SOUTHWEST PENNSYLVANIA
ENVIRONMENTAL HEALTH
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January 19, 2018

Jessica Drylie
Business Manager
Fort Cherry School District
110 Fort Cherry Road
McDonald, PA 15057

Dear Ms. Drylie,

The enclosed report describes the findings of an investigation by the Southwest Pennsylvania Environmental Health Project (EHP) to assess the impact of development of a gas pad near the school. There was concern the development of the pad would impact the air in and around the school. EHP has developed monitoring protocols that assess air exposures over long periods of several weeks to months. This joint project between EHP and the school staff is designed to determine whether there is likely transport of well emissions to the school.

Fine particles are part of the mixture of chemicals released into the ambient air during well development and gas production. EHP's protocol measures the particles to determine potential presence of emissions of chemicals from well pad development, including drilling and hydraulic fracturing. Because transport of emissions is influenced by variability in local weather conditions, such as wind speed and direction, continuous measurements over several weeks are needed to identify instances of exposure.

The enclosed report shows the result of monitoring outside of the school at a point nearest to the direction of the pad and 3 other sites where particles could be present in the air: school bus drop off and interior school locations. These findings are consistent with transport of the mixture of emissions from the pad to the school.

For more information on this report and EHP's monitoring activities, please contact EHP at 724.260.5504. Thank you for this opportunity to measure school-based emissions near unconventional natural gas development. We hope this report will help inform further health-protective measures to be taken in and around Fort Cherry's school campus.

Sincerely,

Raina Rippel, Director

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Office: 724.260.5504 Cell: 724.249.7501

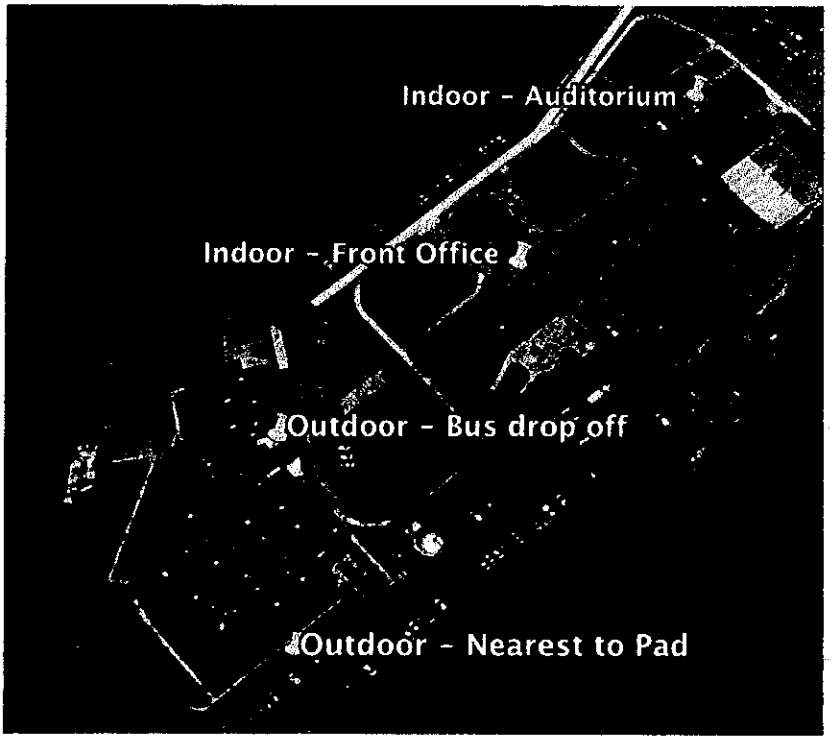
# An Air Quality Assessment of Fort Cherry School:

Measuring $PM_{2.5}$ in proximity to a nearby unconventional natural gas well pad

SWPA Environmental Health Project

January 19, 2018

During a 13-month air quality study conducted at Fort Cherry School, four real-time $PM_{2.5}$[1] air monitors were placed on school grounds to evaluate $PM_{2.5}$ exposure levels at the school. The monitors took measurements every minute for 32 days. The results were used to examine whether the exposures – over five phases of well development – seem to be related to the nearby Yonkers well pad, an unconventional gas well extraction site.




Monitors were placed at an outdoor location on the side of the school nearest to the well pad and at the bus loading/unloading area. Two monitors were inside the school, in the auditorium (low traffic area) and front office (high traffic area). There were, however, instances when monitors did not work properly, e.g., loss of power (in the tables that follow the monitor failures are left blank.)

EHP examines air quality measurements from continuous air monitors for the following 5 parameters: a) number of exposures per day; a) baseline air quality values; c) length of time between exposure events; d) length of exposure; and e) accumulated particle concentration available for inhalation (average $mg/m^3$ per day).

