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ASH REMEDIATION PROJECT (3)

SAFETY ANALYSIS REPORT
SOUTHERLY WASTEWATER TREATMENT PLANT

NORTHEAST OHIO REGIONAL SEWER DISTRICT
CUYAHOGA HEIGHTS, OHIO

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1.0 INTRODUCTION

In April, 1991 an aerial survey conducted over Cleveland by the Nuclear Regulatory Commission (NRC) detected elevated levels of radioactivity at the Southerly Wastewater Treatment Plant (SWTP) (EGG - Energy Measurements, April, 1992). Areas identified included locations at the north edge of the plant, the sanitary pond (ash lagoons) now in use, and a sludge lagoon that was discontinued in the 1960s. The radiological measurements recorded over the SWTP prompted NRC and the Ohio Department of Health (ODOH) to conduct an initial site survey on May 15, 1991 (ORISE, 1992).

Following the initial survey by ODOH and NRC, some radioactivity related to Co^{60} was detected in the incinerator ash in the ash lagoons and in several areas on-site where ash from the lagoons has been deposited. At the request of the NRC's Region III office, the Environment Survey and Site Assessment Program (ESSAP) of Oak Ridge Associated Universities/Oak Ridge Institute for Science and Education (ORAU/ORISE) conducted a radiological characterization survey of selected outdoor areas at the SWTP (ORISE, 1992).

During September, 1991 and March, 1992 ORAU/ORISE conducted radiological characterization surveys of the SWTP. The surveys included surface scans, exposure rate measurements and samples of surface and subsurface soil, sediment and water samples. The surface scans identified elevated radiation readings ranging from 11 to 580 μR/h over areas in the North Fill Area. Surface scans identified elevated radiation readings ranging from 7 to 320 μR/h in the South Fill Area (ORISE, 1992).

Surface samples collected in the North Fill ranged from <0.1 to 6,798 pCi/g and in the South Fill Area ranged from <0.1 to 5,390 pCi/g Co^{60} activity. Subsurface soil samples in the North Fill Area ranged from <0.1 to 7,733 pCi/g and in the South Fill Area ranged from 0.1 to 31,200 pCi/g Co^{60} activity. Sediment samples collected from the North Fill Swamp Area Concrete Canal, the Cuyahoga River, the Ohio Canal, the Plant Outfall and the

Sanitary Ponds Areas, contained Co^{60} concentrations ranging from <0.1 pCi/g (Plant Outfall) to 75 pCi/g (area in the Middle Pond). Concentrations of <0.2 pCi/g Co^{60} were found in the North Fill Swamp Area Concrete Canal. Cobalt 60 concentrations ranged from 0.1 to 0.5 pCi/g for the North Pond and from 0.1 to 1.0 pCi/g for the Middle Pond.

Water samples were collected from the North Fill Swamp Area Concrete Canal, Sanitary Ponds Area and other off-site areas (Cuyahoga River, Ohio Canal, Plant Outfall and Tinkers Creek).

All on-site and off-site areas contained Co^{60} concentrations in water samples of <3.3 pCi/l with the exception of water collected from boreholes in the North Fill Area (<9.3 pCi/l) (ORISE, 1992).

Based on the ORISE Radiological Characterization Survey results, reviews of sewer district records and interviews of sewer district employees, the NRC concluded that the contaminant was introduced into the plant about 10 to 12 years ago and that no immediate threat to worker and public health and safety exists. In conjunction with the activities at the SWTP, an inspection of the Easterly Wastewater Treatment Plant was performed by NRC on August 27, 1991 and no evidence of radioactivity was found.

As the source of the cobalt is investigated, the Northeast Ohio Regional Sewer District (NEORSD), which operates the SWTP, requested that a Site Operations Plan (SOP) be developed to describe the relocation of radioactive ash from three on-site lagoons (Lagoons A, B and C) to a single location, the South Fill Area. The Site Operations Plan (Dames & Moore, March 1993a) and the associated Radiological Control Plan (Dames & Moore, March 1993b) was prepared and submitted to the U.S. Nuclear Regulatory Commission. As part of the SOP, this Safety Analysis Report was prepared as a separate stand alone document to project potential exposures to the workers and general public under normal and abnormal conditions.

2.0 BACKGROUND INFORMATION

2.1 SITE TOPOGRAPHY AND ADJACENT LAND USE

The Southerly Wastewater Treatment Plant (SWTP) is located in Cuyahoga Heights, Ohio. The site is west of the Interstate Route 77 and north of the Cuyahoga River (Figure 1). The site location is indicated on portion of the U.S.G.S. 7.5 minute topographic Quadrangle map #41081-D6-TF-024, Cleveland South, Ohio, 1965, photo-revised 1984. The SWTP consists of a North Fill Area, Main Processing Plant and the South Fill Area.

The South Fill Area and ash lagoons are separated from the main plant by the Ohio Canal and Canal Road. A layout of the Southerly Wastewater Treatment Plant (SWTP) is presented on Figure 2.

The topography as seen on Figure 1 shows that the entire site is located within the flood plain of the Cuyahoga River. The existing lagoons and fill area south of the Ohio Canal are contained by a perimeter dike constructed predominantly of incinerator ash fill and clay with a crest level of approximately 602 feet above mean sea level (MSL) (Figure 3). The flood elevation and frequency at the Southerly Wastewater Treatment Center (SWWTC) were determined during the design and preparation of the "Advanced Wastewater Treatment Facilities," Contract No. 10A, "Outfall Conduits and Ash Lagoons," dated April 1976. The flood elevation and frequency in the Cuyahoga River were identified on Sheet 14 of 33, "End Structure Grading-Plan and Sections," as follows:

Frequency	Elevation of Cuyahoga River*
100 year	26.2
25 year	24.2
10 year	23.4
5 year	22.8
1 year	19.5

Note:

* Elevation in feet above the SWWTC datum. 0 feet equals + 574.7 USGS elevation (Mean Sea Level).

The South Fill Area and related ash lagoons relationships to the Cuyahoga River floodplain is discussed in more detail in a report entitled, "Subsurface Investigation Report, Cleveland Regional Sewer District Southerly Treatment Plant Extension," dated October 16, 1974, prepared by Mueser, Rutledge, Wentworth & Johnston Consulting Engineers.

As noted previously, the 100 year flood elevation is 26.2 feet, or elevation 600.9 feet msl (574.7 feet msl + 26.2 feet = 600.9 feet msl). The elevation of the top of the berm and access road around the three ash lagoons averages 604.7 feet, approximately 3.8 feet higher than the 100 year flood elevation in the Cuyahoga River. As part of the current ash lagoon clean-out work at the SWWTC under Contract No. AR-5, the elevation of a lower portion of the top of the perimeter berm around the South Fill Area ("Old Sludge Lagoon"), which is the disposal area for the ash excavated from the ash lagoons, is being raised to elevation 602.2 feet msl. The perimeter berm will be about 1.1 feet higher than the 100 year flood elevation.

The ash that is stored in the three ash lagoons, and in the Old Sludge Lagoon disposal area is isolated by earthen berms from the 100 year flood elevation in the Cuyahoga River. Therefore, the ash lagoons and Old Sludge Lagoon can only be flooded by storm events that

are significantly more remote than the 100 year storm even, which statistically can only occur once every 100 years. Therefore, there is little potential for radionuclides to be transported downstream of the SWWTC by flood waters. Construction and routine inspection and maintenance of the earthen berms constitutes the precautions taken by the Northeast Ohio Regional Sewer District to isolate the ash and radionuclides from flood waters.

