Appendix M

Air Quality, Weather, and Greenhouse Gas Analysis

DATE: April 22, 2024
TO: Deschutes County
FROM: Adam Romey, Justin Overdevest, Josh Wozniak
SUBJECT: Air Quality, Weather, and Greenhouse Gas Analysis
CC:
PROJECT NUMBER: 553-2509-011
PROJECT NAME: Moon Pit and Roth East Site Evaluations

Parametrix has prepared this technical memorandum in support of environmental due diligence activities for the Moon Pit and Roth East sites near Millican, in Deschutes County, Oregon. This technical memorandum summarizes local air quality data, weather data, and greenhouse gas (GHG) analysis for the Moon Pit and Roth East areas and provides a brief discussion of facilities in close proximity to the site that may contribute to local air quality issues.

Weather Summary

Available relevant weather data from the past 5 years were acquired from two weather stations (BEND and BEND 7 NE) in Bend, Oregon. Data available from these locations included minimum and maximum temperatures, as well as daily precipitation. $PM_{2.5}$ and ozone (air quality) data were obtained from the Prineville Davidson Park and Bend NE 8th and Emerson stations. Windspeed and/or direction data were obtained from the Redmond Roberts Field station, station EW8160, and US 20 eastbound at Horse Ridge (see Table 1 and Map 1).

Table 1. Selected Weather Stations & Locations

Station ID	Location
BEND	44.056908°N 121.284989°W
BEND 7 NE	44.118408°N 121.210197°W
BEND NE 8TH AND EMERSON	44.054661°N 121.294068°W
REDMOND ROBERTS FLD	44.255811°N 121.139192°W
PRINEVILLE DAVIDSON PARK	44.299787°N 120.844773°W
EW8160 BEND	43.97271°N 121.19860°W
US20 EB AT HORSE RIDGE	43.90011°N 120.98703°W

The 5-year record of temperature data collected at the BEND station (Chart 1a) shows a minimum temperature of -7° Fahrenheit (F) on February 23, 2022, and a maximum temperature of 107° F on June 30, 2021. Temperature data at this station are spotty for the latter part of 2022 and 2023. The 5-year record of temperature data collected at the BEND 7 NE station (Chart 1b) shows a minimum temperature of -6° F on January 30, 2023, and a maximum temperature of 106° F on June 30, 2021. The average temperature for each day of the year during this 5-year period is shown in Charts 2a and 2b.

Map 1. Weather Station Locations

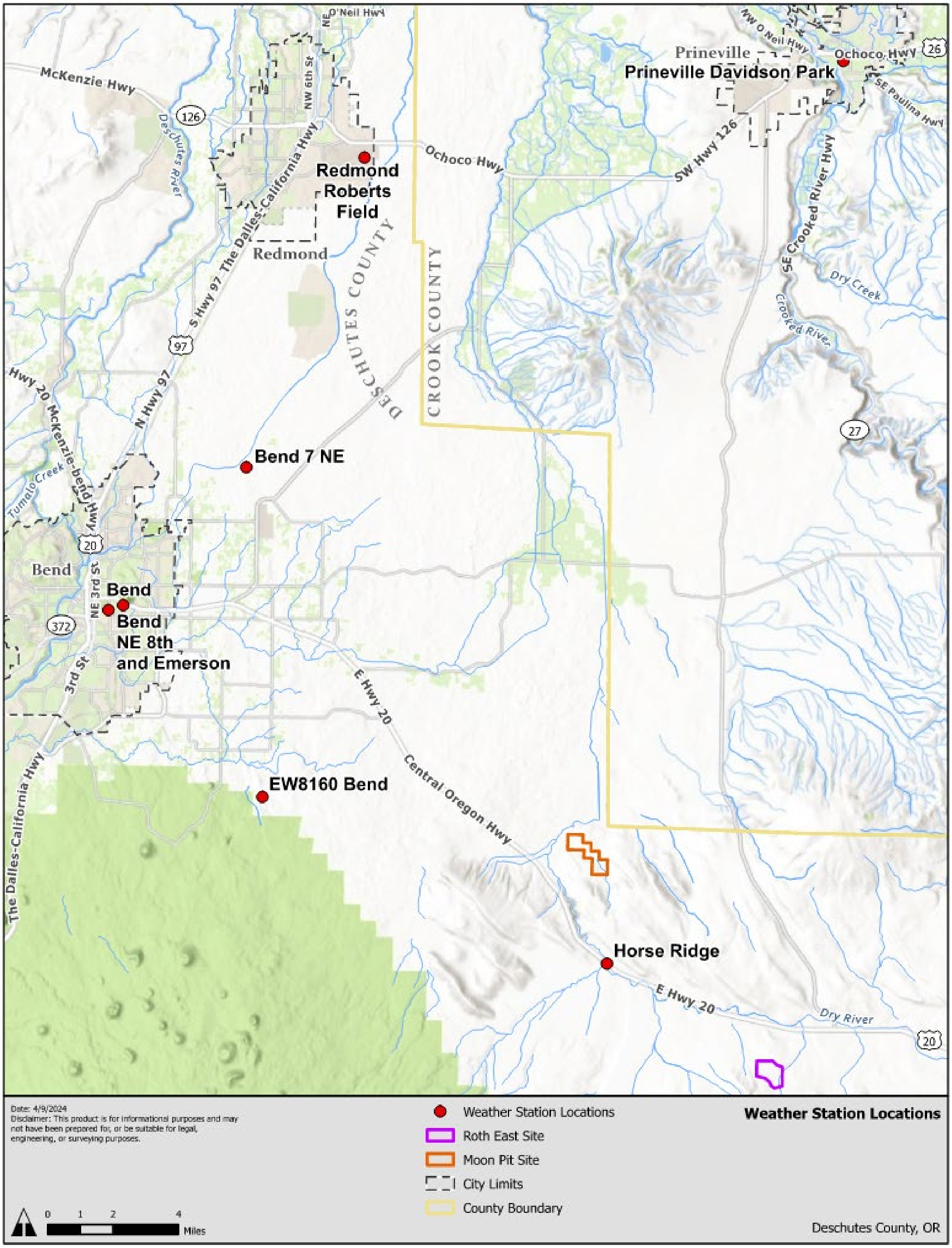


Chart 1a. Bend - Temperature Min/Max

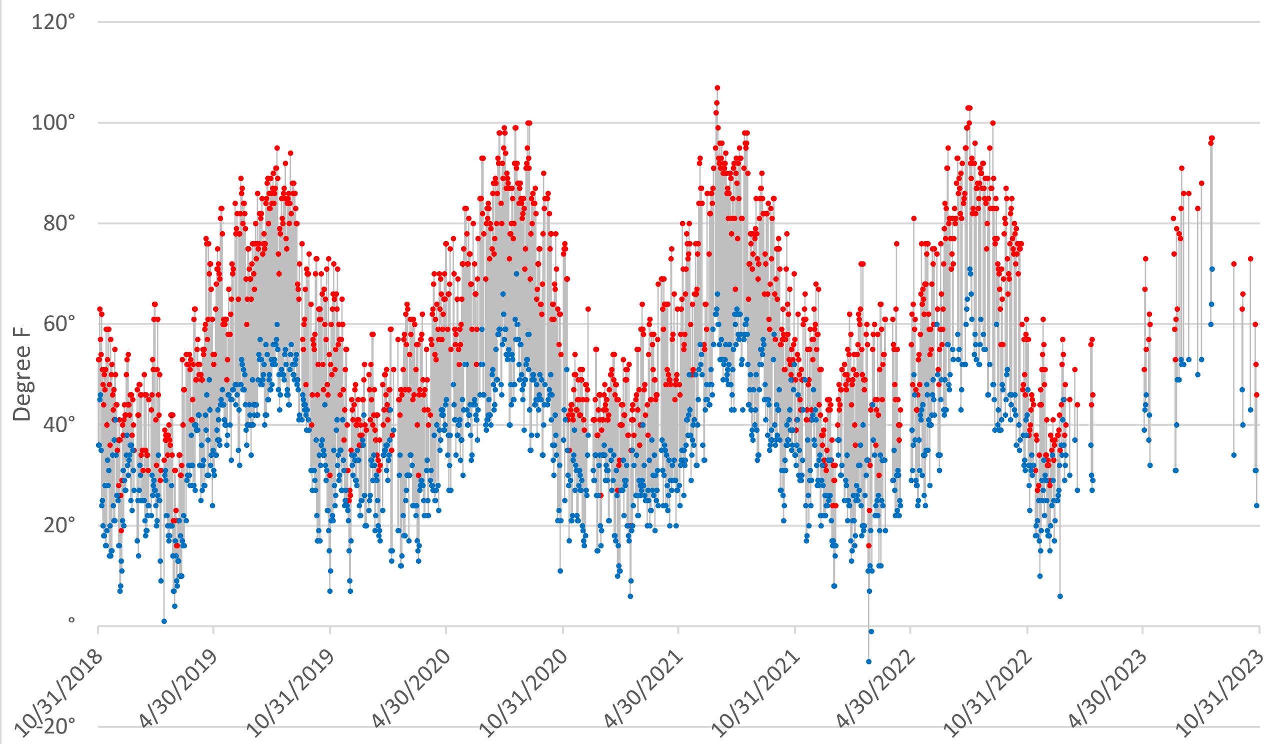
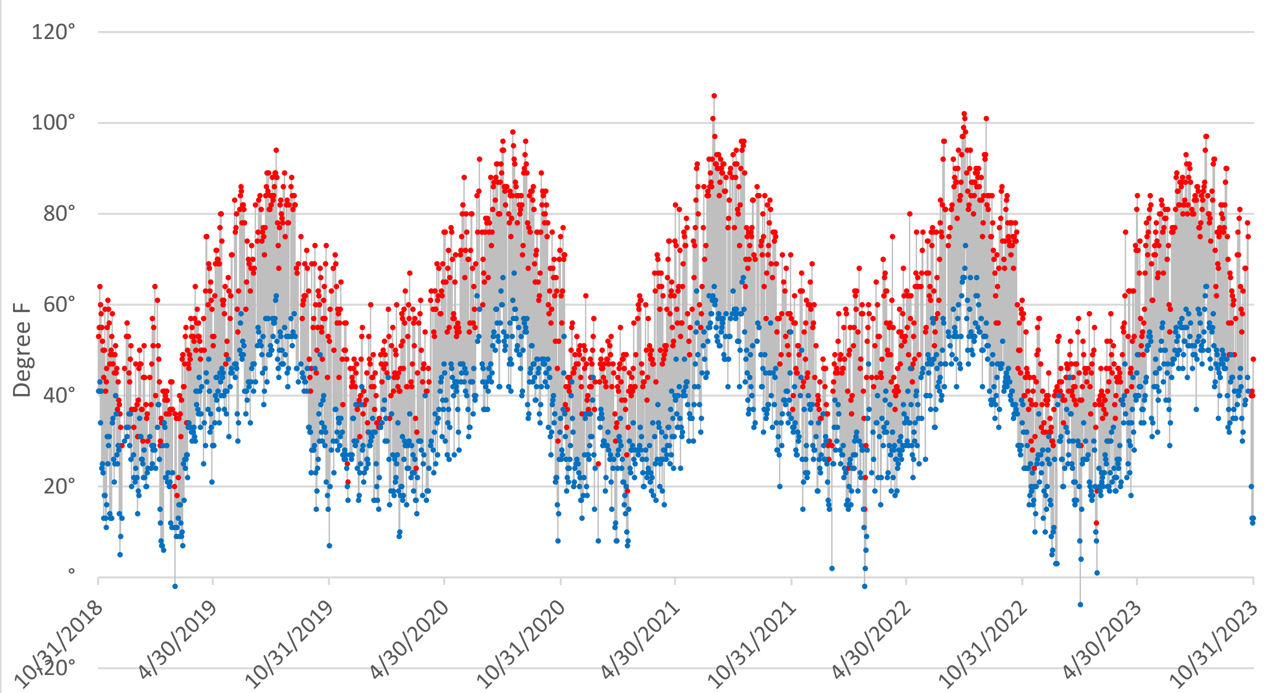


