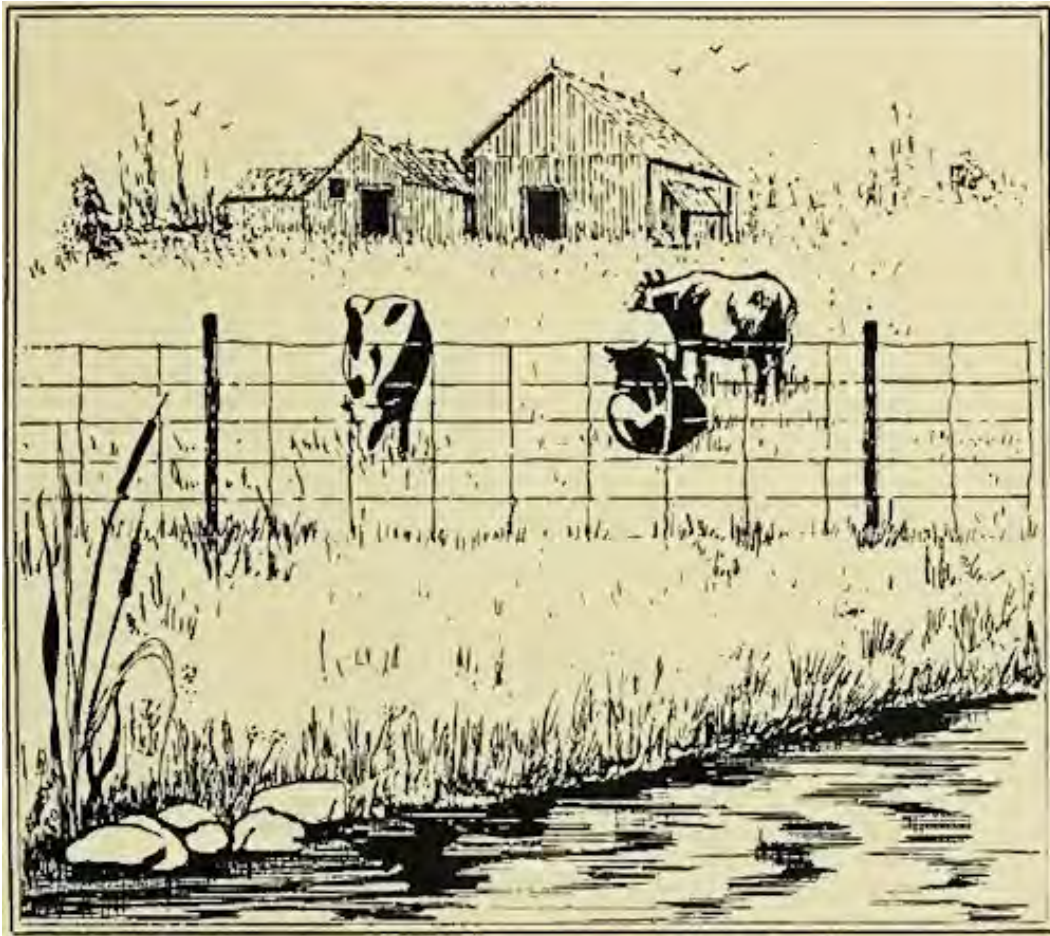


**CLEAN UP RURAL BEACHES
(CURB) PLAN**

FOR THE SAUBLE RIVER WATERSHED



PRODUCED BY
THE GREY SAUBLE
CONSERVATION AUTHORITY
FOR THE ONTARIO MINISTRY OF THE ENVIRONMENT
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DISCLAIMER

This report has been reviewed by the local Technical Steering Committee and approved for publication. Approval does not necessarily signify that the contents reflect the position and/or policies of individual agencies.

FOREWORD

This report is one of a series produced under the Provincial Rural Beaches Program. The objective of the Program is to identify the relative impact of pollution sources, and develop a course of action leading to the restoration and long term maintenance of acceptable water quality at provincial rural beaches.

Significant enrichment and bacterial contamination in southern Ontario rivers and lakes originates from rural sources. The discharge of waste material to streams can result in elevated bacterial concentrations, nuisance algae blooms, fish kills, and present a potential health hazard to humans and livestock using the water. Watershed studies have found that a multitude of pollution sources and pathways may affect beaches in Ontario. These include:

- 1) Urban sanitary and stormwater runoff,
- 2) Direct livestock manure access to watercourses,
- 3) Inadequate manure management practices,
- 4) Direct discharge of milkhouse wastes,
- 5) Contaminated field tile systems, and
- 6) Faulty septic systems

The impact upon beaches of any of these sources, either singly or in combination, can range from a few days of elevated concentrations to complete seasonal closures.

Numerous beach closings in 1983 and 1984, drew public and government attention to the severity of this water quality problem. In 1985, the Ontario Ministry of the Environment's (MOE) Water Resources Branch formulated the Provincial Rural Beaches Strategy Program. Directed by the Provincial Rural Beaches Planning and Advisory Committee, it includes representatives from MOE, Ministry of Agriculture and Food (OMAF), and Ministry of Natural Resources (MNR).

With financial and technical assistance from the MOE, local Conservation Authorities carry out studies under the direction of a local technical steering committee. Chaired by an MOE regional staff, the committees typically include representation from OMAF, MNR, the Medical Officer of Health, Conservation Authority, the local Federation of Agriculture, and a local farmer. The chairs of the local committees assure communication between all the projects by participating on the Provincial Committee.

The primary objective of each local study is to identify the relative impact of pollution sources, their pathways to beaches, and to develop a Clean Up Rural Beaches (CURB) plan specific to the watershed upstream of each beach. The CURB plan develops remedial strategy options and respective cost estimates for each beach through:

- 1) Field inspections,
- 2) Farmer consultations,
- 3) Water quality monitoring, and
- 4) Basic mathematical modelling techniques.

Recommended actions will include both measures for specific beaches and broader scale Provincial measures based on cumulative results of component studies.

The following related research projects were also MOE funded and undertaken by various Conservation Authorities to improve our understanding of bacterial and nutrient dynamics:

- 1) *In-situ* bacterial survival studies determine longevity: in watercourses, offshore of beaches, in sediments, and in milkhouse washwater tiles.
- 2) Biotracer studies determine the speed and nature of travel for bacteria introduced into a watercourse.
- 3) A liquid manure spreading study examines bacterial movement through the soil column and exiting field tile drains.
- 4) A target sub-basin study evaluates the effectiveness of a watershed with comprehensive remedial measures.

Numerous demonstration farms have been established with the cooperation of local farmers to display innovative management practices. Research continues on their effectiveness at improving water quality.

Comments and/or questions on this report are welcome. Please send written comments to:

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ACKNOWLEDGEMENTS

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ABSTRACT

In response to the ever-growing number of beach closures in Southern Ontario, the Ontario Ministry of the Environment (O.M.O.E.) initiated a study to determine and design solutions for sources of agricultural pollution in identified watersheds throughout the province.

In 1986, the Grey Sauble Conservation Authority was approached by O.M.O.E. Rural Beaches Staff about commencing a study of the Sauble River watershed because of the river's potential impact on Sauble Beach, a popular tourist attraction during the summer season. This study would include the collecting of water quality data, field surveys, landowner interviews and the reading of air photos to determine areas of high priority. The watershed was divided into 14 subwatersheds based on the location of tributary junctions and was sampled accordingly.

The purpose of this report is to outline a "Clean Up Rural Beaches Plan" (C.U.R.B.) specifically for the Sauble River Watershed, an area 967 km² in size.

Study results indicate that free livestock access is the major contributor of agricultural pollution in the watershed occurring on a total of 173 farms. Poor manure spreading and storage practices also pose significant problems occurring on 158 and 56 farms respectively. Faulty septic systems were identified on 27 farms and 23 farms exhibited poor milkhouse water control.

This study recommends cost-effective remedial measures including restricted cattle access, proper manure storage facilities, proper milkhouse water control and replacement of faulty septic systems to improve and maintain water quality throughout the watershed and at Sauble Beach. Total cost of this remedial work is estimated to be \$3,530,660.00.

Other recommendations including increased public awareness, continued research and funding, related legislation and local government involvement are also discussed in this report.

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INTRODUCTION

During the past few years, beaches in Southern Ontario have had an increasing number of closures as a result of bacterial and nutrient loading from agricultural sources. In response to this growing problem, the Ontario Ministry of the Environment (OMOE) initiated a multi-year study, through the Provincial Rural Beaches Strategy Program, to examine both the sources of agricultural pollution as well as possible solutions.

In the spring of 1986, Grey Sauble Conservation Authority (G.S.C.A.) was approached by OMOE Rural Beaches staff about initiating a study of the Sauble River watershed since Sauble Beach had been identified as one of seven "priority" beaches in Southwestern Ontario being impacted primarily by agricultural sources of bacterial contamination. The intent of this study was to initially gather data, then determine the areas of priority and finally to make recommendations for the most cost-effective methods of remediation.

This report outlines a Clean Up Rural Beaches (CURB) Plan, specifically for the Sauble River watershed in which an effort has been made to quantify all the sources of agricultural pollution and determine the most cost-effective methods of maintaining suitable water quality at Sauble Beach.

Should the measures recommended in this CURB Plan be implemented, the environmental benefits will be felt not only at the beach but also along the river.

Socio-Economic Importance of Sauble Beach

Sauble Beach is major tourist attraction in the Grey-Bruce area during the summer months. It has seven miles of sandy beach for swimming and sun-bathing as well as a variety of gift shops, eating establishments, and other recreation opportunities. On a long weekend, it's not unusual to have upwards of 35,000 visitors to the area.

There are over 200 seasonal businesses which depend on the beach for their income. The ratepayers from Sauble Beach contribute approximately 55% of Amabel Township's entire tax base. Two-thirds of the Amabel Township electors are non-residents with cottages at the beach. From this information, it is evident that the socio-economic value of Sauble Beach is quite substantial and warrants maintaining suitable water quality.

Background

Prior to the initiation of this study, only very limited water quality information was available on this watershed. Sauble Beach, itself, has never been closed as a result of bacterial contamination, yet there has been several instances when bacterial concentrations exceeded the OMOE guideline. Also, a drainage report completed by Ecologistics in 1984 indicated that both water quality and aquatic communities within the Sauble River system were in very poor condition due to livestock access and open agricultural drains.

During the course of the Sauble River Rural Beaches study, water quality data was collected, field surveys were conducted, and information from various agencies was assembled and used to identify the problems as well as prioritize the areas requiring remediation. Also, throughout this study period, landowners were encouraged to participate in the Ontario Soil Conservation and Environmental Protection Assistance Program (OSCEPAP II) to correct agriculture-related problems.

The Curb Model

This CURB Plan was developed to quantify all the sources of agricultural pollution and determine the most cost-beneficial methods of maintaining suitable water quality at Sauble Beach. In order to assist all Rural Beaches Program staff with this task, OMOE contracted Ecologistics to develop a suitable model. However, this model, known as the Pollution from Livestock Operations Predictor (PLOP) only provided site specific pollution predictions based on more detailed information than was presently known from each of the watersheds involved in this program.

Therefore, OMOE representatives and Rural Beaches staff from all participating watersheds met at a workshop held at the Kempenfelt Centre near Barrie, Ontario to discuss various ways to adopt the PLOP model to best suit the available information. The algorithms used in this CURB Plan reflect the discussions from that workshop. As more detailed information becomes available, fewer assumptions will be necessary which will improve the accuracy of the CURB model.

METHODS

For the purposes of this CURB Plan, the Sauble River watershed was divided into 14 subwatersheds, as outlined in Figure 1. Divisions were made at, or immediately downstream of the junction of each tributary with the main channel. The Rankin River system and the Sauble watershed north of highway 21, excluding the Maryville Creek subwatershed, were considered as only two subwatersheds, not divided by tributaries due to the relatively low intensity of agriculture in these areas. The main channel of the Sauble River south of Highway 21 was divided into three subwatersheds, these being the Sauble headwaters, the main Sauble central (highway 21 to Tara sinkhole) and main Sauble south (upstream of Tara sinkhole).

Agricultural operations and their potential pollution contributions were identified from field surveys, landowner interviews and air photos from 1986-1988. The locations and descriptions of each identified source within each subwatershed are given in figures 2-14. Table 1 summarizes the total drainage area, stream length and number of each fecal coliform source-type farms occurring within each of the 14 subwatersheds. All sources identified in this table were further divided into either continuous discharges where inputs were constant or pulse discharges where inputs occurred during runoff or rainfall events.

As stated previously, this model deals only with fecal coliform bacteria loadings from agricultural sources. Very little information is available in the literature regarding other sources of bacterial input. Subsequently, contributions from other potential bacterial sources including wildlife, urban centres and industrial areas have not been included. It has also been assumed that runoff from feedlots and/or intensively used barnyards does not contribute to the fecal coliform loading in the Sauble River since these conditions do not exist within what is described as the critical distance of 150 metres of any watercourse.

