Engineering Report

for the:

56th Street Transfer Station
540 56th Street
Niagara Falls, New York 14304
NYSDEC Permit No. T.B.D.

January 2024
Rev.1: May 2024
Rev.2: September 2024
Rev.3: February 2025

prepared for:

56th Street Transfer, LLC
661 Main Street
Niagara Falls, New York 14301

prepared by:

EnSol
ENGINEERING + ENVIRONMENTAL

EnSol, Inc.
3000 Alt. Blvd.,
Grand Island, NY 14072
716.285.3920

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David A. Lenox, NYS P.E. #093384

PN 169-A0001

Table of Contents

Engineering Report
56th Street Transfer Station
540 56th Street
Niagara Falls, New York 14304
NYSDEC Permit No. T.B.D.

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

David A Lenox, P.E.
EnSol, Inc.

2/7/2025
Date

STATE OF NEW YORK
DAVID A. LENOX
093384
LICENSED PROFESSIONAL ENGINEER

1. Introduction

1.1 Site Description

As indicated on **Sheets 1 and 2**, 540 56th Street is an approximate 4.54-acre property which is currently owned by Simfall LLC. It should be noted that this property was formerly comprised of four individual sub-lots which were recently amalgamated into one property during the Site Plan application process with the City of Niagara Falls. For reference, the four individual former lots were:

- 4800 Charles Ave., 2.5 acres, SBL 160.10-1-1
- 4802 Charles Ave., 0.24 acres, SBL 160.10-1-2
- 4803 Simmons Ave., 1.38 acres, SBL 160.10-1-3
- 4829 Simmons Ave., 0.46 acres, SBL 160.10-1-4

The current property definition is:

- 540 56th Street, 4.54 acres, SBL 160.10-1-1.1

As indicated on **Sheet 2**, the property consists of an overgrown gravel/crushed concrete surface and is largely vacant with the only current features including a small vacant building, a concrete block divider wall, and a small pile of excess concrete divider blocks. All features will be removed prior to development. The property is zoned I2 Industrial, and per Chapter 1315.2 of the City of Niagara Falls Zoning Code a solid waste management facility is permitted in an I2 Industrial district requiring only Site Plan approval. The surrounding land use is industrial/commercial including active railroad lines/spurs adjacent to the west. A residential zoning district is present in the vicinity of the site approximately 500' southeast of the proposed Facility. The project location is shown on the Regional Map included on **Figure 1**. The Vicinity Map (**Figure 2**) identifies zoning and land use, residences, surface waters, and wetlands within one-half mile of the perimeter of the property boundary.

1.2 Facility Description

The Facility will operate as a Transfer Facility in accordance with Subpart 362-3. A transfer facility is defined in Title 6 of the New York Codes, Rules and Regulations (6 NYCRR) Part 360 in paragraph 360.2(b)(276) as "… a facility that receives solid waste for the purpose of subsequent transfer to another Facility for further processing, treatment, transfer, or disposal."

The 56th Street Transfer Station (Facility) will be comprised of one main process/transfer building, a covered outdoor trailer storage area, as well as scales and a scalehouse for operations support. Activities conducted within the Facility will consist of consolidation and transfer of municipal solid waste (MSW), Construction and Demolition debris (C&D), and Single Stream Recyclables (SSR) for disposal and/or further processing. The Site Plan and Floor Plan are included as **Sheets 3 and 4** respectively.

The operation intends to adapt to meet a variety of market conditions and future opportunities, with a proposed design capacity of 950 tons per day (tpd) based on weekly average comprised of an average of 900 tpd of solid waste (MSW and C&D) and 50 tpd of all combined recyclables. The Facility will not accept medical or hazardous wastes, friable asbestos, liquids or septage, or any other unauthorized materials as defined in the regulations and this application.

All material unloading, handling, and loading activities will occur within the transfer station building. Features of the transfer station building include a steel fiber reinforced (5,000 psi) concrete floor, floor drains that are connected to the sanitary sewer system, separate handling areas for MSW/C&D and SSR, concrete push walls in each handling area, and recessed loadout bays for outbound trailers. The Facility yard will be surfaced with asphalt pavement suitable for heavy truck traffic.

1.3 Type and Quantity of Materials

The Facility operation intends to adapt to meet a variety of market conditions and future opportunities. The proposed design capacity of the 56th Street Transfer Station is 950 tons per day (tpd) as a maximum weekly average. At 306 operating days per year, the material stream is expected to be approximately 290,700 tons per year (tpy) comprised of:

- MSW, including putrescible materials with a loose density estimated at 500 pounds per cubic yard (pcy)
- C&D with a loose density estimated at 1,500 pcy.
- SSR with a loose density estimated at 160 pcy.
- Tires with a loose density estimated at 200 pcy.

The facility will not accept medical or hazardous wastes, friable asbestos, liquids or septage, or any other unauthorized materials. Unacceptable waste is discussed in Section 4 of the Facility Manual.

2. Description of Operations

2.1 Process Description

Access to the Facility will be through the gated entrance on 56th Street. Materials will arrive at the Facility in roll-off trucks, front, rear and side loaders, and dump trucks. The trucks will be initially weighted at the inbound truck scale. All material unloading, handling, and loading activities will be conducted within the enclosed building. Walking floor transfer trailers will be loaded within two sunken loading pits on each side of the tipping floor. Outbound material will be top loaded into the transfer trailers by the loader, and excavator with grapple for transport to the disposal or processing facility. The empty delivery trucks will be weighed at the outbound truck scale. Process flow diagrams illustrating the movement of materials through the facility are included as **Attachment 1**.

All MSW/C&D and SSR transfer and storage will take place within the enclosed building. MSW/C&D and SSR transfer activities will be separated by a movable concrete block divider wall positioned on the tipping floor. Normal operations are anticipated to consist of accepting MSW through two of the four inbound overhead doors and C&D and SSR will be accepted via one each of the remaining two inbound overhead doors. All inbound materials shall be loaded into outbound transfer trailers within the recessed loadout bays by a front wheel loader or excavator with grapple.

2.2 Process Equipment

The Facility will maintain sufficient process equipment to safely and efficiently conduct material handling and transfer operations. This equipment will include the following pieces of equipment (or equivalent):

- Excavator with trash grapple (1);
- 22 Ton, 53-foot-long walking floor transfer trailers, (as needed);
- Wheel loader with 4-cubic yard bucket (1);
- Low-Profile Motor inbound and outbound truck scales (2);
- Yard Goat Semi-Tractor; and,
- Sweeper Truck (1).

Specifications for each piece of equipment are included in **Attachment 2**. The Operator will rent or lease equipment from local vendors where appropriate when on-site equipment is being serviced or is otherwise not available. Additionally, where a specific equipment need is identified, the Operator may rent, lease or purchase the equipment from area vendors.

Equipment operators will be responsible for ensuring that equipment is routinely inspected and maintained in accordance with manufacturers' recommendations for safe operation. Equipment manuals will be provided to operators. All equipment will be equipped with mufflers so as not to exceed a maximum allowable 80-decibel combustion-powered equipment noise source level (when measured 50 feet from the source). At minimum, the truck scales will be inspected and tested for accuracy on an annual basis. Recalibrations will be performed as needed.

2.3 Process Design and Performance

For purposes of the calculations described below it is assumed that the average breakdown of the 950tpd material acceptance rate will consist of 800 tons of MSW, 100 tons of C&D, 49 tons of SSR, and 1 ton of tires.

The Facility process design information/calculations are included as Tables 1 through 3 in **Attachment 2**. Table 1 shows the Facility throughput and capacity and lists the respective storage structure type, size, volume, and capacity in tons for each material to be accepted. Table 1 also shows the Facility throughput including the expected maximum average daily rate, the average annual rate, and the maximum daily rate based on the Facility performance in weight and volume for each material type.

Table 2 lists the Facility process equipment and storage structures for each material type. The capacity for each storage structure and the relevant processing equipment for each material is listed in tons and tons per day respectively. The expected detention time is also provided for each storage structure and processing equipment on Table 2. The detention time for each storage area represents the time to fill the storage area based on the maximum average daily receipt rate for the material to be stored.

The MSW/C&D transfer performance is controlled by the excavator with grapple. The equipment capacity assumes a grapple capacity of 4.5 cubic yards, a cycle time of 25 seconds, and two minutes to switch out transfer trailers. The time to fill a 53 foot long transfer trailer is estimated at approximately 10 minutes, the number of trailers that can be filled over 10 operating hours is 59. The resulting equipment capacity is 1,298 tons per day.

The SSR transfer performance is controlled by the front wheel loader. The equipment capacity assumes a bucket capacity of 4 cubic yards, and an estimated cycle time of one minute. Assuming two minutes to switch out transfer trailers, and a transfer trailer capacity of 11 tons, the number of trailers that can be filled over 10 operating hours is approximately 17. The resulting capacity is 187 tons per day.

Tables 3-1 Waste/Truck Traffic and 3-2 Employee/Visitor Traffic show the estimated daily traffic flow to and from the Facility based on the maximum average material receipt rate. Table 3-3 shows the maximum amount of waste trucks that can be accommodated onsite based on the maximum daily processing rate. Collectively, the calculations presented in Tables 1 through 3 exhibit that the relevant processing and transportation capacities are sufficient compared to the expected maximum daily rate for each material type.

3. Noise Evaluation

A detailed model was developed to predict noise levels generated by the Facility operations. All sound modeling was completed using the SoundPlan Essential software provided by Navcon Engineering Network. The model considers the 3-D effects of existing buildings, topography, vegetation, distance attenuation, atmospheric absorption, and the ground. Noise generated from the facility operational equipment and the truck and personal vehicle traffic was modeled. The predicted noise levels across the site were compared to the NYSDEC subdivision 360.19(j) day time requirements. The Noise Evaluation results are included in **Attachment 3**.

Based on the model results, predicted noise levels meet the applicable NYSDEC Part 360 requirements. Since operations at the facility satisfy the operational noise provision specified in subdivision 360.19(j), a Noise Monitoring and Control Plan is not required. Noise impacts will be minimized by conducting all material handling operations inside the building. Internal combustion engine equipment used at the Facility will be equipped with mufflers.

4. Drainage and Water Supply

4.1 Water Supply

Potable water will be supplied to the Facility via a water line to be connected to the existing water main inside the west ROW of 56th Street.

Water for fire control will be available from two existing hydrants inside the west ROW of 56th Street.

4.2 Sanitary Waste and Leachate

Sanitary facilities will be available in the transfer station building and scalehouse. Sanitary waste will be gravity drained to the existing combined sewer line inside the west ROW of 56th Street.

Leachate is expected to primarily be derived from precipitation gathered on vehicle cabs, trailers, or chassis, and incidental liquid contained within materials received within the building. Leachate generation is expected to be kept at a minimum as all unloading, processing, and storage operations will be conducted inside the fully enclosed building. To ensure any leachate generated in the building is adequately contained and is properly treated for disposal, floor drainage inside the building is directed towards floor drains and drop inlets as identified on the Floor Plan (**Sheet 4**). The outdoor loaded-trailer parking area will be covered to minimize the potential for precipitation-based leachate generation and the floor of the parking area will be sloped towards a drop inlet. This system of floor drains will convey collected liquids through an oil/water separator, which will discharge to the existing combined sewer for treatment and disposal.

Typical details for the floor drains, the drainpipe trench, clean-outs, manholes, the oil/water separator, are included on **Sheet 5**. Cleanouts located along each main floor drain will be used to clean and maintain the drain system. The minimum oil water separator size was determined according to the Highland Tank Co. Oil/Water Separators Sizing Guide for Indoor Applications. The required oil water separator size was calculated as 2,000 gallons.

4.3 Stormwater

There will only be minor grading of the site to accommodate the proposed development/Transfer Station. Stormwater runoff from the paved/developed area will be directed towards perimeter vegetated drainage swales on the northern and southern edges of the Facility. The swales will discharge into catch basins which will ultimately discharge to the City's combined sewer system. The layout of the stormwater management system is depicted on **Sheet 3b** and associated details are included in **Sheet 5**.

A Notice of Intent for coverage under the NYSDEC SPDES General Permit for Stormwater Discharges from Construction Activity Permit No. GP-0-20-001 including a Storm Water Pollution Prevention Plan (SWPPP) will be submitted to NYSDEC prior to construction of the Facility. The objective of the SWPPP is to minimize the number and amount of pollutants in stormwater runoff and to maintain compliance with stormwater regulatory requirements. The SWPPP identifies potential pollutant sources, pollution prevention measures and BMPs (best management practices), monitoring procedures, and inspection and reporting requirements.

5. Safety

All materials will be handled and stored in a manner that will ensure no hazards to employees or the public are created. No hazardous waste will be stored at the site. On-site access routes will be maintained to allow unrestricted movement of Facility vehicles and emergency response equipment. Fire extinguishers will be maintained at strategic locations in the transfer building and all commercial material-hauling vehicles.

Emergency response actions are detailed in the Contingency Plan (Section 6.0 of the Facility Manual).

Drawings

EnSol, Inc.

ENGINEERING + ENVIRONMENTAL

NOTES:

1. SUBJECT PROPERTY LINES AS SURVEYED BY APEX CONSULTING SURVEY & ENGINEERING SERVICES, P.C. OF LOCKPORT, NY (APEX) IN A DRAWING DATED 9/15/23 AND TITLED 171221 SUB-MAP. (SEPARATELY PROVIDED WITH APPLICATION)
2. SUBJECT PROPERTY PREVIOUSLY CONSISTED OF FOUR SEPARATE PROPERTIES (SBLs 160.10-1-1 THROUGH 160.10-1-4 WITH ADDRESSES ON EITHER CHARLES OR SIMMONS). PROPERTY AMALGAMATION TO COMBINE THESE PARCELS INTO ONE LOT AND RE-ASSIGN A 56TH STREET ADDRESS WAS COMPLETED WITH THE CITY OF NIAGARA FALLS AND WITH THE NIAGARA COUNTY CLERK'S OFFICE ON 10/27/23 VIA INSTRUMENT #M2023-00031.
3. ADJACENT PROPERTY LINES AS APPROXIMATED FROM THE NIAGARA COUNTY GIS DIGITAL TAX MAPS WEB APPLICATION.
4. PROPERTY OWNER INFORMATION AS PRESENTED ON NIAGARA COUNTY GIS AS OF AUGUST 1, 2023.
5. ZONING DISTRICT BOUNDARY LINE AS APPROXIMATED FROM "SCHEDULE 8: OFFICIAL ZONING MAP" (VER 20.03.25) OF THE CITY OF NIAGARA FALLS ZONING ORDINANCE.

LEGEND:

- SUBJECT PROPERTY LINES
- ADJACENT PROPERTY LINES
- ZONING DISTRICT BOUNDARY

IT IS A VIOLATION OF THE NEW YORK STATE EDUCATION LAW, ARTICLE 145 SECTION 7209, FOR ANY PERSON, UNLESS HE IS ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER OR LAND SURVEYOR TO ALTER AN ITEM IN ANY WAY.

NO.	REVISION	BY	DATE
1	UPDATED SUBJECT PROPERTY LINES TO AS-SURVEYED AND POST-AMALGAMATION OF 4 SUBLOTS	JMS	11/15/23
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Niagara Falls, NY 14301
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STATE OF NEW YORK · DAVID A. LENOX · 093384 · LICENSED PROFESSIONAL ENGINEER

DAVID A. LENOX, P.E.
NYSPE LICENSE NO. 093384

CLIENT: 56th STREET TRANSFER, LLC

INSERT CLIENT LOGO HERE

SITE: 540 56th STREET

CITY OF NIAGARA FALLS
COUNTY OF NIAGARA
STATE OF NEW YORK

PROJECT: 56th TRANSFER STATION SITE PLAN APPLICATION

TITLE:

LOCATION PLAN

ISSUE: REVIEW

DES: JMS	DRN: JMS	CHK: DAL
PROJECT NO: 169-A0001	DATE: MAY 2024	

GRAPHIC SCALE: (1:1200)
0' 50' 100'

FILE: 075-C0001 56th TS Application Dwgs.Rev3.dwg

REV NO: 1 SHEET NO: 1

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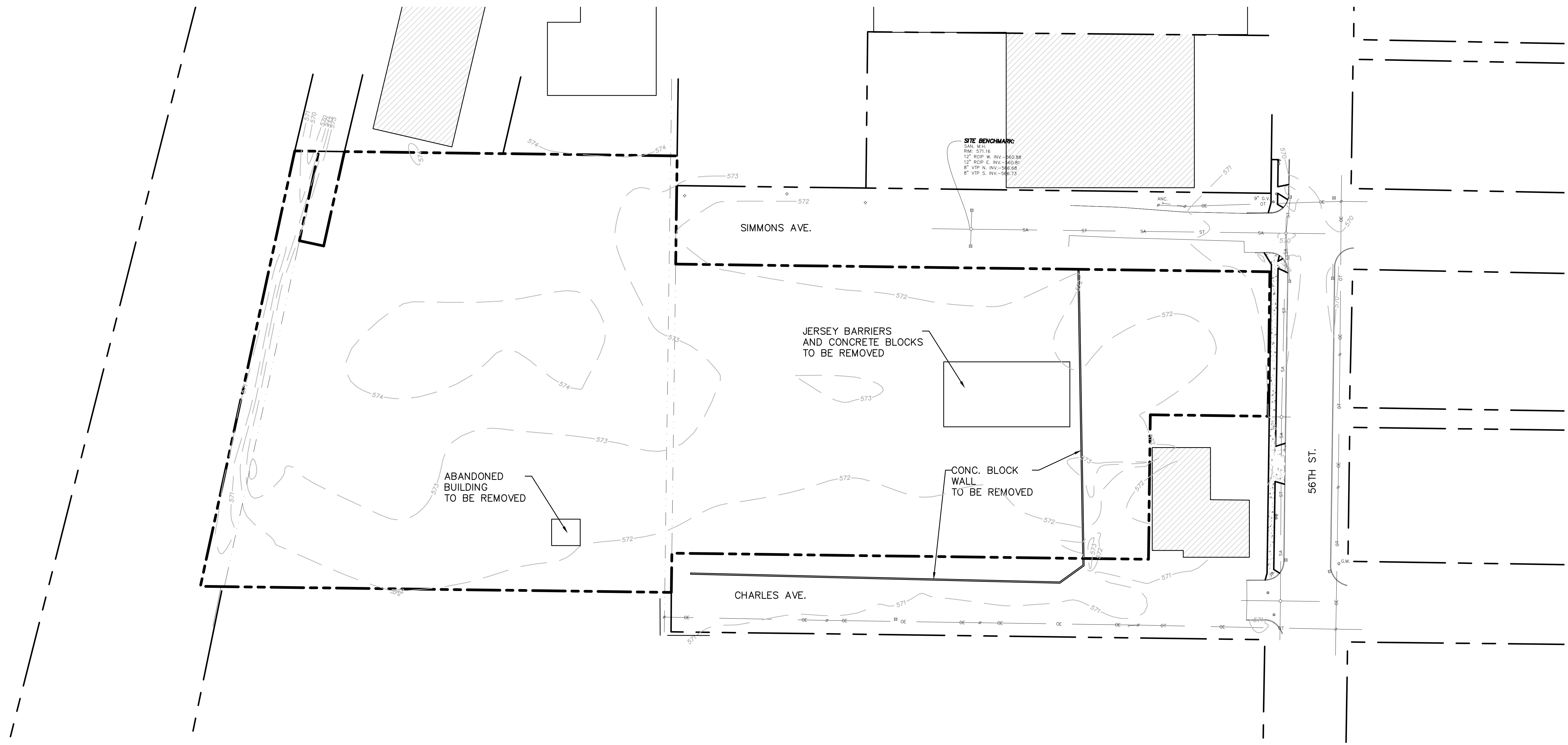

NOTES:

1. SUBJECT PROPERTY LINES AS SURVEYED BY APEX CONSULTING SURVEY & ENGINEERING SERVICES, P.C. OF LOCKPORT, NY (APEX) IN A DRAWING DATED 9/15/23 AND TITLED 171221 SUB–MAP. (SEPARATELY PROVIDED WITH APPLICATION)
2. SUBJECT PROPERTY PREVIOUSLY CONSISTED OF FOUR SEPARATE PROPERTIES (SBLs 160.10–1–1 THROUGH 160.10–1–4 WITH ADDRESSES ON EITHER CHARLES OR SIMMONS). PROPERTY AMALGAMATION TO COMBINE THESE PARCELS INTO ONE LOT AND RE–ASSIGN A 56TH STREET ADDRESS WAS COMPLETED WITH THE CITY OF NIAGARA FALLS AND WITH THE NIAGARA COUNTY CLERK'S OFFICE ON 10/27/23 VIA INSTRUMENT #M2023–00031.
3. ADJACENT PROPERTY LINES AS APPROXIMATED FROM THE NIAGARA COUNTY GIS DIGITAL TAX MAPS WEB APPLICATION.
4. EXISTING EASEMENTS, TOPOGRAPHY, UTILITIES, PAVEMENT, AND CONCRETE AS SURVEYED BY APEX IN A DRAWING DATED 9/26/23 AND TITLED 171221 TOPT–MAP. (SEPARATELY PROVIDED WITH APPLICATION)
5. THERE IS NO FORMAL STORMWATER MANAGEMENT SYSTEM CURRENTLY ONSITE AND CURRENT STORMWATER MANAGEMENT GENERALLY CONSISTS OF SHEET FLOW OVER THE CURRENT GRAVEL SURFACE TOWARDS EXISTING DRAINAGE STRUCTURES WITHIN SIMMONS AND CHARLES AVE.

LEGEND:

- SUBJECT PROPERTY LINES
- ADJACENT PROPERTY LINES
- EXISTING TOPOGRAPHIC CONTOUR (1–FOOT INTERVAL)
- EASEMENT BOUNDARY

N

NO.	REVISION	BY	DATE
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1	UPDATED SUBJECT PROPERTY LINES TO AS-SURVEYED AND POST-AMALGAMATION OF 4 SUBLOTS	JMS	11/15/23

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661 Main St.
Niagara Falls, NY 14301
716.285.3920

DAVID A. LENOX, P.E.
NYSPE LICENSE NO. 093384

CLIENT:
56th STREET TRANSFER, LLC

SITE:
540 56th STREET
CITY OF NIAGARA FALLS
COUNTY OF NIAGARA
STATE OF NEW YORK

PROJECT:
56th TRANSFER STATION SITE PLAN APPLICATION

TITLE:
EXISTING CONDITIONS

ISSUE:
REVIEW

DES:	DRN:	CHK:
JMS	JMS	DAL

PROJECT NO: 169-A0001
DATE: MAY 2024

GRAPHIC SCALE: (1:960)
0' 40' 80'

FILE:
075-C0001 56th TS Application Dwgs.Rev3.dwg

REV NO:	SHEET NO:
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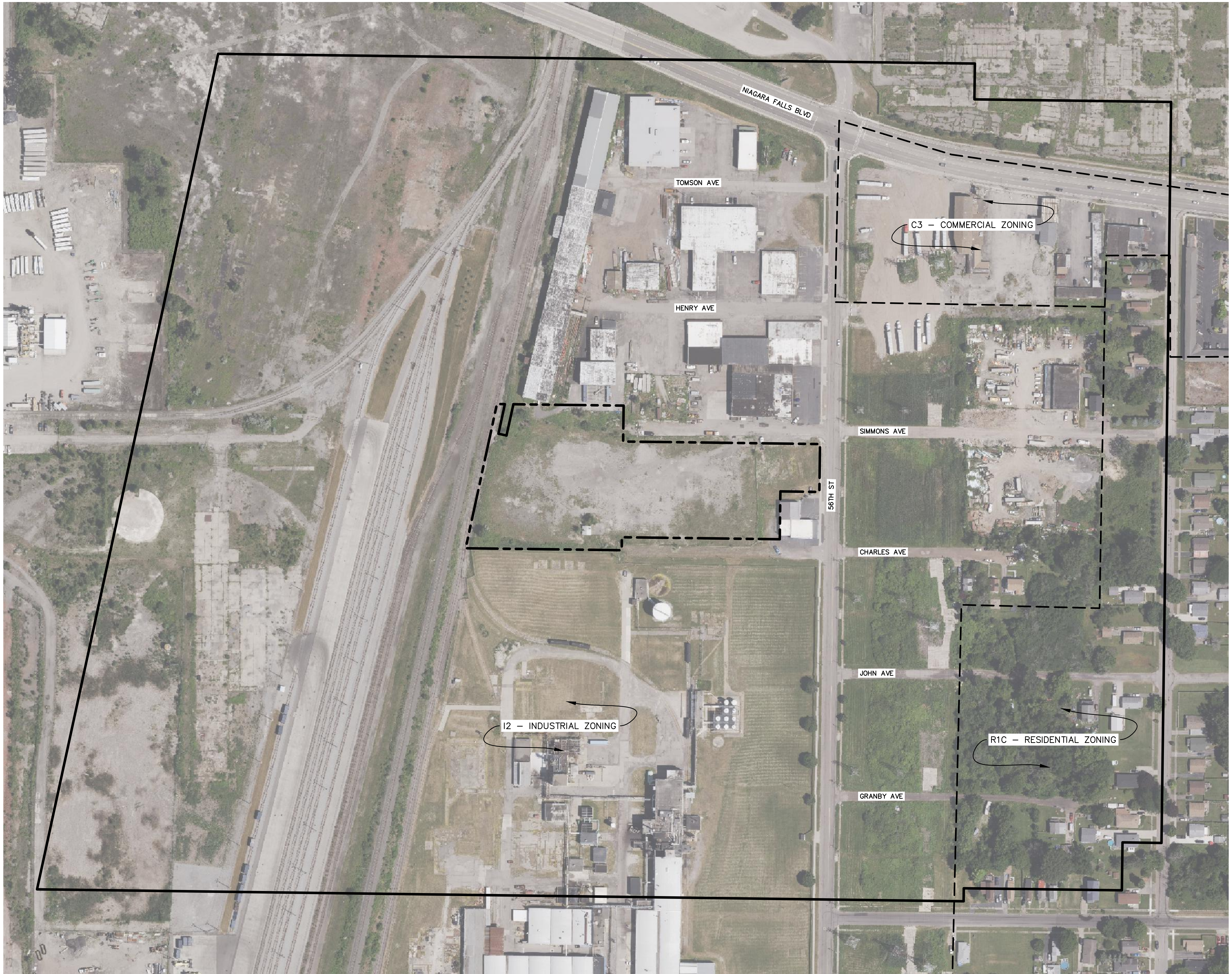

N

NOTES:

1. FACILITY BOUNDARY LINE AS SURVEYED BY APEX.
2. NO FLOOD ZONES, WETLANDS OR SURFACE WATER BODIES ARE WITHIN 800 FT OF THE FACILITY.
3. ZONING DISTRICT BOUNDARY LINE AS APPROXIMATED FROM "SCHEDULE 8: OFFICIAL ZONING MAP" (VER 20.03.25) OF THE CITY OF NIAGARA FALLS ZONING ORDINANCE.
4. THE APPLICANT/OPERATOR (56TH STREET TRANSFER LLC) DOES NOT CURRENTLY OWN ANY BUILDINGS EITHER ON THE SITE OF THE PROPOSED FACILITY OR WITHIN THE 800 FT OFFSET AREA.

LEGEND:

- SUBJECT PROPERTY LINES
- 800 FT OFFSET
- ZONING DISTRICT BOUNDARY

NO	REVISION	BY	DATE

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Niagara Falls, NY 14301
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STATE OF NEW YORK
DAVID A. LENOX
093384
LICENSED PROFESSIONAL ENGINEER

DAVID A. LENOX, P.E.
NYSPE LICENSE NO. 093384

CLIENT:
56th STREET TRANSFER, LLC

SITE:
540 56th STREET

CITY OF: NIAGARA FALLS
COUNTY OF: NIAGARA
STATE OF: NEW YORK

PROJECT:
56th TRANSFER STATION SITE PLAN APPLICATION

TITLE:
SITE PLAN 1

ISSUE: REVIEW

DES:	DRN:	CHK:
JMS	JMS	DAL

PROJECT NO: 169-A0001
DATE: MAY 2024

GRAPHIC SCALE: (1:2700)
0' 112.5' 225'

FILE:
075-C0001 56th TS Application Dwgs.Rev3.dwg

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SHEET NO: 3a

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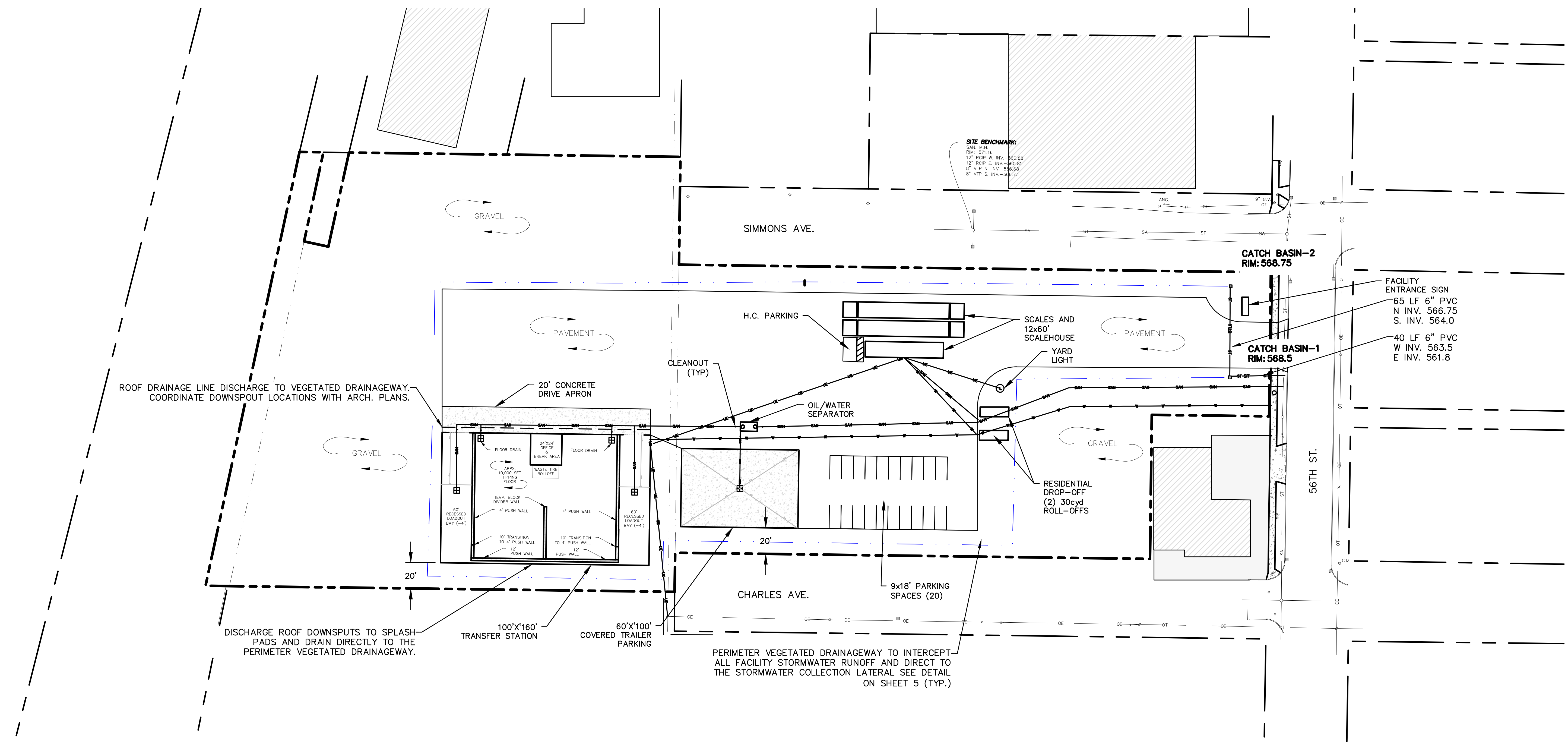

NOTES:

1. SUBJECT PROPERTY LINES AS SURVEYED BY APEX CONSULTING SURVEY & ENGINEERING SERVICES, P.C. OF LOCKPORT, NY (APEX) IN A DRAWING DATED 9/15/23 AND TITLED 171221 SUB-MAP. (SEPARATELY PROVIDED WITH APPLICATION)
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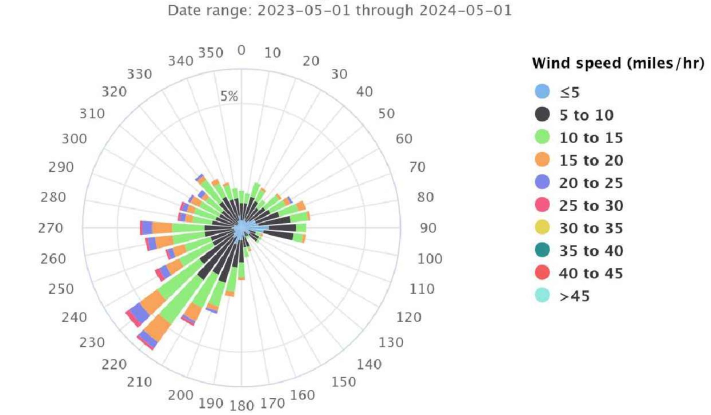
3. ADJACENT PROPERTY LINES AS APPROXIMATED FROM THE NIAGARA COUNTY GIS DIGITAL TAX MAPS WEB APPLICATION.
4. EXISTING EASEMENTS, TOPOGRAPHY, UTILITIES, PAVEMENT, AND CONCRETE AS SURVEYED BY APEX IN A DRAWING DATED 9/26/23 AND TITLED 171221 TOPT-MAP. (SEPARATELY PROVIDED WITH APPLICATION)
5. ACIS WIND ROSE GATHERED FROM CORNELL.