Immediately to the west SWTP are low-lying undeveloped lands along the Cuyahoga River and Ohio Canal. Immediately to the north and south of the SWTP are industrial and commercial properties. Additionally, along 49th Street, approximately 3,000 feet northwest of the South Fill Area is an area of single and two-family housing. The nearest residential community approximately 1,000 feet northeast of the South Fill Area and consists of single and two-family structures. This residential community is on the east side of Interstate Route 77 and at an elevation of approximately 700 feet above MSL.

2.2 METEOROLOGY

Climatological data for the greater Cleveland area are presented in Table 2-1. In summary, the following annual temperature and precipitation amounts have been recorded and averaged over the past 30 years:

- The average annual temperature is 49.7°F.
- The average annual rainfall is 35.4 inches.
- The average annual snowfall is 53.6 inches.

The wind rose for the Greater Cleveland Area is presented in Figure 4. The predominant wind direction is from the south (Cleveland International Airport, 1981).

2.3 GEOLOGY AND HYDROGEOLOGY

The SWTP is located in the flood plain of the Cuyahoga River and therefore natural soils immediately underlying the existing fills are a series of alluvial deposits. The alluvial materials typically consist of a stratum of stiff to medium clays and silt overlying loose sand and are underlain by a stiff gray clay which extends to great depth below the ground surface. The clay consists of glacial lake deposits and glacial tills that fill the preglacial valley along which Cuyahoga River now flows. These clays have been eroded before the present flood plain of the Cuyahoga River. The clay surface rises steeply forming high ground east, south, north and west of the site.

Groundwater levels measured in borings placed in 1973 by Lake Drilling Company under the continuous inspection of Mueser, Rutledge, Wentworth and Johnson, indicate a perched water layer above the impervious clay stratum (Malcolm Pirnie, 1974). The perched water beds are generally similar to the observed levels of standing water in low-lying areas and in the existing lagoons.

Interpretations of hydrogeologic conditions at the SWTP site are primarily based on information contained in investigative reports by Malcolm Pirnie, Inc. (1974 and 1976). Those reports presented results of two phases of borings (total of 189) intended to establish subsurface conditions relative to a proposed facility expansion.

Malcolm Pirnie subdivided the soils underlying the SWTP site into the following six major categories:

1) Fill - consisting mainly of incinerator ash but including gray-brown silty clay and traces of sand, gravel, cinders, concrete and vegetation. Ash fill described as a red-brown, fine-to-medium grained sandy silt forms the confining berm at the fill area. The top of the berm is approximately 10 feet above the interior surface

grade but the fill may reach 30 feet thick where the berm overlies the old river channel. The density of the fill is generally low, owing to a lack of compaction during placement.

2) Sludge - from treatment plant operations is described as soft, dark gray, organic, silty clay. Consistency varies depending mainly on consolidation. Greatest thicknesses probably exist where sludge was used to fill old channels of the Cuyahoga River.

3) C1 - is the uppermost natural material beneath the SWTP site and is described as gray-brown to gray, silty clay to fine sandy silt. This deposit is stiffer near the top and softens with depth. It is slightly organic and ranges from 0 to 20 feet thick beneath the SWTP fill area. Water content averages 33 percent of dry weight.

4) S1 - constitutes the uppermost sandy deposit described as gray and gray-brown fine-to-medium sand with some silt and traces of vegetation. Thickness of this unit ranges from 2 to 15 feet beneath the SWTP. Loose consistency of this unit is illustrated by an average penetration resistance of three blows per foot.

5) S2 - is similar in texture and color to S1 but is somewhat stiffer and generally coarsens with depth to include gravel. Thickness varies from 5 to 15 feet beneath the SWTP. Resistance to penetration averaged 10 blows per foot and presumably reflected the fining upward nature of the unit.

6) C2 - consists of stiff, gray, silty clay glacial lake deposits with a trace of fine-to-coarse sand and gravel and occasional silt lenses. Resistance to penetration averaged 18 blows per foot in the upper 50 feet of the unit. Water content generally ranged from 19 to 25 percent of dry weight.

Limited groundwater data indicated locally perched water conditions above C1. Primarily unconfined, but locally confined water levels were observed present in strata S1 and S2 which are apparently hydraulically connected.

2.3.1 NORTH FILL AREA

The North Fill Area constitutes approximately three acres of land situated in the floodplain of the Cuyahoga River and north of the main plant. The North Fill Area is bounded to the south by the SWTP to the east by Interstate Route 77, to the north and east by the Penn Central Railroad spur and relative lowlands.

The borings located closest to the North Fill Area numbered approximately 10. Water level data is scarce but sufficient to grossly determine probable groundwater flow directions.

Groundwater flow directions (determined from data nearly 20 years old) are predominantly south toward the Cuyahoga River and west toward under gradients ranging from 0.3 to 2.0 percent (ft/ft). Depth to the water table varies from 2 to 15 feet below grade and little is know concerning water table fluctuations with time. Standing water at the surface prevails to the north of the North Fill Area and no information exists on the confining capability of the fill underlying this wet area.

2.3.2 SOUTH FILL AREA

The South Fill Area constitutes approximately eight acres of land situated in the floodplain north of the Cuyahoga River. An available survey of the property (Figure 5) illustrates that prior to relocation of the river, the area had been occupied by a meander. The South Fill Area is bounded to the north by the Ohio Canal, to the east by a railroad spur, to the south by the Cuyahoga River, and to the west by relative lowlands. A berm of

somewhat varying height surrounds the area. Prior to placement of the ash from the ash lagoons, the berm around the South Fill Area will be raised to an elevation of 602 feet (MSL). This elevation is approximately 2 feet above the calculated 100 year flood elevation of 600 feet.

The borings located closest to the South Fill Area numbered approximately 30 and received the closest attention in this analysis. Soil descriptions were comprehensive, but it is important to note that fill has been added to the area since completion of the borings. Water level data is scarce but sufficient to grossly determine probable groundwater flow directions.

The South Fill Area is immediately underlain by varying depths of sludge, incinerator ash and general fill material. Beneath this assemblage are natural alluvio-fluvial deposits ranging from medium-to-stiff silts and clays to fine-to-coarse sands. These are in turn underlain by a thick unit of stiff, gray clay which represents glacial valley deposition. These glacial clays were eroded in the floodplain of the Cuyahoga River but the clay surface rises steeply to form a high ground north, east and west of the South Fill Area.

Groundwater flow directions (determined from data nearly 20 years old) are predominantly south toward the Cuyahoga River and west toward adjacent lowlands under gradients ranging from 0.3 to 2.0 percent (ft/ft). Depth to the water table varies from 5 to 15 feet below grade and little is known concerning water table fluctuations with time. Standing water at the surface prevails in the western and southern portions of the South Fill Area and no information exists on the confining capability of the sludges, and fills underlying these wet areas. Recharge of strata S1 and S2 is not fully understood but elevations suggest the Ohio Canal to the north may provide significant volumes depending on it's water level. Discharge apparently occurs at seeps along the bank of the Cuyahoga River and within the wet lowlands to the west.

As part of the Site Characterization activities performed at the North Fill and South Fill Areas, the hydrogeologic regime and confinement capability of existing sludges and fills will be evaluated.

2.4 FACILITY DESCRIPTION

The Northeast Ohio Regional Sewer District (NEORSD) is responsible for operating three wastewater treatment plants (the Southerly, Easterly and Westerly Plants) in and near Cleveland, Ohio. The Southerly Wastewater Treatment Plant (SWTP) began operation in 1927 to remove grit and debris from the wastewater and is located on a site of approximately 217 acres in the Village of Cuyahoga Heights, south of Cleveland, Ohio. The SWTP site is west of Interstate Route 77 and north of the Cuyahoga River. The southern quarter of the SWTP site is separated from the northern part by Canal Road and the Ohio Canal.

