IVY SOLAR LANDFILL FINAL DESIGN REPORT

SPRING 2025

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1 INTRODUCTION

1A DESIGN PROBLEM STATEMENT

Develop a solar power facility on a capped cell Ivy Landfill (4576 Dick Woods Road) that optimizes the solar energy output while adhering to state and municipality guidelines for renewable energy, stormwater runoff, erosion and sediment control.

1B DESIGN OBJECTIVES

This project will focus on producing the final design plans for the solar facility, including the solar arrangement design, erosion and sediment control (E&SC) phase I and phase II plans and stormwater management. Additionally, a community engagement plan will be developed, and a cost estimate will be compiled. A more detailed list of project deliverables is described below:

- Sheet Sets detailing:
  - Existing Conditions
  - Proposed Site Design
  - E&SC Phase I and II
  - Drainage Flowpath Map
- GIS Site Slope, Solar Irradiance, and Visibility Analyses
- Panel and Ballast Specifications
- Array Output Analysis
- Stormwater Report
- Cost Estimation
- Community Engagement Plan

Each of these deliverables are discussed thoroughly in the report; with deliverables detailed in the appendixes and attached as separate files. A complete initial Design Schedule is included as well, with each phase of the project and subtasks mapped out (See Appendix A).

1C BACKGROUND

This project seeks to develop a capped cell of the Ivy Landfill into a productive solar facility that produces a maximum of 3 megawatts (MW) of alternating current (AC) power. This maximum output objective was based on the definition of small-scale solar as outlined by Virginia Clean Economy Act (VCEA). Upon completion of the final design, the project will be turned over to Dominion Energy, the largest electricity provider in Virginia, for development and operation, integrating the power generated into the utility grid. The facility should optimize the solar energy output while adhering to state and municipality guidelines for renewable energy, stormwater runoff, and erosion and sediment control. The design must also consider the array of limitations that coincide with developing on a closed landfill, such as the structural integrity of the ground, location of gas vents, non-disturbance of the landfill cap, and sloping of the topography.

2 DESIGN SPECIFICATIONS

The design of a solar facility must consider many factors including local and federal guidelines (see Appendix B), energy production, topography and stormwater restrictions and community impact. This project's design process was split into two components: site design and solar design. Dividing work in this manner allows understanding of the landfill's topography and identification of any restrictions imposed by the post-closure plans, stormwater regulations, and E&SC measures. Simultaneously, we are exploring different standards and guidelines for the installation of small-scale solar facilities in Virginia to generate an array layout. We will then model the energy output to confirm the design's feasibility given the site design analysis.

2A SITE DESIGN

2A I EXISTING CONDITIONS MODELING

To create a base file for our project, GIS files were located and downloaded from several different online databases, including the Virginia GIS Clearinghouse (VGIN), the Albemarle County GIS database, and the Virginia DOT Open Data Portal, Virginia Roads. These shape files were then uploaded into ArcGIS, projected onto the correct coordinate system (VA83 State Plane South Zone), and clipped down to the general vicinity of our parcel. A general base file was then created in Civil3D based around the Albemarle County parcel shapefile, with the Ivy Landfill parcel highlighted in red; the coordinate system was set. Each other clipped shape file was subsequently uploaded into the base file using the "MAPIMPORT" command.

Existing data imported into the base included roadway centerlines and edges, building footprints, waterways and floodplains, bridges, culverts, and locations of gas vents on the site. The "LAYER" manager was then opened, and a naming convention was created to identify varying linework in a consistent manner; linework from the shapefiles was then transferred over to the appropriate layers. Topography data retrieved from the online databases was used to create an embedded surface within the drawing; settings were manipulated so that contours are visible but not obstructive, and elevation data is visible at any point. Aerial imagery was activated, and polylines were then drawn to identify the area of usable land for development on the site. Soil reports for the site were compiled and downloaded from the USDA Web Soil Survey, and a FEMA Digital Flood Map was downloaded for the adjacent waterway to the site parcel, Broad Axe Creek. A plan sheet picturing a map of existing conditions can be found attached in Appendix D.

2A II STORMWATER MANAGEMENT

An analysis of the hydraulic nature of the site and the existing stormwater management efforts was conducted to understand how the alteration of the site will affect pollutant discharge into the environment. The site is located within the 100-year flood plain of Broad Axe Creek and existing stormwater management measures, including channels, sediment ponds and diversion systems, are fitted for 25-year, 24-hour storms. We also conducted a geologic analysis utilizing data from the United States Department of Agriculture Web Soil Survey, indicating that the site is almost entirely composed of loamy soils, with the primary classifications being Hayesville loam, Ashe loam and Minnieville loam. Currently, stormwater is transported through a 24-inch pipe and conveyance channels to sediment basins to the east, north and west of the site. The Virginia Department of Environmental Quality (DEQ) announced that any solar project with interconnection approval after December 31, 2024, will have to treat solar panels as unconnected impervious areas. However, as our project was approved prior to this date, the installation of solar panels will not alter the percentage of impervious surface and therefore, the stormwater management efforts will remain largely the same. The full stormwater management plan and future recommendations are detailed in Appendix D.

