A Preliminary Screening Method to Estimate Cumulative Environmental Impacts

New Jersey Department of Environmental Protection

December 22, 2009

Introduction

Governor Corzine signed Executive Order 131 (EO-131) promoting environmental quality in low-income and minority communities in February 2009. Among other things, Executive Order 131 reconstituted the Environmental Justice Advisory Council (EJAC), which is charged with making recommendations to the Commissioner of the New Jersey Department of Environmental Protection (DEP) about issues involving environmental justice in the State. Under the order, the DEP is instructed to review and consider recommendations submitted to it by the EJAC, which can include recommendations for policy and regulatory changes. More specifically, EO-131 requires DEP to evaluate and consider the EJAC's recommendations in their March 2009 report: "*Strategies for Addressing Cumulative Impacts in Environmental Justice Communities.*"

On July 29, 2009, Acting DEP Commissioner Mark N. Mauriello provided comments on the EJAC report. In his comments, the Commissioner indicated that the DEP would work with EJAC in developing a preliminary geographic information system-based screening tool that integrates a variety of environmental measures along with demographic and socioeconomic factors. The purpose of the screening tool would be to assist DEP with identifying communities of concern in New Jersey. It is important to stress that the preliminary screening tool is only a first step to begin to address the complex issues surrounding cumulative impacts and environmental justice. The tool is continuously being evaluated for improvement to include new data sources, to update existing data sources, and to integrate new methods and applications.

This paper discusses the data and methods currently being used by DEP to develop this preliminary screening tool. The Department is seeking input on the methods and data used in development of this proposed screening tool.

Background

It is important for the reader to clearly understand what the preliminary screening tool does and does not do. The tool does use publicly available data to identify a set of indicators to compare environmental conditions between geographic areas. In some cases such as use of the National-Scale Air Toxics Assessment (NATA) data, the indicators do reflect estimates of human exposure. However, in other cases the indicators only reflect incidence of certain conditions (for example, density of contaminated sites) and do not present any estimate of human exposure. As a result, this preliminary tool does not and cannot be used to quantify or predict human health risk. The current state of science simply does not yet allow for an assessment of cumulative health risk nor a more accurate quantification of risk at a community level.

In developing the preliminary approach to assess cumulative environmental impact, DEP reviewed the current literature, efforts underway in other states and U.S. EPA, and approaches promoted by the non-governmental organization community.

Appendix A summarizes the different methodologies, approaches and recommendations that were evaluated by the DEP.

Data and Methods

In developing the preliminary tool, DEP relied on publicly available data. DEP determined that it was appropriate to focus on data that meet several key criteria:

- Data need to be available statewide to ensure that all areas of the state are included in the analysis;
- Data must be accurate and consistent across the state;
- Data must be relatively easy to access and be in a consistent electronic format, or be easy to convert, to allow simultaneous evaluation;
- Data must be in a consistent GIS format to allow the data to be aligned and evaluated spatially; and
- Data must be in a consistent temporal format.

DEP focused on nine indicators (Table 1) as initially meeting its key criteria.

Table 1: Summary of Indicators

Indicator	Data source	Original Geographic Scale	Original Units
NATA cancer risk (1999)	EPA data	Census tract	Risk per million
NATA diesel (1999)	EPA data	Census tract	Ug/m3
NJDEP Benzene estimate	DEP emission inventory	100 meter grid	Ug/m3
Traffic All	Congestion Management System	1000 foot buffer	Traffic Counts all vehicles
Traffic trucks	Congestion Management System	1000 foot buffer	Traffic Counts heavy trucks
Density of Major Regulated sites	DEP NJEMS data	100 meter grid	Sites per acre
Density of Known Contaminated	DEP SRP data	100 meter grid	Sites per acre
Density of Dry Cleaners	DEP GIS data	100 meter grid	Sites per acre
Density of Junkyards	DEP NJEMS data	100 meter grid	Sites per acre

