundations if settling occurred.*

3.2 WASTE BURIED BETWEEN JULY 16, 1965 AND 1973

On-site burial of waste materials contaminated with SNM was allowed by the AEC pursuant to then regulation 10 CFR 20.304 (1964) according to the following limitations: (a) The total quantity of licensed and other radioactive materials buried at any one location and time does not exceed, at the time of burial, 1000 times the amount specified in Appendix C of 10 CFR 20; and (b) Burial is at a minimum depth of four feet; and (c) Successive burials are separated by distances of at least six feet and not more than 12 burials are made in any year.

The following are excerpts from ABB memorandum, "The Hematite Burial Grounds," from J. Rode, previous Hematite Plant Manager, to B. Sharkey, Hematite Licensing Manager, dated March 5, 1996 (Reference B-1):

> *A few years later after the departure of Dr. North, Fred Stengel was hired as Manager of Chemical Operations at Hematite. He had worked at General Atomic where radioactive wastes were already being buried routinely on site in conformance with the newly issued AEC* [Atomic Energy Commission] *regulations providing for such burials (10 CFR 20.304). When I raised questions about the advisability of burying Uranium rather than shipping it to Maxie Flats for burial, I was told that since our competitors were saving money by burying on-site, we would be at an economic disadvantage if we did not utilize this option offered us by the AEC. I would point out that these burials were quite different from the burials initiated by Dr. North. The burials under Dr. North's management* [prior to 1965] *were not intended to bury any Uranium.*

UNC memorandum, "Burial of Material," dated May 14, 1965 (Reference B-18), states in part: "We do not have a licensed burial ground and therefore are subject to certain restrictions on the burial of contaminated or Uranium bearing materials. Effective immediately, NO material is to be sent to our 'unofficial' burial ground without a release from either Darr or Swallow relative to its suitability for burial." By carbon copy of this memo, Mr. Stengel is requested to publish the ground rules for such a release. Secondly, the Production Department is requested to initiate a log that will describe items buried, date, contamination level and release.

As a result, two log books were generated that identify materials that were placed in the Burial Pits with the beginning entry on July 16, 1965, and the final entry on November 6, 1970 (Reference B-19). UNC memorandum, "Burial of Residues and Contaminated Material," from L. J. Swallow to E. F. Sanders, dated July 19, 1965 (Reference B-20), includes a summary of burial criteria to be followed. It appears from this summary and other available records that AEC regulation 10 CFR 20.304 (1964) was the intended basis for the criteria to be used for the Burial Pits. Each Burial Pit log book includes this memorandum attached to the first page.

UNC memorandum, "Burial of Contaminated Materials," from L. J. Swallow to D. G. Darr, dated September 3, 1965 (Reference B-21), states: "The burial of contaminated materials per my memo of July 19, 1965, to Sanders has been in effect now for over a month. Would you please evaluate from the Health Physics and Safety point of view: 1. Adherence to the S.O.P., 2. Records of burial, 3. Adherence to AEC regulations." Mr. Darr investigated on September 10, 1965 and wrote on his copy of the memo that records were good, but noted no tie-back for accountable material transfer.

UNC memorandum, "Burial List #5," from T. J. Collopy to E. F. Sanders dated October 8, 1965 (Reference B-22), is one of many memorandums that show UNC management was provided a list of waste materials identified for burial. A comparison between the log book (Page 23) and this memorandum identifies that the same information in the log book was included in the memorandum, an indication of management oversight of the burial program.

In 1972, as a result of the increased governmental regulation of waste, the AEC required licensees to submit descriptions of their waste management program. GUNFC responded in a letter dated May 3, 1972 (Reference B-23): "Enclosed are the seven copies of the description of Gulf United's Waste Management Program for Chemical Operations at Hematite, MO...Solid waste is generated, processed and disposed of in quantities shown on an attached table. Solid waste is collected as soon as it is generated and placed in bins or drums which are located strategically throughout the facility. Processing consists of compacting or incineration; however, unprocessed drums may be released for disposal. Disposal refers to on-site burial and shipment for burial." It should be noted that on-site burial was reportedly stopped in November 1970 and off-site burial purportedly has been used exclusively since. Through November 1970, approximately 71,200 grams of (total) Uranium (approximately 4.81 curies) had been buried on the site.

As noted in Appendix A of the Historical Site Assessment, an exposed burial excavation appears in photographic evidence in March through May of 1973. This period coincides with the cleanup period of the site performed by GUNFC in preparation of the sale to CE. An interview with J. Rode on February 13, 2008, yielded that it is quite possible that commercial waste materials (without SNM contamination) were buried during that site cleanup phase. However, no documentation detailing that burial has been found to corroborate that assumption.

