DOCKETED	
Docket Number:	24-OPT-03
Project Title:	Soda Mountain Solar
TN #:	261587
Document Title:	Appendix Z – Mitigation Measure MM BIO-3
Description:	This document provides specific information related to MM BIO-3.
Filer:	Hannah Arkin
Organization:	Resolution Environmental
Submitter Role:	Applicant Consultant
Submission Date:	2/7/2025 12:33:51 PM
Docketed Date:	2/7/2025

Mitigation Measure MM BIO-3

Soda Mountain Solar Project

California Energy Commission Opt-In Application 24-OPT-03

1. Introduction

To reduce direct, indirect and cumulative impacts from the mass grading that is necessary for installation of standard solar panel tracker systems (including grading impacts due to removal of native topsoil and vegetation, habitat disruption from non-native re-vegetation, fugitive dust and long-term soil erosion and drainage modifications to vegetation and jurisdictional waters), the project is required to implement the following mitigation measure:

> **MM BIO-3: Construction Impact Minimization.** The project shall implement an advanced technology terrain-following solar tracker system (such as the Nextracker NX Horizon-XTR-0.75 10-inch tracker system, Nevados All Terrain Tracker system, or other system resulting in a similar reduction) that reduces grading under the solar field, consisting of solar power arrays identified as East Array and South Arrays 1, 2 and 3. Quarterly construction monitoring reports shall be provided to the California Energy Commission during the construction period for the project. The quarterly construction monitoring reports shall quantify and document all remaining permanent and temporary grading acreage from project construction with the terrain-following tracker system. All temporary grading impact areas shall be revegetated onsite as described in the project-specific Temporary Disturbance Revegetation Plan (APM BIO-7 and MM-BIO-21). All permanent grading impact areas shall be mitigated at the required compensatory mitigation standards of the resource agencies (APM BIO-36, MM BIO-12, MM BIO-24).

2. Suitable Construction Technologies for Implementing MM BIO-3

Multiple equipment manufacturers offer advanced technology terrain-following tracker systems that can be employed to substantially reduce the extent of temporary and permanent impacts from grading beneath the solar power arrays to implement MM BIO-3. By accommodating greater variability in native land contours without the need for grading in many areas of the solar field, the amount of grading, and consequent grading impacts, are substantially reduced. To determine the estimated reduction in impacts from grading by using one of these terrain-following tracker systems, a project-specific earthwork analysis was completed and is included as Attachment 1. Attachment 1 provides the earthwork volumes that would result from utilizing the Nextracker NX Horizon-XTR-0.75 10-inch tracker system as compared to use of a conventional tracker system, which requires substantially greater grading. Attachment 2 contains a technology datasheet for the Nextracker NX Horizon-XTR-0.75 10-inch tracker system. Attachment 3 provides a case study identifying how this terrain-following tracker system can be implemented effectively and in a quantifiable manner.

Due to rapidly advancing tracker system technology, the project may implement any alternative terrain-following tracker system that results in a similar reduction in grading on the project site as the Nextracker NX Horizon-XTR-0.75 10-inch tracker system. The Nevados All Terrain Tracker is an example of an alternative terrain-following tracker system that may be employed by the project to implement MM BIO-3. Attachment 4 contains a technology datasheet for the Nevados All Terrain Tracker and Attachment 5

provides a case study identifying how this tracker system can be implemented effectively and in a quantifiable manner.

3. Reduced Impacts from MM BIO-3

Mitigation measure MM BIO-3 requires the project to implement an advanced technology terrain-following tracker system that significantly reduces the amount of onsite grading under the solar field. Without implementation of MM BIO-3, project impacts under the solar field would total 1,506 acres of permanent impacts. With implementation of MM BIO-3, project impacts under the solar field would be reduced to an estimated 79 acres of permanent impacts and 1,427 acres of temporary impacts (SWCA 2025). For the entire project footprint, implementation of MM BIO-3 is estimated to result in 340 acres of total permanent impacts and 1,719 acres of total temporary impacts.

With implementation of MM BIO-3, all temporary impacts will be revegetated onsite as described in the project-specific Temporary Disturbance Revegetation Plan (APM BIO-7 and MM BIO-21), and all permanent impacts will be mitigated at the required compensatory mitigation standards of the resource agencies (APM BIO-36, MM BIO-12, MM BIO-24). However, with reduced grading impacts from implementing MM BIO-3, the amount of this mitigation will be lessened when compared to the original July 23, 2024 Opt-In Application (24-OPT-03) for the project.

To ensure the project adequately mitigates all temporary and permanent project impacts from grading under the solar fields, after employing the terrain-following tracker system required by MM BIO-3 the Applicant will provide quarterly construction monitoring reports to the California Energy Commission during the construction period for the project. The reports will quantify and document all permanent and temporary impacts related to MM BIO-3.

Utilizing an advanced technology terrain-following tracker system minimizes a variety of environmental impacts by avoiding destruction of native topsoil and vegetation; preventing habitat disruption from non-native re-vegetation; and preventing long-term soil erosion and drainage modification. The discussion below identifies how implementation of MM BIO-3 will affect the environmental issue areas evaluated within the original July 23, 2024 Opt-In Application (24-OPT-03).

Aesthetics: Under implementation of MM BIO-3, the visual aspects of the solar field remain unchanged. All applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Agricultural Resources: There are no significant agriculture or forestry resources on the project site. Therefore, implementation of MM BIO-3 would not result in any change in impacts to agricultural resources.

Air Quality: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground disturbance would reduce the project's air quality emissions due to a decrease in construction equipment usage and an associated decrease in fuel usage. The reduction in on-site grading would also result in less fugitive dust during construction, due to less ground disturbance. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03) provides a conservative analysis

of project impacts related to greenhouse gas emissions. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Biological Resources: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground disturbance would reduce direct, indirect and cumulative impacts related to biological resources. Without implementation of MM BIO-3, project impacts under the solar field would total 1,506 acres of permanent impacts. With implementation of MM BIO-3, project impacts under the solar field are estimated to be reduced to 79 acres of permanent impacts and 1,427 acres of temporary impacts (SWCA 2025). For the entire project footprint, implementation of MM BIO-3 is estimated to result in 340 acres of total permanent impacts and 1,719 acres of total temporary impacts (SWCA 2025).

The reduction in on-site grading and associated ground disturbance would reduce the potential for the project to result in direct, indirect or cumulative impacts to candidate and special status species, riparian habitat and sensitive natural communities, migratory fish and wildlife species. Implementation of MM BIO-3 would require all temporary grading impact areas to be revegetated onsite as described in the project-specific Temporary Disturbance Revegetation Plan (APM BIO-7 and MM-BIO-21). Additionally, all permanent grading impact areas associated with MM BIO-3 would be mitigated at the required compensatory mitigation standards of the resource agencies (APM BIO-36, MM BIO-12, MM BIO-24).

Implementation of MM BIO-3 would significantly reduce biological resources impacts. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03), which does not take into account the reduction in grading that would result from using a terrain-following tracker system as MM BIO-3 requires, provides a conservative analysis of the project impacts related to biological resources. When compared to the impacts contained within the original July 23, 2024 Opt-In Application (24-OPT-03), implementation of MM BIO-3 would reduce the compensatory mitigation requirements related to onsite habitat, desert tortoise, desert bighorn sheep, Mohave fringed toed lizard, burrowing owl and waters of the State.