Once the nine indicators were identified, DEP developed each of the nine indicators using a consistent 100 meter grid covering the state. The state-wide grid includes just over 2 million grid cells. This grid was generated using the Create Fishnet tool in ESRIs Arc Toolbox. The statewide grid is used for each indicator and ensures that the data are aligned spatially and can be "stacked" in the same location for easy

comparison. The grid analysis was done using the Spatial Analyst tool in ESRI ArcMAP 9.2. The 100-meter grid data are then used to estimate cumulative impacts at the block group level (there are 6,521 block groups in the New Jersey that average approximately 800 acres in size).

Since the units used to quantify the nine indicators are not consistent (see Table 1), it is necessary to normalize the data so it can be compared with other data. Normalization is also important to allow for the individual indicators to be combined to show how multiple indicators affect the same geographic area.

The Department reviewed various methods to normalize these indicators and convert them into common units. The method currently used to normalize these indicators is to calculate a z-score for each value. A z-score is a statistical measure that quantifies how far a value is from the mean of its distribution. Another description of the z-score is that it is a measure of the distance in standard deviation of a value from the mean. A z-score for any value is calculated by the equation:

$$Z\ score = (value-mean)/standard\ deviation$$

The NJDEP calculated z-scores for each grid for each indicator. The mean and standard deviation for each indicator dataset was obtained from the statistics summary in the source information for each raster. The z-scores were calculated using the Raster Calculator function and the equation above. Any z-score higher than 3 was assigned a value a 3. This adjustment impacts only a small number of the total grids.

Options to combine indicators

The NJDEP reviewed various methods to combine the indicators to estimate cumulative impacts. Currently two methods are used. The first method sums all indicators in the consistent 100 meter grids. Since each of the 9 indicators can have a maximum z-score of 3, the highest combined score a grid location can have is 27 (3 x 9). The summation was done using the Raster Calculator.

The second method counts each indicator that has a z-score above 1. Since there are nine indictors, the maximum score any one grid location can have is 9.

Application to larger geographic areas

The grid-level estimates provide spatially consistent data across a range of indicators at a fine geographic scale. This enables multiple indicators with different geographic boundaries to be combined and evaluated. The grid-level estimates can also be used to "scale up" estimates of cumulative impacts to larger geographic areas, such as administrative boundaries including municipalities, census tracts and block groups. Estimates of cumulative impacts at these larger geographic scales also provide useful information and allow the estimates of cumulative impact to be evaluated with other important information such as Census data.

The DEP preliminary screening tool currently uses two metrics to estimate potential cumulative impacts at a block group level. The block group level was selected because it is the finest geographic scale with census information on income and poverty

levels. Each method uses the Zonal Statistics function of the Raster Calculator. Each method was applied to the two combined indicators discussed above (sum and count).

The first metric selects the mean of the grid-level estimates within each block group. This metric provides a measure of the average potential impact for the entire population within a block group. The second metric selects the maximum grid within each block group. This metric provides an estimate for the maximum impact for a portion of the block group. The final output from this block group analysis contains four scores: the mean and maximum for the sum of z-scores; and the mean and maximum for the count of z-scores above 1.

### Evaluation of Social/Economic Factors

To better understand the relationship between the environmental indicators discussed above and socioeconomic factors, DEP evaluated 2000 US Census data for poverty and minority status for each block group in New Jersey. An estimate for total minority for each block group was calculated using information from US Census Summary File 1. Specifically, data from Table P8 Hispanic or Latino by Race, fields P008001 (Total Population) and P008003 (Not Hispanic, white only) were used. Total minority percent was estimated with the following equation:

$$\text{Total Minority Percent} = [(\text{P008001} - \text{P008003})/(\text{P008001})] * 100$$