2A III EROSION & SEDIMENT CONTROL PHASE I

In accordance with the Virginia Stormwater Management Handbook, a phase one erosion and sediment control plan was prepared to stabilize the site before major construction activities begin and document initial site preparation measures. The E&SC Phase I plan sheet can be found in Appendix D. The primary objectives of erosion and sediment control measures are to minimize soil disturbance, control erosion at the source, and prevent sediment-laden runoff from leaving the site and polluting nearby waterways, such as Broad Axe Creek. The topography of the site will necessitate the installation of a *C-PCM-04 Silt Fence*, as seen below.

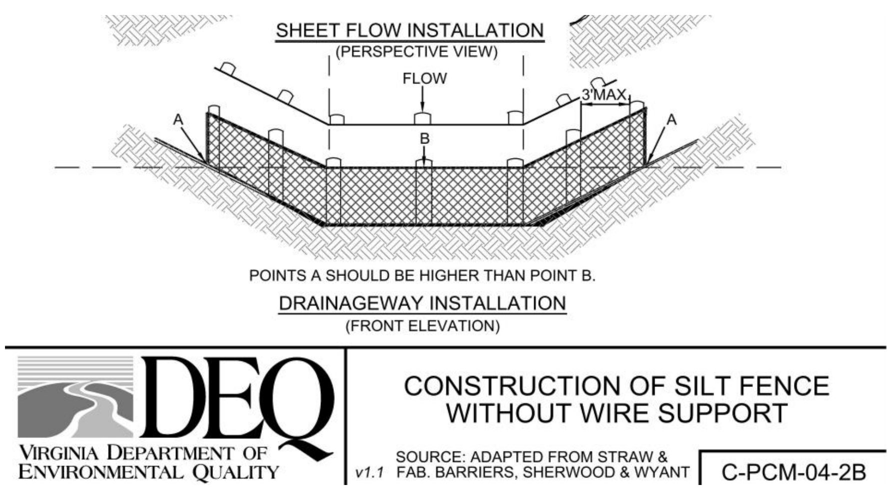

Figure 1. Silt Fence Details

Installation of the silt fence will intercept and detain even small amounts of sediment that may run off from disturbed ground areas during construction, preventing any pollutants from leaving the site. Additionally, silt fences decrease the water velocity of sheet flow and low-level channel flows, in turn decreasing erosion. During installation, any silt fence must be placed at least 5 to 7 feet beyond the bases of disturbed slopes with grades greater than 7 percent. A filter fabric consisting of woven slit film must be used for construction, and a minimum of 4 inches vertical by 4 inches horizontal of anchor trench must be used to fix the bottom of the fence into the ground. The silt fence must be maintained and replaced when clogged beyond cleaning, but the fabric should be used for at least 6 months before being discarded.

To carry stormwater runoff to the existing sediment basins on site (consistent with *C-SCM-12 Temporary Sediment Basin* standards) a *C-ECM-09 Stormwater Conveyance Channel* must run around the edge of the proposed site that is down-grade from slopes.

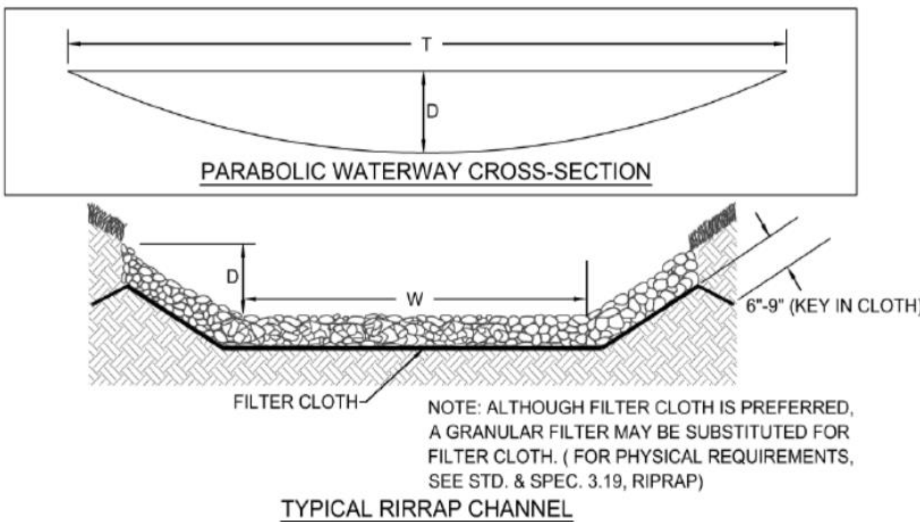

Figure 2. Stormwater Conveyance Channel Details

The stormwater conveyance channel will stand as a permanent, designed waterway, shaped, sized, and lined with appropriate vegetation or structural material such that the channel safely conveys stormwater runoff within or away from a developing area. The channel will convey runoff for sediment removal while diverting runoff from undisturbed upslope areas, conveying it around areas of earth disturbance. The exact dimensions of the channel have not yet been defined. V-shaped channels are suitable when the quantity of water to be handled is relatively small, and can be lined with grass or sod, but require riprap lining for steeper slopes. Parabolic channels are used where the quantity of water to be handled is larger and there is more space available. Riprap is also used. Combinations of grass and riprap are useful where there is continuous low flow in the channel. To prevent on-site activities from damaging assets on any other areas of the property, *C-SSM-01 Tree Preservation and Protection* should be implemented around the edge of the proposed site bordered by trees.

