UPPER THAMES RIVER LIVESTOCK
MANURE AND WASTE MANAGEMENT PROGRAM
1985 - 1986

Prepared by: D. Hayman
C. Merkley

For: Ministry of the Environment
Southwest Region

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PREFACE

Through the cooperative program between the Upper Thames River Conservation Authority and the Ministry of the Environment, Southwest Region, various tasks were completed in 1985 and 1986. This report supplies an overview of the findings. Certain projects merited full separate technical reports which have been attached to the summary in Appendices.

Actual field data has not been included to minimize the bulk of the summary report. Enquiries with respect to this report should be directed to the authors or to:

Upper Thames River Conservation Authority
P.O. Box 6278, Station "D"
London, Ontario
N5W 5S1

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1.0 SUMMARY AND RECOMMENDATIONS

1.1 Summary

In the late seventies, Pittock Reservoir began to experience annual beach closures for variable lengths of time each summer, either due to fecal contamination or blue green algae blooms in the nearshore waters. Studies of the Pittock Reservoir watershed found that many factors affect the reservoir water quality.

Agriculture is one of the significant contributing sources of downstream water quality problems and has received little attention in the past. Hence the U.T.R.C.A. and M.O.E. initiated studies to assess the potential impacts of agriculture. Over 25% of the identified livestock operations in the reservoir watershed exhibited a potential to pollute nearby watercourses as a result of existing manure and waste management practices (U.T.R.C.A. and M.O.E. 1984).

Further follow-up investigations in a smaller sub-basin of the Pittock watershed (Glasman and Hawkins 1985) and the Avon River upper basin (Hayman 1985) identifies livestock access, milkhouse wash water discharges and overland runoff to be the other factors attributing to poor rural water quality.

These findings prompted the U.T.R.C.A., in cooperation with M.O.E., Southwestern Region, to document the pollution potential of all livestock operations upstream of Fanshawe and Wildwood Reservoirs which also began to experience beach postings due to public health concerns. Of the more than 2080 livestock operations identified, 324 were considered to have a potential to pollute from manure storage runoff, feedlot runoff and/or livestock access. An additional 523 dairy operations were located which have a potential to pollute via milkhouse wash water discharge to the open water (Appendix A).

1.2 Recommendations

OSCEPAP II and MOE Enhancement Promotion

1) mail OSCEPAP II and MOE Enhancement Brochures to livestock operators previously identified as potential sources of pollution,

2) visit each identified livestock operation to further promote the use of available grants and technical information,

3) evaluate pollution potential of each operation in more detail in order to estimate potential impact on water quality after remediation,

4) estimate cost benefit of remedial efforts for each of the three reservoir watersheds.

5) increase information and education program.

Preliminary Milkhouse Wash Water Investigations

1) study the effect of milkhouse wash water discharges on tile outlet and sub-basin water quality,

2) sub-basin #2 would be a suitable site for the demonstration work.

Assessment of Milkhouse Wash Water Discharges

1) continue to monitor tile outlet, demonstration and control sub-basin water quality,

2) implement milkhouse wash water treatment on all dairy operations in study area,

3) monitor changes in water quality,

4) develop cost benefit analysis of proper wash water treatment on rural water quality,

Private Domestic Waste Treatment

1) further investigate condition of rural private septic systems,

2) characterize water quality impact of inadequately treated domestic wastes,

3) determine cost/benefit of updated systems on receiving water quality.

Integration of MOE Abatement and U.T.R.C.A. Extension

1) assist MOE Abatement staff in investigation when needed,

2) follow-up all reported spills with farm calls to promote use of available grants and technical assistance. In the event the source of the spill is not pin-pointed, approach all neighbouring operations,

3) assess relative impact of spills on reservoir water quality.

Kintore Creek Target Watershed Study

1) promote wide spread adoption of conservation tillage and cropping in the demonstration subwatershed,

2) continue monitoring of water quality and quantity in the seven sub-basins of the Kintore Creek Target Study through weekly background and event samples,

3) compare changes in sediment and phosphorus loading as a result of remedial measures.

2.0 BACKGROUND

By 1982, the Upper Thames River Conservation Authority and the Ministry of Environment, Southwest Region had launched a combined effort to determine the sources of water quality impairment. Findings from the study suggested agricultural activities were significant contributors to the beach closing problem (UTRCA and MOE 1984). As also outlined in a previous Thames River Basin Study (1975), the agricultural sources were considered to be:

1) overland runoff of sediment and associated nutrients and chemicals,

2) contaminated sub-surface drainage

3) uncontained manure and feedlot runoff, and

4) livestock access to open water.

Other potential sources of impact on reservoir quality are being addressed through other programs not related to the direction of the rural water quality program.

To better identify specific agricultural sources of pollution, a smaller completely rural sub-basin was selected for more intensive study (Glasman and Hawkins 1985).

Past field investigations, inventories, water sampling, ranking of pollution potential and landowner contact has provided insight into the specific impacts of landuse and management practices on water quality. Emphasis was placed on livestock operations.

2.1 Study Area

The Upper Thames River Conservation Authority (UTRCA) watershed is situated in Southwestern Ontario (Figure 1). Approximately 90% of the 3432 km^2 area is utilized for agricultural production. In the remaining 10%, over 80% of the 390,000 watershed residents are concentrated into urban centres: London, Woodstock, Ingersoll, Stratford, Mitchell and St. Marys (Municipal Directory, 1985).

In 1952, Fanshawe Reservoir was constructed by the U.T.R.C.A. for flood control for the City of London. By 1967, Wildwood and Pittock Reservoirs had been built for low flow augmentation and flood control in their respective areas. Keeping in mind the primary function of the reservoirs, the surrounding parkland has been developed to maximize the potential use and benefit of these man-made lakes.

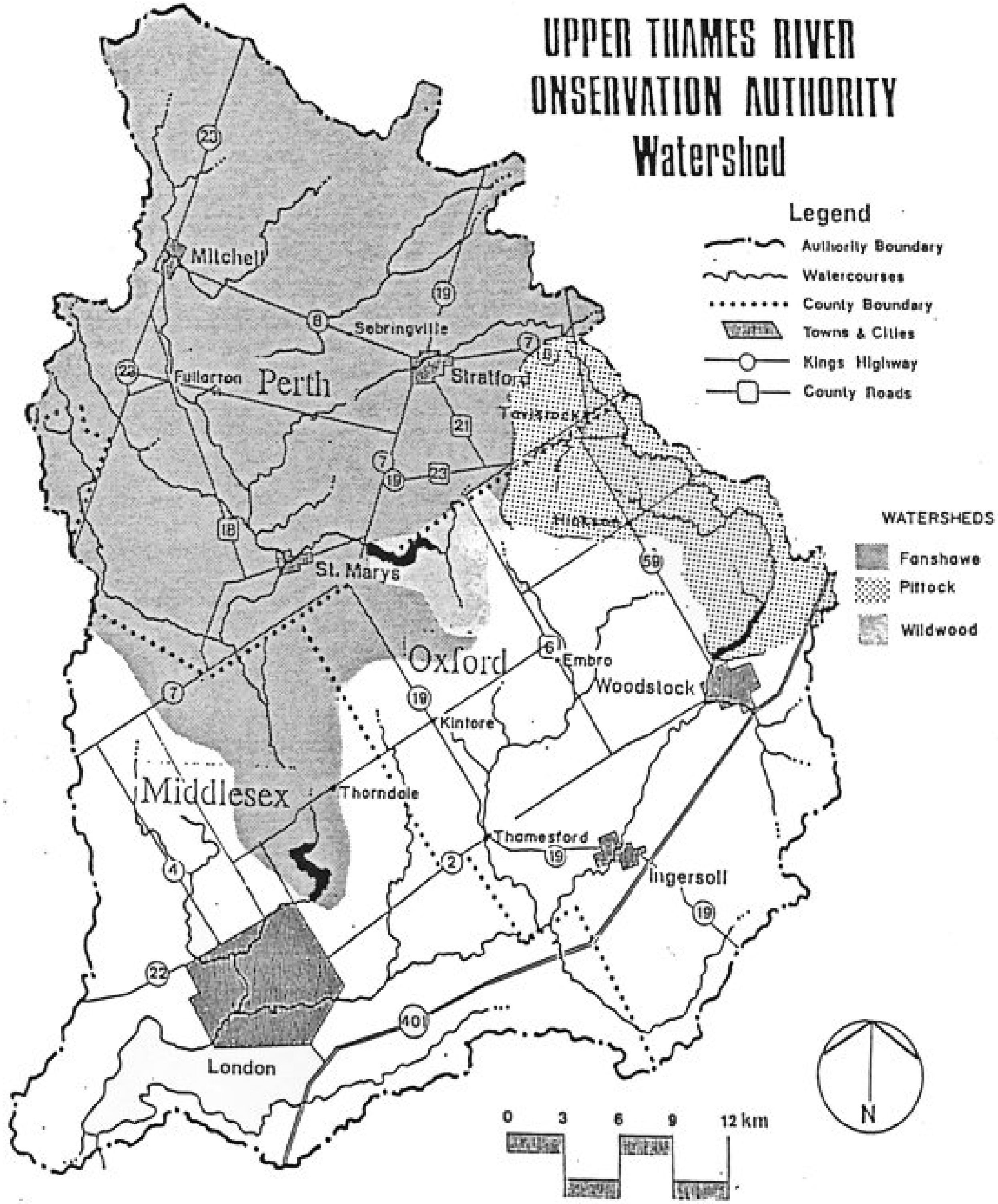

Figure 1: Upper Thames River Watershed

Recently, each reservoir has begun to show signs of water quality impairment. Upstream landuse management has resulted in various short term restrictions on the recreational use of the water due to public health concerns.

