5 Section 5: Land Use

5.1 Introduction

The Chesapeake Bay Land Change Model provides the Watershed Model with an estimate of land cover acres in each land-river segment. These data are combined with the USDA Census of Agriculture to generate a land use data set. Table 5-1 provides a list of land uses provided. Land uses are grouped into agricultural, developed and natural categories. Details about how acres of each land use are generated are included within this section, followed by a description of how the two sets of land use acres are combined to create a final set for each land-river segment.

Table 5-1: Phase 6 land uses

	Developed			
Agriculture	**Non-Regulated**	**MS4**	**CSS**	**Natural**
Full Season Soybeans	Non-Regulated Roads	MS4 Roads	CSS Roads	Disturbed Forest
Grain with Manure	Non-Regulated Buildings and Other	MS4 Buildings and Other	CSS Buildings and Other	Harvested Forest
Grain without Manure	Non-Regulated Tree Canopy over Impervious	MS4 Tree Canopy over Impervious	CSS Tree Canopy over Impervious	Forest
Legume Hay	Non-Regulated Tree Canopy over Turfgrass	MS4 Tree Canopy over Turfgrass	CSS Tree Canopy over Turfgrass	Palustrine Forested Wetland
Silage with Manure	Non-Regulated Turf Grass	MS4 Turf Grass	CSS Turf Grass	Palustrine Scrub-Shrub Wetland
Silage without Manure		MS4 Construction	CSS Construction	Palustrine Emergent Wetland
Small Grains and Grains				Open Space
Small Grains and Soybeans				Water
Specialty Crop High				
Specialty Crop Low				
Other Agronomic Crops				
Other Hay				
Pasture				
Permitted Feeding Space				
Non-Permitted Feeding Space				
Ag Open Space				

5.2 CHESAPEAKE BAY LAND CHANGE MODEL

Fifteen land use classes have been mapped for input to the Phase 6 Beta watershed model. These classes were largely mapped using nationally available data throughout the watershed augmented with local land use and parcel data to differentiate turf grass from cropland and pasture where such data were available. National data informing the land use classes include the National Land Cover Dataset (land cover, tree canopy, and impervious cover), Decennial Census of Population and Housing, NAVTEQ streets and land use, National Wetlands Inventory, National Hydrography Dataset (1:24K), and the NASS

Cropland Data Layer. In Lancaster County, Pennsylvania all classes except for cropland and pasture were derived from locally provided information. For Maryland, MDE and MDP used local data to estimate land use extents in 19 counties for 10 of the 15 land uses.

Each of the fifteen land use classes were mapped as fractional 10m-resolution raster datasets with values ranging from 0 to 100 representing the fraction of each cell composed by each class. Most cells are composed of multiple classes (e.g., 50% turf grass, 10% tree canopy over turf grass, 10% tree canopy over impervious roads, and 30% impervious roads). The land use classes can be viewed at:

http://ec2-52-4-30-207.compute-1.amazonaws.com/chesbay/

5.2.1 Mapped P6 Beta Land Use Classes (listed in production order):

Impervious Roads (IR) – paved and unpaved roads and bridges.

Impervious Non-Roads (INR) – buildings, driveways, sidewalks, parking lots, runways and some private roads.

Forest (FOR) – large (> 1-acre) contiguous patches of trees and shrubs assumed to have an unmanaged understory

Tree Canopy (TCT, TCIR, TCINR) – small fragments of trees over turf grass, impervious roads, and impervious non-roads.

Water (WAT) – all streams, ponds, swimming pools, canals, ditches, wet detention basins, reservoirs, etc. mapped in the National Hydrography Dataset, NWI ponds & lakes, and the National Land Cover Dataset (Open Water). Assumes all single-line streams are 15' wide.

Wetlands (WTF, WTO, WTT) – National Wetlands Inventory (NWI) non-pond, non-lake wetlands divided into tidal (WTT), floodplain (WTF), and headwater (WTO) subclasses based on NWI attributes and landscape position. Tidal wetlands removed from the watershed model and added to the water quality hydrodynamic model.

