

# Generally Accepted Agricultural and Management Practices for the Care of Farm Animals

---

January **2021 - DRAFT**  
Michigan Commission of  
Agriculture & Rural Development  
PO BOX 30017  
Lansing, MI 48909

---



In the event of an agricultural pollution emergency such as a chemical/fertilizer spill, manure lagoon breach, etc., the Michigan Department of Agriculture and Rural Development and/or the Michigan Department of Environment, Great Lakes, and Energy (EGLE) should be contacted at the following emergency telephone numbers:

Michigan Department of Agriculture and Rural Development: 800-405-0101  
Michigan Department of Environment, Great Lakes, and Energy's Pollution  
Emergency Alerting System (PEAS): 800-292-4706

If there is not an emergency, but you have questions on the Michigan Right to Farm Act or items concerning a farm operation, please contact the:

Michigan Department of Agriculture and Rural Development (~~MDARD~~)  
Right to Farm Program (~~RTF~~)  
P.O. Box 30017  
Lansing, Michigan 48909  
517-284-5619  
517-335-3329 FAX  
877-632-1783

## Table of Contents

<b>PREFACE</b>	<b><i>iii</i></b>
<b>OVERVIEW</b>	<b>1</b>
<b>BEEF CATTLE AND BISON</b>	<b><i>43</i></b>
<b>DAIRY</b>	<b><i>1310</i></b>
<b>VEAL</b>	<b><i>2118</i></b>
<b>SWINE</b>	<b><i>2724</i></b>
<b>EQUINE</b>	<b><i>3733</i></b>
<b>PRIVATELY OWNED CERVIDAE</b>	<b><i>4843</i></b>
<b>SHEEP and GOATS</b>	<b><i>5347</i></b>
<b>LAYING CHICKENS</b>	<b><i>5953</i></b>
<b>BROILERS, TURKEYS, AND GAMEBIRDS</b>	<b><i>6558</i></b>
<b>DOMESTIC RABBITS</b>	<b><i>7063</i></b>
<b>FARM-RAISED MINK AND FOX</b>	<b><i>7669</i></b>
<b>AQUACULTURE SPECIES</b>	<b><i>8477</i></b>
<b>SOUTH AMERICAN CAMELIDS</b>	<b><i>9184</i></b>
<b>BEEKEEPING AND APIARY MANAGEMENT</b>	<b><i>9790</i></b>
<b>ADVISORY COMMITTEE</b>	<b>99</b>

## PREFACE

The Michigan legislature passed into law the Michigan Right to Farm Act, (Act 93 of 1981, as amended), which requires the establishment of Generally Accepted Agricultural and Management Practices (GAAMPs). —These practices are written to provide uniform, statewide standards and acceptable management practices based on sound science. —These practices can serve producers in the various sectors of the industry to compare or improve their own managerial routines. —New scientific discoveries and changing economic conditions may require revision of the pPractices. The GAAMPs are reviewed annually and revised as considered necessary.

The GAAMPs that have been developed are as follows:

- 1) 1988 - Manure Management and Utilization
- 2) 1991 - Pesticide Utilization and Pest Control
- 3) 1993 - Nutrient Utilization
- 4) 1995 - Care of Farm Animals
- 5) 1996 - Cranberry Production
- 6) 2000 - Site Selection and Odor Control for New and Expanding Livestock Facilities
- 7) 2003 - Irrigation Water Use
- 8) 2010 - Farm Markets

These practices were developed with industry, university and multi-governmental agency input. As agricultural operations continue to change, new practices may be developed to address the concerns of the neighboring community. Agricultural producers who voluntarily follow these practices are provided protection from public or private nuisance litigation under the Right to Farm Act.

This GAAMP does not apply in municipalities with a population of 100,000 or more in which a zoning ordinance has been enacted to allow for agriculture, provided ~~that~~ the ordinance designates existing agricultural operations present prior to the ordinance's adoption as legal non-conforming uses as identified by the Right to Farm Act for purposes of scale and type of agricultural use.

The website for the GAAMPs is at <http://www.michigan.gov/righttofarm>

## OVERVIEW

These voluntary Generally Accepted Agricultural and Management Practices (~~Practices~~GAAMPs) are intended to be used by the livestock industry and other groups concerned with animal welfare as an educational tool in the promotion of animal husbandry and care practices. -The recommendations do not claim to be comprehensive for all circumstances; but attempt to define general standards for livestock production and well-being on farm operations.

Scientifically derived guidelines and handbooks for species care are referenced in each section of the GAAMPs for the purpose of providing more detailed guidance when required. -Certain references used within this document must also be carefully considered based on production objectives. -The National Research Council (NRC) publishes various documents containing the nutrient requirements of domestic animals. These documents are referenced frequently herein. -In general, NRC requirements are for growing and reproducing animals experiencing different levels of productivity or performance. -That level of productivity or performance may not be sought or required in all situations. -Thus, referral to NRC herein is meant to serve as a guideline or resource, and not intended to be used as the minimum acceptable practice. -In all cases, the animal's nutritional needs for health and well-being must be met. -The assistance of a nutrition consultant in recognizing these needs ~~in a given~~in each production situation and subsequently in establishing a feeding program for that situation, is recommended.

These ~~Practices~~GAAMPs can serve producers in the various sectors of the livestock industry to compare or improve their own managerial routines. -It should be understood, ~~that~~ new scientific discoveries, legislation, and changing economic conditions may make necessary revision of the ~~Practices~~GAAMPs. In addition, farm operations may be engaged in producing animals to certain specifications that are audited and certified such as the National Organic Program, animal welfare or natural programs. -Farmers producing honey, meat, milk, ~~egg~~eggs, and other products should reference the program standards to adhere to animal care specifications. -The ~~Practices~~GAAMPs herein are written to address animal care across the board spectrum of farm operations in the state of Michigan.

Proper animal management is essential to the ~~well-being~~well-being of animals and the financial success of livestock operations. -A sound animal husbandry program provides a system of care that permits the animals to grow, mature, reproduce and maintain health. -~~SS~~Specific operating procedures depend on many objective and subjective factors unique to individual farm operations and the local environment.

In addition to husbandry, animal well-being is also a function of many environmental variables, including physical surroundings, nutrient ~~intake~~intake, and social and biological interactions. -Environmental conditions should minimize disease, death loss and behavioral problems and enhance performance. -~~Particular~~ ~~components~~Components of the environment that should be managed include housing,

space concentrations, pests, nutritional factors and water.- Domestic animals readily adapt to a wide range of environments.

Sometimes procedures that result in temporary stress and even some pain are necessary to sustain the long-term welfare of the animals. -Some of these procedures reduce aggressive behavior and injuries among animals. -These practices have developed over generations of animal care and husbandry and include, but are not limited to: beak-trimming, dehorning, tail docking and castration of males. -Various humane techniques are available, but at present, no technique can be recommended as ideal under all circumstances for any species.

The livestock industry is involved in many activities that require the movement of animals. -The handling of livestock in shows, exhibitions, fairs, and races should always be done with primary concern for handler, public, and animal safety. -Animals need to be humanely trained, shown, and exhibited using safe and non-harmful devices and procedures. -Animal care under exhibition conditions can differ from farm conditions; but, the basic needs of animals remain the same.

Transportation by road, boat, rail and air requires careful planning to reduce adverse effects on animals. -Animal should be fit and able to withstand transport. -Any preconditioning of the animals to the conditions they will face will ease their stress during transportation. -Vehicles should be of adequate size and strength for the animals carried. -Floors, in particular, should be in good repair and sufficiently solid to prevent animals from breaking through. -The inside walls and lining should have no sharp edges or protrusions likely to cause injury. -Vehicles should be constructed of materials that are easily cleaned and kept as clean as possible. -Enclosed vehicles must have adequate ventilation, especially when stationary.

A complete manure management plan is suggested when caring for farm animals. -The goals of this plan should be to:

- Maintain acceptable levels of animal health and production through clean facilities;
- prevent pollution of water, soil, and air;
- minimize generation of odors and dust;
- minimize vermin and parasites; and,
- compliance with local, state, and federal laws, regulations, and policies.

A farm or farm operation that conforms to these and other applicable GAAMPs adopted under the Michigan Right to Farm Act according to the Michigan Right to Farm Law (Act 93 of 1981, as amended), shall not be found to be a public or private nuisance. This protection also covers farm operations that existed before a change in the land use or occupancy of land within one mile of the boundaries of the farmland, if before that change, the farm would not have been a nuisance. -Likewise, this conditional protection applies to any of the following circumstances (Section 3):

- (b)(a) A change in ownership or size.
- (e)(b) Temporary cessation or interruption of farming.
- (d)(c) Enrollment in governmental programs.
- (e)(d) Adoption of ~~new technology~~ innovative technology.
- (f)(e) A change in type of farm product being produced.

Domestication of livestock has made farm animals dependent on humans. Consequently, humans have accepted this dependence as a commitment to practice humane conduct towards domestic animals and to prevent avoidable suffering at all stages of their lives. -These voluntary Practices GAAMPs represent a step toward meeting that commitment. -The se Practices GAAMPs include care for the major farm animals raised in Michigan.

Owners of calves raised for veal, gestating sows, or egg-laying hens need to be aware of Act No. 117, Public Acts of 2009. This law identifies some specific care standards for these types of animals on farms. -Requirements for veal calves ~~become~~ became effective October 1, 2012. Requirements for gestating sows and egg-laying hens ~~become~~ became effective in 2020 (10 years after the law was enacted).

## BEEF CATTLE AND BISON

### MANAGEMENT OVERVIEW

Because of similarities among production practices between beef cattle and bison, ~~Generally Accepted Agricultural and Management Practices (Practices)~~ GAAMPs for care of these animals will be similar in many cases. -Unless specified otherwise, the term “cattle” used throughout this section will refer to both beef cattle and bison. Genetic variation among cattle species, breeds and individuals makes it possible for them to thrive in a wide range of natural conditions and artificial environments. - When behavioral and physiological characteristics of cattle are matched to local conditions, cattle thrive in virtually any natural environment in Michigan without artificial shelter. Protection, however, may be beneficial, especially for newborns, during adverse weather conditions. -Cattle reside on pastures and woodlots, in small drylot facilities, in a variety of ~~different types~~ diverse types of feedlots, and in confinement. Programs and manuals covering the proper care and management of beef cattle can be found at the web-sites listed for Beef Quality Assurance and for bison at the web-site for National Bison Association (see references).

### MANAGEMENT PRACTICES

**Nutrition:** Feed and water should be presented to cattle in ways that minimize contamination by urine, feces, and other materials. -Feed bunks, where used, should be monitored and kept clean. -Animals should be fed and watered in a manner consistent with one of the following publications: -Nutrient Requirements of Beef Cattle (National Research Council, 1984, ~~1996~~ 2000, and National Academies of Sciences, Engineering, and Medicine, 2016 ~~editions~~); National Beef Cattle Handbook (Midwest Plan Service, 1999; Bison Producers Handbook (1<sup>st</sup> and 2<sup>nd</sup> edition; National Bison Association); and Buffalo Producer’s Guide to Management and Marketing (Dowling, 1990). -Avoid feed and water interruption that lasts longer than 24 hours.

Cattle may vary considerably in body weight ~~during the course of~~ during grazing and reproductive cycles. Feeding programs should make it possible for animals to regain the body weight lost during the normal periods of negative energy balance. -Cattle should have frequent or free access to a source of clean water. -When continuous access to water is not possible, ~~individual animals should have access to~~ water should be made available at minimum for a minimum of 30 minutes per animal each day ~~daily~~, ~~or more frequently depending on weather conditions, amount of feed consumed, and level of production of the animals.~~ -Warmer weather conditions, greater amounts of feed consumed, and higher levels of animal production may increase this suggested minimum access time. - Snow has been shown to be an acceptable source of water for a short period of time (Degen and Young, 1990<sup>a</sup> and Degen and Young, 1990<sup>b</sup>).



**Manure Management and Sanitation:** Manure management should conform to the recommendations presented in the current Right to Farm Practices Manure Management and Utilization GAAMPs (Michigan Agriculture Commission). -Midwest Plan Service (1993) has a publication on recommended waste handling facilities. -For the pasture-pasture-based systems, manure management and sanitation are less of a ~~concern~~concern, but care should be taken to protect surface waters and prevent erosion. -When surface waters are used as a water source, it is recommended that cattle have restricted-controlled crossing and drinking access to lakes, streams, and wetlands (Rector and Powers. 20092008). -Cattle crossings and watering sites should be constructed to minimize erosion and water pollution.

Cattle may be managed indoors on a bedded pack, which combines manure storage with a permeable and/or moisture-absorbing bedding material. -Materials used for bedding vary, but often consist of crop straws, crop residues, grain hulls, wood shavings, or sawdust. Maintenance of a firm, relatively dry environment that maintains cattle health and comfort, depends on management of cattle stocking rate, adequate air ventilation, bedding addition frequency, and periodic manure removal (Pastoor, et al., 2012; Endres and Schwartzkopf-Genswein, 2018).

**Animal Handling and Restraint:** Some aggressive behaviors of larger farm animals risk the health and well-being of herd mates as well as the humans handling these animals. -Such behaviors may be ~~modified~~modified, and their impact reduced by a number of acceptable restraint devices (e.g., hobbles, squeeze chutes, and stanchions) and practices. -Restraint should be the minimum necessary to control the animal and still ensure the safety of attendants. Restraints and chutes should be free of sharp edges and ramps should have solid sides and ~~the~~ cleats be eight inches” apart on the floor to reduce slips and falls. Cattle should be moved at a normal and comfortable pace. Proper design of the handling facility will facilitate safe animal movement (Grandin, 2014; National Cattleman’s Beef Association, 2019, Midwest Plan Service, 19951987). Roping of cattle is necessary under certain conditions (e.g., in pastures when an animal needs treatment and no restraining facility is readily available). -It is strongly encouraged to apply the principles of low stress handling when moving cattle and bison (Bartlett and Swanson, n.d., and Grandin et al., 2015).

Bison are less domesticated than cattle and require special handling facilities. -Specific practices can be obtained from the Bison Producers Handbook (1<sup>st</sup> edition; National Bison Association, 2016) and Buffalo Producer’s Guide to Management and Marketing (Dowling, 1990). -Bison are much more nervous and excitable in close quarters. -Work bison slower and calmer than you would other stock. -Handling facilities will need to be stronger and taller than pasture fences. ~~Your facility~~Facilities for capturing, sorting, treating, testing, loading out, or confining your bison should be strong, long lasting, cost efficient, and most importantly, safe for ~~you and your animals~~animals and the operator (National Bison Association).

**Transportation:** Safety and comfort should be the primary concerns in the transportation of any animal. -A delay or cancellation of transport should occur for animals that appear unhealthy, ~~dehydrated~~dehydrated, or exhausted, unable to stand, and unfit to withstand travel (AABP ~~2014~~2019). -When animals are transported, they should be provided with proper ventilation and a floor surface that minimizes slipping. Animal injuries, bruises, and carcass damage can result from improper handling of animals during transport. -Recommendations on facility design for loading and unloading trucks and restraint of animals have been published (Grandin, 2000).

Additional information is available on the Beef Quality Assurance section of the National Cattlemen's Beef Association NCBA website (<http://www.bqa.org/resources/manuals>). ~~Transport~~ Transport and handling stresses can be aggravated greatly by adverse weather conditions, especially when the weather is changing rapidly. - Water and feed ~~should~~ must be readily available for long trips as described in Federal Regulations (~~the~~ Transportation of Animals statute ~~from the U.S. Code~~ (49 USC Sec. 80502 Reference)). The maximum transportation duration is based on the 28-hour rule. Stocking density and bedding should be adjusted for extreme weather conditions. More information on handling cattle can be found at Beef Quality Assurance web-site (see references). All Michigan cattle moving to show, sale or exhibition on or after March 1, 2007 are required to have an official (Michigan Animal Industry Act. Act 466 of 1988. MCL section 287.711b) Radio Frequency Identification (RFID) ear tag. This includes all out-of-state cattle exhibited in Michigan.

## **RECOMMENDATIONS FOR THE ENVIRONMENT**

Cattle on pasture and woodlots are often monitored less directly and less frequently than cattle raised in other indoor systems. - Cattle in woodlot and pasture systems are more likely to be affected by weather, predators, insects, internal and external parasites, poisonous plants, and variation in feed supply. -Hot or extremely cold weather is stressful and special accommodations may be needed (National Research Council, 1981). -In extreme heat, cattle will be more comfortable with provision of shade and free access to water. Air temperature, humidity, and movement should be considered to ensure animal comfort and dietary alterations to reduce heat stress. -Likewise, cattle exposed to extreme cold and wind chill should be provided extra feed and shelter from the wind. -A properly maintained perimeter fence is ~~recommended~~ required for the safety of the animals and surrounding community (Michigan Fences and Fence Viewers. Act 34 of 1978. MCL section 43.51 et seq.). -Cattle in back-grounding facilities or feed yards must be offered adequate space for comfort, ~~socializations~~ socialization, and environmental management. -Periodic pen maintenance and cleaning are strongly encouraged. -When muddy conditions exist, realistic intervention, such as addition of bedding, should be employed.

The quality-strength and height of fencing is more important for bison than beef cattle. Many producers recommend an exterior fence of six feet in height. -If a bison can get his-its nose over the fence and wants to be out, it is likely the animal will try to jump or

push over the fence. -Grown bulls can make a standing six-foot jump, if so inclined (National Bison Association).

## FACILITIES AND EQUIPMENT

Cattle may be housed in intensive management systems, either indoors or in open lots, with or without overhead shelter. -Proper airflow and ventilation are essential in confinement facilities to control for gas and particulate matter. -For open lots, south-sloping exposure, mounds, and a windbreak are recommended so dry areas with low air velocities are available for the cattle to rest. -Floors in housing facilities should be properly drained. -Barns and handling alleys should provide adequate traction to prevent injuries to animals and handlers. -Additionally, handling alleys and pens should be free of sharp edges and protrusion to prevent injuries. -Handling facilities should be designed to encourage safe animal movement as much as possible. -When handling the animals, excessive noise should be avoided. -Hydraulic and mechanical equipment should be adjusted to the size of the animal to minimize injuries.

For additional information, see the Structures and Environment Handbook (Midwest Plan Service, 1987), Grandin, 2000, Boyles, et al. undated2002, and the Beef Housing and Equipment Handbook (Midwest Plan Service, 19951987).

## HEALTH CARE AND MEDICAL PROCEDURES

Adequate health care is an essential part of a profitable cattle operation. -A health care program should be planned to address potential problems as appropriate for local conditions. -Appropriate health care involves: -1) methods to prevent, control, diagnose, and treat diseases and injuries; 2) training and guidance to animal caretakers on appropriate antibiotic therapy; 3) instruction on proper handling of pharmaceuticals and biologicals and withdrawal times, and, 4) adequate record keeping systems. -All confined animals must be observed daily for signs of illness, injury, or unusual behavior. ~~Organic production programs should work with a veterinarian to ensure adequate protection and treatment for sick animals.~~

Methods of prophylaxis, diagnosis, therapy, vaccinationvaccination, and disease control should follow currently accepted practices. -Assistance from a veterinarian in

establishment of a health care program is recommended. -Organic production programs should work with a veterinarian to ensure adequate protection and treatment for sick animals.

**Pharmaceutical Use:** It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products. -To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. -In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. -Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. ~~T~~there is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and,
- ~~t~~ 3. ~~T~~he veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:** -Animals that are seriously injured or ill and show no promise for recovery after 2 days of treatment should be euthanized immediately. -Methods can be physical (captive bolt gun or firearm) or chemical and one of the approved methods ~~r~~recommended by the [American Veterinary Medical Association AVMA](#) Guidelines on Euthanasia (AVMA, 2020). Manually applied blunt force trauma is unacceptable.

**Dead Animal Disposal:** -Animal tissue, whole ~~carcasses~~~~carcasses~~, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

**Non-Ambulatory (Downed) Cattle:** -A prompt examination should be performed on non-ambulatory animals to determine whether extended care or euthanasia is recommended. -If the animal is not in extreme distress and continues to eat and drink, it is recommended that the producer contact a veterinarian for assistance/advice and provide food, water, shelter, and appropriate nursing care to keep the animal comfortable. -If the animal is in extreme distress and the condition is obviously

irreversible, the animal should be euthanatized immediately. -Downed animals should be moved carefully to avoid compromising animal welfare. -Dragging downed animals is unacceptable. -Non-ambulatory animals are not fit for transport and must not be sent to a livestock market or to a processing facility ([AABP, 2019](#)).

### Beef Quality Assurance

Beef Quality Assurance ([BQA](#)) and Beef Quality Assurance Transportation ([BQAT](#)) are ~~is a~~ training and certification programs supported by ~~the~~ Beef Checkoff funding to ensure cattle are properly cared for and a safe and nutritious product is presented to consumers. -It is recommended all owners/managers of cattle consider receiving training on the proper handling and care of livestock, antibiotic stewardship, and transportation of cattle. ~~This~~ Certification in BQA and BQAT is mandatory ~~training~~ for commercial truckers and owners/managers of cattle entering some cattle processing facilities.

## REFERENCES

American Association of Bovine Practitioners ~~2014-2019~~ Transportation and fitness-to-travel recommendations for cattle ~~Recommendations for Cattle~~.

~~[https://www.aabp.org/Resources/AABP\\_Guidelines/transportationguidelines-2019.pdf](https://www.aabp.org/Resources/AABP_Guidelines/transportationguidelines-2019.pdf)~~~~[http://www.aabp.org/resources/aabp\\_guidelines/transportationguidelines-03-11-2014.pdf](http://www.aabp.org/resources/aabp_guidelines/transportationguidelines-03-11-2014.pdf)~~. (Visited ~~6.22.2018~~7.29.2020)

American Veterinary Medical Association. 2020. AVMA ~~Guidelines~~ guidelines on for the Euthanasia ~~euthanasia~~ of Animals ~~animals: 2020 Edition~~. Available at:

~~<https://www.avma.org/sites/default/files/2020-01/2020-Euthanasia-Final-1-17-20.pdf>~~~~<https://www.avma.org/KB/Policies/Documents/euthanasia-highres.pdf>~~ (Visited ~~6.228.2018~~2020)

Bartlett, B. and J. Swanson. ~~n.d.~~ Low-stress ~~Cattle~~ cattle Handling ~~handling~~: The ~~Basics~~ basics. ~~<http://msue.anr.msu.edu/uploads/236/58549/LowStressHandling.pdf>~~. (Visited 6.14.18)

Beef Quality Assurance. Programs. Funded by Beef Checkoff. ~~<https://www.bqa.org/programs>~~ (Visited 7.29.2019)

BQA Transportation

BQA Stockmanship and Stewardship

Dairy FARM Program

Beef Quality Assurance. Manuals. Funded by the Beef Checkoff. ~~<https://www.bqa.org/resources/manuals>~~ (Visited 7.29.2019)

National BQA Manual

Antibiotic Stewardship for Beef Producers

Cattle Industry Guidelines for the Care and Handling of Beef Cattle

Boyles, S., J. Fisher, and G. Fike. Cattle Handling ~~handling~~ and Working ~~working~~ Facilities ~~facilities~~. Bulletin #906. Ohio State University Extension, Columbus. ~~<https://agmr.osu.edu/sites/agmr/files/imce/pdfs/Beef/CattleFacilities.pdf>~~ ~~Bulletin # 906~~. (Visited 6.22.18)

Degen, A.A. and B.A. Young. 1990<sup>a</sup>. The performance of pregnant beef cows relying on snow as a water source. Can. J. Anim. Sci. 70:507-515.

Degen, A.A. and B.A. Young. 1990<sup>b</sup>. Average daily gain and water intake in growing beef calves offered snow as a water source. Can. J. Anim. Sci. 70:711-714.

Dowling, Kim. 1990. "Buffalo Producer's ~~producer's~~ Guide ~~guide~~ to Management ~~management~~ and Marketing ~~marketing~~." Ft. Pierre, S.D.: National Buffalo Assn., Jennings, Dana C., and Hebring, Judi.

Endres M. I., and K. Schwartzkopf-Genswein 2018. Overview of cattle production systems. In: C. B. Tucker, Ed. Advances in cattle welfare. Woodhead Publishing, Kidlington, U.K. p. 1-26. <https://doi.org/10.1016/B978-0-08-100938-3.00001-2>.

Ensminger, M.E. 1970. The Stockman's Handbook. 4th Ed. Interstate, Danville, IL.

Grandin, T. 2014. Livestock Handling handling and Transporttransport. 4<sup>th</sup> Edition. CABI. ISBN 9781780643212

Grandin, T. 2000. Behavior of cattle, pigs, buffalo, and antelope during handling and transport. <https://www.grandin.com/behaviour/transport.html> Visited (4/29/19)

Grandin, T. 2000. Livestock Handling handling Systemssystems, Cattle cattle Corralscorrals, Stockyardsstockyards, and Racesraces. <http://www.grandin.com/behaviour/transport.html>. Visited 6.14.18.

Grandin, T., J. Lanier, and M. Deesing. 2015. Low Stress stress Methods methods for Moving moving and Herding herding Cattle cattle on Pasturespastures, Paddockspaddocks, and large Feedlot feedlot Penspens. <http://grandin.com/B.Williams.html>. (Visited 6.14.18)

Michigan Commission of Agriculture and Rural Development. Generally Accepted accepted Agricultural agricultural and Management management Practices practices for Manure manure Management management and Utilization utilization. Lansing, MI.

Michigan Animal Industry Act. Act 466 of 1988. MCL Section 287.711b. Official identification. [http://www.legislature.mi.gov/\(S\(5dyru4stwxpuwwjfftcs0no5\)\)/mileg.aspx?page=getObject&objectName=mcl-287-711b](http://www.legislature.mi.gov/(S(5dyru4stwxpuwwjfftcs0no5))/mileg.aspx?page=getObject&objectName=mcl-287-711b) see also: [https://www.michigan.gov/mdard/0,4610,7-125-48096\\_48149---,00.html](https://www.michigan.gov/mdard/0,4610,7-125-48096_48149---,00.html). (Visited 6.10.20)

Michigan Bodies of Dead Animals Act. Act 239 of 1982. MCL section 287.651. [http://www.legislature.mi.gov/\(S\(5dyru4stwxpuwwjfftcs0no5\)\)/mileg.aspx?page=getObject&objectName=mcl-Act-239-of-1982](http://www.legislature.mi.gov/(S(5dyru4stwxpuwwjfftcs0no5))/mileg.aspx?page=getObject&objectName=mcl-Act-239-of-1982) see also: [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited (4/29/19)-2008

Michigan Fences and Fence Viewers, Act 34 of 1978. MCL section 43.51 et seq. [http://www.legislature.mi.gov/\(S\(5dyru4stwxpuwwjfftcs0no5\)\)/mileg.aspx?page=getObject&objectName=mcl-Act-34-of-1978](http://www.legislature.mi.gov/(S(5dyru4stwxpuwwjfftcs0no5))/mileg.aspx?page=getObject&objectName=mcl-Act-34-of-1978).

Midwest Plan Service. 1993. Livestock Waste waste Facilities facilities Handbookhandbook. Midwest Plan Serv., Iowa State Univ., Ames, IA. Third Edition, MWPS-18.

Midwest Plan Service. ~~1995~~1987. Beef ~~Housing~~housing and ~~Equipment~~equipment ~~Handbook~~handbook. 4th Ed. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service ~~1999~~. ~~National~~ Beef ~~cattle~~ ~~Handbook~~handbook. Midwest Plan Serv., Iowa State Univ., Ames, IA.

~~National Bison Association. 2001. Bison Breeders Handbook. 4th Ed. Mountain West Printing Denver, CO.~~

~~National Bison Association. 2010. Bison producers' handbook. 1<sup>st</sup> Ed. National Bison Assoc. Westminster, CO.~~

~~National Bison Association. 2016. Bison producers' handbook. 2<sup>nd</sup> Ed. National Bison Assoc. Westminster, CO.~~

National Bison Association. <https://www.bisoncentral.com>. (Visited 6.14.18).

~~National Cattlemen's Beef Association. 2019. Beef Quality Assurance national manual. NCBA, Centennial, CO~~ <https://www.bqa.org/resources/manuals>

~~National Research Council. 1981. Effect of environment on nutrient requirements of domestic animals. The National Academies Press, Washington, D.C.~~ <https://doi.org/10.17226/4963>.

National Research Council. 1984. Nutrient Requirements of Beef Cattle. 6th Rev. Ed. National Academies Press, Washington, DC. <https://doi.org/10.17226/19398>.

~~National Research Council. 1996. Nutrient Requirements of Beef Cattle. 7th Rev. Ed. National Academy Press, Washington, DC.~~

~~National Research Council. 2000. Nutrient requirements of beef cattle. 7<sup>th</sup> Rev. Ed. Update 2000. The National Academies Press, Washington, D.C.~~ <https://doi.org/10.17226/9791>.

~~National Academies of Sciences, Engineering, and Medicine. 2016. Nutrient requirements of beef cattle. 8<sup>th</sup> Rev. Ed. The National Academies Press, Washington D.C.~~ <https://doi.org/10.17226/19014>. ~~National Research Council. 2016. Nutrient Requirements of Beef Cattle. 8th Rev. Ed. National Academy Press, Washington, DC.~~

~~Pastoor, J. W., D. D. Loy, A. Trenkle, and J. D. Lawrence. 2012. Comparing fed cattle performance in open lot and bedded confinement feedlot facilities. Prof. Anim. Sci. 28:410-416.~~ [https://doi.org/10.15232/S1080-7446\(15\)30381-8](https://doi.org/10.15232/S1080-7446(15)30381-8).

Rector, ~~Natalie N.~~ and ~~Wendy W.~~ Powers. ~~2009~~2008. Acceptable practices for managing livestock along lakes, streams, and wetlands. Michigan State University Extension. Bulletin E3066. <http://www.msue.msu.edu>. (Visited 5.6.18)



Transportation of [Animalsanimals](#). 2006. 49 USC Sec.80502.  
<https://www.gpo.gov/fdsys/granule/USCODE-2011-title49/USCODE-2011-title49-subtitleX-chap805-sec80502> (Visited 6.22.18)

## DAIRY

### MANAGEMENT OVERVIEW

Michigan's female dairy cattle population is currently over [422426](#),000 mature dairy cows (USDA's National Agricultural Statistics Service) and about 378,000 calves and heifers. The remainder of the dairy population consists of castrated calves used for veal, dairy steers raised for beef and approximately 4,000 bulls used for breeding purposes. -Proper care of dairy animals consists of providing a clean, comfortable environment, adequate access to quality feed and water while employing management techniques designed to limit injuries, stress, [diseasesdiseases](#), and disorders. Proper care of animals can be maintained with either confinement or pasture management systems.

Dairy cows, because of milk production, have special needs that require proper management every day. -Calves and heifers should be managed to minimize health problems and to provide for adequate growth and development. -Application of sound management practices will result in healthy dairy cows, and healthy, properly grown calves and heifers.

### MANAGEMENT PRACTICES

Management practices on a dairy farm are specific for five classes of dairy cattle: calves, heifers, dry cows, lactating cows, and bulls. -Calf mortality and morbidity from birth to weaning can be minimized by utilizing sound management practices (Raising Dairy Replacements; Midwest Plan Service, 2003).

**Newborn Calves:** -Calves should be born in a clean, dry environment and receive an adequate amount (12-15% of body weight) of high-quality colostrum soon after birth. Hand feeding ensures that each calf receives an adequate amount of colostrum (Raising Dairy Replacements, 2003, Feeding the Newborn Calf, Pennsylvania State Extension, 2003). - To ensure their health, calves are normally removed from their mothers immediately or as soon as the calf's hair coat is dry to reduce risk of exposure to infectious pathogens (Raising Dairy Replacements, 2003). - Newborn calves remain healthier when housed individually in a clean, properly ventilated environment (Raising Dairy Replacements, 2003, Penn State for Calf and Heifer Housing, The Welfare of Veal Calves, 1994). -Young calves are normally fed milk or milk replacer during the first 6-8 weeks of life. - Calves should be observed several times a day. The amount of feed and times fed per day should increase as temperatures decrease in the winter.

Some farms use automated or robotic nursing machines during part of this stage of a calf's life which may involve group pens with adequate clean and dry bedding and proper ventilation. -Stocking rates of no more than 25 calves per nipple are advised, calves can be started on feeders by day 7 to day 14. - Prior to moving calves, monitoring immune levels and individual housing help determine if calves are healthy and eating well (James et al, 2017). -Increased calf density will impact air quality as well. Sick calves should be isolated to minimize disease spread.

**Calves and Heifers:** -Calves are normally weaned when adequate intake of dry feed has been reached (NRC 2001). -All calves should have access to clean, fresh water and nutritionally adequate diets to support an appropriate growth rate. - Proper heifer growth can be achieved with varied management systems (Raising Dairy Replacements, 2003). - Heifer and intact male calves can be housed together from 2-6 months but bull calves should be separated after that to prevent early pregnancies. - Heifers should be managed in groups to ensure adequate access to feed and water. -The number of groups will depend on herd size. - Each group of heifers should be fed a balanced ration (NRC 2001) to maintain adequate growth.

Underfeeding delays normal heifer development. -Overfeeding may result in overly fat heifers that may cause health problems at first calving.

Heifers may be bred upon reaching an adequate size and weight (Raising Dairy Replacements, 2003, Midwest Plan Service). - Use of artificial insemination or natural service (bull) are acceptable practices to breed heifers and/or cows.

**Dry Cows:** -Cows benefit from a dry period prior to a subsequent lactation. - Restricting feed and water intake a few days prior to dry-off are acceptable practices that will aid cessation of milk secretion and improve udder health (Managing the Dry Cow for More Profit, 1996). Nutrition must be adequate to allow mammary involution and the support the needs of the fetus.

Proper management of the lactating cow starts during the dry period. -Since approximately 70 percent of health problems in a dairy herd are associated with calving, proper management of pre-calving, calving and post calving periods will improve the health of mother and calf. - A clean and dry environment should be provided for bred heifers and dry cows. - In addition, access to good nutritional diets that maintain appetite and feed intake should also be provided. - Nutrition for the majority of dry cows should follow a maintenance program according to NRC requirements (NRC 2001). - Nutrition and housing needs will change 2-3 weeks prior to calving.

**Lactating Cows:** -Nutrition programs for dairy cows should provide for adequate intake of the essential nutrients needed for maintenance, growth, milk production and proper development of the fetus (NRC 2001). -Grouping cows according to nutrient needs will help meet the nutrient requirements of any particular cow. Good quality, fresh water must be available at all times.

**Animal Handling:** -Facilities designed specifically to handle dairy cattle for health checks or treatment, vaccinations, weighing, or hoof trimming and for handling bulls during hand-mating will decrease risk of injury to cattle and people, as well as, reducing the stress of handling. -All traffic areas should have non-skid surfaces that avoid causing excessive hoof wear. -A number of Several restraint devices are acceptable, such as halters, hobbles, breeding chutes, squeeze chutes, headlocks, tables and stanchions. -Restraint should be the minimum necessary to control the animal and ensure the safety of the animal and attendants. -Proper design of the handling facility will facilitate animal movement.

**Transportation:** - Safety and comfort of dairy cattle should be the primary concerns in their transportation. -A delay or cancellation of transport should occur for animals that appear unhealthy, dehydrateddehydrated, or exhausted and unfit to withstand travel (AABP, 2014). Animals should be provided with adequate ventilation and a floor surface to minimize slipping. -Animal injuries, bruises, and carcass damage can result from improper handling of animals during transport. -Recommendations on facility designs for loading and unloading trucks and restraint of animals have been published (Grandin 2000, Cattle Handling and Transport, 2007). - Transport and handling stresses can be aggravated greatly by adverse weather conditions, especially when the weather is changing rapidly. -Water and feed should be readily available for long trips as described in Federal Regulations (the Transportation of Animals statute from the U.S. Code (49 USC Sec. 80502 Reference). -All Michigan cattle moving to show, sale or exhibition on or after March 1, 2007 are required to have an official RFID ear tag. -This includes all out-of-state cattle exhibited in Michigan.

## RECOMMENDATIONS FOR THE ENVIRONMENT<sup>1</sup>

Proper management of the environment enhances animal production and minimizes animal disease, death loss, and behavioral problems. -Dairy cattle are bred for growth, production, and reproduction in a variety of environments to which they can readily adapt. They can be raised outdoors on pasture, dry lot, and in hutches, or indoors in stalls and pens.

Environmental temperature affects an animal's comfort that, in turn, affects an animal's behavior, metabolism, and performance. - Even though cattle are adaptable and can thrive in almost any region of the world, they must be protected from heat and cold stress caused by extreme weather events. - Access to shelter can be beneficial even in moderate climatic regions. -Heat stress adversely affects animal comfort as does cold stress. - Windbreaks, sunshades, or solid-roofed shelters are needed if trees or other landscape features do not provide adequate protection from winter storms and

---

<sup>1</sup> Condensed from environment chapter in Caring for Dairy Animals Reference Guide, 1994.

extremely cold or hot temperatures.- Sunshades, sprinklers, misting, fans, and other methods of cooling, as well as dietary alterations, will reduce heat stress during hot weather. -Air temperature, humidity, quality, and movement should be considered to ensure animal comfort and prevent diseases.

## **FACILITIES AND EQUIPMENT**

Housing for calves, heifers, and cows varies widely. However, each housing facility should provide adequate space per animal for eating, ~~drinking~~drinking, and resting (Dairy Freestall Housing and Equipment - MWPS #7. 2000, Bickert, W., and R. Stowell. 1994). Calf housing systems are varied, but it is recommended that calves be housed individually with cold housing preferred. -Cold housing ranges from calf hutches to larger naturally ventilated barns. -Bedding should be kept clean and dry. Adequate housing for heifers can range from bedded packs to free stalls to pasture. Housing should be well ventilated and keep heifers clean and dry. -Heifers should be protected from winter winds. ~~SS~~Summer resting areas may need shade.

Feed bunks or feeding areas should be designed to allow animals to eat with a natural motion.- Watering sites should be easily accessible to provide adequate water intake without risk of injury.- Adequate feed space per animal should be provided (Dairy Freestall Housing and Equipment- MWPS #7. 2000).

Milking equipment should be designed, ~~installed~~installed, and maintained correctly to provide for maximum comfort of the cow at milking (Milking Systems and Parlors, 2001, Building Freestall Barns and Milking Centers. 2003). -To eliminate the potential of stray voltage at time of milking, feeding, or watering, guidelines for proper wiring of a farm should be followed.- (Stray Voltage and Dairy Farms, 2003, Effects of Electrical Voltage/Current on Farm Animals. 1991).

## **HEALTH CARE AND MEDICAL PROCEDURES**

Proper care of dairy animals includes the establishment of a herd health program that covers all ages of cattle and emphasizes disease prevention. -Dairy farmers should establish a valid veterinarian/client/patient relationship with a licensed veterinarian to assist them in providing proper health care to their herd. -An ongoing preventive herd health program designed for each farm by the veterinarian and farmer will result in healthy animals. -This includes a veterinarian designed vaccination program for cows, calves, and heifers. -Appropriate health care involves: -1) methods to prevent, control, diagnose, and treat diseases and injuries; 2) training and guidance to animal caretakers on appropriate antibiotic therapy; 3) instruction on proper handling of pharmaceuticals and biologicals and withdrawal times; and 4) accurate record keeping systems with proper animal identification.- All confined animals should be observed daily for signs of

illness, injury, or unusual behavior. -Management practices to reduce the risk of introduction and spread of infectious disease should be implemented. -Health programs for heifers are designed to prevent disease and increase efficiency of growth. Organic production programs should work with a veterinarian to ensure adequate protection and treatment for sick animals.

External and internal parasites need to be controlled. -Pasturing may increase risk of internal parasites and will increase exposure to diseases carried by wild animals.

Suggested husbandry procedures such as castration, dehorning, removal of extra teats, etc. should be carried out by skilled personnel. -These procedures are best done when calves are small, but may be done at other times. -All procedures should follow the veterinarian's recommendations or accepted management practices. - These techniques can be done with little discomfort to calves, heifers, or cows (Seykora, 3<sup>rd</sup> Edition).

**Pharmaceutical Use:**- It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products. -To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended.- In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. - Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and,
3. The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Non-Ambulatory (Downed) Cattle:** -A prompt examination should be performed on non-ambulatory animals to determine whether extended care or euthanasia is recommended.- If the animal is not in extreme distress and continues to eat and drink, it is recommended that the producer contact a veterinarian for assistance/advice and

provide food, water, shelter, and appropriate nursing care to keep the animal comfortable.- If the animal is in extreme distress and the condition is obviously irreversible, the animal should be euthanized immediately. -Downed animals should be moved carefully to avoid compromising animal welfare. ~~DD~~ragging downed animals is unacceptable. Non-ambulatory animals must not be sent to a livestock market or to a processing facility.

**Euthanasia:** Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately.- Methods can be physical (captive bolt gun or firearms) or chemical and one of the approved methods recommended by the AVMA Guidelines on Euthanasia (AVMA, 2020). Manually applied blunt force trauma is unacceptable.

**Dead Animal Disposal:** Animal tissue, whole ~~carcasses~~carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

## REFERENCES

American Association of Bovine Practitioners. 2014. Transportation Recommendations for Cattle. [http://www.aabp.org/resources/aabp\\_guidelines/transportationguidelines-03-11-2014.pdf](http://www.aabp.org/resources/aabp_guidelines/transportationguidelines-03-11-2014.pdf) (Visited 6/22/2018)

American Veterinary Medical Association. 2020. AVMA Guidelines on Euthanasia of Animals. Available at: <https://www.avma.org/KB/Policies/Documents/euthanasia-highres.pdf> (Visited 6/22/2018)

Bickert, W., and R. Stowell. 1994. Hoard's Dairyman Plan Guide for Freestall Systems, Caring for Dairy Animals – Technical Reference Guide and On-The-Dairy Self-Evaluation Guide, Agri-Education, Stratford, IA. 2004

Cattle Handling and Transport, 3<sup>rd</sup> Ed. 2007. Grandin T, Ed. CABI International.

Dairy Freestall Housing and Equipment- MWPS #7. 2000. Midwest Plan Service, Iowa State University, Ames, IA.

Effects of Electrical Voltage/Current on Farm Animals. 1991. USDA Agriculture Handbook No. 696.

Feeding the Newborn Calf. Pennsylvania State Extension. 2003. <https://extension.psu.edu/feeding-the-newborn-dairy-calf> (Visited 6/22/2018)

James, Bob, Kayla Machado, Alyssa Dietrich. 2017. Group Housing Systems for Calves, Facilities, Equipment, Protocols and Personnel Proceedings Western Dairy Herd Management Conference.

Generally Accepted Agricultural and Management Practices for Manure Management and Utilization. Michigan Agriculture Commission. Lansing, MI.

Grandin, T. 2000. Behavior of cattle, pigs, buffalo, and antelope during handling and transport. <https://grandin.com/behaviour/transport.html>. (Visited 4/29/2019)

Livestock Waste Facilities Handbook. MWSP #18. 1995. Midwest Plan Service Iowa State University, Ames, IA.

Managing the Dry Cow for More Profit. 1996. MSU Staff Dairy Extension Notebook.

Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited 4/29/19)

Milking Systems and Parlors, 2001. Planning and Managing for Quality Milk and Profitability NRAES-131.

USDA's National Agricultural Statistics Service Great Lakes Regional Field Office  
[https://www.nass.usda.gov/Quick\\_Stats/Ag\\_Overview/stateOverview.php?state=MICHIGAN](https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=MICHIGAN) (Visited 6/25/2018)

NRC (National Research Council). 2001. Nutrient Requirements of Dairy Cattle. Seventh Rev. Ed. National Academy Press, Washington, DC.

Penn State Calves and Heifer Housing. 2008.  
<https://extension.psu.edu/calf-and-heifer-housing>. (Visited 6/25/2018)

Raising Dairy Replacements, 2003. Midwest Plan Service. <https://www-mwps.sws.iastate.edu/catalog/livestock-operations/dairy/raising-dairy-replacements-pdf> (accessed 6/25/2018)

Seykora, T. 2000. Practical Techniques for Dairy Farmers. 3<sup>rd</sup> Edition.  
<https://www.ansci.umn.edu/sites/ansci.umn.edu/files/practical-techniques.pdf> (Visited 6/25/2018)

Stray Voltage and Dairy Farms. NRAES-149. 2003.  
The Welfare of Veal Calves: A Review of the Scientific Evidence. 1994. Jeffrey Rushen. The Centre for the Study of Animal Welfare. University of Guelph, Guelph, Ontario, Canada.

Transportation of Animals. 2006. 49 USC Sec. 80502.  
<https://www.gpo.gov/fdsys/granule/USCODE-2008-title49/USCODE-2008-title49-subtitleX-chap805-sec80502> (accessed 6/25/2018)



# VEAL

## MANAGEMENT OVERVIEW

Most veal comes from dairy calves.- Three types of veal in the United States include: Bob veal, which are fed a milk-based liquid diet and marketed at less than three weeks of age and at less than 150 lbs., grain-fed veal, which are fed a milk-based liquid diet and possibly hay, pasture or other feeds including grain, -and formula-fed veal (also known as milk-fed or special-fed), which are fed a milk-based liquid diet throughout the feeding period (Schwartz, 1990).- Formula-fed veal is the most common in Michigan and these recommendations will be specific to this type.

## MANAGEMENT PRACTICES

Veal calves should be handled with the same management practices afforded to dairy calves. Special care, gentleness, and patience are recommended management practices for all dairy calves.- Until they are selected for veal production systems, they should receive the same husbandry practices as dairy replacement heifers.- Young dairy animals not intended for dairy herd replacements or formula-fed veal should follow beef management recommendations.

It is recommended that veal producers observe calves several times a day. -The herds person should monitor the feed intake and health of each calf (Guide for the Care and Production of Veal Calves, 1994) and provide appropriate health care.

Individual stall housing is a management recommendation for formula-fed veal production to minimize calf-to-calf contact which limits the spread of infectious diseases (Guide for the Care and Production of Veal Calves, 1994, Raising Dairy Replacements. 2003, The Welfare of Veal Calves, 1994).- This management practice is important, considering that veal calves are usually grouped together from many dairy farms, and the calves may have been exposed to disease at the collecting facilities.— Revision of the Michigan Animal Industry Act 446 of 1988, Sec 46(1) by Act 117, effective March 31, 2010 provides for the following regulations for calves raised for veal after October 1, 2012: 1) Calves should be able to fully extend all limbs without touching the side of an enclosure, and 2) turn around in a complete circle without any impediment, including a tether, and without touching the side of an enclosure or another animal.- If calves are to be housed in groups, it is recommended that calves be kept in individual pens for at least 1 to 2 months of age for health reasons (Roy, 1980, Stephens, 1982, van Putten and Elshop, 1982). -Ohio Livestock Care Standards for Veal recommend veal calves not be housed in group pens until 10 weeks of age and then a minimum of two veal calves in an area with a minimum of 14 square feet per calf. -Ohio guidelines are supported by the American Veal Association (personal communication - [Julian BartelseDale Bakke](#), AVA President). Size of groups and space per animal for group pens that calves are initially placed into should be considered as is done with weaned dairy calves to reduce stress caused by competition for food and space. -Determination

of area requirements should be based on body size, head height, stage of life cycle, behavior, health, and weather conditions. (Guide for the Care and Use of Agricultural Animals in Research and Teaching 2010). Draft control within a group pen should be accomplished by draft barriers (Raising Dairy Replacements, 2003).

Diets should be formulated to meet nutrient requirements for both maintenance and growth (NRC, 2001).- Feeding calves individually assures that competition among animals does not result in some animals receiving insufficient quantities of feed.- More efficient growth results because the farmer can feed calves differently, depending on weight, appetite, and individual calf differences.

**Transportation:** Safety and comfort should be the primary concerns in the transportation of any animal. A delay or cancellation of transport should occur for animals that appear unhealthy, ~~dehydrated~~dehydrated, or exhausted and unfit to withstand travel (AABP, 2014). -Animals should be provided with adequate ventilation and a floor surface to minimize slipping. -Animal injuries, bruises, and carcass damage can result from improper handling of animals during transport. -Recommendations on facility design for loading and unloading trucks and restraint of animals have been published (Grandin 2000, Cattle Handling and Transport, 2007, Modern Veal Production, 1989). -Transport and handling stresses can be aggravated greatly by adverse weather conditions, especially when the weather is changing rapidly. -Water and feed should be readily available for long trips as described in Federal Regulations (the Transportation of Animals statute from the U.S. Code 49 USC Sec. 80502 Reference).

## **RECOMMENDATIONS FOR THE ENVIRONMENT**

A clean, dry, draft-free building or outside surrounding is recommended for animal comfort and performance.- For enclosed “warm” buildings, ventilation rates in winter should be sufficient to remove moisture produced in the building.- Rates should be increased as the weather warms to provide temperature control. -Recommendations for calculating ventilation rates are similar to those for dairy calves in warm housing (Midwest Plan Service, 2000).- It is important that the building air inlets are properly positioned and can supply the airflow for the exhaust fans when veal calves are housed indoors.

Thermostats can be effectively used for automatic control of the fans and temperature. Heating and ventilation systems should be planned simultaneously.- Control of temperature is important to the health of calves, and is a factor in feed conversions. Michigan's climate can be erratic; therefore, producers should attempt to provide a comfortable temperature and level of relative humidity.- Sudden fluctuation in temperature should be avoided.

During daylight periods, natural or artificial indoor lighting intensity should allow for every housed calf to be seen clearly for inspection (Ohio Livestock Care Standards for Veal).

## FACILITIES AND EQUIPMENT

The internal surfaces of barns and holding systems for veal calves should be made of materials that can be cleaned and disinfected effectively and routinely. -Surfaces of barns, stalls, pens, and other equipment accessible to the calves should have no sharp edges or projections.- All floor surfaces should be designed, constructed, and/or maintained to avoid injury or stress to the calves.

## HEALTH CARE AND MEDICAL PROCEDURES

Individual stalls for veal calves are recommended for health reasons in contrast to housing of dairy replacements in groups after weaning. -Calves housed individually can be observed more closely, facilitating early detection of problems. -Disease spread is reduced because of reduced calf-to-calf contact and cross-suckling (The Welfare of Veal Calves, 1994; Raising Dairy Heifers, 2003).

Proper care of animals includes the establishment of a health program that emphasizes disease prevention.- Veal farmers, including those participating in organic programs, should establish a valid veterinarian/client/patient relationship with a licensed veterinarian to assist them in providing proper health care to their animals. -An ongoing preventive health program designed for each farm by the veterinarian and producer will result in healthy animals. -This includes a veterinarian designed vaccination program. Appropriate health care involves: 1) methods to prevent, control, diagnose, and treat diseases and injuries; 2) training and guidance to animal caretakers on appropriate antibiotic therapy; 3) instruction on proper handling of pharmaceuticals and biologicals and withdrawal times; and 4) accurate record keeping systems with proper animal identification.- All confined animals should be observed daily for signs of illness, injury, or unusual behavior.- Management practices to reduce the risk of introduction and spread of infectious disease should be implemented.- Preventive and therapeutic health programs, and medical procedures including castration and dehorning should follow a veterinarian's recommendation.

**Pharmaceutical Use:** It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products. -To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals.- Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical

treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;

2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and
3. The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Non-Ambulatory (Downed) Calves:-** A prompt examination should be performed on non-ambulatory animals to determine whether extended care or euthanasia is recommended. -If the animal is not in extreme distress and continues to eat and drink, it is recommended that the producer contact a veterinarian for assistance/advice and provide food, water, shelter, and appropriate nursing care to keep the animal comfortable. - If the animal is in extreme distress and the condition is obviously irreversible, the animal should be euthanatized immediately. - Downed animals should be moved carefully to avoid compromising animal welfare. - Dragging downed animals is unacceptable. -Non-ambulatory animals must not be sent to a livestock market or to a processing facility.

**Euthanasia:** Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately. -Methods can be physical or chemical and one of the approved methods recommended by the AVMA Guidelines on Euthanasia (AVMA, 2020).

**Dead Animal Disposal:** Animal tissue, whole ~~carcasses~~carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

## REFERENCES

American Association of Bovine Practitioners. 2014. Transportation Recommendations for Cattle. [http://www.aabp.org/resources/aabp\\_guidelines/transportationguidelines-03-11-2014.pdf](http://www.aabp.org/resources/aabp_guidelines/transportationguidelines-03-11-2014.pdf) (Visited 6/25/2018)

American Veterinary Medical Association. 2020. AVMA Guidelines on Euthanasia of Animals. Available at: <https://www.avma.org/KB/Policies/Documents/euthanasia.pdf> (Visited 6/25/2018)

Cattle Handling and Transport, 3<sup>rd</sup> Ed. 2007. Grandin T, Ed. CABI International.

Grandin, T. 2000. Behavior of cattle, pigs, buffalo, and antelope during handling and transport. <http://grandin.com/behaviour/transport.html>. (Visited 6/25/18)

Guide for the Care and Production of Veal Calves – American Veal Association 1994.

Guide for the Care and Use of Agricultural Animals in Research and Teaching, Third Edition, January 2010. Federation of Animal Science Societies. [https://www.aaalac.org/about/Ag\\_Guide\\_3rd\\_ed.pdf](https://www.aaalac.org/about/Ag_Guide_3rd_ed.pdf). (Visited 6/25/2018)

Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html). (Visited 6/25/18)

Modern Veal Production: Industry Perspective. 1989. National Live Stock and Meat Board. pp. 29-30. Chicago, IL.

NRC (National Research Council). 2001. Nutrient Requirements of Dairy Cattle. Seventh Rev. Ed. National Academy Press, Washington, DC.

Ohio Livestock Care Standards for Bovine Animals – Veal, Dairy, and Beef. 2011. Ohio Department of Agriculture. <http://codes.ohio.gov/oac/901%3A12-5> (Visited 6/25/2018)

Ohio Livestock Care Standards for Veal:  
<http://codes.ohio.gov/oac/901%3A12-5> (Visited 6/25/2018)

Raising Dairy Replacements. 2003 Midwest Plan Service

Roy, J.H.B. 1980. The Calf, 4<sup>th</sup> Ed. Butterworths, London, United Kingdom.

Schwartz, A. 1990. The Politics of Formula-fed Veal Calf Production. 1990. Journal of American Veterinarian Medical Association. 196: 1578-1586.

|

Stephens. D.B. 1982. A review of some behavioral and physiological studies which are relevant to the welfare of young calves. Pages 47-67 Welfare and Husbandry of Calves. J.P. Signoret, ed. Martinus Nijhoff, Boston, MA.

The Welfare of Veal Calves: A Review of the Scientific Evidence, 1994. Jeffrey Rushen. The Centre for the Study of Animal Welfare. University of Guelph, Guelph, Ontario, Canada

Transportation of Animals. 2006. 49 USC Sec.80502.  
<https://www.gpo.gov/fdsys/granule/USCODE-2008-title49/USCODE-2008-title49-subtitleX-chap805-sec80502> (visited 6-25-2018)

James, Bob, Kayla Machado, Alyssa Dietrich. 2017. Group Housing Systems for Calves, Facilities, Equipment, Protocols and Personnel Proceedings Western Dairy Herd Management Conference.

Van Putten, G. and W.J. Elshof. 1982. Inharmonious behaviour of veal calves. Pages 61-71 in Distributed Behaviour in Farm Animals. Verlag Eugen Ulmer. Stuttgart, Germany.

# SWINE

## MANAGEMENT OVERVIEW

In Michigan, swine can be raised humanely in a variety of production systems, provided they are given ample protection from extreme cold, excessive wind, solar radiation, and precipitation. - Production systems used include: (1) environmentally controlled buildings in which the pigs remain inside; (2) open front buildings that permit the pigs to go outside; and (3) outside lot or pasture production with portable shelters. - Well maintained facilities and sound management practices optimize animal comfort and well-being regardless of the type of production system. -The swine care practices described herein are relative to domestic swine production. National Pork Board - Swine Care Handbook, Pork Quality Assurance Plus (PQA Plus), Youth Quality Assurance and Transport Quality Assurance programs are available to swine producers wanting additional information on swine management and production (<https://www.pork.org/production>).

## MANAGEMENT PRACTICES

**Observation:** - Pigs must be observed daily, but more frequently during specific events such as farrowing-or recovery from illness. Drinkers and feeders must be monitored to make sure pigs have access to both fresh water and feed. - Pigs should be examined for signs of health problems, physical discomfort, or injuries. - Facilities need to be inspected to be sure they are functioning properly. -Producers need to be aware of these responsibilities during normal work hours, nights, holidays, and weekends. Caretakers are encouraged to adopt neutral or positive animal interactions to improve the well-being of the pigs.

### **Managing Sick and Injured Animals:**

With daily observations, caretakers can develop a method for tracking and identification of healthy and non-healthy pigs. A pig is considered non-ambulatory if it cannot get up or if unable to stand without support and unable to bear weight on two of its legs. Handling of non-ambulatory pigs should include equipment appropriate for size and age and condition of the animal. Dragging of conscious animals by any body part is unacceptable, however in the rare case whereby a pig must be moved from a **life threatening** situation. In addition, a caretaker might have to reposition a pig to perform the euthanasia safely and effectively.

**Identification and Records:** - Pigs may have some form of identification that can be easily read. - These identification methods may include ear notches, ear tattoos, electronic transponders, ear tags, body tattoos, or by temporary mark. - Pigs not individually identified but kept in groups can be identified as a group by using group identification. -Identification is important to maintain records and track pigs as they are moved through the various production phases. **Many different types** **Several types** of management records that may be kept **include:** **include** -health programs, housing

location, genetic lineage, and nutrition. The farm should have its own premise identification number (PIN) assigned for the appropriate tracking of diagnostic submissions and other regulatory purposes such as a VFD.

**Piglet care:** After birth, any of the following procedures may be performed on piglets by a skilled individual as a part of routine husbandry or to help reduce the risk of disease and infections: ~~(1)~~ disinfection of navel, ~~(2)~~ clipping or grinding of needle teeth tips, ~~(3)~~ supplementing iron by injection or orally, ~~(4)~~ docking of tail, ~~(5)~~ identifying permanently, and ~~(6)~~ castrating males.

### **Herd Health Management Program:**

The overall goals of a herd health program are to eliminate or minimize disease by reducing exposure or controlling existing disease. -The management plan should include Standard Operating Procedures (SOP) and compliance for biosecurity, vaccination, daily observation, timely euthanasia, vector control, pig flow, entry and culling, management of compromised pigs, treatment and mortality records.

**Nutrition:** Livestock should have access to clean drinking water. Swine are raised on a variety of feeds. - Feedstuffs should be free from harmful molds, mycotoxins, or impurities. -If the presence of any of these substances or organisms is suspected, samples should be submitted for laboratory testing. -Feed with unrecognized nutritional value and lacking in wholesomeness should not be used.

The diet should meet the nutritional needs to support the intended performance of swine in a given phase of production (i.e., age specific growth, pregnancy, lactation, active and inactive breeding males).

High intake of rations may cause excessive weight gain during gestation. - Sows allowed ad libitum access to feed will become obese negatively impacting her ability to raise born piglets. - Restriction of energy intake is suggested for gestating females. -This may be done by decreasing daily feed intake, adding fiber to the diet, or feeding ~~every one~~everyone to three days. - This is also true for boars. Consult your specialist for suggestions on how to adjust feed intake for breeding animals. Pigs in other phases of production are generally given ad libitum access to feed and water.

**Manure Management and Sanitation:** Manure handling and utilization systems for swine facilities should conform to practices adopted by the Michigan Agriculture Commission in its document entitled ~~Generally Accepted Agricultural and Management Practices~~ GAAMPs for Manure Management and Utilization.

Pigs should be kept comfortable and healthy. - Defecating and resting preferences should be considered in designing facilities and in the day-to-day operation of those swine facilities. -The frequency of manure removal from swine facilities is dependent on several factors including: -pen size, animal density, temporary manure storage capacity and flooring type. -Building interiors, corridors, storage space, and other work and production areas should be kept clean and free of any sharp edges or protrusions which may cause injury to pigs passing by.



**Animal Handling:** An understanding of the behavioral characteristics of pigs will aid in handling and moving of swine, as well as increase productivity, improve meat quality, and help reduce undesirable stress. - At all stages, pigs should be handled with care, gentleness, time for acclimation, time for rest, and patience. -Pigs have wide angle vision in excess of 330 degrees. -Although this allows them to ~~almost completely see behind~~almost see behind themselves completely themselves-without turning their heads, it also causes them to be sensitive to sharp contrasts in light and dark. -Pigs may balk if they encounter shadows, puddles, bright spots, a change in flooring type or texture, drains, metal grates, or flapping objects.

Pigs will stop when a solid barrier is placed in front of them. Small portable panels will allow efficient moving and sorting. A light aluminum, plastic or wood panel is useful in separating pigs from a pen.

For physical examination, collection of samples, and other clinical procedures, pigs can be restrained manually or with handling aids, such as snout snares, restraint stocks or stalls. -It is important that these devices be the right size and designed for the pig being held and that they are operated properly to minimize injury.

#### **Zero Tolerance for pig abuse or purposeful neglect:**

At all levels of production, training must emphasize that there will be zero tolerance for pig abuse or purposeful neglect. Egregious acts of abuse include, but are not limited to:

- Intentionally applying electric prods to sensitive parts of the animal such as the eyes, ears, nose, genitals/genitals, or rectum. Excessive prod use could qualify as a willful act of abuse.
- Malicious hitting/beating of an animal. This includes forcefully striking an animal with closed fist, foot, handling equipment (e.g., sorting board, rattle paddle, etc.-), or other hard/solid objects that can cause pain, bruising or injury.
- Driving pigs off high ledges, platforms or steps while moving, loading/loading, or unloading (animals are falling to the ground).
- Dragging of conscious animals by any part of their body except in the rare case where a non-ambulatory animal must be moved from a life threatening/life-threatening situation Non-ambulatory pigs may be moved by using a drag mat
- Purposefully dropping or throwing animals.
- Causing physical damage to the snout or tusks of a boar as a means to reduce aggression (this excludes nose ringing and tusk trimming)
- Failure to provide food, water/water, and care that results in significant harm or death to animals. This includes the intentional failure to provide food, water or care that falls outside of normal husbandry practices and would reasonably be considered neglect

**Transportation:-** Recommendations of facility design for loading and unloading trucks have been published (Grandin, 1988 and 2000) and by the National Pork Board. -Weak,

sick, or fatigued pigs should not be loaded or transported with healthy ones.

**A**Appropriate steps should be taken immediately to segregate sick pigs and care for their special needs.- Injuries and bruises can result when pigs are improperly managed during loading and transport. -Lights inside a building or inside a truck will attract pigs because they have a tendency to move from a darker area to a more brightly lit area. Funnel-shaped pens should not be used to load pigs because pigs have a tendency to continue to press forward.- Loading ramps with solid sides are more efficient than "see through" sides because they decrease distractions.

Safety and comfort should be a primary concern when transporting pigs.- When pigs are transported, ventilation should be ~~adequate~~adequate, and the floor should be slip-resistant. Animals should be shipped in groups of uniform weight and provided with adequate space.- (Grandin, 1988; Grandin, and Shultz-Kaster, 2001). -Truck beds should be clean and equipped with a non-slip floor.

Transport stresses can be intensified by adverse weather and wide temperature fluctuations. -Hot weather is a time for particular caution. -While in transit in warm weather, pigs should be protected from heat stress by being shaded, wetted, and bedded with wet sand or shavings.- Prompt unloading in hot weather is essential because heat builds up rapidly in a stationary vehicle.

During transportation in cold weather, pigs should be protected from cold stress. -Wind protection should be provided when the air temperature drops below 32°F, but ventilation must always be adequate.- When trucks are in transit in cold weather for more than a few minutes, pigs should be bedded with sufficient material that has high insulating properties.- Water and feed should be readily available for long trips as described in the Transportation of Animals statute from the U.S. Code (49 USC Sec. 80502).

Truck beds should be clean and dry and equipped with a bedded, non-slip floor.

## **RECOMMENDATIONS FOR THE ENVIRONMENT**

Production systems should be designed with consideration of the environment of the pigs, the protection of air and water, and the working environment of the producer and employees.

**Social:** -All classes and groups of pigs form an order of social dominance.- These orders are formed by competition soon after birth or when the pigs are first grouped together. Addition of new pigs or regrouping of pigs will usually lead to reestablishment of social order.- Adult boars that have not been living together should not be regrouped.

Females can be bred to farrow at any time of the year.- Three mating options are: (1) pen mating (placing a boar with a group of sows without observation of matings); (2) attended or hand mating; and (3) artificial insemination (utilizing semen collected from boars).

During gestation sows may be housed individually or in groups (CAST, 2009). Resolution 3 of the American Association of Swine Veterinarians, and the American Veterinary Medical Association states: -The American Veterinary Medical Association supports the use of sow housing configurations that: (1) minimize aggression and competition between sows; (2) protect sows from detrimental effects associated with environmental extremes, particularly temperature extremes; (3) reduce exposure to hazards that result in injuries; (4) provide every animal with daily access to appropriate food and water; (5) facilitate observation of individual sow appetite, respiratory rate, urination and defecation, and reproductive status by caretakers; and (6) allow sows to express most normal patterns of behavior (Vet Med Today: Sow Housing Task Force, 2005). -Public Act No. 117 of October 12, 2009 ~~will require~~requires, ~~that~~-by April 1, 2020, all gestating sows be housed so that they are able to fully extend their limbs and turn around freely. Sows may be housed in individual pens or stalls which are large enough to do so, until they are determined pregnant. For further information on this enactment and exemptions see Rozeboom et al. (2019). -Housing in groups in pens may be most easily applied and affordable. -When housed in pens and in groups, pregnant sows may be fed to meet all nutrient requirements by providing a variable number of meals per day using one or more of the following methods: clean solid flooring, a common trough, in individual feeders within individual feeding stalls, controlled access to a self-feeder, or an electronic sow feeder.

Sows can farrow in pens, farrowing stalls, or pasture huts. -Pens and pasture huts allow the sow to move around freely but may result in higher newborn piglet death loss because the sow may accidentally crush her newborn piglets (McGlone and Blecha, 1987; Stevermer, 1991). -Stalls allow the sow to stand, lie, eateat, and drink, but not to turn around. Restricting the movement of the sow in some manner during lactation allows the piglets more opportunity to escape being crushed when the sow lies down.

Weaning most often takes place at 2 to 5 weeks of age. -Weaned pigs should be provided a warm, dry, and draft free environment and proper nutrition. -Growing pigs should be provided space as summarized by the National Pork Board (2003; Tables 3, 4, and 5).

**Thermal:** -With outdoor production, trees can provide adequate shade. -Facilities to provide shade can be constructed to also serve as protection from wind and cold during winter. -Adequate dry bedding must be maintained during cold weather.

Ventilation typically is the primary means of maintaining the desired air temperature and humidity and gas concentrations for pigs housed inside of buildings. -The amount of ventilation depends on the size, number, type, age, and dietary regimen of the pigs, the manure management system, and atmospheric conditions.

Appropriate, effective temperatures ranges for pigs have been summarized by the National Pork Board (2018).

**Air quality:** -Air quality refers to the effects that the air has on the health and well-being of animals. -Gases, dusts, and microorganisms are present in pig facilities, and, to a lesser extent, in outdoor operations. -Harmful amounts of gases and dust in the air should be avoided in or around buildings (Meyer et al., 1991).- Acceptable air quality can usually be achieved with proper ventilation and air distribution, regular cleaning and sanitation, feed dust control, and manure gas control.

**Photoperiod:**- Lighting should give enough illumination to permit practicing good husbandry, inspecting the pigs adequately, maintaining their well-being, and working safely (ASABE, 2005; Clarke and Chambers, 2006).- Compared with some species, the domestic pig is less sensitive to its environmental lighting and no particular daily photoperiod regimen is necessary.

## **FACILITIES AND EQUIPMENT**

Swine housing systems may be as simple as a fenced pasture with man-made shelters, or they may be much more complex.- Whatever the system, it should be appropriate for the age of the pigs and the local climate.- In enclosed structures, the system should be capable of maintaining environmental conditions within an acceptable range of temperature, humidity, chemical emissions and particulates. -Descriptions of cold and warm housing systems have been given by the National Pork Board (2018).

Swine facilities should conform to applicable building codes unless deviations and variances are justified and approved. -Physical facilities should be well maintained and clean. -Facilities and equipment should be inspected, repaired, and maintained regularly to provide a safe environment for animals and people.- The MWPS publications and publications of other organizations provide guidance for planning, specifications, cost estimates, and construction of commercial agricultural swine facilities in different parts of the U.S.

**Feeders and waterers:** -Feeders should provide adequate access to feed.- Feeders should be cleaned regularly to prevent feed accumulation and spoilage, and be maintained with no rough edges to injure the pigs. -Waterers should be positioned to ensure pigs have adequate access.

## **HEALTH CARE AND MEDICAL PROCEDURES**

Adequate health care is an essential part of a pork production enterprise. -Appropriate health care involves: -methods to prevent, control, diagnose and treat diseases and injuries; training of and guidance to animal caretakers on antibiotic therapy; instruction on proper handling of pharmaceuticals and biologicals and withdrawal times; and

adequate record keeping programs. -Animals should be observed daily for signs of illness or injury.

Methods of prophylaxis, diagnosis, therapy, and disease control should follow a herd health monitoring program based on Good Production Practices outlined in the PQA Plus practices. - Animals should receive appropriate treatment even if marketing must be delayed or forgone due to withdrawal time indicated by the product. -Assistance of a veterinarian in establishment of a health care program is recommended. Organic production programs should work with a veterinarian to ensure adequate protection and treatment for sick animals.

**Pharmaceutical Use:** - It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products. -To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. - In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and,
- 3.2.
- 4.3. The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:** -Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately. -Methods can be physical or chemical and one of the approved methods recommended by the American Association of Swine Veterinarians, which is consistent with the AVMA Guidelines on Euthanasia (AVMA, 2020). -See the manual On-Farm Euthanasia of Swine- Recommendations for the Producer (National Pork Board, 20192016). In the event of a foreign animal disease or major market disruptions, a large number of swine may need to be depopulated. See the AASV guidelines for Depopulation of Swine (American Association of Swine Veterinarians, 2020).

**Dead Animal Disposal:** Animal tissue, whole ~~carcasses~~carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

DELETED

## REFERENCES

ASABE, 2005. Lighting Systems for Agricultural Facilities. ASAE EP344.3 JAN2005

[American Association of Swine Veterinarians. 2020. Recommendations for the Depopulation of Swine. Available at: https://www.google.com/search?q=aasv+depopulation&rlz=1C1GCEA\\_enCA819CA819&oq=aasv+depopulation&aqs=chrome..69i57j69i64.9331j0j9&sourceid=chrome&ie=UTF-8 \(Visited 6.18.2020\)](https://www.google.com/search?q=aasv+depopulation&rlz=1C1GCEA_enCA819CA819&oq=aasv+depopulation&aqs=chrome..69i57j69i64.9331j0j9&sourceid=chrome&ie=UTF-8)

American Veterinary Medical Association. 2020. AVMA Guidelines on Euthanasia of Animals. Available at: <https://www.avma.org/KB/Policies/Documents/euthanasia-highres.pdf> (Visited 6.22.2018)

Clarke, S. and R. Chambers. 2006. Energy Efficient Swine Lighting. Ontario Ministry of Agriculture, Food and Rural Affairs Factsheet 717.

Council for Agricultural Science and Technology (CAST). 2009. Scientific Assessment of the Welfare of Dry Sows Kept in Individual Accommodations. Issue Paper 42. CAST, Ames, IA.

Grandin, T. 1988. Livestock Trucking Guide. Livestock Conservation Institute, Madison, WI.

Grandin, T. 2000. Behavior of cattle, pigs, buffalo, and antelope during handling and transport. <http://grandin.com/behaviour/transport.html> (Visited 6.22.18)

Grandin, T. and C. Shultz-Kaster. 2001. Handling Hogs. PIH-116, Pork Industry Handbook. Coop. Ext. Serv., Purdue Univ., W. Lafayette, IN.

Vet Med Today: Sow Housing Task Force – Rhodes, R, Tracy, Michael C. Appleby, Kathy Chinn, Lawrence Douglas, Lawrence D. Firkins, Katherine A. Houpt, Christa Irwin, John J. McGlone, Paul Sundberg, Lisa Tokach, Robert W Wills. 2005. A comprehensive review of housing for pregnant sows. J Am Vet Med Assoc. Nov 15;227(10):1580-90. doi: 10.2460/javma.2005/227.1580.

McGlone, J.J., and F. Blecha. 1987. An Examination of the Behavioral, Immunological and Reproductive Traits in Four Management Systems for Sows and Piglets. Appl. Anim. Behav. Sci. 18:269-296.

Meyer, V. M., L. Bynum-Driggers, K. Ernest, and D. Ernest. 1991. Swine growing-finishing units. PIH-11, Pork Industry Handbook. Coop. Ext. Serv., Purdue Univ., W. Lafayette, IN.

Michigan Agriculture Commission. Generally Accepted Agricultural and Management Practices for Manure Management and Utilization. Lansing, MI.

Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited 7.29.19)

Midwest Plan Service. 1983. Swine Housing and Equipment Handbook. 4th Edition. Midwest Plan Service, Iowa State Univ., Ames, IA.

Midwest Plan Service. 1993. Livestock Waste Facilities Handbook. Midwest Plan Service, Iowa State Univ., Ames, IA.

Midwest Plan Service. 2006 Wiring Handbook for Rural Facilities. Midwest Plan Service, Iowa State Univ., Ames, IA.

National Pork Board. 2018 Swine Care Handbook. Des Moines, IA.

National Pork Producers Council. 1999. Swine Care Handbook, 1<sup>st</sup> Edition. Des Moines, IA.

On-Farm Euthanasia of Swine – Recommendations for the Producer. 2016. National Pork Board, Des Moines, IA.  
(<http://www.porkcdn.com/sites/porkorg/library/2016/11/2016-On-Farm-Euthanasia-of-Swine.pdf>). (Visited 6.22.2018)

[Rozeboom, D., Ferry E., Swanson, J., Benjamin, M. 2019. Michigan's Pork Industry future: No more gestation stalls as of April 1, 2020.](https://www.canr.msu.edu/news/michigan-s-pork-industry-future-no-more-gestation-stalls-as-of-april-1-2020)  
(<https://www.canr.msu.edu/news/michigan-s-pork-industry-future-no-more-gestation-stalls-as-of-april-1-2020>). (Visited 6.18.2020).

Stevermer, E.J., 1991. 1990 Swine Enterprise Record. ASB:EJS-185. Iowa State University, Ames, IA.

Transportation of Animals. 2011. 49 USC Sec. 80502  
<https://www.gpo.gov/fdsys/granule/USCODE-2011-title49/USCODE-2011-title49-subtitleX-chap805-sec80502>. (Visited 6.22.18)



## EQUINE

### MANAGEMENT OVERVIEW

The equine industry in Michigan is large and diversified. Management systems ~~include:~~include breeding farms; training facilities; show, exhibition, and racing enterprises; mare and foal operations; transportation companies; horses used for work on farms or for transportation; boarding stables, pleasure horse operations and riding stables. Equine management systems include operations with only a few animals to those with several hundred on one premise. The industry has state-wide distribution and the various components are integrated to provide specialized services. The show and racing operations accommodate horses throughout the country; therefore, a large number of horses are transported into and out of this state on a regular basis.

The seasonal changes and climate extremes of this state present possible management and health problems which need to be considered and managed. Housing and pasture systems may vary and be modified to meet the needs of the enterprise, to use existing facilities, and to be economically feasible. Emphasis on safety and minimizing stress, are important factors when transporting one or several horses. Herd health, disease prevention and emergency care programs should be individually developed and implemented for each equine operation. These programs need to be reviewed and modified as disease potential and needs change. Since horses are athletes and perform different tasks, nutritional programs need to meet the growth and performance requirements of each horse.

Federal and state laws concerning horse protection, animal cruelty, riding stables, and sale barns need to be understood by the industry and individual horse owners, complied with, and enforced.

### MANAGEMENT PRACTICES

**Nutrition:** Proper nutrition is important in maintaining health. Nutritional demands vary depending on age, ~~size~~size, and use. The amount and composition of feed required is governed by body weight, individual metabolism, age, pregnancy, ~~lactation~~lactation, and

the amount of work the animal does.- Horses need to be adequately fed to maintain their body weight and health; however, idleness, overfeeding and obesity are undesirable and often harmful. -Horses are kept for a much longer time than most farm animals, and feeding programs should support the development of sound feet and legs that will sustain a long and athletic life.

Nutritional demands are usually met with good quality, properly harvested forages and pastures combined with grains and supplements as needed to balance the diet. -To maintain optimum health, most mature horses should derive the majority of their nutrition from good quality roughage, typically 1.5-2.0% of their weight in roughage daily. -There may be exceptions to this forage intake, however, based on individual and workload. -Horses utilize hay or other roughages more efficiently than do other non-ruminants; however, consistency and nutrient quality are essential for optimum productivity and health.- Because horses are particularly sensitive to toxins found in spoiled feeds, grains and roughages should be of good quality and free from visible mold.- Feeding of dusty feeds should be kept to a minimum because of their tendency to initiate or aggravate respiratory problems.

When horses are fed in groups, adequate feeding space should be provided so that dominant animals do not prevent others from eating.- Horses should be fed regularly, and since they have a relatively limited capacity for roughage at any one time, they should have frequent access to it.- A horse should be rested after eating large grain meals before strenuous work starts.

Availability of clean water is essential. -Water requirements depend largely upon environment, amount of work being performed, the nature of the feed, and the physiological status of the horse. -Extreme water temperatures (very hot or cold) may reduce water intake and lead to dehydration. -Horses should be offered water during long exercise bouts and immediately following exercise and several hours throughout the recovery period.

**Transportation:** -Trailers and vans should be free of protruding objects on the sides and top and should be of adequate height for the animal.- When appropriate, protective devices such as helmets, leg wraps, boots, blankets, and tail wraps can be used to further protect the animal from injury.

Available hay in the trailer will help prevent boredom during transit.- Suitable non-slippery flooring, e.g. rubber mats, straw, shavings, or a combination of these, should be available for transits.- The vehicle exhaust system should not pollute the air inside the trailer. -When trips are over 24 hours, an ample rest stop, fresh feed and water should be given. -On shorter trips, a walking rest stop with water may be appropriate depending on the length of the trip. -The ability to lower their head during transit (especially long distance) may reduce the incidence of shipping fever. Seriously debilitated or non-ambulatory animals should not be transported unless they can be appropriately accommodated without further injury or distress and the purpose of transport is to obtain

medical care. A delay or cancellation of transport should occur for animals that appear unhealthy, ~~dehydrateddehydrated~~, or exhausted and unfit to withstand the travel.

For the safety of the equine and handlers, the tranquilization of horses during transit is acceptable. -Products should be administered by a person knowledgeable about the product and in consultation with a veterinarian.- Administration of mineral oil may be helpful in preventing intestinal stasis during long trips.

**Training:-** Horses in training, exhibition, racing and work should be treated in a humane manner.- The acceptable standards for training, exhibition, racing and work are those which an informed and recognized equine association (e.g., United States Equestrian Federation Rule Book, 2013, and American Quarter Horse Association Official Handbook, 2013) has developed and shall be in compliance with the Federal Horse Protection Act and Michigan cruelty to animals laws.

## **RECOMMENDATIONS FOR THE ENVIRONMENT**

Proper illumination in barns and indoor riding arenas are important for the convenience and safety of both the horse and the attendant.

As a rule, horse owners can obtain adequate housing for their horses with non-insulated buildings.- In northern regions, insulated buildings and supplemental heat are more commonly used to protect the animals and attendants from severe winter weather. Healthy horses with adequate diet and good body condition only require protection from the wind. -Heated barns may be used for show horses to keep them in show condition throughout the year. -Overcrowding should be avoided to minimize injuries and parasite problems.

Pastures should have adequate shelter where horses can get out of the sun, wind, rain, and other inclement weather.- These may include, but are not limited to: open barns, lean-tos, constructed windbreaks and woodlots. -There should be enough space to accommodate all animals comfortably. -Riding stables licensed by Michigan Department of Agriculture and Rural Development are required to have constructed shelters per R 285.154.5.

If horses are confined to small spaces, manure should be stored away from the horse housing to decrease fly and parasite exposure. -The manure should be stored, ~~transferredtransferred~~, and utilized in compliance to practices outlined by the GAAMP for Manure Management and Utilization.

## **FACILITIES AND EQUIPMENT**

The basic purpose of horse housing is to provide an environment that protects the horses from temperature extremes, keeps them dry and out of the wind, eliminates drafts through the stables, provides fresh air in both winter and summer and protects

the horses from injury.- See reference section for more information on general housing requirements.

In cold non-insulated or insulated barns, fresh air is usually provided by natural air movement through wall openings and ridge vents or devices.- Examples of wall openings may be small windows, wall panels or slots under the eaves.- In tight, warm barns, fans, and spaced air inlets may be necessary.- Adequate air exchange and distribution should be provided to remove moisture generated within the barn.- If using supplemental heat, adequate ventilation will be required. -Adequate air exchange and air distribution systems to provide adequate cooling should be provided during hot weather.

In most horse barns, some box stall space is necessary for sick animals, mares at foaling time and foals. -Stall walls should be tight, smooth, and free of loose wires, protruding objects such as bolts and nails, and anything else that might injure the horse as it moves about and lies down. -The walls should be flush with the floor, so a horse cannot get its feet under the partition. -The walls should be constructed from material and in a manner that will withstand pushing and kicking from the horses and that, if damaged, will not become a potential hazard to the horse (e.g., a horse kicks a hole in sheet metal). -Wooden kick boards should be placed at least up to 4 feet' for the average 1000 ~~lb~~pound. horse. -For riding horses (1000 ~~lb~~pound. average) a typical box stall would be 10 feet' ~~x~~by 10 feet'.- Stalls of 16 feet' ~~x~~by 20 feet', or larger, are useful for foaling mares. Box stalls for ponies and miniature horses may be smaller, depending on the size of the animal.

Tie stalls require about half the area, use less bedding, are easier to clean than box stalls, and can often be constructed in existing buildings suitable for box stalls. -A possible example of a typical tie stall is 5 feet' ~~by~~x 9 feet' (3 feet' ~~by~~x 6 feet' for ponies and miniature horses), although stall lengths up to 12 feet' are often used. -For either box stalls or tie stalls, construction materials must be strong enough to contain the animal.

Packed rock-free clay on a well-drained base make comfortable and practical floors for stables.- However, they are difficult to keep clean and ~~have to~~must be renewed from time to time. Packed, crushed limestone makes a good stall surface in that it drains readily, has reduced ~~maintenance~~maintenance, and has a reduced odor. -Wood plank stall floors or wood block floors on concrete are preferred by some, but such floors are difficult to keep dry and free of odors. -Concrete floors are the least desirable; and if used, a considerable amount of bedding is needed. Many stall floors, regardless of the stall base, are covered with some type of stall mat to reduce stall maintenance, bedding requirements and/or provide a more desirable surface for the horse to stand on. -Floor finishes that are slippery should be avoided.