The SWTP treats approximately 134 million gallons of sewage daily for customers in Northeast Ohio. The current processing system involves de-gritting the sludge, thickening it in a centrifuge, and thermally conditioning it before vacuum filtration and incineration. After incineration, the ash is slurried with water and pumped into sanitary ponds on-site. The ash from the sanitary ponds was used as fill at various locations on-site until 1991.

The major features of the SWTP site are the North Fill Area, Main Process Plant, Sanitary Ponds Area (Ash Lagoons A, B and C), and the South Fill Area and can be located on Figure 2.

2.5 MATERIAL CHARACTERISTICS

The material to be relocated from the Sanitary Pond Area (Lagoons A, B, and C) to the South Fill Area consists of ash produced from the on-site incineration facility. The incinerator ash is the remains of sludge that was collected during normal treatment plant

operation. The sludge was contaminated with Cobalt-60 from an unknown source resulting in residual contamination of various degrees within the ash. The activity levels in surface samples range from 0.3 pCi/g to 9900 pCi/g (ORISE, 1992).

Contained within the Sanitary Ponds (A, B & C) is an estimated volume of 4.5 million cubic feet of incinerator ash. During relocation and ash handling, processing the dry ash may produce dust unless proper controls are taken. At some locations within the Sanitary Ponds Area, the ash is saturated with accumulated surface water.

2.6 VOLUME OF MATERIAL TO BE RELOCATED

The Sanitary Pond Area is approximately 474,000 ft^2 and contains three operating sanitary ponds (Lagoons A, B and C). Lagoons A, B and C are approximately 150,000 ft^2, 157,000 ft^2, and 167,000 ft^2, respectively. The ponds have an underlying clay liner. A gravel road encircles each pond (Figures 2 and 3).

The amount of ash present in Lagoons A (1,431,000 ft^3), B (1,539,000 ft^3) and C (1,539,000 ft^3) has been calculated by assuming that Lagoons A and B are 88% and 95% full respectively and that Lagoon C is 95% full. Based on the quantity of ash removed from these lagoons in the past (when all three were full to capacity), there is a total volume of approximately 4.5 million cubic feet (167,000 cubic yards) of material that will be relocated to the South Fill Area.

The South Fill Area is approximately 536,000 ft^2, of which approximately 167,500 ft^2 contains ash previously relocated from the sanitary ponds. A berm surrounds the South Fill Area on the north, south, and west.

The boundaries of the South Fill Area were established assuming that the areas to the north and south of the existing South Fill Area (within the bermed boundary) are 10 feet deep and would be where the material from Lagoons A, B and C would be re-located.

The ash will be placed so that the height of the South Fill Area will be flush with the top of the berms.

3.0 ASH RELOCATION

This section of the Safety Analysis Report describes the method to be used during the excavation and relocation of approximately 4.5 million cubic feet of ash from Lagoons A, B and C to the South Fill Area. On-site excavation hauling and placement activities will be performed in accordance with the NEORSD Site Operations Plan (Dames & Moore, March 1993a) and the NEORSD Radiological Control Plan (Dames & Moore, March 1993b).

3.1 PROCESS DESCRIPTION

In order to facilitate the relocation of 167,000 cubic yards of ash from Lagoons A, B and C to the South Fill Area, four to five 20 cubic yard off road dump trucks will be required for each 6 cubic yard backhoe. Approximately 8,350 trips will be required for the ash relocation effort. The duration is expected to take approximately 4 months (800 hours - 10 hours/day x 20 days/month x 4 months) of time.

The relocation effort has been divided into the three step process as described below:

Step No. 1 - Site Preparation

Prior to excavating ash from within the lagoons, both a staging zone and a decontamination zone will be designated at an appropriate location within the radiologically controlled work area. Decontamination of equipment will be performed whenever necessary and before any equipment or trucks leave the restricted area of the SWTP worksite. Release surveys will be performed prior to any equipment leaving the work site.

Prior to the start of the excavation process, the ash to be removed will be sprayed with water. The water will retard the airborne dispersion of ash during the excavation process while not liquefying the ash and making it difficult to excavate.

Step No. 2 - Ash Removal

A track mounted extended backhoe will be situated on the gravel access road around the lagoons. The backhoe will remove as much ash as possible from the access road. As each truck is filled, it will transport its load to a designated location within the South Fill Area and return to be refilled. Approximately 8,350 truck trips will be needed to relocate the ash. The pattern of placement of ash in the South Fill Area will be first along the east boundary working toward the west berm in the north section of the South Fill Area. The placement of the ash will then proceed in a south direction, again working from an east to west direction.

Each dump truck will be equipped with a liner, if deemed necessary, to guard against leakage during ash relocation. The integrity of the liner will be examined periodically. In addition, each truck will be covered with a tarp or similar material to minimize airborne ash, if water application is not totally effective in minimizing airborne dust.

Once the backhoe cannot reach the ash from the access road, a ramp will be constructed so that the backhoe can enter the lagoons. A bulldozer will be used to push the ash to the backhoe and the backhoe will load the trucks from within the lagoons. The dump trucks will remain on the gravel access road. An alternative approach that may be used would be to bring the dump trucks into the lagoons and load them directly with the backhoe.

Water will be used for dust control and the ash will be removed to within two feet of the underlying clay liner. A bulldozer will be used to remove the remaining ash off of the bottom and sides of the lagoons. This will ensure protection of the clay liner installed on the sides and bottom of each lagoon.

Step No. 3 - Distributing the Ash

A 300 HP bulldozer will be used to spread and compact the ash once it had been transferred to the South Fill Area. The ash will be distributed evenly throughout the pre-designated fill area. During ash distribution, dust control will be maintained via water spray methods as prescribed in the Site Operations Plan.

Any surface water collected within the South Fill Area will be routed to the ash lagoons or to the ash lagoon overflow and redirected back to the headworks of the SWTP. Prior to redirecting the water, samples will be collected and analyzed for Co^{60} and the resultant activity compared to the NEORSD Administrative Limits as prescribed in the Radiological Control Plan.

During loading, transportation and placement of ash, routine exposure rate measurements and contamination control surveys will be performed in accordance with the NEORSD Radiological Control Plan.

3.2 UNUSUAL OCCURRENCE RESPONSE

During the ash relocation efforts, unanticipated occurrences may occur. The occurrences may be personal, medical or equipment related. The on-site radiation worker training will include emergency management procedures to facilitate the handling of these occurrences. There will be an individual who is the designated Emergency Coordinator on site at all times. Spill control and emergency response equipment will be available on the

site to handle emergencies. Equipment will include, but not be limited to water spray equipment, tarp materials, fire control equipment and first aid supplies. The water spray and tarp materials can be used to prevent airborne transport of spilled ash. Fire control equipment will be provided by contractors to supplement equipment in the nearby community.

Prior to the start of work local emergency agencies including fire companies, ambulance units, and hospitals will be notified of the planned activities and provided with training necessary to deal with emergencies, if required. The training may include radiation worker training and radiation practices for medical treatment of injured contaminated workers.

Anti-contamination equipment and personal dosimetry will be made available to emergency response personnel by the contractor. Release of emergency response equipment and materials from the South Fill Area will be in accordance with the NEORSD Radiological Control Plan, unless a life threatening condition exists.

