US Army Corps of Engineers
Buffalo District

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Formerly Utilized Sites Remedial Action Program

EVALUATION OF METEOROLOGICAL DATA AND MODELING APPROACHES TO ASSESS THE DISPERSION OF AIRBORNE RELEASES FROM THE NIAGARA FALLS STORAGE SITE

TECHNICAL REPORT

FOR THE NIAGARA FALLS STORAGE SITE LEWISTON, NEW YORK

December 2011

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TECHNICAL REPORT FOR THE NIAGARA FALLS STORAGE SITE LEWISTON, NEW YORK

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EVALUATION OF METEOROLOGICAL DATA AND MODELING APPROACHES TO ASSESS THE DISPERSION OF AIRBORNE RELEASES FROM THE NIAGARA FALLS STORAGE SITE

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NOTATION

µg	microgram(s)
σ_A	standard deviation of the horizontal wind direction (sigma A or sigma theta)
χ/Q	air concentration per emission rate (Chi over Q, as pCi/m^3 per pCi/s)
AERMAP	terrain data preprocessor of the AERMOD modeling system
AERMET	meteorological data preprocessor of the AERMOD modeling system
AERMOD	AMS/EPA Regulatory MODel
AMS	American Meteorological Society
AQCR	Air Quality Control Region (EPA)
ASOS	Automated Surface Observing System (meteorological stations)
BNI	Bechtel National, Inc.
CAA	Clean Air Act
CAP88-PC	CAA Assessment Package-1988-Personal Computer (dispersion model for NESHAPs)
CD-144	card deck-144 (earlier meteorological data format)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (as amended)
CFR	Code of Federal Regulations
Ci	curie
cm	centimeter(s)
CO	carbon monoxide
CWM	CWM (commercial landfill adjacent to NFSS)
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FLM	Federal Land Manager
FS	feasibility study
ft	foot (feet)
FUSRAP	Formerly Utilized Sites Remedial Action Program
HUSWO	Hourly U.S. Weather Observations (earlier meteorological data format)
ICAO	International Civil Aviation Organization airport code
in.	inch(es)
ISC	Industrial Source Complex (model) (earlier EPA air dispersion model, before AERMOD)
ISCLT	ISC Long Term (model, as above)
ISHD	integrated surface hourly data (meteorological data format, also referred to as ISD)
IWCS	interim waste containment structure (at NFSS)
km	kilometer(s)
kPa	kiloPascal
L	Monin-Obukhov length (boundary layer parameter)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mi	mile(s)

NOTATION *(Cont'd.)*

mm	millimeter(s)
mph	mile(s) per hour
m/s	meter(s) per second
NAAQS	National Ambient Air Quality Standard(s)
NCDC	National Climatic Data Center
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFSS	Niagara Falls Storage Site
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NSR	new source review
NYSDEC	New York State Department of Environmental Conservation
NWS	National Weather Service
O_3	ozone
OU	operable unit
pCi	picocurie
PM	particulate matter
$PM_{2.5}$	PM with an aerodynamic diameter of a nominal 2.5 microns or less
PM_{10}	PM with an aerodynamic diameter of a nominal 10 microns or less
PSD	prevention of significant deterioration
QA/QC	quality assurance/quality control
Rn-222	radon-222
s	second(s)
SAMSON	Solar and Meteorological Surface Observation Network (earlier data format)
SCRAM	Support Center for Regulatory Atmospheric Modeling (EPA TTN)
SIP	state implementation plan
SO_2	sulfur dioxide
SO_x	sulfur oxides
STAR	STability ARray (data file)
TM	technical memorandum
TTN	Technology Transfer Network (EPA)
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force (station number, meteorological data identifier)
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator (coordinate system)
UTME	UTM east
UTMN	UTM north
WBAN	Weather Bureau Army Navy (station number, meteorological data identifier)
W/m^2	watts per square meter
yr	year(s)
z_0	surface roughness length (boundary layer parameter)

CONVERSION TABLE

Multiply	By	To Obtain
English/Metric Equivalents		
acres (ac)	0.4047	hectares (ha) *(1 ha = 10,000 m^2)*
acres (ac)	4,047	square meters (m^2)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
feet (ft)	0.3048	meters (m)
inches (in.)	2.540	centimeters (cm)
knots (kt)	0.5144	meters per second (m/s)
miles (mi)	1.609	kilometers (km)
miles per hour (mph)	0.4470	meters per second (m/s)
ounce (oz.)	28.35	grams (g)
pounds (lb)	0.4536	kilograms (kg)
short tons (tons)	907.2	kilograms (kg)
short tons (tons)	0.9072	metric tons (t)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
yards (yd)	0.9144	meters (m)
Metric/English Equivalents		
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
grams (g)	0.03527	ounce (oz.)
hectares (ha)	2.471	acres (ac)
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	short tons (tons)
kilometers (km)	0.6214	miles (mi)
meters (m)	3.281	feet (ft)
meters (m)	1.094	yards (yd)
meters per second	1.944	knots (kt) *(1 kt = 1.1508 mph)*
meters per second	2.237	miles per hour (mph)
metric tons (t)	1.102	short tons (tons)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	0.0002471	acres (ac) *(1 ac = 43,560 ft^2)*
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)

EVALUATION OF METEOROLOGICAL DATA AND MODELING APPROACHES TO ASSESS THE DISPERSION OF AIRBORNE RELEASES FROM THE NIAGARA FALLS STORAGE SITE

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The U.S. Army Corps of Engineers (USACE) is the lead Federal agency for the Formerly Utilized Sites Remedial Action Program (FUSRAP). The USACE Buffalo District is responsible for addressing the Niagara Falls Storage Site (NFSS) under FUSRAP, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. The CERCLA process is being conducted at NFSS via three operable units (OUs). A feasibility study (FS) will be prepared to identify and evaluate remedial alternatives for each OU in accordance with standard regulations and guidance established by the U.S. Environmental Protection Agency (EPA).

The Interim Waste Containment Structure (IWCS) at NFSS contains high-activity residues and other, lower-level radioactive materials from processing operations and disposal activities that occurred decades ago. The USACE conducts an environmental surveillance program and performs site operations, maintenance, and monitoring to ensure protection of human health and the environment from contaminants contained in the IWCS and elsewhere on the Federally owned NFSS. Because the IWCS represents the primary source of potential contamination at the site, it is being addressed as the first OU. Topical technical reports are being developed to support the upcoming FS for the IWCS OU, and this is one of the initial reports in the series.

ES.2 PURPOSE AND SCOPE

This report addresses two basic elements of upcoming air quality analyses for the site, the meteorological data to be used and the dispersion modeling approach to be applied. Its purpose is twofold:

- Determine appropriate meteorological data to use in modeling the dispersion of airborne contaminants from the site to support the evaluation of remedial alternatives.

- Describe basic concepts of standard air quality analyses and assess the effect of using different models and input data to assess the dispersion of airborne contaminants from an NFSS release.

For the meteorological data component, the scope extends from stations at commercial facilities adjacent to NFSS to those at regional airports. For the modeling component, the scope covers two EPA models: the current standard air quality model jointly developed with the American Meteorological Society; and the model developed to assess compliance with EPA's National Emission Standards for Hazardous Air Pollutants (NESHAPs) established in 1989 for radionuclides, including at U.S. Department of Energy (DOE) facilities.

The objectives of this report are to:

- Identify meteorological stations in the general vicinity that may have data relevant to NFSS.

- Evaluate meteorological data from key candidate stations to evaluate their representativeness and appropriateness for assessing the dispersion of potential airborne releases from NFSS.

- Describe two models used to assess air dispersion and the applications for which they are designed, and compare example dispersion estimates using different meteorological data.

- Indicate the meteorological data and dispersion model well suited for assessing dispersion of airborne releases from the IWCS, to support planning for this OU.

- Make this technical evaluation available to stakeholders in advance of the FS for the IWCS, to facilitate timely input regarding the approach for evaluating dispersion of potential airborne releases.

Role of the IWCS OU in the Remedial Action Process for NFSS

The IWCS OU is the first of the three OUs for NFSS, as illustrated in Figure ES.1. This OU addresses the wastes DOE placed in the IWCS. The other two OUs address the remainder of NFSS, i.e., the balance of the physical features and soil (referred to as "balance of plant") and groundwater. The specific scopes of these subsequent OUs will be defined after the IWCS remedy is selected, because the scopes will depend on that remedy. This sequenced approach for remedial action assures efficient evaluations for each main set of contaminated materials and environmental media at NFSS, with the progressive decisions leading to a final sitewide remedy.

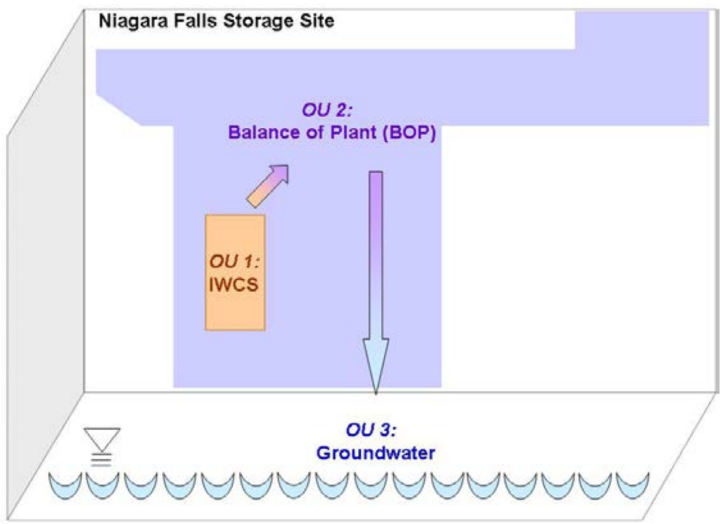


FIGURE ES.1 Schematic of the NFSS Operable Units

Role of this Report in Evaluations for the IWCS OU

The role of this report is to serve as a technical resource for the FS being prepared for the IWCS OU. Its main objective is to determine what meteorological data and modeling approaches are well suited for evaluating the dispersion of airborne releases from the IWCS. This technical report provides the foundation for the upcoming evaluation of potential human exposures and health risks associated with hypothetical airborne releases from the IWCS. Remedial alternatives for the IWCS OU will be developed and evaluated in accordance with the CERCLA process, addressing the standard criteria set forth in the National Oil and Hazardous Substances Pollution Contingency Plan. This report and the companion preliminary exposure-risk analysis will be used to support planning for this alternatives evaluation.

Other reports being developed to support the FS include the following technical memoranda (TMs): (1) a radon assessment, (2) a review of waste disposal options and lessons learned from the cleanup of similar wastes at the DOE Fernald Site in Ohio, (3) an evaluation of applicable or relevant and appropriate requirements, and (4) the development and screening of technologies for remedial alternatives for the IWCS. The radon assessment TM is designed to help guide the consideration of radon-222 (Rn-222) control measures in the FS by estimating a range of potential airborne concentrations from different IWCS releases under various conditions. That TM focused on Rn-222 because as a gas, it represents a key release concern for the IWCS. (The risks associated with other radon isotopes at NFSS would be much lower.)

The IWCS cap currently controls Rn-222 emanation, so releases that might warrant concern would only occur if the cap were breached, either intentionally (e.g., by a mechanical disturbance) or unintentionally (e.g., by a natural disturbance). Several hypothetical release situations are considered in the radon assessment TM, including drilling into the residues and damage from an earthquake or burrowing animal. (Similar releases were considered in developing this technical report.) Consistent with multiple active controls in place at NFSS, results of the preliminary evaluation of Rn-222 in the radon assessment TM are being compared to standards for worker protection, while offsite estimates are being compared to standards established for the general public.

This technical report builds on previous analyses for NFSS related to meteorological data and dispersion modeling, including information presented in the radon assessment TM and historical documentation. The analyses in this report consider several sets of meteorological data that could be relevant to assessing airborne releases from the IWCS, including for contaminants beyond Rn-222, as well as specific modeling approaches that could be applied to evaluate air dispersion.

ES.3 APPROACH

ES3.1 Meteorological Data

Nine meteorological stations were identified as potential candidates for data relevant to the dispersion analyses for NFSS. These stations are shown in Table ES.1. The local setting, including land use and cover, terrain, and proximity to large bodies of water, can significantly affect wind patterns. These station settings were reviewed to assess their representativeness for NFSS conditions. In addition, their meteorological data were considered in terms of standard collection and reporting, time period covered, and degree of quality assurance/quality control (QA/QC).

TABLE ES.1 Candidate Stations for Meteorological Data

Meteorological Station	Location *(ordered by distance from NFSS)*
1. Modern Landfill: Landfill Station	Adjacent to NFSS, to the east-southeast
2. Modern Landfill: Greenhouse Station	Adjacent to NFSS, to the south
3. CWM Landfill	Adjacent to NFSS, to the north-northeast
4. U.S. Coast Guard Station at Ft. Niagara	8 km (5 mi) northwest of NFSS on Lake Ontario
5. Niagara Falls International Airport	12 km (7 mi) south-southeast of NFSS in Niagara Falls, NY
6. Somerset Power Generating Station	34 km (21 mi) east-northeast of NFSS on Lake Ontario in Barker, NY
7. Greater Buffalo International Airport	35 km (22 mi) southeast of NFSS in Buffalo, NY
8. Hamilton Airport	75 km (47 mi) west of NFSS in Ontario, Canada
9. Greater Rochester International Airport	106 km (66 mi) east of NFSS in Rochester, NY

ES3.2 Dispersion Models

Two EPA models are commonly used to assess the dispersion of airborne releases from radioactively and chemically contaminated sites. These models are shown in Table ES.2.

TABLE ES.2 Air Dispersion Models

Dispersion Model	Date Established	Purpose	Application
AERMOD	2006 (with subsequent updates, 2011 and ongoing)	Demonstrate compliance with the National Ambient Air Quality Standards and other requirements under the CAA; multiple additional applications include assessing airborne releases from contaminated sites and facilities under the CERCLA process.	Both chronic and shorter-term releases; includes an option to assess exponential decay (e.g., for radionuclides).
CAP88-PC	1988 (with subsequent updates, 2007)	Demonstrate compliance with the NESHAPs requirements under the CAA for radon and other radionuclides released from specific facilities; also used to assess chronic radionuclide releases from nuclear facilities and for other purposes.	Chronic (annual), routine releases of radionuclides; accounts for radionuclide ingrowth and decay.

The CAP88-PC computer code was developed to demonstrate compliance with NESHAPs requirements for radionuclides under the Clean Air Act (CAA). This model is designed to assess chronic radionuclide releases from nuclear facilities (rather than short-term or accidental releases). In contrast, the AERMOD system can be used to assess both short-term and long-term releases. Both codes can account for radionuclide decay, and CAP88-PC also addresses radionuclide ingrowth, while AERMOD does not.

However, radionuclide decay and ingrowth do not have a significant impact on the evaluation of doses and risks associated with potential remedial alternatives at the IWCS because the radiological contaminants at NFSS occur in relatively long decay series. The principal radionuclides are very long-lived, and the short-lived decay products are already in secular equilibrium. In most cases, short-lived decay products would be released along with the parent, and the dose and risk contributions of these decay products are attributed to the parent (i.e., accounted for in the respective risk estimators). The exception is Rn-222, for which the health risk is largely due to the ingrowth of short-lived decay products. Although within the IWCS these decay products are currently in equilibrium with Rn-222, they are solid particulates and so would not generally accompany a release of radon gas.

Because ingrowth of Rn-222 progeny is not addressed by AERMOD, the ingrowth algorithm of CAP88-PC will be used as a complement to AERMOD to assess the short-lived products that would be formed following a release of this gas. Thus, it is anticipated that both modeling approaches could be used to evaluate potential contaminant releases at NFSS as part of the FS process. For this reason, both models are evaluated in this document to assess the impact on predicted dispersion from a hypothetical release at the IWCS.

ES.4 RESULTS

ES.4.1 Meteorological Data

The review of candidate meteorological stations found that data from two locations -- the CWM landfill and Niagara Falls airport – are most appropriate for a comparative assessment of dispersion models to support upcoming analyses for NFSS. The information leading to this result is summarized below, and the three data sets selected from these stations for the detailed comparisons are identified in Table ES.3.

TABLE ES.3 Meteorological Data Used in Dispersion Modeling Comparisons

Meteorological Station	Location	Data Years	Role of Data in this Evaluation
CWM Landfill	North-northeast of NFSS	2005-2008	Represent recent conditions at NFSS, for comparison with recent airport data.
Niagara Falls Airport	12 km (7 mi) south-southeast of NFSS	2005-2009	National Weather Service station data represent recent regional conditions, for comparison with local conditions at the CWM landfill and NFSS.
		1955-1959	These are the default data for NFSS in the CAP88-PC code; these data also support a qualified comparison with recent airport data (considering changes in data collection at this station, including instrument height, over the past 50 years).

The initial review of nine meteorological stations to support dispersion analyses for the IWCS OU determined that wind patterns at the two stations on Lake Ontario (Ft. Niagara and Somerset) are subject to considerable lake influences, making them less representative of NFSS than other candidates. A third station, at the Modern facility greenhouse, was only recently installed so the time period covered is much less than other nearby stations. Therefore, these three stations were not evaluated further.

Wind speeds and directions for the six remaining stations were compared by developing wind roses using recent data. (In a wind rose, the direction of each bar shows the direction from which the wind blows.) While five of the meteorological stations collect data from the standard height of 10 m (33 ft), the tower at the Modern facility sits atop the landfill so it is nearly four times the standard height. Wind speeds at that height tend to be faster because surface friction is lower, so they cannot be readily compared with measurements at the standard height. Therefore, the Modern data were not considered further.

The wind roses for the four airports assessed indicate the prevailing wind direction in the region is from the southwest. Wind directions associated with lake breezes blowing from the lake to the land stand out, depending on the distance and orientation to the Great Lakes. For example, the more southwesterly winds seen at the Buffalo airport reflect the effect of nearby Lake Erie to the southwest.

In contrast, the more northeasterly winds seen at the Hamilton airport reflect the effect of nearby Lake Ontario to the northeast. More northerly winds from Lake Ontario are not prominent but are slightly higher at the CWM site. Nighttime land breezes blowing from the land to the lake are usually weaker than their daytime counterpart lake breezes, so no land breezes are noticeable at any of the meteorological stations.

From recent data for the four airports, average wind speeds range from 4.0 m/s (8.9 mph) at Rochester to 4.5 m/s (10.1 mph) at Buffalo. By comparison, the average wind speed at the CWM landfill is 3.0 m/s (6.7 mph), which is lower than (slightly more than two-thirds of) the average wind speed at the Niagara Falls airport of 4.4 m/s (9.8 mph), even though these two stations are only about 13 km (8 mi) apart. This difference can be explained by differences in surface roughness, with relatively tall trees in the CWM area compared with open space at the airport. Prevailing winds also differ slightly between these two stations; these winds come from the southwest at the Niagara Falls airport but from the west-southwest at the CWM site. This same local pattern is seen in a historical wind rose for NFSS based on 1981-1985 data from a previous onsite meteorological station. This may be due in part to terrain features, notably the nearby escarpment south of NFSS.

The wind rose comparisons identified two stations for detailed evaluation: the CWM landfill and Niagara Falls airport. The CWM facility is directly adjacent to NFSS at the same elevation, so these meteorological data clearly represent local conditions. The Niagara Falls airport is the closest station in the National Weather Service Automated Surface Observing System (ASOS) program. (ASOS is a joint effort of the National Weather Service, Federal Aviation Administration, and U.S. Department of Defense.) Two sets of data from the Niagara Falls airport are evaluated in this technical report: (1) recent data from 2005 to 2009, and (2) historical data from 1955 to 1959. The latter are included because they are the default set for NFSS in the CAP88-PC code. The recent data reflect today's standard instrumentation and collection and reporting protocols, and they provide the basis for comparison with recent data collected at the CWM landfill. The recent airport data also offer insights regarding changes in conditions from decades ago. (No 1950s data are available for the NFSS or CWM area for a parallel historical comparison.)

Additional analyses confirm that the recent CWM data are well suited for use in modeling the dispersion of airborne releases from NFSS to support the evaluation of remedial alternatives for the IWCS OU. These data reflect: (1) the current local setting, including land cover and the escarpment between NFSS and the airport; (2) current collection and reporting protocols; and (3) appropriate coverage and quality for use in dispersion modeling (e.g., the measurements span several years and have undergone QA/QC review).

The meteorological data from the Niagara Falls airport can be considered spatially and temporally representative of regional wind patterns. These patterns differ somewhat from local patterns at the CWM landfill and NFSS because the airport is at a higher elevation and its surrounding land use and land cover differ. For this reason, the airport data do not fully account for the effects of local features on wind patterns at NFSS, and the CWM data are considered most representative of conditions at the site.

The USACE Buffalo District recently installed a new meteorological station onsite to support upcoming evaluations. When sufficient measurements are available and have undergone standard QA/QC reviews, these data are expected to be used in future dispersion modeling for NFSS.

ES.4.2 Dispersion Models

ES.4.2.1 CAP88-PC Comparisons

Airport data from the 1950s are the default set of meteorological data for NFSS in the CAP88-PC code. Thus, those data have long been reflected in compliance analyses for the radionuclide NESHAPs at NFSS, as presented in annual environmental surveillance reports for the site. This approach is clearly reasonable and in accordance with EPA expectations.

The CAP88-PC model was developed in the 1980s, so its meteorological input files reflect a representation of atmospheric stability used to assess air quality at that time (extending back several decades). Meteorological data input to CAP88-PC represent a three-way joint frequency distribution of wind speed, wind direction, and Pasquill stability class. Wind speed and direction are routinely reported at meteorological stations, but Pasquill stability class is derived from reported measurements. Several popular methods are available to derive the stability class, such as Turner's method (using cloud and solar insolation data), the delta-T method (using vertical temperature difference), or the turbulence-based method (using horizontal or vertical wind fluctuation data).

To input recent meteorological data from the Niagara Falls airport and CWM landfill into the CAP88-PC code, the Pasquill stability class needs to be derived, for example, from the data preprocessed by the AERMOD system. These data reflect a different stability parameter, Monin-Obukhov length. Note that the CWM data include the standard deviation of the horizontal wind direction (σ_A), which can also be used to generate the Pasquill stability class directly, as described below.

For the first CAP88-PC comparison, an indirect conversion method was applied to the recent airport and CWM data using an algorithm from the scientific literature. For the second evaluation, a direct method that involves an intermediate conversion of the data format was applied to both data sets. An additional direct method was used with the CWM data, based on σ_A (this method could not be used with the airport data because σ_A is not included in that set.). As a further supporting evaluation, the stability measures indicated for several airports in the region from earlier to more recent data were compared with the measure derived from the recent CWM landfill data.

Results of the CAP88-PC model comparisons using meteorological data from different places and times based on the indirect conversion method are highlighted in Table ES.4 and described further below. These results address dispersion of contaminants to nearby offsite receptors from a hypothetical release at the IWCS.

TABLE ES.4 Results of CAP88-PC Evaluations Using Different Meteorological Data

Place-Time Comparisons	Meteorological Data	Relative Air Concentrations at Nearby Offsite Receptors	Influence Notes
1 **Same place** *(regional),* **different times** *(recent/historical)*	Airport: 2005-2009 vs. 1955-1959	Recent airport data: 0.7 to 1.8 times historical airport data *(average 20% higher)*	Instrumentation, measurement heights, and reporting have changed since the 1950s
2 **Different places** *(local/regional),* **different times** *(recent/historical)*	CWM 2005-2008 vs. Airport 1955-1959	Recent CWM data: same to 2.2 times historical airport data *(average 60% higher)*	Meteorological conditions differ; time may have a smaller overall impact on results
3 **Different places** *(local/regional),* **same time** *(recent)*	CWM 2005-2008 vs. Airport 2005-2009	Recent CWM data: same to 2 times recent airport data *(average 40% higher)*	CWM data reflect local conditions for NFSS

The first CAP88-PC evaluations, which compare Niagara Falls airport data taken 50 years apart, indicate that relative air concentrations predicted at offsite locations average about 20% higher with recent data than with historical data. Depending on the location, the concentration ratios range from about 0.7 to nearly 2. These somewhat higher predictions likely reflect the change in the wind instrument height and use of better instrumentation and measurement and reporting protocols today compared to years ago, among other factors. In any case, an average 20% difference is not considered unusual in the context of the overall uncertainties associated with this type of analysis.

The second set of CAP88-PC evaluations, which compare recent meteorological data from the CWM landfill with historical airport data, indicate that concentrations at nearby offsite receptors predicted from the CWM data average about 60% higher than those based on 1950s airport data, with ratios ranging from 1 to 2.2. These larger differences likely reflect the influences of different meteorological conditions at these separate locations, as summarized in Section ES.4.1.

The third set of CAP88-PC evaluations, which compare the two recent data sets (CWM landfill and Niagara Falls airport), indicate that concentrations at nearby offsite receptors predicted from the CWM data average about 40% higher than those from the recent airport data. As for the other comparisons, relative air concentrations offsite vary by location, and these values range from 1 to 2. Because this comparison addresses data from the same time period, differences mainly reflect the different settings. These results indicate that air dispersion at NFSS may be somewhat less than at the Niagara Falls airport, for example, due to lower average wind speeds caused by the vegetation cover.

A comparison of the spatial distribution of the plumes estimated from these three sets of meteorological data indicate they are generally similar, especially for the comparison of historical and recent airport data. The contours generally stretch to the northeast, reflecting prevailing southwesterly winds. When CWM data are used, the contours shift eastward a bit, becoming more east-northeasterly. This shift could reflect the influence of the nearby escarpment that runs east-northeast to west-southwest (and might steer prevailing regional winds from the southwest toward a more east-northeasterly direction).

When the entire modeling domain is considered the range of relative concentrations increases, with the lower value decreasing and the higher value increasing as expected. Although the range of concentration ratios increases, the overall results are generally comparable to those estimated for the offsite receptor locations.

In summary, the concentrations predicted by CAP88-PC at representative offsite locations increase by an average of 20% when recent airport data are used instead of historical data. The relative concentrations further increase when recent CWM data are used. This indicates that the local setting has a greater impact on the estimated dispersion of airborne releases than when the data were collected (i.e., in the past few years or decades ago).