Cultural Resources: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground disturbance would reduce the potential for the project to result in direct, indirect or cumulative impacts to any known or undiscovered archaeological or cultural resources on the project site. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03) provides a conservative analysis of project impacts related to cultural resources. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Energy: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground disturbance would reduce the project's energy usage due to a decrease in construction equipment use and the associated use of fuels and oils. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03) provides a conservative analysis of project impacts related to energy. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Geology and Soils: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground

disturbance would reduce the potential for the project to result in direct, indirect or cumulative impacts to soil erosion, topsoil loss, and paleontological resources. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03) provides a conservative analysis of project impacts related to geology and soils. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Greenhouse Gas Emissions: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground disturbance would reduce the project greenhouse gas emissions due to a decrease in construction equipment use and the associated use of fuels and oils. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03) provides a conservative analysis of project impacts related to greenhouse gas emissions. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Hazards and Hazardous Materials: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground disturbance would reduce the fuels and oils required to operate construction equipment, which would reduce the amounts of hazardous materials utilized for the project. Therefore, the environmental analysis provided within the original Opt-In Application (24-OPT-03) provides a conservative analysis of project impacts related to hazards and hazardous materials. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Hydrology and Water Quality: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground disturbance would reduce the potential for the project to result in direct, indirect or cumulative impacts related to water quality standards, waste discharge requirements, surface and groundwater quality degradation and the alteration of onsite drainage patterns. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03) provides a conservative analysis of project impacts related to hydrology and water quality. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Land Use and Planning: Under implementation of MM BIO-3, the land use and planning components of the project remain unchanged. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Mineral Resources: There are no significant mineral resources on the project site. Therefore, implementation of MM BIO-3 would not result in any change of impacts to mineral resources.

Noise and Vibration: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. Project specific noise and vibration created during the project construction period is expected to be less, due to a reduction in construction equipment noise associated with grading equipment. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03) provides a conservative analysis of project impacts related to noise and vibration. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Population and Housing: Under implementation of MM BIO-3, the population and housing components of the project remain unchanged. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Public Services: Under implementation of MM BIO-3, the public service components of the project remain unchanged. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Recreation: Under implementation of MM BIO-3, the recreation components of the project remain unchanged. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Transportation: Under implementation of MM BIO-3, the transportation and traffic components of the project remain unchanged. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Tribal Cultural Resources: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground disturbance would reduce the potential for the project to result in direct, indirect or cumulative impacts to any undocumented tribal cultural resources. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03) provides a conservative analysis of project impacts related to tribal cultural resources. Mitigation requirements related to this environmental issue area remain unchanged.

Utilities and Service Systems: Under implementation of MM BIO-3, the utility and service system components of the project remain unchanged. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Wildfire: Under implementation of MM BIO-3, the wildfire components of the project remain unchanged. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

Public Health: With implementation of MM BIO-3, on-site grading and associated ground disturbance would be significantly reduced under the solar field. The reduction in on-site grading and associated ground disturbance would reduce the potential for the project to result in direct, indirect or cumulative impacts related to fugitive dust, naturally occurring asbestos and valley fever. Therefore, the environmental analysis provided within the original July 23, 2024 Opt-In Application (24-OPT-03) provides a conservative analysis of project impacts related to public health. Applicant proposed measures and mitigation requirements related to this environmental issue area remain unchanged.

4. References

1. Nextracker Earthwork Summary Report for the Soda Mountain Solar Project
2. Nextracker NH Horizon XTR Data Sheet
3. Nextracker NX Horizon-XTR Winneke Water Treatment Plant Casestudy
4. Nevados Solar All Terrain Tracker Data Sheet
5. Nevados. The Problem of Mass Grading for Solar. Why and How the Practice Must Stop.
6. Soda Mountain Solar California Energy Commission Opt-In Application 24-OPT-03
7. SWCA Environmental Consultants GIS Analysis 2025

Attachment 1

PROJECT: Nextracker **– Soda Mountain Solar Project**	Terabase
DOC. TITLE: **Earthwork Summary Report – Soda Mountain Solar Project**	
DOC. NO: DT-23-013A-Soda Mountain-RP-A-Earthwork Summary	

Earthwork Summary Report

Created for Nextracker – Soda Mountain Solar Project

Rev.	Date	Description	Prepared By	Checked By	Approved By
A	2024-12-11	Submitted for Client Review	C. Lucanas	C. Aber	D. Morra

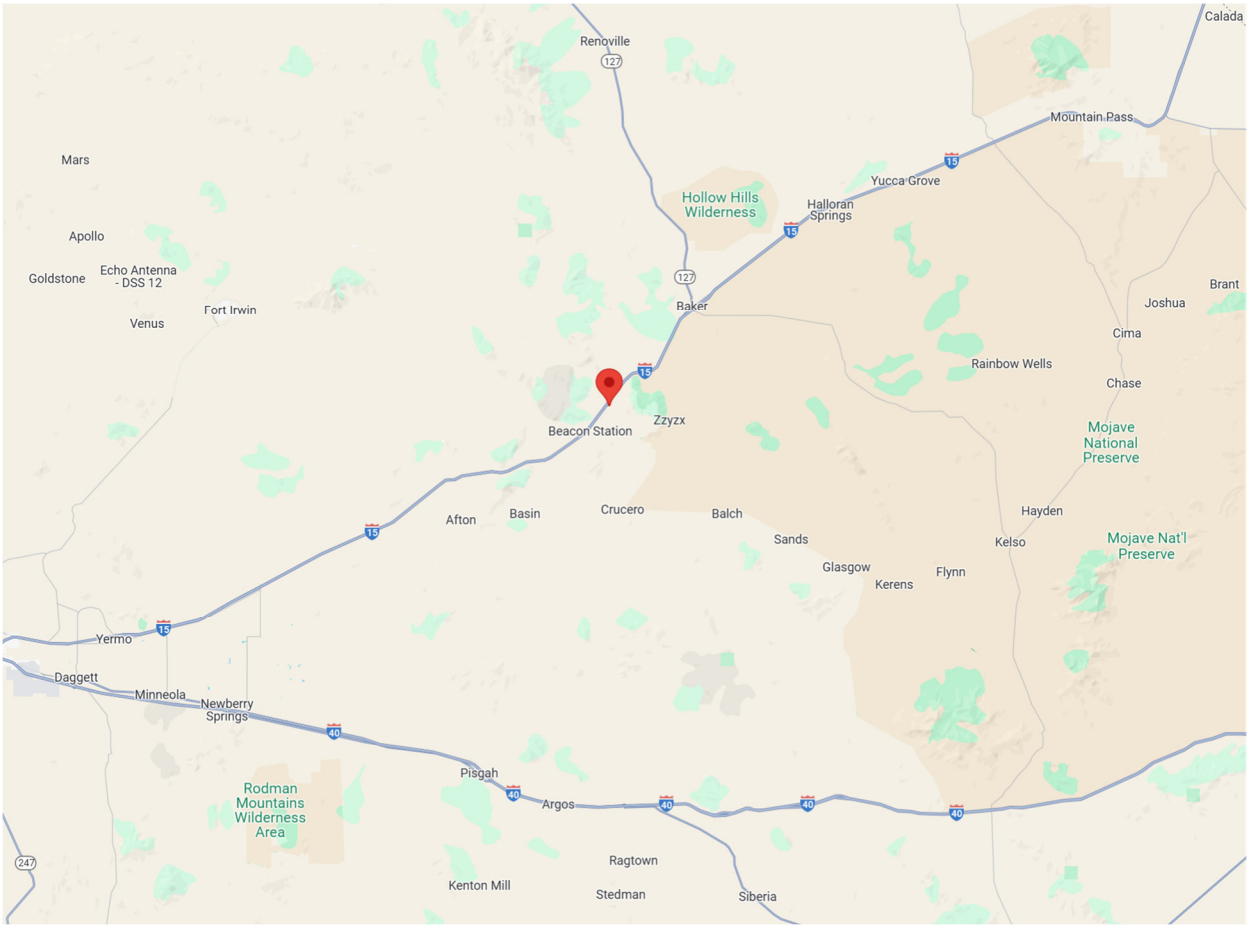
PROJECT: Nextracker – **Soda Mountain Solar Project**	Terabase
DOC. TITLE: **Earthwork Summary Report – Soda Mountain Solar Project**	
DOC. NO: DT-23-013A-Soda Mountain-RP-A-Earthwork Summary	

