"E"

Use Permit Application Packet

Soscol Ferry Solar P19-00338-UP
Planning Commission Hearing Date December 18, 2019

Renewable Properties, LLC
655 Montgomery Street, Suite 1430
San Francisco, CA 94111
www.renewprop.com

September 17, 2019

John McDowell, Principal Planner
Napa County Planning, Building & Environmental Services
1195 3rd Street, Suite 210
Napa, CA 94559

Dear John,

RE: Soscol Ferry Solar Use Permit Application (#P19-00338-UP)

As a follow-up to the Soscol Ferry Solar Use Permit incomplete letter dated August 30, 2019, please see our responses to staff comments below in the order received:

1.
    a. Per your request, updated plans which include a grading and a drainage sheet are submitted attached.
    b. We will hydroseed under/around the panels with a native forbs and seeds mix. If suitable, we will use pollinator plant habitat here.
    c. Please see the previously submitted pollinator habitat report. As discussed on the site walk, we will collaborate with our partners, Pollinator Partnership, in order to find the most suitable area to plant.
    d. For module cleaning, water will be purchased off site and trucked to the site. The trucks will deliver the water to the point of cleaning operations. Cleaning is anticipated to occur one to two times a year to ensure optimum solar absorption by removing dust particles and other buildup.
    e. Please refer to plan set to for the finishing treatment of access paths. In cases where it is not noted as gravel, the path with be compacted dirt paths.

2. Please refer to updated plan set for the 150’ creek setbacks. We will not install the fence within the setback area.

3. Per our conversation and initial submittal, we continue to request a variance to Development Standards specified under Napa Valley Business Park Specific Plan (formerly the Airport Industrial Area Specific Plan, AIASP). Due to the fact that the project has very low-impact use which requires minimal human invention including traffic, the requirement for curb, gutter, sidewalk and landscaping seems unnecessary. Additionally, given our site is at the end of the road improvement area for Soscol Ferry Road, it does not appear that this variance request will alter the character of this area. We kindly request that you consider our variance request from this improvement standard.

4. Per our conversation and initial submittal, we continue to request a variance to AIASP Development Standards for the landscaping requirement. The site will maintain natural features on the property and the appropriate setbacks.

5. As seen and discussed during our site visit, the wetlands located off-site will not be impacted by this project, as we plan to use the existing gravel access road and culvert for access to the site. Our project will not alter the existing natural condition of the wetlands. Per your request, the wetlands are being mapped and will be sent to you under separate cover here shortly.

6. Please see the attached biological resources report.

7. Please see the attached cultural resources report.

8. Per the site visit, the tree removal and preservation plan is in the process of being completed and will be sent to you under separate cover here shortly.

9. Please see the attached bridge testing report.

10. As discussed, the proposed use of our site does not need County services.

11. The Project requires minimal water. Water is only required for module cleaning, water will be purchased off site and trucked to the site. The trucks will deliver the water to the point of cleaning operations. Cleaning is anticipated to occur one to two times a year to ensure optimum solar absorption by removing dust particles and other buildup. We expect to have six (6) regular trips (one man in one truck) annually to handle operations responsibilities including solar panel washing, vegetation management and equipment preventative maintenance.

12. Security fence detail and gate locations are provided in the plan set, please refer to the plan set. Gates will comply with Fire Marshal site requirements by providing a lock and therefore access for them. RP will have an agreement with an operations and maintenance provider, they will maintain and keep the area between the fence line and the western and northern property lines manicured. The fence will be installed on the eastern and southern property lines.

13. The utility wires will be installed overhead from the site to driveway. They will be spaced appropriately as to not encroach on Suscol Creek. This scope will be part of PG&E's extension of electrical service from Soscol Ferry Road to the array location on site. Trenching plan detail for the trenches required for the plant itself are provided in the updated plan set.

14. Per our conversation, a similar decommissioning condition as to what was done for the American Canyon Project is acceptable. RP and the County will work on the decommissioning cost valuation methodology.

15. No lighting is proposed for the project.

16. As discussed, we are requesting to go before the ALUC at the same public hearing as the PC.

ENGINEERING COMMENTS – DATED 8/29/19

1. Please see the attached updated plan set.

2. Please see the attached bridge testing report.

3. Please see the attached updated plan set.

4. Please see the attached updated Stormwater Control Plan.

Please don't hesitate to reach out with any questions and/or comments. We look forward to working with you on this project.

Sincerely,

RENEWABLE PROPERTIES

Aaron Halimi
President
530-518-7669
aaron@renewprop.com

CC: Sean Kennings, Planning Consultant, LAK Associates

Renewable Properties, LLC
655 Montgomery Street, Suite 1430
San Francisco, CA 94111
www.renewprop.com

August 1, 2019

John McDowell, Principal Planner
Napa County Planning, Building & Environmental Services
1195 3rd Street, Suite 210
Napa, CA 94559

Dear John,

RE: Soscol Ferry Solar Use Permit Application Submissions

As a follow-up to the project pre-application meeting on May 16, 2019 and our recent communications over the past few months, we are writing today with our complete Use Permit Application for the Soscol Ferry Solar project. To make your application seamless, please see a list of our submissions below.

Use Permit Application Submission

Items Submitted	File Name
1.0 Application Form	1.0 RPCA Soscol Ferry Use Permit Application Form 190731
2.0 Project Narrative	2.0 RPCA Soscol Ferry Project Narrative rev5 190805 FINAL
3.0 Variance Request	3.0 RPCA Soscol Ferry Variance Request Rev5 190805 FINAL
4.0 Site Plan	4.0 RPCA Soscol Ferry Road C&D Site Plan 8.2.19
5.0 Phase 1	5.0 RPCA Soscol Ferry Phase I Rev1 7.16.19 FINAL
6.0 Stormwater Control Plan	6.0 RPCA Soscol Ferry Stormwater Control Plan Rev2 8.5.19 FINAL
7.0 1K Guarantee (CoN) Fidelity	7.0 RPCA Soscol Ferry 1K Guarantee 7.19.19
8.0 PV Health & Safety White Paper	8.0 RPCA Soscol Ferry Health & Safety White Paper (Compiled) 7.31.19 FINAL
8.1 Affidavit of Safety Expert	8.1 RPCA Soscol Ferry Cleveland Affidavit 7.31.19 FINAL
9.0 Glare Impact Report	9.0 RPCA Soscol Ferry Glare Impact Study 8.4.19 FINAL
10.0 Pollinator Program	10.0 RPCA Soscol Ferry Solar Pollinator Habitat Rev3 8.2.19 FINAL

Please don't hesitate to reach out with any questions and/or comments. We look forward to working with you on this project.

Sincerely,

RENEWABLE PROPERTIES

Aaron Halimi
President
530-518-7669

1/16/19

NAPA COUNTY

Planning, Building and Environmental Services

A Tradition of Stewardship
A Commitment to Service

USE PERMIT APPLICATION

Before you file an application…

Before you submit your application materials, and generally as early in the process as possible, you may schedule a Pre-Application Review Meeting (or Pre-App) with a member of the Planning Department Staff. The Pre-App is helpful as it will give you an opportunity to: get initial feedback from Planning Staff; discuss the specific items which will need to be included in your submittal; and, (as necessary) review the property's history and the County's environmental sensitivity mapping. Please give the Planning Division a call at 707.253.4417 or send us an email at planning@countyofnapa.org to schedule a meeting.

Contents

- ✔ General Application Form
- ✔ Use Permit Checklist of Required Application Materials
- ✔ **Signed** Indemnification Form
- ✔ **Signed** Hourly Fee Agreement
- ✔ Voluntary Best Management Practices Checklist for Development Projects Form

A Tradition of Stewardship
A Commitment to Service

Planning, Building, & Environmental Services
1195 Third Street, Suite 210
Napa, CA 94559
Main: (707) 253-4417
Fax: (707) 253-4336

PLANNING APPLICATION FORM

Applicant Information

Applicant's Name: Aaron Halimi	Phone: 530-518-7669	Fax: E-Mail Address: aaron@renewprop.com
Applicant's Mailing Address: 2914 Larkin Street	City: San Francisco	State/Zip Code: CA 94109
Property Owner's Name: (if different from Applicant) Kimbal Griggs Giles & Theresa Blodgett-Giles	Phone: 707-888-9998	Fax: E-Mail Address: teriblodgett@gmail.com
Property Owner's Mailing Address: 1605 G Street	City: Napa	State/Zip Code: CA 94558
Agent's Name: (if different from Applicant)	Phone:	Fax: E-Mail Address:
Agent's Mailing Address:	City:	State/Zip Code:
Other Representative: (Engineer/Architect)	Phone:	Fax: E-Mail Address:
Representative's Mailing Address:	City:	State/Zip Code:

Property Information

Project Name and Address: Soscol Ferry Solar, located off of Soscol Ferry Road

Assessor's Parcel Number(s): 057-170-001-000

Site of site (acreage and/or square footage): ~23 acres

General Plan Designation: Industrial Zoning: Industrial Park with an Airport Compatibility zoning overlay

Application Type[1] (For Staff Use)

Administrative	Zoning Administrator	Planning Commission/ALUC/BOS	Misc. Services
☐ Admin Viewshed	☐ Certificate of Legal Non Conformity	☐ AG Preserve Contract	☐ Use Determination
☐ Erosion Control Plan: Track II	☐ Viewshed	☐ Development Agreement	☐ Status Determination
☐ Erosion Control Plan: Track I	☐ Minor Modification	☐ Airport Land Use Consistency Determination	
☐ Fence Entry Structure Permit	☐ Road Exception	☐ General, Specific or Airport Land Use Plan Amendment	
☐ Land Division/Mergers	☐ Variance	☐ Use Permit	
☐ Site Plan Approval/Modif.		☐ Major Modification	
☐ Temporary Event: __________		☐ Variance	
☐ Very Minor Modification		☐ Zoning Map/Text Amendment	
☐ Addressing		☐ Road Exception	
☐ Signs		☐ Con. Reg. Exception	
☐ Other: ________________	☐ Other: ________________	☐ Other: ________________	☐ Other: ____________

[1]: Include corresponding submittal requirements for each application type.

Detailed Project Description (required): A typed, detailed project description is required that describes the proposed development or use(s); the existing site conditions/uses; the number, size, type and nature of any proposed residential dwelling units or total amount of new non-residential square-footage by type of use. Please refer to specific Supplemental Application submittal handouts for details to describe the project and required special studies.

Conditions of Application

1. All materials (plans, studies, documents, etc.) and representations submitted in conjunction with this form shall be considered a part of this application and publicly available for review and use, including reproduction.
2. The owner shall inform the Planning Division in writing of any changes.
3. Agent authorization: The property owner authorizes the listed agent(s) and/or other representative(s) to appear before staff, the Director, the Zoning Administrator, and Planning Commission to represent the owner's interests and to file applications, plans and other information on the owner's behalf.
4. Certification and Indemnification Form: Refer to attached form for notifications and required signature.
5. Fees: The applicant agrees to pay the County any and all processing fees imposed by Board of Supervisor Resolution No. 2018-102 including the establishment of an hourly fee application agreement and initial deposit (Section 80.250 Hourly Project Policies and Procedures). Applicant understands that fees include, but not limited to: Planning, Engineering, Public Works, and County Counsel staff time billed at an hourly rate; required Consultant service billed rates; production or reproduction of materials and exhibits; public notice advertisements; and postage. In the event the property owner is different than the applicant, the property owner must sign to indicate consent to the filing and agreement to pay fees in the event of the applicant's failure to pay said fees. Failure to pay all accumulated fees by the time of public hearing will result in a continuance.
6. This form, together with the corresponding application forms for specific permits, will become the Permit Document.

I have read and agree with all of the above. The above information and attached documents are true and correct to the best of my knowledge. All property owners holding a title interest must sign the application form. If there are more than two property owners, list their names, mailing addresses, phone numbers and signatures on a separate sheet of paper.

If you wish notice of meetings/correspondence to be sent to parties other than those listed on Page 1, please list them on a separate piece of paper.

7-23-19
Property Owner's Signature and Date

7/23/201
Property Owner's Signature and Date

Applicant/Agent Statement

I am authorized and empowered to act as an agent on behalf of the owner of record on all matters relating to this application. I declare that the foregoing is true and correct and accept that false or inaccurate owner authorization may invalidate or delay action on this application.

7/31/19
Applicant's Signature and Date

	Application Fees	
Date Received: ______	**Deposit Amount**	**$**
Received by: ______	**Flat Fee Due**	**$**
Receipt No. ______	**Total**	**$** 0.00
File No. ______	**Check No**	

Certification and Indemnification

Applicant certifies that all the information contained in this application, including all information required in the Checklist of Required Application Materials and any supplemental submitted information including, but not limited to, the information sheet, water supply/waste disposal information sheet, site plan, floor plan, building elevations, water supply/waste disposal system site plan and toxic materials list, is complete and accurate to the best of his/her knowledge. Applicant and property owner hereby authorize such investigations including access to County Assessor's Records as are deemed necessary by the County Planning Division for preparation of reports related to this application, *including the right of access to the property involved.*

Pursuant to Chapter 1.30 of the Napa County Code, as part of the application for a discretionary land use project approval for the project identified below, Applicant agrees to defend, indemnify, release and hold harmless Napa County, its agents, officers, attorneys, employees, departments, boards and commissions (hereafter collectively "County") from any claim, action or proceeding (hereafter collectively "proceeding") brought against County, the purpose of which is to attack, set aside, void or annul the discretionary project approval of the County, or an action relating to this project required by any such proceeding to be taken to comply with the California Environmental Quality Act by County, or both. This indemnification shall include, but not be limited to damages awarded against the County, if any, and cost of suit, attorneys' fees, and other liabilities and expenses incurred in connection with such proceeding that relate to this discretionary approval or an action related to this project taken to comply with CEQA whether incurred by the Applicant, the County, and/or the parties initiating or bringing such proceeding. Applicant further agrees to indemnify the County for all of County's costs, attorneys' fees, and damages, which the County incurs in enforcing this indemnification agreement.