Chart 1b. Bend 7 NE - Temperature Min/Max



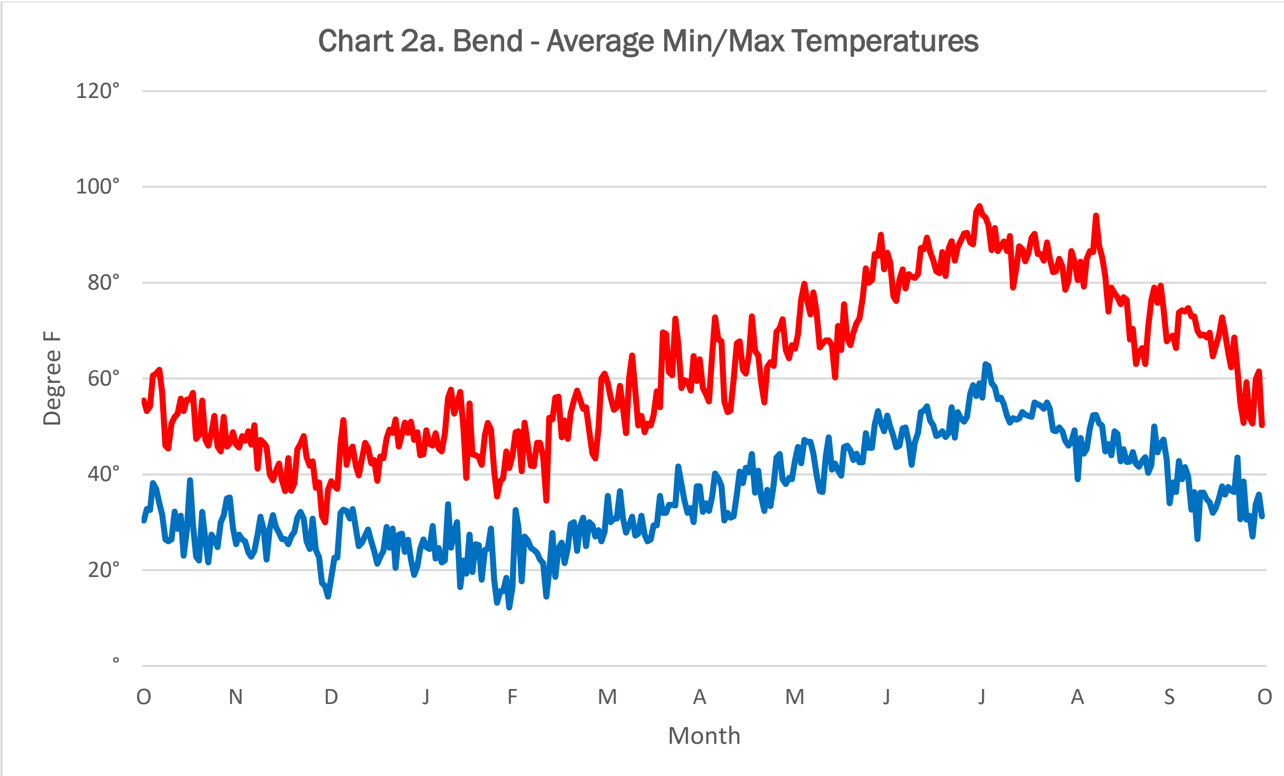


Chart 2a. Bend - Average Min/Max Temperatures

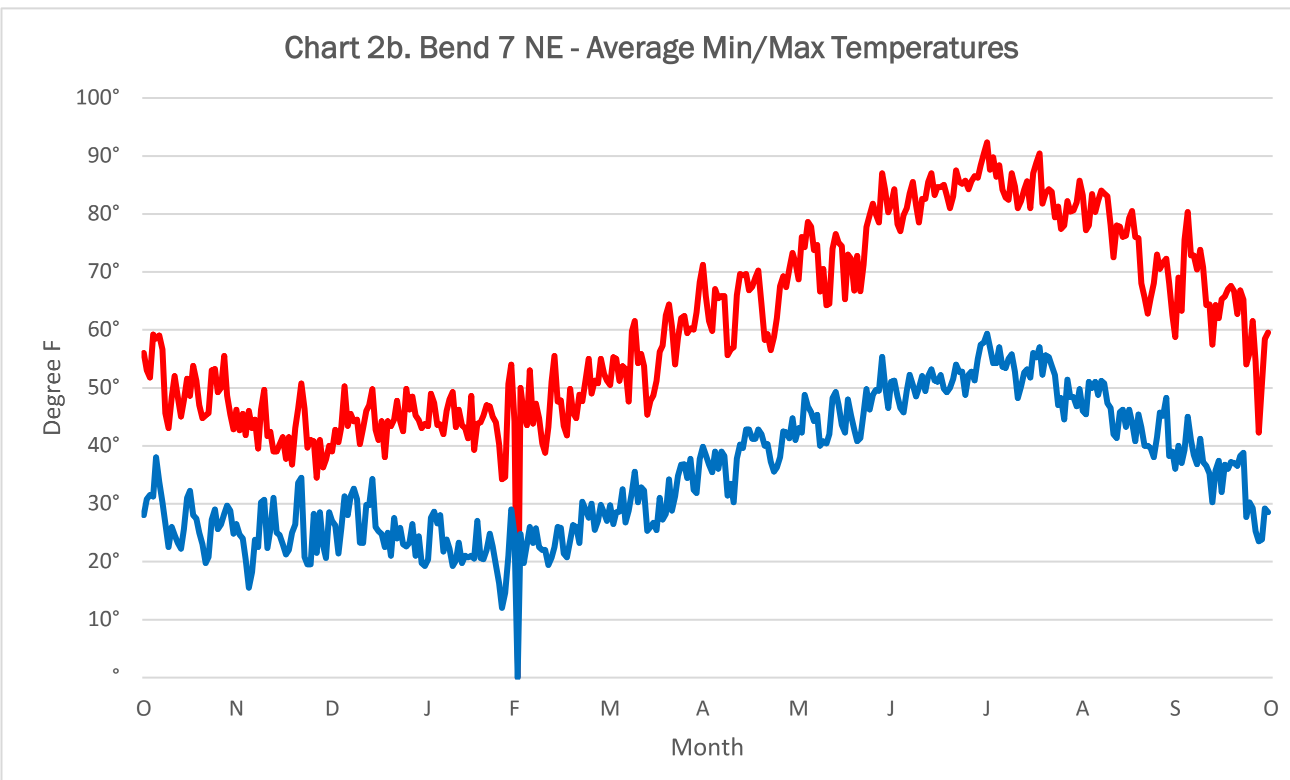
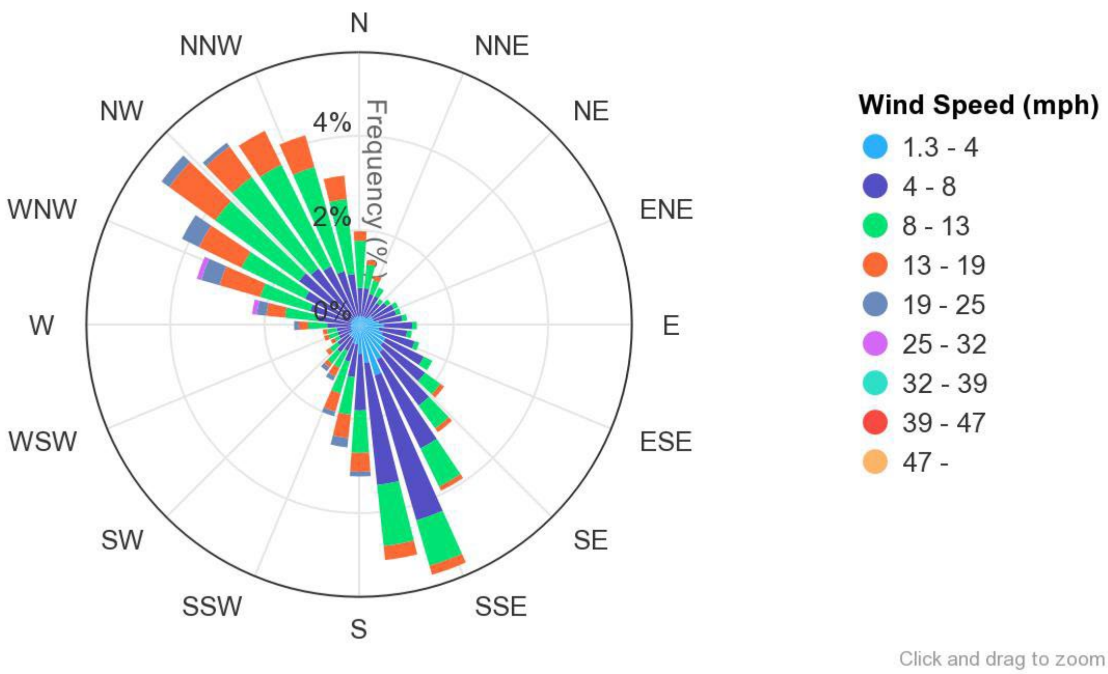


