

Attachment I

Food Processors Wastewater Discharge Strategy Draft March 3, 2009

Goal: To have all food processors in Michigan handle their wastewater discharges to groundwater such that groundwater is protected as required in Section 3109 of Part 31 of Act 451. It is the DEQ's goal to achieve this in a manner that allows the food processors to continue to be viable in Michigan.

Issue: Groundwater discharges of food processing wastes with high BOD from some facilities (less than 20% of the total universe of facilities in the Groundwater Permit database) have caused metals such as arsenic, iron and manganese to be released into groundwater, resulting in contamination of groundwater, including public and private wells. Wastewater discharges from food processors have been permitted for the past 30+ years but its connection to groundwater contamination was only recently discovered.

Strategy outline

1. Identify the universe of food processing dischargers.
2. Prioritize the food processing dischargers based on knowledge of the discharge, risk to the groundwater, and if proper controls are in place and being met.
3. Determine the appropriate control factors that prevent discharges from causing groundwater contamination as a result of discharging high organic content wastewater. This will likely be an approach that sets initial requirements and provides the discharger a reasonable time to come into compliance with those requirements. As additional information becomes available, either as a result of university research or field operational compliance data, the conditions required in the orders and/or permits may be modified to ensure continued compliance with groundwater standards.
4. Determine the appropriate administrative approach to deal with the dischargers to resolve the past discharges, such as with a General ACO.
5. Determine the field appropriate approach to handle the negative groundwater impacts of past discharges, such as with the Long Term Interim Remedial Action (LTIRA).
6. Issue timely GW Discharge Permits with appropriate requirements, including compliance schedules as appropriate.
7. Update the groundwater sampling techniques related to food processors.
8. Conduct discharge sampling at food processors.
9. Compile and make available food processing waste treatment technologies, especially success stories in meeting Part 31 requirements.
10. Actively work with MSU and other researchers to pursue additional information on this issue.
11. Outreach with MSU, MDA, food processors, and other to work on these issues in an open and transparent manner.
12. Complete benchmarking of other states regarding this issue and solutions.

Food Processors. Wastewater Strategy
March 3, 2009

Issue

The majority of food processing facilities are located in remote areas that do not have access to municipal wastewater treatment plants. As a result, many food processing facilities dispose of their wastewater by discharging to the ground and groundwater. The most common disposal system consists of discharge by means of land application using spray irrigation, which takes place all year long. Some facilities provide storage lagoons and stabilization prior to discharge through lagoon seepage or spray irrigation, others spray irrigate effluent without providing any pretreatment. Decades ago, it was thought that such systems were a viable means of wastewater disposal for the food processing industry. However, in the last five to ten years, groundwater monitoring results have shown that not to be the case.

Prior to 2000, Groundwater Discharge Permits for food processors generally did not require groundwater monitoring for iron and manganese, primarily because these substances were not present in the effluent wastewater. Through the course of permit application reviews and complaints from adjacent property owners, the DEQ discovered that groundwater hydraulically downgradient of these discharges contained high levels of iron, manganese, occasionally arsenic and transition metals such as cadmium, cobalt, lead and nickel. Even after identifying the problem in groundwater, it took some time to establish the cause and effect relationship. The problem results from the fact that wastewater from food processing has a very high organic content which is broken down biologically. The relative amount of organic matter present in water is measured as Biochemical Oxygen Demand (BOD).

In order to avoid negative groundwater impacts, these constituents must receive treatment aerobically within the soil matrix through oxidative microbial degradation. This process relies on the presence of adequate levels of oxygen within the soil environment to proceed. When oxygen becomes depleted within the soil environment, anaerobic bacteria take over the digestion of the organic constituents.

In 1987, research that was conducted by the United States Geological Survey in South Carolina identified the first known bacteria to conduct iron reduction in a shallow groundwater aquifer, *Geobacter metallireducens*. Iron reduction was well known in the oil drilling industry, it was assumed, incorrectly, that with the ready supply of oxygen in the soil column and dissolved oxygen in groundwater, that anaerobic bacteria were not present in the soil column. In 1989, the USGS went on to identify anaerobic bacteria that can exist in aerobic soil conditions, *Geobacter Chappelleii*, which simply goes dormant until the optimum conditions are available for proliferation. What happens in the soil column is that under anaerobic conditions, grain coating Fe (III) oxyhydroxides, and any other metal oxides bound to a soil particle, are reduced (oxygen removed) and the mobile valence of the metal goes into solution, eventually leaching into groundwater. Without another source of oxygen, metals will move with groundwater and the

Food Processors. Wastewater Strategy
March 3, 2009

concentration of those metals is only reduced through dispersion. Unless oxygen is introduced into groundwater, only when the groundwater “plume” vents to surface water will the metals precipitate out.

