City of Grand Haven, MI

Chinook Pier

Green Infrastructure Opportunities Analysis

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Executive Summary

Goal of this Report

As a part of the Catalyst Leadership Circle Fellowship, this report analyses the integration of green and sustainable infrastructure practices into the redevelopment of the Chinook Pier in Grand Haven, Michigan. By evaluating site conditions and local planning goals, it identifies key opportunities to enhance stormwater management, improve environmental resilience and quality, and promote placemaking. An integrated site-wide network can support local livability, provide financial savings, and expand recreational opportunities for residents. Along with the Green Infrastructure Policy Report and ArcGIS StoryMap, this research helps address awareness gaps and provides a replicable framework for green infrastructure development.

Site Context and Constraints

Relevant factors for the determination of green infrastructure types, including site characteristics, local regulations, surrounding land uses, and historical effects are identified in this document. The Chinook Pier site has significant limitations surrounding historical land use, pollution, and a high water table. Surrounded by the local watershed and near Lake Michigan, runoff control systems should minimize pollutant levels to the greatest extent possible. In this context, green infrastructure that avoids reliance on subsurface infiltration is the most appropriate and effective.

Opportunities

Various green infrastructure systems for this site are proposed in this document, including an extensive green roof system, bioretention pond, floating wetlands, multi-use ice rink and splash pad, rain barrels, downspout disconnection, and raised beds. Together, these systems would create a local green stormwater infrastructure network that provides energy savings, improved aesthetics, and flexible recreational opportunities to augment the site's use value. This replicable framework can be used to help inform other communities facing similar waterfront redevelopment and climate adaptation challenges. A companion ArcGIS StoryMap summarizes this process as a demonstrative example.

Methodology

This analysis highlights resources for information gathering and site factors to guide development that were identified from qualitative research practices. Noted criteria are based on information from the Southeast Michigan Council of Governments (SEMCOG). This was developed with support from Tim Dekker, CEO of Limnotech and Brian Urquhart, City Planner at Grand Haven. Other information contained in this report utilizes resources from federal agencies, the City of Grand Haven, Michigan State University, and other entities.

Introduction

This 3.4 acre historic park site has experienced issues related to stormwater and flooding management, leading to the removal of the main structure housing local businesses due to unhealthy levels of mold contained in the building. The Beyond the Pier Master Plan, conducted in 2018, surveyed the public about their ideas for the future of the site, identifying a community vision surrounding what is missing and opportunities for improvement. Overall, residents envision a more connected gateway to downtown, an active waterfront with all-season amenities, a multi-use, flexible space, and an expanded farmer's market - all while maintaining the historical character and viewsheds of the area.

After issuing a Request for Proposals (RFP) in January 2024, the City selected architectural firm Architektura PLC and construction management company Copperrock to lead redevelopment efforts. This site plan aligns with community goals for the space, including a greatly expanded multi-use farmer's market space, welcome plaza, restaurant, active green space, and riverwalk - reimagining this site as an activated waterfront park with a much greater variety of offerings for residents, entrepreneurs, and visitors.

Given the site's location in a sensitive area, stormwater quality and runoff management is a high priority - safeguarding local ecosystems and recreational opportunities while improving community climate resilience. With rainfall and temperatures forecasted to increase in the future,[1] green and sustainable infrastructure systems help prevent flooding, reduce the urban heat island effect, and protect local species. In the waterfront setting of this site, these systems can intercept contaminated runoff, naturally removing pollutants before stormwater reaches the local watershed.

This report builds upon current plans to promote green infrastructure that not only improve local sustainability, but provide greater aesthetic quality and placemaking opportunities. The author used site analysis principles to identify improvements that will help purify stormwater, promote local ecosystem health, and enhance the use value of the site in alignment with goals outlined in the City's 2023 Beyond the Pier Waterfront Master Plan. Green and sustainable infrastructure practices, such as green roofs, can also work to reduce energy use and reliance on existing gray infrastructure systems, leading to long-term cost savings. This report serves as a case study, explaining this process, highlighting relevant resources, and providing a framework for site analysis that can be applied elsewhere.

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[1] National Oceanic and Atmospheric Administration, Michigan State Climate Summary 2022, (2022), https://statesummaries.ncics.org/chapter/mi/

Methodology

Informed by standards outlined in the Southeast Michigan Council of Governments (SEMCOG) Low Impact Development Manual for Michigan and the Grand Haven Stormwater Standards Manual (shown in Appendix A) and Grand Haven's requirements (Appendix B), site conditions and infrastructure requirements were determined. This analysis aimed to identify green infrastructure best management practices (BMPs) that are responsive to site conditions while aligning with City priorities. Community feedback gathered by the City was utilized to identify features to be preserved, such as current viewsheds and the site's historical character. In addition, this analysis considered a variety of site characteristics like natural features, protected areas, landscaping requirements, restrictions, proximate uses, and applicable regulations for a holistic review of local conditions. This inventory process is explained in greater detail below.