Flooding may be an unusual occurrence. The lagoon berms (604.7 feet MSL) are approximately 3.8 feet higher than the 100 year flood elevation (600.9 feet MSL). The berms around the South Fill area which will contain the contaminated ash will be raised to an elevation of 602 feet MSL, approximately 1.1 feet higher than the 100 year flood elevation. Thus, the elevation of the berms and continuing inspection and maintenance of these berms will minimize leached berms, flooded lagoons, and downstream transport of Cobalt 60 by flood waters. Furthermore, the contaminated ash in the South Fill area will be covered with a clay and soil cap/cover and seeded to prevent release of contamination during flooding.

4.0 POTENTIAL EXPOSURES UNDER NORMAL OPERATING CONDITIONS

4.1 POTENTIAL EXPOSURES TO WORKERS

During the transfer of cobalt-contaminated ash from the lagoons to the South Fill Area, workers will be exposed to low-levels of gamma radiation and airborne radioactivity. This analysis evaluates the potential doses to workers from these exposures and compares them to the regulatory limits given in 10 CFR 20. Additionally, potential exposures to the general public due to the inhalation of contaminated ash are evaluated and compared to the regulatory limits prescribed in 10 CFR 20.

4.2 POTENTIAL EXPOSURES TO WORKERS ON-SITE

The radioactive decay of Cobalt-60 results in the emission of two relatively high energy gamma rays (1.17 and 1.33 MeV). The contamination is mixed with incinerator ash to be relocated from Lagoons A, B, and C to the South Fill Area. Therefore, doses may result from the inhalation and direct radiation exposure to the contaminated ash.

4.2.1 INHALATION DOSES

Doses from uptake of radioactivity into the body are estimated from the quantity of the isotope inhaled and a dose factor related to the isotope of concern. The uptake can be broken down into several parts, such as the concentration of the isotope in the air, the rate the air is breathed, and the length of time the contaminated air is breathed. The airborne concentration can be expressed as the product of the dust loading and the concentration of the activity in the dust (NUREG 5512, 1992).

The overall dose due to inhalation can be derived by calculation 4-1:

$$H = C_s \, M \, BR \, DF \, T \qquad (4\text{-}1)$$

where:

H	= 50 Year Committed Effective Dose Equivalent	(mrem)
C_s	= Cobalt-60 Concentration in Ash	(μCi/g)
M	= Dust loading in air	(g/m^3)
BR	= Breathing rate	(m^3/hr)
DF	= Dose Factor for Inhalation	(mRem/μCi)
T	= Duration of Activity	(hr)

For workers, the breathing rate is assumed to be 1.2 m^3/hr (ICRP 1979). The Cobalt-60 dose factor for inhalation is 219 mrem/μCi (NUREG/CR 5512). It is assumed that the effort will require four months (800 hours).

The dust load is assumed to be 10^{-2} g/m^3, the nuisance level for dust (29 CFR 1910.1001 - Table Z-3). This is a very conservative assumption, both in terms of actual dust levels and in the amount breathed, since the workers will be wearing nuisance dust masks and not all the dust particles will be of respirable size (in most cases only 20% of the particles are of respirable size - NUREG/CR 5814, 1992).

Using these assumptions, the potential dose to a worker (for 800 hours) from inhalation would be:

$$\begin{aligned} H &= M \, BR \, DF \, T \, C_s \\ &= (10^{-2}\ g/m^3)(1.2\ m^3/hr)(219\ mrem/\mu Ci)(800\ hr)(C_s\ \mu Ci/g) \\ &= 2{,}102\ C_s\ mrem \end{aligned}$$

where C_s is described above.

Discounting the single cobalt particle found, the highest cobalt concentration found in the ash was 32,000 pCi/g. If all ash had this concentration, the estimated dose from inhalation would be 67 mrem (2,102 * 0.032 μCi/g). More realistically, the NRC estimates the average concentration in the lagoon ash to be about 245 pCi/g (2.45 E-4 μCi/g) (ORISE, 1992), which would produce an inhalation dose of about 0.5 mrem.

4.2.2 DIRECT RADIATION

Radiation surveys have mapped exposure rates ranging from 11 μR/hr to 94 μR/hr. The workers will not, in general, be as close to the material as the survey team was, and would thus be exposed to lower levels of radiation. To be conservative, the average worker exposure rate is assumed to be 75 μR/hr which would result in a external dose of 60 mR over the 800 hour project period.

This calculated dose is very conservative since the actual average exposure rates are much lower than 75 μR/hr, and the exposure rates will be reduced during the project as the ash lagoon is excavated and the South Fill Area is capped and covered with soil and the area revegetated.

As stated in the Radiological Control Plan, if the exposure rate in the work area (ash excavations, ash transport, ash placement) exceeds 1 mR/hr, the work will be immediately stopped and a review performed to re-evaluate the risk to the workers and to the public.

4.2.3 SUMMARY

Conservative estimates of worker exposures during transfer of material from the lagoons to the fill area indicate an inhalation dose of approximately 67 mrem and a direct radiation dose of about 60 mR. The combined dose equivalent (127 mrem) is below the current NRC limit of 5,000 mrem/y for radiation workers. In fact, the combined dose

equivalent (127 mrem) is well below the current NRC limit of 500 mrem/y to members of the public. (Note: For purposes of this calculation 1 mR = 1 mRem since Cobalt 60 is a gamma emitter.)

However, the conservative nature of the calculation and assumptions overstates the inhalation dose by at least an order of magnitude. Likewise, the direct radiation dose is probably overstated by at least a factor of two. Additionally, the time used to calculate the direct and inhalation doses has been overstated by a month (200 hours). The excavation will be completed within the first three months. The fourth month, if necessary will be used to perform final road and lagoon berm repairs which will not involve exposure to contaminated ash. Therefore the expected dose equivalent to the maximally exposed worker is well below 50 mrem.

4.3 POTENTIAL INHALATION EXPOSURES TO THE GENERAL PUBLIC

4.3.1 INHALATION DOSES

During ash relocation efforts, contaminated ash may become suspended in the air and deposited off-site. The potential doses resulting from the inhalation of the suspended contaminated ash are described below.

The closest community to the South Fill Area is approximately 1,000 feet (240 meters) to the northeast. Utilizing the Plume Depletion Effect for Ground Level Releases from U.S. NRC Regulatory Guide 1.111, 98% of the suspended material may remain in the downwind plume at the closest community. This is assuming stable winds on flat terrain.

Utilizing the result from Section 4.2.1 (calculation 4-1) and correcting for a 2% deposition from the plume, the maximum inhalation exposure will be 66 mrem from the projected 4 month (800 hour) ash removal project (67 mrem work area x .98 = 66 mrem).

This is overly conservative since all of the airborne is considered respirable when in fact only 20% of the contaminated ash is normally considered respirable (NUREG/CR 5814, 1992). The very conservative 32,000 pCi/g Co^{60} concentration was used. If the more realistic 245 pCi/g Co^{60} concentration is used the inhalation exposure is 0.49 mrem (0.5 x .98).

The percentage of time that the wind will disperse the airborne ash towards the closest community is 33.6%, (sum of 5.3, 8.2, 10.1 and 10.0) from the wind rose data collected at the Hopkins Airport outside of Cleveland shown on Figure 4. Utilizing the percentage of time that the wind will disperse airborne activity towards the closest potential receptors the maximum exposures will be less than 22 mrem for the 32,000 pCi/g Cobalt 60 concentrations (0.16 mrem for the more realistic 245 pCi/g concentration).