An estimate for percent population below the poverty level was developed using information from US Census Summary File 3. Specifically, data from Table P87 Poverty Status in 1999 by Age, Fields P087001 (population for whom poverty status is determined) and P087002 (Income in 1999 below poverty level total). Percent poverty is calculated as:

$$\text{Percent Poverty} = [(\text{P087002})/(\text{P087001})] * 100$$

The NJDEP used the block-level estimates of potential cumulative impacts to compare to the percent minority and percent poverty to understand the relationship between these two important factors. Figures 1 and 2 below present results. The cumulative impact estimates in Figure 1 and 2 above use the mean of the block group for the count above 1. Cumulative impact estimates based on the summation method show a similar relationship, with increasing impacts as percent minority or poverty increase.

Figure 1: Relationship Between Cumulative Impact and Percent Minority

Figure 2: Relationship Between Cumulative Impact and Poverty
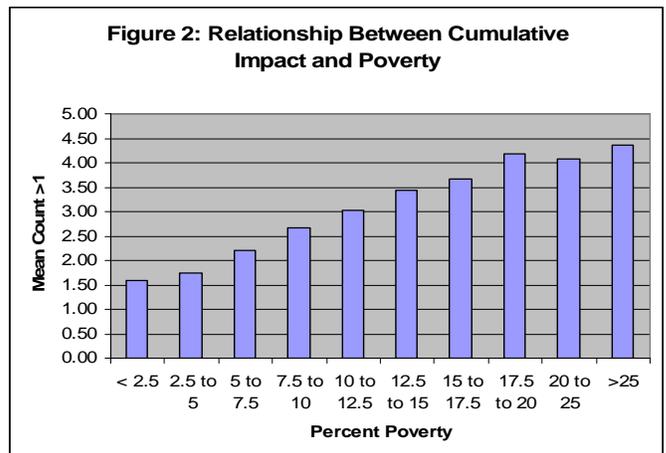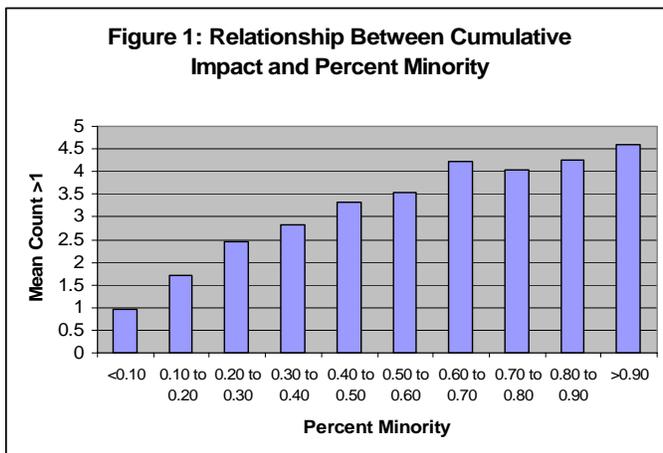
Next Steps

As discussed at the outset, the method used to develop a tool to estimate cumulative impact outlined in this paper is very preliminary. Data used to develop the indicators used here need to be updated as data is continuously updated. Additionally, new sets of data continually become available in formats that meet DEP's key criteria for inclusion in its tool. DEP is also very eager to receive input on the statistical methods used to develop the current preliminary screen tool.

Examples of where data used to develop the environmental indicators needs to be updated are:

▪ NATA Cancer Risk - The current indicator for NATA total cancer risk uses assessment results from 1999. EPA has recently completed NATA results for 2002 with improved estimates of cancer risk. The Department will incorporate the updated NATA results into the estimates of cumulative impact.

▪ Density of Known Contaminated Sites - The Department's Site Remediation program continuously tracks and updates the list of Known Contaminated Sites. The latest update to the list was completed on October 20, 2009. The new lists can be used to develop updated indictors for.

