Feasibility of Solar Development on State-Managed Closed Landfills: A Report to the Legislature

Exploring the potential to deploy solar photovoltaic devices on sites in the Minnesota Pollution Control Agency's Closed Landfill Program

MINNESOTA ENVIRONMENTAL QUALITY BOARD

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Legislative charge

The Minnesota Legislature appropriated funds to the Environmental Quality Board for the completion of this study, as provided by Laws 2019, First Special Session chapter 4, article 1, section 2:

Subd. 9. Environmental Quality Board. (b) $300,000 the first year is from the remediation fund to conduct a study of the potential to deploy solar photovoltaic devices on closed landfill program sites. This is a onetime appropriation. By December 1, 2020, the board, in consultation with the Pollution Control Agency and the commissioners of administration, commerce, and management and budget, must provide to the chairs and ranking minority members of the legislative committees and divisions with jurisdiction over environment and natural resources policy and finance and energy policy and finance a report on the use of properties in the state's closed landfill program for solar energy production. The report must include:

(1) Identification and assessment of properties in the closed landfill program with the highest potential for solar energy production;

(2) Identification of potential barriers to solar energy production and potential ways to address those barriers; and

(3) Policy recommendations that would facilitate solar energy production on closed landfill program sites in a manner that would contribute to state and local government sustainability goals.

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Cover photo: A 2.4 megawatt solar farm built on a landfill in Rehoboth, Massachusetts. (United States Department of Energy, Lucas Faria)

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This report is available in alternative formats upon request, and online at www.eqb.state.mn.us.

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Executive summary

The state of Minnesota has an opportunity to lead by example and promote solar development on brownfields (contaminated sites) like landfills, reducing development pressure on agricultural and natural lands while generating jobs in clean energy. Minnesota's climate is rapidly changing, and climate change impacts are likely to worsen in coming decades unless we can dramatically reduce greenhouse gas (GHG) emissions. The state of Minnesota has ambitious goals to reduce emissions, and while we have made progress on these goals, meeting them will require much more aggressive state and federal policies.

Clean energy, such as solar power, is increasingly displacing the use of fossil fuels in Minnesota, helping to reduce emissions. The cost of solar has fallen in recent years, driving up solar installations and demand for land on which to site solar arrays. Siting solar development on brownfields including closed landfills, may be a way to meet some of the demand for land.

The 1994 Landfill Cleanup Act created Minnesota's Closed Landfill Program (CLP) acknowledging that long term care of waste is a shared responsibility of a waste generating society. The scope of the program however is limited to a subset of 110 closed, state-permitted, mixed municipal solid waste landfills, other closed landfills and dumps in the state are not included in the program.

This legislative report examines: 1) the potential for solar photovoltaic development on sites in the State of Minnesota's Closed Landfill Program (CLP), 2) barriers to development, and 3) recommendations that would facilitate solar development on these sites in line with state and local sustainability goals. To complete this study, the Environmental Quality Board (EQB) assembled an interagency team with members from the Departments of Administration, Commerce, and Management and Budget (MMB); the Metropolitan Council; and the Minnesota Pollution Control Agency (MPCA). Additionally, the EQB contracted with Barr Engineering Co. (Barr) to complete a technical assessment of the CLP sites.

Key takeaways

Solar potential

There is significant potential for solar development on Minnesota's CLP sites. The technical assessment estimated that there is potential to generate 950 megawatts (MW) using solar on 4,500 acres in the CLP, or enough to power over 100,000 homes.

Barriers

Several barriers limit solar development on CLP sites.

- The current statutory mission of the CLP is limited to taking environmental response actions and protecting human health and the environment. **Establishing beneficial property reuse was is not included and funded in the original CLP program mission.**
- Half of the CLP's 110 sites have use restrictions because of **past general obligation bond financing** of cleanup actions. The prospects for beneficial reuse, including solar development, are limited for property where bond financing was used until the bonds are retired.
- **Solar development could be more costly and complex on closed landfills** than on greenfield (uncontaminated) sites. Solar developers face uncertainty about site-specific suitability for solar, increased costs associated with construction on the landfill cap as well, as real and perceived risks associated with CLP responsibilities.

- **State regulations impose limitations on solar projects** under some solar ownership and operation models. For example, Community Solar Garden projects are limited to 1 MW, which is well below the estimated solar energy generation capacity of many CLP sites. Legislative action would be required to raise this limit at brownfield locations such as CLP sites.

Recommendations

1. **Expand statutory authority of the CLP to authorize and fund proactive work on property reuse, including solar development, and provide funding to establish a Closed Landfill Beneficial Reuse Program.**
    - The CLP is able to enter into leases when there is an expressed interest in leasing state property provided the proposed land use is appropriate. However, CLP is not authorized or funded to proactively facilitate beneficial property reuse. With increased authority and resources, the CLP could facilitate beneficial reuse, including solar development on state-owned sites, and develop guidance for local government- and privately-owned CLP sites.
    - Development of a Closed Landfill Beneficial Reuse Program would require further investigation into several topics, including solar ownership models, incentives, lease revenue uses, Solar Renewable Energy Certificate ownership, and interconnection costs. Continued interagency collaboration would be necessary to develop a Closed Landfill Beneficial Reuse Program aligned to the state's economic, equity, environmental justice, and environmental goals.
2. **Appropriate funds to retire bond debt early and legislatively authorize the release of state bonding restrictions for select CLP sites.** Freeing property from bond restrictions would open up lands for solar development and could generate significant revenues into the future

Introduction

Solar development is rapidly increasing in Minnesota but is constrained by access to suitable land. As climate change threatens our way of life, businesses, communities, and families, the state of Minnesota is seeking creative ways to increase renewable energy generation and reduce greenhouse gas emissions. Locating large-scale solar development on sites in the State's Closed Landfill Program would make land available for clean energy projects, protect agricultural and natural lands from development, advance the State's climate goals, and transform blighted property into community assets. Minnesota has a unique challenge, however – half of these closed landfill sites have use restrictions that limit solar development due to past utilization of general obligation bond financing to remediate the sites. This challenge is unique to Minnesota as compared to other states, which typically do not have restrictions due to bond financing on closed landfill sites.

In 2019, the Minnesota Legislature appropriated funds to the EQB to gain a better understanding of the solar opportunity at sites in the State's Closed Landfill Program and ways to address barriers to solar, including bond restrictions. The EQB contracted with Barr Engineering Co. to conduct a technical assessment of the sites, as well as stakeholder engagement to uncover barriers and opportunities and inform policy recommendations. This assessment, completed in October 2020, is in Attachment I.

The EQB also convened a Solar on Closed Landfills interagency team, which collaborated closely with Barr throughout 2020. Following the completion of Barr's assessment, the interagency team prepared reflections on the conclusions, followed up on additional lines of inquiry beyond the scope of Barr's assessment, and summarized information and recommendations in this legislative report.

Background

Facilitating solar development on closed landfill sites in Minnesota has the potential to forward the State's climate, environmental justice, and equity goals while minimizing land development impacts and generating clean energy jobs.

While the threat of climate change can feel like a far-off possibility, the scientific consensus is clear: Minnesota's climate has already rapidly changed over the last several decades and additional, significant changes are expected through the end of this century. Dramatic reductions in GHG emissions are needed to avoid the worst impacts of climate change.

Minnesota has ambitious goals to reduce GHGs outlined in the 2007 Next Generation Energy Act, which calls for reducing annual emissions by 80% between 2005 and 2050. While we have made progress, achieving our goal will require much more aggressive action. Minnesota is taking important steps, including establishing a Climate Change Subcabinet and Advisory Council[1] and setting GHG reduction goals for state government operations.[2] Transitioning from fossil fuels to renewable sources of energy, including solar, is important for meeting the state's climate goals.

Solar energy generation specifically and directly supports the State's equity and environmental justice goals through pollution reduction. As outlined in the 2015 MPCA Environmental Justice Framework,[3] the agency will proactively target resources to address environmental justice concerns and commit to the goal that "pollution does not have a disproportionate negative impact on any group of people." In its

[1] Executive Order 19-37, December 2019.
[2] Executive Order 19-27, April 2019.
[3] Minnesota Pollution Control Agency. Environmental Justice Framework, December 17, 2015.

2017 report,[4] the Interagency Climate Adaptation Team recommended that the State identify ways to strengthen the health and resilience of vulnerable populations through cooperation with local governments. Climate-vulnerable populations include the very old and very young, people of color, and people with health issues, disabilities, economic vulnerability, outdoor occupations, disproportionate exposure to environmental pollution, and cultural/language barriers.

Solar in Minnesota

Interest in solar power is surging in Minnesota. Driven in part by advances in technology, the cost of installed solar has fallen by over 70% in the last decade, [5] making it competitive with other sources of energy. Solar development began accelerating in 2013 after Minnesota passed legislation[6] promoting the growth of solar energy. This included a goal of achieving 10% of Minnesota's electricity from solar by 2030. Additionally, the Department of Commerce and the Solar Pathways Project estimate that the state can meet 70% of electricity demand from solar and wind by 2050 at costs comparable to other sources.[7]

Solar now accounts for about 3% of Minnesota's energy portfolio[8] and is expected to continue growing and displacing generation from other sources of energy, particularly fossil fuels. Solar power offers many benefits, including a reliable "homegrown" energy source, reduced greenhouse emissions, and job growth. These are especially important as the state faces economic damage and job losses from the COVID-19 pandemic as well as the urgent need to address climate change.

Large-scale solar development requires sizable areas of land and applies development pressure on agricultural and natural lands. The Department of Commerce's Solar Energy Production and Prime Farmland report[9] notes that areas with the best solar resources overlap with the state's prime farmland, and "solar production removes the entire area…from agricultural production" for the life of the project. State policy is to "preserve agricultural land and conserve its long-term use for the production of food and other agricultural products" by means including:

> Guiding the orderly construction and development of energy generation and transmission systems and enhancing the development of alternative energy to meet the needs of rural and urban communities and preserve agricultural land to the greatest possible extent by reducing energy costs and minimizing the use of agricultural land for energy production facilities […].[10]

As the State seeks to protect prime farmland and natural lands while promoting solar energy, it is looking to reduce pressure on these lands through reuse of closed landfills as potential sites for solar development.

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[4] Minnesota Pollution Control Agency. Adapting to Climate Change in Minnesota: 2017 Report of the Interagency Climate Adaptation Team, May 2017.

[5] Solar Energy Industries Association (SEIA)/Wood Mackenzie. Power & Renewables U.S. Solar Market Insight, 2020 Q3.

[6] Minn. Stat. § 216B.1691.

[7] Minnesota Solar Pathways. Solar Potential Analysis Report, November 2018.

[8] United States Energy Information Administration. Minnesota State Profile and Energy Estimates, May 21, 2020.

[9] Minnesota Department of Commerce. Solar Energy Production and Prime Farmland. May 19, 2020.

[10] Minn. Stat. § 17.80.

Beneficial reuse of brownfields

A brownfield is any property that is abandoned or underused due to the known or likely presence of contamination. Reuse and revitalization of brownfields can include green space, residential, commercial, industrial, or mixed-use development. Brownfield reuse can benefit communities by growing the local tax base and jobs, reducing development pressure on higher value lands, using existing infrastructure, and increasing recreational space and habitat.[11] A closed landfill is a unique type of brownfield that may not be suitable for construction of buildings, but offers a great opportunity to expand our reliance on renewable energy sources.

Solar development on brownfield sites is a win-win for Minnesota because we can put low-value, contaminated land to use generating clean energy and revenue while maintaining the integrity of the sites to protect human health, safety, and the environment. Brownfields reused for solar energy are called "brightfields." Minnesota has one example of brightfield development on the waste footprint of a landfill in Hutchinson, where solar energy powers a wastewater treatment plant. Some other states, most notably Massachusetts, have successfully implemented solar on closed landfills. To date, Massachusetts has approved over 100 projects rated to generate over 220 MW.[12] These projects can offer specific benefits to communities, such as electricity cost savings, and be implemented with diverse native plant communities to benefit pollinators.

Initiatives at the state and federal levels are promoting and supporting renewable energy development on brownfields:

- **U.S. Environmental Protection Agency's RE-Powering America's Lands** encourages renewable energy development on current and formerly contaminated lands, landfills, and mine sites when such development is aligned with the community's vision for the site. The program tracks projects and their community benefits.[13] Goals of the program are to:
  - Provide technical and programmatic assistance
  - Promote policies and best practices that encourage renewable energy on brownfields
  - Partner with stakeholders and leverage agency efforts
- **Minnesota Brightfields Initiative** focuses on creating an environmentally, fiscally, and socially responsible development pathway for solar on Minnesota's closed landfills. The statewide partnership was formed in late 2017 to offer cost-free professional, technical, financial, and regulatory expertise and analysis to support local governments across Minnesota. The desired outcomes of the initiative are to:
  - Bring redevelopment potential to land that is otherwise undevelopable
  - Bring value-adding economic redevelopment to the local governments (townships, cities, counties) and their communities, which stand to benefit from such developments
  - Make Minnesota a national leader in solar on landfills, showcasing how projects can save money, create jobs, and decrease negative environmental impacts from landfills
  - Bring these savings and benefits to all of Minnesota
  - Guide national and state policies and incentives to support renewable energy redevelopment projects on landfills, brownfields, Superfund sites, other contaminated lands

[11] U.S. Environmental Protection Agency. Overview of the EPA's Brownfields Program. Accessed October 28, 2020.
[12] State of Massachusetts. Siting Clean Energy on Closed Landfills. Accessed October 28, 2020.
[13] U.S. Environmental Protection Agency. RE-Powering America's Lands Benefits Matrix. December 2019.

As the Minnesota Brightfields Initiative worked with local governments to explore solar development, they encountered a barrier unique to Minnesota: solar development could not proceed on some sites due to use restrictions imposed on the property by past use of bond financing. While these sites were owned by local governments, they are managed by the state through the Minnesota Pollution Control Agency's Closed Landfill Program. The Closed Landfill Program has frequently used general obligation bonds to finance closure and remediation activities at landfill sites. Revenue generation of a solar project would threaten the tax-exempt status of the State's general obligation bonds.

Closed Landfill Program

The 1994 Landfill Cleanup Act created Minnesota's Closed Landfill Program (CLP) to properly close, monitor, and maintain Minnesota's closed municipal sanitary landfills. The creation of the program acknowledged that the adverse environmental effects at mixed municipal solid waste landfills resulted not just from industrial waste, but also from household garbage. Therefore, cleanup of these landfills, which served a public need, is a public responsibility. The CLP is unique in that it is the first such program in the nation that provides an alternative to the U.S. Environmental Protection Agency's Superfund program (Comprehensive Environmental Response, Compensation and Liability Act of 1980) for cleaning up and maintaining closed landfills.

The CLP gives the Minnesota Pollution Control Agency (MPCA) the responsibility to care for up to 114 closed, state-permitted, mixed municipal solid waste landfills to mitigate risks to the public and the environment. The CLP manages these sites by:

- Monitoring environmental impacts and site conditions associated with each landfill
- Determining the risk each landfill poses to public health, safety and the environment
- Implementing environmental response actions to help reduce site risks
- Maintaining the landfill properties and the landfill covers and operating any engineered remedial systems that are necessary
- Managing land issues on the property the CLP is responsible for, including working with local governments to incorporate land-use controls at and near the landfills.

Closed landfills in the CLP are a subset of closed landfills in Minnesota. Currently, 110 landfills are the responsibility of the CLP, with four more eligible for the program. Of the 110, 45 are state-owned, 53 are owned by municipalities, and 12 are in private ownership.

Funding for the CLP comes from the Remediation Fund, the Closed Landfill Investment Fund, and state general obligation bonds (GOB). GOBs are used to fund capital improvements, including the construction of new landfill covers and engineered remediation systems to address groundwater contamination and landfill gas generation, and sometimes to acquire "buffer" land to separate the waste footprint from the surrounding privately owned lands. GOBs have been spent at about half of the program landfills.

The CLP is required to develop Land Use Plans for each program landfill. These plans determine appropriate land uses where cleanup activities are occurring and provide information about properties that are affected by groundwater contamination and methane gas migration. The CLP partners with local governments to adopt zoning amendments or other land-use controls to incorporate land uses compatible with the risks at each landfill.

The CLP can entering into leases for appropriate property reuse, like solar, at the landfills that are state owned. At landfills that are owned by municipalities or are privately owned, the CLP can review proposed plans for reuse, taking into account prior use of general obligation bonds, where appropriate. However, proactively developing a beneficial reuse program is not authorized or funded in the existing CLP mission.

Use of bond financing

A frequent theme in this study has been the barrier to solar development imposed by the prior use of state general obligation bonds for remediating closed landfills. When the Legislature first appropriated bonds to the CLP program in 1994, no one could foresee the potential these sites might provide for future solar energy generation. Nonetheless, federal tax law, the state constitution, and state statute impose various restrictions on the use of these sites for nongovernmental purposes; these restrictions must be resolved before large-scale solar developments can advance on bond restricted sites.

The state constitution and state statutes require bond funded projects to be publicly owned and used for the governmental program identified by the Legislature. In the case of prior use of bonds for the CLP, this means MPCA must have a qualifying ownership interest (fee ownership or a qualifying long-term lease or easement) in the CLP sites and the sites must be operated in compliance with the CLP statutory program. These restrictions apply for a time period equal to 125% of the useful life of the improved project, which for CLP sites has been deemed to be 37.5 years. The restrictions attach to parcels when bonds are first spent on the property and remain in place for 37.5 years from the last date when GOB funds were used.

While MPCA does have authority to enter into leases when a proposal for a property reuse is made it does not have explicit statutory authority to proactively engage in property reuse as part of authorized CLP activities. Even if state law authority amended the CLP statutes to include beneficial reuse of the sites, including solar development, federal tax law prevents the use of bond restricted sites for private use. Private use can include site leases that grant a private solar developer rights to access and use the CLP site for their own purposes. Private use can also include the generation of electricity that is excess to the needs of the power-producing site and that flows into the grid thus benefitting the utility service provider. This second scenario can include arrangements like net metering, interconnection agreements, and power purchase agreements. The consequence of approving private use on bond financed property is that the bonds issued for the closed landfill program may lose their tax-exempt status thus subjecting the state to financial penalties.

On bond restricted CLP sites, one avenue to pursue is the installation of publicly owned smaller scale solar installations on CLP sites. Additionally, there are alternative financing mechanisms to consider for CLP sites that are not yet bond restricted.

Solar ownership models on CLP sites

There are many possible models for solar ownership, operations, and financing. Below are a few examples that may apply to CLP sites. More study is needed to enumerate possible models and fully explore the benefits and risks of each model.

Land lease

In this scenario, the agency or site owner would negotiate a land lease with the developer who would own the solar asset. The value of the lease is dependent on several factors, including distance to interconnection points, ease of access, and cost for site prep. In many, if not most, of this type of agreement a power purchase agreement (PPA) is also included. This PPA may be separate from the lease payment or the lease payment may be factored into the PPA price.

A land lease scenario reduces much of the risk and responsibility for the agency and places it with the developer or owner of the solar project. The design, finance, construction, and maintenance become the responsibility of the developer. In return, the developer maintains much of the project revenue and tax advantages. Land lease develop model could be an option for sites that are free from general obligation bond restrictions.

Power purchase agreement (PPA)

A PPA is a contract between the landfill owner and the developer or project owner where the agency purchases all the electricity produced by the array at a predetermined price. This price may have periodic steps or escalators throughout the term of the contract which is typically 25-30 years. This model provides a predictable price for the electricity for the agency.

This model allows for an owner with limited capital resources to reap the benefits of solar without a capital investment, and it also allows for a third party to take advantage of the tax benefits of solar development further reducing the PPA price.

It is important to note that the availability of utility incentives such as Solar Rewards in Xcel Energy territory would also help to lower the PPA price, though many CLP sites are served by utilities lacking such incentives. Incorporating a utility incentive reduces the cost of the solar but forfeits the Solar Renewable Energy Credits to the utility for a period of ten years, thus impacting which entity gets credit for GHG reductions during this time period. Taking advantage of the incentives allows for an agency with a limited budget to participate in solar and lower their energy bills but pushes out the timetable for meeting their GHG reduction goals for that 10-year period.

Public ownership

In this model, the State or local government landfill owner would pay the full market-value cost of purchasing, installing, maintaining, and operating a solar photovoltaic system without the benefit of utilizing tax incentives. The owner may then do one of two things:

1. Sell the power generated tax-free to the local electric utility.
2. Sell the power generated tax-free via a public-to-public transaction with another publicly-owned entity.

Community Solar Gardens

Community Solar Gardens are subscription-based, centrally located solar installations. Community solar subscribers participate in a solar energy system along with other subscribers. Each subscriber's share of the electricity generated by the project is credited on their utility bill. Most community solar projects in Minnesota are owned and operated by electric cooperative utilities, which offer subscriptions to their customers. The largest community solar program (Solar*Rewards Community) is administered by Xcel Energy and regulated by the state, but private solar developers—not the utility—own the projects and sell the subscriptions. The State or local governments could lease land for Community Solar Garden projects.

Reflections on the technical assessment

The technical assessment prepared by Barr (Attachment I) offered valuable insights into the solar capacity represented at CLP sites, the key barriers, and recommended steps to facilitate solar development at CLP sites. The following are the interagency team's reflections on Barr's findings:

- **Solar potential**
    - CLP sites represent a **significant opportunity for solar development**, both on landfill waste footprints (caps) and in buffer areas.
    - **Half of the CLP sites do not have bond restrictions,** and even on some landfill sites where bonds were used, there are non-bond encumbered parcels. Facilitating solar development on non-GOB restricted property may be a way to move forward with solar development quickly. Because the technical assessment considered each landfill site as a whole, more information is needed to understand the opportunity for solar development on non-bond encumbered acres at sites where bonds were used.
- **Barriers**
    - The study helped clarify that there are relatively **few technological barriers to siting solar on closed landfill**s. Solar development can be done safely and in a way that protects the integrity of the landfill.
    - The **study helped clarify ways the state can and cannot remove existing GOB restrictions**, and illuminated steps to take in future projects to limit use restrictions on CLP sites.
    - Many of the **highest-ranking sites have GOB-restricted property** and are located near electricity demand.
    - **Many barriers to solar identified in the technical assessment are not unique to solar on closed landfills** and relate to solar in general. These include upgrades to the grid, funding of small projects, and in some cases, a higher cost of energy relative to other energy sources.
- **Recommended steps**
    - Many of the recommended steps would **require expanded statutory authority and funding for the CLP** to focus on property reuse.
    - While **solar development may proceed on non-bond restricted CLP sites**, the process may be constrained by the CLP's existing staff capacity.
    - The **MPCA can develop publicly owned and operated small-scale solar to serve electricity needs** on-site, even on bond restricted sites. It may be possible that the MPCA could size a solar project to offset electricity use from multiple MPCA CLP sites within a utility service area, however more study is needed to determine what the exact barriers might be.
    - **More study is needed to explore incentives and policies** that would facilitate solar development. Understanding the specific revenues and costs of solar development at closed landfills, as well as market conditions, would help the state determine whether incentives are necessary, and how they would be best applied in Minnesota's context.
    - **More study is needed to explore various solar ownership models**, the costs and benefits of each, and which would be appropriate for Minnesota.

