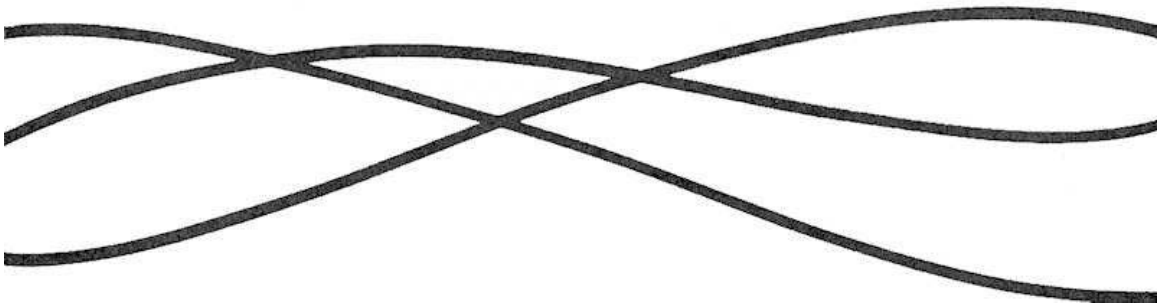
POLLUTION PROBLEMS

Associated with Poultry and Animal Wastes

in the Ontario Great Lakes Basin



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WATER POLLUTION POTENTIAL OF FARM ANIMAL AND POULTRY MANURES

INTRODUCTION

Farm animal and poultry manures are of major concern in the abatement of water pollution. Over 90 million farm animals and birds produce in excess of 38 million tons of manure annually in the Canadian portion of the. Great Lakes Basin. About 40 percent of this is produced in the Lake Erie Watershed area alone.

The trend in livestock, milk, poultry and egg production is towards automation and centralization. The production of animals has emerged from the small, individual farm operation into a large-scale industrial enterprise involving hundreds of animals and frequently very few acres.

Intensive confinement housing of animals and poultry creates a waste disposal problem. Ordinarily, these wastes are used as a fertilizer source for field crop production and if the farmer grows his own feed, there is generally sufficient land available for this method of disposal. However, many poultry and hog producers do not grow their own feed and rely on commercially available feedstuffs for their feed requirements. Thus, they frequently do not have adequate land of their own for the disposal of the manure produced. The cash crop farmer, on the other hand, can usually buy and apply chemical fertilizers more cheaply than he could use free sources of animal manures.

THE CHARACTERISTICS OF ANIMAL MANURES

There are many criteria which may be used for assessing the water pollution potential of farm manures. The general criteria used in sewage treatment are biochemical oxygen demand (BOD), suspended solids (SS) and coliform bacteria. More recently nutrient relationships have become important especially those of nitrogen and phosphorus. While these criteria may also be applied to farm manures it should be stressed that manure unlike domestic sewage is not normally discharged to surface water.

In the following tables both sewage treatment criteria and plant nutrients have been used to characterize farm animal wastes. These figures represent total production values and do not represent quantities reaching water. As is pointed out later proper manure management would prevent all, or a very large proportion of these potential pollutants from reaching receiving waters.

Table 1 expresses, in units of pounds per day per animal, the production quantities of the various manure components mentioned above. These figures have been used in calculating the data presented in Table 2 and 3 for the Lake Erie Watershed (refer to Figure 1, section on Fertilizer Use and Pollution) and in Tables 4 and 5 for the Great Lakes Basin.

Table 1. Production Quantities and Characteristics of Livestock Manures as Excreted.

	Total Manure	BOD	SS	Nitrogen	P_2O_5	Sodium
Bulls						
Cows (milk)	90	1.45	1.95	0.33	0.13	0.03
Cows (beef)						
Steers (beef)						
Heifers (milk)	50	1.65	2.05	0.16	0.10	0.01
Heifers (beef)						
Calves	25	0.36	0.52	0.08	0.03	0.01
Pigs (Feeder)	10	0.38	0.34	0.06	0.04	0.006
Sows	14	0.41	0.18	0.062	0.042	0.008
Sheep (Ewes)	12	0.32	0.21	0.05	0.03	0.002
Sheep (Lambs)	8	0.22	0.11	0.03	0.02	0.001
Horses & Ponies	55	1.40	1.90	0.26	0.09	0.01
Hens (Layers)						
Chickens (Hatchery)	0.31	0.025	0.013	0.004	0.0028	0.00025
Turkeys (Heavy)						
Hens (Pullets)	0.16	0.013	0.011	0.0015	0.0008	0.00018
Turkeys (Broiler)						
Chicken (Broiler)	0.09	0.009	0.008	0.0033	0.0002	0.0001
Turkeys (Hatchery)	0.31	0.03	0.02	0.0046	0.00041	0.0004

Units are lb/day/animal

Table 2. COMPONENTS OF ANIMAL MANURES PRODUCED ON FARMS IN THE LAKE ERIE WATERSHED.

