SECTION 077273 - VEGETATED ROOF SYSTEMS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
	* + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
			1. SUMMARY
				1. Section Includes:

Continuous vegetated roof assemblies.

Tray-type vegetated roof assemblies.

Walkway pavers.

Geofoam fill.

Refer to sections listed below for cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections. Sections listed below are for spec editor’s and design team coordination and are to remain as Editor’s Notes. Remove referenced specification sections within the body of the specification if not applicable to the project.

Section <Insert Section number> "<Insert Section title>" for roofing membrane, roof thermal insulation, aggregate or roof-paver ballast, and roofing system warranty.

Section 323300 "Site Furnishings" for exterior unit planters.

* + - 1. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. Captured Water: Water that is retained in the drainage layer of a vegetated roof assembly after new water additions have ceased and that cannot escape the roof except through evaporation or plant transpiration.
				2. Finish Elevation: Elevation of finished growing-media surface of planting area.
				3. Planting Area: Areas to be planted.
				4. Plant; Plants; Plant Material: Vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
				5. Growing Medium: Manufactured, lightweight soil mixture that promotes good growing conditions for specific varieties of plants.

Insert other definitions if required.

* + - 1. PREINSTALLATION MEETINGS

Retain "Preinstallation Conference" paragraph below if Work of this Section is extensive or complex enough to justify a conference.

* + - * 1. Preinstallation Conference: Conduct conference at Project site.
			1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Product Data: For each vegetated roof assembly.

Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

Include material descriptions for each growing medium.

Include manufacturer’s installation instructions.

* + - * 1. Sustainable Design Submittals:
				2. Shop Drawings: For each vegetated roof assembly.

Include plans, sections, slopes, and drain locations.

Indicate dimensions, weights, and loads.

Detail field assembly of components, depth of growing media, and attachments to other work.

Revise subparagraph below to suit Project.

Indicate **[walkway pavers] [geofoam fill] [locations of irrigation] [coordination with lighting] [and] [accessories]**.

Revise "Samples for Verification" paragraph below to suit Project.

* + - * 1. Samples for Verification: For each of the following components of vegetated roof assembly:

Retain subparagraphs below to suit Project; coordinate with requirements for each vegetated roof assembly. Insert other Samples if required.

Preplanted Vegetative Mat: 12 by 12 inches.

Growing Media: **[1-pint] [1-quart] <Insert quantity>** volume of each growing medium, in sealed plastic bags labeled with content and source. Each Sample shall be typical of the lots of growing media to be furnished. Provide an accurate representation of texture and composition.

Carlisle SynTec's "Drainage Composite" combines a moisture-retention mat with a drainage panel.

Moisture-Retention Mat: 12 by 12 inches.

Drainage Panels: 12 by 12 inches.

Root Barrier: 12 by 12 inches.

Walkway paver, **[full size,] [manufacturer's standard size,] <Insert requirement>** in each color and texture required; include installation accessories to illustrate assembly.

Geofoam Fill: 12 by 12 inches.

Separation Geotextile: 12 by 12 inches.

Access Boxes: One in each size and color required.

Soil Retainer: Manufacturer's standard size to verify configuration and color selected.

* + - * 1. Quality Control Submittals:

Qualification Data: For Installer.

Retain "Product Certificates" paragraph below to require submittal of product certificates from manufacturers.

Product Certificates: For each type of manufactured product.

Manufacturer's certified analysis of standard products.

Analysis of other materials by a recognized laboratory, according to methods established by the Association of Official Analytical Chemists, where applicable.

Product Test Reports: For complete analysis of each growing medium, for tests performed by manufacturer and witnessed by a qualified testing agency or by a qualified testing agency.

Field quality-control reports.

Sample Warranty: For special warranties.

* + - * 1. Contract Closeout Submittals:

Maintenance Data: For vegetated roof assembly and plants, including a recommended maintenance plan with procedures for inspection and care during a calendar year. Submit before start of required warranty and maintenance periods.

Retain "Continuing Maintenance Proposal" paragraph below if required. Continuing maintenance may be required for a plant-growth warranty. Revise starting date if required. paragraph provides a service contract beyond initial maintenance service. If continuing maintenance proposal is submitted at time of bid, include that information in the Instructions to Bidders.

Continuing Maintenance Proposal: From vegetated roof assembly Installer **[approved by roofing-membrane manufacturer]** to Director’s Representative, in the form of a standard **[one-year] [two-year] [five-year] <Insert agreement period>** maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

* + - 1. QUALITY ASSURANCE

Retain option in "Installer Qualifications" paragraph below if retaining a roofing manufacturer's special warranty that also includes the vegetated roof assembly. See the Evaluations.

* + - * 1. Installer Qualifications: A qualified vegetated roof assembly Installer **[, approved, authorized, or licensed by roofing-membrane manufacturer,]** whose work has resulted in successful establishment of vegetated roofs.

Retain "Field Supervision" subparagraph below if required; revise to suit Project.

Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when vegetated roof assembly work is in progress.

* + - 1. DELIVERY, STORAGE, AND HANDLING
				1. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and Federal laws if applicable.
				2. Bulk Materials:

Do not dump or store bulk materials on or near structures, utilities, walkways and pavements, or existing roof areas or plants.

Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of debris-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

Accompany each delivery of bulk materials with product certificates.

* + - * 1. Handle and store materials, and place equipment in a manner to avoid overloading roof structure or damaging roofing membrane.
			1. FIELD CONDITIONS
				1. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.
			2. WARRANTY

When warranties are required, verify with Director’s Representative that warranties stated in this article are not less than remedies available to Director’s Representative under prevailing local laws.

