2026

# Localized Air Pollution Impacts from Data Centers in Northern Virginia

Damian Pitt
*Virginia Commonwealth University*, dpitt@vcu.edu

Ivan Suen
*Virginia Commonwealth University*, isuen@vcu.edu

Ellie Plisko
*Virginia Commonwealth University*, pliskoe@vcu.edu

# Modeling Localized Air Pollution Impacts from Data Centers in Northern Virginia

Dr. Damian Pitt,[a,b] Dr. Ivan Suen,[a] Ellie Plisko [a]

a. *Urban and Regional Studies and Planning program, L. Douglas Wilder School of Government and Public Affairs, Virginia Commonwealth University*

b. *Institute for Sustainable Energy and Environment, Virginia Commonwealth University*

*This project is supported by a research seed grant from the VCU Institute for Sustainable Energy and Environment (ISEE), and with data provided by the Virginia Dept of Environmental Quality.*

## 1. Background

The goal of this research is to examine the extent of current and potential future air pollution emissions from data centers in Northern Virginia. As has been well documented, Northern Virginia has the largest concentration of data centers in the world, which is greatly increasing electricity demand and associated greenhouse gas (GHG) emissions and other forms of air pollution from fossil-fuel power plants. However, this study does not examine the implications of data centers' electricity consumption. Rather our focus is on the direct criteria air pollution emissions (i.e., pollutants such as carbon monoxide and nitrous oxides that directly harm human health) resulting from the data centers' use of backup diesel and natural gas generators.

This project addresses the following research questions about the total current criteria emissions from Northern Virginia data centers, as well as the much larger amount that is allowed under the data centers' air pollution permits from the Virginia Department of Environmental Quality (DEQ):

- What are the total current criteria air pollutant emissions from data centers in Northern Virginia, how much have those emissions increased from 2015 - 2023, and what percentage do they represent of total criteria air pollution in the region?
- How does the total criteria air pollution from data centers compare to the amount of air pollution emitted by other notable facilities in the region (electric power plants, etc.)?
- How much additional criteria air pollution would Northern Virginia's data centers emit, if they were to reach the total level of emissions allowed by their DEQ air permits?

Additionally, given that many of Northern Virginia's data centers are concentrated in certain parts of the region, our research addresses the following additional questions about the localized air pollution exposure from data centers in Northern Virginia:

- What is the total cumulative exposure to criteria air pollution from data centers in individual Northern Virginia neighborhoods?
- What is the potential cumulative exposure to criteria air pollution from data centers in Northern Virginia neighborhoods, if they emit the total amounts allowed by their permits?
- To what degree does the current and potential neighborhood-level air pollution exposure from data centers compare to that from other notable facilities in the region?
- To what degree do the current and potential neighborhood-level air pollution levels in Northern Virginia correlate with demographic characteristics such as race, income, etc.?

## 2. Data Sources and Methodology

[*Note: See Appendix A for a more detailed discussion of this report's methodology*]

To answer the first set of research questions, about current air pollution emissions from data centers, we utilized back-end data provided directly by the Virginia DEQ. Additional contextual data about air pollution in the region was sourced directly from the National Emissions Inventory (NEI) website maintained by the U.S. Environmental Protection Agency (EPA).

To evaluate potential future emissions from data centers, we downloaded all available data center air pollution permits from the Virginia DEQ website on Issued Air Permits for Data Centers, as of June, 2025, identified those within our Northern Virginia study area, and built a database of the key details from those permits including their annual emission limits.

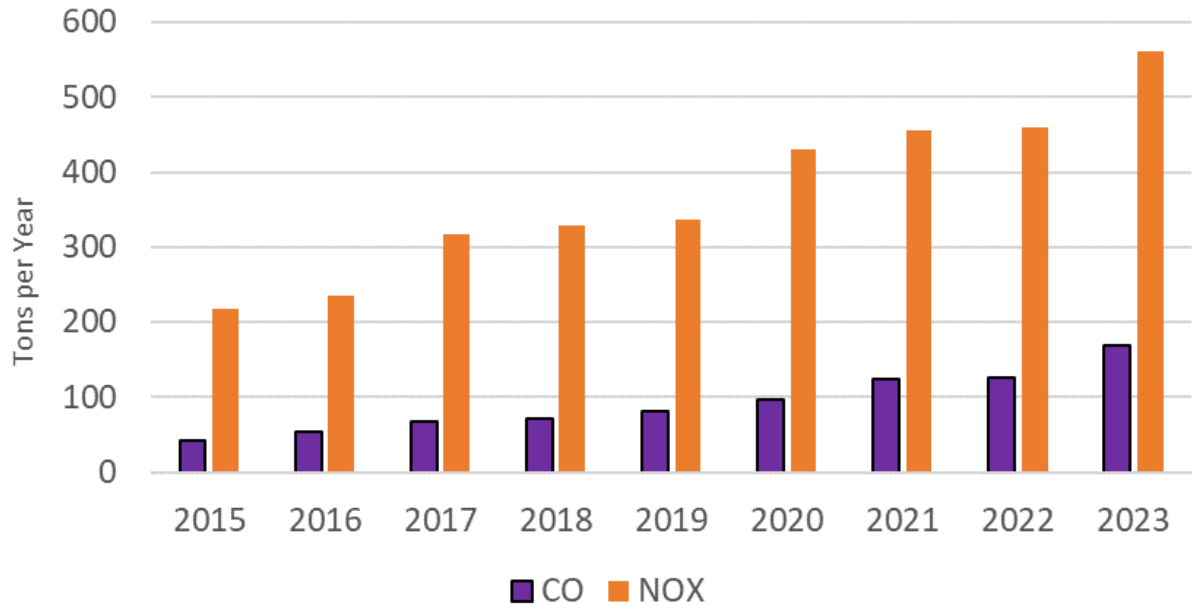
The study area for this project is the four counties in Northern Virginia (Arlington, Fairfax, Loudoun, Prince William), and the five independent cities contained within those counties (Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park). This is a more narrowly defined area than the Virginia DEQ's "Northern" region, which also includes an outer perimeter of localities such as Fauquier County, Culpepper, etc. This study area includes 138 of the 170 data centers with air pollution permits identified on the DEQ website, as of June 2025, of which 106 have actual criteria air pollution emissions data available from DEQ and/or NEI. While no data centers requiring air pollution permits currently operate in Arlington County or Alexandria, these localities were included in our study area for the sake of regional comparison.

For the second set of research questions we imported the actual and potential air pollution emissions data into GIS. Using this software we modeled the diffusion of air pollution emissions from Northern Virginia's data centers and other notable facilities, to estimate total emissions exposure at the Census Block Group level. We then downloaded Census data for these same block groups, in order to analyze the correlations between data center air pollution emissions exposure and demographic characteristics such as race, income, and education level.

## 3. Current Air Pollution Emission Totals from Data Centers in Northern Virginia

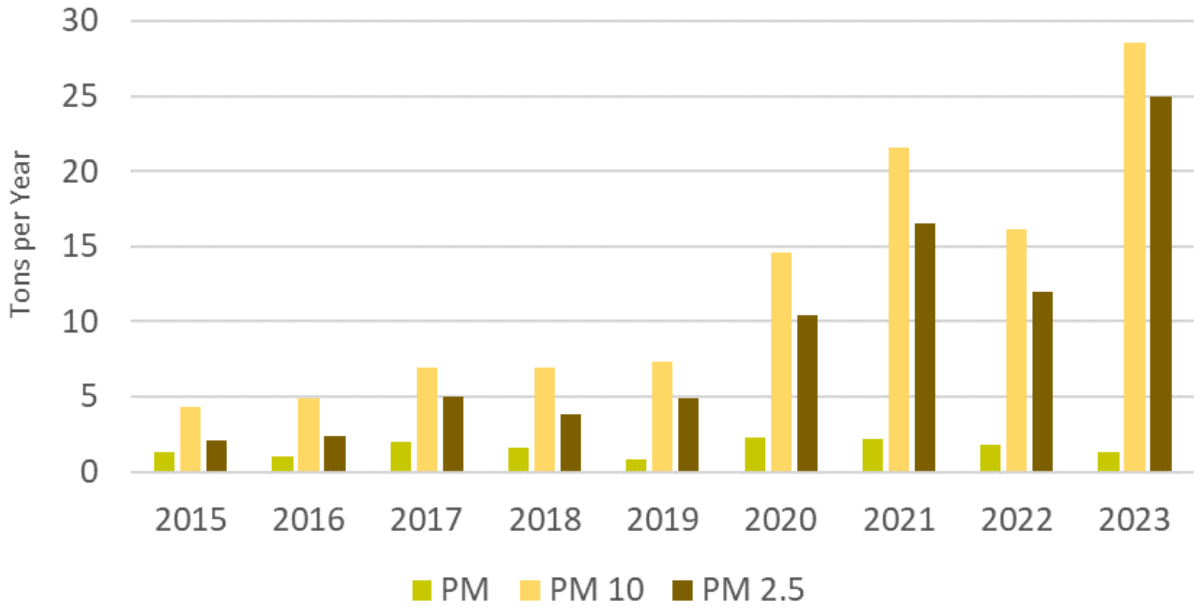
Total criteria air pollution emissions from Northern Virginia have increased substantially since 2015, as shown in Figures 1 and 2 below.

**Figure 1. CO and NOx Emissions from Northern Virginia Data Centers, 2015-2023**




*Source: Virginia Department of Environmental Quality (DEQ)*

**Figure 2. Particulate Matter Emissions from Northern Virginia Data Centers, 2015-2023**




*Source: Virginia Department of Environmental Quality (DEQ)*

As indicated in Figure 1 above, the total reported carbon monoxide (CO) and nitrous oxides (NOx) emissions from Northern Virginia data centers increased substantially between 2015 and 2023. Emissions of CO increased 196% over that time, from 42.91 tons in 2015 to 169.29 tons in 2023. Emissions of NOx increased 111%, from 218.03 to 562.01 tons. These increases are due in part to the growth of data centers themselves, as the data provided by DEQ included 50 reporting facilities in 2015, increasing to 92 reporting facilities by 2023. (While our data set includes 106 facilities, some have shut down since 2015, while others have not reported emissions every year).

Analysis of particulate matter (PM) emissions is more complicated, as permitting and reporting standards have evolved over the years, and there is some overlap in the data between PM, PM 10, and PM 2.5. Nevertheless, Figure 2 demonstrates a clear increase in particulate matter emissions overall, with PM 2.5 emissions – the most dangerous form of particulate matter, from a public health perspective – increasing 139% from 2020 to 2023.

The actual current emissions from data centers represent a small percentage of total criteria air pollution emissions within the Northern Virginia region. For example, as of 2022 the NEI data shows over 187,000 tons of CO and over 21,000 tons of NOx. Much of these emissions comes from onroad sources (i.e., vehicles), and other "mobile" or "non-point" sources. "Point sources" such as power plants, factories, etc. make up less than 5% of Northern Virginia's CO, SO2, and VOC emissions, but much higher percentages of NOx (19%) and SO2 (50%) emissions. (See here for an explanation of how the NEI defines these emissions source categories. This information is summarized in Table 1 below. [Note that the data provided by DEQ does not include SO2 and VOC emissions for 2015 - 2022, but does include those for 2023].

**Table 1. Emissions from Data Centers Compared to NOVA Region Totals (tons)**

| Emissions Type | CO | NOx | PM 2.5 | SO2 | VOC |
|---|---|---|---|---|---|
| Regional Emissions - All Sources (2022) | 187,427 | 21,070 | 9,734 | 1,170 | 62,494 |
| Regional Emissions – Point Sources (2022) | 4,432 | 4,061 | 368 | 581 | 762 |
| Data Center Emissions (Actual, 2022) | 127 | 460 | 12 | No Data | No Data |
| Actual DC Emissions as Pct of All Sources | 0.1% | 2.2% | 0.1% | No Data | No Data |
| Actual DC Emissions as Pct of Point Sources | 2.9% | 11.3% | 3.2% | No Data | No Data |

*Sources: Virginia DEQ, U.S. EPA National Emissions Inventory 2022 v2 Emissions Modeling Platform.*

Note that the percentage of total regional emissions coming from data centers will likely be higher for 2023, once the baseline NEI data for that year becomes available, as the DEQ data shows significant increases in data center emissions from 2022-2023.

## 4. Permitted Air Pollution Emission Totals from Data Centers in Northern Virginia

While current air pollution emissions from Northern Virginia data centers is not insignificant, Table 2 shows that the total emissions allowed under the DEQ data center permits are far higher.

**Table 2. Permitted Data Center Emissions Compared to NOVA Region Totals (tons per year)**

| Emissions Type | CO | NOx | PM 2.5 | SO2 | VOC |
|---|---|---|---|---|---|
| Permitted Data Center Emissions (Totals) | 4,105 | 9,995 | 351 | 45 | 1,102 |
| Actual DC Emissions (2022) as Pct of Permitted | 3.1% | 4.6% | 3.4% | No Data | No Data |
| Permitted DC Emissions as Pct of All Sources* | 2.1% | 32.7% | 3.5% | 3.7% | 1.7% |
| Permitted DC Emissions as Pct of Point Sources* | 48.8% | 73.5% | 49.6% | 7.2% | 59.1% |
| Permitted DC Emissions as Increase in All Sources** | 2% | 45% | 3% | 4% | 2% |
| Permitted DC Emissions as Increase in Point Sources** | 90% | 235% | 92% | 8% | 145% |

*Sources: Virginia DEQ, U.S. EPA National Emissions Inventory 2022 v2 Emissions Modeling Platform.*

** These percentages are calculated by adding the additional permitted data center emissions to the total 2022 emissions, then dividing the total permitted data source emissions by those new regional totals*

*** These percentages are calculated as the difference between the actual 2022 emissions (both point sources and all sources) and the total emissions once the additional permitted emissions are added*

The key takeaways from the data summarized in Table 2 are as follows:

- The actual data center emissions from 2022 were between 3% - 5% of total permitted data center emissions. While not shown in the tables above, the actual data center emissions from 2023 are significantly higher (see Figures 1 and 2 on p. 3), and represent between 3% (VOC) and 10% (SO2) of total permitted data center emissions.
- If Northern Virginia data centers were to emit their total allowed pollution, per their DEQ permits, this would significantly increase the region's total point source air pollution, for all pollutants other than SO2. Point-source emissions would increase by about 90% for CO and VOC, 145% for VOC, and 235% for NOx. Total emissions (including mobile, etc.) would only increase by less than 5% for most pollutants, but would increase 45% for NOx.
- After adding the additional permitted emissions, data centers would represent about 50 - 75% of the new point source pollution totals for all pollutants, except SO2 (only 8%). The permitted data center emissions would then represent about 2% - 4% of regional totals for most air pollution emissions, but would be 33% of total regional NOx.

## 5. Comparison of Data Center Air Pollution to Other Facilities in Northern Virginia

To further contextualize the air pollution emissions from data centers, we compared those totals to the reported air pollution emissions from the NEI (2022) for other notable facilities in the Northern Virginia region, focusing on visible and easily comprehensible facilities such as electric power plants, natural gas compressor stations, and municipal facilities, as shown in Table 3.

**Table 3. Emissions (tons) from Data Centers (2023) and Other Notable Facilities (2022)**

| Facility Name | Facility Type | Locality | CO | NOx | PM 2.5 | SO2 | VOC |
|---|---|---|---|---|---|---|---|
| Dominion - Leesburg Compressor Station | Compressor Station | Loudoun County | 6.8 | 10.1 | 1.3 | 0.1 | 3.9 |
| Michigan Cogeneration Systems Inc | Landfill Gas Power Plant | Fairfax County | 64.9 | 32.1 | 7.5 | 2.6 | 14.8 |
| Prince William County Sanitary Landfill | Municipal Landfill | Prince William Co. | 328.6 | 61.0 | 20.8 | 42.6 | 36.2 |
| Covanta Alexandria/ Arlington | Municipal Waste Combustor | Alexandria City | 51.4 | 275.5 | 6.7 | 4.5 | 0.2 |
| Covanta Fairfax | Municipal Waste Combustor | Fairfax County | 73.3 | 1,030.2 | 148.0 | 304.0 | 5.8 |
| Dominion - Possum Point Power Station | Natural Gas Power Plant | Prince William Co. | 73.0 | 100.0 | 55.9 | 8.0 | 4.8 |
| Panda Stonewall / Potomac Energy | Natural Gas Power Plant | Loudoun County | 29.2 | 64.8 | 44.0 | 1.1 | 3.7 |
| Norman M Cole Jr Pollution Control Plant | Wastewater Treatment Plant | Fairfax County | 98.1 | 35.9 | 0.0 | 0.4 | 3.8 |
| Current Total: All Data Centers in NoVA Study Area (2023) | | | 169.3 | 562.0 | 24.9 | 4.4 | 35.5 |
| Permitted Total: All Data Centers in NoVA Study Area | | | 4,105 | 9,995 | 351 | 45 | 1,102 |
| Actual Data Center Emissions (2023) as percent of Total Permitted Data Center Emissions | | | 4.1% | 5.6% | 7.1% | 9.8% | 3.2% |

*Sources: Virginia DEQ, U.S. EPA National Emissions Inventory 2022 v2 Emissions Modeling Platform.*

Following are some observations from the comparisons shown in Table 3:

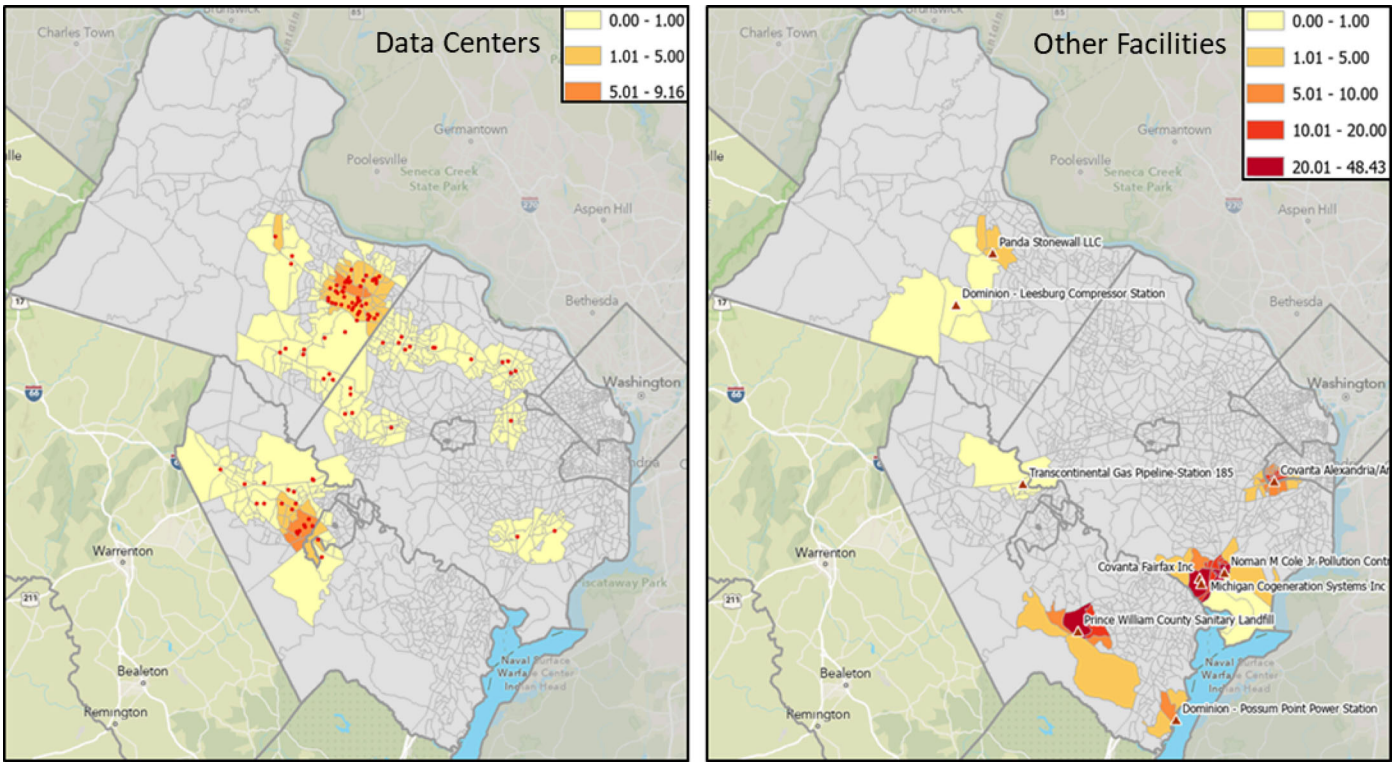
- Current data center emissions of CO and NOx are far higher than in most of these other facilities, while the data center PM 2.5 and VOC emissions are comparable in many cases.
- The current data center emissions of CO, NOX, and VOC are substantially higher than the corresponding emissions from the Dominion Possum Point Power Station.
- Permitted data center emissions would be orders of magnitude higher than those from these other facilities, particularly for CO, NOx, and VOC.

## 6. Localized Air Pollution Emissions from Data Centers in Northern Virginia

The next step in this research was to analyze the actual current neighborhood-level exposure to criteria air pollution from data centers, at the Census block group level. Our study area includes 1,565 block groups, of which 338 are located within one mile of a data center identified in the 2023 data center emissions data set from DEQ. First, we used Geographic Information Systems (GIS) tools to convert the tons of emissions from each data center facility into diffusion maps, which illustrating how each facility's emissions would spread into nearby neighborhoods, including the combined effects where multiple data centers are clustered near each other (See figures B-1A, B-2A, etc., in the Appendix). From these diffusion maps we were able to derive block-group-level estimates of the emissions concentrations from these data centers, as can be seen in Figures 3 - 5 below. (See also full-sized versions of each map in Appendix B).

We used this same process to estimate the block-group-level emissions exposure from the other notable facilities in the study area, listed above in Table 3. Those facilities are far enough apart that we could isolate each one's individual emissions impacts. However, three of the facilities are in the same industrial complex in the Lorton area of South Fairfax County, requiring us to model the combined block-group level emissions exposure from those facilities.

**Figure 3. Concentrations of Carbon Monoxide (CO) Emissions (tons / sq. mi.) from Northern Virginia Data Centers (2023) versus Select Other Facilities (2022)**



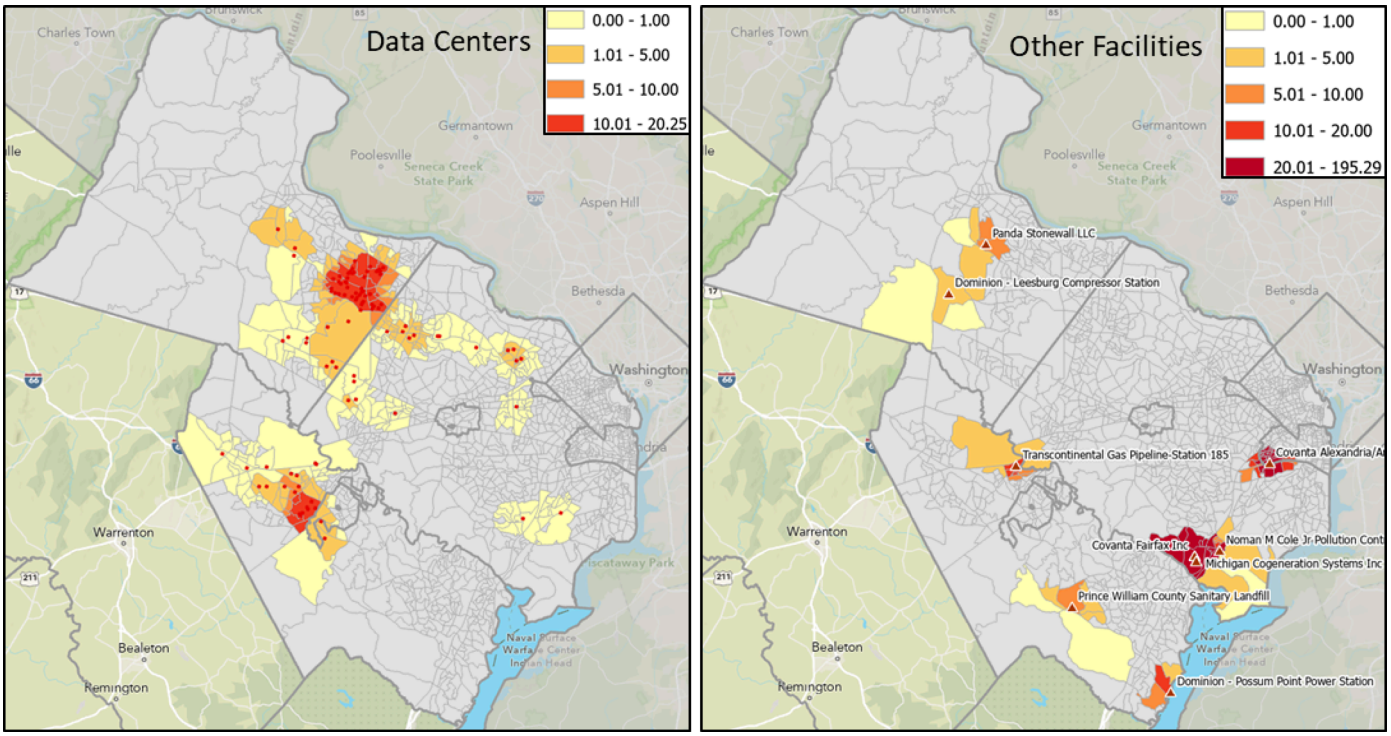

*Sources: Virginia DEQ data and U.S. EPA National Emissions Inventory 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.*

Comparing the data center (left) and non-data center (right) images in Figure 3 (above) reveals the following takeaways:

- Current data center operations result in small amounts of CO exposure across much of eastern Loudoun County, western Prince William County, and parts of Fairfax County.
- In the areas with large clusters of data centers, CO pollution exposure can be equal to, or higher, than that from natural gas power plants and compressor stations.
- Data center CO exposure is much lower than that from some other notable facilities, including the Prince William County landfill, the Arlington / Alexandria municipal waste combustor, and the cluster of facilities – a municipal waste combustor, a landfill gas plant, and a wastewater treatment plant – in southeast Fairfax County.

Figure 4 compares nitrous oxide (NOx) exposure from current data center operations to those of the other notable facilities in the region.

**Figure 4. Concentrations of Nitrous Oxides (NOx) Emissions (tons / sq. mi.) from Northern Virginia Data Centers (2023) versus Select Other Facilities (2022)**




*Sources: Virginia DEQ data and U.S. EPA National Emissions Inventory [2022 v2 Emissions Modeling Platform](). Analysis by Virginia Commonwealth University research team.*

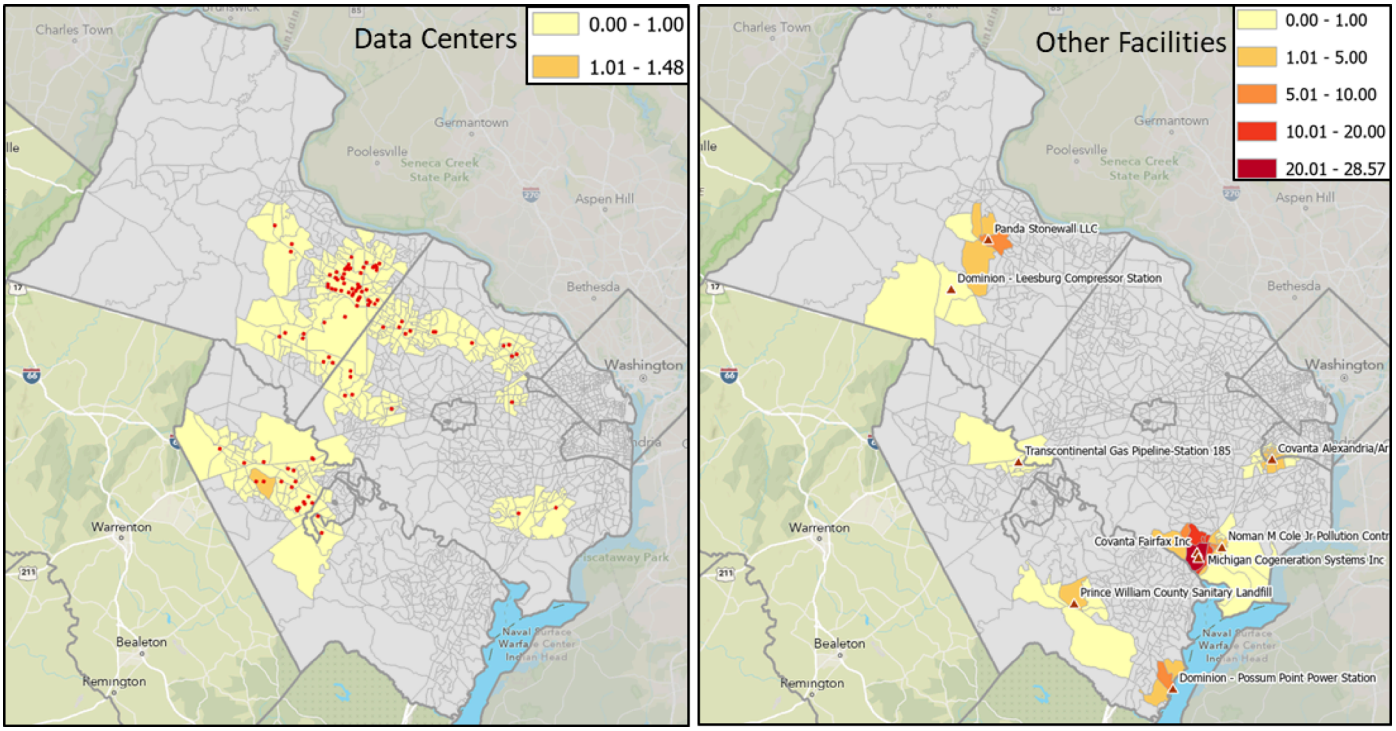
Key observations from Figure 4 are as follows:

- Data center pollution exposure, in tons per sq. mi., is generally higher for NOx than for CO.

- NOx exposure from data centers meets or exceeds that from the natural gas power plants and compressor stations in Northern Virginia.
- Data center NOx emissions exposure also exceeds that from the Prince William Co. landfill, but remains much lower than the highest concentrations of NOx from the Alexandria / Arlington municipal waste combustor and the cluster of facilities in SE Fairfax County.

Figure 5 provides the same side-by-side comparison for particulate matter (PM 2.5) exposure.

**Figure 5. Concentrations of Particulate Matter (PM 2.5) Emissions (tons / sq. mi.) from Northern Virginia Data Centers (2023) versus Select Other Facilities (2022)**




*Sources: Virginia DEQ data and U.S. EPA National Emissions Inventory 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.*

Comparing the PM 2.5 exposure from data centers (left image) and non-data-center facilities (right image) in Figure 5 results in similar patterns as the other two pollutants shown in Figures 3 and 4:

- Exposure to PM 2.5 pollution, in total tons per sq. mi., is generally lower than those from the other two pollutants, for both the data centers and other non-data-center facilities.
- The highest concentrations of PM 2.5 are also found around the wastewater treatment plant and municipal waste facilities in southeast Fairfax County.
- PM 2.5 is the only pollutant for which the highest levels of emissions exposure from data center operations is lower than that from the two natural gas power plants in the study area.

Table 4 below identifies the ten Census Block Groups in the study area with the highest current emissions impacts from data centers, per our analysis of the 2023 DEQ data. These totals range as high as 9.16 tons / sq. mi. of CO and 20.25 tons / sq. mi. of NOx. Several other block groups not shown in Table 4 have higher PM 2.5 exposure, up to a maximum of 1.48 tons / sq. mi., but lower exposure to CO and NOx. (See additional descriptive statistics in the Appendix, Table B-1).

The block groups with the highest NOx and/or CO exposure are all in the Sterling / Ashburn areas of east Loudoun Co., or in the area of Prince William Co. just west of Manassas (e.g., around the Broad Run Industrial Park), both of which are home to large clusters of active data centers. These areas correspond to the two large “hot spots” of data center emissions shown in Figures 3 - 5.

**Table 4. Census Block Groups with Highest Data Center Emissions Exposure (tons per square mile, 2023)**

| Block Group | Location | CO | NOx | PM 2.5 |
|---|---|---|---|---|
| 51-153-901409-6 | Prince William County, west of Manassas | 9.16 | 19.83 | 0.66 |
| 51-107-611006-1 | Loudoun Co. / Sterling / Ashburn, w. of Route 28 | 5.55 | 20.25 | 0.35 |
| 51-153-901409-1 | Prince William County, west of Manassas | 7.09 | 16.45 | 0.52 |
| 51-107-611020-3 | Loudoun Co. / Sterling / Ashburn, w. of Route 28 | 4.93 | 18.76 | 0.34 |
| 51-107-611601-2 | Loudoun County / Sterling, east of Route 28 | 4.93 | 17.79 | 0.31 |
| 51-107-611502-1 | Loudoun County / Sterling, east of Route 28 | 4.58 | 17.90 | 0.34 |
| 51-107-611601-1 | Loudoun County / Sterling, east of Route 28 | 5.00 | 16.95 | 0.38 |
| 51-153-901409-3 | Prince William County, west of Manassas | 6.06 | 12.85 | 0.43 |
| 51107-611018-2 | Loudoun Co. / Sterling / Ashburn, w. of Route 28 | 4.25 | 14.31 | 0.24 |
| 51153-901409-8 | Prince William County, west of Manassas | 3.91 | 12.58 | 0.33 |

*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

Comparing Table 4 with Table 5 (next page), one can see that the maximum block group level exposures from the other non-data-center facilities can be much higher in some cases.

(See Tables B-1 and B-3 of the Appendix for additional descriptive statistics on emissions exposure from data centers and non-data-center facilities in the study area).

**Table 5. Census Block Groups in Study Area with Highest Emission Exposure from Select Non-Data Center Facilities (tons / sq. mi., 2022)**

| Block Groups | Location | CO | NOx | PM 2.5 |
|---|---|---|---|---|
| Norman M Cole Jr Pollution Control Plant (Wastewater Treatment Plant), Covanta Fairfax Inc (Municipal Waste Combustor), Michigan Cogeneration Systems Inc (Landfill Gas Power Plant) | | | | |
| 51-059-422202-2 | Lorton / Southeast Fairfax County | 26.82 | 195.29 | 28.57 |
| 51-059-422202-1 | Lorton / Southeast Fairfax County | 14.25 | 115.92 | 16.65 |
| 51-059-422102-2 | Lorton / Southeast Fairfax County | 19.85 | 91.29 | 13.21 |
| Covanta Alexandria / Arlington Inc. (Municipal Waste Combustor) | | | | |
| 51-510-200408-3 | Southwest Alexandria | 15.31 | 82.09 | 1.99 |
| 51-510-200408-2 | Southwest Alexandria | 12.87 | 68.98 | 1.67 |
| 51-510-200403-1 | Southwest Alexandria | 12.61 | 67.59 | 1.63 |
| Prince William County Sanitary Landfill (Landfill) | | | | |
| 51-153-901234-2 | Manassas area / SE Prince William County | 48.43 | 9.00 | 3.07 |
| 51-153-901234-1 | Manassas area / SE Prince William County | 13.80 | 2.56 | 0.87 |
| 51-153-901306-3 | Manassas area / SE Prince William County | 9.26 | 1.72 | 0.59 |
| Dominion - Possum Point Power Station (Natural Gas Power Plant) | | | | |
| 51-153-900904-2 | Dumfries / SE Prince William County | 9.20 | 12.60 | 7.04 |
| 51-153-901101-3 | Dumfries / SE Prince William County | 4.60 | 6.30 | 3.52 |
| 51-153-900904-4 | Dumfries / SE Prince William County | 2.92 | 4.00 | 2.24 |
| Panda Stonewall LLC / Potomac Energy Center (Natural Gas Power Plant) | | | | |
| 51-107-611004-1 | Leesburg area / Loudoun County | 3.88 | 8.62 | 5.85 |
| 51-107-610604-4 | Leesburg area / Loudoun County | 3.11 | 6.91 | 4.69 |
| 51-107-610604-2 | Leesburg area / Loudoun County | 1.31 | 2.91 | 1.97 |
| Transcontinental Gas Pipeline - Station 185 (Natural Gas Compressor Station) | | | | |
| 51-153-901602-4 | Manassas area / Prince William County | 0.46 | 15.50 | 0.28 |
| 51-153-901602-3 | Manassas area / Prince William County | 0.45 | 15.00 | 0.28 |
| 51-153-901602-5 | Manassas area / Prince William County | 0.31 | 10.37 | 0.19 |
| Dominion - Leesburg Compressor Station (Natural Gas Compressor Station) | | | | |
| 51-107-611029-3 | Leesburg / Loudoun County | 0.77 | 1.13 | 0.15 |
| 51-107-611029-2 | Leesburg / Loudoun County | 0.06 | 0.09 | 0.01 |
| 51-107-610900-2 | Leesburg / Loudoun County | 0.02 | 0.04 | 0.00 |

*Source: U.S. EPA, NEI 2022 v2 Emissions Modeling Platform. Analysis by VCU research team.*

The following are some key observations from the comparison of the highest block-group level air pollution emissions exposure from data centers (Table 4) and notable non-data-center facilities (Table 5) in the study area:

- Some of the Census block groups near the cluster of facilities in southeast Fairfax County (wastewater treatment plant, municipal waste combustor, and landfill gas power plant) have a much higher cumulative emissions exposure from those facilities – across all three pollutants – than anything seen in the areas of clustered data centers.
- The block groups around the Covanta Alexandria / Arlington municipal waste combustor also receive higher emissions exposure from that facility, across all three pollutants, than any block group receives from data center emissions.