Common fencing materials are wood, pipe, PVC, electrical wire or tape, smooth, non-electrical wire, rubber belt and woven wire (the mesh should be small enough that a horse or foal cannot get their feet through). -The perimeter fence should provide an

adequate physical barrier that is not dependent on electricity for containment.- Electric fencing can be used as a psychological barrier to keep horses from leaning on the fence, reduce fighting over the fence or provide an interior fence.- The fence should be free of sharp projections, such as nails, bolts and latches. -Single or double strand wire fences may lack visibility and have the potential for severe cuts to horses entangled in them. -More visible products are available for wire fencing or large strips of plastic or cloth can be tied to wire to increase visibility. -Fences should be approximately 5 feet in height for light horses with additional height necessary for stallions and draft horses. Overcrowding in pastures and lots should be avoided to minimize injuries due to kicking and fighting.

Bands of horses may be housed in open sheds. -If halters are left on in the pasture, they should be of a material that will break if the halter becomes caught on an object. (i.e., breakaway or thin leather halters).

Where animals are housed for any lengthy period, clean bedding should be provided regularly.- Animals should be provided with daily exercise to maintain healthy skeletal – muscle system and reduce behavioral problems. -Daily exercise could be in the form of free exercise provided by turnout or forced exercise like lunging or riding for at least 30 minutes per day.

## **HEALTH CARE AND MEDICAL PROCEDURE**

Disease and injury prevention can best be achieved through nutritional management, adequate housing, vaccination programs, parasite control, cleanlinesscleanliness, and general equine husbandry in consultation with a veterinarian.

A healthy horse is active, drinks readily, has clear eyes and nose, a clean skin, and a good general body condition, without being excessively fat.- A moderate body condition score of 4.5 – 6.5 ensures adequate energy reserves without excessive weight that could predispose a horse to nutritional or skeletal problems. -The health of the horses should be routinely assessed to recognize appropriate signs of illness, so that care may be instituted. Management plays a ~~major role~~ a significant role in the prevention of disease and injury.

A proper preventive vaccination program should be developed for individual horse needs. -Effective vaccines are available to protect horses from fatal diseases including: Tetanus, Encephalomyelitis, West Nile Virus, and Rabies. -The manufacturer's and/or veterinarian's recommendations should be followed for all vaccines.

Internal parasitism is one of the most serious of all equine diseases.- Parasitism is associated with general unthriftiness, poor hair coat, and a high incidence of colic.

Stable and pasture management can be helpful in parasite control. -A parasite control program should be developed and implemented for all horses. If grazing, appropriate grazing management strategies should be employed to minimize parasitic infestation.

Horses' teeth should be examined periodically and floated when necessary. -Elongated enamel points on the teeth can cause trauma and constant irritation and result in improper chewing.- Excessive salivation or dropping of feed from the mouth indicate the mouth should be examined and may indicate that dental care is needed.

Proper foot care is essential to maintain normal health of the foot and to prevent lameness. -The hooves should be examined regularly and trimmed or shod as needed. For stabled horses, clean, dry bedding should be maintained. -Excessive dryness of the hoof should be avoided.

**Pharmaceutical Use:** -It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products.- To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. -Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3)

(<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and,
- 3.2. The practicing veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:** -Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately. -Methods can be physical or chemical and one of the approved methods recommended by the AVMA Guidelines on Euthanasia (AVMA, 2020).

|  
| **Dead Animal Disposal:** -Animal tissue, whole ~~carcasses~~carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

DRAFT

## REFERENCES

American Association of Equine Practitioners, Core Vaccination Guidelines. [http://www.aaep.org/core\\_vaccinations.htm](http://www.aaep.org/core_vaccinations.htm). 2012.

American Veterinary Medical Association. 2013. AVMA Guidelines on Euthanasia of Animals. Available at: <https://www.avma.org/KB/Policies/Documents/euthanasia.pdf>. (Visited 6.28.2013).

Butudom, P. et al., 2003. Effect of varying initial drink volume on rehydration of horses. *Phys. Behav.* 79(2):135-142.

Code of Recommendations and Minimum Standards for Welfare of Horses, PO Box 2526, Wellington, New Zealand: 2008. <http://www.biosecurity.govt.nz/animal-welfare/codes/horses/index.htm>

Disease-Management Interaction: Horses, The Merck Veterinary Manual, Ninth Edition, [www.merckvetmanual.com](http://www.merckvetmanual.com), 2008.

Ensminger, M. E. Horses and Horsemanship. Interstate Publishers. Seventh Edition. 1999.

Evans, J. W., Borton, A., Hintz, H., Van Vleck, L.D. 1990. The Horse. W.H. Freeman and Company, Second Edition.

Horse Industry Handbook: A Guide to Equine Care and Management. Updated 2007. American Youth Horse Council, 557 N. Boyero Ave., Pueblo West, CO.

Housing Your Pleasure Horse, Cooperative Extension Service, Michigan State University, Extension Bulletin E-1403, June 1980.

Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited (4/29/19))

National Research Council. 2007. Nutrient Requirements of Horses. Sixth Rev. Ed. National Academy Press, Washington, DC.

Nutrition: Horses, The Merck Veterinary Manual, Ninth Edition: 2008. [www.merckvetmanual.com](http://www.merckvetmanual.com)

Official Handbook of the American Quarter Horse Association, 2013. American Quarter Horse Assoc., P.O. Box 200, Amarillo, TX 79168. [www.aqha.com](http://www.aqha.com)

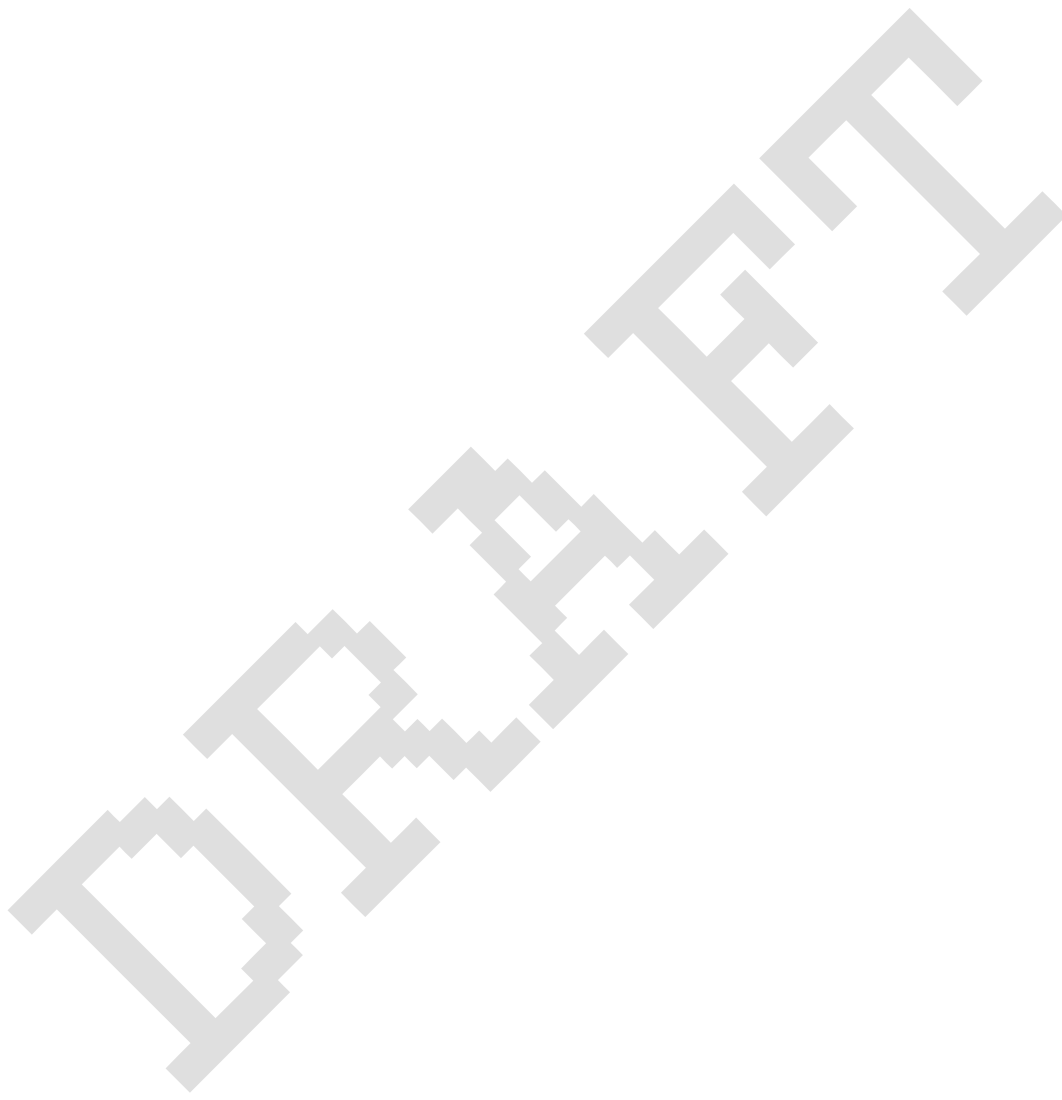
Producing Hay and Pasture for Horses in Michigan, Cooperative Extension Service, Michigan State University, Extension Bulletin E-643.



Rations for Light Horses, Cooperative Extension Service, Michigan State University, Extension Bulletin E-919, September 1975.

Wheeler, E., Koenig, B., Harmon, J., Murphy, P. and Freeman, D Horse Facilities Handbook, Midwest Plan Service, Iowa State University: 2005.

United States Equestrian Federation Rule Book. 2013. United States Equestrian Federation. 4047 Iron Works Parkway, Lexington, KY. [www.usef.org](http://www.usef.org)



## **ADDENDUM: CURRENT STATE AND FEDERAL LAWS**

The Michigan Penal Code, Act 328 of 1931, as amended, MCL 750.50--A person who willfully, maliciously and without just cause or excuse kills, tortures, mutilates, maims, or disfigures an animal or who willfully and maliciously and without just cause or excuse administers poison to an animal, or exposes an animal to any poisonous substance, other than a substance that is used for therapeutic veterinary medical purposes, with the intent that the substance be taken or swallowed by the animal, is guilty of a felony, punishable by imprisonment for not more than 4 years, or by a fine of not more than \$5,000.00, or community service for not more than 500 hours or any combination of these penalties.

Michigan Public Act, Act 93 of 1974, as amended, MCL 287.112--A person, firm, or corporation shall not own or operate a riding stable (any establishment in which, for business purposes, six or more horses or ponies are rented, hired, or loaned for riding) or sale barn (any establishment where horses or ponies owned by others are sold or offered for sale) without first having obtained a license. A person who violates this Act is guilty of a misdemeanor.

Michigan Animal Industry Act, Act 466 of 1988, as amended, MCL 287.739--A facility for exhibition of livestock shall be constructed to allow sufficient separation of each exhibitor's livestock. The facility shall be constructed of a material that can be adequately cleaned and disinfected. An exhibition building or yarding facility shall be cleaned and disinfected with USDA-approved disinfectant used in accordance with label instructions before livestock are admitted by removing from the premises all manure, litter, hay, straw, and forage from pens, runways and show rings, and thoroughly disinfecting walls, partitions, floors, mangers, yarding facilities, and runways in a manner approved by the director.

Michigan Penal Code, Act 328 of 1931, as amended, MCL 750.60 Docking Horses Tails--Any person who shall cut the bone of the tail of any horse for the purpose of docking the tail, or any person who shall cause or knowingly permit it to be done upon the premises of which he is the owner, lessee, proprietor or user, or any person who shall assist in or be present at such cutting, shall be guilty of a misdemeanor, punishable by imprisonment in the county jail of not more than one year or by a fine of not more than \$500.00. Provided, that such cutting of the bone of the tail of any horse for the purpose of docking the tail shall be lawful when a certificate of a regularly qualified veterinary surgeon shall first be obtained certifying that such cutting is necessary for the health or safety of such horse.

The Federal Horse Protection Act was passed in 1970 and amended in 1976. The legislation is aimed at stopping the cruel and inhumane practice of having horses take part in a horse show or sale while they are "sore". A horse is deemed to be sore if it suffers abnormal pain, distress, inflammation, or lameness when it walks, trots, or otherwise moves. Generally, soring refers to any application, infliction, injection, or practice which makes a horse sore in a way that exaggerates its gait, producing a

flourish prized by show judges and viewers. The law forbids the entering of sore horses in shows, exhibitions, sales, or auctions; permitting such an entry to occur; and transporting horses for such an entry. Regulations further forbid acts that may cause horses to become sore at regulated events. Criminal offenses are prosecuted in federal courts.

### **SPECIFIC REFERENCES**

Horse Riding Stables and Sale Barns, 1974 PA 93, as amended, MCL 287.111-287.119.

Animal Industry Act, Act 466 of 1988, as amended, MCL 287.701-287.747.

Michigan Penal Code (Excerpts), 1931 PA 328, as amended, MCL 750.49-750.70.

The Horse Protection Act, Code of Federal Regulations, Title 9, Chapter I, Subchapter A, Part II.

## PRIVATELY OWNED CERVIDAE

### MANAGEMENT OVERVIEW

The Michigan Animal Industry Act, Act 466 of 1988, as amended, describes farmed cervidae (hence known as privately owned cervidae, or cervids) as members of the cervidae family including, but not limited to, deer, elk, moose, reindeer and caribou living under the husbandry of humans. - Because of their unique behavioral characteristics, a high degree of skill and sensitivity need to be exercised when raising cervidae as livestock (Coon et al. 2001). -Cervids are generally less easy to tame than other domestic species and, therefore, have special management, environmental, facility and health care requirements. - Though exact husbandry systems may vary by species and/or location, all farmed deer require adequate nutrition, shelter, holding/handling facilities, and health management. Recommended husbandry and handling procedures for cervids can be found at: [http://www.nfacc.ca/pdfs/codes/deer\\_code\\_of\\_practice.pdf](http://www.nfacc.ca/pdfs/codes/deer_code_of_practice.pdf).

### MANAGEMENT PRACTICES

**Handling:** -Handling cervidae requires care and caution to minimize undue noise and/or commotion, thereby avoiding over-excitement of the animals. -To minimize stress, handling should occur as infrequently as possible. -However, familiarization with routine management and facilities from an early age may reduce animal apprehension. Routine management procedures such as weighing, identification, vaccination, and anthelmintic (dewormer) administration need to be carefully scheduled and performed simultaneously when feasible. - To decrease the chances of animal or human injury during handling, antlers may be removed before the onset of rut. -Handling equipment designed specifically for use with privately owned captive cervidae should be used. Tranquilization may be required if proper handling facilities are not available. - A veterinary/client relationship is needed in-order-to handle these medications without direct veterinary supervision. Working cervidae with dogs is not recommended. If used, dogs must be well-trained on cervidae and used under the direction of experienced handlers.

**Nutrition:** - Adequate feed and water are vital to all animals and farmed cervidae provide no exception. -Access to clean, fresh drinking water is essential for all cervidae. Nutritional requirements vary both between and within species. -There are differences between those species that are primarily grazers and those that prefer to browse. Within species, nutritional requirements differ among adult males, adult females, and growing animals. - In addition, seasonal variation exists within each of these animal classifications and must be taken into consideration to meet their nutritional requirements throughout the year.

**Reproduction:** Reproductive characteristics vary somewhat between cervidae species, but all are highly seasonal. -Important management considerations to achieve

good reproductive performance include: -Paddock size and female: male ratio during breeding; aggressive behavior by males in the rut; normal parturition (birthing) behavior; environmental needs of newborns; and ~~special requirements~~ specific requirements at weaning.- Information from veterinarians, experienced individuals and/or reliable published sources can be valuable (see references).

**Transportation:-** Transporting cervidae successfully requires specific attention to several ~~important details~~ key details. -Cervids should be separated according to species, age, and sex when handling or transporting.- Quiet handling and darkened transport crates or trailers tend to enhance outcomes.

Adequate ventilation is required, and confinement during transport for over 12 hours necessitates provision of feed and water.- Extra caution should be exercised in transporting the following cervidae and should be done only when the cervidae welfare is at stake: ~~1~~ males with antlers in velvet; ~~2~~ females due to give birth within two months; and ~~3~~ lactating females and offspring when those fawns/calves are less than one month of age. -Bucks and bulls in hard antler should be transported individually or in separate compartments. -A delay or cancellation of transport should occur for animals that appear unhealthy, ~~dehydrated~~ dehydrated, or exhausted and unfit to withstand travel. Finally, transportation of cervidae should be avoided in extremely hot weather to minimize associated stress.

## RECOMMENDATIONS FOR THE ENVIRONMENT

Farmed cervidae can be successfully raised under a wide variety of systems. -Their environmental needs vary from those of major livestock species based mainly on their behavioral differences.- Accordingly, requirements often differ among individual cervidae species.- For example, paddock size and stocking density should be determined by species preference toward social and gregarious behavior, and the relative proportions of open pasture and forested land should be based on species preference for browsing ~~vs~~ versus grazing.- Cervidae must become habituated to their environment, and disruptions by people, other animals, or machines should be minimized.- Newborn cervidae require cover for hiding and shelter from inclement weather in some situations.- Though most cervidae are quite tolerant of climatic fluctuations, provision of shelter to temper climatic extremes can be beneficial. -As with other aspects of cervidae farming, environmental design should utilize expert input.

## FACILITIES AND EQUIPMENT

For the most part, the facilities and equipment needed for cervidae farming are dictated by the requirements in handling, nutrition, reproduction, transportation, and environment. -Fences should be tall enough to avert jumping by the species of interest, and sharp protrusions in the confined areas should be strictly eliminated. Recommendations and specifications for fencing and other facility requirements for privately owned cervidae can be found on the Michigan Department of Natural Resources website: <https://www.michigan.gov/dnr/0,4570,7-350--165414--00.html>

## HEALTH CARE AND MEDICAL PROCEDURES

In managing the health of farmed cervidae, aggressive prevention of disease and injury is much preferred to treatment. -Reliable success with both prevention and treatment is more likely if a veterinarian skilled in cervidae management is involved. -Adherence to regulatory requirements must be observed in the transport and transfer of cervidae. Development of a herd-specific health management program in consultation with a local veterinarian is recommended.- This program should incorporate routine herd health evaluations appropriate for the particular management, environment, and facilities involved. -Vaccination, anthelmintic administration, antler removal, and other health management practices can then be appropriately executed in a timely manner. Organic production programs should work with a veterinarian to ensure adequate protection and treatment for sick animals.

**Pharmaceutical Use:** It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products.- To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended.- In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals.- Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and
- 3.2. The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:-** Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately. -Methods can be physical or chemical and one of the approved methods recommended by the AVMA Guidelines on Euthanasia (AVMA, 2020).

|  
|  
**Dead Animal Disposal:** Animal tissue, whole ~~carcasses~~carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

DRAFT

## REFERENCES

American Veterinary Medical Association. 2020. AVMA Guidelines on Euthanasia of Animals. Available at: <https://www.avma.org/KB/Policies/Documents/euthanasia-highres.pdf> (Visited 6.22.2018)

Coon, Thomas G., Henry Campa, Alexandra Felix, John Kaneene, Felix Lupi, Ben Peyton, Mary Schulz, James Sikarski, Michael Vandehaar, Scott Wintersteen. 2001. Farming Captive Cervids in Michigan: A review of Social, Economic, Ecological and Agricultural Opportunities and Risks. Research Report WO1026. Michigan Agricultural Experiment Station. Michigan State University, East Lansing, MI.

Canadian Agri-Food Research Council. Recommended Code of Practice for the Care and Handling of Farmed Deer (Cervidae). 1996. National Farm Animal Care Council website: [http://www.nfacc.ca/pdfs/codes/deer\\_code\\_of\\_practice.pdf](http://www.nfacc.ca/pdfs/codes/deer_code_of_practice.pdf)

Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited (4/29/19)

Midwest Plan Service. 1993. Livestock Waste Facilities Handbook. Midwest Plan Serv., Iowa State Univ., Ames, IA. Third Edition, MWPS-18.

OPERATIONAL STANDARDS FOR REGISTERED PRIVATELY OWNED CERVIDAE FACILITIES Revised December, 2005 Adopted by the Michigan Commission of Agriculture, January 9, 2006 Adopted by the Natural Resources Commission, January 12, 2006.

[https://www.michigan.gov/documents/dnr/POC\\_OP\\_Standards\\_07\\_191455\\_7.pdf](https://www.michigan.gov/documents/dnr/POC_OP_Standards_07_191455_7.pdf)  
(Visited 5.30.19)

Privately Owned Cervidae Registration. Michigan Department of Natural Resources. <https://www.michigan.gov/dnr/0,4570,7-350--165414--,00.html> (Visited 5.30.19)

Rector, Natalie and Wendy Powers. 2009. Acceptable practices for managing livestock along lakes, streams, and wetlands. Michigan State University Extension. Bulletin E3066. <http://www.msue.msu.edu>. (Visited 6. 22.18)



## SHEEP and GOATS

### MANAGEMENT OVERVIEW

The sheep industry is segmented into four major groups. -Commercial flocks produce market lambs and wool, the lamb feeding industry specializes in market lamb production, the registered flocks produce breeding stock and exhibition animals, and the small, special interest flocks are involved in specialty fiber production, rare breeds, etc. In addition, the dairy sheep industry, still in its infancy, has begun in Michigan to produce specialty cheeses and other milk products.

The goat industry is smaller than the sheep industry and is divided differently. -There are a very small number of Grade A dairy farms, and the rest of the dairy goats are kept in small herds for home milk production, 4-H youth projects, and exhibition. -Angora goats are kept for mohair production. -The meat goat industry is currently in a state of growth. The meat goat industry had a by-product of the Angora and dairy goat herds but more recently has become more specialized utilizing breeds specifically for carcass quality. References are provided for more specific guidance on the care of sheep and goats.

### MANAGEMENT PRACTICES

~~The majority of~~Most sheep and goats in Michigan are seasonal breeders, breeding in the fall and giving birth in the spring each year. - The marketing period is extended however by different production systems and lamb/kid feeding strategies. - Indoor birth is to lamb/kid indoors typically early in the calendar year. -Drop lot birth which comprises the majority of Michigan production generally occurs March-June and involves outdoor birth near a barn or similar facility followed by brief individual housing of mother and offspring to facilitate bonding and subsequent release on pasture. - Pasture birth system involves birth on actively growing pasture during warm periods (commonly May-June) without individual housing and is the least laborious system. -Accelerated lambing, currently in minor adoption in Michigan, may use a combination of the above systems and utilizes breeds that are aseasonal in breeding and can reduce the birth interval to 6-8 months. Layered on top on these production systems are different rearing strategies that vary the rate of lamb/kid growth to effectively extend the marketing season and take advantage of seasonal feeding opportunities. - The major system involves early growth on pasture followed by finishing in confinement. -Other strategies include complete confinement or pasture rearing.

**Nutrition:** -The nutritional program is of paramount importance in production of sheep and goats and largely determines animal well-being and closely associated profitability of animal production. -Sheep and goats at all stages of production should be fed and watered in a consistent manner to supply requirements as established by the National Research Council publication *Nutrition of Small Ruminants:- Sheep, Goats, Cervids, and New World Camelids* (NRC, 2007). -These guidelines detail nutritional requirements

according to physiological state and emphasize the importance of matching nutrition to physiological state. -Sheep and goats are commonly litter bearing species and require a higher plane of nutrition in proportion to litter size during the last month of pregnancy. This requires a more concentrated diet due to this increased demand coupled with constraints on voluntary intake imposed by the pregnant uterus.- Proper feeding during late pregnancy also sets the stage for subsequent lactation performance. -The requirements of lactation are dependent on litter size and require a much higher plane of nutrition than other states of production.- Special attention must be given to animals that are still in their growth phase during pregnancy and lactation. -These animals should be fed to meet all requirements (growth and lactation or pregnancy) without providing excess nutrients during pregnancy which can create problems with dystocia (difficult birth).- In addition to the ensuring adequate macronutrient supply as outlined above, micronutrient supply is also an important consideration especially as it relates to mineral nutrition. -Iodine and selenium are deficient in Michigan soils and supplementation must be provided to small ruminants. -This can be done most effectively in the form of mineral or grain supplement. -Copper toxicity can be a problem for sheep.- They have a much lower copper requirement than other livestock species and care should be taken to avoid feeding feeds formulated for other species to prevent toxic accumulation.

Water requirements can be met by routine access to water. -Animals can meet water requirements by consumption of lush forage and or snow depending on seasonal conditions. -Water consumption in its various forms must be sufficient to allow appropriate dry matter intake for each stage of production. -In practice, ewes fed a dry diet during late pregnancy and lactation and lambs fed a dry diet during finishing will have higher requirements for water and will benefit from continuous access to water.

**Transportation:** -Transportation of sheep and goats should be handled with regard to climatic conditions and productive stage of the animals. -Temperature extremes should be avoided and transport of late pregnant animals or debilitated and non-ambulatory animals should be done with caution. -Sheep in short fleece should be transported in trailers designed to minimize drafts during sub-freezing weather.- Proper hydration of animals is especially important before and after shipment during hot, humid conditions. During hot, humid conditions, transport periods should be minimized, and consideration given to night travel to reduce animal stress.- Animals should be handled carefully and quietly during loading and unloading. -A ramp is advised for animal and human safety when animals need to make large changes in elevation. A delay or cancellation of transport should occur for animals that appear unhealthy, dehydrated, or exhausted and unfit to withstand travel.

## RECOMMENDATIONS FOR THE ENVIRONMENT

Nutrition, air quality and in the case of sheep, length of fleece, are primary considerations in the housing of animals during cold weather. Adult sheep, in particular, can be housed outdoors all year round if certain conditions are met. -During winter, sheep housed outdoors need sufficient wool cover and improved quality and or quantity

of feed to maintain body weight and condition depending upon temperature, precipitation, and wind speed. -Wind breaks, either man made or natural, are effective in reducing heat loss and thereby reduce nutrient requirements for heat production and are advised under extreme winter conditions. - If adult animals are housed indoors during winter, adequate ventilation should be provided to prevent humid conditions which promote the spread of respiratory disease. - Buildings should be designed to allow adjustment of air turnover by natural or mechanical means depending on climatic conditions and animal density.

During the summer, housed animals require a more frequent rate of air change to prevent excessive temperature, humidity, and gas exposure that can lead to respiratory disease. -This increased ventilation can be met by natural ventilation in properly designed buildings or facilitated with the aid of mechanical ventilation in other buildings.

Shearing should be performed by skilled personnel using techniques designed to minimize animal stress. -There are shearing schools available in Michigan that provide quality training in this skill. - Sheep and angora goats should be shorn at least annually but care should be taken to avoid release of freshly shorn animals during cold, wet weather. -The stress of such climatic conditions can be minimized by adjusting shearing combs to leave extra wool stubble. - The practice of providing extra wool stubble is also advised for pre-lambing shearing during indoor winter lambing periods. - Shearing pregnant ewes in this manner 2-4 weeks prior to lambing, reduces humidity in the barn at animal level and provides adequate fleece to protect from the cold while also improving maternal feed intake.

Newborn lambs and kids are very susceptible to **hypothermia**, and therefore outdoor birth periods need to be chosen to coincide with favorable conditions for newborn survival. - Newborns vary in their ability to mount an adequate heat response and seek milk according to birth size and genetics. - Soil temperature above 50° F provides a reasonable lower limit for outdoor birth. -Outdoor birth is also possible when soil temperature is less than 50°F but the option of shelter should be available nearby under these conditions. - Indoor birth offers the opportunity for lambing/kidding year round but facilities should be designed to minimize drafts at animal level while maintaining adequate air turnover to prevent humid conditions. - A draft-free environment should be provided during very cold or wet conditions. -In the case of newborns especially susceptible to hypothermia under extreme conditions, supplemental heat in the form of a forced air, warming box or zone heat in early rearing areas may be beneficial.

## **FACILITIES AND EQUIPMENT**

Pastures should be fenced to minimize predator entry and reduce escapes and entrapment of horned or heavily fleeced animals in the fence itself. - Innovations in fencing have made this task easier. -Portable electric fencing allows great flexibility in secure fencing options. - Dry lots should be of sufficient size and well drained to prevent excessive mud during times of prolonged rainfall.

Minimum space recommendations for sheep in confinement can be found in the Midwest Plan Service, Sheep Housing and Equipment Handbook (MWPS, 1994). Recommendations for goats can be found in the National Goat Handbook (1992). Feeders should be designed to avoid waste and minimize fecal contamination of feed. Feeder designs for sheep are often inappropriate for goats. -For this reason, sheep and goats are not usually housed together in close confinement. Additionally, horned goats tend to dominate polled goats and sheep. Extra space must be allowed when horned animals are kept.

Well designed, well-lit facilities can aid in minimizing stress to the animals and the livestock attendants. -Sheep and goats have a strong flocking/herding instinct and handling systems take advantage of this. - Possible causes of accident or trauma to the animals or handlers should be eliminated. -Gates and feed room doors should be securely fastened with livestock-proof latches to avoid illness and/or deaths that occur when animals suddenly have access to large amounts of feed without adequate fermentable fiber. -Shearing facilities should be kept clean and dry and shearing equipment disinfected between flocks.

## **HEALTH CARE AND MEDICAL PROCEDURES**

A health care program should be devised for the particular farm based on its production system and goals. - A health care program should emphasize preventative procedures and be thoroughly integrated with the farm's nutritional program. - Assistance of nutrition and veterinary consultants (MSU Extension or private) are advised in developing such a program. A parasite control program will be an important part of such a program and should emphasize strategic de-worming along with control measures that prevent the development of antihelminthanthelmintic resistant parasite populations (example grazing management).

Husbandry procedures, such as disbudding, castrating and tail docking of sheep, should be carried out by skilled personnel, while the animals are still small, preferably during the first two weeks of life. If lambs are to be tail docked the dock should be performed at the distal end of the caudal fold where the fold meets the tail to prevent rectal prolapse (Thomas, et al. 2003).

Animals that are lame should be treated promptly to minimize pain or distress. -Foot rot is a contagious disease that is endemic in many flocks. -There are sound economic and welfare reasons why foot rot eradication should be carried out. Recognition should be given to the fact that certain sheep and goat diseases are potentially transmissible to people, and appropriate precautions should be taken (Goelz, 2002). Animals that are suffering and/or dying should be treated or euthanized. -All carcasses should be disposed of promptly and in accordance with state and local regulations. Organic production programs should work with a veterinarian to ensure adequate protection and treatment for sick animals.

**Pharmaceutical Use:** -It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products. - To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. -In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. -Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and
3. The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:** - Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately. -Methods can be physical or chemical and be one of the approved methods recommended by the AVMA Guidelines on Euthanasia (AVMA, 2020).

**Dead Animal Disposal:** Animal tissue, whole ~~carcasses~~carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

## REFERENCES

- American Sheep Industry Association. 2002. Sheep Production Handbook. Englewood, CO.
- American Veterinary Medical Association. 2013. AVMA Guidelines on Euthanasia of Animals. Available <https://www.avma.org/KB/Policies/Documents/euthanasia-highres.pdf> (Visited 6.22.2018)
- Animal Care Series: Goat Care Practices. First Edition. 2000. University of California Cooperative Extension Service, Davis, CA.
- Faerber, C.W. 2004. Small Ruminant Production Medicine and Management: Sheep and Goats. Third Edition. Animal Health Publications, Preston, ID.
- Goelz, J.L. 2002. Sheep diseases that can infect humans. International Sheep Letter 22 #8, Sheep World, Pipestone, MN. See also: <http://www.pipevet.com/articles/articles.htm.Zoonoses>. (Visited 7.22.18)
- Meat Goat Production Handbook. 2007. ISBN1-880667-04-5. American Institute for Goat Research. Langston University, Langston, OK.
- Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited (4.29.19)
- Midwest Plan Service. 1994. Sheep Housing and Equipment Handbook. 4th Edition, Midwest Plan Service, Iowa State Univ., Ames, IA.
- Miller, A.J. 1984. Fencing Dairy Goats. In: Goat Extension Handbook. 2<sup>nd</sup> edition. G.F.W. Haenlein and D.L. Ace ed. University of Delaware, Newark, DE.
- National Research Council. 2007. Nutrient Requirements of Small Ruminants: sheep, goats, cervids and New World Camelids. National Academy Press, Washington, DC.
- Thomas, D.L., D.F. Waldron, G.D. Lowe, D.G. Morrical, H.H. Meyer, R.A. High, Y.M. Berger, D.D. Clevenger, G.E. Fogle, R.G. Gottfredson, S.C. Loerch, K.E. McClure, T.D. Willingham, D.L. Zartman and R.D Zelinsky. 2003. Length of docked tail and the incidence of rectal prolapse in lambs. J. Animal Science 81:2725-2732.

## LAYING CHICKENS

### MANAGEMENT OVERVIEW

Nearly all commercial birds are kept in confinement housing with light control, power ventilation and mechanical feeding.- Confinement housing varies from a few birds per house to more than 100,000 birds per house.- In addition, there are many small and some commercial flocks that utilize a variety of free range and/or confinement shelters and housing.

### MANAGEMENT PRACTICES

**Nutrition:** -Feed and clean water shall be available to the birds and when new birds are placed in the system, care must be taken to ensure that the birds find the feed and water sources. -Knowing that all birds do not feed or drink at the same time, an average of 2.2 inches of feeder space and 1 inch of trough watering space per bird is acceptable for most systems, but may vary based on bird type. -A maximum of 20 birds per mechanical water cup or nipple is recommended. -In situations where high environmental temperatures may be encountered, fewer birds per cup or nipple is recommended.

Laying hens normally ~~enter into~~enter a natural molt period after 8-12 months of producing eggs, and therefore, it is considered sound management to induce this molt so that all the birds molt at the same time. -To accomplish this molt, it may be necessary to put the birds on a dietary regime in which feed may be altered but not withdrawn for a period of time allowing the birds a period of rest from egg production. -As a result of this molting program, the birds' productive life will be prolonged.

**Stocking Density:** -Regardless of the type of enclosure or system of management used, all birds should have sufficient freedom of movement.- Minimum space allowance should be in the range of 67 to 86 square inches of usable space per bird housed in conventional cages (United Egg Producers, 2016).

**Beak Trimming and Dubbing:** -Due to the temperament of chickens toward feather picking, fighting and cannibalism, the beaks of domestic birds can be trimmed to remove their sharp tips.- Trimming should be done by properly trained workers and should be done at prescribed times, usually prior to 10 days of age.- More detailed guidelines on beak trimming are available in the United Egg Producers Animal Husbandry Guidelines (2016).

Partial removal of the comb at one day of age is commonly called dubbing and is an acceptable management practice. - It is usually done at the hatchery before shipment of the chicks. -In laying strains that develop large combs, dubbing reduces injury and bleeding caused by contact with their peers, as well as cages and/or equipment during feeding and drinking.

**Transportation:** -Safety and comfort of the animals are of prime importance when transporting poultry. -Poultry in transit should be provided with proper ventilation for the conditions; clean, sanitized vehicles and equipment; and a floor surface that minimizes slipping. A delay or cancellation of transport should occur for birds that appear unhealthy, ~~dehydrated~~dehydrated, or exhausted and unfit to withstand travel. More detailed guidelines are available in the United Egg Producers Animal Husbandry Guidelines.

**Chick delivery:** -The day-old chick delivery vehicle should have the capability of maintaining a uniform temperature of 75°F (24°C) to 80°F (27°C) regardless of ambient temperature. Air circulation ~~must be maintained around all chick boxes at all times~~must always be maintained around all chick boxes regardless of their location in the vehicle. The vehicle should not stop from the time it is loaded until it reaches its destination. Provisions for maintenance of proper ventilation and temperature control should be provided in case of vehicle's mechanical failure or any other unforeseen vehicle stop(s). The transportation vehicle should be properly cleaned and sanitized between deliveries.

**Adult poultry delivery:** -When adult poultry are transported, adequate ventilation, space and flooring should be provided. -Hot weather is a time for particular caution. The birds should be protected from heat stress by being shaded and/or moved during the dark hours. -Prompt unloading and/or auxiliary ventilation is essential when the birds reach their destination.

During transportation in cold weather, birds should be protected by use of windbreaks, partial covering, etc. - Ventilation must always be adequate.

## RECOMMENDATIONS FOR ENVIRONMENT

**Ventilation and Lighting:** -Ventilation in the layer house should provide a healthy level of moisture, gases and temperature maintained without drafts or dead air pockets.

Lighting should be provided to allow effective inspection of all the birds and sufficient light for the birds to eat and drink. -Light intensity within the house should average between 0.125 and 1.0 foot candle during the daily light period.

The housing should provide shelter from disturbing noises, strong vibrations, or unusual stimuli, regardless of origin.



## FACILITIES AND EQUIPMENT

**Housing:** The design, construction and management of a poultry housing system must meet the birds' need for shelter against undesirable environmental conditions such as extreme cold, excessive heat, rain and wind and modify these climatic conditions to conform to an adequate environment for laying hens.- They shall be constructed to minimize transmission of disease, parasites and other vermin infestation and optimize the principles of disease prevention. -The housing should also protect the birds from all forms of predators and allow for daily visual inspection and care. -Public Act No. 117 of October 12, 2009 will require that by April 1, 2020 all egg laying hens be housed so that they are able to fully extend their limbs and turn around freely. -Hens may be housed in a variety of housing arrangements such as aviary, single tier systems or colony systems that are large enough to do so with a minimum of 1 ~~sq.~~sq.~~ft.~~ft.~~square~~square ~~foot~~foot per hen.

**Housing in cages:** -Cages shall be designed, ~~constructed~~constructed, and maintained to avoid injury to the birds and allow bird comfort and health.- The cages must be so constructed as to allow the safe placement and removal of birds.- Cage height shall allow a minimum of 14 inches with a floor slope not to exceed 8.5 degrees.- As stated above conventional battery cage systems will be eliminated as a housing option on April 1, 2020.

**Housing on floors:** -All flooring shall be designed, ~~constructed~~constructed, and maintained to avoid injury and allow comfort and health to the birds.- More complete guidelines for floor space, nesting area, feed and water spacing and litter management are available in the United Egg Producers Animal Husbandry Guidelines (2016) or standards set by certification bodies for special label marketing purposes.

**Maintenance:** -When mechanical systems are utilized for feeding, watering, ventilating, egg collecting, manure removal, etc., properly trained personnel shall regularly check the operation of these systems and adjust and maintain them when necessary to prevent injury to the birds and maintain the health and comfort of the laying hens. -All aspects of the housing facility must be checked regularly to assure both the structure and systems are operating correctly.

**Cleaning of poultry houses:** -Poultry houses should be cleaned periodically to provide a healthy environment for the birds. -The length of time between cleaning depends upon the type of housing, mechanical systems installed, removal of birds from the house and other factors peculiar to each individual farm. ~~Typically~~Typically, cleaning is done in the time period after depopulation of the old flock and before the arrival of the new flock. Manure management should conform to the recommendations presented in the current Right to Farm Practices (Michigan Manure GAAMPs).

## HEALTH CARE AND MEDICAL PROCEDURES

Optimal management practices are essential to maintain good health status in the egg production facilities and may be in consultation with a veterinarian. -A program of disease prevention and control should be established for both conventional and organic production programs.

Only federally approved medications and vaccines shall be used, following label directions in accordance with state and federal regulations.

**Pharmaceutical Use:** - It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products.- To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended.- In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. -Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. ~~t~~There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and
- ~~3.2.~~
- 4.3. ~~t~~The practicing veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:** - Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately. -Methods can be physical or chemical and one of the approved methods recommended by the AVMA Guidelines on Euthanasia (AVMA, 2020). On the farm euthanasia recommendations are also available in the United Egg Producers Guidelines (2016).

|  
| **Dead Animal Disposal:** Animal tissue, whole ~~carcasses~~carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

DRAFT

## REFERENCES

American Veterinary Medical Association. 2013. AVMA Guidelines on Euthanasia of Animals. Available at: <https://www.avma.org/KB/Policies/Documents/euthanasia.pdf>. (Visited 6.28.13)

Esmay, M.L. and C. J. Flegal, 1982. Poultry Housing for Layers, North Central Regional Extension Publication #183, Michigan State University.

Michigan Commission of Agriculture and Rural Development. Generally Accepted Agricultural and Management Practices for Manure Management and Utilization. Lansing, MI.

Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited (4.29.19)

"United Egg Producers Animal Husbandry Guidelines for U.S. Egg Laying Flocks." United Egg Producers Certified. 2016 Edition. United Egg Producers. <http://www.unitedegg.org/information/pdf/UEP-Animal-Welfare-Guidelines2016.pdf>. (Visited 6.22.2016)

## BROILERS, TURKEYS, AND GAMEBIRDS

### MANAGEMENT OVERVIEW

Nearly all commercial turkeys and commercial broiler facilities are kept in confinement housing with light control, power ventilation and mechanical feeding. Commercial gamebirds facilities, along with small farm hobby and backyard flocks, utilize a wide variety of free range and/or confinement shelters and housing.

These ~~Generally Accepted Agricultural and Management Practices (GAAMPs)~~ are intended to assist the broiler, turkey, and gamebird producer in attaining and maintaining a high quality of bird comfort and well-being in broiler, turkey, and gamebird production facilities and will focus on the birds' basic requirements.

### MANAGEMENT PRACTICES (INCLUDING TRANSPORTATION)

**Nutrition:**- Feed and clean water ~~should be available to the birds at all times~~should always be available to the birds and when new birds are placed in the system, care must be taken to ensure that the birds find the feed and water sources. -Birds should be fed a feed that is appropriate for the stage of life of the particular species and formulated for that species.- Commercial turkeys typically are raised on 6 to 7 different diets starting with a 28 ~~percent%~~ protein content in the feed and ending with a 16 ~~percent%~~ protein in the feed. -Commercial broilers typically are fed two, sometimes three different diets in their production period. -In situations where high environmental temperatures can be encountered, additional water space per bird is recommended.

**Beak trimming and specs:** -Due to the temperament of chickens, turkeys, and gamebirds toward feather picking, fighting and cannibalism, the beaks of birds can be trimmed to remove their sharp tips as an aid in prevention of these actions.- Trimming should be done by properly trained workers and should be done at the prescribed times, generally at the hatchery.- In addition, specs or blinders may be attached to the beak of the bird so that the birds can see to the right or left, but not straight ahead. -This should be done by properly trained workers and should be done when the birds are of sufficient age to readily find the feed, ~~water~~water, and other visual environmental necessities.

**Toe trimming:**- Due to the tendency of turkeys to inflict bodily damage upon each other with their toenails in confinement situations, one or more toenails (generally the inside and middle toes on both feet) may be removed. -Toe trimming (or declawing) should be done by properly trained workers and is generally done at the hatchery.

**Transportation:** -Safety and comfort of the animals are of prime importance when transporting live poultry and gamebirds. - When poultry and gamebirds are transported, they should be provided with proper ventilation for the conditions, and clean sanitized vehicles and equipment. A delay or cancellation of transport should occur for birds that appear unhealthy, ~~dehydrated~~dehydrated, or exhausted and unfit to withstand travel.

**Chick and poultry delivery:** -The day-old chick and poultry delivery vehicle should have the capability of maintaining a uniform temperature of 75°F (24°C) to 80°F (27°C) regardless of ambient temperature. -Air circulation ~~must be maintained around all chick-poultry boxes at all times~~must always be maintained around all chick-poultry boxes regardless of their location in the vehicle. -The vehicle should not stop from the time it is loaded until it reaches its destination. -Provisions for maintenance of proper ventilation and temperature control should be provided in case of vehicle's mechanical failure or any other unforeseen vehicle stop(s). -The transportation vehicle should be properly cleaned and sanitized between deliveries.

**Adult poultry and gamebird delivery:** -When adult poultry and gamebirds are transported, adequate ventilation, space and flooring should be provided. -Hot weather is a time for particular caution. -The birds should be protected from heat stress by being shaded and/or moved during the dark hours. -Prompt unloading and/or auxiliary ventilation is essential when the birds reach their destination. -During transportation in cold weather, birds should be protected by use of windbreaks, partial covering, etc. Ventilation must always be adequate.

**Range rearing:** -The growing of chickens, turkeys, and gamebirds in range pens, after the brooding period, is an accepted practice and may be the system of choice, especially for several species of gamebirds. -Range reared birds should have adequate space (see references) as well as protection from extremes in climatic conditions, predators and disease inherent with this growing system.

## RECOMMENDATIONS FOR THE ENVIRONMENT

**Ventilation and lighting:** -Ventilation in the grower house shall be such that a healthy, acceptable level of moisture, gases, ~~dust~~dust, and temperature is maintained without drafts or dead air pockets (UEP, 2016). -The ventilation system should be adjusted daily, or more often, as the environmental conditions dictate.

Lighting should be provided to allow effective inspection of all the birds and sufficient light for the birds to eat and drink. -Light intensity within the house should be a minimum of 0.4 foot candles.

The housing should provide shelter from disturbing noises, strong vibrations, or unusual stimuli, regardless of origin.

## FACILITIES AND EQUIPMENT

**Housing:** -The design, construction and management of a poultry housing system should meet the birds' need for shelter against undesirable environmental conditions such as extreme cold, excessive heat, rain and wind and modify these climatic conditions to conform to an adequate environment for broilers, turkeys, and gamebirds. They shall be constructed to minimize transmission of disease, parasites and other vermin infestation and optimize the principles of disease prevention. -The housing should also protect the birds from all forms of predators and allow for daily visual inspection and care.

**Broilers:** -Brooding and growing space requirements and water and feeder space should conform to the general needs as outlined in the particular broiler company's management guide, if applicable, e.g., Cobb's Broiler Manual (2012) or Ross Broiler Management Guide, 2012.

**Turkeys:** - Brooding and growing space allowances and feeder and water space for turkeys should conform to the general needs as outlined by Berg and Halvorson (1985).

**Gamebirds:** -Brooding and growing space allowances and feeder and water space for gamebirds should conform to the general needs as outlined by Flegal and Sheppard (1981) and Eleazer, et al., (1990).

**Litter:** -Many different types of litter can be used. - All litter must be dry and of acceptable quality. -It is acceptable to reuse litter for several successive flocks **as long as if** ammonia and insects are controlled and there has been no disease outbreak.

Manure management should conform to the recommendations presented in the current Right to Farm Practices (Michigan Manure GAAMPs).

## **HEALTH CARE AND MEDICAL PROCEDURES**

Optimal management practices are essential to maintain good health status in the production facilities and may be in consultation with a licensed veterinarian. - A program of disease prevention and control should be established, including producers participating in organic production programs. - Only federally approved medications and vaccines shall be used, following label directions in accordance with state and federal regulations.

**Pharmaceutical Use:** -It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products. -To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. -In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. - Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;

2.1.

3. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and,

4.2.

5.3. The practicing veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:** -Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately. -Methods can be physical or chemical and one of the approved methods recommended by the AVMA Guidelines on Euthanasia (AVMA, 2020).

**Dead Animal Disposal:** - Animal tissue, whole ~~carcasses~~carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.



## REFERENCES

American Veterinary Medical Association. 2013. AVMA Guidelines on Euthanasia of Animals. Available at: <https://www.avma.org/KB/Policies/Documents/euthanasia.pdf>. (Visited 6.28.2013)

Arbor Acre Broiler Management Manual (2000) Arbor Acres. 29 June, 2008  
[http://www.aviagen.com/pdf/AA/Broiler\\_Manual\\_2000.htm](http://www.aviagen.com/pdf/AA/Broiler_Manual_2000.htm)

Arrington, L.C. 1980. Market Turkey Management-Brooding, North Central Regional Extension Publication #115.

Berg, R. and D. Halvorson. 1985. The Turkey Management Guide, The Minnesota Turkey Grower's Association, St. Paul, MN.

Cobb Broiler Manual. 2012. Cobb Incorporated, Siloam Springs, AR.

Eleazer, T.H., C.R. Douglas, and G.D. Butcher, 1990. Bobwhite Quail Production, Florida Extension Publication Circular 879.

Flegal, C.J. and C.C. Sheppard. 1981. Managing Gamebirds, Michigan Extension Bulletin E692.

Michigan Commission of Agriculture and Rural Development. Generally Accepted Agricultural and Management Practices for Manure Management and Utilization. Lansing, MI.

Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited (4.29.19)

Ross Broiler Management Guide, 2012 <http://freepdfdb.net/pdf/ross-broiler-management-guide>.

## DOMESTIC RABBITS

### MANAGEMENT OVERVIEW

Rabbits are raised for research, meat, wool, pelts, show, pets, and as a hobby (Cullere and Zotte, 2018). -They are maintained under a wide variety of conditions ranging from single backyard hutches to large environment-controlled commercial production units. Rabbits are adaptable to a wide range of housing and management systems provided their needs for shelter, nutrition and health care are met.

If rabbits are raised and sold for laboratory use, they must be raised according to the provisions of the Animal Welfare Act (1966). Rabbitries producing rabbits for laboratory use must also be licensed by the U.S. Department of Agriculture.

### MANAGEMENT PRACTICES

**Nutrition:-** Rabbits must be fed a sufficient quantity of wholesome, palatable feed to meet their nutrient requirements. -Each pen should be provided with suitable feed receptacles (typically a crock or metal feeder and a hay manger if loose hay is fed) to allow easy access to uncontaminated feed.

Rabbits must have access to clean, fresh water daily.- Water receptacles (crops, water bottles, etc.) or automatic waterers may be used. -Frequent watering or use of heating systems should be employed to assure that an adequate supply of drinking water is available to the animals during freezing temperatures.

Feeding young newly weaned rabbits between the ages of 5 and 10 weeks of age requires special attention as they are prone to infectious digestive disorders such as epizootic rabbit enteropathy. With new rules regarding the feeding of antibiotics, feeding and management strategies that establish healthy growth, resistance to digestive problems, and promote a strong immune system should be employed.

**Handling and Transportation:-**Proper handling of rabbits will help prevent injury to the animals, as well as to the handlers. -Recommended methods for handling and examining rabbits are given in Rabbit Production (Cheeke, et al. 2000) and in the Domestic Rabbit Guide (ARBA, undated).

The safety and comfort of the animals are of prime importance when transporting rabbits. -Wire carrying cages are recommended for transporting rabbits. -Carrying cages should be of sufficient size to allow the rabbits to turn about freely and make normal

postural adjustments. -Carrying cages with wire (1/2 1/2 inch "by x-1 inch") floors suspended above solid bottoms are recommended. -Cat carriers are not recommended for transporting rabbits, as rabbits could be injured when removing them from the carrier. -Rabbits should be provided with a non-toxic absorbent bedding material to prevent leakage in transit. -Loading rabbits into transport crates or cages should be conducted with care. Carefully placing each rabbit into the transport crate or cage can help to minimize fear and distress associated with transport. Handlers must avoid hurried loading and rough handling such as inappropriate lifting and must not carry and throw rabbits into the crates.

Rabbits being transported should be observed frequently and should have access to feed and water (or feed that will satisfy their water needs) if in transit for more than 6 hours. -A delay or cancellation of transport should occur for animals that appear unhealthy, ~~dehydrated~~dehydrated, or exhausted and unfit to withstand travel. During hot weather, precautions should be taken to guard against heat stress.

## **RECOMMENDATIONS FOR THE ENVIRONMENT**

It is essential that good sanitation and vermin (insects, ectoparasites, and avian and mammalian pests) control be provided whether rabbits are housed indoors or out-of-doors. -The use of screens and approved sprays and baits are suggested to help control insects in the rabbitry. -Pens, feed, and watering equipment should be cleaned and sanitized periodically. -Accumulations of hair on rabbit pens should be removed. Frequent removal of manure from under the cages will help prevent unpleasant odors and ammonia fumes, as well as, reduce environments that are conducive to insect propagation. -All feed and bedding should be stored in bins or containers in a cool, dry, area which would not attract rodents.

## **FACILITIES AND EQUIPMENT**

**Housing:** -Although rabbits may be housed under a variety of conditions, they should be provided a comfortable environment which will limit stress and risk of injury, and afford good ventilation and protection from the elements. -If rabbits are raised in outside hutches, the hutches should have ~~water-tight~~watertight roofs. -Hutches should be designed to protect the rabbits from wind, snow, rain, sun, and predators, yet allow for sufficient ventilation for removal of hot air in summer and moisture in winter. -Hutches suspended above the ground with welded wire floors and sides are conducive to good air circulation and sanitation, as opposed to solid wooden hutches. -The size of hutch required will depend on the size and number of the rabbits to be housed (see pens below).

When rabbits are housed in a building, the building should provide adequate ventilation and drainage to maintain a healthy environment for the animals. -Ventilation may be natural or by mechanical means (fans) when natural air movement is not sufficient. Typically, in indoor housing, single-tiered, all-wire pens are suspended. -Single-tiered pens facilitate animal care and sanitation and are preferred over multi-tiered pens.

Concrete or dirt floors with pits under the pens to contain the droppings are recommended for indoor rabbitries. -Automatic pit cleaners are desirable but not essential. Disposal of manure should be in accordance with Michigan Manure GAAMPs.

Rabbits are herbivorous animals and under semi-wild conditions may spend up to 70 percent % of their day searching for food and feeding (Torcino and Xiccato, 2004). Rabbits have an innate need to gnaw or chew. -The provision of enrichments such as gnawing sticks within intensive cage or hutch environments may reduce the incidence of abnormal behavior. Cage biting is one abnormal behavior associated with barren environments and can cause tooth damage. Provision of enrichments may improve growth and carcass characteristics for meat rabbits (Verga, et al. 2004). For example, recent research conducted with New Zealand White rabbits has indicated the provision of gnawing sticks can improve carcass traits and body weights (Mohammed and Nasr, 2016).

**Pens:** -Rabbit pens must be clean, dry, and of sufficient size to allow the animals to perform their normal physiological functions, including rest, sleep, grooming, defecation, breeding, kindlingkindling, and raising young. -Giant breeds of rabbits require larger pens than the small breeds. -Suggested pen sizes for various size rabbits are given by Cheeke, et al. (2000), and the American Rabbit Breeders Association (see references). Pens should be structurally sound and constructed of durable, non-toxic materials which resist corrosion and are conducive to good sanitation. -The pens should be maintained in good repair and afford protection to the rabbits from injury and predators.

It is desirable to house rabbits in wire bottom pens suspended above the ground to allow feces and urine to fall through the pen floors and for ease in removal of these waste products from under the pens. Wire mesh (1/2 1/2 inch" by 1 inch" ) floors are recommended and should be of woven or flat construction. Flat is more easily cleaned. Recent research comparing different floor types and its impact on rabbit foot health, soiling of fur, parasite control and the sanitation of pens indicate flat metal slatted floors kept rabbits' cleaner and lowered parasite counts (Tillman et al.2019). Another study examined the impact of stocking density and collective housing on behavior and stress in male and female rabbits (Torcino et al. 2018). They found that floor type (wooden slats) was more challenging to rabbit welfare than higher stocking density regardless of gender. Solid floored pens may be more suitable for some giant breeds of rabbits that are prone to foot problems. Rabbits in wire bottom cages could be given a section of drywall (plaster board) or pegged board for a resting place and to help eliminate foot problems. -Solid floored pens should be provided with clean, dry litter and should be cleaned frequently. -A solution of household bleach with water and sunshine are effective disinfectants.

Bred does should be provided with an adequate sized nest box in which to raise their young during the first few weeks after kindling. -The nest box should contain a suitable bedding material and should be placed in the pen a few days prior to kindling. -Various typesSeveral types of bedding, including straw, wood chips or sawdust (do not use cedar which is a respiratory irritant or walnut which can be toxic), crushed/shredded

sugar cane, and newspaper, can be used. -Nest boxes may be constructed of wood, metal, plastic, or wire. -Disposable liners should be used with wire nest boxes. - In non-heated rabbitries during cold weather, well insulated nest boxes should be provided or the does should be moved to a warm area to kindle and raise their litters for the first few weeks. - Good nest box sanitation is essential. Studies on the impact of group housing on breeding does indicate issues with maintaining health status, kit survivability, and stress (Pérez-Fuentes et al. 2020; Zomeña et al. 2018). A recent review of research outcomes on doe housing was published by Szendrő, et al. 2019.

## HEALTH CARE AND MEDICAL PROCEDURES

Optimal management practices are essential to maintain good health status in the rabbitry. -A program of disease prevention and control should be established and may include consultation with a veterinarian. -Rabbit breeders should be on the lookout for signs of illness. -Any sick or injured animals should be immediately treated, or if necessary, humanely euthanized. -Rabbits that are under quarantine or suspected of having an infectious disease should be separated from other rabbits to minimize the spread of disease. -Organic production programs should work with a veterinarian to ensure adequate protection and treatment for sick animals.

**Pharmaceutical Use:** - It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products. -To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. -In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. - Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and
3. The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:** -Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately.- Methods can be physical or chemical and one of the approved methods recommended by the AVMA Guidelines on Euthanasia (AVMA, 2020).

**Dead Animal Disposal:** -Animal tissue, whole ~~carcasses~~carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

## REFERENCES

American Veterinary Medical Association. 2013. AVMA Guidelines on Euthanasia of Animals. Available at: <https://www.avma.org/KB/Policies/Documents/euthanasia.pdf>. (Visited 6.22.2018)

Animal Welfare Act, 1966. The Act of August 24, 1966 (Public Law 89-544) commonly known as the Laboratory Animal Welfare Act, as amended by the Act of December 24, 1970 (Public Law 91-579), the Animal Welfare Act of 1970, the Health Research Extension Act of 1985.  
[https://www.aphis.usda.gov/aphis/ourfocus/animalwelfare/sa\\_awa](https://www.aphis.usda.gov/aphis/ourfocus/animalwelfare/sa_awa) (Visited 5.30.2019)

ARBA (American Rabbit Breeders Association) Recommendation for Rabbit & Cavy Care. <https://www.arba.net/PDFs/CAW.pdf> (Visited 6.22.2018)

ARBA (American Rabbit Breeders Association). Domestic Rabbit Guide. American Rabbit Breeders Association, Bloomington, IL. 33 pp. Purchased at: <https://www.arba.net/store/store.php?ac=viewProduct&id=7&cid=0> (Visited 6.22.2018.)

ARBA (American Rabbit Breeders Association), 1996. Official Guide to Raising Better Rabbits and Cavies. American Rabbit Breeders Association, Bloomington, IL. 192 pp. Purchased at: <https://www.arba.net/store/store.php?ac=viewSimilar&id=9> (Visited 6.22.2018)

Cheeke, P.R., N.M. Patton, S.D. Lukefahr, and J.I. McNitt, 2000. Rabbit Production. 8<sup>th</sup> Ed. Interstate Printers and Publishers, Inc., Danville, IL. 493 pp.

Cullere, Marco and Antonella Dalle Zotte. 2018. Rabbit meat production and consumption: State of knowledge and future perspectives. Meat Science, 143: 137-146. See also: <https://doi.org/10.1016/j.meatsci.2018.04.029> (Visited 6.03.19)

Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited (4.29.19)

Mohammed, H. and N. Nasr, 2016. Growth performance, carcass traits, behavior and welfare of New Zealand White rabbits housed in standard cages with different wooden sticks as enrichment. Animal Production Science (accepted April 26, 2016)

[http://www.publish.csiro.au/view/journals/dsp\\_journals\\_pip\\_abstract\\_scholar1.cfm?nid=72&pip=AN15865](http://www.publish.csiro.au/view/journals/dsp_journals_pip_abstract_scholar1.cfm?nid=72&pip=AN15865) (Visited 6.22.2018)

National Research Council, 1977. Nutrient Requirements of Rabbits. National Academy Press, Washington, DC. 30 pp.

[S. Pérez-Fuentes, A. Muñoz-Silvestre, E. Moreno-Grua, E. Martínez-Paredes, D. Viana, L. Selva, A. Villagrà, C. Sanz-Tejero, J. J. Pascual, C. Cervera, and J. M. Corpa. 2020. Effect of different housing systems \(single and group penning\) on the health and welfare of commercial female rabbits. \*Animal\* 14: 1270-1277. DOI: <https://doi.org/10.1017/S1751731119003379>](#)

[Szendrő, Z., A. Trocino, S. Hoy, G. Xiccato, A. Villagrà and L. Maertens. 2019. A review of recent research outcomes on the housing of farmed domestic rabbits: reproducing does. \*World Rabbit Science\* 27: 1–14.](#)

Tillman, K., I. Windschnurer, J. Gamper, B. Hinney, T. Rüllicke, B.K. Podesser, J. Troxler and R. Plasenzotti. 2019. Welfare assessment in rabbits raised for meat and laboratory purposes in enclosures with two floor types: Perforated plastic with holes versus slats. *Research in Veterinary Science*, 122 : 200-209. See: <https://doi.org/10.1016/j.rvsc.2018.11.016> (Visited 6.03.18)

Torcino, A., E. Filiou, C. Zomeño, M. Birolo, D. Bertotto and G. Xiccato. 2018. Behaviour and reactivity of female and male rabbits housed in collective pens: Effects of floor type and stocking density at different ages. *World Rabbit Science*, 26:135 – 147. See: <https://doi.org/10.4995/wrs.2018.7747> (Visited 6.03.19)

Torcino, A. and G. Xiccato. 2004. Animal welfare in reared rabbits: A review with emphasis on housing systems. *World Rabbit Science*, 14:77-93.

Verga, M., I. Zingarelli, E. Heinzl, V. Ferrante, P.A. Martino, and F. Luzi. 2004. Effects of housing and environmental enrichment on performance and behavior in fattening rabbits. *World Rabbit Science*, 13: 139-140.

[Zomeño, C., M. Birolo, F. Gratta, A. Zuffellato, G. Xiccato, and A. Trocino. 2018. Effects of group housing system, pen floor type, and lactation management on performance and behaviour in rabbit does. \*Applied Animal Behaviour Science\* 203: 55–63.](#)

## FARM-RAISED MINK AND FOX

### MANAGEMENT OVERVIEW

The humane raising of mink or fox under farm conditions requires a thorough knowledge of the animals' natural life cycle and their normal behavior including breeding cycles, whelping and lactation behavior, weaning and separation procedures, growing and furring periods. -The mink or fox farmer must have a working knowledge or access to the nutritional needs of the animals throughout their life cycle. It is imperative to have adequate facilities to supply and maintain proper housing, a reliable supply of clean drinking water and storage capabilities for quality feed. Proper protocols must be in place for the daily recording and treatment of sick or injured animals, the monitoring of death losses, extreme environmental conditions, manure management, pest control and euthanasia. The mink or fox farmer must assure the welfare of their mink, which includes developing the skills of observation and the management knowledge/training to properly ensure quality welfare for the mink, as well as ensuring that employees on the farm are competent, properly trained individuals who have a good understanding of all the farm management protocols that they will be involved with. The mink or fox farmer should develop a site plan of the farm, and ensure it is present on the farm. - A written entrance biosecurity policy for both farm employees and visitors to the farm should be in place with signage to identify bio-secure areas and directions and/or contact information to instruct visitors. Farm employees who are involved with the care of the mink or fox must be trained to practice proper animal handling and understand proper animal husbandry. A record should be kept by the farm indicating when each employee was trained, and the employee must sign-off that he/she completed the training. - There should be an employee Code of Conduct developed to instruct all employees that all farm specific protocols and biosecurity measures must be adhered to, that all mink or fox need to be handled with care and require that all employees, if they witness any practice that causes avoidable pain or suffering, that employee must immediately notify a supervisor.

These Generally Accepted Agricultural and Management Practices (Practices)-GAAMPs for the care of farm-raised mink and fox were compiled primarily from the Standard Guidelines for Operation of Mink Farms in the United States Fur Commission U.S.A., 2019 and the Standard Guidelines for the Operation of Fox Farms in the United States (North Central Fox Producers and U.S. Fox Shipper's Council, 2006). -These guidelines were developed by the Fur Commission U.S.A. (mink) and the North Central Fox Producers and U.S. Fox Shipper's Council (fox) and adopted by the mink and fox farming industries to promote sound husbandry and humane treatment of these animals in accordance with current accepted moral and ethical standards. -Other pertinent guidelines include the Code of Practice for the Care and Handling of Mink (National



Farm Animal Care Council, 2013) and the Code of Practice for the Care and Handling of Farmed Fox (National Farm Animal Care Council, 2013).

## MANAGEMENT PRACTICES

**Nutrition:** Mink and fox should be fed a complete diet that fulfills the animals' various nutritional needs and modified as nutritional requirements of the life stages of the mink or fox change. Nutritional information is available from a variety of sources (National Research Council, 1982; Rouvinen-Watt et al., 2005). The farm should have a nutritionally balanced ration developed through consultation with a nutritionist or purchase a fully balanced complete feed. Analysis of mixed food rations, when needed, should be obtained from a qualified laboratory. -Feed ingredients should be tested for nutritional value (protein, carbohydrates, fat, moisture) and for bacterial levels (plate count). -The total mixed ration should be tested for nutritional value (protein, carbohydrates, fat, moisture) and bacterial levels (plate count) at least quarterly throughout the year. -Complete dry and/or complete ready-mixed wet foods must be stored and fed according to the manufacturer's instructions. Ready access to potable water is particularly important to animals fed dry diets and during extremely warm weather and periods of freezing temperatures.

**Feed Storage and Preparation:** When the farmer is handling fresh and frozen animal by-products that can deteriorate quickly, the collection, storage and preparation of feed should be carried out under sanitary conditions. -Transport vehicles and containers used for collection of animal by-products should be drip-proof and be thoroughly washed after each collection. -Animal by-products should be refrigerated or preserved to ensure freshness and nutritional value. -Feed preparation machinery, grinders, ~~mixers~~mixers, and blenders should be cleaned after use and regularly maintained. -Dry foods such as cereals and supplements should be stored under dry and pest-free conditions. Individuals involved with feed preparation should be properly trained.

**Feed Distribution:** Sufficient feed ~~must be given at all times~~must always be given to ensure the health and ~~wellbeing~~well-being of the animals. -Feed should be placed in such a position that animals can easily reach it. -This is particularly important with young animals and during periods of extreme cold. -Feed must be provided at least daily to growing and mature animals. Once full growth is achieved, it may be desirable to skip feed occasionally to aid conditioning. Feed carts used to deliver wet feed, hoppers for dry feed and the wet feed area of cages should be cleaned and maintained on a routine schedule. Waste feed should be disposed of in accordance with the farm's waste management plan.

**Watering Systems:** Farmers must ensure that clean, fresh water ~~is readily available to animals at all times~~is always readily available to animals. -When either a fully automatic or semiautomatic system is used, an alternative supply of water should be available. Care must be taken so that automatic water systems remain clean and that individual valves or nipples function properly. Regular maintenance must be carried out to

prevent leaking of valves and connections that can cause wet areas on the farm. -The watering system must ensure easy access to drinking water and the system should be checked during hot weather to ensure uninterrupted availability.- In areas where weather can be uncomfortably warm in the summers, water mist systems in the sheds are recommended to ensure the comfort of animals. The farm's water source should be tested for its component content (i.e. pH, nitrates, nitrites, lead, salt) and bacterial content at least once yearly or after any major repair work is done on the system.- The farm should have a written back up plan in place in the event the primary watering system fails (i.e., e: equipment breakdown, power failure, freezing).- The watering systems must be checked daily to be sure that they are functioning.

**Handling and Transportation:** -Precautions must be taken when handling mink and fox to prevent injury to the animals and the handler. -Mink are routinely handled with heavy leather gloves, while fox are most commonly handled with metal tongs.

Transportation of mink and fox requires special attention to traveling crates design, care of the animals in transit, and where required, proper documentation.- A delay or cancellation of transport should occur for animals that appear unhealthy, dehydrated, or exhausted and unfit to withstand travel. Detailed recommendations for transportation of mink and fox can be found in the Standard Guidelines for Operation of Mink Farms in the United States (Fur Commission U.S.A., 2019) and the Standard Guidelines for the Operation of Fox Farms in the United States (North Central Fox Producers and U.S. Fox Shipper's Council, 2006), respectively.

## RECOMMENDATIONS FOR THE ENVIRONMENT

The mink or fox farmer must develop an effective hygienic and sanitary program to promote a healthy environment. -Farmers must observe all local, state, and federal laws intended to protect ground and surface water quality and should cooperate with officials in their jurisdictions to develop appropriate management practices. -The farm should follow a written waste management plan and have a water quality control program. Sheds/barns should be designed to keep ~~rain water~~rainwater off the manure.- Feed preparation buildings and surroundings areas must be kept clean.- Pens and nest boxes must be cleaned regularly as dictated by the time of year. -The farm should have a plan in place to address manure buildup on false cage bottoms. -The farm should have a written pest management plan that addresses the housing area and the feed storage and preparation areas.

## FACILITIES AND EQUIPMENT

**Site:** A new mink or fox farm's location must be carefully selected. Due consideration must be given to local environmental conditions, artificial light, foreseeable neighborhood development, and subsequent development of the farm. The location must comply with local, state, and federal environmental regulations. A protective fence must be constructed around the perimeter of the area where mink or fox are housed or the buildings housing the animals are closed to protect the animals from predators

and/or disease-carrying wildlife, and to keep unconfined mink or fox from exiting a bio-secure environment. A site plan of the farm needs to be available at the farm office, showing all sheds and describing the types, number, dimensions, maximum animal densities of the specific pens, date of construction and date of any major repairs of all pens within the specific sheds. The farm must have a process in place to capture any mink that have escaped. Live traps must be checked daily or as appropriate.

**Sheds:** -Any building erected to house mink or fox must provide proper ventilation as well as clean, hygienic conditions, and at the same time afford protection from the elements. -The sheds should be constructed to allow for adjustments to protect against weather extremes and the farm should develop a written plan to address extreme heat or cold. The sheds should be constructed in a way that allows for adequate light to observe the animals and designed to allow for exposure to natural or artificial light that mimic the needed natural photoperiod stimulation. -Sheds may be constructed to hold any number of rows, providing air quality and farm manure management protocols are met. -Air quality can be measured by determining ammonia levels at the cage level; 25 ppm is the standard and maximum acceptable level. -Sheds should be designed to keep the ~~rain-water~~rainwater off the manure found below the pens. -The areas under the pens must allow the efficient removal of manure and used bedding materials. -The pens that house mink or fox should be a minimum of 12 inches above ground level to allow feces to fall out of the pen. The alleyways between the pens should be wide enough to allow for ease in observing and handling the animals and allow movement of any needed equipment.

**Pens:** -Mink and fox are typically reared singly or in pairs or as littermates (foxes) from weaning through pelting. -It is recommended that breeder mink be housed singly while breeder fox may be housed singly or in breeding pairs. -Pens must provide sufficient area for animals to perform natural physical movement and must allow for comfort activities such as rest, sleep, grooming, defecation, and in the case of breeding pens, the rearing of young. -Recommended pen sizes for mink and fox are provided in the Standard Guidelines for the Operation of Mink Farms in the United States (Fur Commission U.S.A., 2019) and the Standard Guidelines for the Operation of Fox Farms in the United States (North Central Fox Producers and U.S. Fox Shipper's Council, 2006), respectively. Current guidelines for mink (Fur Commission U.S.A., 2013) state that whelping pens should have a volume of 4,300 cubic inches and furring pens of 3,800 cubic inches for the first two animals and 900 cubic inches for each additional mink. The nesting box volume counts as additional space when attached to the outside of the pen. To ensure timely weaning of kits, the minimum height all pens should be 12 inches. Pens containing single breeder females should have a minimum width of 6 inches and those containing single breeder males, a minimum width of 7.5 inches. Pens designed for single mink should have a minimum of 2,500 cubic inches.

Guidelines for minimum dimensions of pens constructed after January 1, 2019 are given in the table on the following page.

New Pen Construction Table

<b>Pen density</b>	<b>Minimum height</b>	<b>Minimum width</b>	<b>Nest box size</b>	<b>Minimum living space (floor, nest box, shelf)</b>
Single female	15 inches	7.5 inches	45 sq. inch minimum	225 sq. inch minimum (shelf is not counted)
Single male	15 inches	9 inches	60 sq. inch minimum	275 sq. inch minimum (shelf is not counted)
Female with litter	15 inches	12 inches	80 sq. inch minimum	440 sq. inch minimum (100 sq. inch max countable living space for a shelf)
2 juveniles	15 inches	12 inches	80 sq. inch minimum	440 sq. inch minimum (100 sq. inch max countable living space for a shelf)
More than 2 juveniles				75 sq. inches of living space per each additional female and 100 sq. inches of living space per each additional male

Pens should be durably constructed with non-toxic, corrosion-resistant materials to contain the animals securely and to prevent animals from injuring themselves or those in adjacent pens. Pens should be of sufficient height above the ground to allow feces to fall from the pen and to allow for clearing of manure. -In the case of mink, breeding pens should permit the fitting of a false floor to prevent the young from falling to the ground.

The arrangement of pens should enable visual and physical inspection of all areas and all housed animals. -In each pen, there should be a fresh water source available that is easily accessible by the animal and allows inspection and cleaning by the farmer. All pens need some form of enrichment that adds complexity to the pen environment (jump-up nest box, drop-in nest box, feed board, shelf, hammock, tube and/or manipulative enrichment fulfill this requirement).

**Nest Boxes:** Each pen should be provided with a clean, dry nest box or "nester" in the form of a wooden box or wire-nester of adequate size where the mink or fox can rest or

sleep comfortably. -A clean, dry nester should be designed to accommodate appropriate nesting materials such as marsh hay, straw, wood shavings, excelsior, or crushed sugarcane. -Nesters should be designed to provide sufficient space according to the sex and size of the animal, to permit each animal to rest and sleep comfortably. -Breeder nest boxes should allow sufficient space for the mother and her litter. Special consideration should be given at time of whelping to methods of avoiding unnecessary exposure of the mother and her young. Guidelines for minimum nest box sizes for pens constructed after January 1, 2019 are given above.

## HEALTH CARE AND MEDICAL PROCEDURES

Developing a close working relationship with a licensed veterinarian will facilitate development of a program of disease prevention and control. -The mink or fox farmer should consult with their veterinarian at least once per year. -Mink and fox farmers and their employees must be aware of the **wellbeing** ~~well-being~~ of ~~their~~ ~~the~~ animals and must be able to detect signs of a distressed or sick animal including abnormal behavior, change in appetite, abnormal feces and other indicators of ill health. - All mink and fox should be observed at least once a day. - Any sick or injured animals should be immediately treated or, depending upon the severity of their condition, humanely euthanized. - A veterinarian should investigate unexplained deaths, if possible. -The farm should keep written treatment records and written records of daily mortalities. -The farm should maintain some basic medicines and supplies to treat basic illnesses and injuries through consultation with a veterinarian. - An abnormal increase of mortalities should be investigated by a veterinarian. -The mink or fox farm should have a vaccination protocol developed through consultation with a veterinarian and the mink farm should have an Aleutian Disease Virus testing protocol through consultation with a veterinarian.

When mink herds are infected with Aleutian Disease virus, animals should be tested, infected animals culled, facilities appropriately cleaned and disinfected with parvocidal disinfectants and biosecurity improved. -Recommendations for biosecurity procedures can be found in Appendix (Biosecurity Protocols for the Operation of Mink Farms in the United States) of the Standard Guidelines for Operation of Mink Farms in the United States (Fur Commission U.S.A., 2013).

**Pharmaceutical Use:** It is imperative that those engaged in raising livestock understand the prudent and legal use of pharmaceutical products. -To help ensure that health and welfare of livestock, a veterinary-client-patient relationship (VCPR) is highly recommended. In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. ~~t~~There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and,
3. ~~t~~The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:** -It is imperative that mink and fox farmers utilize humane techniques for euthanasia of their animals. -Euthanasia methods used must have an initial depressive action on the central nervous system to ensure immediate insensitivity to pain without causing fear and anxiety. -The Standard Guidelines for Operation of Mink Farms in the United States (Fur Commission U.S.A., 2019) and the Standard Guidelines for the Operation of Fox Farms in the United States (North Central Fox Producers and U.S. Fox Shipper's Council, 2006) recommend acceptable procedures for euthanasia of mink and fox that are described in the AVMA Guidelines on Euthanasia (AVMA, 2020). The American Veterinary Medical Association (AVMA) and Fur Commission USA (FCUSA) recommend pure, carbon monoxide or carbon dioxide in cylinders. -The farm should have a written euthanasia protocol and all personnel involved with the euthanasia of mink and fox should be trained and have a documented understanding of the euthanasia protocol. -The euthanasia chamber should be purpose built and in good repair. -The chamber should be mobile, easy to clean and provide for consistent performance, ease of operation and safety to the operator. - Carbon monoxide is a highly toxic gas. Since it has no odor, it must be used only under well-ventilated conditions, and personnel administering it must adhere strictly to appropriate safety practices. Carbon monoxide euthanasia chambers must be charged at a minimum rate of 4 percent% carbon monoxide by volume. -Carbon dioxide euthanasia chambers must be charged at a minimum rate of 80 percent% carbon dioxide by volume. - When animals are removed from the chamber, they must be checked to ensure that death has occurred.

**Dead Animal Disposal:** Animal tissue, whole carcasses, or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

## REFERENCES

American Veterinary Medical Association, 2020. AVMA Guidelines on Euthanasia of Animals. <https://www.avma.org/KB/Policies/Documents/euthanasia.pdf>. (Visited 6.28.2013)

Fur Commission U.S.A, 2013. Standard Guidelines for the Operation of Mink Farms in the United States. Fur Commission U.S.A., Medford, OR. 26 pp.

Fur Commission U.S.A, 2018. Draft Standard Guidelines for the Operation of Mink Farms in the United States Fur Commission U.S.A., Medford, OR.17 pp.

Michigan Bodies of Dead Animal Act. 2008.– [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited (4.29.19)

National Farm Animal Care Council. 2013. Code of Practice for the Care and Handling of Mink. [http://www.nfacc.ca/pdfs/codes/mink\\_code\\_of\\_practice.pdf](http://www.nfacc.ca/pdfs/codes/mink_code_of_practice.pdf). 60 pp.

National Farm Animal Care Council. 2013. Code of Practice for the Care and Handling of Farmed Fox (*Vulpes vulpes*). [http://www.nfacc.ca/pdfs/codes/Farmed\\_Fox\\_Code.pdf](http://www.nfacc.ca/pdfs/codes/Farmed_Fox_Code.pdf). 52 pp.

National Research Council, 1982. Nutrient Requirements of Mink and Foxes. Rev. Ed. National Academy Press, Washington, DC. 72 pp.

North Central Fox Producers and U.S. Fox Shipper's Council, 2006. Standard Guidelines for the Operation of Fox Farms in the United States. North Central Fox Producers, Nisswa, MN and U.S. Fox Shipper's Council, Shell Rock, IA. 15 pp.

Rouvinen-Watt, K., M. White and R. Campbell, 2005. Mink Feeds and Feeding. Canadian Centre for Fur Animal Research, Nova Scotia Agricultural College, Truro, Nova Scotia, Canada. (ISBN 1-555174-323-X) Also on CD-ROM. (ISBN 1-55174-324-8).

## AQUACULTURE SPECIES

### MANAGEMENT OVERVIEW

Aquaculture is regulated and afforded rights of agriculture enterprises under the Michigan Aquaculture Development Act (Act 199 of 1996). -The definition of aquaculture as stated within this act is:- “the commercial husbandry of aquaculture species on the approved list of aquaculture species, including, but not limited to, the culturing, producing, growing, using, propagating, harvesting, transporting, importing, exporting, or marketing of aquacultural products under an appropriate permit or registration”.

Aquaculture facilities are required to obtain an aquaculture registration from the Michigan Department of Agriculture and Rural Development. -Rearing of fishes for the aquarium trade in closed indoor systems is exempted from registration. -People involved in production of fishes for stocking public waters shall also obtain a permit from the Michigan Department of Natural Resources and fishes must be certified free of specific diseases prior to release into public waters.- Michigan complied laws and permit requirements for aquaculture and baitfish industries are summarized on the North Central Regional Aquaculture Center (NCRAC) website:  
<http://www.ncrac.org/Info/StateImportRegs/michigan.htm>.

Michigan aquaculturists are composed mainly of small firms concentrating on trout production which includes a mixture of food fish and shrimp, fee-fishing, planting stock sales, and aquaponics.

Because of the diversity of aquaculture species approved for aquaculture production and the variety of husbandry systems used, recommendations for their care must be general in nature. -More specific management practices for a wide variety of aquatic species can be found through the search engine on the NCRAC home web page:  
<http://www.ncrac.org/>.

### MANAGEMENT PRACTICES

**Stock Procurement:** -An established list of approved species for aquaculture production is contained in the Michigan Aquaculture Development Act.- Only aquaculture species on the approved list are allowed for purposes of aquaculture production.- Any movement, importing, or exporting of aquaculture species must be in compliance with the Animal Industry Act, 1988 PA 466, MCL Section 287.729a; as amended.

Aquaculture species should be obtained from a source with a history of freedom from disease.- Live fishes obtained from an out-of-state hatchery must be certified as being free of certain diseases which are summarized on the North Central Regional Aquaculture Center website: “State Importation and Transportation Requirements for Cultured Aquatic Animals”. Pre-entry permits must also be obtained from the Michigan



Department of Agriculture and Rural Development prior to importation of fish to an aquaculture facility from outside the state.

Newly acquired aquaculture species should be checked to determine that they are in good condition, regardless of the availability of health history information. Healthy aquaculture species should show good coloration with no obvious abrasions or lesions.

**Transportation:** -Healthy aquaculture species may be safely and easily transported as long as care is taken to reduce the associated stress. -Feed should be withheld from farm-reared species for two days prior to transport to reduce fouling of the transport water. - Since the stress of transport often results in animals going off feed, withholding feed for one or two days after receipt, followed by a gradual return to normal feeding levels, may be beneficial.

To minimize stress, the temperature of transport water should remain as close as possible to the supplier's ambient water temperature. - However, aquaculture species will generally travel better in cool water because of lowered oxygen requirements and higher levels of available dissolved oxygen. -Salt, in a mild concentration (0.1-1.0 percent%), is commonly used to reduce stress during transportation of fresh waterfreshwater fish depending on the species. - Also, a mild anesthesia may be employed during transport; however, this is usually unnecessary.

Small numbers of aquaculture species are commonly shipped in plastic bags with use of pure oxygen (oxygen bagging). -Plastic (polyethylene) bags should be filled about 4/3third with water, the remaining air being expelled and replaced with pure oxygen. The top of the bag should be firmly tied by twisting and bending over on itself. -The bag should preferably be placed inside another similar one and then placed in a protective container or box for short term shipping. - For long term direct and air shipments, oxygen bagging, followed by packaging in insulated containers is also common practice and a method recommended by the International Air Transport Association (IATA). -Ice packs could be placed inside the insulated container if necessarynecessary, for cold water species. Most aquaculture species packed in this manner may be shipped for period of 48 hours without inducing significant stress and subsequent diseases.

It is difficult to generalize on the number or weight of an aquaculture species that may be safely transported in a givenin each volume of water. -Safe transport densities vary according to species, age, water temperature, oxygenation, and the distance and length of time over which they are to be transported.

The same general principles apply to transporting eggs; however, eggs may be extremely susceptible to damage at certain stages in their incubation. -For example, Salmonid eggs may be transported for a period of approximately two days immediately after fertilization and water hardening (1-2 hours), or after they have become "eyed" (eyes of the embryo visible through the shell). -Between these periods, eggs should not be transported or handled.

**Handling:**- Handling should be minimized to reduce stress and damage to the skin leading to bacterial and fungal disease.- Nets and other materials for handling aquaculture species should be sanitized before and after use to reduce disease transfer.