The resulting committed effective dose equivalent due to inhalation can be calculated by multiplying the result of calculation 4-1 by the percentage (98%) of airborne material remaining in the plume and the percentage of the time the wind blows towards the potential receptors (33.6%).

$$H = (2{,}102\ C_s\ \text{mrem})\ (0.98)(0.336)(0.032\ \mu Ci/g)$$
$$H = 22\ \text{mrem}$$

If the more realistic 245 pCi/g Co^{60} concentration is used, the inhalation exposure is 0.16 mrem. Even if the percentage of time the wind blows toward the potential receptor is increased to 50% the resulting doses using the very conservative 32,000 pCi/g and the 245 pCi/g are 33 and 0.25 mrem, respectively.

4.3.2 DIRECT RADIATION

Direct radia ion exposures to the closest potential public receptor (at the boundary fence line) is currently being monitored by the Northeast Ohio Regional Sewer District through implementation of their environmental monitoring program. The program consists of several (6) environmental Thermoluminescence Dosimeters placed at various locations along the fence line of the South Fill Area. During the first calendar quarter of 1993, the maximum recorded exposure at the boundary of the South Fill Area was 10 mrem/quarter (Landauer, 1993) or 5 μrem/hr. It is anticipated that the direct radiation exposure rates at the fence line will not increase due to excavation activities. The 5 μrem/hr value is comparable to the naturally occurring background radiation measured at the Southerly Wastewater Treatment Plant.

4.4 SUMMARY

Conservative estimates of exposures to the public during excavation and transferring of material from the lagoons indicate an inhalation dose of 22 mrem and essentially no (background) dose from direct radiation exposure. This is well below the NRC correct limit of 500 mrem/yr to members of the public. With the conservative nature of the calculation and assumptions, the expected dose equivalent to the nearest public receptor is well below 1 mrem.

5.0 POTENTIAL EXPOSURES DURING ABNORMAL CONDITIONS

Trucks and equipment will be operated with a great emphasis on safety. In the worst case, the truck could tip over causing a spill. A second occurrence could be the outbreak of a fire at the site of a tipped truck causing radioactively contaminated ash to be dispersed in the air.

5.1 TRUCK OVER TURN

The truck tipping accident assumes that a fully laden (20 cy) truck tips over and spills ash contaminated with Co^{60}. It is assumed that the ash is uniformly contaminated to 245 pCi/g as in Section 4.2.1, spread over a 300 ft^2 area. The total activity available for release is:

$$(540\ ft^3)\ (2.83E+04\ cc/ft^3)\ (0.96\ g/cc)\ (245\ pCi/g) = 3.6\ E+09\ pCi$$

Assuming that 0.01% of this is released in a 10 second period as a result of wind, the release rate would be:

$$(0.0001)\ (3.6\ E+09\ pCi)/10\ sec = 3.6\ E+04\ pCi/sec$$

Based on a conservative x/q of 10^{-4} sec/m^3 the concentrations in air at the edge of the controlled area would be:

$$(3.6\ E+04\ pCi/sec)(10^{-4}\ sec/m^3) = 3.6\ pCi/m^3$$

Using the inhalation factor DCF discussed in Section 4.2.1, the dose to an individual at the controlled area boundary would be:

$(3.6\ pCi/m^3)(1.2\ m^3/hr)(219\ mrem/\mu Ci)/(1.0\ E\text{-}06 \mu Ci/pCi) = 9.5\ E\text{-}04\ mrem/hr$

The spilled ash would be covered with tarpaulins or a water spray within a half-an-hour of the occurrence so the maximum dose received at the controlled area boundary is estimated to be 4.7 E-04 mrem (0.5 μrem) (9.5 E-04 mrem/hr x .5 hr = 4.75 E-04 mrem 2.5 E-04 mrem).

The worker dose from the clean-up activities would be similar to the dose received by workers during soil excavation since the dose conversion factor (DCF) is based on activity per unit area which is assumed to be the same for all ash. Based on average direct exposure rate of 75 μR/hr, the direct exposure during the initial half-hour is estimated to be 38 μR. The total dose equivalent is estimated to be 39 μrem to the maximumly exposed individuals.

5.2 FIRE

In the event of a truck fire, it is assumed that the diesel fuel in the tanks on the truck would spread on the ash, catch fire and burn. The heat from the fire would dry some of the ash, and conversion currents could cause ash particulates to rise and be carried downwind. The closest deposition point is assumed to occur at the controlled area boundary since workers inside the radiological controlled area would have respiratory protection available.

It is assumed that the diesel fuel would mix with the ash so as to mobilize ash particles to the atmosphere. It is further assumed that the fuel might catch fire during light wind conditions and a very conservative x/q of 10^{-2} sec/m^3 is used. The truck is assumed to tip over leaving a pile 15 feet by 40 feet in size. It is also assumed that the truck carries 50 gallons of fuel which would spread over half the surface (15 ft x 20 ft). Because the truck transports saturated ash, it is assumed that 90 percent of the fuel would run off and soak into uncontaminated soil around the spill and that 10 percent would soak into the contaminated

ash. It is assumed that the fuel will soak a layer approximately 0.4 cm (0.2 inches) thick and potentially mobilize during a fire. It is assumed that the fire duration will be approximately one hour. The release rate would be:

$$(456 \text{ cm}) (607 \text{ cm}) (0.4 \text{ cm}) (0.96 \text{ g/cc}) (245 \text{ pCi/g}) = 2.6 \text{ E+07 pCi/hr}$$

The concentration at the boundary can be estimated by:

$$((2.6 \text{ E+07 pCi/hr})/(3{,}600 \text{ sec/hr})) (10^{-2} \text{ sec/m}^3) = 72 \text{ pCi/m}^3$$

Based on the same DCF used in Section 4.2.1, the exposure rate at the site boundary can be estimated to be:

$$(72 \text{ pCi/m}^3) (219 \text{ mrem/}\mu\text{Ci}) (1.0 \text{ E-06 } \mu\text{Ci/pCi}) (1.2 \text{ m}^3\text{/hr}) = 0.02 \text{ mrem/hr}$$

The potential fire is estimated to take one hour to control and extinguish. During that time an individual at the site boundary may receive 0.02 mrem of exposure. The worker dose due to direct exposures from the control and clean-up activities would be similar to the doses received by workers during soil excavation activities. Based upon an average direct dose rate of 75 μR/hr, and estimating 3 hours for the complete control and clean-up activities, the direct dose can be estimated to be 225 μR (0.23 mR). Inhalation exposure estimates are separated into two constituents. Airborne exposures as a result of the fire will be 0.02 mrem. The second constituent will be the inhalation exposures that will occur during the two hour clean-up phase. These inhalation exposures will be similar to the remediation inhalation exposures calculated in Section 4.2.1., but only for a two hour exposure time. The result is 13.0 E-4 mrem (10^{-2} g/m^3 x 1.2 m^3/hr x 219 mrem/μCi x 2 hours x 2.45 E-04 μCi/g).

The total postulated exposure to control and recovery workers is the addition of the three exposure constituents. The exposure components are:

Direct dose equivalent	(3 hours)	0.23 mrem
Control inhalation	(1 hour)	0.02 mrem
Clean-up inhalation	(2 hours)	13.0 E-4 mrem
		0.25 mrem total

Note: For purpose of these calculation 1 mR = 1 mRem since Cobalt 60 is a gamma emitter.

6.0 CONCLUSIONS

In consideration of the information, data and calculated potential maximum exposures, the relocation of the ash from Lagoons A, B, and C to the old sludge storage area in the South Fill Area will not present undue risk of exposure to radioactive materials to the worker or general public.

7.0 REFERENCES

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Code of Federal Regulations, Title 29, *Occupational Health and Safety Administration*, Part 1910.

