Groundwater Permits Unit
Water Resources Division
Department of Environment, Great Lakes, and Energy
State of Michigan

Guidesheet II: Guidance for the Development of a Discharge Management Plan

(Management of Wastewater Land Application)

EGLE Environmental Assistance Center
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Land application of wastewater may be used as part of the overall treatment to meet the standards of R 323.2222. In such cases, the discharger is required to incorporate the use of slow rate or overland flow processes in the design of the discharge system. Rapid infiltration may be utilized when the objective is to dispose of wastewater that meets the standards of R 323.2222 prior to discharge.

The Department of Environment, Great Lakes and Energy requires all facilities that discharge to the groundwaters of the state to develop a discharge management plan (DMP). The DMP is part of the permit application and becomes enforceable as part of the permit by reference; however the DMP is subject to the Part 22 Administrative Rules, of Part 21, Water Resources Protection (Part 31), of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), the regulatory authority. A provision included as part of a DMP contrary to Part 22 is inherently invalid and should not be implemented.

The following information is presented as a general guideline for the development of a DMP. Sample language is included in shaded boxes. This Guidesheet will not cover all possible scenarios and it may be necessary in some instances to contact the Groundwater Permits Unit of EGLE for further assistance.

The complexity of a DMP is a function of the system to which it applies. A DMP can be as simple as a plan addressing a one-time discharge to a rapid infiltration bed or as complex as a plan for the management of a multiphase operation utilizing various technologies to address specific land treatment issues. The author of the DMP should be aware that all land treatment systems are required to meet the general requirements for land treatment systems as set forth in R 323.2233(4). It should be noted that generally R 323.2233(4)(a)(iii), (iv)(D) and (F), and (vi), as well as 323.2233(4)(b) do not apply to Rapid Infiltration Systems. Land treatment systems must also meet the specific requirements applicable to the type of land treatment system provided in R 323.2234 (slow rate land treatment), R 323.2235 (overland flow land treatment), and/or R 323.2236 (rapid infiltration). If a land treatment system utilizes more than one process, the overall system must comply with the general requirements in R 323.2233(4). In addition, the individual component processes of such a system must comply with the applicable requirements provided in R 323.2234 to R 323.2236.

The purpose of a DMP is to provide the operator of the treatment system, facility administrators, public officials, and regulators with important information regarding system function, design, and operation. **It should be targeted to the treatment plant operator and facility management personnel, as they will be responsible for implementation of the plan within the context of operating the system.** A list of information that is typically needed to prepare an acceptable DMP is provided in Appendix A. The list is not intended to be exhaustive. It is recommended that the writer of a DMP gather as much of the applicable information listed prior to beginning the task of writing the DMP. Additional information may be needed depending on the type of system(s) utilized and the specific conditions found at the site. **This information must accompany your DMP upon submittal**. A properly written DMP will include the nature of the discharge as well as the overall management of the system utilized by the discharger.

EGLE Evaluation of DMP

1. Include only land treatment acreage that will be routinely wetted by the discharge. The discharger will not be given credit for acreage available for irrigation unless it is part of an active irrigation area or cell.

2. Uniform distribution of the wastewater during discharge is mandatory for all three general processes: slow rate, overland flow, and rapid infiltration.

3. Nutrient uptake characteristics of the crop are reviewed in relation to the level of treatment required to meet the groundwater standards.

4. Year-round discharges in Michigan are generally not acceptable where there is reliance on biological treatment of wastewater within the soil matrix. During the winter months in Michigan, it is difficult and often impossible to maintain a viable crop capable of utilizing nutrients, maintain acceptable soil hydraulic conductivity to accommodate the discharge, and maintain adequate unsaturated zone protective of groundwater. Winter discharges in Michigan are allowed only under the following conditions:

   The only required treatment of the effluent is through physical-chemical processes.

   The standards (requirements) of R 323.2222 have been met.

   Hydraulic conductivity is maintained such that the discharge does not lead to ponding or pooling conditions.

   An adequate unsaturated zone protective of the groundwater is maintained.

5. Occasionally, native soil must be replaced to attain more desired soil characteristics. In that event, it is necessary to assess the hydraulic conductivity on-site according to the requirements set forth in the section on Hydraulic Loading under *General Design Information*.

6. **The discharge to a land treatment system is to be limited so that the discharge volume combined with the precipitation from a 10-year frequency, 24-hour duration rainfall event does not overflow the designed discharge area.**

Requirements of a Discharge Management Plan

Introduction

The introduction of a DMP should provide a brief overview of the system, the nature of the discharge, general information regarding facility operations, and information regarding the use of the DMP itself. It is recommended that the author of a DMP refrain from editorializing. Instead, the document should be concise and factual.

Sample language for the Introduction:

This land treatment system was designed and built as part of the wastewater treatment facility which serves the city, village, community of _______________. This wastewater treatment facility is authorized under Part 31, Water Resource Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 31), and the Part 22 Groundwater Quality Administrative Rules (Part 22) promulgated thereunder to discharge ____ gallons per day and ______ million gallons annually.

Any and all discharges from the facility are to be in compliance with the conditions, limits, practices, and procedures established in this facility's discharge permit and with this Discharge Management Plan (DMP). Any deviation from the conditions, limits, practices, or procedures specified in this facility's discharge permit or this DMP without prior authorization from the Department of Environment, Great Lakes, and Energy (EGLE) constitutes a violation of the discharge authorization and will subject the facility and its operator to potential enforcement action as provided in Part 31.

This facility generates wastewater effluent which does (does not) meet the Part 22 groundwater standards for Total Inorganic Nitrogen (TIN) or Total Phosphorus (TP) prior to discharge. As such it utilizes __________ technology as a means of treating the wastewater before it reaches the groundwater. The permit for this facility limits the concentration of TIN and TP in the discharged effluent to ___ mg/l and ___ mg/l respectively.

The discharge from this facility must not cause the concentration of TIN in its compliance monitor wells to exceed 5 mg/l or 1 mg/l TP. As such, proper operation of the land treatment system to provide the necessary treatment of the applied wastewater is very important in order to achieve and maintain compliance with this facility's discharge permit and all applicable regulations.

Sample Introduction continued:

The system utilizes _________ as a means of distributing its wastewater to area totaling ___ acres. The area has been planted with _____________ as a means of helping to treat the applied effluent.

NOTICE!!!

Any and all violations of this DMP, the discharge authorization or applicable regulations must be reported to EGLE, Water Resources Division, at the District Office located in _______________, Phone Number _________.

Be advised, the discharge authorization contains specific instructions regarding certain types of violations in addition to reporting such occurrences.

General Design Information

R 323.2233 specifies the general requirements for all land treatment systems. All DMP's must be written to provide the information necessary to operate the land treatment system in compliance with these requirements.

Application Rate

***Hydraulic loading*:** Provide the information that supports the proposed hydraulic loading (application) rate for the system. Keep in mind that the design hydraulic loading or application rate, whether daily, monthly, or annually, should not exceed:

> Seven percent of the permeability of the most restrictive soil layer within the solum, over the area of the discharge as determined by the saturated hydraulic conductivity laboratory method using undisturbed cores; or,
>
> Twelve percent of the permeability as determined by the basin infiltration method; or,
>
> Three percent of the permeability of the solum when determined by either cylinder

infiltration or air entry permeameter test methods.

If the saturated hydraulic conductivity test is chosen, it shall be performed on undisturbed soil samples. If undisturbed samples cannot be retrieved or where application sites contain replacement soils or are otherwise disturbed via site development, one of the two alternative test methods must be used.

The test method chosen must be one designed to determine only the vertical aspect of soil infiltration. To determine the application rate under R 323.2233, only the above methods for on-site testing are appropriate. Slug test, grain size analysis, and percolation test are examples of tests that are not appropriate for this purpose. Appendix B: *Soil Permeability Testing* provides additional information.

Methods referenced above, for determining soil permeability may be found in the publication titled "Methods of Soil Analysis, Part 1, Physical and Mineralogical Properties", Second Edition, American Society of Agronomy, 1986 or later edition. Methods for determining soil permeability are also found in "Process Design Manual, Land Treatment of Municipal Wastewater," U. S. Environmental Protection Agency, EPA 625/1-81-013, 1981 updated, 2006; EPA/625/R-06/016. Document EPA 625/1-81-013a offers additional explanations and guidance for rapid infiltration beds and overland flow systems. At this time the United States Environmental Protection Agency (USEPA) Manuals can be found online at *http://nepis.epa.gov/EPA/html/pubindex.html.*

In lieu of on-site testing, permeability data may be obtained from published information, such as Soil Surveys. However, if the soil has been excavated, replaced, or modified, published information is no longer applicable and on-site testing is required. The discharger, if utilizing published information, is to determine the methodology used to measure the reported hydraulic conductivity [United States Department of Agriculture (USDA) Soil Surveys use the saturated hydraulic conductivity test]. When published information is utilized and it is given as a range of expected values, use the minimum value given the most restrictive soil layer within the solum when calculating the hydraulic loading or application rate.

The Solum: Rule 2203(d) of Part 22 states; "'Solum' means soil from the surface to a maximum depth of 60 inches." The term solum is defined in the "Glossary of Soil Science Terms 1996, Soil Science Society of America, 1997 (Glossary), as "A set of horizons that are related through the same cycles of pedogenic processes; the A, E and B horizons." The definition provided in the Part 22 Rules provides adequate guidance in terms of applying the requirements of the rules to typical systems. The definition provided in the Glossary provides more specific information useful in determining when a solum is present or not.

As it relates to land application of wastewater, the Part 22 Rules are silent on the matter of how the permeability of the unsaturated soil column beneath the solum is to be determined. The excavation of surface material does not in any way diminish the authority or responsibility of EGLE to impose or otherwise require appropriate testing to determine the vertical hydraulic conductivity of the solum as defined by Part 22 utilizing the methods identified in Rule 2233(4)(v). EGLE recommends the use of the "Basin Infiltration Method" as it provides the best information representative of on-site conditions as well as allowing the use of 12 percent of the permeability (as opposed to seven or three percent when using other methods) when calculating the annual hydraulic load to a system. It is important to keep in mind the final application rate and hydraulic load may also be impacted by the presence of subsurface features identified in the hydrogeological study.

For purposes of the Part 22 Rules, the facility must demonstrate the permeability of the most restrictive layer of the newly exposed solum as defined in Part 22.

Sample language for application rate:

The design hydraulic loading rate for this facility was determined using the tables published in the _______ county soil survey. The discharge area is dominated by (number) soil series. The reported vertical permeability for the most restrictive layer of each of the soils is listed in the attached appendix. (Number) soils dominate the site but have similar permeability; therefore, the reported vertical permeability for the most restrictive layer ranged _________. Based on the lowest number in the range, the application rate is ______ (__in/hr x 24 hr x .07).

or,

Natural soils at this discharge site have been replaced with clean sand. Since the site contains replacement soils, the basin infiltration test was performed to determine the soil permeability. Permeability was determined to be _____inches/hour. The application rate was based on 12.0 percent of the permeability.

Nutrient Treatment/Management

Nutrient management becomes an issue for a wastewater treatment facility when the concentration of total inorganic nitrogen TIN and or total phosphorus TP exceed the groundwater standard. For such a facility, the utilization of a harvested crop is a popular means of providing the necessary treatment to meet the standard. Perennial crops, such as but not limited to alfalfa, orchard grass, and reed canary grass are typical selections for wastewater treatment facilities. These crops can be grown either as monocultures or in combination with one another.

In addition to crop uptake, soil within the discharge area may be able to provide treatment of applied phosphorus through the physio-chemical process of adsorption. Different soils possess varying degrees of adsorptive capacity. While there is published information regarding the adsorptive capability of many soils found in Michigan, it may be necessary to conduct site specific testing of the soil(s) within a given site to determine its treatment capability.

A land treatment system must be designed, constructed, and operated to address concerns associated with the nutrient load to the system. This is accomplished through an understanding of the relationships between the annual nutrient load for each nutrient, managing according to the most limiting nutrient, realistic yield goals, the nutrient uptake capability of the crop grown and the phosphorus adsorptive capacity of the soil within the discharge area. The sample DMP language below includes equations for estimating annual nutrient loading. Information regarding realistic yield goals and nutrient utilization can be obtained from the local County Extension Office, the County Soil Survey or other published data relating to the yield capabilities of the soils within the wastewater application area. Appendix C is also provided as an example of expected nutrient removal values for selected crops.

When a facility relies on crop uptake and or soil adsorption as a means of providing the treatment necessary to meet the groundwater standard harvesting and removal of the crop is required as part of the treatment process. It is important the operator be made aware of these facts. As such, the DMP must provide specific guidance regarding each nutrient of concern.

***Sample language for Nutrient loading*:**

Effluent discharged from this facility may not contain more than ____ mg/l TIN and ____ mg/l TP. Effluent with any constituent at a concentration higher than specified in the permit is not to be discharged. Such a discharge will constitute a violation of the facility's DMP and its discharge authorization and must be reported to EGLE's Water Resources Division District Office in _________. Calculations pertaining to the evaluation of the system assumed even distribution of the discharge with the maximum permitted concentrations of both constituents.

This land treatment system is designed and constructed to provide the necessary treatment to the applied effluent. Do not apply sewage sludge, biosolids, septage waste, or any other residual or by-product to supplement the nutrient needs of the crop which may not be satisfied through the application of wastewater. Application of these or similar materials will introduce contaminants to the system which could migrate to the groundwater resulting in a violation of the facility's discharge authorization. Supplemental nutrient additions, should they be necessary, must be addressed through prescriptive use of commercial grade fertilizer following specific recommendations of the local County Extension Office.

Nitrogen loading: If land application is considered part of the overall treatment process, the rate of application of wastewater to land treatment systems is most often limited by nitrogen in the discharge. The rate of application must be agronomic and should take into consideration both the crops' needs as well as the amount of available nitrogen in the soil. Testing of soil for nitrate is an inexpensive method and helps ensure against needless over-application of nitrogen and the potential for exceeding the nitrogen limit in groundwater (see standards under R 323.2222). A description of how to sample for soil nitrate is in Appendix D: *Michigan's Soil Nitrate Test for Corn 2005*. The combination of nitrogen from the application of wastewater and any fertilizer must not exceed the uptake capability and characteristics of the crop grown.

Sample language for Nitrogen:

Discharging the maximum permitted volume of effluent containing the maximum permitted concentration of TIN distributed evenly over the irrigated area will result in an application rate of ____ pounds (lbs) TIN per acre per year. However, the wastewater discharged to the land treatment area will often contain less than the permitted concentration of TIN and volume of wastewater. In order to maintain the health of the crop grown within the land treatment area it is important for the operator to know the actual quantity of nitrogen applied.

Equation 1.1 below provides a means of determining the amount of nitrogen applied as a function of the concentration (mg/l) of TIN in the effluent, the volume (millions of gallons) of wastewater to be applied at that concentration and the area (acres) to which the volume is applied:

Lbs TIN applied per acre =
$(mg/l_{TIN}$ X volume X 8.34*) / area Eq. 1.1

$$^{*}\ 8.34x10^{-6}\ lb/gal = \frac{2.2x10^{-6}\ lb/mg}{0.264\ gal/l}$$

$$8.34 = \frac{8.34x10^{-6}}{1{,}000{,}000}$$

Example calculation of a discharge of 950,000 gallons of effluent containing 12 mg/l TIN applied to 10 acres:

(12 mg/l X 0.95 million gallons X 8.34) / 10 acres = 9.5 lb TIN/acre applied

Note that this calculation does not take into account losses resulting from volatilization or denitrification which could be as much as 10 to 15 percent.

The permit for this facility requires the effluent to be analyzed on a (weekly, monthly) basis. To provide the most accurate estimate of the quantity of nitrogen applied, the most recent analytical results for a given time frame will be used. The resulting calculations will be recorded and provided upon request.

Please refer to the crop management section of this DMP regarding treatment of the applied nitrogen.

Phosphorus: When phosphorus adsorption within the solum or unsaturated soil column is part of the overall treatment process, R 323.2233 requires that the Phosphorus Adsorption Capacity (PAC) within the unsaturated soil column must be sufficient to provide the necessary treatment to ensure the applicable limit established in the permit is not exceeded for the duration of the permit.

Loading cycle(s) must be developed to provide the necessary contact time within the unsaturated soil column required for phosphorus to be removed from the applied wastewater through the adsorption processes.

If any portion of the land application area has a remaining estimated site life of less than two permit cycles; conditions in the permit will require the facility to submit a plan to address the long-term ability to meet phosphorus limitations in groundwater.

***Sample language for Phosphorus**:*

This facility relies on two separate mechanisms in its land treatment system to provide the necessary treatment of effluent phosphorus. One mechanism for removing the applied phosphorus is through plant uptake which is achieved through growing and harvesting the crop within the irrigated area. The other mechanism for treating the applied phosphorus is through adsorption by the soil.

Discharging the maximum permitted volume of effluent containing the maximum permitted concentration of TP distributed evenly over the irrigated area will result in an application rate of ____ lbs TP per acre per year. This amount of TP exceeds the uptake capability of the crop grown within the irrigated area. As such, this facility relies on adsorption by the soil as a means of providing the necessary treatment of the applied wastewater to meet the groundwater standard.

Sample language for Phosphorus continued:

Equation 1.1 above can be utilized to calculate the quantity of TP being applied for any given volume of wastewater. Simply substitute the concentration of TP for TIN in the equation.

Example calculation of a discharge of 5,000,000 gallons of effluent containing 10 mg/l TP applied to 15 acres:

(10 mg/l X 5.0 million gallons X 8.34) / 15 acres = 27.8 lb TP / acre

To convert the TP value to its P_2O_5 equivalent, multiply by 2.3:

27.8 lb TP X 2.3 = 63.9 lb P_2O_5

R 323.2233 establishes the procedures for determining the available PAC of the discharge area. Those procedures are as follows:

Subtract the phosphorus levels of the unsaturated soil column, as determined through on-site Bray P_1 analysis, from published PAC data for the solum found within the discharge area.

Or,

Subtract phosphorus levels of the unsaturated soil column, as determined through on-site Bray P_1 analysis, from the phosphorus adsorption maximum as determined through Langmuir isotherm analysis of on-site soils, **after adjustments for the concentration of phosphorus in the effluent and fraction of utilization within the solum are made**. “Soil Sampling Protocol and Evaluation of Phosphorus Adsorption by Soils at Sites Receiving Wastewater” (Appendix E) contains specific information regarding sampling requirements for determining PAC.

Operation changes that are inconsistent with the original assumptions used to determine PAC according to the Langmuir isotherm may necessitate reevaluation of the PAC. Such changes include, but are not limited to, adjustments to the effluent phosphorus concentration, the discharge volume, cropping activity, and current soil phosphorus levels (Bray p_1, Mehlich 3, or Olsen analyses).

If treatment of effluent phosphorus is to be accomplished through the mechanism of adsorption by the soil column, address the issue in detail in the DMP. Include which of the two aforementioned procedures were used in the determination along with supporting documentation.

Sample language for phosphorus adsorption:

Published information regarding the PAC of all of the soil types within the irrigated area was used to evaluate the treatment capability of this facility's land treatment system. The specific information used, and its source is referenced in Appendix ___ of this DMP. This information along with an assumed maximum permitted annual TP load, adjustment for plant uptake as well as current Bray P_1 soil phosphorus levels indicate a minimum theoretical site life, with regard to the ability of the soil to provide treatment of the applied phosphorus, to be ___ years.

It is expected soil phosphorus levels will increase over time. Once the level of Bray P_1 Phosphorus reaches 150 mg/kg (300 lb P per acre) it may be necessary to conduct actual phosphorus adsorption tests on the soil to determine site (soil) specific characteristics regarding the adsorptive capability of the land treatment system. More granular soils may reach the break-through level at 100 mg/kg (200 lb P per acre).

Alternate Language (for use when PAC is determined through testing):

The soil types within the irrigated area were analyzed to determine their PAC through the use of Langmuir Isotherms. The results of the analysis can be found in Appendix ___ of this DMP. This information, along with an assumed maximum permitted annual TP load, adjustment for plant uptake as well as current Bray P_1 soil phosphorus levels indicate a minimum theoretical site life, with regard to the ability of the soil to provide treatment of the applied phosphorus, to be ___ years.

Additional Considerations

Biochemical Oxygen Demand (BOD): Recent groundwater monitoring data indicate impacts from wastewater discharges containing high BOD, where heavy metals such as iron, manganese, arsenic, and lead are being detected at levels above those allowable under Part 22 and Part 201, Environmental Remediation, of the NREPA. The Part 22 Rules do not specify a limit for BOD in wastewater; however, to address the observed impacts, EGLE recommends limiting the concentration of BOD in effluents to 30 mg/l prior to discharge to land.

The mechanisms in the process whereby high BOD wastewaters are causing elevated concentrations of heavy metals in groundwater are complicated. Essentially, heavy metals in soil are solubilized under reducing (highly anoxic or low oxygen) conditions. Many factors promote a reducing condition in soils including flooding, limited oxygen, low pH, and addition of organic matter. The discharge of wastewater containing a significant concentration of BOD may cause a reducing condition to develop in the soil resulting in solubilization of heavy metals. Oxygen in the soil becomes limited as it is used up in the process of microbial metabolism of applied organics. Under increasingly anaerobic conditions, the reactions in soils favor the formation of organic acids that promote solubilization of native heavy metals (not those already associated with the discharge) that consequently are more easily leached to groundwater.

So, while the Part 22 Rules do not specify a limit for BOD in wastewaters discharged to the land, there are standards established for heavy metals which are solubilized and leach to groundwater as a result of elevated BOD in discharged wastewater. Facilities discharging wastewaters with BOD concentrations above 30 mg/l should evaluate their discharge and develop strategies to avoid impacting the groundwater resource as a result of the character of their discharge. All facilities with effluent having elevated BOD must provide these treatment strategies in their DMP.

Sodium: If the effluent that is discharged contains a significant concentration of sodium, the system is required to be designed, constructed, and operated to prevent the development of sodic conditions within the solum of the discharge area. If the development of sodic conditions is a concern, the DMP should address prevention and monitoring of such conditions as well as contingency plans to be implemented in the event such conditions develop.

Sample language for sodium:

The effluent from this facility has elevated levels of sodium resulting from the significant number of residential water softeners in use. As a result of the elevated sodium and the clay content of the soil within the discharge area, there is a concern regarding the potential development of sodic conditions in the soil. Such conditions, should they develop, will interfere with crop growth, and have the potential to cause significant reduction in soil permeability. The annual soil test must include an analysis for EXCHANGABLE SODIUM PERCENTAGE (ESP). A sodic condition exists when the ESP is 15 or more. Should such a condition develop, contact EGLE, Water Resources Division at the District Office in ____. Correcting the sodic condition requires implementation of specific soil management strategies. Before proceeding with such action, you must develop a work plan to be reviewed and approved by the District Office. It is recommended you contact the local County Extension Office for assistance regarding the specific strategy to use to correct the problem.

pH: For slow rate and overland flow treatment systems, the pH of the soil within the plow layer within the discharge area is to be maintained between 6.0 and 7.5 S.U.

Sample language for pH:

The pH of the soil within the land treatment system must be maintained between 6.0 and 7.5 S.U. This is a requirement of the Part 22 Rules as well as the proper soil pH for the crop grown within the irrigated area. This facility's discharge authorization requires the soil to be tested once per year.

Surface runoff: R 323.2233(3)(a)(i) requires that the system be designed and constructed to prevent surface runoff from either entering or exiting the system. Inherent natural site conditions (i.e., little or no slope, coarsely-grained soils with adequate soil infiltration, natural barriers to runoff) along with management restrictions (i.e., seasonal land application when soils are not frozen and/or water table is low, extensive isolation from adjacent property, application rates which are not conducive to taxing the limits of the soils inherent capacity) may preclude the necessity for engineered surface runoff prevention. The DMP must address how the system complies with the requirement to prevent surface runoff from either entering or exiting the system.

Sample language for prevention of runoff:

There is a berm surrounding each sub site. These berms were designed and installed to prevent any wastewater from exiting its designated application area as well as keep any runoff from other areas from entering onto the sub site. These berms should not be altered or damaged. The vegetation on the berms should be kept mowed to a height of no more than six inches. Inspect the berms weekly for any signs of animal burrowing and or erosion. Should any damage occur, it is to be repaired immediately.