The concentrations of iron, manganese and arsenic leached into groundwater as a result of this process exceed not only the aesthetic standards for iron and manganese, but also the health based standards for iron, manganese and arsenic. The health based standard for iron is 2.0 milligrams per liter (mg/l), the health based standard for manganese is 0.86 mg/l, and the health based standard for arsenic is 0.01 mg/l. The concentration of iron in groundwater at these facilities has been observed as high as 60 mg/l, manganese at 5.0 mg/l, and arsenic up to 40 ug/l.

In addition to the leaching of metals into groundwater, the Department has dealt with other significant issues in bringing food processing facilities into compliance with the Part 22 Rules of Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, PA 451, as amended (Act 451). These issues include ponding, pooling and off-site run-off of wastewater at spray irrigation fields caused by over-application of wastewater, especially winter application and nuisance odor conditions caused by over-application of wastewater and high BOD levels.

It is the DEQ’s responsibility to protect groundwater resources for the benefit and use of all citizens of Michigan. This is primarily a public health issue related to drinking water, since half of the people in the state rely on groundwater as a drinking water source. However, the DEQ must also protect for other uses of both groundwater and surface water such as agricultural irrigation and recreational use. The DEQ has concluded that it is not an efficient use of our very limited resources to continue evaluating food processing facilities that have contaminated groundwater and issuing enforcement orders on a case by case basis. Case by case reviews are time consuming and very inefficient relative to making sure everyone in the industry is meeting the same environmental standards. The current regulatory situation has created a substantial competitive disadvantage across the industry between those sites the DEQ is actively working with and those whose reviews have not yet begun.

The following strategy has been developed to address the current imbalance in the way food processors that discharge large volumes of wastewater are regulated. The DEQ recognizes that there is very little research available that provides guidance on the relationship between concentration of BOD, application rates, soil temperature, soil moisture, oxygen reduction potential, and perhaps other factors related to soils in preventing leaching of metals into groundwater. One laboratory study indicated that for certain soil types metals begin leaching from soils with a BOD loading rate of 25 pounds per acre per day. Another study had to load soils at 500 pounds per acre per day to create metals leaching. While there isn’t enough information from these studies to

Food Processors. Wastewater Strategy
March 3, 2009

definitively establish loading rates as the single controlling parameter, it is what the DEQ currently has to work with. The DEQ is aware that organic matter applied to the land is broken down biologically, and that aerobic breakdown in the soil is critical to preventing metals leaching. The DEQ also is aware that biological activity during Michigan winters is dramatically reduced in the upper portion of the soil column where most of the treatment should be taking place. These two factors are the primary considerations in developing the technical portion of this strategy.

1. Identify the universe of food processing dischargers

The Water Bureau (WB) queried our existing computer database to list all food processing facilities that have groundwater discharge permits, applications for groundwater discharge permits, or are discharging pursuant to individual Administrative Consent Orders. This exercise resulted in the identification of 110 facilities as food processing discharges.

2. Prioritize the food processing dischargers based on knowledge of the discharge, risk to the groundwater, and if proper controls are in place and being met

From the dischargers identified in #1, the WB developed a priority order for how we will approach both permitting and compliance for food processors. The discharges were organized relative to three major categories. Those categories included the following:

- Un-addressed groundwater contamination
- Groundwater contamination already addressed by ACO or permit
- No groundwater contamination identified or suspected

Within each category, there were further subdivisions relative to compliance status of each facility relative to the ACO or permit.

There are a total of 110 facilities in the groundwater discharge permit database. Of those, 86 (78%) do not have groundwater contamination, and only minor if any compliance issues related to their discharges. The DEQ will be focusing its efforts on the remaining 24 (22%).

- Appendix I describes the priority categories.
- Appendix II lists all of the facilities and their priority ranking.

3. Determine the appropriate control factors that prevent discharges from causing groundwater contamination as a result of discharging high organic content wastewater. This will likely be an approach that sets initial requirements, provides the discharger a reasonable time to come into compliance with those requirements, and then adjusts those requirements in GW Discharge Permits as new information becomes known.

Appendix III is a full technical discussion of the issue relative to discharging high BOD wastewater to the ground and ultimately to groundwater, the following is a detailed summary of that analysis and the DEQ's current position and recommendations regarding BOD.

A large number of facilities in Michigan discharge untreated and partially treated process wastewater throughout the year. Most of these facilities discharge to the land

Food Processors. Wastewater Strategy
March 3, 2009

using slow rate (sprinkler irrigation) systems with the expectation of some level of treatment within the soil. Process wastewater contains significant concentrations of organic constituents resulting in very high Biochemical Oxygen Demand (BOD) as well as high levels of Total Suspended Solids (TSS). In order to avoid negative groundwater impacts, these constituents must receive treatment aerobically within the soil matrix through oxidative microbial degradation. This process relies on the presence of adequate levels of oxygen within the soil environment to proceed. However, when oxygen becomes depleted within the soil environment, anaerobic bacteria take over the digestion of the organic constituents. When this occurs, metals in the soil are chemically reduced making them soluble and a potential threat to the groundwater and public health.