Chart 2b. Bend 7 NE - Average Min/Max Temperatures

The 5-year record of wind speed and direction data from Redmond Roberts Field (Chart 3) is displayed in a wind rose diagram. The wind rose indicates dominant wind directions out of the southeast. Most oftenly occurring wind speeds are between 8 and 13 miles per hour (mph).

Chart 3. Redmond Roberts Field Wind Rose



Wind speed data from stations at EW8160 (Bend) (Chart 4a) and US 20 at Horse Ridge (Chart 4b) for approximately 24 months between 2021 and 2023 are displayed to aid in evaluating conditions in closer proximity to the Moon Pit and Roth East sites. The Moon Pit site is located between these two weather stations, and the Roth East site is located farther east of the Horse Ridge station. These sites provide insight into potential conditions at the two sites. General sustained wind speeds and gusts at the Horse Ridge station are higher than at the EW8160 station indicating that wind conditions at Roth East are likely more intense than at the Moon Pit site, though these station data do not necessarily represent site conditions.

During development and operation of the landfill, an on-site weather station will be located at the site to aid the County in adjusting site activities based on current conditions.

Chart 4a. EW8160 Bend Wind Speed

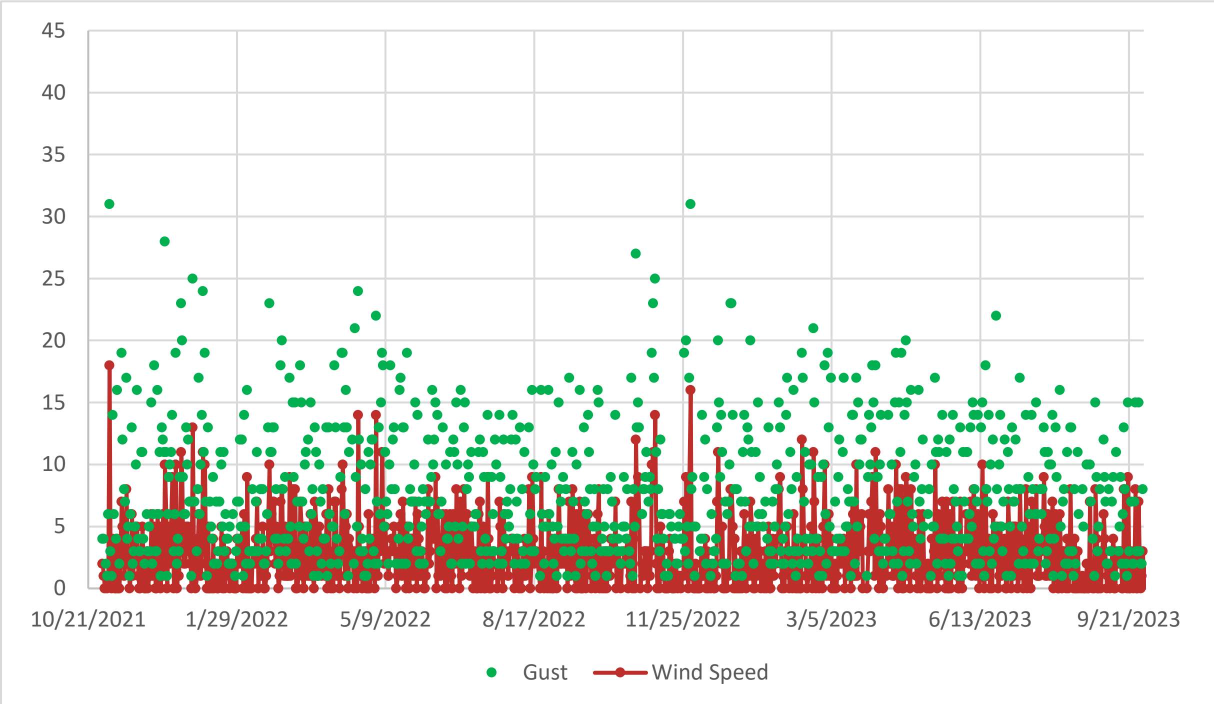
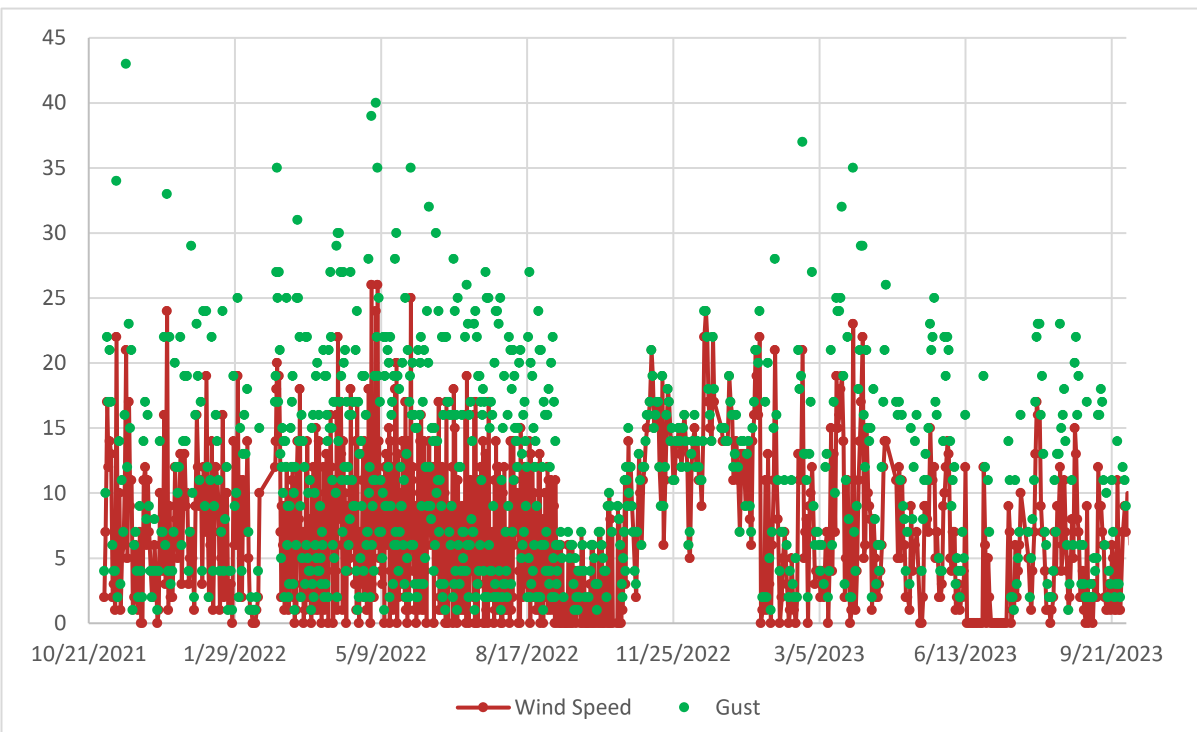
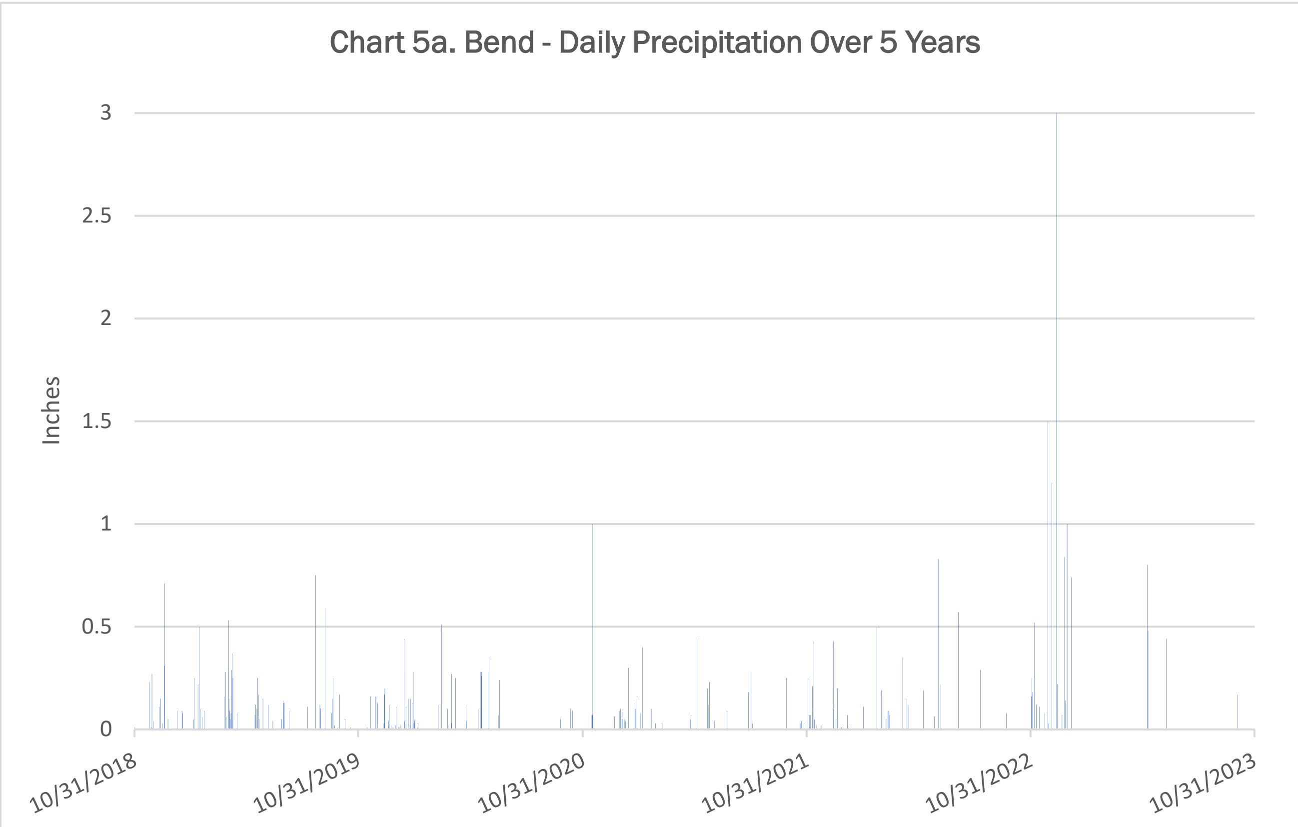