Table of Contents

Project Location

San Bernardino County, California, USA

35°09’37” N, 116°11’01” W



1. INTRODUCTION

This Earthwork Summary Report (Report) presents grading analysis results for the Soda Mountain Solar Project, located in San Bernardino County, California, USA. This Report was prepared for Nextracker under the supervision of a civil engineer. The inputs and assumptions, a description of the analysis, and analysis results are presented below.

2. INPUTS AND ASSUMPTIONS

The grading analysis was performed using data provided by Nextracker, including:

Title/Filename	Format	Dated
Layout: 2841719_VC Renewables_Soda Mountain_Site Plan / Rev A	DWG	2024-12-05
Topo: 193833-TP-001	DWG	Unknown

<u>Model Parameters:</u>

Pier Reveal Window(s): 10-inch

Minimum Pier Height: 4.16-feet

Maximum North-South Slope of Torque Tube: 8.5 degrees (14.95%)

Maximum Articulation Angle: 0-, 0.75-degrees (1.31%) and 1.5-degrees (2.62%)

Units: US Customary Units

Array Area: 1479.0-acres

Coordinate System: NAD83 California State Planes, Zone V, US Foot (CA83-VF)

EPSG Code: 2229

Benchmark (Vertical Datum): Not Provided

4. RESULTS

Table 1: Earthwork Summary

	XTR-0.75
Pier Reveal Window (Undulation Tolerance)	10-inch
Total Disturbed Area (ac)	54.9
Area Cut (ac)	7.0
Area Fill (ac)	47.9
Percent Disturbed	3.7%
Maximum Depth of Cut (ft)	-1.7
Maximum Height of Fill (ft)	3.6
Total Cut (bcy)	-3,300
Total Fill (bcy)	36,700
Net Cut/Fill (bcy)	33,400
Balance Earthwork (lcy)	88,100

Table Notes:

1) ft = feet; in = inch
2) ac = acre
3) bcy = bank cubic yards, in-situ volume
4) lcy = loose cubic yards, excavated volume
5) Cut is shown as negative (-), fill is considered positive.
6) Percent disturbed is calculated based on the array area shown in **Section 2**.
7) Earthwork quantities do not include clearing and grubbing, stripping of topsoil, grading of drainage features, roads, equipment pads, or substation.
8) Earthwork quantities are limited to the array areas only.
9) Maximum uniform ground slope to be 6.1% in north-south direction, up to 15% with approval from Nextracker.
10) Nextracker is not the Civil Engineer of Record. All surfaces and values are preliminary. Final analysis to be provided by others.
11) Balanced Earthwork quantifies the total earthwork of a balanced system. To calculate this, the larger absolute value between “Total Cut” and “Total Fill” is multiplied by two, and then increased using a soil swell factor of 1.2x.

5. FIGURES

Cut/Fill Legend		
Range (feet)		Color
Maximum Cut	-2.00	
-2.00	-1.50	
-1.50	-1.00	
-1.00	-0.50	
-0.50	-0.10	
0.10	0.50	
0.50	1.00	
1.00	1.50	
1.50	2.00	
2.00	Maximum Fill	

Figure 2: XTR-0.75 Tracker – 10in Undulation Tolerance (no scale)

Attachment 2


nextracker
NX Horizon XTR™

NX Horizon XTR™

Break free from traditional tracker constraints and follow the grade

By following native land contours to eliminate or massively reduce grading, NX Horizon XTR saves construction cost, minimizes environmental impacts, and reduces project risk for terrain-challenged projects. Horizon XTR features an innovative approach to terrain following built on NX Horizon's™ existing, proven technology, and may be paired with TrueCapture™ energy yield optimization to maximize energy generation for each project's unique topography. The latest version, XTR 1.5, doubles Horizon XTR's ability to conform to undulating terrain, further expanding opportunities for solar development on challenging sites.

Key Features and Benefits

Cut Construction Costs and Timeline

Grading can be time consuming and expensive.
NX Horizon XTR can deliver up to:

- 100% grading reduction, cutting 1,000-3,000 cubic yards / MW of cut and fill
- 36" pile length reduction, saving 5,000-9,000 lbs / MW steel consumption
- 100% re-vegetation reduction, cutting 5 acres / MW of re-seeding

Minimize Environmental Impacts

Grading can be damaging to the local ecosystem.
NX Horizon XTR helps protect the land by:

- Avoiding destruction of native topsoil and vegetation
- Preventing habitat disruption from non-native re-vegetation
- Preventing long-term soil erosion and storm runoff

We are seeing more and more projects these days having undulating terrain, and Horizon XTR allows us to build up and over a hill, without having to flatten it out.

– Donny Gallagher
VP Engineering,
SOLV Energy

6200 Paseo Padre Parkway | Fremont, CA 94555 | USA | +1 510 270 2500 | nextracker.com

Mitigate Project Risk

Grading introduces risks throughout the project lifecycle. NX Horizon XTR helps mitigate by:

- Simplifying permitting, improving community acceptance, and mitigating topographic study inaccuracies during the development phase
- Avoiding grading-related delays and cost overruns due to unforeseen conditions, inclement weather, and remediations during the construction phase
- Preventing escalating land maintenance and project remediations due to soil erosion during operations phase

Horizon XTR allows us to decouple some of the earthwork that used to be mandatory and allows us to build the best structure for the land as it is now.

– Nick de Vries
CTO, Silicon Ranch

SILICON RANCH®

Proven Technology

NX Horizon XTR is based on NX Horizon's proven core architecture, uniquely suited for terrain-following applications without the use of complex joints. Risks associated with other tracker technology may include:

- Loss of tracker row torsional stiffness
- Friction or binding of bearing components, wearing of articulating joints
- Complex drive mechanisms
- Limited track records

6200 Paseo Padre Parkway | Fremont, CA 94555 | USA | +1 510 270 2500 | nextracker.com

GENERAL AND MECHANICAL

Architecture	Horizontal single-axis, independent row, mechanically balanced
Configuration	1 x module in portrait
Tracking range of motion	±60° standard ±50°, ±75° available
Row size	Configurable per module type, string length, and site layout
Drive type	High accuracy slew gear
Modules supported	All utility-scale crystalline and thin-film modules
Bifacial design	High-rise mounting rails, bearing and driveline gaps, round torque tube
Materials	Galvanized steel; other coatings available
Structural connections	Engineered fastening system, vibration proof
Wind protection	Intelligent wind stowing with symmetric damping system