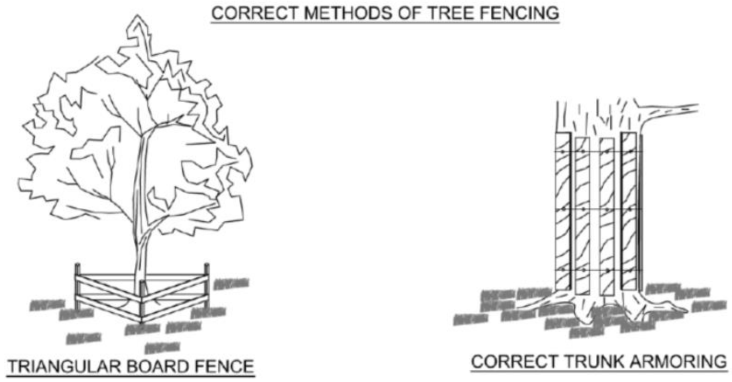

Figure 3. Tree Fencing Details

Tree preservation and protection should be implemented where the survival of desirable trees and their root zones may be affected by erosion and assist sediment control, landscape maintenance, dust and pollution control, habitat preservation, and other environmental benefits. Tree protection may also be used on previously developed lands where there are existing trees or other plant materials needing protection from damage by construction equipment or soil compaction by vehicular traffic. Construction exposes trees to a variety of stresses, both natural and man-related, which, whether on the tree or above the ground, can cause significant damage. At locations where stormwater runoff exits the conveyance channel, *C-ECM-15 Outlet Protection* should be implemented to dissipate energy, prevent erosion, and control sediment transport.

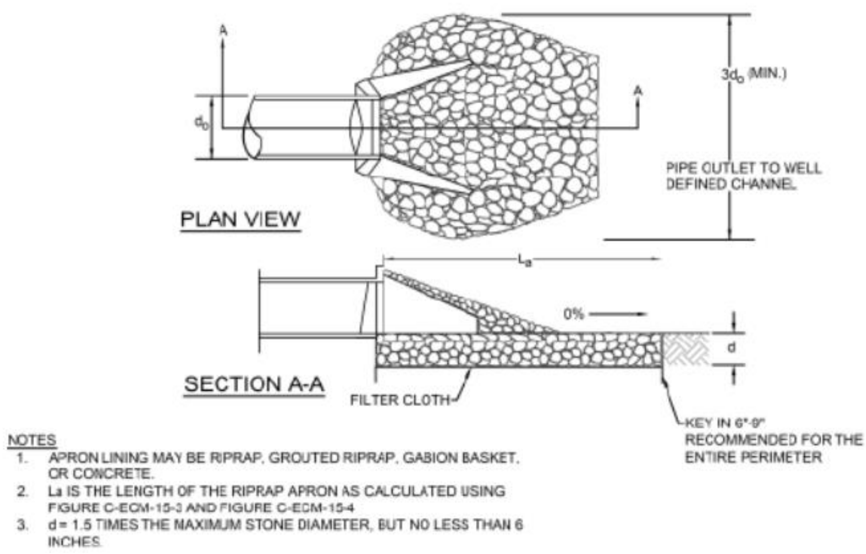

Figure 4. Outlet Protection Details

Outlet protection involves structurally lined aprons or other forms of energy-dissipating devices placed at the outlets of pipes, ditch turnouts, or paved channel sections. This prevents the formation of erosive conditions at stormwater outlets, protects the outlet structure, and minimizes the potential for downstream erosion. Before any stormwater conveyance channel can be utilized on-site, adequate outlet protection should be installed in both the conveyance channel and the receiving basin. Outlet protection should be implemented at any existing site outlets that may be affected by new erosion and sediment control plans. For proper implementation, the depth of tailwater immediately below the pipe outlet must be determined using Manning's equation and compared to the diameter of the outlet pipe to classify tailwater conditions.

2A IV EROSION & SEDIMENT CONTROL PHASE II

In accordance with the *Virginia Stormwater Management Handbook,* a phase two erosion and sediment control plan was prepared to stabilize the site after the completion of major construction activities and document site stabilization measures. The E&SC Phase 2 plan sheet can be found in Appendix D. The primary objective of post-construction erosion and sediment control measures is to stabilize disturbed areas for long-term dependence so that the site's status as a productive pollinator meadow will not be depleted. The activity on site, both construction and the storage of materials, may damage grass or other vegetation, potentially leaving the landfill cap exposed. Post construction, *C-SSM-10 Permanent Seeding* should be implemented wherever necessary to protect the integrity of the site using only species native to the locality.

2B SOLAR DESIGN

Considerations influencing the project's solar design are primarily from state and local guidelines and the Ivy Landfill's post-closure plan. The Virginia Clean Economy Act places the largest restriction on the project, confining the output of a small-scale solar facility to 3 MW AC, despite the project site having potential to produce beyond this constraint. Alternatively, a solar facility producing under 5 MW AC could be developed and utilized by the Virginia Shared Solar Program, Virginia's subscription-based community solar initiative. However, the scope of our project is to produce a design compatible with VCEA's solar requirements set for Dominion Energy.

