



LEVEL II ODOR BEST MANAGEMENT PRACTICE (BMP) GUIDE FOR VEGETATIVE BUFFER ESTABLISHMENT

I. OVERVIEW

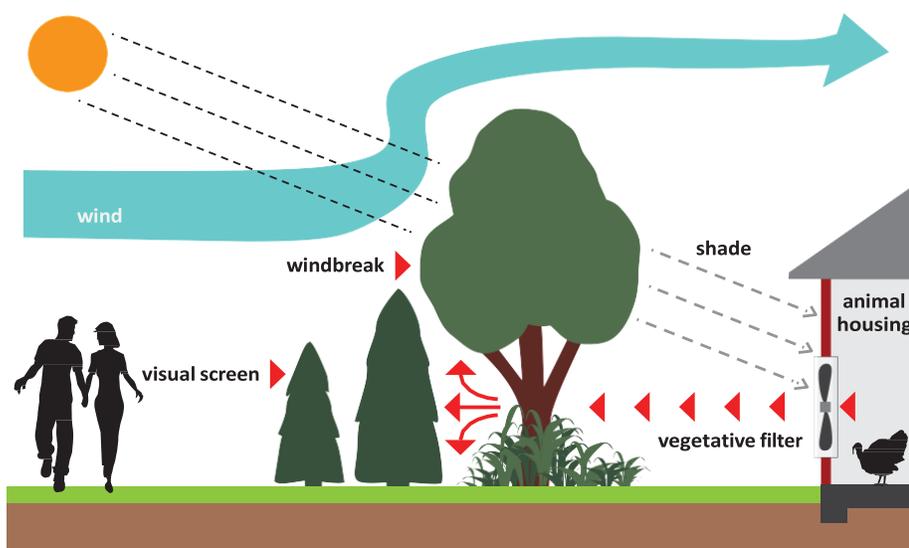
Vegetative Buffers are plantings of grasses, trees and/or shrubs that are strategically located around animal housing facilities and/or manure storage facilities on poultry and livestock operations. Vegetative Buffers are considered Level II Odor Best Management Practices (Odor BMPs) and are generally established to address potential odors from the animal housing facilities and manure storage facilities being evaluated in an Act 38 Odor Management Plan (OMP). Additionally, when used for their Visual Screening capacity, Vegetative Buffers may be located along property lines, or other locations on the poultry or livestock operation. Vegetative Buffers filter and trap dust, odor, particulate matter, and ammonia from the odor plume.

When used for their Vegetative Bio-Filtering and Windbreak capacities, Vegetative Buffers serve as a means of disruption of the odor plume. This allows heavier odorous molecules and odor-carrying material to settle out in areas of decreased air velocity and 'dead spots'. Lighter molecules may lift up and away. Turbulence allows fresh air from above to mix with odorous air, diluting the concentration of odorous molecules toward or below odor detection thresholds.

Vegetative Filtering Concept – Vegetative Buffers, when used for their Vegetative Bio-Filtering and Windbreak capacities, are plantings of multiple rows of grasses, trees and/or shrubs that are strategically located around animal housing facilities and/or manure storage facilities on poultry and livestock operations. This active filtering helps to reduce the odor transport.

Visual Screening Concept – Vegetative Buffers, when used for their Visual Screening capacity, are plantings of single or multiple rows of grasses, trees and/or shrubs. Attractive trees and shrubs visually screen farm management activities and can serve as landscape plants to beautify the barn and farm. Research concludes that farms judged as "attractive" have fewer odor complaints.

Figure 1. Vegetative Filtering & Screening



Vegetative Buffers have a direct impact on odor transport and odor perception in the odor generation-transport-perception continuum.

Additionally, Vegetative Buffers can provide other useful benefits for the farm setting such as:

- Slow and buffer roof, road / lane, and barnyard runoff in addition to filtering nutrients and sediment.
- Protect animal housing

Illustration: Tom Laird

facilities from winter winds.

- Act as a living snow fence by strategically depositing snow in acceptable locations.
- During hot weather, shade trees block solar load on barns, improving animal comfort and reducing energy expense.
- Trees provide nesting habitat for wild birds and ground level habitat for wild animals.
- When grown for Biomass, can be harvested and used as animal bedding or combusted as a renewable, carbon-neutral source of heat for animal housing facilities.

This practice incorporates concepts of the United State Depart of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Field office technical guide (Pa Tech Guide) conservation practice standards for Windbreak Shelterbelt (380) and the Hedgerow Plantings (422).

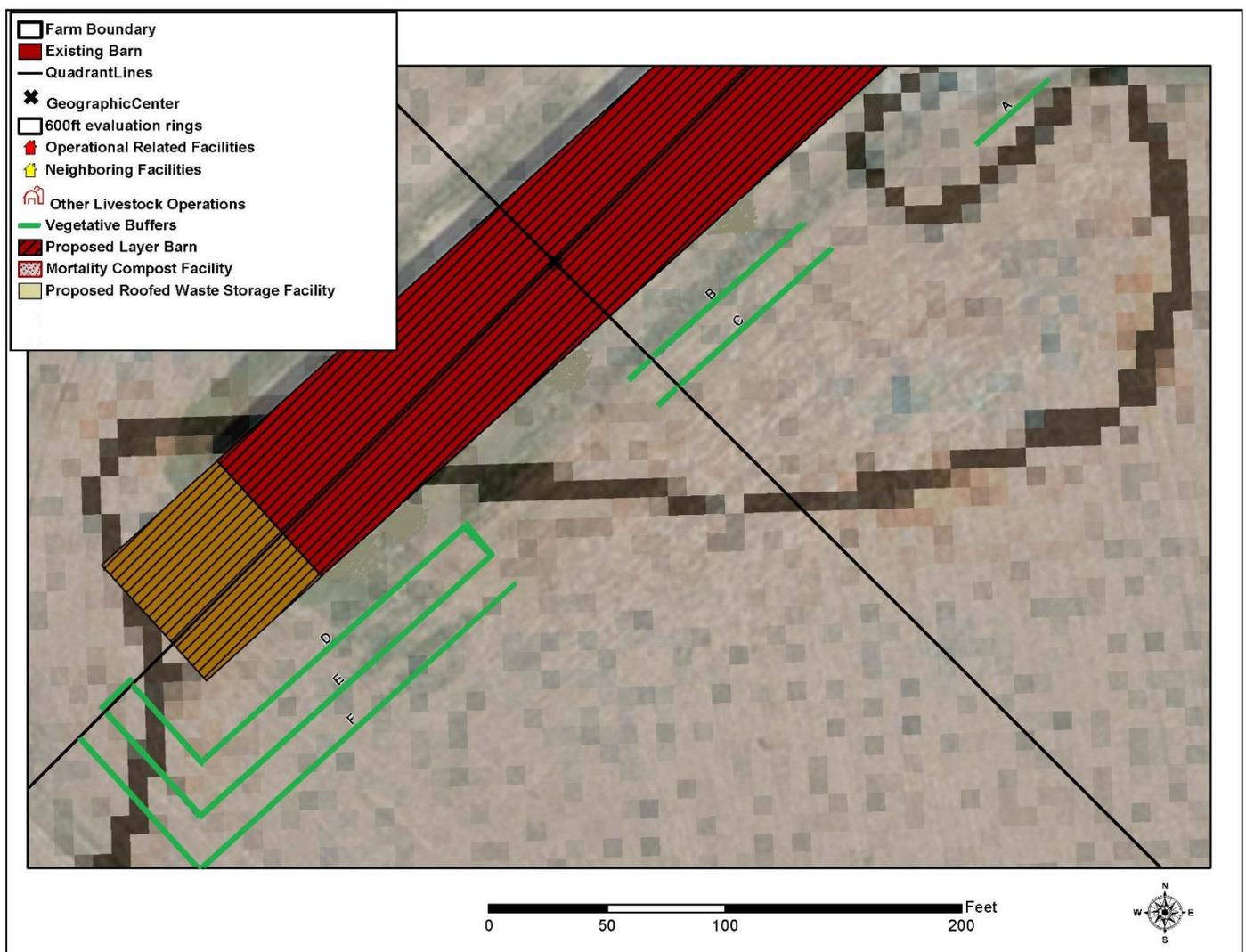
II. DESIGN PLANS AND SPECIFICATIONS

Procedures, technical details, and other information listed below provide additional guidance for carrying out selected components of the Vegetative Buffer Odor BMP Establishment.