LEGEND:

- SUBJECT PROPERTY LINES
- ADJACENT PROPERTY LINES
- EASEMENT BOUNDARY
- PROPOSED SANITARY SEWER
- PROPOSED WATER SERVICE
- PROPOSED ELECTRIC SERVICE
- VEGETATED SWALE
- STORMWATER COLLECTION LATERAL
- EXISTING COMBINED SEWER LINE

ACIS WIND ROSE



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NO.	REVISION	BY	DATE
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3	ADDED WIND ROSE PER NYSDEC REQUEST	JMS	5/6/24
2	ADDED PERIMETER DRAINAGE SWALE/STORMWATER SYSTEM CONNECTION TO COMBINED SEWER	JMS	2/7/24
1	UPDATED SUBJECT PROPERTY LINES TO AS-SURVEYED AND POST-AMALGAMATION OF 4 SUBLOTS	JMS	11/15/23

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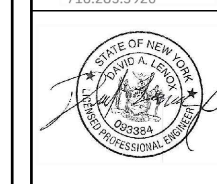

DAVID A. LENOX, P.E.
NYSPE LICENSE NO. 093384

CLIENT: 56th STREET TRANSFER, LLC

SITE: 540 56th STREET

CITY OF NIAGARA FALLS
COUNTY OF NIAGARA
STATE OF NEW YORK

PROJECT: 56th TRANSFER STATION SITE PLAN APPLICATION

TITLE: SITE PLAN 2

ISSUE: REVIEW

DES:	DRN:	CHK:
JMS	JMS	DAL

PROJECT NO: 169-A0001
DATE: MAY 2024

GRAPHIC SCALE: (1:960) 0' 40' 80'

FILE: 075-C0001 56th TS Application Dwgs.Rev3.dwg

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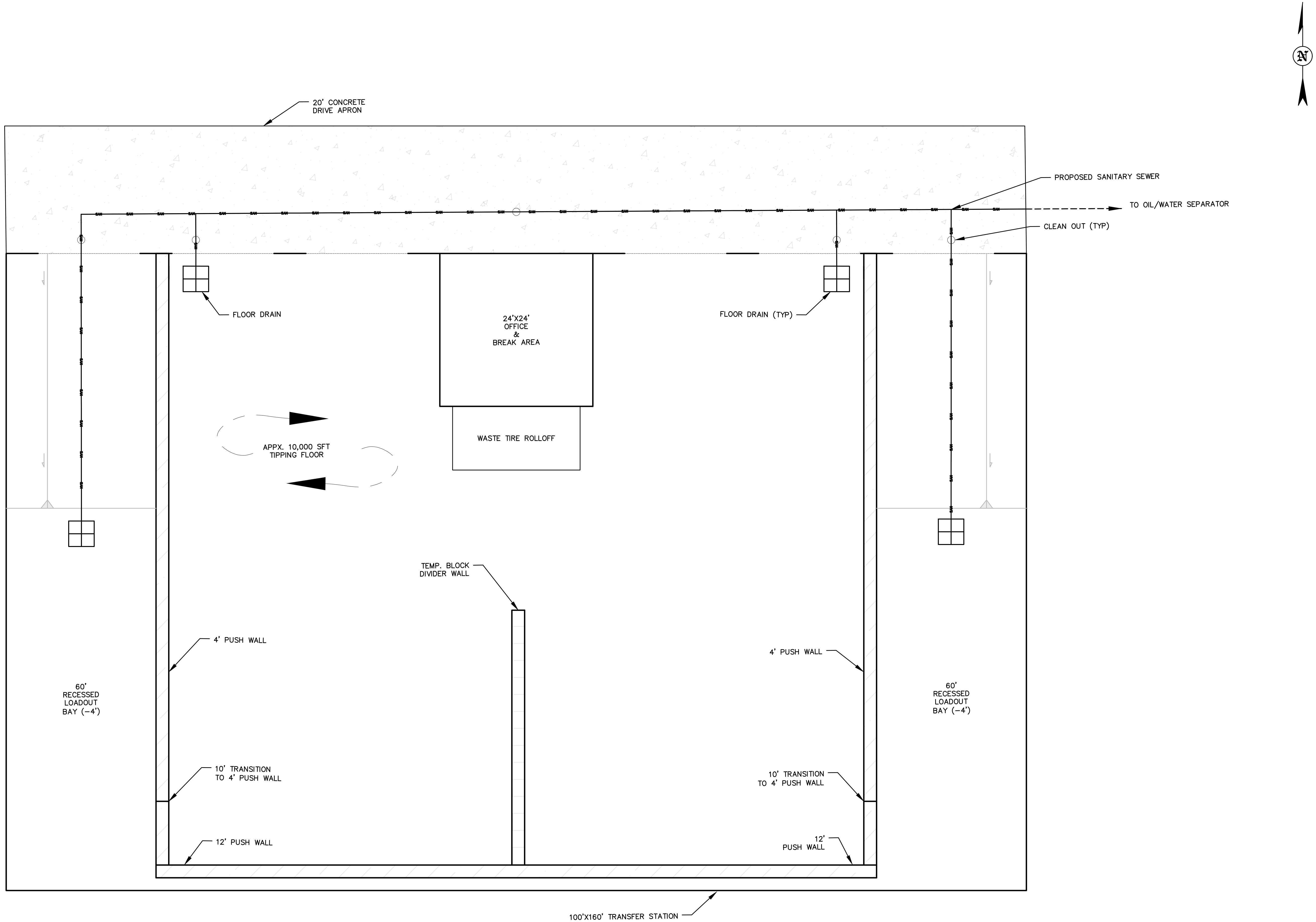
SHEET NO: 3b



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STATE OF NEW YORK · DAVID A. LENOX · 093384 · LICENSED PROFESSIONAL ENGINEER

DAVID A. LENOX, P.E.
NYSPE LICENSE NO. 093384

CLIENT: 56th STREET TRANSFER, LLC

SITE: 540 56th STREET

CITY OF NIAGARA FALLS
COUNTY OF NIAGARA
STATE OF NEW YORK

PROJECT: 56th TRANSFER STATION PART 360 APPLICATION

TITLE: FLOOR PLAN

ISSUE: REVIEW

DES: JMS | DRN: ACC | CHK: DAL

PROJECT NO: 169-A0001 | DATE: MAY 2024

GRAPHIC SCALE: 0' 7.5' 15'

FILE: 075-C0001 56th TS Floor Plan.dwg

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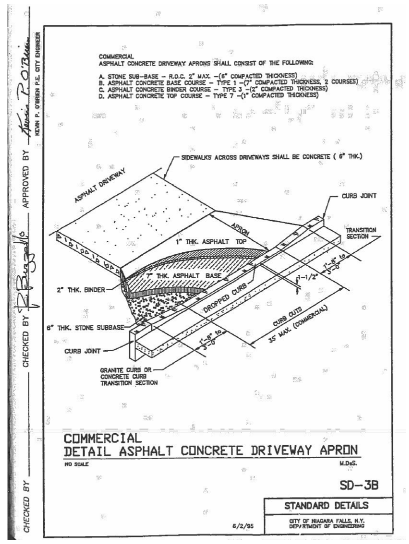

COMMERCIAL ASPHALT CONCRETE DRIVEWAY APRON DETAIL
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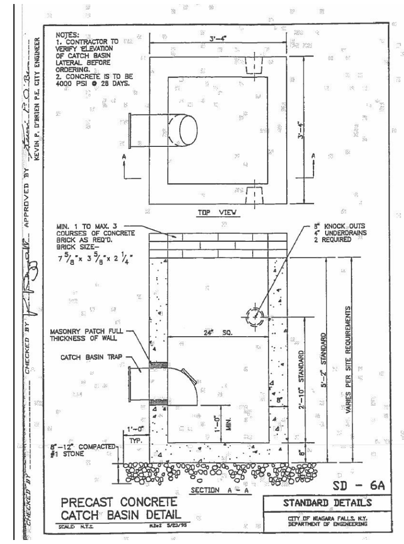
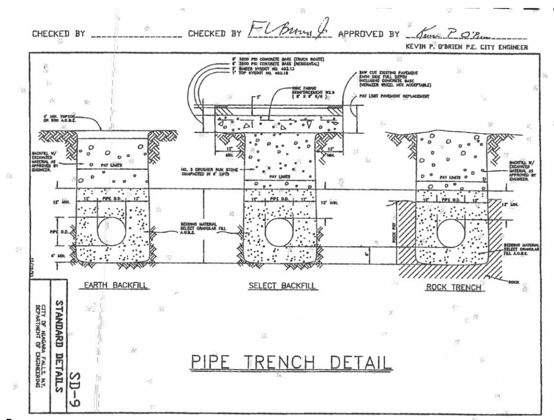
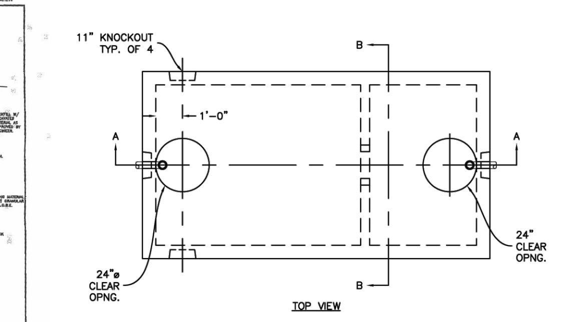
SCALE: NOT TO SCALE



PRECAST CONCRETE CATCH BASIN DETAIL
(FROM CITY OF NF ENG. DEPT.)
SCALE: NOT TO SCALE

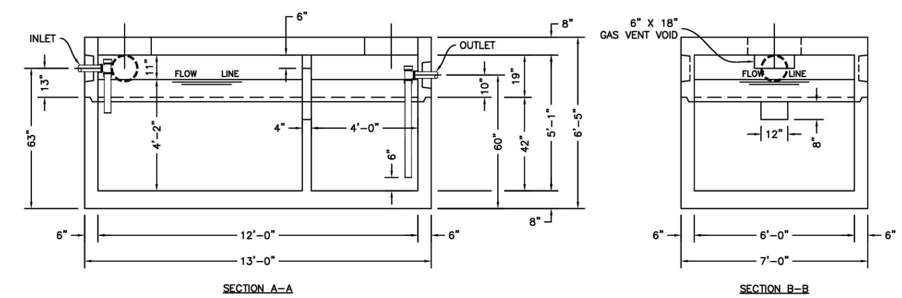


PIPE TRENCH DETAIL
(FROM CITY OF NF ENG. DEPT.)
SCALE: NOT TO SCALE



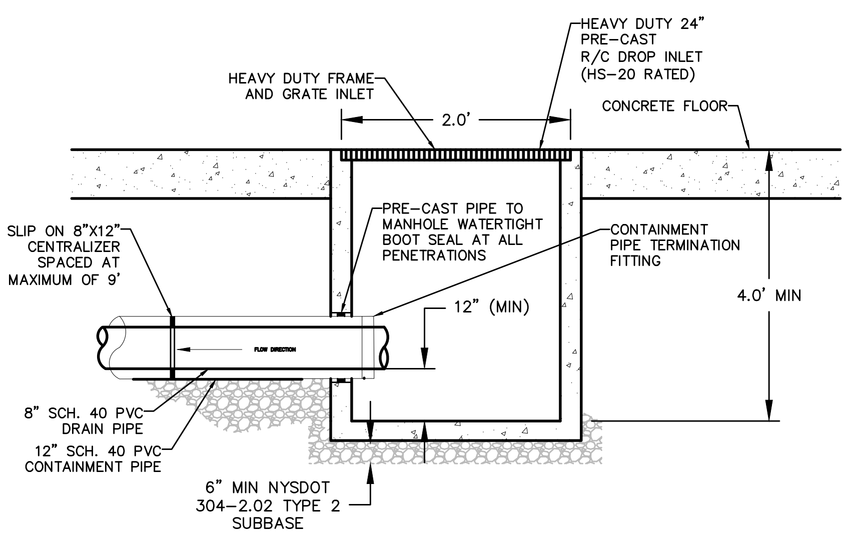
SP-7A
SPECIFICATIONS:

CONCRETE:	5,000 P.S.I. @ 28 DAYS.
ENTRAINED AIR:	5% – 8%
STEEL:	A.S.T.M. A496–A615 GRADE 60–80 KSI.
DESIGN LOADING:	ACI 318–99 TRAFFIC. USE ACI LOAD FACTORS. A.A.S.H.T.O. METHOD OF DESIGN. EQUIVALENT SOIL PRESSURE OF 40 (PCF).
LIVE LOAD:	H20.
EARTH FILL:	0 TO 6'.
WATER TABLE:	3' BELOW GRADE.
WEIGHT:	
TOP SECTION:	14,145 LBS.
BOTTOM SECTION:	22,000 LBS.
TOTAL:	36,145 LBS.
PIPING:	TEES, DROP LEGS & FITTINGS SUPPLIED AND INSTALLED BY G.C.

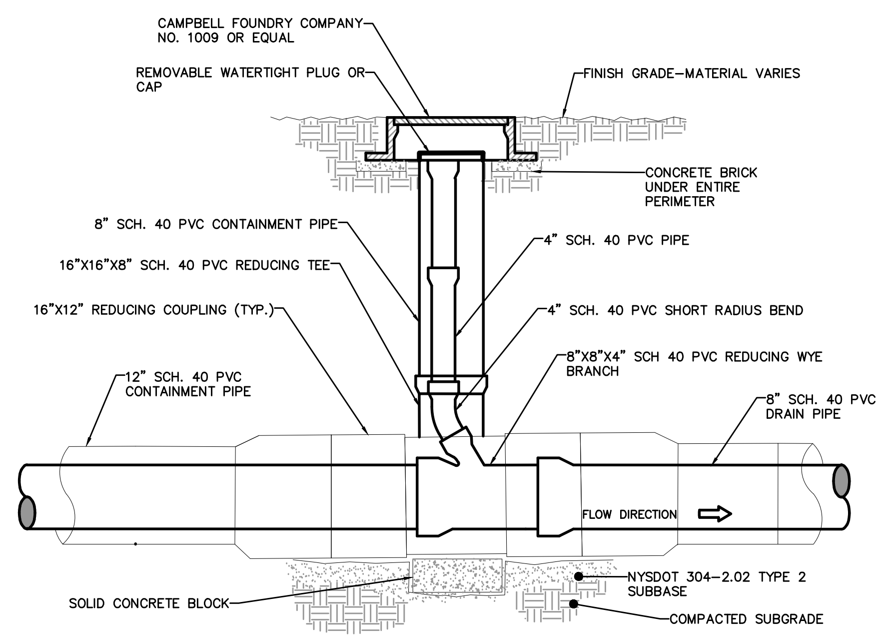


NOTE: DETAIL FROM KISTNER CONCRETE 2,000 GAL OIL SEPARATOR DETAIL

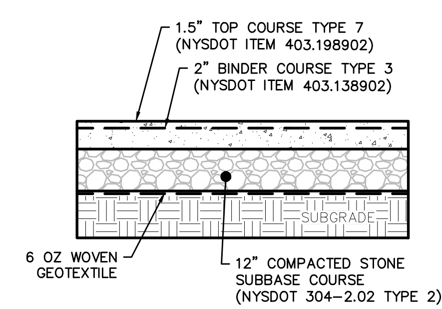
2,000 GALLON OIL WATER SEPARATOR DETAIL
SCALE: NOT TO SCALE



TYPICAL DROP INLET FLOOR DRAIN DETAIL
SCALE: NOT TO SCALE

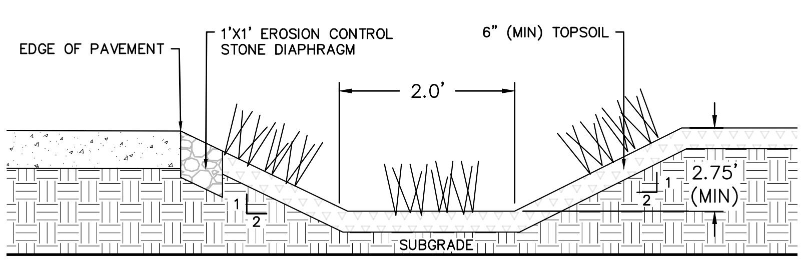


TYPICAL FLOOR DRAIN CLEANOUT DETAIL
SCALE: NOT TO SCALE

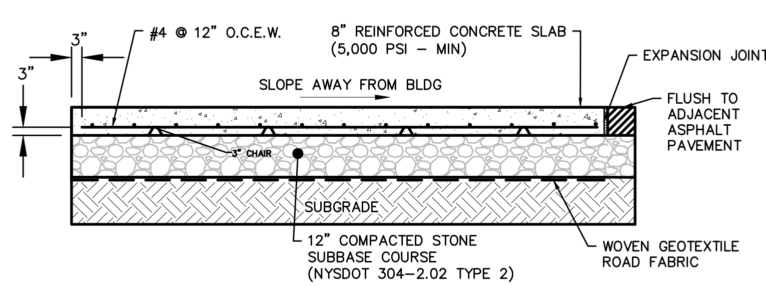


ASPHALT PAVEMENT DETAIL
SCALE: NOT TO SCALE

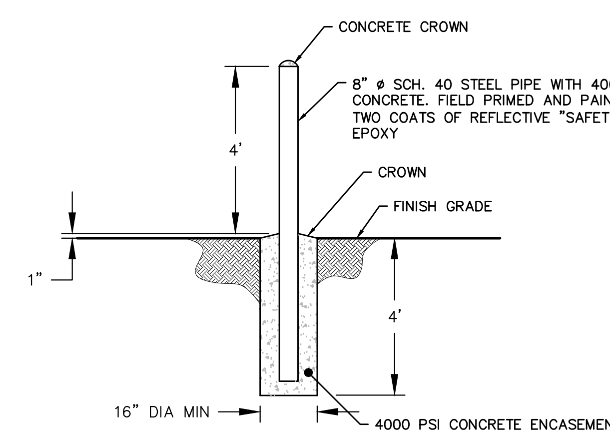
ENTRANCE SIGN DETAIL
SCALE: NOT TO SCALE



VEGETATED SWALE DETAIL
SCALE: NOT TO SCALE



CONCRETE APRON/PAD DETAIL
SCALE: NOT TO SCALE



CONCRETE BOLLARD DETAIL
SCALE: NOT TO SCALE

NO.	REVISION	BY	DATE
	UPDATED UNACCEPTABLE MATERIALS ON SIGN DETAIL TO INCL. ELECTRONICS AND MERCURY CONTAINING ITEMS	JMS	5/22/24
	ADDED CATCH BASIN AND DRAINAGE SWALE DETAILS	JMS	2/7/24

EnSol
661 Main St.
Niagara Falls, NY 14301
716.285.3920

STATE OF NEW YORK — DAVID A. LENOX — 093384 — LICENSED PROFESSIONAL ENGINEER
DAVID A. LENOX, P.E.
NYSPE LICENSE NO. 093384

CLIENT:
56th STREET TRANSFER, LLC

SITE:
540 56th STREET
CITY OF NIAGARA FALLS
COUNTY OF NIAGARA
STATE OF NEW YORK

PROJECT:
56th TRANSFER STATION
SITE PLAN APPLICATION

TITLE:
DETAILS

ISSUE:
REVIEW

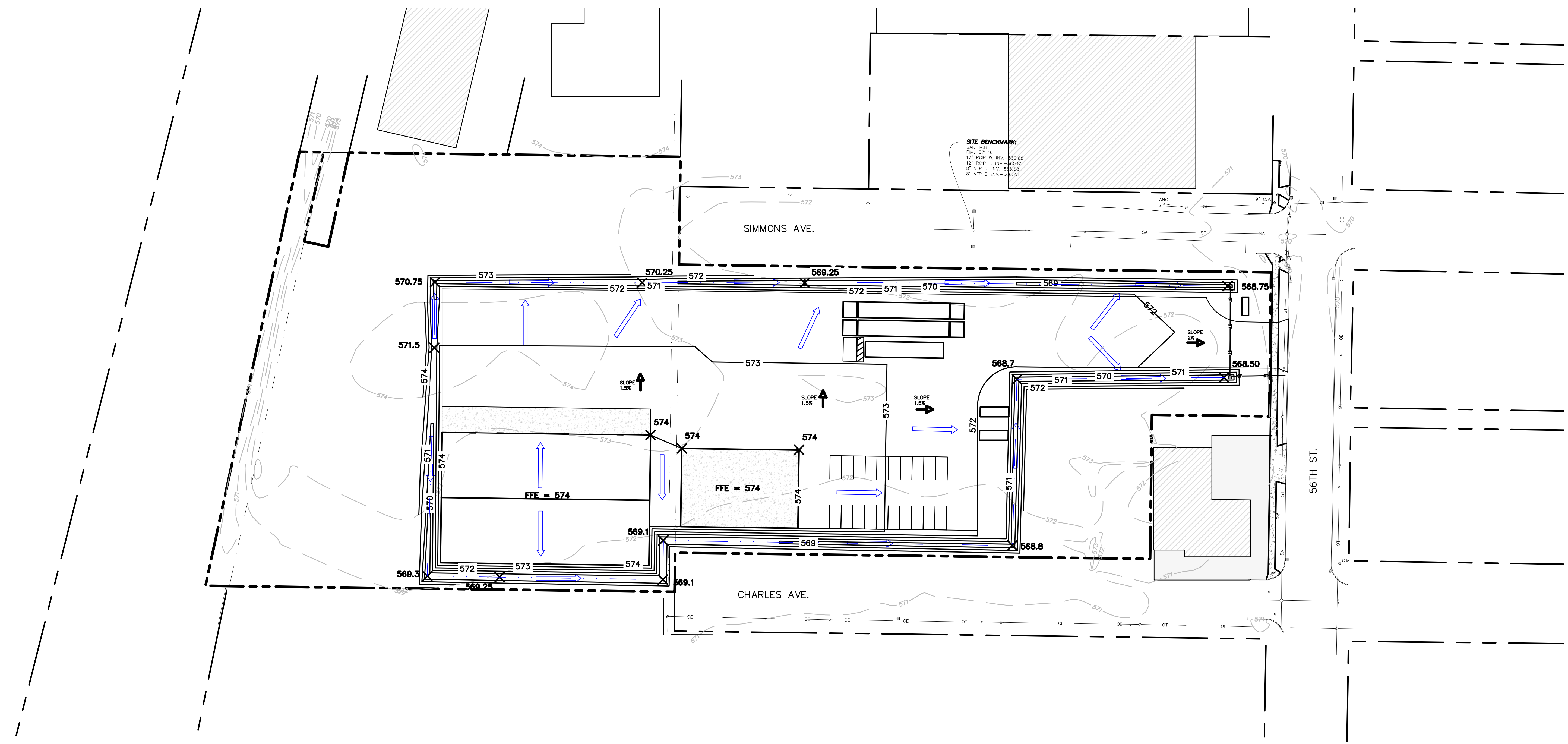
DES:	DRN:	CHK:
JMS	JMS	DAL

PROJECT NO:	DATE:
169-A0001	MAY 2024

GRAPHIC SCALE:
NTS NTS NTS

FILE:
075-C0001 56th TS Application Dwgs.Rev3.dwg

REV NO:	SHEET NO:
1	5



NOTES:

1. PROVIDED SPOT ELEVATIONS ARE ONLY REPRESENTATIVE OF CONCEPTUAL PROPOSED GRADING AND ARE NOT FOR CONSTRUCTION PURPOSES
2. DETAILED GRADING PLANS/CONTOURS WILL BE PREPARED FOR CONSTRUCTION FOLLOWING FINAL SITE PLAN APPROVAL

LEGEND:

	SUBJECT PROPERTY LINES
	ADJACENT PROPERTY LINES
572	EXISTING TOPOGRAPHIC CONTOUR (1–FOOT INTERVAL)
X 572	PROPOSED GRADING SPOT ELEVATION
	PROPOSED FINAL GRADE DRAINAGE PATTERN
	VEGETATED SWALE
ST	STORMWATER COLLECTION LATERAL
ST SA ST	EXISTING COMBINED SEWER LINE
573	PROPOSED TOPOGRAPHIC CONTOURS (1–FOOT INTERVALS)

IT IS A VIOLATION OF THE NEW YORK STATE EDUCATION LAW, ARTICLE 145 SECTION 7209, FOR ANY PERSON, UNLESS HE IS ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER OR LAND SURVEYOR TO ALTER AN ITEM IN ANY WAY.

NO.	REVISION	BY	DATE
1.	ADDED PERIMETER DRAINAGE SWALE AND ASSOCIATED BOTTOM OF SWALE SPOT ELEVATIONS	JMS	2/7/24
2.			
3.			
4.			
5.			
6.			

EnSol
661 Main St.
Niagara Falls, NY 14301
716.285.3920

DAVID A. LENOX, P.E.
NYSPE LICENSE NO. 093384

CLIENT:
56th STREET TRANSFER, LLC

SITE:
540 56th STREET
CITY OF NIAGARA FALLS
COUNTY OF NIAGARA
STATE OF NEW YORK

PROJECT:
56th TRANSFER STATION SITE PLAN APPLICATION

TITLE:
GRADING PLAN

ISSUE: REVIEW

DES:	DRN:	CHK:
JMS	JMS	DAL

PROJECT NO: 169-A0001
DATE: MAY 2024

GRAPHIC SCALE: (1:960) 0' 40' 80'

FILE: 075-C0001 56th TS Application Dwgs.Rev3.dwg

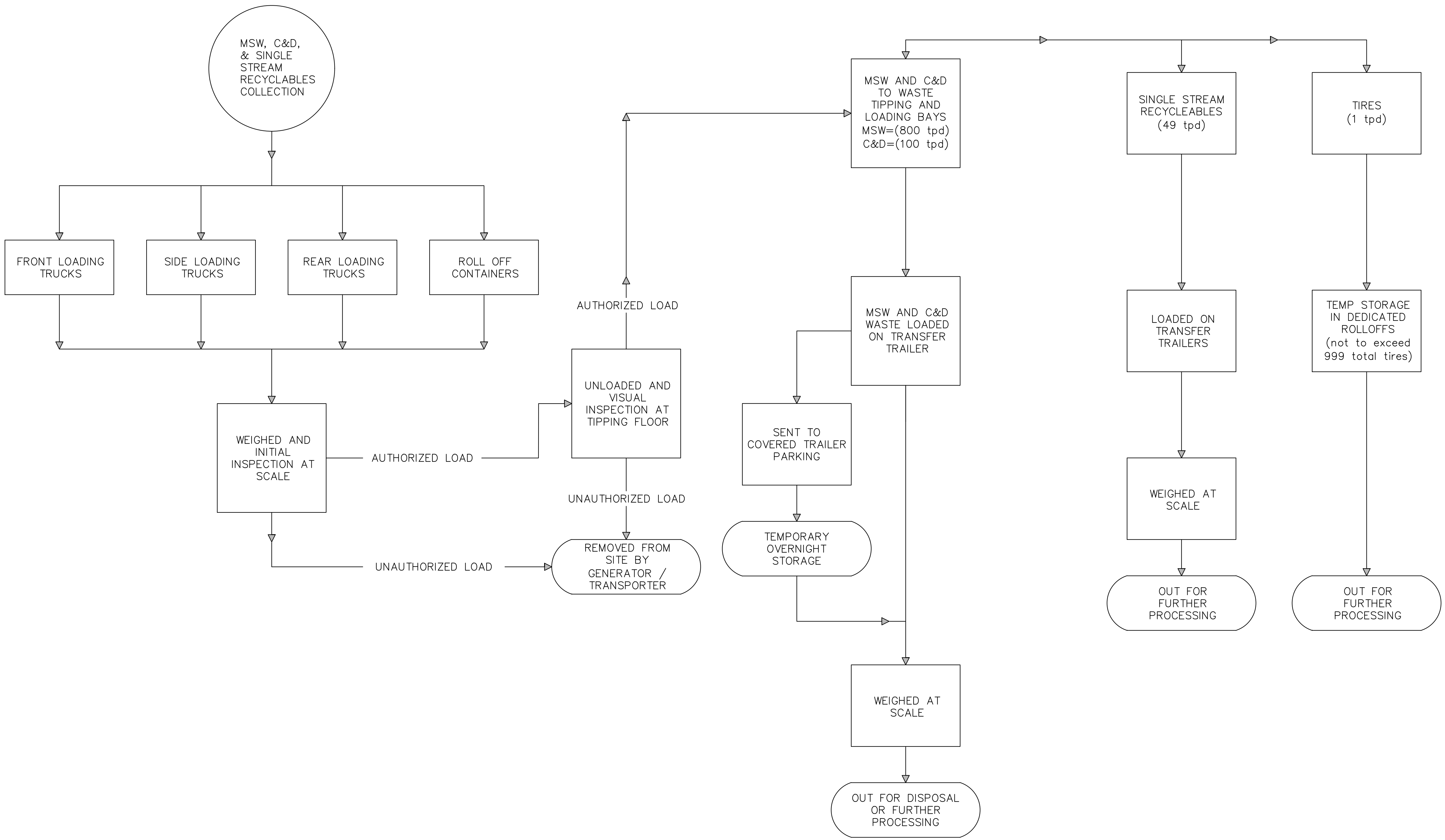
REV NO: 1
SHEET NO: 6

Attachment 1

EnSol, Inc.

ENGINEERING + ENVIRONMENTAL

Process Flow Chart



NO	REVISION	BY	DATE

EnSol
661 Main St.
Niagara Falls, NY 14301
716.285.3920

CLIENT:
56TH STREET TRANSFER, LLC

SITE:
540 56TH STREET
CITY OF NIAGARA FALLS
COUNTY OF NIAGARA
STATE OF NEW YORK

PROJECT:
56th TRANSFER STATION ENGINEERING REPORT

TITLE:
PROCESS FLOW CHART

ISSUE:
REVIEW

DES: JMS	DRN: ACC	CHK: DAL
PROJECT NO: 169-A0001	DATE: MAY 2024	

GRAPHIC SCALE: N/A N/A N/A

FILE: Process Flow Chart.dwg

REV NO:	SHEET NO:
0	1

Attachment 2

EnSol, Inc.

ENGINEERING + ENVIRONMENTAL

Waste Processing Calculations and Equipment Specifications

56TH STREET TRANSFER STATION

TABLE 1 - Facility Throughput and Capacity

Material	Storage Structure						Throughput						Density (lbs/CY)
	Storage Area	Capacity					Expected Maximum Average Daily Rate (Tons/Day)	Expected Annual Rate (Tons/Year)	Maximum Daily Rate (Tons/Day)	Average Daily Rate (CY/Day)	Annual Rate (CY/Year)	Maximum Rate (CY/Day)	
		Area (SQFT)	Cubic Yards (CY)	# of Trailers	Trailer Capacity (tons)	Tons							
Indoor Storage (Tipping Floor):													
Municipal Solid Waste (MSW) - Tipping Floor	Tipping Floor	5,000	1,667	na	na	416.67	800	244,800	1,093	3,200	979,200	4,372	500
Construction and Demolition Debirs (C&D) - Tipping Floor	Tipping Floor	2,500	833	na	na	625.00	100	30,600	137	133	40,800	182	1500
Single Stream Recyclables (SSR) - Tipping Floor	Tipping Floor	2,500	833	na	na	66.67	49	14,994	67	613	187,425	837	160
Tires	Tipping Floor (40 CY Roll-Off Container)	na	40	na	na	4.00	1	306	1	10	3,060	14	200
	Sub-Totals:	**10,000**	**3,373**			**1,112.33**	**950**	**290,700**	**1,298**	**3,956**	**1,210,485**	**5,405**	**na**
Outdoor Storage (Covered Trailer Parking Area):													
MSW & C&D - Trailer Storage Area	Concrete Trailer Parking Area	na	900	6	22	132.00	na	na	na	na	na	na	na
	Sub-Totals:	**na**	**900**	**6**	**na**	**132.00**	**na**	**na**	**na**	**na**	**na**	**na**	**na**
	TOTALS:	**na**	**4,273**			**1,244.33**	**950**	**290,700**	**1,298**	**3,956**	**1,210,485**	**5,405**	**na**

Notes:

1. The Expected Maximum Average Daily Rate is based on a weekly average. The Expected Annual Rate is based on the maximum average daily rate and assumes 306 operating days per year.
2. Storage volumes assume a 12 foot storage height over 75% of the storage area.
3. The Full Trailer Parking Area capacity assumes six trailers with a 22 ton capacity.
4. The Maximum Daily Rate values are based on the Equipment Capacity as shown on Table 2.

56TH STREET TRANSFER STATION

Table 2 - Process and Storage Equipment/Structure Capacity and Detention Time

Material	Process Step/Structure	Capacity	Unit	Equipment	Detention Time	Unit
MSW/C&D	Sort/Tipping Floor	36	Tons	-	15	Min
	Concrete Push Wall Storage Area	1,042	Tons	-	1.3	Days
	Load into Transfer Trailer	1,298	Tons/Day	Excavator with 4.5 CY Grapple	10	Min
SSR	Tipping Floor	12	Tons	-	10	Min
	Concrete Push Wall Storage Area	67	Tons	-	1.4	Day
	Load onto Transfer Trailer	187	Tons/Day	Front Loader with 4 CY Bucket	35	Min
Tires	40 CY Roll-Off Container	4	Tons	-	4.0	Days

Notes:

1. No back-up facilities or equipment shall be maintained at the Facility. Should back-up equipment become necessary, the operator will arrange for a rental or lease.
2. Tipping floor capacity is based on three doors for the MSW/C&D tipping floor, one door for the SSR tipping floor, and one truck unloads a 12 ton load at each door. The Tipping floor detention time is based on a peak rate of 12 inbound trucks per hour.
3. Storage Area detention times represent the time to fill the storage area based on the expected maximum average daily rate.
4. The Excavator with grapple capacity is based on a 4.5 cubic yard grapple with a 25 second cycle time. The estimated time to fill a 22 ton capacity transfer trailer is 8 minutes, the estimated time to switch out transfer trailers is two minutes. The estimated number of outbound 22 ton transfer trailers that can be loaded over 10 operating hours is 59.
5. The SSR Front Loader capacity is based on a 4 cubic yard bucket, with a cycle time estimated at approximately one minute. The estimated time to fill a 11 ton capacity transfer trailer is 35 minutes. The estimated time to switch out transfer trailers is two minutes. The estimated number of outbound trailers that can be loaded over 10 operating hours is 17.

56TH STREET TRANSFER STATION
Table 3 - Daily Traffic Flow

Table 3-1 Waste/Truck Traffic

Vehicle Type	Average Vehicle Size (Tons per Load)	Expected Maximum Average Daily Rate (Tons/Day)	Loads/Trucks Per Day	Trips Per Day
Inbound Trucks: Front, Rear, and Side Packers, Dump Trucks, Pickup Trucks, Trailers, Roll Off Containers	12	950	80	160
Outbound Trucks: 53 foot long Trailers	25	950	38	76
		Total:	**118**	**236**

Table 3-2 Employee/Visitor Traffic

		Per Day	Trips Per Day
Visitors / Employees		12	24
Total:		**12**	**24**

Total Maximum Average Traffic Flow (Trips Per Day):	**260**

Table 3-3 Maximum Number of Waste Trucks That Can be Accommodated On-Site

Vehicle Type	Average Vehicle Size (Tons per Load)	Maximum Daily Processing Rate (Tons Per Day)	Maximum No. of Vehicles per Day
Inbound Trucks: Front and Rear Packers, Pickup Trucks, Trailers, Roll Off Containers	12	1,298	109
Outbound Trucks: 53 foot long Trailers	25	1,298	52
Total Amount of Waste Trucks that can be accomodated:			**161**

PRODUCT SPECIFICATIONS FOR 320 - TIER 4 / STAGE V

ENGINE

Net Power - ISO 9249	172 hp
Net Power - ISO 9249 (DIN)	175 hp (metric)
Engine Model	Cat® C4.4
Engine Power - ISO 14396	174 hp
Engine Power - ISO 14396 (DIN)	176 hp (metric)
Bore	4 in
Stroke	5 in
Displacement	269 in³
Biodiesel Capability	Up to B20[1]
Emissions	Meets U.S. EPA Tier 4 Final, EU Stage V, and Japan 2014 emission standards.
Note (1)	Net power advertised is the power available at the flywheel when the engine is equipped with fan, air intake system, exhaust system, and alternator with engine speed at 2,200 rpm. Advertised power is tested per the specified standard in effect at the time of manufacture.
Note (2)	[1]Cat diesel engines are required to use ULSD (ultra-low sulfur diesel fuel with 15 ppm of sulfur or less) or ULSD blended with the following lower-carbon intensity fuels** up to: 20% biodiesel FAME (fatty acid methyl ester)* or 100% renewable diesel, HVO (hydrotreated vegetable oil) and GTL (gas-to-liquid) fuels. Refer to guidelines for successful application. Please consult your Cat dealer or "Caterpillar Machine Fluids Recommendations" (SEBU6250) for details. *Engines with no aftertreatment devices can use higher blends, up to 100% biodiesel (for use of blends higher than 20% biodiesel, consult your Cat dealer). **Tailpipe greenhouse gas emissions from lower-carbon intensity fuels are essentially the same as traditional fuels.

HYDRAULIC SYSTEM

Main System - Maximum Flow	429 l/min (113 gal/min)
Maximum Pressure - Equipment	5075 psi
Maximum Pressure - Travel	4974 psi

Maximum Pressure - Swing	3988 psi

SWING MECHANISM

Swing Speed	11.25 r/min
Note (1)	For CE-marked machine default value may be set lower.
Maximum Swing Torque	60300 lbf·ft

WEIGHTS

Operating Weight	49800 lb
Note	Reach boom, R2.9 (9'6") stick, Heavy Duty (HD) 1.19 m³ (1.56 yd³) bucket 790 mm (31") triple grouser shoes, 4200 kg (10,400 lb) counterweight.

SERVICE REFILL CAPACITIES

Fuel Tank Capacity	86.6 gal (US)
Cooling System	6.6 gal (US)
Engine Oil	4 gal (US)
Swing Drive - Each	1.6 gal (US)
Final Drive - Each	1.1 gal (US)
Hydraulic System - Including Tank	61.8 gal (US)
Hydraulic Tank	30.4 gal (US)
DEF Tank	10.3 gal (US)

DIMENSIONS

Boom	Reach 5.7 m (18'8")
Stick	Reach 2.9 m (9'6")
Bucket	1.19 m ³ (1.56 yd³)
Shipping Height - Top of Cab	9.7 ft
Handrail Height	9.7 ft
Shipping Length	31.3 ft
Tail Swing Radius	9.3 ft
Counterweight Clearance	3.4 ft
Ground Clearance	1.5 ft
Track Length	14.6 ft

Length to Center of Rollers	11.7 ft
Track Gauge	7.8 ft
Transport Width	9.8 ft

WORKING RANGES AND FORCES

Maximum Digging Depth	22 ft
Boom	Reach 5.7 m (18'8")
Stick	Reach 2.9 m (9'6")
Bucket	1.19 m^3 (1.56 yd^3)
Maximum Reach at Ground Level	32.3 ft
Maximum Cutting Height	30.7 ft
Maximum Loading Height	21.3 ft
Minimum Loading Height	7.1 ft
Maximum Depth Cut for 2440 mm (8 ft) Level Bottom	21.5 ft
Maximum Vertical Wall Digging Depth	17 ft
Bucket Digging Force - ISO	38811 lbf
Stick Digging Force - ISO	23911 lbf

AIR CONDITIONING SYSTEM

Air Conditioning	The air conditioning system on this machine contains the fluorinated greenhouse gas refrigerant R134a (Global Warming Potential = 1430). The system contains 0.85 kg (1.9 lb) of refrigerant which has a CO_2 equivalent of 1.216 metric tonnes (1.340 tons).