- **Minnesota has access to technical assistance and resources** from the federal level (e.g., U.S. Environmental Protection Agency, National Renewable Energy Laboratory) as well as from other states that have implemented solar on closed landfills. These programs can offer valuable information and reassurances to funders, developers, landowners, and others about this type of development.

Recommendations

The interagency team followed up on the recommended steps suggested in the technical assessment to assess resource needs and present additional information to guide action. We also identified areas that need further study to ensure that solar development is aligned with state and local government sustainability and equity goals. The team incorporated the recommended steps from Barr into the following three recommendations to facilitate solar development on closed landfills.

1. Expand CLP statutory authority and fund Beneficial Reuse Program

Expand statutory authority of the CLP to authorize and fund proactive work on property reuse, including solar development, and provide funding to establish a Closed Landfill Beneficial Reuse Program. The current scope of the CLP as outlined in the 1994 Landfill Cleanup Act includes environmental response actions at qualified facilities. While the CLP is able to enter into leases when there is an expressed interest in leasing state property, provided the proposed land use is appropriate, the CLP is not authorized or funded to proactively facilitate property reuse. Lack of direct authority and resources have constrained landfill property reuse. Expanding the scope of the CLP outlined in the Landfill Cleanup Act to specifically authorize and fund work focused on beneficial property reuse would facilitate beneficial reuse, including solar development.

The creation of a Closed Landfill Beneficial Reuse Program would actively enable and facilitate all appropriate beneficial closed landfill reuses. A closed landfill is a unique type of brownfield that has fewer options for beneficial reuse than many other types of brownfields, in part because constructing buildings on or near landfills is problematic. Renewable energy development, such as solar, can be a compatible reuse for closed landfills because public access is often restricted, solar panels can be installed without penetrating the cap, and landfill maintenance activities can be accommodated. Additionally, there may be compatibility of different reuses, for example, pollinator habitat can be paired with solar development.

This recommendation would incorporate three of the recommended steps included in the technical assessment, including:

- **Develop a technical guide to solar development on CLP sites.** A technical guide could provide general information about the unique design aspects of closed landfills and more detailed information about the CLP program responsibilities associated with the landfills and process for developing solar on a closed landfill site.
- **Provide detailed technical and regulatory information for CLP sites.** Detailed technical and regulatory information may include specific design elements of the sites, permit conditions, information on cap construction and maintenance status, surrounding land use and natural features and other site-specific information deemed useful. The MPCA or Department of Commerce could also consider completing techno-economic analysis for each of the top sites using the free System Advisor Model[14] from the National Renewable Energy Laboratory.
- **Reach out to stakeholders.** One common barrier to development of solar energy on CLP sites is lack of awareness of these sites and the solar development potential they represent among non-developers. The Department of Commerce and MPCA could prepare informational materials for the top 10 sites and invite key stakeholders to open discussions about the sites and solar

[14] National Renewable Energy Laboratory. System Advisor Model, accessed November 6, 2020.

development potential. These meetings would provide an opportunity to gauge interest, collect site specific feedback and identify local barriers/concerns and opportunities.

Developing a Closed Landfill Beneficial Reuse Program

Continued interagency collaboration would be necessary to develop a Closed Landfill Beneficial Reuse Program aligned to the state's economic, equity, environmental justice, and environmental goals. Development of a Closed Landfill Beneficial Reuse Program would require further investigation into several topics, including solar ownership models, incentives, lease revenue uses, Solar Renewable Energy Certificate ownership, and interconnection costs. In the process of answering some questions in this study, the team encountered many more. The interagency team began documenting topics requiring further study. The following is not an exhaustive list of these topics:

Continued research relating to bonds

- **Use of lease revenue.** If CLP land is leased to a developer according to Minnesota Statute 115B.17, all CLP lease revenue must be deposited in the Remediation Fund. Adjustments to that statute could allow for lease revenue to be used in other ways. For example, the interagency team could explore whether it would be feasible to use lease revenue to finance other renewable projects or pay off GOB obligations at other sites.
- **Publicly owned and operated solar on bond-restricted property.** One possible path forward where the bonded status of a CLP site would not present a barrier is for the MPCA to acquire, install, own and operate solar equipment sized to meet the energy needs of the landfill it is situated on and directly connected to the energy-using elements on the landfill. It may also be possible for MPCA to install solar equipment on a CLP site that produces energy in excess of that site's needs if MPCA remains a net purchaser of energy from the utility company within its territory. This scenario needs further vetting under state statutes and consultation with the State's bond counsel. If allowable, the maximum amount of solar energy produced by MPCA-owned equipment would be limited to the amount of energy consumed by MPCA within a utility service territory.
- **Non-bond restricted property at sites where bonds were used.** On many CLP sites where bond financing was used there are property parcels that did not have bond financed construction activities and have no bond restrictions. Understanding more about these lands and their suitability for solar development could help the MPCA and other landfill owners understand the solar potential.
- **Future financing of capital projects at CLP sites.** There are many CLP sites that are not bond restricted. To the extent any of these sites will require future remediation work under the closed landfill program *and* appear to be ideal locations for solar development, there are several options that should be considered before undertaking cleanup work. First, if the land area most suitable for solar development is not located on the area of the landfill to be improved, MPCA could still seek general obligation bonds to pay for the work but first subdivide the real estate in advance of using any bonds. If the exact boundary of the landfill improvements cannot be determined until the work is completed, thus making an initial parcel split infeasible, MPCA and MMB can develop a means for documenting an intent to subdivide once construction is complete. This would leave the areas suitable for solar separate and distinct from the bond restricted parcels. Second, MPCA could seek alternative sources of financing for future improvements that would not result in bond restrictions. These options can include cash or taxable state appropriation bonds, which are a slightly more expensive form of debt for the state.

Determining best practices in program design

- **Solar ownership models.** More research is needed to enumerate the possible models for solar development, considering land ownership, solar system ownership, Renewable Energy Credit (REC) ownership, and financing arrangements. Research is needed to understand the risks and benefits of each, and how these can be structured to align with Minnesota's economic, environmental, and equity goals.
- **Environmental and social considerations.** The MPCA could consider incorporating aspects that contribute to the environment and communities, particularly environmental justice communities and climate-vulnerable populations. For example:
    - **Equity and environmental justice considerations.** Program design must take into account who benefits from solar development at CLP sites and who bears the costs and risks. Use of an equity policy review tool could help the MPCA and partner agencies develop a program that considers equity and environmental justice in its processes and results and incorporates ways to address environmental, social, and public health needs.
    - **Pollinator habitat and solar development.** Executive Order 19-28 aimed at restoring pollinator health in Minnesota directs the MPCA to "manage closed landfills under its supervision to create, protect, and enhance pollinator habitat." Pollinator habitat is commonly implemented in conjunction with solar projects in Minnesota. The Board of Soil and Water Resources (BWSR) has a Habitat Friendly Solar program that offers guidance and encourages those implementing solar to meet program standards. Pollinator habitat has been implemented in brightfield projects in other states, including Massachusetts. The MPCA could seek guidance from BWSR and other states on specifications and implementation. More study is needed to understand how pollinator habitat could lower or increase costs associated with a solar project.

Understanding economics of solar development on landfills

- **Preliminary interconnection study for top sites.** The interconnection to a local transmission/distribution system is a large cost component to solar development and uncertainty around what would be required on a site-by-site basis makes it difficult to determine the viability of solar development.
- **Hard-to-develop sites and policies and incentives that would make these developable.** State policy and incentive programs have proven very valuable in Minnesota, in other states, and at the federal level in encouraging renewable energy development. Some landfill sites may require additional incentives and policies to facilitate development. Many ideas were raised during the study, however, these need to be vetted. For example:
    - **Virtual net metering**. Virtual net metering or a similar policy for grid-tied projects could assist in overcoming financial barriers related to developing solar on landfills. Virtual net metering is a mechanism allowing energy customers to credit kilowatt-hours from one meter to another. Many CLP sites are large enough to support solar systems that can produce many megawatts of electricity. Most of those sites, however, do not have need for the power onsite. These sites will be connected to the grid and can provide power to nearby communities or to other grid connected users.
    - **Brownfield adder**. In Minnesota, there is one policy that most closely approximates net metering, the Community Solar Gardens program (CSG). These projects, however, are limited to one MW, and at this threshold are not cost effective for a developer. Projects with one MW cap would not make use of many potential acres of available land. A solution could be to include a "brownfield adder" to the CSG rules allowing for development of projects greater than one MW.

- **Public Use Community Solar Gardens.** Add language to the Community Solar Garden statute (MN Stat. § 216b.1641) to create a new subsection for Public Use CSGs with parameter exceptions for size, number of subscribers, colocation, and ownership structure amenable to public entities exclusively hosting and subscribing to CSG's closed landfill sites. Public entities would include school districts, municipalities, libraries, park agencies, state agencies, sports arenas, water treatment facilities, etc.
- **CLP solar development incentives.** The state could earmark incentives for solar development on CLP sites. If Minnesota determines that brownfield projects are a public good and worth encouraging, the Legislature could set up incentives to offset the additional costs associated with solar development on CLP sites and other brownfield sites. A rule of thumb for developing solar on brownfields to cover the cost of ballasted systems and permitting is approximately 15 percent more than a greenfield site. A state incentive that bridged that additional cost could assist in making solar development at brownfield sites feasible for solar developers.

2. Retire bond debt and release state bond restrictions

Appropriate funds to retire bond debt early and legislatively authorize the release of state bonding restrictions for select CLP sites. Freeing property from bond restrictions would open up lands for solar development and could generate significant revenues into the future.

Under existing law, the only ways to release the bonding restrictions are either the running of time (37.5 years) or sale at fair market value. However, it may be possible for the Legislature to release bonding restrictions by appropriating funds to MMB for the purpose of retiring outstanding bonds and legislatively releasing the property from the bonding restrictions.

If the Legislature appropriated funds, retiring outstanding debt for a CLP site would require MMB to first calculate the amount of outstanding bonds for that site. This is complicated by the following factors: 1) when MMB sells bonds it is not for specifically identified projects, but rather for the group of projects included in any bonding bill as a whole; 2) adequate accounting records going back 20 or more years may not always exist; and 3) many bond appropriations for CLP sites were made to the program as a whole, and not specific projects, which might complicate the tracing of particular bonds to specific projects.

For the top five bond restricted sites identified in the Barr report, MMB attempted to calculate the amount of debt still outstanding. MPCA originally expended a total of $19.7 million of bond proceeds for those sites. Expenditures covered the years 1999 through 2016 and involved approximately 18 separate bond sales. MMB estimates that $7.5 million of principal debt remains outstanding. If the Legislature desired to appropriate funds to retire the outstanding debt in order to remove any bonding restrictions, MMB would need an amount sufficient to pay principal for the portion of debt that can be retired early, to pay principal and interest on the portion of debt that cannot be retired early but could be legally defeased (terminated when funds sufficient to service the debt are set aside), and to pay costs associated with the debt retirement. A precise figure is not available for purposes of this report, but MMB would provide the Legislature with an accurate figure in the event a legislative proposal is introduced.

Any legislation would also need to create a mechanism for expressly releasing the CLP sites from the state's bonding restrictions. As mentioned above, those restrictions extend for a time period equal to 125% of the useful life of the project and are not tied to the status of any bonds. The appropriate mechanism should be investigated in consultation with the state's bond counsel and is an area requiring further inquiry.

Conclusion

Prior to this study, we knew little about the opportunity for solar development on Minnesota's Closed Landfill Program sites. The technical assessment of the sites provides a conservative estimate of land suitable for solar that could support nearly one gigawatt of power (950 MW).

Bond restrictions at half of these sites represent a significant barrier to development, which would need to be resolved to achieve the high aims outlined in this report. Nonetheless, these sites represent a significant economic opportunity distributed across the state that could increase access to clean energy, bring underutilized land back onto the tax rolls, and spur job growth.

Facilitating large-scale solar developments across closed landfills will require expanded statutory authority and funding for the CLP to specifically allow and fund proactive property reuse. Creation of a Closed Landfill Beneficial Reuse Program will require continued interagency collaboration and research to ensure that solar development is aligned with the State's environmental, equity, and economic goals. Minnesota has been a leader in both renewable energy development and responsible management of brownfields. With statutory changes and investment in staffing and bond retirement, Minnesota could accelerate brightfield development – simultaneously improving brownfields and growing clean energy.

Attachment I. Technical assessment

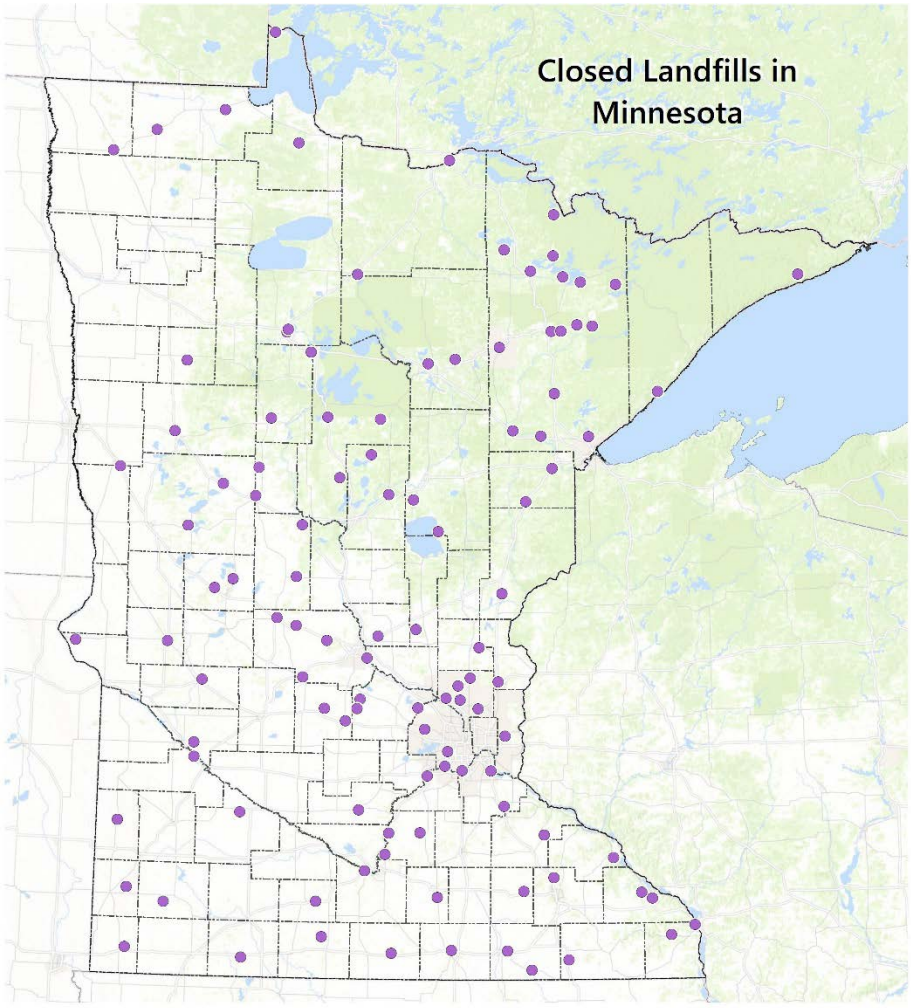
Solar Panels on Closed Landfills Study

Solar Panels on Closed Landfills Study

Prepared for
Minnesota Environmental Quality Board

Prepared by
Barr Engineering Co

October 2020



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Solar Panels on Closed Landfills Study

October 2020

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Abbreviations

Atlas	Minnesota Groundwater Contamination Atlas
Barr	Barr Engineering Co.
CLP	Closed Landfill Program
co-ops	cooperatives
CSG	community solar garden
EQB	Minnesota Environmental Quality Board
GIS	geographical information system
GOB	general obligation bond
LMA	land management areas
MMB	Minnesota Department of Management and Budget
MPCA	Minnesota Pollution Control Agency
MW	megawatt(s)
PV	photovoltaic
REC(s)	Renewable Energy Credits or Renewable Energy Certificate(s)

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Minnesota Department of Management and Budget (MMB)
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In addition, we would like to thank representatives from the following groups that participated in our focus group meetings and online survey.

Academia
Contractor/construction companies
Energy development companies
Legal
Midcontinent Independent System Operator (MISO)
Minnesota Solar Energy Industries Association (MnSEIA)
Municipalities
Nonprofit organizations
Utilities

Executive Summary

The Environmental Quality Board (EQB) received Minnesota Legislature funding in 2019 to conduct a study on the potential to deploy solar photovoltaic (PV) systems on the Minnesota Pollution Control Agency's (MPCA) Closed Landfill Program (CLP) sites. There are currently 110 sites in the CLP; however, there is insufficient information about the sites and their viability for PV development. In this study, Barr Engineering Co. (Barr) and a team of Minnesota state agency representatives (agency team) examine the important criteria relative to PV development on CLP sites, rank the sites for PV development based on key criteria, identify barriers to PV development and make recommendations to address those barriers.

Criteria

Barr and the agency team assembled stakeholders in a wide-ranging engagement/outreach effort to identify a comprehensive list of criteria and determine their relative importance.

The comprehensive list of criteria includes the following:

- General obligation bond (GOB) status
- Interested power purchaser
- Cost associated with connection to transmission and distribution grid
- Finance / investor interest and availability
- Site generation capacity
- Transmission / distribution / substation grid capacity
- Increased construction costs / constructability
- Local acceptance and interest
- Geotechnical characteristics of the cap
- CLP program authorized actions
- Availability of incentives
- Ownership
- Equity considerations
- Local land use and zoning

In discussions with stakeholders, the comprehensive list of criteria was refined to the following list of key criteria which are central to solar development on CLP sites:

- GOB status
- Cost associated with connection to the transmission and distribution infrastructure
- Site generation capacity
- Increased construction costs/constructability
- Availability of incentives

These key criteria were carried forward in our analysis of the sites and identification of barriers and recommended actions.

Geospatial Analysis and Ranking

The geospatial analysis was limited by the availability of geospatial data relative to the key criteria. In light of these limitations, we used the following criteria in our scoring and ranking model:

- Landfill cap generation potential in megawatts (MW)
- Buffer generation potential in MW
- Total site solar generation potential in MW
- Distance to the nearest substation (miles)

We ranked all 110 CLP sites and identified the top five sites where GOBs were used and the top five sites where GOBs were not used. They are:

- Flying Cloud Landfill – GOB restricted
- Western Lake Superior Sanitary District Landfill – GOB restricted
- Anoka-Ramsey Landfill – GOB restricted
- Redwood County Landfill – GOB restricted
- Winona County Landfill – GOB restricted
- Olmsted County Landfill
- Freeway Landfill
- Hibbing Landfill
- Kummer Landfill
- Maple Landfill

Geospatial analysis and scoring/ranking results are provided in the study for all 110 CLP sites.

Barriers and Recommendations

Stakeholders identified many potential barriers. The following three key barriers are common to all sites and were the focus of discussion with the agency team and external stakeholders:

- Uncertainty about costs to connect to nearby transmission or distribution systems
- Uncertainty related to site suitability and CLP program responsibilities
- Increased construction costs associated with the unique features of closed landfill caps

The use of GOBs to improve 55 of the CLP sites represents a unique barrier to solar development on those sites. According to the Minnesota Department of Management and Budget (MMB), federal tax law imposes certain restrictions on the parcels where funds from a GOB were spent, and restrict private benefits deriving from use of the parcels.

Barr worked with the agency team to develop the following recommendations to address the three key barriers and the GOB restrictions:

- Develop a technical guide to solar development on CLP sites
- Provide detailed technical and regulatory information for each of the top 10 sites
- Initiate a preliminary interconnection study for each of the top 10 sites
- Reach out to stakeholders with information about CLP solar development potential
- Pursue state-wide policy and incentive programs to encourage solar development on CLP sites
- Retire GOB obligations early (prior to their natural expiration)

Conclusions

Based on the results of this study Barr has developed the following conclusions:

- There is significant capacity for solar development on Minnesota's CLP sites. Generating capacity, on a site-by-site basis, is approximate; however, we have estimated 950 MW of solar potential on approximately 4,500 acres of CLP land.
- The top ten sites, five bond-restricted and five non bond-restricted sites, do not represent the only favorable CLP sites for solar development. The scope of this study required us to rank the sites in the CLP and identify the top five bond-restricted and top five non bond-restricted sites. In fact, there is no significant difference between the tenth and eleventh sites (and so on) in the ranking. Many sites have favorable characteristics and will be attractive to solar development.
- Solar power and energy storage are a valuable combination. The scope of the study required our focus on solar development. More than one stakeholder suggested we consider other distributed energy resources such as energy storage.
- There are barriers but they are not insurmountable. The most significant barrier is GOB restrictions; however, this only impacts half of the sites and it is possible solar development could proceed on non-GOB restricted land at sites where there is some GOB restricted land. There is some uncertainty with respect to site suitability and state CLP responsibilities, construction costs associated with some unique features of CLP sites, and capacity of transmission/distribution infrastructure. There are many examples of solar energy successfully installed on landfill sites in Minnesota and in other states. Acting on the recommendations in this study report will help to address these barriers and enable development of solar energy on Minnesota CLP sites.

1 Introduction

Closed landfills are promising sites for solar PV systems. Solar on closed landfills could make use of already disturbed land, avoid greenfield development of prime farmland or other undisturbed or undeveloped land, provide a revenue stream from land that would otherwise have no use, and assist the state in meeting carbon reduction goals. The EQB received Minnesota Legislature funding in 2019 to conduct a study on the potential to deploy solar PV systems on the MPCA CLP sites. The MPCA-administered CLP is a program established by the Legislature in 1994 to properly construct, monitor, and maintain closed municipal sanitary landfills.

There are currently 110 sites in the CLP (Figure 1). However, there has been insufficient information regarding whether CLP sites are viable for solar development. The EQB issued a competitive request for proposal and selected Barr to facilitate a study to evaluate the viability of CLP sites for solar development, examine barriers to solar development, and recommend actions to address those barriers.