There are three components to the high BOD wastewater disposal issue. First, since the current predominant disposal practice (spray irrigation) relies exclusively on biological treatment in the soils, there are temperatures at which the biological activity is so reduced that it becomes ineffective as a treatment mechanism. The second component, also related to cold temperatures, is the concern that ice can form at the surface (there are photographs included with Appendix III that provides examples of winter land application. These photos demonstrate significant icing and ponding/pooling at the ground surface). Since thawing is a random event, either runoff from the site will occur, which is a violation of the Part 22 rules, or a flush of wastewater will pass through the soil column, leading to the development of anaerobic soil conditions. The third component relates to the ability to maintain aerobic conditions in the soil to prevent metals leaching. Even when temperatures are such that biological activity within the soil is adequate for bacteria to remain active, we do not understand the relationship between other control factors (soil moisture, oxygen/reduction potential, etc.) that allow anaerobic bacteria to become the primary degradation mechanism, which leads to the leaching of metals to groundwater.

There are significant concerns with regard to the discharge of process wastewater with high organic content during periods when winter conditions are present (average ambient outdoor air temperatures at or below 40 °F (4 °C) for five or more consecutive days, and or the Soil temperature at or below 50 °F (10 °C)). The nature, depth and extent of freezing of soils, and the impact that freezing has on infiltration is influenced by a number of natural climatic factors. The presence of frozen water within or on the soil surface results in the reduction of infiltration. The reduced infiltrative capacity can lead to substantial accumulation of wastewater within the area of discharge eventually having a negative impact on the oxygen status within the underlying soil. Reduction in soil infiltrative capacity increases the likelihood of the development of nuisance conditions and that soil treatment will be severely compromised.

There are also concerns regarding the capability of the microbial component of the soil matrix to provide the necessary treatment during winter conditions. Regardless of which bacteria are active, thermal conditions are an important factor affecting the treatment process. As soil temperature falls below 15°C, microbial metabolic activity becomes insufficient to metabolize enough organic matter to prevent the development of a biological mat. Soil temperatures in Michigan fall considerably lower than 15°C for extended periods.

Over the course of a winter, microbial populations flourish and crash repeatedly complicating the ability of the soil to provide treatment while increasing the potential for clogging of soil pores. Flooded soils can become depleted of oxygen very quickly. Depleted of oxygen, soil anaerobic and facultative microbes multiply and continue the decomposition process utilizing alternative electron acceptors (NO₃, Mn, Fe, SO₄, and SO₃). Prolonged flooding causes reduction of aggregate stability, disruption of soil peds and the clogging of pores.

Frozen distribution equipment is another important issue associated with discharges occurring during winter conditions. Facilities are typically unable to keep their system completely clear of ice build-up. Discharging through frozen or otherwise malfunctioning distribution equipment will result in over-application of the wastewater.

Based on these considerations, the following approach is proposed for facilities discharging high BOD wastewater:

Non-growing season:

- Due to the inability of soils to provide treatment during cold temperatures, effluent discharged between November 15th and April 15th should have a concentration no greater than 10 mg/l BOD as a monthly average and 25 mg/l BOD as a daily maximum prior to discharge. Facilities may propose alternative approaches which can be demonstrated by the discharger to be protective of the water resources of the State.
- Groundwater discharges which occur during winter conditions should be accomplished through the use of rapid infiltration basins consistent with the requirements of Part 22. The use of disposal methods other than rapid infiltration may be considered for winter discharges if the discharger can demonstrate that the technology can function properly during the period when winter conditions occur and will be so maintained.

Growing season

During the growing season there is an adequate capability for bacteria to aerobically treat BOD wastewater in the soil. However, as indicated previously, there is limited information to evaluate all of the factors that would maintain an aerobic treatment population. For example, we simply do not know the difference in the potential impact from a discharge that takes place during July and August of wastewater containing 2,000 mg/l of BOD to the ground at an application rate of 0.125 inches per day and 0.5 inches per week, as opposed to a discharge during the same time period of wastewater discharged with a BOD concentration of 200 mg/l at 1.0 inched per day, 6 inches per week. Based on current available information, the following approach was developed to maintain aerobic treatment in the soil and prevent mobilization of metals to groundwater:

- Effluent discharged during the growing season, April 15 through November 15, should be land applied at a loading rate of 50 lbs/acre/day, calculated as a monthly average, while maintaining aerobic conditions in the soil.

This approach will be reevaluated as additional information comes available, which can be either research data or data from a specific facility.

