Appendix C

Agricultural Impact Mitigation Plan and Vegetation Management Plan

Red Rock Solar, LLC
Docket No. 19-620
November 2020

AGRICULTURAL IMPACT MITIGATION PLAN
FOR THE
RED ROCK SOLAR PROJECT

RED ROCK SOLAR, LLC

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COTTONWOOD COUNTY, MINNESOTA

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ABBREVIATIONS & DEFINITIONS

AC	alternating current
AIMP or Plan	Agricultural Mitigation Plan
BMPs	best management practices
Contractor	construction contractor
CSAH	County State Aid Highway
DC	direct current
decompaction	Treatment which relieves soil compaction by introducing air space into the soil.
drain tile	System that removes excess water from the soil; typically, below-ground.
GPS	global positioning system
kV	kilovolt
Red Rock Solar or Red Rock	Red Rock Solar, LLC
LCC	Land Capability Class
Monitor	environmental monitor
MDA	Minnesota Department of Agriculture
MNDNR	Minnesota Department of Natural Resources
MW	megawatts
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&M building	operations and maintenance building
Project Area	Approximately 846-acre area of privately-owned land for which Red Rock Solar, LLC has leases to allow siting and construction of the Project
Project Footprint	Approximate 483-acre area where Red Rock Solar, LLC proposes to build the Red Rock Solar Project facilities
Project or Project Site	Red Rock Solar Project
PV	photovoltaic
SCADA	Supervisory Control and Data Acquisition
SSURGO	Soil Survey Geographic Database
SWPPP	Stormwater Pollution Prevention Plan
Tile Contractor	agricultural drain tile contractor

1.0 PURPOSE AND APPLICABILITY OF PLAN

The objective of this Agricultural Impact Mitigation (the Plan or AIMP) and the accompanying Vegetation Management Plan is to identify measures that Red Rock Solar, LLC (Red Rock Solar/Red Rock) and its contractors will take to avoid, and/or repair potential negative agricultural impacts that may result from the construction, operation, and eventual decommissioning of the Red Rock Solar Project (Project, Project Site, Project Area). Although Red Rock Solar will own or lease the property on which the Project is constructed, and would cease agricultural production on the land during the life of the Project, this Plan outlines measures to ensure the land may be returned to future agricultural usages following the closure and decommissioning of the Project, including descriptions of best management practices (BMPs) that will be used during construction to minimize long-term impacts to soil. It is important to note that while Red Rock Solar and the construction contractor (the Contractor) hired to build the facility fully intend to adhere to the specifics of this plan, certain practices may vary as the Contractor identifies methods that work more efficiently in this specific location and provide the highest degree of safety while constructing the facility.

Red Rock Solar consulted with the Minnesota Department of Agriculture (MDA) in November 2019 to discuss the AIMP's contents and site-specific characteristics. MDA also reviewed and commented on draft versions of the AIMP. The Plan presented here incorporates agency feedback on the draft version of the Plan.

The strategy outlined in this Plan consists of creating a prairie habitat within the footprint of the solar project while the Project is in operation. The solar site will be vegetated with an Array Mix that can be managed with traditional annual mowing (native option) or potentially grazers (sheep grazing option), and a Wet Area Mix for stormwater basins. The mixes are designed to be native and are developed utilizing guidance documents from Minnesota Department of Natural Resources (MNDNR) and Minnesota Board of Water and Soil Resources. The mixes achieve Red Rock's goals for operating the solar facility, promote pollinator habitat, establish stable ground cover successfully, reduce erosion, reduce runoff, and improve infiltration. Additionally, the contracted restoration company will work with Red Rock to develop implementation plans for maintenance of the prairie throughout the life of the Project. More information on maintenance of the prairie is outlined in the Vegetation Management Plan.

This Plan is separated into several distinct sections: Section 2 provides an overview of the proposed Project and its components. Section 3 addresses limitations and suitability of the soils at the Project, Section 4 discusses the BMPs that will be used during construction and operation of the Project, and Section 5 outlines decommissioning.

2.0 PROJECT OVERVIEW

2.1 Background

Red Rock Solar, an affiliate of Apex Clean Energy Holdings, LLC (Apex), proposes to construct the Red Rock Solar Project on approximately 846.2 acres (Project Boundary) of land in Sections 1, 2, 11, 12, 14, 22, and 23, Township 106 North, Range 34 West, Cottonwood County, Minnesota (Figure 1 – Project Location). Based on preliminary design, Project facilities will cover approximately 488 acres of the Project Boundary (Project Footprint). There are approximately 363.8 acres of the Project Boundary for which Red Rock has site control, but are currently not contemplated for occupation by solar facilities (Figure 2 – Project Boundary and Project Footprint). The 362.9-acre portion of the Project Boundary that will not be utilized by the Project is currently under lease with the underlying landowner; however, the landowner will be able to continue to farm this area for the life of the Project. The Red Rock Solar Project is located 4 miles north of the City of Mountain Lake. The Project will generate up to 60 megawatts (MW), enough energy to provide electricity for approximately 12,000 homes annually. The Project is to be placed in service by the end of 2022.

Red Rock Solar is currently developing the Red Rock Solar Project, an up to 60 MW solar photovoltaic (PV) facility located in eastern Cottonwood County, Minnesota. Additionally, Big Bend Wind, LLC, also an affiliate of Apex, is developing the Big Bend Wind Project. Together, the Big Bend Wind Project and Red Rock Solar Project represent Minnesota's first potential wind-solar hybrid renewable energy project. As proposed, the renewable energy generation could consist of up to 308 MW of wind, or a combination of wind and up to 60 MW of solar. Big Bend will need to build approximately 18 miles of 161 kV transmission line to connect the Solar Project and the Wind Project to the Blue Lake-Wilmarth-Interstate Junction 345 kV transmission line at Xcel Energy's Crandall switching station. Red Rock Solar selected this site due to its close proximity to planned transmission facilities, existing road infrastructure, and the relatively flat, unobstructed terrain on the Project site. Importantly, in selecting the Project site, Red Rock Solar also concluded that its development will not result in significant environmental impacts.

Red Rock has entered into lease agreements with landowners for all of the parcels on which the Project would be constructed. Red Rock would exercise its purchase options and hold title to the property it will purchase after the Site Permit is issued and prior to the start of construction. Concurrently, leased property that will be utilized by the Project will move into an operation term of the lease agreement and property currently under lease that is not utilized by the Project will be allowed to revert to previous land uses (e.g., farming). All Project facilities shown in the preliminary site layout (Figure 3 – Project Layout) were sited on land for which Red Rock Solar currently has either a purchase option or lease. The current land interests under lease are sufficient to accommodate the Project's facilities and setback requirements.

2.2 Project Components

The Project will include the following major components, systems and associated facilities:

- Solar panels, linear axis tracking rack system, and inverters
- Electrical collection system
- Project substation
- Operations and maintenance building (O&M building)
- Access roads

- Up to three weather stations (up to 10 feet tall)
- Perimeter fencing
- Stormwater drainage basins

Each of these components is described in more detail below.

2.2.1 Configuration of Solar Panels, Arrays, and Racking

The Project will convert sunlight into direct current (DC) electrical energy within photovoltaic (PV) panels. For purposes of describing construction, the Project can be considered an aggregate of individual PV panel components interconnected by cabling and infrastructure at increasing scales to ultimately deliver up to 60 MW of nameplate alternating current (AC) of electricity to the existing Blue Lake-Wilmarth-Interstate Interconnection transmission line currently on the electrical grid and approximately 18 miles from the Project. From smallest to largest scales Project components are described below and presented on Figure 4 (Configuration of Project Components):

1. **Individual PV panels** are approximately 7 feet long by 3 feet wide, and 1 to 2 inches thick and are installed on metal foundations that are driven or screwed into the ground.
2. **Lines** of interconnected PV panels consist of a line of short-edge butted panels approximately 195-feet long, with each line oriented to and rotating along a north-south axis to track the east-west movement of the sun and maximize the interception of solar energy. These lines represent the racking upon which the individual panels are mounted upon.
3. **Arrays** PV of north/south lines of PV panels organized in racks associated with an east/west oriented access road.
4. **Blocks** of PV panels typically consist of one to two arrays north, and one or two arrays south of a permanent access and maintenance road. Depending on site constraints, there may be more or fewer arrays associated with a specific block.
5. **Construction Units** consist of Blocks of PV panels delineated by their connectivity, relationship to main roads, and location within the same perimeter fence. The Project consists of:
    a. a 58-acre (approximate) **Northwest Unit** bounded by County State Aid Highway (CSAH) 8 on the east and 330th Street on the south.
    b. a 245-acre (approximate) **Northeast Unit** bounded by CSAH 8 to the west, 330th Street to the south, 610th Avenue to the east and 320th Street to the north.
    c. a 60-acre (approximate) **Southwest Unit** bounded by CSAH 8 to the east and 330th Street to the north.
    d. a 85-acre (approximate) **Southeast Unit** bounded by CSAH 8 to the west and 330th Street to the north.
6. Approximately 3.1 miles of electrical collection system to connect the solar panels to the Solar Project Substation located approximately 2.25 miles southwest, at the northwest corner of the intersection of 590th Avenue and 360th Street.

Red Rock Solar will use a single axis tracking system where the panels within a line are rotated by small motors to track with the sun throughout the day. The panels aligned in rows north and south face east in the morning, parallel to the ground during mid-day, and then west in the afternoon. Panels can be manually oriented to the east or west at maximum tilt angle to facilitate maintenance access and vegetation management, if necessary, although spacing between the panel edges when at a horizontal position is typically 23.5 feet and sufficient for maintenance vehicles. Separation of PV Panel lines will typically be 37.5-feet from turning axis to turning axis.

2.2.2 Inverters and Transformers

Inverters and transformers are housed together on a "skid." This equipment converts approximately 1,500 volts of DC output of the PV panels to 34.5 kV of AC. Inverter skids will be utilized at locations throughout the Project Footprint and include a transformer to which the inverters will feed electricity. The final number of inverters for the Project will depend on the inverter size, as well as inverter and panel availability. The Project's preliminary design includes 16 central inverter skids (one inverter is required for every 3-4 MW). These skids provide the foundation for the inverter, transformer, and Supervisory Control and Data Acquisition (SCADA) system. The skids will be placed atop a concrete slab or pier foundations and typically measure 15 feet wide by 20 feet long, with a structure height of approximately 12 feet above grade. Concrete foundations will be poured onsite or precast and assembled off-site.

The inverters are within the interior of the Project along access roads.

2.2.3 Electrical Collection System

2.2.3.1 Linear Axis Tracking Rack System

A linear axis tracking rack system allows the PV panels to track the solar resource throughout the day. The panels and tracking rack system are generally aligned in rows north and south with the PV panels facing east toward the rising sun in the morning, parallel to the ground during mid-day, and then west toward the setting sun in the afternoon. The panels are rotated by a small motor connected to the tracking rack system to slowly track with the sun throughout the day. The tracking rack system allows the Project to optimize the angle of the panels in relation to the sun throughout the day thereby maximizing production of electricity and the capacity value of the Project.

The tracking rack system is mounted on top of steel piers that are typically driven into the ground, without a need for excavation or concrete to install the piers.

2.2.3.2 Electrical Collection System

Electrical wiring (DC) will connect the panels to inverters, which will convert the power from DC to AC. The AC will be stepped up through a transformer from the inverter output voltage to 34.5 kV and brought via the collection cables to the Solar Project Substation. The DC cabling will be mounted underneath the panels in a hanging harness system. Use of this system minimizes soil disturbance and trenching along every row of panels. The AC collection system between the inverters and Solar Project Substation will be located in a below-ground trench (approximately four feet deep and one to two feet wide). Below-ground AC collection systems from the inverter skids to the Solar Project Substation will be installed in trenches or ploughed into place at a depth of at least four feet below grade. Once the cables are laid in the trench, the area will be backfilled with subsoil followed by topsoil.

2.2.4 Project Substation and Operations and Maintenance Building

The Solar Project Substation will be a 34.5/161 kV step-up substation with metering and switching gear. It will be designed according to regional utility practices, Midcontinent Independent Transmission System Operator Standards, Midwest Reliability Organization Standards, National Electrical Safety Code, and the Rural Utility Service Code. The area within the substation will be graveled to minimize vegetation growth in the area and reduce fire risk. The substation will be fenced with a 6-foot chain-link fence, topped with one foot of barbed wire for security and safety

purposes. The substation's area will be approximately 300 feet by 200 feet once construction is complete.

The O&M Facility will be a shared facility with the Big Bend Wind Farm. As such, this facility is permitted with the Wind Farm. A description of the O&M Facility, including size, location, and associated footprint of impacts are included in the Big Bend Wind Farm Site Permit Application in Docket No. IP7013/WS-19-619.

2.2.5 Access Roads

The Project will include approximately 4.1 miles of graveled access roads that lead to the inverters. The final length of the access roads will depend on the equipment selected and final engineering. These roads are up to 20 feet wide along straight portions of the roads and wider along curves at internal road intersections and turn arounds (approximately 30 foot radius). There are seven access points to the Project from existing county roads. These entrances will have locked gates.

Some upgrades or other changes to the public roads may be required for construction or operation of the Project. Red Rock will work with Cottonwood County to facilitate and pay for required upgrades that meet the required public standards. Upgrades or changes could include, but are not limited to, road improvements, additional aggregate, and driveway changes. Road improvements may require a road use and repair agreement with Cottonwood County and/or Midway Township; Red Rock will continue to coordinate with both agencies as the Project develops. Driveway changes will require a county entrance permit from Cottonwood County, which will be obtained prior to construction.

2.2.6 Permanent Fencing

Permanent security fencing will be installed along the perimeter of the solar arrays and Project Footprint. Fencing will be secured to posts which will be directly embedded in the soil or set in concrete foundations as required for structural integrity. The fencing will consist of an agricultural woven wire fence and will extend approximately 7 feet above grade. At the request of MNDNR, barbed wire will not be used around the perimeter of the Project, and instead one foot of 3-4 strands of smooth wire will be used for a total height of 8-feet. However, the fencing around the Solar Project Substation will be a 6-feet above grade chain-link fence and include one foot of barbed wire to comply with the National Electric Code. This fencing will be designed to prevent the public from gaining access to electrical equipment which could cause injury. Additionally, the fencing will prevent larger wildlife from entering the facility.

2.2.7 Stormwater Drainage Basins

Red Rock has preliminarily designed 10 drainage basins throughout the Project Footprint that range in size from 0.4 to 10.1-acre. These basins are located in existing low areas that also contain hydric soils and for which the preliminary design for solar facilities has avoided. These areas will be vegetated with a wet seed mix that will help stabilize soils after rain events.

2.2.8 Transmission System

The Project will interconnect into the existing Blue Lake-Wilmarth-Interstate Interconnection 345 kV transmission line approximately 11 miles south of the southernmost portion of the Project Area via a 161-kV overhead gen-tie transmission line of approximately 18 miles. As previously

discussed, the Solar Project and Wind Project will connect to the Blue Lake-Wilmarth-Interstate Interconnection 345 kV transmission line at the Xcel Energy Crandall Switching Station. Additional information on the POIs is presented in Big Bend's RP application (see Docket No. IP7013/TL-19-621).

2.2.9 Temporary Facilities

Red Rock will utilize three temporary laydown areas, one within the fenced solar facility and two outside of the fence, totaling 7.6 acres. These areas will serve both as a parking area for construction personnel and staging areas for Project components during construction. These laydown areas have been sited to avoid any tree clearing. After construction, the laydown area within the fence will be restored and reseeded as described in the Vegetation Management Plan. The two laydown areas outside the fence will be restored to pre-construction conditions and suitable for agricultural use by the landowner.

2.3 Construction

2.3.1 Site Clearing & Vegetation Removal

Depending on timing of the start of construction, the Project may require the clearing of residual row-crop debris from the 2021 harvest season. Alternatively, and depending on construction timing, Red Rock may plant a cover crop in Spring 2022 that is compatible with the Project's VMP. This cover crop will stabilize soils if row crops are not planted that year.

2.3.2 Earthwork

The majority of soil disturbances will occur during the first phase of Project construction when the grading activities take place. The Contractor may need to move some soils to "flatten" certain parts of the local terrain or, at the very least, to complete minor grading of topsoils. The earthwork activities will be completed using typical civil construction equipment – scrapers, bulldozers, front-end loaders, back-hoes or skid-steers. BMPs that will be used during these earthmoving activities are described in detail in Section 2.3.3 - Access Road Construction.

2.3.3 Access Road Construction

As a component of earthwork, permanent access roads and permanent turnouts will be developed. This work will start with the stripping and segregating of topsoil materials from the anticipated 20-foot-wide road width. The subgrade materials will be compacted 32-feet wide to the specified compaction requirements as laid out by the civil and geotechnical engineer. After compaction is reached and verified, the road will be installed as designed, typically done with or without geo-fabric depending on the soil type, and then, with a surface of 4 to 12 inches of gravel. The gravel will be placed level with the existing grade to facilitate drainage and minimize ponding.

After gravel is installed and compacted to engineers' requirements, the Project drainage ditches will be shaped as identified on the final grading plan. Finally, the previously stripped and windrowed topsoil material will be re-spread throughout the Project area.

Topsoil removed from permanent access roads will be removed to suitable locations near the site of removal and graded for storage. Storage locations will be identified (global positioning system [GPS] boundary and depth) and recorded on site maps to facilitate final reclamation after decommissioning.

2.3.4 Solar Array Construction

Once grading activities are complete, the racking system supports will be constructed using steel piles driven into the ground. The solar facilities will be constructed in blocks, and multiple blocks could be constructed simultaneously. Construction of the blocks will include pre-positioning and driving piles, mounting the tracking rack system to the piles, pre-positioning of panel pallets, mounting panels to the tracking rack system, the completion of electrical connections, terminations and grounding, and installation of cable management systems. In some situations where soils are low strength or consist of loose, non-cohesive sand, helical screw or auger-type foundation posts may be used. Foundations are typically galvanized steel and used where high load bearing capacities are required. The pile is driven using a hydraulic ram that moves along tracks and is operated by two workers. Soil disturbance would be restricted to the hydraulic ram/ screw machinery, about the size of a small tractor, temporarily disturbing soil at each pile insertion location and while driving between drilling locations.

The remainder of the tracking rack system will be installed by construction crews using hand tools and all-terrain tracked equipment to distribute materials. Array racking will be bolted on top of the foundation piling to create a “rack” to which the solar panels can be fastened.

During array and racking assembly, multiple crews and various types of vehicles will be working within the Project area. To the extent practicable, vehicular traffic will be limited to permanent and temporary access roads to minimize soil disturbance, mixing and compaction; however vehicular traffic will occur off of roads throughout the Project during construction. These vehicles include flatbed trucks for transporting array components, small all-terrain vehicles, rough-terrain forklifts, and skid-steers, as well as pick-up trucks for transporting equipment and workers throughout the Project area. Panels will be staged in advance throughout the Project area and brought to specific work areas for installation by wagon-type trailers pulled by small tractors or by all-terrain tracked equipment. The solar panels will be installed by multiple crews using hand tools. Installation crews will proceed in serpentine fashion along staked temporary access roads in a pre-established route to minimize off-road traffic.

2.3.5 Electrical Collection System

As noted in Section 2.2.3, the DC collection system would be installed underneath the panels in a hanging harness system; the AC collection system will be installed in a below-ground system. For the purposes of this Plan, Red Rock provides construction methods and BMPs for trenching; aboveground collection lines would not require a trench.

Collection system cabling will be installed along access roads using trenching machine or excavator. The trencher will cut an exposed trench approximately 1 foot wide by 4 feet deep. Topsoil will be stripped from the trenched area up to a maximum depth of 12 inches using a small backhoe and would be temporarily stored adjacent to the trench. Similar to the pile drivers used to install the racking, the soil disturbance from the trenching machines would be restricted to the trenching machine tracks only. This machine is the size of a small tractor. Once cables are installed, the trenches would be backfilled using a small, rubber tire or tracked backhoe and compaction equipment. Topsoil would be replaced to the restored trench line, and the pre-construction contour would be re-established using a small front-end loader.

BMPs that will be used during these earthmoving activities are described in detail in Section 3.

2.3.6 Inverter Installation

The inverters units will be placed on frost-footing supported concrete pads or driven/helical screw pier foundations that will be designed to specifications necessary to meet the local geotechnical conditions. Topsoil will be removed and will be stored at suitable pre-established locations and graded to facilitate revegetation. Underground conduit and junction boxes will be installed throughout the Project to facilitate required cabling connecting equipment. Premanufactured skids with inverter, transformer and SCADA equipment may be used. These arrive by typical flat-bed trailer and truck and are set in place by a Rough-terrain hydraulic crane.

2.3.7 Project Substation Construction

Construction work within the substation site will include site preparation and installation of substructures and electrical equipment. Installation of concrete foundations and embedments for equipment will require the use of trenching machines, concrete trucks and pumpers, vibrators, forklifts, boom trucks, and large cranes. Above-ground and below ground conduits from this equipment will run to a control enclosure that will house the protection, control, and automation relay panels. A station service transformer will be installed for primary AC power requirements. Batteries and battery chargers will be installed inside the enclosure for auxiliary power to the switchyard's control system. Crushed rock will cover the area of the substation and adequate lighting will be installed around the substation for worker safety during construction and operation.

One of two methods will be used to install substation foundations. Option 1 would be to use a small rubber tire backhoe to dig out major foundations prior to pouring the concrete slabs. Option 2 would use an auger/drill type machine for minor foundations.

In both scenarios, the limit of disturbance will be within the footprint of the substation for both the foundation equipment and the concrete delivery trucks. All topsoil from the Solar Project Substation footprint will be removed to a pre-established suitable location for storage. The storage area would be near the site where the soil was removed, accurately located (GPS boundary, soil depth) and graded to facilitate revegetation. Subsoil would be removed, if necessary, to an acceptable preestablished and approved area for storage. After decommissioning, subsoil will be returned to the area from which it was excavated (as needed), topsoil will be replaced, and the area will be brought back to pre-construction contours.

2.3.8 Stormwater Drainage Bains

Similar to Project substation construction described above, drainage basins would have topsoil removed and temporarily stored in a pre-established suitable location. Subsoil would then be excavated to a depth of three to six feet and the sides of the drainage basin sloped to design, including inlet/outlet. Excavated subsoil would be distributed throughout the site as fill material in areas where grading is required. Topsoil would be replaced and the basins vegetated with a wet seed mix.

2.3.9 Project Fencing Installation

A fencing company will be contracted to construct the perimeter fencing around the Project. The fencing will consist of an agricultural woven fence and will extend approximately 7 feet above grade. At the request of MNDNR, barbed wire will not be used around the perimeter of the Project, and instead 1 foot of 3-4 strands of smooth wire will be used. However, the fencing around the substation will be a 8-feet above grade chain-link fence and include 1 foot of barbed wire to comply

with the National Electric Code. The wooden posts for the agricultural fence will be augured or directly embedded, set in place, and backfilled with the soil that was displaced by the auger, if necessary. Chain link posts around the Project substation will be spaced at 10 feet on center. Corner posts will be augured 3.5 feet and embedded in concrete for structural support. All tangent posts will be direct buried 3.5 feet similar to corner posts. The Site will have man doors and gates installed, as needed.

3.0 LIMITATIONS AND SUITABILITY OF SITE SOILS

Soil varies considerably in its physical and chemical characteristics that strongly influence the suitability and limitations that soil has for construction, reclamation, and restoration. Major soil properties include:

- Soil texture
- Drainage and wetness
- Presence of stones, rocks, and shallow bedrock
- Fertility and topsoil characteristics
- Soil slope

Interpretative limitations and hazards for construction and reclamation are based to a large degree on the dominant soil properties, and include:

- Prime farmland status
- Hydric soil status
- Susceptibility to wind and water erosion
- Susceptibility to compaction
- Fertility and Plant Nutrition
- Drought susceptibility and revegetation potential

3.1 Land Use Considerations

Based on an air photo history, virtually all of the Project Area has been in agriculture starting prior to 1938, with several hundred acres of wet areas converted to agriculture by subsurface tile drainage. Most of the agricultural land is prime farmland or prime farmland if drained. Typically, high value crops such as corn and soybean rotations are grown in the area. Red Rock assumes that all subsurface and surface drainage systems will be maintained during Project operation, and that upon decommissioning, all surface infrastructure will be removed and the land will be restored to agriculture.

3.2 Important Soil Characteristics

The Soil Survey Geographic Database (SSURGO) is the digitized county soil survey and provides a GIS relating soil map unit polygons to component soil characteristics and interpretations. Soil map unit polygons in the SSURGO database were clipped to the Project and internal infrastructure boundaries, including the major pieces of infrastructure:

- Fenced area hosting solar panels, racks, and arrays
- Inverter locations
- Access roads
- Laydown areas
- Project substation and O&M building

The acreage of major Project features sharing physical properties, classifications, and limitation interpretations important for construction, use, revegetation, and reclamation were determined by spatial query of the GIS. Soils within the 846.2-acre Project Boundary but not anticipated to be affected by construction or operations are indicated in tables but not included in the following

analysis, which only includes the 483.2 acres that will be affected by construction (Project Footprint).