Fanshawe Reservoir has, by far, the largest contributing watershed (1450 km^2). Although predominantly agricultural, the watershed also receives drainage and treated sewage effluents from the City of Stratford and Towns of St. Marys and Mitchell (Figure 1). There are approximately 1600 livestock farms within the Fanshawe Reservoir watershed. Two hundred and twenty are estimated to have a high potential to contribute to downstream bacterial pollution by overland runoff or livestock access (Appendix A).

Wildwood Reservoir and its 141 km^2 watershed are contained within the Fanshawe Reservoir watershed. The basin is entirely agricultural with no serviced population centres. One hundred and seventy livestock operations are within the watershed boundaries with 30 potential pollution sources of manure runoff, feedlot runoff or livestock access (Appendix A).

The Pittock Reservoir watershed contains over 300 livestock operations within its 240 km^2 boundary. Twenty-five percent of these were considered to have a potential to impact on receiving water quality from manure runoff, feedlot runoff and livestock access (Appendix A). Tavistock is the main population centre within the watershed. The sewage treatment lagoons for Tavistock are presently undergoing a $2 Million dollar improvement. Treated effluent is discharged according to flow in early spring and late fall.

Figure 2 outlines the beach closing history of Fanshawe, Wildwood and Pittock Reservoirs between 1982 and 1986.

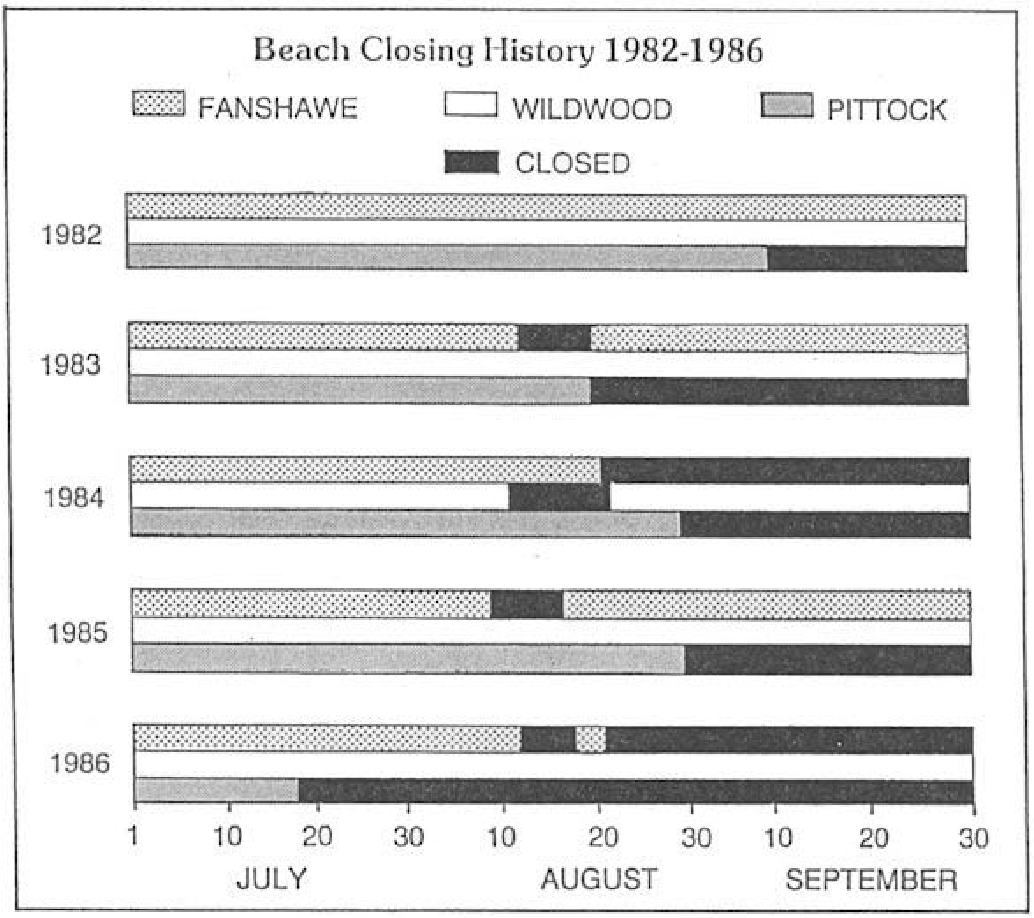

Figure 2: Beach Closing Summary From 1982 - 1986
For Fanshawe, Wildwood and Pittock Reservoirs

3.0 TERMS OF REFERENCE

Under contract to the Southwest Region, UTRCA agreed to provide assistance to the Ministry of Environment in:

a) promotion of corrective livestock manure management measures for farms previously identified as causing water quality impairment,

b) recording and monitoring water quality in rural watersheds,

c) recording and monitoring upstream and downstream conditions of receiving waters as a result of rural sources. Documentation of results.

d) monitoring of background and runoff event conditions of the Kintore Creek east and west sub-basins, The Program included provision of the following services:

a) liaison with the local Beaches Steering Committee and the Joint Agricultural Soil and Water Conservation Program to bring about solutions,

b) improvement of farmer awareness of OSCEPAP program of OMAF and, if applicable, the MOE-enhanced OSCEPAP,

c) definition and measurement of the water quality impact of selected problem farms including sample collection for MOE analysis,

d) recording of implementation of corrective measures and measurement of resultant improvements,

e) contacting dairy operators in the study area to promote installation of milkhouse waste handling systems,

f) reporting to MOE problem situations which present difficulty or involve gross negligence in causing pollution,

g) participation in local meetings and discussions on farm pollution to promote corrective measures,

h) production of press releases for local distribution and provision of livestock manure management display at relevant events,

i) other duties as identified by the local Beaches Strategy Steering Committee.

4.0 WORK PROGRAM SUMMARY

4.1 OSCEPAP II and MOE Enhancement Promotion

Government grants have been made available to livestock producers to financially assist the implementation of improved livestock manure and waste management practices. Since the objective of the grant program is to improve receiving water quality for downstream uses, promotion of the grant should be directed towards areas with a high potential to pollute.

Through 1985, under MOE Southwest Region funding, livestock operations with a high potential to pollute were located in the watersheds upstream of Fanshawe, Wildwood and Pittock Reservoirs. Of the over 2080 total livestock operations 324 showed visible evidence of potential pollution sources. Considering proper milkhouse wash water treatment should be promoted on all dairy operations a further 523 were also identified (Appendix A).

The nearly 850 livestock operations found to have a potential to pollute will be approached to promote remedial action and the financial incentive available. At the same time some information will be collected to provide an indication of the benefit improved management practices will have on receiving water quality. Over the years, as remedial work is implemented, there will be estimates of the potential water quality improvements. The data will also help to determine which agricultural sources of bacteria and nutrients are the most significant relative to each other.

4.2 Milkhouse Wash Water Evaluation

Studies in the sub basin #2 of the Pittock Reservoir watershed found most dairy operations directly discharged the milkhouse wash water to open water through sub-surface drains. A grab sample of each cycle of one milkline washing process suggested milkhouse wash water discharges could affect receiving water when all sources are collectively considered.

A second study was conducted with a more rigorous sampling program to better assess the bacterial and nutrient content in milkhouse wash water. The results found these discharges to potentially have an even greater impact than originally expected (Appendix B).

More information is necessary to determine the processes of effluent transport through the tile and the impact of these effluents on receiving water quality. It was recommended the best procedure would be to intensively study a small subwatershed to assess the overall impact of wash water discharges to open water.