Turf Grass (TG) – all herbaceous lands within developed areas including remaining fractions of land within a pixel after accounting for tree canopy, impervious, and water.

Open Space (OSP) – non-fertilized herbaceous and non-forest scrub/shrub that is justifiably not turf or extractive (e.g., beaches, vacant lots, transmission line right-of-ways, junkyards, fairgrounds, gravel roads, railroads).

Cropland (CRP): rural herbaceous lands with a high frequency of crops detection in the annual Cropland Data Layer from 2008 to 2013.

Pasture/Hay (PAS): rural herbaceous lands with a high frequency of pasture/hay detection in the annual Cropland Data Layer from 2008 to 2013.

From these classes, additional information such as MS4 and CSO boundary area polygons were used to separate out classes into individual land uses.

5.3 ESTIMATING AGRICULTURAL ACRES

Acres of each agricultural land use which includes crops are estimated based upon acres of crops reported by the Census of Agriculture. While many nutrient application and uptake processes are

simulated at the crop level, the resulting data are then lumped into land uses with similar crop management. Table 5-2 lists the land use category for each crop. Note that some crops are also eligible for the double cropped land use – small grains and soybeans.

Table 5-2: Census of Agriculture Crops and Associated Land Uses

Crop Name	Land Use(s)	Eligible for Double Crops	Legume
Alfalfa Hay Harvested Area	Legume Hay	N	Y
Alfalfa seed Harvested Area	Legume Hay	N	Y
Aquatic plants Area	Specialty Crop Low	N	N
Asparagus Harvested Area	Specialty Crop Low	N	N
Barley for grain Harvested Area	Small Grains and Grains/Small Grains and Soybeans	Y	N
Bedding/garden plants Area	Specialty Crop High	N	N
Beets Harvested Area	Specialty Crop High	N	N
Berries- all Harvested Area	Specialty Crop Low	N	N
Birdsfoot trefoil seed Harvested Area	Legume Hay	N	Y
Broccoli Harvested Area	Specialty Crop High	N	N
Bromegrass seed Harvested Area	Other Hay	N	N
Brussels Sprouts Harvested Area	Specialty Crop High	N	N
Buckwheat Harvested Area	Small Grains and Grains/Small Grains and Soybeans	Y	N
Bulbs, corms, rhizomes, and tubers – dry Harvested Area	Specialty Crop High	N	N
Canola Harvested Area	Small Grains and Grains/Small Grains and Soybeans	Y	N
Cantaloupe Harvested Area	Specialty Crop High	N	N
Carrots Harvested Area	Specialty Crop High	N	N
Cauliflower Harvested Area	Specialty Crop High	N	N
Celery Harvested Area	Specialty Crop High	N	N
Chinese Cabbage Harvested Area	Specialty Crop High	N	N
Collards Harvested Area	Specialty Crop High	N	N
Corn for Grain Harvested Area	Grain with Manure/Grain without Manure/Small Grains and Soybeans	Y	N
Corn for silage or greenchop Harvested Area	Silage with Manure/Silage without Manure/Small Grains and Soybeans	Y	N
Cotton Harvested Area	Other Agronomic Crops	N	N
Cropland idle or used for cover crops or soil improvement but not harvested and not pastured or grazed Area	Other Agronomic Crops	N	N
Cropland in cultivated summer fallow Area	Other Agronomic Crops	N	N
Cropland on which all crops failed or were abandoned Area	Other Hay	N	N
Cropland used only for pasture or grazing Area	Pasture	N	N
Cucumbers and Pickles Harvested Area	Specialty Crop High	N	N
Cut Christmas Trees Production Area	Specialty Crop Low	N	N
Cut flowers and cut florist greens Area	Specialty Crop High	N	N
Dry edible beans, excluding limas Harvested Area	Other Agronomic Crops	N	Y
Dry Onions Harvested Area	Specialty Crop High	N	N