Applicant further agrees, as a condition of project approval, to defend, indemnify and hold harmless the County for all costs incurred in additional investigation of or study of, or for supplementing, redrafting, revising, or amending any document (such as an EIR, negative declaration, specific plan, or general plan amendment) if made necessary by said proceeding and if the Applicant desires to pursue securing approvals which are conditioned on the approval of such documents.

In the event any such proceeding is brought, County shall promptly notify the Applicant of the proceeding, and County shall cooperate fully in the defense. If County fails to promptly notify the Applicant of the proceeding, or if County fails to cooperate fully in the defense, the Applicant shall not thereafter be responsible to defend, indemnify, or hold harmless the County. The County shall retain the right to participate in the defense of the proceeding if it bears its own attorneys' fees and costs, and defends the action in good faith. The Applicant shall not be required to pay or perform any settlement unless the settlement is approved by the Applicant.

Kimbal Griggs Giles	Aaron Halimi
Print Name of Property Owner	
[signature] 7-23-19	[signature] 7/31/19
Signature of Property Owner / Date	Signature of Applicant / Date

Renewable Properties, LLC
655 Montgomery Street, Suite 1430
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www.renewprop.com

John McDowell, Principal Planner
Napa County Planning, Building & Environmental Services
1195 3rd Street, Suite 210
Napa, CA 94559

RE: Soscol Ferry Solar – Project Narrative

Dear John,

On behalf of RP Napa Solar 2, LLC, we submit this letter as a description of the Soscol Ferry Project ("Project"), a small-scale utility solar project located on approximately 15 acres of a +/-22-acre parcel of land in Napa County, CA (the "Project"). The Project site is approximately 700 feet south of Soscol Ferry Road (APN 057-170-001; "Property"), adjacent to the Napa Sanitation District. We have entered into a purchase agreement with the property owners (Kimbal Griggs Giles and Therese Blodgett-Giles) to facilitate the development of a small-scale, utility solar power generation facility.

The Project consists of two arrays and will generate a total of approximately 2 megawatts (MW) AC (3.0 MW DC) of clean, reliable solar energy when complete. The Project will interconnect to PG&E's pre-existing electrical distribution system, which is already located on-site. The power generated from this facility will be sold to Marin Clean Energy (MCE) through a long-term Power Purchase Agreement (PPA). Electricity generated from the Project will power roughly 750 homes per year.

The Project will utilize approximately 7,896 solar modules and 16 string inverters which convert the sun's energy into useable AC power. Single axis tracking technology will be utilized to allow the modules to efficiently track the sun throughout the day and maximize the efficiency of solar collection. The modules will be mounted on a steel racking system, which will be anchored into the ground using driven steel piers. The overall height of the array will be no more than 8 feet tall.

The Property has a General Plan designation of Industrial and the zoning is IP (Industrial Park) with an Airport Compatibility overlay. The property is currently dry farmed and planted with grapes that are near the end of their useful life. The property is an orphaned, irregularly shaped parcel with no road frontage (with the exception of the 80-foot-wide entrance) or visibility from Soscol Ferry Road to the North or Devlin Road/Highway 29 to the east, making it an ideal site for solar.

The Project will only use approximately 15 acres (68%) of the 22-acre parcel for solar and will leave the balance of the site preserved (32%). Although sited in an industrial area, the Project proposes the continued agricultural use by incorporating a pollinator habitat and limited animal grazing.

The Project, in partnership with the Pollinator Partnership, is actively designing a plan to create a pollinator plant meadow, that will not only enhance the biological diversity of the parcel but will in addition provide some benefits to the neighboring parcels and wineries. Please see the attached

Pollinator Habitat Benefits Report from the Pollinator Partnership – an industry leading pollinator non-profit. Some relevant highlights are below:

- The Project will be directly beneficial to the environment and agriculture by creating more heterogeneous landscapes and by providing habitat that can enhance ecosystem services and crop yields, while also increasing biodiversity. Rather than being a threat to agricultural production, solar can be part of the solution. By integrating pollinator habitat within solar arrays, sites can be multi-functional—delivering clean, renewable energy as well as ecosystem services to agriculture and wider conservation benefits.

- The Project could provide multiple benefits to local agricultural operations, including vineyards (e.g., Carneros and Suscol Ridge areas), and the ecology of adjacent lands, some of which are riparian waterways. These benefits include increased soil health, reduced storm water runoff, reduced erosion, greater soil moisture retention, enhanced carbon sequestration, and increased biodiversity and ecosystem function.

- Solar installations that integrate long-term quality pollinator habitat, comprised of native plant species, can be directly beneficial to the agricultural landscape. These efforts create heterogeneity in the landscape and provide habitat that can enhance ecosystem services, increase crop yields, and sustainability of production while also benefiting natural ecosystems and conservation of biodiversity (Montag et al., 2016; Walston et al., 2018).

- The many potential benefits that the Soscol Ferry Solar Project native pollinator installation will have for surrounding agricultural endeavors include those that produce direct economic benefits to the surrounding crops from enhanced biocontrol, as well as other benefits, such as improved storm water retention, reduced erosion, and soil quality improvement. To the wider surrounding landscape, the solar-pollinator plantings at the site will improve water quality, increase carbon sequestration, create biodiversity reservoirs with increased plant and wildlife habitat, provide forage for native and honey bees, and improve landscape aesthetics.

- Much of the agricultural operations within 3 miles of the proposed site are vineyards producing wine grapes. While wine grapes do not require insect pollination, there are many significant benefits of having nearby pollinator habitat. Pollinator habitat will benefit local vineyards by increasing the natural enemies of pests. This increase of beneficial insects also deters avian pests that prefer to eat wine grapes. Instead, birds will predate the beneficial insects resulting in less impact on the crop. Additionally, studies have found that despite the commercial grape vine (Vitis vinifera L.) being self-pollinating, vintners observed an increase of crop yield with the increase of functional biodiversity (Richards AJ, 2001).

- Other benefits that cannot be monetized with current information include improved storm water retention, soil quality improvement, reduced erosion, greater plant and wildlife biodiversity, and improved aesthetics. To the wider, surrounding landscape, the solar-pollinator plantings at the site will improve water quality, increase carbon sequestration, create biodiversity reservoirs, reduce the need for farmers to create ecosystem service habitat in the immediate area, provide forage for native bees and honey bees, and improve landscape aesthetics.

- This Project would also benefit Suscol Creek, which runs directly north of the Property to the Napa River, approximately 2,400 feet to the west. The installation of pollinator habitat in the form of buffer strips, hedgerows, and meadows helps to mitigate nonpoint source pollution from industrial and agricultural areas. In particular, these types of riparian restoration elements can help prevent an influx of Nitrogen and Phosphorus inputs that can be detrimental to the local watershed (Clausen et al, 2000; Peterjohn and Correll, 1984).

The Project will also be available for sheep or cattle grazing as needed. Finally, it's important to note that solar is a temporary use – it does not permanently change the underlying land, soil condition, or land use and the site will be fully restored to its original condition at the end of the Project's useful life.

As you're aware, the Project's viability depends on a variation request from the Napa Valley Business Park Specific Plan standards. The variation request is enclosed with this application under separate cover. The variation request includes that access to the Property be classified as a Special Purpose Way by the Engineering and Fire Departments, as identified during our pre-application meeting on May 16, 2019. Based on feedback from Engineering Manager, Patrick Ryan, this road classification can only be made if the existing bridge (which we plan to leave "as is" as part of this project) meets certain testing and loading requirements. Renewable Properties has engaged a local professional engineer to conduct these tests and their report is forthcoming.

Once you've had an opportunity to review the information provided, please let me know when we can schedule a meeting to further discuss the Project, appropriate next steps, and a path forward. I look forward to hearing from you.

Sincerely,

RENEWABLE PROPERTIES

Aaron Halimi
President

Renewable Properties, LLC
655 Montgomery Street, Suite 1430
San Francisco, CA 94111
www.renewprop.com

August 5, 2019

John McDowell, Principal Planner
Napa County Planning, Building & Environmental Services
1195 3rd Street, Suite 210
Napa, CA 94559

RE: Soscol Ferry Solar Variation Request

Dear John,

As part of our Use Permit Application for the Soscol Ferry Solar Project ("Project"), RP Napa Solar 2, LLC requests a variation to the development standards for projects within the Napa Valley Airport Industrial Area Specific Plan (AIASP) area pursuant to Chapter 18.40 of the Napa County Code. The Project's variation request includes but is not limited to deviations from the setback, landscaping, coverage and street/road/parking/walkway standards.

As detailed below and subject to staff's further input, the Planning Commission can make the requisite findings in order to grant the variation request under Chapter 18.40:

Napa County Code Section 18.40.250, subd. (D)(1) – Variation to Development Standards

a. The development plan results in a project that is superior in terms of design and environmental impacts when compared to a project processed under the development standards specified by this chapter.

> Analysis: The Industrial Park zoning district allows a wide variety of heavy industrial uses. However, the Project consists of low intensity solar arrays with relatively less environmental impacts compared with the typical projects processed under the development standards.
>
> In light of the negligible traffic generated by the Project and maintaining the permeable features of the project site (including roadways), the Project is superior in terms of design and environmental impacts when compared with the Project processed under the development standards. Specifically, imposing the road and parking improvements required by the Code would result in more paving and impervious surfaces on the site, which increases aesthetic and environmental impacts. In contrast, the proposed variation will improve long-term hydrology and water quality resources.
>
> In addition, a project that meets the 150-foot Suscol Creek setback is not required to enhance the environment surrounding the creek. However, this project will

install a pollinator plant meadow throughout the project area, which will enhance the natural habitat of the creek and surrounding riparian area and improve biodiversity in the area.

b. The development plan results in a cohesive design and treatment of the site, including architecture, landscaping, signage and lighting.

Analysis: The Project is a very low-impact use which requires minimal human intervention. The Project does not require the development of any buildings, landscaping, signage, or lighting. The only structures part of the project are solar arrays resulting in a uniform orientation. In addition, The Project has a high-quality design for a solar array installation utilizing a single axis tracking design with tier one solar modules and equipment to efficiently capture the sun's energy.

c. The orientation and location of buildings, structures, open space and other features of the site plan protect and enhance existing natural resources or site features including significant existing vegetation and maintain and enhance existing views from and through the site.

Analysis: The Project site is significantly setback from the buildings and structures throughout the specific plan area. Moreso, the only structures on the property are photovoltaic electric panels that are at an overall height of less than 8 feet above grade and uniform throughout the project site. Relative to the neighboring or planned industrial buildings, lighting poles, and other structures throughout the specific plan area—typically exceeding 20 feet above grade—the solar arrays would maintain existing viewsheds through the project site and would not be visible from Soscol Ferry Rd, Devlin Rd, or Highway 29.

d. The overall project is consistent with the AIASP.

Analysis: The Project is consistent with the AIASP, which was prepared in a manner consistent with the requirements of State Planning and Conservation Law, Title VII, Article 8, Section 65450. By law, the AIASP implements and must be consistent with the policies of the Napa County General Plan. General Plan Policy AG/LU-38 also provides that the AIASP, as amended, implements the General Plan in the Airport Industrial Area.

Since General Plan Policies AG/LU-29 [public utility uses implementing state programs allowed in urban and non-urban areas], CON-68 [promote renewable energy resources in industrial areas], CON-70 [increase energy produced through locally available energy sources, including establishing incentives for and removing barriers to solar resources] and CON-75 [County shall work to implement state and federal air pollution standards related to GHGs], as well as Sections 18.120.010.8

and 18.120.010.9 of the Zoning Ordinance allow the proposed project, it is consistent with the AIASP.

e. The site plan minimizes the effect of traffic on abutting streets through careful layout of the site with respect to location, dimensions of vehicular and pedestrian entrances, exit drives and walkways; through the adequate provision of off-street parking and loading facilities; through an adequate circulation pattern within the boundaries of the development; and through the surfacing and lighting of off-street parking facilities.

Analysis: The Project does not generate traffic. Nevertheless, the site plan and access minimizes the effect of traffic on abutting streets by maintaining the existing driveway.

f. The site plan shall encourage alternatives to travel by automobile where appropriate, through the provision of facilities for pedestrians and bicyclists including covered parking for bicycles and motorcycles where appropriate. Public transit stops and facilities shall be accommodated as appropriate and other incentive provisions considered which encourage non-automotive travel.

Analysis: The Project does not generate traffic, where such travel alternatives are needed or appropriate.

g. The site shall provide open space and landscaping which complement building and structures. Said open space shall be provided in a manner so as to be useful to residents, employees, or other visitors to the site. Landscaping shall be used to separate and/or screen service and storage areas, separate and/or screen parking areas from other areas, break up expanses of paved area, and define open space for usability and privacy.

Analysis: The site will maintain natural features on the property. It does not require any permanent parking areas, paved areas, or landscaping. In addition, the Project does not require any service of storage areas.

The project site is significantly setback from the neighboring buildings and structures throughout the AIASP area. More so, the only structures on the property are photovoltaic electric panels that are at an overall height of less than 8 feet above grade and uniform throughout the project site. Relative to the industrial buildings, lighting poles, and other structures throughout the specific plan area—typically exceeding 20 feet above grade—the solar arrays would maintain existing viewsheds through the project site and would not be visible from Highway 29.

h. Design of the site plan and proposed structures shall respect design principles in terms of maintaining a balance of scale, form and proportion, using design components which are harmonious and materials and colors which blend with elements of the site plan and surrounding areas. Location of structures shall take into account maintenance of view. Rooftop mechanical equipment shall be incorporated into the roof design or screened from adjacent properties. Utility installations such as trash enclosures, storage units, traffic control devices, transformer vaults, and electrical meters shall be accessible and screened.