For Vegetative Buffers surrounding poultry production facilities, refer to ‘Windbreak Plant Species for Odor Management around Poultry Production Facilities’, USDA MD PMC Technical Note 1(2007) and ‘Plants Tolerant of Poultry House Emissions in the Chesapeake Bay Watershed’ USDA MD PMC (2015).

LOCATION & LAYOUT

Figure 2. Example Location & Layout Map



Location & Layout Map. A Location & Layout Map must be included to visually show where the Vegetative Buffer will be located and how it will be laid out. Alternatively, this information can be added to the Odor Management Plan (OMP) Site Map, provided that all of the required information can easily be seen and interpreted.

Effectiveness for intercepting particulates and odors improves when rows are oriented perpendicular to prevailing winds. Wider (deeper) and taller plantings are more effective than narrower, shorter ones. Rows positioned closer to the odor source, e.g. poultry house, manure storage facility, etc., contain or limit dispersion of more emissions than those further away. Long, uninterrupted rows (at least 10 times as long as high) are more effective than shorter ones with gaps.

The closer the row is located to the odor source, e.g. poultry house, manure storage facility, etc., the more effectively the odor and dust will be trapped and dispersed. Particulate trapping efficiencies may be significantly reduced beyond 100 feet, depending on height of trees, wind speed/direction, and atmospheric conditions. Proximity of the plants for trapping efficiency must be balanced with plant survival, which decreases the closer the plants are to the ventilation fans.

A. VEGETATIVE FILTERING

To reduce odor transport, the vegetative buffer must be situated so that the odor plume (from a concentrated source like the fans or manure storage) must pass through the buffer before reaching the odor receptor. In most cases, this means that the vegetation should concentrate around fans or outdoor manure storage structures. A vegetative buffer expected to reduce odor transport must be at least 3 layers deep. The layers should consist of one row of fast-growing grasses or shrubs (positioned nearest the odor source), one row of fast-growing deciduous trees or shrubs, and finally a row of evergreens planted furthest from the fans.

Plant Materials

Multiple row plantings (> 2 rows) should contain a variety of species to lessen the chance of loss due to species specific insects or disease. In multiple row plantings containing more than 3 rows, the leeward rows may be planted in groups or segments containing 5 or more plants of one species in a series to enhance wildlife values.

See the Plant Materials section (V. Design – Plant Materials Selection) for information on individual plant materials.

Rows

First Row Placement. Remember to account for changes in the site topography, e.g., you would not typically plant in a depression. Every poultry house will differ as to the location of ventilation fans, access roads, drainage ditches, etc., so each planting design will need to accommodate these features. Where vehicle access is needed, locate the first row a minimum of 50 feet from the sidewall fans and 80 feet from the end wall fans of the poultry house. If the house does not have tunnel ventilation and has a south or west exposure, use a minimum setback of 100 feet to provide for air movement.

Plantings in fan impact areas. For plant survival in fan impact areas, the nearest row of plantings must be set back from the fans by a distance that is at least 10 times the exhaust fan diameter. (For example, if the ventilation fan has a diameter of 4 feet, then the first line of plants needs to be planted at least 40 feet away.) Where multiple fans are used in one location, this planting distance formula may be increased a minimum of 5 feet for each fan, depending on the number of fans that are likely to be running at the same time (e.g., bank of two 4-ft. diameter fans may need a 50-foot setback, four fans may need a 60-foot setback, etc.).

Length of Rows. Length of the buffer should be a minimum of 10 feet longer, at each end, than the odor source. For a single 48-inch sidewall fan, the buffer should be 24-feet long, centered at the mid-point of the fan. For a bank of fans spanning the entire end of a 40-foot building, the buffer should be 60 feet long. All individual fans and fan banks must be fitted with a vegetative buffer to meet the requirements of this standard.

Spacing Between Rows

Spacing between adjacent rows can vary or be uniform. Plan the between-row spacing wide enough for maintenance equipment to operate freely between rows. Usually this requires about 4 additional feet to allow mower access during the establishment period. Alternatively, Weed Control Barriers may be used, e.g. landscape fabric and woody mulch, etc.

Maximum between-row spacing should depend on site conditions and planned vegetative buffer function but should not exceed 20 feet. Exceptions to these between-row spacing include the use of vegetation as a living snow fence and when the landowner plans to remove every other row prior to excessive crowding.

Row Types/Heights	Spacing Between Rows
Between shrubs less than 10 ft. tall	10 feet
Between shrubs and small trees (10 to 25 ft.) tall	12 feet
Between small trees less than 25 ft. tall	12 feet
Between small and tall trees (> 25 ft.) in height	16 feet
Between tall trees > 25 ft. tall	16 feet
Between any wide-crowned species and conifers	20 feet
Between faster growing species and conifers	20 feet

Spacing Within Rows

Where plantings exceed the minimum number of rows, a plant-to-plant spacing of up to 20 feet in those additional rows may be planned for any appropriate tree/shrub species.

Closer spacing's result in protection in the shortest time. Where appropriate, plantings with narrow spacing's can be designed with future thinning required to achieve the ultimate required spacing and density.

Plant types at 20-year heights	Spacing Within Rows
Shrubs < 10 feet tall	3 to 6 feet
Shrubs and trees (10 – 25 ft.) tall	5 to 16 feet
Trees > 25 ft. tall	8 to 16 feet

Vegetative Filtering Exception

In the case of an animal housing facility that uses both side-wall fans and end-wall fans (tunnel fans), the individual fans (side-wall fans) may use less than 3 rows of plant material **only when** there are also 3 or more rows of Vegetative Filtering being used to address the end-wall fans or tunnel fans.

B. VISUAL SCREENING

Since the goal of visual screening is not explicitly to filter odors and dust, the plant material requirements are lessened. One or two rows of plant material are sufficient to visually enhance and beautify the facility. For year-round visual screening, use at least one row of evergreen trees.

Plant Materials

See the Plant Materials section (V. Design – Plant Materials Selection) for information on individual plant materials.

C. PLANT MATERIAL CALCULATIONS

Vegetative Filtering:

Example Scenario: End-Wall Fan Buffer Plant Material Needs

Number of rows planned 3 (Note, Vegetative Filtering requires 3 rows)

Distance from Fan to Row 1

Row 1 (Nearest the fan)

Species (A) (Select from Shrubs and Grasses, e.g. Streamco Willow or Switchgrass)

Buffer length (feet) (B)

Distance Between plants (C)

Number of plants needed = $(B / C + 1) =$

Distance between Row 1 and Row 2 to accommodate mowing

Row 2 (Second row from the fans)

Species (A) (Select from Deciduous Trees, e.g. Hybrid Poplar or Sycamore)

Buffer length (feet) (B)

Distance Between plants (C)

Number of plants needed = $(B / C + 1) =$

Distance between Row 2 and Row 3 to accommodate mowing

Row 3 (Row furthest from the fan)

Species _____ (A) (Select from Evergreen Trees, e.g. Arborvitae or Spruce)

Buffer length (feet) _____ (B)

Distance Between plants _____ (C)

Number of plants needed = $(B / C + 1) =$ _____

Vegetative Filtering Exception:

Example Scenario: Individual Fan Buffer Plant Material Needs

Number of rows planned _____ (Note, may be 1 or multiple rows, provided that additional Vegetative Filtering is planned)

Distance from Fan to Row 1 _____

Row 1 (Nearest the fan)

Species _____ (A) (Select from Shrubs and Grasses, e.g. Streamco Willow or Switchgrass)

Buffer length per fan (feet) _____ (B)

Distance Between plants _____ (C)

Number of plants needed = $(B / C + 1) =$ _____

Distance between Row 1 and Row 2 to accommodate mowing _____

Row 2 (Second row from the fans)

Species _____ (A) (Select from Deciduous Trees, e.g. Hybrid Poplar or Sycamore)

Buffer length per fan (feet) _____ (B)

Distance Between plants _____ (C)

Number of plants needed = $(B / C + 1) =$ _____

Visual Screening:

Plant Material Needs for Visual Screening only (not odor control)

Number of rows planned _____ (may be 1 or multiple rows; May be near property line, etc.)

