HSP

CLEAN UP RURAL BEACHES

BROAD ENVIRONMENTAL ACCOUNTING METHOD

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for

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DISCLAIMER

The conclusions and recommendations made in this report are those of the authors and do not necessarily reflect the views of the Ontario Ministry of the Environment or Conservation Authorities.

The proposed environmental accounting method is the first version of a system that will evolve over time as new data and information becomes available.

This system is not to evaluate the relative priority of specific candidate projects. Rather, it is a simplified method to measure Provincial progress employing data which may be considered the lowest common denominator of available information.

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ACKNOWLEDGEMENTS

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Dave Hayman	Upper Thames River Conservation Authority
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and staff of the following Conservation Authorities:

Ausable Bayfield
Grand River
Grey Sauble
Lake Simcoe Region
Maitland Valley
Metropolitan Toronto and Region
Niagara Peninsula Region
Otonabee Region
Upper Thames River

The contributions from these people are gratefully acknowledged.

1.0 EXECUTIVE SUMMARY AND RECOMMENDATIONS

All Clean-Up-Rural-Beaches, (CURB) Plans developed to date by participating Conservation Authorities were reviewed with the purpose of developing a consistent means of quantifying the environmental progress of the Provincial CURB Implementation Program.

Staff of each Conservation Authority which had completed CURB Plans were requested to provide any other published studies completed under the program, which may provide additional data to quantify the effectiveness of practices.

Conclusions were derived based on the collected information. From these, a simplified consistent means of quantifying environmental progress versus program grant expenditures was developed. The environmental accounting technique was developed to be simple so that a management burden would not be created and all areas could apply it easily. It was based on the best-available data recognizing that improvements would be a continuous evolving process.

The method was developed into a spreadsheet format. Average remedial costs were taken from the data collected during the first year of implementation and are included in the spreadsheet. However, local costs are also accommodated and should be used to compare to the average provincial cost.

Rural Beaches Programs are at various stages of progress throughout the province. Some local programs have advanced into their implementation phases while others are just beginning their investigation phases.

With the first official year of CURB Implementation underway, it was considered necessary to develop a consistent means of progress-measurement that publically accounts for the dollars spent through quantitative environmental benefits.

1.1 Conclusions

Quantification of environmental benefits is an extremely complex task which has been approached by Program staff since 1986. Based on a review of the existing CURB Plans and research/monitoring data by the programs, it was concluded that:

1. Significant phosphorus and bacteria loading reductions were not apparent in individual farm practice studies due, in part, to site selection problems which did not eliminate or minimize external sources upstream of the remediation sites.

2. Insufficient numbers of studies were conducted to derive final conclusions for the impacts of practices other than milkhouse waste control.

3. Practices which are not directly eligible for CURB funding assistance (such as the timing, methods and locations of manure-spreading) may play a larger overall role than previously anticipated. Currently, however, there is no documented method to predict such potential impacts.

4. Most subwatershed studies undertaken showed significant reductions in phosphorus and bacteria loadings except where other non-CURB-eligible factors, such as improper or suspect manure spreading practices, were used and were not eliminated.

5. Recognizing fiscal constraints with respect to laboratory capabilities, a consistent protocol for water sampling is required especially for new program areas.

6. Reductions of pollutant loads at the concerned beaches may not be measurable over the term of the CURB Implementation Program due to uncontrollable factors such as climate variability and complex in-stream processes.

7. The cost estimates documented in 1988 for remedial practices are not consistent with current costs. In the case of livestock restriction from streams, alternate watering facilities have not been a major requirement and thus the costs have been much less than originally projected. Average costs were updated with average costs derived from Provincial records after the first year of implementation.

8. Any broad environmental accounting method such as that recommended, will be a simplification of specific processes. The method presented is designed to be simple; readily applied, regardless of available data base and to provide a general measure of provincial progress.

1.2 Recommendations

1. **All Authorities should make estimates of sources which are eligible for CURB Implementation funding**.

2. **Authorities should implement the source-accounting spreadsheet as one means of progress measurement**. For approved implementation within the program, Authorities should use the spreadsheet to record the amount of phosphorus and bacteria reduction as well as the amount of money spent or required for implementation. Using this methodology, Authorities can both record progress and can roughly predetermine the most cost beneficial scheme for pollution reduction, if no other predictive model was applied.

3. **Other social aspects of the program such as the changes in public attitude and problem recognition are important.** Efforts should be made to document social changes to support the emphasis on water quality documentation.

4. **The Provincial Rural Beaches Committee should collect these spreadsheet data files from each participating Authority at least annually.** The committee should use this data to evaluate the progress being made collectively by the Authorities expending implementation funds. At the time of collection, the participating Authority should also include any documentation of changes made in the default application of the source-accounting spreadsheet. Such deviations may alter spreadsheet results, and hence, the Committee should be made aware of these deviations.

5. **Each Authority participating in the CURB Implementation Program should carry out four site-specific farm practice studies.** These four studies will be based on the types of practices which are eligible for CURB Implementation funds. The practice studies should involve before and after and upstream & downstream monitoring and each study should use the following procedure:

   i. Identify the source of phosphorus and bacteria loading ensuring that any other upstream source contributions are minimized (preferably headland area).

ii. Before implementation:
Take water samples at a consistent location, preferably 10 to 50m upstream and downstream of identified source. Samples will be taken bi-weekly for a total of ten samples. Ensure that 2 samples are during events.

iii. Install a staff gauge at sampling site to record water levels which, in turn, provide an indication of flow magnitude during sampling.

iv. Allow remediation to take place. Document any changes made at the remediation site

v. After implementation:
Take water samples 10 to 50m upstream and downstream of identified sources. Samples will be taken bi-weekly for a total of ten samples. Ensure that 2 samples are during events. Record staff gauge levels at the time of sampling.

As a result of the four proposed farm practice studies, each Authority will have a lab load of 160 samples for phosphorus and bacteria analysis over the duration of the Implementation Program. The cumulative data will provide statistically valid results regarding the effectiveness of each practice.