ES.4.2.2 AERMOD and CAP88-PC Comparisons

This report also assesses the impact of the specific dispersion model used to predict air concentrations at representative locations from emissions at the IWCS. This evaluation accounts for differences in both the inputs and outputs of the two key models, AERMOD and CAP88-PC. The AERMOD system processes meteorological data in the format that has been standard since the 1990s. The 1950s airport data are in the previous standard format that does not directly align with the input needs for AERMOD, so CAP88-PC was used to evaluate those data.

The typical outputs of AERMOD and CAP88-PC differ due to differences in their applications. That is, CAP88-PC is designed to assess chronic releases so it produces annual average estimates, whereas AERMOD is designed to assess both short-term and chronic releases, and it uses hourly meteorological measurements to produce concentration estimates for user-defined times, e.g., from hourly to annual. To facilitate comparisons with the CAP88-PC analyses of historical data, annual averages were selected as the output for the AERMOD analyses. Results based on the different models and meteorological data are highlighted in Table ES.5 and described further below.

In the first comparison, air concentrations predicted at representative offsite locations by AERMOD with recent airport data and CAP88-PC with older airport data indicate that the latter average about 20% lower for the nearby offsite receptors. Depending on location, the relative concentrations from CAP88-PC with historical data range from more than 60% lower to 30% higher than those from AERMOD with recent data. These lower estimates likely reflect inherent differences in the dispersion algorithms of these two models, because when the same computer code (CAP88-PC) was used with both sets of meteorological data, the more recent data produced 20% higher average concentrations.

TABLE ES.5 AERMOD and CAP88-PC Comparisons with Different Meteorological Data

Place-Time Comparisons	Meteorological Data	Dispersion Model	Relative Air Concentrations at Nearby Offsite Receptors
1 **Same place** *(regional)*, **different times** *(recent/historical)*	Airport: 2005-2009 vs. 1955-1959	AERMOD for recent data CAP88-PC for 1950s data	Recent airport data: 0.4 to 1.3 times historical airport data *(average 20% lower)*
2 **Different places** *(local/regional)*, **different times** *(recent/historical)*	CWM 2005-2008 vs. Airport 1955-1959	AERMOD for recent data CAP88-PC for 1950s data	Recent CWM data: 0.9 to 3.6 times historical aiport data *(average 70% higher)*
3 **Different places** *(local/regional)*, **same time** *(recent)*	CWM 2005-2008 vs. Airport 2005-2009	AERMOD (both data are recent)	Recent CWM data: 1.4 to 3.9 times recent airport data *(average 2.1 times higher)*

The second comparison – recent local data and historical regional data – indicates that relative concentrations at nearby offsite receptors estimated with AERMOD using CWM data average about 70% higher than those estimated by CAP88-PC using older airport data. The ratios range from 0.9 to 3.6. The larger difference between these estimates likely reflects the influence of different meteorological conditions at these locations, as well as inherent differences between the two models.

The third comparison – recent CWM and airport data – indicates that AERMOD estimates at nearby offsite receptors based on local data average about 2.1 times higher than those based on regional data. As for the other comparisons, relative air concentrations vary by location, with ratios ranging from 1.4 to nearly 4. Because the same model was used with data from the same time period, the differences reflect the different environmental settings at these two locations. This last comparison also indicates the more detailed calculations afforded by the AERMOD system, which can account for meteorological conditions that exhibit hourly to seasonal changes. Using CAP88-PC with recent CWM data compared to recent airport data produces relative air concentrations for the nearby receptors that average 1.4 times higher, compared to 2.1 times higher with AERMOD.

As a note, the use of hourly meteorological data by AERMOD can result in higher estimates than CAP88-PC under stable conditions and low wind speed due to differences in the underlying algorithms. Because the air concentrations estimated by AERMOD under stable conditions and low wind speed can be higher than those predicted by CAP88-PC, these results can also translate to higher estimates of annual average concentrations. Like the preceding CAP88-PC comparisons, results of these AERMOD and CAP88-PC comparisons also indicate that dispersion at NFSS is less than at the airport.

As was seen in the spatial distribution patterns from the CAP88-PC analyses, the plume distributions for the three sets of meteorological data in these CAP88-PC and AERMOD comparisons are generally similar, especially for the recent and historical airport data. Even though these two data sets were evaluated with different computer codes (AERMOD for the recent data and CAP88-PC for the historic data), the contours are comparable. These contours generally stretch to the northeast, reflecting the prevailing regional wind direction. The contours shift a bit to the east when data from the CWM facility are used, becoming more east-northeasterly, likely reflecting the impact of local terrain. When the entire modeling domain is considered (i.e., including onsite), the range of concentration ratios increases, but overall results are comparable to those indicated for the representative offsite locations.

In summary, compared with the CAP88-PC estimates based on 1950s airport data, the concentrations predicted at nearby offsite receptor locations by AERMOD using recent airport data are about 20% lower. Concentrations are about 70% higher when CWM meteorological data are used. A comparison of AERMOD results for these two recent data sets indicate that using local data produces concentrations that average 2.1 times higher than when the Niagara Falls airport data are used. As described for the CAP88-PC analyses, this indicates that the location (local vs. regional) has a greater impact on dispersion estimates than time period (data collected in the last several years compared to more than 50 years ago).

ES.5 CONCLUSIONS

The main conclusions of this analysis are highlighted below. While uncertainties are inherent to any modeling effort, the results presented in this report are considered to reasonably address the potential dispersion and deposition of airborne releases from NFSS.

From the meteorological data evaluations:

- Recent data (2005-2008) from the CWM landfill are well suited for use in current dispersion modeling for NFSS.

- Data from the new meteorological tower at NFSS will be used for future dispersion modeling once a sufficient period of collection is achieved and the data have undergone standard QA/QC reviews.

These conclusions are supported by the main findings of the meteorological data comparisons:

- Data from the Niagara Falls airport are spatially and temporally representative of regional wind patterns, but these differ somewhat from the local patterns at the CWM landfill and NFSS.

- Prevailing winds differ slightly between the airport and the NFSS area; these winds are from the southwest at the airport but from the west-southwest at the CWM landfill and NFSS.

- Average wind speed in the NFSS area is nearly 30% lower than at the airport. This likely reflects differences in local features compared to those at the airport, where the elevation is higher and the land is more open (with fewer trees).

Regarding the dispersion modeling, both CAP88-PC and AERMOD are considered appropriate for NFSS evaluations, with each model serving the purpose for which it was developed. Relative air concentrations estimated by both models at nearby offsite receptor locations are summarized in Table ES.6. The main findings are:

- The local setting has a greater impact on dispersion estimates than when the data were collected.

- Predicted dispersion at NFSS is less than at the airport, as a reflection of the lower wind speed. Less dispersion translates to higher airborne concentrations. Using local rather than regional meteorological data in dispersion modeling for NFSS helps avoid the potential to underpredict airborne concentrations.

- The AERMOD system is well suited for assessing short-term to longer-term releases associated with potential remedial activities at NFSS. AERMOD also provides user-defined (e.g., hourly to annual) estimates of airborne concentrations and associated deposition.

TABLE ES.6 Comparison of Dispersion Modeling Results Using Different Meteorological Data[a]

***Compare* ↓ *to* →**		**AERMOD: Recent Meteorological Data**		**CAP88-PC: Historical Data**
		CWM Landfill 2005-2008	**Niagara Falls Airport 2005-2009**	**Niagara Falls Airport 1955-1959**
CWM Landfill 2005-2008	**CAP88-PC**		Same to 2 times higher *(average 40% higher)*	Same to 2.2 times higher *(average 60% higher)*
	AERMOD		1.4 to 3.9 times higher *(average 2.1 times higher)*	0.9 to 3.6 times higher *(average 70% higher)*
Airport 2005-2009	**CAP88-PC**	*(average 30% lower)*		0.7 to 1.8 times higher *(average 20% higher)*
	AERMOD	*(average 50% lower)*		0.4 to 1.3 times higher *(average 20% lower)*
Airport 1955-1959	**CAP88-PC**	*(average 30% lower)*	*(average 40% higher)*	

[a] Entries above the dark-shaded boxes reflect the results summarized in Tables ES.4 and ES.5.

- Concentrations predicted by AERMOD using local meteorological data from the CWM facility are higher than those predicted by CAP88-PC. Contributing factors include a more sophisticated dispersion algorithm in AERMOD compared with earlier models.

- CAP88-PC is useful for assessing chronic radionuclide releases to estimate annual doses for NESHAPs compliance. CAP88-PC is also useful for assessing the ingrowth of Rn-222 progeny as a complement to AERMOD (e.g., linked to the AERMOD dispersion estimate for a Rn-222 release).

- Both indirect and direct conversion approaches can be applied to recent meteorological data to estimate the form of the stability parameter used in CAP88-PC. Thus, recent data from the CWM landfill could be used with CAP88-PC for the annual NESHAPs compliance evaluations.

- Differences in air concentrations estimated by the indirect and direct methods are small. General agreement among the results of substantially different approaches supports the interpretations presented in this report.

The following suggestions are offered to further strengthen future dispersion analyses for NFSS.

- If CAP88-PC is used for the NESHAPs compliance evaluations, it is recommended that meteorological data from the CWM landfill be used with the most direct conversion method (σ_A).
- For the evaluation of potential remedial action activities at the site, it is recommended that CWM data be used with AERMOD at this time.
- When a sufficient and appropriate data record has been established from the new onsite station, it is recommended that these onsite data be used for all dispersion modeling at NFSS.

1 INTRODUCTION

The U.S. Army Corps of Engineers (USACE) is the lead Federal agency for the Formerly Utilized Sites Remedial Action Program (FUSRAP). The USACE Buffalo District is responsible for addressing the Niagara Falls Storage Site (NFSS) under FUSRAP, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. The CERCLA process is being conducted at NFSS via three operable units (OUs). A feasibility study (FS) will be prepared to identify and evaluate remedial alternatives for each, in accordance with standard regulations and guidance established by the U.S. Environmental Protection Agency (EPA 1988, 1989, 1990).

The Interim Waste Containment Structure (IWCS) at NFSS contains high-activity residues and other, lower-level radioactive materials from processing operations and disposal activities that occurred decades ago. The USACE conducts an environmental surveillance program and performs site operations, maintenance, and monitoring to ensure protection of human health and the environment from contaminants contained in the IWCS and elsewhere on the Federally owned NFSS. Because the IWCS represents the primary source of potential contamination at the site, it is being addressed as the first OU. Topical technical reports are being developed to support the upcoming FS for the IWCS OU, and this is one of the initial reports in that series.

1.1 PURPOSE AND SCOPE

This report addresses two basic elements of upcoming air quality analyses for the site, the meteorological data to be used and the dispersion modeling approach to be applied. Its purpose is twofold:

- Determine appropriate meteorological data to use in modeling the dispersion of airborne contaminants from the site to support the evaluation of remedial alternatives.

- Describe basic concepts of standard air quality analyses and assess the effect of using different models and input data to assess the dispersion of airborne contaminants from an NFSS release.

For the meteorological data component, the scope extends from stations at commercial facilities adjacent to NFSS to those at regional airports. For the modeling component, the scope covers two EPA models: the current standard air quality model jointly developed with the American Meteorological Society (AMS); and the model developed to assess compliance with EPA's National Emission Standards for Hazardous Air Pollutants (NESHAPs) established in 1989 for radionuclides, including at U.S. Department of Energy (DOE) facilities. The objectives of this report are to:

- Identify meteorological stations in the general vicinity that may have data relevant to NFSS.

- Evaluate meteorological data from key candidate stations to evaluate their representativeness and appropriateness for assessing the dispersion of potential airborne releases from NFSS.

- Describe two models used to assess air dispersion and the applications for which they are designed, and compare example dispersion estimates using different meteorological data.

- Indicate the meteorological data and dispersion model well suited for assessing dispersion of airborne releases from the IWCS, to support planning for this OU.

- Make this technical evaluation available to stakeholders in advance of the FS for the IWCS, to facilitate timely input regarding the approach for evaluating dispersion of potential airborne releases.

1.2 HISTORICAL MODELING OF AIR DISPERSION FOR NFSS

The dispersion of airborne contaminants from NFSS was first evaluated in detail more than 25 years ago by DOE as part of the environmental impact statement (EIS) process (DOE 1986). Meteorological data from the Greater Buffalo International Airport were used for those analyses. Subsequent evaluations, including those presented in annual site environmental surveillance reports, have relied on meteorological data from the Niagara Falls International Airport (hereafter referred to as Niagara Falls airport, or the airport), which is closer to NFSS.

Meteorological data collected more than 50 years ago from the Niagara Falls airport are used for routine NFSS evaluations to demonstrate compliance with the NESHAPs requirements for radionuclides under the Clean Air Act (CAA). This is because EPA accepts the use of the CAP88-PC computer model for estimating dispersion of radionuclides to demonstrate compliance with the NESHAPs annual dose limits, and the default set of meteorological data for NFSS in that code are those collected at the airport from 1955 to 1959 (Trinity Engineering Associates, Inc. 2007). (Note CAP88-PC represents CAA Assessment Package-1988-Personal Computer; see further discussions of this model in Chapter 6.)

To assure the best information is available for the IWCS FS, an evaluation of more recent meteorological data was undertaken to determine their appropriateness for assessing the dispersion of airborne releases associated with remedial action alternatives at NFSS. There are four main reasons for this updated evaluation. First, an escarpment (cliff-like ridge resulting from faulting or erosion that separates two relatively level areas of different elevations) lies between NFSS and the Niagara Falls airport, which raises a question as to whether the airport data are sufficiently representative of meteorological conditions at NFSS. The second reason is land use around the site differs from that at the airport, which translates to differences in land cover that can affect atmospheric dispersion. (For example, the NFSS area has a number of trees, while the airport is in an open area with minimal obstruction for safe operations.)

The third reason for this evaluation is that a number of changes have occurred since the 1950s in how meteorological data are collected and managed. For example, today's instruments are more advanced, the height of the meteorological tower has been standardized to 10 m (33 ft), and new measurement protocols are in place. The final reason is that storm tracks have shifted northward over the last 50 years, as evidenced by a decrease in the frequency of storms in mid-latitude areas of the Northern Hemisphere, while high-latitude activity has increased. Accordingly, climatological patterns in many areas of the United States have been altered due to the northward migration of storm tracks. Thus, in this evaluation, historical data are compared with more recent meteorological data to determine which are representative of NFSS conditions and well suited for modeling air dispersion to support upcoming analyses for the site.

1.3 REPORT ORGANIZATION

This report is organized as follows:

- Chapter 2 highlights key surface features near NFSS.
- Chapter 3 identifies nine candidate meteorological stations and the six evaluated in further detail to assess representativeness for NFSS.
- Chapter 4 presents the assessment of meteorological data from the six stations.
- Chapter 5 summarizes the conclusions of these meteorological data evaluations.

- Chapter 6 describes standard air quality requirements and dispersion models, as well as the characteristics of a standard meteorological station.
- Chapter 7 compares illustrative dispersion estimates from different models using different meteorological data.
- Chapter 8 summarizes the findings of these preliminary evaluations for NFSS.
- Chapter 9 lists the references cited in this document.

2 LOCAL SETTING

Wind patterns can be significantly affected by the local setting, including land use and cover, terrain, and proximity to large bodies of water. To provide context for this aspect of the evaluation, key features in the vicinity of NFSS are shown in Figure 1.

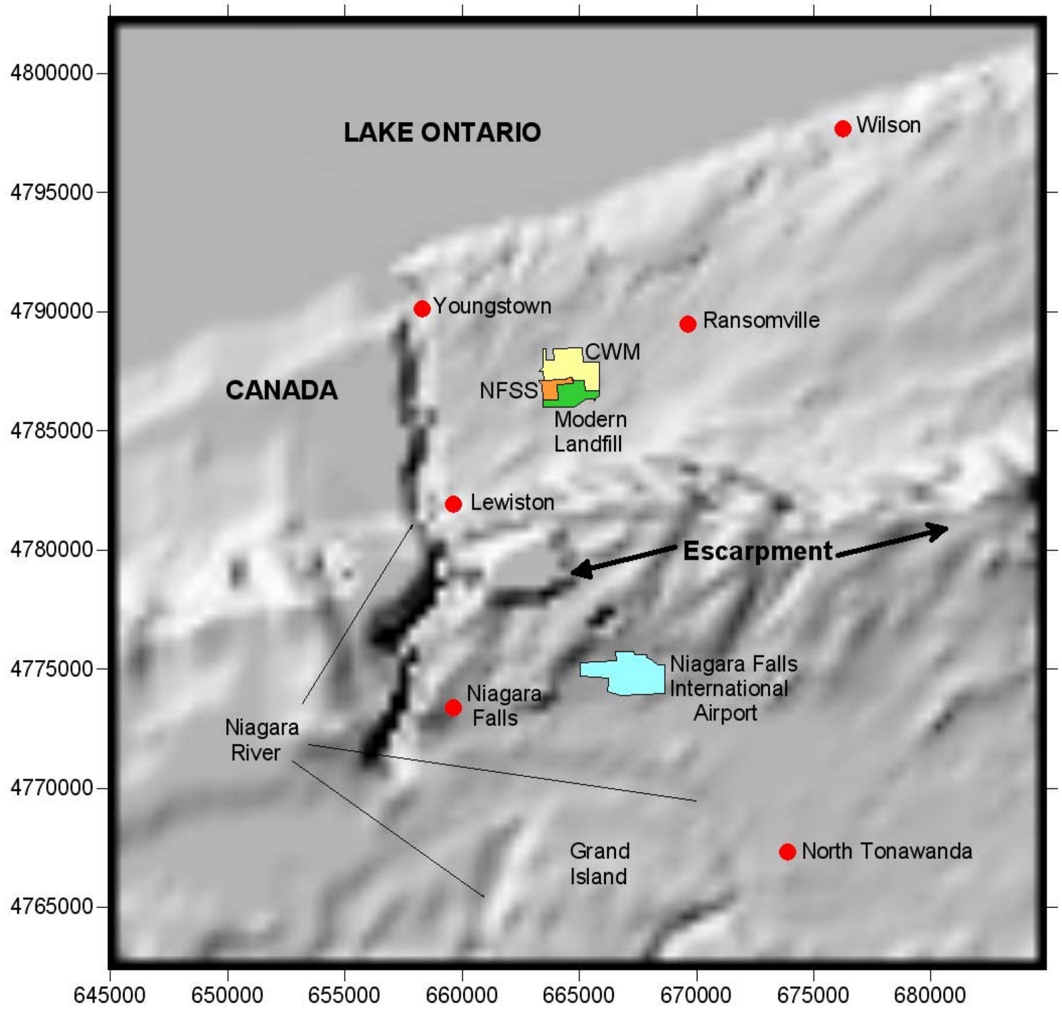


FIGURE 1 Topographic Features near NFSS (UTM = Universal Transverse Mercator coordinate system; source of elevation data: USGS 2010.)

Lake Ontario, shown in Figure 1, is about 7 km (4 mi) north of NFSS (note Lake Erie is about 37 km [23 mi] south of the site.) The Niagara Falls airport is about 12 km (7 mi) south-southeast of NFSS. The escarpment evident in Figure 1 runs from east-northeast to west-southwest, and top of the ridge is about 5 km (3 mi) south of NFSS. The difference in elevation between this point and the site is about 95 m (310 ft). The slope of the escarpment is relatively gentle, with an average grade of about 2% from the ground level near NFSS to the plateau. The slope is steepest between 3 and 5 km (2 and 3 mi) from the site, as illustrated in Figure 2; the change in elevation of about 76 m (250 ft) in this area translates to a grade of about 4%.

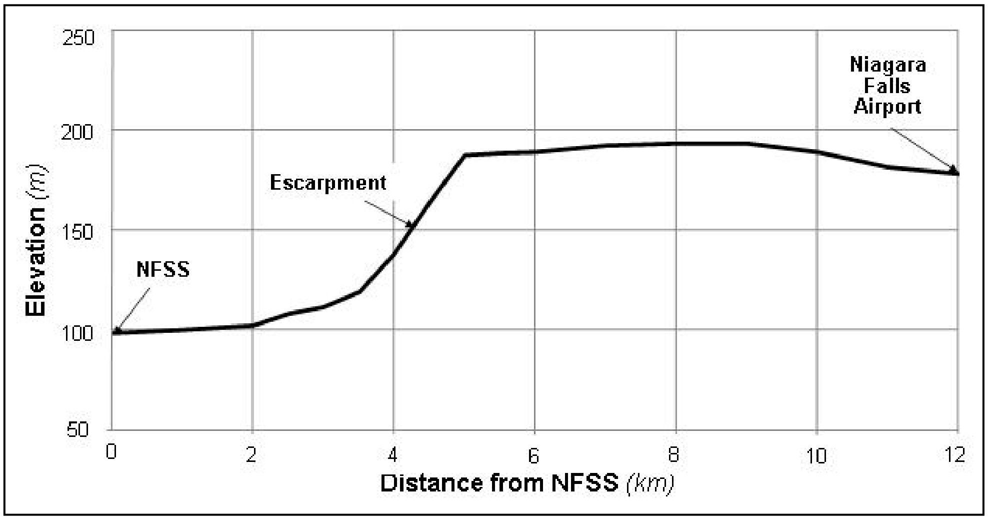


FIGURE 2 Schematic Cross-Section of the Escarpment

The distances to the candidate meteorological stations discussed in Section 3.1 are from a representative point at NFSS, which is the former location of Building 403 (see Figure 3). This is where the onsite DOE meteorological station was located in the 1980s (see Section 4.5).

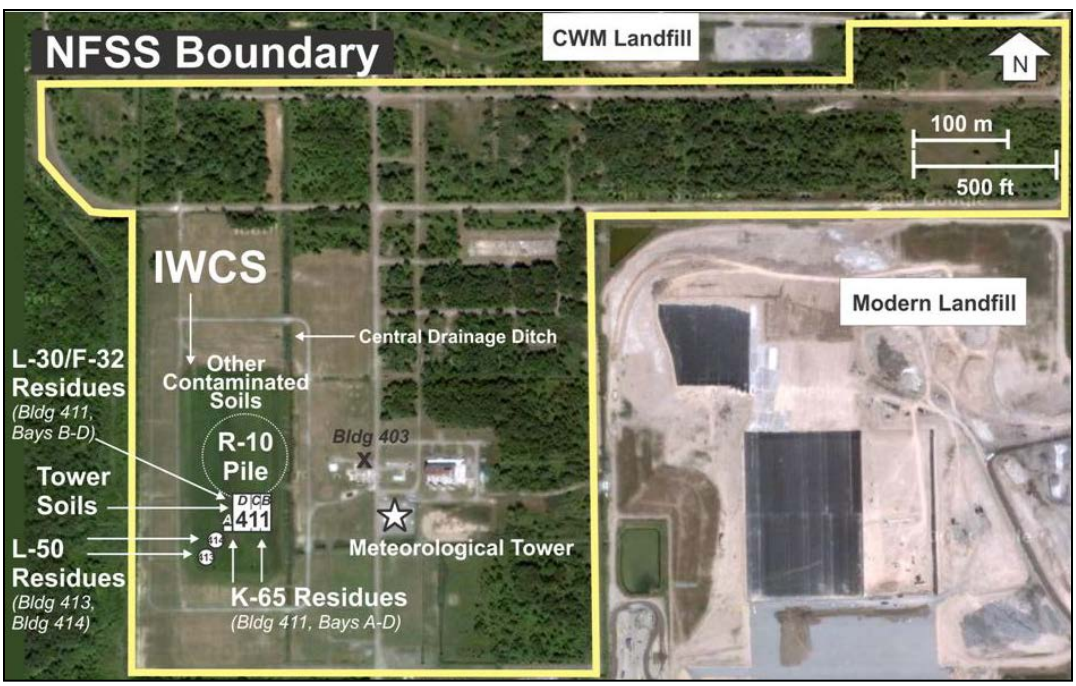


FIGURE 3 The NFSS (with Former Buildings) and Adjacent Landfills

3 CANDIDATE METEOROLOGICAL STATIONS

3.1 STATIONS IN THE GENERAL NFSS AREA

A key objective of this technical evaluation is to consider meteorological data from the Niagara Falls airport as well as other stations in the area to determine whether the 1950s airport data (the default set for NFSS in CAP88-PC) are representative of current conditions at the site, or if other data now available better reflect those conditions. Nine meteorological stations were identified as potential candidates for this evaluation, as shown in Table 1. Recognizing that data from airports commonly reflect a very high level of quality assurance/quality control (QA/QC), this list includes four airport stations. Three are Automated Surface Observing System (ASOS) stations in New York: at the Niagara Falls, Greater Buffalo, and Greater Rochester International Airports. The fourth is a Canadian ASOS-equivalent station at Hamilton Airport in Ontario (NCDC 2010).

TABLE 1 Candidate Stations for Relevant Meteorological Data

Meteorological Station	Location *(ordered by distance from NFSS)* [a]
1. Modern Landfill: Landfill Station	Adjacent to NFSS, to the east-southeast
2. Modern Landfill: Greenhouse Station	Adjacent to NFSS, to the south
3. CWM Landfill	Adjacent to NFSS, to the north-northeast
4. U.S. Coast Guard Station at Ft. Niagara	8 km (5 mi) northwest of NFSS on Lake Ontario
5. Niagara Falls International Airport	12 km (7 mi) south-southeast of NFSS in Niagara Falls, NY
6. Somerset Power Generating Station	34 km (21 mi) east-northeast of NFSS on Lake Ontario in Barker, NY
7. Greater Buffalo International Airport	35 km (22 mi) southeast of NFSS in Buffalo, NY
8. Hamilton Airport	75 km (47 mi) west of NFSS in Ontario, Canada
9. Greater Rochester International Airport	106 km (66 mi) east of NFSS in Rochester, NY

[a] Distances are from the representative point shown in Figure 3, the former location of Building 403.