SUSTAINABILITY

Recyclability 97%

320 - TIER 4 / STAGE V STANDARD EQUIPMENT

NOTE

- Standard and optional equipment may vary. Consult your Cat® dealer for details.

CAB

- Rollover Protective Structure (ROPS)
- Air-adjustable seat with heat (Deluxe only)
- Auto-adjustable seat with heat and air ventilation (Premium only)
- High-resolution 254 mm (10 inch) LCD touchscreen monitor

CAT TECHNOLOGY

- VisionLink®
- Remote Flash
- Remote Troubleshoot
- Work tool recognition and tracking (PL161)
- Cat Grade with 2D
- Cat Assist
- Cat Payload

ELECTRICAL SYSTEM

- Two 1,000 CCA maintenance-free batteries
- Programmable time-delay LED working lights
- LED chassis light, left-hand/right-hand boom lights, cab lights

ENGINE

- Cat C4.4 twin turbo diesel engine
- Three selectable power modes
- Automatic engine speed control
- 52°C (126°F) ambient cooling capacity
- -32°C (-25°F) cold start capability
- Double element air filter with integrated precleaner
- Reversing electric cooling fans

HYDRAULIC SYSTEM

- Boom and stick regeneration circuits

- Auto warm up
- Auto two-speed travel
- Auto dig boost
- Auto heavy lift
- Boom and stick drift reduction valve

SAFETY AND SECURITY

- 2D E-Fence
- Auto hammer stop
- Rearview and right-side-view cameras
- Ground-level engine shutoff switch
- Lockable disconnect switch
- Right-hand handrail and hand hold
- Signaling/warning horn

SERVICE AND MAINTENANCE

- Scheduled Oil Sampling (S·O·S℠) ports
- Ground-level and platform-level engine oil dipsticks
- Integrated vehicle health management system

UNDERCARRIAGE AND STRUCTURES

- Tie-down points on base frame

320 - TIER 4 / STAGE V OPTIONAL EQUIPMENT

NOTE

- Standard and optional equipment may vary. Consult your Cat® dealer for details.

BOOMS AND STICKS

- 5.7 m (18'8") Reach boom
- 5.7 m (18'8") HD Reach boom
- 2.8 m (9'2") Stub + 3.3 m (10'10") Fore, VA boom
- 8.85 m (29') Super Long Reach boom

- 2.5 m (8'2") Reach stick
- 2.9 m (9'6") Reach stick
- 2.5 m (8'2") HD Reach stick
- 2.9 m (9'6") HD Reach stick
- 2.9 m (9'6") HD Thumb Ready Reach stick
- 6.28 m (20'7") Super Long Reach stick

CAB

- Operator Protective Guards (OPG)
- Cat Stick Steer
- Auxiliary relay

CAT TECHNOLOGY

- VisionLink Productivity
- Operator Coaching
- Cat Grade with 2D with Attachment Ready Option (ARO)
- Cat Grade with 3D (single or dual GNSS)
- Cat Grade 3D Ready
- Cat Grade Connectivity
- Cat Advanced Payload
- Cat Tiltrotator (TRS) integration

HYDRAULIC SYSTEM

- Boom and stick lowering check valves
- SmartBoom™ (Europe only)
- Hammer return filter circuit
- Hydraulic efficiency monitoring
- Advanced tool control (two pump, one/two way high-pressure flow)
- Medium-pressure circuit
- Quick coupler circuit for Cat pin grabber

SAFETY AND SECURITY

- Cat Command (remote control)
- 360° visibility
- Swing alarm
- Inspection lighting

UNDERCARRIAGE AND STRUCTURES

- 600 mm (24") triple grouser shoes
- 700 mm (28") triple grouser shoes
- 790 mm (31") triple grouser shoes
- 900 mm (35") triple grouser shoes
- 4200 kg (9,300 lb) counterweight
- 4700 kg (10,400 lb) counterweight

FUEL CONSUMPTION

Excavators

Fuel and DEF consumption values are sourced from VisionLink telematics data by region and assume the following idle time percentages: 50% for low, 30% for medium, 10% for high

	Low fuel consumption	Medium fuel consumption	High fuel consumption	DEF consumption (% of fuel)	Low DEF consumption	Medium DEF consumption	High DEF consumption
Cat 300.9D	0.53 gal/hr	0.7 gal/hr	0.87 gal/hr				
Cat 301.5-05	0.58 gal/hr	0.77 gal/hr	0.96 gal/hr				
Cat 301.7-05 CR	0.58 gal/hr	0.77 gal/hr	0.96 gal/hr				
Cat 301.8-05	0.58 gal/hr	0.77 gal/hr	0.96 gal/hr				
Cat 302.7-07 CR	0.71 gal/hr	0.96 gal/hr	1.2 gal/hr				
Cat 302-05 CR	0.63 gal/hr	0.84 gal/hr	1.04 gal/hr				
Cat 303.5-07 CR	0.85 gal/hr	1.14 gal/hr	1.44 gal/hr				
Cat 303-07 CR	0.78 gal/hr	1.05 gal/hr	1.32 gal/hr				
Cat 304-07 CR	0.92 gal/hr	1.25 gal/hr	1.58 gal/hr				
Cat 305-07 CR	1.15 gal/hr	1.55 gal/hr	1.94 gal/hr				
Cat 306-07 CR	0.74 gal/hr	1.03 gal/hr	1.33 gal/hr				
Cat 307.5-07	0.75 gal/hr	1.04 gal/hr	1.34 gal/hr				
Cat 308-07 CR	0.68 gal/hr	0.95 gal/hr	1.22 gal/hr				
Cat 308E2 CR	0.74 gal/hr	1.04 gal/hr	1.33 gal/hr				
Cat 309-07 CR	0.93 gal/hr	1.3 gal/hr	1.67 gal/hr				
Cat 310-07	0.87 gal/hr	1.21 gal/hr	1.56 gal/hr				
Cat 311FL RR		1.95 gal/hr		2.5%		0.05 gal/hr	
Cat 313-07	1.64 gal/hr	2.11 gal/hr	2.57 gal/hr	2.5%	0.04 gal/hr	0.05 gal/hr	0.06 gal/hr
Cat 313-07 GC	1.49 gal/hr	1.9 gal/hr	2.31 gal/hr				
Cat 315-07	1.72 gal/hr	2.21 gal/hr	2.7 gal/hr	2.5%	0.04 gal/hr	0.06 gal/hr	0.07 gal/hr
Cat 315-07 GC	1.59 gal/hr	2.03 gal/hr	2.47 gal/hr	2.5%	0.04 gal/hr	0.05 gal/hr	0.06 gal/hr
Cat 317-07	1.96 gal/hr	2.52 gal/hr	3.09 gal/hr	2.5%	0.05 gal/hr	0.06 gal/hr	0.08 gal/hr
Cat 317-07 GC	1.88 gal/hr	2.42 gal/hr	2.97 gal/hr	2.5%	0.05 gal/hr	0.06 gal/hr	0.07 gal/hr
Cat 320-07	2.42 gal/hr	3.07 gal/hr	3.72 gal/hr	2.5%	0.06 gal/hr	0.08 gal/hr	0.09 gal/hr
Cat 320-07 GC	2.18 gal/hr	2.78 gal/hr	3.37 gal/hr	2.5%	0.05 gal/hr	0.07 gal/hr	0.08 gal/hr
Cat 323-07	2.71 gal/hr	3.45 gal/hr	4.18 gal/hr	2.5%	0.07 gal/hr	0.09 gal/hr	0.1 gal/hr
Cat 325-07	2.25 gal/hr	2.89 gal/hr	3.53 gal/hr	2.5%	0.06 gal/hr	0.07 gal/hr	0.09 gal/hr
Cat 326-07	3.29 gal/hr	4.17 gal/hr	5.06 gal/hr	2.5%	0.08 gal/hr	0.1 gal/hr	0.13 gal/hr
Cat 329FL	3.61 gal/hr	4.72 gal/hr	5.84 gal/hr	2.5%	0.09 gal/hr	0.12 gal/hr	0.15 gal/hr
Cat 330-07	3.69 gal/hr	4.73 gal/hr	5.77 gal/hr	2.5%	0.09 gal/hr	0.12 gal/hr	0.14 gal/hr
Cat 330-07 GC	3.51 gal/hr	4.5 gal/hr	5.49 gal/hr	2.5%	0.09 gal/hr	0.11 gal/hr	0.14 gal/hr
Cat 335-07	3.88 gal/hr	4.95 gal/hr	6.03 gal/hr	2.5%	0.1 gal/hr	0.12 gal/hr	0.15 gal/hr
Cat 336-07	3.9 gal/hr	5.05 gal/hr	6.19 gal/hr	2.5%	0.1 gal/hr	0.13 gal/hr	0.15 gal/hr
Cat 336-07 GC	4.15 gal/hr	5.36 gal/hr	6.58 gal/hr	2.5%	0.1 gal/hr	0.13 gal/hr	0.16 gal/hr
Cat 336-08	4.86 gal/hr	6.3 gal/hr	7.75 gal/hr	2.5%	0.12 gal/hr	0.16 gal/hr	0.19 gal/hr

Cat®
Trash Grapples

HYDRAULIC EXCAVATORS

FEATURES:

Greater Capacity

- The basic 4-over-5 tine construction and wide jaws are ideal for handling municipal solid waste, wood chips, wood debris, and other low-density material.
- Cat® Trash Grapples are matched to the capacities of Cat excavators, providing you with the best possible productivity for your machine and application, whether it is tamping and sorting or production loading. Multiple grapples are offered for some machines to optimize performance in differing loading conditions.

Simple Installation, No Additional Hydraulics Required

- Cat Trash Grapples operate using the power of the excavator bucket cylinder—no additional hydraulics required.
- Installation is fast and simple with only a single plate to be welded to the underside of the excavator stick for the fixed link. All brackets have three holes so the fixed link can be pinned in any of three positions for maximum efficiency in varying job conditions.

Minimal Weight, Maximum Durability

- Box-type construction is used in the frame to minimize weight and maximize durability.
- Grapples are effectively protected with wear plates on the inner wrapper.
- Wear plates and wear strips are fully replaceable.
- The outer wrapper features thick steel, high hardness wear strips.
- Grapple bearings are made of high hardness, quality alloy steel.

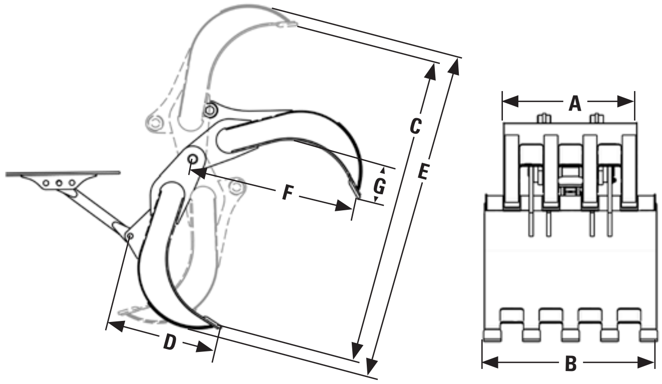
Trash Grapple/Hydraulic Excavator Compatability

Recommended machine matches. Contact your local Cat dealer for more detailed matching information.

Model	Machines
TG-315	315, 316, 318
TG-B	319, 320, 321
TG-CB	324, 328, 329
TG-DB	324, 329, 336
TG-TB	336, 345, 349

Cat Trash Grapples

Specifications



Tamping & Sorting

				TG-315		TG-B		TG-B		TG-CB		TG-DB		TG-TB	
	Capacity	m^3	(yd^3)	1.83	(2.40)	2.70	(3.60)	3.44	(4.5)	3.80	(5.00)	4.60	(6.00)	5.03	(6.58)
	Weight	kg	(lb)	907	(2,000)	1,288	(2,840)	1,392	(3069)	2,077	(4,569)	2,268	(5,001)	2,800	(6,174)
A	Upper Jaw Width	mm	(in)	1,118	(44)	1,118	(44)	1,100	(43)	1,196	(47)	1,295	(51)	1,581	(62)
B	Lower Jaw Width	mm	(in)	1,480	(58)	1,450	(57)	1,450	(57)	1,545	(61)	1,676	(66)	2,038	(80)
C	Max Opening	mm	(in)	2,210	(87)	2,540	(100)	2,600	(102)	3,129	(123)	3,086	(122)	3,161	(124)
D	Minimum (jaw closed)	mm	(in)	665	(26)	740	(29)	300	(12)	878	(35)	1,126	(44)	338	(13)
E	Maximum (jaw open)	mm	(in)	2,244	(88)	2,500	(98)	2,802	(110)	3,205	(126)	3,248	(128)	3290	(130)
F	Tip Radius	mm	(in)	1,165	(46)	1,390	(55)	1,449	(57)	1,639	(64)	1,658	(65)	1,679	(66)
G	Jaw Depth	mm	(in)	246	(10)	285	(11)	204	(8)	403	(16)	417	(16)	430	(17)
	Tip Thickness	mm	(in)	13	(0.51)	13	(0.51)	25	(0.98)	25	(0.98)	25	(0.98)	25	(0.98)
	Wear Plate Thickness	mm	(in)	13	(0.51)	13	(0.51)	14	(0.55)	12	(0.47)	12	(0.47)	12	(0.47)
	Wrapper Thickness	mm	(in)	10	(0.39)	10	(0.39)	10	(0.39)	16	(0.63)	16	(0.63)	16	(0.63)

Production Loading

				TG-DB		TG-TB	
	Capacity	m^3	(yd^3)	5.50	(7.25)	8.17	(10.69)
	Weight	kg	(lb)	2,033	(4,473)	3,075	(6780)
A	Upper Jaw Width	mm	(in)	1,257	(49)	1,667	(66)
B	Lower Jaw Width	mm	(in)	1,626	(64)	2,148	(85)
C	Max Opening	mm	(in)	3,470	(137)	3,800	(150)
D	Minimum (jaw closed)	mm	(in)	1,185	(47)	540	(21)
E	Maximum (jaw open)	mm	(in)	3,610	(142)	3,862	(152)
F	Tip Radius	mm	(in)	1,815	(71)	2,037	(80)
G	Jaw Depth	mm	(in)	461	(18)	626	(25)
	Tip Thickness	mm	(in)	20	(0.79)	19	(0.75)
	Wear Plate Thickness	mm	(in)	14	(0.55)	12	(0.47)
	Wrapper Thickness	mm	(in)	10	(0.39)	12	(0.47)

For more Work Tool Attachments available for your excavator, contact your local Cat dealer.

For more complete information on Cat products, dealer services, and industry solutions, visit us on the web at **www.cat.com**

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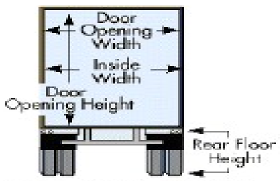
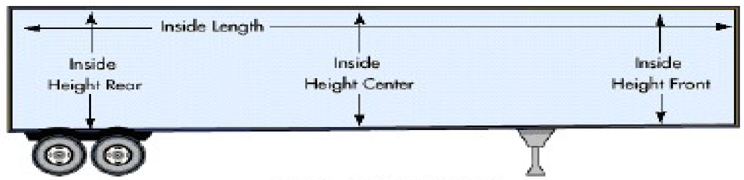
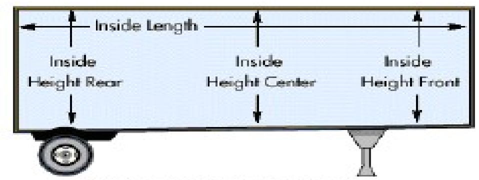


28 ft., 45 ft., 48 ft. or
53 ft. Wedge Trailer



45 ft., 48 ft. or 53 ft.
Wedge Trailer



28 ft. High Cube Trailer

Semi-Trailer Dimensions

	Length	Inside Width	Inside Height Rear	Inside Height Center	Inside Height Front	Door Opening Width	Door Opening Height	Rear Floor Height	Cubic Capacity	Overall Width	Overall Height
28′ High Cube	27′3″	100″	110″	109″	107″	93″	104″	47.5″	2029 cu. ft.	102″	13′6″
45′ Wedge	44′ 1.5″	93″	112″	109″	106″	87″	105.5″	50″	3086 cu. ft.	96″	13′6″
48′ Wedge	47′3″	99″	112.5″	110.5″	108.5″	93″	105″	48.5″	3566 cu. ft.	102″	13′6″
53′ Wedge	52′	99″	110.25″	110.25″	110.25″	93″	105″	49″	4050 cu.ft.	102″	13′6″

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PRODUCT SPECIFICATIONS FOR 962

ENGINE

Engine Power - 2,100 rpm ISO 14396:2002	269 hp
Engine Power - 2,100 rpm ISO 14396:2002	273 hp (metric)
Engine Model	Cat® C7.1
Gross Power - 2,100 rpm SAE J1995:2014	273 kW
Gross Power - 2,100 rpm SAE J1995:2014	277 hp (metric)
Net Power - 2,100 rpm ISO 9249:2007, SAE J1349:2011	255 hp (metric)
Engine Torque - 1,400 rpm ISO 14396:2002	918 lbf·ft
Gross Torque - 1,400 rpm SAE J1995:2014	926 lbf·ft
Net Torque - 1,400 rpm ISO 9249:2007, SAE J1349:2011	867 lbf·ft
Displacement	427 in³
Emissions	Meets U.S. EPA Tier 4 Final, EU Stage V, and Japan 2014 emission standards.
Biodiesel Capability	Up to B20[1]
Note (1)	The net power advertised is the power available at the flywheel when the engine is equipped with fan, alternator, air cleaner, and aftertreatment.
Note (2)	[1]Cat engines are compatible with diesel fuel blended with following lower carbon intensity fuels up to: • 20% biodiesel FAME (fatty acid methyl ester)* • 100% renewable diesel, HVO (hydrogenated vegetable oil) and GTL (gas-to-liquid) fuels Refer to guidelines for successful application. Please consult your Cat dealer or “Caterpillar Machine Fluids Recommendations” (SEBU6250) for details. *For use of blends higher than 20% biodiesel, consult your Cat dealer. **Tailpipe greenhouse gas emissions from lower-carbon intensity fuels are essentially the same as traditional fuels.

WEIGHTS

Operating Weight	44469 lb
Note	Weight based on a machine configuration with parallel lift Z-bar linkage, Bridgestone 23.5R25 VJT L3 radial tires, full fluids, operator, standard counterweight, ride control, cold start, roading fenders, Product Link™, front manual differential/open rear axles, powertrain guard,

secondary steering, sound suppression, and a 3.3 m³ (4.3 yd³) general purpose bucket with BOCE.

TRANSMISSION

Forward - 1	4.3 mile/h
Forward - 2	7.5 mile/h
Forward - 3	12 mile/h
Forward - 4	16 mile/h
Forward - 5	24.5 mile/h
Reverse - 1	4.3 mile/h
Reverse - 2	7.5 mile/h
Reverse - 3	16 mile/h
Note	Maximum travel speed in standard vehicle with empty bucket and standard L3 tires with 787 mm (31 in) roll radius.

SOUND

Operator Sound Pressure Level - ISO 6396:2008	70 dB(A)
Exterior Sound Power Level - ISO 6395:2008	107 dB(A)
Operator Sound Pressure Level - ISO 6396:2008 [1]	69 dB(A)
Exterior Sound Power Level - ISO 6395:2008[2]	104 dB(A)
Note (1)	[1]Including countries that adopt the EU and UK Directives.
Note (2)	[2]Exterior Sound Power Level - European Union Directive 2000/14/EC and UK Noise Regulation 2001 No. 1701.

AIR CONDITIONING SYSTEM

Air Conditioning	The air conditioning system on this machine contains the fluorinated greenhouse gas refrigerant R134a (Global Warming Potential = 1430). The system contains 1.6 kg (3.5 lb) of refrigerant which has a CO2 equivalent 2.288 metric tonnes (2.522 tons).

OPERATING SPECIFICATIONS

Static Tipping Load - Full 40° Turn - With Tire Deflection	25869 lb
Static Tipping Load - Full 40° Turn - No Tire Deflection	27529 lb
Breakout Force	42489 lbf
Note (1)	For a machine configuration as defined under “Weight.”
Note (2)	Full compliance to ISO 14397-1:2007 Sections 1 thru 6, which requires 2% verification between calculations and testing.

SERVICE REFILL CAPACITIES

Fuel Tank	68.6 gal (US)
DEF Tank	4 gal (US)
Cooling System	14.3 gal (US)
Crankcase	5.5 gal (US)
Transmission	11.4 gal (US)
Differential - Final Drives - Front	11.4 gal (US)
Differential - Final Drives - Rear	11.4 gal (US)
Hydraulic Tank	25.6 gal (US)

HYDRAULIC SYSTEM

Implement System - Maximum Pump Output at 2,340 rpm	85 gal/min
Implement System - Maximum Operating Pressure	4250 psi
Hydraulic Cycle Time - Total	9.4 s

DIMENSIONS - STANDARD LIFT

Height - Top of Hood	8.75 ft
Height - Top of ROPS	11.25 ft
Ground Clearance	1.08 ft
Wheel Base	10.92 ft
Overall Length - Without Bucket	23.83 ft
Hinge Pin Height at Carry Height	2.17 ft
Hinge Pin Height at Maximum Lift	13.83 ft

Lift Arm Clearance at Maximum Lift	11.33 ft
Rack Back - Maximum Lift	55 °
Rack Back - Carry Height	51 °
Width over Tires (Loaded)	9.33 ft
Tread Width	7 ft
Note	All dimensions are approximate and based on machine equipped with 3.3 m³ (4.3 yd³) general purpose bucket with BOCE and Bridgestone 23.5R25 VJT L3 radial tires.

DIMENSIONS - HIGH LIFT

Height - Top of Hood	8.75 ft
Height - Top of ROPS	11.25 ft
Ground Clearance	1.08 ft
Wheel Base	10.92 ft
Overall Length - Without Bucket	25.17 ft
Hinge Pin Height at Carry Height	2.5 ft
Hinge Pin Height at Maximum Lift	14.75 ft
Lift Arm Clearance at Maximum Lift	11.83 ft
Rack Back - Maximum Lift	56 °
Rack Back - Carry Height	48 °
Width over Tires (Loaded)	9.33 ft
Tread Width	7 ft
Note	All dimensions are approximate and based on machine equipped with 3.3 m³ (4.3 yd³) general purpose bucket with BOCE and Bridgestone 23.5R25 VJT L3 radial tires.

962 STANDARD EQUIPMENT

NOTE

- Standard and optional equipment may vary. Consult your Cat dealer for details.

OPERATOR ENVIRONMENT

- Cab, pressurized, sound suppression
- EH implement controls, parking brake
- HMU steering wheel
- Seat belt, monitored
- Seat, cloth, air suspension

- Touchscreen display
- Keypad, programmable buttons
- Air conditioner, heater, defroster (auto temp, fan)
- Sun visor, front and rear, retractable

ON-BOARD TECHNOLOGIES

- Cat Payload scale
- Autodig with auto set tires
- Operator ID & machine security
- Application Profiles
- Job Aids
- Controls help and eOMM
- Key Features Inform
- Bucket Carry Display Widget
- Remote Flash

POWERTRAIN

- Cat C7.1 engine
- Electric fuel priming pump
- Fuel-water separator and secondary fuel filter
- Engine, air precleaner
- Axles, open/open differentials (Standard depending on region)
- Axles, auto front differential lock (LHD)
- Transmission, countershaft, automatic powershift
- Torque converter with lock-up
- Service brakes, hydraulic, fully enclosed wet disc, wear indicators
- Park brake, caliper on front axles, spring applied–pressure released
- Brake pedal neutralizer with decel function

HYDRAULICS

- Implement system, load sensing with variable displacement piston pump

- Steering system, load sensing with dedicated variable displacement piston pump
- Oil sampling valves, Cat XT™ hoses

ELECTRICAL

- Starting and charging system, 24V
- Starter, electric, heavy duty
- Lights: halogen, 4 work lights, 2 front roading lights with turn signals, 2 rearview lights

MONITORING SYSTEM

- Front dash with analog gauges, LCD display, and warning lights
- Primary touchscreen monitor (Cat Payload, quad screens, machine settings & messages)
- Maintenance reminders

LINKAGE

- Parallel Lift, Z-bar
- Kickouts: lift and tilt

SAFETY

- Visibility: mirrors, rearview camera
- Window cleaning platform, front

962 OPTIONAL EQUIPMENT

NOTE

- Standard and optional equipment may vary. Consult your Cat dealer for details.

OPERATOR ENVIRONMENT

- Door, remote opening system (Standard depending on region)
- Footrest
- Steering, joystick (LHD)
- Implement joystick (2V, 3V only)
- Entertainment radio
- CB radio ready

- Seat, suede/cloth, air suspension, heated
- Seat, leather/cloth, air suspension, heated/cooled
- Mirrors, heated
- Window, front, laminated
- Windows, front, heavy duty
- Full cab window guard

ON-BOARD TECHNOLOGIES

- Cat Advanced Payload
- Cat Payload Printer with E-ticket

POWERTRAIN

- Turbine, air precleaner
- Radiator, high debris
- Cooling fan, reversible
- Axles, auto front differential lock (HMU)
- Axles, auto differential locks front and rear
- Axles, ecology drains, AOC ready, extreme temperature seals
- Axles, oil cooler
- Ride control, dual accumulators (Standard depending on region)

HYDRAULICS

- 3rd and 4th auxiliary functions with ride control
- Quick coupler control

ELECTRICAL

- Cold start, 120V or 240V
- Lights: LED

LINKAGE

- High lift

MONITORING SYSTEM

- Tire pressure monitor

ADDITIONAL EQUIPMENT

- Cat Autolube system
- Fenders, extensions or roading
- Guards: powertrain, crankcase, window glass, cylinders, rear
- Biodegradable hydraulic oil
- High-speed oil change system
- Rear cab access
- Toolbox

SAFETY

- Cat Detect rear radar system
- Dedicated rearview screen
- Multiview (360°) vision system
- 4-Point seat belt retractor
- Reversing strobe lights
- Seat belt monitoring beacon
- Secondary steering system, electrical (Standard depending on region)
- Wheel chocks
- Warning beacon

SPECIAL CONFIGURATIONS

- Auxiliary Counterweight
- Waste and industrial
- Forestry
- Corrosion resistant

CAT

FUEL CONSUMPTION

Wheel loaders

Fuel and DEF consumption values are sourced from VisionLink telematics data by region and assume the following idle time percentages: 50% for low, 30% for medium, 10% for high

	Low fuel consumption	Medium fuel consumption	High fuel consumption	DEF consumption (% of fuel)	Low DEF consumption	Medium DEF consumption	High DEF consumption
Cat 903C2	0.4 gal/hr	0.56 gal/hr	0.73 gal/hr				
Cat 903D	0.6 gal/hr	0.84 gal/hr	1.08 gal/hr				
Cat 906M	0.57 gal/hr	0.75 gal/hr	0.92 gal/hr				
Cat 907M	0.52 gal/hr	0.73 gal/hr	0.93 gal/hr				
Cat 908M	0.66 gal/hr	0.79 gal/hr	0.92 gal/hr				
Cat 910-14	0.96 gal/hr	1.16 gal/hr	1.36 gal/hr	1.5%	0.01 gal/hr	0.02 gal/hr	0.02 gal/hr
Cat 914-14	0.93 gal/hr	1.14 gal/hr	1.34 gal/hr	1.5%	0.01 gal/hr	0.02 gal/hr	0.02 gal/hr
Cat 920-14	1.05 gal/hr	1.31 gal/hr	1.56 gal/hr	1.5%	0.02 gal/hr	0.02 gal/hr	0.02 gal/hr
Cat 926M	1.72 gal/hr	2.11 gal/hr	2.51 gal/hr	1.5%	0.03 gal/hr	0.03 gal/hr	0.04 gal/hr
Cat 930M	1.83 gal/hr	2.25 gal/hr	2.68 gal/hr	1.5%	0.03 gal/hr	0.03 gal/hr	0.04 gal/hr
Cat 938M	1.9 gal/hr	2.36 gal/hr	2.82 gal/hr	1.5%	0.03 gal/hr	0.04 gal/hr	0.04 gal/hr
Cat 950-01 GC				2.5%			
Cat 950M	2.38 gal/hr	3.02 gal/hr	3.66 gal/hr	2.5%	0.06 gal/hr	0.08 gal/hr	0.09 gal/hr
Cat 950M Waste Handler		2.8 gal/hr		2.5%		0.07 gal/hr	
Cat 962M	2.41 gal/hr	3.06 gal/hr	3.7 gal/hr	2.5%	0.06 gal/hr	0.08 gal/hr	0.09 gal/hr
Cat 962M Waste Handler		2.8 gal/hr		2.5%		0.07 gal/hr	
Cat 966-14	3.01 gal/hr	3.79 gal/hr	4.56 gal/hr	5%	0.15 gal/hr	0.19 gal/hr	0.23 gal/hr
Cat 966-14 XE	2.55 gal/hr	3.12 gal/hr	3.68 gal/hr	5%	0.13 gal/hr	0.16 gal/hr	0.18 gal/hr
Cat 966M	3.08 gal/hr	3.88 gal/hr	4.69 gal/hr	2.5%	0.08 gal/hr	0.1 gal/hr	0.12 gal/hr
Cat 966M XE	2.61 gal/hr	3.19 gal/hr	3.78 gal/hr	2.5%	0.07 gal/hr	0.08 gal/hr	0.09 gal/hr
Cat 972-14	3.23 gal/hr	4.07 gal/hr	4.92 gal/hr	5%	0.16 gal/hr	0.2 gal/hr	0.25 gal/hr
Cat 972-14 XE	2.64 gal/hr	3.24 gal/hr	3.84 gal/hr	5%	0.13 gal/hr	0.16 gal/hr	0.19 gal/hr
Cat 972M	3.3 gal/hr	4.18 gal/hr	5.06 gal/hr	2.5%	0.08 gal/hr	0.1 gal/hr	0.13 gal/hr
Cat 972M XE	2.7 gal/hr	3.32 gal/hr	3.94 gal/hr	2.5%	0.07 gal/hr	0.08 gal/hr	0.1 gal/hr
Cat 980-14	3.92 gal/hr	4.99 gal/hr	6.05 gal/hr	2.5%	0.1 gal/hr	0.12 gal/hr	0.15 gal/hr
Cat 980-14 XE	3.37 gal/hr	4.21 gal/hr	5.05 gal/hr	2.5%	0.08 gal/hr	0.11 gal/hr	0.13 gal/hr
Cat 980M	4.07 gal/hr	5.19 gal/hr	6.32 gal/hr	2.5%	0.1 gal/hr	0.13 gal/hr	0.16 gal/hr
Cat 982-14	4.34 gal/hr	5.55 gal/hr	6.76 gal/hr	2.5%	0.11 gal/hr	0.14 gal/hr	0.17 gal/hr
Cat 982-14 XE	3.77 gal/hr	4.75 gal/hr	5.73 gal/hr	2.5%	0.09 gal/hr	0.12 gal/hr	0.14 gal/hr
Cat 982M	4.49 gal/hr	5.77 gal/hr	7.04 gal/hr	2.5%	0.11 gal/hr	0.14 gal/hr	0.18 gal/hr
Cat 986K	5.62 gal/hr	7.16 gal/hr	8.7 gal/hr	2.5%	0.14 gal/hr	0.18 gal/hr	0.22 gal/hr
Cat 988K	6.76 gal/hr	8.62 gal/hr	10.48 gal/hr	2.5%	0.17 gal/hr	0.22 gal/hr	0.26 gal/hr
Cat 988K XE	5.94 gal/hr	7.61 gal/hr	9.28 gal/hr	2.5%	0.15 gal/hr	0.19 gal/hr	0.23 gal/hr
Cat 990K	12.12 gal/hr	15.31 gal/hr	18.49 gal/hr	2.5%	0.3 gal/hr	0.38 gal/hr	0.46 gal/hr
Cat 992-12	13.11 gal/hr	17.14 gal/hr	21.16 gal/hr	2.5%	0.33 gal/hr	0.43 gal/hr	0.53 gal/hr

Kalmar Ottawa T2
6x4 DOT/EPA Certified
Standard Specifications

KALMAR OTTAWA

Wheelbase: 146"

Frame / Chassis:
- 14" x 4.25" x 3.5" Steel 50,000 PSI 3/8" Formed C-Channel with L-reinforcements
- Modular Frame Design
- Reinforced Removable Bumper with 55° Taper Curbside
- 50-Gallon Rectangular "Step-Tank" Mounted on Driver Side, 10" Deep Step
- 5-Gallon DEF Tank
- Integral Front and Rear Tow Points
- Mud Flaps Rear Spring Loaded

Engine:
- Cummins B6.7-200 HP with OBD, Clean Idle Certified @ 2300 RPM, 520 lb./ft. Torque @ 1600 RPM
- Fleetguard Air Filter
- Air Restriction Indicator Mounted Under Hood

Transmission:
- Allison 3000RDS (6 Speed) Automatic Transmission with Fuel Sense 2.0 MaxiMizer
- Push-Button Shifter

Front Axle:
- Meritor FF-961 12,000 lb. Rated
- "S" Cam Type 16.5" x 5" Brakes

Rear Axle:
- Meritor MT-40-14X, 40,000 lb. Rated, 7.17:1 Ratio
- "S" Cam Type 16.5" x 7" Brakes

Suspension:
- Front—Parabolic 3-Leaf Spring, Lube Free, Shackle Free
- Rear—Hendrickson HN 522

Slack Adjusters:
- Automatic Front and Rear

Tires:
- 11R22.5 Radial Highway Treat Tires

Steel Disc Wheels:
- 8.25" x 22.5" 10 Bolt 285mm (11.25") BC
- Hub Piloted

Cab:
- Steel and Composite Cab with Aluminum Sliding Rear Door
- Certified Roll-Over Protection Structure (ROPS)
- High Roof Cab
- 3-Point Cab Mounting with Air Suspension
- Integral Heating/Ventilation System with (3) Vents for Driver; (4) Front and (2) Side Defrost Vents
- High Air Flow Heater/Defroster with Molded Air Ducts
- Tinted Glass All Windows
- Laminated Solar Grey Window in Rear Door
- Air Ride Seat with Isolator and 2-Point Retractable Seat Belt
- Digitally Driven Instrument Cluster: Air Pressure, Fuel Level, Hour Meter, Odometer, Speedometer, DEF and Critical Situation Indicators
- Mounting Plate and Power Connection Points for Yard Management System
- Electric Windshield Washer with Intermittent Pantograph Wipers
- Suspended Brake and Throttle Pedals
- Coat Hook Behind Driver Seat
- Cup Holder
- Cab Insulation for Thermal Protection and Noise Abatement
- Cab Tilt: 40° with 90° Tilt Capability
- West Coast 16" x 7" Mirrors
- See Through Sun Visor
- Cab Dome Lights
- ICC Light Package

Batteries:
- (2) 12 Volt Maintenance Free

Trailer Equipment:
- (2) Color-Coded, Coiled Air Lines with Glad Hand Receivers
- 7 Wire Female Receptacle at Rear of Cab
- 7 Wire Coiled Trailer Light Cord

Kalmar Ottawa T2 6x4 DOT/EPA Certified Standard Specifications

KALMAR OTTAWA

Fifth Wheel:
- Holland FW35TT Fifth Wheel with 80,000 lb. Plate Rating

Hydraulic System:
- Upper and Lower Spherical Bearings
- 17" Lift
- 20 Gallon Tank with Sight Glass
- 10 GPM System
- Wet Spline PTO
- Constant Running PTO/Pump with Priority Steering Circuit

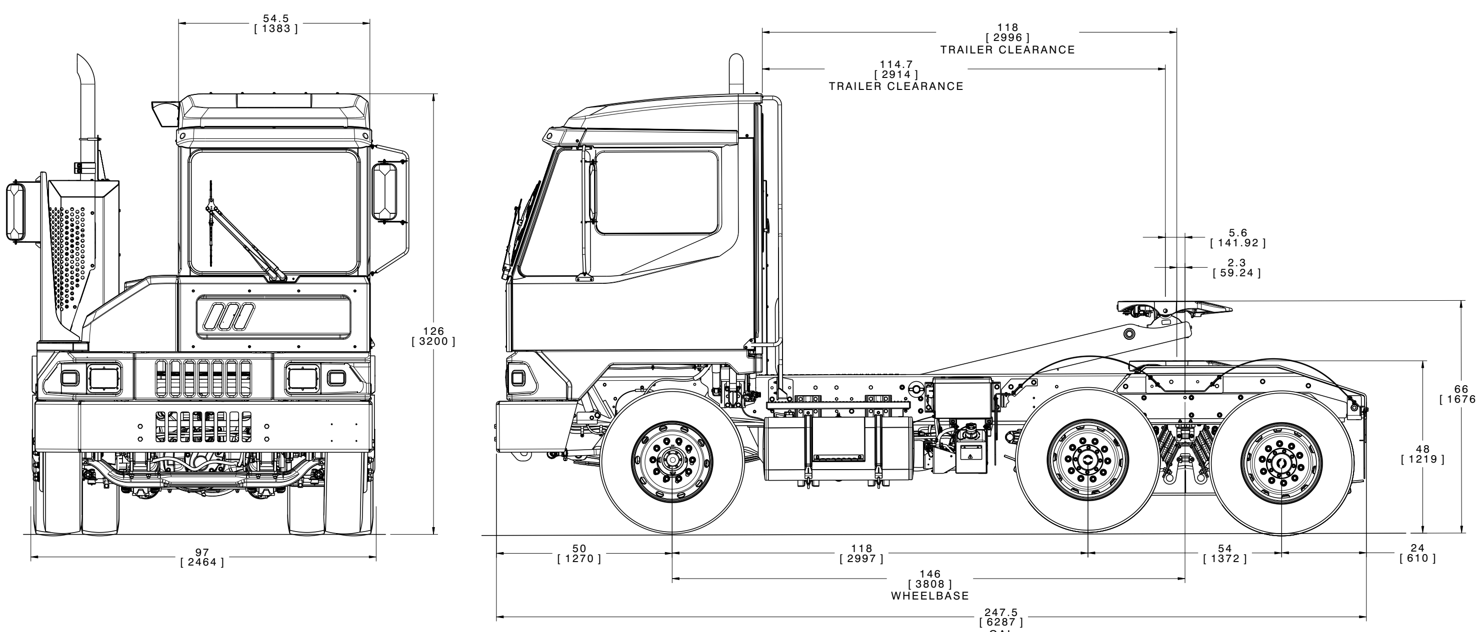
Pneumatic:
- 18.7 CFM Wabco Compressor with (3) Reservoir Tanks, Total Capacity 5444 cu. in.
- Color-Coded Air Lines, Complies to TMC Recommended Practices
- Split Air Brake System without ABS

Power Steering:
- Integral Gear Type with Mechanical Back-Up

Electrical:
- 12 Volt Electrical System — Negative Ground
- Electric Cab Tilt System
- 130 Amp Alternator
- Electric Back-Up Alarm
- All Wires Color and Number Coded
- All Connectors External to Cab are Sealed

Paint:
- Cab
  - Metal Structure/Components — Full Immersion, Multi-Stage, "E" Coat with White Powder Top Coat
  - Composite Components — Color Impregnated
- Chassis — Black Powder Coat
- Wheels — White Powder Coat
- Grab Handles, Steps and Platforms — Yellow Powder Coat
- Rubberized Undercoating Under Cab

Max Road Speed 33 MPH
approx. weight: 18,000 lbs.