The following section will outline the algorithms used to estimate fecal coliform bacteria loadings from the various sources identified within the Sauble River watershed. The algorithms presented here are based upon those developed by Ecologistics (1987) from their Pollution for Livestock Operations Predictor (PLOP) model. These algorithms have been simplified in order to utilize the Limited amount of site specific data presently available. Both the algorithms and methods utilized in the development of this CURB plan follow those recommended during the July 1988 CURB Plan Workshop, held at the Kempenfelt Centre, Barrie, Ontario.

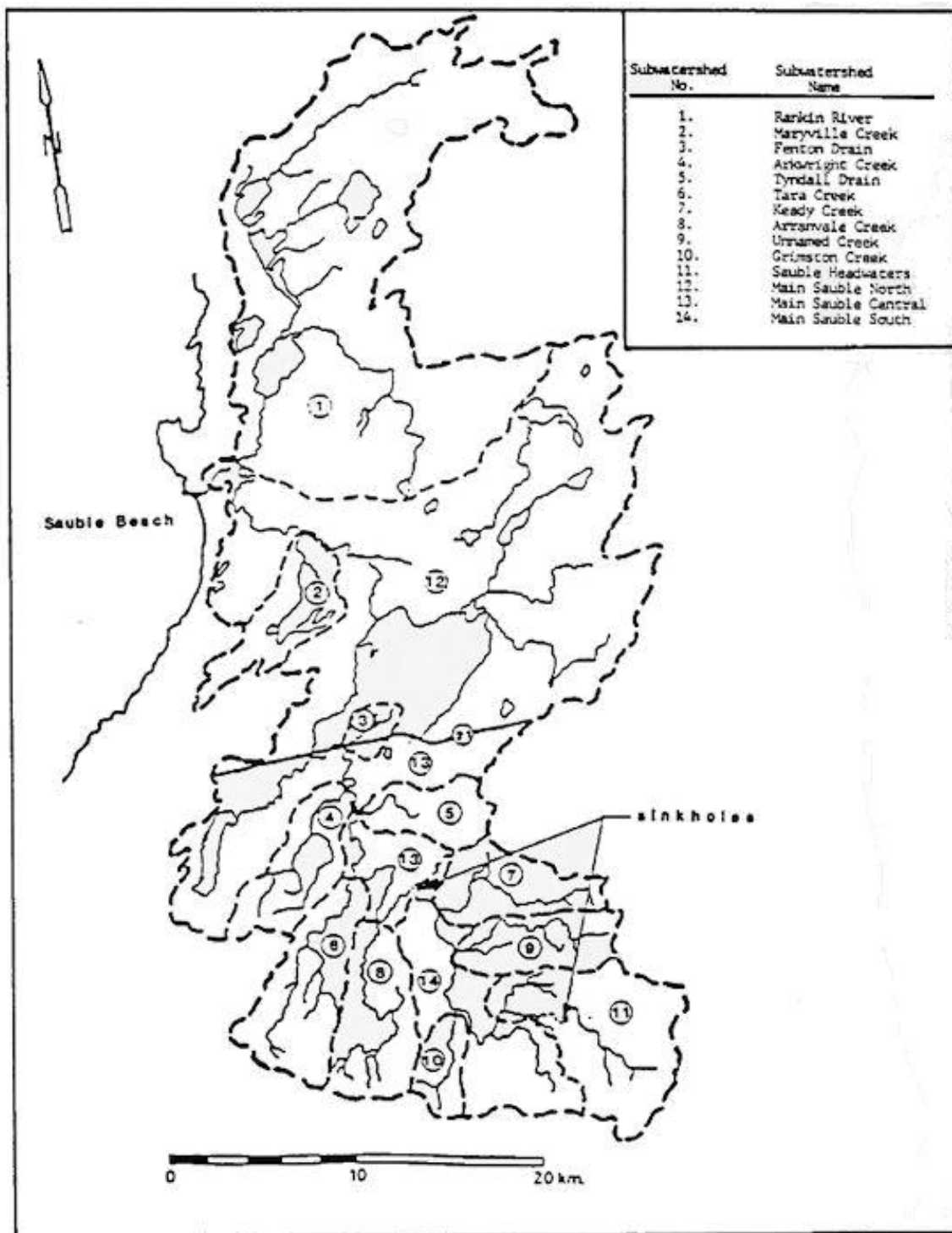


Figure 1: Map of Sauble River Watershed showing the main Tributaries

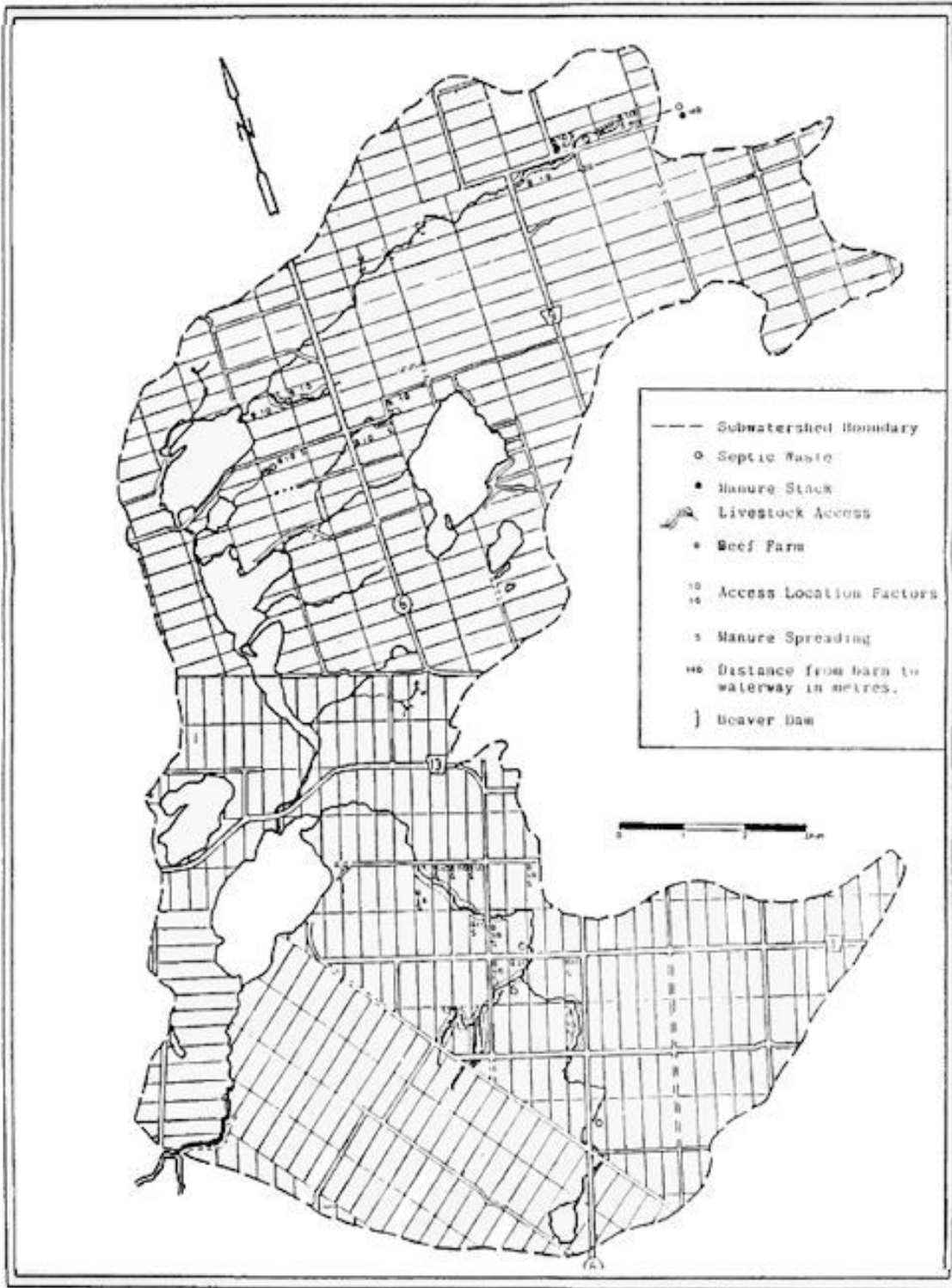


Figure 2: Map of Rankin River subwatershed showing fecal coliform loading sources.

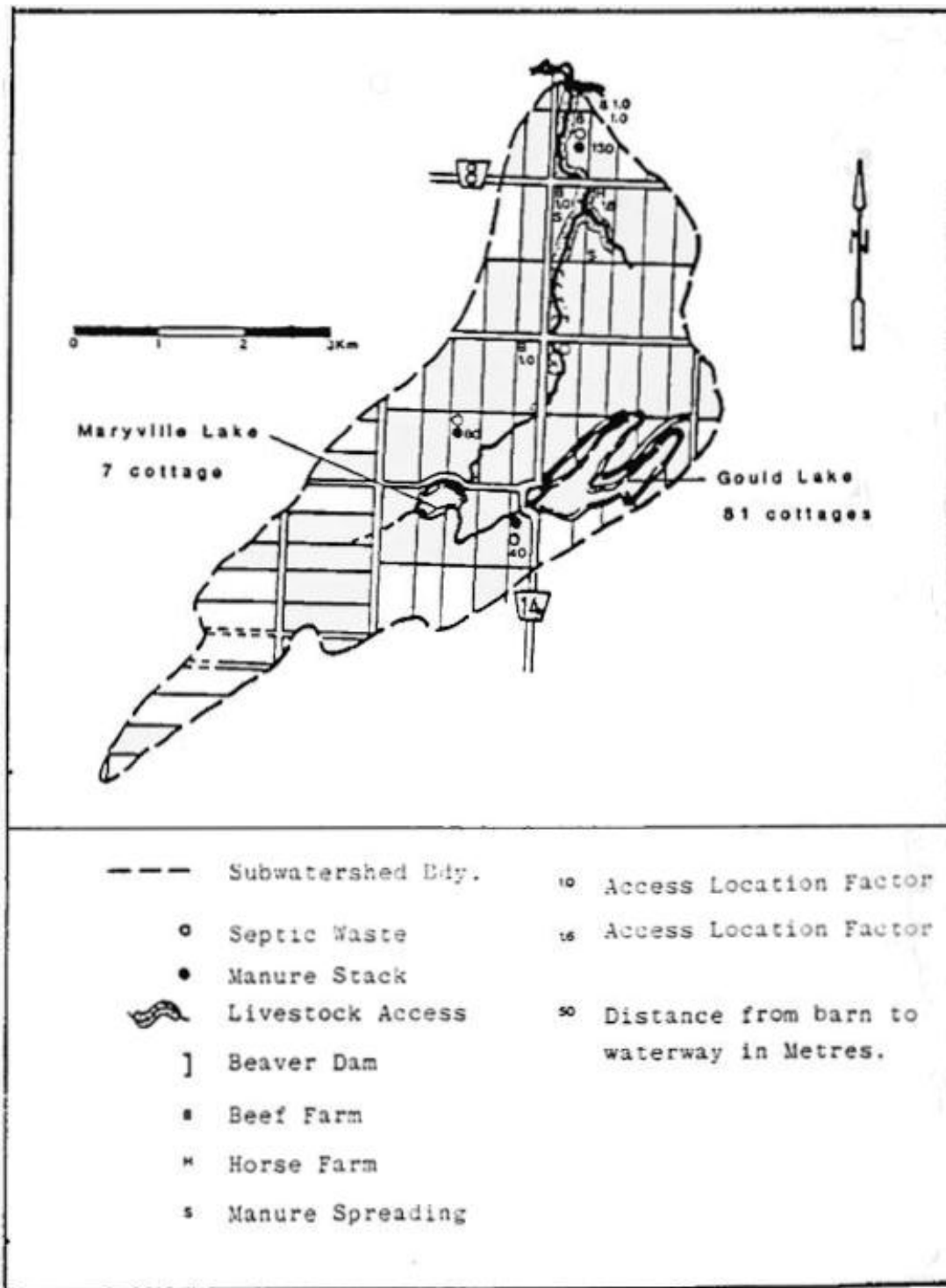


Figure 3: Map of Maryville Creek subwatershed showing fecal coliform loading sources.