Chart 4b. US 20 at Horse Ridge Wind Speed



The 5-year record of precipitation data collected at the BEND station (Chart 5a) shows 16 precipitation events exceeding 0.5 inches in a day—occurring in fall, winter, and spring. Fewer significant precipitation events occurred during summer. The 5-year record of precipitation data collected at the BEND 7 NE station (Chart 5b) shows seven precipitation events exceeding 0.5 inches in a day—occurring in fall, winter, and spring. Fewer significant precipitation events occurred during summer. Average daily precipitation data collected at the BEND station (Chart 6a) shows 11 daily averages above 0.2 inches and significantly lower averages during summer months. Average daily precipitation data collected at the BEND 7 NE station (Chart 6b) shows two daily averages above 0.2 inches and significantly lower averages during summer months.

Lightning susceptibility in the vicinity of the Moon Pit and Roth East sites is relatively low (a risk index score of 20.7 based on FEMA National Risk Index methodology, https://hazards.fema.gov/nri/lightning).



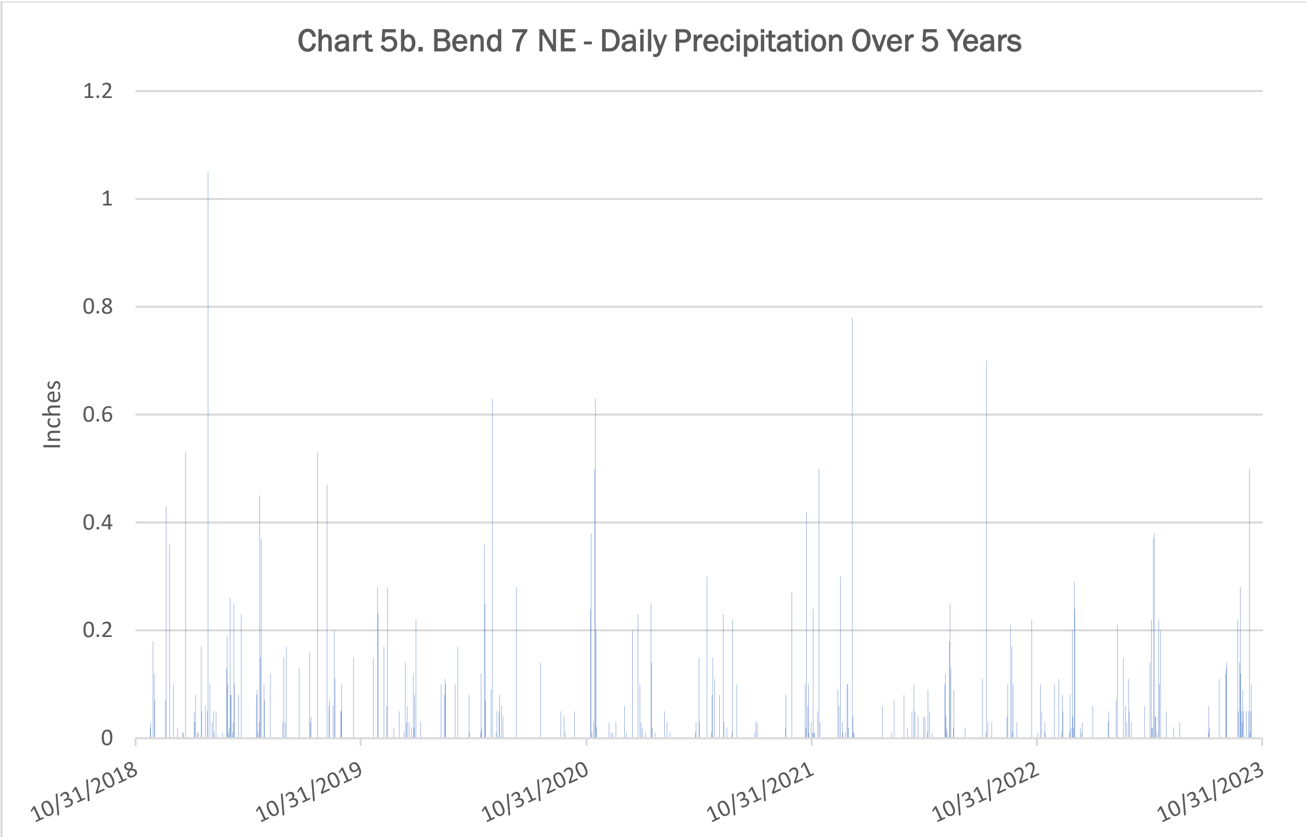


Chart 5b. Bend 7 NE - Daily Precipitation Over 5 Years
Inches
1.2
1
0.8
0.6
0.4
0.2
0
10/31/2018
10/31/2019
10/31/2020
10/31/2021
10/31/2022
10/31/2023

