Transfer of Agricultural Technology Generated through the Canada-Ontario Green Plan

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David Morris

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List of Acronyms

Agency or Organization

AAFC	Agriculture and Agri-Food Canada
CA	Conservation Authority
CARC	Canadian Agri-food Research Council
CWS	Canadian Wildlife Service, Environment Canada
EC	Environment Canada
FON	Federation of Ontario Naturalists
IFAO	Innovative Farmers Association of Ontario
MISB	Marketing and Industry Services Branch, AAFC
OFA	Ontario Federation of Agriculture
OASCC	Ontario Agricultural Services Co-ordinating Committee
OMAF	Ontario Ministry of Agriculture and Food [now OMAFRA]
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
OMEE	Ontario Ministry of Environment and Energy
OMNR	Ontario Ministry of Natural Resources
OSCIA	Ontario Soil and Crop Improvement Association
UTRCA	Upper Thames River Conservation Authority

Program-related

COESA	Canada-Ontario Environmental Sustainability Agreement
CURB	Clean Up Rural Beaches (Program)
AMC	Agreement Management Committee
BMP	Best Management Practices (Program)
EFP	Environmental Farm Plans (Program)
ESI	Environmental Sustainability Initiative
ICAR	Inventory of Canadian Agri-food Research
GLWQP	Great Lakes Water Quality Program
LMAP	Land Management Assistance Program
LSP	Land Stewardship Program
NSCP	National Soil Conservation Program
RAP	Remedial Action Plan
RFP	Request for Proposal
RCC	Rural Conservation Clubs Program
SIB	Stewardship Information Bureau (Info Bureau), University of Guelph
TT	Technology Transfer
SWEEP	Soil and Water Environmental Enhancement Program
3W	Woodlands, Wetlands & Wildlife Program (also abbreviated as WWW)

Executive Summary

The overall objectives of the Canada-Ontario Green Plan for agriculture are directed towards achieving sustainable agri-food systems. Green Plan supported many research and demonstration projects to address a range of environmental concerns, for which suitable technology or information was lacking. However, the process integrating the information developed within these projects with the existing body of knowledge, and transferring the recommendations to farmers was never clearly defined.

One of the objectives of the Technology Transfer Committee, of the Canada-Ontario Agriculture Green Plan, is recommend, to the Green Plan Accord Committee, means to ensure the effective and efficient transfer Green Plan results to Ontario farmers. The project described in this report, was initiated, by the Technology Transfer Committee, to provide the committee with information needed to develop such recommendations. Because of the complexity of manure management systems and their effects on the environment, the Technology Transfer Committee selected the transfer of technology related to manure management as the area to be examined in this study. Although the examples in the report relate to manure management technologies, most of the comments and concepts presented here can be applied equally well to other agriculture/environmental concerns.

Specific tasks conducted as part of this project included:

- identification of barriers to implementation of environmentally sustainable technologies.
- compilation of identified needs for additional information or technology transfer.
- indication of the extent to which Green Plan research or demonstration projects are expected to enhance the knowledge base or the technology transfer process.
- assessment of the extension resource materials available.
- a review of the system in Ontario for transferring technology related to manure management.

Barriers to Implementation of Environmentally Sustainable Technologies

A lack of information has limited development or implementation of environmentally sustainable technologies to address a number of manure management issues. On many farms, there also are significant financial and operational barriers to changing manure management practices, unrelated to the availability of information. Environmentally sustainable practices will not be employed if they are not affordable, or if they conflict with activities that are more important and more profitable at the time.

Identification of Information Needs

In recent years, a number of activities, coordinated through Green Plan, OASCC or OMAFRA, were undertaken to identify research and information needs related to manure management in Ontario. Together, these activities resulted a comprehensive list of issues for which additional information was required. The process might, however, have benefited from more coordination among the groups involved to reduce duplication of effort.

In Ontario, research is increasingly being conducted, on contract, by institutions or organizations not represented in the OASCC committee structure. A standard process by which OASCC committees and sub-committees can offer input into or obtain information from such projects should be established. Similarly, it will be important to develop effective means of gathering and transferring non-proprietary information generated on farms and by agri-businesses.

Research and Demonstration Programs
Most of the issues that were rated as being of high priority are being addressed to some degree, within Canada , if not, Ontario. Thirty-one research or demonstration projects, conducted under the Canada-Ontario Green Plan and similar programs since 1987, addressed aspects of manure management. In addition, the national Green Plan has supported many projects on manure management in other provinces. Still other sources have provided funding for a number of projects, that address issues not fully covered within the Ontario Green Plan.

There continues to be a lack of information related to the cost and benefits of technologies for reducing the environmental impact of manure. The environmental costs of livestock manures are even less well documented. Despite the difficulties inherent in obtaining economic information related to manure management, this should continue to be a priority area for research and technology transfer activities.

Extension Resources
Information related to livestock manures is available to farmers through a number of sources, within both the private and public sectors in Ontario, supported by an extensive array of resource materials. Few of the available resources provide the type of information or the level of detail required to compare options, to design and manage an integrated, sustainable system, or to implement the technology described. To obtain this level of guidance, therefore, farmers have little choice but to contact directly people with expertise in the subject.

In Ontario, a number of groups, including OASCC committees and the OMAFRA Publications Committee, are involved in the development and publication of materials for farmers. The respective responsibilities of these groups, in relation to initiation and production of extension resources, need to be clearly defined to improve coordination and to reduce duplication of effort. Lines of accountability for implementing committee recommendations related to technology transfer also need to be clarified.

Technology Transfer in Ontario
Farm management is an exercise in compromise since it is a process of harmonizing multiple goals that are sometimes in conflict (e.g. agricultural, financial, environmental and social). Each farm situation is unique and development of appropriate solutions for its technical problems requires a set of information unique to that farm. For an information source to become the one of choice, clients must perceive the information it contains to be current, relevant, specific, reliable, credible, comprehensive and at the appropriate level of detail. The information delivery system itself must be seen to be readily accessible, easy to use, useful, interactive and sufficiently flexible as to allow the clients' needs and priorities to be reflected in the recommended solutions.

A system for transferring agricultural technology is well established in Ontario and has generally served the agricultural industry well. Traditionally, the transfer of information has relied heavily on personal contact between advisors and farmers. To date, most of the transfer of sustainable technology for manure management has been facilitated by advisors in the public sector. In the future, technology transfer will likely make more use of electronic channels of communications, with a concurrent reduction in the level of personal advisory services available directly to individual farmers, from at least some sectors of the system. (It should not be assumed that the private sector will automatically assume more of this role, especially for information or technology that has not been commercialized.)

Despite the rapid advances in communications technology, however, the need to deliver information to some clients through traditional channels, including personal contact with advisors, will not disappear for some time. Provision must be made to ensure that such advisors are adequately trained and supported with up-to-date, readily useable information packages.

As the role played by computer-based information systems in technology transfer increases, it will be essential that sufficient resources, especially human, be provided to maintain the reliability of the information system itself, and the currency of the information contained within it. Maintenance of the system must include continual revision of the information base and extension resource materials, in light of recent research and on-farm experience, within Ontario and elsewhere. Currently, this task is hampered because research information is dispersed among a number of databases. Higher priority should be given to the establishment and maintenance of a truly comprehensive database for Ontario research.

Conclusions

Much useful information, about a wide range of important topics has been generated within the Research Program and the Rural Conservation Clubs Program of Green Plan, and much valuable experience in addressing other environmental concerns has been gained through the Woodlands, Wetlands and Wildlife Program. However, the activities planned within each of these programs to distribute project results may not be sufficient to ensure effective and efficient transfer of Green Plan results to farmers across Ontario.

A specific project should be undertaken to summarize and integrate information from related projects into recommendations for sustainable agricultural practices, and subsequently into extension resource materials. Sub-projects would be needed to address each major issue area addressed by Green Plan research and demonstration projects. Given the limited staff resources within both senior levels of government, it is likely that the tasks of preparing summary documents would need to be contracted to private sector firms or individuals, working under the guidance and supervision of task teams, comparable to those used to develop the BMP booklets.

Chapter 1: Introduction

Canada-Ontario Agricultural Green Plan Priorities

Canada's Green Plan lists three objectives vital to achieving sustainable agri-food systems:

- to conserve and enhance the natural resources that agriculture uses and shares.
- to be compatible with other environmental resources that are affected by agriculture.
- to be proactive in protecting the agri-food sector from the environmental impacts caused by other sectors and factors, external to agriculture.

The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) has similarly identified the parallel goals of achieving environmental sustainability while maintaining an economically competitive agricultural industry.

The authors of the report, *Phase I Evaluation of the Canada-Ontario Agreement on the Agricultural Component of the Green Plan: Evaluation Assessment*, (Deloitte and Touche Management Consultants and Apogee Research International) state:

> *"The (Treasury Board) approval (for the Green Plan) also specifies that Green Plan effectiveness is to be judged on:*
>
> - *the contribution to the intended reduction in severity of environmental problems;*
> - *the related impact on the agricultural productivity and economic viability of the natural resource base for agriculture, and:*
> - *the contribution to increased knowledge on the parts of all partners in the sector about environmental sustainability and solutions to current problems"* (page 32)
>
> *"The ultimate Green Plan goal, stated clearly in the Treasury Board evaluation requirements, is to improve environmental conditions and the viability of the agricultural resource base. These improvements will occur only if farmers change their current practices and adopt the more environmentally sustainable ones being encouraged by the Green Plan activities."* (page 33)

Concerns Related to Technology Transfer within Green Plan

The process by which information[1] developed within the Agricultural Green Plan is to be integrated with existing recommendations and transferred to farmers was never clearly defined when the first Green Plan programs were initiated. The Technology Transfer Committee[2] of the Canada-Ontario Agriculture Green Plan was formed "*to work, in cooperation with the existing systems for technology*

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[1] For convenience, I have used "technology" and "information" more or less interchangeably throughout this document :

I have also used the following definitions:

client - anyone seeking to obtain information, including farmers, advisors, extension specialists, researchers and members of the general public.

advisor - person, in either the public or private sectors, who provides services or advice directly to farmers.

channel - a method of distributing information, e.g. booklets, newsletters, factsheets, radio or T.V. broadcast, workshops, personal contact, Internet, CD-ROM, etc.

[2] Information describing the terms of reference, composition and activities of the Technology Transfer Committee is available via Internet from the Canada-Ontario Agricultural Green Page Home Page (URL: http://res.agr.ca/lond/gp/gphompag.html)

transfer in Ontario, for the benefit of the agriculture and food industry in Ontario, by ensuring that information related to sustainable technology for agriculture, generated by Green Plan-funded research and demonstration projects, and related programs, is effectively and efficiently transferred to Ontario farmers and to the wider community" (from the committee's Terms of Reference. The Technology Transfer Committee did not assume responsibility for transferring the results of Green Plan projects to the farmers of Ontario. Rather, the committee has worked to ensure that the information is positioned such that it can be readily transferred to farmers by the established technology transfer agents in the province. Towards this end, one objectives of the committee is "*to demonstrate, evaluate and recommend, to the Accord Committee of the Canada-Ontario Environmental Sustainability Accord, the most appropriate processes for ensuring the effective and efficient transfer of information related to sustainable technology to the Ontario agricultural sector*".

A 1995 report, prepared for the Technology Transfer Committee of the Canada-Ontario Agriculture Green Plan, entitled *An Approach to Technology Transfer within the Canada-Ontario Green Plan*, contained several recommendations to be considered in developing and implementing such a process (See Appendix A), but did not present specific examples. Because of the complexity of manure management systems and their effects on the environment, the Technology Transfer Committee selected the area of Manure Management as a pilot project to elaborate on the concepts outlined in *An Approach to Technology Transfer within the Canada-Ontario Green Plan*.

Although the examples in the report that follows relate to manure management technologies, the relevance of the observations and suggestions is not limited specifically to manure management issues alone. Most of the comments and concepts presented here can be applied equally well to other agriculture/environmental concerns.

Barriers to Implementation of Sustainable Manure Management Practices

At the outset, it must be recognized that in virtually all reports and surveys dealing with farmers' needs and attitudes, farmers identified financial concerns as the main barrier to their implementation of more sustainable manure management systems. For many farmers, the cost of some technologies, especially those for manure storage, are prohibitively high. Even the best technology transfer program will not precipitate change if farmers cannot afford to implement the required technology.

On many farms, operational barriers to changing manure management practices also exist. For example, the optimum time to spread manure, from both agronomic and environmental points of view, is in the spring. However, spring is also the period during which the workload on many farms is at a peak. Manure spreading competes with many other tasks that must be performed, the timing of which is more crucial to the profitability of the enterprise, than it is for manure application. Even the most sustainable and profitable practices will not be employed if they conflict with other activities that are more important and more profitable at the time.

The Challenge of Technology Transfer for Manure Management

In general, a technology transfer system must be able to provide farmers and their advisors with sufficient information to enable them to:

- recognize if their farming practices are causing damage to the environment,
- evaluate the available options,
- select those that are appropriate for the particular situation, and

- implement them as part of a sustainable farming system.

At the same time, the system must be able to keep researchers informed of emerging issues for which additional information is needed. Technology transfer agents must be aware of the need for any additional technology transfer activities.

Ensuring that farmers obtain the information they require on manure management is an especially complex task. To plan a manure management system, a farmer must design a total management system that also considers nutrients, water and air quality (Figure 1). At each stage of a manure management system, the farm manager must evaluate a number of options and has to consider many factors in choosing among them. A farmer may also have to decide how to harmonize apparently conflicting objectives for environmental protection, as practices adopted to reduce the effect on one aspect of the environment may adversely affect another (Table 1). In the past, farmers wishing to implement sustainable manure management practices have been hampered by a lack of information on certain key questions and by a lack of planning aids, to assist them in evaluating their options and in integrating them into an optimum system.

Objective of this Report

The objective of this report is to outline an integrated system for transferring technology related to manure management, through performance of the following tasks:

1) identification of issues related to manure or manure management for which farmers, and others involved in designing manure management systems, might require information.
2) assessment of the extension resources currently available, with reference to the issues addressed and the level of information presented.
3) determination of the resources currently available to assist farmers in evaluating management options and integrating them into an optimum system, and the degree to which farmers are dependent upon "experts" for interpretation of the information.
4) identification of gaps in the current information and other barriers to the transfer of the required information or to the implementation of sustainable technologies.
5) indication of how the results of current Green Plan research projects are expected to enhance the knowledge base or delivery system.
6) description of the process by which new information is integrated with existing recommendations, new recommendations are formulated, and the revised recommendations are communicated to those who require them.
7) recommendation of actions to enhance the technology transfer system in Ontario so that the information generated within Green Plan and related programs is transferred effectively and efficiently to Ontario farmers.

Figure 1: **Potential Pathways for the Movement of Manure or its Constituents on Farms and Other Factors Influencing Manure Management on the Farm.**

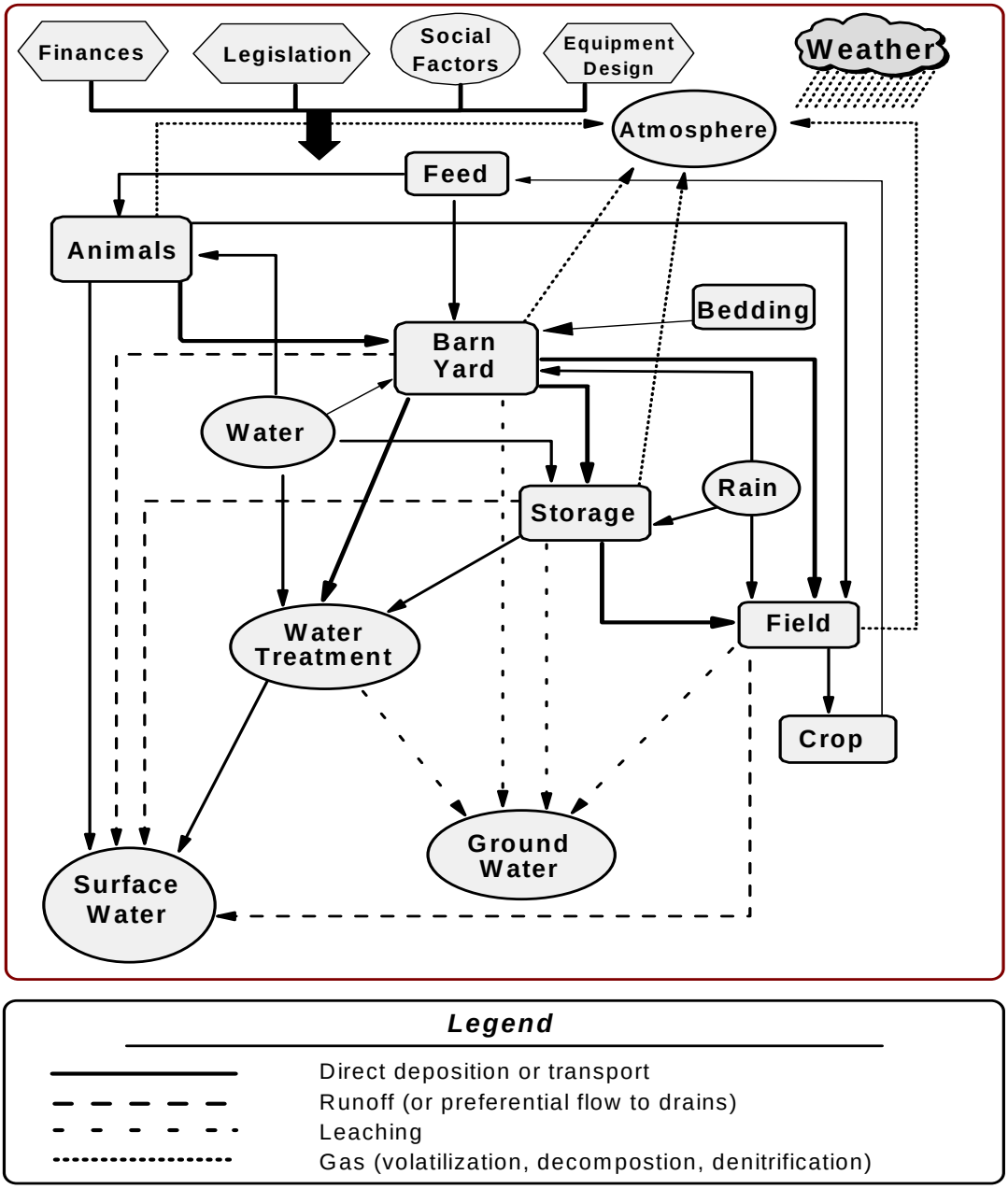

Table 1a: Possible Environmental Effects of Current Best Management Practices for Manure

Concern BMP	Nutrient Runoff *	Preferential Flow *	Nutrient Leaching *	NH_3 Volatilization *	Denitrification *	Nitrogen Immobilization *	Efficiency of N use *	Soil Compaction *	Complicating Factors
Add bedding	B *	B	B *	N *	N *	N *	 *		Cost & availability. Nutrient content can be more variable. Can affect spreading characteristics. Increased immobilization and denitrification, if high C/N.*
Compost manure	B *	B	B *	 *	N	N *	 *	B	Cost. Labour. Not suitable for all types of manure.* N in stable compost slow to mineralize.
Supply 75% of N from manure (rather than all)		B	B	B	B		B		Could require additional land. Determining nitrogen supply in soil.* Determining N supply in manure.*
Spread evenly	B *	B *	B		B		B		Variable manure composition, especially from uneven mixing. Limitations of sp reading equipment.* Effect of wind on manure distribution.*
Spread when soil is dry	B *	B *	B		B		B	B	Weather; wet soil. Timing conflicts with other field work. Can require increased storage capacity.
Improve drainage	B		N?		B		B	B	Cost. Soil Texture.
Spread on bare, unfrozen soil	B						B	N	Will require increased storage capacity. Adds to work scheduling conflicts.
Match time with crop demand *	 *	 *	B *		B *	 *	B *	N	Timing conflicts with other field work. Soil may not be dry enough in early spring. Can require increased storage capacity.

Explanation of ratings for possible environmental:

(B) Beneficial - likely to reduce environmental impact
(N) Negative - likely to worsen environmental impact
Blank cell - effect unclear or variable

* Information available or expected from Green Plan projects.

Table 1 cont'd: Possible Environmental Effects of Current Best Management Practices for Manure

Concern / BMP	Nutrient Runoff *	Preferential Flow *	Nutrient Leaching *	NH_3 Volatilization *	Denitrification *	Nitrogen Immobilization *	Efficiency of N use *	Soil Compaction *	Complicating Factors
Till soil before applying liquid manure	B *	B *					B *	N	Adds to work scheduling conflicts. Might not be compatible with no-till .* Risk of recompaction of topsoil.
Incorporate within 24 hours	B *	B *		B			B		Adds to work scheduling conflicts. Not compatible with no-till systems.*
Inject liquid manure	B *	B *	*	B	N *		B *		Cost. Can leave soil very rough.* Possible denitrification in manure band.
Irrigation of liquid manure	*	*		N			N	B	Increases odours & losses from ammonia volatilization.* Tendency to overapply.
Mulch Tillage	B *	B *	*	*		*	B *		
No Till	N *	N *	*	N *	N	*	*	*	Difficult to incorporate manure into soil.* Soil moisture contents tend to be higher.
Use cover crops			B *		B	B	B *		Questionable effectiveness.* Time of N release may not match crop needs.* Not compatible with some crop rotations. Limited usefulness with fall tillage.*
In emergencies, spread on hay/ grass in summer	N			N	?			B	Risk of runoff. High loss of nitrogen from volatilization. Can overstimulate grasses in mixtures.

Explanation of ratings for possible environmental:

(B) Beneficial - likely to reduce environmental impact
(N) Negative - likely to worsen environmental impact
Blank cell - effect unclear or variable

* Information available or expected from Green Plan projects.

Chapter 2: Identification of Information Needs for Manure Management

In elaborating on the priorities set by Agriculture and Agri-Food Canada (AAFC) for Green Plan funding, many groups have identified "manure management" as a specific area in which additional effort was required, either to acquire new information on methods for reducing the impact of manure on the environment or to transfer new or existing technology to livestock producers. These included:

A: Green Plan Agricultural Stakeholders Forum (Kempenfelt)
B: Current State of the Art on Manure/Nutrient Management (by Goss et al)
C: Best Management Practices Study (conducted by Decima Research)
D: Ontario Agricultural Services Coordinating Committee
E: Ontario Ministry of Agriculture, Food and Rural Affairs

Each of these groups developed a list of priorities for additional research or technology transfer activities. The respective lists have been compiled into a single list in this report. This would have been redundant, since the list of concerns identified in the report, *Current State of the Art on Manure/Nutrient Management (*Goss et al, 1994), is very comprehensive and includes all of the topics identified by the others (Table 2).

A: Green Plan Agricultural Stakeholders Forum

Recommendations 1 and 2 from the Stakeholders Forum addressed the issue of minimizing the impact of livestock manures on air and water quality, while improving the economic efficiency of farming operations, through more efficient use of manure nutrients.

1: *Develop alternative manure management systems appropriate for different soil and livestock management combinations.*

2: *Improve utilization of nutrients by expanded use of soil and manure analyses.*

B: Current State of the Art on Manure/Nutrient Management

In their report, *Current State of the Art on Manure/Nutrient Management,* Goss et al, (1994), describe the major gaps in the information base and in technology transfer activities for manure management. Table 2 lists areas identified in that report as being those for which additional information is required regarding the influence of manure management and environmental conditions on either the utilization of nutrients from manure by crops, or on the effect of manure on the environment, or both.

In preparing their report, Goss et al consulted with The Expert Evaluation Panel for Manure Management, a multi-disciplinary group with producer, government, university and industry representatives. This panel identified and ranked twelve priority areas for research and extension, related to manure management, for the rest of the 1990's. Their recommendations are listed in Table 3 in order of priority.

Table 2: Topics related to manure management for which additional information is required (as identified by Goss et al)

Water Quality

Contamination of surface water by nutrients, pathogens or solids from manure through:

- runoff from barnyards, feedlots or manure storages, including control and treatment*
- leakage or spills, especially from manure storages;
- runoff from fields after manure application*: effects of manure type and composition, time and method of application, tillage system, soil conditions, weather and soil nutrient levels.
- preferential flow to tile drains*: effects of manure type and composition, time and method of application, tillage system, soil conditions and weather.

Contamination of groundwater by nutrients, pathogens or solids from manure through:

- leakage from manure storages;
- leaching from fields after manure application*: effects of manure type and composition, time and method of application, soil conditions, weather and elevated soil nutrient levels.
- preferential flow to ground water*: effects of manure type and composition, time and method of application, tillage system, soil conditions and weather.

Nutrient management

- effects on manure nutrient content of livestock species, ration and feeding regime.*
- carbon & nitrogen transformations in storage*: effects on manure nutrient content of type and design of storage structures, handling and processing, moisture content and weather.
- carbon & nitrogen transformations in soil*: effects on utilization of manure nutrients by crops (and conversely on nutrient losses) of manure type and composition, time or method of application, tillage systems, soil conditions (texture, structure, pH, crop residues, moisture content) and weather.

Air Quality

Generation of odours and toxic gases in barns and storages

- effects of livestock species, barn design, livestock ration, feed conversion, type and design of storage structures, manure pH and weather.

Release of odours and toxic gases by spreading

- effects of manure type and composition, time and method of application, tillage systems, soil conditions and weather.

Generation of greenhouse gases in barns, storages or processing*

- effects of livestock species, livestock ration, feed conversion, barn design, type or design of storage structures, manure pH, moisture content, composting, and weather.

Generation of greenhouse gases after application*

- effects of manure type and composition, time and method of application, tillage systems, soil conditions and weather.

Deterioration of structures by corrosive gases released from manure

- factors affecting the generation of corrosive gases in manure storages.

Soil

- effects of manure application on crops, soil biota, soil structure, soil compaction, pH, weed populations and plant pathogens*.

Tillage

- practices to minimize environmental effects of manure use in conservation tillage systems*.

Economics

- relative costs and benefits of all manure management practices.*
- environmental costs of manure management practices.*

* signifies an area addressed by Green Plan research, demonstration or technology transfer activities

Table 3: Priorities for research and extension in manure management determined by the Expert Evaluation Panel for Manure Management

1: Develop extension packages to assist farmers in making more effective use of nutrients in manure.*

2: Establish a research programme involving engineers, animal scientists, agronomists, soil scientists and economists, to develop a comprehensive framework by which alternative manure management systems can be compared.

3: Establish the relationship between environmentally safe and the most profitable rates of manure application to cropland, taking account of the method and timing of applications*. Develop more acceptable manure application methods in conservation tillage systems*.

4: Develop the means of predicting the composition of the major types of poultry, pig and cattle manures, based on feeding regimes.

5: Improve nitrogen application recommendations for different crops, based on a soil N test, taking into consideration losses on NH_3 with different times and methods of application*.