Additional considerations for the solar design layout come from the Ivy Landfill post-closure plan. The layout must avoid the landfill gas vents and the mounting and wiring systems must be implemented without penetrating the landfill cap. Other considerations that influenced the design include slope, site access, landfill stability, tax incentives, output results and module-ballast compatibility.

We conducted research on best practices for siting solar on municipal solid waste landfills primarily from resources by the Environmental Protection Agency (EPA), the National Renewable Energy Laboratory (NREL) and the Solar Energy Industries Association (SEIA). Our research has focused on the different types of photovoltaic modules, inverters, mounting systems, and wiring as well as the inter-relationship between the photovoltaic system design and landfill cap considerations. We utilized the software Helioscope by AuroraSolar to model solar arrangements and analyze how different design considerations like tilt, azimuth, row spacing and module height influence the output and panel shading. Upon completion of the design, we estimated the energy production with NREL's PVWatts. Specific aspects of the solar design process are outlined below:

2B I SITE AREA SELECTION

The parcel, Cell 2 of the Ivy Landfill, was modeled in ArcGIS Pro using publicly available USGS LiDAR point cloud data to generate a reliable digital surface model. This model was then used to perform a series of raster analyses concerning solar irradiance, ground slope, and visibility from adjoining local residences. From the resulting data, we were able to identify portions of each landfill cell which provided the greatest solar power production potential and minimum visibility to nearby residents while remaining under the maximum ground slope for ballasted solar systems of 7-10%. These areas were determined to have the greatest development potential and will be prioritized in our design process accordingly.

The layers provided by ArcGIS were then exported and imported into HelioScope to begin evaluating and experimenting with potential site arrangements and solar panel modules. Polygon drawings bordering the solar arrangement were then drawn according to the GIS analyses and keep outs were used to create spatial buffers around the methane venting pipes throughout the cells. The completed solar arrangement can be found in Appendix D.

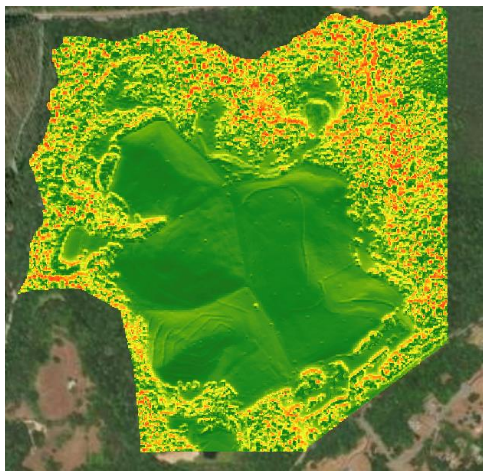

Figure 5. Solar Irradiance

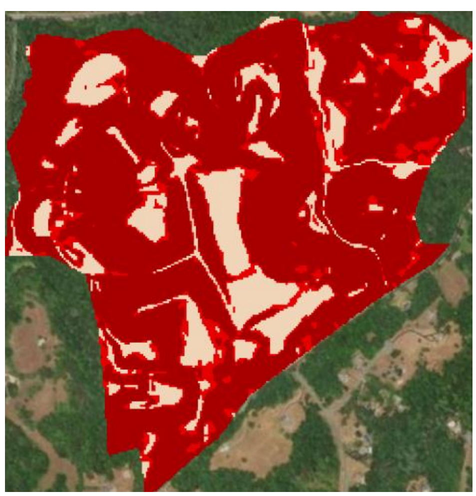

Figure 6. Slope Map

Figure 7. Visibility Analysis

2B II PANEL SELECTION

The first step in selecting a solar module for this project was deciding between the three principal PV module technologies: mono-crystalline, multi-crystalline and thin film cells. Without financial constraint, we elected to use a mono-crystalline panel because these silicon-based cells have the highest conversion rates of roughly 25%. Another factor considered when researching modules was the credits available for this project. Both the Investment Tax Credit and Production Tax Credit offer a Domestic Content Bonus for projects in which a required percentage of the total cost of manufactured products must be mined, produced or manufactured in the United States. For this reason, we explored options from some of the top American Solar Panel manufacturers: QCells, JinkoSolar and Silfab Solar.

We selected the Q.PEAK DUO XL-G11S/BFG, a mono-crystalline bifacial panel, from QCells over the other manufacturers due to a few considerations (see Appendix D for module specifications). First, QCells' manufacturing facility is closest to our project site, which allows us to minimize transportation costs and reduce the carbon footprint of our project. Moreover, the QCells module technology is readily available in the Helioscope modeling software, allowing us to efficiently integrate its specifications into our energy modeling design. When discussing our decision with our professional advisor, she said her company has successfully utilized QCells panels in previous projects, which gives us confidence in the performance and reliability of the panel.

2B III SOLAR ARRAY SPECIFICATIONS

The design process for the solar panel array involved careful consideration of how various design inputs affected energy production and panel shading. The optimal row spacing and panel height were determined through multiple iterations in Helioscope with the intention of minimizing shading losses and maximizing efficiency (see Table 1) The row spacing distances tested were 8, 10, and 12 feet. Eight feet was set as the minimum row spacing based on the width necessary to accommodate an access vehicle, and iterations of 10 and 12 feet were considered due to the potential shading effects caused by panels in close proximity to one another.