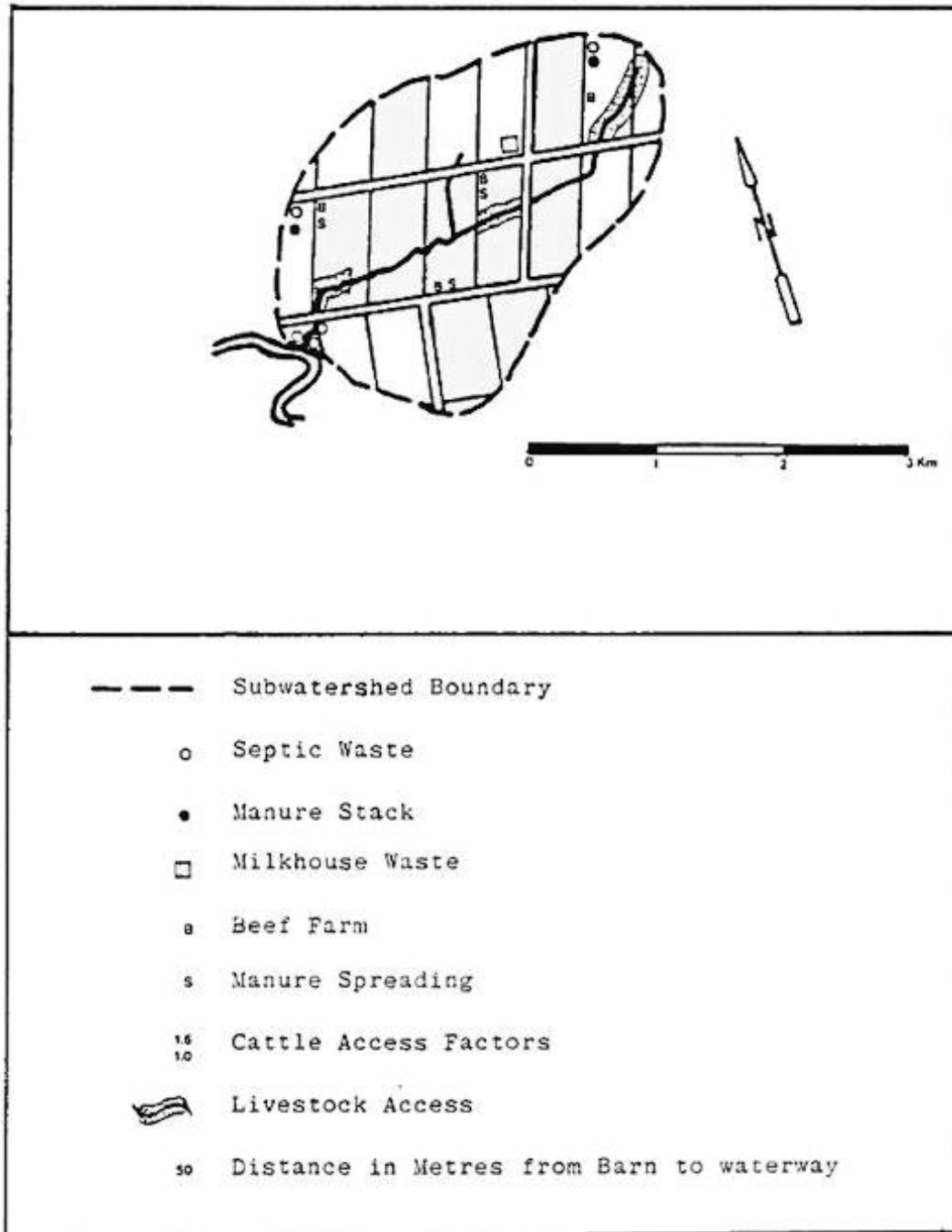


Figure 4: Map of Fenton Drain Subwatershed showing fecal coliform loading sources.

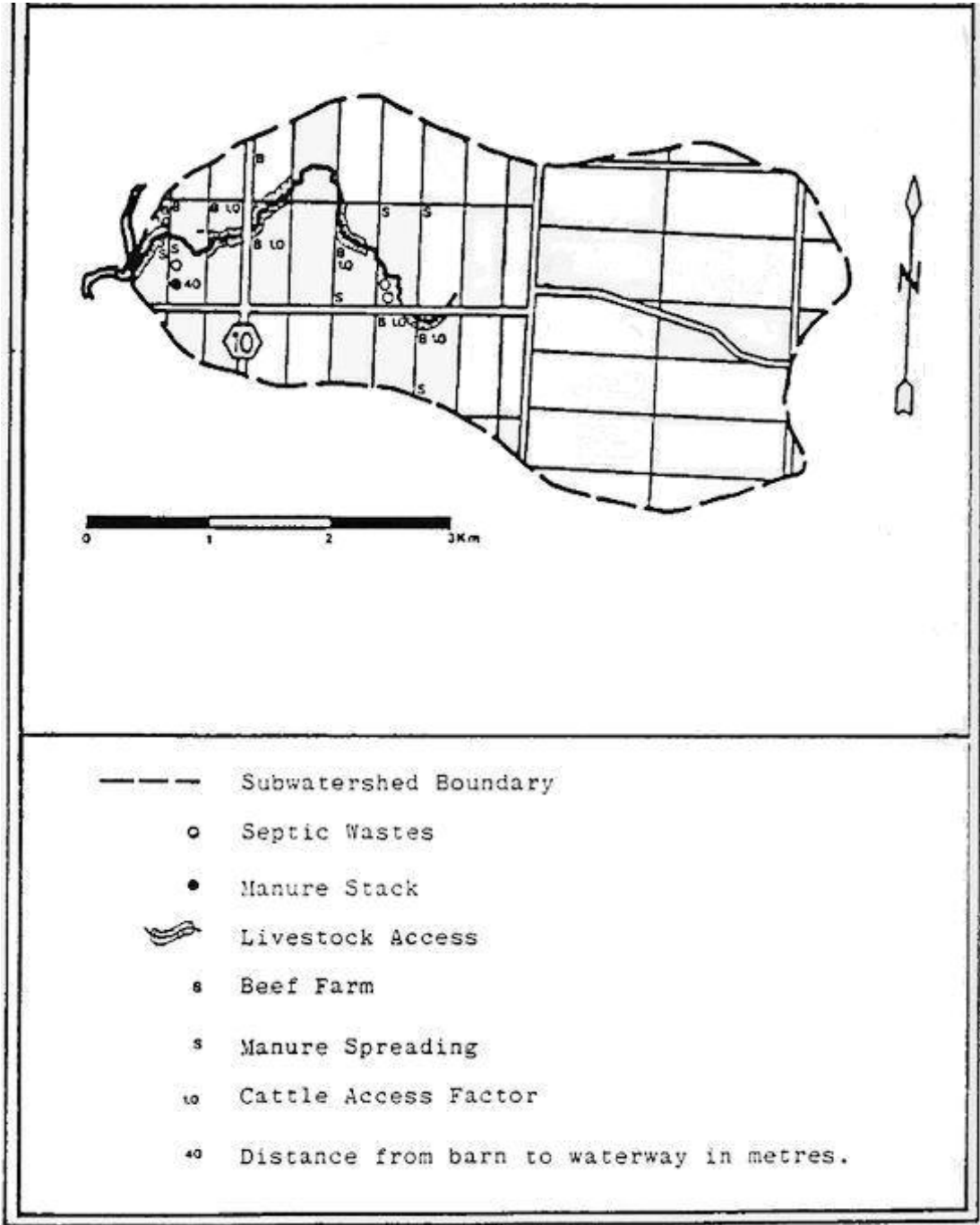


Figure 5: Map of Tyndall Drain showing fecal coliform loading sources.

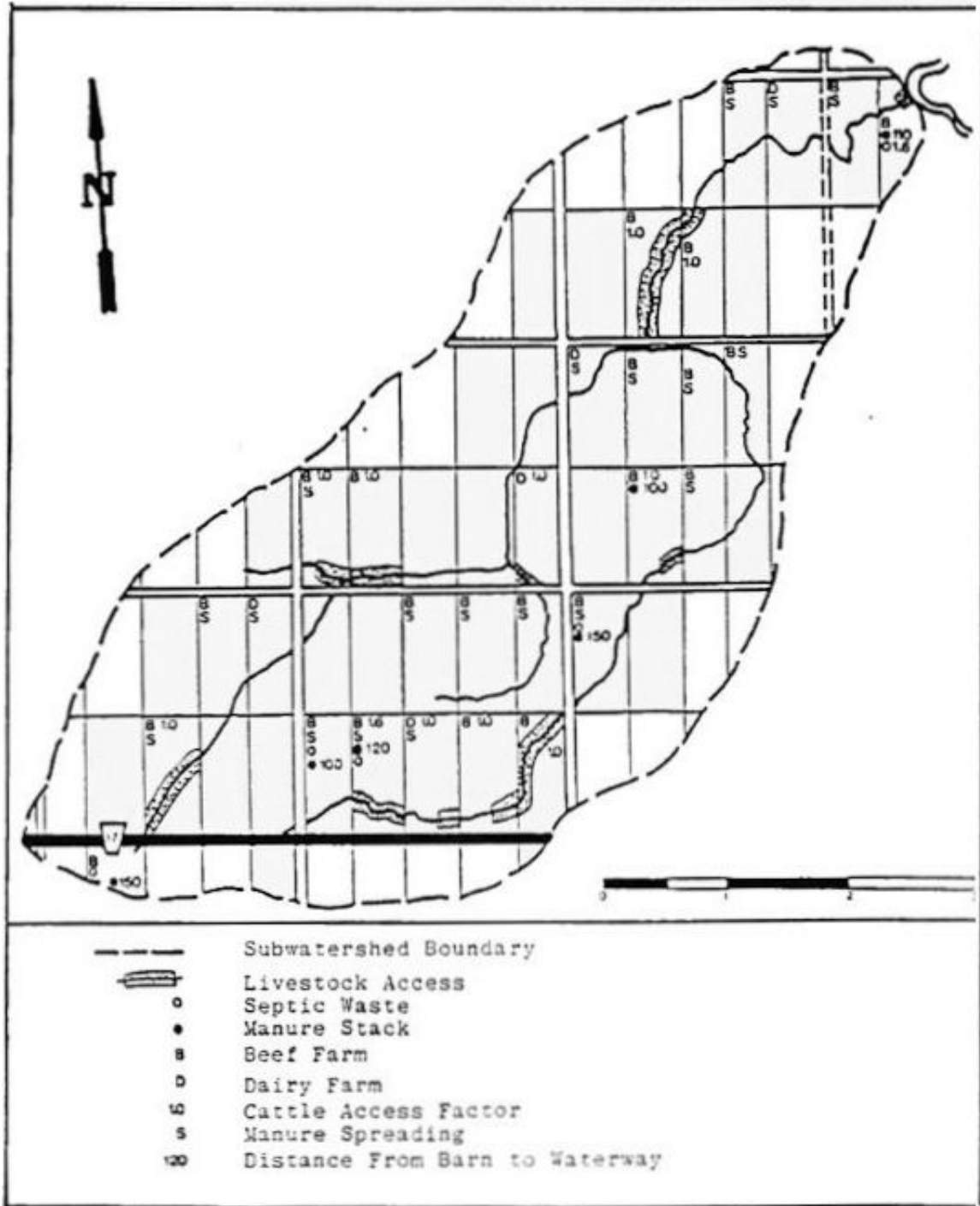


Figure 6: Map of Arkwright Creek showing fecal coliform loading sources.

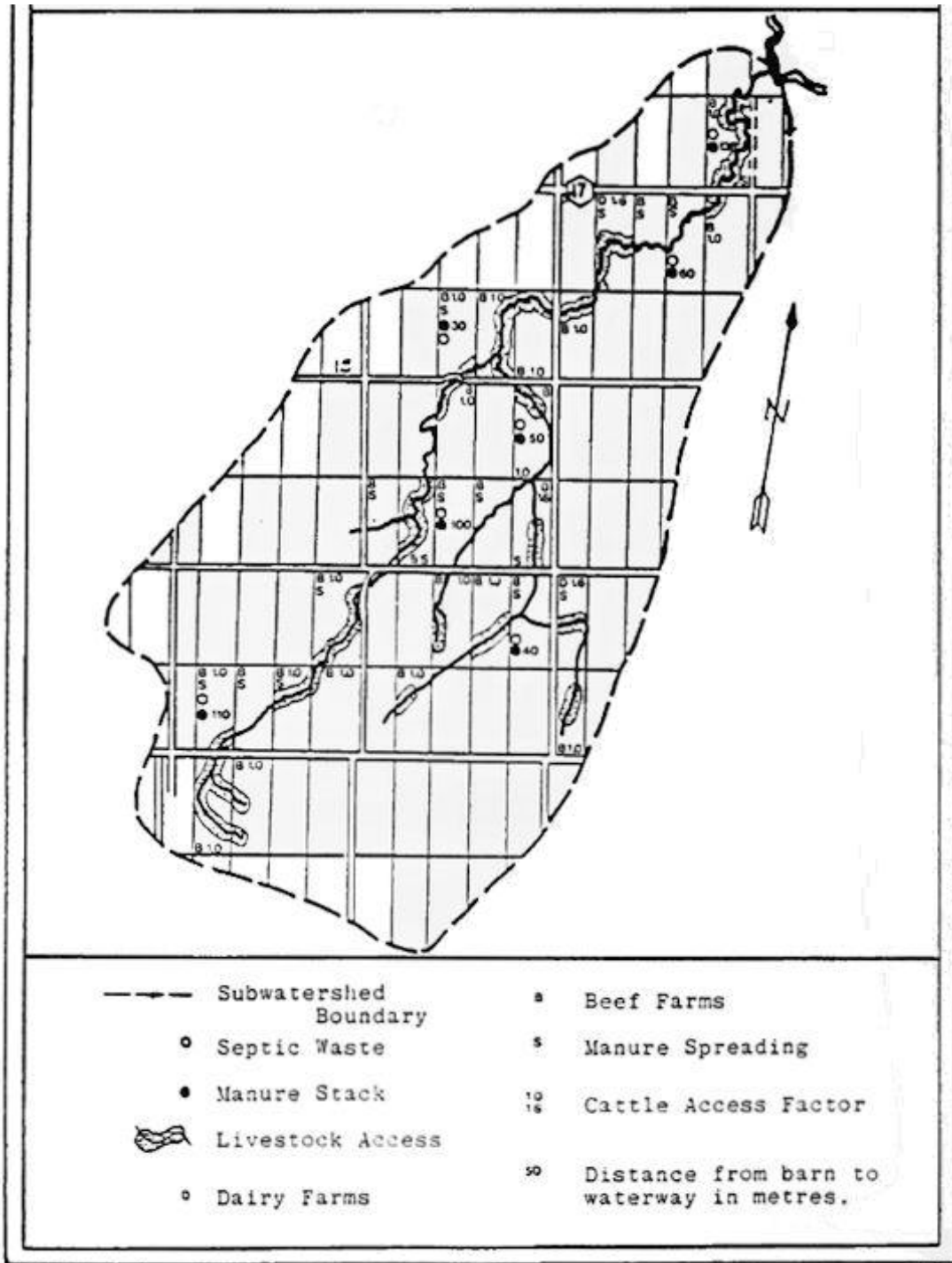


Figure 7: Map of Tara Creek subwatershed showing fecal coliform loading sources.