* + - * 1. Special Warranty for Vegetated Roof Assembly: Installer agrees to repair or replace components of vegetated roof assembly that fail in materials or workmanship within specified warranty period.

Failures include, but are not limited to, ponding water or prolonged wetness of growing medium caused as a result of failure of the assembly to properly drain.

Verify available warranties and warranty periods for vegetated roof assembly and components. Insert start date in "Warranty Period" subparagraph below according to local practice and the type of vegetated roof assembly required.

Warranty Period: **[Two] [Five] [10] <Insert number>** years from date of **[Substantial Completion] [Planting Completion] <Insert starting date>**.

Warranty in "Special Warranty for Plant Growth" paragraph below may be available only for extensive landscapes that have plants approved by manufacturer and with a concurrent maintenance agreement with maintenance company approved by manufacturer; revise to suit Project. Verify coverage offered by manufacturers before specifying.

* + - * 1. Special Warranty for Plant Growth: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

Foliage Cover: Planted materials shall grow to achieve and maintain at least **[80] <Insert number>** percent foliage cover over planting area commencing **[24] <Insert number>** months after planting, through the duration of this warranty.

Failures include, but are not limited to, death and unsatisfactory growth except for defects resulting from abuse, lack of adequate maintenance, neglect by Director’s Representative, or incidents that are beyond Contractor's control.

Insert start date in "Warranty Period" subparagraph below according to local practice and the types of planting required; coordinate with the maintenance period. It is usually not equitable to require Installer to warrant living plant material beyond the maintenance period. A long maintenance period may be required for a manufacturer's warranty.

Warranty Period: From date of **[Substantial Completion] [Planting Completion] <Insert starting date>** as follows:

Warranty periods in "Trees and Shrubs" and "Ground Covers, Perennials, Vines, and Ornamental Grasses" subparagraphs below are examples for some categories of plants; revise to suit Project. Warranty for trees and shrubs in first subparagraph may not be available; verify coverage offered before specifying, and coordinate with initial and continuing maintenance service.

Trees and Shrubs: **[Two] [Five] <Insert number>** years.

Ground Covers, Perennials, Vines, and Ornamental Grasses: **[Two] [Five] <Insert number>** years.

Include the following remedial actions as a minimum:

Immediately remove dead plants and replace unless required to plant in the succeeding planting season.

Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

A limit of one replacement of each plant will be required except for losses or replacements due to failure to comply with requirements.

Retain subparagraph below if required; revise to suit Project.

Provide extended warranty for period equal to original warranty period, for replaced plant material.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and Masterworks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. MANUFACTURERS

Generally retain first option in "Source Limitations" paragraph below. Retain other options to suit Project.

* + - * 1. Source Limitations: Obtain **[vegetated roof assembly components] [growing medium] [walkway pavers and setting bed or supports] [geofoam fill and separation geotextile] [and] [accessories]** from single source from single manufacturer.
			1. VEGETATED ROOF ASSEMBLIES

Copy "Continuous Vegetated Roof Assembly (Insert drawing designation)" paragraph below and re-edit for each type of continuous vegetated roof assembly.

Insert drawing designation. Use these designations on Drawings to identify each product.

* + - * 1. Continuous Vegetated Roof Assembly **<Insert drawing designation>**: Continuous-coverage assembly consisting of manufacturer's standard vegetated roof assembly components for installation over roofing system.

Coordinate "Assembly Depth," "Assembly Weight," and "Plantings" subparagraphs below with manufacturers. The three general categories of vegetated roof landscapes; extensive, intensive, and hybrid; can have identical assembly components but differ in the thickness (depth) of the growing medium, which is a component of the assembly depth.

Assembly Depth, Nominal: **[3 inches] [4 inches] [6 inches] [8 inches] [Manufacturer's standard for required plantings] [As shown on Drawings] <Insert dimension>**, including growing medium.

Weight in "Assembly Weight" subparagraph below is similar to "total dead load" described in ASTM E2397, except that ASTM E2397 includes the weight of roofing system components. Generally retain last option if large perennials or trees are required for intensive landscapes, because ASTM E2397 excludes the weight of "large perennials and trees" for intensive plant material in its "dead load summation." Coordinate weight of vegetated roof assembly with Project's Structural Engineer.

Assembly Weight: Maximum **[15 lb/sq. ft.] [28 lb/sq. ft.)] <Insert requirement>**, including growing medium and plants **[except for large perennials and trees]** and saturated with captured water, but not including weight of roofing system.

Plantings: **[Preplanted vegetative mat as selected by Director’s Representative from manufacturer's standard mixes] [Sedum as selected by Director’s Representative from manufacturer's standard varieties] [As shown on Drawings] <Insert plant varieties or designations>**.

Copy "Tray-Type Vegetated Roof Assembly (Insert drawing designation)" paragraph below and re-edit for each type of tray-type vegetated roof assembly.

Insert drawing designation. Use these designations on Drawings to identify each product.

* + - * 1. Tray-Type Vegetated Roof Assembly <**Insert drawing designation**>: Modular assembly consisting of manufacturer's standard [, **preplanted**] trays for field assembly adjacent to and interlocking with each other over roofing system.

Coordinate "Tray Depth, Nominal," "Tray Size," "Assembly Weight," and "Plantings" subparagraphs below with manufacturers. First three options in first subparagraph are offered by Weston Solutions, Inc.; third option is also offered by GreenTech, Inc. The three general categories of vegetated roof landscapes; extensive, intensive, and hybrid; can have identical assembly components but differ in the thickness (depth) of the growing medium, which is a component of the tray depth.