Table 1. Shading Analysis

Module height (ft)	Row spacing (ft)	# Modules	Module Cutoff	Nameplate (MWp) DC	Energy GWh	Shade Losses	Actual output (based on inverter conversion)
11.7	8	8354	35%	4.89	6.63	16.5	3.26
11.7	10	7638	32%	4.47	6.22	14.4	2.98
11.7	12	6996	25%	4.09	5.91	11.2	2.73
12.7	8	8354	35%	4.89	6.63	16.5	3.26
12.7	10	7638	32%	4.47	6.19	14.8	2.98
12.7	12	6996	25%	4.09	5.91	11.2	2.73
13.7	8	8354	35%	4.89	6.66	16.2	3.26
13.7	10	7638	32%	4.47	6.21	14.5	2.98
13.7	12	6996	25%	4.09	5.91	11.3	2.73
14.7	8	8354	35%	4.89	6.63	16.5	3.26
14.7	10	7638	32%	4.47	6.21	14.5	2.98
14.7	12	6996	25%	4.09	5.9	11.4	2.73

The panel height was set to meet the minimum requirements determined by the mounting specifications, 11.7 feet, followed by one-foot iterations up to 14.7 feet. Iterations were considered to observe whether changes in height and/or row spacing would affect the total output. Ultimately, a module height of 11.7 feet and a row spacing of 8 feet were selected. The total output decreased as the row spacing increased; therefore, it was determined that 8 feet would produce an optimal output. Variation in module height had no impact on total output, so the baseline module height of 11.7 feet was maintained. By utilizing a lower module height, we will consume significantly less material in the ballast construction, thus reducing overall costs and environmental impact.

The frame size and default orientation of the panels were determined by the racking system of the chosen panel. We chose a fixed tilt racking system as recommended by industry standards for landfill development, due to the load bearing and settlement restrictions imposed by the cap. By default, the chosen Q.PEAK DUO XL-G11S/BFG panel is oriented vertically, with 2 panels aligned vertically within each frame (2x1) frame size. The azimuth was set to 180 degrees, ensuring south-facing alignment as recommended for fixed-tilt solar modules in the northern hemisphere. To determine the optimal tilt angle, we consulted industry standards, which advise aligning the tilt with the site's latitude. Additionally, we utilized several online tilt angle calculators to refine our design, ultimately setting the tilt angle at 35 degrees based on this analysis. See Figure 8 for a depiction of the sample module set up.

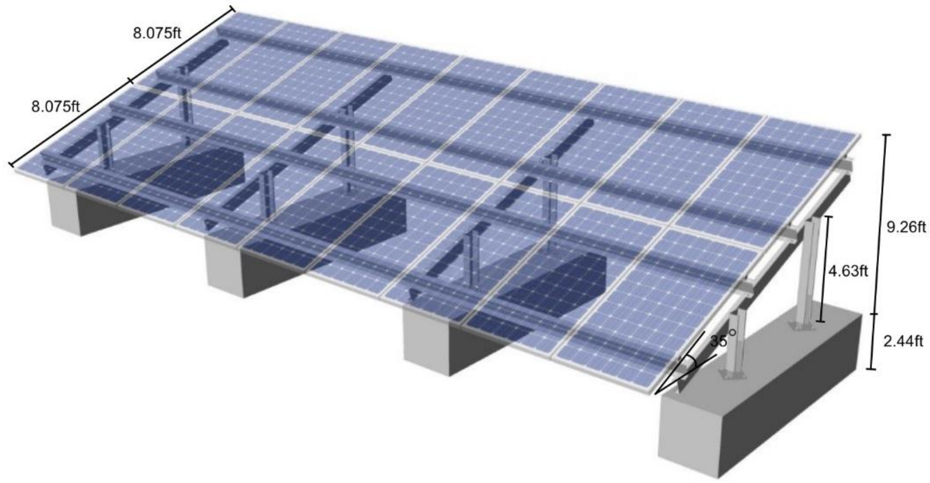

Figure 8. Sample Module Set-Up

2B IV BALLAST SELECTION

To determine the appropriate ballast, we began by identifying solar mounting manufacturers based in the United States to ensure eligibility for the Domestic Content Bonus. Using a list published by *Solar Power World*, we shortlisted five providers offering fixed tilt mounting systems. From this selection, we chose the PLP Power Base because it offers a fixed-tilt option and traditional ballast design, which aligns well with our mounting requirements. The ballast system features a prefabricated concrete base. Additionally, PLP provides extensive online documentation detailing mounting specifications and module compatibility, including confirmation that the Q.PEAK DUO XL-G11S/BFG module we selected is compatible (see Appendix D for ballast specifications).

2B V OUTPUT

During the iterative design process of determining the solar array specifications, peak power output in megawatts was given in terms of direct current (DC), as solar panels produce a direct current, due to the nature of the flow of electrons caused by the sun shining on the panels. The electric grid uses alternating current (AC), because AC power transmits power over long distances better, and can be converted to different voltages. Due to this discrepancy between solar panels and the utility grid, an inverter is required to convert the power output from DC to AC.