**Nutrition:**- Active feeding is often a good indicator of the health status of aquaculture species.- Sick animals often quit eating before other disease signs become noticeable. Commercially prepared pellets are available for a variety of aquaculture species which are often acceptable to other similar species.- Live feeds may be required for rearing some aquaculture species; however, live feeds may not meet the nutritional needs of the aquaculture species unless multiple species of feed items are used.

Optimum feeding rates vary depending on species, size, feed composition, water temperature, and desired growth response (maintenance vs. maximum growth rate). Feeding tables have been developed for some aquaculture species which can be used for general care recommendations. -Feeding once or twice a day for the five working days is usually adequate; however, larval stages and young animals may require more frequent feedings which should extend throughout the entire week.

## RECOMMENDATIONS FOR THE ENVIRONMENT

Aquaculture species are in constant, intimate contact with their aquatic environment and even minor changes in water quality may cause stress that predisposes them to disease. Chemical, ~~physical~~physical, and biological factors in the water environment will affect different aquaculture species in different ways.

Water temperature is an important environmental factor.- Aquaculture species are, with a very few exceptions, unable to physiologically control their body temperature. Most body functions, such as rate of growth, appetite, ~~respiration~~respiration, and heart rate, are ~~temperature-dependent~~temperature dependent. -Each aquaculture species has a preferred temperature that is affected by its acclimation temperature.- In general, the preferred temperature range for cold water fishes is 46-60°F, for cool water fishes is 60-68°F, for warm water fishes is 64-72°F, and for tropical fishes is 73-86°F. -Temperatures outside these ranges may, however, prove perfectly acceptable, depending on the species and other variables involved.

The acclimation of aquaculture species to a new temperature, either when introducing new animals to a facility or when adjusting temperatures within a facility, should proceed as gradually as possible.- If possible, changes should be limited to between 1—3 degrees Fahrenheit per hour and should be even more gradual at the extremes. Aquatic animals should be carefully observed for 1—2 weeks after transport and/or handling for signs of stress induced bacterial diseases. -When adjusting water temperatures, all other stresses (e.g., handling) should be minimized.

**Oxygen (O<sub>2</sub>):** Oxygen is another important factorkey factor in aquaculture, and oxygen concentrations are closely related to temperature. -As the temperature of water rises, its holding capacity for O<sub>2</sub> decreases. -At the same time however, the O<sub>2</sub> requirements of the aquaculture species increases because of an increased metabolic rate. -At temperatures in the preferred range, decreasing availability with increasing demand usually causes no problem as there is still enough O<sub>2</sub> available. -When waters are above preferred temperature ranges, polluted or heavily overstocked, there may be insufficient O<sub>2</sub> available. -Respiratory stress syndrome may occur if energy expenditures in obtaining the limited O<sub>2</sub> available exceed the potential energy gain. -Respiratory stress syndrome can result in death.

Variables other than temperature, that under normal circumstances affect O<sub>2</sub> requirements, include: -species - active aquaculture species require more O<sub>2</sub> than slower moving aquaculture species; size – within an aquaculture species smaller animals require relatively more O<sub>2</sub> per unit of body mass than larger animals; and plane of nutrition - aquaculture species require additional O<sub>2</sub> for metabolism of feeds. As a general guide, it is recommended to maintain O<sub>2</sub> concentrations at or above 5-6 ppm for cold water fish and 23 ppm for warm water fish whenever possible.

Spring, well, and surface water can be acceptable sources of water for aquaculture in Michigan. -Spring and well water are generally excellent water sources for aquaculture. The ground acts as a filter to remove microbial flora and parasites. - Ground water temperatures at most locations will remain relatively constant, often varying by little more than 2 degrees° throughout the year. However, water temperatures will vary considerably across the state. - Levels of dissolved oxygen can be low and well waters may be supersaturated with nitrogen or carbon dioxide. - Under such conditions aeration/degassing systems, such as packed columns, cascading weirs or pure oxygen systems may be essential in order to add oxygen to the water and to drive off other supersaturated gases. -Surface waters are generally less biosecurebio-secure than closed (non-open) sources of water.

## **FACILITIES AND EQUIPMENT**

Facilities and equipment needed for farming aquaculture species are primarily dictated by the species and life stage of the animals being raised and the type of operation. Aquaculture species can be raised in tanks, ponds, raceways, cages, and net pens. The design and suitability of these systems depend on water availability and quality. Expert input needs to be sought and incorporated in the designs of systems to meet specific needs of the aquaculture species and production system.

## HEALTH CARE AND MEDICAL PROCEDURES

Stressors, such as changes in water quality or handling, may predispose aquaculture species to disease. However, most aquatic animal diseases can be treated and controlled, especially when caught at early stages.

Observation is a critical component in the health care of aquaculture raised aquatic animals. The earliest signs of disease are usually changes in behavior. For example, aquaculture species may aggregate at the inflow if O<sub>2</sub> levels are too low. Conversely, they may accumulate at the outflow of the tank, if a toxic substance is present in the inflow. Sick animals usually lose their appetite. Certain conditions may cause animals to whirl or spiral in the water or, in the case of some external parasites, show their irritation by "flicking/flushing" which is where they appear to be scraping themselves off the sides or bottom of the tank. Individuals that become sickly usually separate from the group and will frequently be found at the sides of tanks or riding higher in the water column that most of the fish, often in the lower end of the rearing unit in rectangular flow-through tanks and raceways; and they will also prove less active in their response to stimuli. Loss of vertical equilibrium can also be indicative of some bacterial infections.

Various changes in appearance also signal disease problems. Examples include a change in color (lighter or darker), excessive mucus production in gills and on skin, lesions, and fungal growth. Fungi are frequent secondary invaders on virtually any skin or fin lesion, regardless of its primary cause.

Very often parasites and microorganisms that have the potential to cause disease may be isolated from diseased aquaculture species. This can be accomplished at the facility, depending on the experience of the aqua-culturist, or diagnosed from samples in an aquatic animal health laboratory. The advantage of sending samples to a laboratory is the ability to obtain a full evaluation including hematology, histopathology, biochemistry and microbiology. Disadvantages of laboratory diagnostics include cost (e.g. cost prohibitive), the proximity of the laboratory to the facility, and/or the time required to obtain results may be far too long for a producer to take meaningful action. Aquatic animal health specialists and/or the Michigan Department of Agriculture and Rural Development should be consulted when a serious or reportable disease outbreak occurs.

The treatment of external parasitic, fungal, or bacterial disease includes the use of baths, flushes and dips with chemicals specifically approved for use with that specific aquaculture species. Treatment of some systemic diseases may require therapeutic agents administered in the feed to those animals still feeding. Such agents may act both externally and internally, being absorbed from the water. Drugs approved for disease treatment of fish in registered aquaculture facilities are fairly-very limited in number and are required to meet U.S. Food and Drug Administration and U.S. Fish and Wildlife Service (FWS) restrictions and regulations. A list of approved drugs for aquaculture use and additional information is available on the FWS website:

<https://www.fws.gov/fisheries/aadap/home.htm>.

Disease prevention is much preferred over disease treatment. The aquaculturist can help prevent disease by paying close attention to the long-term health history of the facilities and brood stocks from which they source their eggs and fish for importation to their facilities. Careful observation of populations within a facility, paired with close attention to maintaining a clean rearing environment are of the utmost importance. Other measures, including staying under stressful biomass levels and having dedicated fish culture tools and implements for each rearing unit are also critical.

**Pharmaceutical Use:** It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products. To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and
3. The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

## REFERENCES

AVMA. 2020. American Veterinary Medical Association Guidelines on Euthanasia of Animals. <https://www.avma.org/KB/Policies/Pages/Euthanasia-Guidelines.aspx> )

FDA 2015. The Index of Legally Marketed Unapproved New Animal Drugs for Minor Species.

<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/MinorUseMinorSpecies/ucm125452.htm>.

Leitritz, E. and R.C. Lewis. 1976. Trout and Salmon Culture (Hatchery Methods). California Dept. Fish and Game, Fish Bulletin No. 164. 197 p.

Michigan Animal Industry Act, 1988 PA 466, MCL Section 287.729.

[http://www.legislature.mi.gov/\(S\(un3111u3y3ghuoyndph3gh2oc\)\)/mileg.aspx?page=getObject&objectName=mcl-287-729a](http://www.legislature.mi.gov/(S(un3111u3y3ghuoyndph3gh2oc))/mileg.aspx?page=getObject&objectName=mcl-287-729a).

Michigan Aquaculture Development, Act 199 of 1996, as amended, 286.875, Section 5(2).

[http://www.legislature.mi.gov/\(S\(2ivoh1452nuufz55an5prb45\)\)/documents/mcl/pdf/mcl-Act-199-of-1996.pdf](http://www.legislature.mi.gov/(S(2ivoh1452nuufz55an5prb45))/documents/mcl/pdf/mcl-Act-199-of-1996.pdf).

Michigan Bodies of Dead Animal Act. 2008.

[http://www.legislature.mi.gov/\(S\(ekjsayev2vpg3m55sk05dg45\)\)/documents/mcl/pdf/mcl-Act-239-of-1982.pdf](http://www.legislature.mi.gov/(S(ekjsayev2vpg3m55sk05dg45))/documents/mcl/pdf/mcl-Act-239-of-1982.pdf). See also: [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html). (Visited 5.6.10)

Michigan National Resources and Environmental Protection Act., Act 451 of 1994, as amended, Part 459. Propagation of Game Fish in Private Waters.

[http://www.legislature.mi.gov/\(S\(543h2qilcxu1kkjdz43w3qf\)\)/mileg.aspx?page=getobject&objectname=mcl-451-1994-III-2-3-AQUATIC-SPECIES-459&query=on&highlight=Propagation%20AND%20of%20AND%20Game%20AND%20Fish%20AND%20in%20AND%20Private%20AND%20Waters](http://www.legislature.mi.gov/(S(543h2qilcxu1kkjdz43w3qf))/mileg.aspx?page=getobject&objectname=mcl-451-1994-III-2-3-AQUATIC-SPECIES-459&query=on&highlight=Propagation%20AND%20of%20AND%20Game%20AND%20Fish%20AND%20in%20AND%20Private%20AND%20Waters)

Michigan Public water stocking permits.

[https://www.michigan.gov/documents/dnr/Private\\_Fish\\_Stocking\\_Permit\\_Process\\_458281\\_7.pdf](https://www.michigan.gov/documents/dnr/Private_Fish_Stocking_Permit_Process_458281_7.pdf)

North Central Regional Aquaculture Center. Michigan - Aquaculture Contacts, Transport Regulations, Approved Aquatic Species, Health Regulations, and Permitting.

<http://www.ncrac.org/Info/StateImportRegs/michigan.htm#permitting>.

[http://www.ncrac.org/import\\_regulations/michigan](http://www.ncrac.org/import_regulations/michigan).

Piper, R.G. et al., 1982. Fish Hatchery Management. USDI, FWS, Washington, DC. 517 p.

## SOUTH AMERICAN CAMELIDS

### MANAGEMENT OVERVIEW

The Camelidae family consists of camels from Africa and Asia (Bactrian and Arabian) and those from South America (llamas, vicunas, alpacas and guanacos). Llamas and alpacas make up the domestic population of camels owned in the United States. Llamas are most popular with fewer alpacas. Vicunas and guanacos are not as tame and considered less adaptable to domestic environments. Llamas and alpacas are used as pack animals, for producing textiles and clothing from their wool, as guard animals for sheep and goats, as companion animals, and in rare cases for meat and milk products; however recent indicators point to camelids playing a greater role in world food security (Zarrin, et al. 2020). Unlike our common species of farm livestock, information on the biological needs, breeding, genetics, behavior, nutrition and health management of camelids has not been studied as extensively. Owners of South American camelids should become knowledgeable to avoid problems associated with poor camelid welfare and management (Gunsser, 2013; see: Llama and Alpaca Care... 2014).

Llamas and alpacas can be kept in conditions similar to cattle. They thrive more under natural conditions such as pasture, range and well-managed dry lots, compared to confined areas such as stalls. They are ruminant-like animals similar to cattle, sheep and goats but walk on foot pads rather than hooves. Llamas and alpacas can be thrifty and have water conservation capability under dry conditions. They are considered medium sized animals with males being larger than females at maturity. Llamas are the largest of the South American camelids with males weighing up to 300 pounds. Alpacas are smaller and weigh up to 175 pounds. Both are considered docile animals with temperaments suited for domestic conditions. They may spit when threatened or provoked and can be protective of their offspring (cria).

### MANAGEMENT PRACTICES

**Nutrition:** Llamas and alpacas are three stomached animals. They are not true ruminates but possess complex multi-compartmentalized stomachs that engage foregut rather than hind gut fermentation. However similar to cattle, sheep, and goats regurgitate and chew cud (San Martin and Van Saun, 2014). They are efficient foragers and browsers. Alpacas have similar nutritional habits and demands as llamas except alpacas are better browsers than grazers. Both can be fed grain concentrates to provide supplemental energy or protein. Grass or legume hays or grazing on quality pasture are excellent sources of roughage and general nutrition. Protein requirements for these camelids are lower than for common species of domestic livestock and range from 10 to 16 percent depending on stage of development or physiological state such as gestation and lactation (see NRC, 2007). As with other domestic livestock, water

should be potable and easily accessible whether supplied from natural streams or ponds or artificial means such as buckets, troughs or automatic devices. Troughs, buckets or other containers should be regularly cleaned. If animals are pastured, forage should be suitable for grazing and free of poisonous plants. Plants considered toxic to common livestock are also toxic to llamas and alpacas. Concentrate feeds or simple grains used for feeding other ruminant livestock are suitable for feeding llamas and alpacas. Texturized feeds, such as steam rolled corn and barley mixed with soy pellets, rather than a fully pelleted ration are preferred and result in less choking and compaction. Supplementation with mineral mix and salt is recommended. In selenium deficient areas supplementation with selenium is recommended along with Vitamin E. Good quality hay, free of molds and spoilage, can be fed in round or square bales and serve as a source of roughage when concentrates and/or brassicas are fed. The use of body condition scoring can assist in determining nutritional status of camelids. A body condition score of 3three (1 – 5 scale) or 6six (1 - 10), with 1one being thin and 3three or 6six as obese, is considered to be ideal. Remedial action should be taken when body condition score is too low or too high. Monitoring of the body condition is recommended for females during pregnancy and lactation, cria during growth and all animals during the winter months. Feeder or trough and watered space should be sufficient to ensure that no distress or injury to animals is caused by competition for food and water. Camelids are hierarchal by nature and subordinate animals may get less feed or water when housed and fed in group situations.

**Reproduction:** Camelids are different from large livestock in reproductive traits. They are induced ovulators and behaviorally receptive to breeding throughout the year. Breeding occurs while the female is lying down. The normal length of camelid gestation is 335 to 365 days. The use of pasture and pen breeding is most common and an acceptable strategy. Consideration should be given to time of breeding with respect to season and average daily temperature at the time of birth. Winter births require close management of mother and young and can be difficult for the cria. Shelter should be provided for winter birthing and periods of inclement weather. Keeping the cria warm and vigilance with respect to energy intake is important to managing winter births.

**Handling:** The llama and alpaca are a social herd-dwelling prey animal. They respond best to calm, slow and quiet handling. Camelids are best handled using calm and gentle encouragement and visual and audio cues rather than physical contact. They are smart and instinctual animals and if they perceive danger they will take flight. Social order is kept through maintenance of a social hierarchy. Pregnant females or females with nursing young can be temperamental and protective. Intact males may show dominance and require more experienced handlers. Understanding the natural behavior of llamas and alpacas will help avoid injury to animals and human handlers. Llamas and alpacas can be halter broken and led. Halters should be adjusted so nose bands ride in the middle of the nose. Low riding nosebands may cut off breathing.

When loose, llamas and alpacas can be herded as a group. Llamas and alpacas may panic if separated from the herd. Unless specifically trained to calmly accept well-trained stock dogs, the use of dogs to herd llamas or alpacas is not recommended.



Restraining chutes or stocks that are adjusted to accommodate size and body shape work well for conducting preventative or therapeutic health procedures or standard care practices such as nail trimming. Depending on size, docility and training, many common care procedures can be carried out with minimal restraint. Camelids should not be hit, lifted by fleece, head, neck, ears or tails twisted. Electric prods are not recommended for use with camelids.

**Transportation:** Llamas and alpacas can be conditioned to ride in a variety of transport vehicles including trucks and trailers designed for livestock or vans that have been properly prepared for the animal and avoid injury or interference with the driver. Safety and comfort should be of primary importance in the transport of llamas or alpacas. Llamas and alpacas can be loaded loose into a transport vehicle or led by halter and loaded. Larger animals can walk or lightly jump into the transport vehicle. Small adult or young llamas or alpacas can be carried into the vehicle. Principles of calm and quiet handling are important to low stress transport. Llamas and alpacas tend to lie down during transport and should not be tied inside the vehicle. Space allotment should sufficiently accommodate lying down, resting posture and standing-up without struggle or seriously impacting an adjacent animal if more than one animal is being transported. Attention to weather conditions such as high heat or extreme cold, vehicle ventilation and animal coat condition (wool or sheared) are important to avoiding heat or cold stress. Seriously debilitated or non-ambulatory animals should not be transported unless they can be appropriately accommodated without further injury or distress and the purpose of transport is to obtain medical care. A delay or cancellation of transport should occur for animals that appear unhealthy, dehydrated or exhausted and unfit to withstand travel.

## **RECOMMENDATIONS FOR THE ENVIRONMENT**

Alpaca and llamas are known as being tidy. They tend to defecate in specific areas away from grazing and feeding areas. These areas should be cleaned of dung piles periodically depending on size of paddock. In barn situations manure should be managed to prevent significant build up or wet areas. Areas should be kept bedded and dry within covered facilities. Pastures should be managed to maintain forage base (if principle source of nutrition) and minimize parasite loads. A general rule of thumb for stocking rate on a good quality pasture is 2 – 3 llamas or 4-5 alpacas per 2 acres. Dry lots should be of sufficient size and well drained to avoid mud conditions during rainy periods and retain cover to prevent dusty conditions when dry. Protection of surface waters and conservation practices to minimize soil erosion is part of good environmental stewardship. As with any livestock operation good hygiene and adherence to local, state (Michigan GAAMPs) and federal guidelines and requirements is important to maintaining good community relations.

## **FACILITIES AND EQUIPMENT**

**Shelter:** Llamas and alpacas are suited to outdoor and semi-confined housing systems such as three-sided sheds and barns of various configurations. Attention should be

given to provision of space within the shelter so that it is easily accessible to all animals in the group. As wool bearing animals, special attention to hot conditions and the mitigation of heat stress through shearing and/or the provision of shade from natural or constructed shelter is recommended. Alpacas are especially hardy and adapted to cold weather conditions under normal cold conditions and under good care. The timing of shearing should be adapted to account for local weather conditions as the status of the fleece carries significant impact on the animal's vulnerability to weather conditions (Gerken, 2010). For animals housed outdoors, natural shelter belts or artificial shelters should be available for relief during extreme cold or inclement conditions. Crias are more susceptible to cold stress for a week after birth and should be sheltered during this period. Indoor housing should provide enough space such that all camelids are able to lie down and rest simultaneously and be kept dry and well ventilated. Waste and contaminated bedding material should not accumulate to the extent it poses a health threat to the animals. Waste disposal should be in accordance with Michigan Manure GAAMPs.

**Fencing:** Exterior fencing should be higher than fencing used for common domestic livestock and should keep deer out. Deer fencing or custom constructed livestock fencing with heights sufficient to prevent escape or entrapment are strongly recommended. Electric fencing is not recommended for containment of camelids.

## HEALTH CARE AND MEDICAL PROCEDURES

Health care programs for llamas and alpacas include addressing nutritional requirements, preventative health care measures such as vaccinations, parasite control, foot care, and emergency procedures in case of injury or illness as appropriate to local conditions (Björklund et al. 2019; Jones and Boileau, 2009; see Llama and Alpaca Care., 2014). All animals should be observed daily for signs of illness, injury or abnormal behavior. Procedures requiring invasion of the body cavity (like castration) or that result in pain or distress should be carried out by a veterinarian or properly trained and experienced individual. Assistance of a veterinarian in developing a health care program is strongly recommended.

**Pharmaceutical Use:** It is imperative that those engaged in raising livestock and poultry for human consumption understand the prudent and legal use of pharmaceutical products. To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical

treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;

2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and
3. The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Euthanasia:** Animals that are seriously injured or ill and show no promise for recovery should be euthanized immediately. Methods can be physical or chemical and one of the approved methods recommended by the AVMA Guidelines on Euthanasia (AVMA, 2020).

**Dead Animal Disposal:** Animal tissue, whole carcasses or portions thereof, must be disposed of according to the Michigan Bodies of Dead Animal Act, Act 239 of 1982, Amended Act No. 311, Public Acts of 2008, December 18, 2008.

## REFERENCES

American Veterinary Medical Association. 2020. AVMA Guidelines on Euthanasia of Animals. Available at: <https://www.avma.org/KB/Policies/Documents/euthanasia.pdf>. (Visited 6.22.2018)

[Björklund, C., R. Båge, J. Morrell, K. deVerdier, L.N. Hartzell, N. Kjellinbro, K. Belak, K. Bernodt, and D. Gavier-Widen. 2019. Diseases and causes of death among alpacas in Sweden: a retrospective study. Veterinary Record Open;6:e000239. doi:10.1136/vetrec-2017-000239.](#)

Gerken, M. 2010. Relationships between integumental characteristics and thermoregulation in South American camelids. *Animal* 4 (9): 1451 – 1459, doi: 10.1017/S1751731109991443.

Gunsser, I. 2013. Animal welfare problems in Alpacas and Llamas in Europe. Symposium on South American Camelids and other Fibre Animals. In: Proceedings of the 64<sup>th</sup> EAAP Annual Meeting, 25-30 August, Nantes, France.

Jones, M. and Boileau. 2009. Camelid Herd Health. *Vet. Clin. Food Anim.* 25:239-263.

Llama and Alpaca Care: Medicine, Surgery, Reproduction, Nutrition and Herd Health. 1<sup>st</sup> Edition. Eds. C. Cebra, D.E. Anderson, A. Tibury, R. Van Saun and L.W. Johnson. 2014. Elsevier Inc., St. Louis MO. <https://www.sciencedirect.com/book/9781437723526/llama-and-alpaca-care> (Visited 6.03.19).

Michigan Bodies of Dead Animal Act. 2008. [http://www.michigan.gov/mda/0,1607,7-125-48096\\_48404---,00.html](http://www.michigan.gov/mda/0,1607,7-125-48096_48404---,00.html) (Visited (4.29.19)

National Research Council. 2007. Nutrient Requirements of Small Ruminants: sheep, goats, cervids and New World Camelids. National Academy Press, Washington, DC.

San Martín, Felipe and Robert J. Van Saun. 2014. Part 2. Nutrition. Chapter 8. Applied Digestive Anatomy and Feeding Behavior. In: Llama and Alpaca Care: Medicine, Surgery, Reproduction, Nutrition and Herd Health. 1<sup>st</sup> Edition. Eds. C. Cebra, D.E. Anderson, A. Tibury, R. Van Saun and L.W. Johnson. Elsevier Inc, St. Louis, MO. pp.51-58.

[Zarrin, M., J.L. Riveros, A. Ahmadpour, A.M. de Almeida, G. Konuspayeva, E. Varga-Bello-Pérez, B. Faye, and L. E. Hernández-Castellano. 2020. Camelids: new players in the international animal production context. Tropical Animal Health and Production 52:903-913.](#)

## BEEKEEPING AND APIARY MANAGEMENT

### MANAGEMENT OVERVIEW

European honey bees (*Apis mellifera* L.) play a critical role in Michigan and U.S. agriculture. At least 60 of Michigan's important fruit and vegetable crops (including apple, blueberry, cherry, cucumber, and pumpkins) rely on honey bee pollination. Without honey bees to supply pollination services, much of Michigan's rich fruit and vegetable production would not be possible, and producers would be forced out of business. In short, Michigan's agricultural industry would be devastated.

Despite the importance of honey bees, the beekeeping industry has struggled since the introduction of two parasitic mites to the U.S. in the mid-1980s. The introduction of the Tracheal Mite (*Acarapis woodii*) and Varroa mite (*Varroa destructor*) has nearly eliminated the feral (wild) honey bee population in the [U.S. United States](#). (Kraus and Page, 1995). The number of beekeepers managing honey bee colonies also declined due to the more complicated management requirements caused by the mites. In 1993, Michigan's Apiary law was changed to open the state for free movement of honeybee colonies as beekeepers sought to take colonies to southern states where they could better manage for mite control during the winter months. In recent years, Michigan beekeepers have moved bees to California for almond pollination, Florida for pickle pollination, and to Maine and Mississippi for blueberry pollination. Michigan has become a migratory beekeeping state.

The Michigan Department of Agriculture and Rural Development provides inspection service to beekeepers needing a certificate of health for movement of their bees. However, because of the varied requirements for health certificates for movement, many of them voluntary, there is not a reliable estimate of the number of colonies moved into and out of the state each year.

Beekeepers now use an array of management tools, including miticides, antibiotics, and insecticides for the management of mites, the small hive beetle (*Aethina tumida*), brood diseases, and microsporidian parasites. As research on colony strength continues, the use of dietary supplements for stimulating hive buildup and to maintain colony health has increased.

As part of the national strategy to reduce the losses of honey bees and other pollinators, Michigan has developed a managed pollinator protection (MP3), Communication Strategies for Reducing Pesticide Risk for Managed Pollinators in Michigan. It's designed to improve and protect the health of pollinators in Michigan by mitigating the risk of pesticide exposure, while recognizing that pesticides are important tools for crop, property, and human health protection. To view the document, visit this link [https://www.michigan.gov/mdard/0,4610,7-125-2390\\_76976---,00.html](https://www.michigan.gov/mdard/0,4610,7-125-2390_76976---,00.html).

## MANAGEMENT PRACTICES

Understanding some basic bee biology and beekeeping will facilitate your inspection of the hives, gauging of quality/strength of the hives, and help maximize the use of bees for your pollination.

**Social Structure:** Honey bees are social insects and only the sterile female workers do all the in-hive work (cleaning, drying nectar into honey, feeding young) and outside work (foraging for water, pollen, nectar and propolis, and colony defense). The queen's only job is to lay about 2,000 eggs per day and releases queen mandibular pheromone to let the workers know that she is present and healthy. The males' (drones) only job is to mate with queens and are produced only during May to August. A typical colony of bees has about 30,000 – 60,000 workers, one queen and a few to hundreds of drones. About 1/3 of these workers are foragers. Foragers show flower constancy so they tend to focus on flowers of a single species, resulting in more efficient pollination.

**Internal Factors Affecting Foraging Behavior:** To provide adequate pollination, honey bee colonies must be of sufficient strength, free of diseases and parasites, have a laying queen, and have adequate "brood" (immature stages which include eggs, larvae and pupae). A newly installed package bee colony, with 2 pounds of bees, would start with about ~9,000-11,000 workers and would not be considered ready for pollination work. Such a colony would concentrate heavily on brood rearing and only have about 1,000-2,000 foragers. Stronger colonies would send out about 30 percent% of bees as foragers. A typical median strength over-wintered colony would have about 30,000 workers and can send out 10,000 foragers. With adequate resources, colonies can develop a work force of 60,000 or more workers at the peak of the season. Brood frames should be inspected for the presence of chalkbrood, American and European foulbrood, parasitic mites and symptoms of virus or other pathogens of honeybees. In general, 3-5 frames of solid brood suggest a fertile queen and a healthy colony. Bees should be periodically inspected for presence of Nosema disease.

**External Factors Affecting Foraging Behavior:** Environmental factors affect honey bee foraging. Bees do not work in the rain and work less on cloudy days. Foraging activity is positively related to temperature, with a linear relationship from 60-90°F. --Foraging activity slows when it gets too hot (over 90°F). High winds (above 20 mph) will alter or inhibit flying activity, with bees choosing flight paths that are less affected by wind. As an example, honey-bees placed for pollination of orchards will concentrate their efforts near the orchard floor under windy conditions, leaving the orchard crop poorly pollinated. By contrast, bumble bees can forage at lower temperature and lower light conditions.

**Hive Density Recommendations for Pollination:** Because Varroa mites had wiped out most of our feral (wild) honey bee populations, recommended rates for pollination prior to 1987 have to be increased to compensate for the lack of "free" honey bees. The table below lists recommended rates for hive density. From an economic point of view, it is best to start with the highest number of hives you can afford, and then alter your

hive count based on your observations. As new fruit and vegetable varieties are released, review pollination recommendations made by the developer, and then monitor pollination activity. (See also: <http://www.pollinator.ca/canpolin/>) **Table 1.** Recommended density of honey bee colonies (per acre) for Michigan crops:

Crop	Colonies	Notes
Apple	1-3	The more high density varieties need more hives
Sweet cherry	1	Balaton may need more
Pear, Plum, Peach	1	
Blueberry	3	Cultivars vary in their dependence on pollination
Cranberry	-3	
Raspberry, strawberry	1	
Pickles	3	

**Hive Density Recommendations for Neighbor Relations:** One of the primary limitations to keeping bees is the real or perceived interaction between the bees and the people who live in or use the surrounding area. The following practices are intended to minimize potential conflicts between people and honeybees. Hive density (colonies per acre), placement and orientation of hives in relation to property boundaries, and providing a barrier between hives and neighboring properties to interrupt and prevent the direct line of flight from a colony into living areas on neighboring properties are important factors to accomplish this objective.

**Table 2a.** Recommended maximum density of honey bee colonies relative to lot size

Lot/Acreage	Number of Colonies
Up to 1/4 acre (1/4 acre=10,890 sq. ft., roughly 50 ft. x 215 ft.)	2
More than 1/4 acre, less than 1/2 acre (1/2 acre = 21,780 sq. ft., roughly 100 ft. x 218 ft.)	4
More than 1/2 acre, less than 1 acre (1 acre = 43,560 sq. ft., roughly 150 ft. x 290 ft.)	6
1 acre or more	8

Table 2a provides general guidelines for the maximum number of bee colonies to keep on small lots. Other limitations for placement of bees on small lots include the orientation of colonies in relation to adjacent and nearby developed property as described in the sections for 'Hive Placement' and 'Recommendations for Considerate Hive Management'.

**Table 2b.** Recommended density of honey bee colonies regardless of lot size

Condition	Number of Colonies
If all hives are situated at least 200 feet in any direction from all property lines of the lot on which the apiary is situated	No limit
As long as all adjoining property that falls within a 200-foot radius of any hive is undeveloped property	No Limit

Table 2b is used when lot size is larger than one acre, where colonies will be located at least 200 feet from property lines and any adjoining or nearby developed portion of property.

**Hive Placement:** Correct placement of hives is an important consideration for responsible beekeeping in urban/suburban situations.

- Hives must be located in a quiet area of the lot.
- Hives must be oriented so that a direct line of flight from the hive entrance does not impact living areas on neighboring properties.
- When placing hives on small lots (Table 2a) or at locations within 200 feet of any developed portion of property, a solid fence, wall, or dense vegetative barrier capable of interrupting the direct flight of bees shall be used to redirect the bee's flight pattern and prevent a direct line of flight from the hives into neighboring properties. The barrier shall start at the ground, be a minimum of six feet in height and shall extend beyond the direct line of sight from the entrance of the hive to the neighboring or adjacent property.
- Hives must not be placed along property lines unless a solid fence, wall or dense vegetative barrier capable of interrupting the direct flight of bees forms the property boundary.
- Hives placed in elevated locations need to be placed so bees do not have a direct line of flight to neighboring properties with elevated living areas.
- Do not place hives next to roads, sidewalks, and public rights of way.
- Hive entrances should face so that bees fly across your property. If this is impossible, use barriers (hedges, shrubs, or fencing six to twelve feet high) to redirect the bees' flight pattern.

**Swarming:** Swarming is a natural instinct of honeybees that occurs chiefly from spring to early summer. Swarms should be collected to prevent their becoming a nuisance. Honeybee colonies can and should be managed to prevent or minimize swarming. For example, brood chamber manipulation, colony division, adding supers for brood rearing and honey storage, and replacing old or failing queens can all reduce the swarming impulse. These and other management practices to control swarming are explained in detail in good beekeeping textbooks. Beekeepers who learn of a swarm should take reasonable measures to see that the swarm is retrieved.



**Provision of Water:** Beekeepers should assure an adequate source of fresh water for their bees prior to establishing an apiary. Where adequate fresh water from a nearby pond or stream is not available, beekeepers should establish a water source that will be available throughout the active flight season. Bees prefer a sunny place where they can gather surface moisture, for example wet sand or gravel or the edge of a birdbath. If you establish such water sources, your bees will become habituated to them and will be less likely to visit swimming pools or hot tubs. Remember that in very hot weather, bees use a large amount of water to maintain temperature and humidity within the hive.

**Queens:** In most cases, European honeybees are considered gentle. When a colony exhibits unusually defensive characteristics (stinging or attempting to sting without provocation), or exhibits a frequent tendency to swarm, it is the beekeeper's duty to re-queen from European stock. Queens should also be replaced as they get older, or as they begin to fail to ensure that the colony maintains strong numbers of healthy brood.

**Robbing Behavior:** When nectar is scarce, honeybees may rob honey from other hives. Under such conditions, beekeepers should work hives for only a very short time, if at all. Exposing honey (especially sticky honeycombs) outdoors often encourages robbing. All spilled honey should be cleaned up immediately. To prevent robbing, buildings and trailers used for honey extraction must be made bee-proof, as far as is practicable.

**Transportation of Hives:** Beekeepers must take appropriate care when transporting hives of honeybees. All loads of hives and supers of honey should be secured. Bees being transported should have entrance screens or be secured under netting.

**Migratory Movement of Honeybees and use of Consolidation Yards:** Migratory beekeeping practices include the use of temporary consolidation yards where beekeepers bring hundreds to thousands of honeybee colonies together to facilitate inspection and shipment of colonies for migratory purposes. Likewise, large number of colonies may be temporarily unloaded upon return from migratory movement.

Beekeepers must be aware of the impact caused by congregating large numbers of colonies in one location, and take appropriate steps to mitigate the impact to their neighbors.

In most cases it is to the beekeepers benefit to quickly disperse excess colonies from a consolidation yard. However, unforeseen factors including weather and the timing of pollination needs can inhibit the dispersal of colonies and must be taken into account when deciding where to unload the bees.

During periods of cold, honeybees cluster in the colony and little or no activity is observed. On sunny or mild days, honeybees will leave the colony for cleansing flights, but they quickly return to their colony. Overwintering large numbers of colonies in one location has benefits to the beekeeper and is considered an acceptable practice as long

as the beekeeper arranges to disperse the colonies before the bees become active in the spring.

Honeybees being prepared for migratory movement are brought to one location to facilitate loading and shipping. A beekeeper may consolidate from 100 to several thousand colonies of honeybees in one location, depending on the number of colonies to be placed on a truck, and the number of trucks to be loaded at a single time. If warm weather is anticipated, large numbers of colonies should not be consolidated in a location where they can impact developed properties.

The beekeeper must anticipate the length of time colonies will be at the site and provide adequate food and water to address the foraging needs of the colonies for the time of year. The beekeeper must anticipate the time needed to complete inspections, prepare the colonies for movement, and schedule transportation to move the bees. A beekeeper must provide a consolidation yard with enough setback from developed property that, with appropriate food and water resources, the beekeeper will mitigate the activity of honeybees around neighboring homes and farmsteads. Tables 2a and 2b address setback distances for normal beekeeping activity and should not be considered as guides for consolidation yards.

Colonies brought to Michigan from southern states are, in general, stronger than colonies that were overwintered in Michigan. When moved into Michigan, southern raised colonies will have an active field force and will immediately begin searching for water and food resources. Adequate food and water must be provided no later than at the time the bees are unloaded. A consolidation yard must be located so that the distance from developed properties coupled with adequate food and water resources prevents honeybees from invading developed properties.

Disbursal of colonies from receiving yards to pollination or honey production locations should occur as soon as possible. It is to the beekeepers advantage to minimize the number of times bees are moved. For this reason, unload large numbers of colonies further from neighbors if constraints of weather or the timing of pollination activities prohibits immediate movement.

**Recommendations for Considerate Hive Management:** Beekeepers should take into account that weather conditions influence bee behavior and plan to work bees when conditions are favorable. They should make sure that neighbors are not working or relaxing outdoors when they open hives and should try to perform hive manipulations as quickly as possible, with minimum disturbance to the bees. Extended hive manipulations, particularly removing honey, should be carefully planned to accommodate neighbors' activities. Beekeepers should use smoke when working bees and should smoke hive entrances before mowing or trimming in the hive area. Clippings and exhaust should be directed away from hive entrances.

Adherence to the following list of beekeeping and apiary management practices will help beekeepers avoid conflicts with neighbors and demonstrate good beekeeping management:

1. Situate hives away from lot (property) lines and occupied buildings.
2. Locate hives away from roads and areas frequented by pedestrian and animal traffic.
3. In populated areas, use fences and hedges as screens to conceal hives and to elevate the bees' flight path. Vegetation and fences also serve as windbreaks.
4. Do not situate hives on or next to utility right-of-ways (power lines, pipelines or underground cables).
5. Avoid placement of hives near schools, recreation areas, picnic grounds or other locations that may result in adverse honey bee/public interactions.
6. Provide a water source so the bees don't fix on neighborhood swimming pools, birdbaths, livestock/pet water sources, etc. The water source must be established before the weather gets hot so the bees are trained to it. Provide fresh water on a regular basis.\*
7. Keep no more than 4 hives on a lot less than 1/2 acre.
8. Maintain gentle colonies. If hives become defensive, determine the cause and requeen with gentle stock if necessary. Skunks are often the reason for hives to suddenly become defensive.
9. Work bees when neighbors are not in their yard. Minimize robbing behavior.
10. Manage hives for swarm prevention.
11. When mowing the grass in front of hives, direct the clippings and exhaust away from the entrance.
12. Share your enthusiasm and knowledge of beekeeping with the community.

\* Common water sources include birdbaths, pebble filled sections of gutter with end caps, plastic wading pools and entrance feeders. Pieces of carpet screen stapled to wooden frames, ~~styrofoam~~Styrofoam floats, and stones and pebbles provide ample footing for the bees to prevent drowning. The addition of salt (water softener, pickling, and sea) or sugar often aids in the training process of honey bees.

## HEALTH CARE

**Disease Control:** There are a number of honeybee diseases and pests, of which American Foulbrood (AFB) is the most serious. Other brood diseases, including European Foulbrood, Chalkbrood, Nosema, and viruses must be considered when caring for honeybee colonies. Beekeepers should be extremely cautious about mixing hive equipment or purchasing hives from sources that are not certain to be disease-free. Finally, it is incumbent on beekeepers to manage parasitic mites and other pests responsibly for both colony health and honey quality.

**Pharmaceutical Use:** It is imperative that those engaged in raising livestock (including bees) and poultry for human consumption understand the prudent and legal use of pharmaceutical products. To help ensure that health and welfare of livestock and poultry and the safety of food they produce for the public, a veterinary-client-patient relationship (VCPR) is highly recommended. In most cases, a valid VCPR is mandatory for acquiring and using pharmaceutical products in food producing animals. Michigan currently follows the federal definition for a VCPR which states that a VCPR is considered valid if the following is observed (Code of Federal Regulations 530.3) (<http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm460406.htm>):

1. A licensed veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
2. There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and
3. The veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s), and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

**Pest Management during Pollination:** Always make growers mindful that honeybees are active on their farm and that they need to follow appropriate practices to protect your honeybees. The use of broad-spectrum insecticides when flowers are open should always be avoided. Pesticide labels, as well as precautions regarding honeybee toxicity to a pesticide or combination of pesticides should be heeded by growers.

Bee hives should be removed immediately after pollination if post-bloom pesticide applications are planned. By monitoring for pest problems carefully during bloom, growers can help minimize the need for pest control. If an insecticide application is necessary during bloom, the compounds that are least toxic to bees should be used,

|

with careful observation of the pollinator-restrictions on the label. If an application is required, the beekeeper should carefully determine whether the bees need to be moved prior to the application event.

In general dusts, wettable powders and emulsifiable concentrate formulations are more harmful to honey bees. Applications conducted in the morning or daytime are not as safe for bees as evening applications. Ask the grower to inform the beekeeper before a spray so that colonies can be moved or shut down for 1-2 days with wetted-burlap blocking entrances, especially if highly toxic insecticides have to be used. This database lists the toxicity of various pesticides to honey bees:  
<http://apiculture.com/databases/pesticides.htm>.

Our appreciation to the Maine State Beekeepers Association for allowing us to use their excellent material in this document. Their full document can be seen at [mainebeekeepers.org](http://mainebeekeepers.org).

## DEFINITIONS

**Apiarist and beekeeper:** A person keeping bees

**Apiary:** A place where honeybee hives are kept

**Apiculture and Beekeeping:** The management of beehives

**Bee sting:** Injury sustained and inflicted by a worker honeybee

**Beehive:** Removable framed housing for a honeybee colony

**Brand:** Identification for marking frames and hives

**Consolidation Yard:** A location where large numbers of colonies are placed temporarily to accommodate migratory shipping needs or winter management practices

**Flight path:** The distinct route taken by many bees leaving from or returning to their hive

**Foraging bees:** Bees seeking water or food - Bees naturally forage flowers for nectar and pollen. In abnormal circumstances, when natural sources of food and water are scarce, bees may forage supplies of animal feed, water or protein.

**Hive:** A honey bee hive, being a nucleus colony or a standard size colony

**Honey extraction:** The removal of honey from combs

**Honey flow:** The gathering of nectar from flora by honeybees

**Honeycomb:** Removable frames, containing wax cells which house honey, pollen, and/or brood (eggs, larvae, pupae)

**Package bees:** A number of adult bees, with or without a queen, contained in a ventilated shipping cage transported via USPS or other carriers

**Pollination:** The transfer of pollen by honeybees from anthers to stigmas of flowers for the purpose of plant fertilization

**Robbing:** Bees attempting to access honey stored or spilled in another hive

**Strong hive:** A populous honeybee colony

**Super:** Box or boxes containing frames placed above the bottom or brood

**Swarm:** Cluster of flying mass of honeybees including workers, queen, and drones

**Undeveloped Property:** Means idle land that has no structures or facilities intended for human use or occupancy. Property used exclusively for streets, highways, or commercial agriculture is considered undeveloped property.

**Water supply:** Taps, hoses, pools, hot tubs, streams, ponds, puddles, etc.

## REFERENCES

~~Besey, Kevin. Food Manager, Michigan Department of Agriculture & Rural Development, Food and Dairy Division: [Beseyk@michigan.gov](mailto:Beseyk@michigan.gov)~~

Best Management Practices of Pollination in Ontario Crops:  
<http://www.pollinator.ca/canpolin/>

Colony Collapse Disorder: <https://agdev.anr.udel.edu/maarec/category/ccd/>

Hansen, Michael G., State Apiarist, Michigan Department of Agriculture and Rural Development, Pesticide and Plant Pest Management Division: [hansenmg@michigan.gov](mailto:hansenmg@michigan.gov)

Honey bees as pollinators: <http://cyberbee.net/column/pollinator/beepoll.pdf>

Huang, Dr. Zachary. Apiculturalist, Michigan State University, Department of Entomology. [bees@msu.edu](mailto:bees@msu.edu)

Kraus, B. & R.E. Page, Jr. 1995. Effect of *Varroa jacobsoni* (Mesostigmata: Varroidae) on feral *Apis mellifera* (Hymenoptera: Apidae) in California. Environmental Entomology 24: 1473-1480

Michigan Beekeepers Association. [www.michiganbees.org](http://www.michiganbees.org)

Mid Atlantic Apicultural Resource and Extension Consortium,  
[agdev.anr.udel.edu/maarec/](http://agdev.anr.udel.edu/maarec/)

Milbrath, Meghan. Coordinator, Michigan Pollination Initiative, Michigan State University, Department of Entomology. [mpi@msu.edu](mailto:mpi@msu.edu)

Ontario Recommendations for Honeybee Management and Disease Control  
<http://www.omafra.gov.on.ca/english/foodinspections/bees/recommendations.htm>

Pett, Walter. Apiculture and Pollination Specialist, Michigan State University, Department of Entomology. [pett@msu.edu](mailto:pett@msu.edu)

Pollination and pesticides <http://cyberbee.net/column/pollinator/pesticides.pdf>

## ADVISORY COMMITTEE

Listed below are the advisory committee members for the Generally Accepted Agricultural and Management Practices for the Care of Farm Animals.

Dr. Janice Swanson  
Committee Chair  
MSU Animal Science  
3270 E Anthony Hall  
East Lansing, MI 48824  
[swansoj@anr.msu.edu](mailto:swansoj@anr.msu.edu)  
517-353-8714

Dr. Judith Barry  
MSU Center for Regional  
Food Systems  
312A Natural Resources  
480 Wilson Road  
East Lansing, MI 48824  
[barryjud@msu.edu](mailto:barryjud@msu.edu)  
517-432-0308

Dr. Madonna Benjamin  
MSU College of Veterinary  
Medicine D202  
East Lansing, MI 48824  
[gemus@cvm.msu.edu](mailto:gemus@cvm.msu.edu)  
517-355-9593

Ernie Birchmeier  
Michigan Farm Bureau  
7373 West Saginaw  
Lansing, MI 48909  
[ebirchm@michfb.com](mailto:ebirchm@michfb.com)  
517-323-7000 ext. 2024

[Dr. Dan Buskirk](mailto:buskirk@msu.edu)  
[MSU Animal Science](mailto:buskirk@msu.edu)  
[2265C Anthony Hall](mailto:buskirk@msu.edu)  
[East Lansing, MI 48824](mailto:buskirk@msu.edu)  
[buskirk@msu.edu](mailto:buskirk@msu.edu)  
[517-432-0400](mailto:buskirk@msu.edu)

Dr. Richard Ehrhardt  
MSU Animal Science  
1287F Anthony Hall  
East Lansing, MI 48824  
[Ehrhard5@msu.edu](mailto:Ehrhard5@msu.edu)  
517-353-2906

Dr. John Easley  
Fur Comm. USA  
W 8366 Spring Valley Dr  
Glenbeulah, WI 53023  
[johnneasleydvm@hotmail.com](mailto:johnneasleydvm@hotmail.com)  
920-980-9660

[Dr. Daniel Grooms, DVM](mailto:groomsd@cvm.msu.edu)  
[MSU A110 Vet Medical](mailto:groomsd@cvm.msu.edu)  
[Center](mailto:groomsd@cvm.msu.edu)  
[East Lansing, MI 48823](mailto:groomsd@cvm.msu.edu)  
[groomsd@cvm.msu.edu](mailto:groomsd@cvm.msu.edu)  
[517-432-1494](mailto:groomsd@cvm.msu.edu)

Dr. Barbara Evans  
School of Science and  
Medicine  
Lake Superior State  
University  
650 W Easterday Ave.  
Sault St. Marie, MI 49783  
[bevans@lssu.edu](mailto:bevans@lssu.edu)  
906-440-1370

Meghan Milbrath  
MSU Department of  
Entomology  
1129 Farm Lane, B186  
Food Toxicology BLDG  
East Lansing, MI 48824  
[mpi@msu.edu](mailto:mpi@msu.edu)  
517-884-9518

[Katherine Ockert](mailto:ockertka@msu.edu)  
[MSU Extension Ionia](mailto:ockertka@msu.edu)  
[50 E Sprague Rd](mailto:ockertka@msu.edu)  
[Ionia MI 48846 US](mailto:ockertka@msu.edu)  
[ockertka@msu.edu](mailto:ockertka@msu.edu)  
[616-527-5357](mailto:ockertka@msu.edu)

[Dr. Madonna Benjiman](mailto:ockertka@msu.edu)  
[MSU](mailto:ockertka@msu.edu)  
[D202 Vet Medical Center](mailto:ockertka@msu.edu)

[East Lansing, MI 48824](mailto:gemus@cvm.msu.edu)  
[gemus@cvm.msu.edu](mailto:gemus@cvm.msu.edu)  
[517-355-9593](mailto:gemus@cvm.msu.edu)

Dr. Chris Skelly  
MSU Animal Science  
2209 F Anthony Hall  
East Lansing, MI 48824  
[skellych@msu.edu](mailto:skellych@msu.edu)  
810-338-8200

Dr. Miriam Weber-Nielsen  
MSU Animal Science  
2265 H Anthony Hall  
East Lansing, MI 48824  
[mw@msu.edu](mailto:mw@msu.edu)  
517-432-5443

Dr. Zach Williams  
MSU Animal Science  
1287 C Anthony Hall  
East Lansing, MI 48824  
[Will3343@msu.edu](mailto:Will3343@msu.edu)  
517-355-8383





# Generally Accepted Agricultural and Management Practices for Cranberry

---

Production

January **DRAFT 2020-2021**

Michigan Commission of Agriculture & Rural  
Development

---

PO BOX 30017  
Lansing, MI 48909



In the event of an agricultural pollution emergency such as a chemical/fertilizer spill, manure lagoon breach, etc., the Michigan Department of Agriculture &and Rural Development and/or Michigan Department of Environment, Great Lakes, and Energy should be contacted at the following emergency telephone numbers:

Michigan Department of Agriculture &and Rural Development: 800-405-0101  
Michigan Department of Environment, Great Lakes, and Energy: 800-292-4706

If there is not an emergency, but you have questions on the Michigan Right to Farm Act, or items concerning a farm operation, please contact the:

Michigan Department of Agriculture &and Rural Development (MDARD)  
Right to Farm Program (RTF)  
P.O. Box 30017  
Lansing, Michigan 48909  
517-284-5619  
877-632-1783  
517-335-3329 FAX

## Table of Contents

<b>PREFACE</b>	<b>iii</b>
<b>INTRODUCTION</b>	<b>1</b>
<b>SITE SELECTION</b>	<b>2</b>
<b>DESIGN AND CONSTRUCTION OF CRANBERRY FARM OPERATIONS</b>	<b>4</b>
<b>WATER MANAGEMENT</b>	<b>5</b>
<b>IRRIGATION</b>	<b>6</b>
<b>FLOODING</b>	<b>8</b>
<b>NUTRIENT MANAGEMENT</b>	<b>8</b>
<b>INTEGRATED PEST MANAGEMENT (IPM)</b>	<b>9</b>
<b>PESTICIDE APPLICATIONS AND HANDLING</b>	<b>9</b>
<b>WEED MANAGEMENT</b>	<b>12</b>
<b>INSECT MANAGEMENT</b>	<b>12</b>
<b>DISEASE MANAGEMENT</b>	<b>13</b>
<b>WILDLIFE MANAGEMENT</b>	<b>15</b>
<b>POLLINATION</b>	<b>15</b>
<b>PRUNING</b>	<b>15</b>
<b>HARVESTING</b>	<b>15</b>
<b>SANDING</b>	<b>16</b>
<b>NEIGHBOR TO NEIGHBOR RELATIONS</b>	<b>16</b>
<b>APPENDICES</b>	<b>17</b>
<b>APPENDIX I. REFERECNES</b>	<b>17</b>
<b>APPENDIX II. AGENCIES, PERMITS AND REGULATORY PROGRAMS</b>	<b>20</b>
<b>APPENDIX III. CRANBERRY SITE REQUIREMENTS</b>	<b>26</b>
<b>ADVISORY COMMITTEE</b>	<b>34</b>

## PREFACE

The Michigan legislature passed into law the Michigan Right to Farm Act (Act 93 of 1981, as amended) which requires the establishment of Generally Accepted Agricultural and Management Practices (GAAMPs). These practices are written to provide uniform, statewide standards and acceptable management practices based on sound science. These practices can serve producers in the various sectors of the industry to compare or improve their own managerial routines. New scientific discoveries and changing economic conditions may require necessary revision of the Practices.

The GAAMPs that have been developed are as follows:

- 1) 1988 Manure Management and Utilization
- 2) 1991 Pesticide Utilization and Pest Control
- 3) 1993 Nutrient Utilization
- 4) 1995 Care of Farm Animals
- 5) 1996 Cranberry Production
- 6) 2000 Site Selection and Odor Control for New and Expanding Livestock Facilities
- 7) 2003 Irrigation Water Use
- 8) 2010 Farm Markets

These practices were developed with industry, university, and multi-governmental agency input. As agricultural operations continue to change, new practices may be developed to address the concerns of the neighboring community. Agricultural producers who voluntarily follow these practices are provided protection from public or private nuisance litigation under the Right to Farm Act.

This GAAMP does not apply in municipalities with a population of 100,000 or more in which a zoning ordinance has been enacted to allow for agriculture provided that the ordinance designates existing agricultural operations present prior to the ordinance's adoption as legal non-conforming uses as identified by the Right to Farm Act for purposes of scale and type of agricultural use.

The web-site for the GAAMPs is <http://www.michigan.gov/righttofarm>.

## INTRODUCTION

Michigan has the climate, soils, and processing infrastructure necessary to support a cranberry industry. High market demand and price have stimulated interest in cranberry production outside traditional cranberry producing areas. Several individuals have recently begun growing cranberries in Michigan; numerous others are considering this crop, and Michigan cranberry production is expected to increase over the next few years.

The cranberry plant is a wetland crop species (an obligate hydrophyte) that is grown commercially in natural or artificial wetlands managed for crop production. Since the production of cranberries is a water dependent activity, many unique cultural and management practices have been developed for their production. Five to ten acre-feet of water may be needed annually per acre of cranberry bed. Farming within a wetland environment presents considerable potential for adversely affecting existing natural resources or the function of those resources. Cranberry producers need to minimize these risks by utilizing environmentally sensitive and sound management practices.

Cranberries are commercially produced in the mild marine climate of western Oregon and Washington, the moderate climate of Massachusetts, New Jersey, and Maine, and the harsh continental climate of Wisconsin. Some management practices differ from one region to another to reflect these climatic differences. For example, winter flooding and ice cover is a necessity in Wisconsin, but no winter protection is required in Oregon and Washington. Some characteristics of Michigan's climate fall between these extremes. Therefore, Michigan growers may eventually find that management practices employed in other states may not be completely suited to all areas of Michigan. Recommendations for commercial cranberry production in Michigan will likely change as the industry develops and technologies change.

These current Generally Accepted Agricultural and Management Practices (GAAMPs) were developed as a result of a Memorandum of Agreement between the Michigan Department of Agriculture &and Rural Development (MDARD) and the Michigan Department of Environment, Great Lakes, and Energy (EGLE). These agencies have a mutual interest in the development of a viable cranberry industry in Michigan, and are dedicated to protecting environmental quality. The GAAMPs are intended to provide technical and regulatory guidance that is economically viable and environmentally sensitive. Farm operations voluntarily following these GAAMPs will be provided nuisance litigation protection and other provisions pursuant to the Michigan Right to Farm Act, PA 93 of 1981 (RTFA), as amended (MRFA). The Michigan Commission of Agriculture &and Rural Development (Commission) has the responsibility to define GAAMPs under the RTFA and has identified the need for these GAAMPs to address the unique issues relative to cranberry production. GAAMPs will be reviewed annually and revised by the Commission when necessary.

## SITE SELECTION

Nearly all regions of Michigan meet the climatic requirements of cranberries. However, it is necessary that cranberry production operations be located in sites with proper soil and hydrologic conditions for successful commercial production. These conditions will directly influence the design, construction and operational costs of the farming operation. Because cranberries require the existence or establishment of wetland conditions and large quantities of water, certain regulatory requirements may also need to be met for a specific site. Site selection, farm design, construction of beds and associated facilities, and operational activities must take into account the federal, state, and local regulatory requirements. The presence of regulated wetlands and water bodies within, or adjacent to, a site considered for cranberry production, and possible permit requirements regarding wetland alterations or impacts to bodies of water should be considered, and may influence site selection, as well as farm design and placement and construction of cranberry beds, reservoirs, dikes, and associated management facilities. A cranberry site review team composed of MDARD, EGLE, and MSU staff can provide technical assistance in determining the suitability of potential cranberry sites.

### **Sites need to meet the soil and water requirements of cranberries.**

Cranberries require a growing media of sand or organic soil with an acidic pH (below 5.5). Higher pH materials are suitable if pH can be reduced economically. A nearby source of suitable sand is needed for construction and future sanding practices. Hydrologic and soil characteristics should provide the capacity to maintain the water table at or near the bed surface. Preferred sites also have minimal slope, since flat areas generally require less earth moving to develop. A ready supply of water is needed, which is physically and legally usable. Water with an acidic pH is preferred. More detailed cranberry site selection considerations are provided in Appendix III. The USDA Natural Resources and Conservation Service (NRCS) can provide copies of local soil surveys and other soils data.

### **Regulatory requirements must be met.**

Site selection, farm design, construction and operational activities need to consider all applicable federal, state and local regulatory requirements, and any tribal laws and regulations. Prior to establishing a cranberry production site, producers should consult with the Water Resources Division (WRD, formerly the Land and Water Management Division) of EGLE and all other appropriate agencies to determine if any permits are required. All required permits need to be obtained prior to initiation of any regulated activities, such as, construction of cranberry beds and associated facilities. Regulatory programs are described in Appendix II. Early contact will advance the identification of possible permit requirements and the application review process. The MDARD Environmental Stewardship Division and Michigan State University Extension may also be helpful in identifying potential sites.

The selection of a site for growing cranberries that recognizes environmental concerns along with proper farm design and operation will ease compliance with

applicable regulatory requirements. A qualified environmental consultant who is familiar with regulatory requirements may be helpful in the site selection and design process. The grower or their consultant should contact the regulatory agencies in the initial stages of site selection and design of the farm operation.

The following information on site selection is provided to help identify locations that either do not require a wetland or other state permit(s) for development, or represent sites that are more acceptable under permit review criteria.

**A. Sites that are considered either upland sites or prior wetland areas that have previously been drained for agricultural use and no longer meet the regulatory definition of a wetland. These are the more desirable sites for cranberry development and do not require a wetland permit for bed development but may require other local, state, or federal permits.** In a number of regions in Michigan, former wetland areas with suitable soils have been drained for agricultural use and may be suitable for cranberry growing if steps are taken to restore the high water table (e.g. placement of water control structures on drainage outlets) and other criteria are met.

**B. Sites having soils which have been drained for agricultural use but which do meet the state and federal definitions of a wetland. These sites require permits for construction of cranberry beds and associated facilities. However, permits will likely be issued unless other resources would be adversely impacted by the proposed conversion.** For sites which are still technically a wetland, but which have reduced wetland values due to past or current agricultural drainage, EGLE wetland review criteria will not be more stringent than federal permit review requirements. The applicant will need to minimize impacts on wetlands and associated resources, and should locate support facilities within upland areas where feasible.

**C. Permits are required for construction of cranberry beds in natural, undisturbed wetlands.** Permit review requirements will be consistent with federal programs regarding construction of cranberry beds in natural, undisturbed wetlands, and will weigh the impacts and benefits of the proposed project.

EGLE will evaluate applications for permits involving potential sites for cranberry development on a case by case basis, including sites that do not clearly meet the above criteria. As required by the 2009 amendments to Part 303, Wetland Protection of the Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended, the Commission in consultation with the EGLE is to prepare informational maps that identify a total of 5000 acres of land in Michigan considered suitable for cranberry ~~production.~~production. When completed, these informational maps will be made available to the public on the EGLE website.



## DESIGN AND CONSTRUCTION OF CRANBERRY FARM OPERATIONS

An economically feasible and environmentally sound cranberry farm operation depends on appropriate planning for facility design and construction activities. The NRCS provides useful information on most aspects of design and construction for erosion and sedimentation control. The Conservation Practice Standards and Specifications are contained in the NRCS electronic Field Office Technical Guide (eFOTG), available at <http://www.nrcs.usda.gov/technical/efotg>. Additional technical assistance may also be obtained from local NRCS or conservation district offices or private sector professional engineering firms or technical service providers.

### **Cranberry beds need to meet the growth requirements of the plants and facilitate management.**

Arrangement, dimensions, and elevations of beds depend on the topography and other site characteristics. Construction procedures are site specific, but some general steps are followed. To construct cranberry beds, the surface soil is usually removed and, if suitable, often used to build dikes and roads. In most cases, clean sand is spread over the bed, and the surface is leveled. Drainage ditches are usually dug around the perimeter of the beds. Subsurface (tile) drain and pumping plant for water control may also be installed.

**Water management facilities need to meet the annual water requirements.** The large quantity withdrawal of either surface and/or groundwater statutorily requires the property owner or their authorized agent to use the EGLE's online ([https://www.egle.state.mi.us/wwat/\(S\(hcu05pgtpzjdqp44xl3exzfl\)\)/default.aspx](https://www.egle.state.mi.us/wwat/(S(hcu05pgtpzjdqp44xl3exzfl))/default.aspx)) water withdrawal assessment tool to evaluate and determine if the proposed withdrawal is acceptable or requires a site specific review by the WRD of the EGLE. The tool is intended to assist in water use planning decisions and to prevent adverse resource impacts to surface waters that can result from the withdrawal of too much water. The registration of an acceptable large quantity withdrawal (LQDW) may be completed using the online tool. If the tool indicates that the LQDW may cause an adverse resource impact, the property owner may submit a request to the EGLE for a site specific review.

A detailed water budget should be calculated to help insureensure an adequate and timely water supply. An example of a water budget evaluation is provided in Appendix IV. Ponds are usually constructed to serve as water reservoirs. Wells may supplement the water supply. Various drainage ditches, dikes, canals, bulkheads, and irrigation and drainage systems are usually installed to move water to and away from beds.

All new cranberry growers should consider designs that allow for water recycling. These systems are referred to as "closed systems" because surface runoff and drainage water from the beds is retained and later reused. Properly managed closed systems can provide a higher level of environmental protection.

Closed systems usually have an upper reservoir that serves as the water source and a lower recovery reservoir. It is desirable to have the beds at a lower elevation than the water source. Water is temporarily stored in the down slope reservoir where potentially

nutrient-bearing sediments are trapped and some breakdown of pesticides occurs. Generally, water levels in the down slope reservoir should be kept low when pesticides are applied. Pesticide residues moving out of beds in the drain water can then be retained and degraded in the down slope reservoir. This will help to protect groundwater and surface water quality. This water can also be pumped back into the beds or an upslope reservoir and reused. Recycling water in this manner reduces the water capacity required in the upslope reservoir and the need for water from other sources. In sites where a large amount of surface water runoff from higher land may inundate the bed area, diversion ditches may channel excess water from the beds.

Cranberry operations that divert surface water runoff, and drainage water from beds to streams or other surface water bodies (and do not collect and recycle water) are called "open systems". After a pesticide application, any water in the treated area needs to be held for no less than the time indicated on the pesticide labels before it can be released. Open systems have a greater potential than closed systems to adversely affect the environment. Proper design and management of an open system should minimize the potential for adverse environmental impacts.

**Control soil erosion and sedimentation during construction.**

Soil erosion control is an important component of agricultural non-point source pollution prevention programs, because soil itself can be a pollutant and may be a carrier of pollutants, such as adsorbed pesticides and nutrients. Avoid disturbing soil during heavy rain or wind storms. Blowing dust and wind erosion can be reduced by sprinkling water on dry soil or sand. Excavated sand should be stockpiled away from open water. Consider lining stream and ditch banks with silt fences to prevent sedimentation. Grass or vegetation should be established on roadways, dike roads, etc. as soon as possible to reduce the likelihood of soil erosion.

## **WATER MANAGEMENT**

Water is essential to cranberry production; it is used for spring reflow, frost protection, irrigation, harvest, and winter protection. Depending on the site, water may be obtained from or discharged into sources such as lakes, rivers, streams, drains, or reservoirs, as allowed by common law water rights and subject to obtaining necessary state permits. Water movement in and out of beds is controlled by a system of dikes and ditches. Excessive water may be drained or pumped to various water recovery or release areas.

**Dikes, ditches, reservoirs and flumes should be maintained.**

Dikes control water movement and support production equipment. Since wind, water, and burrowing animals deteriorate dikes, maintenance and upgrading are essential for efficient water containment and movement, and safe vehicle passage. Burrowing animals are the primary cause of dike failure and must be controlled. Establish grass or other vegetation on dikes and ditch banks to stabilize the soil. However, vegetation should be mowed so that it does not produce seed and increase weed pressure in the beds. Ditch bank erosion commonly occurs when saturated, unstable soil materials are subject to high velocity water flow. Erosion can be reduced by installing geofabric or geogrid material, rock cover, or

riprap to unstable embankments and down gradient sides of flumes, and by lowering water levels in ditches to improve bank stability during periods when the soil is wet, because saturated soil has little strength. Designed soil erosion control practices, such as those identified above, can be requested from the [USDA Natural Resources Conservation Service \(NRCS\)](#) and the local conservation district or technical service providers.

Private ditches and waterways need to be free of excessive vegetation and sedimentation that can impede drainage. If beds have adequate soil drainage, some live aquatic vegetation left in the ditches during the growing season may help filter nutrients and pesticides from the water. In this case, delay cleaning ditches and waterways until later in the season to take full advantage of this filtering action.

When cleaning private ditches, ponds, or reservoirs, be careful not to undercut ditch banks or to dig ditches too deep, since undercutting leads to instability and bank failure. If sediment being dredged from ditches has a fine texture, a silt fence is effective to capture sediments before they move offsite. Cleaning ditches from the point most distant from the flume (moving towards the flume) will enhance sediment settling. Dispose of spoils on established dikes or other upland areas. Allow ample time for excess water to drain out of dredged sediments before being moved. Use silt fences to keep sediments contained. Growers should employ all reasonable sediment control and removal techniques to receive and cleanse waters exiting the bed. Growers should also consider diverting sediment-charged water to holding ponds to allow settling of solids.

Worn or damaged flume or bulkhead boards should be replaced regularly to prevent the escape of ditch or flood water. Keep boards free of debris and consider using rubber gasket strips on channel guides or a tension activated tie down system to decrease leakage. Consider locking flume or bulkhead boards in place.

**Reduce ditch water levels as much as possible before applying nutrients and pesticides.**

Lower water levels in ditches before applications to allow for absorption of nutrients and pesticides into ditch sediment and vegetation, and increase water holding time.

**Adequate drainage is needed in all beds.**

Proper soil drainage is needed for healthy vines. Healthy vines may require less fungicide because they are less prone to diseases such as root rot. Drainage may be improved by installing surface drainage, main or laterals or subsurface (tile) drains, or by winter sanding.

**Anticipate weather.**

Heavy rainfall can wash nutrients, especially nitrogen and pesticides off the target area. Follow weather forecasts and halt fertilizer and pesticide applications when rainstorms are forecasted or frost protection is required.

**IRRIGATION**

Sprinkler irrigation is essential for cranberry culture to protect plants from spring and fall frost damage, supply water during the growing season, and apply nutrients and pesticides.

To perform these functions effectively, irrigation systems should be engineered and maintained to provide maximum water application uniformity. The current Generally Accepted Agricultural and Management Practices for Irrigation Water Use (MDARD) provide useful general guidance on irrigation use.

**Irrigation systems should be designed for uniform water application.**

Irrigation systems should deliver uniform application rates of 0.1 to 0.15 inches per hour. To optimize uniformity, reduce system pressure losses by protecting pipes from dents and limit the number of 90 degree elbows. Reduce plugging by installing clean out plugs at lateral ends and a strainer basket on the intake pipe. Secure risers to a vertical stake to limit wobble. Straight, stationary risers provide more uniform water application.

**Irrigation equipment should be maintained in effective operating condition.**

Follow manufacturer recommendations for pump, valve, and sprinkler head maintenance. Inadequate maintenance can result in breakdowns at critical times, reduced system uniformity, and inappropriate application rates. Precautions should be taken to prevent fuel leaks or spills.

**Irrigation application rates and uniformity should be tested periodically.**

-Irrigation system uniformity should be tested regularly. Systems with low uniformity cause some areas to receive adequate water while others receive too little or too much. Coefficient of Uniformity (CU) of less than 60 percent indicates the system needs updating or was not properly installed. The NRCS recommends a CU of 85 percent, an attainable goal using current technology. Uniformity may be affected by sprinkler rotation speed, pattern type and spacing (closer spacings give higher uniformities), nozzle pressure, wear, and size, different trajectory angles resulting from leaning risers, friction losses in laterals, different sprinkler elevations, and wind. Data collected from an irrigation uniformity test can be used to calculate the system's irrigation rate, and modifications can be made by changing operating pressure or nozzle size.

**Irrigation should be applied at appropriate rates and intervals.**

Newly set plants should receive frequent, light applications of water for the first two weeks or until roots form. To promote deeper rooting, irrigate newly planted beds less frequently but longer after plants become established. Established beds require one to two inches of water per week. Irrigation rates should be reduced to reflect rainfall received in lieu of irrigation water. Apply up to 0.5 inches per irrigation event.

Irrigation should be used to cool plants when ambient air temperatures reach 85°F or higher. Cool plants by irrigating for about one hour to thoroughly wet the plants and soil surface. Irrigate again when temperatures rise to 85°F. Drain surface pipes between irrigations to prevent scalding caused by hot water in pipes.

When irrigating for frost control, monitor both temperature and growth stage, since lethal temperatures vary with growth stage. Begin irrigating when temperatures at bed level are one to two degrees above the critical temperature, and stop irrigating when temperatures rise safely above the critical temperature. Effective frost protection requires irrigation rates of at least 0.1 inches per hour. This rate protects buds and fruit to a temperature of 20°F

(under wind conditions of 0 to 1 mph). Sprinklers should rotate at least once per minute to provide frost protection.

## **FLOODING**

Cranberry beds are flooded in the fall to harvest berries following dry harvest to remove trash and debris, during the winter to protect plants from cold injury and in the spring to control some pests, remove frost from the soil and protect plants from severe freezes.

### **Harvest.**

Hold harvest flood water in beds for at least one day, and then slowly pump or drain the water from the beds.

### **Winter flooding.**

The cranberry is an evergreen plant that can be damaged by cold and fluctuating temperatures. Beds are usually flooded in early winter so that ice covers the plants and protects them from cold, windy weather. This ice layer also makes it possible to apply sand.

Winter flood water should be applied when the surface layer of soil has frozen. The water needs to come from a surface source rather than ground water. Having the ground frozen decreases the potential of losing flood water through seepage. Using surface water that is already near freezing also reduces the chance of removing frost from the ground. The winter flood water should be applied as quickly as possible without causing soil erosion. Fast flooding reduces the chance of the wave action of the water pulling out the plants.

Drain flood water slowly to minimize water fluctuations and sedimentation in water recovery or release areas.

## **NUTRIENT MANAGEMENT**

Cranberry beds require fertilizer applications to produce economic yields. However, nutrients such as nitrogen (N) and phosphorus (P) can harm water quality if not managed properly. Excessive use of fertilizers can injure cranberry plants and reduce yields. Refer to the GAAMPs for Nutrient Utilization, Michigan Commission of Agriculture [&and](#) Rural Development, for general information on how fertilizers should be handled and used to minimize environmental impacts. Refer to university recommendations for guidance on fertilization practices.

### **Nutrient use should be based on plant performance, tissue analysis, and soil test results.**

Beds on organic soils may require as little as 10 lbs. N per acre per year, whereas those on sandy soils may need as much as 60 lbs. per acre. Determine the appropriate rate for specific beds based on vine growth and yields, tissue N levels, and previous fertilization practices. Refer to the Compendium of Blueberry and Cranberry Diseases (APS Press) for descriptions of nutrient deficiency and toxicity symptoms.

**Plan fertilizer applications to correspond with crop demand.**

Fertilizers containing N and P should be applied between bud break and late August, when plants are most able to utilize nutrients. This reduces chances of N or P loss to the environment. Fall or early spring applications of fertilizer increase the risk of nutrient losses through leaching and should be avoided. Potential for leaching is greatest on coarse textured soils. Lower rates applied when the plants are able to use the nutrients reduce runoff potential and increase nutrient efficiency.

**Ammonium forms of N should be used.**

Cranberries prefer ammonium-N over the nitrate form. Ammonium-N adsorbs to clay and organic matter in the soil, so it is less mobile than nitrate-N, and less prone to leaching.

**Fertilizer application equipment should be calibrated.**

Fertilizer is applied to cranberry beds with spreaders or booms, airplanes, or helicopters, or through irrigations systems. All application equipment should be calibrated according to the manufacturer's recommendations to ~~insure~~ensure the proper amount of fertilizer is applied.

**Direct application of fertilizers to open water on cranberry beds should be minimized.**

When applying fertilizer to cranberry beds through irrigation systems, use part-circle sprinklers or sprinkler guards to minimize fertilizer applications to open water on cranberry beds, which can result in off-site movement.

**Soil pH should be maintained in the proper range.**

Nutrient utilization and plant growth are optimized when soil pH is between 4.0 and 5.5. Additions of sulfur may be needed to keep soil pH sufficiently low. Sulfuric acid may need to be added to irrigation or flood water that is high in alkalinity. Water discharged off the site should be in compliance with water quality standards. Safety precautions should be followed to prevent inadvertent contact with concentrated sulfuric acid.

## **INTEGRATED PEST MANAGEMENT (IPM)**

Commercial cranberry production requires management of insect pests, diseases, and weeds. Integrated Pest Management (IPM) integrates biological, cultural, and chemical control practices to manage these production problems. IPM requires knowledge of pest life cycles and identifying characteristics, and an understanding of all available control options. By scouting cranberry beds and understanding pest biology and control options, growers are able to make appropriate pest management choices. Useful references may be found in Appendix I.

## **PESTICIDE APPLICATIONS AND HANDLING**

The current version of the GAAMPs for Pesticide Utilization and Pest Control, Michigan Commission of Agriculture &and Rural Development, provides general guidance on agricultural pesticide use. These GAAMPs describe information on applicator certification, application equipment, methods and record keeping, pesticide handling and safety, disposal of excess spray mixtures, and unused pesticides and pesticide containers. Instructions on the pesticide label must be followed. They are the law. Pesticide applicator certification is required to purchase or apply restricted use pesticides. Certification is recommended for all persons applying pesticides. Pesticide users also must comply with the Federal Worker Protection Standards. Keeping accurate records of pesticide applications is essential for farm planning and performance evaluation. Some considerations in pesticide use that are specific for cranberries are discussed below.

**Understand alternatives to pesticide, which are available for the crop to be grown.**

The options for pest management in agricultural crops include non-chemical and chemical control. The pesticide user should consider alternatives and make conscious decisions concerning pesticide use that evaluate potential site contamination, pest management, and economics of use. Non-chemical means of control include sanding, flooding, and biological controls including Bts, nematodes, etc.

**Calibrate application equipment properly.**

Proper calibration ensures equipment is delivering the correct amount of pesticide and applying it uniformly over the target area. Over-application creates needless risks to water resources and increases economic inputs and must be avoided. Under-application will result in inadequate control and economic loss.

**Develop a plan to follow in case of pesticide emergencies.**

Pesticide applicators should develop an emergency plan that lists actions to take and persons to contact in case of pesticide poisoning, spill, fire, or other accidents. Compliance with SARA Title III regulations is described in MSU Extension Bulletin E-2175.

**Keep pesticide applications out of surface waters by avoiding over-spray and drift.**

Prevent non-target application by shutting off sprayer when boom or mist blower crosses ditches or waterways. In most cases, label language prohibits application directly to open or surface waters. Follow label guidelines regarding wind speeds and equipment requirements in order to direct applications to the target. Application of pesticides during excessive wind (greater than five mph) causes unnecessary non-target application, reduces uniformity of the application, and reduces pesticide efficacy. Use anti-drift agents when appropriate. Regardless of application method, every effort should be made to keep pesticides confined to the bed and out of open or running water.

**Consider the vulnerability of water and other natural resources when making pest management decisions.**

The risk of inadvertent contamination of surface and groundwater resources differs for each farm. Pesticide users should include the risk to water resources as criteria of pest

management decisions. The potential for contaminating groundwater is influenced by soil characteristics, depth and type of bedrock, and depth to the water table.

**Apply pesticides only as needed.**

When making pesticide applications, use the lowest effective rate. IPM allows for better management of pest problems. IPM can provide information on pest populations that allows spot treatments and improves timing of treatments. These two strategies can lead to a reduction in overall use due to increased efficacy and earlier control.

**Hold water containing pesticide residues for required or recommended times.**

Holding water in ditches allows for degradation and dissipation of pesticide residues. All waters in contact with the beds must be retained for the length of time required by the label and, ideally, held as long as practical to allow maximum degradation. Low water levels in ditches prior to application increases the water holding capacity of a bed.

**When aerial applications of pesticides are made on beds adjacent to or near a road or highway, consider using flag people to control or stop traffic flow during application.**

Inadvertently spraying pesticides on motor vehicles traveling on public roads is illegal and will initiate an investigation by the MDARD. Repeated occurrences could jeopardize continued availability of aerial pesticide applications. Posting of flag people to stop traffic along both approaches to the bed, prior to a pesticide application, will minimize the incidence of accidental exposure.

**When chemigating, make sure your system complies with federal and state laws.**

Label instructions must be followed when applying chemicals through the irrigation system (chemigation). Pay particular attention to application, reentry, pre-harvest and water retention times. If an irrigation system is used to apply pesticides, it must be fitted with a check valve, low pressure drain, vacuum breaker, low pressure shutoff switch, and injection port on the discharge side of the pump. Pesticides cannot be legally introduced into an irrigation system through the suction side of the pump. Refer to MSU Extension Bulletin 2099 for chemigation techniques and compliance rules. Determine the amount of time it takes a pesticide to travel through an irrigation system by injecting a dye into the system and monitoring its flow through the system with a stopwatch. This information is necessary to optimize pesticide performance. Pesticide will be left in the irrigation lines if the system is operated for less than the injection time, whereas running the system for too much time can result in pesticide being washed off the target area. Pesticide injection times of greater than ten minutes may adversely affect pesticide performance.

Check your irrigation system and property before every pesticide application. Effective insect and disease control requires that the irrigation system performs satisfactorily. Confirm that main and lateral lines are not leaking and sprinkler nozzles are not plugged. Inspect the entire property to insure people or animals are not present at or near the pesticide application area. These procedures should be followed if the pesticides are applied by the grower or custom applicator. Inspect property after application to be sure all



signs are properly posted and that there are no people or animals present or near the application site.

Chemigation should only be practiced when uniformity, as measured by Coefficient of Uniformity Test, exceeds 60 percent. Non-uniform application of pesticides can pose a serious environmental and food safety risk. Optimize irrigation system performance before using chemigation as a pesticide application technique. Use of part-circle sprinklers can be effective in keeping pesticides out of surface water and off dikes and travel lanes.

## **WEED MANAGEMENT**

Weeds in cranberry beds need to be managed. Effective weed control usually requires the integrated use of chemical and cultural strategies.

### **Scout for weeds.**

Weeds must be identified correctly in order to choose effective control measures. Several references listed at the end of these GAAMPs may be useful in identifying common weed species. In scouting, note the species, infestation severity, and location for future management decisions.

### **Use cultural practices where possible.**

Sanding and hand weeding can be effective weed management practices, especially in young plantings. Weed competition can be reduced by maintaining a low soil pH and encouraging healthy, vigorous vine growth that competes with weeds.

**Use herbicides judiciously and always according to label instructions.** Refer to university recommendations for specific suggestions on herbicide use. Always read and follow label instructions and use the lowest effective rates. Consider bed conditions such as soil composition, weed pressure and species, and drainage in choosing herbicides and rates. Spot treat if possible. Use markers or dyes to double check where you have already applied herbicides. Apply herbicides when vines and beds are dry. Splitting applications of granular herbicides may result in better control and minimize off-site movement.

Herbicide application equipment should be calibrated annually or each time a new material is applied. Check for changes in output due to equipment wear. Ground equipment is the preferred method of granular application, providing uniform coverage and minimal off-target exposure. Understand the leaching potential of each herbicide.

### **Prevent weeds from establishing in beds.**

Start with a clean, weed free bed. Control weeds when they first appear and before they spread. For example, hand wipe or pull brambles, tree seedlings, and dodder. Mow dikes and other adjacent areas to prevent weeds and weed seeds from moving into the bed.

## **INSECT MANAGEMENT**

Various insect pests may infest cranberry beds and require chemical and cultural control practices in order to avoid crop losses.

**Avoid resistance.**

Repeated use of the same insecticide can rapidly select for resistance in certain insects and should be avoided by rotating insecticides used, integrating biological and cultural controls into management programs, and reducing insecticidal inputs to a minimum. Spot treat whenever possible.

**Predict insect infestations to increase scouting efficiency.**

Heat unit accumulation models, migration prediction systems, pheromone and light trapping networks, and other predictive technologies should be used to maximize scouting efficiency, optimize timing of applications and improve pesticide decisions made by growers.

**Protect natural controls.**

Natural predators and parasites play an important role in regulating pest insects. Their role should be enhanced wherever possible by minimizing exposure of beneficial insects to disruptive insecticidal treatments. Beneficial insect populations can be encouraged by conservation and reduced reliance on chemical control practices.

**Adopt biological controls that are effective alternatives to insecticides.**

In cases where biological controls play a major role in regulation of pests in natural systems, such controls should be utilized. When natural controls are present, these should be encouraged and protected to achieve maximum potential. In the absence of natural controls, parasites or predators may sometimes be introduced and successfully established.

**Consider the environmental risk when selecting insecticides.**

When insecticide applications are needed, select products that will provide control and minimize the potential for adverse environmental effects. Factors such as risk to non-target organisms, toxicity, persistence and potential for contamination of ground and surface water should be considered. If the potential exists for adverse aquatic effects, consider less toxic compounds.

**DISEASE MANAGEMENT**

Cranberry diseases can be best managed by integrating cultural and chemical control practices. The susceptibility of cranberry vines to disease is often associated with the overall plant health and vigor, as well as environmental and cultural conditions. The strategies and practices below may help increase disease resistance in the plant and make conditions in the bed less favorable for disease development. Optimum integration of several of these practices, where appropriate, will help manage diseases with minimal chemical input and environmental impact in an economically feasible and profitable way.

**Growers should be familiar with disease symptoms and pathogen biology.** Refer to references in Appendix I for information on cranberry disease diagnosis and life cycles. Beds should be scouted regularly to determine disease presence and severity. Make sure the disease is correctly diagnosed before deciding on control measures.

### **Optimize nutrient practices to increase disease resistance in plants.**

Plants that are stressed by inadequate nutrition may be more susceptible to some diseases. Also, excessive nitrogen can result in rank vine growth that is susceptible to pathogen attack. Overgrowth often results in increased humidity and extended vine wetness, which encourages pathogen activity.

### **Adopt cultural disease control practices.**

Cultural practices aimed at removing or disrupting pathogens should be employed when feasible. The practice of sanding buries pathogen infested duff and proper disposal of trash piles following harvest removes inoculum. In some regions, spring floods can effectively disrupt pathogen activity. New beds should be planted with vines from healthy beds or plug plants, using disease tolerant varieties where practical. Reduce soil, water, and plant material movement from diseased beds to non-infested beds in order to limit the spread of pathogens.

Plants stressed by too little water, over watering, and/or poor drainage may be more susceptible to pathogen attack and disease development. Practices that improve drainage where needed and minimize the time during the growing season when plants are wet, should be considered. Optimizing irrigation system uniformity will improve drought management, reduce freeze damage due to inadequate frost protection, and improve disease control where chemigation is practiced.