Tray Depth, Nominal: **[4 inches] [6 inches] [8 inches] [Manufacturer's standard for required plantings] <Insert dimension>**.

First option in "Tray Size" subparagraph below is offered by Weston Solutions; second option is offered by GreenTech.

Tray Size: **[24 by 24 inches] [46 by 46 inches] [Manufacturer's standard] [As shown on Drawings] <Insert dimensions>**.

Weight in "Assembly Weight" subparagraph below is similar to "total dead load" described in ASTM E2397, except that ASTM E2397 includes the weight of roofing system components. Generally retain last option if large perennials or trees are required for intensive landscapes, because ASTM E2397 excludes the weight of "large perennials and trees" for intensive plant material in its "dead load summation." Coordinate weight of vegetated roof assembly with Project's structural engineer.

Assembly Weight: Maximum **[15 lb/sq. ft.] [28 lb/sq. ft. ] <Insert requirement>**, including growing medium and plants **[except for large perennials and trees]** and saturated with captured water, but not including weight of roofing system.

Plantings: **[Preplanted vegetative mat as selected by Director’s Representative from manufacturer's standard mixes] [Sedum as selected by Director’s Representative from manufacturer's standard varieties] [As shown on Drawings] <Insert plant varieties or designations>**.

* + - 1. VEGETATED ROOF ASSEMBLY COMPONENTS

Revise paragraphs below to suit Project.

Vegetated roof assembly components are typically determined by the assembly manufacturer. Before inserting manufacturers for these components, verify acceptability with the assembly manufacturers retained in the "Vegetated Roof Assemblies" Article.

Retain "Moisture-Retention Mat" paragraph below if moisture-retention mat is required. Some manufacturers do not use a moisture-retention mat but use deeper drainage panels with plastic "cups" that have greater water-holding capacity. Carlisle SynTec's "Drainage Composite" combines a moisture-retention mat with a drainage panel.

* + - * 1. Moisture-Retention Mat: Assembly manufacturer's standard water-retaining fabric manufactured from **[recycled]** synthetic fibers.

Revise "Drainage Panels" paragraph below if another form of drainage panel is required. First option below is most common. Xero Flor America and perhaps other manufacturers use the third option exclusively. See the Evaluations.

* + - * 1. Drainage Panels: Assembly manufacturer's standard drainage board formed from **[geotextile-faced, molded-plastic sheet with a geotextile face and "cups" of the molded sheet facing upward like small reservoirs to retain water while allowing excess water to drain away below the board] [or] [geotextile-faced, entangled plastic-filament core]**.

Retain "Root Barrier" paragraph below if this product is required. A root barrier is not required for Carlisle SynTec's "Shallow Assembly" or Sika Sarnafil's roofing membranes, according to these manufacturers.

* + - * 1. Root Barrier: Vegetated roof assembly manufacturer's standard plastic sheet manufactured from **[recycled]** polyethylene or polypropylene plastic; formulated to resist root growth and bacteria.

Generally retain one or both of "Erosion-Control Fabric" and "Anti-Slip Devices" paragraphs below for roofs sloping more than 1/2 inch per 12 inches (1:24) or for temporary wind resistance of small plants until plant root systems have grown together. Insert more detailed descriptions of products to suit Project. See "Plant Stabilization and Erosion Control" Article in the Evaluations.

* + - * 1. Erosion-Control Fabric: **[Vegetated roof assembly manufacturer's standard erosion-control fabric] <Insert description>**.
				2. Anti-Slip Devices: **[Vegetated roof assembly manufacturer's standard anti-slip devices] <Insert description>**.
			1. MANUFACTURED GROWING MEDIA

Retain "Growing Medium (Insert drawing designation)" or "Custom Growing Medium (Insert drawing designation)" paragraph below. Retain first paragraph for growing medium based on vegetated roof assembly manufacturer's standard products, which is more common; retain second paragraph for a custom mixture.

Copy "Growing Medium (Insert drawing designation)" paragraph below and re-edit for each product.

Insert drawing designation. Use these designations on Drawings to identify each product.

More than one growing medium may be required for different plants and planting areas. Revise paragraph to suit Project; retain either the first option or one or more of the remaining options.

* + - * 1. Growing Medium **<Insert drawing designation>**: Vegetated roof assembly manufacturer's lightweight, manufactured soil mixture designed for **[plants indicated on Drawings] [Planting Area 1] [Planting Area 2] [and] [Tree Type 1] <Insert planting area or plant type>**.

Delete "Manufacturers" and "Basis-of-Design Product" subparagraphs below if using vegetated roof assembly manufacturer's proprietary growing media.

General Condition at Time of Planting: Free of aggregates 1/2 inch or larger in any dimension; free of roots, plants, clods, pockets of sand, paint, building debris, oils, solvents, roofing materials, and other extraneous materials harmful to plant growth; free of weeds, disease-causing plant pathogens, and other undesirable organisms.

Coordinate "Maximum Media Density," "Maximum Media Water Retention," and "Water Permeability" subparagraphs below with structural loading requirements of Project.

Maximum media density is a measurement of the water-saturated weight of a growing medium and is an important limitation for rooftop use. Coordinate weight with Project's Structural Engineer.

Maximum Media Density: ASTM E2399, <**Insert weight**> lb/cu. ft. for basic growing-medium mixture.