As background information, ASOS represents a joint effort of the National Weather Service (NWS), Federal Aviation Administration, and U.S. Department of Defense (DoD), and it serves as the nation's primary surface weather observing network. The ASOS program is designed to support weather forecast activities and aviation operations while also supporting the scientific needs of the meteorological, hydrological, and climatological research communities. Meteorological data from these stations are widely used because of the thorough QA/QC procedures applied, relatively long duration of record, comprehensiveness and consistency in measurement techniques, and comparability to other NWS stations. For example, the height of the anemometer (which measures wind speed and direction) at most ASOS stations is standardized to 10 m (33 ft).

3.2 INITIAL REPRESENTATIVENESS CHECK

Two of the nine candidate stations were included as potential backup sources of meteorological data in case no other data were found to be both representative of meteorological conditions at NFSS and of sufficient quality for use in site-specific dispersion analyses. Both of these stations – Ft. Niagara and Somerset – are located on the shores of Lake Ontario. Because the lake can significantly affect local wind patterns, these two stations were only to be considered if needed. The initial analysis began with candidate stations closer to NFSS, and some of those data were found to be more suitable for detailed analysis. Therefore, the two shoreline stations were not considered further.

Similarly, from the initial review of candidate stations, the greenhouse station on the Modern property was not carried forward to the detailed evaluation phase. A key reason for screening this station from further analysis is that it has only been operating for about a year, while up to five years of data are preferred for integrated input to dispersion modeling (see the introductory text of Chapter 4). In contrast, the original station located on the landfill itself has been operating for a number of years. Thus, of the two meteorological stations, the latter was considered a better candidate for the detailed evaluation of meteorological data, and the greenhouse station was not considered further.

From the initial phase of this review, six stations were retained for more detailed analyses. These six are listed in Table 2, with descriptive information including the name, location, distance and direction from NFSS, site elevation, height of the anemometer (used to measure wind speed and direction), the station identification number, and the format used for the data files.

TABLE 2 Six Meteorological Stations Evaluated for Data Representativeness for NFSS

Station Name	**Location** (latitude, longitude)	**Distance and Direction from NFSS**[a]	**Site Elevation** m *(ft)*	**Anemometer Height** m *(ft)*	**Station ID**[b]	**Data Format**[c]
Airport Stations						
Niagara Falls International Airport	43.100N 78.933W	12 km (7 mi) south-southeast	180 *(590)*	10 *(33)*	ICAO: KIAG USAF: 725287 WBAN: 04724	ISHD (DS3505)
Greater Buffalo International Airport	42.933N 78.717W	35 km (22 mi) southeast	220 *(720)*	10 *(33)*	ICAO: KBUF USAF: 725280 WBAN: 14733	ISHD (DS3505)
Hamilton Airport (Ontario, Canada)	43.167N 79.933W	75 km (47 mi) west	240 *(780)*	10 *(33)*	ICAO: CYHM USAF: 712630 WBAN: 99999	ISHD (DS3505)
Greater Rochester International Airport	43.117N 77.667W	106 km (66 mi) east	170 *(550)*	10 *(33)*	ICAO: KROC USAF: 725290 WBAN: 14768	ISHD (DS3505)
Landfill Stations						
Modern Landfill	43.2117N 78.9771W	0.6 km (0.4 mi) east-southeast	98 *(320)*	39 *(130)*	-	Site-specific
CWM Landfill	43.2222N 78.9794W	1.0 km (0.6 mi) north-northeast	97 *(320)*	10 *(33)*	-	Site-specific

[a] Distances are rounded to two significant figures and are from the representative point shown in Figure 3, the former location of Building 403: latitude 43.2142N (north), longitude 78.9841W (west), elevation 96 m (315 ft).

[b] An identifier is available for stations in the ASOS program. ICAO = International Civil Aviation Organization airport code, USAF = U.S. Air Force station number, WBAN = Weather Bureau Army Navy station number. A dash indicates the entry is not applicable.

[c] ISHD = integrated surface hourly data (current standard format for meteorological data from ASOS stations).

4 ANALYSES AND COMPARISONS OF CANDIDATE METEOROLOGICAL DATA

Key meteorological data are typically integrated into a single figure referred to as a wind rose, which graphically summarizes wind speed and wind direction as a series of bars pointing in different directions. (In this report, wind speed refers to the horizontal wind speed unless otherwise noted.) The direction of each bar shows the direction from which the wind blows. Each bar is divided into segments that represent wind speeds in a given range, and the length of each segment represents the percentage of the summarized hours that winds blew from that direction with a speed in that range.

A wind rose also shows the prevailing wind direction for a given location. To examine regional wind patterns in this report, wind roses were developed from recent data for several meteorological stations in the general area of NFSS (Figure 4).

Wind roses are designed to show the distribution of wind direction and wind speed experienced at a given location over a substantial time interval, typically five years. Considering more than one year of data addresses the variability of meteorological conditions across seasons and from one year to another. For the wind roses shown in Figure 4, all but one cover the period 2005 through 2009; for the CWM landfill station, the wind rose is for the period 2005 through 2008.[1]

To support this evaluation, data from meteorological stations at the two commercial landfill sites adjacent to NFSS were shared with the USACE Buffalo District by helpful personnel from each facility (Goehrig 2010, Zayatz 2010). Based on their proximity to NFSS and similar land covers, the meteorological data from these two facilities were evaluated as a priority. These results are highlighted in Sections 4.1 and 4.2, and selected comparisons with Niagara Falls airport data are presented in Sections 4.3 through 4.5.

4.1 MODERN LANDFILL

The Modern landfill site abuts NFSS from east to south clockwise. The main meteorological tower is about 0.6 km (0.4 mi) east-southeast of the former location of Building 403 (see Figure 3). The tower is at the top of the slope on the western face of this landfill, such that the anemometer is 39 m (128 ft) above the local ground level. This is nearly four times the standard height of 10 m (33 ft).

Two factors limit the usefulness of these data for air dispersion modeling at NFSS. First, the measurement height is much greater than at any nearby meteorological tower, which makes data comparisons difficult. This substantial difference also limits the possibility of filling data gaps or addressing typical reporting errors by tapping similar data from nearby stations.

Second, the review of these data suggests some inconsistencies. For example, although reported wind directions are relatively consistent from year to year, reported wind speeds vary widely. As another indicator, the five-year average wind speed appears low compared to what would be expected for a measurement at that height. This might reflect the position of the tower atop the face of the landfill. (Note that a higher instrument would be expected to measure higher wind speeds due to lower surface friction effects.) Thus, these data were not considered further in the evaluation of potential data sets for modeling air dispersion at NFSS.

[1] Meteorological data for 2009 were not included in the integrated set for the CWM landfill because the data recovery rate for that year was below 90%, which is the EPA expectation for including data in air quality modeling analyses (EPA 2000).

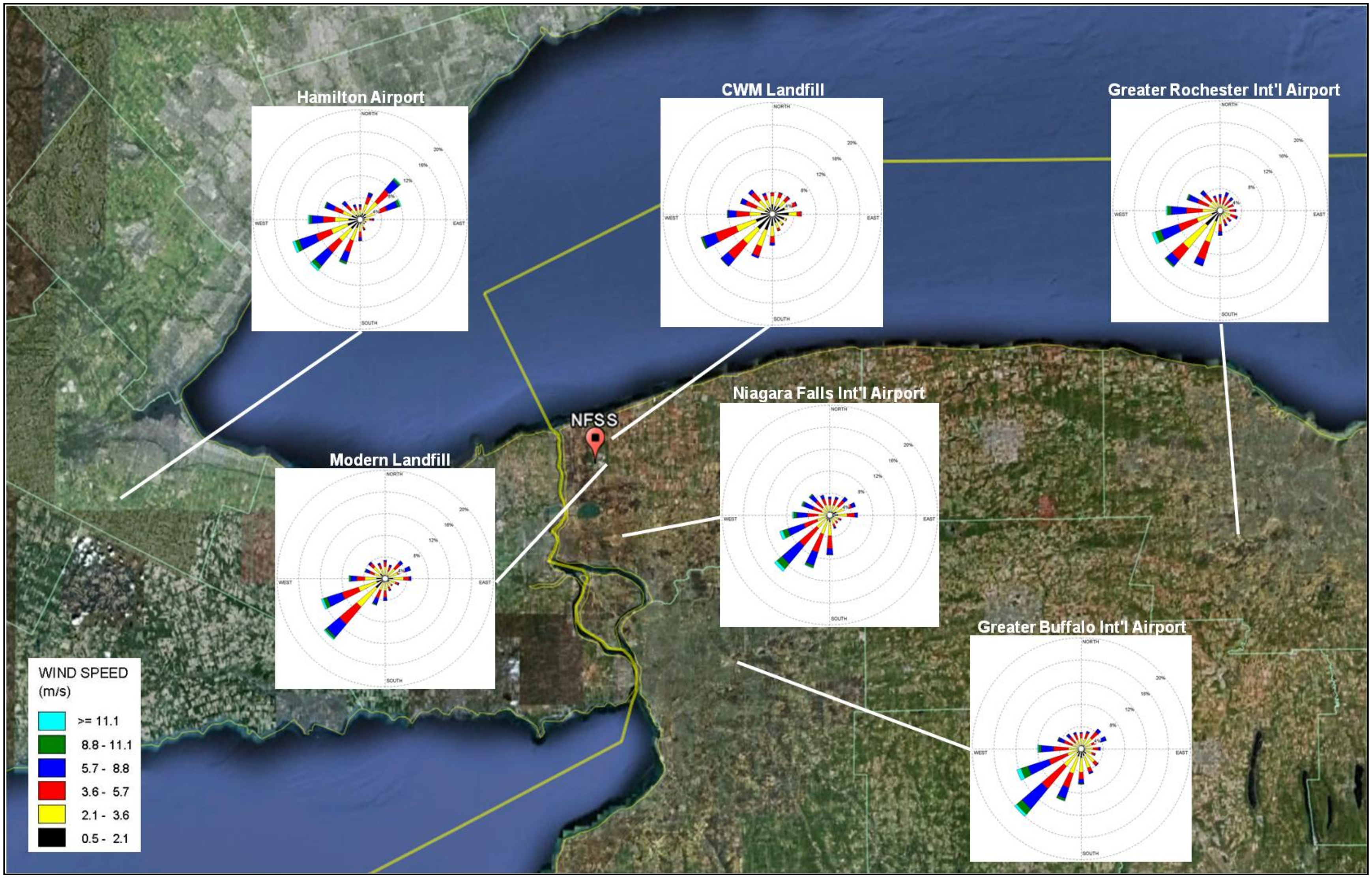


FIGURE 4 Wind Roses for Six Meteorological Stations in the NFSS Region
(Data sources: NCDC 2010, Zayatz 2010. The underlying map is from Google Earth; the irregular yellow line delineates the U.S.-Canadian border.)

4.2 CWM LANDFILL

The CWM landfill site abuts NFSS to the north, and its tower is about 1 km (0.6 mi) north-northeast of the former location of Building 403 (see Figure 3). The anemometer is 10 m (33 ft) above ground level, which is the standard height for this instrument. It is important to note that the data for the Modern and CWM facilities were collected for different purposes than those at the standard airport stations, so the quality is understandably not at the level of an ASOS station. However, CWM evaluates its data in accordance with a sound internal QA/QC program.

The further review conducted for this report found that these data are of sufficient quality for use in air dispersion modeling for NFSS. Considering how close this station is to NFSS and how similar the elevation and surrounding land cover are, together with the fact that these measurements are taken from the standard height, the CWM data are considered representative of air dispersion patterns at NFSS and appropriate for use in site-specific modeling (see supporting evaluations in Sections 4.3 and 4.4).

4.3 AIRPORT STATIONS AND GENERAL COMPARISONS TO CWM AND MODERN DATA

Data from the airport meteorological stations indicate the prevailing wind direction is from the southwest, which is typical of the region. With regard to lake impacts, the wind directional elements associated with lake breezes blowing from the lake to the land stand out, depending on the distance and orientation to the nearby lakes. For example, more southwesterly winds are shown at the Greater Buffalo International Airport, which reflects the effect of nearby Lake Erie to the southwest.

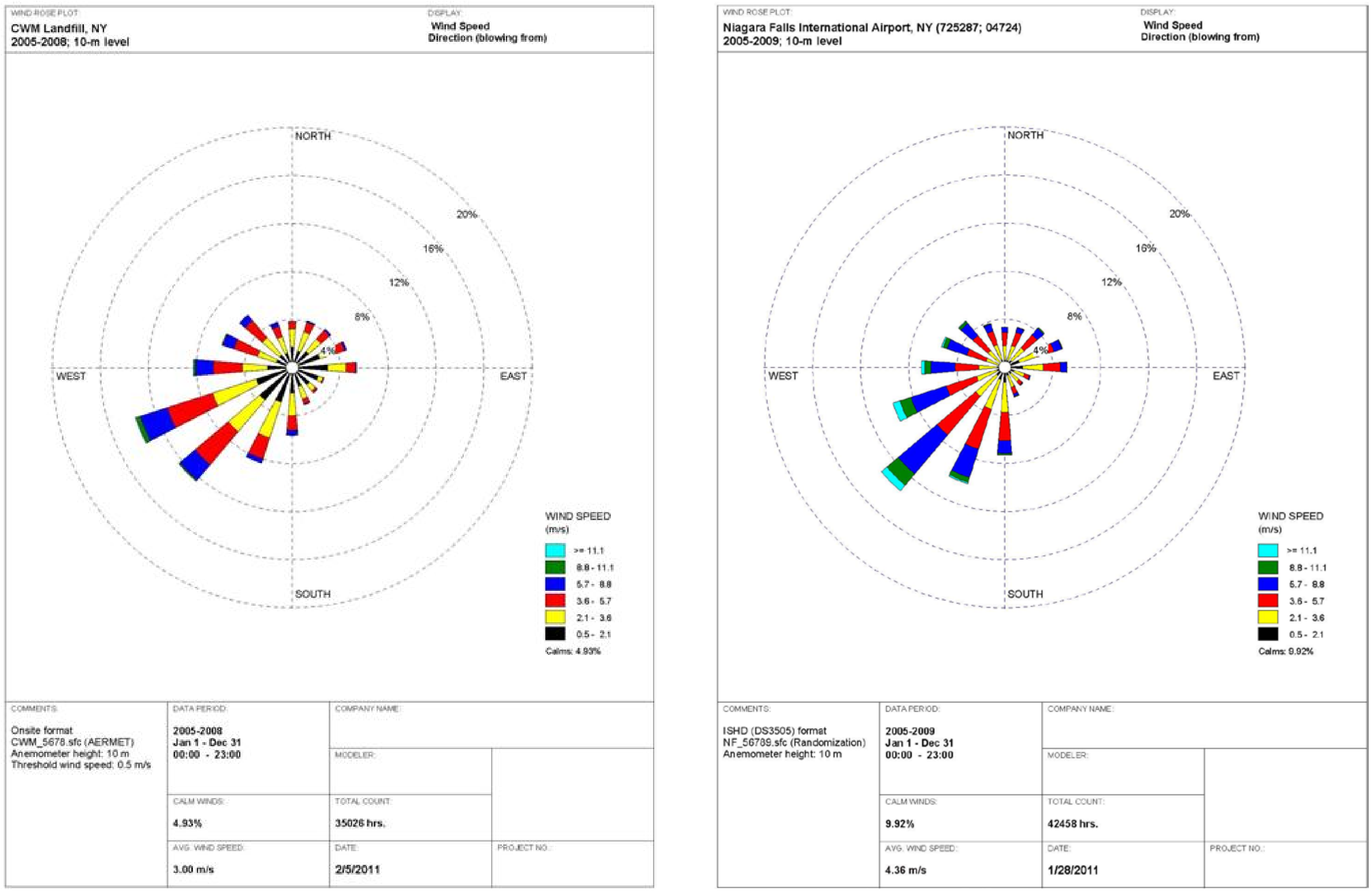
In contrast, more northeasterly winds are evident at the Hamilton Airport, which reflects the effect of nearby Lake Ontario to the northeast. In addition, more northerly winds from Lake Ontario are not prominent but are slightly higher at the CWM site. Nighttime land breezes blowing from the land to the lake are usually weaker than their daytime counterpart lake breezes, so no land breezes are noticeable at any of the meteorological stations.

Average wind speeds at the ASOS stations range from 4.0 m/s (8.9 mph) at the Rochester airport to 4.5 m/s (10.1 mph) at the Buffalo airport. The average wind speed of 3.0 m/s (6.7 mph) at the CWM site is slightly more than two-thirds of the average wind speed of 4.4 m/s (9.8 mph) at the Niagara Falls airport, even though these two stations are only about 13 km (8 mi) apart. This can be explained by differences in surface roughness, because relatively tall trees are associated with the CWM site while the Niagara Falls airport is in an open area.

Such a substantial difference in wind speed is not unusual for two nearby meteorological sites with different land covers. Note that the average wind speed at the Modern landfill is reported as about 3.2 m/s (7.1 mph), which is only slightly higher than the average at the CWM site. (Considering the difference in anemometer height – i.e., 39 m [128 ft] vs. 10 m [33 ft] – the average wind speed reported for the Modern landfill appears somewhat low. An average wind speed of around 4 m/s [9 mph] might be expected at that height.)

4.4 ADDITIONAL COMPARISONS OF CWM DATA AND NIAGARA FALLS AIRPORT DATA

Due to their proximity to NFSS and appropriate levels of QA/QC, the data from the Niagara Falls airport and CWM landfill stations were examined even more closely; the first additional comparison is presented in Figure 5. This figure shows that while wind speeds at the CWM site are about two-thirds those at the airport (due in part to differences in land cover), the wind patterns at these locations are generally similar. Note, however, that the prevailing wind direction differs slightly between these two stations.



(a) **(b)**

FIGURE 5 Wind Roses at the 10-m Level for (a) CWM Landfill, 2005-2008; and (b) Niagara Falls Airport, 2005-2009
(Data sources: NCDC 2010, Zayatz 2010.)

That is, the direction at CWM is west-southwesterly compared to southwesterly at the airport. This can be explained by the higher elevation and more open terrain at the airport, which represents the regional patterns of prevailing southwesterly winds. The prevailing southwesterly wind direction is also substantiated by data from the Modern landfill station (Figure 4), which were collected from a height of 39 m (128 ft). That height is well above the tree line near the tower, which means those wind data are not much affected by local terrain and thus more likely represent regional patterns. In contrast, the CWM site can be seen as representing local wind patterns, considering its lower elevation and nearby land cover. What is certain from Figure 5 is that (1) wind directions differ slightly between these two stations, and (2) wind speeds in the NFSS area are lower than those at the Niagara Falls airport. Accordingly, if contaminants were released from NFSS (e.g., during future activities at the IWCS), downwind concentrations calculated using data from the airport instead of CWM could be lower (underestimated).

However, it is important to note that airborne concentrations are not directly proportional to the ratio of average wind speeds between two stations. The surface roughness length and mixing heights are also important components of the dispersion modeling. In general, downwind concentrations are higher with lower wind speed, smaller surface roughness length, and lower mixing heights. The surface roughness length is somewhat higher for NFSS than for the airport, due to the nearby trees and onsite structures that promote dispersion. However, the mixing heights, through which relatively vigorous vertical mixing occurs, are lower at NFSS compared with those at the Niagara Falls airport.[2]

As a further observation, it appears that wind patterns at NFSS are affected by the escarpment to some degree. Considering the more frequent west-southwesterly winds reported for CWM, it can be postulated that the escarpment south of NFSS might steer prevailing southwesterly regional winds somewhat, to the orientation of the escarpment running in the east-northeast to west-southwest direction. However, the base of the escarpment is about 3 km (2 mi) away from the NFSS and its slope is relatively gradual. Thus, it is not clear whether wind patterns are affected by its presence (and this question could not be answered unless more validated and reliable measurements were available from near its northern foothill).

Although annual patterns are similar for the Niagara Falls airport and CWM data, seasonal patterns differ significantly in some cases. The seasonal patterns in wind speed for the 2005-2008 period are shown in Figure 6. In general, wind speed is highest in winter and lowest in summer. While the seasonal variations at each site are similar, the wind speeds differ from one year to another (as noted above). In particular, the unusual wind speeds for fall and winter 2005 reflected in the Niagara Falls airport data (which differ markedly from those for other years) are well matched by the data reported for CWM during the same period. The annual frequencies of wind direction are presented in Figure 7. Wind direction patterns are quite similar at these two stations and do not fluctuate much from year to year, except for 2006 at the CWM facility. A key difference between the sites is the prevailing wind direction. That is, prevailing winds are from the southwest at the airport but from the west-southwest at the CWM site. Another difference is in the representation for calm winds. This difference can be explained by the lack of standard airport data for lower wind speeds; i.e., the lowest wind speed commonly reported in ISHD format is 1.5 m/s (3.4 mph) (see Chapter 5). Winds below this threshold are addressed as calm.

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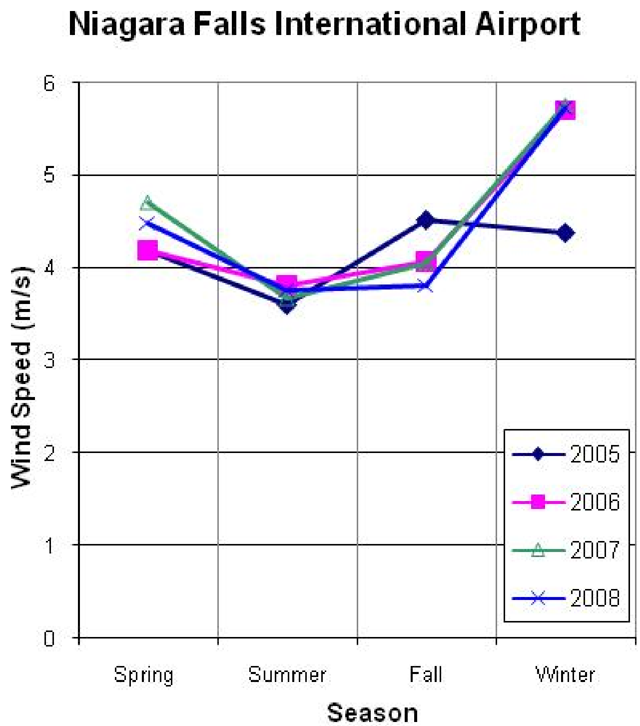
[2] The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero. Values range from less than 0.1 cm (0.04 in.) over a calm water surface to 1 m (3.3 ft) or more over a forest or urban area, and this measure varies by land cover and season. The greatest surface roughness length at the CWM facility adjacent to NFSS (which is representative of local conditions) is about 50 cm (1.6 ft). With regard to mixing height, during daytime hours when buoyant turbulence prevails, more solar radiation heats the ground at the airport than at the NFSS area, thus generating higher mixing heights at the airport than at the site. (More of the solar radiation energy is consumed by evapotranspiration at NFSS because the area has more vegetation.) During nighttime hours, when the mixing height reflects only mechanical turbulence, the mixing heights at NFSS are relatively low compared with those at the airport due to the lower wind speeds at the site.



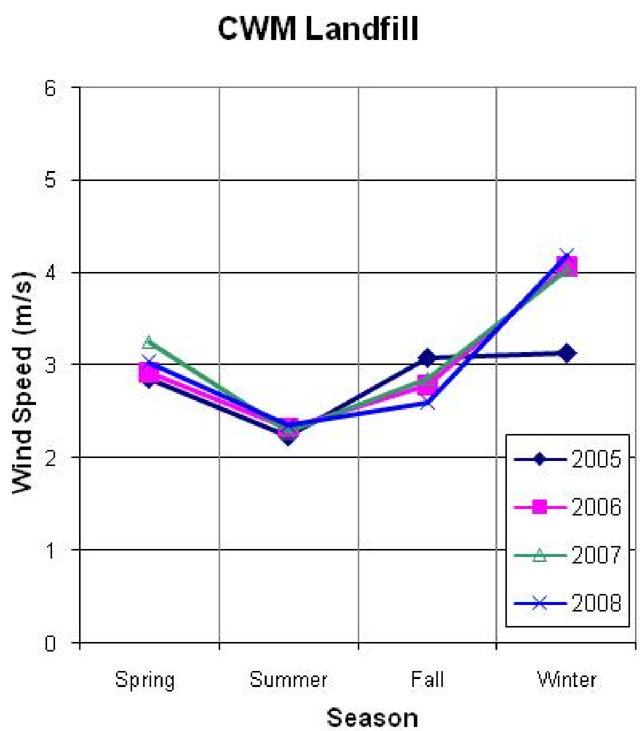
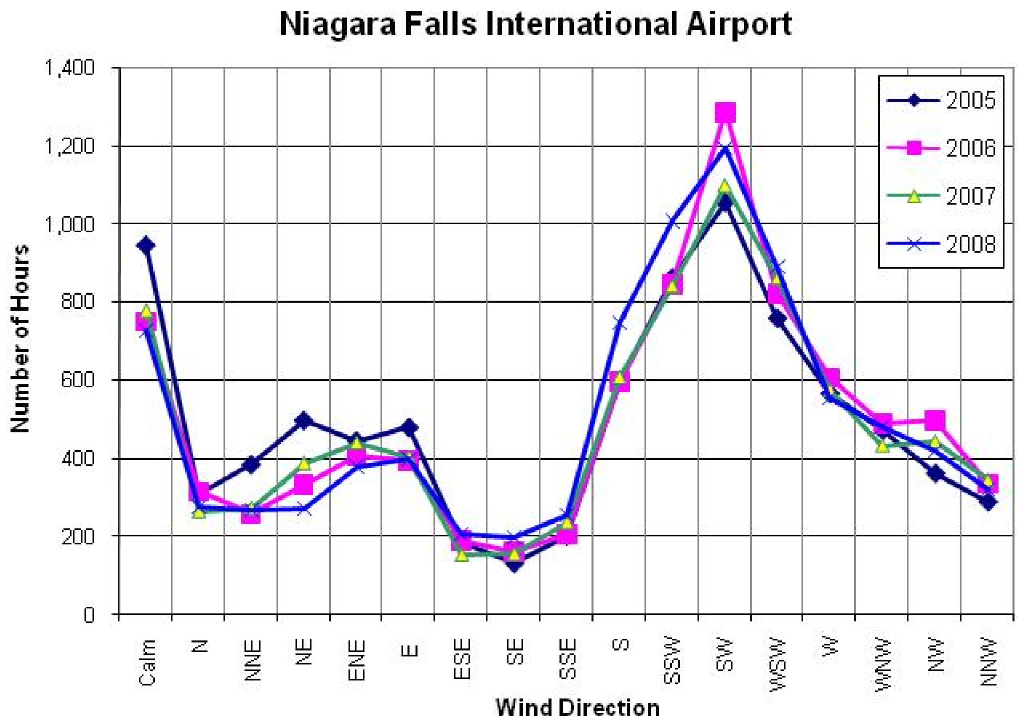


FIGURE 6 Seasonal Patterns in Wind Speed for 2005-2008 from the Niagara Falls Airport and CWM Landfill (Data sources: NCDC 2010, Zayatz 2010.)