A hand-drawn sketch on UNC letterhead of the Hematite Site found in historical plant files shows rough (inexact) locations of on-site burials. Review of this sketch yields a burial excavation labeled "#39." This information taken in context provided by the Burial Pit logs, which documents 40 pits but due to numbering methods Pit #38 is designated as the final pit closed in November 1970, as noted above, may indicate that there were further burials after the cessation of the use of documented Burial Pits under 10 CFR 20.304 (1964). It also appears that this "Burial #39" may coincide with the burial excavation in photographic evidence of March through May 1973.

In 1982, the NRC hired RMC Technical Services to perform a radiological survey of the burial site at Hematite. NUREG/CR-3387, "Radiological Survey of the Combustion Engineering Burial Site, Hematite, Missouri" (Reference B-24), documents the survey and results. RMC Technical Services noted that 40 pits exist and concluded: "The results of this survey confirm that small quantities of Uranium have been buried in the pits adjacent to the CE plant in Hematite, MO... highest level measured 38 pCi/g of U-238, which was the only measurement that exceeded the target criteria of 30 pCi/g. These measurements tend to confirm that generally only low-level contaminated materials and equipment were disposed of in these pits... and that the buried material is essentially stable at this time. The Burial Pits have little or no effect on the population or the surrounding environment."

An internal NRC memorandum dated October 29, 1985 (Reference B-25), discusses an allegation of improper burial of radioactive wastes at Hematite. However, a routine NRC safety inspection report dated February 3, 1986 (Reference B-26), responding in part to the allegation, concluded: "while radioactive material is buried on the CE site, no evidence was found that the burials violated applicable NRC (or AEC) regulations... The licensee's environmental sampling program appears adequate to ensure that any future creek contamination will be detected."

In 1996, the NRC addressed the issue of decommissioning 10 CFR 20.304 (1964) burials by developing a screening methodology for determining courses of action to take to address said burials that was published in the Federal Register (61 FR 56716). CE responded to the NRC on September 13, 1996, requesting postponement of burial site decommissioning. The NRC responded in a letter dated November 25, 1996, stating in part: "Based on our review [of 10 CFR 20.304 burial] we cannot grant your request for delay because you have not adequately justified such delay in accordance with NRC requirements in 10 CFR 70.38(f)... If you determine that remediation is necessary, you will need to submit a decommissioning plan for the disposal area within 12 months of your notification (i.e., no later than September 13, 1997)" (Reference B-27).

A follow-up letter from the NRC to CE, dated November 21, 1997 (Reference B-28), stated in part: "In response to request for alternate schedule for decommissioning of the 10 CFR 20.304 burial area... You indicated that within 1.3 years of approval of the work plan by NRC and MDNR [Missouri Department of Natural Resources] you will submit a hydrogeological report on the results of the investigation... Request is granted. Note compliance issue is separate from and unaffected by this approval."

After the site was acquired by the then parent company of Westinghouse - British Nuclear Fuels Limited (BNFL) - and merged into Westinghouse as part of a purchase of ABB's nuclear division, Burial Pit decommissioning was incorporated into the overall site decommissioning effort.

4.0 EVAPORATION POND HISTORY

Two Evaporation Ponds are located south of the process buildings along the current fence line. They were used for on-site disposal of solutions containing contaminants of Uranium, Technetium-99 and trichloroethylene. One pond was used as a primary Evaporation Pond (EP1) and the other as a larger secondary/overflow Evaporation Pond (EP2). When constructed, the ponds were placed 12 ft. apart and excavated to a depth of approximately 3 ft. Soil removed was used to construct a 1.5 ft. berm around each pond. The ponds were lined with a 6 in. bed of 3 in. diameter rock, followed by a 4 in. bed of half-inch diameter rock. The primary pond was 30 ft. by 40 ft. and the secondary pond was 30 ft. by 85 ft.

The Evaporation Ponds were built to receive filtrates from the low enriched Ammonium Diuranate (ADU) conversion recovery process, and may have been used to receive effluents from high enriched processes as well. In June 1964, Mallinckrodt management decided to use the ponds to dispose of filtrate containing low levels of Uranium from the Blue and Green rooms as it was becoming problematic to dispose of filtrate at the Mallinckrodt St. Louis facility. Limestone was added as liner to the primary pond and its use was expanded. Filtrate from Green Room operations was apparently disposed of into the Crystal City landfill from April 1964 to July 1964 (Reference B-29).