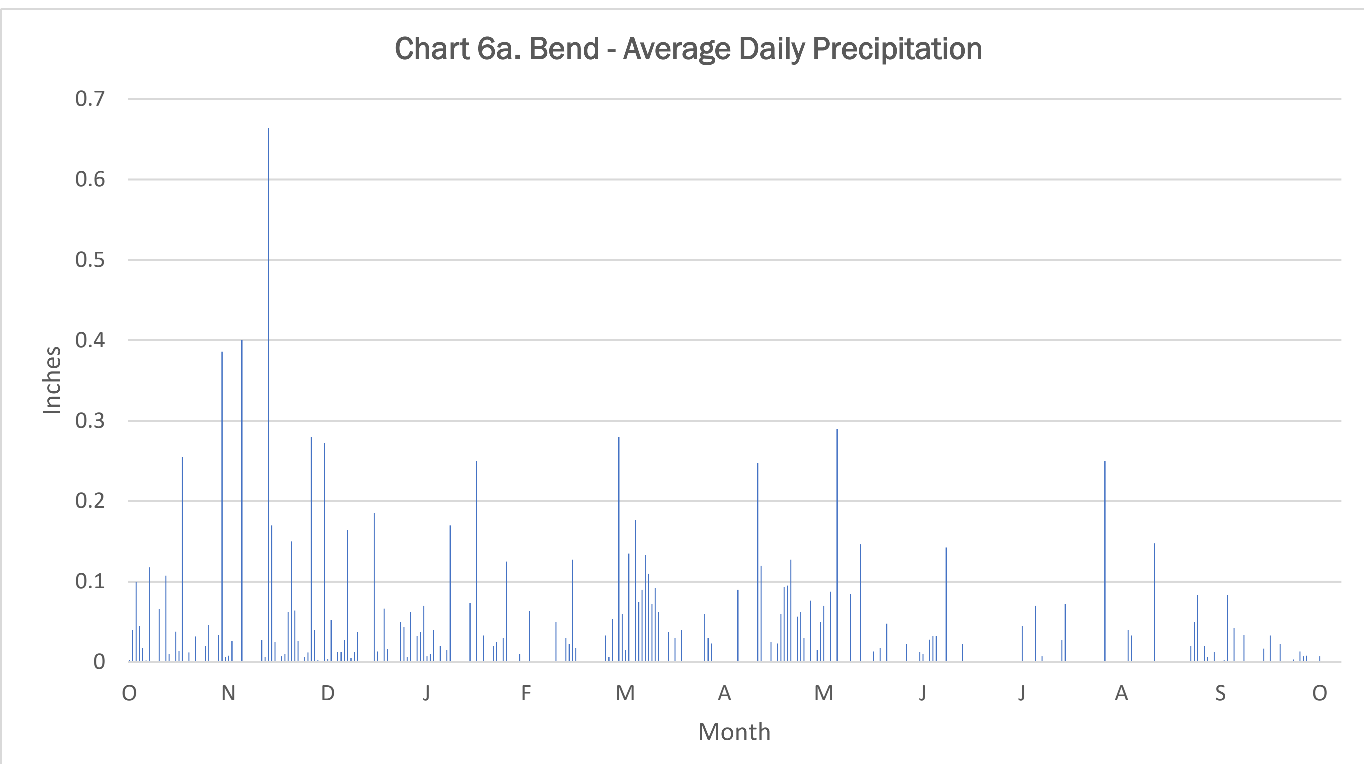
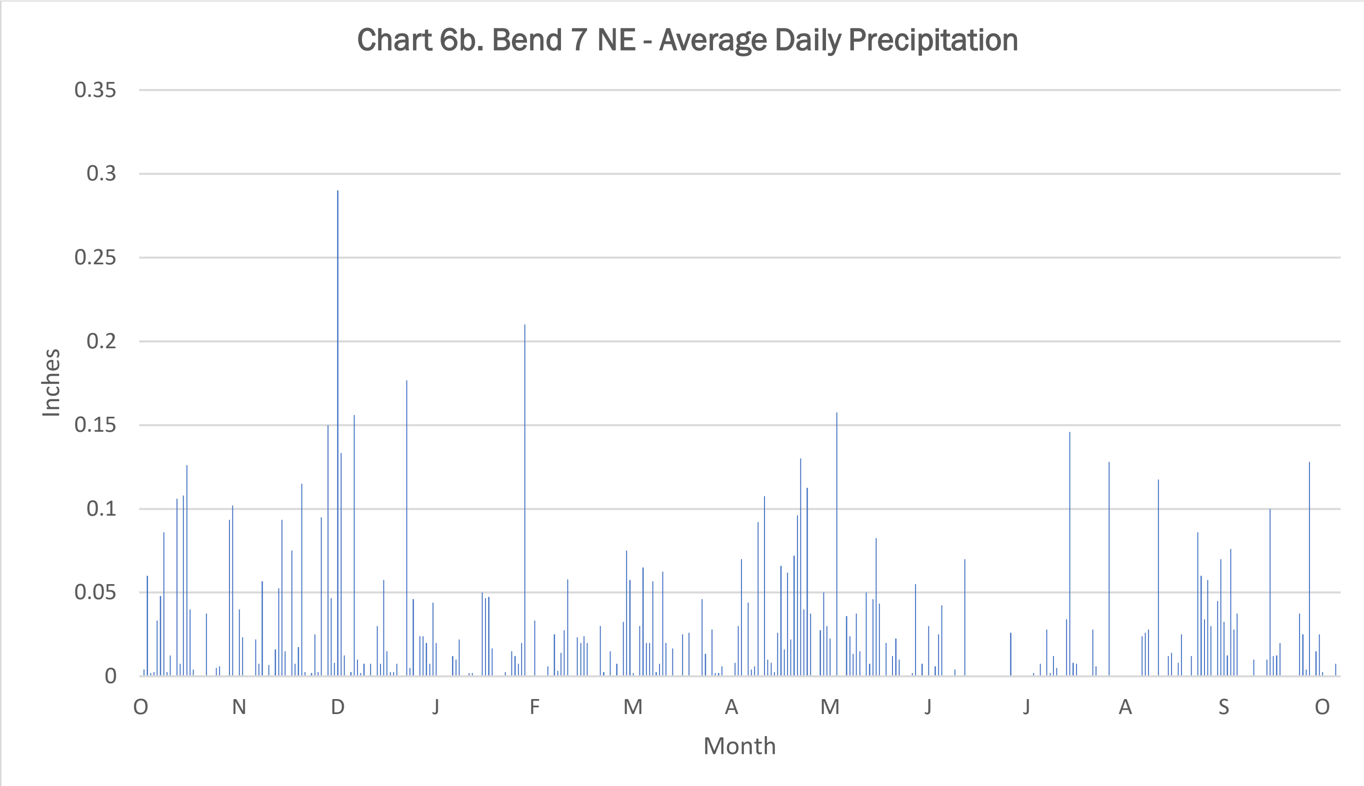


Chart 6a. Bend - Average Daily Precipitation
Inches
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
O N D J F M A M J J A S O
Month



Air Quality Summary

Available relevant air quality data from the past 5 years were downloaded from the Oregon Department of Environmental Quality (DEQ) website (https://oraqi.deq.state.or.us/Report/stationreport). The closest publicly owned air quality monitoring station is located at Prineville Davidson Park (44.299787°N 120.844773°W). Air quality data from this station monitors particulate matter ($PM_{2.5}$) and ozone. $PM_{2.5}$ is atmospheric particulate matter with a diameter less than 2.5 micrometers. Ozone can cause oxidation of electronics and sensitive instruments.

The maximum $PM_{2.5}$ level (Chart 7, 518.1 micrograms per cubic meter [μg/m^3]) measured at the Prineville Davidson Park station was recorded on September 12, 2020. These data were supplemented with $PM_{2.5}$ data from the Bend NE 8th and Emerson station. The maximum $PM_{2.5}$ level (Chart 9, 547.1 micrograms per cubic meter [μg/m^3]) measured at the Bend NE 8th and Emerson station was recorded on August 16, 2021. The spikes in monitored $PM_{2.5}$ are likely associated with large wildfires in Oregon, Washington, and California during those time periods. Local and regional wildfires are generally the largest contributor to spikes in airborne particulates in eastern Oregon.

The maximum ozone level (Chart 8, 39 parts per billion [ppb]) was recorded on September 12, 2020.

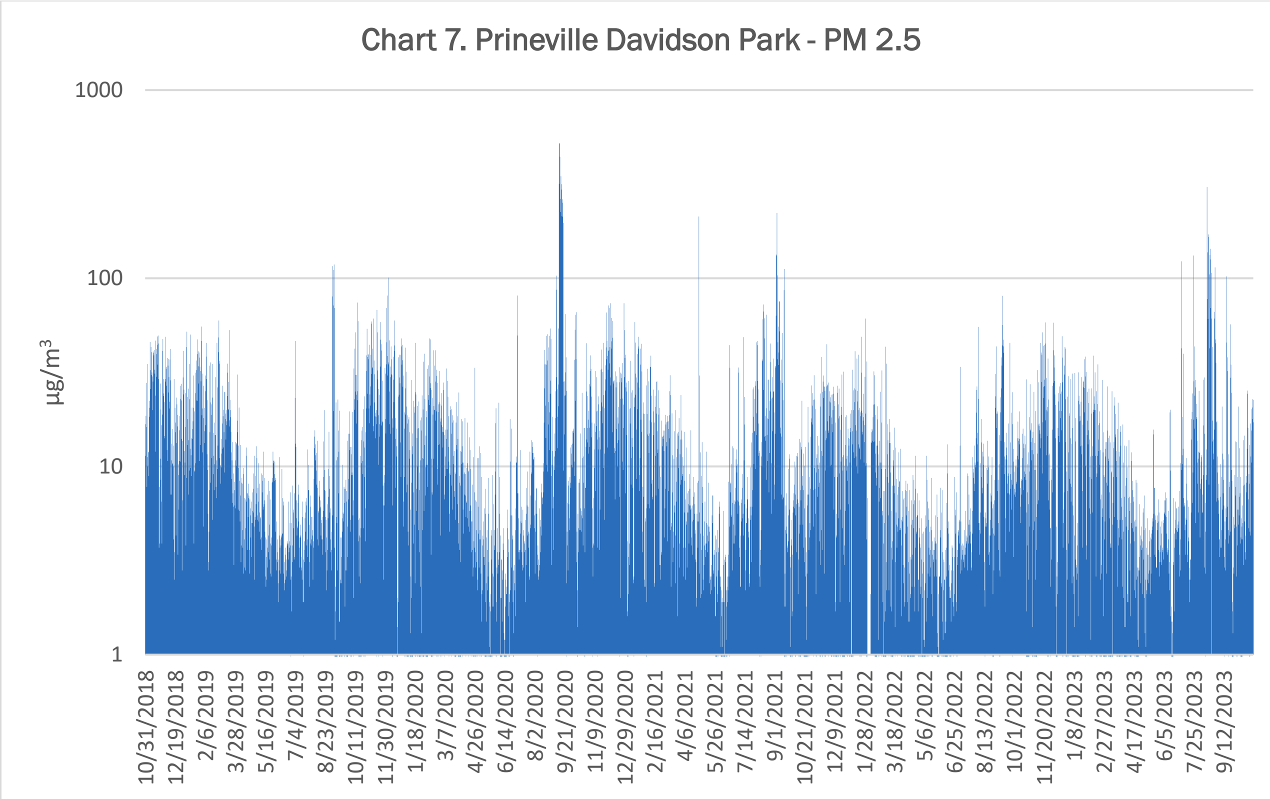


Chart 7. Prineville Davidson Park - PM 2.5
1000
100
10
1
µg/m3
10/31/2018
12/19/2018
2/6/2019
3/28/2019
5/16/2019
7/4/2019
8/23/2019
10/11/2019
11/30/2019
1/18/2020
3/7/2020
4/26/2020
6/14/2020
8/2/2020
9/21/2020
11/9/2020
12/29/2020
2/16/2021
4/6/2021
5/26/2021
7/14/2021
9/1/2021
10/21/2021
12/9/2021
1/28/2022
3/18/2022
5/6/2022
6/25/2022
8/13/2022
10/1/2022
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6/5/2023
7/25/2023
9/12/2023