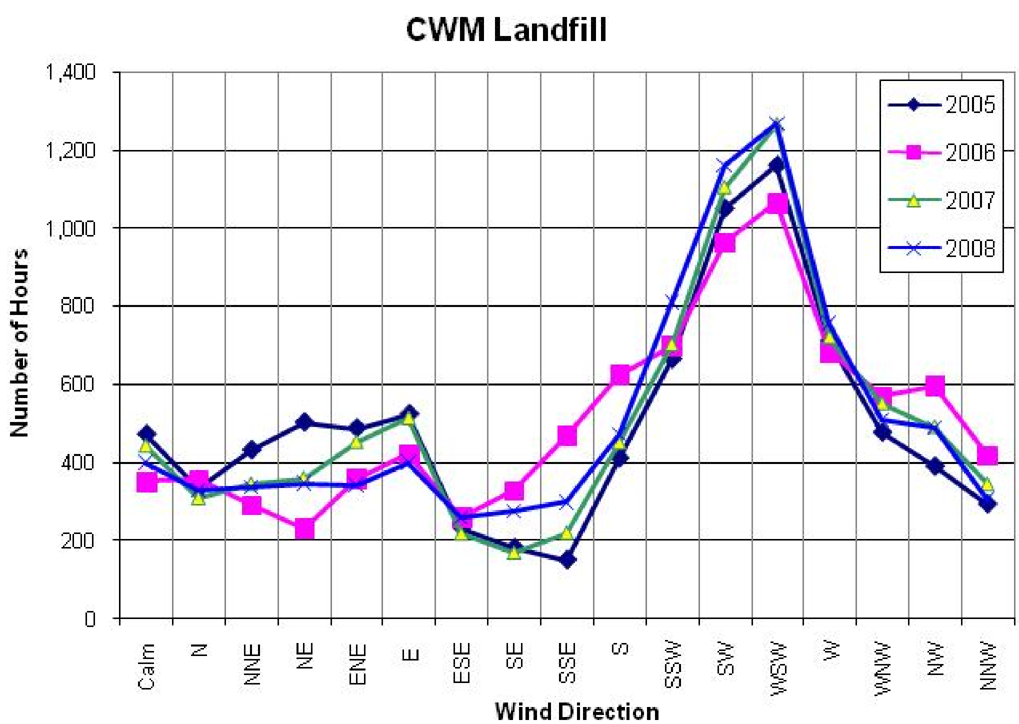


FIGURE 7 Annual Patterns in Wind Direction for 2005-2008 from the Niagara Falls Airport and CWM Landfill (Data sources: NCDC 2010, Zayatz 2010.)

4.5 COMPARISON OF 1980s WIND ROSE FOR NFSS AND CURRENT CWM WIND ROSE

Meteorological data were collected onsite for a limited time during the 1980s. An initial station was installed atop Building 403 in 1980 (see Figure 3 for its location; this building was demolished in 2000), and a (subsequent) meteorological monitoring station began operating in April 1983 (BNI 1984). The data collected onsite are reflected in the wind roses presented in annual environmental monitoring reports for NFSS (BNI 1982-1990). Four separate wind roses are presented in the successive annual reports, representing data for 1981, 1982, 1984, and 1985. Note that the wind rose based on 1982 data is used in the 1983 report, and the wind rose based on 1985 data is used in the annual environmental reports for 1986 through 1990.

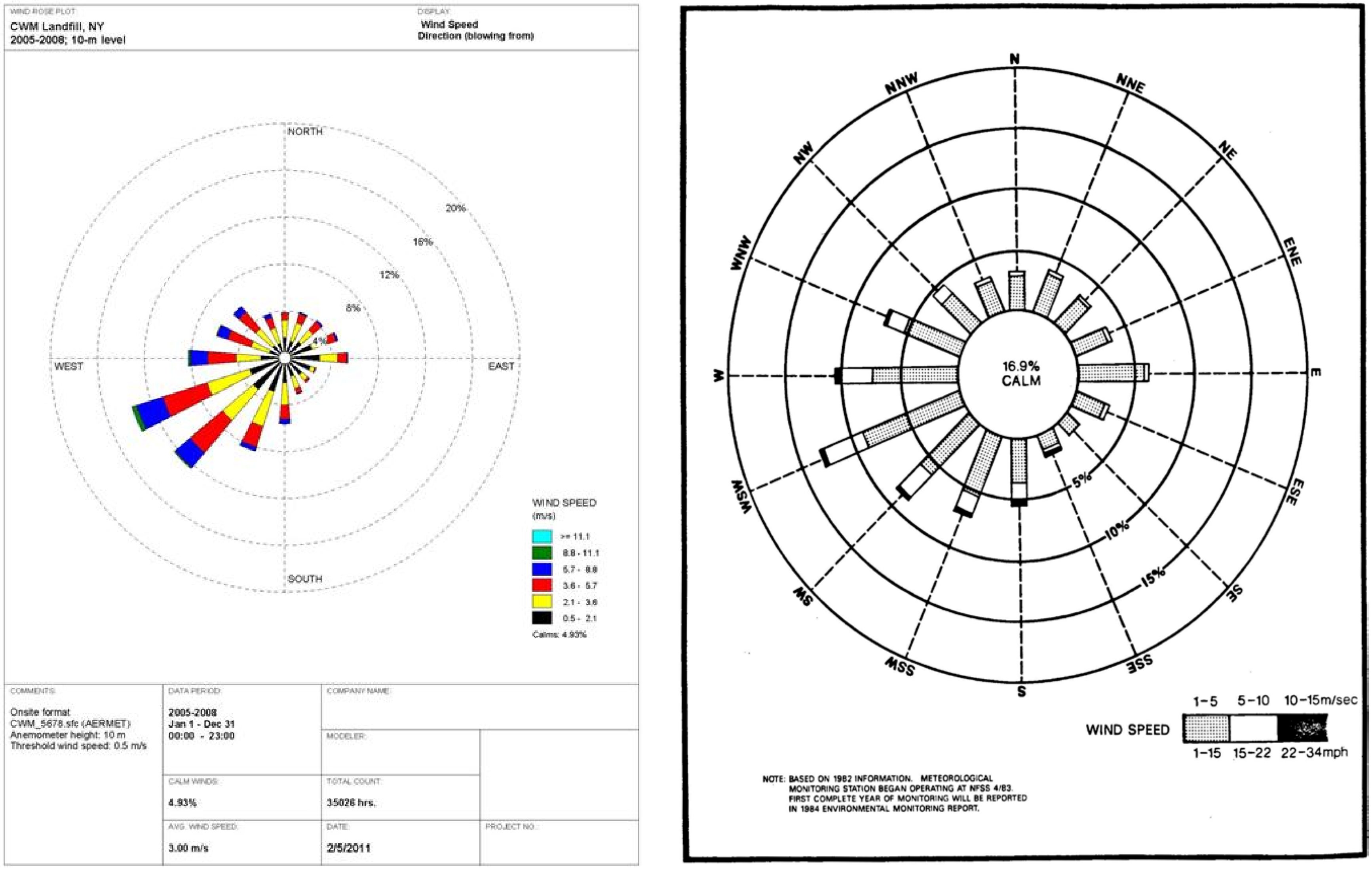
These four wind roses are generally comparable, and the wind rose based on 1982 data (which is reflected in both the 1983 and 1984 annual reports) is shown in this current technical report to represent onsite meteorological data for that time. After that decade, the annual site environmental reports for NFSS no longer included a wind rose.

As context, the NESHAPs requirements for DOE facilities (including NFSS) given in 40 CFR 61 Subparts H and Q were developed and promulgated during that time period (as discussed in BNI 1991). Subpart Q addresses radon at DOE facilities, and Subpart H addresses radionuclides other than radon (EPA 2011a). Three computer models were identified in Subpart H for demonstrating compliance with the NESHAPs radiation dose standard of 10 millirem/yr: CAP88-PC, AIRDOS, and COMPLY (which can only be used in certain situations). The DOE initially used AIRDOS for this purpose (BNI 1992) but converted to CAP88-PC shortly thereafter (BNI 1993). The default meteorological data set for NFSS in CAP88-PC was collected from the Niagara Falls airport during 1955-1959. (This data set would not produce the same wind rose as that obtained using site-specific meteorological data at NFSS in 1985.)

No numerical wind data were provided with the wind roses in the documents prepared by Bechtel National, Inc. (BNI) from 1982 to 1990. For example, the anemometer height was not identified, nor were annual average wind speeds. Because of these limitations, and because wind speed categories differ from year to year, a composite wind rose could not be constructed for NFSS as part of the current effort. Thus, no direct comparisons can be made with the other meteorological data sets evaluated in this report. Nevertheless, general wind patterns shown in the historical wind rose can be compared and interpreted in that context, as illustrated in Figure 8.

The shapes of the two wind roses in this figure show that the earlier wind patterns at NFSS are quite similar to those at the CWM site from 2005 to 2008. Average calm winds at NFSS, as defined for this site-specific (non-ASOS) station, occurred about 20% of the time from 1981 to 1985. This is almost 50% higher than the parallel frequency at CWM, which is nearly 14% (13.6%). (Note that the historical wind rose for NFSS defines calm wind as less than 1 m/s [2.2 mph]; thus, for purposes of comparing these two figures, the same definition is applied for the wind rose developed from the recent CWM data.) This difference is relatively minor, considering that this combined difference of less than 7% is distributed across 16 directional sectors.

The comparison of wind roses also shows that the prevailing wind direction is from the west-southwest for both NFSS (1981-1985) and CWM (2005-2008). For the NFSS 1981-1985 data, the frequency of winds from this direction ranged from 12.5% to 15.0%, with an average of 14.0%; this value is comparable to the average of 13.7% for the CWM site. The next most frequent wind direction over the combined years is also the same for both NFSS and CWM: from the southwest. Those winds occurred about 11.8% of the time at NFSS, which is slightly less than the frequency at CWM (12.4%). From these comparisons of average wind speeds and prevailing wind directions, it can be concluded that wind data from the CWM site appropriately represent the wind patterns at NFSS.



(a) (b)

FIGURE 8 Wind Roses for (a) CWM Landfill, 2005-2008; and (b) NFSS, 1982 (Data sources: Zayatz 2010, BNI 1984.)

5 CONCLUSIONS REGARDING DATA REPRESENTATIVENESS FOR NFSS

Of the meteorological data evaluated in this review, those from the CWM site were found to best characterize the wind and dispersion patterns in the area of NFSS. They are also considered of appropriate quality for use in dispersion modeling; e.g., the measurements are taken from the standard height and have undergone an appropriate QA/QC review.

Meteorological data from the Niagara Falls airport can be considered both spatially and temporally representative of regional wind patterns, but the regional patterns differ somewhat from local patterns at the NFSS area. The airport is at a higher elevation than the site, and the surrounding land use and land cover are different, so meteorological data from the airport do not fully account for the effects of local features on the wind patterns at the CWM landfill and NFSS. Thus, the CWM data (2005-2008) are considered appropriate for use in modeling the dispersion of airborne releases from NFSS at this time.

An additional consideration is that using Niagara Falls airport data for dispersion analyses at NFSS might produce a low bias (underestimate) of predicted offsite concentrations. Although meteorological data from ASOS stations are of very high quality, these stations have not generally reported wind speeds below 1.5 m/s (3 knots, or 3.4 mph). This is because measurements have been limited by the threshold of the cup anemometer system that was widely used until recently.[3] Most ASOS stations now use sonic anemometers, which have essentially no reportable threshold, but the long-standing observing rules and practices have not yet changed (Stephens 2011). Thus, consistent with other ASOS stations, the lowest wind speed reported for the Niagara Falls airport as used in air modeling analyses is 1.5 m/s (3.4 mph).

This information provides context for the dispersion modeling discussed in subsequent chapters, because wind speeds below a given threshold are assumed to be calm. This means that some wind speeds below the standard reporting threshold may not be fully accounted for in the illustrative dispersion calculations reflected in this document. Note that for ground-level or near-ground-level releases, low wind speeds under stable conditions produce maximum downwind concentrations. This is because the release is transported in a very narrow plume (and thus is more concentrated) compared to higher wind speeds and/or unstable conditions that would disperse the release over a much wider area.

As the default data for NFSS in CAP88-PC, the 1950s airport data have long been used appropriately to demonstrate compliance with the radionuclide NESHAPs; they can also be used for a comparative evaluation of potential impacts of Rn-222 releases, to support ongoing evaluations as part of the FS process for the IWCS OU. Now that local data have become available from the adjacent CWM landfill (Zayatz 2010), and those data have been determined to be appropriate for use in dispersion modeling, it is anticipated that these recent data will be incorporated in upcoming dispersion analyses for NFSS.

In conclusion, because the CWM data represent meteorological conditions at NFSS well and are of appropriate quality for dispersion modeling, they are considered well suited for modeling the dispersion of airborne contaminants from NFSS. When sufficient onsite data become available (see Chapter 6 regarding the meteorological station recently installed by the USACE Buffalo District), the onsite data would be used in the dispersion modeling for NFSS.

[3] The threshold wind speed is the speed below which air movement cannot be detected, and it depends on the instrument. For mechanical anemometers such as the cup anemometer that rely on air movement to overcome the friction of the instrument, the threshold is typically 0.5 m/s (1.1 mph). No such threshold exists for the sonic anemometer because it has no moving parts.

6 FRAMING CONTEXT FOR DISPERSION MODELING

This chapter provides general background information on the current standard approach for modeling air dispersion across mutiple program applications. Air quality analyses are routinely conducted at facilities across the country to address EPA requirements established under the CAA. These analyses include dispersion modeling that incorporates information for site-specific emissions, local topography, and representative meteorological data. This chapter highlights information on typical modeling expectations and how they are reflected in plans for assessing the dispersion of airborne contaminants at NFSS. The USACE Buffalo District recently installed an onsite meteorological station, and when sufficient measurements are available and have undergone appropriate review, this station is expected to provide the best meteorological data for use in NFSS dispersion analyses.

Key air quality requirements are described in Section 6.1, and the attainment status for the NFSS area is identified in Section 6.2. Basic context for dispersion modeling is presented in Section 6.3, and characteristics of standard meteorological stations are provided in Section 6.4.

6.1 REQUIREMENTS FOR ADDRESSING AMBIENT AIR QUALITY

The EPA has established National Ambient Air Quality Standards (NAAQS) under the CAA, as well as regulations for the prevention of significant deterioration (PSD) of air quality by major emission sources. The PSD regulations are designed to control the increase of air pollution in “clean” areas by defining maximum allowable increments that can be emitted above established baseline levels, including for criteria pollutants such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulate matter (PM, specifically PM_{10} [PM with an aerodynamic diameter of 10 microns or less], and as of October 20, 2010, also $PM_{2.5}$ [PM with an aerodynamic diameter of 2.5 microns or less]).

The PSD regulations apply to a major new emission source or modification of an existing major source within attainment and unclassified areas. A major stationary source is defined as any source that belongs to the set of categories listed in 40 CFR 52.21 (EPA 2011b), which has the potential to emit 100 tons per year (tons/yr) or more of any pollutant regulated under the CAA. These categories include certain smelters, iron and steel mills, ore processing plants, chemical plants, coal-fired power plants, and petroleum refineries. The potential to emit is based on the maximum design capacity of the source and takes into account the efficiency of its pollution controls. The NFSS does not fall under any major source category listed in the PSD regulations.

Beyond the category list, sources are considered “major” if they have the potential to emit 250 tons/yr or more of any pollutant regulated under the CAA. Once an existing source is considered major, a PSD review is required if any modification to that source could result in a net increase in pollutants in significant amounts. Like many small industrial facilities, emissions from activities at NFSS would be far below this threshold used to identify a major source. Thus, NFSS is not considered a major source under this definition.

6.2 NONATTAINMENT AREAS

The NFSS is located in Niagara County, which is within EPA’s Niagara Frontier Intrastate Air Quality Control Region (AQCR) 162. This AQCR consists of Erie and Niagara Counties, as identified in 40 CFR 81.24; the status of Niagara County with regard to attaining EPA standards for criteria pollutants is given in 40 CFR 81.333 (EPA 2011c). This information, summarized in Table 3, indicates that Niagara County is designated as nonattainment status for one criteria pollutant: ozone (8-hour standard).

TABLE 3 Attainment Status Designations for Niagara County

Criteria Pollutant[a]	Designation	Notes
Carbon monoxide (CO)	Unclassifiable/attainment	Reflects date of November 15, 1990.
Lead	Not designated	Same as rest of state except Onondaga County, which is designated unclassifiable.
NO_2	Cannot be classified or better than national standards	
Ozone (O_3), 8-hr standard	Nonattainment, Subpart 1	Reflects date of June 15, 2004.
O_3, 1-hr standard (shown in italics because this standard was since revoked)	*Nonattainment*	*Classification listed as marginal; reflects date of January 16, 2001; standard revoked for all areas of New York effective June 15, 2005.*
PM_{10}		Only listed for New York County, as nonattainment (moderate); reflects date of January 20, 2004.
$PM_{2.5}$ (annual NAAQS)	Unclassifiable/attainment	Reflects date of 90 days after January 5, 2005.
$PM_{2.5}$ (24-hr NAAQS)	Unclassifiable/attainment	For the 2006 NAAQS; reflects date of 30 days after November 13, 2009.
SO_2	Better than national standards	

[a] This information is summarized from EPA (2011c). As context for the upcoming evaluation of potential airborne releases associated with remedial action activities at the IWCS, the NAAQS for PM_{10} is 150 µg/m^3 as a 24-hour average, and the standards for $PM_{2.5}$ are 35 µg/m^3 as a 24-hour average and 15 µg/m^3 as an annual average. The NAAQS for lead is 0.15 µg/m^3 (EPA 2011d).

The nonattainment status for ozone is important because the requirement for general conformity to the EPA regulations also applies to Federal actions taking place in nonattainment or maintenance areas. A multi-step conformity review is conducted to determine and document whether an action meets the conformity rule. The overall process consists of two main components: (1) an applicability analysis to determine whether a conformity determination is required, and if it is, (2) a conformity determination to determine whether the action conforms to the state implementation plan (SIP).

For each pollutant of concern, the maximum total net annual emissions must be compared with the threshold values specified in 40 CFR 93.153(b)(1) (EPA 2011e). If emissions of pollutants of concern are below their thresholds, then the conformity requirements are not applicable and no further analysis is required. Note that the New York State Department of Environmental Conservation (NYSDEC) is responsible for overseeing air permitting/enforcement, including for the SIP (NYSDEC 2011).

In addition to capping increases in criteria pollutant concentrations below the levels set by the NAAQS, the PSD regulations mandate stringent control technology requirements for new and modified major sources (EPA 2011f). As a matter of policy, EPA recommends that the permitting authority notify the Federal Land Managers (FLMs) when a proposed PSD source would be located within 100 km (62 mi) of a Class I area. A Class I area is subject to the most stringent standards to prevent impairment of visibility from PM, SO_2, or NO_2. The EPA classification system used to protect areas from visibility degradation is summarized in Table 4, along with the PSD increments corresponding to each of the three classes.

Incremental increases of regulated pollutants in PSD Class I areas are strictly limited, while those in Class II areas allow for moderate net emission increases. Most areas of the United States are classified as Class II areas. (Redesignation to Class III can be requested in accordance with the process and conditions set forth in the PSD requirements, but that has not generally been pursued.) If the source's emissions are considerably large, EPA recommends that sources beyond 100 km (62 mi) be brought to the attention of the FLMs. The FLMs then become responsible for demonstrating that the source's emissions could have an adverse effect on air quality-related values, such as scenic, cultural, biological, and recreational resources.

TABLE 4 Air Quality Area Classifications and Corresponding PSD Increments[a]

Class	Level of Visibility Protection and Application	Maximum Allowable Increase (*µg/m³*)							
		Particulate Matter (PM)				Sulfur Dioxide			Nitrogen Dioxide
		Annual		*24-hour*					
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	*Annual*	*24-hour*	*3-hour*	*Annual*
I	Highest protection, applies to: - National wilderness areas and memorial parks >5,000 acres; - National parks >6,000 acres; and - International parks.	1	4	2	8	2	5	25	2.5
II	Moderate protection; applies to most U.S. areas, i.e.: - All areas not established as Class I (unless redesignated).	4	17	9	30	20	91	512	25
III	Least stringent protection; little application in practice (redesignation to this class is subject to the rigorous process and conditions set forth in Section 21 of 40 CFR Part 52)	8	34	18	60	40	182	700	50

[a] Maximum allowable increases are above baseline concentrations. Annual values are arithmetic means. For any period other than an annual period, these increases may be exceeded during one such period per year at any one location. (Sources: EPA 2011b, 2011f.)

No Class I areas exist in the State of New York, and none of the nearby Class I areas are situated within the 100-km (62-mi) range (see EPA 2011g). The nearest such areas are Otter Creek and Dolly Sods Wilderness Areas in West Virginia (40 CFR 81.435), which are located about 465 km (290 mi) south of the NFSS. The next nearest include Lye Brook Wilderness Area in Vermont (40 CFR 81.431) and Shenandoah National Park in Virginia (40 CFR 81.433), which are located nearly 480 km (300 mi) east and 480 km (300 mi) south of NFSS, respectively. Considering the locations and elevations of these Class I areas, the prevailing southwesterly wind directions, their distances from NFSS, and the minor nature of ground-level air emissions from NFSS, there is little likelihood that activities at NFSS could adversely impact air quality or air quality-related values in any of these areas.

6.3 MODELING DISPERSION OF AIR EMISSIONS

Two EPA models are used to assess the dispersion of airborne releases from radioactively and chemically contaminated sites such as those being addressed under the CERCLA process: CAP88-PC and AERMOD. These two models reflect the nature of the release and historical program context. The models are discussed in Section 6.3.1, and their use at NFSS is described in Section 6.3.2. The corresponding evaluations are described in Chapter 7, and results are presented in Chapter 8.

6.3.1 EPA Models for Air Quality Analyses and NESHAPs Compliance

The CAP88-PC code was developed to support compliance analyses for the annual dose requirements set forth in the NESHAPs for radionuclides under the CAA. It has also been used to assess other chronic radionuclide releases from nuclear facilities. CAP88-PC is frequently used to estimate impacts from routine releases of radionuclides over relatively long time periods; the NESHAPs require annual estimates of radiation doses, and CAP88-PC provides the annual average estimates to support this evaluation. In contrast, the AERMOD system is used to assess both short-term and long-term (chronic) releases. This model includes an option to account for exponential decay (e.g., for radionuclides), but it does not calculate radionuclide ingrowth or annual radiation doses (Smith et al. 2004). However, radionuclide decay and ingrowth do not have a significant impact on the evaluation of doses and risks associated with potential remedial alternatives at the IWCS because the radiological contaminants at NFSS occur in relatively long decay series. The principal radionuclides are very long-lived, and the short-lived decay products are already in secular equilibrium.

In most cases, short-lived decay products would be released along with the parent, and the dose and risk contributions of these decay products are attributed to the parent (i.e., accounted for in the respective risk estimators). The exception is Rn-222, for which the health risk is largely due to the ingrowth of short-lived decay products. Although within the IWCS these decay products are currently in equilibrium with Rn-222, as solid particulates they would not generally accompany a release of radon gas.

It is anticipated that AERMOD and CAP88-PC could be used for different specific NFSS evaluations, for example, as part of the FS process and to support the annual NESHAPS evaluation for the environmental surveillance report, respectively. Because AERMOD does not address ingrowth, the algorithm from CAP88-PC can be used together with the AERMOD estimates for Rn-222 gas to address the Rn-222 progeny. In this way, the best features of each code can be combined to address specific modeling needs and objectives for the site. An overview of the two dispersion models is presented in Table 5.

TABLE 5 Overview of EPA Air Dispersion Models

Dispersion Model	Date Established	Purpose	Application
AERMOD	2006 (with subsequent updates, 2011 and ongoing)	Demonstrate compliance with the NAAQS and other requirements under the CAA; multiple additional applications include assessing airborne releases from contaminated sites and facilities under the CERCLA process.	Both chronic and shorter-term releases; includes an option to assess exponential decay (e.g., for radionuclides).
CAP88-PC	1988 (with subsequent updates, 2007)	Demonstrate compliance with the NESHAPs requirements under the CAA for radon and other radionuclides released from specific facilities; also used to assess chronic radionuclide releases from nuclear facilities and for other purposes.	Chronic (annual), routine releases of radionuclides; accounts for radionuclide ingrowth and decay.

In the early 1990s, EPA formed a committee with the AMS to improve regulatory models that were being used to evaluate air dispersion of pollutants emitted from various facilities and processes, in order to incorporate state-of-the-art concepts into EPA's air quality models. From that joint effort, the updated modeling system, AERMOD (*A*MS/*E*PA *R*egulatory *MOD*el) was introduced into EPA's rulemaking process for air programs via 40 CFR 51. Following model development, independent reviews, and model validation activities through the late 1990s, the EPA issued a proposed rulemaking in April 2000 to replace its Industrial Source Complex Short-Term model version (ISCST3)[4] with AERMOD (EPA 2003). The final rule was established more than five years later (EPA 2005), and by December 2006 the AERMOD system was fully promulgated in accordance with Appendix W of 40 CFR 51 (EPA 2011f). The models in Appendix W of these codified regulations are required to be used for SIP revisions for existing sources, as well as for new source review (NSR) and PSD programs (see EPA 2011h).