### **Optimize uniformity of fungicide applications.**

The degree of disease management with fungicides is highly dependent on uniform application coverage. Enhance disease management by making cost effective improvements to application systems where needed, to optimize uniformity of coverage across the bed and on the target plant parts. For each chemical application systems used to apply fungicides, determine and use the optimum amount of water, pressure, injection timing, etc., needed to obtain desired product application.

### **Optimize number and timing of fungicide applications.**

For most fungal diseases in cranberries, control is best or only obtained by preventing initial attack by the pathogen. Understand life cycles and the influences of weather, and apply protective fungicides only during infection periods. Complete control is not always needed or cost effective, so only make applications when the fungicide provides substantial economic benefit.

**Choose fungicide and formulation best suited to the current target problem.** A steady increase or a noticeable change in disease problems over a few years may indicate a need to change fungicides or rates to better manage fungal populations. Pathogen populations and activity change from year to year for many different reasons, so fungicides may lose effectiveness. Choose the fungicide that will provide adequate control but is also the most cost effective and environmentally compatible. Choose formulations best suited for your application system. Use less persistent, but effective, fungicides late in the

growing season to reduce fungicide residues on fruit. Use the lowest effective fungicide rate.

## **WILDLIFE MANAGEMENT**

Gates and fencing may be needed to control access to cranberry operations and reduce deer damage and, in some cases, vandalism and theft by humans. Muskrats and other burrowing animals need to be monitored and controlled, since they damage dikes and roads. Contact the Michigan Department of Natural Resources (DNR) Wildlife Division for regulations regarding trapping of nuisance animals. Noisemakers, projectiles and other scare devices may be used to minimize damage from all forms of wildlife, as warranted.

## **POLLINATION**

Cranberries require bees for pollination. During the bloom period (mid-June to mid-July), honey bee hives are placed in the production area. One or more hives should be used per acre of cranberries. Insecticides that may harm bees should not be applied during bloom. Bumble bees may also be used for pollination.

## **PRUNING**

Vines should be mechanically pruned periodically to remove excessive growth and encourage upright production. Vines removed during pruning may be sold or used to establish new beds or renovate less productive beds.

## **HARVESTING**

Cranberries should be harvested when they have met the proper maturity indices (primarily color). Harvest will be from late September through October.

### **Flood harvest.**

Berries to be sold for processing are generally harvested by flooding the beds and mechanically removing the berries. The berries float and are corralled to one side of the bed and removed by elevators or suction pumps. When flooding for harvest, flood as quickly as possible without causing bed erosion. Harvesters should contain food grade hydraulic oil and each harvester must have an oil containment kit and the operator instructed on how to properly use it. Flood water should be pumped or drained slowly after harvest is complete. Trash collected from beds at harvest should be removed from the planting area to reduce disease inoculum.

### **Dry harvest.**

Berries sold for fresh consumption are generally dry harvested. Typically, berries are mechanically removed from the plants, placed in bins and removed from the bed for cleaning and storage. Dry harvested beds may be flooded after the berries are removed so the trash can be floated off. This sanitary practice removes diseased fruit and vegetation, and reduces the disease pressure the following season. All flood water should be released slowly to minimize erosion.

## SANDING

### **Cranberry beds should be sanded every two to five years.**

Sanding encourages growth and suppresses some insect pests and diseases. Sanding on top of the ice is preferred to applying sand in water since ice sanding usually provides a more uniform application. Ice sanding may also have less environmental impact because the water is usually held for sufficient time to allow silt-sized particles to settle out before water is discharged. Always release flood waters slowly.

## NEIGHBOR TO NEIGHBOR RELATIONS

U.S. Census data indicates people are leaving urban population centers for suburban and rural areas. Some people move to rural areas with certain expectations that conflict with agricultural practices. Several management practices listed here can be helpful in maintaining good relations with your neighbors.

**Keep your cranberry farm and adjoining property clean and free of debris.** A clean and well managed cranberry operation demonstrates pride of ownership and portrays a high level of professionalism to outsiders, whether it be residential neighbors or regulatory agency personnel. If stockpiles of pipe, culverts, and equipment parts must be maintained, try to keep material orderly and not in view.

### **Communication is the key to good neighbor relations.**

Effective communication with neighbors helps prevent and resolve problems. Inform neighbors about all aspects of cranberry production. Consider hosting tours around a social event or to observe harvest. This gives you the opportunity to explain cranberry growing firsthand. Once your neighbors have a better understanding of what you do, they may be more comfortable with your activities. It also gives you the opportunity to hear their concerns and develop positive relationships with them.

Explain to neighbors the importance of safe and ecologically-sound crop management practices, including IPM, pesticide use, and the importance of adhering to pesticide notices and sign posting. Be selective in crop management practices and evaluate the human and environmental risks associated with their use.

Be sensitive to concerns of neighbors. Be aware there are strong odors associated with certain pesticides. Post your property with appropriate signs prior to pesticide applications. Consider notifying neighbors before pesticide applications.

Much of the information in this document was derived from the Wisconsin State Cranberry Growers' Association, "Cranberry Grower Resource Notebook" of March, 1995, and "Standard Agricultural Practices for Cranberry Production in Wisconsin" of February, 1992.

## APPENDICES

### APPENDIX I. REFERECNES

#### GENERAL CULTURE

- *Best Management Practices Guide for Massachusetts Cranberry Production Bulletin 445*. University of Massachusetts.
- *Cranberry Production in Wisconsin*. University of Wisconsin.
- *Cranberry Agriculture in Maine Grower's Guide*. Maine Dept. of Ag., Food & Rural Resources, Division of Production Development, State House Station 2.
- *Cranberry Grower Resource Notebook*. 1995. Wisconsin State Cranberry Growers Association.
- *Cranberry IPM Notebook*. University of Massachusetts.
- *Cranberry Production Guide, SP-127*. University of Massachusetts.
- *Cranberry Production in the Pacific Northwest*. Washington State University. PNW-27.
- *Michigan Fruit Management Guide*. Michigan State University Extension Bulletin No. 154.

#### PEST AND DISEASE MANAGEMENT

- A field identification guide: Insect pests. University of Massachusetts.
- *Black Rot of Cranberry*. University of Wisconsin A3197.
- *Botryosphaeria Fruit Rot & Leaf Drop*. University of Wisconsin A3351.
- *Compendium of Blueberry and Cranberry Diseases*. The American Phytopathological Society. (1995).
- *Cranberry Fruit Rot Diseases in Wisconsin. A3745. University of Wisconsin (2001)*.
- *Cranberry Insects of the Northeast*. University of Massachusetts.
- *Cranberry Insect, Disease & Weed Control Program*. Washington State University Bulletin EB845.
- *Cranberry Pest Management in Wisconsin*. University of Wisconsin A3276.
- *Cranberry Chart Book and Management Guide for Massachusetts*. University of Massachusetts. (Updated annually).
- *Cranberry Stem Gall*. A3795. University of Wisconsin (2004).
- *Early Rot (Scald) of Cranberry & Blast of Blossoms & Young Fruit*. University of Wisconsin A3352.
- *Fungal Leaf Spot Diseases of Cranberry in Wisconsin*. A3711. University of Wisconsin (1999).
- *Gibbera Leaf Spot & Berry Speckle of Cranberry*. University of Wisconsin A3193.
- *Hard Rot & Tip Blight of Cranberry*. University of Wisconsin A3194.
- *Insect Pests of Massachusetts Cranberry Bogs, A Field Identification Guide*, University of Massachusetts.
- *Major Cranberry Insect Pests IPM Fact Sheet*. University of Massachusetts.
- *Red Leaf Spot*. University of Wisconsin A3343.
- *The Blackheaded Fireworm IPM Fact Sheet*. University of Massachusetts.

- *The Cranberry Fruit Worm IPM Fact Sheet*. University of Massachusetts.
- *The Cranberry Girdler*. University of Wisconsin A3188.
- *The Cranberry Weevil IPM Fact Sheet*. University of Massachusetts.
- *The Southern Red Mite IPM Fact Sheet*. University of Massachusetts.
- *Viscid Rot & Upright Dieback of Cranberry*. University of Wisconsin A3195.
- *Yellow Rot of Cranberry*. University of Wisconsin A3350.

## **WATER AND NUTRIENT MANAGEMENT**

- *Cranberry Tissue Testing for Producing Beds in North America*. EM-8610. Oregon State University.
- *Fertilizer Guide, South Coastal Oregon Cranberries*. Oregon State University FG75
- *Fertilizer Guide, Irrigation Water Quality*. Oregon State University. FG76
- *Nitrogen in Bearing Cranberries in North America*. Oregon State University
- *Phosphorus for Bearing Cranberries in North America*. University of Wisconsin.
- *Sprinkler Irrigation Application Rates & Depths*. Washington State University Bulletin EB1305.

## **WEED MANAGEMENT**

- *Aquatic Vegetation Management & Control*. Washington State University PNW224.
- *Calibrating & Using a Backpack Sprayer*. Washington State University PNW320.
- *Control of Aster & Birdsfoot Trefoil in Cranberries with Napropamide*. Washington State University.
- *Cranberry Pest Control Weed Identification Series*. University of Wisconsin.
- *Cranberry Weed Control in Wisconsin*. University of Wisconsin A2226.
- *Field Guide to Common Weeds in Southeastern MA*. University of Massachusetts.

## **PESTICIDE USE AND REGULATIONS**

- *Chemical Applications in Agriculture, Methods and Equipment for Field Sprayers*. Michigan State University NCR 520.
- *FARM\*A\*SYST for Michigan Producers*. FAS-107. Michigan State University (2011)
- *SARA Title III, The Farmer's Responsibility Under the Emergency Planning and Community Right-To-Know Law*. Michigan State University E-2175.
- *Using Chemigation Safely and Effectively*. Michigan State University E-2099.

## **MISCELLANEOUS**

- *Conservation Practice Standards and Specifications*. USDA Natural Resources Conservation Service Technical Guide (available through local NRCS offices).
- *Right-To-Farm Generally Accepted Agricultural and Management Practices for Irrigation Water Use*. Michigan Department of Agriculture & Rural Development,

Right to Farm Program

- *Right-To-Farm Generally Accepted Agricultural and Management Practices for Nutrient Utilization*. Michigan Department of Agriculture & Rural Development, Right to Farm Program.
- *Right-To-Farm Generally Accepted Agricultural and Management Practices for Pesticide Utilization and Pest Control*. Michigan Department of Agriculture & Rural Development, Right to Farm Program.
- *Frost Protection Guide for Massachusetts Cranberries*. University of Massachusetts.

## TO ORDER REFERENCES

**Michigan Department of Agriculture & Rural Development, Right to Farm Program.**

P.O. Box 30017, Lansing, Michigan 48909

**Michigan State University.** MSU Bulletin Office, 117 Central Services, MSU, East Lansing, MI 48824-1001 Phone: 517-353-6740.

[http://www.msue.msu.edu/portal/default.cfm?pageset\\_id=25744&page\\_id=25794&msue\\_portal\\_id=25643](http://www.msue.msu.edu/portal/default.cfm?pageset_id=25744&page_id=25794&msue_portal_id=25643)

**Oregon State University.** Agriculture Communications, Admin. Services A422, Corvallis, OR 97331. <http://extension.oregonstate.edu/catalog/>

**University of Massachusetts.** Cranberry Experiment Station, Glen Charlie Road, P.O. Box 569, East Wareham, MA 02538.

<http://www.umass.edu/cranberry/services/publications.shtml>

**University of Wisconsin.** Cooperative Extension Service, 630 Linden, Madison, WI 53706. <http://learningstore.uwex.edu/>

**Washington State University.** Long Beach Research & Extension Unit, Route 1, Box 570, Long Beach, WA 98631. <http://pubs.wsu.edu/cgi-bin/pubs/>



## **APPENDIX II. AGENCIES, PERMITS AND REGULATORY PROGRAMS**

### **AGENCIES**

Prospective cranberry growers should have a general knowledge of the programs and responsibilities of federal, state, and local agencies and their regulatory programs that may be involved in cranberry production and harvest activities. Prior to establishing a cranberry production site, producers should consult with the EGLE Water Resources Division (WRD), and all other appropriate state and federal agencies to identify potential permit requirements. All required permits need to be obtained prior to initiation of any regulated activities, such as construction of cranberry beds and associated facilities.

### **STATE AGENCIES AND REGULATORY PROGRAMS**

**MICHIGAN DEPARTMENT OF AGRICULTURE & RURAL DEVELOPMENT (MDARD)** administers the Soil Survey Act, Conservation Districts Act, Michigan Right to Farm Act, Michigan Drain Code, Fertilizer and Pesticide Control Act, and others, and is responsible for assembling agricultural statistics and promoting agricultural development in Michigan. The MDARD is involved in a joint effort with the EGLE and the Michigan Cranberry Council to ensure consistency regarding the administration of the Memorandum of Agreement (MOA) on Cranberry Production and Environmental Protection between the two departments. Landowners may contact the Environmental Stewardship Division, MDARD for information on development and operation of cranberry production facilities. One function or purpose of the MOA is to ensure that staff of both agencies receive clear guidance on how to make decisions relative to cranberry production in Michigan.

**MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY (EGLE)** administers the state's regulatory programs involving wetlands, lakes, streams and similar water bodies and floodplains. The key EGLE regulatory and permitting programs that may be involved with the production of cranberries are commonly referred to as Part 303 Wetlands Protection Part 301, Inland Lakes and Streams, and the Floodplain Regulatory Authority found in Part 31, Water Resources of the Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended. EGLE also administers Section 404 of the Federal Clean Water Act in the non-coastal areas of Michigan through a Memorandum of Agreement with the U.S. EPA. Permit applications for work in regulated wetlands, lakes, streams or floodplains are submitted to EGLE's WRD.

**STATE WETLAND PERMIT PROGRAM.** The construction of commercial cranberry farm operations in Michigan will typically include activities that involve regulatory programs administered by the WRD. Part 303 requires that an individual obtain a state permit for work in any regulated wetland. Wetlands are defined as "land characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation or aquatic life and is commonly referred to as a bog, swamp, or marsh, and which is any of the following: - Contiguous to the Great Lakes or Lake St. Clair, an inland lake or pond, or a river or stream;

- Not contiguous to the Great Lakes, an inland lake or pond, or a river or stream; and more than 5 acres in size;

- Not contiguous to the Great Lakes, an inland lake or pond, or a river or stream; and 5 acres or less in size if EGLE determines that protection of the area is essential to the preservation of the natural resources of the state, from pollution, impairment, or destruction and EGLE has so notified the owner.

The term, "Contiguous" is further defined within the Part 303 Administrative Rules, as meaning any of the following:

(i) A permanent surface water connection or other direct physical contact with an inland lake or pond, a river or stream, one of the Great Lakes, or Lake St. Clair.

(ii) A seasonal or intermittent direct surface water connection to an inland lake or pond, a river or stream, one of the Great Lakes, or Lake St. Clair.

(iii) A wetland is partially or entirely located within 500 feet of the ordinary high watermark of an inland lake or pond or a river or stream or is within 1,000 feet of the ordinary high watermark of one of the Great Lakes or Lake St. Clair, unless it is determined by the department, pursuant to R

281.924(5), that there is no surface water or groundwater connection to these waters. (iv) Two or more areas of wetland separated only by barriers, such as, dikes, roads, berms, or other similar features, but with any of the wetland areas contiguous under the criteria described in paragraph (i), (ii), or (iii) of this subdivision.

The connecting waters of the Great Lakes, including the St. Marys, St. Clair, and Detroit rivers, shall be considered part of the Great Lakes for purposes of this definition.

A state wetlands permit is required for any grading, filling, drainage, construction of dikes, ditches, or reservoirs, or placement of other structures within a regulated wetland. There is no fee for a pre-application assessment for cranberry production activities.

For a fee, EGLE has available a Wetland Identification Program (WIP) whereby a person can request EGLE to assess whether a parcel of property or portion of a parcel is wetlands and regulated under Part 303. The findings of EGLE under the WIP are guaranteed for a 3-year period. Application forms to request a WIP assessment can be obtained at:

[https://www.michigan.gov/egle/0,9429,7-135-3313\\_3687-10193--,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3687-10193--,00.html)

County wetland inventory maps, which combine information from the Michigan Resources Inventory (MIRIS); United States Fish and Wildlife Service, National Wetland Inventory (NWI) maps; and the United States Department of Agriculture, Natural Resources Conservation Service, soil surveys, are available at the County Register of Deeds, the County Clerks office, or the County Extension Services offices. In addition, county wetland

inventory maps and information regarding county wetland inventory maps are available at the following EGLE website:

[https://www.michigan.gov/egle/0,9429,7-135-3313\\_3687-11178--,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3687-11178--,00.html) The National Wetland Inventory maps for Michigan are available at the U.S. Fish and Wildlife Service offices with county soil surveys available at USDA Natural Resources Conservation Service county offices. Although these sources may be helpful initially in identifying potential wetlands areas, EGLE has final authority for identifying regulated wetland areas based upon site visits.

**OTHER STATE REGULATORY PROGRAMS.** In addition to a wetland permit, Part 301 - Inland Lakes and Streams requires that an individual obtain a permit for construction of upland reservoirs, construction of stream crossings, construction activities in a water body to facilitate water withdrawal, placement of water control structures or for alteration of lakes and streams, as defined by the statute.

An individual planning a cranberry farm operation should be aware that in addition to construction permits that may be required under Part 301 and/or 303, additional construction permits may also be required from the WRD under the Floodplain Regulatory Authority (Part 31) and the provisions of Part 315, Dam Safety. In applying for state permits, the WRD requires the submittal of a single application form for permitting programs, administered by the WRD. A separate and different permit application form is required to be submitted to Wildlife Division, DNR for impacts to a listed, threatened, or endangered species. In addition, depending on the operation of the cranberry facility, there may be water reporting requirements for withdrawal of water under provisions of the water use reporting authority of Part 327 NREPA.

Part 31, Water Resources protection of NREPA, Section 3109, states that: "A person shall not directly OR INDIRECTLY discharge into the waters of the state any substance that is OR MAY BECOME injurious to any of the following: (a) to the public health, safety, or welfare. (b) to domestic, commercial, industrial, agricultural, recreational, or other uses that are being made or may be made of such waters. (c) to the value or utility of riparian lands. (d) to livestock, wild animals, birds, fish, aquatic life, or plants or to their growth or propagation thereof be prevented or injuriously affected; or whereby (e) to the value of fish and game. (Emphasis added)

Part 31 defines "Waters of the state" as groundwaters, lakes, rivers, and streams and all other watercourses and waters within the jurisdiction of the state and also the Great Lakes bordering the state. Additional state permits may be required for discharges to surface waters of the state. The property owner and/or producer should check with the WRD to identify potential permit requirements for discharges to waters of the state.

**LOCAL APPROVAL.** If a project involves a change to or use of a designated county drain, the producer should check for necessary approvals from the county drain office.

**THE MICHIGAN RIGHT TO FARM ACT**, PA 93 of 1981, as amended, cites the following MCL 286.473, Sec. 3 (3): "A farm or farm operation that is in conformance with subsection (1) shall not be found to be a public or private nuisance as a result of any of the following:

- (a) A change in ownership or size.
- (b) Temporary cessation or interruption of farming.
- (c) Enrollment in governmental programs.
- (d) Adoption of new technology.
- (e) A change in type of farm product being produced."

## **FEDERAL AGENCIES AND REGULATORY PROGRAMS**

**UNITED STATES ARMY CORPS OF ENGINEERS (COE)** is the permitting authority for Section 404 of the Clean Water Act, except as modified by the Michigan's administration of the Federal Section 404 Program.

**ENVIRONMENTAL PROTECTION AGENCY (EPA)** has veto authority over the COE decisions and is the lead agency for the Clean Water Act.

**FEDERAL SECTION 404 PERMIT PROGRAM.** In addition to the state permit requirements under Michigan's regulatory programs, Section 404 of the Federal Clean Water Act regulates placement of fill and dredge materials in waters of the United States, including wetlands. In most states, a permit must be obtained from the COE for dredge and fill activities that would result in the placement or redistribution of material in wetlands and waters of the United States. In 1984, the U.S. Environmental Protection Agency (EPA) authorized Michigan to administer the Federal Section 404 program in most areas of Michigan. In those areas where Michigan has Section 404 authority, a state issued inland lakes and streams or wetland permit also authorizes activity under the Federal Clean Water Act. Michigan's Section 404 program is required to meet Federal Clean Water Act standards as long as Michigan administers the federal permit program. Action taken under the state-assumed Section 404 program is a state action taken under state law, not a federal action. EGLE may not issue a permit that carries Section 404 authority if the EPA objects to the project.

The COE has retained Section 404 jurisdiction over traditionally navigable waters including the Great Lakes, connecting channels, and other waters connected to the Great Lakes where navigational concerns are maintained. The COE also retained Section 404 jurisdiction in wetlands directly adjacent to these waters. Therefore, in Great Lakes coastal areas and adjacent wetlands, both state and federal permits are required for dredge and fill activities within wetlands and surface waters. To avoid confusion to the permit applicant, the Detroit District COE and EGLE provide a joint application process that utilizes the same application form. The application is submitted to EGLE, which forwards copies of the application to the COE if there is separate federal jurisdiction. Application forms and additional information on materials to submit with the application for a proposed cranberry farm operation can be obtained from the WRD, EGLE at:

[https://www.michigan.gov/egle/0,9429,7-135-3313\\_3687-10813--,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3687-10813--,00.html)

**U.S. DEPARTMENT OF INTERIOR, FISH AND WILDLIFE SERVICE (FWS)** has an advisory role in the permitting process and mitigation decisions.

**U.S. DEPARTMENT OF AGRICULTURE (USDA):** Three USDA agencies may be helpful with cranberry production issues. The Natural Resources Conservation Service (NRCS) is the lead agency for soil surveys and soil information, such as prime, unique and important agricultural land. NRCS also provides highly erodible land and wetland determinations for purposes of USDA program eligibility. NRCS also provides direct technical assistance to landowners to develop and implement their conservation plans. The Farm Service Agency (FSA) is responsible for providing, filing, and maintaining the official copy of the land determinations provided by the NRCS. FSA uses this and other information to identify farms and land areas suitable for different uses. FSA also provides loans and grants as per farm bills and farm programs. Rural Development (RD) is responsible for providing financial assistance to rural businesses and both financial and technical assistance to cooperatives. RD may consider the market value of brand names, patents, or trademarks.

## **THE FEDERAL FARM BILL**

The 1935 Farm Bill is an Act to provide protection of land resources from soil erosion and sedimentation, and also protect water resources. In 1977, USDA's OGC reinterpreted the 1940 Presidential reorganization, permitting the Soil Conservation Service, presently the NRCS, to work on tribal lands situated within boundaries of a conservation district. In 1980, the USDA extended conservation assistance to Indians on tribal lands. The 1985 Farm Bill (Food Security Act of 1985), as amended by the 1990 Farm Bill (Food, Agriculture, Conservation and Trade Act of 1990), the 1996 Farm Bill (Federal Agriculture Improvement and Reform Act of 1996), the 2002 Farm Bill (Farm Security and Rural Investment Act of 2002) and the 2008 Farm Bill (Food, Conservation and Energy Act of 2008), addresses producer eligibility for USDA programs such as the Conservation Security Program (CSP).

Proposed cranberry production on existing wetlands will be exempted for USDA program benefit eligibility as a Manipulated Wetland (Wx). This exemption will require that a Wx plan be developed and filed with the Natural Resources Conservation Service (NRCS). An application for an exemption must be submitted to and approved by the local NRCS office before conversion activities begin. The area will then be labeled Wx and recorded on the USDA Farm Services Agency aerial photography.

Cranberry production is allowed on prior converted wetlands as defined in USDA Farm Bill legislation. Prior converted croplands (PC) are wetlands that were drained, dredged, filled, leveled, or otherwise manipulated, including the removal of woody vegetation, before December 23, 1985, for the purpose of, or to have the effect of, making the production of an agricultural commodity possible, and an agricultural commodity was planted or produced at least once prior to December 23, 1985. Prior converted croplands converted before December 23, 1985, are exempt from Farm Bill Swampbuster provisions and may not be considered to be waters of the United States subject to regulatory jurisdiction under

Section 404 of the Clean Water Act. Certified wetland determinations made by NRCS and accepted by the Corp of Engineers for Clean Water Act purposes will be considered valid by the Corps for five years.

## **APPENDIX III. CRANBERRY SITE REQUIREMENTS**

The three basic considerations in choosing a suitable cranberry site are climate, soils, and water. These items will be addressed separately, although they are related to some degree. The climatic considerations can be discussed on a regional basis. However, the suitability of a specific location is based primarily on the soil and water characteristics. Since these characteristics are very site specific, we will discuss soil and water requirements in a general sense.

### **Climate**

The American cranberry is native to Maine and Nova Scotia, west to Minnesota, and as far south as Virginia and Tennessee. This represents a wide range of climatic conditions. Commercial production areas also vary enormously from the moderated marine climates of western Oregon and Washington to the harsh continental climate of central and northern Wisconsin. The suitability of Michigan regions for cranberry production can be assessed by comparing the climate to perhaps the harshest production area, Wisconsin.

There is little doubt that most of Michigan offers suitable climate. Cranberries have been successfully grown experimentally and commercially in the severe conditions of the U.P. In most respects, the climate in southern Michigan is less challenging.

### **Minimum Winter Temperatures**

Cranberry leaves and buds are subject to cold injury during the winter. Generally, midwinter temperatures below 10°F will injure plants and higher temperatures may cause injury if accompanied by wind. Since these temperatures are common in Wisconsin, Massachusetts and New Jersey, bogs in these states are typically covered during the winter with a protective layer of ice.

The USDA Hardiness Zones reflect primarily average minimum winter temperatures. Cranberry production regions range from Zone 3 (northern Wisconsin) to Zone 9 (Pacific Northwest). Michigan falls between these extremes (Zone 4 in the Western U.P. to Zone 6 in Southwest Lower Michigan).

The fact that Michigan winters are more moderate than those in Wisconsin, presents some questions about winter protection. Wisconsin growers are able to maintain ice on beds throughout the winter. Southern Michigan frequently experiences "winter thaws", when ice cover would likely be lost. Beds would periodically need to be re-flooded to form new ice. Southwest Michigan also receives more snow than production areas of Wisconsin, which could impede ice formation and cause oxygen shortages beneath the ice. Growers in this area may need to develop winter protection strategies more similar to those in Massachusetts or New Jersey than Wisconsin.

## **Soils**

Most traditional cranberry sites are on two general soil types - acid organic soils or poorly drained mineral soils. The properties of these soils include a pH of 3.5 to 5.0 in the surface and a water table at six to 12 inches during the growing season. These traditional sites are easily converted and have adequate water. The disadvantage of these soils is that they are wetlands with surface water systems, and their development requires permitting. The following characteristics of traditional cranberry sites are fundamental plant requirements:

1. Surface Texture - usually a peat or muck organic soil surface or sandy mineral soil.
2. Depth - greater than 40 inches to bedrock.
3. Slope - zero to two percent.
4. Water Table - ranges from 1.5 to 3.0 feet during the growing season (generally poorly drained or very poorly drained soils).
5. Reaction - surface horizon pH of 4.0 to 5.5.

Some cranberry operations have recently been developed by modifying nontraditional sites so that the basic requirements above are met. This approach has been taken to avoid wetland and water use regulations, and because these sites are readily available in some areas. Other non-traditional soils have been proposed for cranberries, but they have not been tested. It is important to recognize that although several basic non-traditional sites have been proposed, the basic requirements listed above need to be met in order to successfully produce cranberries. This may require significant additional development costs. We have categorized non-traditional sites into two alternatives:

### **Somewhat poorly drained and moderately well drained sands with regional water tables.**

These soils have sandy surfaces with varying amounts of organic matter, pH of 4.0 to 5.5 in the surface, and water tables one to three feet (somewhat poorly drained) to 2.5 to 6.0 feet (moderately well drained) during the growing season.

An advantage of these soils is that they are not typically classified as wetlands. The major disadvantage is their high permeability, which could lead to problems maintaining desired water table levels or with movement of chemicals into groundwater. Several existing cranberry operations in Wisconsin have expanded into these upland sites.

## **Water**

Cranberry production requires large amounts of water. Water is needed to protect plants against frost damage in the spring and fall. Traditionally, plantings were flooded before predicted frosts. Most growers now frost protect by sprinkling water on plants, since this requires much less water than flooding. Irrigation is also needed throughout the growing season to meet the water demands of the plants. Cranberry plants are shallow rooted and desiccate easily. Sprinkler systems may also be used to cool the plants during hot summer



weather. Beds that are wet harvested are flooded in October with one foot of water to remove the berries, and a second one foot flood may be used to remove trash from the bed. Beds are again flooded with one foot of water in the winter to protect plants from winter weather.

Actual water requirements vary with location and management practices, and are often expressed in acre-feet. One acre-foot is the water needed to cover an acre to a depth of one foot (about 330,000 gallons). Water use estimates range from 5.1 acre-feet in Maine, to 6 acre-feet in Wisconsin, and 7.8 acre-feet in Massachusetts. However, if beds and reservoirs are designed to recycle water, actual water use may be as little as 1.5 acre feet. This system would require impervious soil substrata to prevent deep seepage losses of water, and a topographical layout that allows cycling of water from one bed to another and from beds to reservoirs.

Seasonal Water Need Estimates (acre-feet) for Cranberries			
Time	Use	Maine <sup>1</sup>	Massachusetts <sup>2</sup>
April – May	Spring frost protection	0.5	1.7
June - August	Irrigation, cooling, chemigation	1.2	1.1
September - October	Fall frost protection	0.4	
October	Harvest flood	1.0	2.0
October - November	De-trash flood	1.0	
December	Winter flood	1.0	2.0
Winter	2 <sup>nd</sup> Winter flood		1.0
	<b>Annual Total</b>	<b>5.1</b>	<b>7.8</b>
<sup>1</sup> Cranberry Agriculture in Maine Grower's Guide. Maine Cranberry Development Comm., 1993 <sup>2</sup> Massachusetts Cranberry Production. Univ. Mass. Coop. Ext. Serv., 1993			

Acquiring and discharging water are prime concerns in selecting cranberry sites. Cranberry operations typically use surface water from existing sources (lakes, streams, drainage ditches) or from reservoirs. Access to water from lakes or streams may require permits. Construction of reservoirs of sufficient size may also require permits if they are located on existing wetlands. Wells typically do not have the capacity to supply the large volumes of water required at specific times. Well water may also be difficult to use for winter floods because it requires more time to cool and freeze. Wells can be used to replenish smaller reservoirs.

In addition, relatively large volumes of water may be discharged to drainage ditches, streams or lakes. Discharge may also require permits, since the temperature and chemistry of receiving waters can be affected.

### **Agricultural Water Use Reporting**

Water use reporting is one of the tools that Michigan uses to catalogue water use for the protection of the state's water resources from diversions to other regions of the country, and to improve Michigan's stewardship of this precious resource. The original legislation, now Part 327 of NREPA was signed into law in 2003. Michigan law requires that all new or increased large quantity water withdrawals (groundwater or surface water) use the Michigan Water Withdrawal Assessment Tool, to register an acceptable water withdrawal, or seek a site specific review from EGLE to determine whether a proposed large quantity withdrawal will cause an "adverse resource impact". A large quantity withdrawal (LQW) is defined as one with a pump capacity that exceeds 100,000 gallons per day or greater from all sources (excluding residential use) under common ownership or farm as defined by the Michigan Right to Farm Act. Once a large quantity water withdrawal is registered with the state, the operator is required to continue to report their water use on a yearly basis to the MDARD. For access to the Michigan Water Withdrawal Assessment Tool and information on water use reporting or registering a new withdrawal go to:

[https://www.michigan.gov/egle/0,9429,7-135-3313\\_3684\\_45331---,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3684_45331---,00.html)

### **Spring and Autumn Frost Potential**

The average time between the last killing spring frost and the first killing fall frost defines the growing season. In natural environments, cranberries need about 150 frost free days to mature the berry crop. The growing season in cranberry production areas is longest in Oregon and Washington (280 days) and shortest in Wisconsin (110 days in some northern areas and 160 days in the south). The growing season in Michigan ranges from 100 days in the western U.P. to 170 days in southwest Lower Michigan. Cranberry growers protect against frosts and extend the effective growing season by sprinkle irrigating or flooding. However, production in short season areas will require more frequent frost protection and thus greater management costs.

### **Precipitation/Evapo-transpiration: Irrigation Requirements.**

Irrigation requirements are dependent on the amount of precipitation and evapotranspiration or amount of water lost to the air from leaves and the soil surface. Annual precipitation in major production areas ranges from 30 inches in Wisconsin to 80 inches in parts of Oregon and Washington. Average annual precipitation in Michigan ranges from 28 inches in parts of the U.P. to 36 inches in southern Michigan. Warm-season precipitation (April-September) provides an indication of the need for supplemental irrigation during the growing season. Production areas in Wisconsin receive 20 to 22 inches between April and September, whereas warm-season totals for Michigan range from 16 to 22 inches. The lowest April to September totals in Michigan (16 inches) occur in the eastern U.P. and the extreme northern portion of the Lower Peninsula.

The evapo-transpiration from cranberry bogs in Michigan would likely be similar to bogs in Wisconsin. Air temperatures and relative humidity, which largely control evapo-transpiration, are generally similar in Wisconsin and Michigan. Because water losses through evapo-transpiration and precipitation are similar, irrigation requirements are generally expected to be similar between the two states.

Sprinklers are also used to cool cranberry plants during very warm days. High temperatures or dry winds early in the season may cause new growth to desiccate and "blast", whereas hot weather later in the season may cause scalding of the berries. Temperatures as low as 80°F can injure plants in the normally cool Pacific Northwest, whereas 85°F may cause injury under New Jersey conditions. Plantings in Michigan may require less water for cooling than plantings at similar latitudes in Wisconsin.

### **Heat Units and Growing Degree Days**

Temperatures during the growing season may have affected the growth of cranberry plants and fruit differently. Optimum temperatures appear to be 60 to 80°F. Lower temperatures may limit yields by slowing growth and berry development. Higher temperatures can cause sun burning of berries during the summer, and inhibit color development if occurring during the fall. Growing degree days (GDD) are a measure of the heat accumulation during the season. Production areas in Wisconsin usually accumulate 2500 (north-central areas) to 3000 (central) GDD base 45°F. The U. P. of Michigan typically accumulates 2300-2500 GDD base 45°F, and extreme southern Michigan sees up to 3800 GDD. On average, GDDs in the U.P. are slightly lower than those in even the cooler production areas of Wisconsin, and the GDDs in southern Michigan are comparable to those in southern Wisconsin.

This worksheet addresses questions that should be considered for proposed cranberry sites. Each cranberry operation is unique in regard to the source of water, layout, etc., so only consider those questions that pertain to your operation (i.e., if your cranberry operation has a river as its water source, answer the questions under River/Stream and not those under Groundwater and Lake). Calculations, assumptions and sources of information should be retained.

## **I. DESCRIBE YOUR WATER SOURCE(S)**

### **A. River/Stream**

1. Use gauging data if available; if not available, provide best calculations based on drainage area, land use, etc., or data from a similar stream and watershed located as near as possible to the project site.

Average annual flow in cubic feet per second (cfs)

CFS flow and elevation for 100-year flood event

7Q10 flow (lowest 7-day flow in 10-year period)

7Q2 flow (lowest 7-day flow in a 2-year period)

Quantify the anticipated stream diversion, cfs /day, number of days.

2. Provide a map (to scale, 1"= 1,000') showing that portion of the project area within the 100-year floodplain and/or floodway.
3. Provide a cross-sectional drawing of the stream, upstream and downstream of the operation, showing water level at average annual flow and at 7Q2 and 7Q10.

### **B. Lake/Reservoir**

1. Describe the surface elevation, surface acreage and acre-feet (AF) of storage of the lake/reservoir during average, high water, and drought conditions.
2. Is the lake/reservoir isolated or connected to other lakes and/or river systems? Describe. Provide map as appropriate.

### **C. Watershed Information**

1. Size (acres or square miles).
2. Average slope of watershed.
3. Characterize soils of the watershed (percent peat, percent sand, percent clay, percent impervious surfaces, etc.) using the county soil survey (if none has been prepared for your county, provide best available information).
4. Characterize watershed land use (percent in upland forest, wetland, lakes, cranberry reservoirs, cranberry beds, other agriculture, urban, etc.)
5. If there are existing cranberry reservoir(s) on site, describe the distance from the project area, surface elevation, surface area, and AF of storage capacity during:
  - a. Average conditions.
  - b. High water conditions.
  - c. Drought conditions (e.g. 1976 and 1988).

### **D. Groundwater**

1. Average depth to water table.
2. Describe springs and seeps (e.g. number, location, estimated flow (in gallons per minute [gpm], etc.)
3. Describe the permeability rate of the soil(s) involved at your site (refer to county soil survey information).
4. If reservoirs are to be constructed or enhanced, include the permeability rate of soils in the area. If a county soil survey is not available, take representative core samples to estimate permeability using methods similar to those utilized in soil surveys.

- 5 Identify wetlands that may be drained as a result of groundwater removal.

## II. DESCRIBE HOW YOUR WATER SUPPLY SYSTEM WOULD WORK

- A. What is the total water supply (in AF) combining river/stream, lake/reservoir and/or groundwater sources? What percentage would each contribute to your water supply?
- B. If the proposal is an expansion of an existing cranberry operation, describe how the proposed expansion would tie in.
- C. Identify discharge points on the site plan and for each indicate the frequency, duration, and volume. (If more than one point, give percentages for each):
1. Reservoir(s) - (Give estimated detention time for reservoirs used as temporary detention basins.)
  2. Natural lake.
  3. Stream/river.
  4. Wetland complex.

## III. WATER USE

Precipitation, evapo-transpiration, and runoff amounts vary throughout Michigan. Data for specific locations can be obtained from the State Climatologists Office, Room 417, Natural Science Building, Michigan State University, East Lansing, MI 48824, 517-355-0231. the average annual water use for cranberry production is 6 AF per acre of bed. Average annual precipitation ranges from 28 to 36 inches, and runoff from 6 to 21 inches.

- A. Water requirements of your cranberry operation (acres of beds x 6 AF), both proposed and existing (if applicable)
- B. Estimate, in AF and percentage of total water use, how much water would be reused (i.e., pumped back into reservoir), during what time period.
- C. Estimate how much water would be lost due to seepage.
- D. Estimate AF of water discharged from the cranberry operation (i.e., to river or lake).
- E. Complete a balance sheet of water sources (river, lake, reservoir, groundwater, net precipitation, etc.) and water uses (6 AF per bed, seepage, discharged outside of cranberry operation, etc.) for a one year period assuming average conditions.

## **IV. IMPACT ANALYSIS**

Prior to completing the following elements, the owner and/or operator is required to run the online [MDEQ/EGLE Water Withdrawal Assessment Tool](#) to determine if the withdrawal, as proposed, withdrawal is acceptable or requires a site specific review by EGLE to determine if there is sufficient water available or if the proposed use will result in an adverse resource impact.

### **A. River/Stream Water Source**

1. Provide a water quantity analysis evaluating the in-stream impacts, both upstream and downstream, of withdrawing water for your cranberry operation.
2. Under a worst case situation, such as the drought of 1976 or 1988, what percent of the cfs flow of the river/stream would be diverted to your cranberry operation?

Use cross-sectional drawings similar to those in Part I.A.3. to show downstream water levels under average conditions and at 7Q2 with the proposed project in place.

### **B. Lake/Reservoir Water Source**

1. How much would the surface elevation be lowered during the maximum short-term withdrawal (e.g. putting on the winter flood)?
2. If a reservoir (impoundment) is used, what is the distance and difference in elevation to the nearest occupied buildings located downstream and laterally (adjacent to the reservoir) considering both on your property and neighboring properties?

### **C. Groundwater Water Source**

Describe the effect on the groundwater elevation due to proposed dikes, reservoirs, etc. (e.g. would the proposed reservoir raise the groundwater elevation? If so, how much?)

### **D. Summary**

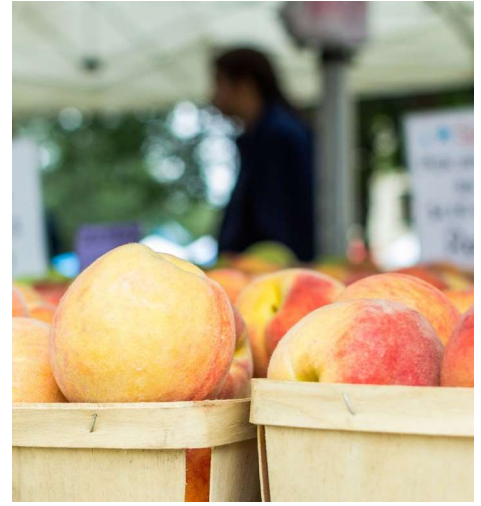
Describe how your water use could affect neighboring property owners (both upstream and downstream), wildlife refuges, recreational areas, public or private water supplies, other cranberry operations, and/or other agricultural users.

## ADVISORY COMMITTEE

Listed below are the annual review committee members for the Generally Accepted Agricultural and Management Practices for Cranberry Production.

Tom Allenson  
U.S. Army Corps of Engineers  
Detroit District  
P.O. Box 1027  
Detroit, MI 48231  
Voice: 313-226-2221  
FAX: 313-226-6763  
[Thomas.E.Allenson@usace.army.mil](mailto:Thomas.E.Allenson@usace.army.mil)

Mike DeGrandchamp  
Michigan Cranberry Council  
15575 77<sup>th</sup> Street  
South Haven, MI 49090  
Voice: 269-637-3915  
FAX: 269-637-2531  
[mike@degranamps.com](mailto:mike@degranamps.com)



# Generally Accepted Agricultural and Management Practices for Farm Markets

---

**June 2020 Draft 2021**

Michigan Commission of Agriculture & Rural  
Development  
PO BO 30017  
Lansing, MI 48909





In the event of an agricultural pollution emergency such as a chemical/fertilizer spill, manure lagoon breach, etc., the Michigan Department of Agriculture & Rural Development and/or Michigan Department of Environment, Great Lakes, and Energy should be contacted at the following emergency telephone numbers:

Michigan Department of Agriculture & Rural Development: 800-405-0101  
Michigan Department of Environment, Great Lakes, and Energy's Pollution  
Emergency Alert System: 800-292-4706

If there is not an emergency, but you have questions on the Michigan Right to Farm Act, or items concerning a farm operation, please contact the:

**Michigan Department of Agriculture & Rural Development**  
**(MDARD) Right to Farm Program (RTF)**  
P.O. Box 30017  
Lansing, Michigan 48909  
517-284-5619  
877-632-1783  
517-335-3329 FAX

## Table of Contents

<b>PREFACE</b>	<b>iii</b>
<b>INTRODUCTION</b>	<b>1</b>
<b>DEFINITIONS</b>	<b>2</b>
<b>PHYSICAL CHARACTERISTICS OF A FARM MARKET</b>	<b>3</b>
Use of space	3
Buildings	3
Parking and Driveways	3
Vehicle Ingress and Egress	3
Signage	3
<b>REFERENCES</b>	<b>4</b>
<b>ADVISORY COMMITTEE</b>	<b>5</b>

## **PREFACE**

The Michigan legislature passed into law the Michigan Right to Farm Act (Act 93 of 1981, as amended) which requires the establishment of Generally Accepted Agricultural and Management Practices (GAAMPs). These practices are written to provide uniform, statewide standards and acceptable management practices based on sound science. These practices can serve producers in the various sectors of the industry to compare or improve their own managerial routines. New scientific discoveries and changing economic conditions may require necessary revision of the practices. The GAAMPs are reviewed annually and revised as considered necessary.

The GAAMPs that have been developed are as follows:

- 1) 1988 Manure Management and Utilization
- 2) 1991 Pesticide Utilization and Pest Control
- 3) 1993 Nutrient Utilization
- 4) 1995 Care of Farm Animals
- 5) 1996 Cranberry Production
- 6) 2000 Site Selection and Odor Control for New and Expanding  
Livestock Facilities
- 7) 2003 Irrigation Water Use
- 8) 2010 Farm Markets

These practices were developed with industry, university, and multi-governmental agency input. As agricultural operations continue to change, new practices may be developed to address the concerns of the neighboring community. Agricultural producers who voluntarily follow these practices are provided protection from public or private nuisance litigation under the Right to Farm Act.

The website for the GAAMPs is <http://www.michigan.gov/righttofarm>.

## **INTRODUCTION**

As farmers look for ways to keep their businesses economically viable, many have chosen to shift their operations from a farmer-to-processor to a direct market business model. This includes selling raw and value-added products directly to the consumer through on-farm establishments, farmers markets, and other agricultural outlets. This allows farms to take advantage of consumer interest in agritourism, the “buy local” movement, and a desire for a connection with farmers and food production. These activities have far-reaching economic impacts. Many regions have capitalized on the growth of farm markets by developing regional farm market and culinary trails, and tourism promotion based on authentic culinary experiences offered by local farm markets. Farm markets provide the opportunity for visitors to meet a farmer, learn about modern agricultural practices, and gain access to fresh, local, nutritious food. Finally, farm markets and the associated farm, help maintain green space adding to the quality of life. Thriving farmland enhances the beauty of communities, retains residents, and attracts visitors. As farm operations engage in direct sales and on-farm activities, conflicts have arisen regarding oversight of these businesses.

Michigan is a Right to Farm (RTF) state and the RTF Act defines a “farm operation” as meaning the operation and management of a farm or a condition or activity that occurs at any time as necessary on a farm in connection with the commercial production, harvesting, and storage of farm products. This definition includes, but is not limited to marketing produce at roadside stands or farm markets. Farm markets offer farm related experiences and farm products through a variety of agritourism activities. The experience in turn promotes sale of more farm products and provides an added income stream to support the farm business, the farm family, and surrounding communities; and keeps farmland in production.

Although the RTF Act includes farm markets in the definition of a farm operation, this definition does not define a farm market or describe specific marketing activities. These GAAMPs for Farm Markets were developed to provide guidance as to what constitutes an on-farm market and farm market activities.

## **DEFINITIONS**

**Affiliated** – “Affiliated” means a farm under the same ownership or control (e.g., leased) as the farm and does not need to be on the same parcel of land.

**Expanding Farm Market** – An addition to an existing farm market that increases the square footage of the farm market.

**Farm** – A “farm” means the land, plants, animals, buildings, structures, including ponds used for agricultural or aquacultural activities, machinery, equipment, and other appurtenances used in the commercial production of farm products.

**Farm Market** – A farm market is a year-round or seasonal location where transactions and marketing activities between farm market operators and customers take place. While the location must take place on property controlled by the affiliated farm, it does not have to be a physical structure such as a building. Fresh products as well as processed products may be sold at the farm market. At least 50 percent% of the products offered must be produced on and by the affiliated farm measured by retail floor space during peak production season, or 50 percent% of the average gross sales for up to the previous ~~5~~ five years or as outlined in a business plan. Processed products will be considered as produced on and by the farm if at least 50 percent% of the product’s primary or namesake ingredient was produced on and by the farm, such as apples used in apple pie, maple sap in maple syrup, strawberries in strawberry jam, etc.

**Farm Product** – A “farm product” means those plants and animals useful to humans produced by agriculture and includes, but is not limited to forages and sod crops, grains and feed crops, field crops, dairy and dairy products, poultry and poultry products, cervidae, livestock (including breeding and grazing), equine, fish and other aquacultural products, bees and bee products, berries, herbs, fruits, vegetables, flowers, seeds, grasses, nursery stock, trees and tree products, mushrooms and other similar products, or any other product which incorporates the use of food, feed, fiber, or fur as determined by the Michigan Commission of Agriculture & Rural Development.

**Marketing** – Promotional and educational activities at the farm market incidental to farm products with the intention of selling more farm products. These activities include, but are not limited to, farm tours (walking or motorized), demonstrations, cooking and other classes utilizing farm products, and farm-to-table dinners.

**Processed** – A farm product or commodity that has been converted into a product for direct sales. Processing may include, but is not limited to, packing, washing, cleaning, grading, sorting, pitting, pressing, fermenting, distilling, packaging, cutting, cooling, storage, canning, drying, freezing, or otherwise preparing the product for sale.

## PHYSICAL CHARACTERISTICS OF A FARM MARKET

### Use of space

A farm market may be a physical structure such as a building or tent, or simply an area where a transaction between a customer and a farmer is made. The farm market must be located on property owned or controlled (e.g., leased) by the producer of the products offered for sale at the market. A new or expanding farm market All retail space, farm market structures, and locations where transactions occur, at a new or expanding farm market, that are greater than 120 square feet must meet a minimum setback of 165 feet from all non-farm residences and all new or expanding farm markets are not authorized under this GAAMP on platted lots within a subdivision created under the Michigan Land Division Act (Act 288 of 1967, MCL 560.101, *et seq.*) or preceding statutes and on condominium units within a condominium (sometimes referred to as “site-condos”) created under the Michigan Condominium Act (Act 59 of 1978, MCL 559.101, *et seq.*); however, farm markets are permitted in such areas if authorized by association rules or pursuant to a local ordinance designed for that purpose, unless prohibited by association rules. A farm market should have a written site plan for potential MDARD review that preempts local government regulations.

### Buildings

If the farm market is housed in a physical structure as defined and regulated by the Stille-Derossett-Hale Single State Construction Code Act (Act 230 of 1972), the structure must comply with the Stille-Derossett-Hale Single State Construction Code Act (Act 230 of 1972), including road right-of-way areas and ingress and egress points.

### Parking and Driveways

Parking and driveway surfaces may be vegetative, ground, pavement, or other suitable material. However, other parking and driveway requirements must comply with all applicable regulations.

### Vehicle Ingress and Egress

Any farm market and affiliated parking operating along a public road must obtain all appropriate ingress and egress permits.

### Signage

The operator of the farm market must comply with all applicable state and federal regulations for signs. A minimum of one roadside sign is allowed pursuant to local sign ordinance setbacks, lighting, height and size requirements.

For further information concerning this GAAMP you may contact the Michigan Department of Agriculture and Rural Development or Michigan State University Extension.

## **REFERENCES**

State of Michigan. *Report of Recommendations*. Report of the Michigan Agricultural Tourism Advisory Commission. Commission report of Governor Granholm. January 2007.

State of Michigan. *Agricultural Tourism Local Zoning Guidebook and Model Zoning Ordinance Provisions*. Report of the Michigan Agricultural Tourism Advisory Commission. Commission report of Governor Granholm. January 2007.

Michigan Commission of Agriculture & Rural Development. *Final Report to the Michigan Commission of Agriculture & Rural Development*. Report of the Michigan Farm Market Task Force. Task Force report to the Michigan Commission of Agriculture & Rural Development. September 2008.

State of Michigan. Michigan Department of Transportation. Directory of Offices by Region.

[http://www.michigan.gov/mdot/0,1607,7-151-9623\\_26662\\_26679\\_27267\\_48606-182161--\\_00.html](http://www.michigan.gov/mdot/0,1607,7-151-9623_26662_26679_27267_48606-182161--_00.html).

## ADVISORY COMMITTEE

Listed below are the advisory committee members for the Generally Accepted Agricultural and Management Practices for Farm Markets.

Dr. Ron Goldy, Chair  
MSU Extension  
1791 Hillandale Road  
Benton Harbor, MI 49022  
269-208-1651- Cell  
[goldy@msu.edu](mailto:goldy@msu.edu)

Robert Beckon  
Michigan Dept. of Transportation  
517-335-2211  
[beckonr2@michigan.gov](mailto:beckonr2@michigan.gov)

John Behrens  
Farmhaus Cider  
5025 Stanton Street  
Hudsonville, MI 49426  
616-723-7087 – Cell  
[john@farmhauscider.com](mailto:john@farmhauscider.com)

Janice Benson, Ex. Dir.  
Michigan Agritourism Assoc.  
P.O. Box 303  
Traverse City, MI 49685  
616-952-1151  
[executivedirector@michiganfarmfun.com](mailto:executivedirector@michiganfarmfun.com)

Lori Buchan  
Buchan's Blueberry Hill  
1472 Nelson Road  
Traverse City, MI 49686  
231-649-0844  
[lbuc246@aol.com](mailto:lbuc246@aol.com)

-  
Ryan Coffey Hoag  
MSU Extension  
5479 W. 72<sup>nd</sup> Street, Suite 206  
Fremont, MI 49412  
231-924-9677  
[coffeyr@msu.edu](mailto:coffeyr@msu.edu)

Mandy Cooley  
South Region Food Supervisor,  
MDARD  
517-749-5192  
[cooleya@michigan.gov](mailto:cooleya@michigan.gov)

Kyle Harris  
Commissioner, Saginaw County  
P.O. Box 222  
St. Charles, MI 48655  
989-666-6504 - Cell  
[kharris@saginawcounty.com](mailto:kharris@saginawcounty.com)

Jeanne Hausler  
MDARD  
Food and Dairy Communications  
P.O. Box 30017  
Lansing, MI 48909  
517-256-8614  
[hauslerj@michigan.gov](mailto:hauslerj@michigan.gov)

Matt Kapp  
Michigan Farm Bureau  
Government Relations Specialist  
7373 West Saginaw Highway  
Lansing, MI 48917  
517-679-5338  
[mkapp@michfb.com](mailto:mkapp@michfb.com)

Natalie Klackle  
Michigan Agritourism  
Association  
PO Box 303  
Traverse City, MI 49685  
616-952-1151  
[president@michiganfarmfum.com](mailto:president@michiganfarmfum.com)

Jay Korson  
MDARD  
Right to Farm Program  
517-285-1918  
[korsonj@michigan.gov](mailto:korsonj@michigan.gov)

Vikki Papesh  
Walnut Hill Farm  
54180 Dequindre Road  
Shelby Chtr. Township, MI  
48316  
[farmer@walnuthillfarmmi.com](mailto:farmer@walnuthillfarmmi.com)

Janene Rawlinson  
Shades of Lavender Farm  
47222 24<sup>th</sup> Street  
Mattawan, MI 49071  
269-668-5267  
[shadesoflavenderfarm@gmail.com](mailto:shadesoflavenderfarm@gmail.com)

-  
Shannon Rowe  
Spicer Orchards  
10750 Clyde Road  
Fenton, MI 48430  
Phone 810-569-5758  
[shannonrowe@spicerorchards.com](mailto:shannonrowe@spicerorchards.com)

~~Ben Tirrell  
Manager, Right to Farm Program  
517-284-5618  
517-256-8899 – Cell  
tirrellb@michigan.gov~~

-  
Bob Tritten  
District Fruit Educator  
MSU Extension  
605 N. Saginaw St. Suite 1A  
Flint, MI 48502  
810-244-8555  
810-516-3800 - Cell  
[tritten@msu.edu](mailto:tritten@msu.edu)

Garrett Ziegler  
MSU Extension  
109 Logan Street SW, Suit B102  
Grand Rapids, MI 49503  
616-608-7436  
[zieglerg@msu.edu](mailto:zieglerg@msu.edu)





# Generally Accepted Agricultural and Management Practices for Irrigation Water Use

---

January ~~2020~~DRAFT 2021

Michigan Commission of Agriculture & Rural  
Development  
PO BOX 30017  
Lansing, MI 48909



In the event of an agricultural pollution emergency such as a chemical/fertilizer spill, manure lagoon breach, etc., the Michigan Department of Agriculture &and Rural Development (MDARD) and/or Michigan Department of Environmental Quality, Great Lakes, and Energy (EGLE) should be contacted at the following emergency telephone numbers:

Michigan Department of Agriculture & Rural Development: 800-405-0101  
Michigan Department of Environment, Great Lakes, and Energy's Pollution  
Emergency Alert System: \_\_\_\_\_ 800-292-4706

If there is not an emergency, but you have questions on the Michigan Right to Farm Act, or items concerning a farm operation, please contact the:

**Michigan Department of Agriculture & Rural Development (MDARD)  
Right to Farm Program (RTF)**

**P.O. Box 30017  
Lansing, Michigan 48909  
517-284-5619  
877-632-1783  
517-335-3329 FAX**

Table of Contents

<b>INTRODUCTION</b>	<b>1</b>
<b>GENERALLY ACCEPTED AGRICULTURAL AND MANAGEMENT PRACTICES FOR IRRIGATION WATER USE</b>	<b>2</b>
<b>System Management</b>	<b>2</b>
<b>Record Keeping</b>	<b>4</b>
<b>Irrigation Scheduling</b>	<b>5</b>
<b>Additional Reasons to Irrigate</b>	<b>9</b>
<b>Application Practices</b>	<b>10</b>
<b>BACKGROUND</b>	<b>12</b>
<b>Irrigation in Michigan</b>	<b>12</b>
<b>Overview of Existing GAAMPs and their Relation to Irrigation</b>	<b>14</b>
<b>ADVISORY COMMITTEE</b>	<b>20</b>

## PREFACE

The Michigan legislature passed into law the Michigan Right to Farm Act (Act 93 of 1981, as amended) which requires the establishment of Generally Accepted Agricultural and Management Practices (GAAMPs). These practices are written to provide uniform, statewide standards and acceptable management practices based on sound science. These practices can serve producers in the various sectors of the industry to compare or improve their own managerial routines. New scientific discoveries and changing economic conditions may require necessary revision of the Practices.

The GAAMPs that have been developed are as follows:

- 1) 1988 Manure Management and Utilization
- 2) 1991 Pesticide Utilization and Pest Control
- 3) 1993 Nutrient Utilization
- 4) 1995 Care of Farm Animals
- 5) 1996 Cranberry Production
- 6) 2000 Site Selection and Odor Control for New and Expanding Livestock Facilities
- 7) 2003 Irrigation Water Use
- 8) 2010 Farm Markets

These practices were developed with industry, university, and multi-governmental agency input. As agricultural operations continue to change, new practices may be developed to address the concerns of the neighboring community. Agricultural producers who voluntarily follow these practices are provided protection from public or private nuisance litigation under the Right to Farm Act.

This GAAMP does not apply in municipalities with a population of 100,000 or more in which a zoning ordinance has been enacted to allow for agriculture provided ~~that~~ the ordinance designates existing agricultural operations present prior to the ordinance's adoption as legal non-conforming uses as identified by the Right to Farm Act for purposes of scale and type of agricultural use.

The ~~W~~web-site for the GAAMPs is <http://www.michigan.gov/righttofarm>

## INTRODUCTION

The Generally Accepted Agricultural and Management Practices (GAAMPs) for Irrigation are based on the core principle of stewardship. Stewardship in irrigation management includes stewardship of water quantity, water quality, soil, plant quality, and crop yield.

- Stewardship of the water quantity means using water as efficiently as possible while providing for the crop/landscape water needs. Utilizing more water than necessary for production of a quality crop is wasteful of the water resource and can have negative environmental and production impacts resulting from leaching of nitrogen and possibly pesticides. With certain exceptions, over-irrigation is when water applications exceed the quantity needed to replace the soil/substrate moisture deficit. The amount of irrigation water to apply generally is equal to the total evapotranspiration since the last irrigation minus any precipitation that occurred during the period.
- Stewardship of the water quality means being careful to apply water at a rate that will infiltrate uniformly into the soil/substrate and be properly stored for crop use while not causing surface runoff or water movement below the root zone.
- Stewardship of the soil means following management practices that will sustain and improve soil surface infiltration characteristics and soil moisture holding capacity through increasing organic matter levels and biological activity while reducing compaction.
- Stewardship of the crop means managing water to promote plant establishment, sustain plant development, and foster the long-term sustainability of the managed landscape system.
- Stewardship of the agricultural sector of the Michigan economy means producing high-quality crops that maintain and enhance Michigan's reputation as a superior supplier in the marketplace.

These GAAMPs do not establish legal criteria to resolve water use conflicts, nor do they confer priority rights to water use. Individual water users who are concerned about their rights or abilities to establish new uses or to continue or increase their water withdrawals are encouraged to consult with advisors at Michigan State University Extension (MSUE), the USDA Natural Resources Conservation Service (NRCS), the Michigan Department of Agriculture **&and** Rural Development (MDARD), the Michigan Department of Environment, Great Lakes, and Energy (EGLE), or an attorney versed in this area of law.

# GENERALLY ACCEPTED AGRICULTURAL AND MANAGEMENT PRACTICES FOR IRRIGATION WATER USE

## System Management

Proper management of an agricultural irrigation system is an integral part of GAAMPs. Six practices contribute to proper system management.

- 1. Select an appropriate source of water. Common sources of irrigation water include, but are not limited to groundwater, lakes, ponds, rivers, streams, drainage ditches, reservoirs, and municipal water supplies.**

Irrigation systems are designed to provide the water needed by the crop that is not met by natural rainfall. As a general rule of thumb, 5—7 five to seven gallons per minute per irrigated acre are required for common irrigation systems (i.e., 200– 280 gallons per minute discharge is required for a 40-acre field). Deep wells may have a steel or plastic casing with a shaft drive turbine or submersible electric pump. Shallow suction wells and horizontal wells are used when the static water level is near the land surface. They use a centrifugal suction pump or a submersible pump.

Irrigation water is pulled from lakes, ponds, rivers, streams, drainage ditches and reservoirs by use of a centrifugal suction pump. Suction pipes are typically suspended or anchored in place to avoid movement with water flow and the inlet is usually set at least 24 feet below the water surface to avoid drawing air. Screens, rotary screens, and water jets are often used at the inlet end of the pipe to prevent debris from entering the pump.

Drainage ditches often require a deepened area in the bottom of the ditch or a temporary constructed flow restriction to provide the depth for the suction inlet below the surface. Irrigation ponds should be constructed deep enough to accommodate the screen or suction line and need to be adequately sized to meet the irrigation system demand. Typical irrigation ponds are half acre or greater in area and eight or more feet deep to provide water storage volume and to increase the chance of adequate discharge from groundwater.

Before constructing or installation of the water supply refer to the material in the background section of this document “*Water Law, Agricultural Water Use, Permits and Regulatory Compliance*” including the requirements for large volume water users and requirements related to construction near existing water features.

- 2. Determine all water applications accurately.**

The objective of this practice is to accurately apply a known amount of water with each irrigation. To do this, irrigators need to accurately determine the water delivery. Application amount may be determined by knowing the actual flow delivered when the system is operating at a set pressure and monitoring time of application. Another method is to have a flow meter installed that will measure the flow. In addition to indicating the irrigation application rate and total flow, these meters will also serve as a

warning of ~~possible problems~~potential problems with wells or pumps. On pressurized systems, the flow meter used in conjunction with a pressure gauge can show whether the system is performing as it was designed. To be accurate, flow meters must be installed according to manufacturer's specifications.

### **3. Evaluate the irrigation system uniformity.**

The objectives of this procedure are to ensure the irrigation system hardware is in good operating condition and the irrigation system design is matched to the site conditions. It will also indicate where system management can be improved so distribution uniformity and overall potential application efficiency is increased. System uniformity evaluation involves 1) the overall condition of the system, and 2) how the design and management of this system work together to achieve high or low distribution uniformities and application efficiencies. Checklists are available from NRCS, irrigation dealers, and MSUE, and can be used to evaluate the overall conditions of the irrigation system and to assure that all vital components are in place.

### **4. Maintain the irrigation system in good working condition.**

The objective of this practice is to maximize the potential application efficiency by maintaining the sprinkler system so that it operates as designed. An important aspect of uniformity is to make sure every component is in good operating condition and the nozzles/emitters are not worn. Regular inspection for obvious equipment malfunctions should take place. The system should be periodically inspected for leaky pipeline or riser gaskets. Leaks can result in a significant loss of water. Deep percolation from leaking pipes could leach nutrients or chemicals to groundwater. Pressure should be checked in the system regularly.

### **5. Pressure variations can be an early indication of problems with a pump that could indicate a malfunctioning or an incorrectly set valve. Correct system pressure is essential for efficient operation. Keep a record of when inspections are made. Systems that link active pumping with forward movement of the irrigation system can improve water use and energy efficiency and avoid over-application. Operate sprinkler systems to minimize drift and off-target application.**

The objective of this practice is to reduce the detrimental effects of wind on application uniformity and off-target application of water. High winds can greatly reduce application uniformity and ~~waste water~~wastewater. Avoiding operation under high wind situations will improve application uniformity and reduce the potential for water applications to non-target areas. Care should be taken to avoid drift or direct spraying of water over roads, adjacent property, or structures. Systems should be both designed and managed to avoid off-target application that does not fall on the irrigated field.

### **6. Ensure that irrigation system output does not greatly exceed the infiltration rate of the soil or substrate.**

The objective of this practice is to maintain system uniformity and infiltration into the soil

or substrate, and reduce transported sediments and other pollution to surface water. This is accomplished by ensuring the application rate of the sprinkler system ~~is lower than the infiltration rate of the soil or substrate at all times~~ is always lower than the infiltration rate of the soil or substrate during irrigation. This practice can be implemented by checking the application rate versus the infiltration of the soil or substrate and modifying the application rate when it is appropriate to do so. Runoff can be managed to some extent by applying lower amounts per irrigation and/or, in the case of container production, by increasing the gap between the container rim and the substrate surface. If runoff is noted, reduce the application amount, and increase the frequency of irrigation. Check to see if there is a soil structure problem or if surface crusting is caused from too large of water droplets being applied. Center pivot sprinkler systems vary in application rates over the span of the pivot. The application rates under the pivot center are much lower than the rates near the end. This is because the field areas covered by the outside portions are much greater than those covered by the inside. Since the pivot will pass over a spot much more rapidly toward the outside end of the pivot, yet apply the same amount of water, the amount applied per hour is much greater.

Irrigation systems used for container production include traditional overhead sprinkler systems, flood, trickle or drip, low volume or micro- systems, and sub-surface. Each system employs technology, equipment, and materials to satisfy the delivery requirements. It is important that the application characteristics of the irrigation system match the targeted plants, production and/or management operations, intake characteristics of the soil/substrate, and subsequent collection/ discharge systems.

#### **7. Provide noise control for engine driven pumping units.**

Where an internal combustion engine is used to power a part of the irrigation system, such as a pump or electric generator, provisions should be made for sound control. This may be in the form of mufflers specifically designed to quiet the sound from the engine or sound baffles to minimize sound carrying toward neighboring properties. Sound travels easily over water bodies. Placement of engines should be considered carefully with respect to population density and sound transmission.

#### **Record Keeping**

Written documentation of an agricultural irrigator's water applications and management practices is an integral part of generally accepted agricultural and management practices.

- 8. Records should conform to the requirements of the Michigan Water Use Reporting laws and regulations.**
- 9. Keep records on all system inspections and repairs that influence uniformity and leaks.**
- 10. Maintain records of regularly calibrated chemigation equipment, if used.**



**11. Keep records of the results each time the sprinkler system uniformity is evaluated.**

**Irrigation Scheduling**

Irrigation scheduling for each field or unit to be irrigated is an integral part of GAAMPs. Irrigation scheduling is the process of determining when it is necessary to irrigate and how much water should be applied during each irrigation event.

Various irrigation scheduling aids exist to help the irrigator keep track of the soil/substrate moisture balance, determine when to irrigate, and the quantity of water to apply. However, these aids do not replace the need for good judgment on the part of the irrigator, who must balance a multitude of factors in managing irrigation, such as:

- Soil variations within an irrigation unit
- Species variations within an irrigation unit
- The time from start to finish of an irrigation cycle
- The probability of rainfall in the near-term future
- Stage of plant growth and its susceptibility to a moisture deficit
- Wind and heat energy impacts
- Potential environmental impacts

Scheduling can be done by manually keeping a running balance of the soil moisture status in each field or irrigation unit using a balance sheet approach, by using various instruments to measure soil moisture status and trigger irrigation, or by using a computerized approach to do the record keeping. All irrigators schedule by some method, and they should keep sufficient records so that they accurately apply the correct amount of water.

Irrigation scheduling helps the irrigator determine the appropriate timing and amount of water to be applied to the growing crop. The primary factors in scheduling are:

- Available soil water per unit depth of soil.
- Depth of rooting for the crop being scheduled.
- Soilless substrates, water retention, and container volume in nursery operations.
- Allowable soil/substrate moisture depletion at each stage of crop growth.

- Crop evapotranspiration at each stage of crop growth as determined by measured evaporation multiplied by the crop co-efficient. The crop co-efficient relates the actual evapotranspiration for a crop to the potential evapotranspiration. It depends on the crop development stage, is low during the initial stage, and reaches a peak at mid- season.
- Rainfall in the field.

**12. Avoid applying irrigation water in excess of the quantity of water needed to replace the soil/substrate moisture deficit in the root zone.**

Plant water stress occurs when soil moisture has been depleted below some critical level, expressed as a percentage of available soil water. For a particular soil, *available soil water* is the amount of moisture held between its field capacity or drained upper limit (the amount of water retained in the total soil pore space after saturated soil has drained) and the permanent wilting point (the point at which plants can no longer obtain water from the soil and thus wilt and die). In Michigan, this difference for most soils is typically on the order of 0.07 to 0.15 inches of water for every inch in soil depth (e.g., a 10-inch layer of soil with a 0.13 inches of available water per inch of soil would contain 1.3 inches of plant available water at the drained upper limit). The coarser-textured soils more commonly irrigated in the state fall closer to the lower end of this range. The amount of available soil water for crops in a particular soil largely depends on its texture (the proportion of sand, silt, and clay particles), organic matter content, and the effective rooting depth of the crop in that soil. It may also vary with depth, as does soil texture. In general, the amount of available soil water increases with increasing clay content of the soil. For the highly variable soil textures and types in Michigan, this translates to a typical range of three to eight inches of plant available water in the top ~~six~~ 6 feet of the soil profile. However, because losses of yield and quality occur long before the permanent wilting point is reached, the amount of available soil water that can be depleted without inducing damage is less than the total available. This amount is defined as the *allowable depletion*, and it is crop specific.

Available water holding capacity data for a specific soil type can be obtained from *USDA/Natural Resources Conservation Service's Field Office Technical Guide (FOTG)*, Section II at <http://www.mi.nrcs.usda.gov>. These data can be used to calculate the available soil water within the rooting depth of a crop grown on that soil. An average or representative value can then be determined for each field and can be used to calculate the allowable depletion for the field.

**13. Know the available water for each unit scheduled.**

**14. Know the depth of rooting for each crop irrigated.**

The amount of water needed for irrigation and the frequency of application also depends on the crop to be irrigated. Some crops, such as alfalfa, have a very extensive primary and secondary rooting system that penetrates to greater depths. The effective rooting depth of alfalfa will vary from three to six feet, or more depending on soil

physical properties and depth of the water table. Corn also has a very good branching root system and can effectively use water to a depth of four feet or more. Soybeans, however, have a tap root system with secondary branch roots and seldom use water effectively from more than two feet deep. Field grown nursery stock usually has roots concentrated in the upper two feet of soil. Lettuce and many other vegetable crops have a very shallow root system and will rarely use water below one or two feet. Shallow rooted crops need to be irrigated frequently with small amounts of water, while deep rooted crops may be irrigated with larger applications of water at less frequent intervals.

**15. Use container capacity in scheduling irrigation for container grown crops.**

In container production systems, soilless substrates contain a limited amount of water and roots and are confined to the container volume (*Southern Nurserymen's Association*, 1997). Container capacity refers to the container's capacity to hold moisture. It is used to define the maximum volume of water a substrate can hold following irrigation and drainage, expressed as the percent water retained relative to the substrate volume. Container capacity depends on the type of substrate and the container dimensions. A substrate is a mixture of different components to provide desired physical and chemical properties for proper plant growth. Increasing the percentage of fine particle substrate components, such as peat and sand, increase the moisture holding capacity of a substrate.

However, addition of too many fine particle components can result in inadequate drainage. Container capacity is also influenced by the height/diameter ratio of the container. Recommended container capacities range from 45 to 65 percent, with the resultant available moisture ranging from 25 to 35 percent.

Weather conditions, the availability of water, the particular plants grown, and production cycles, are used in determining the scheduling of irrigation. Irrigation often occurs daily during the season and starts earlier and extends later in the season compared to traditional field operations.

**16. Know the allowable soil moisture depletion at each stage of crop growth.**

Most soils must be maintained above 40 percent to 65 percent of available water in the rooting zone to avoid plant stress, and that critical value varies by crop. During certain stages of crop growth of some sensitive crops, it is necessary to maintain very uniform soil moisture above 70 to 75 percent of available water, to avoid impacting yield and quality.

Examples are tomatoes during fruit set and potatoes during tuber formation.

**17. Measure, estimate, or use published evapotranspiration data and crop co-efficient (when available) to determine crop water use.**

For some crops, you may wish to consult an irrigation specialist for assistance.

Because of the difficulty and expense of direct measurement of available soil water, most irrigation scheduling is based on an indirect measure. In this case, irrigation is scheduled according to a water budget in which crop water use estimated using meteorological measurements is balanced against water applied as irrigation and measured precipitation. Crop water use or evapotranspiration is the sum of two forms of water loss – evaporation from the soil surface and transpiration from the plants. Evapotranspiration is affected by several climatic factors and plant characteristics. It increases as solar radiation, air temperature, and wind velocity increase, and as the size of the plant canopy (leaf area) increases. It decreases as relative humidity increases and as stomata on the leaves close in response to water (or other forms of) stress. In relatively humid climates such as Michigan's, the most important meteorological factors in determining the evapotranspiration rate are solar radiation and temperature. Evapotranspiration data is available from Enviroweather at <https://enviroweather.msu.edu/>.

Even with good evapotranspiration estimation and accounting, the available water should be monitored in the field or container to determine when the allowable depletion has been reached. This can be accomplished by judging the feel and appearance of the soil at depths throughout the root zone, or by using direct measurement and monitoring instruments, such as tensiometers, Time Domain Reflectometry (TDR), or electrical conductivity sensors.

Guides to Michigan crop water use are available from your local NRCS or MSUE office that provide accurate estimates of water use patterns of specific crops.

#### **18. Measure rainfall in each field irrigated.**

Natural rainfall and irrigation applications work together to replace water used by plants. Accurate determination of how much irrigation water is needed depends directly on knowing how much rain falls in the field where irrigation is being scheduled. Rainfall events, especially summer storms, are variable and may drop widely varying amounts of water in locations that are not far apart geographically. Every field being managed for irrigation must have a rain gauge in the field ~~in order to~~ accurately manage irrigation water applications.

#### **Scheduling methods.**

Irrigation scheduling programs must be tailored to take into account soils and climatic conditions at a given location ~~and also~~ the requirements of different types of crops at different stages of growth. These programs can then calculate daily depletions of available water, usually from estimates of evapotranspiration. They also estimate how much water needs to be added when allowable depletion has been reached.

Irrigation scheduling programs commonly use the following data:

- Allowable depletion (AD) of soil moisture determined for the field or container.

- Initial AD balance – the portion of AD that is present at crop emergence, or when irrigation scheduling begins.
- Amount of rain and irrigation water added to the field.
- Daily potential evapotranspiration estimate based on calculations done by the manager or obtained from local sources.
- Percent canopy cover (or other coefficient) to adjust the evapotranspiration ET estimate when the crop is at less than full cover (These coefficients are crop specific and adjusted for stage of growth).

The program then provides the following information for management:

- Evapotranspiration ET estimate adjusted for the crop at less than full cover.
- Current AD balance – the portion of AD present in the field.
- Projected AD balance for the next 24 and 48 hours

The manager then can decide how much and when water should be applied. Scheduling recommendations are adjusted to allow for the crops changing water needs at various growth stages.

### **Additional Reasons to Irrigate**

- 19. At certain times during the growing season, the need for irrigation may be compelling even though water applications are not driven by the need to replenish a soil moisture deficit.**

Examples of such other reasons to apply irrigation water include:

- Frost protection: Application of water through sprinkler irrigation systems, during radiation frosts and conditions where the temperature drops below freezing for a few hours, may prevent crop damage. As water freezes, it releases heat that keeps the crop from freezing even though ice builds on the foliage. Irrigation must be sustained until all the ice is off the plant to prevent the thawing water from extracting heat from the plant.
- Aid in seed germination or transplant establishment: Light applications of irrigation water may be needed at planting to assist in seed germination, assist transplants through the shock of being placed in the soil, and stimulate root movement into moist surrounding soil.
- Aid in herbicide activation: Herbicides require moisture within the first few days of application to enhance the release of the effective ingredients. A light irrigation application can be used to provide the needed moisture.

- Reduction of disease: Some disease organisms proliferate under dry conditions. A timely water application can function as a natural disease-control agent.
- Establishment of post-harvest cover crops: Soil moisture may be limiting, when cover crops are seeded or irrigation water application may assist soil contact for seeds, if they are broadcast.
- Control of wind erosion in small and emerging crops: Wind erosion can destroy small, tender seedlings of crops like vegetables and sugar beets, just as they are emerging, by blowing soil particles against them and essentially cutting them off. Irrigation to maintain a moist soil surface can be used to reduce wind erosion.
- Post-harvest maintenance of ornamentals: Post-harvest maintenance refers to care and handling between harvest and subsequent use, whether use is replanting in continued production systems or shipping to an end user. Plants are held during this period as bare root, balled and burlaped, or in some form of a container and require appropriate irrigation for the stock type.
- Provision of proper soil conditions for harvesting crops: Harvest of some crops requires soil moisture above a critical level. Irrigation may be needed to provide proper conditions. Optimal soil moisture aids in the efficient use of equipment, allows for the ease of soil separation from roots/tubers in specific crop types, and minimizes damage to the desired plant part. Soil moisture is especially critical in the lifting of bare-root seedlings and in harvesting root/tuber crops and plants with soil balls.
- Chemigation: Application of fertilizers and pesticides through irrigation equipment with properly chosen, usually small, amounts of irrigation water can be beneficial and reduce field operations and/ or aerial applications. Correct amounts of water can assist soil incorporation or apply the chemical primarily to the foliage, as needed.
- Crop cooling in special cases: Certain sensitive crops may benefit from light applications of water through an overhead irrigation system to wet plant surfaces and keep the plant cooler through evaporation.
- Establishment and maintenance of a water table for sub-surface irrigation: Sub-surface irrigation is not generally addressed in these GAAMPs, but application of water through specially designed tile drainage systems may be used to control the water table in certain soil conditions and provide capillary movement unto the root zone of crops to provide their water need from below.

### **Application Practices**

Irrigation can be applied at or below the quantity of water needed to replace the soil/substrate moisture deficit.

**20. Choose irrigation application amounts that will avoid surface runoff under sprinkler irrigation.**

The amount to apply with each irrigation cycle will depend on the soil type (or container substrate) and its infiltration rate. Runoff can be minimized when irrigating soil by reducing application rates to not exceed the soil infiltration rate. By adjusting the frequency and amount of irrigation water applied, the irrigator should maintain adequate soil moisture within the rooting zone. More frequent applications of smaller amounts may be desirable for some crop, soil, and cultural practice combinations. The application rate at which water can be applied is determined by the infiltration characteristics of the soil. The actual intake rate varies with soil structure, organic matter content, tillage practice, and the amount of crop residue remaining on the surface. Soils with good soil structure, high organic matter, and plenty of plant residues on the surface have higher rates of water intake than compact soils low in organic matter or without residues on the surface. Management practices that include cover crops and other practices to increase surface residue and soil organic matter, along with practices to reduce compaction, will help improve infiltration and soil moisture holding capacity. No-till and conservation tillage result in higher intake rates than clean tillage.

### **Nutrient Leaching**

Leaching of nitrate-nitrogen or any other contaminant into groundwater should be prevented as much as possible. Manage irrigation systems to minimize nutrient leaching. The following list of practices may be used to minimize nutrient leaching:

- 21. Assure that sprinkler application rates are below the soil infiltration rate ~~in order to~~ prevent runoff and accumulation of water in lower areas, which may result in excess infiltration and leaching.**
- 22. When irrigation is used, split application of nitrogen fertilizer or use controlled release fertilizer.**

Multiple applications will help to ensure that nitrogen is available when plants need it most and to minimize the amount that can be leached.

- 23. Incorporate appropriate backflow-prevention safety devices if a chemigation system is used.**
- 24. Irrigation systems used for applying chemigation should have adequate interlock and safety systems to prevent over application of pesticide, fertilizer and water when pumps continue to run, and the distribution system stops moving.**

### **Practical Considerations**

Many Michigan soils are variable. Thus, it is necessary to decide which soil type or which zone in the field should govern irrigation management. This decision may compromise the moisture stress situation for another soil type in the field. The irrigator must always consider the time it takes for the irrigation system to complete the irrigation

cycle in any given field. An irrigation cycle may need to be started when part of a field still has some allowable depletion left in the profile. This decision is made ~~in order for~~ for the system to irrigate the entire field before any segment of the crop has gone beyond the allowable depletion and moisture stress has resulted. Field soil variability should be taken into consideration when designing drip irrigation systems. Drip irrigation systems should be zoned, when possible, with zones designed so that the soil within a zone is as consistent as possible.

Monitor pumping plant efficiency. The objective of this practice is to maintain the design pressure and flow in the irrigation system while maximizing energy use efficiency. The distribution uniformity and the potential application efficiency of many irrigation systems are dependent on maintaining the design flow and pressure from the pumping plant. If the flow or pressure during operation are not as designed, something may be wrong with the pumping plant. The system may not be set up correctly, is being operated incorrectly, or there may be worn nozzles.

Other management factors that influence irrigation include crop scouting schedules, crop protectant application schedules, and any restricted entry intervals that must be observed. For example, growers may use a custom applicator and may not have total control of the timing of applications, which can complicate irrigation management. In all of these situations, growers need to consider good stewardship practices, as well as the crop needs, with the goal of producing profitable yields and acceptable quality, and promoting environmental stewardship.

## **BACKGROUND**

*The material in this section of the document is educational and informational in nature and should not be interpreted as containing specific generally accepted agricultural and management practices. The GAAMPs and their explanation are in Section II.*

### **Irrigation in Michigan**

The importance of irrigation in agricultural production is recognized worldwide and is especially important in the United States. According to the *2012 Census of Agriculture*, irrigated farms represented just 14 percent of U.S. farms, but contributed about 39 percent of the country's farm sales—over \$152 billion. For high value crops, the proportion produced under irrigation is even higher.

In Michigan, only 7.7 percent of our land is irrigated, but the irrigated area produces primarily high value crops, making the value of the irrigated crops as a percentage of all crops produced higher than 7.7 percent. High-value crops such as vegetables, potatoes, seed crops, turf, and ornamentals are almost 100 percent produced and/or managed under irrigation.

The major reason for irrigation is to minimize or eliminate the negative impacts of moisture stress and thereby produce a high-quality crop at a profit. The goal of irrigators should be to maximize crop quality and profit while minimizing the effect on the environment and water resources of the state. Michigan is a water-rich state, but rain-



fed crops often suffer from a moisture deficit during a part of the growing season. Rainfall records show that Michigan is the driest state east of the Mississippi River during the critical growing months of July and August. However, annual rainfall exceeds annual crop and landscape water use. Therefore, there is typically water available to recharge aquifers and supply surface water needs in rivers, lakes, and wetlands during other parts of the year. In much of the state, groundwater is abundant and can be used for irrigation. However, these GAAMPs do not establish legal criteria to resolve water use conflicts nor do they confer priority rights to water use.