6: Develop practical, cost-effective methods for managing manure odours from farm systems. This should include seeking means by which the hazard to human or animal health from toxic gases, such as H_2S, can be relieved in different manure systems, and developing better engineered and economic manure management systems, that minimize gaseous losses from manure.

7: Investigate the transformations of manure N following addition to soil to provide more accurate estimates of denitrification, mineralization and immobilization*.

8: Investigate and develop the ability to predict the transformations of manure N during storage and/or composting to characterize the impact on availability of N to crops, the potential for nitrate leaching and gaseous losses of NH_3, NO_x, CO_2 and CH_4*.

9: Examine the potential for reducing the nutrient content of manures by using improved feeding programmes, including use of feed additives.

10: Assess on-farm economics of different manure management systems in direct association with research on storage, application and utilization of manure.

11: Assess off-farm costs due to environmental impacts, but not solely with respect to manure management. Information on environmental degradation associated with alternative manure management systems must be quantified to allow the costs to be determined.

12: Develop the means by which the deterioration of livestock facility structures by gases produced from manure can be minimized.

* signifies an area addressed by Green Plan research, demonstration or technology transfer activities

Goss et al also conducted three workshops across the province, in March 1993, with representation from a broad cross-section of the agricultural industry. Participants in these workshops were asked to identify the main information needs for farmers and society to address manure issues. The main issues identified in this way are listed below. (It was also noted that although much useful information was available, it was not reaching those who needed it most.)

- application rates and timing.
- the nutrient content of manure (including manure testing) and its value to crops.
- the economic benefits and environmental costs of manure.
- the relative merits of different manure handling and storage systems.
- methods and equipment to apply manure properly and uniformly.
- alternate uses for manure.

C: Best Management Practices Study

On behalf of the Ontario Federation of Agriculture, Decima Research conducted a survey of Ontario farmers, in 1995, regarding their understanding and attitudes towards environmentally sound farming techniques, with specific objectives to:

- *identify the most important environmental concerns facing farmers today.*
- *determine the awareness and usage levels of various techniques that minimize these concerns.*
- *identify the most useful media outlets for disseminating information about environmentally friendly farm practices.*
- *determine the awareness among Ontario farmers of individual Best Management Handbooks.*
- *identify usefulness, ease of reading, helpfulness and credibility of the Best Management Handbooks.*
- *determine the willingness of Ontario farmers to pay for Best Management Handbooks.*

When asked to name the "most important problem in running your farm operation", approximately 60% of the farmers surveyed identified issues related to profitability or costs - only 1.3% named environmental issues. However, 91% did rate environmental issues as being either Very Important or Somewhat Important to them.

The ten issues identified most frequently by respondents, as their first and second most important environmental concern, are listed in Table 4. Depending on the issue, 40 to 50% of the respondents also indicated that they needed more information on at least one of these topics. Issues related to manure storage and use ranked high on their list of concerns.

Table 4: Important environmental concerns identified by farmers in the Decima BMP Study

Concern	Percentage of Respondents
Soil Management	24
Water Wells	20
Manure Storage and Odours	19
Manure Use/Management	17
Pest Control	17
Energy Efficiency	16
Pesticide Storage and Handling	12
Nutrient Management	11
Streams/Ditches and Floodplains	9
Livestock Yards	6

As part of this study, livestock producers were also asked to describe, in their own words, issues related to manure storage and manure use/management for which they required additional information (Table 5). The cost of manure storage and allocation was the predominant concern - several respondents commented that they knew what was needed to lessen the effects of manure on the environment, but were unable to do so because of the costs involved. Many also sought information to assist them in determining the appropriate rate at which to apply manure to cropland.

Four focus group discussions were conducted as part of the BMP study. Most participants in these groups said they would pay for information that was specific and detailed enough to allow them to determine if a practice was feasible for their operation. They also identified the following information requirements:

- information on new technologies, specific to their farm, in sufficient detail to allow them to determine the feasibility of implementing the practices on their farm.
- help in determining costs and financial benefits of implementing specific techniques.
- opportunities to visit farms where techniques were being used successfully.
- seminars specific to their enterprises.
- seminars led by BMP authors, with opportunity to ask questions specific to their operations.
- an index linking issues, techniques and sources of information.

Table 5: Manure management information needs identified in the Decima BMP Study

A: Information needs about manure storage

Area of Interest	Number of Respondents
Reducing costs; sources of financing	23
All aspects, especially new technology	10
Selection, construction, management	6
Regulations (present and future)	5
Manure application and use	3
Environmental impact	3
None	54

B: Information needs about manure use/management

Area of Interest	Number of Respondents
Uses of manure and application rates	10
Reducing costs; sources of financing	7
Regulations (present and future)	7
Environmental impact	5
Manure storage	5
Runoff control	3
General/New technology	3
None	44

D: Ontario Agricultural Services Coordinating Committee

Within Ontario, responsibility for coordination of agricultural research and services is assigned to the Ontario Agricultural Services Coordinating Committee (OASCC) (Fraser, 1994). The eight committees that report to OASCC and their sub-committees (Appendix B) have the responsibility to identify issues for which additional research is required. Several of these committees have identified the need for a number of research or service programs related to manure management. The issues identified in these recommendations are listed below. (Recommendations made between 1993 and 1995 are listed in Appendix C.)

- systems to minimize nitrogen contamination of surface and groundwater.
- affordable solutions to environmental issues related to beef production.
- improving the availability of nutrients in livestock feeds.
- reducing the impact of swine production on the environment.
- investigating the ability of manure application equipment to apply manure uniformly.
- reducing, detecting and dealing with hazardous gases.
- reducing odours.
- nutrient management extension programs.
- effect of livestock housing alternatives on the environment.
- effect of manure handling methods on the environment.
- non-conventional methods of treating contaminated water.

- manure application methods suitable for conservation tillage systems.
- long-term effectiveness of earthen storage structures for liquid manures.
- protecting steel and concrete from corrosive gases.

E: Ontario Ministry of Agriculture, Food and Rural Affairs

Two "Areas of Focus" established by OMAFRA, as part of its planning process, were "Environmental Sustainability" and "Competitive Agriculture". Within these areas, OMAFRA staff have identified "Areas of Concerns" and developed goals, objectives and activities required to reach OMAFRA's goals achieving environmental sustainability while enhancing the competitive position of Ontario agriculture. "Areas of Concern" related directly to manure management are listed below. (Excerpts from these "Areas of Concern" are presented in Appendix D.)

Environmental Sustainability:	Competitive Agriculture:
Environmental Farm Planning	Nutrient Management
Environmental Engineering	Soil Management
Groundwater Management	Livestock Production Management
	Feeding Organic Wastes to Livestock
	Livestock and Poultry Housing
	Resources Management Engineering
	Agricultural Health and Safety

OMAFRA manure specialists (Don Hillborn and Chris Brown, personal communication) indicate that most producers who contact them for assistance are seeking specific information on one or more the following topics:

- sizing of manure storages.
- integrating new buildings or new technology with existing system.
- operation of new facilities or equipment.
- application rates and nutrient management.
- selling manure.
- reducing odours.
- groundwater protection.

Chapter 3: Green Plan Research and Demonstration Programs in Ontario

Over the past decade, AAFC and OMAFRA have sponsored several programs related to Green Plan to further the goal of achieving sustainable agri-food systems (Table 6). Funding was provided for projects covering a wide range of activities intended either to generate new information, or to transfer existing information to the agricultural community, or both. These have included: literature reviews, surveys of farmers' attitudes or farming practices, scientific studies, computer software development and on-farm demonstrations. (Abstracts of 187 individual projects, that generated information related to environmental issues are contained in the 1995 report *An Approach to Technology Transfer within the Canada-Ontario Green Plan*.) Two sub-programs of Green Plan have generated information related to manure management, the Research Sub-program and the Rural Conservation Clubs program, respectively.

Table 6: Government programs to promote sustainable agri-food systems (1987-1995)

Program Title	Dates	Abbrev.
Soil and Water Environmental Enhancement Program	(1985-1992)	(SWEEP)
Ontario Land Stewardship Program	(1987-1990)	(LS)
Soil Quality Evaluation Program	(1989-1994)	(SQEP)
National Soil Conservation Program	(1989-1993)	(NSCP)
Great Lakes Water Quality Program	(1989-1994)	(GLWQP)
Ontario Land Stewardship II Program	(1990-1993)	(LSII)
Environmental Sustainability Initiative	(1992-)	(ESI)
Land Management Assistance Program	(1992-1994)	(LMAP)
Green Plan	(1993-1997)	

Green Plan Research Projects Related to Manure Management

The Agreements Management Committee of Green Plan determined that in evaluating research proposals for funding, projects related to manure management or to its effect on the environmental would be assessed by the degree to which they could lead to achievement of the following objectives:

- Improved utilization of nutrients by expanded use of soil/manure analysis to determine the proper rate of application to land base.
- Reduced rate of delivery of bacteria and nitrates to streams and groundwater.
- Investigation of manure management systems options and their impact on various soils/tillage systems and water quality.

Thirty-two research or demonstration projects, that were conducted under the Canada-Ontario Green Plan[3] and related programs since 1987, addressed aspects of manure management (Table 7). Green Plan research and demonstration projects addressed many of the key issues identified through the various processes described in Chapter 2. In Table 8, these projects are categorized, based on the manure management concerns which they address most directly. (Note that some projects appear in more than one category in Table 8.)

Other Research Related to Manure Management

In addition to the projects listed in Table 7, the national Green Plan has supported a number of research or demonstration projects on manure management in other provinces. These are listed in Appendix F.

One project related to manure was conducted under The Technology Evaluation and Development component of the Soil and Water Environmental Enhancement Program:
Samson, R., A. Weill, A. Arkinstall and J. Quinn. 1992. *Manure Management in Conservation Farming.* SWEEP Report # 58

Numerous projects have been undertaken with funding from other sources. A keyword search of Inventory of Canadian Agri-food Research[4] (ICAR) conducted in the fall of 1995 using the keywords "manure" and "waste", returned the titles of 87 projects, initiated since 1987 in 8 provinces. (See Appendix G).

A search of OASIS[5] conducted in September of 1996 using the keyword "manure", returned the titles of 12 projects currently in progress at the University of Guelph. (Appendix H)

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[3] More details about these projects are presented in Appendix E. Outlines of projects funded through Green Plan and summaries of completed projects are available via Internet from the Canada-Ontario Agricultural Green Plan Home Page (URL: http://res.agr.ca/lond/gp/gphompag.html). Summaries of projects from a number of previous programs are available through the Pest Management Research Centre Home Page. (URL: http://res.agr.ca/lond/pmrc/pmrchome.html).

[4] The Inventory of Canadian Agri-food Research is coordinated by The Canadian Agri-food Research Council and is a database for agriculture and food research in Canada containing detailed information on research projects in agriculture, food, human nutrition, aquaculture and related areas of biotechnology. The Internet URL for ICAR is http://aceis.agr.ca/icar/icarhome.html/

[5] OASIS is a computerized listing of research projects at the University of Guelph supported by OMAFRA. The Internet URL for OASIS is http://bobby.uoguelph.ca:443/

Table 7: Manure management research or demonstration projects conducted in Ontario under Green Plan or related programs (1987-1996).

Project Title (slightly modified)[1]	Key Links to Framework[2]			
Literature Search on Manure/Nutrient Management	1.0	2.0	3.0	
Rainfall Simulator/Grid Lysimeter System for Solute Transport Studies	1.3.2	1.6.3.3	2.6.2	
Soil Macropore Structures & Their Effect on Solute Transport to Tile Drains	1.3.2	1.6.3.2	2.6	
Regional Agric. Practices and Their Potential for Land & Water Contamination	1.3.2			
Partitioning of Solutes from Agricultural Fields within the Hydrologic System	1.3.2			
Prediction of Agrochemical Migration	1.3.2			
Fate of Agricultural Chemicals in Soil, Ground Water and Drainage Water	1.3.2			
Beef Feedlot\Yard Runoff Control by Vegetative Filter Strip	2.5.2			
Milkhouse Wash Water Control Using a Vegetative Filter	2.5.2	3.2.3.3		
Renfrew County Environmental Demonstration Site	2.5.2	3.2.3.3		
Constructed Wetland Treatment Facility	2.5.2	3.2.3.3		
Constructed Wetland Project	2.5.2	3.2.3.3		
Simcoe Conservation Club (artificial wetland project)	2.5.2	3.2.3.3		
Manure Management for Swine	2.5.2	2.5.5		
Assessment of the Influence of Manures for the Control of Soilborne Pests	1.6.6.2			
N & C Transformations in Conventionally-Handled Livestock Manures	1.3.1	1.3.2	4.0	
Composting Poultry Manure with a Passive Aeration Windrow System	2.5.4.3			
Evaluation of Three Manure Composting Methods	1.3.2	2.5.4.3	4.0	
Manure Composting Techniques: Understanding N and C Conservation	1.3.2	2.5.4.3	4.0	
Transformation of Inorganic N in Animal Manures into Plants and Soil O.M.	1.3	1.6.4.2	3.4	4.2
Transformation in Soil: Crop Response to Nitrogen in Manures	1.3	1.6.4.2	3.4	4.2
Impact of Manure Application Methods on Water Quality	1.3.2	2.5.8	2.6	3.4
Effects of Manure Application & Management on Surface Water Quality	1.3.2	2.5.8	2.6	3.4
Investigating Methods of Integrating Liquid Manures into a Cropping System	1.3.2	1.6.4.2	2.5.8	3.4
Managing Cover Crops & Tillage to Conserve N after Manure Application	1.3.2	3.3.1	2.6	
Manure Management to Sustain Water Quality	1.3.2	1.6.4.2	3.3.1	2.6
Field Drainage Tile Water Quality Study	1.3.2			
Renfrew Manure Analysis, Sampling and Spreader Calibration Project	3.4	4.0		
Oxford Manure Application Study	2.5.8	3.4	4.0	
Manure Management in High Residue Applications	2.5.8			
Computer Simulation of BMP's to Locate and Manage Artificial Wetlands	2.5.2	3.2.3.3		
Program to Assess Water Quality at Farm Sites for Artificial Wetlands	2.5.2	3.2.3.3		

1 Refer to Appendix E for complete project titles

2 Links to information framework relate to topics identified in Appendix K.

Codes beginning with: 1 - relate to Constraints or Standards that may limit a farmer's management options.
2 - relate to topics for which farmers are required to make Strategic Decisions.
3 - relate to topics for which farmers are required to make Tactical Decisions.
4 - relate to Nutrient Losses or Transformations.

Table 8: Issue areas, related to manure, addressed by research or demonstration projects conducted in Ontario under Green Plan or related programs.

Issue and Project Titles (slightly modified)[1]	Type[2]	Links to OASCC[4]		
Contamination of surface or ground water				
Rainfall Simulator/Grid Lysimeter System for Solute Transport Studies	R	WM	SM	RE
Soil Macropore Structures & Their Effect on Solute Transport to Tile Drains	R,O	WM	SM	RE
Regional Agric. Practices and Their Potential for Land & Water Contamination	M	WM		RE
Partitioning of Solutes from Agricultural Fields within the Hydrologic System	M	WM		RE
Prediction of Agrochemical Migration	M	WM		RE
Fate of Agricultural Chemicals in Soil, Ground Water and Drainage Water	R	WM		RE
Beef Feedlot\Yard Runoff Control by Vegetative Filter Strip	D	WM		RE
Milkhouse Wash Water Control Using a Vegetative Filter	D	WM		RE
Renfrew County Environmental Demonstration Site	D	WM		RE
Constructed Wetland Treatment Facility	D	WM		RE
Constructed Wetland Project	D	WM		RE
Simcoe Conservation Club (artificial wetland project)	D	WM		RE
Manure Management for Swine	D	WM		RE
N & C Transformations in Conventionally-Handled Livestock Manures	R	SM	RE	
Transformation of Inorganic N in Animal Manures into Plants and Soil O.M.	R	SM		
Transformations in Soil: Crop Response to Nitrogen in Manures	R	SM		
Impact of Manure Application Methods on Water Quality	M,O	WM	SM	RE
Effects of Manure Application & Management on Surface Water Quality	R,O	WM	SM	RE
Investigating Methods of Integrating Liquid Manures into a Cropping System	R,O	WM	SM	
Managing Cover Crops & Tillage to Conserve N following Manure Applications	R,O	SM		
Manure Management to Sustain Water Quality	R,O	SM		
Field Drainage Tile Water Quality Study	D	WM		
Computer Simulation of BMP's to Locate and Manage Artificial Wetlands	R	WM		RE
Program to Assess Water Quality at Farm Sites for Artificial Wetlands	R	WM		RE

1 Titles
Refer to Appendix E

2 Type of Project
L Literature Review
R Basic Research
M Monitoring/Modelling
D Demonstration
O will provide Operational information

3 OASCC committees to which results should be referred
WM Water Management
SM Soil Management
RE Rural Environ. Engineering
CP Crop Protection

continued....

Table 8: continued

Issue and Project Titles	Type	Links to OASCC		
Nutrient content and management (including transformations and application methods)				
N & C Transformations in Conventionally-Handled Livestock Manures	R	SM	RE	
Composting Poultry Manure with a Passive Aeration Windrow System	D	SM	RE	
Evaluation of Three Manure Composting Methods	R,O	SM	RE	
Manure Composting Techniques: Understanding N and C Conservation	R,O	SM	RE	
Transformation of Inorganic N in Animal Manures into Plants and Soil O.M.	R	SM		
Transformations in Soil: Crop Response to Nitrogen in Manures	R	SM		
Impact of Manure Application Methods on Water Quality	M,O	WM	SM	RE
Effects of Manure Application & Management on Surface Water Quality	R,O	WM	SM	RE
Investigating Methods of Integrating Liquid Manures into a Cropping System	R,O	WM	SM	
Managing Cover Crops & Tillage to Conserve N following Manure Applications	R,O	SM		
Manure Management to Sustain Water Quality	R,O	SM		
Renfrew Manure Analysis, Sampling and Spreader Calibration Project	D	SM		
Oxford Manure Application Study	D	SM		
Manure Management in High Residue Applications	D	SM		
Generation of Greenhouse Gases				
N & C Transformations in Conventionally-Handled Livestock Manures	R	SM	RE	
Evaluation of Three Manure Composting Methods	R,O	SM	RE	
Manure Composting Techniques: Understanding N and C Conservation	R,O	SM	RE	
Transformations in Soil: Crop Response to Nitrogen in Manures	R	SM		
Effect of manure application on plant diseases				
Assessment of the Influence of Manures for the Control of Soilborne Pests	R	CP	SM	

Rural Conservation Club Demonstration Projects

The Rural Conservation Clubs Program was established to support innovative research and demonstration projects related to environmentally sustainable agriculture in a way that would promote exchange of ideas and experiences within and among agricultural communities. Projects ranged from demonstrations, with little emphasis on collection of information, to replicated scientific studies. At the time of writing, 39 clubs were expected to produce a final report. Of these, six clubs conducted projects that were related in some way to manure management.

Table 9 briefly summarizes the activities of these six Conservation Clubs, outlining the issues addressed by their projects, the type of information produced and an assessment of the potential for additional transfer of technology arising from the project. (These clubs are also included in the lists in Tables 6 and 7.)

Table 9: Rural Conservation Club Projects Related to Manure Management

Project Title and Program File Number		Organization	Information gathered	Transfer Index
Manure Management in High Residue Applications	29	Charing Cross Conservation Club	Demonstration; Unreplicated yields; Observations	1
Manure Management for Swine	33	Essex Manure Management Club	Plans; Construction method; Factsheets; Video; Observations	4
Constructed Wetland Project	90	South Nation River Conservation Authority	Literature review; Plans; Construction method; Costs; Observations;	4
South Simcoe Wetland Project	92	South Simcoe Conservation Club	Plans; Construction method; Costs; Observations;	2
Beef Feedlot\Yard Runoff Control by Vegetative Filter Strip	102	Ontario Cattlemen's Association	Plans; Construction method; Costs; Observations; Data; Technical papers	4
Milkhouse Wash Water Control Using a Vegetative Filter	124	Farm Pollution Control Alternatives Assoc.	Literature review; Plans; Construction method; Costs; Observations;	4

Notes on Table 9: Explanation of Technology Transfer Index
This rating should not be interpreted as an evaluation of the merits of the club per se. Many clubs have been quite valuable at the local level but were not meant to provide detailed documentation of their activities or experiences.

1: Limited Potential

Several clubs, organized by local farm groups, were intended primarily to acquaint the cooperators, other club members and neighbours with new practices to enhance agricultural and environmental sustainability. Although most reports contain estimates of crop performance (usually yields from unreplicated strips), a relatively low priority was placed on collecting accurate data. The reports also do not appear to contain sufficient detail regarding the practices used to enable farmers in other areas to implement them without contacting the cooperators. The observations and conclusions of the cooperators could be useful to those preparing BMPs and similar publications in the future. Otherwise, there appears to little potential for extending information from these clubs beyond the local level without additional consultations with the cooperators.

2: Fair Potential

These clubs were similar to those described above in that they were sponsored by local farms groups and tended to focus on providing information for local farmers. However, higher priority was placed on collection and reporting of methods, results and observations. The reports contain varied combinations of information such as: details of equipment modification or operation; crop yields from replicated strips; plant tissue analyses; soil nutrient analyses; manure or biosolid analyses; water quality assessment.

3: Good Potential

A number of clubs were conducted by organizations with a regional or provincial focus. Because of the need to communicate with a wider clientele, these clubs have tended to place a high priority on the collection of detailed and reliable information and often engaged the services of professional consultations and/or coordinators.

4: High Potential

Several clubs were initiated by universities, or regional or provincial organizations and agencies that placed a high priority on the collection of accurate, detailed information. Several projects include replicated field studies, which could be suitable for reporting in scientific journals. Others involved design and construction of professionally engineered structures and should produce design specifications for similar projects.

Distribution of the Results of Green Plan Research and Demonstration Projects

General Promotion

The accomplishments of each research project that was active in 1996 and of each Green Plan program will be highlighted at the Green Plan Final Workshop, to be held in London March 25 -26, 1997. Two projects sponsored by the Technology Transfer Committee will promote wider awareness of the accomplishments of Green Plan. The Stewardship Information Bureau will prepare and distribute a summary bulletin describing the overall accomplishments of the Canada-Ontario Green Plan for Agriculture. Articles featuring the achievements of a number of individual projects, from the Research Program, Rural Conservation Clubs and the Woodlands, Wetlands and Wildlife Program, will be made available to the farm press.

Research Program

Current plans call for a printed copy of the final report of each project to be sent to a mailing list maintained by the AAFC Pest Management Research Centre in London. This list is comprised mainly of administrators in AAFC and libraries within in AAFC, OMAFRA and Ontario universities. A limited number of printed copies will be available from PMRC upon request. Executive summaries of completed projects will be posted on the Green Page Home Page on internet and entire reports will be available for download as ZIP files.

Rural Conservation Clubs

A one-page leaflet will be published for each Club, in both official languages, summarizing the club's goals, activities and achievements. Complete sets of these leaflets will be distributed to libraries, the farm media and individuals requesting them. Copies of the final reports of each club will be available through the Marketing and Industry Services Branch of AAFC, in Guelph, upon request.

Chapter 4: Extension Resource Materials

Information related to livestock manures is available to farmers through a number of sources, within both the private and public sectors in Ontario. Much of the transfer of technology related to manure management is realized through direct personal contact between farmers and those with the required expertise (e.g. government extension workers, industry sales personnel, other farmers and researchers). They are supported by an extensive array of resource materials, including technical bulletins, factsheets, booklets, videos, computer software and construction plans, the majority of which have been produced by OMAFRA or the Canada Plan Service (CPS). Although these resources span a wide range of topics related to manure and manure management (See Appendix K[5]), they tend to emphasize design and operation of livestock buildings and manure storages, selection and use of manure handling equipment, health and safety, or manure application rates. Of the resource materials that have been released by the public sector[6], at least 111 items related to manure management were still in circulation in 1995. (See Appendix I[7]).

Level of Information

Awareness:

The majority of the resource materials listed in Appendix I contain information at the awareness level. They provide the reader with a general introduction to the subject and some basic principles. They do not discuss the topic in sufficient detail to allow the user either to implement the technology described or to fully evaluate it relative to alternatives. A large proportion of the factsheets are written at this level of detail.

Planning:

In addition to providing information at the awareness level, several extension resources, most notably the *Best Management Practices*[8] (BMP) booklets and the *Environmental Farm Plan*[9]

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[5] In Appendix K, subjects for which extension resources exist are indicated by "Y" in the final column.

[6] No attempt was made to compile a list of printed materials produced by agribusinesses that market manure storage or handling equipment. Preliminary investigations indicated that these firms distribute mainly technical information related to their products and generally do not produce reference material related to the effect of manure on the environment.

[7] Knowledge of related production topics, such as livestock nutrition, soil fertility, soil conservation, drainage, crop nutrient management, is an essential component of a manure management plan. For the sake of simplicity, however, materials dealing with these topics are not included in Appendix I nor in Appendix K.

[8] Each BMP booklet contains an introduction to the subject, a discussion of management and environmental concerns, lists of available options, practical tips and a list of references for more detailed information. The majority of readers surveyed as part of the Decima BMP Study have found the booklets to be useful, credible, comprehensive and easy to read. Two-thirds indicated that they made changes in their management practices as a result of reading one or more BMP booklet. Almost all of those making changes indicated that the booklets had been helpful in dealing with the environmental issue in question.

[9] EFP worksheets and workshops provide farmers with a process for rating the potential for environmental damage from various aspects of their farming operations, under 23 areas of potential concern. As of March 31, 1996, over 6400 farmers had attended EFP workshops and over 2350 farm plans had been approved by local peer review committees. Participants in EFP have generally found it to have been very helpful in identifying aspects of their farming system most in need remedial action and in identifying possible approaches to correcting the problems. While the EFP worksheets do not assist users in

(EFP) worksheets, outline the factors to be considered in planning a manure management system and allow the user to compare options in general terms.

Technical Specifications:

A few of the older factsheets list design and operating specifications of various types of manure handling equipment. However, these publications are 5 to 11 years old, and it is unlikely that the information presented in them is complete and current.

Operational:

If a client has already decided to adopt a particular management approach, several resources, most notably the CPS plans and the software packages, provide sufficient operational details to allow the user to implement the technology described. They tend to focus on a single component of a manure system, with little emphasis on the system as a whole and most do not discuss the topic in sufficient detail to allow the user to evaluate it against alternatives.

CPS plans provide excellent information regarding design and construction for a wide range of buildings and manure handling or storage facilities, once a course of action has been made.

Software

1: *Nutrient Management Computer Program* (NManpc), a program developed within OMAFRA, (Hillborn and Brown, 1995), assists the user in calculating the required manure application rate and the amounts of nitrogen, phosphorus and potassium available per hectare, using information supplied by the user about their livestock enterprise, manure storage and handling system and cropping program.

As much as possible, NManpc is distributed as part of a training course, in which participants learn the principles of good manure management, along with being introduced to the program. NManpc is a good tool for calculating application rates and is increasingly being used by OMAFRA extension staff, soil testing laboratories, custom manure applicators and farms with large livestock operations.