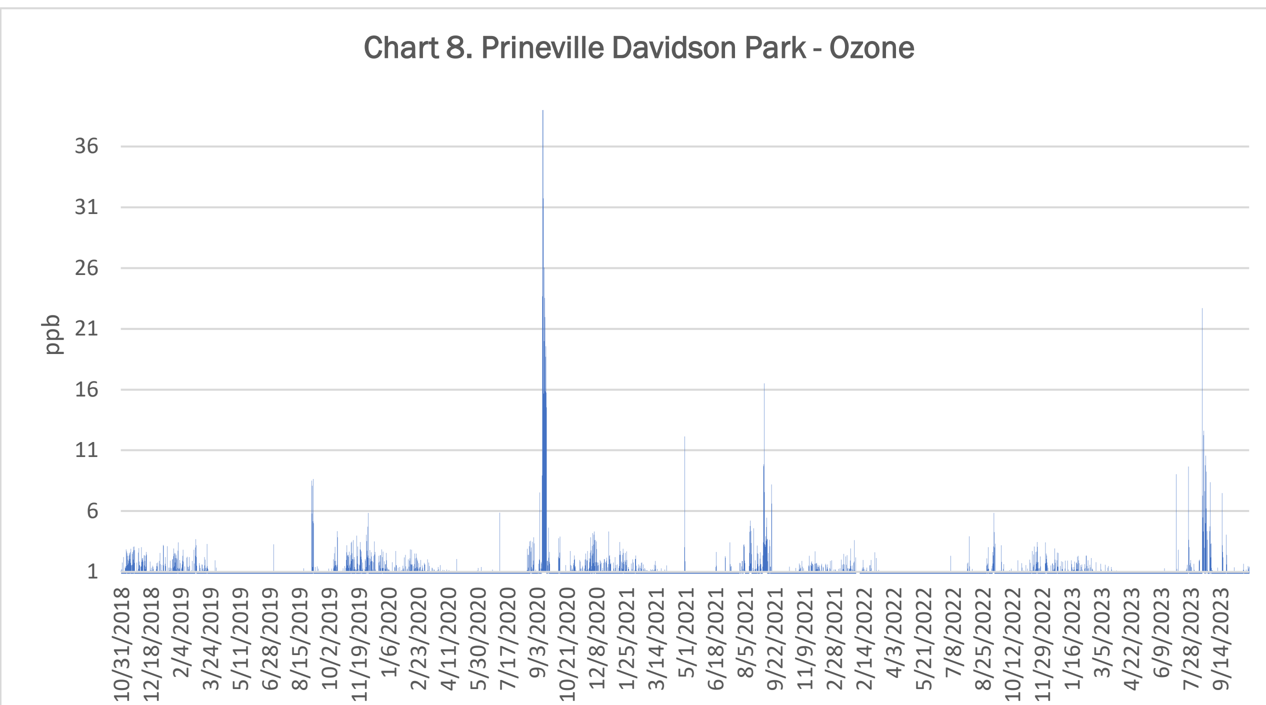
Chart 8. Prineville Davidson Park - Ozone
36
31
26
21
16
11
6
1
ppb
10/31/2018
12/18/2018
2/4/2019
3/24/2019
5/11/2019
6/28/2019
8/15/2019
10/2/2019
11/19/2019
1/6/2020
2/23/2020
4/11/2020
5/30/2020
7/17/2020
9/3/2020
10/21/2020
12/8/2020
1/25/2021
3/14/2021
5/1/2021
6/18/2021
8/5/2021
9/22/2021
11/9/2021
2/28/2021
2/14/2022
4/3/2022
5/21/2022
7/8/2022
8/25/2022
10/12/2022
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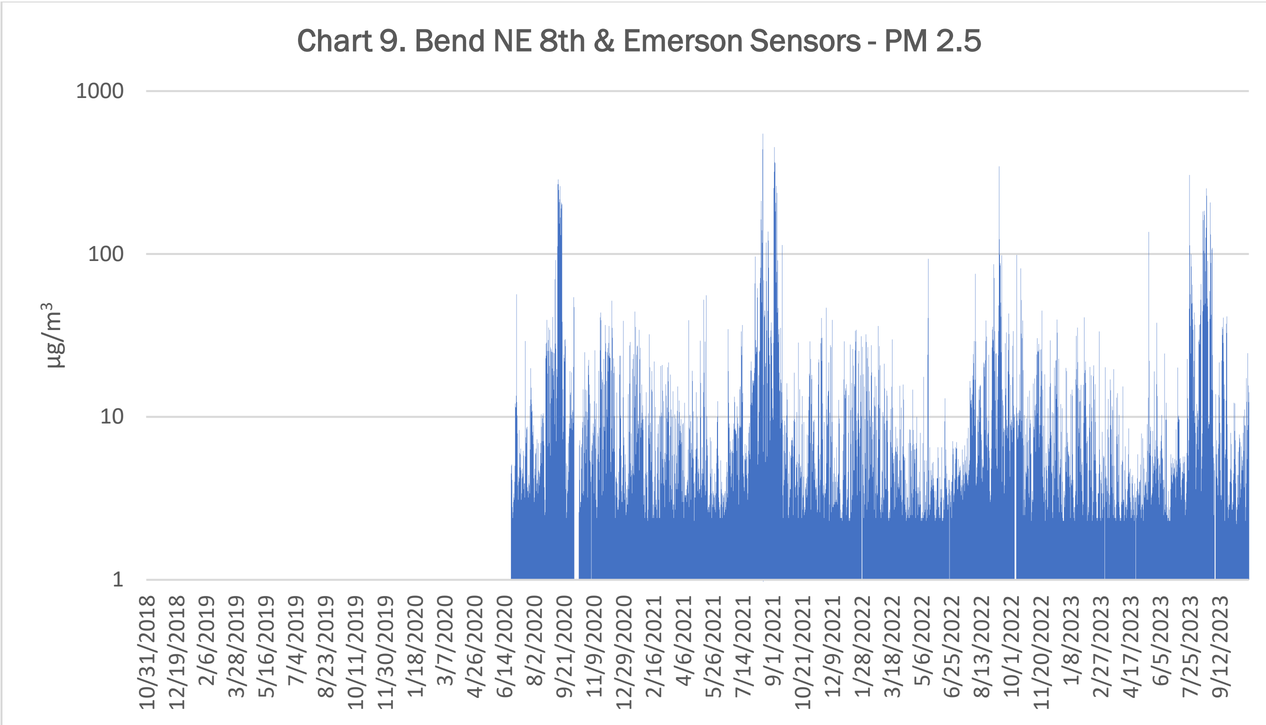
7/28/2023
9/14/2023



Local Air Quality Activities and Impacts

The vicinity of both sites is predominantly vacant, undeveloped land. There are no industrial or power-generating plants within a 3-mile radius of either site that would contribute to areawide air quality conditions.

Wildfire Susceptibility

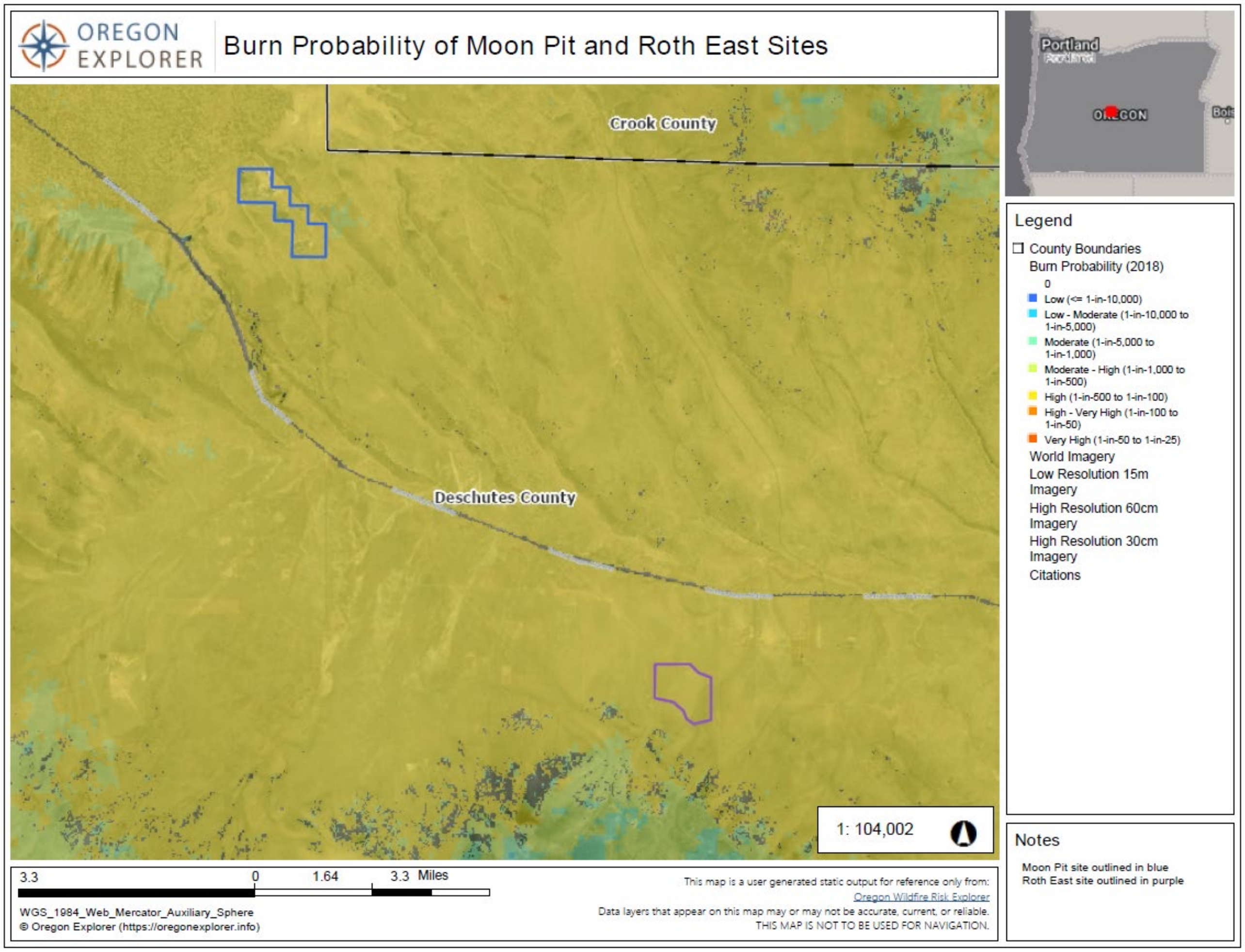
Both the Moon Pit and the Roth East sites have the same burn probability (high, Map 2). As defined by the U.S. Forest Service, burn probability is based on the likelihood of over 250 acres burning at a given location (determined by wildfire simulation modeling). A high probability indicates between 1 in 500 and 1 in 50 chance of a wildfire over 250 acres in a single year. High represents the 29th to 96th percentile of values across the landscape.