	Numbers	Manure (lb/day)	BOD (lb/day)	SS (lb/day)	Nitrogen (lb/day)	P_2O_5 (lb/day)	Sodium (lb/day)
Bulls	6,200						
Cows (milk)	248,000						
Cows (beef)	85,000						
	339,200	30,528,000	491,840	661,440	111,936	44,096	10,176
Steers (beef)	230,000						
Heifers (milk)	73,300						
Heifers(beef)	87,300						
	390,600	19,530,000	644,490	976,500	62,496	39,060	3,906
Calves	178,400	4,460,000	64,224	92,768	14,272	5,352	1,484
Pigs (feeder)	1,588,000	15,880,000	603,440	539,920	95,280	63,520	9,528
Sows	198,500	2,779,000	81,385	35,730	12,307	8,337	1,588
Sheep (ewes)	34,000	408,000	10,880	7,140	1,700	1,020	68
Sheep (lambs)	31,100	248,800	6,842	3,421	933	622	31
Horses & Ponies	22,200	1,221,000	31,080	42,180	5,772	1,998	222
Total Animals		75,054,800	1,934,181	2,359,099	304,696	164,005	27,003

Table 3. COMPONENTS OF POULTRY MANURES PRODUCED ON FARMS IN THE LAKE ERIE WATERSHED.

	Numbers	Manure (lb/day)	BOD (lb/day)	SS (lb/day)	Nitrogen (lb/day)	P_2O_5 (lb/day)	Sodium (lb/day)
Hens (layers)	3,965,331						
Chickens (Hatchery)	656,912						
Turkeys (Heavy)	1,819,366						
	6,441,609	1,996,899	161,040	83,741	27,055	18,036	1,610
Hens (Pullets)	2,960,000						
Turkeys (Broilers)	3,464,229						
	6,424,229	1,039,392	111,363	74,242	11,136	5,140	1,134
Chickens (Broilers)	33,016,660	2,971,449	297,150	264,133	10,895	6,603	3,302
Turkeys (Hatchery)	290,259	83,780	8,108	5,405	1,243	1,108	108
Total Poultry		6,091,570	577,661	427,521	50,521	30,887	6,154
Total Poultry & Animals (lbs/day)		81,146,370	2,511,842	2,786,620	355,025	194,892	33,157
(Tons/year)		14,809,212	458,411	508,558	64,792	35,567	6,051

Table 4. COMPONENTS OF ANIMAL MANURES PRODUCED ON FARMS IN THE GREAT LAKES BASIN.

	Numbers	Manure (lb/day)	BOD (lb/day)	SS (lb/day)	Nitrogen (lb/day)	P_2O_5 (lb/day)	Sodium (lb/day)
Bulls	24,400						
Cows (milk)	668,700						
Cows (beef)	327,000						
	1,019,100	91,809,000	1,479,145	1,939,195	336,613	132,611	30,603
Steers(beef)	609,300						
Heifers (milk)	189,700						
Heifers (beef)	269,900						
	1,068,900	53,445,000	1,763,685	2,191,245	171,024	106,890	10,689
Calves	578,000	14,450,000	208,080	300,560	46,240	17,340	5,780
Pigs (feeders)	3,039,200	30,392,000	1,154,896	1,033,328	182,352	121,568	18,235
Sows	379,500	5,313,000	155,595	68,310	23,529	15,938	3,036
Sheep (ewes)	118,600	1,423,200	37,952	24,906	5,930	3,558	237
Sheep (lambs)	105,400	843,200	23,188	11,594	3,162	2,108	105
Horses & Ponies	53,700	2,953,500	75,180	102,030	13,962	4,833	537
Total Animals		200,628,900	4,897,701	5,721,168	783,833	404,847	69,222

Table 5. COMPONENTS OF POULTRY MANURES PRODUCED ON FARMS IN THE GREAT LAKES BASIN.

	Numbers	Manure (lb/day)	BOD (lb/day)	SS (lb/day)	Nitrogen (lb/day)	P_2O_5 (lb/day)	Sodium (lb/day)
Hens (layers)	7,386,556						
Chickens (hatchery)	1,296,755						
Turkeys (heavy)	3,489,897						
	12,173,208	3,773,694	304,330	158,252	51,127	34,085	3,043
Hens (pullets)	5,356,000						
Turkeys (broilers)	4,716,199						
	10,072,199	1,611,552	171,227	101,794	13,094	8,058	1,812
Chickens (broilers)	63,447,476	5,710,273	571,027	507,580	20,938	12,689	6,344
Turkeys (hatchery)	299,966	92,989	9,000	6,000	1,380	1,230	120
Total Poultry		11,188,508	1,055,584	773,626	86,539	56,062	11,319
Total Poultry & Animals (lbs/day)		211,817,408	5,953,285	6,494,794	869,372	460,909	80,541
Tons/year		38,656,668	1,086,474	1,185,300	158,660	84,116	14,699

SOURCES

Nitrogen may well be the most important of the potential pollutants in farm animal manures. It is present in extremely high concentrations and is readily carried by water. A convenient way to present the intensity of nitrogen production by manures on farms in Ontario is to establish a livestock distribution pattern for the Great Lakes Basin.

Table 6 shows the quantities of nitrogen and phosphorus excreted by different kinds of livestock and since there is considerable variation in the production of manure between different species and ages of livestock, the concept of the "animal unit" has been developed. An animal unit will produce the amount of nitrogen normally sufficient to bring a one-acre crop of corn to maturity.