TYMCO®

REGENERATIVE AIR SWEEPERS

210h® AIR SWEEPER

GENERAL SPECIFICATIONS

MODEL 210h® REGENERATIVE® AIR PARKING LOT SWEEPER

HYDROSTATIC DRIVE / DIESEL CONVENTIONAL CAB CHASSIS

HYDRAULICS
hDRIVE® POWER SYSTEM

Main pump .... Piston pump
Reservoir .... 17 gal (64 L)
Main system pressure ... 3500 psi (24,132 kPa)
Main pump drive .... Direct drive
  from transmission PTO, operates blower, dump door, and pick-up head
Broom pump .... Vane type
  Belt driven from blower shaft
Filter .... 10 µm in-line
Hydraulic oil .... Extended life 10W ISO 46
Cooler .... Air to oil
  w/thermostatically controlled electric fan
Hydraulic level/temperature shutdown system
Hydraulic oil filter restriction indicator
Hydraulic oil sight/temperature gauge

BLOWER

Aluminum alloy, high volume, open face turbine
Bearings .... (2) Anti-friction
Housing .... Steel w/abrasion resistant, replaceable liner
Drive ....Hydraulic direct drive

DUST SEPARATOR

Type..................................Cyclonic, multipass, centrifugal separation
Cylindrical area..............................20 x 22.5 in (51 x 57 cm)
Location .... Adjacent to hopper
Particulate removal achieved through 22.5 in (57 cm) skimmer slot into skimmer hood
Inspection/cleanout port

HOPPER

Capacity (volumetric)..............2.4 yd^3 (1.83 m^3)
Capacity (useable)..................2.1 yd^3 (1.61 m^3)
Construction ....Welded steel plate
Dump door opening ....52 x 23 in (132 x 58.5 cm)
Dump door hydraulically opened/closed
Dump method ....Hydraulic tilt
Dump direction ....Rear
Dump floor angle ....37°
Dump height (F-450) .... 58 in (147 cm)
Dump height (F-350) .... 55 in (140 cm)
Dump clearance height....................................
  (F-450) .... 142 in (360.5 cm)
  (F-350) .... 139 in (353 cm)

PICK-UP HEAD

Type...Dual chamber
Width (inside dimension) .... 78 in (198 cm)
Pick-up head area ....2028 in^2 (1.31 m^2)
Suspension ....(4) springs, (2) drag links
Skids .... DUO-SKID®, long life carbide
Suction hose diameter............. 12 in (30.5 cm)
Pressure hose diameter .... 12 in (30.5 cm)
Pressure bleeder ....Cable operated
Reverse pick-up head system

GUTTER BROOM, LEFT, Patented

Drive ....Constant speed non-reversible hydraulic motor
Adjustment................................Adjustable for down pressure, pattern and wear
Down pressure ....Automatic
Flexibility..Integral anti-damage "swing away" relief valve
Broom .... Poly wafer 36 in (91 cm)
Floodlight ....LED
Parabolic mirror .... 10.5 in (26.67 cm) dia.

CONTROL SYSTEM

BlueLogic® Control System

Multiplexed electrical system includes hardware and TYMCO designed software that integrates the in-cab controls to all sweeper functions; as well as provides intelligent safety features, assists in troubleshooting through LED input/output diagnostics, and controls the hDrive Power System. Specific to the 210h, BlueLogic communicates with the truck to engage the PTO and maintain the blower at a constant speed (low or high), and monitors and controls the hydraulic oil level and temperature shutdown system.

Interior Components

Pressure bleeder control, illuminated control switches: pick-up head, gutter broom, blower on/off (2 speeds), dust control water system nozzles (if applicable), safety lights

Exterior Components

Dump switch, BlueLogic Control Module (BCM)

SAFETY/WARNING DEVICES

Rear view camera system
Back-up alarm
Alternating LED rear flashers (2)
BlueLogic® Control System provides several safety interlocks which includes stopping the blower when the hopper is raised/hopper door is opened, shutting down the hydraulic system when hydraulic oil temperature is too high or the level is too low and disengaging the PTO and raising the pick-up head when excessive ground speed is met (default is 18 mph). It also provides ASI.
Hopper safety prop

OPTIONAL EQUIPMENT

Abrasion protection package
Additional camera view - pick-up head
Amber beacon light
Auxiliary fuse panel
Auxiliary hand hose 6 in (15 cm) dia.
Backpack blower storage box
Dust control system.................... 30 gal (113 L)
Gutter broom .... Right (in lieu of left)
  Broom...Poly digger 32 in (81 cm) (Ford F-450 only)
Hopper drain system
Hopper slide-out screen
Hydraulic tank heater
Light bar, cab mounted, LED
Magnet, front bumper mounted, light duty
Rubber coated blower
Shop air purge, dust control system
Stainless steel (non-magnetic) options:
  Hopper:
    Hopper weldment
    Hopper door
    Inspection door
    Skimmer hood
    Slide-out hopper screen
  Blower housing
  Dust separator
  Hopper drain
  Hopper inspection door
  Hopper screen
  Auxiliary hand hose hardware
Paint color (other than TYMCO standard white)

Special options are available. Contact your local dealer or TYMCO.

CHASSIS AVAILABLE

Ford F-450 Diesel
Ford F-350 Diesel

Attachment 3

EnSol, Inc.

ENGINEERING + ENVIRONMENTAL

Noise Evaluation

Noise Evaluation
Rev.2: October 2024
Proposed 56th Street Transfer Station
City of Niagara Falls, Niagara County, NY

INTRODUCTION

56th Street Transfer, LLC proposes to obtain City of Niagara Falls and New York State Department of Environmental Conservation (NYSDEC Part 360) approvals to construct and operate a Transfer Station facility that accepts municipal solid waste (MSW), construction and demolition debris (CDD), and single stream recyclables (SSR) at a property located on 56th Street, between Charles and Simmons Avenues, in the City of Niagara Falls. As part of the application process, it is required to demonstrate the Facility's compliance with the current NYSDEC Part 360 Solid Waste Management regulations. This evaluation has been completed via sound modeling using standard modeling techniques in general accordance with International Organization for Standardization standard ISO 9613-2 (Attenuation of Sound During Propagation Outdoors).

Refer to all Drawings as included with the City and NYSDEC applications for depictions of the Facility, property, and surrounding area.

REGULATORY REQUIREMENTS – PART 360

Noise associated with the operation of the Facility will be governed by New York State under Title 6 of the Official Compilation of Codes, Rules and Regulations (6 NYCRR), Part 360: Solid Waste Management Facilities General Requirements. As related to noise, subdivision 360.19 (Operating Requirements), subdivision (j)(Noise), states,

> *The owner or operator of a facility must ensure that noise (other than that occurring during construction of the facility) resulting from equipment or operations at the facility does not exceed the following energy equivalent sound levels beyond the property line owned or controlled by the owner or operator of the facility at locations authorized for residential purposes:*

Community	***Leq Energy Equivalent Sound Levels***	
	7am - 10pm	***10pm - 7am***
Rural	*57 decibels (A)*	*47 decibels (A)*
Suburban	*62 decibels (A)*	*52 decibels (A)*
Urban	*67 decibels (A)*	*57 decibels (A)*

> *The Leq is the equivalent steady-state sound level which contains the same acoustic energy as the time-varying sound level during a one-hour period. It is not necessary that the measurements be taken over a full one-hour time interval, but sufficient measurements must be available to allow for a valid extrapolation to a one-hour time interval.*

Currently published census data for Census Tract 220 (of which the subject property is part) indicate a population density of 2,937 people per square mile. Therefore, per 6 NYCRR Part 360.2(b)(239), the Suburban Community standards of 62dB(A) at day (operating hours of 7am-10pm) shall apply. No night time operations are proposed.

NOISE TERMINOLOGY

Sound results from traveling compression waves that move through the atmosphere. Sound from a single source can be schematically or graphically represented in the same manner as when an object is dropped into a still water body. The waves ripple outward and radiate away from the source or center in straight lines, decreasing in intensity as they travel outward. As sound waves pass through a point in the atmosphere, the waves result in an alternate compression and expansion of the air. Human perception of sound results from vibrations induced within the ear by these pressure waves.

The perceived loudness of a sound is directly proportional to the magnitude of the pressure fluctuations within a given sound wave. The larger the amplitude of the pressure fluctuation, the louder the sound is perceived by the human receptor. Sound pressure is measured in a unit called a Pascal (a measure of force per unit area of the air pressure wave). The human ear is sensitive to a very large range of sound pressures, from 0.00002 Pascals to 200 Pascals. In order to make the numbers more manageable, a logarithmic sound pressure scale known as the decibel scale is used. Each increase of 10 dB(A) is equivalent to 3.2 times greater sound pressure. Each increase of 20 dB(A) is equivalent to a ten-fold increase in sound pressure. The range of audible sound pressure levels that can be heard by the human ear is from 0 dB(A) to over 130 dB(A), which is the threshold of painful noise. The maximum achievable sound level is about 194 dB(A).

In contrast, the pitch of a sound is related to the frequency of the sound wave (the number of waves that pass any point in one second); high frequencies are associated with a high pitch and low frequencies are associated with a low pitch. In actuality, sound heard in everyday life generally consists of a range of frequencies and the perceived pitch reflects those frequencies that dominate in amplitude. The characterization of noise or sound therefore considers both its loudness, and frequency (pitch).

For analysis of environmental noise, the A-weighted decibel scale, or dB(A) scale, is generally used. This scale weighs different frequencies in a complex sound in proportion to the human ear's sensitivity and assigns one dB(A) value to the sound. The dB(A) scale provides a good measure of human perception of a sound's loudness, provides a good assessment of speech interference, and defines community disturbance conditions. This means the dB(A) scale is appropriate for measuring the impact of a new sound source on the existing audio environment. In addition to its recognition by the NYSDEC, the widely-gained acceptance and use of noise A-weighting is substantiated by the fact that the US EPA, Federal Aviation Administration (FAA), Department of Defense (DOD), and American Conference of Governmental Industrial Hygienists (ACGIH) have all adopted this measurement standard.

SITE LOCATION AND SURROUNDING AREA

The Facility is situated in a mixed use/primarily industrial environment, and immediate surrounding property uses are summarized as follows:

- North: Industrial/Commercial (Apollo Steel, M&M Electric, etc.)
- East: Mixed uses of Commercial (southeast adjacent/Fred's Collision), Industrial (Niagara Mohawk overhead utility corridor along east side of 56th) & residential (further east of utility corridor – closest residence approximately 600' east/southeast)
- South: Industrial (Goodyear chemical manufacturing plant)
- West: Railroad and Industrial (Covanta, Niacet, Greenpac, Praxair, etc.)

Topography of the Facility and surrounding area generally slopes in a southerly direction toward the

Niagara River, which is located approximately one mile south of the Facility.

EXISTING NOISE ENVIRONMENT

Beyond the immediate adjacent property uses listed above, the Facility and areas to the north, west and south are within the City's I2 Industrial zoning district. Uses are primarily industrial in nature with numerous industrial or commercial property uses occurring within a half-mile radius of the site. Heavy truck traffic and rail traffic associated with the various commercial or industrial properties is a currently existing condition.

PRIMARY RECEPTORS

Although the Facility (and immediate surrounding areas) are within the City's I2 Industrial zoning district, there is a residential zoning district/neighborhood to the east of the Facility (R1C-Detached Single) and a Commercial district to the northeast of the Facility (C3-General Commercial) that, per the City's zoning Code, does allow for "Multi-dwelling structures (3+ units) by code as well as multiple "group living" uses with issuance of a Special Permit only. These zoning district boundaries are displayed on **Figures 1 through 4** and the City's Zoning Map and Use Table are included as **Attachment 1**. As both the R1C and C3 zoning districts allow for residential uses, the NYSDEC Part 360.19 standards were evaluated at various locations along these district boundaries that are closest to the proposed Facility.

FACILITY NOISE MODELING

A detailed model was developed to predict noise levels generated by operations at the Facility. All sound modeling was completed using the SoundPlan Essential software provided by Navcon Engineering Network. Assumptions regarding traffic and equipment operating on the site were developed based on operations of similar facilities.

Noise generated at the Facility falls into two categories: vehicular traffic and operations of site-related equipment as described below.

Modeling Scenarios

As described further below, the modeled scenario predicts the potential maximum equipment and traffic noise levels at the points of compliance using conservative assumptions. It should also be noted that the primary noise sources at the Facility are either on-site traffic (trucks and automobiles) or the operation of heavy equipment which is associated with material unloading, handling, and consolidation/loading to outbound tractor-trailers. The heavy equipment and traffic modeling scenarios are described further below.

Model Inputs – Traffic

Noise resulting from predicted site vehicular traffic was modeled within the SoundPlan Essential software in accordance with the United States Department of Transportation Federal Highway Administration Traffic Noise Model TNM 3.0. For the purpose of conservative modeling, the estimated peak-hour traffic volume of 18 trucks (12 medium inbound and 6 heavy outbound) and one passenger vehicle was used for the modeling scenario. Modeling also assumed a maximum on-site vehicular traffic speed of 22 miles per hour (35 km/h) for all vehicle types.

Model Inputs – Industry

Heavy equipment is operated within the transfer station building. Initial material deliveries are brought into the building via overhead doors located on the north side of the building. Outbound tractor-trailers are loaded within the building and then exit the building through a separate overhead door located on the north side of the building once loaded. This model assumes operation of a front end loader just outside the inbound overhead door and an excavator just outside the outbound overhead door. Note that this is a conservative assumption as actual operation of these pieces of equipment will be within the building on the tipping floor where additional noise attenuation from the building walls would be realized. The model also assumed the operation of the tractor (yard goat) outdoors at the location of the proposed covered trailer parking area which is also a conservative assumption as this location is the closest towards the offsite receptors that this piece of equipment may operate. Lastly, the model also assumes the operation of a sweeper at the approximate location of the truck scales which is also a conservative assumption as the bulk of sweeping activities will likely occur at/around the building.

Noise generated from each piece of equipment, at a distance of 50 feet from the noise source, was assumed at the following levels:

- Front end loader and Sweeper = 80dB(A)
- Excavator = 85dB(A)
- Tractor = 84dB(A) .

These values are based on the L_{max} Spec. value for these pieces of equipment as reported on Table 9.1 (Default Noise Emission Reference Levels and Usage Factors) of the Construction Noise Handbook published by the Federal Highway Administration (FHA) which is included as **Attachment 2.**

Respective source sound power levels of 111.7, 116.7, and 115.8dB were back-calculated (from 80, 85, and84dB(A)) for data entry into the model using calculation tools provided at noisetools.net, and screenshots of these calculations are included in **Attachment 3**. Screenshots of the final data entry of these sound power values into the model are included as **Attachment 3** and SoundPlan's native summary table "Noise Emissions of Industry Sources" is also included as **Table 1**.

Noise resulting from industrial sources (Facility equipment) was modeled in accordance with International Organization for Standardization standard ISO 9613-2 (Attenuation of Sound During Propagation Outdoors) (**Attachment 4**). Modeled industrial noise sources include the simultaneous and continuous operation of all pieces of equipment.

The multiple sources are calculated within the model in consideration of the Additive Effects of Multiple Sound Sources theory which states that the total sound pressure created by multiple sound sources does not create a mathematical additive effect. For instance, two proximal noise sources that are 70dB(A) each do not have a combined noise level of 140dB(A). In this case the combined noise level is 73dB(A).

<u>Model Inputs – Buildings</u>
The SoundPlan modeling software considers the entire three-dimensional environment of the modeled area, rather than completing just simple two-dimensional distance attenuation calculations. The existing buildings located in the immediate vicinity of the Facility were included in the model. Buildings meet the definition of a screening barrier as discussed in section 7.4 of ISO 9613-2 and, to account for their anticipated effect on sound propagation, were incorporated into the model. Note that the Covered Trailer Parking area building was not included in the model as it is a pavilion-style structure with no walls, so no attenuation associated with this structure should be included in the model.

<u>Model Inputs – Topography</u>

As an additional consideration of the three-dimensional environment of the modeled area, SoundPlan uses ground elevation data published by Google Earth® as the base of the model, and all resulting model calculations consider the topography of the model area.

Model Attenuation Calculations – Distance Attenuation

The primary attenuation calculation is sound level reduction over distance. As defined in DEP-00-1, sound pressure levels (SPL) change in inverse proportion to the square of the distance from the sound source. At distances greater than 50 feet from a sound source, every doubling of the distance produces a 6dB reduction in the sound.

Model Attenuation Calculations – Landscape Buffer Zones

No existing heavily-vegetated areas are present within the model area.

Model Attenuation Calculations – Atmospheric Absorption

Additional noise attenuation via atmospheric absorption is also considered in the model in general accordance with section 7.2 of ISO 9613. The primary variables that affect atmospheric absorption are temperature, humidity, and pressure. As defined in Part 360.19(j)(5), noise assessments are allowed to utilize average annual conditions when calculating atmospheric absorption. This model was prepared based upon atmospheric conditions of a temperature of 49 degrees (F), humidity of 72%, and air pressure of 1,017mbar which are the average annual weather conditions as measured at the Niagara Falls Internation Airport and as reported by www.timeanddate.com, and a screenshot of this information is included in **Attachment 3**.

Model Attenuation Calculations – Ground Effect

The final attenuation effect included in the model calculation is the ground effect as defined in section 7.3 of ISO 9613. In summary, the ground effect applies additional attenuation of noise over soft (non-reflective) ground surfaces. The ground effect factor ranges from 0 (hard surfaces) to 1 (soft surfaces). A ground effect of 0 assumes complete reflectivity of the surface and therefore no additional ground effect attenuation would be applied to any ground surface defined with an effect factor of 0. For purposes of this model, the entire model area was assigned a ground effect factor of 0, although numerous vegetated areas are present within the model area.

Model Standards Conformance

Information provided by Navcon regarding ISO standards conformance is included as **Attachment 5**.

Conservative Modeling Scenario

Using the inputs described above, the operations scenarios were analyzed in this modeling effort with the following conservative assumptions:

- *Maximum potential on-site traffic loads.* The actual average traffic loads during typical Facility operations are lower; however, the estimated peak-hour load was used for modeling.
- *Simultaneous and continuous operation of equipment.* The model assumes simultaneous and continuous operation of the three pieces of equipment. This is a condition that would rarely occur during actual Facility operations as the equipment is more typically operated individually and on an intermittent basis. Additionally, a third equipment operator would not typically be employed solely for operation of the Yard Goat Tractor. As indicated in the separate CLCPA analysis, estimated daily usage rates of the Excavator, Loader, and Yard Goat are 75%, 25%, and 15% respectively.

- *Ground Effects.* As discussed above, a ground effect of 0 (hard surfaces) was applied to the entire model area. The model area contains multiple interior landscaped areas (soft surfaces). However, the model considers the entire footprint as a hard surface for both conservative purposes and model simplicity.

MODEL RESULTS & CONCLUSIONS

Using all modeling inputs and attenuation factors described above, the model was run and the final results are presented on **Figures 1 and 2**. All model results are presented as 1-hour Leq values representing the scenario defined above. It should be noted that Figures 1 and 2 represent the maximum "simultaneous and continuous" operation scenario above and are the results that are compared to Part 360.19(j) standards for purposes of this evaluation. However, for comparison purposes, the typical operating scenario discussed above (75%, 25%, and 15% operation for Excavator, Loader, and Tractor) was also modeled and the results of which are included as **Figures 3 and 4**, which more accurately represent expected typical conditions.

Note that the model displays only noise generated by the previously-described inputs and does not factor in additional background/ambient noise that is generated by business operations and local road traffic within the study area.

As indicated on **Figures 1 and 2**, the limits of Facility-related noise at or exceeding the Part 360.19(j) Suburban Standard of 62dBA only extend onto the closest industrial/commercial properties. The modeled noise levels at the receivers range from 50.5 to 58.2dB(A), and each receiver's noise level contribution by source type is also summarized on **Table 2**. As the projected noise levels at each receiver under the most conservative modeling assumption are below 62dB(A), noise emanating from the proposed Facility will be in compliance with the requirements of Part 360.19(j).

Figures

Figure 1 – Point Receiver Results (Max. Ops. Scenario)
Figure 2 – Noise Contour Map (Max. Ops. Scenario)
Figure 3 – Point Receiver Results (Typ. Ops. Scenario)
Figure 4 – Noise Contour Map (Typ. Ops. Scenario)

Tables

Table 1 – Noise Emissions of Industry Sources
Table 2 – Contribution Levels of the Receivers

Attachments

Attachment 1 – City of Niagara Falls Zoning Map and Use Table
Attachment 2 – FHWA Construction Noise Handbook, Chapter 9
Attachment 3 – Model Data Entry & Inputs Calculation Screenshots
Attachment 4 – International Standard ISO 9613-2: Attenuation of Sound During Propagation Outdoors
Attachment 5 – Navcon Standards Conformance Documentation

Figures

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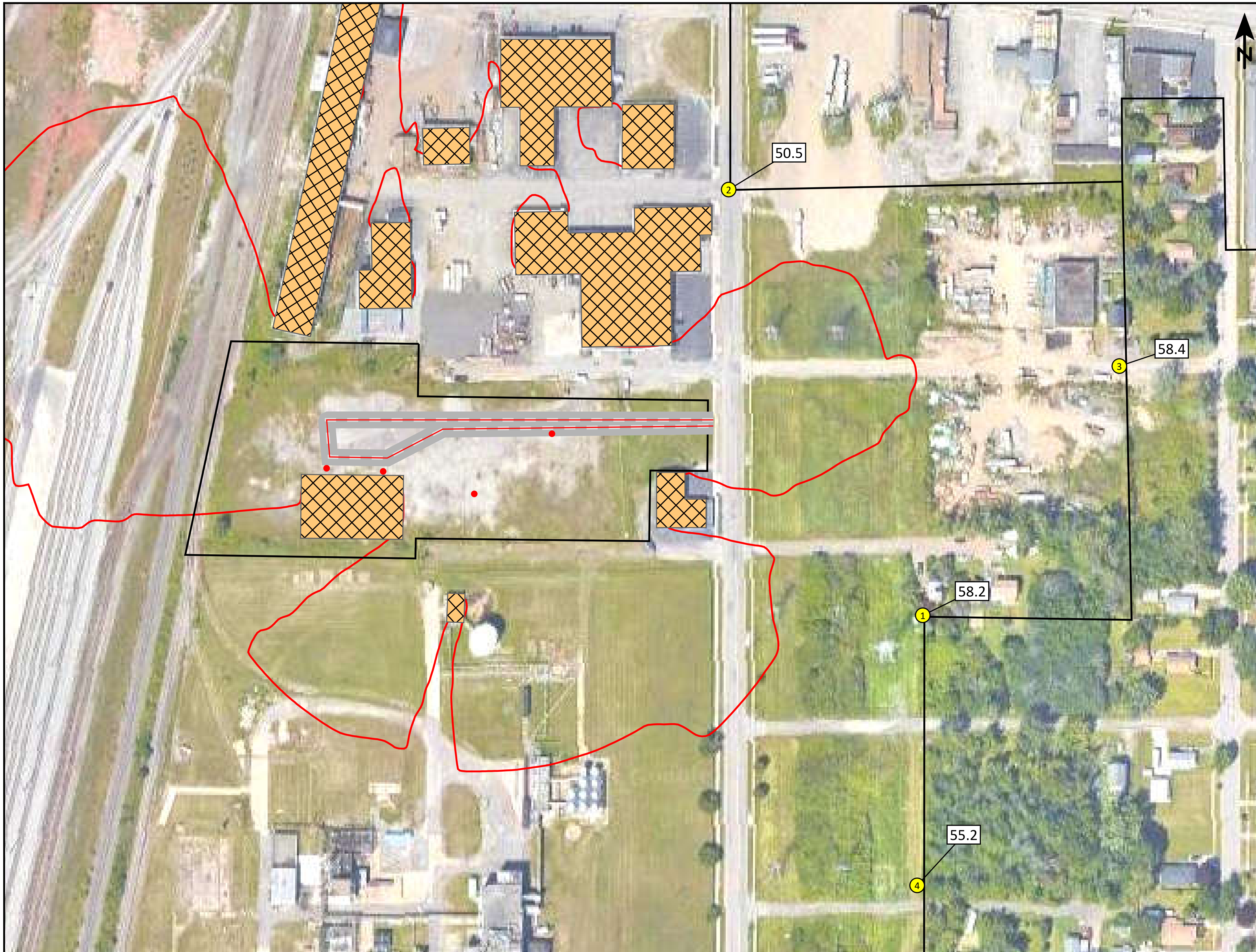

Figure 1
Point Receiver Results
56th Transfer Station
Noise Evaluation
(Max. Ops. Scenario)

Excavator, Loader, Tractor, and Sweeper running simultaneously

Full traffic load (18 trucks and 1 car/hr)

Receivers 1-4 located at closest zoning district boundaries for NYSDEC 360 evaluation.

Modeled Atmospheric Conditions:
Temperature = 49F, Humidity = 72%
Air Pressure = 1,017 mbar

Noise modeling completed with SounPlan Essential ver. 5.1 modeling software

Legend:

- Property line / Zoning District Boundary
- Building
- Receiver
- Traffic Pattern
- Point source
- Limit line Day: 62 dB(A)

0 37.5 75 150 225 300 feet

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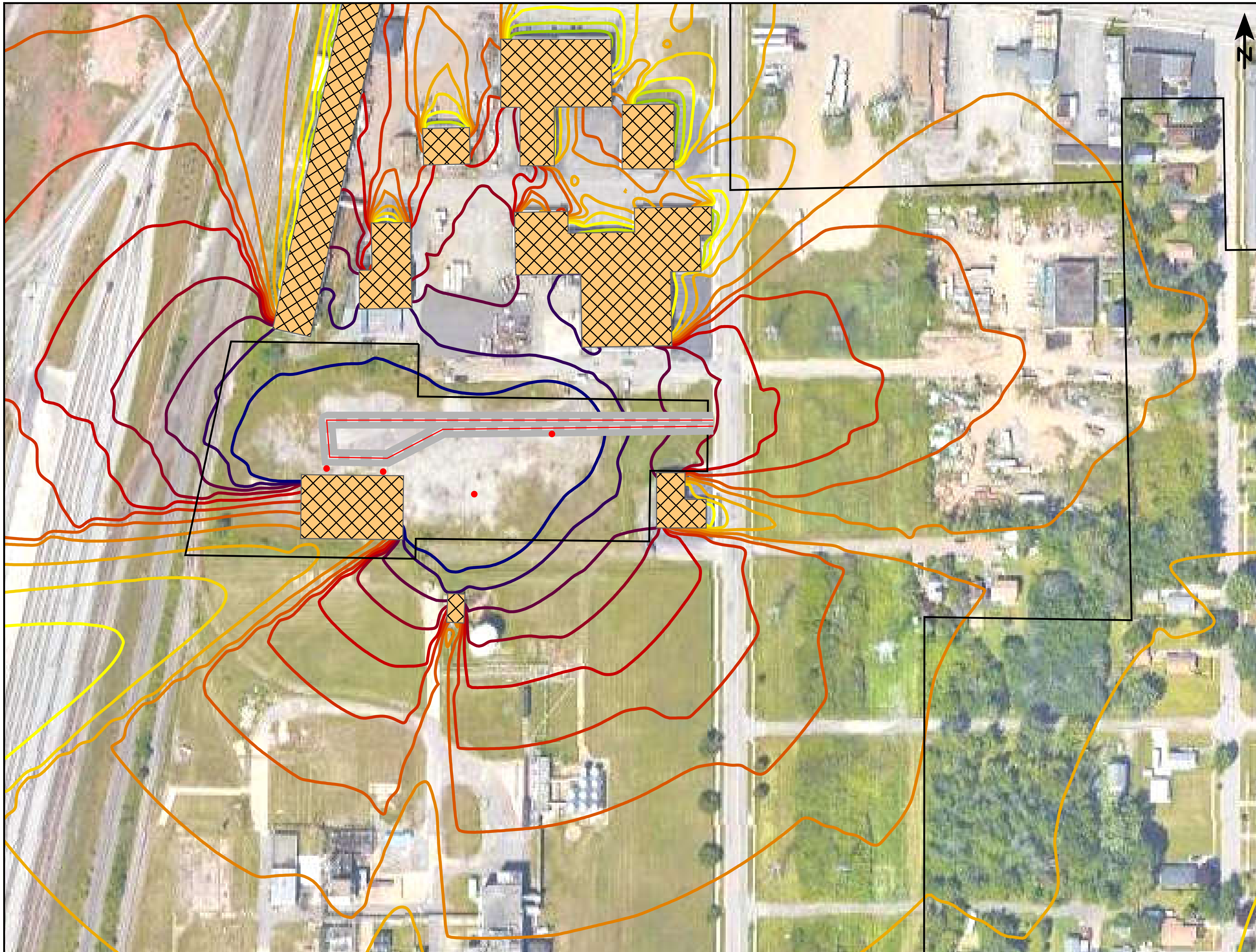

Figure 2
Noise Contour Map
56th Transfer Station
Noise Evaluation
(Max. Ops. Scenario)

Modeled Atmospheric Conditions:
Temperature = 49F, Humidity = 72%
Air Pressure = 1,017 mbar

Noise modeling completed with SounPlan Essential ver. 5.1 modeling software

Legend:

- Property line / Zoning District Boundary
- Building
- Traffic Pattern
- Point source

Levels in dB(A)

- = 40.0
- = 42.5
- = 45.0
- = 47.5
- = 50.0
- = 52.5
- = 55.0
- = 57.5
- = 60.0
- = 62.5
- = 65.0
- = 67.5
- = 70.0
- = 72.5
- = 75.0

0 37.5 75 150 225 300 feet

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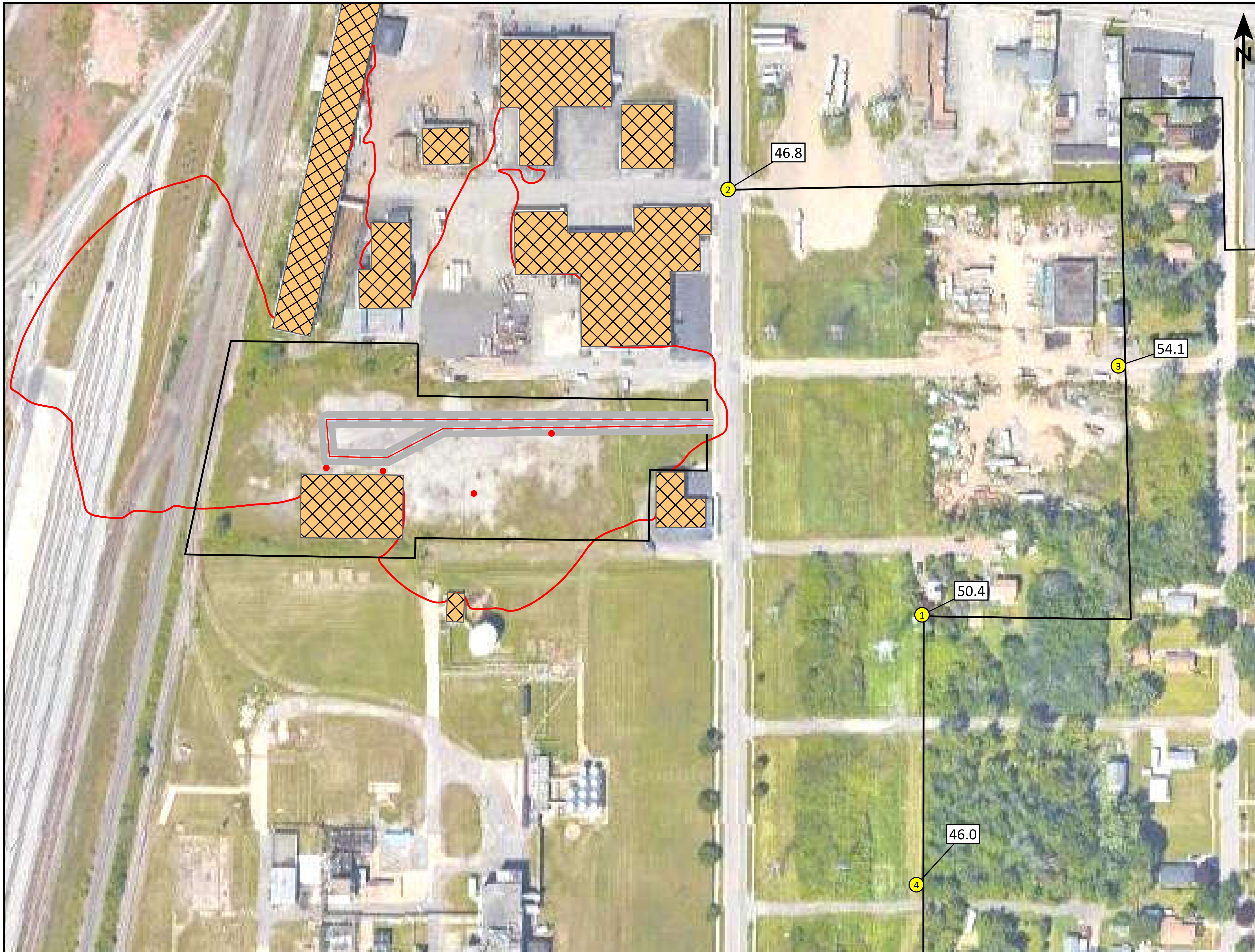

Figure 3
Point Receiver Results
56th Transfer Station
Noise Evaluation
(Typ. Ops. Scenario)

Excavator, Loader, Tractor, and Sweeper running at 75% (45min/hr), 25% (15min/hr), 15% (9min/hr), and 10% (6min/hr) respectively.