Natural Features and Characteristics

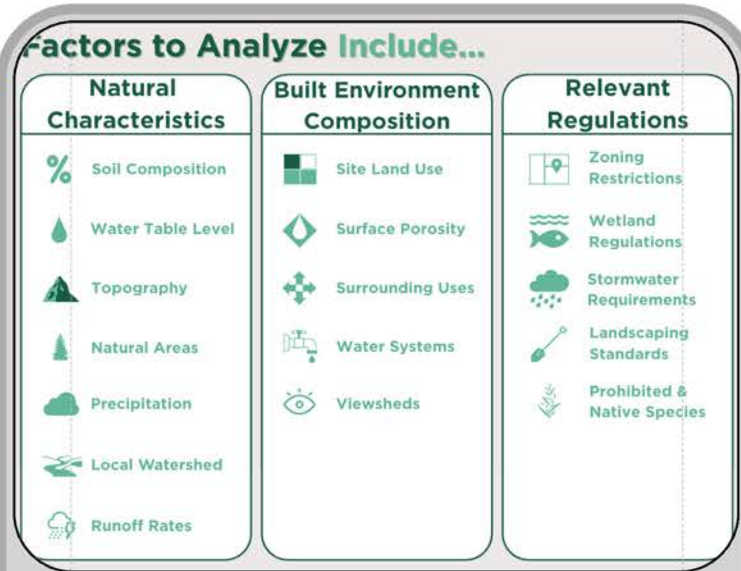

Figure 1 - Site Analysis Factors

- **Soil Composition:** Compiled data from Michigan State University Extension (MSUE) and the United States Department of Agriculture (USDA) to determine the local soil association as well as the property soil type, respectively.
- **Topography:** Downloaded contour data from Ottawa County Geospatial Insights and Solutions database to determine elevation changes.
- **Ground Pollution:** Reviewed Michigan Department of Environment, Great Lakes, and Energy (EGLE) RIDE Mapper brownfield status and known contamination risk from historical land use on the site.
- **Water Table:** Determined high water table level based on Lake Michigan water level data gathered from Great Lakes Integrated Sciences and Assessments (GLISA) data.
- **Watershed:** Researched local watershed characteristics, total maximum daily load (TMDL) status, pollutant issues, protected areas, and existing green infrastructure from the Lower Grand River Organization of Watersheds

- **Sensitive Areas:** Evaluated presence and proximity of historic sites, woodlands, and sand dunes (Michigan Center for Geographic Information), parks and recreation areas (Explore the Grand Region: A Community Parks and Recreation Plan in Northwest Ottawa County), as well as wellhead protection areas from the EGLE Maps and Data Viewer.
- **Flooding:** Analyzed historic flooding events from local news sources such as WOODTV, MLive, and the Grand Haven Tribune as well as a flood risk assessment from First Street.
- **Vegetation:** Determined characteristics and composition of current vegetation from a site visit, Google Earth, and the EGLE Wetlands Map Viewer.
- **Local Rainfall and Snowfall:** Gathered precipitation data and seasonal trends from the National Oceanic and Atmospheric Administration (NOAA) Centers for Environmental Information.
- **Stormwater Volume:** Utilized ModelMyWatershed to determine required volume of stormwater to manage from a 1 inch rainfall event (as specified in local ordinance).

Local Built Environment

- **Surface Cover & Porosity:** Georeferenced site plan in ArcGIS to estimate amounts of impervious surface cover and open space included in the site plan.
- **Site Land Use:** Identified the effects of historical, current, and planned land use for the site on stormwater management and environmental quality based on site characteristics and research.
- **Surrounding Land Uses:** Noted existing uses surrounding the property and how they may interact.
- **Existing Water Systems:** Determined locations of on-site and nearby sewer systems from City data, in addition to existing well locations from the Michigan GIS Open Data Portal.
- **Viewsheds:** Identified important viewsheds for preservation based on findings from the Beyond the Pier Master Plan and current site plan.

Relevant Federal, State, County, & Local Regulations

- **City Master Plan:** Researched community feedback and vision included in the 2023 Grand Haven Master Plan Update.
- **City Zoning Ordinance:** Evaluated parking requirements, landscaping standards, native species standards, zoning restrictions, and site overlay districts.
- **City Stormwater Management Plan & Stormwater Standards Manual:** Noted stormwater management requirements for the site, standards for pollutant levels, and local stormwater management goals in addition to relevant design standards. If this is missing from a municipal ordinance, the Low Impact Development Manual for Michigan may be used to inform site stormwater management.

- **Wetland Regulations:** Researched state and federal level requirements gathered from EGLE and their applicability to this project.

This preliminary analysis was limited by a lack of observational data related to pollutants in the soil, water table elevation, exact soil composition, and soil drainage rate. On-the-ground data collection (e.g. infiltration testing, soil borings, and pollutant loading analysis) will be conducted further in the site development process to confirm findings.

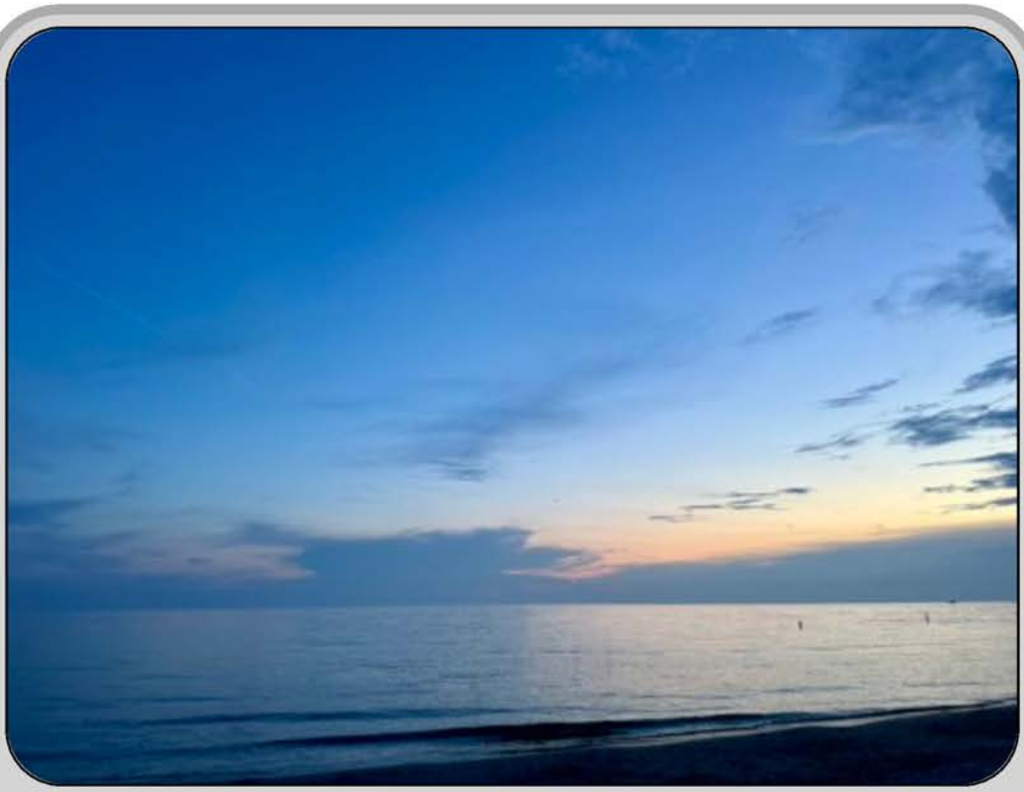

Figure 2 - Grand Haven Shoreline at Sunset

Historical Context & Land Use

Beginning in the 1960s and 1970s, this waterfront space was converted from a former industrial site and cargo station into a park, with space for local businesses and historic preservation in mind. At present, the site is home to a coal tipple, locomotive, fish cleaning station, mini golf course, farmer's market, splash pad, and picnicspace. Part of the local waterfront, the area is bordered by the Lynne Sherwood Waterfront Stadium and the Bicentennial Park to the southwest, the HarborIsland Linear Park across the river to the north, and the Wharf Marina to the northeast (Figure 2).