2: *Manure Storage Sizing* (MStorpc), also developed within OMAFRA, assists the user in calculating the size of manure storage(s) required based on the type of storage, duration of storage and livestock species, sizes and numbers. The program also calculates the total volume of manure handled per year.

3: *M-Clone*, a prototype expert system for swine manure was developed at the University of Guelph (Fleming and Ogilvie, 1989a and b). (M-Clone was not released to the public.) Users of this system are required to input information regarding their swine operation, manure handling system and cropping program. The program then rates the

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comparing across categories to determine the relative importance of the potential damage from various aspects of their operations, some advice of this nature is provided by the technical advisors presenting the workshops and by the Peer Review Committees that review the farm plans.

manure system for cost, labour requirements, potential for odours and the potential for water pollution, weighted according to priorities set by the user. Although the program did not include a number of significant factors, M-Clone did demonstrate that it was feasible to use a computerized expert system for simultaneously evaluating several criteria related to manure use. A project to develop a more comprehensive decision support system for manure management is currently in progress at the University of Guelph (Goss, Stonehouse and Giraldez, 1996). The revised version is expected to be available in 1999.

Limitations of Existing Materials

To obtain the information they require, clients may have to sort through a large number of publications, of varying levels of detail and currency. As a result, the very process of obtaining information could be a barrier to the implementation of environmentally sustainable agricultural practices, for some people.

Few of the available resources provide the type of information or the level of detail required to compare options, to design and manage an integrated, sustainable system, or to implement the technology described. (Admittedly, it would be very difficult to produce a printed resource that could do this adequately and still be user-friendly.) Printed material does not exist for some questions because of the lack of information. To obtain this level of guidance, therefore, farmers have little choice but to contact people with expertise in the subject.

Several factsheets, that are listed in the 1994/95 OMAFRA booklet, *Publications*, are ten years old or more but remain in circulation, although appear to be outdated or superseded by Best Management Practice booklets.

Chapter 5: Transfer of Agricultural Technology in Ontario

Assumptions

As noted in the Introduction to this report, one of the criteria by which Green Plan will be evaluated is the degree to which farmers adopt the environmentally sustainable practices being encouraged by Green Plan activities. Before a farmer will implement new environmentally sustainable practices, that farmer must believe that:

- current farming practices are damaging the health of the farm family, the viability of the farming operation or the health of the environment, and
- the proposed changes will result in a significant reduction in the problem without threatening the economic viability of the farm, and
- the recommended solutions can be integrated with existing operations, or replace them, relatively easily.

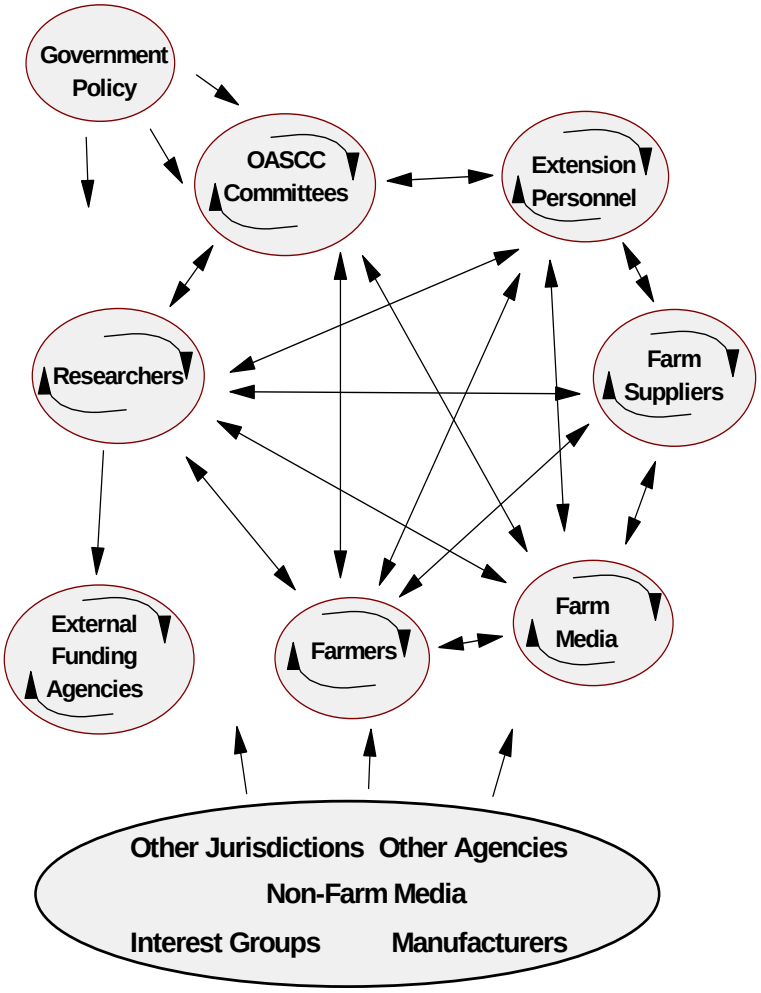
For farmers to be able to implement new, sustainable technologies, they must be able to obtain information that is sufficiently detailed as to enable them to:

- objectively evaluate their farming system and its potential for environmental damage.
- assess the effects of the available technologies on their overall farming operation and on the environment,
- estimate, at least qualitatively, the costs and benefits of implementing the options available to them,
- select the technologies that are appropriate for the particular situation, and
- incorporate them into a sustainable farming system.

At the same time, researchers and transfer agents must be able to obtain information about emerging issues for which farmers require additional assistance, if they are to direct their research and service activities appropriately.

A system for transferring agricultural technology is already well established in Ontario and has generally served the agricultural industry well. In its most simplified form, the process of transferring agricultural technology in Ontario can be viewed as the flow of information within a web linking researchers, farmers and technology transfer agents, in both the public and private sectors (Figure 2). The transfer of information has relied heavily on personal contact between advisors and farmers, either individually or in group settings. In the future, those with technology to transfer will likely plan to rely more on electronic communication channels, including computerized databases and decision support systems, accessible through channels such as CD-ROMs or Internet. Concurrently, there is likely to be a reduction in the level of personal advisory services available directly to individual farmers, from at least some sectors of the system. The existing channels of communication will likely continue to be the core of Ontario's extension system for the foreseeable future, but the system will undergo considerable change.

Figure 2: Patterns of the Flow of Agricultural Information in Ontario.



System Requirements

Those providing information on sustainable technology undoubtably hope that all farmers in Ontario will be able to obtain it easily, either directly or through advisors, in a way that is cost effective for all involved. Most people seeking information will be "solution-oriented", wanting to quickly locate the best available information applicable to their problems. After an initial trial period, clients will continue to use an information source only if they have found it to have been a satisfactory means of obtaining the information they need or want. For an information source to become the one of choice, therefore, clients must perceive the information it contains to be current, relevant, specific, reliable, credible, comprehensive and at the appropriate level of detail. The information delivery system itself must be seen to be readily accessible, easy to use, useful, interactive and flexible.

Relevance

In the past, agents who developed information packages for mass distribution could focus on presenting information that either the **agent wanted to publicize** or that the **agent believed that the clients needed to know**. To be acceptable to the clients of the future, information delivery systems will increasingly have to provide information that the **clients want to know.** The delivery system must provide a process by which clients can find information relevant to their situations and make informed decisions about possible solutions to their problems. One of the challenges facing people designing systems to transfer sustainable technology, therefore, will be to develop information management systems that assist clients in identifying and retrieving the information that they **need to know** to arrive at a sustainable solution to their problems.

Level of detail

Because of the diversity among farmers in their information needs, the overall delivery system must continue to provide information at several levels, ranging from the general (for awareness and motivation) to the detailed (for evaluation and implementation).

Awareness

The emphasis of much of the discussion this chapter relates to means of providing farmers with information for evaluating and implementing new technologies. It must not be forgotten, however, that information at the awareness and motivation level must continue to be distributed. Over the past decade or so, many programs have succeeded in raising awareness of environmental concerns within the agricultural sector[10]. Despite the success of these programs, there is still a wide diversity of opinion among agriculturists in their perceptions of the degree to which farming activities affect the environment and in the importance which they attach to such effects. Farmers differ also in the extent to which they are willing to change practices to protect the environment.

In the Producer Attitudes section of the Benchmark Survey, respondents were asked to indicate whether they agreed or disagreed with a number of statements reflecting various attitudes towards environmental concerns or adoption of sustainable agricultural practices. Although the majority of farmers surveyed recognized that agricultural practices could be detrimental to the environmental and that changes were needed, a significant percentage of producers agreed with statements that reflected a

[10] These programs have included the Ontario Soil Conservation and Environmental Protection Assistance Program, The Soil and Water Environmental Enhancement Program, Land Stewardship Programs I & II, The National Soil Conservation Program, Clean Up Rural Beaches, The Environmental Farm Plan, Best Management Practices, Rural Conservation Clubs and the Wetlands Wildlife Woodlands program.

negative attitude towards adoption of environmentally sustainable farming practices. (The percentage ranged from 20% to 60%, depending on the statement.) A similar proportion of those who had not yet participated in the EFP program indicated that they did not intend to do so (27%), while another 15% were undecided. The results of this study suggest that it will continue to be necessary to motivate and assist some farmers to:

- commit themselves to lessening the negative impacts of their operations on the environment.
- evaluate the effect of their farm on the environment and identify areas needing improvement.
- obtain the required information and apply it in addressing the problem.

The Environmental Farm Plan (EFP) and the Best Management Practices (BMP) booklets, in particular, have been very successful in helping farmers learn to recognize environmental problems and in encouraging farmers to implement environmentally sustainable practices. Given the success of these programs, it would seem important that they, or similar programs, be continued.

Site-Specific

Because each farm situation is unique, development of appropriate solutions for its technical problems requires a set of information unique to that farm. In the future, farmers and their advisors are likely to require more specific information than they may have been able to obtain in the past.

From an environmental standpoint, this trend towards site-specific or farm-specific management should be beneficial. If developed and implemented properly, solutions that have been developed to address a specific situation should be more sustainable than those based on generalized recommendations. Farmers are also more likely to implement solutions for which they feel a sense of ownership, than those perceived to have been dictated by an external authority.

Economic Information

Farmers definitely perceive the cost of some technologies for reducing the environmental impact of manure as a barrier to their adoption. This barrier is strengthened to some degree by the lack of information related to the costs and agricultural benefits of these technologies, or in the difficulty of assembling it and maintaining its currency (Stonehouse and Giraldez, 1996.). The environmental costs are even less documented (Weersink, 1996). Despite the difficulties inherent in providing economic information related to manure management, this should continue to be a priority area for research and technology transfer activities.

Accessibility

People are most likely to use the sources of information in their own offices or homes and other sources that they can access quickly. It would be advantageous for clients to be able to obtain all of the detailed information they require from one source. Ultimately, computer-based information systems, especially those with links to the Internet, offer the promise of single-window access to a large volume of information. Despite the advantages of computer-based systems, however, the need for some clients to continue to have access to information that is distributed through more traditional channels (e.g. publications, radio, television, workshops, demonstrations, etc.) will not disappear for the foreseeable future. Many farm families currently do not have access to Internet, either because they do not yet own a computer or because they live in areas with telephone services that are not adequate to support Internet connections. For example, in 1994, only 8.6 % of the farmers who responded to the Benchmark Survey had access to a computer equipped with a modem. It is questionable if many farmers will invest in computer technologies for the sole purpose of obtaining

access to an information source. They are more likely to first acquire computers to perform other functions and gradually expand their use to include information retrieval, as they become comfortable with this communications channel.

Ease of Use

The fact that information is physically available to clients (in either hard copy or electronic form) does not necessarily mean that it is accessible. It must also be readable and presented in a format that is compatible with the particular client's skills and style of learning. It may also have to be available through communications technology with which the client is familiar, since learning to use a new system may require a greater investment of time (and perhaps, money) than clients are willing or able to commit. To some degree, this is a question of motivation. Those who are highly motivated to obtain information on a particular topic might adapt their learning style - those who are resistant will not.

Preferred Communication Channels

People tend to prefer to use information that is presented in the formats with which they are currently most familiar. (See also pages 40 to 41) It is likely, therefore, that most farmers and advisors currently prefer printed formats, such as OMAFRA publications, BMP booklets, technical publications from agribusiness, and farm magazines. In the future, the popularity of electronic formats may increase, as clients become familiar with these communications technologies and if they find them to be an effective and efficient way of retrieving information.

Two recent studies, The Benchmark Survey and the Decima BMP Study, respectively, examined the preferences of farmers for receiving information. In the Communications section of Benchmark Survey, beef, dairy and hog producers were asked to name the best source of information for manure management. Table 10 summarizes the percentage of respondents who indicated a preference for each source of information.

Table 10: Preferred Sources of Information on Manure Management: Benchmark Survey

Information Source		Farm Type Beef	Dairy	Hog
Farm Press		23	43	44
OMAFRA		24	33	22
Other Farmers	18	11	14	
Gov't Publications		13	12	10
Machinery Dealers		1	1	2
Researchers		2	3	1
InfoSource Newsletter (SIB)		2	4	-
Don't Know		24	8	13

Participants in the Decima BMP Study were asked to select the two ways of disseminating information that they find to be the most useful personally (Table 11) for obtaining:

a) general information about practices or techniques.
b) information to help them decide whether to try a particular practice or technique.
c) information to help them implement a particular practice or technique.

Table 11: Preferred Media Sources for Receiving Information About Environmentally Friendly Farm Practices: Decima BMP Study

Source	Use of Information General	Try New Technique	Implement Technique
Magazines	**33**	19	13
Visiting Farm Operations	28	**42**	**34**
Demonstration Tours	28	**30**	**27**
Communication with Experts	24	**32**	**44**
Seminars/Workshops	23	22	22
Factsheets	20	19	23
Newspapers	19	10	7
Government Publications	13	10	16
Videos	11	12	12

Several conclusions can be drawn from the results of these studies, that are of particular significance to those planning technology transfer activities:

- The so-called mass media appear to be best suited to transferring awareness level information.
- To obtain information needed to implement new practices, farmers rely heavily on interactive forms of communication, especially those involving personal contact.
- Farmers seeking information on manure management practices are highly dependent on information originating with the government. (Much of the information delivered through Magazines, Communication with Experts, Seminars, Tours and Factsheets flows in some manner from government sources.)

- People learn most effectively in different ways - listening, reading, observing, experimenting. (They also differ in the degree to which they can learn using methods other than their preferred style).
- Equipment dealers are not seen as a source of information about environmental aspects of manure management (Benchmark Survey).
- A disturbing proportion of livestock farmers, especially beef producers, did not know where to find information about manure management (Benchmark Survey).

Adaptability

It would be most cost-effective if the information contained in the primary storage and retrieval system was in a format adaptable to serving the needs of several levels of clients (e.g. researchers, advisors, farmers, general public). Given the stated preferences of their clients, advisors are likely to need to distribute information in printed form, even if they themselves obtain information electronically. Information distributed through electronic channels should be prepared in a way that will allow it to also be easily transferred through other communication channels[11].

Personal Contact

As noted above, a large proportion of farmers still prefer to receive information in ways that involve direct contact with a person knowledgeable about the subject matter. For several reasons, the need for some level of personal service to farmers is unlikely to disappear in the near future.

- The information contained in many current extension resources, related to many aspects of manure management, is not sufficiently detailed or specific enough to enable farmers to implement the technology described. Written information does not exist for some questions because of the lack of information. To obtain guidance in implementing new technologies, farmers have little choice but to contact someone with expertise in the subject, until acceptable alternatives to personal contact are developed.
- Although personal contact is an expensive means of technology transfer, it is the most effective way to motivate people to change and may be the only way to do so for some clients. To date, Green Plan technology transfer programs (EFP, BMP, SIB, WWW and RCC) have been quite successful in encouraging farmers to consider changing unsustainable farming practices. Over time, however, the farmers who have yet to adopt environmentally sustainable practices are likely to be those who are most resistant to change (or those who can least afford to do so.) It is unlikely that such clients will implement the needed changes, unless they have a high degree of trust in the source of information. The most effective means to establish a sufficient level of trust to create an openness to change is through personal relationship, or a similar common bond.

- It must also be recognized that as much as 40% of the adult population of Canada functions at literacy levels 1 or 2 (i.e. very limited reading skills). Print or electronic forms of communications will not be effective means of communicating with clients at these levels of literacy.

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[11] The Florida Agricultural Information Retrieval System, FAIRS, is an example of one approach to distributed information electronically in a format suitable for printing (Beck and Cilley, 1994). The CD-ROM, based on the Water Management BMP being produced as another project of the Technology Transfer Committee is another example of a means to present information in a multi-media format.

Integration

Clearly, those transferring information will need to use different methods to reach different client groups. The challenge will be to harmonize the possibly conflicting needs of the clients, relative to communication channels and learning styles, with the most effective means to present specific information and with the overall cost of the delivery system. Determining the most effective communications methods for achieving the desired level of change in specific client groups is the focus of another project of the Technology Transfer Committee, entitled *Technology Transfer System Integration.*

Structure

Because the potential client group includes people at all stages in the adoption continuum for any technology, the delivery system must be able to supply existing information as well as that which will become available from current and future research projects and from on-farm experience. Together, these represent a substantial body of information spanning a wide range of topics. Because farmers and their advisors must be able to evaluate and select technologies from among a number of options, for each aspect of their operations, they will require information about many specific, interacting factors. This information will need to be organized and linked in a framework, to facilitate the efficient retrieval of specific information and the identification of pertinent information on related topics. The organization of such a framework for manure management information is discussed in more detail in the next chapter of this report. (The organization of information to facilitate retrieval and transfer was also the focus of another project of the Technology Transfer Committee, *An Agricultural Information Integration and Exchange System.)*

Interactivity

As noted above, farmers have relied heavily on personal contact with experts (either individually or at workshops or tours) for obtaining information about implementing manure management practices. Manure management systems can be very complex and a high degree of expertise can be required to accurately assess the suitability of the various options. Farmers are likely, therefore, to continue to seek expert evaluation of their situations.

Personal contact between experts and clients is a particularly effective means of transferring detailed information because the interaction enables both parties to focus and clarify the questions sufficiently to arrive at practical solutions for specific needs. Demand for personal contact with experts might be reduced if other interactive methods of delivering information were available. Clients must be able to determine:

- Their information needs, with respect to both topic and level of detail. Users seeking a particular level of information should be able to reach that level quickly without having to progress labouriously through other levels. At each level, however, clients should be alerted that other levels of detail are available.
- The assumptions used within the system in identifying and evaluating the information to which clients are directed, such that clients can test its relevance to their situations;
- Whether their own assumptions regarding their situations are valid.
- Available options, and where more than one course of action is feasible, the relative merits of each.
- Situations for which a particular technology appears to be suitable and those for which it does not.
- Effects of the proposed change on other aspects of their farming operation. Clients currently

often request information about a single aspect of manure management. Because implementation of a best management practice rarely affects only one aspect of a farm operation, clients should be encouraged to use a systems approach when evaluating the situation and possible remedial measures.

- Related topics for which they require information in order to implement the technology properly;
- Limitations of the information provided. Manure management is a complex and dynamic topic. New questions arise as old ones are answered. Recommendations continue to change. Clients must clearly understand that the information and recommendations presented are the best available at the time of writing and that with additional information, our understanding and recommended solutions may change.

Some aspects of the support required could be provided by a computerized information management system such as that developed in the Technology Transfer Committee project, *An Agricultural Information Integration and Exchange System*. Assistance in evaluating the suitability of technologies could be provided through a Decision Support System, such as that under development at the University of Guelph (Goss, Stonehouse and Giraldez, 1996). However, these are unlikely to soon replace the need for personal contact, for reasons noted above.

Flexibility

Because farm planning is a process of harmonizing multiple goals, (agricultural, financial, environmental and social), it is an exercise in compromise. A change in one farming practice inevitably necessitates a change in one or more other aspects of the operation, and together they are affected by many economic factors, including capital cost, operating costs, labour, management, risk and convenience. All farming systems simultaneously affect different parts of the environment (air, water, soil, wildlife) to varying degrees. Suggested solutions must also be compatible with the subjective criteria which determine a farm family's approach to farming and their lifestyle (e.g. tradition, religion, community acceptance, etc.).

Because there is no consensus within society as a whole regarding the relative importance of these factors, the priority attached to them by farm operators is understandably varied and somewhat subjective. Although farm managers develop their plans within the constraints imposed by both society and nature, there will be great differences among farm operations in the degree to which any given target can be achieved, and in the degree to which farm operators will even attempt to achieve them. Information delivery systems, especially computer-based systems, must be sufficiently flexible as to allow the clients' needs and priorities to be reflected in the recommended solutions.

Client satisfaction

In an ideal system, every user would be able to identify practical, affordable solutions to their problem quickly and easily, at the appropriate level of detail. However, this will not always be possible. In some cases, the required information might not exist in the database. In others, the client may not have assembled sufficient background information regarding the problem. In such situations, other advice that could be beneficial to the client might include:

- listing of questions for which further background information is required;
- suggestions for other management practices to investigate.
- current research which might address their concern;
- other sources of information.

- when the needed information does not exist, acknowledgement that their concern will be forwarded to the appropriate research coordinating committee.

Feedback

To assist those managing the information system in monitoring its relevance, clients should have the opportunity to offer feedback about the structure and operation of the system, the degree to which it met their needs, and questions for which sufficient information was not available.

Support for advisory personnel

As the government reduces the amount of personal service it provides, farmers are likely to increasingly depend on advisors in the private sector and other farmers, to obtain information to evaluate and implement new technology. From the government perspective, increased reliance upon the private sector for the personal delivery of information offers a number of advantages and disadvantages (Table 12). If the private sector is to undertake a larger proportion of the transfer to farmers of sustainable technology for manure management[12], provision must be made to ensure that the advisors who deliver technical information about manure management to farmers are adequately trained and supported.

[12] The degree to which companies and staff in the private sector are willing to assume this role for manure management information has yet to be determined. Whether sufficient farmers are willing to pay for this service to it make a profitable undertaking for the private sector has also not been established.

Table 12: Potential advantages and disadvantages of increased reliance on private sector personnel to transfer technology related to manure management

Possible Advantages	Possible Disadvantages
- increased resources within the total system for delivery of information. - less duplication of services. - wider range of client contacts.	- less control of the use of information. - increased effort to manage information delivery system. - clients' contact patterns may need to be changed
- access to a wider range of expertise. - availability of more information.	- technology not related to a specific product may not be promoted
- increased credibility and acceptance of the information by some clients. - wider public awareness of programs.	- less recognition of contribution of public sector.
- government specialists able to concentrate on resource development and training.	- less exposure of government specialists to operational situations. - increased effort to ensure that advisors receive adequate training.

Training

In some subject matter areas, much technology now is transferred by advisors or dealers in the private sector. However, as noted above, relatively few farmers consider dealers to be a preferred source of information about environmentally sustainable manure practices (Table 10). While the reasons need to be investigated, the limited extent to which farmers rely on private sector sources suggests that expertise on manure management within the private sector is limited or highly specific (i.e. related to a particular range of products). If this is the case, considerable effort may have to be devoted to a comprehensive training program to develop the necessary expertise within the private sector to deliver information about manure management with a systems approach. In the meantime, any reduction in the opportunity for farmers to consult manure specialists within the public sector could leave a significant void in the system for delivering information on manure management.

Information sources for advisors

The author is not aware of any published reports describing the information needs of agricultural advisors in Ontario. It is likely, however, that they parallel those of the extension advisors in Illinois, who were interviewed in a study by Shih and Evans, (1991). This study indicated that the written sources of information used most frequently by extension advisors were those available in their own office, especially publications from their own state. For oral information, they most frequently contacted state extension specialists. Electronic channels were rarely used. Libraries and scientific papers were considered to be inaccessible, difficult to use and not particularly relevant. (The complete paper by Shih and Evans is available on Internet from the Journal of Extension. URL is http:\joe.org.joe)

Shih and Evans drew the following conclusions from their study:

> *Results of this study underscore the continuing importance of a strong internal support system for field staff, including close linkages with subject-matter specialists. This internal system seemed vital, even as field staff gained access to agricultural information from a growing number of sources. The impact of electronic technologies wasn't yet apparent. Local agricultural Extension advisers in this study reported they drew heavily on information provided by their own Extension organization, through written and oral sources. The top three information sources were Extension publications, Extension specialists, and personal files. As advisers gained experience and contacts, they tended to use oral information sources increasingly often and continued to use written sources extensively.*
>
> *Advisers also continued to use more information from internal than from external sources. When searching for information, they resorted to external sources mainly when their internal sources didn't provide it.*
>
> *Electronic information sources, such as satellite programming and on-line bibliographic databases, were used infrequently, and by relatively few advisers. Problems of accessibility and user friendliness were major hindrances. Another problem was that literature included in major databases often wasn't easily translated into localized, field-level applications. These problems suggest directions for future efforts by the Extension Service.*

It is likely that the needs of advisors in Ontario parallel those of farmers to some degree (i.e. advisors, in either the public or private sector, need information that is readily accessible, easy to use, practical and credible, etc.) Advisors (and clients) are most likely to use the sources of information in their own office, that they can access most quickly and currently, to prefer to use information in printed form over that in electronic formats. If electronic channels are to become an accepted means of distributing information, it will be essential to train field staff, within both the public and private sectors, to use the system comfortably, efficiently and effectively. In the meantime, it may be necessary to continue to publish printed resource materials for field staff, so as to ensure that up-to-date resource materials are available in their offices.

Maintenance of the information system

Human Resources

Computer-based systems have the capacity to store and sort vast quantities of information and to distribute it, almost instantaneously, across large distances, apparently at relatively low cost. The perception that these are low cost systems, however, recognizes only the cost of actually distributing the information. It does not consider the cost of the infrastructure necessary to prepare and position the information so that it can be distributed. Sufficient resources, especially human, must be provided to maintain:

a) the reliability of the information system itself, and
b) the currency of the information contained within it.

a) Communications systems specialists would be needed to guide the preparation of material and to provide users of computer-based systems with technical support in dealing with problems encountered in use of the systems.

b) Subject matter specialists would be needed to compile and edit information into formats appropriate for the type of information, the communications channel being used, and the intended audiences. If clients are to arrive at solutions that are practical and sustainable in the broadest sense, the information provided must be accurate and up-to-date. Maintenance of the system must include continual review and revision of the information base in the light of recent research and on-farm experience, both within Ontario and elsewhere.

Research reports will need to be reviewed. The information they contain will need to be integrated with existing knowledge and the summarized conclusions edited into the appropriate formats. As much as possible, information should be prepared in formats that would allow it be easily adapted to distribution through a variety of communication channels. Thus, the information should be presented in sections that are easy to use (brief; written in clear language), easy to file and easy to retrieve.