[1] $PM_{2.5}$ is a particle size that is only a fraction of the diameter of a human hair.

## Exposures per Day

*Exposures per day (EPD),* are the number of times $PM_{2.5}$ levels were high relative to the baseline, or background, levels of particles in the air. These are considered "peak exposure periods."

### FINDINGS

- The monitor recording the most frequent exposures per day was located outside of the middle school, near the bus loading zone. This monitor was used from February to March 2017, during the estimated drilling period and while school was in session. The monitor registered an average of 3.5 exposures per day. It is likely that some spikes were the result of bus traffic and idling.

- The second most frequent exposures per day were outside the Middle School on the well pad side, collected from June through July 2017, during the estimated fracking phase and when school was not in session. There was an average of 3.1 exposures per day.

- The monitor recording the least frequent exposures per day was located in the high school's auditorium. This monitor was in place from August through September, during the baseline collection period and recorded an average of 0.7 exposures per day. This is an expected result as the auditorium was not used during the time of collection, offering an optimal indoor baseline measurement.

    - Recap
        - Highest levels of concern: Outdoors, near the school bus loading zone, during the estimated drilling phase, school in session;[2] and at the site nearest the well pad, fracking phase.
        - Lowest level of concern: In the high school auditorium, collected prior to well pad activity, school not in session for most of data collection.

[2] School buses produce diesel emissions which contain PM and so increase the presence of PM in and around the school.

SUMMARY

Table 1. *Average Exposures per Day* (EPD) by estimated well activity period. When 2 monitors were used indoors simultaneously, their average appears in the table.

| | Indoor avg EPD | Outdoor EPD Bus | Outdoor EPD Nearest to Well Pad |
|---|---|---|---|
| Pre-construction average | 2.0 | 2.8 | |
| Drilling average | 2.7 | 3.5 | 2.6 |
| Hydraulic fracturing prep average | | 3 | |
| Hydraulic fracturing average | 1.8 | | 3.1 |
| Production phase average | 2.7 | | |

* Measurements were averaged every 15 minutes over 32 days of monitoring.
*Highlighted cells represent the highest level(s) of concern*

## Baseline Reading (measured by weight of particulate in the air)

*Baseline readings* are the $PM_{2.5}$ measurements when peaks in exposures are not occurring; often referred to as background. In this analysis, it is at or below the 35th percentile of measurements[3]. The highest 15-minute averaged peaks could reach 50-100 ug/$m^3$. The National Ambient Air Quality Standard for $PM_{2.5}$ is 35 ug/$m^3$.[4]

- The monitor with the highest baseline was located outside the middle school nearest to the well pad. This monitor was used from June through July 2017, during the estimated fracking period and measured an average of 18.5 ug/$m^3$ as a baseline value.

- The monitor with the lowest baseline was located inside the high school's administrative office. This monitor was used from late July through August 2017 during the production phase of the well pad and when school was not in session. It measured only 1.2 ug/$m^3$ as a baseline average.

    - Recap
        - Highest level of concern: Outdoors, nearest to the well pad, estimated during the fracking phase, school not in session.
        - Lowest level of concern: Indoor school admin office, estimated during the well pad production phase, school in session.

SUMMARY

Table 2. Baseline readings in micrograms/meter$^3$/day by estimated well activity period. When 2 monitors were used indoors simultaneously, their average appears in the table.

| | Indoor (ug/$m^3$/day) | Outdoor (ug/$m^3$/day) Bus | Outdoor (ug/$m^3$/day) Nearest to Well Pad |
|---|---|---|---|
| Pre-construction average | 9.6 | 17.5 | |
| Drilling average | 6.7 | 4.7 | 5.8 |
| Hydraulic fracturing prep average | 13.1 | 5.1 | |
| Hydraulic fracturing average | 4.6 | 14.1 | 18.5 |
| Production phase average | 1.2 | 10.1 | |

* Measurements were averaged every 15 minutes over 32 days of monitoring.

*Highlighted cell(s) represent the highest level(s) of concern*

[3] Percentile is a statistical term used to identify a portion of the data, in this case the lowest group of levels recorded.

[4] https://www.epa.gov/criteria-air-pollutants/naaqs-table

## Time Between Exposures (measured in hours)

*Time between exposures* is the average number of hours recorded between consecutive peak exposures. Having a longer break between $PM_{2.5}$ exposures is better for the respiratory system because it leaves time to clear the particles from the lung before another peak occurs. For this parameter, the lowest average time can signify greater risk than the highest average time.

- The monitor recording the least amount of time between exposures was located outside of the middle school, near the bus loading zone. This monitor was used from February to March 2017, during the estimated drilling period and when school was in session. It recorded an exposure once every 6.6 hours which may, at least in part, reflect bus exhaust.