However, comparing Tables 4 and 5 also reveals instances in which the cumulative data centers exposure for certain block groups is greater than the emissions exposure from some of these other notable facilities. For example:

- The block groups shown in Table 4 experience levels of carbon monoxide exposure from data centers that are much higher than the CO emissions from the Dominion - Leesburg or Transcontinental Gas natural gas pipeline compressor stations.
- The peak block-group level NOx emissions from data centers also far exceed the local NOx impacts from the Dominion - Leesburg compressor station, and are about equal to those from the Transcontinental Gas compressor station. Likewise the local PM 2.5 impacts from data centers are at times higher than those from either compressor station.

Perhaps more notably, the combined local emissions exposure from clusters of data centers can sometimes even exceed the pollution exposure associated with a natural gas power plant:

- The highest levels of CO exposure from data centers are generally similar to those found in the block groups receiving the highest emissions from Possum Point.
- Some block groups receive much more NOx exposure from data centers, compared to the highest block group NOx exposures from Dominion - Possum Point.
- The highest amount of block-group level PM 2.5 exposure from the Dominion - Possum Point power plant (7.04 tons / sq. mi.) far exceeds any PM 2.5 exposure from data centers.
- The highest levels of local block-group-level CO and NOx impacts from data centers exceeds those associated with the Panda Stonewall / Potomac Energy Center natural gas power plant, but that gas plant has higher PM 2.5 impacts.

## 7. Permitted Localized Air Pollution Emissions from Data Centers In Northern Virginia

In this next phase of the research we evaluated the potential localized air pollution emissions from data centers in Virginia, based on the total allowed emissions of CO, NOx, and PM 2.5 from their use of back-up generators, as per the requirements of each data center's respective air pollution permits issued by the Virginia Department of Environmental Quality (DEQ).

As noted in Table 3 above, the actual emissions from data centers in 2023 was only about 4 - 7% of the total permitted emissions for the three pollutants evaluated in this study. However, in comparing the actual versus permitted emissions of individual data centers, we find that 14 out of 104 facilities emitted 20% or more of their allotted totals in 2023, for at least one of the three pollutants. In some cases the data centers emitted more than 40% of their total permitted emissions for a given pollutant. Table 6 shows some examples of data centers for which the tons of emissions reported in 2023, per the data provided by DEQ, equaled at least 30% of the allowed tons / year of a given pollutant on the applicable air permit issued by DEQ for that facility.

**Table 6. Data Centers with Reported Emissions (2023) at 30% or Greater of Permitted Level**

| DEQ Air Permit Registration Number | Location | 2023 Emissions as % of Permitted | | |
|---|---|---|---|---|
| | | CO | NOx | PM 2.5 |
| 74167 | Manassas area, Prince William County | 78% | 78% | 76% |
| 72367 | Ashburn area, Loudoun County | 39% | 39% | NA |
| 73158 | Sterling area, Loudoun County | 41% | 49% | NA |
| 74109 | Sterling area, Loudoun County | 34% | 34% | 0% |
| 74112 | Manassas area, Prince William County | 30% | 22% | 19% |

*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

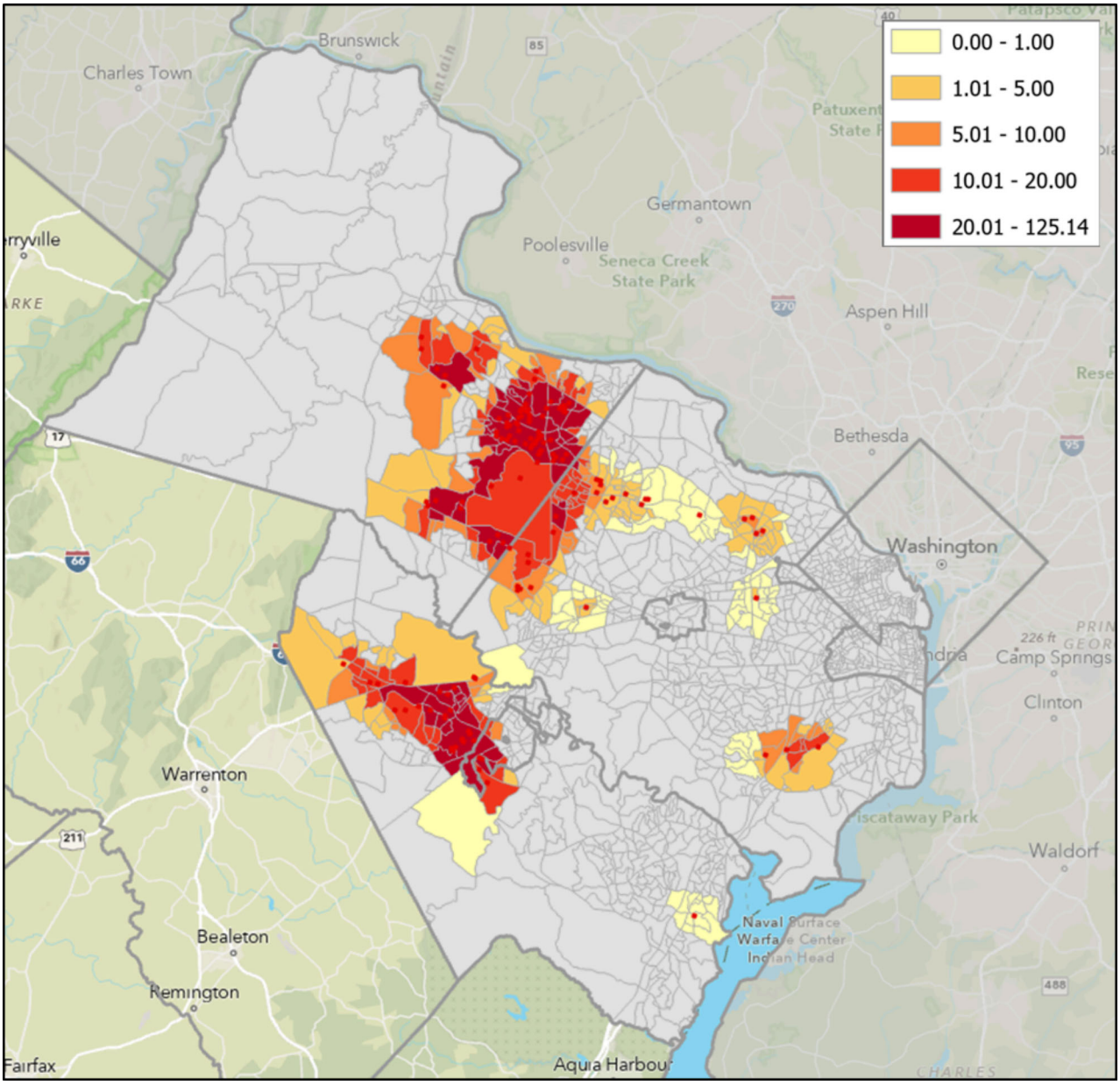
*Note: "NA" indicates that the data center had no permitted or reported 2023 emissions for PM 2.5.*

Given that the data center facility permits allow much higher levels of pollution than the current totals, and that some facilities are already emitting far more than the average of 4 - 7% of their allotment, we therefore find it instructive to model the potential pollution exposure from these facilities, in the event that data center emissions were to reach their maximum allowed levels.

Following the same methodology as used for the actual emissions from data centers and non-data center facilities, we converted the total permitted emissions levels for each data center in the study area into diffusion maps, shown in Figures C-1A, C-2A, and C-3A of the Appendix, which show how the potential criteria air pollution emissions from each data center would spread across a 1-mile radius. From those diffusion maps we derived the potential emission concentrations for each block group, in tons / year / sq. mi., thus creating the maps shown in Figures 6 - 8 below.

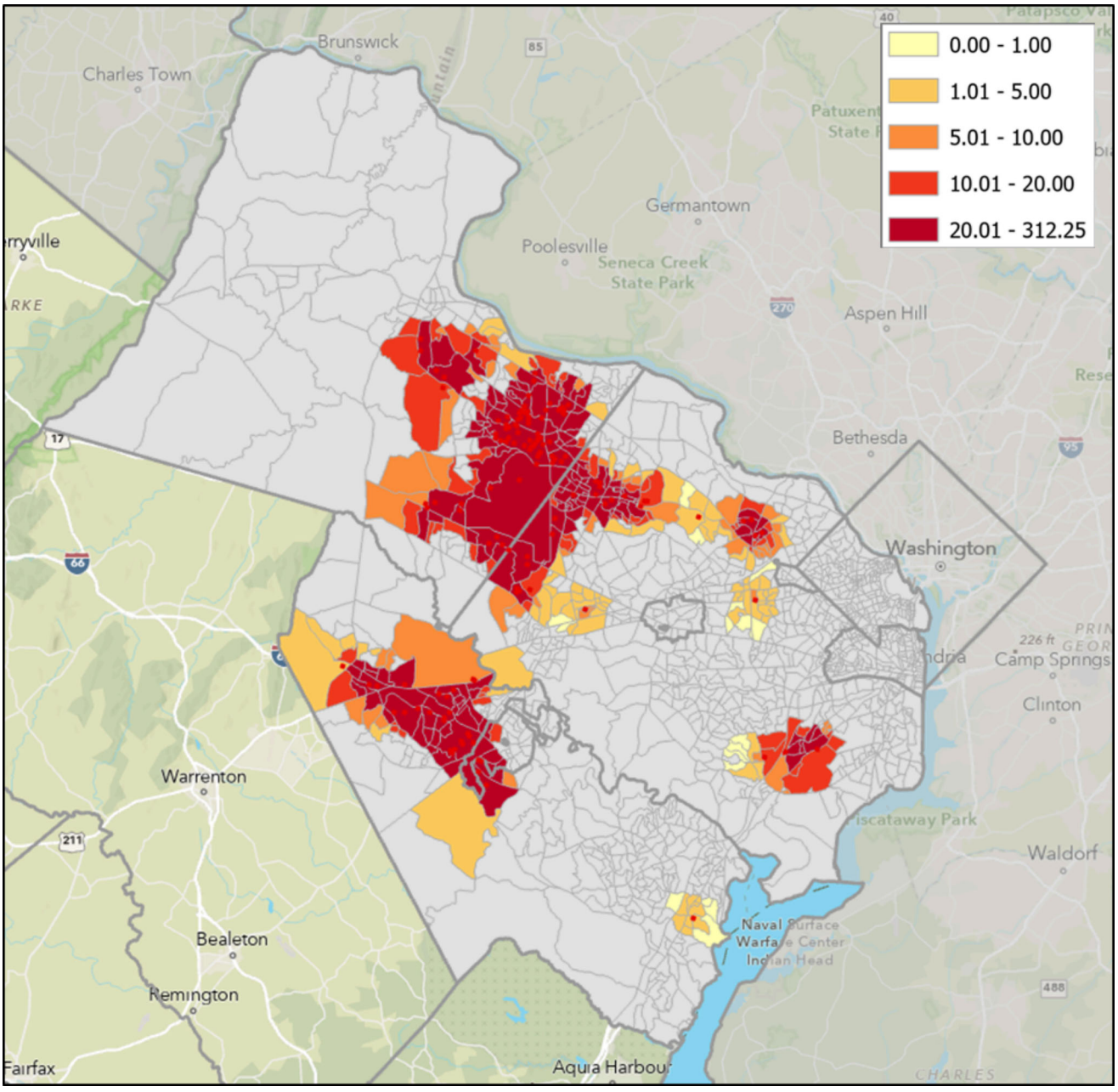
It is important to note that the potential emissions concentrations shown in Figures 6 - 8 are mapped at the same scale as the actual reported 2023 emissions shown in Figures 3 - 5 above. Thus it is possible to visually compare these maps and understand the relative differences in actual or potential pollution concentrations. In doing so, one can see that the potential emissions concentrations from Northern Virginia data centers far exceed both the actual emissions concentrations from current data center operations, and the concentrations associated with any of the other notable facilities evaluated in this report (landfills, natural gas power plants, etc.)

**Figure 6. Potential Carbon Monoxide (CO) Emission Concentrations from Northern Virginia Data Centers (Maximum Allowed under DEQ Permits)**



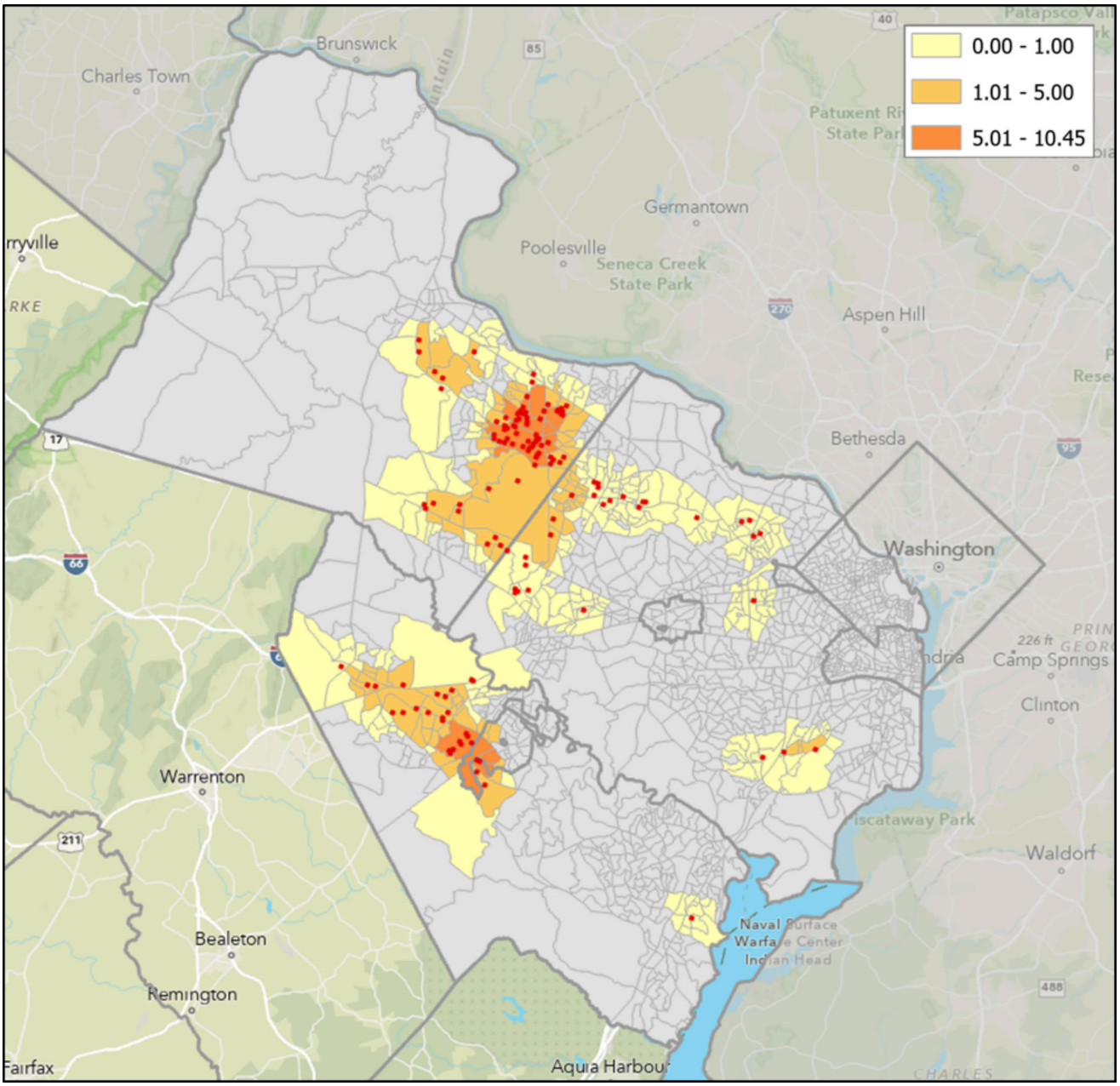

*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

**Figure 7. Potential Nitrous Oxides (NOx) Emission Concentrations from Northern Virginia Data Centers (Maximum Allowed under DEQ Permits)**




*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

**Figure 8. Potential Particulate Matter (PM 2.5) Emission Concentrations from Northern Virginia Data Centers (Maximum Allowed under DEQ Permits)**




*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

Table 7 below identifies the ten Census Block Groups in the study area with the highest levels of potential data center emission concentrations, per our analysis of the DEQ air permits for those facilities. All of these block groups are in the "data center alley" area of Loudoun County, in the Sterling and Ashburn areas on either side of Route 28. Many of these block groups are also identified in Table 4 as having the highest estimated current (2023) data center pollution.

