CDOT Research Project: R121.05: Air Quality Impacts of Highway Construction

I. Project Overview

CDOT and the Colorado Department of Public Health and Environment (CDPHE) are conducting a study of **Air Quality Impacts of Highway Construction**, to document and seek to understand impacts of typical highway construction activities on air quality. The primary focus is on sources and concentrations of a subset of National Ambient Air Quality Standard (NAAQS) criteria pollutants. Although the measurement suite is not finalized, measurements are likely to be PM2.5, PM10 and NOx. Other non-criteria measurements, such as total VOC, will also be collected. This project is Phase 1 and is focused on the reconstruction of the I-270 corridor, with future phases expected to study a similarly busy highway corridor in a less complex emissions environment, and a rural, low volume highway reconstruction project.

Research Questions are still being finalized, but are likely to include:

1. How does air quality change from before a typical highway improvement project to after? What are the impacts of better traffic flow with less idling, and the impacts of higher traffic flow due to induced demand?
2. How does air quality change as a function of downwind distance from construction activity, of height above the ground, and of meteorological conditions (atmospheric mixed layer depth)? For example, what are the PM10 and PM2.5 concentrations as a function of downwind distance? How much material settles out near the construction activity and how much is carried downwind? In addition, what is the height profile as modified through mixing and dilution?
3. To what extent is local air quality affected during specific construction activities? What are the impacts of engine emissions from construction equipment? What are the impacts of digging and other moving of material?
4. How well do model predictions from the pre-project NEPA analysis match post-construction observations? Some researchers have suggested that (in general) model predictions can be significantly off. If so, is there an opportunity to improve air quality models?

The questions are intended to address the burden and distribution of emissions and pollutants, but not specifically effects on human health.

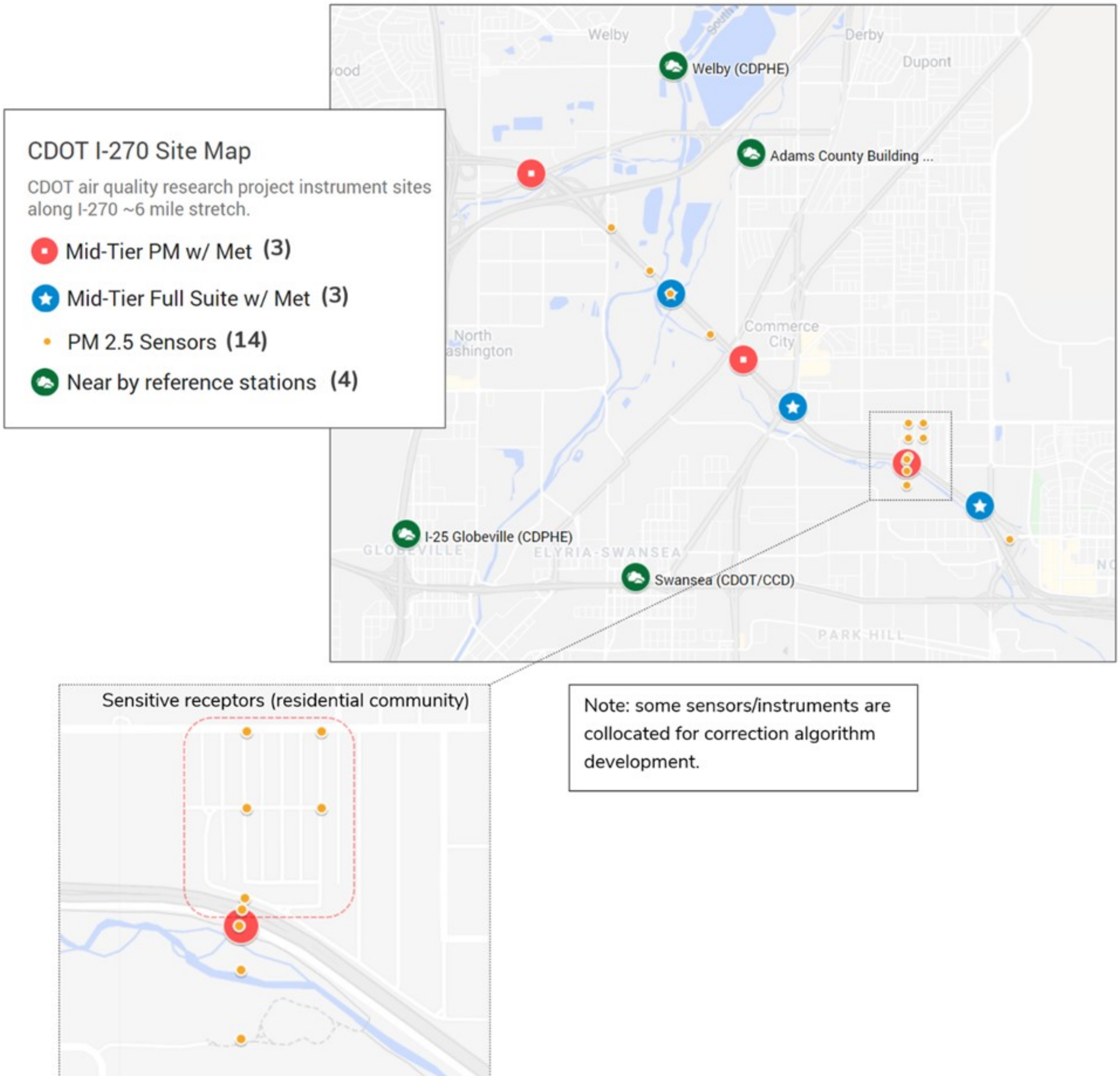
To address these questions, the project will collect data at multiple sites covering a range of characteristics, a range of construction activities, varied weather, and long timelines.