A review of the practice of using the ponds was undertaken by the health physics representative on-site. Note that Mr. Darr suggested that it "might be wise to keep a material balance on the pond," however, no such log was maintained (Reference B-30). From 1965 through 1970, entries made into Burial Pit logs included solutions that were disposed of into the Evaporation Ponds. A review of those entries yielded the following liquid wastes: oil, perclene, trichloroethylene (TCE), potassium hydroxide, hydrochloric acid, acetic acid and nitric acid.

By letter dated August 16, 1976 (Reference B-31), CE requested authority from the NRC to license a wet scrap recovery process. In the associated September 19, 1977 License No. SNM-33 amendment (Reference B-32), the NRC authorized operation of the process subject to the condition that "liquid waste from this system shall not be discharged to the on-site Evaporation Ponds."

Use of the Evaporation Ponds was discontinued in September 1978. The approach was then to solidify liquid wastes and transport to off-site burial. When pond use was discontinued, approximately 12,000 ft^3 of sludge was pumped out of the primary pond, dried and placed in 136 drums for future disposal in October 1979. The sludge was shipped off site to a licensed disposal facility from 1982 to early 1984 (Reference B-33).

A December 8, 1980, NRC Systematic Assessment of Licensee Performance (SALP) review (Reference B-34), included the following: "The status of the two small, unused lagoons at Hematite was discussed. The NRC explained that the lagoons were not a present problem but removal and disposal of the Uranium waste in the lagoons should continue to be a goal. In 1979 the licensee voluntarily began removal of the sludge from the lagoons. The licensee is

considering methods of disposing of the sludge and how best to proceed with removing and disposing of the deeper, hard packed material in the lagoons."

By letter dated March 8, 1984 (Reference B-35), the NRC included Condition 19 to License No. SNM-33 stating that "The licensee shall decommission the Evaporation Ponds as soon as reasonably achievable." In response, CE submitted a decommissioning plan to the NRC by letter dated May 31, 1984 (Reference B-33). The NRC approved the Plan on October 3, 1984, which changed License Condition 19 to state: "The licensee shall decontaminate the two Evaporation Ponds such that the average residual contamination in each pond does not exceed the appropriate limit of either 250 picoCuries of insoluble Uranium or 100 picoCuries of soluble Uranium per dry gram of soil. The Tc-99 concentrations in a composite sample for each pond shall be determined" (Reference B-36).

Approximately 2,800 ft^3 of sludge, rock and dirt was removed from the primary pond in August 1985. Detailed sampling of the primary pond was performed from August through October 1986. Sampling following the remediation effort determined the average total Uranium contamination of the soil in the ponds was below the 250 pCi/g total Uranium decontamination limit set by the NRC, however, spot contamination levels in excess of the limit remained. In a status report to the NRC dated February 12, 1987 (Reference B-36), CE stated, "Although we plan further sampling of the large pond this summer, we expect that both now meet the decommissioning criteria."

In a status report dated May 20, 1988 (Reference B-37), CE provided the NRC with further information concerning the remediation of the ponds. CE reported that core samples from the sides and bottom of the primary pond were taken and analyzed. The samples revealed an average total Uranium contamination of approximately 60 pCi/g, with one sample as high as 674 pCi/g. Approximately 1,200 ft^3 of soil and rock were also removed from the secondary pond during 1987, and detailed surface soil samples were taken. The average total Uranium contamination from these 150 samples was 173 pCi/g, and the highest reported level was 745 pCi/g.

An internal NRC memorandum from November 23, 1994 (Reference B-38), states, "Please review CE's Hematite Evaporation Ponds Decommissioning Plan. The objective is to close the ponds in accordance with Option 2 of NRC's Branch Technical Position. For the final status survey, CE plans to follow the guidelines in NUREG/CR-5849." A responding NRC memorandum dated January 27, 1995 (Reference B-39), states, "My staff has reviewed CE's Hematite Evaporation Ponds Decommissioning Plan. ...A groundwater impact evaluation and a review of Uranium solubility are recommended. This evaluation needs to demonstrate that groundwater impact would not result in an unacceptable dose to the maximally exposed individual under a 1000-year unrestricted use scenario."

On May 4, 1995 (Reference B-40), the NRC issued a Safety Evaluation Report (SER) on the proposed Hematite Evaporation Pond Decommissioning Plan, concluding that there would be no adverse effect on health and safety of public or environment and recommending approval of the

amendment request. In a status update to the NRC on the ponds dated August 13, 1999, CE-ABB indicated that, over the past four years since the decommissioning plan had been implemented, approximately 6,000 ft^3 of additional soil had been removed and disposed.