Table 7 gives the animal unit equivalent of the various classes of farm animals and poultry.

Tables 8 and 9 show the animal units in the Great Lakes Basin broken down by county. The Lake Erie Watershed (refer to Figure 1, section on Fertilizer Use and Pollution), because of its special significance, is given as a percentage for the total of the Basin in Table 9. Commercial farm acreages in these tables were obtained from the 1969 Farm Statistics for Ontario. The acreage concentrations of animal units shown in the final column of each table suggests that there is ample land available for the effective utilization of the manure being produced in the Great Lakes Basin.

The maps in Figure 1 and Figure 2 graphically illustrate the distribution of the livestock populations and their concentrations on an animal unit basis. The data for these figures were taken from Tables 8 and 9.

Table 6. The Nitrogen and Phosphorus Excreted by Different Kinds of Livestock.

Kind of Livestock	N (lb)	P (lb)
1000 chicken broilers (60 days) (0 to 4 lb)	155	31
100 laying hens (365 days) (5 lb)	125	44
10 feeder hogs (140 days) (30 to 200 lb)	115	29
2 beef steers (365 days) (400 to 1100 lb)	140	29
1 dairy cow (365 days) (1200 lb)	140	29

Table 7. Animal Unit Equivalents of Various Classes of Livestock.

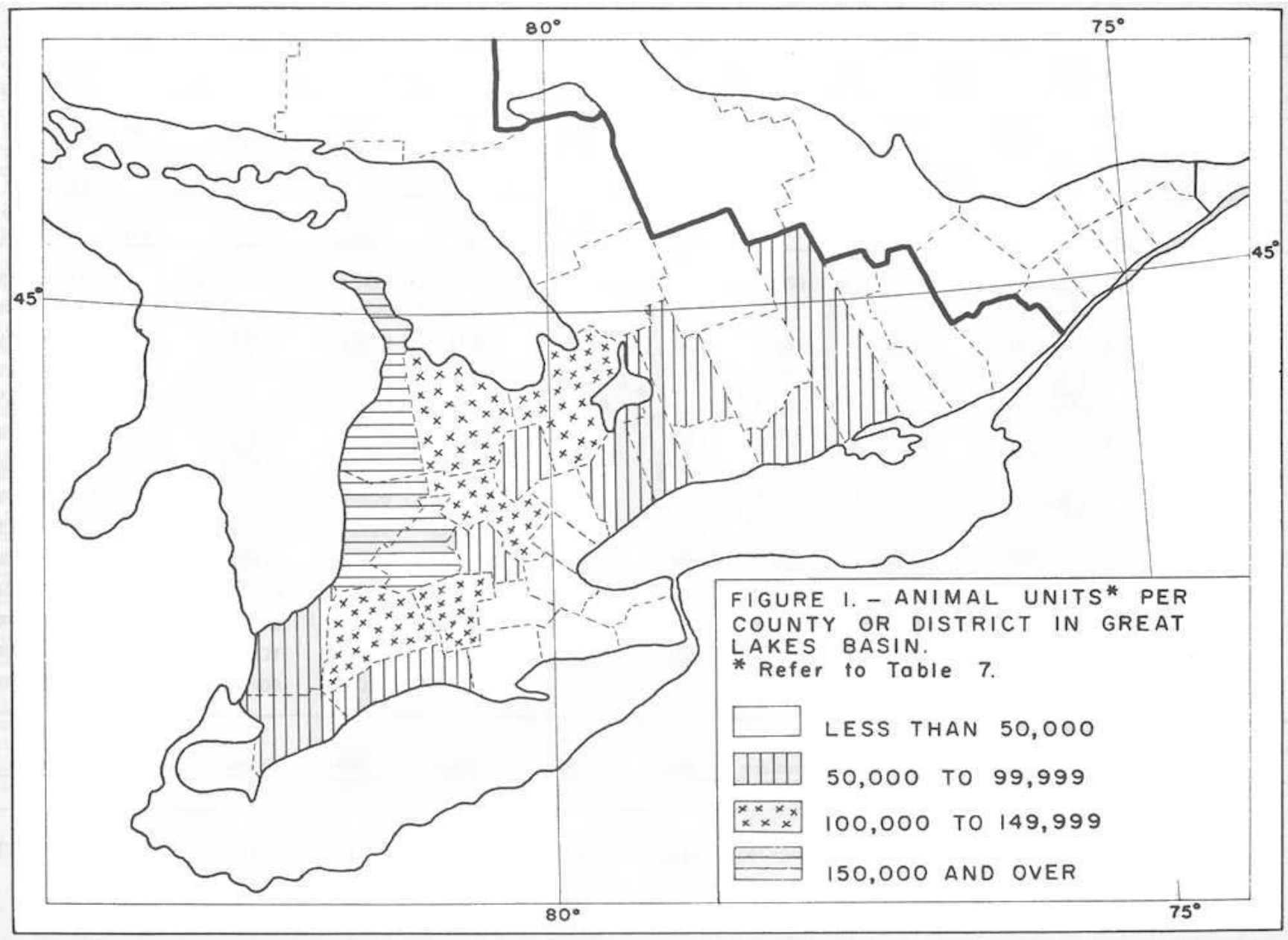
1 dairy cow	1 animal unit (365 days)
2 heifers (for milk purposes)	1 animal unit (365 days)
4 calves (under one year)	1 animal unit (365 days)
1 beef cow	1 animal unit (365 days)
2 beef steers (400-1100 lb.)	1 animal unit (365 days)
2 beef heifers (400-1000 lb.)	1 animal unit (365 days)
1 bull	1 animal unit (365 days)
1 horse (includes ponies)	¾ animal unit (365 days)
4 sows	1 animal unit (365 days)
10 feeder hogs (30-200 lb.)	1 animal unit (140 days)
4 sheep (ewes and rams)	1 animal unit (365 days)
6 lambs (to 100 lb. market weight)	1 animal unit
100 hens (layers)	1 animal unit (365 days)
100 hens (breeders)	1 animal unit (365 days)
300 pullets	1 animal unit (160 days)
1000 chicken broilers (0-4lb.)	1 animal unit (60 days)
300 turkeys (broilers)	1 animal unit (85 days)
100 turkeys (heavys)	1 animal unit (160 days)
75 turkeys (breeders)	1 animal unit (365 days)