6. Each Authority participating in the CURB Implementation Program should carry out at least one small subwatershed study using the following procedure:

i. Select two subwatersheds similar in size and characteristics. One subwatershed will undergo implementation in future years, and one or more others will be controls, where implementation would not be encouraged (preferably in a non-eligible area).

ii. For one season (June - Sept), obtain background levels of both watersheds by monitoring subwatershed outlets bi-weekly. Include at least two "wet" events.

iii. For each subsequent season (June - Sept), monitor subwatershed outlets in the same manner. Promote and document any remediation efforts which take place within the subwatershed eligible for CURB Implementation funds.

As a result of the proposed single subwatershed study, each Authority will have an additional lab load of 100 samples (20 per year) for phosphorus and bacteria analysis over the duration of the Implementation Program.

The subwatershed studies provide local demonstrations of improvement as well as documentation of effectiveness on a larger scale.

7. **Algorithms which estimate loadings of phosphorus and bacteria from manure stack and feedlot/barnyard runoff should be reassessed with respect to manure spreading algorithms.** Further modification of these source-accounting algorithms are required since remediation of manure stack and feedlot/barnyard sources can contribute to the probability of source loading by manure spreading. The process of manure spreading and predicted bacteria mortality rates are extremely variable between programs and suggest that reassessment of the algorithms be completed based on further research. Winter-spreading, in particular, but also summer spreading should be examined. The timing, and methods of manure spreading can be impacted by storage conditions. The location, rate and some aspects of methods and timing of spreading are not controlled by storage conditions.

8. **A method to predict manure-spreading impacts should be developed.** Further research is required regarding the effect of various soil types on the susceptibility of tile drain contamination under various cultural practices.

9. The Provincial spreadsheet includes decay rates and other specific factors as lumped Provincial average values. Authorities that have accurately determined travel times and bacteria decay rates should compare their values to the lumped Provincial average. (load at beach divided by number of priority sources).

10. **The Provincial and Local Implementation Committees should closely examine the need for targeting efforts in light of the problem magnitude versus available funds.**

11. **The environmental accounting system should be viewed as a dynamic framework (changing as better values become available) to enable a simplistic but consistent quantification of progress relative to expenditures without major administrative time-consumption.** The accounting system should <u>not</u> be used to determine the relative priority of site-specific individual sources nor the effectiveness of a specific installation. More detailed information is required when assessing the priority of individual sources.

    Future local refinement of the accounting system may include the addition of more detailed site-specific factors using the current estimates as default values.

12. **Practices which are not eligible for CURB funding should be quantified at the onset of CURB Implementation.**

MOE should be consulted for estimates of urban point and non-point sources from industry and municipalities in the watersheds of concern.

The significant phosphorus contributions from soil erosion and other agricultural sources should also be reflected as "other sources" which the CURB Implementation program will not address.

2.0 BACKGROUND

Each of the Beaches Investigations in Ontario since 1985 identified specific areas which were affected or had potential to be affected by abnormally high levels of phosphorus and/or bacteria from upstream runoff. Most of these investigations included detailed inventories of upstream land uses and estimates of an input budget for sources of bacteria and phosphorus. A number of the program participants undertook comprehensive before/after monitoring of specific practices which provided estimates of the impact and potential reduction achievable by remediation. In addition, some program participants analyzed the costs associated with remediation of specific sources.

Those programs which have moved from the study phase to the implementation phase now require a framework within which progress can be measured with respect to environmental impact reduction within the existing financial constraints. Because funds are limited, it is in the best interest of the participating Authority (or other proponent) to effectively allocate the available funds in a manner which maximizes the local environmental benefits at minimum cost.

3.0 STUDY OBJECTIVES

This assignment arose due to a need to quantify CURB Implementation Program results relative to financial expenditures. More specifically the objectives are to:

1. document and characterize existing work in the form of an overview of modelling techniques used and monitoring studies carried out.

2. determine further water sampling needs and investigative studies.

3. provide a broad simple environmental accounting technique in the format of a spreadsheet. This technique will provide a consistent means of progress measurement relative to financial expenditures for each watershed.

3.1 Limitations

1. The assignment was limited to a review of existing Beaches Program investigative reports and not external publications.

2. A recognition of the short (5 year) implementation term must be acknowledged. This will limit the ability to detect significant improvements of a downstream beach or area of impact and therefore demands an approach based on source-magnitude accounting.

3. The environmental source-accounting method will be limited to practices which are eligible for funding under the CURB Implementation Program.

4.0 METHOD

The study was carried out in steps.

4.1 Obtaining Data and Reports

Completed CURB reports were requested from the individual study areas and from the Ministry of the Environment (MOE). Documentation of additional CURB-eligible studies of individual farm demonstrations and sub-watersheds were also requested from Conservation Authorities with completed CURB plans.

4.2 Interviews of Program Administration and Technical Staff

Certain program staff were interviewed to ascertain the background of the various modelling techniques used to estimate relative source magnitudes. Three client meetings were held to guide the approach.

4.3 Synthesis and Assessment of Studies

These studies were classified into three categories:

a) individual farm practice studies
b) sub-watershed studies
c) broad large watershed studies

In part, this was to justify the different approaches taken in each type of study.

4.4 Source - Accounting

The methods used to estimate source-magnitudes in each type of study were documented. The specific algorithms used in the broad modelling applications in the large watershed studies were assessed and common features and differences were noted.

4.5 Assessment of Source-Reduction Efficiencies of CURB-Eligible Practices

Specific farm practice studies were reviewed to estimate the efficiency of individual practices in reducing both phosphorus and bacteria inputs to streams.

4.6 In-stream Transport and Bacteria Survival

In-stream transport mechanisms, travel times and bacteria survival characteristics were examined.

4.7 Assessment of Average Costs of CURB-Eligible Practices

A review was conducted of the average costs of CURB-eligible practices based on results reported in the various CURB Implementation Plans.

4.8 Development of a Spreadsheet for Environmental Accounting

Algorithms were developed which could estimate practice efficiency and were placed into a spreadsheet format to produce a fast, simple method of estimating the overall source magnitude reduction relative to the cost of implementation.

5.0 RURAL BEACHES STUDIES AND INVESTIGATIONS

During the latter part of the 1980's, Conservation Authorities started to carry out investigative watershed studies as part of the Provincial Rural Beaches Program. These investigative studies generally consisted of large watershed studies; however, some Authorities also carried out more detailed studies on a smaller watershed, sometimes within the context of the larger watershed study. Large watershed studies investigated agricultural and rural sources of pollution, namely phosphorus and bacteria, which were affecting downstream water quality, particularly at beaches. The smaller studies monitored and evaluated the changes in water quality directly from installations of demonstration/control practices. These studies are described in the following sections[1].