> Analysis: The structures on the property are photovoltaic electric panels that are at an overall height of less than 8 feet above grade. Relative to the industrial buildings, lighting poles, and other structures throughout the specific plan area—typically exceeding 20 feet above grade—the solar arrays would maintain existing viewsheds through the project site and would not be visible from Highway 29. The Project would maintain a balance of scale relative to the surrounding buildings and open space areas based on the limited height of these panels and the natural features surrounding the property.

i. Signs, lighting fixtures, landscape improvements and similar common area features shall complement the site plan and avoid dominating the site and/or existing buildings on the site or overwhelming the building or structures to which they are attached. Multiple signs on a given site shall be of a consistent design theme.

> Analysis: The Project is a very low-impact use which requires minimal human intervention. The Project does not require signs, lighting fixtures or other common area features because there are no buildings or employees on site.

j. Provisions have been made for the permanent use and maintenance of parking areas and other common area fixtures used jointly by owners of the parcels included within the development plan.

> Analysis: The Project does not require parking or other common area fixtures because there are no buildings or employees on site. In addition, there is not joint ownership or use of the parcel.

We appreciate your time and consideration of this request. Please don't hesitate to reach out with any questions or comments.

We look forward to working with you on this project.

Sincerely,

RENEWABLE PROPERTIES

Aaron Halimi
President

Stormwater Control Plan for a Regulated Project

Soscol Ferry Solar

August 2019

September 2019 (Revision 1)

RP Napa Solar 2, LLC

Renewable Properties LLC

655 Montgomery Street

Suite 1430

San Francisco, California 94111

Prepared by:

Anderson Pine Corporation

1057 MacArthur Blvd. Suite 213

San Leandro, California 94577

I. Project Data

Table 1.

Project Name	**Soscol Ferry Solar**
Application Submittal Date	August 2019 (September 2019 Rev. 1)
Project Location	Soscol Ferry Road Napa, California 94559 (APN: 057-170-001-000)
Project Phase	Composite of two (2) phases.
Project Type and Description	The proposed solar project will be constructed with solar modules, which will be mounted on single axis tracking rack systems. The rack systems will be anchored to the ground by way of steel piles, typically driven 6 to 8 ft below the existing ground surface. The direct current power generated from the modules will be converted into alternating current power by string inverters and the voltage stepped-up to the interconnection voltage of 12kV at each of the two (2) power stations.
Project Total Site Area (Within the Proposed Project Fence and Gravel Road Outside of Fence)	690,518 sqft (15.9 acres)
Total New and Replaced Impervious Surface Area	187,507 sqft (4.3 acres)
Total Pre-Project Impervious Surface Area	~ 0 sqft (0.0 acres)
Total Post-Project Impervious Surface Area	187,507 sqft (4.3 acres)

II. Setting

A. PROJECT LOCATION AND DESCRIPTION

The Soscol Ferry Solar project is a small-scale utility solar project located on approximately 15.6 acres of land (proposed fenced) in Napa County, CA. Access to the project site is via Soscol Ferry Road. The project does not have a street address, it is located off of Soscol Ferry Rd, Napa, California 94559 and consists of one parcel (APN: 057-170-001-000). The project site is currently zoned as Industrial with a stream setback requirement of 150 ft from Soscol Creek.

The proposed solar project will be constructed with solar modules, which will be mounted on single axis tracking rack systems. The racking systems will be anchored to the ground by way of steel piles, typically driven 6 to 8 ft below the existing ground surface. The direct current power generated from the modules will be converted into alternating current power by string inverters and the voltage stepped-up to the interconnection voltage of 12kV at each of the two (2) power stations.

B. EXISTING SITE FEATURES AND CONDITIONS

The project site is located on mildly sloped terrain of approximately 1 - 2%, with grades sloping towards the west. Figure 2 shows the general grades and drainage directions.

The site is agriculture land with crops of vineyards / grapes. Other vegetation includes a stand of trees along Soscol Creek at the northern boundary, within the interior, and along the western boundary of the proposed project site.

Surficial soils information, per the SURRGO website are as follows:

- The NRCS soil classification are as follows:
    - Hdkr Coombs gravelly loam, 2 to 5 percent slopes
    - Hdk4 Bale clay loam, 0 to 2% percent slopes
- USCS – Primary CL.
- Hydrologic Soils Group: B, C, and D. The predominate soils group being Hydrologic Soils Group C.

C. OPPORTUNITIES AND CONSTRAINTS FOR STORMWATER CONTROL

The proposed Soscol Ferry Solar project site includes several opportunities for stormwater control:

- Relatively mild slopes of 1 - 2% and small elevation changes.
- Surface drainage travels towards the western perimeter of the project site.
- Open space between the rotating module arrays - an inherent design feature of ground-mount photovoltaic solar projects.
- Open space covered with a favorable hydrological soils group, Groups C and B.
- Boundary setbacks that will provide impervious areas.

The following are identified constraints for stormwater control:

- None. Additional constraints may arise upon additional development due diligence.

III. Low Impact Development Design Strategies

A. OPTIMIZATION OF SITE LAYOUT

Limitation of Development Envelope

The Soscol Ferry Solar project is designed to optimize land usage and energy-yield. Greater energy-yield is achieved when the arrays are spaced to avoid interrow shading or shading from adjacent structures or trees. The proposed design provides considerable energy-yield, while providing approximately 19.89 ft of pervious space between solar arrays.

Preservations of Natural Drainage Features

The proposed solar development utilizes the existing topography and favorable natural drainage features. The existing drainage paths identified in Figure 2 will be maintained post-construction.

Setbacks from Creeks, Wetlands, and Riparian Habitats

Soscol Creek runs along the northern boundary of the site. Our proposed project arrays will be setback from the creek a minimum of 150 ft.

The design also includes a self-retaining area of approximately 6.5 ft in minimum width, which will run along the western outer edge on the proposed 12ft – wide aggregate-based road.

Minimization of Imperviousness

Imperviousness is minimized by utilizing W-shape posts, which are driven directly into the ground. This typical ground-mount solar design feature provides a smaller impervious footprint than ballasted foundations. The elevated modules will also allow rainfall to reach the grassed-covered soil beneath the modules.

B. USE OF PERMEABLE PAVEMENTS

The project will incorporate grassed covering within the array field and along the western edge on the proposed 12ft-wide aggregate-based road. The two (2) proposed power stations of approximately 314 sqft each (accounting for less than 0.1% of the proposed fenced area), will be constructed on reinforced concrete and will drain onto the surrounding grass covering.

C. DISPERSAL OF RUNOFF TO PERVIOUS AREAS

Runoff from the solar arrays will disperse onto the grassed-covered space between and underneath the arrays. Runoff from the proposed aggregate-surfaced road will be dispersed onto a grassed-covered area of approximately 6.5 ft in width. Runoff from the two (2) proposed power stations will be dispersed onto the surrounding grassed-covered land.

D. STORMWATER CONTROL MEASURES

Proposed stormwater control measure includes maintaining the existing grass covering. This control measure is similar to CASQA's BMP, *Vegetated Buffer Strip, TC-31* (see Appendix), and is fitting for the proposed site for the following reasons:

- The existing ~1% slopes on the site are within the applicable range (1% - 15%).
- Low runoff flow velocities are anticipated.
- Low pervious to impervious ratio.

Some constraints associated with grass covering are as follows:

- Attenuation of runoff rates and volume is limited for large events.

IV. Documentation of Drainage Design

A. DESCRIPTIONS OF DRAINAGE MANAGEMENT AREA

Table of Drainage Management Areas

Table 2.

DMA Name	Surface Type	Descriptions	Drains to	Area, sqft (acres)
Module Arrays	Glass-Covered – Impervious	Rows of elevated modules of approximately 6.5 ft in width and various lengths.	Array Inter-Row Spacing	170,595 sqft (3.92 acres)
Array Inter-Row Area	Grass-Covered – Pervious	Grass-covered area between module arrays.	Self - Retaining	342,023 sqft (7.85 acres)
12 ft – Wide Gravel Access Road	Aggregate-Surfaced – Impervious	Access road composed of an aggregate surface.	Min. 6.5 ft Wide Grass-Covered Area	16,283 sqft (0.37 acres)
Min. 6.5 ft Wide Grass-Covered Area	Grass-Covered – Pervious	Grass-covered area along the western edge of the road.	Self - Retaining	8,778 sqft (0.20 acres)
Power Stations	Concrete – Impervious	Two (2) power stations atop a concrete pad.	Grassed-Covered Area Surrounding PS	629 sqft (0.014 acres)
Min. Grassed-Covered Area Surrounding PS	Grass-Covered – Pervious	Grassed-covered area downslope of power stations.	Self - Retaining	314.5 sqft (0.007 acres)

B. TABULATIONS

Information Summary of Bioretention Facility Design

Not applicable

Self-Treating Areas

Not applicable

Self-Retaining Areas

Table 3.

DMA Name	Area, sqft (acres)
Array Inter-Row Area	342,023 sqft (7.85 acres)
Min. 6.5 ft Wide Grass-Covered Area	8,778 sqft (0.20 acres)
Min. Grassed-Covered Area Surrounding PS	314.5 sqft (0.007 acres)

Areas Draining to Self-Retaining Areas

Table 4.

DMA Name	Area (acres)	Post-Project Surface Type	Runoff Factor	Area x Runoff Factor [A]	Receiving Self-Retaining DMA	Receiving Self-Retaining DMA Area [B]	Ratio [A]/[B]
Module Arrays	3.92	Glass - Covered	1.0	3.92	Array Inter-Row Area	7.85	0.50 : 1
12 ft – Wide Gravel Access Road	0.37	Aggregate-Surfaced Road	1.0	0.37	Min. 6.5 ft - Wide Grass-Covered Area	0.20	1.85 : 1
Power Stations	0.014	Concrete	1.0	0.014	Min. Grassed-Covered Area Surrounding PS	0.007	2 : 1

Areas Draining to Bioretention Facilities

Not applicable

C. SIZING CALCULATIONS

The project does not propose alternative treatments method to the those proposed in the BASMAA Post-Construction Manual. The project proposes BASMAA Post-Construction Manual treatment methods that were developed in accordance with Phase II Small MS4 General Permit, 2013-0001-DWQ.

V. Source Control Measures

A. SITE ACTIVITIES AND POTENTIAL SOURCES OF POLLUTANTS

The proposed solar project will be constructed with solar modules, which will be mounted on single axis tracking rack systems. The rack systems will be anchored to the ground by way of steel piles, typically driven 6 to 8 ft below the existing ground surface. The direct current power generated from the modules will be converted into alternating current power by string inverters and the voltage stepped-up to the interconnection voltage of 12kV at each of the two (2) power stations.

The relatively simple solar farm construction and operation does not yield identified potential sources of pollutants.

B. SOURCE CONTROL TABLE

Table 5. - Not Applicable

Potential Source of Runoff Pollutants	Structural Source Control BMPs	Operational Source Control BMPs
None Identified		

C. FEATURES, MATERIALS AND METHODS OF CONSTRUCTION OF SOURCE CONTROL BMPS

Not applicable.

VI. Stormwater Facility Maintenance

A. OWNERSHIP AND RESPONSIBILITY FOR MAINTENANCE IN PERPETUITY

RP Napa Solar 2, LLC will own and operate the solar project for the life of the facility. RP Napa Solar 2, LLC will enter into various agreements with local service providers to ensure the solar project operates in a safe and reliable manner. RP Napa Solar 2, LLC is a wholly owned subsidiary of Renewable Properties, LLC.

RP Napa Solar 2, LLC accepts responsibility for interim operation and maintenance of stormwater treatment and flow-control facilities until such time as this responsibility is formally transferred to a subsequent owner.

B. SUMMARY OF MAINTENANCE REQUIREMENTS FOR EACH STORMWATER FACILITY

Typical maintenance requirements for the grass-covered stormwater management solutions are as follows:

- Inspection of coverage for damage
- Mowing
- Inspection for long-standing water / pools for debris accumulation.

To ensure that the minimum 6.5 ft-wide grassed-cover area, located on the western edge of the road, and that the grassed-covered inter-row space between modules is maintained in good hydrologic condition (75% + ground cover), the following operational practices will be adhered to:

- Grass-covered ground cover will be actively maintained as noted above and routinely inspected for damage and erosion.
- Place native grass seed mixes to maintain a good hydrologic condition.
- Best management practices will be utilized to prevent erosion of soil during seed growth.