A soil map of the Project Area is provided along with a table of selected characteristics of site soils including physical properties, classifications, and construction-related limitations in Appendices A and B.

3.2.1 Selected Physical Characteristics: Texture, Slope, Drainage and Wetness, Topsoil Depth, Bedrock and Presence of Stones and Rocks

There are approximately 846.2 acres within the Project Boundary. Selected physical characteristics of site soils are broken down by acreage within the 483.2-acre Project Footprint and the 362.9-acre undisturbed area in Table 1.

Table 1: Acreage of Soils with Selected Physical Characteristics by Project Feature within the Project Footprint (Total 846.2 acres)

Project Feature	Total Acres[1]	Textural Family[2]		Slope Range[3]		Drainage Class[4]				Topsoil Thickness[5]			Shallow Bedrock/ Stony[6]
		Fine Loamy	Fine-Loamy over Sandy or Sandy-Skeletal	0-5	>5-8	MW	SWP	P	VP	>6 -12	>12 -18	>18	
	Acres												
Project Footprint (Potential Disturbance)													
Fence Area	412.3	410.9	1.3	412.3	--	90.9	106.3	191.2	23.9	--	225.2	187.1	--
Access Roads	10.1	10.1	--	10.1	--	2.2	2.6	4.4	0.8	--	5.7	4.4	--
Inverters	0.1	0.1	--	0.1	--	0.0	0.0	0.1	0.0	--	0.1	0.0	--
Laydown Yards	1.8	1.8	--	1.8	--	--	0.9	0.9		--	0.9	0.9	--
Laydown Yards – Outside Fence	5.8	5.5	0.3	5.8	--	--	3.5	1.9	0.3	--	4.3	1.5	--
Substation	5.4	5.4	--	10.0	--	--	2.2	0.9	2.3	--	2.8	2.6	--
Collection	24.1	23.6	0.5	24.5	--	0.4	7.5	13.5	2.7	--	10.1	14.0	--
Basins	23.7	22.8	0.9	23.7	--	0.3	1.0	13.5	9.0	--	3.7	20.1	--
Subtotal	**483.2**	**480.2**	**3.1**	**483.2**	**--**	**93.8**	**124.0**	**226.4**	**39.0**	**--**	**252.6**	**230.6**	**--**
Land Under Control but Not Currently Planned for Development													
Undisturbed	362.9	345.9	17.1	362.9	--	46.8	86.6	165.3	64.2	--	173.2	189.7	--
Grand Total													
Grand Total	**846.2**	**826.0**	**20.2**	**846.2**	**--**	**140.6**	**210.6**	**391.8**	**103.2**	**--**	**425.9**	**420.3**	**--**

1 Total acres of Project features that are anticipated to be disturbed by supporting construction equipment traffic, excavation, and grading. Data obtained by merging Project facility polygons with the SSURGO spatial data in ArcGIS. Summations were performed in Microsoft[tm] Access.

2 Data available directly from the Natural Resources Conservation Service (NRCS) SSURGO spatial or attribute database via geospatial query of the spatial or attribute data.

3 Representative slope values are taken directly from the SSURGO database. The SSURGO database provides representative slope values for all component soil series. Slope classes represent the slope class grouping in percent that contains the representative slope value for a major component soil series. For example, a soil mapped in the 2-6% slope class has an average slope of 4%, which is within the 0-5% slope range.

4 Drainage class as taken directly from the SSURGO database.

5 Topsoil thickness is the aggregate thickness of the A horizons described in the SSURGO database.

6 Depth to bedrock taken directly from the SSURGO database. Stony/Rocky soils are those soils that have either a cobbley, stony, boulder, shaly, very gravelly or extremely gravelly modifier to the textural class of the surface layer or that have a surface layer with > 5% stones or rocks > 3 inches in any dimension.

Soil texture affects water infiltration and percolation, drought tolerance, compaction, rutting, and revegetation among other things. Soil texture is described by the soil textural family which indicates the range of soil particle sizes averaged for the whole soil. All of the soils within the Project Footprint (483.2 acres) are in the Fine Loamy (480.2 acres, 99 percent) and Fine Loamy over Sandy-Skeletal (3.1 acres, 1 percent) textural families, indicating medium-textured soils. Medium-textured soils typically have good physical and available-water characteristics to support plant growth if not in excessively steep or wet conditions. They have high water-holding capacity, with most of the water being readily available for plant growth.

Slope affects constructability, water erosion, revegetation, compaction and rutting, among other properties. All of the soils (483.2 acres, 100 percent) within the Project Footprint are nearly level soils with representative slopes falling within the 0-5 percent slope range.

Soil drainage indicates the wetness in the soil profile along with the speed at which internal water moves. Soil Drainage affects constructability, erosion by wind and water, and revegetation success. Most of the soils within the Project Footprint are in the Somewhat Poor and Poor drainage classes (124.2 and 226.4 acres, respectively, cumulatively 73 percent of the Project Footprint acreage), with smaller areas mapped into Moderately Well (93.8 acres, 19 percent) and Very Poor (39.0 acres, 8 percent) drainage classes. None of the soils are excessively drained that would be subject to drought. Soils in Somewhat Poor and Poor drainage classes are highly productive when drained and are frequently converted to agriculture by the installation of subsurface drain tile. Virtually all of the soils in Somewhat Poor and Poor drainage classes in the Project Footprint have been drained. Moderately well and somewhat poorly drained soils typically are not droughty or wet and are typically well suited to intensive agriculture.

Topsoil depth affects soil plant nutrition and surface soil structure. To maintain soil productivity, soils with thick topsoil will require larger areas for storage of larger volume of topsoil stripped from permanent infrastructure footprints such as permanent access roads, inverters, and the Project substation. All soils within the Project Footprint are Mollisols and are characterized by the presence of relatively thick topsoil; 252.6 acres (52 percent) of soil have topsoil depths between 12 and 18 inches and 230.6 (48 percent) have topsoil depths greater than 18 inches.

The presence of bedrock near the soil surface and rocks and stones in the soil profile affects constructability and revegetation. No soils in the Project Footprint are shallow to bedrock or have stones at the soil surface or within the soil profile.

3.2.2 Selected Classification Data: Prime Farmland, Land Capability Classification, Hydric Soils.

Selected classification information for site soils are broken down by acreage within the 483.2-acre Project Footprint and the 362.9-acre undisturbed area in Table 2.

Table 2: Acreage of Soils with Selected Classification Data by Project Feature Within the Project Footprint (Total 846.2 acres)

Project Feature	Total Acres[1]	Prime Farmland[2]		Land Capability Class[2]					Hydric Soil[2]
		All Soils	If Drained	1	2e	2s	2w	3e	
	Acres								
Project Footprint (Potential Disturbance)									
Fence Area	412.3	197.2	215.1	106.3	90.9	--	191.2	23.9	215.1
Access Roads	10.1	4.9	5.2	2.6	2.2	--	4.4	0.8	5.2
Inverters	0.1	0.1	0.1	0.0	0.0	--	0.1	0.0	0.1
Laydown Yards	1.8	0.9	0.9	0.9	--	--	0.9		0.9
Laydown Yards – Outside Fence	5.8	3.5	2.3	3.5	--	--	1.9	0.3	2.3
Substation	5.4	2.2	3.2	2.2	--	--	0.9	2.3	3.2
Collection	24.1	7.9	16.2	7.5	0.4	--	13.5	2.7	16.2
Basins	23.7	1.2	22.5	1.0	0.3	--	13.5	9.0	22.5
Subtotal	**483.2**	**217.8**	**265.4**	**124.0**	**93.8**	**--**	**226.4**	**39.0**	**265.4**
Land Under Control but Not Currently Planned for Development									
Undisturbed	362.9	133.4	229.5	86.6	46.8	--	165.3	64.2	229.5
Grand Total									
Grand Total	**846.2**	**351.2**	**495.0**	**210.6**	**140.6**	**--**	**391.8**	**103.2**	**495.0**

[1] Total acres of Project features that are anticipated to be disturbed by supporting construction equipment traffic, excavation, and grading. Data obtained by merging facility polygons with the SSURGO spatial data in ArcGIS. Summations were performed in Microsoft™ Access.

[2] Data available directly from the NRCS SSURGO spatial or attribute database via geospatial query of the spatial or attribute data.

Natural Resources Conservation Service (NRCS)-designated prime farmland soils have the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and are also available for these uses[1]. All of the soils in the Project Footprint are classified into prime farmland or prime farmland if drained (217.8 and 265.4 acres respectively; cumulatively 100 percent); however, it is important to note that the prime farmland designation is independent of current land use.

Land Capability Class (LCC) is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. Soils within the Project Footprint are in LCC 1, 2e, 2w and 3e classes. A numerical value of 1 and 2 indicates soils with no or few limitations that restrict the choice of plants or require very careful management; a numerical value of 3 indicates soils with limitations that reduce the choice of plants or require special conservation practices, or both. Most of the soils in the Project site are

[1] Prime farmland is defined as land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, and oilseed crops, and is also available for these uses (the land could be cropland, pasture, woodland, or other lands). Urbanized land and open water cannot be designated as prime farmland. Prime farmland typically contains few or no rocks, is permeable to water and air, is not excessively erodible or saturated with water for long periods, and is not subject to frequent or prolonged flooding during the growing season. Soils that do not meet the above criteria may be considered prime farmland if the limiting factor is mitigated (e.g., by draining or irrigating).

in LCC 1, 2e, and 2w classes (124.2 acres, 93.8 acres and 226.4 acres respectively; cumulatively 92 percent).

Hydric soils are generally described as soils in poorly drained to very poorly drained drainage classes. Hydric soils are formally a component of regulated wetlands and can be used to indicate areas with potential jurisdictional wetlands. Approximately half of the soils are hydric (265.4 acres, 55 percent), with 217.8 acres (45 percent) being considered non-hydric soils. Virtually all of the hydric soils that were historic wetlands have been legally converted to non-wetland by subsurface tile drainage.

3.2.3 Construction-Related Interpretations: Highly Erodible Land (Wind and Water), Compaction Prone, Rutting Prone, and Drought Susceptible with Poor Revegetation Potential.

Selected construction-related interpretative data for site soils are broken down by acreage within the 483.2-acre Project Footprint and the 362.9-acre undisturbed area in Table 3.

Table 3: Acreage of Soils in Selected Construction-related Interpretations by Project Feature Within the Project Footprint (Total 846.2 acres)

Project Feature	Total Acres[1]	Highly Erodible[2]		Compact. Prone[3]	Rutting Hazard[4]			Drought Susceptible[5]
		Water	Wind		Probable	Possible	Unlikely	
	Acres							
Project Footprint (Potential Disturbance)								
Fence	412.3	-	-	318.4	412.3	-	-	-
Roads	10.1	-	-	7.8	10.1	-	-	-
Inverter	0.1	-	-	0.1	0.1	-	-	-
Laydown	1.8	-	-	1.8	1.8	-	-	-
Laydown - Outside	5.8			5.8	5.8			
Project Substation	5.4	-	-	5.4	5.4	-	-	-
Collection	24.1	-	-	23.7	24.1	-	-	-
Basin	23.7			23.5	23.7			
Subtotal	**483.2**	-	-	**386.5**	**483.2**	-	-	-
Land Under Control but Not Currently Planned for Development								
Undisturbed	362.9	-	-	315.7	362.9	-	-	-
Grand Total								
Total	**846.2**	**-**	**-**	**702.2**	**846.2**	**-**	**-**	-

1 Total acres of Project features that are anticipated to be disturbed by supporting construction equipment traffic, excavation, and grading. Data obtained by merging facility polygons with the SSURGO spatial data in ArcGIS. Summations were performed in Microsoft™ Access.

2 Highly Erodible Water Includes soils in Land Capability Class 4e through 8e or that have a representative slope value greater than or equal to 9%. Highly Erodible Wind Includes soils in wind erodibility groups 1 and 2.

3 Includes soils that are somewhat poorly drained to very poorly drained soils in loamy sands and finer textural classes.

4 Rutting potential hazard based on the soil strength as indicated by engineering texture classification, drainage class, and slope. In general, soils on low slopes in wetter drainage classes, and comprised of sediments with low strength will have potential rutting hazards.

5 Includes soils with a surface texture of sandy loam or coarser that are moderately well to excessively drained.

Highly erodible land is identified as being susceptible to water and wind erosion. The majority of soils in the Project Footprint are low relief, medium-textured soils with intermediate water infiltration characteristics that limit soil erosion by the agent of water. None of the Project Footprint has soils that are highly water erodible.

Wind erosion was evaluated using the wind erodibility group. Highly wind erodible soils are medium textured, relatively well drained soils with poor soil aggregation, resulting in soils with soil surfaces dominated by particles that can be dislodged and carried by the wind. None of the soils within the Project Footprint are considered highly wind erodible.

Soils prone to compaction and rutting are subject to dramatic and adverse changes in soil porosity and structure as a result of mechanical deformation caused loading by equipment during construction. Compaction and rutting are related to moisture content and texture and are worse when medium- and fine-textured soils are subject to heavy equipment traffic when wet. Compaction and rutting are anticipated on 386.5 acres (80 percent) and 483.2 acres (100 percent), respectively, if they are trafficked when wet. Red Rock will develop prescriptions that avoid trafficking soils when wet to avoid and minimize potential compaction and rutting.

Soils susceptible to drought include coarse textured soils in moderately well to excessive drainage classes. Revegetation during seed germination and early seedling growth is severely compromised during dry periods on droughty soils. None of the soils within the Project Footprint are susceptible to drought.

3.2.4 Summary of Major Soil Limitations at the Red Rock Solar Project

3.2.4.1 Prime Farmland

Soils within the Red Rock Project Area are nearly level, deep, moderately drained, medium-textured Mollisols. All of the soils within the Project Area are prime farmland. The primary limitations for the soils during construction, operations and maintenance, and decommissioning include compaction and rutting that may occur when the soils are trafficked when wet, and the need to reserve and store large volumes of topsoil.

While soils classified as prime farmland will be impacted by the solar facility, Red Rock will implement BMPs during construction detailed in Section 4.0 including soil segregation and decompaction, wet weather conditions, erosion and sediment control. After construction, and for the life of the Project, soils will be stabilized and soils given an opportunity to rest, as the site is revegetated with a permanent cover of prairie grasses according to seeding and management specifications agreed to between Red Rock and the MNDNR to the benefit of wildlife and the soil. Upon decommissioning, the land could be returned to its pre-construction agricultural use or to another use if the economic conditions at that time indicated another use is an appropriate use for the site. Red Rock anticipates that the property will be restored to agricultural use on decommissioning of the Project.

Initial post-construction revegetation efforts and maintenance of vegetation during operations and maintenance will consider selecting suited plants, managing seeding times for late spring early summer when soil moisture is optimum for germination, use of mulch and other BMPs. Existing tile drainage systems will be maintained during Project operations. The only impact to prime farmland is that the land will not be farmed for the life of the Project, approximately 35 years.

3.2.4.2 Topsoil Storage

Topsoils are thick ranging from 12 to greater than 18 inches, relatively high in organic matter, and fertile. Storing topsoil in relatively sterile, large piles that are not active plant growth media is not recommended as the storage conditions may adversely influence soil flora and fauna affecting soil quality when topsoils are restored to areas from which the topsoil was taken. To the extent practicable, topsoil should be conserved by preselecting areas to receive excess topsoil from nearby areas, grading and seed bed preparation as appropriate, and revegetation to maintain a rhizosphere suitable for plant growth.

3.2.4.3 Compaction and Rutting

Compaction and rutting are potential limitations in the Project Footprint. Red Rock will design construction access and manage construction passes to minimize the number of trips occurring on a given soil and will implement wet weather procedures any time that rutting is observed. Deep compaction is not anticipated to be a significant problem as the number of construction equipment passes over a given area is limited, and construction equipment consists of smaller, low-ground-pressure tracked vehicles.

4.0 BMPS DURING CONSTRUCTION AND OPERATION

The Project will be constructed and operated on property owned or leased by Red Rock. As stated above, the Project is located on highly productive farmland occupying a flat to gently rolling loess-covered till plain in southwestern Minnesota.

Because all construction activities will be limited to land owned or leased by Red Rock, no direct impacts to adjacent land are expected. Additionally, the technology to be deployed at this facility does not require that the entire Project Site be completely flat or a uniform grade. Because most of the Project site is currently nearly level or has slightly rolling terrain (Table 1), the amount of grading anticipated within the Project Footprint is expected to be minimal. The PV arrays can be designed to follow the existing grade of the Project Site within certain tolerances, which allows the designer of the facility to minimize the amount of earthmoving activities that are required (see Figures 3 and 4).

While some grading activities may be required to raise or lower certain areas within the Project Site, the majority of the Project Site's topography would be left unchanged. The remainder of earthmoving activities would consist of work on the interior access roads, trenches for the DC and AC collection system, and foundational work for the Project substation and inverter skids, as necessary. The sections below describe the measures that the Contractor will implement to minimize the physical impacts to the integrity of the topsoils and topography of the Project Site.

4.1 Environmental Monitor

Red Rock will contract with a third-party to monitor earthmoving activities during the initial phase of Project construction to ensure appropriate measures are taken to properly segregate and handle the topsoils. Red Rock will coordinate with MDA to identify a suitable environmental monitor (Monitor). The Monitor will have a variety of duties, including but not limited to:

- Perform weekly inspections, or more frequently as necessary, during the major earthmoving phase of Project construction;
- observe construction crews and activities to ensure that topsoil is being segregated and managed appropriately;
- monitor the site for areas of potential soil compaction (except within access roads) and make specific recommendations for decompaction;
- make recommendations to Red Rock's construction manager;
- assist in determining if weather events have created "wet weather" conditions and provide recommendations to the construction manager on the ability to proceed with construction; and
- submit a report of Red Rock's adherence to soil BMPs to MDA on a weekly basis during Project construction.

Potential issues with BMPs will be reported to Red Rock's construction manager and to MDA. The construction manager will use discretion to either correct the activity or stop work.

4.2 Soil Segregation and Decompaction

During construction, one of the primary means to protect and preserve the topsoil at the Project Site will be to separate the topsoil from the other subgrade/subsoil materials when earthmoving activities or excavation are taking place during grading, road construction, cable installation,

foundation installation, etc. There may be limited situations where excavated subsoil must be stored on adjacent undisturbed topsoil. In these situations, subsoil will be returned to the excavation with as little disturbance of the underlying topsoil as practicable. Laying down a thin straw mulch layer as a buffer between the subsoil and topsoil may be used as practicable to facilitate more effective separation of the subsoil and underlying topsoil during the excavation backfill process.

Based on SSURGO data, topsoil thickness is typically over 12 inches. This will be confirmed with tests by a Minnesota Licensed Professional Soil Scientist prior to earthwork activities on the site. Red Rock will work with the soil scientist to identify the appropriate depth of topsoil that should be stripped and segregated from other subsoil materials during earthwork activities. Red Rock will provide this information and a recommendation on specific segregation methods/techniques to the Monitor for review and input. As an interim recommendation Red Rock suggests that the full depth of topsoil be stripped up to 12 inches in thickness. Topsoil greater than 12 inches from the soil surface would be treated similarly to the underlying subsoil. During the activities that require temporary excavations and backfilling (i.e., trenching activities) the subgrade material will be replaced into the excavations first and compacted as necessary, followed by replacement of topsoil to the approximate locations from which it was removed. Topsoil will then be graded to the approximate pre-construction contour[2]. Red Rock will strive to avoid compaction in other areas where it is not required by the design.

Following earthwork activities that require segregation of topsoils/subsoils, topsoil materials will be re-spread on top of the backfilled and disturbed areas to maintain the overall integrity and character of the pre-construction farmland. Any excess topsoil material would be re-spread on the Project Site at pre-established locations on the site. The location and amount of topsoil will be documented to facilitate re-spreading of topsoil after decommissioning. This practice is described in more detail below for each of the earthmoving activities that are anticipated for this Project.

4.3 Wet Weather Conditions

During the construction of the Project, it is likely that there will be periods of wet weather that may necessitate a temporary halt of construction activities. The Red Rock Construction Manager will have responsibility for halting activities if weather conditions pose a risk to worker safety or if conditions are such that heavy equipment would cause severe rutting of the Project Site. Following initial grading at the Site, many activities could still proceed in wet weather given the lack of heavy equipment required for those tasks. However, Red Rock's Construction Manager would be responsible for ensuring that topsoil erosion, rutting, compaction, or damage to drain tiles (as present) is avoided or minimized to the extent possible. Because compaction of soils can become problematic during wet weather conditions, as stated above, the Construction Manager will work with the soil scientist and the Monitor to ensure that techniques/practices are employed to decompact soils appropriately following wet weather conditions. Decompaction with chisel plows prior to disking and planting will typically be a standard method of soil preparation in areas proposed for seeding to native grasses, forbs, and pollinator species. Agricultural equipment capable of operating within the approximate 20-foot wide space between panel lines when panels

[2] Red Rock recognizes that topsoil mixing is both an aesthetic and crop-productivity issue and will strive to minimize to the extent practicable topsoil and subsoil mixing during initial construction, operations, and decommissioning/reclamation. For the purpose of identifying areas where topsoil mixing is a problem, the Environmental Monitor will consider topsoil storage piles, restored trench excavations, and post-closure restored areas with > 5% area of the soil surface as obvious subsoil inclusions to be out of compliance. Remediation may consist of removal of subsoil and replacement with acceptable topsoil.

are oriented vertically would be used to decompact, prepare a seedbed, and plant suited seed mixes.

4.4 Adaptive Management During Construction

Should weather or site conditions during construction require different BMPs than those that are described in this section, Red Rock will work with the Monitor, MDA and other appropriate agencies to discuss potential new approaches to the specific conditions that are encountered.

Red Rock will remain flexible and implement new practices/procedures that will help ensure the quality of the land while maintaining the safety of the workers.

4.4.1 Grading/Earthwork

The first phase of Project construction will be the general civil works at the Project Site where all major cut and fill activities will be performed by the Contractor. As stated above, Red Rock Solar will consult with a qualified soil scientist to identify the appropriate depth of topsoil up to 12 inches that should be stripped and segregated from other materials during initial grading activities. Based on discussions with MDA, topsoils in this region of Minnesota may reach depths of 3-feet. This will be confirmed with tests by the soil scientist prior to grading activities. Red Rock Solar will provide this information and a recommendation on specific segregation methods/techniques to the MDA for review and input.

The Contractor will first strip topsoil around the few selected hills/valleys on site. This will ensure that the topography falls within the tolerances allowed for by the solar array design. During this civil work, topsoil will be pushed outside of the cut/fill areas and collected into designated spots for later use. Once topsoil is removed from the cut/fill areas, the sub-grade materials will be removed as required from on-site hills and relocated to on-site low spots. Prior to relocating sub-grade materials to the low spots, top soil in the low areas will be stripped and set aside before the fill is added, then respreads over the new fill. The sub-grade materials would be compacted in place. When compaction is complete, the topsoil spoil piles will be re-spread over the reconditioned sub-grade areas. See footnote 2 for information on identifying topsoil/subsoil mixing when and where it occurs.

This newly spread topsoil will be loosely compacted and/or “tracked” and employ the wind and stormwater erosion prevention BMPs described below in Section 4.8.

4.4.1.1 Access Roads

As a component of earthwork, permanent access roads and permanent turnouts will be developed. This work will start with the stripping and segregating of topsoil materials from the anticipated 20-foot-wide road width. The subgrade materials will be compacted 32-feet wide to the specified compaction requirements as laid out by the civil and geotechnical engineer. After compaction is reached and verified, the road will be installed as designed, typically done with or without geo-fabric depending on the soil type, and then, with a surface of 4 to 12 inches of gravel. The gravel will be placed level with the existing grade to facilitate drainage and minimize ponding.

After gravel is installed and compacted to engineers’ requirements, the Project drainage ditches will be shaped as identified on the final grading plan. Finally, the previously stripped and windrowed topsoil material will be re-spread throughout the Project area.

Topsoil removed from permanent access roads will be removed to suitable locations near the site of removal and spread across existing topsoil for storage. Storage locations will be identified (Global Positioning System [GPS] boundary and depth) and recorded on site maps to facilitate final reclamation after decommissioning.

4.4.2 Solar Array Construction

Once grading activities are complete, the racking system supports will be constructed using steel piles driven into the ground. The pile is driven using a hydraulic ram that moves along tracks and is operated by two workers. In some situations where soils are low strength or consist of loose, non-cohesive sand, helical screw or auger-type foundation posts may be used. Soil disturbance would be restricted to the hydraulic ram/ screw machinery, about the size of a small tractor, temporarily disturbing soil at each pile insertion location and while driving between drilling locations.

During array and racking assembly, multiple crews and various types of vehicles will be working within the Project area. To the extent practicable, vehicular traffic will be limited to permanent and temporary access roads to minimize soil disturbance, mixing and compaction; however vehicular traffic will occur off of roads throughout the Project during construction. Very little soil disturbance is expected from this activity.