Water used in irrigation replaces water extracted by plants from the soil profile or substrates in container nursery systems. The main reason that plants use water is to moderate their temperature and remain in a productive state through evaporative cooling. Only a very small fraction of the water taken up by plants ~~actually is~~ used in their metabolic processes such as photosynthesis. Plant growth and associated crop production are dependent on the ability of the plant to remain within an acceptable temperature range. If the plant gets too hot, it wilts and dies, or at the very least, experiences a loss of productive potential. As long as plants can access soil/substrate moisture, they can transport water to plant surfaces that are exposed to the energy from the sun and make water available for evaporation from the plant surface (typically the leaves), thus cooling the plant. If insufficient water is available, the plant then must try to reduce the energy it is absorbing by curling or dropping the leaf so that less area is exposed to the sun. When the plant is stressed in this way, it not only is likely to get warmer than normal but suffer a reduction in its ability to produce new dry matter, whether in the form of foliage, floral, fruit, or grain. Irrigation allows the producer to maintain soil moisture at a level where plants can extract the water they need for cooling. Thus, the main effect of irrigation is to provide the moisture plants need to stay cool and productive.

Agricultural irrigation water use in Michigan began to develop rapidly in the early 1970's with the availability of highly mechanized sprinkler irrigation equipment and the recognition that in certain low-water-holding soil areas of the state there was abundant water available. Irrigation could greatly increase production, crop quality, and the number of crops that could be grown. The ability to irrigate meets contract requirements to grow certain high value crops, maintains crop production requirements for a wide variety of commodities, and allows managers to reduce risks. High-value crops currently grown could not be produced in Michigan without irrigation. Examples are potatoes, seed corn, vegetables, turf and landscape, and nursery crops. Loss of the ability to produce these crops would not only jeopardize the farms on which they are grown, but would have serious adverse economic ripple effects in both the agricultural and non-agricultural sectors of the economy. Access to irrigation water for these crops is the keystone in the production of the quality and reliability of yield that Michigan growers have accomplished.

The amount of water applied through irrigation in Michigan augments natural precipitation, which ranges from 28 inches annually in northeastern sections of the state to over 38 inches in far southwestern and northwestern counties. While in some areas of the country, irrigators may need to provide for the total crop water needs through irrigation, in Michigan, only some of the plant water is provided through irrigation.

Irrigation water requirements vary greatly depending on the rainfall, the crop grown and its stage of development, weather conditions, and the water holding capacity of the soil. There are usually episodes or periods of the growing season when precipitation is not sufficient to meet crop needs. The ability to irrigate enables growers to effectively minimize or eliminate soil/substrate moisture deficit periods by increasing the moisture available for plant growth.

Limitations to utilizing irrigation include the significant capital and energy costs, labor and management requirements, and the availability of adequate water supplies that are impacted by a variety of environmental, economic, and legal factors. Most important of these is the availability of a sufficient supply of surface water and/or groundwater. Irrigation is concentrated during the summer months when stream flows and lake levels are at their lowest. This makes careful evaluation of the adequacy of the water source available at a site before irrigation is started and the subsequent good management of the water resource very important.

### **Overview of Existing GAAMPs and their Relation to Irrigation**

The Michigan Right to Farm Act, PA 93 of 1981, as amended, states that “generally accepted agricultural and management practices” means practices defined by the Michigan Commission of Agriculture **&and** Rural Development. The Act indicates that the Commission, in developing these practices, shall give due consideration to information available from:

- Michigan Department of Agriculture **&and** Rural Development Michigan State University Extension
- Michigan Agricultural Experiment Station
- USDA Natural Resources Conservation Service and Farm Service Agency Michigan Department of Natural Resources
- Michigan Department of Environment, Great Lakes, Energy
- Other professional and industry organizations

Other GAAMPs mention irrigation. The current *Manure Management and Utilization GAAMPs* recognizes (Section III) that irrigation is one method whereby manures may be applied to the surface and indicates that the irrigation must be done in such a manner that it does not cause ponding or runoff. The current GAAMPs for Nutrient Utilization discuss irrigation in Section V, Practices 16 and 17. It recognizes that proper irrigation management can help assure plant growth and yields that are sufficient to remove applied nutrients and that irrigators should use modern scheduling techniques to avoid applying excess water that could result in movement of nitrates below the root zone. The *GAAMPs for Nutrient Utilization* recommend that irrigation water be applied in a manner such that after irrigation, some soil water holding capacity remains unfilled to hold rainfall should it occur shortly after irrigation. Specifically, it recommends that “irrigation should occur when 40 percent to 70 percent of the available soil water is

depleted, depending upon the soil, crop, and capacity of the irrigation system...” and that “irrigation water should not fill the soil rooting profile to more than 80 percent” of its moisture holding capacity. The nutrient management GAAMPs also indicates that “irrigators should use multiple applications of N-fertilizer to improve N-efficiency and minimize potential losses of nitrate-N to groundwater.” It states that “nitrogen fertilizer applied through the irrigation system, referred to as fertigation (or chemigation) offers special advantages to irrigators, and 1) may be applied when the crops demand is the greatest, and in trickle-irrigated orchards, where roots are the most concentrated; 2) the technique requires little energy for application; and, 3) it is well suited to sandy soils where irrigation is needed and leaching may be a problem.” The GAAMPs cautions producers who fertigate should test the uniformity of their irrigation system to assure that no extremely high or low zones of water application occur. Irrigation systems used for pesticide and nutrient application must have appropriate back flow prevention safety devices.

Section VI of the Nutrient Utilization GAAMPs states that “frequent fertilization and irrigation of container grown plants are needed since common root media lack nutrient and water holding capacity.” In such conditions, it is important that effective management practices be adopted to minimize water and fertilizer leaching and/or runoff.

The current *Pesticide Utilization and Pest Control GAAMPs* recognize that chemigation (application of pesticides through irrigation equipment) is one generally accepted method for application (Section II). Section II, G-6, states that when utilizing chemigation, the applicator should make a determined effort to “utilize safety measures including back flow safety devices” to prevent possible contamination of the water source.

### **Water Law, Agricultural Water Use, Permits, and Regulatory Considerations**

The Michigan Right to Farm Act, PA 93 of 1981, as amended, provides Michigan farmers with limited protection from nuisance suits. The statute authorized the Michigan Commission of Agriculture **&and** Rural Development to develop and adopt GAAMPs for farm operations. Adherence to the GAAMPs does not provide a complete barrier against lawsuits, but it does give protection from nuisance litigation in many circumstances. The Act [MCL 286.472, Sec. 2 (b) (iii)] defines “farm operation” as including:

“The operation of machinery and equipment necessary for a farm including, but not limited to, irrigation and drainage systems and pumps ...”

It also states in MCL 286.473, Sec. 3 (1):

“A farm or farm operation shall not be found to be a public or private nuisance if the farm or farm operation alleged to be a nuisance conforms to generally accepted agricultural and management practices ...”

In addition, in MCL 286.473, Sec. 3 (3):

“A farm or farm operation that is in conformance with subsection (1) shall not be found to be a public or private nuisance as the result of any of the following:

- (a) A change in ownership or size
- (b) Temporary cessation or interruption of farming
- (c) Enrollment in government programs
- (d) Adoption of ~~new technology~~innovative technology
- (e) A change in type of farm product being produced”

These GAAMPs do not establish legal criteria to resolve water use conflicts or disputes. Complaints against agricultural use high-capacity wells (> 70 gpm) from small well owners (< 70 gpm.) are handled by the MDARD Groundwater Dispute Resolution program. Complaint can be made via a toll-free number (855-629-4337). More information on the program can be found at: [https://www.michigan.gov/egle/0,9429,7-135-3313\\_3684\\_66257-342245--,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3684_66257-342245--,00.html)~~https://www.michigan.gov/deq/0,4561,7-135-3313\_3684\_66257-342245--,00.html~~

These GAAMPs do not confer priority rights to water use. Individual water users who are concerned about their rights or abilities to establish new uses or to continue or increase their water withdrawals are encouraged to consult with advisors at MSUE, NRCS, MDARD, EGLE, or an attorney versed in this area of law. Water withdrawal for irrigation purposes has the potential to impact other adjacent property owners, other riparian surface water users, and/or the natural resources of the area. Several regulatory programs exist to consider those potential impacts.

In accordance with PA 148 of 2003, as amended, all ~~systems-properties~~ with the capacity to withdraw more than 100,000 gallons per day (70 gallons per minute) average in any consecutive 30-day period are required to register and annually report their water use. This requirement applies to both surface water and wells. These laws apply to all agricultural water uses (irrigation, cooling, animal watering, etc.). Information is available from the MDARD’s Web site at [https://www.michigan.gov/mdard/0,4610,7-125-1599\\_29980--,00.html](https://www.michigan.gov/mdard/0,4610,7-125-1599_29980--,00.html) ~~www.michigan.gov/wateruse-reporting~~ or by contacting Abigail Eaton at 517-284-5612.

As of July 9, 2009, proposed new or increased capacity withdrawal users that meet reporting thresholds must consult the Water Withdrawal Assessment Tool prior to installation and the use must be registered in accordance with Part 327 of P.A. 451 of 1994. To access the tool directly, go to [https://www.michigan.gov/egle/0,9429,7-135-3313\\_3684\\_45331\\_45335-477090--,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3684_45331_45335-477090--,00.html)~~www.michigan.gov/egle/0,9429,7-135-3313\_3684\_45331\_45335-477090--,00.html~~  
~~www.michigan.gov/egle/0,9429,7-135-3313\_3684\_45331\_45335-477090--,00.html~~

As part of the Water Withdrawal Assessment Process, EGLE is required to inform registered water users located in areas of potential adverse resource impacts and to encourage implementation of voluntary measures that would prevent adverse resource

impacts (e.g. private agreements, formation of water user committees, etc.). The process for water use committees is outlined in Part 327 of P.A. 451 of 1994 or by contacting Andy LeBaron at 517-599-3792.

EGLE has the key regulatory and program provisions involving wetlands, lakes, and streams. EGLE administers what is commonly known as the Inland Lakes and Streams Part and the Wetlands Protection Part of the Natural Resources and Environmental Protection Act (NREPA), PA 451 of 1994, as amended. This authority was granted to EGLE by the state legislature. EGLE also administers Section 404 of the Federal Clean Water Act in the non-coastal areas of Michigan through a Memorandum of Agreement with the United States Environmental Protection Agency. Permit applications for construction activities in regulated wetlands, lakes, and streams are submitted to EGLE's Water Resources Division.

Inland Lakes and Streams, Part 301 of NREPA, requires permits where construction activities will occur in a lake or stream to facilitate the withdrawal of water. A state inland lakes and streams permit will generally be required for dredging in the water body, construction of a structure in or over the stream, stream relocations, creation of a lake (water body five acres or larger), or creation of a pond within 500 feet of a lake or stream. Wetlands Protection, Part 303 of NREPA, may require permits where irrigation activities will result in the drainage of or construction in a regulated wetland. Regulated wetlands include any of the following:

- (a) Wetlands located within 500 feet of other surface waters, or within 1,000 feet of the Great Lakes, regardless of wetland size.
- (b) Isolated wetlands larger than five acres.
- (c) Other wetland areas deemed essential to the preservation of the natural resources of the state and where the property owner has been so notified.

A state wetlands permit will generally be required for work in regulated wetlands where the project will require grading, filling, construction of dikes, construction of ditches, and/or the placement of other structures within the wetland area.

EGLE has a Wetland Identification Program (WIP) whereby a person can request the wetlands be identified and their regulatory status is determined. The findings of EGLE under this program are guaranteed for a three-year period. Application forms for a WIP assessment can be obtained at the EGLE website at

[https://www.michigan.gov/egle/0,9429,7-135-3313\\_3687---,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3687---,00.html).

[www.michigan.gov/egle/0,9429,7-135-3313\\_3687---,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3687---,00.html). State wetland inventory maps which combine information from the Michigan Resources Information System (MIRIS), the US Fish and Wildlife Service National Wetland Inventory maps (NWI), and the USDA Natural Resources Conservation Service soil surveys are available at the County Register of Deeds, the County Clerks office, the County Extension Service, and at the EGLE website: [https://www.michigan.gov/egle/0,9429,7-135-3313\\_3687---,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3687---,00.html)

Web site: [https://www.michigan.gov/egle/0,9429,7-135-3313\\_3687---,00.html](https://www.michigan.gov/egle/0,9429,7-135-3313_3687---,00.html)

Additional background information relating to GAAMPs can be found at:  
<http://www.eqr.msu.edu/bae/water>.

## REFERENCES

- Davidson, H. Mecklenburg, R., Peterson, C. *Nursery Management, Administration, and Culture*. 4<sup>th</sup> Ed. Prentice Hall, Englewood Cliffs, New Jersey, 2000.
- Green, J.L. *Practices to Minimize Contamination of Groundwater and Runoff Water in Production of Container–Grown Plants: A Literature Review*. Horticulture Department, Oregon State University, 1998.
- MCARD. 2015. Right to Farm. *Generally Accepted Agricultural and Management Practices for Manure Management and Utilization*. Michigan Commission of Agriculture & Rural Development.
- MCARD. 2015. Right to Farm. *Generally Accepted Agricultural and Management Practices for Nutrient Utilization*. Michigan Commission of Agriculture & Rural Development.
- MCARD. 2015. Right to Farm. *Generally Accepted Agricultural and Management Practices for Pesticide Utilization and Pest Control*. Michigan Commission of Agriculture & Rural Development.
- MDEQ. *Irrigation Water Use in Michigan*. A report prepared by the Michigan Department of Environmental Quality Office of Water, 2004.
- MWPS – 30. *Sprinkler Irrigation Systems*; first edition. A handbook from the Midwest Plan Service, Ames Iowa, the Agricultural Engineering Department, Michigan State University, 1999.
- Southern Nurserymen’s Association. *Best Management Practices – Guide for Producing Container Grown Plants*. Southern Nurserymen’s Association, 1997.
- Stark, J. C., McCann, I. R., Westermann, Izadi, D. T., B. and Tindall, T. A., 1993. *Potato Response to Split Nitrogen Timing with Varying Amounts of Excessive Irrigation*. American Potato Journal, 70:765-777, 1993.
- State of Michigan. *Water Resources for the Future*. Report of the Great Lakes and Water Resources Planning Commission. Commission report to Governor William Milliken. September 1987.

## ADVISORY COMMITTEE

Listed below are the advisory committee members for the Generally Accepted Agricultural and Management Practices for Irrigation Water Use.

[Lyndon Kelley, Interim-Chair](#)  
[MSUE - St. Joseph County](#)  
[612 E. Main St.](#)  
[Centreville, MI 49032](#)  
[269-467-5511](#)

[kelleyl@msu.edu](mailto:kelleyl@msu.edu)

[Steve A. Miller, Chair](#)  
[Biosystems & Agricultural](#)  
[Engineering](#)  
[East Lansing, MI 48824](#)  
[517-353-4456](#)  
[mil1229@msu.edu](mailto:mil1229@msu.edu)

Jeff Andresen  
State Climatological  
Department of Geography  
Michigan State University  
673 Auditorium Rd., Rm 236A  
East Lansing, MI 48824-1117  
517-432-4756  
[andresen@msu.edu](mailto:andresen@msu.edu)

Joel Annable  
Peerless-Midwest, Inc  
574-254-9050  
[Joel.annable@peerlessmidwest.com](mailto:Joel.annable@peerlessmidwest.com)

Josh Crandall  
USDA-NRCS  
Centreville, MI 49032  
269-467-6336  
[josh.crandall@mi.usda.gov](mailto:josh.crandall@mi.usda.gov)

Tom Dudek  
MSUE - Horticulture and Marketing  
333 Clinton St.  
Grand Haven, MI 49417  
616-846-8250  
[dudek@msu.edu](mailto:dudek@msu.edu)

Laura Doud  
Michigan Department of  
Agriculture and Rural Development

Environmental Stewardship Division  
P.O. Box 30017  
Lansing, MI 48909  
517-284-5626  
[DoudL@michigan.gov](mailto:DoudL@michigan.gov)

Ben Weerling  
MSUE - Horticulture and Marketing  
210 E. Johnson Street  
Hart, MI 49420  
231-873-2129  
[werlingb@msu.edu](mailto:werlingb@msu.edu)

Tom Kluck  
Kluck's Nursery  
1020 Van Wormer Road  
Saginaw, MI 48609  
989-781-1650  
[tomkluck@klucknursery.com](mailto:tomkluck@klucknursery.com)

Tom Zimnicki  
MI Environmental Council  
602 W Ionia Street  
Lansing, MI 48933  
517-487-9539  
[Tom@environmentalcouncil.org](mailto:Tom@environmentalcouncil.org)

Abigail Eaton  
Michigan Department of Agriculture  
and Rural Development  
Environmental Stewardship Division  
P.O. Box 30017  
Lansing, MI 48909  
517-284-5612  
[eatona@michigan.gov](mailto:eatona@michigan.gov)

Tom Fernandez  
Department of Horticulture, MSU  
A288 Plant and Soil Sciences Bldg.,  
East Lansing, MI 48824  
517-355-5191 ext. 1336  
[fernan15@msu.edu](mailto:fernan15@msu.edu)

Ron Goldy

Senior Extension Educator, MSUE  
1791 Hillandale Rd.  
Benton Harbor, MI 49022  
616-944-1477, ext. 207  
[goldy@msu.edu](mailto:goldy@msu.edu)

Bill Guertal  
United States Geological Survey  
6520 Mercantile Way, Suite 5  
Lansing, MI 48911  
517-887-8903  
[wguertal@usgs.com](mailto:wguertal@usgs.com)

Pete Philips  
Michigan Valley Irrigation  
14265 Beadle Lake Road  
Battle Creek, MI 49014  
269 565-4426, 616-299-5725  
[petephillips@mivbc.com](mailto:petephillips@mivbc.com)

Josh Appleby  
Michigan Department of Agriculture  
and Rural Development  
Environmental Stewardship Division  
P.O. Box 30017  
Lansing, MI 48909  
268-330-0851  
[applebyj@michigan.gov](mailto:applebyj@michigan.gov)

Kevin Robson  
Michigan Farm Bureau  
7373 W. Saginaw Highway  
Lansing, MI 48917  
517-323-7000  
[krobson@michfb.com](mailto:krobson@michfb.com)

Karl Ritchie  
Walther Farms  
52944 US-131  
Three Rivers, MI 49093  
269-279-2450  
[karl.ritchie@waltherfarms.com](mailto:karl.ritchie@waltherfarms.com)

[Jerimiah-Jeremiah Asher](#)



Institute of Water Research, MSU  
204 Manly Miles Bldg.  
East Lansing, MI 48823  
[asherjer@msu.edu](mailto:asherjer@msu.edu)

~~Michel Wenkel~~Kelly Turner  
Michigan Potato Industry  
Commission  
3515 West Road, Suite A  
East Lansing, MI 48823  
517-253-7370  
[Kellymike@mipotato.com](mailto:Kellymike@mipotato.com)

Jeremy Walker  
21610 Redfield Road  
Edwardsburg, MI 49112  
269-876-0817  
[walkerprecisionag@gmail.com](mailto:walkerprecisionag@gmail.com)

Chris Lattak  
Trickl-eez Company  
4266 Hollywood Road  
St. Joseph, MI  
1-800-874-2553  
[chris.k-line@sbcglobal.net](mailto:chris.k-line@sbcglobal.net)

~~Lyndon Kelley~~  
~~MSUE – St. Joseph County~~  
~~612 E. Main St.~~  
~~Centreville, MI 49032~~  
~~269-467-5511~~  
~~[kelleyl@msu.edu](mailto:kelleyl@msu.edu)~~

Andrew LeBaron  
Michigan Department of  
Environment Quality  
Water Resources Division  
Lansing, MI  
517-241-1435/599-3792  
[lebrona@michigan.gov](mailto:lebrona@michigan.gov)

~~Dave Lusch~~  
~~Institute of Water Research~~  
~~Michigan State University~~  
~~673 Auditorium Rd., Rm 212~~  
~~East Lansing, MI 48824-1117~~  
~~517-355-8497~~  
~~[lusch@msu.edu](mailto:lusch@msu.edu)~~

Bruce MacKeller

~~MSU Extension – Southwest Field~~  
~~Crops, Hazen St., Suite D,~~  
~~Paw Paw, MI 49079,~~  
~~269-657-8213~~~~MSUE – St. Joseph~~  
~~County~~

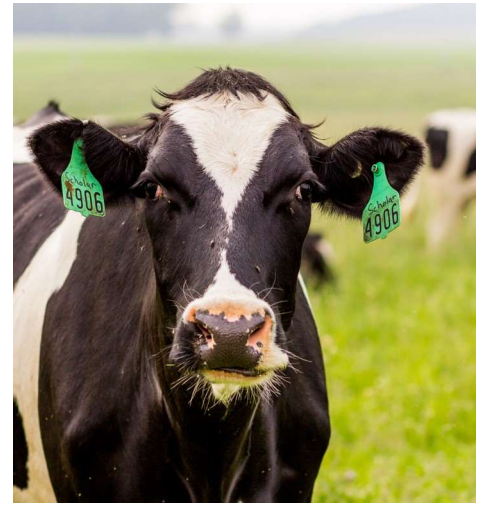
~~612 East Main St.~~  
~~Centreville, MI 49032~~  
~~269-467-5511~~  
~~[mackella@msu.edu](mailto:mackella@msu.edu)~~

Laura Campbell  
Michigan Farm Bureau  
7373 W. Saginaw Highway  
Lansing, MI 48917  
517-679-5332  
~~[lcampbe@michfb.com](mailto:lcampbe@michfb.com)~~

Ben Russell  
Michiana Irrigation Association  
66164 Constantine Rd.  
Constantine, MI 49042  
877-825-0643

Younsuk ~~D~~oung  
~~MSU Extension & Institute of Water~~  
~~Research~~~~MSU, Biosystems and~~  
~~Agricultural Engineering~~

East Lansing, MI 48824  
~~[dongyoun@msu.edu](mailto:dongyoun@msu.edu)~~



# Generally Accepted Agricultural and Management Practices for Manure Management and Utilization

---

January ~~2020~~2021 **DRAFT**

Michigan Commission of Agriculture & Rural  
Development  
PO BOX 30017  
Lansing, MI 48909



In the event of an agricultural pollution emergency, such as a chemical/fertilizer spill, manure lagoon breach, etc., the Michigan Department of Agriculture & Rural Development and/or the Michigan Department of Environment~~al~~, Great Lakes, and Energy should be contacted at the following emergency telephone numbers:

Michigan Department of Agriculture & Rural Development: 800-405-0101  
Michigan Department of Environment, Great Lakes, and Energy's Pollution  
Emergency Alert System: \_\_\_\_\_ 800-292-4706

If there is not an emergency, but you have questions on the Michigan Right to Farm Act, or items concerning a farm operation, please contact the:

**Michigan Department of Agriculture & Rural Development**

**~~(MDARD)~~ Right to Farm Program ~~(RTF)~~**

**P.O. Box 30017**

**Lansing, Michigan 48909**

**517-284-5619**

**517-335-3329 FAX**

**(Toll Free) 877-632-1783**

## Table of Contents

<b>PREFACE</b>	<b>iii</b>
<b>INTRODUCTION</b>	<b>1</b>
<b>RUNOFF CONTROL AND WASTEWATER MANAGEMENT</b>	<b>2</b>
Storage Facilities for Runoff Control	2
Land Application of Runoff	3
Infiltration Areas	4
Pasture Systems	4
Outside Lots	5
<b>ODOR MANAGEMENT</b>	<b>5</b>
Outside Lots	6
Feed Materials	7
Manure	8
Stacked Solid Manure	8
Farmstead Stockpiling	8
Field Stockpiling	9
Storages and Acceptable Covers	10
Treatment Systems	10
Lagoons and Storage Facilities	11
Composting	12
Anaerobic Digesters	12
Application of Manure to Land	13
<b>CONSTRUCTION DESIGN AND MANAGEMENT FOR MANURE STORAGE AND TREATMENT FACILITIES</b>	<b>14</b>
Construction Design	14
Seepage Control for Earthen Basins	15
Management	15
<b>MANURE APPLICATION TO LAND</b>	<b>15</b>
Soil Fertility Testing	16
Fertilizer Recommendations	17
Manure Nutrient Loadings on Pasture Land	20
Method of Manure Application	20
Timing of Manure Application	23

Management of Manure Applications to Land	24
<i>APPENDICES</i>	<i>27</i>
APPENDIX A	27
APPENDIX B	33
APPENDIX C	36
<i>REFERENCES</i>	<i>44</i>
<i>ADVISORY COMMITTEE</i>	<i>51</i>

## PREFACE

The Michigan legislature passed into law the Michigan Right to Farm Act (Act 93 of 1981, as amended), which requires the establishment of Generally Accepted Agricultural and Management Practices (GAAMPs). These practices are written to provide uniform, statewide standards and acceptable management practices based on sound science. These practices can serve producers in the various sectors of the industry to compare or improve their own managerial routines. New scientific discoveries and changing economic conditions may require necessary revision of the GAAMPs.

The GAAMPs that have been developed are as follows:

- 1) 1988 Manure Management and Utilization
- 2) 1991 Pesticide Utilization and Pest Control
- 3) 1993 Nutrient Utilization
- 4) 1995 Care of Farm Animals
- 5) 1996 Cranberry Production
- 6) 2000 Site Selection and Odor Control for New and Expanding Livestock Facilities
- 7) 2003 Irrigation Water Use
- 8) 2010 Farm Markets

These GAAMPs were developed with industry, university, and multi-governmental agency input. As agricultural operations continue to change, new practices may be developed to address the concerns of the neighboring community. Agricultural producers who voluntarily follow these practices are provided protection from public or private nuisance litigation under the Right to Farm Act.

This GAAMP does not apply in municipalities with a population of 100,000 or more in which a zoning ordinance has been enacted to allow for agriculture provided ~~that~~ the ordinance designates existing agricultural operations present prior to the ordinance's adoption as legal non-conforming uses as identified by the Right to Farm Act for purposes of scale and type of agricultural use.

The MDARD website for the GAAMPs is [www.michigan.gov/righttofarm](http://www.michigan.gov/righttofarm).

## INTRODUCTION

Like all other segments of our economy, agriculture has changed significantly during the past 50 years and will continue to change in the future. The trend toward larger facilities (the overwhelming majority being family owned and operated) has resulted in farm operations being more capital intensive and less labor intensive. A H larger farm size offers marketing advantages and generally lower unit cost of production compared to smaller sized operations. However, increased farm size brings new management challenges for environmental protection, animal care, and neighbor relations.

Animal agriculture in Michigan must have the flexibility and opportunity to change agricultural enterprises and adopt new technology to remain economically viable and competitive in the market place while being protective of the environment. If a healthy, growing livestock industry in Michigan is to be assured, efforts must continue to address concerns of livestock producers and their neighbors, particularly in two areas: (1) producers who use GAAMPs in their livestock operations should be protected from harassment and nuisance complaints, and (2) persons living near livestock operations, who do not follow GAAMPs, need to have concerns addressed when odor nuisance or water quality problems occur.

No two livestock operations in Michigan can be expected to be the same, due to the large number of variables, which together determine the nature of a particular operation. The GAAMPs presented in this document provide options to assist with the development of environmental practices for a particular farm that prevents surface water and groundwater pollution.

These GAAMPs are referenced in Michigan's Natural Resources and Environmental Protection Act (NREPA), Act 451 of 1994, as amended. NREPA protects the waters of the state from the release of pollutants in quantities and/or concentrations that violate established water quality standards. In addition, the GAAMPs utilize the nationally recognized construction and management standards to provide runoff control for a 25-year, 24-hour rainfall event. Air quality issues related to production agriculture are addressed in the Odor Management Section.

### About this Document

Management practices are presented as a numbered list and categorized in four areas: (1) runoff control and wastewater management, (2) odor management, (3) construction design and management for manure storage and treatment facilities, and (4) manure application to land.

Appendix A provides essential data for manure management system planning.

Appendix B discusses the difference between Manure Management System Plans (MMSP) and Comprehensive Nutrient Management Plans (CNMP) and explains who needs a CNMP.

Appendix C shows a sample MMSP to help the reader become more familiar with the type of information that is typically included in an MMSP.

The final portion of this document is a list of references that can provide detailed information not supplied in this document.

## **RUNOFF CONTROL AND WASTEWATER MANAGEMENT**

Rainfall and snowfall-induced runoff from uncovered livestock facilities requires control to protect neighboring land areas and prevent direct discharge to surface or groundwaters. Livestock facilities, which require runoff control, include all holding areas where livestock density precludes sustaining vegetative growth on the soil surface.

- 1. Facilities may be paved, partially paved around waters and feed bunks, or unpaved.**
- 2. Runoff control is required for any facility if runoff from a lot leaves the owner's own property or adversely impacts surface and/or groundwater quality. Examples include runoff to neighboring land, a roadside ditch, a drain ditch, stream, lake, or wetland.**
- 3. Milk parlor and milk house wastewater shall be managed in a manner to prevent pollution to waters of the state.**
- 4. Provisions should be made to control and/or treat leachate and runoff from stored manure, silage, food processing by-products, or other stored livestock feeds to protect groundwater and surface waters.**

For runoff control and wastewater management guidance, refer to the [USDA Natural Resources Conservation Service \(-NRCS\) Michigan \(MI\) -MI](#) Conservation Practice Standard *Waste Treatment 629* (USDA-NRCS-MI Field Office Technical Guide [FOTG]), chapter 4 of *Livestock Waste Facilities Handbook 3<sup>rd</sup> Edition*, (MidWest Plan Service, 1993), the *Guideline for Milking Center Wastewater* (Wright and Graves, 1998) and the *Milking Center Wastewater Guidelines* (Holmes and Struss, 2009).

### **Storage Facilities for Runoff Control**



Runoff control can be achieved by providing facilities the option to collect and store the runoff for later application to cropland.

- 5. Runoff storage facilities should be designed to contain normally occurring direct precipitation and resulting runoff and manure that accumulate during the storage times projected in the MMSP. In addition, storage volume should be provided that will contain the direct rainfall and runoff that occur as a result of the average 25-year, 24-hour rainfall event for the area. Storage facilities must be constructed to reduce seepage loss to acceptable levels.**

Refer to the NRCS-MI Conservation Practice Standard *Waste Storage Facility 313* for controlling seepage from waste impoundments (USDA-NRCS-MI FOTG). Additional guidance can also be found in Chapter 10, Appendix 10D of the *Agricultural Waste Management Field Handbook (AWMFH)*, Part 651, (USDA-NRCS, 2008).

### **Land Application of Runoff**

Equipment must be available for land application of stored runoff wastewater. Land application should be done when the soil is dry enough to accept the water.

- 6. Application rates should be determined based upon the ability of the soil to accept and store the runoff and wastewater and the ability of plants growing in the application area to utilize nutrients. Land application should be done when the wastewater can be used beneficially by a growing crop. On fields testing over 150 ppm P (300 lb. P/acre) soil test Bray P1, there may be instances where on-farm generated wastewater, <1 percent solids, can be utilized if applied at rates that supply 75 percent or less of the annual phosphorus removal for the current crop or next crop to be harvested.**

In these instances, the following conditions must be met:

- a) **annualAnnual sampling of the applied wastewater to determine its P content, so P2O5 loadings can be calculated;**
- b) **soil P test levels must show a progressive decline over time;**
- c) **no other phosphorus can be applied to the crop field from other sources;**
- d) **when using irrigation as an application method, the GAAMPs for Irrigation Water Use must be followed to ensure ~~that~~ irrigation scheduling is used to meet and not exceed evapotranspiration needs of the crop/soil system to avoid excess wastewater disposal that would flush soluble phosphorus past the depth of crop rooting; and,**
- e) **tile drained fields must be monitored in accordance with GAAMP 30.**

Sprinkler irrigation methods will provide uniform application of liquid with minimum labor requirements. Directing lot runoff through a structure for settling solids can reduce odor from the liquid storage and application.

### **Infiltration Areas**

- 7. An alternative to a storage structure is a structure for settling solids with a vegetated infiltration area for handling lot runoff, and/or silage leachate wastewater. The vegetative area may be a long, grassed, slightly sloping channel or a broad, flat area with minimal slope for positive drainage and surrounded by a berm or dike. All outside surface water should be excluded from the infiltration area so that the only water applied is lot runoff and/or diluted silage leachate and direct precipitation. Vegetation should be maintained and harvested at least once per year so that the nutrients contained in the plant material are removed, in order to prevent excessive nutrient build up in the soil of the infiltration area.**

Design information about infiltration areas, such as sizing, establishment, and maintenance, is available in the NRCS [MI](#) Conservation Practice Standard *Vegetated Treatment Area 635* (USDA-NRCS-MI FOTG), chapter 4, about runoff and infiltration areas, and chapter 5, about settling basins, in the *Livestock Waste Facilities Handbook 3<sup>rd</sup> Edition*, (MidWest Plan Service, 1993), and the *Vegetative Treatment Systems for Open Lot Runoff: A Collaborative Report* (USDA-NRCS, 2006). These systems are not practical for every situation.

### **Pasture Systems**

Pasture land is land that is primarily used for the production of forage upon which livestock graze. Pasture land is characterized by a predominance of vegetation consisting of desirable forage species. Sites such as loafing areas, confinement areas, or feedlots which have livestock densities that preclude a predominance of desirable forage species are not considered pasture land.

- 8. Stocking densities and management systems should be employed which ensure that desirable forage species are present with an intensity of stand sufficient to slow the movement of runoff water, ~~and~~ control soil erosion and movement of manure nutrients from the pasture land.**
- 9. Livestock should be excluded from actual contact with streams or water courses except for controlled crossings and accesses for watering.**

As authorized by the Riparian Doctrine, producers are entitled to utilize surface waters traversing their property. However, this use is limited to activities which do not result in water quality degradation. The goal for controlling livestock access to surface waters is to prevent water quality degradation. Livestock can impact water quality by the erosion

of sediment and nutrients from stream banks and by the direct deposition of manure nutrients, organic matter, and pathogens into surface water.

Direct deposition is effectively prevented by restricting livestock to controlled access locations. Banks are effectively stabilized by maintaining vegetation or, as in the case of controlled watering accesses and crossings, stream banks and beds may be stabilized with appropriate protective cover, such as concrete, rocks, crushed rock, gravel, or other suitable cover. In addition to addressing environmental and public health aspects, controlling livestock access to surface water and providing alternate drinking water sources may improve herd health by reducing exposure to water and soil-borne pathogens.

For more information, see the NRCS-MI Conservation Practice Standard *Prescribed Grazing 528* (USDA-NRCS-MI FOTG) or Bulletin E-3066 entitled *Acceptable Practices for Managing Livestock along Lakes, Streams and Wetlands* (Michigan State University Extension, 2008).

**10. Runoff from pasture feeding and watering areas should travel through a vegetated filter area to protect surface and groundwater.**

See the NRCS-MI Conservation Practice Standards *Wastewater Treatment Area 635 and Filter Strip 393* (USDA-NRCS-MI FOTG) for criteria.

**Outside Lots**

**11. Provisions should be made to collect, store, utilize, and/or treat manure accumulations and runoff from outside open lots used for raising livestock.**

Outside open lots used for raising livestock are areas of animal manure accumulation. Maintenance of open lot systems requires manure handling methods to periodically remove accumulated solid or semisolid manure and control lot runoff. Solid manure is typically transferred from the lot to storage facilities or equipment for application to cropland. The frequency of removal of accumulated manure will depend on the animal density (square feet of lot area per animal), the amount of time the animals spend on the lot, the animal size, and the type of feed system. Clean runoff should be diverted away from the livestock lot area.

While paved lots generally result in more runoff than unpaved lots, a paved surface improves manure collection and runoff control and minimizes the potential for groundwater contamination.

**ODOR MANAGEMENT**

The goal for effective odor management is to reduce the frequency, intensity, duration

and offensiveness of odors, and to manage the operation in a way that tends to create a positive attitude toward the operation. Because of the subjective nature of human responses to certain odors, recommendations for appropriate technology and management practices are not an exact science. The recommendations in this section represent the best professional judgment available.

The following eight management practices (GAAMPs numbered 12 to 19) provide guidance on how to minimize potential odors from livestock operations. Producers should select those practices which are applicable to their livestock operations and develop an Odor Control Plan as part of their MMSP. See Appendix C, Section IX, for a sample MMSP that contains an example Odor Control Plan.

## **12. Livestock producers should plan, design, construct, and manage their operations in a manner that minimizes odor impacts upon neighbors.**

The proximity of livestock operations to neighbors and populated areas is usually the most critical factor in determining the level of technology and management needed to minimize odor impacts upon neighbors. Therefore, site selection is an important factor in minimizing odor impacts for and upon neighbors. The more remote the livestock operation, the better the likelihood that odors will not become an annoyance for neighbors; and, therefore, a lower level of technology and management will adequately manage odors at the livestock facility. However, the distance which a livestock operation should be located from neighboring land uses to effectively control odors is not easily established. Additional information and recommendations can be found in the current GAAMPs for Site Selection and Odor Control for New and Expanding Livestock Facilities.

The principles upon which the most common and effective techniques for odor control are based include (a) reducing the formation of odor-causing gases and (b) reducing the release of odorous gases into the atmosphere. The degree to which these principles can be applied to the various odor sources found in livestock operations depends on the level of technology and management that can be utilized. Feed materials and manure are the most common and predominant sources of odor and are discussed in the following subsections.

### **Outside Lots**

Outside open lots are acceptable for raising livestock in Michigan. In these systems, manure is deposited over a relatively large surface area per animal (compared to a roofed confinement system for example) and begins to decompose in place. Odor impacts can be mitigated by keeping the lot surface as dry as possible; thus limiting the microbiological activity that generates odors. Providing adequate slopes, orientation that takes advantage of sunlight, diverting up-slope runoff water away from the lot, and using recommended stocking densities will enhance drying of the lot surface. The *Beef Cattle*

*Notebook* (Beef Cattle Resource Committee, 1999) provides details and alternatives to accomplish this. Most feed additives and odor control chemicals applied to feedlot surfaces have not been demonstrated to be effective in reducing odors from feedlots in humid areas, such as Michigan.

**13. New outside lot systems should not be located in close proximity to residences and other odor-sensitive land uses.**

In spite of good facilities design and management, odors may be generated from outside livestock lot systems. The intensity of these odors is somewhat proportional to the surface area of the odor producing sources. The frequency of impact and offensiveness to neighbors is often related to the distance to neighbors' houses and their location relative to prevailing winds. They should not be located uphill along a confining valley leading toward residences. For additional guidance [see therefer to the current](#) GAAMPs for Site Selection and Odor Control for New and Expanding Livestock Facilities (MDARD, 202018)

**Feed Materials**

Using fermented feeds, such as corn or hay silage, is an acceptable animal husbandry practice throughout Michigan for dairy and beef cattle, horses, sheep, and goats. Some odors associated with the storage and feeding of these materials are normal for these livestock operations.

**14. The odor of fermented feed materials, such as corn or hay silage, can be minimized by harvesting and storing them at an appropriate dry matter content (generally greater than 33 percent dry matter).**

The practice of feeding human foodstuffs, surplus and processing by-products (e.g., cull potatoes, dairy milk or whey, cereal by-products, surplus garden and orchard produce, pastry by-products, sugar beet pulp, and sweet cornhusks) to livestock is a generally accepted practice. This is especially common where livestock operations exist within close proximity to food production and food processing facilities. Using these materials for livestock feed diverts useful by-products (that can pose a substantial load on local sewage treatment plants and a major problem for food processing plants) from the waste stream and converts them into a valuable resource. Properly handled in a livestock operation, these feeds pose no threat to the environment. These products may require special feed handling systems and may substantially increase or change the manure generated by the animals to which they are fed. Some by-products themselves and/or the manure produced by livestock with their consumption can be the source of unusual, offensive, and intense odors. In these situations, feed handling and manure management practices should be used to control and minimize the frequency and duration of such odors. Garbage is defined [in in-the Animal Industry](#) Act 466 of 1988, as

amended; Section 287.704<sup>3</sup> as products containing animal materials and cannot be fed to livestock in Michigan.

## **Manure**

Fresh manure is usually considered to be less odorous than anaerobically decomposing manure. Fresh manure emits ammonia but in general is not accompanied by other products of decomposition, which contribute to odors.

- 15. Frequent (daily or every few days) removal of manure from animal space, coupled with storage or stacking and followed by application to cropland at agronomic rates, is an acceptable practice throughout Michigan.**

Manure odors are generally those associated with the anaerobic (in the absence of oxygen) decomposition of organic material by microorganisms. The intensity of odors depends upon the biological reactions that take place within the material, the nature of the excreted material (which is dependent upon the species of animal and its diet), the type of bedding material used, and the surface area of the odor source. Sources of decomposing manure can include stacked solid manure, outside lots when manure is allowed to accumulate, uncovered manure storages, manure treatment systems, and land application areas.

- 16. Where possible, do not locate manure storage in close proximity to residential areas.**

[Additional information and recommendations can be found in the current GAAMPs for Site Selection and Odor Control for New and Expanding Livestock Facilities in the Manure Storage Structure Change or Installation Section.](#)

## **Stacked Solid Manure**

- 17. Solid manure that may contain bedding materials and/or is dried sufficiently, such as that from poultry, cattle, sheep, swine, horse, and fur-bearing animal facilities, can be temporarily stacked outside the livestock building.**

## **Farmstead Stockpiling**

Stockpiling manure at a farmstead is an acceptable practice that should be protective of the environment and mindful of neighbors. Manure should be stockpiled on a hard surface pad (such as concrete or asphalt) with sides to prevent leachate and runoff. Stockpiling manure on the ground is also an acceptable practice with appropriate

management such as rotating locations and complete periodic removal of manure from the location annually or more frequently, records documenting timing of removal and location used, and seeding of the previous location after removal to allow for vegetation to take up the nutrients that have accumulated in the soil. Stockpile locations should remain vegetated without stockpiled manure for a minimum of three years before reusing the site. In addition, the stockpile should be in a location that does not allow for runoff to flow onto neighboring property or into surface waters. The location should also consider odors and pests if the stockpile is in close proximity to homes, schools or other high use areas. Practices such as covering stockpiled manure with a tarp, fleece blanket<sup>1</sup>, straw, woodchips or other materials, or additives such as lime, can be used to help reduce odors and pests. Unless a tarp, fleece blanket<sup>1</sup>, or straw cover is maintained, manure stockpiles need to be kept at least 50 feet away from property lines or 150 feet away from non-farm homes.

### **Field Stockpiling**

Temporary stockpiling of manure at field application sites may be necessary when crop production and field conditions preclude immediate application to cropland. Temporary stockpiling is not an annual staging practice. Rotating and use of the footprint for crop production is recommended. The stockpile should be in a location that does not allow for runoff to flow onto neighboring property or into surface waters. The location should also consider odors and pests if the stockpile is in close proximity to homes, schools or other high use areas.

Proximity to surface water, field drainage, predominate wind direction, field slope and applicable conservation practices should be factored into infield manure stacking locations. Manure stockpiles need to be kept at least 150 feet from non-farm homes. Manure stockpiles also need to be kept at least 150 feet from surface waters or areas subject to flooding unless conservation practices are used to protect against runoff and erosion losses to surface waters.

Leachate from solid stacked manure is subject to control as described in Section II, Runoff Control and Wastewater Management, GAAMP No. 4. When initially placed in the field, stockpiles should be at least 6 feet high and have a conical shape. Moderate compaction and a sloped surface enhance the shedding of precipitation and lessen leaching. Manure that is temporarily stockpiled in the field should be spread as soon as field and weather conditions allow. Stockpiled manure must be spread onto fields within six months of initial pile placement if uncovered, or within twelve months if covered with an impermeable cover for the additional time until spread. Covering is recommended for the entire time the manure is stockpiled in the field. Timely application of stockpiled

---

<sup>1</sup> A fleece blanket is a non-woven textile material made from synthetic fibers, such as polypropylene. The non-woven texture of a fleece blanket prevents rainfall from penetrating into the composting material, but allows the necessary exchange of carbon dioxide and oxygen.

manure to land at agronomic rates and soil incorporation within 48 hours after application will help to control odors and may have nutrient management crop production benefits. Practices such as a tarp, a straw cover, or additives such as lime, can be used to help reduce odors and pests. Odors from such manure stockpiles should be minimized, except when disturbed such as during removal for application to land.

Livestock operations may utilize a variety of bedding materials as part of their manure management system. The use of straw, hay, sand, sawdust, wood shavings, waste paper, or other suitable materials, either individually or in combination as livestock or poultry bedding, is a common generally accepted practice. Bedding materials should be of an appropriate size to maximize absorptive properties and to prevent blowing and dispersion when subsequently applied to cropland. Waxed paper, aluminum foil, and plastics should not be present in bedding material.

### **Storages and Acceptable Covers**

#### **18. Use covered manure storage if technically and economically feasible.**

The primary objective of storage is to temporarily store the manure before application to land. However, some biological activity occurs in these storages, and the gases generated can be a source of odors. If storage facilities are left uncovered, the potential for manure odors to be carried away by air movement will increase. Various types of covers can be used to prevent wind driven air from coming into direct contact with a liquid manure surface and incorporating odors.

Acceptable covers that can retard odor escape from manure storages include the following:

- a) Natural fibrous mats similar to those which develop on liquid manure storages receiving manure from beef and dairy cattle fed a high roughage diet. Slotted flooring or other underbuilding tanks. Ventilation must be provided in the building to prevent accumulation of noxious and flammable gases.
- b) A flexible plastic, or similar material, that covers the liquid surface and is of such strength, anchorage and design that the covering will not tear or pull loose when subjected to normal winds that have an average recurrence interval of 25 years. Gas escape vents should be provided which allow any gas that may evolve to escape.
- c) A solid covering such as concrete, wood, plastic or similar materials that covers the entire liquid surface and is of such strength, anchorage, and design that it will withstand winds and expected vertical loads. Adequate air exchange should be provided which will prevent the occurrence of explosive concentrations of flammable gases.

### **Treatment Systems**



A biological treatment system is designed to convert organic matter (e.g., feed, bedding, animal manure, and other by-products) to more stable end products. Anaerobic processes (i.e., without free oxygen) can liquefy or degrade high BOD (biochemical oxygen demand) wastes. They can decompose more organic matter per unit volume than aerobic treatment processes. Aerobic processes require free oxygen and are helpful in reducing odor but are generally not considered economical for livestock operations. Extreme environmental changes alter microbial activity. When microorganisms are stressed by their environment, waste treatment processes can malfunction, and odors may become more intense.

### **Lagoons and Storage Facilities**

Anaerobic treatment lagoons are generally basins containing diluted manure and are designed to provide degradation of the organic material. Well-designed and managed anaerobic lagoons can be short-term odor sources. The occurrence of purple sulfur-fixing bacteria can significantly reduce odors from an anaerobic treatment lagoon. The intensity of odors is usually greatest during the early spring and occasionally in the fall.

Aerobic treatment of manure liquids can be accomplished by natural or mechanical aeration. In a naturally-aerated system, such as a facultative oxidation treatment lagoon, an aquatic environment occurs in which photosynthesis from algae and surface aeration from the atmosphere provides an aerobic zone in the upper regions of the treatment lagoon. A transition zone occurs below this aerobic zone that has a limited amount of oxygen. This is the facultative zone where bacteria are present that can live either with or without oxygen. At the bottom, there may be a sludge layer that is anaerobic. The processes that occur in the aerobic zone have a low odor potential, and the odorous compounds that are created in the facultative and anaerobic zones are converted to low odor forms in the aerobic zone. For a naturally aerated system to function properly, design specifications and quantities of manure solids to be treated must be closely followed.

An aerobic treatment lagoon should be loaded at a rate no higher than 44 pounds of ultimate BOD/day/acre. The material in the treatment lagoon should be diluted enough to allow light to penetrate three to four feet into the water. The lagoon should be a minimum of four feet deep (or deeper to allow for accumulation of sludge) to prevent rooted vegetation from growing from the bottom of the lagoon.

Mechanically-aerated systems can be used to treat animal manures to control odors, decompose organic material, remove nitrogen, conserve nitrogen, or a combination of these functions. When adequate oxygen is supplied, a community of aerobic bacteria grows that produce materials with low odor potential. Alternative treatment systems to accomplish mechanical aeration include facultative lagoons, oxidation ditches, or completely mixed lagoons.

Storage facilities are designed for manure storage only with no manure treatment. Treatment lagoons (aerobic and anaerobic) are designed specifically for manure treatment.

Effluent from treatment lagoons and storage basins should be land applied to avoid long-term and extensive ponding and to utilize manure nutrients at agronomic rates (see Section V). Construction design for treatment lagoons and storage basins should conform to the recommendations in Section IV.

### **Composting**

Composting is a self-heating process carried on by actinomycetes, other bacteria, and fungi that decompose organic material in the presence of oxygen. Composting of organic material, including livestock and poultry manures, can result in a rather stable end product that does not support extensive microbial or insect activity, if the process and systems are properly designed and managed. The potential for odors during the composting process depends upon the moisture content of the organic material, the carbon-nitrogen ratio, the presence of adequate nutrients, the absence of toxic levels of materials that can limit microbial growth, and adequate porosity to allow diffusion of oxygen into the organic material for aerobic decomposition of the organic material. Stability of the end product and its potential to produce nuisance odors, and/or to be a breeding area for flies, depends upon the degree of organic material decomposition and the final moisture content. Additional information and guidance about alternatives for composting manures are available in the *On-Farm Composting Handbook* (Rynk, 1992) and in the *National Engineering Handbook*, Part 637, Chapter 2 (USDA-NRCS, 2000). The occurrence of leachate from the composting material can be minimized by controlling the initial moisture content of the composting mixture to less than 70 percent and controlling water additions to the composting material from rainfall. Either a fleece blanket or a roofed structure can be used as a cover to control rainfall additions or leachate from composting windrows.

Provisions should be made to control and/or treat leachate and runoff to protect groundwater and surface water. If the composting process is conducted without a cover, provisions must be made to collect the surface runoff and it either be temporarily stored (see Section IV) and applied to land (see Section V), added to the composting material for moisture control during the composting process, or applied to vegetated infiltration areas (see Section II).

### **Anaerobic Digesters**

Methane can be produced from organic materials, including livestock and poultry manures by anaerobic digestion. This process converts the biodegradable organic portion of animal wastes into biogas (a combination of methane and carbon dioxide).

The remaining semi-solid is relatively odor free but still contains all the nitrogen, phosphorus, and potassium originally present in the animal manure, although some of the nitrogen can be lost after storage in a holding structure. Anaerobic digestion is a stable and reliable process, as long as the digester is loaded daily with a uniform quantity of waste, digester temperature does not fluctuate widely, and antibiotics in the waste do not slow biological activity.

### **Application of Manure to Land**

Manure applications can and should be managed to avoid and minimize nuisance odor conditions that may be experienced by neighbors. Livestock and poultry manure applied to cropland at agronomic rates followed by timely soil incorporation, where feasible, helps to control excessive odors and reduce ammonia (NH<sub>3</sub>) loss. The following list of practices may be used to reduce the amount of odor and the impact of odor during the application of manure to land. Appropriate implementation will help reduce complaints of odors.

- a) Avoid spreading when the wind is blowing toward populated areas.
- b) Avoid spreading on weekends/holidays when people are likely to be engaged in nearby outdoor and recreational activities.
- c) Spread in the morning when air begins to warm and is rising, rather than in late afternoon.
- d) Use available weather information to best advantage. Turbulent breezes will dissipate and dilute odors, while hot and humid weather tends to concentrate and intensify odors, particularly in the absence of breezes. Take advantage of natural vegetation barriers, such as woodlots or windbreaks, to help filter and dissipate odors.
- e) Establish vegetated air filters by planting conifers and shrubs as windbreaks and visual screens between cropland and residential developments.

**19. Incorporate manure into soil during, or as soon as possible after, application. This can be done by (a) soil injection or (b) incorporation within 48 hours after a surface application when weather conditions permit. Incorporation may not be feasible where manures are applied to pastures, forage crops, wheat stubble, or where no-till practices are used to retain crop residues for erosion control.**

Incorporation means the physical mixing or movement of surface applied manures and other organic byproducts into the soil so that a significant amount of the material is not present on the soil surface. The physical mixing can be done by using minimal disturbance tillage equipment such as aeration tools. Incorporation also means the soaking of liquid material being applied with irrigation water, barnyard manure runoff, liquid manure, silage leachate, milk house wash water, or liquids from a manure treatment process that separates liquids from solids into the surface soil layer by

infiltration, thereby moving surface applied liquid into soils that have void air space not completely filled by soil water.

Irrigation of manure to land can be an effective land application method for delivering manure to land in a short period of time without the potential damage to soil structure that can occur with other methods. However, the process can be odorous for a short period of time.

Land application of liquid manure through an irrigation system is an acceptable method. Three methods are commonly used: center pivot spray, center pivot with drop tubes, and volume guns either stationary or movable. Center pivots offer excellent uniformity of application, minimize compaction, and allow for timely application. Except for pivots with drop tubes, all the irrigation systems have potential for odor release.

If liquid manure is applied through an irrigation system, care should be taken to assure that runoff does not occur due to application rates exceeding the soil infiltration rates. On fractured soils or those with preferential flow paths, care must be taken to assure that manure does not flow into subsurface drains. On systems where the manure is diluted with well or surface water, a check valve assembly must be installed to prevent back flow of manure into the well or surface water source.

Spray irrigation produces aerosol sprays that can be detected for long distances. Wind direction and impact on neighbors need to be observed closely. An alternative to traveling big guns that reduces odor is a boom fitted with drop tubes to place the manure below the plant canopy on the soil surface. Research in Europe has shown this method to be effective in minimizing odors.

## **CONSTRUCTION DESIGN AND MANAGEMENT FOR MANURE STORAGE AND TREATMENT FACILITIES**

### **Construction Design**

#### **20. Construction design for manure storage and treatment facilities must meet standards and specifications.**

Standard and specifications for manure storage and treatment facilities need to follow industry standards, state codes for structures, or under university guidance and technology development. For further information, see NRCS-MI Conservation Practice Standard *Waste Storage Facility 313* (USDA-NRCS-MI FOTG) and Chapter 10, Appendix 10D of the *AWMFH*, Part 651, (USDA-NRCS, 2008). Additional publications that can be used are the *Rectangular Concrete Manure Storages Handbook* MWPS-36, 2<sup>nd</sup> Ed. (MidWest Plan Service, 2005), the *Circular Concrete Manure Tanks* publication TR-9 (MidWest Plan Service 1999), and the *Building Code Requirements for Structural Concrete* industry standard of the American Concrete Institute ACI-318-14 (ACI

Committee 318, 2014).

### **Seepage Control for Earthen Basins**

- 21. To protect groundwater from possible contamination, utilize earthen liners that meet standards and specifications that meet acceptable seepage rates.**

For more information on acceptable seepage rates for earthen liners, see the section about “Additional Criteria for Waste Storage Ponds” in the NRCS-MI Conservation Practice Standards *Waste Storage Facility 313* (USDA-NRCS-MI FOTG) and Chapter 10, Appendix 10D of the *AWMFH*, Part 651, (USDA-NRCS, 2008). Liners include bentonite treatment, soil dispersant, compacted clay treatment, concrete, and flexible membranes.

### **Management**

- 22. All manure storage structures shall maintain a minimum freeboard of twelve inches (six inches for fabricated structures) plus the additional storage volume necessary to contain the precipitation and runoff from a 25-year, 24-hour storm event.**

When considering total storage volume, include all bedding, storm runoff water, milk house and parlor wastewater, and silage leachate that enter the storage structure. In addition, manure storage structure integrity should also be maintained by means of periodic inspections. During these inspections, identify any item that would minimize integrity, such as animal burrows, trees and shrubs growing on the berm, and low areas in the structure that may be conducive to leakage.

## **MANURE APPLICATION TO LAND**

One of the best uses of animal manure is as a fertilizer for crop production. Recycling plant nutrients from the crop to animals and back to the soil for growth of crops again is an age-old tradition. Depending on the species of animal, 70-80 percent of the nitrogen (N), 60-85 percent of the phosphorus (P), and 80-90 percent of the potassium (K) fed to the animals as feed will be excreted in the manure and potentially available for recycling to soils.

Livestock operations can generate large amounts of manure and increase the challenge of recycling manure nutrients for crop production. Good management is the key to ensure that the emphasis is on manure utilization rather than on waste disposal. Utilizing manure nutrients to supply the needs of crops and avoiding excessive loadings achieves two desirable goals. First, efficient use of manure nutrients for crop production will accrue economic benefits by reducing the amounts of commercial fertilizers needed.

Second, water quality concerns for potential contamination of surface waters and groundwater by nutrients, microorganisms and other substances from manure can best be addressed when nutrients are applied at agronomic rates and all GAAMPs for manure applications are followed.

Application of animal manure to fields used for crop production is the predominant form of manure recycling. Three overriding criteria that need to be considered for every manure application are environmental protection, neighbor relations, and nutrient utilization. The manure should be managed in a manner to retain the nutrients in the soil-plant system. The rate and method of application are influenced by soil and weather conditions. For liquid manure, the receiving soil needs to have enough air space for timely infiltration. All manure applications need to be managed to control odors and prevent runoff from the cropland where the manure is applied. Nutrient utilization management includes the use of current soil test results, manure nutrient analysis or book values, and realistic yield goals. Manure applications may provide certain nutrients for multiple years of crop production; and, in some cases, the additional carbon supplied as organic matter improves the tilth of mineral soils.

The following management practices are suggested for livestock producers to help them achieve the type of management that will accomplish these two goals. However, adverse weather conditions may, in part, prevent responsible livestock producers from adhering to these practices for a short duration of time. In addition to effective nutrient management and water quality protection, applying manure to land warrants close attention to management practices so potential odor problems can be minimized or avoided. Section III contains odor control measures, which should be implemented as part of the land application program.

### **Soil Fertility Testing**

#### **23. All fields used for the production of agricultural crops should have soils sampled and tested on a regular basis to determine where manure nutrients can best be utilized.**

One goal of a well-managed manure application program is to utilize soil testing and fertilizer recommendations as a guide for applying manures. This will allow as much of the manure nutrients as possible to be used for supplying crop nutrient requirements. Any additional nutrients needed by the crop can be provided by commercial fertilizers. Soil test results will change over time depending on fertilizer and manure additions, precipitation, runoff, leaching, soil erosion, and nutrient removal by crops. Therefore, soil testing should be done once every one to four years, with the frequency of soil sampling dependent on (a) how closely an individual wants to track soil nutrient changes, (b) the crop(s) grown, (c) cropping rotation, (d) soil texture, and (e) the approach used for sampling. For information about soil fertility testing see Warncke, 1998 and Warncke and Gehl, 2006.

## **Fertilizer Recommendations**

- 24. Use current fertilizer recommendations, consistent with those of Michigan State University (MSU), to determine the total nutrient needs for crops to be grown on each field that could have manure applied.**

Fertilizer recommendations made by MSU Extension (Warncke *et al.*, 2009a and 2009b) are based on the soil fertility test, soil texture, crop to be grown, a realistic yield goal (average for past 3-5 years), and past crop. Fertilizer recommendations can then be utilized by the livestock producer to help identify on which fields manure nutrients will have the greatest value in reducing the amounts of commercial fertilizers needed, thereby returning the greatest economic benefit. For additional information, see the current GAAMPs for Nutrient Utilization.

## **Manure Analysis**

- 25. To determine the nutrient content of manure, analyze it for percent dry matter (solids), ammonium N (NH<sub>4</sub>-N), and total N, P, and K.**

Several factors which will determine the nutrient content of manures prior to land application are: (a) type of animal species, (b) composition of the feed ration, (c) amount of feed, bedding, and/or water added to manure, (d) method of manure collection and storage, and (e) climate. Because of the large variation in manure nutrient content due to these factors, it is not advisable to use average nutrient contents provided in publications when determining manure nutrient loadings for crop production. The best way to determine the nutrient content of manure and provide farm-specific information is to obtain a representative sample(s) of that manure and then have a laboratory analyze the sample(s). In order to establish "baseline" information about the nutrient content of each manure type on the farm, sample and test manures for at least a two year period. MSU [Extension \(MSUE\)](#) can provide information on collecting representative manure samples and where to send samples for analysis. A second approach to determine the nutrient content of manure is the use of mass balance as described by ASAE (2014) in the bulletin entitled *Manure Production and Characteristics*.

## **Manure Nutrient Loadings**

- 26. The agronomic (fertilizer) rate of N recommended for crops (consistent with current MSU N fertilizer recommendations) should not be exceeded by the amount of available N added, either by manure applied, or by manure plus fertilizer N applied, and/or by other N sources. For legume crops, the removal value of N may be used as the maximum N rate for manure applications. The available N per ton or per 1000 gallons of manure should**

**be determined by using a manure analysis and the appropriate mineralization factors for organic N released during the first growing season following application and the three succeeding growing seasons.**

Excessive manure applications to soils can: (a) result in excess nitrate-N ( $\text{NO}_3\text{-N}$ ) not being used by plants or the soil biology and increase the risk of  $\text{NO}_3\text{-N}$  being leached down through the soil and into groundwater; (b) cause P to accumulate in the upper soil profile and increase the risk of contaminating surface waters with P where runoff/erosion occurs; and (c) create nutrient imbalances in soils which may cause poor plant growth or animal nutrition disorders for grazing livestock. The greatest water quality concern from excessive manure loadings, where soil erosion and runoff is controlled, is  $\text{NO}_3\text{-N}$  losses to groundwater. Therefore, the agronomic fertilizer N recommendation (removal value for legumes) should never be exceeded.

The availability of N in manure for plant uptake will not be the same as highly soluble, fertilizer N. Therefore, total manure N cannot be substituted for that in fertilizers on a pound-for-pound basis, because a portion of the N is present in manure organic matter which must be decomposed, before mineral (inorganic) forms of N are available for plant uptake.

The rate of decomposition (or mineralization) of manure organic matter will be less than 100% during the first year and will vary depending on the type of manure and the method of manure handling. Therefore, in order to estimate how much of the total manure N in each ton or 1000 gallons of manure will be available for crops (and a credit against the N fertilizer recommendation), some calculations are needed. The total N and  $\text{NH}_4\text{-N}$  content from the manure analysis can be used with the appropriate mineralization factors to calculate this value. Management tools to assist with these calculations include (a) *Recordkeeping System for Crop Production--Manure Management Sheet #2* (Jacobs, 2015), (b) *Utilization of Animal Manure for Crop Production* Bulletins MM-2 and MM-3 (Jacobs 1995a and b), (c) *Nutrient Recommendations for Field Crops in Michigan* Bulletin E-2904 (Warncke *et al.*, 2009a), (d) *Nutrient Recommendations for Vegetable Crops in Michigan* Bulletin E-2934 (Warncke *et al.*, 2009b) or the *MSU Nutrient Management (MSUNM)* computer software program (Jacobs and Go, 2001)<sup>2</sup>.

In addition to the amount of plant-available N provided during the first year after a manure application, more N will be released from the residual organic matter not decomposed the first year. This additional decomposition and release of N will occur during the second, third and fourth years and should be estimated and included as an N

---

<sup>2</sup> Jacobs, L.W., and A. Go. 2001. *Michigan State University Nutrient Management (MSUNM) Microcomputer Program, Windows Version 1.0.* Department of Crop and Soil Sciences and Department of Agricultural Engineering, Mich. State Univ., East Lansing, MI. As of 29 June 2015, this software is no longer being distributed, but it is still used by certain technical service providers and consultants.



credit against the fertilizer recommendation to avoid excessive N additions to the soil-plant system. At the present time, organic N released (mineralized) during the second, third and fourth cropping years is estimated to be 50 percent, 25 percent, and percent, respectively, of the amount released the first year. To assist with the calculations for estimating this carryover N from previous manure applications, the same management tools listed in the preceding paragraph can be used.

**27. If the Bray P1 soil test level for P reaches 150 lb./acre<sup>3</sup> (75 ppm), manure applications should be managed at an agronomic rate where manure P added does not exceed the P removed by the harvested crop. (If this manure rate is impractical due to manure spreading equipment or crop production management, a quantity of manure P equal to the amount of P removed by up to four crop years may be applied during the first crop year. If no additional fertilizer or manure P is applied for the remaining crop years, and the rate does not exceed the N fertilizer recommendations for the first crop grown). If the Bray P1 soil test reaches 300 lb./acre (150 ppm) or higher, manure applications should be discontinued until nutrient harvest by crops reduces P test levels to less than 300 lb./acre. To protect surface water quality against discharges of P, adequate soil and water conservation practices should be used to control runoff, erosion and leaching to drain tiles from fields where manure is applied.**

While the availability of N and P in manure may be considerably less than 100 percent, the availability of K in manure is normally considered to be close to 100 percent. Periodic soil testing can be used to monitor the contribution made by P and K to soil fertility levels, but soil tests have not been very effective to determine the amount of N a soil can provide for plant growth.

When manures are applied to supply all the N needs of crops, the P needs of crops will usually be exceeded, and soil test levels for P will increase over time. If Bray P1 soil test P levels reach 300 lb./acre (150 ppm), the risk of losing soluble P and sediment-bound P by runoff and erosion (i.e., nonpoint source pollution) increases. Therefore, adequate soil and water conservation practices to control runoff and erosion should be implemented. For example, conservation tillage can enhance infiltration of water into soils, thereby reducing runoff, soil erosion, and associated P loadings to surface waters. Nevertheless, if Bray P1 soil test P levels reach 300 lb./acre, no more manure (or fertilizer) P should be applied until nutrient harvest by crops reduces P test levels to less than 300 lb./acre.

To avoid reaching the 300 lb./acre Bray P1 soil test level, manure application rates

---

<sup>3</sup> If the Mehlich 3 extractant is utilized for the soil fertility test instead of the Bray P1 extractant, then the following equivalent Mehlich 3 soil test levels can be used for Michigan soils: 150 lb. P/acre (Bray P1) = 165 lb. P/acre (Mehlich 3) and 300 lb. P/acre (Bray P1) = 330 lb. P/acre (Mehlich 3).

should be managed to provide the P needs of crops rather than providing all of the N needs of crops and adding excess P. Therefore, if the Bray P1 soil test level for P reaches 150 lb./acre (75 ppm), manure applications should be managed at a rate where manure P added does not exceed the P removed by the harvested crop. The quantity of manure P<sub>2</sub>O<sub>5</sub> that should be added can be estimated from Tables A1 and A2 (Appendix A), using a realistic yield goal for the crop to be grown. Fertilizer P recommendations are given in, and fertilizer P is sold as, pounds of phosphate (P<sub>2</sub>O<sub>5</sub>). For example, if a yield of 120 bu./acre for corn grain is anticipated, the amount of manure P<sub>2</sub>O<sub>5</sub> added to this field should be limited to no more than 44 lb./acre (120 bu./acre X 0.37 lb. P<sub>2</sub>O<sub>5</sub>/bu. nutrient removal rate).

Up to four crop years of P<sub>2</sub>O<sub>5</sub> removal is allowed to be applied as manure P<sub>2</sub>O<sub>5</sub> when the Bray P1 soil test is 150-299 lb. P/acre. A two to four year crop removal rate of P<sub>2</sub>O<sub>5</sub> will accommodate application rates more practical for manure spreading equipment and crop rotations when one crop (e.g., alfalfa) will be grown for two to four years, making manure applications to this crop difficult. An acceptable manure application rate can be calculated using the P<sub>2</sub>O<sub>5</sub> content of the manure and the P<sub>2</sub>O<sub>5</sub> crop removal (Tables A1 and A2, Appendix A) for the crop(s) to be grown and yields expected for up to four crop years. However, the calculated manure application rate cannot apply more plant-available N (calculated as described above following Practice No. 32) than the amount of the N fertilizer recommendation for the crop to be grown the first year.

Once a suitable manure application rate is calculated, the manure P<sub>2</sub>O<sub>5</sub> that is applied becomes a P<sub>2</sub>O<sub>5</sub> credit for that field. No additional fertilizer or manure P<sub>2</sub>O<sub>5</sub> can be applied to this field until accumulative crop P<sub>2</sub>O<sub>5</sub> removal by harvest (Tables A1 and A2, Appendix A) for one or more years has equaled this P<sub>2</sub>O<sub>5</sub> credit. Since several fields and different time periods for individual fields may be used for this two to four year P<sub>2</sub>O<sub>5</sub> option, a good recordkeeping system tracking these P<sub>2</sub>O<sub>5</sub> credits should be used.

### **Manure Nutrient Loadings on Pasture Land**

In pasture systems where the grazed forage is the sole feed source for livestock, nutrients from manure deposited by the grazing livestock will not exceed the nutrient requirement of the pasture forage. These types of pasture systems may actually require supplemental nutrient applications to maintain forage quality and growth. Pasture systems utilizing supplemental feed (e.g., swine farrow/finish) often result in manure nutrient deposition in excess of pasture forage requirements. Therefore, nutrient management with rotation to harvested forage or row crops is necessary. Available nutrient deposition should be quantified based on livestock density and nutrient mineralization factors. Manure nutrient loadings should be based on the rotational crop nutrient requirement consistent with those recommended by MSU, as noted above.

### **Method of Manure Application**

**28. Manures should be uniformly applied to soils. The amount of manure applied per acre (gallons/acre or tons/acre) should be known, so manure nutrients can be effectively managed.**

As is true with fertilizers, lime and pesticides, animal manures should be spread uniformly for best results in crop production. Also, in order to know the quantity of manure nutrients applied, the amount of manure applied must be known. Determining the gallons/acre or tons/acre applied by manure spreading equipment can be accomplished in a variety of ways. One method is to measure the area of land covered by one manure spreader load or one tank wagon of manure. A second method is to record the total number of spreader loads or tank wagons applied to a field of known acreage. With either approach, the capacity of the spreader (in tons) or the tank wagon (in gallons) must be known, and some way to vary the rate of application will be needed, such as adjusting the speed of travel or changing the discharge settings on the manure spreading equipment. Guidance is available from MSUE to help determine the rates of manure application that a livestock producer's equipment can deliver.

Incorporating manure immediately (i.e., within 48 hours following surface application) will minimize odors and ammonia ( $\text{NH}_3$ ) loss. When manures are surface applied, available N can be lost by volatilization of  $\text{NH}_3$ . These losses will increase with time and temperature and will be further increased by higher wind speeds and lower humidities. Therefore, injecting manures directly into the soil or immediately incorporating surface-applied manure will minimize  $\text{NH}_3$  volatilization losses and provide the greatest N value for crop production. Table A3 (Appendix A) shows potential volatilization losses when manures are applied to the soil and allowed to dry on the surface before incorporation. When dilute effluents from lagoons that contain low solids (<2 percent) are applied/irrigated at rates that do not cause ponding, most of the  $\text{NH}_4\text{-N}$  will likely be absorbed into the soil and retained. Surface application of manures viathrough irrigation (or other methods without incorporation provides alternatives to producers who use (a) reduced or no-till soil management, (b) supplemental irrigation of crops, or (c) application to land with established pasture or other forages, etc.

**29. Manures should not be applied to soils within 150 feet of surface waters or to areas subject to flooding unless: (a) manures are injected or surface-applied with immediate incorporation (i.e., within 48 hours after application) and/or (b) conservation practices are used to protect against runoff and erosion losses to surface waters.**

**30. Liquid manure applications should be managed in a manner to optimize nutrient utilization and not result in ponding, soil erosion losses, or manure runoff to adjacent property, drainage ditches or surface water. Manure applications to crop-land with field drainage tiles should be managed in a manner to keep the manure within the root zone of the soil and to prevent**

## **manure from reaching tile lines.**

To reduce the risk of runoff/erosion losses of manure nutrients, manures should not be applied and left on the soil surface within 150 feet of surface waters. Manures that are injected or surface applied with immediate incorporation can be closer than 150 feet, as long as conservation practices are used to protect against runoff and erosion. A vegetative buffer between the application area and any surface water is a desirable conservation practice. Manure should not be applied to grassed waterways or other areas where there may be a concentration of water flow, unless used to fertilize and/or mulch new seedlings following waterway construction. Manure should not be applied to areas subject to flooding unless injected or immediately incorporated. Liquid manures should not be applied in a manner that will result in ponding or runoff to adjacent property, drainage ditches, or surface water. Therefore, application to saturated soils, such as during or after a rainfall, should be avoided.

Manure applications to crop-land with field drainage tiles should be managed in a manner that keeps manure from reaching tile lines. Liquid manure has the risk of following preferential flow paths through cracks, worm holes, and other soil macropores to field drainage tiles. Liquid manure can also reach field drainage tiles when soils are saturated. This flow can result in a discharge of manure nutrients and contaminants to surface waters. Risks of manure entering field tile can be reduced by analyzing field conditions prior to land application of liquid manure such as tile location and depth, tile inlets, soil type, evidence of soil cracking and soil moisture holding capacity. Recent precipitation and forecasted precipitation should be considered. Enviroweather (<https://www.enviroweather.msu.edu/>) and Michigan Enviroimpact (<http://www.enviroimpact.iwr.msu.edu/>) are tools that can help in making land application decisions although neither are designed to be used exclusively.

Whenever possible, tile outlets should be observed before and after land application. Observations should note the relative amount of flow, color, and odor to confirm that no flow of manure nutrients is occurring. Indications of a discharge may be confirmed by an odor or change in discharge water color or cloudiness from observation done prior to application, oil films, floating solids, or foams (EPA, 1999). Tile which is flowing prior to land application may be an indication that the soil is saturated. A saturated soil does not have any additional holding capacity. Land application to saturated soils should be avoided. Manure application rates and application methods should be based on field and weather conditions.

Complementary information and preventative actions can be found in *Keeping Land-Applied Manure in the Root Zone Part 2: Tile-Drained Land* Bulletin WO-1037 (Harrigan *et al.*, 2007)) and the NRCS [MI](#) Conservation Practice Standard *Drainage Water Management 554* (USDA-NRCS-MI FOTG). These actions are not a substitute for properly evaluating field and weather conditions as described above.

Guidance and specific actions to take in response to a discharge of manure from a crop field subsurface drainage tile line that reaches surface water include reporting a manure spill to the Michigan Department of Environmental Quality (MDEQ), Great Lakes, and Energy (EGLE) district office during business hours or the Pollution Emergency Alerting System (PEAS) at 1-800-292-4706 during other times.

**31. As land slopes increase from zero percent, the risk of runoff and erosion also increases, particularly for liquid manure. Adequate soil and water conservation practices should be used which will control runoff and erosion for a particular site, taking into consideration such factors as type of manure, bedding material used, surface residue or vegetative conditions, soil type, slope, etc.**

As land slopes increase, the risk of runoff and erosion losses to drainage ways, and eventually to surface waters, also increases. Soil and water conservation practices should be used to control and minimize the risk of nonpoint source pollution to surface waters, particularly where manures are applied. Injection or surface application of manure with immediate incorporation should generally be used when the land slope is greater than ~~6-six~~ percent. However, a number of factors, such as liquid ~~vsversus~~ solid or semi- solid manures, rate of application, amount of surface residues, soil texture, drainage, etc. can influence the degree of runoff and erosion that could pollute surface water. Therefore, adequate soil and water conservation practices to control runoff and erosion at any particular site are more critical than the degree of slope itself.

### **Timing of Manure Application**

**32. Where application of manure is necessary in the fall rather than spring or summer, using as many of the following practices as possible will help to minimize potential loss of NO<sub>3</sub>-N by leaching: (a) apply to medium or fine rather than to coarse textured soils; (b) delay applications until soil temperatures fall below 50°F; and/or (c) establish cover crops before or after manure application to help remove NO<sub>3</sub>-N by plant uptake.**

Ideally, manure (or fertilizer/other source) nutrients should be applied as close as possible to, or during, periods of maximum crop nutrient uptake to minimize nutrient loss from the soil-plant system. Therefore, spring or early summer application is best for conserving nutrients, whereas fall application generally results in greater losses, particularly for nitrogen as NO<sub>3</sub>-N on coarse textured soils (i.e., ~~17~~ sands, loamy sands, sandy loams).

**33. Application of manure to frozen or snow-covered soils should be avoided, but where necessary, (a) solid manures should only be applied to areas where slopes are six percent or less and (b) liquid manures should only be applied to soils where slopes are three percent or less. In either situation,**

**provisions must be made to control runoff and erosion with soil and water conservation practices, such as vegetative buffer strips between surface waters and soils where manure is applied.**

Winter application of manure is the least desirable in terms of nutrient utilization and prevention of nonpoint source pollution. Frozen soils and snow cover will limit nutrient movement into the soil and greatly increase the risk of manure being lost to surface waters by runoff and erosion during thaws or early spring rains. When winter application is necessary, appropriately-sized buffer strips should be established and maintained between surface waters and frozen soils where manure is applied to minimize any runoff and erosion of manure from reaching surface waters. Particular attention to field slopes, reductions in manure application rates, and fields with surface water inlets can help prevent runoff and erosion from frozen and/or snow covered soils where manure is applied. Weather forecasts should be considered when planning winter applications to avoid a significant rain or melting event.

A field-specific assessment, such as the *Manure Application Risk Index v 4.0 (MARI)*; Grigar, 2013) and the Michigan P Assessment Tool v 2.0 (Gangwer, 2012) will help evaluate the risk for runoff losses. MARI and Michigan P Assessment Tool can be found at USDA-NRCS-MI, 2018, in Section IV, "Conservation Practices" sub section, "Nutrient Management Tools (AC) (590)", folder "Nutrient Management Tools and References" subfolder.

### **Management of Manure Applications to Land**

**34. Records should be kept of manure analyses, soil test reports, and rates of manure application for individual fields. Records should include manure analysis reports and the following information for individual fields:**

- a. Ssoil fertility test reports;**
- b. date(s) of manure application(s);**
- c. rate of manure applied (e.g., gallons or wet tons per acre);**
- d. previous crops grown on the field; and,**
- e. yields of past harvested crops.**

Good record keeping demonstrates good management and will be beneficial for the producer.

An important ingredient of a successful program for managing the animal manure generated by a livestock operation is "planning ahead". An early step of a manure application plan is to determine whether enough acres of cropland are available for utilizing manure nutrients without resulting in excess nutrient application to soils. This is often referred to as 'agronomic balance'.

Determination of agronomic balance requires estimates of manure quantities and manure nutrients produced by different types of livestock and estimates of crop nutrient removal. Balance is most often determined for phosphorus, but may also include projections for other nutrients. Animal manure and crop removal estimates may be obtained using the following:

- Table A4 of these GAAMPs which was derived by ASAE (2014) using the default or average for each animal type. Together, Table A4 and A5 can provide further guidance regarding N losses that can occur during handling and storage of manures before they are applied.
- Nutrient Recommendations for Field Crops in Michigan Bulletin E-2904 (Warncke *et al.*, 2009a)
- Nutrient Recommendations for Vegetable Crops in Michigan Bulletin E-2934 (Warncke *et al.*, 2009b).

Computer software has been developed to assist with development of manure spreading plans, the determination of agronomic balance, and the maintenance of manure spreading-crop production records:

- *MSUNM* (Jacobs and Go, 2001)<sup>2</sup>
- *Manure Management Planner* (Purdue Research Foundation, 2014)
- *Nutrient Inventory* (Koelsch and Powers, 2010; 2013).

This information can be used to compare the quantity of available manure nutrients against the quantity of nutrients removed by the crops to be grown in the livestock operation. If the quantity of manure nutrients being generated greatly exceeds the annual crop nutrient needs, then alternative methods for manure utilization should be identified. For example, cooperative agreements with neighboring landowners to provide additional land areas to receive and properly utilize all of the manure nutrients may be necessary.

Another consideration is to use good judgment when planning manure applications in conjunction with normal weather patterns, the availability of land at different times during the growing season for different crops, and the availability of manpower and equipment relative to other activities on the farm which compete for these resources. Having adequate storage capacity to temporarily hold manures can add flexibility to a management plan when unanticipated weather occurs, preventing timely applications. Nevertheless, unusual weather conditions do occur and can create problems for the best of management plans.

Finally, good recordkeeping is the foundation of a good management plan. Past manure analysis results will be good predictors of the nutrient content in manures being produced and applied today. Records of past manure application rates for individual

fields will be helpful for estimating the amount of residual N that will be available for crops to use this coming growing season. Changes in the P test levels of soils with time, due to manure P additions, can be determined from good records, and that information can be helpful in anticipating where manure rates may need to be reduced and when additional land areas may be needed. Recordkeeping systems, such as that described in MSUE Bulletin E-2340 (Jacobs, 2015) or available as a microcomputer program called MSUNM (Jacobs and Go, 2001)<sup>2</sup>, may be helpful in accomplishing this goal.



## APPENDICES

### APPENDIX A

Table A1. Approximate nutrient removal (lb./unit of yield) in the harvested portion of several Michigan field crops.<sup>4</sup>

Crop		Unit	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
---- lb. per unit ----					
Alfalfa	Hay	ton	45 <sup>5</sup>	13	50
	Haylage	ton	14	4.2	12
Barley	Grain	bushel	0.88	0.38	0.25
	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	bushel	1.7	0.25	0.25
Canola	Grain	bushel	1.9	0.91	0.46
	Straw	ton	15	5.3	25
Clover	Hay	ton	40 <sup>5</sup>	10	40
Clover-grass	Hay	ton	41	13	39
Corn	Grain	bushel	0.90	0.37	0.27
	Grain <sup>6</sup>	ton	26	12	6.5
	Stover	ton	22	8.2	32
	Silage	ton	9.4	3.3	8.0
Millet	Grain	bushel	1.1	0.25	0.25
Oats	Grain	bushel	0.62	0.25	0.19
	Straw	ton	13	2.8	57
Orchardgrass	Hay	ton	50	17	62
Potatoes	Tubers	cwt	0.33	0.13	0.63
Rye	Grain	bushel	1.1	0.41	0.31
	Straw	ton	8.6	3.7	21
	Silage	ton	3.5	1.5	5.2
Sorghum	Grain	bushel	1.1	0.39	0.39
Sorghum-Sudangrass (Sudax)	Hay	ton	40	15	58
	Haylage	ton	12	4.6	18
Soybeans	Grain	bushel	3.8	0.80	1.4
Spelts	Grain	bushel	1.2	0.38	0.25
Sugar Beets	Roots	ton	4.0	1.3	3.3
Sunflower	Grain	bushel	2.5	1.2	1.6
Timothy	Hay	ton	45	17	62
Trefoil	Hay	ton	48 <sup>5</sup>	12	42
Wheat	Grain	bushel	1.2	0.63	0.37
	Straw	ton	13	3.3	23

<sup>4</sup> Source: Warncke *et al.*, 2009a.

<sup>5</sup> Legumes get most of their nitrogen from air.

<sup>6</sup> High moisture grain.