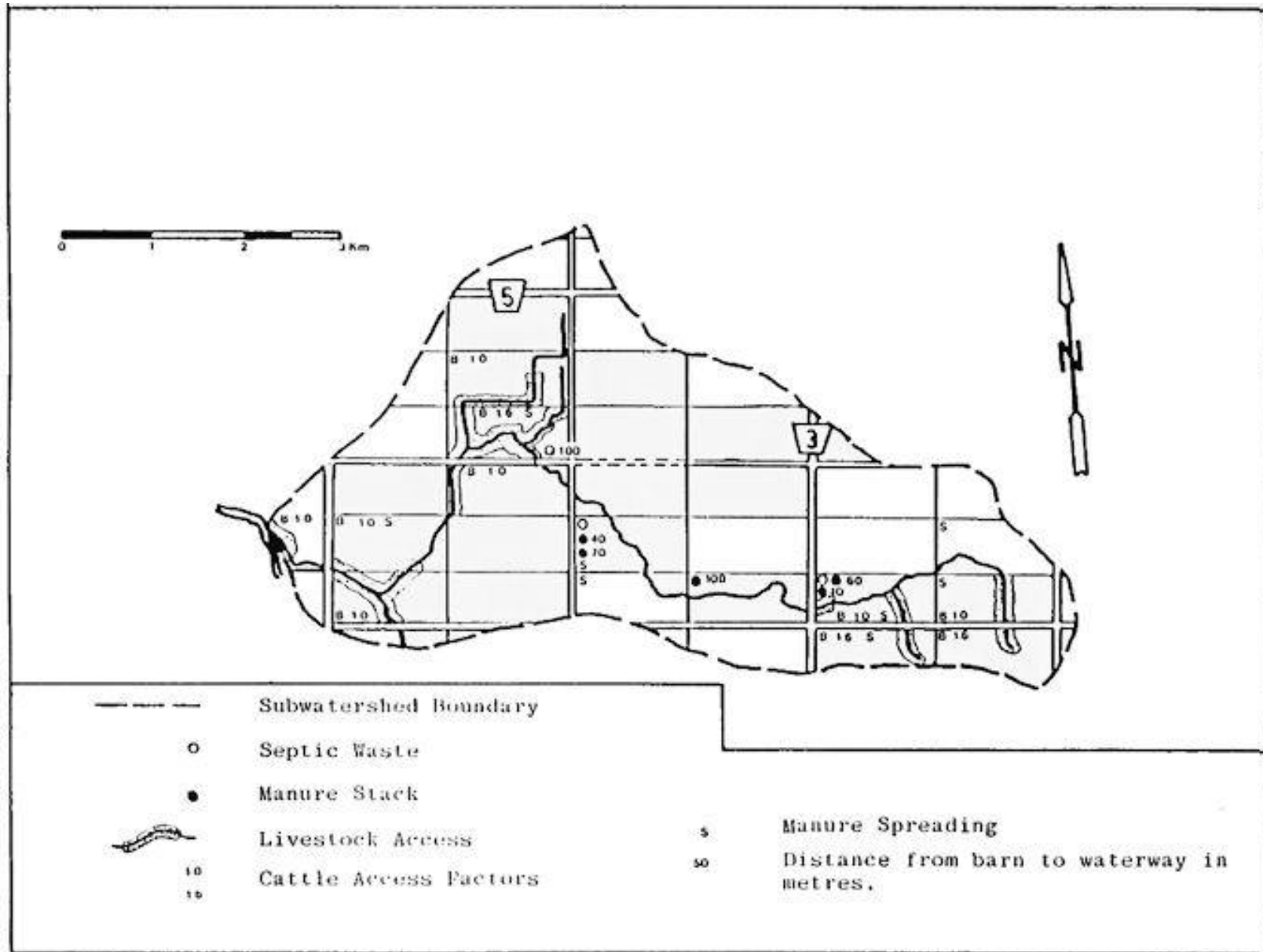


Figure 8: Map of Keady Creek subwatershed showing fecal coliform loading sources.

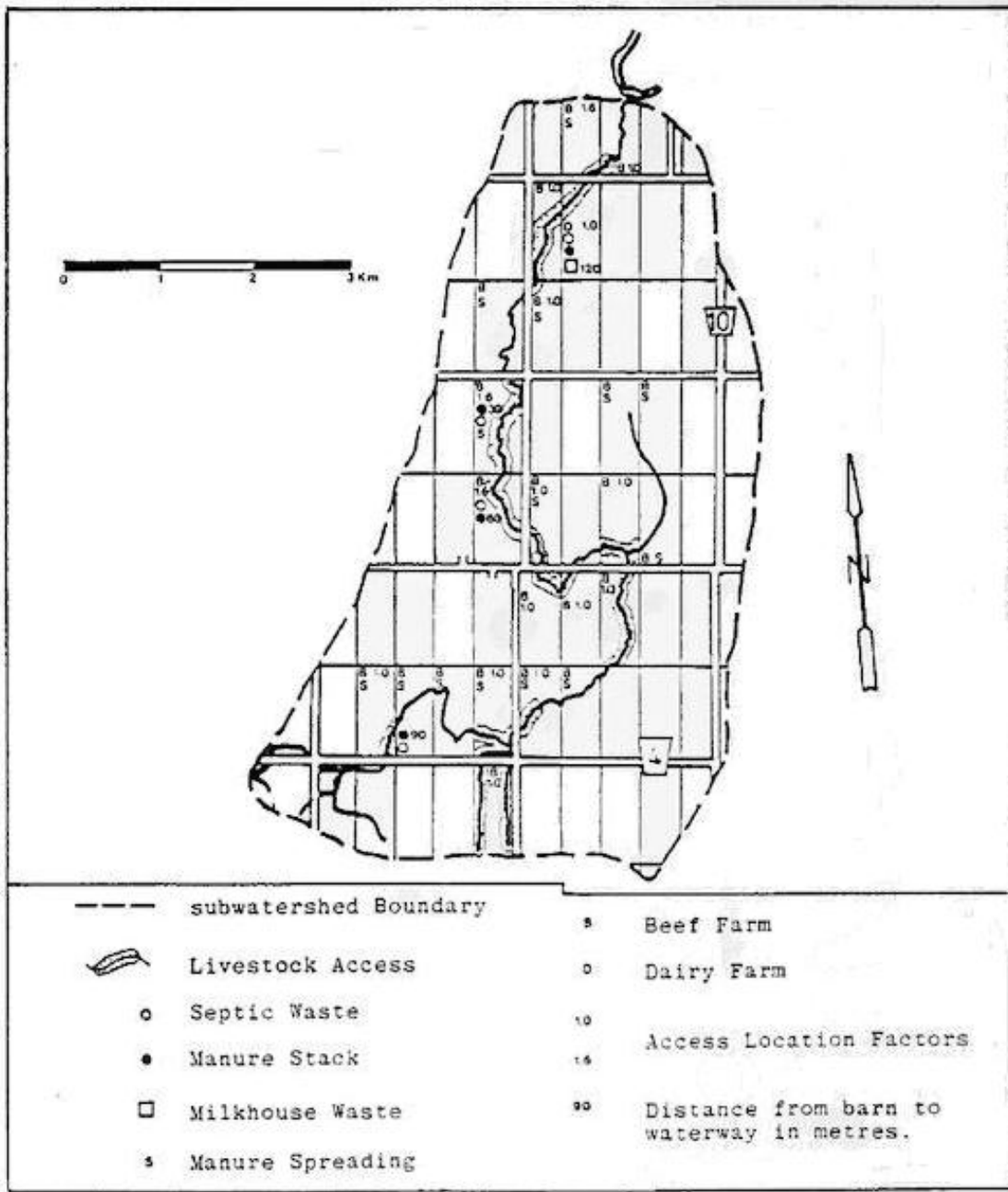


Figure 9: Map of Arranvale Creek subwatershed showing fecal coliform loading sources.

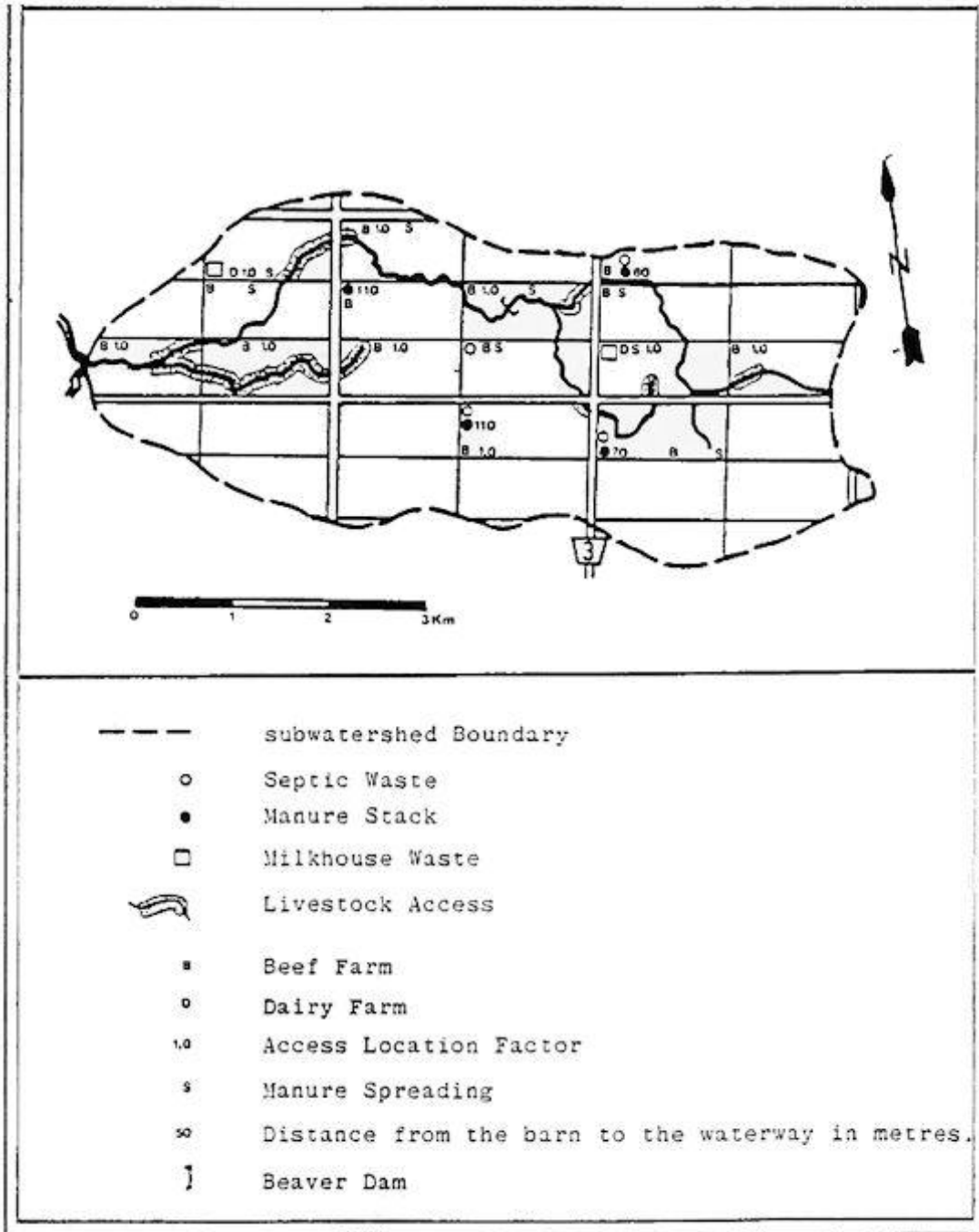


Figure 10: Map of Unnamed Creek subwatershed showing the fecal coliform loading sources.