Even distribution: The even distribution of applied wastewater is critical with regard to the ability of the system to provide the intended level of treatment. Even distribution of the wastewater is also assumed in all calculations associated with nutrient and hydraulic loading, phosphorus adsorption, and crop yield goals and as such is required of all slow rate and overland flow land treatment systems. Distribution systems that prove incapable of providing even distribution will be required to be modified or replaced with systems that are capable of achieving this requirement.

Explain how the system has been designed, constructed, and is to be operated to provide even distribution of wastewater during application. If a header ditch is used, explain how it has been designed and constructed to allow for complete drainage after each wastewater loading, or lined in order to prevent seepage.

> ***Sample language covering even distribution:***
>
> In order for the land treatment system to be able to function properly, the application of wastewater must be evenly distributed across the site. "Overloading" or "under loading" any portion of the system may result in malfunction and potentially lead to groundwater impacts.
>
> It is critical that the distribution system is inspected daily for any blockages, breakage, or improper function. In addition, the system must be observed while in operation. Any part of the system which is damaged or not operating properly is to be repaired or replaced immediately. Do not operate the distribution system within any sub site which is malfunctioning.

Loading and Resting Cycle: An appropriate loading cycle is one that allows time between applications for soil organisms to biologically decompose organic constituents in the wastewater. It also allows for organic solids on the soil surface to decompose, for the soil to become aerated, and for vegetative cover to utilize nutrients provided through the application of the wastewater. The cycle should accommodate the harvesting, maintenance, and soil sampling schedules. For guidance on developing appropriate loading cycles, please refer to the "Process Design Manual, Land Treatment of Municipal Wastewater," U.S. Environmental Protection Agency, EPA 625/1-81-013, 1981 and updated.

The DMP must explain how the system has been designed, constructed, and is to be operated to allow an appropriate loading and resting cycle. A loading and resting cycle is appropriate for slow rate, overland flow, and rapid infiltration beds.

> ***Sample language for the dosing cycle:***
>
> The irrigated area has been divided into _ acre sub sites. They are designated __, __, __ etc. This facility is authorized to apply its wastewater at a rate not to exceed ___ inches per day and ___ inches per week.
>
> The valves which direct wastewater to each sub site are located in the pump house. Each valve is clearly labeled indicating which sub site it serves.
>
> The system is currently set up to operate such that each sub site receives an application of wastewater on a given day and then rested for ___ days. Each of the sub sites has been sized to accommodate the daily maximum volume of wastewater and still be slightly under the daily maximum application rate of __ inches. A daily maximum volume applied to a given sub site will result in an application rate of __ inches. The current rotation schedule for this system is as follows:
>
> **Example Discharge Schedule**
> Maximum volume per day: 67,800 gallons
>
> | | |
> |---|---|
> | Monday | area A |
> | Tuesday | area B |
> | Wednesday | area C |
> | Thursday | area D |
> | Friday | area E |
> | Saturday | optional |
> | Sunday | optional |
>
> A copy of the rotation schedule must be posted in the appropriate location to be viewed by operational staff.

***Vegetation as part of treatment*:** If vegetative cover is utilized and considered part of the overall treatment system, the DMP must show how the design and construction of the system allows for the mechanical harvesting of vegetative cover. If additional nutrients are required to maintain the vegetation/crop the operator must monitor the additional input. A spreadsheet should be maintained to ensure that excess nutrients are not applied to the discharge area. An example spreadsheet can be found in Appendix F. The author of the DMP should be advised that the discharge areas are first part of the wastewater treatment. Any excess nutrients found in the groundwater as a result of the discharge are the responsibility of the facility permitted to discharge.

Sample language for crop management:

This crop will provide from ____ to ___ cuttings per season. This facility has arranged for an outside contractor, __________, phone number ____________ to cut and harvest the crop grown within the land treatment system. To avoid scheduling conflicts and provide for the best quality of harvested vegetation, the harvesting contractor must be contacted well in advance of the crop reaching harvest stage. It is important that yield information be obtained from the contractor after each harvest event. The annual yield is the sum of all the cuttings in a particular season.

If the facility experiences an annual yield lower than the design minimum it is critical that steps are taken to correct the problem. Reduced yields may be caused by any one of a combination of factors. Refer to the information found in Appendix ___ of this DMP for assistance.

Soil Sampling: Pursuant to R 323.2233 unless otherwise specified in a permit, each individual discharge area of a Slow Rate or Overland Flow System is to be sampled annually in accordance with the procedures established in Michigan State University Extension Bulletin E-498 and E-498S (Appendix G), or other method approved by EGLE. Typically, these samples are to be analyzed for cation exchange capacity, available Bray P_1, phosphorus, pH, and sodium; however, there may be additional parameters required by the facility's authorization to discharge or as necessary as guidance for crop maintenance (i.e., Ca, Mg, K, and occasional micronutrients). Questions regarding the interpretation of test results can be directed to the County's Michigan State University (MSU) Extension Office.

Sample language procedures for soil sampling:

Annual soil sampling and testing is required by this facility's discharge authorization. This facility conducts soil sampling in the _____ of each year. Soil samples from each sub site are to be collected and sent to ____________ for analysis. Each sample is to be tested for the following parameters:

Cation Exchange Capacity
Bray P-1 Soil Phosphorus
pH
Sodium
Exchangeable Sodium Percentage*

Please refer to Extension Bulletin E-498 and E-498S found in Appendix ____ of this DMP for information regarding the soil sampling procedures.

* Required for those facilities discharging wastewaters with elevated levels of sodium to soils susceptible to impact.

Operations and Maintenance

R 323.2233 requires that the wastewater distribution system be designed so that portions of the system may be taken out of service for maintenance and other operational activities without disruption to the remainder of the system. The system must also be capable of providing rest to portions of the irrigation area without disrupting applications to other areas of the system. In addition, all areas within a system are to be accessible to maintenance equipment. The DMP must show the operator how these requirements are accomplished.

Include clear instructions for the operator on how to measure and calculate the daily discharge volume. Include a sample daily log in the DMP.

Emphasize the importance of keeping records current and where records are to be maintained.

Sample language for operating system:

Each sub site is equipped with a system of _____ (solid set, vented pipe, center pivot etc.). Operating the system as designed, will discharge approximately ___ gallons per hour. Thus, the time interval to discharge the daily maximum volume is approximately ___ hours.

Before commencing with the discharge on a given day, check all valve settings to ensure the effluent is being directed to the proper sub site for that day. After the pumps have been started, observe that the effluent is being applied to the intended sub site.

The volume of wastewater discharged each day must be recorded and kept on file. At the end of each day, record the volume of wastewater discharged. Calculate and record the total volume of effluent discharged that day as well as the volumes applied to the individual sub sites.

All inspection logs are kept on file in the main office of the treatment facility. These records are to be kept up to date in accordance with the requirements of the facility's discharge authorization.

Use of pesticides: Use herbicides and insecticides only according to the manufacturer's instructions printed on the label. Use of these chemicals on areas in direct contact with wastewater such as infiltration basins requires prior approval from EGLE.

Regular duties: There are duties to be performed periodically to maintain proper performance of a wastewater treatment plant. The DMP must identify those duties and the frequency at which those duties need to be performed. Maintenance operations can be sub-divided into daily, weekly, monthly, annually, or other periodic divisions.

Sample language covering periodic duties:

Daily:

- Inspect pumps, end of pipes, valves, and spray heads. Free them of debris before discharge.
- Monitor the proper function of discharge equipment during operation.

At Least weekly:

- Mow berms and surrounding areas, clear debris.
- Inspect condition of the pump house. It must be clean, free of debris, etc. Store only authorized equipment.
- Visually inspect berms for evidence of erosion, burrowing animals, or improper vegetation.

Semi-annually:

- Discharge is seasonal, by November 1, begin preparation for winter shut down. Refer to the operation and maintenance manual for these procedures.

Annually:

- Inspect and repair fences as needed.
- Schedule harvest operations, shut off irrigation to field to be harvested at least five days before harvest.
- Schedule sampling and testing of the soils within the discharge area (annual: in spring or fall).

Other periods:

- The Facility contracts with _____to sample effluent and monitoring wells. Refer to the permit for the parameters to be sampled and frequency of the sampling.
- _________will prepare and forward the Discharge Monitoring Reports (DMRs) to the Facility director. The director will review the DMRs, sign and forward them to EGLE offices as directed in the permit.
- If exceedances occur the director will report them to the __________ District office as noted in the permit which can be found ______________.

List the locations of all supporting information such as, but not limited to, the Operation and Maintenance Manual (O & M Manual), equipment manuals, site map, and a copy of the current permit.

Contingency Plan: **Despite the best intentions for maintaining a smooth and uneventful operation, occasional disruptions happen. The facility should have a contingent operations plan that will be followed during a period of unscheduled interrupted service such as during extended rain, power outage, or other disruption.**

The DMP must clearly outline procedures to be followed in the event of a disruption. It should refer the operator to the permit authorization or other document that will indicate the person responsible for notifying the District in the event of a violation of the permit.

Sample instructions during unexpected events:

In the event the facility experiences extended periods of precipitation, the land treatment system is not to be operated. Applying wastewater to saturated or nearly saturated soil can cause the untreated wastewater to reach the groundwater in violation of the discharge authorization. The system has been designed to accommodate up to _____ days of disruption of the discharge resulting from rain, maintenance, harvesting and the like.

Should the system experience a disruption in the power to the pumps during a discharge, maintain the daily schedule established and described in section ____ of the DMP. That is, the following day move the discharge to the scheduled sub site for that day. Do not "finish up" the discharge on the following day to the sub site in use when the disruption occurred. Record the flow volume(s) on the log sheet and note the cause of the disruption. Should the power come back on during the typical operation period in the day, resume the discharge to the same sub site.

The following sections provide specific guidance for the three general processes for land application. Appendix H is a DMP Checklist to help determine the completeness of DMP preparation.

Slow Rate Land Treatment

Slow rate land treatment according to R 323.2234 is the application of wastewater to a vegetated land surface with the applied wastewater being treated as it flows through the plant and soil matrix. A portion of the flow is expected to percolate to the groundwater while the remainder is utilized by plants or lost through evaporation. Usually, one of the critical elements of Slow Rate Treatment technology is nutrient utilization. It is very important to understand the relationship between the mass of nutrients and other constituents per unit area that are provided as a result of the discharge and the uptake and tolerance characteristics of the crop(s) to be grown.

All DMP's must be written to provide the information necessary to operate the land treatment system in compliance with these requirements.

Effluent Flow and Characterization

The quantity per unit area of nutrients and other constituents of concern that are applied through the discharge is a function of the volume of effluent discharged during the discharge season, the concentration of the various parameters, the uptake characteristics of the crop to be grown, and the soil's ability to aid in treatment. Properly installed, calibrated and maintained metering devices will provide the necessary information regarding the quantity of effluent discharged.

In order to calculate the quantity of nutrients being applied, the operator will need the most recent results of the effluent analysis. This, along with knowing the volume and application rate of the effluent will provide the information needed to calculate the mass of nutrients and other constituents being applied.

The DMP must establish the procedures to be followed by the operator to verify application rates and nutrient loads to the irrigated area(s).

Sample language:

Each spray head is equipped with a ____ inch diameter nozzle, and when operated at the design pressure of ___ pounds per square inch (psi), will cover an area of ____ square feet. This system was designed such that there should be little to no overlap of the spray patterns from each spray head.

This system is equipped with a meter which indicates the total flow to the land treatment area as well as meters indicating flow to the individual sub sites located inside the pump house.

The permit for this facility prohibits wastewater aerosol from drifting off site. If winds exceeding ___ miles per hour (mph) develop during a period when effluent is being applied to a sub site, the system must be shut down. The application of effluent to the sub site may resume once wind speed drops below ___ mph.

Due to the number and configuration of the spray heads and the capacity of the pump, the system is best operated one sub site at a time.

Loading and Resting Cycle

An appropriate loading cycle is one that allows time between applications for soil organisms to biologically decompose organic constituents in the wastewater. It also allows for organic solids on the soil surface to decompose; for the soil to become aerated; for vegetative cover to utilize nutrients provided through the application of the wastewater. The cycle should accommodate the harvesting, maintenance, and soil sampling schedules. For guidance on developing appropriate loading cycles, please refer to the "Process Design Manual, Land Treatment of Municipal Wastewater," U.S. Environmental Protection Agency, EPA 625/1-81-013, 1981 and updated.

The DMP must show how the system has been designed, constructed, and is to be operated to allow an appropriate loading and resting cycle.

Sample language for the dosing cycle:

The irrigated area has been divided into _ acre sub sites. They are designated __, __, __ etc. This facility is authorized to apply its wastewater at a rate not to exceed ___ inches per day and ___ inches per week.

The valves which direct wastewater to each sub site are located in the pump house. Each valve is clearly labeled indicating which sub site it serves.

The system is currently set up to operate such that each sub site receives an application of wastewater on a given day and then rested for ___ days. Each of the sub sites has been sized to accommodate the daily maximum volume of wastewater and still be slightly under the daily maximum application rate of __ inches. A daily maximum volume applied to a given sub site will result in an application rate of __ inches. The current rotation schedule for this system is as follows:

Example Discharge Schedule

Maximum volume per day: 67,800 gallons

Monday	area A
Tuesday	area B
Wednesday	area C
Thursday	area D
Friday	area E
Saturday	optional
Sunday	optional

A copy of the rotation schedule must be posted in a location common to operational staff.

Crop Selection and Management

Selection: Crop selection is an important factor with regard to a system's overall ability to treat the applied effluent for specific parameters such as nitrogen and phosphorus. It is recommended that the irrigated area(s) be seeded with a crop of perennial species to provide a vegetative cover. Grasses such as rye, reed canary grass, tall fescue, and orchard grass, alone or in combination with legumes such as clover, alfalfa, or birdsfoot trefoil, suited to the climate and the on-site soil moisture conditions is recommended. If for some reason the use of perennial vegetative cover is not an option, EGLE may approve an alternative crop on a case-by-case basis.

However, EGLE has the authority to impose restrictions based upon the characteristics of the approved alternative. It is recommended that the facility investigate the marketability of various crops that may be suitable for the area. This is important because without a market to which the harvested crop is directed, the material will need to be disposed at an appropriate facility.

> ***Sample language for nutrient management:***
>
> This facility relies on crop uptake as a means of providing the necessary treatment of TIN in its wastewater to meet the groundwater standard. Plant uptake also removes a significant percentage of the TP applied to the system. It is important for the operator to be aware of the quantity of nitrogen and phosphorus being applied to the land treatment system at any given time to ensure adequate treatment of the applied wastewater is occurring. Applying nitrogen at a time or rate which does not match the uptake characteristics of the crop has been shown to result in the migration of TIN in the applied effluent to the groundwater. Phosphorus applied to the land treatment system in excess of the uptake capability of the crop is expected to be removed through adsorption as discussed earlier in this DMP.

The DMP should identify the crop(s) grown within the irrigated areas(s) and inform the operator of the rationale for the selection. The DMP must also provide information regarding the harvest schedule for the crop(s) identified.

Estimating Yields: With regard to the expected yield of the crop grown within the land treatment area, it is EGLE's experience that wastewater treatment facilities are not prepared to engage in the level of crop management required to achieve and sustain the yields reported from typical farm operations. This is not to say that such yields are not attainable. Many facilities occasionally experience a "good" year or two and report yields at or near those observed from intensively managed farms. It is important to keep in mind that the goal of a land treatment system is the protection of the groundwater resource. As such, effluent limits established in a given facility's discharge authorization are calculated based upon conservative assumptions regarding the potential yields of a given facility's chosen crop.

> ***Sample language to determine crop nutrient uptake:***
>
> The crop selected for this facility is ____. This crop was selected due to its nutrient uptake characteristics and relatively low maintenance requirement. Information specific to the management of this crop such as stand health, harvest, disease, and pest control is included in Appendix ___ of this DMP.
>
> The design of this system assumed a minimum yield of ___ tons per acre per year. This yield is expected to remove __ lbs of nitrogen and __ lbs of phosphorus per acre per year. As discussed earlier, the discharge of the maximum volume of wastewater with the maximum permitted concentration of TIN and TP will result in application of _____ lb TIN and _____ lb TP per acre per year. It can be expected that yields higher than the design minimum will be achieved at the land treatment site. At the minimum yield of ___ tons per acre per year it is expected that all of the TIN authorized to be applied to the land treatment system in accordance with this DMP will be removed through plant uptake. The excess phosphorus applied to the land treatment system is expected to be removed or otherwise treated through adsorption within the soil prior to the wastewater reaching the groundwater.

As indicated previously, if additional nutrients are required to maintain the vegetation/crop, the operator should carefully monitor the additional input. A spreadsheet should be developed and maintained to ensure that excess nutrients are not applied to the discharge area. Be advised that the discharge areas are first and foremost part of the wastewater treatment system. Any excess nutrients found in the groundwater as a result of the discharge or any other inputs are the responsibility of the facility.

An example DMP for a Slow Rate System can be found in Appendix I, beginning on page I-1.

Overland Flow Treatment

R 323.2235 (1) defines Overland Flow Treatment (OFT) of wastewater as the application of wastewater to the upper reaches of grass covered slopes with excess wastewater collected at the end of the slopes for reapplication. This process was originally developed to overcome the restrictions created by low permeability soils. A facility utilizing an OFT system for the land treatment of wastewater is required to design and construct such a system consistent with this rule. As with Slow Rate systems nutrient utilization is usually a critical element of OFT technology. It is very important to understand the relationship between the quantity of nutrients and other constituents per unit area that are provided as a result of the discharge and the uptake and tolerance characteristics of the crop(s) to be grown. The slope grade of the terraces as well as the velocity of the wastewater flow will affect the nutrient treatment performance.

All DMP's must be written to provide the information necessary to operate the land treatment system in compliance with the requirements.

Effluent Flow and Characterization

The quantity per unit area of nutrients and other constituents of concern that are applied through the discharge is a function of the quantity of effluent discharged during the discharge season and the concentration of the various parameters. Properly installed, calibrated, and maintained metering devices will provide the necessary information regarding the quantity of effluent discharged.

In order to calculate the quantity of nutrients being applied, the operator will need the most recent results of the effluent analysis. This, along with knowing the volume and application rate of the effluent will provide the information needed to calculate the mass of nutrients and other constituents being applied.

The DMP must provide the procedures followed by the operator to verify application rates and nutrient loads to the irrigated area(s).

Sample language:

Each spray head is equipped with a ____ inch diameter nozzle. and when operated at the design pressure of ___ psi, will cover an area of ____ square feet. This system was designed such that there should be little to no overlap of the spray patterns from each spray head.

This system is equipped with a meter which indicates the total flow to the land treatment area as well as meters indicating flow to the individual sub sites located inside the pump house.

The permit for this facility prohibits wastewater aerosol from drifting off site. If winds exceeding ___ mph develop during a period when effluent is being applied to a sub site, the system must be shut down. The application of effluent to the sub site may resume once wind speed drops below ___ mph.

Due to the number and configuration of the spray heads and the capacity of the pump, the system is best operated one sub site at a time.

OFT Cell/Terrace Management

An OFT system is required to consist of an adequate number of cells/terraces that can be alternately loaded and rested, unless there is adequate storage or pretreatment to allow the loading and resting of a single cell/terrace. A DMP for a system that utilizes OFT must explain how the system meets this requirement.

The wastewater distribution system for a multi-cell OFT system is required to be designed and constructed to allow individual cells within the system to be shut down for resting or other purposes without disruption to the remaining cells.

The DMP must explain how the system has been designed to provide smooth sheet flow for optimum performance.

Sample language covering cell/terrace management:

This overland flow system is equipped with _____ (number) ________ (type: conventional, step-up, etc.) terraces. Each terrace covers _______acre(s) for a total of ______acres for irrigation. Distribution is provided by ______________ (surface methods, gated pipe, sprinklers, etc.) Flow to each terrace operates independently of the other terraces. When necessary, each terrace can be isolated and taken out of service without impacting the operation of the other terraces. Consult the O & M Manual for details on operation of the valves for this purpose.

Because the facility uses a ____ (surface, low or high pressure) distribution system, the length of the terrace(s) is/are ________feet. This system was designed so that all the wastewater infiltrates the surface before reaching the bottom of the slope. However, a drain has been installed at the bottom of each terrace to return water to the top of the slope in the event reapplication is necessary. This provides an additional safeguard to prevent runoff, and flexibility for changing weather conditions.

Even distribution is achieved because each terrace was graded and planned to provide smooth sheet flow. The resulting grade has a ___ percent slope (1 to 12 percent). Periodic re-smoothing of the surface may be necessary to maintain the plane and grade of the surface.

Land application for this type of system is seasonal and covers the period _____ to _______. During the remainder of the year effluent is stored. The storage lagoon was designed to hold _______days of effluent during cold weather and can provide in-season management of the loading cycle.

During the irrigation season each terrace is irrigated according to the established loading/resting cycle set forth below.

Loading and Resting Cycle

An appropriate loading cycle is one that allows time between applications for soil organisms to biologically decompose organic constituents in the wastewater. It also allows for organic solids on the soil surface to decompose; for the soil to become aerated; for vegetative cover to utilize nutrients provided through the application of the wastewater. The cycle should accommodate the harvesting, maintenance, and soil sampling schedules. For guidance on developing appropriate loading cycles, please refer to the “Process Design Manual, Land Treatment of Municipal Wastewater,” U.S. Environmental Protection Agency, EPA 625/1-81-013, 1981 and updated.

The DMP must show how the system has been designed, constructed, and is to be operated to allow an appropriate loading and resting cycle.

Sample language for the dosing cycle:

The irrigated area has been divided into ___ acre sub sites. They are designated __, __, __ etc. This facility is authorized to apply its wastewater at a rate not to exceed ___ inches per day and ___ inches per week.

The valves which direct wastewater to each sub site are located in the pump house. Each valve is clearly labeled indicating which sub site it serves.

The system is currently set up to operate such that each sub site receives an application of wastewater on a given day and then rested for ___ days. Each of the sub sites has been sized to accommodate the daily maximum volume of wastewater and still be slightly under the daily maximum application rate of __ inches. A daily maximum volume applied to a given sub site will result in an application rate of __ inches.

The current rotation schedule for this system is as follows:

Example Discharge Schedule

Maximum volume per day: 67800 gallons

Monday	area A
Tuesday	area B
Wednesday	area C
Thursday	area D
Friday	area E
Saturday	optional
Sunday	optional

A copy of the rotation schedule must be posted in the appropriate location to be viewed by operational staff.

Crop Selection and Management

Selection: The rules require that each OFT system be seeded with perennial grass, or other vegetation approved by EGLE. The vegetative cover or crop must be capable of high nutrient uptake and be suited to the climate and soil moisture conditions created by the operation of the system. The vegetation must be at least two inches high and capable of preventing significant erosion to furrows or embankments. It shall be established prior to the system being used for wastewater treatment.

As stated earlier, when nutrient utilization by a crop is considered part of the treatment process, crop selection is an important factor with regard to a system's overall ability to treat the applied effluent. It is recommended that the irrigated area(s) be seeded with a crop of perennial species to provide a vegetative cover. Grasses such as rye, reed canary grass, tall fescue, and orchard grass, alone or in combination with legumes such as clover, alfalfa, or birdsfoot trefoil, suited to the climate and the on-site soil moisture conditions is recommended. If, for some reason, the use of perennial vegetative cover is not an option, EGLE may approve an alternative crop on a case-by-case basis. However, EGLE has the authority to impose restrictions based upon the characteristics of the approved alternative. It is recommended that the facility investigate the marketability of various crops that may be suitable for the area. This is important because without a market to which the harvested crop is directed, the material will need to be disposed at an appropriate facility.

Estimating Yields: With regard to the expected yield of the crop grown within the land treatment area, it is EGLE's experience that wastewater treatment facilities are not prepared to engage in the level of crop management required to achieve and sustain the yields reported from typical farm operations. This is not to say that such yields are not attainable. Many facilities occasionally experience a "good" year or two and report yields at or near those observed from intensively managed farms. It is important to keep in mind that the goal of a land treatment system is the protection of the groundwater resource. As such, effluent limits established in a given facility's discharge authorization are calculated based upon conservative assumptions regarding the potential yields of a given facility's chosen crop.

