Delaware Air Quality Management
$PM_{2.5}$ Indian River MiniVol Study
Final Report

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Summary

Statistical and graphical comparison of $PM_{2.5}$ data from all sites in this study indicates there is no significant difference between ambient concentrations around the NRG power plant compared to the Seaford area. The conclusion is that the Seaford monitoring site adequately represents air quality in the Indian River area.

Background

The Delaware Division of Public Health (DPH) issued a report on July 17, 2007, concerning a cancer cluster investigation in Indian River area of Sussex County. The investigation was conducted in part as a response to community requests. The DPH study confirmed the existence of a statistical cancer cluster, but did not identify any increased rate of unusual cancers or cancer incidence among young people. DPH stated that without further information, it was not possible to assign a cause to the cancer cluster.

One DPH recommendation for additional information included ambient air monitoring in the area of a large coal burning power plant (NRG) in the Indian River area. The NRG plant has been identified as a major source of fine particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), and the citizens in the community identified this pollutant as a specific concern. The Air Surveillance Branch therefore initiated a short-term study using portable battery-operated monitors to determine $PM_{2.5}$ concentrations in the Indian River area.

Study Plan

Concentrations of $PM_{2.5}$ have been monitored since 1999 in Sussex County at the Delaware Ambient Air Monitoring Network site in Seaford. The data from this site has been designated as representative of Sussex County. The specific hypothesis of the study around the NRG power plant was that the $PM_{2.5}$ concentrations in the area impacted by the NRG plant are similar to the concentrations measured at the Seaford site.

Preliminary analysis of the data quality objectives indicated a minimum number of 15 valid samples from each monitoring site would be needed to detect a concentration difference of three ug/m^3 (the minimum detection limit) between the Indian River area and Seaford at the 95% confidence level. Computer modeling (AERMOD model) using local meteorological data was conducted to estimate the location of maximum deposition of the power plant emissions. Because the ambient air quality standard for $PM_{2.5}$ includes a along term or annual average and a short term or 24-hour average, both maximum annual average and maximum monthly concentration impacts were estimated using the computer model. Because this study was conducted from December into March, a winter season model run was also conducted. Model results are included in Appendix A.

After identifying three monitoring sites for maximum impacts around the power plant, a monitoring schedule of every third day was established. This schedule coincided with the national $PM_{2.5}$ monitoring schedule and would provide comparability with data collected by the

federal reference method (FRM) $PM_{2.5}$ monitor at other sites, including Seaford. Because the sample filters must be manually changed between each sampling event, exceptions to the every third day schedule occurred on holidays and weekends; in those cases samples were collected on the next available work day.

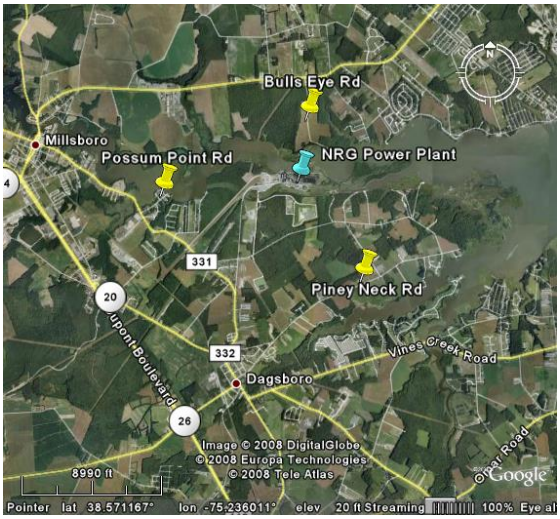
The Air Surveillance Branch has six portable samplers available for special particulate matter studies and all were used in this study. One portable monitor was located at the Seaford site to confirm comparability between the portable monitors and the FRM monitor. Two of the three sites (Bulls Eye Rd and Piney Neck Rd) around the power plant had collocated (i.e., two monitors close to each other that are sampling the same air) monitors to provide estimates of repeatability and assure samples were still collected in case one monitor malfunctioned. Individual sample results from the collocated monitors were averaged at each site to provide a final result. Possum Point Rd had the remaining single monitor.

