Importance Of Local Meteorological Data For Remedial Action Projects: Niagara Falls Storage Site (NFSS) Example – 14680

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ABSTRACT

Local dispersion of airborne contaminants released from cleanup sites has long been a concern for nearby communities. Many sites are located near homes, schools, and businesses, including sites being addressed by the U.S. Army Corps of Engineers (USACE) under the Formerly Utilized Sites Remedial Action Program (FUSRAP). At such sites, potential impacts to offsite air from releases during remedial activities are of keen interest to the local public. Releases associated with baseline conditions can also pose a concern in some circumstances, such as from natural disasters or unintentional disturbance of contaminated materials. Understanding near-field dispersion is also important to guiding plans for onsite worker protection. For these reasons, a careful assessment of air dispersion can be crucial to developing and evaluating practical remedial alternatives for sites where inhalation exposures are a key concern. Appropriate meteorological data are central to these assessments, as illustrated by technical analyses conducted by the USACE for the Niagara Falls Storage Site (NFSS), a FUSRAP site in Lewiston, New York. As a general simplifying approach, meteorological data from a nearby airport are often used to estimate air dispersion at another location. This approach is problematic in many settings because wind patterns can differ substantially even across short distances. Airports are typically in level, open areas – which translate to higher winds and more neutral atmospheric stability conditions – while the location of interest may be surrounded by agricultural lands, forests, and other surface features. Such differences can lead to underpredicting pollutant concentrations for the study location. To address this issue as part of rigorous planning for the NFSS, the USACE conducted a detailed analysis to evaluate the role of meteorological data in assessing air dispersion for the site. The findings echo those of other studies across the country, demonstrating that meteorological data from a nearby airport tend to underestimate air concentrations predicted for the site area compared with data from the site area. Differences of two- to four-fold can affect site-specific plans for sustaining protection of workers and the public throughout the remedial action program. These results emphasize that for sites where inhalation of airborne contaminants is a potential issue, representative meteorological data are important to guiding practical remedial action plans.

INTRODUCTION

Air dispersion of contaminants released from cleanup sites has long been a concern for nearby communities. A number of sites are located near homes, schools, and commercial facilities, including sites being addressed by the U.S. Army Corps of Engineers (USACE) under the Formerly Utilized Sites Remedial Action Program (FUSRAP). At such sites, offsite impacts from airborne releases during remedial activities are of keen interest to the local public. Baseline conditions can also pose a concern in some cases, due to natural disasters (such as tornados or earthquakes) or from unintentional disturbance of contaminated materials. In addition to offsite interest, understanding potential dispersion of contaminants within the site boundary is also important to guiding plans for protecting onsite personnel. For these reasons, a careful assessment of air dispersion can be crucial to developing and evaluating practical remedial alternatives for sites where inhalation exposures are a key concern. Appropriate meteorological data are central to these analyses. Technical evaluations conducted by the USACE for the Niagara Falls Storage Site (NFSS) in Lewiston, New York, consider this important aspect.

The USACE is developing and evaluating potential remedial alternatives for the 77-hectare (ha) (191-acre) NFSS under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. During the 1940s and 1950s, the Manhattan Engineer District (MED) and Atomic Energy Commission (AEC) brought radioactive wastes to the site, including residues with high activities of radium-226. In the 1980s, the U.S. Department of Energy (USDOE) consolidated these wastes into a 4-ha (10-acre) interim waste containment structure (IWCS) in the southwest portion of the site.

The USACE is responsible for developing and evaluating remedial alternatives for the site, including the materials currently stored in the IWCS. To support ongoing planning, the USACE is evaluating potential airborne releases from this FUSRAP site, including of radium-226 (Ra-226) and its decay product radon-222 (Rn-222) gas, through a series of technical analyses. These analyses include an evaluation of meteorological data [1] to assess the dispersion of airborne contaminants that might be released at some point in the future, e.g., during remedial action activities at the NFSS.