Specie(s) _____ (A) (Select from any species)

Number of rows _____ (B)

Buffer length (feet) _____ (C)

Distance Between plants _____ (D)

Number of plants needed = $(C / D + 1) \times B =$ _____

Total Plant Material Needs:

Species _____ Number of plants _____

Species _____ Number of plants _____

Species _____ Number of plants _____

The results of these planning details are to be entered into the Plant Materials Information Chart, which will be used in the OMP.

PLANT MATERIALS INFORMATION CHART:

Species/cultivar by row number	Kind of stock ¹	Planting dates ² :	Distance between plants within row (ft.)	Total number of plants for row	Distance (ft.) from this row to next row ³
1.					
2.					
3.					
4.					
5.					
6.					
7.					

¹ Bareroot, container, cutting, balled and burlapped (B&B), etc. Include size, caliper, height, and age as applicable.

² Date: Month & Year

³ Adjusted for width of maintenance equipment.

III. IMPLEMENTATION SPECIFICATIONS

Containerized and balled-and-burlapped (B&B) plants are usually available throughout the year. The preferred planting times are in the fall or spring, but plants can also be installed during the summer months and irrigation must be used. Planting during the dormant period (winter and early spring) is also an option if the ground is not frozen. Ask your plant supplier for recommendations.

The site should be flagged to identify exactly where each plant will be placed.

A. Site Preparation

Follow the NRCS Conservation Practice Standard Tree/Shrub Site Preparation (490) for site preparation guidance.

Remove debris and control competing vegetation to allow enough spots or sites for planting and planting equipment. Prepare supplemental moisture (irrigation) materials for installation if required by trees and/or shrubs.

Because vegetative buffers can take years to become large enough to reach full effectiveness, good site planning will establish the plants as soon as possible. It is recommended that plant establishment occur prior to construction where possible. Good site planning and construction management will make efforts to leave soil undisturbed in the areas where the buffer will be established. Prior to establishment, the site should be limed in accordance with a soil test recommendation. Disturbed sites around a newly constructed livestock facility often have poor fertility. Soil quality remediation should be accomplished as far in advance of planting as possible.

Appropriate site preparation will be sufficient for establishment and growth of selected species and suitable for the site. Perform necessary site preparation at a time and manner to support the survival and growth of planted species.

Avoid sites that have had recent applications of pesticides harmful to woody species. If pesticides are used apply only when needed, and handle and dispose of properly within federal, state and local regulations. Follow label directions and precautions listed on containers.

Always check for utility lines (gas, water, cable, electricity) before planting. Avoid planting on top of buried utility lines or under low-hanging overhead lines. Contact [Pennsylvania One Call](#) or [Call 811](#) before you dig.

B. Irrigation

Installation of a trickle or emitter irrigation system is highly recommended for all plantings. Drip irrigation lines should be installed prior to planting.

Grasses – Between rows of grasses, use ½-inch polypropylene irrigation line with 0.5 gallon per hour emitters placed every 12–18 inches, or 15 mil thickness drip tape with 12-inch dripper spacing.

Shrubs & Trees – For the irrigation line, use ½-inch polypropylene with 0.5 gallon per hour emitters placed at each tree and shrub. A 15-mil thickness drip tape with 12-inch dripper spacing may be appropriate for closely spaced plantings.

C. Weed Control Barriers

Weed control will be part of the required maintenance activities. To ease weed control, place a layer of landscape fabric/ weed barrier cloth over the planting area.

Wood products, such as shredded or chipped hardwood bark, pine bark, bark chips, and wood chips, can be used as mulch around the plants, but will not provide long-term weed control unless more mulch is periodically added. Apply mulch to a depth of 3 to 4 inches. Use a minimum of a 3-foot wide strip of mulch in the planting row, or a 3-foot diameter circle of mulch around each plant.

Black polyethylene sheeting (6 mil thickness) or woven plastic landscape fabric can also provide an effective weed barrier. Black poly is generally cheaper than landscape fabric and works well if trickle or emitter irrigation is also implemented. Be aware that woven plastic fabric can be difficult to remove after plants are established because roots will grow into the material. Additional drawbacks to these artificial weed control barriers include increased soil temperatures that may limit beneficial microbial activity, and the inconvenience of disposing of the materials when they are no longer needed.

Treatment of the site with a pre- and post-emergent herbicide before planting is also helpful for controlling weed growth.

Natural or synthetic fabric weed mats may also be used around individual tree and shrub plantings to suppress weeds and conserve soil moisture. Mats should be at least 3 feet square, or 3 feet in diameter if round, and installed according to the manufacturer's instructions.

D. Temporary Storage Instructions for Planting Stock

Planting stock that is dormant may be stored temporarily in a cooler or protected area. For stock that is expected to begin growth before planting, dig a V-shaped trench (healing-in-bed) sufficiently deep and bury seedlings so that all roots are covered by soil. Pack the soil firmly and water thoroughly.

E. Planting Methods

Refer to the NRCS Conservation Practice Standard for Tree/Shrub Establishment (612) for planting criteria for establishing trees and shrubs. Criteria concerning, planting stock, stock handling, survival rates, planting dates and all other criteria for establishing woody plants are found in this standard.

For container and bareroot stock, plant stock to a depth even with the root collar in holes deep and wide enough to fully extend the roots. Pack the soil firmly around each plant. Cuttings are inserted in moist soil with at least 2 to 3 buds showing above ground.

Plant Materials. Unless written approval is obtained from State Conservation Commission staff and documented in Appendix 5 of the Odor Management Plan, the plant material must come from the approved lists in the V. **Design – Plant Materials Selection** section. All plant material options are proven to withstand dust accumulation and thrive near livestock fans.

Rows should be staggered so that plants in row #2 are planted-in adjacent to the gaps in row #1. See figure 3 in the V. **Design – Plant Materials Selection** section.

IV. OPERATION & MAINTENANCE SPECIFICATIONS

Perform the following actions to ensure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation) and repair and upkeep of the practice (maintenance):

A. Inspections

Year 1. Inspect the Vegetative Barrier twice a month from spring until fall. Identify areas damaged by heavy rainfall, animals, chemicals, tillage, or equipment traffic, and any other areas where the vegetation is not adequate to achieve the intended purpose of the practice. Replant during the growing season.

Years 2 – 4. Inspect the Vegetative Barrier monthly during the growing seasons. Identify areas damaged by heavy rainfall, animals, chemicals, tillage, or equipment traffic, and any other areas where the vegetation is not adequate to achieve the intended purpose of the practice. Replant during the growing season. A higher level of care is required until 3 years after plant establishment.

Years 5 and on. Inspect the windbreak at least annually. Identify areas damaged by heavy rainfall, animals, chemicals, tillage, or equipment traffic, and any other areas where the vegetation is not adequate to achieve the intended purpose of the practice. Replant during the growing season.