Full traffic load (18 trucks and 1 car/hr)

Receivers 1-4 located at closest zoning district boundaries for NYSDEC 360 evaluation.

Modeled Atmospheric Conditions:
Temperature = 49F, Humidity = 72%
Air Pressure = 1,017 mbar

Noise modeling completed with SounPlan Essential ver. 5.1 modeling software

Legend:

- Property line / Zoning District Boundary
- Building
- Receiver
- Traffic Pattern
- Point source
- Limit line Day: 62 dB(A)

0 37.5 75 150 225 300 feet

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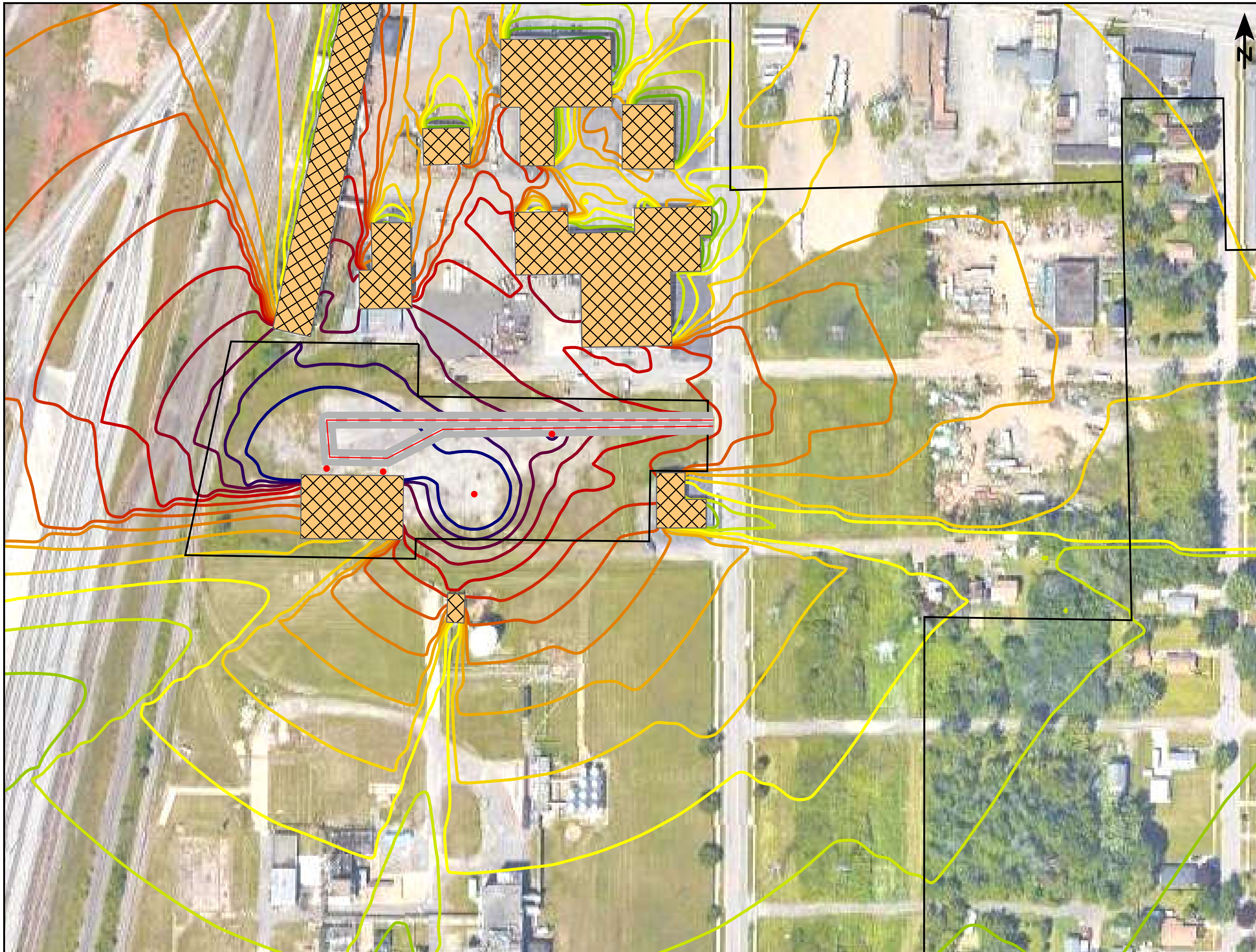

Figure 4
Noise Contour Map
56th Transfer Station
Noise Evaluation
(Typ. Ops. Scenario)

Modeled Atmospheric Conditions:
Temperature = 49F, Humidity = 72%
Air Pressure = 1,017 mbar

Noise modeling completed with SounPlan Essential ver. 5.1 modeling software

Legend:

- Property line / Zoning District Boundary
- Building
- Traffic Pattern
- Point source

Levels in dB(A)

- = 40.0
- = 42.5
- = 45.0
- = 47.5
- = 50.0
- = 52.5
- = 55.0
- = 57.5
- = 60.0
- = 62.5
- = 65.0
- = 67.5
- = 70.0
- = 72.5
- = 75.0

0 37.5 75 150 225 300 feet

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Tables

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Table 1: Noise Emissions of Industry Sources
56th Street Tansfer Station
Noise Analysis

Source name	Reference	Level	Corrections		
		Day	Cwall	CI	CT
		dB(A)	dB	dB	dB
Loader	Lw/unit	111.7	-	-	-
Excavator	Lw/unit	116.7	-	-	-
Yard Goat Tractor	Lw/unit	115.8	-	-	-
Sweeper	Lw/unit	111.7	-	-	-

Table 2: Contribution levels of the receivers
56th Street Tansfer Station
Noise Analysis

Source name	Traffic lane	Level Day dB(A)
1 GF		50.4
Excavator	-	41.4
Loader	-	38.8
Site Traffic	-	32.9
Sweeper	-	25.2
Yard Goat Tractor	-	49.3
2 GF		46.8
Excavator	-	45.7
Loader	-	36.1
Site Traffic	-	34.1
Sweeper	-	21.9
Yard Goat Tractor	-	36.3
3 GF		54.1
Excavator	-	53.0
Loader	-	41.4
Site Traffic	-	30.6
Sweeper	-	29.8
Yard Goat Tractor	-	46.3
4 GF		46.0
Excavator	-	33.4
Loader	-	28.2
Site Traffic	-	28.0
Sweeper	-	29.7
Yard Goat Tractor	-	45.4

Attachment 1

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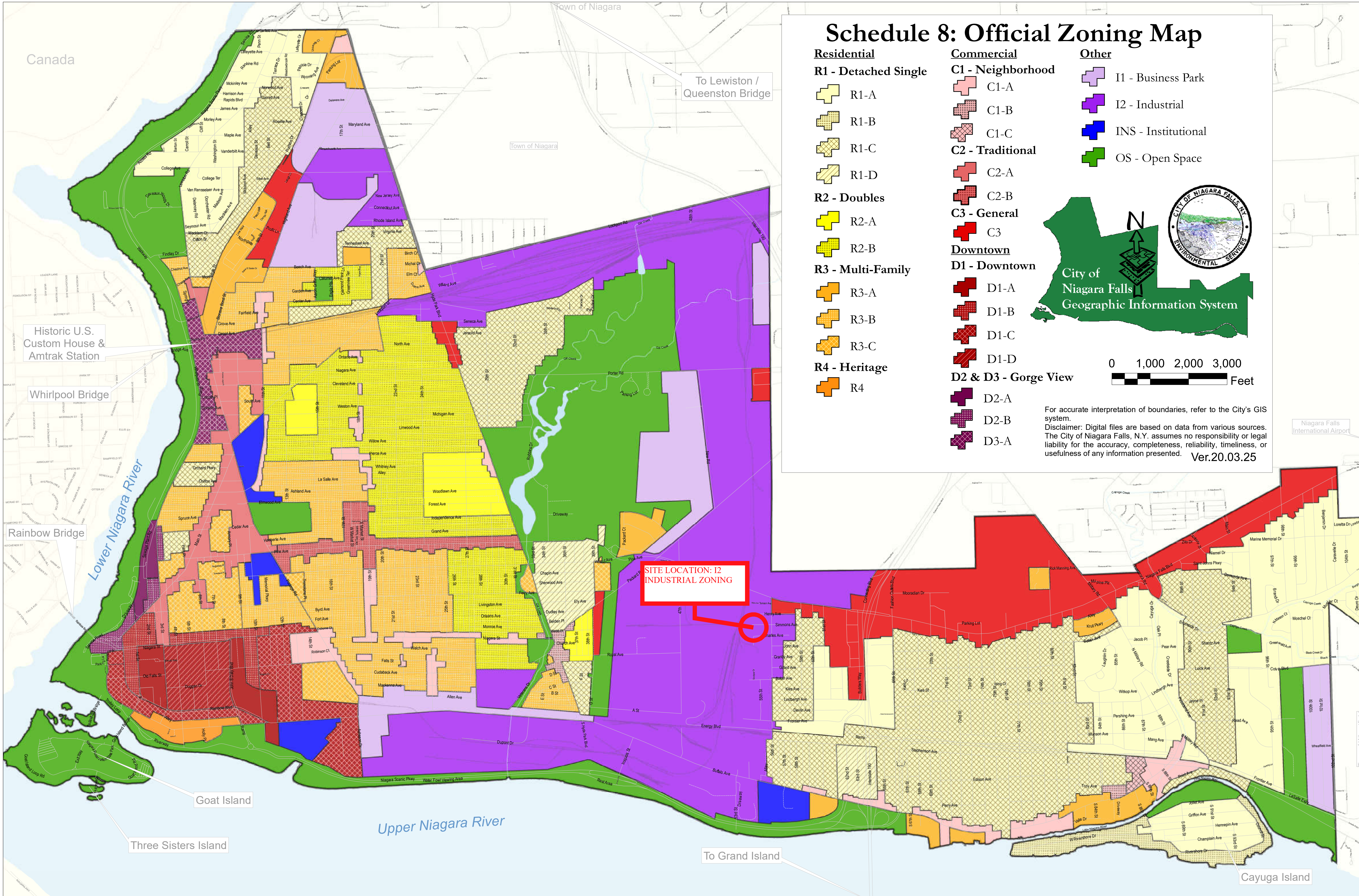
ENGINEERING + ENVIRONMENTAL

City of Niagara Falls Zoning Map and Use Table


Schedule 8: Official Zoning Map
Residential
R1 - Detached Single
R1-A
R1-B
R1-C
R1-D
R2 - Doubles
R2-A
R2-B
R3 - Multi-Family
R3-A
R3-B
R3-C
R4 - Heritage
R4
Commercial
C1 - Neighborhood
C1-A
C1-B
C1-C
C2 - Traditional
C2-A
C2-B
C3 - General
C3
Downtown
D1 - Downtown
D1-A
D1-B
D1-C
D1-D
D2 & D3 - Gorge View
D2-A
D2-B
D3-A
Other
I1 - Business Park
I2 - Industrial
INS - Institutional
OS - Open Space
City of Niagara Falls Geographic Information System
CITY OF NIAGARA FALLS, NY ENVIRONMENTAL SERVICES
N
0 1,000 2,000 3,000 Feet
For accurate interpretation of boundaries, refer to the City's GIS system.
Disclaimer: Digital files are based on data from various sources. The City of Niagara Falls, N.Y. assumes no responsibility or legal liability for the accuracy, completeness, reliability, timeliness, or usefulness of any information presented.
Ver.20.03.25
SITE LOCATION: I2 INDUSTRIAL ZONING
Canada
Town of Niagara
To Lewiston / Queenston Bridge
Historic U.S. Custom House & Amtrak Station
Whirlpool Bridge
Rainbow Bridge
Lower Niagara River
Upper Niagara River
Goat Island
Three Sisters Island
To Grand Island
Cayuga Island
Niagara Falls International Airport
Town of Wheatfield

USE CATEGORIES	Residential Districts				Commercial Districts			Downtown Districts				Industrial Districts		Open Space	Institutional	Negotiated Planned Dev.
	Detached Single R1 A, B, C, D	Doubles R2 A, B	Multi-Family R3 A, B, C	Heritage R4	Neighborhood C1 A, B, C	Traditional C2 A, B	General C3	Downtown D1 A, B, C, D	Gorge View D2 A	Transition D2 B	North Main D3 A	Business Park I1	Industrial I2	OS	Institutional INS	NPD (Refer to 1318.2)
Residential Categories																
Accessory Dwelling Unit		✓	✓	✓	✓	✓		✓		✓	✓					
Duplex/Semi Detached		✓	✓	✓	✓					✓						
Multi-dwelling structure (3+ units)			✓	✓	✓	✓	✓	✓		✓	✓					
Single Detached Dwelling	✓	✓	✓	✓	✓					✓						
Townhouse			✓	✓	✓	✓		✓		✓	✓					
Group Living																
Bed and Breakfast [1]	S [1]	S [1]	✓ [1]	✓ [1]	✓ [1]	✓ [1]		✓ [1]		✓ [1]	✓ [1]					
Boarding/Rooming House			S [1]			S	S									
Day Care, Adult Home			S			S	S									
Group Home	✓	✓	✓	✓	✓					✓					✓	
Fraternity or Sorority House			S			S	S	S			S					
Halfway House						S	S					S	S		✓	
Homeless Residential Facilities						S	S					S	S		✓	
Hostel			S	S		S	S					S	S			
Rectory	✓	✓	✓	✓	✓	✓	✓				✓				✓	
Industrial Categories																
Junkyard																-
Manufacturing, Light						S	✓					✓	✓			-
Manufacturing, Heavy													✓			-
Recycling Operation													✓			-
Warehouse							✓					✓	✓			-
Waste-related													✓			-
Wholesale Establishment												✓	✓			-

✓ = Permitted Use   Empty Box = Not Permitted   [1] Owner Occupied   [2] Accessory Only   S = Permitted only with Special Permit (Chapter 1328)

Attachment 2

EnSol, Inc.

ENGINEERING + ENVIRONMENTAL

FHWA Construction Noise Handbook, Chp. 9

Construction Noise Handbook

9.0 Construction Equipment Noise Levels and Ranges

9.1 Equipment Type Inventory and Related Emission Levels

Noise levels generated by individual pieces of construction equipment and specific construction operations form the basis for the prediction of construction-related noise levels. A variety of information exists related to sound emissions related to such equipment and operations. This data transcends the period beginning in the 1970s thru 2006. This information exists for both stationary and mobile sources and for steady, intermittent, and impulse type generators of noise.

9.1.1 Stationary Equipment

Stationary equipment consists of equipment that generates noise from one general area and includes items such as pumps, generators, compressors, etc. These types of equipment operate at a constant noise level under normal operation and are classified as non-impact equipment. Other types of stationary equipment such as pile drivers, jackhammers, pavement breakers, blasting operations, etc., produce variable and sporadic noise levels and often produce impact-type noises. Impact equipment is equipment that generates impulsive noise, where impulsive noise is defined as noise of short duration (generally less than one second), high intensity, abrupt onset, rapid decay, and often rapidly changing spectral composition. For impact equipment, the noise is produced by the impact of a mass on a surface, typically repeating over time.

9.1.2 Mobile Equipment

Mobile equipment such as dozers, scrapers, graders, etc., may operate in a cyclic fashion in which a period of full power is followed by a period of reduced power. Other equipment such as compressors, although generally considered to be stationary when operating, can be readily relocated to another location for the next operation.

9.2 Sources of Information

Construction-related equipment and operation noise level data may be provided by numerous sources, including suppliers, manufacturers, agencies, organizations, etc. Some information is included in this document, and many web-based links are given for equipment manufacturers.

9.3 Specifics of Construction Equipment and Operation Noise Inventories

Details included in each specific inventory of construction equipment and operation noise emission levels are often variable in terms of how data is represented. Some inventories include ranges of noise levels while others present single numbers for each equipment type. Others provide levels for specific models of each type of construction equipment. Often, different noise descriptors are used, such as L_{Aeq}, L_{max}, L_{10}, sound power level, etc. As such, the array of data does not readily lend itself to being combined into a single table or easily compared. As such, this Handbook attempts to summarize a variety of such inventories and provide links to each, thereby providing the reader with a variety of sources from which to choose the appropriate levels for use in his or her respective analysis.

9.4 Summaries of Referenced Inventories

Included below are examples of several inventories of construction-related noise emission values. These and additional inventories are included on the companion CD-ROM.

9.4.1 RCNM Inventory

Equipment and operation noise levels in this inventory are expressed in terms of L_{max} noise levels and are accompanied by a usage factor value. They have been recently updated and are based on extensive measurements taken in conjunction with the Central Artery/Tunnel (CA/T) Project. Table 9.1 summarizes the equipment noise emissions database used by the CA/T Project. While these values represent the "default" values for use in the RCNM, user-defined equipment and corresponding noise levels can be added.

Table 9.1 RCNM Default Noise Emission Reference Levels and Usage Factors.

Equipment Description	Impact Device?	Acoustical Usage Factor (%)	Spec. 721.560 L_{max} @ 50 feet (dBA, slow)	Actual Measured L_{max} @ 50 feet (dBA, slow) (Samples Averaged)	Number of Actual Data Samples (Count)
All Other Equipment > 5	No	50	85	N/A	0

HP					
Auger Drill Rig	No	20	85	84	36
Backhoe	No	40	80	78	372
Bar Bender	No	20	80	N/A	0
Blasting	Yes	N/A	94	N/A	0
Boring Jack Power Unit	No	50	80	83	1
Chain Saw	No	20	85	84	46
Clam Shovel (dropping)	Yes	20	93	87	4
Compactor (ground)	No	20	80	83	57
Compressor (air)	No	40	80	78	18
Concrete Batch Plant	No	15	83	N/A	0
Concrete Mixer Truck	No	40	85	79	40
Concrete Pump Truck	No	20	82	81	30
Concrete Saw	No	20	90	90	55
Crane	No	16	85	81	405
Dozer	No	40	85	82	55
Drill Rig Truck	No	20	84	79	22
Drum Mixer	No	50	80	80	1
Dump Truck	No	40	84	76	31
Excavator	No	40	85	81	170
Flat Bed Truck	No	40	84	74	4
Front End Loader	No	40	80	79	96
Generator	No	50	82	81	19
Generator (<25KVA, VMS Signs)	No	50	70	73	74
Gradall	No	40	85	83	70
Grader	No	40	85	N/A	0
Grapple (on backhoe)	No	40	85	87	1
Horizontal Boring Hydraulic Jack	No	25	80	82	6
Hydra Break Ram	Yes	10	90	N/A	0
Impact Pile Driver	Yes	20	95	101	11
Jackhammer	Yes	20	85	89	133
Man Lift	No	20	85	75	23
Mounted Impact Hammer (hoe ram)	Yes	20	90	90	212
Pavement Scarifier	No	20	85	90	2

Paver	No	50	85	77	9
Pickup Truck	No	40	55	75	1
Pneumatic Tools	No	50	85	85	90
Pumps	No	50	77	81	17
Refrigerator Unit	No	100	82	73	3
Rivit Buster/Chipping Gun	Yes	20	85	79	19
Rock Drill	No	20	85	81	3
Roller	No	20	85	80	16
Sand Blasting (single nozzle)	No	20	85	96	9
Scraper	No	40	85	84	12
Sheers (on backhoe)	No	40	85	96	5
Slurry Plant	No	100	78	78	1
Slurry Trenching Machine	No	50	82	80	75
Soil Mix Drill Rig	No	50	80	N/A	0
Tractor	No	40	84	N/A	0
Vacuum Excavator (Vac-Truck)	No	40	85	85	149
Vacuum Street Sweeper	No	10	80	82	19
Ventilation Fan	No	100	85	79	13
Vibrating Hopper	No	50	85	87	1
Vibratory Concrete Mixer	No	20	80	80	1
Vibratory Pile Driver	No	20	95	101	44
Warning Horn	No	5	85	83	12
Welder/Torch	No	40	73	74	5

For each generic type of equipment listed in Table 9.1, the following information is provided:

- an indication as to whether or not the equipment is an impact device;
- the acoustical usage factor to assume for modeling purposes;
- the specification "Spec" limit for each piece of equipment expressed as an L_{max} level in dBA "slow" at a reference distance of 50 foot from the loudest side of the equipment;
- the measured "Actual" emission level at 50 feet for each piece of equipment based on hundreds of emission measurements performed on CA/T work sites; and
- the number of samples that were averaged together to compute the "Actual" emission level.

A comparison of the "Spec" emission limits against the "Actual" emission levels reveals that the Spec limits were set, in general, to realistically obtainable noise levels based on the equipment used by contractors on the CA/T Project. When measured in the field, some equipment such as pile drivers, sand blasting, demolition shears, and pumps tended to exceed their applicable emission limit. As such, these noisy devices needed to have some form of noise mitigation in place in order to comply with the Spec emission limits. Other equipment, such as clamshell shovels, concrete mixer trucks, truck-mounted drill rigs, man-lifts, chipping guns, ventilation fans, pavers, dump trucks, and flatbed trucks, easily complied. Therefore, the Spec emission limits for these devices could have been reduced somewhat further. It is recommended that the user review the RCNM User's Guide contained in Appendix A for detailed guidance regarding application of values contained in Table 9.1.

9.4.2 FHWA Special Report Inventories

Appendix A of the 1977 Handbook provides tables of construction equipment noise levels and ranges. The majority of the data were provided by the American Road Builders Association. These data were taken during a 1973 survey in which member contractors were asked to secure readings of noise exposure to operators of various types of equipment. Additionally, the contractors were asked to take readings at 50 feet from the machinery. These 50-foot peak readings are provided in Tables 9.2 through 9.8. Though the data were produced under varying conditions and degrees of expertise, the values are relatively consistent.

Table 9.2 Construction Equipment Noise Levels Based on Limited Data Samples - Cranes.

Manufacturer	Type or Model	Peak Noise Level (dBA)	Remarks
Northwestern	80D	77	Within 15m 1958 mod
Northwestern	8	84	Within 15m 1940 mod
Northwestern	6	72	Within 15m 1965 mod
American	7260	82	Within 15m 1967 mod
American	599	76	Within 15m 1969 mod
American	5299	70	Within 15m 1972 mod
American	4210	82	Within 15m 1968 mod
Buck Eye	45C	79	Within 15m 1972 mod
Buck Eye	308	74	Within 15m 1968 mod
Buck Eye	30B	73	Within 15m 1965 mod
Buck Eye	30B	70	Within 15m 1959 mod
Link Belt	LS98	76	Within 15m 1956 mod
Manitowoc	4000	94	Within 15m 1956 mod
Grove	RF59	82	Within 15m 1973 mod
Koehr	605	76	Within 15m 1967 mod
Koehr	435	86	Within 15m 1969 mod
Koehr	405	84	Within 15m 1969 mod

Table 9.3 Construction Equipment Noise Levels Based on Limited Data Samples - Backhoes.

Manufacturer	Type or Model	Peak Noise Level (dBA)	Remarks
Link Belt	4000	92	Within 15m 1971 mod
John Deere	609A	85	Within 15m 1971 mod
Case	680C	74	Within 15m 1973 mod
Drott	40 yr.	82	Within 15m 1971 mod
Koehr	1066	81 & 84	Within 15m 2 tested

Table 9.4 Construction Equipment Noise Levels Based on Limited Data Samples - Front Loaders.

Manufacturer	Type or Model	Peak Noise Level (dBA)	Remarks
Caterpillar	980	84	Within 15m 1972 mod
Caterpillar	977K	79	Within 15m 1969 mod
Caterpillar	977	87	Within 15m 1971 mod
Caterpillar	977	94	Within 15m 1967 mod
Caterpillar	966C	84	Within 15m 1973 mod
Caterpillar	966C	85	Within 15m 1972 mod
Caterpillar	966	81	Within 15m 1972 mod
Caterpillar	966	77	Within 15m 1972 mod
Caterpillar	966	85	Within 15m 1966 mod

Caterpillar	955L	90	Within 15m ;1973 mod
Caterpillar	955K	79	Within 15m 1969 mod
Caterpillar	955H	94	Within 15m 1963 mod
Caterpillar	950	78 & 80	Within 15m 1972 mod
Caterpillar	950	75	Within 15m 1968 mod
Caterpillar	950	88	Within 15m 1967 mod
Caterpillar	950	86	Within 15m 1965 mod
Caterpillar	944A	80	Within 15m 1965 mod
Caterpillar	850	82	Within 15m 1968 mod
Michigan	75B	90	Within 15m 1969 mod
Michigan	475A	96	Within 15m 1967 mod
Michigan	275	85	Within 15m 1971 mod
Michigan	125	87	Within 15m 1967 mod
Hough	65	82	Within 15m 1971 mod
Hough	60	91	Within 15m 1961 mod
Hough	400B	94	Within 15m 1961 mod
Hough	H90	86	Within 15m 1961 mod
Trojan	3000	85	Within 15m 1956 mod
Trojan	RT	82	Within 15m 1965 mod
Payloader	H50	85	Within 15m 1963 mod

Table 9.5 Construction Equipment Noise Levels Based on Limited Data Samples - Dozers.

Manufacturer	Type or Model	Peak Noise Level (dBA)	Remarks
Caterpillar	D5	83	Within 15m 1967 mod
Caterpillar	D6	85	Within 15m 1967 mod
Caterpillar	D6	86	Within 15m 1964 mod
Caterpillar	D6	81	Within 15m 1967 mod
Caterpillar	D6B	83	Within 15m 1967 mod
Caterpillar	D6C	82	Within 15m 1962 mod
Caterpillar	D7	85	Within 15m 1956 mod
Caterpillar	D7	86	Within 15m 1969 mod
Caterpillar	D7	84	Within 15m 1969 mod
Caterpillar	D7	78	Within 15m 1970 mod
Caterpillar	D7	78	Within 15m 1972 mod
Caterpillar	D7E	86	Within 15m 1965 mod
Caterpillar	D7E	78	Within 15m 1970 mod
Caterpillar	D7E	84	Within 15m 1973 mod
Caterpillar	D7F	80	Within 15m 1972 mod
Caterpillar	D8	92	Within 15m 1954 mod
Caterpillar	D8	95	Within 15m 1968 mod
Caterpillar	D8	86	Within 15m 1972 mod
Caterpillar	D8H	88	Within 15m 1966 mod
Caterpillar	D8H	82	Within 15m 1972 mod
Caterpillar	D9	85	Within 15m 1972 mod

Caterpillar	D9	94	Within 15m 1972 mod
Caterpillar	D9	90	Within 15m 1963 mod
Caterpillar	D9	87	Within 15m 1965 mod
Caterpillar	D9	90	Within 15m 1965 mod
Caterpillar	D9	88	Within 15m 1968 mod
Caterpillar	D9	92	Within 15m 1972 mod
Caterpillar	D9G	85	Within 15m 1965 mod
Allis Chambers	HD41	93	Within 15m 1970 mod
International	TD15	79	Within 15m 1970 mod
International	TD20	87	Within 15m 1970 mod
International	TD25	90	Within 15m 1972 mod
International	TD8	83	Within 15m 1970 mod
Case	1150	82	Within 15m 1972 mod
John Deer	350B	77	Within 15m 1971 mod
John Deer	450B	65	Within 15m 1972 mod
Terex	8230	70	Within 15m 1972 mod
Terex	8240	93	Within 15m 1969 mod
Michigan	280	85	Within 15m 1961 mod
Michigan	280	90	Within 15m 1962 mod
Caterpillar	824	90	Within 15m 1968 mod

Table 9.6 Construction Equipment Noise Levels Based on Limited Data Samples - Graders.

Manufacturer	Type or Model	Peak Noise Level (dBA)	Remarks
Caterpillar	16	91	Within 15m 1969 mod
Caterpillar	16	86	Within 15m 1968 mod
Caterpillar	140	83	Within 15m 1970 mod
Caterpillar	14E	84	Within 15m 1972 mod
Caterpillar	14E	85	Within 15m 1971 mod
Caterpillar	14C	85	Within 15m 1971 mod
Caterpillar	14B	84	Within 15m 1967 mod
Caterpillar	12F	82	Within 15m 1961-72 mod
Caterpillar	12F	72-92	Within 15m 1961-72 mod
Caterpillar	12E	81.3	Within 15m 1959-67 mod
Caterpillar	12E	80-83	Within 15m 1959-67 mod
Caterpillar	12	84.7	Within 15m 1960-67 mod
Caterpillar	12	82-88	Within 15m 1960-67 mod
Gallon	T500	84	Within 15m 1964 mod
Allis Chambers		87	Within 15m 1964 mod

Table 9.7 Construction Equipment Noise Levels Based on Limited Data Samples - Scrapers.

Manufacturer	Type or Model	Peak Noise Level (dBA)	Remarks
Caterpillar	660	92	Within 15m
Caterpillar	641B	85	Within 15m 1972 mod
Caterpillar	641B	86	Within 15m 1972 mod

Caterpillar	641	80 & 84	Within 15m 1972 mod
Caterpillar	641	83 & 89	Within 15m 1965 mod
Caterpillar	637	87	Within 15m 1971 mod
Caterpillar	633	87	Within 15m 1972 mod
Caterpillar	631C	89	Within 15m 1973 mod
Caterpillar	631C	83	Within 15m 1972 mod
Caterpillar	631B	94	Within 15m 1969 mod
Caterpillar	631B	84-87	Within 15m 1968 mod
Caterpillar		85 avg.	Within 15m 1968 mod
Caterpillar	621	90	Within 15m 1970 mod
Caterpillar	621	86	Within 15m 1967 mod
Caterpillar	613	76	Within 15m 1972 mod
Terex	TS24	87	Within 15m 1972 mod
Terex	TS24	84-91	
Terex	TS24	82	Within 15m 1971 mod
Terex	TS24	81-83	Within 15m 1971 mod
Terex	TS24	94	Within 15m 1966 mod
Terex	TS24	92-98	Within 15m 1966 mod
Terex	TS24	94.7	Within 15m 1963 mod
Terex	TS24	94-95	Within 15m 1963 mod
Terex	TS14	82	Within 15m 1969 mod
Terex	S35E	84	Within 15m 1971 mod

Table 9.8 Noise Levels of Standard Compressors.

Manufacturer	**Model**	**Silenced or Standard**	**Type Eng.**	**Type Comp.**	**Test Avg. Cond. (cfm.psi)**	**Avg. Cond. Noise Lev. (cfm.psi) (dBA) at 7m***
Atlas	ST-48	Standard	Diesel	Reciprocal	160,100	83.6
Atlas	ST-95	Standard	Diesel	Reciprocal	330,105	80.2
Atlas	VSS-170Dd	Silenced	Diesel	Reciprocal	170,850	70.2
Atlas	VT-85M	Standard	Gas	Reciprocal	85,100	81.4
Atlas	VS-85Dd	Silenced	Gas	Reciprocal	85,100	75.5
Atlas	VSS-125Dd	Silenced	Diesel	Reciprocal	125,100	70.1
Atlas	STS-35Dd	Silenced	Diesel	Reciprocal	125,100	73.5
Atlas	VSS-170Dd	Silenced	Diesel	Reciprocal	170,100	
Gardner-Denver	SPWDA/2	Silenced	Diesel	Rotary-Screw	1200,000	73.3
Gardner-Denver	SPQDA/2	Silenced	Diesel	Rotary-Screw	750,000	78.2
Gardner-Denver	SPHGC	Silenced	Gas	Rotary-Screw	185,000	77.1
Ingersoll-Rand	DXL 1200	Standard	Diesel	Rotary-Screw	1200,125	92.6
Ingersoll-Rand	DXL 1200 (doors open)	Standard	Diesel	Rotary-Screw	1200,125	
Ingersoll-Rand	DXL 900S	Silenced	Diesel	Rotary-Screw	900,125	76.0
Ingersoll-Rand	DXL 900S	Silenced	Diesel	Rotary-	900,125	75.1

				Screw		
Ingersoll-Rand	DXLCU1050	Standard	Diesel	Rotary-Screw	1050,125	90.2
Ingersoll-Rand	DXL 900S	Silenced	Diesel	Rotary-Screw	900,125	75.3
Ingersoll-Rand	DXL 900S	Silenced	Diesel	Rotary-Screw	900,125	75.0
Ingersoll-Rand	DXL 900	Standard	Diesel	Rotary-Screw	900,125	89.9
Ingersoll-Rand	DXL 750	Standard	Diesel	Rotary-Screw	750,125	87.7
Jaeger	A	Standard	Gas	Rotary-Screw	175,100	88.2
Jaeger	A(doors open)	Standard	Gas	Rotary-Screw	175,100	
Jaeger	E	Standard	Gas	Vane	85,100	81.5
Jaeger	E(doors open)	Standard	Gas	Vane	85,100	
Worthington	60 G/2Qt	Silenced	Gas	Vane	160,100	74.2
Worthington	750-QTEX	Silenced	Diesel	Rotary-Screw	750,100	74.7

*Data taken from EPA Report - EPA 550/9-76-004.

9.4.3 FTA Noise and Vibration Assessment Procedure

Chapter 12 of the FTA Transit Noise and Vibration Guidance Handbook discusses construction noise evaluation methodology and contains the noise emission levels for construction equipment displayed in Table 9.9.

Table 9.9 FTA Construction Equipment Noise Emission Levels.

Equipment	Typical Noise Level (dBA) 50 ft from Source*
Air Compressor	81
Backhoe	80
Ballast Equalizer	82
Ballast Tamper	83
Compactor	82
Concrete Mixer	85
Concrete Pump	82
Concrete Vibrator	76
Crane Derrick	88
Crane Mobile	83
Dozer	85
Generator	81
Grader	85
Impact Wrench	85
Jack Hammer	88
Loader	85
Paver	89
Pile Driver (Impact)	101
Pile Driver (Sonic)	96
Pneumatic Tool	85

Pump	76
Rail Saw	90
Rock Drill	98
Roller	74
Saw	76
Scarifier	83
Scraper	89
Shovel	82
Spike Driver	77
Tie Cutter	84
Tie Handler	80
Tie Inserter	85
Truck	88

*Table based on EPA Report, measured data from railroad construction equipment taken during Northeast Corridor improvement project and other measured data.

9.5 Links to Equipment Manufacturers

Table 9.10 contains web-based links to manufacturers of construction equipment. While few of these links contain noise-related data associated with the equipment, they provide descriptions and/or specifications related to the equipment, as well as sources for possibly obtaining additional information related to the equipment. Information in this table is by no means all-inclusive and does not represent any type of endorsement of the manufacturers, suppliers, or equipment. Users are hereby advised that the referenced websites may have certain restrictions, copyrights, etc., associated with any use of data contained therein.

Table 9.10 Equipment Manufacturers and Websites.