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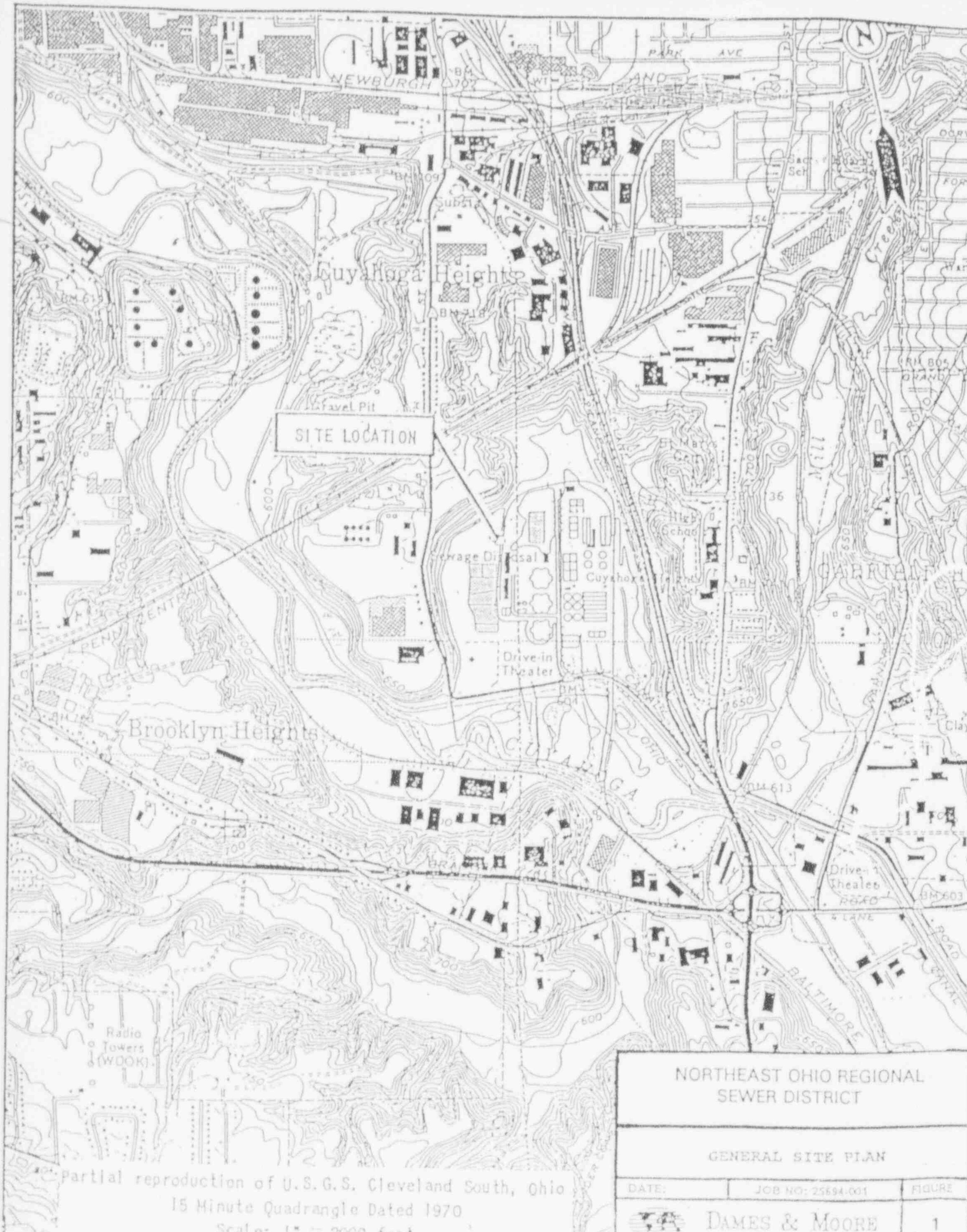
TABLE 2-1
CLIMATOLOGICAL AVERAGE OF 30 YEARS

Month	Average High Temperature	Average Low Temperature	Precipitation (Normal)	Snow
January	33°	19°	2.47"	12.1"
February	35°	20°	2.20"	11.5"
March	45°	28°	2.99"	10.1"
April	58°	38°	3.32"	2.2"
May	69°	48°	3.30"	0.1"
June	78°	57°	3.49"	
July	82°	61°	3.37"	
August	80°	61°	3.38"	
September	74°	54°	2.92"	Trace
October	63°	44°	2.45"	0.7"
November	49°	34°	2.76"	5.4"
December	38°	25°	2.75"	11.5"
Average	58.5°	40.75°	35.40"	53.6"
Average Yearly Temperature: 49.70°				

Source: National Weather Service, Cleveland-Hopkins Airport, personal communication, 1990.