Eggplant Harvested Area	Specialty Crop High	N	N
Emmer and spelt Harvested Area	Small Grains and Grains/Small Grains and Soybeans	Y	N
Escarole and Endive Harvested Area	Specialty Crop High	N	N
Fescue Seed Harvested Area	Other Hay	N	N
Foliage plants Area	Specialty Crop High	N	N
Garlic Harvested Area	Specialty Crop High	N	N
Green Lima Beans Harvested Area	Specialty Crop Low	N	Y
Green Onions Harvested Area	Specialty Crop High	N	N
Greenhouse vegetables Area	Specialty Crop High	N	N
Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area	Legume Hay	N	N
Head Cabbage Harvested Area	Specialty Crop High	N	N
Herbs, Fresh Cut Harvested Area	Specialty Crop High	N	N
Honeydew Melons Harvested Area	Specialty Crop High	N	N
Kale Harvested Area	Specialty Crop High	N	N
Land in Orchards Area	Specialty Crop Low	N	N
Lettuce, All Harvested Area	Specialty Crop High	N	N
Mushrooms Area	Specialty Crop High	N	N
Mustard Greens Harvested Area	Specialty Crop High	N	N
Nursery stock Area	Specialty Crop Low	N	N
Oats for grain Harvested Area	Small Grains and Grains/Small Grains and Soybeans	Y	N
Okra Area	Specialty Crop High	N	N
Orchardgrass seed Harvested Area	Other Hay	N	N
Other field and grass seed crops Harvested Area	Other Hay	N	N
Other haylage, grass silage, and greenchop Harvested Area	Other Hay	N	N
Other managed hay Harvested Area	Other Hay	N	N
Other nursery and greenhouse crops Area	Specialty Crop High	N	N
Parsley Harvested Area	Specialty Crop High	N	N
Pastureland and rangeland other than cropland and woodland pastured Area	Pasture	N	N
Peanuts for nuts Harvested Area	Other Agronomic Crops	N	Y
Peas, Chinese (sugar and Snow) Harvested Area	Specialty Crop Low	N	Y
Peas, Green (excluding southern) Harvested Area	Specialty Crop Low	N	Y
Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	Specialty Crop Low	N	Y
Peppers, Bell Harvested Area	Specialty Crop High	N	N
Peppers, Chile (all peppers – excluding bell) Harvested Area	Specialty Crop High	N	N
Popcorn Harvested Area	Specialty Crop High	N	N
Potatoes Harvested Area	Specialty Crop High	N	N
Potted flowering plants Area	Specialty Crop High	N	N
Pumpkins Harvested Area	Specialty Crop High	N	N
Radishes Harvested Area	Specialty Crop High	N	N
Red clover seed Harvested Area	Legume Hay	N	Y

Rhubarb Harvested Area	Specialty Crop High	N	N
Rye for grain Harvested Area	Small Grains and Grains/Small Grains and Soybeans	Y	N
Ryegrass seed Harvested Area	Other Hay	N	N
short-rotation woody crops Harvest Area	Specialty Crop Low	N	N
Small grain hay Harvested Area	Other Hay	N	N
Snap Beans Harvested Area	Specialty Crop Low	N	Y
Sod harvested Area	Other Agronomic Crops	N	N
Sorghum for Grain Harvested Area	Grain with Manure/Grain without Manure/Small Grains and Soybeans	Y	N
Sorghum for silage or greenchop Area	Silage with Manure/Silage without Manure/Small Grains and Soybeans	Y	N
Soybeans for beans Harvested Area	Full Season Soybeans/Small Grains and Soybeans	Y	Y
Spinach Harvested Area	Specialty Crop High	N	N
Squash Harvested Area	Specialty Crop High	N	N
Sunflower seed, non-oil varieties Harvested Area	Specialty Crop Low	N	N
Sunflower seed, oil varieties Harvested Area	Specialty Crop Low	N	N
Sweet Corn Harvested Area	Other Agronomic Crops	N	N
Sweet potatoes Harvested Area	Specialty Crop High	N	N
Timothy seed Harvested Area	Other Hay	N	N
tobacco Harvested Area	Other Agronomic Crops	N	N
Tomatoes Harvested Area	Specialty Crop High	N	N
Triticale Harvested Area	Small Grains and Grains/Small Grains and Soybeans	Y	N
Turnip Greens Harvested Area	Specialty Crop High	N	N
Turnips Harvested Area	Specialty Crop High	N	N
Vegetable & flower seeds Area	Specialty Crop High	N	N
Vegetables, Mixed Area	Specialty Crop High	N	N
Vetch seed Harvested Area	Legume Hay	N	Y
Watermelons Harvested Area	Specialty Crop High	N	N
Wheat for Grain Harvested Area	Small Grains and Grains/Small Grains and Soybeans	Y	N
Wild hay Harvested Area	Ag Open Space	N	N