It should be noted that the portable samplers are not reference methods. There is a higher degree of uncertainty associated with results from non-reference method samplers. Although collocating a portable sampler with a FRM sampler provides additional information on the precision of the portable sampler, as was done in this study at Seaford, the non-reference method results can not be used to determine compliance with national ambient air quality standards.

The sampling sites were located in the following directions from the NRG power plant:

- Bulls Eye Rd north of the plant (impacted by winds from the south)
- Piney Neck Rd southeast of the plant (impacted by winds from the north west)
- Possum Point Rd west of the plant (impacted by winds from the east)
- Seaford west of the plant (impacted by winds from the east)

Figure 1. Locations of special study monitoring sites.



Sampling began on December 2, 2007 and concluded on March 7, 2008. There were a total of 26 scheduled sampling days.

Results

Table 1 shows the individual $PM_{2.5}$ sample results in ug/m^3 for the portable samplers and the FRM sampler at Seaford. Bulls Eye Rd and Piney Neck Rd results are the averages of those sites collocated monitors.

Table 1. $PM_{2.5}$ concentrations in ug/m^3

	Bulls Eye Rd	Possum Pt Rd	Piney Neck Rd	Seaford	FRM Seaford
12/2/2007	6.1	7.2	7.9	13.1	6.4
12/5/2007	8.7	8.9	8.4	9.7	13.0
12/8/2007	22.5	30.9	27.7	25.3	25.4
12/11/2007	10.0	11.4	11.7	14.4	15.6
12/14/2007	20.9	23.1	20.8	19.8	22.9
12/18/2007	17.0	11.1	18.8	20.8	NR
12/20/2007	18.0	19.3	21.3	19.9	23.3
12/23/2007	5.2	4.7	4.0	1.5	3.5
1/1/2008	7.2	7.3	8.4	7.4	7.7
1/4/2008	9.9	12.2	11.6	12.6	13.7
1/10/2008	5.3	5.5	6.9	5.8	8.0
1/13/2008	8.7	10.4	8.4	NR	9.9
1/16/2008	10.4	11.4	12.8	13.3	15.2
1/19/2008	13.0	NR	9.4	12.9	12.8
1/25/2008	13.6	10.5	10.9	10.9	12.9
1/29/2008	22.9	24.7	21.8	24.3	NR
1/31/2008	6.4	6.8	7.1	6.7	8
2/3/2008	20.1	14.7	15.6	17.4	19.5
2/6/2008	12.9	14.2	12.8	12.3	12.5
2/9/2008	11.9	15.7	13.4	16.8	17.0
2/12/2008	12.5	7.0	7.5	10.5	5.7
2/15/2008	12.9	17.1	12.7	NR	17.0
2/21/2008	11.9	13.2	12.3	NR	12.6
2/27/2008	7.8	12.1	6.8	8.0	11.4
3/1/2008	9.4	8.6	9.8	8.8	9.0
3/4/2008	9.4	8.9	8.4	8.7	NR
3/7/2008	5.3	5.3	6.2	5.9	8.2
Average	11.8	12.4	12.0	12.8	13.0