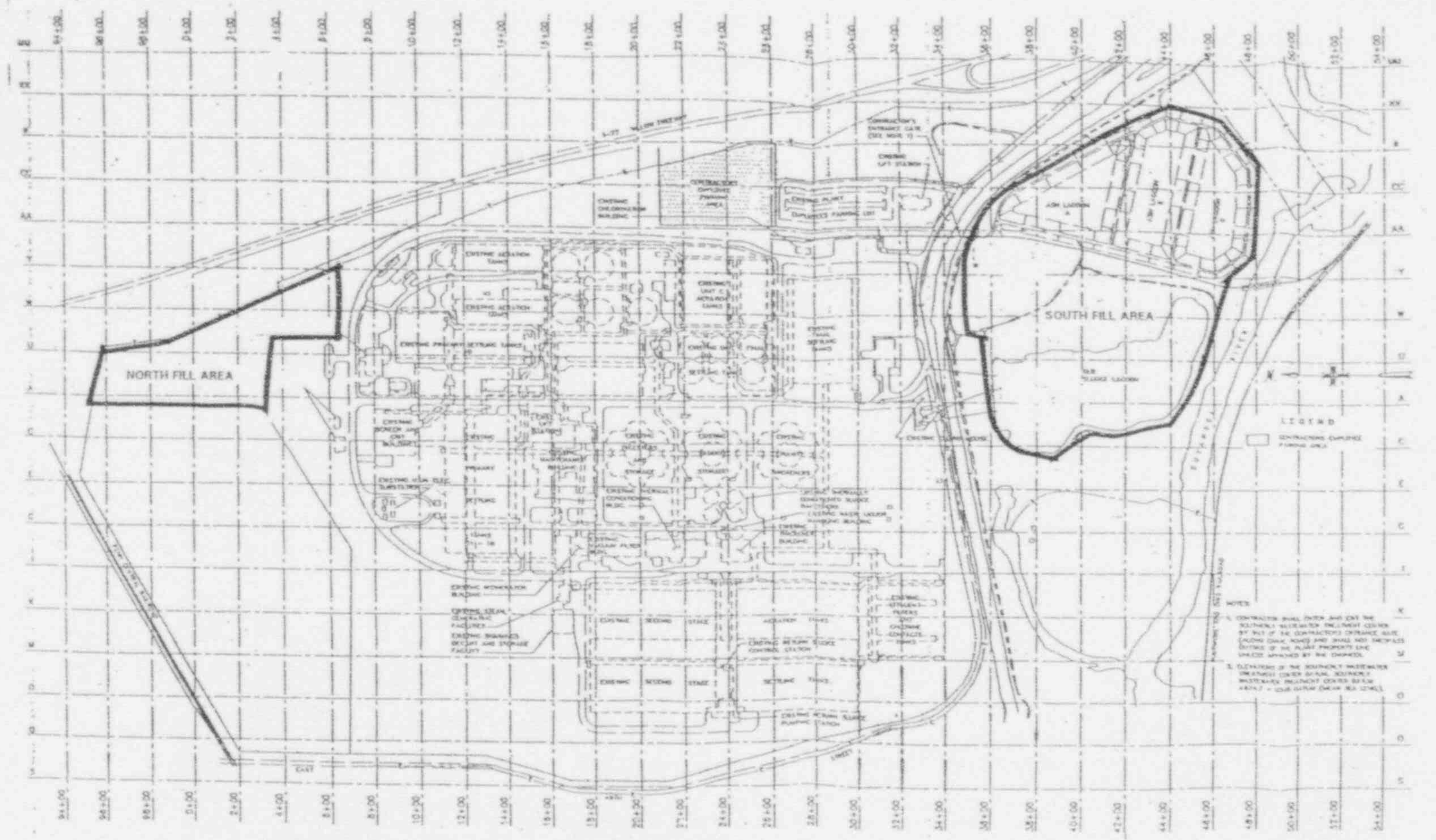


NORTHEAST OHIO REGIONAL SEWER DISTRICT

GENERAL SITE PLAN

DATE:	JOB NO: 25694-001	FIGURE
DAMES & MOORE		1

Partial reproduction of U.S.G.S. Cleveland South, Ohio 15 Minute Quadrangle Dated 1970
Scale: 1" = 2000 feet



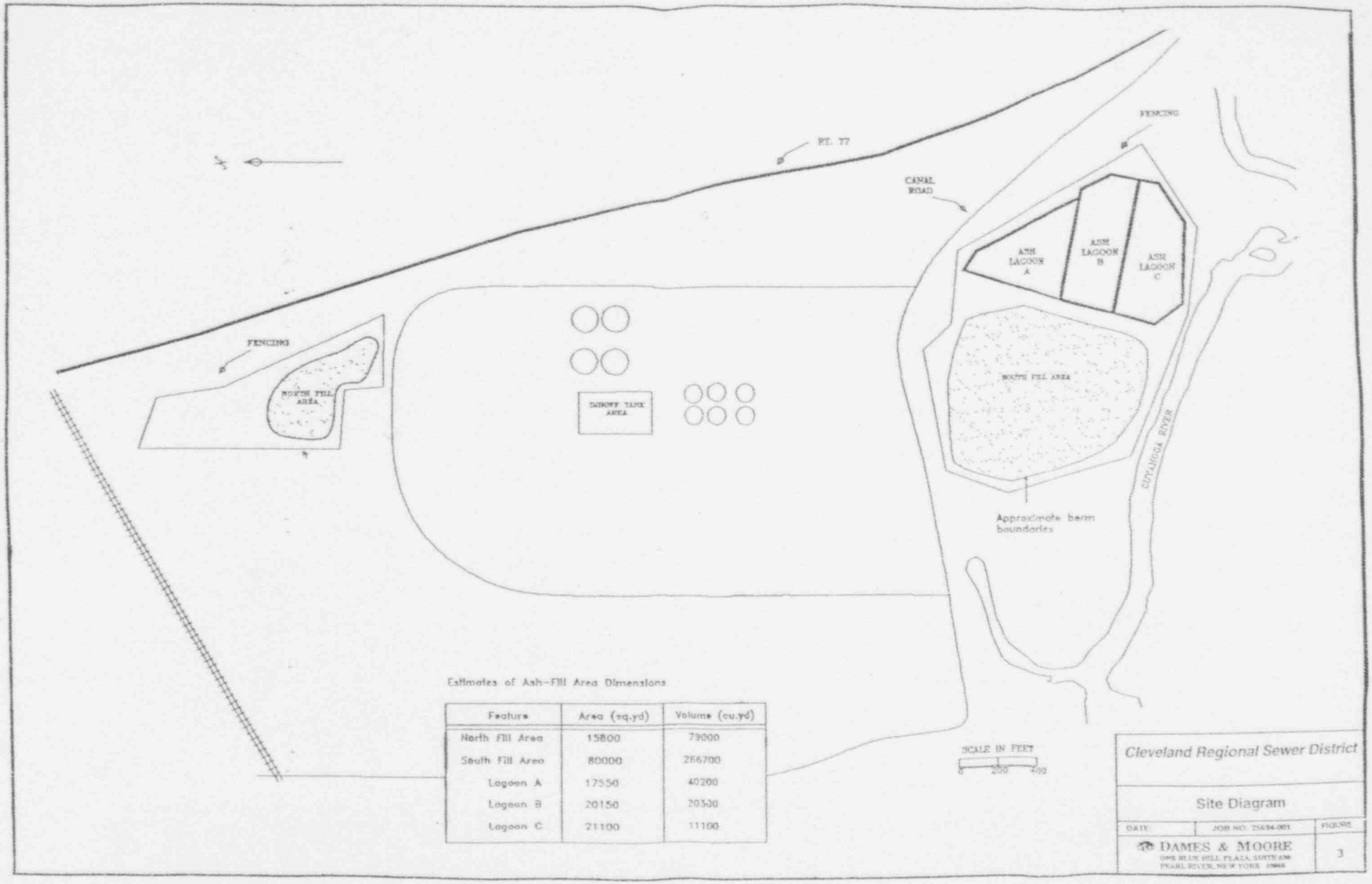
SOUTHERLY WWTC
KEY PLAN

Northeast Ohio Regional
Sewer District

FIGURE 2

SITE LAYOUT INCLUDING NORTH
FILL AND SOUTH FILL AREA

Dames & Moore JOB No.



Estimates of Ash-Fill Area Dimensions

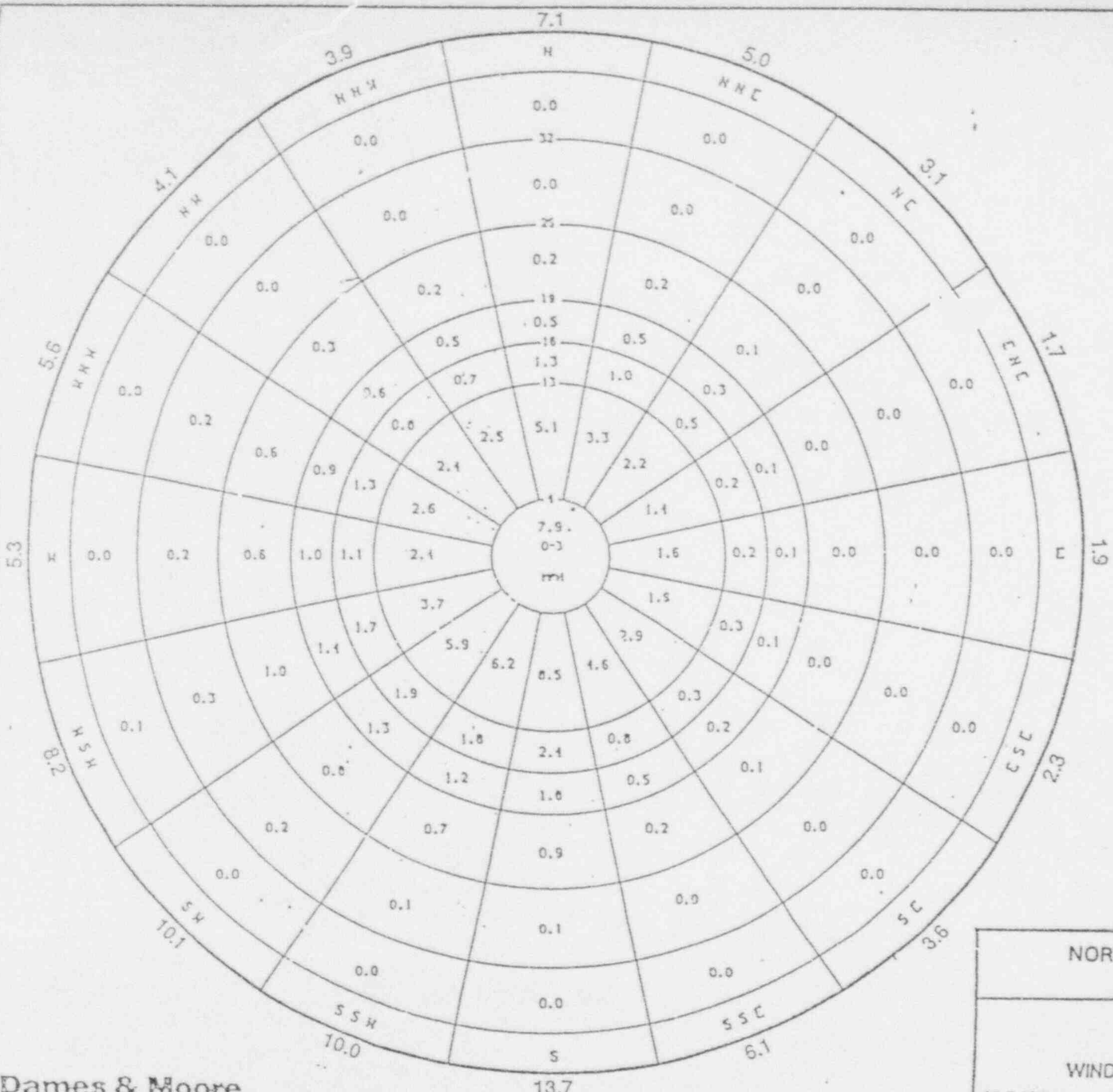
Feature	Area (sq.yd)	Volume (cu.yd)
North Fill Area	15800	79000
South Fill Area	80000	266700
Lagoon A	17550	40200
Lagoon B	20150	20300
Lagoon C	21100	11100