- The monitor recording the longest duration of time between exposures was located in the high school's administrative office. This monitor was used from June through July 2017, during the estimated fracking period and when activity in the school was low. It recorded an exposure only once every 13.4 hours.

    - Recap
        - Highest level of concern: Outdoors, near the school bus loading zone, estimated during drilling period, school in session; and average indoor.
        - The second shortest average time between peaks was shortest during fracking phase, nearest the well pad.
        - Lowest level of concern: Indoor school administrative office, estimated during fracking period, school not in session.

Table 3. *Average Time between Exposures,* reported in hours, by estimated well activity period. When 2 monitors were used indoors simultaneously, their average appears in the table.

| | Indoor | Outdoor Bus | Outdoor Nearest to Well Pad |
|---|---|---|---|
| Pre-construction average | 6.6 | 8.5 | |
| Drilling average | 10.7 | 6.6 | 9.1 |
| Hydraulic fracturing prep average | | 7.8 | |
| Hydraulic fracturing average | 13.4 | | 7.7 |
| Production phase average | 8.7 | | |

* Measurements were averaged every 15 minutes over 32 days of monitoring.
*Highlighted cells represent the highest level(s) of concern*

## Length of Exposure (measured in minutes)

*Length of exposure* is the amount of time from the beginning of an exposure peak until the end.

- The monitoring site which recorded the longest duration of exposure was located inside the high school's administrative office. This location had lengthy exposures, lasting 31.3 - 37.2 minutes each during several different monitoring periods. This result was expected as the monitoring location was in a high foot-traffic area, known to cause higher levels of $PM_{2.5}$. Additionally, particles can stay trapped in a building long after they have dispersed in the ambient outside air.

- The site with the second longest average exposure was outside the middle school, located closest to the well pad. These high readings were recorded from February to March 2017, during the estimated drilling period, recording exposures lasting 30.7 minutes.

- The monitoring site which recorded the shortest average duration of exposure was outside the middle school near the bus loading zone, from August through September 2016, during the collection period before construction of the site began.

- Recap
    - Highest level of concern: Inside the high school admin office during several collection periods while school was in session.
    - Results near well pad: second longest average exposure
    - Lowest level of concern: Outdoors, near the school bus loading zone, during the pre-construction period, school not in session for most of data collection.

Table 4. *Average Length of peak exposure*, in minutes, by estimated well activity period. When 2 monitors were used indoors or outdoors simultaneously, their average appears in the table.

| | Indoor | Outdoor Bus | Outdoor Nearest to Well Pad |
|---|---|---|---|
| Pre-construction average | 18.5 | 19.2 | |
| Drilling average | 36.2 | 21.7 | 30.7 |
| Hydraulic fracturing prep average | | 20.5 | |
| Hydraulic fracturing average | 31.3 | 28.5 | |
| Production phase average | 37.2 | | |

* Measurements were averaged every 15 minutes over 32 days of monitoring.
*Highlighted cells represent the highest level(s) of concern*

## Accumulated Particle Concentration (mg/m$^3$ each day)

*Accumulated Particle Concentration* is the total amount of $PM_{2.5}$ present during the full duration of peak exposures, averaged by day. This is an indication of the potential inhaled dose of $PM_{2.5}$.

- The monitoring site that recorded the greatest amount of $PM_{2.5}$ (measured in mg/m$^3$/day) was located outside the middle school nearest to the well pad. This monitor was used from February to March of 2016, during the estimated drilling period and measured 8.2 mg/m$^3$/day.

- The monitor which recorded the least amount of $PM_{2.5}$ (measured in mg/m$^3$/day) was located inside the high school auditorium. This monitor was used from August through September 2016, during the collection period before construction of the well pad, measuring 1.2 mg/m3/day. The auditorium was not used during data collection, offering an optimal indoor baseline measurement.

    - Recap
        - Highest level of concern: Outdoors, nearest to well pad during the estimated drilling phase, during months when school is in session.
        - Lowest level of concern: In the high school auditorium, collected prior to well pad activity, school not in session for most of data collection.