In years for which acres of crops are provided by the Census of Agriculture (1982, 1987, 1992, 1997, 2002, 2007 and 2012), those acres are used directly in estimating the total land use acres after considering any acres upon which two crops may have been grown described in section 5.3.3. Acres of crops (and thus, land uses) in intervening years are interpolated. For example, if the Census of Agriculture reported 1,000 acres of pasture in a county in 1992 and 500 acres in 1997, then it is assumed that the county lost 100 acres of pasture each year from 1993 through 1997.

5.3.1 Forecasting Agricultural Acres

Crop acres for any year after the last available census year, 2012 for the Phase 6 calibration, are projected for each county using a double-exponential smoothing projection method approved by the Agriculture Workgroup.

Double-exponential smoothing (NIST/SEMATECH 2016) is a short-term data forecasting method that is most often used when future values are believed to be related to both long-term and short-term trends in historic values. The method allows users to combine predictions of long-term and short-term trends by placing different weights or emphasis on each type of trend. The Agriculture Workgroup was asked to determine the weights of the alpha and beta values. The choices of the alpha and beta weighting factors, of 0.8 and 0.2 respectively, were chosen based upon an analysis of which factors best predicted both poultry and cattle populations reported in the 2007 Census of Agriculture.

A formula, explanation of terms, and example projections are provided below.

Equation 5-1: double exponential smoothing

- y_t = Actual county value as reported by Census of Agriculture at time t
- S_t = Smoothed value for time t
- b_t = Estimated trend for time t
- AF_t = Trend-adjusted forecast for time t
- a = Alpha value is the weight placed upon the most recent Census of Agriculture value
- Beta = Beta value is the weight placed upon the long-term trend in Census of Agriculture values

$$S_t = a* y_t + (1-a) * (S_{t-1} + b_{t-1})$$

$$S_1 = y_1$$

$$b_t = Beta * (S_t - S_{t-1}) + (1 - Beta) * b_{t-1}$$

$$b_1 = average((y_2 – y_1), (y_3 – y_2), (y_4 – y_3))$$

$$AF_t = S_{t-1} + b_{t-1}$$

Table 5-3: Hypothetical Projection of a County's Legume Hay Acres

Period	Year	y_t (Reported Acres Value)	St	bt	AFt
1	1982	**2,000**	2,000	-367	
2	1987	**1,250**	1327	-428	1633
3	1992	**1,000**	980	-412	899
4	1997	**900**	834	-359	568
5	2002	**850**	775	-299	475
6	2007	**900**	815	-231	476
7	2012	**800**	757	-196	584
*8	2017				**561**
9	2022				**364**

*For periods t >= T, $Af_t = Af_T + (t-T) * b_T$

Blue text indicates the value – reported or projected – that would be used by Scenario Builder.

In the hypothetical projection above, the long-term trend showed a steep decline in acres from 1982 through 2012. When coupled with a short-term trend showing another sharp decline from 2007 to 2012, the projection methodology predicts a continued loss of acres in 2017 and 2022.

These projections are done for each agricultural land use aside from the farmstead and feeding operation land uses. Once the projections at the land use level are complete, Scenario Builder assumes that the mixture of crops within each land use is the same as reported in the 2012 Census of Agriculture. In the hypothetical example above, Scenario Builder projected the county would have 688 acres of the land use, "Legume Hay." That land use actually combines acres of six unique crops reported by the Census of Agriculture. Table 5-4 provides an example of how 2017 projected acres of Legume Hay are converted into acres of each individual crop.