ELECTRONICS AND CONTROLS

Solar tracking method	Astronomical algorithm with backtracking standard. TrueCapture™ available for enhanced energy yield
Tracker controller	Self-Powered Controller (SPC) with integrated inclinometer and UPS
Motor	Brushless DC
Power supply	Standalone smart solar panel
Site-level control and communications	Network control units (NCUs) at inverter pads/skids Self-powered weather stations Centralized data hub Encrypted Zigbee wireless mesh communications
Defensive stowing functions	Wind, hail, hurricane, snow, flood, loss of grid power
Operator interface	NX Navigator™ advanced HMI available, with SCADA integration

SITE CONDITIONS

N-S site slope	Up to 15%
N-S terrain following	Conformance to native land contours Angular tolerance configured to site conditions
E-W site slope	Up to 15%
Ground coverage ratio (GCR)	No specific limit. Typical range 25-45%
Operating temperature range	-40°C to 55°C (-40°F to 131°F)
Wind speed	Configurable up to 240 kph (150 mph) 10m, 3-second gust
Snow load	Configurable up to 4800 Pa (100 psf) ground load
Flooding	Standard module elevation 1.3 to 1.8 m (4'3" to 5'10"). All drive and control components at torque tube elevation. Increased elevation available with additional engineering
Soils	Complete range of foundation solutions available

SERVICE, WARRANTY, AND STANDARDS

Tracker engineering and PE stamped design package	Standard
Foundation engineering and PE stamped design package	Available
Onsite construction support and commissioning service	Available
Warranty	10-year structural, 5-year drive and controls standard Extended warranty available
Certifications	UL 2703, UL 3703, IEC 62817, CSA

Attachment 3

NX Horizon-XTR

Winneke Water Treatment Plant

Australia's first terrain-following solar tracker project protects sensitive land and provides a behind-the-meter solution to power essential drinking water treatment.

NX Horizon-XTR™ breaks the paradigm of the 'straight-line row' design constraint by conforming to the existing ups and downs of north-south ground slope undulations. By adopting this new technology, trackers no longer require installation along a single plane but can follow natural site contours.

Project Overview

Hidden among the rolling hills and bushland in Christmas Hills, Victoria, is Australia's first-ever solar farm equipped with Nextracker's pioneering NX Horizon-XTR terrain-following technology.

More than just solar panels in a field, the new 9.54MWdc solar farm at Melbourne Water's Winneke Water Treatment Plant tells the story of Australia's shift to renewable energy, and the innovative technology now available to protect cultural and environmental land values.

The Winneke Water Treatment Plant project showcases the engineering and partnership needed to create a behind-the-meter project among a unique landscape with significant environmental values.

The 19,143-panel solar farm covers 10 hectares alongside Sugarloaf Reservoir's rocky shoreline. The project is expected to generate 11.7 gigawatt-hours of clean electricity per year, enough to power almost 3,000 homes. In addition, the project will cut the treatment plant's emissions by up to 12,000 tonnes of carbon dioxide per year.

The project site is culturally and environmentally significant, therefore, it was important to minimise groundwork to avoid disturbing Indigenous artifacts. Necessary earthworks for piles or trenching underwent heritage screening during the site assessment stage.

Name of Project	Winneke Water Treatment Plant
Location	Sugarloaf Reservoir, Christmas Hills, Victoria, Australia. Wurundjeri Country
Customer	BEON (EPC), Melbourne Water (developer/offtaker)
Financier	Melbourne Water (developer/offtaker)
Capacity	9.4 MWdc Behind the meter
Construction length	6 months, commissioned in September 2022, operational in late 2022

The Winneke site is incredibly unique for a solar farm given the nature of the slope, environmental sensitivity of the construction area and the geotechnical considerations of the site. The NX Horizon-XTR product was the ideal solution to deal with these challenges."

– Glen Thomson, General Manager, Beon Energy Solutions

The Challenge

The Victorian water sector is responsible for almost a quarter of the Victorian Government's total greenhouse gas emissions. Melbourne Water has committed to reducing emissions by 50% by 2025 and becoming carbon neutral by 2030. By 2025, Melbourne Water aims to draw all electricity from 100% renewable sources. As an essential service and providing a quarter of Melbourne's drinking water from Sugarloaf Reservoir alone, power supply and yield are critical to delivering the high-quality drinking water Melburnians expect.

Although Sugarloaf Reservoir sits within an open catchment requiring a treatment process to filter out impurities, Melbourne Water works hard to minimise the impact of erosion, farming and recreation on the water quality. Therefore, a solution to protect the surrounding land from erosion, minimise grading and ground disturbance, and reduce any reseeding time was crucial.

In addition, due to the cultural requirements of the site, the typical tracker height of 1.5 m meant approximately 8,050 m^3 of cut was not possible. Instead, a 2.6 m pile height was required with no cut and only minor fill (270 m^3).

The project was also a pre-drill site, which made it even more challenging to construct within the cultural and environmental constraints and variances.

Features & Benefits

Maximum pile height
reduced
2.6 m to **1.9** m
on 33% of the piles

No grading was permitted on site

Without NX Horizon-XTR, fixed tilt would be required resulting in less energy yield.

Less pile height required

with NX Horizon-XTR meant ease of construction due to taller trackers on steep slopes. This led to a reduced steel tonnage and lower costs.

Solution

Nextracker worked closely with Melbourne Water and Beon to understand site challenges on the undulating terrain and installed NX Horizon-XTR to help eliminate grading and minimise erosion and vegetation loss on the sloped, uneven terrain.

TrueCapture™ and Navigator™ software was also deployed at the site to mitigate any row-to-row shading and energy loss due to the significant east-west slopes on site.

Designing and building a tracker for 2.6 m height on a steep and challenging site with high structural design inputs was proven unsafe and not economically feasible. However, with NX Horizon-XTR, more pile height flexibility was provided. Nextracker worked with Beon to assess the full potential for Horizon-XTR and proposed a maximum pile height of 1.9 m (a small percentage of the site) using the new technology and without any earthworks.

NX Horizon-XTR allowed an expansion into complex site topography, including rolling hills where conventional tracking systems are limited. Most tracker systems require longer foundation piles, extensive grading, or a combination of both to accommodate rolling north-south terrain installations, adding to delays and environmental concerns. By using NX Horizon-XTR technology, the project was able to take on the uneven terrain, conform to topography and enable the Winneke Water Treatment plant to accomplish its renewable energy objectives

Results

Australia's first terrain-following solar tracker project successfully protected sensitive land and provided a behind-the-meter solution to power essential drinking water treatment.

The NX Horizon-XTR technology also allowed for trackers to be economically built on this site due to reduced steel for pilings and minimal earthworks.

Attachment 4

ALL TERRAIN TRACKER

BECAUSE THE WORLD IS NOT FLAT

Nevados is the premier solar tracker company for PV power plants built on sloped and rolling terrain. We offer innovative all-terrain trackers paired with a comprehensive software suite in an integrated technology platform that optimizes solar performance, improves plant reliability and respects the natural landscape.