The AERMOD system represents a steady-state plume dispersion model for assessing pollutant concentrations from a variety of sources. This model simulates transport and dispersion from both flat and complex terrain, addresses surface and elevated releases, applies to both rural and urban areas, and accounts for multiple sources that include point sources (such as a smokestack), volume sources (such as wind-blown dust from a large storage pile), and area sources (such as a construction site). Line sources (such as road traffic) may also be modeled as a string of volume sources or as elongated area sources.

This widely used modeling system is based on an updated characterization of the atmospheric boundary layer and accounts for building wake effects and plume downwash. Further information about AERMOD, including its implementation guide, the downloadable model, and other technical resources are available via EPA's Technology Transfer Network, Support Center for Regulatory Atmospheric Modeling (TTN, SCRAM) (EPA 2011h). Note that updates of the AERMOD system were released in February 2011 (Version 11059 for AERMET) and April 2011 (Version 11103 for AERMAP and AERMOD).

The CAP88 model was established in 1988 for the specific purpose of assessing compliance with the NESHAPs for radionuclides, for which the final rule was promulgated in 1989 (see the discussion in Section 4.5). This model has a number of features that make it a useful tool for assessing chronic, routine releases of radionuclides. CAP88-PC was an updated version of this Gaussian plume dispersion model released in 1992, which made it possible to run the software on a personal computer (EPA 2011i). This model has certain capabilities and some limitations compared with the AERMOD system. One useful feature of CAP88-PC not available in AERMOD is an algorithm that calculates the ingrowth of short-lived Rn-222 decay products.

CAP88-PC can be used to estimate radiation doses at various receptor locations, while AERMOD is not used for this purpose. However, all CAP88-PC assessments assume a flat terrain, while AERMOD can account for variations in concentrations due to complex terrain. While CAP88-PC was designed for NESHAPs compliance and can be used for other chronic release situations, the AERMOD system is designed for both short-term and long-term analyses and a broader suite of applications; thus, AERMOD is widely used to assess compliance with the NAAQS under the CAA, as well as to assess dispersion of other airborne contaminants as part of CERCLA evaluations.

Another difference between CAP88-PC and AERMOD is in the parameter used to reflect atmospheric stability. The input files for CAP88-PC use the Pasquill stability class, which is part of the dispersion modeling approach utilized by ISC (subsequently replaced by the AERMOD system). The stability parameter used in AERMOD is the Monin-Obukhov length (see Section 7.1). This parameter is derived from meteorological data in the current National Climatic Data Center (NCDC) standard format, ISHD. Because of the different stability parameters for these two models, recent meteorological data cannot be used directly with CAP88-PC. Thus, meteorological data in the standard ISHD format must be converted

[4] The EPA originally released two types of ISC models, short term (ISCST) and long term (ISCLT). However, EPA stopped supporting ISCLT in the 1990s because ISCST could simulate long-term averages as well and ISCLT had lost its advantage of shorter computing time with the advent of faster computers.

to estimate a Pasquill stability class in order to be used with CAP88-PC. Both indirect and direct methods can be applied for this conversion, as described in Section 7.1.

For example, the Pasquill stability class could be estimated using EPA software (STAR.EXE or PCRAMMET) to process meteorological data in older formats such as the card deck [CD]-144 format (used until the early 1990s), Solar and Meteorological Surface Observation Network (SAMSON) format (released in 1993, which compiled data from 1961-1990), or the related Hourly U.S. Weather Observations (HUSWO) format (released in 1997, which compiled data from 1990-1995). Other formats from site-specific (non-ASOS) stations could also be processed to estimate the Pasquill stability class. (Note that the PCRAMMET program generates hourly data which are directly input to the short-term model, so additional processing is needed to construct a STAR summary, which is for the longer-term period.)

For input to CAP88-PC, *ST*ability *AR*ray (STAR) summaries must be generated from the meteorological data as processed to generate the stability class. The STAR summaries represent three-way joint frequency distribution tables of six wind speed categories and 16 wind direction categories, classified according to the six Pasquill stability categories – which underlie the earlier standard air dispersion model ISCLT. In the STAR format, the wind is blowing *from* a particular direction, at a particular stability, and at a particular speed. The GETWIND program provided by CAP88-PC converts the STAR format to a WIND file, which reflects wind blowing *toward* a particular direction; that file is then directly input to the CAP88-PC model.

In considering the use of current data in standard ISHD format with CAP88-PC, direct mapping between the current ISHD format and older formats is complicated by the fact that meteorological data collected decades ago are much less extensive than current data. For example, historical data are organized into up to 140 columns, while current data are much more detailed and the number of columns varies from 105 (including control and mandatory data) to 742, depending on additional data collected. Thus, a direct one-to-one correspondence is not easily established for specific parameters relevant to the stability estimate. To address this issue, a program was identified that can extract data from the ISHD format to generate data in the SAMSON format, which can then be processed by PCRAMMET to generate the Pasquill stability class.

A further complication is that, unlike for the Niagara Falls airport, meteorological data are not available for the CWM landfill location from decades ago to compare with recent data from this facility. See Table 6 for highlights of differences between the former and current data formats and associated models, and see Section 7.1 for a discussion of approaches to convert data in the current standard (ISHD) format for use in CAP88-PC.

6.3.2 Dispersion Modeling for NFSS

While CAP88-PC has long been used to support annual evaluations for NESHAPs compliance at NFSS, it is expected that the AERMOD system will be used for upcoming analyses of the dispersion of airborne pollutants associated with various release scenarios to guide the evaluation of remedial alternatives for the IWCS. That is, this standard dispersion model is expected to frame the evaluation of airborne releases associated with alternatives for the IWCS to be presented in the FS, as indicated in the work plan for that future document (USACE 2009). This EPA model is appropriate for estimating incremental concentrations of air pollutants for both onsite and offsite receptors. The AERMOD system uses hourly sequential preprocessed meteorological data determined to be representative of the site to estimate concentrations for averaging times that can range from one hour to one year (and longer, extending the entire data period). This modeling system has three key components: AERMOD (air dispersion model), AERMET (meteorological data preprocessor), and AERMAP (terrain data preprocessor).

TABLE 6 Highlights of Earlier and Current Meteorological Data and Associated Models

Feature	**Earlier Meteorological Data for Dispersion Modeling** ***(ISC and CAP88-PC)***	**Current Meteorological Data for Standard Dispersion Model** ***(AERMOD System)***
Nature of meteorological data	Less detailed *(Maximum of about 80 data columns for CD-144, 140 for SAMSON, and 110 for HUSWO)*	Standardized collection and systematic reporting of extensive data *(100 to 700 columns)*
Format	HUSWO SAMSON CD-144	ISHD
EPA program used to estimate stability parameter	STAR.EXE PCRAMMET	AERMET *(Note this program can also accept data in the earlier formats.)*
Input needed to estimate stability parameter	Wind speed Solar insolation (day) Cloud cover, ceiling height (day and night)	Surface roughness length Sensible heat flux Ambient temperature Wind speed Cloud cover
Stability parameter output	Pasquill stability class *(Discrete; six common classes: A-F)*	Monin-Obukhov length, L *(Continuous value)*
Nature of stability parameter	Easy to estimate based on routine measurements; can be imprecise across various data sets due to the subjectivity of the underlying algorithm (e.g., subjective demarcation for solar insolation, cloud cover, and wind speed). An error of one stability class can result in a substantial (e.g., up to three-fold) difference in the estimated hourly air concentrations (Turner and Schulze 2007).	Systematically determined, consistent across data sets.

(As further comparison context, CAP88-PC has no algorithm for estimating short-term, e.g., hourly averages, like the AERMOD system. Its focus is on longer-term averages such as for annual or seasonal periods, and these averages are estimated using the STAR summaries [wind speed, wind direction, and Pasquill stability class]. Thus, the evaluations in this report compare annual averages from AERMOD and CAP88-PC, but such short-term averages cannot be compared because they are not available from CAP88-PC per the intent and design of that model.)

Topographical data from standard sources are processed for AERMAP, and meteorological data representative of the site are used for AERMET. For AERMOD, the inputs will reflect emission inventories per anticipated activities (release events), source characteristics, and the estimated time frames of the releases, as well as the (preprocessed) meteorological data and receptor locations of interest.

It is anticipated that the dispersion modeling conducted to support the IWCS FS will involve these three basic system components. The topography at NFSS is not expected to change. The meteorological data could be updated as new information becomes available, notably from the new station recently installed at NFSS. The emissions inputs will depend on the activities being assessed.

The AERMOD component would incorporate emission inventories for the specific activities, associated source characteristics, and schedule information, based on preliminary project plans. The EPA is in the process of further refining the AERMOD system, and the most up-to-date version will be used when the dispersion of airborne contaminants is modeled for the primary evaluation documents for NFSS.

Based on the analyses presented in Chapters 3 through 5, the recent meteorological data from the CWM site are well suited for use in dispersion modeling for NFSS. These data are expected to be used with AERMET, and the dispersion modeling for hypothetical releases from the IWCS will be conducted with AERMOD. This initial assessment of meteorological data and dispersion modeling will provide a key foundation for the upcoming assessment of hypothetical exposures and risks associated with remedial alternatives at the IWCS; both of these early technical analyses will support the evaluations to be presented in the FS.

To provide further modeling context for the future remedial action period at NFSS, fugitive dust from soil disturbances and engine exhaust from heavy equipment and support vehicular traffic within and around the site could contribute to air emissions of criteria pollutants, volatile organic compounds, greenhouse gases (e.g., carbon dioxide), and a small amount of hazardous air pollutants (such as benzene). Airborne concentrations of coarser fugitive dust ($PM_{10\text{-}2.5}$), which accounts for a considerable portion of the total mass released from soil disturbances, might be elevated for a short time, but those larger particles would not be transported a considerable distance from the emission source.

In contrast, fine particles ($PM_{2.5}$), albeit a small portion of fugitive dust, act like a gas and can travel a considerable distance. Airborne concentrations from engine exhaust emissions such as nitrogen oxides (NO_x) (and perhaps smaller amounts of sulfur oxides, SO_x) would be anticipated to be far below those associated with any regional impacts such as visibility degradation or acid deposition. Nevertheless, construction vehicle exhaust could generate localized concentrations of these pollutants. Because these exhaust emissions are released mostly at the near-ground level, their impacts on ambient air quality are limited to neighboring areas. Thus, a local-scale Gaussian model (e.g., up to 50 km [31 mi]) is expected to be appropriate to assess the dispersion of airborne emissions during the cleanup period.

In addition to serving as the basis for assessing air quality impacts of criteria pollutants (NAAQS) and others commonly associated with construction activities, AERMOD will be used to estimate airborne concentrations of contaminants associated with NFSS. The first analysis will focus on the IWCS. For example, if a bulldozer or other construction vehicle were to drive over an area of exposed residues at the IWCS, it would generate fugitive dust contaminated with radionuclides and chemicals. The AERMOD system would be used to estimate the concentrations of these particulates at representative onsite and offsite receptor locations, and the contaminants associated with that PM would reflect the characteristics of the source (in this example, the residues). That information would be used to estimate doses and risks for the representative receptors. By this approach, AERMOD will provide a consistent basis for assessing impacts of airborne releases associated with the site, to be reflected in the technical documents being prepared to support the upcoming evaluation of remedial alternatives.

Meanwhile, the CAP88-PC code is useful for demonstrating annual compliance with the NESHAPs requirements for radionuclides at NFSS. This computer code could also be used to assess other potential long-term releases of radionuclides. In addition, the algorithm for evaluating the ingrowth of Rn-222 progeny – which is available in CAP88-PC (and other codes used to address NESHAPs for radionuclides) is expected to be used to assess the impacts associated with Rn-222 releases (notably, the progeny), to support the evaluation of remedial alternatives. Note that conversions and programming modifications have been applied to support the consideration of using more recent meteorological data with this code, as part of the modeling evaluations in this report (see Chapter 7). A key purpose of these efforts is to facilitate the use of current data in future dispersion analyses using the CAP88-PC computer code.

6.4 CHARACTERISTICS OF A STANDARD METEOROLOGICAL STATION

6.4.1 Tower Height and Distance from Obstruction

The instruments for wind measurements and other information used to model dispersion should be located over level, open terrain at a height of 10 m (33 ft) above the ground, as recommended by the EPA and other Federal agencies (including the U.S. Nuclear Regulatory Commission). The meteorological tower should be located at a distance that is at least 10 times the height of any nearby obstruction (EPA 2000). Aerodynamic effects due to buildings and other major structures (e.g., cooling towers) should be avoided to the extent possible in siting wind sensors because such effects are significant, not only in the vicinity of the structures themselves but at considerable distances downwind.

Some facilities have installed wind sensors on building rooftops if no level and open space is available. In those cases, the sensors would need to be at a sufficient height above the rooftop to avoid the aerodynamic wake caused by the building. As a rule of thumb, the total height of a building's wake is estimated to be about 2.5 times the building height. This "two and one-half times" rule applies to a typical building, for which the width is greater than the height. However, for a tall, thin building, the height of a building's wake (which can be estimated by the building height plus 1.5 times the lesser of the building height or projected building width) is lower than the value obtained by using the "two and one-half times" rule.

Note that some industrial facilities have considered a 3-m (10-ft) meteorological tower instead of the standard height because of the relative ease of installation, access for maintenance, portability, and lower cost. However, wind data collected from that height are generally not accepted as official inputs for dispersion analyses, because they are significantly affected by local surface characteristics (such as surface friction and land cover). Thus, they are not representative of general atmospheric dispersion patterns of air pollutants over relatively longer distances. For this reason, measurements taken at such a low level are typically used only for screening purposes or to assess accidental releases from low buildings or the ground that last only a short time.

As a further note, to be used in AERMOD, the meteorological data should be collected from an instrument height that is more than seven times the surface roughness length. As indicated in Section 4.4, the surface roughness length is related to the height of obstacles to the wind flow, and values range from less than 0.001 m (0.04 in.) over a calm water surface to 1 m (3.3 ft) or more over a forest or urban area. For the NFSS area, the greatest surface roughness length is about 0.5 m (1.6 ft). Thus, data collected from an instrument height above 3.5 m (11.5 ft) would be acceptable for dispersion modeling with AERMOD. However, instrument heights are standardized to 10 m (33 ft) for most weather stations, which allows direct comparisons as well as substitution of data from other stations (e.g., if site-specific data are missing for a given hour), so that height is highly recommended unless there are ample reasons to not meet it. It is recognized that many large industrial facilities are surrounded by buildings or other obstructions that could affect the siting of a meteorological tower. These height and siting factors were considered in planning for the tower that was recently installed at NFSS.

6.4.2 Instrumentation

For low-level releases such as those that would occur at the IWCS, a 10-m (33-ft) tower is appropriate. Instrumentation should generally address the meteorological parameters recommended for the AERMOD system, which are listed below (along with several practical notes). Note that given its proximity, the weather station at the Niagara Falls airport is a useful source of supporting information for certain standard parameters such as solar radiation and pressure that are not affected by local surface features.

- Wind speed (0.5 m/s threshold, ±0.5 m/s accuracy) and wind direction (±5 degree accuracy). (Both are measured by a sonic anemometer at higher accuracy.)

- σ_A (standard deviation of the horizontal wind direction) and σ_W (standard deviation of the vertical wind speed). (Both are estimated by a datalogger [computer] from three-dimensional sonic anemometer data.)

- Ambient temperature (accuracy ±0.1 degree).

- Relative humidity (accuracy ±5%).

- Precipitation (accuracy ±1 mm). (This information is needed to model wet deposition.)

- Net solar radiation (accuracy ±5 W/m^2). (This is not critical for low-level releases but is useful for a general comparison of historical stability classes; data from the nearby airport can be used.)

- Pressure (accuracy ±3 kPa). (This parameter is not critical to the dispersion or deposition estimates.)

In late spring 2011, the USACE Buffalo District installed a meteorological tower onsite south of the former Building 403 and east of the IWCS (see Figure 3). The tower stands 10 m (33 ft) high, and it is equipped with standard instruments. Data have been collected from this onsite tower since June, including ambient temperature, relative humidity, wind speed, wind direction, σ_A (also referred to as σ_θ or sigma theta), and precipitation. When sufficient measurements are available (e.g., covering at least a year), it is anticipated that these onsite data will be used to support air dispersion analyses for NFSS.

7 COMPARISONS OF DISPERSION MODELING WITH DIFFERENT INPUT DATA

This report evaluates the use of meteorological data from the CWM landfill as well as data from the Niagara Falls airport (which have long been used to assess compliance with NESHAPS for NFSS). As part of this evaluation, three sets of meteorological data were used with CAP88-PC and AERMOD to assess similarities and differences in predicted airborne contaminant concentrations at representative receptor locations offsite following a hypothetical contaminant release from the IWCS.

Two of these sets are recent: the 2005-2009 airport data and 2005-2008 CWM data. Thus, both require conversion for use in CAP88-PC (as described in Section 6.3). The aim of these evaluations is to assess the potential for using recent data in CAP88-PC to support future dispersion analyses for NFSS. An overview of current and historical processes for incorporating meteorological data into air dispersion models is presented in Figure 9. The three data sets evaluated are shown in Table 7, together with information about their formats relative to model needs for an initial suite of comparisons with CAP88-PC.

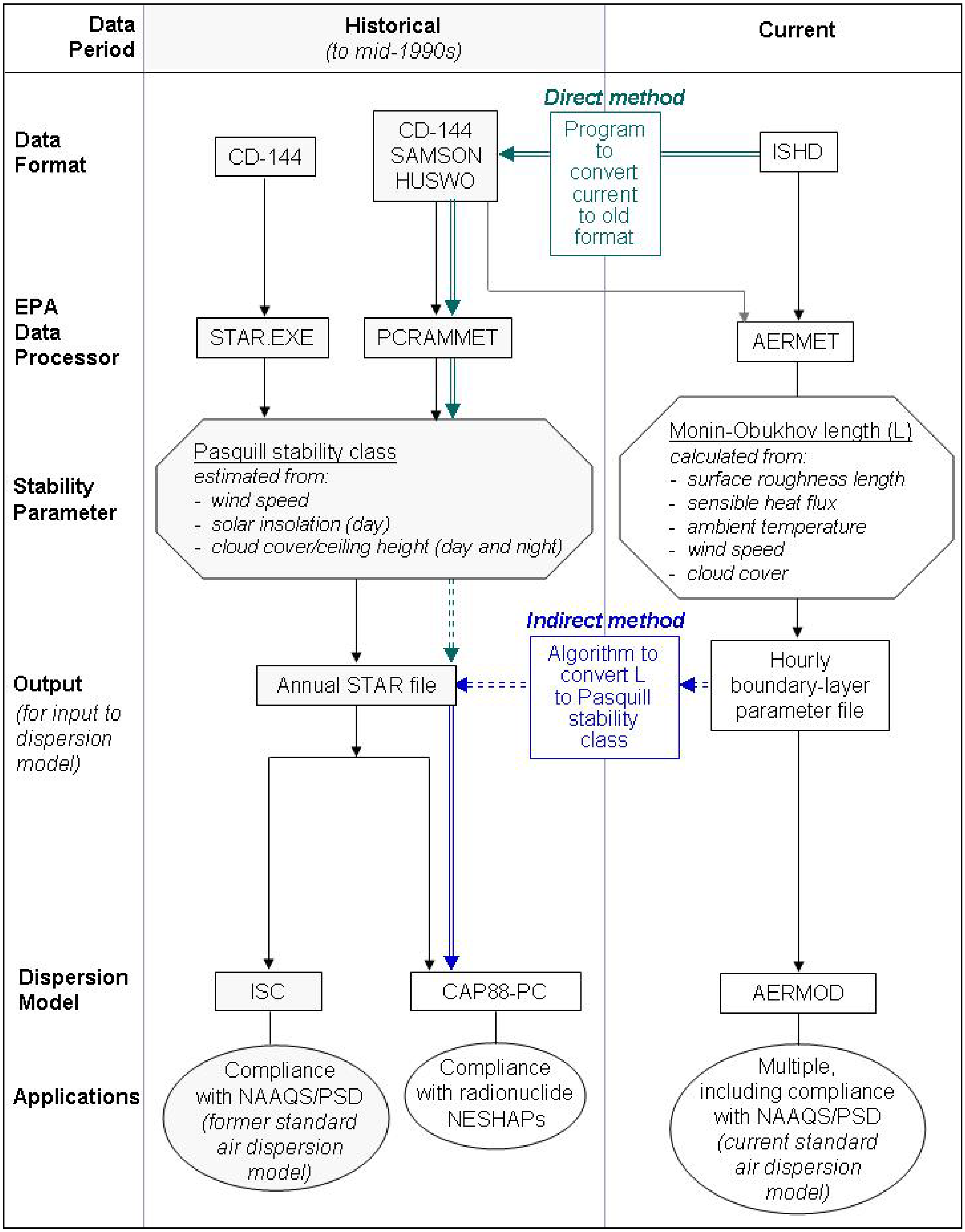


FIGURE 9 Overview of Dispersion Modeling Processes and Conversion Methods Applied to Use Current Standard Data in CAP88-PC *(Solid double lines indicate the path followed for the conversions; dashed lines indicate new programming created for this NFSS analysis.)*

TABLE 7 Meteorological Data Sets and Formats for the Model Comparisons

Meteorological Data Set			Dispersion Model	
Location	**Years**	**Format**	**CAP88-PC**	**AERMOD**
1. Niagara Falls airport	1955-1959	CAP88-PC-ready *(This is the default data set for NFSS in CAP88-PC.)*	Ready	Not applicable *(AERMOD reflects hourly data, which were not found for the 1950s; CAP88-PC provides longer-term averages.)*
2. Niagara Falls airport	2005-2009	ISHD *(Current standard format, AERMET-ready.)*	Conversion needed	Ready[a]
3. CWM landfill	2005-2008	Site-specific *(Made AERMET-ready as part of data evaluation.)*	Conversion needed	Ready[b]

[a] With surface data from the Niagara Falls airport and twice-daily upper air sounding data (including pressure and temperature data with elevation) from the Buffalo airport, which is the closest station with upper soundings data in the region.

[b] With primary data from the CWM landfill, surface data from the Niagara Falls airport, and twice-daily upper air sounding data from the Buffalo airport. Surface data from the Niagara Falls airport are used to estimate boundary layer parameters for dispersion calculations and in some cases to substitute for missing data.

The approach used to compare relative air concentrations estimated by AERMOD and CAP88-PC with these data consists of three main steps. The first involves converting the recent meteorological data to a form that can be used in CAP88-PC. This step is described in Section 7.1. The second step involves reviewing historical information from the scientific literature relevant to atmospheric stability in the general NFSS area, to check the stability parameters derived in the first step from the recent meteorological data. This step is presented in Section 7.2. The third step involves identifying the input parameters for the dispersion models, including topographic, meteorological, and emission data and representative locations of offsite receptors to be evaluated, and then estimating the relative air concentrations at these locations. This step is discussed in Section 7.3.

7.1 ESTIMATE OF STABILITY PARAMETER FOR CAP88-PC COMPARISONS

Both indirect and direct methods have been applied to convert recent data into a form that can be used in CAP88-PC. These approaches are summarized in Table 8 and described in the subsections that follow.

7.1.1 Indirect Conversion Method

The AERMET preprocessor (a component of the current AERMOD modeling system) is used to process the recent airport data and the CWM landfill data, to create the meteorological data files needed for further processing to generate a Pasquill stability class. This processing is needed to address one of the differences between the CAP88-PC model and AERMOD system: CAP88-PC uses Pasquill stability classes while AERMET uses the Monin-Obukhov length (L) as the stability parameter. Thus, the parameter L from the AERMET output file is converted to a Pasquill stability category for input to the CAP88-PC model. (The earlier ISCLT model used the annual STAR files as input, as shown in the lower left of Figure 9.)

TABLE 8 Conversion Methods Applied to Recent Data for Use in CAP88-PC

Conversion Approach	Indirect Method	Direct Method	
	Golder	***SAMSON***	σ_A
Process	Map Monin-Obukhov length in the preprocessed (AERMET) data file to Pasquill stability class with an algorithm from the literature	Extract ISHD data into the SAMSON format and process with PCRAMMET to generate an hourly data file, then generate the annual file	Determine the Pasquill stability class based on a turbulence-based calculation using the standard deviation of the horizontal wind direction (σ_A) and wind speed
Application	Both *(recent CWM data and recent airport data)*	Both *(recent CWM data and recent airport data)*	Recent CWM data *(σ_A is not included in the airport data)*

The indirect conversion method applied for these analyses is illustrated in Figure 9. With this method, after the AERMOD preprocessor AERMET is used to determine L, this parameter is then converted to a Pasquill stability class using an algorithm from the scientific literature (Golder 1972). The Golder algorithm establishes a relationship between Pasquill stability class, the roughness length z_0, and L, as shown in Figure 10. To simplify the calculation of 1/L, the Golder plot can be approximated by the correlation from Seinfeld and Pandis (1998) which is also shown in Table 9: $1/L = a + b \log_{10}(z_0)$. The coefficients for the regression straight lines (slopes and intercepts) are the 1/L representing each stability class for a given z_0. The Pasquill stability classes are determined by selecting the stability corresponding to the nearest 1/L value.

7.1.2 Direct Conversion Methods

In addition to the empirical method outlined above, a further evaluation was conducted to determine whether the current data format could be more directly converted to the form needed for CAP88-PC. The AERMOD system uses L as the stability parameter, which is obtained by processing current data (in ISHD format), and no program was found that can directly estimate Pasquill stability class from this format. Thus, an approach was developed for this NFSS analysis to convert recent Niagara Falls airport data to a form that could be used with CAP88-PC as follows:

1. Convert the ISHD data format downloaded from the NCDC web site into a space-delimited simplified ISHD format using the NCDC software, ishJava (NCDC 2010).