Equipment	Manufacturer	Website Address
Arrow Boards		
	North Star	http://northstar-traffic.com/index.cfm?SC=14&PT=1
	Trafcom	http://www.trafcon.com
	Allmand	http://www.allmand.com/MB%20AB%20page.htm
Articulated Trucks		
	Case	http://www.casece.com/products/products.asp?RL=NAE&id=196
	Hitachi	http://www.hitachi-c-m.com/global/products/articulate/index.html
	Terex	http://www.terex.com/main.php
	Caterpillar	http://www.cat.com/cda/layout?m=37840&x=7
	Volvo	http://www.volvo.com/constructionequipment/na/en-us/products/articulatedhaulers/
Asphalt Saws		
	Allied	http://www.alliedcp.com/products/rotocut.asp
Augers - See Drills / Augers		
Backhoes - See Loaders/Backhoes		
Boring Equipment - See Pile Drivers/Boring Equipment		
Compaction Equipment		
	Allied	http://www.alliedcp.com/products/compactor.asp
Compressors		
	Sullair	http://www.sullair.com/corp/details/0,10294,CLI1_DIV61_ETI5714,00.html
	Compair	http://www.compair.com/Products/Portable_Compressors.aspx
Concrete and Asphalt Batch/Mixing Plants and Equipment		

	Con-E-Co	http://www.con-e-co.com/products.cfm
	Terex	http://www.terex.com/main.php
	Gunter & Zimmerman	http://www.guntert.com/concrete_mobilebatching.asp
	Rex Con	http://www.rexcon.com
Concrete Breakers/ Hydraulic Hammers/Hydraulic Breakers		
	Drillman	http://www.drillmanindia.com/concrete-breaker.html
	Hydro Khan	http:/www.sangi.co.kr/english/e_product1_2.php
	Stanley	http://www.stanley-hydraulic-tools.com/Hand%20Held/NoAmbreakers.htm
	Lynx	http://www.stanley-hydraulic-tools.com/Lynx/breakers.htm
Concrete Chain Saws		
	Lynx	http://www.stanley-hydraulic-tools.com/Lynx/concrete-saws.htm
Concrete Core Drilling Machines		
	Multiquip	http://www.multiquip.com/multiquip/318_ENU_HTML.htm
Concrete Cutters		
	Vermeer	http://www.vermeermfg.com/vcom/TrenchingEquipment/Line.jsp?PrdlnID=3618
Concrete/Material Pumps		
	Multiquip	http://www.multiquip.com/multiquip/309_ENU_HTML.htm
	Reed	http://www.reedpumps.com/
Concrete Mixer Trucks		
	Oshkosh	http://www.oshkoshtruck.com/concrete/products~overview~home.cfm
	London	http://www.lmi.ca/mixers.cfm
	Terex/Advance	http://www.advancemixer.com
Concrete Saws		
	Multiquip	http://www.multiquip.com/multiquip/315_ENU_HTML.htm
	Diamond Core Cut	http://www.diamondproducts.com/dp_home.htm
Concrete Screeds		
	Multiquip	http://www.multiquip.com/multiquip/317_ENU_HTML.htm
Concrete Vibrators		
	Multiquip	http://www.multiquip.com/multiquip/313_ENU_HTML.htm
	Sullair	http://www.sullair.com/corp/details/0,10294,CLI1_DIV61_ETI5722,00.html
Cranes		
	Malcolm Drilling	www.malcolmdrilling.com
	Link-Belt	http://www.linkbelt.com/lit/products/frameproducthome.htm
	Casagrande	http://www.casagrandegroup.com
	Liebherr	http://www.liebherr.com/em/en/35381.asp
	Terex	http://www.terex.com/main.php
Crawler Tractors - See Dozers/Crawler Tractors		
Crushing and Screening Equipment		
	Cedarapids	http://www.cedarapids.com/crushscr.htm
	Hitachi	http://www.hitachi-c-m.com/
	Komatsu	http://www.komatsu.com/ce/products/mobile_crushers.html
	Terex	http://www.terex.com/main.php
Crushers/Pulverizers		
	Hydro Khan	http://www.sangi.co.kr/english/e_product3.php

Cutoff Saws		
	Multiquip	http://www.multiquip.com/multiquip/309_ENU_HTML.htm
	Lynx	http://www.stanley-hydraulic-tools.com/Lynx/cutoff%20saw.htm
Dozers/CrawlerTractors		
	John Deere	http://www.deere.com/en_US/cfd/construction/deere_const/crawlers/deere_dozer_selection.html
	Caterpillar	http://www.cat.com/cda/layout?m=37840&x=7
	Case	http://www.casece.com/products/products.asp?RL=NAE&id=2
	Komatsu	http://www.komatsu.com/ce/products/crawler_dozers.html
Dewatering Pumps		
	Multiquip	http://www.multiquip.com/multiquip/371_ENU_HTML.htm
Drills / Augers		
	Malcolm Drilling	www.malcolmdrilling.com
	Casagrande	www.casagrandegroup.com
	Soilmec	http://www.soilmec.com/_vti_g1_techno.aspx?rpstry=4_
	Terex	http://www.terex.com/main.php
Excavators		
	Hitachi	http://www.hitachi-c-m.com/global/products/excavator/index.html
	Caterpiller	http://www.cat.com/cda/layout?m=37840&x=7
	Volvo	http://www.volvo.com/constructionequipment/na/en-us/products/compactexcavators/
		http://www.volvo.com/constructionequipment/na/en-us/products/wheeledexcavators/
		http://www.volvo.com/constructionequipment/na/en-us/products/crawlerexcavators/
	John Deere	http://www.deere.com/en_US/cfd/construction/deere_const/excavators/deere_excavator_selection.html
	Liebherr	http://www.liebherr.com/em/en/18891.asp
	Soilmec	http://www.soilmec.com/_vti_g1_t02.aspx?rpstry=29_
	Gehl	http://www.gehl.com
	Case	http://www.casece.com/products/products.asp?RL=NAE&id=216
	Komatsu	http://www.komatsu.com/ce/products/crawler_excavators.html
		http://www.komatsu.com/ce/products/wheel_excavators.html
	Terex	http://www.terex.com/main.php
	Link-Belt	http://www.lbxco.com/lx_series.asp
	Gradall	http://www.gradall.com/
	Badger Daylighting	http://www.badgerinc.com/
Fork Lifts - See Lifts / Variable Reach Fork Lifts/ Material Handlers		
Generators		
	Terex	http://www.terex.com/main.php
	Multiquip	http://www.multiquip.com/multiquip/212_ENU_HTML.htm
	Sullair	http://www.sullair.com/corp/details/0,10294,CLI1_DIV61_ETI5714,00.html
	Baldor	http://www.baldor.com/products/generators/ts.asp
Graders		
	Case	http://www.casece.com/products/products.asp?RL=NAE&id=190
	Volvo	http://www.volvo.com/constructionequipment/na/en-us/products/MotorGraders/
	Komatsu	http://www.komatsu.com/ce/products/motor_graders.html
	Terex	http://www.terex.com/main.php

Hand Compaction Equipment		
	Terex	http://www.terex.com/main.php
	Multiquip	http://www.multiquip.com/multiquip/56_ENU_HTML.htm
Hydraulic Hammers/Hydraulic Breakers - See Concrete Breakers/ Hydraulic Hammers/Hydraulic Breakers		
Jackhammers - See Rock Drilling Equipment/Jackhammers		
Lifts / Variable Reach Fork Lifts/ Material Handlers		
	Genie Lift	www.genielift.com
	Sky Track	www.kirby-smith.com/
	Ingersol-Rand	www.ingersollrand.com
	Terex	http://www.terex.com/main.php
	Roadtec	http://www.roadtec.com/www/docs/102/mtv-material-transfer-vehicle/
Light Towers		
	Baldor	http://www.baldor.com/products/generators/mlt.asp
	Multiquip	http://www.multiquip.com/multiquip/293_ENU_HTML.htm
	Allmand	http://www.allmand.com/Night%20Lite%20Pro%20page.htm
Loaders/Backhoes		
	Case	http://www.casece.com/products/products.asp?RL=NAE&id=54
	Caterpillar	http://www.cat.com/cda/layout?m=37840&x=7
	Volvo	http://www.volvo.com/constructionequipment/na/en-us/products/backhoeloaders/
	John Deere	http://www.deere.com/en_US/cfd/construction/deere_const/backhoes/deere_backhoe_selection.html
	Komatsu	http://www.komatsu.com/ce/products/backhoe_loaders.html
Material Handlers - See Lifts / Variable Reach Fork Lifts/ Material Handlers		
Milling Machines		
	Wirtgen	http://www.wirtgenamerica.com/en-us/
Mining Trucks - See Rigid Dump Trucks/Mining Trucks		
Pans - See Scrapers/Pans		
Pavers/Paving Equipment		
	Caterpillar/ Barber Greene	http://www.cat.com/cda/layout?m=37840&x=7
	Rosco	http://www.leeboy.com/rosco/
	Bomag	http://www.bomag.com/americas/index.aspx?&Lang=478
	Gehl	http://www.gehl.com/const/prodpg_ap.html
	Leeboy	http://www.leeboy.com/leeboy/
	Terex	http://www.terex.com/main.php
	Ingersoll-Rand	http://www.road-development.irco.com/Default.aspx?MenuItemID=12
	Vogele	http://www.vogeleamerica.com/noflash.html
	GOMACO	http://www.gomaco.com/index.html
	Roadtec	http://www.roadtec.com
Pile Drivers/Boring Equipment		
	Soilmec	http://www.soilmec.com/_vti_g1_t09.aspx?rpstry=29_
	Leffer	http://www.leffer.com/hme.html
	Bauer	http://www.bauer.de/en/maschinenbau/produkte/drehbohrgeraete/bg_reihe/usbg15h.htm
Pipelayers/Trenchers		

	Liebherr	http://www.liebherr.com/em/en/18908.asp
	Caterpillar	http://www.cat.com/cda/layout?m=37840&x=7
	Case	http://www.casece.com/products/products.asp?RL=NAE&id=28&archived=1
	Vermeer	http://www.vermeermfg.com/vcom/TrenchingEquipment/trenching-equipment.htm
	Ditchwitch	http://www.ditchwitch.com/dwcom/Product/ProductView/115
	Eagle	http://www.guntert.com/trenchers_home.asp
Profilers - See Roadway Planers/Profilers		
Rammers		
	Multiquip	http://www.multiquip.com/multiquip/56_ENU_HTML.htm
Rebar Benders/Cutters		
	Multiquip	http://www.multiquip.com/multiquip/1316_ENU_HTML.htm
Recyclers - See Stabilizers/Recyclers		
Rigid Dump Trucks/Mining Trucks		
	Hitachi	http://www.hitachi-c-m.com/global/products/rigid/index.html
	Caterpillar	http://www.cat.com/cda/layout?m=37840&x=7
	Liebherr	http://www.liebherr.com/em/en/18898.asp
	Komatsu	http://www.komatsu.com/ce/products/dump_trucks.html
	Terex	http://www.terex.com/main.php
Roadway Planers/Profilers		
	Terex	http://www.terex.com/main.php
	Roadtec	http://www.roadtec.com/products/cold_planers/default.htm
Rock Drilling Equipment/Jackhammers		
	Drillman	http://www.drillmanindia.com/rock-drilling-machine.html
	Whaker	http://www.wackergroup.com/webapp/wcs/stores/servlet/
	Sullair	http://www.sullair.com/corp/details/0,10294,CLI1_DIV61_ETI5721,00.html
	Allied	http://www.alliedcp.com/products/hammers.asp
Rollers - See Tampers/Rollers		
Scrapers/Pans		
	Terex	http://www.terex.com/main.php
Screening Equipment - See Crushing and Screening Equipment		
Slabbuster		
	Allied	http://www.alliedcp.com/products/slabbuster.asp
Slip Form Pavers		
	Huron	http://www.huronmanufacturing.com/
	Guntert & Zimmerman	http://www.guntert.com/concreteSlipformPavers.asp
Stabilizers/Recyclers		
	Bomag	http://www.bomag.com/americas/index.aspx?&Lang=478
	Komatsu	http://www.komatsu.com/ce/products/mobile_crushers.html
	Terex	http://www.terex.com/main.php
	Wirtgen	http://www.wirtgenamerica.com/en-us/
	Roadtec	http://www.roadtec.com
Sweepers		
	Elgin	http://www.elginsweeper.com
	Johnston	http://www.johnstonsweepers.com/

Tampers/ Rollers		
	Bomag	http://www.bomag.com/americas/index.aspx?&Lang=478
	Komatsu	http://www.komatsu.com/ce/products/vibratory_rollers.html
	Whaker	http://www.wackergroup.com/webapp/wcs/stores/servlet/
	Lynx	http://www.stanley-hydraulic-tools.com/Lynx/tamper.htm
	Multiquip	http://www.multiquip.com/multiquip/181_ENU_HTML.htm
	Ingersoll-Rand	http://www.road-development.irco.com/Default.aspx?MenuItemID=15
Trenchers - See Pipelayers/Trenchers		
Trucks - See Articulated Trucks, Concrete Mixer Trucks, Rigid Dump Trucks/Mining Trucks		
Vacuum Units		
	Advanced Recycling Systems	www.arsrecycling.com/
	Vacmasters	http://www.vacmasters.com/airsystm.htm
	Vector	http://www.vector-vacuums.com/
Variable Message Signs		
	Allmand	http://www.allmand.com/MB%20only%20page.htm
	North Star	http://northstar-traffic.com/index.cfm?SC=13&PT=1
	Trafcom	http://www.trafcon.com
	Daktronics	http://www.daktronics.com/vms_prod/dak_vms_products.cfm
Vibratory Rammers		
	Whaker	http://www.wackergroup.com/webapp/wcs/stores/servlet/
Welders/Welding Equipment		
	Airgas	www.airgas.com
	Multiquip	http://www.multiquip.com/multiquip/408_ENU_HTML.htm
	Miller	http://www.millerwelds.com/products/
	Lincoln	http://www.mylincolnelectric.com/Catalog/equipmentseries.asp?browse=101|400|
Wheel Loaders		
	Hitachi	http://www.hitachi-c-m.com/global/products/loader/index.html
	Case	http://www.casece.com/products/products.asp?RL=NAE&id=30
	Caterpillar	http://www.cat.com/cda/layout?m=37840&x=7
	Volvo	http://www.volvo.com/constructionequipment/na/en-us/products/wheelloaders/
	Terex	http://www.terex.com/main.php
	Komatsu	http://www.komatsu.com/ce/products/wheel_loaders.html
	TCM	http://www.tcmglobal.net/products/main02.html

Attachment 3

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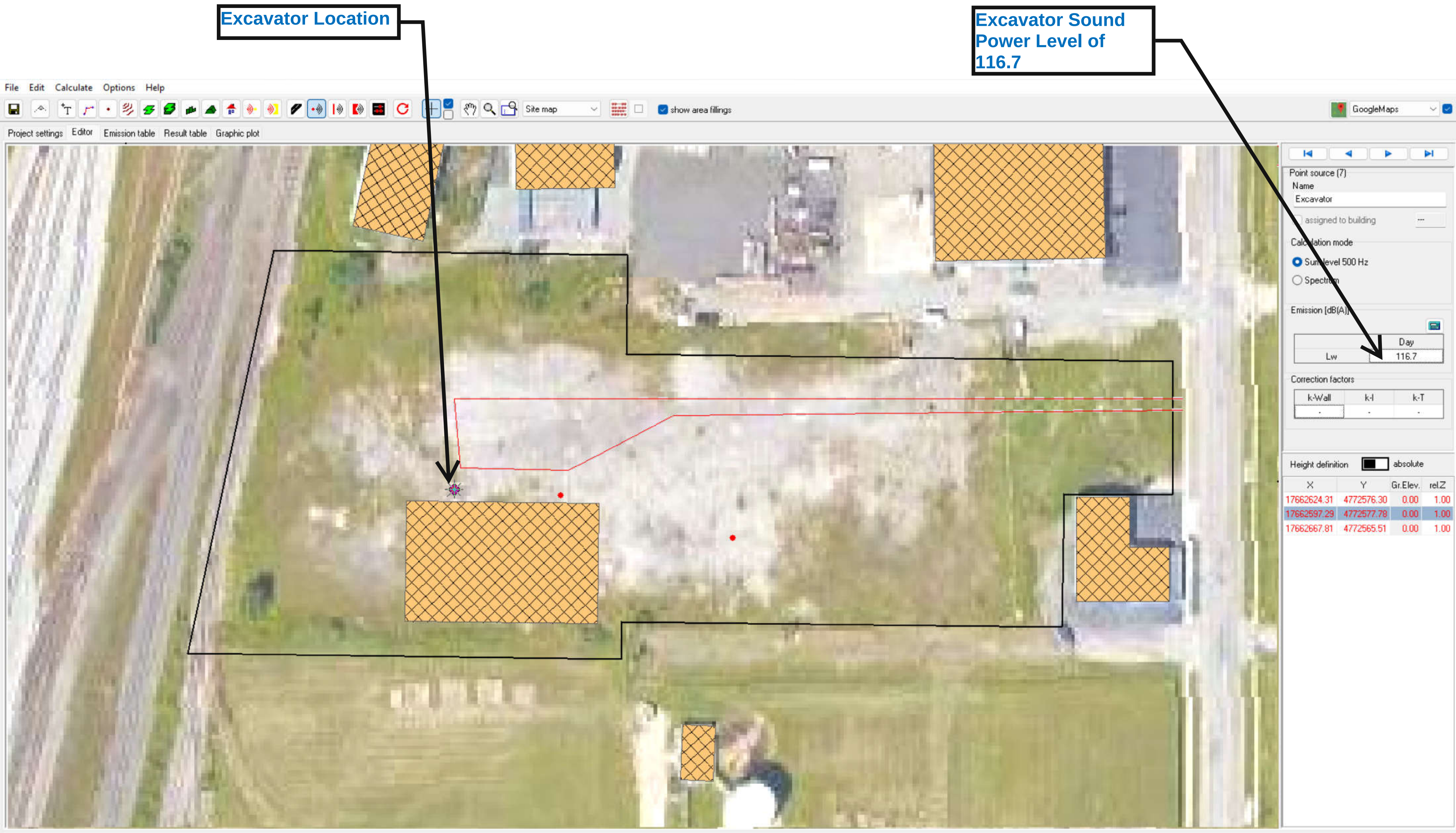
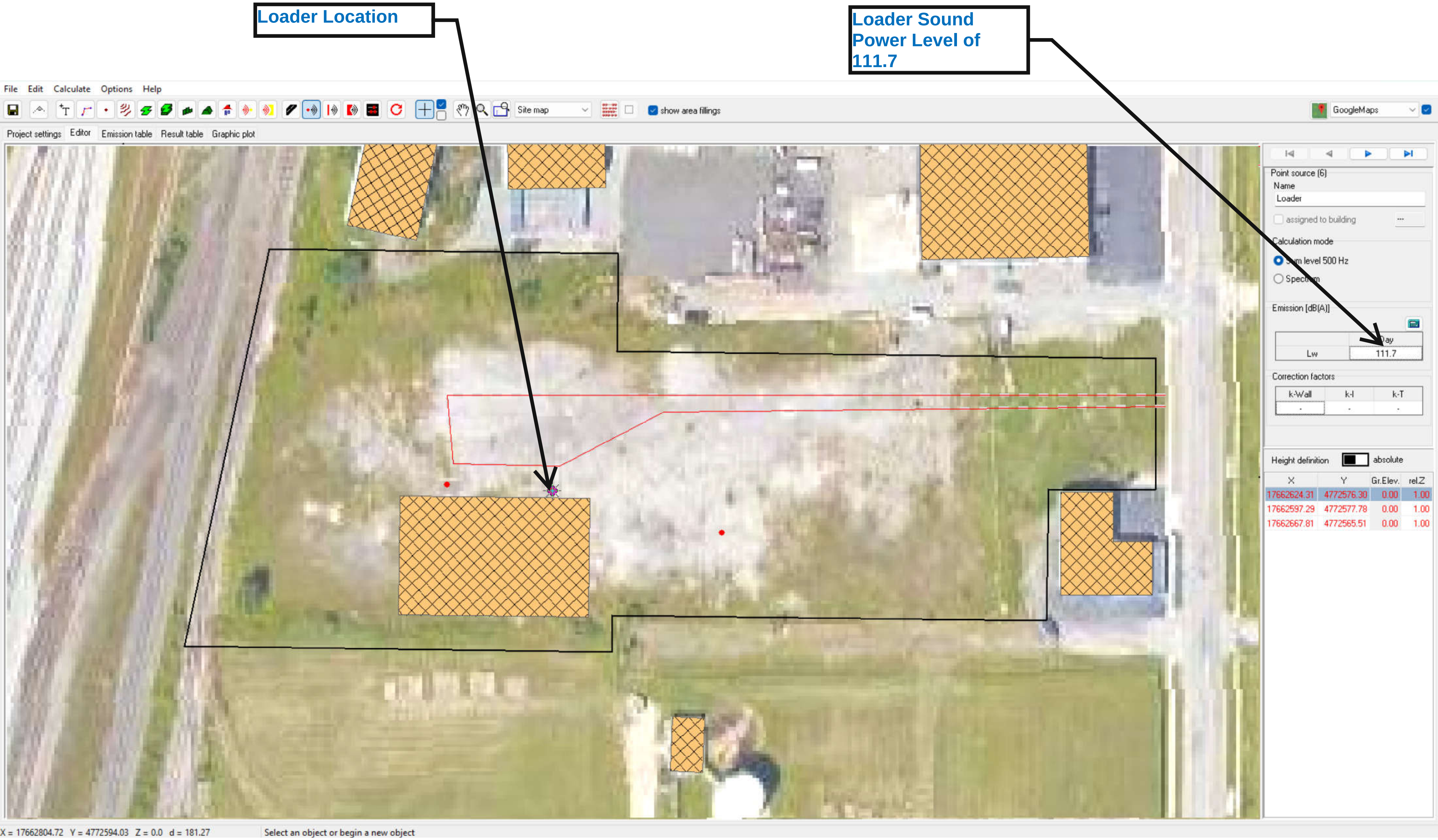
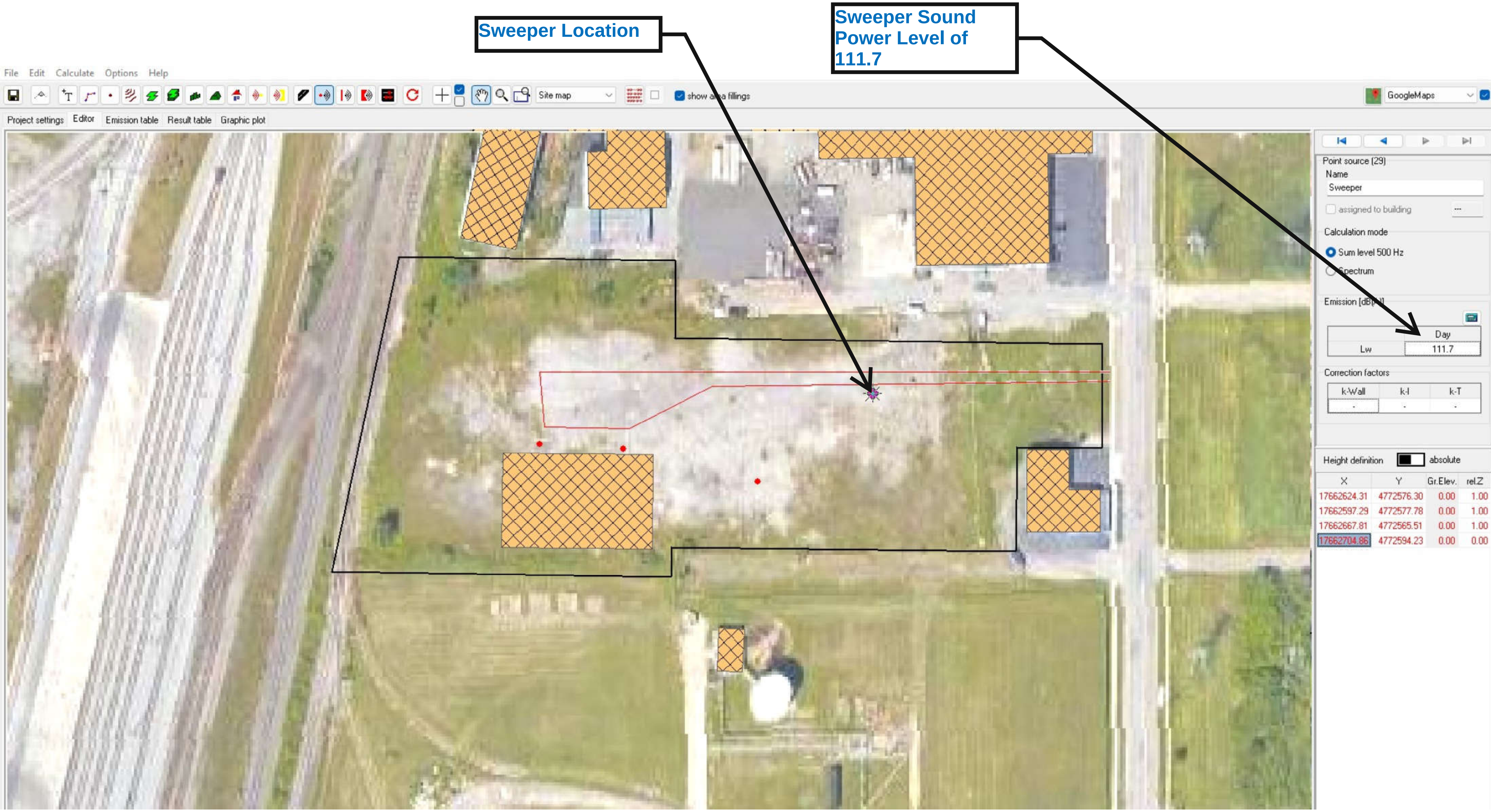
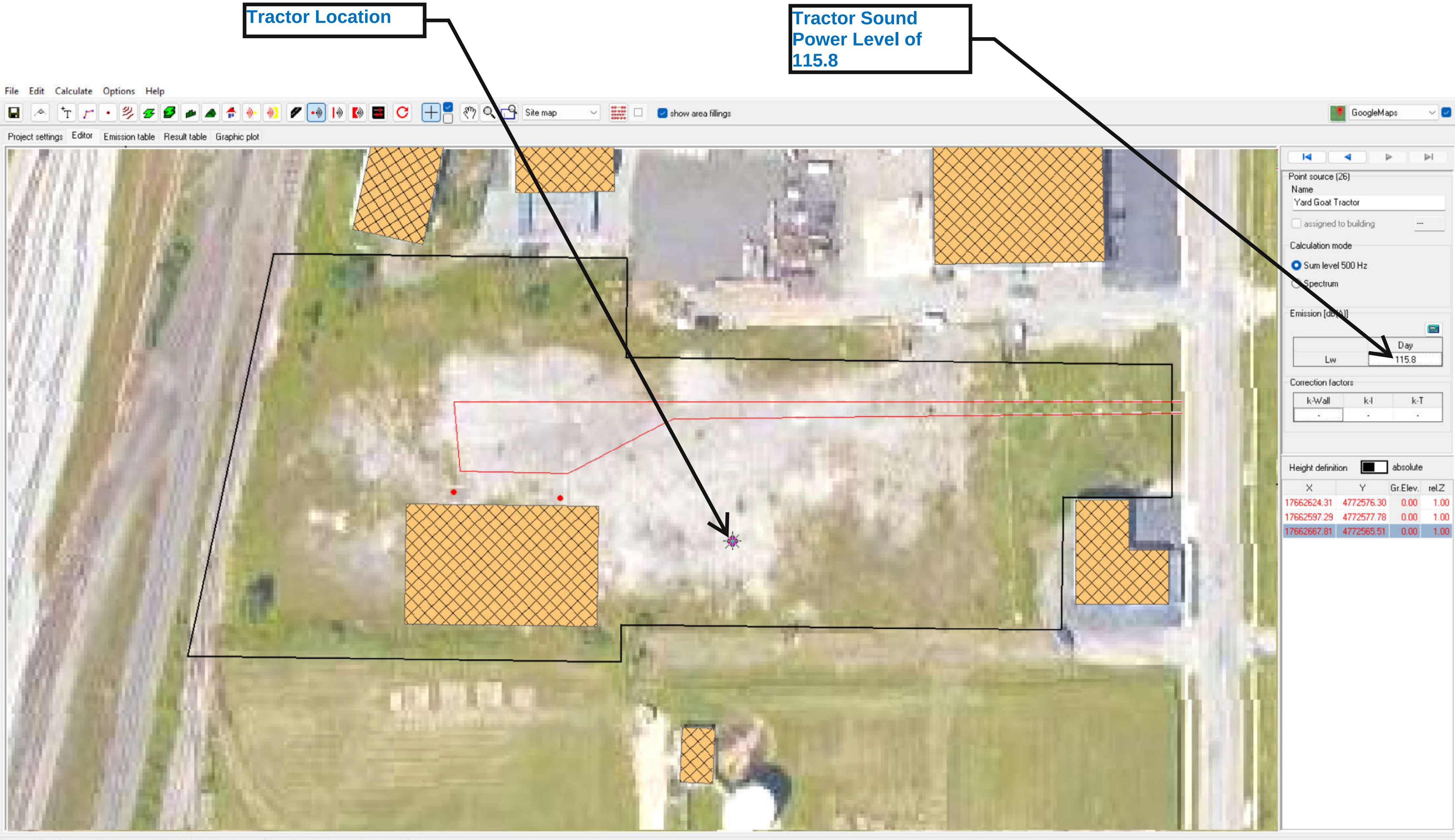
Model Data Entry Screenshots


Excavator Location
Excavator Sound Power Level of 116.7
File Edit Calculate Options Help
Site map
show area fillings
GoogleMaps
Project settings Editor Emission table Result table Graphic plot
Point source (7)
Name
Excavator
assigned to building
Calculation mode
Sum level 500 Hz
Spectrum
Emission [dB(A)]
Day
Lw 116.7
Correction factors
k-Wall k-I k-T
Height definition absolute
X Y Gr.Elev. relZ
17662624.31 4772576.30 0.00 1.00
17662597.29 4772577.78 0.00 1.00
17662667.81 4772565.51 0.00 1.00


Loader Location
Loader Sound Power Level of 111.7
File Edit Calculate Options Help
Site map
show area fillings
GoogleMaps
Project settings Editor Emission table Result table Graphic plot
Point source (6)
Name
Loader
assigned to building
Calculation mode
Emission [dB(A)]
Lw
111.7
Correction factors
k-Wall k-I k-T
Height definition absolute
X Y Gr.Elev. rel.Z
17662624.31 4772576.30 0.00 1.00
17662597.29 4772577.78 0.00 1.00
17662667.81 4772565.51 0.00 1.00
X = 17662804.72 Y = 4772594.03 Z = 0.0 d = 181.27
Select an object or begin a new object


Sweeper Location
Sweeper Sound Power Level of 111.7
File Edit Calculate Options Help
Site map
show area fillings
GoogleMaps
Project settings Editor Emission table Result table Graphic plot
Point source (29)
Name
Sweeper
assigned to building
Calculation mode
Sum level 500 Hz
Spectrum
Day
Lw
111.7
Correction factors
k-Wall
k-I
k-T
Height definition
absolute
X
Y
Gr.Elev.
rel.Z
17662624.31 4772576.30 0.00 1.00
17662597.29 4772577.78 0.00 1.00
17662667.81 4772565.51 0.00 1.00
17662704.86 4772594.23 0.00 0.00


Tractor Location
Tractor Sound Power Level of 115.8
File
Edit
Calculate
Options
Help
Site map
show area fillings
GoogleMaps
Project settings
Editor
Emission table
Result table
Graphic plot
Point source (26)
Name
Yard Goat Tractor
assigned to building
Calculation mode
Sum level 500 Hz
Spectrum
Correction factors
Day
Lw
115.8
k-Wall
k-I
k-T
Height definition
absolute
X
Y
Gr.Elev.
rel.Z
17662624.31
4772576.30
0.00
1.00
17662597.29
4772577.78
0.00
1.00
17662667.81
4772565.51
0.00
1.00
Select an object or begin a new object

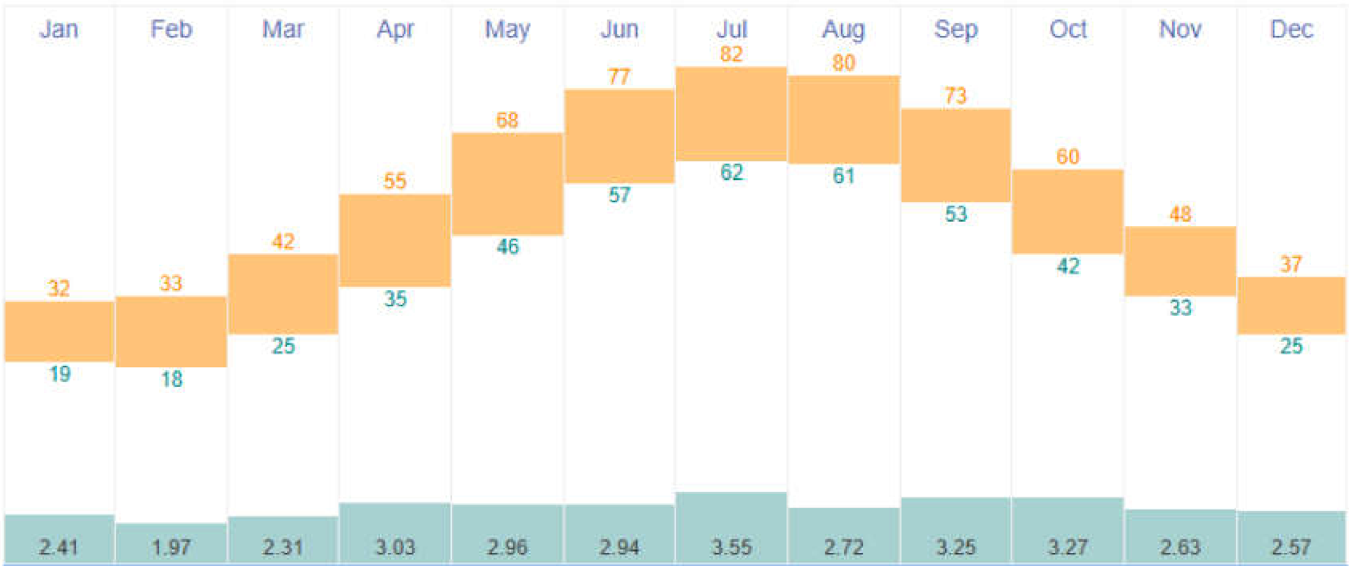
ps://www.timeanddate.com/weather/@5128723/climate

Currently: 70 °F. Sunny. (Weather station: Niagara Falls International Airport, USA). See more current weather ›

Annual Weather Averages Near Niagara Falls

Averages are for Niagara Falls International Airport, which is 6 miles from Niagara Falls.

Based on weather reports collected during 1992–2021.