Maximum Media Water Retention: ASTM E2399, <**Insert number**> percent by volume for basic growing-medium mixture at maximum media density.

Water permeability at maximum media density is important when considering drainage conditions in vegetated roofs.

Water Permeability: ASTM E2399, **<Insert number>** in/min. for basic growing-medium mixture at maximum media density.

Retain "Organic Material Content" and "Chemical Properties" subparagraphs below to suit soil and nutritional requirements of plantings. Delete both subparagraphs if vegetated roof assembly manufacturer's proprietary growing medium or media are sufficient.

Organic Material Content: ASTM F1647, Method A, organic material as measured using the loss-on-ignition procedure.

Minimum: **[4] [6] [10] <Insert number>** percent.

Maximum: **[10] [20] [30] <Insert number>** percent.

Chemical Properties:

Retain one or more of first five subparagraphs below for basic chemical properties required for optimal plant growth. Confer with a soil consultant to determine optimal values to suit Project.

Growing-Medium pH (Reaction): **[5.5] [6.0] [6.0 to 7.0] [6.5] [7.0] <Insert value or range>**.

CEC in "Cation Exchange Capacity" subparagraph below measures the ability of soil particles to hold and release nutrients; the higher the number, the more fertile the soil. See the Evaluations.

Cation Exchange Capacity: Minimum **[20] [50] [75] <Insert value>** meq/100 g of growing medium.

Nitrogen: Minimum **[0.10] [0.15] <Insert number>** percent by weight.

Phosphorous: Minimum **<Insert number>** percent by weight.

Potassium: Minimum **<Insert number>** percent by weight.

**<Insert property and value>**.

Retain "Custom Growing Medium (Insert drawing designation)" paragraph below to modify a known growing medium. The maximum media density, maximum media water retention, water permeability, organic material content, and chemical properties should already be known. Coordinate weight with Project's structural engineer. If vegetated roof assembly manufacturer's proprietary growing medium soil mixture or media mixtures are sufficient, it may be unnecessary to specify custom growing media.

Copy "Custom Growing Medium (Insert drawing designation)" paragraph below and re-edit for each product.

Insert drawing designation. Use these designations on Drawings to identify each product.

More than one custom growing medium may be required for different plants and planting areas. Revise paragraph to suit Project; retain either the first option or one or more of the remaining options.

* + - * 1. Custom Growing Medium **<Insert drawing designation>:** Manufactured soil mixture for **[plants indicated on Drawings] [Planting Area 1] [Planting Area 2] [and] [Tree Type 1] <Insert planting area or plant type>** and that complies with the following:

Basic Growing-Medium Mixture: **<Insert drawing designation for a specified growing medium, or insert a manufacturer's name; product name or designation>**.

General Condition at Time of Planting: Free of aggregates 1/2 inch or larger in any dimension; free of roots, plants, clods, pockets of sand, paint, building debris, oils, solvents, roofing materials, and other extraneous materials harmful to plant growth; free of weeds, disease-causing plant pathogens, and other undesirable organisms.

Retain "Mixture Modification" subparagraph below to modify the chemical properties of the basic growing-medium mixture to produce different growing media for specific plant areas. Confer with a soil consultant and manufacturer of the basic growing-medium mixture to determine optimal values to suit Project. Coordinate materials retained with "Soil Amendments" Article.

Mixture Modification: Mix basic growing-medium mixture with the following soil amendments in the following quantities to modify the mixture's chemical properties and produce the required custom growing medium:

Retain applicable subparagraphs below or revise to suit Project. Revise "Weight of Lime per Cu. Ft." subparagraph if a specific type of liming material (ground dolomitic limestone, calcitic limestone, mollusk shells, or other type) is required.

Weight of Lime per Cu. Ft.: **<Insert value>**.

Weight of **[Sulfur] [Iron Sulfate] [Aluminum Sulfate]** per Cu. Ft.: **<Insert value>**.

Additional Perlite per Cu. Ft.: **<Insert value>**.

Weight of Agricultural Gypsum per Cu. Ft.: **<Insert value>**.

Weight of **[Diatomaceous Earth] [Zeolites]** per Cu. Ft.: **<Insert value>**.

Weight of Bonemeal per Cu. Ft.: **<Insert value>**.

Weight of Superphosphate per Cu. Ft.: **<Insert value>**.

Weight of Commercial Fertilizer per Cu. Yd.: **<Insert value>**.

Weight of Slow-Release Fertilizer per Cu. Yd.: **<Insert value>**.

**<Insert material and quantity>**.

* + - 1. SOIL AMENDMENTS

Coordinate materials in this article with "Manufactured Growing Media" Article to produce a custom growing medium. Delete this article if no custom growing medium is required.

Limestone is used to raise pH. In "Lime" paragraph below, insert percentages of carbonates, calcium, and magnesium if required. The classes refer to particle size.

* + - * 1. Lime: ASTM C602, Class T or Class O agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent.

Retain one or both of "Sulfur" and "Iron Sulfate" paragraphs below if required. Do not use aluminum sulfate. Sulfur is used to lower pH and neutralize alkaline soils. Revise descriptions and insert proprietary products if required for Project.

* + - * 1. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.
				2. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
				3. Perlite: Horticultural perlite, soil amendment grade.

Gypsum is used to supply calcium-deficient soil mixtures, improve soil structure, and unlock or make available other nutrients to plant roots. If using ground-up, recycled gypsum board as a soil amendment, replace or revise "Agricultural Gypsum" paragraph below or insert another paragraph for this additional material.

* + - * 1. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 sieve.