SLOPE CHANGE AT EVERY PILE

BEARING TYPE	SLOPE CHANGE (%)
Straight-Through	± 4.4
Articulating	± 26

1 FOLLOW THE LAND

- Industry's first and most capable terrain following tracker
- Eliminates civil grading & eases permitting
- Reduced pile length saves steel

2 INCREASE SITE OPTIONS

- Convert sites from fixed tilt to tracker
- Revisit sites previously disqualified due to grading
- Build on sites with differential settlement risk
- Fastest installation, zero custom tools or jigs

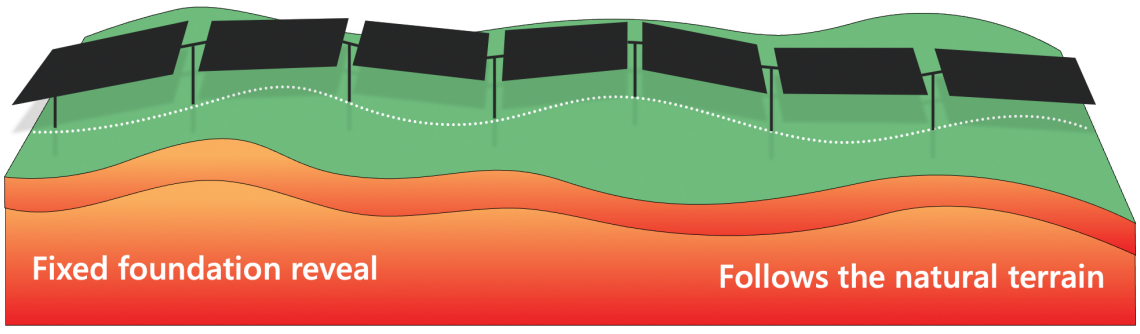
3 MANAGE EXTREME WEATHER RISK

- Extensive wind tunnel studies on variable terrain
- 75° hail stow
- Integrated friction dampers for unparalleled wind performance

4 OPTIMIZE SITE DESIGN AND PERFORMANCE

- Proprietary TRACE Terrain-Aware Backtracking schedules for zero shading & increased energy yield
- Unique software for site design optimization
- Off-azimuth, variable GCR, variable tilt schedules

Nevados All Terrain Tracker (ATT)



NEVADOS
ALL TERRAIN TRACKER

BECAUSE THE WORLD IS NOT FLAT

ROW CONFIGURATION	• Up to 96 modules per row • 5 to 8 modules per bay
TRACKING ANGLE CAPABILITIES	• ± 60° tracking expandable to ± 75° tracking • Single row actuation with 24VDC slew drive
TERRAIN FOLLOWING	• Straight Through bearing: ±3.5% slope change at each foundation • Articulating bearing: ±26% slope change at each foundation • 37% max N-S and E-W slope
FOUNDATION	• I-Beam or ground screw foundations installed at consistent reveal throughout site
GROUND COVERAGE RATIO	• Configurable, typically greater than or equal to 28%
DESIGN LOADS	• Designed to applicable ASCE • Configurable to any wind speeds • Configurable to 50+ PSF snow load • Loads studied in wind tunnels for variable terrain; no external dampers required for wind dynamics
INCLUDED SERVICES	• Preliminary layouts and site design optimization • Structural calculations, IFC package and foundation design • TRACE Terrain-Aware Backtracking or True Tracking
OPERATING TEMPERATURE	• -20°C – 55°C
MODULE CONNECTION/GROUNDING:	• Self-grounding module brackets • UL2703 and UL3703
TOLERANCES	• Reveal height: +4” / -0”, N-S: ±1.5” (expandable), 2° vertical plumb, 9° twist • Flat-land: ±12” vertical & E-W at each pile, may change based on neighboring foundations
CONTROLS	• Web-based dashboard for monitoring & operation with row-level control • SCADA integration via Modbus TCP/IP for monitoring & operation with row-level control • Wireless, self-powered row controllers and weather stations • AC-powered Zone Controllers
WARRANTY	• 10-year structural, 5-year drive & controls warranty

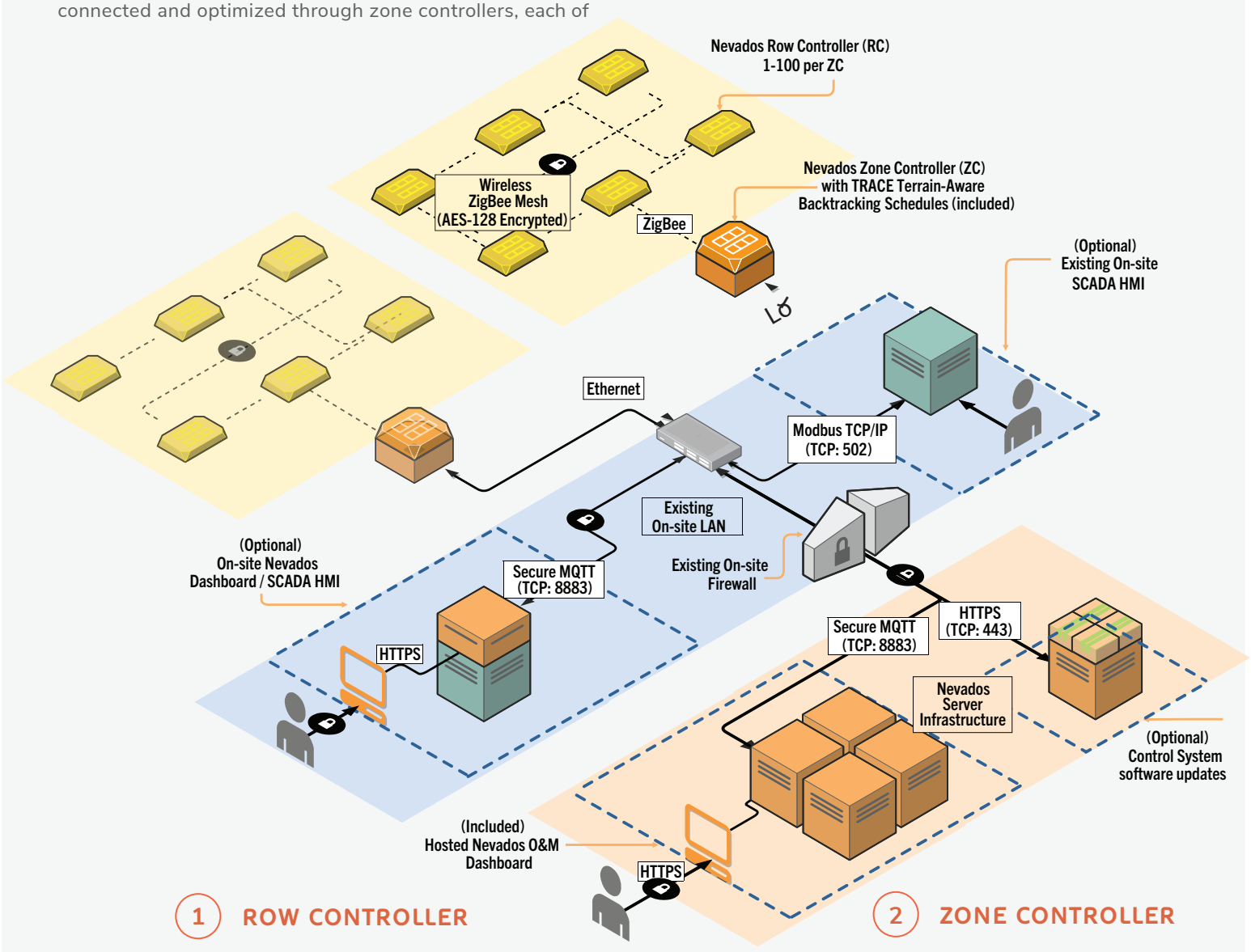
55 4th St, Oakland CA 94607 • 415-730-0159 • Nevados.Solar

NEVADOS

SOLAR TRACKER CONTROLS

FOR ALL TERRAIN ENVIRONMENTS

The Nevados control system is designed to optimize power generation from your project site and account for variable shadow fall on flat, sloped, and rolling terrain. Each row is monitored by a single row controller. Row controllers are connected and optimized through zone controllers, each of which can manage up to 100 row controllers. The system provides detailed operational information from each row, which can be utilized to increase row-to-row efficiency and maximize output.