VII. Construction Checklist

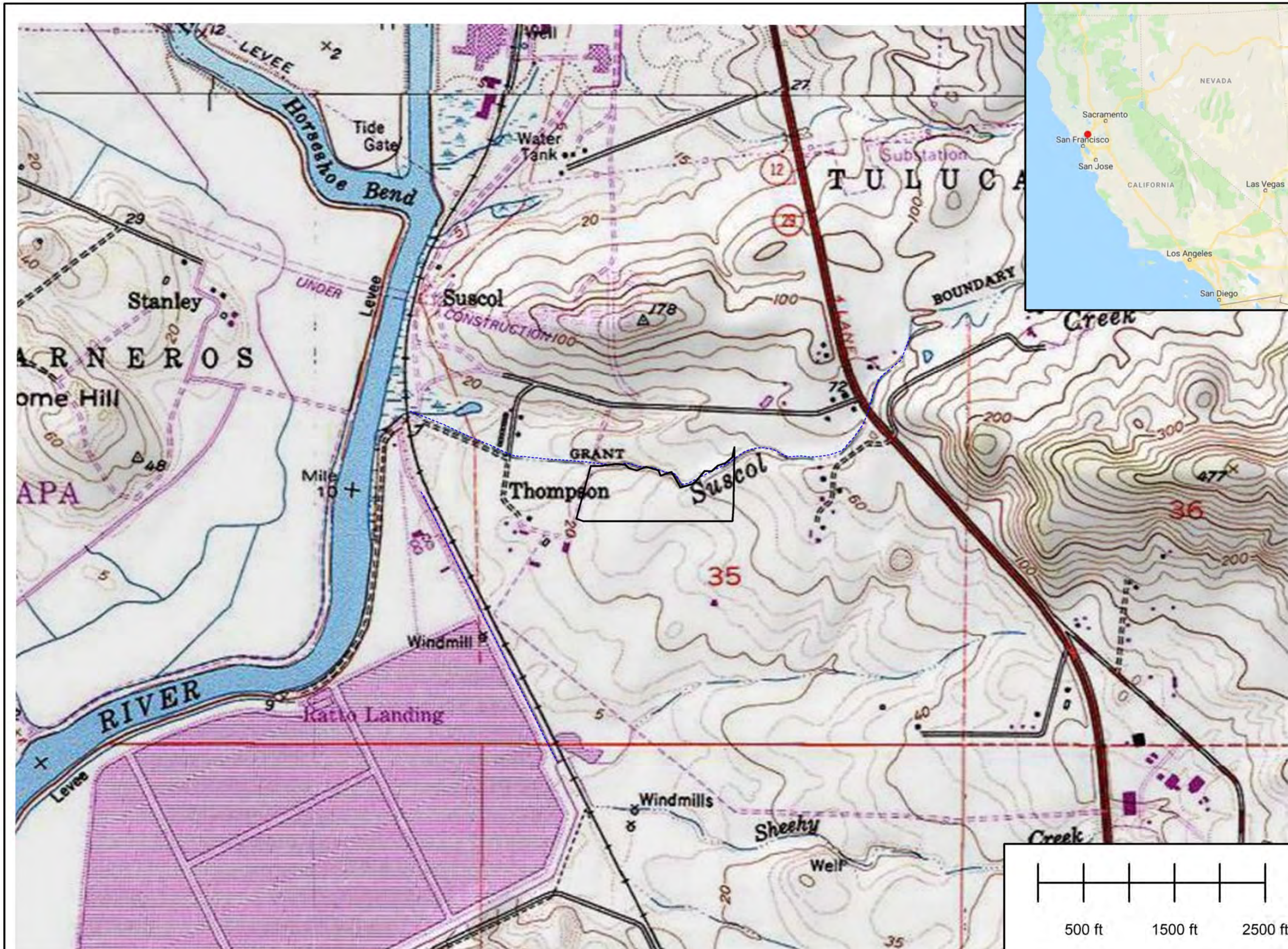
Table 6. - Not Applicable

Page Number in Stormwater Control Plan	Source Control Measure	See Plan Sheet

VIII. Certifications

The preliminary design of stormwater treatment facilities and other stormwater pollution control measures in this plan are in accordance with the current edition of the BASMAA *Post-Construction Manual.*

IX. Figures



ANDERSON PINE

1057 MACARTHUR BLVD.
STE #213
SAN LEANDRO, CA 94577

N

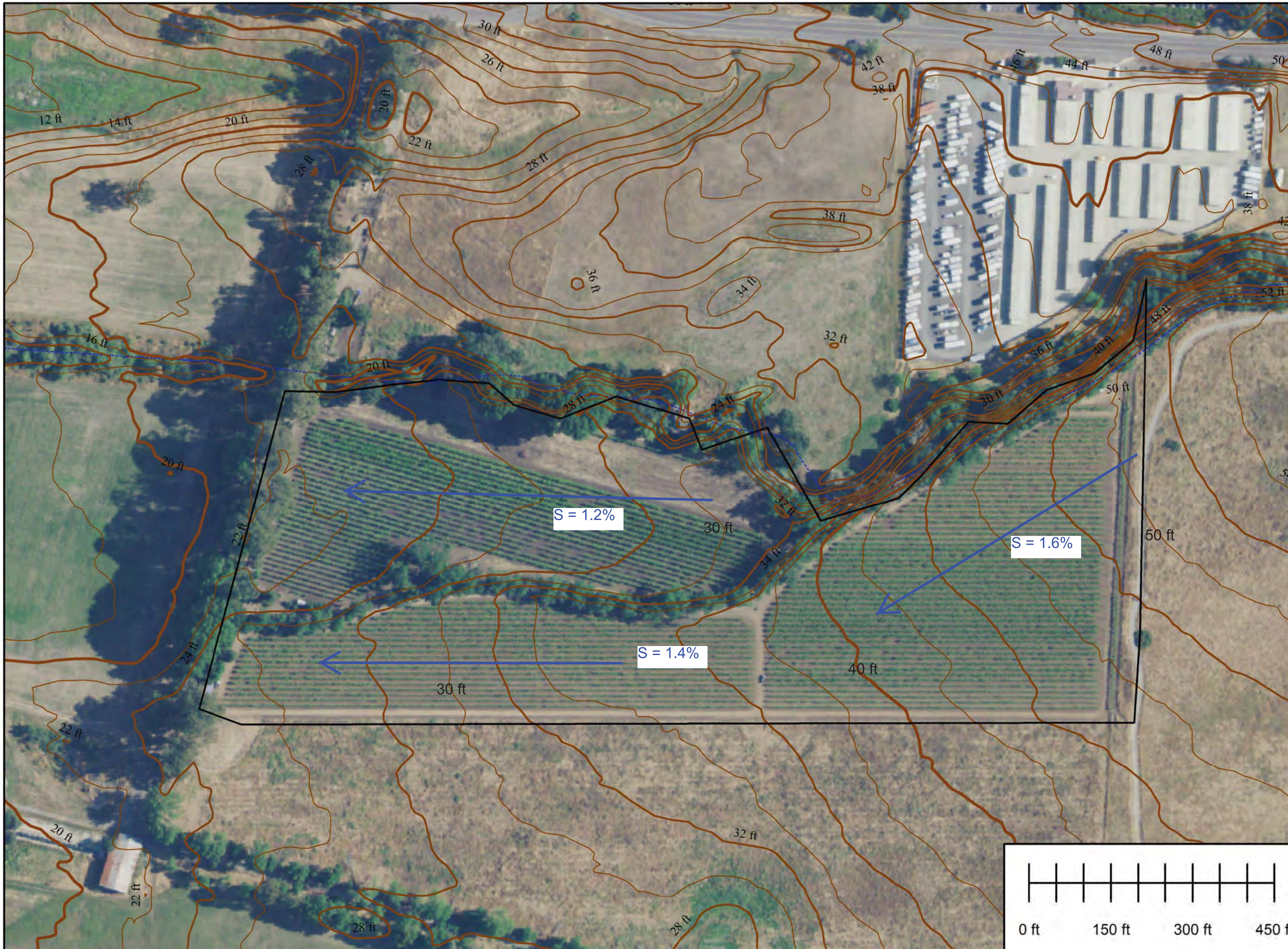
Soscol Ferry Solar

Napa County, CA

Property Boundary
NHD - Linear

Location / Vicinity

Figure 1



ANDERSON PINE

1057 MACARTHUR BLVD.
STE #213
SAN LEANDRO, CA 94577

Soscol Ferry Solar

Napa County, CA

Existing Conditions

Figure 2

ANDERSON PINE

1057 MACARTHUR BLVD.
STE #213
SAN LEANDRO, CA 94577

N

Soscol Ferry Solar

Napa County, CA

Property Boundary
NHD - Linear

Proposed Conditions

Figure 3

X. Appendices

APPENDIX A – CASQA, VEGETATED BUFFER STRIP, TC-31

Design Considerations

- Tributary Area
- Slope
- Water Availability
- Aesthetics

Description

Grassed buffer strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure. Consequently, there is little resistance to their use.

California Experience

Caltrans constructed and monitored three vegetated buffer strips in southern California and is currently evaluating their performance at eight additional sites statewide. These strips were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the southern California sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- Buffers require minimal maintenance activity (generally just erosion prevention and mowing).
- If properly designed, vegetated, and operated, buffer strips can provide reliable water quality benefits in conjunction with high aesthetic appeal.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	●
☑	Trash	▲
☑	Metals	■
☑	Bacteria	●
☑	Oil and Grease	■
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

- Flow characteristics and vegetation type and density can be closely controlled to maximize BMP effectiveness.
- Roadside shoulders act as effective buffer strips when slope and length meet criteria described below.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Buffer strips cannot treat a very large drainage area.
- A thick vegetative cover is needed for these practices to function properly.
- Buffer or vegetative filter length must be adequate and flow characteristics acceptable or water quality performance can be severely limited.
- Vegetative buffers may not provide treatment for dissolved constituents except to the extent that flows across the vegetated surface are infiltrated into the soil profile.
- This technology does not provide significant attenuation of the increased volume and flow rate of runoff during intense rain events.

Design and Sizing Guidelines

- Maximum length (in the direction of flow towards the buffer) of the tributary area should be 60 feet.
- Slopes should not exceed 15%.
- Minimum length (in direction of flow) is 15 feet.
- Width should be the same as the tributary area.
- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified. Vegetation whose growing season corresponds to the wet season is preferred.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install strips at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be required.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

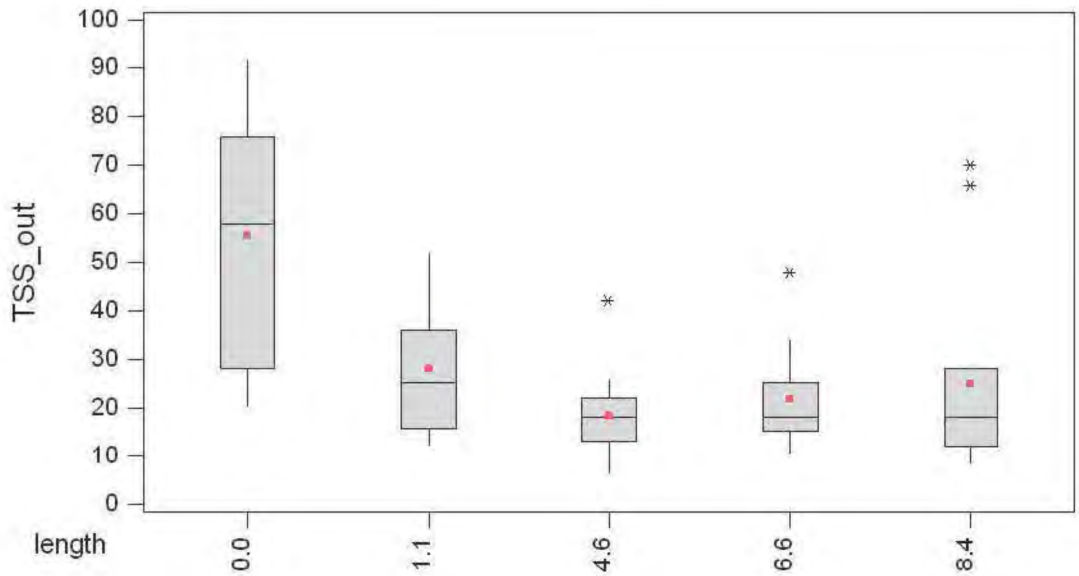
Vegetated buffer strips tend to provide somewhat better treatment of stormwater runoff than swales and have fewer tendencies for channelization or erosion. Table 1 documents the pollutant removal observed in a recent study by Caltrans (2002) based on three sites in southern California. The column labeled "Significance" is the probability that the mean influent and effluent EMCs are not significantly different based on an analysis of variance.

The removal of sediment and dissolved metals was comparable to that observed in much more complex controls. Reduction in nitrogen was not significant and all of the sites exported phosphorus for the entire study period. This may have been the result of using salt grass, a warm weather species that is dormant during the wet season, and which leaches phosphorus when dormant.

Another Caltrans study (unpublished) of vegetated highway shoulders as buffer strips also found substantial reductions often within a very short distance of the edge of pavement. Figure 1 presents a box and whisker plot of the concentrations of TSS in highway runoff after traveling various distances (shown in meters) through a vegetated filter strip with a slope of about 10%. One can see that the TSS median concentration reaches an irreducible minimum concentration of about 20 mg/L within 5 meters of the pavement edge.

Table 1 Pollutant Reduction in a Vegetated Buffer Strip

Constituent	Mean EMC		Removal %	Significance
	Influent (mg/L)	Effluent (mg/L)		P
TSS	119	31	74	<0.000
NO_3-N	0.67	0.58	13	0.367
TKN-N	2.50	2.10	16	0.542
Total N[a]	3.17	2.68	15	-
Dissolved P	0.15	0.46	-206	0.047
Total P	0.42	0.62	-52	0.035
Total Cu	0.058	0.009	84	<0.000
Total Pb	0.046	0.006	88	<0.000
Total Zn	0.245	0.055	78	<0.000
Dissolved Cu	0.029	0.007	77	0.004
Dissolved Pb	0.004	0.002	66	0.006
Dissolved Zn	0.099	0.035	65	<0.000



Filter strips also exhibit good removal of litter and other floatables because the water depth in these systems is well below the vegetation height and consequently these materials are not easily transported through them. Unfortunately little attenuation of peak runoff rates and volumes (particularly for larger events) is normally observed, depending on the soil properties. Therefore it may be prudent to follow the strips with another practice than can reduce flooding and channel erosion downstream.

Siting Criteria

The use of buffer strips is limited to gently sloping areas where the vegetative cover is robust and diffuse, and where shallow flow characteristics are possible. The practical water quality benefits can be effectively eliminated with the occurrence of significant erosion or when flow concentration occurs across the vegetated surface. Slopes should not exceed 15 percent or be less than 1 percent. The vegetative surface should extend across the full width of the area being drained. The upstream boundary of the filter should be located contiguous to the developed area. Use of a level spreading device (vegetated berm, sawtooth concrete border, rock trench, etc) to facilitate overland sheet flow is not normally recommended because of maintenance considerations and the potential for standing water.