Examples of where opportunities exist to expand the number and type of indicators currently included in the preliminary screening tool are:

▪ Drinking Water - Two sources for drinking water data have potential to be used for new indicators. The first is data on drinking water quality for over 600 community water systems in New Jersey. The second is data on water quality for numerous private wells.

▪ Soil and Ground Water - The Department is also developing ways to access data on ground water and soil contaminant levels using the Environmental Exchange Network managed by the Departments Site Remediation Program.

▪ Ozone and Fine Particulate (PM2.5) Air Concentrations - EPA is in the process of developing estimates of ozone and PM2.5 concentrations at both 36 and 12 km grid scales. The goal of this effort is to provide estimates of ambient air quality in areas and times where no ambient monitors exist and to provide a consistent estimate both temporally and spatially. These data are intended for use by statisticians and environmental scientists interested in the spatial distribution of pollution over daily time periods over 2001-2006.

Developing an initial version of a screening tool

The Department plans to develop an initial screening tool starting with the data and methods discussed above. Plans for this tool will allow some of the data, methods and

results from the current desk-top applications to be shared and used by a widely. As with the methods discussed here, any tool developed will be considered a "living" tool to be continuously evaluated, updated and revised as new data and methods are available.

APPENDIX A: Summary of Literature Review and Research on Cumulative Assessment Methods

Research Sources: Articles, Guidance Documents, Tools and Reports	Characteristics
"If Cumulative Risk Assessment Is the Answer, What is the Question?"[1] Callahan & Sexton	Provides analysis of EPA Framework and advocates for more holistic approaches to address effects of cumulative exposure to multiple stressors.
Community Evaluation Tool (COMET)[2] California EPA Air Resources Board (ARB)	A community-level air pollution cumulative risk modeling approach that can estimate cumulative risk at the neighborhood level.
"Framework for Cumulative Risk Assessment"[3] EPA Report	The Framework openly discusses the concept of "multiple agents or stressors", moving beyond single chemicals. It expands stressors to include non-chemicals such as lack of needed health care or loss of habitat. It also includes a focus on "community" instead of individuals and discusses the utility of "qualitative" vs. quantitative assessments. It quantifies risk from exposure.
"Guidelines for Conducting Environmental Justice Analyses"[4]. Environmental Load Profile EPA Region 2	Uses indicators focused on environmental exposure and/or public health to assess area of concern
Region 6 GIS Screening Tool (GISST)[5] Cumulative Risk Index Analysis EPA	Tool is focused on NEPA reviews and uses some public health information.
"Smart Enforcement Assessment Tool."[6] EJ SEAT - EPA	This tool uses an additive approach to aggregate multiple indicators.
"Toolkit for Assessing Potential Allegations of Environmental Injustice"[7].	This toolkit provides broad guidance. It does not propose a specific tool or model.

[1] Callahan Michael A. and Ken Sexton. "If Cumulative Risk Assessment Is the Answer, What is the Question? " Environmental Health Perspectives 115 (May 2007): 799-806.

[2] California EPA Air Resources Board (ARB). Community Evaluation Tool (COMET). Cal/EPA Environmental Justice Action Plan ARB Wilmington Pilot Project Update. May 2007

[3] EPA. "Framework for Cumulative Risk Assessment." /630/P-02/001F. Washington , DC: US Environmental Protection Agency, Office of Research and Development. May 2003

[4] EPA. "Guidelines for Conducting Environmental Justice Analyses." Interim Environmental Justice Policy, Section 2: Environmental Load Profile. December 2000. <http://www.epa.gov/region2/ej/guidelines.htm.>

[5] EPA. Region 6 GIS Screening Tool (GISST). Osowski, S. L., G. R. Carney, D. Lueckenhoff, D. A. Parrish, J. E. Danielson. US EPA Region 6 Compliance Assurance and Enforcement Division, Office of Planning & Coordination.

[6] EPA. "Smart Enforcement Assessment Tool." Office of Enforcement and Compliance. September 2005.