As an overview, the CLP program includes the following key features:

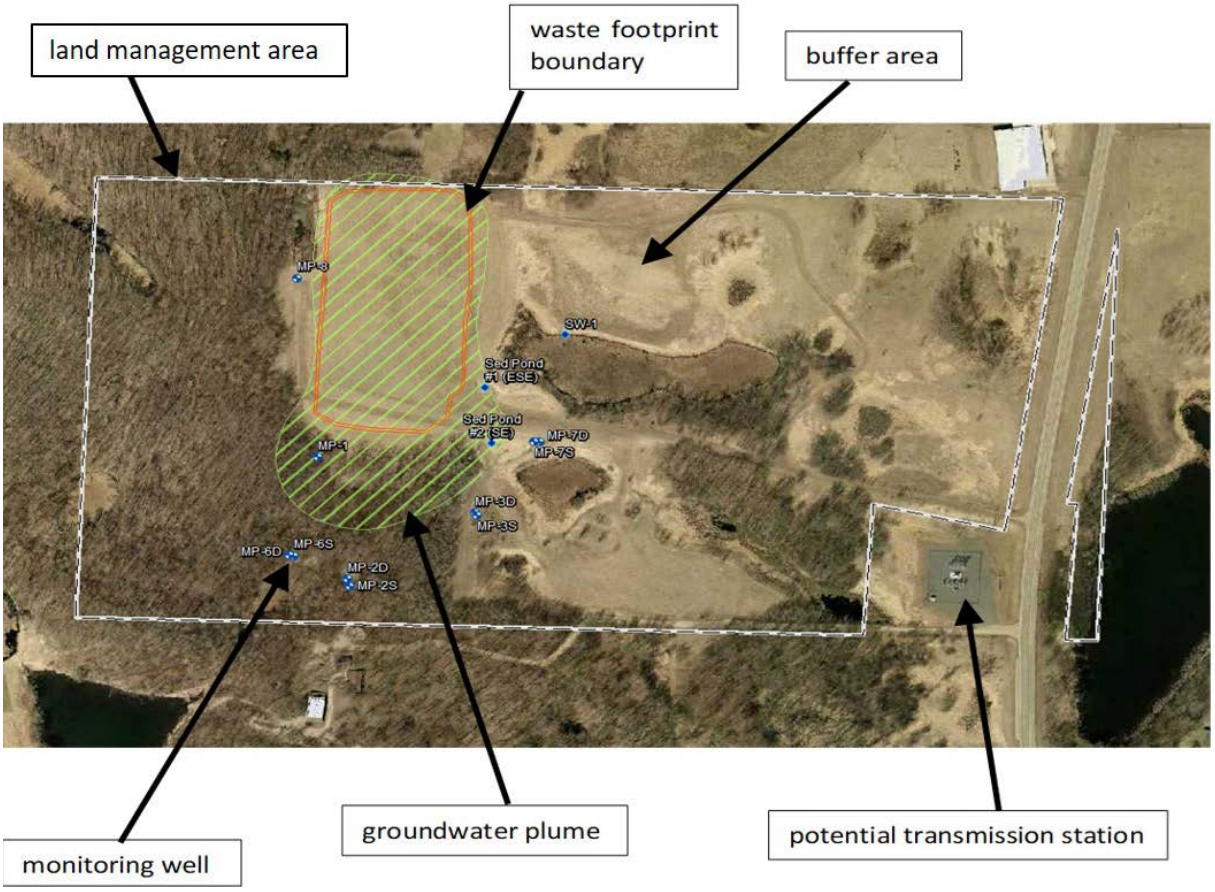
- The CLP currently manages over 8,500 acres of closed landfill property—about 75 percent of this acreage does not contain solid waste. Each site is defined by a land management area (LMA) which is land under control of the MPCA and includes permitted areas and adjacent waste management areas plus any lands acquired by the MPCA. At each CLP site, the capped waste footprint ("cap") is surrounded by buffer areas, which vary in size from minimal to dozens of acres.
- The underlying ownership of the CLP sites is as follows: 45 state-owned sites, 54 local government-owned sites, and 11 privately-owned sites. Appendix A provides a list of sites and current ownership.
- Some of the landfills use electricity to manage environmental impacts of the closed landfill, for example 20 landfills have active gas extraction and 6 landfills have groundwater treatment systems.
- The CLP develops land-use plans for each landfill with which local government plans must be consistent. According to the MPCA, The CLP includes solar energy generation as a use in nearly all its land-use plans.
- In Minnesota, GOB funds were used to improve some of the sites. The use of these bond funds creates restrictions for certain uses including site leases to private solar developers, energy output contracts governing the sale of solar energy generated onsite, or other revenue generating activities. Fifty-five of the sites include these restrictions on some portion of the site.

Solar PV systems on closed landfills must be designed to consider the following unique characteristics of a closed landfill site:

- Solar PV systems on landfills outside of Minnesota are typically installed on the landfill caps; however, Minnesota landfills often include ample buffer land available for solar development around the cap.

- Topography is important. Large, flat areas are optimal. While it may be technically feasible in certain cases to develop mounting structures for steeply sloped areas (greater than 15%) usually the cost of engineering and custom mounting structures is too high to be economically feasible. CLP sites have significant area where topography on the cap and in the buffer is conducive to solar development.
- Construction activities and solar generating equipment used on the cap area must not impact the integrity of the landfill cap and the gas management systems if present. The load limit of the cap dictates the weight of the construction equipment that can be used to install solar generating systems. Typically, the cap cannot be penetrated, so solar panels attach to the surface using weighted ("ballasted") racking systems, and above-ground cabling systems to avoid burying wires.
- Heavy concrete pads and inverters (electrical equipment) are typically placed in the buffer area to avoid settlement issues on the cap.
- Solar development in a buffer area is conducted as a typical solar development without the unique conditions of the cap area.
- Like any solar energy development, a solar PV system on a closed landfill needs to be connected to an electrical "load" or user. A load can be a local user through a distribution system or the electrical grid through the regional transmission system. A load could also be an energy storage system.

The aerial photo below illustrates a typical closed landfill site and the basic features mentioned throughout this report.



At least one other state – Massachusetts – has successfully developed solar PV systems on hundreds of privately owned closed landfill properties (albeit without bond restrictions) over the last ten years. Massachusetts is a good example (reference (1)). Minnesota can learn from these successes.

There are many criteria to consider when determining if solar development is appropriate for a specific CLP site. To learn more about these criteria and their relative importance, Barr led a process of stakeholder engagement, gathering input from state agencies, utilities, solar developers, local government units, and non-profit organizations. We carefully considered the input and criteria and, using geospatial analysis techniques, created a ranking system to identify the top five GOB-restricted sites and the top five non-GOB restricted sites for solar development. With input from the state agencies participating in this study, barriers were identified and recommendations to address those barriers developed. The balance of this report organized as follows:

Section 2. Presents the criteria this study identified that affect the potential for solar development on closed landfill properties.

Section 3. Describes the geospatial analysis used to rank closed landfills for potential solar development.

Section 4. Describes barriers to solar development on closed landfills and actions to address those barriers.

Section 5. Presents recommendations for initiating solar development on the top ranked closed landfill properties.

Section 6. Provides conclusions.

Section 7. Contains a list of references cited.

2 Criteria That Affect the Potential for Solar Development on Closed Landfills

We identified criteria that affect the potential for solar development on closed landfills by reviewing literature and consulting with a wide range of stakeholders. Details of the criteria identification process are in Appendix B. The full list of criteria developed through the literature review and stakeholder consultation process is presented in Table 2-1. Stakeholder input was used to assess the relative importance of the criteria in regard to feasibility and they are listed from most to least important in Table 2-1.

In our discussions with stakeholders we identified key criteria which are central to development of solar on closed landfill sites. These criteria were carried forward in our geospatial analysis and ranking and are discussed further with respect to barriers and actions to address those barriers. They are:

- GOB status
- Cost associated with connection to the transmission and distribution infrastructure as represented by distance to transmission and distribution infrastructure
- Site generation capacity
- Increased construction costs/constructability
- Availability of incentives

Table 2-1 Criteria that Affect the Potential for Solar Development on Closed Landfills

Criteria	Description/Comments	Data Source
General obligation bond (GOB) status	The environmental controls at 55 CLP sites were improved by the MPCA using state-issued GOBs funds. Using GOBs places significant restrictions on the use of land where bond money was spent. All 55 of the sites where GOBs were originally used still include land subject to the State's bonding restrictions. The Minnesota Department of Management and Budget manages this debt. The GOBs can be retired by any one of two methods: 1) allowing the term (37.5 years) to expire, and 2) selling the property at fair market value. A third possibility requiring new legislation was also discussed: retiring the GOB debt early through legislative appropriation and action releasing the GOB restrictions. There are outstanding questions surrounding this criterion which are addressed more fully in Section 4.2.	MPCA
Interested power purchaser	Renewable energy projects, including solar, require an interested party who will agree to purchase or use the power generated. Power purchasers can include property owners/operators, governmental organizations, investor owned utilities, and municipal or other independent power cooperatives. Often price of energy is the primary driver for power purchasers. Price can be dependent on solar technology, financial incentives, time of use, price of alternative generation sources and other factors. The federal investment tax credit has been an effective driver for solar development in that it allows power to be sold and purchased at very competitive rates. Interest in carbon reduction and other societal goals can also motivate purchases of solar power.	none identified
Cost associated with connection to transmission and distribution (T/D) grid	In general terms, the transmission grid carries electricity from a generating station (power plant) to a substation. The distribution grid carries electricity from a substation to the user such as a home or commercial/industrial site. Interconnection of a PV generating system to T/D grid infrastructure can be costly. Costs include easements, engineering, studies (depending on size of the PV system) and construction. In some cases, substations must be upgraded or new ones constructed.	Minnesota Electric Transmission Mapping Project
Finance / investor interest / availability	An interested financial partner with experience weighing the various opportunities and risks associated with solar projects is important. Opportunities include stable return on investment, equipment depreciation, renewable energy credits (RECs) and federal investment tax credits. Risks specific to solar on closed landfills include insurance risk such as long-term stability of the site (cap) and loss due to premature removal of PV equipment. Premature removal of PV equipment could be caused by presence or discovery of some public health issue arising from the landfill and requiring removal of the cap or other excavation where PV equipment is installed. Additional information about solar project finance can be found in the following National Renewable Energy Laboratory publication https://www.nrel.gov/docs/fy16osti/66991.pdf	none identified
Site generation capacity	Generally, a solar development project benefits from scale. The larger the site the more generating capacity. The sites in the CLP range in size from over 400 acres to as little as five acres. In this study we looked at the cap and buffer areas in some detail to identify buildable area within each. Features that limit solar panel installation on the cap include steep slopes, stormwater management features, and gas and leachate collection systems. Features that limit solar panel installation in the buffer areas include open water, wetlands, floodplains, slopes, forest land, and human development (buildings and roads).	– National Land Cover Database – National Wetland Inventory – Land contour data provided in MnGEO LiDAR – MPCA
Transmission / distribution / substation grid capacity	The size in megawatts (MW) of a solar development may be limited by the capacity of the nearby T/D grid or substation. Grid systems and substations at or near capacity may not be able to accommodate a solar development at the scale at which the solar project is feasible. It is difficult to determine the capacity of the T/D grid or substation without specific input from the owner of that system.	Utilities, transmission/distribution system owners/operators.
Increased Construction Costs / Constructability	Construction techniques, construction equipment and solar generating equipment are all important factors when building a solar project on a landfill site. Construction techniques and equipment in the buffer area are typical relative to other ground mounted solar installations, however construction on the cap requires special equipment and construction techniques. To prevent damaging the cap, low ground pressure construction equipment is used and ballasted racking systems and above ground wiring systems are required, which increase construction costs.	none identified
Local Acceptance / interest	Nearby landowners, local government units, and local advocates or detractors can promote development or prevent development of solar on CLP sites. The budget and schedule for this study did not allow for an analysis of local acceptance or interest.	unknown
Geotechnical characteristics of cap	A landfill cap is an engineered cover constructed of soil and sometimes includes a plastic layer. The cap is designed to minimize or eliminate infiltration of rainwater and manage stormwater runoff rate and minimize erosion. When a cap is new, there is typically a period when some settling of the cap occurs. It is important to know if settling is complete and if these geotechnical characteristics have stabilized before constructing a solar project on the cap. There is no clear consensus as to the age when a cap is done settling and it can be site specific; however, it is an important consideration when choosing to construct solar on a landfill cap.	MPCA
CLP Program Authorized Actions	The MPCA's Closed Landfill Program is responsible for the long-term care of the program landfills in-perpetuity. These responsibilities include monitoring, addressing groundwater and vapor impacts, operating engineered gas and groundwater remediation systems, and site care and repairs. Solar development cannot interfere with the program's ability to take these environmental response actions nor jeopardize the integrity each site's response action equipment, including the landfill cover system. Facilitating reuse of closed landfill properties was not part of the scope of the CLP program outlined in statute.	MPCA
Ecological co-benefits	Depending on how the solar project is engineered and constructed, there can be water quality improvements and the creation and protection of habitat. There can also be carbon reduction benefits resulting from solar power generation if the solar power replaces or reduces the use of fossil-fuel generation sources.	– National Land Cover Database – National Wetland Inventory
Availability of incentives	Incentives can be a strong driver of solar development. Accelerated equipment depreciation, renewable energy credits, federal investment tax credits and net metering laws are some of the existing incentives which have facilitated a great deal of solar development in the United States. At this time there are no incentives focused on the development of solar on MN CLP sites.	Minnesota Public Utilities Commission has more information on net metering https://mn.gov/puc/energy/distributed-energy/net-metering/.

Criteria	Description/Comments	Data Source
Ownership	Depending on the situation the ownership (state, local government, or private) of a site could impact the process for procuring a site or leasing a site for solar development.	MPCA
Equity considerations	The way solar energy is implemented can have potential to harm or benefit low income or underserved populations. Low income or underserved populations must be proactively engaged in the conversation for solar development on CLP sites to help address equity and social justice issues.	none identified
Local land use / zoning	Local counties, townships and cities may have land use/zoning requirements that are incompatible with solar development at the CLP site.	City/county land use authorities.

3 Geospatial Analysis and Scoring of Sites

Barr performed a geospatial analysis of the landfill sites in the CLP and ranked their potential for solar development. The following subsections describe the data sources and the ranking methodology and present the results.

3.1 Data Sources

To identify potential data sources, we reviewed the comprehensive list of criteria developed during our outreach to stakeholders in Task 1. With these criteria in mind we assembled publicly available sources of geographical information system (GIS) data sets and using ESRI's ArcGIS created a GIS tool to analyze the sites. The list of GIS data sets are as follows:

- LMA – MPCA. Received via email on February 6, 2020.
- Waste Footprints – MPCA. Received via email on February 6, 2020.
- Bond Restricted Parcels – MPCA. Received via email on March 20, 2020.
- National Wetland Inventory within the LMAs – Minnesota Department of Natural Resources (reference (2)).
- Elevation contours – derived from MnGEO LiDAR data (reference (3))
- Electric substations – Minnesota Electric Transmission Mapping Project (reference (4))
- Electric transmission lines – Minnesota Electric Transmission Mapping Project (reference (4))
- Land Cover – National Land Cover Database (reference (5))

3.2 Criteria

To facilitate ranking our focus centered on four important criteria where we could identify GIS data for each criterion or could complete straightforward calculations to create a data set that could be scored for each CLP site. Each criterion is described in detail below:

- Landfill cap generation potential in MW
- Buffer generation potential in MW
- Total site solar generation potential in MW
- Distance to the nearest substation (miles)

Landfill cap generation potential represents the solar capacity of the portion of the site where waste is managed and covered with an engineered cap. This is an important criterion because solar construction on landfill caps presents some unique challenges when compared to greenfield solar development. The landfill cap is designed to prevent water from percolating through waste material and creating contamination issues in local ground water. For this reason, penetrations are not allowed, and solar developers will use ballasted racking systems and equipment with lower ground pressure ratings when constructing solar on landfill caps. To refine the available construction acreage on each cap we used our GIS system to identify slopes greater than 15% and we subtracted these steeply sloped areas from total cap acreages reported by our GIS system. Thus, we created a "buildable area" in acres for each landfill cap. To calculate the generating potential for each landfill cap we divided each buildable area in acres by a

capacity factor (4.81 acres per MW) to calculate the generating potential in MW. Our capacity factor is calculated based on typical equipment specifications and a ground coverage ratio of 30%. Capacity factor will vary depending on equipment, arrangement of panels and barriers/obstructions to equipment. The resulting number represents the nameplate capacity which is the maximum or rated capacity for typical installed equipment.

Buffer generation potential represents the solar capacity of the non-cap areas within the LMA. While the "buffer," as it is commonly called, does not present the same unique construction challenges as the cap area, we found a wide variety of natural and human-made features which can reduce the buildable area within the buffer. Using our GIS tool, we identified data sets for wetlands, open water, scientific and natural areas, forest (conifer, deciduous and mixed), and developed areas (low, medium, and high density). We identified the acreage for each of these natural and human-made features for each site, subtracted those acres from the total buffer acreage and calculated the buildable acres for each buffer. To calculate the generating potential for each buffer we divided each buildable area in acres by a standard capacity factor to calculate the generating potential in MW. The standard capacity factor for solar development is 4.81 acres per MW. The resulting number represents the nameplate capacity for the landfill buffer.

Site solar generation potential represents the combined solar capacity of the buffer and the cap to calculate the total nameplate capacity of the landfill site. This is an important criterion because it gives a more complete picture of the generating potential of a site. It is important to identify both the cap and buffer capacity because each has solar potential, and each may be preferred for solar development for different reasons. We received feedback from developers suggesting the cap area has been more likely to be developed in other states where solar had been developed on landfill sites. This may be related to a lack of buffer land or the way in which solar development incentives were crafted. Advantages of solar development on the cap include large, relatively flat surfaces with little or no large vegetation to remove or wetlands/open water to work around or requiring a permit. Disadvantages include operational features which need to be avoided: gas extraction wells, passive gas vents, stormwater management features and leachate cleanout access. Another disadvantage is increased construction costs associated with the use of ballasted racking systems in order to avoid penetrating the cap. The advantages to the buffer include good quantity of available land and the ability to use lower cost conventional construction equipment and techniques. Disadvantages associated with the buffer include natural landscape that will have to be affected (wetlands, forests, and other vegetation), the existing grade may not be conducive to solar development and human development within the LMA (buildings, roads, and residents). In any case, calculating the site solar generation potential provides a sense of the scale of the development opportunity of these sites. Specific challenges with cap and/or buffer development at any site may be overcome with greater scale.

Distance to the nearest electrical substation is an important criterion because of the significant cost of connecting solar generation to the existing transmission or distribution grid. We chose distance to a substation because a substation represents a logical place to connect to an existing transmission or distribution network. We identified existing, publicly available data regarding the location of existing electrical substations and used our GIS system to measure the distance in miles from the closed landfill sites to the nearest substation.

3.3 Limitations and Exceptions

It is important to acknowledge the limitations of our data and subsequently our analysis of the characteristics of these sites relative to the criteria described above:

- Our scope and budget did not include the design/layout work necessary to provide more accurate generation capacities. For example, we did not plot or estimate small reductions in acreages related to leachate or gas collection systems. Our generation capacities are estimates based on the GIS data available at the time of this study.
- The buildable acreages calculated for the buffer may underestimate the buildable area. The various data sets may double count some acres for exclusion that appear similar depending on the method of data acquisition and sensing/analysis technique. We attempted to eliminate double counting (e.g., wetlands and open water) where we could. Generally, we believe our buffer generation capacity values to be conservative.
- Data on substation type was not considered for this study, only distance to a substation. Because a substation is close doesn't necessarily mean it is available for connection. Transformer capacity is a key variable as is the capacity of the lines attached to the substation. The accuracy and availability of public information about substation capacity is questionable. This type of information would need to be obtained from the owner and was beyond the scope of this study.

In our review of available GIS data sets we discovered there is much readily available GIS data describing land use and features for Minnesota. However, we discovered some issues which limited their usefulness in ranking all CLP sites.

- For many of the criteria there were no readily available GIS data to support ranking for each landfill site. The following are examples of criteria excluded for this reason:
    - Local land use/zoning
    - Transmission/distribution/substation grid capacity
- Some of the criteria were associated with multiple variables and there was no viable way to accurately score the criteria for all the sites in the CLP based on the GIS data. The following is a list of criteria that was excluded for this reason:
    - Interested power purchaser
    - Local acceptance
    - Investor interest and availability
    - Ecological co-benefits
    - Equity considerations
- For some criteria we were unable to identify a workable scoring model that made sense and accurately compared the sites across the state. The following is a list of criteria that was excluded for this reason:
    - Interested power purchaser

- Investor interest
- Equity considerations
- Ecological co-benefits

Two criteria received significant discussion among the agency team participants: GOBs and landfill cap age. A brief description of the issues and approach during scoring and ranking follows:

- GOBs are an important criterion. However, in our geospatial analysis GOBs were considered a binary factor for CLP sites and not a physical characteristic. Whole landfill sites were considered bonded or not bonded, even when some "bonded" landfills had parcels not restricted by bond appropriations. The study, as described in the scope of work, is intended to identify the top five sites with GOB restrictions and the top five sites without GOBs. Our ranking identified the top sites irrespective of GOB status and then applied the GOB criteria as a means to narrow down the top five sites with and without GOB restrictions. The GOB issue is complex and adds significant restrictions to the use of parcels at sites where GOB funds were used to improve or close the site. There are ways to address or remove these restrictions; however, they are complex and not well tested in the context of solar development on CLP sites.

- Cap age was also considered as a criterion for our geospatial analysis. As mentioned previously; the CLP caps are soil material meeting certain design specifications and there may or may not be a barrier layer of man-made material (plastic) incorporated below the earthen material. The cap is designed to minimize or eliminate infiltration of rainwater and manage stormwater runoff rate and minimize erosion. The MPCA has records of cap construction and provided data regarding the age of the soil cap. Settlement is often an issue with soil caps during the first few years after construction and is dependent on the relative consolidation of the waste material, the characteristics of the soil used to construct the cap and the construction techniques used to install the cap. A specific age, after which settlement is considered minimal, is difficult to determine and there is no clear consensus. Ten years was discussed as a conceptual age; however, there are only five sites with caps less than ten years old, (Flying Cloud, Hopkins, Washington County, WLSSD and East Mesaba). Regardless of the age of the cap, it is likely that the cap construction documentation will be reviewed, and a geotechnical survey completed to verify the status of the cap prior to solar development.

3.4 Ranking Method

Our GIS analysis provided data for each landfill site which we scored to rank the sites and identify the top five GOB-restricted and top five non-GOB-restricted sites. For each of the criteria described above we used a simple scoring system. The range of values for a criterion was divided into equal parts and a score (five being high and one being low) was assigned for each landfill. The criteria were weighted based on our assessment of importance: cap generation capacity 20%, buffer generation capacity 20%, site generation capacity 40% and distance to nearest substation 20%. The weighted scores for each criterion were added together to create a composite score for each site. The limited number of criteria and

simplicity of the scoring system created some duplicate scores. To address duplicate scores, a secondary sort was performed based on site generation capacity (highest capacity to lowest capacity).