ASSESSMENT ISSUES AND TECHNICAL APPROACH

To assess air dispersion for a given site, measurements are generally more accurate and are thus preferred over models. As a practical matter, the number of monitoring locations or measurements that could be obtained is severely constrained by cost. To address this limitation, air dispersion modeling is widely used to calculate air concentrations of pollutants resulting from emissions. The inherent errors introduced by this modeling (caused by simplifications and parameterizations of real, complex atmospheres) are an understood tradeoff, considering the prohibitive cost of using actual measurements.

Once the air dispersion model has been developed based on coherent atmospheric physics and parameterizations followed by model validation with various field measurements, modeling is far less expensive than monitoring. For example, air concentrations at tens of thousands of “receptor locations” can be estimated with a dispersion model for the same cost as a single measurement. In addition, the air dispersion model is especially useful in simulating hypothetical sources, evaluating various emission control options, estimating concentrations below detection thresholds, and predicting concentrations at locations where air monitors would be difficult to set up.

To model air dispersion of pollutants released from a site, information is needed regarding the emission source or sources, meteorology, and receptor locations of interest. Together with appropriate emission rates, the types and configurations of the source(s) and use of meteorological data representative of the modeling domain under consideration are crucial to reasonably estimating air concentrations at the receptor locations. It is often tempting to use meteorological data from a nearby airport to evaluate potential air quality impacts and/or estimate potential health risks associated with emissions from a given facility or site.

The reasons for using standard airport data include easy accessibility and reliability of those data that have undergone a high level of quality assurance/quality control (QA/QC), cover a long time period, are comprehensive, reflect consistent measurement techniques, and are comparable to other standard regional datasets. Unfortunately, in many cases the meteorological data from nearby airports are not representative of the specific area of interest in terms of land cover, land use, topographic features, and other factors that affect air dispersion.

Airports are usually located in level, open areas with minimal obstruction to assure safe aircraft operations. In contrast, areas of interest for project-specific assessments (such as contaminated sites) are often surrounded by agricultural lands, short and tall forests, structures, and other surface features. Accordingly, meteorological conditions between such areas and nearby airports can be quite different, even when they are only a short distance apart.

In most cases, using airport data to assess air dispersion at another area will underestimate concentrations for the latter. Thus, particularly for sites where the air pathway is a primary issue, it is very important to reflect local meteorological conditions. This is especially critical in areas where local air quality conditions could approach the limits established under the Clean Air Act, or when other pollutants (not covered by those standards) could potentially exceed health-based benchmark concentrations in areas where people could be exposed.

Standard meteorological data from airports are available from the Automated Surface Observing Systems (ASOS) program, which is a joint effort of the National Weather Service (NWS), the Federal Aviation Administration (FAA), and the Department of Defense (DoD). The ASOS systems serve as the nation's primary surface weather observing network, as ASOS is designed to support weather forecast activities and aviation operations and, at the same time, support the needs of the meteorological, hydrological, and climatological research communities. These airport data are available from the National Climatic Data Center (NCDC) ftp site [2] in the integrated surface hourly data (ISHD or ISD) format, which is a current standard format for meteorological data from ASOS stations. These data have many advantages as described above, and they also have a few disadvantages.

First, meteorological data from ASOS stations are of very high quality, but 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 to measure wind speed until recently. Although most ASOS stations now use sonic anemometers, which have essentially no reportable threshold, to a large degree the long-standing observing rules and practices have not yet changed [3]. Thus, consistent with other ASOS stations, the lowest wind speed commonly reported for airports and used in air modeling analyses that use those data is 1.5 m/s (3.4 mph). This is important because low wind speeds (below that level) can play an important role in local elevated concentrations of airborne contaminants, so using airport data to assess air dispersion at another location might produce a low bias (underestimate) of predicted pollutant concentrations at that separate location.