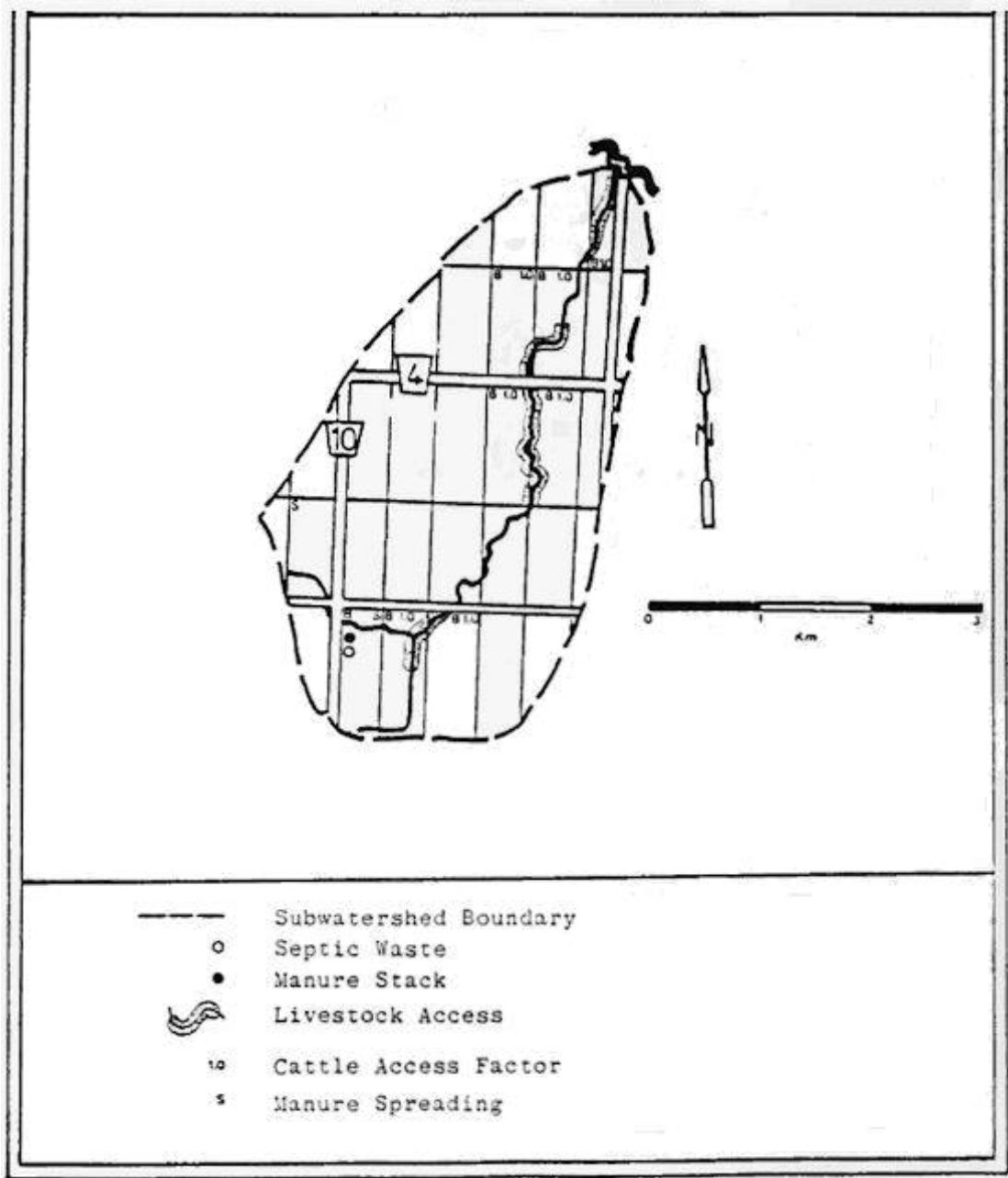


Figure 11: Map of Grimston Creek subwatershed showing fecal coliform loading sources.

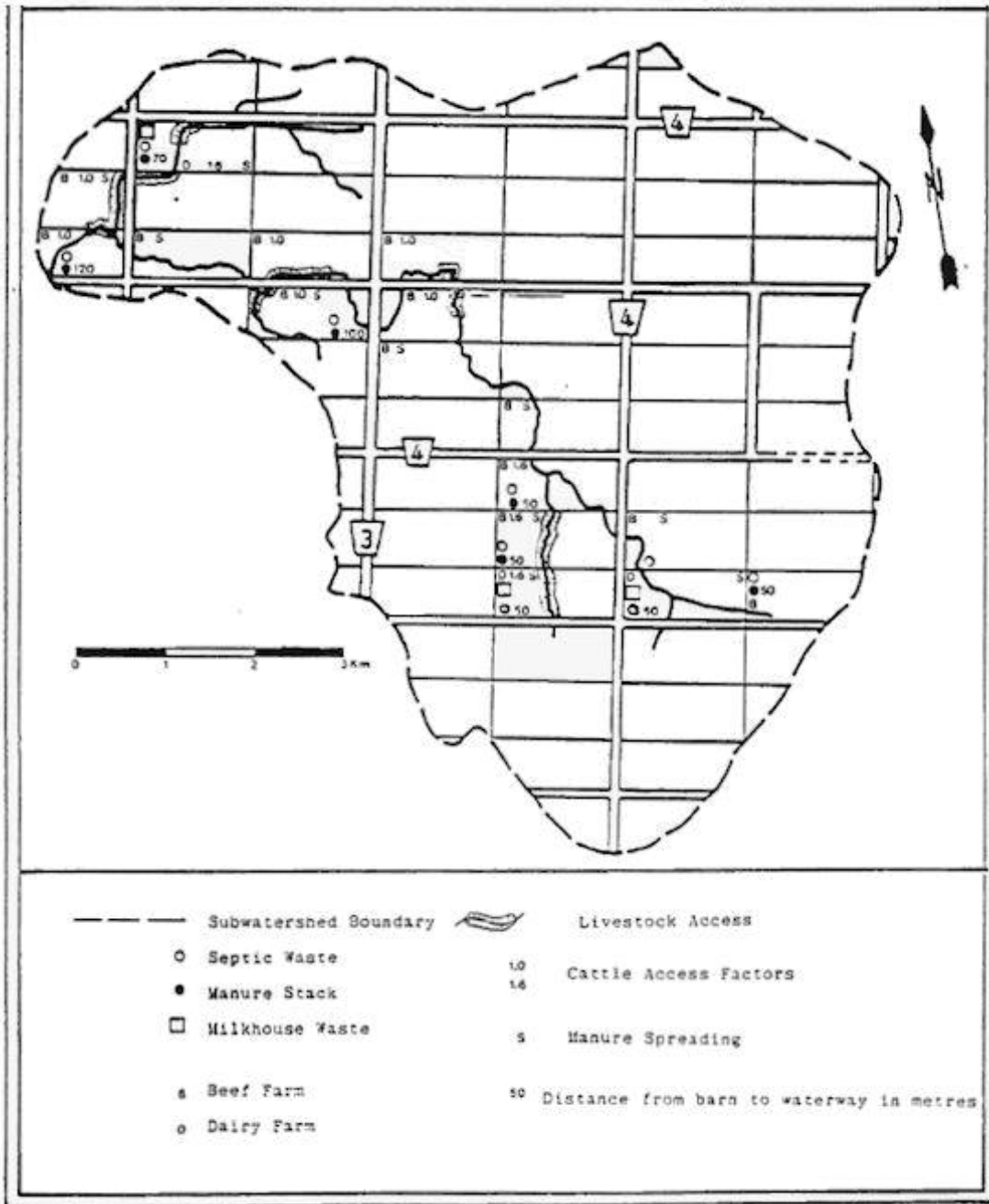


Figure 12: Map of Sauble Headwaters subwatershed showing fecal coliform loading sources.

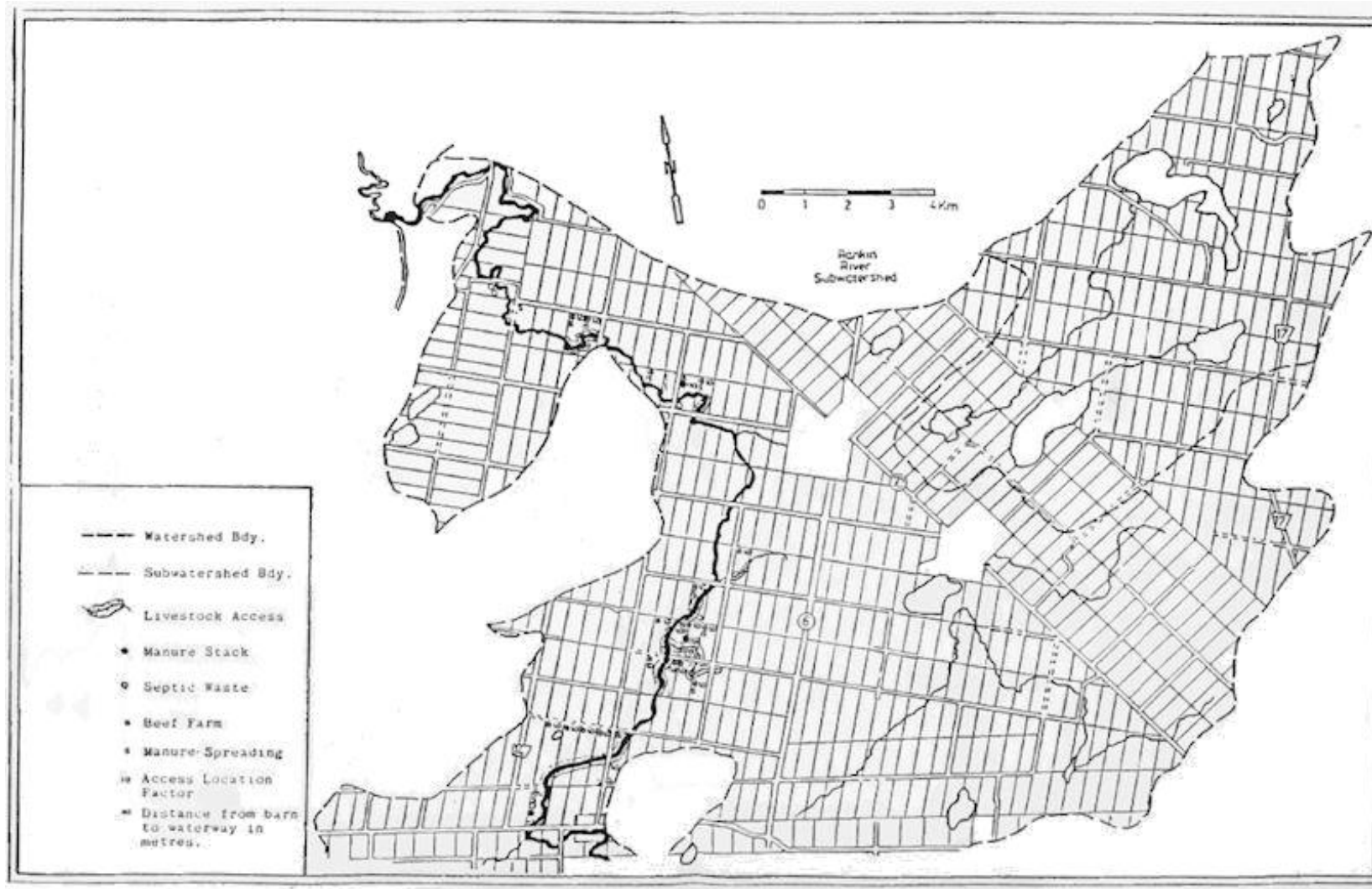


Figure 13: Map of Watershed Balance (North of (HWY 21) showing fecal coliform loading sources.