5.1 Farm Practice Studies

Farm practice studies are smaller studies which evaluate the changes in water quality directly resulting from installations of demonstration/control practices. Generally, these studies involve monitoring either upstream and downstream of implementation and/or before and after implementation in order to assist in the evaluation of the implementation. Completed farm practice studies, along with a brief description of methodology, are listed in Table 5.1.

The significance of the results from the farm practice studies listed in Table 5.1 is highly dependent on the site specific processes and sampling intensity involved with each farm practice study. For example, the construction of a manure storage facility in a demonstration project with the Grey Sauble Conservation Authority showed a significant reduction in bacteria and phosphorus loadings, whereas a demonstration project within the Grand River Conservation Authority involving milkhouse waste control and livestock access restriction did not show a significant reduction in either bacteria or phosphorus loadings. One difference between these two demonstration projects is the level of sampling: the Grey Sauble project had a medium level of sampling and the Grand River project had a low level of sampling.

Perhaps, even more importantly, if the sample site is not in a headland watershed, the impacts of other upstream sources can easily mask the progress and successes of the remedial project without intensive sampling and flow monitoring.

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[1] The Terms of Reference compared to the magnitude of information which needed to be reviewed may have resulted in incomplete descriptions.

Table 5.1: Farm Practice Studies

Study Year	Conservation Authority	Type of Study	Type of Monitoring	Reduction Bacteria	Sampling	Reduction Phos.	Sampling
1986	Maitland Valley	Cattle Access	Upstream/Downstream Before/After	Not Apparent	med.	Not Apparent	med.
1987	Maitland Valley	Manure Storage	Upstream/Downstream Before/After	Not Apparent	med.	Not Apparent	med.
1987	Maitland Valley	Cattle Access Manure Storage	Upstream/Downstream Before/After	N/A	N/A	N/A	N/A
1988	Grey Sauble	Manure Storage	Before/After	Significant Improvement	med.	N/A	N/A
1988	Grey Sauble	Cattle Access	Before/After	Significant Improvement	med.	N/A	N/A
1988	Grey Sauble	Cattle Access	Before/After	Not Apparent	med.	N/A	N/A
1988	Grey Sauble	Cattle Access	Before/After	N/A	low	N/A	low
1987-1988	Grand River	Milkhouse Waste livestock access	Upstream/Downstream Before/After	Not Apparent	low	Not Apparent	low
1987-1988	Grand River	Cattle Access Milkhouse Waste	Upstream/Downstream Before/After	Not Apparent	low	Not Apparent	low
1986-pres.	Upper Thames River	Milkhouse Waste	Upstream/Downstream Before/After	N/A	N/A	Significant Improvement	high

N/A - not available
high - once/biweekly
med - once/month
low - less than once/month

All of the farm practice studies which showed significant improvements in phosphorus and bacteria loadings also had a medium level of sampling intensity. Since a majority of the farm practice studies showed that significant improvements were not apparent, this suggests that the processes involved with phosphorus and bacteria loadings are complex and that verification of these loadings requires intensive sampling unless the site is chosen in a headland area.

5.2 Subwatershed Studies

Like farm practice studies, subwatershed studies are smaller studies which evaluate the changes in water quality directly resulting from installations of demonstration/control projects. Generally, subwatershed studies involve monitoring before and after implementation at the outlets of the studied watershed and a control watershed. Comparison of the monitored results of the studied watershed and the control watershed assist in the evaluation of implementation projects. Completed subwatershed studies, along with a brief description of methodology, are listed in Table 5.2.

For most of the subwatershed studies, significant improvements in reductions of phosphorus and bacteria loadings were apparent. Significant improvements in bacteria loadings were apparent for two of three subwatershed studies and significant improvements in phosphorus loadings were also apparent for two of three subwatershed studies. Since all of these studies had a high level of sampling intensity, the results indicate that verification of remediation is dependent on the high level of sampling intensity.

Like farm practice studies, however, the results of the subwatershed studies may also be dependent on the site specific processes involved with each study. For example, the repair of livestock accesses, manure stack and feedlot runoff, milkhouse waste systems and septic systems in the Target Sub-Basin within the Ausable Bayfield Conservation Authority has not shown a significant improvement in bacteria and phosphorus loadings. In this case, the contribution of bacteria and phosphorus may be coming from sources which are not directly eligible for CURB implementation funds, such as the timing, rate and method and location of manure spreading.

5.3 Large Watershed Studies

Large watershed studies usually involve far greater than 25 farms, (often several hundred), and identify agricultural and rural sources of pollution which could affect downstream water quality, particularly at the beach. These studies involve the investigation of sources of phosphorus and bacteria within the watershed, an evaluation of source magnitude and a subsequent classification of the source. Table 5.3 lists the completed large watershed studies, along with the significant sources of bacteria and phosphorus identified within the watershed. These sources are deemed significant only if the Authority undertaking the study evaluated the source as having a major impact on the watershed. Based on the inventory of these significant sources, a number of Authorities attempted broad based large scale modelling.

Table 5.2: Subwatershed Studies with Controls

Study Year	Conservation Authority	Name of Subwatershed	Types of Demonstrations	Reduction Bacteria	Sampling	Reduction Phos.	Sampling
1986 - pres.	Ausable Bayfield	Target Sub-Basin	Livestock Access Manure Storage Milkhouse Wastes Septic Systems	Not Apparent	high	Not Apparent	high
1986- pres.	Upper Thames River	Pittock Sub-Basin #2	Milkhouse Wastes	N/A	N/A	Significant Improvement	high
1986- pres.	Upper Thames River	Embro Pond	Milkhouse Wastes Manure Storage	Significant Improvement	high	Significant Improvement	high
	Upper Thames River	Timm's Creek	Livestock Access	In Progress	N/A	N/A	N/A
	Upper Thames River	Havelock Study	Septic Systems	Significant Improvement	high	N/A	N/A

N/A - not available
high - once/biweekly
med - once/month
low - less than once/month