NR = No Result

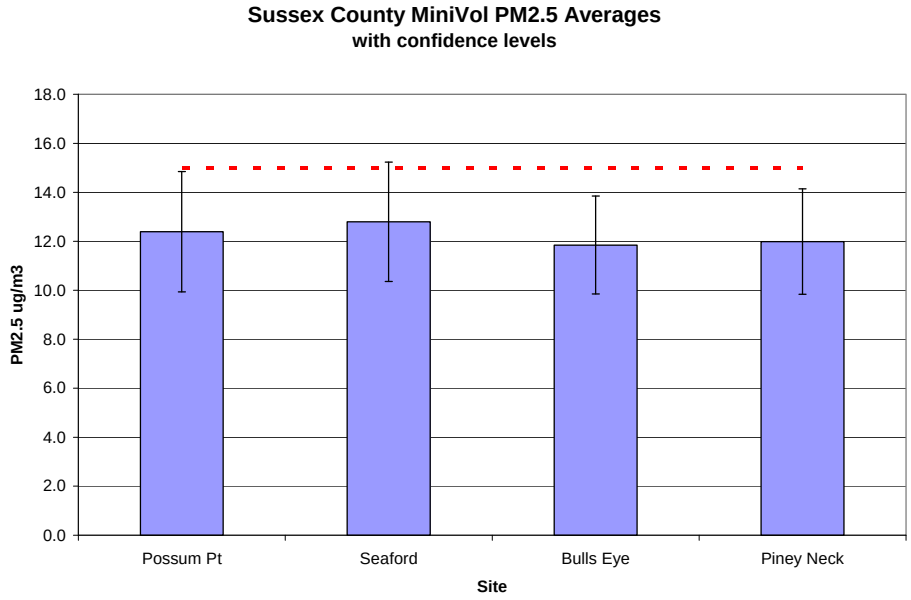
Analysis

Data Quality Assessment of the samplers was performed using the collocated sampler results, and is shown in Appendix B.

Both graphical and statistical tests were performed to look for similarities and differences over time and between sites. Results of the statistical tests are shown in Appendix C.

Average concentrations for each site were graphed as shown in Figure 2. The annual average ambient air quality standard is shown as a dotted line for comparison purposes only. The 95% confidence intervals are shown as the vertical bars at the top of each column.

Figure 2.

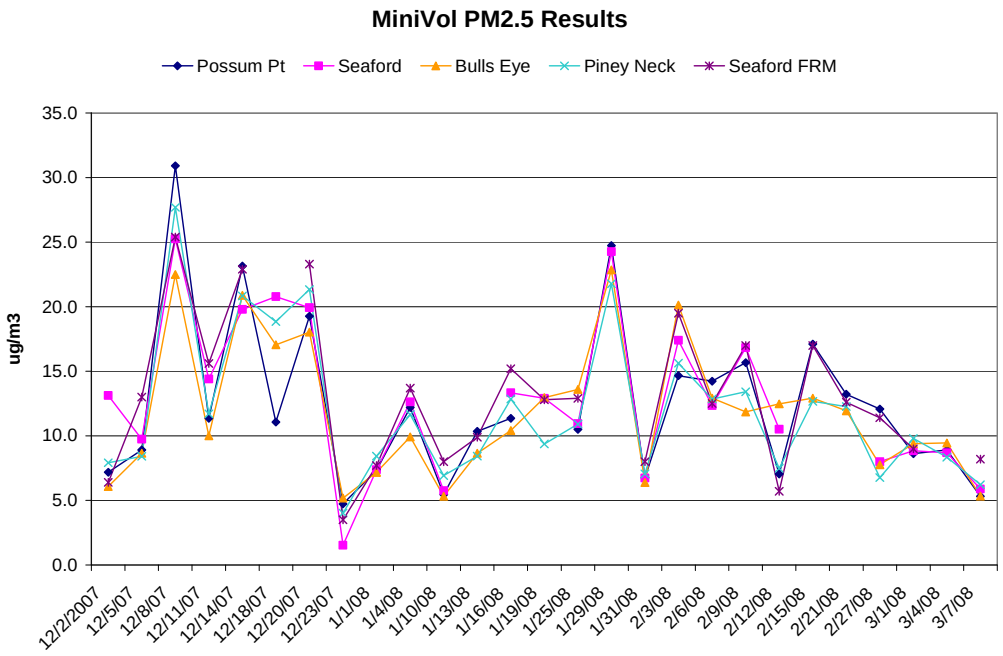


The averages at each site are similar, ranging from 11.8 to 13.0 ug/m^3. Although the Seaford site had the highest average, the confidence intervals at all sites show a large degree of overlap, so the differences did not meet the level of significance.

Although the average concentrations at all sites were below the annual average ambient air quality standard of 15 ug/m^3, sampling was conducted for only three months, and used a non-reference method. The standard is included here only for general comparison.

Individual sample results were plotted graphically as shown in Figure 3. The Seaford FRM results are included for comparison purposes.

Figure 3.