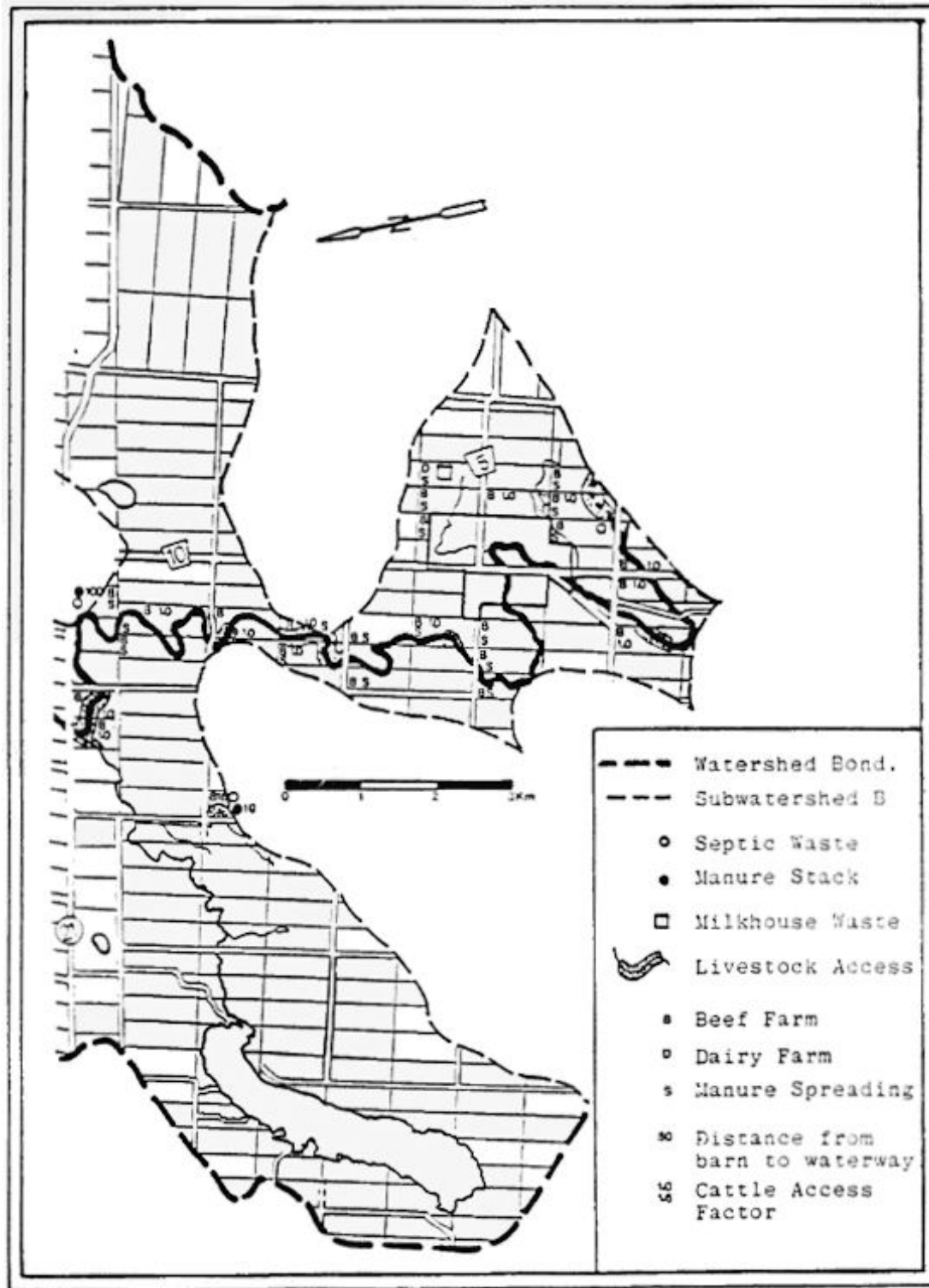


Figure 14: Map of Main Sauble Central from the Tara Sinkhole to HWY 21, showing fecal coliform loading sources.

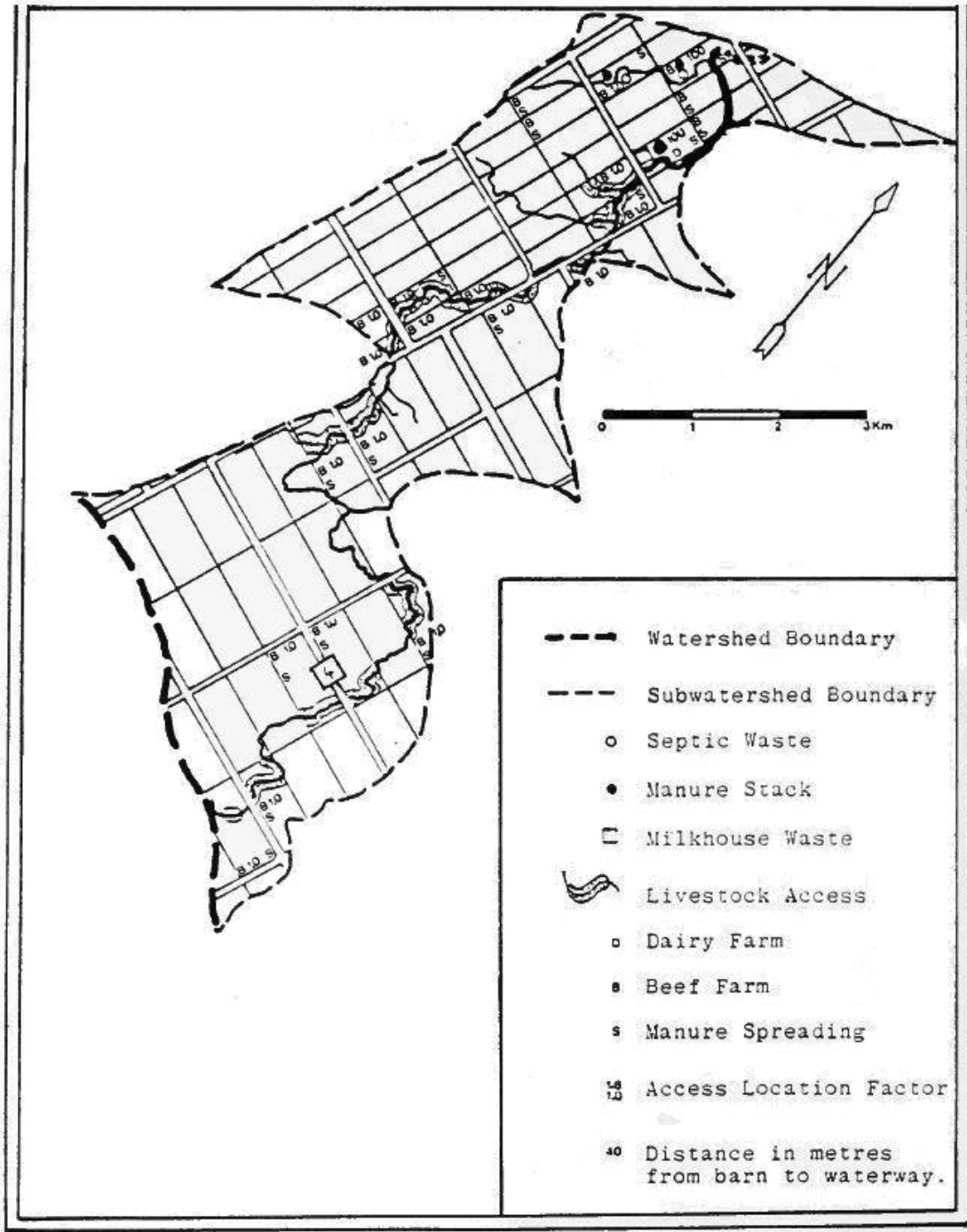


Figure 15: Map of Main Sauble South from the Tara Sinkhole to the headwaters, showing fecal coliform loading sources.

Table 1: Size, length and number of Fecal Conform source farms for each Sauble River subwatershed (1988).

Subwatershed	Area (km ²)	Stream Length* in Subwatershed Area (km)	F.C. Source Farms				
			Continuous Discharges			Pulse Discharges	
			Milkhouse Waste	Livestock Access	Faulty Septic Systems	Manure Stacks	Manure Spreading
Tara Creek	49.54	31.85	1	22	2.1	7	16
Arkwright Creek	29.59	18.06	0 (4)	13	2.4	10	10
Main Sauble North	296.08	109.03	0	17	2.7	3	14
Arranvale Creek	36.01	17.46	1 (2)*	17	1.8	5	13
Rankin River	269.37	106.44	0	21	4.5	2	14
Tyndall Drain	23.39	17.00	0	7	0.9	1	7
Main Sauble South	31.19	42.86	4 (1)	18	0.9	3	20
Ready Creek	31.19	22.70	0	10	1.2	6	9
Sauble Headwaters	64.10	20.00	2 (2)	11	2.7	7	13
Unnamed Creek	26.60	25.92	2	9	1.2	4	8
Fenton Drain	7.48	10.32	1	3	3.9	2	3
Main Sauble Central	64.48	35.96	3	13	0.9	2	17
Maryville Creek	23.16	23.93	0	5	1.8	3	2
Grimston Creek	13.53	6.40	0	7	0.3	1	2
Total	966.94	487.93	14	173	27.3	56	158

* The number in brackets represents additional milkhouse waste load sources that have been included in manure storage column. i.e. The actual number of milkhouse waste "problem" farms on Arranvale Creek is three. However, two of these farms are also within 150m of the stream and so require manure storage tanks which will also receive the milkhouse washwater. Hence the value given for Milkhouse Water Control on Arranvale Creek 3 - 2 - 1.

CURB ALGORITHMS

Continuous Sources

Milkhouse Waste

FC Output = (discharge volume) x (bacterial concentration in discharge)

- Discharge volume = (13 L/cow/day) x (no. of cows) x (no. of farms) x (365 days/year)
- Bacterial concentration of discharge = 1,100 FC/100 mL
(midpoint of reported values 200 - 2,000 FC/100 mL)

FC Delivery = FC Output x 500 (50,000% increase assumed with 100% delivery)

Livestock Access

FC Output = (fc/d) x EAU x 0.18 x 2.5 x 153 x Location Factor x no. of animals

FC Delivery = 100% of FC Output

Septic System Failure

FC Output = FC concentration x Volume of effluent x no. of days x no. of people x no. of homes x % of failure

FC Delivery = 100% of FC Output

Milkhouse Waste & Livestock Access

(fc/d) = fecal coliforms/defecation (Bos, pers. comm., 1989)
(EAU) = Equivalent Animal Units - beef cattle - 1.0
- dairy cows - 1.62
- horses - 0.013

0.18 = probability of an animal defecating directly into the watercourse
2.5 = frequency of watering per day
153 = no. of days of access to watercourse

Location Factor = a value of 1.0 was usually used unless there was a barn on pasture and if 25% or less of pasture area on barn side of stream and if heavily used travel lane crossed watercourse - in this case, a value of 1.6 was used

No. of animals = OMAF averages were used for Grey and Bruce Counties x the no. of farms within the subwatershed

Bruce County

Beef Farms - 173 animals

Dairy Farms - 40 animals

Grey County

Beef Farms - 112 animals

Dairy Farms - 31 animals

Septic System Failure

FC concentration = 10^7 FC/litre of effluent (Hocking, pers. comm. 1989)
Volume of effluent = 168 litres/person/day
No. of days = 365 days/year
No. of people = 3.29 - average family size for Bruce County (OMAF, 1988)
No. of homes = all houses more than 20 years old and within 150 m of the watercourse
% of failure = 0.3 (assumed that 30% of these homes have faulty septic systems)

Pulse Sources

Manure Stack Runoff

$$\text{Average Stack Volume} = \frac{(\text{volume of manure}) \times (\# \text{ of animals}) \times (\text{days}) \times 1}{(\text{no. of cleanouts per year} + 1)}$$

$$\text{Average Stack Area} = \text{Area of a cone (m}^2\text{)} \times 1 \text{ ha per } 10,000 \text{ m}^2$$

$$\text{Runoff Load} = \text{Concentration} \times \text{rain} \times \text{percent runoff} \times \text{ASA} \times \text{delivery}$$

Manure Spreading

$$\text{Volume of Manure (VOM)} = \frac{(\text{Volume of Manure}) \text{ (m}^3\text{)} \times \text{no. of animals} \times \text{day}}{(\text{no. of days}) \times \text{weight of manure (kg/m}^3\text{)}} \times \text{years}$$

$$\begin{aligned} \text{FC Runoff Load} = & \text{VOM (kg/year) } \times \% \text{ volume produced} \times \text{no. of operators} \\ & \text{spreading manure} \times \text{amount spread /overspread (\%)} \\ & \times \text{delivery to stream} \times \frac{(\text{no. of FC}) \times \text{stack decay}}{\text{kg manure}} \\ & \times \text{field decay} \end{aligned}$$

Manure Stack Runoff & Manure Spreading

VOM = volume of manure (kg/year)

% volume produced = 0.42 (winter season = 90 days);
based on 212 days of total accumulation
= 0.58 (spring/fall season = 122 days);
based on 212 days of total accumulation

no. of operators

spreading manure = 0.50 (assumed that 50% of the farmers spread during the winter)
= 0.05 (assumed that 5% of the farmers overspread during the summer)

amount spread/overspread = 0.75 winter (assumed that 75% of the volume produced in winter is spread)
= 0.25 summer (assumed that 25% of the volume is overspread)

delivery to stream = $0.1 \times 1.09 \times 0.15 \text{ km} = 0.01635$

no of FC = 3×10^{10} (Hocking, pers. comm. 1989)
kg manure

stack decay = 0.01 (assuming 2 log die-off in 15 days - (Kress & Gifford. 1989)

field decay = 0.37 (E^{-kt} : $E = 2.7183$, $k = 0.066 \text{ PLOP}$, $pa35$,
 $t = \text{average age between runoff events}$)

Fecal Conform Delivery to Sauble Mouth

The preceding algorithms were used to predict the total fecal coliform loadings within each subwatershed in the Sauble River system. These loadings are only relative values and do not represent predicted actual loadings. In an attempt to estimate the impact of these loadings at the mouth of the Sauble River and to facilitate the ranking of each subwatershed according to its contribution to beach coliform levels, a bacterial die-off algorithm was developed.