Table 5.3: Large Watershed Studies

Study Year	Conservation Authority	Name of Study	Type of Sources
1983-1988	Ausable Bayfield	Ausable Bayfield	1,2,3,4,5,7,8,9
1986 - 1989	Grand River	Upper Nith Upper Speed Upper Conestoga	1,2,3,7
1986 - 1988	Grey Sauble	Sauble River	2,3,4,5,7,8
1986 - 1987	Lake Simcoe Region	Pefferlaw Brook Beaverton River	1,2,3,4,5,7
1986 - 1988	Maitland Valley	Lake Huron Beaches	1,2,3,4,5,6,7,8,9,10
1986 - 1989	Metropolitan Toronto & Region	East Humber River Centreville Creek Bruce Creek	1,2,3,4,5,7,8,10,11
1987 - 1991	Niagara Peninsula Region	Binbrook Reservoir	1,2,3,4,5,7,8,11
1986 - 1987	Otonabee Region	Indian River	1,2,3,4,5,7,8
1986 - 1989	Upper Thames River	Fanshawe Pittock Wildwood	1,2,4,5,7,8,9,10

1 - Feedlot/Barnyard Runoff
2 - Livestock Access
3 - Manure-Stacks
4 - Manure-Winter Spreading
5 - Manure-Summer Spreading
6 - Manure-Spills
7 - Milkhouse Wastes
8 - Septic Systems
9 - Sewage Treatment Plants
10 - Urban Non-Point
11 - Wildlife

6.0 EVOLUTION OF AN ACCOUNTING METHOD

The broad large-scale modelling question was reviewed by Beaches Program staff in 1986/87 at various program workshops. It was recognized that bacteria transport was extremely difficult to model since bacteria are organisms which respond to habitat condition. Bacteria generally reproduce to balance mortality rates in turbid, warm, sediment-enriched conditions and experience net mortality under cold and more pristine conditions and over time.

Bacteria, because of their dynamics, could only therefore be modelled in the most simplistic manner. Hence, an accounting method rather than a sophisticated model was developed by program staff faced with large territories and corresponding large numbers of potential sources. The environmental source-accounting technique is schematically illustrated in Figure 6.1.

The same process was used for both phosphorus and bacteria. It was assumed that phosphorus, once in the stream system, would have a constant impact regardless of the point of entry. Bacteria, on the other hand, were considered to have less impact if introduced further upstream of the area of concern because of a net reduction due to mortality over time. The impact of bacteria sources on receiving water therefore was inversely related to the stream travel time between the point of introduction to the watercourse and the area or beach of concern.

6.1 Algorithms Developed During Rural Beaches Studies

During their Rural Beaches Investigations, most Authorities implemented a source accounting technique which estimated the amount of phosphorus and bacteria loading to the outlet of the study watershed. This technique consisted of a number of algorithms, each estimating the amount of phosphorus or bacteria loading from a specific source. Algorithms varied from one Authority to the next; some Authorities did not use any algorithms to make loading estimates.

For the purposes of this assignment, only the algorithms which estimate loadings of phosphorus and bacteria from sources eligible for CURB Implementation funds will be considered. These sources are livestock access, milkhouse wastes, private septic systems, manure stack and barnyard/feedlot runoff. It is recognized that other sources, as identified in Table 5.3, contribute to phosphorus and bacteria loading within the watershed; however,