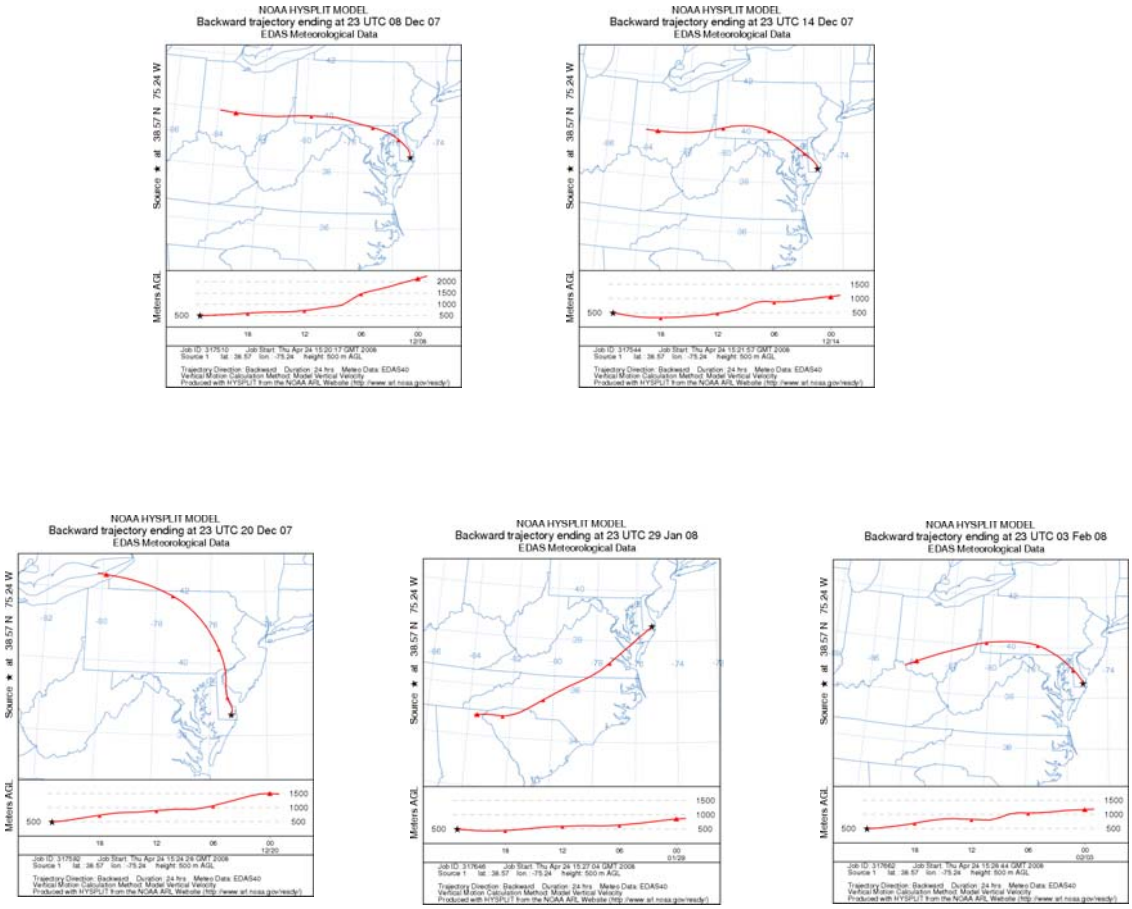
The results shown are typical for $PM_{2.5}$ concentrations monitored throughout Delaware in that all sites generally show higher or lower concentrations on the same days. This consistency across all sites is typical of areas where the dominant source of $PM_{2.5}$ is regional as opposed to local.

The portable sampler collocated with the FRM sampler at Seaford showed good agreement between the methods, with a correlation coefficient of 0.91. This indicates the $PM_{2.5}$ concentrations measured by the portable non-reference samplers are acceptable to achieve the goals of this study.

There were not enough samples collected for each wind direction to perform statistical tests for significant differences. However, another method to investigate the impact of wind direction on $PM_{2.5}$ concentrations involves the use of the NOAA Hysplit back trajectory model. This model uses meteorological data to track air parcels backwards from a particular location through the previous 24 hours. The results are plotted on maps that show the path of the air parcel as a colored line.

The Hysplit model analysis was run for the five sample days with the highest $PM_{2.5}$ concentrations. Because the samples are actually composites collected over 24 hours, a single hour must be chosen as the starting point for the back trajectory. In this case 6:00 PM EST was chosen as the start hour for all five examples. The results are shown in Figure 5.

Figure 5. Hysplit Back Trajectories



Reference: Rolph, G.D., 2003. Real-time Environmental Applications and Display sYstem (READY) Website (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD.