Filter strips are applicable in most regions, but are restricted in some situations because they consume a large amount of space relative to other practices. Filter strips are best suited to treating runoff from roads and highways, roof downspouts, small parking lots, and pervious surfaces. They are also ideal components of the "outer zone" of a stream buffer or as pretreatment to a structural practice. In arid areas, however, the cost of irrigating the grass on the practice will most likely outweigh its water quality benefits, although aesthetic considerations may be sufficient to overcome this constraint. Filter strips are generally impractical in ultra-urban areas where little pervious surface exists.

Some cold water species, such as trout, are sensitive to changes in temperature. While some treatment practices, such as wet ponds, can warm stormwater substantially, filter strips do not are not expected to increase stormwater temperatures. Thus, these practices are good for protection of cold-water streams.

Filter strips should be separated from the ground water by between 2 and 4 ft to prevent contamination and to ensure that the filter strip does not remain wet between storms.

Additional Design Guidelines

Filter strips appear to be a minimal design practice because they are basically no more than a grassed slope. In general the slope of the strip should not exceed 15fc% and the strip should be at least 15 feet long to provide water quality treatment. Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion. The top of the strip should be installed 2-5 inches below the adjacent pavement, so that vegetation and sediment accumulation at the edge of the strip does not prevent runoff from entering.

A major question that remains unresolved is how large the drainage area to a strip can be. Research has conclusively demonstrated that these are effective on roadside shoulders, where the contributing area is about twice the buffer area. They have also been installed on the perimeter of large parking lots where they performed fairly effectively; however much lower slopes may be needed to provide adequate water quality treatment.

The filter area should be densely vegetated with a mix of erosion-resistant plant species that effectively bind the soil. Native or adapted grasses, shrubs, and trees are preferred because they generally require less fertilizer and are more drought resistant than exotic plants. Runoff flow velocities should not exceed about 1 fps across the vegetated surface.

For engineered vegetative strips, the facility surface should be graded flat prior to placement of vegetation. Initial establishment of vegetation requires attentive care including appropriate watering, fertilization, and prevention of excessive flow across the facility until vegetation completely covers the area and is well established. Use of a permanent irrigation system may help provide maximal water quality performance.

In cold climates, filter strips provide a convenient area for snow storage and treatment. If used for this purpose, vegetation in the filter strip should be salt-tolerant (e.g., creeping bentgrass), and a maintenance schedule should include the removal of sand built up at the bottom of the slope. In arid or semi-arid climates, designers should specify drought-tolerant grasses to minimize irrigation requirements.

Maintenance

Filter strips require mainly vegetation management; therefore little special training is needed for maintenance crews. Typical maintenance activities and frequencies include:

- Inspect strips at least twice annually for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before major fall run-off to be sure the strip is ready for winter. However, additional inspection after periods of heavy run-off is most desirable. The strip should be checked for debris and litter and areas of sediment accumulation.

- Recent research on biofiltration swales, but likely applicable to strips (Colwell et al., 2000), indicates that grass height and mowing frequency have little impact on pollutant removal;

consequently, mowing may only be necessary once or twice a year for safety and aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in strip areas, particularly along highways. The need for litter removal should be determined through periodic inspection but litter should always be removed prior to mowing.

- Regularly inspect vegetated buffer strips for pools of standing water. Vegetated buffer strips can become a nuisance due to mosquito breeding in level spreaders (unless designed to dewater completely in 48-72 hours), in pools of standing water if obstructions develop (e.g. debris accumulation, invasive vegetation), and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available on the actual construction costs of filter strips. One rough estimate can be the cost of seed or sod, which is approximately 30¢ per ft^2 for seed or 70¢ per ft^2 for sod. This amounts to between $13,000 and $30,000 per acre of filter strip. This cost is relatively high compared with other treatment practices. However, the grassed area used as a filter strip may have been seeded or sodded even if it were not used for treatment. In these cases, the only additional cost is the design. Typical maintenance costs are about $350/acre/year (adapted from SWRPC, 1991). This cost is relatively inexpensive and, again, might overlap with regular landscape maintenance costs.

The true cost of filter strips is the land they consume. In some situations this land is available as wasted space beyond back yards or adjacent to roadsides, but this practice is cost-prohibitive when land prices are high and land could be used for other purposes.

Maintenance Cost

Maintenance of vegetated buffer strips consists mainly of vegetation management (mowing, irrigation if needed, weeding) and litter removal. Consequently the costs are quite variable depending on the frequency of these activities and the local labor rate.

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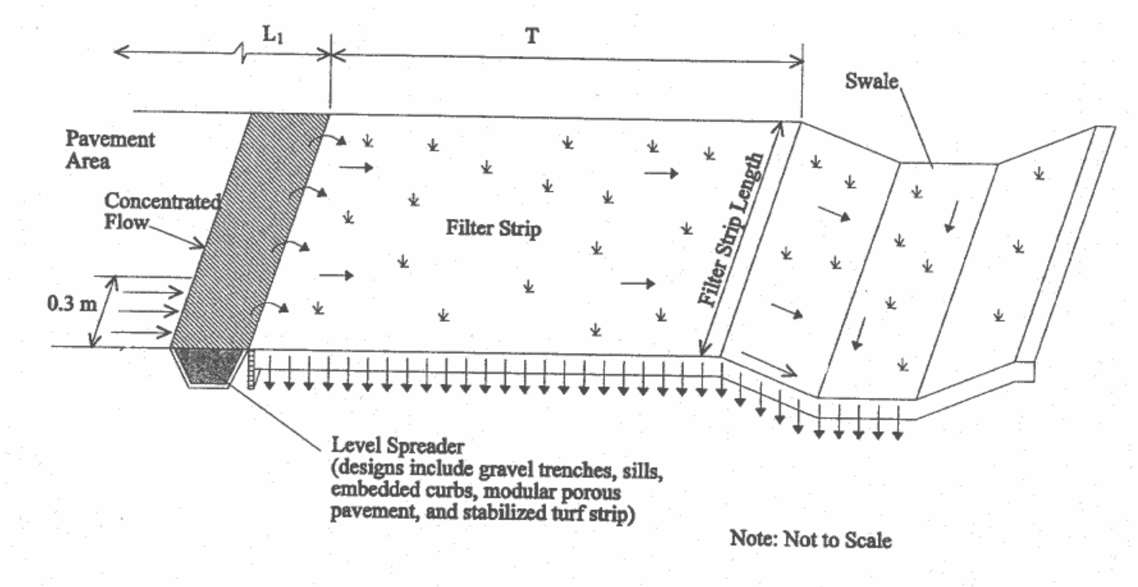
L1
T
Swale
Pavement Area
Concentrated Flow
Filter Strip
Filter Strip Length
0.3 m
Level Spreader
(designs include gravel trenches, sills, embedded curbs, modular porous pavement, and stabilized turf strip)
Note: Not to Scale

Health and Safety Impacts of Solar Photovoltaics:

A California-Focused Forward to the Health and Safety Impacts of Solar Photovoltaics white paper published by the N.C. Clean Energy Technology Center at North Carolina State University in May 2017

By: Thomas H. Cleveland, P.E., lead author of the North Carolina white paper
RE: Soscol Ferry Road Solar, a proposed 1.98 MW_{AC} PV facility in Napa, CA
Date: July 31, 2019

For the last several years North Carolina (NC) has trailed only California in the capacity of annual solar photovoltaic (PV) installed. For most of that time North Carolina's PV development was nearly entirely distribution-connected ground-mounted solar facilities, most commonly 5 MW_{AC} projects. More recently, North Carolina is developing a mixture of transmission-connected PV facilities between 20 and 75 MW_{AC} and distribution-connected facilities of 1 to 5 MW_{AC}, but still has relatively few commercial or residential PV projects. As the state quickly transitioned from zero utility-scale solar facilities to over 400 utility-scale solar facilities concerns about the health and safety impacts of photovoltaics were raised at countless public hearings across the state and in many meetings of state officials and regulators, including several NC general assembly committee meetings. These concerns led to several years of engagement on this topic by the NC Clean Energy Technology Center at North Carolina State University that resulted in a detailed, peer-reviewed university white paper on the latest scientific understanding regarding PV health and safety impacts, with a focus on North Carolina.

Naturally, there is also interest in the potential health and safety impacts of PV in California, where there is significantly more installed solar capacity than in North Carolina, in a mixture of residential, commercial, and small- and large-scale ground-mounted utility-scale solar projects. While there are massive similarities between the PV installations and their potential health and safety impacts in each state, there are some differences in policy, climate, industry practices, electricity regulation, and more that are worth highlighting. This forward is an attempt by the lead researcher and author of the North Carolina white paper to provide a supplement to the original paper that clearly demonstrates the applicability of the paper to PV in California and to offer California-specific supplements or modifications where the original paper had a North Carolina focus.

Most importantly, all the white paper's conclusions about the negligible negative health and safety impacts of photovoltaics apply fully in California, as well as anywhere in the United States. Similarly, there is nothing unique about the 1.98 MW_{AC} Soscol Ferry Road Solar project that would cause any health or safety impacts different than those discussed in the N.C. white paper.

Throughout the white paper there are instances of North Carolina-specific information, or issues where the situation in California is different than it is in North Carolina. The following is a list of the significant instances of either situation, in the order they appear in the white paper, along with the relevant California-specific information.

- Type of PV Technology Used: Crystalline silicon, Cadmium Telluride (CdTe), and CIGS are all being installed in California as they are in N.C. Since the publication of the N.C. report the author has confirmed the recent installation of utility-scale projects using CIGS modules, but these are still not common. Like in NC, the majority of the current PV installation capacity in California is crystalline silicon, also like NC these are generally Tier I modules. The Soscol Ferry Rd. project will use Tier I crystalline silicon modules.
- Design Wind Speed: The ASCE 7-2016 design wind speed in the vast majority of California, including in Napa County where the Soscol Ferry Road Solar project is located, is 90-95 MPH, which is much lower than the design wind speeds of hurricane-prone eastern N.C. where most PV development in the state is located. A few mountainous regions of California have design wind speeds over 100 MPG, however these extreme

terrains are unlikely to install ground-mounted PV systems.

- Offset Electricity Fuel Mix: The white paper includes a rough estimation that the fuel mix of the generators offset by PV energy production in N.C. is 90% natural gas and 10% coal. From this mix an estimate of the reduction in cadmium emissions due to PV was calculated. The 10% coal estimate is certainly too high for California. An offset fuel mix for California could be reasonably estimated as 100% natural gas, resulting in about 75% of the cadmium emissions savings calculated for NC.

- PV Module Recycling: The white paper included local reports from PV developers in North Carolina of recycling damaged PV modules. It is quite possible that the same is occurring in California, but the author does not have data on the current common waste management practices for damaged PV modules in California. The Electric Power Research Institute (EPRI) published two extensive reports on the Photovoltaic Module Recycling in the United States (April 2018) and Insights in Photovoltaic Recycling Processes in Europe (December 2017), which are great sources for current information on PV module recycling. The EPRI report on recycling in the U.S. states that there are commercial recyclers in the U.S. accepting and recycling PV modules, using processes not unlike those described in the white paper.

- PV Module Washing: Unlike North Carolina, many regions of California regularly experience long periods of time with little to no rain, which can result in enough accumulation of dirt on the PV modules that it justifies occasionally washing the modules to renew their performance. In North Carolina there is generally a heavy rain often enough to keep the panels clean enough to not require manual panel washing. This difference does not have an impact on the health or safety impact of the photovoltaic modules other than perhaps some increased risk of electric shock when washing the modules. Proper installation, maintenance, and washing techniques should reduce this risk to near zero.

- Vegetation Maintenance: The climate in many regions of California, including Napa County where the Soscol Ferry Road Solar project is located, cause the growth of vegetation requiring maintenance to be less vigorous than the vegetation in moist North Carolina. Thus, PV sites in California use similar vegetation maintenance techniques to North Carolina however they need to spend less time and make fewer trips to adequately maintain vegetation on site.

- California Hazardous Waste Policy:
  - As explained in the white paper, in the United States a waste material is considered hazardous waste if the results of a Toxicity Characteristic Leaching Procedure (TCLP) test find concentrations of any of 40 hazardous chemicals above the allowed EPA concentration limit for that chemical. However, in California, materials must additionally meet the more stringent Hazardous Waste Control Law (HWCL), which is like the Reduction of Hazardous Substances (ROHS) directive, adopted in February 2003 by the European Union (EU).[i]
  - In 2015, California passed SB-489 directing the CA DTSC (Department of Toxic Substances Control) to write rules to reclassify PV modules as universal waste, even if they fail TCLP. These rules exclude physically damaged, fractured, or fragmented PV modules that are no longer recognizable as PV modules.[ii] A primary goal of the legislation is to allow producers of waste PV modules to avoid difficult and costly waste determination procedures. In April 2019 the CA DTSC proposed rules to implement SB-489. After the public comment period that ended in June 2019 DTSC may adjust and adopt the rules.[iii]

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[i] *Program on Technology Innovation: Feasibility Study on Photovoltaic Module Recycling in the United States, Technical Update, April 2018*; Electric Power Research Institute (EPRI); April 2018.
[ii] ibid
[iii] (webpage) Beveridge & Diamond law firm; News alert: California Department of Toxic Substances Control Proposes Regulation Classifying Discarded Solar Panels as Universal Waste ; https://www.bdlaw.com/publications/california-department-of-toxic-substances-control-proposes-regulation-classifying-discarded-solar-panels-as-universal-waste/ (last accessed 7/22/2019)

NC CLEAN ENERGY
TECHNOLOGY CENTER

Health and Safety Impacts of Solar Photovoltaics

MAY 2017

NC STATE UNIVERSITY

Health and Safety Impacts of Solar Photovoltaics

The increasing presence of utility-scale solar photovoltaic (PV) systems (sometimes referred to as solar farms) is a rather new development in North Carolina's landscape. Due to the new and unknown nature of this technology, it is natural for communities near such developments to be concerned about health and safety impacts. Unfortunately, the quick emergence of utility-scale solar has cultivated fertile grounds for myths and half-truths about the health impacts of this technology, which can lead to unnecessary fear and conflict.