Table A2. Approximate nutrient removal (lb./unit of yield) in the harvested portion of several Michigan vegetable crops.<sup>7</sup>

Crop <sup>8</sup>	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	---- lb./ton <sup>9</sup> ----		
Asparagus crowns, new planting, or established	13.4	4.0	10
Beans, snap	24	2.4	11
Beets, red	3.5	2.2	7.8
Broccoli	4.0	1.1	11
Brussels Sprouts	9.4	3.2	9.4
Cabbage, fresh market, processed Chinese	7.0	1.6	6.8
Carrots, fresh market or processing	3.4	1.8	6.8
Cauliflower	6.6	2.6	6.6
Celeriac	4.0	2.6	6.6
Celery, fresh market or processing	5.0	2.0	11.6
Cucumbers, pickling (hand or machine harvested)	2.0	1.2	3.6
Cucumber, slicers	2.0	1.2	3.6
Dill	3.5	1.2	3.6
Eggplant	4.5	1.6	5.3
Endive	4.8	1.2	7.5
Escarole	4.8	1.2	7.5
Garden, home	6.5	2.8	5.6
Garlic	5.0	2.8	5.6
Ginseng	4.6	1.2	4.6
Greens, Leafy	4.8	2.0	6.0
Horseradish	3.4	0.8	6.0
Kohlrabi	6.0	2.6	6.6
Leek	4.0	2.6	4.8
Lettuce, Boston, bib	4.8	2.0	9.0
Lettuce, leaf, head, or Romaine	4.8	2.0	9.0
Market Garden	6.5	2.8	5.6
Muskmelon	8.4	2.0	11
Onions, dry bulb or green	5.0	2.6	4.8

<sup>7</sup> Source: Warncke *et al.*, 2009b

<sup>8</sup> Values used for some crops are estimates based on information for similar crops.

<sup>9</sup> 1 ton = 20 cwt.

Table A2. Continued.

<b>Crop<sup>8</sup></b>	<b>N</b>	<b>P<sub>2</sub>O<sub>5</sub></b>	<b>K<sub>2</sub>O</b>
	---- lb./ton <sup>9</sup> ----		
Pak Choi	7.0	1.6	6.8
Parsley	4.8	1.8	12.9
Parsnip	3.4	3.2	9.0
Peas	20	4.6	10
Peppers, bell, banana, or hot	4.0	1.4	5.6
Pumpkins	4.0	1.2	6.8
Radish	3.0	0.8	5.6
Rhubarb	3.5	0.6	6.9
Rutabagas	3.4	2.6	8.1
Spinach	10	2.7	12
Squash, hard	4.0	2.2	6.6
Squash, summer	3.6	2.2	6.6
Sweet Corn	8.4	2.8	5.6
Sweet potato	5.3	2.4	12.7
Swiss Chard	3.5	1.2	9.1
Tomatoes, fresh market or processing	4.0	0.8	7.0
Turnip	3.4	1.2	4.6
Watermelon	4.8	0.4	2.4
Zucchini	4.6	1.6	6.6

Table A3. Ammonium nitrogen volatilization losses for surface application of solid and semi-solid manures.<sup>10</sup>

<b>Days Before Incorporation</b>	<b>Retention Factor (RF)</b>	<b>Loss Factor (LF)</b>
0-1 day	0.70	0.30
2-3 days	0.40	0.60
4-7 days	0.20	0.80
>7 days	0.10	0.90

<sup>10</sup> Source: Jacobs, 2015.

Table A4. Manure and manure nutrients produced by different livestock species.<sup>11</sup>

Species	Type and production grouping	Manure/day			Nutrients-lb./day		
		Total ft <sup>3</sup>	Total lb. wet	Total solids-lb.	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Dairy	Calf-330 lb.	0.300	19.0	3.20	0.140	0.046	0.048
	Heifer-970 lb.	0.780	48.0	8.20	0.260	0.101	0.132
	Lactating cow-88 lb. milk/d	2.400	150.0	20.00	0.990	0.389	0.276
	Dry cow	1.300	83.0	11.00	0.500	0.151	0.396
	Veal-260 lb.	0.120	7.8	0.27	0.033	0.023	0.053
Beef	Growing calf-450 to 750 lb. in confinement	0.810	50.0	6.00	0.290	0.126	0.228
	Finishing-750 to 1215 lb. and 153 d growth	1.046	64.0	5.10	0.350	0.110	0.298
	Cow-confinement, not lactating, in first 6 mo. of pregnancy	2.000	125.0	15.00	0.420	0.222	0.360
Swine	Nursery pig-27.5 lb.	0.039	2.4	0.28	0.025	0.010	0.012
	Growing & finishing-154 lb.	0.167	10.0	1.00	0.083	0.032	0.044
	Gestating-440 lb.	0.180	11.0	1.10	0.071	0.046	0.058
	Lactating-423 lb.	0.410	25.0	2.50	0.190	0.126	0.144
	Boar-440 lb.	0.130	8.4	0.84	0.061	0.048	0.047
Sheep	Lamb-100 lb. feeder	0.060	4.0	1.05	0.040	0.020	0.040
Horse	Average of sedentary and exercised-1100 lb.	0.910	57.0	8.50	0.270	0.117	0.252
Poultry-per 100 birds	Chicken layers <u>- 3 lb. average</u>	0.310	19.0	4.90	0.350	0.252	0.156
	Chicken broilers-2.6 lb. average in 48 d growth	0.354	22.9	5.83	0.250	0.167	0.170
	Turkeys-toms 17 lb. average in 133 d growth	0.977	58.6	15.04	0.902	0.620	0.514
	Turkeys-hens 8 lb. average in 105 d growth	0.581	36.2	9.33	0.543	0.349	0.286
	Ducks-4 lb. average in 39 d growth	0.590	35.9	9.49	0.359	0.282	0.209

<sup>11</sup> Source: ASAE, 2014. Where the ASAE D384.2 excretion estimates could not be made, values were obtained from Chapter 4 of the AWMFH, Part 651, (USDA-NRCS, 2008) and Midwest Plan Service Publication MWPS-18, Section 1 (2000) and are presented in the table as bolded text.

Table A5. Nitrogen losses during handling and storage.<sup>12</sup>

<b>Manure Type</b>	<b>Handling System</b>	<b>Nitrogen Lost (percent)</b>
Solid	Daily scrape & haul	20-35
	Manure pack	20-40
	Open lot	40-55
	Deep pit (poultry)	25-50
	Litter	25-50
Liquid	Anaerobic pit	15-30
	Above-ground	10-30
	Earth Storage	20-40
	Lagoon	70-85

<sup>12</sup> Source: *MidWest Plan Service, 1993.*

Table A6. Michigan 25-Year, 24-Hour Precipitation by County.<sup>13</sup>

County	Precipitation (inches)	County	Precipitation (inches)
Alcona	3.49	Lake	4.50
Alger	3.70	Lapeer	4.05
Allegan	4.67	Leelanau	3.98
Alpena	3.39	Lenawee	4.15
Antrim	3.92	Livingston	4.05
Arenac	3.87	Luce	3.69
Baraga	4.14	Mackinac	3.67
Barry	4.41	Macomb	3.97
Bay	4.17	Manistee	4.42
Benzie	4.18	Marquette	3.96
Berrien	4.63	Mason	4.69
Branch	4.43	Mecosta	4.43
Calhoun	4.28	Menominee	3.91
Cass	4.71	Midland	4.24
Charlevoix	3.82	Missaukee	4.39
Cheboygan	3.64	Monroe	3.98
Chippewa	3.69	Montcalm	4.47
Clare	4.10	Montmorency	3.59
Clinton	4.34	Muskegon	4.98
Crawford	3.88	Newaygo	4.64
Delta	3.82	Oakland	4.12
Dickinson	3.96	Oceana	4.96
Eaton	4.14	Ogemaw	3.81
Emmet	3.62	Ontonagon	4.40
Genesee	4.08	Osceola	4.25
Gladwin	4.10	Oscoda	3.54
Gogebic	4.75	Otsego	3.87
Grand Traverse	4.01	Ottawa	4.92
Gratiot	4.43	Presque Isle	3.53
Hillsdale	4.27	Roscommon	3.88
Houghton	4.04	Saginaw	4.34
Huron	3.94	Sanilac	3.92
Ingham	4.08	Schoolcraft	3.72
Ionia	4.50	Shiawassee	4.24
Iosco	3.69	St Clair	3.97
Iron	4.19	St Joseph	4.58
Isabella	4.34	Tuscola	4.12
Jackson	4.06	Van Buren	4.64
Kalamazoo	4.49	Washtenaw	3.96
Kalkaska	3.95	Wayne	3.98
Kent	4.71	Wexford	4.19
Keweenaw	3.70		

<sup>13</sup> Source: National Oceanic and Atmospheric Administration Atlas 14, (NOAA-14), Volume 8, Version 2, 2015. <http://hdsc.nws.noaa.gov/hdsc/pfds/>

## **APPENDIX B**

### Manure and Nutrient Management Plans

Manure and nutrient management plans are management tools that provide detailed information about your farm and any operations dealing with the farm regarding the GAAMPs previously discussed. Every farm should have a plan, and one may be needed to determine conformance to the GAAMPs, especially if a complaint is registered with the MDA~~RD~~'s complaint response program.

#### **Manure Management System Plan**

A Manure Management System Plan (MMSP) focuses on two subject areas: (1) management of manure nutrients and (2) the management of manure and odor. The most critical aspect of a MMSP to ensure that a livestock operation remains environmentally sustainable is to determine the quantity of manure nutrients (nitrogen, phosphate, and potash) that is being generated by the operation. Then you must determine how these nutrients can be utilized in accordance with the aforementioned GAAMPs either on the livestock farm or transported off the farm for utilization elsewhere. Good management of manure nutrients for crop uptake and nutrient utilization will help prevent loss of nutrients into surface water and groundwater resources.

A MMSP will include most, but probably not all, of the following components:

1. Production refers to the amount of volume of manure and any other agricultural by-products produced and the associated nutrient content. Examples include total manure produced, silage leachate, milk house wastewater, and/or rainwater that flow through the barnyard.
2. Collection refers to how manure and any other by-products will be gathered for management. This includes collection points, method and scheduling of collection, and structural facilities needed. Examples include: solid stacking, a scraping system, a flushing system, slotted floors, etc.
3. Transfer occurs throughout the system and may take different forms at different steps in the system. Transfer includes movement between production and collection points, storage facilities, treatment facilities, and land application. The plan may specify the method, distance, frequency, and equipment needs for transfer.
4. If storage facilities are part of the system, the type of storage device should be described (e.g., underground concrete tank, solid manure stack, earthen basin). The plan should include the intended storage time, storage volume, shape and dimensions, and site location.
5. Treatment of manure and any other by-products may occur either before or after storage, depending on the system, and can be physical, biological, and/or

chemical. Common forms of treatment include solids separation, anaerobic and aerobic lagoons, composting and methane digesters. Treatment usually involves more intensive management and may require specialized equipment, but it is not a necessary component for all systems.

6. Utilization refers to the end-use of the manure and other livestock operation by-products. A use needs to be identified for the full quantity of manure and other by-products, as described in the "production" section. For most livestock operations, manure and other by-products are used as a nutrient source for crops. Soil test information, manure and by-product nutrient content, crops to be grown, realistic yield goals, and availability of crop fields are key elements in scheduling land applications and utilizing manure and other by-products for nutrients. Other end-uses may include, but are not limited to, use as a feed supplement and use of composted manure as a mulch, soil amendment, or as bedding material.
7. Recordkeeping plays a critical role in helping make decisions that lead to effective environmental protection and beneficial use of manure related materials. Records also play a critical role in documenting, communicating, and assessing sound manure management practices that can help assure the general public that the environment is being protected.
8. Odor management practices that reduce the frequency, intensity, duration, and offensiveness of odors may be included in any of the above steps. Air quality is an important factor when considering neighbor relations and environmental impacts.

A MMSP ~~that~~ accurately and completely describes the current physical system and the associated management practices, along with records that document implementation of the plan, and demonstrate responsible management. For additional assistance on developing a MMSP, contact MSU Extension, USDA ~~Natural Resources Conservation Service~~ NRCS, Conservation Districts, or a private consultant.

### Comprehensive Nutrient Management Plan

A Comprehensive Nutrient Management Plan (CNMP) is the next step beyond a MMSP. All efforts put towards a MMSP may be utilized in the development of a CNMP, as it is founded on the same eight components as the MMSP, with a few significant differences. Some of the "optional" sub-components of a MMSP are required in a CNMP. Examples include veterinary waste disposal and mortality management. In addition, the "production" component is more detailed regarding items such as rainwater, plate cooler water, and milk house wastewater. More thorough calculations are also needed to document animal manure and by-product production.

Another difference between a MMSP and a CNMP is in the "utilization" component. With a MMSP, nutrients need to be applied at agronomic rates and according to realistic



yield goals. However, with a CNMP, a more extensive analysis of field application is conducted. This analysis includes the use of the MARI (Gangwer, 2008; Grigar, 2013) to determine suitability for winter spreading, and the Revised Universal Soil Loss Equation, Version 2 (RUSLE2; USDA-ARS, 2014) to determine potential nutrient loss from erosive forces, and other farm specific conservation practices. More detail regarding the timing and method of manure applications and long term cropping system/plans must be documented in a CNMP.

Additional information on potential adverse impacts to surface and groundwater and preventative measures to protect these resources are identified in a CNMP. Although the CNMP provides the framework for consistent documentation of a number of practices, the CNMP is a planning tool not a documentation package.

Odor management is included in both the MMSP and CNMP.

Implementation of a MMSP is ongoing. A CNMP Implementation Schedule typically includes long-term change. These often include installation of new structures and/or changes in farm management practices that are usually phased in over a longer period of time. Such changes are outlined in the CNMP Implementation Schedule, providing a reference to the producer for planning to implement changes within their own constraints.

As is described above, a producer with a sound MMSP is well on his/her way to developing a CNMP. Time spent developing and using a MMSP will help position the producer to ultimately develop a CNMP on their farm, if they decide to proceed to that level or when they are required to do so.

## WHO NEEDS A CNMP?

1. Some livestock production facilities receiving technical and/or financial assistance through USDA-NRCS Farm Bill program contracts.
2. A livestock production facility that a) applies for coverage with the ~~MDEQ's~~ EGLE's National Pollutant Discharge Elimination System (NPDES) permit<sup>14</sup>, or b) is directed by ~~MDEQ-EGLE~~ on a case by case basis.
3. A livestock farm that is required to have a CNMP as a result of NPDES permit coverage that desires third party verification in ~~the~~ MDARD's Michigan Agriculture Environmental Assurance Program (MAEAP) Livestock System verification<sup>15</sup>.

<sup>14</sup> For additional information regarding the NPDES permit, go to: [http://www.michigan.gov/deq/0,4561,7-135-3313\\_51002\\_3682\\_3713-10440--,00.html](http://www.michigan.gov/deq/0,4561,7-135-3313_51002_3682_3713-10440--,00.html)

<sup>15</sup> For additional information regarding MAEAP, go to: [www.maeap.org](http://www.maeap.org) or telephone 517-284-5609.

## **APPENDIX C**

### Sample Manure Management System Plan (MMSP)

#### **I. General Overview**

Dairy farm is currently a partnership between a farmer and his two sons. The dairy currently has 150 head of cows in the milking herd and approximately 100 replacement stock on the farm (one animal unit equals 1,000 pounds), which includes lactating and dry cows, replacement heifers and calves. The land base of the operation is approximately 1,275 acres. Crops grown on the farm are corn grain, corn silage, wheat, and alfalfa. The purpose of this plan is to indicate how manure produced on the farm is managed to meet the current Michigan Right-To-Farm management practices, while utilizing the nutrients for crop production, without causing any adverse environmental impacts. Currently, there are no plans of any future expansion of the operation.

Soil testing is being done on the crop fields to have current soil tests on hand. Soil testing will be done on any field, which does not have a current soil test (no more than three years old). Manure testing is planned for the spring of 2010 to obtain nutrient levels of the manure. Manure tests will be done at least three times during the first year to establish a base line and then at least once a year thereafter, or more often if feed rations or bedding types and quantities are changed.

#### **II. Volume and Nutrient Production from All Sources**

Table C1. Estimated Annual Volume and Nutrient Production from All Sources

<b>Name of M Storage</b>	<b>Numbers of Animals (Size)</b>	<b>Consistency/ Contents</b>	<b>Estimated Annual Manure and Nutrient Production (values rounded)</b>			
			<b>Volume* (ft<sup>3</sup>)</b>	<b>Total N<sup>16</sup> (lb.)</b>	<b>P<sub>2</sub>O<sub>5</sub></b>	<b>K<sub>2</sub>O (lb.)</b>
Free Stall Barn	150 (1,400 lb.)	Liquid/Sand	131,000	44,900	23,000	26,300
Loafing Barn	50 (250 lb.)	Solid/Straw	5,840	1,460	360	1,280
Calf Barn	25 (150 lb.)	Solid/Straw	1,820	460	90	360
Open Heifers	25 (750 lb.)	Solid/Straw	9,120	2,100	640	2,010
<b>Totals</b>			148,000	48,900	24,100	30,000

<sup>16</sup> The nitrogen value does not include any nitrogen losses from storage, handling or land applications.

\*These volumes do not include bedding. (If manure storage facilities are to be built, the volume of bedding that will be included with the stored manure will need to be determined in order to size the storage appropriately.)

The manure produced is currently scraped daily and hauled from the free stall barn and parlor. The heifer barns, calf barn, and loafing barn are dry packed for up to one month and sometimes two, if needed, due to weather conditions. See the attachments for the locations of manure storage and animal numbers per barn.

Straw bedding in the additional barns is also hauled to the fields with the manure when the barns are cleaned. Any spoiled feed is hauled and spread on crop fields.

### **III. Manure Collection**

The free stall barn is scraped and hauled daily. This manure is scraped to a ramp where the manure spreader is parked below for loading. The milkhouse wastewater and parlor washwater are collected in an earthen structure south of the parlor. Any manure in the parlor is scraped away prior to flushing with clean water. The flush water is also collected in the earthen structure.

The manure from the young stock is dry packed in the corresponding barns (see attachment). All manure is under cover of the barns so polluted runoff is not a concern from the housed animals. The feed lot could be a potential source of polluted runoff, but any runoff will be contained on the farm and not allowed to move off site.

### **IV. Manure Storage**

The heifer barn is 30 ft. x 50 ft., the calf barn is 28 ft. x 48 ft., and the loafing barn is 62 ft. x 100 ft. The dry pack will vary from one to two feet in depth, depending on the spreading schedule. This allows for at least two months storage of manure.

There currently are no plans for additional storage facilities or expansion within the near future.

### **V. Manure Treatment**

There currently is no additional treatment of manure.

### **VI. Manure Transfer and Application**

The manure spreader used is a John Deere 785 Hydra Push Back. The box capacity is 243 cu. ft. or 1,818 gallons. This spreader is used for both liquid and solid manure.

The manure from the free stall barn is scraped from the barn down a ramp. The manure spreader is parked below the ramp, and the manure is scraped directly into the box. A front-end loader is used to load the spreader with the dry packed manure from the young stock barns.

Manure is typically applied during the summer after wheat, in the fall after corn harvest, through the winter, as needed, and in the spring just before planting. Manure, which is spread during the winter, is applied only to fields with slopes no greater than 6%. A 150 feet setback from surface water will be followed when spreading manure. Manure is incorporated within 48 hours after application in the summer. In order to assess the potential for polluted runoff from the spreading of manure in winter, all fields to which manure may be applied will be evaluated using MARI. Manure is transported from 1/4 to 1 1/2 miles from the headquarters. Most fields are located directly adjacent to the headquarters.

The manure spreader has not been calibrated in the past, but it has been planned for the summer of 2002. The Groundwater Stewardship Technician from MSU Extension is available to assist in calibrating the manure spreader.

## **VII. Manure Utilization**

Table C2. Estimated Annual Farm Nutrient Balance for Fields Receiving Manure

Crop Grown	Yield Goal	Acres (Typ Year)	Nitrogen (lb.)	Estimated Crop Nutrient Removal	
				P <sub>2</sub> O <sub>5</sub> (lb.)	K <sub>2</sub> O (lb.)
Corn	125 bu.	580	83,500	26,825	19,575
Corn Silage	20 tons	70	13,160	5,040	10,920
Alfalfa Haylage	20 tons	150	21,000	4,800	23,400
Alfalfa Hay	10 tons	150	21,000	4,800	23,400
Wheat	50 bu.	100	4,000	3,100	1,900
<b>Totals</b>		1050	142,680	44,565	79,195
Annual nutrient production from Table C1			45,920	20,656	30,918
Nutrients needed to balance cropping system			96,760	23,909	48,277

The manure nutrients will be utilized as fertilizer in the production of the field crops. The manure will provide approximately 45,920 lbs. of nitrogen (which does not include any N losses due to storage, handling or land application), 20,656 lbs. of P<sub>2</sub>O<sub>5</sub> and 30,918 lbs. of K<sub>2</sub>O annually. The manure will be land applied after the harvesting of the crops and in the spring before planting, with daily spreading throughout the year.

The crop rotation will be a corn, hay, and wheat rotation. Refer to Table C2 for realistic crop goals and acres planted during a typical year. The soils on this farm are loamy sands and sandy loams with clay loam inclusions. The slopes on these fields run from 2 percent% to 10 percent%.

To help determine rates of manure that can be applied to individual fields, a list of fields is included showing the average Bray P1 soil test levels in Table C3. The fields have been grouped by those fields having Bray P1 test levels <150 lb. P/ac, 150-299 lb. P/ac, and ≥300 lb. P/ac. Fields having <150 lb. P/ac will usually have manure applied to provide all of the N recommended for the crop and yield to be grown. To be in compliance with the Right To Farm GAAMPs, fields having soil test levels of 150-299 lb. P/ac will receive manure P<sub>2</sub>O<sub>5</sub> loadings equal to the P<sub>2</sub>O<sub>5</sub> expected to be removed by the harvested crop, and fields with soil tests ≥300 lb. P/ac will not receive any manure (currently, 225 of 1,275 acres will not be receiving manure i.e. applications).

Table C3. Field Identification Bray P1 Soil Test Results and Crops Grown.

Field Number	Acres	Bray P1 (lbs./ac.)	2010 Crop	2009 Crop
Fields with Bray P1 soil test levels <150 lb. P/ac				
7	40	114	Corn	Corn
8	80	102	Corn	Corn
5	160	97	Corn	Corn
6	150	132	Alfalfa Hay	Corn
13	150	128	Alfalfa Hay	Corn
4	100	142	Wheat	Corn Silage
Fields with Bray P1 soil test levels 150-299 lb. P/ac				
2	60	192	Corn	Corn
9	80	246	Corn	Alfalfa Hay
10	70	178	Corn Silage	Wheat
12	160	163	Corn	Alfalfa Hay
Fields with Bray P1 soil test levels ≥300 lb. P/ac				
1	75	354	Corn	Alfalfa Hay
11	110	315	Corn Silage	Corn Silage
3	40	456	Corn	Alfalfa Hay

## **VIII. Manure Recordkeeping System**

Yearly records will be kept on the following:

- Soil test results (three years old or less) on all fields where manure will be applied;
- mManure analysis (most recent);
- Manure and fertilizer spreading by field (where, when, how much, weather conditions, etc.);
- cCrops grown and yield data;
- dDate of spreader calibration; and
- Ccropping plan.

These records will be kept in a three-ring binder located at the farm headquarters.

## **IX. Odor Control Plan**

Odors from manure applications will be controlled by using the following practices:

- Spreading during times when neighbors may be spending time outside, such as on holidays or weekends will be avoided.
- Spreading during hot humid days when the air is heavy and still will be avoided as much as possible.
- Manure will be incorporated immediately or at least within 48 hours of application, unless being applied to alfalfa.

Odors from the facility will be controlled by using the following practices:

- Install visual screen via-through tree lines or fence rows to contain odors and reduce complaints from neighbors.
- Clean water will be diverted to help keep the facility dry.
- A cover will be kept on the silage or it will be kept in “Ag Bags”.

**THE FOLLOWING ITEMS ARE OPTIONAL, BUT ARE STILL GOOD IDEAS TO INCLUDE IN YOUR PLAN:**

## **X. Community Relations**

To develop and maintain a positive relationship with the entire community, one or more of the following should be considered:

- Keeping the farmstead area esthetically pleasing should be a high priority.

- Each spring, a farm newsletter could be sent to all appropriate community members describing farm activities, personnel, and management.
- A community picnic and farm tour could be held once a year for all in the immediate community and manure application areas.
- Your farm could be made available to local schools for farm visits as field trips or school projects.
- Participate in local community such as a local town festival, parade, etc., where there is an opportunity to do so.
- Communicate with your neighbors before and after applying manure near their respective homes.

## **XI. Emergency Manure Spill Plan**

Points that should be covered:

- Detailed procedure to be used in the event of a spill (e.g., listing contact people and notification phone numbers);
- Include the Michigan Department of Agriculture & Rural Development Ag Pollution Hotline (800)405-0101;
- Plan for spills that might happen at various places including a breach of the storage structure, at loading, during transport, and in the field;
- A large part of the Manure Spill Plan should have to do with prevention and monitoring (e.g., maintaining a minimum freeboard in your manure storage to prevent overflows, mowing manure storage berms and inspecting for burrowing animal activity periodically to prevent manure releases); and
- Include a farm map showing all structures at the farmstead.

## **XII. Veterinary Waste Disposal**

Explain how veterinary waste will be disposed of by the farm staff or attending veterinarian(s), e.g.,

- Any veterinary waste generated from farm medicating will be disposed of by having it picked up by a sanitary waste disposal company (residential trash removal).
- Any sharps (e.g, needles) will be placed in a closed container (such as an empty plastic bleach bottle, water bottle, juice bottle, etc.) to prevent needle pricks from occurring to any potential handler of the waste.

## **XIII. Mortality Disposal**

Explain how dead animals will be handled.



- Dead animals will be picked up by a rendering service within 24 hours.
- If animals are going to be buried, the Michigan Bodies of Dead Animals Act will be consulted for proper burial procedures.

#### **XIV. Conservation Plan**

Points that should be covered:

- Farm field soil conservation measures being used, such as conservation tillage, no till, and grass filter strips;
- Storm water runoff control measures, such as berms, retention basins, and infiltration strips;
- Runoff from driveways, silo aprons, and open feed lots; and
- Measures used to keep clean roof runoff out of manure.

**This Manure Management System Plan was prepared by:**

---

---

---

## REFERENCES

ACI Committee 318. 2014. *Building Code Requirements for Structural Concrete*, ACI-318-14 American Concrete Institute. Available at: <http://www.concrete.org/topicsinconcrete/topicdetail/318>. Accessed on 17 July 2015.

ASAE. 2014 (Reaffirmed). *Manure Production and Characteristics*. ASAE Standard D384.2. American Society of Agricultural and Biological Engineers. St. Joseph, MI. Available at: <http://www.asabe.org/publications/order-publications/standards.aspx>. Accessed on 29 June 2015.

Beef Cattle Resource Committee, 1999. *Beef Cattle Handbook*. Iowa State University Midwest Plan Service Available at: <https://www-mwps.sws.iastate.edu/catalog/livestock-categories/beef-operations/beef-cattle-handbook-pdf>. Accessed on 20, July 2018.

EPA. 1999. Storm Water Management Fact Sheet: Visual Inspection. No. 832-F-99-046. Available at: <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=200044CU.txt>  
~~Accessed on 28 June 2020.~~  
~~[http://water.epa.gov/scitech/wastetech/upload/2002\\_06\\_28\\_mtb\\_visnspect.pdf](http://water.epa.gov/scitech/wastetech/upload/2002_06_28_mtb_visnspect.pdf).~~  
~~Accessed on 26 June 2015.~~

Gangwer, M. 2012. Spreadsheet: MI P Risk Assessment Tool- 42.0. USDA. Natural Resources Conservation Service, East Lansing, MI. Available at: [https://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/nrcs141p2\\_024448.xls](https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_024448.xls)  
~~Accessed on 28 August 2020.~~  
~~<http://efotg.sc.egov.usda.gov/treemenuFS.aspx> (located in the “Conservation Practices” folder; subfolder “Nutrient Management (AC)(590)”, subfolder “Nutrient Management Tools and References”).~~  
~~Accessed on 20 September 2018.~~

Grigar, J.J. 2013. Mich. Agronomy Tech Note 35, *Manure Application Risk Index Spreadsheet v4.0 and the Procedure for Determining the Land Available for Winter Spreading of Manure*. USDA Natural Resources Conservation Service, East Lansing, MI. Available at: [http://efotg.sc.egov.usda.gov/references/public/MI/No\\_35\\_MARI\\_Spreadsheet\\_4\\_and\\_Winter\\_Spreading\\_Manure\\_2013.pdf](http://efotg.sc.egov.usda.gov/references/public/MI/No_35_MARI_Spreadsheet_4_and_Winter_Spreading_Manure_2013.pdf). ~~Accessed on 28 August 2020~~  
~~Accessed on 20 September 2018.~~

Grigar, J.J. 2011. Spreadsheet: Manure Application Risk Index v 4.0 (MARI). USDA Natural Resources Conservation Service, East Lansing, MI. Available at: <https://efotg.sc.egov.usda.gov/#/details> (Select Michigan, Section IV, located in the “Conservation Practices” folder; subfolder “Nutrient Management (AC)(590)”, subfolder “Nutrient Management Tools and References”). Accessed on 20 September 2018.

Harrigan, T., B. Northcott, N. Rector and D. Bolinger. 2007. Keeping Land-applied Manure in the Root Zone Part 2: Tile-drained Land. Bulletin WO-1037, Mich. State Univ., East Lansing, MI. Located at:  
[https://www.canr.msu.edu/resources/manure\\_management\\_tile\\_drained\\_land\\_wo1037](https://www.canr.msu.edu/resources/manure_management_tile_drained_land_wo1037)  
7 Accessed on 28 August 2020.

~~Available at: [http://shop.msu.edu/category\\_s/345.htm](http://shop.msu.edu/category_s/345.htm).~~

---

~~Accessed on 29 June 2015.~~

Holmes, B.J. and S. Struss. 2009. *Milking Center Wastewater Guidelines*. Available at: <http://clean-water.uwex.edu/pubs/pdf/milking.pdf>. Accessed on 29 June 2015.

Jacobs, L.W. 1995a. *Utilization of Animal Manure for Crop Production. Part II. Worksheet to Calculate Manure Application Rates*. Bulletin MM-2, Animal Manure Management Resource Notebook. Available at: [https://archive.lib.msu.edu/DMC/extension\\_publications/MM2/MM2.pdf](https://archive.lib.msu.edu/DMC/extension_publications/MM2/MM2.pdf). Accessed on 27 August 2020. ~~<http://expeng.anr.msu.edu/uploads/files/20/Bull%20MM-2.pdf>. Accessed on 25 June 2015.~~

Jacobs, L.W. 1995b. *Utilization of Animal Manure for Crop Production. Part III. Worksheet to Calculate Manure Application Rates*. Bulletin MM-3, Animal Manure Management Resource Notebook. Available at: [https://archive.lib.msu.edu/DMC/extension\\_publications/e2343/E2343-1992.PDF](https://archive.lib.msu.edu/DMC/extension_publications/e2343/E2343-1992.PDF). Accessed on 27 August 2020.

~~at <http://expeng.anr.msu.edu/uploads/files/20/Bull%20MM-3.pdf>. Accessed on 25 June 2015.~~

Jacobs, 2015 File Folders: *Recordkeeping System for Crop Production*. Bulletin E2343, Mich. State Univ., East Lansing, MI. Available at: [https://archive.lib.msu.edu/DMC/extension\\_publications/e2343/E2343-1992.PDF](https://archive.lib.msu.edu/DMC/extension_publications/e2343/E2343-1992.PDF). Accessed on 27 August 2020. ~~[http://www.canr.msu.edu/resources/field\\_file\\_folders\\_recordkeeping\\_system\\_for\\_crop\\_production\\_e2343](http://www.canr.msu.edu/resources/field_file_folders_recordkeeping_system_for_crop_production_e2343). Accessed on 29 August 2015.~~

Koelsch, R. and W. Powers. 2010. Software: *Nutrient Inventory - Manure Nutrient and Land Requirement Estimator*. Univ. of Nebr. Available at: <http://water.unl.edu/manure/software>. Accessed on 29 June 2015.

Koelsch, R. and W. Powers. 2013. Instructions: *Manure Nutrient and Land Requirement Estimator*. Univ. of Nebr. Available at: <http://water.unl.edu/manure/software>. Accessed on 29 June 2015.

Purdue Research Foundation, 2014. *Manure Management Planner*. Available at: <http://www.purdue.edu/agsoftware/mmp/>. Accessed on 29 June 2015.

MDARD. 2018~~20~~. Right to Farm. Generally Accepted Agricultural and Management Practices for Site Selection and Odor Control for New and Expanding Livestock Facilities. Michigan Commission of Agriculture & Rural Development. Available at [https://www.michigan.gov/mdard/0,4610,7-125-1599\\_1605---,00.html](https://www.michigan.gov/mdard/0,4610,7-125-1599_1605---,00.html). Accessed on ~~25, August 2018~~ 4, September 2020.

MidWest Plan Service. 1993. *Livestock Waste Facilities Handbook*, 3<sup>rd</sup> Ed. MWPS-18, MidWest Plan Service, Iowa State Univ., Ames, IA. Available at: <https://www-mwps.sws.iastate.edu/>.

MidWest Plan Service. 1999. *Circular Concrete Manure Tanks*. Pub. TR-9, MidWest Plan Service, Iowa State Univ., Ames, IA. Available at: <https://www-mwps.sws.iastate.edu/>. Accessed on 29 June 2015.

MidWest Plan Service. 2000. *Manure Characteristics*, MWPS-18, Section 1. MidWest Plan Service, Iowa State Univ., Ames, IA.

MidWest Plan Service. 2005. *Rectangular Concrete Manure Storages Handbook*. MWPS-36, 2<sup>nd</sup> Ed. MidWest Plan Service, Iowa State Univ., Ames, IA. Available at: <https://www-mwps.sws.iastate.edu/>. Accessed on 29 June 2015.

Michigan State University Extension. 2008. *Acceptable Practices for Managing Livestock along Lakes, Streams and Wetlands*. Bulletin E-3066, Mich. State Univ., East Lansing, MI. Available at: [https://www.canr.msu.edu/resources/acceptable\\_practices\\_for\\_managing\\_livestock\\_along\\_lakes\\_and\\_streams\\_e3066](https://www.canr.msu.edu/resources/acceptable_practices_for_managing_livestock_along_lakes_and_streams_e3066). Accessed on 28 August 2020 [http://shop.msu.edu/category\\_s/345.htm](http://shop.msu.edu/category_s/345.htm). Accessed on 29 June 2015.

National Oceanic and Atmospheric Administration Atlas 14. 2013. NOAA-14, Volume 8, Version 2.0. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Silver Spring, Maryland, 2013 2014. Available at: <http://hdsc.nws.noaa.gov/hdsc/pfds/>. Accessed on 27 July 2016.

Rynk, R. 1992. *On-Farm Composting Handbook*. NRAES-54, Northeast Regional Agricultural Engineering Service, Ithaca, NY. Available at: <https://campus.extension.org/pluginfile.php/48384/course/section/7167/NRAES%20FarmCompost%20manual%201992.pdf>. Accessed 27, August 2020. ~~composting-handbook. Accessed 20, September 2018~~

USDA-ARS. 2014. *Revised Universal Soil Loss Equation, Version 2*. U.S. Department of Agriculture, Agricultural Research Service. Washington, D.C. Available at: [http://fargo.nserl.purdue.edu/rusle2\\_dataweb/RUSLE2\\_Index.htm](http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm). Accessed on 29 June 2015.

USDA-NRCS. 2000. *National Engineering Handbook*, Part 637, *Environmental Engineering*, Chapter 2, *Agricultural Waste Characteristics*. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C. Available at: [http://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/nrcs143\\_022229.pdf](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_022229.pdf). Accessed on 29 June 2015.

USDA-NRCS. 2006. *Vegetative Treatment Systems for Open Lot Runoff: A Collaborative Report*. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C. Available at: <http://socwisconsin.org/wp->

content/uploads/2016/04/NRCS\_2006\_VTACollaborativeReport.pdf. Accessed on 20 July, 2018.

USDA-NRCS. 2008. *Agricultural Waste Management Field Handbook Part 651*, Chapters 4 and (or) 10. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C. Available at: <http://directives.sc.egov.usda.gov/viewerFS.aspx?id=3851>. Accessed on 17 July 2015.

USDA-NRCS-MI FOTG. 2018. *Field Office Technical Guide*. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C. Available at: <https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/fotg/>. Accessed on 28 August 2020. ~~<https://efotg.sc.egov.usda.gov/#/details>. Accessed on 20 September 2018.~~

Warncke, D.D. 1998. *Sampling Soils for Fertilizer and Lime Recommendations*. Bulletin E-498, Mich. State Univ., East Lansing, MI. Available at: [https://www.canr.msu.edu/uploads/236/43114/soil\\_sampling\\_guide.pdf](https://www.canr.msu.edu/uploads/236/43114/soil_sampling_guide.pdf) Accessed on 28 August 2020. ~~<http://www.michigan.gov/mdard/0,4610,7-125-1599-1605---,00.html>. Accessed on 29 June 2015.~~

Warncke, D., J. Dahl, and L. Jacobs, and C. Laboski. 2009a. *Nutrient Recommendations for Field Crops in Michigan*. Bulletin E-2904, Mich. State Univ., East Lansing, MI. Available at: [http://shop.msu.edu/category\\_s/345.htm](http://shop.msu.edu/category_s/345.htm). Accessed on 29 June 2015.

Warncke, D., J. Dahl, and B. Zandstra. 2009b. *Nutrient Recommendations for Vegetable Crops in Michigan*. Bulletin E-2934, Mich. State Univ., East Lansing, MI. Available at: [https://www.canr.msu.edu/resources/nutrient\\_recommendations\\_for\\_vegetable\\_crops\\_in\\_michigan\\_e2934](https://www.canr.msu.edu/resources/nutrient_recommendations_for_vegetable_crops_in_michigan_e2934). Accessed on 28 August 2020. ~~[http://shop.msu.edu/category\\_s/345.htm](http://shop.msu.edu/category_s/345.htm). Accessed on 29 June 2015.~~

Warncke, D., and R. Gehl. 2006. *Sampling Soils for Fertilizer and Lime Recommendations: Frequency of Soil Sampling*. Bulletin E-498S, Mich. State Univ., East Lansing, MI. Available at: [https://archive.lib.msu.edu/DMC/extension\\_publications/e498/E0498S.pdf](https://archive.lib.msu.edu/DMC/extension_publications/e498/E0498S.pdf). Accessed on 28 August 2020. ~~[http://shop.msu.edu/category\\_s/345.htm](http://shop.msu.edu/category_s/345.htm). Accessed on 29 June 2015.~~

Wright, P.E., and R.E. Graves. 1998. *Guideline for Milking Center Wastewater*, DPC-15, NRAES-115, Natural Resource, Agriculture, and Engineering Service, Ithaca, NY. Available at: <http://www.dairypc.org/catalog/guidelines/waste-management/milking-center-wastewater>. Accessed on 17 July 2015.



## ADVISORY COMMITTEE

Listed below are the advisory committee members for the Generally Accepted Agricultural and Management Practices for Manure Management and Utilization.

Steven Safferman, Chair  
Associate Professor/  
Ext~~ension~~\_Specialist  
MSU Biosystems & Agricultural  
Extension  
212 Farrall Hall  
East Lansing, MI 48823  
517-432-0812  
[safferma@msu.edu](mailto:safferma@msu.edu)

Laura A. Campbell, Manager  
Agricultural Ecology Department  
Michigan Farm Bureau  
517-679-5332  
[lcampbe@michfb.com](mailto:lcampbe@michfb.com)

James DeYoung  
CJD Farm Consulting, Inc.  
4328 3 Mile Rd NW STE 300  
Grand Rapids, MI 49534-1188  
616-608-5022  
[James@CJDFarmConsulting.com](mailto:James@CJDFarmConsulting.com)

Dr. Betsy Dierberger  
State Resource Conservationist  
USDA-NRCS  
3001 Coolidge Road, Ste. 250  
East Lansing, MI 48823  
517-324-5265  
[betsy.dierberger@mi.usda.gov](mailto:betsy.dierberger@mi.usda.gov)

Sarah Fronczak  
Environmental Management  
Educator  
MSU Extension 20 Care Drive  
Hillsdale, MI 49036  
517-439-9301  
[froncza3@msu.edu](mailto:froncza3@msu.edu)

Dr. Ehsan Ghane, Assistant  
Professor/  
Extension Specialist  
MSU Extension and Biosystems and  
and Agricultural Engineering  
220 Farrall Hall  
East Lansing, MI 48823  
517-353-4458  
[ghane@msu.edu](mailto:ghane@msu.edu)

Steve Mahoney  
Michigan Dept. of Agriculture and  
Rural Development  
P.O. Box 30017  
Lansing, MI 48909  
517-930-2966  
517-335-3329 - FAX  
[mahoneys@michigan.gov](mailto:mahoneys@michigan.gov)

Sue Reamer  
Environmental Engineer  
USDA-NRCS  
3001 Coolidge Road, Ste. 250  
East Lansing, MI 48823  
517-324-5252  
[suzanne.reamer@usda.gov](mailto:suzanne.reamer@usda.gov)

Erica Rogers,  
Environmental Management  
Educator  
MSU Extension  
219 N. State Street  
Alma, MI 48801  
989-8750-5233 Ext. 5296  
[roger392@msu.edu](mailto:roger392@msu.edu)

Dr. Dale Rozeboom  
Professor/Extension Specialist  
MSU Extension and Department of  
Animal Science  
524 S. Shaw Lane  
2209 Anthony Hall  
474 S. Shae Lane  
East Lansing, MI 49924  
517-355-8398  
[rozeboom@msu.edu](mailto:rozeboom@msu.edu)

Dr. James M. Wallace  
Senior Vice President, Newtrient,  
LLC  
10255 W. Higgins Road  
Suite 900  
Rosemont, IL 60018  
517-614-2007  
[jim.wallace@newtrient.com](mailto:jim.wallace@newtrient.com)

Bruce Washburn  
Environmental Quality Specialist  
Water Resources Division –  
Kalamazoo Office  
Michigan Department of  
Environment, Great Lakes and  
Energy  
7953 Adobe Road  
Kalamazoo, MI 49009  
269-567-3500  
[washburnb2@michigan.gov](mailto:washburnb2@michigan.gov)

Wayne Whitman  
Independent Consultant  
Holt, MI 48842  
517-282-1104  
[whitmanww13@gmail.com](mailto:whitmanww13@gmail.com)

Dr. Lois Wolfson  
MSU Institute of Water Research  
101 Manly Mile Building  
1405 S. Harrison Road  
East Lansing, MI 48823  
517-353-9222  
[wolfson1@msu.edu](mailto:wolfson1@msu.edu)

### **MDARD Advisors**

[Michael Wozniak, PE](#)  
[Right to Farm Program Manager](#)  
[Michigan Dept. of Agriculture and](#)  
[Rural Development](#)  
[P.O. Box 30017](#)  
[Lansing, MI 48909](#)  
[O: 517-284-5618](#)  
[C: 517-285-1752](#)  
[517-335-3329 - FAX](#)  
[WozniakM1@michigan.gov](#)

Ben Tirrell, Program Manager  
Right to Farm Program  
Michigan Department of Agriculture and Rural  
Development  
P.O. Box 30017  
Lansing, MI 48909  
517-284-5618  
[tirrellb@michigan.gov](mailto:tirrellb@michigan.gov)

Michael Wozniak  
Right to Farm Program  
Michigan Department of Agriculture and Rural  
Development

P.O. Box 30017  
Lansing, MI 48909

517-285-1752  
[wozniakm@michigan.com](mailto:wozniakm@michigan.com)

---



# Generally Accepted Agricultural and Management Practices for Nutrient Utilization

---

**January DRAFT 2021**

Michigan Commission of Agriculture & Rural Development  
PO BOX 30017  
Lansing, MI 48909



In the event of an agricultural pollution emergency such as a chemical/fertilizer spill, manure lagoon breach, etc., the Michigan Department of Agriculture & Rural Development and/or Michigan Department of ~~Environmental Quality~~Environment, Great Lakes and Energy should be contacted at the following emergency telephone numbers:

Michigan Department of Agriculture & Rural Development: 800-405-0101  
Michigan Department of Environment, Great Lakes, and Energy's Pollution Emergency Alerting System (PEAS): 800-292-4706

If there is not an emergency, but you have questions on the Michigan ~~Right to~~Right to Farm Act, or items concerning a farm operation, please contact the:

Michigan Department of Agriculture & Rural Development (MDARD)  
Right to Farm Program (RTF)  
P.O. Box 30017  
Lansing, Michigan 48909  
(517) 284-5619  
(877) 632-1783  
(517) 335-3329 FAX

## TABLE OF CONTENTS

<b>PREFACE</b>	<b>iii</b>
<b>INTRODUCTION</b>	<b>4</b>
<b>ON-FARM FERTILIZER STORAGE AND CONTAINMENT PRACTICES</b>	<b>5</b>
Security for Fertilizer Storage Areas	5
Fertilizer Storage Facilities	6
<b>FERTILIZATION PRACTICES FOR LAND APPLICATION</b>	<b>8</b>
Soil Fertility Testing and Tissue Analysis	8
Fertilizer Recommendations	9
Nutrient Credits	10
Nitrogen Management Practices	11
Phosphorus Management Practices	13
<b>NUTRIENT MANAGEMENT PRACTICES FOR ORGANIC SOILS</b>	<b>14</b>
RECORDKEEPING	15
FERTILIZER APPLICATION EQUIPMENT ADJUSTMENT	15
<b>SOIL CONSERVATION PRACTICES</b>	<b>16</b>
<b>IRRIGATION MANAGEMENT PRACTICES</b>	<b>16</b>
<b>FERTILIZATION AND IRRIGATION PRACTICES FOR CONTAINER-GROWN PLANTS</b>	<b>17</b>
RUNOFF PREVENTION	17
RUNOFF COLLECTION	20
RECORDKEEPING	20
<b>LAND APPLICATION OF ORGANIC (BIOLOGICAL) MATERIALS AND BY-PRODUCT LIMING MATERIALS FOR CROP PRODUCTION</b>	<b>20</b>
<b>LAND APPLICATION OF CONDITIONALLY-EXEMPTED ORGANIC MATERIALS, COMPOSTED ORGANIC, AND LIMING MATERIALS</b>	<b>24</b>
<b>APPENDICES</b>	<b>36</b>
APPENDIX I -- References on State and Federal Laws and Regulations	36
APPENDIX II -- References Cited	39
<b>ADVISORY COMMITTEE</b>	<b>41</b>

## PREFACE

The Michigan legislature passed into law the Michigan Right to Farm Act (Act 93 of 1981), which requires the establishment of Generally Accepted Agricultural and Management Practices (GAAMPs). These practices are written to provide uniform, statewide standards and acceptable management practices based on sound science. These practices can serve producers in the various sectors of the industry to compare or improve their own managerial routines. New scientific discoveries and changing economic conditions may require revision of the GAAMPs during the annual review.

The GAAMPs that have been developed are the following:

- 1) 1988-Manure Management and Utilization
- 2) 1991-Pesticide Utilization and Pest Control
- 3) 1993-Nutrient Utilization
- 4) 1995-Care of Farm Animals
- 5) 1996-Cranberry Production
- 6) 2000-Site Selection and Odor Control for New and Expanding Livestock Facilities
- 7) 2003-Irrigation Water Use
- 8) 2010-Farm Markets

These current GAAMPs were developed with industry, university, and multigovernmental agency input. As agricultural operations continue to change, new practices may be developed to address the concerns of the neighboring community. Agricultural producers who voluntarily follow these practices are provided an affirmative protection from public or private nuisance litigation under the Right to Farm Act.

This current GAAMP does not apply in municipalities with a population of 100,000 or more in which a zoning ordinance has been enacted to allow for agriculture provided ~~that~~ the ordinance designates existing agricultural operations present prior to the ordinance's adoption as legal non-conforming uses as identified by the Right to Farm Act for purposes of scale and type of agricultural use.

The website for the GAAMPs is <http://www.michigan.gov/righttofarm>

## INTRODUCTION

Fertilizer use in Michigan has increased steadily since the 1930's when commercial fertilizers first became available. In 1970 and 1990, nearly 0.9 and 1.3 million tons of commercial fertilizer were used in Michigan to supply 160 and 185 pounds, respectively, of plant nutrients per harvested acre (TVA, 1990). By 2004, total consumption of fertilizers in Michigan had leveled off to slightly more than 1.4 million tons per year (AAPFCO/TFI, 2005). While fertilizer use has been increasing, total ~~farm-land~~farmland has been on the decline. In 1920, Michigan had 19.0 million acres of cropland, but in 1970, 1990, 1999, and 2004 total land in farms had decreased to 12.7, 10.8, 10.4, and 10.1 million acres, respectively (MDARD, 1991, 2005). As a result of modern agricultural practices, Michigan's agricultural system has become one of the most productive in the world.

Many factors are responsible for this increase in productivity. Government policy, farm programs, improved hybrids, new varieties, and many technological advances, including improved and ~~readily-available~~readily available fertilizer products, at reasonable prices, are some of the major factors responsible for today's modern agricultural practices and increased productivity.

The environmental costs and risks associated with this increased efficiency are not well understood but are rapidly becoming a public concern. The increased fertilizer use on fewer farm acres has caused soil test phosphorus (P) levels to increase dramatically on some soils in recent years. The median soil test level for P in soil samples received by the Michigan State University (MSU) Soil Testing Laboratory in the 1994-95 season was 106 pounds of Bray P1 per acre (Warncke and Dahl, 1995). More than 50 percent of the corn and soybean fields represented by these samples would not need any more P to be applied, based on current MSU nutrient recommendations (Warncke *et al.*, 2004a). Christenson (1989) and Vitosh and Darling (1990) have demonstrated the validity of MSU fertilizer recommendations on corn, soybeans, dry beans, and sugar beets on numerous Michigan farms.

Evidence is increasing that fertilizer nutrients are finding their way into both surface and groundwater. Michigan's 1988 Non-Point Pollution Assessment Report (DNR, 1988) indicates that agricultural fertilizer was perceived as a nonpoint source pollution problem in 71 percent of the 279 watersheds in Michigan. Significant P loading of Michigan's lakes and streams has been documented (DNR, 1985).

Nitrate contamination of groundwater in Michigan has also been well documented (Bartholic, 1985; Ellis, 1988; and Vitosh *et al.*, 1989). Cummings *et al.*, (1984) reported that nitrates in groundwater located in Van Buren cCounty were related to fertilizer use patterns, number of irrigated acres, and the amount of irrigation water applied. Nitrogen (N) fertilizer demonstrations have shown that many corn producers may also be using more N fertilizer than necessary (Vitosh *et al.*, 1991).

Although the use of other fertilizer nutrients has also increased, changes in soil test levels of nutrients such as potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), and micronutrients have been less dramatic. Currently, these nutrients are not causing any known environmental damage, and there are no concerns for their continued use as long as they benefit the farmer agronomically and economically.

The increasing presence of P in surface water and nitrates in groundwater, and the fact that some farmers are using excess fertilizer, have led to the conclusion that utilization of ~~the Generally Accepted Agricultural and Management Practices (GAAMPs)~~ should be encouraged to prevent degradation of the environment. The purpose of this document is to present acceptable and recommended agricultural practices that will significantly reduce the potential for nitrate movement to groundwater and nonpoint losses of P to surface water.

Adoption of these management practices for nutrient utilization will not ~~totally eliminate~~eliminate nutrient movement into surface water or groundwater, because nutrients are an integral part of the natural hydrologic cycle. However, following these GAAMPs will contribute to environmental protection from nutrient pollution of surface water and groundwater.

These GAAMPs are referenced in Michigan's Natural Resources and Environmental Protection Act (NREPA), Public Act 451 of 1994, as amended. NREPA protects the waters of the state from the release of pollutants in quantities and/or concentrations that violate established water quality standards. Discharges are regulated as violations to Part 4 Rules, Water Quality Standards, of Part 31, Water Resources Protection, of the NREPA. Agricultural producers who voluntarily follow these practices are provided protection from public or private nuisance litigation under Public Act 93 of 1981, as amended, the Michigan Right to Farm Act, Michigan Department of Agriculture & Rural Development.

## **ON-FARM FERTILIZER STORAGE AND CONTAINMENT PRACTICES**

Fertilizer should be stored in a manner that protects the environment, ensures human and animal safety, and preserves the product and container integrity. Well-water surveys have indicated that improper or defective fertilizer storage and containment facilities can be a source of surface water and groundwater contamination. Before fertilizers are stored on the farm, several concerns should be ~~reviewed~~reviewed and precautions observed.

### **Security for Fertilizer Storage Areas**

- 1. Fertilizer storage areas, valves, and containers should be secured when not in use to prevent access by unauthorized personnel, children, or animals.**

Security of the fertilizer storage area should be provided by use of locks, fencing, and/or lighting. Fertilizers should not be stored in the direct presence of fuel products or



pesticides due to the increased potential for explosions and significant disposal problems.

### **Fertilizer Storage Facilities**

- 2. Dry fertilizer should be stored inside a structure or device capable of preventing contact with precipitation and/or surface water.**

The storage area should be able to handle and contain fertilizer spills properly. The structure or device should consist of a ground cover or base and a cover or roof top. Walls and floors should prevent absorption or loss of fertilizer. Dry fertilizer in an individual quantity of more than 2,000 pounds is considered "bulk fertilizer" and is regulated by Regulation No. 641, "Commercial Fertilizer Bulk Storage." While dry fertilizer is not regulated by Regulation No. 642, "On Farm Fertilizer Bulk Storage," producers are encouraged to follow the guidance provided in Regulation No. 641, when bulk quantities of dry fertilizer are stored on their farm.

Following these regulations is not required for bulk storage of liming materials or for the temporary staging of potash in a field where it is being applied.

- 3. Liquid fertilizer should be stored in containers approved for and compatible with the fertilizer being stored. Bulk liquid fertilizer should be stored in accordance with Regulation No. 642, "On Farm Fertilizer Bulk Storage," NREPA, Part 85.**

All liquid fertilizer storage areas should have secondary containment that will properly handle and contain spills. The floor of the containment area should be constructed to prevent the absorption or loss of fertilizer. Secondary containment areas should not have a working floor drain unless it leads to a collection sump. All liquid fertilizer storage containers should be labeled properly. Containers, valves, gauges, and piping should be made of materials compatible with the products being stored. Backflow protection is recommended when liquid fertilizers are associated with any water supply. The level of the liquid in the containers should be able to be determined readily.

Under Regulation No. 642, "bulk fertilizer" means fluid fertilizer in a single container that has a capacity of more than 2,500 United States gallons, or a combined total capacity for all storage containers or tanks located at a single site or location greater than 7,500 United States gallons. Storage of liquid fertilizers on the farm at these capacities is regulated by Regulation No. 642, so the producer must follow specific requirements in siting and locating new bulk storage facilities. Existing bulk storage facilities will have five years from August 2003 to comply with Regulation No. 642.

- 4. Fertilizer storage areas should be inspected at least annually by the owner or the person responsible for the fertilizer to ensure safe storage of fertilizers and to minimize mishaps.**

Fertilizer storage containers should be inspected prior to use to ensure container integrity. Replace containers as needed to prevent leaks. Regular inspection of bulk fertilizer storage facilities is required by Regulation No. 642.

### **LOCATION OF BULK FERTILIZER STORAGE AREAS**

A site should be selected that minimizes potential for contamination of surface water or groundwater by drainage, runoff, or leaching. Locate the storage site at an adequate distance away from wells, surface water, and other sensitive areas, as herein described. For the purpose of this section, "surface water" means a body of water that has its top surface exposed to the atmosphere and includes lakes, ponds, or water holes that cover an area greater than 0.25 acres, and streams, rivers, or waterways that maintain a flow year-round. "Surface water" does not include waterways with intermittent flow. For bulk liquid fertilizer, reference Regulation No. 642.

- 5. Existing bulk fertilizer storage areas shall be located a minimum of 50 feet from any single-family residential water well, a minimum of 200 feet from Type I or Type IIA public water supply wells, and a minimum of 75 feet from Type IIB and Type III public water supply wells.**

Existing bulk fertilizer storage areas are those areas that were used to store or hold bulk liquid fertilizers on a farm before August 2003. Type III water supplies include farms that hire at least one employee. See MSU Extension Bulletin E-2335 (Wilkinson, 1996) and Regulation No. 642 for information on protection measures for existing storage sites.

- 6. New bulk fertilizer storage areas shall be located a minimum of 150 feet from any single-family residential water well, a minimum of 200 feet from surface water, and above a floodplain. The set-back distance from any Type I or Type IIA public water supply well (communities with 25 or more persons and large resorts including municipalities, subdivisions, condominiums, and apartment complexes) is 2,000 feet, if the public water supply does not have a well-head protection program. If there is a well-head protection program, the facility must be located outside the delineated wellhead protection area. For Type IIB and Type III public water supply wells, which include noncommunity water supplies such as schools, restaurants, industries, campgrounds, parks, and motels, the setback is 800 feet.**

To the greatest extent possible, new bulk fertilizer storage areas shall meet these water supply set-back distances. A new bulk fertilizer storage area may be located closer than these distances, upon obtaining a deviation from the well isolation distance through Michigan Department of Environment, Great Lakes, and Energy (EGLE) or the local health department. Additionally, a new bulk fertilizer storage area that meets the requirements of Regulation No. 641 or Regulation No. 642 may be located closer than

the above water supply set-back distances, but not less than those distances specified in Practice #5.

When planning a new facility, see MSU Extension Bulletin E-2335 (Wilkinson, 1996) and Regulation No. 642 for information on design and construction and for the required setback distance from drinking water supplies. Additional detailed information on the design or construction of new fertilizer and pesticide containment facilities is available in the MidWest Plan Service Handbook No. 37 (MidWest Plan Service, 1995) or in the United States Department of Agriculture, Natural Resources Conservation Service (NRCS) Agrichemical Containment Facility (702), Michigan Standard ~~(USDA-NRCS)~~.

For more information on these set-back distances, reference Public Act 399, the State of Michigan Safe Drinking Water Act of 1976, and Public Act 368, the Michigan Public Health Code of 1978, as amended. These storage set-back distances pertain to bulk fertilizer storage sites and facilities, but do not include staging and application sites. A storage facility is a place for safekeeping of fertilizer. A staging site is an area where fertilizer is temporarily stored, loaded, and/or otherwise prepared in a field where it is being applied. An application site is where fertilizers may be appropriately used.

New bulk liquid fertilizer storage areas shall be located above a floodplain, which means any land area that, is subject to a 1 percent or greater chance of flooding, or equivalent to a 100-year flood event (as defined in Regulation No. 642). All fertilizer should be stored and handled in a manner which minimizes the potential for drinking water contamination or nutrient losses to surface water.

## FERTILIZATION PRACTICES FOR LAND APPLICATION

The following management practices are suggested for farmers to help achieve efficient and effective use of fertilizers and to reduce the potential for nutrient contamination of surface water and groundwater.

### Soil Fertility Testing and Tissue Analysis

- 7. All fields used for the production of agricultural crops should have soils sampled and tested on a regular basis before fertilizer nutrients are applied. For small fruit and tree crops, using tissue analysis and/or observing seasonal growth, are better methods to determine their nutrient requirements.**

Routine soil testing for pH, P, K, Ca, and Mg is one of the best tools available for determining the availability of nutrients in soil for most crops. One of the keys to a good soil testing program is proper soil sampling. MSU Extension Bulletins E-498 (Warncke, 1998), E- 1616 (Meints and Robertson, 1983), and E-498S (Warncke and Gehl, 2006) give instructions on how to obtain a good representative soil sample and how often soils should be re-sampled. Once the capability of the soil to supply nutrients has been

assessed, the appropriate amount of supplemental nutrients can be determined. Soil test results will change with time depending on fertilizer and manure additions, precipitation, runoff, leaching, soil erosion, and nutrient removal by crops. Therefore, soil testing needs to be done on a regular basis within a one to four year time frame, where the appropriate frequency of soil sampling depends on (a) how closely an individual wants to track soil nutrient changes, (b) the crop(s) grown, (c) cropping rotation, (d) soil texture, and (e) the approach used for sampling fields (see Warncke and Gehl, 2006 for more details).

The nutrient requirements of small fruit and tree crops are best monitored by tissue analysis. Tissue samples should be taken every three to five years according to instructions in MSU Extension Bulletin E-2482 (Hanson and Hull, 1994). The nitrogen status of fruit plantings can also be monitored effectively by observing leaf color, shoot growth, and production levels, as described in MSU Extension Bulletin E-852 (Hanson, 1996).

For cranberry production, see the current "Generally Accepted Agricultural and Management Practices for Cranberry Production".

### **Fertilizer Recommendations**

- 8. Fertilizer use should follow recommendations consistent with those of Michigan State University (MSU) and should consider all available sources of nutrients.**

Michigan State University fertilizer recommendations for field crops and vegetables are found in Extension Bulletins E-2904 and E-2934 (Warncke *et al.*, 2004a, 2004b). Recommendations are based on a soil fertility test, soil texture, crop to be grown, and for most field and vegetable crops, yield goal. Selecting a realistic yield goal for these crops is one of the most important steps in obtaining economic and environmentally sound recommendations. Excessively high yield goals can lead to loss of income and over-fertilization that may threaten water quality. A yield goal that is both realistic and achievable should be based on the soil potential and the level of crop management utilized. A realistic yield goal is one which is achievable at least 50 percent of the time. If the yield goal is seldom achieved, the entire crop management system should be reevaluated to identify those factors other than soil fertility that are limiting yields.

Most commercial soil testing laboratories use the same soil test procedures as MSU. These procedures are described in the North Central Regional Research Publication No. 221 (Brown, 1998). Soil tests from these laboratories can be used to determine MSU Extension nutrient recommendations (Warncke *et al.*, 2004a, 2004b). Occasionally, fertilizer recommendations vary between MSU and agribusiness. When differences exist, farmers should follow the MSU recommendations because they have been proven to be sound agronomically, economically, and environmentally (Ellis and Olson, 1986).

~~MSU Michigan State University~~ fertilizer recommendations for fruit crops are found in MSU Extension Bulletins E- 852 (Hanson, 1996) and E-2011 (Hanson and Hancock, 1996). Fertilizer recommendations for these crops are often adjusted for each specific planting by tissue testing and observing crop performance (see above bulletin).

Recommended fertilization practices for field-grown perennial woody ornamentals are available from MSU (Fernandez, 2004). Rates of fertilization are based on soil testing, foliar analysis, and growth rates of the crop. Fertilization of annual and perennial field grown cut flowers is based on similar criteria, but published recommendations are not currently available.

The MSU Soil and Plant Nutrient Laboratory can provide nutrient recommendations for most crops grown in Michigan that include fruit, turfgrass, flowers, shrubbery, and trees. When ~~Michigan State University~~MSU recommendations are not available for a specific crop or soil type, other land grant university recommendations developed for the region may be used.

Essential plant nutrients from sources other than fertilizer salts may also be used to satisfy the nutrient recommendations for crops. These sources of nutrients can include animal manure and other biological materials, inorganic by-products, irrigation water, and residual nutrients present in the soil from one growing season to the next. Nonfertilizer materials should be tested for their nutrient content, and residual mineralizable N should be estimated (when possible) to determine the appropriate quantities of nutrients that should be credited against the nutrient recommendations.

### **Nutrient Credits**

#### **9. Take credit for nutrients supplied by organic matter, legumes, and manure or other biological materials.**

The contribution of soil organic matter to plant nutrition should be taken into account before determining the final or actual N recommendation. High organic matter soils will need less fertilizer N to obtain the same crop yield because they are capable of mineralizing more N than low organic matter soils. Michigan State University N fertilizer recommendations are based on soils with two to four percent organic matter. See MSU Extension Bulletin WQ-25 (Vitosh and Jacobs, 1996) for suggested N credits for field and vegetable crops grown on soils with higher organic matter levels. Since soil organic matter levels do not change rapidly, routine analysis of organic matter is not necessary. Organic matter content, however, is important in determining proper herbicide rates, so you may want to periodically determine soil organic matter content for this purpose.

Legumes are often grown and plowed under to improve the fertility and tilth of soils in field and vegetable crop rotations. The N supplied by legumes, due to an N fixation process in root nodules, should be credited for subsequent crops in the nutrient

management plan. The amount of credit given for legume N fixation depends on the type of legume, how long the legume has been growing, and the density of the legume stand when it is killed by tillage or applying an herbicide. See MSU Extension Bulletin E-2904 (Warncke *et al.*, 2004a) for suggested legume N credits.

Livestock manure is also a good source of plant nutrients. Manure should be analyzed periodically to determine the appropriate credit for the nutrients supplied. See the current "Generally Accepted Agricultural and Management Practices for Manure Management and Utilization" for recommended management practices when utilizing manure.

Other organic (biological) materials, such as human sewage, food processing by-products, industrial organic by-products, wood, and municipal refuse can potentially be used as a source of plant nutrients. Most of these materials are regulated by EGLE. More information on the use of these organic materials and by-product liming materials can be found in Section VII and Section VIII of these GAAMPs.

## **Nitrogen Management Practices**

### **10. A. To enhance N uptake, match N fertilizer applications to the demand of the crop and the conditions of the soil.**

Efficient use of N fertilizer is important economically, agronomically, and environmentally. Greater efficiencies can be achieved by using university recommended rates of N fertilizer, by using sources of N fertilizer compatible with the crop and the environment, and by following good N management practices.

#### **Nitrogen Fertilizer Rate**

The amount of N fertilizer applied is crucial for efficient use by plants. Excessive applications can lead to contamination of both surface water and groundwater. The amount of N fertilizer used for field and vegetable crops should be based on a realistic yield goal and the amount of N available from the soil, previous crop, manure, and/or other biological materials. See MSU Extension Bulletins E-2904 and E-2934 (Warncke *et al.*, 2004a, 2004b) for more information on selecting the appropriate rate of N fertilizer. Recommended N rates for fruit crops are given in MSU Extension Bulletins E-852 (Hanson, 1996) and E-2011 (Hanson and Hancock, 1996).

#### **Forms of Nitrogen Fertilizer**

Nearly all N fertilizers are soluble in water and are subject to movement in soils as soon as they are applied. However, certain forms of N fertilizers have greater potential for movement out of the root zone. Nitrate N, in calcium nitrate or ammonium nitrate, is readily available for plants but is subject to immediate leaching when added to soil. Under conditions of high leaching potential, nitrate forms of N should not be used unless the plants are actively growing and can utilize the applied nitrate N. Where there is a high potential for leaching, ammonium forms of N, such as urea, ammonium sulfate,

anhydrous ammonia, are preferred sources of N. Ammonium in soil is held on clay and organic matter and must first be converted to nitrate N before it can be leached or denitrified. This process, known as nitrification, occurs rapidly under warm, moist conditions.

Urea and N solutions containing urea are subject to volatilization loss as gaseous ammonia if surface applied and not incorporated. Conditions which favor this loss are high temperatures, high soil pH, moist soils, and high levels of plant residue on the soil surface. Because the volatilization loss of a urea-based fertilizer is difficult to assess, and since it represents an economic loss to the farmer, urea-containing fertilizers should be incorporated whenever possible. See MSU Extension Bulletin E-896 (Vitosh, 1990) for more information on fertilizer types, uses and characteristics. In fruit plantings and sod production fields where incorporation is not possible, apply urea when conditions are cool and not conducive to volatilization.

### Time and Placement of Nitrogen Fertilizer

A small amount of N in a starter fertilizer applied to annual row crops at planting time is often desirable and normally has a beneficial effect on P uptake, particularly under cool, wet conditions. Crops on sandy soils low in organic matter and available N are also likely to respond to starter N fertilizer.

Spring applications of N on corn in Michigan are clearly superior to fall applications (Vitosh, 1991). Fall applications of N for spring or summer-seeded crops are not recommended. Climatic conditions from fall to spring can significantly affect the amount of N movement from the plant root zone. Estimates of N loss from fall applications vary from ~~ten~~ 10 to 20 percent on fine to medium textured soils (e.g., clay, clay loams, and loams) and 30 to greater than 50 percent on coarse textured soils (e.g., sandy loams, loamy sands, and sands).

For establishment of winter small grains, such as winter wheat or rye, small applications of N fertilizer (20-30 lbs./acre) can be made in the fall at planting time. The remainder of the N requirement for these crops should be applied just prior to green-up in the spring. Avoid applications of N to snow-covered ground and to frozen land with slopes greater than six percent. Nitrogen applications on highly sloping land should be made after the spring thaw.

Split applications of N fertilizer during the growing season on corn and most vegetable crops are frequently beneficial on coarse textured soils (Vitosh, 1986). The benefits of split applications of N on corn grown on fine textured soils are less likely to occur, therefore, total N applications at planting or after emergence are acceptable. Fruit plantings on coarse textured soils may also benefit from split applications of N. Apply part of the N in early spring and part in late spring. Rates in the second application can be adjusted for anticipated yield.

For sod production, a small application of N fertilizer (20-40 lbs./acre) can be made in the fall at seeding time. During the growing season, multiple small applications of N can be made at four to six-week intervals as long as roots are actively growing. This practice will help to maintain turf density and reduce the need for herbicides.

Additional N fertilizer may be used in emergency situations, such as when heavy rains occur early in the growing season causing excessive leaching and/or denitrification. The use of additional N fertilizer in these situations may be necessary to prevent severe yield losses. Adding N fertilizer after heavy rains or flooding late in the season is usually not agronomically or economically effective and should be done only after careful consideration of the benefits and the effect on the environment.

**10. B. Use special N management practices on sandy soils and in groundwater-sensitive or well-head protection areas.**

Many site-specific management practices and tools can be adopted which may improve N recovery and reduce the potential for nitrate contamination of groundwater. Crop rotations, forage crops, cover crops, plant analysis, soil sampling for nitrate, split applications of N, and use of nitrification inhibitors are some of the special N management practices that can be used on sandy soils and other groundwater-sensitive areas to minimize nitrate losses to groundwater. See MSU Extension Bulletin WQ-25 (Vitosh and Jacobs, 1996) for more information on these management practices. The [USDA NRCS Field Office Technical Guide, ~~\(USDA-NRCS\)~~](#) located in each conservation district office, contains information for identification of groundwater-sensitive areas.

**Phosphorus Management Practices**

**11. A. Apply phosphorus fertilizer based on soil tests or plant tissue analyses using ~~Michigan State University~~MSU recommended rates and methods of application that will enhance P recovery and uptake.**

Michigan State University fertilizer recommendations are found in Extension Bulletins E-2904 (Warncke *et al.*, 2004a) E-2934, (Warncke *et al.*, 2004b), E-852 (Hanson, 1996), and E-2011 (Hanson and Hancock, 1996). When soils have a Bray P1 test of 80-100 lbs./acre (40 to 50 ppm), fertilizer recommendations for P<sub>2</sub>O<sub>5</sub> will likely be zero for most crops and yields grown in Michigan. So, increasing soil P test levels beyond this range will usually not be beneficial agronomically or economically.

Band application of starter fertilizer to the side and below the seed at planting time is considered ~~to be~~ the most efficient placement of P for field and vegetable crops when grown in rows. Broadcast applications of P are less efficient and normally will result in lower yields than band applications when soil test P levels are low. When broadcast applications are necessary, the P fertilizer should be applied and incorporated prior to establishment of the crop, to improve nutrient utilization by plants and prevent excessive nutrient runoff. For no-till crops, such as soybeans and wheat planted with a narrow row



drill, the necessary broadcast application should be made just prior to planting. For established crops, such as grass sod, pastures, legumes, and other forages, where it is impossible to incorporate the fertilizer, the P fertilizer may be broadcast when soil conditions are favorable for rapid growth, and soil compaction is minimized.

For no-till row crops, all P should be banded at planting time. For perennial crops, P fertilizer should be applied in the spring when soil conditions allow fertilizer applications to be made with minimal soil compaction. The need for P on perennial crops should be determined from plant tissue analyses.

Establish and maintain filter strips between surface waters and fields where fertilizers are applied to prevent any soil erosion and runoff of fertilizer nutrients from reaching surface waters. For more information on filter strips, see the [USDA NRCS-FOTG eConservation Practice Standard No. 393A-\(USDA-NRCS\)](#).

**11. B. Avoid broadcast applications of phosphorus fertilizers on frozen or snow-covered ground.**

Fertilizer applied in the winter is the least desirable from a nutrient utilization and environmental point of view. Frozen soils and snow cover limit nutrient movement into the soil and greatly increase the risk of nutrients being carried to surface waters by runoff and erosion following rainstorms or rapid snow melt.

## **NUTRIENT MANAGEMENT PRACTICES FOR ORGANIC SOILS**

**12. Manage water table, irrigation, and nutrients to minimize runoff and soil loss.**

Organic soils are unique in that they contain 1.0 to 1.7 percent N and may have an annual mineralization rate of 320 to 530 lbs. N per acre. Of this vast amount of mineralized N, nearly 90 percent is denitrified to form gaseous N. While the remaining ten percent is available for plant use, it is also susceptible to movement into surface water and groundwater. Thus, it is important to apply only the amount of N needed by the crop at times when it can be utilized. Nitrogen should not be applied in the fall or winter because leaching could be excessive. Cover crops should be planted after harvest to utilize and hold N in a nonleachable form. For sod production, small N applications (20 to 40 lbs./acre) can be made in the fall as long as turf roots are actively growing.

Mineralization is an aerobic process, which can be reduced by keeping the water table high enough to obtain good crop yields while allowing for the least amount of soil decay. For most cropping situations this depth is 24 to 30 inches.

Nitrate N concentrations in drainage water can be reduced by controlling the level of the water table and by slowing the movement of water in drainage ditches. For more

information on this subject see Lucas and Warncke (1988).

## **RECORDKEEPING**

### **13. Maintain records of soil test reports and quantities of nutrients applied to individual fields.**

Good recordkeeping demonstrates good management and will be beneficial for the crop producer, if the producer's management practices are challenged. Annual records should include the following for individual fields:

- a. Most recent soil fertility test(s) and/or plant tissue analysis reports;
- b. previous crop grown and yield harvested;
- c. date(s) of nutrient application(s);
- d. the nutrient composition of fertilizer or other nutrient-supplying material used (If the nutrient composition, availability or solubility is not provided with the purchase of the nutrient-supplying material, then representative samples of this material should be analyzed to provide nutrient composition information. Grass clippings and non-legume crop residues grown in the field and left to recycle nutrients are not considered to be nutrient additions.);
- e. amount of nutrient-supplying material applied per acre;
- f. method of application and placement of applied nutrients (i.e., broadcast and incorporated, broadcast and not incorporated, subsurface-banded, surface-banded, soil injected, applied through an irrigation system, etc.);
- g. the name of the individual responsible for fertilizer applicator calibration, and the dates of calibration (If the equipment is owned by a fertilizer dealer, or someone else who is responsible for proper calibration, then the name of the individual and/or business responsible for calibrating fertilizer application equipment should be retained); and,
- h. vegetative growth and cropping history of perennial crops.

A recordkeeping system, such as that described in MSU Extension Bulletin E-2340 (Jacobs *et al.*, 1992) or available as a computer program like MSU Nutrient Management (Jacobs and Go, 2006), may be helpful in accomplishing this goal.

## **FERTILIZER APPLICATION EQUIPMENT ADJUSTMENT**

### **14. Check all fertilizer application equipment for proper adjustment so the desired rate of application and placement are achieved.**

Fertilizer can be applied in either dry or liquid form. In either case, the application rate should be determined, and the equipment adjusted so that the desired rate of application is achieved. Details for the calibration of fertilizer applicators can be found in equipment manufacturers' publications, ASAE Standards (ASAE Standards, 2004), or in Circular Z138 (Broder, 1982). The equipment owner is responsible for providing instructions for proper calibration, and users of the equipment are responsible for

following the instructions to the best of their ability.

## SOIL CONSERVATION PRACTICES

### **15. Use soil erosion control practices to minimize nutrient runoff and soil loss.**

Soil erosion and runoff can result in a loss of soil and nutrients from cropland, which reduce the land's productivity and increase the need for nutrient inputs. Sediment and sediment-borne nutrients are two types of nonpoint source pollution, which can be carried from cropland by runoff causing degradation of surface water. Whenever possible, soil and water conservation practices should be used, both to protect soil productivity and to control and minimize the risk of nonpoint source pollution to surface waters. Examples of such practices are conservation tillage, crop rotations, [strip cropping](#), contour planting, cover crops, vegetative filter strips between cultivated cropland and adjacent surface waters, and runoff control structures.

When choosing soil and water conservation practices for a [particular site](#), consider factors, such as land slope, surface residue or vegetative conditions, crop rotations, soil texture, and drainage. Local conservation districts and the NRCS can provide technical assistance for producers to plan and implement conservation practices. See the current [USDA NRCS-FOTG \(USDA NRCS\)](#) for more information on conservation practice standards and specifications.

## IRRIGATION MANAGEMENT PRACTICES

Careful N management for irrigated crop production also involves careful management of irrigation water. Proper irrigation management can help assure plant growth and crop yields sufficient to remove nutrients that have been applied for realistic yield goals, while minimizing nitrate remaining in the soil that is subject to potential leaching. Excess water from irrigation and/or precipitation can cause nitrates to move below the root zone and eventually to groundwater.

### **16. Irrigators should use modern irrigation scheduling techniques to avoid applying excess water.**

Irrigation scheduling involves keeping track of the amount of water in the soil, or water losses to the atmosphere (evapotranspiration) and irrigating before plants are stressed. After irrigation, some soil water-holding capacity should remain to hold rainfall, should it occur. In most cases, irrigation should occur when 40 to 70 percent of the available soil water is depleted, depending on the soil, crop, and capacity of the irrigation system. Irrigation water should not fill the soil rooting profile to more than 80 percent. Precise scheduling of irrigation water during the growing season can minimize percolation losses (Vitosh, 1992). See the current "Generally Accepted Agricultural and Management Practices for Irrigation Water Use" for recommended irrigation management practices.

**17. Irrigators should use multiple applications of N fertilizer to improve N efficiency and minimize potential loss of nitrate-N to groundwater.**

Multiple applications will help to ensure that N is available when plants need it most and to minimize the amount that can be leached. Any combination of application methods can be used, such as starter fertilizers at planting time, side dressing by soil injection, dribbling on the surface, application during cultivation, and/or by injection through the irrigation system.

Nitrogen fertilizer applied through the irrigation system, referred to as fertigation or chemigation, offers several advantages: (1) N can be applied when the crop's demand is greatest, and in trickle-irrigated orchards, where roots are most concentrated; (2) the technique requires little energy for application; and (3) it is well suited to sandy soils where irrigation is needed and leaching may be a problem. Producers who fertigate should test the uniformity of their irrigation system to assure that no extremely high or low zones of water application occur. Careful adjustment of fertilizer injection equipment to obtain the desired rate of application is very important. Irrigation systems used for fertigation must have appropriate backflow-prevention safety devices. (Reference Public Act 368, the Michigan Public Health Code of 1978, as amended, and Public Act 399, the State of Michigan Safe Drinking Water Act of 1976, as amended). See MSU Extension Bulletin E-2099 (Hay *et al.*, 1988) and Northeast Regional Agricultural Engineering Service Bulletin NRAES-4 (NRAES, 1981) for proper and safe use of fertigation equipment.

## **FERTILIZATION AND IRRIGATION PRACTICES FOR CONTAINER-GROWN PLANTS**

Growing plants in greenhouses or outdoor container nurseries requires rapid growth to maintain production schedules and quality. Frequent fertilization and irrigation are needed since common root media lack nutrient and water-holding capacity. However, effective management practices can be adopted to minimize water and fertilizer leaching and/or runoff (Horticultural Water Quality Alliance, 1992).

### **RUNOFF PREVENTION**

**18. Use management practices that prevent or minimize water and fertilizer runoff, such as selecting good quality root media, using slow-release fertilizer, improving irrigation systems, reducing leaching, and scheduling irrigations.**

#### **Root Media**

Greenhouse root media composed primarily of peat, bark, and other components, such as vermiculite, perlite, or rockwool should be formulated to provide high water-holding

capacity, while maintaining adequate drainage and air space. When preparing root media, components, and additives, like wetting agents, which increase the rate of absorption of water, should be incorporated. Commercially prepared root media with high water holding capacity are available for greenhouse use. For outdoor nursery production, root media are composed primarily of bark, peat, and other components and must be porous enough to drain excess water under heavy rainfall conditions.

### Fertilization

Essential nutrients should be applied based on plant nutrient requirements, plant growth rate, and root media nutrient availability. Pre-plant incorporation of water-soluble nutrients like N and P that will readily leach from the root media should be minimized. Current fertilizer recommendations are based on the concentration of water-soluble fertilizer to be applied weekly or at every watering. However, nutrient levels in the root media are a function of both the concentration and volume applied. With reduced leaching, fertilizer concentrations can be decreased (Biernbaum, 1992). Sampling of root media, testing electrical conductivity, and completing an elemental analysis will help determine actual fertilizer requirements. Media analysis for longer term outdoor nursery crops may be conducted less frequently. Test results generated by MSU, other Land Grant Universities, and approved commercial testing laboratories using the testing methodology of the North Central Committee on Soil Testing and Plant Analysis (Chapter 14 of Brown, 1998), can be used for making nutrient recommendations.

Recommended root media nutrient levels and nutrient recommendations are available in MSU Extension Bulletin E-1736 (Warncke and Krauskopf, 1983) for greenhouse crops. Nutrient recommendations for container-grown and field-grown nursery crops can be found in "Management Practices for Michigan Wholesale Nurseries" (Fernandez, 2004). Guidelines for nutrient levels in plant foliar tissue for nursery crops are available (Fernandez, 2004). For greenhouse pots and container-grown nursery crops, water management and use of controlled release fertilizers are important to maintain adequate nutrient levels for optimum plant growth and to minimize leaching and loss of soluble nutrients (Horticultural Water Quality Alliance, 1992; Fernandez, 2004).

Slow release fertilizer, such as sulfur-coated urea or resin-coated fertilizer (RCF), can be incorporated into the root media or surface-applied to reduce water-soluble fertilizer applications and nutrient leaching. With outdoor, overhead irrigation of container-grown nursery stock where heavy rainfall can leach the root medium, RCF can be used to prevent runoff of water-soluble fertilizer. Formulations containing a variety of nutrient levels and release rates are available. Nevertheless, RCF may be an unacceptable alternative for some cropping situations. Problems due to excess nutrient release may occur during the summer when root medium temperatures in the containers become too high, or during over-wintering of nursery crops when nutrient uptake decreases. Therefore, use proper monitoring to avoid these high soluble salt conditions.

When water-soluble fertilizers are added to irrigation systems, fertilizer injectors or

diluters should be checked regularly for proper operation and dilution. Backflow preventers and antisiphon devices must be installed on all water supplies when fertigation or chemigation is used (Reference Public Act 368, the Michigan Public Health Code of 1978, as amended, and Public Act 399, the State of Michigan Safe Drinking Water Act of 1976, as amended).

### Irrigation Systems

Overhead sprinklers, traveling booms, and drip systems should be designed to maximize uniformity of application and water absorption by the root media. Overhead fertigation of container-grown nursery plants with water-soluble fertilizers should be avoided unless runoff can be collected and recirculated. Overhead irrigation with sprinklers, or traveling booms, can be efficient if growing containers are closely spaced, as in the production of bedding plants in flats. Low-volume drip systems can also be designed to be efficient with 90 percent or more of the water available for plant uptake. Subirrigation with water recirculation is very efficient, but is not always practical or affordable (Biernbaum, 1993).

### Leaching

In greenhouse production, application of a sufficient quantity of water to facilitate leaching with every irrigation is advised routinely to prevent the accumulation of fertilizer and other salts (Biernbaum, 1992). For container nursery production, rainfall is often sufficient to adequately leach containers.