Table 8. Livestock Populations (Animal Units) by Counties in the Great Lakes Watershed not including Lake Erie Watershed - Ontario.

County or District	Poultry	Pigs	Dairy	Beef	Sheep	Horses	Animal Units Total	Commercial Farms (acreage)	Animal Units (per 100 acre)
Bruce	3,491	16,850	49,400	89,950	1,800	1,350	162,841	616,921	26.4
Dufferin	1,964	8,150	15,400	24,100	1,650	750	52,014	236,107	22.0
Grey	6,391	17,975	48,100	62,000	4,658	1,575	140,699	653,114	21.5
Halton	5,692	3,675	11,950	5,850	1,333	825	29,325	116,349	25.2
Huron	17,998	29,875	51,550	66,500	1,242	1,125	168,290	678,300	24.8
Peel	2,233	2,100	17,575	12,050	1,033	975	35,966	163,489	22.0
Perth	17,034	38,500	71,750	31,700	717	1,500	161,201	470,738	34.2
Simcoe	5,783	20,050	40,275	45,000	4,467	1,800	117,375	486,944	24.1
Durham	3,940	4,400	13,350	22,250	1,033	750	45,723	200,442	22.8
Haliburton	--	90	575	1,150	30	150	1,995	4,741	42.0
Hastings	3,984	5,375	30,275	12,400	975	975	53,984	318,984	16.9
Muskoka	300	210	2,525	1,050	170	215	4,470	28,484	15.7
Northumberland	4,740	5,500	26,300	15,000	708	900	53,158	274,793	19.3
Ontario	5,214	9,925	27,700	21,300	2,175	1,350	67,664	274,440	24.6
Parry Sound	--	315	4,825	5,050	333	450	10,973	77,365	14.2
Peterborough	1,547	2,050	15,950	15,150	742	825	36,264	181,742	20.0
Prince Edward	1,967	2,010	16,100	3,750	717	300	24,844	163,274	15.2
Victoria	1,734	4,225	12,400	32,800	2,400	750	54,309	290,913	18.7
York	8,583	11,900	20,300	12,500	1,450	3,225	57,958	226,174	25.6
Frontenac	553	1,050	21,625	11,200	742	825	35,995	189,601	19.0
Leeds	3,192	1,625	32,300	8,550	817	1,050	47,534	244,696	19.4
Lennox-Addington	2,014	2,225	19,750	8,950	592	675	34,206	200,023	17.1
Algoma	--	190	5,100	5,600	471	300	11,607	79,457	14.6
Manitoulin	1,608	1,125	4,075	12,100	2,258	225	21,391	182,081	11.7
Rainy River	--	145	5,400	10,000	950	300	16,795	103,572	16.2
Sudbury	--	400	4,800	3,150	41	225	8,616	64,679	13.3
Thunder Bay	--	435	7,250	2,050	83	225	10,043	81,272	12.4

Table 9. Livestock Populations (Animal Units) by Counties in the Lake Erie Watershed - Ontario.