3.5 Results

Results of our analysis are presented as a table in Appendix C. CLP sites are listed from the most likely suitable for development to the least. The top five bond-restricted sites are highlighted in blue and the top five non-bond restricted sites are highlighted in green in Appendix C. Table 3-1 summarizes the results for the top five bond-restricted and top five non-bond-restricted sites, and indicates the figure showing each site.

Table 3-1 Top 5 Ranked Bond Restricted and Non-Bond Restricted CLP Sites

CLP Site	City	County	Overall Ranking [1]	Bond Restricted [2]	Figure
Flying Cloud Landfill [4]	Eden Prairie	Hennepin	1	Yes	Figure 2
Western Lake Superior Sanitary District Landfill [4]	Duluth	St. Louis	2	Yes	Figure 3
Anoka-Ramsey Landfill	Ramsey	Anoka	4	Yes	Figure 4
Redwood County Landfill	Redwood Falls	Redwood	5	Yes	Figure 5
Winona County Landfill	Winona	Winona	6	Yes	Figure 6
Olmsted County Landfill	Oronoco	Olmsted	3	No	Figure 7
Freeway Landfill [3]	Burnsville	Dakota	8	No	Figure 8
Hibbing Landfill	Hibbing	St. Louis	15	No	Figure 9
Kummer Landfill	Bemidji	Beltrami	21	No	Figure 10
Maple Landfill	Pequot Lakes	Cass	22	No	Figure 11

[1] The scope of this study required identification of the top five GOB restricted and top five non-GOB restricted sites in the CLP. The majority of the top twenty ranked sites were GOB restricted which necessitated using sites farther down the ranking to find five non-GOB restricted sites. This ranking does not suggest that sites further down the ranking are in some way unsuitable for solar development.

[2] In this analysis bond restriction is treated as a binary criterion (yes or no). The reality is more complex. GOB restrictions are specific to a defined area of land or parcel. Some of these landfill sites are divided into multiple parcels of land and in some cases only part of the site carries a GOB restriction. GOB restrictions are described in more detail in Section 4.2.

[3] Freeway Landfill does not currently include GOB-restricted parcels. In recent years there have been discussions about using bond money to make improvements to the site.

[4] The cap for this landfill is identified as less than 10 years old. Cap construction documentation and geotechnical information should be reviewed to understand potential subsidence risks.

4 Barriers and Actions to Address Barriers

Stakeholders identified numerous potential barriers and opportunities associated with developing solar on CLP sites. These barriers and opportunities are summarized (in no particular order) in Table 4-1 and Table 4-2. The literature review and stakeholder engagement process to identify these barriers is described in Appendix B.

Table 4-1 Barriers Associated with Developing Solar on CLP Sites

Barriers
Use of state general obligation bonds to pay for site improvements restricts use for solar power generation.
Need approximately 5 "buildable" acres per megawatt (MW). Not all acres at a site can support solar development. Awareness of the size of these sites is not well known.
Connection to transmission/distribution and an off-taker (user of electricity) can be expensive and some of these sites may be too far from this infrastructure to be economically feasible. This is unique to CLP sites because the sites were originally located where they are because of the need to manage waste, not generate energy for a near-by user.
Upgrades to transmission/distribution system may be required to accommodate solar on landfills. This is not unique to solar development on CLP sites.
MPCA CLP responsibilities for closed landfills (maintenance, erosion control, gas collection system management/maintenance) may make development of solar more complex.
Funding may be hard to get for small sites. This is not unique to solar development on CLP sites.
Local and state support for solar development on closed landfills is not assured for every site.
Current contracts with power producers may prohibit or limit development of distributed energy sources (small-scale power generation connected to the grid at the distribution level). This is specifically an issue with Municipal and other cooperative power producers and is not unique to solar development on CLP sites.
Competition with other energy generation sources on price of power, or levelized cost of energy (LCOE). Solar on closed landfills might not be the cheapest source of electricity.
Construction limitations on the landfill cap (smaller equipment, prohibition of penetrations, ballasted racking systems, prohibition of buried/trenched lines) leading to higher construction costs.
Perception of risk affecting lenders (increased risk premium over greenfield site). Landfill sites carry some risk that future maintenance or contamination issues will require part or all of a solar installation to be moved.
The age and stability of the landfill cap can be a barrier to installing solar equipment.
Local zoning/land use requirements may not be amenable to solar development. This is not unique to solar development on CLP sites.
Interconnect queue. For larger sites, the queue for connecting to the existing transmission infrastructure is long and difficult to predict. This is not unique to solar development on CLP sites.

Table 4-2 Opportunities Associated with Developing Solar on CLP Sites

Opportunities
CLP sites represent large amounts of available land that currently do not have a higher value use. These sites could replace agricultural land as solar development options.
Production of renewable energy and corresponding reduction of greenhouse gas emissions from the power generation sector.
Support for short-term construction and long-term maintenance jobs.
Electricity to serve on-site load.
Opportunity for local developers to continue solar development in Minnesota.
Good use for otherwise marginal/impaired land, beneficial reuse.
Solar energy could help local government meet their renewable energy/greenhouse gas reduction goals.
Energy production is a potential source of stable revenue.
Solar energy could be a community asset/amenity.
Solar energy can provide various grid services including peak shaving. Peak shaving reduces the load on the local transmission and distribution grid during times of peak electricity use.
Development of solar on CLP sites could be an opportunity to create streamlined/standardized program for leasing and selling power.
Minnesota could show leadership in brownfield solar development.
Solar energy could be a source of tax revenue.
Solar development has the potential to support pollinator-friendly and other natural habitat development.

4.1 Common Key Barriers to All Sites and Potential Actions to Address Those Barriers

Based on the July 13, 2020 focus group discussion and participant feedback, the key barriers common to solar development at all CLP sites are uncertainty about costs to connect to nearby transmission or distribution systems, uncertainty related to site suitability and CLP program responsibilities , and increased construction costs related to the unique features of closed landfill caps. These, of course, do not represent all the barriers; however, these barriers were repeatedly mentioned by stakeholders as key barriers that were common to all CLP sites and would need to be addressed in order to enable solar development on MN CLP sites. In the balance of Section 4.1 we will describe each of these barriers in more detail and recommend some actions to address these barriers.

Uncertainty About Costs to Connect to Nearby Transmission or Distribution Systems. We learned from our stakeholders the cost to connect to existing infrastructure is a significant part of the total cost to construct solar generating systems. These costs are directly related to several important variables: distance from the solar generating equipment to the existing electrical infrastructure, availability of a substation, existing equipment in a substation, electrical capacity of the substation and associated transmission/distribution system and permitting and interconnect costs. Publicly available GIS data, showing locations of transmission and distribution infrastructure (wires and substations), gave us a means of calculating the distance to local electrical infrastructure from our CLP sites. Generally, as a rule of

thumb, closer is better and results in lower connection costs. However, the other variables associated with the connection to local transmission/distribution systems can have a significant impact on costs and information regarding these variables is not easy to acquire for all sites and therefore they were not investigated as part of this study. In this case the barrier is the uncertainty about the costs to connect to nearby electrical infrastructure. To illustrate the uncertainty, we provide some feedback from developers and utilities.

Several utilities and developers discussed the importance of distance to grid infrastructure. Qualitatively speaking, if a project is very large then it can be further from grid infrastructure to make it cost-effective. That said, predicting the weight of the distance criteria is difficult. One developer said: *"In rural areas, sometimes the distance can be farther than you'd expect. I have connected a 5MW [*solar on landfill*] project to a substation located 2 miles away, for very reasonable cost. I have also connected a 30MW project with the substation located on the same parcel at a very high cost. Utilities are hard to predict!"*

Another developer seemed to say it was difficult to predict the weight of the distance criteria. She said, *"Most of the smaller projects (from less than 1 to over 10 megawatts) can be tied into the nearest 3-phase distribution line, even if the line has to be extended to the site for some distance at a cost to the project… Most of these sites have little on-site load and may only have a single-phase pole at the site. Therefore, extending the line could be a significant cost. But interconnection is always costly, and the additional cost will not likely be overly burdensome relative to typical ["*greenfield" or undeveloped sites*] interconnection costs."*

The solar project developer typically bears all costs associated with interconnection. Therefore, it is critical to understand what is required and the costs for interconnection. The voltage rating for a distribution line may dictate the largest size project that can be installed in a given location. Some rules of thumb from developers include that a 5 kV transmission line can support only a few hundred kW of intermittent renewable generation capacity. A 13 kV line can typically only support up to 3 MW of renewable generation capacity. A 23 kV line may support up to 6 MW of renewable generation capacity. There are many factors that influence what a given transmission or distribution line can support. Finally, a large-scale solar array will require three-phase power.

To address this uncertainty, we recommend performing an interconnection survey for the top ten sites (five bonded and five non-bonded). We are not advocating for a complete interconnect study as required under state siting requirements; however, contacting utilities and collecting information to identify information about the critical characteristics of local electrical infrastructure would provide some level of certainty about the costs required to connect.

Uncertainty Related to Site Suitability and CLP Program Responsibilities. Generally, landfill caps provide a clear, engineered surface on which to install solar equipment; however, they also present unique technical and engineering challenges which result in increased costs (when compared to greenfield solar installations). Specific issues include age of cap, use of lighter weight installation/construction equipment, presence of steep slopes, presence of leachate and gas collection systems, potential for cap maintenance activities and a general restriction from penetrations of the cap. Steep slopes and the presence of leachate

and gas collection systems can reduce the buildable area available for solar installations. Using the GIS tool developed for this project, we eliminated slopes on each cap greater than 15% when calculating buildable cap area; however, we did not plot or estimate reductions associated with leachate or gas collection systems. These features can also reduce the buildable area which reduces the site generating capacity.

With respect to the age and maintenance activities associated with the cap, there is not good agreement about the rate of settlement and corresponding appropriate age for installing solar on a cap. Based on data provided by the MPCA, there are five caps in the CLP that are less than ten years old (Flying Cloud, Hopkins, Washington County, WLSSD and East Mesaba). This does not mean they are unsuitable. It means a geotechnical evaluation may be necessary to verify suitability. Future cap maintenance activities could also impact a solar installation; however, a good method of predicting maintenance activities with any precision is not available. Stormwater management is an especially important issue on a landfill cap. A solar site design will be required to manage stormwater to prevent cap erosion. Developers indicated that solar installations on landfill caps are inspected at a greater frequency than landfill caps without solar installations. This tends to ensure erosion and other issues with the integrity of the cap are identified earlier. In general, the cap issues described here represent a potential financial risk for the solar installation during the economic life (approximately 25 years) of the site. This risk may be addressed with additional insurance coverage at additional cost to the project.

Increased Construction Costs Associated with the Unique Features of Closed Landfill Caps. Based on experience in other parts of the country, where solar installations on landfill caps is more common, construction techniques and solar racking and cabling required for landfill cap installations is where the significant increases in construction costs are associated. The cap must not be damaged by construction activities/equipment and because the cap cannot be penetrated, ballasted racking systems are usually employed. Smaller, lighter equipment results in longer construction schedules and ballasted racking systems and above ground cabling are more expensive to purchase and install.

Investor owned and cooperative (co-op) utility stakeholders pointed out power pricing is a key issue for them. Their goal is to provide customers the lowest priced electricity. There is a perception solar is not the least expensive option and given the increased capital and construction costs (over greenfield sites), utilities are skeptical these sites can be developed, and power purchased economically.

These barriers, and the resulting additional costs, cannot necessarily be changed but it might be possible to reduce the real and perceived risk associated with them by collecting and providing some detailed technical information about the sites. We recommend developing a guide for solar development on CLP sites to help interested parties understand the opportunities and challenges associated with building solar on MN CLP sites. We suggest this guide include technical details about the sites and more general information about installing solar on the sites.

It is unlikely the state of Minnesota can directly impact the increased capital and construction costs associated with solar installations on closed landfills; however, we recommend the state consider

promoting the development of solar energy on MN CLP sites and also consider the adoption of a variety of policy and financial incentives. Policy and financial incentives are described in more detail in Section 5.

The US Department of Energy's National Renewable Energy Laboratory recently completed a technical and economic analysis of a potential solar energy development for the Becker landfill. At the time this report was completed this analysis had not yet been vetted; however, the process and information provided in the analysis could be very helpful in explaining the potential for development on CLP sites in Minnesota. We recommend the state consider doing this analysis on the top ten sites identified in this study.

4.2 Specific Barriers to the Top Five Bond Restricted Sites and Specific Actions to Address those Barriers

The top five bond restricted and top five non-bond restricted sites share the common barriers described in Section 4.1. In Section 4.2 we will focus on the barrier exclusive to the bond restricted sites: prior use of state tax-exempt GOBs to finance improvements.

There are 55 CLP sites where MPCA used state GOBs to clean up the sites. It should be noted these CLP sites often contain more than one parcel of land and, in some cases, some of the parcels carry the bond restrictions and some do not. According to the MMB, federal tax law imposes certain restrictions on the parcels where funds from a GOB were spent, and restrict private benefits deriving from use of the parcels. The restrictions attach to parcels identified in a real property declaration recorded with the associated county by the MPCA and remain in place for 37.5 years from the last date when GOB funds were used. MMB reports private use under federal tax law may include site leases to private solar developers, energy output contracts governing the sale of solar energy generated onsite, or other revenue generating activities.

MMB has indicated if solar energy systems are to be developed on GOB-restricted parcels, and if those developments benefit private parties such as developers or lessees, the GOB restrictions will first have to be removed. There are two methods MMB described under existing law for removing the restrictions: 1) allow the declaration as restricted property to expire at the end of the 37.5-year period, or 2) sell the GOB-restricted land at fair market value. A third possibility requiring new legislation was also discussed: retiring the GOB debt early through legislative appropriation and action releasing State bonding restrictions. Appendix D shows GOB expenditures by site, the estimated GOB expiration date, the acres of restricted parcels and the acres of unrestricted parcels. The next paragraphs describe the bond challenges in more detail and identify questions to be answered if solar is to be developed on GOB-restricted land.

Expiration of 37.5-year time period. Waiting for GOB debt to expire at the end of the 37.5-year period may be challenging. Based on the table of GOB expenditures (Appendix D), the soonest some of the restricted parcels would be available is 2034 and the last restrictions would expire in 2056. GOB funds were expended over multiple years and some sites have multiple restricted parcels, all improved at different times. This suggests some individual sites may have GOB's retiring over a series of years, further complicating a solar development plan.

Sale at fair market value. It is not unreasonable to expect a site with GOB-restricted land to be of interest to a solar developer, utility, or local unit of government. Interest may be high enough to make purchase of a GOB restricted site or portion of a GOB restricted site an option to consider. However, MPCA has statutory responsibilities for these sites which may limit sale is a feasible option.

Retiring GOB debt. The remaining debt and time left on the obligation are important datapoints if attempting to retire the debt early. Appendix D includes MPCA's records regarding expenditures and timeframes by landfill but does not indicate the amount of the remaining debt for each site. MMB reports it is challenging to identify remaining debt for a specific landfill site because when the State sells bonds it is not for specifically identified projects but rather for particular enacted bonding bills. Any assessment of outstanding debt will require a careful analysis of past accounting records. It is unlikely that remaining debt could be determined at the individual parcel level. Because parcel-by-parcel debt accounting is so complex MMB has indicated all GOB debt for a site would need to be retired at a site for solar development to occur.

MMB has indicated retiring a bond obligation early would require legislative action. At this time, it is difficult to gauge the legislature's interest in or ability to pay off this debt to promote or enable solar development on closed landfills.

The following are questions summarized from the discussion above that may serve as future lines of inquiry:

- How much is the outstanding bond obligation for a given CLP site?
- What is the legislative process for retiring the obligation early?

The existence of GOB restrictions presents a significant challenge to development of solar on bond-restricted parcels at 55 sites. Given the potential for solar development at non-GOB restricted sites it might be prudent to first focus on the sites where there are no such restrictions, and non-bond restricted parcels on landfill sites where bond-restricted parcels exist. However, the state is interested in understanding the barrier imposed by GOBs and identifying options to addressing it.

To address this barrier, we might suggest using the top five sites with bond obligations (identified in Section 3) to develop a process and report identifying options for addressing the existing general bond obligation and allow solar development on these five sites. This would supply options and valuable information regarding the legal actions and associated time-frames necessary to proceed with potential development. Furthermore, a successful process could perhaps be replicated for other sites as interest in those sites is identified.

5 Recommended Steps for Initiating Solar Development on the Top Ranked Sites

To respond to this element of the scope of work we make the distinction between those sites with GOBs (bond-restricted) and all top ten sites regardless of bond status. We will begin with the bond-restricted sites.

Top Five Bond-Restricted Sites

As previously stated in Section 4, half of the sites in the CLP have at least one bond-restricted parcel. The top five bond-restricted CLP sites as ranked are:

- Flying Cloud
- Western Lake Superior Sanitary District
- Anoka-Ramsey
- Redwood County
- Winona County

The first step to consider solar development on these five sites (and all bond-restricted sites) is to continue the dialog between the MMB and MPCA to resolve questions around this barrier. Specific considerations are: what the remaining debt is on each of the top five bond-restricted sites, and what the legislative process is for retiring the debt early.

Top Ten Sites Regardless of Bond Status

The top ten ranked sites are:

- Flying Cloud
- Western Lake Superior Sanitary District
- Olmsted County
- Anoka-Ramsey
- Redwood County
- Winona County
- Freeway
- Hibbing
- Kummer
- Maple

We identified the following action items to address the barriers identified. We acknowledge state agencies may need additional authority to act on some of these recommendations.

Retire GOB obligations early. The Minnesota Legislature could take action to retire GOB obligations early to remove the associated restrictions. This would seem to be a strong incentive for solar develop and

other beneficial reuse of closed landfills and would indicate the legislature's intent to promote development on the sites in the CLP.

Develop a technical guide to solar development on CLP sites. A technical guide could provide general information about the unique design aspects of closed landfills and more detailed information about the CLP program responsibilities associated with the landfills and process for developing solar on a closed landfill site. The audience would be utilities, developers, local government, and finance stakeholders who are unfamiliar with closed landfills and their potential for solar development. Subject matter experts at the MPCA and Department of Commerce could develop this guide and be a clearinghouse for questions or comments from users of the guide. We reference an example technical guide from the state of Massachusetts for use as a starting point, which includes guidance in terms of working with local governments, financers, utilities, and developers and a process to address many of the same barriers discussed in this document.

Provide detailed technical and regulatory information for each of the top 10 sites. The MPCA is developing the Minnesota Groundwater Contamination Atlas (Atlas) which is a GIS tool. The Atlas is intended to develop into being the primary communication platform for information about environmentally impacted properties in Minnesota. The MPCA is currently in the process of adding information about the CLP sites and is awaiting additional Environment and Natural Resource Trust Fund money to further expand the Atlas We recommend MPCA identify detailed technical and regulatory information that would be important to solar development on the CLP sites and ensure the information is integrated into the Atlas platform. Detailed technical and regulatory information may include specific design elements of the sites, permit conditions, information on cap construction and maintenance status, surrounding land use and natural features and other site-specific information deemed useful. The MPCA or Department of Commerce could also consider completing techno-economic analysis for each of the top sites using the free System Advisor Model. The audience for this information would be developers, local land-use planning/zoning officials, utilities, and finance stakeholders who are interested in developing plans and specifications for solar development on these sites.

Initiate a preliminary interconnection study for each of the top 10 sites. The interconnection to local a transmission/distribution system is a large cost component to solar development and uncertainty around what would be required on a site-by-site basis makes it difficult to determine the viability of solar development. We do not assume a full-scale interconnection study as required by certain size solar developments; however, collecting more detailed information about nearby transmission/distribution and substation equipment, capacity, and ownership/control status. We believe this study could be conducted by Minnesota Department of Commerce and the audience for this information is developers, utilities, and transmission/distribution planners.

Reach out to stakeholders. One common barrier to development of solar energy on CLP sites is lack of awareness of these sites and the solar development potential they represent among non-developers. The Department of Commerce and MPCA could prepare informational materials for the top 10 sites and invite key stakeholders to open discussions about the sites and solar development potential. Key stakeholders include owners, utilities, transmission operators, developers, local government, and other regulators.

These meetings would provide an opportunity to gauge interest, collect site specific feedback and identify local barriers/concerns and opportunities. Providing stakeholders information on specific sites helps to "make it real" and could create opportunities.

Pursue state-wide policy and incentive programs to encourage solar development on CLP sites. State policy and incentive programs have proven very valuable in Minnesota, other states and at the federal level in encouraging renewable energy development. In Minnesota, our practice of upgrading the environmental controls at closed landfills with GOBs has resulted in proactive management of these legacy waste management sites. It has also created a barrier to solar development for about half of the sites. Increased capital and construction costs associated with solar installations on closed landfills is also a significant barrier. Based on previous experience in Minnesota with the community-based solar program and elsewhere in other states there are many policy and incentive programs to consider. Here are a few ideas:

- **Virtual net metering.** Virtual net metering or a similar policy for grid-tied projects could assist in overcoming financial barriers related to developing solar on landfills. Virtual net metering is a mechanism allowing energy customers to credit kilowatt-hours from one meter to another. Many CLP sites are large enough to support solar systems that can produce many MW of electricity. Most of those sites, however, do not have need for the power onsite. These sites will be connected to the grid and can provide power to nearby communities or to other grid connected users. With a virtual net metering policy, the landfill owners could be compensated for the power they produce. In Massachusetts, a similar net metering policy allowed those who owned the solar systems to receive 100 percent net metering credits for their solar generation up to six MW. For example, credits could be transferred to a customer of the same distribution utility as long as they are within the same service territory and MISO (Midwest Independent System Operator - the regional electricity grid operator) load zone. The value of each kilowatt-hour could be valued more as a net-metered credit under this policy than if the kWh was sold to the utility grid at the clearing price.

  In Minnesota, there is one policy that most closely approximates net metering, the community solar garden (CSG) program. These projects, however, are limited to one MW, and at this threshold are not cost effective for a developer. Projects with one MW cap would not make use of many potential acres of available land. A solution could be to include a "brownfield adder" to the CSG rules allowing for development of projects greater than one MW.

- **CLP solar development incentives.** The state could earmark incentives for solar development on CLP sites. If Minnesota determines that brownfield projects are a public good and worth encouraging, the Legislature could set up incentives to offset the additional costs associated with solar development on CLP sites and other brownfield sites. A rule of thumb for developing solar on brownfields to cover the cost of ballasted systems and permitting is approximately 15 percent more than a greenfield site. A state incentive that bridged that additional cost could assist in making solar development at brownfield sites feasible for solar developers.