4.3 Milkhouse Wash Water Subwatershed Study

Based on the preliminary water sampling of milkhouse wash water discharges, the potential impact of these collective wastes could be quite significant. This study was conducted in sub-basin #2 of the Pittock Reservoir watershed to determine the quality of milkhouse wash water as it reaches the open watercourse.

Eight dairy operators are within the sub-basin #2 watershed. One is a cream producer and the wash water is fed to the livestock. Of the seven remaining, one has attempted to treat the water while the others directly discharge to the nearby drains.

Over the summer of 1987, outlet quality of the tiles which transport milkhouse wash water will be monitored intensively. Treatment of the discharges will be implemented on a sub-basin wide basin and changes in downstream water quality recorded.

4.4 Domestic Waste Treatment System Evaluation

Through a number of rural beaches strategy programs within Ontario, it became evident that many private and community domestic waste treatment systems were non-existent or not up to 1986 design standards.

Little information was available on the extent of the problem or its impact on the bacteriology downstream.

Twenty rural residences were interviewed to determine the general location, condition and maintenance program of their septic systems. Most were deemed to be in reasonable working order, however, two systems were in definite need of repair (Appendix C).

Over the next year, more information will be collected to obtain a broader perspective on the condition of rural septic systems. Efforts will be made to assess the actual bacteriological inputs to open water from antiquated or non-functioning systems.

4.5 Integration of Abatement and Extension

Over the years, numerous manure spills have occurred throughout the Upper Thames River watershed. Unfortunately, many of these spills could not be properly investigated since the MOE Abatement staff were not notified in time to be at the scene while manure discharge was still in progress. At that point it is difficult to obtain sufficient evidence to legitimately pin-point the actual source of the spill. In these cases, there is no process to follow-up with any remedial efforts.

MOE abatement and U.T.R.C.A. extension staff met to develop a better integrated approach. U.T.R.C.A. Rural Beaches Strategy staff will assist in investigations when needed. When spill sources are pin-pointed, U.T.R.C.A. staff will approach the landowner to promote the use of the available grants and technical assistance in order to prevent a similar occurrence. In the event the source is not pin-pointed, all landowners in the vicinity of the spills will be approached.

4.6 Kintore Creek Target Watershed Study

The Kintore Creek Target Watershed Study was initiated in January of 1984. The Project was originally funded by Environment Canada Lands Directorate to help calibrate and evaluate their sediment/delivery mapping methodology (Snell 1984). Seven water sampling stations were established in the two sub-basins of the watershed. Water quality data was collected to establish the existing levels of phosphorus and suspended solids in the watercourse of each sub-basin prior to any remedial measures carried out in the "demonstration" basin (Glasman and Merkley, 1984).

Subsequent funding from the Ontario Ministry of the Environment enabled weekly and event sampling to continue at the seven stations for two additional years (Appendix D). During the past field season, a total of 242 samples were collected at the 7 stations. An additional 7 runoff events were sampled at the outlets of each sub-basin with automatic ISCO samplers.

To date, most gully erosion problems in the demonstration basin have been eliminated by the installation of structural erosion control measures. The larger sheet erosion problem has remained unchanged. A number of small conservation tillage plots were established in the basin, however, only the wide spread adoption of such practices would significantly reduce the rate of sediment and phosphorus loads which reach the subwatershed outlet.

If landowners in the demonstration basin changed their tillage methods, the effect these changes have on water quality could be compared to three years of existing background water quality data. To accomplish such a task, an incentive program would have to be offered to the affected landowners to ensure a long term commitment to the project. Funds must also be in place to ensure the continuous collection of water samples and data analysis.

During the past three years the landuse in the control basin has remained unchanged. However, as time goes on, there is an increased risk of landowners adopting the same practices proposed for the demonstration basin. Therefore, to ensure successful results, the project must be initiated in the near future.

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APPENDIX A

INVENTORY OF LIVESTOCK OPERATIONS WITH A POTENTIAL TO IMPACT ON THREE U.T.R.C.A. RESERVOIRS

By: D. Hayman
C. Merkley

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1.0 SUMMARY AND RECOMMENDATIONS

1.1 Summary

Through 1985, livestock operations with a high potential to pollute were located in the watersheds of Fanshawe, Wildwood, and Pittock Reservoirs. Of the 2081 livestock operations, 324 showed visible evidence of a potential impact on the receiving waters.

Considering proper milkhouse wash water treatment should also be promoted to all dairy operations, a further 523 operations can be added to high priority list.

1.2 Recommendations

1) mail OSCEPAP II and Enhanced OSCEPAP II brochure to identified high priority farms,

2) visit each identified high priority livestock operation to further promote the use of available grants and technical assistance,

3) evaluate pollution potential of each visited operation to estimate impact on water quality,

4) increase information and education program,

5) future roadside surveys should emphasize surveyor training to reduce discrepancies and bias in source identification,

6) visual identification of high priority farms could include a breakdown into several categories to reflect the varying degrees of impact on downstream uses,

7) develop a standardized analytical technique to indicate when algae blooms are a risk to public health,

8) determine whether or not water quality problems which close beaches are site specific or reservoir wide.

2.0 INTRODUCTION

Due to algae blooms and elevated bacteria levels, beach closures in Pittock Reservoir have become an annual problem for the Upper Thames River Conservation Authority (U.T.R.C.A.). In an effort to identify the potential pollution sources, the U.T.R.C.A. and Ministry of the Environment (M.O.E.) Southwest Region, began a joint study in 1983. These water quality investigations pin-pointed agriculture as a significant contributor of nutrient and bacterial contamination (UTRCA and MOE, 1984).

In its second year of the joint study, a smaller sub-basin of the Pittock Reservoir watershed was selected for a more intensive analysis of specific agricultural diffuse source inputs. Emphasis was placed on bacterial contamination. Throughout this rural sub-basin, MOE water quality guidelines (MOE, 1984) were regularly exceeded. Primary sources were found to be, in no particular order, manure and feedlot runoff, livestock access, milkhouse wash water effluents and contaminated sub-surface tile drainage systems (Glasman and Hawkins 1985).

In the same year, a second study was conducted in the upper basin of the Avon River which has shown a history of poor water quality before it flows through the City of Stratford (SAREMP - Final Report, 1983). This rural watershed was surveyed by walking all the open watercourses to visually determine potential impacts from livestock operations. Densities of potential diffuse sources in the upper Avon River basin were found to be similar to Pittock Reservoir (Hayman, 1984).

In the meantime, Fanshawe Reservoir began to experience beach closures on an annual basis. Wildwood Reservoir has also been posted. Therefore, the U.T.R.C.A. and M.O.E., Southwest Region began a program to inventory pollution sources upstream of these reservoirs as well (Figure A.1).

