Missouri Department of Natural Resources

***Buoyant Line Sources***

Buoyant line sources are typically used to characterize fugitive releases from aluminum reduction facilities whose emissions are dispersed from low level, parallel line sources. The reduction of raw alumina is a complex industrial process where aluminum is produced in cells (pots) through electrolytic reduction. The buildings where the electrolytic cells are located are often referred to as potrooms. Each potroom may contain several cells arranged in rows known as potlines. An aluminum reduction facility can have several potline buildings that are configured parallel to one another. A portion of the emissions are captured in hoods above the cells and vented through nearby stacks. The remainder of the emissions, however, escape from a continuous vent that often spans the length of the potline building, refer to Figure 1, entitled "Aluminum Reduction Facility Potline Building."

**Figure 1**
**Aluminum Reduction Facility Potline Building**

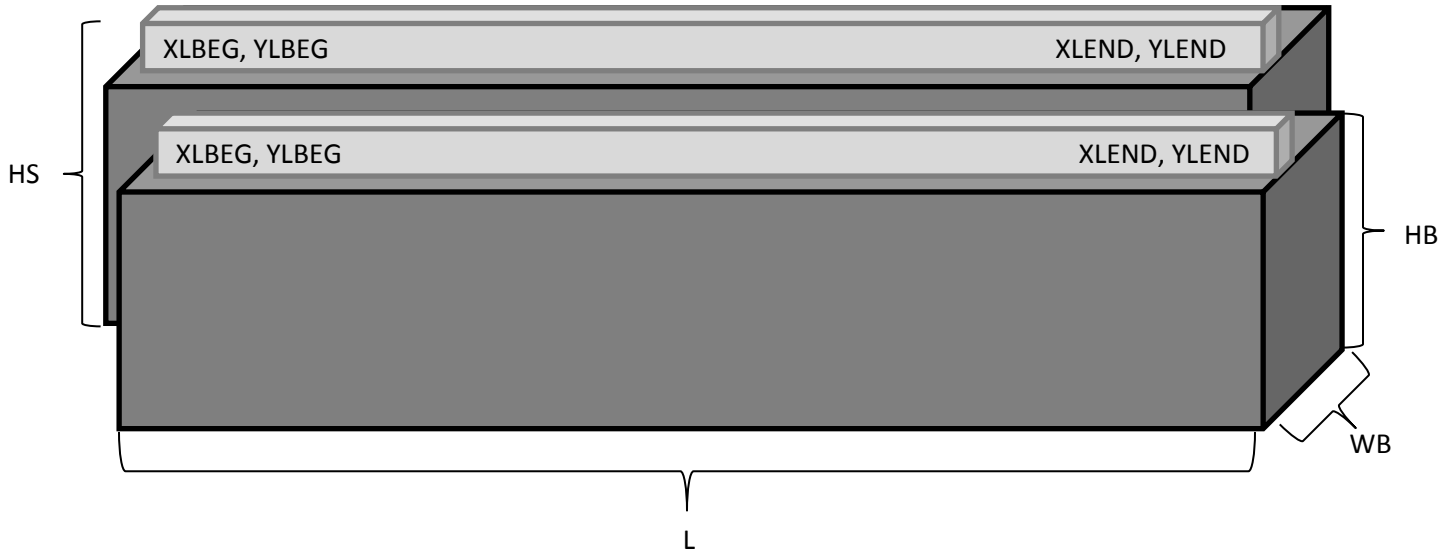
***Buoyant Line Sources***

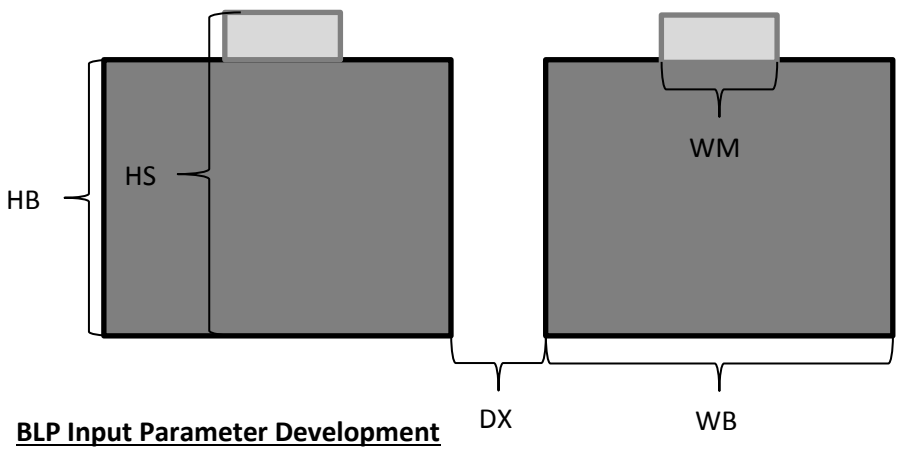
This type of release can experience enhanced plume rise and may be subject to building downwash effects. To address these unique source release parameters, the Aluminum Association retained Environmental Research & Technology, Inc. in the early 1980's to develop an air quality dispersion model that could be used to determine air quality impacts from aluminum reduction facilities. The final product, the buoyant line and point source (BLP) dispersion model, underwent numerous field studies and wind tunnel experiments and has been declared the guideline model for aluminum reduction facilities by the Environmental Protection Agency.