B. Maintenance Activities

Pruning. Thin or prune the rows of plantings to maintain its function only after trees and shrubs are established. Refer to Use NRCS Conservation Practice Standards Tree/Shrub Pruning (PA660), and Forest Stand Improvement (PA666) and for these maintenance activities.

Fertilize. Apply nutrients periodically as needed after the first year, but only if needed to maintain plant vigor and at a rate based on soil test results.

Protect from damage. Protect the planting from wildfire and damage from livestock, wildlife, and equipment, to the extent feasible. Refer to the NRCS Conservation Practice Standards Access Control (PA472) or Fencing (PA382).

Weed Control. Control undesirable plants by pulling, mowing, or spraying with a selective herbicide. Replace woody mulch; reapply mulch to a depth of 3 to 4 inches. Refer to NRCS Conservation Practice Standards Brush Management (PA314) and Herbaceous Weed Treatment (PA315).

Irrigation. Provide supplemental water to plantings via a localized or drip irrigation during the growing season for the first 3-years' post-establishment. Ensure irrigation equipment is properly working; replace components as needed. Refer to NRCS Conservation Practice Standard Irrigation System, Micro-irrigation (PA 441).

V. DESIGN – PLANT MATERIALS SELECTION

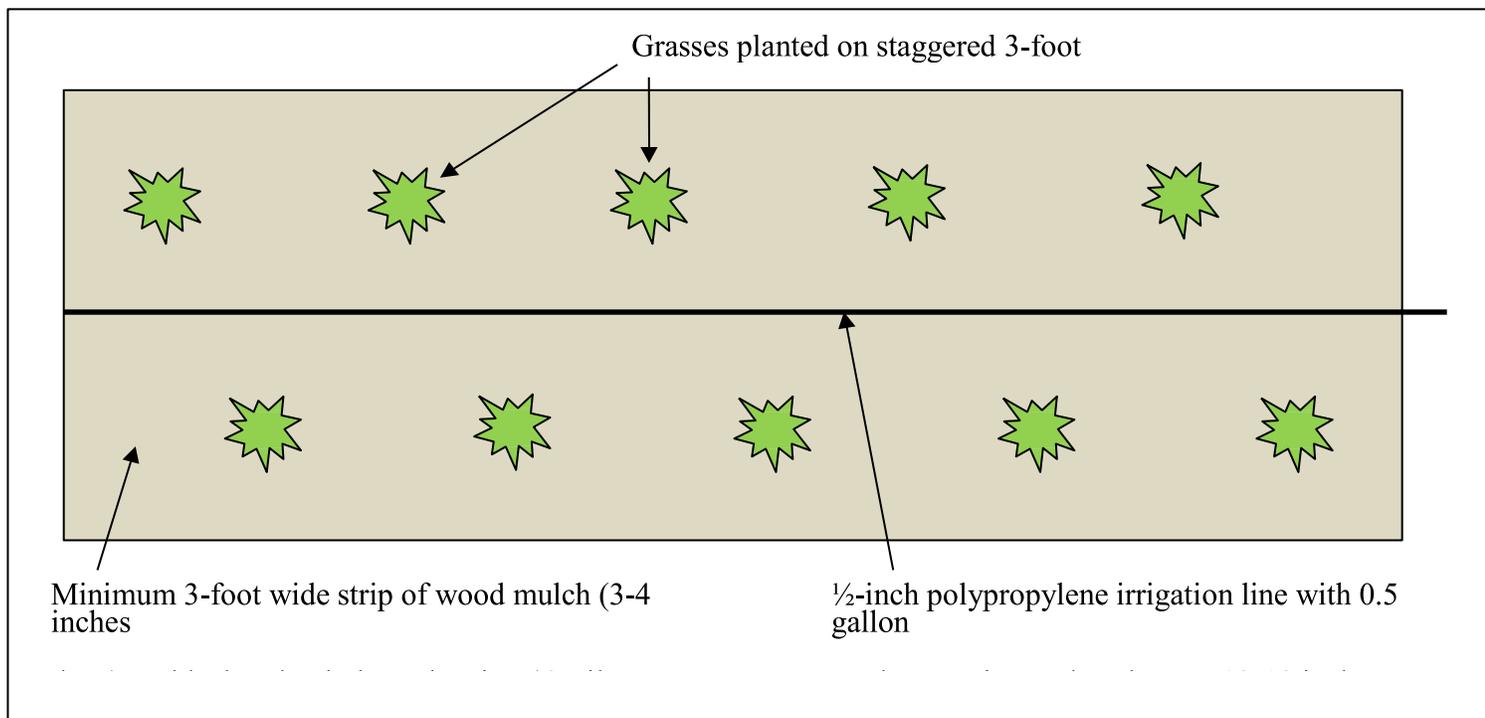
This standard includes four groups of plant materials; Grasses, Shrubs, Deciduous Trees, and Evergreen Trees.

Mixed Species Note – Since dust (particulate matter) carries odors, incorporating a mixed species of native plants in the plant design is encouraged. By using a mixed species of plant material, there will be a higher chance of the Vegetative Buffer filtering out the different sizes of Particulate Matter, i.e. PM_{2.5} & PM₁₀, which in turn helps to disrupt the odor transport pathway. Additionally, incorporating a mixed species planting should provide for better plant health – more diversity equals a more resilient stand of plants, or at least minimize monocultures by mixing up the cultivars if you're planting a buffer of just willow, for example.

Invasive Species Note – Invasive species need to be avoided! Highly invasive species examples – *Ailanthus* (Tree of Heaven), Bradford or Callery Pear, Privet, Autumn Olive, Honeysuckle, Japanese Barberry, Multiflora Rose, and *Euonymus*. Please refer to other plant resource sources such as the Invasive Plant Atlas of the United States (<https://www.invasiveplantatlas.org/index.html>) for more information.

Plant Materials Selection Note – This section V. Design – Plant Materials Selection will be updated as more research and plant species recommendations emerge. The below plant material recommendations are based off of research current at the time of the publication of this standard.

Figure 3. Grass planting layout.



A. Grasses

Preferred Plant Materials Selection:

- Warm Season Grasses:** Switchgrass (*Panicum virgatum*) and Coastal Panicgrass (*Panicum amarum*). Note: Miscanthus (*Miscanthus giganteus*) does well in these applications too, but it is a non-native plant.
- Cool Season Grasses:** Prairie Cordgrass (*Spartina pectinate*)

Planting Methods Note –

Use containerized plants (1-quart containers or larger) that have well-developed root systems. Plants of this size will be able to survive better in the harsh conditions near the ventilation fans than smaller plants or seedlings. In ventilation fan impact areas, planting 1-quart container stock in the spring, along with irrigation and good weed control, should produce the best results for plant survival and growth.

Spacing Within & Between Rows –

Plant the grasses 3 feet apart on center within and between rows, with a staggered planting arrangement between rows (see Figure 3). It also is advisable to use more than one species or variety of grass so that a single insect or plant pathogen won't devastate the entire planting.

Table 1. Recommended grasses for planting near poultry house ventilation fans.

Common Name	Scientific Name	Cultivar	Mature Size (width x height)	Remarks
WARM SEASON GRASSES				
PANICGRASS, COASTAL	<i>Panicum amarum</i> var. <i>amarulum</i>	'Atlantic' or 'Dewey Blue'	3' x 6'	Quickest to establish, but not as stiff-stemmed as others on this list. 'Dewey Blue' has especially attractive bluish leaves. Do not plant Coastal Panicgrass on wet sites.
SWITCHGRASS	<i>Panicum virgatum</i>	'Kanlow'	5' x 7'	Vigorous lowland switchgrass, typically used for biofuel production. Especially good for moist soils.
SWITCHGRASS	<i>Panicum virgatum</i>	'Northwind'	2' x 6'	Does not spread as much as other cultivars. Useful for planting closest to the ventilation fans if space is limited
SWITCHGRASS	<i>Panicum virgatum</i>	'Thundercloud'	4' x 8'	Tallest switchgrass cultivar on this list. If using multiple rows, can be planted downwind of shorter plants. Also, can be placed at greater distances from ventilation fans due to taller height.
SWITCHGRASS	<i>Panicum virgatum</i>	Timber Germplasm	5' x 7'	Vigorous lowland switchgrass, typically used for biofuel production. Especially good for moist soils; lodges a little less than 'Kanlow.' Commercial availability of container plants may be limited.
MISCANTHUS, GIANT	<i>Miscanthus giganteus</i>		3' x 9'	Clumps of corn-like stalks. Good for moist soils, but also tolerate moderate drought conditions.