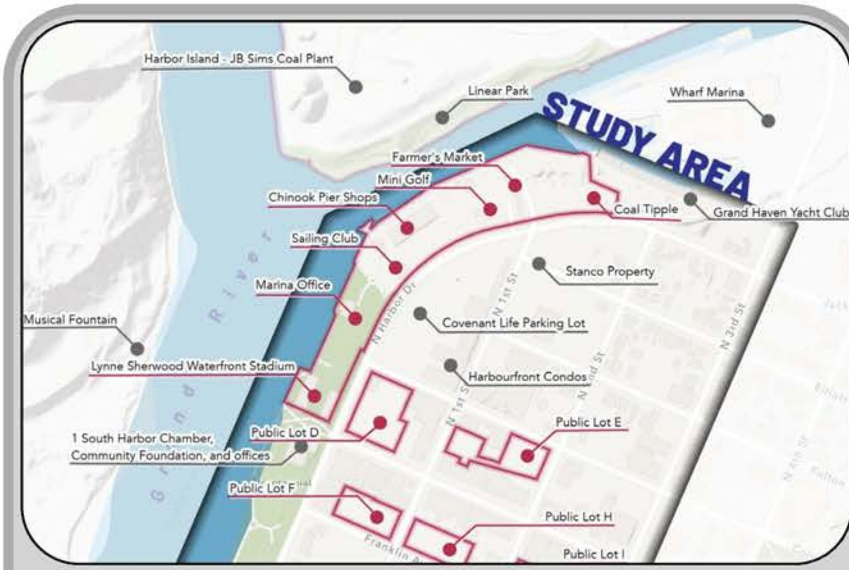

Figure 2 - Beyond the Pier Master Plan Study Area[2]

Development must be based upon conditions both within and surrounding the site, ensuring that it anticipates problem areas, cohesively works with proximate uses, and does not adversely affect local environmental quality. Historical context is another important aspect to consider when evaluating development opportunities and limitations. While it does not have official brownfield status from the Michigan Department of Environment, Great Lakes, and Energy (EGLE), the legacy of industrial

[2] City of Grand Haven et. al., *Beyond the Pier Waterfront Master Plan* (Grand Haven, MI: City of Grand Haven, 2021), https://grandhaven.s3.amazonaws.com/pdf_documents/departments/planning_building/beyond_the_pier_master_plan.pdf

land use makes ground pollution likely. Soil borings conducted further in the development process will confirm the severity of pollution, but this contamination makes green infrastructure that relies on groundwater infiltration much less feasible. If an infrastructure system such as a rain garden purifies stormwater on the surface but infiltrates it into the contaminated groundwater, it will have more limited environmental benefits.

Figure 3 - Site Drainage Systems[3]

Existing drainage systems (Figure 3) should also be identified to avoid conflicts with and maximize the effectiveness of green infrastructure. This map was used to ensure that suggested improvements did not interfere with these existing systems, reducing the risk of unintended impacts to existing gray infrastructure.

[3] City of Grand Haven, *Storm Water System Viewing Map* (Grand Haven, MI: City of Grand Haven, n.d.)

Surface Types, Soil Composition & the Water Table

A high proportion of impervious surfaces such as parking lots, combined with local topography that directs runoff towards the river, has the potential to increase runoff velocity and divert more contaminants to the watershed. Open space may permit modest levels of stormwater infiltration into the ground, but the high water table (Figure 4) combined with significant seasonal flooding limits this potential. The current site plan does not increase the amount of impervious surface - however, it still contains a high proportion (approx. 81.58%) of surfaces over 3.4 acres that do not allow stormwater infiltration and facilitate runoff. Therefore, green infrastructural solutions must work to preserve necessary surfaces while improving the site's ability to manage stormwater and prevent harm to the surrounding landscape. Soil type is another important factor for stormwater management, with the site's Entisol soil type and made land designation[4] indicating young, underdeveloped soil that has been significantly impacted by human activity. This soil type is dominated by sand - which facilitates infiltration - but typically has a low ability to filter pollutants due to a low clay concentration.[5] [6]

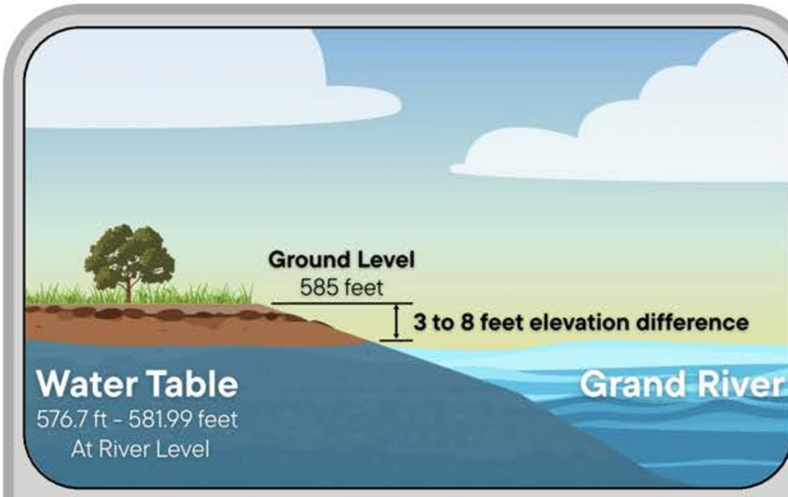

Figure 4 - Site Water Table

[4] Michigan State University, *USA Soils Map Units via ArcGIS Online*, Michigan State University GIS Platform, https://msugis.maps.arcgis.com/apps/mapviewer/index.html?url=https%3A%2F%2Flandscape11.arcgis.com%2Farcgis%2Frest%2Fservices%2FUSA_Soils_Map_Units%2Ffeatureserver.