Retain one or more of "Superphosphate," "Commercial Fertilizer," and "Slow-Release Fertilizer" paragraphs below to suit Project. Revise descriptions and name proprietary products if required.

Note the use of phosphate-containing fertilizers in paragraphs below may be limited or disallowed in some jurisdictions. Before specifying, verify use with authorities having jurisdiction. Revise fertilizer composition to suit Project.

* + - * 1. Superphosphate: Commercial, phosphate mixture, soluble; minimum 20 percent available phosphoric acid.

Product composition in "Commercial Fertilizer" paragraph below is an example only; revise to suit Project.

* + - * 1. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of **<Insert number>** percent fast- and slow-release nitrogen (50 percent derived from natural organic sources of urea formaldehyde), 4 percent phosphorous, and 2 percent potassium, by weight.

Product composition in "Slow-Release Fertilizer" paragraph below is an example only; revise to suit Project.

* + - * 1. Slow-Release Fertilizer: Granular or pelleted fertilizer, consisting of 20 percent nitrogen (50 percent of which is water insoluble), 10 percent phosphorus, and 10 percent potassium, by weight.
			1. WALKWAY PAVERS

Retain this article if walkway pavers are required. Roof pavers, not to be confused with walkway pavers, are used as ballast to meet wind-uplift requirements at the perimeter of roofs and can also serve for public or maintenance access to planted areas. If retaining more than one type of walkway paver, indicate locations on Drawings. See the Evaluations. Retain "Walkway Pavers" paragraph below if cross-referencing paver materials in another Section; revise to suit Project.

* + - * 1. Walkway Pavers: **[Brick] [Concrete] [Asphalt-block] [Stone] <Insert material>** pavers specified in Section 321400 "Unit Paving."

Delete "Walkway Pavers" paragraph above and retain "Heavyweight Concrete Walkway Pavers" paragraph below to specify concrete walkway pavers in this Section; revise to suit Project. Verify with manufacturers the availability of pavers with characteristics selected below. Paragraph below describes concrete pavers commonly used in pedestal-set applications over roof insulation and roofing or for placement on a setting bed. Consider specifying the same concrete roof paver used as ballast for the roofing system.

Insert other types of pavers if required; verify wind-uplift resistance to suit location on roof.

* + - * 1. Heavyweight Concrete Walkway Pavers: Heavyweight, hydraulically pressed, concrete units, **[square edged] [with top edges beveled 3/16 inch]**, manufactured for use as roof- or plaza-deck pavers; with absorption not greater than 5 percent according to ASTM C140; with no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C67.

Retain one thickness and one face size in "Thickness" and "Face Size" subparagraphs below. Include special paver sizes and insert descriptions of custom pavers, such as curbed termination pavers, and oversize pavers. Coordinate with "Weight" subparagraph below.

Thickness: **[1-5/8 inches] [1-3/4 inches] [2 inches] [2-3/8 inches] <Insert dimension>**.

Face Size: **[8-7/8 inches square] [9 inches square] [9 by 18 inches] [12 inches square] [12 by 24 inches] [18 inches square] [24 inches square] [As indicated] <Insert dimensions and shape>**.

Retain "Weight" subparagraph below if weight of paver unit is a consideration; coordinate with thickness of paver. SPRI identifies heavyweight roof pavers as weighing 18 lb/sq. ft. (90 kg/sq. m) or more. Verify availability with manufacturers.

Weight: **[18 lb/sq. ft.] [22 lb/sq. ft.] <Insert value>**.

Compressive Strength: **[7500 psi] [6500 psi ] <Insert value>** minimum when tested according to ASTM C140.

Color: **[As indicated by manufacturer's designations] [Match Director’s Representative’s sample] [As selected by Director’s Representative from manufacturer's full range] <Insert color>**.

Retain "Setting Bed" paragraph below if continuous setting-bed system is required; revise to suit Project. Coordinate setting bed with Section in which it is specified.

* + - * 1. Setting Bed: Aggregate setting-bed material **[furnished standard by vegetated roof assembly manufacturer.] [specified in Section 321400 "Unit Paving."] <Insert requirement.>**

Retain "Paver Supports" paragraph below if using pedestal system for paver supports.

* + - * 1. Paver Supports: Paver manufacturer's standard SBR rubber, high-density polyethylene, or polyurethane paver support assembly, including **[fixed-height] [adjustable or stackable]** pedestals, shims, and spacer tabs for joint spacing of **[1/8 inch] [3/16 inch] [1/8 to 3/16 inch]**.
			1. GEOFOAM FILL

Retain this article if required and one or more products in this article to suit Project. Geofoam fill is used for forming topography changes in a vegetated roof. It is not used for overall thermal insulation for roofs, which is specified in low-slope roofing Sections.

Delete "Manufacturers" and "Basis-of-Design Product" subparagraphs below if vegetated roof assembly manufacturer is providing the geofoam fill as part of the assembly.

Compressive strengths in "Extruded-Polystyrene Board Insulation" and "Molded-Polystyrene Board Insulation" paragraphs below are the compressive resistance at 10 percent deformation according to ASTM C578. Verify availability of type of insulation with manufacturers.