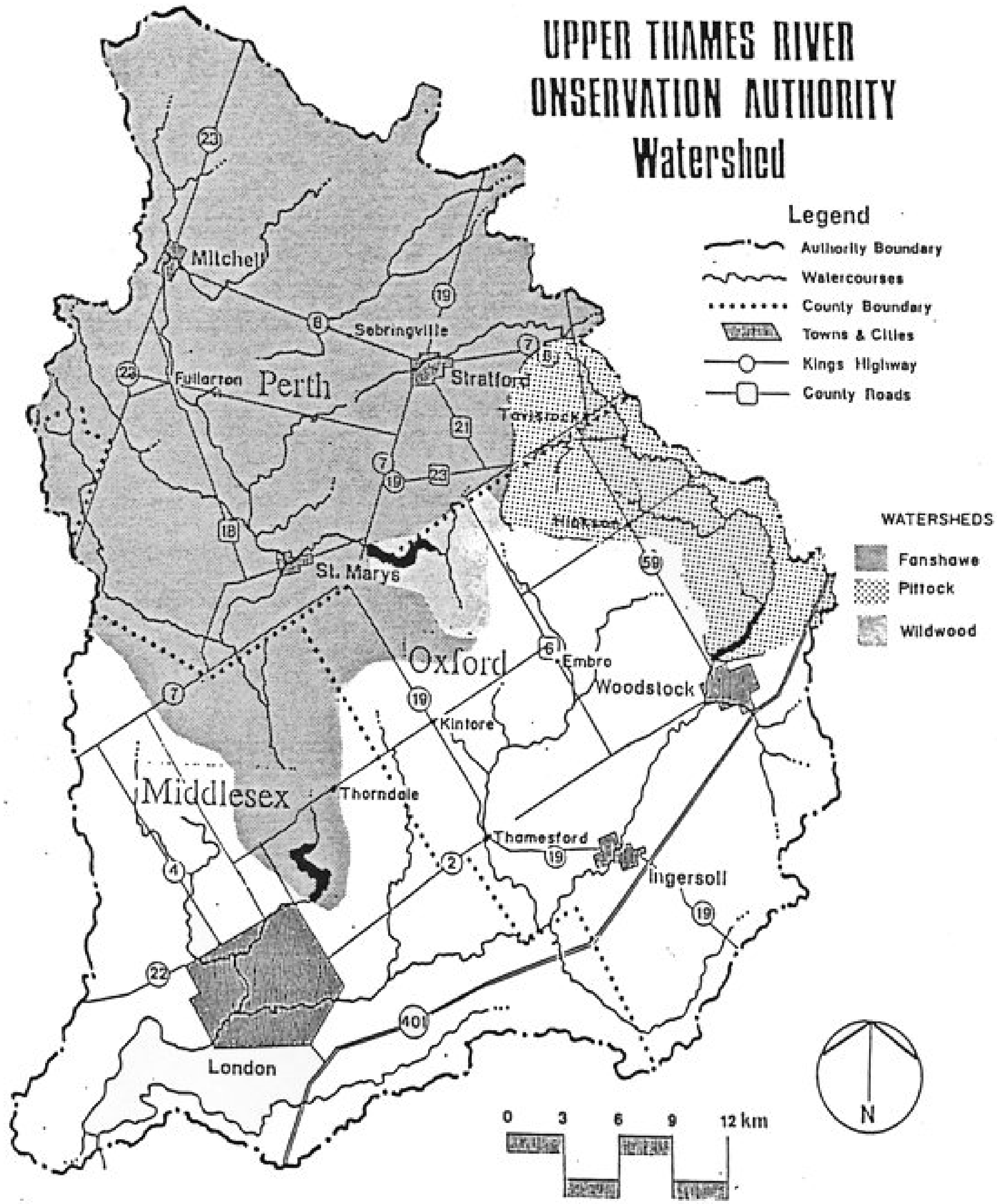

Figure A.1: Upper Thames River Watershed

2.1 Background

Previous attempts to determine the pollution potential of a livestock operation involved aerial photograph interpretation to initially identify the livestock enterprises (Ryan 1982; Bolient 1984; SAREMP R-15 1983; U.T.R.C.A. and M.O.E., 1983). In each instance, the information on an identified livestock farm was verified by a visual roadside survey. Accuracy of aerial photograph interpretation was highly dependent on staff training and age of the photographs.

A pollution potential ranking was attached to each identified operation by one of the two following methods.

1) distance to an open watercourse or drainage ditch (SAREMP R-15 1983; Balint, 1984)

2) location of operation overlayed on Soil Erosion Sediment Delivery Targeting Maps developed by Snell (1984) (UTRCA and MOE, 1984).

Both systems assisted only in targeting potential manure and feedlot runoff. Other sources, namely livestock access, contaminated tile effluent and milkhouse washwater effluents were not considered.

The distance approach uses only an arbitrary distance to open waster which does not consider slope, type of storage and possible runoff buffers, and does not necessarily represent degree of runoff. All these aspects must be field inspected.

The sediment delivery map does account for the potential of materials to be delivered to open water. However, the methodology was designed for regional targeting (Snell 1984) and was never intended for such site specific use.

At the beginning of the Fanshawe and Wildwood Reservoir Watershed inventory, the aerial photographs were seven years old and likely not completely representative of current land uses. With the inherent drawbacks of the aforementioned identification techniques and since ground truthing was a necessary stage anyway, the map interpretation step was eliminated. This avoided some redundancy, saved time and provided for the opportunity to account for other potential pollution sources.

This above method was also used in a study to assess the effect of livestock operations on fishing recreational uses (Huzevka *et al* 1985).

3.0 METHODS

Initially, Fanshawe and Wildwood Reservoir watersheds were sub-divided into basins which represent the major tributaries to the North Branch of the Thames River. 1:50,000 topographic maps were photocopied to obtain field maps of each township with the major tributaries boundaries marked on. All the roads in a township within the study area were driven to visually identify livestock operations and determine their pollution potential. Binoculars and van were useful tools which enabled surveyors to gain a better view, especially as crops began to block vision near the end of the summer.

Building configuration, surrounding crops, signs at the road or on the barn, visible livestock and smell were used to determine type of livestock operation. The location was circled and numbered on the field topographic map. Information pertaining to the type of operation, manure storage facilities, other livestock management practices and additional comments were recorded on a field sheet beside the corresponding map number. Each livestock operation was also ranked according to its pollution potential based on the following objective and subjective visual observations;

High Potential:
- livestock access
- burnt vegetation and/or eroded area between manure storage or feedlot and an open watercourse
- inadequate manure storage and/or feedlot in close proximity to open watercourse
- dairy operations - potential milkhouse wash water effluent (Hayman and Merkley 1986)

Medium Potential:
- inadequate storage or feedlot which may runoff to open water under extreme conditions however no visible evidence, gentle long slope to open watercourse with a good buffer,
- contained storage which may cause problems in an overflow situation.

Low Potential:
- not near watercourse and negligible slope
- contained storage and no indication of overflow.

These are best observed in the summer and fall.

In the office, lot and concession numbers and tributary basin were added to the field sheets to locate each identified operation. Names and mailing addresses were obtained from the township records office.

All the field information was transferred to a computer file on a township basis. High priority ranked livestock operations and all other dairy operations were sorted into a mailing list.

Table A.1: Identified Livestock Operations and Targeted High Priority Sources

	Livestock Operations	Area (km^2)	Livestock Operation Density (#/km^2)	High Priority (Runoff & Access)	Additional Dairy	Total High Priority	% of Total Livestock	
							High Priority Runoff/Access	High Priority Total
Fanshawe	1603	1450	1.1	220	393	613	14	38
Pittock	308	242	1.3	75*	65	140	24	45
Wildwood	170	141	1.2	29	64	93	17	55
TOTAL	2081	1833	1.1	324	522	846	16	41

* Does Not include livestock access

4.0 RESULTS

Upstream of Fanshawe, Wildwood and Pittock Reservoirs, 2,081 livestock operations were identified. Three hundred and twenty four (324) were visually identified as having a high potential to pollute open water from manure or feedlot runoff and/or livestock access. An additional 523 dairy operations not otherwise considered potential sources were added to the high priority list to identify potential problems from milkhouse wash water effluent (Table A.1).

In a comparison of the three reservoir watersheds, livestock farm densities were similar (Table A.1). Pittock Reservoir had the greatest density of high priority rankings (24% of total livestock operations) even without consideration of livestock access impacts. With the addition of dairy operations for milkhouse wash water effluents, Wildwood Reservoir had the highest percentage (66%) of total livestock operations.

5.0 DISCUSSION

A total of 846 livestock operations were considered to have a potential to affect receiving water quality. With such a large number of potential inputs, an extensive information and education program is essential to promote remedial measures.

The OSCEPAP (Ontario Soil Conservation and Environmental Protection Assistance Program) II brochure and an Enhanced OSCEPAP II brochure should be mailed to all targeted livestock operators in order to quickly notify them of the improved funding.

Over the next few years, all target livestock operators should be approached to discuss the grants in more detail.

The Pittock Reservoir watershed, which has had the longest history of beach closures of the three U.T.R.C.A. reservoirs, also has the greatest abundance of high priority livestock operations. However, the method of targeting was different from Fanshawe and Wildwood, the Pittock Survey did not include livestock access or consider the manure handling facilities.

Pittock Reservoir should be surveyed again using the visual assessment method in order to obtain information which could be more easily compared with the other two reservoir watersheds.

Fanshawe and Wildwood had a similar density of runoff and access locations. With the addition of potential milkhouse discharges, Wildwood exceeds Fanshawe in high priority livestock farm density. This is not reflected in the predominance of beach closures since Wildwood has only been posted once. Five factors could account for this apparent discrepancy;

1) degree of potential impact from each source was not considered,

2) milkhouse wash water discharges may not be as predominant in Wildwood as in Fanshawe,

3) subjective decisions on ranking may vary between surveyors,

4) closure of a beach to blue green algae blooms is also subjective and may differ between counties.

5) location of the beach within the reservoir relative to inputs as it pertains to bacteria die-off rates.

6) reservoir flushing characteristics.

In the follow-up farm calls, attempts will be made to further define the degree of potential impact from each source with the use of specific guidelines. This procedure should provide a reasonable indication of the overall impact on rural water quality. Future roadside surveys should place an emphasis on surveyor training to reduce inconsistencies and bias in source identification. It is interesting to note, surveyors with an agricultural background tended to miss potential sources due to a familiarity with current livestock management practices. A breakdown of the high priority rank into several categories would also have helped determine the degree of input on the downstream reservoirs.