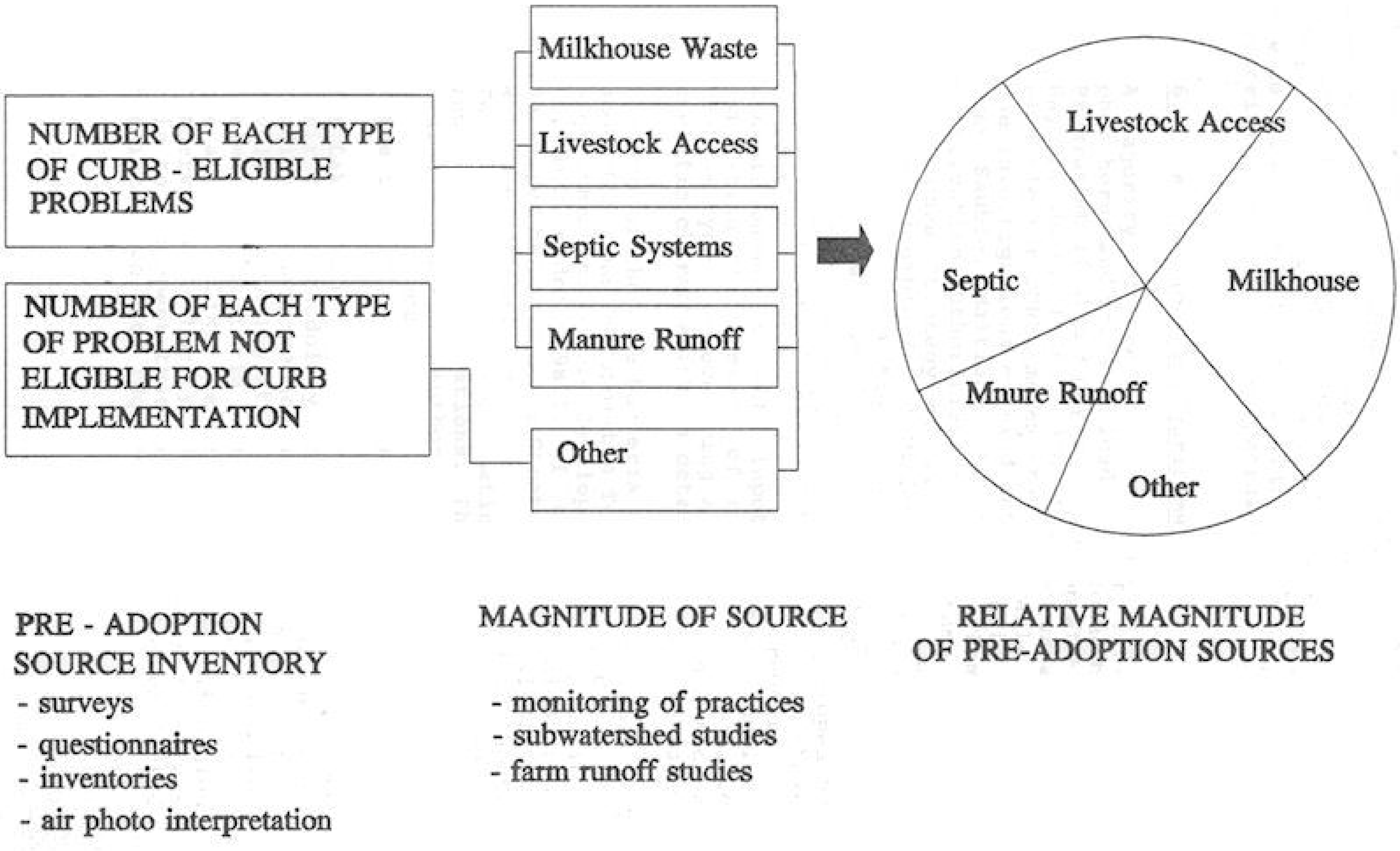

Figure 6.1: CURB Plan - Source Accounting

since the objective of this assignment is to provide a consistent means of progress measurement within the context of the CURB Implementation Program, only the five eligible sources will be considered. Tables 6.1 and 6.2 list the sources of the algorithms which were used by Conservation Authorities to estimate phosphorus and bacteria loadings.

6.1.1 evaluation of algorithms

A majority of the algorithms used for estimates of phosphorus and bacteria loading were developed by Beaches Program staff at a 3 day intensive workshop at Kempenfelt Bay in July, 1988. For the five bacteria sources eligible for CURB Implementation funds, Table 6.1 lists the investigations carried out by the Ausable Bayfield, Grey Sauble, Maitland Valley and Upper Thames River Conservation Authorities using the algorithms developed by Beaches Strategy staff. For the five phosphorus sources eligible for CURB Implementation funds, Table 6.2 lists the investigations carried out by the Ausable Bayfield and the Upper Thames River Conservation Authorities as using algorithms which were developed by Beaches Program staff. The general form of these algorithms, shown in Figure 6.2, is simple, requiring a minimal amount of data input. This method involves estimating the numbers of occurrences of a specific problem type and developing a loading function based on specific characteristics determined in the watershed.

For four of the five bacteria source estimates, Table 6.1 shows that the Metropolitan Toronto and Region C.A. used algorithms which were developed by Ecologistics Limited (P.L.O.P. model, 1988). In contrast to the algorithms developed by the Beaches Strategy staff, these algorithms are extremely detailed and require intensive data input. This method involved estimating the bacteria sources of individual farm operations. The Metropolitan Toronto and Region Conservation Authority was able to implement these algorithms since their investigation was on a smaller scale than other investigations.

The Lake Simcoe Region Conservation Authority developed their own methodology for the estimation of bacteria loading. Their method was similar to the algorithms developed by Ecologistics Limited. This method involved estimating bacteria sources on individual farm operations. Like the Metropolitan Toronto and Region Conservation Authority, the Lake Simcoe Region C. A. was able to implement these algorithms since they collected the intensive data required.

Table 6.1: Origin of Bacteria Algorithms for CURB-Eligible Sources

Conservation Authority	Milkhouse Waste	Livestock Access	Septic Discharges	Manure Stack Runoff	Barnyard/ Feedlot Runoff
Ausable Bayfield	Beaches Staff	Beaches Staff	Beaches Staff	Beaches Staff	Beaches Staff
Grand River	N/A	N/A	N/A	N/A	N/A
Grey Sauble	Beaches Staff	Beaches Staff	Beaches Staff	Beaches Staff	Beaches Staff
Lake Simcoe Region	L.S.R. Staff	L.S.R. Staff	L.S.R. Staff	L.S.R. Staff	L.S.R. Staff
Maitland Valley	Beaches Staff	Beaches Staff	Beaches Staff	Beaches Staff	Beaches Staff
Metropolitan Toronto & Region	Ecologistics	Ecologistics	Beaches Staff	Ecologistics	Ecologistics
Niagara Peninsula Region	N/A	N/A	N/A	N/A	N/A
Otonabee Region	N/A	N/A	N/A	N/A	N/A
Upper Thames River	Beaches Staff	Beaches Staff	Beaches Staff	Beaches Staff	Beaches Staff

N/A - not available
Beaches Staff - Beaches Strategy Staff
L.S.R. - Lake Simcoe Region C.A. Staff
Ecologistics - Ecologistics Limited (P.L.O.P. model)

Table 6.2: Origin of Phosphorus Algorithms for CURB-Eligible Sources

Conservation Authority	Milkhouse Waste		Livestock Access		Septic Discharges		Manure Stack Runoff		Barnyard/ Feedlot Runoff	
Ausable Bayfield	Beaches	Staff	Beaches	Staff	Beaches	Staff	Beaches	Staff	Beaches	Staff
Grand River	N/A		N/A		N/A		N/A		N/A	
Grey Sauble	N/A		N/A		N/A		N/A		N/A	
Lake Simcoe Region	N/A		N/A		N/A		N/A		N/A	
Maitland Valley	N/A		N/A		N/A		N/A		N/A	
Metropolitan Toronto and Region	N/A		N/A		N/A		N/A		N/A	
Niagara Peninsula Region	N/A		N/A		N/A		N/A		N/A	
Otonabee Region	N/A		N/A		N/A		N/A		N/A	
Upper Thames River	Beaches	Staff	Beaches	Staff	Beaches	Staff	Beaches	Staff	Beaches	Staff

N/A - not available
Beaches Staff - Beaches Strategy Staff
L.S.R. - Lake Simcoe Region C.A. Staff
Ecologistics - Ecologistics Limited (P.L.O.P. model)

MILKHOUSE WASTES ALGORITHM

MHW LOAD = Concentration x Volume/Cow/Day x No. of Cows x 365 days x Delivery

LIVESTOCK ACCESS ALGORITHM

ACCESS LOAD = C/D x EAU x Prob. of defecation x access events/day x LF x no. of animals x no. of days

C/D - Concentration per Defecation
EAU - Equivalent Animal Units
LF - Location Factor

SEPTIC SYSTEM FAILURE ALGORITHM

SSF LOAD = Concentration x Volume x Sub-basin Population x Failure Rate x Delivery

FEEDLOT/BARNYARD RUNOFF ALGORITHM

FEEDLOT LOAD = - Concentration x Average Manure Pack x Volume of Runoff x Delivery

MANURE STACK RUNOFF ALGORITHM

STACK LOAD = Concentration x Average Stack Area x Runoff x Delivery

Figure 6.2: General Form of Algorithms Developed by Rural Beaches Staff

7.0 SELECTED APPROACH

Figure 7.1 outlines, graphically, the environmental accounting approach. The method is made up of three main components:

1)	ADOPTION:	monitoring the change in the implementation of CURB-eligible practices.
2)	EFFECTIVENESS:	estimating or measuring the effects (on bacteria and phosphorus delivery) of these practices on a particular circumstance.
3)	EXTRAPOLATION:	combining the results of 1 and 2 above and extrapolating to the watershed.