4.4.3 Foundations

The Contractor will also perform foundation work for the Project substation and inverters. For the substation, the Contractor will strip topsoil off the substation area, install the pier-type foundations, compact sub-grade materials, re-grade spoils around the substation yard, and then install clean washed rock on the surface. All topsoil stripped from the substation area will be pushed outside of the substation area and collected into designated spots for later use. These topsoil piles will be windrowed or piled and loosely compacted and/or “tracked” with stormwater and wind erosion BMPs in place. Once substation construction is advanced, the topsoil piles would be distributed in a thin layer adjacent to the substation area.

For the inverters, topsoil will again be stripped and placed adjacent to the inverter. Afterwards, the foundations will be dug using a rubber-tire backhoe and then rebar and concrete installed and left to cure. After cure and testing of concrete strength is completed, the subgrade spoils will be compacted around the inverters. After the inverter is set, the adjacent topsoil will be re-spread around the inverter.

After decommissioning, subsoil will be returned to the area from which it was excavated (as needed), topsoil will be replaced, and the area will be brought back to pre-construction contours.

4.4.4 Trenching

Construction of the Project will require trenching for the installation the AC collection lines across the Project Area; the DC collection system would be installed underneath the panels in a hanging harness system. Where the collection lines are buried, the Contractor will be installing AC collection cables in trenches of 4 feet deep using the “open trench” method or by ploughing into place. Topsoil and subgrade materials would be excavated from the trench using typical excavating equipment or backhoes and segregated as described above. The bottom of each trench may be lined with clean fill to surround the cables. Red Rock anticipates that native subsoil will be rock free (Table 1), and that no foreign fill will be necessary. After cables have been

installed on top of bedding materials in the trench, 1 foot of screened, native backfill will be placed on the cables followed by additional 2 feet of unscreened native backfill trench spoil. This material would be compacted as necessary. The last 1 foot of each trench will then be backfilled with topsoil material only to return the surface to its finished grade. See footnote 2 for information on identifying topsoil/subsoil mixing when and where it occurs.

4.5 Temporary Erosion and Sediment Control

Red Rock Solar will prevent excessive soil erosion on lands disturbed by construction by adhering to a Stormwater Pollution Prevention Plan (SWPPP) required under the National Pollutant Discharge Elimination System (NPDES) permitting requirement that will be administered by the Minnesota Pollution Control Agency.

Prior to construction, Red Rock will work with engineers or the Contractor to outline the reasonable methods for erosion control and prepare the SWPPP.

These measures would primarily include silt fencing on the downside of all hills, near waterways, and near drain tile inlets. This silt fencing would control soil erosion via stormwater. Check dams and straw waddles will also be used to slow water during rain events in areas that have the potential for high volume flow. In addition, the Contractor can use erosion control blankets on any steep slopes, although given the site topography, this BMP will not likely be required. Lastly, as outlined above, topsoil and sub-grade material will be piled and loosely compacted and / or "tracked" while stored. The BMPs employed to mitigate wind and stormwater erosion on these soil stockpiles will include installing silt fence on the downward side of the piles as needed and installation of straw waddles if these spoil piles are located near waterways.

The SWPPP will identify designated onsite SWPPP inspectors to be employed by the Contractor for routine inspections as well as for inspections after storm events per the plan outlined in the SWPPP.

4.6 Drain Tile Identification, Avoidance and Repair

Red Rock Solar is aware of the presence of drain tile within the Project Area which appears to be adequately draining the Project Area. To minimize unforeseen repairs or damages to existing drain tile and/or drain tile systems, Red Rock Solar has developed a comprehensive plan to address the presence and treatment of this tile before, during, and after construction. The plan consists of the following components and each component is discussed in detail below:

- Pre-Construction Tile Mapping and Repair
- Project Design Considerations
- Construction Mitigation Measures
- Repair/Remediation of Damaged Tile

4.6.1 Pre-Construction Tile Mapping and Repair

Red Rock Solar has contacted landowners and is aware of the presence of drain tile in the Project Footprint. In the event the remaining drain tile mapping cannot be identified, Red Rock will utilize other sources, including infrared aerial photographs, LiDAR data, and, if necessary, a site-specific tile locate survey with a local agricultural drain tile contractor (Tile Contractor).

If necessary, physical location of drain tile will be performed by using a small excavator to dig a shallow trench perpendicular to and at varying intervals across areas where research indicated tile could be found.

Visible surface inlets will be identified and a tile probe inserted to locate the tile line and determine its direction from the inlet. Using an excavator, a shallow trench will be dug to confirm the presence of the tile. Once confirmed, a tile probe will locate the tile line to determine the direction of the tile. As necessary, appropriate tile lines will be exposed to determine size, type, flow direction, and condition. Any damaged tile encountered in the tile location process will be repaired or replaced to its original size and capacity.

Clogged tiles found during the location process will be assessed. Clogged tile is often an indication of a failing line tile. However, cleaning clogged tile is not usually cost effective and may lead to future problems, so a remediation plan is being developed to address clogged tile locations during the construction process. Remediation may involve replacing the clogged portion of tile or replacing the line completely.

In some locations within the Project Footprint, existing tile lines may need to be relocated to avoid damage from Project facilities. In the event a tile line requires replacement, the new tile will have the capacity, depth, and appropriate slope to ensure the new tile line performs adequately for the line it is replacing. All replacement or rerouting of tile will take place proactively during construction or as it is identified in order to maintain the integrity of the drainage lines during construction. This practice should minimize interruption of any drainage on site or on any neighboring farms that may drain through the property.

Repairs or rerouting will be performing using a small to mid-sized excavator. Laser equipment will be used to ensure proper grading of the pipe. In the event a line of significant size and length needs to be rerouted or installed, a commercial drainage plow could be used.

The drainage plow typically utilizes GPS-grade control to ensure pipe is installed to specified slopes. The following considerations will also apply:

- Tiles will be repaired with materials of the same or better quality as that which was damaged.
- Tile repairs will be conducted in a manner consistent with industry-accepted methods.
- Before completing permanent tile repairs, tiles will be examined within the work area to check for tile that might have been damaged by construction equipment. If tiles are found to be damaged, they will be repaired so they operate as well after construction as before construction began.
- Red Rock Solar will make efforts to complete permanent tile repairs within a reasonable timeframe, taking into account weather and soil conditions.

4.6.2 Project Design Considerations

By establishing an accurate assessment of the drain tile in the Project Site prior to construction, Red Rock can overlay the location of the tile lines on their construction plans and identify any conflicts with the drainage lines. Following the location process, GIS layers and CAD files of tile locations will be generated and provided to the solar array design engineer. The engineers will design around the tiles to ensure placement of the solar racking systems do not damage the tile to the extent feasible. In some areas, re-routing of the tile is necessary and this re-routing work will take place immediately prior to or during construction.

4.6.3 Construction Measures

In areas where it will be impossible to design solar arrays around tile locations, steps will be taken to ensure the integrity of the drainage system will remain intact both during and after construction. Tile lines that are in direct conflict with solar array installation or trenches (i.e., collection lines) will be rerouted around the conflict area. Tile lines that have the potential to be damaged by construction traffic will be bridged or reinforced to maintain integrity.

4.6.4 Operational Measures

Following completion of construction, Red Rock Solar will inspect the Project Site after significant snow melt or rainfall events for evidence that tile systems are functioning adequately. If localized wet areas or standing water are observed, it is likely the tile system is not operating as anticipated. In this situation, the Tile Contractor will be reengaged to pin-point any damaged tile that may have been missed during construction. Tile would be repaired following the process outlines above.

4.7 Construction Debris

Construction-related debris and unused material will be removed by Red Rock Solar and the Contractor. Any below-grade, unusable materials will be removed and loaded immediately onto trucks for subsequent disposal at a designated off-site location. The Contractor will use locally sourced dumpsters and removal services to regularly check and schedule pick-ups for full dumpsters which will be switched out for empty ones. To the extent practicable, recyclable materials (i.e., cardboard) will be sorted and recycled at a local facility.

Debris/trash collection points and dumpsters will be located both in the laydown yards as well as at strategically designated locations close to where actual work is being performed. If loose debris fails to be deposited into dumpsters or if it becomes wind-blown, the Contractor will inspect and clear fence lines of debris on a daily basis to ensure that debris and trash does not leave the Project Area. Contaminated materials are not expected; however, if any such materials are encountered during construction, specialized dumpsters and handling instructions will be employed to suit the types of contaminated materials that are discovered. Contaminated materials will be disposed of at the nearest appropriate facility in accordance with applicable laws, ordinances, regulations, and standards.

5.0 DECOMMISSIONING

At the end of the Project's useful life, Red Rock will either take necessary steps to continue operation of the Project (such as re-permitting and retrofitting) or will decommission the Project and remove facilities. Decommissioning activities will include:

- Removing the solar arrays, inverters/transformers, electrical collection system, fencing, lighting, and substation;
- Removal of below-ground electrical cables to a depth of four feet (cables buried below four feet will be left in place);
- Removal of buildings and ancillary equipment to a depth of four feet;
- Removal of surface road material and restoration of the roads to substantially the same physical condition that existed immediately before construction. If the Project is decommissioned and the land sold to a new owner, Red Rock would retain any access roads the new landowner requested be retained;
- Grading, adding or re-spreading topsoil, and reseeding according to the Natural Resources Conservation Service (NRCS) technical guide recommendations and other agency recommendations, areas disturbed by the construction of the facility or decommissioning activities, grading and soil disturbance activities will be kept to the minimum necessary to restore areas where topsoil was stripped in construction, topsoil in decommissioned roads and compaction only in areas that were compacted during decommissioning activities so that the benefits to the soil that were achieved over the life of the Project are not counteracted by decommissioning; and
- Standard decommissioning practices would be utilized, including dismantling and repurposing, salvaging/recycling, or disposing of the solar energy improvements, and restoration.

5.1 Timeline

Decommissioning is estimated to take from five to nine months to complete depending on seasonality, and the decommissioning crew will ensure that all equipment is recycled or disposed of properly.

5.2 Removal and Disposal of Project Components

The removal and disposal details of the Project components are found below:

- **Modules**: Modules will be inspected for physical damage, tested for functionality, and disconnected and removed from racking. Functioning modules will be packed and shipped to an offsite facility for reuse or resale. Non-functioning modules will be packed, palletized, and shipped to the manufacturer or a third party for recycling or disposal.
- **Racking**: Racking and racking components will be disassembled and removed from the steel foundation posts, processed to appropriate size, and sent to a metal recycling facility.
- **Steel Foundation Posts**: All structural foundation steel posts will be pulled out to full depth, removed, processed to appropriate size, and shipped to a recycling facility. During decommissioning, the area around the foundation posts may be compacted by equipment and, if compacted, the area will be de-compacted in a manner to adequately restore the topsoil and sub-grade material to a density consistent for vegetation.

- **Underground Cables and Lines**: Underground cables and conduits contain no materials known to be harmful to the environment. Decommissioning will include removing underground cables buried above 48 inches. Topsoil will be segregated and stockpiled for later use prior to any excavation and the subsurface soils will be staged next to the excavation. The subgrade will be compacted to a density of approximately 90 percent of standard Proctor density. Topsoil will be redistributed across the disturbed area.
- **Inverters, Transformers, and Ancillary Equipment**: All electrical equipment will be disconnected and disassembled. All parts will be removed from the site and reconditioned and reused, sold as scrap, recycled, or disposed of appropriately, at the Owner's sole discretion, consistent with applicable regulations and industry standards.
- **Equipment Foundation and Ancillary Foundations**: The ancillary foundation for Red Rock Solar are pile foundations for both equipment skids and met towers. As with the solar array steel foundation posts, the foundation piles will be pulled out completely. Duct banks will be excavated to a depth sufficient to remove all conduits, cables, etc. to a depth of 48 inches below grade. The remaining excavation will be filled with clean subgrade materials of quality comparable to the immediate surrounding area. All unexcavated areas compacted by equipment used in decommissioning will be de-compacted in a manner to adequately restore the topsoil and sub-grade material to a density of approximately 90 percent of standard Proctor density. All materials will be removed from the site and reconditioned and reused, sold as scrap, recycled, or disposed of appropriately, at the owner's sole discretion, consistent with applicable regulations and industry standards.
- **Fence**: All fence parts and foundations will be removed from the site and reconditioned and reused, sold as scrap, recycled, or disposed of appropriately, at the owner's sole discretion, consistent with applicable regulations and industry standards. The surrounding areas will be restored to pre-construction conditions to extent feasible.
- **Access Roads**: Facility access roads will be used for decommissioning purposes, after which removal of roads will be discussed with the Landowner, using the following process:
    - After final clean-up, roads may be left intact through mutual agreement of the landowner and the owner unless otherwise restricted by federal, state, or local regulations.
    - If a road is to be removed, aggregate will be removed and shipped from the site to be reused, sold, or disposed of appropriately, at the Owner's sole discretion, consistent with applicable regulations and industry standards. Clean aggregate can often be used as "daily cover" at landfills for no disposal cost. All internal service roads are constructed with geotextile fabric and eight inches of aggregate over compacted subgrade. Any ditch crossing connecting access road to 600th Avenue or 610th Avenue will be removed unless the landowner requests it remain. The subgrade will be de-compacted to a depth of approximately 18 inches using a chisel plow or other appropriate subsoiling equipment. All rocks larger than four inches will be removed. Topsoil that was stockpiled during the original construction will be distributed across the open area. The access roads and adjacent areas that are compacted by equipment will be de-compacted.

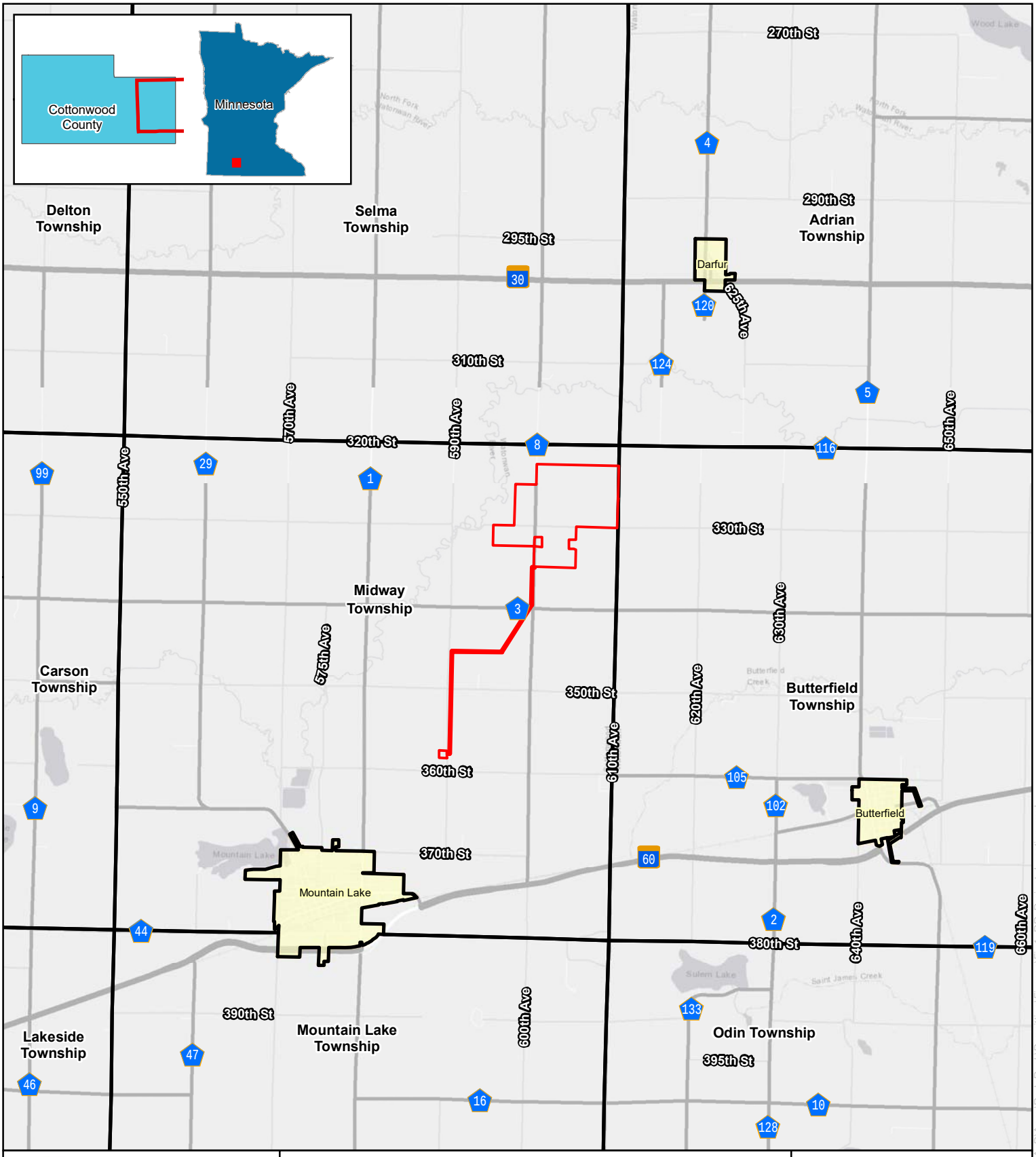
5.3 Restoration/Reclamation of Facility Site

After all equipment is removed, the facility would be restored to an agricultural use, in accordance with the AIMP or to another use if the economic conditions at that time indicate another use is an appropriate use for the site. Holes created by steel pier foundations and fence poles, concrete pads, re-claimed access road corridors and other equipment will be filled in with soil to existing conditions and seeded. Grading and other soil disturbance activities during decommissioning will

be kept to the minimum necessary to effectively decommission the site to maintain the soil benefits realized during the long-term operation of the Project, such benefits include: building topsoil through plant matter decay, carbon capture, and beneficial, soil bacteria that are often absent from soil subject to row crop agriculture.

Red Rock reserves the right to extend operations instead of decommissioning at the end of the site permit term. In this case, a decision may be made on whether to continue operation with existing equipment or to retrofit the facilities with upgrades based on newer technologies. If the decision is made to continue operations, the Project will be re-permitted.

FIGURES



RED ROCK SOLAR

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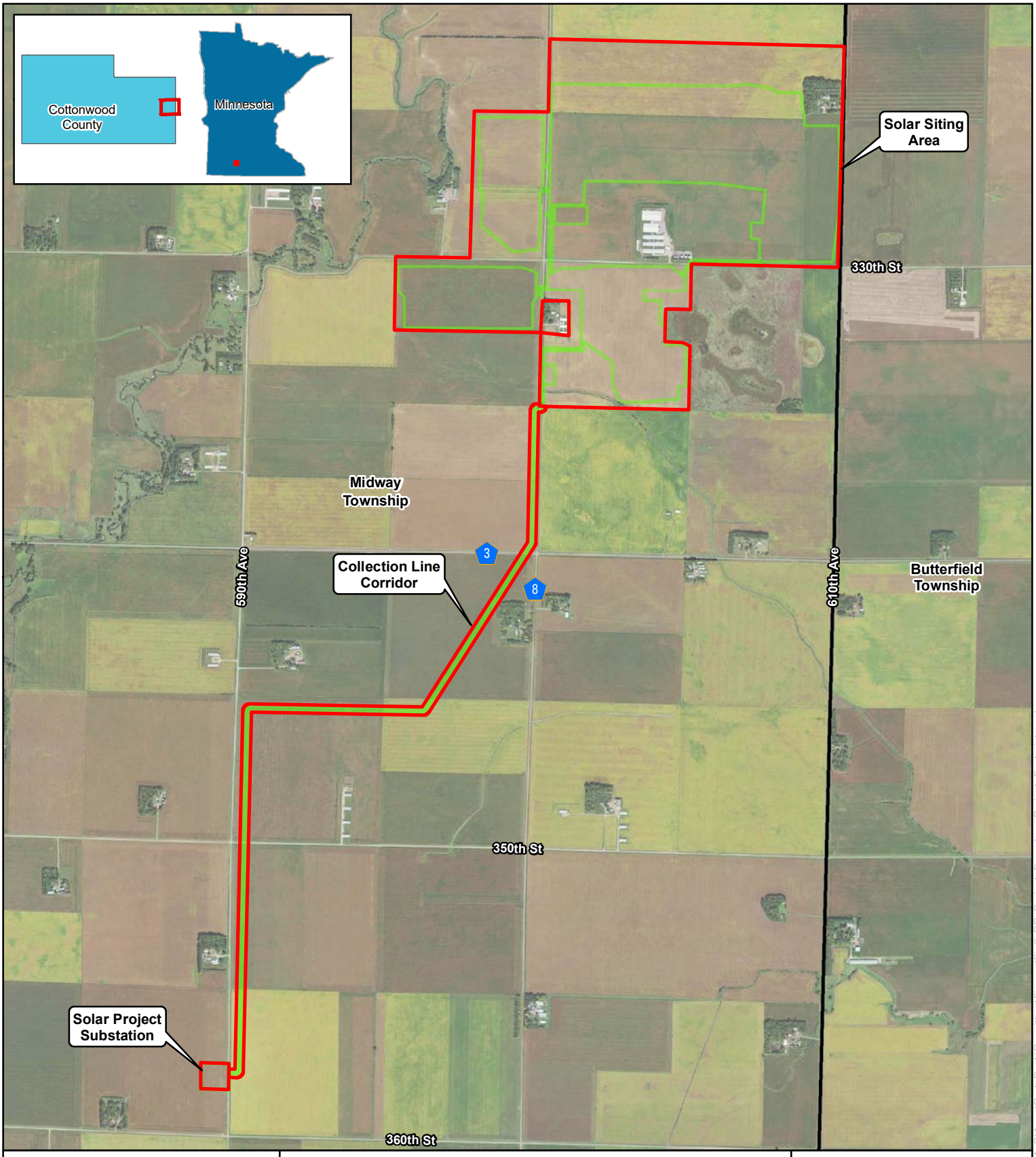
For Environmental Review Purposes Only

Figure 1
Project Location
Red Rock Solar Project
Cottonwood County, Minnesota

- Project Boundary
- City/Town
- Civil Township
- MN Highway
- County Road
- Local Road

Source: Z:\Clients\A_D\Apex\Red_Rock\Permitting\Figures\Fig1_RR_Project_Location.mxd

Date: (9/10/2020)



RED ROCK SOLAR

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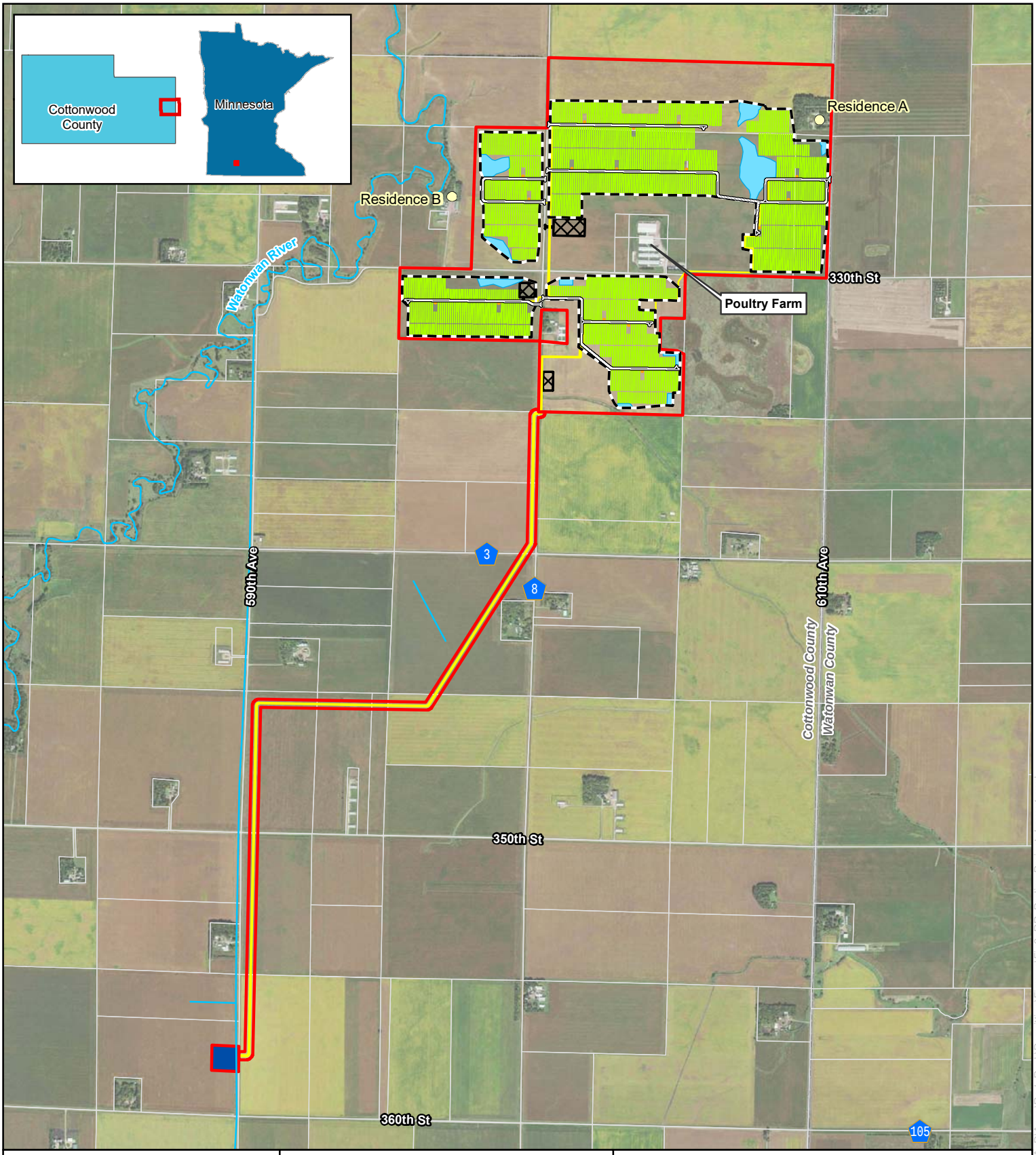
For Environmental Review Purposes Only