Investigations should be underway to develop a standardized approach to the assessment of blue green algae blooms and when it is extensive enough to pose a health risk to swimmers. A consistent scientific measure would help establish a relative comparison of beach quality throughout Ontario.

In the event of a beach closure, additional samples should be collected in near shore areas throughout the reservoir to determine if the closing is site specific or reservoir wide. Information collected from such a study may help future developments determine the most ideal beach location.

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APPENDIX B

EVALUATION OF MILKHOUSE WASH WATER DISCHARGED FROM THE MILKHOUSE WASH CYCLES

D. G. Hayman
January 1987

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1.0 SUMMARY AND RECOMMENDATIONS

1.1 Summary

Detailed sampling of two different milkhouse systems suggest a significant phosphorus loading is being discharged to nearby watercourses. In the Pittock Reservoir watershed subbasin study, 80% of the dairy operations had direct discharges for their milkhouse wash water. If this situation reflects Southwestern Ontario diary operations then proper treatment of milkhouse wastes could potentially reduce phosphorus loadings by 205 tonnes. With 70% of the phosphorus in the soluble reactive form, algae biomass reduction may be even more significant than expected through soil conservation promotion.

Suspended solids and BOD loadings, as well as pH stress, would also improve, particularly at the effluent outlet.

Reductions in bacterial inputs could also be expected. In fact an even greater reduction may be realized since the milk solids associated with the wastes may promote bacterial growth as the effluent migrates through the tile. Although, disinfectants also associated with the wastes may retain their effectiveness to keep bacterial contamination to a minimum. Further study is recommended.

1.2 Recommendations

In order to best determine the pollution potential of direct discharges of milkhouse wash water it is recommended that:

1) milkhouse wash water effluents be characterized at the source and the outlet to determine any changes in quality during transport through the tile,

2) a demonstration control study be conducted to field test changes in subbasin water quality as a result of proper treatment, and,

3) determine the efficiency and cost effectiveness of various methods of milkhouse waste treatment.

2.0 INTRODUCTION

In 1982, the Ministry of the Environment (M.O.E.), Southwestern Region and the Upper Thames River Conservation authority, (U.T.R.C.A.) began a joint venture to study the cause of annual beach closings in Pittock Reservoir. General investigations of the entire reservoir watershed indicated nutrient and bacterial contamination existed upstream through to the headwaters. Agriculture was considered a significant source of water degradation via manure and feedlot runoff, subsurface drainage contamination, livestock access and overland runoff of eroded soil and associated nutrients and chemicals (M.O.E. and U.T.R.C.A., 1984).

A more detailed study of a smaller subbasin of the Pittock Reservoir watershed was conducted in 1984 (Glasman & Hawkins, 1985). Field investigations and landowner liaison revealed a significant percentage of the dairy operations had direct hookups from the milkhouse to open water in order to discharge milkhouse wash water effluents.

A grab sample of each cycle of one milkhouse washing found high concentrations of phosphorus, primarily in the soluble form, and suspended solids, a significant biochemical oxygen demand and heavy bacterial contamination (Table B.1). Assuming 100% delivery of these materials to the receiving waters, and realizing the washing process is done twice daily, 365 days of the year, each dairy farm potentially contributes a measurable amount of phosphorus loading.

This study sponsored by the Ministry of Environment was undertaken to provide a more robust sampling program in order to better evaluate the potential impacts of untreated milkhouse wastes on rural water quality.

Table B.1: Sample results from various washing cycles during cleaning of milkhouse pipelines

	Bucket Wash Water	First Cycle	Second Cycle	Third Cycle
Number of Gallons	2	8	8	8
Total Coliforms (#/100 ml)	G490000	33000	L10	L100
Fecal Coliforms (#/100 ml)	G142000	G17200	L4	L10
Fecal Streptococci (#/100 ml)	6300	9200	L4	L10
Total Phosphorus (mg/L)	18	10	280	440
Soluble Phosphorus (mg/L)	2	4	136	435
Biochemical Oxygen Demand (mg/L)	441	2790	--	--
Suspended Solids (mg/L)	163	1096	L0.1	1.8

G - Actual Count is greater than that reported
L - Actual count is less than that reported
-- Chlorine present - no results

Table from: (Glasman and Hawkins 1985)

3.0 METHODS

In selecting sites for milkhouse waste sampling, staff considered dairy operators who have shown previous interest in soil and water conservation. The first two operators approached were very cooperative and supportive of the program. Farm 1, which used the Buomatic line of milking equipment, installed a milkhouse waste treatment trench while the study was in progress, using Rural Beaches Strategy technical and financial assistance. Farm 2, milked with Surge equipment and had previously installed a treatment trench using U.T.R.C.A. technical and financial assistance.

Both milking systems used four cycles in the milk line washing procedure;

1) pre-sanitize
2) rinse
3) wash and,
4) acid wash.

To prevent cross contamination between cows, udder wash disinfectant is used to clean the teats before milking. Farm 1 uses a bucket which is dumped after milking.

At both operations, each cycle was sampled individually for four separate milkhouse washings to provide representative data for two morning and two evening milkings.

For each cycle a fresh plastic garbage bag was placed in a 75 L plastic garbage pail. Care was taken to only handle the bag on the outside to avoid contamination. Both the Surge and Buomatic systems outlet in three separate locations. The water which empties through the sink drain was collected with a 20 L autoclaved bag and transferred to the 75 L garbage pail. Due to the quantity of discharged water from the sink, all the water could not be collected. Therefore, this wastewater is represented through a composite collection.

In the Buomatic system, clearance permitted the 75 L pail to be placed under the other two outlets to collect the remaining cycle waste water. For the Surge system, the autoclave bag was also used to collect a composite sample from these two remaining outlets.

After draining of a cycle was complete, a 1 L glass chemical bottle and a sterilized bacteriological bottle were used to obtain a sample from the composited cycle wash water in the garbage pail. Disposable surgical gloves were worn on the sampling hand then discarded to prevent cross contamination between cycles.

At Farm 1, the udder wash was collected from the small pail in a similar manner.

All water was then dumped down the milkhouse drain and the autoclave and garbage bags were discarded.

The samples were placed in a cooler of ice and submitted the same day to the Ministry of the Environment, Southwest Region Lab. Analyses included the following parameters; *E. coli*, fecal coliforms, fecal streptococci, *Pseudomonas ag.*, total phosphorus, soluble reactive phosphorus, biochemical oxygen demand (BOD), suspended solids and pH.

4.0 RESULTS

Farm 1 utilized approximately 68 L of wash water for each of four cycles. Farm 2 used almost three times that amount with 205 L per cycle.

Chemicals used for washing the milk lines at Farm 1 (Table B.2) were measured by hand. Farm 2 had an automated system which dispensed the exact amount of chemical each time.

Discussions with the chemical supply companies indicated the amount of chemical used on each farm is dependent on source water quality, particularly water hardness. Therefore, other farms with similar systems will vary in volmes of water and quantities of chemicals used.

Table B.2: Active Ingredients of Chemicals Used For Milking Equipment Washing

	Farm 1	Farm 2
Pre Sanitize	Sodium Hypochlorite 6.4%	Sodium Hypochloride 2% available chlorine
Udder Wash	Chlorohexidine Acetate 1.6%	Chlorhexidine Acetate 0.5%
Rinse	Water Only	Water Only
Wash		Liquid Chlorinated 2.8% Phosphorus
Acid Rinse	Organic Acid	Organic Acid

Because of the high chlorine concentrations in both the pre-sanitize and acid rinse cycles, biochemical oxygen demand (BOD) could not be analyzed. A significant BOD of 169 to 5150 mg/L was created in the other cycles (Table 3). pH for each was relatively comparable between the two farms since they were basically in the same order of magnitude. The wash and acid rinse cycles created the greatest pH stress of 11.4 to 11.5 and 2.4 to 3.5 respectively (Table B.3).

Geometric means of *E. coli* bacteria were between 4 and 8/100 ml except in the rinse cycle when geometric means were as high as 12,034/100 ml (Table B.3). Suspended solids concentrations which ranged from 2.5 mg/L to 1835 mg/L were highest in the rinse and wash cycles. Loadings for the year averaged 205 kg (Table B.3).

Total phosphorus concentrations were high, ranging from 1.6 mg/L to 569.0 mg/L. Soluble reactive phosphorus accounts for 72% of the total phosphorus component on average. Through the year, with two washes per day 365 days a year, an average 39.9 kg of phosphorus is discharged down the drain annually (Table B.3).