Decay or die-off rates of 0.25 logs/day and 0.4 logs/day were used for spring runoff (March 24 - April 14) and summer baseflow conditions (June 2 - August 18), respectively. These rates were provided by M. Young (MOE, pers. comm.) and were based upon rates recorded within other Ontario watersheds presently studying in-situ bacterial survival. The following is the formula used to calculate the 'surviving' fecal coliform Loading at the Sauble mouth from each subwatershed.

$$\text{FC loading at mouth} = \text{antilog} ((\log A) - (B \times C))$$

Where;

A = Total FC load within each subwatershed

B = Estimated time of travel (days) from midpoint of subwatershed to Sauble mouth

C = Seasonal die-off rate

Travel times within the Sauble watershed were calculated for both event-flow and base-flow conditions. An event-flow velocity of 4.00 km/hr was determined from stream record data from the Sauble River Hydrology Study Technical Appendix (Crysler & Latham Ltd., 1979). A base-flow velocity of 0.307 km/hour was determined from several on-site measurements throughout the watershed during the summer season (lowest yearly flow).

The transport and decay of continuous discharge sources (milkhouse waste, livestock access and septic discharges) were treated separately from that of pulse discharges (manure stack runoff and manure spreading), as recommended during the July 1988 CURB Plan Workshop. The travel time and die-off rates for baseflow conditions, 0.307 km/hr and 0.4 logs/day, respectively, were applied to the continuous discharge sources, while the travel time and die-off rates for event-flow conditions, 4.0 km/hr and 0.25 logs/day, respectively, were applied to pulse discharges since loadings from these sources are assumed to occur only in association with rainfall/runoff events.

Within each subwatershed, the loading rates from the various source types will be used to identify the most significant source types in terms of their relative bacterial loading contributions to pollution problems. Using the Sauble Beach loading rates, the 14 subwatersheds will be ranked according to their relative bacterial contributions to mouth as an indicator of remote pollution problems.

A cost-effectiveness analysis will be done for each subwatershed for the identified source areas and with standard control methods/structures and costing data. This analysis will deal with cost-effectiveness both at the beach as well as locally.

RESULTS

Fecal Coliform Source Loadings

Total fecal coliform loading rates for each source type within each subwatershed are summarized in Table 2. The total watershed loading from all sources is predicted to be 178.303×10^{13} . Overall, livestock access accounted for 93.7% of the total fecal coliform inputs, while faulty septic systems and manure spreading contributed 3.1% and 2.7% respectively. Milkhouse waste water added 1.2% of the total fecal coliform load with the remaining 0.02% contributed through manure stack runoff.

In general, continuous discharges inputs contribute 98% of all the estimated bacteria loading in the Sauble River Watershed. Livestock access is the top contributor in all 14 subwatersheds. Tara Creek, Arranvale Creek, Arkwright Creek, and the main Sauble River south of Highway 21 have the highest bacterial loadings from livestock access; these results reflect the fact that Bruce County is the major beef producer in the Province. A low intensity of dairy farms within the entire watershed reflects a corresponding small relative loading (1.2%) from this source of bacterial input.

Expected Loadings at Sauble Mouth

Event flow and base flow travel times from the midpoint of each subwatershed to the mouth of the Sauble River are given in Table 3.

The expected FC loadings at the mouth from bacterial contributions within each subwatershed are given in Table 4. Loadings were calculated for combined pulse and combined continuous sources within each subwatershed. The subwatersheds have been arranged from highest to lowest in terms of expected total contribution to beach loadings.

Table 2: Total Fecal Coliform Loadings, by Source, for the 14 Subwatersheds of the Sauble River (#FC x 10¹³)

Subwatershed	Continuous Discharges				Pulse Discharges			TOTAL (all sources)
	Milkhouse Waste	Livestock Access	Faulty Septic Systems	Total	Manure Stack Runoff	Manure Spreading Winter Sumner	Total	
Rankin River	Nil	22.90	.91	23.81	0.003	0.428 0.020	0.451	24.261
Maryville Creek	Nil	4.24	.36	4.60	0.004	0.027 0.001	0.032	4.632
Fenton Drain	0.10	3.82	.79	4.71	0.003	0.076 0.003	0.082	4.792
Arkwright Creek	0.42	13.73	.48	14.63	0.006	0.434 0.020	0.460	15.090
Tyndall Drain	Nil	7.42	.18	7.60	0.002	0.176 0.008	0.186	7.786
Tara Creek	0.10	23.96	.42	24.48	0.007	0.360 0.017	0.384	24.864
Unnamed Creek	0.16	5.42	.24	5.82	0.004	0.120 0.006	0.130	5.950
Arranvale Creek	0.31	18.63	.36	19.30	0.004	0.342 0.016	0.362	19.662
Keady Creek	Nil	8.10	.24	8.34	0.006	0.130 0.006	0.142	8.482
Grimston Creek	Nil	7.42	.06	7.48	0.002	0.050 0.002	0.054	7.534
Sauble Headwaters	0.32	7.98	.54	8.84	0.005	0.147 0.007	0.159	8.999
Main Sauble North	Nil	13.27	.54	13.81	0.004	0.327 0.015	0.346	14.156
Main Sauble Central	0.31	14.42	.18	14.91	0.003	0.417 0.019	0.439	15.349
Main Sauble South	0.47	15.72	.18	16.37	0.003	0.357 0.016	0.376	16.746
TOTAL	2.19	167.03	5.48	174.70	.056	3.391 0.156	3.603	178.303
	1.2%	93.7%	3.1%	98%	.02%	1.9% 0.8%	2%	

Overall, the results indicate that continuous discharges accounted for 98.0% of all fecal coliform bacteria predicted to reach the Sauble River mouth.

Table 3: Distance and Travel Time from the midpoint of each subwatershed to the Sauble River mouth.

	Distance from midpoint of Subwatershed to Sauble mouth (km)	Baseflow travel time (days) (0.307 km/hr)	Event flow travel time (days) (4 km/hr)
Sauble Headwaters	82.21	11.16	0.86
Unnamed Creek	83.31	9.95	0.76
Grimston Creek	69.26	9.40	0.72
Keady Creek	68.78	9.33	0.72
Main Sauble South	63.47	8.61	0.66
Tara Creek	60.96	8.27	0.64
Arranvale Creek	60.45	8.20	0.63
Rankin River	56.54	7.67	0.59
Tyndall Drain	50.76	6.89	0.53
Arkwright Creek	49.19	6.68	0.51
Main Sauble Central	46.73	6.34	0.49
Fenton Drain	41.33	5.61	0.43
Maryville Creek	27.18	3.69	0.28
Main Sauble North	18.11	2.46	0.19

Cost-Effective Analysis

Table 5 summarizes the actual number of each source-type farm within the 14 subwatersheds. The predicted total costs of the remedial work required to eliminate fecal coliform loading from identified sources within the Sauble River watershed, excluding manure spreading sources, are given in Table 6. Assumptions regarding the type of control measure used are also given. A similar cost-effective analysis cannot be done regarding manure spreading, since it is mainly a management problem that can be partially, if not completely, remediated at minimal cost to the farmer. Proper manure storage facilities in some cases will also help alleviate improper spreading. If all measures were implemented, the total cost is estimated to be just over 3.5 million dollars.

Table 7 provides cost-effective ratios for improvement within the subwatersheds and for improvement at the beach. The relatively small contributions from faulty septic systems and milkhouse waste discharge, along with the relatively high cost per control structure results in these being ranked at the bottom of the list in terms of cost-effectiveness.

Table 4: Total Beach Fecal Coliform Loading, by Source, for 14 Subwatersheds in the Sauble River in order of % contribution to Total Loading at the beach (worst to best).

Subwatershed	Continuous Discharge Sources At Beach Loadings (PC x 10 ⁹)				Pulse Discharge Sources At Beach Loadings (FC x 10 ⁹)				Total All Sources)	% Contribution to Total Loading at the Beach
	Milkhouse Waste	Livestock Access	Faulty Septic Systems	Total	Manure Stack	Manure Winter	Spreading Summer	Total		
Rankin River	Nil	195.8	8.0	203.8	.2	30.4	1.4	32.0	235.8	1.3% (6)
Maryville Creek	Nil	1417.0	120.0	1537.0	.3	2.3	0.1	2.7	1539.7	8.7% (2)
Fenton Drain	0.9	217.8	45.0	263.7	.2	5.9	0.2	6.4	275.1	1.5% (5)
Arkwright Creek	8.9	292.2	10.0	311.1	.4	32.3	1.5	34.2	345.3	1.9% (4)
Tyndall Drain	Nil	130.1	3.0	133.1	.1	13.0	0.6	13.7	146.8	.8% (7)
Tara Creek	0.5	118.0	2.0	120.5	.5	24.9	1.2	26.6	147.1	.8% (7)
Unnamed Creek	0.2	5.7	0.3	6.2	.3	7.7	0.4	8.4	14.6	.1% (9)
Arranvale Creek	1.6	98.0	2.0	101.6	.3	23.8	1.1	25.2	126.8	.8% (7)
Keady Creek	Nil	15.0	0.4	15.4	.4	8.6	0.4	9.4	24.8	.1% (9)
Grimston Creek	Nil	13.0	0.1	13.1	.1	3.3	0.1	3.6	16.7	.1% (9)
Sauble Headwaters	0.1	3.0	0.2	3.3	.3	9.0	0.4	9.7	13.0	.1% (9)
Main Sauble North	Nil	11,768.0	560.2	14,328.2	.4	29.3	1.3	31.0	14,359.2	80.2% (1)
Main Sauble Central	9.0	419.7	5.0	433.7	.2	31.4	1.4	33.0	466.7	2.6% (3)
Main Sauble South	1.7	56.6	0.6	58.9	.2	24.4	1.1	25.8	84.7	.4% (8)
TOTAL	22.9	16,749.9	756.8	17,529.6	3.9	2,463	11.2	261.1	17,796.3	100.0

Table 5: Number of each different F.C. load source farm occurring on Sauble River subwatershed in 1988.

Subwatershed	Milkhouse Water Control	F.C. Load Source Farms			
		Restrict Access	Septic Systems	Manure Storage	Manure Spreading
Tara Creek	1	22	2.1	7	16
Arkwright Creek	0 (4)*	13	2.4	10	10
Main Sauble North	0	17	2.7	3	14
Arranvale Creek	1 (2)	17	1.8	5	13
Rankin River	0	21	4.5	2	14
Tyndall Drain	0	7	0.9	1	7
Main Sauble South	4 (1)	18	0.9	3	20
Keady Creek	0	10	1.2	6	9
Sauble Headwaters	2 (2)	11	2.7	7	13
Unnamed Creek	2	9	1.2	4	8
Fenton Drain	1	3	3.9	2	3
Main Sauble Central	3	13	0.9	2	17
Maryville Creek	0	5	1.8	3	2
Grimston Creek	0	7	0.3	1	2
Total	14	173	27.3	56	158

* The number in brackets represents additional milkhouse waste load sources that have been included in manure storage column. ie. The actual number of milkhouse waste "problem" farms on Arranvale Creek is three. However, two of these farms are also within 150m of the stream and so require manure storage tanks which will also receive the milkhouse washwater. Hence the value given for Milkhouse Water Control on Arranvale Creek $3 - 2 = 1$.

Table 6: Expected total cost of remedial work required to (eliminate) F.C. loadings within each subwatershed.

<u>Expected Total Cost of Remedial Practice (x \$1,000.00)</u>					
Subwatershed	Milkhouse Water Control*	Restrict Access**	Manure Storage***	Septic Systems****	Total
Tara Creek	\$ 4.50	\$ 308.00	\$ 120.47	\$ 6.30	\$ 439.27
Arkwright Creek	0	182.00	172.10	7.20	361.30
Main Sauble North	0	238.00	51.63	8.10	297.73
Arranvale Creek	4.50	238.00	86.05	5.40	333.95
Rankin River	0	294.00	34.42	13.50	341.92
Tyndall Drain	0	98.00	17.21	2.70	117.91
Main Sauble South	18.00	252.00	51.63	2.70	324.33
Ready Creek	0	140.00	103.26	3.60	246.86
Sauble Headwaters	9.00	154.00	120.47	8.10	291.57
Unnamed Creek	9.00	126.00	68.84	3.60	207.44
Fenton Drain	4.50	42.00	34.42	11.70	92.62
Main Sauble Central	13.50	182.00	34.42	2.70	232.62
Maryville Creek	0	70.00	51.63	5.40	127.03
Grimston Creek	0	98.00	17.21	0.90	116.11
Total	\$ 63.00	\$ 2,422.00	\$ 963.76	\$ 81.90	\$3,530.66

* assume 50% of dairy farms install treatment trench @\$3,000.00/farm and 50% of dairy farms install concrete storage @\$6,000.00/farm.

** assume fencing on one side of stream on 20% of farms @\$6,000.00/farm and fencing on two sides of stream on 80% of farms @\$16,000.00/farm.

*** assume installation of covered concrete tank on 100% of farms @\$17,210.00/farm

**** assume \$3,000.00 per septic system

Table 7: Cost-Effectiveness Ratio (cost/reduction in bacteria numbers at the beach) for implementation of remedial practices to control both continuous and pulse discharge sources, ranked in order from most cost-effective to least cost-effective.