Sample language for nutrient management:

This facility relies on crop uptake as a means of providing the necessary treatment of TIN in its wastewater to meet the groundwater standard. Plant uptake also removes a significant percentage of the TP applied to the system. It is important for the operator to be aware of the quantity of nitrogen and phosphorus being applied to the land treatment system at any given time to ensure adequate treatment of the applied wastewater is occurring. Applying nitrogen at a time or rate which does not match the uptake characteristics of the crop has been shown to result in the migration of TIN in the applied effluent to the groundwater. Phosphorus applied to the land treatment system in excess of the uptake capability of the crop is expected to be removed through adsorption as discussed earlier in this DMP.

Provide procedures which when implemented by the operator will prevent erosion of cells/terraces and side slopes due to velocity of wastewater flows, lack of vegetation, etc., and how to make adjustments if there are problems.

Sample language covering the prevention of erosion:

________has been planted at a high-density seeding rate to maintain adequate coverage. Vegetation coverage was established and grown to at least two inches before beginning discharge.

The operator will visually inspect the site during irrigation to determine that the velocity of the flow is not causing erosion. It may be necessary to adjust the flow rate to accommodate site conditions. Care should be taken in making adjustments. Changing the flow velocity may affect the effectiveness of nutrient uptake or overall loading cycle.

If erosion occurs, discontinue discharge to the affected cell/terrace. Temporarily establish a new loading/resting cycle excluding the affected terrace until it can be repaired. Repair the affected areas and replant vegetation. Allow the newly seeded area to reestablish growth before returning the terrace to operation.

As indicated previously, if additional nutrients are required to maintain the vegetation/crop, the operator should carefully monitor the additional input. A spreadsheet should be developed and maintained to ensure that excess nutrients are not applied to the discharge area. Be advised that the discharge areas are first and foremost part of the wastewater treatment system. Any excess nutrients found in the groundwater as a result of the discharge or any other inputs are the responsibility of the facility.

An example DMP for an Overland Flow System can be found in Appendix J, beginning on page J-1.

Rapid Infiltration

R 323.2236 defines rapid infiltration (RI) as the application of wastewater to areas with soils that possess moderate to high permeability. The majority of applied wastewater percolates through the soil, and the treated effluent drains naturally to groundwater. The effluent is minimally treated as it travels through the soil matrix and credit for nutrient treatment is not expected. Vegetation is not typically a part of the overall treatment process. While the utilization of vegetation or its presence within a discharge area typically does not interfere with system performance if it is not properly controlled, it has been shown to have a negative impact on the rate of wastewater infiltration. The conditions present when permeability was measured should be the conditions maintained to sustain the authorized application rate.

Over time the infiltration rate will diminish with use. All facilities utilizing rapid infiltration basin (RIB) technology must periodically demonstrate continued infiltration capacity by conducting one of the approved test methods previously set forth in *General Design Information* under *Application Rate*. When basins are renovated or following multiple permit cycles it is necessary to conduct a permeability test and submit the results along with information needed to prepare a DMP (see Appendix A) at the time of permit reissuance.

All DMP’s must be written to provide the information necessary to operate the land treatment system in compliance with these requirements.

> ***Sample system specific introductory language:***
>
> This facility utilizes rapid infiltration as its means of disposing treated wastewater. As such, the effluent discharged must meet specific standards prior to discharge.

Rapid infiltration systems are required to consist of two or more cells or absorption areas which can be alternately loaded and rested, or one cell or absorption area preceded by an effluent storage or stabilization pond system. Where only one cell or absorption area is provided, the storage or stabilization pond is to be operated on a fill and draw basis and have sufficient capacity to allow intermittent loading of the cell or absorption area. The DMP for a RI system must show how the system meets these requirements. This should include size of the various cells along with calculations determining hydraulic loading rate and the adequacy of the hydraulic loading cycle.

> ***Sample explanation of cell design:***
>
> This system is designed with one infiltration cell to discharge its wastewater. It is sufficiently sized to accommodate the permitted maximum volume of discharge. The storage cell is constructed with sufficient capacity to hold up to eight months of treated effluent.
>
> Or;
>
> This system has been designed with multiple infiltration cells. The cells are designated _, _, _, etc.
>
> See “Site Map” with cell(s) numbered and with cell dimensions and corresponding size (in ft^2).

For systems with more than one cell or absorption area, the rules establish specific management requirements. Each individual cell or absorption area of the system is to be capable of being taken out of service without disruption to other areas of the system. The DMP for a multi-cell RI system must include the rotation schedule for the system.

Sample language describing cell operation:

The discharge to each cell is controlled independently. The valves directing the discharge to the individual cells are located _____. Each valve is clearly marked indicating which cell the valve controls.

This facility is authorized to apply its wastewater at a rate not to exceed ____gallons per square foot per day.

The total volume discharged to the infiltration system is measured by a meter between the pump and the valves directing wastewater to the individual cells. The volume of wastewater discharged to each infiltration cell is measured by a flow meter between the valve and the infiltration cell. Each day the meters are to be read and the data recorded. At the end of each day the meters are to be read again and the data recorded. The total volume of wastewater discharged for the day is to be calculated and recorded as well as the volume(s) discharged to the individual infiltration cells.

Loading and Resting Cycle

As indicated previously, the author of the DMP should develop a loading and resting cycle. The loading and resting cycle will affect the application rate set forth in the permit. The USEPA Design Manual states: "…a regular drying period is essential for the successful performance of RIB systems. The ratio of loading to drying periods within a single cycle for successful RIB systems varies, but is almost always less than one." Regardless, it is important that the cells be managed to maximize drying periods to allow for soil re-aeration after periods of wastewater discharge and for drying and oxidation of filtered solids. Time required for regular maintenance should be considered when developing the cycle.

The appropriate hydraulic loading cycle shall be developed and implemented to maximize long-term infiltration rates and allow for periodic maintenance.

Please refer to the "Process Design Manual, Land Treatment of Municipal Wastewater," U.S. Environmental Protection Agency,
EPA 625/1-91-013, 1981 updated, 2006; EPA/625/R-06/016 for guidance on developing appropriate loading cycles. Document EPA 625/1-81-013a offers additional explanations and guidance for RIBs and overland flow systems. At this time the USEPA Manuals can be found online at https://nepis.epa.gov/EPA/html/pubindex.html.

Sample loading and resting cycle:

The RI system is currently set up with a ___day loading cycle with ___day(s) of discharge followed by ___day(s) of rest for each cell in the system.

Schedule Layout for a One Cell system

Monday	_____	gallons
Tuesday	_____	gallons
Wednesday	_____	gallons
Thursday	_____	gallons
Friday	_____	gallons
Saturday	_____	gallons
Sunday	_____	gallons

Schedule Layout for Two Cell System

	Cell 1		Cell 2	
Monday	____	gallons	____	gallons
Tuesday	____	gallons	____	gallons
Wednesday	____	gallons	____	gallons
Thursday	____	gallons	____	gallons
Friday	____	gallons	____	gallons
Saturday	____	gallons	____	gallons
Sunday	____	gallons	____	gallons

Note: Other layouts and time frames are possible depending on the number of cells and the rotational scheme established for the system.

The DMP must inform the operator how uniform distribution is attained.

Sample language explaining even distribution:

The system utilizes _________to distribute the wastewater within the infiltration cells. It is critical that the distribution system is inspected daily for any blockages, breakage, or improper function. In addition, the system must be observed while in operation. Any part of the system which is damaged or not operating properly is to be repaired or replaced immediately. Do not operate the distribution system within any infiltration cell which is malfunctioning.

The nature of a RIB system can create a potential groundwater mounding situation that is not typically present in the other systems previously discussed. Since mounding may be an issue, the DMP should instruct the operator to monitor the beds during operation.

The DMP must provide procedures instructing the operator to observe and note the performance of the beds based on water levels and observed speed of infiltration.

The operator must visually inspect the impact of the dosing of one bed on the conditions of the other bed(s) such as rising water, or slowed drying out of soil surface, etc.

Even though proper design of the RIB configuration will lessen the mounding potential, over time problems may occur that may be resolved operationally. The USEPA Process Design Manual contains discussion about mounding and includes this suggestion to ‘stagger basin operation so that no two adjacent basins are ever dosed sequentially’

If mounding conditions develop which cannot be resolved through modification of operational protocol, revision to the design of the system may be necessary.

Sample language describing observations the operator should make routinely:

This system relies upon the infiltrative capacity of the soil within the infiltration beds in order to discharge the volume of wastewater established in the discharge authorization. Vegetative growth within the infiltration cells is to be expected; however, care must be taken to ensure that vegetation within the infiltration beds does not interfere with the ability of the soil to absorb the applied wastewater.

It is expected that the infiltration rate of the soil within each cell will diminish over time. At least once per season each bed is to be observed to determine the time interval taken to absorb the maximum daily volume permitted. The time interval for each infiltration cell to empty should be recorded and kept on file. If the time interval increases by more than ___ percent within any or all of the infiltration beds, appropriate action should be taken to restore the bed(s) to their original infiltration rates. This can usually be accomplished through removal of any vegetation and or working up the upper three feet of the soil material within the infiltration bed(s). However, if restoration of infiltration rates is not achieved, more extensive renovation is necessary.

An example DMP for a RI System can be found in Appendix K, beginning on page K-1.

The DMP should set forth any regular duties specific to RIB’s that the operator should perform to maintain the area in and around the infiltration beds not already covered in the *Operation and Maintenance* section.

To request this material in an alternate format, contact EGLE-Accessibilty@Michigan.gov or call 800-662-9278.

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Appendix A

Information Needed to Prepare a DMP

1. Maximum and average discharge volumes,

   Gallons/day Max:

   Current Average:

   Gallons/year Max:

   Current Average: ________________

2. Type of land treatment system: ____________

3. Site map indicating the location and size of each field/cell/bed utilized in the system:

4. Total "wetted" area of each field/cell/bed in acres and square feet: __________________

5. Permit Limits for TIN and TP

   mg/l TIN,

   mg/l TP

6. *Permitted quantity of TIN applied per year:

   (__ mg/l TIN x __ mgy x 8.34) / __ acres = ___lb TIN/Acre/yr

7. *Permitted quantity of TP applied per year:

   (__ mg/l TP x __ mgy x 8.34) / __ acres = ___ lb TP/Acre/yr

8. Proposed application rate of wastewater,

   inches/hour: __, /day:___ , /week:___ ,

   /year:___ ,gal/ft²:____.

9. *The 10 yr / 24 hr precipitation event value:

   ____

10. Proposed irrigation season: ______ through

    ____

11. Proposed irrigation schedule, ___ days/wk,

    _____ wks/yr.

12. Field or cell rotation schedule: ____________

* *Typically does not apply to RIBs.*

13. Isolation distances from maximum extent of "wetted area" to property lines: ____________

14. Type of application technology used (spray, flood, ridge & furrow, etc.):

15. *Crop(s) to be grown:

- o Anticipated yield: ____ ton/acre
- o Proposed harvest schedule: _____

  ____

- o Anticipated nutrient removal by proposed crop

  ___ lb TIN/acre/year,

  ___ lb TP/acre/year

16. Soil information:

- o Type(s) of soil found within the proposed irrigation area(s).
- o Minimum permeability of the soil(s) within the irrigated area(s). ___ inches / hour

  _____ Published Data

  _____ Site Specific Testing (attach test results)

- o Presence of any anthropogenic hardpan layers within discharge area (s).
- o *Bulk density of the soil(s) within the irrigated area(s) (attach separate sheet).
- o Soil maps with the facility property boundaries and the "wetted" area of the irrigation field(s) clearly outlined.
- o Depth of the seasonal high water table. __________
- o Depth to groundwater across the proposed site:

  ____

- o *Bray P_1 Soil Phosphorus : ___________________

  *Phosphorus adsorption capacity for the irrigated field:

  ____

  _____ Published Data

  _____ Site Specific Testing (attach test results)

  ____

Wastewater Characterization

A minimum of four (4) samples of the wastewater should be collected on different days, at a point just prior to discharge to the irrigation system, and tested for. **Spaces for eight samples have been provided.**

Ammonia-Nitrogen	______	______	______	______	______	______	______	______
Nitrate-Nitrogen	______	______	______	______	______	______	______	______
Nitrite-Nitrogen	______	______	______	______	______	______	______	______
Total Inorganic Nitrogen	______	______	______	______	______	______	______	______
Total Kjeldahl Nitrogen	______	______	______	______	______	______	______	______
Total Kjeldahl Nitrogen	______	______	______	______	______	______	______	______
Total Phosphorus	______	______	______	______	______	______	______	______
Dissolved Sodium	______	______	______	______	______	______	______	______
Dissolved Calcium	______	______	______	______	______	______	______	______
Dissolved Magnesium	______	______	______	______	______	______	______	______
BOD_5,	______	______	______	______	______	______	______	______
Specific Conductance (umhos)	______	______	______	______	______	______	______	______
pH. (S.U.)	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______

Additional parameters may be required depending on the nature of the operations at the facility

All units in mg/l unless otherwise specified Additional parameters may be required depending on the nature of the operations at the facility

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Appendix A Glossary

Anticipated nutrient removal by proposed crop
If the facility is relying on crop uptake as a means of treating effluent to meet the groundwater standard, it is important to know the quantity of nutrients the chosen crop can be expected to remove. Information regarding the nutrient uptake characteristics of various crops can be obtained from the local County Extension Office or by contacting the Groundwater Permits Unit of EGLE (517-284-5570). The quantity of nutrients removed is typically reported as pounds of nutrient per ton of harvested crop. For grains, such as corn, removal is reported as pounds of nutrient per bushel harvested. This information along with establishing realistic yield goals is critical to determining the ability of a particular crop to provide the necessary level of treatment needed by a particular facility relative to the quality of its effluent.

Bray P_1 Soil Phosphorus
This information is used for determining the level of plant available phosphorus as well as calculating the remaining Phosphorus Adsorption Capacity (PAC) of the soil. It is obtained from analyzing a representative number of soil samples collected from within the discharge area for this specific parameter. Soil samples analyzed for PAC determination are typically analyzed for Bray P_1 Phosphorus as well; however, this is not always the case. Facilities submitting soil samples for PAC analysis should check to make sure Bray P_1 Phosphorus is included.

Bulk density of the soil(s) within the irrigated area(s)
This information is primarily needed by those facilities conducting phosphorus adsorption analysis on the soil(s) found within their discharge area. The bulk density of the various soil horizons is used to calculate the approximate mass of soil present in a given horizon within the area in question. Once the mass of soil is known, it can be used along with test results from Langmuir Isotherm analysis to determine the site ability of the soil to contribute to the treatment of phosphorus in a facility’s wastewater. EGLE routinely utilizes bulk density information contained in county soil surveys. This information is typically reported as a range and the lowest value in the range is used in the calculation to estimate mass of soil.

Crop(s) to be grown
If the facility relies on crop uptake to provide treatment of the applied wastewater, the DMP must identify the specific crop(s) to be grown within the discharge area. In addition to identifying the crop(s), information pertaining to the overall management of the intended crop must also be collected in order for the operator to maintain crop health to ensure adequate treatment of the applied wastewater.

Depth of the seasonal high-water table
The high-water table is the highest level of a saturated zone in the soil in most years. County Soil Surveys typically provide this information in the Soil and Water Features portion of the Soil Properties section. This information is used to identify potential problems associated with year-round discharges and discharges with significant reliance on phosphorus adsorption as a means of treatment.

Depth to groundwater across the proposed site
Information regarding the depth to the groundwater plays a critical role in evaluating the capability of a system to provide the necessary treatment to prevent negative impacts to the resource. Facilities which rely on plant uptake and soil adsorption as a means of meeting the Part 22 standards are responsible for ensuring their discharge is applied to soil with adequate unsaturated depth to allow: soil organisms to biologically decompose organic constituents in the wastewater; the vegetative cover crop to absorb the nutrients in the applied wastewater; and the

soil to adsorb excess phosphorus not taken up by the crop prior to the discharge reaching the groundwater. Furthermore, many discharges result in significant mounding of the groundwater. When mounding occurs, the depth to the groundwater decreases resulting in a shortening of the unsaturated soil column in which treatment is expected to occur.

Field or cell rotation schedule
For those systems utilizing multi-field/cell configurations, the operator must be informed of the sequence and duration of the rotations between and among the available discharge sites.

Isolation distances from maximum extent of “wetted area” to property lines
The point of discharge must not be less than 100 feet inside the boundary of the property where the discharge occurs unless specifically authorized in the facility’s discharge authorization.

Maximum and average discharge volumes
This information is needed for the calculations performed to determine hydraulic loading, nutrient loading, area requirements, scheduling, and permit compliance. All design calculations must be based upon maximum discharge values.

Minimum permeability of the soil(s) within the irrigated area(s)
This information is required to calculate the hydraulic loading rate to the land treatment system. County Soil Surveys typically report permeability information as a range within a diagnostic soil horizon. If a facility chooses to utilize the information from a County Soil Survey to calculate hydraulic loading rates, the Part 22 Rules require the use of the most restrictive permeability reported for the soils found within the discharge area.

Monthly Average
Monthly average is defined as the sum of all daily loadings of a parameter, i.e., Biochemical Oxygen Demand (BOD), divided by the number of days in which a discharge occurred during a given calendar month. The number of days is not intended to include each day of the month, only the number of days on which a discharge occurred.

Permit limits of Nitrogen (TIN) and Total Phosphorus (TP)
This information is needed to calculate the mass of each constituent applied to the land treatment area(s) and make decisions regarding acreage needed, crops to be grown, type of land treatment system to be used, etc.

Phosphorus adsorption capacity (PAC) of the irrigated field
This information is needed by those facilities discharging wastewater with TP concentrations which exceed the uptake capability of the crop being grown within the discharge area and must therefore rely on the soil to treat or otherwise remove the phosphorus through adsorption. Facilities generally have a couple of options with regard to determining the PAC of the soil(s) within their land treatment area.

The first option is to determine if there is published information on the PAC of the soil(s) in the treatment area. EGLE routinely utilizes information presented in Research Report 195, “Soil Limitations for Disposal of Municipal Waste Waters,” Michigan State University and the Michigan Water Resources Commission, 1972 (RR 195), when estimating the PAC of a given site when on-site data is not available. The information in RR 195 provides PAC data on several Michigan soils. However, the PAC information is typically given as a range of potential values. To be conservative in its estimates, EGLE utilizes the lowest value in the range as a default in its calculations of PAC for a given site.

A second option for a facility is to conduct the necessary sampling and testing of the soil(s) within the site to determine its PAC. Appendix E presents the protocol for site-specific PAC determinations. The Part 22 Rules require facilities relying on soil treatment of applied phosphorus to have sufficient capacity to meet groundwater limits for the duration of the facility's permit (five years).

Proposed application rate of wastewater (inches/hour, /day, /week, /year)
Calculated from the information regarding volume(s), wetted area, and scheduling. Application rates must be in compliance with the requirements of the Part 22 Rules regarding hydraulic and nutrient loading.

Proposed harvest schedule
Successful management of a crop grown within a land treatment area includes understanding the specific period(s) of optimal harvest. The palatability of forages harvested for livestock consumption depends in large part on the growth stage at which the crop is harvested. In addition, nutrient uptake occurs most rapidly from the soil when the plant is experiencing vegetative growth. As such, it is important to understand the growth characteristics of the crop grown within the land treatment area to ensure it is being harvested at the proper growth stage in terms of its usefulness as feed as well as optimizing nutrient uptake from the applied wastewater.

Proposed irrigation season
Typically beginning in early May and running through October to mid-November, this information is needed to establish the facility's various schedules (discharge, harvest, maintenance, etc.) and ensure accommodation of the volume discharged.

Proposed irrigation schedule
The irrigation schedule is established from information pertaining to the daily maximum volume, available (wetted) area, effluent nutrient content, treatment requirements, hydraulic loading, soil permeability, crop type and management.

Quantities of TIN and TP applied per acre per year
This information is needed to determine the appropriate crop to be grown and land requirements to provide the necessary treatment to meet the permit limits in the groundwater.

Site map indicating the location and size of each field/cell/bed utilized in the system
A diagram showing the general layout of the system, the size of each separate discharge area, and any other pertinent information.

Soil information
Information regarding the soil(s) found within the land treatment area is critical for determining application rates, phosphorus treatment, distribution and treatment technologies to be used, crop selection, and more. Most, but not all, information regarding the soil(s) within a given land treatment area can be obtained from the County Soil Survey for the county in which the system is located. Some information may need to be obtained through site specific testing.

Soil maps
The information provided from soil maps helps to identify the various soils found within and around a discharge area. This information is then used to obtain any published data regarding the physical and chemical characteristics of those soils. Soil maps can be obtained from the Soil Survey of the County in which the discharge area is located.

Soil Series found within the proposed irrigation area(s)
County Soil Surveys list or otherwise identify soils contained within them by their Series Name. The Series Name is typically the lowest category at which soils are identified. This information is needed in order to obtain the physical and chemical properties of the various soils found within a given land treatment area.

Total "wetted" area of each field/cell/bed in acres and/or square feet
Indicate the actual area to which the effluent is applied. This information will be used along with the volume information in calculating and evaluating hydraulic and nutrient loading rates.

Type of application technology used
Identify the specific technology utilized by the facility to distribute its wastewater onto the land treatment area. For example, if the facility uses spray irrigation, indicate whether the system uses solid set or center pivot. If utilizing flood or sheet application technology, provide specifics regarding the header ditches and or pipes used in the system.

Type of land treatment system
Land treatment systems typically utilize one of the three technologies identified in the Part 22 Rules (Slow Rate, Overland Flow, and Rapid Infiltration).

Wastewater Characterization
This information is needed to determine the extent to which the wastewater must be treated by the land treatment system and provides an indication of the level of management which may be necessary to ensure compliance with permit requirements and applicable regulations. It is critical to have sufficient information to reveal any and all cyclical fluctuations in effluent quality which may necessitate the implementation of specific procedures during certain periods.