2. Convert this simplified ISHD data format into the SAMSON data format (RLC 2011).

3. Generate hourly meteorological data with Pasquill stability class using the PCRAMMET program (EPA 1999).

4. Generate annual STAR summaries from these hourly meteorological data using a program developed for this NFSS analysis.

For the recent data from the CWM landfill, the wind speed and direction for the Niagara Falls airport obtained in Step 2 above were replaced with those for the CWM facility, and Steps 3 and 4 were performed as described above for the airport data. This direct method is shown in Figure 9. (The method is referred to as direct because the meteorological data are used directly to derive Pasquill stability class, compared with the Golder method in which the Pasquill stability class is estimated from the empirical map.) Results are presented in Table 10 and illustrated in Figure 11.

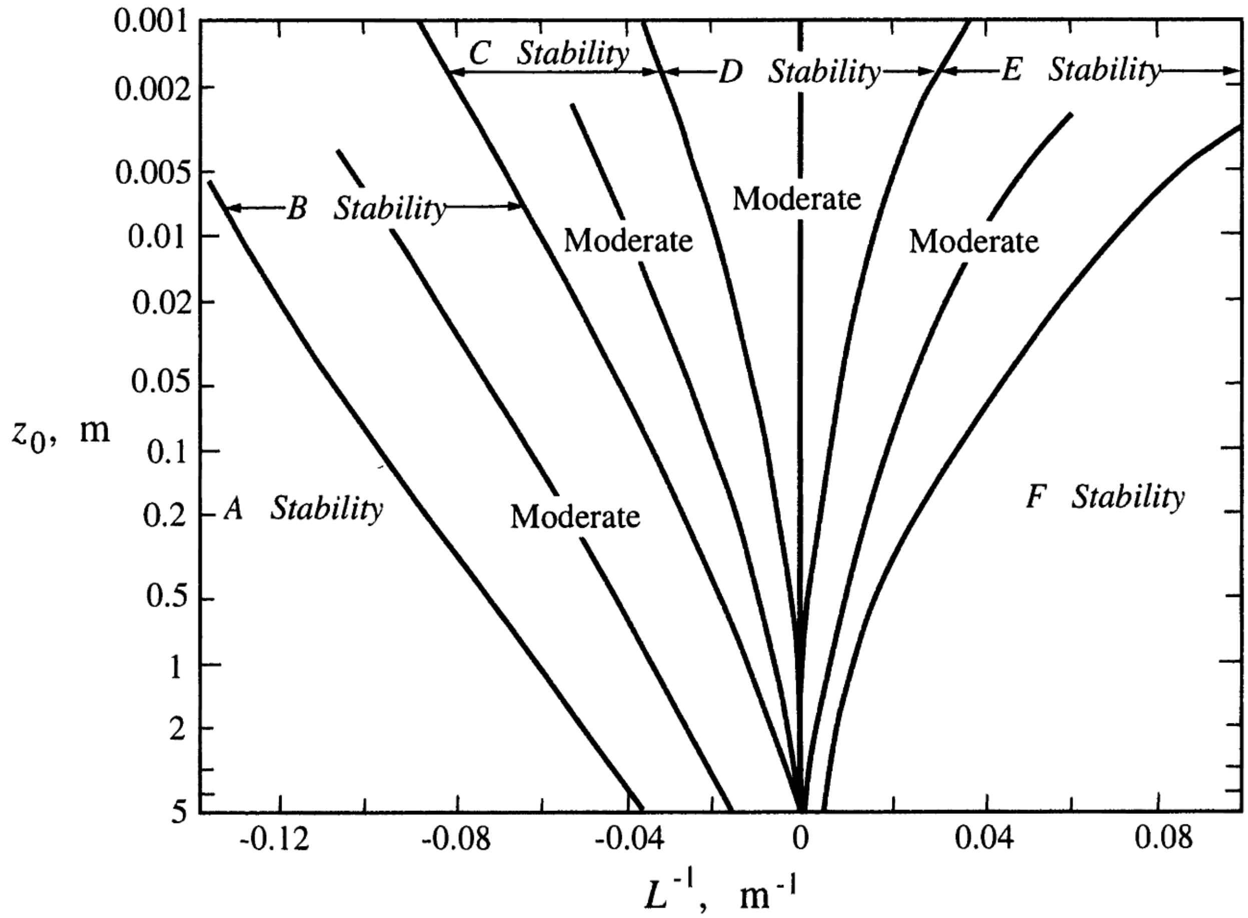


FIGURE 10 A Relationship between Monin-Obukhov Length, L, and Surface Roughness Length, z_0, for Various Pasquill Stability Classes

(Source: Seinfeld and Pandis 1998; reprinted with permission of John Wiley & Sons, Inc.)

TABLE 9 Coefficients for Straight-Line Approximation as a Function of Pasquill Stability Class

Pasquill Stability Class		**Coefficients for: 1/L = a + b $\log_{10}(z_0)$**	
		a	**b**
Extremely unstable	A	-0.096	0.029
Moderately unstable	B	-0.037	0.029
Slightly unstable	C	-0.002	0.018
Neutral	D	0	0
Slightly stable	E	+0.004	-0.018
Moderately stable	F	+0.035	-0.036

(Source: Seinfeld and Pandis 1998; reprinted with permission of John Wiley & Sons, Inc.)

TABLE 10 Comparison of Pasquill Stability Class Distributions from Indirect and Direct Conversion Methods

Stability	Niagara Falls Airport Data (2005-2009)		CWM Landfill Data (2005-2008)		
	Indirect[a]	**Direct** *(SAMSON)*[b]	**Indirect**[a]	**Direct** *(SAMSON)*[b]	**Direct** *(σ_A)*[c]
A	0.3%	0.1%	3.7%	0.8%	5.6%
B	1.7%	2.8%	5.3%	6.2%	5.0%
C	10.3%	8.8%	14.8%	11.7%	12.1%
D	59.8%	63.8%	36.1%	53.0%	53.1%
E	15.8%	12.3%	12.4%	10.8%	12.4%
F	12.2%	12.2%	27.7%	17.4%	11.8%
Unstable[d]	12.3%	11.7%	23.8%	18.7%	22.6%
Neutral	59.8%	63.8%	36.1%	53.0%	53.1%
Stable[e]	27.9%	24.5%	40.1%	28.3%	24.2%

[a] For this comparison, the Pasquill stability class is calculated using the relationship between Monin-Obukhov length (in the AERMET output file) and Pasquill stability class (Seinfeld and Pandis 1998).

[b] Using a recently created program (RLC 2011), ISHD data are converted to the SAMSON format, which is accepted by the PCRAMMET program that generates the Pasquill stability class.

[c] Pasquill stability class is calculated using the σ_A data (standard deviation of the horizontal wind direction) and wind speed at the CWM landfill based on the σ_A method (EPA 2000). In Figure 11, σ_A is represented as SA.

[d] Unstable represents the sum of all unstable stability classes (A, B, and C).

[e] Stable represents the sum of both stable stability classes (E and F).

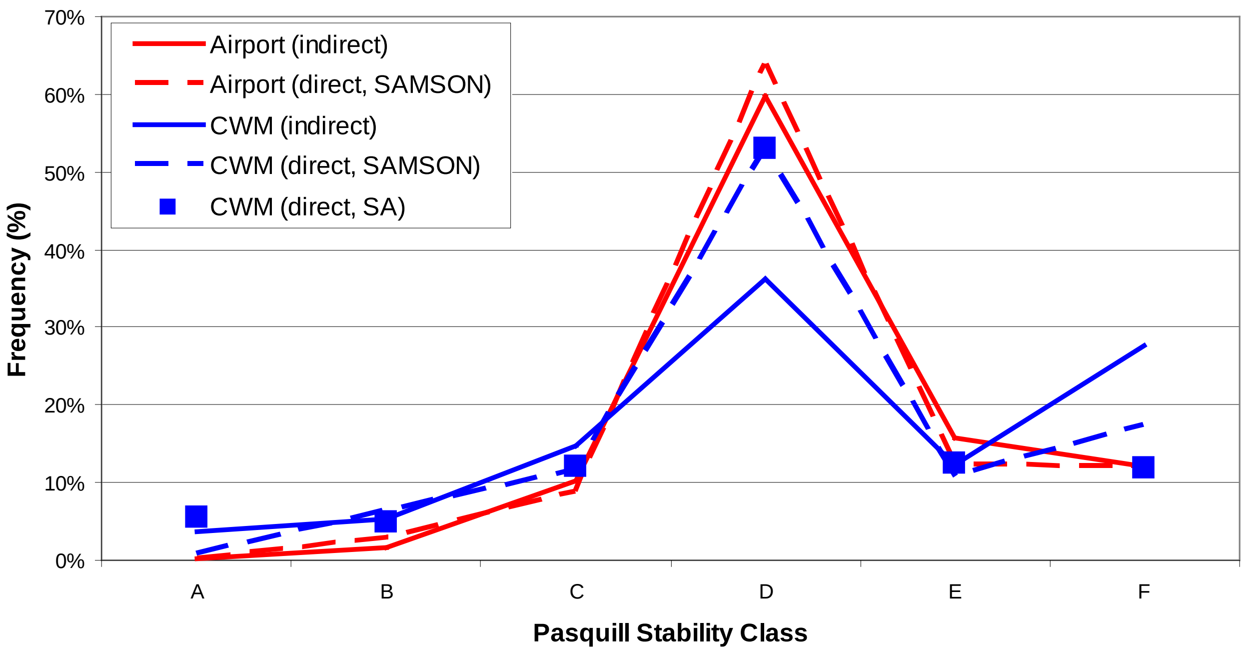


FIGURE 11 Comparison of Pasquill Stability Class Distributions for Recent Data from the Niagara Falls Airport and CWM Landfill Using Indirect and Direct Conversion Methods *(SA is used here to represent σ_A.)*

An even more direct method can be used to estimate Pasquill stability class if the meteorological data include σ_A (also referred to as σ_θ). This parameter is the standard deviation of the horizontal wind direction (or the standard deviation of the azimuth angle of the wind vector). This approach, referred to as the σ_A method (EPA 2000), is turbulence-based and uses σ_A in combination with the mean wind speed. The CWM data include σ_A, but this measure is not available from the airport data so this direct method can only be applied to the CWM data. The σ_A method is conducted in two steps. An initial Pasquill stability class is estimated based on the σ_A value, and the final estimate is then based on where the wind speed lies within a given range and whether it is daytime or nighttime (EPA 2000).

In comparing the Pasquill stability class distributions, results for the recent Niagara Falls airport data using the indirect (Golder) and direct (SAMSON) methods are comparable, with a ratio of 1:6:3 for unstable:neutral:stable conditions. For the CWM data, neutral conditions occur more frequently with the direct methods while unstable and stable conditions occur more frequently with the indirect method.

The lower wind speeds at the CWM landfill due to the local land cover (see Section 4.3) tend to correspond to more unstable and stable conditions. Applying the two direct methods (SAMSON and σ_A) to the CWM data indicate that the Pasquill stability class distributions are comparable, with a ratio of 2:5:3 for unstable:neutral:stable conditions. However, results using the indirect method (Golder) differ somewhat, with a ratio of 2:4:4, as shown in Table 10 and Figure 11. This is not suprising because stability classes between different methods tend to differ by up to one stability class about 90% of the time (e.g., over a year, an estimate of D stability class from one method could be C, D, or E in the second), while they are only the same about 50% of the time (EPA 2000).

7.2 REVIEW OF HISTORICAL INFORMATION RELEVANT TO STABILITY CLASSES

Because the default meteorological data for NFSS in CAP88-PC are from the late 1950s, it is useful to consider whether other information has been compiled since then that could offer insights into stability distribution patterns in the area over time. Such information could help with interpreting the comparisons between the older and more recent data being evaluated in this report.

The pursuit of relevant historical information produced annual and seasonal spatial distribution maps of Pasquill stability classes that were created by Doty et al. (1976) for the contiguous 48 states using STAR summary data. That study included two stations in the general NFSS area: the Buffalo and Rochester airports. These maps indicate that neutral conditions occurred roughly two-thirds of the time at both stations, primarily due to relatively high wind speeds, as shown in Table 11. In contrast, unstable and stable conditions occurred about 10% and 20% of the time, respectively. By comparison, when the atmospheric stability parameter for the 2005-2009 data for the Buffalo and Rochester airports is converted from L to Pasquill stability class (as described in Section 7.1), neutral conditions occur with a lower frequency.

The second valuable set of historical information produced from this search is a compilation of meteorological data collected for the Buffalo and Rochester airports from 1984 to 1992 in the older (CD-144) format (EPA 2010). To provide further comparison context for the current evaluation, these data were processed using the EPA processing program STAR.EXE (EPA 2011j) to determine the distributions of Pasquill stability classes for that period. Results are shown in Table 11, and they illustrate the percent of time that atmospheric conditions fall in the different stability classes. These results indicate that neutral conditions for the Buffalo and Rochester airports were somewhat decreased, but unstable and stable conditions increased, compared with the data for these two airports in CAP88-PC from Trinity Engineering Associates, Inc. (2007) and the data reflected in Doty et al. (1976).

TABLE 11 Pasquill Stability Class Distribution Summaries for Various Meteorological Data Sets[a]

Pasquill Stability Class	Greater Buffalo Airport				Greater Rochester Airport				Niagara Falls Airport		CWM Landfill
	Pre-1976[b]	**1973[c]**	**1984-1992[d]**	**2005-2009**	**Pre-1976[b]**	**1955-1964[c]**	**1984-1992[d]**	**2005-2009**	**1955-1959[c]**	**2005-2009**	**2005-2008**
A	NA	0.1%	0.4%	0.6%	NA	0.4%	0.5%	0.5%	0.9%	0.3%	3.7%
B	NA	2.0%	3.3%	2.2%	NA	3.3%	4.3%	2.0%	4.1%	1.7%	5.3%
C	NA	8.0%	8.6%	11.5%	NA	8.3%	9.5%	12.0%	9.6%	10.3%	14.8%
D	NA	71.1%	66.6%	55.3%	NA	65.4%	59.3%	53.5%	57.0%	59.8%	36.1%
E	NA	18.7%	11.3%	16.5%	NA	12.1%	11.0%	17.2%	28.4%	15.8%	12.4%
F	NA	0.0%	9.8%	13.9%	NA	10.5%	15.4%	14.7%	0.0%	12.2%	27.7%
Unstable[e]	6-15%	10.2%	12.3%	14.3%	6-15%	12.0%	14.3%	14.6%	14.6%	12.3%	23.8%
Neutral	66-75%	71.1%	66.6%	55.3%	56-65%	65.4%	59.3%	53.5%	57.0%	59.8%	36.1%
Stable[f]	16-25%	18.7%	21.1%	30.4%	16-25%	22.6%	26.4%	31.9%	28.4%	27.9%	40.1%
Average wind speed *(m/s)*	NA	5.2	5.1	4.5	NA	5.1	4.0	4.0	4.0	4.4	3.0

[a] Gray shading highlights recent data for the airports (NCDC 2010); yellow shading (right-most column) highlights recent CWM data (Zayatz 2010). NA denotes not available.

[b] Source: Doty et al. (1976).

[c] Source: Trinity Engineering Associates, Inc. (2007).

[d] Source: EPA (2010).

[e] Unstable frequency is the sum of all three unstable classes (A, B, and C).

[f] Stable frequency is the sum of both stable classes (E and F).

For the Niagara Falls airport, the Pasquill stability distributions are similar for the 1955-1959 meteorological data (the CAP88-PC default set for NFSS) and the converted 2005-2009 meteorological data, although average wind speeds differ. It is important to note that instrumentation and data collection protocols in the 1950s differed from those used at standard stations today; for example, the anemometer height at that time was lower than its current height of 10 m (33 ft).

For the CWM landfill, neutral conditions are estimated to be lower, and unstable and stable conditions are higher compared with those at the Niagara Falls airport. This shift is primarily due to lower wind speeds at the CWM landfill, likely reflecting the surrounding vegetation.

Establishing a specific relationship between average wind speed and Pasquill stability class distributions from the earlier data is problematic for several reasons. In addition to limitations in the algorithm used to convert from L to Pasquill stability class for the initial evaluation described in Section 7.1 (which make the conversion imprecise), discrepancies exist among the meteorological data records themselves due to a number of factors that reflect changes in how data are collected now compared to 50 years ago (including anemometer height, wind sampling duration, and instrumentation), as well as differences in meteorological conditions (e.g., associated with climatic changes). However, in general, high average wind speeds shift atmospheric stability to neutral conditions.

Thus, considering these factors combined with the comparison of past regional maps with recent conditions, the algorithm used to convert L to Pasquill stability class appears reasonable for purposes of evaluating different meteorological data in the CAP88-PC comparisons. This initial analysis based on the indirect conversion method was further corroborated by the results of the direct conversion methods.

7.3 APPROACH FOR ESTIMATING RELATIVE AIR CONCENTRATIONS FROM DIFFERENT METEOROLOGICAL DATA

The purpose of the initial comparisons described in this section is simply to assess the impact of using different meteorological data with CAP88-PC to estimate the dispersion of airborne contaminants released from NFSS. The CAP88-PC code can be applied to estimate relative air concentrations using various meteorological data, with recent data first converted for input to this model.

The impact of meteorological conditions on the dispersion estimates can be assessed by estimating relative air concentrations, or Chi/Q (χ/Q) values, which can be calculated for specific points representing example receptor locations. (This evaluation does not estimate actual air concentrations; that analysis will be presented in upcoming assessments, including an evaluation of hypothetical exposures and risks associated with airborne releases and direct exposures at the IWCS.) The standard equation for estimating concentrations along the center line of a plume is:

$$\chi/Q = 1/[\pi(u)(\sigma_y)(\sigma_z)]\exp[-(H^2/2\sigma_z^2)]$$

where, for a hypothetical radiological release:

- χ = estimated air concentration (pCi/m^3)
- Q = emission rate (pCi/s)
- H = effective release height (m)
- u = wind speed (m/s)
- σ_y = horizontal diffusion coefficient (m)
- σ_z = vertical diffusion coefficient (m)

To simplify this evaluation, a unit release is assumed from the IWCS at ground level; this release of 1 Ci/yr translates to 32,000 pCi/s. The comparative results presented in this report are independent of the release rate. The isotope selected for this evaluation is uranium-238, because radioactive decay is not a factor for this isotope due to its very long half life of 4.5 billion years. (As described in Section 6.3, radionuclide ingrowth and decay is only an issue for Rn-222, and the algorithm incorporated in the CAP88-PC code will be used to evaluate Rn-222 progeny.) For ground-level releases, the value of H is 0, so the exponential term on the right becomes 1.

The measured wind speed is used directly in this calculation, while the two diffusion coefficients are typically taken from formulae that were derived from field experimental data. (These coefficients are a function of Pasquill stability class and downwind distance.) The rest of the variables are constant for a given release type, so reliable meteorological data are crucial to these calculations. Note that wind speed is in the denominator, so χ/Q is lower at higher wind speeds, and conversely as wind speed decreases, χ/Q increases. Similarly, both diffusion coefficients are in the denominator, so χ/Q decreases as they increase and vice versa. The diffusion coefficients increase with distance from the release and are largest with the most unstable class (stability class A) and decrease as the stability class becomes more stable.

For this evaluation, an area source of airborne releases is assumed to be 100 m × 100 m, or 10,000 m^2 (2.5 acres), centered on Building 411 in the IWCS (see Figure 3), which contains the higher-activity residues. The evaluation considers a total of 224 regularly spaced polar receptor grids placed in 14 rings extending outward up to 10 km (6 mi) from Building 411, along with sixteen 22.5-degree radials.

To minimize the loss of mass due to wet deposition, it is assumed that no precipitation occurs during the release period considered for this comparison. The input parameters selected for the CAP88-PC comparison runs are presented in Table 12, and the receptor locations are shown in Figure 12. The eight "nearby offsite" receptor locations shown in the lower left quadrant of this figure are of interest because they reflect actual locations at which people could potentially be exposed per current land use; the additional four on the right side of the figure are hypothetical locations that represent points more distant from the site. The results of the CAP88-PC comparisons described here are presented in Chapter 8.

7.4 COMPARISON OF AERMOD AND CAP88-PC WITH DIFFERENT METEOROLOGICAL DATA

As a companion assessment to the CAP88-PC comparisons described in Sections 7.1 through 7.3, modeling comparisons were also conducted with AERMOD to evaluate dispersion using recent meteorological data from both the Niagara Falls airport and the CWM landfill. The same basic approach used to compare CAP88-PC estimates using different meteorological data was also applied for these AERMOD comparisons, in order to compare the parallel outputs. That is, the assumed release rate of uranium-238 from the IWCS, the effective release height (ground level), the offsite receptor locations, and the modeling domain used for the CAP88-PC analyses (as outlined in Section 7.3) were also used for the AERMOD calculations.

The AERMOD system uses hourly meteorological data in ISHD format and can also use site-specific formats, so the recent data for the Niagara Falls airport and CWM landfill are used directly in this model. However, the older airport data (which are annual meteorological summary data) are not in a format that can be directly used in AERMOD. Thus, only CAP88-PC is used with the earlier airport data. The AERMOD estimates based on recent data for the airport and CWM landfill are then compared with the CAP88-PC estimates using historical airport data.

TABLE 12 Parameters Selected for the CAP88-PC Comparison Runs

Data Set	Parameter	Selection
Facility Data	Facility	NFSS
	City/State	Niagara Falls/NY
	Emission Year	2010
	Source Category	Area
Run Options	Run Type	Individual
	Midpoint Distances (m)	200; 400; 600; 800; 1,000; 1,250; 1,500; 1,750; 2,000; 2,250; 2,500; 5,000; 7,500; 10,000
	Buildup Time in Years	100
Meteorological Data	Custom Wind File	Vary
	Annual Precipitation (cm/yr)	0
	Annual Ambient (Celsius)	10 (default)
	Height of Lid (m)	1,000 (default)
	Absolute Humidity (grams/m^3)	8 (default)
Source Data	Source	Area
	Number of Sources	1
	Height (m)	0
	Area (m^2)	10,000
	Plume	None
Agricultural Data	EPA Food Source Scenarios	Rural
Nuclide Data	Time Step Days	365
	Limit Chain	Unchecked
	Add Nuclide	Uranium-238
	Release Rate (Ci/yr)	1
	Do you wish to enter the rest of the chain?	No

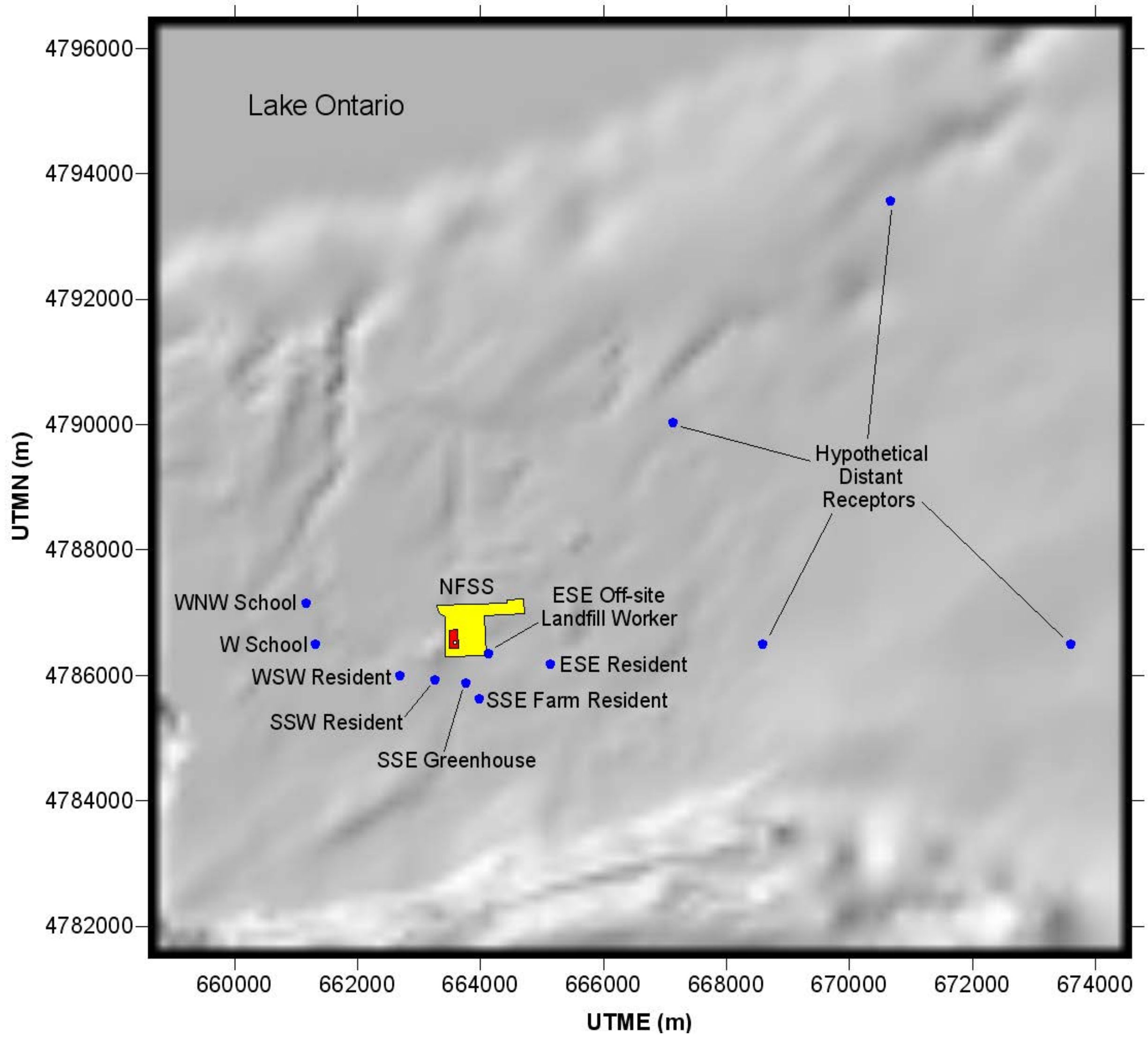


FIGURE 12 Receptor Locations Evaluated in the Dispersion Modeling Comparisons

(The IWCS is the dark rectangle in the lower left of the NFSS outline; Building 411 is the small dot within the IWCS, the representative point used to estimate distances to the offsite receptor locations.)