County	Poultry	Pigs	Dairy	Beef	Sheep	Horses	Animal Units Total	Commercial Farms (Acreage)	Animal Units (per 100 acres)
Brant	4,806	6,525	14,225	6,750	800	750	33,856	180,999	18.7
Elgin	5,431	10,800	18,700	21,850	1,117	1,350	59,248	359,922	16.5
Essex	3,967	5,575	11,500	4,300	125	525	25,992	319,384	8.1
Haldimand	5,983	6,900	32,250	8,150	1,250	750	46,283	209,260	22.1
Kent	5,539	17,525	5,850	24,820	792	675	55,201	527,041	10.5
Lambton	10,240	21,550	22,575	35,150	2,083	1,500	93,098	501,907	18.5
Lincoln	13,854	5,750	12,050	2,190	416	525	34,785	118,136	29.4
Middlesex	16,558	22,650	47,800	51,170	2,283	1,875	142,336	591,420	24.1
Norfolk	6,060	4,925	10,350	4,950	417	1,275	27,977	296,809	9.4
Oxford	13,763	24,150	57,750	21,200	775	1,125	118,763	397,201	29.9
Welland	6,719	2,425	9,650	1,970	400	525	21,689	79,483	27.3
Wentworth	8,752	7,075	17,300	5,900	375	825	40,227	133,653	30.1
Waterloo	12,708	33,350	31,100	18,850	875	2,625	99,508	240,446	41.4
Wellington	11,653	39,225	47,050	43,100	1,975	2,325	145,328	471,165	30.8
Erie Watershed (animal units)	126,033	208,425	329,150	250,350	13,683	16,650	944,291	4,426,826	21.3
Great Lakes Basin (animal units)	225,995	398,795	905,750	791,500	47,216	40,265	2,409,521	11,735,521	20.5
Erie as % of Great Lakes	56	52	36	32	29	41	39	38	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75°
45°
45°
80°
75°
FIGURE I. – ANIMAL UNITS* PER COUNTY OR DISTRICT IN GREAT LAKES BASIN.
* Refer to Table 7.
LESS THAN 50,000
50,000 TO 99,999
100,000 TO 149,999
150,000 AND OVER

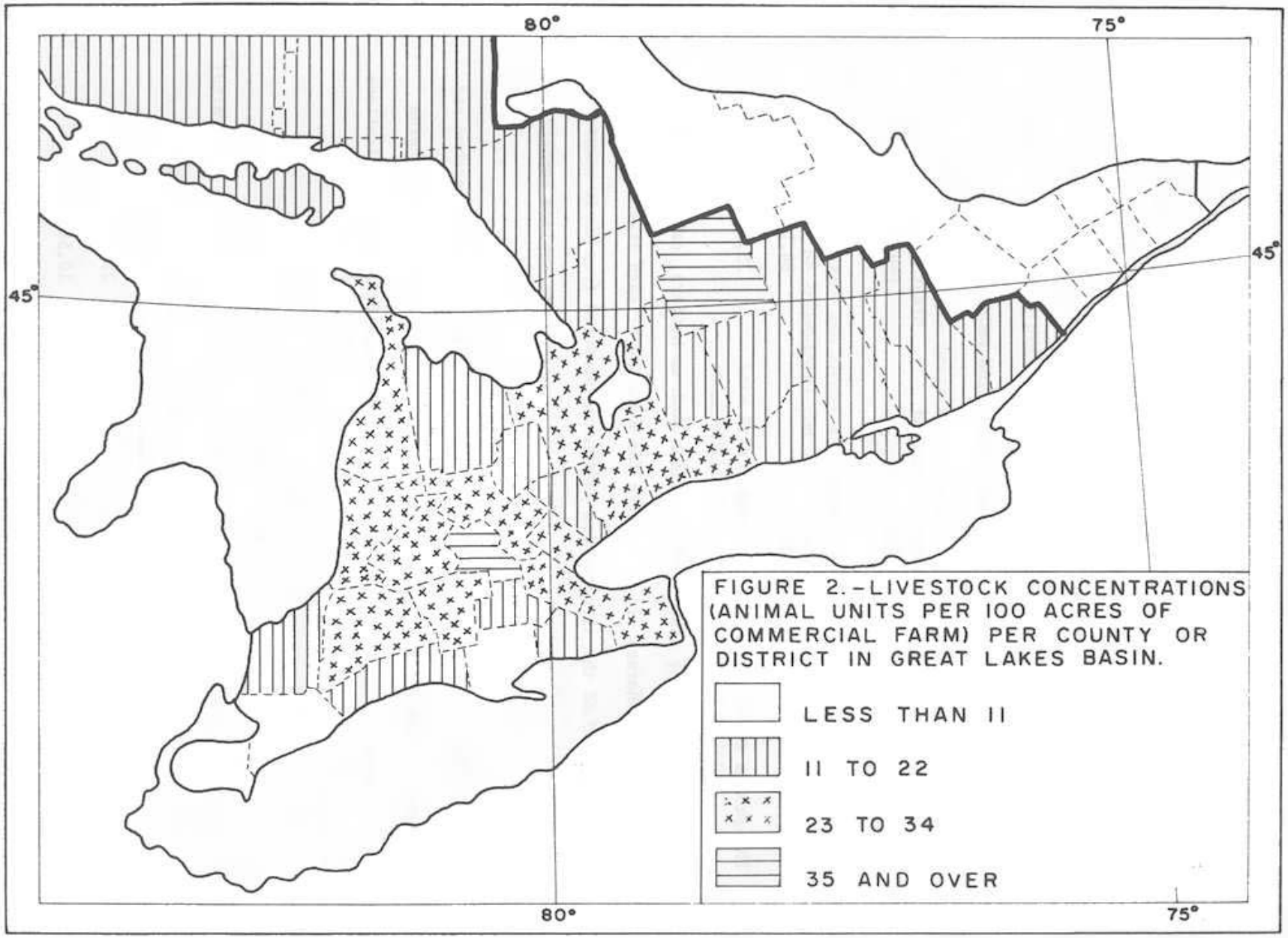
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FIGURE 2.–LIVESTOCK CONCENTRATIONS (ANIMAL UNITS PER 100 ACRES OF COMMERCIAL FARM) PER COUNTY OR DISTRICT IN GREAT LAKES BASIN.
LESS THAN 11
11 TO 22
23 TO 34
35 AND OVER

On the basis of the livestock populations in both the Lake Erie Watershed and the Great Lakes Basin an estimate of nitrogen and phosphate production of manure is presented in the following table.