COOL SEASON GRASSES

CORDGRASS, PRAIRIE	<i>Spartina pectinata</i>	Common	6' x 8'	Prefers wet sites (e.g., swales between poultry houses), but also tolerates dry sites and saline environments. Can spread rapidly by rhizomes, up to 2 feet in a growing season, to make a dense mat.
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B. Shrubs

Preferred Plant Materials Selection:

Streamco Willow, Redosier Dogwood, Grey Dogwood, Dwarf Hackberry, Northern Bayberry, Japanese Holly

Planting Methods Note –

In ventilation fan impact areas, planting 1- to 2-gallon container stock in the spring, along with irrigation and good weed control, should produce the best results for plant survival and growth. 1- to 2-gallon container plants are recommended because they generally survive better in fan impact areas than seedlings or balled-and-burlapped plants.

If the tree/shrub planting distance will be less than 40 feet from the ventilation fans, use at least one row of stiff-stemmed warm-season grasses in front of the trees/shrubs.

Table 2. Recommended shrubs for planting near poultry house ventilation fans.

Plant Names	Height at 20 Years ^{1/}	Growth Rate ^{2/}	Density ^{3/} Summer	Density - Winter	Planting Distance from Fans	Remarks
SHRUBS						
WILLOW, PURPLEOSIER ^{5/} <i>Salix purpurea</i> 'Streamco'	15 ft.	Fast	Medium to High	Low	≥40 feet	Shrub/small tree. 'Streamco' is a male clone, does not root sucker, and does not spread readily beyond the planting site. Proven effective for odor control (passive ammonia absorption).
HACKBERRY, DWARF <i>Celtis pumila</i>	25 ft.	Fast	High	Low	≥30 feet	Deciduous shrub/small tree. Adapted to a wide range of soil and site conditions. Fruits are attractive to birds.
DOGWOOD, REDOSIER <i>Cornus sericea</i>	15 ft.	Fast	Medium to High	Low	≥40 feet	Tolerant of fluctuating water tables. Fruits are attractive to birds. Often used for landscaping and as a secondary plant in windbreaks.
DOGWOOD, GREY <i>Cornus racemosa</i>	12 ft.	Slow	Medium to High	Low	≥40 feet	Tolerates many climatic conditions. Tolerance to shade is considered intermediate. Often used for streambank planting. Plant in the early spring with dormant planting stock.
Shrubs – Visual Screening Only						
BAYBERRY, NORTHERN <i>Morella pennsylvanica</i> (formerly <i>Myrica pennsylvanica</i>)	10 ft.	Moderate	Medium	Low	N/A	Semi-evergreen foliage. Need male and female plants for fruit production. Salt tolerant (0-20 ppt.) Suckers to form colonies. Suitable for visual screens and similar uses. <u>Not recommended for planting in fan impact areas.</u>
HOLLY, JAPANESE ^{5/} <i>Ilex crenata</i> 'Steeds'	8 ft.	Fast	High	High	N/A	Evergreen. Need male and female plants for fruit production. Fruits are attractive to birds. Tolerates partial shade. Suitable for visual screens and similar uses. <u>Not recommended for planting in fan impact areas.</u>

C. Deciduous Trees

Preferred Plant Materials Selection:

Red Maple, Common Hackberry, Honey Locust, Black Locust, Hybrid Poplar, Tulip Poplar, Sycamore, Bald Cypress, American Elm, Osage-Orange, Dawn Redwood, Hybrid Willow

Planting Methods Note –

In ventilation fan impact areas, planting 1- to 2-gallon container stock in the spring, along with irrigation and good weed control, should produce the best results for plant survival and growth. 1- to 2-gallon container plants are recommended because they generally survive better in fan impact areas than seedlings or balled-and-burlapped plants.

If the tree/shrub planting distance will be less than 40 feet from the ventilation fans, use at least one row of stiff-stemmed warm-season grasses in front of the trees/shrubs.

Table 3. Recommended trees and shrubs for odor control, visual screening, shade, and shelter around poultry houses.

Plant Names	Height at 20_ Years ^{1/}	Growth Rate ^{2/}	Densit_ y ^{3/} - Summer	Density - Winter	Planting Distance from Fans	Remarks
DECIDUOUS TREES						
CYPRESS, BALD <i>Taxodium distichum</i>	30 ft.	Fast	Medium to High	Low	≥25 feet	Naturally occurring on streambanks and in swamps. Fine-textured leaves are highly efficient for trapping dust and odors.
ELM, AMERICAN <i>Ulmus americana</i> 'New Harmony' and 'Valley Forge'	35 ft.	Fast	Medium to High	Low	≥30 feet	Prefers moist soil but will tolerate drier sites. The New Harmony and Valley Forge cultivars are Dutch Elm disease-resistant. Careful pruning is recommended to insure upright growth.
HACKBERRY, COMMON <i>Celtis occidentalis</i>	35 ft.	Fast	High	Low	≥30 feet	Adapted to a wide range of soil and site conditions. Fruits are attractive to birds. Proven effective for odor control (passive ammonia absorption).
HONEYLOCUST <i>Gleditsia triacanthos</i> var. <i>inermis</i>	40 ft.	Fast	Low to Medium	Very Low	Use formula ^{4/}	Prefers well-drained sites but will tolerate brief inundation. Drought-resistant and somewhat tolerant of salinity. Small leaves are highly efficient for trapping dust and odors. Proven effective for odor control (passive ammonia absorption).
LOCUST, BLACK <i>Robinia pseudoacacia</i> Steiner Group	30 ft.	Fast	Low to Medium	Very Low	≥30 feet	Adapted to a wide range of soil and site conditions, except very wet. Small leaves are highly efficient for trapping dust and odors. The Steiner Group of black locust consists of three cultivars: 'Appalachia,' 'Allegheny,' and 'Algonquin.' Tolerant of locust borers.
MAPLE, RED <i>Acer rubrum</i>	35 ft.	Fast	Medium to High	Low	≥30 feet	Adapted to a wide range of soil and site conditions. Extremely variable growth rate.

OSAGE-ORANGE <i>Maclura pomifera</i> 'White Shield'	20 ft.	Moderate	High	Low	Use formula ^{4/}	Adapted to a wide range of soil and site conditions. Trunk is usually short and divides into several prominent limbs. Fruits are messy, so select male plants. 'White Shield' may be the most thorn-free cultivar.
POPLAR, HYBRID <i>Populus deltoids x Populus nigra</i>	45 ft.	Very Fast	Medium		Use formula ^{4/}	Thrives under a wide range of soil and climatic conditions, and resists insects and diseases.
POPLAR, TULIP <i>Liriodendron tulipifera</i>	50 ft.	Very Fast	Medium		Use formula ^{4/}	It does best on moderately moist, deep, well drained, loose textured soils; it rarely grows well in very dry or very wet situations.
REDWOOD, DAWN ^{5/} <i>Metasequoia glyptostroboides</i>	35 ft.	Fast	High	High	≥30 feet	Prefers moist soil but will tolerate drier sites. Similar in appearance to bald cypress. Fine-textured leaves are highly efficient for trapping dust and odors. <u>Test data are from sidewall fans only.</u>
SYCAMORE <i>Platanus occidentalis</i>	50 ft.	Fast	High	Low	Use formula ^{4/}	Best growth on moist, rich soil. Often found on moist bottomlands along streams and rivers. Tolerant to a wide range of soil conditions. Susceptible to anthracnose during wet years.
WILLOW, HYBRID ^{5/} <i>Salix matsudana x alba</i> 'Austree'	60 ft.	Very Fast	Medium to High	Medium	Use formula ^{4/}	Sterile hybrid. Due to its extremely fast growth (>3 ft./yr.), can provide visual screen in 1 – 2 years. Dense branch structure. Proven effective for odor control (passive ammonia absorption).

