**OPEN BURNING - LAND CLEARING DEBRIS**

***a. Source Category Description***

Open burning of land clearing debris is the purposeful burning of debris, such as trees, shrubs, and brush, from the clearing of land for the construction of new buildings and highways. Criteria air pollutant (CAP) and hazardous air pollutant (HAP) emission estimates from open burning of land clearing debris are a function of the amount of material or fuel subject to burning per year.

For this source category, the following SCC was assigned:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCC** | **SCC Level 1** | **SCC Level 2** | **SCC Level 3** | **SCC Level 4** |
| 2610000500 | Waste Disposal, Treatment, and Recovery | Open Burning | All Categories | Land Clearing Debris (use 28-10-005-000 for Logging Debris Burning) |

***b. Activity Data***

The amount of material burned was estimated using the county-level total number of acres disturbed by residential, non-residential, and road construction. County-level weighted loading factors were applied to the total number of construction acres to convert acres to tons of available fuel.

Acres Disturbed from Residential Construction

The US Census Bureau has 2010 data for *Housing Starts - New Privately Owned Housing Units Started1* which provides regional level housing starts based on the groupings of 1 unit, 2-4 units, 5 or more units. A consultation with the Census Bureau in 2002 gave a breakdown of approximately 1/3 of the housing starts being for 2 unit structures, and 2/3 being for 3 and 4 unit structures. The 2-4 unit category was divided into 2-units, and 3-4 units based on this ratio. To determine the number of structures for each grouping, the 1 unit category was divided by 1, the 2 unit category was divided by 2, and the 3-4 unit category was divided by 3.5. The 5 or more unit category may be made up of more than one structure. *New Privately Owned Housing Units Authorized Unadjusted Units*2 gives a conversion factor to determine the ratio of structures to units in the 5 or more unit category. For example if a county has one 40 unit apartment building, the ratio would be 40/1. If there are 5 different 8 unit buildings in the same project, the ratio would be 40/5. Structures started by category are then calculated at a regional level. The table *Annual Housing Units Authorized by Building Permit3* has 2010 data at the county level to allocate regional housing starts to the county level. This results in county level housing starts by number of units. The following surface areas were assumed disturbed for each unit type:

**Table 1: Surface Acres Disturbed per Unit Type**

|  |  |
| --- | --- |
| 1-Unit | 1/4 acre/structure |
| 2-Unit | 1/3 acre/structure |
| Apartment | 1/2 acre/structure |

The 3-4 unit and 5 or more unit categories were considered to be apartments. Multiplication of housing starts to surface acres disturbed results in total number of acres disturbed for each unit category.

Acres Disturbed from Non-Residential Construction

*Annual Value of Construction Put in Place in the U.S4* has the 2011 National Value of Non-residential construction. The national value of non-residential construction put in place (in millions of dollars) was allocated to counties using county-level non-residential construction (NAICS Code 2362) employment data obtained from *County Business Patterns*5 *(CBP)*. Because some county employment data was withheld due to privacy concerns, the following procedure was adopted:

1. State totals for the known county level employees were subtracted from the number of employees reported in the state level version of CBP. This results in the total number of withheld employees in the state.
2. A starting estimate of the midpoint of the range code was used (so for instance in the 1-19 employees’ range, an estimate of 10 employees would be used) and a state total of the withheld counties was computed.
3. A ratio of estimated employees (Step 2) to withheld employees (Step 1) was then used to adjust the county level estimates up or down so the state total of adjusted guesses should match state total of withheld employees (Step 1)

In 1999 a figure of 2 acres/$106 was developed. The Bureau of Labor Statistics *Producer Price Index6* lists costs of the construction industry from 1999-11

2011 acres per $106 = 1999 acres per $106 x (1999 PPI / 2011 PPI)

= 2 acres/$106 (132.9 / 229.3)

= 1.159 acres per $106

Acres Disturbed by Road Construction

The Federal Highway Administration provides data on spending by state in several different categories of road construction and maintenance in *Highway Statistics, Section IV - Highway Finance, Table SF-12A, State Highway Agency Capital Outlay7* for 2008. (Note that this table has not been available in subsequent versions of *Highway Statistics*. Thus, 2008 is the latest data currently available.) For this SCC, the following sets of data (or columns) are used: New Construction, Relocation, Added Capacity, Major Widening, and Minor Widening. Each of these data sets are also differentiated according to the following six roadway classifications:

1. Interstate, urban

2. Interstate, rural

3. Other arterial, urban

4. Other arterial, rural

5. Collectors, urban

6. Collectors, rural

The State expenditure data are then converted to new miles of road constructed using $/mile conversions obtained from the North Carolina Department of Transportation (NCDOT) in 2000. A conversion of $4 million/mile was applied to the interstate expenditures. For expenditures on other arterial and collectors, a conversion factor of $1.9 million/mile was applied, which corresponds to all other projects.