The need for the people performing these roles to be highly competent technical experts will not diminish. They must have a sufficiently comprehensive understanding of the subject matter area to enable able them to assess the relevance and reliability of information from the wide variety of sources to which their clients will have access in the future. In addition, they will need expertise in information management and in editing information appropriately either for distribution directly to farmers via various channels of mass communications, or for use by advisors.

It may be most efficient and effective to establish task teams which include both subject matter specialists and writers/editors skilled in the preparation of materials for use in electronic channels, rather than to attempt to develop the full range of skills in a few individuals. Nevertheless, to facilitate the work of these teams, the subject matter specialists will need to acquire at least a basic understanding of the characteristics of the newer channels, relative to the preparation of information for distribution through electronic media.

Individuals, or task teams collectively, will need to have a thorough understanding of:

- traditional and innovative farming practices in Ontario and concerns related to them.
- farming practices used elsewhere that might be adaptable to Ontario.
- availability of information related to their area of expertise within Ontario and worldwide.
- current research, local and international.
- advantages and limitations of modern communications technologies.
- the most appropriate communications channels through which to deliver specific information or to reach certain target audiences.
- the most effective formats in which to present information on the various channels.
- the process of preparing and distributing information for each communications channel.

Research Database

To perform the functions described above, those responsible for maintaining the information system will need to know the "state of the art" for their area of interest. They will need ready access to the most recent research results and other pertinent information in Ontario and to relevant information from other provinces and countries.

The Ontario system for technology transfer currently suffers from the lack of a truly comprehensive

database of Ontario research. For example, many current research projects, including several funded through Green Plan, are not listed in ICAR. Other listings by program or agency do exist, but the lack of a comprehensive database adds to the time required to identify and obtain the information needed to develop recommendations[13]. As a result, information generated at public expense has not always been adequately transferred. If ICAR is to be a truly comprehensive database, the general level of commitment to maintaining the currency of the information it contains needs to be increased. Otherwise, a more effective alternative would need to be developed.

Research projects conducted by institutions and researchers represented on OASCC committees are coordinated through OASCC and project reports are often channelled through the respective committee. However, the same does not necessarily apply on a wider scale. There is no standard process by which OASCC committees can offer input into or obtain information from projects being conducted at institutions not represented on the committee, or in some cases, by researchers not present on the committee. (This could include either research at public institutions or private contractors working on publicly funded projects.) Because of this lack of communications and co-ordination, the results of some projects may not integrate well with other related work or may even not be considered in any reviews. Coordination could be improved through designating one or more members of each committee to act as liaison to such programs. Public agencies which fund research projects could include liaison with the relevant OASCC committees as a component of the reporting mechanisms of their programs. Copies of the reports from current projects should be forwarded to the appropriate OASCC committee (See Table 8) or sub-committee and OMAFRA specialists designated with the corresponding specialty.

Information Generated by Other Sources

Much technology development, if not invention, occurs on the farm. Often, this work addresses questions at the leading edge of environmental issues. Although the design of many of their experiments makes it difficult to integrate the results with those from scientific research, the information generated by farmers can be very relevant and useful. Indeed, some innovators must be recognized as our best experts on certain technologies. Similarly, agri-business is both a significant source of new technologies and information regarding their use. It will be important to gather and integrate information from these sources with the general body of knowledge.

Coordination and Production of Extension Materials

In Ontario, a number of groups are involved in the development and publication of recommendations for farmers. These include some OASCC committees, the OMAFRA Publications Committee and task teams created for specific projects. Collectively, these groups have produced many useful extension resource materials, as noted in Chapter 6. However, the respective responsibilities of OASCC committees and the OMAFRA Publications Committee, with respect to initiation and production of extension resources, need to be more clearly defined to improve coordination and to reduce duplication of effort. The lines of accountability for implementing committee recommendations also need to be clarified.

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[13] It is difficult even to compile a complete list of current projects. The listings of research or demonstration projects contained in this report were assembled from at least 10 sources and the author makes no claim that they include all the relevant publicly funded projects.

OASCC Committees

Although much of the work of OASCC committees and sub-committees is devoted to monitoring research activities within their subject matter area, these committees have also been given the responsibility to coordinate certain service activities. These include aspects of technology transfer, such as:

- review of the results of recent research, related to their subject matter area;
- integration of those results with existing information;
- development or revision of management/production recommendations to farmers;
- revision of related existing publications or portions thereof.
- recommendation to OMAFRA for the production of new extension materials to communicate the information to farmers.

There has been considerable variation among committees in the regularity with which they review production recommendations and the degree to which they attempt to coordinate production of extension materials. Committees with mandates related to crop production or soil management have generally reviewed the content of sections of the crop production booklets for which they are responsible on a biannual basis, revising them when necessary. For other types of publications, the process of developing published recommendations appears to have been less systematic and not well defined. Some committees have been active regularly in this regard; others have not.

Although the committees have the responsibility to recommend the production of extension materials, they do not have the authority to ensure that it happens. It would also appear that none of the agencies involved in preparation and publication of extension resources, public or private, is obliged to implement OASCC committee recommendations related to technology transfer.

Nor are committee members themselves necessarily required to implement committee recommendations regarding technology transfer - the responsibility to do so often is not part of the job description of any committee member. The production of resource materials appears to depend of the presence on the committee of an individual(s) with the interest, ability and time to devote to the tasks involved. Preparation of extension materials, regardless of the channel or format, requires a considerable investment of time to become familiar with the scope of current research in Ontario and beyond, conduct literature searches, develop draft recommendations for review by the committee and write the needed documents. Some committees do include people whose job descriptions clearly designate them as resource people to other advisors (with limited responsibility to serve farmers directly, themselves) and assign high priority to preparation of extension materials. Several aspects of manure management, especially those related to engineering, fall into this category. In these cases, the system appears to have worked reasonably well, resulting in the publication of materials on current issues, as required. In other cases, the researchers and government extension specialists on OASCC committees have not been able to devote sufficient time to the preparation of extension resources on a regular basis, because of their other responsibilities. As a result, the production of needed resource materials has often been considerably delayed.

OMAFRA Publications Committee

Within OMAFRA, the Publications Committee and its sub-committees meet periodically to review the list of publications in circulation and to identify existing materials that need to be reprinted, revised or deleted, and new materials that should be produced. (The priorities established in this process may, or may not, coincide with those set by the comparable OASCC committee.)

Although there is more accountability within this system than to the OASCC committees, technology transfer in several subject matter areas has been similarly hampered by the lack of staff time to devote to the preparation of extension resources. The area of manure management has been better served in this regard than others because of the presence within OMAFRA of staff designated with the responsibility to generate resource materials related to several aspects of manure management.

Task Groups

Task groups have been used to generate the EFP Workbook, the BMP booklets and extension resources for other specific issue areas, including some aspects of manure management. In general, this approach has been very successful, in part because:

- the group has a single focus, related to technology transfer.
- all members of the group are clearly responsible to assist in the production of the resource and accountable to their employers to do so.
- budget is allocated to the project, both for writing (either by public sector staff or by hired writers) and for publication of the finished product.

Identification of issues requiring additional research.

The process used in recent years in Ontario to identify research and information needs for manure comprised a combination of activities coordinated through Green Plan, OASCC or OMAFRA (See Chapter 2). The process involved representatives from research, extension, industry and the farm. The review was very comprehensive and was very effective in identifying the issues for which additional information was required. Many of the issues rated as being of high priority were addressed within Green Plan either through the research program or conservation clubs. (See Chapter 3). Areas that were not addressed fully within the Ontario Green Plan (e.g. on-farm costs and benefits; environmental costs; odour control; effect of ration on manure nutrient content) are being addressed to some degree by Green Plan programs in other jurisdictions and by projects in Ontario funded through other sources. (See Appendices F, G and H.)

The process used in Ontario might have benefited from more coordination among the groups involved to reduce duplication of effort. The objectives of several of the groups appear to have been very similar; there was much overlap in their membership; and most arrived at a very similar set of priorities. The similarity in their results is confirmation of their validity, but it would appear that more coordination could have resulted in a more cost-effective process.

Conclusions:

As noted in Chapter 3, much useful information, about a wide range of topics has been generated within the Research Program and the Rural Conservation Clubs Program of Green Plan, and much valuable experience in addressing other environmental concerns has been gained through the Woodlands, Wetlands and Wildlife Program.

Within each program, there is provision for a limited number of activities to distribute the final reports from their projects and to inform the public of the program's accomplishments. (See page 21). However, the intended approach is largely passive, placing most of the onus on those requiring information to assemble reports from the various programs and projects of interest, and to integrate them into useful knowledge. It is unlikely that most people will be willing to do so. The size of project reports, and the style in which they are written, limit their usefulness as extension resources. They are often hard to read and contain much more detail than most users require. Thus, the planned activities may not be sufficient to ensure that the information will be widely accessible to farmers across Ontario. (Furthermore, other considerations aside, such a process would be very inefficient overall, because of the inherent duplication of effort.)

For maximum benefit, the results of Green Plan need to be synthesized, along with previously existing information, into recommended practices that can be readily implemented on the farm. Recommendations subsequently need to be incorporated into resource materials such as factsheets, BMP booklets, EFP workbooks, or web page documents.

At the least, copies of the reports from current projects should be forwarded to the appropriate OASCC committee or sub-committee, and to OMAFRA specialists designated with the corresponding specialty. However, such summarization, integration and distribution of Green Plan project results is unlikely to happen unless a deliberate plan is instituted to do. Although OMAFRA has played an active role in the production of extension resource materials, in similar situations in the past, one cannot assume that this will happen in the future, given the changing nature of OMAFRA and the reductions in its staff .

To ensure the effective and efficient transfer of Green Plan results, a specific project should be undertaken to summarize, integrate and distribute information from related projects. Sub-projects would be needed to address each major issue area addressed by Green Plan research and demonstration projects (e.g. soil quality and management, water quality, manure management, management of other wastes). Given the limited staff resources within both senior levels of government, it is likely that the tasks of preparing summary documents would need to be contracted to private sector firms or individuals with the appropriate qualifications, working under the guidance and supervision of task teams comparable to those used to develop the BMP booklets.

In addition to the reports that were required, some organizations, that participated in RCC or WWW, have produced bulletins, factsheets and other resource materials. To assist those who might wish to refer to these documents in the future, complete sets for each program should be assembled and made available through appropriate libraries or resource centres.

List of References Cited

1992 *The Green Plan Agricultural Stakeholders Forum* Soil and Water Conservation Information Bureau, Guelph, Ontario

1994 *Phase I Evaluation of the Canada-Ontario Agreement on the Agricultural Component of the Green Plan: Evaluation Assessment* Deloitte and Touche Management Consultants Guelph, Ontario and Apogee Research International, Toronto, Ontario

1994 *Phase I Evaluation of the Canada-Ontario Agreement on the Agricultural Component of the Green Plan: Benchmark Survey Report* Deloitte and Touche Management Consultants, Guelph, Ontario and Apogee Research International, Toronto, Ontario

1995 *Best Management Practices Study* Decima Research, Toronto

1994 *Four Focus Group Discussions Concerning Environmental Issues and the Best Management Practices Material* Decima Research, Toronto

1994 *Publications 1994/95* Ontario Ministry of Agriculture, Food and Rural Affairs, Toronto, Ontario

Beck, H. and M.L. Cilley. 1994 *Change and the Agricultural Communicator: Electronic Dissemination of Extension Information* J. of Applied Communications 78: 1 - 10

Goss, M.J., J.R. Ogilvie, E. G. Beauchamp, D.P. Stonehouse, M.H. Miller and K. Parris. 1994 *Current State of the Art On Manure/Nutrient Management* Agriculture and Agri-Food Canada, London, Ontario COESA Report RES/MAN-001/94

Goss, M.J., D.P. Stonehouse and J.C. Giraldez, 1996. *Managing Manure for Dairy and Swine: Towards Developing a Decision Support System.* Centre for Land and Water Stewardship, University of Guelph, Guelph, Ontario

Fleming, R. J., and J. R. Ogilvie. 1989a *An expert system on swine manure management* ASAE Paper 89-4091

Fleming, R. J., and J. R. Ogilvie. 1989b *Development of a rating scheme for manure management systems* ASAE Paper 89-4092

Fraser, J. 1994 *Co-ordination of Agri-Food Research and Services in Ontario* OMAFRA, Guelph, Ontario

Hillborn, D., and C. Brown. 1995 *Development and utilization of OMAFRA nutrient management computer program (NManpc)* OMAFRA paper 514

Morris, D. T. 1995. *An Approach to Technology Transfer within the Canada-Ontario Green Plan* Agriculture and Agri-Food Canada, Guelph, Ontario

Stonehouse, D.P. and J.C. Giraldez, 1996. "On-Farm Socio-economics of Manure Management"

Chapter 8 in *Managing Manure for Dairy and Swine* by Goss, M.J., D.P. Stonehouse and J.C. Giraldez, 1996.

Weersink, A. 1996. *Evaluating Environmental Damage from Animal Manure*, Chapter 9 in *Managing Manure for Dairy and Swine* by Goss, M.J., D.P. Stonehouse and J.C. Giraldez, 1996.

Win-Yuan Shih and J.F. Evans. 1991. *Where Field Staff Get Information: Approaching the electronic times.* J. of Extension Vol. 29 No. 3

Appendix A: Recommendations from the Report *An Approach to Technology Transfer within the Canada-Ontario Green Plan*

Recommended Goals:

1) Information must presented in ways that will allow potential users to assess the impact of a change in technology on their production system and the environment.

2) An effective alternative to direct contact with experts must be developed to transfer detailed information to clients.

3) The technology transfer system must ensure that the best available information is widely accessible in formats that will facilitate widespread usage.

Recommended Objectives:

1) For each issue area, an individual, or group, should be assigned the task, and held accountable, to ensure that, as information becomes available, it is:
   - assembled at a central location, preferably in both printed and electronic formats.
   - reviewed and integrated with previous information, noting whether they support current recommendations or necessitate change.
   - summarized with previous information.
   - presented, with draft recommendations, to the appropriate OASCC committee for review.
   - available to extension personnel and private sector sales staff, in a readily usable form.

2) To ensure that the summarization of data in this manner will occur, it is likely that funding will have to be provided specifically for this task.

3) Design of projects on related topics should be coordinated to facilitate integration of their results. Collection of a standard dataset should be encouraged, as appropriate.

4) Information from on-farm demonstrations and experiments should be integrated into the reviews outlined above. Use of a standard design for on-farm plots and collection of a standard dataset should be encouraged, especially where the work is conducted with public sector input (e.g. Soil and Crop Improvement Association projects, Wetlands/Woodlots/Wildlife demonstrations and Rural Conservation Clubs).

5) Extension materials should be designed to meet the needs of specific client groups, with regard to the level of detail and format. In such materials, either printed or electronic, the pathway by which a user can obtain more information must be clear.

6) All extension materials related to a particular topic should be available, or accessible, through the same location.

7) Production recommendations and related information should be organized and presented in ways that facilitate use of a systems-approach in considering and applying new technology.

8) Extension material should outline the potential impact of a technology on both other parts of the farm system and the environment or indicate where such information can be obtained. Prerequisites for implementing the technology on a farm should also be identified.

9) Materials should be developed to assist farmers in comparing the costs and benefits of alternate technologies, objectively, relative to both farm and environmental goals. Through such an approach, farmers should be able to arrive at a least-cost, practical system.

Appendix B: Committees and Sub-committees Within the OASCC System

Agricultural Economics (OAERSC)
- **Farm Mgt. & Prod'n Economics** (FM)
- Marketing
- **Resources Development** (RD)
- Rural Community Development

Agriculture & Food Engineering (OAFERSC)
- Food Engineering
- On-farm Energy and Processing
- Power and Machinery
- **Rural Environment Engineering** (RE)
- **Structures and Buildings** (SB)

Animal (OARSC)
- Aquaculture
- **Beef** (B)
- **Dairy** (D)
- Deer
- Equine
- Fur-bearing
- Goat
- **Pork** (Pk)
- **Poultry** (Py)
- Sheep

Soil, Water and Air (OSWARC)
- **Agrometeorology*** (AM)
- **Soil Management*** (SM)
- Soil Survey and Land Use
- **Water Management** (WM)

Field Crops (OFCRSC)
- Cereal Crop*
- Corn*
- Forage Crop*
- Oil and Protein Seed Crops*
- Pulse*
- Tobacco*

Food Processing (OFPRSC)
- Dairy Products & Processing
- Fruit/vegetable Products & Processing
- Grain/oilseed Products and Processing
- Meat Products and Processing

Horticultural Crops (OHCRSC)
- Agroforesty
- Apiculture & Pollination
- Berry Crops
- Crucifer Crops
- Ginseng
- Grape and Wine
- Greenhouse Flowers
- Greenhouse and Protected Crops*
- Low Acreage and Specialty Crops*
- Marketing
- Muck Crops
- Nursery/Landscape and Turf
- Pome Fruit
- Potatoes
- Stone Fruit
- Tomatoes*

Pest Management (OPMRSC)
- Crop Protection* (CP)
- Livestock & Poultry Pest Control
- Weed

* These Committees have formed sub-committees, some of which review research and draft recommendations.
Bold print denotes committee with lead responsibilities for issues related to manure management or its effects on the environment.

Appendix C: Research and Service Priorities Related to Manure Management Developed by OASCC Sub-Committees

RESEARCH priorities submitted to OASCC by Main Committees

Issue Area	Committee	Recommendation	Year
Water Quality Nutrient Mgt.	OSWARC	Investigate management systems to minimize contamination of surface and groundwater by nitrogen originating from fertilizers, legumes, manures and other organic sources, and by bacteria from manures and organic wastes applied to soils.	1993 & 1994
Nutrient Mgt.	OSWARC	Improve the OMAFRA Soil Test by developing and evaluating new methods of soil testing and calibrating soil tests for crops grown in Ontario.	1993 1994
Manure Mgt. Water Quality	OARSC	Improved Cost Efficiencies in Cattle Production and Processing: research to provide new technological innovations and refinements which will improve the cost effectiveness and efficiency of Ontario beef farmers and processors, with affordable solutions to environmental issues.	1994
Nutrient Mgt.	OARSC	To maintain environmental integrity and lower feed input costs, by reduction of nitrogen and phosphorus excretion through improvement of nutrient availability.	1994
Manure Mgt. Nutrient Mgt.	OARSC	Research on the impact of swine production on the environment and to develop systems which reduce this impact, as well as improve the health, safety and comfort of the pigs and operators.	1994
Manure Mgt. Nutrient Mgt.	OAFERSC	Investigate the spreading ability of solid and liquid manure applicators for uniformity at desired rates.	1993 1994
Water Quality Air Quality	OAFERSC	To assess the potential impact of large livestock operations on the rural environment.	1994
Air Quality	OAFERSC	C To develop an economical warning devices to alert farm personnel that a hazardous gas is at a dangerous level. C To evaluate devices and develop procedures for dealing with gas hazards in typical animal environments and feed storage areas. C To examine the chronic effects of sub-lethal gas levels and evaluate the extent of this aspect of the problem, on both humans and livestock.	1994

SERVICE Priorities submitted to OASCC by Main Committees

Issue Area	Committee	Recommendation	Year
Nutrient Mgt.	OSWARC	That a strong educational/awareness thrust be undertaken on: C the use and benefits of sewage sludge and other wastes; C the use, benefits and interpretation of the nitrogen soil test for corn and barley C soil management practices to maintain environmental quality	1993 & 1994
Nutrient Mgt.	OAFERSC	To develop a nutrient management extension program for Ontario farmers.	1994

RESEARCH Priorities Prepared by Sub-committees, but not Submitted to OASCC

Issue Area	Committee	Recommendation	Year
Water Quality Nutrient Mgt. Manure Mgt.	Water Mgt. (OSWARSC)	To develop an integrated approach for the management of water quality and nutrients for environmentally sustainable use of manure and agro-chemicals.	1994
Water Quality Nutrient Mgt. Manure Mgt.	Water Mgt.	To develop improved technical means & methods to properly interface the use of fertilizers in conjunction with livestock manures within the farm system. The intent is to minimize probable impacts to the surface and ground water systems.	1994
Water Quality Air Quality	Dairy (OARSC)	To support research into the assessment of different housing alternatives and their effects on animal welfare, profitability, producer welfare and the environment.	1994
Water Quality Air Quality	Dairy (OARSC)	To support research which assesses the impact of different manure handling and milking washwater disposal systems on the environment.	1994
Nutrient Mgt. Air Quality	Egg Layer (OARSC)	More research is needed into decreasing the amount of nitrogen and phosphorus in poultry manure. Other methods of recycling poultry manure need to be researched. New methods of formulating feeds, as a means of reducing nitrogen content in manure and ammonia levels in the barn, need to be investigated.	1994
Air Quality	Swine (OARSC)	Technology to reduce the impact of swine production through reduction of the nutrient content and odour associated with swine manure and through improved feed utilization.	1993 & 1995
Air Quality	Swine (OARSC)	To study of siting swine barns as to the odours generated, the risk of disease transmission to other swine units and the acceptance of large swine operations by the community.	1993 1995
Water Quality	Rural Env. Eng. (OAFERSC)	To investigate, develop and evaluate non-conventional methods of water treatment that could be used to reduce the amount of contaminants reaching water sources.	1994

RESEARCH Priorities Prepared by Sub-committees, but not Submitted to OASCC

Issue Area	Committee	Recommendation	Year
Water Quality	Rural Env. Eng.	To verify the effectiveness of existing and proposed structures and management practices intended to control the quality of water leaving areas of agricultural production.	1994
Manure Mgt.	Rural Env. Eng.	To study the effects of manure application in combination with soil conservation methods.	1994
Water Quality	Rural Env. Eng.	Assess water quality improvement with outlet-controlled watertable management.	1994
Manure Mgt.	Rural Env. Eng.	Investigate long term effectiveness of earthen storage structures as a method of storing liquid manure and contaminated runoff.	1993
Manure Storage	Structures & Building Env. (OAFERSC)	Determine feasibility of using steel coating and/or concrete additives to inhibit corrosion of reinforcing steel in adverse situations such as slatted floors, silos and manure storages.	1993
Air Quality	Structures & Building Env.	Encourage research to establish of Threshold Limit Values for the combination of air pollutants inside farm buildings.	1993

Appendix D: Excerpts from OMAFRA "Areas of Concern" Related to Manure Management

Environmental Sustainability

Environmental Farm Planning

The agricultural industry must demonstrate responsibility for achieving environmental sustainability within the sector through self-directed initiatives if it is to effectively respond to societal concerns regarding the environment in a pro-active manner. Two initiatives, funded by the federal government and supported by the province through technical assistance are the Environmental Farm Plan and the Best Management Practices programs assist the industry to achieve this goal. The role of OMAFRA is primarily to provide technical support in the continual development of these programs and their delivery. The programs have received strong endorsement from the senior management and are promoted in the field through the normal course of business.

Environmental Engineering

To develop, evaluate, demonstrate and transfer engineering technology to the agriculture and food industry so it can improve its efficiency, competitiveness and sustainability while ensuring a safe and healthy environment. Four engineering specialists (Water Management, Soil Management, By-Product/Waste Management, and Rural/Urban Interface) take a lead role on environmental engineering issues. All OMAFRA engineers have an assigned area in the province where they are OMAFRA's lead field people responsible for dealing with problems in the area of odours, noise, dust, waste management, pollution abatement, Ag Code of Practice, Minimum Distance Separation (MDS) calculations, and the Certificate of Compliance program. To administer the Farm Practices Protection Act: this Act deals with on-farm complaints about odours, noise and dust.

Overall Goal:

Enhance the agri-food industry's ability to utilize the most appropriate technologies and integrated systems and support an industry which actively invests in new technologies consistent with a safe and healthy environment. To increase competitiveness while enhancing environmental sustainability; and to increase the viability of rural communities.

Groundwater Management

Surveys carried out under the federal Green Plan indicated that about a third of farm wells exceed drinking water criteria for either bacteria or nitrates.

Objectives

1. Increase the regular testing of farm domestic well water by well owners.
2. Protect the groundwater resource while minimizing the negative impact of municipal well head protection programs on agriculture.
3. Increase the awareness of the farm community of potential impacts of specific agricultural, waste and well management practices on the quality farm and neighbouring well water.
4. Increase the number of field staff who are capable of providing basic groundwater information to clients.

Competitive Agriculture

Nutrient Management

Nutrient management encompasses a broad range of activities to ensure that nutrients for plant growth are managed and used in an environmentally responsible way in the economic production of crops. Nutrients are obtained from a number of sources including the soil, commercial fertilizers, livestock manures, municipal sewage sludges, and other urban wastes.

Overall Goal:
Utilize nutrients from a variety of sources efficiently in crop production minimizing or eliminating environmental impacts, in a cost effective manner by Ontario producers.

Soil Management

Improved soil management techniques are necessary in crop production to ensure long term soil productivity. This includes information on systems to reduce soil erosion, enhance organic matter content, improve soil structure, etc. Crop production systems challenge soil eco systems because of intensive cropping which includes poor rotations, and exposure to wind and water erosion.

Objectives
1. Improved recommendations on production systems to conserve soils (ie. windbreaks. shelterbelts, organic matter application, cover crops, etc).
2. Development and demonstration of new technologies which enhance the economic returns of adopting conservation tillage practices.

Livestock Production Management

Developing, implementing, evaluating and refining new management practices which will minimize costs and maximize returns is essential for survival in a world economy. Ontario's livestock producers are continually searching for the latest technology which will improve their competitive position. Providing producers with up-to-date information and assistance to implement breeding, feeding and other management programs and practices will result in improvements in productivity and efficiency in each livestock sector.

Overall Goal:
To establish in cooperation with other industry stakeholders sustainable livestock production sectors which contribute to the environmental, social and economic well being of Ontario.

Feeding Organic Wastes to Livestock

Utilizing organic wastes as livestock feed ingredients offers potential cost savings. Increased use of these opportunity feeds however must occur in an environmentally responsible manner. Nor can it compromise livestock health and welfare or the quality and safety of Ontario meat, milk and eggs.

Overall Goal:
Establish technologies, guidelines and advice on incorporating organic wastes in livestock rations that contribute to the environmental, social and economic well-being of Ontario.

Livestock and Poultry Housing

To develop, evaluate, demonstrate and transfer engineering technology to the agriculture and food industry so it can improve its efficiency, competitiveness and sustainability while ensuring a safe and health environment. Four engineering specialists (Beef and Dairy, Swine, Poultry and Other Livestock Housing and Equipment; Livestock Heating and Ventilating) take a lead role on livestock/poultry housing management requirements and issues. Areas covered include: stall/pen dimensions; traffic flow; labour efficient layouts; livestock/poultry comfort; manure collection, handling and transfer; air quality, gas and dust; heating and ventilating; feed and water handling; animal/poultry handling; product handling; alternative housing; deadstock disposal.

Program Goals:
1. Enhance the competitiveness of Ontario's livestock and poultry producers by increasing the efficiencies of building designs, layouts, labour requirements, etc.
2. Improved indoor environment translates into healthier animals and poultry, which can mean better feed efficiency and a better quality end product for the consumer.