II. Project Approach and Methodology

The approximate Phase 1 experimental design for measurements is shown in the figure below. Exact locations and number of measurement sites are not finalized. The design has a backbone set of measurement sites to collect air measurements along the I-270 corridor over several seasons, beginning about one full year prior to the reconstruction project. Data provided by this project-specific network will be supplemented by the regional air quality network of CDPHE and other measurements-of-opportunity.

In addition, the experimental resources include a network of readily deployable measurement stations that will be moved several times during the project. This dense network can investigate the spatial distribution of pollutants at higher resolution, and will be used during intensive construction phases at specific locations.

Other information, such as from logs of construction activities, traffic information, plowing, deicing and other surface treatments, and broader meteorological measurements, can also be analyzed.



III. Instrumentation and Network Design

This section provides an approximate scenario of the instrumentation, network design, costs that address the project goals and budget. The chart below provides additional detail about some instrumentation, and is consistent with the Figure.

The scenario prioritizes good quality baseline measurements at fixed locations along the corridor for the duration of the project, and maximizing the density of measurement points for re-deployable sites. Reference air quality instrumentation can be expensive and typically requires additional infrastructure and significant maintenance costs. Instead, this scenario employs a mix of near-reference instrumentation ("Mid-tier Instrumentation") and lower cost sensors ("Low cost sensors") to provide a hybrid mix of devices providing measurement density and data quality suitable. While flexible and pragmatic, hybrid networks have challenges such as data calibration for the lower cost instruments, and normalization of the various data types from different instruments. To address the complexity of hybrid network data management, an IoT (Internet-of-Things) data platform agnostic to data type will be developed.

"Mid-tier Instrumentation" Near-reference quality (eg. 2BTech, Aeroqual, TSI DustTrak, others): These instruments provide high quality data that can be calibrated using reference standards. They require some O&M, such as periodic calibration and filter replacement, but do not require frequent onsite maintenance. Power consumption is significant, and they generally require continuous 110V power, limiting their siting options and adding to installation costs. Data from these devices can be transmitted at high data rates (1-min) via cellular networks.

"Low cost sensors" (Clarity, Lunar Outpost, others): A larger number of lower cost instruments will provide a higher density of measurements near intensive construction activities. The higher density is useful to study microenvironments such as fine particulate gradients near sensitive receptors (see for example the area detail in the Figure). Measurements from these sensors can drift over time and can be sensitive to changes in air temperature and humidity. Using the IoT platform, data adjustments will be performed to ensure the most accurate data. The IoT platform facilitates this, with simultaneous access to better calibrated data from the Midtier Instrumentation and reference sites. A collocated sensor with internal measurements of temperature and humidity, provides sufficient input for an algorithm to make the needed data adjustments. The Low cost sensors typically do not need an external power source and also transmit data via cellular networks.

"Meteorology sensors" (add-on for both Mid-tier sites and Low Cost sites): The data systems of both Mid-tier and Low cost sensors sites can host sonic anemometers for measurement of wind speed and wind direction. Not all sites need this addition, which adds a significant cost. Sonic anemometers can leverage the other instrumentation for communication and data transmission.

The charts below illustrates capabilities of a network with 6 fixed Mid-tier sites and 14 Low cost re-deployable sites.

Midtier (Near Reference)	**Quantity**	**Measurements and Notes**
2BTech Near reference unit (Suite, no PM10)	**3**	**CO, CO2, NOx, O3, PM2.5, PM1, BC**, **Met (WS/WD)**
TSI DustTrak	**3**	**PM1, PM2.5, PM10, Total PM**, **Met (WS/WD)**; Temp rating -4 to 122°F

Sensors (Lower cost)	**Quantity**	**Notes**
Clarity Node-S	**7**	**PM1, PM2.5, NO2,** Temp, RH
LO Canary-S	**4**	**PM1, PM2.5, NO2 (or CO),** Temp, RH, **tVOC** + Summa Trigger*, **Met (WS/WD)**
LO Canary-S	**3**	**PM1, PM2.5,** Temp, RH