Table B.3: Milkhouse Washwater Quality Results from Two Dairy Operations

		Arithmetic Mean					Geometric Mean	
		Total Phosphorus mg/L	Soluble Reactive Phosphorus mg/L	Suspended Solids mg/L	Biochemical Oxygen Demand mg/L	pH	*E. coli* #/100 ml	Volume L
Pre-sanitize	Farm 1	9.4	1.8	4.4	-	8.87	4	68
	Farm 2	1.6	1.4	2.7	-	8.32	4	205
Udder Wash	Farm 1	13.6	4.0	151.0	1438	7.73	8	4.5
Rinse	Farm 1	25.2	11.9	1795.0	3309	7.47	12,034	68
	Farm 2	33.5	15.6	1835.0	4806	6.62	263	205
Nash	Farm 1	64.3	5.6	48.0	249	11.51	8	68
	Farm 2	83.4	3.7	176.0	169	11.41	6	205
Acid Rinse	Farm 1	Acid	501.0	10.5	-	2.46	4	68
	Farm 2	192.0	192.0	2.5	-	3.52	5	205
Total Loading mg/wash	Farm 1	45,478	35,398	123,616				
	Farm 2	64,699	43,798	439,984				
Total Loading kg/yr	Farm 1	33.2	25.8	90.2				
	Farm 2	46.5	32.0	321.2				
Avg. (kg/yr)		39.9	28.9	205.7				

- Chlorine present

5.0 DISCUSSION

Of the parameters sampled in the milkhouse wastes, phosphorus, suspended solids and biochemical oxygen demand appear to be the most significant problems for receiving water quality.

Total loadings of phosphorus from Farm 1 and Farm 2 were 33.2 kg/yr and 46.5 kg/yr respectively for an average 39.9 kg/yr.

The 1984 Pittock Subbasin 2 Study (Glasman & Hawkins, 1985) found 80% of the dairy operations had direct tile connections from the milkhouse to nearby open watercourses. In Southwestern Ontario, there were 6,423 dairy operations in 1983 with sales over $2,500 (OMAF 1983). If the Pittock figures are representative of Southwestern Ontario, 5,138 dairy operations require milkhouse waste treatment.

Assuming 100% delivery of the wastes to be receiving water, 205 tonnes of phosphorus are discharged annually to the Southwestern Ontario Watershed based on two washings per day 365 days of the year. 200 tonnes of phosphorus loading reduction was the agreed upon target from agricultural sources under the International Joint Commissions, Great Lakes Water Quality Agreement. Since 70% of the total phosphorus is in the form readily available to plants, a significant reduction in algae biomass would be expected with milkhouse waste treatment; perhaps more so than expected through phosphorus reduction from soil conservation.

Suspended soils loadings were around 200 kg per year from each dairy operation. Compared to inputs from soil erosion, this source of solids is relatively minimal.

However, what should be considered is that milkhouse solids are a good growth medium for bacteria and are in fact used in the microbiology lab for such a purpose. Although, bacteria counts are not high in the effluents as they discharge from the milking equipment, it is not known what happens in the tile on the way to the outlet. Given the good milk solids culture medium and the absence of light or competition in the tile run, bacteria numbers may increase. On the other hand, chemicals used in the washing process may retain their disinfectant qualities to keep bacteria contamination to a minimum. Further sampling is needed to determine microbial dynamics in tiles which transport milkhouse wastes.

Biochemical oxygen demand is also a concern with milkhouse waste effluent, with levels as much as 150 times higher than the M.O.E. guidelines for sewage lagoon discharges (pers comm. D. Huber, M.O.E.). For BOD as with pH stress, changes in milkhouse waste chemistry within the tile may alter the quality at the effluent outlets sufficiently to cause only localized problems.

In order to determine how extensively milkhouse wastes affect receiving waters, detailed monitoring must be undertaken. Results from such a study should provide the basis for recommendations on the need for proper milkhouse waste treatment.

6.0 REFERENCES CITED

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APPENDIX C

A SEPTIC SYSTEM SURVEY OF RURAL LANDOWNERS IN THE UPPER THAMES RIVER WATERSHED

T. Briggs
January, 1987

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1.0 SUMMARY AND RECOMMENDATIONS

1.1 Summary

It was determined through this septic system survey that there are only a few problems to be found.

Most are in good working condition and are set up with the proper treatment system (settling tank and weeping bed), therefore limiting the chance of the waste water from directly reaching a nearby watercourse. There is some concern with the possibility of waste water reaching field tiles due to the location of certain weeping beds.

Another concern may be that many of these systems are quite old, some having been put in upwards of 30 years ago. Although there appears to be no problem at the present time there is a possibility that they may begin causing problems within the next few years, if not already.

1.2 Recommendations

1) Some of the problems associated with septic systems could best be rectified through improved public education. Knowing system regulations, how septic systems function and their maintenance needs, can only aid in people becoming more conscientious in this area.

2) Anyone moving into a home that was built before septic regulations came into affect in 1974 should have the system inspected to find whether it meets regulations and if it is in good working condition.

3) Additional surveys using a random sample would possibly give a more precise indication of the condition of septic systems in the U.T.R.C.A. watershed.

4) Through the surveys, a problem area could be located and a demonstration/control study set up to find the effect of private septic systems on water quality.

2.0 INTRODUCTION

Previous studies completed by several conservation authorities in Ontario, have brought to light the possibility that antiquated systems and possible illegal hookups may be a contributing factor to the poor water quality in rural areas.

Recent evidence suggests some rural residences, particularly old ones, have septic systems which may not adequately meet the needs of the household or lack proper treatment systems. As a result, waste water may be finding its way into surrounding watercourses.

This survey was designed to provide incite into the public's knowledge of the condition of their septic systems, with specific concern being placed on the following:

1) the condition of their system,

2) whether or not these septic systems are harming regional water quality,

3) if problems are present would people be willing to upgrade their systems with government assistance.

3.0 METHODS

Nineteen U.T.R.C.A. board members who are rural landowners were selected for the survey. They were contacted beforehand by letter (Figure C.1) to inform them of the survey's intent.

All surveys were completed over the telephone using a questionnaire (Figure C.2) that was divided into five main sections.

1) a description of the septic system (including tank size, weeping bed, proximity to fields and water-courses and possible hookups to field tiles),

2) its maintenance history,

3) connections into the septic system,

4) quality of drinking water, and,

5) interest in system upgrading with substantial financial incentive.

Three sewage hauling companies were also surveyed for information concerning the frequency that households have their septic tanks pumped out and also some of the problems they come across with septic systems.

Upper Thames River
Conservation
Authority

PO Box 6278 Station "D" London, Ontario N5W 5S1Telephone 451-2800

Dear

As a result of numerous beach closures around the province, several conservation authorities, including ours, have been working with the Ministry of the Environment in an attempt to remedy this situation.

Outdated livestock manure and waste handling practices are considered to be the primary rural contributors to poor water quality. However, it is becoming apparent inadequate or antiquated septic treatment may also have an impact on rural water quality. A meeting between conservation authorities, Ministry of the Environment and County Boards of Health lead to the conclusion that more information is needed to determine the extent and impact of the problem. With a good data base, the need for future efforts and/or grant incentives can be assessed.

Dave Hayman or Craig Merkley of this office would appreciate a few moments of your time to discuss your present system. If you are agreeable, they will visit your home to fill out a questionnaire before year end.

Your cooperation would be greatly appreciated.

Yours truly
UPPER THAMES RIVER CONSERVATION AUTHORITY

D. R. Pearson General Manager
DA DH/sb

Member of the Association of Conservation Authorities of Ontario

Fig. C.1: Letter to rural landowners

4.0 RESULTS

Sixty-eight percent of the people surveyed had lived in their homes for over 20 years. Of these only 4 systems were under 20 years old. Fifty-nine percent of the households had just two people living there which means if the system was designed for a larger family, there would be a reduced demand on their system. Forty-seven percent had their systems inspected. Five households at the time of installation, after 1974 (Table C.1).

Table 1: Septic System Survey Results

19 Households Surveyed

1) How long have you lived here?

Years	No. of Families
1- 10	3
11-20	3
21-30	5
31- 40	6
over 40	2

2) How many people are served by the present system?

People	No. of Households
2	11
3	3
4	4
5	1

3) Has septic system ever been inspected?

YES	NO
9	10

4) Description of system:

a) size of tank

Gallon	Households
500 - 700	5
800 - 1000	6
UNKNOWN	8

b) size of weeping bed

Feet	Households
150 - 200	7
201 - 400	1
401 - 600	2
UNKNOWN	9

c) soil type

Light	Medium	Heavy	Unknown
7	7	4	1

d) do you know location of weeping bed?