[7] EPA. "Toolkit for Assessing Potential Allegations of Environmental Injustice." Enforcement and Compliance Assurance. Office of Environmental Justice. EPA 300-R-04-002. November 2004.

Research Sources: Articles, Guidance Documents, Tools and Reports	Characteristics
EPA	
"Unequal Exposure to Ecological Hazards: Environmental Injustices in the Commonwealth of Massachusetts."[8] Faber & Krieg	This study analyzes the social and economic distribution of ecological hazards and develops a composite measure of cumulative risk that combines census and environmental data. The tool uses a weighting approach or point system for environmental indicators to rank cumulative exposure.
"Cumulative Risk and a Call for Action in Environmental Justice Communities."[9] Hynes & Lopez	The authors propose a screening framework that can be used to identify "communities most burdened, most vulnerable and in greatest need of intervention and action." The tool incorporates multiple factors that have been found to increase vulnerability to pollution and risk of poor health. Some of these factors include: poverty, economic isolation, racial segregation, health disparities and political empowerment. The authors propose that a rank scoring or z-score methodology could help to identify areas.
Community Profile Tool[10] Maryland State Commission on Environmental Justice and Sustainable Communities (CEJSC)	A Working Group of the (CEJSC) proposed to create a "Community Profile Tool" by using community-based indicators focused on environmental exposure and public health. The working group made clear that causal inferences about the relationship between environmental indicators and health indicators could not be drawn from this tool.
"A Phased Approach for Assessing Combined Effects from Multiple Stressors"[11] Menzie, MacDonell, & Mumtaz	The authors propose a phased or "tiered" approach for evaluating combined effects of multiple indicators.
"The Air is Always Cleaner on the Other Side: Race, Space and Ambient Air Toxics Exposures in California."[12]	The authors used the 1996 NATA to estimate potential lifetime cancer risks from mobile and stationary sources and integrated these risk data with 2000 Census and land

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[8] Faber, Daniel R. and Eric J. Krieg. "Unequal Exposure to Ecological Hazards: Environmental Injustices in the Commonwealth of Massachusetts." Environmental Health Perspectives 110 (April 2002): 277-288.

[9] Hynes, H. Patricia, Russ Lopez. "Cumulative Risk and a Call for Action in Environmental Justice Communities."[9] Journal of Health Disparities Research and Practice. Vol. 1, No. 2. Winter 2007

[10] Maryland State Commission on Environmental Justice and Sustainable Communities. Community Profile Tool Development Report. Annual Report. 2004. <http://www.mde.state.md.us/assets/document/environmental_justice/ej_2004_Annual_Report.pdf>

[11] Menzie, Charles A., Margaret M. MacDonell, and Moiz Mumtaz. "A Phased Approach for Assessing Combined Effects from Multiple Stressors." Environmental Health Perspectives 115 (May 2007): 807-816.

[12] Pastor Jr., Manuel., Rachel Morello-Frosch, James L. Sadd. "The Air is Always Cleaner on the Other Side: Race, Space and Ambient Air Toxics Exposures in California." Journal of Urban Affairs 27, (2005): 127-148.

Research Sources: Articles, Guidance Documents, Tools and Reports	Characteristics
Pastor Jr., Manuel., Rachel Morello-Frosch, James L. Sadd.	use data and other independent variables to conduct an environmental justice analysis in California using spatial regression techniques.
Healthy Development Measurement Tool[13] (HDMT) San Francisco Department of Public Health, Program on Health, Equity and Sustainability	Tool includes broad range of indicators beyond environmental and public health and is used to support comprehensive and health- responsive planning and development.

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[13] San Francisco Department of Public Health. "Healthy Development Measuring Tool." San Francisco Department of Public Health, Program on Health, Equity and Sustainability. March 2007. <http://www.thehdmt.org/>

Appendix B: Powerpoint Presentation: A Preliminary Screening Tool to Estimate Cumulative Environmental Impact