- **Renewable Energy Credit or Renewable Energy Certificate (REC) ownership by MPCA.** One developer said they had heard the MPCA would like to retain the RECs earned by solar development at CLP sites, as a way of meeting its greenhouse gas reduction obligations. This may be possible. Understanding in more detail what MPCA REC ownership means in terms of policy and how it works practically is key to determining whether it hinders or encourages solar development at CLP sites.

6 Conclusions

There is significant capacity for solar development on Minnesota's CLP sites

In developing and analyzing data regarding the sites in the MN CLP we estimate solar energy capacity statewide to be on the order of 950 MW. Landfill caps have the potential for 280 MW on approximately 1300 acres and buffer areas could produce 670 MW on approximately 3200 acres. The generating capacity varies from site to site. Table 6-1 shows groupings by capacity.

Table 6-1 Solar Generating Capacity at CLP Sites

Range of generating capacity (megawatts)	Number of sites
20 – 45	8
10 – 19	22
5 – 9	42
1 – 4	35
Less than 1	4

These numbers are approximate; exact capacities are typically determined by developers during the solar equipment design phase. For context: according to the Minnesota Department of Commerce report (reference (6)), there were 596 MW of solar PV capacity operating in Minnesota in 2017.

The solar potential at CLP sites could be well aligned with solar development plans being pursued by power utilities with operations in Minnesota. Here are a few examples:

- By 2030 **Xcel Energy** plans to reduce carbon dioxide emissions 80 percent below 2005 levels company wide. They intend to invest in wind and solar under their "Steel for Fuel" strategy and offer customers more renewable energy options. From their most recent carbon report: "*We anticipate adding thousands of megawatts of wind and solar power to our system and incorporating both natural gas and storage resources to help balance high levels of renewables*" For more information about Xcel's plans see their most recent carbon report: https://www.xcelenergy.com/staticfiles/xe/PDF/Xcel%20Energy%20Carbon%20Report%20-%20Feb%202019.pdf
- **Minnesota Power** is implementing their "Energy Forward" strategy and intend to be at 50% renewable energy by 2021. They intend to install about 23 MW of new solar in Minnesota to be operational in 2021. For more information about their Energy Forward strategy see their website: https://www.mnpower.com/Environment/EnergyForward

- In 2018 **Great River Energy** (GRE) adopted its corporate goal to achieve 50% renewable energy for its member co-ops by 2030. GRE has been adding solar in various co-op service territories. For more information see their "Renewable Energy Position Statement": https://greatriverenergy.com/the-cooperative-difference/legislative-activity/renewable-energy-position-statement/

The top ten sites, five bond-restricted and five non bond-restricted sites, do not represent the only favorable CLP sites for solar development. The scope of this study required us to rank the sites in the CLP and identify the top five bond-restricted and top five non bond-restricted sites. In fact, there is no significant difference between the tenth and eleventh sites in the ranking. We believe many of the sites have favorable characteristics (e.g., capacity and distance to transmission/distribution infrastructure) and will be attractive to power users (off-takers), utilities and solar developers. With proper application of incentives and with improved awareness among non-developer stakeholders many of these sites will attract interest and eventually solar power development.

Solar power and energy storage are a valuable combination. During focus group discussions the concept of co-located solar and energy storage was mentioned by more than one stakeholder. Solar paired with energy storage systems can provide stacked electrical grid support services (e.g., voltage regulation, peak shaving, and peak shifting) which can improve the economics of distributed energy resource development on CLP sites. Although not specifically included in the scope of this study, CLP sites, especially the buffer area, is well suited to co-located energy storage systems.

There are barriers. While MN CLP sites hold great potential for solar development there are barriers which can make development challenging for some of the sites. Some of these barriers are more challenging than others but all can be overcome. Based on discussions with stakeholders and MN agency representatives we developed the following list of barriers.

GOBs. Over $100 million in GOB funds were used to make improvements, including closure, at 55 of the CLP sites. Restrictions associated with use of GOB funds affect approximately 4100 acres across these 55 sites, while there are approximately 1,100 acres at these 55 sites where GOB funds were not spent. The non-bond restricted acres at these 55 sites may have fewer barriers to solar development., however the presence of GOB restrictions elsewhere at the landfill site may complicate solar development at these sites. It is highly likely many of these 55 sites will be attractive to power users, utilities, and developers. Eliminating a majority of acreage from half of the CLP sites from consideration for solar power development solely on the basis of bond status would severely limit the opportunity to meet renewable energy goals and reduce carbon emissions in Minnesota.

In the course of this study there have been several conversations about this topic with members of MPCA and MMB. Section 4.2 describes the issues as we understand them now and identifies outstanding questions requiring further investigation to move forward. We recommend MPCA and MMB work together to find answers to the outstanding questions so this barrier can be

addressed balancing the benefits of renewable energy development and our obvious need to comply with the conditions of our GOB requirements.

Uncertainty related to site suitability and CLP program responsibilities. There are perceived and real risks associated with building solar on CLP sites. Some of these risks are associated with the structures (cap) and systems (leachate and gas collection and management) and some are related to future events that are difficult to predict. Future events include CLP program required cap maintenance and potential discovery of contaminants requiring removal of solar equipment. Anyone seeking to develop solar systems on these sites will attempt to quantify risks and insure against associated losses. The MPCA has technical information about these sites and their construction that could be provided to interested parties to help explain the risks better and address this barrier.

Increased construction costs related to the unique features of closed landfill caps. Constructing solar power systems on a landfill cap requires lighter weight construction equipment and construction techniques and racking systems that eliminate penetrations. Stormwater management and erosion control are also especially important considerations when working on a landfill cap. We have heard this increases the costs to construct solar on the landfill cap. We believe state renewable energy policy could be created to help off-set these costs and promote solar energy development on CLP sites.

Investments in transmission and distribution infrastructure may be needed. CLP sites were typically located to be convenient, from a transportation standpoint, to the point of waste generation and on marginal land without competing uses. This does not mean they are convenient to an off-taker (someone who would use the electricity). We have identified the location of existing transmission and distribution infrastructure and assumed distance to infrastructure is an important criterion for siting solar on CLP sites. Distance is important but there are other factors that can also impact the cost to connect solar on CLP sites to the local/regional infrastructure. We recommended a preliminary interconnect study for the top ranked sites to help identify these other important factors and determine their impact on solar development on CLP sites. It is possible that investments in Minnesota's transmission and distribution infrastructure would enable or promote solar development on CLP sites across Minnesota.

7 References

1. **Nexamp.** The Guide to Developing Solar Photovoltaics at Massachusetts Landfills. s.l. : Commonwealth of Massachusetts; Massachusetts Department of Energy Resources, undated.

2. **Minnesota Department of Natural Resources.** National Wetland Inventory for Minnesota. *Minnesota Geospatial Commons.* [Online] 2015. [Cited: March 26, 2020.] https://gisdata.mn.gov/dataset/water-nat-wetlands-inv-2009-2014.

3. **Minnesota Geospatial Information Office.** LiDAR Elevation Data Download. [Online] [Cited: March 26-27, 2020.] www.mngeo.state.mn.us/chouse/elevation/lidar.html#data.

4. —. Electric Transmission Lines and Substations, 60 Kilovolt and Greater, Minnesota, 2016. *Minnesota Geospatial Commons.* [Online] https://gisdata.mn.gov/dataset/util-elec-trans.

5. **Multi-Resolution Land Characteristics Consortium.** National Land Cover Database (NLCD) 2016. [Online] https://www.mrlc.gov/national-land-cover-database-nlcd-2016.

6. **Minnesota Department of Commerce.** Minnesota Renewable Energy Update. November 2018.

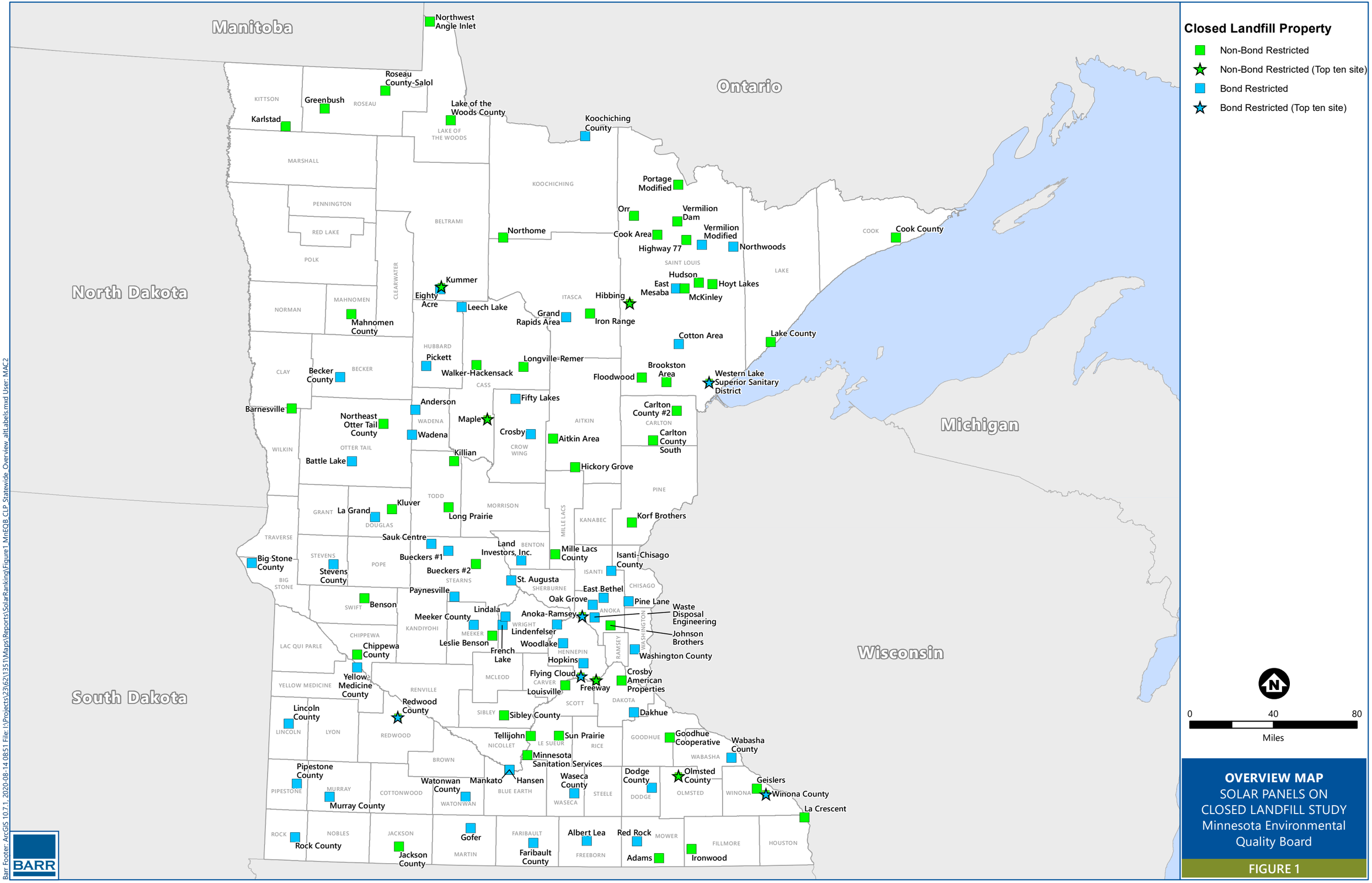
Figures

Important notes to figures:

"Buildable Area" and estimated generating potential in MW – The yellow hatch pattern shown on the top ten site figures recognizes the buildable acres and approximate generating potential for the landfill cap and buffer areas. To identify the buildable area on the landfill cap, we used our GIS system to identify slopes greater than 15% and we subtracted these steeply sloped areas from total cap acreages reported by our GIS system. To identify the buildable area in the buffer we identified data sets for wetlands, open water, scientific and natural areas, forest (conifer, deciduous and mixed), and developed areas (low, medium, and high density). We identified the acreage for each of these natural and human-made features for each site, subtracted those acres from the total buffer acreage, and calculated the buildable acres for each buffer. To estimate the generating potential for each site, we divided each buildable area in acres by a capacity factor (4.81 acres per MW) to calculate the approximate generating potential in MW. Our capacity factor is calculated based on typical equipment specifications and a ground coverage ratio of 30%.

The buildable area within the buffer appears fragmented and discontinuous at some of the sites. This is a function of the National Land Cover Database (NLCD) used to identify the specific natural and human made features that were subtracted from the total buffer area. The NLCD may occasionally misinterpret land cover and, due to time and scope constraints, we did not attempt to field verify land cover for each site.

GIS data for GOB restricted parcels was provided by the MPCA. The restrictions attach to parcels identified in a real property declaration recorded with the associated county by the MPCA. The location of parcels with GOB restrictions should be verified by reviewing the declaration prior to contemplating development of non-GOB restricted parcels.



Closed Landfill Property

- Non-Bond Restricted
- Non-Bond Restricted (Top ten site)
- Bond Restricted
- Bond Restricted (Top ten site)

OVERVIEW MAP
SOLAR PANELS ON CLOSED LANDFILL STUDY
Minnesota Environmental Quality Board

FIGURE 1

BARR

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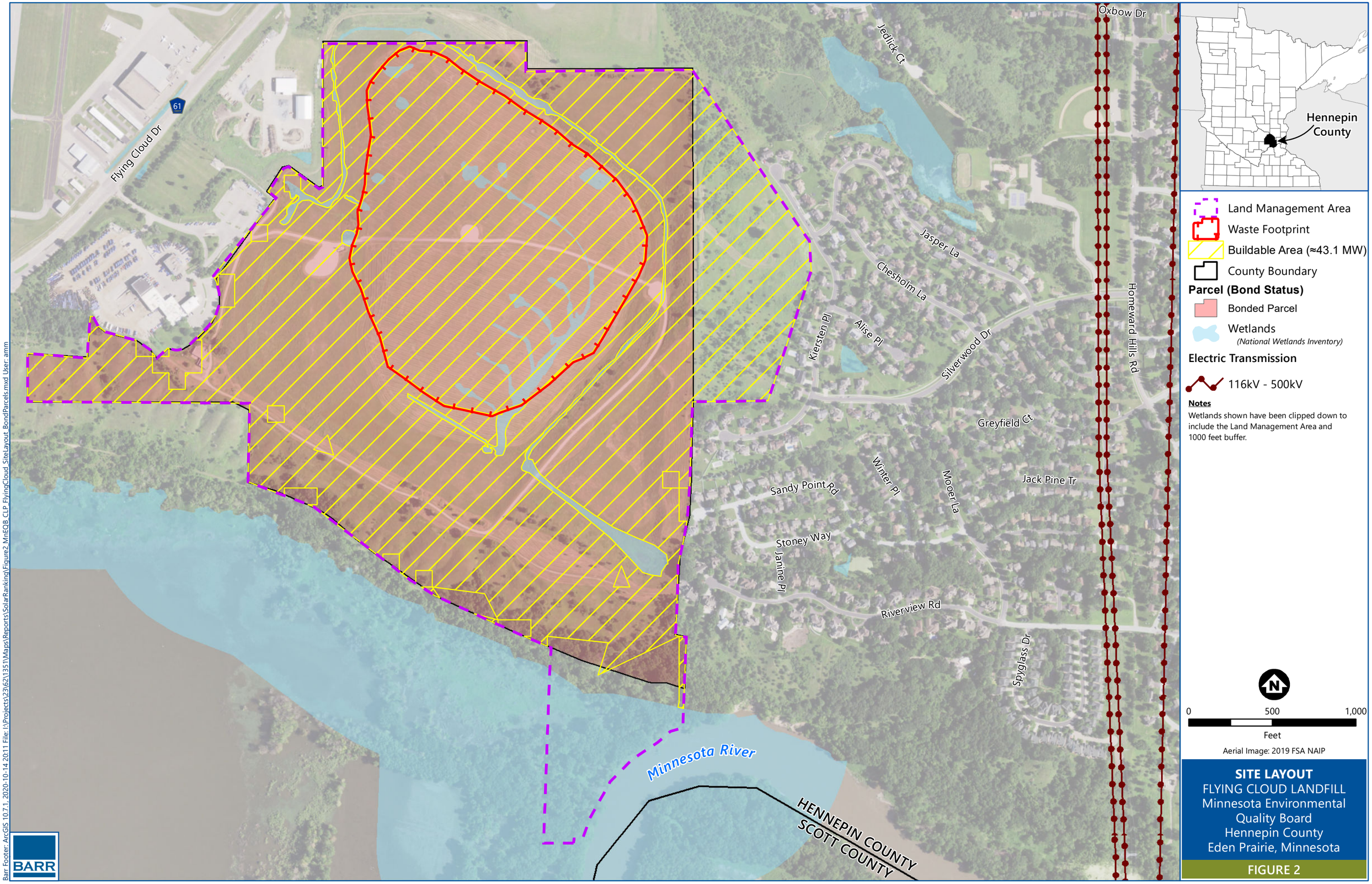

SITE LAYOUT
FLYING CLOUD LANDFILL
Minnesota Environmental Quality Board
Hennepin County
Eden Prairie, Minnesota

FIGURE 2

BARR

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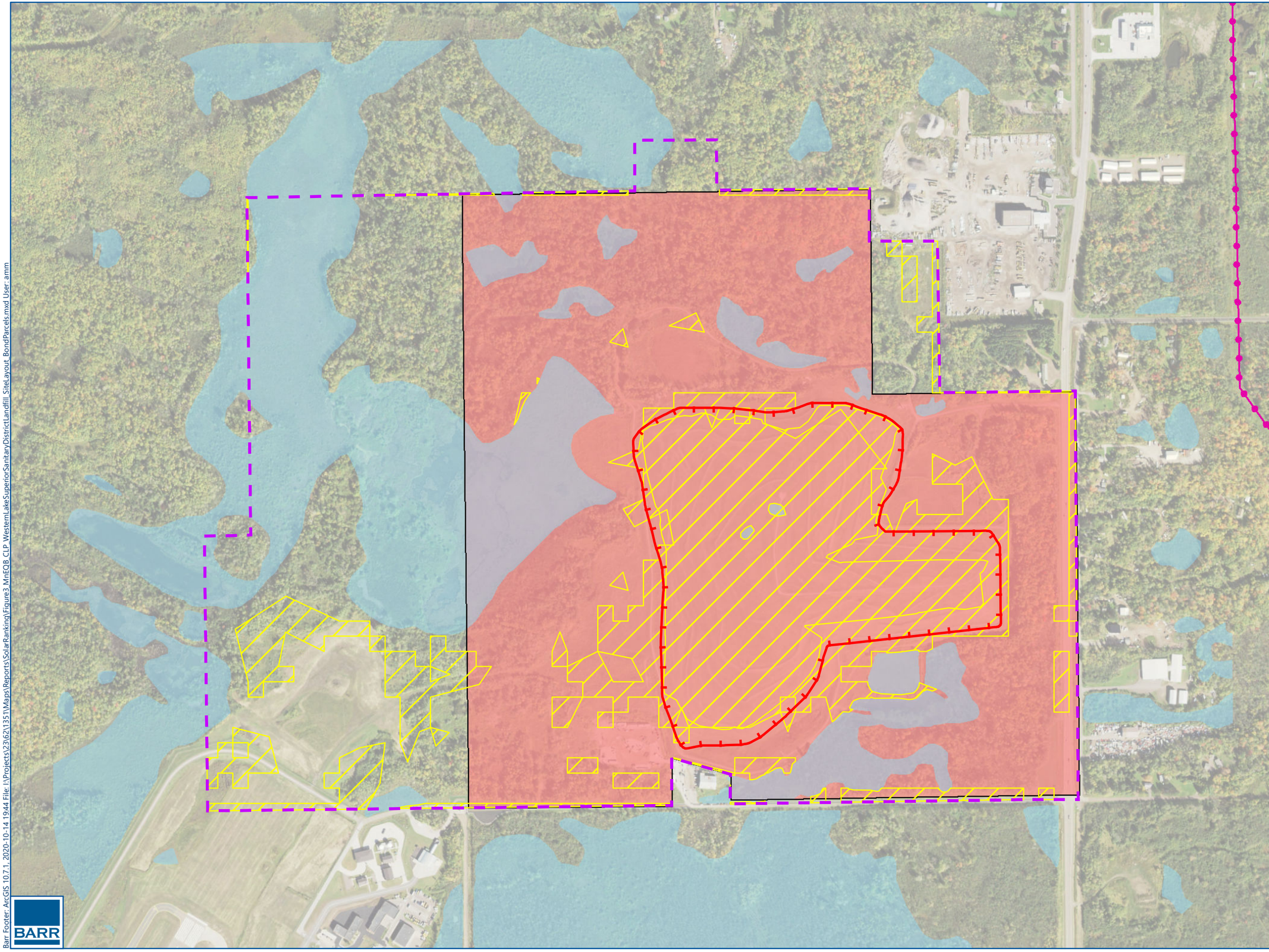


Land Management Area

Waste Footprint

Buildable Area (≈40.3 MW)

County Boundary

Parcel (Bond Status)

Bonded Parcel

Wetlands
(National Wetlands Inventory)

Electric Transmission

34kV - 115kV

Notes

Elevation contours shown based on MnTOPO LiDAR elevation data.

Elevation contours and wetlands shown have been clipped down to include the Land Management Area and 1000 feet buffer.

0 500 1,000

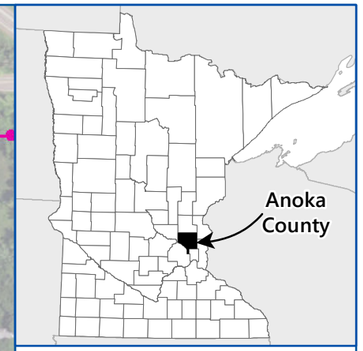
Feet

Aerial Image: 2019 FSA NAIP

SITE LAYOUT
WESTERN LAKE SUPERIOR SANITARY DISTRICT LANDFILL
Minnesota Environmental Quality Board
St. Louis County
Duluth, Minnesota

FIGURE 3

BARR



Land Management Area

Waste Footprint

Buildable Area (≈27.5 MW)

County Boundary

Parcel (Bond Status)

Bonded Parcel

Wetlands
(National Wetlands Inventory)

Electric Transmission

34kV - 115kV

Notes

Wetlands shown have been clipped down to include the Land Management Area and 1000 feet buffer.