Surveys in 1999 of the pond area indicated an average concentration of 170 pCi/g. Uranium concentrations of approximately 100 pCi/g were detected at depths of 10 ft below ground surface, greater than originally assumed. Remediation efforts in and around the Evaporation Ponds were suspended to investigate other remedial options (Reference B-41).

Finally, in a letter to the NRC dated June 2, 2000 (Reference B-42), Westinghouse proposed that the Decommissioning Plan for the Hematite Evaporation Ponds be deleted. Westinghouse planned to incorporate decommissioning the area into a general site Decommissioning Plan upon cessation of operations. The Hematite Site had been purchased by BNFL (Westinghouse), which had declared its intent to shut down and decommission the facility.

5.0 REFERENCES FOR APPENDIX B

B-1 Combustion Engineering, Memorandum, J. Rode to W. Sharkey, "The Hematite Burial Grounds," March 5, 1996.

B-2 Mallinckrodt Chemical Works, Letter to U.S. Atomic Energy Commission, "SNM-33 Amendment Request, Letter," January 21, 1957.

B-3 U.S. Atomic Energy Commission, Letter to United Nuclear Corporation, "Compliance Inspection Report - January 1B-14, 1960," February 10, 1960.

B-4 U.S. Atomic Energy Commission, Letter to United Nuclear Corporation, "United Nuclear Corporation, Hematite-License Amendment, Docket 70-36, dated June 7, 1963," June 17, 1963.

B-5 United Nuclear Corporation, Letter to U.S. Atomic Energy Commission, "Amendment of SNM-33 to Include "Item" Plant," July 15, 1964.

B-6 United Nuclear Corporation, Letter to U.S. Atomic Energy Commission, "SNM-33 Amendment to Permit Blending Fully Enriched UO_2 with Natural ThO_2 in The Pellet Plant," March 31, 1964.

B-7 United Nuclear Corporation, Letter to U.S. Atomic Energy Commission, "Amendment to SNM-33 for Processing and Shipping Fully Enriched UO_2-ZrO_2 Pellets," June 20, 1964.

B-8 U.S. Atomic Energy Commission, Letter to United Nuclear Corporation, "SNM-33 Amendment No.59," June 8, 1970.

B-9 U.S. Atomic Energy Commission, Letter to Mallinckrodt Chemical Works, "Compliance Inspection Report – August 18-19, 1959," February 4, 1959.

B-10 Mallinckrodt Chemical Works, Letter to U.S. Atomic Energy Commission, " Special Nuclear Material License No. 33," April 14, 1960.

B-11 Mallinckrodt Chemical Works, Letter to U.S. Atomic Energy Commission, "SNM-33 Extension: Contaminated Trash Incinerator," October 6, 1960.

B-12 United Nuclear Corporation, Letter to U.S. Atomic Energy Commission, "Fabrication of Uranium-Aluminum Ceramic Cores – SNM-777, Docket 70-820, Section 6A," October 26, 1968.

B-13 United Nuclear Corporation, Letter to U.S. Atomic Energy Commission, "Renewal of Special Nuclear Materials License SNM-33," (Docket 70-36), November 27, 1968.

B-14 United Nuclear Corporation, Procedure, "Section 800 - Chemical Operation," October 31, 1968.

B-15 U.S. Department of Energy, Project Overview and Field Site Report, "A Preliminary Review of the Flow and Characteristics of Recycled Uranium throughout the DOE Complex 1952-1999."

B-16 Combustion Engineering, Operating Sheet (O.S.) No. 604.15, "Dry Scrubber Operation."

B-17 Combustion Engineering, Operating Sheet (O.S.) No. 801.14, "Outside Hold and Evaporation Tanks."

B-18 United Nuclear Corporation, Memorandum, F. G. Stengel to E. F. Sanders, "Burial of Material," May 14, 1965.

B-19 Hematite Burial Pit Log Books, Volumes 1 and 2, July 16, 1965, through November 6, 1970.

B-20 United Nuclear Corporation, Memorandum, L. J. Swallow to E. F. Sanders, "Burial of Residues and Contaminated Material," July 19, 1965.

B-21 United Nuclear Corporation, Memorandum, L. J. Swallow to D. G. Darr, "Burial of Contaminated Materials," September 3, 1965.

B-22 United Nuclear Corporation, Memorandum, T. J. Collopy to E. F. Sanders, "Burial List #5," October 8, 1965.

B-23 Gulf United Nuclear Fuels Corporation, Letter to U.S. Atomic Energy Commission, "Waste Management Program AEC License No. SNM-33 Docket 70-36," May 3, 1972.

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