[5] Natural Resources Conservation Service, "Entisols," *Conservation Basics: Natural Resource Concerns—Soil*, U.S. Department of Agriculture, https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soil/entisols.

[6] Sustainability Directory, "How Does Soil Type Affect Water Purification Efficiency?" *Lifestyle – Sustainability Directory*, https: //lifestyle.sustainability-directory.com/question/how-does-soil-type-affect-water-purification-efficiency/#:~:text=Purification%20Mechanisms%20In%20Different%20Soil%20Types&text=Think%20of%20sand%20acting%20like,microbial%20activity%20in%20unique%20ways.

Considering these conditions, green infrastructure systems that do not rely on ground infiltration will be the most effective at limiting flooding, controlling runoff, and reducing levels of pollutants that enter the local watershed.

Topography & Natural Areas

Runoff transports pollutants like chemicals, bacteria, trash, and heavy metals, with the current drainage system conveying pollutant-containing runoff to the Grand River and Lake Michigan. Identifying these critical natural areas is important to understand where improvements can be placed and maximize the water quality improvements that green infrastructure can bring.

Similarly, understanding a site's terrain can help provide a foundation for limiting runoff and determining placement of green infrastructure. An analysis of topography is critical to understand where runoff is being directed, how this infrastructure can intercept and manage it, as well as where installations would be unsuitable. GIS data obtained from Ottawa County Geospatial Insights provides this information, which shows relatively level topography within the site area (Figure 5). With minor terrain variation - at most a two-foot difference - this site may require intentional regrading to reliably direct stormwater away from the Grand River.

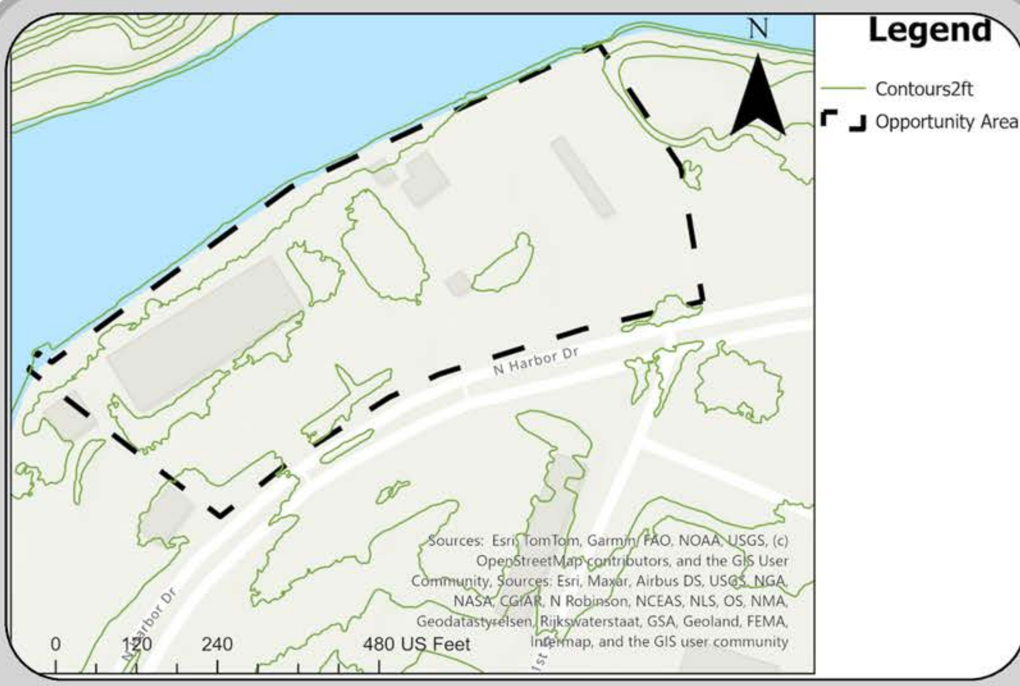

Figure 5 - Site Geography

Due to the required utilization of plants - both for green infrastructure systems and the local landscaping ordinance - the present distribution of trees on-site is an important factor. Not only that, but avoiding a monocultural composition of tree types helps reduce the impact of pests and diseases that may affect specific species more than others. Through site observation and satellite imagery, it was determined that the site and its immediate surroundings contains an estimated 67 trees (Figure 6), predominantly composed of deciduous species such as elm, linden, and ash trees. Together with the City's high proportion of old growth maple trees, it may be prudent to choose alternative species for green infrastructure and landscaping elements.