0 500 1,000

Feet

Aerial Image: 2019 FSA NAIP

SITE LAYOUT
ANOKA-RAMSEY LANDFILLL
Minnesota Environmental Quality Board
Anoka County
Ramsey, Minnesota

FIGURE 4

BARR

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Land Management Area

Waste Footprint

Buildable Area (≈31.7 MW)

County Boundary

Parcel (Bond Status)

Bonded Parcel

Wetlands
(National Wetlands Inventory)

Notes

Wetlands shown have been clipped down to include the Land Management Area and 1000 feet buffer.

0 250 500

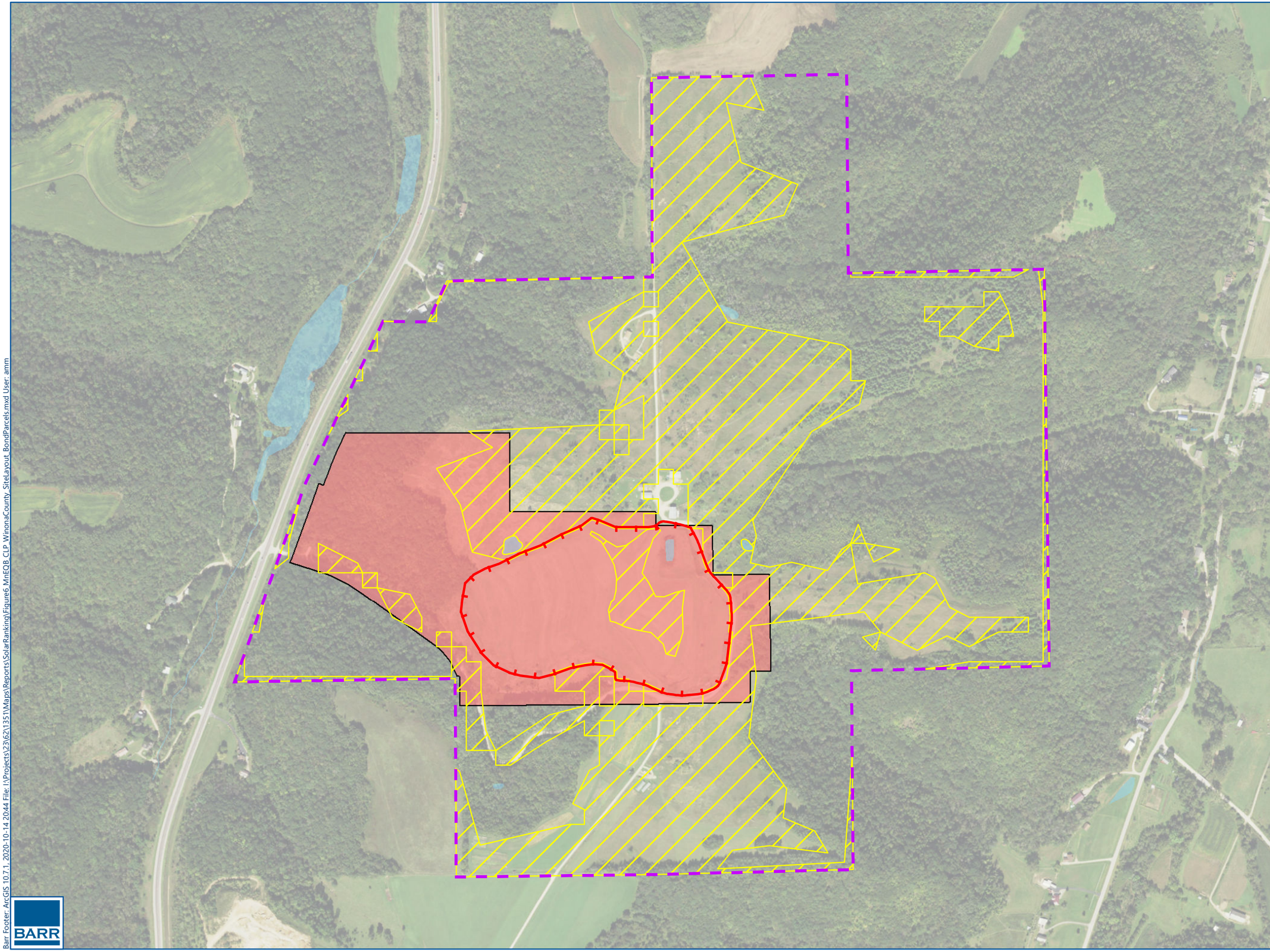
Feet

Aerial Image: 2019 FSA NAIP

SITE LAYOUT
REDWOOD COUNTY LANDFILL
Minnesota Environmental Quality Board
Redwood County
Redwood Falls, Minnesota

FIGURE 5

BARR



Land Management Area

Waste Footprint

Buildable Area (≈30.9 MW)

County Boundary

Parcel (Bond Status)

Bonded Parcel

Wetlands
(National Wetlands Inventory)

Notes

Wetlands shown have been clipped down to include the Land Management Area and 1000 feet buffer.

0 500 1,000

Feet

Aerial Image: 2019 FSA NAIP

SITE LAYOUT
WINONA COUNTY LANDFILL
Minnesota Environmental Quality Board
Winona County
Winona, Minnesota

FIGURE 6

BARR

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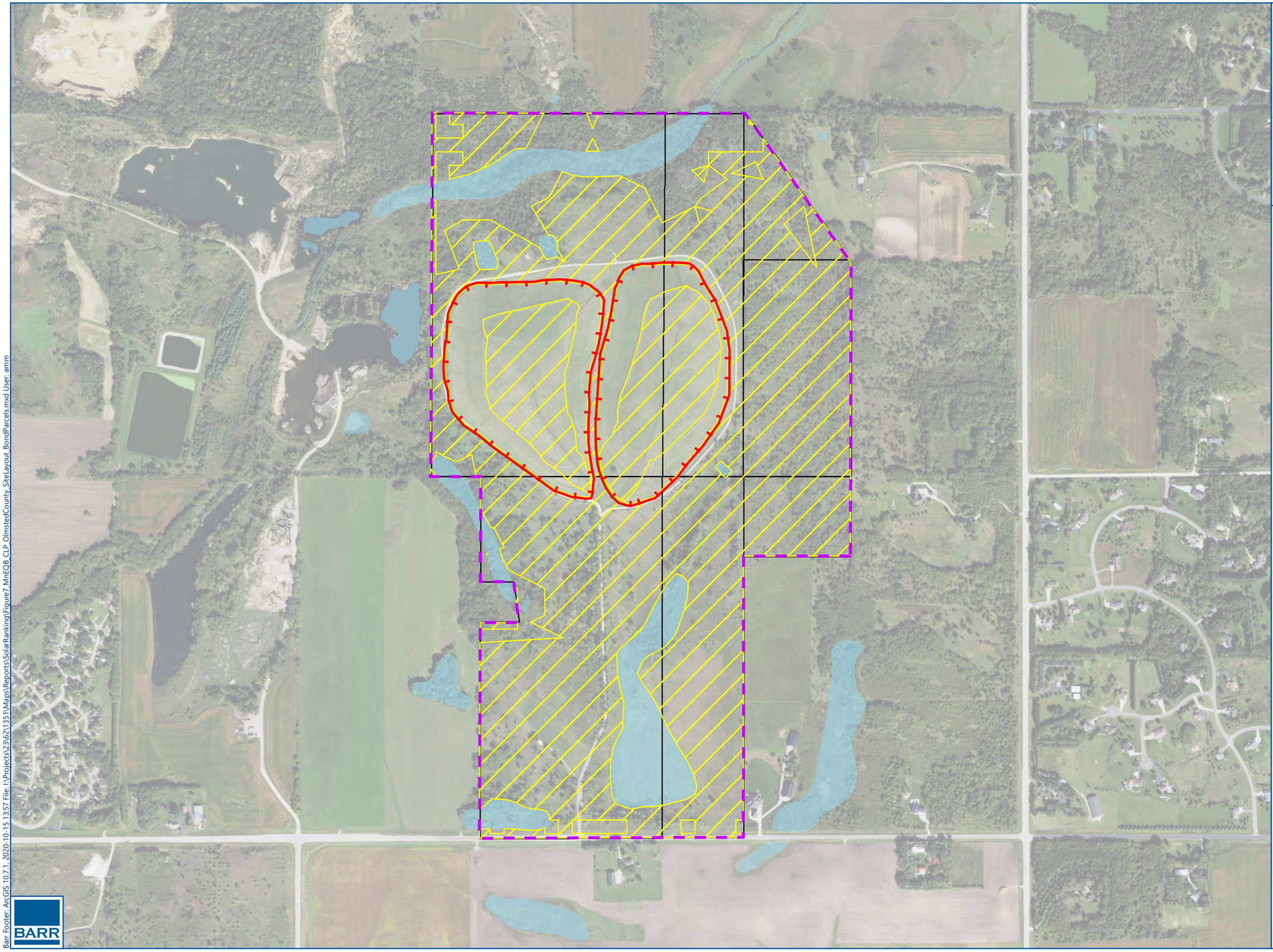

Land Management Area

Waste Footprint

Buildable Area (≈44.8 MW)

County Boundary

Parcel (Bond Status)

Bonded Parcel

Wetlands
(National Wetlands Inventory)

Notes

Wetlands shown have been clipped down to include the Land Management Area and 1000 feet buffer.

0 600 1,200

Feet

Aerial Image: 2019 FSA NAIP

SITE LAYOUT
OLMSTED COUNTY LANDFILLL
Minnesota Environmental Quality Board
Olmsted County
Oronoco, Minnesota

FIGURE 7

Barr Footer: ArcGIS 10.7.1, 2020-10-15 13:57 File: I:\Projects\23\62\1351\Maps\Reports\SolarRanking\Figure7_MnEQB_CLP_OlmstedCounty_SiteLayout_BondParcels.mxd User: amm

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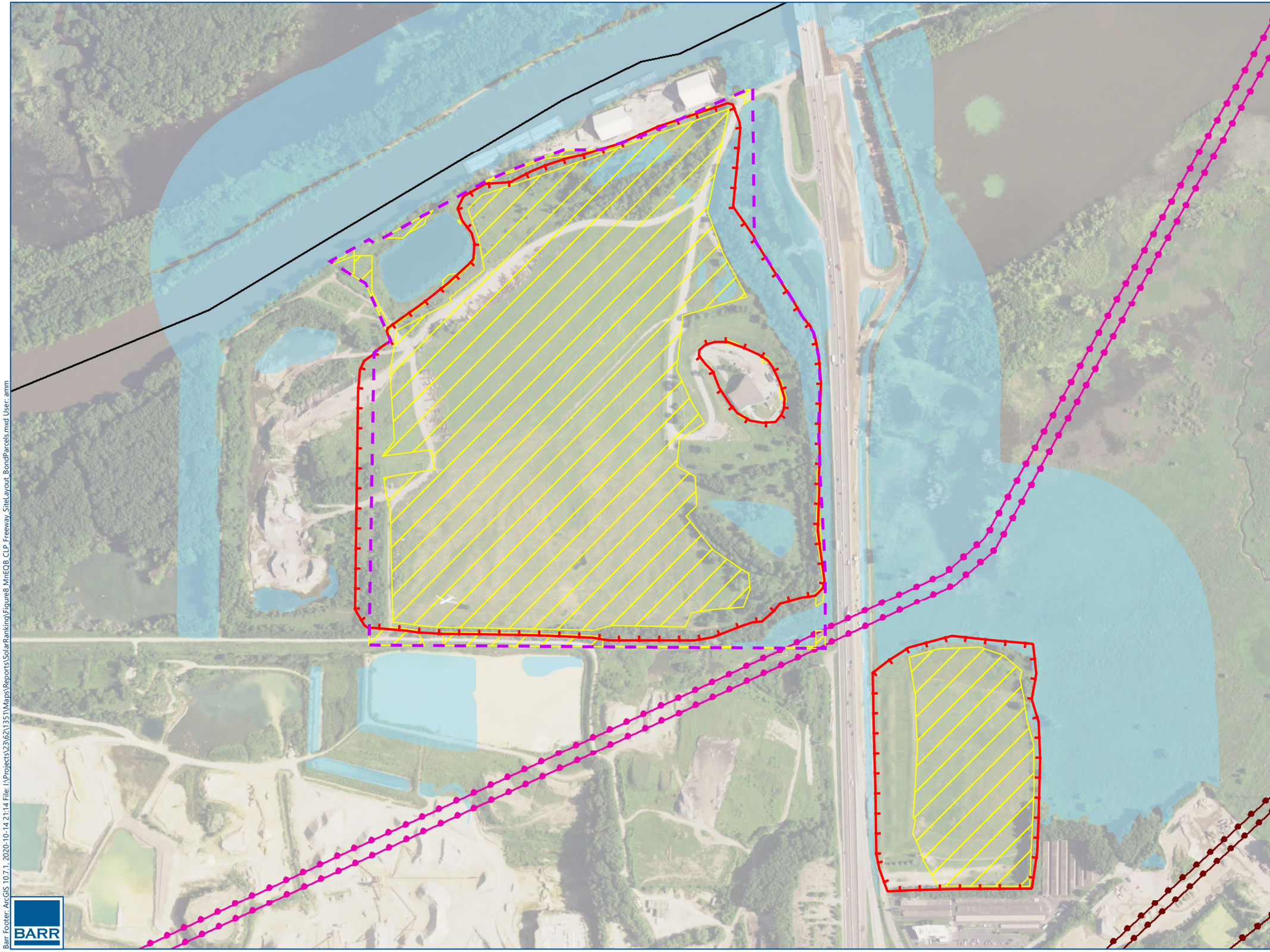


Land Management Area

Waste Footprint

Buildable Area (≈23.6 MW)

County Boundary

Parcel (Bond Status)

Bonded Parcel

Wetlands
(National Wetlands Inventory)

Electric Transmission

34kV - 115kV

116kV - 500kV

Notes

Wetlands shown have been clipped down to include the Land Management Area and 1000 feet buffer.

0 400 800

Feet

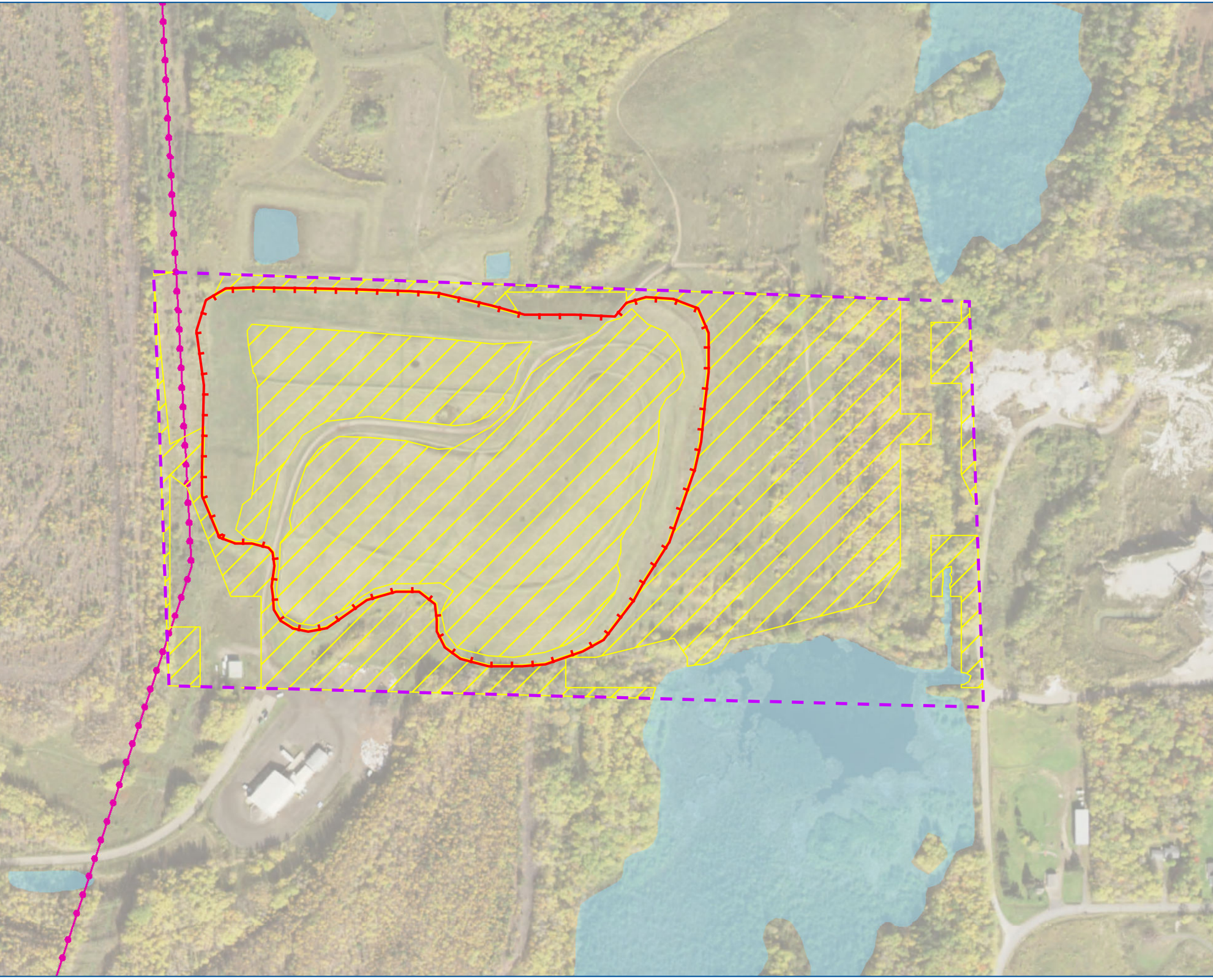
Aerial Image: 2019 FSA NAIP

SITE LAYOUT
FREEWAY LANDFILL
Minnesota Environmental Quality Board
Dakota County
Burnsville, Minnesota

FIGURE 8

BARR

Barr Footer: ArcGIS 10.7.1, 2020-10-14 21:14 File: I:\Projects\23\62\11351\Maps\Reports\SolarRanking\Figure8_MnEQB_CLP_Freeway_SiteLayout_BondParcels.mxd User: amm



Land Management Area

Waste Footprint

Buildable Area (≈12.4 MW)

County Boundary

Parcel (Bond Status)

Bonded Parcel

Wetlands
(National Wetlands Inventory)

Electric Transmission

34kV - 115kV

Notes

Wetlands shown have been clipped down to include the Land Management Area and 1000 feet buffer.

0 300 600

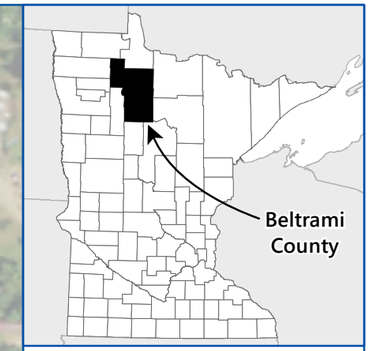
Feet

Aerial Image: 2019 FSA NAIP

SITE LAYOUT
HIBBING LANDFILL
Minnesota Environmental Quality Board
St. Louis County
Duluth, Minnesota

FIGURE 9

Barr Footer: ArcGIS 10.7.1, 2020-10-14 21:21 File: I:\Projects\23\62\1351\Maps\Reports\SolarRanking\Figure9_MnEQB_CLP_Hibbing_SiteLayout_BondParcels.mxd User: amm



Land Management Area

Waste Footprint

Buildable Area (≈11.1 MW)

County Boundary

Parcel (Bond Status)

Bonded Parcel

Wetlands
(National Wetlands Inventory)

Electric Transmission

34kV - 115kV

Notes

Wetlands shown have been clipped down to include the Land Management Area and 1000 feet buffer.

0 200 400

Feet

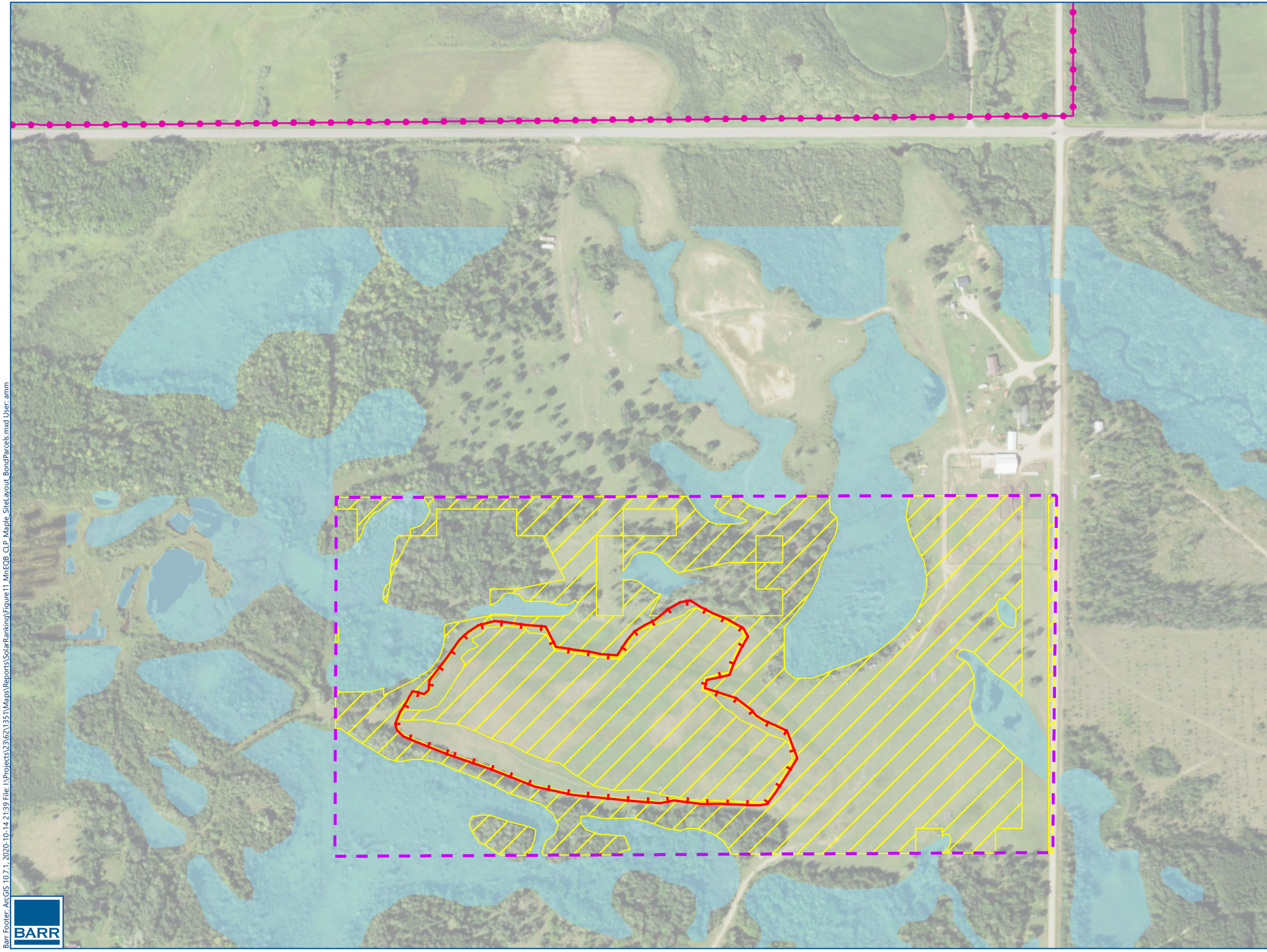
Aerial Image: 2019 FSA NAIP

SITE LAYOUT
KUMMER LANDFILL
Minnesota Environmental Quality Board
Beltrami County
Bemidji, Minnesota

FIGURE 10

BARR

Barr Footer: ArcGIS 10.7.1, 2020-10-14 21:29 File: I:\Projects\23\62\1351\Maps\Reports\SolarRanking\Figure10_MnEQB_CLP_Kummer_SiteLayout_BondParcels.mxd User: amm



Land Management Area

Waste Footprint

Buildable Area (≈10.6 MW)

County Boundary

Parcel (Bond Status)

Bonded Parcel

Wetlands
(National Wetlands Inventory)

Electric Transmission

34kV - 115kV

Notes

Wetlands shown have been clipped down to include the Land Management Area and 1000 feet buffer.