Photovoltaic (PV) technologies and solar inverters are not known to pose any significant health dangers to their neighbors. The most important dangers posed are increased highway traffic during the relative short construction period and dangers posed to trespassers of contact with high voltage equipment. This latter risk is mitigated by signage and the security measures that industry uses to deter trespassing. As will be discussed in more detail below, risks of site contamination are much less than for most other industrial uses because PV technologies employ few toxic chemicals and those used are used in very small quantities. Due to the reduction in the pollution from fossil-fuel-fired electric generators, the overall impact of solar development on human health is overwhelmingly positive. This pollution reduction results from a partial replacement of fossil-fuel fired generation by emission-free PV-generated electricity, which reduces harmful sulfur dioxide (SO_2), nitrogen oxides (NO_x), and fine particulate matter ($PM_{2.5}$). Analysis from the National Renewable Energy Laboratory and the Lawrence Berkeley National Laboratory, both affiliates of the U.S. Department of Energy, estimates the health-related air quality benefits to the southeast region from solar PV generators to be worth 8.0 ¢ per kilowatt-hour of solar generation.[1] This is in addition to the value of the electricity and suggests that the air quality benefits of solar are worth more than the electricity itself.

Even though we have only recently seen large-scale installation of PV technologies, the technology and its potential impacts have been studied since the 1950s. A combination of this solar-specific research and general scientific research has led to the scientific community having a good understanding of the science behind potential health and safety impacts of solar energy. This paper utilizes the latest scientific literature and knowledge of solar practices in N.C. to address the health and safety risks associated with solar PV technology. These risks are extremely small, far less than those associated with common activities such as driving a car, and vastly outweighed by health benefits of the generation of clean electricity.

This paper addresses the potential health and safety impacts of solar PV development in North Carolina, organized into the following four categories:

(1) Hazardous Materials
(2) Electromagnetic Fields (EMF)
(3) Electric Shock and Arc Flash
(4) Fire Safety

1. Hazardous Materials

One of the more common concerns towards solar is that the panels (referred to as "modules" in the solar industry) consist of toxic materials that endanger public health. However, as shown in this section, solar energy systems may contain small amounts of toxic materials, but these materials do not endanger public health. To understand potential toxic hazards coming from a solar project, one must understand system installation, materials used, the panel end-of-life protocols, and system operation. This section will examine these aspects of a solar farm and the potential for toxicity impacts in the following subsections:

(1.2) Project Installation/Construction
(1.2) System Components
- 1.2.1 Solar Panels: Construction and Durability
- 1.2.2 Photovoltaic technologies
  - (a) Crystalline Silicon
  - (b) Cadmium Telluride (CdTe)
  - (c) CIS/CIGS
- 1.2.3 Panel End of Life Management
- 1.2.4 Non-panel System Components

(1.3) Operations and Maintenance

1.1 Project Installation/Construction

The system installation, or construction, process does not require toxic chemicals or processes. The site is mechanically cleared of large vegetation, fences are constructed, and the land is surveyed to layout exact installation locations. Trenches for underground wiring are dug and support posts are driven into the ground. The solar panels are bolted to steel and aluminum support structures and wired together. Inverter pads are installed, and an inverter and transformer are installed on each pad. Once everything is connected, the system is tested, and only then turned on.

Figure 1: Utility-scale solar facility (5 MW_{AC}) located in Catawba County. Source: Strata Solar

1.2 System Components

1.2.1 Solar Panels: Construction and Durability

Solar PV panels typically consist of glass, polymer, aluminum, copper, and semiconductor materials that can be recovered and recycled at the end of their useful life.[2] Today there are two PV technologies used in PV panels at utility-scale solar facilities, silicon, and thin film. As of 2016, all thin film used in North Carolina solar facilities are cadmium telluride (CdTe) panels from the US manufacturer First Solar, but there are other thin film PV panels available on the market, such as Solar Frontier's CIGS panels. Crystalline silicon technology consists of silicon wafers which are made into cells and assembled into panels, thin film technologies consist of thin layers of semiconductor material deposited onto glass, polymer or metal substrates. While there are differences in the components and manufacturing processes of these two types of solar technologies, many aspects of their PV panel construction are very similar. Specifics about each type of PV chemistry as it relates to toxicity are covered in subsections a, b, and c in section 1.2.2; on crystalline silicon, cadmium telluride, and CIS/CIGS respectively. The rest of this section applies equally to both silicon and thin film panels.

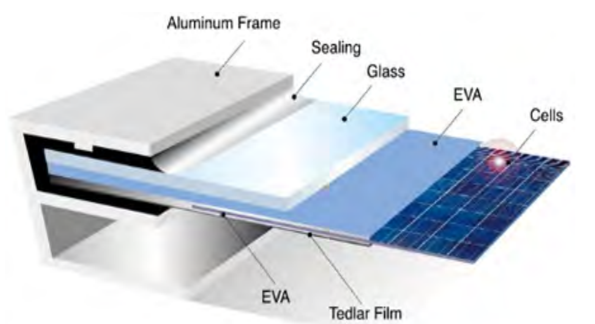

Figure 2: Components of crystalline silicon panels. The vast majority of silicon panels consist of a glass sheet on the topside with an aluminum frame providing structural support. Image Source: www.riteksolar.com.tw

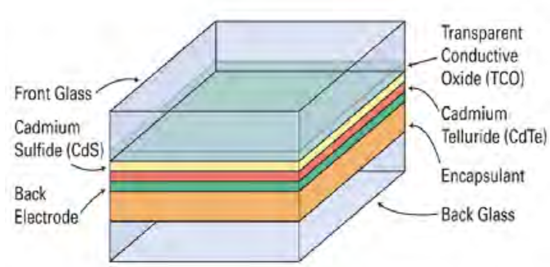

Figure 3: Layers of a common frameless thin-film panel (CdTe). Many thin film panels are frameless, including the most common thin-film panels, First Solar's CdTe. Frameless panels have protective glass on both the front and back of the panel. Layer thicknesses not to scale. Image Source: www.homepower.com

To provide decades of corrosion-free operation, PV cells in PV panels are encapsulated from air and moisture between two layers of plastic. The encapsulation layers are protected on the top with a layer of tempered glass and on the backside with a polymer sheet. Frameless modules include a protective layer of glass on the rear of the panel, which may also be tempered. The plastic ethylene-vinyl acetate (EVA) commonly provides the cell encapsulation. For decades, this same material has been used between layers of tempered glass to give car windshields and hurricane windows their great strength. In the same way that a car windshield cracks but stays intact, the EVA layers in PV panels keep broken panels intact (see Figure 4). Thus, a damaged module does not generally create small pieces of debris; instead, it largely remains together as one piece.

Figure 4: The mangled PV panels in this picture illustrate the nature of broken solar panels; the glass cracks but the panel is still in one piece. Image Source: http://img.alibaba.com/photo/115259576/broken_solar_panel.jpg

PV panels constructed with the same basic components as modern panels have been installed across the globe for well over thirty years.[3] The long-term durability and performance demonstrated over these decades, as well as the results of accelerated lifetime testing, helped lead to an industry-standard 25-year power production warranty for PV panels. These power warranties warrant a PV panel to produce at least 80% of their original nameplate production after 25 years of use. A recent SolarCity and DNV GL study reported that today's quality PV panels should be expected to reliably and efficiently produce power for thirty-five years.[4]

Local building codes require all structures, including ground mounted solar arrays, to be engineered to withstand anticipated wind speeds, as defined by the local wind speed requirements. Many racking products are available in versions engineered for wind speeds of up to 150 miles per hour, which is significantly higher than the wind speed requirement anywhere in North Carolina. The strength of PV mounting structures were demonstrated during Hurricane Sandy in 2012 and again during Hurricane Matthew in 2016. During Hurricane Sandy, the many large-scale solar facilities in New Jersey and New York at that time suffered only minor damage.[5] In the fall of 2016, the US and Caribbean experienced destructive winds and torrential rains from Hurricane Matthew, yet one leading solar tracker manufacturer reported that their numerous systems in the impacted area received zero damage from wind or flooding.[6]

In the event of a catastrophic event capable of damaging solar equipment, such as a tornado, the system will almost certainly have property insurance that will cover the cost to cleanup and repair the project. It is in the best interest of the system owner to protect their investment against such risks. It is also in their interest to get the project repaired and producing full power as soon as possible. Therefore, the investment in adequate insurance is a wise business practice for the system owner. For the same reasons, adequate insurance coverage is also generally a requirement of the bank or firm providing financing for the project.

1.2.2 Photovoltaic (PV) Technologies

a. **Crystalline Silicon**

This subsection explores the toxicity of silicon-based PV panels and concludes that they do not pose a material risk of toxicity to public health and safety. Modern crystalline silicon PV panels, which account for over 90% of solar PV panels installed today, are, more or less, a commodity product. The overwhelming majority of panels installed in North Carolina are crystalline silicon panels that are informally classified as Tier I panels. Tier I panels are from well-respected manufacturers that have a good chance of being able to honor warranty claims. Tier I panels are understood to be of high quality, with predictable performance, durability, and content. Well over 80% (by weight) of the content of a PV panel is the tempered glass front and the aluminum frame, both of which are common building materials. Most of the remaining portion are common plastics, including polyethylene terephthalate in the backsheet, EVA encapsulation of the PV cells, polyphenyl ether in the junction box, and polyethylene insulation on the wire leads. The active, working components of the system are the silicon photovoltaic cells, the small electrical leads connecting them together, and to the wires coming out of the back of the panel. The electricity generating and conducting components makeup less than 5% of the weight of most panels. The PV cell itself is nearly 100% silicon, and silicon is the second most common element in the Earth's crust. The silicon for PV cells is obtained by high-temperature processing of quartz sand (SiO_2) that removes its oxygen molecules. The refined silicon is converted to a PV cell by adding extremely small amounts of boron and phosphorus, both of which are common and of very low toxicity.

The other minor components of the PV cell are also generally benign; however, some contain lead, which is a human toxicant that is particularly harmful to young children. The minor components include an extremely thin antireflective coating (silicon nitride or titanium dioxide), a thin layer of aluminum on the rear, and thin strips of silver alloy that are screen-printed on the front and rear of cell.[7] In order for the front and rear electrodes to make effective electrical contact with the proper layer of the PV cell, other materials (called glass frit) are mixed with the silver alloy and then heated to etch the metals into the cell. This glass frit historically contains a small amount of lead (Pb) in the form of lead oxide. The 60 or 72 PV cells in a PV panel are connected by soldering thin solder-covered copper tabs from the back of one cell to the front of the next cell. Traditionally a tin-based solder containing some lead (Pb) is used, but some manufacturers have switched to lead-free solder. The glass frit and/or the solder may contain trace amounts of other metals, potentially including some with human toxicity such as cadmium. However, testing to simulate the potential for leaching from broken panels, which is discussed in more detail below, did not find a potential toxicity threat from these trace elements. Therefore, the tiny amount of lead in the grass frit and the solder is the only part of silicon PV panels with a potential to create a negative health impact. However, as described below, the very limited amount of lead involved and its strong physical and chemical attachment to other components of the PV panel means that even in worst-case scenarios the health hazard it poses is insignificant.

As with many electronic industries, the solder in silicon PV panels has historically been a lead-based solder, often 36% lead, due to the superior properties of such solder. However, recent advances in lead-free solders have spurred a trend among PV panel manufacturers to reduce or remove the lead in their panels. According to the 2015 Solar Scorecard from the Silicon Valley Toxics Coalition, a group that tracks environmental responsibility of photovoltaic panel manufacturers, fourteen companies (increased from twelve companies in 2014) manufacture PV panels certified to meet the European Restriction of

Hazardous Substances (RoHS) standard. This means that the amount of cadmium and lead in the panels they manufacture fall below the RoHS thresholds, which are set by the European Union and serve as the world's de facto standard for hazardous substances in manufactured goods.[8] The Restriction of Hazardous Substances (RoHS) standard requires that the maximum concentration found in any homogenous material in a produce is less than 0.01% cadmium and less than 0.10% lead, therefore, any solder can be no more than 0.10% lead.[9]

While some manufacturers are producing PV panels that meet the RoHS standard, there is no requirement that they do so because the RoHS Directive explicitly states that the directive does not apply to photovoltaic panels.[10] The justification for this is provided in item 17 of the current RoHS Directive: "The development of renewable forms of energy is one of the Union's key objectives, and the contribution made by renewable energy sources to environmental and climate objectives is crucial. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources (4) recalls that there should be coherence between those objectives and other Union environmental legislation. Consequently, this Directive should not prevent the development of renewable energy technologies that have no negative impact on health and the environment and that are sustainable and economically viable."