Another disadvantage in using airport data is that wind directions in the ISHD format are reported to the nearest 10 degrees. In contrast, meteorological data from various other facilities often report wind directions to the nearest degree or lower. Thus, when ISHD data (from ASOS stations) are used to model air dispersion at another location, a specific set of randomly generated numbers should be used with those ISHD data to address the bias regarding these wind data.

In addition, meteorological data available in the STability ARray (STAR) format (a three-way joint frequency distribution of wind speed, wind direction, and Pasquill stability class) for use in the CAP88-PC program (personal-computer software developed decades ago to estimate doses from radiological dispersion) for NFSS are from the 1940s to 1970s [4]. Since that time, average storm tracks (defined as the path followed by a center of low atmospheric pressure) have shifted northward, as evidenced by a decrease in the frequency of storms in mid-latitude areas of the Northern Hemisphere, while high-latitude activity has increased. Meteorological patterns in many areas of the United States (including the New York region of interest) have been altered over the past 50 years due to the northward migration of storm tracks associated with such climatic changes. Thus, meteorological patterns reflected in data from decades ago are expected to differ from those representing conditions today.

Other discrepancies between old and recent meteorological data include wind measurement height, wind sampling duration, instrumentation, and land use around the monitoring stations. For example, today's instruments are more advanced and new measurement protocols are in place. Now, the height of the meteorological tower has been standardized to 10 m (33 ft), compared to heights ranging from a few meters to a few tens of meters for old meteorological towers. Due to differences in wind measurement heights, direct comparisons between two sites with different wind measurement heights could be problematic, with the result that modeling estimates would be inconsistent among sites.

Per the USEPA guideline on air quality models [5], meteorological data used in dispersion models should be selected based on spatial and climatological (temporal) representativeness as well as the ability of selected parameters to characterize the transport and dispersion conditions in the area of interest. Data representativeness depends on a number of factors, including proximity of the candidate (NWS) station to the area of interest, complexity of the respective terrains, and the data collection period. The first and second factors can affect spatial representativeness, while the third addresses temporal representativeness.

Because weather conditions vary from year to year, the USEPA recommends using at least one year of site-specific meteorological data or at least five years of NWS data, preferably consecutive years from the most recent five-year period. When the terrain at a site is complex, site-specific measurements or data from other meteorological stations much closer than the candidate airport that are more representative than NWS data should be pursued. The USEPA emphasizes the importance of selecting meteorological data to model air dispersion for a given location that is both laterally and vertically representative of the transport and dispersion within that domain [5].

EXAMPLE DIFFERENCES BETWEEN NEARBY AIRPORTS AND ONSITE DATA

Differences in wind patterns between study areas of interest and nearby airports are illustrated below for the NFSS and two other example facilities. Airport data in the ISHD format were obtained from the NCDC ftp site [2], and site-specific data were obtained from the parties responsible for these three facilities.

The first example is from northern Wisconsin, comparing meteorological data for the Rhinelander-Oneida County Airport with those for a research facility located about 13 km (8 mi) to the west-northwest. This facility is surrounded by agricultural lands and scattered forests. Data collected from 2004 through 2008 from the 10-m (33-ft) height at both locations indicate similar wind directions, with predominant winds from the southwest quadrant. However, in comparing wind speeds, the average for the research facility was about 1.9 m/s (4.3 mph), which was roughly 60% of the average wind speed of 3.1 m/s (6.9 mph) at the airport.

The second example is from southeastern North Carolina, comparing data for the Wilmington International Airport with those for a research station about 6 km (4 mi) to the north. For the period from 2004 through 2008, wind patterns are similar although prevailing wind directions are somewhat shifted; prevailing winds are from the southwest with secondarily from south-southwest/north-northeast at the airport, while at the research station they are from the southwest with secondarily from west-southwest/northeast. Similar to the Wisconsin example, the average wind speed of 2.1 m/s (4.7 mph) from the onsite station is about 60% of that reported for the nearby airport (3.4 m/s [7.6 mph]).