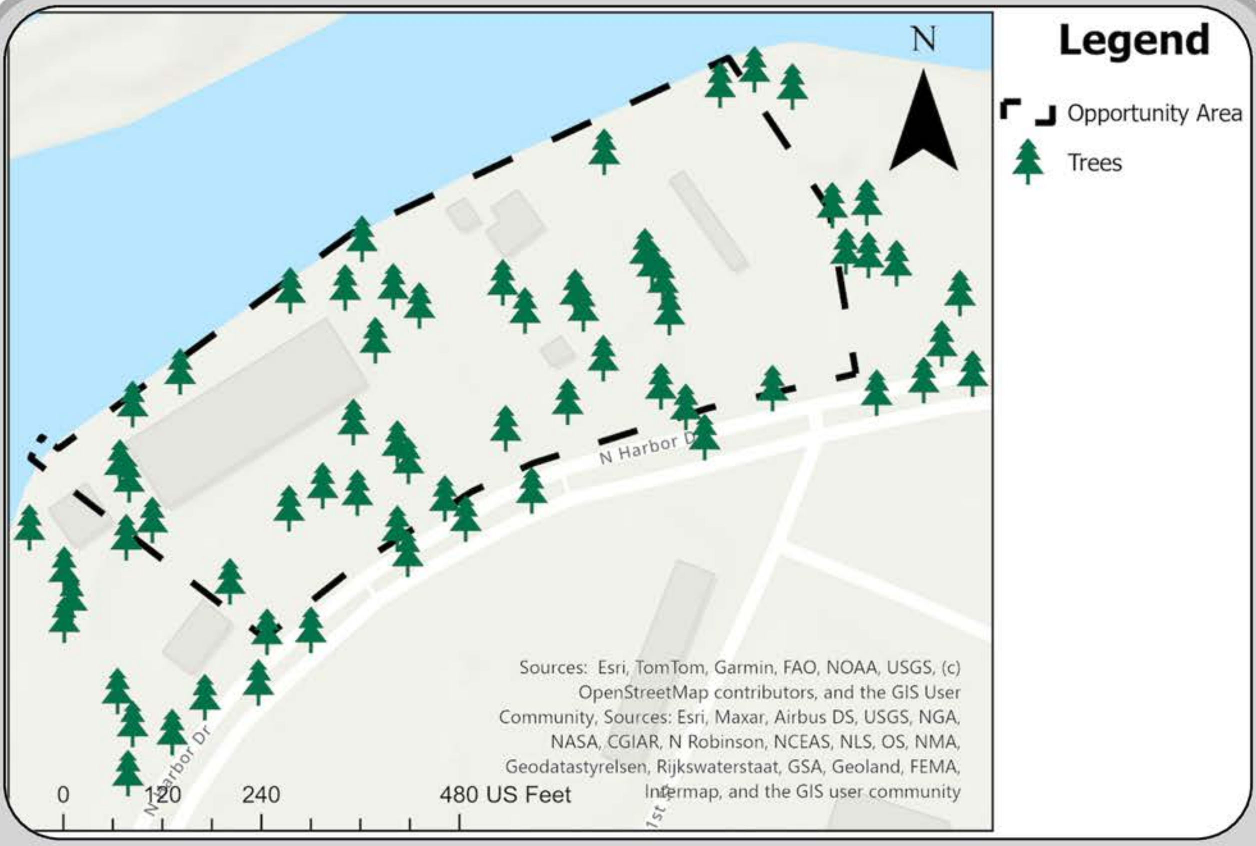

Figure 6 - Site Tree Map

Applicable Laws, Standards, & Regulations

Community needs included within the City's 2021 Beyond the Pier Waterfront Master Plan, along with relevant regulations, was a focal point of this analysis. Coupling sustainable stormwater management solutions with community amenities works to improve local recreational offerings, benefit the local economy, and build support for expanded green infrastructure. Protecting aspects of the site that the community identified as important, such as viewsheds and historical significance, can work to keep and build trust in local government.

Understanding local ordinances is critical to determine development opportunities and limitations. Minimum parking requirements, landscaping standards, and zoning specifications helped determine the available unpaved surface area, requirements for plantings, and overlay district restrictions for development, respectively. The City's stormwater management regulations provided abenchmark for treatment, along with examples of best management practices (BMPs) that could be used on-site. These regulations also outline

Precipitation, Climate, & Runoff Rates

Local climate patterns and precipitation can impact and restrict the feasibility of different green infrastructure systems. Considering the variable characteristics of plant species related to environmental resilience, such as salt tolerance and flood resistance, analyzing local environmental characteristics is important to determine species that are most viable.

Other Considerations

Green infrastructure development does not solely require site analysis, but necessitates a friendly policy environment, community outreach, technical support, and financial assistance. Cities with restrictive parking requirements, for instance, limit available area for management of runoff. While these aspects are not a focus of this report, they are critical to holistically promote development of this type of infrastructure beyond a single site. More about this aspect of development is explored in a separate report.

Opportunities

Through the consideration of these characteristics and limitations, several types of green infrastructure can be developed on the site that adequately manage runoff while providing benefits to the developer and the public at large. Figure 7 below illustrates this potential, with recommended improvements (shown in green) added to the proposed site plan. A bioretention pond, floating wetland, multi-season ice rink space, green roof, rain barrels, and raised beds can all work together to limit runoff and protect the local environment. Furthermore, these improvements help provide additional opportunities for recreation, help create place, make the park more naturally integrated, and improve energy efficiency. These systems are outlined in Figure 7 and the following pages.