Table 5-4: Creating 2017 Crop Acres of Legume Hay for a County

Census of Agriculture Crop	Census of Agriculture Acres 2012	Fraction Census of Agriculture Acres 2012	2017 Projected Acres
Alfalfa Hay Harvested Area	150	0.1875	129
Alfalfa seed Harvested Area	150	0.1875	129
Birdsfoot trefoil seed Harvested Area	150	0.1875	129
Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area	150	0.1875	129
Red clover seed Harvested Area	100	0.125	86
Vetch seed Harvested Area	100	0.125	86
Total	800	1	688

5.3.2 Filling in the D's

The Census of Agriculture withholds data that could identify individual farm operations. These data are reported with a "D." However, values initially reported as D's are aggregated and reported as "all other counties" by the Census of Agriculture. Individual counties may have a "D" value in one year, yet have actual values in other years. In order to estimate acres of crops and numbers of animals, Scenario builder must remove the D's and replace them with values using a procedure described below.

All non-reported values are first replaced by linearly interpolating between actual values reported in other years. This interpolation occurs at both the state and county scale. If this results in the sum of all county values being greater than the reported state values for a particular year or if 30 percent of more of all counties' D's in a state cannot be replaced by linear interpolation, then a second method is used.

If linear interpolation fails or there are no reported values for prior and subsequent years, then the difference between the state total value and the sum of all county values is redistributed proportionally to all counties listed as "D." This proportional redistribution is done by taking the average county fraction out of the state total for each year in which there are data.

Occasionally, a state value may be listed as "D." In order to remove the "D," a linear regression is performed at the state level over all years for which there are data.

5.3.3 Estimating Double-Cropped Acres

The Census of Agriculture reports harvested acres of over 115 individual crops grown throughout the watershed. These harvested acres naturally add up to more than the acres of agricultural land within the watershed because many acres are reported as being harvested for two different crops in a single year. This is most common within the widely-maintained corn/soybean/wheat crop rotation. To avoid double-counting some agricultural acres, Scenario Builder estimates those acres that have two or more crops harvested from them using the following procedure. The acres resulting from this procedure are assumed to be major field crops and become the acres of the small grains and soybeans land use.

Double-Cropping Procedure using Census of Agriculture Harvested Crop Acreages

1. Determine acres that are double-cropped:
    a. Determine total "Major Field Cropland Harvested Area" by subtracting acres harvested of the following crops from "Harvested Cropland Area." The result of this step should represent the geographic extent of acreage from which two crops could theoretically be harvested.
        i. Alfalfa hay
        ii. Berries – all
        iii. Cut Christmas trees
        iv. Land in orchards
        v. Nursery, greenhouse, floriculture, aquatic plants, mushrooms, flower seeds, vegetable seeds, and sod
        vi. Other managed hay
        vii. Short-rotation woody crops
        viii. Small grain hay
        ix. Vegetables (includes many crops)
        x. Wild hay
        xi. Dry edible beans, excluding limas
        xii. Tobacco
        xiii. Potatoes
        xiv. Field and grass seed crops
        xv. Sunflower seed (all varieties)
        xvi. Cotton
        xvii. Canola
        xviii. Popcorn
    b. Determine the total acres harvested of the "Major Field Crops" listed below. The result of this step is often greater than the geographic extent of "Major Field Cropland Harvested Area," thus representing the acres from which two crops could theoretically be harvested.
        i. Barley
        ii. Buckwheat
        iii. Canola
        iv. Corn for grain
        v. Corn for silage
        vi. Emmer and spelt
        vii. Oats for grain
        viii. Rye for grain

ix. Sorghum for Grain
x. Sorghum for Silage
xi. Soybeans for beans
xii. Triticale
xiii. Wheat for grain

c. If "Major Field Cropland Harvested Area" – "Major Field Crops" >= 0, then there are no double-cropped acres in county.

If "Major Field Cropland Harvested Area" – "Major Field Crops" <0, then this amount becomes the double-cropped acres (acres of small grains and soybeans) in county.