The inverter Sununo Plus 1.5K by AEC was selected, based on guidance from our industry advisor. The 1.5kW inverter is a string inverter that converts power from DC to AC with a conversion factor of 1.63, meaning that the power in DC is 1.63 times greater than the final output in AC. A string inverter connects to a string of solar panels, unlike the central which converts all the power produced by an array in a single unit. Utilizing a string inverter in a utility-scale project improves the system's resilience, allows for more flexibility in the design and increases the potential energy harvest. Typically, inverter ratios can range anywhere from 1 to 1.6; for this project, we chose to push the upper bounds of inverter conversion, to maximize energy production during peak solar irradiance. This decision was informed by a study done by Solar Power World called *Why Array Oversizing Makes Financial Sense*, which analyzed the impacts of different DC-to-AC to ratios.

Knowing how we would calculate our final power output was important in conducting the shading analysis, because the 3 MW limit for the solar arrangement was in accordance with the power output in AC.

We used the shading analysis feature in Helioscope to determine the optimal combination of row spacing and module height. From this analysis, the nameplate peak output, energy output, shade losses, and module cutoff via shading were calculated. The analysis revealed the module height had no effect on the final output; row spacing was the influential factor. Our analysis also revealed that while shade losses were greater with more panels, the losses were not great enough to cause a reduced output due to higher levels of shade loss. For this reason, we picked the specifications with the highest energy output of 4.89 MWp in DC, or 3.0 MWp in AC. See Table 2 below for a summary of solar array specifications.

Table 2. Solar Specifications

Solar Module	QCells, Q. Peak Duo XL-G11s.3	**Prefab Ballast**	PLP Power Base
# of Modules	8,354	**Module Tilt**	35°
Racking	Fixed Tilt Racking	**Frame Size**	2 up, 1 wide
Module Height	11.7 Ft	**Row Spacing**	8 ft
Module Azimuth	180°	**Facility Inverter**	AEC, Sununo Plus 1.5K

2B VI PVWATTS ANALYSIS

We used the National Renewable Energy Laboratory's PVWatts Calculator to estimate the energy production of the designed system. The results are shown in the tables below.

Table 3. Array Outputs

Month	Daily Average POA Irradiance (kWh/m2/day)	DC Array Output (kWh)	AC System Output (kWh)
1	3.391	383.521	369.867
2	4.207	421.893	401.642
3	4.843	514.891	479.043
4	5.777	577.182	548.468
5	6.039	602.95	580.37
6	6.608	625.632	603.97
7	6.593	642.263	620.701
8	6.258	605.129	584.595
9	5.503	534.747	515.348
10	4.569	478.717	462.176
11	3.85	402.167	388.373
12	3.12	347.444	335.145

Table 4. PVWatts Parameters

PVWatts Monthly PV Performance Data	Value
Requested Location	4576 Dick Woods Road
Location	Lat, Lng: 38.01, -78.66
Latitude (DD)	38.01
Longitude (DD)	-78.66
Elevation (m)	227.5200043
DC System Size (kW)	4887.1
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt (deg)	35
Array Azimuth (deg)	180
System Losses (%)	25.95
DC to AC Size Ratio	1.6
Inverter Efficiency (%)	97.2
Ground Coverage Ratio	0.3
Albedo	From weather file
Bifacial	No (0)
Nameplate Rating	1% (default value)

2C COST ESTIMATION

Preliminary cost estimates for the design and construction of the Ivy Landfill Solar Farm were compiled from previous similar projects and summarized in the table below.

Table 5. Cost Estimates

Site Name		**Ivy Solar Landfill**	
System Size (W DC)			4,887,100
System Size (W AC)			2,998,221
Module Assumption		Q Cells, Q.PEAK DUO XL-G11S.3	
Engingeering & Equipment	**Quantity**	**Cost ($)**	**Cost ($/ W)**
Building & Electrical Permit Fees and Inspections	---	---	---
Interconnection Fees	---	---	---
Modules	8,354	$ 1,954,840	$ 0.40
Inverters	2,173	$ 245,000	$ 0.05
Transformers	---	$ 100,000	$ 0.02
Ballast System (PLP Power Base)	2,089	$ 1,000,000	$ 0.20
Data Acquisition Systems	---	$ 150,000	$ 0.03
Structural Engineering	---	$ -	$ -
Electrical Engineering	---	$ 20,000	$ 0.01
Civil Engineering	---	$ 20,000	$ 0.01
Construction Services	**Quantity**	**Cost ($)**	**Cost ($/ W)**
Site Preparation / Civil Work	---	$ 90,000	0.02
Structural Installation	---	$ 1,000,000	0.20
Electrical Installation	---	$ 1,000,000	0.20
Landscape Buffer	---	$ 50,000	0.01
Commissioning/Capacity Testing	---	$ 80,000	0.02
2 Year Maintenance Bond	---	$ 10,000	0.01
Base Price ($, not including tax)		**$ 5,719,840**	**$ 1.19**

Listed line items are compilations of various subtasks. For example, “Civil Engineering’ consists of stormwater management, drainage mapping, and ballast cross section sheets. Certain items, such as permits and interconnection fees, were nullified as those costs will be borne by our customer, Dominion Energy. Other items, such as structural engineering, were not included as prefabricated ballasts were employed for this project. Module cost estimates were based on quotes from Green Tech Renewables based in Richmond, VA. It should be noted that these cost-estimates lean conservative as the Ivy Landfill site does not require grading changed, demolition, or other extensive civil work. Furthermore, the costs of these items will likely fluctuate over the course of project construction. The cost estimate per watt of DC power production is $1.19; however, recent project of similar size had a final cost per watt prices in the range of $1.40 to $1.50.