* + - * 1. Extruded-Polystyrene Board Insulation: ASTM C578, **[Type X, 1.30-lb/cu. ft. density, 15-psi compressive strength] [Type IV, 1.55-lb/cu. ft. density, 25-psi compressive strength] [Type VI, 1.80-lb/cu. ft. density, 40-psi compressive strength] [Type VII, 2.20-lb/cu. ft. density, 60-psi compressive strength] [Type V, 3.00-lb/cu. ft. density, 100-psi compressive strength]**.
				2. Molded-Polystyrene Board Insulation: ASTM C578, **[Type I, 0.90-lb/cu. ft. density, 10-psi compressive strength] [Type VIII, 1.15-lb/cu. ft. density, 13-psi compressive strength] [Type II, 1.35-lb/cu. ft. density, 15-psi compressive strength]**.

Retain "Treatment" subparagraph below if requiring molded polystyrene to deter termites.

Treatment: Manufacture molded polystyrene with a termite treatment for below-grade applications that is an EPA-registered material labeled for use with foam plastic.

AFM Corporation and perhaps other manufacturers offer products that comply with the requirements in "Rigid Cellular Polystyrene Geofoam" paragraph below. ASTM D6817 lists compressive resistances at 1, 5, and 10 percent deformation.

* + - * 1. Rigid Cellular Polystyrene Geofoam: ASTM D6817, **[Type EPS 19, 1.15-lb/cu. ft. density, 5.8-ps compressive strength at 1 percent deformation; 16-psi compressive strength at 10 percent deformation] [Type EPS 39, 2.40-lb/cu. ft. density, 15-psi compressive strength at 1 percent deformation; 40-psi compressive strength at 10 percent deformation] <Insert requirement>**.

Products in "Geofoam Connectors" paragraph below are used to limit displacement of geofoam-fill blocks. Multibarbed galvanized-steel sheet connectors in first option are trademarked by AFM Corporation. Steel reinforcing bars in second option may also be used.

* + - * 1. Geofoam Connectors: **[Geofoam-fill manufacturer's multibarbed, galvanized-steel sheet connectors] [Deformed steel reinforcing bars, 3/4 inch in diameter] <Insert requirement>**.

Retain "Separation Geotextile" paragraph below if required. The typical use is to separate geofoam fill from growing medium. See "Manufacturers" Article in the Evaluations for a list of geotextile manufacturers.

* + - * 1. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; **[according to AASHTO M 288] [as recommended by vegetated roof assembly manufacturer] <Insert requirement>**.

Insert requirements for additional anchorage if needed to restrain geofoam fill from displacement due to wind loading on roof. Coordinate design of additional anchorage with Project's structural engineer.

* + - 1. ACCESSORIES

Asphaltic protection board in "Protection Board" paragraph below is available from several manufacturers for use as a protection course; revise to suit Project and requirements of roofing-membrane manufacturer.

* + - * 1. Protection Board: **[ASTM D6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners; 1/4-inch nominal thickness] [As recommended by roofing-membrane manufacturer] <Insert requirement>**.

Verify with manufacturers the availability of options in "Access Boxes" paragraph below; revise to suit Project. Some manufacturers use a soil retainer configured as an access box without a cover.

* + - * 1. Access Boxes: Manufacturer's standard **[stainless-steel] [plastic] [fiber-reinforced cement] [or] [aluminum]** boxes with removable, rigid covers for accessing drains, valves, and switches beneath the finish elevation of growing medium; secure each cover with four noncorrosive screws.

Size: **[12 inches square by depth of vegetated roof assembly at each location] [12 inches in diameter by depth of vegetated roof assembly at each location] [As shown on Drawings for each location] <Insert dimensions>**.

Product in "Soil Retainer" paragraph below is also called an "edge," "edging," or "side panels"; varies among manufacturers; and is used to retain unsupported growing medium at edges of continuous vegetated roof assemblies or to align units of tray-type vegetated roof assemblies. Soil retainer may not be necessary for tray-type assemblies. Verify availability of desired configuration and color with manufacturers. Revise paragraph if a thicker product, a solid product, concrete, recycled wood, or plastic composite is required.

* + - * 1. Soil Retainer: Vegetated roof assembly manufacturer's **[polyethylene or vinyl] [extruded-aluminum] [or] [formed stainless-steel] <Insert material>** edging with drainage openings.

Configuration: **[L-shaped] [T-shaped] [Flat-top curb] [Manufacturer's standard] [As shown on Drawings] <Insert configuration>**.

Coordinate color in "Color" subparagraph below with required material.

Color: [**Black**] [**or**] [**Mill-finish metal**] <**Insert requirement**>.

Retain "Method of Attachment" subparagraph below if attachment is required; revise if another method of temporary or permanent attachment is required.

Method of Attachment: Manufacturer's standard adhesive compatible with the roofing system.

Insert article for plant-stabilization materials other than erosion-control fabric if required; coordinate with details on Drawings. See the Evaluations.

1. EXECUTION
	* + 1. EXAMINATION
				1. Examine each area to receive vegetated roof assembly for compliance with requirements for installation tolerances and other conditions affecting performance.

Retain first subparagraph below for protected membrane roofing; revise to suit specified protected membrane roofing assembly.

Verify that roof insulation over roofing membrane is in place, secure, and flush along all seams.

Verify that perimeter and other flashings are in place and secure along entire lengths where they will be covered by vegetated roof assembly.

* + - * 1. Inspect growing medium.

Verify that no foreign or deleterious material or liquid, such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in growing medium within a planting area.

If growing medium is contaminated by foreign or deleterious material or liquid, remove growing medium and contamination and replace with new growing medium.

* + - 1. INSTALLATION, GENERAL
				1. Protection Course: Cover roofing system with protection board with butted and fully taped joints before roofing system is subject to vegetated roof assembly installation work.
				2. Install vegetated roof assembly according to manufacturer's written instructions.