Cleveland Regional Sewer District

Site Diagram

DATE: | JOB NO. 25694-001 | FIGURE 3

DAMES & MOORE
ONE BLUE HILL PLAZA, SUITE 630
PEARL RIVER, NEW YORK 10965



CLASS 7
CEILING-VISIBILITY

LEGEND:

4.1 Percent of time wind blows from a given direction

SOURCE:
National Climatic Data Center, Wind-Ceiling Visibility Data at Cleveland International Airport, 1981.

Dames & Moore

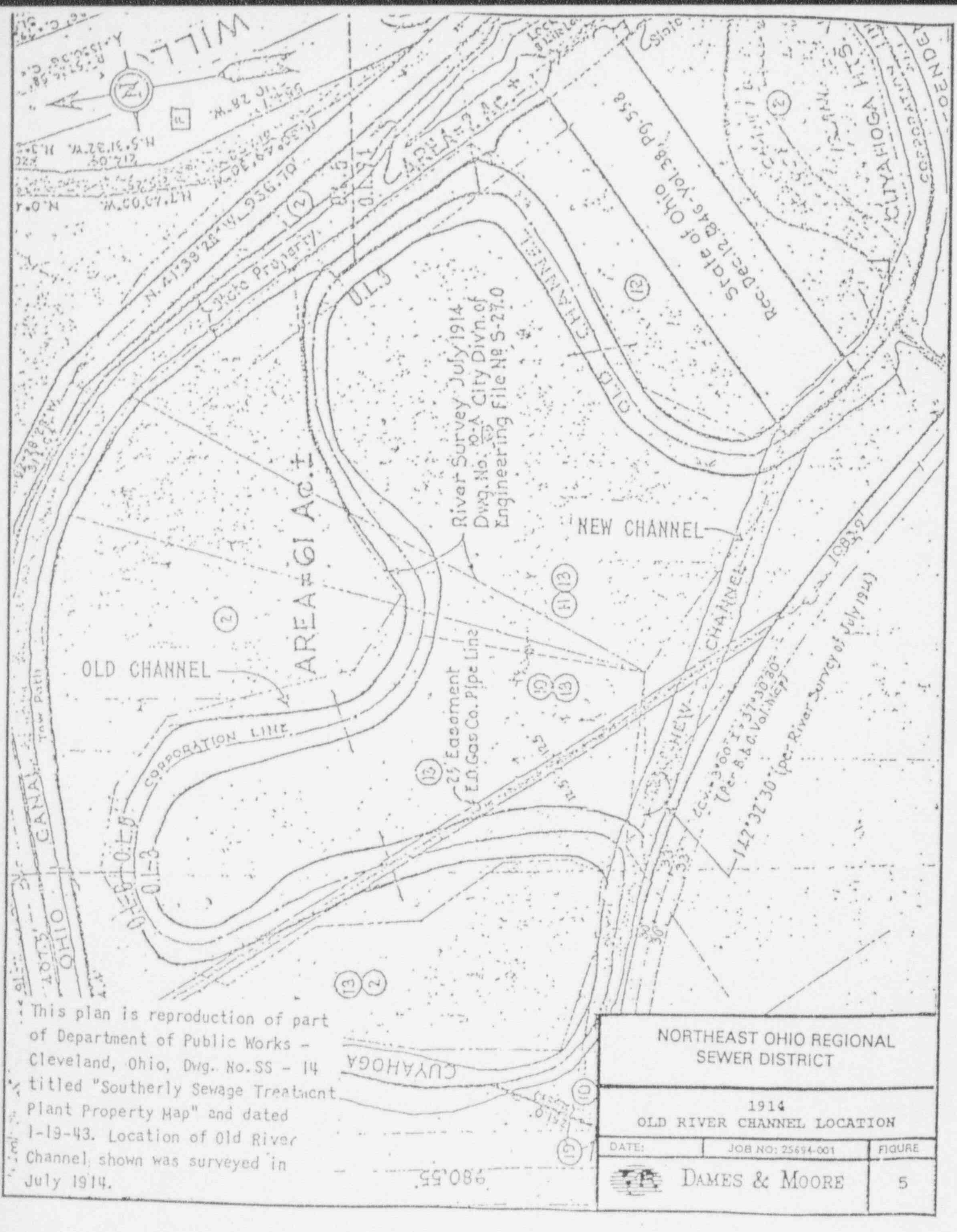
NORTHEAST OHIO REGIONAL SEWER DISTRICT

Cleveland, Ohio

FIGURE 4

WIND ROSE FOR CLEVELAND, OHIO

JOB NO.


OHIO CANAL
Tow Path
OLD CHANNEL
CORPORATION LINE
AREA = 61 Ac. ±
River Survey July 1914
Dwg. No. 10-A City Div'n. of
Engineering File No S-27.0
NEW CHANNEL
OLD CHANNEL
State Property
AREA = 2 Ac. ±
State of Ohio
Rec. Dec. 12, 1846 - Vol. 38, Pg. 558
CUYAHOGA HTS.
CORPORATION LINE
25' Easement
E.O. Gas Co. Pipe Line
NEW CHANNEL
(per River Survey of July 1914)
CUYAHOGA
980.55
This plan is reproduction of part of Department of Public Works - Cleveland, Ohio, Dwg. No. SS - 14 titled "Southerly Sewage Treatment Plant Property Map" and dated 1-19-43. Location of Old River Channel shown was surveyed in July 1914.
NORTHEAST OHIO REGIONAL SEWER DISTRICT
1914
OLD RIVER CHANNEL LOCATION
DATE:
JOB NO: 25694-001
FIGURE
5
DAMES & MOORE