5.3.4 Estimating Grains with Manure and Silage with Manure Acres

The Agricultural Modeling Subcommittee wished to separate the most commonly grown crop in the watershed – corn – into land uses that could and could not receive manure. By doing so, a fraction of corn (and sorghum) acres simulated across the watershed receive only inorganic fertilizer applications. This was recommended in order to account for producers who do not have access to manure or other organic nutrient sources.

The Census of Agriculture does not provide a breakout of acres of each crop type that received manure and those that did not in a given year. It does provide an estimate of the total acres that received manure in each county. This value inherently includes acres of pasture and other crops that do not pertain to the Grains with Manure land use, and should be accounted for if the information is used to estimate acres of grains with manure. However, with very little additional information about manure applications to specific crops, the Agricultural Modeling Subcommittee recommended that acres of corn and sorghum available for manure application be determined using equation 3.

Equation 5-2: Estimating Fraction for Grains with Manure Land Use

Fraction = Census of Agriculture Acres Receiving Manure/ (Census of Agriculture Acres of Harvested Cropland + Census of Agriculture Acres of Pasture – Census of Agriculture Acres of Soybeans)

The Agricultural Modeling Subcommittee was skeptical that this proxy variable could accurately estimate acres of corn and sorghum that received manure. In an attempt to improve the procedure, the group asked the Maryland Department of Agriculture to provide estimates of the amount of manure nitrogen out of the total amount of nutrients applied to corn in 2011, 2012 and 2013, as reported by farmers on the Annual Implementation Reports. These estimates were compared to the fractions calculated by equation 2. The resulting comparisons are provided in Table 6. After comparing the two values, the Subcommittee felt comfortable using Equation 2 to estimate the fraction of corn and sorghum acres that would be eligible for manure in the Grains with Manure land use.

Table 5-5: Comparing Manure Eligible Crop Percentages

Region	MD AIR Percentage (2011, 2012, 2013 combined)	Census of Agriculture Percentage (2012)

Statewide	17	21
Lower Eastern Shore	28	32
Western	24	20
Central	2	6
Northwestern	14	26
Northern	5	11
Southern	8	7
Upper Eastern Shore	17	20

5.4 COMBINING ACRES

Initial acreage estimates of total agricultural area along with estimates of each developed and natural land use are provided by the CBLCM. However, these initial estimates are then combined with crop acreages from the Census of Agriculture, and adjusted to create a final set of land use acres for every land-river segment. This adjustment must occur because the combination of CBLCM-generated acres (which includes an estimate of agricultural land) and Census of Agriculture acres will naturally exceed the actual acres of land and water in each county. If too many acres exist in a land-river segment, the initial estimates of acres are reduced in the following, stepwise fashion, taking acres down to zero at the end of each step if necessary:

1. CBLCM Open Space (which includes CBLCM estimates of agricultural land)
2. CBLCM Disturbed Forest and Forest proportionally
3. CBLCM Non-Regulated Developed and MS4 Developed and Extractive proportionally, includes:
    a. Non-Regulated Roads
    b. Non-Regulated Buildings and Other
    c. Non-Regulated Tree Canopy over Impervious
    d. Non-Regulated Tree Canopy over Turfgrass
    e. Non-Regulated Turf Grass
    f. MS4 Roads
    g. MS4 Buildings and Other
    h. MS4 Tree Canopy over Impervious
    i. MS4 Tree Canopy over Turfgrass
    j. MS4 Turf Grass
    k. Abandoned Extractive Lands
    l. Active Extractive Lands
4. All agricultural land uses derived from Census of Agriculture proportionally, includes:
    a. Ag Open Space
    b. Full Season Soybeans
    c. Grain with Manure
    d. Grain without Manure
    e. Legume Hay
    f. Silage with Manure
    g. Silage without Manure
    h. Small Grains and Grains
    i. Small Grains and Soybeans
    j. Specialty Crop High

   k. Specialty Crop Low
   l. Other Agronomic Crops
   m. Other Hay
   n. Pasture
5. CBLCM wetlands proportionally, includes:
   a. Palustrine Forested Wetland
   b. Palustrine Scrub-Shrub Wetland
   c. Palustrine Emergent Wetland
6. CBLCM combined sewer system lands proportionally, includes:
   a. CSS Roads
   b. CSS Buildings and Other
   c. CSS Tree Canopy over Impervious
   d. CSS Tree Canopy over Turfgrass
   e. CSS Turf Grass
7. CBLCM Harvested Forest, MS4 Construction and CSS Construction, proportionally
8. Census of Agriculture-derived Permitted Feeding Space and Non-Permitted Feeding Space, proportionally
9. CBLCM Water