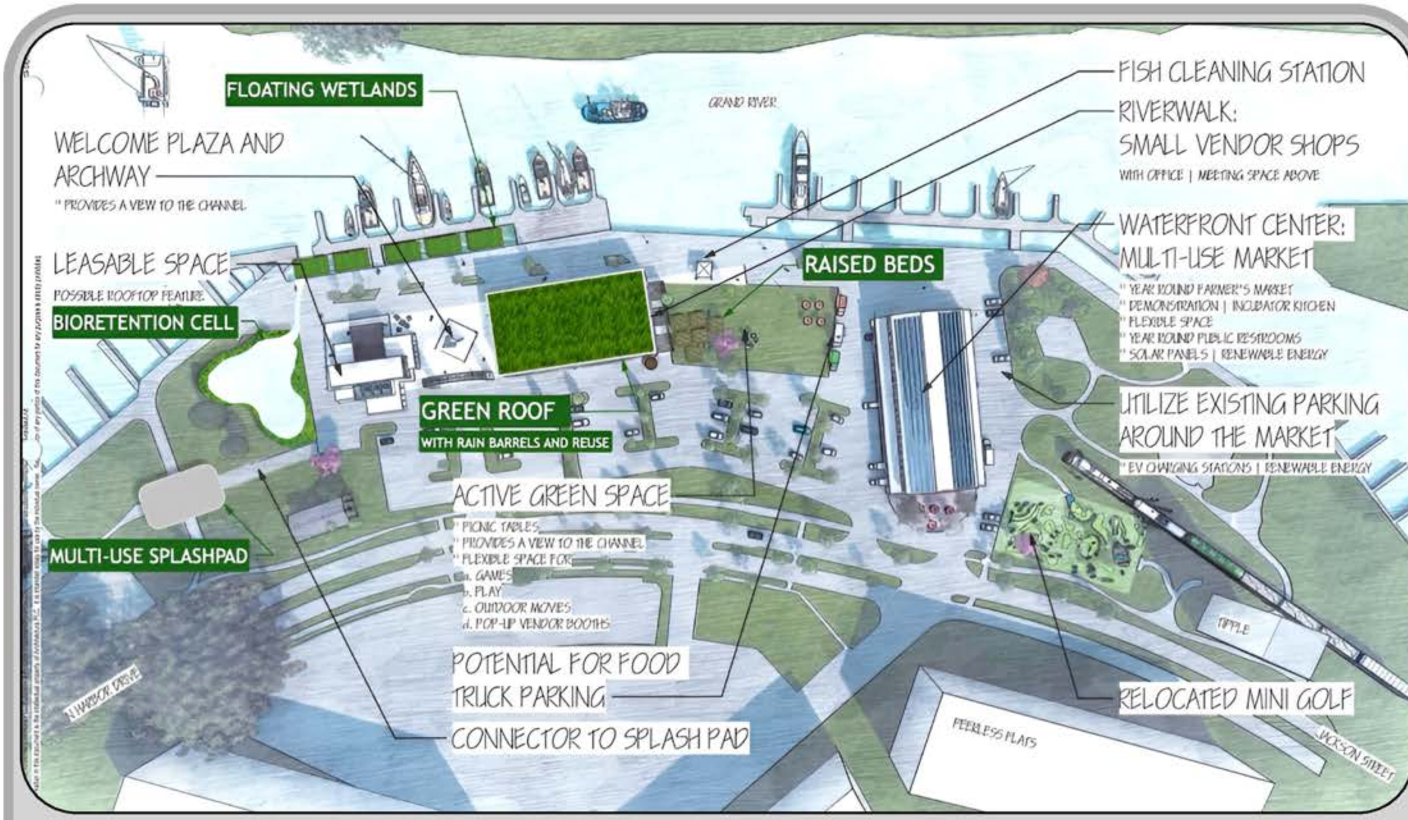

Figure 7 - Site Plan

Regrading

Considering the site's flat terrain, regrading could be done to redirect runoff. With many of the following improvements located on the west side of the site (Shown in Figure 7), regrading of the parking lot could work to limit the amount of stormwater that enters the river. According to this site plan, the parking lot is already being altered from its current layout - regrading this area during the construction process could reduce its cost and protect buildings on the site from flooding. The following green infrastructure improvements would be much more effective with a .5% minimum slope that directs water towards them for treatment.

Bioretention Pond and Floating Wetlands

A bioretention pond and floating wetland system, located on the left side of Figure 7, would help manage runoff, provide improved aesthetic quality, and augment existing habitat for native species. The pond would include a catchment basin to facilitate the entrance of stormwater from the sloped parking lot, which would run through it for its exit into the Grand River. A system of floating wetland cells are located along the river to help remove pollutants and improve the quality of the river's natural environment. Coupled with the flexible use splash pad and ice rink for overflow, the pond would work as a high capacity management system for site runoff. Proximate to the planned restaurant, this system would provide greater aesthetic quality for visitors while including native species to replicate a natural wetland.

Multi-Use Ice Rink, Splash Pad, and Detention Basin

A reimagined splash pad space with greater seasonal flexibility and recreational offerings could help increase the park's attractiveness for residents while managing stormwater. This installation would be used as a splash pad in the summer while retaining water from large surges. In the winter, it would be converted into an ice rink, improving winter recreational offerings to bring more traffic to the site during off-peak seasons. Additionally, it could include a designated site for snow drop-off, controlling snowmelt that may otherwise divert pollutants into the watershed.

Figure 8 - Cone Park Ice Rink & Splash Pad[8]

Cone Park in Sioux City, Iowa has a similar installation - blending multiple uses to be responsive to seasonal conditions and improve the use of available space. The city hired an outside contractor to construct this development, which features a removable curb and at-grade water sprayers that can be altered depending on its current use.[7] While it does not include stormwater management features, this example could be adapted with inlets or a drainage system that diverts water from the bioretention pond during storm surges and floods.

This improvement, on the southwestern portion of the site, would transform the existing splashpad into a multi-season, adaptable recreation space that improves the site's resilience to high flooding. Considering the past identification of multi-seasonal offerings as a priority, offering this type of amenity can help demonstrate a commitment to turning public engagement into action.

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[7] JEO Consulting Group Inc., "Sioux City, IA – Cone Park Splashpad and Ice Rink," *JEO.com*, ©2024, https://jeo.com/our-work/sioux-city-ia-cone-park-splashpad-and-ice-rink.

[8] *Side View of Cone Park Ice Rink & Splash Pad*, photograph, https://jeo.com/our-work/sioux-city-ia-cone-park-splashpad-and-ice-rink.

Green Roof

Due to limited pervious surface area on the site and the imperative to capture stormwater, a green roof is a viable option to maximize the use of available space. Green roofs can come in a variety of forms: extensive systems require minimal maintenance but support a limited range of plants, while intensive systems allow for more diverse vegetation but involve higher maintenance and costs. While intensive green roofs present greater opportunities for recreation and plant types, an extensive system would be more feasible for this site. Located in the middle of Figure 7, this proposed extensive system would allow for stormwater redirection while limiting initial hurdles and future maintenance issues. Since the currently proposed building was not designed for this kind of system, an extensive type reduces the weight requirements for that structure were this to be implemented. At the time of writing, this structure's weight capacity is unknown - the building must have the capacity to support an additional 20-45 lbs/ft^2 to use this system.[9]

Rain Barrels and Downspout Disconnection

In conjunction with an extensive green roof, rain barrels and downspout disconnection could be utilized to redirect stormwater. As relatively low cost and low maintenance options, these systems would be highly feasible for this site. Functionally, these improvements could work to direct water treated by the green roof for on-site landscaping and plumbing systems. Furthermore, downspout disconnection could work to facilitate the transfer of runoff into the bioretention pond, particularly for the restaurant structure located on the west side of the site.