The new miles of road constructed are used to estimate the acreage disturbed due to road construction. The total area disturbed in each state was calculated by converting the new miles of road constructed to acres using an acres disturbed/mile conversion factor for each road type as given in Table 2 below:

**Table 2: Spending per Mile and Acres Disturbed per Mile by Highway Type**

|  |  |  |
| --- | --- | --- |
| **Road Type** | **Thousand Dollars per mile** | **Acres Disturbed per mile** |
| Urban Areas, Interstate | 4000 | 15.2 |
| Rural Areas, Interstate | 4000 | 15.2 |
| Urban Areas, Other Arterials | 1900 | 15.2 |
| Rural Areas, Other Arterials | 1900 | 12.7 |
| Urban Areas, Collectors | 1900 | 9.8 |
| Rural Areas, Collectors | 1900 | 7.9 |

County-level building permits data are used to allocate the state-level acres disturbed by road construction to the county.8 A ratio of the number of building starts in each county to the total number of building starts in each state was applied to the state-level acres disturbed to estimate the total number of acres disturbed by road construction in each county.

Converting Acres Disturbed to Tons of Land Clearing Debris Burned

Version 2 of the Biogenic Emissions Land cover Database (BELD2) within EPA’s Biogenic Emission Inventory System (BEIS) was used to identify the acres of hardwoods, softwoods, and grasses in each county. Table 3 presents the average fuel loading factors by vegetation type. The average loading factors for slash hardwood and slash softwood were adjusted by a factor of 1.5 to account for the mass of tree that is below the soil surface that would be subject to burning once the land is cleared.9 Weighted average county-level loading factors were calculated by multiplying the average loading factors by the percent contribution of each type of vegetation class to the total land area for each county.

**Table 3. Fuel Loading Factors by Vegetation Type**

|  |  |  |
| --- | --- | --- |
| **Vegetation Type** | **Unadjusted Average Fuel Loading Factor (Ton/acre)** | **Adjusted Average Fuel Loading Factor**  **(Ton/acre)** |
| Hardwood | 66 | 99 |
| Softwood | 38 | 57 |
| Grass | 4.5 | Not Applicable |

The total acres disturbed by all construction types was calculated by summing the acres disturbed from residential, non-residential, and road construction. The county-level total acres disturbed were then multiplied by the weighted average loading factor to derive tons of land clearing debris.

***c. Controls***

Controls for land clearing debris burning are generally in the form of a ban on open burning of waste in a given municipality or county. Counties that were more than 80% urban were assumed not to practice any open burning. Therefore, criteria pollutant and HAP emissions from open burning of land clearing debris are zero in these counties. In addition, the State of Colorado implemented a state-wide ban on open burning. Emissions from open burning of land clearing debris in all Colorado counties were assumed to be zero.

***d. Emission Factors***

Emission factors are reported in Table 4 below. Emission factors for CAPs were developed by the U.S. Environmental Protection Agency (EPA) in consultation with the Eastern Regional Technical Advisory Committee and based primarily on the AP-42 report.10,11 The PM2.5 to PM10 emission factor ratio for brush burning (0.7709) was multiplied by the PM10 emission factors for land clearing debris burning to develop PM2.5 emission factors.

Emission factors for HAPs are from an EPA Control Technology Center report12 and emission factors for 17 dioxin congeners were obtained from an EPA dioxin report.13 The dioxin emission factors were multiplied by 0.002 to convert from mg/kg to lb/ton.

***e. Emissions***

County-level criteria pollutant and HAP emissions were calculated by multiplying the total mass of land clearing debris burned per year by an emission factor.

***f. Example Calculations***

VOC emissions in Autauga County, Alabama from open burning of land clearing debris:

Rural fraction of Autauga County population = 0.42, so no emission controls

Acres disturbed by residential, non-residential, and road construction in Autauga County = 84.83

Weighted average fuel loading factor for Autauga County = 65.48 tons/acre

Mass of land clearing debris burned = 84.83 acres \* 65.48 tons/acre = 5,555 tons

VOC emission factor = 11.6 lbs/ton

Factor to convert from lbs to tons = 1/2000

VOC emissions = tons of land clearing debris burned \* VOC emission factor

VOC emissions from land clearing debris burning = 5,555 tons \* 11.6 lbs/ton \* 1 ton/2000 lbs

VOC emissions from land clearing debris burning in Autauga County in 2010 = 32 tons