0 200 400

Feet

Aerial Image: 2019 FSA NAIP

SITE LAYOUT
MAPLE LANDFILL
Minnesota Environmental Quality Board
Cass County
Pequot Lakes, Minnesota

FIGURE 11

Appendices

Appendix A

Closed Landfill Program Property Owners

Closed Landfill Program Property Owners

Landfill	Property Owner
Adams Landfill	City of Adams
Aitkin Area Landfill	Aitkin County
Albert Lea Landfill	City of Albert Lea
Anderson Landfill	State of Minnesota
Anoka-Ramsey Landfill	State of Minnesota
Barnesville Landfill	State of Minnesota
Battle Lake Landfill	City of Battle Lake; Clitherall & Everts Townships
Becker County Landfill	Becker County
Benson Landfill	State of Minnesota
Big Stone County Landfill	State of Minnesota
Brookston Area Landfill	St. Louis County
Bueckers #1 Landfill	State of Minnesota
Bueckers #2 Landfill	Ervin J. Bueckers Trust
Carlton County #2 Landfill	Carlton County
Carlton County South Landfill	Carlton County
Chippewa County Landfill	Chippewa County
Cook Area Landfill	St. Louis County
Cook County Landfill	Cook County
Cotton Area Landfill	St. Louis County
Crosby American Properties Landfill	State of Minnesota
Crosby Landfill	City of Crosby; State (Department of Natural Resources)
Crow Wing County Landfill	Crow Wing County
Dakhue Landfill	State of Minnesota
Dodge County Landfill	Dodge County
East Bethel Landfill	State of Minnesota
East Mesaba Landfill	State of Minnesota
Eighty Acre Landfill	City of Bemidji
Faribault County Landfill	Faribault County
Fifty Lakes Landfill	Crow Wing County
Floodwood Landfill	State of Minnesota
Flying Cloud Landfill	State of Minnesota
Freeway Landfill	RB McGowan Co., Inc.
French Lake Landfill	State of Minnesota
Geislers Landfill	John David Fort & Thomas Fort, et al.
Gofer Landfill	Martin County

Landfill	Property Owner
Goodhue Cooperative Landfill	John & Janice Holst Trust
Goodhue County Landfill	Goodhue County
Grand Rapids Area Landfill	Itasca County
Greenbush Landfill	City of Greenbush
Hansen Landfill	Harvey Hanel; Raymond & Evelyn Hanel Trust
Hibbing Landfill	St. Louis County
Hickory Grove Landfill	David & Lydia Simonson
Highway 77 Landfill	St. Louis County
Hopkins Landfill	City of Hopkins
Houston County Landfill	Hop Hollow, LLP
Hoyt Lakes Landfill	St. Louis County*
Hudson Landfill	St. Louis County
Iron Range Landfill	Itasca County
Ironwood Landfill	Wilderness Lake Estates, LLC; Brian Mildenstein
Isanti-Chisago County Landfill	State of Minnesota
Jackson County Landfill	Jackson County
Johnson Brothers Landfill	City of Blaine
Karlstad Landfill	State of Minnesota
Killian Landfill	Harlan & Myrna Killian
Kluver Landfill	State of Minnesota
Koochiching County Landfill	State of Minnesota
Korf Brothers Landfill	State of Minnesota
Kummer Landfill	Kummer Land Holding Co.*
La Crescent Landfill	City of La Crescent
La Grand Landfill	State of Minnesota
Lake County Landfill	Lake County
Lake of the Woods County Landfill	Lake of the Woods County
Land Investors, Inc. Landfill	State of Minnesota
Leech Lake Landfill	State of Minnesota
Leslie Benson Landfill	Joan Benson
Lincoln County Landfill	Lincoln County
Lindala Landfill	State of Minnesota
Lindenfelser Landfill	State of Minnesota
Long Prairie Landfill	State of Minnesota
Longville-Remer Landfill	Cass County
Louisville Landfill	State of Minnesota
Mahnomen County Landfill	State of Minnesota

Landfill	Property Owner
Mankato Landfill	State of Minnesota
Maple Landfill	Oakridge Ranch, LLC
McKinley Landfill	State of Minnesota
Meeker County Landfill	Meeker County
Mille Lacs County Landfill	Mille Lacs County
Minnesota Sanitation Services Landfill	State of Minnesota
Murray County Landfill	Murray County
Northeast Otter Tail County Landfill	Northeast Otter Tail County
Northome Landfill	Koochiching County
Northwest Angle Inlet Landfill	Lake of the Woods County
Northwoods Landfill	St. Louis County
Oak Grove Landfill	State of Minnesota
Olmsted County Landfill	State of Minnesota
Orr Landfill	St. Louis County
Paynesville Landfill	State of Minnesota
Pickett Landfill	State of Minnesota
Pine Lane Landfill	State of Minnesota
Pipestone County Landfill	State of Minnesota
Portage Modified Landfill	St. Louis County
Red Rock Landfill	State of Minnesota
Redwood County Landfill	Redwood County
Rock County Landfill	Rock County
Roseau County-Salol Landfill	State of Minnesota
Sauk Centre Landfill	State of Minnesota
Sibley County Landfill	Sibley County
St. Augusta Landfill	State of Minnesota
Stevens County Landfill	Stevens County
Sun Prairie Landfill	State of Minnesota
Tellijohn Landfill	Tom Kat Trux, Inc.; Tim Tellijohn
Vermillion Dam Landfill	St. Louis County
Vermillion Modified Landfill	State of Minnesota
Wabasha County Landfill	State of Minnesota
Wadena Landfill	City of Wadena
Walker-Hackensack Landfill	Cass County
Waseca County Landfill	Waseca County
Washington County Landfill	City of Lake Elmo*
Waste Disposal Engineering Landfill	State of Minnesota

Landfill	Property Owner
Watonwan County Landfill	Watonwan County
Western Lake Superior Sanitary District Landfill	State of Minnesota
Winona County Landfill	Winona County
Woodlake Landfill	State of Minnesota
Yellow Medicine County Landfill	Yellow Medicine County

Appendix B

Development of Criteria That Affect the Potential for Solar Development on Closed Landfills and Identification of Barriers

Appendix B

Development of Criteria That Affect the Potential for Solar Development on Closed Landfills and Identification of Barriers

Contents

B1. Introduction

To identify criteria that affect the potential for solar development on closed landfills, as well as barriers and opportunities, Barr staff conducted a literature review (Section B2) and gathered stakeholder input in a variety of settings (Section B3).

B2. Literature Review

B2.1 Approach

Barr reviewed publicly available information retrieved from online resources. The goal of this task was to become familiar with case studies and key issues related to solar development on brownfield sites and benefit from previous studies/efforts that were publicly available.

B2.2 Results

The online materials from the EPA's Re-Powering America's Land website (https://www.epa.gov/re-powering) and the Massachusetts Siting Clean Energy at Closed Landfills website (https://www.mass.gov/siting-clean-energy-at-closed-landfills) are the best available sources of information for this project that we identified. We include highlights from these materials below. We also spoke to Laura Strine, United States Environmental Protection Agency (EPA), regarding the EPA website and resources. In addition, we reviewed and consulted state specific materials including presentations from the Closed Landfill Program (CLP) program and information from the Minnesota (MN) Office of Management and Budget regarding bonding of CLP sites.

B2.2.1 EPA's Repowering America's Land Website

EPA's Repowering America's Land website provided the following key information applicable to the MN Environmental Quality Board (EQB) CLP Solar project.

- Project Benefits
    - Improve the local tax base, create jobs, and turn blight into an economic opportunity. (RE-powering America's Land Initiative: Benefits Matrix https://www.epa.gov/sites/production/files/2019-12/documents/benefits_matrix_508_121119.pdf)
- Mapping and Screening Tools
    - Mapping tool with locations by state of a range of brownfield sites. Can search for MN only sites https://www.epa.gov/re-powering/re-powering-mapper
- Solar Decision Trees
    - The RE-Powering Electronic Decision Tree tool guides interested parties through a process to screen sites for their suitability for solar photovoltaics or wind installations. EPA encourages renewable energy on already developed or degraded land instead of green space https://www.epa.gov/re-powering/re-powerings-electronic-decision-

tree#:~:text=Developed%20by%20US%20EPA%27s%20RE-Powering%20America%27s%20Land%20Initiative%2C,developed%20or%20degraded%20land%20instead%20of%20green%20space

- The tool addresses the following types of sites:
    - Potentially Contaminated Sites (Superfund, Brownfield, RCRA, mine site)
    - Landfill (Municipal Solid Waste, Construction and Demolition or similar unit)
    - Underutilized (Abandoned parcels, parking lots, buffer zones)
    - Rooftop (Solar PV only; Commercial / Industrial roofs)
- This informational resource will help ascertain whether potential barriers to a solar or wind project exist at a site of interest. It provides:
    - A step-by-step walk through of key considerations for renewable energy development at the site;
    - Suggested resources to help you answer screening questions to gauge the site's potential; and
    - Reports summarizing your answers to the screening questions, initial findings regarding suitability and other comments about the site.

- Feasibility Studies
    - National Renewable Energy Laboratory (NREL), 2013. Feasibility Study of Economics and Performance of Solar Photovoltaics at the Peru Mill Industrial Park in the City of Deming, New Mexico, **Technical Report** NREL/TP-7A30-58368 April 2013.
    - NREL, 2013. Feasibility Study of Economics and Performance of Solar Photovoltaics at the Former Chicago, Milwaukee, and St. Paul Rail Yard Company Site in Perry, Iowa, **Technical Report** NREL/TP-7A40-56793 March 2013.

- Solar on Landfills
    - Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills (https://www.epa.gov/re-powering/best-practices-siting-solar-photovoltaics-municipal-solid-waste-landfills)

- Financing projects https://www.epa.gov/sites/production/files/2015-06/documents/re-powering_financing_fact_sheet.pdf
    - Owner-operator financing, where the system is purchased directly
    - Third-party power purchase agreements, where the system is owned by an energy developer and the site owner purchases electricity for a given term.
    - Sale/lease back models, which enable the energy user, such as a city government, to use the energy through leasing agreements, while the system owner benefits from tax advantages.

- In several states, community solar gardens or virtual net metering policies enable energy developers to partner with consumers who subscribe to purchase power for a given period of time.
- For large, utility-scale projects, financing is typically provided through project banks. Development of these utility-scale projects typically employs complex financing deal structures. The potential project scale, site owner, market conditions, and renewable energy developer typically dictate the financing option.

- Available incentives and policies
    - EPA may have some funding sources; need more details from EPA about these.

B2.2.2 Massachusetts Siting Clean Energy at Closed Landfills

The Massachusetts Siting Clean Energy at Closed Landfills Program website https://www.mass.gov/siting-clean-energy-at-closed-landfills is user-friendly and leads the viewer to the requirements for developing solar on landfills in MA. The following information from that site is applicable to the MN EQB CLP Solar project.

- Highlights of the Program
- Factsheet that is brief and provides a concise overview and key procedures to development (https://www.mass.gov/doc/fact-sheet-developing-renewable-energy-facilities-on-closed-landfills
    - Emphasizes key goals of these projects: not to compromise environmental protection from cap and provide income to landfill owners
    - Path to Approval
    - List of Resources

- Detailed Report (https://www.mass.gov/doc/photovoltaics-on-massachusetts-landfills-0/download)
    - Overview: outstanding guide to developing solar on landfills in Massachusetts; seems a terrific guide for other states trying to do the same thing
    - Incentives for solar (specific to landfills – RECs, net metering, ITC, accelerated depreciation)
    - Design considerations for solar on landfills (feasibility, construction considerations, specific landfill issues affecting solar development, post-closure use/maintenance)
    - Ownership structures (development tasks, municipal ownership, land leases, PPA, Credit Purchase Agreements, Hybrid land lease and PPA revenue structure)
    - Development and design considerations (permitting, interconnection, system design)
    - Project cost profile (design/engineering, permitting, interconnection, operations, monitoring, insurance, taxation)
    - Procurement (Solicitation, vendors, procurement)
    - Long term management (operations, equipment warranty, monitoring, end-of-life, buy-out provisions)

    - Example projects
    - Project checklists

- Permit List and Map https://www.mass.gov/lists/closed-landfills-with-permits-for-renewable-energy
    - Lists of tens of projects with permitting information

- Summarized top criteria for evaluating and developing solar on brownfields in Massachusetts are listed as follows. Note, they are not weighted, but all considered important and necessary for evaluation prior to developing these projects.
    - System ownership
        - Experience with solar development on brownfields
        - Experience with brownfields
        - Experience with operations and maintenance
    - Power purchasers
        - Utilities/ electric cooperatives
        - Municipalities
        - Behind-the-meter
        - Hybrid ownership for power purchase
    - Power purchase arrangements and incentives
        - Power purchase agreements (PPAs)
        - Net Metering
        - State incentives
        - Other
    - Proximity to transmission and distribution Lines
    - Environmental factors
        - Cap age and settlement
        - Permitting challenges – political or environmental
            - NIMBYism or project opposition
            - Key natural resources: threatened/endangered species; wetlands; other protected/regulated resources

B3. Gathering Stakeholder Input

B3.1 Minnesota Brightfields Conference

Barr staff attended a Minnesota Brightfields conference on February 20, 2020 and heard from a range of experts from the EPA, State of MN, developers, non-profits, industry representatives, and consultants. That conference assisted in providing some background and context for this study.

B3.2 Virtual Focus Group Meetings

The scope of work required two in-person focus group meetings to gather feedback on stakeholders' concerns, questions, and perceived barriers to solar development on closed landfills. The COVID-19 pandemic required us to modify our approach and provide an on-line venue for these meetings.

Barr invited representatives from solar development companies, general contractors, utilities, transmission system operators (Midcontinent Independent System Operator (MISO)), state governments, local governments, and non-profit organizations who have experience and/or interest in both solar development and landfills. Attendees were identified from lists of people who had previously attended conferences and events focused on solar development on brownfields. Barr reached out to people individually to gauge their interest and obtained additional recommendations for persons to invite. Through this process of identifying potential participants, we heard several names repeated as persons who could contribute to this project. The invitee list was reviewed with the EQB and other project leads. In total, approximately 125 people were invited to the virtual focus group sessions.

Barr held two virtual focus group meetings via WebEx (full audio and video) for approximately 2 hours each on March 27, 2020 and April 1, 2020. Each meeting was attended by approximately 15 to 20 participants, representing a mix of industry categories. The sessions included a project introduction, overview of MN Closed Landfills, an introduction to the draft Web tool (description provided in next paragraph), results from a survey sent to all participants, and small and large group discussions.

The draft Web tool started with the list of 114 land management areas. The tool includes many key site features including facility address, local utility, solid waste permit number, land management area size, waste-footprint size, power transmission lines, power distribution lines, and substations. The tool allows users to query sites by a range of site features. The query function allows users to put in ranges of values. For example, a user can query "sites larger than 5 acres; sites less than 1 mile from transmission; sites more than 1 mile from a substation, etc."

Additional information was gathered from a survey questionnaire included with the invitation to the focus group meetings, which invitees were allowed to complete up to several weeks after the last focus group. There were 11 total respondents: four worked in state government, two were solar developers, two were contractors (not solar), one worked in local government, and two fell into the category of "other." One of those in the "other" category did brownfields work for a nonprofit.

A summary of responses received from stakeholders following the focus group meetings indicated that perceived benefits of placing solar energy on closed landfill sites include:

- trees and vegetation would not need to be removed
- the presence of pollinators/native vegetation could be encouraged
- there may be greater public acceptance of this use
- the site may generate tax revenue to local governments
- local governments may buy power
- states may issue incentives for this type of use

Respondents also documented some perceived negatives for developing solar energy on closed landfills. These include:

- greater costs for constructing solar facilities
- geotechnical challenges inherent at these sites
- public distaste for seeing solar arrays
- access to monitoring wells and vents may be required, which could reduce MWs per acre
- production may be too little to gain utility interest
- sites may be too far from transmission lines to make distribution economical
- there is no one clearing house to aid developers
- access to private funding is difficult

Notes from six small group discussions held during the two focus group meetings were prepared by volunteers in each small group and forwarded to Barr for review. These small group notes and the observations of focus group facilitators and agency committee members provided important input to our identification of barriers and opportunities, which fed into our initial development of the comprehensive list of criteria affecting the feasibility of solar development on CLP sites.

B3.3 One-on-one Discussions

Following the focus group meetings, Barr reached out to individuals regarding specific feedback to obtain more information and to clarify key findings or observations. They included solar developers with much experience developing solar projects on landfills across the U.S., utility representatives, both from investor owned utilities and regional electric cooperatives, solar contractors and vendors with experience constructing solar projects on landfills, and energy experts from government or non-profit organizations. These follow up meetings were critical to analyzing information obtained during the focus group meetings and clarifying key points and feedback.

B3.4 EPA – Brightfields Program

Following the focus group meetings, the EQB set up a meeting with EPA staff, Minnesota's Interagency Solar on Closed Landfills team, and Barr to discuss opportunities and barriers to solar development on CLP sites and the potential for technical assistance from EPA. The meeting was held April 20, 2020 and was led by Laura Strine, EPA's RE-Powering America's Lands Initiative Coordinator. The EPA provided information regarding state policies, incentive programs, and strategic engagement for communities to states such as Massachusetts, New Jersey, New Hampshire, and Colorado who are developing or interested in developing solar on brownfields. The EPA has provided technical assistance regarding streamlining permitting programs, and financial analyses to assist states in determining whether there is

enough added economic benefit to make a solar project at a brownfield site viable. They have expertise in examining brownfield sites and assisting in understanding issues such as liability, clean-up requirements, and financial incentives. The EPA has also developed its own mapping tool to identify a broad range of energy projects on brownfield sites across the United States.

The EPA provided some feedback gleaned from their work across the country looking at solar development on brownfields. First, it appears that state financial incentives have played a key role in the viability of solar development. Second, site characteristics and solar radiance are less important than having sufficient financial support for this development. Third, identifying who will purchase the power and sign a power purchase agreement is critical to successful project development.

The EPA works closely with the National Renewable Energy Laboratory (NREL). NREL has performed detailed analyses of the viability of solar development at specific brownfield sites throughout the United States. The EPA agreed to work with NREL to offer a commitment to reviewing one or more MN CLP sites and their potential for solar development including opportunities and barriers.

B3.5 NREL Assessment

During discussions with contacts in EPA's Repowering Americas Land program, connections were made with staff at NREL who offered to provide an analysis of the techno-economic viability of a standalone solar PV system for one of MN's CLP sites. MPCA staff chose the Becker site as there has been strong local interest. Meetings were held with Barr Engineering, MPCA, and other members of the team of agency staff working on this study to set the parameters of the study and exchange information needed for the analysis. The results of the NREL study of the Becker site are pending and were not available for use in this study report.

B3.6 Interagency Team Meetings

The MN EQB organized bi-weekly meetings throughout the course of this study. Participants included MPCA, Mn EQB, Mn MMB, Mn COMM, Met Council, and Barr. Typical agenda items included: criteria, geospatial analysis results, ranking of sites, barriers and opportunities, recommended actions, and conclusions. The issue of GOB restrictions was the subject of a great deal of discussion as this is a very complicated issue and everyone involved was focused on providing an accurate portrayal of the issue and reasonable recommendations.

B3.7 Criteria Development Focus Group Meeting

Following the development of site criteria and some initial site evaluation and scoring, we held a (full audio) focus group meeting on July 13, 2020 with a subset of participants from the first focus group meetings. We discussed the initial site scoring results. We focused on some key criteria: solar generation potential (nameplate capacity – on the waste footprint, and on the buffer area) and distance to transmission/distribution/substations. We also experimented with weighting the scores.