7.1 Selected Algorithms

Algorithms developed by the Beaches Strategy staff to estimate phosphorus and bacteria loading are selected and used in the development of the environmental accounting approach. These algorithms are simple, easy to apply, and as a result, are a common denominator for applications to all of the watersheds. In cases where different algorithms were applied, the algorithms developed by the Beaches Strategy staff can also be applied since the data requirements are minimal. In cases where algorithms have not been applied, the algorithms developed by the Beaches Strategy staff can be applied once again. As shown in Table 5.3, inventories of sources eligible for CURB Implementation funds have been taken by all of the Authorities, and consequently, the algorithms can be applied since the inventories taken by the Authorities is sufficient for the determination of input parameters.

7.2 Assessment of Source-Reduction Efficiencies of CURB - Eligible Practices

Assessment of source-reduction efficiencies of CURB-eligible practices is based on subwatershed and farm practice studies which were carried out during the Rural Beaches Investigations.

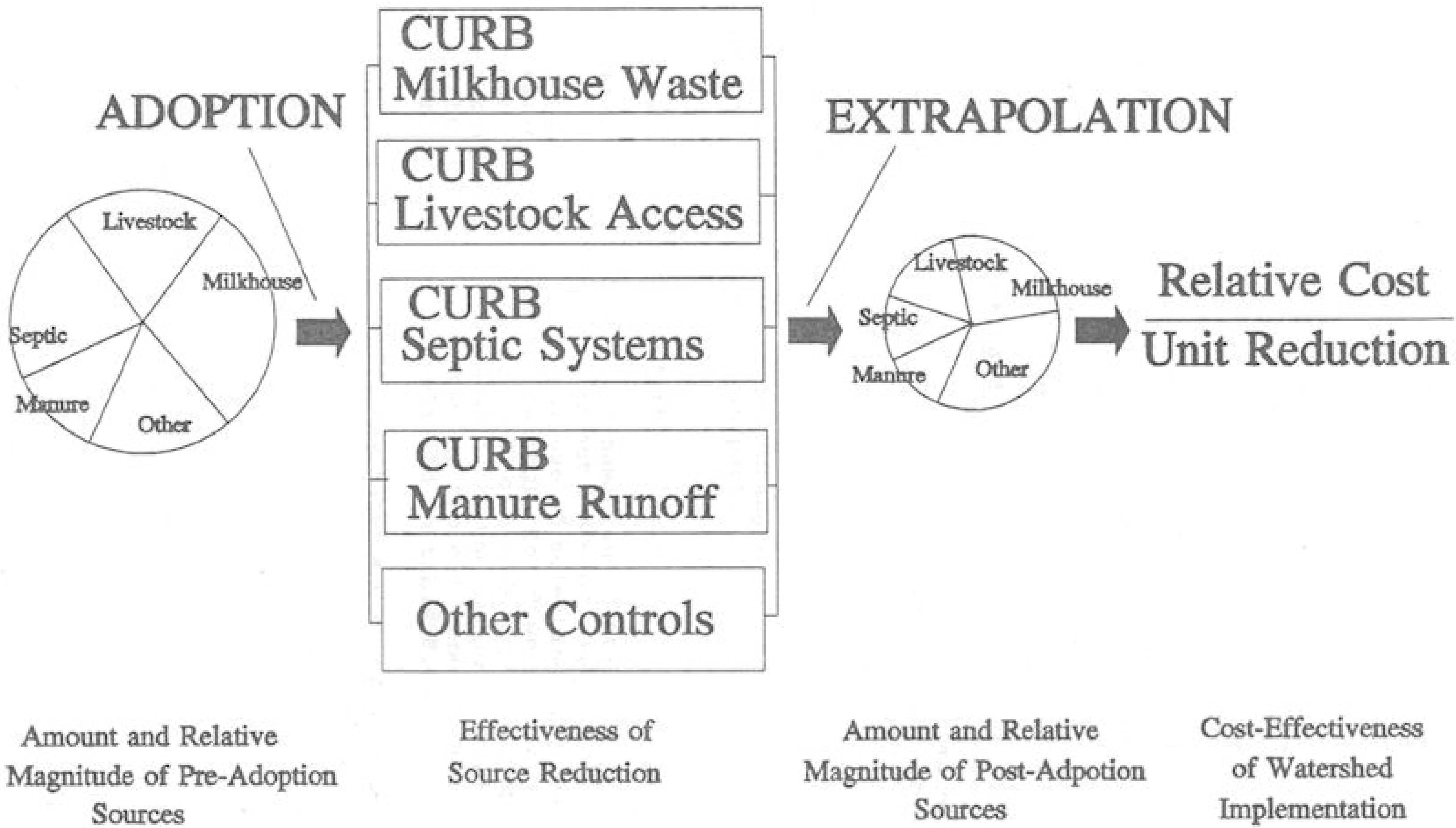

Figure 7.1: Broad Environmental Accounting Framework

The results from these implementation studies are listed in Tables 5.1 and 5.2, and in most of the studies, significant improvement in either phosphorus or bacteria loadings was not apparent. A number of reasons could be cited to explain this lack of significant improvement, but the main reason is that sources upstream of the remediation site were not considered and likely had an over-riding impact on concentrations.

As a result of this lack in study information, development of source-reduction efficiencies is difficult to deduce. For the sake of estimating phosphorus and bacteria loadings from specific sources, any source which undergoes remediation will be assumed to no longer contribute phosphorus or bacteria. If the development of source-reduction efficiencies is an objective, further intensive studies will be required.

7.3 In-stream Transport and Bacteria Survival

Many Authorities implemented algorithms which estimated the in-stream transport of bacteria. These Authorities recognized that bacteria loadings to downstream areas of concern were dependent on a number of factors namely, travel time from point of entry and sunlight. Decay functions to estimate the change in bacteria loadings as a result of some of these factors were developed by Authorities. Table 7.1 lists the Authorities which estimated changes in bacteria loadings resulting from in-stream transport.