The BLP model plume rise formulation assumes that each line source is equally spaced, with identical heights, widths, buoyancy parameters and line lengths. This assumption was incorporated into the model to allow for the input of multiple line source releases where the plume rise could be enhanced due to plume interactions and the presence of adjacent buildings that could block entrainment of ambient air.

In order for the BLP model to calculate the plume rise associated with the release of fugitive potline emissions, the user must input the release parameters that describe the characteristics of source being modeled. At a minimum, the user must provide the following data for each line source that is being considered: the location of the line source endpoints, the base elevation of the line source, the line source release height and the pollutant emission rate. In addition, the user must provide the distance between buildings, the length and width of the line source, the length and width of each building and an average buoyancy parameter.

The dimensions of each line source should be based upon the spacing between each parallel potline building and the physical characteristics of each potline release. The syntax, type and units of measure for input into the BLP model are summarized below:






**BLP Input Parameter Development**

Table 1 contains the source parameters that are required inputs into the BLP dispersion model for buoyant line sources. In addition, the applicant is also required to calculate the average buoyancy parameter FPRIME, which is also a required input into the BLP model.

**Table 1**
**BLP Input Parameter Development**

| ***Input Parameter Variable*** | ***Input Parameter Description*** | ***Units of Measure*** |
|---|---|---|
| Source I.D. | Emission unit identifier. | Not Applicable |
| Source Description | Application description. | Not Applicable |
| XLBEG | X-coordinate of the beginning of line source. | Meters |
| YLBEG | Y-coordinate of the beginning of line source. | Meters |
| XLEND | X-coordinate of the end of line source. | Meters |
| YLEND | Y-coordinate of the end of line source. | Meters |
| LELEV | Line source base elevation | Meters |
| QT | Pollutant emission rate of the line source. | Grams/Second |
| HS | Release height of the line source. | Meters |
| L | Average building length. | Meters |
| HB | Average building height. | Meters |
| WB | Average building width. | Meters |
| WM | Average line source width. | Meters |
| DX | Average building separation | Meters |
| FPRIME | Calculated buoyancy parameter. | $m^4/s^3$ |

With the exception of FPRIME, all of the input parameters contained within Table 1 can be obtained from the facility site or plans for the site design. FPRIME, however, is a calculated input parameter based upon the following equation:

$$FPRIME = \frac{g * L * W_m * w * (T_s - T_a)}{Ts}$$

Where:

FPRIME = Average line source buoyancy parameter ($m^4/s^3$)
g = Acceleration of gravity (9.81 $m/s^2$)
L = Line source length (meters)
$W_m$ = Line source width (meters)
w =Exit velocity (meters/second)
$T_s$ = Exit temperature (degrees Kelvin)
$T_a$ = Ambient temperature (degrees Kelvin)

For multiple line sources, the buoyancy parameter should be calculated for each line source and then averaged to obtain FPRIME for model input.

**BLP Input Parameter Development Example Problem**

An example buoyant line source input parameter determination is given below. Figure 2, entitled "BLP Input Parameter Example," provides a visual depiction of the potlines used in the example. Table 2, entitled "Example BLP Input Parameter Development" provides the BLP input parameters based upon a fictional aluminum reduction facility.

FPRIME was calculated using the equation above and was averaged across the potlines depicted in Figure 2. All of the example inputs are fictional and do not represent any particular facility or location within the State of Missouri.