Figure 2
Project Boundary and Project Footprint
Red Rock Solar Project
Cottonwood County, Minnesota

Project Boundary
Project Footprint
Civil Township

Source: Z:\Clients\A_D\Apex\Red_Rock\Permitting\Figures\Fig2_RR_Project_Boundary_Project_Footprint.mxd

Date: (9/10/2020)



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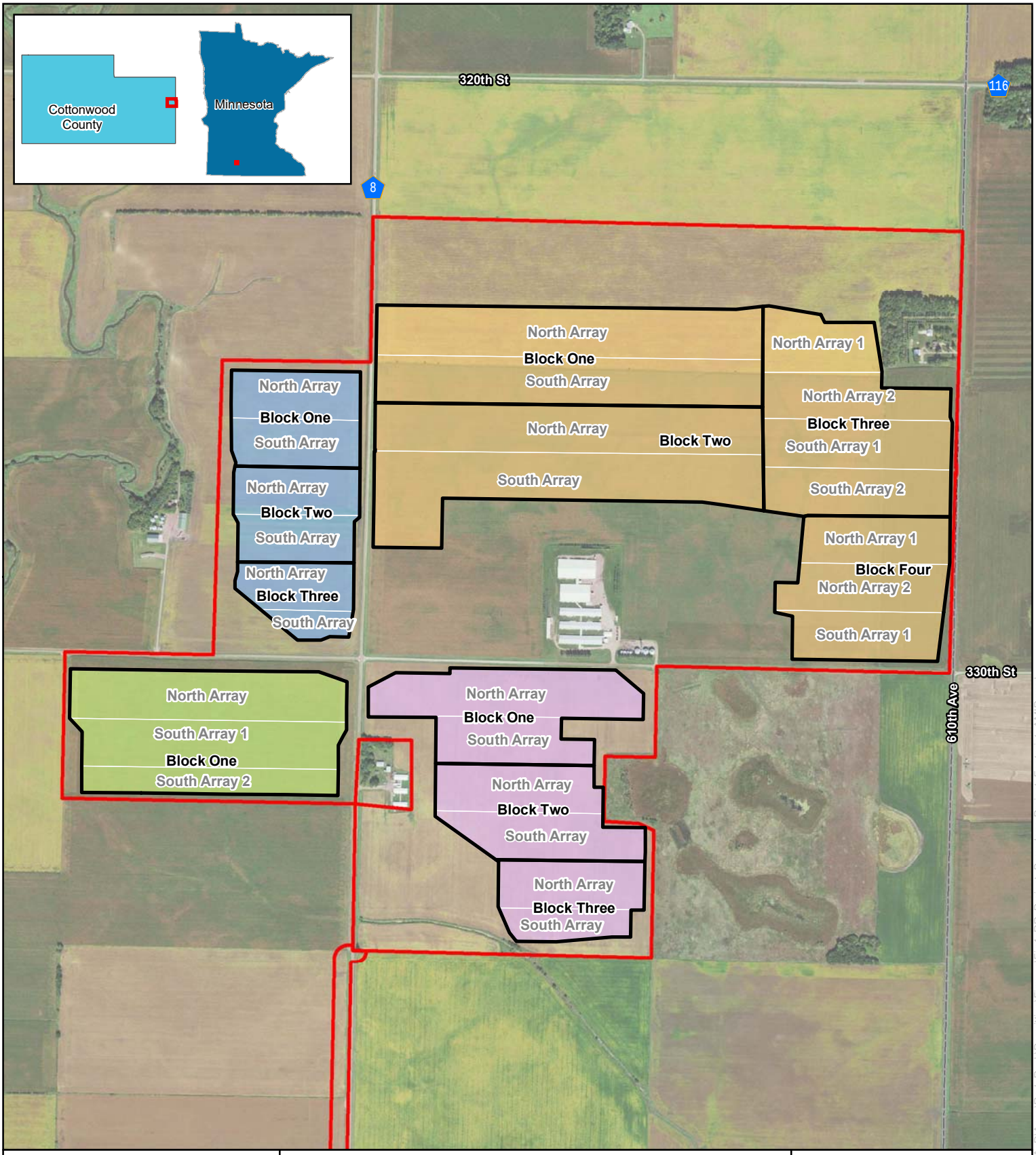
For Environmental Review Purposes Only

Figure 3
Preliminary Project Layout
Red Rock Solar Project
Cottonwood County, Minnesota

- Residence on Solar Development Parcel
- Collection Line
- Project Boundary
- Access Road
- Security Fence
- Inverter
- Solar Array
- Project Substation
- Laydown Area
- Basin
- Parcel Boundary
- NHD Stream (Perennial)

Source: Z:\Clients\A_D\Apex\Red_Rock\Permitting\Figures\Fig3_RR_Prelim_Project_Layout.mxd

Date: (9/10/2020)



RED ROCK SOLAR

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For Environmental Review Purposes Only

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Figure 4
Configuration of Project Components
Red Rock Solar Project
Cottonwood County, Minnesota

- Project Boundary
- Northeast Unit
- Northwest Unit
- Southeast Unit
- Southwest Unit

Source: Z:\Clients\A_D\Apex\Red_Rock\Permitting\Figures\Fig4_RR_Project_Boundary_Project_Footprint_AMIP.mxd

Date: (9/30/2020)

APPENDIX A

Selected Soil Physical Features, Classifications, and Interpretations and Limitations

Appendix A: Selected Soil Physical Features, Classifications, and Interpretations and Limitations

Feature Type[1]	Acres[2]	Map Unit Symbol[3]	Map Unit Name[3]	Selected Soil Physical Features					Selected Soil Classifications			Construction/Reclamation Interpretations and Limitations				
				Particle Size Family[3]	Slope Range[4]	Drainage Class[5]	Topsoil Thickness[6]	Shallow Bedrock/ Stony and Rocky[7]	Prime Farmland[3]	Land Capability Classification[3]	Hydric Soil Rating[3]	Highly Erodible Water[8]	Highly Erodible Wind[9]	Compaction Prone[10]	Rutting Potential[11]	Droughty[12]
Fence	163.2	L83A	Webster clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	103.3	L85A	Nicollet clay loam, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	Yes	Severe	No
	90.9	L79B	Clarion loam, 2 to 6 percent slopes	fine-loamy	0-5	Moderately well drained	>12-18	No	All areas are prime farmland	2e	No	No	No	No	Severe	No
	28.0	L78A	Canisteo clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	22.6	L84A	Glencoe clay loam, 0 to 1 percent slopes	fine-loamy	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	3.0	L98A	Crippin-Nicollet complex, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	No	Severe	No
	1.3	L167A	Mayer clay loam, depressional , 0 to 1 perent slopes	fine-loamy over sandy or sandy-skeletal	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	0.0	L165A	Mayer loam, 0 to 2 percent slopes	fine-loamy over sandy or sandy-skeletal	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	No	Severe	No
Roads	3.6	L83A	Webster clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	2.6	L85A	Nicollet clay loam, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	Yes	Severe	No
	2.2	L79B	Clarion loam, 2 to 6 percent slopes	fine-loamy	0-5	Moderately well drained	>12-18	No	All areas are prime farmland	2e	No	No	No	No	Severe	No
	0.8	L78A	Canisteo clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	0.8	L84A	Glencoe clay loam, 0 to 1 percent slopes	fine-loamy	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
Inverter	0.04	L83A	Webster clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	0.03	L79B	Clarion loam, 2 to 6 percent slopes	fine-loamy	0-5	Moderately well drained	>12-18	No	All areas are prime farmland	2e	No	No	No	No	Severe	No
	0.02	L85A	Nicollet clay loam, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	Yes	Severe	No
	0.01	L78A	Canisteo clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No

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Feature Type[1]	Acres[2]	Map Unit Symbol[3]	Map Unit Name[3]	Selected Soil Physical Features					Selected Soil Classifications			Construction/Reclamation Interpretations and Limitations				
				Particle Size Family[3]	Slope Range[4]	Drainage Class[5]	Topsoil Thickness[6]	Shallow Bedrock/ Stony and Rocky[7]	Prime Farmland[3]	Land Capability Classification[3]	Hydric Soil Rating[3]	Highly Erodible Water[8]	Highly Erodible Wind[9]	Compaction Prone[10]	Rutting Potential[11]	Droughty[12]
	0.01	L84A	Glencoe clay loam, 0 to 1 percent slopes	fine-loamy	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
Laydown	0.9	L83A	Webster clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	0.9	L85A	Nicollet clay loam, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	Yes	Severe	No
Laydown - Outside	3.5	L85A	Nicollet clay loam, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	Yes	Severe	No
	1.1	L83A	Webster clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	0.8	L78A	Canisteo clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	0.3	L167A	Mayer clay loam, depressional , 0 to 1 percent slopes	fine-loamy over sandy or sandy-skeletal	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	0.0	L84A	Glencoe clay loam, 0 to 1 percent slopes	fine-loamy	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
Project Substation	0.3	L83A	Webster clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	2.3	L84A	Glencoe clay loam, 0 to 1 percent slopes	fine-loamy	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	2.2	L85A	Nicollet clay loam, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	Yes	Severe	No
	0.6	L107A	Canisteo-Glencoe complex, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
Collection	11.3	L83A	Webster clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	7.5	L85A	Nicollet clay loam, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	Yes	Severe	No
	2.2	L84A	Glencoe clay loam, 0 to 1 percent slopes	fine-loamy	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	1.6	L78A	Canisteo clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	0.5	L107A	Canisteo-Glencoe complex, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No

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Feature Type[1]	Acres[2]	Map Unit Symbol[3]	Map Unit Name[3]	Selected Soil Physical Features					Selected Soil Classifications			Construction/Reclamation Interpretations and Limitations				
				Particle Size Family[3]	Slope Range[4]	Drainage Class[5]	Topsoil Thickness[6]	Shallow Bedrock/ Stony and Rocky[7]	Prime Farmland[3]	Land Capability Classification[3]	Hydric Soil Rating[3]	Highly Erodible Water[8]	Highly Erodible Wind[9]	Compaction Prone[10]	Rutting Potential[11]	Droughty[12]
	0.5	L167A	Mayer clay loam, depressional , 0 to 1 percent slopes	fine-loamy over sandy or sandy-skeletal	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	0.4	L79B	Clarion loam, 2 to 6 percent slopes	fine-loamy	0-5	Moderately well drained	>12-18	No	All areas are prime farmland	2e	No	No	No	No	Severe	No
Basin	11.1	L83A	Webster clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	8.1	L84A	Glencoe clay loam, 0 to 1 percent slopes	fine-loamy	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	2.4	L78A	Canisteo clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	1.0	L85A	Nicollet clay loam, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	Yes	Severe	No
	0.9	L167A	Mayer clay loam, depressional , 0 to 1 perent slopes	fine-loamy over sandy or sandy-skeletal	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	0.3	L79B	Clarion loam, 2 to 6 percent slopes	fine-loamy	0-5	Moderately well drained	>12-18	No	All areas are prime farmland	2e	No	No	No	No	Severe	No
	0.0	L98A	Crippin-Nicollet complex, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	No	Severe	No
Outside Project Footprint	125.1	L83A	Webster clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	86.6	L85A	Nicollet clay loam, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	Yes	Severe	No
	47.5	L84A	Glencoe clay loam, 0 to 1 percent slopes	fine-loamy	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	46.8	L79B	Clarion loam, 2 to 6 percent slopes	fine-loamy	0-5	Moderately well drained	>12-18	No	All areas are prime farmland	2e	No	No	No	No	Severe	No
	38.8	L78A	Canisteo clay loam, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	16.7	L167A	Mayer clay loam, depressional , 0 to 1 perent slopes	fine-loamy over sandy or sandy-skeletal	0-5	Very poorly drained	>18	No	Prime farmland if drained	3w	Yes	No	No	Yes	Severe	No
	1.0	L107A	Canisteo-Glencoe complex, 0 to 2 percent slopes	fine-loamy	0-5	Poorly drained	>12-18	No	Prime farmland if drained	2w	Yes	No	No	Yes	Severe	No
	0.4	L165A	Mayer loam, 0 to 2 percent slopes	fine-loamy over sandy or sandy-skeletal	0-5	Poorly drained	>18	No	Prime farmland if drained	2w	Yes	No	No	No	Severe	No

Appendix A: Selected Soil Physical Features, Classifications, and Interpretations and Limitations

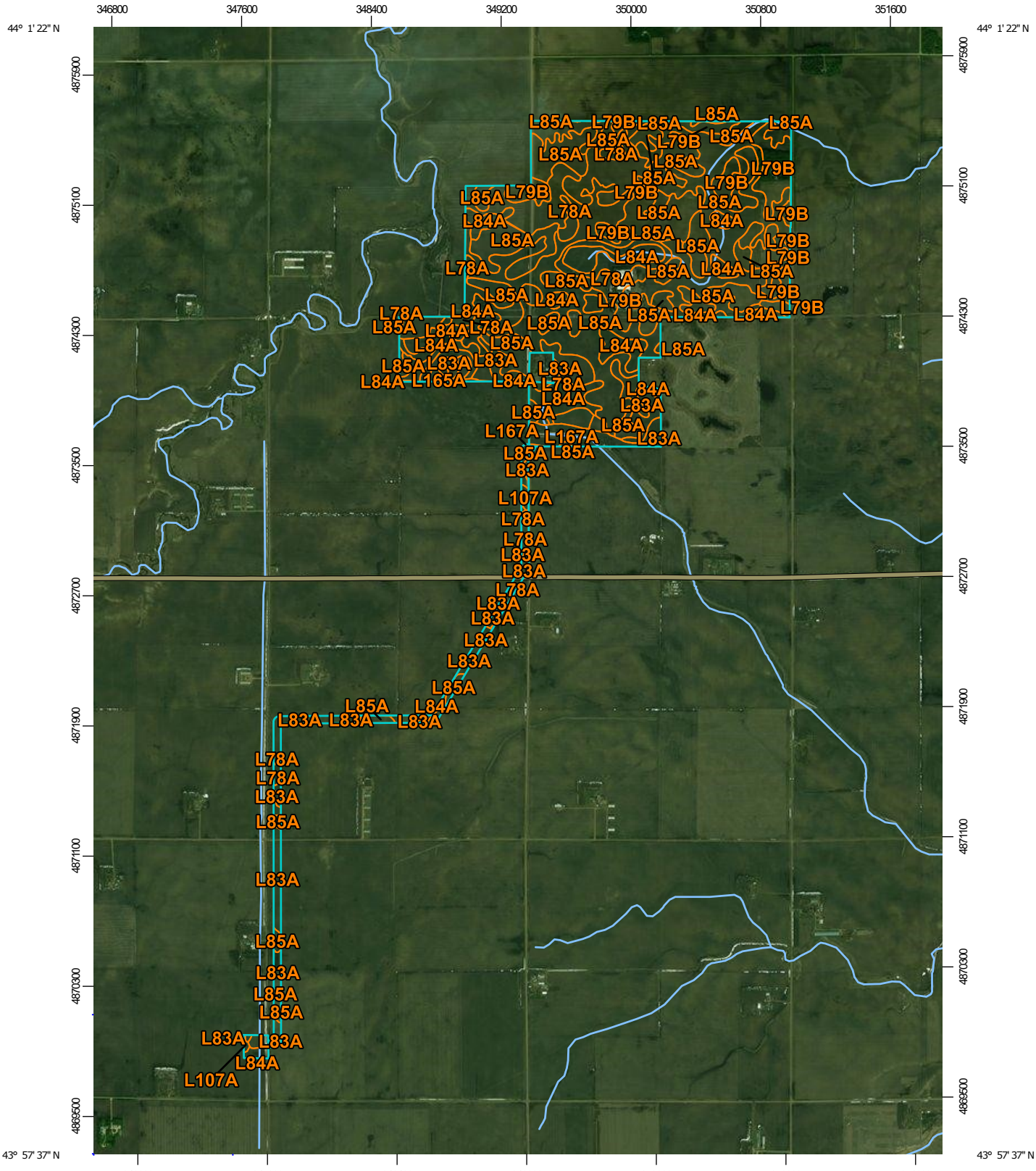
Feature Type[1]	Acres[2]	Map Unit Symbol[3]	Map Unit Name[3]	Selected Soil Physical Features					Selected Soil Classifications			Construction/Reclamation Interpretations and Limitations				
				Particle Size Family[3]	Slope Range[4]	Drainage Class[5]	Topsoil Thickness[6]	Shallow Bedrock/ Stony and Rocky[7]	Prime Farmland[3]	Land Capability Classification[3]	Hydric Soil Rating[3]	Highly Erodible Water[8]	Highly Erodible Wind[9]	Compaction Prone[10]	Rutting Potential[11]	Droughty[12]
	0.0	L98A	Crippin-Nicollet complex, 1 to 3 percent slopes	fine-loamy	0-5	Somewhat poorly drained	>12-18	No	All areas are prime farmland	1	No	No	No	No	Severe	No

1 Outside Project Footrpint include soils under Red Rock Solar lease but that are not anticipated to be disturbed during construction or operations.
2 Data obtained by merging Feature Type polygons with the SSURGO spatial data in ArcGIS. Summations were performed in Microsoft[tm] Access.
3 Obtained directly by query of the SSURGO geospatial database.
4 Representative slope values are taken directly from the SSURGO database. The SSURGO2 database provides representative slope values for all component soil series. Slope classes represent the slope class grouping in percent that contains the representative slope value for a major component soil series. For example, a soil mapped in the 2-6% slope class has an average slope of 4%, which is within the 0-5% slope range.
5 Drainage class as taken directly from the SSURGO database.
6 Topsoil thickness is the aggregate thickness of the A horizons described in the SSURGO database.
7 Shallow Bedrock taken directly from the SSURGO database. Stony/Rocky soils are those soils that have either a cobbley, stony, boulder, shaly, very gravelly or extremely gravelly modifier to the textural class of the surface layer or that have a surface layer with > 5% stones or rocks > 3 inches in any dimension.
8 Includes soils in land capability classes 4e through 8e or that have a representative slope value greater than or equal to 9%.
9 Includes soils in wind erodibility groups 1 and 2.
10 Includes soils that are somewhat poorly drained to very poorly drained soils in loamy sands and finer textural classes.
11 Rutting potential hazard based on the soil strength as indicated by engineering texture classification, drainage class, and slope. In general, soils on low slopes in wetter drainage classes, and comprised of sediments with low strength will have potential rutting hazards.
12 Includes soils with a surface texture of sandy loam or coarser that are moderately well to excessively drained.

APPENDIX B

NRCS Soil Map for the Red Rock Solar Project

Soil Map—Cottonwood County, Minnesota
(Red Rock Solar Project)



Map Scale: 1:33,700 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 450 900 1800 2700

Feet
0 1500 3000 6000 9000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cottonwood County, Minnesota
Survey Area Data: Version 21, Jun 10, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 17, 2011—Sep 26, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
L78A	Canisteo clay loam, 0 to 2 percent slopes	72.5	8.6%
L79B	Clarion loam, 2 to 6 percent slopes	140.6	16.6%
L83A	Webster clay loam, 0 to 2 percent slopes	316.7	37.4%
L84A	Glencoe clay loam, 0 to 1 percent slopes	83.5	9.9%
L85A	Nicollet clay loam, 1 to 3 percent slopes	207.6	24.5%
L98A	Crippin-Nicollet complex, 1 to 3 percent slopes	3.0	0.4%
L107A	Canisteo-Glencoe complex, 0 to 2 percent slopes	2.1	0.3%
L165A	Mayer loam, 0 to 2 percent slopes	0.4	0.0%
L167A	Mayer clay loam, depressional , 0 to 1 perent slopes	19.7	2.3%
Totals for Area of Interest		**846.2**	**100.0%**

APPENDIX C

Vegetation Management Plan

VEGETATION MANAGEMENT PLAN
FOR THE
RED ROCK SOLAR PROJECT

RED ROCK SOLAR, LLC

C/O APEX CLEAN ENERGY, INC.
8665 HUDSON BLVD. NORTH, SUITE 110
LAKE ELMO, MINNESOTA
55042

COTTONWOOD COUNTY, MINNESOTA

AUGUST 2020

Prepared by:

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ABBREVIATIONS & DEFINITIONS

BSWR	Minnesota Board of Soil and Water Resources
MDNR	Minnesota Department of Natural Resources
MW	megawatt
PLS	pure live seed
Red Rock or Owner	Red Rock Solar, LLC
UMN	University of Minnesota
VMP	Vegetation Management Plan

1.0 GOALS AND OBJECTIVES

Red Rock Solar, LLC (Red Rock or Owner) is developing a solar energy facility which is planned to cover approximately 970 acres in Cottonwood County, Minnesota, and generate up to 60 megawatts (MW) of energy. Red Rock has developed this Vegetation Management Plan (VMP) to guide site preparation, installation of prescribed seed mixes, management of invasive species and noxious weeds, and control of erosion/sedimentation. The goal of this Plan is to establish vegetative cover that complies with all permits and regulations, either via a native vegetation establishment regime, or alternatively as an agricultural pasture actively managed through grazing should Red Rock pursue long-term use of the solar energy facility cooperatively with agricultural production. The required management is designed to continue for three years prior to transitioning into a long-term vegetation maintenance.

This document is intended to be a working document. Revisions will be made as new information is obtained with respect to vegetation management, site characteristics, and availability of management practices at the time of procurement of services.

2.0 VEGETATION INSTALLATION

Seed mixes developed for the project will be installed where designated in the proposed Seeding Plan for the site (in development). Recommended seed mixes are included in Appendix A of this plan. These include an Array Mix that can be managed with traditional annual mowing (native option) or potentially grazers (sheep grazing option), and a Wet Area Mix for stormwater basins. The native vegetation seed mix is designed to be used with a vegetation management practice of traditional mowing. It is possible Red Rock could implement a vegetation management practice that uses sheep as grazers. Should Red Rock implement grazing as a long-term management technique, a pasture seed mix composed of native and non-native species oriented toward soil stabilization, forage palatability and grazing resilience would be installed. All plant material must be installed as instructed, with regard for the time of installation, as described below. Any exceptions must be discussed with the Owner, and the Contractor shall receive written authorization for any changes prior to the start of work.

All seed mixes must adhere to the specifications described in the Plan. Genetic source origin of all native seed shall be local, preferably from within a 200-mile radius of the site when feasible. Species shall be true to their scientific name as specified. Seed tags or nursery confirmation of the order must be provided to Red Rock prior to installation. Any elimination or substitution of species or source origin exceptions must be approved by Red Rock prior to installation. If planted in the spring, seeds shall have been properly stratified and/or scarified to break seed dormancy. All legumes shall be inoculated with proper rhizobia at the appropriate time prior to planting.

2.1 GENERAL SEEDING GUIDELINES

Native plant seeds require special considerations related to planting depth and application method. Native grasses generally prefer a shallow planting depth of ¼ inch, so preparation of a firm seedbed shall be conducted using a cultipacker or by equivalent means prior to seed installation. Native seed mixes include grass and forb seeds of varying sizes, therefore the broadcast or drill seeder shall be of the style and design capable of evenly distributing native seed, when applicable. Conventional grain drills are not capable of handling diverse seed sizes and will not deliver satisfactory results when installing a native plant seed mix.

Mulch application of two tons/acre certified weed-free straw is recommended with all seed installations, including temporary cover crops listed in Table 2.3-1, and may also be a construction stormwater permit requirement during circumstances when construction activities are dormant for a prolonged period. Disc-anchor mulch following its application to provide temporary soil stabilization while seeds establish. Seeding rates presented in Appendix A are for drill seed installations. The Contractor should increase rates by 50 percent when broadcast seeding to account for greater variability in planting depths and seed predation from wildlife.

Additional protocols for installing the seed mixes is dependent on the timing of construction, and options are presented in further detail below.

2.2 PERMANENT SEEDING PRIOR TO INFRASTRUCTURE INSTALLATION

If site preparation and final grading is completed in the spring, allowing for seeding prior to June 30, Red Rock may elect to plant the entire site with permanent seed mixes and temporary nurse crop prior to the installation of solar panels and other infrastructure. This approach would allow native vegetation to begin root development and vegetation establishment concurrent with installation of solar infrastructure, affording the project the advantages associated with an initial seeding phase on an undeveloped construction site (i.e., less labor-intensive seeding application). Minnesota Department of Natural Resources (MDNR) recommends that a spring seeding occur after the soil temperature is 60 degrees Fahrenheit or higher. A spring seeding application shall include 20 pounds per acre pure live seed (PLS) of oats (*Avena sativa*) as a temporary nurse crop. Should Red Rock elect to initiate seed installation prior to panel infrastructure, it is anticipated that limited supplemental reseeding at heavily trafficked areas of the site, particularly during wet soil conditions, would be required following completion of project infrastructure. Therefore, it is recommended that rubber-tracked, rather than rubber-tired, equipment be utilized during construction as practicable to minimize ground disturbance.