Retain "Sloped Roofs" paragraph below for roofs sloping more than 1/2 inch per 12 inches (1:24) if required; revise to suit Project. Coordinate with products specified in "Vegetated Roof Assembly Components" Article.

* + - * 1. Sloped Roofs: Install **[erosion-control fabric] [and] [anti-slip devices]** for slopes steeper than **[1/2 inch per 12 inches (1:24)] <Insert slope>** according to manufacturer's written instructions.

Retain "Small Plant Stabilization" paragraph below if required. Coordinate with products specified in "Vegetated Roof Assembly Components" Article.

* + - * 1. Small Plant Stabilization: Install **[erosion-control fabric]** over planting area to secure small plants according to manufacturer's written instructions.

Retain "Geofoam Fill" paragraph below if geofoam fill is required. Show locations and thicknesses on Drawings.

* + - * 1. Geofoam Fill: Install geofoam-fill blocks in as few layers as possible with abutting edges and ends and with the long dimension of each block placed at right angles to blocks in each subsequent layer. Offset joints of blocks in successive layers.

Install geofoam connectors at each layer, without damaging roofing system, to resist horizontal displacement of geofoam and according to geofoam-fill manufacturer's written instructions.

Insert requirements for installing additional anchorage to restrain geofoam fill from displacement due to wind loading on roof if required.

Cover geofoam fill with separation geotextile before placing overlying growing medium.

* + - * 1. Access Boxes: Install access box **[at each drain, valve, and switch] [and] [at locations shown on Drawings]**. Install top of boxes **[level with] [beneath] [1 inch above] <Insert requirement>** the finish elevation of growing medium.
			1. PLANTING
				1. Perform planting according to vegetated roof assembly manufacturer's written instructions.
				2. Do not place growing medium or plants during frozen, wet, or muddy conditions.
				3. Suspend spreading, grading, and planting operations during periods of excessive moisture until the moisture content in growing medium reaches acceptable levels to attain the required results.
				4. Uniformly moisten an excessively dry growing medium that is too dusty or unworkable.

Retain "Preplanted Vegetative Mat" paragraph below if required; revise to suit Project. Preplanted mats afford the shortest establishment period for plantings.

* + - * 1. Preplanted Vegetative Mat: Install in full contact with growing medium and secure in position.

Retain "Site Planting" paragraph below to reference requirements in other planting Sections; revise to suit Project. Delete paragraph below if only preplanted vegetative mat is required for plantings or required planting is specified in other paragraphs retained below.

* + - * 1. Site Planting: Plant vegetated roofs according to requirements specified in **[Section 329200 "Turf and Grasses."] [and] [Section 329300 "Plants."]** except as otherwise indicated on Drawings and required by vegetated roof assembly manufacturer's written instructions. Perform digging carefully to prevent damaging roofing system below the vegetated roof assembly.

Retain one or more of "Seeding Grasses," "Meadow Grasses and Wildflowers," "Sprigging Grasses," "Plugging," and "Individual Plant Planting" paragraphs below to specify seeding and plant spacing where preplanted vegetative mat is not required and if requirements of other planting Sections are not referenced; revise to suit Project. Closer spacing of sprigs, plugs, and individual plants results in more rapid establishment of slower-growing species. Consider copying additional text from Section 329300 "Plants" and Section 329200 "Turf and Grasses" if paragraphs below are insufficient.

Retain "Seeding Grasses" paragraph for sowing turfgrass seed. Sowing rates vary with grass species and mixtures.

* + - * 1. Seeding Grasses: Sow seed at a total rate of **[2 lb/1000 sq. ft.] [3 to 4 lb/1000 sq. ft.] [5 to 8 lb/1000 sq. ft.] <Insert values>**.

Retain "Meadow Grasses and Wildflowers" paragraph below for sowing seed for meadow grasses or wildflowers. Sowing rates vary with mix of species but are usually much lighter than turfgrass-seed application rates.

* + - * 1. Meadow Grasses and Wildflowers: Sow seed at a total rate of **[4 oz./1000 sq. ft.] [5 oz./1000 sq. ft.] [6 oz./1000 sq. ft.] <Insert values>**.

Retain "Sprigging Grasses" paragraph below for planting grass sprigs. Sprigging rates vary with grass species and mixtures.

* + - * 1. Sprigging Grasses: Plant individual sprigs with roots and portions of stem in moistened growing medium, **[6 inches] [12 inches] <Insert dimension>** apart in rows **[10 inches] [12 inches] <Insert dimension>** apart, and fill furrows without covering growing tips. Lightly roll and firm growing medium around sprigs after planting.

Retain "Plugging" paragraph below for planting grass or plant plugs, which are typically cut from sod or plant mats. Plugging rates vary with plant type and grass species and mixtures.

* + - * 1. Plugging: Plant plugs in holes or furrows, spaced **[12 inches] <Insert dimension>** apart in **[both directions] [triangular pattern]**.

Retain "Individual Plant Planting" paragraph below for planting individual potted or bagged plants; revise spacing to suit Project. If preferred, insert spacing for each plant type or indicate spacing on Drawings.

* + - * 1. Individual Plant Planting: Set out and space plants other than grasses and wildflowers **[9 inches apart] [12 inches apart] [18 inches apart] [24 inches apart] [as indicated on Drawings] <Insert dimension>** in even rows with triangular spacing.

Dig holes large enough to allow spreading of roots.

Free up or remove girdling roots.

Work growing medium around roots to eliminate air pockets.