Light Pollution Mitigation

While not typically considered green infrastructure, employing techniques to reduce light pollution works to both limit energy costs while protecting local pollinator species. Using warm low-CCT LED, LPS, or HPS fixtures to limit blue light in conjunction with dimmers, motion sensors, and shields around bulbs are viable and low-cost options to make lighting more efficient and environmentally sensitive. Similarly, reducing unnecessary lighting, such as indoor lights in unoccupied spaces, works similarly to make the site more sustainable. This graphic summarizes some of these practices with visual representations of light pollution-sensitive fixtures.[10] Utilizing green infrastructure installations that feature native species and light pollution reducing practices would make the Chinook Pier a hospitable ecosystem for native pollinators.

[9] Architecture Helper, "5 Key Design Principles for Green Roofs," *Architecture Helper* (blog), https://architecturehelper.com/blog/5-key-design-principles-for-green-roofs/.

[10] DarkSky International, Solutions to Light Pollution, https://darksky.org/resources/what-is-light-pollution/light-pollution-solutions/.

Raised Beds

Raised beds, or planter boxes, help reuse and redirect stormwater while providing opportunities for urban gardening (Figure 9). Considering the planned farmer's market expansion, offering on-site growing space can help provide locally-sourced food while engaging community members. While they have relatively limited potential for direct stormwater capture, their use in conjunction with water sourced from downspout disconnection and rainwater harvesting can redirect stormwater that would otherwise become runoff.

Figure 9 - Raised Beds

City Events

Hosting events, particularly ones based around sustainability, could take advantage of these new facilities while benefiting the community. Last run in 2019, the Grand Haven Salmon Festival took place in the vicinity of Chinook Pier Park with a variety of activities. This two-day event happened alongside the annual Salmon migration period, hosting a fish boil, fishing contest, fun walk, art fair, and more. The festival also included significant sustainability initiatives, becoming a zero-waste-to-landfill event in 2013. A Green Team composed of local sustainability professionals helped coordinate this event, which worked to educate and engage attendees about the value of sustainability and environmental protection.[11]

To further these efforts, the City could plan to once again host this event. Taking advantage of this site once it is renovated could help bring traffic to the area, showcase its local amenities, and continue education efforts surrounding sustainability. Furthermore, this event could take advantage of planned site facilities, such as the expanded farmer's market with test kitchens, to host the fish boil on-site. Businesses both within and surrounding the site could significantly benefit from increased traffic while highlighting the City's investments in sustainable infrastructure. While event planning can be resource-intensive, working to restart this event can help preserve and promote the site's historical value while engaging the community and benefiting the local economy.

[11] Grand Haven Salmon Festival, "Journey Towards Sustainability," *Grand Haven Salmon Festival*, http://www.ghsalmonfest.com/about/sustainability/.

Conclusions & Transferability

Site characteristics, local uses, relevant laws, and potential benefits were considered to determine suitable improvements. Through that framework, this report recommends that a flexible splash pad and ice rink green roof, rain gardens with downspout disconnection, and raised planter beds be considered for use as the park undergoes redevelopment. Moreover, the site has potential to host City events - such as the Salmon Festival - to bring traffic to the area, promote sustainability locally, and align the future of the site to its historical character.

It is intended to be utilized both by the City of Grand Haven as well as other Michigan municipalities as a framework for site analysis. Determination of a variety of factors is included to help guide a comprehensive analysis of local conditions and how they affect development of green infrastructure. This kind of infrastructure can help communities protect the public from flood risk, reduce environmental impact, and improve local climate resiliency. The ArcGIS StoryMap and related suitability flowchart serve as a distilled version of this report, guiding the user through selection criteria, suitable infrastructure types, and this case study with the aim of providing an relevant example for cities pursuing low impact development.

References

This material is based upon work supported by the Department of Energy and the Michigan Department of Environment, Great Lakes, and Energy (EGLE) under Award Number EE0008653. The views expressed herein do not necessarily reflect those of the United States Government or any agency thereof. Find this document and more about the CLC Fellowship that supported this project at graham.umich.edu/clcf.

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Side View of Cone Park Ice Rink & Splash Pad. Photograph.

Sustainability Directory. "How Does Soil Type Affect Water Purification Efficiency?" *Lifestyle – Sustainability Directory*. https: //lifestyle.sustainability-directory.com/question/how-does-soil-type-affect-water-purification-efficiency/#:~:text=Purification%20Mechanisms%20In%20Different%20Soil%20Types&text=Think%20of%20sand%20acting%20like,microbial%20activity%20in%20unique%20ways.

Reinforcing the site design process: A site design checklist for LID

The site design process for LID is structured to facilitate and guide an assessment of a site's natural features together with stormwater management needs. The LID Site Design Process Checklist will help implement the site design process. It provides guidance to the land development applicant, property owner, or builder/developer in terms of the analytical process which needs to be performed as the development proceeds. The outcome is the formulation of a LID concept for the site.

Local communities may also benefit by using this checklist for considering possible impacts to natural resources in the community and local watersheds.

Step 1: Property acquisition and use analysis

Step 2: Site inventory and evaluation

Watershed factors inventory

- ❑ Major/minor watershed location?
- ❑ State stream use/standards designation/ classification?
  - ❑ Special high quality designations? (e.g., natural rivers, cold water fishery)
  - ❑ Rare or endangered species or communities present?
  - ❑ Are there required standards?
- ❑ Any 303d/impaired stream listing classifications?
- ❑ Any existing or planned Total Maximum Daily Loads (TMDLs) for the waterbody?
- ❑ Aquatic biota, other sampling/monitoring?
- ❑ Do other special fishery issues exist?
- ❑ Is the site linked to a special habitat system?
- ❑ Are there known downstream flooding problems?
- ❑ Are there known problems with run-on from neighboring properties?
- ❑ Is additional development anticipated for the area that could lead to further restrictions? (e.g., protection of downstream land and water uses)
- ❑ Is additional development anticipated for the area that could lead to further opportunities (e.g., partnerships in multi-site or regional water quality or quantity controls)?