Seeding may be conducted with a seed drill (preferred) and/or by broadcast seeding; the Contractor shall evaluate the site and determine which technique will produce the best results, though it is anticipated the majority of the open site may be drill seeded given the advantages of that application method. If broadcast seeding is used, raking of seeded areas with a chain or harrow drag may be needed to ensure good seed-to-soil contact.

Alternatively, Red Rock may elect to forgo permanent seeding and initiate vegetation installation only following completion of solar infrastructure.

2.3 PERMANENT SEEDING FOLLOWING INFRASTRUCTURE INSTALLATION

If site preparation and final grading is not completed prior to June 30th, or if Red Rock otherwise elects not to apply permanent seed prior to solar infrastructure installation, then the site shall be seeded with a temporary cover crop following establishment of final site grade to stabilize the soil from erosion during the remainder of the solar infrastructure installation. Installation of a temporary cover crop will help mitigate erosional issues related to construction stormwater within the site, minimize maintenance requirements of sediment control devices, and minimize the amount of additional site grading required prior to final seedbed preparation. Recommended applications of temporary cover crops vary by season, as described in Table 2.3-1 below.

Table 2.3-1 Temporary Cover Crops		
Season	**Seed**	**Seeding Rate[a]**
Spring and Summer	Oats (*Avena sativa)*	80-100 pounds/acre
Fall	Winter Wheat *(Triticum aestivum)*	75-100 pounds/acre
[a] Seed rates are based on drill seed application and will vary based on site-specific conditions. Source: Minnesota BWSR, 2019.		

Installation of permanent seed mixes would take place in late fall or the following spring if infrastructure installation is not completed prior to soil freezing. MDNR recommends that a fall dormant seeding occur after soil temperatures fall below 50 degrees Fahrenheit for a consistent period. Seed application the following spring would adhere to the same techniques described in Section 2.1 of this Plan. If construction is completed in late fall, allowing for seeding after November 1 but before the soil starts to freeze, seed mixes shall include 30 pounds per acre PLS winter wheat to provide a temporary nurse crop for the following year. If agreed to by both the Owner and the Contractor, a spring seeding the following year can be substituted for a fall dormant seeding, though it is preferred that installation occur the same year to facilitate early spring vegetative establishment to advance the timeline for terminating site construction stormwater permits and monitoring requirements.

Seeding may be conducted with a seed drill (preferred) and/or by broadcast seeding; the Contractor shall evaluate the site and determine which technique will produce the best results. However, seed installed into an established cover crop or other vegetation must be installed with a seed drill unless mowing and thatch removal is completed prior to seed application. This step may be necessary within the array footprint where installation via a driller seeder is not feasible. If broadcast seeding is used, raking of seeded areas may be needed to ensure good seed-to-soil contact.

3.0 VEGETATION MANAGEMENT TASKS

After the land is cleared and the panels are installed, a range of invasive plants will take advantage of the open soil and abundant light and germinate across the site, though the application of a temporary cover crop as described in Section 2.2 will help moderate the proliferation of those species. For the purpose of this Plan, “invasive plants” refers to both non-native species and native species that grow in an invasive manner or have the potential to negatively affect the success of the project. This list also includes noxious weeds designated in statute by the State of Minnesota as “prohibited.” These invasive plants must be managed effectively during the first three years to ensure that the desired species planted are given the opportunity to flourish. The care taken in the first three years after installation strongly determines the quality of the resulting plantings. The initial period of work on site is referred to as the “establishment phase,” while management after that period is called the “long-term maintenance phase.”

3.1 ESTABLISHMENT PHASE

The first three years of vegetation management are a concerted effort to remove invasive plants from the site while also helping the planted vegetation establish. General tasks described below will be applied as directed, while other management techniques will be used only if required by the unique conditions at the Red Rock facility.

3.1.1 General Tasks for Managing Vegetation

Establishment Year 1. The first year of establishment is focused on consistent invasive plant control on a site-wide basis, as native vegetation focuses primarily on root development and grass seedlings may only reach 4 to 6 inches in height. Mowing during the first year should prevent invasive plants from adding new seeds to the soil and begin to exhaust the soil seed bank (a process that often requires several years to complete). From June 1 of the first establishment year, site-wide mowing to a height of 6 to 8 inches shall occur prior to seeds being allowed to set on invasive plants (usually as invasive species reach 12 to 14 inches). If seeding was conducted in the spring, mowing is recommended every 30 days following the initial planting and through September 30, whereas if fall seeding occurred, one mowing in May, June and July during the following growing season is recommended. Care shall be taken during the nesting season (May 15 to August 1) to not destroy the nests of ground-nesting birds.

Repeated mowings may produce a buildup of organic thatch, which discourages the development and persistence of diverse native vegetation. In order to help prevent thatch buildup onsite, either mowing shall be conducted with a flail-type mower to mulch the cut vegetation, or the site shall be hayed so that cut vegetation is removed. A swing arm specifically designed for mowing under solar panels is recommended for cutting beneath panels, but spot-mowing with brush saws, weed whips, and similar equipment is also permitted. It may be possible to coordinate with Red Rock to adjust the orientation of the panels to increase the ease of mowing, but the Contractor should not depend on this coordination to complete its work. Any other techniques must be approved by Red Rock prior to the start of work. Mowing equipment shall be cleaned prior to use on site to prevent the introduction and spread of invasive species. This mowing regime will prevent annual and perennial weeds from flowering and setting seed, prevent weeds from shading out the solar panels, and help control woody plant growth onsite. Additionally, noxious and perennial weeds (e.g., thistles) shall be treated by spot-herbicide applications, as described below, to prevent roots from resprouting.

Establishment Year 2. The second year of establishment continues invasive plant control but generally employs more targeted techniques. Native grasses should have begun to form clumps but remain short, and some flowering should occur throughout the growing season. Site-wide mowing to a height of 6 to 8 inches shall occur once between June 1 and August 15 prior to weeds setting seed. Care shall be taken during the nesting season (May 15 to August 1) to not destroy the nests of ground-nesting birds.

Spot-mowing may be employed to treat specific problem areas as needed. Noxious and perennial weeds shall be treated with spot-herbicide applications at least twice, with the focus on achieving the required performance standards described in further detail below.

Establishment Year 3. In the third year of the establishment phase, invasive plant control should consist of spot-herbicide applications to control the remaining small patches of persistent weeds. Efforts should be focused on achieving the required performance standards (described below). Additional onsite treatment with spot-mowing or hand weeding can be employed at the discretion of the Contractor.

3.1.2 Prescribed Treatment for Common Invasive Species

Every solar energy facility will express a suite of invasive plant species determined by the makeup of the seed bank and the seed inputs from the surrounding environment, so management must be flexible and respond to the specific needs of the Red Rock site. This Plan describes common

techniques to manage a variety of invasive plants and common weeds growing in Minnesota, but not every technique will be required. In the establishment period, monthly evaluations of the plantings during the growing season (May to September) shall be conducted to determine the appropriate treatment techniques to use and the timing of those treatments. Management techniques for five categories of weeds are described below.

The Contractor shall designate to the Owner a responsible person (or subcontractor) that has the botanical expertise to correctly identify plant species and know the difference between species that must be removed, and similar native species being established.

3.1.2.1 Annual Weeds

Annual weeds include all unwanted species that grow for a single year, set seed, and die. A list of problematic and common annual weeds that may be encountered on the site are shown in Table 3.1-1 below.

Table 3.1-1
Problematic Annual Cropland Weeds

Grasses	Broadleaf Weeds
Banryard Grass *(Echinochloa spp.)*	Plant Amaranth *(Amaranthus palmeri)*
Large crabgrass *(Digitaria sanguinalis)*	Redroot pigweed *(Amaranthus retroflexis)*
Green, giant and yellow foxtail *(Setaria spp.)*	Pennsylvania smartweed *(Polygonum pensylvanicum)*
Wild Oat *(Avena fatua)*	Ragweed *(Ambrosia spp.)*
Fall panicum *(Panicum dichotomiflorum)*	Common cocklebur *(Xanthium strumarium)*
Wild proso millet *(Panicum miliaceum)*	Lambsquarters *(Chenopodium spp.)*
	Velvetleaf *(Abutilon theophrasti)*
Source: University of Minnesota Extension, 2018	

The most important purpose and result of treating annual weeds is preventing seed production. Beginning around June 1, the site shall be mowed as described in Section 3.1.1 to prevent annual weeds from flowering and setting seed.

3.1.2.2 Minnesota Department of Agriculture Prohibited Noxious Weeds

The Minnesota Department of Agriculture maintains a list of prohibited noxious weeds in the state which must be eradicated and controlled. All species of prohibited noxious weeds present at Red Rock shall be treated by manual removal, mowing, herbicide application, or a combination of these methods, with the intention of preventing the weeds from setting seed or spreading by rhizomes, stolons, or other vegetative means. Mowing will not be a prescribed treatment in areas where seed is present on prohibited noxious weeds. The Contractor must utilize a licensed applicator with knowledge of the herbicide treatments available and their suggested timing based on the species identified. Appendix B provides a complete list of the prohibited noxious weeds, as well as fact sheets to inform the Contractor on the identification, plant reproduction, and treatment applications most suitable for a given season.

3.1.2.3 Perennial Weeds

Perennial weeds include all unwanted species that persist for two or more years after germination, from biennials to those that live for many years. Many of these weeds greatly diminish during the

establishment phase with proper maintenance, but several require special attention when establishing native vegetation due to their highly competitive behavior. A list of common Minnesota perennial weeds that colonize former cropland and compete with native vegetation (in addition to the listed noxious weeds) is provided in Table 3.1-2 below.

Table 3.1-2
Problematic Perennial Weeds When Establishing Native Vegetation

Species	Plant Group
Kentucky bluegrass (*Poa pratensis*)	Grass
Reed canary grass *(Phalaris arundinacea)*	Grass
Smooth brome *(Bromus inermis)*	Grass
Quack grass *(Elymus repens)*	Grass
Purple loosestrife (*Lythrum salicaria)*	Forb
Canada thistle (*Cirsium arvense)*	Forb
Crown Vetch *(Securigera varia)*	Legume
Birdsfoot trefoil (*Lotus corniculatus)*	Legume
Source: Minnesota BWSR, 2019.	

Mowing is important to prevent seed production, but herbicide is generally required to prevent the spread of perennial weeds. Perennial grasses shall be treated by spot-spraying or boom spraying, as warranted, with glyphosate or comparably effective herbicide, or the aquatic formulation of the same if near open water. Perennial broadleaf weeds shall be treated by spot-spraying or boom spraying, as warranted, with glyphosate, triclopyr, clopyralid, or comparably effective herbicides. All herbicides shall be applied by a licensed applicator, following instructions provided by the manufacturer.

3.1.2.4 Problematic Native Plants

Several native species that are present in the soil seed bank or enter the site by seed rain from neighboring properties have the potential to interfere with the functioning of the solar panels. Giant ragweed (*Ambrosia trifida*) grows tall enough to shade the panels. Several native vines have the potential to overgrow installations, including wild grape (*Vitis riparia*), wild cucumber (*Echinocystis lobata*), bur cucumber (*Sicyos angulatus*), and Woodbine/Virginia creeper (*Parthenocissus spp.*). Giant ragweed, or any other native species shading the arrays, should be controlled by mowing. If growing under or near the solar panels, wild cucumber and bur cucumber can be pulled and removed manually, but woody vines such as wild grape and Woodbine/Virginia creeper shall be cut to within one inch of the ground and the stump treated with glyphosate, triclopyr, or a comparable herbicide by a licensed applicator, following instructions provided by the manufacturer.

3.1.2.5 Woody Species

Almost all woody species on site can shade or otherwise interfere with the operation of solar panels. During the establishment phase, all woody plants must be removed. This can be accomplished by mowing, herbicide application, or a combination of both methods. All woody plants over 0.5 inches diameter at breast height shall be cut to within one inch of the ground and the stump treated with triclopyr or a comparable herbicide by a licensed applicator, following instructions provided by the manufacturer. Cut brush shall be removed from the site.

3.1.3 Reseeding Bare Soil

Areas of bare soil are detrimental to successful establishment of native vegetation. Bare soil provides opportunities for the common invasive species described above to colonize and spread. Bare soil also contributes to soil loss by sheet erosion and may prevent Red Rock from discharging its construction stormwater permit in a timely fashion. If areas of bare soil greater than 75 square feet are found on site, the Contractor shall remedy the issue at its own expense by reseeding the area, using the seed mix previously installed and following the timing instructions laid out in Section 2.0.

3.2 LONG-TERM MAINTENANCE PHASE

3.2.1 Mowing for Long-Term Maintenance

Following the end of the Establishment Phase of vegetation management, yearly management is still required to control the re-establishment and spread of invasive species, combat the establishment of undesirable and invading trees and shrubs, and reduce biomass/fuel load on site. This management may take the form of rotational mowing or haying, depending on Red Rock preference and site feasibility. Some degree of hand weeding, spot-mowing, and/or spot-herbiciding may be warranted thereafter to maintain vegetation quality and achieve the project goals.

Annual haying (preferred) or mowing to a height of 6 to 8 inches shall occur each October, or when prairie plants have gone dormant. Rotational mowing/haying will be comprised of site-wide mowing over a three-year period, with no more than one-third of the site mowed each year. Site-wide mowing on an annual basis should only occur if vegetation height begins to interfere with power generation of the solar energy facility. Where feasible, mowed vegetation shall be raked, baled, and removed to prevent the buildup of organic thatch, which will discourage the development and persistence of diverse native vegetation. If vegetation removal is not achievable, mowing shall be conducted with a flail-type mower to finely chop plant material and accelerate decomposition. Should Red Rock enter into a haying partnership for some or all the site prior to construction, seed mixes will be reviewed and potentially revised to meet the local agricultural needs.

3.2.2 Grazing for Long-Term Maintenance

Red Rock may decide to use grazing with sheep as a long-term vegetation management technique. Well-managed grazing can restrict woody vegetation, prevent excessive litter accumulation, improve forage production, and accelerate decomposition and nutrient cycling. Should grazing be selected as a management technique for some or all the site, an additional section for this Plan will be developed that addresses methodology, stocking rate, water sources, and grazing objectives. Grazing solar energy facilities with livestock is a developing management approach; the instructions in this plan should be considered a guide, but the actual practices must adapt year-to-year to evolving vegetation conditions at the Red Rock Solar project.

4.0 VEGETATION QUALITY TARGETS

The Minnesota Board of Water and Soil Resources (BWSR) guidelines for achieving soil stabilization and water quality on agricultural field conversion sites recommend a minimum of 15 species when using native vegetation. Vegetation management should result in a diverse plant community dominated by native species, as envisioned in the planting plans, or alternatively an

actively grazed pasture where invasive plant populations and prohibited noxious weeds have been successfully controlled during vegetation establishment. Construction stormwater permits and regulations may impose additional requirements on the final quality and performance of native plantings.

4.1 Native Vegetation Targets

By the end of the first growing season of the vegetation establishment phase, at least 80 percent of the site shall be vegetated. In order to discharge the construction stormwater permit for the site, at least 70 percent of the site must be covered with uniform perennial vegetation; the Contractor shall endeavor to achieve this by the end of the first growing season and must achieve this in the second growing season. By the end of the vegetation establishment phase (approximately 36 months after vegetation installation), at least 95 percent of the site shall be vegetated, and at least 90 percent of the cover shall be comprised of the planted species.

4.2 Noxious Weeds and Problem Plants

All Minnesota prohibited noxious weeds (Appendix B) and other plants previously identified in Tables 3.1-1 and 3.1-2 shall be treated repeatedly with herbicide and mowed where appropriate at a frequency sufficient enough to prevent seed set and to remove target weeds over time. Each treatment shall show evidence of at least 90 percent of the target vegetation having been affected by herbicide or removed. Two weeks after treatment, at least 95 percent of all plants treated with herbicide shall be dead or dying within any 100 square foot area.

By the end of the vegetation establishment phase (approximately 36 months after vegetation installation), all prohibited noxious and other problem plants shall not exceed five percent aerial cover within any 100 square foot area across the site.

5.0 REFERENCES

Minnesota Board of Water and Soil Resources (BWSR). 2019. Native Vegetation Establishment and Enhancement Guidelines, January 2019. Available online at: https://bwsr.state.mn.us/sites/default/files/2019-07/Updated%20guidelines%20Final%2007-01-19.pdf. Accessed July 2020.

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APPENDIX A

SEED MIXES FOR THE RED ROCK SOLAR PROJECT

ARRAY MIX – PRAIRIE OPTION

Scientific Name	Common Name	PLS oz./ac.	PLS lbs./ac.
Permanent Grasses/Sedges			
Bouteloua curtipendula	Side-Oats Grama	48.00	3.00
Bouteloua gracilis	Blue Grama	16.00	1.00
Koeleria macrantha	June Grass	1.00	0.06
Schizachyrium scoparium	Little Bluestem	48.00	3.00
Sporobolus heterolepis	Prairie Dropseed	4.00	0.25
Elymus trachycaulus	Slender Wheatgrass	16.00	1.00
Carex bicknellii	Bicknell's Sedge	4.00	0.25
Forbs/Legumes			
Achillea millefolium	Common Yarrow	0.25	0.02
Anemone canadensis	Canada Anemone	2.00	0.13
Asclepias syriaca	Common Milkweed	4.00	0.25
Chamaecrista fasciculata	Partridge Pea	16.00	1.00
Dalea purpurea	Purple Prairie Clover	4.00	0.25
Oenothera biennis	Common Evening Primrose	2.00	0.13
Rudbeckia hirta	Black-Eyed Susan	2.00	0.13
Solidago nemoralis	Gray Goldenrod	1.00	0.06
Zizia aurea	Golden Alexanders	2.00	0.13
	Total	**170.25**	**10.64**
Temporary Nurse Crop		**Application Season**	
Avena sativa	Oats	Spring/Summer	20.00
Anemone canadensis	Winter Wheat	Fall	30.00

ARRAY MIX – SHEEP PASTURE OPTION

Scientific Name	Common Name		PLS lbs./ac.
Permanent Grasses			
Poa pratensis	Kentucky Bluegrass		8.00
Dactylis glomerata	Orchardgrass		4.00
Festuca arundinacea	Tall Fescue		2.00
Legumes			
Trifolium repens	Medium White Clover		4.00
Lotus corniculatus	Birdsfoot Trefoil		2.00
		Total	**20.00**
Temporary Nurse Crop		**Application Season**	
Avena sativa	Oats	Spring/Summer	20.00
Anemone canadensis	Winter Wheat	Fall	30.00

WET MIX

Scientific Name	Common Name		PLS lbs./ac.
Permanent Grasses/Sedges			
Andropogon gerardii	Big Bluestem		2.00
Bromus ciliatus	Fringed Brome		2.00
Calamagrostis canadensis	Blue-Joint Grass		0.06
Elymus trachycaulus	Slender Wheat Grass		1.00
Elymus virginicus	Virginia Wild Rye		1.50
Panicum virgatum	Switchgrass		0.38
Poa palustris	Fowl Bluegrass		1.06
Sorghastrum nutans	Indian Grass		0.12
Spartina pectinata	Prairie Cord Grass		0.38
Carex stipata	Common Fox Sedge		0.25
Scirpus atrovirens	Green Bulrush		0.19
Scirpus cyperinus	Woolgrass		0.06
Forbs/Legumes			
Anemone canadensis	Canada Anemone		0.07
Asclepias incarnata	Marsh Milkweed		0.11
Bidens frondosa	Beggar's Tick		0.11
Doellingeria umbellata	Flat-topped Aster		0.06
Eutrochium maculatum	Spotted Joe-Pye Weed		0.06
Helenium autumnale	Sneezeweed		0.13
Physostegia virginiana	Obedient Plant		0.07
Rudbeckia laciniata	Wild Golden Glow		0.07
Symphyotrichum novae-angliae	New England Aster		0.07
Verbena hastata	Blue Vervain		0.05
Zizia aurea	Golden Alexanders		0.20
		Total	**10.00**
Temporary Nurse Crop		**Application Season**	
Avena sativa	Oats	Spring/Summer	20.00
Anemone canadensis	Winter Wheat	Fall	30.00

Source: Minnesota Department of Natural Resources Stormwater South & West 33-261 state seed mix.

APPENDIX B

MINNESOTA PROHIBITED NOXIOUS WEEDS

Minnesota Noxious Weeds

DEPARTMENT OF TRANSPORTATION

Dalmatian toadflax

Black swallow-wort

Grecian foxglove

Oriental bittersweet

Japanese hops

Cutleaf teasel

Poison hemlock

Brown knapweed

Minnesota State Listed Noxious Weeds

	Page	Common Name	Scientific Name	Family
Prohibited: Eradicate	5	Black swallow-wort	*Cynanchum louiseae* Kartesz & Gandhi	Asclepiadaceae
	6-7	Common / cutleaf teasel	*Dipsacus fullonum* L. and *D. laciniatus* L.	Dipsacaceae
	8	Dalmatian toadflax	*Linaria dalmatica* (L.) Mill.	Scrophulariaceae
	9	Giant hogweed	*Heracleum mantegazzianum* Sommier & Levier	Apiaceae
	10	Grecian foxglove	*Digitalis lanata* Ehrh.	Scrophulariaceae
	11	Japanese honeysuckle	*Lonicera japonica* Thunb.	Caprifoliaceae
	12	Japanese hops	*Humulus japonicus* Siebold & Zucc.	Cannabaceae
	13-14	Knapweed, brown	*Centaurea jacea* L.	Asteraceae
		Knapweed, diffuse	*Centaurea diffusa* Lam.	Asteraceae
		Knapweed, meadow	*Centaurea* x *moncktonii* C.E. Britton [*jacea* × *nigra*]	Asteraceae
	15	Oriental bittersweet	*Celastrus orbiculatus* Thunb.	Celastraceae
	16	Palmer amaranth	*Amaranthus palmeri* S. Watson	Amaranthaceae
	17	Poison hemlock	*Conium maculatum* L.	Apiaceae
	18	Tree-of-heaven	*Ailanthus altissima* (Mill.) Swingle	Simaroubaceae
	19	Yellow starthistle	*Centaurea solstitialis* L.	Asteraceae
Prohibited: Control	20	Barberry, common	*Berberis vulgaris* L.	Berberidaceae
	21	Canada thistle	*Cirsium arvense* (L.) Scop.	Asteraceae
	22	Common tansy	*Tanacetum vulgare* L.	Asteraceae
	23	Knapweed, spotted	*Centaurea stoebe* L. subsp. *micranthos* (Gugler) Hayek	Asteraceae
	24-25	Knotweed, Japanese	*Polygonum cuspidatum* Siebold & Zucc.	Polygonaceae
		Bohemian and giant	*Polygonum sachalinense* F. Schmidt ex Maxim.	Polygonaceae
	26	Leafy spurge	*Euphorbia esula* L.	Euphorbiaceae
	27	Narrowleaf bittercress	*Cardamine impatiens* L.	Brassicaceae
	28	Plumeless thistle	*Carduus acanthoides* L.	Asteraceae
	29	Purple loosestrife	*Lythrum salicaria* L. and *Lythrum virgatum* L.	Lythraceae
	30	Wild parsnip	*Pastinaca sativa* L.	Apiaceae


Black swallow-wort


Cut leaved teasel


Dalmatian toadflax


Brown knapweed


Poison hemlock


Tree-of-heaven


Common tansy


Japanese knotweed


Purple loosestrife


Wild parsnip

Prohibited: Eradicate

Black swallow-wort : *Cynanchum louiseae* Kartesz & Gandhi

Identification: Synonyms: *C. nigrum* (L.) Pers., non Cav.; *Vincetoxicum nigrum* (L.) Moench

Plant: A perennial, herbaceous vine with a twining habit reaching heights of 3-8 feet. Only milkweed family member in Minnesota that vines. Also, plants have clear sap, not milky.
Leaves: Opposite, shiny and dark green foliage has a smooth (toothless) edge terminated by a pointed tip. Leaves are somewhat oval at 3-4 inches long by 2-3 inches wide.
Flower: Clustered, small (1/4 inch) dark purple flowers with five downy, thickened petals.

Bloom time is June to July.

Fruit and seed: Slender pods, taper to a point at about 1½-3 inches. Pods are described as milkweed-like and at maturity split open to release flattened seeds carried on the wind by downy, filamentous fibers.

Life History: Herbaceous vine that dies back to the ground every winter. Below ground rhizomes sprout to create a group of stems. With more stems, plants in full sun will produce more flowers and set more seed (up to 2,000/meter square). Long distance wind dispersal of seeds can begin in late July. Seeds contain one to four embryos which helps to ensure germination. Seed viability is potentially 5 years.