D. Evergreen Trees

Preferred Plant Materials Selection:

Arborvitae, Eastern Red Cedar, Norway Spruce, Atlantic White Cedar, Eastern White Pine, American Holly, Nellie Stevens Holly

Planting Methods Note –

In ventilation fan impact areas, planting 1- to 2-gallon container stock in the spring, along with irrigation and good weed control, should produce the best results for plant survival and growth. 1- to 2-gallon container plants are recommended because they generally survive better in fan impact areas than seedlings or balled-and-burlapped plants.

If the tree/shrub planting distance will be less than 40 feet from the ventilation fans, use at least one row of stiff-stemmed warm-season grasses in front of the trees/shrubs.

Table 4. Recommended evergreen trees for planting near poultry house ventilation fans.

Plant Names	Height at 20 Years ^{1/}	Growth Rate ^{2/}	Density ^{3/} Summer	Density - Winter	Planting Distance from Fans	Remarks
EVERGREEN TREES						
ARBORVITAE <i>Thuja occidentalis</i>	25 ft.	Slow	Very High	Very High	Use formula ^{4/}	Frequently planted statewide as an ornamental. Prefers moist, well-drained soil, but tolerates a wide range of conditions. Prone to bagworms.
ARBORVITAE ^{5/} <i>Thuja plicata x standishii</i> 'Green Giant'	40 ft.	Fast	Very High	Very High	Use formula ^{4/}	Prefers well-drained soil, but tolerates a wide range of conditions. Bagworms are potential pests. Proven effective for odor control (passive ammonia absorption).
CEDAR, ATLANTIC WHITE <i>Chamaecyparis thyoides</i>	25 ft.	Moderate	Very High	Very High	Use formula ^{4/}	Prefers moist soil. Similar to Arborvitae in growth form.
CEDAR, EASTERN RED <i>Juniperus virginiana</i>	20 ft.	Moderate	Very High	Very High	Use formula ^{4/}	Growth rate and size is site dependent and can be variable. Should not be planted near apple orchards; alternate host of cedar- apple rust. Proven effective for odor control (passive ammonia absorption).
HOLLY, AMERICAN <i>Ilex opaca</i>	20 ft.	Slow	High	High	N/A	Need male and female plants for fruit production. Fruits are attractive to birds. Shade tolerant; very slow-growing. Suitable for visual screens and similar uses. <u>Not recommended for planting in fan impact areas.</u>

PINE, EASTERN WHITE <i>Pinus strobus</i>	50 ft.	Fast	High	High	Use formula ^{4/}	Grows on a variety of soils ranging from light, sandy, to heavy soils.
SPRUCE, NORWAY ^{5/} <i>Picea abies</i>	35 ft..	Fast	High	High	Use formula ^{4/}	Fast growth rate when young, slows down with age. Prefers moderately moist, well- drained soil. Fine-textured leaves are highly efficient for trapping dust and odors. Proven effective for odor control (passive ammonia absorption).
Evergreen Trees – Visual Screening Only						
HOLLY, NELLIE STEVENS ^{5/} <i>Ilex cornuta x aquifolium</i> 'Nellie Stevens'	20 ft.	Fast	High	High	N/A	Shrub/small tree. Need male and female plants for fruit production. Fruits are attractive to birds. Tolerates partial shade. Plants may be multi-stemmed or pruned to have one main stem when young. Suitable for visual screens and similar uses. <u>Not recommended for planting in fan</u>

Tables # 2 – 4 Notes:

- 1. Height at 20 Years:** Actual height may be shorter than the potential height on an optimal site, especially in fan discharge areas.
- 2. Growth Rate:** Slow = less than 1 ft./year; Moderate = 1–2 ft./year; Fast = 2-3 ft./year; Very Fast = more than 3 ft./year.
- 3. Density:** For an individual plant species, defined as the amount of space that is occupied by foliage, twigs, and branches and can be estimated by the amount of light that can be seen through the plant. Low density – 25-35% of space occupied by plant material (with 65-75% open space through which air can travel); Medium density – 40-60% of space occupied by plant material; High density - 60-80% of space occupied by plant material; Very High – more than 80% of space occupied by plant material. The overall density of a hedgerow is affected by the species selected, number of rows, and spacing between plants.
- 4. Planting Distance from Fans:** As a general rule for plant survival in fan impact areas, the nearest row of tree/shrub plantings must be set back from the fans by a distance that is at least 10 times the exhaust fan diameter. (For example, if the ventilation fan has a diameter of 4 feet, then the first line of plants needs to be planted at least 40 feet away.) Where multiple fans are used in one location, this planting distance formula may be increased a minimum of 5 feet for each fan, depending on the number of fans that are likely to be running at the same time (e.g., bank of two 4-ft. diameter fans may need a 50-foot setback, four fans may need a 60-foot setback, etc.).
- 5. Non-native plant;** not considered to be invasive.

Plant Reference Materials:

Shrubs

Willow, Purpleosier https://plants.sc.egov.usda.gov/factsheet/pdf/fs_sapu2.pdf

Hackberry, Dwarf <https://plants.usda.gov/core/profile?symbol=CEPU10>

Dogwood, Redosier https://plants.usda.gov/plantguide/pdf/cs_cose16.pdf

Dogwood, Grey https://plants.usda.gov/factsheet/pdf/fs_cora6.pdf

Bayberry, Northern <http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=e310>

Holly, Japanese <https://www.hortmag.com/plants/plants-we-love/steeds-japanese-holly-for-foundation-plantings-and-entries>

Deciduous Trees

Maple, Red https://plants.usda.gov/plantguide/pdf/pg_acru.pdf

Hackberry, Common https://plants.usda.gov/plantguide/pdf/pg_ceoc.pdf

Locust, Honey https://plants.usda.gov/plantguide/pdf/pg_gltr.pdf

Locust, Black https://plants.usda.gov/factsheet/pdf/fs_rops.pdf

Poplar, Hybrid <http://www.missouribotanicalgarden.org/>

Poplar, Tulip https://plants.usda.gov/factsheet/pdf/fs_litu.pdf

Sycamore <http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=a891>

Cypress, Bald https://plants.usda.gov/plantguide/pdf/pg_tadi2.pdf

Elm, American <http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=a922>

Osage-Orange https://plants.usda.gov/factsheet/pdf/fs_mapo.pdf

Redwood, Dawn <http://conifersociety.org/>

Willow, Hybrid <https://will.illinois.edu/images/tvPrograms/AustreeBittersweet.pdf>

Evergreens

Arborvitae, Eastern https://plants.usda.gov/plantguide/pdf/cs_thoc2.pdf

Arborvitae, Western https://plants.usda.gov/plantguide/pdf/cs_thoc2.pdf

Cedar, Atlantic White https://plants.usda.gov/plantguide/pdf/pg_chth2.pdf

Cedar, Eastern Red https://plants.usda.gov/plantguide/pdf/cs_juvi.pdf

Holly, American https://plants.usda.gov/factsheet/pdf/fs_ilop.pdf

Holly, Nellie Stevens <http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=c822>

Pine, Eastern White https://plants.usda.gov/factsheet/pdf/fs_pist.pdf

Spruce, Norway <http://www.mortonarb.org/trees-plants/tree-plant-descriptions/norway-spruce>

VI. EXAMPLE OMP

The following is an example of a Vegetative Buffer write-up in an Act 38 Odor Management Plan (OMP). The certified OM Specialist plan writer will detail this information in the OMP. The plan writer will indicate if the Vegetative Buffer was a Required Level II Odor BMP or a Supplemental Level II Odor BMP, by selecting the appropriate checkbox.