7.3.1 selected algorithm

In-stream loadings are dynamic and difficult to estimate and some Authorities do not have data required for these algorithms. For the purpose of selecting an algorithm to estimate bacteria loadings to downstream areas of concern, a reduction of one order of magnitude was incorporated as an estimate of the bacteria net mortality rate. This was based on typical reported results in table 8.1 and is identified in table 8.3.

It is suggested that decay rates and travel times be used for local targeting where estimates are available.

Table 7.1: Algorithms for In-stream Bacteria Transport

Conservation Authority	Characteristics of Algorithms
Ausable Bayfield	Travel Time & Bacteria Decay Rate
Grand River	N/A
Grey Sauble	Travel Time & Bacteria Die-Off
Lake Simcoe	N/A
Maitland Valley	Travel Time & Decay Rates
Metropolitan Toronto & Region	Travel Time and Bacteria Disappearance Rate
Niagara Peninsula Region	N/A
Otonabee Region	N/A
Upper Thames River	Travel Time and Bacteria Die-Off

N/A - not available

7.4 Assessment of Average Costs

The question of average costs was reviewed by Beaches Program staff at a workshop at Kempenfelt Bay in 1988. They analyzed the rural contaminant source and the maximum and minimum costs associated with the remediation. Associated cost estimates established at that time are listed in Table 7.2 with the maximum and minimum costs for remediation.

For the purpose of the predictive mode only, average costs were determined for each source eligible for CURB Implementation funds based on expenditures during the first year of the Implementation program. With these average costs, the amount of reduction in bacteria and phosphorus loading per dollar spent can be projected for various implementation scenarios. These costs are listed in Table 7.3. The cost estimates (table 7.2) formed the basis for estimating the level of funding required for the CURB Implementation Program and may be compared to the actual costs in table 7.3.

Accommodation is also made within the spreadsheet to input actual remedial costs incurred for a particular watershed.

Table 7.2: Costs Associated with Remediation

Rural Contaminant Sources	Maximum Costs	Remedial Facility	Minimum Cost	Remedial Facility
Milkhouse Wastes	$ 6000.	Storage Tank and spreading	$ 3000.	Treatment Trench
Livestock Access	$16000.	Fence 2 sides and alternative water	$ 6000.	Fence 1 side and alternative water
Feedlot, barnyard runoff	$ 4992.	Covered Concrete Tank	$ 1829.	Earthen Lagoon
Manure stack runoff	$32750.	Covered solid storage	N/A	N/A
"	$17210.	Covered concrete tank	$13641.	Earthen Lagoon
Household septic wastes	$ 3000.	Septic tank and weeping bed	$ 3000.	Septic tank and weeping bed

N/A - not available
Reference - Ausable Bayfield Conservation Authority CURB Plan

Table 7.3: Average Costs of Remediation

Rural Contaminant Source	Average Costs - based on June 1992 CURB Implementation data	Average Cost - based on 1988 estimates
Milkhouse Waste	$ 8,000	$ 4500.
Livestock Access	$ 6,300	$11000.
Feedlot, barnyard runoff	(included with manure storage)	$ 3410.
Manure Stack runoff	$23,200	$24087.
Household septic wastes	$ 4,700	$ 3000.

Note: The first column of data was used to represent the average values used in the spreadsheet.

8.0 A SPREADSHEET FOR ENVIRONMENTAL ACCOUNTING

The source-reduction algorithms were incorporated into a LOTUS 1-23 spreadsheet format to facilitate use by all CURB Implementation Programs, locally and provincially. The simple data requirements consist of essentially the number of each type of project required and implemented, which can be regularly updated by program staff. The spreadsheet will then apply the functions to arrive at an anticipated amount of total phosphorus and bacteria reduction and the remaining distribution of sources in the watershed.

8.1 Development of Selected Source—Reduction Algorithms

As mentioned in section 7.1, only algorithms developed by the Beaches Program staff are used in the development of the environmental accounting approach. Despite a common conception, these algorithms were implemented in different manners by some Authorities.

In order to develop a consistent method of comparison of bacteria and phosphorus loading estimates for each type of source, algorithms are simplified to a single multiplier encompassing the amount of loading reduction resulting from the remediation of a single specific source [1]. Tables 8.1 and 8.2 show the amount of loading reduction resulting from each remediation.

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[1] In many cases, loading rates could be derived by simple multiplication of the contributing rates (eg. Septics: persons x rate x concentration). In other cases, rates depended on site specific factors such as the percent of time cattle spend on pasture, herd sizes. lot sizes, etc. For the sources having this type of algorithm, the total loading (phosphorus or bacteria) to the streams in the watershed from this type of source was determined and divided by the frequency of the source to obtain a unit loading value. This value thus incorporates an average of the relevant factors, i.e. lot size, herd size, etc. In some cases, total loading from sources such as feed lots and manure storages only applied to priority sites. However, under the CURB Guidelines, all manure storage sites are potentially eligible. It is therefore evident that if no local attempts are made to limit funding to priority farms, a correction factor must be applied to 'spread' the watershed load over all ELIGIBLE farms. PLUARG statistics showed that priority farms represent about 60% of all farms, and therefore 0.6 may be multiplied to correct for this bias.

Table 8.1: Bacteria Loading Functions

Source	Reference	Loading (No. Bact./Year)	Comments
Milkhouse Wastes	ABCA*	3.90 E+10/discharge*	delivered to beach
	GSCA	8.60 E+11/discharge	based on 1000 bacteria/L but using MVCA volume/farm
	MVCA	1.60 E+11/discharge	
	MVCA*	1.10 E+10/discharge	delivered to beach
	UTRCA	1.66 E+11/discharge	
Livestock Access	ABCA*	3.70 E+11/site*	delivered to beach
	GSCA	2.24 E+12/site	shorter pasture season (157 vs.180 days)
	MVCA	3.70 E+12/site	greater delivery to channel
	MVCA*	1.50 E+11/site*	delivered to beach
	UTRCA	2.60 E+12/site	based on weighted means of# animals,% time of 3 subwatersheds
Septic Systems	ABCA	4.40 E+12/failed unit	
	GSCA	2.02 E+12/failed unit	
	MVCA	1.30 E+12/failed unit	
	MVCA*	1.40 E+1/failed unit*	delivered to beach
	UTRCA	1.60 E+12/failed unit	
Barnyard/feedlot Runoff	ABCA*	9.00E+10/site*	delivered to beach
	MVCA	1.00 E+11/problem site	
	UTRCA	8.40 E+10/problem site	includes stack runoff
Manure Stack Runoff	ABCA*	1.60 E+09/farm*	delivered to beach
	MVCA	2.50 E+10/problem site	
	MVCA*	5.00 E+09/farm*	delivered to beach
	UTRCA	---	included in Lot runoff

* Rates are shown for interest only. Generally, the reductions of bacteria as a result of decay were between 75% and 90% on an Aggregate watershed basis.