Water thoroughly after planting, taking care not to cover plant crowns with wet growing medium.

Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

* + - 1. WALKWAY-PAVER INSTALLATION

Revise "Installation" paragraph below to suit Project.

* + - * 1. Installation: Install walkway pavers according to manufacturer's written instructions.

Retain "Setting Bed" paragraph below if setting pavers on continuous bed. Delete paragraph if using paver pedestal supports.

* + - * 1. Setting Bed: Install setting bed according to **[paver manufacturer's written instructions.] [requirements in Section 321400 "Unit Paving."] <Insert requirement.>**

Retain first paragraph below if setting pavers on paving pedestals. Delete paragraph if using setting bed.

* + - * 1. Install paver supports according to pedestal manufacturer's written instructions. Adjust for final level and slope with shims.
				2. Loosely set walkway pavers, maintaining a uniform joint width. Tightly seat pavers against spacers to eliminate lateral movement or drift of paving assembly. Align joint patterns parallel in each direction.

Revise subparagraph below to suit Project. Consider paving layout, paver module, and construction tolerances when imposing limits.

Lay out pavers to avoid less-than-half-width pavers at perimeter or other terminations.

Insert special installation requirements in additional paragraph(s) here. Examples might include tread or riser units on tabs or treatment of pavers at expansion joints.

Retain option in "Tolerances" paragraph below only for smooth, flat pavers.

* + - * 1. Tolerances: Do not exceed **[1/16-inch unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches and]** 1/4 inch in 10 feet from level, or indicated slope, for finished surface of paving.
			1. SOIL-RETAINER INSTALLATION

Soil retainer in paragraph below may be unnecessary for tray-type assemblies. Revise paragraph if another method of temporary or permanent attachment is required; delete option if no attachment is required.

* + - * 1. Install soil retainer where indicated according to manufacturer's written instructions. **[Secure with adhesive.]**

Insert article for installation of tree and shrub stabilization materials if required; coordinate with details on Drawings. See the Evaluations.

* + - 1. FIELD QUALITY CONTROL

Generally retain this article if retaining a roofing manufacturer's special warranty that also includes the vegetated roof assembly. See the Evaluations.

* + - * 1. Testing Agency: Engage a qualified testing agency to perform tests.

Retain "Perform the following tests" paragraph below to require Contractor to perform tests. Delete paragraph if leak testing is specified in the roofing Section and retesting is not required. See the Evaluations.

* + - * 1. Perform the following tests:

Retain one or both of "Flood Testing" and "Electronic Leak-Detection Testing" subparagraphs below. Delete first subparagraph if roof slope is too steep for flood testing. Revise subparagraph by identifying particular Project areas to flood test if required. Limit water depth to not exceed deck load capacity.

Flood Testing: Flood test each deck area for leaks, according to procedures in ASTM D5957, after completing and protecting roofing membrane but before placing overlaying construction. Install temporary containment assemblies, plug or dam drains, and flood with potable water.

Flood to an average depth of 2-1/2 inches, with a minimum depth of 1 inch and a maximum depth of 4 inches. Maintain 2 inches of clearance from top of sheet flashings.

ASTM D5957 sets 24 hours as the minimum and 72 hours as the maximum duration for flood testing.

Flood each area for **[24] [48] [72]** hours.

The language in "Electronic Leak-Detection Testing" subparagraph below accommodates both low- and high-voltage testing of roofing that has a permanent electronic leak-detection system.

Electronic Leak-Detection Testing:

Testing agency shall test **[each deck area] [each deck area indicated for testing on Drawings] <Insert area to be tested>** for leaks using an electronic leak-detection method that locates discontinuities in the roofing membrane.

Testing agency shall perform tests on abutting or overlapping smaller areas as necessary to cover entire test area.

Testing agency shall create a conductive electronic field over the area of roofing to be tested and electronically determine locations of discontinuities or leaks, if any, in the roofing.

Testing agency shall provide survey report indicating locations of discontinuities if any.

Proceed with installation of vegetated roof assembly only after unsatisfactory conditions have been corrected.

* + - * 1. Manufacturer's Field Service: Engage roofing-membrane manufacturer's authorized service representative to provide **[full-time]** inspection of vegetated roof assembly installation and prepare inspection reports.
				2. Correct deficiencies in work that do not comply with requirements.
				3. Prepare test and inspection reports.
			1. PROTECTION
				1. Protect vegetated roof assemblies from damage, including growing-medium contamination, due to operations of other contractors and trades. Repair or replace damaged vegetated roof assemblies.
			2. MAINTENANCE SERVICE

Verify with Director’s Representative that maintenance service is required for Project. Generally, a maintenance period should be long enough to ascertain the initial establishment of healthy plants and is usually required for a plant-growth warranty.

* + - * 1. Maintenance Service: Provide maintenance by skilled employees of vegetated roof assembly Installer **[approved by roofing-membrane manufacturer]**. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than the specified maintenance period.

Assembly and Plant Maintenance: During maintenance period, maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing devices, resetting plants to proper elevations or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.

Replace growing medium that becomes displaced or eroded because of settling or other processes.

Apply treatments as required to keep plant materials, planted areas, and growing medium free of pests and pathogens or disease. Use integrated past management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

Use only products and methods acceptable to roofing-membrane manufacturer.

Coordinate "Maintenance Period" subparagraph with warranty requirements; revise to suit Project.

Maintenance Period: **[12] <Insert number>** months from date of **[Substantial Completion] [Planting Completion] <Insert starting time>**.

END OF SECTION 077273