For both sites, fire protection measures would be in-place and the selected site is expected to function as a firebreak – relatively devoid of fuel sources - that would interrupt the continuation of wildfires moving near the site.

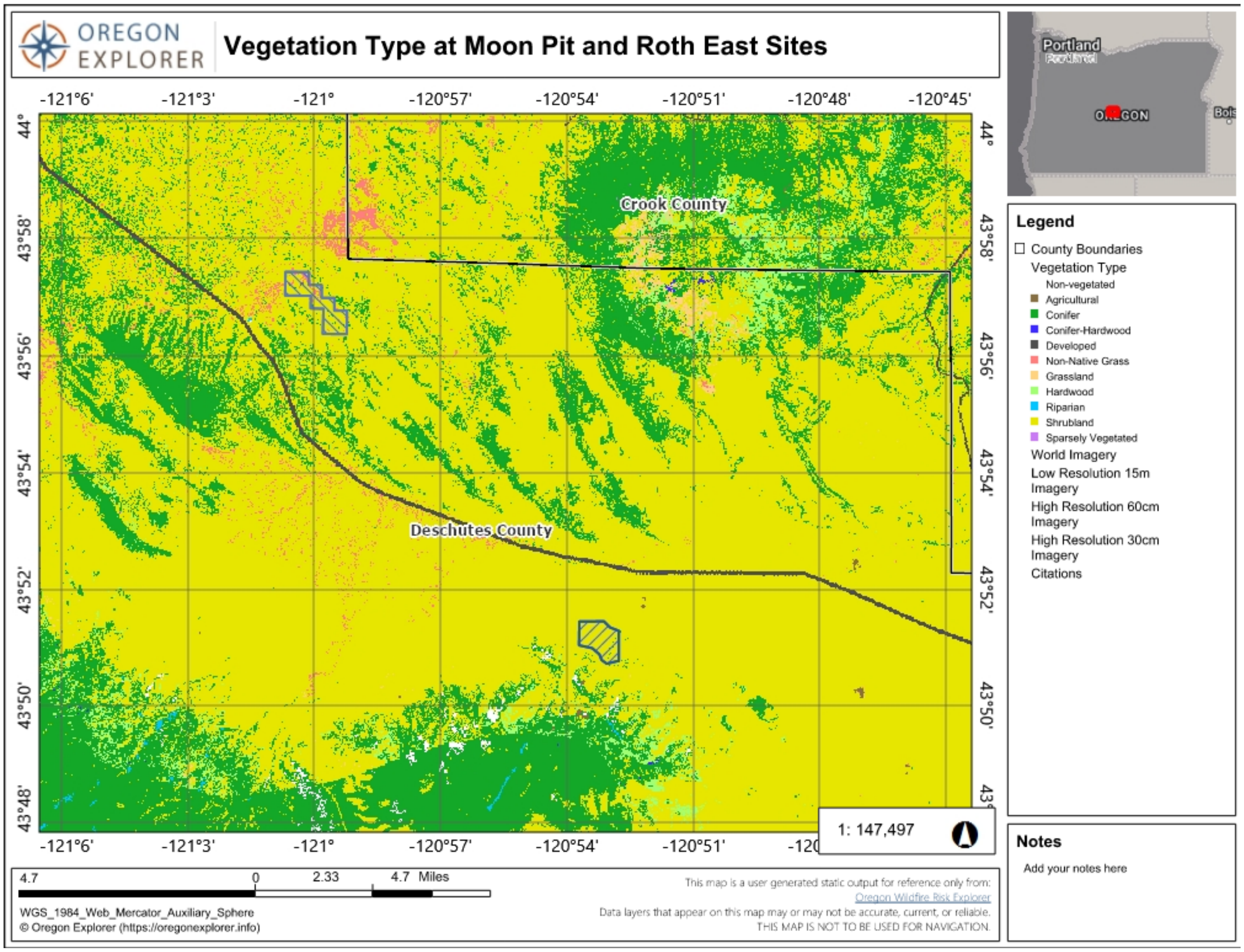
Although mapped as the same overall vegetation type (Map 3), the soils and landforms of the Moon Pit site have low vegetation production potential which limits the accumulation of fuels. Thus, fire events historically have been typically limited to a few trees. Stand replacement, and mixed-severity fire events were infrequent (more than 150 years (Miller et al. 1999, 2005,).

The Roth site has more productive soils supporting sage steppe and more invasive species, especially cheatgrass, that have a higher potential of carrying wildfire. Where there is an abundance of invasive nonnative species such as cheatgrass, areas that used to burn once every 20 to 100 years can now burn every 7.5 to 15 years in sage steppe habitat (USDA 2024). Map 4 shows the frequency of lightning strikes (higher near Moon Pit) and the extent of historical fires (larger near the Roth site), which also suggest that fires near the Moon site are smaller and less-likely to propagate..

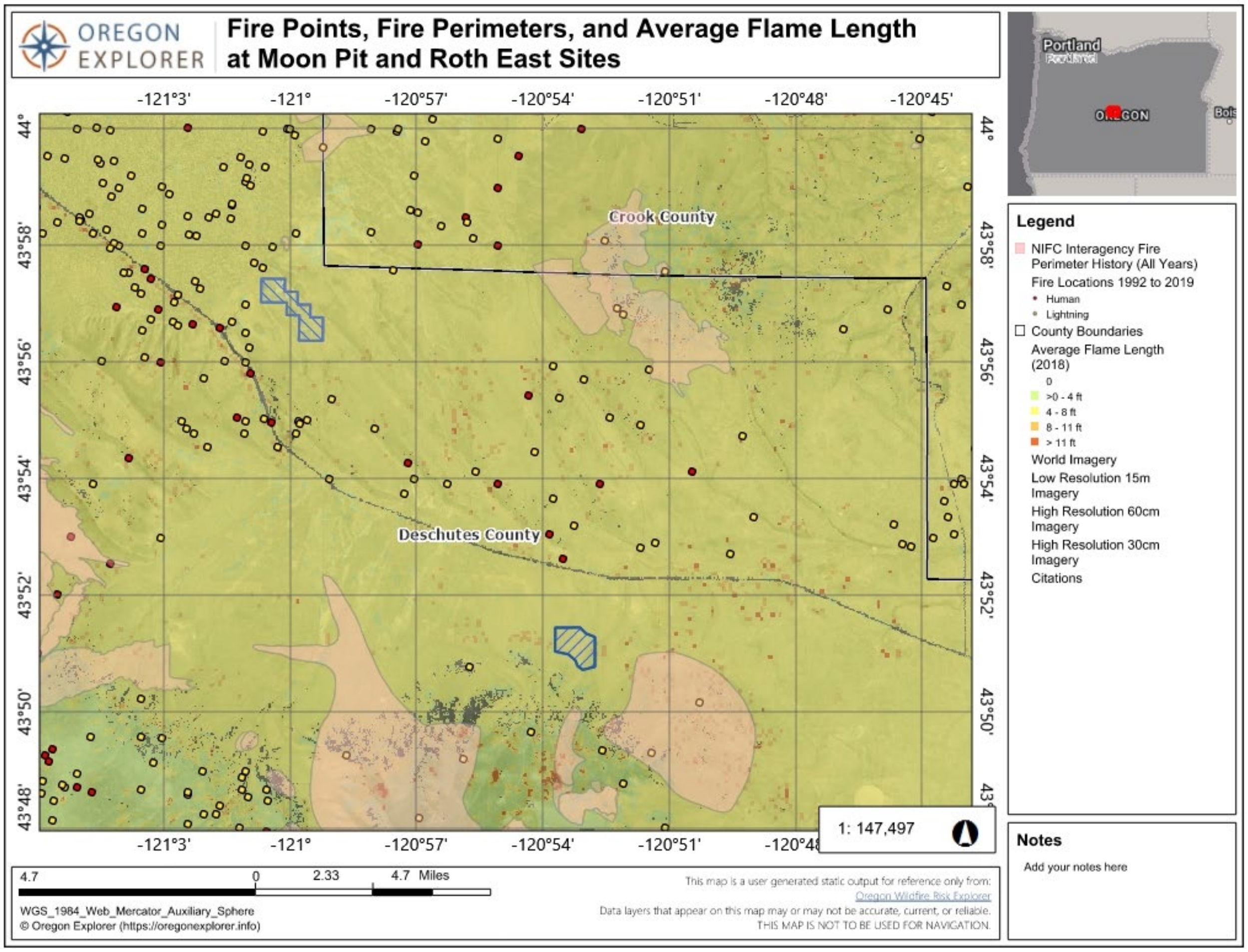
Map 2. Burn Probability of Moon Pit and Roth East Sites