Resources Management Engineering
To develop, evaluate, demonstrate and transfer engineering technology to the agriculture and food industry so it can improve its efficiency, competitiveness and sustainability while ensuring a safe and healthy environment. Three engineering specialists (Structural Design; Farmstead Planning/ Health and Safety; Electronic Technology and Information Management) take the lead role on these engineering safety and high tech issues. Areas covered include: building codes (the Ontario Building Code, the Canadian Farm Building Code, the National Building Code); the Occupational Health and Safety Code; indoor air quality (gas, odours, dust, noise); structural design; building component durability; satellite tracking; global positioning; data management.

Overall Goals:
Enhance the quality of life for farmers, their families, farm workers and the visiting public while on farms by providing a safe on-farm working environment. To enhance the competitiveness of Ontario's farmers through technology.

Agricultural Health and Safety
Reduced exposure to workplace hazards for farm operators, workers, and family members requires farmers to include health and safety measures as a farm management issue.

Objectives:
Establish a farm management approach to agricultural health and safety to decrease work related injuries and fatalities on Ontario farms.

Appendix E: Summaries of Individual Projects Conducted Under Green Plan (Ontario) Programs

1: Literature Search on Manure/Nutrient Management

Contractor: Dr. Michael Goss, Dept. of Land Resource Science, U. of Guelph, Guelph, ONT, N1G 2W1

Program: Green Plan Research: Manure/Nutrient Management

Objectives: To establish the current state of the art of Manure/Nutrient Management in North America and Europe by summarizing the current scientific and applied literature and by identifying pertinent research projects in other jurisdictions while commenting on their relationship to the Ontario experience.

Summary: A report has been printed containing a detailed literature review, bibliography and consensual information as an overview of the present state of our knowledge, helpful in identification of apparent gaps in our current knowledge.

Published as "Current State of the Art on Manure/Nutrient Management", April 1994, COESA Report No: RES/MAN-001/94

2: Rainfall Simulator - Grid Lysimeter System for Preferential Solute Transport Studies Using Large, Intact Soil Blocks

Contractor: Dr. B. T. Bowman, London Research Centre, AAFC

Program: National Soil Conservation Program

Objectives: To characterize macropore development under the influence of crops with different root development capabilities.
To relate macropore development to development of the subsequent crop and to solute transport.
To suggest or develop soil management systems which will curtail excessive amounts of adverse transport while retaining advantages of enhanced root development.

Summary: A technique was developed to study preferential flow of water and solutes in large blocks of intact soil, isolated at field sites and transported to the laboratory. Tracer experiments confirmed extensive preferential flow of water and solutes. The grid lysimeter system shows promise as a means to validate solute transport models, to investigate the behaviour of solute transport across soil interlayer boundaries and intermittent flow phenomena in soils.

3: Soil Macropore Structures and Their Effect on Solute Transport to Tile Drains.

Contractor: Dr. Gary Kachanoski, Environmental Soil Services, 605 Arkell Rd., Arkell, Ont N0B 1C0

Program: National Soil Conservation Program

Objectives: To characterize macropore transport of contaminants to tile drains.
To suggest or develop soil management systems which will curtail excessive amounts of such transport.

Summary: Significant preferential flow of contaminants can occur even under unsaturated conditions. Average values of hydraulic properties for each site did not predict the observed preferential flow and transport. More information will have to be included in predictions.

Tillage incorporation of tracer chemicals into the top 10 cm. of soil reduced loss of both reactive and non-reactive tracers from the root zone. Solutes applied to the soil are more likely to reach tile lines or the water table as the initial soil water content at the time of chemical application is increased. Increasing retention time of a solute in the soil matrix allowed it to reach equilibrium absorption and reduced its downward movement.

4: Regional Agricultural Practices and Their Potential for Land and Water Contamination.

Contractor K. B. MacDonald, I. E. Jarvis and F. Wang, A.A.F.C., Guelph 519-766-9180

Program Great Lakes Water Quality Program

Objectives

1) To characterize agricultural land use and management practices and land resource conditions in the Canadian Great Lakes Basin.
2) To incorporate data from a wide range of sources into one consistent spatial framework for analysis, classification and reporting of more detailed results.
3) To explore procedures to extrapolate field research to surrounding areas where conditions are similar.

Summary: Data from the following sources were assembled, and digitized, as required:

- Soil Landscapes of Canada at 1:1,000,000 scale.
- OMAFRA artificial drainage maps.
- data representing stream flow volumes and sediment loadings, from the Monitoring and Systems Branch of Environment Canada.
- 1991 Census of Agriculture
- Advanced Very High Resolution Radiometer imagery, classified according to land cover class.
- detailed soil pedon data from the Ontario Soil Names and Soil Layer files.

The GIS provided a powerful tool to manage, integrate and analyze data at various scales, for themes such as: land cover, surface texture, slope, surface shape, intensity of cropping and intensity of livestock production. Using existing databases, it was possible to develop broad scale characterizations of the biophysical, land use and management conditions in the basin and to apply models to predict the potential for contaminant loss. Detailed soils and slope data can be used to produce even better estimates of loss potential.

The potential for adsorbed and solution runoff of atrazine were estimated for the entire Mixed

Wood Plain Ecozone of southern Ontario (Lakes Erie, Huron and Ontario watersheds). Potentials were based on soil erodibility, drainage class, and the half life of specific pesticides and their ability to bind to soil particles or to become dissolved, using a generalized soil-pesticide model. Almost all intensively farmed areas were rated as having a high or medium potential for loss of pesticides in the adsorbed and solute forms, although adsorbed loss potentials were lower.

Three field scale sites were characterized in detail to determine the conditions of soil, crop, management and/or manure use that may lead to contamination of water with pesticides or nitrate.

The intensive cash crop region in Essex and Kent Counties was identified as having conditions that have implications for movement of pesticides and nitrate to tile drains and ground water. Conditions in intensive livestock-based areas, such as parts of Oxford, Perth, Huron and Wellington Counties, result in high susceptibility to surface and subsurface loss of pesticides, bacteria and nitrate. In the remainder of the Mixed Wooded Plain area, the susceptibility to loss of pesticides, bacteria and nitrate decreased in proportion to the reduction in input levels.

5: Partitioning of Solutes from Agricultural Fields within the Hydrologic System at Two Sites in Southern Ontario and the Subsequent Impact on Adjacent Aquatic Ecosystems

Contractor: Dr. David Rudolph (Kachanoski, van Wesenbeeck, Barton), Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, ONT N2L 3G1

Program: Green Plan Research: Development of Integrated Resource Monitoring Capability

Objectives: To construct a sufficient data base which will represent annual variations in the agricultural cycle by quantifying the contaminant flux distribution over the annual cycle though a hydrologic water balance focusing on water partitioning between the unsaturated zone, saturated zone, tile drainage and surface water systems; by evaluating the significance of spatial positioning within the field; by documenting subsurface geochemical conditions that control the nitrification-denitrification processes in relation to the spatial positioning; by assessing the health of the aquatic ecosystem in the surface water drains compared to systems not impacted by similar toxins and finally, to employ newly-developed mathematical models to develop predictive capabilities for agricultural land-use impact assessment.

Expected Outputs: Documentation of the annual variability in water flux as a result of seasonal variation and during specific hydrologic events such as large rain storms will be provided. In addition the spatial and temporal variability of nitrogen compounds including ammonia and nitrate will be tracked. Additional chemical parameters will include dissolved oxygen, dissolved organic carbon and pH. The combination of the water balance and nitrogen balance measurements will provide a fairly detailed view of contaminant flux partitioning between soil water, shallow groundwater, tile drainage, deep ground water and surface water. Non-reactive tracers will be used at both sites to provide additional information for calibration and interpretation of contaminant transport observations.

Ending: 1996-97:

6: Prediction of Agrochemical Migration

Contractor: W. D. Reynolds, R. de Jong, S. R. Vieira and R. S. Clemente, CLBRR, Ottawa

Program: Soil Quality Evaluation Program

Objectives: To develop the capability to quantify the soil's potential for preventing pollution of ground water by the leaching of agrochemicals.

Summary: Methods were developed for characterizing and predicting the downward migration of atrazine. Spatial and temporal variability in atrazine movement is being accounted for via the combined use of a solute transport model, pedotransfer functions, geostatistical analyses and a GIS.

Two submodels of LEACHM (Leaching Estimation And CHemistry Model) were modified for use in this study: LEACHW, which describes soil water flow, and LEACHP, which describes sorption, migration, and degradation of pesticides. These submodels were tested in both laboratory and field studies and then were used to predict atrazine leaching through soils in the Grand River watershed.

The Grand River predictions were consistent with results of a recent ground water quality survey. Both studies concluded that non-point contamination of ground water with atrazine was rare and not strongly related to soil type or land use. Although further development and testing is required, the modified submodels appear capable of simulating both laboratory and field-measured transport of water, chloride and atrazine with acceptable accuracy. Ultimately, the methodology should prove useful in the development of agricultural practices and guidelines that will maintain inputs to groundwater at acceptable levels.

7: Fate of Agricultural Chemicals in Soil, Ground Water and Agricultural Drainage Water, Under Farm Conditions.

Contractor: N.K. Patni L. Masse, P.Y. Jui and B.S. Clegg, A.A.F.C., Ottawa, 613-993-6002

Program: Great Lakes Water Quality Program

Objectives: To determine the long-term fate of metolachlor, atrazine, nitrate and phosphorus in tile-drained, loam corn fields under no tillage and conventional tillage, by measuring chemical concentrations in tile effluent, and soil, ground and surface waters.

Summary: Trials were conducted at a site that has been established near Ottawa for long-term monitoring (since 1987) of field-scale transport of chemicals in soil and water under different management practices.

Tile drainage. Flow was higher under NT than CT during the spring/snowmelt but was not significantly different during the growing season or fall. Atrazine and deethylatrazine were almost always present in tile effluent, usually below the Canadian drinking water guideline. Concentrations did exceed the guidelines in rainfall-induced flows within a few weeks of application. Metolachlor was present in only a few samples, well below the drinking water guideline. Nitrate-nitrogen concentrations were above the drinking water limit in 93% of the samples and were higher under CT than NT, except in the spring. Soluble total phosphorus exceeded 30 ug/L in about 25% of the samples tested.

Groundwater Atrazine, deethylatrazine and metolachlor concentrations were well below

drinking water standards. Atrazine and deethylatrazine concentrations were consistently higher under NT than CT up to 3.0 m depth. Nitrate-nitrogen concentrations decreased with depth, but still exceeded the drinking water standard in 80% of the samples at depths up to 3.0 m. Soluble phosphorus concentrations exceeded 30 ug/L in over 50% of the samples at depths up to 3.0 m.

8: Beef Feedlot\Yard Runoff Control by Vegetative Filter Strip
Ontario Cattlemen's Association; Green Plan: Rural Conservation Club

A three year project on up to 5 farms to study the effectiveness of vegetative filter strips as means of treating barnyard runoff. The strips will be level across their width and have slopes 0.5% to 4%, to evenly spread runoff across the strip to allow time for proper treatment. Grass species (e.g. reed canary, brome or orchard grass) will be planted.

Peter Doris, Ontario Cattlemen's Association, (519) 824-0334.

9: Milkhouse Washwater Control Using a Vegetative Filter
Farm Pollution Control Alternatives Assoc.; Green Plan: Rural Conservation Club

The club was established to install and monitor a vegetated filter strip at Kemptville College of Agricultural Technology, with the following objectives:

- to evaluate the performance of a vegetated filter strip for the treatment of milkhouse washwater and yard runoff under Eastern Ontario conditions.
- to evaluate the effectiveness of a vegetated filter strip during the winter and early spring when vegetation is dormant.
- to evaluate the environmental impact of vegetated filter strips under Ontario conditions.
- to determine the long-term impact of vegetated filter strips on soil nutrient content and subsurface water quality.
- to develop design criteria for implementation of vegetative filters on Ontario farms.

Luc Brunet, M.Sc., P. Eng., Kemptville College 1-613-258-3411

11: Constructed Wetland Treatment Facility
The Belle River Conservation Club; Green Plan: Rural Conservation Club

A four year project in which, club members with the Essex Region Conservation Authority constructed a 3-stage wetland treatment system which will help dispose of livestock wastes from a dairy operation. Wastewater produced at the farm will be stored in a pond and released into the wetland during the summer months. The wetland, composed of cattails, bulrushes and other vegetation provides both an anaerobic and aerobic environment which will effectively remove harmful nitrates, phosphorous and bacteria from the wastewater. Trees and various shrubs will also be planted in and around the site.

Paul Hermans, Region Conservation Authority, (519) 776-5209

12: Constructed Wetland Project
South Nation River Conservation Authority; Green Plan: Rural Conservation Club

A four year project to design and develop a constructed wetland to treat runoff from a manure storage, milkhouse wastewater and a large adjacent feedlot area. The site has a high fluctuating water table, which, in the fall, was located just below the soil surface. The wetland system will be constructed above grade in addition to other measures in order to protect the groundwater quality from contamination. As a result, pumping will also be required. The wetland will consist of 3 treatment areas: a marsh, a pond and an overland filter strip.

Mary-Ann Wilson, c/o South Nation River Conserv. Auth., (613)984-2949

13: Essex Manure Management Club; Green Plan: Rural Conservation Club
In this four year project members of this Club have constructed a two stage earthen lagoon in Sandwich South Township to receive liquid swine manure from a primary tank under the farrowing barn. The effluent from the 3rd

stage of the manure storage will be irrigated onto a 20 acre pasture grazed by cattle. A different mixture was used in each of the four paddocks, to evaluate pasture mixtures in an irrigated rotational grazing program. The mixtures are as follows: Birdsfoot Trefoil and Creeping Red Fescue, TPR Pasture Blend/Creeping Red Fescue/Grassland White Clover/Perennial Ryegrass and Kenny Hybrid Fescue, Ryegrass/Tall Fescue/Reed Canary Grass and White Dutch Clover, Reed Canary Grass and White Clover.

Five piezometers have been installed around the project site in order to monitor groundwater quality. Background samples have been taken on a weekly basis since October. Monitoring will continue on a reduced frequency throughout the winter. Following the installation of catch basins intercepting subsurface tiles, subsurface drainage water quality will be monitored for baseline date.

Essex Region Conservation Authority, (519) 776-5209

14: South Simcoe Conservation Club Wetland Project

South Simcoe Conservation Club; Green Plan: Rural Conservation Club

Objectives:

- to provide environmental learning opportunities for club members.
- to provide environmental learning opportunities for farmers in Simcoe County.
- to develop innovative and cost effective approaches to farm wastewater management.
- to have technically and enviromentally sound construction and monitoring in order to produce a meaningful and defensible research project.
- to develop useful techniques, models and literature for future farm wastewater management projects.

Mark Peacock, P.Eng., Nottawasaga Valley Conserv. Auth., R.#1, Angus 1-705-424-1479

15: Assessment of the influence of manures for the control of soilborne pests including nematodes, fungi and bacteria.

Contractor: Dr. George Lazarovits, Pest Management Research Centre, AAFC, 1391 Sandford St, London, ONT, Canada, N5V 4T3

Program: Green Plan Research: Manure/Nutrient Management

Objectives: To assess potential of manures and related organic materials for reducing plant diseases caused by soilborne pests.

Expected Outputs:

1) To conduct an initial survey of manures from various sources and in various stages of decomposition to determine if these materials exhibit an ability to suppress Verticillium;
2) To measure the capacity of the "active" manures for reducing the survival of Verticillium and controlling diseaes.
3) To monitor changes in populations of beneficial microbes in manures;
4) To identify factors which may influence disease control efficacy, (e.g. manure source, application rate, composting, soil type, etc.) Treatments found effective in the laboratory will be field tested in microplots and on farms growing potato and tomato crops. Field observation will measure pathology, soil microbiology and agronomic changes in the crop plants tested. Information as to the appropriate methods of application of manures for disease control will be generated.

Ending: 1995-96:

16: Nitrogen & Carbon Transformations in Conventionally-Handled Livestock Manures.

Contractor: Dr. G. Kachanoski, Environ. Soil Services, 605 Arkell Rd., Arkell, Ont N0B 1C0

Program: Green Plan Research: Manure/Nutrient Management

Objectives: Document the state of our knowledge of nitrogen and carbon transformations which occur during conventional storage and handling of solid and liquid livestock and poultry manures; to investigate various manure storage and handling techniques with respect to N and C changes during storage and handling while recognizing nutrient conservation and availability for plant growth; to provide a comparative economic assessment of costs associated with manure handling, the nutrient content and value of the final product.

Expected Outputs: Nitrogen and carbon components in the feed, bedding and excrement of livestock will be tracked during handling and storage. Recognizing the changes which are certain to occur after application of the manure to the land consideration will be given to techniques which involve incubation of manure with soil. Consideration will also be given to monitoring the losses from the greenhouse gas perspective. Information obtained should enable the prediction of manure nitrogen availability for plants and losses of environmental importance.

Ending: 1996-97

17: Composting Poultry Manure with a Passive Aeration Windrow System

Contractor: Niagara South S.C.I.A.: Hugh Fraser, OMAFRA; Chris Attema, Niagara Peninsula C. A.

Program: Ontario Land Stewardship Program II

Objectives: Evaluate suitability of the Passively Aerated Windrow System for composting poultry manure.

Summary: The system was tested on a small scale, but larger scale testing did not proceed because the system was impractical and did not produce high quality compost. Placing manure on the aeration pipes was costly and time-consuming. Poultry manure appeared to be too dry to compost properly and the pile reached very high temperatures.

18: Evaluation of Three Manure Composting Methods for Nitrogen Conservation, Environmental Impact, Crop Growth Response and Operating and Maintenance Costs

Contractor: Richard St. Jean, Ecologistics, 490 Dutton Drive, Suite A1, Waterloo, Ontario N2L 6H7

Program: National Soil Conservation Program

Objectives: To evaluate three methods of manure composting as a means to retain nitrogen in a non-leachable form during the fall and winter following application.
To measure the effectiveness of these approaches as a means for supplying nitrogen to a crop during the subsequent growing season.
To compare operating and maintenance costs of each system.

Summary: Nitrogen losses from volatilization or from leaching did not differ significantly among treatments (passive aeration, turned pile, forced aeration, control pile).

A cover of peat moss on the passive aeration windrow showed an excellent capacity to retain nitrogen, although about one third was in the ammonical form.

For composting to be completed under cover, the moisture content of the manure must be maintained above 45 percent. The high evaporative capacity of composting manure suggests potential as a means to process barnyard runoffs and milkhouse washwater.

There was no significant difference in corn yields among treatments; yields were more consistent in plots receiving commercial fertilizers as compared to all other treatments.

19: Manure Composting Techniques: Understanding N & C Conservation

Contractor: Richard St. Jean, Ecologistics Ltd, 490 Dutton Drive, Suite A1, Waterloo, ONT N2L 6H7

Program: Green Plan Research: Manure/Nutrient Management

Objectives: To evaluate composting techniques suitable for use by livestock and poultry farm operations with emphasis on carbon, nitrogen and other transformations and losses, the effect on productivity, sustainability, environmental impact, economic viability and potential for implementation in an manure management and nutrient recycling program.

Expected Outputs: Information on carbon, nitrogen and other nutrient transformations and losses; economic and physical limitations of optimizing manure C/N ratios; the evaporative potential of composting manure; relative nutrient leaching potential of manures and compost; comparison with composting techniques promoted by the Ecological Farmers of Ontario; the practicality of recycling finished compost as livestock bedding; the quantification of greenhouse gas production; and databases to establish labour, energy and capital requirements in each process.

Ending: 1996-97

20: Transformation Rates of Inorganic Nitrogen in Animal Manure Into Plants and Soil Organic Matter and its Re-Release From Soil Organic Matter

Contractor: Dr. M.J. Goss, and P.S. Smith, Centre for Land and Water Stewardship, Univ. of Guelph, Guelph, ONT N1G 2W1

Program: Land Management Assistance Program

Objectives: To study the fate of nitrogen from liquid dairy cattle and composted cattle manures in two field experiments (at the Elora Research Station, and at the Winchester research Station of Kemptville College), in which cover crops are grown to investigate the cycling of manure nitrogen between soil and crops in the fall, and to identify whether significant nitrogen is transferred from the cover crop to corn planted in the following spring.

Expected Outputs: Improved understanding of nitrogen cycling from animal manures into soils and crops, and show the role of cover crops in nitrogen transformations.

Ending: COMPLETED: Published as *An Investigation into Management of Manure-nitrogen to Safeguard the Quality of Groundwater* LMAP Report 013/95

21: Transformations in Soil: Crop Response to Nitrogen in Manures with Widely Different Characteristics

Contractor: Dr. E. G. Beauchamp, J. Buchanan-Smith and M. Goss, Dept. of Land Resource Science, University of Guelph

Program: Green Plan Research: Manure/Nutrient Management

Objectives: Develop an understanding how the N in manures with different characteristics applied to soil in the field is immobilized or mineralized and released in synchrony with crop N requirement. Soil factors include time of application, soil texture and soil acidity. Manure characteristics include the effects of the protein levels in the dairy rations.

Expected Outputs:

Phase 1 - Development of a yield response curve for corn with fertilizer, and comparison with manure N rates;

Phase 2 - Comparison of the mineralization/ immobilization and availabilities of N from five different manures following fall and spring applications on one site;

Phase 3 - A laboratory study on the influence of soil texture involving four soils ranging from loamy sand to clay loam;

Phase 4 - A laboratory incubation study of four soils ranging in soil acidity to monitor ammonium and NO^-_3 contents.

Phase 5 - Using feeding trials and characterization of the manure to develop one or more models for predicting manure N content of manures from animals given different feedstuffs.

Ending: 1996-97

22: Impact of Manure Application Methods on Water Quality, Focusing on Nitrogen and Bacteria Transport in Soil.

Contractor: Dr. Greg Wall, Land Resource Division, C.L.B.R.R., Guelph

Program: Green Plan Research: Manure/Nutrient Management

Objectives: Field scale study of liquid manure applications to identify pathways and process of nutrient and bacterial transport to tile drains and ground water with emphasis on preferential flow. The objectives include the validation of water quality models (GLEAMS, DRAINMOD) with field scale data and to use the models to identify scenarios in which water quality standards are likely to be exceeded.

Expected Outputs: Agronomic monitoring with liquid hog manure as the source of the N requirement for corn production; the determination of basic solute transports parameters for each soil type; tile water quantity/quality measurement in response to manure treatments; ground water quality; and solute transport measurements. The use of reactive and nonreactive tracers will be used to indicate the affect of initial soil moisture levels on solute travel times and macropore flow. Results should enable prediction of environmentally safe rates of liquid manure application to land, and development of methods for manure application in no-till systems.

Ending: 1996-97

23: The Effects of Livestock Manure Application and Management on Surface Water Quality.

Contractor: D. King, G.C. Watson, G.J. Wall, and B.A. Grant, A.A.F.C., Guelph 519-766-9180

Program: Great Lakes Water Quality Program

Objectives:

1) To evaluate several manure management application techniques and timing of application used in conservation management systems to determine the best method to minimize downward movement of nutrients and bacteria to tile drains:
2) To compare fuel consumption requirements of manure management application techniques and recommend practices with field scale testing;
3) To formulate remedial steps for reducing nutrient and bacterial contamination of tile drains.

Summary: A modified injection technique (ie. disturbance of the macropores by cultivation prior to injection), can significantly reduce nutrient and bacteria contamination in both surface runoff and tile drain water, compared to conventional techniques.

Liquid manure application on medium-textured soils under no-tillage (NT) may result in excessive levels of nutrient and bacteria contamination in tile drain waters. Observation of manure contaminants in tile drain water shortly after manure application suggests downward movement by preferential flow. While posing an environmental concern, the loss of nutrients to tile drains from liquid manure applied at at rate equivalent to crop nitrogen requirements is relatively low from a crop production standpoint.

The prototype modified injection technique required slightly more draft, power and fuel than conventional injection, but not so much more as to pose an obstacle to adoption by farmers.

The system used for monitoring flow in tile drains proved to be an inexpensive and reliable method to monitor relatively low flow rates continually over an extended period of time.

24: Investigating Methods of Integrating Liquid Manures into a Cropping System and the Effect on Soil and Water Quality.

Contractor: David Charlton, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, N1G 3M5

Program: Green Plan Research: On-Farm Research

Objectives: To examine in cooperation with farmers the effectiveness of several methods and rates of liquid manure application within conservation farming systems; and to investigate techniques for retaining the nutritive value of manure in the root zone.

Expected Outputs: Evaluations of the prescribed rate of manure, determined by soil test for N, as a source of nitrogen, in comparison with mineral fertilizer; effectiveness of the manure from different types of livestock; and importance of timing of the manure application relative to the stage of growth where comparisons are directed to the feasibility of soil injection, sidedressing or top dressing of liquid manures.

Ending: 1996-97:

25: Managing Cover Crops and Tillage to Conserve Nitrogen following Manure Applications

Contractor: Perth County Pork Producers, Cattlemen and Milk Committee; Dr. T. Vyn, Univ. of Guelph

Program: Ontario Land Stewardship Program II

Objectives: To evaluate the ability of various cover crop species to absorb nitrogen from fall applications of manure and to reduce nitrogen losses over winter.
To examine the effect of the type of manure and tillage system on nitrogen conservation and utilization.

Summary: Trials were conducted at two sites in 1992-93. At Sebringville, soil nitrate-N levels in late November were greater where liquid hog manure was applied than where solid dairy cattle manure was used. Both were greater than the check. Because of late planting, cover crops were able to absorb relatively little nitrogen, although concentrations were higher in plants grown in manured plots. In the spring (April 30 and May 20), soil nitrate-N levels were always higher in plots that were fall plowed than in no-till; by June 24, there was no difference between tillage treatments, except where red clover was grown. Fall application of manure did not increase soil nitrate levels until the June 24 sampling date.

At Elora, tillage prior to application of liquid manure did not alter the nitrate-N concentrations in the upper 30 cm. Cover crop growth and total N in biomass were much greater in the manured plots, than in the check plots, but plant N concentrations were not different. Soil nitrate-N levels were significantly higher were there was no cover crop.

26: Manure Management to Sustain Water Quality

Contractor: Dr. M. J. Goss, University of Guelph

Program: National Soil Conservation Program

Objectives: 1) To evaluate the risk of nitrate leaching from fall-applied cattle manure on land previously under alfalfa.
2) To determine if the risk of nitrate leaching can be reduced through use of cover crops, incorporation of straw or sowing of winter wheat.

Summary: Growth and yield of corn and the yield of barley were largely unaffected by treatment. Barley lodged preferentially on plots receiving manure.
Nitrogen released by ploughing of the alfalfa sod was sufficient for the corn crop. The main release of nitrogen from cover crops occurred late in the growing season. The nitrogen soil test did not adequately reflect the release of nitrogen from crop residues. None of the fall treatments to immobilize nitrogen was adequate to reduce the risk of nitrate leaching significantly.