4. Determine the appropriate administrative approach to deal with the dischargers to resolve the past discharges.

The DEQ has entered approximately 12 individual administrative consent orders (ACO) with facilities in the food processing industry related to elevated metals in groundwater. We have evaluated this group of ACO's, and determined that there are many commonalities in those orders. Therefore, a general administrative consent orders (GACO) has been developed for these situations.

The fundamental requirements of the GACO will be similar to the DEQ's current process dealing with food processors that have caused negative groundwater impacts. That process generally entails removing the ongoing source of high BOD wastewater, identifying the extent of groundwater impacted by previous discharges and making sure that any receptors affected by the facility's discharge are provided a permanent supply of potable water.

Facilities meeting applicable criteria will be offered a GACO to resolve these issues at their site. The offer will be for a limited time period. GACO's will have associated civil fines. However, a facility that agrees to the GACO within the allotted time period will be assessed a lower fine than those that refuse the GACO.

Appendix IV is an outline of the proposed Generic Administrative Consent Order

(GACO).

5. Determine the appropriate individual site approach to handle the groundwater effects of past discharges

Discharges from the food processing industry were authorized for 30+ years before the problem of metals leaching to groundwater was discovered. Hydrogeologic investigations have revealed groundwater plumes that are in excess of a mile wide, and one and a half miles long. The volume of water that would need to be pumped and treated to remediate that amount of groundwater would be cost prohibitive, and most likely bankrupt all of the major processors in the state. Additionally, that volume of pumped groundwater could very easily have detrimental hydraulic affects on nearby domestic and irrigation wells. Taking both of those potential consequences into account led the WB to develop its current approach to addressing elevated metals in groundwater at food processing facilities.

Rule 2204 of the Part 22, Groundwater Quality Rules prohibits a discharge from causing a facility as that term is defined under Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act (NREPA) 1994 PA 451 as amended. Therefore, food processors whose discharge has caused groundwater contamination above the generic residential clean up criteria are liable parties under Part 201 and are required to perform response activities to address the contamination. These response activities include source removal, performing remedial investigations to determine the nature and extent of the contamination, interim responses to address issues such as contamination of private water supplies, and remedial action plans (RAP) to address the identified contamination. The WB requires food processors whose discharge has created a facility to comply with Part 201 of the NREPA. However, due to the issues discussed above, the WB allows the liable party some flexibility in achieving compliance with Part 201 via implementation of a Long Term Interim Remedial Action (LTIRA) plan. In conjunction with reduction of the elevated BOD via treatment or modification of the land application system, and interim response activities to address private water supply contamination, the LTIRA allows the liable party to perform long term monitoring of the groundwater contaminant plume in place of active remediation. The LTIRA must be approved by the WB, the party must fully comply with the provisions of the LTIRA and the LTIRA must remain effective in protecting human health and the environment. Provided that these conditions are met, the WB suspends the due date for a RAP until the party can prepare one that fully complies with Part 201. The liable party may also complete the process by submitting a closure report if site conditions have improved to the point that the generic residential clean up criteria are met. The WB closely monitors implementation of the LTIRA and may, at any time, require preparation of a RAP if the liable party does not comply with the terms of the LTIRA, or if the LTIRA is no longer effective

6. Issue timely GW Discharge Permits with appropriate requirements, including compliance schedules as appropriate.

One of the chief complaints from the industry is that although some of the facilities have entered into individual consent orders to address the BOD issue, the DEQ still has not issued a groundwater discharge permit. The DEQ is proposing to draft a generic groundwater discharge permit concurrent with the GACO that will mirror requirements in the GACO, contain schedules to provide items such as a groundwater monitor well network and discharge management plan, and will public notice the permit as required in the Part 21 rules at the same time the facility enters into the GACO.

The DEQ is also on schedule to eliminate the groundwater discharge permit backlog by the end of this year. Part of this process will include final processing of the permit applications for those food processors that previously entered into an ACO. Elimination of the backlog will allow the DEQ to focus on keeping the Groundwater Permits timely and to promptly issue new permits and reissue existing permits.

7. Update the groundwater sampling techniques related to food processors

The WB is recommending the following activity to address this issue:

- The WB will update the Hydrogeologic Study Guidesheet to include groundwater sampling techniques. The portion of the guidesheet that deals with groundwater sampling will also be added to the groundwater discharge permit boilerplate.

8. Conduct discharge sampling at food processors

The WB is recommending the following activity to address this issue:

- District staff should conduct at least one sampling inspection during a five year permit cycle at all food processors that are required to provide effluent and groundwater quality data. Samples would be split with the WB, and analysis conducted both by the facilities' designated laboratory and the State lab.

9. Compile and make available food processing waste treatment technologies, especially success stories in meeting Part 31 requirements

The WB will act as a clearinghouse for treatment technology that has been demonstrated to achieve BOD reductions to 10 mg/l or less and success stories in protecting groundwater from metal mobilization. The data should include very specific information about the type and concentration of the wastewater that was treated, and effluent quality. The information would be placed on the Groundwater Discharge web site and be available to the industry at any time.