YES	NO
17	2

If farm, what is the distance to:

i) field:

Feet	Households
adjoining	5
0 - 200	10
700 - 800	1
residential	3

ii) field tiles:

Feet	Households
0 - 100	5
500	3
600	1
800	1
2500	4
no creeks/ drains	5

Are there any connections to:

	Yes	No
a) Field tiles:	1	18
b) Municipal drains:	I	18

5)Maintenance History:

	Yes	No	Unknown
a) Does it need any repair now?	1	17	1
b) Has the system given trouble?	5	11	3
c) Has anything been repaired?	7	7	5
d) Are there any persistent problems?		16	3

e) When was the tank last pumped out?

Years	Households
Never	1
1	3
2	4
3	3
4	1
5	4
6	1
10 & over	1

6) Are any of the following connected to the septic system?

	Yes	No	Unknown
a) eavestroughs		17	1
b) sinks	14	3	1
c) washing machines	12	5	1
d) showers	16	2	

7) Is the drinking water

	Private	Municipal
a) house	18	1
b) barn	13	

	Yes	No	unknown
c) is adequate supply?	18	1	
d) has it ever been tested?	15	4	
were results: Good 13, Bad 0			2

	Yes	No	Unknown
e) has it ever been treated?	4	13	1
f) have there been any health problems related to drinking water? Family:		19	
Livestock:		13	
8) If farm. does the barn have washroom facilities and/or milkhouse in use?	4	7	
9) If a substantial grant were available would you upgrade the present septic system?	5	13	1

5.0 DISCUSSION

All of the households surveyed had a fairly good knowledge of their septic systems, however, a bias may be present in this study.

U.T.R.C.A. board members were surveyed in order that we would receive full co-operation in compiling the necessary information. We must take into account that: being a member of the authority's board may mean that they are more conservation minded than the average person, they were previously warned by a letter (Figure C.1) that we would be contacting them to do the questionnaire.

The majority of households contacted said that their systems were adequately serving their household needs. A conscientious effort to repair and upgrade problem systems has led to this good result. Also, knowledge of the need for their settling tanks to be pumped out on a fairly regular basis is shown in the fact that 89% of the households have had their tank pumped out within the last 6 years. When we take into account that 8 of the households with 2 and 3 people residing in it had settling tanks designed for use by a family with 4 and 5 members, we find that every 6 years is still a satisfactory length of time. This is shown in the fact that a family of 4 with a 600 gallon tank should be pumped out every 3 years (personal communication, ABC Sanitation).

With a below average demand on their systems, a longer interval between pumping is acceptable.

Of the known weeping beds none had under 150 feet of line, some in the unknown category said that they were up to early 1970's regulations.

The first regulations came into effect in 1974. It is believed prior to this date that settling tanks and weeping beds were half the size of today's standards. (personal communication, D. Birnbaum, Head Public Sewage Unit, MOE, Toronto). Therefore, quite a few are undersized for today's standards.

Five weeping beds ran into fields. Two of these fields were not tiled, therefore no problem is likely to be present. Two systems ran into tiled fields and it is possible that some of the waste water is finding its way into the field tile. Local Health Units say that weeping beds should be 15m (50 ft.) from surface tile which are 0.6m (2 ft.) in the ground (Regulation 374-81, Ontario Environmental Act). For tile which are at least 1.5m (5 ft.) in the ground the local Health Units are using a 6m (20 ft.) distance between tile and weeping bed.

One system had a direct hookup into a field tile, combined with a settling tank which has not been pumped out in 18 years. This is the only system of the nineteen interviewed that definitely requires major renovations.

Another identified problem area, which should be repaired has a weeping bed tile surfacing on a hill, approximately 10m (30 ft.) from an open ditch.

Overall, the survey shows that while most systems are in fairly good shape, there are some trouble spots which should be attended to.

Only 26% of the people surveyed said that they would be interested in upgrading their present septic system with an available grant.

The remainder had well maintained systems and an attitude of, 'why fix something if it is not causing any apparent problems'.

In speaking with sewage pumping companies it was found that about 15 years ago many households were running into the problem of having their system continually backing up due to faulty weeping beds. However, through public education of these problems, only about 1% of the homes dealt with now, experience similar circumstances. However, very wet periods during the season will being an increase to this problem as was experienced during September of this past year (1986).

APPENDIX D:

Kintore Creek Watershed Project - Update Report

March, 1986
Craig Merkley

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I. Introduction / History

The Kintore Creek Watershed Project was initiated in January of 1984. The selection of the watershed was based on Environment Canada erosion/delivery maps, which identified high priority management areas. One of the first tasks of the original three month Background Study was to establish a water quality monitoring program. Weekly and event samples were collected at 7 stations in the western and eastern sub-basin. The data was collected to establish the existing levels of phosphorus and suspended solids in the watercourse of each sub-basin prior to any remedial measures carried out in the western basin.

After completion of the Background Study, Environment Canada - Lands Directorate provided funding for the continuation of the project for an additional year. The Lands Directorate was interested in accumulating additional data to help calibrate their mapping methodology. In a subsequent draft report, (Field Evaluation of Environment Canada Lands Directorate Sediment Delivery Mapping in the Avon River and Kintore Creek Basins), a number of observations and recommendations were made with regards to the Kintore water quality data. One of these recommendations identified the need of at least another year of data collection to permit watershed comparisons without the influence of the 1984 pipe-line construction.

In the spring of 1985, the Ontario Ministry of Environment provided funds to ensure an additional four month period of water quality monitoring. During this time period (June 1 to September 30) a number of other tasks were completed.

II Water Sampling

During the four month period weekly and event samples were collected at 7 sampling stations. A total of 161 samples were collected using the USDH-48 depth integrated sampler. The data was organized and entered into a computer data base.

The water level recorder, automatic samples and rain gauges were monitored weekly to assure their proper working condition.

To help determine the optimum time to sample an event, a dats gauge was installed at station 6 in the eastern basin. The eastern basin responds more quickly to an event then the western basin. By locating the dats in the eastern basin, the chances of missing an event were minimized.

Staff regularly monitor the Kintore Creek watershed to estimate the amount *of eroded soil reaching the stream.*

III Landowner Liaison

In addition to continuing the water quality monitoring program other tasks were carried out during the four month period.

Several landowners agreed to work with Authority staff to develop individual conservation farm plans. These plans examined existing conditions on the farm and where applicable laid out a series of alternatives and suggestions for each farm. Among the recommendations were a series of field by field tillage alternatives and potential structural erosion control measures. Work was carried out in both of these areas in 1985.

The mulch tiller, chisel plow and mulch finisher were used on a total of 145 acres in 1985. Four landowners were involved with these conservation tillage practices, none had had previous experience with reduced tillage. These plots were monitored throughout the growing season, all landowners were satisfied with their Yields. Due to poor field conditions, no conservation tillage Was carried out in the fall of 1985. Several landowners have expressed an interest in continuing with plots in the spring of 1986.

Farm plans identified a number of sites where structural erosion control measures were required to help reduce upland erosion problems. Seven water and sediment control basins have been constructed in the demonstration watershed. All of these structures were constructed on land identified as having high potential for erosion by the Lands Directorate mapping. These remedial measures have raised interest from adjacent landowners, work is being planned for their farms in the future.

IV Summary

As the Kintore Background Report notes, the watershed suffers from a high rate of sheet erosion. While structural erosion control measures help alleviate gully erosion, sheet erosion must be dealt with through the promotion of conservation tillage methods. It is not easy to convince a farmer to change his tillage system. However, if equipment is accessible and an experienced technician is available for consultation, it is hoped the number of tillage plots will increase. Perhaps changes will slowly come about.

The problem of wind erosion has also been addressed in the demonstration watershed. Approximately 9500 trees are to be planted in the spring of 1986. These trees will establish four large windbreaks and three areas of reforestation. One of these areas is an 8 acre site near the headwaters of the Vannatter Drain. The Ministry of Natural Resources has agreed to manage this site under its Woodlot Improvement Act.