The use of lead is common in our modern economy. However, only about 0.5% of the annual lead consumption in the U.S. is for electronic solder for all uses; PV solder makes up only a tiny portion of this 0.5%. Close to 90% of lead consumption in the US is in batteries, which do not encapsulate the pounds of lead contained in each typical automotive battery. This puts the lead in batteries at great risk of leaching into the environment. Estimates for the lead in a single PV panel with lead-based solder range from 1.6 to 24 grams of lead, with 13g (less than half of an ounce) per panel seen most often in the literature.[11] At 13 g/panel[12], each panel contains one-half of the lead in a typical 12-gauge shotgun shell. This amount equates to roughly 1/750th of the lead in a single car battery. In a panel, it is all durably encapsulated from air or water for the full life of the panel.[14]

As indicated by their 20 to 30-year power warranty, PV modules are designed for a long service life, generally over 25 years. For a panel to comply with its 25-year power warranty, its internal components, including lead, must be sealed from any moisture. Otherwise, they would corrode and the panel's output would fall below power warranty levels. Thus, the lead in operating PV modules is not at risk of release to the environment during their service lifetime. In extreme experiments, researchers have shown that lead can leach from crushed or pulverized panels.[15, 16] However, more real-world tests designed to represent typical trash compaction that are used to classify waste as hazardous or non-hazardous show no danger from leaching.[17, 18] For more information about PV panel end-of-life, see the Panel Disposal section.

As illustrated throughout this section, silicon-based PV panels do not pose a material threat to public health and safety. The only aspect of the panels with potential toxicity concerns is the very small amount of lead in some panels. However, any lead in a panel is well sealed from environmental exposure for the operating lifetime of the solar panel and thus not at risk of release into the environment.

b. Cadmium Telluride (CdTe) PV Panels

This subsection examines the components of a cadmium telluride (CdTe) PV panel. Research demonstrates that they pose negligible toxicity risk to public health and safety while significantly reducing the public's exposure to cadmium by reducing coal emissions. As of mid-2016, a few hundred MWs of cadmium telluride (CdTe) panels, all manufactured by the U.S. company First Solar, have been installed in North Carolina.

Questions about the potential health and environmental impacts from the use of this PV technology are related to the concern that these panels contain cadmium, a toxic heavy metal. However, scientific studies have shown that cadmium telluride differs from cadmium due to its high chemical and thermal stability.[19] Research has shown that the tiny amount of cadmium in these panels does not pose a health or safety risk.[20] Further, there are very compelling reasons to welcome its adoption due to reductions in unhealthy pollution associated with burning coal. Every GWh of electricity generated by burning coal produces about 4 grams of cadmium air emissions.[21] Even though North Carolina produces a significant fraction of our electricity from coal, electricity from solar offsets much more natural gas than coal due to natural gas plants being able to adjust their rate of production more easily and quickly. If solar electricity offsets 90% natural gas and 10% coal, each 5-megawatt (5 MW_{AC}, which is generally 7 MW_{DC}) CdTe solar facility in North Carolina keeps about 157 grams, or about a third of a pound, of cadmium *out of* our environment.[22, 23]

Cadmium is toxic, but all the approximately 7 grams of cadmium in one CdTe panel is in the form of a chemical compound cadmium telluride,[24] which has 1/100th the toxicity of free cadmium.[25] Cadmium telluride is a very stable compound that is non-volatile and non-soluble in water. Even in the case of a fire, research shows that less than 0.1% of the cadmium is released when a CdTe panel is exposed to fire. The fire melts the glass and encapsulates over 99.9% of the cadmium in the molten glass.[27]

It is important to understand the source of the cadmium used to manufacture CdTe PV panels. The cadmium is a byproduct of zinc and lead refining. The element is collected from emissions and waste streams during the production of these metals and combined with tellurium to create the CdTe used in PV panels. If the cadmium were not collected for use in the PV panels or other products, it would otherwise either be stockpiled for future use, cemented and buried, or disposed of.[28] Nearly all the cadmium in old or broken panels can be recycled which can eventually serve as the primary source of cadmium for new PV panels.[29]

Similar to silicon-based PV panels, CdTe panels are constructed of a tempered glass front, one instead of two clear plastic encapsulation layers, and a rear heat strengthened glass backing (together >98% by weight). The final product is built to withstand exposure to the elements without significant damage for over 25 years. While not representative of damage that may occur in the field or even at a landfill, laboratory evidence has illustrated that when panels are ground into a fine powder, very acidic water is able to leach portions of the cadmium and tellurium,[30] similar to the process used to recycle CdTe panels. Like many silicon-based panels, CdTe panels are reported (as far back ask 1998[31]) to pass the EPA's Toxic Characteristic Leaching Procedure (TCLP) test, which tests the potential for crushed panels in a landfill to leach hazardous substances into groundwater.[32] Passing this test means that they are classified as non-hazardous waste and can be deposited in landfills.[33, 34] For more information about PV panel end-of-life, see the Panel Disposal section.

There is also concern of environmental impact resulting from potential catastrophic events involving CdTe PV panels. An analysis of worst-case scenarios for environmental impact from CdTe PV panels, including earthquakes, fires, and floods, was conducted by the University of Tokyo in 2013. After reviewing the extensive international body of research on CdTe PV technology, their report concluded, "Even in the worst-case scenarios, it is unlikely that the Cd concentrations in air and sea water will exceed the environmental regulation values."[35] In a worst-case scenario of damaged panels abandoned on the ground, insignificant amounts of cadmium will leach from the panels. This is because this scenario is much less conducive (larger module pieces, less acidity) to leaching than the conditions of the EPA's TCLP test used to simulate landfill conditions, which CdTe panels pass.[36]

First Solar, a U.S. company, and the only significant supplier of CdTe panels, has a robust panel take-back and recycling program that has been operating commercially since 2005.[37] The company states that it is "committed to providing a commercially attractive recycling solution for photovoltaic (PV) power plant and module owners to help them meet their module (end of life) EOL obligation simply, cost-effectively and responsibly." First Solar global recycling services to their customers to collect and recycle panels once they reach the end of productive life whether due to age or damage. These recycling service agreements are structured to be financially attractive to both First Solar and the solar panel owner. For First Solar, the contract provides the company with an affordable source of raw materials needed for new panels and presumably a diminished risk of undesired release of Cd. The contract also benefits the solar panel owner by allowing them to avoid tipping fees at a waste disposal site. The legal contract helps provide peace of mind by ensuring compliance by both parties when considering the continuing trend of rising disposal costs and increasing regulatory requirements.

c. **CIS/CIGS and other PV technologies**

Copper indium gallium selenide PV technology, often referred to as CIGS, is the second most common type of thin-film PV panel but a distant second behind CdTe. CIGS cells are composed of a thin layer of copper, indium, gallium, and selenium on a glass or plastic backing. None of these elements are very toxic, although selenium is a regulated metal under the Federal Resource Conservation and Recovery Act (RCRA).[38] The cells often also have an extremely thin layer of cadmium sulfide that contains a tiny amount of cadmium, which is toxic. The promise of high efficiency CIGS panels drove heavy investment in this technology in the past. However, researchers have struggled to transfer high efficiency success in the lab to low-cost full-scale panels in the field.[39] Recently, a CIGS manufacturer based in Japan, Solar Frontier, has achieved some market success with a rigid, glass-faced CIGS module that competes with silicon panels. Solar Frontier produces the majority of CIS panels on the market today.[40] Notably, these panels are RoHS compliant,[41] thus meeting the rigorous toxicity standard adopted by the European Union even thought this directive exempts PV panels. The authors are unaware of any completed or proposed utility-scale system in North Carolina using CIS/CIGS panels.

1.2.3 Panel End-of-Life Management

Concerns about the volume, disposal, toxicity, and recycling of PV panels are addressed in this subsection. To put the volume of PV waste into perspective, consider that by 2050, when PV systems installed in 2020 will reach the end of their lives, it is estimated that the global annual PV panel waste tonnage will be 10% of the 2014 global e-waste tonnage.[42] In the U.S., end-of-life disposal of solar products is governed by the Federal Resource Conservation and Recovery Act (RCRA), as well as state policies in some situations. RCRA separates waste into hazardous (not accepted at ordinary landfill) and solid waste (generally accepted at ordinary landfill) based on a series of rules. According to RCRA, the way to determine if a PV panel is classified as hazardous waste is the Toxic Characteristic Leaching Procedure (TCLP) test. This EPA test is designed to simulate landfill disposal and determine the risk of hazardous substances leaching out of the landfill.[43,44,45] Multiple sources report that most modern PV panels (both crystalline silicon and cadmium telluride) pass the TCLP test.[46,47] Some studies found that some older (1990s) crystalline silicon panels, and perhaps some newer crystalline silicon panels (specifics are not given about vintage of panels tested), do not pass the lead (Pb) leachate limits in the TCLP test.[48,49]

The test begins with the crushing of a panel into centimeter-sized pieces. The pieces are then mixed in an acid bath. After tumbling for eighteen hours, the fluid is tested for forty hazardous substances that all must be below specific threshold levels to pass the test. Research comparing TCLP conditions to conditions of damaged panels in the field found that simulated landfill conditions provide overly conservative estimates of leaching for field-damaged panels.[50] Additionally, research in Japan has found no detectable Cd leaching from cracked CdTe panels when exposed to simulated acid rain.[51]

Although modern panels can generally be landfilled, they can also be recycled. Even though recent waste volume has not been adequate to support significant PV-specific recycling infrastructure, the existing recycling industry in North Carolina reports that it recycles much of the current small volume of broken PV panels. In an informal survey conducted by the NC Clean Energy Technology Center survey in early 2016, seven of the eight large active North Carolina utility-scale solar developers surveyed reported that they send damaged panels back to the manufacturer and/or to a local recycler. Only one developer reported sending damaged panels to the landfill.

The developers reported at that time that they are usually paid a small amount per panel by local recycling firms. In early 2017, a PV developer reported that a local recycler was charging a small fee per panel to recycle damaged PV panels. The local recycling firm known to authors to accept PV panels described their current PV panel recycling practice as of early 2016 as removing the aluminum frame for local recycling and removing the wire leads for local copper recycling. The remainder of the panel is sent to a facility for processing the non-metallic portions of crushed vehicles, referred to as "fluff" in the recycling industry.[52] This processing within existing general recycling plants allows for significant material recovery of major components, including glass which is 80% of the module weight, but at lower yields than PV-specific recycling plants. Notably almost half of the material value in a PV panel is in the few grams of silver contained in almost every PV panel produced today. In the long-term, dedicated PV panel recycling plants can increase treatment capacities and maximize revenues resulting in better output quality and the ability to recover a greater fraction of the useful materials.[53] PV-specific panel recycling technologies have been researched and implemented to some extent for the past decade, and have been shown to be able to recover over 95% of PV material (semiconductor) and over 90% of the glass in a PV panel.[54]

A look at global PV recycling trends hints at the future possibilities of the practice in our country. Europe installed MW-scale volumes of PV years before the U.S. In 2007, a public-private partnership between the European Union and the solar industry set up a voluntary collection and recycling system called PV CYCLE. This arrangement was later made mandatory under the EU's WEEE directive, a program for waste electrical and electronic equipment.[55] Its member companies (PV panel producers) fully finance the association. This makes it possible for end-users to return the member companies' defective panels for recycling at any of the over 300 collection points around Europe without added costs. Additionally, PV CYCLE will pick up batches of 40 or more used panels at no cost to the user. This arrangement has been very successful, collecting and recycling over 13,000 tons by the end of 2015.[56]

In 2012, the WEEE Directive added the end-of-life collection and recycling of PV panels to its scope.[57] This directive is based on the principle of extended-producer-responsibility. It has a global impact because producers that want to sell into the EU market are legally responsible for end-of-life management. Starting in 2018, this directive targets that 85% of PV products "put in the market" in Europe are recovered and 80% is prepared for reuse and recycling.

The success of the PV panel collection and recycling practices in Europe provides promise for the future of recycling in the U.S. In mid-2016, the US Solar Energy Industry Association (SEIA) announced that they are starting a national solar panel recycling program with the guidance and support of many leading PV panel producers.[58] The program will aggregate the services offered by recycling vendors and PV manufacturers, which will make it easier for consumers to select a cost-effective and environmentally responsible end-of-life management solution for their PV products. According to SEIA, they are planning the program in an effort to make the entire industry landfill-free. In addition to the national recycling network program, the program will provide a portal for system owners and consumers with information on how to responsibly recycle their PV systems.

While a cautious approach toward the potential for negative environmental and/or health impacts from retired PV panels is fully warranted, this section has shown that the positive health impacts of reduced emissions from fossil fuel combustion from PV systems more than outweighs any potential risk. Testing shows that silicon and CdTe panels are both safe to dispose of in landfills, and are also safe in worst case conditions of abandonment or damage in a disaster. Additionally, analysis by local engineers has found that the current salvage value of the equipment in a utility scale PV facility generally exceeds general contractor estimates for the cost to remove the entire PV system.[59, 60, 61]

1.2.4 Non-Panel System Components (racking, wiring, inverter, transformer)

While previous toxicity subsections discussed PV panels, this subsection describes the non-panel components of utility-scale PV systems and investigates any potential public health and safety concerns. The most significant non-panel component of a ground-mounted PV system is the mounting structure of the rows of panels, commonly referred to as "racking". The vertical post portion of the racking is galvanized steel and the remaining above-ground racking components are either galvanized steel or aluminum, which are both extremely common and benign building materials. The inverters that make the solar generated electricity ready to send to the grid have weather-proof steel enclosures that protect the working components from the elements. The only fluids that they might contain are associated with their cooling systems, which are not unlike the cooling system in a computer. Many inverters today are RoHS compliant.

The electrical transformers (to boost the inverter output voltage to the voltage of the utility connection point) do contain a liquid cooling oil. However, the fluid used for that function is either a non-toxic mineral oil or a biodegradable non-toxic vegetable oil, such as BIOTEMP from ABB. These vegetable transformer oils have the additional advantage of being much less flammable than traditional mineral oils. Significant health hazards are associated with old transformers containing cooling oil with toxic PCBs. Transfers with PCB-containing oil were common before PCBs were outlawed in the U.S. in 1979. PCBs still exist in older transformers in the field across the country.