10. Actively work with Michigan State University (MSU) and other researchers to pursue additional information on this issue, including funding

The WB will meet with MSU and any other researchers as available to identify activities that would serve to further our knowledge on this issue. WB will also continue to monitor the published scientific literature on this subject.

11. Outreach with MSU, MDA, food processors, and other to work on these issues in an open and transparent manner

The Michigan Department of Agriculture (MDA) is currently involved in anaerobic digestion evaluation, and MSU has done research in the area of converting waste to energy. The WB will continue to participate in discussions relative to this issue with the MDA, MSU, the Michigan Economic Development Corporation (MEDC) and the food industry.

12. Complete benchmarking of other states regarding this issue and solutions.

The WB will continue to solicit input from other Region 5 states to determine how they regulate wastewater discharges of this type and the standards that apply to iron, manganese and arsenic. The following table summarizes those efforts to date relative to standards.

State	State/Federal Standards	Fe (ug/l)	Mn (ug/l)	Notes
Michigan	State	300/2000*	50/860*	The first value is the aesthetic standard, the second is the health based standard
Indiana	Federal	None	None	
Ohio	Federal	None	None	
Wisconsin	State	300	50	Can require action if 10% of standard is detected in groundwater
New York	State	300	300	Sum of Fe + Mn < 500 ug/l
Illinois	State	5,000	150	

TECHNICAL DISCUSSION – HIGH BOD DISCHARGE

DEQ's legal responsibilities

Many facilities discharge large volumes of untreated and partially treated process wastewater throughout the year. Typically the discharge is to the land using slow rate (sprinkler irrigation) systems with the expectation of some level of treatment. Process wastewater, unlike its sanitary counterpart, is typically low in nitrogen and phosphorus and contains significant concentrations of organic constituents resulting in very high Biochemical Oxygen Demand (BOD) as well as high levels of Total Suspended Solids (TSS). Rule 2233(4) of the Part 22 Rules (Part 22) requires that these constituents receive treatment aerobically within the soil matrix through oxidative microbial degradation, and are the major constituents of concern for these types of wastewaters. Oxidative degradation relies on the presence of adequate levels of oxygen within the soil environment to proceed. However, when oxygen becomes depleted within the soil environment, anaerobic bacteria take over the digestion of the organic constituents in such a way that metals in the soil are utilized as the terminal electron acceptors thus reducing them and making them soluble and subsequently leached to the groundwater. For many discharges of untreated or partially treated process wastewater, this treatment mechanism has not been proven to provide adequate treatment even under optimal conditions.

The DEQ's responsibility and authority to take steps to address the issues associated with the discharge of high organic content wastewaters is established in Section 3106 of Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA) provides the DEQ with the responsibility and authority to establish pollution standards for waters of the state, to issue permits and set permit restrictions, to promulgate rules and issue orders restricting pollution, and to take all appropriate steps to prevent pollution. In addition, Rule 2137, Terms and Conditions of Permits; Effluent Standards and Limitations, of the Part 21 Rules, Wastewater Discharge Permits, states in part: "When applicable, a permit issued by the commission shall contain terms and conditions deemed necessary by the commission to ensure compliance with at least the following effluent standards and limitations: (d) Any other more stringent limitation deemed necessary by the commission to meet applicable water quality standards, treatment standards or schedules of compliance established pursuant to the commission act or rules promulgated pursuant thereto, or necessary to meet other federal law or regulation enacted or promulgated subsequent to these rules, or required to meet any applicable water quality standards including applicable requirements necessary to meet maximum daily loads established by and incorporated into the state's continuing planning process required pursuant to section 303 of the federal act."

Summary

The practice of discharging these wastewaters during the winter months, or when winter conditions exist, raises significant concerns with regard to the ability of the wastewater to infiltrate into the soil as well as receive the required treatment. For the purposes of this discussion the criteria for the existence of winter conditions include, but are not limited to; average ambient outdoor air temperatures at or below 40 °F (4 °C) for five or more consecutive days, and or the Soil temperature at or below 50 °F (10 °C). In the Upper Peninsula of Michigan, these conditions typically occur between October 15th and April 30th. In the Northern tier of the Lower Peninsula these conditions typically occur between November 15th and April 15th. In the Southern tier of the Lower Peninsula the period typically runs between December 1st and April 1st. It has been argued that spray irrigated process wastewater is warm and will retain sufficient heat energy to prevent soil from freezing. As such, the infiltration of applied wastewater into the soil would not be impacted and the soil temperature would be adequate to support microbial activity levels typically associated with warmer climatic conditions. However, the historical record indicates winter discharge of process wastewater by means of slow rate technology has been proven to be an environmentally unsound practice. It has been well documented the wastewater discharged through various slow rate spray irrigation methods freezes much more frequently and to a greater extent than suggested by the regulated community and their consultants.