27: Field Drainage Tile Water Quality Study

Contractor: Eastern Ontario Progressive Farmers Assoc.; Pierre-Yves Gasser, Ag-Knowledge, Ontario

Program: Ontario Land Stewardship Program II

Objectives: To determine if liquid manure applications on barley stubble adversely aggects the quality of water emitted from underlying drainage tiles.

Summary: E. coli counts in tile water increased 10 fold between 16 and 25 hours after spreading of liquid poultry manure. The concentration of ammonia in the water also increased over the same period, going from non-detectable to 2.3 mg/L in 55 hrs.

28: Renfrew Manure Analysis, Sampling and Spreader Calibration Project

Contractor: Renfrew S.C.I.A., c/o Paul Sullivan, OMAFRA, Nepean

Program: Ontario Land Stewardship Program II

Objectives: To provide farmers with information regarding the nutrient analysis of the manure from their farms and the rates at which they are applying manure.

Results: No final report was included in the file.

29: Oxford Manure Application Study

Contractor: Oxford SCIA, c/o Chris Brown, OMAFRA, Woodstock

Program: Ontario Land Stewardship Program II

Objectives: 1) To evaluate crop response to the application of different types of manure at varying application rates.
2) To collect information regarding the nutrient contents of different types of manures.
3) To measure application rates and assess uniformity of spreading patterns.

Summary: Information was compiled on the nutrient contents of 139 samples of manure over a 3 year period. There was little year-to-year variability in the analysis of the manure from an individual storage provided that the livestock ration and management of the system was not changed significantly.

There was little or no response in yield to manure use at most sites, relative to unmanured checks. The large amount of nitrogen in unmanured soil was also confirmed by spring soil nitrate-nitrogen tests. Little nitrate-N tests was present in the soil in the fall, although total N supply applied from "normal" application rates exceeded crop requirements in most cases, especially for liquid hog manure.

Data from four experiments indicate the variability in spreading patterns - in general, the application rate close to the spreader was at least double that halfway between spreader paths. Some information illustrating the effect of wind on the spreading pattern from irrigated manure is presented.

30: Manure Management in High Residue Applications

Charing Cross Conservation Club; Green Plan: Rural Conservation Club

This four year project involves trying to develop a system that will allow use of manure in high residue systems, using different coulter configurations to build up soil organic matter and to improve soil structure.

Rob Smyth, Director, (519) 436-0501.

31: COMPUTER SIMULATION OF BMP'S - A strategy to locate and manage artificial wetlands, ponds, infiltration systems and overland flow treatment systems in Ontario

Contractor: Claude Weil, Alfred College

Program: Land Management Assistance Program

Objectives: Over the past twenty years, there has been increasing public pressure to improve the quality of recreational waters in urban areas. Best Management Practices (BMP's), such as wet ponds, have been extensively tested and are routinely constructed. Global urban strategies for the control and treatment of stormwater runoff have been established using powerful computer planning models such as **QUALHYMO** (Rowney, 1985) and Express SWMM (Nix et al, 1989).

The objective of the work is to provide decision makers with a computer model for the management of water quality in rural areas using: artificial wetlands, slow and fast infiltration beds, facultative and aerobic ponds and overland flow systems.

For each watershed, such a model would allow the definition of a network of selected BMP's. Their type, location, design, operational mode and interaction would be defined for local climatic and land use conditions.

32: A Program to Assess Surface- and Groundwater Quality At Farm Sites Selected for Artificial Wetland Construction

Contractor: Assoc. of Conservation Authorities of Ontario, 418A Sheridan Street, Peterborough, ONT K9H 3J9 (Contact: Mr. David Hayman, Upper Thames Conservation Authority, R. R. #6, London, ONT N6A 4C1)

Program: Land Management Assistance Program

Objectives: 1) To identify approximately 12 farm sites across the province of Ontario which would meet at least one of the accepted design layouts for constructing an artificial wetland;
2) To install equipment for the monitoring of both surface and groundwater quality at each of the identified farm sites identified in Objective 1 in advance of the construction phase (which is to be completed by the end of 1994), to provide baseline water quality information.

Expected Outputs: The report from this project will document the various Artificial Wetland designs used in the study, and will provide detailed information on the instrumentation used to monitor water quality (surface, groundwater) at the sites.

Ending: COMPLETED

Appendix F: Green Plan Manure Management Projects in Other Provinces

Newfoundland

Environmental Education and Awareness Program

Tour of Portable and Semi-portable Manure Handling Facility - 1994/95

Description: This project allowed a Provincial Specialist and 2 farmers to tour Portable and Semi-portable manure handling facilities in Ontario to obtain information about the product and awareness and understanding of new waste management facilities and technology.

On-Farm Training for Composting Poultry Manure - 1994/95

Description: This project allowed a Provincial Soils Specialist and 1 farmer to participate in on-farm training in Ireland that teaches the making of compost, utilizing poultry manure.

Agricultural Resources Management Program

Peat as Alternative Bedding for Poultry Chickens - 1995/96

Description: Funding was provided to assess the suitability of sphagnum peat as bedding in chicken production including the effects on broiler performance and suitability of used bedding for composting with broiler manure.

Technology Adoption Program

Manure Handling Facility

Description: Financial assistance is provided to producers to assist in establishing proper manure handling facilities for their operations.

Other Manure Handling Activities

Description: Financial assistance is provided to assist producers to improve their existing manure handling facilities, through purchase of equipment.

Prince Edward Island

Waste Management Program

Construction of 11 manure storage facilities

Nova Scotia

Sustainable Agriculture and Awareness Program

Slide Sets and Publications on Applied Agricultural Waste Management

Description: The purpose of this project is to produce slide sets (with text) and publications (fact sheets and brochures) which illustrate and inform the agri-food industry about the most current practices of agricultural waste management. The project will also develop and present three workshop/courses on applied waste management with special emphasis on composting.

Agri-Food Resource Management Program

Fly Monitoring and Approaches to Fly Management - Phase I

Description: This project conducted a study to determine suitable fly management scenarios that are both environmentally acceptable and sustainable, and to allow for the safe use of, and enhanced benefits from animal waste resources. Relatively large amounts of manure need to be disposed of and/or stored. The common house fly was the main nuisance fly species involved. It was not possible to solve the problem, during this phase of the project, only problem avoidance and relocation were achieved.

Fly Management - Phase II
Description: The second phase of the builds on the findings of the first to investigate and promote practical and least toxic approaches to managing filth flies. This phase also produced fact sheets to assist farmers and communities with implementing integrated fly management programs.

Assessment of Impact of Manure Application on Water Quality
Description: The purpose of this project was to quantify the impact of manure application (land spreading) on surface and subsurface drainage water quality. The study was conducted, from March 1, 1993 - March 31, 1995, on a field in Streets Ridge, Cumberland County, with a shallow slowly permeable field. Known quantities of solid beef manure were applied and incorporated in experimental drainage plots prior to seeding them in a timothy/alfalfa mix. Data on nitrate and other pollutants in surface and subsurface water, as well as on crop yields were collected.

Deep Pit Conversion
Description: This project provided financial support to convert a deep pit layer barn into a single story barn through the introduction and evaluation of a stack type cage system with a manure drying system above the manure belt. This new system will completely eliminate flies and odour problems, without the use of insecticides. The effectiveness of the technology will be monitored and the site open for farm tours and demonstration days.

Agri-Food Waste Management Program

Feasibility of Municipal and Agricultural Composting
Description: This project enabled the applicant to hire a consulting firm (P. Jacobs & Associates) to conduct a feasibility study for the marketing of compost. It was concluded that the level of waste diverted from landfills to make the facility viable is far from realistic for the short term. Significant quantities must be attracted from food processors if the project is to be viable.

Salmet Poultry Waste Composting Project
Description: This project demonstrates a composting technology for poultry (layer) manure which will eliminate a manure disposal problem, and fly and odour problems associated with manure.

Weather Based Manure Spreading Index
Description: This project will evaluate the magnitude of NH3 emissions from Nova Scotia farm operations. Environmental and physical factors that affect NH3 volatilization from surface applied manure will be identified. Weather based techniques will be developed and supplied to growers through a farm weather forecast index to diminish future ground level emissions of NH3 from surface applied manure. It is hoped that a Manure Spreading Index (MSI) that can be included in Environment Canada's short and long range weather forecasts to help farmers better plan manure spreading activities.

Slide Set & Publication on Agricultural Waste Management
Description: Production of slide sets and publications to inform the agri-food industry about the most current practices of agricultural waste management. The project will also develop and present three workshop on applied waste management with special emphasis on composting.

Evaluation of a Manure Transportation System and Utilization
Description: This project assessed a cost effective method of transporting and storage of barnyard waste a distance from the farm site and immediate area. It also evaluated the advantages of applying liquid manure from a pumping & transfer system.

New Brunswick

Environmental Education and Awareness Program

Environment and Agricultural Conferences

Description: To increase awareness among New Brunswick farmers of environmental issues facing the industry, a one day conference for farmers was held at four locations across the province in March 1994, covering the following: pesticide storage and handling; manure management; soil conservation; watercourse protection; waste utilization/recycling; watercourse alteration; Green Plan program information; and environmental planning.

Conference on Nutrient Management

Description: A one day seminar was held to increase awareness among New Brunswick farmers of various aspects of nutrient management and identify tools for farmers to minimize the impact of agricultural practices and activities on the environment. Subject areas covered included:

- Need for Adequate On-Farm Nutrient Management;
- Manure as a Resource;
- Chemical Fertilizer Efficiency;
- Green Manure Utilisation;
- Integrated Nutrient Management;
- Soil Nutrient Balances for Healthy Plants and Animals;
- Impact of Agriculture on the Environment; and,
- Nutrient Management on Farm makes Dollars and Sense.

Nutrient Management on the Farm

Description: A conference was held for agronomists from the New Brunswick Department of Agriculture and Rural Development to transfer information that to improve nutrient management and reduce the negative impact of agriculture on the environment. Subject areas covered included:

- Applications of Nutrient management to Farm Systems;
- Fall Cover Crops to Optimize Nutrient Utilization;
- Manure Storage for Maximum Nutrient Retention;
- How to Compost Manures on the Farm;
- Soil Compaction: Avoiding and Fixing a Widespread Problem;
- Designing a Nutrient Management Plan for Your Farm;

Horticulture Seminars in Integrated Pest Management

Description: This project sponsored three technical seminar session speakers to address commercial horticulture producers on the subject of Integrated Pest Management in strawberry, sweet corn, cole crops, lettuce and carrot. Subject areas covered included:

- Applications of Nutrient Management to Farm Systems;
- Fall Cover Crops to Optimize Nutrient Utilization;
- Manure Storage for Maximum Nutrient Retention;
- How to Compost Manures on the Farm;
- Soil Compaction: Avoiding and Fixing a Widespread Problem;
- Designing a Nutrient Management Plan for Your Farm;

Manure Management Seminars

Description: A series of Manure Management seminars for farmers were held in March of 1995 across New Brunswick. Topics included: manure application on corn; manure and the nitrogen cycle; and manure systems and their application in New Brunswick.

Environmental Initiatives Programs

On-Farm Manure Management and Evaluation

Description: This project examined the application rate of manure required to obtain economic yields of grain and forage crops on livestock farms in the Southern Region of New Brunswick. It also examined nutrient levels remaining in soil following horticulture crops which can be used to produce more economical grain and green manure crops in the rotation plan.

Demonstration of Manure Injection System

Description: Assisted in the purchase of a manure injector which can inject manure into pasture land or crop land without damage to fields.

Demonstration of a Oligolyt & Manure Treatment System

Description: This project evaluated the Mistex Manure Pump in terms of its ability to handle 40 to 60% more dry material than any other pump on the market. Also, the project evaluated the Oligolyt G manure treatment system in terms of its ability to reduce odour and improve nutrient ability.

Manure Management Planning and Monitoring Phase II

Description: This project continues the manure management planning that was initiated under the Environmental Sustainability Initiative and the Land Management Assistance Program. Manure and agricultural waste management pilot projects dealing with milkhouse wastes, manure storage, odour control, and manure treatment were monitored and evaluated.

Nutrient Management Evaluation

Description: This allowed the New Brunswick Department of Agriculture and Rural Development to purchase an optional Hydraulic Rotator Shredder kit for distribution with the top discharge system used on the Houle tool bar purchased through GPD5001 which allowed the unit to spread liquid manure. These attachments will be used with farmers' existing equipment to demonstrate the value of these attachments in spreading manure.

Quebec

Research Program

Réduction de la pollution agricole par traitement des eaux de laiterie et des eaux provenant d'une plate-forme d'entreposage de fumier solide. L'objectif principal du projet est de fournir une solution techniquement et économiquement intéressante pour le traitement des effluents de ferme.

Adaptation d'un sarcleur existant pour l'incorporation du fumier solide épandu en post-levée dans une culture de maïs. Modifier un sarcleur existant pour incorporer du fumier solide de bovins épandu en post-levée dans le maïs-grain.

Technology Innovation or Promotion Programs

SÉCHAGE ET ENTREPOSAGE DE FIENTE DE VOLAILLES.

Obtenir un fumier de poulet à 85 % de matière sèche pouvant être ensaché et vendu au détail.

Description du projet: À partir d'un pré-séchage du fumier à l'intérieur du poulailler, on veut continuer le séchage dans un séchoir construit à cette fin pour obtenir un produit à 85 % de matière sèche, comparativement à 60 % à la sortie du poulailler. Le fumier une fois séché, sera pelletizé et ensaché.

Évaluation de l'efficacité de l'azote du fumier solide de volaille épandu en post-levée dans le maïs

Évaluer l'efficacité de la pratique épandage en post-levée. Préciser le degré d'économie. Augmenter le nombre de jours d'épandage. Améliorer les aspects techniques. Laisser le moins possible de nitrates résiduels.

Utilisation rationnelle des engrais de ferme dans la culture du maïs-grain et autres cultures

Réduire les risques de pollution dus à l'apport excessif d'engrais. Reconnaître l'importance des analyses de sols et de fumiers pour déterminer la vraie valeur fertilisante de ces derniers. Diminuer les dépenses liées à l'achat d'engrais minéraux.

Suivi dans le fumier de vache
Démontrer l'intérêt de la valorisation des fumiers. Modifier des comportements. Créer une occasion d'échanges entre les producteurs et productrices.

Valorisation des fumiers de ferme chez les producteurs laitiers de Bagot
Promouvoir l'idée de calculer la valeur fertilisante des fumiers. Réduire les coûts de production. Éviter les problèmes de contamination de la nappe.

Valorisation des fumiers de ferme chez les producteurs avicoles de Bagot
Amélioration des connaissances Diminution des volumes d'engrais minéraux Valorisation des engrais organiques Abaissement des coûts de production

Projet de valorisation du compost de boues de fosses septiques.
Conservation des ressources et fertilisation intégrée

Mineralisation des sols en fonction des pratiques culturales: impact pour les PGFI dans le Bas-St-Laurent
Le projet consiste à évaluer la minéralisation de la matière organique de différents types de sol de la région en fonction des pratiques culturales conventionnelles et alternatives, et en tenant compte ou non du précédent cultural, du taux de matière organique du sol et de l'apport d'engrais de ferme pour le plan de fertisation.

Essai de lisier et de BRF pour fertiliser les espaces verts.
Trouver un débouché intéressant à des résidus agricoles et forestiers. Évaluer la qualité d'établissement des gazons traités avec un mélange de fumier liquide et de bois raméaux fragmentés finement. Évaluer l'effet du même mélange appliqué en surface sur des gazons établis. Vérifier les possibilités de réduction des utilisations d'engrais chimiques au gestion de pelouses. Comparer les résultats (en terme de qualité du sol et de pelouse) avec des surfaces témoins et des surfaces traitées aux BRF.

Compostage des boues primaires d'une usine de pâte et papier.
Ce projet vise la valorisation d'une ressource abondante et la mise au point d'une technique de compostage simple, économique et transférable, en plus de permettre la réduction de l'enfouissement des déchets. Les données recueillies serviront de départ à l'implantation d'un système de compostage et valideront la qualité du compost produit, l'utilité et l'efficacité de ce type de compost en milieu agricole.

Évaluation d'un mode de fertilisation de l'azote basé sur le test des nitrates indicateurs dans le maïs sucré.
L'objectif principal est de valider, en sol québécois, le TNI (test des nitrates indicateurs) comme alternative au mode de fertilisation en azote du CPVQ dans la culture du maïs sucré.

Impacts de l'utilisation de différents types de compost à base de fumier, de résidus marins et de tourbes, leur effet sur le sol, l'eau et la plante.

Détermination de la valeur fertilisante du fumier et du lisier de bovin laitier en fonction de leur utilisation sur le maïs-grain et mesure des impacts environnementaux et économiques.

Manitoba

Water Resource Management Program

Development of Lagoon Sampling Techniques
Description: To develop a means of sampling manure lagoons in order to obtain the fertilizer value of its contents without the need for agitation, allowing producers to pre-determine the application rates of manure to achieve optimum results and ensuring economic and environmental sustainability.

Field Trials of Hog Lagoon Odour Control Method
Description: Field trial with a new lagoon covering method to reduce or eliminate odours from hog manure lagoons. To evaluate its performance and economics; demonstrate its use and effectiveness.

On-Farm Measurement of Available Manure Nitrogen
Description: Demonstrate and familiarize producers and extension staff with existing technology to instantly determine the ammonia content of manure.

Pipeline Injection of Liquid Manure
Description: To develop an enhanced manure conveying and land application system that allows manure to be used in an economically viable and environmentally neutral manner through development, evaluation and demonstration of a pipeline injection system.

Procedures Manual for Implementing Manure Management
Description: A procedures manual will be produced that will enable livestock producers to develop environmentally sustainable manure management plans that are economically beneficial to the community and promote the establishment and maintenance of good public relations.

Movement, Mineralization, and Fate of Nutrients from Manure
Description: Two sites will be monitored in Manitoba to assess loading rates of animal manure which optimizes nutrient use and minimizes the potential for groundwater contamination.

Efficient Use of Lagoon Stored Swine Manure for Pasture Production
Description: To evaluate technology for efficient use of liquid pig manure and to determine the potential of nitrogen leaching from applications of manure.

Sub-Surface Effects of Manure Applications
Description: Examine groundwater quality and flow characteristics around agricultural lagoons and manure application sites.

Farm Based Program

Hog Manure as a Fertilizer
Description: Demonstrate management and economics of proper use of hog manure on pasture land.

Manure Composting
Description: Conduct a manure composting demonstration of windrow stockpiled manure.

Narcisse Hog Manure Management
Description: Two Paddocks at Narcisse pasture. Application Rates 1X and 1.5X rec rate hog manure.

Nutrient Value of Manure on Yield
Description: Demonstration Sites with variable rates of manure and fertilizer. Results are monitored.

Straw Covering for Manure Storage
Description: Leasing a straw shredder to cover hog lagoons for odour control

Manure Testing
Description: Sample Hog manure from various types of operations. Baseline nutrient content.

Agronomic Value Assessment of Manure
Description: Plots at three sites to monitor manure application rates and crop yield.

Manure Application Demonstration
Description: Field Day for new manure application equipment & technology.

Manure Nutrient Survey
Description: Analyse manure samples from 30 hog lagoons. Advise on Application Rates and produce a Newsletter.

Hog Manure Odour Control Project
Description: Demonstrating straw covering of two hog lagoons. Soil testing field fertility with hog manure.

Management of Lagoons and Manure
Description: Odour control demonstration on three lagoons. Testing manure and advise farmers on application rates.

Composting Manure
Description: Demonstrating the effect of composting beef manure on volume and nutrient content.

Beef Manure Composting
Description: Demonstrating the pile-and-turn technique for composting beef cattle manure and monitor nutrient content, volume reduction odour levels, and temperature rises during the composting process.

Manure Management
Description: Demonstration at three sites showing the effect of manure application on soil and crops.

Livestock Waste Management Awareness
Description: Trials to determine guidelines for appropriate manure application rates for fertility and environmental protection.

Livestock Waste Management Equipment Rebate
Description: Rebate on the modification or purchase of equipment for injecting manure

Manure Testing Program
Description: Deep nitrate sampling and/or lagoon sampling at 10 sites 0

Waste Application Trials - Somerset
Description: Continuation of site to demonstrate the benefits of properly applying manure.

Waste Application Trials - Rosebank
Description: Continuation of site to demonstrate the benefits of properly applying manure.

Livestock Waste Management
Description: Establishment of a site to demonstrate the nutritive value of manure.

Manure Management Demonstration
Description: Establishment of a site to demonstrate the nutritive value of manure.

Saskatchewan

Farm Based Program

Manure Storage, Handling and Application

Description: Demonstrations to encourage proper storage and application of manure as a soil amendment. Field day on appropriate equipment and methods along with newspaper articles and newsletters are planned.

Gully Restoration and Manure Management

Description: To encourage farmers to fill and grass waterways and to start hilltop manuring program.

Feasibility and Viability of Solar Aquatic Greenhouse Technology for Treating Liquid Hog Manure in Saskatchewan.

Description: To investigate both the feasibility of the solar aquatic technology for purifying liquid hog manure in Saskatchewan, and the viability of the system in a commercial hog operation.

Removal of Soft Sediment from D.O.

Description: Investigate the feasibility of PAMI Prototype "Solid Hog Manure Removal System" for removal of soft sediments in dugouts.

Organic Farming Demonstration

Description: Demonstrate organic farming methods including manure, use of legumes and Provide.

Manure Application for Direct Seeding

Description: Demonstrate incorporation versus non-incorporation on manure on a low disturbance direct seeding.

Manure Management

Description: Applying one, two and three year old manure on cropland to determine the benefits (re crop nutrient and yield) over a number of years.

Innovative Partnerships Program

Manure Lagoon Cover for Swine Facilities

Description: To develop and test a low-cost balloon-type lagoon cover to reduce odour emissions.

Research and Development Program

Earthen Storage Facilities for Hog Manure

Description: Undertake research to support development of a prairie standard for earthen hog effluent storage facilities.

Alberta

Farm-Based Program

Reclamation of Eroded Knolls

Description: To evaluate the long term effects of manure, phosphorous & composting manure applications on the productivity of eroded areas.

Quality/Quantity of Manure in Feedlots

Description: To establish the amount and the nutrient analysis of manure that is produced in southern Alberta finishing Feedlots.

Effects of Manure on Forage Crops

Description: To increase producer and general public awareness knowledge on agronomic and environmental effects of applying liquid and solid manure to forage crops.

Hilda Conservation Club
Description: To provide a visual demonstration of the relative merits of the application of manure and phosphate fertilizer in reclaiming an eroded knoll.

Waste Management
Description: Raise awareness of the value of manure as a soil improver that will add nutrients, organic matter, and improve soil structure. To inform producers of the pollution potential of manure if not handled properly.

Manure Lagoon Cover Demonstration
Description: Demonstrate the use of floating covers to reduce air pollution from manure lagoons.

Manure Management Workshops
Demonstrations: Three one-day manure management workshops for 50 producers, to assess the effect on water quality, practical management, farmer success stories and ways to be a good neighbour.

Resource Monitoring - Water Quality Program

Ground Water/Manure Study
Description: At two sites, different manure and chemical fertilizers rates, applied in a replicated experimental design. The soil and ground water are being monitored for various chemical parameters.

British Columbia

Research Program

Feeding Strategy to Reduce Environmental Pollution from Poultry Manure
Description: A study to determine if changes in diet can reduce environmental pollution from poultry.

Removal of Nitrogen from Swine Manure
Description: Tested possible methods of removing nitrogen from swine manure, to allow the swine industry to exist on small land areas without polluting.

Designer Feeding Program for Swine Waste Reduction
Description: Reducing the land-base requirement and nutrient burden of swine manure by means of dietary changes and more efficient use of dietary ingredients.

Application of Slurry Manure on Established Grassland
Description: Developing recommendations for use by farmers on rates and methods of applying slurry manure on established grass stands.