Plan Summary

C. Odor BMP Implementation, Operation & Maintenance Schedule

Level II Odor BMPs to be Implemented:

Select each check-box that applies; if more than one category applies, clearly detail the respective Level II Odor BMPs criteria with each

respective category. Detail below all Level II Odor BMPs criteria addressing the following:

- 1. the general construction and implementation criteria*
- 2. the corresponding timeframes of when each Odor BMP will be implemented*
- 3. all operation and maintenance procedures for each Odor BMP along with the corresponding timeframes for carrying out those procedures*
- 4. the lifespan of each Odor BMP.*

Required Level II Odor BMP:

Supplemental Level II Odor BMP:

Vegetative Buffers

Vegetative Buffers are plantings of grasses, trees and/or shrubs that are strategically located around animal housing facilities and/or manure storage facilities on poultry and livestock operations. Additionally, when used for their Visual Screening capacity, Vegetative Buffers may be located along property lines, or other locations on the poultry or livestock operation. Vegetative Buffers filter and trap dust, odor, particulate matter, and ammonia from the odor plume.

I. IMPLEMENTATION

Site Preparation

Follow the NRCS Conservation Practice Standard Tree/Shrub Site Preparation (490) for site preparation guidance. Remove debris and control competing vegetation to allow enough spots or sites for planting and planting equipment. Prepare supplemental moisture materials for installation.

Check for utility lines (gas, water, cable, electricity) before planting. Contact [Pennsylvania One Call](#) or [Call 811](#) several working days before you dig or install the plant material.

Location & Layout Map

Refer to the Location & Layout Map for the placement (location) of the individual rows of plant material.

Planting Methods

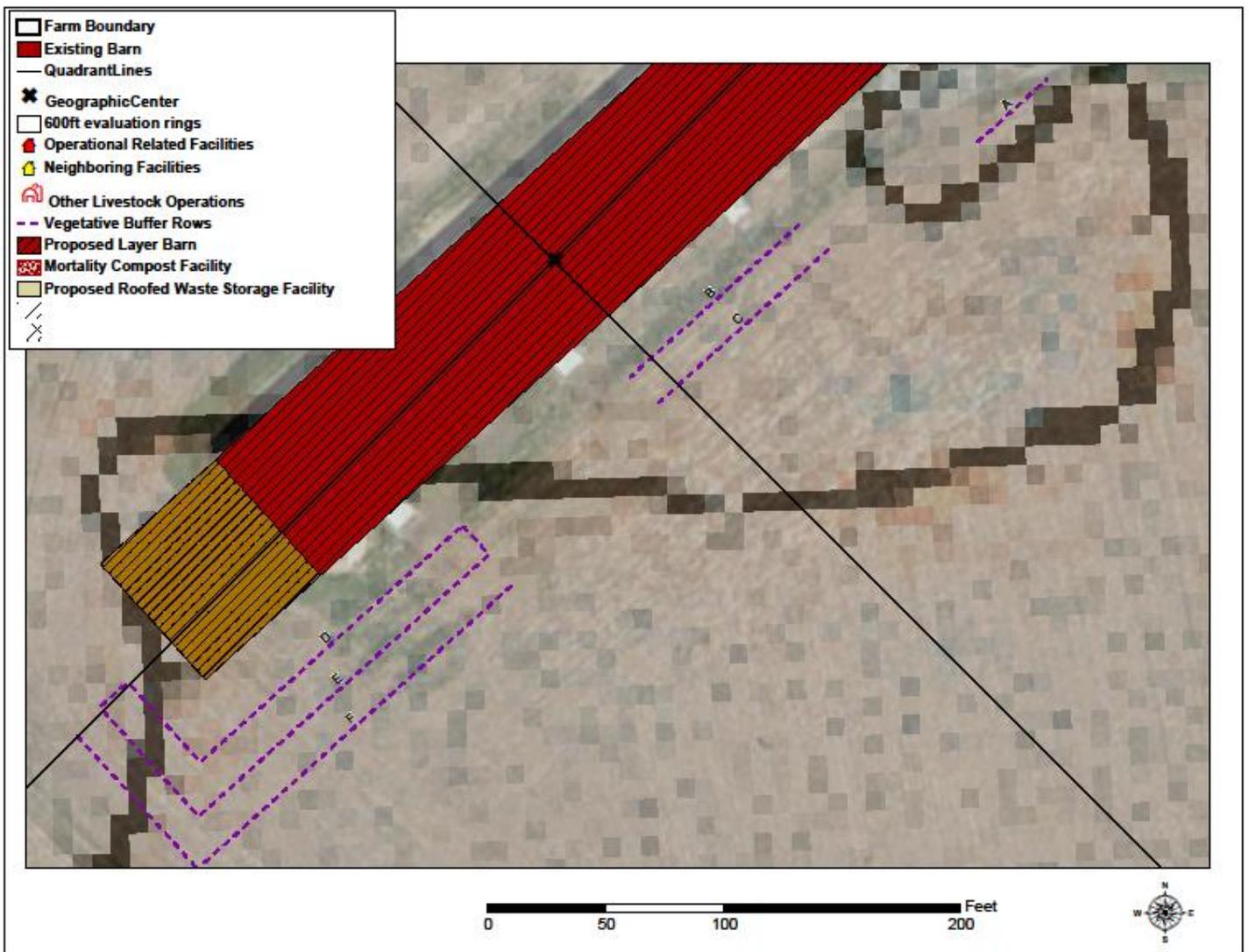
Refer to the Plant Materials Chart. For container, bareroot, and balled & burlapped stock, install the plant stock to a depth even with the root collar in holes deep and wide enough to fully extend the roots. Pack the soil firmly

around each plant and water; repack any voids found from watering. Cuttings are inserted in moist soil with at least 2 to 3 buds showing above ground.

Visual Screening, Rows A, B, & C. These rows are creating visual screening for portions of the layer barn. Rows B & C should be staggered so that plants in row C are planted in adjacent to the gaps in row B.

Vegetative Filtering, Rows D, E & F. These rows are addressing the odor plume from the tunnel ventilation blowing into the roofed, 3-walled manure storage facility. Rows D, E & F should be staggered so that plants in row E are planted in, adjacent to the gaps in rows D & F.

Location & Layout Map



Plant Materials Information Chart

Species/cultivar by row number	Kind of stock ⁴	Planting dates ⁵ :	Distance between plants within row (ft.)	Total number of plants for row	Distance (ft.) from this row to next row ⁶
1. <u>Row A – Evergreen</u> : Green Giant Arborvitae	4' – 5' high B&B	May 2019	10'	5	55' from Facility
2. <u>Row B – Evergreen</u> : Green Giant Arborvitae	4' – 5' high B&B	May 2019	10'	5	40' from Facility
3. <u>Row C – Evergreen</u> : Green Giant Arborvitae	4' – 5' high B&B	May 2019	10'	3	18' from Row B
4. <u>Row D – Deciduous</u> : Mix of American Elm, Red Maple, Common Hackberry, Black Locust, & Hybrid Willow Beech	10' high B&B	May 2019	15'	10	40' from Facility
5. <u>Row E – Evergreen</u> : Green Giant Arborvitae	4' – 5' high B&B	May 2019	10'	5	18' from Row D
6. <u>Row F – Evergreen</u> : Green Giant Arborvitae	4' – 5' high B&B	May 2019	10'	18	18' from Row E
7. <u>Row B – Shrubs</u> : Streamco Willows	Cuttings	May 2019	10'	7	40' from Facility
8. <u>Row C – Shrubs</u> : Streamco Willows	Cuttings	May 2019	10'	8	18' from Row B
9. <u>Row E – Shrubs</u> : Streamco Willows	Cuttings	May 2019	10'	20	18' from Row D
10. <u>Row F – Shrubs</u> : Streamco Willows	Cuttings	May 2019	10'	2	18' from Row E

Weed Control Barriers

Place a layer of black polyethylene sheeting (6 mil thickness) over the planting area. Place wood product mulch (such as shredded or chipped hardwood bark, pine bark, bark chips, and wood chips) around the plants. Apply mulch to a depth of 3 to 4 inches. Use a minimum 3-foot wide strip of mulch in the planting row, or at least a 3-foot diameter circle of mulch around each plant.