Most of the food processing facilities discharge to the land using slow rate (sprinkler irrigation) systems with the expectation of some level of treatment within the soil. Process wastewater contains significant concentrations of organic constituents resulting in very high Biochemical Oxygen Demand (BOD) as well as high levels of Total Suspended Solids (TSS). These constituents must receive treatment aerobically within the soil matrix through oxidative microbial degradation. This process relies on the presence of adequate levels of oxygen within the soil environment to proceed. However, when oxygen becomes depleted within the soil environment, anaerobic bacteria take over the digestion of the organic constituents. When this occurs, metals in the soil are chemically reduced making them soluble and a potential threat the groundwater and public health. In this regard, the DEQ has the responsibility and authority to take steps to address the issues associated with the discharge of high organic content wastewaters under the applicable statute and administrative rules.

There are significant concerns with regard to the discharge of process wastewater with high organic content during periods when winter conditions are present. Despite suggestions that spray irrigated process wastewater retains sufficient heat energy to prevent soil from freezing, experience indicates winter discharge of process wastewater by means of slow rate technology has been proven to be a questionable practice. (See photos at the end of Appendix III)

The nature, depth and extent of freezing of soils, and the impact that freezing has on infiltration is influenced by a number of natural climatic factors. The presence of frozen water within or on the soil surface results in reduced infiltration. The reduced infiltrative capacity can lead to substantial accumulation of wastewater within the area of discharge eventually having a negative impact on the oxygen status within the underlying soil. Reduction in soil infiltrative capacity increases the likelihood of the development of nuisance conditions and that soil treatment will be severely compromised.

Pursuant to Rule 2233(2) of the Part 22 Rules, facilities discharging untreated and partially treated wastewater must utilize slow rate or overland flow technologies. Application rates associated with these methods are insufficient to maintain soil infiltrative capacity during winter conditions. Any discharge which occurs during, or contributes to, the impairment of any of those soil treatment processes is a violation of Part 22.

There are concerns regarding the capability of the microbial component of the soil matrix to provide the necessary treatment during winter conditions. Regardless of which bacteria are active, thermal conditions are an important factor affecting the treatment process. As soil temperature falls below 15°C, microbial metabolic activity becomes insufficient to metabolize enough organic matter to prevent the development of a biological mat. Soil temperatures in Michigan fall considerably lower than 15°C for extended periods.

The accumulation of frozen wastewater containing elevated levels of BOD and TSS represents a significant threat to the groundwater once it begins to thaw. Thawing events are unpredictable, often sudden and fluctuate significantly for extended periods. As the soil thaws after a freeze, the formation of ice crystals within microbial cells disrupts cellular integrity resulting in death. Over the course of a winter microbial populations flourish and crash repeatedly complicating the ability of the soil to provide treatment while increasing the potential for clogging of soil pores. It is not possible to control the thawing process or anticipate the conditions under which it will occur.

Proper treatment within the soil requires having and maintaining an adequate aerobic microbial population with an activity level sufficient to metabolize the organic constituents. Flooded soils can become depleted of oxygen very quickly. Once soils are depleted of oxygen, soil anaerobic and facultative microbes multiply and continue the decomposition process utilizing alternative electron acceptors (NO₃, Mn, Fe, SO₄, and SO₃). Prolonged flooding causes reduction of aggregate stability, disruption of soil peds and the clogging of pores.

Food Processors. Wastewater Strategy
March 3, 2009

Frozen distribution equipment is another important issue associated with discharges occurring during winter conditions. Facilities are typically unable to keep their system completely clear of ice build-up. Discharging through frozen or otherwise malfunctioning distribution equipment will result in over-application of the wastewater in violation of the requirements of the Part 22 Rules.

Control over the application rate of the wastewater is severely compromised when the ice and snow build-up thaws. Daily discharges throughout the winter months combined with the volume of frozen wastewater which is thawing at an unknown and uncontrollable rate has the potential of exceeding the authorized daily maximum hydraulic load to the land treatment system.

The recommendation is made that all facilities discharging such wastewater (regardless of season) take appropriate precautions to ensure the protection of the water resources of the state. Allowing for regional variation with regard to specific dates, the Water Bureau is recommending BOD in wastewater discharged between November 15th and April 15th be treated to concentrations which are not expected to result in adverse impacts to the water resources of the state. At this time the Water Bureau is recommending 10 mg/l BOD as a monthly average and 25 mg/l BOD as a daily maximum prior to discharge. Facilities may propose an alternative concentration which must be demonstrated by the discharger to be protective of the water resources of the State.