***g. References***

1. U.S. Census Bureau, “[New Privately Owned Housing Units Started for 2010 ( Not seasonally adjusted),](https://www.census.gov/const/startsua.pdf)”
2. U.S. Census Bureau, “[Table 2au. New Privately Owned Housing Units Authorized Unadjusted Units for Regions, Divisions, and States, Annual 2010](https://www.census.gov/const/C40/Table2/tb2u2010.txt)”
3. Annual Housing Units Authorized by Building Permits CO2010A, purchased from US Department of Census
4. U.S. Census Bureau, “[Annual Value of Construction Put in Place](https://www.census.gov/construction/c30/ototpage.html),”
5. U.S. Census Bureau, “[County Business Patterns](https://www.census.gov/programs-surveys/cbp.html),”
6. Bureau of Labor Statistics, [Producer Price Index, Table BMNR](https://www.bls.gov/data/),
7. Federal Highway Administration, [2008 Highway Spending](https://www.fhwa.dot.gov/policyinformation/statistics/2008/sf12a.cfm).
8. [2008 Building Permits data from US Census “BPS01”,](https://www.census.gov/library/publications/2011/compendia/usa-counties-2011.html)
9. Ward, D.E., C.C. Hardy, D.V. Sandberg, and T.E. Reinhardt. “Mitigation of Prescribed Fire Atmospheric Pollution through Increased Utilization of Hardwoods, Piled Residues, and Long-Needled Conifers.” Final Report. USDA Forest Service, Pacific Northwest Research Station, Fire and Air Resource Management. 1989.
10. Huntley, Roy, U.S. Environmental Protection Agency, “state\_comparison ERTAC SS\_version7\_3 Oct 20 2009 [electronic file],” November 5, 2009.
11. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. *Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 2.5 Open Burning*. Research Triangle Park, NC. October 1992.
12. U.S. Environmental Protection Agency, “Evaluation of Emissions from the Open Burning of Household Waste in Barrels, EPA-600/R-97-134a,” Control Technology Center. November 1997.
13. Gullet, B.K. and T. Abderrahmne, “PCDD/F Emissions from Forest Fire Simulations,” *Atmospheric Environment*, Vol. 37, No. 6, pp. 803-813. February 2003.

**Table 4. Emission Factors for Open Burning of Land Clearing Debris (SCC 2610000500)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Pollutant** | **Pollutant Code** | **Emission Factor**  **(lb/ton)** | **Emission**  **Factor**  **Reference** |
| VOC | VOC | 11.6 | Reference 10 |
| NOX | NOX | 5 | Reference 10 |
| CO | CO | 169 | Reference 10 |
| PM10-FIL | PM10-FIL | 17 | Reference 10 |
| PM25-FIL | PM25-FIL | 13.1 | PM10-FIL multiplied by 0.7709 |
| PM10-PRI | PM10-PRI | 17 | Reference 10 |
| PM25-PRI | PM25-PRI | 13.1 | PM10-PRI multiplied by 0.7709 |
| 1,2,3,4,6,7,8-HpCDD | 35822469 | 3.33E-07 | Reference 13 |
| 1,2,3,4,6,7,8-HpCDF | 67562394 | 5.08E-08 | Reference 13 |
| 1,2,3,4,7,8,9-HpCDF | 55673897 | 6.12E-09 | Reference 13 |
| 1,2,3,4,7,8-HxCDD | 39227286 | 1.14E-08 | Reference 13 |
| 1,2,3,4,7,8-HxCDF | 70648269 | 3.34E-08 | Reference 13 |
| 1,2,3,6,7,8-HxCDD | 57653857 | 2.14E-08 | Reference 13 |
| 1,2,3,6,7,8-HxCDF | 57117449 | 1.43E-08 | Reference 13 |
| 1,2,3,7,8,9-HxCDD | 19408743 | 3.47E-08 | Reference 13 |
| 1,2,3,7,8,9-HxCDF | 72918219 | 2.23E-09 | Reference 13 |
| 1,2,3,7,8-PeCDD | 40321764 | 7.66E-09 | Reference 13 |
| 1,2,3,7,8-PeCDF | 57117416 | 1.27E-08 | Reference 13 |
| 2,3,4,6,7,8-HxCDF | 60851345 | 1.96E-08 | Reference 13 |
| 2,3,4,7,8-PeCDF | 57117314 | 2.02E-08 | Reference 13 |
| 2,3,7,8-TCDD | 1746016 | 2.30E-09 | Reference 13 |
| 2,3,7,8-TCDF | 51207319 | 1.40E-08 | Reference 13 |
| Cumene | 98828 | 1.33E-02 | Reference 12 |
| Dibenzofuran | 132649 | 6.75E-03 | Reference 12 |
| Ethyl Benzene | 100414 | 4.80E-02 | Reference 12 |
| OCDD | 3268879 | 1.33E-06 | Reference 13 |
| OCDF | 39001020 | 2.05E-08 | Reference 13 |
| Phenol | 108952 | 1.15E-01 | Reference 12 |
| Styrene | 100425 | 1.02E-01 | Reference 12 |