2D COMMUNITY ENGAGEMENT PLAN

The community engagement strategy for this project, fully detailed in Appendix C, is designed to foster trust, transparency and meaningful collaboration between developers and community members. This strategy proactively addresses key stakeholder concerns, including aesthetic impacts, land use, and energy costs, through tailored engagement activities such as surveys, town halls, focus groups and direct outreach efforts.

A strong emphasis is placed on ensuring accessibility and inclusivity, particularly for historically underserved communities, by implementing strategies that accommodate diverse needs and perspectives. Stakeholders identified for collaboration include residents, local government officials, environmental organizations, utility companies, and labor partners. By maintaining ongoing dialogue and mutual trust, the Ivy Landfill Solar Farm aims not only to generate clean energy but also to set a positive precedent for community-driven renewable energy development.

In developing this community engagement plan, we drew on academic research and best practices from institutions such as the University of New Hampshire's Center for Impact Finance, as well as existing community engagement models from projects like the Leading Light Wind offshore wind initiative. Additionally, we incorporated insights from industry leaders, including the National Renewable Energy Laboratory, to ensure our approach aligns with proven strategies for effective stakeholder engagement in renewable energy development.

3 DESIGN CONSTRAINTS

The design of the solar photovoltaic installation on the landfill site is subject to several constraints, including regulatory, environmental, material and site-specific limitations. These constraints were carefully evaluated to ensure feasibility, compliance and long-term project success.

Regulatory Constraints: The U.S. Environmental Protection Agency and the National Renewable Energy Laboratory published the document *Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills*, which served as a key resource for evaluating the technical feasibility of our design. This document outlines critical constraints and considerations for solar photovoltaic developments on closed landfills, including the general physical setting, landfill technical factors, photovoltaic technology and community support, which influenced our design process.

Additionally, the Virginia Clean Economy Act limits the capacity of small-scale solar projects to 3 MW. This restriction influenced both the system sizing and interconnection strategy of our design, ensuring that it aligns with state-level energy policies while maximizing generation potential within the allowed limit.

Environmental Constraints:

- *Stormwater Management* – The existing stormwater management plan provides the basis for our drainage strategies on site to ensure that the installation does not disrupt water flow patterns or increase erosion risks. This project received approval before 2022 when a new Virginia Department of Environmental Quality (DEQ) policy classified solar panels as impervious surfaces for post-development stormwater calculations. Therefore, our design has the option to operate under the previous policy (Appendix B). Without the addition of roads, there will be no change in the percentage of impervious area.
- *Erosion Control* – To prevent negative environmental impacts, erosion and sediment control measures were implemented in accordance with the Virginia Stormwater

Management Handbook pre-construction and we are currently working on the post-construction plan according to the same standards.

- *Ecological Considerations* – The project must ensure minimal disturbance to local habitats.

Material Constraints:

- *Landfill Cap Considerations* – The landfill's post-closure plan indicates that there cannot be penetration into the landfill cap, requiring a ballasted racking system for the solar array. The design accounts for differential settlement, which can cause structural instability over time. The racking system must also be able to withstand strong winds, potential ground movement and ensure corrosion resistance and longevity given potential exposure to landfill gases.
- *Panel Selection* – The selection of the solar module as detailed in Section 2B III considered efficiency, durability and performance under specific site conditions like shading.

Site-Specific Constraints:

- *Landfill Stability* – The landfill cap integrity, settlement risks and existing gas vents influence the foundation of the mounting system.
- *Grid Interconnection* – The site's existing electrical infrastructure and proximity to grid interconnection makes the site ideal for a solar development project for interconnection. Transformer capacity and minor grid updates may impose additional constraints.
- *Space Restrictions* – The usable land is limited by site slopes, gas vents and maintenance roads. The design balances these constraints while optimizing panel placement. While the final design does not add any access roads, the consideration of maintenance vehicles influenced the row spacing of the modules.

Community Considerations:

- *Land Use Concerns* – The project must address any concerns from local stakeholders regarding visibility and land use compatibility. The community engagement plan details our plan to address concerns and minimize visual impact.
- *Public and Regulatory Approval* – Community support and regulatory approvals are crucial for project success and must be incorporated into the design and implementation process.

4 CONCLUSION

The primary objective of this project was to design a photovoltaic system on the capped Ivy Landfill in accordance with the Virginia Clean Economy Act's guidelines for small-scale solar development. Our team successfully produced comprehensive designs for the solar array, erosion and sediment control and stormwater management, alongside a detailed community engagement strategy and cost estimate. The array is designed to generate 3 MW AC, enough to power approximately 750 homes, and features high-efficiency QCells panels mounted on PLP Power Base ballasted fixed-tilt racking system, which leverages domestic manufacturing tax credits and protects the landfill cap from disturbance. E&SC and stormwater measures were designed to protect local waterways, like Broad Axe Creek. While our design adheres to Dominion Energy's 3 MW AC capacity cap imposed by the VCEA, the site holds potential for greater output and would also be suitable for the Virginia Shared Solar Program. Overall, this project advances broader sustainability goals by supporting Virginia's clean energy transition, transforming otherwise dormant land into a productive asset, and serving as a model for community-informed renewable development.