**Table 7. Census Block Groups with Highest Potential Data Center Emission Concentrations (tons per year per sq. mi.), per DEQ Air Permits**

| Block Group | Location | CO | NOx | PM 2.5 |
|---|---|---|---|---|
| 51-107-611006-1 | Loudoun Co. / Sterling / Ashburn, w. of Route 28 | 122.28 | 312.25 | 8.46 |
| 51-107-611020-3 | Loudoun Co. / Sterling / Ashburn, w. of Route 28 | 125.14 | 307.38 | 10.45 |
| 51-107-611601-2 | Loudoun County / Sterling, east of Route 28 | 95.05 | 236.57 | 7.71 |
| 51-107-611018-2 | Loudoun Co. / Sterling / Ashburn, w. of Route 28 | 89.30 | 236.66 | 6.78 |
| 51-107-611601-1 | Loudoun County / Sterling, east of Route 28 | 81.61 | 213.57 | 6.54 |
| 51-107-611019-3 | Loudoun County / Ashburn, west of Route 28 | 78.90 | 194.36 | 4.32 |
| 51-107-611502-1 | Loudoun County / Sterling, east of Route 28 | 68.56 | 192.07 | 5.13 |
| 51-107-611018-3 | Loudoun Co. / Sterling / Ashburn, w. of Route 28 | 67.81 | 171.91 | 5.31 |
| 51-107-611020-6 | Loudoun County / Ashburn, west of Route 28 | 56.35 | 164.95 | 4.81 |
| 51-107-611020-2 | Loudoun County / Ashburn, west of Route 28 | 52.64 | 165.43 | 4.93 |

*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

Comparing these potential block-group-level emissions concentrations in Table 6 to the actual estimated emissions concentrations in Tables 4 and 5 leads to the following observations:

- The highest potential data center emission concentrations are roughly 10 - 20 times greater than the highest actual data center emissions concentrations, across all three pollutants.
- The highest potential emissions concentrations from data centers also far exceed, in most cases, the highest actual estimated concentrations from the other non-data-center facilities.
- The potential CO and NOx concentrations shown in Table 6 dwarf the highest estimated concentrations from any of the natural gas compressor stations or power plants in the study area. The highest potential concentration of CO (125 tons / year / sq. mi.) is about 14 times greater than the highest estimated CO concentration (9.2 tons / year / sq. mi.) from the Possum Point Power Station. Likewise, the potential 312 tons / year / sq. mi. of NOx is nearly 25 times the highest estimated NOx (12.6 tons / year / sq. mi.) from Possum Point.
- The potential CO and NOx concentrations shown in Table 6 also exceed, to varying degrees, the estimated emissions exposure from other facilities such as landfills, wastewater treatment plants, and municipal waste combustors, including the estimated combined exposure from multiple such facilities in southeast Fairfax County.
- The potential PM 2.5 concentrations from data centers remains below the estimated combined exposure from the facilities in southeast Fairfax County, but significantly exceeds the estimated actual concentrations from any of the other non-data-center facilities, including the Possum Point and Potomac Energy Center natural gas power plants.

## 8. Demographics of Data Center Emissions In Northern Virginia

For the final step of this research, we investigated the potential for inequitable environmental impacts from data center emissions, across various demographic categories. To do this, we analyzed the correlations between estimated data center emissions exposure and key socioeconomic indicators such as race, income, and education, among all Census block groups within the Northern Virginia study area.

The results of these analyses are shown in Tables 8 and 9 below. The values shown in bold indicate statistically significant correlations between the corresponding demographic characteristics and estimated concentrations of data center emissions. These statistically significant correlations can be summarized as follows:

- In Table 8, the estimated actual concentrations of CO and NOx, as reported in the 2023 DEQ data, are negatively correlated with Median Household Income and Higher Education (percentage of residents with a college degree). Estimated NOx concentrations are also negatively correlated with home ownership percentage.
- In other words, Census block groups with higher estimated (2023) concentrations of CO and NOx from data centers tend to have lower household income levels, fewer residents with college degrees, and fewer owner-occupied housing units (in the case of NOx) than block groups in the study area that experience lower estimated data center emissions.
- In Table 9, the estimated potential emissions concentrations, from the DEQ data center air permits, are negatively correlated across all three pollutants (CO, NOx, and PM 2.5), for both median household income and higher education percentage. Estimated potential CO and NOx concentrations are also negatively correlated with home ownership percentage.
- This means that Census block groups with higher concentrations of potential CO, NOx, and PM 2.5 emissions tend to have lower household income levels, fewer residents with college degrees, and fewer owner-occupied housing units (in the case of CO and NOx) than block groups in the study area that experience lower estimated data center emissions.
- There are no statistically significant correlations between data center emission concentrations and non-white population percentage, neither with estimated actual (Table 8) nor potential (Table 9) data center emissions.
- Population density is for the most part not correlated with any of the estimated actual or potential data center emissions metrics. The only exception is a statistically significant negative correlation with estimated actual PM 2.5 emission concentrations (Table 8), which would suggest that areas with lower population density tend to have higher estimated concentrations of PM 2.5 emissions from data centers.

**Table 8. Correlations: Estimated Actual (2023) Data Centers Emissions Concentrations and Select Demographic Characteristics**

| Pollutant | Correlation Statistics | Population Density | Non-White Percent | Median HH Income | Higher Ed Percent | Home Owner Percent |
|---|---|---|---|---|---|---|
| CO / sq. mi. | Pearson Corr. | -0.104 | 0.047 | **-.114*** | **-.160**** | -0.108 |
| | Sig. (2-tailed) | 0.06 | 0.39 | 0.041 | 0.004 | 0.051 |
| NOx / sq. mi. | Pearson Corr. | -0.059 | 0.061 | **-.133*** | **-.158**** | **-.156**** |
| | Sig. (2-tailed) | 0.287 | 0.265 | 0.017 | 0.004 | 0.005 |
| PM 2.5 / sq. mi. | Pearson Corr. | **-.121*** | 0.02 | -0.008 | -0.098 | 0.022 |
| | Sig. (2-tailed) | 0.028 | 0.719 | 0.888 | 0.077 | 0.692 |
| ** Correlation is significant at the 0.01 level (2-tailed). | | | | | | |
| * Correlation is significant at the 0.05 level (2-tailed). | | | | | | |

*Source: Virginia DEQ data (2023). Analysis by Virginia Commonwealth University research team.*

**Table 9. Correlations: Estimated Potential Emissions Concentrations from Data Center Permits and Select Demographic Characteristics**

| Pollutant | Correlation Statistics | Population Density | Non-White Percent | Median HH Income | Higher Ed Percent | Home Owner Percent |
|---|---|---|---|---|---|---|
| CO / sq. mi. | Pearson Corr. | -0.051 | 0.064 | **-.117*** | **-.175**** | **-.111*** |
| | Sig. (2-tailed) | 0.327 | 0.219 | 0.027 | <.001 | 0.032 |
| NOx / sq. mi. | Pearson Corr. | -0.018 | 0.051 | **-.154**** | **-.162**** | **-.160**** |
| | Sig. (2-tailed) | 0.724 | 0.326 | 0.003 | 0.002 | 0.002 |
| PM 2.5 / sq. mi. | Pearson Corr. | -0.074 | 0.056 | **-.113*** | **-.185**** | -0.081 |
| | Sig. (2-tailed) | 0.154 | 0.282 | 0.032 | <.001 | 0.119 |
| ** Correlation is significant at the 0.01 level (2-tailed). | | | | | | |
| * Correlation is significant at the 0.05 level (2-tailed). | | | | | | |

*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

## Appendix A. Detailed Methodology

To answer the first set of research questions, about current air pollution emissions from data centers, we utilized back-end data provided directly by the Virginia DEQ. Additional contextual data about air pollution in the region was sourced directly from the National Emissions Inventory (NEI) website maintained by the U.S. Environmental Protection Agency (EPA).

To evaluate potential future emissions from data centers, we downloaded all available data center air pollution permits from the Virginia DEQ website on Issued Air Permits for Data Centers, identified those within our Northern Virginia study area, and built a database of the key details from those permits including their annual emission limits.

The study area for this project is the four counties in Northern Virginia (Arlington, Fairfax, Loudoun, Prince William), and the five independent cities contained within those counties (Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park). This is a more narrowly defined area than the Virginia DEQ's "Northern" region, which also includes an outer perimeter of localities such as Fauquier County, Culpepper, etc. This study area includes 138 of the 170 data centers with air pollution permits as identified on the DEQ website, of which 106 have actual criteria air pollution emissions data available from DEQ and/or NEI. While no data centers requiring air pollution permits currently operate in Arlington County or Alexandria, they were included in our study area for the sake of regional comparison.

For the second set of research questions we imported the actual and potential air pollution emissions data into GIS. Using this software we modeled the diffusion of air pollution emissions from Northern Virginia's data centers and other notable facilities, to estimate total emissions exposure at the Census Block Group level. As shown in the subsequent figures, each pollutant's emissions was interpolated to create a continuous surface of emission levels using ArcGIS Pro's Diffusion Interpolation with Barriers tool. (See diffusion maps in Figures B-1A, B-2A, etc.). The resulting surface was then processed to derive the total emission in tons per year (TPY) for each block group. To adjust for varying geographic areas, block group level TPYs were further divided by their areas measured in square miles. (See derived emissions in Figures B-1B, B-2B, etc.).

We then downloaded Census data for these same block groups, in order to analyze the correlations between data center air pollution emissions exposure and demographic characteristics such as race, income, education level, and home ownership. We obtained this demographic data from the following 2023 American Community Survey (ACS) 5-Year Estimates data tables: B02001 (race), B19013 (median household income), B15003 (educational attainment), and B25003 (housing tenure).

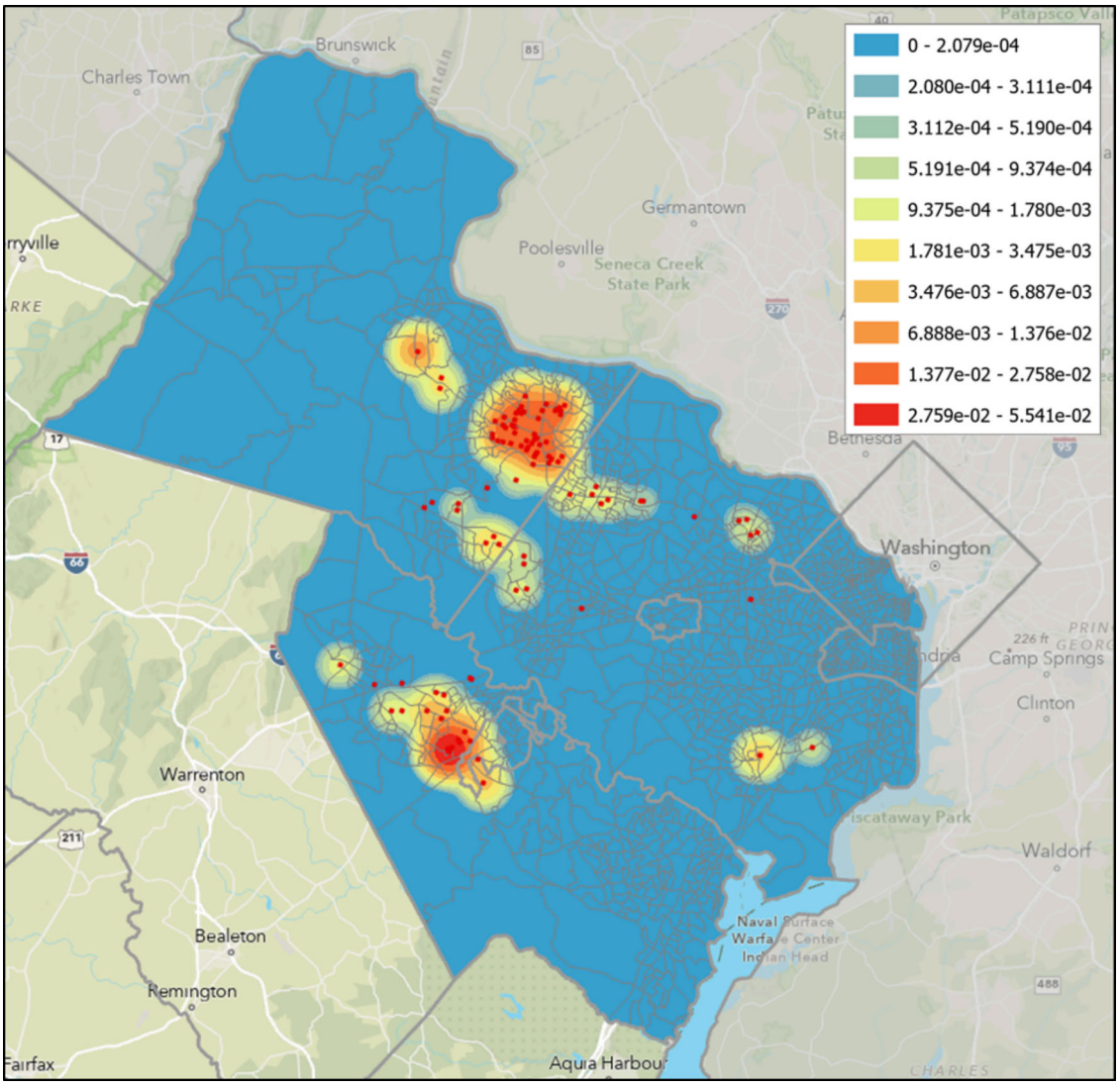
Finally, we used SPSS to compute the descriptive statistics of emissions exposure (Tables B-1 and C-1), as well as the correlation coefficients to examine the strength and direction of relationships between emissions exposure and demographic characteristics (Tables B-2 and C-2).

## Appendix B. Detailed Results for Analysis of Localized Air Pollution Emissions from Data Centers and Other Representative Facilities

The “diffusion maps” in Figures B-1A, B-2A, etc. show the interpolation of the criteria air pollution emissions (CO, NOx, and PM 2.5) from each data center (2023 data from Virginia DEQ) and other non-data center facility (2022 NEI data) in the Northern Virginia study area, to illustrate how those emissions would spread over a one-mile distribution radius.

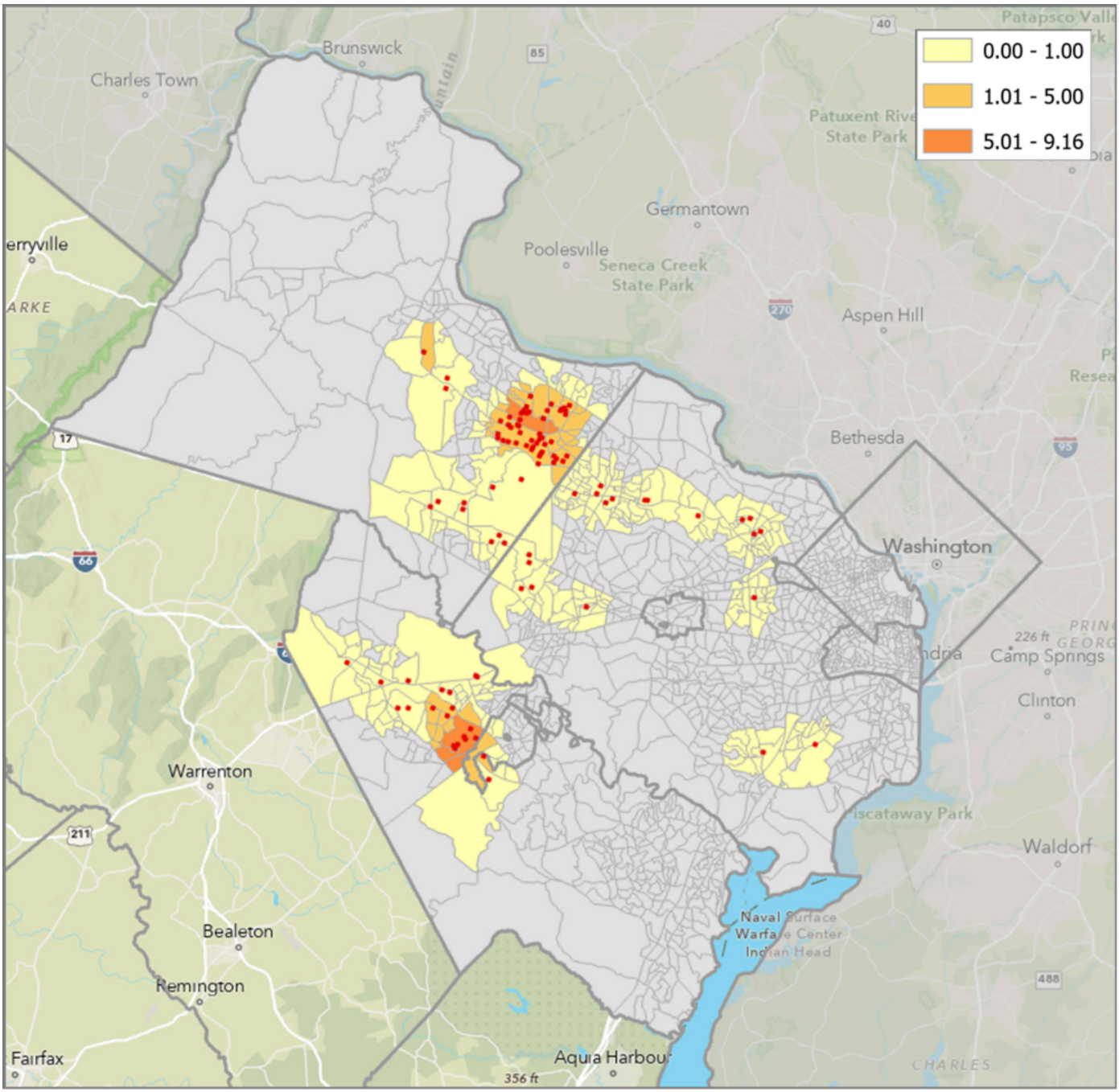
Note that these diffusion maps are provided for graphical representation purposes only, and are on different scales; thus, they should not be compared against one another. For an accurate comparison of the total emissions impacts of these facilities, refer to the “derived emissions” maps (B-1B, B-2B, etc.), both in this appendix and in the main body of this report.