Table 4. *Daily Exposure Level in milligrams/meter$^3$ EACH DAY* by estimated well activity period. When 2 monitors were used indoors or outdoors simultaneously, their average appears in the table. Note: these are milligrams not micrograms, which are used in the other tables.

| | Indoor (mg/m3/day) | Outdoor - Bus (mg/m3/day) | Outdoor Nearest to Well Pad |
|---|---|---|---|
| Pre-construction average | 3.52 | 4.3 | |
| Drilling average | 2.7 | 3.5 | 8.2 |
| Hydraulic fracturing prep average | | 3.35 | |
| Hydraulic fracturing average | 2.11 | | |
| Production phase average | 6.7 | | |

* Measurements were averaged every 15 minutes over 32 days of monitoring.
*Highlighted cells represent the highest level(s) of concern*

## Interpretation & Discussion

PARTICLE POLLUTION IN AND AROUND THE SCHOOL

Particulate matter is a small but ever present component of toxic emissions from well pads. Inside of schools there are two sources of fine Particulate Matter: activity and sources within the school, and polluted air that enters from the outside through ventilation. Outside the school, there are two sources of PM. One is school bus pick-ups and drop-offs which, although high particulate producers, are relatively brief. The second outside source is the well pad which, while not measuring as high at the school, are present for longer periods of time. Furthermore, those outside peaks are indicative of the presence of other pollutants from the gas wells. Both the particles and the chemicals attached to the particles are dangerous.

Understanding the long-term impacts of the well pad requires detailed measurements over a long period of time, at least a month. The length of the continuous measures is important because they include at least three cycles of the weather systems, about 24 to 32 days. In this long-term study of four locations outside and inside of the Fort Cherry schools, significant fluctuations in $PM_2$ exposures are shown.

The five parameters evaluated each tell us something about the exposure someone in or around the school would experience. Ideally – in a relatively pollution-free environment – there would be few episodes of increased PM concentrations and the baseline concentrations would be low. If there were peaks in exposures, ideally those peaks would be far apart – maybe several days between peaks. When the peaks occurred, the length of those high exposures would be brief, only a few minutes, and so the total concentration of particles during those peaks would be smaller than if the peaks lasted for many hours. This results in lowered inhaled doses.

The Fort Cherry School campus is not, however, relatively pollution-free, so it is useful to consider the various measurements of exposure inside and out. What we find is that, for the most part, just outside the school, PM exposure measures are more concerning than inside the school but outdoor pollution does become indoor pollution, so it is useful to consider inside exposure as well. The drilling and fracking phases of well development are especially concerning for exposures because particles will enter the school via ventilation systems.

Outside air quality measurements nearest the well pad indicate periodically high ambient air levels and potential exposures. There were, on average, about 3 peak exposures per day; the baseline levels were highest near this site during the fracking phase; exposure periods were lengthy during the drilling phase; and the daily exposure level (accumulated particle concentration) was highest at this site during the drilling phase. This last measure indicates the potential levels of pollutants inhaled.

Outside air quality measurements near the school bus loading zone are also periodically high. Bus emissions tend to disperse relatively quickly, but there are management options available to address these risks, such as limiting bus idling time.

Inside the school particle levels are also high but comparison of office levels with auditorium levels indicate that this is primarily due to indoor activities which are known to increase particle counts. The school may want to seek guidance about indoor air protective measures.

HEALTH RISKS

Ellen Webb and co-authors explain, in "Potential hazards of air pollutant emissions from unconventional oil and natural gas operations on the respiratory health of children and infant," that PM is a complex mixture of small particle solids, droplets, dust particles, metals, and in some cases radioactive materials. Exposures to high $PM_{2.5}$ concentrations pose known health effects; and children are particularly affected subgroup. Children's lungs are still developing, and, they are more likely to get respiratory inflammation and infections. These conditions are exacerbated when environmental PM concentrations are high. Particle pollution is linked to a variety of health effects including onset and exacerbation of asthma, irritation of airways, coughing, wheezing, chest tightness, and shortness of breath.[5]

The findings in this report support the concerns that pollutant emissions are reaching the school. Continuous real-time monitoring of PM is necessary to understand the risk from PM itself, but also because PM serves as a proxy for other pollutants. When possible, the school could take steps to minimize particulate and other pollution in its indoor air. When outdoor levels are elevated enough to raise concerns, it might be best to keep students inside.

## Conclusions

1. The *Exposures per Day* show peaks of exposure both in the school and near side of school closest to the drill pad.
2. The *Baseline* levels outdoors, nearest the well pad raise concern, with risks apparent during the fracking phase, school not in session.
3. *Accumulated Concentration* indicates that inhalation exposures outside of school nearest to well pad during the estimated drilling phase, are sizable.
4. The school could consider administrative action to reduce inhalation of $PM_{2.5}$ and other gas well emissions both inside and outside of the school.

[5] Webb, Ellen, Jake Hays, Larysa Dyrszka, Brian Rodriguez, Caroline Cox, Katie Huffling, and Sheila Bushkin-Bedient. "Potential Hazards of Air Pollutant Emissions from Unconventional Oil and Natural Gas Operations on the Respiratory Health of Children and Infants" 31, no. 2 (January 1, 2016). https://doi.org/10.1515/reveh-2014-0070.