However, during periods of little or no rainfall, container soluble salt levels should be monitored, and leaching conducted when necessary (Fernandez, 2004). When the irrigation water contains ~~high levels~~elevated levels of boron, chloride, sodium, or other elements, some leaching may be needed. However, when soluble salts in the root zone are a result of over-application of water-soluble fertilizer, the fertilizer concentration should be reduced, or clear water should be applied for several irrigations to bring levels down gradually rather than making heavy applications of water to leach the fertilizer salts. To reduce leaching, water-soluble fertilizer applications with irrigation systems can be made with multiple, short pulses rather than one long application. In some greenhouse situations, plastic trays can be placed under growing containers to catch irrigation water so more of what is applied is available to the plant.

### Irrigation Scheduling

Although many peat and bark-based media can be irrigated frequently and heavily without waterlogging, growth may be reduced due to excessive leaching of nutrients. Irrigation should be scheduled based on crop water requirements. Measuring water availability and scheduling irrigation of root media in small containers is not practical with currently available soil moisture monitoring equipment and is generally done based on personal observation and monitoring. When computer equipment is available, water

requirements and irrigation schedules can be predicted based on environmental conditions, such as accumulated solar radiation and/or vapor pressure deficit measurements.

### **RUNOFF COLLECTION**

- 19. When runoff or leaching of fertilizer cannot be controlled, water that contains fertilizer should be collected and reused.**

Runoff water and fertilizer solutions can be collected from concrete greenhouse floors, field drains under greenhouses or container nursery areas, and then recycled. Filtering of the water to remove solids or treating the water to control plant pathogens may be needed. Grass gullies or runways and filter strips ahead of the collection pond or reservoir will help remove suspended solids. Recirculation of water and nutrient solutions can be accomplished in greenhouses without contamination of the nutrient solution when using closed, flood sub-irrigation systems (Biernbaum, 1993). Flood benches, flood floors, or troughs can be used as methods to provide the water and nutrients by subirrigation. After irrigating, the remaining solution is collected in reservoirs and recycled.

### **RECORDKEEPING**

- 20. Maintain records of fertilizer purchases and irrigation water used.**

Recording individual fertilizer applications is difficult since fertilizer may be applied on an almost daily basis. Records of all fertilizer purchases will probably provide the best measure of fertilizer use. Maintaining annual records of irrigation water use or irrigation scheduling to demonstrate water use patterns and conservation is also recommended.

### **LAND APPLICATION OF ORGANIC (BIOLOGICAL) MATERIALS AND BY-PRODUCT LIMING MATERIALS FOR CROP PRODUCTION**

- 21. The application of organic and by-product liming materials to Michigan soils for crop production is a common and accepted agricultural practice.**

The organic material most commonly applied to soils, excluding plant residues, is animal manure. At one time, most farms had livestock, and the manures generated were a primary source of nutrients for crop production. However, with the introduction of commercial fertilizers and the specialization of farming, only about 40 percent of Michigan farms now have livestock that generate manure nutrients. See current "Generally Accepted Agricultural and Management Practices for Manure Management and Utilization" for recommended management practices when utilizing manure as a source of plant nutrients. In addition to animal manures, other organic materials are applied to soils in Michigan. From an agricultural point of view, the concept of recycling

manure nutrients and organic materials back to cropland is highly desirable. However, the consequences of utilizing some organic wastes from industrialized societies should be addressed to avoid potential negative impacts to animals and humans, the soil-plant system, and the environment.

This section briefly discusses the use of organic materials (i.e., those materials primarily of biological origin) which can be used to supply nutrients for crop production and by-product liming materials used to correct soil acidity and maintain desired soil pH. To provide the reader with a better understanding of the kinds of organic (biological) materials which are produced by our society, the basic categorization used by the U.S. Department of Agriculture (USDA, 1978) was selected. While this USDA report uses the term “organic wastes” to represent the various kinds of organic materials discussed, many of these materials, when used properly, can serve as valuable nutrient resources and organic matter amendments.

The grouping used by the U.S. Department of Agriculture (USDA, 1978) includes most organic materials which might be applied to cropland. The different categories of organic materials and a description of each category follow:

- 1) Animal manure—feces and urine excreted by bovine cattle, horses, sheep, goats, swine, and poultry, with any accompanying bedding or litter.
- 2) Crop residues and green manures—stems, leaves, roots, chaff, and any other plant parts remaining after crops are grazed or harvested; also, plant material, which is green and growing to maturity, that is incorporated into the soil.
- 3) Human wastes—various forms of organic materials containing human feces and urine, such as night soil, septage, sewage wastewater, and sewage sludge (now more commonly called biosolids).
- 4) Food processing wastes—organic by-products from the fruit, vegetable, seafood, sugar, fats, oils, and dairy food processing industries.
- 5) Industrial organic wastes—by-products from paper and allied products; fermentation, including pharmaceutical and food additives; soap and detergent; alcoholic fermentation, including distilleries, wineries and malt beverage industries; meat packing and related industries, including those producing pet food, seafood, and poultry products; leather tanning and finishing; organic fiber processing; petroleum refining and related industries; and milling.
- 6) Logging and wood manufacturing residues—waste debris in forest after logging, such as limbs, leaves, needles, diseased/decayed wood; manufacturing residues, such as chips, bark, sawdust, etc.; and.
- 7) Municipal refuse (also called MSW, municipal solid waste)—the organic portion of collectable solid wastes generated by households, institutions, offices, commercial and industrial premises, and in the streets of urban areas; would also include raw or composted yard wastes and composted MSW.

Potential hazards that may be encountered when organic materials are applied to the



soil-plant system for crop production include poor management of nutrients, additions of undesirable trace elements and trace organic chemicals, pathogens, and creation of soil physical problems. The problem most frequently noted is poor management of organic fertilizer nutrients that can pollute water resources, particularly with N and P. Excess nitrate-N can contaminate groundwater. Excess P may accumulate in surface soils increasing the risk of P runoff/erosion losses to surface water. In addition, odors, disease, and vector attraction can occur if the application of these organic materials is not managed properly.

As noted above, the current GAAMPs for Manure Management and Utilization provide recommended management practices for utilization of manure as a source of plant nutrients. Crop residues and green manures produced on cropland are already part of the soil-plant system. The land application of many other organic materials described in the above categories is regulated by ~~DEQ~~-EGLE, and these residuals are defined by state and federal environmental regulations as “wastes.” The generator of any waste is responsible for characterizing its waste, determining the waste’s suitability for land application, and obtaining all necessary approvals for a land application program.

For these regulated wastes, EGLE ~~has~~ established guidelines for isolation distances of land application sites from surface water, domestic wells or municipal water supplies, residences and commercial buildings, public roads, and property lines. EGLE also has requirements for the incorporation of certain organic materials and restrictions on applications to snow-covered or frozen soils. In addition, any approval granted by EGLE to a waste generator for a land application program carries with it the responsibility to prevent adverse environmental effects, including losses from runoff and leaching.

Commercial and industrial generators of organic residuals or by-product liming materials are required to obtain authorization to land apply these materials. Unless a material is declared inert by the EGLE Materials Management Division (MMD), such authorizations typically take the form of an Agricultural Use Approval (AUA), which is issued through ~~OWMRP~~-MMD. For more information regarding AUAs, contact MMD at PO Box 30241, Lansing, Michigan 48909-7741, or at (517) 5823445.

Municipal and privately owned treatment works that treat sewage may obtain authorization to land apply biosolids (wastewater treatment sludges) through the EGLE Water Resources Division (WRD). For more information regarding authorizations to land apply municipal biosolids and/or septage, contact WRD at P.O. Box 30273, Lansing, Michigan 48909-7773, or at (517) 284-5567.

The land application of certain organic residuals, food processing residuals and by-product liming materials to agricultural or silvicultural land is authorized under the authority of Part 115. Section 11506 (1)(h) conditionally exempts agricultural and silvicultural uses that involve the land application of certain food processing residuals, garbage (defined in Section 11503 as rejected food waste including waste accumulation of animal, fruit, or vegetable matter used or intended for food or that results from the

preparation, use, cooking, dealing in, or storing of meat, fish, fowl, fruit, or vegetable matter), precipitated calcium carbonate from sugar beet processing, lime from kraft pulping (paper) processes generated prior to bleaching, wood ashes resulting solely from a source that burns only wood that is untreated and inert, aquatic plants, or source separated materials approved by EGLE.

In addition to the materials listed above, the generation of new by-products is increasing in Michigan and the U.S. from crop-based bioenergy plants producing ethanol from corn and soy diesel blends from soybeans. Two primary by-products are dried distillers' grains (~~DDGs~~) and wet distillers' grains (~~WDGs~~). These by-products can be utilized as livestock feed, and are exempt from regulation as a solid waste and permit requirements, if these by-products are land applied at an agronomic rate consistent with the current GAAMPs specified in Section VIII below.

Changes to Part 115 in September 2014 define a new class of materials called "beneficial use by-products." EGLE's beneficial use by-products website is at: [https://www.michigan.gov/egle/0,9429,7-135-3312\\_4123-336759--\\_00.html](https://www.michigan.gov/egle/0,9429,7-135-3312_4123-336759--_00.html)

A certain class of beneficial use by-products, beneficial use 3, may be agriculturally land applied provided they are first registered or licensed by the generator under MDARD as a fertilizer, soil conditioner or liming material. The generator needs to provide labeling for these materials for the consumer. MDARD's beneficial use application details are available at [https://www.michigan.gov/mdard/0,4610,7-125-1569\\_16993\\_19405---\\_00.html](https://www.michigan.gov/mdard/0,4610,7-125-1569_16993_19405---_00.html). The materials eligible for registration or a license are coal bottom ash, foundry sand from ferrous and aluminum foundries, cement kiln dust, lime kiln dust, lime water softening residuals, flue gas desulfurization gypsum, soil washed or otherwise removed from sugar beets, and dewatered concrete grinding slurry.

The generator of the land applied materials, along with the applicator and landowner, share responsibility for following the practices. If the land application of the above referenced materials is not managed in a manner consistent with these practices, then the generator of the material is required to obtain the necessary permits and approvals from EGLE.

### Composting Organic Materials

Section 11506. (1)(h) of the NREPA also conditionally exempts the land application of composted organic materials. Composting is a self-heating process carried on by bacteria, actinomycetes, and fungi that decompose organic material in the presence of oxygen. Composting of organic materials prior to land application can result in a rather stable end product that does not support extensive microbial or insect activity, if the process and systems are properly designed and managed. The potential for odors during the composting process depends upon the moisture content of the organic material, the carbon-nitrogen ratio, the presence of adequate nutrients, the absence of

toxic levels of materials that can limit microbial growth, and adequate porosity to allow diffusion of oxygen into the organic material for aerobic decomposition of the organic material. Stability of the end product and its potential to produce nuisance odors, and/or to be a breeding area for flies, depends upon the degree of organic material decomposition and the final moisture content. Additional information and guidance about alternatives for composting organic materials are available in the “On-Farm Composting Handbook” (Rynk, 1992) and the National Engineering Handbook (USDA, 2000).

The occurrence of leachate from the composting material can be minimized by controlling the initial moisture content of the composting mixture to less than 70 percent and controlling water additions to the composting material from rainfall. Either a fleece blanket<sup>1</sup> or a roofed structure can be used as a cover to control rainfall additions and the production of leachate from composting windrows.

If the composting process is conducted without a cover, provisions must be made to collect any surface runoff and/or leachate, so it can be either temporarily stored (see Section IV of the current Manure GAAMPs) and applied to land (see Section V of the current Manure GAAMPs), added to the composting material for moisture control during the composting process, or applied to grassed infiltration areas (See Section II of the current Manure GAAMPs). Therefore, depending on how the composting process is conducted, any leachate or runoff generated from composting material and/or from the composting site, must be controlled and/or treated in a manner to protect groundwater and surface water.

Organic materials generated on a farm, or brought onto a farm, for on-farm composting may be applied to cropland (belonging to that farm operation) as nutrient resources for crop production or as organic matter amendments and is considered an acceptable practice (See GAAMP #21). Composted organic by-products that are land applied should follow the practices specified in Section VIII below.

The “practices” referred to in the NREPA, Public Act 451 of 1994, as amended, that must be followed to conditionally exempt various organic materials, composted organic materials, liming materials, and source separated materials like cull eggs from Solid Waste Management regulations are specified in Section VIII below. Responsibility for determining whether these practices are being followed to qualify for this conditional exemption is shared by ~~the~~ MDARD and ~~the~~ EGLE, as described in the “Memorandum of Understanding (MOU) between MDARD and EGLE Regarding State Agency Response Actions to Environmental and Nuisance Complaints about Farm Operations” and the “MDARD/EGLE Waste Complaint Response Procedure.”

### **LAND APPLICATION OF CONDITIONALLY EXEMPTED ORGANIC MATERIALS, COMPOSTED ORGANIC, AND LIMING MATERIALS**

As was indicated in Section VII above, various by-products that can supply nutrients for

crop production, or correct soil acidity when applied to agricultural or silvicultural land, are conditionally exempt from regulation as a solid waste and permit requirements, if these by-products are applied at an agronomic rate consistent with the current GAAMPs described in this section.

---

<sup>1</sup> A fleece blanket is a non-woven textile material made from synthetic fibers, such as polypropylene. The non-woven texture of a fleece blanket prevents rainfall from penetrating into the composting material, but allows the necessary exchange of carbon dioxide and oxygen.

Practices #22-23 apply to all conditionally exempted organic and inorganic by-products. Management practices #24-33 pertain to organic by-products or composted organic by-products that are used as nutrient sources. Practice #34 discusses wood ashes that have liming value in addition to potash (K<sub>2</sub>O) value, and management practice #35 discusses by-product liming materials used to correct soil acidity. Management practice #36 discusses the application of soil removed from sugar beets or other root vegetables by mechanical means or by washing with water. The final GAAMP in this section, practice #37, discusses recommended recordkeeping for the application of all by-products to agricultural or silvicultural land.

- 22. The by-product should be handled in such a manner as to prevent spillage during transport to application sites. Temporary staging or stockpiling of by-product at the field application site prior to land application should be managed in a manner to prevent runoff and/or leaching of nutrients or by-product lime to surface water or groundwater, and to minimize odor impacts upon neighbors. If conditions of the temporary staging or stockpiling site result in adverse environmental effects, the stockpiled by-product should be immediately removed and properly land applied.**
- 23. All fields to which by-products are applied should have soils sampled and tested on a regular basis to determine where by-product nutrients or by-product lime can best be utilized (see Section III, GAAMP #7).**
- 24. Use fertilizer recommendations, consistent with those of ~~Michigan State University~~MSU, to determine the total nutrient needs for crops to be grown on each field where by-products will be applied (see Section III, GAAMP #8).**
- 25. To determine the nutrient content of a by-product material, analyze it for percent dry matter (solids), ammonium N (NH<sub>4</sub>-N), and total N, P, and K.**

One goal of a well-managed land application program is to utilize soil testing as a basis for fertilizer (nutrient) recommendations and agricultural lime recommendations. The quantity of nutrients recommended for the crop and yield to be grown will likely need to be supplied by a combination of by-product nutrients and commercial fertilizer nutrients. For soils with low pH's, agricultural lime recommendations to correct soil acidity should be based on soil testing results. By-product liming materials can be substituted for agricultural lime, as discussed in management practices #34 and #35.

In order to effectively manage by-product nutrients for crop production, the nutrient content of the by-product material needs to be known. Because of variation in the nutrient content of by-product materials, a representative sample(s) of the by-product should be obtained and analyzed by a laboratory to determine its nutrient content. To establish "baseline" information about the nutrient content of a by-product material, the by-product should be sampled and tested for at least two years. When there is a change in the kind of material being processed or the process by which the by-product is produced, additional testing for baseline nutrient composition should be done. MSU Extension and/or MDARD can provide information on collecting representative by-product samples and where to send samples for analysis.

- 26. The agronomic (fertilizer) rate of N recommended for crops should not be exceeded by the amount of available N added, either from a by-product applied alone or from a by-product plus fertilizer N applied together. For legume crops, the amount of N removed by the legume may be used as the maximum N rate for by-product applications. The available N per ton of by-product material should be determined by using a by-product analysis.**

Excessive by-product applications to soils can: (a) result in excess nitrate N not being used by plants or the soil biology that may increase the risk of nitrate N being leached through the soil and into groundwater; (b) cause P to accumulate in the upper soil profile and increase the risk of contaminating surface waters with P where runoff/erosion occurs; and (c) create nutrient imbalances in soils, which may cause poor plant growth or animal nutrition disorders for livestock eating crops grown on by-product-amended soils. The greatest water quality concern from excessive by-product nutrient loadings, where soil erosion and runoff isare controlled, is nitrate N losses to groundwater. Therefore, the agronomic fertilizer N recommendation, or crop N removal value for legumes, should never be exceeded.

The availability of N in by-products for plant uptake will not be the same as, highly soluble, fertilizer N. Therefore, total by-product N cannot be substituted for that in fertilizers on a pound-for-pound basis, because a portion of the N is present in by-product organic matter which must be decomposed before mineral (inorganic) forms of N are available for plant uptake.

The rate of decomposition (or mineralization) of by-product organic matter is usually less than 100 percent during the first year, and will vary depending on the type of by-product utilized. In order to estimate the amount of available N that will be provided by each ton of by-product, the total N and NH<sub>4</sub>-N content from the by-product analysis can be used with a mineralization factor of 50 percent to calculate this value. This calculation is similar to that used for estimating available N in animal manures. (See Manure Management Sheet #2, MSU Extension Bulletin E-2344 by Jacobs *et al.*, 1993, for more explanation.)

Many of the by-products from fruit, vegetable, or sugar beet processing contain less

than one percent N on a fresh weight basis. By-products may be used to meet some or all of the N requirements of the crop, but it may not be practical or wise to apply these by-products as a sole source of N. The rate of application should allow for ease of incorporation when needed and should not adversely affect the permeability of the soil or physically restrict the growth of plants.

- 27. When the Bray P1 soil test level for P reaches 150 lbs./acre<sup>2</sup> (75 ppm), by-product applications should be reduced to a rate where by-product P added does not exceed the P removed by the harvested crop. (If this by-product rate is impractical due to by-product spreading equipment or crop production management, a quantity of by-product P equal to the amount of P removed by up to four crop years can be applied prior to the first crop year. However, no additional fertilizer or by-product P may be applied for the remaining crop years, and the by-product rate used cannot exceed the N fertilizer recommendation for the first crop grown.)**

**If the Bray P1 test reaches 300 lbs./acre<sup>2</sup> (150 ppm) or higher, by-product applications should be discontinued until nutrient harvest by crops reduces P test levels to less than 300 lbs./acre. To protect surface water quality against discharges of P, adequate soil and water conservation practices should be used to control runoff and erosion from fields where by-product is applied.**

The availability of P and K in by-products is considered to be close to 100 percent for K but considerably less than 100 percent for P. Periodic soil testing can be used to monitor how additions of by-product P and K will affect soil fertility levels.

If by-products are applied to supply all the N needs of crops, the P needs of crops will usually be exceeded, and soil test levels for P will increase over time. If the Bray P1 soil test P levels reach 300 lbs./acre (150 ppm)<sup>2</sup>, the risk of losing soluble P and sediment-bound P by runoff and erosion (i.e., non-point source pollution) increases.

Therefore, adequate soil and water conservation practices to control runoff and erosion should be implemented. In addition, when Bray P1 soil test P levels reach 300 lbs./acre, no more by-product (or fertilizer) P should be added until nutrient harvest by crops reduces P test levels to less than 300 lbs./acre.

To avoid reaching the 300 lbs./acre Bray P1 test level, by-product applications should be reduced to provide the P needs of crops rather than providing all of the N needs of crops and adding excess P. Therefore, when the Bray P1 soil test level for P reaches 150 lbs./acre (75 ppm)<sup>2</sup>, by-product applications should be reduced to a rate where by-product P added does not exceed the P removed by the harvested crop. The quantity of by-product P<sub>2</sub>O<sub>5</sub><sup>3</sup> that should be added can be estimated by using Crop Nutrient Removal Tables 1 and 2 and a realistic yield goal for the crop to be grown. For example, if a yield of 130 bu/acre for corn grain is anticipated, the amount of by-product P<sub>2</sub>O<sub>5</sub> added to this field should be limited to about 48 lbs./acre (130 bu/acre x 0.37 lb. P<sub>2</sub>O<sub>5</sub>/

bu).

---

<sup>2</sup> If the Mehlich 3 extractant is utilized for the soil fertility test instead of the Bray P1 extractant, then the following equivalent Mehlich 3 soil test levels can be used for Michigan soils: 150 lbs. P/acre (Bray P1) = 165 lbs. P/acre (Mehlich 3) and 300 lbs. P/acre (Bray P1) = 330 lbs. P/acre (Mehlich 3).

<sup>3</sup> Fertilizer P recommendations are given in, and fertilizer P is sold as, pounds of phosphate P<sub>2</sub>O<sub>5</sub>.

If the rate of by-product application based on P removal by the crop is lower than the by-product spreader can physically apply, or is not realistic when planning for crop production management, the rate of by-product application can be increased. The higher rate of by-product application can be equal to the P removal (See Table #1 and 2) for up to four crop years, as long as this rate does not exceed the N fertilizer recommendation for the first crop grown after the by-product is applied.

If this higher rate of by-product application is used, no fertilizer or by-product P should be applied during the remaining crop years, or until the accumulative P<sub>2</sub>O<sub>5</sub> removed by crop harvest equals the amount of by-product P<sub>2</sub>O<sub>5</sub> applied. A good recordkeeping system should be used to track the amounts of P<sub>2</sub>O<sub>5</sub> applied and the P<sub>2</sub>O<sub>5</sub> removed by harvested crops, when this higher rate of by-product application is used.

**28. By-products should be applied to soils in a uniform manner. The amount of by-product applied per acre (tons/acre) should be known, so that by-product nutrients can be managed effectively.**

As is true with fertilizers, lime, and pesticides, by-product materials should be spread uniformly for best results in crop production. Also, ~~in order to~~ know the quantity of by-product nutrients applied the amount of by-product applied must be known.

Determining the tons/acre applied by spreading equipment can be accomplished in a variety of ways. One method is to measure the area of land covered by one spreader load of by-product.

A second method is to record the total number of spreader loads applied to a field of known acreage. With either approach, the capacity of the spreader (in tons) must be known, and some way to vary the rate of application will be needed by adjusting the speed of travel or changing the discharge settings on the spreading equipment.

Guidance is available from MSU Extension or the equipment manufacturer to help determine the rates of by-product application that spreading equipment can deliver.

**29. By-products should not be applied to soils within 150 feet of surface waters or to areas subject to flooding unless: (a) by-products are injected or surface-applied with immediate incorporation (i.e., within 48 hours after application) and/or (b) conservation practices are used to protect against runoff and erosion losses to surface waters. By-products should be applied**

**in a manner to optimize nutrient utilization and prevent nutrient runoff to surface water.**

To reduce the risk of runoff/erosion losses of by-product nutrients, by-product materials should not be applied and left on the soil surface within 150 feet of surface waters. By-products that are surface applied with immediate incorporation can be closer than 150 feet, as long as if conservation practices are used to protect against runoff and erosion. A vegetative buffer between the application area and any surface water is a desirable conservation practice. By-products should not be applied to grassed waterways or other areas where there may be a concentration of water flow, unless used to fertilize and/or mulch new seedings during waterway construction. By-products should not be applied to areas subject to flooding unless immediately incorporated. In all cases, by-products should not be applied to land within 50 feet of surface water, a residence, a single family residential well, or within 200 feet of a public water supply well.

- 30. As land slopes increase from zero percent, the risk of runoff and erosion also increases. Adequate soil and water conservation practices should be used which will control runoff and erosion for a particular site, taking into consideration such factors as type of by-product to be applied, surface residue or vegetative conditions, soil type, slope, etc.**

As land slopes increase, the risk of runoff and erosion losses to drainage ways, and potentially to surface waters, also increases. Soil and water conservation practices should be used to control and minimize the risk of non-point source pollution to surface waters, particularly where by-product materials are applied. Surface application of a by-product should be avoided when the land slope is greater than six percent. However, a number of factors, such as the amount of liquid associated with a by-product(s) application, amount of residues present on the soil surface, soil texture, drainage, etc., can influence the degree of runoff and erosion associated with surface water pollution. Therefore, adequate soil and water conservation practices to control runoff and erosion at any particular site are more critical than the degree of slope itself.

- 31. Where application of by-product is necessary in the fall, rather than spring or summer, using as many of the following practices as possible will help to minimize potential loss of NO<sub>3</sub>-N by leaching: (a) apply to medium or fine rather than to coarse textured soils; (b) delay applications until soil temperatures fall below 50°F; and/or (c) establish cover crops before or after by-product application to help remove nitrate N by plant uptake.**

By-product and fertilizer nutrients should be applied as close as possible to, or during, periods of maximum crop nutrient uptake to minimize loss from the soil-plant system. Therefore, spring or early summer application is best for conserving nutrients, whereas fall application generally results in greater nutrient loss, particularly for nitrate N on coarse soils (i.e., sands, loamy sands, sandy loams)



- 32. Application of a by-product to frozen or snow-covered soils should be avoided, but where necessary, by-product materials should only be applied to areas where slopes are six percent or less. In addition, provisions must be made to control runoff and erosion with soil and water conservation practices, such as vegetative buffer strips between surface waters and soils where the by-product is applied**

Winter application of by-products is the least desirable in terms of nutrient utilization and prevention of nonpoint source pollution. Frozen soils and snow cover will limit nutrient movement into the soil and greatly increase the risk of by-product being lost to surface waters by runoff and erosion during thaws or early spring rains. When winter application is necessary, appropriately sized buffer strips should be established between surface waters and frozen soils where by-products are applied to minimize any runoff and erosion of by-product materials or nutrients from reaching surface water.

- 33. By-products should be managed and applied to cropland in a manner to control odors and reduce the potential for complaints concerning excessive odor.**

By-products tend to generate odors that are not typical of agricultural operations and may be offensive to neighbors. Therefore, it is important that by-products be applied to land in a manner which reduces the possibility of odor complaints. The following is a list of practices that can be used to reduce odor in the application of by-products to land:

- a. Avoid spreading when the wind is blowing toward populated areas.
- b. Avoid spreading on weekends/holidays when people are likely to be engaged in nearby outdoor and recreational activities.
- c. Spread in the morning when air begins to warm and is rising, rather than in the late afternoon.
- d. Use available weather information to best advantage. Turbulent breezes will dissipate and dilute odors, while hot, humid weather tends to concentrate and intensify odors, particularly in the absence of breezes.
- e. Take advantage of natural vegetation barriers, such as woodlots or windbreaks, to help filter and dissipate odors.
- f. Establish vegetated air filters by planting conifers and shrubs as windbreaks and visual screens between cropland and residential developments.
- g. Incorporate by-product materials into the soil as soon as possible after application (e.g., within 48 hours). However, incorporation may not be feasible where by-products are applied to pastures or forage crops, such as alfalfa, or where no-till practices are used. When incorporation of the by-product is not feasible, and the potential exists for an odor complaint, it may be advisable to find a more appropriate site for the application.
- h. Open-air stockpiling or storage of by-product materials at field applications sites should be managed in a manner to avoid odor complaints.

**34. Wood ashes should be applied at rates based on their potash (K<sub>2</sub>O) value and/or their acid-neutralizing value as a substitute for agricultural lime.**

The primary value of wood ashes is their potash value and their acid-neutralizing ability. Because of variation in the nutrient content of wood ashes, a representative sample(s) should be obtained and analyzed by a laboratory to determine its K<sub>2</sub>O content. The K<sub>2</sub>O content per ton of wood ash should then be used to determine the appropriate rate of wood ash to use to meet K<sub>2</sub>O fertilizer recommendations.

The wood ash should also be tested to determine its minimum neutralizing value in terms of calcium carbonate equivalent. This information, along with lime recommendations from soil test results, can then be used to determine acceptable wood ash application rates to neutralize soil acidity. Rates applied should be consistent with recommendations of [Michigan State University MSU](#) Extension Bulletin E-471 (Christenson *et al.*, 1993). When there is no lime requirement recommended, wood ash can still be applied for its potash value, as long as the accompanying liming addition will not interfere with achieving desired crop growth. To avoid potential growth problems from unneeded lime additions, growers should monitor soil test values for pH, P, K, and micronutrients by establishing baseline values prior to applying wood ashes on soils with pH>6.8.

**35. By-product liming materials should be applied at rates based on soil pH, lime requirement and neutralizing value of the liming material.**

The Michigan Liming Materials Law, Public Act 162 of 1955, as amended, requires that vendors of by-product liming materials determine and present the minimum neutralizing values in terms of calcium carbonate equivalents. This information, along with lime recommendations from soil test results, should be used to determine acceptable by-product lime application rates. By-product liming materials are usually used to neutralize soil acidity and should be applied in amounts consistent with recommendations of [Michigan State University MSU](#) Extension Bulletin E-471 (Christenson *et al.*, 1993). When there is a desire to apply by-product liming materials on high pH (alkaline) soils, one to two tons per acre of material may be applied to medium and fine textured soils with a pH above 6.8. Research has shown that this practice will not appreciably change soil pH or soil test values for P and K, and will not harm crop yields. As a management tool, growers should monitor soil test values for pH, P, K, and micronutrients by establishing baseline values prior to application of any liming material.

**36. Soil removed from sugar beets or other root vegetables by mechanical means or by washing with water should be applied to cropland at depths that can be physically mixed into the top four to eight inches of the receiving soil.**

Dry soil removed from sugar beets or other root vegetables, before processing or use as fresh market produce, can be returned to fields where these crops were harvested without obtaining a permit to do so from EGLE. To accomplish physical mixing of these

removed soils into the receiving soil, application depths will depend on the type of tillage equipment used. Suggested depths for applying these soils are one to two inches when a disk or chisel-plow is used and three to four inches when a moldboard plow is used.

Soil removed by commercial processors, by washing with water (from a source as specified in Part 22 Rules, R 323.2211) and collected in some type of storage pond or other facility, can also be air dried and returned to fields without an EGLE permit, if no chemical additives, other than lime, are made to this soil/water slurry. These soil/water slurries can be applied to drying beds or placed in seepage ponds/lagoons and the water allowed to drain into the ground under the following conditions: 1) the discharger must obtain a 2211 (permit by rule with notification) authorization; 2) the volume discharged towards groundwater is <50,000 gallons/day; and 3) EGLE must be notified if the wash water contains an additive. Generators of this type of wash water should refer to the Part 22 Groundwater Quality Administrative Rules for more specific information pertaining to these types of groundwater discharges. The soil slurries collected by commercial processors can also be discharged into a storage pond or facility that does not allow seepage of the water to occur, but additional care is needed (i.e., a permit from EGLE may be required) to properly handle any decant water that is removed or any leachate water lost from slurried soils during handling and other processes used to air dry these soils. Once these soils are air dried, they can be applied to fields per the guidance above.

**37. Records should be kept of materials analyses, soil test reports, and rates of material application for individual fields.**

Good recordkeeping demonstrates good management and will be beneficial for the crop producer. Records should include material analysis reports, rates of material applied, and information for individual fields as suggested in Section III under management practice #13.

When planning material applications, consider normal weather patterns; the availability of land at different times during the growing season for different crops; and availability of manpower and equipment relative to other activities on the farm. Having adequate storage capacity to temporarily hold materials can add flexibility to a management plan when unanticipated weather occurs, preventing timely applications. Nevertheless, unusual weather conditions do occur and can create problems for the best of management plans.

Finally, good recordkeeping is the "basis" of a good management plan. Past analysis results for materials should be good predictors of the nutrient content in materials being produced and applied today. Changes in the P test levels of soils with time due to material P additions can be determined from good records, and that information can be helpful in anticipating where material rates may need to be reduced and when additional land areas may be needed. -

Table 1. Approximate nutrient removal (lb./unit of yield) in the harvested portion of several Michigan field crops.<sup>4</sup>

Crop		Unit	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
			---- lb. per unit ----		
Alfalfa	Hay	ton	45	13	50
	Haylage	ton	14	4.2	12
Barley	Grain	bushel	0.88	0.38	0.25
	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	bushel	1.7	0.25	0.25
Canola	Grain	bushel	1.9	0.91	0.46
		ton	15	5.3	25
Clover	Hay	ton	40 <sup>5</sup>	10	40
Clover-grass	Hay	ton	41	13	39
Corn	Grain	bushel	0.90	0.37	0.27
	Grain <sup>6</sup>	ton	26	12	6.5
	Stover	ton	22	8.2	32
	Silage	ton	9.4	3.3	8.0
Millet	Grain	bushel	1.1	0.25	0.25
Oats	Grain	bushel	0.62	0.25	0.19
		ton	13	2.8	57
Orchardgrass	Hay	ton	50	17	62
Potatoes	Tubers	cwt	0.33	0.13	0.63
Rye	Grain	bushel	1.1	0.41	0.31
	Straw	ton	8.6	3.7	21
	Silage	ton	3.5	1.5	5.2
Sorghum	<sup>e</sup> Grain	bushel	1.1	0.39	0.39
Sorghum-Sudangrass (Sudax)	Hay	ton	40	15	58
	Haylage	ton	12	4.6	18
Soybeans	Grain	bushel	3.8	0.80	1.4
Spelts	Grain	bushel	1.2	0.38	0.25
Sugar Beets	Roots	ton		1.3	3.3
			4.0		
Sunflower	Grain	bushel	2.5	1.2	1.6
Timothy	Hay	ton	45	17	62
Trefoil	Hay	ton	48 <sup>5</sup>	12	42
Wheat	Grain	bushel	1.2	0.63	0.37
		ton	13	3.3	23

<sup>4</sup> Source: Nutrient Recommendations for Field Crops in Michigan. (Warncke *et al.*, 2004a)

<sup>5</sup> Legumes get most of their nitrogen from air.

<sup>6</sup> High moisture grain.

Table 2. Approximate nutrient removal (lb./unit of yield) in the harvested portion of several Michigan vegetable crops.<sup>1</sup>

Crop <sup>2</sup>	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	---- lb./ton <sup>3</sup> ----		
Asparagus, crowns new planting or established	13.4	4.0	10
Beans, snap	24	2.4	11
Beets, red	3.5	2.2	7.8
Broccoli	4.0	1.1	11
Brussels Sprouts	9.4	3.2	9.4
Cabbage, —fresh—market, processing, or Chinese	7.0	1.6	6.8
Carrots, fresh market or processing	3.4	1.8	6.8
Cauliflower	6.6	2.6	6.6
Celeriac	4.0	2.6	6.6
Celery, fresh market or processing	5.0	2.0	11.6
Cucumbers, pickling (hand or machine harvested)	2.0	1.2	3.6
Cucumber, slicers	2.0	1.2	3.6
Dill	3.5	1.2	3.6
Eggplant	4.5	1.6	5.3
Endive	4.8	1.2	7.5
Escarole	4.8	1.2	7.5
Garden, home	6.5	2.8	5.6
Garlic	5.0	2.8	5.6
Ginseng	4.6	1.2	4.6
Greens, Leafy	4.8	2.0	6.0
Horseradish	3.4	0.8	6.0
Kohlrabi	6.0	2.6	6.6
Leek	4.0	2.6	4.8

Lettuce, Boston, bib	4.8	2.0	9.0
Lettuce, leaf, head, or Romaine	4.8	2.0	9.0
Market Garden	6.5	2.8	5.6
Muskmelon	8.4	2.0	11
<b>Crop<sup>2</sup></b>	<b>N</b>	<b>P<sub>2</sub>O<sub>5</sub></b>	<b>K<sub>2</sub>O</b>
	---- lb./ton <sup>3</sup> ----		
Onions, dry bulb or green	5.0	2.6	4.8
Pak Choi	7.0	1.6	6.8
Parsley	4.8	1.8	12.9
Parsnip	3.4	3.2	9.0
Peas	20	4.6	10
Peppers, bell, banana, or hot	4.0	1.4	5.6
Pumpkins	4.0	1.2	6.8
Radish	3.0	0.8	5.6
Rhubarb	3.5	0.6	6.9
Rutabagas	3.4	2.6	8.1
Spinach	10	2.7	12
Squash, hard	4.0	2.2	6.6
Squash, summer	3.6	2.2	6.6
Sweet Corn	8.4	2.8	5.6
Sweet Potato	5.3	2.4	12.7
Swiss Chard	3.5	1.2	9.1
Tomatoes, fresh market or processing	4.0	0.8	7.0
Turnip	3.4	1.2	4.6
Watermelon	4.8	0.4	2.4
Zucchini	4.6	1.6	6.6

<sup>1</sup>Source: Nutrient Recommendations for Vegetable Crops in Michigan. (Warncke *et al.*, 2004b)

<sup>2</sup>Values used for some crops are estimates based on information for similar crops. <sup>3</sup>1 ton = 20 cwt.

## APPENDICES

### APPENDIX I -- References on State and Federal Laws and Regulations

A person applying, distributing, and storing fertilizer or organic materials in Michigan, must comply with the relevant state and federal laws and regulations promulgated under these statutes, including but not limited to:

1. The Superfund Amendments and Reauthorization Act (SARA) of 1986 Title III: Emergency Planning and Community Right-to-Know. This federal law provides mechanisms to prepare for chemical emergencies. Persons storing anhydrous ammonia above the "Threshold Planning Quantity" of 500 pounds must notify the State Emergency Response Commission within EGLE, the Local Emergency Planning Committee, and the local fire chief that they store this chemical above threshold at some time. The location of the storage facility and name and telephone number of a responsible person must also be reported. If there is a spill or release of anhydrous ammonia above the "reportable quantity" of 100 pounds, the same organizations must be notified. MSU Extension Bulletin E-2575 (Jess *et al.*, 2001) contains information to help farmers comply with this law.
2. Public Law 92-500, the Federal Water Pollution Control Act of 1972, as amended. This Act established a central goal to "restore and maintain the chemical, physical and biological integrity of the nation's water". The Water Quality Amendment Act of 1987 added provisions for the management of nonpoint source pollution. As part of Michigan's nonpoint source pollution control management strategy, Best Management Practices (BMPs) for fertilizer use and storage have been developed to meet requirements of the U.S. Clean Water Act.
3. Public Act 451, the Natural Resources and Environmental Protection Act of 1994, as amended. This Michigan law was enacted to protect the environment and natural resources of the state; to codify, revise, consolidate, and classify laws relating to the environment and natural resources of the state; to regulate the discharge of certain substances into the environment; and to regulate the use of certain lands, waters, and other natural resources of the state.

- A. Part 31. This part provides a broad substantive basis for protection and conservation of surface water and groundwater resources of the state. Under Part 31, it is unlawful for any person directly or indirectly to discharge into the waters of the state any substances which are or may become injurious to the public health or ecosystem. Violations of Part 31 subject the violator to civil fines up to \$25,000 per day and to criminal penalties including two years in prison. Part 31 defines "waters of the state" as the groundwaters, lakes, rivers and streams and all other watercourses and waters within the confines of the state, as well as the Great Lakes bordering the state.
- B. Part 55. The Michigan Department of Environment, Great Lakes and Energy has statutory authority, powers, duties, functions and responsibilities for rule-making and for issuance of permits and orders to control air pollution. This part provides for control of air pollution which may be in the form of a dust, fume, gas (including anhydrous ammonia), mist, odor, smoke or vapor in quantities which are or can become injurious to human health or welfare, animal life, plant life or to property, or which interfere with the enjoyment of life or property.
- C. Part 83. This part regulates registration, distribution, labeling, storage, disposal, and application of pesticides in Michigan.
- D. Part 85. This part regulates the manufacture, distribution, sale, labeling, advertising, and storage of fertilizers, soil conditioners, peat and peat moss, and composted materials. Regulation No. 641, Commercial Fertilizer Bulk Storage. This set of rules regulates the commercial storage of bulk fertilizer. Regulation No. 642, On Farm Fertilizer Bulk Storage. This set of rules regulates the on farm storage of bulk liquid fertilizer
- E. Part 115. This part is to protect the public health and environment; to provide for the regulation and management of solid waste, such as rubbish, ashes, incinerator ash, incinerator residue, street cleanings, municipal and industrial sludges, solid commercial and solid industrial wastes, and animal waste other than organic waste generated in the production of livestock and poultry; and to regulate materials that can be placed in licensed solid waste disposal facilities, such as sanitary landfills. A person shall not apply sludges, ashes, or other solid waste to the land without authorization under the Act, unless a plan for managing the wastes as non-detrimental materials appropriate for agricultural or silvicultural use has been approved by the director of the Michigan Department of Environment, Great Lakes, and Energy.
- F. Part 201. This part provides for the identification, risk assessment, and priority evaluation of environmental contamination and provides for



response activity at certain facilities and sites. This part also provides exemption from liability for farmers if they follow generally accepted agricultural and management practices.

4. Public Act 154, the Michigan Occupational Safety and Health Act (MIOSHA) of 1974, as amended. The Michigan Department of Health and Human Services and Michigan Department of Licensing and Regulatory Affairs jointly enforce this law to protect workers. Employers are required to have available for employees' review Material Safety Data Sheets (MSDS) on all hazardous chemicals that are present in the workplace. Employers must also develop and implement a written employee training program and ensure that all hazardous material containers are properly labeled.
5. Public Act 162, Michigan Liming Materials Law of 1955, as amended. This Act provides for the licensing and inspection of agricultural liming materials and regulates the labeling and sale of these products. In addition, this law prescribes penalties for violations. Liming materials, as defined by this Act, include any form of limestone, lime rock, marl, slag, by-product lime, industrial or factory refuse lime, water softener lime, and any other material used to correct soil acidity.
6. Public Act 346, the Commercial Drivers' License Law of 1988, as amended. This Act may require farmers to obtain endorsements on their commercial drivers' licenses for transporting U.S. Department of Transportation classified hazardous materials including anhydrous ammonia. This requirement applies if the total vehicle weight (i.e., towing and trailing vehicles) exceeds 26,000 pounds gross vehicle weight rating (GVWR).
7. Public Act 368, the Michigan Public Health Code of 1978, as amended. An Act to protect and promote the public health; to codify, revise, consolidate, classify, and add to the laws relating to the public health; to provide for the prevention and control of diseases and disabilities; and to provide for the classification, administration, regulation, financing, and maintenance of personal, environmental and other health services and activities.
8. Public Act 399, the State of Michigan Safe Drinking Water Act of 1976, as amended. An Act to protect the public health; to provide for supervision and control over public water supplies; to provide for the classification of public water supplies; and to provide for continuous, adequate operation of privately owned, public water supplies. This Act sets forth standard isolation distances from any existing or potential sources of contamination and also regulates the location of public water supplies with respect to major sources of contamination.

## **APPENDIX II -- References Cited**

AAPFCO/TFI. *Commercial Fertilizers*. 2004. Association of American Plant Food Control Officials and the Fertilizer Institute, Univ. of Kentucky, 2005.  
ASAE Standards: ASAE S341.3. *Procedure for Measuring Distribution Uniformity and Calibrating Granular Broadcast Spreaders*. pgs. 198-201. American Society of Agricultural Engineers, 2004.

Bartholic, J.F. Groundwater and Agriculture. pgs. 343-359. *Proceedings of the Plant Nutrient Use and the Environment Symposium*, October 21-23, 1985, Kansas City, MO. The Fertilizer Institute, 1985.

Biernbaum, J.A. *Root-zone Management of Greenhouse Container-grown Crops to Control Water and Fertilizer Use*. Hort Technology, Jan/Mar. 2(1):127-132, 1992.

Biernbaum, J.A. *Subirrigation Could Make Environmental and Economical Sense for Your Greenhouse*. Professional Plant Growers Association News, Vol. 24(4): 2-14, 1993.

Broder, M.F. *Best Ways to Calibrate Your Fertilizer Applicator*. Circular Z-138. TVA/OACD-82/19. Tennessee Valley Authority, National Fertilizer Development Center, 1982.

Brown, J.R. *Recommended Chemical Soil Test Procedures for the North Central Region*. North Central Regional Research Publication No. 221, Missouri Ag. Exp. Sta., 1998.

Christenson, D.R. *Phosphorus Demonstration Trial Results, 1986-1989*. Dept. of Crop and Soil Sciences, Mich. State Univ., 1989.

Christenson, D.R., Warncke, D.D., and Leep, R. *Lime for Michigan Soils*. MSU Extension Bulletin No. E-471, Mich. State Univ., 1993.

Cummings, T.R., Twenter, F.R., and Holtschlag, D.J. *Hydrology and Land Use in Van Buren County, Michigan*. U.S. Geological Survey, Water-Resources Investigations Report No. 84-4112, U.S. Geological Survey, 1984.

Ellis, B.G. 1988. *Nitrates in Water Supplies*. pgs. 75-83. Chapter No. 4, Proceedings Water Quality: A Realistic Perspective, Feb. 28, 1988.

Ellis, B.G., and Olson, R.A. Economic, Agronomic and Environmental Implications of Fertilizer Recommendations. North Central Regional Research Publication No. 310, Ag. Exp. Sta., Mich. State Univ., 1986.

Fernandez, T. (ed). *Management Practices for Michigan Wholesale Nurseries*. Dept. of Horticulture, Mich. State Univ., p. 209, 2004.

Hanson, E.J. *Fertilizing Fruit Crops*. MSU Extension Bulletin No. E-852, Mich. State Univ., 1996.

Hanson, E. J. and Hancock, J.A. *Managing the Nutrition of Highbush Blueberries*. MSU Extension Bulletin No. E-2011, Mich. State Univ., 1996.

Hanson, E.J. and Hull, J. *Plant Tissue Sampling for Determining Fertilizer Needs of Fruit Crops*. MSU Extension Bulletin No. E-2482, Mich. State Univ., 1994.

Hay, D.R., Vitzthum, E.F., Witkowski, J.F., and Nelson, E.W. (eds). *Using Chemigation Safely and Effectively*. MSU Extension Bulletin No. E-2099, Mich. State Univ., 1988.

Horticultural Water Quality Alliance. *Water Quality Action Manual for Greenhouse and Nursery Growers*. Society of American Florists, 1992.

Jacobs, L.W., *Recordkeeping System for Crop Production*. MSU Extension Bulletin No. E-2340, Mich. State Univ., 1992.

Jacobs, L.W., Böhm, S.U., and MacKellar, B.A. *Recordkeeping System for Crop Production--Manure Management Sheets*. MSU Extension Bulletin No. E-2344, Mich. State Univ., 1993.

Jacobs, L.W., and Go, A. *Michigan State University Nutrient Management (MSUNM) Microcomputer Program*, Windows Version 2.0. Dept. of Crop and Soil Sciences, Mich. State Univ., 2006.

Krizek, A., and Jess, L. *Emergency Planning for the Farm*. MSU Extension Bulletin No. E-2575, Mich. State Univ., 2005.

Lucas, R.E., and Warncke, D.D. *Managing Organic Soils to Reduce Non-point Pollution*. MSU Extension Bulletin No. WQ-03, Mich. State Univ., 1988.

MCARD. 2016. Right to Farm. *Generally Accepted Agricultural and Management Practices for Cranberry Production*. Michigan Commission of Agriculture & Rural Development.

MCARD. 2016. Right to Farm. *Generally Accepted Agricultural and Management Practices for Irrigation Water Use*. Michigan Commission of Agriculture & Rural Development.

MCARD. 2016. Right to Farm. *Generally Accepted Agricultural and Management Practices for Manure Management and Utilization*. Michigan Commission of Agriculture & Rural Development.

MDARD. 1991. *Michigan Agricultural Statistics*. Michigan Agricultural Statistics Service, Michigan Department of Agriculture & Rural Development, 1991.

MDARD. *Michigan Agricultural Statistics, 2004-2005*. Michigan Agricultural Statistics Service, Michigan Department of Agriculture & Rural Development, 2005.  
(<http://www.nass.usda.gov/mi>)

DNR. *State of Michigan Phosphorus Reduction Strategy for the Michigan Portion of Lake Erie and Saginaw Bay*. Michigan Department of Natural Resources, Surface Water Quality Division, 1985. (Available from the Michigan Department of Environment, Great Lakes, and Energy, Lansing, MI.)

DNR. *Michigan's 1988 Non-point Pollution Assessment Report*. Michigan Department of Natural Resources, Surface Water Quality Division, 1988. (Available from the Michigan Department of Environment, Great Lakes, and Energy, Lansing, MI.)

Meints, V.W., and Robertson, L.S. *Soil Sampling for No-Till and Conservation Tillage Crops*. MSU Extension Bulletin No. E-1616, Mich. State Univ., 1983.

MidWest Plan Service. *Designing Facilities for Pesticide and Fertilizer Containment*, Revised 1<sup>st</sup> Edition. MWPS-37, Iowa State Univ., 1995.

NRAES. *Trickle Irrigation in the Eastern United States*. Publication NRAES-4, Northeast Regional Agricultural Engineering Service, Cornell Univ., 1981.

Rynk, R. *On-Farm Composting Handbook*. NRAES-54, Northeast Regional Agricultural Engineering Service, 1992.

TVA. *Fertilizer Summary Data - 1990*. Tennessee Valley Authority, National Fertilizer and Environmental Research Center, 1990.

USDA. *Improving Soils with Organic Wastes*. p. 157. U.S. Dept. of Agriculture, 1978.

USDA. *National Engineering Handbook, Part 637, Environmental Engineering, Chapter 2, Composting*. U.S. Department of Agriculture, Natural Resources Conservation Service, 2000.

*USDA-NRCS Field Office Technical Guide*. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC.  
(<http://www.nrcs.usda.gov/technical/efotg/>)

Vitosh, M.L. *Nitrogen Management Strategies for Potato Producers*. MSU Extension Bulletin No. WQ-09, Mich. State Univ., 1986.

Vitosh, M.L. *N-P-K Fertilizers: Types, Uses and Characteristics*. MSU Extension Bulletin No. E-896, Mich. State Univ., 1990.

Vitosh, M.L. *Nitrogen Management Strategies for Corn Producers*. MSU Extension Bulletin No. WQ-06, Mich. State Univ., 1991.

Vitosh, M.L. *Irrigation Scheduling*. IFS/2-80, Michigan Irrigation Guide, Mich. State Univ., 1992.

Vitosh, M.L. and Darling, B.P. *Starter Fertilizers for Corn - Are They Necessary?* MSU Extension Bulletin No. E-2289, Mich. State Univ., 1990.

Vitosh, M.L., Darling, B.P., and Campbell, D.B. *Nitrate Testing Clinics*. Proceedings of the Nineteenth North Central Extension-Industry Soil Fertility Conference, Potash and Phosphate Institute, 1989.

Vitosh, M.L. and Jacobs, L.W. *Nutrient Management to Protect Water Quality*. MSU Extension Bulletin No. WQ-25, Mich. State Univ., 1996.

Vitosh, M.L., Silva, G.H. and Pruden, T.M. *On-Farm Nitrogen Fertilizer Demonstrations*. Proceedings of the Twenty-First North Central Extension-Industry Soil Fertility Conference, Potash and Phosphate Institute, 1991.

Warncke, D.D. *Sampling Soils for Fertilizer and Lime Recommendations*. MSU Extension Bulletin No. E-498, Mich. State Univ., 1998.

Warncke, D.D. and Dahl, J.G. *Median Soil Test Values for Mineral Soils in Michigan Counties*. Dept. of Crop and Soil Sciences, Mich. State Univ., 1995.

Warncke, D.D., Dahl, J., Jacobs, L., and Laboski, C. *Nutrient Recommendations for Field Crops in Michigan*. MSU Extension Bulletin No. E-2904, Mich. State Univ., 2004.

Warncke, D.D., Dahl, J., and Zandstra, B. *Nutrient Recommendations for Vegetable Crops in Michigan*. MSU Extension Bulletin No. E-2934, Mich. State Univ., 2004.

Warncke, D.D. and Gehl, R. *Sampling Soils for Fertilizer and Lime Recommendations: Frequency of Soil Sampling*. MSU Extension Bulletin No. E-498S, Mich. State Univ., 2006.

Warncke, D.D. and Krauskopf, D.M. *Greenhouse Growth Media: Testing and Nutrition Guidelines*. MSU Extension Bulletin No. E-1736, Mich. State Univ., 1983.

Wilkinson, R.H. *On-Farm Agrichemical Storage and Handling*. MSU Extension Bulletin No. E-2335, Mich. State Univ., 1996.

## ADVISORY COMMITTEE

Listed below are the advisory committee members for the Generally Accepted Agricultural and Management Practices for Nutrient Utilization.

Dr. Tim Harrigan - Chair  
MSU - Biosystems &  
Agricultural Engineering  
209 Farrall Hall  
East Lansing, MI 48824  
[harriga1@msu.edu](mailto:harriga1@msu.edu)

~~East Lansing, MI 48824~~  
~~[hansone@msu.edu](mailto:hansone@msu.edu)~~

Dr. Jon Bartholic  
Institute Water Research  
115 Manly Miles Building  
East Lansing, MI 48823  
[bartholi@msu.edu](mailto:bartholi@msu.edu)

Laura Campbell Michigan  
Farm Bureau  
7373 West Saginaw  
Lansing, MI 48909  
[lcampbe@michfb.com](mailto:lcampbe@michfb.com)

Dr. Tom Fernandez  
Department of Horticulture  
Michigan State University  
East Lansing, MI 48824  
[fernan15@msu.edu](mailto:fernan15@msu.edu)

Paul Gross  
MSU Extension Educator  
Isabella County Bldg  
200 N Main St  
Mt Pleasant MI 48858  
Office: 989-317-4079  
Cell: 989-560-1371  
[grossp@msu.edu](mailto:grossp@msu.edu)

~~Jerry Grigar~~  
~~Natural Resources~~  
~~Conservation District~~  
~~3001 Coolidge Road, Ste. 250~~  
~~East Lansing, MI 48823~~  
~~[jerry.grigar@mi.usda.gov](mailto:jerry.grigar@mi.usda.gov)~~

~~Dr. Eric Hanson~~  
~~MSU - Department of~~  
~~Horticulture~~

~~April Hunt~~  
~~Emergency and Response~~  
~~and Enforcement Unit~~  
~~Michigan Department of~~  
~~Agriculture & Rural~~  
~~Development~~  
~~P.O. Box 30017~~  
~~Lansing, MI 48909~~  
~~[hunta9@michigan.gov](mailto:hunta9@michigan.gov)~~

Steve Mahoney  
Michigan Department of  
Agriculture & Rural  
Development  
P.O. Box 30017  
Lansing, MI 48909  
[mahoneys@michigan.gov](mailto:mahoneys@michigan.gov)

Duane Roskoskey  
Michigan Dept. of  
~~Environmental~~  
~~Quality Environment, Great~~  
~~Lakes and Energy~~  
~~Office of Waste Ma Mgmt~~

Protection  
P.O. Box 30241  
Lansing, MI 48909  
[roskoskeyd@michigan.gov](mailto:roskoskeyd@michigan.gov)

~~Bud Smith~~  
~~Michigan Agricultural Business Association~~  
~~Caledonia Farmers Elevator~~  
~~146 East Main Street~~  
~~Caledonia, MI 49316~~  
~~[bsmith@cfeco.com](mailto:bsmith@cfeco.com)~~

Fred Springborn  
MSU Extension Service  
P.O. Box 368  
211 W. Main Street  
Stanton, MI 48888  
[springb2@msu.edu](mailto:springb2@msu.edu)

~~Ray Van Driessche~~  
~~Michigan Sugar Company~~  
~~2600 S. Euclid Avenue~~  
~~Bay City, MI 48706~~  
~~[Ray.VanDriessche@michigansugar.com](mailto:Ray.VanDriessche@michigansugar.com)~~



# Generally Accepted Agricultural and Management Practices for Pesticide Utilization and Pest Control

---

~~June 2020~~ January 2021 DRAFT

Michigan Commission of  
Agriculture & Rural Development  
PO BOX 30017  
Lansing, MI 48909

---





**In the event of an agricultural pollution emergency such as a chemical/fertilizer spill, manure lagoon breach, etc., the Michigan Department of Agriculture & Rural Development (MDARD) and/or Michigan Department of Environment, Great Lakes, and Energy (EGLE) should be contacted at the following emergency telephone numbers:**

**Michigan Department of Agriculture & Rural Development: 800-405-0101**

**Michigan Department of Environment, Great Lakes, and Energy (EGLE)  
Pollution Emergency Alerting System (PEAS): 800-292-4706**

**If there is not an emergency, but you have questions on the Michigan Right to Farm Act, or items concerning a farm operation, please contact the:**

**Michigan Department of Agriculture & Rural Development (MDARD)  
Right to Farm Program (RTF)  
P.O. Box 30017  
Lansing, Michigan 48909  
(517) 284-5619  
(877) 632-1783-Toll Free  
(517) 335-3329 FAX**

## TABLE OF CONTENTS

<b>PREFACE</b>	<b>1</b>
<b>INTRODUCTION</b>	<b>2</b>
<b>PESTICIDE UTILIZATION AND PEST CONTROL PRACTICES</b>	<b>3</b>
PESTICIDE LABELS	3
CERTIFICATION	4
APPLICATION EQUIPMENT, METHODS, AND PESTICIDE FORMULATIONS	5
EQUIPMENT USE AND CALIBRATION	6
WORKER AND HANDLER SAFETY	6
ALTERNATIVE PEST MANAGEMENT TECHNIQUES	7
PROTECTION OF THE ENVIRONMENT	8
AGRICULTURE POLLUTION EMERGENCIES	9
EXCESS SPRAY MIXTURES AND RINSATES	9
MIXING AND LOADING	9
APPLICATION AND STANDARDS FOR USE	10
RECORD KEEPING	11
TRANSPORT OF PESTICIDES	13
DISPOSAL OF UNUSED PESTICIDES	13
DISPOSAL OF PESTICIDE CONTAINERS	13
ON FARM STORAGE AND CONTAINMENT OF PESTICIDES	14
PESTICIDE USE RECOMMENDATIONS AND TECHNICAL ASSISTANCE	15
<b>APPENDICES</b>	<b>17</b>
APPENDIX I: REFERENCES ON STATE AND FEDERAL LAWS AND REGULATIONS	17
APPENDIX II: REFERENCES ON AGENCY RECOMMENDATIONS	21
<b>ADVISORY COMMITTEE</b>	<b>23</b>

## PREFACE

The Michigan legislature passed into law the Michigan Right to Farm Act (PA 93 of 1981, as amended), which requires the establishment of Generally Accepted Agricultural and Management Practices (GAAMPs). These practices are written to provide uniform, statewide standards and acceptable management practices based on sound science. These practices can serve producers in the various sectors of the industry to compare or improve their own managerial routines. New scientific discoveries and changing economic conditions may require necessary revision of the practices.

The GAAMPs that have been developed are as follows:

- 1) 1988 - Manure Management and Utilization
- 2) 1991 - Pesticide Utilization and Pest Control
- 3) 1993 - Nutrient Utilization
- 4) 1995 - Care of Farm Animals
- 5) 1996 - Cranberry Production
- 6) 2000 - Site Selection and Odor Control for New and Expanding Livestock Facilities
- 7) 2003 - Irrigation Water Use
- 8) 2010 - Farm Markets

These practices were developed with industry, university and multi-governmental agency input. As agricultural operations continue to change, new practices may be developed to address the concerns of the neighboring community. Agricultural producers who voluntarily follow these practices are provided protection from public or private nuisance litigation under the Right to Farm Act.

This GAAMP does not apply in municipalities with a population of 100,000 or more in which a zoning ordinance has been enacted to allow for agriculture provided that the ordinance designates existing agricultural operations present prior to the ordinance's adoption as legal non-conforming uses as identified by the Right to Farm Act for purposes of scale and type of agricultural use.

The website for the GAAMPs is <http://www.michigan.gov/righttofarm>.

## INTRODUCTION

American agricultural producers have been able to meet the demands of the public for food through the use of improved agricultural technology. For the past 50 years, agricultural technology has included the use of pesticides and other pest management techniques. Virtually all agricultural commodities produced in Michigan may be threatened by serious pest problems and treated with pesticides to prevent or overcome insect, disease, nematode, vertebrate, or weed pests. Currently, agricultural pesticides, as broadly defined by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), are utilized for livestock and crop protection and production.

The use of pesticides has, however, caused environmental and human safety concerns. These include the appearance of pesticide contamination in surface and groundwater in Michigan, destruction of beneficial or non-target organisms, appearance of resistant pest species, and pest population resurgence. Strategies for managing pests continue to be developed to reduce undesirable pesticide effects.

Agricultural producers in Michigan are encouraged to adopt practices that utilize pesticides only as needed. Such practices employ the appropriate use of all available information, methods, and technologies to achieve the desired commodity quality and yield while minimizing adverse effects on non-target organisms, humans, and the environment. Such practices include, but are not limited to, Integrated Pest Management (IPM), organic production methods, or sustainable agriculture. These practices normally involve environmental and biological monitoring such as scouting, trapping, use of pest prediction models, etc., to help producers determine when pest populations reach the economic action threshold and selection and use of safe and effective control measures. These may include, but are not limited to, biological, chemical (biopesticides and reduced risk pesticides), cultural, mechanical, regulatory -controls (e.g. inspections, quarantines, fumigation, sanitation, etc.), and other pest management methods.

Agricultural producers who comply with pesticide labels and labeling, relevant state and federal laws, Michigan State University (MSU) pesticide recommendation bulletins, and follow pertinent sections of these Generally Accepted Agricultural and Management Practices (GAAMPs) for Pesticide Utilization and Pest Control, will meet provisions of PA 93 of 1981, as amended, the Right to Farm Act, which is administered by the Michigan Department of Agriculture & Rural Development (MDARD).

A farm or farm operation that conforms to these and other applicable current GAAMPs adopted under the Michigan Right to Farm Act (PA 93 of 1981, as amended) shall not be found to be a public or private nuisance. This protection also covers farm operations that existed before a change in the land use or occupancy of land within one mile of the boundaries of the farmland, if before that change, the farm would not have been a

nuisance. Likewise, this conditional protection applies to any of the following circumstances:

- a. A change in ownership or size.
- b. Temporary cessation or interruption of farming.
- c. Enrollment in governmental programs.
- d. Adoption of new technology.
- e. A change in type of farm product being produced.

## **PESTICIDE UTILIZATION AND PEST CONTROL PRACTICES**

### **PESTICIDE LABELS**

All pesticides intended for sale bear labels mandated by law that contain their legal and authorized uses and information on how to store, mix, apply, and dispose of the product and container. In addition to labels, manufacturers also provide supplemental labeling, which includes other specific use directions. Everyone using pesticides must follow label and labeling instructions.

Pesticide labels and labeling contain specific information that constitutes the legal parameters for pesticide use. Labels and product information may contain the following:

1. Trade name, common name, chemical name, inert ingredients of toxicological concern, formulation, U.S. Environmental Protection Agency (EPA) registration number, amount of active ingredient per unit, and net contents of the package.
2. Manufacturer or formulator name, address and telephone number, and EPA establishment number.
3. Required signal words and precautionary statements by toxicity category:
  - a. Danger-Poison includes skull and crossbones; poisonous if swallowed. Do not breathe vapor. Do not get in eyes, on skin, or on clothing.
  - b. Warning may be fatal if swallowed. Do not breathe vapors. Do not get in eyes, on skin, or on clothing.
  - c. Caution harmful if swallowed. Avoid breathing vapors. Avoid contact with skin.
  - d. Caution no caution statement required.
4. Use classification:
  - a. Restricted use - requires applicator certification to purchase and use.

- b. General use - applicator certification not required.
- 5. Statement of practical treatment: includes first aid for human exposure.
- 6. Precautionary statements: includes worker safety rules, environmental hazards, endangered species, physical hazards, and the statement "KEEP OUT OF REACH OF CHILDREN."
- 7. General information about the pesticide.
- 8. Information on storage and disposal of the pesticide and container.
- 9. Application procedures (may include equipment, volume, pressure requirements, weather, adjuvants, mixing, cleaning, field preparation, etc.).
- 10. Pests controlled.
- 11. Directions for Use, including but not limited to: site, maximum allowable rate, timing, crop and pest life stage, rotational restrictions, minimum number of days between last application and harvest, etc.
- 12. Worker Protection Standard (WPS) Agricultural Use Requirements - Reentry interval, and/or restricted entry interval.
- 13. Use restrictions (Examples: depth to groundwater, soil types, sensitive sites, setbacks, etc.).
- 14. Reference to State Management Plans for Groundwater Protection.
- 15. Endangered Species Act guidance for protection of endangered species.
- 16. Pesticide Resistance action group number.

***For detailed information on specific label requirements, refer to MSU Extension Bulletins E- 3007 kitp Private Pesticide Applicator Core Training Manual and Michigan Addendum and E-3008 kitc Commercial Pesticide Applicator Core Training Manual kits with Michigan Addendum.***

#### CERTIFICATION

Purchasers and applicators of restricted-use pesticides must comply with the certification requirements of the 1994 Michigan Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended (PA 451), Part 83 and detailed in Regulation 636 "Pesticide Applicators." This requires studying training manuals prepared by MSU Extension and passing an examination administered by MDARD.

Recertification is required every three years and may be obtained by one of two methods. The private applicator may study a training manual (Extension Bulletin E-3007kitp) and pass an examination, or attend classes accredited by MDARD for continuing education credits and obtain sufficient credits for the specific category of certification. Both methods ensure that additional information was provided to applicators in the safe and effective use of restricted-use pesticides.

For more information about the certification process and a current listing of approved pesticide applicator certification training seminars can be found at [https://www.michigan.gov/mdard/0,4610,7-125-1569\\_16988\\_35289---,00.html](https://www.michigan.gov/mdard/0,4610,7-125-1569_16988_35289---,00.html) <http://www.mda.state.mi.us/schedule/schedule.html> or [www.canr.msu.edu/ipm/pesticide\\_education\\_safety](http://www.canr.msu.edu/ipm/pesticide_education_safety).

The listing for the pesticide certification exams can be found by following these steps: Go to <https://www.michigan.gov/pestexam>, Click Enter as Guest; and Click on a county highlighted or region to find date(s) and time(s).

### APPLICATION EQUIPMENT, METHODS, AND PESTICIDE FORMULATIONS

There are many types of pesticide application equipment and many pesticide formulations. Application methods for particular formulations may be specified on the label. To prevent degradation of water resources (and therefore, to comply with federal and state laws) the applicator should choose a method that is accurate in applying the pesticide to the target. A person applying pesticides may employ any equipment or method of application not contrary to the “Directions for Use” on the pesticide label or labeling.

Generally accepted methods of pesticide application include, but are not limited to, the following equipment, methods, and formulations:

#### EQUIPMENT FORMULATION

#### METHOD

airplane/helicopter	aerial	aerosol
air assisted applicator	banding	aqueous suspension
air blast sprayer	chemigation	bait
backpack sprayer, duster	controlled droplet application (cda)	control release formulation
controlled droplet applicator	dips & drenches	dispersible granule
electrostatic sprayer	dusting	dry flowable
fabric mesh & other products impregnated with pesticides	early pre-plant (epp)	dry soluble
fogger	foliar spray	emulsifiable concentrate
fumigation equipment	hopperbox treatment	emulsifiable solution
granular applicator	granular surface application	encapsulated

ground sprayer	impregnated on fertilizer	flowable
hand gun	In furrow	gas
hand sprayer	Injection	granule
hopperbox application	pre-emergence (pre)	Liquid
incorporation into asphalt	pre-transplant	oil solution
injector	Pre-plant incorporated (ppi)	pellet
irrigation equipment (chemigation)	post-directed	ready to use
low volume applicator	post-emergence (post)	soluble granules
mister	post-transplant	soluble powder
recycling sprayer	ropewick	water dispersible granule
roller	seed treatment	wettable powder
speed treated	ultra low volume (ulv)	suspension concentrate
spreader		soluble liquid
transplanter & seeder		water soluble packet
wick		microencapsulated

### EQUIPMENT USE AND CALIBRATION

The operator shall inspect and maintain all pesticide application equipment to ensure the proper and safe operation of equipment, as well as, the appropriate rate and distribution of application. Equipment must be correctly calibrated at least annually, and leaks minimized to apply specific materials and formulations of pesticides at the intended rate and distribution pattern.

***For detailed information on specific label requirements refer to MSU Extension Bulletin E-3007kitp.***

### WORKER AND HANDLER SAFETY

Any person applying or handling pesticides or working in pesticide treated areas must be knowledgeable in the safe use and handling of pesticides. Everyone must use safety equipment specified on pesticide labels.

The Federal Worker Protection Standard as revised in 2015 protects employees involved in the production of agricultural products on farms, forests, greenhouses, and nurseries from occupational exposure to agricultural pesticides. For both handlers and workers, the standard requires training, notification, and information on the proper use of protective equipment. Handlers include those who apply, load, mix, transport, clean and repair pesticide application equipment, etc. Workers include persons who may physically come in contact with pesticides in treated areas while performing tasks



related to production and harvesting of agricultural plants. Both need to be trained on the recognition of pesticide poisoning symptoms, how to avoid exposure, and emergency assistance, as well as, be provided personal protective equipment and transportation for medical assistance. Handlers need additional training. Employers are required to provide the training, personal protective equipment, decontamination sites, transportation, central notification points, field posting for the duration of the restricted-entry intervals, and maintain pesticide application records for two years. For specific information concerning this law, refer to the EPA-prepared book, "How to Comply With the 2015 Revised Worker Protection Standard For Agricultural Pesticides" "What Owners and Employers Need To Know". (<https://www.epa.gov/pesticide-worker-safety/agricultural-worker-protection-standard-wps>)

Enforcement of the standard occurs in two phases. Label specific requirements will be enforceable when they appear on pesticide labels. These requirements include:

1. Using label-specified personal protective equipment;
2. Obeying label-specific restrictions on entry to treated areas during the restricted-entry intervals; and
3. Obeying the requirement on labels that provide oral warnings and/or treated area posting.

The generic requirements of worker protection standards include:

1. Providing decontamination supplies
2. Annual training of workers and handlers
3. Providing certain notification and information
4. Cleaning, inspecting, and maintaining personal protective equipment
5. Respirator medical evaluation and fit testing
6. Application exclusion zones
7. Emergency assistance.

## ALTERNATIVE PEST MANAGEMENT TECHNIQUES

Growers may use alternatives to pesticides to manage pests. These may include, but are not limited to, audible cannons, ultra-sonic and audio sound equipment, strobe lights, firearms, balloons, scarecrows, streamers, netting, traps and fences for wildlife management, tillage for weed control, controlled burning, traps for pest management, transgenic plants, introduced or managed biological control agents, mechanical

controls, resistant varieties, cover crops, crop vacuums, flammers, mulching, composting, crop rotation, pheromones for mating disruption and trapping, weather monitoring equipment for pest prediction, etc. All such techniques should be used according to dealer and/or manufacturer recommendations and must be used according to federal and state agency recommendations and/or regulations.

## PROTECTION OF THE ENVIRONMENT

Agriculture involves management of biological systems to produce food, feed, fur, and fiber. Pesticides and other pest management practices cause a specific effect in a biological system.

For agriculture to be sustained at biologically and economically sound production levels, growers should recognize their responsibility to be stewards of the soil and the environment. Growers should be aware of environmentally sensitive conditions in their production system and adjust management practices to ensure future productivity and environmental integrity. For example, growers should limit use of highly or moderately leachable pesticides in areas with coarse-textured soils or high water tables.

([https://efotg.sc.egov.usda.gov/references/public/MI/Integrated\\_Pest\\_Management\\_\(AC\)\\_\\_\(595\)\\_CPS.pdf](https://efotg.sc.egov.usda.gov/references/public/MI/Integrated_Pest_Management_(AC)__(595)_CPS.pdf) ;

[https://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/stelprdb1044470.pdf](https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044470.pdf) ;

<https://www.canr.msu.edu/ipm/index?> )

A person applying pesticides in agricultural production should follow label instructions and use good judgment to avoid adverse effects to human health and the environment. A pesticide applicator should make a determined effort to:

1. Assess pest populations and apply pesticides only when needed to manage these pests during the vulnerable or appropriate stage of their life cycle.
2. Avoid directing a pesticide application beyond the boundaries of the target site.
3. Avoid the potential for drift or runoff. (See page 10 - #2. Pesticide Drift for information regarding a drift management plan.)
4. Avoid applications that would result in exposure of persons within or adjacent to the target site, except when such pesticides have approved use patterns permitting treatment of populated areas for specific pest management programs. (e.g., gypsy moth, mosquito, etc.)
5. Avoid applications that would lead to contamination of aquifers (PA 451 of 1994 as amended, Part 87, and Part 31, Rule 2203) or runoff to surface waters (Integrated Pest Management (Code 595)
6. Utilize safety measures including backflow safety devices when applying pesticides through irrigation systems.

## AGRICULTURE POLLUTION EMERGENCIES

The Michigan Department of Agriculture & Rural Development has a toll-free, 24-hour hotline available for reporting agricultural pesticide, fertilizer, and manure spills. The **MDARD Agriculture Pollution Emergency (APE) Hotline, 1- 800-405-0101**, is designed to improve response time and provide appropriate technical assistance, reducing the environmental risk associated with an agricultural chemical spill.

Users of agricultural pesticide, fertilizer, and manure products should report all un-contained spills or releases to the MDARD APE Hotline. MDARD has the responsibility to initiate response activities to immediately stop or prevent further releases at agrichemical spill sites and will do so through possible interaction and assistance from the Michigan Department of Environment, Great Lakes, and Energy (EGLE). The main goal of the MDARD Spill Response Program is to clean up all agrichemical spills quickly and completely and get the recovered material out to where it can be used for its intended purpose. This goal is accomplished through providing immediate response, technical assistance, a common sense approach to clean up, and utilization of legal land application of recovered materials.

This 24-hour hotline should be used for reporting accidental agricultural pesticide, fertilizer and manure spills. (Chemical spills not agriculture-related should be referred to ~~the Michigan Department of Environment, Great Lakes, and Energy~~ EGLE's Pollution Emergency Alerting System (PEAS) number, 1-800-292-4706.) (<https://www.michigan.gov/mdard/0,4610,7-125-1572-310812--,00.html> )

## EXCESS SPRAY MIXTURES AND RINSATES

Use excess mixtures or rinsates on labeled application sites at or below labeled rates as listed on the label. Excess pesticide mixtures include, but are not limited to: leftover solution when spraying is done; haul-back solutions from a spraying job interrupted by weather, and equipment breakdown. All rinsates, including pesticide container rinsate, should be put in the sprayer as part of the mixing solutions.

## MIXING AND LOADING

Pesticides should be mixed and loaded according to label directions in a manner that does not harm individuals, animals, or the environment. The greatest risk occurs when handling pesticide concentrates. Follow these practices to reduce risk:

1. Pesticide mixing and loading areas should be located in such a manner as to reduce the likelihood of a spill or overflow contaminating a water supply. Acceptable areas may include temporary or permanent sites, which are described in MSU Extension Bulletin E-3007kitp.

2. Review the label before opening the container so that you are familiar with current mixing and usage directions. If two or more pesticides are to be mixed, they must be compatible and mixed in the proper order.
3. Measure accurately. Keep all measuring devices in the pesticide storage area to avoid their being used for other purposes. Measuring containers or devices should be rinsed and the rinse water put into the spray tank.
4. Avoid back-flow when filling a spray tank to prevent water source contamination. The simplest technique is an air gap where the fill hose does not come in contact with the tank water. Back-flow prevention devices may also be used. (Reference MSU Extension Bulletin E-3007 kitp).
5. A sprayer must be monitored while it is being filled.
6. Mix only the amount you plan to use immediately. Pesticides should be applied as soon as possible to maintain product effectiveness and reduce the potential for accidental discharge.
7. Clean up spills immediately. Material spilled during mixing or loading may be applied to labeled sites at or below labeled rates. All spills to the soils and/or waters of Michigan must be reported to the state of Michigan according to the Natural Resources and Environmental Protection Act of 1994. Spills exceeding reportable quantities, under SARA Title III, must be reported to the appropriate agencies (Reference MSU Extension Bulletin E-2575 "Emergency Planning for the Farm"- currently being revised available at [http://www.maeap.org/uploads/files/Farmstead/E2575\\_Emergency\\_Plan\\_on\\_the\\_Farm.pdf](http://www.maeap.org/uploads/files/Farmstead/E2575_Emergency_Plan_on_the_Farm.pdf) ) as well as the Michigan Department of Agriculture & Rural Development, APE Hotline, (800) 405-0101.

## APPLICATION AND STANDARDS FOR USE

The 1994 Act 451, Part 83, Pesticide Control and Pesticide Use ([https://www.michigan.gov/mdard/0,4610,7-125-1569\\_16988-209407--,00.html](https://www.michigan.gov/mdard/0,4610,7-125-1569_16988-209407--,00.html)) contain components that are applicable to private applicators using pesticides for agricultural operations, including but not limited to the following.

### 1. Spill Kits

Any person who mixes, loads, or otherwise uses pesticides shall have immediate access to a spill kit. The spill kit requirement does not apply to a person who used single containers of use dilution pesticides in a quantity that is less than 16 ounces.

Spill kits should contain materials appropriate to the material being applied and equipment being used.

## 2. Pesticide Drift

All pesticide applications are required to be made in a manner that minimizes off-target drift. When pesticide off-target drift is anticipated due to the nature of the application, a Drift Management Plan shall be utilized by the applicator to minimize the occurrence and adverse effects of off-target drift.

The Drift Management Plan shall include drift minimization practices. Such practices may include, but are not limited to, any of the following:

- The use of the largest spray droplets that are created by a combination of special nozzles, pressures, and particulating agents to accomplish the objectives of the applications.
- The use of specialized equipment that is designed to minimize off-target drift.
- The use of the closest possible spray release to the target.
- The use of the lowest effective rates of application of the pesticide.
- The establishment of a no-spray buffer zone. The buffer zone may be treated with non-powered equipment.
- The identification of the maximum wind speed and direction under which applications can be made.
- The use of wind shields or windbreaks to contain spray drift or deflect spray drift away from sensitive areas.
- Other specific measures stated in the plan that are effective in minimizing the incidence of off-target drift.

A Drift Management Plan shall be in writing, and MDARD will consider the presence and use of a written Drift Management Plan as a factor in determining appropriate enforcement action in the event of drift. Pesticide off-target drift does not include the off-target movement of a pesticide by means of erosion, volatilization, or windblown soil particles after the application of a pesticide.

### RECORD KEEPING

Farm operators must maintain accurate records of all agricultural crop applications of pesticides for at least three years, and preferably five years.

The federal pesticide recordkeeping regulations, the federal worker protection standards, and the Michigan Right to Farm current GAAMPs all have requirements related to pesticide recordkeeping. The following table is intended to clarify which data

are required for each. The federal recordkeeping regulations and worker protection standards are laws. Right to Farm GAAMPs are voluntary guidelines.

### **USDA Record Keeping Regulations (Redkp)**

The data required by these regulations must be kept by private pesticide applicators for each restricted use pesticide application.

### **Worker Protection Standards (WPS)**

The information listed in the table must be posted for at least 30 days after the end of the restricted-entry interval (REI), or, if there is no REI, for at least 30 days after the end of the application.

### **Michigan Right to Farm (RTF)**

A portion of the Right to Farm document addresses pesticide recordkeeping. By following these voluntary guidelines, producers can reduce their liability.

### **Table Comparing Record Keeping Requirements for Private Pesticide Applicators**

Federal Recordkeeping Regulations (Redkp), Worker Protection Standards (WPS), Michigan Right to Farm (RTF)

<b>Data to Record</b>	<b>Redkp</b>	<b>WPS</b>	<b>RTF</b>
Month/day/year	x	x	x
Time of application		x	
Pesticide brand/product name	x	x	x
Pesticide formulation			x
EPA registration number	x	x	x
Active ingredient(s)		x	
Restricted-entry interval (REI)		x	
Rate per acre or unit			x
Crop, commodity, stored product, or site that received the application	x		x
Total amount of pesticide applied	x		x
Size of area treated	x		x
Applicator's name	x		x
Applicator's certification number	x		x
Location of the application	x	x	x
Method of application			x
Target pest			x
Carrier volume per acre			x

Developed by the Michigan State University Pesticide Education Office

Commercial applicators must send a copy of records required by USDA to clients within 30 days of application. If a medical emergency occurs within 30 days, commercial applicators must provide the necessary information immediately upon request.

For federally restricted use pesticides (RUP), records must incorporate all information required by Title XIV of the Federal Food, Agriculture, Conservation and Trade Act Subtitle H, Section 1491, Pesticide Record Keeping.

## TRANSPORT OF PESTICIDES

A person transporting pesticides will do so in such a manner as to avoid discharge into the environment, human exposure, and contamination of animal feed and human food.

## DISPOSAL OF UNUSED PESTICIDES

Michigan residents may dispose of unused and unwanted pesticides through the Michigan Clean Sweep Program. The Michigan Agriculture Environmental Assurance Program (MAEAP), in cooperation with county and local units of government, has established permanent Clean Sweep sites located throughout the state. More information can be found here: [https://www.michigan.gov/mdard/0,4610,7-125-2390\\_45388-11759--,00.html](https://www.michigan.gov/mdard/0,4610,7-125-2390_45388-11759--,00.html)

Individual Michigan residents may dispose of pesticides by taking them to one of these Clean Sweep sites where they will be collected, packaged for shipping, and disposed of properly. There is no charge for this service. Program costs are covered by MAEAP and a grant from the EPA, and services are provided by the local cooperators.

## DISPOSAL OF PESTICIDE CONTAINERS

Always dispose of containers in a way that minimizes impact on the environment and is consistent with the label specifications. It is desirable to use reusable, returnable, or recyclable containers when available. Pesticide containers should be emptied completely, rinsed when appropriate, and in general rendered into a non-hazardous waste.

1. Triple rinse or use other recommended practices, such as pressure rinsing to clean all glass, metal, or plastic containers to render them non-hazardous waste (MSU Extension Bulletin E-2784 and E-3007kitp) ([https://archive.lib.msu.edu/DMC/extension\\_publications/e2784/E2784-2002.PDF](https://archive.lib.msu.edu/DMC/extension_publications/e2784/E2784-2002.PDF)) .
2. After rinsing, puncture metal and plastic containers. They can then be recycled or buried in a sanitary landfill approved under PA 451 of 1994, as amended, Part 115.
3. Michigan has had an agriculture plastic pesticide container recycling program in operation since 1992. This program allows for the grinding and recycling of clean plastic containers. For more information on this program, contact MDARD at (517) 284-5612 or visit: [https://www.michigan.gov/mdard/0,4610,7-125-1599\\_25432-310935--,00.html](https://www.michigan.gov/mdard/0,4610,7-125-1599_25432-310935--,00.html)
4. Dispose of rinsed glass containers in a sanitary landfill approved under PA 451 of 1994, as amended, Part 115.