**Figure B-1A. Diffusion Map of Carbon Monoxide (CO) Emissions from Northern Virginia Data Centers (2023), tons per year by raster grid cells (330’ x 330’ resolution)**



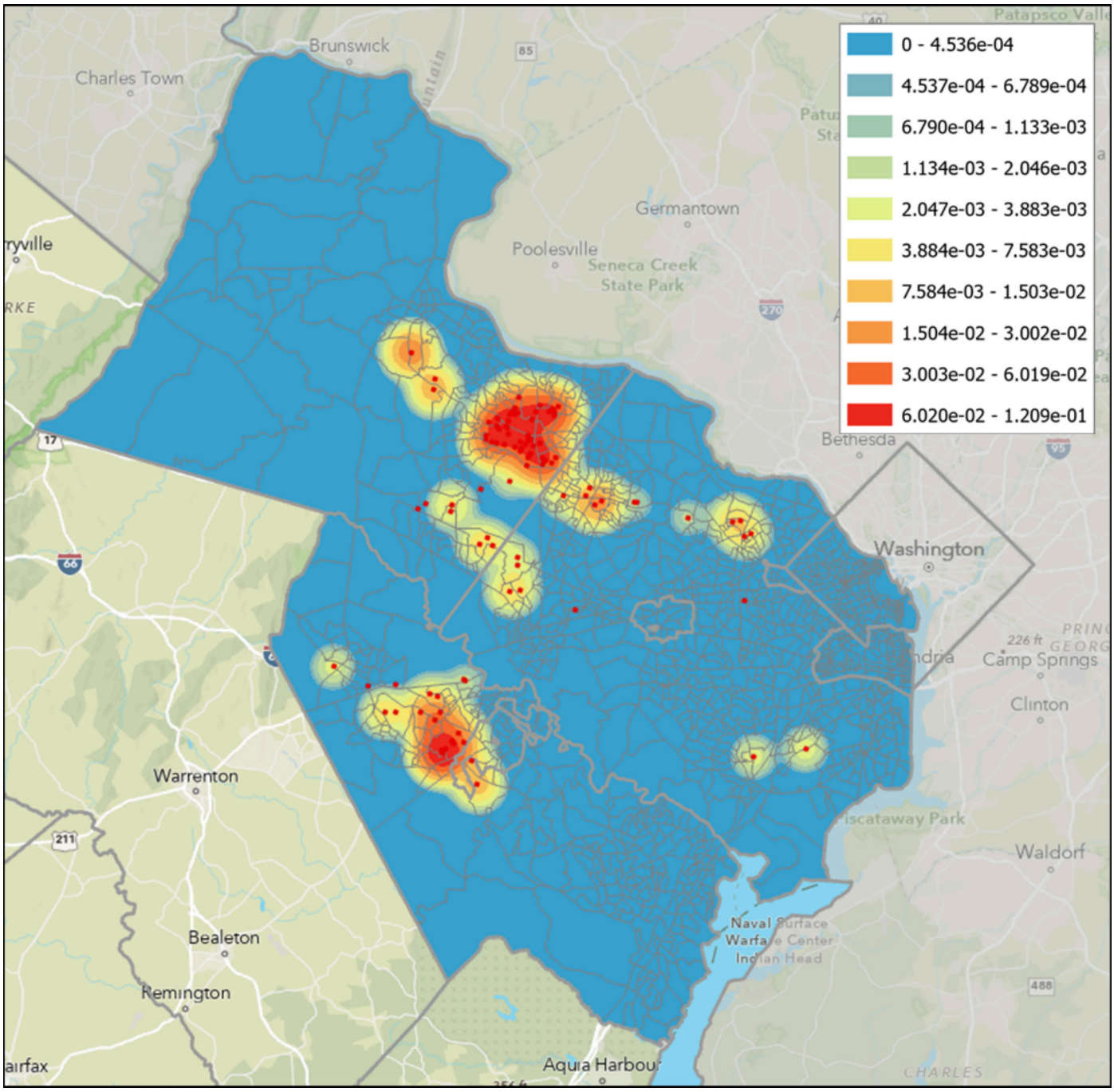

*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

**Figure B-1.B. Map of Derived Total Carbon Monoxide (CO) Emission Concentrations from Northern VA Data Centers (2023), by Census Block Group, tons per year per square mile**



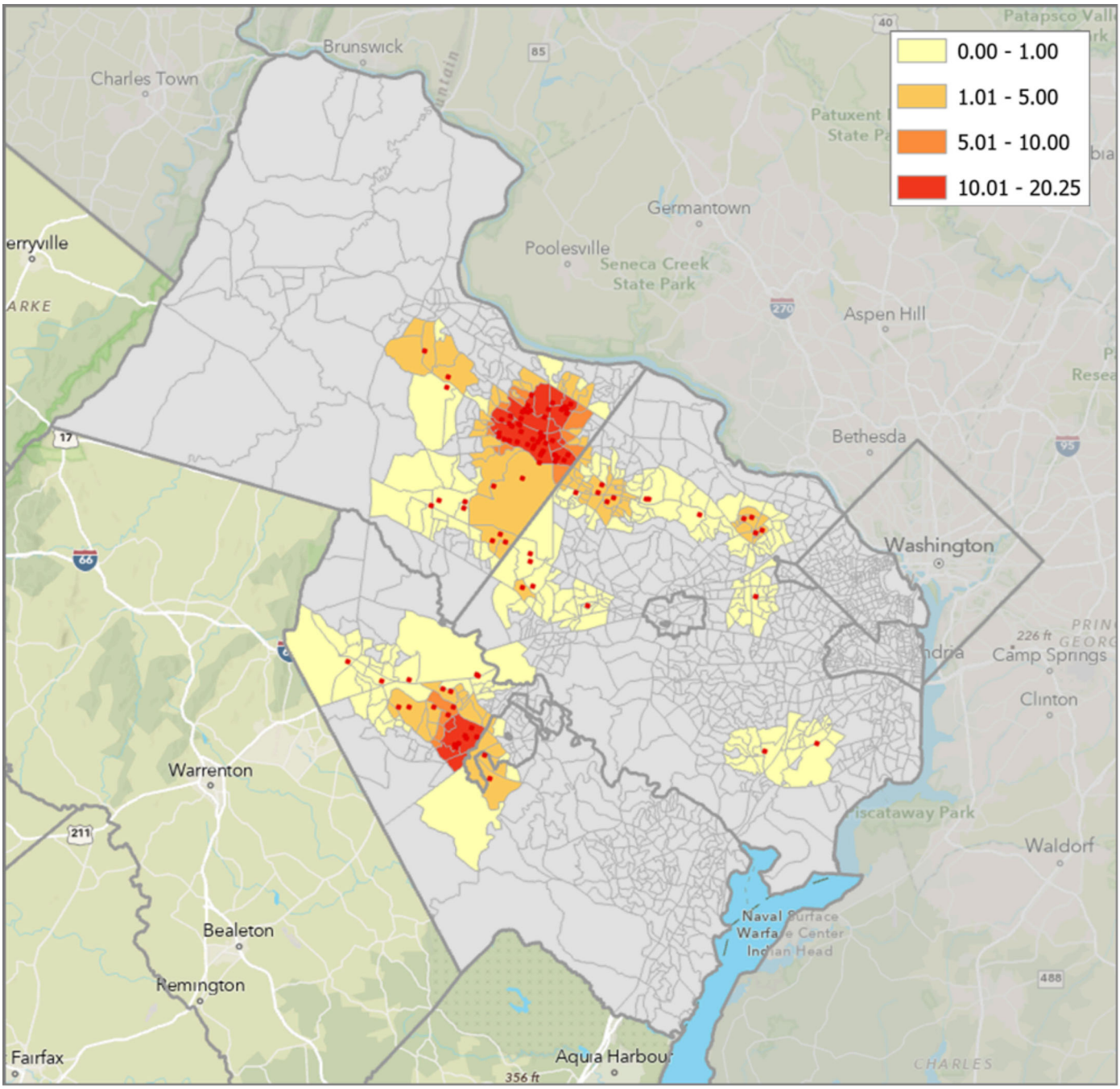

*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

**Figure B-2A. Diffusion Map of Nitrous Oxides (NOx) Emissions from Northern Virginia Data Centers (2023), tons per year by raster grid cells (330’ x 330’ resolution)**



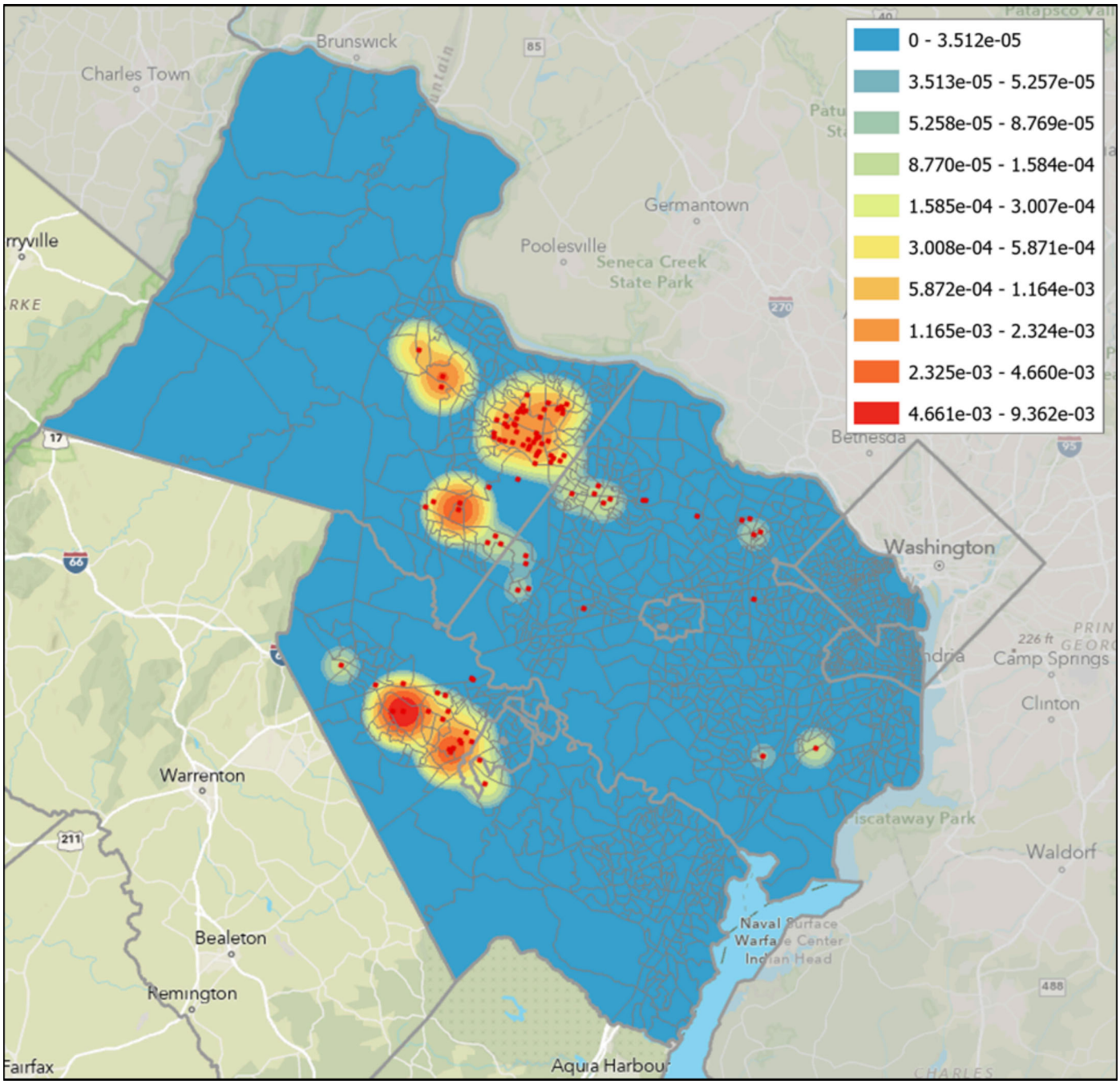

*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

**Figure B-2B. Map of Derived Total Nitrous Oxides (NOx) Emission Concentrations from Northern VA Data Centers (2023), by Census Block Group, tons per year per square mile**



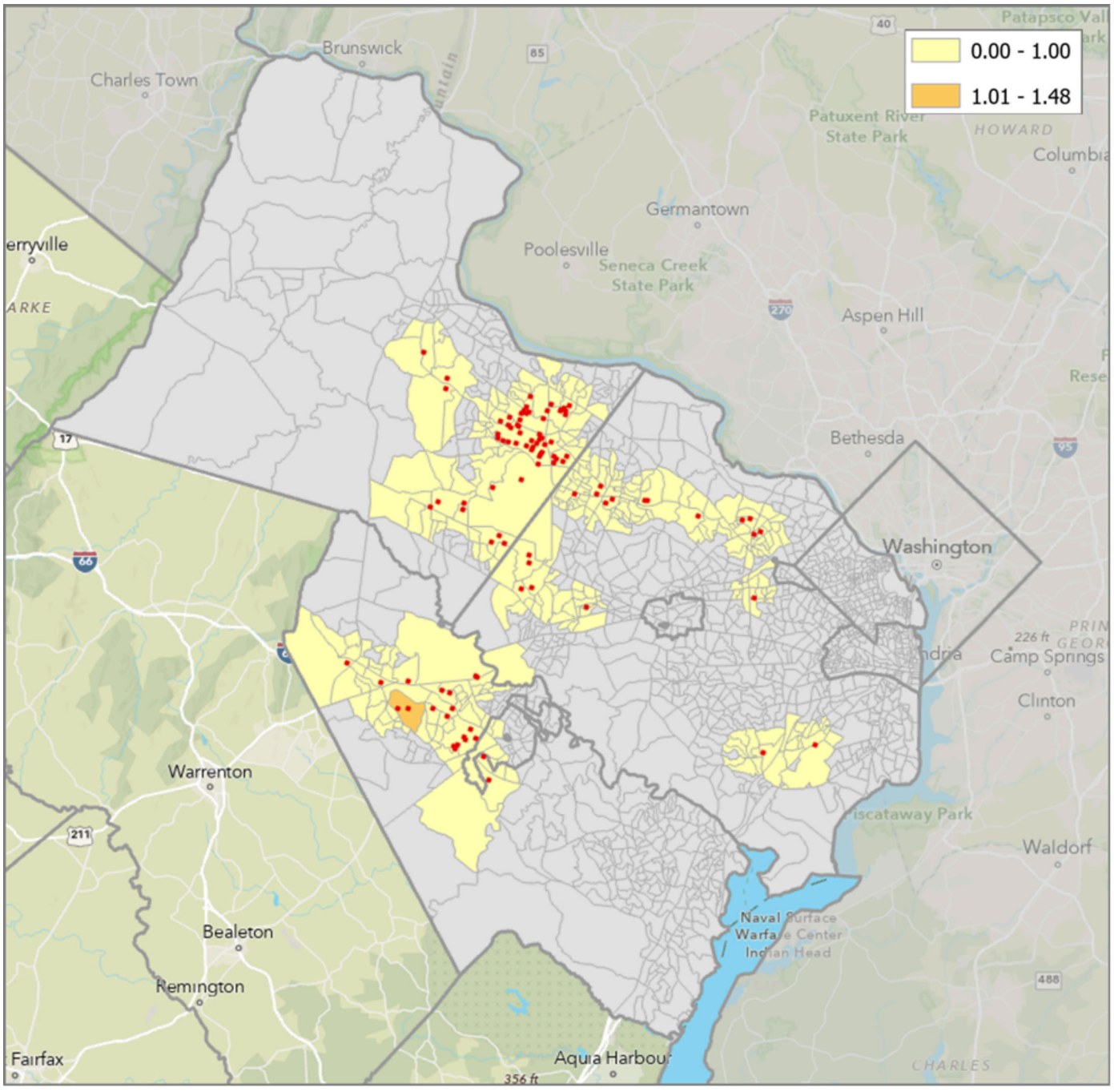

*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

**Figure B-3A. Diffusion Map of Particulate Matter (PM 2.5) Emissions from Northern Virginia Data Centers (2023), tons per year by raster grid cells (330’ x 330’ resolution)**




*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

**Figure B-3B. Map of Derived Total Particulate Matter (PM 2.5) Emission Concentrations from Northern VA Data Centers (2023), by Census Block Group, tons per year per sq. mi.**




*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

**Table B-1. Descriptive Statistics: Cumulative Current Emissions Exposure from Data Centers (2023) – Census Block Groups within 1 Mile of a Data Center (Tons / Sq. Mi.)**

| Pollutant (Tons / Sq. Mi.) | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Carbon Monoxide (CO) | 338 | 0.000 | 9.160 | 0.512 | 0.111 |
| Nitrous Oxides (NOx) | 338 | 0.001 | 20.250 | 1.884 | 3.550 |
| Particulate Matter (PM 2.5) | 338 | 0.000 | 1.478 | 0.063 | 0.155 |