Subwatershed	At Beach FC loadings (x 10 ⁹)				Cleanup Cost (x \$1,000,000)				Cost-Effectiveness Ratio (\$1,000/10 ⁹ bacteria)				Ranking
	Continuous Discharge Sources			Pulse Discharge Manure Stack Runoff	Continuous Discharge Sources			Pulse Discharge Manure Stack Runoff	Continuous Discharge Sources			Pulse Discharge Manure Stack Runoff	
	Milk house	Livestock Access	Septic Systems		Milk house	Livestock Access	Septic Systems		Milk house	Livestock Access	Septic Systems		
Main Sauble North	-	13,768.0	560.2	35.8	0.00	266.00	8.10	51.63	-	0.019	0.014	1.142	1.475
Maryville Creek	-	1,417.0	133.0	34.0	0.00	70.00	5.40	51.63	0	0.050	0.045	1.519	1.614
Tyndall Drain	-	130.1	3.0	14.7	0.00	98.00	2.70	17.21	-	0.753	0.900	1.171	2.824
Main Sauble Central	9.0	419.7	5.0	22.6	13.50	182.00	2.70	34.42	1.500	0.434	0.540	1.523	3.997
Rankin River	-	195.8	8.0	21.3	0.00	294.00	13.50	34.42	0	1.500	1.688	1.616	4.804
Arkwright Creek	8.9	292.2	10.0	44.7	18.00	182.00	7.20	103.26	2.000	0.623	0.720	2.310	5.653
Fenton Drain	0.9	217.8	45.0	23.4	4.50	42.00	11.70	34.42	5.000	0.190	0.260	1.471	6.921
Main Sauble South	17.0	56.6	0.6	33.5	22.50	252.00	2.70	51.63	1.300	4.452	0.222	2.519	8.493
Grimston Creek	-	13.0	0.1	13.2	0.00	98.00	0.90	17.21	-	7.538	0.111	1.304	8.953
Arranvale Creek	1.6	98.0	2.0	27.8	13.50	238.00	5.40	68.84	8.400	0.138	2.700	2.476	13.714
Tara Greek	0.5	118.0	2.0	48.4	4.50	308.00	6.30	120.47	9.000	2.610	3.150	2.489	17.249
Keady Creek	-	15.0	0.4	39.6	0.00	140.00	3.60	103.26	-	9.333	9.000	2.608	30.941
Unnamed Creek	0.2	5.7	0.3	25.8	9.00	126.00	3.60	68.84	45.000	22.105	12.000	2.668	81.773
Sauble Headwaters	0.1	3.0	0.2	30.5	18.00	154.00	8.10	130.47	180.000	51.333	40.500	3.950	275.783
TOTAL	38.2	16,749.9	755.8	402.3	103.50	2,450.03	81.90	877.71	252.200	101.078	71.85	29.066	454.194

DISCUSSION

There are several ways to approach the analysis of the results presented here. Deciding upon the best approach will depend upon the definition of the specific goals of this CURB Plan and the Rural Beaches Program in general. If the goal is simply to improve water quality at rural beaches and specifically Sauble Beach, analysis of the results may best rest solely upon 'at beach' loading rates. Unfortunately, the reality of the situation is far more complex.

The watershed residents would be asked to clean up their act, at some expense to themselves, so that a beach, used predominately by tourists, will be improved. However in this case, the means does not justify the end. Instead, a compromise would appear to be best both for the beach and the local situation. Improvements at the local level will not only serve to gain the cooperation of those who will be responsible for a significant portion of the cleanup costs but also provide beneficial results at the beach.

Within the Sauble River watershed the bacterial pollution problem appears to be most significant on a local level. Over the past ten years, Sauble Beach has never been closed due to elevated bacteria levels. The average fc concentration from the past 1978 to 1988 is 85/100mL. This does not mean that there is not a problem however, since levels above the Ministry of Environment objective of 100 fc/100mL of water have been reported at the beach. The maximum reported was 336/100mL in July, 1980. The average fc count for levels exceeding the MOE objective is 205/100mL. With these results in mind, the goal for beach cleanup may best be to reduce inputs to the point where bacteria levels never exceed the 100 fc/100mL objective.

Fecal Coliform Source Loading

The results presented here based upon the model and die-off algorithms clearly suggest that by restricting livestock access to the open waterways, bacteria loading would be greatly reduced. Livestock access accounts for 93.7% of the total loading sources in the Sauble Watershed. Livestock typically have access to watercourses from early May until late September which coincides with the period of maximum beach use. Therefore, the visual impacts of livestock access make it politically attractive as a cleanup target.

Not only does livestock access contribute significantly to bacterial contamination, but it also results in stream bank erosion and degradation of water quality from a fisheries aspect (eg. siltation, loss of vegetative cover, turbidity, temperature increases and oxygen decreases). With this combination of problems, instead of being more difficult to remedy, the potential is there to cooperate with other agencies and therefore access other sources of funding to help correct the situation. The immediate environmental impacts also help in attaining cooperation from landowners who can see physical evidence of degradation.

The CURB model fails to recognize that continuous discharges will act similarly to pulse discharges during rainfall/runoff events in terms of travel time and die-off; therefore, the total number of fecal coliforms reaching the beach will be increased during these periods. This insufficiency would tend to underestimate the potential of continuous sources to contribute to beach contamination. The movement and behaviour of microbial populations within streams is very complex, and the simplification of the process using the presently available data may not be prudent here.

The other continuous discharge factors contributing to bacteria loading are Milkhouse Waste Water 1.2%, and Septic System Failure 3.1%. The relatively low milkhouse waste

water input reflects the relative low number of dairy farms in the watershed compared to beef farms. Although Septic System failure has a greater impact than first expected the cost benefit ratio makes it less of a priority to repair than livestock access. A educational package informing the public about the problems and hazards of septic leakage would help bring this problem into the forefront of the rural public.

Pulse discharge sources (manure stack runoff, and manure spreading) contribute approximately 2% of the total fecal coliform load in the Sauble Watershed. Once again a public education program to point out the detrimental effects and legalities of allowing effluent from manure stacks to enter water courses would increase landowners' awareness and sense of responsibility for their land. Some of the benefits would include better water quality downstream and possibly improved herd health both for his own animals as well as those of this downstream neighbours. A manure stack can lose over 50% of it's nutrient value if left unchecked and runoff occurs.

Local Benefits of a Clean Up

Improving the quality of water in the Sauble River watershed has many positive benefits not related to the beach area. The cost of improving water quality would be well worth it, even if the beach aspect was not considered.

For the benefit of the farmer, improved water quality means improved herd health, and better weight gains. Studies show that livestock do considerably better when supplied with an adequate amount of cool clean water.

The northern section of the Sauble Watershed, known as the Rankin River supports a number of game fish species. Removal of livestock from the watercourses would greatly

increase habitat and stop the destruction of spawning areas for the fish. In the southern part of the watershed where cattle access is a bigger problem, a number of tributaries are still considered possible cold water streams, and if managed properly, could support populations of cold water species of fish (eg. trout).

Wildlife habitat throughout the watershed could benefit from improved water quality through fencing. The formation of bufferstrips along the streams would act as cover and travel corridors for many species. Increased recreational opportunities for hunting, trapping, or photography would then be available.

With the conversion of marginal agricultural land into recreational property throughout the watershed, an increase in property value would also be gained from improving water quality. A section of property with a waterway clean enough to support fish and some species of wildlife is far more marketable than one which is, in a degraded state.

Last but not least, the Province of Ontario spends millions of dollars each year maintaining municipal drains throughout the province. The life of a drain would be greatly increased with the reduction of livestock access, especially in the Sauble watershed where there is an abundance of heavy clay soils.

Cost-Effective Analysis

Any remedial action will be most cost-effective in terms of reducing beacterial contributions at the Local level, since the numbers of bacteria from a specific source are reduced due to die-off during transport to the beach.

The CURB model reflects a major livestock access problem. With respect to cost effectiveness, the cost of the fencing required to reduce fecal coliform levels is money much better spent than remedial measures for other loading factors. In terms of a landowner point of view the fencing of a watercourse would, in most cases, seem like a smaller commitment than major barnyard renovations, (eg. manure storage projects). Fencing projects should also draw public support as it is a prominent visual change, and people will be more aware of such projects.

It should be noted here that the cost-effective information in this report is sensitive to changes in cost estimates. For example, livestock access may be eliminated from year to year at several locations by simply changing cattle pasturing fields. Also more economical fencing methods are available, and perhaps fencing only one side of the stream may be appropriate more than the assumed 20% of the time.

Priority Ranking

The bacteria loading estimates calculated by this CURB model can be used to rank the fourteen subwatersheds according to their relative total fecal coliform bacteria contributions. It must be noted however, that this ranking does not reflect the actual intensity of the bacterial pollution problem. The total load from a watershed will be influenced by the size and drainage density of the area. In an attempt to compare the model ranking with actual field data (mean fecal coliform concentrations), the total fc loading for each subwatershed was divided by the total stream Length within that subwatershed. The results of the various rankings are given in Table 8.

Table 8: Comparison of subwatershed rankings from worst (1) to best (14) based on the CURB model prediction (both locally and at the beach), the CURB model prediction modified to account for stream length and size of drainage area (both locally and at the beach), and available field data (average fc concentrations).

	Model Ranking		Modified Model Ranking		Field Ranking
	Locally	At Beach	Locally	At Beach	Local
1	Tara	Main Sauble North	Arkwright	Main Sauble North	Arranvale
2	Rankin	Maryville	Grimston	Maryville	Fenton Drain
3	Arranvale	Main Sauble Central	Arranvale	Fenton	Arkwright
4	Main Sauble South	Arkwright	Tara	Main Sauble Central	Keady
5	Main Sauble South	Fenton Drain	Fenton Drain	Tyndall Drain	Tyndall Drain
6	Arkwright	Rankin	Tyndall Drain	Arranvale	Main Sauble South
7	Main Sauble North	Tyndall Drain	Sauble Headwaters	Tara	Unnamed
8	Sauble Headwaters	Tara	Main Sauble Central	Main Sauble South	Tara
9	Keady	Arranvale	Main Sauble South	Rankin	Maryville
10	Tyndall	Main Sauble South	Keady	Keady	Rankin
11	Grimston	Keady	Rankin	Sauble Headwaters	Sauble Headwaters
12	Unnamed	Unnamed	Unnamed	Unnamed	
13	Fenton	Grimston	Maryville	Grimston	
14	Maryville	Sauble Headwaters	Main Sauble North	Arkwright	

Although it may appear at first that the subwatershed contributing the highest total number of bacteria would have the most impact upon beach loadings, by simply enlarging the area of a subwatershed, the total fecal coliform count for the enlarged area would make that area appear more significant in terms of its load than it may actually be.

It is therefore important to realize that once the "amount" of watercourse (length) has been taken into account, the model "fits" better with the field data, pointing out that the

ranking of watersheds by the model may be influenced by the size of the subwatershed and not the intensity of the problem within it.

Having to some extent accounted for the intensity of the subwatershed loadings by partial elimination of the "area" variable, the modified model ranking approximates that of the field data. Therefore, the five subwatersheds which have the most serious impact appear to be Main Sauble North, Arranvale Creek, Main Sauble Central, Tyndall Drain and Fenton Drain. The only discrepancy between this ranking and the actual field ranking seems to be that of Arkwright Creek and Keady Creek. In reality though both of these subwatersheds exhibit substantial amounts of bacterial loading sources. Also, when comparing model information with actual data, it must be remembered that the true picture may not be represented. For instance, a sampling site may be adjacent to a cattle access site, a barnyard or other source of bacterial input which would bias the data from this station.

RECOMMENDATIONS

1. A province-wide public awareness program should be initiated addressing all agriculturally related sources of pollution, especially manure spreading, to educate rural landowners about these problems, the causes and possible solutions. This program should also emphasize to landowners the importance of assuming responsibility for the stewardship of their own land for future generations.
2. The provincial government should continue to provide funding for remedial action through OSCEPAP grants in priority watersheds which impact directly on economically important beaches.
3. Within each watershed, funding should be made available on a "priority" basis as opposed to a "first come, first served basis". According to the modified CURB model, the top five priority subwatersheds in the Sauble River system are Main Sauble North, Maryville Creek, Fenton Drain, Main Sauble Central and Tyndall Drain.
4. More detailed information about the subwatersheds would improve the accuracy of the CURB model algorithms.
5. Research should be continued in an effort to better understand the movement and survival of bacteria in streams.
6. More research is needed to investigate the potential impacts from other sources of pollution including urban centers, industry and wildlife. More information is also needed regarding the movement of lake currents to determine whether other river systems may be impacting upon Sauble Beach.

7. The Drainage Act should be reviewed and provisions made to incorporate streambank fencing with access points, sod establishment and erosion control (where needed) during the construction or clean-out of drains.
8. Extension personnel should be employed to coordinate a remedial action program between government agencies and the landowner. Other sources of funding should be accessed where possible.
9. Meetings with Township councils should be arranged to discuss possible ways for these municipalities to make positive contributions towards reducing bacterial inputs.

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