Habitat: Prefers full sun in upland soils. Disturbances, natural or human caused, provide an opening in which black swallow-wort can gain a foothold. Old fields, grasslands, road or rail corridors, quarries and other disturbed areas provide excellent habitat.

Management: Goals should be to control seed production and stimulate competitive plant cover. **Manual** removal and destruction of plants and root crowns will meet these goals.

Repeated mowing or **cutting** can impact plants, but will not eradicate a population. After early season mowing or cutting, plans must be in place to monitor and repeat the process as necessary. Black swallow-wort if cut early in the season can still produce seed that year and the goal of cutting is to eliminate seed production. If seeds are present, clean equipment before moving offsite.

Prescribed fire can be used in conjunction with other management efforts to encourage stands of native grasses that will compete with black swallow-wort for resources. Monitoring will be necessary to control resprouting and seedlings that germinate after burns are completed.

Herbicide applications should target plants at or beyond flowering stage. As plants reach maturity, foliar applications of glyphosate or triclopyr ester cover enough surface area to potentially deliver a lethal dose to the root system. Timing the application prior to pod formation may limit the production of viable seed that season. Applying herbicide to early emerging plants with limited foliar area will likely result in roots remaining viable and plants resprouting.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn									
Herbicide	Foliar				Treat actively growing plants - once flowering has begun. Treat plants having enough foliage to carry a lethal dose to the root system.					
	Cut stem									
	Mow		Mow to prevent flowering							
	Don't mow				Follow-up mowing to control seed production.					
Flowering Period										

Prohibited: Eradicate

Common teasel : *Dipsacus fullonum* L.

Above: Bracts may be longer than flower head

Image right: common teasel (L), cutleaf teasel (R).

Identification: *Compare to Cutleaf teasel (next page) flower bracts and leaves.*

Plant: Herbaceous, monocarpic perennial (plant dies after bearing fruit), first identifiable as a basal rosette. At maturity 2-7 feet tall with erect, ridged and prickly stems.

Leaves: On upright stems - opposite, stalkless (sessile), cup-forming, up to 12 inches long by 3 inches wide, hairless, yellowish to reddish-green, *lance-shaped with a wavy edged margin*. Central leaf vein forms a whitish line on top with stout prickles below.

Flower: Many irregular, 4-parted and white to lavender flowers. Densely, cylindrically clustered heads up to 4 inches tall and 1½ inches wide.

Stiff and spiny flower bracts are very narrow (linear) and may be taller than flower clusters.

Bloom time is June to October.

Fruit and seed: Each floret or small flower produces one capsule containing a grayish-brown, slightly hairy seed.

Life History: During the rosette stage, which may extend beyond one season, the plant creates a substantial tap root, up to 24 inches long by 1 inch wide at the crown.

Each flower head can produce upwards of 2000 seeds with germination success of 30-80%. Seed on immature heads may still ripen. Seed is viable for approximately two years with typical dispersal up to 50 feet. Seed may be transported longer distances via water.

Habitat: Disturbed, open sunny site with moist to dry soils. Common on roadsides and disturbed areas.

Management:

Cutting of roots below ground and removal of as much as possible will limit sprouting. Accomplish cutting and removal of either life stage with tools such as dandelion pullers or a sharp shovel.

Mowing of the rosette stage does not kill the plant, however mowing of the flowering stalks can disrupt seed production. After mowing or cutting of flowering plants monitor for new flower heads. Preferably, propagating plant parts should be disposed of onsite or when necessary contained (e.g., bagged) and removed to an approved facility. For more information on these disposal options, please read MDA's guide on removal and disposal.

Prescribed fire can be used to increase competition from native warm season grasses, if they are present. Fire can also be used in combination with follow-up herbicide treatments. Keep in mind, high density infestations (large numbers of plants) will not burn well.

Herbicides such as metsulfuron methyl, clopyralid, triclopyr or 2,4-D amine are broadleaf specific herbicides that work on teasel at the rosette stage. Glyphosate is applicable but care must be exercised since it is not broadleaf specific.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
Herbicide	Burn									
	Foliar									
	Mow		Mowing is not recommended: mowing does not kill the plant and flowering may still occur. Seed dispersal can occur if mature plants are mowed. Mower scalping creates a good seed bed.							
	Don't mow									
Flowering Period										

Prohibited: Eradicate

Cutleaf teasel : *Dipsacus laciniatus* L.

Left: teasel flowering on short stems after being mowed.

Right: Prickles underside of leaf.

Identification: *Compare to common teasel (previous page) flower bracts and leaf shape.*

Plant: Herbaceous, monocarpic perennial (plant dies after bearing fruit), first identifiable as a basal rosette. Matures to 2-7 feet tall with erect, ridged and prickly stems.

Leaves: On upright stems - opposite, stalkless (sessile), cup-forming, up to 12 inches long by 3 inches wide, hairless, *lance-shaped, lobed with sinuses cut almost to the midrib*. Prominent leaf vein with stout prickles below.

Flower: Many irregular, 4-parted and white to lavender flowers. Dense, cylindrically clustered heads up to 4 inches tall and 1½ inches wide.

Spiny, stiff flower bracts are not taller than flower cluster and are wider than cutleaf teasel.

Bloom time is July to September.

Fruit and seed: Each floret or small flower produces one capsule containing a grayish-brown, slightly hairy seed.

Life History: During the rosette stage, which may extend beyond one season, the plant creates a substantial tap root, up to 24 inches long by 1 inch wide at the crown.

Each flower head can produce upwards of 2000 seeds with germination success of 30-80%. Seed on immature heads may reach viability. Seed is viable for approximately 2 years with typical dispersal up to 50 feet. Seed may be transported longer distances via water.

Habitat: Disturbed, open sunny site with moist to dry soils. Common on roadsides and disturbed areas.

Management:

Cutting of roots below ground and removal of as much as possible will limit sprouting. Accomplish cutting and removal of either life stage with tools such as dandelion pullers or a sharp shovel.

Mowing of the rosette stage does not kill the plant, however mowing of the flowering stalks can disrupt seed production. After mowing or cutting of flowering plants monitor for new flower heads. Preferably, propagating plant parts should be disposed of onsite or when necessary contained (e.g., bagged) and removed to an approved facility. For more information on these disposal options, please read MDA's guide on removal and disposal.

Prescribed fire can be used to increase competition from native warm season grasses, if they are present. Fire can also be used in combination with follow-up herbicide treatments. Keep in mind, high density infestations (large numbers of plants) will not burn well.

Herbicides such as metsulfuron methyl, clopyralid, triclopyr or 2,4-D amine are broadleaf specific herbicides that work on teasel at the rosette stage. Glyphosate is applicable but care must be exercised since it is a non-selective herbicide.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
Herbicide	Burn									
	Foliar									
	Mow		Mowing is not recommended: mowing does not kill the plant and flowering may still occur. Seed dispersal can occur if mature plants are mowed. Mower scalping creates a good seed bed.							
	Don't mow									
Flowering Period										

Prohibited: Eradicate

Dalmatian toadflax : *Linaria dalmatica* (L.) Mill.

Identification: *Compare to introduced Balkan catchfly (Silene csereii). See page 50.*

Plant: A short-lived herbaceous perennial up to 4 feet tall. Base may be woody and plant is often branched. Waxy stems and leaves have a bluish-gray color.

Leaves: Alternate leaves 1-3 inch in length clasp stems, are wider and more heart-shaped than similarly flowered butter-and-eggs (*Linaria vulgaris*).

Flower: Erect, spike-like racemes of yellow flowers with orangey center markings. Flowers are 1-1½ inches long with slender spurs extending downward from the back.

Bloom time is May to September.

Fruit and Seed: On average 140-250 seeds are contained in ½ inch long pods. Seeds are dark in color, flattened, angular and 3-edged with a slight, narrow wing on each edge. Mature plants produce up to 500,000 seeds with soil viability up to 10 years.

Life History: Reproduction is primarily by seed that is viable in the seedbank up to 10 years, but the plant also forms colonies via vegetative reproduction from roots.

Habitat: Rapidly colonizes disturbed sites such as roadsides, rail right-of-way, and other locations including cultivated ground. Prefers a drier site in coarse, well-drained soils.

Management: Recommendation - identify and treat early.

Eradication is the goal in Minnesota; therefore, biological control is not a compatible option at this time.

Prescribed fire can set plants back and drain some energy while **mowing** can prevent or delay seed production. However, both stimulate vegetative reproduction, thus potentially increasing stem counts. Monitor the infestation and consider follow-up treatments of periodic mowing and / or herbicide treatments.

Manual methods including, **cutting**, **hand pulling** or **tillage** if done repeatedly and in conjunction with other treatments may control infestations. **Grazers** eat the flowers, but may also carry the seeds.

Herbicide formulations of chlorsulfuron, dicamba, imazapic or picloram have had reported success. Also, combinations of picloram and chlorsulfuron or imazapic and chlorsulfuron or diflufenzopyr and picloram and chlorsulfuron are being used in some areas. Re-treatment is likely necessary.

Below center: early season regrowth.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Fire does not kill rhizomes. Result is likely an increased stem count.								
Herbicide	Foliar	■	■				■	■		
	Mow	Mowing can prevent seed production, but forces vegetative reproduction.								
	Don't mow	Therefore, after mowing, monitoring and repeating the process is necessary.								
Flowering Period										

Prohibited: Eradicate | Giant hogweed : *Heracleum mantegazzianum* Sommier & Levier

Caution Use protective clothing, consider goggles or a face mask. Caution

Phytophotodermatitis,

contacting stiff hairs or sap (i.e., phyto) followed by exposure to sunlight (i.e., photo)

can cause severe blistering and swelling (i.e., dermatitis).

Identification: *Compare to native cow-parsnip (Heracleum lanatum). See page 59.*

Plant: Herbaceous, often stated to be biennial but is a monocarpic perennial (plant dies after bearing fruit), giant at 10-15 feet tall (potentially to 20 feet). When enough energy is stored, flowering will take place on a 2-4 inch diameter hollow stalk that is mottled reddish-purple and is covered with sturdy bristles.

Leaves: Alternate, up to 5 feet across, compound leaves with 3 deeply incised (cut) leaflets which may be further divided. The spotted leaf stalks, underside of leaves and stems are covered with coarse white hairs.

Flower: Flat umbels of small white florets create massive displays up to 2½ feet in diameter.

Bloom time is June to July.

Fruit and Seed: Seed is large, flattened, with visible brown resin canals.

Life History: A single flower head can produce upwards of 1500 seeds. First season basal rosette foliage can be 1-5 feet across with flower stalks typically appearing in the second season. When plants die a large bare patch of soil results which creates a good seed bed and potential erosion problems.

Habitat: Moist soils of woodlands and riparian zones with partial shade as found on woodland edges.

Management:

Manual methods including cutting and removal by hand are effective on small infestations. The focus of this method is to prevent seed production. Preferably, propagating plant parts should be disposed of onsite or when necessary contained (e.g., bagged) and removed to an approved facility. For more information on these disposal options, please read MDA's guide on removal and disposal.

Root systems can be weakened by repeated cutting but consider removal for best results. After cutting, monitor sites for follow-up treatment needs.

Herbicide applications of triclopyr or glyphosate are effective when applied early season to basal rosettes. If manual methods such as cutting are used early in the season, plan on returning to chemically treat re-sprouts.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Use fire to improve native plant community.								
Herbicide	Foliar	Before the plant flowers.						Treat rosettes		
	Mow		Mow to prevent flowering							
	Don't mow		Cut and remove roots and			or seeds by hand for disposal.				
Flowering Period										

Prohibited: Eradicate

Grecian foxglove : *Digitalis lanata* Ehrh.

Caution All plant parts contain a cardiac glycoside that is ***poisonous to humans*** and **livestock**. It is reported that the toxin can be absorbed through bare skin. Wear appropriate PPE.

Identification:

Plant: Herbaceous, perennial beginning its first year as a basal rosette with a single flowering stalk from 2-5 feet tall in subsequent years.

Leaves: Alternate, smooth, stalk-less upper leaves with toothless edges are narrow (lance-shaped). Basal leaves are more oval with rounded tips and are densely woolly.

Flower: Many tubular flowers attached to a central stalk (raceme) with bloom progression from the bottom to the top of the stalk. Flowers have a brown or purple veined upper hood and a creamy-white, elongated lower lip.

Bloom time is June to July.

Fruit and seed: Seed capsules are 2-parted and split to release tiny reddish-brown seed with 3-4 year viability. The hook (stiff, persistent style of the flower) on the seed pods are easily caught on clothing or fur and transported to new locations.

Life History: A perennial plant that blooms following its first year as a basal rosette. Each flower produces numerous seeds that are viable for up to 4 years. Small wingless seeds are easily transported by birds, animals, human activity as well as wind and water.

Habitat: Minnesota sites are in full sun to partial shade along roads, woodland edges and in open fields.

Management: Do not pull or handle this plant without protective clothing, in particular, rubber gloves and long sleeves are highly recommended.

Repeated mowing or **cutting** to prevent flowering throughout the year and over several years can drain plants of energy and help control an infestation. Since flowering can occur on mowed, short stems follow-up treatments with herbicide may be necessary.

Prescribed fire, there is no research information available at this time.

Herbicide applications in May and again in July are beneficial to knock down plants before flowering can occur. A fall application is also recommended to kill basal rosettes that were missed earlier or that developed during the season. Metsulfuron-methyl formulations are recommended for good control.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Use fire to improve native plant community.								
Herbicide	Foliar									
	Mow		Mow to prevent flowering							
	Don't mow				When seed is present					
Flowering Period										

Prohibited: Eradicate | Japanese honeysuckle : *Lonicera japonica* Thunb.

Above: white blossoms fading to yellow.
Below: (left) foliage variation on a young stem and (right) smooth leaf edges on mature stem with black berries.

Identification: *Compare to Asian bush honeysuckle and native honeysuckles, pages 31 and 65 respectively.*

Plant: Perennial twining vine potentially reaching 30-45 feet in length. Climbing nearby trees / shrubs or structures for vertical support or sprawling, forming a low, dense ground cover. Stems are pubescent when young but become woody and glabrous (not fuzzy) over time, stems up to 2 inches in diameter.

Leaves: Opposite, simple, up to 2 inches across and 3 inches long. Leaves on younger stems may be lobed or have toothed edges (lower left) while leaves on older stems have smooth edges with an ovate form (upper right).

Flower: Fragrant, pure white initially, becoming yellowish with age. Approximately 1 to 1½ inch tubular flowers develop in pairs from leaf axils. Lower lip droops downward while upper lip, divided into 4 parts, extends upward. Five white stamens and a white pistil extend forward of each flower. Paired leafy bracts, approximately 2 inches in length, are located at flower bases.

Bloom time is June into July.

Fruit and seed: Paired *black berries* approximately ⅛ to ¼ inch across replace each flower pair. Each berry holds 2-3 flattened, oval seeds. *Compare to native honeysuckle vine species with red to orange berries.*

Life History: Late season berries are readily eaten by birds, potentially spreading seed long distances. Additionally, rhizomes below ground and stems contacting ground can root at nodes (runners) increasing spread of infestations.

Habitat: Prefers part-shade but will do well in full sunlight such as abandoned fields or powerline corridors and areas of low maintenance. Plants invade woodlands and floodplain woods often thriving along edge habitats. Fertile soils with moist to mesic conditions produce best growth. Growth is limited by deep shade and droughty conditions. Japanese honeysuckle has a high potential to displace native species.

Management: **Cutting or manual** removal provides good control of small infestations. It is a palatable browse, **grazing** is an option. **Mowing** for control of seedlings or ground mats must be accomplished twice or more per year to be effective. Propagating plant parts (seed) must be contained / controlled. For more information on options, please read MDA's guide on removal and disposal.

Prescribed fire, where applicable, to reduce dense ground mats. However, rhizomes will likely resprout following fire so follow-up with herbicide. Goal with fire is to remove excess vegetation to allow more effective herbicide application.

Herbicide formulations of metsulfuron-methyl, triclopyr or glyphosate are effective for **foliar applications** on smaller plants. For **Cut stem** treatments make cuts as close to the ground as possible prior to treatments with glyphosate or triclopyr. Additionally, **basal bark** treatments with triclopyr formulations may be effective when treating larger stems.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn						Monitor and follow-up.			
Herbicide	Foliar			When fully leafed out and active growth.						Prior to hard freeze
	Basal Bark	Any time. Used for larger stems.								
	Cut stem	Any time except during heavy sap flow. Use to treat larger stems.								
	Mow		Mow frequently to control seedlings.							
	Don't mow									
Flowering Period										

Prohibited: Eradicate | Japanese hops : *Humulus japonicus* Siebold & Zucc.

Below left: Male flower structure.
Below right: Female flower structure.

Caution - Stem prickles are known to irritate the skin, long clothing and gloves are recommended.

Identification: *Compare to native common hops (Humulus lupulus). See page 58.*
Compare to native cucumbers, wild and bur (Echinocystis lobata and *Sicyos angulatus). See page 60.*
Compare to native Virginia creeper/woodbine (Parthenocissus spp.*). See page 71.*

Plant: Herbaceous, annual vine trailing on the ground or climbing vegetation and infrastructure. Stems are covered with downward pointing prickles.

Leaves: Opposite, 2-5 inches long and almost as wide, with 5-7 (maybe 9) palmate lobes. *Compare to common hops: typically 3-lobed occasionally 5.* Japanese hops leaves are rough and edges are toothed. Two bracts (stipules) are at leaf stalk bases and the leaf stalks (petioles) are as long or longer than the leaves.

Flower: Male flowers and female flowers are on separate plants (dioecious). Flowers are small and greenish to reddish, not showy. Male flowers are branched clusters (panicles) while the female flowers are drooping structures that are rather plump and composed of overlapping reddish bracts or scales (hops).

Bloom time is July into August.

Fruit and Seed: Each cluster of female flowers produces flattened seeds that mature in September.

Life History: An annual plant germinating early spring and growing quickly as summer progresses. Vines quickly cover small trees and shrubs weighing them down to the point of breakage and limiting their sunlight. Japanese hops flower in July-August, seeds mature in September. Soon after a killing frost, fragile vines fall apart dispersing their seed.

Habitat: Tolerant of disturbed roadside conditions if there is moist soil. Species prefers conditions found in riparian areas including full sunlight and exposed soils that are moist and rich.

Management:

Manual methods including **cutting** and **pulling**, while labor intensive, can be successful on small infestations. Efforts should be focused on early season work when plants are small and limited entanglement with surrounding vegetation or structures has occurred.

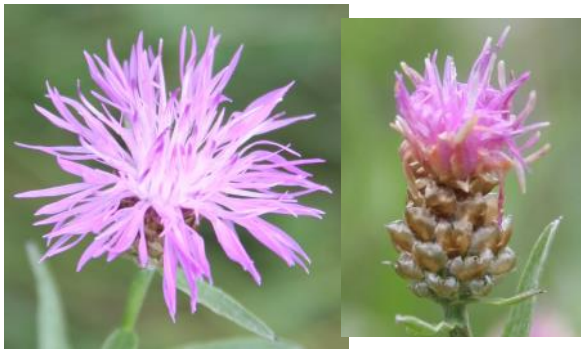
If the area is accessible to **mowers** and vines have limited structure for climbing, such as trees and fences, then **mowing** is an effective method to control maturity and seed production.

Herbicides include pre-emergent and post-emergent applications. Both are useful since this is an annual plant with prolific seed production capabilities. Pre-emergent should be applied prior to the growing season beginning in late March or early April. Once germination has occurred a switch to foliar applications should be made in an effort to keep plants from maturing and producing seed.

Below: Stem prickles

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Use fire to improve native plant community.								
Herbicide	Post-emerge									
	Pre-emerge									
	Mow		Mow to prevent flowering							
	Don't mow					If seed is present				
Flowering Period										

Prohibited: Eradicate | Knapweed complex : *Centaurea* spp.



Top: Brown Knapweed
Middle: Meadow knapweed, images T. Jacobson
Below: *Spotted* (left), Diffuse (center), *Russian* (right)
Image: Bugwood.org.

Prohibited: Eradicate Brown knapweed: *Centaurea jacea* L.
Prohibited: Eradicate Diffuse knapweed: *Centaurea diffusa* Lam.
Prohibited: Eradicate Meadow knapweed: *Centaurea* x *moncktonii* C. E. Britton [*jacea* × *nigra*]
Not listed *Russian knapweed*: *Acroptilon repens* (L.) DC. - synonym: *Centaurea repens* L.
Prohibited: Control Spotted knapweed: *Centaurea stoebe* L. ssp. *micranthos* (Gugler).

Advice, spotted knapweed is established in Minnesota. Learn to identify it and recognize when something is different. Please report infestations that are not easily identified as spotted knapweed to Early Detection and Distribution Mapping System EDDMaps or Minnesota Department of Agriculture's Arrest the Pest.

Compare knapweeds on pages 13, 14 and 23. Compare to thistles (pages 21, 28, 53 and 70) and alfalfa / vetches (pages 49 and 56).

Identification:

Species / Characteristic	Brown	Diffuse	Meadow	*Russian* (Not Listed in Minnesota)	*Spotted* (Prohibited: Control)
Root Types	Short-lived perennial,	Short-lived perennial, tap root	Short-lived perennial,	*Long-lived perennial, creeping perennial, root spread horizontal.*	*Short-lived perennial, tap root.*
Bracts	Brown , with a tan papery tip (edge)	Rigid, spine-like tips	Long fringed (insect-like) Coppery, shiny (mature).	*Rounded bracts, smooth papery transparent tips*	*Darkened tip, short fringe.*
Flowers	Rose to Purplish, 1-1¼ inch wide.	Variable - white to rose Occasionally purplish	Rose to purplish ¾ inch wide.	*Pink to lavender ⅜ to ½ inch*	*Pinkish, cream is rare Approximately 1 inch*
Leaves	Not as deeply lobed as spotted knapweed	Basal leaves deeply and finely, divided with wide lobes.	Basal leaves mostly unlobed, smooth.	*Basal leaves are seldom divided, roughly fuzzy.*	*Gray-green, Deeply lobed leaves, roughly fuzzy*
Habitats	Prefers moist cooler soils.	Dry soils, disturbed sites	Moist soils, wet prairies	*Dry to moist soils, saline soils, disturbed sites*	*Dry to moist soils, disturbed sites*

Table adapted from sources: http://your.kingcounty.gov/dnrp/library/water-and-land/weeds/Brochures/knapweed.pdf
http://bugwoodcloud.org/mura/mipn/assets/File/KnapweedBrochure072814WEB.pdf

Plants: Herbaceous, typically short-lived perennials or biennial. Knapweeds ascend from woody root crowns and reach heights of 8 to 32 inches. Typically, multi branched with solitary, terminal disk flowers.
Leaves: Simple, alternate, green foliage. *Spotted* knapweed has foliage with fine hairs and a blue-gray color, while *meadow* knapweeds foliage is smooth and a green color. Some species are deeply lobed (*spotted*) while others like *brown knapweed* may not be lobed. In all species, basal leaves tend to be larger than the lance-shaped leaves above.
Flower: Flower colors varying from white to purplish make color a less reliable species identifier. Typically flowers are solitary, terminal to branches, purplish disk flowers that are surrounded by 5-petaled florets. Bracts that cover the bulb-like bases of flowers are 2-parted and the bract characteristics are diagnostic to species, especially the bract tips. Refer to the table above for comparison.

Prohibited: Eradicate

Knapweed complex : *Centaurea* spp.

Top: Brown knapweed
Images: Bugwood.org

Middle: Meadow knapweed
Images: Tom Jacobson, MnDOT.

Bottom left: Diffuse knapweed
Image: Bugwood.org

Caution - gloves and long sleeves are recommended, knapweeds have defenses known to irritate skin.

Bloom time is June to September.

Fruit and seed: Small (less than ⅛ inch) (2-3 mm), some have short, bristly hairs (pappus) at the top. A typical achene (seed) of the Aster family but pappus is limited and wind will not carry seeds.
Life History: Reproduction is by seed which can be moved by water, animals, and birds. Human activities are significant transporters of seed in products like mulch, soil or hay and straw. Seed is also potentially moved on construction or farm equipment, recreational vehicles, as well as on personal automobiles, clothes and recreational gear. Depending on species, seed viability can be up to eight years.

Currently unlisted and not known to be in Minnesota, Russian knapweed is a long-lived perennial with deep roots, potentially to 20 feet. Its roots are dark colored and scaley. Russian knapweeds foliage is blue-gray and has fine hairs, similar to spotted knapweed. It is reported that seed production of Russian knapweed is 'limited' but infestations spread aggressively by roots.

Habitat: *Brown and Meadow knapweeds* prefer moist soil types found along water, wet grasslands or meadows, irrigation ditches, roadsides and openings in woodlands. In contrast, other knapweeds tolerate drier sites such as old fields, road and rail right-of ways, gravel pits or similar disturbed areas.

All prefer full sun locations with the exception of *brown knapweed being tolerant of partial shade*.

Threat to Minnesota: potential development of hybrids that can take advantage of intermediate niches.