Map 3. Vegetation Type at Moon Pit and Roth East Sites



Map 4. Fire Points, Fire Perimeters, and Average Flame Length at Moon Pit and Roth East Sites



Greenhouse Gas Analysis

Results Summary

Parametrix staff calculated GHG emissions for scenarios involving the haul transportation of municipal solid waste from transfer stations to Moon Pit and Roth East. The baseline fleet transition that was evaluated (diesel to renewable natural gas [RNG] to electric) resulted in a contribution of Moon Pit of ~50,000 MT CO_2e whereas Roth East would generate ~75,000 MT CO_2e of GHG emissions over the 2029 to 2129 time frame. In addition to the base scenario for the two alternative landfill sites, Parametrix calculated emissions given the anticipated clean fuels that would displace current diesel options. The transition to renewable diesel is already underway, and RNG is also a reasonable, present-day option. These fuel transitions would reduce GHG emissions further but also offer opportunities for cost reduction and revenue streams; but they require financial and scenario analysis.

Chart 10. Emissions Profile by Landfill Location and Project Lifetime

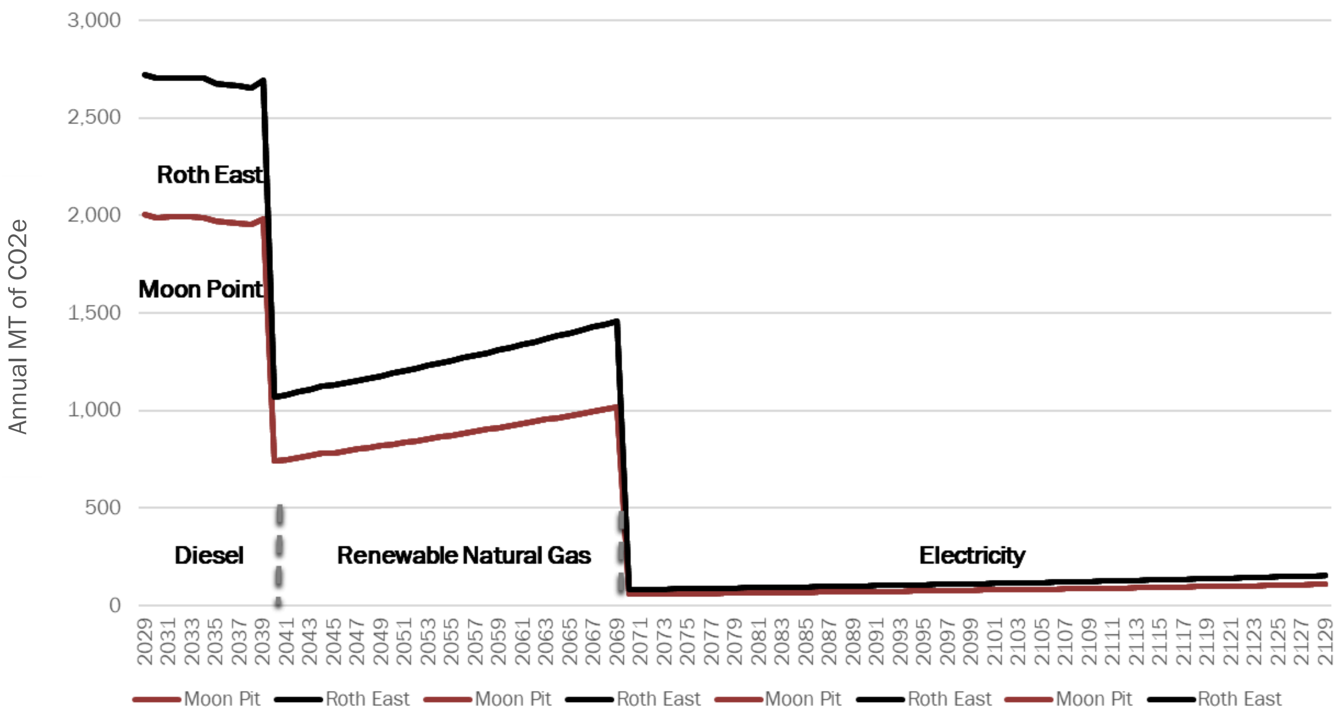


Table 2. Base Scenario Emissions 2029–2129 GHG Emissions (Diesel, Renewable Natural Gas, Electric)

	Moon Pit	Roth East
Diesel (2029-2039)	21,781	29,587
Renewable Natural Gas (2040-2069)	26,185	37,631
Electric (2070-2129)	4,779	6,792
Total (MT CO2e)	52,746	74,010

Cleaner Fuel Pathways

Transitioning from diesel to renewable diesel (RD 99/100) could be the easiest transition as renewable diesel can be used in the existing diesel fleet. Alternatively, RNG has a relatively low carbon intensity (CI); it is higher than renewable diesel but in similar territory. Aside from the RNG environmental benefit, RNG could also leverage a valuable resource from landfill operations. Parametrix recommends assessing how best to optimize the value of landfill gas as there is the tradeoff between using a captive source of fuel versus selling the credit values into different market segments (power generation, transportation fuel, pipeline injection).

Table 3. Emissions 2029-2129 GHG Emissions (Renewable Natural Gas to Electric)

	Moon Pit	Roth East
Renewable Natural Gas (2029-2049)	15,874	22,913
Electric (2050-2129)	8,252	11,824
Total (MT CO2e)	24,126	34,737

Fuel switching is already underway due to financial and regulatory forces. It is nearly certain that electric-powered or green hydrogen refuse haul trucks will become available far before the 2070 timeframe for switching over to these cleaner options. While investor-owned utilities (IOUs) must meet Oregon's Clean Energy Targets (CET) for GHG reductions for electricity generation, consumer-owned utilities such as Central Electric Cooperative (CEC) are not under the same policy requirements yet. For the purposes of this study, the modeling used CEC-specific emissions factors that are reported to DEQ for electricity generation. The relative carbon intensity of CEC (19.22 g CO_2e per mega joule) is lower than the statewide electricity mix (146.02 g CO_2e per mega joule). Parametrix modeled reductions in the CI for CEC with a more conservative timeline than the CET step reductions.

While producing RNG may be functional for the new landfill site, renewable diesel is a drop-in replacement to displace diesel without having to invest in new trucks. Starting with renewable diesel and upgrading to electric or RNG trucks once diesel trucks are at the end of their life will reduce the need for investing in two step changes of fleet transition. *The likely path forward may be a mix of both renewable diesel of the existing fleet and some portion of RNG if on-site production and use is deemed the best approach.*

Table 4. Emissions 2029-2129 GHG Emissions (Renewable Diesel to Electric)

	Moon Pit	Roth East
Renewable Diesel (2029-2039)	13,499	18,894
Electric (2040-2129)	15,948	22,866
Total (MT CO2e)	29,447	41,761

Emissions by Transfer Station

The table below summarizes the apportioned emissions by transfer station to Moon Point and Roth East over the duration of the project period. In addition to other potential scenarios, Parametrix can provide additional detail, if desired, by transfer station.

Table 5. Emissions 2029–2129 by Transfer Station

	Knott Transfer	Negus Transfer	Southwest Transfer	Northwest Transfer	Alfalfa Transfer	Water Truck	Total
Moon Pit (MT CO_2e)	31,733	14,668	4,708	1,615	22	-	52,746
Roth East (MT CO_2e)	47,621	18,193	3,961	1,979	23	2,233	74,010

Methodology

Parametrix was provided the following data:

- Projected miles to be traveled from each facility to each landfill site
- Projected annual solid waste weight (wet short tons)
- Range of current fleet truck fuel efficiency (miles/gallon)
- Average truck capacity (tons/load)

Annual miles were divided by miles per gallon and multiplied by the heat content of fuel to determine annual fuel use in mega joules. The heat content was calculated using heat contents from the Alternative Fuels Data Center. Well-to-wheel carbon intensity factors were used as specified by DEQ to calculate the annual GHG emissions from transporting municipal solid waste in each scenario. These factors are listed in Table 6 for diesel, RNG, renewable diesel, and electricity.

Table 6. Carbon Intensity – Lifecycle Emissions of Fuels (Oregon Clean Fuels Program, Oregon DEQ 2024)

Fuel	g CO2e/MJ
Diesel	100.7
Renewable Natural Gas	47.6
Renewable Diesel	34.8
Biodiesel	33.9
Electricity	19.2
Electricity (2040)	15.4
Electricity (2050)	9.6
Electricity (2070)	3.8
Electricity (2090)	0.0

* Note: Electric Efficiency Ratio (EER) or Electric Vehicle Efficiency Ratio (EVER) is 1.8 times and 3.4 times more efficient than an internal combustion engine for heavy duty trucks and light duty vehicles, respectively. This factor of 1.8 is included in the GHG analysis for heavy duty trucks.

References

Miller and Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management 52:550-559.

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