10 year frequency, 24 hour Duration Precipitation Event
Typically ranging from three to five inches in Michigan, these precipitation events have been known to disrupt operations and cause serious damage to land treatment systems improperly designed to accommodate their occurrence. The Part 22 Rules require land treatment systems to be designed and constructed to address this concern

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Conversion Factors for SI and non-SI Units

To convert Column 1 into Column 2, multiply by	Column 1 SI Unit	Column 2 non-SI Unit	To convert Column 2 into Column 1, multiply by
		Length	
0.621	kilometer, km (10^3 m)	mile, mi	1.609
1.094	meter, m	yard, yd	0.914
3.28	meter, m	foot, ft	0.304
1.0	micrometer, μm (10^{-6} m)	micron, μ	1.0
3.94×10^{-2}	millimeter, mm (10^{-3} m)	inch, in	25.4
10	nanometer, nm (10^{-9} m)	Angstrom, Å	0.1
		Area	
2.47	hectare, ha	acre	0.405
247	square kilometer, km^2 $(10^3 m)^2$	acre	4.05×10^{-3}
0.386	square kilometer, km^2 $(10^3 m)^2$	square mile, mi^2	2.590
2.47×10^{-4}	square meter, m^2	acre	4.05×10^3
10.76	square meter, m^2	square foot, ft^2	9.29×10^{-2}
1.55×10^{-3}	square millimeter, mm^2 $(10^{-3} m)^2$	square inch, in^2	645
		Volume	
9.73×10^{-3}	cubic meter, m^3	acre-inch	102.8
35.3	cubic meter, m^3	cubic foot, ft^3	2.83×10^{-2}
6.10×10^4	cubic meter, m^3	cubic inch, in^3	1.64×10^{-5}
2.84×10^{-2}	liter, L (10^{-3} m^3)	bushel, bu	35.24
1.057	liter, L (10^{-3} m^3)	quart (liquid), qt	0.946
3.53×10^{-2}	liter, L (10^{-3} m^3)	cubic foot, ft^3	28.3
0.265	liter, L (10^{-3} m^3)	gallon	3.78
33.78	liter, L (10^{-3} m^3)	ounce (fluid), oz	2.96×10^{-2}
2.11	liter, L (10^{-3} m^3)	pint (fluid), pt	0.473

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To convert Column 1 into Column 2, multiply by	Column 1 SI Unit	Column 2 non-SI Unit	To convert Column 2 into Column 1, multiply by
	Mass		
2.20×10^{-3}	gram, g (10^{-3} kg)	pound, lb	454
3.52×10^{-2}	gram, g (10^{-3} kg)	ounce (avdp), oz	28.4
2.205	kilogram, kg	pound, lb	0.454
0.01	kilogram, kg	quintal (metric), q	100
1.10×10^{-3}	kilogram, kg	ton (2000 lb), ton	907
1.102	megagram, Mg (tonne)	ton (U.S.), ton	0.907
1.102	tonne, t	ton (U.S.), ton	0.907
	Yield and Rate		
0.893	kilogram per hectare, kg ha^{-1}	pound per acre, lb $acre^{-1}$	1.12
7.77×10^{-2}	kilogram per cubic meter, kg m^{-3}	pound per bushel, bu^{-1}	12.87
1.49×10^{-2}	kilogram per hectare, kg ha^{-1}	bushel per acre, 60 lb	67.19
1.59×10^{-2}	kilogram per hectare, kg ha^{-1}	bushel per acre, 56 lb	62.71
1.86×10^{-2}	kilogram per hectare, kg ha^{-1}	bushel per acre, 48 lb	53.75
0.107	liter per hectare, L ha^{-1}	gallon per acre	9.35
893	tonnes per hectare, t ha^{-1}	pound per acre, lb $acre^{-1}$	1.12×10^{-3}
893	megagram per hectare, Mg ha^{-1}	pound per acre, lb $acre^{-1}$	1.12×10^{-3}
0.446	megagram per hectare, Mg ha^{-1}	ton (2000 lb) per acre, ton $acre^{-1}$	2.24
2.24	meter per second, m s^{-1}	mile per hour	0.447

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To convert Column 1 into Column 2, multiply by	Column 1 SI Unit	Column 2 non-SI Unit	To convert Column 2 into Column 1, multiply by
		Specific Surface	
10	square meter per kilogram, $m^2\ kg^{-1}$	square centimeter per gram, $cm^2\ g^{-1}$	0.1
1000	square meter per kilogram, $m^2\ kg^{-1}$	square millimeter per gram, $mm^2\ g^{-1}$	0.001
		Density	
1.00	megagram per cubic meter, $Mg\ m^{-3}$	gram per cubic centimeter, $g\ cm^{-3}$	1.00
		Pressure	
9.90	megapascal, MPa (10^6 Pa)	atmosphere	0.101
10	megapascal, MPa (10^6 Pa)	bar	0.1
2.09×10^{-2}	pascal, Pa	pound per square foot, $lb\ ft^{-2}$	47.9
1.45×10^{-4}	pascal, Pa	pound per square inch, $lb\ in^{-2}$	6.90×10^3
		Temperature	
1.00 (K - 273)	Kelvin, K	Celsius, °C	1.00 (°C + 273)
(9/5 °C) + 32	Celsius, °C	Fahrenheit, °F	5/9 (°F - 32)
		Energy, Work, Quantity of Heat	
9.52×10^{-4}	joule, J	British thermal unit, Btu	1.05×10^3
0.239	joule, J	calorie, cal	4.19
10^7	joule, J	erg	10^{-7}
0.735	joule, J	foot-pound	1.36
2.387×10^{-5}	joule per square meter, $J\ m^{-2}$	calorie per square centimeter (langley)	4.19×10^4
10^5	newton, N	dyne	10^{-5}
1.43×10^{-3}	watt per square meter, $W\ m^{-2}$	calorie per square centimeter minute (irradiance), $cal\ cm^{-2}\ min^{-1}$	698

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To convert Column 1 into Column 2, multiply by	Column 1 SI Unit	Column 2 non-SI Unit	To convert Column 2 into Column 1, multiply by
		Transpiration and Photosynthesis	
3.60×10^{-2}	milligram per square meter second, mg m^{-2} s^{-1}	gram per square decimeter hour, g dm^{-2} h^{-1}	27.8
5.56×10^{-3}	milligram (H_2O) per square meter second, mg m^{-2} s^{-1}	micromole (H_2O) per square centimeter second, μmol cm^{-2} s^{-1}	180
10^{-4}	milligram per square meter second, mg m^{-2} s^{-1}	milligram per square centimeter second, mg cm^{-2} s^{-1}	10^{4}
35.97	milligram per square meter second, mg m^{-2} s^{-1}	milligram per square decimeter hour, mg dm^{-2} h^{-1}	2.78×10^{-2}
		Plane Angle	
57.3	radian, rad	degrees (angle), °	1.75×10^{-2}
		Electrical Conductivity, Electricity, and Magnetism	
10	siemen per meter, S m^{-1}	millimho per centimeter, mmho m^{-1}	0.1
10^{4}	tesla, T	gauss, G	10^{-4}
		Water Measurement	
9.73×10^{-3}	cubic meter, m^3	acre-inches, acre-in	102.8
9.81×10^{-3}	cubic meter per hour, m^3 h^{-1}	cubic feet per second, ft^3 s^{-1}	101.9
4.40	cubic meter per hour, m^3 h^{-1}	U.S. gallons per minute, gal min^{-1}	0.227
8.11	hectare-meters, ha-m	acre-feet, acre-ft	0.123
97.28	hectare-meters, ha-m	acre-inches, acre-in	1.03×10^{-2}
8.1×10^{-2}	hectare-centimeters, ha-cm	acre-feet, acre-ft	12.33

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To convert Column 1 into Column 2, multiply by	Column 1 SI Unit	Column 2 non-SI Unit	To convert Column 2 into Column 1, multiply by
		Concentrations	
1	centimole per kilogram, cmol kg^{-1}	milliequivalents per 100 grams, meq 100 g^{-1}	1
0.1	gram per kilogram, g kg^{-1}	percent, %	10
1	milligram per kilogram, mg kg^{-1}	parts per million, ppm	1
		Radioactivity	
2.7×10^{-11}	becquerel, Bq	curie, Ci	3.7×10^{10}
2.7×10^{-2}	becquerel per kilogram, Bq kg^{-1}	picocurie per gram, pCi g^{-1}	37
100	gray, Gy (absorbed dose)	rad, rd	0.01
100	sievert, Sv (equivalent dose)	rem (roentgen equivalent man)	0.01
		Plant Nutrient Conversion	
	Elemental	*Oxide*	
2.29	P	P_2O_5	0.437
1.20	K	K_2O	0.830
1.39	Ca	CaO	0.715
1.66	Mg	MgO	0.602

Appendix B

Soil Permeability Testing

For a variety of reasons, many facilities choose to conduct site specific testing of the soils within their land treatment area rather than use published data from sources such as Soil Surveys. The Part 22 Rules identify a number of test methodologies which can be used to determine the hydraulic capability of the soils within land treatment areas. Specifically, R 2233(4)(a)(v) of the Part 22 Rules requires the design hydraulic loading or application rate, whether daily, monthly, or annually, not be more than 7.0 percent of the permeability of the most restrictive soil layer over the area of the discharge as determined by the saturated hydraulic conductivity method, 12.0 percent of the permeability as determined by the basin infiltration method, or not more than 3.0 percent of the permeability when the permeability of the soil is determined by either the cylinder infiltration or air entry permeameter test methods. The methods referenced in the rule for determining soil permeability are set forth in the publication "Methods of Soil Analysis, Part 1, Physical and Mineralogical Properties," Second Edition, American Society of Agronomy, 1986. In addition, the Process Design Manual, "Land Treatment of Municipal Wastewater," USEPA, Center for Environmental Research Information, 1981 also provides information regarding methodologies used to determine soil permeability.

The basin infiltration test and the cylinder infiltration test, referred to above, are essentially cylinder infiltrometer tests as described in Chapter 32 of the *Methods of Soil Analysis, Part 1, Physical and Mineralogical Properties* referenced above. The differences between the tests and therefore, the application of the adjustment factor, are essentially the diameter of the infiltrometer. Chapter 32 presents a lengthy explanation of the inverse correlation between the diameter of the infiltrometer and the error due to lateral divergence. The smaller the diameter is, the greater the error.

The term "basin" used in Part 22, R 323.2233, as well as the recommended adjustment factors of 12 percent and 3 percent, are attributed to the USEPA Design Process Manual, also referenced above. In-field experimentation by the Corps of Engineers determined that an infiltrometer the size of a flooding basin at least three meters in diameter was large enough to provide reliable information. In order to realize the 12 percent adjustment factor the infiltrometer must be sized as indicated in the USEPA manual (at least three meters in diameter).

Regardless of whether the test method is conducted in the laboratory or in the field, accurate measurement of hydraulic parameters is essential to the prediction of water movement into and through the soil. To help ensure the data collected from such tests accomplish the intended goal, it is important the test procedures employed adhere to established principals for determining saturated hydraulic conductivity.

Variability in both spatial distribution and physical characteristics of Michigan soils may make determining the hydraulic capability of some land treatment areas more complicated than others. It should be anticipated that the number of samples collected for testing, or the number of test runs conducted on-site will increase with the size of the land treatment area, and the number of soil types found within the land treatment area.

In addition to reviewing permeability data, with regard to determining the appropriate hydraulic loading rate for the facility in question, EGLE staff will evaluate the quality of the data with respect to the following:

Laboratory Methods

Is the test methodology identified, and is there a detailed description of test procedures followed provided along with data logs (including technician's comments)?

Do the number, location, and depth of sample collection and sample size reflect an accurate characterization of the site conditions?

Is there a site map indicating location of sample collections, depths and corresponding sample identification?

In Situ Field Methods

Is the test methodology identified, and is there a detailed description of test procedures followed along with data logs (including technician's comments)?

Do the number and location of test runs conducted reflect an accurate characterization of the site?

How was verification of saturated conditions prior to initiation of test runs determined? Is there supporting data included?

What was the time interval required to obtain saturated conditions at each location at the site?

Was the test run sufficiently (minimum of four data points) beyond the initial point of reaching stasis to make an accurate determination of permeability?

EGLE will not accept permeability determinations of soils based upon particle size distribution. Likewise, other methodologies used which are not cited in the Part 22 Rules may be determined by EGLE to be unacceptable for the purpose of permeability within the solum. Test methods which fail to eliminate, or otherwise account for, the effect of the horizontal component of flow from the determination of permeability will not be accepted. While such evaluations may be suitable for preliminary evaluations with regard to site suitability, this approach does not satisfy the requirements of the Part 22 Rules. In addition, the practice of using of repacked cores for determining permeability is not recommended and is to be avoided to the greatest extent possible. Permeability data submitted resulting from analysis of repacked soil samples must be identified as such. In addition, all information pertaining to the repacking procedure used, as well as the rational for utilizing repacked samples, is to be included with the submitted data. If the rationale is determined insufficient or the repacked soil samples do not replicate the physical characteristics of on-site soil(s), EGLE may reject the test data and require additional testing.

Appendix C

Nutrient recommendations for Field Crops in Michigan
Table 3 Nutrient Removal in harvest portion in several Michigan Field Crops

Crop	Unit	N lb/unit of yield	P_2O_5 lb/unit of yield	K_2O lb/unit of yield
Alfalfa (Hay)	ton	45	13.0	50.0
Alfalfa (Haylage)	ton	14	3.2	12.0
Barley (Grain)	bu	.88	0.38	0.25
Barley (Straw)	ton	13	3.2	52
Beans (dry edible) (Grain)	cwt	3.6	1.2	1.6
Bromegrass (Hay)	ton	33	13	51
Buckwheat (Grain)	bu	1.7	0.25	0.25
Canola (Grain)	bu	1.9	0.91	0.46
Clover (Hay)	ton	40	10	40
Clover-grass (Hay)	ton	41	13	39
Corn (Grain)	bu	0.90	0.37	0.27
Corn (Stover)	ton	22.0	8.2	32.0
Corn (Silage)	ton	9.4	3.30	8.00
Millet (Grain)	bu	1.1	0.25	0.25
Oats (Grain)	bu	0.62	0.25	0.19
Oats (Straw)	ton	13	2.8	57
Orchardgrass (Hay)	ton	50	17	62
Potato (Tubers)	cwt	0.33	0.13	0.63
Rye (Grain)	bu	1.1	0.41	0.31
Rye (Straw)	ton	8.6	3.7	21
Rye (Silage)	ton	3.5	1.5	5.2
Sorghum (Grain)	bu	1.1	0.39	0.39
Sorghum-Sudangrass (Hay)	ton	40	15	58
Sorghum-Sudangrass(Haylage)	ton	12	4.6	18
Soybean(Grain)	bu	3.8	0.80	1.40
Spelts (Grain)	bu	1.2	0.38	0.25
Sugar beets (Roots)	ton	4.0	1.3	3.3
Sunflower (Grain)	bu	2.5	1.2	1.6
Timothy (Hay)	ton	45	17	62
Trefoil (Hay)	ton	48	12	42
Wheat (Grain)	bu	1.2	0.63	0.37
Wheat (Straw)	ton	13.0	3.3	23

Warncke et al. 2004a Nutrient Recommendations for Field Crops in Michigan

Appendix D

MICHIGAN'S SOIL NITRATE TEST FOR CORN
2005

MSU SOIL AND PLANT NUTRIENT LAB
Michigan State University Extension,
Crop and Soil Sciences Department, Michigan State University

WHY TEST SOIL FOR NITRATES

Nitrate testing of soil is an excellent and inexpensive way of evaluating the available nitrogen (N) status of your soil. Michigan State University research and demonstration studies have shown that many farmers could reduce their N fertilizer application rate on corn without risk of reducing yields if they used the nitrate soil test. Nitrate testing provides credit for available nitrogen already in the soil and therefore helps to prevent over-use of N fertilizers. Excess N fertilizer use adds cost and may increase nitrate contamination of groundwater.

WHAT DOES THE TEST MEASURE The soil nitrate test measures only nitrate N. It does not measure ammonium N or organic N. If samples are taken in late May or in June, much of the ammonium and some of the organic N will have been converted to nitrate and will show up in the test.

WHEN TO TAKE SOIL SAMPLES Soil samples may be taken any time, however, samples taken in late May or in June after the soil has warmed-up usually contain the greatest amount of nitrate N. At this time the test measures both residual nitrate N from the previous year and recently mineralized N from ammonium and organic matter (plant residues and manure).

Soil samples taken in early spring (April or early May) measure primarily residual nitrate, therefore the amount of N credit will be smaller.

However, testing in early spring may still be well worth the effort. Testing for ammonium in early spring where manure has been applied will provide a preliminary indication of available nitrogen release.

Samples taken just prior to sidedress time can be used to the greatest advantage to determine the appropriate rate of sidedress N. **When sampling fields where anhydrous ammonia or liquid N has been knifed in preplant, you will need to double the number of sub-sample cores to avoid problems associated with sampling N fertilizer bands.** The test provides the best information about the available soil N status when small amounts of nitrogen (less than 40 lb N/A) have been broadcast preplant.

Samples taken in June from fields where N has been broadcast prior to planting can be used as a guide to adding additional N through the irrigation system or for planning next year's application. If the soil test in June indicates more than 25 ppm, no additional N is needed. Soil test levels in excess of 40 ppm at this time indicate excess soil N.

Samples taken in the fall may be used to evaluate how much N is left at the end of the season. Soil test levels in excess of 15 ppm at harvest indicate excess soil N.

Growers who have excess soil N in June or at harvest time, should consider reducing next year's fertilizer rate or use the presidedress soil nitrate test (PSNT) to determine the appropriate N rate.

WHAT FIELDS SHOULD BE SAMPLED
Sample all fields where corn is to be planted. Manured fields and legume fields sampled in June will likely contain the most nitrate. Sampling these fields early, however will not result in the maximum N credit that should be taken because ammonium N and easily decomposed organic N will not be measured by the test. See Extension Bulletin E-2344 and E-2567 for determining the appropriate N credit from manure and legumes if samples are taken in early spring.

Other fields that show the most nitrate N are fields with fine textured soils (i.e., loam, clay loam and clay) that were heavily fertilized with N the previous year. Sandy soils even though heavily fertilized the previous year may not show much N carryover.

WHERE TO GET SOIL SAMPLE BOXES
Soil sample boxes for nitrate testing and information on taking soil samples for the nitrate test are available from your County Extension office or the MSU Soil and Plant Nutrient Laboratory, East Lansing, MI 48824-1325. ph. 517-355-0218

HOW TO TAKE SOIL SAMPLES
Each sample should be a composite of 15-20 soil cores taken from a uniform field area no larger than 20 acres. Use a soil sampling probe. **Take each core to a depth of 12 inches.** Place the 15-20 cores in a clean pail and mix thoroughly. Save one quart of the soil sample for drying.

HOW TO HANDLE SOIL SAMPLES
Air dry the sample immediately in a warm room. Placing the sample near a hot air vent or space heater will speed up the drying process. **Do not hold wet samples in a plastic bag for any length of time.** Microbial action in wet samples can significantly change the nitrate test results and the sidedress N recommendation

WHERE TO GET SAMPLES ANALYZED
See your County Extension office. Dry soil samples may be mailed to the MSU Soil and Plant Nutrient Laboratory, East Lansing, MI 48824-1325. If the samples are still moist, do not put them in the mail. Moist samples should be transported directly to the County Extension office or to the MSU laboratory for drying.

NITROGEN RECOMMENDATIONS FOR CORN
The following table gives N recommendations for corn at four yield goal levels and seven soil nitrate test levels. The amount of N credit given is obtained by multiplying the concentration (ppm) of nitrate in the surface soil sample by a factor of 6.

EXAMPLE: If the test shows 10 ppm of nitrate in the soil sample, the estimated N credit is 60 lb/A. Reading across in the table we obtain the adjusted N recommendation of 100 lb N/A for 140 bu/A yield goal.

NITROGEN RECOMMENDATIONS FOR CORN					
Soil Nitrate	Nitrogen Credit	Yield Goal – bu/A			
		100	120	150	180
ppm	lb/A	-------------lb N/A------------			
0	0	110	135	175	220
5	30	80	105	145	190
10	60	50	75	115	160
15	90	20	45	85	130
20	120	0	15	55	100
25	150	0	0	25	70
30	180	0	0	0	40

N Recommendation = - 27 ÷ 1.36*YG - (6*ppm NO_3-N).

ECONOMICS OF NITRATE TESTING

The cost of a soil nitrate analysis by the Michigan State University Soil and Plant Nutrient Lab is $9.00 per sample ($12.00 for ammonium & nitrate). Each sample should represent no more than 20 acres. Assuming it costs $6.00 to take the sample, the total cost is $15.00 to $18.00 per 20 acres or **75 to 90 cents per acre** (less than one-half bushel corn). At 33 cents per pound of N, each 10 lbs per acre of N credit is worth $3.30. A 60 lbs N/A credit is worth $19.80 /A. This is a good return on investment. Using the correct amount of nitrogen also has value in terms of good water quality. **Results from research and on-farm demonstration studies indicate that nitrogen adjustments based on the soil nitrate test would return at least $5.00 per acre in either cost savings or improved yield.**

The above is from From MSU Field Crop Advisory Team (CAT) Alert Newsletters

Appendix E

Soil Sampling Protocol and Evaluation of Phosphorus Adsorption by Soils at Sites Receiving Wastewater

The following procedure is recommended to be used when obtaining soil samples for laboratory analysis and prediction of phosphorus adsorption capacity (PAC) through the use of the Langmuir Isotherm. Soil samples shall be sent to a laboratory equipped and capable of accurately performing appropriate sample analysis.

The laboratory results reported must include:

- Adsorption maximum (b value) for the soil in mg P per kg of soil,
- The adsorption rate constant (K),
- Measure of the existing adsorbed phosphorus in the soil (Bray P_1).

Part 22 Rules also require the use of theta (θ) in the equation. The phosphorus adsorption maximum should then be converted to pounds of phosphorus per soil horizon per acre using a measured soil bulk density value.

Soil sampling procedures are as follows:

Areas: Each soil series covering more than 10 percent of the total wetted area must be identified and sampled separately. Use of the county soil survey for this purpose may be appropriate.

Depth of Sampling: Each identified soil series shall be sampled, using a coring device, to a depth that is to be credited for phosphorus adsorption. Credit for PAC is given only for the depths sampled, and the depth of sampling is not to exceed that of the unsaturated zone.

Number of Samples: The number of soil samples to be taken shall be determined by the following factors.

- The number of identified soil series within the wastewater application area as indicated above. That is, every soil series identified that makes up at least 10 percent of the total wetted area of the site.
- At least one coring shall be obtained for every five acres of each soil series identified at the site.
- The number of master diagnostic horizons or layers identified in each sample. Each soil coring obtained from within the proposed wastewater application area shall be divided by the master diagnostic horizons. Only the horizons sampled can be considered for phosphorus adsorption credit.

Each coring obtained must be divided by master diagnostic horizon or layer identified by apparent physical, chemical, or biological differences between adjacent soil layers. Differences between soils layers may include characteristics such as color, structure, texture, consistency, or degree of acidity or alkalinity. The county soil survey may be useful as a guide since it typically describes specific soil horizons for each soil found within the county. However, keep in mind that the information contained in the county soil survey generally relates to the upper 60 inches of soil. The methods and procedures developed by the United States Department of Agriculture, Natural Resources Conservation Service (NRCS) were used in the county soil survey and should be consulted before attempting to identify and divide the soil coring by horizon.

After each coring has been divided into master diagnostic horizons as described above, each horizon of each coring becomes a distinct sample and shall be analyzed individually. Each soil coring of an identified soil series, multiplied by the number of master diagnostic horizons specific to that sample will equal the number of soil samples to be analyzed for that coring. Sample identity must be maintained and must include at least the following information:

- Sample location identified on a site map
- Soil Series
- Soil horizon (sampling depth interval)

When samples are submitted to a laboratory for PAC determination, the testing facility should be informed of the average effluent concentration of TP (known or anticipated) and requested to include at least one equilibrium solution with a concentration below the effluent average in the testing procedure.

The soil analytical methods and procedures must be consistent with those utilized by the Michigan State University Soil Testing Laboratory. Any deviation from those methods and/or procedures must be noted and explained by the testing facility.

For each sample tested the following information is expected to be included with the analytical results submitted to the Groundwater Permits Unit of the Water Resources Division of the Michigan Department of Environment, Great Lakes, and Energy:

- Soil Sample Size
- Equilibrium solution concentrations (mg/l), initial and final
- Volume of shaker tube used in the method (ml)
- Volume of equilibrium solution used (ml)
- Shake method
- Duration of shaking (hrs.)
- Bray P_1 soil test level (mg/kg)
- Activity Coefficient of Ca

General Information: It is inappropriate to extrapolate information regarding the PAC of the upper horizons to the parent material or any material beneath the depth of sampling. Therefore, if credits for phosphorus removal from within the material(s) of deep subsoil are sought, samples of the subsoil will need to be obtained and a PAC calculated for this layer of the soil profile.

Sites proposed for receiving wastewater discharge must be unsaturated to the sampling depth. If groundwater is encountered within four feet of the soil surface, the site may be unsuitable for the discharge.

Sufficient time must be allowed for wastewaters to come into contact with soil and reach equilibrium. The constants for the Langmuir equation are determined in the laboratory by a 24-hour equilibrium period.

Soils which are anaerobic (saturated) during wastewater application may have much lower PAC than when they are aerobic. For this reason, direct application of Langmuir Isotherm results to anaerobic soils may not be acceptable.

If the soil sampling plan for determining a soil's PAC deviates from that prescribed above, it should be reviewed and approved by the Groundwater Permits Unit.

Calculating PAC:

The laboratory data is plotted according to the following equation:

$$\frac{(P)}{(x/m)} = \frac{1}{Kb} + \frac{(P)}{b}$$

Where: (P) = the activity of P in the equilibrium solution in moles P/liter
(x/m) = phosphorus adsorbed in soil in mg/kg
(b) = adsorption maximum of phosphorus in the soil mg/kg
(K) = a constant related to the bonding energy

$K = \frac{\theta}{(P)(1-\theta)}$ is used to derive θ (theta) the fraction of the adsorption maximum that is occupied by phosphorus at the specified level of phosphorus in solution. $\theta = \frac{PK}{1+PK}$

Following is an example situation:

Effluent from a wastewater treatment system is to be discharged onto a one-acre site. Groundwater is encountered at eight (8) feet. The depth beginning at the surface and ending at five (5) feet below the surface is used in estimating PAC. The dominant soil is Spinks. The five (5) feet include the A and B horizons and 10 inches of the C horizon. Phosphorus concentration in the wastewater effluent is 2.0 mg/l. Information given is in Table 1.