This process was be revised in the next calibration run of the Phase 6 Model. The stepwise reductions in each land use are likely to be replaced by proportional reductions across all land uses, with each land use being more or less likely to be adjusted. For example, if the Partnership feels that pasture acres reported in the Census of Agriculture have much less uncertainty than hay acres, the revised procedure is likely to reduce hay at a higher relative proportion than pasture. Details will be provided in the documentation once a method is decided upon.

5.5 ACRES OF FEEDING OPERATIONS

The Census of Agriculture does not provide an estimate of animal production areas. These areas include barnyards or feedlots and structures such as dairy barns or poultry houses. These production areas can be large sources of nutrient runoff if not properly maintained with BMPs. To estimate these acres, Scenario Builder assumes that each animal raised requires an average area of barnyard and or structure for production purposes. These average areas per animal are provided in Table 7. These are multiplied by the estimated number of animals produced in each county.

Table 5-6:Estimated Animal Production Area Requirements

Source Name	Open-Air Barnyard (sq feet)			Roofed Structures (sq feet)			All Area (sq feet)	Cycles (NRCS)	Adjusted All Area (sq ft)	All Area (acres/animal)
	MAX	MIN	MED	MAX	MIN	MED	Total	Total	Total	Total
Pullets*						1.0	1.0	2.25	0.44	0.000010
Turkeys				2.0	2.0	2.0	2.0	2.00	1.02	0.000023
Broilers*						0.85	0.85	6.00	0.14	0.000003
Layers				1.7	1.7	1.7	1.7	1.00	1.72	0.000040
Hogs for Slaughter				9.7	9.7	9.7	9.7	2.00	4.84	0.000111

Hogs and Pigs for Breeding				13.6	13.6	13.6	13.6	1.00	13.56	0.000311
Beef (Beef Heifers)	60.3	50.6	55.4	35.5	18.3	26.9	82.3	1.00	82.31	0.001890
Dairy (Dairy heifers)	96.8	96.8	96.8	28.6	28.6	28.6	125.5	1.00	125.46	0.002881
Other Cattle	50.6	39.8	45.2	24.7	11.8	18.3	63.5	1.00	63.48	0.001458
Horses	147.3	147.4	147.4	147.3	147.3	147.3	294.7	1.00	294.66	0.006765
Sheep and Lambs*						25.0	25.0	1.00	25.02	0.000574
Goats*						15.0	15.0	1.00	15.00	0.000344

*Maximum, minimum and median values provided by Maryland Department of Agriculture, 2015.

All other maximum, minimum and median values provided by FASS, 2010.

The values in the table were provided by the Federation of Animal Science Societies (FASS) and by the Maryland Department of Agriculture. The median values for open-air barnyard and roofed structures were combined to create the average square footage required to raise a single animal. However, some farms have multiple animals which share the same space at different times during the year. For example, a broiler may require 0.85 square feet of production area, but a producer may move flocks of broilers in and out of the house six times over a single year. Thus, the 0.85 square feet is used by six broilers. To avoid counting the same area six times, the median values were divided by the average number of cycles (or flocks) of animals produced, as provided by NRCS, 2003 as shown in Equation 5-3: acres of feeding operationsEquation 5-3.

Equation 5-3: acres of feeding operations

Countywide Acres of Feeding Operations = All Area (sq ft)/Yearly Cycles of Production X 2.296e-5 (acres/sq ft) X Animals Produced in County

Total acres of feeding operations are then broken further into permitted and non-permitted feeding space land uses based upon the fraction of animals that are permitted and non-permitted in each county. These fractions are provided by each jurisdiction, and can vary by year. Scenario Builder does not treat nutrients deposited on permitted feeding operations differently than those deposited on non-feeding operations.