Management: **Hand pulling** or **digging** while time consuming can be an effective step when coupled with chemical treatments. Preferably, propagating plant parts should be disposed of onsite or when necessary contained (e.g., bagged) and removed to an approved facility. For more information on these disposal options, please read MDA's guide on removal and disposal.
Repeated mowing or **cutting** can reduce seed production, but sites must be monitored and applications likely repeated or followed up with herbicide treatments.
Prescribed fire can be used to encourage stands of native grasses that will compete with knapweeds. However, monitoring is needed to check for knapweed germination in bare soil soon after burns are completed.

Herbicide foliar applications with formulations including aminopyralid, clopyralid, or picloram have proven effective in controlling knapweeds.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn			Use fire to improve native plant community.						
Herbicide	Foliar		Foliar treatments target rosettes.							
	Mow	Mow to prevent flowering								
	Don't mow			Do not mow when seed is present						
Flowering Period										

Prohibited: Eradicate | Oriental bittersweet : *Celastrus orbiculatus* Thunb.

Above: location of fruit is in leaf axils (where leaves attach to stem).

Identification: *Compare to native American bittersweet (Celastrus scandens). See page 55.*

Plant: Woody, twining, perennial vines up to 60 feet long, reaches tree tops and covers fences. Stem diameters of 4 inches documented in Minnesota.

Leaves: Alternate, fine rounded teeth on the leaf edge, dark green and shiny turning yellow in autumn. Typically, elliptical with a blunt leaf tip and nearly as wide as long at 2-5 inches.

Flower: Female flowers are small, inconspicuous, greenish clumped (3-7) in leaf axils along stems. Dioecious species, male and female flowers on separate plants. Male flowers are also axial but may be terminal. Compare white pollen on male flowers to *yellowish pollen on American bittersweet flowers*. *Also, American bittersweet flowers are similar in size and color but are found **only terminal** on vine branches (on the ends).*

Bloom time is May to June.

Fruit and Seed: Along the vine in leaf axils are potentially 3-7 yellowish, 3-parted capsules enclosing reddish-colored, 3-parted, berry-like arils. Each part contains 1-2 seeds; therefore, potential total of 3-6 seeds per fruit. Dioecious, separate fruiting (female) and non-fruiting (male) plants. *American bittersweet's 3-parted fruit is more red, the 3-parted capsules more orange and fruits are terminal on the vine branches (on the ends).*

Life History: Vegetative reproduction occurs from below-ground rhizomes, above-ground stolons and suckering of roots. Birds will eat the fruits (arils) during the winter and disperse the seeds. Seeds germinate late spring.

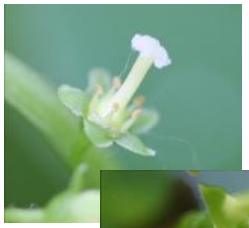
Habitat: Readily invades disturbed, open, sunny sites, yet Oriental bittersweet is moderately tolerant of shade allowing it to grow in open woodlands.

Management:

Prescribed fire research has shown that basal sprouting is stimulated and stand density increases dramatically.

Cutting of stems can be used to kill above ground portions of plants especially if the infestation is covering large areas or is climbing high into forest canopy. Preferably, propagating plant parts should be disposed of onsite or when necessary contained (e.g., bagged) and removed to an approved facility. For more information on these disposal options, please read MDA's guide on removal and disposal. Combine with herbicide applications for best results.

Herbicides that act systemically such as formulations of triclopyr or glyphosate can be applied as foliar, basal bark or cut stem applications. Foliar applications are reserved for easy to reach foliage, re-sprouting or along fence lines. Once foliage is out of reach, application to cut stems or basal bark will yield the best results.



Left above: greenish, female flower.
Left below: greenish male flower, note white pollen grains on anthers of the upper flower.

Right: Light brown seeds. Each structure is 3 parted and each part contains 1-2 seeds. Image shows 5 seeds from a single fruit.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn		Burning is not recommended							
Herbicide	Basal Bark	Any time.								
	Foliar		When fully leafed out and active growth.							
	Cut stem				Any time except during heavy sap flow.					
	Mow		Mowing is not recommended.							
	Don't mow									
Flowering Period										

Prohibited: Eradicate | Palmer amaranth : *Amaranthus palmeri* S. Watson

Above: male plants have soft flower spikes, female flower spikes have sharp bracts (below - upper right).

Below: poinsettia-like foliage, white V-shaped markings (inset), and thick stems.

Identification: Palmer amaranth is one of several native pigweeds and is native to southwestern deserts of the United States. Link: Pigweed Identification, a pictorial guide.

Plant: Herbaceous, annual plant, a potential growth rate of 2-3 inches per day. Plants attain heights of 6-8 feet, potentially 10 feet. Stems are stout, up to 2 inches thick and without hairs (smooth). Top-view of plants as foliage develops resembles a poinsettia.

Leaves: Alternate, green color, some plants with white V-shaped markings on leaves. Elliptical to diamond-shaped leaf blades terminated by a small spine. Petioles up to 2-3 times longer than leaves, image at right.

White petiole bent back over a green leaf blade.

Flower: Plants are dioecious with male and female flowers on separate plants. Flowers are not showy, but flower spikes are significant and useful in positive identification.

Bloom time is June to Sept. Flowers can occur 8 weeks post-emergence to end of season.

Fruit and seed: Seeds are dark colored and extremely small. Research shows pigweeds including palmer amaranth can produce upwards of 250,000 or more seeds per plant.

Life History: Seedling emergence can occur throughout the growing season; thus, flowering and seed set can persist late into the season. **Monitoring** is a necessary activity for control efforts. Seeds germinate in spring if within an inch of soil surface. Research on pigweeds suggests if seed is buried deeper than 3 inches viability is decreased annually with a potential longevity of approximately 3 years. Research on redroot pigweed (*A. retroflexus*) and waterhemp (*A. rudis*) suggests longevity can be as short as 3-4 years in Mississippi/Illinois or as long as 12 years in Nebraska.

Habitat: Native habitat is desert climate, species performs well during heat of summer. Pigweeds are shade intolerant.

Management: Preventing establishment is key. Proper identification and frequent scouting to limit seed production. **Repeated mowing** or **cutting** are not effective at controlling Palmer amaranth infestations. Continue monitoring and consider alternative methods such as cultivation, manual methods like hand-pulling or herbicide applications.

Prescribed fire has the potential to kill seedlings and drain energy from maturing plants, but fire should be considered as a tool to strengthen the health and competitive advantage of the desirable plant community.

Biotypes have shown resistance to **herbicides** in groups 2, 3, 5, 9 and 27 (Group number - check herbicide labels). Yet, **herbicide** applications both pre- and post- emergent are possible. Roger Becker (Univ. of MN, Agronomist) provided the following comment: "There are many products that will control the pigweed group across the different labeled sites, but the challenge will be knowing what the resistance of the particular biotype is that gets here (Minnesota), if at all. Many of the standard ROW (right-of-way) broadleaf materials will control non-resistant palmer."

Useful herbicides in group 4 include 2,4-D, aminocyclopyrachlor, aminopyralid, clopyralid, and dicamba. Group 2 herbicides include imazapyr, imazapic, metsulfuron and sulfometuron. Nonselective glyphosate, group 9 and glufosinate, group 10 can be used depending on crop tolerance traits or desired vegetation outcomes for non-cropland sites.

For best results, treat plants when they are small, under 1 foot tall.

As plants mature, use approved higher rates of herbicides.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Use fire to improve native plant community.								
Herbicide	Post-emerge									
	Pre-emerge									
	Mow		Mow to prevent flowering							
	Don't mow				Follow-up mowing to control seed production.					
Flowering Period										

Prohibited: Eradicate

Poison hemlock : *Conium maculatum* L.

Caution All plant parts are ***poisonous to humans*** and livestock. Caution

It is reported that toxin can be absorbed through bare skin. Wear appropriate PPE.

Identification: *Compare to wild carrot and native water hemlock on pages 44 and 72. Also compare to carrot look-alikes, wild chervil and common yarrow on pages 51, 52 and 73.*

Plant: Herbaceous, biennial, first year as a basal rosette and second year poison hemlock is a branched, 3-7 feet tall, robust plant. Stems are smooth (no hairs), hollow, appear ridged due to veins and are light green, mottled (spotted) with purplish spots.

Leaves: Alternate, generally triangular in form. Doubly or triply pinnately compound up to 18 inches long by 12 inches wide. Leaflets are fern-like, deeply divided and typically twice as long (2 inches) as wide (1 inch). Basal leaves tend to be larger and have longer petioles than upper stem leaves. Petiole to stem attachments are covered by a sheath.

Flower: Flat or slightly dome-shaped open compound umbels of 3-16 umbellets with 12-25 five-petaled, white florets. There are small ovate-lanceolate bracts with elongated tips under main umbels. Bracts are also present under umbellets.

Bloom time is variable - June to August.

Fruit and Seed: Paired seeds are ⅛ inch tall schizocarps, these split at maturity becoming two carpels . Each carpel is a seed, flattened on 1 side and lined vertically by broken ridges described as wavy ribs. There are no hairs.

Habitat: Partial shade is tolerated but preference is full sun with moist fertile soils. Often found near water or in riparian zones. Can tolerate drier conditions.

Management:

If performed frequently **cutting** or **mowing** are effective control methods to prevent seed production. Same is true for hand pulling, however roots and root fragments remaining in soil may resprout. Monitor and plan additional treatments.

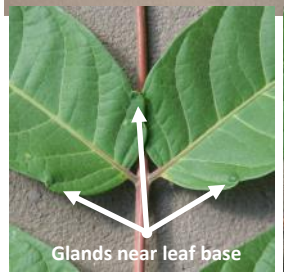
Prescribed fire as a tool should be used to improve the health of surrounding native vegetation. Fire will kill seedlings and top kill other plants; however, after the fire healthy root systems will likely resprout.

Foliar herbicide applications to plants at rosette stage or during active growth (before flowering). Herbicide formulations with 2,4-D or 2,4-D including dicamba or triclopyr have produced good results. Nonselective herbicides such as glyphosate (concentration of 41% or greater) formulations can also produce results.

Other potential herbicide choices include aminopyralid, chlorsulfuron, clopyralid, dicamba, imazapic, imazapyr, metsulfuron-methyl or 2,4-D plus picloram.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn		Use fire to improve native plant community.							
Herbicide	Foliar		Target pre-flower.							
					Target rosette					
	Mow		Mowing must be repeated to prevent flowering							
	Don't mow					Do not mow when seed is present				
Flowering Period										

Prohibited: Eradicate | Tree-of-Heaven : *Ailanthus altissima* (Mill.) Swingle



Synonyms: *A. glandulosa* Desf. and *Toxicodendron altissimum* Mill.

Identification: *Compare to native sumacs* (*Rhus typhina* and *R. glabra*). *See page 69.*

Plant: Tree, woody perennial plant that can attain heights of 70 feet. Very thick twigs with dime-sized leaf scars aid winter identification. Cutting twigs reveals a soft white pith.

Leaves: Alternate, 1-4 feet long, odd-pinnate compound with 11-25 (up to 40) leaflets. Leaflets are 3-5 inches long by up to 2 inches wide, smooth edged with 1-5 distinct glands (bumps) near leaflet bases. **Key difference:** *leaflets are smooth edged, unlike toothy sumac leaflets.*

Flower: Clusters of small yellowish-green flowers are showy due to the sheer number of flowers per cluster. Species is predominantly dioecious (male and female flowers on separate trees).

Bloom time is June.

Fruit and Seed: Clusters of 1-1½ inch long twisted samaras develop mid-summer. A pinkish hue develops, then maturing to light tan. Samaras are documented to wind disperse up to 300 feet.

Life History: Trees sprout vigorously from stumps when cut or broken and there is also strong root sprouting potential. Trees in the 12 to 20 year age class produce lots of seed. Seed bank capability is reported to be low, but initial seed viability is high. Allelopathic (chemical) effects prevent germination of other plants near tree-of-heaven.

Habitat: Tolerant of urban stresses including pollution, soil disturbance, nutrient poor soils, drought conditions (once established), compaction, salty roadside soils and prefers full sun.

Management: Prevention is key - early detection and removal is required.

Cultural methods like **Cutting** or **mowing** are beneficial but should be followed up with good monitoring. Goal with these methods is to prevent flower and seed.

Prescribed fire, where applicable, can top kill seedlings and or saplings. The goal would be to strengthen the native plant community.

Herbicide applications of glyphosate during July through September are effective when applied to **cut stumps**. Other active ingredients would include triclopyr, dicamba, and imazapyr. Stumps should be cut as low as possible to minimize surface area from which potential resprouts occur.

Hack-and-squirt applications with dicamba, glyphosate, imazapyr, picloram or triclopyr formulations are effective. In addition, **basal bark** treatments with triclopyr or imazapyr active ingredients in oil are also recommended.

At full leaf-out during active growth, **foliar** applications with 2,4-D, glyphosate, imazapyr, picloram or triclopyr are also effective when targeting smaller trees and resprouts.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn						Monitor and follow-up.			
Herbicide	Foliar			When fully leafed out and active growth.						
	Basal Bark	Any time.								
	Cut stem	Any time except during heavy sap flow.								
	Mow		Mow frequently to control seedlings.							
	Don't mow									
Flowering Period										

Prohibited: Eradicate | Yellow starthistle : *Centaurea solstitialis* L.

Caution - Gloves and long sleeves are recommended.
Knapweeds have chemical and in some species physical defenses. These are known skin irritants.

A member of the knapweeds, genus *Centaurea*.

Identification:

Plant: Herbaceous, annual with heights of 6 to 36 inches. Plants start as a biennial or winter annual with a basal rosette the first season. Mature plants are described as bushy with a grayish or bluish cast to otherwise green color.

Leaves: Basal leaves are lobed, dandelion-like at about 8 inches. Basal leaves may not persist as plants bolt to flower. Stem leaves are alternate, narrow to oblong and an extended leaf attachment provides a winged appearance to stems.

Flower: Approximately 1 inch long flowers with substantial ¾ inch yellowish spines emanating from bracts beneath flowers. Flowers are terminal and solitary on stems.

Bloom time is June to August.

Fruit and Seed: Each terminal flower produces between 35 to 80 plumeless or plumed seeds.

Life History: Yellow starthistle is a strong invader. Due to a lack of tufting on some seeds, reliance is on animals and humans for movement any distance from parent plants.

Habitat: Periods of summer drought favor infestations on disturbed sites such as roadsides. Also an invader of prairies, fields, woodlands and pastures where spines can cause injury to grazing animals.

Management: Limit movement of seed on grazing animals, mowing equipment and vehicles.

Eradication is the goal in Minnesota; therefore, biological control agents are not a compatible option at this time.

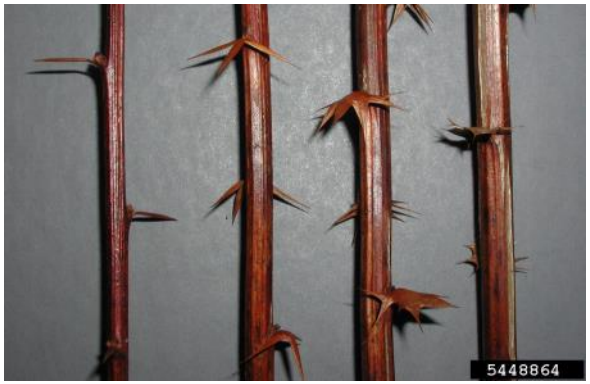
Mowing, monitor infestations and time mowing at early flowering stages, soon after spine development.

Herbicide formulations of aminopyralid, clopyralid or picloram applied as foliar applications early in the growing season appear to be most effective.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Use fire to improve native plant community.								
Herbicide	Foliar									
	Mow		Mow to prevent flowering							
	Don't mow					Do not mow when seed is present				
Flowering Period										

Prohibited: Control

Common barberry : *Berberis vulgaris* L.



Above: common barberry spine variations.

Above: common barberry leaf variations.

Identification: *Compare to Japanese barberry on pages 38-39 and Korean barberry on page 39.*

Plant: Deciduous shrub reaching 8-10 feet in height and up to 6 feet in width. Slender branches are straight between nodes, strongly grooved and common barberry may have single or multi-branched spines, usually 3-branched possibly 5.

Bark on second year stems is gray as opposed to reddish second year branches of Korean barberry.

Key difference - *Japanese barberry spines, usually single maybe 3-branched. Korean has 1-5 (7), often 3, flat spines.*

Leaves: Alternate, but clustered not appearing alternate, simple leaves are ovate, narrow near the base, toothed on the edges, described as finely serrate, as few as 8, often 16 to 30 spiny teeth. In particular, young shoots have spiny leaves.

Key difference - *Japanese barberry leaves have smooth edges (no teeth). Korean barberry has toothed leaf edges.*

Flower: Drooping, 1-2 inch long clusters (racemes) of 10-20 yellow, ½ inch long flowers. Flowers are somewhat showy, however; fragrance is not described as pleasant.

Key difference - *Japanese barberry has 1-4 flowers hanging in loose clusters. Korean barberry has 10-25 flowers.*

Bloom time is May to June.

Fruit and Seed: Fruit is an oblong berry, up to ½ inch long, bright red and fleshy. Berries persist into and through winter. Each fruit contains 1-3 seeds. Based on studies in Minnesota and North Dakota the US Forest Service fire effects database indicates seed viability of 7-9 years in soil.

Key difference - *Japanese barberry berries are ¼ to ⅜ inch long with dry flesh. Korean barberry has ¼ inch fleshy berries and fruits are more rounded - not as oblong.*

Life History: Most propagation is by seed dispersal. Birds are a primary disperser. Vegetative reproduction is important to persistence. Mainly through sprouting from rhizomes and lower branches may root at points of ground contact.

Habitat: Typically, found in open or lightly shaded woods. Also found in pastures, fencerows and roadsides in full sun.

Management:

Cutting or **mowing** can be effective once mature shrubs are removed. Follow-up with frequent mowing to control regeneration or utilize other treatments as needed.

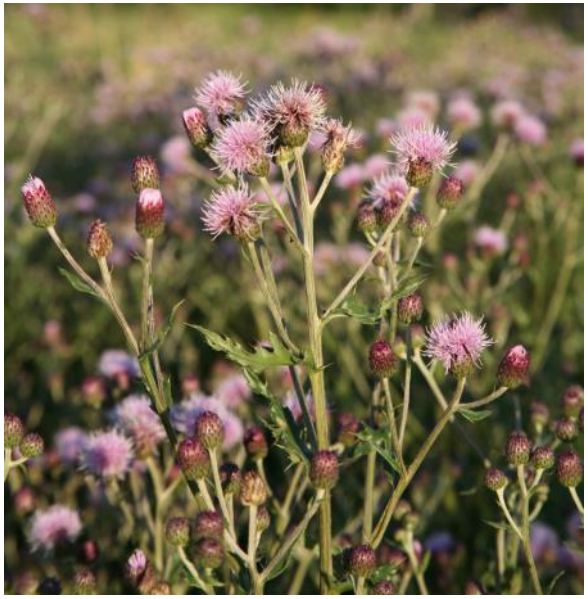
Repeated **prescribed fire** can damage above ground parts and drain energy from shrubs; however, resprouting will likely occur. Monitor after fire and follow up as necessary with additional treatments.

As with most woody species, there are several methods to apply **herbicide. Foliar** applications should be made when plants are fully leafed out and for best effect while plants are fruiting. Active ingredients include dicamba + 2,4-D, glyphosate, metsulfuron-methyl and triclopyr. **Cut stump** treatments using glyphosate or triclopyr will likely be successful and **basal bark** treatments with triclopyr or imazapyr formulations are also effective.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn				Use fire to improve native plant community.					
Herbicide	Foliar			When fully leafed out and when in fruit.						
	Basal Bark	Any time.								
	Cut stem	Any time except May-June during heavy sap flow.								
	Mow		Mow frequently to control seedlings.							
	Don't mow				Do not mow when seed is present					
Flowering Period										

Prohibited: Control

Canada thistle : *Cirsium arvense* (L.) Scop.



Identification: *Compare to nonnative plumeless thistle (Carduus acanthoides), page 28.*
Compare to native swamp thistle (Cirsium muticum). See page 70.
Compare to nonnative musk thistle (Carduus nutans). See page 53.
Compare to nonnatives alfalfa and hairy vetch. See page 49.
Compare flower similarities to spotted knapweed, page 23.

Plant: Herbaceous, perennial with grooved, non-spiny, hairy and typically upright stems to a height of 2-6+ feet tall.

Leaves: Alternate, simple, pinnately lobed leaves that are generally lance-shaped. The leaves are irregularly lobed, with toothed, spiny edges. The leaves are stalkless (sessile) and at maturity are downy or hairy on the underside.

Flower: Male and female (dioecious) ¾ inch flowers occur singly on the end of branches. The disk or composite inflorescence is comprised of numerous purple to pinkish small florets. Bracts below the inflorescence do not have spines on the tips.

Bloom time is June to October.

Fruit and Seed: Tufted light brown seeds are easily dispersed by wind. Do not mow after seed has developed as this strongly aids seed dispersal.

Life History: Reproduction can occur from seed, root cuttings and from rhizomes. Clonal stands are common and spread significant from roots that can grow horizontally 10-12 feet per year.

Habitat: A successful inhabitant of disturbed areas such as roadsides and old fields but will also move into open woodlands and prairies. This species is also found where water levels fluctuate such as in wet meadows, along stream banks and ditches.

Management:

A **biological control** is under investigation, stem-mining weevil (*Ceutorhynchus litura*). This insect is available from commercial vendors and is acceptable for distribution in Minnesota.

Cutting or **mowing** should target plants that are approximately 3 inches tall and the process must be repeated throughout the season to maintain the plants at 3 inches or less in height. Continuing this approach for several years can drain the plants of reserves.

Repeated **prescribed fire** can be used to encourage stands of native grasses that will outcompete thistle. However, monitoring is needed to check for thistle that germinates in bare soil soon after burns are completed.

Herbicide foliar sprays with formulations of clopyralid, aminopyralid, or metsulfuron-methyl. These foliar applications are made as the plants bolt, prior to flower set, or in late summer/early autumn to rosettes.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Monitor and follow-up.			Use fire to improve native plant community.					
Herbicide	Foliar									
	Mow		Mow to prevent flowering							
	Don't mow				Do not mow when seed is present					
Flowering Period										

Prohibited: Control

Common tansy : *Tanacetum vulgare* L.

Caution - Alkaloids contained in common tansy are toxic to humans and livestock if consumed in quantity. Toxins are potentially absorbed through skin, gloves are recommended when handling this plant.

Identification: *Compare to native goldenrods (Solidago* spp.*). See page 63.*

Plant: Herbaceous, perennial reaching 2-5 feet in height. Stems appear woody, are slightly hairy to smooth and at the base are purplish-red.

Leaves: Alternate, pinnately divided, toothed on edges and 2-12 inches long, typically smaller near the top of plants. Leaves are strongly aromatic when crushed.

Flower: Single stems support multi-branched, flat clusters of bright yellow button-like flowers. Each ¼-½ inch wide button is comprised of many small florets and the flower heads, like the leaves, are strongly aromatic.

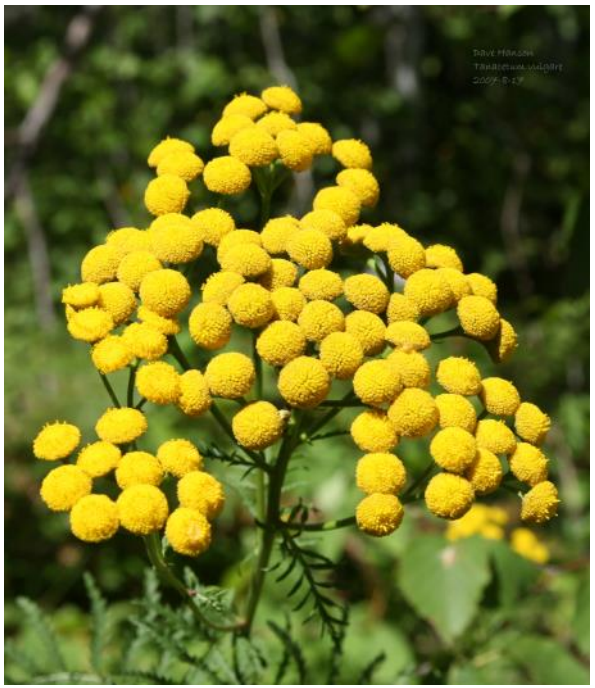
Key difference - *Note the lack of ray petals surrounding the flower heads. Compare to native goldenrods which have ray petals.*

Bloom time is July to October.

Fruit and seed: Small, yellowish-brown, dry, 5-toothed crowned seeds.

Life History: Reproduction is both vegetative from rhizomes and root fragments or by seed. Seeds are dispersed by wind, water and human activities such as vehicle traffic and mowing.

Habitat: Found most often in open, disturbed areas typical of stream and river banks, trail edges, roadsides, gravel pits and old farmsteads or pastures. Can be found in riparian areas, but most often in dry, well drained soils in full sun.



Management:

Mechanical methods like **tilling** can spread common tansy by spreading small root segments. **Pulling** also may leave root segments in the ground which may resprout.

Cutting or **mowing** to prevent seed production can be effective and should be timed just prior to flowering.

Prescribed fire can eliminate competition and create favorable conditions for common tansy by opening the canopy and preparing bare soil. Thus, fire can make an infestation worse; however, fire can be used to remove dead material to improve follow-up herbicide application providing better contact and potentially better control.