1 ROW CONTROLLER

- Configurable for most environments
- IP65

2 ZONE CONTROLLER

- O&M reporting
- IP65

MODULES | ROW CONTROLLER | ZONE CONTROLLER | WEATHER STATION | DASHBOARD

NEVADOS
ALL TERRAIN TRACKER

BECAUSE THE WORLD IS NOT FLAT

COMMUNICATIONS	ROW CONTROLLER	ZONE CONTROLLER
WIRELESS	• Zigbee	• Zigbee communication to RC
WIRED	• 8P8C or SFP between ZC and site network • Optional RS 485 communication link	• Manage with SCADA over Modbus • Reporting to cloud-hosted monitoring & control dashboard • Cat5/6 between ZC and SCADA
ENCLOSURE		
SIZE (LxWxD)	• 10” x 12” x 3.5” – max external dimension of enclosure (not including mounting tabs)	• 12” x 10” x 6”
DESIGN	• IP65, Plastic (injection molded), Membrane vent	• IP65, Polycarbonate
SERVICE/ACCESS	• Access battery field serviceable	• Access for configuration
MOUNTING	• Direct mount RC to torque tube	• Mounted near or on inverter skid, or other ethernet and power access point.
POWER	• Auxiliary solar module, 40+W and 30V, approx 645mm x 345mm x 25mm	• 120V, 277V AC wired to enclosure
BATTERY	• 150+Wh LiFePO4 battery with optional cold weather package	
INPUTS	• RS485 port for string current sensor • E-Stop • Built-in keypad with status LEDs • Auxiliary module power cables	• 120V, 277V AC • Ethernet or fiber (SFP)
OUTPUTS	• Motor Cable • Antenna	• Antenna
BOARD COMPONENTS	• Zigbee radio • Motor over-current monitoring and protection • Accelerometer • Cell-level battery monitoring and charge management	

55 4th St, Oakland CA 94607 • 415-730-0159 • Nevados.Solar

The Problem of Mass Grading for Solar: Why and How the Practice Must Stop

By Amitoj Gill and Jenya Meydbray

Executive Summary

Mass grading for solar projects is costly and environmentally destructive. Managing the negative consequences of this practice are particularly difficult and expensive at greenfield solar projects on hilly terrain, and these sites are increasingly common as the utility-scale market expands geographically.

Intensive grading to level uneven topographies substantially increases overall project risk, drives anti-solar sentiment in local communities, and invites regulatory action that threatens future project development. Solar tracker technology must advance to provide project developers and EPCs with a cost-effective technical solution to topography challenges. All-terrain solar tracking solutions from Nevados achieve this goal by eliminating or greatly reducing grading requirements.

This white paper examines the problem of grading, highlights a case study from Primoris, an EPC that achieved a 95% reduction in grading at a Louisiana solar farm by deploying Nevados trackers, and explains how Nevados trackers help project stakeholders avoid the challenges of grading.

NEVADOS

Introduction

What is Grading?

Grading is the process of flattening land. While it is a common practice for all types of civil projects, mass grading is fundamentally destructive to the environment. Its negative consequences are directly related to the amount of grading conducted and the specific environmental conditions at a given property. Cut and fill grading consists of shearing high points on a property and using the disturbed soil, imported soil and other backfill to fill in low points.

In large solar developments on channelized or uneven land, hundreds of thousands of cubic yards of soil may be moved to accommodate for traditional solar trackers. Top soil is typically stripped or covered, destroying the land's fertility. Soil stabilizing root balls may be removed, exacerbating erosion and increasing sedimentation to downstream areas. Erosion and sedimentation can also lead to violations permitting requirements related to the Clean Water Act and cause lengthy construction delays.

The process of grading greatly reduces the value of the land and can cause irreparable environmental harm. The degree of harm increases with the amount of grading conducted. When mass grading is conducted on hilly terrain, it fundamentally reduces the overall sustainability of solar assets and increases risks throughout the project lifecycle.

Why Are Solar Projects Graded?

Level terrain has long been a requirement for utility-scale PV installations because conventional solar ground-mountings can only be installed on flat land. Viable greenfield sites that meet key developer requirements (i.e., flat topography, proximity to transmission infrastructure, low cost) are now scarce: in many markets, solar projects are already operating on every level, rectangular property that is well-located for utility-scale PV deployment.

Many developers and EPCs have turned to mass grading to achieve the topographic profile required to deploy industry-standard tracker technology on available project sites. This practice comes with tremendous risks, especially as market growth pushes developers to increasingly hilly terrain.

INDUSTRY PERSPECTIVE: CHANGING SITE CONDITIONS

"The market for clean energy is now asking more of its projects than ever before. It is no longer adequate to develop and construct a solar project and claim that it is a net-benefit, new projects must also preserve and protect the land as much as possible.

Building low-risk, environmentally responsible projects in today's market requires equipment that adapts to terrain and is as low-impact as possible, like Nevados solar trackers."

Dr. Owen Ransom, Ph.D.
CEO of Sierra Overhead Analytics, a civil-solar specialist firm

Grading Creates Problems for the Solar Industry

The destruction of soil structure and existing vegetation are inevitable when grading occurs, and they have far-reaching implications:

- Soil structures that have developed over centuries vanish.
- Established vegetation that exists in a delicate balance with the existing soil profile is often removed to ease construction.
- The watershed is fundamentally altered.
- Intensive reseeding and revegetation efforts are often required to stabilize the soil, and these may continue for years at extreme costs.
- Costly delays due to lack of soil stabilization, Stormwater Pollution Prevention Plan (SWPPP) violations, or other grading-caused issues are a constant risk in many modern projects.
- Dust control measures such as water spraying are necessary to prevent reduced air quality that affects public health. Dust control is particularly costly in drought-affected regions.

Grading also presents a major point of friction in public engagement due to concerns over erosion, stormwater runoff, and the destruction of prime farmland, not to mention the change in aesthetics.

Rural communities are often culturally and economically invested in their landscape and farmland. They raise strong objections to the modification of terrain, seeing it as a violation of their identity and destruction of their agricultural capacity.

As the industry matures, the risks of grading for solar projects are garnering attention from regulators. In addition to increasingly robust federal and state level requirements, many localities are becoming savvy to the risks of grading for solar farms. For example, Connecticut now requires that solar sites "not materially affect the status of any prime farmland." Grading functionally halts projects in localities with this type of regulation.

INSIGHTS FROM THE FIELD: RURAL VIRGINIA

"All the cows have to drink is red, muddy water."

When two solar projects affected local farmers in Virginia, there were financial consequences for asset owners and long-term regulatory implications:

- A poorly graded solar site in Essex County caused sediment runoff that turned a local creek brown in 2018, and the asset owner was fined $245,000.
- In 2021, farmers in Louisa County protested that the local solar farm was destroying their land. The asset owner issued a formal public apology and was fined $50,000.

Both incidents generated state-wide media attention and public backlash.