APPENDIX A DETAILED SCHEDULE

WBS	TASK	LEAD	START	END	DAYS	% DONE	WORK DAYS
0	**Report Writing**			-			-
0.1	Interim Progress Report	Mina	Thu 10/03/24	Thu 10/17/24	15	100%	11
0.1.1	Problem statement	Mina	Thu 10/03/24	Thu 10/03/24	1	100%	1
0.1.2	Statement of Project Scope	Mina	Thu 10/03/24	Thu 10/03/24	1	100%	1
0.1.3	Project schedule	Mina	Thu 10/03/24	Thu 10/03/24	1	100%	1
0.1.4	Design Report [DRAFT #1]		Wed 1/15/25	Sun 2/09/25	26	100%	18
0.1.5	Design Report [DRAFT #2]		Mon 2/10/25	Sun 3/30/25	49	100%	35
0.1.6	Final Design Paper		Mon 3/31/25	Sun 4/27/25	28	100%	
0.2	Poster					100%	7
0.2.1	Poster Symposium Draft		Mon 3/31/25	Tue 4/08/25	9	100%	
0.2.2	Final Poster Symposium Submission		Thu 4/10/25	Wed 4/16/25	7	100%	5
1	**Assess Existing Conditions**			-			-
1.1	Topography Mapping	Group 1	Thu 10/03/24	Fri 10/04/24	2	100%	2
1.2	Identify usable land for development	Group 1	Fri 10/04/24	Tue 10/08/24	5	100%	3
1.3	Erosion & Sediment Control	Group 1	Mon 10/07/24	Fri 11/08/24	33	0%	25
1.3.1	Drainage Mapping- ToC, Longest Path, Drainage Area (pipe stuff)	Group 1	Mon 10/21/24	Tue 10/22/24	2	60%	2
1.3.2	Erosion conditions- E&SC Measures	Group 1	Mon 10/21/24	Tue 10/22/24	2	60%	2
1.3.3	Erosion Sediment Control Report	Group 1		-	2	60%	-
2	**Energy Modeling & Prelim Design**			-			-
2.1	Select most ideal solar panels based on size, capacity, weight	Group 2	Mon 10/07/24	Thu 10/24/24	18	0%	14
2.1.1	Research US incentives for certain manufacturers		Mon 10/07/24	Thu 10/10/24	4	60%	4
2.1.2	Research available panels on market		Mon 10/07/24	Thu 10/10/24	4	60%	4
2.1.3	Arrange & orient panels using modeling software		Wed 10/16/24	Thu 10/24/24	9	60%	7
2.2	Select pre-fab ballasts to support panels		Thu 10/24/24	Mon 10/28/24	5	0%	3
2.3	PV Watts		Wed 1/29/25	Wed 1/29/25	5	0%	1
3	**CAD Proposed site layout w electrical components**			-			-
3.1	Research arrangement of electrical components		Thu 10/24/24	Mon 10/28/24	5	0%	3
3.2	Draw in arrangement & components in Civil3D		Mon 10/28/24	Fri 11/08/24	12	0%	10
4	**Water Management Plan (E&SC Phase II)**			-			-
4.1	Erosion & Sediment Control		Mon 2/17/25	Sat 3/08/25	20	0%	15
4.1.1	Drainage Mapping- ToC, Longest Path, Drainage Area (pipe stuff)		Mon 2/10/25	Sun 2/16/25	7	60%	5
4.1.2	Erosion conditions- E&SC Measures Phase II		Mon 2/17/25	Wed 2/26/25	10	60%	8
4.1.3	Erosion Sediment Control Report		Mon 2/24/25	Sat 3/08/25	13	60%	10
5	**Community Engagement Plan**			-			-
5.1	Research community, demographics, & sentiments		Wed 1/29/25	Fri 2/14/25	16	0%	13
5.2	Create engagement plan memo (action plan, demographics)		Mon 2/17/25	Sun 3/30/25	41	0%	30
6	**Cost Estimating**			-			-
6.1	Determine cost of materials		Mon 2/10/25	Fri 2/28/25	15	0%	15
6.1.1	Ballast & panels		Mon 2/10/25	Fri 2/14/25	5	60%	5
6.1.2	Storm water measures		Mon 2/17/25	Fri 2/21/25	5	60%	5
6.1.3	Labor		Mon 2/24/25	Fri 2/28/25	5	60%	5
6.2	Determine hourly labor rates, equipment rental costs, etc.		Mon 3/03/25	Fri 3/07/25	5	0%	5

APPENDIX B ENGINEERING STANDARDS

See file named “Engineering Standards.pdf” in Final Report Files folder.

APPENDIX C COMMUNITY ENGAGEMENT PLAN

See file named “Community Engagement Plan.pdf” in Final Report Files folder.

APPENDIX D TECHNICAL DELIVERABLES

Sheet Set – See file name “Ivy Landfill Sheet Set.pdf” in Final Report Files folder.

Stormwater Report – See file name “Stormwater Report.pdf” in Final Report Files folder.

Solar Panel Specifications – See file name “Solar Panel Data Sheet.pdf” in Final Report Files folder.

Ballast Specifications – See file name “Ballast Assembly Instrictions.pdf” in Final Report Files folder.

APPENDIX E DESIGN EVOLUTION

See Section 2 Design Specifications for detailed report of project evolution.