Herbicide formulations of metsulfuron-methyl, imazapyr, glyphosate or 2,4-D provide good control when applied as foliar applications in spring.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Use fire to improve native plant community.								
Herbicide	Foliar		Foliar treatments target rosettes.							
	Mow		Mow to prevent flowering							
	Don't mow				Do not mow when seed is present					
Flowering Period										

Prohibited: Control

Spotted knapweed : *Centaurea stoebe* L. ssp. *micranthos* (Gugler) Hayek

Above: basal rosette, Middle right: basal foliage, Middle Left: linear foliage near top of plant, Bottom right: flowers.

Caution - gloves and long sleeves are recommended, knapweeds have defenses known to irritate skin.

Identification: *Compare to knapweed complex members. See pages 13 and 14.*
Compare to nonnatives alfalfa and hairy vetch. See page 49.
Spotted knapweed is widely established in Minnesota.
Learn to identify it and recognize when something is different.

Compare flower similarities to Canada thistle, page 21.

Plant: Herbaceous, short-lived perennial living 1-4 years. Initial stage is a rosette before the plant produces 1-6 stems ranging from 1-4 feet tall.
Leaves: Simple, alternate, grayish-green basal rosette leaves up to 6 inches long have deep sinuses. Alternate leaves on mature stems vary from smaller, 1-3 inch, versions of the basal leaves to very small linear leaves near the top.
Key difference: *meadow / brown knapweed - green leaves, lacking lobes.*
Flower: Strongly resemble the flowers of thistles in their pink to purple color (rarely white) and multi-parted texture. Below the petals, flowers are held together by bracts that are stiff and tipped with darkened hairs (see image above).
Compare *bract tips; brown - brown, tan papery edge; diffuse - rigid, sharp spines - terminal spine can be ⅛ inch long; meadow - long fringed; Russian - rounded, opaque with transparent tips; and spotted - dark tip, short fringe.*
Bloom time is July to September.
Fruits and Seed: Small (⅛ inch long), brownish, tufted, seeds.
Life History: Allelopathic properties (chemicals exuded by the plant) can suppress the germination of seeds of other plants nearby. Plant removal can lead to bare patches of soil subject to erosion.
Seeds are the primary means of reproduction and a mature plant produces thousands of seeds that may remain viable for up to 5 years. Wind disperses seeds short distances while animal and human activity disperse it far and wide.
Habitat: In contrast to meadow knapweed's preference to moist sites, spotted knapweed prefers disturbed sites with gravely or sandy dry soils. Roadsides, abandoned lots, old fields and gravel pits are habitat that support infestations.
Management:
Biological control agents approved for use in Minnesota are seedhead weevils (*Larinus minutus* and *L.* obtusus) and a root-boring weevil (*Cyphocleonus achates).* Weevils are collected July through September and released on infestation sites larger than 1/3 acre. When a combination of seedhead and root boring weevils work together, infestations can be reduced over a number of years. Contact Minnesota Department of Agriculture.
While **cutting, mowing** and **prescribed fire** can encourage competition from native grasses and help reduce the extent of an infestation they will likely not eradicate it. Early spring prescribed fire is compatible with biological control.
Herbicide formulations including aminopyralid, clopyralid, glyphosate, imazapyr, aminocyclopyrachlor or picloram have demonstrated control with foliar applications.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn			Use fire to improve native plant community.						
Herbicide	Foliar		Foliar treatments target rosettes.							
	Mow		Mow to prevent flowering							
	Don't mow				Do not mow when seed is present					
Flowering Period										

Prohibited: Control | Knotweed complex : Japanese, Bohemian and giant

Three knotweeds, often referred to as bamboo, are described here. They are large perennial plants with non-woody stems. Stems are smooth, green with reddish-brown blotches and hollow between swollen nodes where leaves attach. All three have branched flower structures at these leaf attachments holding many small, creamy white to greenish flowers.

Giant knotweed has perfect flowers. Japanese and Bohemian are gynodioecious.

Bloom time (all 3 knotweeds discussed) is August to September.

Seeds: Small, black, 3-sided. Reported as not commonly produced on Japanese knotweed.

Japanese knotweed Identification: *Polygonum cuspidatum* Siebold & Zucc.

Synonyms: *Fallopia japonica* (Houtt.) Ronse Decr. , *Reynoutria japonica* Houtt.

Plant: Height *5-8 feet* (*10 feet*), potentially multiple branches. Typically, only female flowers.

Leaves: Alternate, simple, can be *2 to 7 inches long* with a *truncate base* (mostly straight across). *Tips of leaves are acuminate* (narrowed to an abrupt point) and *undersides of leaves along veins* may have *brown, fuzzy ridges*.

Flowers: Typically, plants with female flowers only. If male flowers present - reported to be sterile. Japanese knotweed's branched *flower structures are longer than nearby leaves*.

Above: Bohemian knotweed.

Bohemian knotweed Identification :

Polygonum ×bohemicum (J. Chrtek & Chrtková) Zika & Jacobson [*cuspidatum* × *sachalinense*]

Synonym: *Fallopia* × *bohemica* (Chrtek & Chrtková) J.P. Bailey

Synonym: *Reynoutria* × *bohemica* Chrtek & Chrtková

Bohemian: an intermediate hybrid with characteristics of both parents, Japanese and Giant.

Plant: Heights from *6 to 16 feet*. Typically few, but potentially several branches.

Leaves: Alternate, simple, can be 2 to 12 inches long and width about ⅔ of length. Leaf bases may be straight across (see Japanese) or rounded (heart-shaped like Giant). Leaf tip may be blunt, gradually tapered or pointed. *Few to no hairs on the leaf edges* (margin) and *veins under leaves may have stiff, broad-based, small hairs*.

Flowers: Fertile female flowers. Male flowers, also fertile, consist of anthers attached to long stamens extending beyond a flower's petals. Structure is branched with variable length.

Above: Extended male stamens and anthers of Bohemian.

Below: Female flowers of Japanese knotweed.

Giant knotweed Identification : *Polygonum sachalinense* F. Schmidt ex Maxim.

Synonym: *Fallopia sachalinensis* (F. Schmidt ex Maxim.) Ronse Decr.

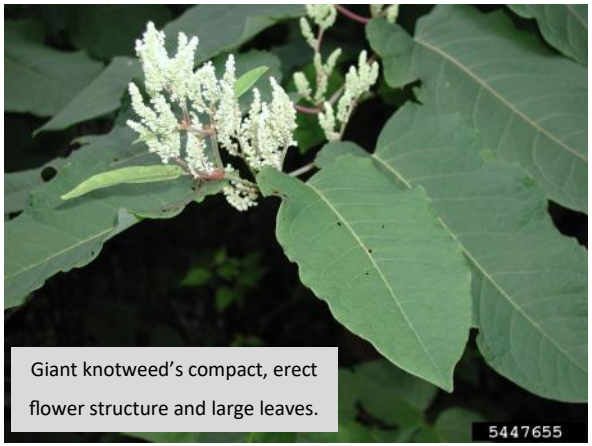
Synonym: *Reynoutria sachalinensis* (F. Schmidt ex Maxim.) Nakai

Plant: Larger plant attaining heights of *9 to 20 feet*. Typically few or no branches.

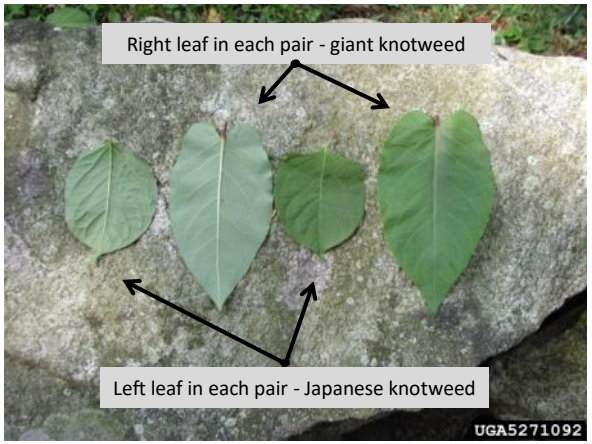
Leaves: Alternate, simple, can be up to *12 inches across* and *6-14 inches long* (width about ⅔ of length) with *rounded lobes at the base* (heart-shaped). *Tips of leaves are blunt* and *undersides of leaves may have scattered* (segmented) *hairs* early in the season.

Flowers: Perfect flowers (male + female) and fertile. Branched, flower structures of giant knotweed are compact, *shorter than nearby leaves*.

Prohibited: Control | Knotweed complex : Japanese, Bohemian and giant



Giant knotweed's compact, erect flower structure and large leaves.



Common Name	Plant form	Leaves	Leaves, underside	Flowers
Japanese knotweed	5-10 feet multiple branches	1-4 inches long, ⅔ as wide leaf base - straight across	along veins, scabers brownish, ridges, fuzzy	branched, loose female, sterile male
Bohemian knotweed (*hybrid*)	6-16 feet, few to several branches	2-12 inches long, ⅔ as wide leaf base - variable	along veins, short, triangular hairs	branched, variable form fertile female and male
Giant knotweed	9-20 feet few or no branches	7-16 inches long, ⅔ as wide leaf base - heart shaped	along veins, hairs scattered, segmented	branched, compact perfect and fertile

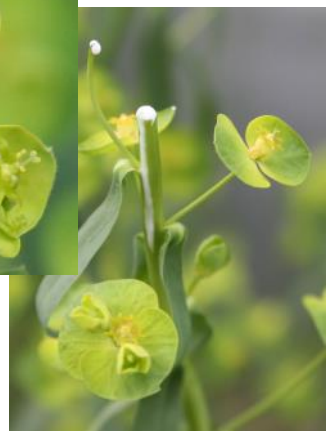
Life History: It is believed that seed production is limited (especially, *Japanese*) and most reproduction is vegetative. Even small rhizome parts will re-sprout after plants are manually removed or moved. Stem fragments resulting from mowers or other machinery can sprout if nodes are present and in contact with moist soil. Plants or rhizomes uprooted by flooding, digging or other mechanical means will likely re-root if left in contact with moist soil.
Seeds, if produced, are said to be viable four to five years if near the soil surface and up to 15 years if buried.
Habitat: Prefers moist soils in full sun to partial shade. Plants readily inhabit moist roadside ditches, wetlands, and areas along rivers and streams. However, plants will thrive on dry soils.
Management: Much of the research has been performed on *Japanese knotweed*. Develop a four to five year plan. **Prescribed fire** in spring can set plants back and drain some energy while **mowing** can prevent or delay seed production. However, both can stimulate vegetative reproduction, thus potentially increasing stem counts. After treatments, monitor approximately 60 feet beyond original infestations and utilize follow-up treatments of periodic mowing and/or herbicide. Reasoning, rhizomes can spread outward to 60 feet or more.
Manual methods including **cutting, digging, hand pulling, grazing** or **tarping** should not be considered eradication tools. If done repeatedly **and in conjunction** with other treatments infestations may be controlled. Monitor and consider supplemental herbicide treatments. All plant parts should be disposed of onsite or contained (e.g., bagged) and removed to an approved facility. For more information on disposal options, read MDA's guide on removal and disposal.
Option 1) **Foliar** treatments with non-selective **herbicides,** imazapyr or glyphosate, are recommended for mid to late summer applications performed as flowering ends and prior to first frost.
Option 2) Prior to **foliar** treatments with **herbicides,** aminopyralid, glyphosate, imazapyr, triclopyr, or 2,4-D, it is recommended that plants be cut or bent down twice during the growing season when 3 feet tall. Cutting or bending (breaking) forces regrowth. Follow with a fall **foliar application** when regrowth is 3 feet tall and prior to first frost.
Cut stem applications with glyphosate, triclopyr or triclopyr + 2,4-D can be made at anytime during active growth when the plants are over 3 feet tall. **Stem injection** treatments with glyphosate can be made anytime during active growth periods. See glyphosate's supplemental label for hollow stem injection.

Any management efforts will likely result in bare ground; therefore, all treatment planning should include revegetation.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
Herbicide	Inject			During active growth, treat when 3' tall.						
	Foliar	Mow / cut twice - fall treatment.								
	Cut stem			During active growth, treat when 3' tall.						
	Mow	Mowing is not recommended. If used, collect cuttings, monitor and repeat. Follow-up with herbicide treatments at 3 feet of regrowth in fall.								
	Don't mow									
Flowering Period										

Prohibited: Control

Leafy spurge : *Euphorbia esula* L.



Above: Flower and bracts.
Right: Cut stem exuding white latex.

Squares = ¼ inch.

Caution - Some people develop skin rashes after pulling or handling plants, so gloves and long clothing are recommended. Additionally, the milky sap is toxic to cattle and horses.

Left: Leafy spurge
Right: Cypress spurge.

Identification: *Similar to invasive cypress spurge (E. cyparissias). Due to bloom period overlap confused with introduced yellow rocket (Barbarea vulgaris). Compare to yellow rocket, page 54.*

Plant: Herbaceous, perennial to 3 feet tall. *Cypress spurge is 8-14 inches tall.* Broken stems of many *Euphorbia* spp. produce a milky sap (latex) that is a good identification characteristic.

Leaves: Alternate, linear to lance-like, bluish-green and 1-4 inches in length. *Cypress spurge leaves are about 1 inch in length, alternate or whorled and narrower than leafy spurge leaves.*

Flower: There are no petals or sepals on the small yellowish-green flowers. Upper stem leaves or bracts develop just below flowers and are yellow-green in color providing the appearance of yellowish petaled flowers. The bracts develop before the true flowers.

Bloom time is May to August.

Fruit and Seed: Three-celled capsules that expel seeds up to 20 feet. Each cell contains a seed.

Life History: Leafy and cypress spurge reproduction can be vegetative from buds on roots, rhizomes and root cuttings. The ability to reproduce vegetatively makes these plants difficult to control. Deep roots to 21 feet and extensive horizontal roots allow plants to store vast reserves providing the ability to recover after removal attempts. Seed production is significant with plants producing on average 140 seeds per stem. Seeds can remain viable in the soil up to 8 years.

Habitat: Leafy and cypress spurge readily invade dry sites in full sun, but tolerance of a range of conditions allows them to invade moist, rich soils as well.

Management:

Biological control agents are available for controlling leafy spurge. Flea beetles (*Aphthona lacertosa*) are widely used in Minnesota. Flea beetles are collected late May to early June and released on infested sites larger than 1/3 acre. Additionally in Minnesota, stem and root boring beetles (*Oberea erythrocephala*) provide some control. Early spring prescribed fire is compatible with biological control on this plant species. Contact Minnesota Department of Agriculture.

Cutting or **mowing** if timed before flower development can reduce or limit seed production. Grazing goats and sheep can effectively limit the spread of infestations.

Prescribed fire is another tool that helps drain plants of reserve energy. Control of spurges typically requires a multi-tactic approach - eliminate or reduce seeding, exhaust seed banks, and drain reserves of existing plants while attempting to encourage native plants for competitive cover. So, consider spring mowing or fire with a fall application of imazapic.

Herbicide controls are applied as foliar applications and usually involve formulations of aminocyclopyrachlor, picloram, 2,4-D, glyphosate, dicamba, or imazapic. Repeated applications are likely necessary.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn									
Herbicide	Foliar									
	Mow	Mow to prevent flowering								
	Don't mow			Do not mow when seed is present						
Flowering Period										

Prohibited: Control | Narrowleaf bittercress : *Cardamine impatiens* L.

Identification:

Plant: Herbaceous, annual or biennial starting its first season as a basal rosette and in the second season sending up a smooth flower stem to approximately two feet in height.

Leaves: Basal rosette leaves are pinnately compound with 3-11 round lobed leaflets. Alternate leaves on flowering stems, while still pinnately compound, likely will not have rounded lobes but 6-20 lance or arrowhead shaped leaflets. Edges of flowering stem leaves may be smooth or sharply toothed.

An important differentiation from other plants can be found at the point where leaves attach to stems, look for narrow pointed ears or auricles that grasp and may extend beyond stems.

Flower: Small (0.1 inch), white 4-parted flowers. White petals may not be present.

Bloom time is May to August.

Fruit and Seed: Similar to other mustard family members, seed pods are long (0.6 - 0.8 inch) and slender. Seed ripens from May to September and is dispersed short distances from plants.

Life History: Reproduction is by seed. Seed pods average 10-24 seeds and individual plants can produce thousands of seeds. Movement of seeds is aided by water, animals and human activities.

Habitat: Moist woodlands, forested areas and on margins of thickets. River bottom sites, streambanks and other moist areas are very good habitat and provide avenues for dispersal. This species can tolerate a variety of conditions and has been reported in areas such as roadsides, vacant lots, as well as yards and gardens.

Management: Recommendations at this time focus on hand pulling infestations.

Good advice from the Minnesota Department of Agriculture in reference to controlling narrowleaf bittercress;

"Following guidelines for controlling other biennial mustards such as garlic mustard, *Alliaria petiolata*, may be helpful."

Hand pulling timed to prevent flower and/or seed production is recommended. Preferably, propagating plant parts should be disposed of onsite or when necessary contained (e.g., bagged) and removed to an approved facility. For more information on these disposal options, please read MDA's guide on removal and disposal. Subsequent re-treatments will be required due to germination and recruitment from the seedbank. If infestations are large or dense, consider the need for ground cover to prevent erosion and to provide competing vegetation.

Prescribed fire in spring to top-kill basal rosettes and seedlings. Follow-up treatment with **herbicide** is imperative after seedling germination to further slow growth of infestations.

Herbicide applications to foliage with formulations of triclopyr, metsulfuron-methyl, or imazapic.
Use glyphosate or 2,4-D after native plants have entered dormancy and narrowleaf bittercress is still active.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn			Use fire to improve native plant community.						
Herbicide	Foliar									
	Mow	Mow to prevent flowering								
	Don't mow			Do not mow when seed is present						
Flowering Period										

Prohibited: Control

Plumeless thistle : *Carduus acanthoides* L.

Identification: *Compare to nonnative Canada thistle (Cirsium arvense). See page 21.*
Compare to native swamp thistle (Cirsium muticum). See page 70.
Compare to nonnative musk thistle (Carduus nutans). See page 53.
Compare to nonnatives alfalfa and hairy vetch. See page 49.

Plant: Herbaceous, biennial reaching heights of 1-4 feet. Unlike native thistles, the stems of plumeless thistle are winged and spiny.

Leaves: Edges of rosette leaves are wavy with yellowish spines. Stem leaves are alternate, attached directly to stems and typically have hairs on bottoms along mid-veins.

Flower: Numerous stem branches support terminal, single, composite flowers that are ½ to 1½ inches wide. Linear or narrow bracts with short spines are found immediately below pink to purple flowers.

Bloom time is July to October.

Fruit and Seed: Small seeds approximately 1/16 inch long described as straw colored and tufted with fibers on the terminal end. The fibers aid in wind dispersal.

Life History: Reproduction is by seed and seeding is prolific building a large seed bank in a short period of time. Thus, control measures should focus on eliminating seed production and exhaustion of seed banks. Movement is greatly increased by animal and/or human activities such as mowing or haying.
It is reported that musk thistle (*Carduus nutans*) and plumeless thistle hybridize.

Habitat: Found on dry to moist soils in pastures, woodlands, waste areas, along roadsides, ditches and stream banks.

Management:

Cutting taproots 1-2 inches below ground is effective but time consuming for large numbers of plants. **Mowing** should be timed at flower bud stage to prevent seed production and should be repeated 2-3 times per season to be effective. Avoid spreading seed with hay or straw and with mowing and vehicle movement through infestations.

Prescribed fire can be used to encourage stands of native grasses that will outcompete thistle. However, monitoring is needed to check for thistle that germinates in bare soil soon after burns are completed.

Herbicide applications timed at the early bolting phase are foliar applications of 2,4-D ester or dicamba formulations. For foliar applications at the budding to flower stage or fall applications to basal rosettes turn to formulations of aminopyralid, clopyralid, metsulfuron-methyl or triclopyr.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Monitor and follow-up.					Fire supports native plant communities			
Herbicide	Foliar									
	Mow	Mow to prevent flowering								
	Don't mow				Do not mow when seed is present					
Flowering Period										

Prohibited: Control

Purple loosestrife : *Lythrum salicaria* L.

Listing includes European wand loosestrife (*Lythrum virgatum* L.).

Identification: *Compare to native fireweed (Chamerion angustifolium). See page 61.*

Plant: Herbaceous, wetland perennial, 4-7 feet tall with a 4 to 6 sided wood-like stem.

Leaves: Opposite, sometimes whorled, lance-shaped, and downy with a slightly wavy yet smooth edge. Leaf pairs are positioned at right angles to the leaf pairs above and below.

Flower: Each plant can have from one to many spikes of pinkish-purple flowers. Center of the flower is yellowish and surrounded by 5-7 petals that have a wrinkled appearance.

Bloom time is July to September.

Fruit and seed: Tiny seeds are released from 2-parted capsules.

Life History: Reproduction by seeds and rhizomes produce large monoculture infestations.

Habitat: Purple loosestrife can be found on upland sites but is best known as an invader of wetlands or aquatic habitats such as ditches, wet meadows, ponds, marshes, river and stream banks as well as lake shores. Purple loosestrife disrupts aquatic habitats as it displaces wetland emergent species.

Management:

Biological control agents in the form of two leaf feeding beetles of the same genus (*Galerucella calmariensis* and *G. pusilla*) have been very effective in Minnesota. For more information visit Minnesota Dept. of Natural Resources.

Mowing is seldom an option due to wet environments. **Cutting** of flower spikes can be an effective control of seed production. **Hand pulling** or **digging** of plants can also be effective but care should be taken to remove entire root systems if possible. Resprouting can occur from roots and root segments left in the ground or on the site. Preferably, propagating plant parts should be disposed of onsite or when necessary contained (e.g., bagged) and removed to an approved facility. For more information on these disposal options, please read MDA's guide on removal and disposal.

Herbicide formulations labeled for use on rights-of-way and near water; 2,4-D, glyphosate, imazamox, metsulfuron-methyl+aminopyralid, triclopyr, imazapyr and aminocyclopyrachlor.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Use fire to improve native plant community.								
Herbicide	Foliar									
	Cut stem									
	Mow		Mow to prevent flowering							
	Don't mow					Do not mow when seed is present				
Flowering Period										

Prohibited: Control

Wild parsnip : *Pastinaca sativa* L.

Caution - Use protective clothing, goggles or face mask. Contact with the sap of the plant (i.e., phyto) when combined with exposure to sunlight (i.e., photo) can cause severe blistering and swelling (i.e., dermatitis) - phytophotodermatitis. See MnDOT factsheet: Work Safely Around Wild Parsnip.

Identification: *Compare to golden alexanders (Zizia aurea) and heart-leaved golden alexanders (Z. aptera), both native.* *See page 62.*

Plant: Herbaceous, often stated to be biennial but is classed as a monocarpic perennial (plant dies after bearing fruit). Early life form is a basal rosette with mature stems developing a hollow, grooved flowering stalk potentially reaching 5 feet.

Leaves: Basal rosette leaves can be 6 inches in height and are pinnately compound with 5-15 leaflets. Flowering stalk leaves are alternate, 2-5 leaflets that become smaller near the top of the stem. Leaflets are coarsely toothed, sinuses cut to varying depths creating lobes of various sizes. The base of the leaf stalks wrap or clasp the grooved stem.

Flower: 12-35, 5-petaled, small yellow flowers on wide, flat umbels of 15-25 umbellets approximately 2 to 6 inches across.

Bloom time is June to July.

Fruit and Seed: Flattened, yet ridged, oval seeds.

Life History: Typical life span is two years, first year a basal rosette. One of the first plants to green up in spring and one of the last to brown down in autumn providing good opportunities for scouting and treating. Mid to late summer, mature second-year plants will bolt, flower and set dozens of seed per plant. Seeds are moved off infested sites by animal and human activity or wind and water movement. Seed is reported to be viable in soil for up to 4 years.

Habitat: Disturbed sites such as roadsides and abandoned fields or lots. Can occur in wet meadows but dry to mesic soils are more typical. Full to partial sun is a must for this species.

Management: See Minnesota Department of Agriculture web for Lifecycle and Treatment Timing poster.

When possible plan early **mowing** at first inflorescence, then monitor and repeat as plants will likely re-sprout, bolt and flower. If **cutting** or **mowing** after seed set, clean equipment to leave seeds on the infested site. Preferably, propagating plant parts should be disposed of onsite or when necessary contained (e.g., bagged) and removed to an approved facility. For more information on disposal options, please read MDA's guide on removal and disposal.

Prescribed fire can be used to encourage stands of native grasses for competition. However, follow-up treatments (herbicide or cutting) are still required to prevent seed production.

Herbicide controls include foliar applications of 2,4-D or metsulfuron-methyl to the rosette stage during May and June and again in September or October. If glyphosate is to be applied to rosettes, it is recommended to hold off until late fall to prevent damage to desirable plants that should then be dormant.

		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.-Mar
	Burn	Use fire to improve native plant community.								
Herbicide	Foliar									
	Mow		Mow to prevent flowering							
	Don't mow				Do not mow when seed is present					
Flowering Period										