Other than a few utility research sites, there are no batteries on- or off-site associated with utility-scale solar energy facilities in North Carolina, avoiding any potential health or safety concerns related to battery technologies. However, as battery technologies continue to improve and prices continue to decline we are likely to start seeing some batteries at solar facilities. Lithium ion batteries currently dominate the world utility-scale battery market, which are not very toxic. No non-panel system components were found to pose any health or environmental dangers.

1.4 Operations and Maintenance – Panel Washing and Vegetation Control

Throughout the eastern U.S., the climate provides frequent and heavy enough rain to keep panels adequately clean. This dependable weather pattern eliminates the need to wash the panels on a regular basis. Some system owners may choose to wash panels as often as once a year to increase production, but most in N.C. do not regularly wash any PV panels. Dirt build up over time may justify panel washing a few times over the panels' lifetime; however, nothing more than soap and water are required for this activity.

The maintenance of ground-mounted PV facilities requires that vegetation be kept low, both for aesthetics and to avoid shading of the PV panels. Several approaches are used to maintain vegetation at NC solar facilities, including planting of limited-height species, mowing, weed-eating, herbicides, and grazing livestock (sheep). The following descriptions of vegetation maintenance practices are based on interviews with several solar developers as well as with three maintenance firms that together are contracted to maintain well over 100 of the solar facilities in N.C. The majority of solar facilities in North Carolina maintain vegetation primarily by mowing. Each row of panels has a single row of supports, allowing sickle mowers to mow under the panels. The sites usually require mowing about once a month during the growing season. Some sites employ sheep to graze the site, which greatly reduces the human effort required to maintain the vegetation and produces high quality lamb meat.[62]

In addition to mowing and weed eating, solar facilities often use some herbicides. Solar facilities generally do not spray herbicides over the entire acreage; rather they apply them only in strategic locations such as at the base of the perimeter fence, around exterior vegetative buffer, on interior dirt roads, and near the panel support posts. Also unlike many row crop operations, solar facilities generally use only general use herbicides, which are available over the counter, as opposed to restricted use herbicides commonly used in commercial agriculture that require a special restricted use license. The herbicides used at solar facilities are primarily 2-4-D and glyphosate (Round-up®), which are two of the most common herbicides used in lawns, parks, and agriculture across the country. One maintenance firm that was interviewed sprays the grass with a class of herbicide known as a growth regulator in order to slow the growth of grass so that mowing is only required twice a year. Growth regulators are commonly used on highway roadsides and golf courses for the same purpose. A commercial pesticide applicator license is required for anyone other than the landowner to apply herbicides, which helps ensure that all applicators are adequately educated about proper herbicide use and application. The license must be renewed annually and requires passing of a certification exam appropriate to the area in which the applicator wishes to work. Based on the limited data available, it appears that solar facilities in N.C. generally use significantly less herbicides per acre than most commercial agriculture or lawn maintenance services.

2. Electromagnetic Fields (EMF)

PV systems do not emit any material during their operation; however, they do generate electromagnetic fields (EMF), sometimes referred to as radiation. EMF produced by electricity is non-ionizing radiation, meaning the radiation has enough energy to move atoms in a molecule around (experienced as heat), but not enough energy to remove electrons from an atom or molecule (ionize) or to damage DNA. As shown below, modern humans are all exposed to EMF throughout our daily lives without negative health impact. Someone outside of the fenced perimeter of a solar facility is not exposed to significant EMF from the solar facility. Therefore, there is no negative health impact from the EMF produced in a solar farm. The following paragraphs provide some additional background and detail to support this conclusion.

Since the 1970s, some have expressed concern over potential health consequences of EMF from electricity, but no studies have ever shown this EMF to cause health problems.[63] These concerns are based on some epidemiological studies that found a slight increase in childhood leukemia associated with average exposure to residential power-frequency magnetic fields above 0.3 to 0.4 µT (microteslas) (equal to 3.0 to 4.0 mG (milligauss)). µT and mG are both units used to measure magnetic field strength. For comparison, the average exposure for people in the U.S. is one mG or 0.1 µT, with about 1% of the population with an average exposure in excess of 0.4 µT (or 4 mG).[64] These epidemiological studies, which found an association but not a causal relationship, led the World Health Organization's International Agency for Research on Cancer (IARC) to classify ELF magnetic fields as "possibly carcinogenic to humans". Coffee also has this classification. This classification means there is limited evidence but not enough evidence to designate as either a "probable carcinogen" or "human carcinogen". Overall, there is very little concern that ELF EMF damages public health. The only concern that does exist is for long-term exposure above 0.4 µT (4 mG) that may have some connection to increased cases of childhood leukemia. In 1997, the National Academies of Science were directed by Congress to examine this concern and concluded:

> "Based on a comprehensive evaluation of published studies relating to the effects of power-frequency electric and magnetic fields on cells, tissues, and organisms (including humans), the conclusion of the committee is that the current body of evidence does not show that exposure to these fields presents a human-health hazard. Specifically, no conclusive and consistent evidence shows that exposures to residential electric and magnetic fields produce cancer, adverse neurobehavioral effects, or reproductive and developmental effects."[65]

There are two aspects to electromagnetic fields, an electric field and a magnetic field. The electric field is generated by voltage and the magnetic field is generated by electric current, i.e., moving electrons. A task group of scientific experts convened by the World Health Organization (WHO) in 2005 concluded that there were no substantive health issues related to *electric* fields (0 to 100,000 Hz) at levels generally encountered by members of the public.[66] The relatively low voltages in a solar facility and the fact that electric fields are easily shielded (i.e., blocked) by common materials, such as plastic, metal, or soil means that there is no concern of negative health impacts from the electric fields generated by a solar facility. Thus, the remainder of this section addresses magnetic fields. Magnetic fields are not shielded by most common materials and thus can easily pass through them. Both types of fields are strongest close to the source of electric generation and weaken quickly with distance from the source.

The direct current (DC) electricity produced by PV panels produce stationary (0 Hz) electric and magnetic fields. Because of minimal concern about potential risks of stationary fields, little scientific research has examined stationary fields' impact on human health.[67] In even the largest PV facilities, the DC voltages and currents are not very high. One can illustrate the weakness of the EMF generated by a PV panel by placing a compass on an operating solar panel and observing that the needle still points north.

While the electricity throughout the majority of a solar site is DC electricity, the inverters convert this DC electricity to alternating current (AC) electricity matching the 60 Hz frequency of the grid. Therefore, the inverters and the wires delivering this power to the grid are producing non-stationary EMF, known as extremely low frequency (ELF) EMF, normally oscillating with a frequency of 60 Hz. This frequency is at the low-energy end of the electromagnetic spectrum. Therefore, it has less energy than other commonly encountered types of non-ionizing radiation like radio waves, infrared radiation, and visible light.

The wide use of electricity results in background levels of ELF EMFs in nearly all locations where people spend time – homes, workplaces, schools, cars, the supermarket, etc. A person's average exposure depends upon the sources they encounter, how close they are to them, and the amount of time they spend there.[68] As stated above, the average exposure to magnetic fields in the U.S. is estimated to be around one mG or 0.1 µT, but can vary considerably depending on a person's exposure to EMF from electrical devices and wiring.[69] At times we are often exposed to much higher ELF magnetic fields, for example when standing three feet from a refrigerator the ELF magnetic field is 6 mG and when standing three feet from a microwave oven the field is about 50 mG.[70] The strength of these fields diminish quickly with distance from the source, but when surrounded by electricity in our homes and other buildings moving away from one source moves you closer to another. However, unless you are inside of the fence at a utility-scale solar facility or electrical substation it is impossible to get very close to the EMF sources. Because of this, EMF levels at the fence of electrical substations containing high voltages and currents are considered "generally negligible".[71, 72]

The strength of ELF-EMF present at the perimeter of a solar facility or near a PV system in a commercial or residential building is significantly lower than the typical American's average EMF exposure.[73, 74] Researchers in Massachusetts measured magnetic fields at PV projects and found the magnetic fields dropped to very low levels of 0.5 mG or less, and in many cases to less than background levels (0.2 mG), at distances of no more than nine feet from the residential inverters and 150 feet from the utility-scale inverters.[75] Even when measured within a few feet of the utility-scale inverter, the ELF magnetic fields were well below the International Commission on Non-Ionizing Radiation Protection's recommended magnetic field level exposure limit for the general public of 2,000 mG.[76] It is typical that utility scale designs locate large inverters central to the PV panels that feed them because this minimizes the length of wire required and shields neighbors from the sound of the inverter's cooling fans. Thus, it is rare for a large PV inverter to be within 150 feet of the project's security fence.

Anyone relying on a medical device such as pacemaker or other implanted device to maintain proper heart rhythm may have concern about the potential for a solar project to interfere with the operation of his or her device. However, there is no reason for concern because the EMF outside of the solar facility's fence is less than 1/1000 of the level at which manufacturers test for ELF EMF interference, which is 1,000 mG.[77] Manufacturers of potentially affected implanted devices often provide advice on electromagnetic interference that includes avoiding letting the implanted device get too close to certain sources of fields such as some household appliances, some walkie-talkies, and similar transmitting devices. Some manufacturers' literature does not mention high-voltage power lines, some say that exposure in public areas should not give interference, and some advise not spending extended periods of time close to power lines.[78]

3. Electric Shock and Arc Flash Hazards

There is a real danger of electric shock to anyone entering any of the electrical cabinets such as combiner boxes, disconnect switches, inverters, or transformers; or otherwise coming in contact with voltages over 50 Volts.[79] Another electrical hazard is an arc flash, which is an explosion of energy that can occur in a short circuit situation. This explosive release of energy causes a flash of heat and a shockwave, both of which can cause serious injury or death. Properly trained and equipped technicians and electricians know how to safely install, test, and repair PV systems, but there is always some risk of injury when hazardous voltages and/or currents are present. Untrained individuals should not attempt to inspect, test, or repair any aspect of a PV system due to the potential for injury or death due to electric shock and arc flash, The National Electric Code (NEC) requires appropriate levels of warning signs on all electrical components based on the level of danger determined by the voltages and current potentials. The national electric code also requires the site to be secured from unauthorized visitors with either a six-foot chain link fence with three strands of barbed wire or an eight-foot fence, both with adequate hazard warning signs.

4. Fire Safety

The possibility of fires resulting from or intensified by PV systems may trigger concern among the general public as well as among firefighters. However, concern over solar fire hazards should be limited because only a small portion of materials in the panels are flammable, and those components cannot self-support a significant fire. Flammable components of PV panels include the thin layers of polymer encapsulates surrounding the PV cells, polymer backsheets (framed panels only), plastic junction boxes on rear of panel, and insulation on wiring. The rest of the panel is composed of non-flammable components, notably including one or two layers of protective glass that make up over three quarters of the panel's weight.

Heat from a small flame is not adequate to ignite a PV panel, but heat from a more intense fire or energy from an electrical fault can ignite a PV panel.[80] One real-world example of this occurred during July 2015 in an arid area of California. Three acres of grass under a thin film PV facility burned without igniting the panels mounted on fixed-tilt racks just above the grass.[81] While it is possible for electrical faults in PV systems on homes or commercial buildings to start a fire, this is extremely rare.[82] Improving understanding of the PV-specific risks, safer system designs, and updated fire-related codes and standards will continue to reduce the risk of fire caused by PV systems.

PV systems on buildings can affect firefighters in two primary ways, 1) impact their methods of fighting the fire, and 2) pose safety hazard to the firefighters. One of the most important techniques that firefighters use to suppress fire is ventilation of a building's roof. This technique allows superheated toxic gases to quickly exit the building. By doing so, the firefighters gain easier and safer access to the building, Ventilation of the roof also makes the challenge of putting out the fire easier. However, the placement of rooftop PV panels may interfere with ventilating the roof by limiting access to desired venting locations.

New solar-specific building code requirements are working to minimize these concerns. Also, the latest National Electric Code has added requirements that make it easier for first responders to safely and effectively turn off a PV system. Concern for firefighting a building with PV can be reduced with proper fire fighter training, system design, and installation. Numerous organizations have studied fire fighter safety related to PV. Many organizations have published valuable guides and training programs. Some notable examples are listed below.

- The International Association of Fire Fighters (IAFF) and International Renewable Energy Council (IREC) partnered to create an online training course that is far beyond the PowerPoint click-and-view model. The self-paced online course, "Solar PV Safety for Fire Fighters," features rich video content and simulated environments so fire fighters can practice the knowledge they've learned. www.iaff.org/pvsafetytraining
- Photovoltaic Systems and the Fire Code: Office of NC Fire Marshal
- Fire Service Training, Underwriter's Laboratory

- Firefighter Safety and Response for Solar Power Systems, National Fire Protection Research Foundation
- Bridging the Gap: Fire Safety & Green Buildings, National Association of State Fire Marshalls
- Guidelines for Fire Safety Elements of Solar Photovoltaic Systems, Orange County Fire Chiefs Association
- Solar Photovoltaic Installation Guidelines, California Department of Forestry & Fire Protection, Office of the State Fire Marshall
- PV Safety & Firefighting, Matthew Paiss, Homepower Magazine
- PV Safety and Code Development: Matthew Paiss, Cooperative Research Network

Summary

The purpose of this paper is to address and alleviate concerns of public health and safety for utility-scale solar PV projects. Concerns of public health and safety were divided and discussed in the four following sections: (1) Toxicity, (2) Electromagnetic Fields, (3) Electric Shock and Arc Flash, and (4) Fire. In each of these sections, the negative health and safety impacts of utility-scale PV development were shown to be negligible, while the public health and safety benefits of installing these facilities are significant and far outweigh any negative impacts.

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Published by the N.C. Clean Energy Technology Center at N.C. State University