Irrigation

Install a trickle or emitter irrigation system with the drip irrigation lines to cover the rows of plants.

⁴ Bareroot, container, cutting, balled and burlapped (B&B), etc. Include size, caliper, height, and age as applicable.

⁵ : Date: Month & Year or Season & Year

⁶ Adjusted for width of maintenance equipment.

II. OPERATION & MAINTENANCE

Inspections

Year 1. Inspect the Vegetative Barrier twice a month from spring until fall. Shape areas damaged by heavy rainfall, animals, chemicals, tillage, or equipment traffic, and any other areas where the vegetation is not adequate to achieve the intended purpose of the practice. Replant during the growing season.

Years 2 – 4. Inspect the Vegetative Barrier monthly during the growing seasons. Shape areas damaged by heavy rainfall, animals, chemicals, tillage, or equipment traffic, and any other areas where the vegetation is not adequate to achieve the intended purpose of the practice. Replant during the growing season. A higher level of care is required until 3 years after plant establishment.

Years 5 and on. Inspect the Vegetative Barrier at least annually. Shape areas damaged by heavy rainfall, animals, chemicals, tillage, or equipment traffic, and any other areas where the vegetation is not adequate to achieve the intended purpose of the practice. Replant during the growing season.

Maintenance Activities

Pruning. Thin or prune the rows of plantings to maintain its function only after trees and shrubs are established.

Fertilize. Apply nutrients periodically as needed after the first year, but only if needed to maintain plant vigor and at a rate based on soil test results.

Protect from damage. Protect the planting from wildfire and damage from livestock, wildlife, and equipment, to the extent feasible.

Weed Control. Control undesirable plants by pulling, mowing, or spraying with a selective herbicide. Replace woody mulch; reapply mulch to a depth of 3 to 4 inches.

Irrigation. Provide supplemental water to plantings via a localized or drip irrigation during the growing season for the first 3-years' post-establishment. Ensure irrigation equipment is properly working; replace components as needed.

D. Documentation Requirements

The following information will be documented by the Operator for each Odor BMP to ensure compliance with the plan. Documentation is needed to demonstrate implementation of the plan as well as for corrective actions taken for significant maintenance activities needed to return an Odor BMP back to normal operating parameters.

Level II Odor BMP Documentation Requirements

Select each check-box that applies; if more than one category applies, clearly detail each documentation criterion.

None Required – *(NOTE: Delete the Level II Quarterly Observation Log)*

Level II Odor BMP Documentation Criteria:

The Operator will complete the Level II Odor BMPs Quarterly Observation Log, at least on a quarterly basis, detailing the proper implementation of the Odor BMPs as identified in the Implementation, Operation

& Maintenance Schedule. The Operator will also complete the Level II Odor BMPs Quarterly Observation Log upon any of the following occurrences:

1. Implementation – Document the initial implementation dates of the plant materials. After the initial planting, document quarterly that the Vegetative Buffer is still actively being implemented.
2. Inspections – Document that you inspected the Vegetative Buffer in accordance with the OMP Plan Summary, C. Odor BMP Implementation, Operation & Maintenance Schedule details, and document any corrective actions taken.
3. Pruning, Fertilize, & Protect from Damage – Document when you pruned, applied fertilizer to, and/or protected the plants in the Vegetative Buffer from damage, in accordance with the OMP Plan Summary, C. Odor BMP Implementation, Operation & Maintenance Schedule details.
4. Weed Control – Document that you provided weed control activities for the Vegetative Buffer, in accordance with the OMP Plan Summary, C. Odor BMP Implementation, Operation & Maintenance Schedule details.
5. Irrigation – Document your irrigation activities for the Vegetative Buffer, in accordance with the OMP Plan Summary, C. Odor BMP Implementation, Operation & Maintenance Schedule details.

Level II Odor BMPs – Quarterly Observation Log **YEAR** _____

(NOTE: The operator will record observations relating to 1) the implementation of each Level II Odor BMP at least on the first day (approximately) of each quarter of the year or in accordance with the Implementation, Operation & Maintenance Schedule, and 2,) for mechanically related maintenance activities, as soon as possible upon the observation that maintenance is needed, or upon each occurrence of any corrective actions taken.)

(Copy This Page For Future Use)

Select Quarter: 1st Quarter (January) 2nd Quarter (April) 3rd Quarter (July) 4th Quarter (October)

LEVEL II ODOR BMP NAME: VEGETATIVE BUFFER

<i>List ACTIVITIES</i>	<i>DATE</i>	<i>NOTES</i>
<i>Implementation</i>		
<i>Maintenance Activities: Inspections</i>		
<i>Pruning, Fertilize & Plant Protection</i>		
<i>Weed Control</i>		
<i>Irrigation</i>		

VII. REFERENCE MATERIALS

1. Belt, S.V., M. van der Grinten, G. Malone, P. Patterson and R. Shockey. 2007. Windbreak Plant Species for Odor Management around Poultry Production Facilities. Maryland Plant Materials Technical Note No. 1. USDA-NRCS National Plant Materials Center, Beltsville, MD. 21p.
https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/mdpmctn7166.pdf
2. Belt, Shawn. 2015. Plants Tolerant of Poultry House Emissions in the Chesapeake Bay Watershed. Maryland Plant Materials Final Report. USDA-NRCS Norman A. Berg National Plant Materials Center, Beltsville, MD.
https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIA_LS/publications/mdpmcsr12671.pdf
3. USDA-NRCS Field Office Technical Guide (FOTG). (Select a state for documents; Section IV). 2018. <https://efotg.sc.egov.usda.gov/#/>
4. USDA-NRCS Conservation Practice Standard Tree/ Shrub Site Preparation (490). 2009.
<https://efotg.sc.egov.usda.gov/references/public/PA/490.pdf>
5. USDA-NRCS Conservation Practice Standard Tree/ Shrub Site Establishment (612). 2017.
[https://efotg.sc.egov.usda.gov/references/public/PA/TreeandShrubEstablishment\(612\)Standard.pdf](https://efotg.sc.egov.usda.gov/references/public/PA/TreeandShrubEstablishment(612)Standard.pdf)
6. USDA-NRCS Conservation Practice Standard Tree/ Shrub Pruning (660). 2015.
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7. USDA-NRCS Conservation Practice Standard Forest Stand Improvement (PA666). 2016.
<https://efotg.sc.egov.usda.gov/references/public/PA/666CPSPAFinal2016.pdf>
8. USDA-NRCS Conservation Practice Standard Access Control (PA472). 2018.
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https://efotg.sc.egov.usda.gov/references/public/PA/PA314_CPS_Dec2017.pdf
11. VEB Tool-Kit, A Guide to Vegetative Environmental Buffers for Tunnel-Ventilated Chicken Houses. 2017. <http://www.dpichicken.org/VEB/docs/VEB-manual-2017-edition.pdf>