The trajectories for December 8, 14, and February 3 show a pattern that is typical of air parcels passing through a region of very large $PM_{2.5}$ sources in the Ohio River valley, and has previously been associated with elevated $PM_{2.5}$ concentrations in Delaware. The trajectories for December 20 and January 29 also pass through areas with major sources of $PM_{2.5}$ that have been associated with elevated levels of $PM_{2.5}$ and/or ozone concentrations at other monitoring sites in Delaware.

None of the five highest concentration day trajectories was consistent with a dominant impact from a local source in the Indian River area.

To answer the hypothesis of the study, that there is no significant difference between $PM_{2.5}$ concentrations in the Indian River area and the Seaford monitoring site, statistical evaluations were included as discussed below. The primary goal is to detect significant differences and determine correlations. Because the sample populations were not normally distributed, nonparametric statistical tests were used. The evaluations included:

- Means: To examine whether the average concentrations (means) represent different populations, the Kruskal-Wallis One Way Analysis of Variance (ANOVA) on Ranks was performed instead of the standard ANOVA.
- Correlations: To examine the degree of correlation between sites, Pearson Correlation tests were conducted between all site locations. Correlation coefficients can range from 1 (perfect correlation) to 0 (no correlation).

Specific test reports are included in Appendix C.

The analyses for differences between sites showed no statistically significant differences between the average concentrations. Sample concentrations between sites are strongly correlated as determined by the Pearson Correlation test, with correlation coefficients ranging from 0.848 to 0.940.

Discussion

The strong correlation among $PM_{2.5}$ concentrations at all sites on all days is consistent with dominance by regional sources of $PM_{2.5}$ as opposed to local sources. Because ambient $PM_{2.5}$ concentrations result from a combination of primary emissions of particles and atmospheric formation of aerosols from precursor emissions, the strong regional influence is not unusual.

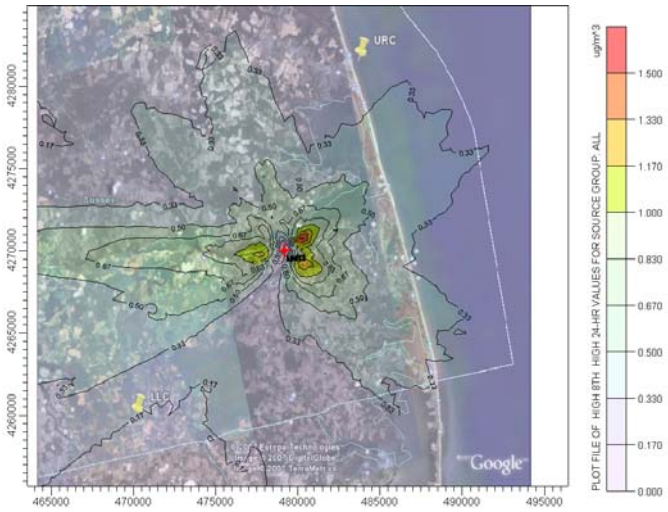
Although the study period was too brief to fully investigate the relationship of concentrations to wind directions, the Hysplit back trajectory tool was used to examine the track of the air parcels on the five highest $PM_{2.5}$ concentration days. The results were consistent with strong regional source influence, and did not support a strong influence from local sources.

The results from this study are consistent with previous evaluations on $PM_{2.5}$ concentrations in Delaware, which have shown the dominance of regional sources on ambient concentrations measured in the state. While local sources contribute to the total concentration, particularly in the urban Wilmington area, $PM_{2.5}$ concentrations are dominated by regional pollution transported from areas outside of Delaware.