The third example is the NFSS, comparing data for the Niagara Falls International Airport located about 12 km (7 mi) south-southeast of the site with data from a meteorological station 1 km (0.6 mi) north of the site, on an adjacent landfill with the same land cover, elevation, and topography as the NFSS. At this adjacent station, the average wind speed is 3.0 m/s (6.7 mph), which is lower than (roughly two-thirds of) that at the airport where the average wind speed is about 4.4 m/s (9.8 mph). The difference reflects differences in surface roughness, with relatively tall trees in the area of the landfill and NFSS compared with open space at the airport. In addition, the elevation of this nearby airport is about 76 m [250 ft] higher than at the site area. Prevailing winds differ slightly between these two stations, coming from the southwest at the airport but from the west-southwest at the landfill adjacent to NFSS. More frequent west-southwesterly winds at the NFSS area compared to the airport may in part reflect the influence of an escarpment that runs east-northeast to west-southwest between the site and the airport, such that the prevailing southwesterly regional winds could be steered somewhat to that orientation [1].

As a note, the USEPA recently adjusted ASOS wind speeds to account for bias due to wind speeds being truncated to whole knots, by adding 0.257 m/s (about 0.57 mph) to the reported speeds [6]. Adding this adjustment to the wind speeds identified above for the comparison airports has the effect of further increasing the differences between the airport and location-specific data by roughly 5% for these three examples.

INPUT TO REMEDIAL ACTION PLANNING

As part of the suite of analyses conducted by USACE for NFSS, meteorological data from the Niagara Falls airport were also compared with data from other regional airports and were found to be spatially and temporally representative of *regional* wind patterns. However, those patterns differed somewhat from local patterns at the NFSS area, which is not unexpected given that the airport is at a higher elevation and the surrounding land use and land cover differ from those at the site area.

The evaluation of meteorological data for use in air dispersion models to help support remedial action planning for NFSS found that: (1) wind directions differ slightly between the nearby airport and the station adjacent to the site; (2) wind speeds in the NFSS area are lower than those at the airport; and (3) the frequency of stable conditions, which contributes significantly to higher local concentrations of air pollutants, is greater at the site area than at the airport. These results indicate that if contaminants were released from NFSS (such as during future remediation activities), downwind concentrations calculated using meteorological data from the airport would be lower (underestimated) compared with those estimated using meteorological data representative of the site area. When local meteorological data (from the adjacent landfill) were used to estimate dispersion of airborne contaminants from NFSS using the current standard EPA model (AERMOD), the predicted air concentrations at nearby offsite receptor locations averaged twice as high (and ranged up to four times higher) than when the airport data were used [1].

These analyses demonstrated that meteorological data from the nearby airport do not fully account for the effects of local features on wind patterns at NFSS. In contrast, the meteorological data from the landfill station adjacent to the site represent local conditions and are considered well-suited for assessing air dispersion of contaminants that might be released from NFSS.

Responsive to community interest in local conditions, the USACE installed a meteorological station at NFSS in early 2011 and data collection began that spring. With nearly three years of data now available, a preliminary evaluation of onsite meteorological data confirms the findings of the initial comparison between airport data and those from the station adjacent to NFSS. That is, conditions in the site area differ enough from those at the airport to warrant use of local/onsite data in the air dispersion modeling conducted to support ongoing remedial action planning for the NFSS.

CONCLUSIONS

These analyses demonstrate that using meteorological data from a nearby airport to predict concentrations of air pollutants from releases at a separate site – even when the airport is only a relatively short distance away – could result in underestimating concentrations for the area of interest. For contaminated sites, this underestimation could in turn affect the determination of appropriate measures to protect onsite personnel and the nearby public throughout the cleanup program. Thus, for those sites where potential inhalation exposures are a key concern, pursuing meteorological data that reflect site-specific conditions can substantially benefit the development and evaluation of remedial alternatives to assure sustained protection of workers and the public.

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