5. Open burning of pesticide containers is prohibited by state statute, PA 451 of 1994, as amended, Part 55.

## ON FARM STORAGE AND CONTAINMENT OF PESTICIDES

All pesticides must be stored in a manner that maintains environmental quality, ensures human and animal safety, and preserves product and container integrity. (Reference MSU Extension Bulletin E-2335, E-3007kitp, and NRCS Practice Standard 309, Agrichemical Handling Facility). Legal storage requirements are on pesticide labels. ([https://archive.lib.msu.edu/DMC/extension\\_publications/e2335/E2335-1996.PDF](https://archive.lib.msu.edu/DMC/extension_publications/e2335/E2335-1996.PDF) ; [https://efotg.sc.egov.usda.gov/references/public/MI/Agrichemical\\_Handling\\_Facility\\_\(NO\)\\_309\\_CPS\\_9-16.pdf](https://efotg.sc.egov.usda.gov/references/public/MI/Agrichemical_Handling_Facility_(NO)_309_CPS_9-16.pdf) )

1. Bulk pesticide storage site - A site should be selected that minimizes potential for contamination of surface or groundwater by drainage, runoff, or leaching. Locate the storage site an adequate distance away from wells, surface water, and other sensitive areas. For purposes of these practices, a bulk storage area is an area where pesticides are stored over 15 days in a single container greater than 55 gallons (liquid) or 100 pounds (dry material).
  - a. Bulk pesticide storage areas should be located a minimum of 150 feet from any single-family residential water well or a minimum of 50 feet with secondary containment for the pesticide storage; 800 feet from a Type IIB or III public water supply, or a minimum of 75 feet with secondary containment of the pesticide storage; and a minimum of 200 feet from surface water. Dairy farms and farms with employees generally have Type III public water supply. If an existing bulk storage area is located closer than 150 feet from a single--family residential water well, 800 feet from a public water supply, or less than 200 feet from surface water, appropriate security measures should be taken to prevent pesticide contamination of surface water or groundwater.
  - b. The pesticide storage set-back distance from any Type I community public water supply or Type II non-community public water supply well is 2,000 feet, if the public water supply does not have a well-head protection program. If there is a well-head protection program, the facility must be located outside the delineated well-head protection area. For more information on well set-back distances from pesticide storages, contact the Michigan Department of Agriculture and Rural Development Environmental Stewardship Division engineering staff.

These set-back distances pertain to bulk pesticide storage sites and facilities and do not include application sites. A storage facility is a place for the safe keeping of pesticides. An application site is where pesticides can be used according to label specifications.



2. Storage facility - Pesticides should be stored in a facility that is securable to prevent unauthorized access (MSU Extension Bulletin E----3007kitp).

- Keep all pesticides out of the reach of children, pets, livestock, and unauthorized people.
- Within the storage area, store pesticides in a manner to prevent cross contamination with other pesticides or accidental misuse. Store pesticides away from food, feed, potable water supplies, veterinary supplies, seeds, and protective equipment.
- The storage facility should be ventilated to reduce dusts and fumes.
- Keep pesticides cool, dry, and out of direct sunlight. Consider freeze protection as required by labels.
- Post the pesticide storage area with highly-visible, weather-proof signs that indicate that pesticides are stored there. Also post "NO SMOKING" signs.
- Store pesticides only in their original labeled containers, or containers appropriate for pesticide storage that are properly labeled.
- Have absorbent materials, such as cat litter box filler or sawdust and clean-up equipment immediately available. A fire extinguisher approved for chemical fires should also be easily accessible.
- The storage of combustible and flammable chemicals may require special storage requirements. Contact your local fire chief and refer to the Standard 30A, Code for Motor Fuel Dispensing Facilities and Repair Garages, for further information. (<https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=395> )

## PESTICIDE USE RECOMMENDATIONS AND TECHNICAL ASSISTANCE

Michigan State University Extension provides education and recommendations on correct and effective use of pesticides on most agricultural commodities grown in Michigan (See Appendix II).

Growers meet pesticide rate standards for GAAMPs if they apply pesticides at or less than legal labeled rates. Pesticide uses for commodities not included in MSU recommendations but in accordance with their respective labels or labeling will also meet the application rate requirements of these GAAMPs.

The Natural Resources Conservation Service (NRCS) role is to provide technical and financial assistance to agricultural producers. Its Field Office Technical Guide (FOTG)

provides the standards, which establish elements of conservation planning designed to maintain soil productivity and protect the environment. Financial assistance may be available through USDA Farm Bill programs.

Financial assistance may be available through USDA Farm Bill programs. The Michigan Agriculture Environmental Assurance Program (MAEAP) provides for technical assistance for agricultural producers to facilitate improvement of their practices that may impact groundwater and surface water.

Spill Response Program - This program helps reduce environmental impacts associated with pesticide, fertilizer, and manure spills. If a spill occurs, agri-chemical users must call MDARD's 24-hour hotline at 1-800-405-0101. This gives access to information, technical assistance, and in some cases, financial assistance for dealing with the control, containment, and cleanup of a spill. MAEAP provides funding for this program.

Clean Sweep Program - Individuals can bring unwanted pesticides to one of Michigan's Clean Sweep sites for proper disposal at little or no cost to themselves. The Michigan Agriculture Environmental Assurance Program (MAEAP), along with the Environmental Protection Agency and local agencies, pays for the disposal of these pesticides. A list can be found at: [https://www.michigan.gov/mdard/0,4610,7-125-2390\\_45388-11759--,00.html](https://www.michigan.gov/mdard/0,4610,7-125-2390_45388-11759--,00.html) <http://www.michigan.gov/mdard> or by contacting MDARD at 517-284-5612.

The Michigan Certified Crop Adviser (CCA) program is a nationally-recognized, voluntary certification program developed through the collaborative effort of the public sector and the agriculture industry to ensure high standards for crop advisers. It is intended for anyone who makes nutrient, pesticide, crop, or environmental recommendations to producers. This includes dealers, distributors, applicators, consultants, manufacturers, allied industries, and state and federal government agency personnel. The CCA program is administered by state boards in association with the American Society of Agronomy, which handles similar programs for specialists in agronomy, crop consulting, weed science, and other agricultural disciplines. In Michigan, the Michigan Agri-Business Association manages the program.

## APPENDICES

### APPENDIX I: REFERENCES ON STATE AND FEDERAL LAWS AND REGULATIONS

State and Federal Laws and Regulations: A person applying agricultural pesticides in Michigan must comply with all relevant state and federal laws and regulations. These include, but are not limited to:

1. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947, as amended. This is the basic federal law regulating pesticide registration and use in the United States. A new part of this law requires states to implement a state management plan for specific pesticides that may contaminate groundwater. Pesticide applicators are required to adhere to state components of this plan.
2. Federal Worker Protection Standard of 1992. This regulation was written by U.S. Environmental Protection Agency (EPA) governing the protection of employees on farms, forests, nurseries, and greenhouses from occupational exposures to agricultural pesticides. They are intended to reduce the risk of pesticide poisoning and injuries among agricultural workers and pesticide handlers through appropriate exposure reduction measures. The regulations expand the requirements for ensuring warnings about pesticide applications, use of personal protective equipment, and restriction on entry to treated areas. New requirements are added for decontamination, emergency assistance, maintaining contact with handlers of highly toxic pesticides, and pesticide safety training. (<https://www.epa.gov/pesticide-worker-safety/agricultural-worker-protection-standard-wps> )
3. Federal Record Keeping. Authorized by the 1990 Federal Food, Agriculture, Conservation and Trade Act (Farm Bill), new requirements are being developed for record keeping of federally restricted use pesticides (RUP) by certified applicators.
4. The Superfund Amendments and Reauthorization Act (SARA) of 1986 Title III: Emergency Planning and Community Right-to-Know. This federal law provides mechanisms to prepare for chemical emergencies. Persons storing pesticides that are considered to be extremely hazardous by EPA above "Threshold Planning Quantities", must notify the State Emergency Response Commission within Michigan Department of Environment, Great Lakes and Energy (EGLE), the Local Emergency Planning Committee and the local fire chief that they store at least one of these chemicals above threshold at some time. The location of the storage facility and name and telephone number of a responsible person must be reported also. If there is a spill or release of one of these chemicals above the "Reportable Quantity", the same organizations must be notified. MSU Extension Bulletin E-2575 contains information to help farmers comply with the law.

5. The Endangered Species Act (ESA) of 1973, as amended. This federal law protects endangered species and their habitats from the adverse effects of pesticides. Pesticide labels contain information on endangered species and restricted use areas.
6. National Fire Prevention Association (NFPA) Standard Code 30A. The Michigan State Fire Marshall has adopted the NFPA Code 395, which regulates the storage of combustible and flammable liquid chemicals with a flash point below 200° F on the farm. If you construct a new chemical storage facility, contact your local building inspector to be sure you are in compliance with the code's construction, diking, and location requirements. The code sets requirements for the amount and location of stored chemicals; the type, construction and size of containers and fire prevention devices that need to be incorporated into structures. (Code 30A, according to the NFPA website: <https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=395>)
7. The Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended.
  - Part 31, Water Resources Protection (formerly PA 245 of 1929, the Michigan Water Resources Commission Act, as amended). This part provides broad substantive bases for protection and conservation of surface and groundwater resources of the state.
  - Part 55, Air Pollution Control (formerly PA 348 of 1965, Air Pollution Control, as amended). DEGLE has statutory authority, powers, duties, functions, and responsibilities for rule making and issuance of permits and orders for air pollution control including burning of pesticide containers. The Part provides for control of air pollution that may be in the form of a dust, fumes, gas, mist, odor, smoke, or vapor, in quantities that are or can become injurious to human health or welfare, animal life, plant life, or to property, or that interfere with the enjoyment of life or property.
  - Part 83, Pesticide Control (formerly PA 171 of 1976, Michigan Pesticide Control Act, as amended). This part regulates registration, distribution, labeling, storage, disposal, and application of pesticides in Michigan. The Act was amended in 1993 to allow MDARD to respond to incidents of confirmed groundwater contamination.
    - Applicator Certification Regulation 636 and Pesticide Use Regulation 637 were established as a requirement of Part 83 Pesticide Control, PA 451 of 1994, the Natural Resources and Environmental Protection Act, as amended to provide regulation for pesticide use.

- Part 87, Groundwater and Freshwater Protection (formerly PA 247 of 1993, Michigan Groundwater and Freshwater Protection Act, as amended). This establishes the necessary legal authorities to develop and implement voluntary, proactive management practices for pesticides and fertilizers that are protective of groundwater. The Act provides for technical assistance, grants, and research and demonstration projects that will be available to agricultural producers so they can change current practices that may be impacting groundwater. The Act also establishes a statewide advisory committee and regional groundwater stewardship teams that will work directly with producers.
  - Part 111, Hazardous Waste Management (formerly PA 64 of 1979, the Hazardous Waste Management Act, as amended). This part protects public health and the natural resources of the state from harmful effects of hazardous wastes. When pesticides are not used according to label directions, are out of condition, or are suspended or canceled, they may become hazardous wastes and have strict transportation, treatment, storage, and disposal requirements. This also includes pesticide containers that are not triple rinsed or power washed.
  - Part 115 Solid Waste Management (formerly PA 641 of 1978, the Michigan Solid Waste Management Act, as amended). This part provides for proper design and licensing of non-hazardous landfills and provides disposal requirements for various types of wastes. It lists over 60 approved licensed landfills that can accept properly rinsed pesticide containers. The MDEGLE Environmental Resource Management Division number is 517-373-2730.
  - Part 201, Environmental Response (formerly PA 307 of 1982, the Environmental Response Act, as amended). This part provides for the identification, risk assessment, and priority evaluation of environmental contamination and provides for response activity at certain facilities and sites. This Act also provides an exemption from liability for farmers if they follow the pesticide label and Generally Accepted Agricultural and Management Practices. Any spills or discharges of polluting material (including pesticides) that may potentially reach any surface or ground water must be controlled and reported to the MDEGLE's Pollution Emergency Hot Line at 1-800-405-0101, or EGLE's~~the MDEQ's~~ PEAS at 1-800-292-4706.
8. PA 154 of 1974, the Michigan Occupational Safety and Health Act (MIOSHA), as amended. The Michigan Department of Health and Human Services~~Community Health~~ and Michigan Department of Labor and Economic Growth~~Opportunity~~ jointly enforce this law to protect workers who handle or during normal working conditions might be exposed to pesticides. Employers are required to develop and implement a written employee training program as well as ensure that all pesticides or other hazardous chemical containers are properly labeled. For

hazardous chemicals other than pesticides, the employer is required to have Material Safety Data Sheets available for employee review. In case of pesticide, labeling information may be furnished if Material Safety Data Sheets are unavailable. Copies of Material Safety Data Sheets for pesticides are normally available from pesticide manufacturers or distributors. Additionally, farmers are advised to cooperate with their local fire department and local emergency planning committees in furnishing requested information.

9. PA 399 of 1976, the State of Michigan Safe Drinking Water Act, as amended. An Act to protect the public health; to provide for supervision and control over public water supplies; to provide for the classification of public water supplies; and to provide for continuous, adequate operation of privately owned, public water supplies. This act sets forth standard isolation distances from any existing or potential sources of contamination and regulates the location of public water supplies with respect to major sources of contamination.
10. PA 368 of 1978, the Michigan Public Health Code, as amended. An Act to protect and promote the public health; to codify, revise, consolidate, classify, and add to the laws relating to public health; to provide for the prevention and control of diseases and disabilities; and to provide for the classification, administration, regulation, financing, and maintenance of personal, environmental, and other health services and activities.

## APPENDIX II: REFERENCES ON AGENCY RECOMMENDATIONS

Michigan State University pesticide use and pest control recommendations are contained in, but not limited to, the following publications and computer programs available from the MSU Educational Materials Distribution Center at <http://www.shop.msu.edu> or by calling 517-353-6740 or from the local MSU Extension office:

- E - 0154      2019 Michigan Fruit Management Guide
- E - 0312      2019 Midwest Vegetable Production Guide for Commercial Growers
- E - 0434      2019 Weed control guide for field crops
- E - 0433      2019 Weed control guide for vegetable crops
- E - 2676      Christmas Tree Pests Manual
- E - 3245      Minimizing Pesticide Risk to Bees in Fruit Crops

MSU Extension bulletins and other resources relevant to these Generally Accepted Agricultural and Management Practices can be obtained through the MSU Educational Materials Distribution Center at this Web site <http://www.shop.msu.edu> or from the local MSU Extension office.

- E-3007 kitp              Private Pesticide Applicator Core Training Manual and Michigan Addendum (Order from: <https://npsecstore.com/pages/michigan>)
- E-3007              ..... Spanish National Applicator Core Training Manual & Michigan Private Applicator Addendum
- E-3008 kitc              ..... Commercial Pesticide Applicator Core Training Manual and Michigan Addendum (Order from: <https://npsecstore.com/pages/michigan>)
- E-3008              ..... Commercial Pesticide Applicator Core Training Manual and Michigan Addendum (also available in Spanish)
- E – 2579              Commodity Fumigation: Training Manual, Commercial & Private Applications
- E – 2342              Recordkeeping System for Crop Production
- E – 2343              Field File Folders: Recordkeeping System for Crop Prod

Useful USDA Natural Resources Conservation Service publications include:

Integrated Pest Management (code 595)

NRCS Practice Standard 309, Agrichemical Handling Facility  
([https://efotg.sc.egov.usda.gov/references/public/MI/Agrichemical\\_Handling\\_Facility\\_\(NO\)\\_309\\_CPS\\_9-16.pdf](https://efotg.sc.egov.usda.gov/references/public/MI/Agrichemical_Handling_Facility_(NO)_309_CPS_9-16.pdf) )

Useful Worker Protection Standard Publications include:

How to Comply With the 2015 Revised Worker Protection Standard For Agricultural Pesticides” “What Owners and Employers Need To Know”

Resources for revised WPS publications:

National Pesticide Safety Education Center:

<https://npsecstore.com/pages/michigan>

Pesticide Educational Resources Collaborative:

[pesticideresources.org//index.html](http://pesticideresources.org//index.html)

These may be available at the EPA National Agricultural Compliance Assistance Center located at 901 North 5<sup>th</sup> Street, Kansas City, KS 66101, (888) 663-2155, website: <https://www.epa.gov/agriculture/about-epas-national-agriculture-center>  
**website for MSUE Bulletins:** <http://www.shop.msu.edu>



## ADVISORY COMMITTEE

Listed below are the advisory committee members for the Generally Accepted Agricultural and Management Practices for Pesticide Utilization and Pest Control.

John Wise-Chair  
Applied Insecticide  
Toxicology Lab  
206 Center for Integrated  
Plant Systems (CIPS)  
578 Wilson Road  
East Lansing, MI 48824  
517-432-2668  
[wisejohn@msu.edu](mailto:wisejohn@msu.edu)

Laura Campbell  
Michigan Farm Bureau  
Manager, Agriculture Ecology  
Department  
7373 West Saginaw  
P.O. Box 30960  
Lansing, MI 48917  
517-679-5332  
[lcampbe@michfb.com](mailto:lcampbe@michfb.com)

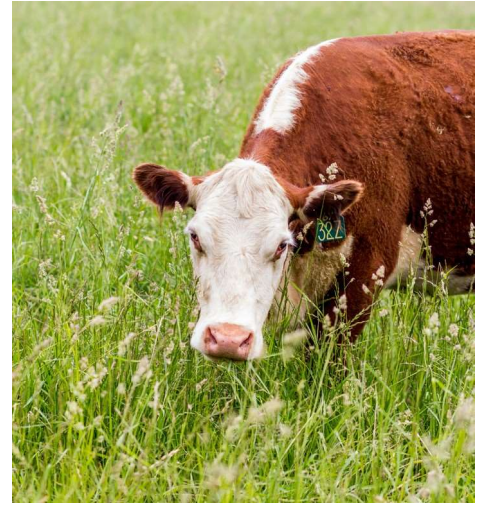
Jack Knorek  
Michigan Department of  
Agriculture & Rural  
Development  
Environmental Stewardship  
Division  
P.O. Box 30017  
Lansing, MI 48909  
517- 243-0072  
[knorekj@michigan.gov](mailto:knorekj@michigan.gov)

Terri Novak  
Michigan Economic  
Development Corporation  
300 North Washington  
Square  
Lansing, MI 48913  
517-930-3170  
[novaktl@michigan.gov](mailto:novaktl@michigan.gov)

John Stone  
Michigan State University  
Coordinator, Pesticide Safety  
Education Program  
Instructor, Michigan State  
University IAT  
Food Safety and Toxicology  
Building  
1129 Farm Lane, Room B18  
East Lansing, MI 48824-1302  
Office Phone: 517-353-5134  
[stonejo2@msu.edu](mailto:stonejo2@msu.edu)

Dr. Ruth Shaffer  
USDA-NRCS  
3001 Coolidge Road,  
Suite 250  
East Lansing, MI 48823  
517-324-5239  
[ruth.shaffer@usda.gov](mailto:ruth.shaffer@usda.gov)

Dr. Bernard Zandstra  
Michigan State University  
Department of Horticulture  
A440 Plant & Soil Science  
East Lansing, MI 48824  
517-353-6637  
[zandstra@msu.edu](mailto:zandstra@msu.edu)



# Generally Accepted Agricultural and Management Practices for Site Selection and Odor Control for New and Expanding Livestock Facilities

---

**June 2020 January 2021-DRAFT**

Michigan Commission of Agriculture & Rural  
Development  
PO BOX 30017  
Lansing, MI 48909



**In the event of an agricultural pollution emergency such as a chemical/fertilizer spill, manure lagoon breach, etc., the Michigan Department of Agriculture and Rural Development and/or Michigan Department of Environment, Great Lakes, and Energy should be contacted at the following emergency telephone numbers:**

**Michigan Department of Agriculture & Rural Development: 800-405-0101**

**Michigan Department of Environment, Great Lakes, and Energy: 800-292-4706**

**If there is not an emergency, but you have questions on the Michigan Right to Farm Act, or items concerning a farm operation, please contact the:**

**Michigan Department of Agriculture & Rural Development (MDARD) Right to Farm  
Program (RTF)**

**P.O. Box 30017 Lansing, Michigan 48909**

**517-284-5619**

**517-335-3329 FAX**

**(Toll Free) 877- 632-1783**

## TABLE OF CONTENTS

<b>PREFACE</b>	<b>iii</b>
<b>INTRODUCTION</b>	<b>1</b>
<b>DEFINITIONS</b>	<b>3</b>
<b>DETERMINING ACCEPTABLE LOCATIONS FOR LIVESTOCK FACILITIES</b>	<b>5</b>
Additional Considerations for all Livestock Facilities	11
Additional Considerations for all Livestock Production Facilities	11
<b>MANURE STORAGE STRUCTURE CHANGE OR INSTALLATION</b>	<b>12</b>
<b>OFFSITE MANURE STORAGE FACILITIES</b>	<b>13</b>
<b>DEVELOPING A SITE PLAN AND A MANURE MANAGEMENT SYSTEM PLAN</b>	<b>14</b>
<b>SITE REVIEW AND VERIFICATION PROCESS</b>	<b>16</b>
<b>APPENDICES</b>	<b>19</b>
Appendix A: Michigan Odor Management Plan	19
Appendix B: Example Dairy Odor Management Plan	22
Appendix C: Comprehensive Nutrient Management Plan	26
Appendix D: Manure Storage Facility Plan	28
Appendix E: Michigan Commission of Agriculture and Rural Development Policy No. 12	29
<b>REFERENCES</b>	<b>32</b>
<b>ADVISORY COMMITTEE</b>	<b>33</b>

## PREFACE

The Michigan legislature passed into law the Michigan Right to Farm Act (Act 93 of 1981) which requires the establishment of Generally Accepted Agricultural and Management Practices (GAAMPs). GAAMPs for Site Selection and Odor Control for New and Expanding Livestock Facilities are written to fulfill that purpose and to provide uniform, statewide standards and acceptable management practices based on sound science. These practices can serve producers in the various sectors of the industry to compare or improve their own managerial routines. New scientific discoveries and changing economic conditions may require necessary revision of these GAAMPs.

The GAAMPs that have been developed are as follows:

- 1) 1988 Manure Management and Utilization
- 2) 1991 Pesticide Utilization and Pest Control
- 3) 1993 Nutrient Utilization
- 4) 1995 Care of Farm Animals
- 5) 1996 Cranberry Production
- 6) 2000 Site Selection and Odor Control for New and Expanding Livestock Facilities
- 7) 2003 Irrigation Water Use
- 8) 2010 Farm Markets

These practices were developed with industry, university, and multi-governmental agency input. As agricultural operations continue to change, new practices may be developed to address the concerns of the neighboring community. Agricultural producers who voluntarily follow these practices are provided protection from public or private nuisance litigation under the Right to Farm Act.

This GAAMP does not apply in municipalities with a population of 100,000 or more in which a zoning ordinance has been enacted to allow for agriculture provided that the ordinance designates existing agricultural operations present prior to the ordinance's adoption as legal nonconforming uses as identified by the Right to Farm Act for purposes of scale and type of agricultural use.

The website for the GAAMPs is <http://www.michigan.gov/righttofarm>.

## INTRODUCTION

Generally Accepted Agricultural and Management Practices for Site Selection and Odor Control for New and Expanding Livestock Facilities will help determine the suitability of sites for livestock production facilities and livestock facilities and the suitability of sites to place or keep livestock. These GAAMPs provide a planning process that can be used to properly plan new and expanding facilities and to increase the suitability of a particular site thus enhancing neighbor relations.

These GAAMPs for Site Selection and Odor Control for New and Expanding Livestock Facilities are written to provide uniform, statewide standards and acceptable management practices based on sound science. They are intended to provide guidance for the construction of new and expanding livestock facilities and livestock production facilities and/or the associated manure storage facilities for the placement and keeping of any number of livestock.

### FARM PLANNING AND SITE DEVELOPMENT

The GAAMPs for site selection and odor control for new and expanding livestock facilities are intended to fulfill three primary objectives:

- 1) Environmental Protection
- 2) Social Considerations (neighbor relations)
- 3) Economic Viability

When all three of these objectives are met, the ability of a farm operation to achieve agricultural sustainability is greatly increased.

Farm planning involves three broad phases: Collection and analysis (understanding the problems and opportunities); decision making; and implementation. Collection and analysis includes: determining objectives, inventorying resources, and analyzing data. Decision support includes formulating alternatives, evaluating alternatives, and making decisions. The final step is implementation.

Producers should utilize recognized industry and university professionals in the evaluation of the economic viability and sustainability of constructing new or expanding existing livestock production facilities and livestock facilities. This evaluation should be comprehensive enough to consider all aspects of livestock production including economics, resources, operation, waste management, and longevity.

The decision to site a livestock production facility or livestock facility can be based on several objectives including: preserving water quality, minimizing odor, working within existing land ownership constraints, future land development patterns, maximizing convenience for the operator, maintaining esthetic character, minimizing conflicts with adjacent land uses, and complying with other applicable local ordinances.

The environmental objectives of these GAAMPs focus specifically on water quality protection and odor control, and how environmental and management factors affect the suitability of sites for livestock production. The suitability of a particular site for a livestock production facility or livestock facility depends upon a number of factors; such as the number of animal units (size); the species of animals; predominant wind directions; land base for use; topography of the surrounding land; adjacent land uses; the availability of Class A roads for feed and product movement; soil types; hydrology; and many others.

Site selection is a complex process, and each site should be assessed individually in terms of its proposed use. These GAAMPs are written in recognition of the importance of site-specificity in siting decisions. While general guidelines apply to all siting decisions, specific criteria are not equally applicable to all types of operations and all locations. In addition to the guidelines provided in these GAAMPs, the United States Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) technical references, including the Agricultural Waste Management Field Handbook (AWMFH) and the electronic Field Office Technical Guide (eFOTG), are excellent sources for information and standards related to the siting of livestock facilities.

It is recognized that there is potential risk for surface or groundwater pollution, or conflict over excessive odors from a livestock facility. However, the appropriate use of technologies and management practices can minimize these risks, thus allowing the livestock facility to operate with minimal potential for excessive odor or environmental degradation. These measures should be incorporated into a Site Plan and a Manure Management System Plan, both as defined in Section V, which are required for all new and expanding livestock facilities.

Groundwater and surface water quality issues regarding animal agriculture production are addressed in the current "Generally Accepted Agricultural and Management Practices for Manure Management and Utilization" as adopted by Michigan Commission of Agriculture & Rural Development (MCARD) and are not duplicated here. The GAAMPs for Manure Management and Utilization cover runoff control and wastewater management, construction design and management for manure storage and treatment facilities, and manure application to land. In addition, the GAAMPs for Manure Management and Utilization stress the importance of each livestock production facility developing a manure management system plan that focuses on management of manure nutrients and management of manure and odors.

These GAAMPs are referenced in Michigan's Natural Resources and Environmental Protection Act (NREPA), PA 451 of 1994, as amended. NREPA protects the waters of the state from the release of pollutants in quantities and/or concentrations that violate established water quality standards. In addition, the GAAMPs utilize the nationally recognized construction and management standard to provide runoff control for a 25- year, 24-hour rainfall event.

While these GAAMPs establish basic set-back standards for livestock facilities of all sizes, existing land uses, development patterns, the cost-benefit of an investment in animal housing, as well as the sustainability of farm animal production should all be analyzed before construction of a livestock facility and bringing farm animals to a site.

## DEFINITIONS

AS REFERENCED IN THESE GAAMPs:

Adjacent Property – ~~An adjacent property is~~ land and owned by someone other than the livestock facility owner that borders the property on which a proposed new or expanding livestock facility will be located.

Animal Units – ~~One thousand pounds live weight Animal units are defined as listed in (Table 1) of these GAAMPs. For siting purposes, an animal unit is~~ Defined as listed in Table 1. For those instances not defined in Table 1-~~One~~, one aAnimal Unit is defined as one-thousand pounds of live weight.

Distances between a Livestock Facility or Livestock Production Facility and Non-Farm Residences - The ~~distancespace span~~ from a livestock facility or livestock production facility and a non-farm residence is measured from the nearest point of the livestock facility or livestock production facility to the nearest point of the non-farm residence.

Existing Livestock Facility – A livestock facility or livestock production facility that has not increased animal unit capacity within the last three years where animals are confined.

Expanding Livestock ~~Production~~ Facility – A contiguous addition to an existing livestock facility to increase the animal unit capacity. A manure storage structure change or installation to accommodate an increase in animal unit capacity within three years from the construction of the manure storage is an expanding livestock facility. Manure storage structure change or installation at an existing livestock facility to accommodate already existing animal unit capacity is not an expanding livestock facility.

Institutional Controls -  ~~Institutional controls are those~~ land or resource use restrictions required by state or federal environmental laws to reduce or restrict exposure to hazardous substances, to eliminate a potential exposure pathway, to assure the effectiveness and integrity of contaminant or exposure barriers, to provide for access, or to otherwise assure the effectiveness and integrity or response activities taken in response to environmental contamination. Institutional controls include, but are not limited to, local ordinances or state laws and regulations that limit or prohibit the use of contaminated groundwater, prohibit the raising of livestock, prohibit development in certain locations, or restrict property to certain uses.

Livestock – For purposes of the Site Selection GAAMPs, livestock means those species of farm animals used for human food, fiber, ~~and fur,~~ recreation and (or) or used for service to humans- (e.g. horse and oxen to pull farm equipment). Livestock includes, but is not limited to, cattle, sheep, new world camelids, goats, bison, privately owned cervids, ratites, swine, equine, poultry, and rabbits. For the purpose of the Site Selection GAAMPs, livestock does not include dogs and cats. Site Selection GAAMPs do not apply to aquaculture and bees.

Livestock Farm Residence - A residential ~~structureee on-land~~ owned/rented by the livestock farm operation and those residential ~~structuresces on-farms~~ affiliated by contract or agreement with the livestock ~~production~~ facility.



Livestock Facility – Any place where livestock are kept or manure is stored regardless of the number of animals. This does not include pasture land.

Livestock Production Facility – Any places where livestock are kept with a capacity of 50 animal units or greater and/or the associated manure storage structures. Sites such as loafing areas, confinement areas, or feedlots, which have livestock densities that preclude a predominance of desirable forage species as vegetation, are considered part of a livestock production facility. This does not include pastureland. Any livestock production facility within 1,000 feet of ~~each-an~~ another livestock production facility, and under common ownership, constitutes a single livestock production facility.

Manure Storage Structure Change or Installation - An alteration or addition to manure storage at a livestock facility. Size is based on the greater of total animal units housed or animal units served by the facility's manure storage structures.

Migrant Labor Housing Camp – Agricultural employee housing that is licensable by MDARD. For purpose of this GAAMP, a migrant labor housing camp owned by a livestock producer applying for Site Selection GAAMP approval will be considered a livestock farm residence.

New Livestock Production Facility – All facilities-places where livestock will be kept and/or manure storage structures that will be built at a new sites and isare not part of another livestock production facility, including facilities-atA -new livestock production facility also isincludes a placesites that isare 1) expanding the animal holding-unit capacity for livestock by 100 percent or greater and the resulting holding animal unit capacity will exceed 749 animal units, or 2) any construction to expand animal existing holding-unit capacity within three years of completion of new constructionan existing facility documented in an MDARD final verification letter and the resulting holding-animal unit capacity will exceed 749 animal units.

Non-Farm Residence - A residential structureee that is habitable for human occupation and is not affiliated with the specific livestock facilityproduction-system.

Offsite Manure Storage Facility - A manure storage facility constructed at a site that is not adjacent to a livestock production facility.

Pasture Land - Pasture land is-I and that is primarily used for the production of forage, upon which livestock graze. Pasture land is characterized by a predominance of vegetation consisting of desirable forage. Heavy-use areas within pastures are part of the pasture land. Examples of heavy-use areas include animal travel lanes and small areas immediately adjacent to shade, feed, water, supplement or rubbing stations.

Primarily Residential – Sites are primarily residential if there are more than 13 non-farm residences within 1/8 mile of the site or have any non-farm residence within 250 feet of the livestock facility.

Property Line Setback – Property line setback is-T the distance from the livestock production facility to the property line as measured from the nearest point of the livestock production facility to the nearest point of the livestock production facility owner's property line. If a producer owns land across a road, the road or right of way does not constitute a property line. Right of way setbacks for public roads, utilities, and easements apply.

**Table 1. Animal Units**

<b>Animal Units</b>	50	250	500	750	1,000
<b>Animal Type<sup>1</sup></b>	<b>Number of Animals</b>				
Slaughter and Feeder Cattle	50	250	500	750	1,000
Mature Dairy Cattle	35	175	350	525	700
Swine <sup>2</sup>	125	625	1,250	1,875	2,500
Sheep and Lambs	500	2,500	5,000	7,500	10,000
Horses	25	125	250	375	500
Turkeys	2,750	13,750	27,500	41,250	55,000
Laying Hens or Broilers	5,000	25,000	50,000	75,000	100,000

<sup>1</sup>All other animal classes, types or sizes (eg. Nursery pigs) not in this table, but defined in the Michigan Right to Farm Act or described in Michigan Commission of Agriculture and Rural Development Policy, are to be calculated as one thousand pounds live weight equals one animal unit.

<sup>2</sup>Weighing over 55 pounds.

## **DETERMINING ACCEPTABLE LOCATIONS FOR LIVESTOCK FACILITIES**

All potential sites for new and expanding livestock facilities can be identified by four general categories. These are:

- Category 1. These are sites normally acceptable for livestock facilities and generally defined as areas that are highly agricultural with few non-farm residences.
- Category 2. These are sites where special technologies and/or management practices could be needed to make new and expanding livestock facilities acceptable. These areas are predominantly agricultural but also have an increased number of non-farm residences.
- Category 3. These are sites that are generally not acceptable for new and expanding livestock production facilities due to environmental concerns or other neighboring land uses.
- Category 4. These are sites that are not acceptable for new and expanding livestock facilities and livestock production facilities.

**Livestock facilities in Categories 1, 2 or 3 with less than 50 animal units are not required to go through the site review and verification process, and conform to the provisions of these GAAMPs. However, these operations are required to conform to all other applicable GAAMPs.**

**Existing livestock facilities installing new, altering, or adding manure storage that is not related to an increase in animal unit capacity are not required to go through the site review and verification process, but must meet the applicable setback criteria under Manure Storage Structure Change or Installation section for this storage to conform to the provisions of Siting GAAMPs.**

Category 1 Sites: Sites normally acceptable for livestock facilities.

Category 1 sites are those sites which have been traditionally used for agricultural purposes and are in an area with a relatively low residential housing density. These sites are located where there are five or fewer non-farm residences within ¼ mile from a new livestock facility with up to 749 animal units, and within ½ mile from a new livestock facility with 750 animal units or greater.

If the proposed site is within Category 1, it is recognized that this is a site normally acceptable for livestock facilities. ~~As shown in Table 2 (REVISED), if the proposed site is within Category 1 and has a capacity of 50 to 499 animal units, MDARD will review and verify the producer's plans at the producer's request.~~ If the proposed site is within Category 1 and has a capacity of 500 or more animal units, the producer must follow the MDARD site selection review and verification process as described in Section V. Category 1 sites with less than 1,000 animal units which are able to meet the property line setbacks as listed in Tables 2 and 3, as appropriate, and which meet the other requirements of these GAAMPs, are generally considered as acceptable for Site Selection Verification. An Odor Management Plan (OMP) will not be required for these sites in most circumstances. It is however, recommended that all producers develop and implement an OMP in order to reduce odor concerns for neighboring non-farm residents.

A request to reduce the property line setbacks, as listed in Tables 2 and 3, will require the development of an OMP for verification. All verification requests for Category 1 sites with 1,000 animal units or greater will require the development and implementation of an OMP to specify odor management practices that will provide a 95 percent odor annoyance-free level of performance as determined by the Michigan Revised OFFSET 2018 odor model (Kiefer, 2018). For new livestock facilities, a property line setback reduction shall only be considered for a proposed site in advance of MDARD site suitability approval. MDARD may grant a property line setback reduction of up to fifty percent of the applicable setback distance (Tables 2 and 3) when requested based upon the Odor Management Plan. In all cases, the minimum property line setback will be 250 feet for new livestock facilities. Any reduction beyond this minimum will require a signed variance by the property owners within the original setback distance affected by the reduction. Factors not under direct control of the operator will be considered if an alternative mitigation plan is provided. Local land use may be considered by MDARD in granting setback reductions.

**Table 2. Category 1 Site Setbacks, Verification and Notification – New Operations**

<b>Total Animal Units <sup>1</sup></b>	<b>Number of Non-Farm Residences within Specified Distance</b>	<b>Property Line Setback<sup>2</sup></b>	<b>MDARD Site Review and Verification Process <sup>3</sup></b>
50-499	0-5 within ¼ mile	250 ft	Yes
500-749	0-5 within ¼ mile	400 ft	Yes
750-999	0-5 within ½ mile	400 ft	Yes
1000 or more	0-5 within ½ mile	600 ft	Yes

<sup>1</sup> Facilities in Category 1 with less than 50 animal units are not required to go through the site review and verification process to be considered in conformance with the provisions of these GAAMPs.

<sup>2</sup> May be reduced or increased based upon the Odor Management Plan.

<sup>3</sup> To achieve approval and MDARD verification, all livestock facilities must conform to these and all other applicable GAAMPs.

For expanding livestock facilities, a variance for property line setback reduction shall only be considered for a proposed site in advance of MDARD site suitability approval. MDARD may grant a property line setback reduction of up to ~~fifty~~50 percent of the setback distance in the following table when requested based upon the Odor Management Plan. The minimum setback will be 125 feet for expanding livestock facilities. Any reduction beyond this minimum will require a signed variance by the property owners that are within the original setback distance affected by the reduction. Local land use may be considered by MDARD in granting setback reductions. Expanding livestock facilities cannot utilize a property line setback less than the property line setback established by structures constructed before 2000 unless the established property line setback is greater than those distances identified in Table 3, in which case setbacks identified in Table 3 and the process detailed above will be used for determining conformance for new or expanding ~~structures~~livestock facilities.

**Table 3. Category 1 Site Setbacks, Verification and Notification – Expanding Operations**

<b>Total Animal Units <sup>1</sup></b>	<b>Number of Non-Farm Residences within Specified Distance</b>	<b>Property Line Setback<sup>2</sup></b>	<b>MDARD Site Review and Verification Process <sup>3</sup></b>
50-249	0-7 within ¼ mile	125 ft	Yes
250-499	0-7 within ¼ mile	200 ft	Yes
500-749	0-7 within ¼ mile	200 ft	Yes
750-999	0-7 within ½ mile	200 ft	Yes
1000 or more	0-7 within ½ mile	300 ft	Yes

<sup>1</sup> Facilities in Category 1 with less than 50 animal units are not required to go through the site review and verification process to be considered in conformance with the provisions of these GAAMPs.

<sup>2</sup> May be reduced or increased based upon the Odor Management Plan.

<sup>3</sup> To achieve approval and MDARD verification, all livestock facilities must conform to these and all other applicable GAAMPs.

Category 2 Sites: Sites where special technologies and/or management practices may be needed to make new and expanding livestock facilities acceptable.

Category 2 sites are those where site-specific factors may limit the environmental, social, or economic acceptability of the site for livestock facilities and where structural, vegetative, technological, and ~~and/or~~ management measures may be necessary to address those limiting factors. These measures should be incorporated into thea Site Plan, Odor Management Plan and a Manure Management System Plan, both as which are defined in Section V, and which are required for all new and expanding livestock production facilities seeking verification within a Category 2 site. ~~Due to the increased density of non-farm residences in Category 2 sites, an OMP is required for all proposed new and expanding livestock production facilities with 50 animal units or more.~~

Tables 4 and 5 show how Category 2 sites are defined and lists property line setbacks and verification requirements. As an example, a proposed site for an expanding livestock production facility (Table 5) with 500 animal units and between eight and 20 residences within ¼ mile of the facility, would have a setback of 200 feet from the owner’s property line, and would be required to have a site verification request approved by MDARD.-

For new livestock facilities, a property line setback reduction shall only be considered for a proposed site in advance of MDARD site suitability approval. MDARD may grant a property line setback reduction of up to fifty percent of the property line setback distance (in the Table 4) when

following table when requested, based upon the Odor Management Plan. The minimum property line setback will be 250 feet for new livestock facilities. Any reduction beyond this minimum will require a signed variance by the property owners that are within the original property line setback distance affected by the reduction. Local land use may be considered by MDARD in granting property line setback reductions.

**Table 4. Category 2 Site Setbacks, Verification and Notification – New Operations**

<b>Total Animal Units<sup>1</sup></b>	<b>Number of Non-Farm Residences within Specified Distance</b>	<b>Property Line Setback<sup>2</sup></b>	<b>MDARD Site Review and Verification Process<sup>3</sup></b>
50-249	6-13 within ¼ mile	250 ft	Yes
250-499	6-13 within ¼ mile	300 ft	Yes
500-749	6-13 within ¼ mile	400 ft	Yes
750-999	6-13 within ½ mile	500 ft	Yes
1000 or more	6-13 within ½ mile	600 ft	Yes

<sup>1</sup> Facilities in Category 2 with less than 50 animal units are not required to go through the site review and verification process to be considered in conformance with the provisions of these GAAMPs.

<sup>2</sup> May be reduced or increased based upon the Odor Management Plan.

<sup>3</sup> To achieve approval and MDARD verification, all livestock facilities must conform to these and all other applicable GAAMPs.

For expanding livestock facilities, a property line setback reduction shall only be considered for a proposed site in advance of MDARD site suitability approval. MDARD may grant a property line setback reduction of up to ~~fifty~~50 percent of the setback distance in the following table when requested based upon the Odor Management Plan. The minimum setback will be 125 feet for expanding livestock facilities. Any reduction beyond this minimum will require a signed variance by the property owners that are within the original setback distance affected by the reduction. Local land use may be considered by MDARD in granting setback reductions. Expanding livestock facilities cannot utilize a property line setback less than the property line setback established by structures constructed before 2000 unless the established property line setback is greater than those distances identified in Table 5, in which case setbacks identified in Table 5 and the process detailed above will be used for determining conformance for new or expanding structures.

**Table 5. Category 2 Site Setbacks, Verification and Notification – Expanding Operations**

<b>Total Animal Units <sup>1</sup></b>	<b>Number of Non-Farm Residences within Specified Distance</b>	<b>Property Line Setback <sup>2</sup></b>	<b>MDARD Site Review and Verification Process <sup>3</sup></b>
50-249	8- 20 within ¼ mile	125 ft	Yes
250-499	8- 20 within ¼ mile	200 ft	Yes
500-749	8- 20 within ¼ mile	200 ft	Yes
750-999	8- 20 within ½ mile	250 ft	Yes
1000 or more	8- 20 within ½ mile	300 ft	Yes

<sup>1</sup> Facilities in Category 2 with less than 50 animal units are not required to go through the site review and verification process to be considered in conformance with the provisions of these GAAMPs.

<sup>2</sup> May be reduced or increased based upon the Odor Management Plan.

<sup>3</sup> To achieve approval and MDARD verification, all livestock facilities must conform to these and all other applicable GAAMPs.

Category 3 Sites: Sites generally not acceptable for new and expanding livestock production facilities.

Category 3 sites are generally not suitable for livestock production facilities. They may be suitable for livestock facilities with less than 50 animal units. Any proposed site with more than the maximum number of non-farm residences specified in Table 4 for a new operation, and Table 5 for an expanding operation is a Category 3 or a Category 4 site. New livestock production facilities are not acceptable for that site. However, expanding livestock production facilities may be acceptable if the farm submits an Odor Management Plan and site verification approval is determined by MDARD. Additional odor reduction and control technologies and (or) management practices may be necessary to obtain site verification approval.

Category 4 Sites: Sites not acceptable for new and expanding livestock facilities and livestock production facilities under the Siting GAAMPs.

Sites that Category 4 Those sites that are primarily residential (in current land use) are and are not acceptable under the Siting GAAMPs for livestock facilities or livestock production facilities regardless of the number of animal units. While However, the possession and rearing/raising of farm animals on those sites may be authorized in such areas pursuant to a local ordinance designed for that purpose, †The placement or keeping of any number of livestock farm animals on those sites does not conform to the Siting GAAMPs.

## **Additional Considerations for all Livestock Facilities**

1. Sites where institutional controls have been adopted to prohibit livestock agriculture are not acceptable for new and expanding livestock facilities if all of these are true:
  - a) The institutional controls were approved by the Michigan Department of Environment, Great Lakes, and Energy pursuant to the Natural Resources and Environmental Protection Act (NREPA), MCL 324.101 et seq., or the United States Environmental Protection Agency pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act or the Resource Conservation and Recovery Act; and
  - b) The institutional controls are necessary to protect human or animal health; and-
  - c) Unacceptability has been confirmed by a vote of the Michigan Commission of Agriculture and Rural Development.

## **Additional Considerations for all Livestock Production Facilities**

The following circumstances or neighboring land uses constitute conditions that are considered unacceptable for construction of new and expanding livestock production facilities or may require additional setback distances or approval from the appropriate agency, as indicated, to be considered acceptable.

1. Wetlands - New and expanding livestock production facilities and manure storage facilities shall not be constructed within a wetland as defined under MCL 324.30301 (NREPA, PA 451 of 1994, as amended).
2. Floodplain - New and expanding livestock production facilities and manure storage facilities shall not be constructed in an area where the facilities would be inundated with surface water in a 25-year flood event.

*The following circumstances require minimum setback distances in order to be considered acceptable for construction of ~~category 1, 2 or 3~~ new livestock production facilities in category 1, 2 or 3 sites. In addition, review and approval of expansion in these areas is required by the appropriate agency, as indicated.*

### 3. Drinking Water Sources

Groundwater protection - New livestock production facilities shall not be constructed within a ten-year time-of-travel zone designated as a wellhead protection area as recognized by the Michigan Department of Environment, Great Lakes, and Energy (EGLE), pursuant to programs established under the Michigan Safe Drinking Water Act, PA 399 of 1976, as amended.

An expanding livestock production facility may be constructed with review and approval by the local unit of government administering the Wellhead Protection Program.



For sites where no designated wellhead protection area has been established, construction of new and expanding livestock production facilities shall not be closer than 2000 feet to a Type I or Type II public water supply and shall not be closer than 800 feet to a Type IIb or Type III public water supply. A new or expanding livestock production facility may be located closer than these distances, upon obtaining a deviation from well isolation distance through EGLE or the local health department. New and expanding livestock production facilities should not be constructed within 75 feet of any known wellhead of an existing private domestic water supply-  
~~(wellhead)~~.

Surface water protection - New and expanding livestock production facilities shall not be constructed within the 100-year flood plain of a stream reach where a community surface water source is located, unless the livestock production facility is located downstream of the surface water intake.

4. High public use areas - Areas of high public use or where a high population density exists, are subject to setbacks to minimize the potential effects of a livestock production facility on the people that use these areas. New livestock production facilities should not be constructed within 1,500 feet of hospitals;<sup>17</sup> churches;<sup>17</sup> licensed commercial elder care facilities;<sup>17</sup> licensed commercial childcare facilities;<sup>17</sup> school, government, commercial, professional, office or retail buildings; publicly accessible parks or campgrounds (excluding terrestrial and aquatic trails). ~~school buildings, commercial areas, parks, or campgrounds.~~ Existing livestock production facilities may be expanded within 1,500 feet of high public use areas with appropriate MDARD review and verification. The review process will include input from the local unit of government and from people who utilize those high public use areas within the 1,500 foot setback.
5. Migrant Labor Housing Camp – New and expanding livestock production facilities shall be constructed within ~~located a minimum of a minimum of~~ 500 feet off from ~~from~~ any existing migrant labor housing ~~facilities~~ camp, unless a variance is obtained from the United States Department of Labor.

### MANURE STORAGE STRUCTURE CHANGE OR INSTALLATION

All manure storage structure changes and installations at existing livestock facilities must be at least 250 feet from non-farm residences or no closer than the established setback distance.

For manure storage structure changes or installations setback distances at an existing livestock facility with 50 AU or more, the minimum setback distances from property lines are shown in Table 6, effective with the release of this GAAMP in 2021. All setback distances should be maximized to the extent possible to minimize odor impacts on neighbors.

**Table 6 – Property Line Setbacks for Manure Storage Structure Change or Installation**

<b>Total Animal Units (AU)<sup>1</sup></b>	<b>Property Line Setback Distances</b>
<b>50 - 249</b>	<b>125 ft or ESD<sup>2</sup></b>
<b>250-749</b>	<b>200 ft or ESD</b>
<b>750-999</b>	<b>250 ft or ESD</b>
<b>1,000 or more</b>	<b>300 ft or ESD</b>

<sup>1</sup>AU- Animal Units as defined in Table 1

<sup>2</sup>Established Setback Distance – An established animal production structure exists (a lot or pasture fence line is not considered part of this criterion)

Manure storage structure changes or installations at livestock facilities < 50 animal units (AU) are exempt from the setbacks in Table 6.

Any reduction to the established property line setbacks for a manure storage structure change or installation will require a signed variance by the property owners that are within the original setback distance affected by the reduction.

Manure storage structure changes or installations must be in conformance with the Manure Management and Utilization GAAMPs; Construction Design and Management for Manure Storage and Treatment Facilities section.

### OFFSITE MANURE STORAGE FACILITIES

**Table 6. Site Setbacks, Verification, and Notification – New or Expanding Operations**

<b>Storage Surface Area at Operational Volume Elevation, sq. ft.</b>		<b>Property Line Setback, ft.</b>	<b>MDARD Site Review and Verification Process</b>
Liquid Manure		Solid Manure	
Pond-type storage	Fabricated structure-type storage, i.e. reinforced concrete or steel		
≤4,200	≤2,000	≤26,000	250 <sup>1</sup> Upon Producer Request

>4,200	>2,000	>26,000	TBD <sup>2</sup>	Yes
--------	--------	---------	------------------	-----

<sup>1</sup>May be reduced up to 50% or increased based upon the Odor Management Plan.

<sup>2</sup>Distance to be determined based upon the Odor Management Plan but no less than 250 feet.

## DEVELOPING A SITE PLAN AND A MANURE MANAGEMENT SYSTEM PLAN

### Site Plan

A Site Plan is a comprehensive layout review of a proposed location for a livestock production facility, and includes at a minimum:

- A site map, including the following features (to scale):
  - ~ Property lines, easements, rights-of-way, and any deed restrictions.
  - ~ Public utilities, overhead power lines, cable, pipelines, and legally established public drains.
  - ~ Positions of buildings, wells, septic systems, culverts, drains and waterways, walls, fences, roads, and other paved areas.
  - ~ Location, type, and size of existing utilities.
  - ~ Location of wetlands, streams, and other bodies of water.
- Existing land uses for contiguous land.
- Names and addresses of adjacent property owners.
- Basis of livestock production facility design.
- Size and location of structures.

- A soils map of the area where all livestock production facilities are located.
- Location and distance to the non-farm residences within ½ mile.
- Location and distance to the nearest primarily residential area.
- Topographic map of site and surrounding area.
- Property deed restrictions.

### Manure Management System Plan<sup>1</sup>

The Manure Management System Plan (MMSP) describes the system of structural, vegetative, and management practices that the owner/operator has chosen to implement on the site for all proposed new and existing facilities. Items to address in the MMSP are described in the GAAMPs for Manure Management and Utilization. The MMSP for a site verification request will include these additional components:

- Planning and installation of manure management system components to ensure proper function of the entire system.
- Operation and Maintenance Plan: This written plan identifies the major structural components of the manure management system, and includes inspection frequency, areas to address, and regular maintenance records.
- Odor Management: Odor management and control is a primary focus relating to the social consideration objectives of these GAAMPs. For new and expanding livestock production facilities, an Odor Management Plan may be required (refer to Category 1 and Category 2 to determine whether an OMP is required for your facility) as part of the Manure Management System Plan for conformance with these GAAMPs. Appendix A includes a detailed outline for development of an effective OMP.
- Manure Storage Facility Plan: Construction plans detailing the design of manure storage components must be submitted to MDARD for review and approval. Structures should be designed in accordance with appropriate design standards. Construction plans should include the design standards utilized, design storage volume, size, and layout of the structure, materials specifications, soil conditions in the structure area, site suitability, subsurface investigation, elevations, installation requirements, and appropriate safety features. The plans will be reviewed for conformance with appropriate specifications. Structures should be designed and constructed by competent individuals or companies utilizing generally accepted standards, guidelines, and specifications (e.g. NRCS, Midwest Plan Service.).

---

<sup>1</sup> Due to your particular circumstances, a Comprehensive Nutrient Management Plan (CNMP) may be required, as referenced in Appendix C.

Other items that may accompany the Manure Management System Plan include the following:

- Emergency Action Plan - Through development of an Emergency Action Plan, identify the actions to take and contacts to be made in the event of a spill or discharge.
- Veterinary Waste Management Plan - Identify the processes and procedures used to safely dispose of livestock-related veterinary wastes produced on the farm.
- Conservation Plan - Field-specific plan describing the structural, vegetative and management measures for the fields where manure and other by-products will be applied.
- Mortality Management Plan - Identify the processes and procedures used to safely dispose of the bodies of dead animals (Bodies of Dead Animals Act, PA 239 of 1994, as amended).

## SITE REVIEW AND VERIFICATION PROCESS

Producers with facilities that require MDARD verification in Categories 1, 2, or 3 should contact the MDARD and begin the site selection review and verification process prior to the construction of new livestock facilities ~~or livestock production facilities~~, and expansion of existing livestock facilities ~~or livestock production facilities~~. Producers with new and expanding livestock facilities that have a total ~~holding animal unit~~ capacity ~~of~~ less than 50 animal units may ~~also~~ request siting verification from MDARD. ~~They are not required to do so as stated previously.~~ The MDARD site review and verification process will use criteria applicable to the ~~animal unit holding~~ capacity for the number of animal units of the proposed facility. The references to local unit of government in this section are intended to notify the township and county in which the farm operation is located.

To begin the review and verification process, contact the Michigan Department of Agriculture ~~&~~ and Rural Development, Right to Farm Program at ~~(877-)~~632-1783. This toll free number is operational during normal business hours. The following steps outline this process:

### 1) Application for Siting Verification:

A request to begin the site review and verification process can be made by submitting a letter from the responsible party to the MDARD, Right to Farm Program. This letter should outline the proposed new construction or expansion project, any areas of concern, agencies and individuals the producer is already working with, and the proposed timeline. The responsible party must also submit a complete site verification request. A request application and a checklist are available at [www.michigan.gov/gaamps](http://www.michigan.gov/gaamps). The checklist will assist you in identifying environmental or social areas of concern. If special technologies or management practices are to be implemented for the successful operation of the livestock production facility, these must be included in the siting request package.

Producers may also utilize recognized industry, university, and agency professionals in the development of their siting request, site plan, and manure management system plan.

Upon submitting a site verification request to MDARD, the producer must individually notify all non-farm residences identified in Tables 2 through 5 and listed in the Site Selection GAAMPs verification checklist (available at: [http://www.michigan.gov/documents/MDA\\_SitingChecklist\\_116499\\_7.pdf](http://www.michigan.gov/documents/MDA_SitingChecklist_116499_7.pdf)) under Appendix A “Certification of Notification of Non-Farm residences that the producer has made application for site verification with MDARD. Documentation that notification has occurred is required as part of the site verification request application.

2) Siting Request Review:

Upon receipt of the siting request package, MDARD will send an acknowledgement letter to the producer. This acknowledgement letter will also be sent to the local unit of government to inform them of the proposed livestock production facility siting request.

For purposes of the Siting GAAMPs, a formal complaint or a request by a livestock facility for a GAAMPs determination will result in a program review of adjacent land uses for the site in question. If the site is primarily residential, then the site is not acceptable for a livestock facility under the Siting GAAMPs.

MDARD will review the completed siting requests upon receipt. The review will determine whether the siting request information submitted conforms to these GAAMPs. MDARD will conduct preliminary site visits to proposed new and expanding livestock production facilities. This site visit will take place upon receipt of the complete siting request package and will focus on addressing conformance with the plan components, identifying areas of concern, and verifying information submitted in the siting request. If deficiencies in the siting request are identified, MDARD will communicate those to the producer for further modification. At the request of the producer, a preliminary site visit could be conducted prior to submission of the complete siting request package.

3) Site Suitability Determination:

MDARD will determine if the siting request is in conformance with the GAAMPs for Site Selection and Odor Control for New and Expanding Livestock Production Facilities. This determination will be conveyed to the responsible party on MDARD letterhead and will be known as “Site Suitability Approval.” This approval will also be copied to the local unit of government, and construction must begin within three years from the date of approval by MDARD. The start of construction is defined as the physical movement of soil or installation of permanent structures. An additional two-year extension to begin construction after three years from the date of the initial approval may be requested in writing to MDARD.

4) Construction Plan Submittal and Review:

Design plans for the manure storage structures must be submitted to MDARD for review and approval and should be submitted prior to construction.

If the plans are found to be in accordance with the required specifications, a letter indicating “Approval of Design Plans” will be sent to the owner. MDARD

will conduct construction site inspections for quality assurance as needed to determine whether the structures are being built according to the accepted plans. The owner should notify MDARD one month prior to beginning the installation of the manure storage facility.

5) Final Inspection:

MDARD will conduct a final inspection, preferably, prior to animal population. The completed project must be reviewed by MDARD to assure conformance with these GAAMPs. The facility must be completed in conformance with the verification request that has been approved by MDARD. Once the facility has been constructed and found in conformance with these GAAMPs, a final verification letter will be sent to the producer. This letter will be copied to the local unit of government.

Appeal of Site Suitability Approval Determination:

The Site Suitability Determination decision by the Michigan Department of Agriculture and Rural Development may be appealed as per Michigan Department of Agriculture and Rural Development Commission Policy number 12. This policy can be found at [http://www.michigan.gov/mdard/0,4610,7-125-1572\\_2878---,00.html](http://www.michigan.gov/mdard/0,4610,7-125-1572_2878---,00.html) or in Appendix E.

## APPENDICES

### **Appendix A: Michigan Odor Management Plan**

The goal of an effective Odor Management Plan is to identify opportunities and propose practices and actions to reduce the frequency, intensity, duration, and offensiveness of odors that neighbors may experience, in such a way that tends to minimize impact on neighbors and create a positive attitude toward the farm. Because of the subjective nature of human responses to certain odors, recommending appropriate technology and management practices is not an exact science. Resources to help identify appropriate management practices to minimize odors are available at: <http://www.animalagteam.msu.edu>

An Odor Management Plan shall include these six basic components:

1. Identification of potential sources of significant odors.
2. Evaluation of the potential magnitude of each odor source.
3. Application and evaluation of odor nuisance potential using Michigan Revised OFFSET 2018 (Kiefer, 2018).
4. Identification of current, planned, and potential odor control practices.
5. A plan to monitor odor impacts and respond to odor complaints.
6. A strategy to develop and maintain good neighbor and community relations.

Note that items 1, 2, and 4 of the Odor Management Plan components may be addressed in tabular format as demonstrated in the example Odor Management Plan (Appendix B).

Component Details:

1. Identify and describe all potential significant sources of odor associated with the farm. Odor sources may include:
  - Animal housing
  - Manure and wastewater storage and treatment facilities
  - Feed storage and management
  - Manure transfer and agitation

Land application areas are addressed in the MMSP.

2. Evaluate the magnitude of each odor source in relation to potential impact on neighbors and other community members.

Odor magnitude is a factor of both the type and size of the source.

Michigan Revised OFFSET 2018 is one means of estimating odor source magnitudes and potential impacts from animal production facilities. Use the Michigan Revised OFFSET 2018 odor emission values to rank each potential odor source on your farm. Note that some odor sources are not considered in this tool.



For odor sources not addressed by Michigan Revised OFFSET 2018, a subjective potential odor magnitude evaluation of high, medium, or low, relative to other odor sources on the farm should be conducted.

3. Analyze potential odor impact on neighboring residences and other non-farm areas with Michigan Revised OFFSET 2018, utilizing the 95 percent odor annoyance-free level. The intent of utilizing the model is to have no non-farm residences for new facilities or no new non-farm residences for expanding facilities to fall within the 5 percent% odor footprint. Evaluate the conclusions as follows:
  - Identify specific odor impact on neighboring residences, utilizing Michigan Revised OFFSET 2018 results and other site-specific odor impact considerations.
  - Assess the magnitude of potential odor-based conflict.
  - Develop an appropriate conflict abatement strategy for each odor-sensitive area of concern which may include:
    - Signed letter from property owner consenting to approval of the new or expanded facility.
    - Description of intensified community relations practices for these homes or other odor sensitive areas.
    - Explanation of specific variables in Michigan Revised OFFSET 2018 that may reduce the concern, such as, variables in terrain, wind velocity, facility layout, variation of facility from typical, and odor management practices not credited in Michigan Revised OFFSET 2018.
4. Identify management systems and practices for odor control including:
  - Practices currently being implemented.
  - New practices that are planned for implementation.
  - Practices that will be considered, if odor concerns arise.

There are numerous odor reduction practices available; however, not all have been proven equally effective. Some practices may reduce odor from one part of the system, but increase it in another. For example, long-term manure storage will reduce the frequency of agitation of the storage thus producing less frequent odor events, but will likely result in greater intensity and offensiveness of each odor event.

Each farm situation is unique and requires site-specific identification and implementation of odor reduction practices to suit the practical and economic limitations of a specific farm. MDARD will consider mitigating factors that are under the direct control of the operator. Factors not under direct control of the operator will be considered if an alternative mitigation plan is provided.

Simple changes in management, such as, but not limited to, improving farmstead drainage, collecting spilled feed, and regular fan maintenance will reduce overall farmstead odor.

“Practices that will be considered, if odor concerns increase” should include only those odor management practices that the producer would seriously consider implementing, if the need arose.

Improved management, as well as, the adoption of new technologies to control odor offer a means for reducing odor from livestock production facilities and manure storage facilities, thus broadening the potential area within which livestock production facilities may be appropriately sited. Odor reduction technologies continue to evolve. Current technologies include, but are not limited to, vent bio-filters, manure storage covers, and composting.

Each technology presents different challenges and opportunities. These should be considered during the planning process for a new or expanding animal livestock facility.

5. Describe the plan to track odor impact and the response to odor concerns as they arise.
  - Outline how significant odor events will be recognized and tracked including potential impact on neighbors and others. For example, one could record odor events noticed by those working on and/or cooperating with the farm. If odor is noticeable to you, your family, or employees, then it is likely noticeable to others.
  - Explain how an odor complaint will be addressed.
  - Indicate the point at which additional odor control measures will be pursued.
6. Identify the strategy to be implemented to establish and maintain a working relationship with neighbors and community members.

Elements of a community relations plan may include:

- Conducting farming practices that result in peak odor generation at times that will be least problematic for neighbors.
- Notifying neighbors of when there will be an increase in odors.
- Hosting an annual neighborhood farm tour to provide information about your farm operation.
- Sending a regular farm newsletter to potentially affected community members.
- Keeping the farmstead esthetically pleasing.
- Supporting community events and causes.

## **Appendix B: Example Dairy Odor Management Plan**

*The Odor Management Plan includes the following text and tables and output from Michigan Revised OFFSET, which is not shown here.*

### **Overview**

The existing 1,200 cow facility is expanding to 1,700 cows. The proposed expansion involves the addition of another 500 cow freestall barn, expansion of the primary sand- laden manure storage, and the addition of another earthen storage for milking center wastewater. All of the additional facilities are located to the south and west of the existing facility.

### **Odor Source Identification & Assessment**

Refer to attached Odor Source Assessment table.

### **Odor Management Practices**

Refer to attached Odor Management Practices table.

### **Potential Odor Impact Analysis**

Michigan Revised OFFSET 2018 has identified two non-farm residences that are definitely within the odor impact zone prior to the expansion and three additional homes that are likely impacted (see Michigan Revised OFFSET 2018 output). An additional five homes are added to the odor awareness zone as a result of the proposed expansion.

The potentially odor-impacted homes are at the following addresses:

(List addresses and homeowner names in order of proximity to odor source.)

All homeowners, with the exception of one, have signed a letter acknowledging the proposed expansion and indicating that they do not object to it proceeding. The lone exception is the residence at (*list address*). This resident was reluctant to sign a letter, but has verbally accepted the expansion. He is also a livestock producer whose odor awareness zone from Michigan Revised OFFSET 2018 would likely overlap the dairy farms. He also has a working relationship with the Example Dairy as a producer of corn grain for dairy feed.

Of the other homes in the odor awareness zone, three are currently or very recently have been active dairy farmers themselves. Another is a landlord of property that is rented and included in the farm CNMP/MMSP.

The three remaining homes are the most distant from the center of the odor awareness zone and furthest from the specific area of the facility expansion.

## **Odor Tracking and Response**

Tracking of odor concerns includes two approaches:

1. All farm employees and some routine farm service providers will be asked to report noticeable offensive odor events as they come and go from the farm and travel the community.
2. The intent is to establish and maintain an effective, open line of communication with immediate neighbors so that they too will be comfortable reporting odor events to example dairy.
3. Response to odor complaints or events reported by neighbors will include investigation of the primary odor incident source on the farm. For example, is it associated with storage agitation, field application, or no specific farm activity? The farm will report back to the person reporting the odor event within 24 hours, or as soon as possible thereafter. Included in the response will be the reason for the odor event, an acknowledgement of the concern, steps – if any – to be taken to prevent it in the future, and a thank you for bringing it to the farm's attention.

If a pattern is identified among odor event complaints by neighbors, an outside observer, such as MSU Extension or MDARD, will be asked to provide an objective analysis of the situation. If the concern is confirmed to be legitimate by a second objective observer, actions will be taken to further control odor per, or comparable to, odor management practices identified in the Odor Management Plan.

## **Community Relations**

In order to develop and maintain a positive relationship with the entire community, the following steps are planned:

1. Keeping the farmstead area esthetically pleasing will continue to be a high priority.
2. Each spring, a farm newsletter will be sent to all appropriate community members describing farm activities, personnel, and management.
3. A community picnic and farm tour will be held at least semi-annually for all in the immediate community and manure application areas.
4. Example Dairy Farm will make itself available to local schools for farm visits as field trips or school projects as appropriate.
5. We will seek to participate in local community events and youth activities, such as the local town festival and youth athletic teams.
6. Additional opportunities to strengthen community relations will be considered whenever they arise.
7. Notify potentially impacted neighboring residences at least 24 hours in advance of manure application.

(The above list of community relations practices may be longer than most farms find necessary, but it provides several examples that farms might consider.)

**Odor Source Assessment – proposed facility**

Potential Odor Source	Description	Odor Emission Number <sup>1</sup>	Odor Control Factors <sup>2</sup>			Odor Emission Factors <sup>1,3</sup>		
			current	planned	potential	current	planned	potential
Large Manure Storage	Sand Land Manure storage for center-drive through barns (170 x 340)	13	0.5 + NV			168.9		
Freestall Barns	Freestall barns (187,104 sq. ft.)	6		NV		112.3		
Milking Center Wastewater	Earthen storages for milking center wastewater. Is recycled to flush holding and treatment areas (49,600 sq. ft.)	13	NV		0.1	50.4		5.0
Run Off Storage	Collects rain runoff from open lot and silage pads (90 x 120)	13	NV			14		
Outside Lots	Outside concrete housing lot (16,200 sq. ft.)	4			NV	6.5		
Settling Basins	Holding area flushed material settling area prior to pumping of liquid to milking center wastewater storage (30 x 60)	28	NV	NV	NV	5		
Bedded Open Housing Barns	Maternity & sick pens (22,620 sq. ft.)	2				4.5		
Open Lot Manure storage	Short-term manure storage (70 x 20)	13	0.5 + NV			.9		
Agitation	Agitation of manure storages	Medium				M	M	M
Land Application	Field application of liquid manure	High	NV			M	M	M
Silage & Feed Storage	Concrete pad and bunker silos (300 x 350)	Medium	NV			L	L	L

1. Michigan Revised OFFSET value if available or High, Medium, Low for sources not addressed in Michigan Revised OFFSET

2. NV = No Value available in Michigan Revised OFFSET; however, a defensible odor control factor is applicable per Odor Management Practices table.

3. Odor Emission Factors are equal to the odor emission number, multiplied by the surface area (ft<sup>2</sup>) and odor control factor, divided by 10,000.

**Odor Management Practices**

Odor Source	Odor Management Practices & Reduction Factor		
	Current	Planned	Potential
Large Manure Storage	<ol style="list-style-type: none"> <li>1. Approximately eight months of potential storage results in agitation being required only 2-3 times per year.</li> <li>2. The natural plant fiber in the manure results in a crusting of the manure. (OCF = 0.5)</li> </ol>		
Freestall Barns		<ol style="list-style-type: none"> <li>1. Plans include the planting of a tree shelterbelt the length of the freestall barns, parlor, and treatment area.</li> </ol>	
Milking Center Wastewater	<ol style="list-style-type: none"> <li>1. Fills from bottom</li> <li>2. Long term storage facilitates minimal disturbance of only about two times per year.</li> </ol>		<ol style="list-style-type: none"> <li>3. Impermeable synthetic cover (OCF = 0.1)</li> </ol>
Run Off Storage	<ol style="list-style-type: none"> <li>1. Long-term storage, disturbed only 1-2 times per year</li> </ol>		
Outside Lots			<ol style="list-style-type: none"> <li>1. Lot could be reduced in size.</li> </ol>
Settling Basins	<ol style="list-style-type: none"> <li>1. Cleaned out frequently, about every ten days, minimizing anaerobic production of odors.</li> </ol>	<ol style="list-style-type: none"> <li>2. Plans include the planting of tree shelterbelt between the basins and the road/property line.</li> </ol>	
Bedded Barns			
Open Lot Manure Storage	<ol style="list-style-type: none"> <li>1. Storage is emptied frequently so that anaerobic activity is limited.</li> <li>2. Storage crusts (OCF = 0.5)</li> </ol>		
Agitation			
Land Application	<ol style="list-style-type: none"> <li>1. Manure is injected or incorporated whenever field conditions permit.</li> <li>2. Weekend and holiday application is avoided.</li> </ol>		
Silage & Feed Storage	<ol style="list-style-type: none"> <li>1. Silage piles are covered with plastic with clean water diverted off of the pile.</li> <li>2. Forages harvested at recommended moisture.</li> <li>3. Concrete pad is mechanically swept at least once per week.</li> </ol>		

## **Appendix C: Comprehensive Nutrient Management Plan**

A Comprehensive Nutrient Management Plan (CNMP) is the next step beyond a Manure Management System Plan (MMSP). All efforts put towards an MMSP may be utilized in the development of a CNMP as it is founded on the same eight components as the MMSP, with a few significant differences. Some of the “optional” sub-components of an MMSP are required in a CNMP. Examples include veterinary waste disposal and mortality management. In addition, the “production” component is more detailed regarding management of rainwater, plate cooler water, and milk house wastewater.

Thorough calculations are also needed to document animal manure production.

Another difference between an MMSP and a CNMP is in the “Utilization” component. With an MMSP, nutrients need to be applied at agronomic rates and according to realistic yield goals. However, with a CNMP, a more extensive analysis of field application is conducted. This analysis includes the use of the Manure Application Risk Index (MARI) to determine suitability for winter spreading, and the Revised Universal Soil Loss Equation (RUSLE) to determine potential nutrient loss from erosive forces, and other farm specific conservation practices. More detail regarding the timing and method of manure applications and long term cropping system/plans must be documented in a CNMP.

Additional information on potential adverse impacts to surface and groundwater and preventative measures to protect these resources are identified in a CNMP. Although the CNMP provides the framework for consistent documentation of a number of practices, the CNMP is a planning tool not a documentation package.

Odor management is included in both the MMSP and CNMP.

Implementation of an MMSP is ongoing. A CNMP implementation schedule typically includes long-term changes. These often include installation of new structures and/or changes in farm management practices that are usually phased in over a longer period of time. Such changes are outlined in the CNMP implementation schedule, providing a reference to the producer for planning to implement changes within their own constraints.

As is described above, a producer with a sound MMSP is well on their way to developing a CNMP. Time spent developing and using a MMSP will help position the producer to ultimately develop a CNMP on their farm, if they decide to proceed to that level or when they are required to do so.

## WHO NEEDS A CNMP?

1. Some livestock production facilities receiving technical and/or financial assistance through USDA-NRCS Farm Bill program contracts.
2. A livestock production facility that a) applies for coverage with the ~~MDEQ~~EGLE's National Pollutant Discharge Elimination System (NPDES) permit, or b) is directed by ~~EGLE~~MDEQ on a case by case basis.
3. A livestock farm that is required to have a CNMP as a result of NPDES permit coverage that desires third party verification in the MDARD's Michigan Agriculture Environmental Assurance Program (MAEAP) Livestock System verification.

For additional information regarding the permit, go to:

~~[www.michigan.gov/deg](http://www.michigan.gov/deg)~~ [www.michigan.gov/EGLE](http://www.michigan.gov/EGLE).

For additional information regarding MAEAP, go to: [www.maeap.org](http://www.maeap.org) or telephone 517-284-5609.



## **Appendix D: Manure Storage Facility Plan**

Construction plans detailing the design of manure storage components must be submitted to MDARD for review and approval. Structures must be designed and constructed in accordance with appropriate design standards (e.g. Michigan NRCS eFOTG Waste Storage Facility (No.) 313 or Midwest Plan Service MWPS-36 Concrete Manure Storages Handbook), that are current at the time of approval of this GAAMP.

Plans must include the following information:

- Design Standards utilized.
- Design storage volume as justified by nutrient utilization plan, runoff volume, precipitation volume, and freeboard.
- Size of structure, including length, width, and depth.
- Materials to be utilized for the construction of the structure, this should include specifications for concrete mixes, flexible membranes, and soil data, as appropriate.
- Subsurface Investigation information to include an adequate representation of soil borings based upon the surface area of the structure. The borings must extend to a depth of at least two feet below the bottom of the structure, and must indicate the depth to high water and any seeps encountered. The soils must be classified according to the Unified Soil Classification System (ASTM D2487 or ASTM D2488).
- For a compacted earth-lined structure permeability test or Plasticity Index (PI) and Atterberg Limits must be submitted for the soil samples.
- Isolation distance from the structure to the drinking water well and isolation reduction criteria worksheet if applicable.
- Method of solids removal to be utilized.
- Elevation of structure relative to surrounding area must be included.
- Construction requirements.
- Appropriate safety features (e.g. fencing, safety signs, ladders, or ropes).
- If a treatment system (e.g. anaerobic digester or gasification) will be utilized, all associated design plans and specifications must be submitted.
- Where substantial changes to the original plans occurred during construction, as built plans must be submitted for review.

Structures should be designed and constructed by individuals or companies qualified in the appropriate area of expertise for that work.

## **Appendix E: Michigan Commission of Agriculture and Rural Development Policy No. 12**

Policy Title: **APPEALS FROM MDARD'S SITE SUITABILITY DETERMINATIONS**

Under the Generally Accepted Agricultural and Management Practices for Site Selection and Odor Control for New and Expanding Livestock Facilities (Site Selection GAAMP), farms may request a site suitability determination from MDARD. MDARD's site suitability determinations are sent to the farmer and the local unit of government and posted on MDARD's RTF website. MDARD's site suitability determination can be appealed to MDARD's Director as provided below.

### **A. Who can request to appeal MDARD's site suitability determination**

The following people or entities can request to appeal MDARD's site suitability determination:

- The owner of the proposed livestock facility.
- A person with property within one-half mile of the site of the proposed livestock facility.
- The local unit of government in which the site for the proposed livestock facility is located.
- Local unit of government which is within one-half mile of the proposed livestock facility.

### **B. Timing of a request to appeal**

A request to appeal must be filed within 30 days from the date MDARD's site suitability determination is posted on MDARD's Right to Farm Siting website.

### **C. Contents of a request to appeal**

A request to appeal MDARD's site suitability determination is made by sending a written description of the appeal including all documentation supporting the appeal to MDARD's Director through the Commission email at [MDA-Ag-Commission@michigan.gov](mailto:MDA-Ag-Commission@michigan.gov).

The request to appeal must identify with specificity the section or requirement in the Site Selection GAAMPs that the requestor believes MDARD failed to or improperly applied when it made its site suitability determination.

The request for appeal must include relevant facts, data, analysis, and supporting documentation for the appellant's position.

A request to appeal that does not identify with specificity the manner in which MDARD failed to or improperly applied the Site Selection GAAMPs or does not provide supporting documentation will be denied. The Director will notify the Site Selection GAAMPs Chair, as well as the Commission of Agriculture and Rural Development of this decision. MDARD will send a letter to the entity who submitted the request to appeal stating the reason the request has been denied. A denial of a request to appeal is a final agency decision on MDARD's site suitability determination.

A request to appeal that meets the requirements of this section will be approved and will proceed through the appeal process outlined below. MDARD shall make all determinations regarding requests to appeal within 14 days after the close of the 30- day appeal window.

#### **D. Appeal process**

Once MDARD approves a request to appeal, the following process will be initiated:

1. MDARD will ask the Chairperson of the Site Selection GAAMPs Committee to convene a panel of recognized professionals to review MDARD's site suitability determination. The panel of recognized professionals may include, but are not limited to, personnel from the following: conservation districts, industry representatives, Michigan Department of Environment, Great Lakes, and Energy, professional consultants and contractors, professional engineers, the United States Department of Agriculture - Natural Resources Conservation Service, university agricultural engineers, and other university specialists and shall contain no less than three recognized professionals.
2. Within 28 days, the panel of recognized professionals shall review MDARD's site suitability determination and consider the information provided by the Appellant. The panel of recognized professionals shall create a written report to be considered at the Commission's next scheduled public meeting.
3. The Commission will consider the panel of recognized professionals report, oral or written comments from the appellant(s), and other public comments regarding MDARD's site suitability determination.
4. The Commission shall make a recommendation to the MDARD Director. The Commission's recommendation can take one of three forms: (i) approve MDARD's site suitability determination; (ii) reverse MDARD's site suitability determination; or (iii) send the case back to the panel of recognized professionals or MDARD staff with instructions to consider certain factors or issues that were not sufficiently considered during the panel's initial review, including a timeframe for providing the information to the Commission. In the event of a tie vote by the Commission, the matter

shall be submitted to the Director without a recommendation from the Commission.

5. The Director shall issue a written final decision regarding the site suitability determination within 14 days of the Commission's recommendation/ submission.
6. Following the Director's final decision, the farmer, appellant, and local unit of government will be sent MDARD's final decision and the final decision will be posted on the MDARD RTF Siting website.

Approved in St. Johns, Michigan

May 15, 2019

## REFERENCES

Jacobsen, Larry and Huiqing Guo. *An Odor Setback Estimator for Feedlots (OSEFF)*. BAE Department, University of Minnesota. (Minnesota Odor Estimator Model).

Jacobson, Larry; Huiqing Guo; Schmidt, David; Nicolai, Richard; Zhu, Jun; and Janni, Kevin. *Worksheet for the Odor Rating System to Estimate Setback Distances for Animal Production Sites*. Version 1.0. BAE Department. University of Minnesota. (Minnesota Odor Estimator Model).

Kiefer, M.T. 2018. Michigan Revised OFFSET 2018 User's Guide: Fundamental Principles, Development History, and User Manual.

*The Michigan Natural Resources and Environmental Protection Act*, PA 451 of 1994, as amended.

MCARD. 2016. Right to Farm. *Generally Accepted Agricultural and Management Practices for Manure Management and Utilization*. Michigan Commission of Agriculture & Rural Development.

*Michigan Right to Farm Act*, PA 93 of 1981, as amended.

*National Pork Producers Council On-Farm Odor Assessment Program*.

United States Department of Agriculture, Natural Resources Conservation Service, *Field Office Technical Guide*.

United States Department of Agriculture, Natural Resources Conservation Service, *Agricultural Waste Management Field Handbook*.

## ADVISORY COMMITTEE

Listed below are the advisory committee members for the Generally Accepted Agricultural and Management Practices for Site Selection and Odor Control for New and Expanding Livestock Facilities.

Dale Rozeboom, Chair  
Department of Animal  
Science

474 S. Shaw Lane  
2209 Anthony Hall  
Michigan State  
University East  
Lansing, MI 48824  
517-355-8398  
[rozeboom@msu.edu](mailto:rozeboom@msu.edu)

Doug Chapin  
Michigan Milk Producers  
Assn.  
5619 60th Ave.  
Remus, MI 49340  
231-349-4059  
[dchapin@mimilk.com](mailto:dchapin@mimilk.com)

Erica Rogers  
Michigan State University  
Extension  
219 N State St.  
Alma, MI 48801  
[roger392@anr.msu.edu](mailto:roger392@anr.msu.edu)

Greg Alexander  
Sanilac County Drain  
Office  
60 W. Sanilac Ave.,  
Room 201 Sandusky, MI  
48471 810-404-8506  
810- 648-5460 – FAX  
[draincommr@sanilaccounty.net](mailto:draincommr@sanilaccounty.net)

Jeff Andresen  
Department of  
Geography, Environment  
and Spatial Sciences  
Room 236 Geography  
Bldg. 673 Auditorium Rd.  
Michigan State University  
East Lansing, MI 48824  
517-432-4756  
[andresen@msu.edu](mailto:andresen@msu.edu)

Laura Doud  
Michigan Dept. of  
Agriculture and Rural  
Development  
P. O. Box 30017  
Lansing, MI 48909  
517-284- 5626  
517-335-3329 –FAX  
[doudl@michigan.gov](mailto:doudl@michigan.gov)

Mary Kelpinski  
Michigan Pork Producers  
Assn. 3515 West Rd.,  
Suite B  
East Lansing, MI 48823  
517-853-3782  
[kelpinski@mipork.org](mailto:kelpinski@mipork.org)

Matthew Kapp  
Michigan Farm Bureau  
P. O. Box 30960  
Lansing, MI 48909  
517- 679-5338\_  
[mkapp@michfb.com](mailto:mkapp@michfb.com)

Steve Mahoney  
Michigan Dept. of  
Agriculture and Rural  
Development  
P. O. Box 30017  
Lansing, MI 48909  
517- 284- 5620  
517- 335-3329 - FAX  
[mahoneys@michigan.gov](mailto:mahoneys@michigan.gov)

Gerald May  
4361 SW County Line  
Rd. St. Louis, MI 48880  
989-506-0373  
[mayg@msu.edu](mailto:mayg@msu.edu)

Catherine Mullhaupt  
Michigan Townships Assn.  
512 Westshire Dr.  
Lansing, MI 48917  
517-321-6467  
517- 321-8908 – FAX  
[catherine@michigantownships.org](mailto:catherine@michigantownships.org)

Cody Yazzie  
Michigan Dept. of  
Environment, Great Lakes,  
and Energy  
Air Quality Division  
7953 Adobe Rd.  
Kalamazoo, MI 49009  
269-567-3554  
[YazzieC@michigan.gov](mailto:YazzieC@michigan.gov)

Suzanne Reamer  
MI- NRCS  
3001 Coolidge Rd.  
Suite 250  
East Lansing, MI 48823-  
6321 517-290-6145  
[Suzanne.reamer@mi.usda.gov](mailto:Suzanne.reamer@mi.usda.gov)

Bruce Washburn Michigan  
Dept. of Environment, Great  
Lakes, and Energy Water  
Resources Division  
7953 Adobe Rd.  
Kalamazoo, MI 49009  
269- 330-6079  
269-567-9440 – FAX  
[washburnb2@michigan.gov](mailto:washburnb2@michigan.gov)

Tom Zimnicki  
Michigan Environmental  
Council  
602 West Ionia St.  
Lansing, MI 48933  
517-487-9539  
517-487-9541 - FAX  
[tom@environmentalcouncil.org](mailto:tom@environmentalcouncil.org)

Wayne Whitman  
Independent  
Consultant Holt, MI  
48842  
517-282-1104  
whitmanww13@gmail.co  
m