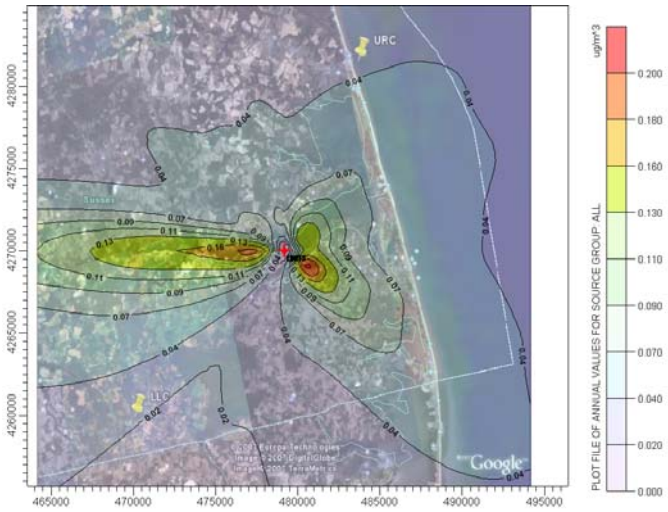
In summary, statistical and graphical evaluations of $PM_{2.5}$ data from all sites in this study indicate there is no significant difference between ambient concentrations around the NRG power plant compared to the Seaford area. The conclusion is that the Seaford monitoring site adequately represents air quality in the Indian River area.

Appendix A. Dispersion Model (AERMOD) Results

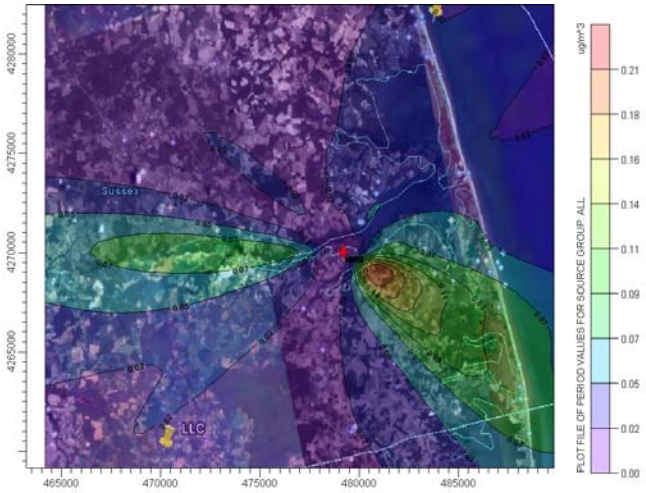
$PM_{2.5}$ Monthly Average



$PM_{2.5}$ Annual Average



$PM_{2.5}$ Winter Average



Appendix B. Data Quality Summary

Data completeness: Completeness is defined as the percent of scheduled samples actually collected with a valid results. An adequate number of samples were collected to achieve the data quality objectives. Completeness for each site was

Piney Neck Rd: 100%
Bulls Eye Rd: 100%
Possum Point Rd: 96%
Seaford (minivol): 92%
Seaford (FRM): 88%

MiniVol correlation: The MiniVols are not a federal reference method, and are associated with a greater degree of uncertainty and imprecision. To assess these factors, two MiniVol samples are collocated at one or more sites and the correlation coefficients between the collocated sample results are calculated and used to evaluate the data quality. In this study there were two sites with collocated MiniVols (Piney Neck Rd and Bulls Eye Rd), and one site with a MiniVol collocated with an FRM sampler (Seaford).

The Piney Neck Rd samplers showed excellent correlation. The Bulls Eye Rd collocated samplers showed a much larger degree of variation, but the differences showed a relatively even distribution (neither sampler was consistently higher or lower than the other).

Piney Neck: Correlation coefficient = 0.991
Bulls Eye: Correlation coefficient = 0.873

MiniVol vs FRM correlation: Correlation between the MiniVol and FRM samplers at Seaford were very good.

Seaford: Correlation coefficient = 0.910

Summary: Data quality met the objectives for this study.

Appendix C. Statistical Results

1. Compare average concentrations:
Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Possum Pt	26	1	11.071	7.297	14.342
Seaford	26	4	12.486	8.698	16.835
Avg BE	26	0	10.210	7.764	12.958
Avg PN	26	0	10.360	7.922	12.848

H = 1.189 with 3 degrees of freedom. (P = 0.756)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.756)

2. Compare correlations between individual samples collected on same days:
Pearson Product Moment Correlation
Cell Contents:
Correlation Coefficient
P Value
Number of Sample Pairs

	Bulls Eye Rd	Seaford	Possum Pt
Piney Neck	0.907	0.940	0.909
	0.000000000163	9.210E-011	0.000000000324
	26	22	25
Bulls Eye Rd			0.884 0.848
		0.0000000471	0.0000000877
		22	25
Seaford			0.850
			0.00000105
			21
Possum Pt			

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.