Site factors inventory

- ❑ Important natural site features have been inventoried and mapped?
  - ❑ Wetlands?
  - ❑ Floodplains?
  - ❑ Wellhead protection areas?
  - ❑ High quality woodlands, other woodlands, and vegetation?
  - ❑ Riparian buffers?
  - ❑ Naturally vegetated swales/drainageways?
  - ❑ Steep slopes or unique topographic features?
  - ❑ Special geologic conditions (limestone?)?
  - ❑ Historical values, certified or non-certified?
  - ❑ Known/potential archaeological values?
  - ❑ Existing hydrology (drainage swales, intermittent, perennial)?
  - ❑ Existing topography, contours?
  - ❑ Soils, their hydrologic soil groups?
  - ❑ Seasonal high water table? Depth to bedrock?
  - ❑ Special geological issues (e.g., karst)
  - ❑ Aesthetics/viewsheds?
  - ❑ Existing land cover/uses?
  - ❑ Existing impervious areas, if any?
  - ❑ Existing pervious maintained areas, if any?
  - ❑ Existing contaminants from past uses, if any?
  - ❑ Existing public sewer and water, if any?
  - ❑ Existing storm drainage system(s), if any?
  - ❑ Existing wastewater system(s), if any?
  - ❑ How does size and shape of the site affect stormwater management?
  - ❑ Are there areas where development should generally be avoided?

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Step 3: Integrate municipal, county, state, and federal requirements

Master plan

- ❑ Is development concept consistent with the master plan?
  - ❑ Consistent with goals/policies of the plan?
  - ❑ Preservation of natural resources consistent with priority areas/maps?

Regulations (e.g., ordinances, engineering standards)

- ❑ Consistent with local existing regulations?
  - ❑ Wetland regulations?
  - ❑ Tree/woodlands ordinance?
  - ❑ Riparian buffer ordinance?
  - ❑ Open space requirements?
  - ❑ Clustering and/or PUD options?
  - ❑ Overlay districts?
  - ❑ Wellhead protection?
  - ❑ Floodplain ordinances?
  - ❑ Are LID solutions required?
    - ❑ or incentivized?
    - ❑ or enabled?
    - ❑ or prohibited?
- ❑ Reduced building setbacks allowed?
- ❑ Curbs required?
- ❑ Swales allowed?
- ❑ Street width, parking requirements, other impervious requirements?
- ❑ Grading requirements?
- ❑ Landscaping that allows native vegetation?
- ❑ Stormwater requirements?
  - ❑ Peak rate?
  - ❑ Total runoff volume?
  - ❑ Water quality provisions?
  - ❑ Maintenance requirements?
- ❑ Consistent with county/state road requirements?
- ❑ Consistent with local stormwater regulations?
- ❑ Consistent with erosion and sedimentation requirements?
- ❑ Contaminated sites have followed state "due care" requirements for soil and groundwater?
- ❑ Consistent with state and federal wetland and/or inland lakes and streams regulations?
- ❑ Consistent with state threatened and endangered species regulations?
- ❑ Meets state floodplain requirements?

Step 4: Develop initial concept design using nonstructural BMPs

Lot configuration and clustering?

- ❑ Reduced individual lot size?
- ❑ Concentrated/clustered uses and lots?
- ❑ Lots/development configured to avoid critical natural areas?
- ❑ Lots/development configured to take advantage of effective mitigative stormwater practices?
- ❑ Lots/development configured to fit natural topography?
- ❑ Connect open space/sensitive areas with larger community greenways plan?

Minimum disturbance?

- ❑ Define disturbance zones (excavation/grading) for site?
  - ❑ Protect maximum total site area from development disturbance?
  - ❑ Barriers/flagging proposed to protect designated non-disturbance areas?
  - ❑ Disturbance setbacks defined from BMP areas, vegetated areas, tree drip lines, etc.?
- ❑ Site disturbance (excavation/grading) minimized for each lot?
- ❑ Considered mitigative practices for minimal disturbance areas (e.g., Soil Restoration)
- ❑ Considered re-forestation and re-vegetation opportunities?

Impervious coverage reduced?

- ❑ Reduced road width?

III. DESIGN PROCESS

The stormwater site design process is summarized in the steps below. This process is intended to minimize negative impacts from development sites that could be avoided through proper planning.

A. Identify Sensitive Areas

Identify existing environmentally sensitive areas on the site plan that may require special consideration or pose a challenge for stormwater management. For the purpose of these standards, sensitive areas include:

1. Waterbodies (lakes and ponds)
2. Rivers and streams
3. Floodplains (and flood prone areas)
4. Riparian areas
5. Wetlands
6. Woodlands
7. Sand dunes
8. Natural drainageways
9. Soils and topography (erodible, steep)
10. Susceptible groundwater supplies
11. Threatened and endangered species habitat

Sensitive areas are determined on a site-specific basis through survey, delineation, aerial photographs, or maps. Sensitive areas must be shown on the site map or drawings. The total acreage of protected areas must also be indicated. The Developer must demonstrate a good faith effort to maximize protection of sensitive areas.

B. Select Source Controls

Source controls reduce the volume of runoff generated onsite, encourage infiltration and evapotranspiration, and prevent pollutants from entering the drainage system. Non-structural BMPs are used for this purpose. Maximize the use of non-structural BMPs as the most effective option for controlling stormwater to meet sensitive area protection requirements and reduce the size of site runoff controls.

C. Size Runoff Controls

After source controls have been maximized, site runoff controls are typically needed to manage the additional post-development stormwater runoff. Determine the standards applicable to the site to properly size runoff controls. Minimum required stormwater standards are summarized in Table 1. Identify additional standards required in Watershed Policy Statements (**Appendix 2**).

D. Confirm an Adequate Outlet

Once all onsite source and runoff controls have been implemented, excess runoff can be discharged offsite. The design criteria specified in this manual is generally protective of the receiving waterbody. However, the Developer must always demonstrate an adequate outlet exists downstream of the development to receive the design rate, volume, and concentration of the post-development site runoff. Discharge from the site, including discharge from emergency overflow spillways and pipes, must not cause adverse impact to downstream properties or infrastructure (refer to Part 2 section "Stormwater Discharge").

E. Select Best Management Practices (BMPs)

Select appropriate stormwater BMPs to meet minimum required pollutant reduction, volume, and peak rate requirements. A list of common BMPs and their treatment ability is given in Table 3. The BMPs selected must be designed in accordance with the calculation methods and design criteria provided in **Appendix 3** of this manual. BMPs proposed for use, but not included in this manual will be evaluated on an individual basis.