Table 1. Soil characteristics

Horizon	Depth (in)	Soil	Bulk density (gm/cc)	Langmuir Results K	b (mg/kg soil P)	Bray P_1 (mg/kg)
A	0-20	Loamy sand	1.26	2.66×10^4	101	20.0
B	20-50	Loamy sand-sandy loam	1.40	1.01×10^4	250	35.0
C	50-60	Sand	1.18	3.54×10^4	76	10.9

1. **Calculate the weight of the soil for each horizon.**

   Soil weight = area x depth x 62.4 lb/ft^3 x bulk density

For this example the soil weight was calculated as follows:

Soil Weight: A horizon

$SoilWeight = 43560 ft^2 \times 1.67 ft \times 62.4 lb/ft^3 \times 1.26 gm/cc$ $SoilWeight = 5{,}719{,}518\ lbs$

Soil Weight: B horizon

$SoilWeight = 43560 ft^2 \times 2.5 ft \times 62.4 lb/ft^3 \times 1.40 gm/cc$ $SoilWeight = 9{,}513{,}504\ lbs$

Soil Weight C horizon

$SoilWeight = 43560 ft^2 \times 0.83 ft \times 62.4 lb/ft^3 \times 1.18 gm/cc$ $SoilWeight = 2{,}662{,}150\ lbs$

2. Calculate theta (θ) for each horizon according to the equation below.

$$\theta = \frac{K \times (\frac{P\ concentration\ in\ solution}{P\ molar\ weight\ in\ mg})}{(K \times (\frac{P\ concentration\ in\ solution}{P\ molar\ weight\ in\ mg})) + 1}$$

For this example, theta was calculated as follows:

Theta: A horizon $$\theta = \frac{26{,}600 \times \frac{2}{31{,}000}}{(26{,}600 \times \frac{2}{31{,}000}) + 1}$$ $\theta = 0.63$

Theta: B horizon $$\theta = \frac{10{,}100 \times \frac{2}{31{,}000}}{(10{,}100 \times \frac{2}{31{,}000}) + 1}$$ $\theta = 0.39$

Theta: C horizon $$\theta = \frac{35{,}400 \times \frac{2}{31{,}000}}{(35{,}400 \times \frac{2}{31{,}000}) + 1}$$ $\theta = 0.69$

Note:

2 = 2 mg/l phosphorus in the effluent
31,000 = molar mass of Phosphorus in mg.

3. Calculate adjusted b.

Multiply the maximum b value by the Theta results obtained from the equations above and subtract Bray P_1 results where: $adjusted\ b = (b \times \theta) - BrayP_1$.

The Bray P_1 value obtained for each diagnostic horizon is subtracted from its corresponding maximum b value adjusted for θ to obtain the soil's remaining PAC.

4. PAC Applicable Results

Convert mg/kg to lb/ac by multiplying *adjusted b* by the soil weight in million pounds. Add together the results obtained for each horizon to determine the total estimated capacity for the soil coring, Table 2.

Note: ppm P as mg/kg in soil is equivalent to lb P/1,000,000 lb soil; therefore,
P removal capacity in pounds = adjusted b x soil weight in million lb
(Example: 43.6 mg/kg P x 5.719 million lb soil = 249.5 lb P)

The soil coring attributed to having the least remaining PAC will be used when determining the potential site-life for each application area with respect to the proposed phosphorus loading.

5. Apply the effluent concentration to the above results

The effluent contains 2 mg/l phosphorus. If the facility will be discharging 2,000,000 gallons of wastewater per year, then the facility will be discharging 33.36 lb/year phosphorus

($2\,mg/l \times 2\,million\ gallons \times 8.34 = 33.36\,lb\ P$). Assume the example summarized in Table 2 has the least remaining PAC. At that rate the soil in the discharge area has a remaining PAC of $\frac{954.7\,lbs\ P}{33.36\,lbs\ P/yr.} = 28.6\ yrs$.

If a crop is also expected to take up at least part of the phosphorus, the denominator will be reduced by the uptake amount. For example, if crop uptake for this one-acre site was estimated at *15 lb P/yr*, the above equation would be modified as $\frac{954.7\,lbs\ P}{33.36\,lbs\ P/yr - 15\,lbs\ P/yr} = 52\ yrs$ of estimated adsorption capacity remaining.

Table 2. Summary of Calculations

Horizon	Soil Weight	Bray P_1 (mg/kg)	Theta (θ)	b value (mg P/kg soil)	adjusted b (mg P/kg soil)	P removal capacity (lb)
A	5,719,518	20.0	0.63	101	43.6	249.5
B	9,513,504	35.0	0.39	250	62.5	594.6
C	2,662,150	10.9	0.69	76	41.5	110.6
					Phosphorus Adsorption Capacity	954.7

The information provided above is based on information contained in *Use of the Langmuir Adsorption Isotherm to Evaluate Adsorption of Phosphorus by Soils* written by Dr. B. G. Ellis. Thank you, Dr. Ellis, for your permission.

Appendix F Field Nutrient Balance

Nitrogen Sources

Field Identification	Number Wetted Acres	General Soil Type	Discharge Gallons per year per field	TIN Effluent lbs per field (1)	Soil Test Baseline Soil Nitrogen lbs per field	Commercial Fertilizer lbs per field	Estimated Total Available N lbs (2)	Estimated* Yield per acre	Total Field Estimated Plant Uptake (3)	Excess N Over Plant Uptake
1										
2										
3										
4										
5										
Total Wetted Areas										

1= gallons per year to field / 1,000,000 x TIN mg/l x 8.34
2= TIN from Effluent + Baseline Soil Nitrogen + Commercial Fertilizer
3= Yield per acre x per unit nitrogen uptake x number of acres
* Initially yields may be reasonably estimated but must be corrected with actual yield.

Phosphorus Sources

Field Identification	Number Wetted Acres	General Soil Type	Discharge Gallons per year per field	TP Effluent as Phosphate lbs per field (1)	Soil Test Baseline Soil Phosphate lbs per field	Commercial Fertilizer lbs per field	Estimated Total Available P_2O_5 lbs (2)	Estimated* Yield per acre	Total Field Estimated Plant Uptake (3)	Excess P_2O_5 Over Plant Uptake
1										
2										
3										
4										
5										
Total Wetted Areas										

1= (gallons per year to field / 1,000,000 x TP mg/l x 8.34) x 2.3
2= Phosphate from Effluent + Baseline Soil Phosphate + Commercial Fertilizer
3= Yield per acre x per unit Phosphate uptake x number of acres
* Initially yields may be reasonably estimated but must be corrected with actual yield..

Michigan State University Extension, Extension Bulletin E498, Reprinted September 2000 Appendix G

AG FACTS

Sampling Soils for Fertilizer and Lime Recommendations

By Darryl D. Warncke, Crop & Soil Sciences Dept.

Soil sampling farm fields is an investment that leads to profitable use of lime and nutrient inputs in crop production. Soil testing begins with a representative composite soil sample and continues with the analysis, interpretation of the test results and recommendations. Soil test results are the basis for developing nutrient management programs for individual fields and farm operations. Evaluation of changes in soil pH and available nutrient levels over time requires collection of soil samples that represent the conditions in a field each time it is sampled.

Sample uniform areas

Before sampling a field, evaluate it for differences in soil characteristics. Consider its productivity, topography, texture, drainage, color of topsoil and past management. Where these features are uniform throughout the field, each composite sample can represent up to 10 or 15 acres. Because most farm fields in Michigan are not uniform, samples representing more acres than this are less likely to be representative of any soil in the field.

Sampling is an averaging process. The goal in soil sampling is to sample within a reasonably uniform area so that the composite sample is relatively uniform. When samples are collected from within a field with variable soil characteristics, the composite sample is quite heterogeneous. Within a variable field, areas with reasonably uniform soil characteristics need to be identified for sampling.

Most farmers are quite familiar with the general properties of their fields and can delineate (map) areas that are similar or different. Farm consultants who offer soil sampling services become familiar with fields over time. But initially, a County Soil Survey is an excellent source of information for determining the kinds of soils in each farm field, and it can be helpful in establishing area boundaries for collecting soil samples. Soil survey information is available from the Crop and Soil Sciences Department at Michigan State University or from the Natural Resources Conservation Service. Many farmers are now monitoring yields when harvesting and developing yield maps. These may also be helpful in delineating soil sampling areas.

Use your County Soil Survey Report for determining the kinds of soils in each field of your farm.

When delineating sampling areas, take into consideration the management history. Knowing the cropping rotation or where manure was spread or where limestone was stockpiled or spread is essential. Knowledge of the tile system also is helpful. Unusual spots, those that are atypical or have exhibited plant growth problems, should be avoided or sampled separately if they're large enough to be of economic importance. Field edges are frequently atypical because of dust from roads, spoil from ditches or the effects of trees.

Using all of the information available, sketch a map of each field indicating the uniform soil areas. This will serve as a guide for collecting soil samples.

Soil sampling tools

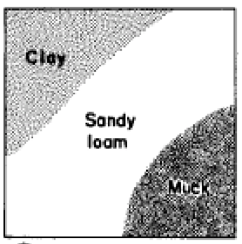
Soils are most easily sampled with a standard soil sampling probe or screw auger, but a spade also works satisfactorily. Screw augers work better in stony soils than does a push probe. Soil probes are available from most county MSU Extension offices, the MSU Soil and Plant Nutrient Lab or a number of mail-order supply companies.

Sample collection

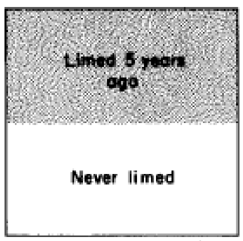
Well mixed composite samples consisting of 20 soil cores from a given area have been found to give more consistent laboratory test values than samples made up of only 5 to 10 cores. Prepare a composite sample from each uniform field area by taking 20 samplings consisting of vertical cores or slices of soil approximately 0.5 to 0.75 inch thick. (A standard soil probe takes a core 0.75 inch in diameter.) Take each slice or core to a consistent depth. The exact depth is especially important for reduced-tillage and no-till systems because of nutrient stratification. Concentrations are highest near the soil surface because of limited incorporation of nutrients from fertilizers, manures and crop residues. Sample soils that are plowed to the depth of plowing. For reduced-tillage systems and no-till systems, sample to 8 inches. Where nitrogen is annually surface applied without incorporation, collect a second sample to a depth of 3 inches for determination of soil pH. This is important for determining the proper lime rate and efficacy of herbicides.

Delineate areas to sample separately based on soil type (1), past management or cropping history (2,3,4), topography (5) and field size (6).

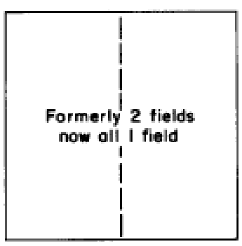
Subsoil samples can provide additional information that may be helpful in determining the appropriate fertilizer and/or lime recommendation. This may be most important for some of the coarser textured soils with a finer textured zone in the subsoil. In these soils, nutrients may accumulate in the subsoil where they can still be utilized by growing crops. When this occurs, crop response to recommended fertilizer amounts, based on a surface soil sample and test, will be less than expected. In organic soils, acid or alkaline layers may occur at varying depths in the profile. As these soils subside, the pH of the plow layer may change significantly over time. Hence, a test of the subsoil may



❶ 3 Composite samples



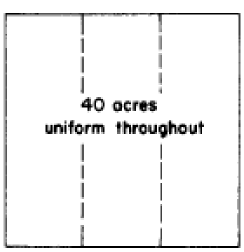
❷ 2 Composite samples



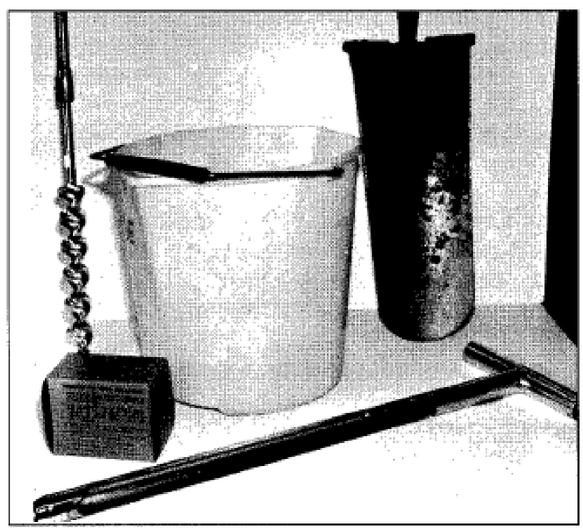
❸ 2 Composite samples

❹ 2 Composite samples

❺ 3 Composite samples



❻ 3 Composite samples



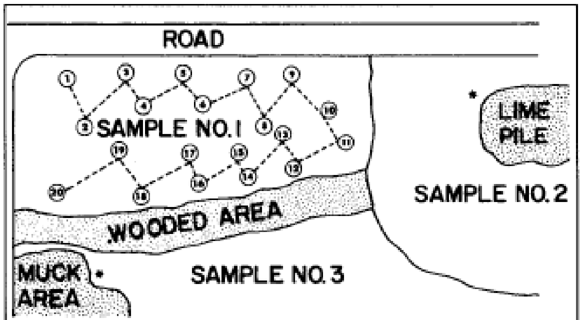
Soil Sampling Equipment

Plastic pail: 10- to 12-quart size. (Do not use metal pail if sample is to be tested for micronutrients.)

Any one of the following: square pointed shovel or spade, soil auger or soil sampling probe.

Containers for samples: sample boxes or special paper bags. All equipment and containers should be absolutely clean.

Follow a Zig-Zag pattern when sampling.



***Omit or take separate samples**

In a non-uniform field, as shown above, a minimum of 3 samples are required to adequately represent the area. Sample numbers 1, 2 and 3 represent 3 different soil management groups. This condition is common in glaciated areas such as Michigan.

Each composite sample is made up of 20 borings taken as in sample No. 1.

help indicate whether the lime or fertilizer recommendation should be adjusted.

Studies have shown that a representative composite sample is best generated by using a zigzag sampling pattern, in which the sampling points are at predetermined distances based on the dimensions of the field. Avoid fertilizer bands when their location is known. And scrape aside the crop residue before inserting the soil probe, auger or spade. Collect the soil cores in a clean plastic pail.

After all the sample cores for one composite sample are taken, mix the soil thoroughly. Be sure to break up the soil cores and discard any stones and crop residue. This is easy to do when the soil is friable. For soils that are quite wet and contain significant amounts of clay, it may be necessary to partially dry the soil prior to mixing the soil. Fill the soil sample bag or box with about a pint of the well mixed soil. This is the composite sample that will be analyzed.

When to sample and test

Soil samples may be taken any time during the year when temperatures, soil moisture and field conditions permit. Hydraulic probes are available that make it possible to collect soil samples even when the ground is frozen.

Soil pH and extractable nutrient levels do vary some with the time of the year. Soil pH tends to be higher in the spring than in the fall. Extractable nutrient levels tend to be lowest in the fall after crop harvest and rebound some over the winter and spring months. For tracking soil test values over time, it is best to soil sample a field at the same time of the year each time. However, if changes are made in the crop management system that necessitate sampling at a different time of the year, do not delay. Having soil test results available in the fall and early winter enables development of a soil fertility management plan in a more timely manner than testing soils in the spring. Where lime is needed, it is desirable to apply it six months before seeding forage crops, especially alfalfa. There may be advantages to sampling at certain times of the year or at certain points in a crop rotation, but the most important thing is to soil sample and soil test sometime.

Frequency of sampling

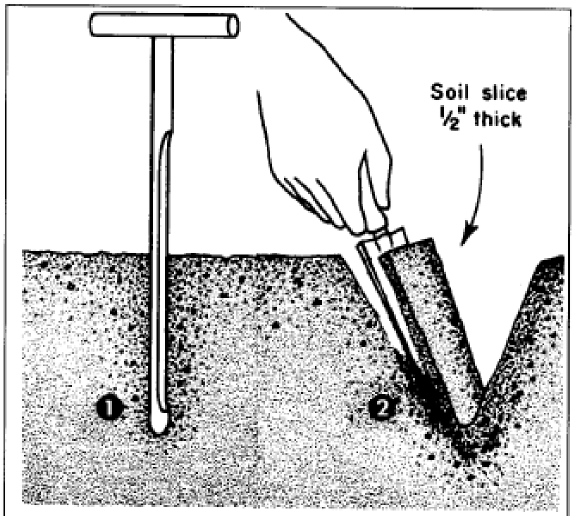
For most field cropping systems, sampling and testing the soil in each field at least once every 3 years is adequate. Soil pH and nutrient levels are more stable in soils with higher cation exchange capacities (CECs). In sandy soils with CECs below 6 me/100 g, the potassium, magnesium and calcium levels may change more rapidly because of crop uptake and possible leaching. In these soils, sampling more frequently is suggested. Sampling the entire farm at one time is a good practice because it provides an evaluation of the whole-farm fertility program at a given point in time. This may not always be practical, however. For large farm operations, sampling and testing one-third of the acreage each year is an alternative that provides continuity over time.

For intensive cropping systems where large amounts of fertilizer may be applied annually or crop removal may be high, annual soil testing enables the grower to maintain stable soil fertility conditions. This is especially important for many of the vegetable crops that are grown on sandy soils.

Intense soil sampling

Advances in fertilizer spreader technology have made it possible to vary the amount of fertilizer applied to various parts of a field on the basis of available nutrient levels. As a result, there is considerable interest in intense soil sampling to develop nutrient management maps. The main approach has been grid sampling - collecting soil samples according to a grid laid out across a field. The objective is to develop a map of soil test values (pH, P, K, Ca, Mg) for a field so that lime

How To Use Sampling Tools



1. **Sampling probe provides uniform sampling cores—easy to use—saves time—best tool for sampling farm soils.**
2. **Use a narrow (1½ inch) garden dibble to take a slice of soil ½ inch thick.**

and fertilizer may be applied at the appropriate rates in the appropriate locations within the field. The appropriate approach, value and economics of intense soil sampling are still the subject of considerable evaluation and discussion. From the economics standpoint, it is difficult to justify a grid size less than 300 x 300 feet (one sample for each 2 acres). Intense soil sampling on a systematic or geo-referenced base does provide a good base of information about the variability of soil test values within a field. Hence, information from a one-time intense sampling can be of value in developing soil fertility management plans over longer periods of time.

Crop management history

The crop management history associated with each soil sample assists the soil test laboratory or consultant to develop the most appropriate lime and nutrient recommendation for the crops to be grown. Be sure to fill out the information sheets provided by the soil testing lab and send them along with the samples. Indicate the previous crop and crops to be grown during the next two years. Also, indicate any significant management practices-such as cover crops, manure application and tillage system-that may affect the recommendation.

Soil testing services are available from the MSU Soil and Plant Lab and several commercial soil testing labs. Contact the local MSU Extension office for more information. An interactive fertilizer recommendation program is available through Michigan State University Extension that allows customizing of fertilizer recommendations. This program can handle soil test information from a number of soil test labs for developing a fertilizer recommendation.

SOIL SAMPLING SUMMARY

1. Develop a map of uniform areas within the field. Make use of soil survey maps, topography and management history.

2. Designate the sampling areas of economic importance.

3. For each composite sample, collect 20 cores to the appropriate depth using a zigzag pattern.

4. Thoroughly mix the soil cores. Partially dry very wet samples before mixing.

5. Fill a soil sample bag or box with the composite sample.

6. Fill out the information form with all the pertinent cropping management information.

7. Send the composite soil sample and information sheet to a reliable soil testing lab for analysis.

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ADDENDUM to MSUE Bulletin E-498

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Sampling Soils for Fertilizer and Lime Recommendations: Frequency of Soil Sampling

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Summary

The appropriate frequency for soil sampling may vary from 1 to 4 years, depending on crops grown, crop rotation, soil texture and the approach used for sampling. Sampling once every 1 to 2 years is appropriate in situations where significant short-term change in soil test values may occur or when there is a need to establish a soil fertility history. Once a history of soil test information is established, sampling once per crop rotation, not to exceed 4 years, is appropriate. Compared with whole-field composite sampling or traditional sampling of 15 to 20 acre blocks, intensive soil sampling enables improved nutrient management by providing information to better match inputs to soil and crop requirements, so sampling once every 4 years is appropriate. Refer to the summary table for suggested sampling frequency guidelines.

Summary table

Sampling situation	Suggested sampling frequency
Need to establish soil test history	1 to 2 years
High nutrient inputs or high nutrient removal by crops	1 to 2 years
2-year rotation	2 or 4 years
3-year rotation	3 years
4-year rotation	2 or 4 years
Rotation greater than 4 years	2 times per rotation; sampling interval not to exceed 4 years
Established forage	3 years
Intensive sampling (zone or grid)	4 years

Introduction

Soil sampling is a management tool used to determine the status of soil pH and available nutrients, which is used to determine the appropriate amounts of lime and nutrient inputs needed for the crop(s) grown. Collecting soil samples representative of the area sampled is the first step toward sound nutrient management. Soil pH and nutrient levels change over time, depending on nutrient inputs and removal of nutrients in harvested portions of a crop.

Soil pH and nutrient levels are in a dynamic state of change immediately after lime or nutrient additions. Therefore, the preferred time to sample soils to assess the nutrient status is either before lime and nutrients are applied or after the soil has had sufficient time to equilibrate.

As a nutrient management tool, soil sampling provides the greatest benefit when samples are collected during the same time of the year and at the same point in a crop rotation each time.

Within a 4-year time frame, the appropriate frequency of soil sampling depends on: how closely an individual wants to track soil nutrient changes, crop(s) grown, cropping rotation, soil texture, and the approach used for sampling fields.

Tracking change: Build to and maintain optimum soil test levels over time.

The goal of nutrient management and soil testing is to maximize return to nutrient inputs while minimizing negative environmental impacts. Minimizing variability in soil test values over time enables stability in nutrient management over time. Stability is attained by tracking soil test values relative to crop production practices that will affect changes. Frequent sampling improves an individual's familiarity with the soil fertility conditions in a field and with how quickly changes are taking place. When initiating a soil sampling and testing program, sampling every 1 or 2 years results in an understanding of how soil test values are changing in relation to nutrient management practices more quickly than sampling

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every 3 or 4 years. Once an adequate history of soil test values is established by sampling at least two times at 2-year intervals, sampling once every 3 or 4 years provides sufficient information for stabilizing soil test values.

Crop grown: Nutrient removal and change in soil test value varies with crop.
Changes in soil nutrient status generally occur most rapidly with crops requiring relatively large nutrient inputs and/or crops that remove relatively large amounts of nutrients. When these types of crops are grown, soil sampling every 1 to 2 years is important for acquiring information necessary to maintain stability of soil fertility conditions. Compared with field crops, potatoes and vegetable crops generally have greater nutrient requirements. When most or all of the above-ground portion of the crop is removed one or more times a year, such as corn silage or hay crops, greater crop removal of soil nutrients will occur than with most other field crops. Therefore, more frequent soil sampling is beneficial for tracking changes in soil nutrient availability for crops.

Crop rotation: Soil sample at the same time during a crop rotation.
Collecting soil samples at the same time during a crop rotation is the best approach for establishing soil sampling intervals. Comparing soil tests from samples taken at different times in a crop rotation may create difficulty in understanding nutrient changes that have occurred. In a 2-year rotation, such as corn-soybean, the appropriate sampling frequency is every 2 or 4 years. For 3-year rotations, such as corn-soybean-wheat, sampling and testing every 3 years is appropriate. For 4-year rotations, sampling once every 4 years is acceptable, but only after establishing a soil test history by sampling at least two times at 2-year intervals. When a rotation is longer than 4 years, soil samples should be collected at two consistent points in the rotation.

Soil texture: Changes in soil pH and potassium level occur more quickly in sandy soils, so more-frequent sampling of these soils is encouraged.
Change in potassium availability for crops and soil pH occurs more rapidly in sand, loamy sand and sandy loam soils because of leaching losses of potassium, calcium and magnesium. Sampling once every 2 years is encouraged for sandy soils.

Sampling approach: Information obtained through intensive soil sampling is useful in understanding and managing a field's nutrient status for up to 4 years. After the initial intensive sampling is completed, samples should be collected every 3 to 4 years from representative grids or zones as guides for modifying nutrient management.
The availability of global positioning system (GPS) technology has enabled users to geographically mark and return to the same soil sample locations or areas, thereby minimizing some of the variability from one sampling event to the next. Information this technology provides in conjunction with intensive soil sampling can be used for the development of soil fertility and nutrient management maps. The two most common intensive soil sampling approaches are grid sampling and zone sampling.

Grid sampling involves the collection of 6 to 10 soil cores around specific grid points or within specified grids across a field. The grid size most commonly used is 2.5 or 3 acres. The grid sampling approach provides useful information about the variability of soil test values in fields and serves as a basis by which lime and nutrient inputs can be more closely matched to variations in soil fertility across a field. Using grid sampling appropriately to plan for and apply nutrients minimizes the potential for overfertilization and adverse environmental effects.