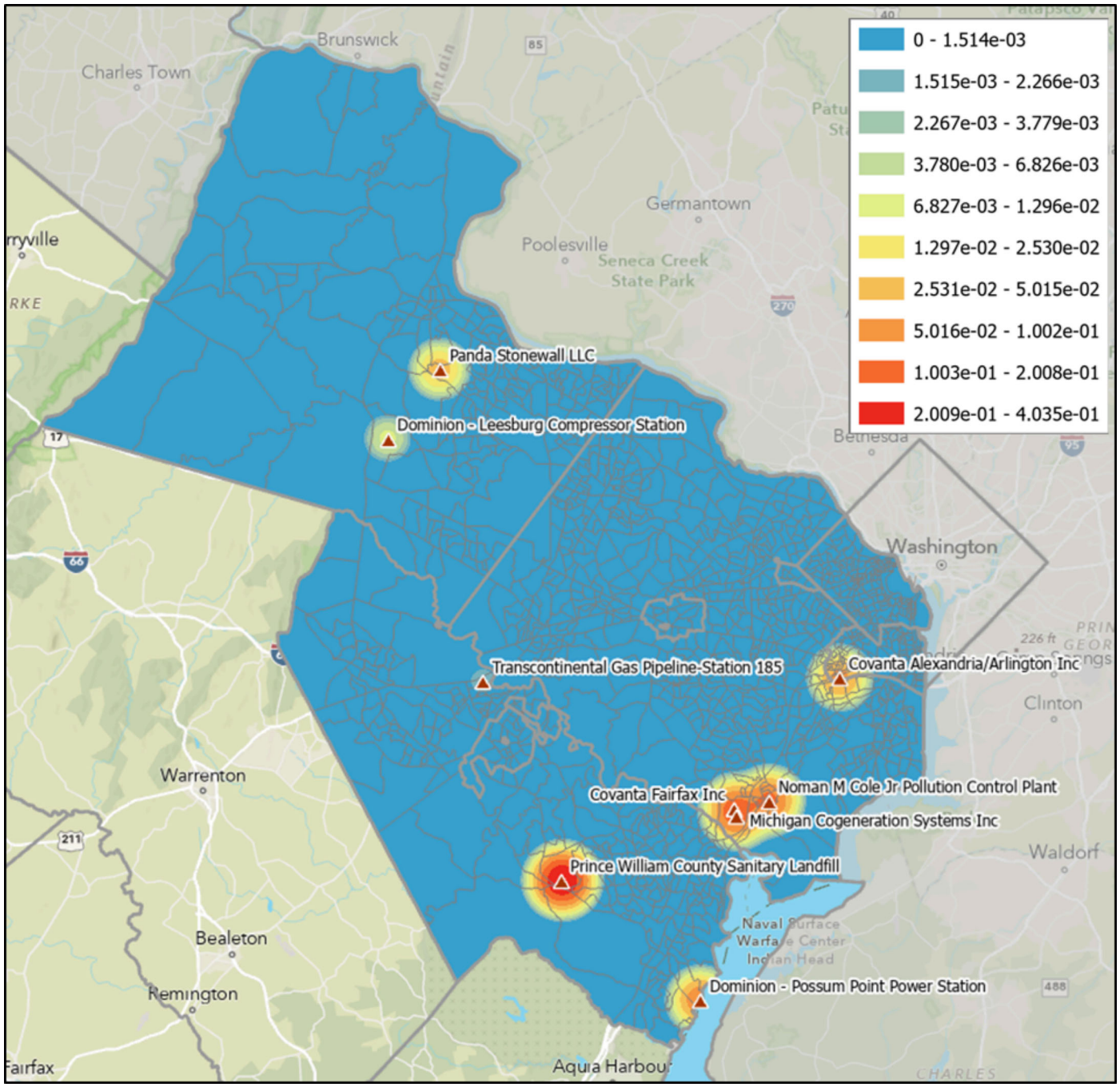
*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

**Table B-2. Correlations: Cumulative Current Emissions Exposure from Data Centers (2023) – Census Block Groups within 1 Mile of a Data Center and Select Demographic Characteristics**

| Pollutant | Correlation Statistics | Population Density | Non-White Percent | Median HH Income | Higher Ed Percent | Home Owner Percent |
|---|---|---|---|---|---|---|
| CO / sq. mi. | Pearson Corr. | -0.104 | 0.047 | -.114* | -.160** | -0.108 |
| | Sig. (2-tailed) | 0.06 | 0.39 | 0.041 | 0.004 | 0.051 |
| NOx / sq. mi. | Pearson Corr. | -0.059 | 0.061 | -.133* | -.158** | -.156** |
| | Sig. (2-tailed) | 0.287 | 0.265 | 0.017 | 0.004 | 0.005 |
| PM 2.5 / sq. mi. | Pearson Corr. | -.121* | 0.02 | -0.008 | -0.098 | 0.022 |
| | Sig. (2-tailed) | 0.028 | 0.719 | 0.888 | 0.077 | 0.692 |
| ** Correlation is significant at the 0.01 level (2-tailed). | | | | | | |
| * Correlation is significant at the 0.05 level (2-tailed). | | | | | | |

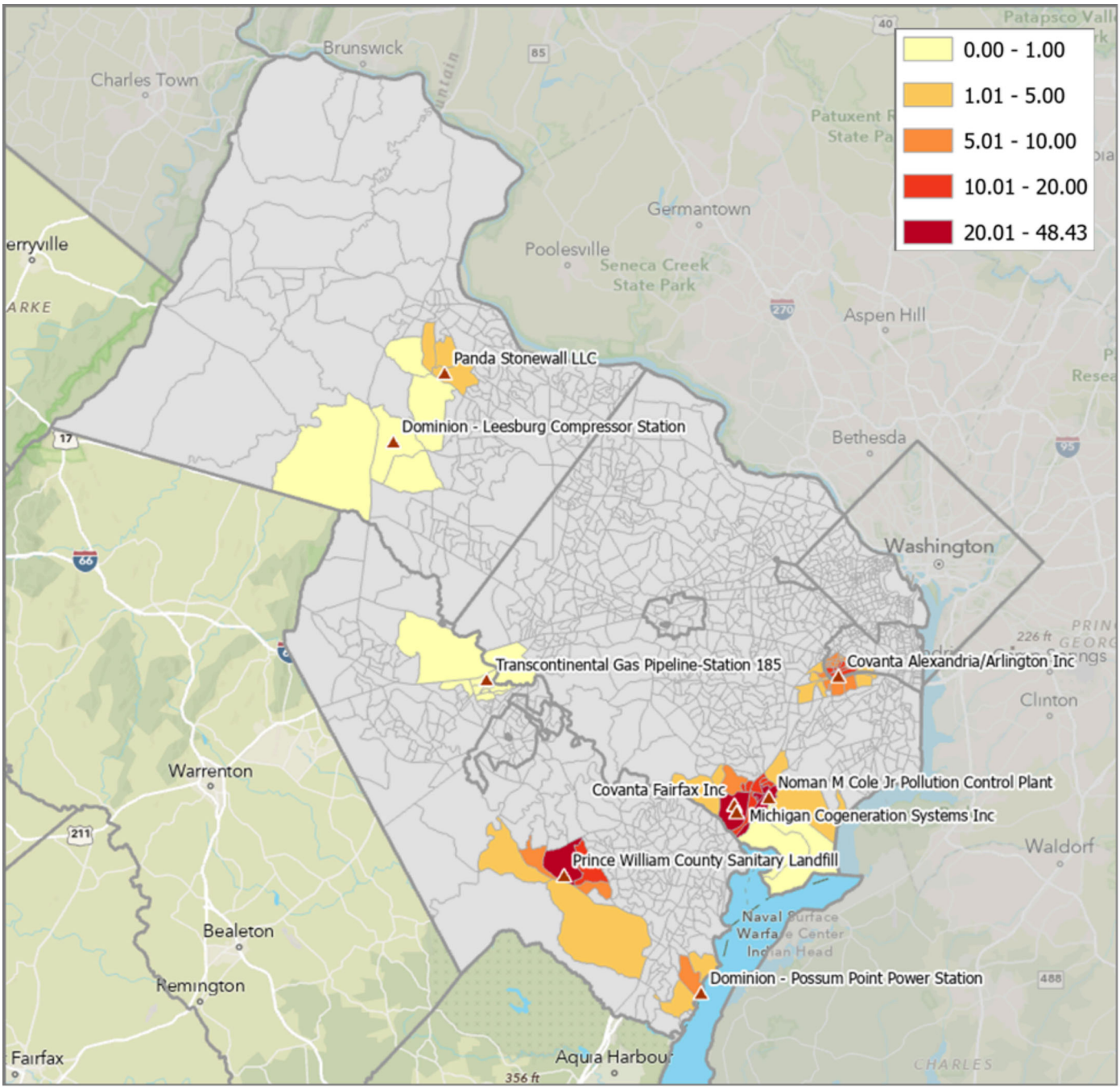
*Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.*

**Figure B-4A. Diffusion Map of Carbon Monoxide (CO) Emissions from Select other NOVA Facilities (2022), tons per year by raster grid cells (330' x 330' resolution)**



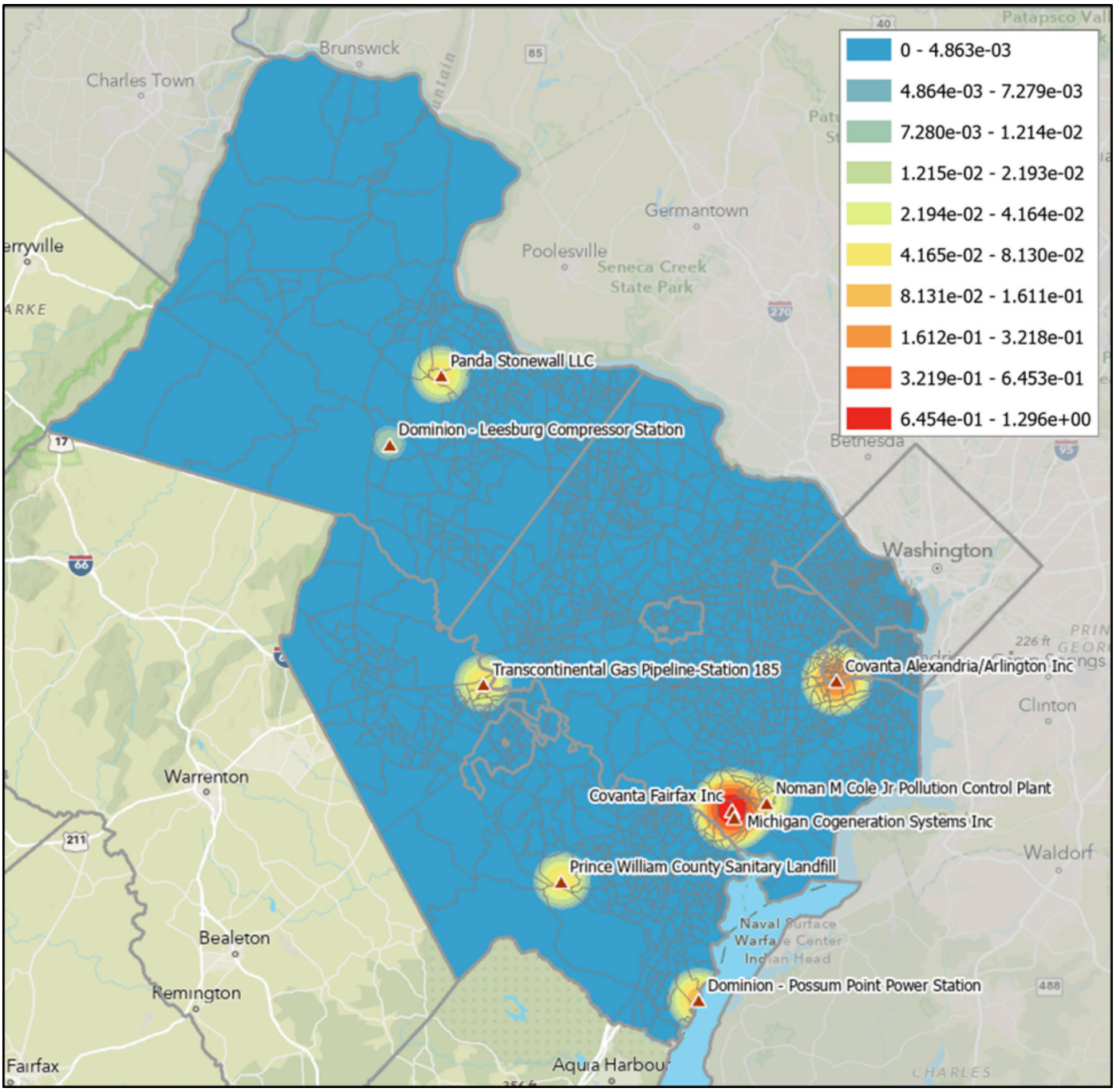

*Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.*

**Figure B-4.B. Map of Derived Total Carbon Monoxide (CO) Emission Concentrations from Select other NOVA Facilities (2022), by Census Block Group, tons per year per square mile**



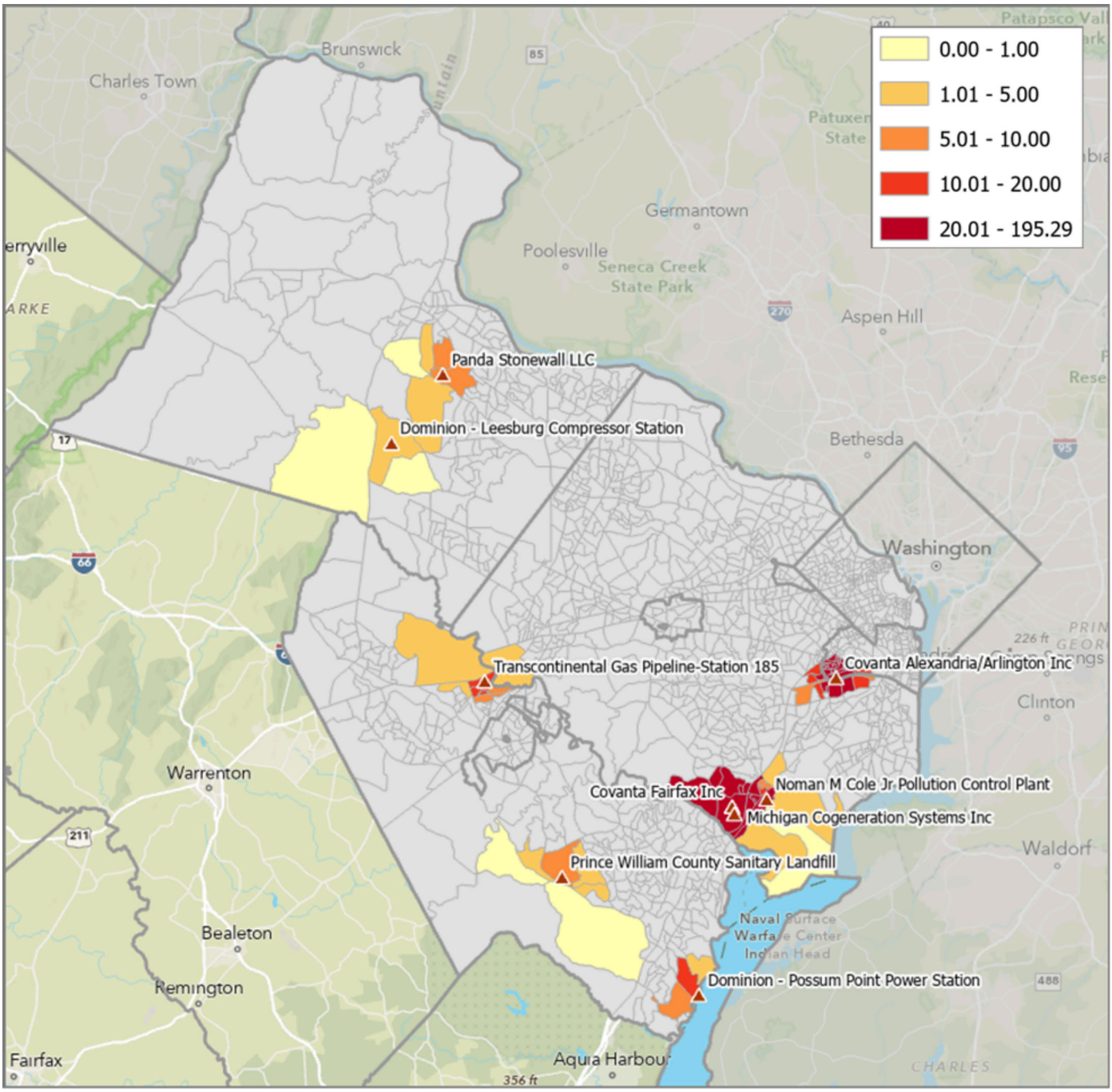

*Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.*

**Figure B-5A. Diffusion Map of Nitrous Oxides (NOx) Emissions from Select other NOVA Facilities (2022), tons per year by raster grid cells (330' x 330' resolution)**