The CAP88-PC output is presented as annual average concentrations, whereas AERMOD uses hourly data as input and can therefore provide hourly output estimates, as well as calculations for other user-defined periods (including annual). Thus, annual averages were obtained from AERMOD in order to compare results with those of the CAP88-PC modeling runs. Results of these comparisons are presented in Chapter 8. Note that for CAP88-PC, calm winds are distributed into the lowest wind speed category (above the standard reporting threshold) for the statistical calculation of the long-term (e.g., annual) average. AERMOD can address much shorter averaging periods, and calm hours are processed according to the EPA "calms" policy, i.e., they are not included in the calculation. For averaging periods of more than an hour, the average concentration for the period is calculated by summing the hourly concentrations for all non-calm hours and dividing by the number of those hours (see EPA 2011f, Appendix W).

8 FINDINGS OF THE DISPERSION MODELING COMPARISONS

This chapter summarizes results of the evaluations described in Chapter 7 to compare dispersion estimates using different meteorological data and modeling approaches. Relative air concentrations estimated by CAP88-PC with different meteorological data are presented in Section 8.1, and relative concentrations estimated by both CAP88-PC and AERMOD with different meteorological data are given in Section 8.2. Overall findings are discussed in Section 8.3.

8.1 CAP88-PC COMPARISONS WITH DIFFERENT METEOROLOGICAL DATA

To assess the impact of the meteorological data used to estimate air dispersion, offsite concentrations predicted by the CAP88-PC computer code were compared for three different sets of meteorological data. A summary of the results for the eight nearby offsite receptor locations using the indirect conversion method with the recent data (which was needed to use these data in CAP88-PC) is presented in Table 13. These results identify relative air concentrations at the dozen offsite locations assessed, of which eight are current nearby receptor locations and four are hypothetical locations more distant from the site. The locations are not directly matched with the regularly spaced polar receptor grids used for the CAP88-PC modeling, so the concentrations at the grid closest to the given receptor (per Figure 12) are used for this analysis. The relative air concentrations estimated from a hypothetical unit release at the IWCS were taken from the χ/Q (Chi/Q) output table file of CAP88-PC, in units of seconds per cubic meter (s/m^3).

TABLE 13 CAP88-PC Comparisons Using Different Meteorological Data

Place-Time Comparisons	Meteorological Data	Relative Air Concentrations at Nearby Offsite Receptors	Influence Notes
1 **Same place** *(regional)*, **different times** *(recent/historical)*	Airport: 2005-2009 vs. 1955-1959	Recent airport data: 0.7 to 1.8 times historical airport data *(average 20% higher)*	Instrumentation, measurement heights, and reporting have changed since the 1950s
2 **Different places** *(local/regional)*, **different times** *(recent/historical)*	CWM 2005-2008 vs. Airport 1955-1959	Recent CWM data: same to 2.2 times historical airport data *(average 60% higher)*	Meteorological conditions differ; time may have a smaller overall impact on results
3 **Different places** *(local/regional)*, **same time** *(recent)*	CWM 2005-2008 vs. Airport 2005-2009	Recent CWM data: same to 2 times recent airport data *(average 40% higher)*	CWM data reflect local conditions for NFSS

The first evaluation produces relative air concentrations at the twelve offsite locations using Niagara Falls airport data taken 50 years apart. Results indicate that concentrations based on the recent data average about 20% higher at the eight nearby locations than those based on the earlier data. Depending on the location, the concentration ratios range from nearly 0.7 to 1.8. These somewhat higher concentrations likely reflect changes in wind instrument heights and use of better instruments and more standardized measurement and reporting protocols today compared to decades ago, among other factors (such as changes in climatological patterns over the last 50 years). In any case, a 20% difference is not considered unusual in the context of the overall uncertainties associated with this type of analysis.

The second evaluation compares the concentrations predicted by CAP88-PC using recent CWM data with those using historical airport data. The results presented in Table 14 indicate that concentrations based on the CWM data average about 60% higher at the nearby offsite receptor locations than those based on 1950s airport data, with relative concentrations at the offsite locations ranging from 1 to 2.2. These larger differences likely reflect the different meteorological conditions at these two distinct locations (including as affected by the respective land covers).

The third evaluation compares the recent data sets from the CWM landfill and Niagara Falls airport. Results indicate that offsite concentrations estimated with local (CWM) data average about 40% higher at the nearby offsite receptor locations than those based on regional (airport) data for the same period. Relative air concentrations vary by location, with ratios ranging from 1 to 2 (see Table 14). Because this comparison addresses data from the same time period, these differences reflect the different environmental settings for these two areas. The results indicate that in general, air dispersion at NFSS is somewhat lower than at the Niagara Falls airport, for example, due to lower average wind speeds. Lower dispersion translates to higher concentrations of airborne contaminants because the plume moves more narrowly instead of being more widely distributed.

Spatial distributions of predicted concentrations over the entire modeling domain are shown in Figure 13. The concentration contours using CAP88-PC with its default set of 1955-1959 meteorological data from the Niagara Falls airport stretch to the northeast, which corresponds to the prevailing southwest wind direction, as shown in Figure 13(a). Another sharp contour exists to the west, and a broad contour is shown in the southeast quadrant.

The concentration distribution patterns using the recent (2005-2009) airport data are quite similar, as shown in Figure 13(b). However, the contour shapes shift to different directions, stretching more in the northerly and westerly directions and retracting in the southeast quadrant. It is interesting to note that in the dispersion patterns for the long-term averages, frequencies in the low wind speed categories play as significant a role as prevailing wind direction. (Note these contours reflect annual average concentrations over multiple years, to represent long-term averages. These plots differ from short-term contours that may be developed for other evaluations to address much shorter intervals; those contours typically reflect maximum concentrations at each modeled grid point over the given time period.)

For example, southwesterly winds prevail at the airport, as shown Figure 5(b). However, the higher concentrations at the grids the same distance from NFSS occur in the north direction, rather than the northeast direction toward which the prevailing winds blow. Concentrations at the grids to the west are also comparable to those to the north.

The spatial distributions of these higher concentrations correspond well to the frequencies of lower wind speeds, for example, wind speed categories 1 and 2 (less than 3.6 m/s [8.1 mph]). As shown in Figure 13(c), distributions based on the CWM data reflect higher concentrations than those estimated by both recent and historical airport data. These higher concentrations occur in the north-northeast, northeast, and east-northeast direction and secondarily to the west, which match well with the frequencies of lower wind speeds as shown in Figure 5(a).

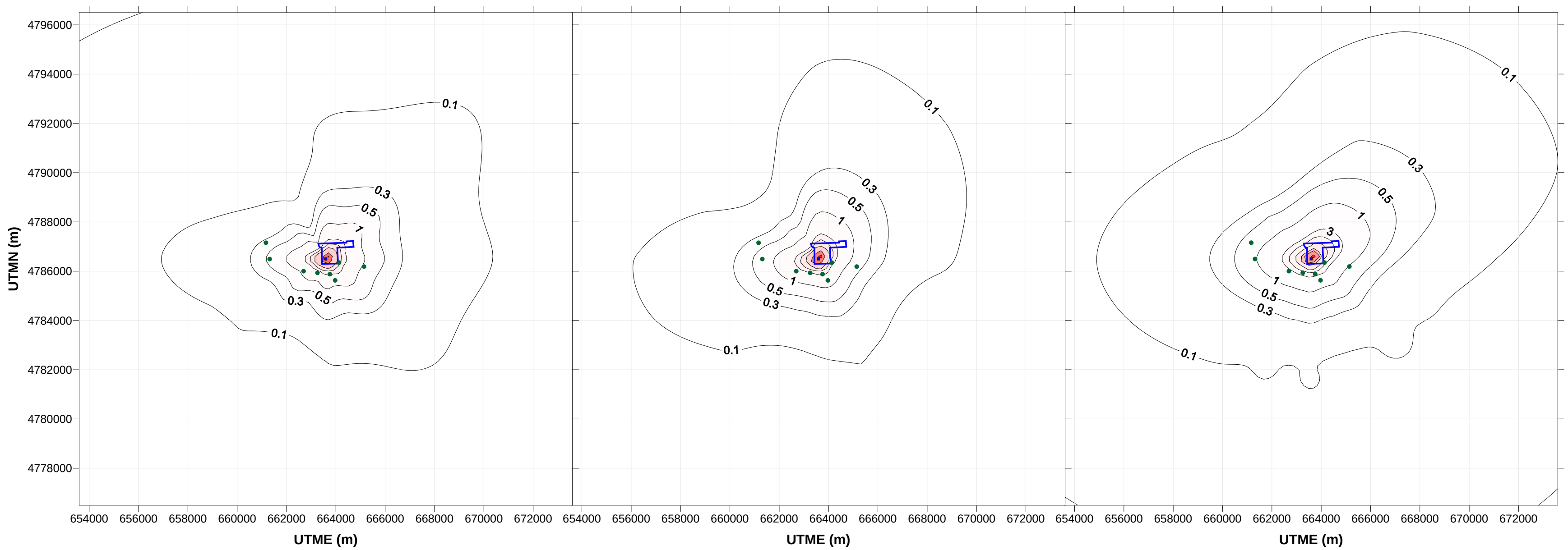
Relative air concentrations estimated from recent data (for the airport and CWM landfill) compared to historical airport data, for a hypothetical unit release from a 10,000-m^2 (2.5-acre) source area at the IWCS, are shown in Figure 14. The plot on the left (a) reflects the relative air concentrations based on recent (2005-2009) airport data compared with earlier (1955-1959) data. The plot on the right (b) reflects relative air concentrations based on recent (2005-2008) CWM data compared with the earlier airport data. For the comparison between recent and historical airport data, relative air concentrations range from 0.5 to 3 over the entire modeling domain extending from Building 411, as illustrated in Figure 14. (Note that this domain covers an area of 20 km × 20 km [12 mi × 12 mi] because the distance in each direction from the center, Building 411, is 10 km [6 mi].)

TABLE 14 Comparison of Relative Air Concentrations Estimated by CAP88-PC for a Hypothetical Release at the IWCS Using Different Meteorological Data[a]

Offsite Receptor	Direction and Distance from Building 411			Ratio of Relative Air Concentrations from Recent Data to those from 1955-1959 Data for Niagara Falls Airport[b]		Ratio of Relative Air Concentrations between the Recent Data Sets: 2005-2008 CWM Landfill compared to 2005-2009 Niagara Falls Airport
	Direction	Distance		2005-2009 Niagara Falls Airport	2005-2008 CWM Landfill	
		m	*ft*			
School individual	West-northwest	2,500	8,200	1.1	2.2	2.0
School individual	West	2,300	7,500	1.2	1.7	1.4
Resident 1	West-southwest	1,000	3,400	1.8	2.2	1.2
Resident 2	South-southwest	660	2,200	1.4	2.0	1.4
Greenhouse worker	South-southeast	650	2,100	1.2	1.2	1.1
Farmer resident	South-southeast	960	3,100	1.1	1.2	1.0
Landfill worker	East-southeast	560	1,800	0.67	1.1	1.6
Resident 3	East-southeast	1,600	5,200	0.65	1.0	1.5
Hypothetical distant 1	East	5,000	16,000	0.75	1.2	1.6
Hypothetical distant 2	East	10,000	33,000	0.80	1.2	1.5
Hypothetical distant 3	Northeast	5,000	16,000	0.86	1.7	2.0
Hypothetical distant 4	Northeast	10,000	33,000	0.75	1.5	2.0

[a] Values are rounded to two significant figures. Relative air concentrations at receptor locations are taken from the nearest grids used in the CAP88-PC runs. Shading indicates hypothetical receptor locations farther from the site.

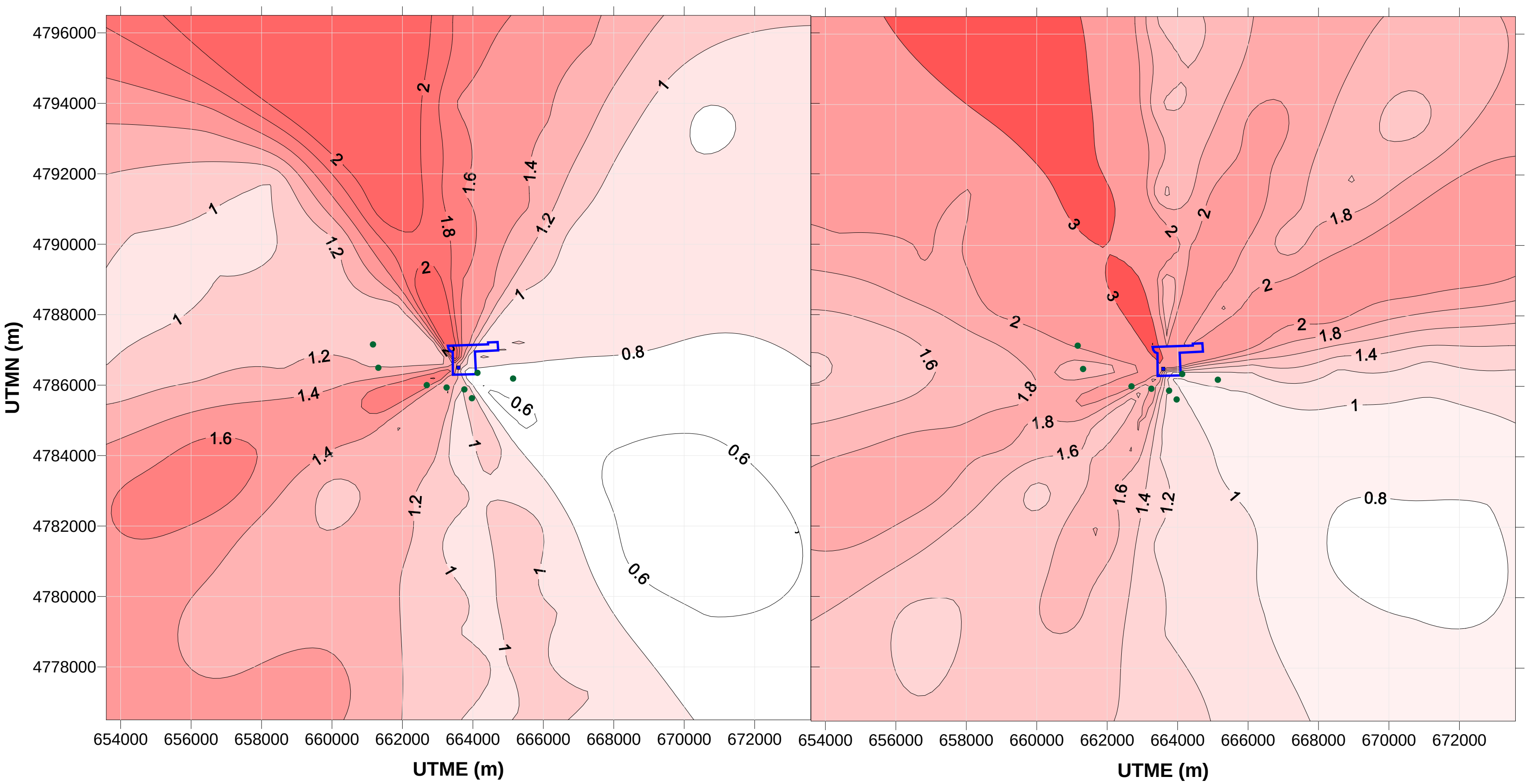
[b] This is the default set of meteorological data for NFSS incorporated in the CAP88-PC code.



(a) Niagara Falls Airport, 1955-1959 **(b) Niagara Falls Airport, 2005-2009** **(c) CWM Landfill, 2005-2008**

FIGURE 13 Distributions of Relative Air Concentrations for an Area Source with an Emission Rate of 1 Ci/yr Using Three Sets of Meteorological Data

(The relative air concentrations are as χ/Q in units of 10^{-6} s/m^3; see Section 7.3. The innermost contours reflect the same progressive series as the outer contours, i.e., following the pattern of 3, 5, 10, and so on toward the center.)



(a) Niagara Falls Airport *(2005-2009 compared to 1955-1959)* **(b) CWM Landfill** *(2005-2008)* **compared to Airport** *(1955-1959)*

FIGURE 14 Relative Air Concentrations Using Recent Meteorological Data Compared to Historical Airport Data

Ratios are less than 1 for the areas ranging from northeast to south clockwise and to the far west-northwest, as shown in Figure 14(a). In contrast, ratios above 2 occur for the areas to the north-northwest. As shown in Table 14, ratios are higher than 1 (up to 1.8) at the nearby offsite receptor locations to the south and west, while ratios are lower at the receptor locations to the east. For the comparison of recent CWM data and historical airport data, relative air concentrations range from 0.75 to 4.4 (see Figure 14(b) for the contours within which these values lie). The ratios are essentially 1 (for the resident to the east-southeast), and above 2 (to the west-southwest and west-northwest); they exceed 3 in areas to the north-northwest. These results indicate that distribution patterns using the 2005-2009 meteorological data from the Niagara Falls airport are similar to those using the 1955-1959 airport data (CAP88-PC default), but the higher concentrations shift to the areas ranging south to northeast clockwise. Concentration distribution patterns estimated from the 2005-2008 CWM data are generally similar, but locations with the higher concentrations differ somewhat from those estimated from the 1955-1959 airport data.

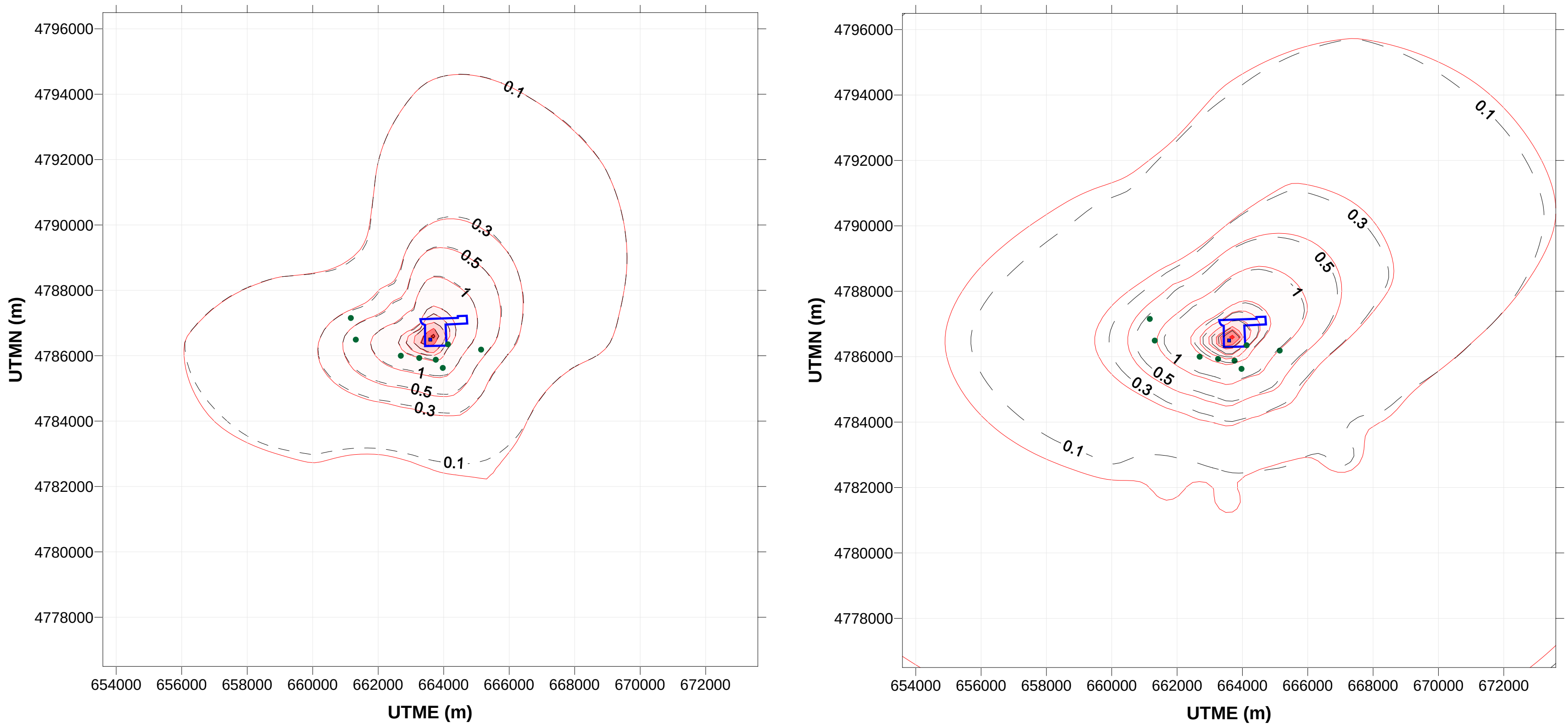
From these analyses, relative air concentrations estimated at offsite receptor locations using the two recent meteorological data sets indicate that those based on CWM data are higher than those based on airport data. The estimated concentrations average 50% higher with the CWM data across all twelve locations, and 40% higher for the eight nearby receptors. Because this comparison addresses the same general time period, these differences reflect meteorological conditions at these distinct locations, which are influenced by different land covers. The lower dispersion indicated for the site area compared to the airport likely reflects lower average wind speeds. For example, measurements at the CWM landfill indicate that the average wind speed is about 3.0 m/s (6.7 mph), while the average wind speed at the Niagara Falls airport is nearly 50% higher, at about 4.4 m/s (9.8 mph). Thus, the different conditions at these two locations are reflected in the associated dispersion estimates.

In summary, predicted offsite concentrations may be about 20% higher when recent airport data are used instead of historical data, and the concentrations further increase when recent CWM data are used. This indicates that location (CWM site vs. Niagara Falls airport) has a greater impact than the time frame for the meteorological data (last several years vs. 1950s).

Of the data sets evaluated to determine potential representativeness for NFSS, the CWM data (2005-2008) are considered well suited for use in modeling the dispersion of airborne releases from the site at this time. The location and common setting conditions of the CWM landfill adjacent to NFSS make these data clearly more representative for NFSS compared with data from the airport 12 km (7 mi) from the site. Thus, the CWM data are recommended for use in dispersion modeling for the site, until such time as sufficient data are available from the meteorological tower recently installed at NFSS.

A further evaluation was conducted to assess the impact of the conversion method applied to recent data to estimate Pasquill stability class, in order to use these data in CAP88-PC. The following comparisons illustrate results using the direct SAMSON method; results for the more direct σ_A method would be comparable because the stability distributions produced by both direct methods are very similar.

For the recent airport data, the relative air concentrations estimated by the indirect method are very similar to those estimated by the direct method, as shown in Figure 15(a). For the CWM data, the concentration contours produced by the two different methods are not as closely matched, although the general contour patterns are similar, as seen in Figure 15(b). The concentration ratios between the direct and indirect methods at the eight nearby offsite receptor locations are presented in Table 15. These ratios range from 0.80 to 0.96, with an average of 0.87. Thus, results using the two methods are comparable even though the Pasquill stability class distributions differ somewhat.



(a) Niagara Falls Airport (2005-2009)

(b) CWM Landfill (2005-2008)

FIGURE 15 Comparison of CAP88-PC Modeling Results Using the Indirect and Direct Methods to Determine Pasquill Stability Classes for Recent Data from the Niagara Falls Airport and CWM Landfill

(This comparison illustrates dispersion of a unit release from a 10,000-m^2 (2.5-acre) source area. The solid [red] line indicates the relative air concentrations estimated by the indirect method; the dashed [black] line indicates that estimated by the direct method based on converting the recent data to the SAMSON format for further processing.)

TABLE 15 Comparison of Relative Air Concentrations Estimated by CAP88-PC for a Hypothetical Release at the IWCS Using Indirect and Direct Methods to Determine Pasquill Stability Classes[a]

Offsite Receptor	Direction and Distance from Building 411			Ratio of Relative Air Concentrations from the Direct Method Compared to the Indirect Method	
	Direction	Distance		Niagara Falls Airport Data (2005-2009)	CWM Landfill Data (2005-2008)
		m	*ft*		
School individual	West-northwest	2,500	8,200	0.97	0.82
School individual	West	2,300	7,500	1.0	0.83
Resident 1	West-southwest	1,000	3,400	0.96	0.80
Resident 2	South-southwest	660	2,200	0.91	0.80
Greenhouse worker	South-southeast	650	2,100	0.92	0.94
Farmer resident	South-southeast	960	3,100	0.94	0.96
Landfill worker	East-southeast	560	1,800	0.98	0.89
Resident 3	East-southeast	1,600	5,200	0.98	0.92
Hypothetical distant 1	East	5,000	16,000	1.0	1.0
Hypothetical distant 2	East	10,000	33,000	1.0	1.0
Hypothetical distant 3	Northeast	5,000	16,000	1.0	0.92
Hypothetical distant 4	Northeast	10,000	33,000	1.0	0.92

[a] The direct method illustrated in this table is based on conversion of the ISHD data to the SAMSON format. Values are rounded to two significant figures. Relative air concentrations at receptor locations are taken from the nearest grids used in the CAP88-PC runs. Shading indicates hypothetical receptor locations farther from the site.

Even though Pasquill stability class distributions differ, the concentration contours between the indirect and direct methods are similar because: (1) the wind speed and direction distributions are the same, resulting in similar contour shapes, and (2) the higher stable conditions estimated by the indirect method (which produce higher concentrations compared to the neutral stability class) appear to be generally offset by higher unstable conditions (which correspond to lower concentrations compared with neutral stability); thus, the net effect is a small difference between the air concentrations estimated by the indirect and direct conversion methods.

Overall, the indirect method produces more conservative results. Closer to the source, air concentrations predicted from the direct method can be up to 20% lower than from the indirect method, while farther away the estimates tend to converge (relative ratio of 1). These differences are not unexpected given that the meteorological parameters and algorithms used in each method are different. Per these underlying differences in the approach, it cannot be determined which method is more or less suited for a given data set. What can be said is that the direct method uses the meteorological data directly, while the indirect method uses a mapping algorithm with the AERMET-processed data.