Appendix C

Ranking of all Minnesota CLP Sites

Appendix C Ranking of all Minnesota CLP Sites

Site Name	City	County	Total Site Area (Acres)	Site Nameplate Capacity (MW)	Site Capacity Score	Buildable Cap Area (acres)	Cap Nameplate Capacity, Buildable Area (MW)	Cap Capacity Score	Buildable Buffer Area (acres)	Buffer Nameplate Capacity Buildable Area (MW)	Buffer Capacity Score	Nearest Substation Distance (miles)	Substation Score	Composite Score	General Obligation Bond Status
Flying Cloud Landfill	Eden Prairie	Hennepin	235.83	43.1	5	60.1	12.5	3	147.2	30.6	5	1.4	10	560	Bonded
Western Lake Superior Sanitary District Landfill	Duluth	St. Louis	471.14	40.3	5	61.8	12.8	3	131.9	27.4	4	2.2	10	540	Bonded
Olmsted County Landfill	Oronoco	Olmsted	294.92	44.8	5	31.9	6.6	2	183.6	38.2	5	3.4	9	520	Not Bonded
Anoka-Ramsey Landfill	Ramsey	Anoka	267.40	27.5	4	4.0	0.8	1	128.1	26.6	4	0.9	10	460	Bonded
Redwood County Landfill	Redwood Falls	Redwood	158.53	31.7	4	22.7	4.7	1	129.7	27.0	4	5.4	9	440	Bonded
Winona County Landfill	Winona	Winona	414.92	30.9	4	5.1	1.1	1	143.7	29.9	4	3.0	9	440	Bonded
Red Rock Landfill	Austin	Mower	159.41	26.6	4	39.8	8.3	2	88.0	18.3	3	3.1	9	440	Bonded
Freeway Landfill	Burnsville	Dakota	148.72	23.6	3	113.7	23.6	5	0.0	0.0	1	1.5	10	440	Not Bonded
Albert Lea Landfill	Albert Lea	Freeborn	173.39	17.6	2	24.5	5.1	2	60.2	12.5	2	0.8	10	360	Bonded
Woodlake Landfill	Medina	Hennepin	194.01	17.3	2	44.7	9.3	2	38.5	8.0	2	2.6	10	360	Bonded
St. Augusta Landfill	St. Cloud	Stearns	117.68	17.1	2	32.7	6.8	2	49.4	10.3	2	0.8	10	360	Bonded
Waste Disposal Engineering Landfill	Andover	Anoka	121.81	17.0	2	49.9	10.4	3	31.8	6.6	1	0.4	10	360	Bonded
Oak Grove Landfill	Oak Grove	Anoka	158.10	15.8	2	30.2	6.3	2	45.8	9.5	2	1.9	10	360	Bonded
Washington County Landfill	Lake Elmo	Washington	129.01	12.9	2	14.1	2.9	1	47.9	10.0	2	2.6	10	340	Bonded
Hibbing Landfill	Hibbing	St. Louis	80.11	12.4	2	25.0	5.2	2	34.7	7.2	1	1.0	10	340	Not Bonded
Grand Rapids Area Landfill	Grand Rapids	Itasca	114.71	11.3	2	13.2	2.7	1	41.3	8.6	2	2.5	10	340	Bonded
Dakhue Landfill	Hampton	Dakota	79.92	11.3	2	16.4	3.4	1	38.1	7.9	2	2.2	10	340	Bonded
Leech Lake Landfill	Cass Lake	Hubbard	82.58	11.1	2	14.9	3.1	1	38.7	8.0	2	0.6	10	340	Bonded
East Mesaba Landfill	Virginia	St. Louis	222.14	15.1	2	8.0	1.7	1	64.7	13.5	2	3.0	9	320	Bonded
Waseca County Landfill	Waseca	Waseca	125.30	14.6	2	6.3	1.3	1	64.2	13.3	2	4.6	9	320	Bonded
Kummer Landfill	Bemidji	Beltrami	53.92	11.1	2	19.5	4.1	1	33.7	7.0	1	1.9	10	320	Not Bonded
Maple Landfill	Pequot Lakes	Cass	80.88	10.6	2	13.3	2.8	1	37.9	7.9	2	4.2	9	320	Not Bonded
Meeker County Landfill	Litchfield	Meeker	76.77	9.0	2	17.9	3.7	1	25.2	5.2	1	1.5	10	320	Bonded
Tellijohn Landfill	Le Sueur	Le Sueur	84.98	15.1	2	14.3	3.0	1	58.3	12.1	2	5.8	8	300	Not Bonded
Roseau County-Salol Landfill	Salol	Roseau	101.53	12.0	1	28.5	5.9	2	29.0	6.0	1	2.1	10	300	Not Bonded
Wadena Landfill	Wadena	Wadena	128.13	11.4	2	9.1	1.9	1	45.6	9.5	2	7.8	8	300	Bonded
Watonwan County Landfill	St. James	Watonwan	71.17	11.4	2	21.6	4.5	1	33.1	6.9	1	4.5	9	300	Bonded
Yellow Medicine County Landfill	Granite Falls	Yellow Medicine	96.52	11.0	2	17.9	3.7	1	34.9	7.3	1	3.5	9	300	Bonded

Site Name	City	County	Total Site Area (Acres)	Site Nameplate Capacity (MW)	Site Capacity Score	Buildable Cap Area (acres)	Cap Nameplate Capacity, Buildable Area (MW)	Cap Capacity Score	Buildable Buffer Area (acres)	Buffer Nameplate Capacity Buildable Area (MW)	Buffer Capacity Score	Nearest Substation Distance (miles)	Substation Score	Composite Score	General Obligation Bond Status
Lake of the Woods County Landfill	Williams	Lake of the Woods	97.55	10.9	2	10.4	2.2	1	42.2	8.8	2	6.4	8	300	Not Bonded
Goodhue Cooperative Landfill	Goodhue	Goodhue	85.16	10.3	1	5.4	1.1	1	44.4	9.2	2	2.2	10	300	Not Bonded
Louisville Landfill	Shakopee	Scott	60.21	6.3	1	28.0	5.8	2	2.5	0.5	1	1.4	10	300	Not Bonded
Ironwood Landfill	Spring Valley	Fillmore	142.69	12.6	1	10.0	2.1	1	50.8	10.6	2	4.4	9	280	Not Bonded
French Lake Landfill	French Lake	Wright	79.68	9.5	1	4.6	0.9	1	41.1	8.6	2	4.2	9	280	Bonded
Walker-Hackensack Landfill	Hackensack	Cass	163.18	8.5	1	8.9	1.8	1	31.9	6.6	1	2.5	10	280	Not Bonded
Johnson Brothers Landfill	Blaine	Anoka	89.14	8.3	1	9.1	1.9	1	30.9	6.4	1	0.8	10	280	Not Bonded
Northwest Angle Inlet Landfill	Angle Inlet	Lake of the Woods	39.97	8.3	1	1.9	0.4	1	37.9	7.9	2	4.5	9	280	Not Bonded
Paynesville Landfill	Paynesville	Stearns	73.83	8.1	1	1.9	0.4	1	36.8	7.7	1	2.2	10	280	Bonded
East Bethel Landfill	East Bethel	Anoka	77.54	7.7	1	6.3	1.3	1	30.9	6.4	1	1.8	10	280	Bonded
Koochiching County Landfill	International Falls	Koochiching	42.78	7.5	1	20.9	4.3	1	15.3	3.2	1	2.3	10	280	Bonded
Becker County Landfill	Detroit Lakes	Becker	47.05	7.0	1	10.6	2.2	1	22.9	4.8	1	2.6	10	280	Bonded
Pine Lane Landfill	Wyoming	Chisago	66.08	6.9	1	19.0	3.9	1	14.1	2.9	1	1.9	10	280	Bonded
Fifty Lakes Landfill	Fifty Lakes	Crow Wing	149.41	6.3	1	4.9	1.0	1	25.6	5.3	1	0.7	10	280	Bonded
Battle Lake Landfill	Battle Lake	Otter Tail	79.08	6.3	1	4.1	0.9	1	26.2	5.5	1	0.8	10	280	Bonded
Hopkins Landfill	Hopkins	Hennepin	33.57	6.1	1	16.3	3.4	1	12.9	2.7	1	2.1	10	280	Bonded
Lincoln County Landfill	Ivanhoe	Lincoln	34.39	6.0	1	0.0	0.0	1	28.9	6.0	1	1.1	10	280	Bonded
Hoyt Lakes Landfill	Hoyt Lakes	St. Louis	79.15	5.9	1	12.9	2.7	1	15.4	3.2	1	1.8	10	280	Not Bonded
Dodge County Landfill	Kasson	Dodge	42.74	5.8	1	4.8	1.0	1	23.2	4.8	1	0.7	10	280	Bonded
Sibley County Landfill	Gaylord	Sibley	39.58	5.7	1	0.8	0.2	1	26.6	5.5	1	0.7	10	280	Not Bonded
Lindala Landfill	Annandale	Wright	69.32	5.7	1	5.2	1.1	1	22.1	4.6	1	0.1	10	280	Bonded
Benson Landfill	Benson	Swift	47.29	5.7	1	4.0	0.8	1	23.4	4.9	1	2.7	10	280	Not Bonded
Cook Area Landfill	Cook	St. Louis	40.58	5.4	1	4.7	1.0	1	21.2	4.4	1	1.9	10	280	Not Bonded
Cotton Area Landfill	Cotton	St. Louis	24.77	5.1	1	2.7	0.6	1	21.7	4.5	1	2.3	10	280	Bonded
Geislers Landfill	Winona	Winona	39.21	4.6	1	0.0	0.0	1	22.0	4.6	1	2.1	10	280	Not Bonded
Eighty Acre Landfill	Bemidji	Beltrami	40.42	4.5	1	6.7	1.4	1	15.0	3.1	1	0.9	10	280	Bonded
Crosby American Properties Landfill	Inver Grove Heights	Dakota	50.98	4.3	1	15.6	3.3	1	5.2	1.1	1	0.5	10	280	Not Bonded
Karlstad Landfill	Karlstad	Kittson	19.84	4.0	1	3.6	0.7	1	15.8	3.3	1	1.9	10	280	Not Bonded
Stevens County Landfill	Morris	Stevens	20.57	3.9	1	12.9	2.7	1	5.7	1.2	1	1.3	10	280	Bonded
Bueckers #1 Landfill	Melrose	Stearns	30.60	3.1	1	9.1	1.9	1	6.0	1.2	1	2.0	10	280	Bonded

Site Name	City	County	Total Site Area (Acres)	Site Nameplate Capacity (MW)	Site Capacity Score	Buildable Cap Area (acres)	Cap Nameplate Capacity, Buildable Area (MW)	Cap Capacity Score	Buildable Buffer Area (acres)	Buffer Nameplate Capacity Buildable Area (MW)	Buffer Capacity Score	Nearest Substation Distance (miles)	Substation Score	Composite Score	General Obligation Bond Status
Iron Range Landfill	Taconite	Itasca	44.84	3.0	1	6.9	1.4	1	7.3	1.5	1	1.4	10	280	Not Bonded
Sauk Centre Landfill	Sauk Centre	Stearns	19.70	2.8	1	2.9	0.6	1	10.7	2.2	1	2.6	10	280	Bonded
Floodwood Landfill	Floodwood	St. Louis	39.36	2.6	1	4.5	0.9	1	8.1	1.7	1	2.3	10	280	Not Bonded
Northeast Otter Tail County Landfill	New York Mills	Otter Tail	21.49	2.5	1	5.7	1.2	1	6.5	1.3	1	1.9	10	280	Not Bonded
Murray County Landfill	Slayton	Murray	16.34	2.5	1	6.8	1.4	1	5.3	1.1	1	1.8	10	280	Bonded
Aitkin Area Landfill	Aitkin	Aitkin	52.47	2.3	1	2.0	0.4	1	9.3	1.9	1	2.2	10	280	Not Bonded
Northome Landfill	Northome	Koochiching	36.26	2.2	1	2.5	0.5	1	8.3	1.7	1	2.3	10	280	Not Bonded
Pickett Landfill	Park Rapids	Hubbard	16.92	2.2	1	5.3	1.1	1	5.3	1.1	1	2.4	10	280	Bonded
Carlton County South Landfill	Moose Lake	Carlton	39.18	2.1	1	2.8	0.6	1	7.1	1.5	1	2.6	10	280	Not Bonded
Adams Landfill	Adams	Mower	12.87	1.7	1	0.0	0.0	1	8.2	1.7	1	0.4	10	280	Not Bonded
Greenbush Landfill	Greenbush	Roseau	8.13	1.6	1	0.0	0.0	1	7.9	1.6	1	1.2	10	280	Not Bonded
Hickory Grove Landfill	McGrath	Aitkin	10.07	1.5	1	5.9	1.2	1	1.4	0.3	1	2.6	10	280	Not Bonded
Bueckers #2 Landfill	Avon	Stearns	89.04	1.5	1	0.4	0.1	1	6.6	1.4	1	2.0	10	280	Not Bonded
La Crescent Landfill	LaCrescent	Houston	15.68	1.3	1	6.2	1.3	1	0.0	0.0	1	0.1	10	280	Not Bonded
Leslie Benson Landfill	Dassel	Meeker	8.24	1.0	1	0.8	0.2	1	4.1	0.8	1	1.6	10	280	Not Bonded
Chippewa County Landfill	Montevideo	Chippewa	46.85	8.5	1	12.5	2.6	1	28.5	5.9	1	4.0	9	260	Not Bonded
Mille Lacs County Landfill	Milaca	Mille Lacs	61.91	8.3	1	2.9	0.6	1	37.0	7.7	1	4.9	9	260	Not Bonded
Rock County Landfill	Luverne	Rock	52.08	7.8	1	13.0	2.7	1	24.8	5.2	1	3.7	9	260	Bonded
Carlton County #2 Landfill	Twin Lakes Township	Carlton	116.03	7.8	1	18.8	3.9	1	18.9	3.9	1	4.8	9	260	Not Bonded
Isanti-Chisago County Landfill	Stanley	Isanti	64.52	7.5	1	16.7	3.5	1	19.5	4.1	1	3.1	9	260	Bonded
Korf Brothers Landfill	Pine City	Pine	78.71	7.1	1	12.1	2.5	1	22.2	4.6	1	4.1	9	260	Not Bonded
La Grand Landfill	Alexandria	Douglas	70.47	6.6	1	1.2	0.3	1	30.3	6.3	1	5.3	9	260	Bonded
Gofer Landfill	Fairmont	Martin	38.82	6.5	1	6.8	1.4	1	24.5	5.1	1	3.0	9	260	Bonded
Hansen Landfill	Mankato	Blue Earth	39.69	6.3	1	7.1	1.5	1	23.0	4.8	1	3.6	9	260	Not Bonded
Sun Prairie Landfill	Le Center	Le Sueur	32.87	5.0	1	10.0	2.1	1	14.2	2.9	1	4.5	9	260	Not Bonded
Hudson Landfill	Aurora	St. Louis	40.56	5.0	1	9.0	1.9	1	15.0	3.1	1	4.5	9	260	Not Bonded
Jackson County Landfill	Lakefield	Jackson	24.44	5.0	1	13.3	2.8	1	10.7	2.2	1	3.6	9	260	Not Bonded
Crosby Landfill	Crosby	Crow Wing	80.75	4.3	1	4.6	1.0	1	16.2	3.4	1	5.2	9	260	Bonded
Long Prairie Landfill	Long Prairie	Todd	128.65	3.6	1	2.7	0.6	1	14.8	3.1	1	3.4	9	260	Not Bonded
Brookston Area Landfill	Brookstone	St. Louis	19.23	3.4	1	5.0	1.0	1	11.3	2.3	1	3.4	9	260	Not Bonded

Site Name	City	County	Total Site Area (Acres)	Site Nameplate Capacity (MW)	Site Capacity Score	Buildable Cap Area (acres)	Cap Nameplate Capacity, Buildable Area (MW)	Cap Capacity Score	Buildable Buffer Area (acres)	Buffer Nameplate Capacity Buildable Area (MW)	Buffer Capacity Score	Nearest Substation Distance (miles)	Substation Score	Composite Score	General Obligation Bond Status
Mankato Landfill	Mankato	Blue Earth	17.68	3.3	1	11.2	2.3	1	4.6	1.0	1	3.6	9	260	Bonded
Longville-Remer Landfill	Remer	Cass	39.81	2.5	1	2.3	0.5	1	9.8	2.0	1	4.8	9	260	Not Bonded
Minnesota Sanitation Services Landfill	Kasota	Le Sueur	17.48	1.9	1	2.4	0.5	1	6.5	1.4	1	3.3	9	260	Not Bonded
Mahnomen County Landfill	Mahnomen	Mahnomen	31.38	1.4	1	3.1	0.6	1	3.9	0.8	1	3.2	9	260	Not Bonded
Land Investors, Inc. Landfill	Sauk Rapids	Benton	8.51	0.8	1	0.0	0.0	1	3.7	0.8	1	3.5	9	260	Bonded
Wabasha County Landfill	Kellogg	Wabasha	25.50	0.7	1	1.2	0.3	1	2.3	0.5	1	3.6	9	260	Bonded
McKinley Landfill	McKinley	St. Louis	5.55	0.6	1	0.0	0.0	1	2.8	0.6	1	4.5	9	260	Not Bonded
Lindenfelser Landfill	St. Michael	Wright	73.92	8.7	1	20.8	4.3	1	20.9	4.4	1	5.8	8	240	Bonded
Cook County Landfill	Grand Marais	Cook	99.27	7.7	1	0.3	0.1	1	37.0	7.7	1	5.6	8	240	Not Bonded
Lake County Landfill	Two Harbors	Lake	40.60	7.6	1	32.3	6.7	2	4.1	0.9	1	9.3	7	240	Not Bonded
Pipestone County Landfill	Pipestone	Pipestone	41.09	6.8	1	10.4	2.2	1	22.3	4.6	1	5.7	8	240	Bonded
Faribault County Landfill	Bricelyn	Faribault	41.23	6.6	1	11.2	2.3	1	20.8	4.3	1	6.8	8	240	Bonded
Killian Landfill	Motley	Todd	79.88	6.3	1	6.5	1.3	1	24.0	5.0	1	5.9	8	240	Not Bonded
Northwoods Landfill	Babbitt	St. Louis	95.55	5.5	1	6.2	1.3	1	20.3	4.2	1	6.2	8	240	Bonded
Kluver Landfill	Alexandria	Douglas	28.79	4.9	1	13.8	2.9	1	9.8	2.0	1	8.1	8	240	Not Bonded
Orr Landfill	Orr	St. Louis	31.90	1.1	1	0.7	0.1	1	4.7	1.0	1	10.8	7	220	Not Bonded
Vermilion Dam Landfill	Cook	St. Louis	41.06	5.4	1	0.0	0.0	1	26.0	5.4	1	13.5	6	200	Not Bonded
Barnesville Landfill	Barnesville	Wilkin	21.22	4.4	1	5.7	1.2	1	15.5	3.2	1	11.3	6	200	Not Bonded
Vermilion Modified Landfill	Tower	St. Louis	44.87	4.0	1	0.8	0.2	1	18.4	3.8	1	13.0	6	200	Bonded
Big Stone County Landfill	Beardsley	Big Stone	20.56	2.8	1	5.2	1.1	1	8.5	1.8	1	12.2	6	200	Bonded
Anderson Landfill	Sebeka	Wadena	27.07	2.0	1	2.0	0.4	1	7.5	1.6	1	13.2	6	200	Bonded
Highway 77 Landfill	Tower	St. Louis	39.29	0.4	1	1.5	0.3	1	0.6	0.1	1	12.9	6	200	Not Bonded
Portage Modified Landfill	Orr	St. Louis	10.95	1.1	1	0.0	0.0	1	5.4	1.1	1	27.7	1	100	Not Bonded

Appendix D

Bonding Status for Closed Landfill Program Sites

Bonding Status for Closed Landfill Program Sites

Landfill	GOB Spent[1]	GOB Expiration Date[2]	Area with GOB Restrictions (acres)[3]	Area without GOB Restrictions (acres)[4]
ALBERT LEA	$6,958,084.58	2048.5	171	2
ANDERSON/SEBEKA	$482,945.00	2038.5	26	1
ANOKA-RAMSEY	$2,996,284.81	2042.5	154	113
BATTLE LAKE	$690,528.30	2035.5	62	17
BECKER CO	$4,165,375.00	2043.5	46	1
BIG STONE	$420,429.16	2039.5	21	0
BUECKERS CONSTRUCTION	$719,845.54	2034.5	28	3
COTTON	$428,800.53	2040.5	24	0
CROSBY	$961,300.54	2036.5	78	3
DAKHUE	$1,118,561.11	2042.5	80	0
DODGE RD/RA	$81,199.71	2037.5	37	6
EAST BETHEL	$3,133,145.94	2044.5	77	0
EAST MESABA	$1,155,950.59	2052.5	222	0
EIGHTY ACRE	$1,182,676.03	2041.5	40	0
FARIBAULT	$135,279.70	2041.5	41	1
FIFTY LAKES RD/RA	$390,104.91	2037.5	107	43
FLYING CLOUD	$1,819,811.21	2054.5	201	35
FRENCH LAKE	$613,913.95	2037.5	80	0
GOFER	$1,750,837.03	2044.5	37	2
GRAND RAPIDS	$811,660.17	2042.5	66	49
HOPKINS	$4,692,053.96	2052.5	33	0
ISANTI/CHISAGO RD/RA	$705,488.79	2034.5	53	11
KOOCHICHING	$8,141,445.96	2052.5	43	0
LAND INVESTORS	$234,829.51	2035.5	8	0
LANDFILL BONDS/LAWS OF 1994	$20,636.14	2038.5	not applicable	not applicable
LEECH LAKE	$1,361,464.63	2042.5	66	16
LEGRAND	$717,016.51	2044.5	70	0
LINCOLN/PIPESTONE	$987,376.20	2035.5	74	2
LINDALA RD/RA	$1,137,147.73	2038.5	69	0
LINDERFELSER	$4,369,294.80	2041.5	68	6
MANKATO	$890,456.84	2036.5	17	1
MEEKER	$497,300.00	2042.5	75	2
MURRAY CO	$394,561.22	2039.5	16	0
NORTHWOODS RD/RA	$1,101,964.02	2037.5	74	21

Landfill	GOB Spent[1]	GOB Expiration Date[2]	Area with GOB Restrictions (acres)[3]	Area without GOB Restrictions (acres)[4]
OAK GROVE	$1,080,576.70	2041.5	149	9
PAYNESVILLE RA	$993,495.46	2035.5	74	0
PICKETT CONSTRUCTION	$1,263,636.94	2034.5	16	1
PINE LANE	$4,868,228.51	2042.5	65	1
RED ROCK	$3,436,073.90	2041.5	80	79
REDWOOD	$1,019,665.95	2043.5	37	122
ROCK CO	$994,678.00	2041.5	52	0
SAUK CENTRE	$868,059.93	2042.5	19	0
ST AUGUSTA	$4,332,304.79	2041.5	117	1
STEVENS CO	$162,202.41	2042.5	20	0
VERMILLION RD/RA	$735,309.68	2039.5	31	14
WABASHA RD	$803,882.94	2038.5	25	0
WADENA	$1,693,206.39	2036.5	127	1
WASECA	$1,407,761.86	2042.5	73	53
WASHINGTON CO	$4,294,062.52	2054.5	127	2
WASTE DISPOSAL ENGINEERING	$2,019,767.83	2056.5	111	11
WATONWAN	$2,730,766.79	2041.5	71	0
WINONA	$4,456,303.82	2045.5	86	329
WLSSD	$9,375,881.33	2051.5	317	154
WOODLAKE	$5,019,158.88	2046.5	182	12
YELLOW MEDICINE	$58,086.01	2039.5	50	47
TOTAL	$106,880,880.76	null	4092	1174

Notes:
55 unique sites
Landfill bonds/Laws of 1994 was expenses for bond sales and not for any particular site

(1) Sum of General Obligation Bond (GOB) spent per landfill. Some landfills have more than one GOB.

(2) GOBs expire 37.5 years from last expenditure. Date is approximate as month/day of last expenditure not available for study. Years are fiscal years (July 1 - June 30)

(3 Area with GOB restrictions provided by MPCA. Values are rounded to the nearest whole acre and should be considered approximate based on data available at time of study.

(4) Area without GOB restrictions calculated as difference between total land management area and area with GOB restrictions. Values should be considered approximate.