Appendix G: Research Projects Related to Manure Management Listed in ICAR

ICAR #	Title / Location	Leader	Start	Ends
85020504	Water movement and nutrient management model for southern Alberta			
	AAFC, Lethbridge	C. Chang	01/01/79	03/31/96
89005542	Composition and transformations of organic matter in Chernozemic soils			
	AAFC, Lethbridge	J. F. Dormaar	09/01/62	05/01/97
89005320	Nutrient cycling and management			
	AAFC, Beaverlodge	Y.K Soon	04/26/84	04/01/00
93000572	Soil Tilth			
	Univ. of Alberta	D.S. Chanasyk	01/01/93	12/31/93
93000569	Relationship of topsoil depth to soil productivity			
	Univ. of Alberta	M. Nyborg	01/01/90	03/01/93
93000505	Manure and nutrient management to sustain groundwater quality near feedlots			
	ADAFRD, Edmonton	D.R. Bennett	04/01/93	03/31/97
94_____	Feedlot runoff - quantity and quality of rainfall and snowmelt runoff from pens			
	ADAFRD, Vermillion	B. Kennedy	04/01/94	03/31/97
94000664	Physical Properties of Composting Materials			
	Univ. of Alberta	J. J. Leonard	05/01/94	03/31/97
94000663	Cold Climate Composting Systems			
	Univ. of Alberta	J.J. Leonard	05/01/94	03/31/97
94000680	Sustainability of manure management: nutrient retention and cost-benefit analysis			
	Univ. of Alberta	W.B. McGill	04/01/93	03/31/94
94000666	Evaluation of oligolysis for odour control under laboratory and field conditions			
	Univ. of Alberta	J.J.R. Feddes	04/01/89	12/31/95
94005039	Protein and amino acid nutrition of beef and dairy cattle			
	AAFC, Lethbridge,	C. Chang	04/01/94	03/31/00
94000680	Sustainability of manure management: nutrient retention and cost-benefit analysis.			
	Univ. of Alberta	W. B. McGill	04/01/93	03/31/96
British Columbia				
90005257	Forage and field crops - improving yield, quality and sustainability			
	AAFC, Vancouver	S. Bittman		
91005148	Improved manure, fertilizer and pesticide managment for reduced ground water contamination			
	AAFC, Vancouver	B. Zebarth	01/01/91	12/31/95
94000265	Development of a feeding strategy to minimize environmental pollution from poultry waste			
	Univ. B.C.	R. Blair	04/01/93	12/31/95
94000276	Economic instruments for sustainable land use in the Fraser Valley			
	Univ. B. C.	J. Vercammen	01/01/94	10/31/94
94005041	Animal waste management to improve nutrient utilization by crops, produce value added products, and minimize pollution during manure storage and land application.			
	AAFC, (B.C.)	J. W. Paul	10/14/93	12/31/97
Manitoba				
93000407	Seepage beneath manure storage lagoons			
	Univ. of Manitoba	R. Sri-Ranjan	01/04/93	12/20/93
95000170	Movement, mineralization, and fate of nutrients from manures			
	Univ. of Manitoba	C. Flynn	04/01/94	03/31/96
95000165	Development of Manure N: A manure nitrogen management model for use in Manitoba			
	Univ. of Manitoba	C. Flynn	04/01/95	03/31/96

ICAR #	Title Location	Leader	Start	Ends
New Brunswick				
90005548	Improvement of the chemical and physical characteristics of dykeland and upland soils for sustainable beef production in the Atlantic Provinces			
	AAFC, Fredericton	A.V. Rodd	04/01/85	09/01/95
Nova Scotia				
92000071	Monitoring soil organic matter following the application of fertility amendments			
	NSAC, Truro	P. Warman	04/01/91	03/31/94
93000026	Evaporation rates & moisture retention characteristics of soil amended with composted manure			
	NSAC, Truro	J. Blanchard	04/01/93	/ /
93000025	Nitrate nitrogen concentration in tile drain water from manure application			
	NSAC, Truro	A. Madani	04/01/93	/ /
94000200	Assessment of the impact of manure application on water quality.			
	NSAC, Truro	A. Madani	04/01/93	/ /
94000204	Artificial wetlands for filtering agricultural waste waters.			
	NSAC, Truro	D. Moerman	03/01/93	/ /
94000237	Monitoring soil organic matter			
	NSAC, Truro	P. Warman	08/01/92	/ /
94000227	Evaluation and design of milkhouse effluent disposal system			
	NSDAM, Truro	K. Bekkers	04/20/93	/ /
95000354	Demonstration artificial wetlands for treatment of waste water			
	NSAC	D. Moerman		
95000340	Reduction in non-point source pollution potential			
	NSAC	A. Madani	05/15/95	
95000389	Gypsum and manure to improve dykeland productivity			
	NSAC	P.R. Warman	12/16/94	
Ontario				
85020810	Increased efficiency of energy utilization by the use of methane inhibitors and/or ionophores in dairy cow rations.			
	AAFC, Ottawa	F. D. Sauer	12/01/85	12/31/95
90000287	Flow of manure through soil macropores			
	Centralia CAT	R. Fleming	05/22/90	11/02/90
90000306	Residual nitrogen from various sources			
	New Liskeard CAT	J. Rowsell	05/01/90	06/01/95
90100125	Hydrogen sulphide monitor for swine facilities			
	Univ. of Guelph	G.L. Hayward	01/01/90	04/01/93
91000151	Milkhouse effluent treatment			
	Alfred CAFT	03/01/91	02/28/94	
91005059	Fate and modelling of agricultural chemicals in soil, groundwater and agricultural drainage water under farm conditions			
	AAFC, Ottawa	N.K. Patni	12/31/90	12/31/95
91005140	Determination of Land Management Strategies for sustainable agricultural production.			
	CLBRR, Ottawa	L.M.Dwyer	04/01/91	03/31/96
91005115	Agrochemical Processes and Transport in relation to Water Quality in Agricultural Landscapes			
	CLBRR, Ottawa	W.D. Reynolds	04/01/91	03/31/96
91005116	Greenhouse gas emissions and toxic substances in air related to agricultural and land-use practices			
	CLBRR	R. DesJardins		
92100160	Movement of agricultural and domestic waste water bacteria through soils.			
	Univ. of Guelph	H. Lee	12/03/91	12/31/94

ICAR #	Title Location	Leader	Start	Ends
92005008	Methane and carbon dioxide emissions from farm animals and manure			
	AAFC, Ottawa	H.A. Jackson	04/01/92	03/31/97
93005022	Anaerobic treatment of manure slurry and slaughterhouse wastewater at ambient temperature using an intermittently fed sequencing batch reactor			
	AAFC, Ottawa	D. I Masse	06/01/92	12/31/97
93100138	Soil N test development			
	Univ. of Guelph	E. Beauchamp	/ /	/ /
93005191	Composting of animal waste slurries			
	AAFC, Ottawa	N.K. Patni	10/12/93	12/31/96
93005022	Treatment of manure slurry using a sequencing batch reactor			
	AAFC, Ottawa	D.I. Masse	06/01/92	12/31/97
93005138	Investigations into strategies for control of soilborne fungal pathogens, with special reference to Verticillim, Rhizoctonia and Phytophthora species			
	AAFC, London	G. Lazarovitis	05/01/93	03/31/98
94000583	Artificial wetland system			
	Alfred CAFT	C. Weil	09/01/93	11/15/96
93000354	A comparison of the suitability of various types of office waste and traditional material as dairy animal bedding			
	Kemptville CAT	D. McKnight	05/01/92	06/01/94
93005005	Engineering of prototype equipment and instruments for agricultural research			
	AAFC, Ottawa	H. A. Jackson	04/01/90	03/31/95
94000600	Artificial wetland system			
	Alfred CAFT	C.Weil	09/01/93	11/15/96
94000599	Chemical precipitation of phosphorus in septic tanks			
	Alfred CAFT	I. Malcolm	08/01/93	06/01/95
94000564	The effect of recycling milk pipeline wash water			
	Kemptville CAT	L. Brunet	09/01/93	03/30/95
94000739	Application of immunogentics and environmental control strategies to reduce or eliminate the Salmonella and Campylobacter carrier states in chickens.			
	ADRI, Ottawa	J. L. Spencer	04/31/93	03/31/96
95005000	Impact of agronomic practices on soil quality, environmental quality and crop productivity in coarse-textured soils in Ontario.			
	PMRC, London	R. P. Beyaert	04/01/95	03/31/00
95000003	Milkhouse wash water control using a vegetative filter			
	Kemptville CAT	L. M. Brunet	09/01/94	03/31/97
95000006	Water quality research			
	Ridgetown CAT	R. Fleming	05/02/94	/ /
96112360	Groundwater contamination from leaching bed/septic tank system.			
	Univ. of Guelph	H. Lee	05/01/95	04/30/96
96114910	Modelling the Fate of Agricultural Pollutants. (FAP)			
	Univ. of Guelph	G. Edwards	05/01/95	04/01/96
96112370	Modelling the pathways of pollution for land application of waste water and manure.			
	Univ. of Guelph	R. Rudra	05/01/95	04/14/96
96113740	Corrosion and deterioration of agricultural building components.			
	Univ. of Guelph	S. Negi	05/01/95	04/30/98
96112470	Detection of cryptosporidium parvum oocysts in water.			
	Univ. of Guelph	J. Barta	05/01/95	04/15/96
96113790	Application of transgenic methodology for enhanced dietary efficiency and reduced waste pollution characteristics in swine.			
	Univ. of Guelph	C. Forsberg	05/01/95	04/30/99

ICAR #	Title Location	Leader	Start	Ends
96114030	Design criteria for cylindrical liquid manure tanks. Univ. of Guelph	J. Jofriet	05/01/95	12/31/96
Prince Edward Island				
91005019	Manure application strategies for environmental safety and efficient crop production AAFC, Charlottetown	A.J. Campbell	05/01/91	05/01/98
Saskatchewan				
86000345	Air quality in livestock buildings Univ. of Saskatchewan	E. M. Barber	04/01/83	03/31/96
Quebec				
90005595	Effect de l'erosion hydriqye et des amendments inorganiques et organiques sur lar productivite et la qualite des sols et de l'eau AAFC, Lennoxville	A.R. Pesant	04/01/90	03/31/96
92000538	Development et demonstration de nouveaux concepts "evacuation-entreposage reprise" des fumiers de bovins laitiers Consult. BPR, Quebec	F. Brindamour	09/01/90	03/31/93
92000537	Developpement d'un modele de prediction de l'evaporation pour les lisiers et fumiers au Quebec Consult. BPR, Quebec	P. Caouette	09/01/90	12/31/92
92000542	Adaptation, evaluation and demonstration de structures de recourvrement a charpentes de bois et d'acier pour les reservoirs de lisier Consult. BPR, Quebec	D. Lord	09/01/90	03/31/93
92000541	Developpement d'un moniteur de doses en vue d'optimiser l'epandage du lisier Consult. BPR, Quebec	C. Dutil	09/01/90	03/31/93
92000540	Etude des solutions de rechange a la gestion sour forme liquide des dejections de porc Consult. BPR, Quebec	J.Y. Drolet	10/01/91	03/31/93
92_____	Relation entre les facteurs du sol, carbone soluble et oxygene et les production de N2O et CH4 Univ. Laval	H. Antoun	12/07/92	12/06/93
92000392	Effet du travail du sol et des dates d'epandage des lisiers sur le ruissellement, l'erosion du sol et l'efficacite fertilisante de cet engrais en monoculture de mais MAPAQ, Sainte-Foy	C. Bernard	04/01/92	04/01/97
92000536	Logiciel d'aide a la gestion des effluents d'elevage de bovins laitiers Consult. BPR, Quebec	C. Dutil	03/01/89	03/31/92
93005185	Developpement d'une methodologie d'optimisation permettant d'ameliorer simultanement le rendement economique et ecologique de production de porc a l'engrais a l'aide de la modelisation mathematique AAFC, Lennoxville	C. Pomar	04/01/93	03/31/98
93000188	Depollution e'effluents par biotraitement solaires et microbiens Univ. Laval	J. de la Noue	06/01/93	05/31/96
93000121	Modification des systemes porteur des epandeurs a lisier utilises au Quebec afin de reduire la compaction des sols Univ. Laval	S. Tessier	04/01/92	12/15/95
93000217	Effect a long terme de l'epandage de grandes quantities de fumier sur le potentiel de retention du phosphore sur les sols du bassin versant de la riviere beaurivage INRS, Ste Foy	C. Cluis	10/01/91	12/31/93
93000098	Effects de l'utilisation de differents composts comme amendement organique sur la compostion et l'activite de la microflore du sol et de la rhizosphere de la tomate			

ICAR #	Title Location	Leader	Start	Ends
	Univ. Laval	H. Antoun	05/01/93	05/01/96
94000327	Revalorisation des residues chitineux marins par compostage. Impacts agronomiques, environnementaux et socio-economiques			
	U. Sherbrooke	R. Brzezinski	07/31/94	09/30/98
94000326	Development d'indicateurs de contamination potentielle des eaux par le phosphore pour les series de sol supportant de grandes surfaces de culture defrichees.			
	INRS, Ste Foy	D. Cluis	05/01/94	12/31/97
94000437	Caclul aux etats limits par elements finis des reservoirs circulairs en beton arme			
	MAPAQ, Deschambault	R. Joncas	04/01/93	/ /
95000203	Valorisation combinee du Lisier de Porc et du permeat de Lactoserum de Fromagerie par Culture de Levures			
	Univ. Laval	J. de la Noue	03/09/95	03/08/96
95000193	Desodorisation, traitement et valorisation du lisier de porcs par biofiltration sur support organique			
	CRIQ	G. Buelna	/ /	/ /
95000210	Reduction des Rejets Mineraux et d'Azote chez les Volailles par modification de l'Aliment et/ou addition d'Enzymes et Impacts sur le Systeme Oiseau-litiere-batiment			
	Univ. Laval	M. Lefrancois	04/01/95	03/31/98
95000208	Le Calcul aux Etats limites par Elements finis des Reservoirs Circulaires			
	Univ. Laval	A. Marquis	04/27/94	03/31/96

Appendix H: OMAFRA-funded Research Projects Related to Manure Management at the University of Guelph

Project title and project leader

Soil N test development.
E. G. Beauchamp, Department of Land Resource Science

Modelling the pathways of pollution for land application of waste water and manure.
R. P. Judra, School of Engineering

Economic assessment of environmental policy instruments for agricultural production.
G. C. Fox, Department of Agricultural Economics and Business

Corrosion and deterioration of agricultural components.
S. C. Negi, School of Engineering

Design criteria for cylindrical liquid manure tanks.
J. C. Jofriet, School of Engineering

Development of a comprehensive decision-support system for animal manure management
D. P. Stonehouse, Department of Agricultural Economics and Business

Modelling the fate of agricultural pollutants.
G. Edwards, School of Engineering

Impact of dietary nitrogen solubility on nitrogen losses from lactating dairy cows.
W. McBride, Department of Animal and Poultry Science

Major genes affecting pork production and meat quality.
E. J. Squires, Department of Animal and Poultry Science

Development of an analytical support package for farmer groups to implement BMPS for nitrogen.
M. J. Goss, Department of Land Resource Science

Evaluation of extraction techniques for estimating potentially available N from manures to crops.
M. J. Goss, Department of Land Resource Science

Identification of indicator bacteria for manure contamination of rural wells and stratigrahpics conducive to bacterial transport.
M. J. Goss, Department of Land Resource Science

Appendix I: Extension Resources on Manure Management Available in Ontario from Government Ministries and Public Agencies[1]

(Note: This listing does not include resources containing information about related topics, such as soil fertility, crop nutrition, animal nutrition, etc. that do not specifically address manure management,)

Number	Title/Topic	Agency	Fmt	Year	Links to Topics in Framework			Level of Info.
	General							
	Agricultural Pollution Control Manual	OMAFRA	L	91	1	2	3	P A
	Ontario Environmental Farm Plan Workbook	OFEC	L	93	1	2	3	P A
450/725	Poultry Manure Handling	OMAFRA	F	93	1	2	3	A
	Canada Animal Waste Management Guide	AAFC	B		1	2	3	P A
	Dairy Manure Handling for Barn to Storage	OMAFRA	V		1	2	3	A
	Livestock and Poultry Waste Management	BMP	B	92	1	2	3	P A
	Field Crop Production	BMP	B	92	1	1.6	3.4	P A
	Nutrient Management	BMP	B	94	1	1.6	3.4	P A
	Soil Management	BMP	B	94	1	1.6	3.4	A
	Water Management	BMP	B	94	1	1.3		A
	No-Till Management	BMP	B	96	1	2.6		P A
	Legal							
	Guide to Agricultural Land Use	OMAFRA	B	95	1.3	2.5	3.4.2	P A
	Minimum Distance Separations I & II	OMAFRA	B	95	2.2.3			P
	Guidelines for Sewage Sludge Utilization on Agricultural Lands	OMAFRA	B	92	1	2	3	P A
	Draft Interim Guidelines for Utilization of Waste (other than Sewage Sludge) on Agricultural Lands	OMAFRA	B	92	1	2	3	P A
700/0	Legislation and Farming Practices	OMAFRA	F	94	1.2			A
700	Odour, Noise and Dust Complaints and the Farm Practices Protection Act	OMAFRA	F	93	1.2			A
	Water Quality							
	Drain Tile Water Quality	CCAT	F	90	1.3	2.5.8	2.6.2.2	A

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1 Agencies:

OMAFRA	Ontario Ministry of Agriculture Food and Rural Affairs
AAFC	Agriculture and Agri-Food Canada
BMP	Best Management Practices
OFEC	Ontario Farm Environmental Coalition
CPS	Canada Plan Service
CCAT	Centralia College of Agricultural Technology
RCAT	Ridgetown College of Agricultural Technology
UTRCA	Upper Thames River Conservation Authority

Formats (Fmt):

F	Factsheet
L	Looseleaf binder
B	Booklet
D	Plan
S	Computer software
V	Video

Level of Information:

A	Awareness
P	Planning
O	Operational
T	Technical specifications

Links to information framework relate to topics identified in Appendix K.

Codes beginning with:
1 - relate to Constraints or Standards that may limit a farmer's management options.
2 - relate to topics for which farmers are required to make Strategic Decisions.
3 - relate to topics for which farmers are required to make Tactical Decisions.
4 - relate to Nutrient Losses or Transformations.

Number	Title/Topic	Agency	Fmt	Year	Links to Topics in Framework			Level of Info.
	Plugging Tile Drains to Reduce Pollution	CCAT	F	94	1.3	2.5.8	2.6.2.2	A
	Health and Safety							
400/717	Air Quality Inside Livestock Barns	OMAFRA	F	93	1.4.2	1.3.1		A
400/717	Farm Workers' Health Problems Related to Air Quality In Livestock Barns	OMAFRA	F	93	1.4.2	1.3.1		A
538	Manure Gases	OMAFRA	F	86	1.4.2	1.3.1		A
710	Manure Gas	CPS	F		1.4.2	1.3.1		P A O
9707	Protecting Workers in Livestock Barns from Dust and Gases	CPS	F		1.4.2	1.3.1		P A O
9708	Farm Workers' Health Problems Related to Air Quality In Livestock Barns	CPS	F		1.4.2	1.3.1		A
721/410	Safety Fencing of Manure Storages	OMAFRA	F	89	1.4.3	2.5		P A
	Livestock Housing							
717	Ventilation System Choice and Economics	OMAFRA	F	94	2.2.2			P A
1000	Beef Cattle Housing and Equipment	CPS	F		2.2	2.5		P A
2000	Dairy Cattle Housing and Equipment	CPS	F		2.2	2.5		P A
2101	Free Stall Dairy System - 60 cows	CPS	F,D		2.2	2.5		A O
2101	Free Stall Dairy System - slotted floors	CPS	F,D		2.2	2.5		A O
2101	Free Stall Dairy System - 100 to 200 cows	CPS	F,D		2.2	2.5		A O
2101	Free Stall Dairy System - 200 stalls	CPS	F,D		2.2	2.5		A O
2220	Single Story Tie Stall Barn	CPS	F,D		2.2	2.5		A O
2342	Cold Calf Nursery	CPS	F,D		2.2	2.5		A O
2343	Warm Calf Nursery - Individual Pens	CPS	F,D		2.2	2.5		A O
2403	Bedded Pack Heifer Barn	CPS	F,D		2.2	2.5		A O
2404	Free Stall Dairy Calf and Heifer Barn	CPS	F,D		2.2	2.5		A O
3000	Swine Housing and Equipment	CPS	F		2.2	2.5		P A
3002	Site and Facilities Planning for Swine	CPS	F		2.2	2.5		P A
3236	Breeding-gestation Unit	CPS	F,D		2.2	2.5		A O
3241	Two-room Breeding and Gestation Unit	CPS	F,D		2.2	2.5		A O
3303	Three-room Farrowing/Weanling Unit	CPS	F,D		2.2	2.5		A O
3304	Five-room Farrowing/Weanling Unit	CPS	F,D		2.2	2.5		A O
3428	Grower Finisher Unit	CPS	F,D		2.2	2.5		A O
3800	Farrowing Pens	CPS	F		2.2	2.5		P A
3812	Welded Steel Farrowing Stall	CPS	F		2.2	2.5		P A
3843	Gestation Pen Stalls	CPS	F		2.2	2.5		P A
4154	Slotted Floor Sheep Barn	CPS	F,D		2.2	2.5		A O
5000	Poultry Housing	CPS	F		2.2	2.5		P A
5210	Layer Housing	CPS	F		2.2	2.5		P A
5310	Broiler Housing	CPS	F		2.2	2.5		P A
5320	Pullet Housing	CPS	F		2.2	2.5		P A
400/721	Renovating Livestock Barns	OMAFRA	F	86	2.2			P A
440/823	Labour Efficiency in Swine Buildings	OMAFRA	F	94	2.2			P A
	Runoff and Contaminated Water							
01-1990	Environmental Planning for Your Farm	UTRCA	F	90	2.3	3.2.3.1	3.2.3.3	A
03-1990	Contingency Planning for Manure Runoff	UTRCA	F	90	2.3			A

Number	Title/Topic	Agency	Fmt	Year	Links to Topics in Framework		Level of Info.
	A Farmers' Responsibilities						
09-1990	Managing Liquid Runoff from Feedlots, Manure Stacks and Milkhouses	UTRCA	F	90	2.3		A
	Manure System Planning						
538	Manure Characteristics	OMAFRA	F	85	2.5	4.0	A
400/721	Livestock Manure Storages	OMAFRA	F	88	2.5		A
725	Planning a Manure System	OMAFRA	F	85	2.5		P A
3700	Swine Manure Systems	CPS	F		2.5		P A
8712	Concrete	CPS	F		2.5		A
410/725	Milking Centre Washwater Disposal	OMAFRA	F	93	2.5.2		P A
08-1990	Milkhouse Wastewater Management	UTRCA	F	90	2.5.2		A
	Collection						
410/743	Flush Systems for Manure Removal from Freestall Dairy Barns	OMAFRA	F	95	2.5.3		P A
410/725	Gravity Manure Transfer Systems	OMAFRA	F	88	2.5.3		P A
743	Liquid Manure Transfer Systems	OMAFRA	F	85	2.5.3		A
743	Specifications for Manure Transfer Pumps	OMAFRA	F	85	2.5.3		T
743	Semi Solid Manure Transfer Systems	OMAFRA	F	85	2.5.3		A
743	Solid Manure Transfer Systems	OMAFRA	F	85	2.5.3		A
743	Solids-Liquid Separation of Manure	OMAFRA	F	86	2.5.4.1		P A
	Manure Storage						
721	Storage of Solid Manure	OMAFRA	F	85	2.5.5		P A
721	Storage of Liquid Manure	OMAFRA	F	94	2.5.5		P A
2702	Clay-lined Manure Storage w. Pumping Dock	CPS	F,D		2.5.5		P A
2703	Curbed Storage Slabs for Stacked Manure	CPS	F,D		2.5.5		O
2705	Rectangular Roofed Storage (Semi-solid)	CPS	F,D		2.5.5		O
8713	Open Rectangular Manure Storage	CPS	F,D		2.5.5		O
Q-8730*	Open Circular Manure Storage Tanks	CPS	F,D		2.5.5		O
Q-8731*	Open Rectangular Manure Storage Tanks with Cantilever Walls	CPS	F,D		2.5.5		O
Q-8732*	Open Rectangular Manure Storage Tanks with Buttressed Walls	CPS	F,D		2.5.5		O
Q-8733*	Covered Circular Manure Storage Tanks	CPS	F,D		2.5.5		O
Q-8734*	Covered Rectangular Manure Storage Tanks	CPS	F,D		2.5.5		O
	Groundwater Impact of Earthen Manure Storages	RCAT	F	94	2.5.5.5		P A
11-1994	Roofed Solid Manure Storages	UTRCA	F	94	2.5.5.6		A
743	Aeration of Liquid Manure	OMAFRA	F	86	2.5.5.7		P A
	Manure Storage Sizing Program	OMAFRA	S		2.5.5.9		P
400/721	Sizing of Manure Storages	OMAFRA	F	83	2.5.5.9		P
	* available only to contractors						
	Removal and Transport						
743	Liquid Manure Removal from Storage	OMAFRA	F	85	2.5.6	2.5.7	A
743	Semi Solid Manure Removal from Storage	OMAFRA	F	85	2.5.6	2.5.7	A

Number	Title/Topic	Agency	Fmt	Year	Links to Topics in Framework		Level of Info.
743	Solid Manure Removal from Storage	OMAFRA	F	85	2.5.6	2.5.7	A
	Manure Application						
400/725	Spray Irrigation of Manure	OMAFRA	F	81	2.5.8		A
538/743	Land Application of Liquid Manure in an Environmentally Responsible Manner	OMAFRA	F	92	2.5.8		P A
743	Comparison of Liquid Manure Spreading Systems	OMAFRA	F	85	2.5.8		A
743	Liquid Manure Tank Spreaders	OMAFRA	F	85	2.5.8		A
743	Specifications for Traveling Gun Irrigation Systems	OMAFRA	F	85	2.5.8		T
743	Specifications for Liquid Manure Spreaders	OMAFRA	F	86	2.5.8		T
743	Spreading Equipment for Solid Manure	OMAFRA	F	86	2.5.8		A
743	Specifications for Manure Spreaders	OMAFRA	F	86	2.5.8		T
	Custom Manure Applicators	CCAT	F	91	2.5.8		A T
	Survey of Custom Manure Applicators	CCAT	F	90	2.5.8		A T
	Nutrient Management						
538/743	Nutrient Management Worksheet for Manure	OMAFRA	F	95	3.4	4.2	O
538	Nutrient Management Computer Program	OMAFRA	S	95	3.4	4.2	O
296	Field Crop Recommendations	OMAFRA	B	95	3.4.3	4.0	P A O
100/538	Manure for Crop Production	OMAFRA	F	83	3.4	4.0	P A
	On-Farm Manure Test Kits	CCAT	F	93	3.4	4.2	O

Appendix J: Bibliography

Although not cited in this report, the following papers were reviewed in its preparation.