Table 10. TOTAL NITROGEN AND PHOSPHORUS PRODUCTION FROM MANURES.

	Lake Erie Watershed tons/year	Great Lakes Basin tons/year
Nitrogen (N)	64,792	158,660
Phosphate (P_2O_5)	35,567	84,116
Phosphorus (P)	15,649	35,911

Since many classes of livestock such as heifers, calves, beef cows, sheep and horses are on pasture for 6 months of each year a considerable portion of the nitrogen and phosphorus produced from their manure would not be available for crop acres and therefore, not replace commercial fertilizer.

It is estimated on the above basis that in the Erie Watershed and the Great Lakes Basin the following quantities of nitrogen and phosphorus are excreted annually on pastures and do not replace fertilizer applications on cropped land.

Table 11. NITROGEN AND PHOSPHORUS IN MANURES DEPOSITED DIRECTLY ON PASTURES (ESTIMATED).

	Lake Erie Watershed tons/year	Great Lakes Basin tons/year
Nitrogen (N)	7,012	22,512
Phosphate (P_2O_5)	3,295	10,588
Phosphorus (P)	1,450	4,659

The total nitrogen production from manure should be discounted at least 25% for losses during handling and storage of manure and again this amount would not replace commercial nitrogen fertilizers applied to cropped land. It cannot of course be argued that this nitrogen does not affect water quality since part of it may leach into the soil as nitrate.

Figures in Table 12 show the quantities of nitrogen and phosphorus produced in the Great Lakes Basin discounted as described above.

Table 12. NITROGEN AND PHOSPHORUS PRODUCTION FROM MANURES AS REPLACEMENT FOR COMMERCIAL FERTILIZER.

	Lake Erie Watershed tons/year	Great Lakes Basin tons/year
Nitrogen (N)	43,335	102,111
Phosphate (P_2O_5)	32,272	73,528
Phosphorus (P)	14,199	32,352

IMPACT

The massive potential of farm animal and poultry manures to pollute the waters of the Great Lakes Basin has been established in the preceding sections. Unlike most industrial and municipal wastes, however, farm manures are not normally discharged to receiving waters. The percentages of pollution materials which reach watercourses from livestock operations are dependent upon a great diversity of factors, hence it is very difficult to determine with any degree of reliance the amount of pollutant materials from manures reaching the Great Lakes Watershed.

The characteristics of farm animal manures having the potential for the greatest impact on the pollution of the Great Lakes Basin are outlined in the following sections.

Biochemical Oxygen Demand

The Biochemical Oxygen Demand, or BOD of a waste is a measure of the amount of oxygen required to biologically oxidize the material. Such oxidation processes occur naturally in receiving waters and if the organic pollution is excessive the natural oxygen content of the receiving stream may be depleted. Under such conditions aerobic stabilization is displaced by anaerobic processes with the resultant release of foul smelling gases and unsightly floating masses of decaying solids. Another result of conditions of depleted oxygen is the death of fish and other aerobic organisms trapped in that body of water. Both the aesthetic as well as the practical values of the watershed may thereby be seriously affected.

The BOD of farm manures is extremely high being in excess of 200 times that of domestic sewage therefore uncontrolled discharge of manures to a watercourse may have devastating effects.

Suspended Solids

Turbidity of a water body is a measure of the extent to which suspended matter inhibits the penetration of light because of particle scattering and absorption. Increases in turbidity result from suspended materials being carried into lakes and rivers through soil erosion, land runoff, water turbulence, plankton growth and the suspended solids content of waste effluents discharged to the water. Turbidity reduces the aesthetic quality of the water and endangers spawning beds where deposition and sedimentation occur.

The suspended solids content of farm manures is extremely high, reaching concentrations of 50,000 ppm or more, and direct discharge results in intolerable suspended solids levels in receiving water.

Nitrogen

The nitrogen component of animal wastes is voided largely as uric acid (birds) or as urea (mammals). Both these compounds are quickly decomposed *by* microorganisms in the manure with the result that ammonium salts accumulate. The ammonium ion is more or less rapidly converted to nitrate depending on availability of oxygen and the nitrate, being an anion, is free to move with any water which leaches through the accumulated waste since nitrate is not adsorbed to clays and other reactive sites as is the ammonium ion. Water moving through manure may then be enriched with nitrogen even if it does not carry any of the carbonaceous or other components of the manure, and this nitrogen may find its way to ground water if conditions permit.

If manure is spread relatively thinly over soil, in quantities not greatly exceeding the requirements of plant production, most of the nitrate is removed by plants or lost

from the soil by reduction of the nitrate to nitrogen gas. However, wherever manure is concentrated in direct contact with soil the possibility of leaching of nitrate to ground water must be considered as well as the possibility of direct surface transport of nitrogen, phosphorous and organic material to watercourses.