Showing: All Year

All Year Climate & Weather Averages in Niagara Falls

High Temp: 82 °F	Precipitation: 2.80"	Wind: 17 mph
Low Temp: 18 °F	Humidity: 72%	Pressure: 30.03 "Hg
Mean Temp: 49 °F	Dew Point: 40 °F	Visibility: 10 mi

Quick Climate Info

Hottest Month	July (72
Coldest Month	January
Wettest Month	July (3.5
Windiest Month	January
Annual precip.	33.61" (

Weather by CustomWeather, © 2024

https://www.convertunits.com/from/inhg/to/mbar

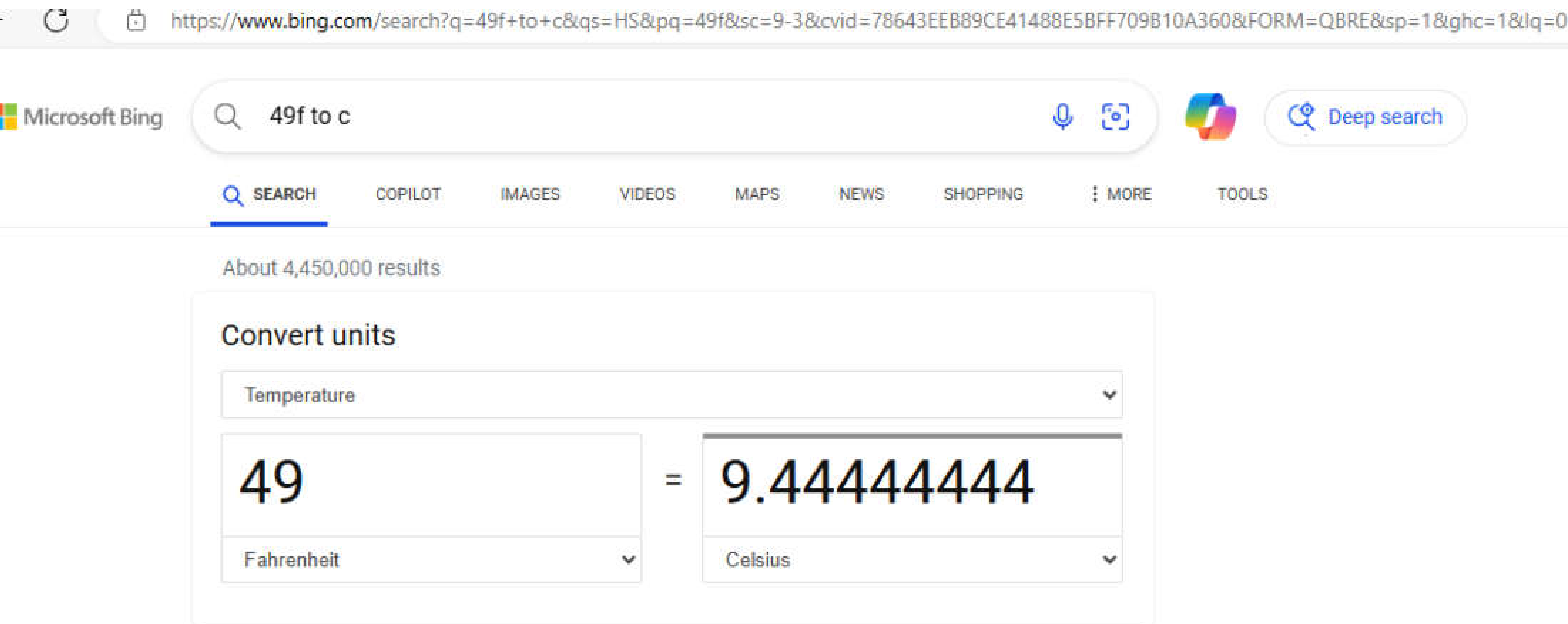
Convert inhg to mbar - Conversion of Measurement Units

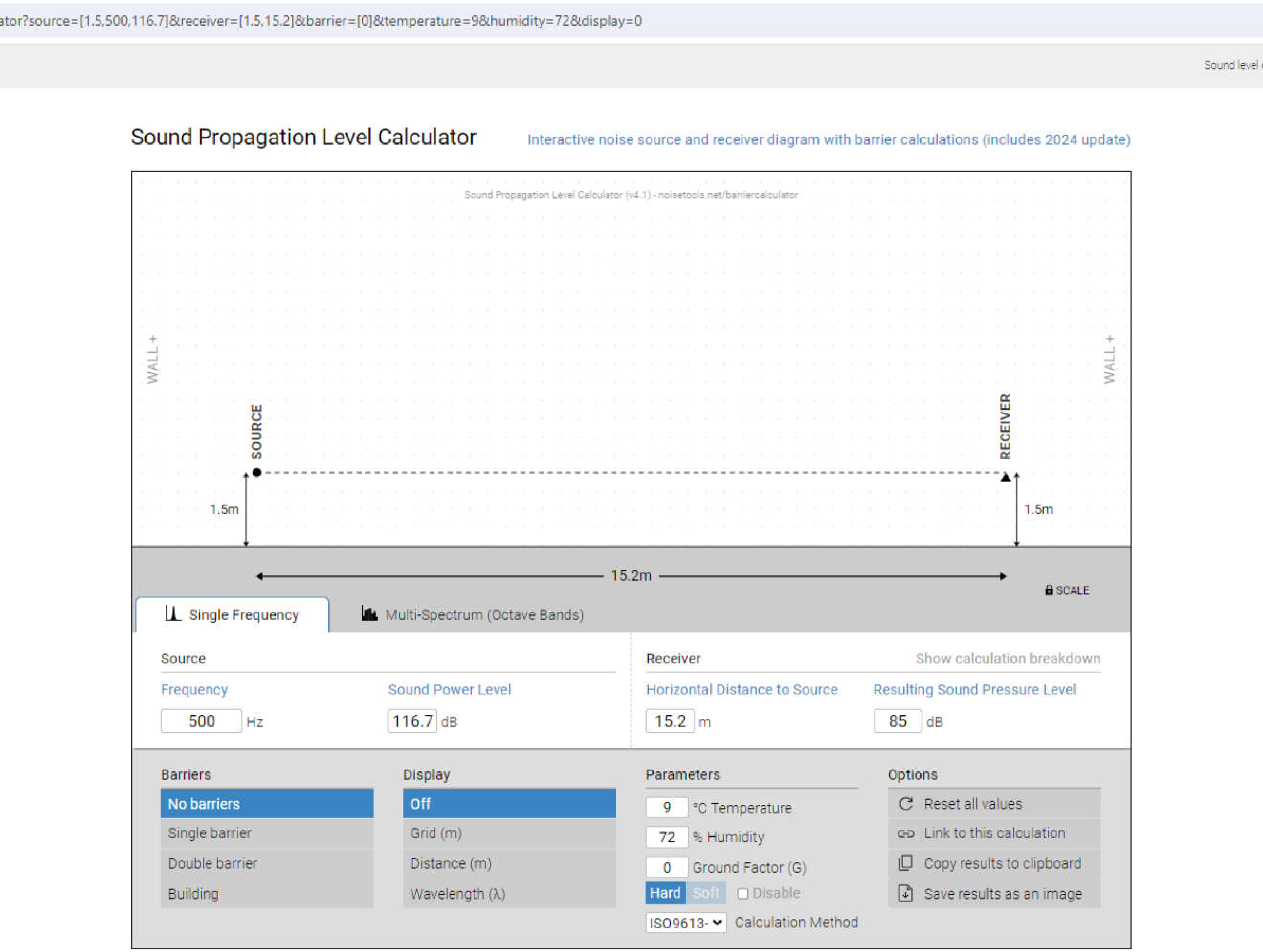
Convert inch of mercury [0 °C] to millibar

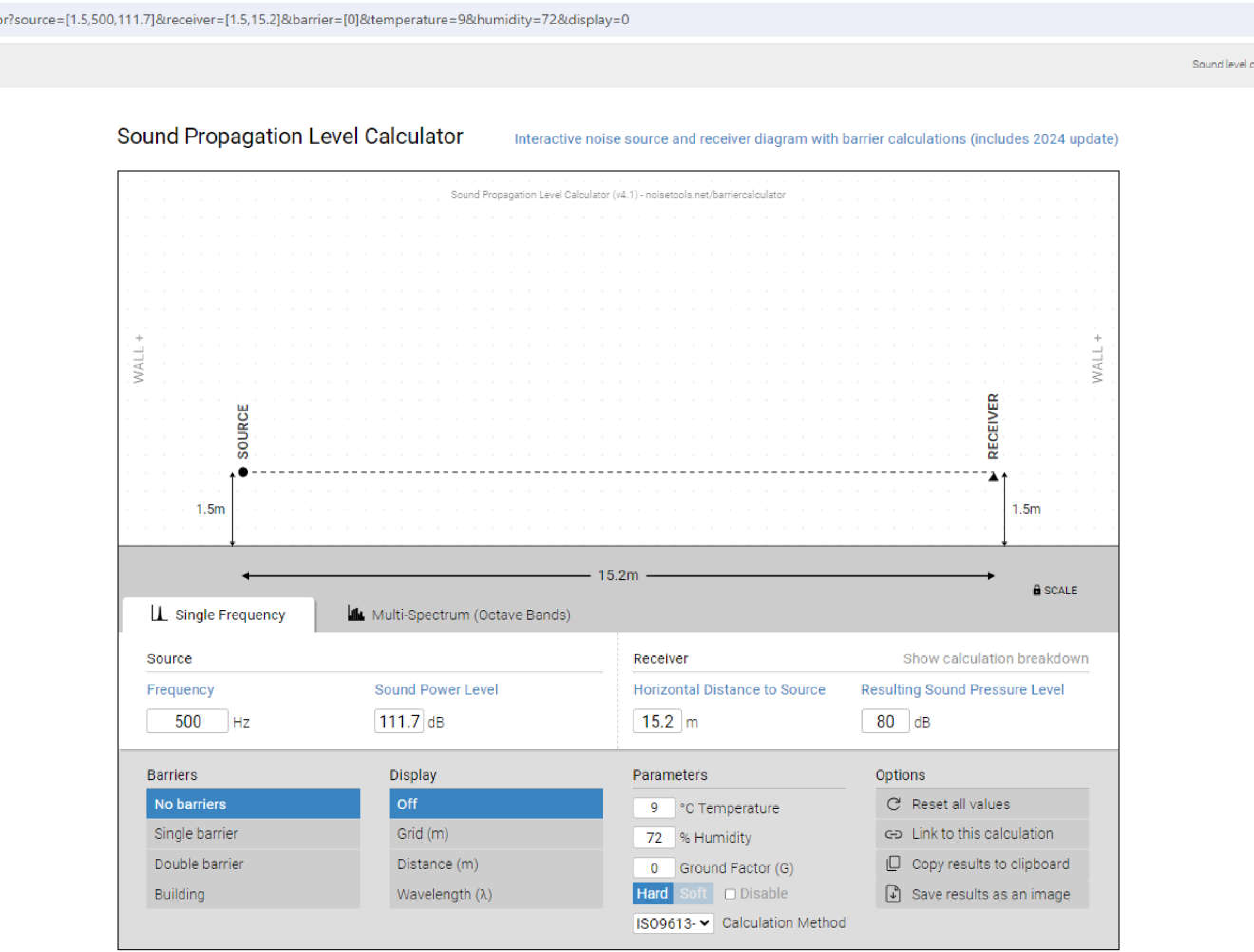
30.03 inhg

1016.93251660001 mbar

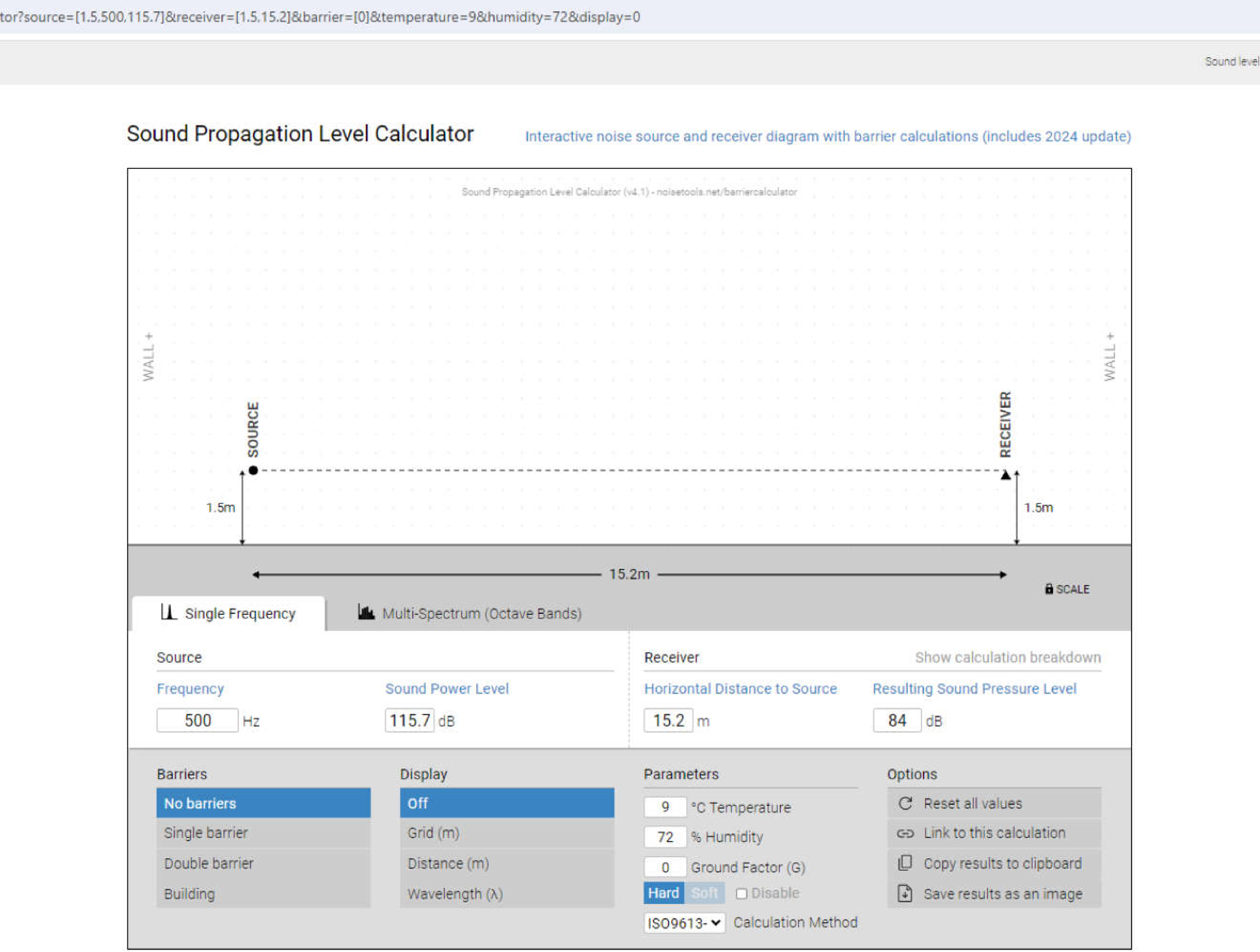
Convert


https://www.bing.com/search?q=49f+to+c&qs=HS&pq=49f&sc=9-3&cvid=78643EEB89CE41488E5BFF709B10A360&FORM=QBRE&sp=1&ghc=1&lq=0
Microsoft Bing
49f to c
Deep search
SEARCH
COPILOT
IMAGES
VIDEOS
MAPS
NEWS
SHOPPING
MORE
TOOLS
About 4,450,000 results
Convert units
Temperature
49
=
9.44444444
Fahrenheit
Celsius


ator?source=[1.5,500,116.7]&receiver=[1.5,15.2]&barrier=[0]&temperature=9&humidity=72&display=0
Sound level
Sound Propagation Level Calculator
Interactive noise source and receiver diagram with barrier calculations (includes 2024 update)
Sound Propagation Level Calculator (v4.1) - noisetools.net/barriercalculator
WALL +
WALL +
SOURCE
RECEIVER
1.5m
1.5m
15.2m
SCALE
Single Frequency
Multi-Spectrum (Octave Bands)
Source
Frequency
500 Hz
Sound Power Level
116.7 dB
Receiver
Show calculation breakdown
Horizontal Distance to Source
15.2 m
Resulting Sound Pressure Level
85 dB
Barriers
No barriers
Single barrier
Double barrier
Building
Display
Off
Grid (m)
Distance (m)
Wavelength (λ)
Parameters
9 °C Temperature
72 % Humidity
0 Ground Factor (G)
Hard
Soft
Disable
ISO9613-
Calculation Method
Options
Reset all values
Link to this calculation
Copy results to clipboard
Save results as an image



r?source=[1.5,500,111.7]&receiver=[1.5,15.2]&barrier=[0]&temperature=9&humidity=72&display=0
Sound Propagation Level Calculator
Interactive noise source and receiver diagram with barrier calculations (includes 2024 update)
Sound Propagation Level Calculator (v4.1) - noisetools.net/barriercalculator
WALL +
WALL +
SOURCE
RECEIVER
1.5m
1.5m
15.2m
SCALE
Single Frequency
Multi-Spectrum (Octave Bands)
Source
Frequency
500 Hz
Sound Power Level
111.7 dB
Receiver
Show calculation breakdown
Horizontal Distance to Source
15.2 m
Resulting Sound Pressure Level
80 dB
Barriers
No barriers
Single barrier
Double barrier
Building
Display
Off
Grid (m)
Distance (m)
Wavelength (λ)
Parameters
9 °C Temperature
72 % Humidity
0 Ground Factor (G)
Hard Soft Disable
ISO9613- Calculation Method
Options
Reset all values
Link to this calculation
Copy results to clipboard
Save results as an image


tor?source=[1.5,500,115.7]&receiver=[1.5,15.2]&barrier=[0]&temperature=9&humidity=72&display=0
Sound level
Sound Propagation Level Calculator
Interactive noise source and receiver diagram with barrier calculations (includes 2024 update)
Sound Propagation Level Calculator (v4.1) - noisetools.net/barriercalculator
WALL +
WALL +
SOURCE
RECEIVER
1.5m
1.5m
15.2m
SCALE
Single Frequency
Multi-Spectrum (Octave Bands)
Source
Frequency
500 Hz
Sound Power Level
115.7 dB
Receiver
Show calculation breakdown
Horizontal Distance to Source
15.2 m
Resulting Sound Pressure Level
84 dB
Barriers
No barriers
Single barrier
Double barrier
Building
Display
Off
Grid (m)
Distance (m)
Wavelength (λ)
Parameters
9 °C Temperature
72 % Humidity
0 Ground Factor (G)
Hard Soft Disable
ISO9613- Calculation Method
Options
Reset all values
Link to this calculation
Copy results to clipboard
Save results as an image

Attachment 4

EnSol, Inc.

ENGINEERING + ENVIRONMENTAL

International Standard ISO 9613-2: Attenuation of Sound During Propagation Outdoors

INTERNATIONAL STANDARD

ISO 9613-2

First edition
1996-12-15

Acoustics — Attenuation of sound during propagation outdoors —

Part 2:
General method of calculation

Acoustique — Atténuation du son lors de sa propagation à l'air libre —

Partie 2: Méthode générale de calcul

Reference number
ISO 9613-2:1996(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9613-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

ISO 9613 consists of the following parts, under the general title *Acoustics — Attenuation of sound during propagation outdoors:*

— *Part 1: Calculation of the absorption of sound by the atmosphere*

— *Part 2: General method of calculation*

Part 1 is a detailed treatment restricted to the attenuation by atmospheric absorption processes. Part 2 is a more approximate and empirical treatment of a wider subject — the attenuation by all physical mechanisms.

Annexes A and B of this part of ISO 9613 are for information only.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Introduction

The ISO 1996 series of standards specifies methods for the description of noise outdoors in community environments. Other standards, on the other hand, specify methods for determining the sound power levels emitted by various noise sources, such as machinery and specified equipment (ISO 3740 series), or industrial plants (ISO 8297). This part of ISO 9613 is intended to bridge the gap between these two types of standard, to enable noise levels in the community to be predicted from sources of known sound emission. The method described in this part of ISO 9613 is general in the sense that it may be applied to a wide variety of noise sources, and covers most of the major mechanisms of attenuation. There are, however, constraints on its use, which arise principally from the description of environmental noise in the ISO 1996 series of standards.

Acoustics — Attenuation of sound during propagation outdoors —

Part 2:
General method of calculation

1 Scope

This part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level (as described in parts 1 to 3 of ISO 1996) under meteorological conditions favourable to propagation from sources of known sound emission.

These conditions are for downwind propagation, as specified in 5.4.3.3 of ISO 1996-2:1987 or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night. Inversion conditions over water surfaces are not covered and may result in higher sound pressure levels than predicted from this part of ISO 9613.

The method also predicts a long-term average A-weighted sound pressure level as specified in ISO 1996-1 and ISO 1996-2. The long-term average A-weighted sound pressure level encompasses levels for a wide variety of meteorological conditions.

The method specified in this part of ISO 9613 consists specifically of octave-band algorithms (with nominal midband frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound which originates from a point sound source, or an assembly of point sources. The source (or sources) may be moving or stationary. Specific terms are provided in the algorithms for the following physical effects:

- geometrical divergence;
- atmospheric absorption;
- ground effect;
- reflection from surfaces;
- screening by obstacles.

Additional information concerning propagation through housing, foliage and industrial sites is given in annex A.

This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground-based noise sources. It does not apply to sound from aircraft in flight, or to blast waves from mining, military or similar operations.

To apply the method of this part of ISO 9613, several parameters need to be known with respect to the geometry of the source and of the environment, the ground surface characteristics, and the source strength in terms of octave-band sound power levels for directions relevant to the propagation.

NOTE 1 If only A-weighted sound power levels of the sources are known, the attenuation terms for 500 Hz may be used to estimate the resulting attenuation.

The accuracy of the method and the limitations to its use in practice are described in clause 9.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9613. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9613 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1996-1:1982, *Acoustics — Description and measurement of environmental noise — Part 1: Basic quantities and procedures.*

ISO 1996-2:1987, *Acoustics — Description and measurement of environmental noise — Part 2: Acquisition of data pertinent to land use.*

ISO 1996-3:1987, *Acoustics — Description and measurement of environmental noise — Part 3: Application to noise limits.*

ISO 9613-1:1993, *Acoustics — Attenuation of sound during propagation outdoors — Part 1: Calculation of the absorption of sound by the atmosphere.*

IEC 651:1979, *Sound level meters,* and Amendment 1:1993.

3 Definitions

For the purposes of this part of ISO 9613, the definitions given in ISO 1996-1 and the following definitions apply. (See table 1 for symbols and units.)

3.1 equivalent continuous A-weighted sound pressure level, L_{AT}: Sound pressure level, in decibels, defined by equation (1):

$$L_{AT} = 10 \lg \left\{ \left[(1/T) \int_0^T p_A^2(t)\, dt \right] \Big/ p_0^2 \right\} \text{ dB} \qquad \ldots (1)$$

where

$p_A(t)$ is the instantaneous A-weighted sound pressure, in pascals;

p_0 is the reference sound pressure ($= 20 \times 10^{-6}$ Pa);

T is a specified time interval, in seconds.

The A-frequency weighting is that specified for sound level meters in IEC 651.

NOTE 2 The time interval T should be long enough to average the effects of varying meteorological parameters. Two different situations are considered in this part of ISO 9613, namely short-term downwind and long-term overall averages.

Table 1 — Symbols and units

Symbol	Definition	Unit
A	octave-band attenuation	dB
C_{met}	meteorological correction	dB
d	distance from point source to receiver (see figure 3)	m
d_p	distance from point source to receiver projected onto the ground plane (see figure 1)	m
$d_{s,o}$	distance between source and point of reflection on the reflecting obstacle (see figure 8)	m
$d_{o,r}$	distance between point of reflection on the reflecting obstacle and receiver (see figure 8)	m
d_{ss}	distance from source to (first) diffraction edge (see figures 6 and 7)	m
d_{sr}	distance from (second) diffraction edge to receiver (see figures 6 and 7)	m
D_I	directivity index of the point sound source	—
D_z	screening attenuation	—
e	distance between the first and second diffraction edge (see figure 7)	m
G	ground factor	—
h	mean height of source and receiver	m
h_s	height of point source above ground (see figure 1)	m
h_r	height of receiver above ground (see figure 1)	m
h_m	mean height of the propagation path above the ground (see figure 3)	m
H_{max}	largest dimension of the sources	m
l_{min}	minimum dimension (length or height) of the reflecting plane (see figure 8)	m
L	sound pressure level	dB
α	atmospheric attenuation coefficient	dB/km
β	angle of incidence	rad
ρ	sound reflection coefficient	—

3.2 equivalent continuous downwind octave-band sound pressure level, L_{fT}(DW): Sound pressure level, in decibels, defined by equation (2):

$$L_{fT}(\mathrm{DW}) = 10\lg\left\{\left[(1/T)\int_0^T p_f^2(t)\,\mathrm{d}t\right]\Big/p_0^2\right\} \quad \mathrm{dB} \qquad \ldots (2)$$

where $p_f(t)$ is the instantaneous octave-band sound pressure downwind, in pascals, and the subscript f represents a nominal midband frequency of an octave-band filter.

NOTE 3 The electrical characteristics of the octave-band filters should comply at least with the class 2 requirements of IEC 1260.

3.3 insertion loss (of a barrier)**:** Difference, in decibels, between the sound pressure levels at a receiver in a specified position under two conditions:

a) with the barrier removed, and

b) with the barrier present (inserted),

and no other significant changes that affect the propagation of sound.

4 Source description

The equations to be used are for the attenuation of sound from point sources. Extended noise sources, therefore, such as road and rail traffic or an industrial site (which mav include several installations or plants, together with traffic moving on the site) shall be represented by a set of sections (cells), each having a certain sound power and directivity. Attenuation calculated for sound from a representative point within a section is used to represent the attenuation of sound from the entire section. A line source may be divided into line sections, an area source into area sections, each represented by a point source at its centre.

However, a group of point sources may be described by an equivalent point sound source situated in the middle of the group, in particular if

a) the sources have approximately the same strength and height above the local ground plane,

b) the same propagation conditions exist from the sources to the point of reception, and

c) the distance d from the single equivalent point source to the receiver exceeds twice the largest dimension H_{max} of the sources ($d > 2H_{max}$).

If the distance d is smaller ($d \leqslant 2H_{max}$), or if the propagation conditions for the component point sources are different (e.g. due to screening), the total sound source shall be divided into its component point sources.

NOTE 4 In addition to the real sources described above, image sources will be introduced to describe the reflection of sound from walls and ceilings (but not by the ground), as described in 7.5.

5 Meteorological conditions

Downwind propagation conditions for the method specified in this part of ISO 9613 are as specified in 5.4.3.3 of ISO 1996-2:1987, namely

— wind direction within an angle of ± 45° of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region, with the wind blowing from source to receiver, and

— wind speed between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground.

The equations for calculating the average downwind sound pressure level L_{AT}(DW) in this part of ISO 9613, including the equations for attenuation given in clause 7, are the average for meteorological conditions within these limits. The term average here means the average over a short time interval, as defined in 3.1.

These equations also hold, equivalently, for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights.

6 Basic equations

The equivalent continuous downwind octave-band sound pressure level at a receiver location, L_{fT}(DW), shall be calculated for each point source, and its image sources, and for the eight octave bands with nominal midband frequencies from 63 Hz to 8 kHz, from equation (3):

$$L_{fT}(\mathrm{DW}) = L_W + D_c - A \qquad \ldots (3)$$

where

L_W is the octave-band sound power level, in decibels, produced by the point sound source relative to a reference sound power of one picowatt (1 pW);

D_c is the directivity correction, in decibels, that describes the extent by which the equivalent continuous sound pressure level from the point sound source deviates in a specified direction from the level of an omnidirectional point sound source producing sound power level L_W; D_c equals the directivity index D_I of the point sound source plus an index D_Ω that accounts for sound propagation into solid angles less than 4π steradians; for an omnidirectional point sound source radiating into free space, D_c = 0 dB;

A is the octave-band attenuation, in decibels, that occurs during propagation from the point sound source to the receiver.

NOTES

5 The letter symbol A (in italic type) signifies attenuation in this part of ISO 9613 except in subscripts, where it designates the A-frequency weighting (in roman type).

6 Sound power levels in equation (3) may be determined from measurements, for example as described in the ISO 3740 series (for machinery) or in ISO 8297 (for industrial plants).

The attenuation term A in equation (3) is given by equation (4):

$$A = A_{\mathrm{div}} + A_{\mathrm{atm}} + A_{\mathrm{gr}} + A_{\mathrm{bar}} + A_{\mathrm{misc}} \qquad \text{... (4)}$$

where

A_{div} is the attenuation due to geometrical divergence (see 7.1);

A_{atm} is the attenuation due to atmospheric absorption (see 7.2);

A_{gr} is the attenuation due to the ground effect (see 7.3);

A_{bar} is the attenuation due to a barrier (see 7.4);

A_{misc} is the attenuation due to miscellaneous other effects (see annex A).

General methods for calculating the first four terms in equation (4) are specified in this part of ISO 9613. Information on three contributions to the last term, A_{misc} (the attenuation due to propagation through foliage, industrial sites and areas of houses), is given in annex A.

The equivalent continuous A-weighted downwind sound pressure level shall be obtained by summing the contributing time-mean-square sound pressures calculated according to equations (3) and (4) for each point sound source, for each of their image sources, and for each octave band, as specified by equation (5):

$$L_{AT}(\mathrm{DW}) = 10 \lg \left\{ \sum_{i=1}^{n} \left[\sum_{j=1}^{8} 10^{0,1\left[L_{fT}(ij) + A_f(j)\right]} \right] \right\} \ \mathrm{dB} \qquad \text{... (5)}$$

where

n is the number of contributions i (sources and paths);

j is an index indicating the eight standard octave-band midband frequencies from 63 Hz to 8 kHz;

A_f denotes the standard A-weighting (see IEC 651).

The long-term average A-weighted sound pressure level L_{AT}(LT) shall be calculated according to

$$L_{AT}(\mathrm{LT}) = L_{AT}(\mathrm{DW}) - C_{\mathrm{met}} \qquad \text{... (6)}$$

where C_{met} is the meteorological correction described in clause 8.

The calculation and significance of the various terms in equations (1) to (6) are explained in the following clauses. For a more detailed treatment of the attenuation terms, see the literature references given in annex B.

7 Calculation of the attenuation terms

7.1 Geometrical divergence (A_{div})

The geometrical divergence accounts for spherical spreading in the free field from a point sound source, making the attenuation, in decibels, equal to

$$A_{\mathrm{div}} = \left[20 \lg(d/d_0) + 11\right] \ \mathrm{dB} \qquad \text{... (7)}$$

where

d is the distance from the source to receiver, in metres;

d_0 is the reference distance (= 1 m).

NOTE 7 The constant in equation (7) relates the sound power level to the sound pressure level at a reference distance d_0 which is 1 m from an omnidirectional point sound source.

7.2 Atmospheric absorption (A_{atm})

The attenuation due to atmospheric absorption A_{atm}, in decibels, during propagation through a distance d, in metres, is given by equation (8):

$$A_{atm} = \alpha d / 1\,000 \qquad \ldots (8)$$

where α is the atmospheric attenuation coefficient, in decibels per kilometre, for each octave band at the midband frequency (see table 2).

For values of α at atmospheric conditions not covered in table 2, see ISO 9613-1.

NOTES

8 The atmospheric attenuation coefficient depends strongly on the frequency of the sound, the ambient temperature and relative humidity of the air, but only weakly on the ambient pressure.

9 For calculation of environmental noise levels, the atmospheric attenuation coefficient should be based on average values determined by the range of ambient weather which is relevant to the locality.

7.3 Ground effect (A_{gr})

7.3.1 General method of calculation

Ground attenuation, A_{gr}, is mainly the result of sound reflected by the ground surface interfering with the sound propagating directly from source to receiver. The downward-curving propagation path (downwind) ensures that this attenuation is determined primarily by the ground surfaces near the source and near the receiver. This method of calculating the ground effect is applicable only to ground which is approximately flat, either horizontally or with a constant slope. Three distinct regions for ground attenuation are specified (see figure 1):

a) the source region, stretching over a distance from the source towards the receiver of $30h_s$, with a maximum distance of d_p (h_s is the source height, and d_p the distance from source to receiver, as projected on the ground plane);

b) the receiver region, stretching over a distance from the receiver back towards the source of $30h_r$, with a maximum distance of d_p (h_r is the receiver height);

c) a middle region, stretching over the distance between the source and receiver regions. If $d_p < (30h_s + 30h_r)$, the source and receiver regions will overlap, and there is no middle region.

According to this scheme, the ground attenuation does not increase with the size of the middle region, but is mostly dependent on the properties of source and receiver regions.

The acoustical properties of each ground region are taken into account through a ground factor G. Three categories of reflecting surface are specified as follows.

Table 2 — Atmospheric attenuation coefficient α for octave bands of noise

Temperature	Relative humidity	Atmospheric attenuation coefficient α, dB/km							
		Nominal midband frequency, Hz							
°C	%	63	125	250	500	1 000	2 000	4 000	8 000
10	70	0,1	0,4	1,0	1,9	3,7	9,7	32,8	117
20	70	0,1	0,3	1,1	2,8	5,0	9,0	22,9	76,6
30	70	0,1	0,3	1,0	3,1	7,4	12,7	23,1	59,3
15	20	0,3	0,6	1,2	2,7	8,2	28,2	88,8	202
15	50	0,1	0,5	1,2	2,2	4,2	10,8	36,2	129
15	80	0,1	0,3	1,1	2,4	4,1	8,3	23,7	82,8

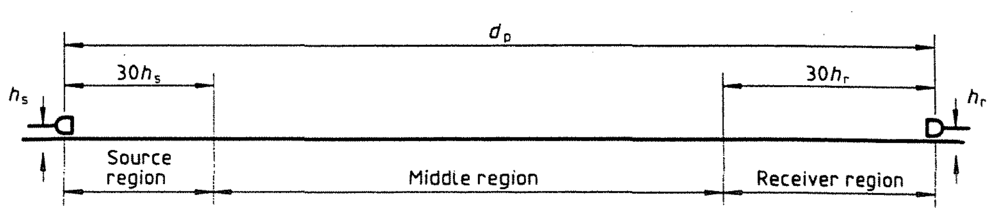


Figure 1 — Three distinct regions for determination of ground attenuation

a) **Hard ground,** which includes paving, water, ice, concrete and all other ground surfaces having a low porosity. Tamped ground, for example, as often occurs around industrial sites, can be considered hard. For hard ground $G = 0$.

   NOTE 10 It should be recalled that inversion conditions over water are not covered by this part of ISO 9613.

b) **Porous ground,** which includes ground covered by grass, trees or other vegetation, and all other ground surfaces suitable for the growth of vegetation, such as farming land. For porous ground $G = 1$.

c) **Mixed ground:** if the surface consists of both hard and porous ground, then G takes on values ranging from 0 to 1, the value being the fraction of the region that is porous.

To calculate the ground attenuation for a specific octave band, first calculate the component attenuations A_s for the source region specified by the ground factor G_s (for that region), A_r for the receiver region specified by the ground factor G_r, and A_m for the middle region specified by the ground factor G_m, using the expressions in table 3. (Alternatively, the functions a', b', c' and d' in table 3 may be obtained directly from the curves in figure 2.) The total ground attenuation for that octave band shall be obtained from equation (9):

$$A_{gr} = A_s + A_r + A_m \qquad \ldots (9)$$

NOTE 11 In regions with buildings, the influence of the ground on sound propagation may be changed (see A.3).