In 2022, Virginia's Department of Environmental Quality issued more restrictive stormwater and permitting requirements for solar projects. Louisa and Essex counties – along with five other counties in the state – have since enacted regulations and/or solar moratoriums to restrict project development.

Grading Increases Project-Level Costs and Risks

As detailed in the table below, grading increases the risk of permitting challenges, project construction delays, and cost overruns.

Increased Burdens	Additional Risks
Site Acquisition & Development	
• Authorites having jurisdiction (AHJs) frequently require the sizing of stormwater (quality and quantity) retention basins based on area of land disturbed • Additional local permitting and zoning approval processes are common • Higher requirements for civil and environmental engineering services • Grading can only be done in certain seasons and weather conditions, limiting construction schedules • Local concerns over disruption to natural landscapes and agricultural assets are more likely	• Risk to timeline after site acquisition due to permitting requirements • Risk of weather-related delays and increased costs • Increased administrative costs for documentation required for approval • Risk of negative local sentiment • Possibility of legal action from environmental and cultural conservation groups • Negative press driven by local community, especially in agricultural areas • Delays or stop-work orders from AHJs for improperly or non-stabilized sites
Construction	
• Additional labor and subcontractor costs • Weather conditions dictate installation timeline • Dust control burden on EPC • Additional labor and expenses for revegetation process • Increased potential for erosion due to compromised soil structure	• Unpredictable costs and timeline due to unforeseen topological and hydrological barriers • Risk of weather-related delays and damage • Difficulties with revegetation leading to erosion, soil compaction, introduction of invasive species, and harm to pollinators
Long Term	
• Ongoing erosion, soil compaction and washout issues • Ongoing soil importation and reseeding until soil stabilization is achieved • Introduction of invasive species that increase mowing costs • Ongoing potential for higher operations and maintenance costs due to erosion and higher decommissioning bond rate	• Legal issues from neighboring properties and local municipalities • Permanent damage to agricultural properties causing legal issues with leasing landowners • Potential that site will be forced to shut down if erosion issues are not addressed • Destruction of biomes, local species collapse

+0.75¢/watt

Average cost to meet Stormwater Pollution Prevention Plan requirements for graded projects across all topographies. Costs are higher for hilly sites.

Source: Primoris

Grading and Unexpected Issues

Unforeseen geological features can astronomically increase grading labor costs and create unpredictable delays. Seasonal constraints of grading and revegetation activities, as well as vulnerability to extreme weather during the grading process can further delay and increase costs. Overall labor costs due to grading are expected to rise as developers take advantage of incentives in the 2022 Inflation Reduction Act, which includes prevailing wage requirements.

Decommissioning bond costs may also pose a liability for graded sites. As the risks to site infrastructure, negative environmental impacts, and the scope of regulatory compliance burden associated with grading become more widely understood, the grading process will soon become a major red flag to bond issuing agencies.

INSIGHTS FROM THE FIELD: THE HIGH COST OF DUST CONTROL

Dust control measures are required whenever grading occurs. In dry and drought-affected regions, water is often trucked in and sprayed at great expense. Failing to contain dust reduces air quality and leads to costly fines.

When grading was conducted at the 200 MW Townsite Solar Garden in Boulder City, Colorado, the EPC spent more than $3M and hired six full-time employees to implement dust control measures – but even those efforts proved insufficient. The county issued more than $220,000 in fines due the project's excess dust, which affected the health and wellbeing of local residents.

Leveraging Technology to Eliminate Grading

Data from the planning and construction of the 50 MW Iris Solar facility in Washington Parish, Louisiana proves that Nevados' integrated solar tracking technology platform dramatically reduces grading requirements.

Primoris, the construction and engineering firm that built the Iris facility, conducted a desktop study comparing earthwork and grading requirements at Iris for conventional 1P trackers vs. the Nevados technology platform.

The study revealed that Nevados trackers reduced grading requirements and disturbed land acreage by 95%.

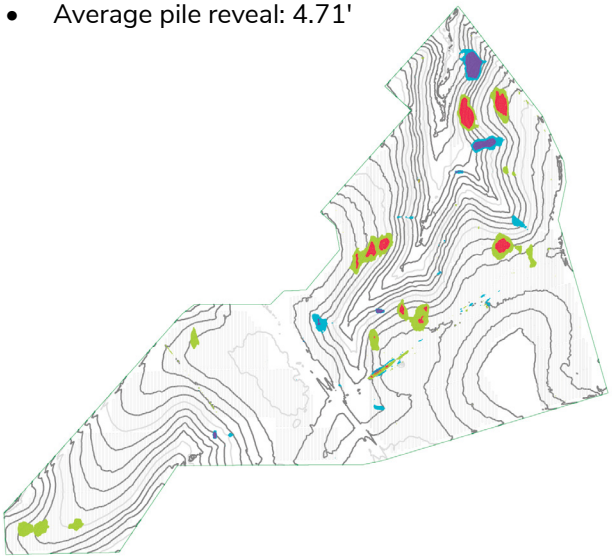
Primoris ultimately utilized 13 MW of Nevados trackers in conjunction with 37 MW of conventional 2P tracker technology for the Iris project. The cost-effective hybrid solution maximized utilization of available land for solar production and minimized grading.

COMPARING GRADING REQUIREMENTS: CONVENTIONAL 1P VS. NEVADOS TRACKERS

The heat maps below compare the grading requirements at the Iris site for a conventional 1P tracker and the Nevados All Terrain Tracker. Disturbed land is highlighted by color as shown in the tables. The Nevados tracker eliminated almost all cut-and-fill grading from the project site.

CONVENTIONAL 1P

- Grading cut/fill: 1,100 yd^3/MW
- Disturbed area: 0.34 acres/MW
- Pile reveal range: 4' - 6'
- Average pile reveal: 4.71'

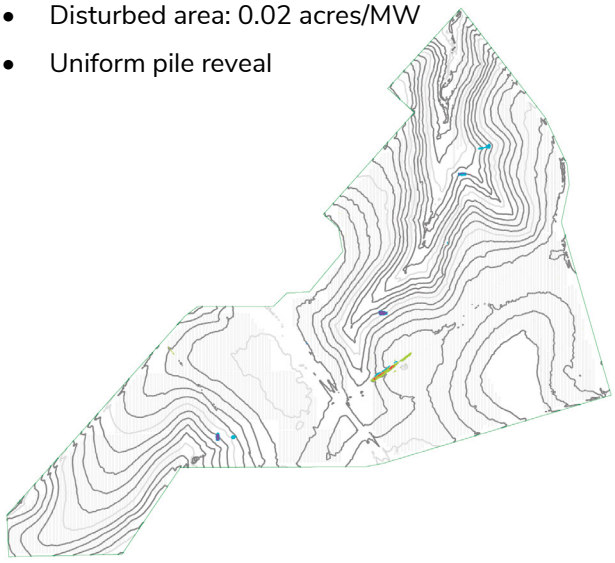


Elevations Table			
Min. Elevation (ft.)	Max. Elevation (ft.)	Area (ac)	Color
-5.00	-1.00	0.60	
-1.00	-0.50	1.64	
0.50	1.00	0.47	
1.00	5.00	0.30	

NEVADOS

95% reduction in grading volume and disturbed area:

- Grading cut/fill: 66 yd^3/MW
- Disturbed area: 0.02 acres/MW
- Uniform pile reveal