Zone sampling includes the identification of specific management zones on the basis of one or more properties, such as topography, soil type, drainage, soil color, yield maps, management history or observations of past crop growth. Management zones will vary in size but are typically around 5 to 8 acres. For any given field, the size of management zones should average about 6 acres with no single management zone exceeding 10 acres. Using GPS or some other means to record management zone boundaries used in soil sampling enables site-specific application of nutrients and/or lime. Within each zone, 15 to 20 soil cores should be collected to form a composite sample. Like the grid sampling approach, zone sampling can provide more detailed information (compared with traditional soil sampling areas of 15 to 20 acres) about variability in the field. More detailed information allows producers to apply nutrients and/or lime where they are needed and at variable rates.

For more materials available online, visit the MSU Extension Web site at:
http://web2.msue.msu.edu/bulletins/intro.cfm

Appendix H

DMP Checklist

The following checklist is provided to help you determine the completeness of the DMP you are developing prior to submitting the document for review by EGLE staff.

- The text of the DMP has been written to be directed towards the operator of the wastewater treatment facility.
- The DMP informs the operator and addresses the management of the maximum and current average discharge volumes.
- The DMP informs the operator of the type of land treatment system used by the facility.
- Site maps indicating the location and size of each field/cell/bed utilized in the system have been included.
- Total "wetted" area of each field/cell/bed in acres and square feet is indicated.
- Permit limits for effluent concentrations of TIN and TP have been included.
- Permitted quantity of TIN applied per year has been calculated and included.
- Permitted quantity of TP applied per year has been calculated and included.
- Application rate of wastewater has been calculated and clearly identified.
- The 10-year /24-hour precipitation event value has been determined and accounted for in the design of the land treatment system.
- Irrigation season has been determined and is clearly identified.
- Irrigation schedule including field and or cell rotation has been determined and is clearly explained.
- Isolation distances from maximum extent of "wetted area" to property lines have been determined and comply with the requirements of the Part 22 Rules.
- Type of application technology used is identified, and appropriate maintenance information has been included.
- Crop(s), if appropriate to the type of system and discharge authorization, to be grown along with appropriate crop maintenance information has been included.
- Harvest schedule and anticipated minimum yield information has been included.
- Information regarding the anticipated nutrient removal by proposed crop has been included.
- All soil information used in the development of the DMP has been attached as an appendix and includes:
  - Type(s) of soil found within the proposed discharge area(s).
  - Areas where native soils have been removed and replaced with alternative soil material(s) have been clearly identified and all pertinent information regarding the alternative soil material(s) used is included as an appendix.
  - Minimum permeability of the soil(s) within the discharge area(s)

- Bulk density of the soil(s) within the discharge area(s).
- Soil maps with the facility property boundaries and the “wetted” area of the discharge field(s) have been clearly outlined.
- The depth of the seasonal high-water table.
- The depth to groundwater across the proposed site.
- PAC for the irrigated field along with the source of such information.

Wastewater Characterization

- A minimum of four (4) samples of the wastewater has been collected on different days, at a point just prior to discharge to the irrigation system and tested for all appropriate parameters and included as an attachment.

Appendix I

This discharge management plan (DMP) for a Slow Rate System is provided as a generic example. It contains at least the minimum information required of a DMP but may not address all information required of your system. Your DMP should be tailored to fit your system.

Discharge Management Plan
For the Land Treatment System
of the Village of Randville

Section 1 Introduction

This land treatment system was designed and built as part of the wastewater treatment facility which serves the Village of Randville. This wastewater treatment facility is authorized under Part 31, Water Resource Protection (Part 31), of the Natural Resources and Environmental Protection Act, P.A 451 of 1994 as amended (NREPA), and the Part 22 Groundwater Quality Administrative Rules (Part 22) promulgated thereunder to discharge 150,000 gallons per day and 10.5 million gallons annually.

Any and all discharges from the facility are to be in compliance with the conditions, limits, practices and procedures established in this facility's discharge permit and with this Discharge Management Plan (DMP). Any deviation from the conditions, limits, practices, or procedures specified in this facility's discharge permit or this DMP without prior authorization from the Department of Environment, Great Lakes, and Energy constitutes a violation of the discharge authorization and will subject the facility and its operator to potential enforcement action as provided in Part 31.

This facility generates wastewater effluent which does not meet the Part 22 groundwater standards for TIN or Total Phosphorus (TP) prior to discharge. As such it utilizes Slow Rate technology as a means of treating the wastewater before it reaches the groundwater. The permit for this facility limits the concentration of TIN and TP in the discharged effluent to 15 mg/l and 8.0 mg/l respectively.

The discharge from this facility must not cause the concentration of TIN in its compliance monitor wells to exceed permit limits (5 mg/l TIN and 1 mg/l TP). As such, proper operation of the land treatment system to provide the necessary treatment of the applied wastewater is very important in order to achieve and maintain compliance with this facility's discharge permit and all applicable regulations.

The system utilizes spray irrigation as a means of distributing its wastewater to area totaling 20 wetted acres. The area has been planted with a 50 – 50 Alfalfa Rye mixture as a means of helping to treat the applied effluent.

NOTICE!!!

Any and all violations of this DMP, the discharge authorization or applicable regulations must be reported to the Department of Environment, Great Lakes, and Energy, Water Resources Division at the District Office located in ________, Phone Number ____________.

Be advised, the discharge authorization contains specific instructions regarding certain types of violations in addition to reporting such occurrences.

Section 2 Nutrient Management

This facility relies on crop uptake as a means of providing the necessary treatment of TIN in its wastewater to meet the groundwater standard. Plant uptake also removes a significant percentage of the TP applied to the system. It is important for the operator to be aware of the quantity of nitrogen and phosphorus being applied to the land treatment system at any given time to ensure adequate treatment of the applied wastewater is occurring. Applying nitrogen at a rate which exceeds the uptake capability of the crop has been shown to result in the migration of TIN in the applied effluent to the groundwater. Quantities of phosphorus applied to the land treatment system in excess of the uptake capability of the crop is expected to be removed through adsorption as discussed later in this DMP.

2.1 Effluent Limits

Effluent discharged from this facility may not contain more than 15.0 mg/l TIN and 8.0 mg/l TP. Calculations pertaining to the evaluation of the system assumed even distribution of the discharge with the maximum permitted concentrations of both constituents. You may discharge effluent with concentrations up to the permitted limit for these constituents; however, effluent with any constituent at a concentration higher than specified in the permit is not to be discharged. Such a discharge will constitute a violation of the facility's DMP and its discharge authorization and must be reported to EGLE'S Water Resources Division District Office in ________.

Refer to the current discharge authorization for a complete list of effluent limits associated with the discharge.

This land treatment system is designed and constructed to provide the necessary treatment to the applied effluent. Do not apply sewage sludge, biosolids, septage waste or any other residual or by-product to supplement the nutrient needs of the crop which may not be satisfied through the application of wastewater. Application of these or similar materials will introduce contaminants to the system which could migrate to the groundwater resulting in a violation of the facility's discharge authorization. Supplemental nutrient additions, should they be necessary, must be addressed through prescriptive use of commercial grade fertilizer following specific recommendations of the local County Extension Office.

2.2 Nitrogen

Discharging the maximum permitted volume of effluent containing the maximum permitted concentration of TIN distributed evenly over the irrigated area will result in an application rate of 66 lb TIN per acre per year. However, the wastewater discharged to the land treatment area will often contain less than the permitted concentration of TIN. In order to maintain the health of the crop grown within the land treatment area it is important for the operator to know the actual quantity of nitrogen applied.

Equation 1.1 below provides a means of determining the amount of nitrogen applied as a function of the concentration (mg/l) of TIN in the effluent, the volume (millions of gallons) of wastewater to be applied at that concentration and the area (acres) to which the volume is applied:

Eq. 1.1 lb TIN applied per acre = (mg/l $_{TIN}$ X volume X 8.34) / area

The permit for this facility requires the effluent to be analyzed on a monthly basis. To provide the most accurate estimate of the quantity of nitrogen applied you must use the most recent analytical results for a given time frame must be used in the calculations. Record the results of these calculations.

Please refer to the crop management section of this DMP regarding treatment of the applied nitrogen.

2.3 Phosphorus Treatment

This facility relies on two separate but related mechanisms to provide the necessary treatment of TP in it effluent. One mechanism for removing the applied phosphorus is through plant uptake which is achieved through growing and harvesting the crop within the irrigated area. The other mechanism for treating the applied phosphorus is through adsorption by the soil.

2.3a Crop Uptake of Phosphorus

Discharging the maximum permitted volume of effluent containing the maximum permitted concentration of TP distributed evenly over the irrigated area will result in an application rate of 35 lb TP per acre per year. This amount of TP exceeds the uptake capability of the crop grown within the irrigated area. As such, this facility relies on adsorption by the soil as a means of providing the necessary treatment of the applied wastewater to meet the groundwater standard.

Equation 1.1 above can be utilized to calculate the quantity of TP being applied for any given volume of wastewater. Simply substitute the concentration of TP for TIN in the equation.

2.3b Phosphorus Adsorption

Published information regarding the Phosphorus Adsorption Capacity (PAC) of all of the soil types within the irrigated area was used to evaluate the treatment capability of this facility's land treatment system. The specific information used and its source is referenced in Appendix 1 of this DMP. This information along with an assumed maximum permitted annual TP load, adjustment for plant uptake as well as current Bray P_1 soil phosphorus levels indicate a minimum theoretical site life, with regard to the ability of the soil to provide treatment of the applied phosphorus, to be approximately 45 years.

It is expected soil phosphorus levels will increase over time. Once the level of Bray P_1 Phosphorus reaches 150 mg/kg (300 lb P per acre) it may be necessary to conduct actual phosphorus adsorption tests on the soil to determine site (soil) specific characteristics regarding the adsorptive capability of the land treatment system.

2.4 Sodium

The effluent from this facility has elevated levels of sodium resulting from the significant number of residential water softeners in use. As a result of the elevated sodium and the clay content of the soil within the discharge area there is a concern regarding the potential development of sodic conditions in the soil. Such conditions, should they develop will interfere with crop growth and have the potential to cause significant reduction in permeability. The annual soil test must include an analysis for EXCHANGABLE SODIUM PERCENTAGE (ESP). A sodic condition exists when the ESP is 15 or more. Should such a condition develop, the operator of the treatment system is obligated to contact and inform EGLE's Water Resources Division at the District Office in Lansing of the development. Correcting the sodic condition requires the addition of compounds such as calcium sulfate (gypsum) however, before proceeding with such action the operator must develop a work plan to be reviewed and approved by the District Office. It is recommended the operator contact the local County Extension Office for assistance regarding specific strategies to correct the problem.

Section 3 Soil pH:

The pH of the soil within the land treatment system must be maintained between 6.0 and 7.5 S.U.. This is a requirement of the Part 22 Rules as well as the proper soil pH for the crop grown within the irrigated area. This facility's discharge authorization requires the soil to be tested once per year and should include soil pH.

Section 4 Prevention of Runoff

There is a one-foot berm surrounding land treatment area. The berm was designed and installed to prevent any wastewater from exiting the application area as well as keep any runoff from other areas from entering onto the land treatment area. The berm should not be altered or damaged. The vegetation on the berm should be kept mowed to a height of no more than six inches. Inspect the berm weekly for any signs of animal burrowing and or erosion. Should any damage occur, it is to be repaired immediately.

Section 5 Hydraulic loading

5.1 Even Distribution

Even distribution of the wastewater is critical for the land treatment system be able to function properly. The system has been designed and constructed as required by the Part 22 rules to provide even distribution.

It is critical that the distribution system is inspected daily for any blockages, breakage, or improper function. In addition, the system must be observed while in operation. Any part of the system which is damaged or not operating properly is to be repaired or replaced immediately. **Do not operate the distribution system if it is malfunctioning.**

5.2 Discharge Scheduling

The irrigated area is managed as one site although it can be subdivided if needed. This facility is authorized to apply its wastewater at a rate not to exceed 0.27 inches per day and 0.82 inches per week.

The valves which direct wastewater to the discharge area are located in the pump house. Each valve is clearly labeled.

The system is currently set up to operate such that the land treatment area receives an application of wastewater on a given day and then rested for one day. The site has been sized to accommodate the daily maximum volume of wastewater. A daily maximum volume applied to a given sub site will result in an application rate of 0.27 inches. The current rotation schedule for this system is as follows:

Discharge Schedule

Maximum volume per day: 150,000 gallons

Monday	Discharge
Tuesday	Rest
Wednesday	Discharge
Thursday	Rest
Friday	Discharge
Saturday	Optional
Sunday	Optional

Notice

Optional days are to be used only to make up for normal discharge days not used due to precipitation events, maintenance activities, or harvest activities.

A copy of the rotation schedule must be posted in the pump house.

Section 6 Crop Management

Section 6.1 Crop Nutrient Uptake

The crop selected for this facility is a 50/50 mixture of alfalfa and rye grass. Information specific to the management of this crop such as stand health, harvest, disease, and pest control is included in Appendix 4 of this DMP.

The design of this system assumed a minimum yield of 2.5 tons per acre per year. This yield is expected to remove up to 140 lb of nitrogen and 15 lb of phosphorus per acre per year. As discussed earlier, the discharge of the maximum volume of wastewater with the maximum permitted concentration of TIN and TP will result in application of 66 lb TIN and 35 lb TP per acre per year. It can be expected that yields higher than the design minimum will be achieved at the land treatment site. At the minimum yield of 2.5 tons per acre per year it is expected that all of the TIN authorized to be applied to the land treatment system in accordance with this DMP will be removed through plant uptake. The excess phosphorus applied to the land treatment system is expected to be removed or otherwise treated through adsorption within the soil prior to the wastewater reaching the groundwater.

Section 6.2 Crop Harvest

This crop will provide from three to four cuttings per season. This facility has arranged for an outside contractor, *John Doe*, Phone Number _________ to cut and harvest the crop grown within the land treatment system. To avoid scheduling conflicts and provide for the best quality of harvested vegetation, the harvesting contractor must be contacted well in advance of the crop reaching harvest stage.

Wastewater should not be applied to the land treatment area for approximately five days prior to cutting. This time is critical to allow the soil to dry adequately to support harvesting equipment without causing damage to the soil. Additional time may be needed if precipitation occurs during this period. Less time may be needed if conditions are dry.

The following tables provide approximate dates for drying and cutting for three and four cutting schedules.

Approximate Harvest Schedules

Three Cuttings

	Drying	Cutting
Cutting #1	June 10 - 15	June 16
Cutting #2	August 5 – 10	August 11
Cutting #3	October 10 – 15	October 16
Four Cuttings		
Cutting #1	May 20 – 25	May 26
Cutting #2	June 25 – 30	July 1
Cutting #3	August 5 – 10	August 11
Cutting #4	October 10 – 15	October 16

Note: If the crop is harvested as green chop no additional drying time is needed; however, if the crop is to be bailed, an additional three to four days may be necessary for additional drying prior to bailing operations.

It is important that yield information be obtained from the contractor after each harvest event. The annual yield is the sum of all the cuttings in a particular season.

If the facility experiences an annual yield lower than the design minimum it is critical that steps are taken to correct the problem. Reduced yields may be caused by any one of a combination of factors. Refer to the information found in Appendix 2 of this DMP for assistance.

Section 7 Soil Sampling

Annual soil sampling and testing is required by this facility's discharge authorization. This facility conducts soil sampling in the *spring* of each year. Soil samples are to be collected and sent to *the Soil and Plant Nutrient Laboratory at Michigan State University* for analysis. Each sample is to be tested for the following parameters:

Cation Exchange Capacity	Bray P1 Soil Phosphorus
pH	
Sodium	
Exchangeable Sodium Percentage*	

Please refer to Extension Bulletin E-498 found in Appendix 3 of this DMP for information regarding the soil sampling procedures.

* Required due to the elevated levels of effluent sodium to soils susceptible to impact.

Section 8 General Operation Of Land Treatment System

8.1 Spray heads

The site is equipped with a solid set irrigation system. There are 20 spray heads. Each spray head has a radius of 118 feet (approximately one acre). Operating the system as designed will discharge approximately 30,000 gallons per hour. Thus, the time interval to discharge the daily maximum volume is approximately five hours.

8.2 Valves

Before commencing with the discharge on a given day, check all valve settings to ensure the effluent is being directed as intended. After the pumps have been started, observe that the effluent is being discharging properly.

8.3 Records

The volume of wastewater discharged each day must be recorded and kept on file. At the end of each day, record the volume of wastewater discharged.

All inspection and compliance logs are kept on file in the main office of the treatment facility. These records are to be kept up to date in accordance with the requirements of the facility's discharge authorization.

Section 9 Seasonal Maintenance

There are specific steps to follow to prepare the system for operation in the spring as well as shutting it down for the winter. Please refer to the operation and maintenance manual for these procedures.

Section 10 Disruptions and Unexpected Events

In the event the facility experiences extended periods of precipitation, the land treatment system is not to be operated. Applying wastewater to saturated or nearly saturated soil can cause the untreated wastewater to reach the groundwater in violation of the discharge authorization. When operated at full capacity, the system has been designed to accommodate up to 126 non-discharge days resulting from scheduling, rain, maintenance, harvesting and the like.

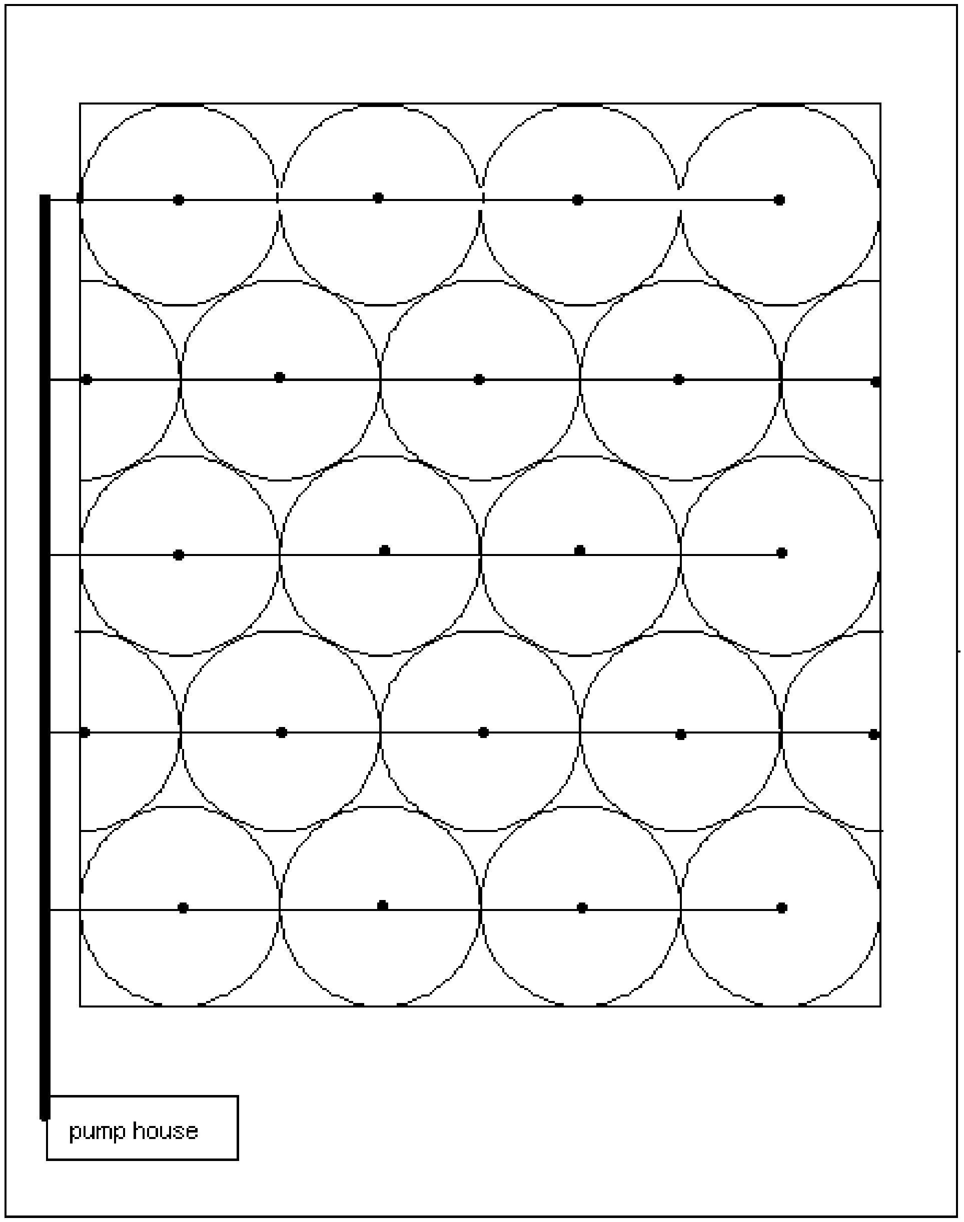
Approximate breakdown of Non-discharge days

Weekends	29 wks X 2 d/wk = 58 days
Harvest	4 events X 7 d/event* = 28 days
Rain and maintenance	126 – (58+ 28) = 43 days

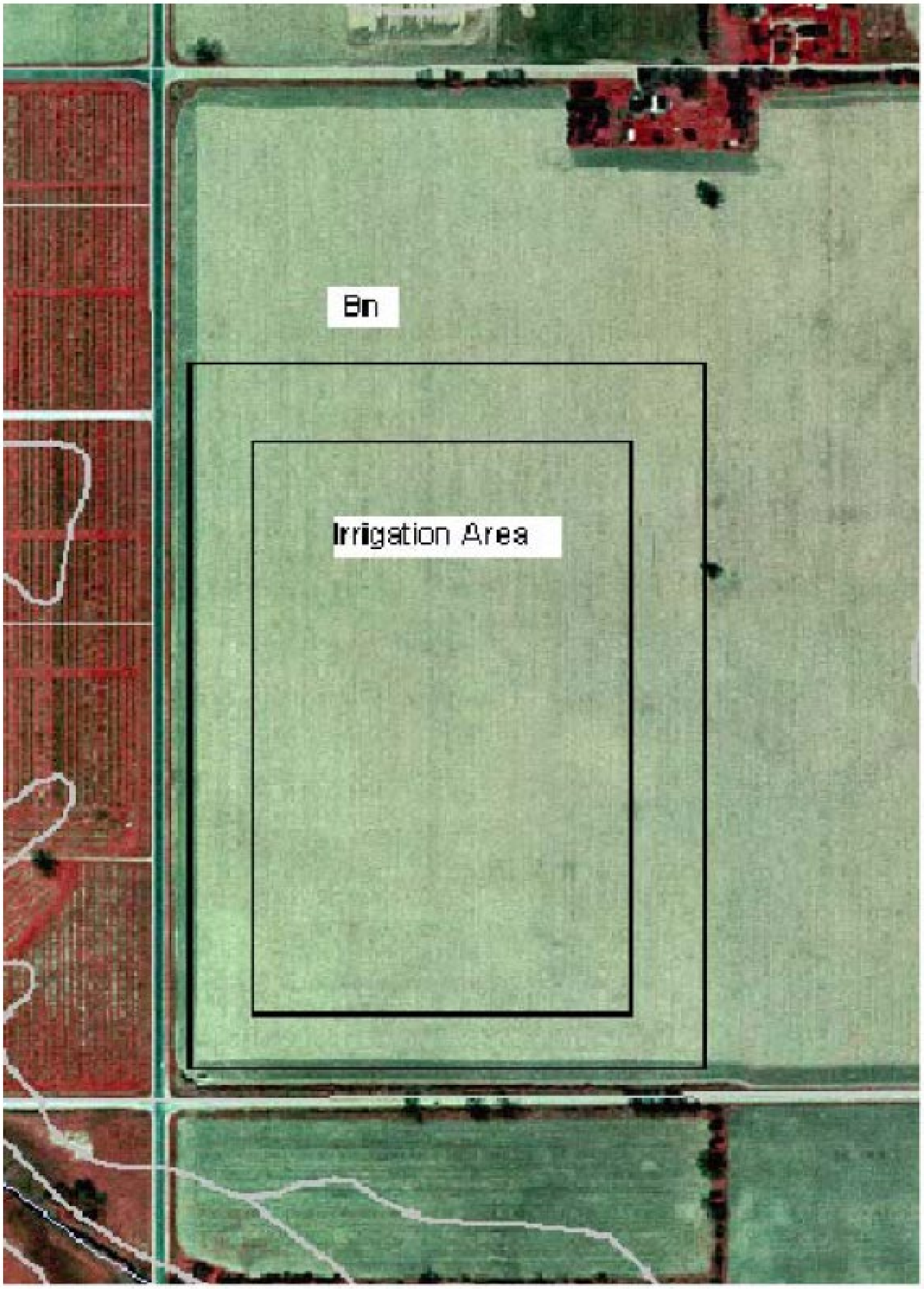
* assumes green chop harvest with one day added for precipitation.