**Figure 2**
**BLP Input Parameter Example**

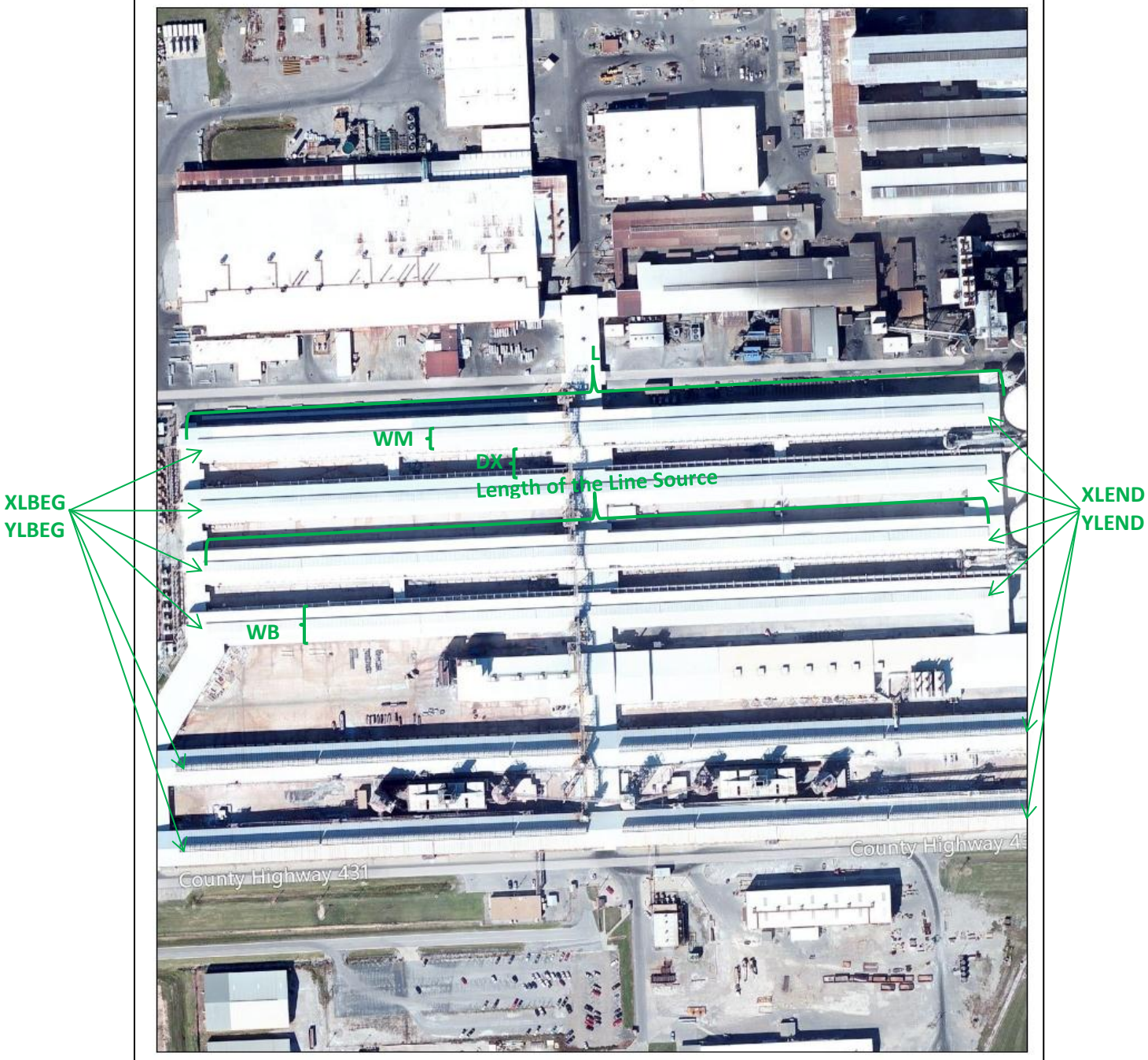


**Table 2**
**Example BLP Input Parameter Development**

| Source I.D. | Description | XLBEG | YLBEG | XLEND | YLEND | Base Elevation | Release Height |
|---|---|---|---|---|---|---|---|
| | | (Meters) | (Meters) | (Meters) | (Meters) | (Meters) | (Meters) |
| Pot1 | Potline #1a | 807360.5 | 4045783.1 | 807878.2 | 4045787.8 | 95.4 | 18.5 |
| Pot2 | Potline #1b | 807360.5 | 4045835.5 | 807878.2 | 4045840.2 | 95.2 | 18.5 |
| Pot3 | Potline #2a | 807401.8 | 4045922.0 | 807908.5 | 4045927.9 | 95.1 | 20.5 |
| Pot4 | Potline #2b | 807401.8 | 4045962.6 | 807908.5 | 4045968.6 | 95.2 | 20.5 |
| Pot5 | Potline #3a | 807401.8 | 4046001.3 | 807908.5 | 4046007.2 | 92.2 | 22.0 |
| Pot6 | Potline #3b | 807401.8 | 4046041.9 | 807908.5 | 4046047.8 | 92.5 | 22.0 |

| Input Variable | Average | Line #1 | Line #2 | Line #3 | | |
|---|---|---|---|---|---|---|
| Building Length (L) | 457.33 | 427.0 | 435.0 | 510.0 | | |
| Building Height (HB) | 20.33 | 18.5 | 20.5 | 22.0 | | |
| Building Width (WB) | 18.67 | 18.0 | 18.0 | 20.0 | | |
| Line Source Width (WM) | 5.67 | 6.0 | 6.0 | 5.0 | | |
| Line Source Length | 450.33 | 420 | 428 | 503 | | |
| Building Separation (DX) | 18.167 | 17.5 | 17.5 | 19.5 | | |
| Gravity | | 9.81 | 9.81 | 9.81 | | |
| Exit Velocity | | 0.691 | 0.691 | 0.691 | | |
| Stack Temperature | | 350.0 | 350.0 | 400.0 | | |
| Ambient Temperature | | 293.0 | 293.0 | 293.0 | | |
| Buoyancy Parameter (FPRIME)* | 3410.14 | 2834.97 | 2834.972 | 4560.46 | | |

*FPRIME calculated for each potline and averaged.