The DEQ is also recommending groundwater discharges which occur during winter conditions to be accomplished through the use of rapid infiltration and consistent with the requirements of Part 22 in that regard. The use of disposal methods other than rapid infiltration may be considered for winter discharges if the discharger can demonstrate to the DEQ's satisfaction the technology can function properly during the period when winter conditions occur and will be so maintained.

These recommendations are made with the expectation that facilities which engage in activities resulting in the production of wastewater with high organic content can operate throughout the winter season with minimal potential for adverse impacts to the water resources of the state.

The following is a more detailed discussion of the various aspects of the winter discharge issue:

Physical Aspects

A number of natural climatic factors affect the nature, depth and extent of freezing of soils, and the impact that freezing has on infiltration. These factors include but are not limited to, soil type, water holding capacity, presence or absence of snow pack, depth of snow pack (if present), soil temperature at the time of first accumulation of snow pack, soil moisture status at the time of freezing. The presence of frozen water (waste or otherwise) either on the surface as solid ice or within the surface layer of soil as concrete frost, results in the reduction of infiltration. The reduced infiltrative capacity of the soil creates the opportunity for substantial accumulation of wastewater within the area of discharge. These accumulations (frozen or otherwise) eventually have a negative impact on the oxygen status within the underlying soil.

Rule 2204 of Part 22 prohibits a discharge which is or may become injurious, which creates nuisance conditions such as odors, vectors, runoff onto adjacent property, pathogens, or changes in aesthetic qualities of groundwater. Rule 2204 also prohibits, the creation of a facility as defined by Part 201 of the Natural Resources and Environmental Protection Act. A reduction in the infiltrative capacity greatly increases the likelihood that one or more of these nuisance conditions will occur, and that soil treatment will be severely compromised. If a discharge contains constituents which will or may result in an impact to the groundwater resource, those constituents must be treated before such an impact occurs. With regard to treatment, Rule 2233(2) requires the discharger to incorporate the use of slow rate or overland flow processes in the design of the land treatment system if land application is considered part of the overall treatment of the wastewater to meet the standards of Rule 2222 and by extension Part 201.

In addition, Rule 2233(4) limits hydraulic loading based factors relative to plant and soil processes. In that regard land treatment systems must be designed, constructed, and operated to allow:

- soil organisms to biologically decompose organic constituents in the wastewater,
- organic solids on the soil surface to decompose,
- the soil to become aerated,
- soil conditions to become unsaturated and aerobic,
- vegetative cover to utilize available nutrients provided through the application of wastewater,
- harvesting operations to occur at appropriate times.

These processes are affected by conditions which exist before, at, and subsequent to the time of wastewater application. Seasonal weather conditions and discharge practices which lead to reductions of soil permeability will negatively impact each of

these processes. Any discharge which occurs during, or contributes to, the impairment of any of these processes is a violation of Part 22.

Facilities utilizing rapid infiltration technology treat their wastewater to meet Part 22 standards prior to discharge and are able to adjust their discharge strategies so as to maintain the infiltrative characteristics of the media within their infiltration beds. However, due to the reliance on the soil for treatment to meet Part 22 standards, facilities discharging untreated and partially treated wastewater must utilize slow rate or overland flow technologies. Application rates associated with these technologies are relatively low compared to rapid infiltration, and as such are insufficient to maintain soil infiltrative capacity during winter conditions. Furthermore, these low application rates ultimately contribute to the reduction in the ability of the soil to provide the necessary treatment.

Biological Aspect

Should conditions exist where the applied wastewater is able to infiltrate the soil, there is still the question regarding the capability of the microbial component of the soil matrix to provide the necessary treatment. The majority of the soil bacterial community, both aerobic and anaerobic, is comprised of mesophilic bacteria. Their active temperature range is between 15-45°C (59-113°F) (Tate, 1995). As soil temperature falls below 15°C, microbial metabolic activity becomes insufficient to metabolize enough organic matter to prevent the development of a biological mat. Soil temperatures in Michigan fall considerably lower than 15°C for extended periods.

The accumulation of frozen wastewater containing elevated levels of BOD and TSS represents a significant threat to the groundwater once it begins to thaw. If the thawing process is slow enough and oscillation between frozen and liquid states within the soil is not extended, it may be possible for the soil microbial population to grow and be capable of processing the accumulated BOD and TSS. However, thawing events are unpredictable, often sudden and fluctuate significantly for extended periods. Foth (1990) indicated that at temperatures below freezing, “. . . there is extremely limited biological activity.” In addition, Tate (1995) noted that as the soil thaws after a freeze, the formation of ice crystals within microbial cells disrupts cellular integrity resulting in death. Over the course of a winter's application of wastewater there are typically several intermittent freezing and thawing cycles. As such, microbial populations flourish and crash repeatedly which further complicates the ability of the soil to provide the treatment resulting from reductions in soil microbial populations and lag times associated with recovery. There is also the potential for clogging resulting from accumulated microbial biomass. Most importantly, there is no way to control the thawing process or anticipate the conditions under which it will occur. Regardless of which bacteria are active, thermal conditions are an important factor affecting the treatment process (BOD digestion) expected by facilities discharging high strength

wastewaters.