Should the system experience a disruption in the power to the pumps during a discharge, maintain the daily schedule established in section 5.2 of the DMP. That is, the following day implement the scheduled discharge for that day. Do not attempt to "finish up" the discharge disrupted the previous day by adding volume to the scheduled discharge the following day. If necessary, the weekend can be used to address disruptions to the discharge schedule. If the day following the disruption has been scheduled as a rest period, it may be possible to address the disruption by completing the previous day's discharge. In any case, log the volume of wastewater discharged on the log sheet and note the cause of the disruption. Should the power come back on during the typical operation period in the day, resume the discharge.

Example Diagram of Irrigation System Layout



The entire site is approximately 36 acres. The wetted area is 20 acres. Each spray head has an approximate radius of 120 feet. As such, each full circle covers slightly more than one acre. The isolation distance from the wetted area to the nearest property boundary is 100 feet.



Soil map showing the location of the irrigated area.

<u>Information Needed to Prepare a DMP</u>

1. Maximum and average discharge volumes,

   Gallons/day Max: **150,000**

   Current Average: **110,000**

   Gallons/year Max: **10,500,000**

   Current Average: **7,500,000**

2. Type of land treatment system: **Slow Rate**

3. Site map indicating the location and size of each field/cell/bed utilized in the system: **Attached**

4. Total "wetted" area of each field/cell/bed in acres and square feet: One Field, 20 Acres

5. Permit Limits for TIN and TP:
   15.0 mg/l TIN,
   8.0 mg/l TP

6. Permitted quantity of TIN applied per year:

(15 $_{\text{mg/l TIN}}$ x 10.5 $_{\text{mgy}}$ x 8.34) / 20 $_{\text{acres}}$ = 65.6 $_{\text{lb TIN/Acre/yr}}$

7. Permitted quantity of TP applied per year:

(8 $_{\text{mg/l TP}}$ x 10.5 $_{\text{mgy}}$ x 8.34) / 20 $_{\text{acres}}$ = 35 $_{\text{lb TP/Acre/yr}}$

8. Proposed application rate of wastewater,

   inches/hour: _-_, /day: **0.27** , /week: **0.82** ,

   /year: **19.3**

9. The 10 yr / 24 hr precipitation event value:

   3.5 inches

10. Proposed irrigation season: **May 1st through November 15th.**

11. Proposed irrigation schedule, **3 days/wk, up to 29 wks/yr.**

12. Field or cell rotation schedule: **One Field**

13. Isolation distances from maximum extent of "wetted area" to property lines: **>= 100 feet**

14. Type of application technology used (spray, flood, ridge & furrow, etc): **Solid Set Spray Irrigation**

15. Crop(s) to be grown: **50 / 50 Alfalfa / Rye Grass**

   - Anticipated yield: **2.5** ton/acre
   - Proposed harvest schedule: **3 – 4 Cuttings / yr**

Mid-June, Mid-August, Mid-October
Or
Late May, Early July, Mid-August, Mid October

   - Anticipated nutrient removal by proposed crop

     140 lb TIN/acre/year,

     15 lb TP/acre/year

16. Soil information:

   - Type(s) of soil found within the proposed irrigation area(s). **Boyer (Bn)**
   - Minimum permeability of the soil(s) within the irrigated area(s). **0.2** inches / hour

   __**X**__ Published Data

   _____ Site Specific Testing (attach test results)

   - Bulk density of the soil(s) within the irrigated area(s) (attach separate sheet).

Used published PAC information from Rpt 195 (attached).

   - Soil maps with the facility property boundaries and the "wetted" area of the irrigation field(s) clearly outlined.
     Attached
   - Depth of the seasonal high water table. **< 6 feet**
   - Depth to groundwater across the proposed site: **> 6 feet**
   - Phosphorus adsorption capacity for the irrigated field:
     Low PAC (1000 lb / Acre 3 feet)

   __**X**__ Published Data

   _____ Site Specific Testing (attach test results)

Wastewater Characterization

A minimum of four (4) samples of the wastewater should be collected on different days, at a point just prior to discharge to the irrigation system, and tested for. **Spaces for eight samples have been provided.**

Units in mg/L unless otherwise stated.

Ammonia-Nitrogen	5.0	3.1	6	2.5	_____	_____	_____	_____
Nitrate-Nitrogen	8.0	7.0	4.3	5.0	_____	_____	_____	_____
Nitrite-Nitrogen	ND	0.1	0.7	ND	_____	_____	_____	_____
Total Inorganic Nitrogen	13	10.2	11.0	7.5	_____	_____	_____	_____
Total Kjeldahl Nitrogen	6	4.5	6.9	3.2	_____	_____	_____	_____
Total Phosphorus	6	5.2	7.1	2.1	_____	_____	_____	_____
Sodium	160	140	175	145	_____	_____	_____	_____
Dissolved Calcium	325	370	422	365	_____	_____	_____	_____
Dissolved Magnesium	140	160	186	230	_____	_____	_____	_____
BOD_5,	25	15	30	42	_____	_____	_____	_____
Specific Conductance	255	160	280	300	_____	_____	_____	_____
pH.	7.2	6.4	6.9	7.6	_____	_____	_____	_____
	_____	_____	_____	_____	_____	_____	_____	_____
	_____	_____	_____	_____	_____	_____	_____	_____
	_____	_____	_____	_____	_____	_____	_____	_____
	_____	_____	_____	_____	_____	_____	_____	_____
	_____	_____	_____	_____	_____	_____	_____	_____

Additional parameters may be required depending on the nature of the operations at the facility

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Appendix J

This discharge management plan (DMP for an Overland Flow System is provided as a generic example. It contains at least the minimum information required of a DMP but may not address all information required of your system. Your DMP should be tailored to fit your system.

Discharge Management Plan
for the Land Treatment System
of the Village of Claytown

This land treatment system was designed and built as part of the wastewater treatment facility serving the Village of Claytown. This wastewater treatment facility is authorized under Part 31, Water Resource Protection, of the Natural Resources and Environmental Protection Act, P. A. 451 of 1994 as amended (Part 31), and the Part 22 Groundwater Quality Administrative Rules (Part 22) promulgated thereunder to discharge 196,237 gallons per day and 36.5 million gallons annually.

Any and all discharges from the facility are to be in compliance with the conditions, limits, practices and procedures established in this facility's discharge permit and with this Discharge Management Plan (DMP). Any deviation from the conditions, limits, practices, or procedures specified in this facility's discharge permit or this DMP without prior authorization from the Department of Environment, Great Lakes, and Energy (EGLE) constitutes a violation of the discharge authorization and will subject the facility and its operator to potential enforcement action as provided in Part 31.

An irrigation isolation distance is maintained at 300 feet (ft) from property lines to comply with R 323.2204 (c) as well as R 323.2204 (d). In addition, discharge is managed to meet the remaining requirements of R. 2204.

Introduction

This facility generates wastewater effluent which does not meet all of the Part 22 groundwater standards prior to discharge. As such it utilizes Overland Flow technology as a means of treating the wastewater before it reaches the groundwater. The permit for this facility limits the concentration of several constituents contained in the effluent. Irrigation by overland flow to grass covered slopes is expected to treat primarily total inorganic nitrogen (TIN) and to ensure that the groundwater standards for total phosphorus (TP) are met. The permit limits the concentration of TIN and TP in the discharged effluent to 20 mg/l and 4 mg/l respectively.

The discharge from this facility must not cause the concentration of TIN to exceed 5 mg/l or the concentration of TP to exceed 1 mg/l in its compliance monitor wells. As such, proper operation of the land treatment system to provide the necessary treatment of the applied wastewater is required to achieve and maintain compliance with this facility's discharge permit and all applicable regulations.

The system distributes wastewater to a wetted area totaling approximately 44 acres. The dominant soil is Blount Loam. The permeability of the most restrictive layer is

0.2 inches/hour. Since this overland flow system is designed so that most of the wastewater applied will infiltrate the soil, the hydraulic loading rate was determined as it would be for slow rate application. The hydraulic loading rate was calculated as 0.336 inches/day (0.2 x 24hr. x .07). The area is sloped at a 6-8 percent grade. It is divided into four separate terraces that have been leveled across the grade to accommodate the sheet flow necessary for even distribution. Two terraces are dosed each day, and two are rested. Each terrace is 118.1 ft long equipped with half-circle raised sprinklers with a spray radius of 75 ft located at the head of the slope and a drainage channel at the bottom. While the irrigation site is sized so that all wastewater infiltrates the soil, if wastewater reaches the bottom of a terrace it is collected and pumped back to the lagoon for reapplication. The area has been planted with our private mixture of reed canarygrass, tall fescue, redtop, dallisgrass, and ryegrass as a means of helping to treat the applied effluent.

NOTICE:
Any and all violations of this DMP, the discharge authorization or applicable regulations must be reported to EGLE Water Resources Division at the District Office located in ________, Phone Number ____________.

Be advised, the discharge authorization contains specific instructions regarding certain types of violations in addition to reporting such occurrences.

Nutrient Treatment:

Effluent discharged from this facility may not contain more than 20 mg/l TIN and 4 mg/l TP. Effluent with any constituent at a concentration exceeding that specified in the permit is not to be discharged. Such a discharge will constitute a violation of the facility's DMP and its discharge authorization and must be reported to EGLE's Water Resources Division District Office in _________. Calculations pertaining to the evaluation of the system assumed even distribution of the discharge with the maximum permitted concentrations of both TIN and TP.

This land treatment system is designed and constructed to provide the necessary treatment to the applied effluent. Supplemental nutrient additions, should they be necessary, must be addressed through prescriptive use of commercial grade fertilizer following specific recommendations of the local County Extension Office. Do not apply sewage sludge, biosolids, septage waste, or any other residual or by-product to supplement the nutrient needs of the crop which may not be satisfied through the application of wastewater. Application of these or similar materials will introduce contaminants to the system which could migrate to the groundwater resulting in a violation of the facility's discharge authorization.

Discharging the maximum permitted volume of effluent containing the maximum permitted concentration of TIN distributed evenly over the irrigated area will result in an application rate of 138 lb TIN per acre per year. However, the wastewater discharged to the land treatment area may contain a concentration of TIN and volume of wastewater that is less than what is permitted. In order to maintain the health of the crop grown within the land treatment area it is important for the operator to know the actual quantity of nitrogen applied.

Use the following equation to determine the amount of TIN applied on any given day as a function of the effluent concentration in mg/l and the wastewater volume in millions of gallons.

$$Lbs\,TIN\ per\ acre = \frac{TIN\ mg/l \times wastewater\ mgd \times 8.34}{wetted\ acreage}$$

For example: The maximum allowable effluent concentration of TIN = 20 mg/l
The maximum allowable daily discharge volume = 196,237 gallons
The maximum wetted acreage per day is 22 acres (1/2 of designed area)

$$1.49\ Lbs\,TIN\ per\ acre = \frac{20 mg/l \times .196237 \times 8.34}{22\ acres}$$

This facility relies heavily on the crop uptake to achieve treatment for the effluent concentration of phosphorus. The same equation as above should be used to determine the amount of phosphorus applied in the wastewater on any given day.

For example: The maximum allowable effluent concentration of TP = 4 mg/l
The maximum allowable daily discharge volume = 196,237 gallons
The maximum wetted acreage per day is 22 acres

$$0.30\ Lbs\,TP\ per\ acre = \frac{4\ mg/l \times .196237 \times 8.34}{22\ acres}$$

To convert elemental phosphorus to phosphate (P_2O_5) for fertilizer applications, multiply the above outcome by 2.3.

The permit for this facility requires the effluent to be analyzed for nutrients on a weekly basis. To provide the most accurate estimate of the quantity of nitrogen or phosphorus applied the most recent analytical results for a given time frame will be used. Record the resulting calculations and make them available if requested to those authorized.

Please refer to the crop management section of this DMP regarding the plant uptake expectation of the grasses planted on the four terraces.

Crop Management and Plant Uptake of Nutrients:

This facility relies on crop uptake as a means of providing the necessary treatment of TIN in its wastewater to meet the groundwater standard. Although a percentage of TP is removed in treatment, the facility also relies on plant uptake to remove the remaining TP necessary to meet the groundwater standard. It is important for the operator to be aware of the quantity of nitrogen and phosphorus being applied to the land treatment system at any given time to ensure adequate treatment of the applied wastewater is occurring. Applying nitrogen at a time or rate which does not match the uptake characteristics of the crop has been shown to result in the migration of TIN in the applied effluent to the groundwater. While phosphorus may be removed by soil adsorption, reliance is on crop uptake and removal through the treatment system.

The terraces have been planted with a mixture of grasses. While all grasses in the mixture are suited for this area of Michigan, each grass has certain characteristics that may dominate given changing conditions such as temperature, time of season, moisture, etc. While this practice promotes adequate coverage regardless of prevailing conditions, the resulting mixture may vary some and so will the nutrient uptake potential of the acreage. Therefore, a conservative estimate of the nutrient uptake potential was calculated at 143 lb/acre TIN and 27 lb/acre TP (62.1 lb P_2O_5). This estimate may be adjusted based on yield results and tissue analysis. At least annually, visually inspect the grasses for species distribution. It may be necessary to rejuvenate areas from time to time to maintain the mixture distribution.

This crop will provide from 3 to 4 cuttings per season. This facility has arranged for an outside contractor, Timothy Farms, Phone Number ____________ to cut and harvest the crop grown within the land treatment system. To avoid scheduling conflicts and provide for the best quality of harvested vegetation, the harvesting contractor must be contacted well in advance of the crop reaching harvest stage. It is important that yield information be obtained from the contractor after each harvest event. The annual yield is the sum of all the cuttings in a particular season. Record the yield information from each harvest event along with any additional notes such as field conditions. This information will be used to finalize the details of future nutrient balances between effluent and crop nutrient uptake as well as the field management.

If the facility experiences an annual yield lower than the design minimum it is critical that steps are taken to correct the problem. Reduced yields may be caused by any one of a combination of factors.

The pH of the soil within the land treatment system must be maintained between 6.0 and 7.5 SU. This is a requirement of the Part 22 Rules as well as the proper soil pH for the grasses grown within the irrigated area. This facility's discharge authorization requires the soil to be tested once per year.

Surface Runoff, Spray Drift, and Even Distribution

Since the facility uses overland flow technology applied wastewater is expected to flow across each terrace and down the slope. A percentage of the wastewater is expected to infiltrate as the water flows. Even distribution is achieved because each terrace was graded and planned to provide smooth sheet flow. The resulting grade has between 6-8 percent; within the 2-8 percent slope range considered not to affect process performance. Sprinklers are spaced evenly across the top of each terrace to deliver wastewater across the entire terrace. If any wastewater does not infiltrate the soil before it reaches the bottom of the slope, it is collected at the bottom and redirected to the lagoon for reapplication. See further discussion under *Terrace Management* below. Since the facility uses raised sprinklers to deliver wastewater to the slopes they may be subject to aerosol drift if winds are too high. If winds exceeding 10 miles per hour (mph) develop during a period when effluent is being applied to a terrace, irrigation must cease until the wind speed falls below 10 mph.

This type of technology is particularly susceptible to erosion. The terraces have been planted at a high-density seeding rate to maintain adequate coverage. Vegetation coverage was established and grown to at least two inches before beginning discharge.

The operator will visually inspect the site during irrigation to determine that the velocity of the flow is not promoting conditions that will result in erosion. It may be necessary to adjust the flow rate to accommodate site conditions. Care should be taken in making adjustments. Changing the flow velocity may impact the effectiveness of nutrient uptake and/or overall loading cycle.

If erosion occurs, discontinue discharge to the affected terrace. Temporarily establish a new loading/resting cycle excluding the affected terrace until it can be repaired. Repair the affected areas and replant vegetation using the facility's special blend. Allow the newly seeded area to reestablish growth before returning the terrace to operation.

Inspect the terraces weekly for any uneven vegetative growth or eroded slopes. They should be repaired immediately before using the terrace. In addition, the grasses should be scouted periodically for pest infestations. This crop is a primary part of the wastewater treatment system and it must be protected from conditions that will weaken or prematurely thin the stand and reduce its vigor.

Terrace Management:

This overland flow system is equipped with four conventional terraces. Each terrace covers 11 acres for a total of 44 acres for irrigation. Distribution is provided by sprinklers. Flow to each terrace operates independently of the other terraces. When necessary each terrace can be isolated and taken out of service without impacting the operation of the other terraces. Consult the O & M Manual for details on operation of the valves for this purpose.

Because the facility uses a low-pressure distribution system, the length of the terraces is 118.1 ft. To maintain the grade and integrity of the slopes periodic re-smoothing of the surface may be necessary to maintain the plane and grade of the surface. This system was designed so that all the wastewater infiltrates the surface before reaching the bottom of the slope. However, a drain has been installed at the bottom of each terrace to return water to the top of the slope in the event reapplication is necessary. This is an additional safeguard to prevent runoff, and provides flexibility for changing weather conditions.

Land application for this system is seasonal and covers the period April 1 to October 31. During the remainder of the year effluent is stored. The storage lagoon was designed to hold 180 days of effluent during cold weather and can provide in-season management of the loading cycle. During the irrigation season each terrace is irrigated according to the established loading/resting cycle set forth below.

Loading and Resting Cycle

The irrigated area has been divided into four 11-acre terraces. They are designated 1A, 2A, 1B, 2B. This facility is authorized to apply its wastewater at a rate not to exceed 0.336 inches per day and 1.0 inches per week. Using the equation below, the application rate is 3.09 gallons/hour/foot.

$$Application\ Rate = \left[\frac{(hydraulic\ loading\ rate)(slope\ length)}{(period)(12"/ft)} \right](7.48 gal/ft3)$$

$$3.09\ gal/hr/ft = \left[\frac{(0.336"/day)(118.1 ft)}{(8hr)(12"/ft)} \right](7.48 gal/ft3)$$

This application rate over a period of 8 hours/day across 8,114.5 ft (two terraces) will deliver at least the daily maximum volume of 196,237 gallons.

$$200{,}590.44\ gal = 3.09\ gal/hr/ft \times 8114.5 ft \times 8hrs$$

The valves that direct wastewater to each terrace are located in the pump house. Each valve is clearly labeled indicating which terrace it serves.

The system is currently set up to dose two terraces a day, and then rested a day. All terraces are rested on Sunday. Each of the terraces has been sized to accommodate one-half of the daily maximum volume of wastewater. One-half the daily maximum volume applied to a given terrace will result in a hydraulic loading rate of 0.336 inches. The current rotation schedule for this system is as follows:

Discharge Schedule

Monday	1A, 2A
Tuesday	1B, 2B
Wednesday	1A, 2A
Thursday	1B, 2B
Friday	1B, 2B
Saturday	1B, 2B
Sunday	No irrigations

A copy of the rotation schedule must be posted in the pump house.

Soil Sampling

Annual soil sampling and testing is required by the facility's discharge authorization. This facility conducts soil sampling in the spring of each year. Three soil samples from each terrace are to be collected and sent to the MSU Soil and Plant Nutrient Lab. Each sample is to be individually tested for the following parameters:

Cation Exchange Capacity
Bray P-1 Soil Phosphorus
pH
Sodium

Results of the sample analysis will be used to adjust or finalize management plans for the upcoming irrigation season. Please refer to Extension Bulletin E-498 and E-498S found in Appendix A of this DMP for information regarding the soil sampling procedures.

General Operation and Maintenance

Daily: Before commencing with the discharge on a given day, inspect pumps, end of pipes, valves, and spray heads. Check all valve settings to ensure the effluent is being directed to the proper terrace for that day. After the pumps have been started, observe that the effluent is being applied to the intended terrace and monitor the proper function of discharge equipment.

The volume of wastewater discharged each day must be recorded and kept on file. At the end of each day, record the volume of wastewater discharged. Calculate and record the total volume of effluent discharged that day as well as the volumes applied to the individual terraces.

All inspection logs are kept on file in the main office of the treatment facility. These records are to be kept up to date in accordance with the requirements of the facility's discharge authorization.

At least weekly: Mow and inspect berms and surrounding facility areas. Make sure the area is not compromised by erosion, burrowing animals, or improper vegetation. Clear debris. Inspect the condition of the pump house. It must be kept clean and free of debris, and junk. Only authorized equipment may be stored in the pump house.

Semi-Annually: Since discharge is seasonal and ends on October 31, during the first week in November begin preparation for winter shut down. Refer to the O & M Manual for these procedures.

By March 15 start-up preparations for the irrigation season should begin. Inspect and ready equipment according to the O & M Manual.

Annually: Inspect and repair fences as needed. Schedule soil sampling during early spring during preparation for the irrigation season start-up.

Other: The Contract Co. does the periodic sampling of effluent and monitoring wells. Refer to the permit for the parameters to be sampled and the frequency of sampling.

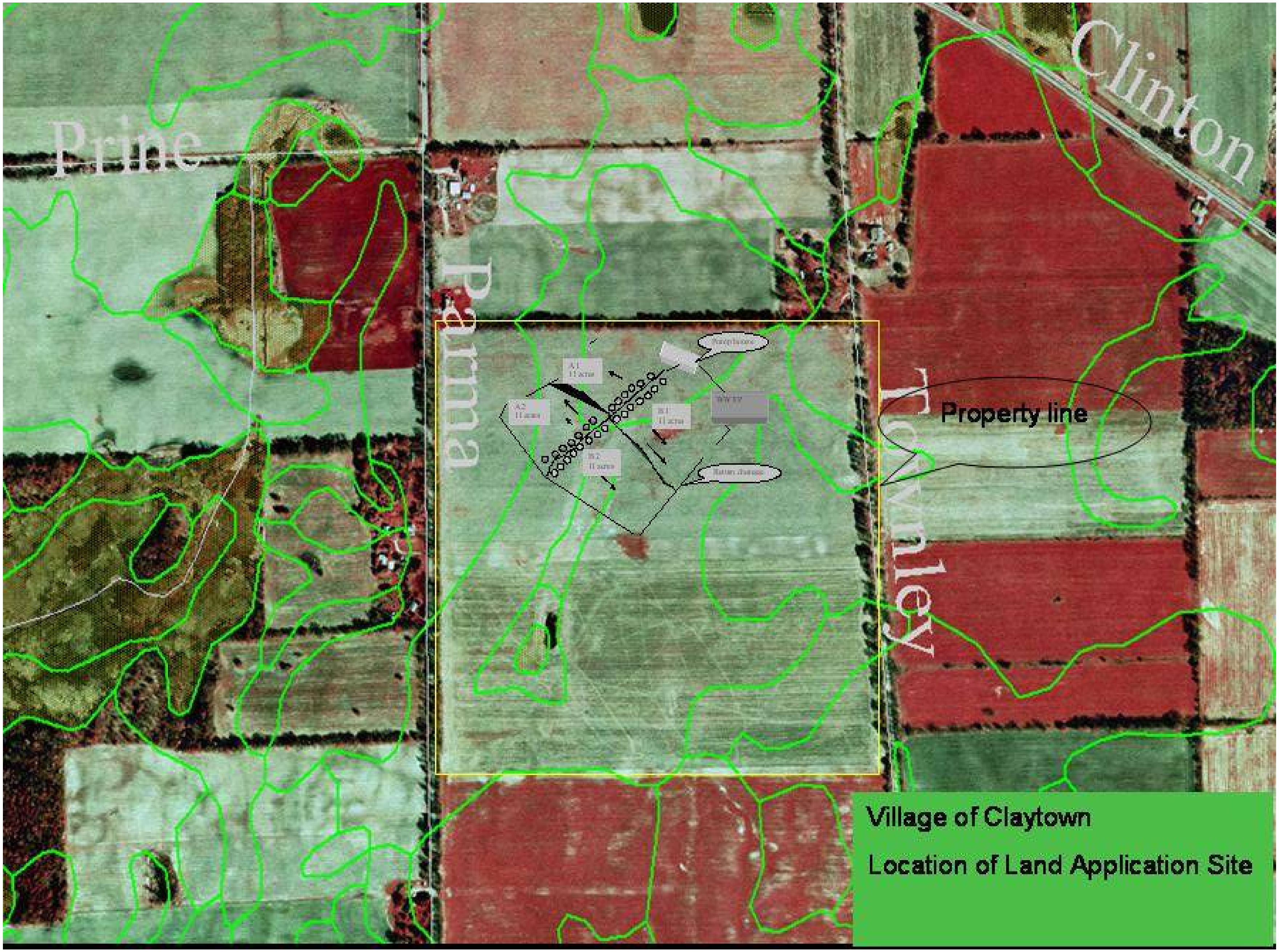
Contract Co. prepares and forwards the Discharge Monitoring Reports (DMRs) to the Facility director. The director will review the DMRs, sign, and forward them to EGLE's offices as directed in the permit.