The EPA processing programs (including PCRAMMET) that generate Pasquill stability classes for use in CAP88-PC do not explicitly consider the surface roughness length, while this measure is incorporated in the Monin-Obukhov length that is used in the AERMOD system. Although generically one might assume a direct conversion method is preferred over an indirect one, in this case it is not clear that the direct SAMSON approach (which does not explicitly consider land cover), is useful for application to the CWM data because the surface in this area is somewhat rough compared with the land cover at the airport. In any case, the difference is relatively small in the context of the overall modeling results.

8.2 COMPARISON OF AERMOD WITH RECENT DATA AND CAP88-PC WITH HISTORICAL DATA

To assess the impact of the specific dispersion model on estimated offsite concentrations from airborne releases at NFSS, the approach described for the CAP88-PC comparisons was also applied for further comparisons with AERMOD. To review, CAP88-PC is designed to address chronic radionuclide releases from nuclear facilities, while the AERMOD system is designed to assess both short-term and long-term (chronic) releases. The AERMOD system is expected to be used to assess releases that could occur over shorter time periods (such as specific intervals of a construction season) to support the upcoming evaluation of remedial alternatives for NFSS. It is anticipated that certain useful features of CAP88-PC (notably the radionuclide ingrowth algorithm) will also be used to complement the AERMOD analyses in the analyses for the IWCS FS.

Differences exist in both the inputs and outputs of these two EPA models. With regard to data inputs, the AERMOD system processes meteorological data in the standard format that has been used since the 1990s. The 1950s airport data are in an older format that does not directly align with the input needs for AERMOD, so only CAP88-PC can be used to evaluate those data. In addition, CAP88-PC is limited to flat terrain while AERMOD can account for terrain features. The terrain option in AERMOD was not employed for these analyses so results could be compared on the same basis.

The outputs of AERMOD and CAP88-PC also differ because of differences in their intended applications. That is, CAP88-PC is designed to assess chronic releases so it produces annual average estimates, whereas AERMOD is designed to assess both short-term and longer-term releases. Thus, hourly measurements are used to produce concentration estimates defined by the user for the given assessment for example, from hourly to annual averages. To facilitate comparisons with the CAP88-PC analyses with historical data, annual averages were selected as the output for the AERMOD analyses. The dispersion models and different meteorological data sets used for the last set of comparisons in this report are summarized in Table 16. Relative concentrations in this table are those estimated for the nearby offsite receptors (see Figure 12). More detailed results of these three comparative evaluations are presented in Table 17 and Figures 16 and 17.

TABLE 16 AERMOD and CAP88-PC Comparisons Using Different Meteorological Data

Place-Time Comparisons	Meteorological Data	Dispersion Model	Relative Air Concentrations at Nearby Offsite Receptors
1 **Same place** *(regional)*, **different times** *(recent/historical)*	Airport: 2005-2009 vs. 1955-1959	AERMOD for recent data CAP88-PC for 1950s data	Recent airport data: 0.4 to 1.3 times historical airport data *(average 20% lower)*
2 **Different places** *(local/regional)*, **different times** *(recent/historical)*	CWM 2005-2008 vs. Airport 1955-1959	AERMOD for recent data CAP88-PC for 1950s data	Recent CWM data: 0.9 to 3.6 times historical aiport data *(average 70% higher)*
3 **Different places** *(local/regional)*, **same time** *(recent)*	CWM 2005-2008 vs. Airport 2005-2009	AERMOD (both data are recent)	Recent CWM data: 1.4 to 3.9 times recent airport data *(average 2.1 times higher)*

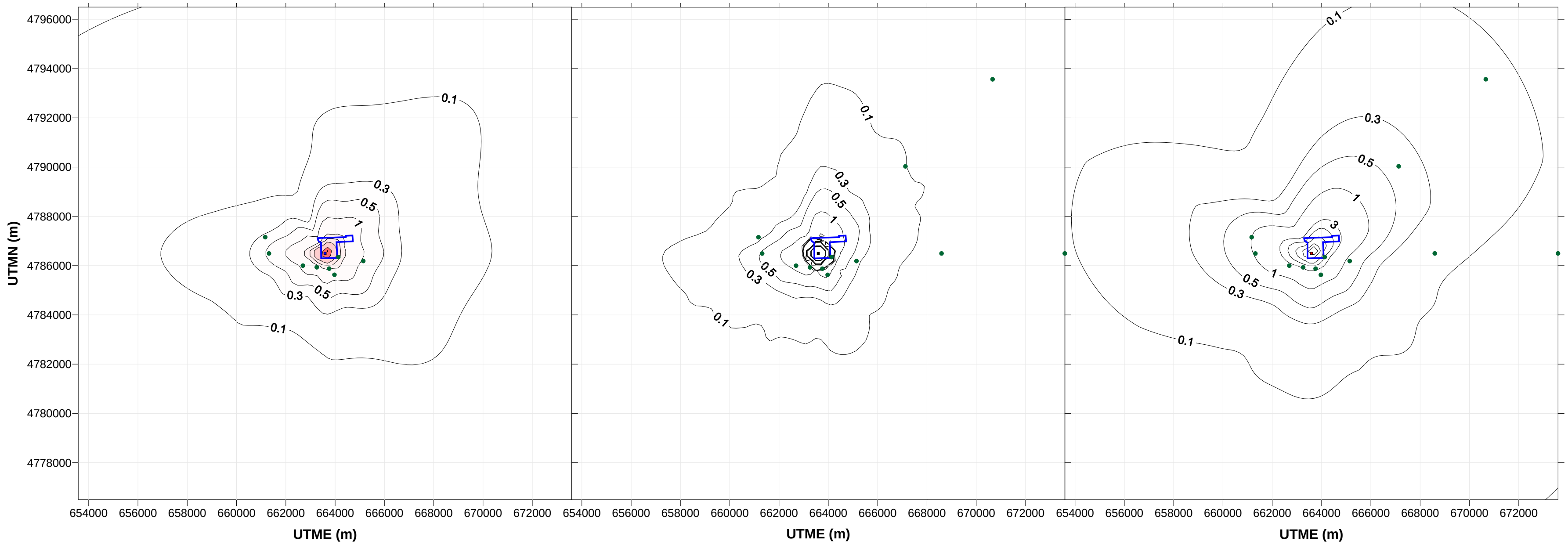
TABLE 17 Comparison of Relative Air Concentrations Estimated by AERMOD and CAP88-PC for a Hypothetical Release at the IWCS Using Different Meteorological Data[a]

Offsite Receptor	Direction and Distance from Building 411			Relative Air Concentrations Estimated by AERMOD with Recent Data and CAP88-PC with 1955-1959 Airport Data[b]		Relative Air Concentrations Estimated by AERMOD with Recent Data for CWM Compared to the Airport
	Direction	Distance m	Distance ft	Airport 2005-2009	CWM Landfill 2005-2008[c]	
School individual	West-northwest	2,500	8,200	0.93	3.6	3.9
School individual	West	2,300	7,500	0.94	1.9	2.0
Resident 1	West-southwest	1,000	3,400	1.3	2.2	1.7
Resident 2	South-southwest	660	2,200	1.0	1.7	1.7
Greenhouse worker	South-southeast	650	2,100	0.82	1.2	1.4
Farmer resident	South-southeast	960	3,100	0.90	1.2	1.4
Landfill worker	East-southeast	560	1,800	0.38	0.89	2.3
Resident 3	East-southeast	1,600	5,200	0.38	0.94	2.5
Hypothetical distant 1	East	5,000	16,000	0.38	1.0	2.5
Hypothetical distant 2	East	10,000	33,000	0.39	1.0	2.6
Hypothetical distant 3	Northeast	5,000	16,000	0.46	1.8	3.9
Hypothetical distant 4	Northeast	10,000	33,000	0.40	1.6	4.0

[a] Values are rounded to two significant figures; concentrations are estimated for a hypothetical unit release from an area source at the IWCS. Relative air concentrations estimated for the receptor locations are taken from the nearest polar grids. Shading indicates hypothetical receptor locations farther from the site. Note that differences between AERMOD and CAP88-PC estimates tend to be greater farther from the IWCS, which reflect differences in the dispersion algorithms for the respective models and in the meteorological data (contours closer to a source typically overlap and then diverge at a greater distance).

[b] The 1955-1959 airport data represent the default set for NFSS in CAP88-PC.

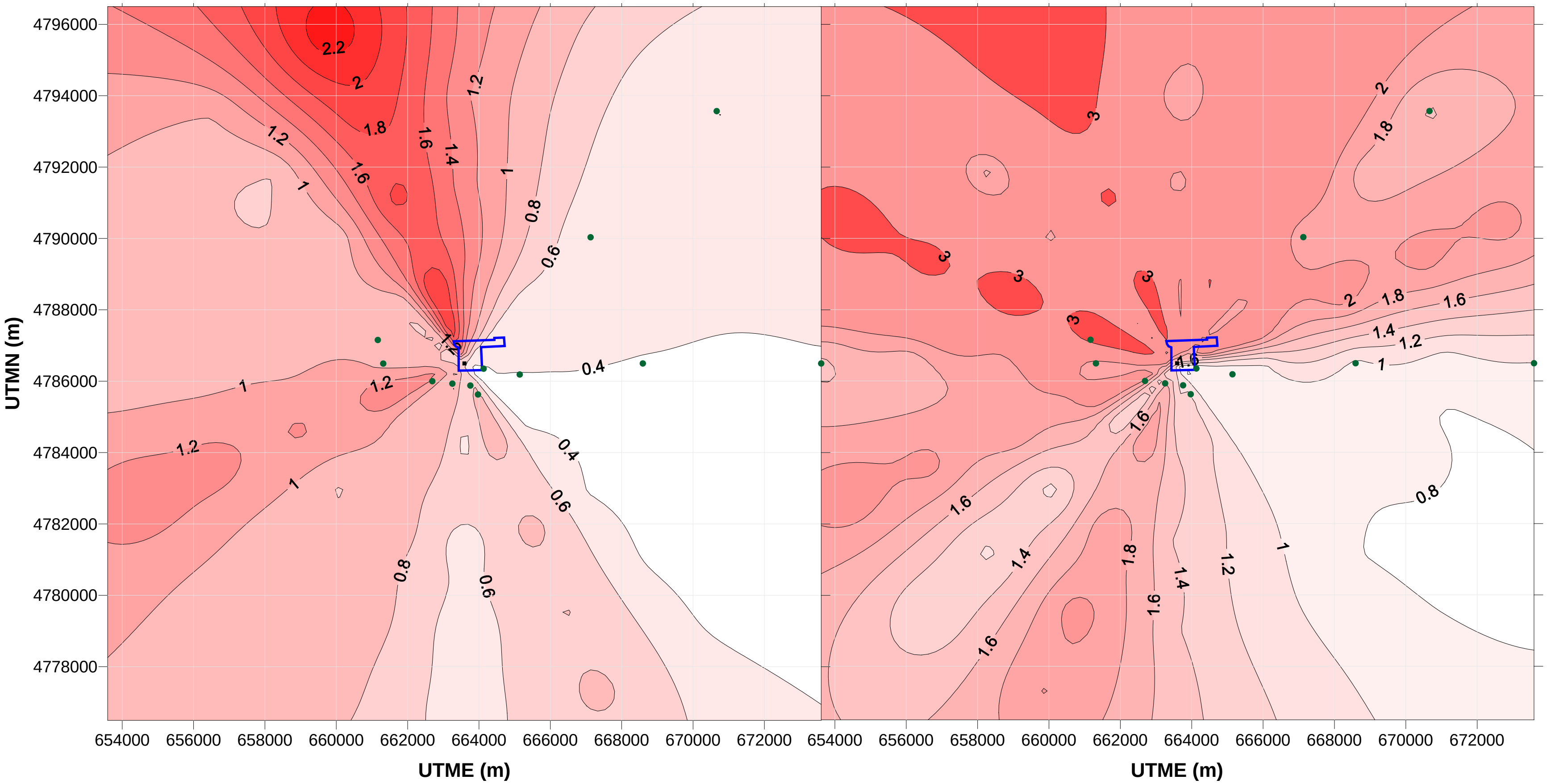
[c] Assumes a threshold wind speed of 1.0 m/s.



(a) CAP88-PC, Niagara Falls Airport, 1955-1959 **(b) AERMOD, Niagara Falls Airport, 2005-2009** **(c) AERMOD, CWM Landfill, 2005-2008**

FIGURE 16 Distributions of Relative Air Concentrations for an Area Source with an Emission Rate of 1 Ci/yr Using CAP88-PC with Default Historical Airport Data and AERMOD with Recent Data for the Airport and CWM Landfill

(Relative air concentrations are as χ/Q, in units of 10^{-6} s/m^3.)



(a) Niagara Falls Airport: Recent vs. Historical Data

AERMOD with 2005-2009 data (wind speed threshold 1.5 m/s) compared to CAP88-PC with 1955-1999 data

(b) Recent CWM Landfill Data vs. Historical Airport Data

AERMOD with 2005-2008 data (wind speed threshold 1 m/s) compared to CAP88-PC with 1955-1959 data

FIGURE 17 Relative Air Concentrations from AERMOD Using Recent Data Compared to CAP88-PC with Historical Airport Data

The first evaluation compares concentrations predicted by AERMOD with recent airport data to the concentrations estimated by CAP88-PC using airport data from the 1950s. Results show that AERMOD estimates based on recent data average about 20% lower for the nearby offsite receptors than those from CAP88-PC with historical airport data. Depending on the location, the concentration ratios range from about 0.4 to 1.3. These lower relative concentrations likely reflect inherent differences in the two modeling approaches, notably the dispersion algorithms, because when CAP88-PC was used to compare these two data sets, the concentrations estimated with recent data averaged 20% higher (see Table 13).

The second evaluation compares relative air concentrations calculated by AERMOD with recent data from CWM to concentrations calculated by CAP88-PC with historical airport data. Results indicate that concentrations predicted by AERMOD with the local (CWM) data average about 70% higher for the nearby offsite receptors than those predicted by CAP88-PC with the older airport data; concentration ratios offsite range from 0.9 to 3.6. The larger differences likely reflect the effect of different meteorological conditions at these distinct locations, as well as inherent differences between the two models (notably the dispersion algorithms).

The third evaluation compares estimates from AERMOD with the two recent data sets – from the CWM landfill and the Niagara Falls airport. Results indicate that concentrations predicted using the local data average about 2.1 times higher for the nearby offsite receptors than those based on the airport data. As for the other comparisons, relative air concentrations vary by location, with ratios ranging from 1.4 to nearly 4. Because this comparison evaluates data from the same time period using the same model, differences in predicted air concentrations reflect differences in the environmental settings for these two locations. This last comparison also indicates that more detailed calculations are afforded by the AERMOD system, which can account for meteorological conditions that exhibit hourly to seasonal changes. Using CAP88-PC with recent CWM data compared to recent airport data produces relative air concentrations for the nearby receptors that average 1.4 times higher, compared to 2.1 times higher with AERMOD (see last columns in Tables 13 and 16, respectively).

The use of hourly meteorological data by AERMOD can result in higher estimates than CAP88-PC under stable conditions and low wind speed due to differences in the underlying algorithms. Because the air concentrations estimated by AERMOD under stable conditions and low wind speed can be higher than those predicted by CAP88-PC, these results can also translate to higher estimates of annual average concentrations. Like the preceding CAP88-PC comparisons, results of these AERMOD and CAP88-PC comparisons also indicate that dispersion at NFSS is less than at the airport.

The spatial distributions of these relative concentrations over the full modeling domain are presented in Figure 16. The concentration contours estimated by AERMOD using recent meteorological data from the Niagara Falls airport are shown in Figure 16(b), and those using recent data from the CWM landfill are shown in Figure 16(c). The general patterns of these contours are comparable to those developed using CAP88-PC, although the concentrations are higher. As for the CAP88-PC results, the contour shapes using CWM data differ from those for the Niagara Falls airport in that they are stretched more in the northeasterly and westerly directions, while the contours retract from the west for the old airport data and further shrink across most directions for the recent airport data.

Concentrations estimated by AERMOD with recent data (from both the airport and the CWM landfill) are compared to those estimated by CAP88-PC with the default 1950s airport data, for a hypothetical unit release from a 10,000-m^2 (2.5-acre) source area; results are shown in Figure 17. The plot on the left (a) reflects relative air concentrations for the 2005-2009 airport data compared with the 1955-1959 data, while the plot on the right (b) reflects relative air concentrations based on the CWM data compared with the 1950s airport data.

For the comparison between recent and historical airport data, relative air concentrations vary from 0.4 to 2.2 over the entire modeling domain, as illustrated in Figure 17(a). Ratios are less than 1 for the areas ranging from north to southwest clockwise and to the west-northwest, as shown in this figure. In contrast, ratios above 2 occur in the area to the north-northwest. As shown in Table 17, ratios exceed 1 (up to 1.3) at nearby offsite receptor locations to the southwest, while ratios are lower at the locations to the east.

For the comparison of recent CWM landfill data and historical airport data, relative air concentrations range from 0.8 to 3, as shown in Figure 17(b). Over the entire modeling domain, the ratios approach 1 (0.80) or higher, and they exceed 3 in areas to the west-northwest and north-northwest as shown in this figure. These results indicate that the concentrations of airborne contaminants predicted by AERMOD using CWM data tend to be higher than those predicted by CAP88-PC with the historical airport data. Comparing only airport data, offsite concentrations at the nearby receptors predicted by AERMOD using recent airport data are about 20% lower than CAP88-PC estimates using 1950s airport data. The concentrations estimated by AERMOD using local (CWM) data are about 70% higher than the CAP88-PC predictions based on the historical airport data.

The comparison of AERMOD results for the two recent data sets indicates that local (CWM) meteorological data predict concentrations that average 2.1 times higher than predicted by the regional (Niagara Falls airport) data. As described for the previous CAP88-PC analyses, this finding indicates that the location (CWM landfill vs. airport) has a greater impact on the dispersion estimates than the time period (data collected in the last several years to those from more than 50 years ago). In terms of the modeling approach, being able to evaluate shorter time periods (via the AERMOD system) makes it possible to use the dispersion modeling to help guide the evaluation of different options for implementing various remedial actions at the IWCS in a way that would best limit airborne releases.

To illustrate, during the day, mixing height is determined by either mechanical turbulence or buoyant turbulence – with the latter dominating due to the effect of sunlight. During nighttime hours, mixing height is only determined by mechanical turbulence, which is a function of surface friction velocity (which is related to wind speed and surface roughness length). Under stable conditions typical of nighttime hours, a low wind speed generates a low mixing height, which translates to higher pollutant concentrations near the ground surface.

Estimated air concentrations (e.g., of PM) are typically highest around sunrise when the mixing height is low, before the earth's surface is warmed by the sun and buoyancy increases. During the couple hours around sunrise, the maximum concentrations in air are markedly higher than at any other time of the day. This effect is especially pronounced during the colder months (late fall to early spring) when wind speed is low (e.g., 1 m/s [2.2 mph]), atmospheric conditions are stable, and the mixing height is relatively low.

In fact, most exceedances of the NAAQS standards for PM (as 24-hour averages) are associated with the couple of hours of high concentrations in the early morning (around sunrise) in the colder months with these typical conditions. Thus, any remedial action activities that would involve exposing highly contaminated residues at the IWCS during these early sunrise hours would be discouraged. Night shifts involving such disturbance would be similarly discouraged. In addition, waste disturbance should be avoided during windy days (e.g., when wind speeds exceed 9 m/s [more than 20 mph]) because even though the high winds would promote dispersion, wind erosion would produce high fugitive dust emissions that could more than offset the dispersion benefit.

These examples illustrate how the more sophisticated dispersion model that can account for these phenomena can help guide practical planning evaluations of potential remedial actions involving waste disturbance at the IWCS. With sound meteorological and source data, the AERMOD calculations generally reflect accuracy in the range of ±10% to 40%. Note this primarily reflects uncertainty in the specific time and location, not in the concentration estimate itself; i.e., the model is fairly reliable in predicting the maximum concentration estimated to occur sometime within the given area (from Turner and Schulze [2007], reflecting EPA guidance on air quality models: "the uncertainty does not indicate an estimated concentration does not occur, only that the precise time and location are in doubt.")

8.3 SUMMARY AND CONCLUSIONS

Nine meteorological stations in the general NFSS area were identified as potential sources of meteorological data for use in modeling air dispersion at NFSS. From these nine stations, three sets of data were found to warrant detailed evaluation:

- Recent data (2005-2009) from the Niagara Falls airport, 12 km (7 mi) south-southeast of NFSS.
- Historical data (1955-1959) from the airport, which are the default set for NFSS in CAP88-PC.
- Recent data (2005-2008) from the CWM landfill, directly adjacent to NFSS.

When sufficient measurements are available from the meteorological station installed at NFSS in spring 2011, those data will be used in dispersion modeling for the site. Until that time, the CWM data are considered well suited for the dispersion analyses. These CWM data reflect:

- The current local setting, including land cover and the escarpment between NFSS and the airport.
- Standard collection and reporting protocols for current meteorological data.
- Appropriate coverage and quality, as measurements span several years with sound QA/QC.

The meteorological data comparisons presented in this report indicate the following:

- Data from the Niagara Falls airport are spatially and temporally representative of regional wind patterns, which differ somewhat from local patterns at NFSS and the CWM landfill.
- Prevailing winds differ slightly between the airport and the NFSS area; these winds come from the southwest at the airport but from the west-southwest at the CWM landfill and NFSS.
- Average wind speed in the NFSS area is nearly 30% lower than at the airport. This likely reflects local features that differ from those at the airport, where the elevation is higher and the land is more open (with fewer trees).

This information further supports using onsite data in future dispersion analyses for NFSS when a sufficient data record has been achieved, to assure that local dispersion patterns are addressed. The Niagara Falls airport is not recommended as the primary data source because among other reasons, low wind speeds play an important role in determining elevated concentrations of airborne contaminants, and wind speeds below 1.5 m/s (3 knots, or 3.4 mph) are not reported at the airport. However, this station serves a valuable supporting role. Certain data that vary little spatially and are already being collected at nearby airports are not collected onsite. For both CWM and NFSS, the stations tapped for these data are: (1) the Niagara Falls airport, for surface data such as solar radiation and cloud data; and (2) the Buffalo airport, for twice-daily upper air sounding data, including pressure and temperature data with elevation (the Buffalo airport is the closest station with these data).

Results of the dispersion modeling comparisons for NFSS are highlighted in Table 18. These estimates reflect dispersion from a hypothetical unit release at the IWCS to nearby offsite receptors.

TABLE 18 Comparison of Dispersion Modeling Results Using Different Meteorological Data[a]

Compare ↓ *to* →		AERMOD: Recent Meteorological Data		CAP88-PC: Historical Data
		CWM Landfill 2005-2008	**Niagara Falls Airport 2005-2009**	**Niagara Falls Airport 1955-1959**
CWM Landfill 2005-2008	**CAP88-PC**		Same to 2 times higher *(average 40% higher)*	Same to 2.2 times higher *(average 60% higher)*
	AERMOD		1.4 to 3.9 times higher *(average 2.1 times higher)*	0.9 to 3.6 times higher *(average 70% higher)*
Airport 2005-2009	**CAP88-PC**	*(average 30% lower)*		0.7 to 1.8 times higher *(average 20% higher)*
	AERMOD	*(average 50% lower)*		0.4 to 1.3 times higher *(average 20% lower)*
Airport 1955-1959	**CAP88-PC**	*(average 30% lower)*	*(average 40% higher)*	

[a] Entries above the dark-shaded boxes reflect the results summarized in Tables 13 and 16.

Both standard EPA models evaluated are appropriate for dispersion analyses, each for their intended purpose. The main conclusions from the dispersion modeling are as follows:

- The local setting has a greater impact on the estimated dispersion of airborne releases than when the data were collected.

- Dispersion at NFSS is less than at the airport, which reflects the lower wind speed at the site identified above. Less dispersion translates to higher airborne concentrations. For this reason, using local data rather than regional (airport) data in the dispersion modeling for NFSS helps avoid the potential for underpredicting these concentrations.

- The AERMOD system is well suited for assessing releases associated with possible remedial action activities at NFSS because this system is designed to assess contaminant dispersion and deposition over both short-term and longer-term periods. AERMOD provides user-defined (e.g., hourly to annual) estimates of airborne concentrations and associated deposition, and this system relies on a more sophisticated dispersion algorithm than earlier models. These and other factors contribute to dispersion estimates that are higher than those predicted by CAP88-PC with the local meteorological data.

- The CAP88-PC model is useful for assessing chronic radionuclide releases to assess compliance with NESHAPs requirements, i.e., to estimate annual average airborne concentrations and radiation doses for presentation in the annual environmental surveillance reports for NFSS. CAP88-PC is also useful for assessing the ingrowth of Rn-222 progeny, which can be conducted as a complementary analysis to AERMOD (e.g., tiered from the AERMOD dispersion estimate for a Rn-222 release).

- Both indirect and direct conversion methods can be applied to current meteorological data to estimate the stability parameter used in CAP88-PC. Thus, recent data from the CWM landfill could be used with CAP88-PC for the annual NESHAPs compliance evaluations.

- The wind speed and direction distributions estimated from the direct and indirect conversion methods are the same, resulting in similar contour shapes. The higher stable conditions estimated by the indirect method (which would produce higher concentrations compared to the neutral stability class) appears to be generally offset by higher unstable conditions (which would correspond to lower concentrations compared with neutral stability). Thus, the net difference between the air concentrations estimated by the indirect and direct methods is small. General agreement among the results of substantially different approaches supports the interpretations presented in this report.

The following suggestions are offered to further strengthen future dispersion analyses for NFSS:

- If CAP88-PC is used for the NESHAPs compliance evaluations, it is recommended that meteorological data from the CWM landfill be used with the most direct conversion method (σ_A).

- For the evaluation of potential remedial action activities at the site, it is recommended that CWM data be used with AERMOD at this time.

- When a sufficient and appropriate data record has been established from the new meteorological station onsite, it is recommended that these data be used for all dispersion modeling at NFSS.

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