Excessive concentrations of nitrates in ground water used for drinking purposes may be biologically converted to nitrites in the digestive system and can cause methemoglobinemia in both livestock and humans.

Nutrients

With the present emphasis on eutrophication, the nutrient contribution of farm manures to surface waters is now recognized. Although nitrogen and phosphorus are the principal elements involved, other nutrients are also important and farm animal manures contain virtually all of the macro-nutrients as well as the trace elements required to promote algal growth.

At low concentrations, these nutrients are essential in providing aquatic growths as food for fish. In excessive concentrations they permit an over-abundance of growth and algae blooms frequently develop causing serious aesthetic and economic considerations. When streams and lakes reach the "pea soup" stage of algae growth, the odour of decaying plants becomes extremely offensive, fish are killed because of the reduced oxygen content of the water and the water is reduced in its economic and aesthetic importance.

Because of their high concentrations of nitrogen and phosphorus, farm manures have frequently been blamed for localized extreme algae blooms in ponds, or small lakes where significant runoff has been allowed to enter such water bodies. The nutrient content of farm manures is therefore of great importance in the assessment

of their water pollution potential.

Infectious Agents and Allergens

Agricultural losses caused by infectious agents of livestock, poultry, wildlife and man carried by water have been well documented. Some of the diseases so transmitted are salmonellosis, leptospirosis, hog cholera, foot-and-mouth disease, tuberculosis, brucellosis and anthrax. A number of these may infect humans.

Waters receiving direct discharges of farm manures must therefore be considered as hazardous to the health of farm animals and humans if used for drinking purposes. Farm wells may also become contaminated from the drainage from feed lots.

CURRENT PRACTICE

An ideal system of animal waste management would incorporate the following concepts: the waste would be allowed to accumulate in a water-tight storage to prevent seepage. The storage would be large enough to hold an amount of waste sufficient to obviate the necessity of spreading it on land during winter (when ground is frozen and run-off in Spring can occur) or during wet periods (when leaching might result). The waste would be spread on land at seasons when crop uptake would be expected to be maximum and at rates not exceeding those necessary to achieve maximum crops. No animal wastes would be spread on slopes subject to run-off to watercourses.

While practices approaching the ideal are current on some farms in the Ontario Great Lakes basin, animal production units often fall short in some important aspects. Unfortunately, statistics are, for the most part, unavailable and, because of the very dynamic state of animal management concepts, it is difficult even to generalize. A description of some of the waste-handling practices in the study area is all that can be attempted.

I. Storage of manure.

1. Housed animals

(a) Solid wastes: Most of the chicken and turkey broilers in Southern Ontario; many laying flocks; many breeding swine herds and many dairy herds are housed with litter or bedding in such a way as to permit wastes to be handled as a solid. Similarly most beef cow-calf enterprises and some feeder pig operations are on solid waste handling. In some of these latter establishments some liquids may he drained away from the solids and collected in a tank. In all

cases, the solids are moved outside the building periodically and may be stored, often on the bare ground but sometimes on a concrete slab, for some period before being spread on land. There are no regulations presently in Ontario regarding storage of solid animal wastes although such storage areas must be deemed potential sources of nutrient enrichment of both surface and ground water.

So far as the authors are aware, few establishments follow the practice of storing manure on an impervious slab from which fluids can be drained for storage in an approved way. Nor are manure piles covered to prevent the leaching action of rain. In certain areas where broilers are reared in high density conditions on many small farms, manure has been moved by a contractor to a storage area and piled on bare ground in very large quantities for periods of a year or more.

1. (b) Liquid wastes: There is a growing trend in Ontario, among egg producers and pig feeders particularly as well as among dairy producers to manage manure in a liquid or slurry form. While this system has disadvantages in that odour problems are likely to be enhanced there is generally considered to he an economic advantage over solid handling. Early attempts at liquid handling involved the use of lagoons but these were so often undersized, subject to overflow and odour problems that their use has largely been abandoned. Current practice usually involves storage of the liquid or slurry in concrete tanks, often below grade. Provided these are of durable construction they satisfactorily prevent contamination of ground water.

No regulations govern the size or construction design of manure storage tanks in Ontario, however, where new facilities are being constructed an approval must be obtained from the Air Management Branch of the Dept. of

Energy and Resources Management. The Code of Practice followed by the A.M.B. requires that the storage provides capacity for 6 months accumulation of manure.

2. Feed lots

As elsewhere in North America there is a trend in Ontario to produce beef cattle under confined conditions with minimum shelter. Typically, cattle are held in a yard on a concrete floor (or on a partially paved surface) with access to a partially open shelter. No bedding is used and manure is removed periodically and is usually spread on land immediately. In some cases a larger feeding area is used and no floor is provided. The manure solids may accumulate over long periods. At least one operation in the Ontario Great Lakes basin has been constructed on a zero-housing basis. On this farm 1000 steers are confined on a one-acre un-roofed concrete slab, manure is removed daily and stored as a thin slurry in a concrete tank.