If exceedances occur notify the director who will report them to the _______District office as noted in the permit which can be found in the main office of this facility along with the O & M Manual.

Unexpected Events

In the event the facility experiences extended periods of precipitation, the land treatment system may be operated as long as runoff does not occur during operation. The terraces are designed to accept a certain amount of rainfall. Wastewater that reaches the bottom of the slope will collect in drains located at the end of each terrace. The water is redirected to the top of the slope and re-circulated through the holding lagoon. Close monitoring of the land treatment system is required to ascertain the point at which irrigation must be discontinued. The system has been designed to accommodate up to 180 days of holding capacity resulting from the need to store effluent or due to disruption resulting from weather conditions, maintenance, harvesting, etc.

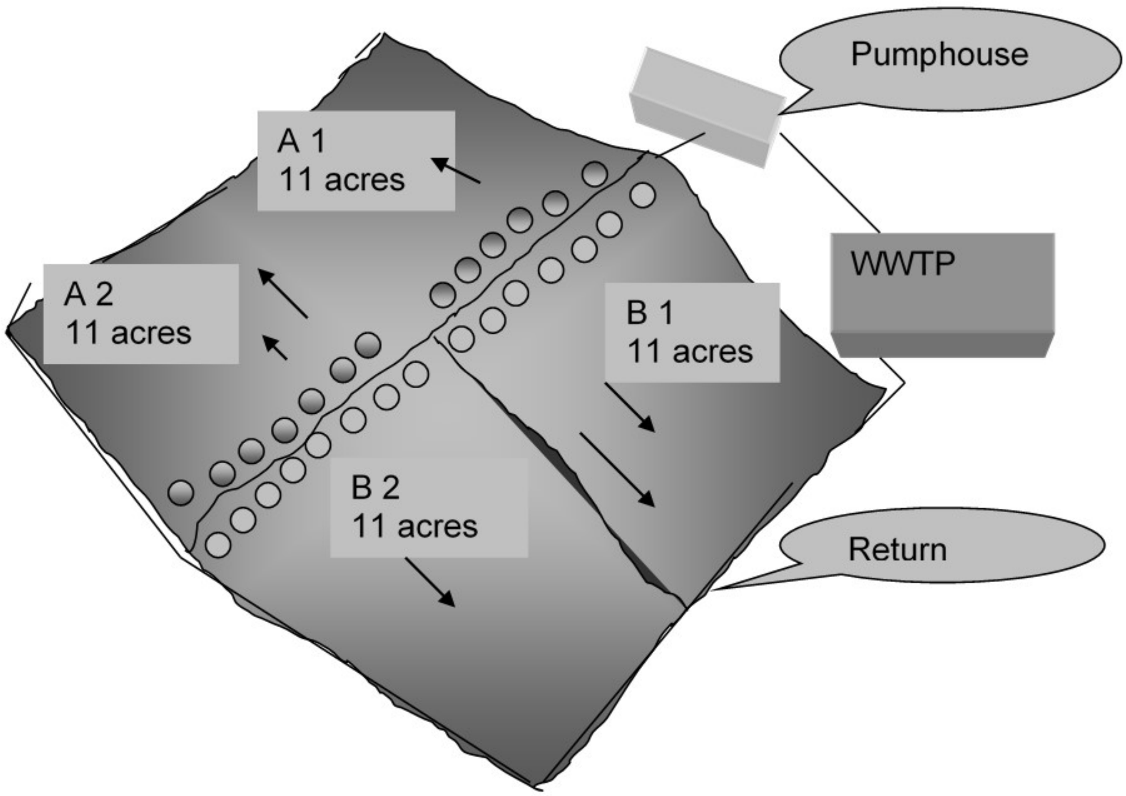
Should the system experience a disruption in the power to the pumps during a discharge, maintain the daily schedule set forth in the Loading/Resting section above. That is, once the power is restored; follow the schedule for that day. Do not “finish up” the discharge on the following day to the terrace in use when the disruption occurred unless power is restored the same day. Record the flow volume on the log sheet and note the cause of the disruption.


Clinton
Prine
Parma
Townley
Property line
A1
A2
B1
B2
WWTP
Village of Claytown
Location of Land Application Site

Village of Claytown Land Disposal Site

Slope direct

Sprinkler placement



Information Needed to Prepare a DMP

1. Maximum and average discharge volumes,

   Gallons/day Max: _196,237_________

   Current Average: _150,000_________

   Gallons/year Max: __36,500,000_____

   Current Average: ________________

2. Type of land treatment system: Overland Flow

3. Site map indicating the location and size of each field/cell/bed utilized in the system:

4. Total "wetted" area of each field/cell/bed in acres and square feet: _4 cells @ 11 acres each total 44 acres 1,916,640 square feet

5. Permit Limits for TIN and TP:

   20 mg/l TIN,

   4 mg/l TP

6. Quantity of TIN applied per acre per year:

   (20 $_{\text{mg/l TIN}}$ x 36.5 $_{\text{mgy}}$ x 8.34) / 44 $_{\text{acres}}$ = 138 $_{\text{lb TIN/Acre/yr}}$

7. Quantity of TP applied per acre per year:

   (4 $_{\text{mg/l TP}}$ x 36.5 $_{\text{mgy}}$ x 8.34) / 44 $_{\text{acres}}$ = 27.7lb $_{\text{TP/Acre/yr}}$

8. Proposed application rate of wastewater,

   inches/hour: __, /day: 0.336 , /week: 1.0 ,

   /year:___

9. The 10 yr / 24 hr precipitation event value:

   3.34 inches

10. Proposed irrigation season: _April 1 through _October 31

11. Proposed irrigation schedule, 6_ days/wk, 31 wks/yr.

12. Field or cell rotation schedule: 1A, 2A Mon., Wed., Fri. 1B, 2B Tues.,Thurs., Sat.

13. Isolation distances from maximum extent of "wetted area" to property lines: _100 ft

14. Type of application technology used (spray, flood, ridge & furrow, etc): spray – half circle sprinklers

15. Crop(s) to be grown: grass mixture

- Anticipated yield: .064 ton/acre
- Proposed harvest schedule: June 1, August 1, October 1
- Anticipated nutrient removal by proposed crop

  143 lb TIN/acre/year,

  27 lb TP/acre/year

16. Soil information:

- Type(s) of soil found within the proposed irrigation area(s). Dominated by Blount
- Minimum permeability of the soil(s) within the irrigated area(s). _0.20 inches / hour
- Bulk density of the soil(s) within the irrigated area(s) (attach separate sheet). 1.40 gm/cc moist
- Soil maps with the facility property boundaries and the "wetted" area of the irrigation field(s) clearly outlined.
- Depth of the seasonal high water table. __3 ft
- Depth to groundwater across the proposed site: > 4 feet

  ____

- Phosphorus adsorption capacity for the irrigated field: ______not relied on________________

  ___n/a__ Published Data

  ____n/a_ Site Specific Testing (attach test results)

  ____

Wastewater Characterization

A minimum of four (4) samples of the wastewater should be collected on different days, at a point just prior to discharge to the irrigation system, and tested for. **Spaces for eight samples have been provided.**

In mg/L

Ammonia-Nitrogen	3	10	7	7	______	______	______	______
Nitrate-Nitrogen	17	10	13	12	______	______	______	______
Nitrite-Nitrogen	nd	nd	nd	nd	______	______	______	______
Total Kjeldahl Nitrogen	5	12	9	9	______	______	______	______
Total Phosphorus	3	4	4	2.5	______	______	______	______
Dissolved Sodium	87	47	82	90	______	______	______	______
Chloride	130	63	123	135	______	______	______	______
Dissolved Calcium	59	59	62	61	______	______	______	______
Dissolved Magnesium	17	17	19	15	______	______	______	______
Dissolved Potassium	25	20	25	27	______	______	______	______
Bicarbonate	218	218	210	209	______	______	______	______
Sulfate	150	90	95	95	______	______	______	______
Total Dissolved Solids	290	300	300	302	______	______	______	______
Total Suspended Solids	20	15	9	9	______	______	______	______
BOD$_5$,	70	30	25	60	______	______	______	______
Specific Conductance	60	60	62	61	______	______	______	______
pH.	6.8	6.7	7.0	6.5	______	______	______	______

Additional parameters may be required depending on the nature of the operations at the facility.

Appendix K

This discharge management plan (DMP) for a Rapid Infiltration System Is provided as a generic example. It contains at least the minimum information required of a DMP but may not address all information required of your system. Your DMP should be tailored to fit your system.

Discharge Management Plan
for the Land Treatment System
of the Village of Sands

This land treatment system was designed and built as part of the wastewater treatment facility which serves the Village of Sands. This wastewater treatment facility is authorized under Part 31, Water Resource Protection, of the Natural Resources and Environmental Protection Act, P.A 451 of 1994 as amended (Part 31), and the Part 22 Groundwater Quality Administrative Rules (Part 22) promulgated thereunder to discharge 500,000 gallons per day and 104,000,000 gallons annually.

Any and all discharges from the facility are to be in compliance with the conditions, limits, practices, and procedures established in this facility's discharge permit and with this Discharge Management Plan (DMP). Any deviation from the conditions, limits, practices, or procedures specified in this facility's discharge permit or this DMP without prior authorization from the Department of Environment, Great Lakes, and Energy (EGLE) constitutes a violation of the discharge authorization and will subject the facility and its operator to potential enforcement action as provided in Part 31.

Introduction

This facility generates wastewater effluent that meets the Part 22 groundwater standards for Total Inorganic Nitrogen (TIN) and Total Phosphorus (TP) prior to discharge. As such it utilizes Rapid Infiltration technology as a means of disposing treated wastewater. Since this land application system uses rapid infiltration technology to dispose of wastewater, the facility must meet the groundwater limitations before discharge to the basins. Therefore, the permit for this facility limits the concentration of TIN and TP in the discharged effluent to 5 mg/l and 1 mg/l respectively.

The discharge from this facility must not cause the concentration of TIN in its compliance monitor wells to exceed 5 mg/l or 1 mg/l TP. Proper operation of the land treatment system to provide the necessary treatment of the applied wastewater is very important in order to achieve and maintain compliance with this facility's discharge permit and all applicable regulations.

NOTICE!!!

Any and all violations of this DMP, the discharge authorization or applicable regulations must be reported to EGLE, Water Resources Division at the District Office located in _______, Phone Number __________.

Be advised, the discharge authorization contains specific instructions regarding certain types of violations in addition to reporting such occurrences.

Nutrient Loading

Effluent with any constituent at a concentration higher than specified in the permit is not to be discharged. Such a discharge will constitute a violation of the facility's DMP and its discharge authorization and must be reported to EGLE's Water Resources Division District Office in _________.

Discharge Control and Monitoring

The discharge to each basin is controlled independently. The valves directing the discharge to the individual basins are located inside the pump house. Each valve is clearly marked indicating which cell the valve controls.

The total volume discharged to the infiltration system is measured by a meter between the pump and the valves directing wastewater to the individual basins. The volume of wastewater discharged to each infiltration cell is measured by a flow meter between the valve and the infiltration cell. Each day the meters are to be read and the data recorded. At the end of each day the meters are to be read again and the data recorded. The total volume of wastewater discharged for the day is to be calculated and recorded as well as the volume(s) discharged to the individual infiltration basins.

Number and Size of Basins

This system has been designed with four infiltration basins. The basins are designated 1, 2, 3, and 4 (See Site Map). The bottom area of each basin is 6,207.5 square feet (ft^2) for a total wetted area of 24,830 ft^2. The basins were sized according to USEPA guidelines to accommodate the winter freezing conditions in Michigan as shown below. The natural soil in the basin area was replaced with clean sand. Since the application site contains replacement soils, the basin infiltration test was performed to determine the soil permeability of the altered site. Permeability was determined at 10.0 inches/hour (in/hr).

(10 in/hr x 24 hr/day x 365 days/yr) / 12 in/ft = 7,300 ft/yr vertical infiltration

7,300 ft/yr x 0.12 allowed with Basin infiltration test = 876 ft of allowable vertical infiltration

Summer Period: (Apr-Oct, 210 days with 120 days dosing)
Winter Period: (Nov-Mar, 155 days with 88 days dosing)

Cycle design parameters	Wet	Dry	Total days	Number Cycles
Summer	1	6	7	210 days/ 7 = 30
Winter	2	12	14	155 days/14 = 11

876 ft/yr allowable vertical infiltration divided by 41 cycles equals 21.4 ft/cycle application rate.

During the summer period 60,000,000 gallons of wastewater (8,020,833 ft^3) may be discharged. Therefore, 8,020,833 ft^3 / (21.4 ft/cycle x 30 cycles) x 43,560 ft^2 = 0.29 ac or 12,632.4 ft^2

This would be the total wetted area needed for discharge; however, during the winter the basins require a longer resting period for wastewater infiltration.

During the winter period 44,000,000 gallons of wastewater (5,881,944 ft^3) may be discharged. Therefore, 5,881,944 ft^3 / (21.4 ft/cycle x 11 cycles) x 43,560 ft^2 = 0.57 ac or 24,829.2 ft^2

The winter period controlled the design in this case. The total design wetted area needed was 24,830 ft^2. 24,830 ft^2 / 4 basins = 6,207.5 ft^2/ basin. Winter application cycle requires 2 dosing days. 21.4 ft/cycle / 2 dosing days = 10.7 ft/dosing day.

10.7 ft/dosing day x 6,207.5 ft^2/basin = 66,420.25 ft^3/dose. 66,420.25 ft^3 x 7.48 g/ft^3 ≈ 500,000 gallons/dose. 500,000 gallons / 6207.5 ft^2 = 80.5 gallons/ft^2/day dosed during either the summer or winter cycle.

Hydraulic Loading Rates and Scheduling of the Discharge

This facility is authorized to apply its wastewater at a rate not to exceed 80.5 gallons per square foot per day. The RI system is currently set up with a seven-day loading cycle during the summer period that lasts for 210 days, from April through October. One day of discharge followed by six days of rest for each basin in the system. The winter cycle lasts for a period of 155 days, from November through March. During that period the dosing cycle for each bed is extended to 14 days. Two days of dosing followed by 12 days of rest. Below are tables showing the seasonal dosing/resting schedules.

Summer Dosing/Resting Cycle: in maximum gallons per day

Day of Week	Basin 1	Basin 2	Basin 3	Basin 4
Monday	500,000			
Tuesday		500,000		
Wednesday			500,000	
Thursday				500,000
Friday	Flex day[1]	Flex day	Flex day	Flex day
Weekend rest				

[1]Friday is used as a substitute dosing day in the case of extended maintenance.

Winter Dosing/Resting Cycle: in maximum gallons per day

Day of Week	Cell 1	Cell 2	Cell 3	Cell 4
Monday	500,000			
Tuesday	500,000			
Wednesday		500,000		
Thursday		500,000		
Friday	Flex day[1]	Flex day	Flex day	Flex day
Weekend rest				
Monday			500,000	
Tuesday			500,000	
Wednesday				500,000
Thursday				500,000
Friday	Flex day[1]	Flex day	Flex day	Flex day
Weekend rest				

[1]Friday is used as a substitute dosing day in the case of extended maintenance.

Basin and Berm Management, and Even Distribution of Wastewater

In order for the land treatment system to be able to function properly, the application of wastewater must be evenly distributed across the site. “Overloading” or “under loading” any portion of the system may result in malfunction and potentially lead to groundwater impacts.

The system utilizes a combination of flow velocity and splash plate, discharge volume, and size to evenly distribute the wastewater within the infiltration basins. It is critical that the distribution system is inspected before discharge for any blockages, breakage or improper function. In addition, the system must be observed while in operation. Any part of the system which is damaged or not operating properly is to be repaired or replaced immediately. Do not operate the distribution system within any infiltration basin which is malfunctioning.

There is a berm surrounding each basin. These berms were designed and installed to prevent any wastewater from exiting its designated application area as well as keep any runoff from other areas from entering onto the sub site. These berms should not be altered or damaged. The vegetation on the berms should be kept mowed to a height of no more than six inches. Inspect the berms weekly for any signs of animal burrowing and or erosion. Should any damage occur, it is to be repaired immediately.

Infiltration Bed Performance

This system relies upon the infiltrative capacity of the soil within the infiltration basins in order to discharge the volume of wastewater established in the discharge authorization. Vegetative growth within the infiltration basins is to be expected; however, care must be taken to ensure that vegetation within the basins does not interfere with the ability of the wastewater to infiltrate the soil.

It is expected that the infiltration capacity of the soil within each basin will diminish over time. At least once per season each basin is to be observed to determine the time interval taken to absorb the maximum daily volume permitted. The time interval for each infiltration basin to empty should be recorded and kept on file. If the time interval increases by more than 15 percent within any or all of the infiltration basins, appropriate action should be taken to restore the basins to their original infiltration rates. This can usually be accomplished through removal of any vegetation and or working up the upper three feet of the soil material within the infiltration basins. However, if restoration of infiltration rates is not achieved, more extensive renovation is necessary.

Records, Operation, and Maintenance

Operating the system as designed, will discharge approximately 42,000 gallons per hour. Thus, the time interval to discharge the daily maximum volume is approximately 12 hours.

Before commencing with the discharge on a given day, check all valve settings to ensure the effluent is being directed to the proper basin for that day. After the pumps have been started, observe that the effluent is being applied to the intended basin.

The volume of wastewater discharged each day must be recorded and kept on file. Calculate and record the total volume of effluent discharged that day as well as the volumes applied to the individual cells.

All inspection and compliance logs are kept on file in the main office of the treatment facility. These records are to be kept up to date in accordance with the requirements of the facility's discharge authorization.

Daily:

- Inspect pumps, end of pipes, valves, and spray heads. Make sure they are free of debris before discharge.
- Monitor the proper function of discharge equipment during operation.

At Least weekly:

- Mow berms and surrounding areas, clear debris.
- Inspect condition of the pump house. It must be kept clean, free of debris, etc. Only store authorized equipment.
- Visually inspect berms; make sure they are not compromised by erosion, burrowing animals, or improper vegetation.

Semi-annually:

- Since operation of the basins is challenging during the winter months, by November 1 thoroughly inspect all aspects of the system subject to weather conditions. Make sure all is in good operating condition before the start of freezing conditions. Refer to the operation and maintenance manual for these procedures.

Annually:

- Inspect and repair fences as needed.

Other periods:

- The Facility contracts with Wells Maintenance to sample effluent and monitoring wells. Refer to the permit for the parameters to be sampled and frequency of the sampling.
- Wells Maintenance will prepare and forward the DMRs to the Facility director. The director will review the DMRs, sign and forward them to EGLE offices as directed in the permit.
- If exceedances occur the director will report them to the ________District office as noted in the permit. A copy can be found with the operations manuals.

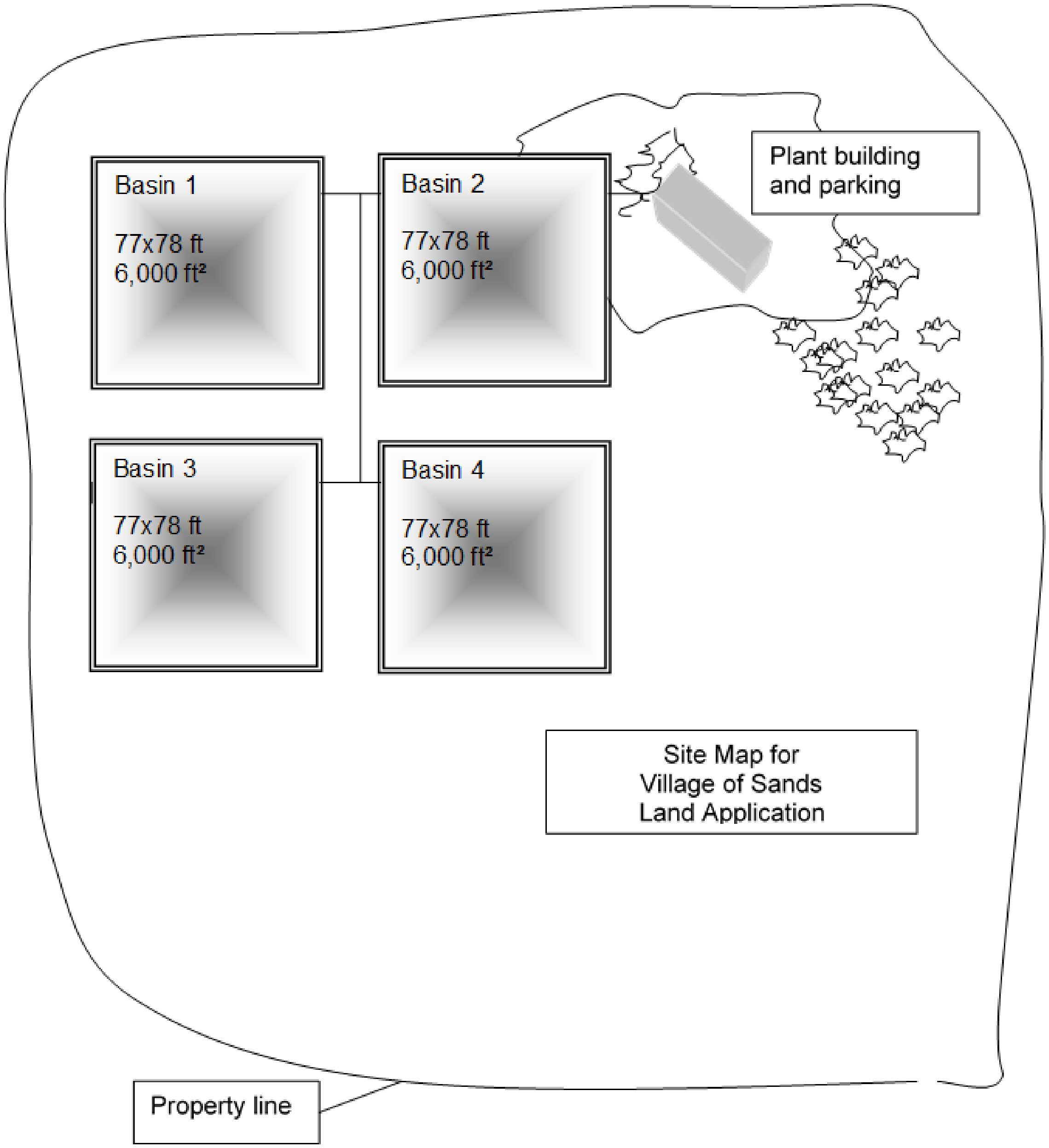
Unexpected events:

In the event the facility experiences extended periods of precipitation, the schedule for the disposal of wastewater may have to be altered. The treatment system has been designed to store wastewater up to 10 additional days. Beyond the additional storage, daily volume can be reduced and dosing extended. Since wastewater is normally discharged over four days each week, reduced loading with the dosing period extended beyond the expected 12-hour period can be spread over the entire week.

If the system experiences a disruption in the power to the pumps during a discharge, maintain the daily schedule established under *Hydraulic Loading Rates and Scheduling of the Discharge.* That is, the following day move the discharge to the scheduled basin for that day. Do not “finish up” the discharge on the following day to the basin in use when the disruption occurred. Record the flow volumes on the log sheet and note the cause of the disruption. Should the power come back on during the typical operation period in the day, resume the discharge to the same basin.

Site Map Village of Sands

North


Basin 1
77x78 ft
6,000 ft²
Basin 2
77x78 ft
6,000 ft²
Plant building and parking
Basin 3
77x78 ft
6,000 ft²
Basin 4
77x78 ft
6,000 ft²
Site Map for
Village of Sands
Land Application
Property line