Elevations Table			
Min. Elevation (ft.)	Max. Elevation (ft.)	Area (ac)	Color
-5.00	-1.00	0.01	
-1.00	-0.50	0.06	
0.50	1.00	0.05	
1.00	5.00	0.03	

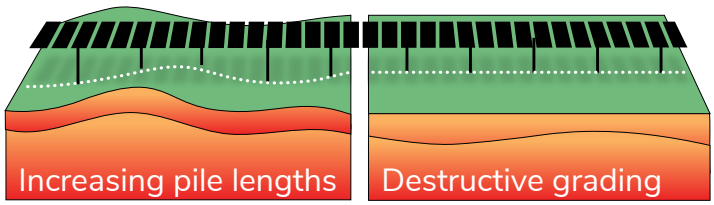
Nevados trackers in the field at the Iris site

Nevados: An Integrated Solar Technology Platform

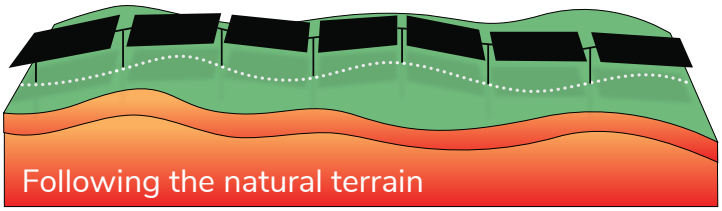
Nevados solar trackers are differentiated by a proprietary product design that is engineered to eliminate or greatly reduce grading requirements on solar projects. The structures are uniquely characterized by highly flexible bearings and non-continuous torque tubes.

Most trackers require flattening the land because they utilize a single torque tube across an entire row (see diagram below). Because Nevados trackers have segmented torque tubes and highly flexible bearings, they can accept angle changes of up to 15 degrees (26%) between posts and all bearings can handle maximum slopes of up to 37% (20 degrees). Nevados trackers also use standardized short piles that reduce steel as compared to conventional trackers.

Traditional tracker



Nevados All Terrain Tracker



INDUSTRY PERSPECTIVE:
THE IMPACT OF NEVADOS TECHNOLOGY

"Minimizing grading allows EPCs like Primoris to significantly reduce project risks that threaten construction timelines and increase costs in solar farm construction. Challenges like dust control, revegetation, and erosion present much fewer issues.

The benefits of Nevados' trackers are massive, especially for sites like Iris that did not require the extensive grading that a traditional system would."

John TeBockhorst, PE
Sr. Civil Structural Environmental Engineering Manager,
Primoris Renewable Energy

Nevados Technology: Designed for Easy Installation on Variable Topography

No terrain is the same, so the Nevados solution is not one-size-fits all. Instead, Nevados offers three separate bearing options with torque tube cradles for a tracking structure that is highly adaptable to variable topography.

Bearing types can be mixed and matched throughout a project site to maximize available land for solar deployment. Nevados maintains constant reveal heights which results in less above ground steel than is typical for 1P trackers.

Nevados trackers are also designed for easy installation in the field:

- The tracker has very few steps for assembly because the driveline and factory-assembled bearing are integrated into the same assembly.
- No specialized tools, jigs, or fixtures are required for installation. The entire system has only two bolt sizes with two torque specifications.
- Non-continuous torque tubes, shorter pilings, and large tolerances simplify and speed up the installation process.
- The shorter torque tubes are easily handled and installed by two people.
- Tracker installation occurs at chest-height, so no ladders or step stools required.
- Torque tubes and straight bearings auto-align during installation, so no alignment labor is needed. Articulated bearings are hand-aligned whenever they are used.
- Solar modules self-align during installation with top-clamp clips that can easily accommodate different module sizes.

The Nevados team engineered every aspect of its technology platform with topography in mind. It includes proprietary performance optimization software, TRACE. Each row is programmed with its own tilt schedule to prevent all row-to-row shading for any topography and ensure maximum energy yield.

NEVADOS TECHNOLOGY: THREE INNOVATIVE BEARINGS

Nevados double-articulating bearing: +/-26%

Nevados single-articulating bearing: +/-13%

Nevados straight-through bearing: +/-3.5%

Conclusion

Grading is a destructive practice that undermines solar power as an environmentally responsible power source. Grading also introduces potentially serious permitting and construction risks that can threaten the long-term financial performance of solar assets and the viability of project development in rural areas. Furthermore, the project sites available today are more vulnerable to the negative consequences of grading than sites that were developed in the past. Continuing to engage in the practice of mass grading is likely to engender further regulations that prevent the solar market's expansion into new geographies.

Fortunately, the inherent risks and harms of grading are easily avoided with All Terrain Trackers from Nevados. Nevados' technology opens up potential greenfield sites that have previously been deemed non-viable for utility-scale installation. Additionally, older sites that utilized fixed-tilt racking to avoid intensive grading can now be upgraded with Nevados solar trackers that increase energy yield.

It is time for project developers and EPCs to end the practice of grading by leveraging the most advanced technology from Nevados.

About the Authors

Amitoj Gill, Vice President of Engineering, Nevados

Amitoj Gill has more than a decade of experience in mechanical engineering and manufacturing that spans the solar, electronics, and semiconductor industries. He has directed the engineering and design of Nevados solar trackers since 2019.

Connect with Amitoj on LinkedIn

Jenya Meydbray, Chief Commercial Officer, Nevados

Jenya Meydbray is a solar industry veteran with more than fifteen years of experience. Prior to joining Nevados in 2023, he served as CEO of PV Evolution Labs (PVEL), an independent solar testing laboratory that he co-founded in 2010.

Connect with Jenya on LinkedIn

INTERESTED IN LEARNING MORE?
VISIT US ONLINE AT NEVADOS.SOLAR

Nevados is the premier solar tracker company for PV power plants built on sloped and rolling terrain. We offer innovative all-terrain trackers paired with a comprehensive software suite in an integrated technology platform that optimizes solar performance, improves plant reliability, and respects the natural landscape. Headquartered in San Francisco and backed by institutional capital, Nevados is transforming utility-scale PV deployment with our tracking solutions and partnership approach. Our mission is to pioneer sustainable solar solutions to preserve the earth for today and for tomorrow.

Sources

1. Apgar, Blake. “Boulder City solar farm fined nearly $220k for air quality violations.” Las Vegas Review-Journal. (2021). Accessed March 29, 2023. https://www.reviewjournal.com/news/politics-and-government/clark-county/boulder-city-solar-farm-fined-nearly-220k-for-air-quality-violations-2483023/

2. Kameli, Reza, and Sun Shen. “Developing Solar Energy in Rural Virginia: An Analysis of Legal, Environmental and Policy Issues.” (2022). Accessed March 28, 2023. https://law.wm.edu/academics/programs/jd/electives/clinics/practicum_list/vacoastal/reports/rural-solar-final.pdf

3. Moore-O'Leary, Kara A. et al., "Sustainability of Utility-Scale Solar Energy – Critical Ecological Concepts." Frontiers in Ecology and the Environment 15, no. 7 (2017): Page 385-394. Accessed March 14, 2023. https://esajournals.onlinelibrary.wiley.com/doi/10.1002/fee.1517.

4. Grout, Travis, and Jennifer Ifft. "Approaches to Balancing Solar Expansion and Farmland Preservation: A Comparison across Selected States." (2018). Accessed March 8, 2023. https://dyson.cornell.edu/wp-content/uploads/sites/5/2019/02/Cornell-Dyson-eb1804.pdf.

NEVADOS