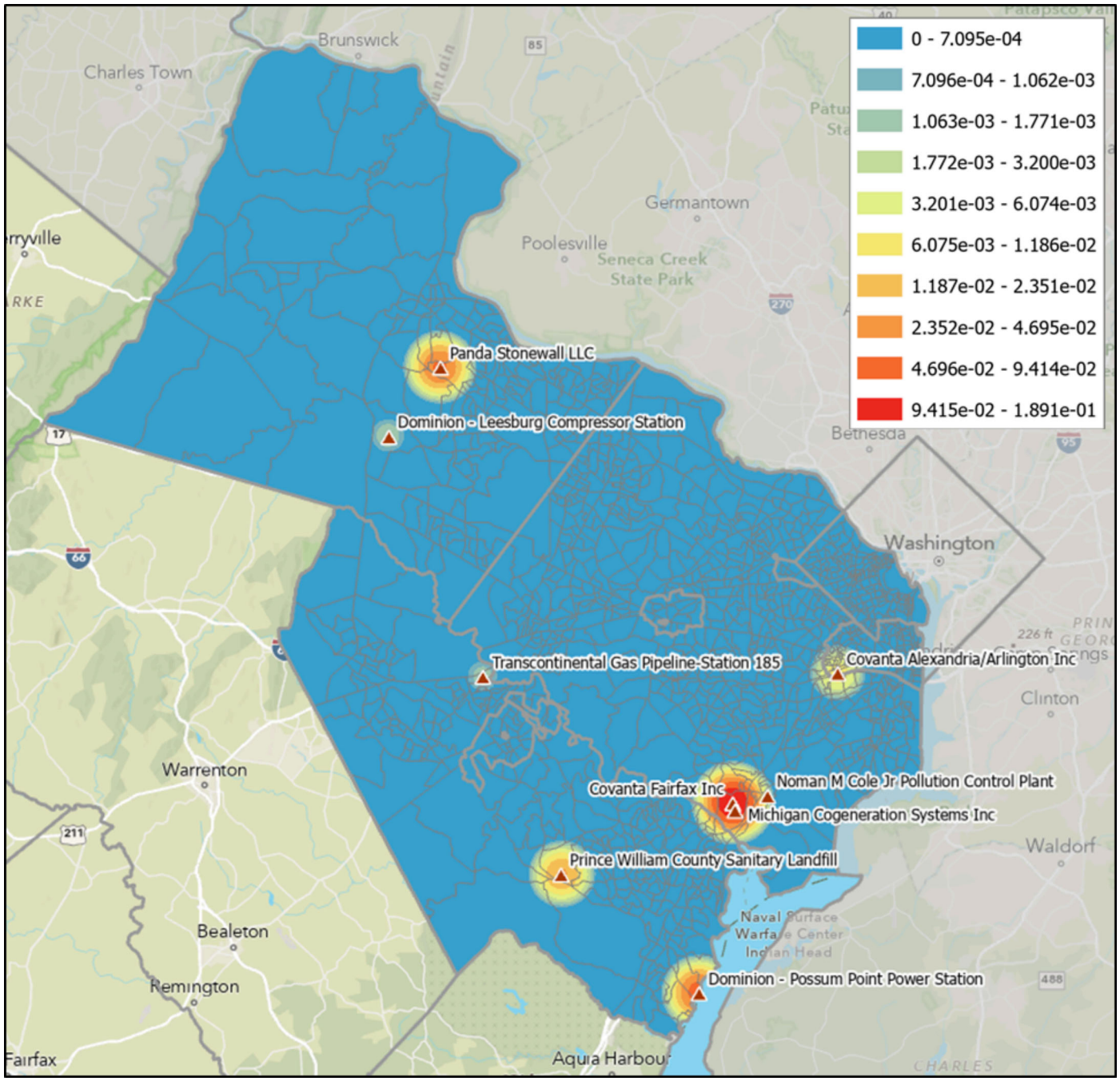

*Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.*

**Figure B-5.B. Map of Derived Total Nitrous Oxides (NOx) Emission Concentrations from Select other NOVA Facilities (2022), by Census Block Group, tons per year per square mile**



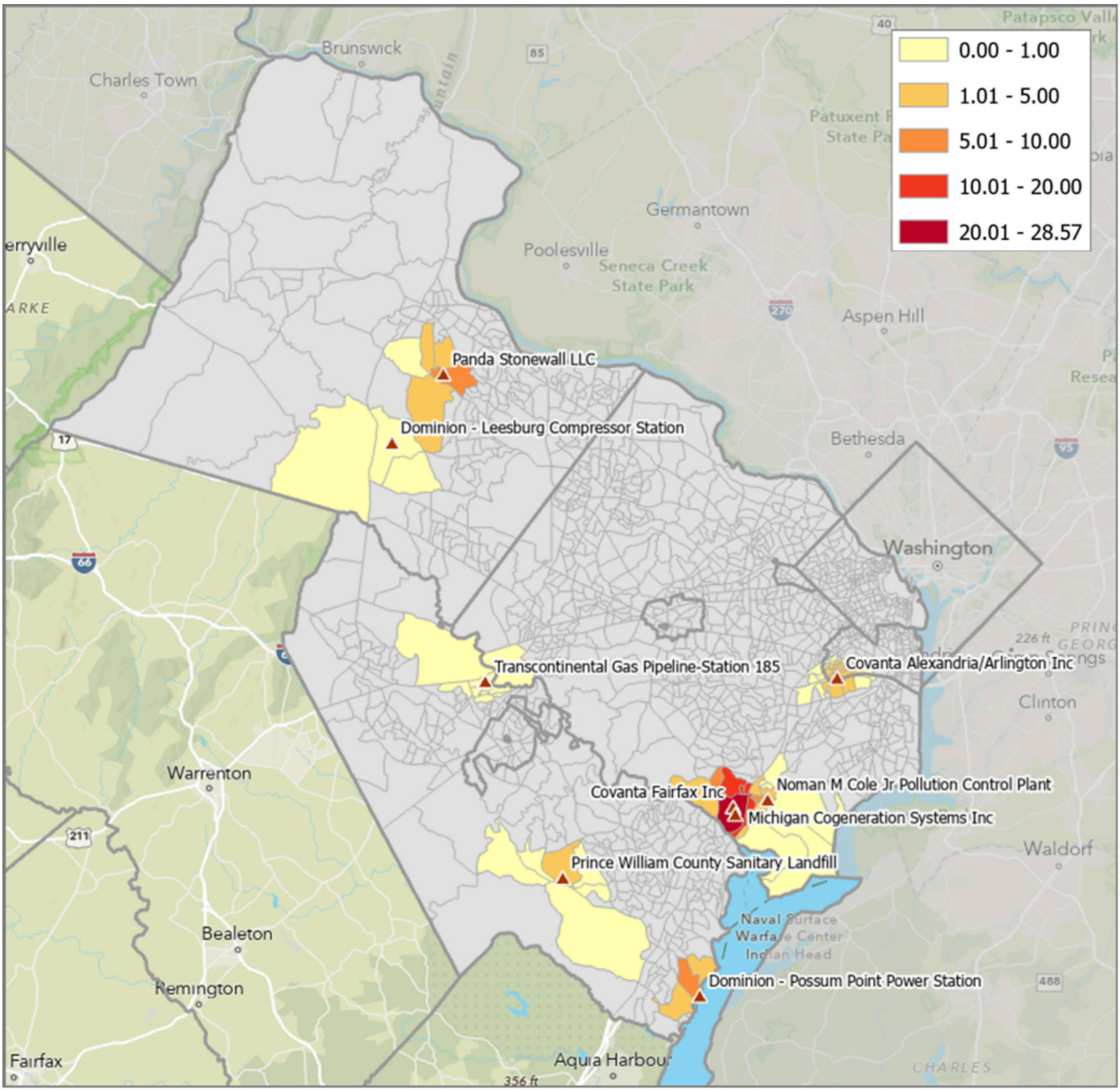

*Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.*

**Figure B-6A. Diffusion Map of Particulate Matter (PM 2.5) Emissions from Select other NOVA Facilities (2022), tons per year by raster grid cells (330' x 330' resolution)**




*Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.*

**Figure B-6.B. Map of Derived Total Particulate Matter (PM 2.5) Emission Concentrations from Select other NOVA Facilities (2022), by Census Block Group, tons / year / square mile**




*Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.*

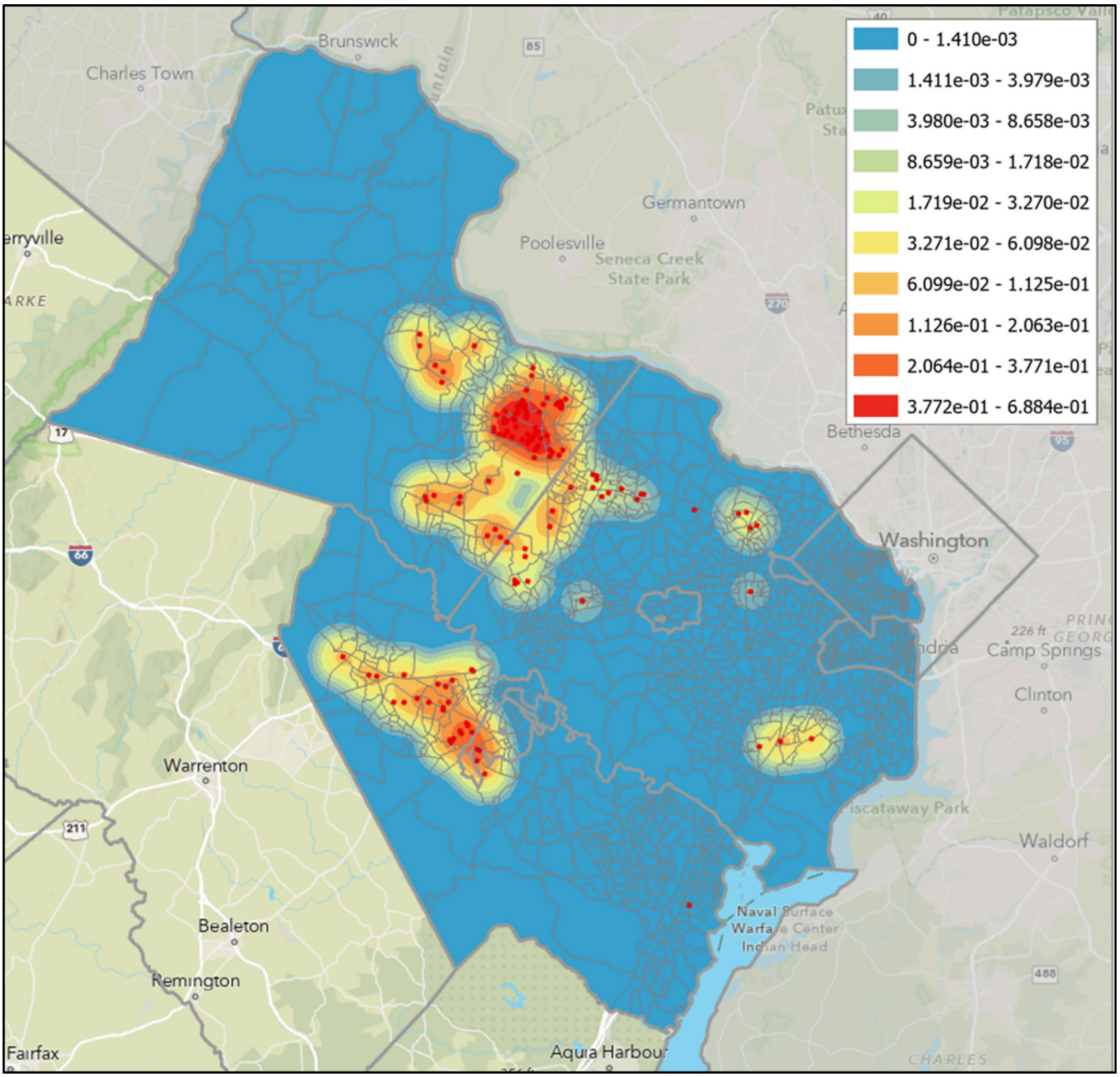
**Table B-3. Descriptive Statistics: Current Emissions Exposure (2023) from Select NOVA Facilities – Census Block Groups within One Mile of Facility (Tons per Square Mile)**

| Pollutant (Tons / Sq. Mi.) | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Norman M Cole Jr Pollution Control Plant (Wastewater Treatment Plant), Covanta Fairfax Inc (Municipal Waste Combustor), Michigan Cogeneration Systems Inc (LandfillGas Power Plant) | | | | | |
| Carbon Monoxide (CO) | 19 | 0.842 | 26.823 | 13.285 | 8.993 |
| Nitrous Oxides (NOx) | 19 | 0.504 | 195.286 | 44.101 | 50.204 |
| Particulate Matter (PM 2.5) | 19 | 0.010 | 28.569 | 5.999 | 7.457 |
| Covanta Alexandria / Arlington Inc. (Municipal Waste Combustor) | | | | | |
| Carbon Monoxide (CO) | 34 | 1.123 | 15.312 | 7.373 | 3.578 |
| Nitrous Oxides (NOx) | 34 | 6.022 | 82.087 | 39.524 | 19.182 |
| Particulate Matter (PM 2.5) | 34 | 0.146 | 1.985 | 0.956 | 0.464 |
| Prince William County Sanitary Landfill (Landfill) | | | | | |
| Carbon Monoxide (CO) | 6 | 1.478 | 48.430 | 13.770 | 17.530 |
| Nitrous Oxides (NOx) | 6 | 0.275 | 8.996 | 2.558 | 3.256 |
| Particulate Matter (PM 2.5) | 6 | 0.094 | 3.067 | 0.872 | 1.110 |
| Dominion - Possum Point Power Station (Natural Gas Power Plant) | | | | | |
| Carbon Monoxide (CO) | 3 | 2.923 | 9.204 | 5.576 | 3.252 |
| Nitrous Oxides (NOx) | 3 | 4.002 | 12.601 | 7.634 | 4.452 |
| Particulate Matter (PM 2.5) | 3 | 2.237 | 7.044 | 4.267 | 2.489 |
| Panda Stonewall LLC / Potomac Energy Center (Natural Gas Power Plant) | | | | | |
| Carbon Monoxide (CO) | 5 | 0.371 | 3.880 | 1.890 | 1.527 |
| Nitrous Oxides (NOx) | 5 | 0.823 | 8.618 | 4.196 | 3.395 |
| Particulate Matter (PM 2.5) | 5 | 0.559 | 5.851 | 2.846 | 2.307 |
| Transcontinental Gas Pipeline - Station 185 (Natural Gas Compressor Station) | | | | | |
| Carbon Monoxide (CO) | 10 | 0.037 | 0.462 | 0.224 | 0.152 |
| Nitrous Oxides (NOx) | 10 | 1.250 | 15.503 | 7.505 | 5.104 |
| Particulate Matter (PM 2.5) | 10 | 0.023 | 0.285 | 0.138 | 0.094 |
| Dominion - Leesburg Compressor Station (Natural Gas Compressor Station) | | | | | |
| Carbon Monoxide (CO) | 3 | 0.024 | 0.768 | 0.285 | 0.419 |
| Nitrous Oxides (NOx) | 3 | 0.036 | 1.134 | 0.420 | 0.618 |
| Particulate Matter (PM 2.5) | 3 | 0.005 | 0.149 | 0.055 | 0.081 |

*Source: U.S. EPA, NEI 2022 v2 Emissions Modeling Platform. Analysis by VCU research team.*

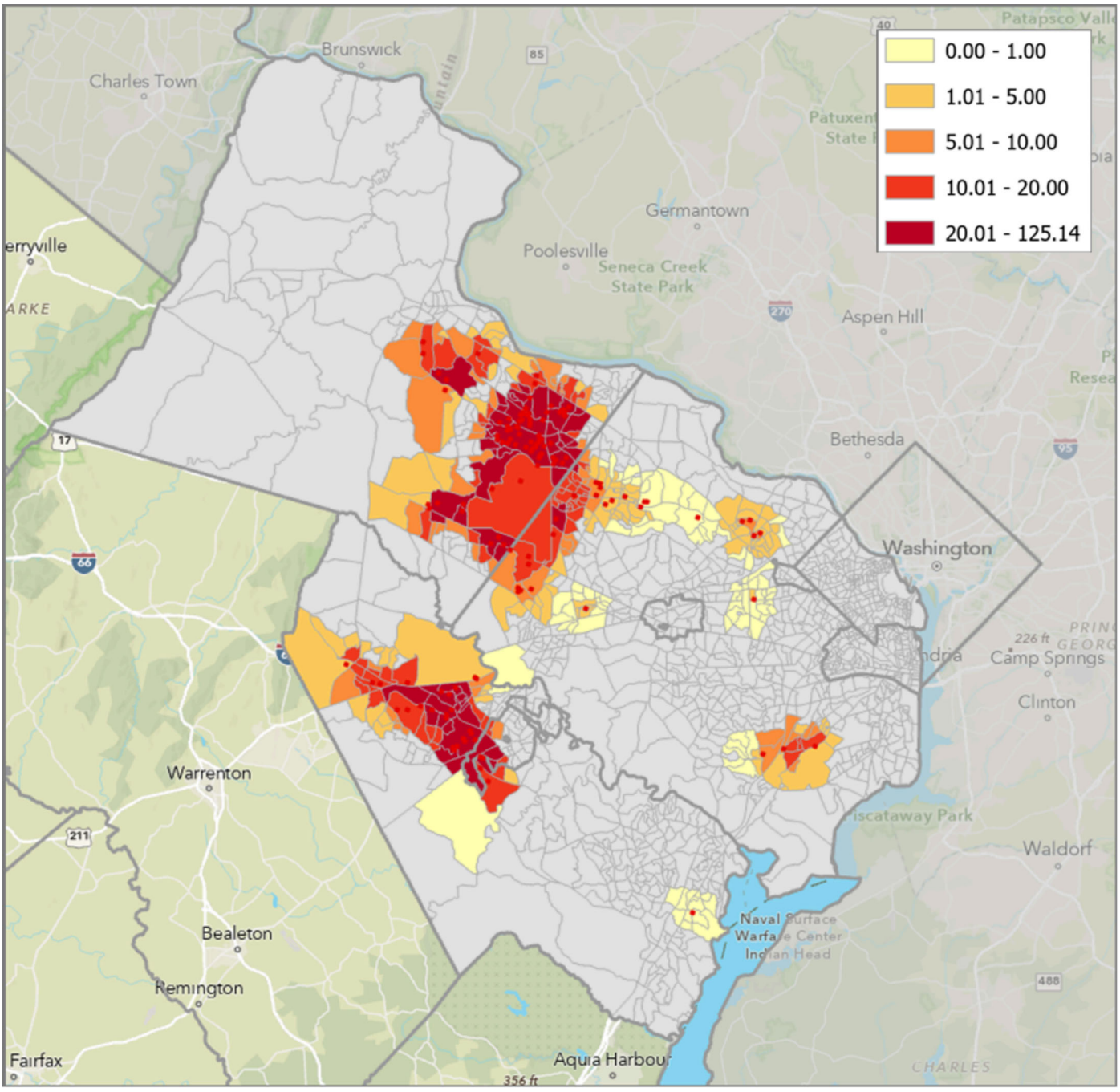
## Appendix C. Detailed Results for Analysis of Potential Localized Air Pollution Emissions from Data Centers In Northern Virginia

**Figure C-1A. Diffusion Map of Potential Carbon Monoxide (CO) Emissions from NOVA Data Center Permits, tons per year by raster grid cells (330' x 330' resolution)**