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Anon 1995 *Liquid manure application systems: proceedings from the liquid manure application systems conference* Northeast Regional Agric. Eng. Service Pub'n NRAES-79

Acton, D. F., and L. J. Gregorich. 1995 *The health of our soils* Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada Pub'n 1906/E

Agunga, R. A. 1995 *What Ohio extension agents say about sustainable agriculture* J. Sust. Agric. 5:169-187

Alessi, R. S. et al *Systems engineering principles and applications for the design of a whole-farm information system* J. Prod. Agric. 7:135-143

Alonge, A.J., and R.A. Martin. 1992 *Impact of communication and innovation variable on adoption of sustainable agricultural practices* J. Appl. Communic. 76: 34-42

Barao, Scott M. 1992 *Behavioral Aspects of Technology Adoption: The role of on-farm demonstration.* J. of Extension Vol. 30, No. 2

Beegle, D.B. and L.E. Lanyon, 1994. *Understanding the nutrient management process* J. Soil and Water Conserv. 49: 23-30 (Nutrient management special supplement)

Bezdicek, D.F., and C. DePhelps. 1994 *Innovative approaches for integrated research and educational programs* Am. J. Altern. Agric. 9: 3-8

Blackburn, D.J. ed. 1994 *EXTENSION HANDBOOK: Processes and Practices* Thompson Educational Publishing, Inc., Toronto, Ontario

Blake, J., J. Donald and W. Magette, eds. 1992 *National livestock, poultry and aquaculture waste management: Proceedings of the national workshop* ASAE Pub'n. 03-92

Bloome, Peter. 1993 *Privatization Lessons for U.S. Extension from New Zealand and Tasmania* J. of Extension Vol. 31, No. 1

Boyd, W.H. 1994 *Managing animal wastes: agricultural waste management planning.* J. Soil and Water Conserv. 49: 53-57 (Nutrient management special supplement)

Brophy, L.S., H. Murray, L.S. Kev, R.P. Dick and L.M. Butler. 1991 *In the face of change: A rapid reconnaissance survey of Northwest horticultural crop producers* Am. J. Altern. Agr. 6:23-28

Bruening, T.H. 1991 *Communicating with farmers about environmental issues* J. Appl. Communic. 75: 34-41

Compton, R.B. 1988 *Survey of Southwestern Ontario farmers for the evaluation of SWEEP* SWEEP Report # 5

Connolly, S. and S. Hilts. 1988 *Sources of motivation in the adoption of conserveration tillage* SWEEP Report # 7

Daniel, T.C., A.N.Sharpley, D.R. Edwards, R. Wedepohl, and J.L Lemunyon, 1994 *Minimizing surface water eutrophication from agriculture by phosphorus management.* J. Soil and Water Conserv. 49: 30-38 (Nutrient management special supplement)

Eastwood, Basil R. *Informational Databases* paper presented at the 81st Annual Meeting of the American Dairy Science Association 1986

Eastwood, Basil R. 1996 *What if? Some Philosophy Behind the ADDS Projects*

Enshayan, K., and D. Stinner and B. Stinner. 1992. *Farmer to farmer* J. Soil and Water Conserv. 47:127-130

Favero, Philip and Daryl K. Heasley 1991 *Managing Innovative Programs: Three effective strategies.* J. of Extension, Vol. 29, No. 1

Fleming, R. J., J. E. McLellan and S. H. Bradshaw. 1993 *On-farm measurement of available manure-N* ASAE Paper 934025

Fraser, Janet. 1990 *Coordination of Agricultural Research in Ontario* OMAFRA Factsheet

Harrington, L., 1995. *Sustainability in Perspective: Strengths and limitations of farming systems research in contributing to a sustainable agriculture* J. Sust. Agric. 5:41-59

Hendrix, P.F., D.C. Coleman and D. A. Crossley Jr. 1992 *Using knowledge of soil nutrient cycling processess to design sustainable agriculture* J. Sust. Agric. 2:63-82

Jefferson, D.H., H.C.Lynn, and J.G. Shaner. 1992. *Examining new directions in media and channel selection in the adoption process.* J. Appl. Communic. 76:59-71

Lanyon, L.E. 1994 *Participatory assistance: An alternative to transfer of technology from promoting change on farms* Am. J. Altern. Agric. 9:136-142

Lanyon, L.E. 1995 *Does nitrogen cycle?: Changes in the spatial dynamics of nitrogen with industrial nitrogen fixation.* J. Prod. Agric. 8: 70-78

Lanyon, L.E. and D.B. Beegle, 1989 *The role of on-farm nutrient balance assessments in an integrated approach to nutrient management.* J. Soil and Water Conserv. 44: 164-168

Lanyon, L.E., and H.K. Meij. 1992 *FINFO: A field and farm technical information management program* J. Prod. Agric. 5:88-94

Laughlin, Kevin M., and Janet L. Schmidt. 1995 *Maximizing Program Delivery in Extension: Lessons from Leadership for Transformation* J. of Extension Vol. 33, No. 4

Lemberg, B., W.T. McSweeney and L.E. Lanyon. 1992 *An information management technology program for ex ante nutrient loss reduction from farms.* J. Envir. Qual. 21: 574-8

Lockeretz, W. 1990 *What have we learned about who conserves soil?* J. Soil and Water Conserv. 45: 517-523

Moore, P.A. Jr., T.C.Daniel, A.N. Sharpley and C.W. Wood. 1995 *Poultry manure management: Environmentally sound options* J. Soil and Water Conserv. 50: 321-327

Murray, H., and L. M. Butler. 1994. *Whole farm case studies and focus groups: Participatory strategies for agricultural research and education programs.* Am. J. Altern. Agric. 9: 38-43

Musser, Wesley N., George F. Patrick, Gerald F. Ortmann and D. Howard Doster 1994 *Perceptions of Large-Scale Cornbelt Farmers: Implications for Extension* J. of Extension Vol. 32, No. 4

Norman, D.W., T.R. Frankenberger and P.E. Hildebrand. 1994. *Agricultural research in developed countries: Past, present and future of farming systems research and extension.* J. Prod. Agric. 7: 124-131

Oberle, S. 1994 *Farming systems options for U.S. agriculture: An agroecological perspective* J. Prod. Agric. 7:119-123

Power, J.F. 1994 *Understanding the Basics: Understanding the nutrient cycling process* J. Soil and Water Conserv. 49: 16-23 (Nutrient management special supplement)

Radhakrishna, Rama B., Timothy J. Rollins, and Thomas H. Bruening. 1991 *Informing Farmers on Environmental Issues* J. of Extension, Vol. 29, No. 3

Radhakrishna, R.B. and J.S. Thomson. 1996 *Extension Agents' Use of Information Sources* J. of Extension Vol. 34 No. 1

Richardson, J.G, and R.D. Musian. 1994 *Delivery methods preferred by targeted extension clientele for receiving specific information.* J. Appl. Communic. 78: 22-32

Richert, Brian T., Mike D. Tokach, Robert D. Goodband and Jim L. Nelssen 1995 *Assessing Producer Awareness of the Impact of Swine Production on the Environment* J. of Extension, Vol. 33, No. 4

Rivera, William M. 1990 *Future of Extension Worldwide* J. of Extension, Vol. 28, No. 3

Sadler Richards, J.R., P. Brubacher, P., K. McKague, and D. Sebstian 1994. *A Literature Review of On-farm Research Design and Data Evaluation Methods* Agriculture and Agri-Food Canada, London, Ontario COESA Report No.: RES/FARM-001/94

Safley, L.M.Jr. 1994 *Best management practices for livestock production* J. Soil and Water Conserv. 49: 57- 62 (Nutrient management special supplement)

Smith, Terry R. and Angela Faris, 1996 *Agricultural Databases for Decision Support (ADDS)* National Agricultural Databases, University of Wisconsin, Animal Sciences Bldg. Madison,

Schmitt, M.A., R.A Levins and D.W. Richardson. 1994 *A comparison of traditional worksheet and linear programming methods for teaching manure application planning.* J. Nat. Resour. Life Sci. Educ. 23: 23-26

Smithers, J. and B. Smit. 1989 *Conservation practices in Southwestern Ontario: Barriers to adoption* SWEEP Report 9

Snowdon, G., and J. Evans. 1991 *Decision data service: A new resource for communications planning.* J. Appl. Communic. 75: 1-7

Staats, Lewis J. 1995 *Using Satellite Technology in Traditional Programs* J. of Extension Vol. 33, No. 4

Stevenson, G.W., et al. 1994 *Addressing the challenges of sustainable agricultue research and extension at land-grant universities: Radially organized teams at Wisconsin* Am. J. Altern. Agric. 9:76-83

Stockle, C.O., R.I. Papendick, K.E. Saxton, G.S. Campbell & F.K. van Evert 1994 *A framework for evaluating the sustainability of agricultural systems.* Am. J. Altern. Agr. 9:45-50

Supalla, R.J et al 1995 *Adoption of nitrogen and water management practices to improve water quality J. Soil & Water Cons.* 50:77-82

Warriner, G.K. and G.M. Moul. 1989 *Social structure and choice of cropping technology: Influence of personal networks on the decision to adopt conservation tillage* SWEEP Report 8

Wolf, S. 1995 *Cropping systems and conservation policy: The roles of agrichemical dealers and independent crop consultants* J. Soil and Water Conserv. 50: 263-270

Appendix K: Manure Management Issues at the Farm Level

Because the potential client group includes people at all stages in the adoption continuum, the areas identified, in Chapter 2, as priorities for research do not encompass the full range of technology that may need to be transferred. The delivery system must be able to supply existing information as well as that which will become available from current Green Plan projects and from research in the future. Together, these represent a substantial body of information spanning a wide range of topics.

The Planning Framework

To develop and operate a sustainable manure management system, farm managers must be able to evaluate and select from among a number of alternative technologies, each of which interact differently with a range of other parts of the farming system and a variety of environmental factors. Thus, at each step in the decision-making process, farmers may require information about many specific issues. As discussed in Chapter 5, those providing information are likely to increasing rely on electronic communication systems to store, retrieve and transfer information in the future. As this occurs, the manner in which information in "packaged" is likely to change from the production of discrete, lengthy documents to the development of webs of interconnected ideas (Beck and Cilley, 1994). The information database will increasingly consist of modules of information dealing with very specific topics, linked to other related modules.

To facilitate the retrieval and transfer of information on broader themes, therefore, related modules will need to be organized in a framework and linked to related modules. The following pages present an example of a framework that encompasses many of the specific factors that may need to be considered by a farmer in planning or operating a manure management system. Such a framework could form the basis of a system for organizing and linking information related to manure management.

Within this framework, topics are organized according to the degree to which farmers can control the factor in question and the level of decision involved.

Constraints, set by nature or society, determine the limits of what is feasible or acceptable on any farm. These limitations can be either quantitative or qualitative and are imposed by financial, legal, environmental, biological, physical, or social conditions on the farm or external to it. With appropriate management, the farm operator can eliminate or modify some of the on-farm constraints (e.g. fields can be drained, buildings can be removed or renovated, etc.). Others factors are beyond the farmer's direct control or influence (e.g. climate, soil type, etc.). While the farm operator generally has little or no control over external factors or standards, there may be some flexibility in the degree to which one must conform to such standards and in the amount of risk which one is willing to assume. (Conflicts can arise, however, if the priorities set by the farmer differ significantly from those of the surrounding community.)

Within the limitations of the constraints, farm managers make decisions at several managerial levels, including:

Strategic: shape the long-term nature and goals of the farm. These include decisions related to the type and scale of the main enterprises, buildings, manure storage and handling, and soil management.

Tactical: determine medium-term objectives and approaches. These includes sources of labour and some aspects of livestock management, nutrient management and crop rotations.

Operational: specific decisions implemented on a day-to-day basis (what, who, when, where and how), within the limitations imposed by the constraints and strategic or tactical decisions.

Losses and Transformations

The quality of manure and the effect of manure on the environment are influenced by many biological processes, that are themselves influenced by the environment and the decisions of the farmer. An understanding of these processes in essential to effective planning and management of a manure system.

Additional Notes on Information Framework:

1: The options available to the farmer at the tactical and operation levels of decision are limited by or interact with constraints that pertain to the operation and by the decisions made at strategic level. The columns entitled "Links to Other Factors" indicate many of these connections, using code numbers that refer to specific lines in the table. The codes used in the framework are also used in a number of other tables and appendices to indicate the topic areas addressed by publications, research projects, etc.

2: Links shown for a topic also apply to its sub-topics.

3: For simplicity, key linkages are shown at the Strategic and Tactical Levels. Links are not shown at the Constraint Level, because most constraints influence many, if not all, decisions at lower level.

4: Links to financial considerations, personal preferences and social pressures are not shown. It can be assumed that all decisions are influenced by these factors to some degree.

5: Links to the operational level are not shown, because all other levels influence these decisions to some degree.

6: The structure of this framework should not be interpreted as implying that decision-making proceeds linearly from the strategic to the operational. Often, farmers are committed to a particular tactical or operational approach that limits the options available at the strategic level. A number of these important "reverse" links are indicated.

A Decision-making Framework for Manure Management

Code[1]	Discipline/Concern	Links to other factors	Resources[2]
1.0	CONSTRAINTS		
1.1	1 Financial		
1.1.1	1 Availability of funds for capital investment		
1.1.2	2 Availability of operating funds		
1.1.3	3 Anticipated market prices		
1.1.4*	**4 Capital costs**		
1.1.5*	**5 Operating costs**		
1.1.6	6 Interest rates		
1.1.7	7 Taxes		
1.1.8	8 Environmental Cost		
1.2	2 Legal		
1.2.1	1 Agricultural Code of Practice		Y
1.2.2	2 Drainage Act		Y
1.2.3	3 Environmental Protection Act		Y
1.2.4	4 Fisheries Act		Y
1.2.5	5 Health Protection Act		Y
1.2.6	6 Water Resources Act		Y
1.2.7	7 Planning Act		Y
1.2.8	8 Building Codes		Y
1.2.9	9 Local Bylaws		
1.3	3 Environmental Standards or Concerns		
1.3.1	1 Air		
1.3.1.1	1 odours		Y
1.3.1.2	2 toxic gases	Y	
1.3.1.3	3 nitrogen		
1.3.1.3.1	1 ammonia		
1.3.1.3.2	2 nitrogen oxides		
1.3.1.4	4 carbon		
1.3.1.4.1	1 carbon dioxide		
1.3.1.4.2	2 methane		
1.3.2	2 Water		
1.3.2.1	1 Surface		
1.3.2.1.1	1 nitrogen		
1.3.2.1.1.1	1 nitrate		Y
1.3.2.1.1.2	2 ammonia		Y
1.3.2.1.2	2 bacteria		Y
1.3.2.1.3	3 phosphorus		Y
1.3.2.1.4	4 solids (BOD)		Y
1.3.2.1.5	5 other		
1.3.2.2	2 Groundwater		
1.3.2.2.1.1	1 nitrate		Y

[1] An asterisk denotes an issue for which the need for additional information was identified. (See Table 2.) Bold print denotes an issue addressed by Green Plan research or demonstration projects. (See Table 7.)

[2] "Y" indicates that extension resource materials are available on this issue. (Appendix I)

Framework continued:

Code	Discipline/Concern	Links to other factors	Resources
1.3.2.2.2	2 bacteria		Y
1.3.2.2.3	3 phosphates		
1.3.2.2.4	4 other		
1.3.3.1	3 Other 1 Flies		
1.4	4 Human		
1.4.1	1 Personal Preferences		
1.4.2	2 Health		
1.4.2.1	1 on-farm	Y	
1.4.2.2	2 off-farm		
1.4.3	3 Safety		
1.4.3.1	1 on-farm	Y	
1.4.3.2	2 off-farm		
1.4.4	4 Social		
1.4.4.1	1 family		
1.4.4.2	2 community		Y
1.4.4.3	3 tradition		
1.5	5 Animal		
1.5.1	1 Housing		Y
1.5.2	2 Nutrition		Y
1.5.3	3 Health		Y
1.5.4	4 Water		Y
1.6	6 Agronomic		
1.6.1	1 Land area		
1.6.1.1	1 owned		
1.6.1.2	2 rented		
1.6.2	2 Location		
1.6.2.1	1 distance		
1.6.2.2	2 surroundings		
1.6.2.2.1	1 development		
1.6.2.2.2	2 watercourses		Y
1.6.3*	**3 Physical**		
1.6.3.1	1 texture		
1.6.3.2	2 topography		
1.6.3.3	3 drainage		
1.6.3.3.1	1 surface		
1.6.3.3.2	2 internal		
1.6.3.4*	4 structure		
1.6.3.5*	5 density		
1.6.3.6*	6 moisture content		
1.6.3.7	7 depth		
1.6.3.7.1	1 bedrock		
1.6.3.7.2	2 watertable		
1.6.3.8	8 stoniness		
1.6.4*	**4 Chemical**		
1.6.4.1	**1 Nutrient cont.**		
1.6.4.1.1	**1 nitrogen**		

Framework continued:

Code	Discipline/Concern	Links to other factors		
Resources				
1.6.4.1.2	**2 phosphorus**			
1.6.4.1.3	**3 potassium**			
1.6.4.1.4	**4 other**			
1.6.4.2	**2 Nutrient capacity**			
1.6.4.2.1	**1 nitrogen**			
1.6.4.2.2	**2 phosphorus**			
1.6.4.2.3	**3 potassium**			
1.6.4.2.4	**4 other**			
1.6.4.3	**3 pH**			
1.6.4.4	**4 soluble salts**			
1.6.5*	**5 Organic Matter**			
1.6.5.1	**1 living**			
1.6.5.2	**2 readily decomposable**			
1.6.5.3	**3 moderately decomposable**			
1.6.5.4	**4 stable**			
1.6.6	6 Other			
1.6.6.1*	1 weed populations			
1.6.6.2*	**2 plant diseases**			
1.6.6.3	3 other			
1.7	**7 Weather**			
1.7.1	1 Seasonal			
1.7.1.1	1 precipitation			
1.7.1.2	2 temperature			
1.7.1.3	3 wind			
1.7.2	2 Day			
1.7.2.1	1 precipitation			
1.7.2.2	2 temperature			
1.7.2.3	3 wind			
1.7.2.4	4 humidity			
1.8	8 Building site			
1.8.1	1 Soil			
1.8.1.1	1 topography			Y
1.8.1.2	2 texture			Y
1.8.1.3	3 drainage			Y
1.8.1.4	4 stability		Y	
1.8.1.5.1	5 depth			Y
1.8.1.5.1	1 bedrock			Y
1.8.1.5.2	2 watertable			Y
1.8.2	2 Surroundings			
1.8.2.1	1 development			Y
1.8.2.2	2 watercourses			Y
1.8.2.3	3 wells		Y	
1.8.3.	3 Existing facilities			
1.8.3.1	1 building(s)			
1.8.3.1.1	1 house			
1.8.3.1.2	2 barns			Y

Framework continued:

Code	Discipline/Concern	Links to other factors		Resources
1.8.3.1.3	3 other			
1.8.3.2	2 equipment			
1.8.3.3	3 manure storage(s)			
2.0	STRATEGIC			
2.1*	**1 Enterprise**			
2.1.1	1 Animal species			Y
2.1.2	2 - numbers			Y
2.1.3	3 - gender			Y
2.1.4	4 - weights			Y
2.2*	**2 Housing**			
2.2.1	1 Design			
2.2.1.1	1 type	1.2 1.3 1.5 1.7 1.8		Y
2.2.1.2	2 size	1.2 2.1		Y
2.2.1.3	3 flooring	1.3 1.5 1.8 2.1 2.5.3		Y
2.2.1.3.1	1 earth			
2.2.1.3.2	2 concrete			
2.2.1.3.3	3 slatted			
2.2.2	2 Ventilation	1.3 1.4.2 1.5.3 1.7 1.8 2.1		Y
2.2.3	3 Location(s)	1.8 1.2 1.3		
2.2.4	4 Other			Y
2.3.	3 Runoff (clean)	1.3 1.7 1.8 2.2 2.5		Y
2.3.1	1 Diversion			Y
2.3.2	2 Collection			Y
2.3.3	3 Storage			Y
2.4.				
2.5*	**5 Manure system**	1.3 1.7 1.8 2.1 2.2 3.1 3.2		Y
2.5.1	1 Moisture Content	1.7 2.2 2.3 3.2		Y
2.5.2*	**2 Contaminated Water**			
2.5.2.1	1 volume	1.7 2.2 2.3 3.2		Y
2.5.2.2*	**2 treatment**			Y
2.5.2.3	3 storage			
2.5.2.3.1	1 with manure			
2.5.2.3.2	2 separate			
2.5.3	3 Collection			
2.5.3.1	1 frequency	1.3 1.5 1.7 2.1 2.2 3.1		Y
2.5.3.2	2 method	1.5 1.7 1.8 2.1 2.2	3.1	Y
2.5.3.2.1	1 gravity			
2.5.3.2.2	2 tractor + loader			
2.5.3.2.3	3 scraper			
2.5.3.2.4	4 gutter cleaner			
2.5.3.2.5	5 pump			
2.5.3.2.6	6 flush			
2.5.4	4 Processing	1.6.1 2.5.5.3 2.5.1 2.5.5 3.1		Y
2.5.4.1	1 dilution	2.5.1 2.5.2 2.5.3	Y	

Framework continued:

Code	Discipline/Concern	Links to other factors	Resources
2.5.4.2	2 separation		Y
2.5.4.3*	**3 compost**		Y
2.5.5*	**5 Storage(s)**		
2.5.5.1*	**1 type**	1.2 1.7 2.1 2.2 2.5.1 2.5.5.3	Y
2.5.5.1.1	1 solid		
2.5.5.1.1.1	1 manure pack		
2.5.5.1.1.2	2 pad		
2.5.5.1.2	2 semi-solid		
2.5.5.1.3	3 liquid		
2.5.5.1.3.1	1 below barn		
2.5.5.1.3.2	2 above ground		
2.5.5.1.3.3	3 in-ground		
2.5.5.1.4	4 none		
2.5.5.2	2 cover	1.2 1.3 1.7 1.8	Y
2.5.5.3	3 volume	1.7 2.1 2.3 2.5.4 2.5.5.2 3.2	Y
2.5.5.4	4 location	1.2 1.3 1.8	Y
2.5.5.5	5 shape	1.8	Y
2.5.5.6	6 material	1.2 1.3 1.8 2.5.5.1	Y
2.5.5.6.1*	1 earth		
2.5.5.6.2	2 concrete		
2.5.5.5.3	3 steel (glass-lined)		
2.5.5.7	7 duration	1.2 1.3 1.6 1.7 2.7 3.3 3.4	
2.5.5.8	8 treatment	1.3	Y
2.5.5.9	9 size	2.5.5.3 2.5.5.7	Y
2.5.6	6 Removal	2.5.1 2.5.5 2.5.5.3 3.2	Y
2.5.6.1	1 tractor + loader		
2.5.6.2	2 pump		
2.5.6.3	3 vacuum tanker		
2.5.6.4	4 gravity		
2.5.7	7 Transport	1.6 2.5.1 2.5.5.3 2.5.8 3.1	Y
2.5.7.1	1 spreader/tanker		
2.5.7.2	2 truck		
2.5.7.3	3 pipe		
2.5.8*	**8 Spreading**		
2.5.8.1	1 method	1.2 1.3 1.6 2.5.5.3 2.5.1 3.1	Y
2.5.8.1.1	1 spreader/tanker		
2.5.8.1.2	2 irrigation		
2.5.8.1.3	3 hose injector		
2.5.8.2	2 timing	1.2 1.3 1.6 1.7 2.7 3.4 3.1	Y
2.5.8.3	3 incorporation		
2.5.8.3.1	1 injection	1.2 1.3 1.6 1.7 4.2.4 2.7 2.3.1	Y
2.5.8.3.2	2 tillage		
2.5.8.3.3	3 none		
2.6*	**6 Soil Management**		
2.6.1*	**1 Tillage system**		
2.6.1.1	1 conventional	1.3 1.6	
2.6.1.2	2 reduced		

Framework continued:

Code	Discipline/Concern		Links to other factors	Resources
2.6.1.3*	**3 no-till**			
2.6.2*	**2 Drainage**			
2.6.2.1	1 surface			
2.6.2.2*	**2 tile**		4.2.4.5	Y
3.0	TACTICAL			
3.1	1 Labour			
3.1.1	1 Family			
3.1.2	2 Employees			
3.1.3	3 Custom workers			Y
3.2	2 Animal Management			
3.2.1*	1 Feeding	1.5.2		
3.2.1.1	1 ration			
3.2.1.1.1	1 balance			
3.2.1.1.2	2 quality			
3.2.1.2	2 method			
3.2.2	2 Bedding		1.5.1 1.5.3	
3.2.2.1	1 type			
3.2.2.2	2 amount			
3.2.3	3 Water		1.5	Y
3.2.3.1	1 consumption			
3.2.3.2	2 waste			
3.2.3.3	3 washwater		2.5.2	Y
3.3	**3 Crop Management**			
3.3.1	**1 Crops grown**			
3.3.2	2 Rotation			
3.4	4 Nutrient Management			
3.4.1	1 Feed sources			
3.4.1.1	1 homegrown		1.5 1.6 2.1 3.3	Y
3.4.1.2	2 purchased			
3.4.2	2 Crop nutrient sources			
3.4.2.1	1 manure		1.3 1.6 1.7 4.2.4 3.4 3.3	Y
3.4.2.2	2 off-farm			
3.4.2.2.1	1 fertilizers			Y
3.4.2.2.2	2 organic materials			
3.4.3*	**3 Crop requirements**			
3.4.3.1.1	1 criterion			
3.4.3.1.1*	**1 nitrogen**		1.3 1.6 3.3	Y
3.4.3.1.2	2 phosphorus		1.3 1.6 3.3	Y
3.4.3.2	2 timeframe			
3.4.3.2.1	1 current crop		1.3 1.6 3.3	Y
3.4.3.2.2	2 rotation			
3.5	5 Manure use			
3.5.1	1 Fields to manure			

Framework continued:

Code	Discipline/Concern	Links to other factors	
Resources			
3.5.2	2 Management of excess		
3.5.2.1	1 Add land base		
3.5.2.1.1	1 purchase		
3.5.2.1.2	2 rent		
3.5.2.1.3	3 trade		
3.5.2.2	2 Reduce amount		
3.5.2.2.1	1 feeding		
3.5.2.2.2	2 bedding		
3.5.2.2.3	3 watering		
3.5.2.3	3 Alter content		
3.5.2.3.1	1 feeding		
3.5.2.3.2	2 bedding		
3.5.2.4	4 Other uses		
3.5.2.4.1	1 bedding		
3.5.2.4.2	2 feed		
3.5.2.4.3	3 methane		
3.5.2.4.4	4 sale		
4.0*	**LOSSES AND TRANSFORMATIONS**		
4.1*	**1 Carbon**	2.1 2.2 2.3 2.5 3.2	
4.1.1	**1 Initial content**		
4.1.2*	**2 Barn**		
4.1.3*	**3 Storage**		
4.1.3.1*	**1 decomposition**		
4.1.3.2*	**2 runoff**		
4.1.4*	**4 Field**		
4.1.4.1*	**1 decomposition**		
4.1.4.2*	**2 runoff**		
4.1.4.3*	**3 preferential flow**		
4.1.4.4*	**4 leaching**		
4.2*	**2 Nitrogen**	2.1 2.2 2.3 2.5 3.2	Y
4.2.1*	**1 Initial content**		
4.2.2*	**2 Barn**		
4.2.3*	**3 Storage**		
4.2.3.1*	**1 volatilization**		
4.2.3.2*	**2 denitrification**		
4.2.3.3*	**3 runoff**		
4.2.3.4*	**4 leaching**		
4.2.4*	**4 Field**	1.6 1.7 2.5.8 2.6	Y
4.2.4.1*	**1 volatilization**		
4.2.4.2*	**2 denitrification**		
4.2.4.3*	**3 immobilization**		
4.2.4.4*	**4 mineralization**		
4.2.4.5*	**5 preferential flow**		
4.2.4.6*	**6 leaching**		
4.2.4.7*	**7 runoff**		

Framework continued:

Code	Discipline/Concern	Links to other factors	Resources
4.2.5	**5 Available for crop growth**		
4.3	3 Phosphorus	2.1 2.2 2.3 2.5 3.2	Y
4.3.1	1 Initial content		
4.3.2	2 Barn	2.5.2	
4.3.3	3 Storage	2.5.2	
4.3.4	4 Field	1.6 1.7 2.6	
4.3.4.1*	**1 runoff**		
4.3.4.2*	**2 leaching**		
4.3.5	5 Available for crop growth		
4.4	4 Potassium	2.1 2.2 2.3 2.5 3.2	Y
4.4.1	1 Initial content		
4.4.2	2 Barn	2.5.2	
4.4.3	3 Storage	2.5.2	
4.4.4	4 Field	1.6 1.7 2.6	
4.3.5	5 Available for crop growth		
4.5	5 Bacteria		
4.5.1	1 Initial Content		
4.5.2	2 Barn		
4.5.3	3 Storage		
4.5.4*	3 Field	1.6 1.7 2.5 2.6	
4.5.4.1*	**1 runoff**		
4.5.4.2*	**2 preferential flow**		
4.6	6 Other		
4.6.1*	1 Odours		Y
4.6.1.1*	1 Barn		
4.6.1.2*	2 Storage		
4.6.1.3*	3 Field		
4.6.2*	2 Toxic Gases		Y
4.6.2.1*	1 Barn		
4.6.2.2*	2 Storage		
4.6.3*	3 Corrosive Gases		
4.6.3.1*	1 Barn		
4.6.3.2*	2 Storage		
5.0	OPERATIONAL DECISIONS		
5.1.	1 What?		
5.2.	2 When?		
5.3.	3 Where?		
5.4.	4 How?		
5.5.	5 Who?		
5.6.	6 How much?		
			Y