With regard to treatment within the soil under the aforementioned conditions, there is significant concern in terms of having and maintaining an adequate aerobic microbial population with an activity level sufficient to metabolize the organic constituents of the portion of the wastewater which manages to infiltrate into the soil. "Flooded soils with a good supply of readily decomposable organic matter may become depleted of oxygen within a day. Then, anaerobic and facultative microbes multiply and continue the decomposition process. In the absence of oxygen, other electron acceptors begin to function, depending on their tendency to accept electrons. Nitrate is reduced first, followed by manganic compounds, ferric compounds, sulfate, and finally sulfite." In addition, "prolonged flooding (also ponding) causes decomposition of soil organic structural-binding materials, reduction of aggregate stability, and disruption of soil peds and the clogging of pores with microbial wastes reduce soil permeability. This slowdown may interrupt or impair the aerobic processes that are required for aerobic biological decomposition . . ." (Foth, 1990).

It is the impact of melting wastewater build-up, water perched due to frozen soil, the potential impact to soil structure, and inadequate microbial activity during freezing conditions that eventually develop into the anaerobic conditions that allow the undesirable anaerobic bacteria to take over when the soil oxygen is depleted. According to Tate (1995) oxygen-depleted conditions are typically found in swamps or marshes, rice paddies, sediments, and any other sites receiving inputs of easily decomposed organic matter, including, as described by EPA (1975) food process wastewater which contains a higher percentage of sugars rather than starchy or fibrous material.

Mechanical Aspects

Another critical aspect with regard to discharges occurring during winter conditions is frozen distribution equipment. Frozen spray heads and water lines impact the ability of the system to evenly distribute the water. It is very labor intensive to remove ice from frozen wastewater distribution equipment. Facilities are typically unable to keep their system completely clear of ice build-up. Discharges occurring through a malfunctioning distribution system will result in over-application of the wastewater. The Part 22 Rules require wastewater to be evenly distributed over a land treatment area.

Furthermore, control over the application rate of the wastewater is lost when the ice and snow build-up thaws. As stated earlier, facilities typically continue daily discharges throughout the winter months. As a result, each day's discharge, when combined with the volume of frozen wastewater which is thawing at an unknown and uncontrollable

rate has the potential of exceeding the authorized daily maximum hydraulic load to the land treatment system.

Conclusions and Recommendations for Winter Discharge of High Organic Content Wastewater

Experience has shown the discharge of wastewater containing elevated levels of BOD presents a significant risk to the water resources of the State of Michigan. Of particular concern are discharges of this nature occurring during the periods when winter conditions exist. As a result of the impacts to soil physical and microbiological characteristics from conditions associated with winter weather it is clear wastewater discharges occurring under such conditions should be managed in such a way so as to minimize the risk to water resources. The DEQ recommends facilities discharging such wastewater (regardless of season) to take the appropriate precautions to ensure the protection of these resources.

The DEQ has the authority and the responsibility to engage the regulated community and, where appropriate, assist them in their efforts to identify and address issues and concerns associated with the discharge of any wastewater to the waters of the state. In order to reduce the potential threat to the groundwater resource the Water Bureau is recommending wastewater discharged, in general between November 15th and April 15th, be limited in effluent portion of the groundwater discharge permit as follows for BOD:

- 10 mg/l as a monthly average
- 25 mg/l as a daily maximum prior to discharge.

Based upon available information, it is expected these concentrations will not lead to adverse impacts to the water resources of the state. However, facilities may also propose an alternative concentration which must be demonstrated by the discharger, to the satisfaction of the DEQ, to be protective of the water resources of the State.

Winter conditions also impact the performance of wastewater distribution equipment. The DEQ recommends groundwater discharges which occur during winter conditions to be accomplished through the use of rapid infiltration and consistent with the requirements of Part 22 in that regard. The use of spray irrigation and or overland flow distribution technologies for discharges occurring during winter conditions is considered less than optimal due to the tendency for these types of technologies to freeze or otherwise malfunction which leads to potential conflicts with rule based distribution requirements. The use of disposal methods other than rapid infiltration may be considered for winter discharges if the discharger can demonstrate to the DEQ's satisfaction the technology can function properly during the period when winter conditions occur and will be so maintained.

Food Processors. Wastewater Strategy
March 3, 2009

By following the aforementioned recommendations it is expected facilities that engage in activities which result in the production of wastewater with high organic content can operate throughout the winter season with minimal potential for adverse impacts to the water resources of the state.

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