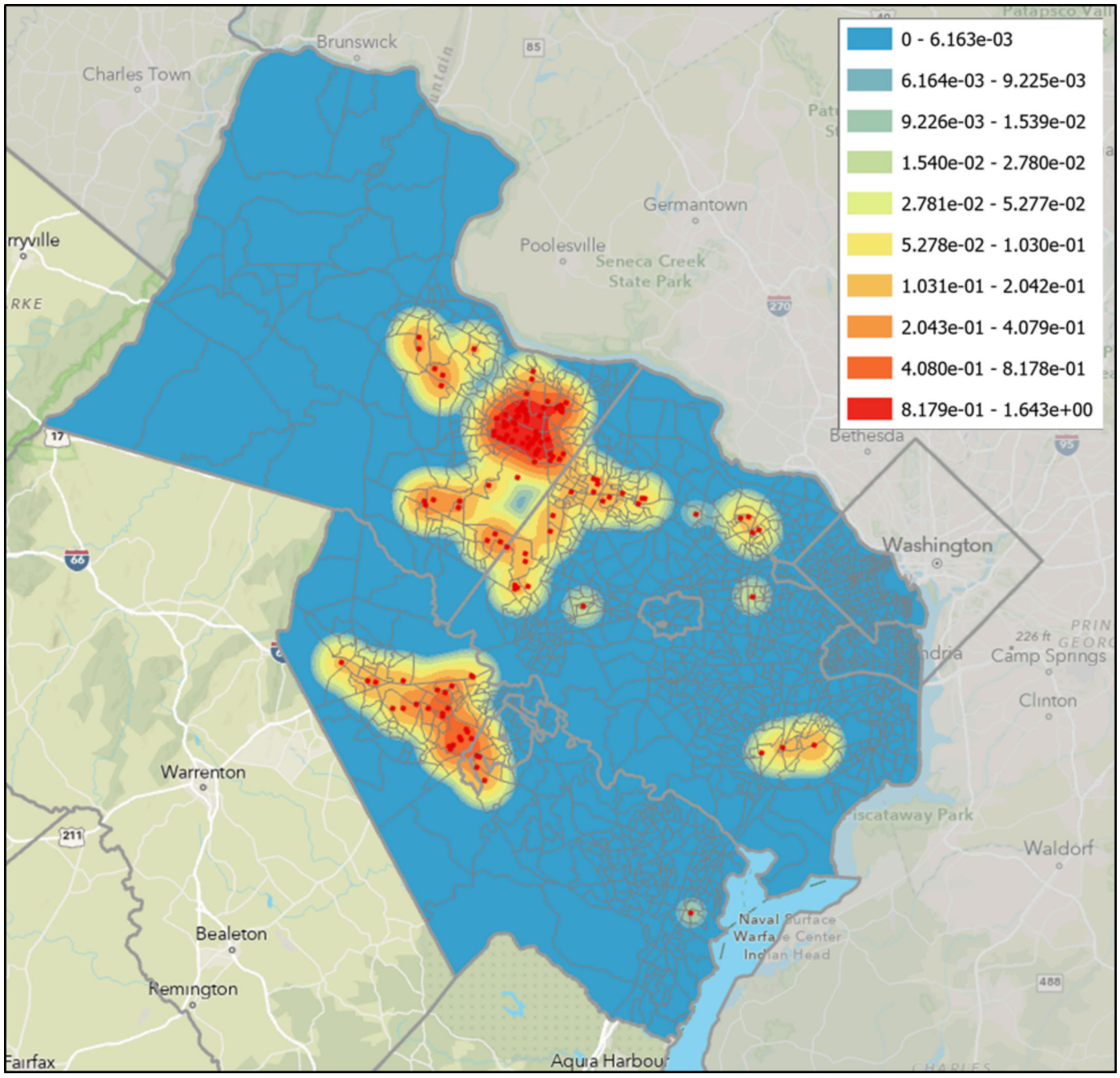

*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

**Figure C-1.B. Map of Derived Potential Carbon Monoxide (CO) Emission Concentrations from NOVA Data Center Permits, by Census Block Group, tons per year per square mile**



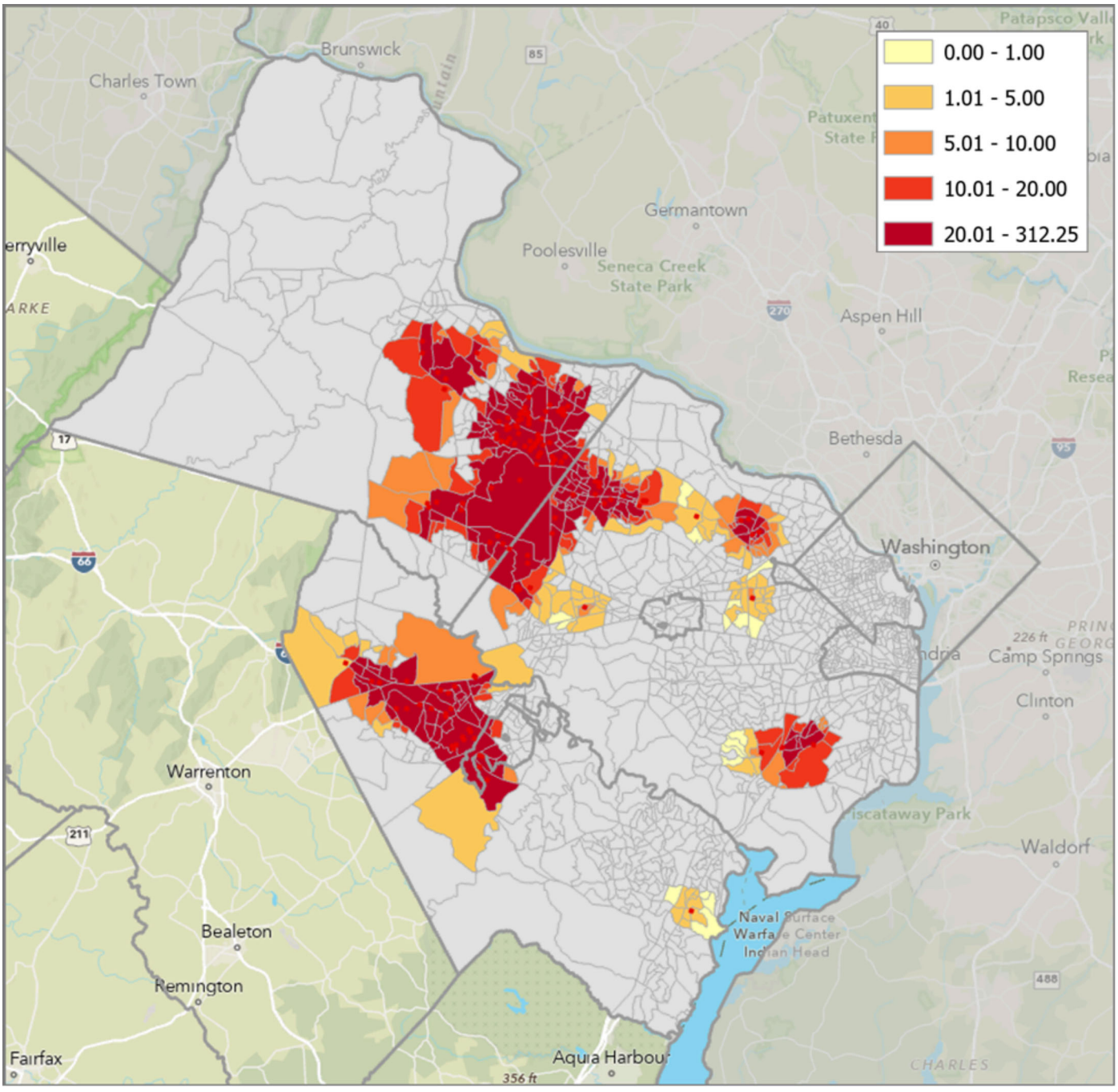

*Source: Virginia DEQ (June, 2025). [Issued Air Permits for Data Centers](). Analysis by VCU research team.*

**Figure C-2A. Diffusion Map of Potential Nitrous Oxides (NOx) Emissions from NOVA Data Center Permits, tons per year by raster grid cells (330' x 330' resolution)**



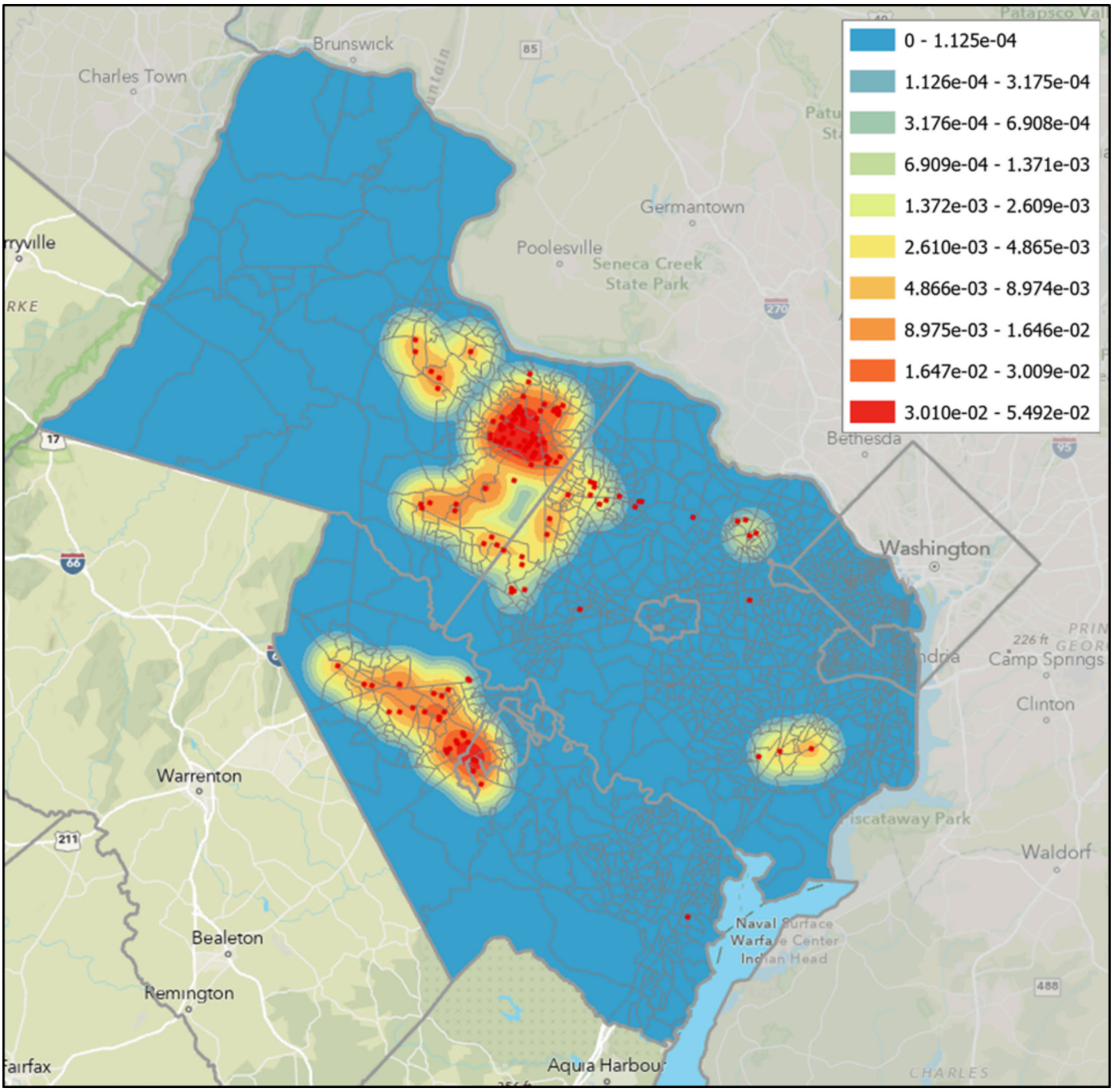

*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

**Figure C-2.B. Map of Derived Potential Nitrous Oxides (NOx) Emission Concentrations from NOVA Data Center Permits, by Census Block Group, tons per year per square mile**



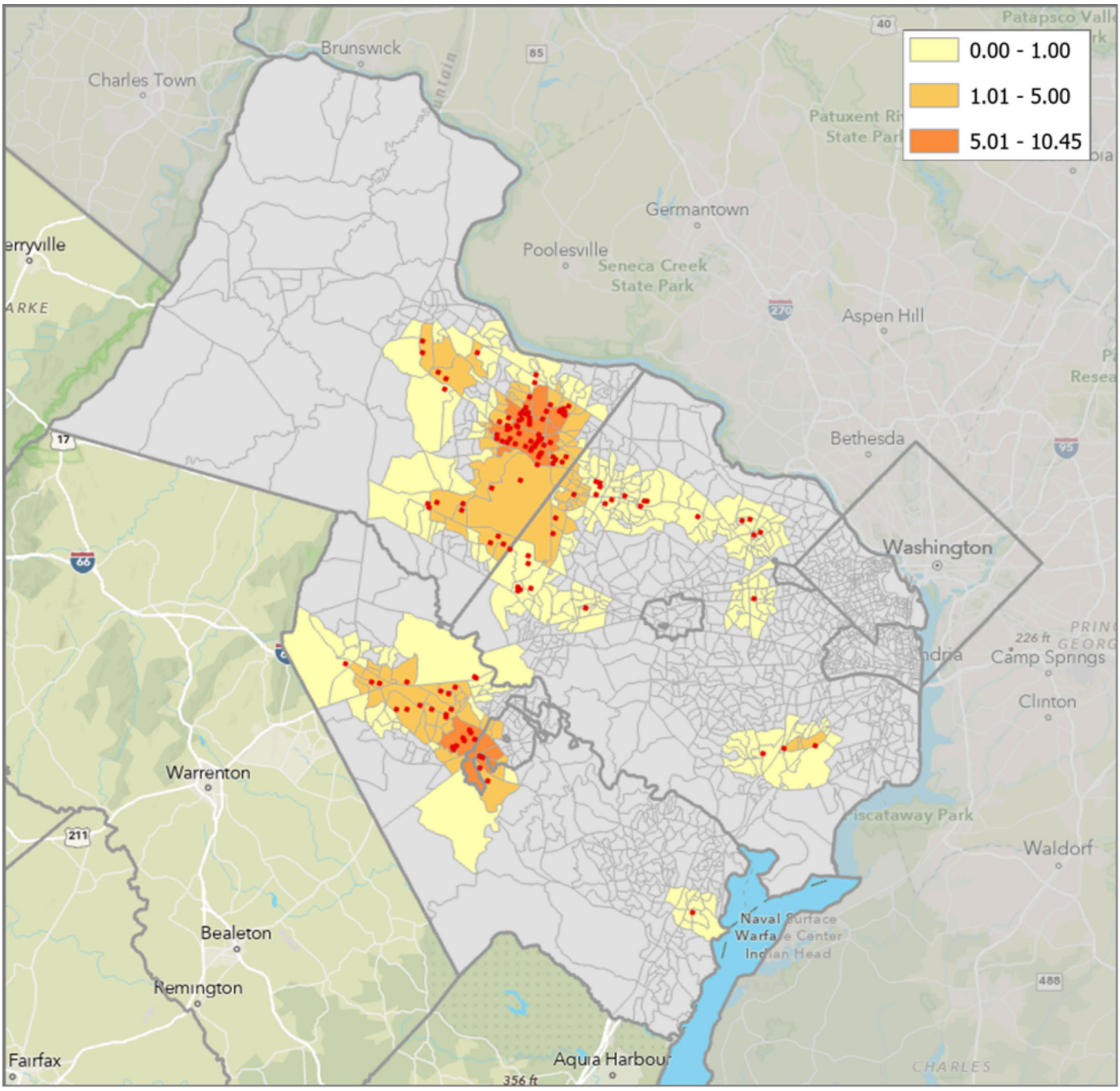

*Source: Virginia DEQ (June, 2025). [Issued Air Permits for Data Centers](). Analysis by VCU research team.*

**Figure C-3A. Diffusion Map of Potential Particulate Matter (PM 2.5) Emissions from NOVA Data Center Permits, tons per year by raster grid cells (330’ x 330’ resolution)**




*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

**Figure C-3.B. Map of Derived Potential Particulate Matter (PM 2.5) Emission Concentrations from NOVA Data Center Permits, by Census Block Group, tons / year / square mile**




*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

**Table C-1. Descriptive Statistics: Cumulative Permitted Emissions Exposure from Data Centers – Census Block Groups within One Mile of a Data Center**

| Pollutant (Tons / Sq. Mi.) | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Carbon Monoxide (CO) | 378 | 0.027 | 125.140 | 11.376 | 17.236 |
| Nitrous Oxides (NOx) | 378 | 0.361 | 312.248 | 29.924 | 42.771 |
| Particulate Matter (PM 2.5) | 378 | 0.000 | 10.446 | 0.932 | 1.487 |

*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*

**Table C-2. Correlations: Permitted Emissions Exposure from Data Centers (Census Block Groups within One Mile of a Data Center) and Select Demographic Characteristics**

| Pollutant | Correlation Statistics | Population Density | Non-White Percent | Median HH Income | Higher Ed Percent | Home Owner Percent |
|---|---|---|---|---|---|---|
| CO / sq. mi. | Pearson Corr. | -0.051 | 0.064 | -.117* | -.175** | -.111* |
| | Sig. (2-tailed) | 0.327 | 0.219 | 0.027 | <.001 | 0.032 |
| NOx / sq. mi. | Pearson Corr. | -0.018 | 0.051 | -.154** | -.162** | -.160** |
| | Sig. (2-tailed) | 0.724 | 0.326 | 0.003 | 0.002 | 0.002 |
| PM 2.5 / sq. mi. | Pearson Corr. | -0.074 | 0.056 | -.113* | -.185** | -0.081 |
| | Sig. (2-tailed) | 0.154 | 0.282 | 0.032 | <.001 | 0.119 |
| ** Correlation is significant at the 0.01 level (2-tailed). | | | | | | |
| * Correlation is significant at the 0.05 level (2-tailed). | | | | | | |

*Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.*