Table 8.2: Phosphorus Loading Functions

Source	Reference	Loading (Phos./Year)	Comments
Milkhouse Wastes	ABCA	37 kg/dairy farm	from P.L.O.P. (Ecologistics)
	ABCA	55 kg/discharge	
	UTRCA	35 kg/discharge farm	
Livestock Access	ABCA	5.16 kg/site	@ 0.155kg/a.u.yr. (close to PLUARG)
	UTRCA	3.58 kg/site	@ 0.0324kg/a.u.yr.
Septic Systems	ABCA	13.1 kg/failed unit	(all seasons only)
	ABCA	7.87 kg/unit	(all seasons only)
	UTRCA	4.65 kg/failed unit	
	UTRCA	1.40 kg/unit	
	DILLON	2.40 kg/unit	@ 3.0persons/unit(seasonal)
Barnyard/feedlot Runoff	ABCA	0.041 kg/site	over ALL types
	UTRCA	4.20 kg/problem site	seems better, but a shade higher than PLUARG assuming 0.7 delivery
Manure Stack Runoff	ABCA	0 . 24kg /site	over ALL types
	UTRCA	---	included in Lot runoff

Based on this comparison of the loading estimates for each type of source, algorithms for the environmental accounting method are developed. These algorithms are developed differently, depending on varying rationales. In some cases, the numbers are selected because they agree with the PLUARG model. In other cases, they were measured in the field or comprise a mean of numbers used by various Authorities. Tables 8.3 and 8.4 give the various multipliers associated with the specific source types and the supporting rationale for the selected numbers.

8.1.1 evaluation of Implementation Program

Use of the spreadsheet to evaluate the Implementation Program is simple and requires only three basic inputs: the number of sources which require remediation at the Program's start [1], the number of remediated sources and the total cost of each project type to date. As a result of these inputs, the spreadsheet estimates the reduction of phosphorus and bacteria for each type of project, the total reduction, the amount of money spent on remediation as well as the reduction in phosphorus and bacteria loading per dollar spent. Figure 8.1 shows the spreadsheet setup.

8.1.2 prediction

Use of the spreadsheet to roughly predict phosphorus and bacteria reductions is also simple, requiring just two basic inputs: the number of sources which require remediation at the Program's start and the predicted number of projects of each type. As a result of these inputs and an assumed average cost of remediation, the spreadsheet provides estimates of anticipated reductions in phosphorus and bacteria loadings as well as the reduction per dollar spent.

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[1] In the case of livestock access, a factor to account for larger or smaller than average herd sizes can also be incorporated to represent site specific conditions however such a factor was not incorporated into the current environmental accounting spreadsheet in favour of average values.

Table 8.3: Selected Annual Bacteria Loading Function

Type	Source Rate (No. Bact./Year)	Source	Rationale
Milkhouse Wastes	1.60 E+11/discharge	--	Basic CURB Algorithm
Livestock Access	2.83 E+12/access	--	Mean of 3 Cons. Authorities
Septic Systems	2.30 E+12/failed unit	--	Mean of 3 Cons. Authorities
Barnyard/feedlot Runoff	5.00 E+10/site (all applicants)	MVCA & UTRCA	Mean * Separation Distance Factor (0. 6)
Manure Stack Runoff	1.2 E+10/site(all applicants)	MVCA & UTRCA	Mean * Separation Distance Factor (0 . 6)

Note: The source rate was reduced by one order of magnitude to arrive at an estimate of the contribution to the beach. This is incorporated into the spreadsheet.

Table 8.4: Selected Annual Phosphorus Loading Function

Type	Rate (Phos./Year)	Source	Rationale
Milkhouse Wastes	35.0 kg/discharge	UTRCA	UTRCA used direct concentration measurement
Livestock Access	5.20 kg/access	ABCA	Agrees with PLUARG model rate
Septic Systems	4.65 kg/failed unit	UTRCA	Closer to DILLON; still very high
Barnyard/feedlot Runoff	0.20 kg/site(all applicants)	ABCA & UTRCA	Approx. mean corrected to cover all sites
Manure Stack Runoff	1.20kg/site(all applicants)	ABCA & UTRCA	Approx. mean corrected to cover all sites

Conservation Authority: Upper Thames River

	*** PROBLEMS ***			*** COST ****		****** BACTERIA ******					****** PHOSPHORUS *****				
	Prob. # Before	Prob. # After	Project Type	Est. Cost	Actual Cost	Bact. Before	Bact. After	Bact. Reduct.	Est. BR/C	Actual B.R./C	Phos. Before	Phos. After	Phos. Reduct.	Est. P.R./C	Actual P.R./C
	No.	No.		Dol.	Dol.	1.0E+09	1.0E+09	1.0E+09	Unit/$	Unit/$	kg	kg	kg	kg/$	kg/$
	10	4	L.S. Access	37800	32005	2830	1132	1498	0.0449	0.0530	52	21	31	0.0008	0.0010
	23	8	Manure Storage	348000	404714	143	50	93	0.0003	0.0002	14	11	3	0.00001	0.00001
	13	5	M. H. Wastes	64000	56098	208	80	128	0.0020	0.0022	455	175	280	0.0044	0.0002
	20	10	Septic Systems	47000	39807	4600	2300	2300	0.0489	0.0577	93	47	46	0.0009	0.0012
Totals:	66	27		496800	532624	7781	3562	4219			614	254	360		

Figure 8.1: Environmental Accounting Spreadsheet

9.0 REFERENCES

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