In general, feed lots are potential sources of surface water pollution since there is only rarely any effort made to collect water which runs off the holding area. Much of this water may percolate into the soil as does contaminated water leaching through unpaved feeding areas and it poses the same threat to ground water purity as was described above. The location of the feed lot in relation to water courses as well as the characteristics of the soil are important considerations in evaluating the impact on the environment of these establishments.

So far as we are aware, there are no specific regulations applying to the location or manure handling practices of feed lots other than the general regulations of O.W.R.C. in regard to surface water quality.

II. Land disposal/utilization of animal wastes.

All animal manure produced in the Ontario Great Lakes Basin should be returned to the land. Ideally, as pointed out earlier in this report, manure would be spread in such a way that the nutrients it contains would be utilized in crop production and no run-off would occur. Because this requires careful timing of manure applications as well as some knowledge of the nutrient content of the manure, the ideal is not easily achieved. In our opinion the practices which have the greatest potential adverse impact on water quality are those of winter spreading of manure; storing or accumulating manure uncovered on the ground; spreading manure at very high application rates, and permitting run-off from feeding areas. Each of these practices is common in the study area and none of them are specifically regulated.

The Air Management Branch Code of Practice calls for sufficient land to be available for complete utilization of the manure produced on each farm receiving a permit, however, the rate and timing of manure application are not regulated.

In connection with land disposal of animal wastes, one particular practice may he singled out for special criticism since, while it is relatively rare, it seems to us to be particularly inadequate. We refer to the use of septic tank systems for disposal of veal calf wastes and milking parlour wastes. This kind of installation has the effect of concentrating large quantities of nitrogen in a very small area. For example, a veal calf unit of 200 capacity puts out about 6-8 lbs. of nitrogen per day or 1-1.5 tons per year which when distributed in a weeping tile bed covering 4500 sq. ft. is equivalent to a rate of nitrogen application of 10-15 tons per acre. Wastes from milk houses also contain large quantities of manure and urine as well as milk solids and are often handled in septic tank - weeping tile systems.

Septic tank installations in the Province are regulated by local Public Health authorities who may not always be aware of problems associated with nutrient enrichment of water.

III. Treatment of manure prior to disposal/utilization.

It seems generally to be recognized in Ontario that there is little possibility for the complete treatment of animal waste to permit liquid fractions to go directly to receiving waters. Treatments of manure have therefore been designed to render the waste less odorous during storage or to improve the efficiency of handling for ultimate land disposal/utilization.

An exception to this general rule may be the use of lagoons for the treatment of water containing relatively small quantities of manure and other waste solids. Some specialized animal production facilities (e.g. duck farms) were large quantities of water are required, may separate solids from the liquid (by settling or mechanical means) and then aerate the liquid by mechanical devices or in aerobic lagoons to produce acceptable effluents. This procedure may have application to wastes from milk houses but is certainly not yet widely applied.

Aeration of liquid manure during storage not only helps to control odour but has the potential for reducing the quantity of nitrogen in the stored manure and therefore reducing the potential impact of the manure on water quality when the waste is spread on land. While aerators have not been widely installed there is growing interest and a number of mechanical devices are in service on farms in the Great Lakes Basin.

Manure drying and composting and re-cycling by feeding to other animals are other forms of treatment which so far have not been widely exploited and which are likely to have a relatively small role in manure management in the study area over the next ten years.

Summary of current practices and Ontario agencies with advisory, regulating and research interests in animal wastes.

1. There are no processes which will satisfactorily treat manure for disposal directly to surface water. Manure in the Ontario Great Lakes basin is disposed of or utilized by returning it to the land.

2. The major inadequacies (in terms of water quality) of current practice are:

   (a) the potential for run-off or percolation from carelessly piled solid manure.

   (b) the practice of spreading manure at rates greatly exceeding the ability of vegetation to remove the nutrients contained in the manure.

   (c) the practice of spreading manure at inappropriate times of the year.

   (d) the practice of permitting run-off and percolation of water from feed lots.

   (e) the inadequate retention and treatment of largely fluid wastes (as from milk houses) containing some manure solids.

3. Advisory, regulatory and research organizations with an interest in the handling of animal manures in the Ontario Great Lakes basin are:

- Ontario Department of Agriculture and Food - advisory through its extension service, particularly the Agricultural Engineering Service.

- Air Management Branch, Ontario Department of Energy and Resources Management - chiefly concerned with odour and other air quality problems arising from manure management practice to which Air Pollution Control Act (1967) applies. Permit system for "stationary sources of air pollution" applies to animal production units and Code of Practice being used since early 1969 requires, among other things, that sufficient land be available for manure utilization.

- Ontario Water Resources Commission, Ontario Department of Energy and Resources Management: through its general responsibility for water quality in the Province is interested in manure management practice and its impact on water quality.

- Ontario Department of Public Health - has powers through the Public Health Act (revised 1967) to regulate waste disposal and public health nuisances which have not been widely applied to animal manure management practices.

- Ontario Committee on Utilization of Animal Wastes - a committee made up of personnel from all agencies above as well as the Universities of Guelph and Toronto which helps to coordinate research on animal wastes in the Province.

- Ontario Advisory Committee on Pollution Control - an interdepartmental committee of senior administrators advisory to the Ontario Cabinet.