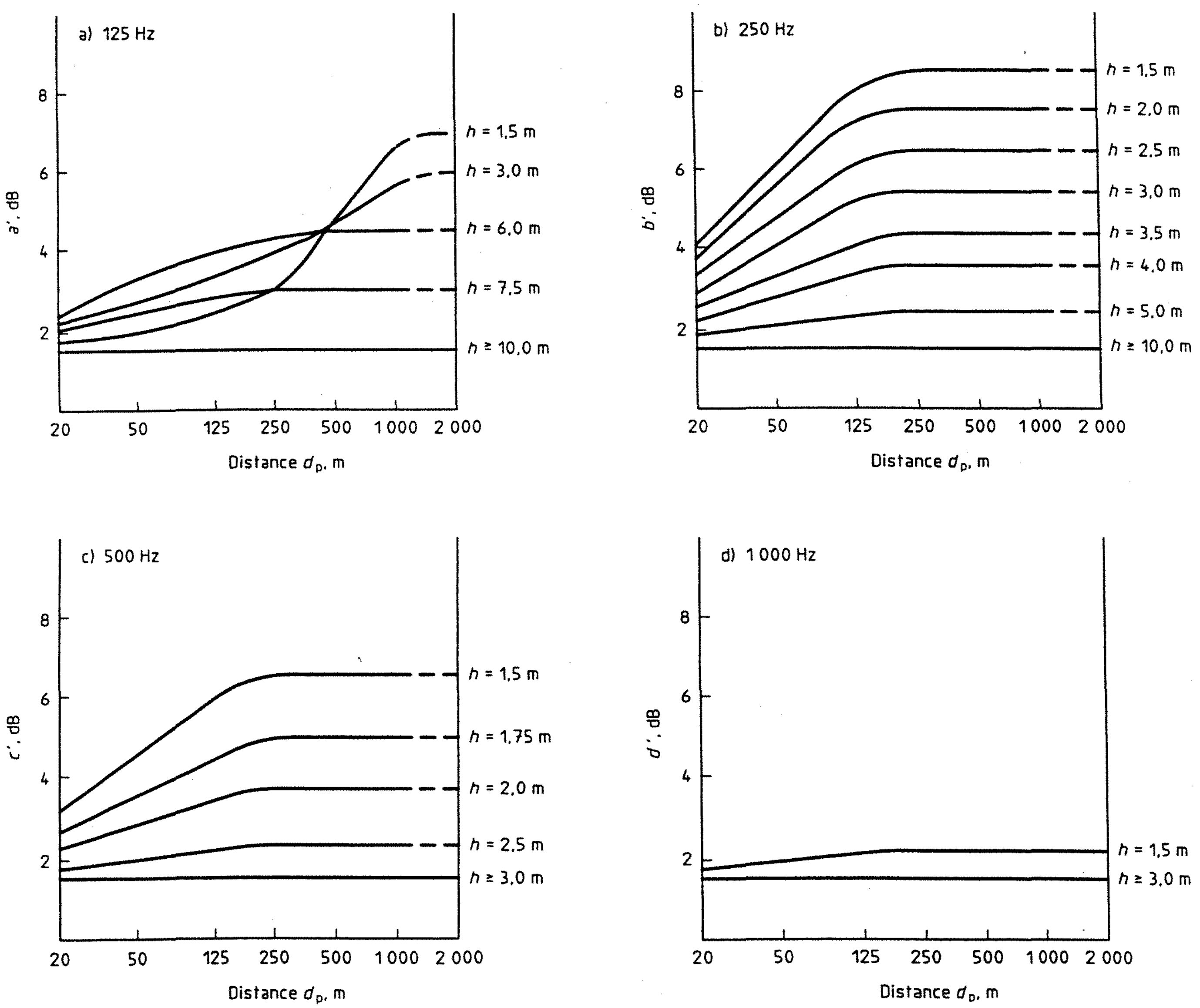


Figure 2 — Functions a', b', c' and d' representing the influence of the source-to-receiver distance d_p and the source or receiver height h, respectively, on the ground attenuation A_{gr} (computed from equations in table 3)

Table 3 — Expressions to be used for calculating ground attenuation contributions A_s, A_r and A_m in octave bands

Nominal midband frequency Hz	A_s or A_r 1) dB	A_m dB
63	$-1,5$	$-3q$ 2)
125	$-1,5 + G \times a'(h)$	$-3q(1 - G_m)$
250	$-1,5 + G \times b'(h)$	
500	$-1,5 + G \times c'(h)$	
1 000	$-1,5 + G \times d(h)$	
2 000	$-1,5(1 - G)$	
4 000	$-1,5(1 - G)$	
8 000	$-1,5(1 - G)$	

NOTES

$$a'(h) = 1,5 + 3,0 \times e^{-0,12(h-5)^2}\left(1 - e^{-d_p/50}\right) + 5,7 \times e^{-0,09h^2}\left(1 - e^{-2,8 \times 10^{-6} \times d_p^2}\right)$$

$$b'(h) = 1,5 + 8,6 \times e^{-0,09h^2}\left(1 - e^{-d_p/50}\right)$$

$$c'(h) = 1,5 + 14,0 \times e^{-0,46h^2}\left(1 - e^{-d_p/50}\right)$$

$$d'(h) = 1,5 + 5,0 \times e^{-0,9h^2}\left(1 - e^{-d_p/50}\right)$$

1) For calculating A_s, take $G = G_s$ and $h = h_s$. For calculating A_r, take $G = G_r$ and $h = h_r$. See 7.3.1 for values of G for various ground surfaces.

2) $q = 0$ when $d_p \leqslant 30(h_s + h_r)$

$$q = 1 - \frac{30(h_s + h_r)}{d_p} \quad \text{when } d_p > 30(h_s + h_r)$$

where d_p is the source-to-receiver distance, in metres, projected onto the ground planes.

7.3.2 Alternative method of calculation for A-weighted sound pressure levels

Under the following specific conditions

- only the A-weighted sound pressure level at the receiver position is of interest,
- the sound propagation occurs over porous ground or mixed ground most of which is porous (see 7.3.1),
- the sound is not a pure tone,

and for ground surfaces of any shape, the ground attenuation may be calculated from equation (10):

$$A_{gr} = 4,8 - (2h_m/d)\left[17 + (300/d)\right] \geqslant 0 \text{ dB} \quad \ldots (10)$$

where

h_m is the mean height of the propagation path above the ground, in metres;

d is the distance from the source to receiver, in metres.

The mean height h_m may be evaluated by the method shown in figure 3. Negative values for A_{gr} from equation (10) shall be replaced by zeros.

NOTE 12 For short distances d, equation (10) predicts no attenuation and equation (9) may be more accurate.

When the ground attenuation is calculated using equation (10), the directivity correction D_c in equation (3) shall include a term D_Ω, in decibels, to account for the apparent increase in sound power level of the source due to reflections from the ground near the source.

$$D_\Omega = 10 \lg \left\{1 + \left[d_p^2 + (h_s - h_r)^2\right] \Big/ \left[d_p^2 + (h_s + h_r)^2\right]\right\} \text{ dB} \quad \ldots (11)$$

where

h_s is the height of the source above the ground, in metres;

h_r is the height of the receiver above the ground, in metres;

d_p is the source-to-receiver distance projected onto the ground plane, in metres.

7.4 Screening (A_{bar})

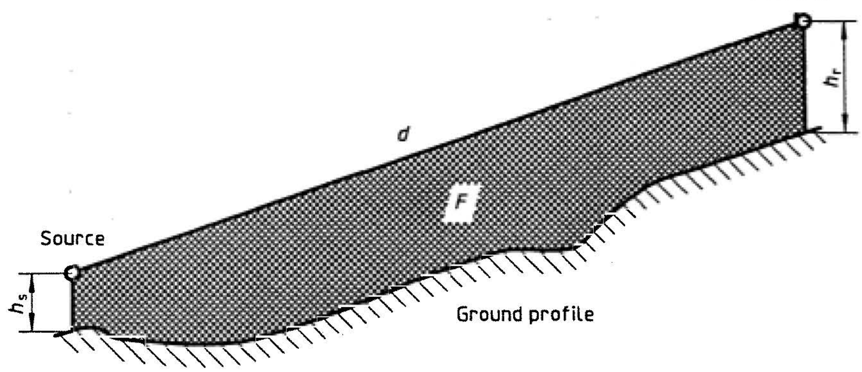
An object shall be taken into account as a screening obstacle (often called a barrier) if it meets the following requirements:

— the surface density is at least 10 kg/m²;

— the object has a closed surface without large cracks or gaps (consequently process installations in chemical plants, for example, are ignored);

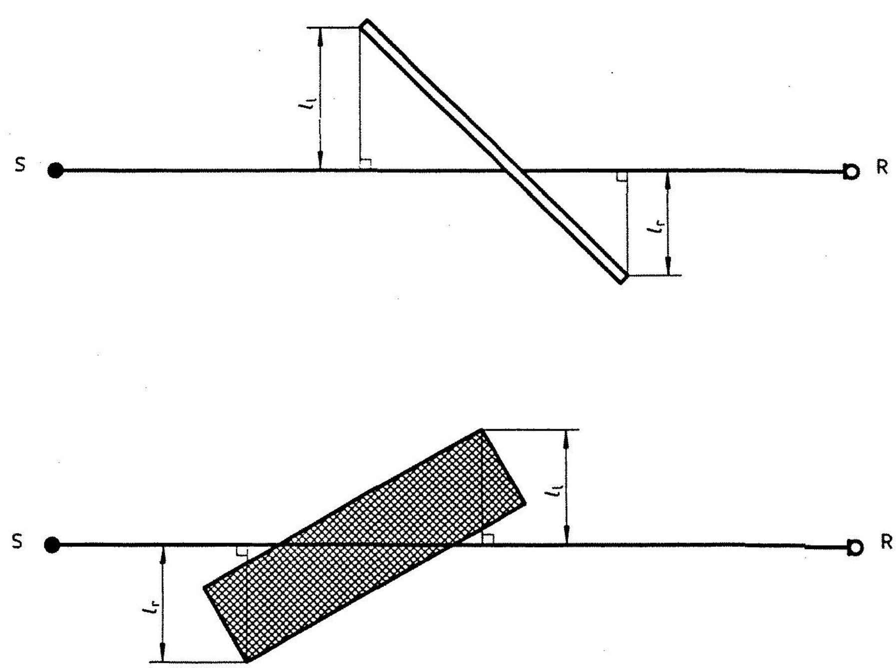
— the horizontal dimension of the object normal to the source-receiver line is larger than the acoustic wavelength λ at the nominal midband frequency for the octave band of interest; in other words $l_l + l_r > \lambda$ (see figure 4).

Each object that fulfils these requirements shall be represented by a barrier with vertical edges. The top edge of the barrier is a straight line that may be sloping.



$h_m = F/d$, where F is the area

Figure 3 — Method for evaluating the mean height h_m



NOTE — An object is only considered to be a screening obstacle when its horizontal dimension perpendicular to the source-receiver line SR is larger than the wavelength: $(l_l + l_r) > \lambda$

Figure 4 — Plan view of two obstacles between the source (S) and the receiver (R)

For the purposes of this part of ISO 9613, the attenuation by a barrier, A_{bar}, shall be given by the insertion loss. Diffraction over the top edge and around a vertical edge of a barrier may both be important. (See figure 5.) For downwind sound propagation, the effect of diffraction (in decibels) over the top edge shall be calculated by

$$A_{bar} = D_z - A_{gr} > 0 \quad \ldots (12)$$

and for diffraction around a vertical edge by

$$A_{bar} = D_z > 0 \quad \ldots (13)$$

where

D_z is the barrier attenuation for each octave band [see equation (14)];

A_{gr} is the ground attenuation **in the absence of the barrier** (i.e. with the screening obstacle removed) (see 7.3).

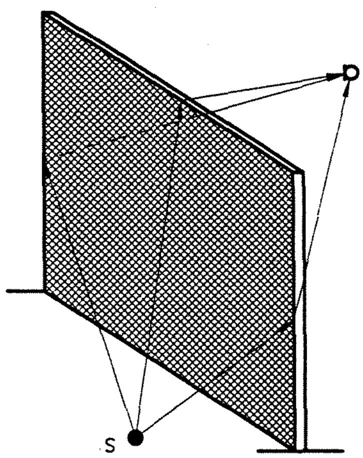


Figure 5 — Different sound propagation paths at a barrier

NOTES

13 When A_{bar} as defined by equation (12) is substituted in equation (4) to find the total attenuation A, the two A_{gr} terms in equation (4) will cancel. The barrier attenuation D_z in equation (12) then includes the effect of the ground in the presence of the barrier.

14 For large distances and high barriers, the insertion loss calculated by equation (12) is not sufficiently confirmed by measurements.

15 In calculation of the insertion loss for multisource industrial plants by high buildings (more than 10 m above the ground), and also for high-noise sources within the plant, equation (13) should be used in both cases for determining the long-term average sound pressure level [using equation (6)].

16 For sound from a depressed highway, there may be attenuation in addition to that indicated by equation (12) along a ground surface outside the depression, due to that ground surface.

To calculate the barrier attenuation D_z, assume that only one significant sound-propagation path exists from the sound source to the receiver. If this assumption is not valid, separate calculations are required for other propagation paths (as illustrated in figure 5) and the contributions from the various paths to the squared sound pressure at the receiver are summed.

The barrier attenuation D_z, in decibels, shall be calculated for this path by equation (14):

$$D_z = 10 \lg \left[3 + (C_2/\lambda) C_3 z K_{met}\right] \text{ dB} \quad \ldots (14)$$

where

C_2 is equal to 20, and includes the effect of ground reflections; if in special cases ground reflections are taken into account separately by image sources, $C_2 = 40$;

C_3 is equal to 1 for single diffraction (see figure 6);

$$C_3 = \left[1 + (5\lambda/e)^2\right] \Big/ \left[(1/3) + (5\lambda/e)^2\right] \quad \ldots (15)$$

for double diffraction (see figure 7);

λ is the wavelength of sound at the nominal midband frequency of the octave band, in metres;

z is the difference between the pathlengths of diffracted and direct sound, as calculated by equations (16) and (17), in metres;

K_{met} is the correction factor for meteorological effects, given by equation (18);

e is the distance between the two diffraction edges in the case of double diffraction (see figure 7).

For single diffraction, as shown in figure 6, the pathlength difference z shall be calculated by means of equation (16):

$$z = \left[(d_{ss} + d_{sr})^2 + a^2\right]^{1/2} - d \quad \ldots (16)$$

where

d_{ss} is the distance from the source to the (first) diffraction edge, in metres;

d_{sr} is the distance from the (second) diffraction edge to the receiver, in metres;

a is the component distance parallel to the barrier edge between source and receiver, in metres.

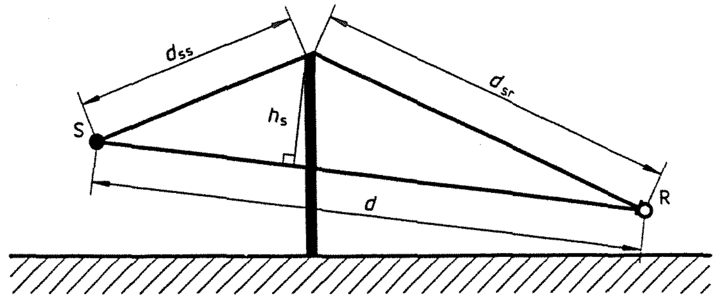


Figure 6 — Geometrical quantities for determining the pathlength difference for single diffraction

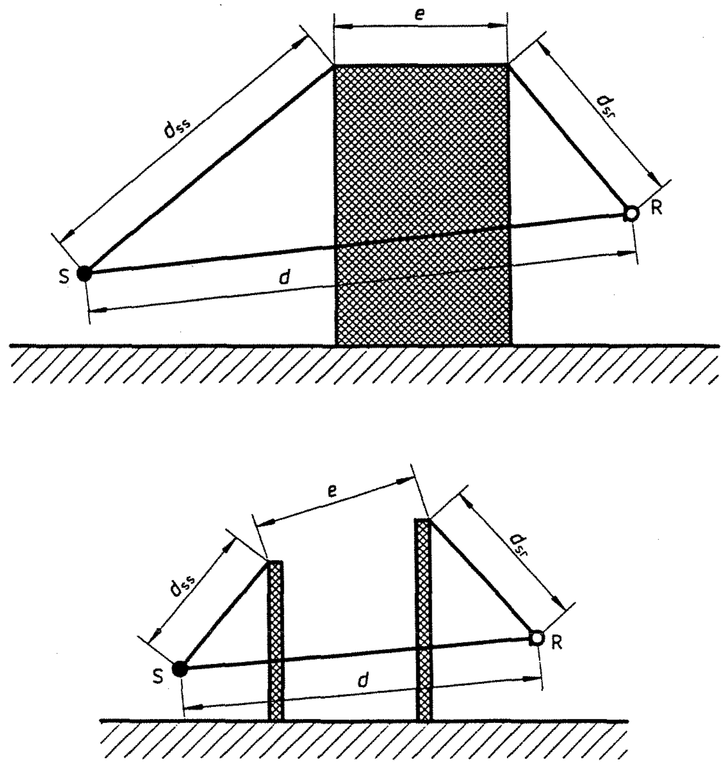


Figure 7 — Geometrical quantities for determining the pathlength difference for double diffraction

If the line of sight between the source S and receiver R passes above the top edge of the barrier, z is given a negative sign.

For double diffraction, as shown in figure 7, the pathlength difference z shall be calculated by

$$z = \left[\left(d_{ss} + d_{sr} + e \right)^2 + a^2 \right]^{1/2} - d \qquad \ldots (17)$$

The correction factor K_{met} for meteorological conditions in equation (14) shall be calculated using equation (18):

$$K_{met} = \exp\left[- (1/2000) \sqrt{d_{ss} d_{sr} d / (2z)} \right] \quad \text{for } z > 0 \qquad \ldots (18)$$

$$K_{met} = 1 \quad \text{for } z \leqslant 0$$

For lateral diffraction around obstacles, it shall be assumed that $K_{met} = 1$ (see figure 5).

NOTES

17 For source-to-receiver distances less than 100 m, the calculation using equation (14) shows that K_{met} may be assumed equal to 1, to an accuracy of 1 dB.

18 Equation (15) provides a continuous transition from the case of single diffraction ($e = 0$) where $C_3 = 1$, to that of a well-separated double diffraction ($e \gg \lambda$) where $C_3 = 3$.

19 A barrier may be less effective than calculated by equations (12) to (18) as a result of reflections from other acoustically hard surfaces near the sound path from the source to the receiver or by multiple reflections between an acoustically hard barrier and the source.

The barrier attenuation D_z, in any octave band, should not be taken to be greater than 20 dB in the case of single diffraction (i.e. thin barriers) and 25 dB in the case of double diffraction (i.e. thick barriers).

The barrier attenuation for two barriers is calculated using equation (14) for double diffraction, as indicated in the lower part of figure 7. The barrier attenuation for more than two barriers may also be calculated approximately using equation (14), by choosing the two most effective barriers, neglecting the effects of the others.

7.5 Reflections

Reflections are considered here in terms of image sources. These reflections are from outdoor ceilings and more or less vertical surfaces, such as the façades of buildings, which can increase the sound pressure levels at the receiver. The effect of reflections from the ground are not included because they enter into the calculation of A_{gr}.

The reflections from an obstacle shall be calculated for all octave bands for which all the following requirements are met:

— a specular reflection can be constructed, as shown in figure 8;

— the magnitude of the sound reflection coefficient for the surface of the obstacle is greater than 0,2;

— the surface is large enough for the nominal midband wavelength λ (in metres) for the octave band under consideration to obey the relationship

$$1/\lambda > \left[2/(l_{min} \cos \beta)^2\right]\left[d_{s,o} d_{o,r}/(d_{s,o} + d_{o,r})\right] \quad \ldots (19)$$

where

λ is the wavelength of sound (in metres) at the nominal midband frequency f (in hertz) of the octave band $\left(\lambda = \frac{340 \text{ m/s}}{f}\right)$;

$d_{s,o}$ is the distance between the source and the point of reflection on the obstacle;

$d_{o,r}$ is the distance between the point of reflection on the obstacle and the receiver;

β is the angle of incidence, in radians (see figure 8);

l_{min} is the minimum dimension (length or height) of the reflecting surface (see figure 8).

If any of these conditions is not met for a given octave band, then reflections shall be neglected.

The real source and source image are handled separately. The sound power level of the source image $L_{W,im}$ shall be calculated from

$$L_{W,im} = L_W + 10 \lg(\rho) \text{ dB} + D_{Ir} \quad \ldots (20)$$

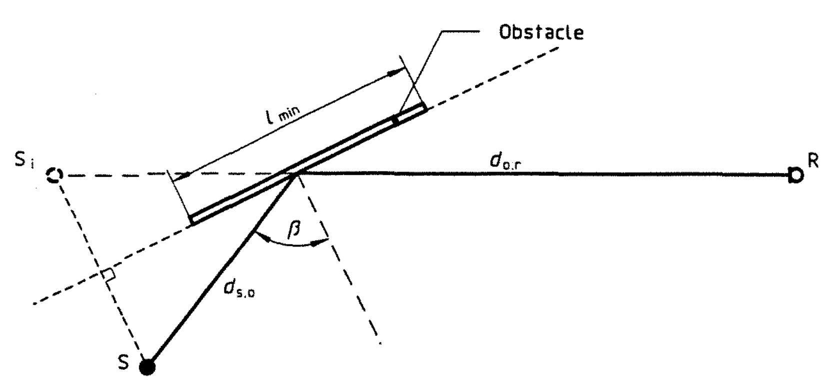
where

ρ is the sound reflection coefficient at angle β on the surface of the obstacle ($\geqslant 0,2$) (see figure 8);

D_{Ir} is the directivity index of the source in the direction of the receiver image.

If specific data for the sound reflection coefficient are not available, the value may be estimated using table 4.

For the sound source image, the attenuation terms of equation (4), as well as ρ and D_{Ir} in equation (20), shall be determined according to the propagation path of the reflected sound.



NOTE — A path $d_{s,o} + d_{o,r}$ connecting the source S and receiver R by reflection from the obstacle exists in which β, the angle of incidence, is equal to the angle of reflection. The reflected sound appears to come from the source image S_i.

Figure 8 — Specular reflection from an obstacle

Table 4 — Estimates of the sound reflection coefficient ρ

Object	ρ
Flat hard walls	1
Walls of building with windows and small additions or bay	0,8
Factory walls with 50 % of the surface consisting of openings, installations or pipes	0,4
Cylinders with hard surfaces (tanks, silos)	$\frac{D \sin(\phi/2)}{2d_{sc}}$ *) where D is the diameter of the cylinder; d_{sc} is the distance from the source to the centre C of the cylinder; ϕ is the supplement of the angle between lines SC and CR.
Open installations (pipes, towers, etc.)	0
*) This expression applies only if the distance d_{sc} from the source S to cylinder C is much smaller than the distance d_{cr} from the cylinder to receiver; see figure 9.	

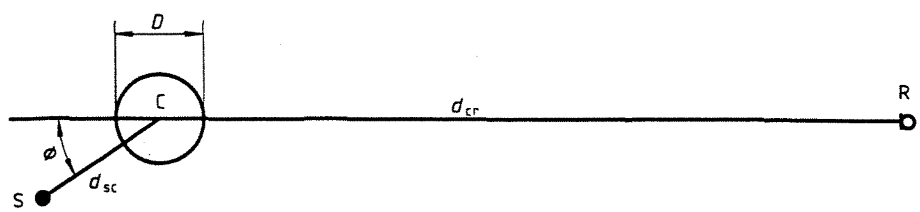


Figure 9 — Estimation of sound reflection coefficient for a cylinder

8 Meteorological correction (C_{met})

Use of equation (3) leads directly to an equivalent continuous A-weighted sound pressure level L_{AT} at the receiver for meteorological conditions which are favourable for propagation from the sound source to that receiver, as described in clause 5. This may be the appropriate condition for meeting a specific community noise limit, i.e. a level which is seldom exceeded (see ISO 1996-3). Often, however, a long-term average A-weighted sound pressure level L_{AT}(LT) is required, where the time interval T is several months or a year. Such a period will normally include a variety of meteorological conditions, both favourable and unfavourable to propagation. A value for L_{AT}(LT) may be obtained in this situation from that calculated for L_{AT}(DW) via equation (3), by using the meteorological correction C_{met} in equation (6).

A value (in decibels) for C_{met} in equation (6) may be calculated using equations (21) and (22) for the case of a point sound source with an output which is effectively constant with time:

$$C_{met} = 0 \qquad \text{... (21)}$$

if $d_p \leq 10(h_s + h_r)$

$$C_{met} = C_0 \left[1 - 10(h_s + h_r)/d_p\right] \qquad \text{... (22)}$$

if $d_p > 10(h_s + h_r)$

where

h_s is the source height, in metres;

h_r is the receiver height, in metres;

d_p is the distance between the source and receiver projected to the horizontal ground plane, in metres;

C_0 is a factor, in decibels, which depends on local meteorological statistics for wind speed and direction, and temperature gradients.

The effects of meteorological conditions on sound propagation are small for short distances d_p, and for longer distances at greater source and receiver heights. Equations (21) and (22) account approxi-

Values in metres

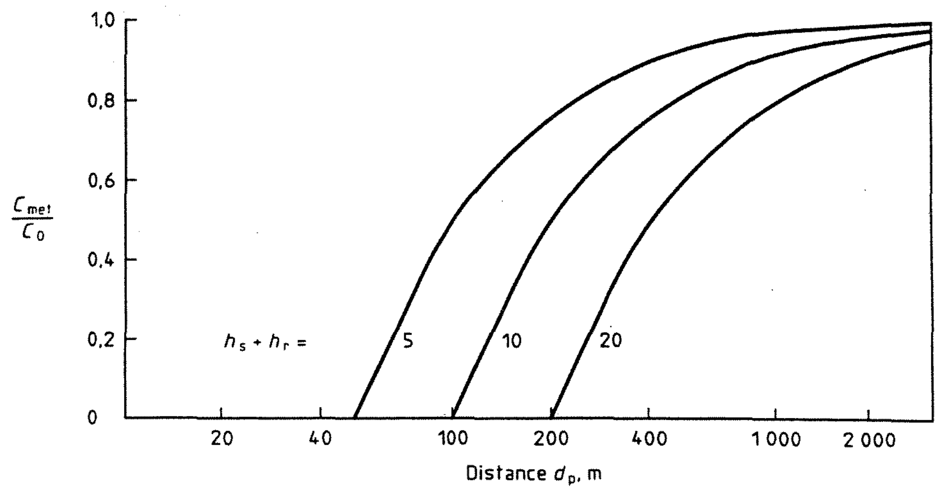


Figure 10 — Meteorological correction C_{met}

NOTES

20 A value for C_0 in equations (21) and (22) may be estimated from an elementary analysis of the local meteorological statistics. For example, if the meteorological conditions favourable to propagation described in clause 5 are found to occur for 50 % of the time period of interest, and the attenuation during the other 50 % is higher by 10 dB or more, then the sound energy which arrives for meteorological conditions unfavourable to propagation may be neglected, and C_0 will be approximately + 3 dB.

21 The meteorological conditions for evaluating C_0 may be established by the local authorities.

22 Experience indicates that values of C_0 in practice are limited to the range from zero to approximately + 5 dB, and values in excess of 2 dB are exceptional. Thus only very elementary statistics of the local meteorology are needed for a ± 1 dB accuracy in C_0.

For a source that is composed of several component point sources, h_s in equations (21) and (22) represents the predominant source height, and d_p the distance from the centre of that source to the receiver.

9 Accuracy and limitations of the method

The attenuation of sound propagating outdoors between a fixed source and receiver fluctuates due to variations in the meteorological conditions along the propagation path. Restricting attention to moderate downwind conditions of propagation, as specified in clause 5, limits the effect of variable meteorological conditions on attenuation to reasonable values.

There is information to support the method of calculation given in clauses 4 to 8 (see annex B) for broad-band noise sources. The agreement between calculated and measured values of the average A-weighted sound pressure level for downwind propagation, L_{AT}(DW), supports the estimated accuracy of calculation shown in table 5. These estimates of accuracy are restricted to the range of conditions specified for the validity of the equations in clauses 3 to 8 and are independent of uncertainties in sound power determination.

NOTE 24 The estimates of accuracy in table 5 are for downwind conditions averaged over independent situations (as specified in clause 5). They should not necessarily be expected to agree with the variation in measurements made at a given site on a given day. The latter can be expected to be considerably larger than the values in table 5.

The estimated errors in calculating the average downwind octave-band sound pressure levels, as well as pure-tone sound pressure levels, under the same conditions, may be somewhat larger than the estimated errors given for A-weighted sound pressure levels of broad-band sources in table 5.

In table 5, an estimate of accuracy is not provided in this part of ISO 9613 for distances d greater than the 1 000 m upper limit.

Throughout this part of ISO 9613 the meteorological conditions under consideration are limited to only two cases:

a) moderate downwind conditions of propagation, or their equivalent, as defined in clause 5;

b) a variety of meteorological conditions as they exist over months or years.

The use of equations (1) to (5) and (7) to (20) (and therefore also table 5) is limited to case a): meteorological conditions only. Case b) is relevant only to the use of equations (6), (21) and (22). There are also a substantial number of limitations (non-meteorological) in the use of individual equations. Equation (9) is, for example, limited to approximately flat terrain. These specific limitations are described in the text accompanying the relevant equation.

Table 5 — Estimated accuracy for broadband noise of L_{AT}(DW) calculated using equations (1) to (10)

Height, h *)	Distance, d *)	
	$0 < d < 100$ m	$100 \text{ m} < d < 1\,000$ m
$0 < h < 5$ m	± 3 dB	± 3 dB
$5 \text{ m} < h < 30$ m	± 1 dB	± 3 dB

*) h is the mean height of the source and receiver.
d is the distance between the source and receiver.

NOTE — These estimates have been made from situations where there are no effects due to reflection or attenuation due to screening.

Annex A
(informative)

Additional types of attenuation (A_{misc})

The term A_{misc} in equation (4) covers contributions to the attenuation from miscellaneous effects not accessible by the general methods of calculating the attenuation specified in clause 7. These contributions include

— A_{fol}, the attenuation of sound during propagation through foliage,

— A_{site}, the attenuation during propagation through an industrial site, and

— A_{hous}, the attenuation during propagation through a built-up region of houses,

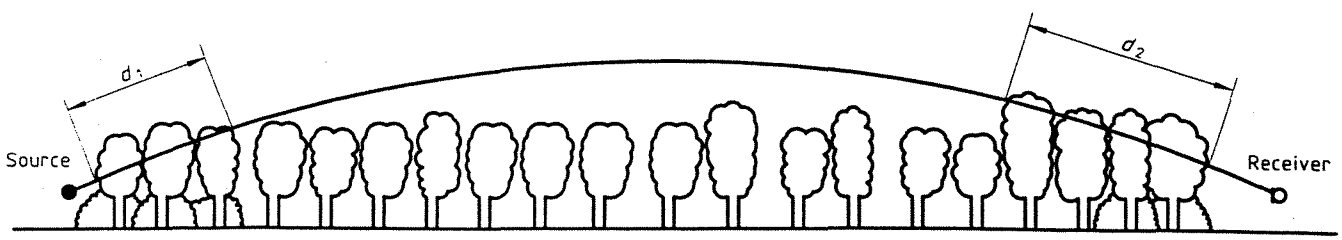
which are all considered in this annex.

For calculating these additional contributions to the attenuation, the curved downwind propagation path may be approximated by an arc of a circle of radius 5 km, as shown in figure A.1.

A.1 Foliage (A_{fol})

The foliage of trees and shrubs provides a small amount of attenuation, but only if it is sufficiently dense to completely block the view along the propagation path, i.e. when it is impossible to see a short distance through the foliage. The attenuation may be by vegetation close to the source, or close to the receiver, or by both situations, as illustrated in figure A.1. Alternatively, the path for the distances d_1 and d_2 may be taken as falling along lines at propagation angles of 15° to the ground.

The first line in table A.1 gives the attenuation to be expected from dense foliage if the total path length through the foliage is between 10 m and 20 m, and the second line if it is between 20 m and 200 m. For path lengths greater than 200 m through dense foliage, the attenuation for 200 m should be used.



NOTE — $d_f = d_1 + d_2$

For calculating d_1 and d_2, the curved path radius may be assumed to be 5 km.

Figure A.1 — Attenuation due to propagation through foliage increases linearly with propagation distance d_f through the foliage

Table A.1 — Attenuation of an octave band of noise due to propagation a distance d_f through dense foliage

Propagation distance d_f m	**Nominal midband frequency** Hz 63	125	250	500	1 000	2 000	4 000	8 000
	Attenuation, dB:							
$10 \leq d_f \leq 20$	0	0	1	1	1	1	2	3
	Attenuation, dB/m:							
$20 \leq d_f \leq 200$	0,02	0,03	0,04	0,05	0,06	0,08	0,09	0,12

A.2 Industrial sites (A_{site})

At industrial sites, an attenuation can occur due to scattering from installations (and other objects), which may be described as A_{site}, unless accounted for under A_{bar}, or the sound source radiation specification. The term installations includes miscellaneous pipes, valves, boxes, structural elements, etc.

As the value of A_{site} depends strongly on the type of site, it is recommended that it is determined by measurements. However, for an estimate of this attenuation, the values in table A.2 may be used. The attenuation increases linearly with the length of the curved path d_s through the installations (see figure A.2), with a maximum of 10 dB.

A.3 Housing (A_{hous})

A.3.1 When either the source or receiver, or both are situated in a built-up region of houses, an attenuation will occur due to screening by the houses. However, this effect may largely be compensated by propagation between houses and by reflections from other houses in the vicinity. This combined effect of screening and reflections that constitutes A_{hous} can be calculated for a specific situation, at least in principle, by applying the procedures for both A_{bar} and reflections described in 7.4 and 7.5. Because the value of A_{hous} is very situation-dependent, such a calculation may be justified in practice. A more useful alternative, particularly for the case of multiple reflections where the accuracy of calculation suffers, may be to measure the effect, either in the field or by modelling.

A.3.2 An approximate value for the A-weighted attenuation A_{hous}, which should not exceed 10 dB, may also be estimated as follows. There are two separate contributions

$$A_{hous} = A_{hous,1} + A_{hous,2} \qquad \text{... (A.1)}$$

A.3.3 An average value for $A_{hous,1}$ (in decibels) may be calculated using the equation

$$A_{hous,1} = 0{,}1Bd_b \quad \text{dB} \qquad \text{... (A.2)}$$

where

- B is the density of the buildings along that path, given by the total plan area of the houses divided by the total ground area (including that covered by the houses);
- d_b is the length of the sound path, in metres, through the built-up region of houses, determined by a procedure analogous to that shown in figure A.1.

The path length d_b may include a portion d_1 near the source and a portion d_2 near the receiver, as indicated in figure A.1.

The value of A_{hous} shall be set equal to zero in the case of a small source with a direct, unobstructed line of sight to the receiver down a corridor gap between housing structures.

NOTE 25 The A-weighted sound pressure level at specific individual positions in a region of houses may differ by up to 10 dB from the average value predicted using equations (A.1) and (A.2).

Table A.2 — Attenuation coefficient of an octave band of noise during propagation through installations at industrial plants

Nominal midband frequency, Hz	63	125	250	500	1 000	2 000	4 000	8 000
A_{site}, dB/m	0	0,015	0,025	0,025	0,02	0,02	0,015	0,015

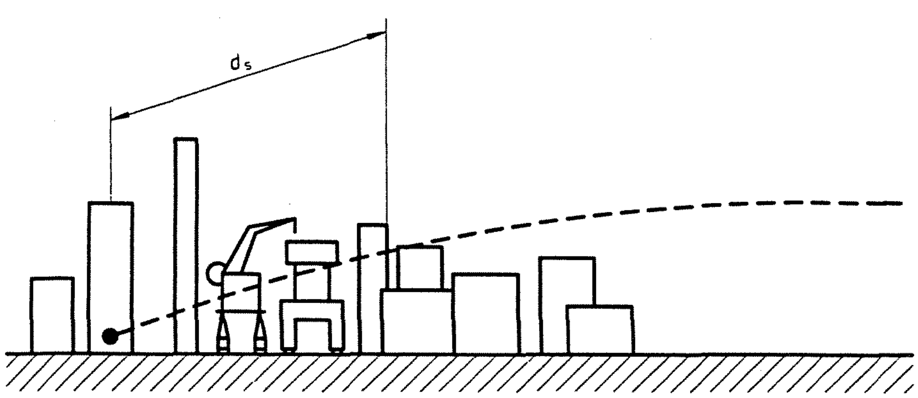


Figure A.2 — The attenuation A_{site} increases linearly with the propagation distance d_s through the installations at industrial plants

A.3.4 If there are well-defined rows of buildings near a road, a railway, or a similar corridor, an additional term $A_{hous,2}$ may be included (provided this term is less than the insertion loss of a barrier at the same position with the mean height of the buildings):

$$A_{hous,2} = -10 \lg[1 - (p/100)] \text{ dB} \qquad \text{... (A.3)}$$

where p (the percentage of the length of the façades relative to the total length of the road or railway in the vicinity) is $\leqslant 90$ %.

A.3.5 In a built-up region of houses, the value of $A_{hous,1}$ [as calculated by equation (A.2)] interacts as follows with the value for A_{gr}, the attenuation due to the ground [as calculated by equation (9) or equation (10)].

Let $A_{gr,b}$ be the ground attenuation in the built-up region, and $A_{gr,0}$ be the ground attenuation if the houses were removed [i.e. as calculated by equation (9) or equation (10)]. For propagation through the built-up region in general, $A_{gr,b}$ is assumed to be zero in equation (4). If, however, the value of $A_{gr,0}$ is greater than that of A_{hous}, then the influence of A_{hous} is ignored and only the value of $A_{gr,0}$ is included in equation (4).

The interaction above is essentially to allow for a range of housing density B. For low-density housing, the value of A_{gr} is dominant, while for high-density housing A_{hous} dominates.

Annex B
(informative)

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1) To be published. (Revision of ISO 266:1975)

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