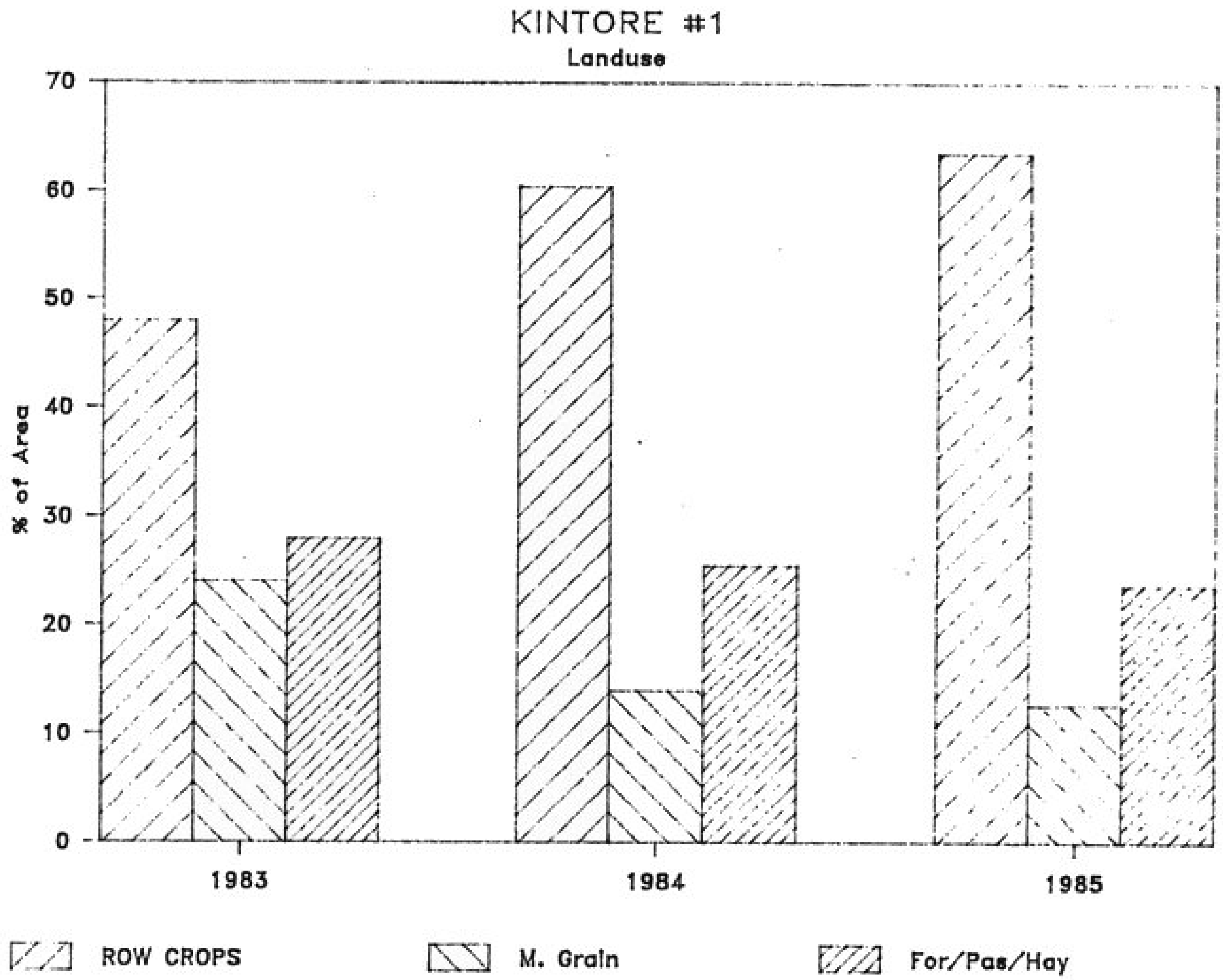
Finally, the most important component of the Kintore Project is the continuation of the water quality monitoring program. With-out the continuous collection of water samples throughout the various seasons, there will not be a way to assess the success of the Project. It is hoped that sufficient funds will be made available for the continuation of this important component of the Project.

Under dry *weather conditions, the Kintore Creek maintains a base flow.*

After runoff events, flows can *increase 20 to 40 times base flows,* carrying *with it large amounts of eroded soil.*

LANDOWNER PARTICIPATION: WESTERN BASIN

NAME	# Acres In Watershed	Participation	Structural Measures	Tillage Plots	Reforestation/ Windbreaks	Farm Plan
Muir	165	X	X	X	X	X
McMurray	100	X	X	X	X	X
Pelkmans	100	X	X	X		X
Vanstrien	300	X	X		X	X
Brekelmans	165	X	X	X	X	
McKay	27	X	X			
Arts	84	X			X	X
Leonhardt	20	X				
McLaron	50	X				
Hutton	77	X				
Kew	50	X				
Davis	50	X				
Arther	17	X				
Sims	20	X				
Stewart	50	X				
Ebert	60					
Rounds	95					
Tasker	22					
TOTAL	1402	15		145 Acres		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50
40
30
20
10
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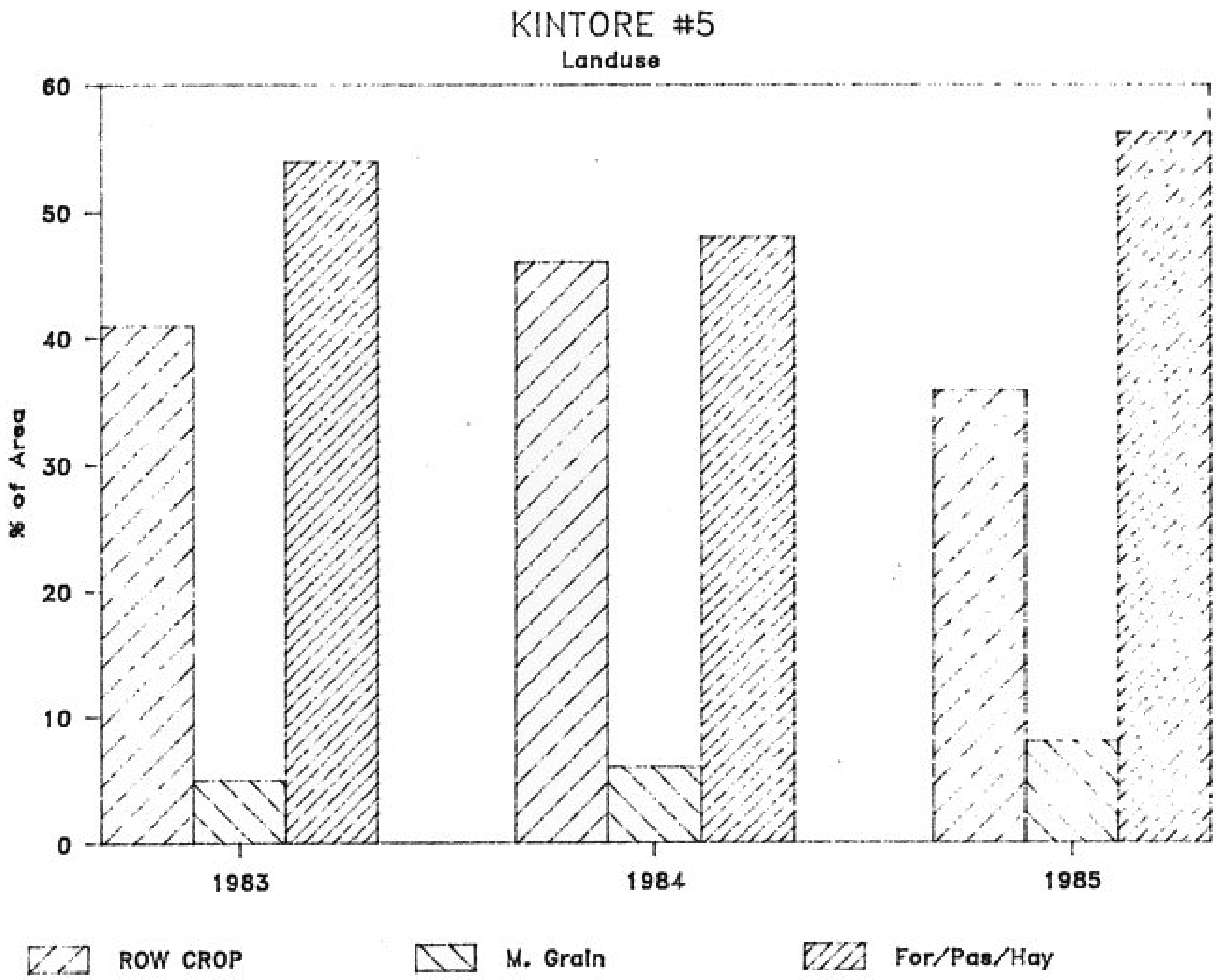
% of Area
1983
1984
1985
ROW CROPS
M. Grain
For/Pas/Hay



KINTORE #5
Landuse
% of Area
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1984
1985
ROW CROP
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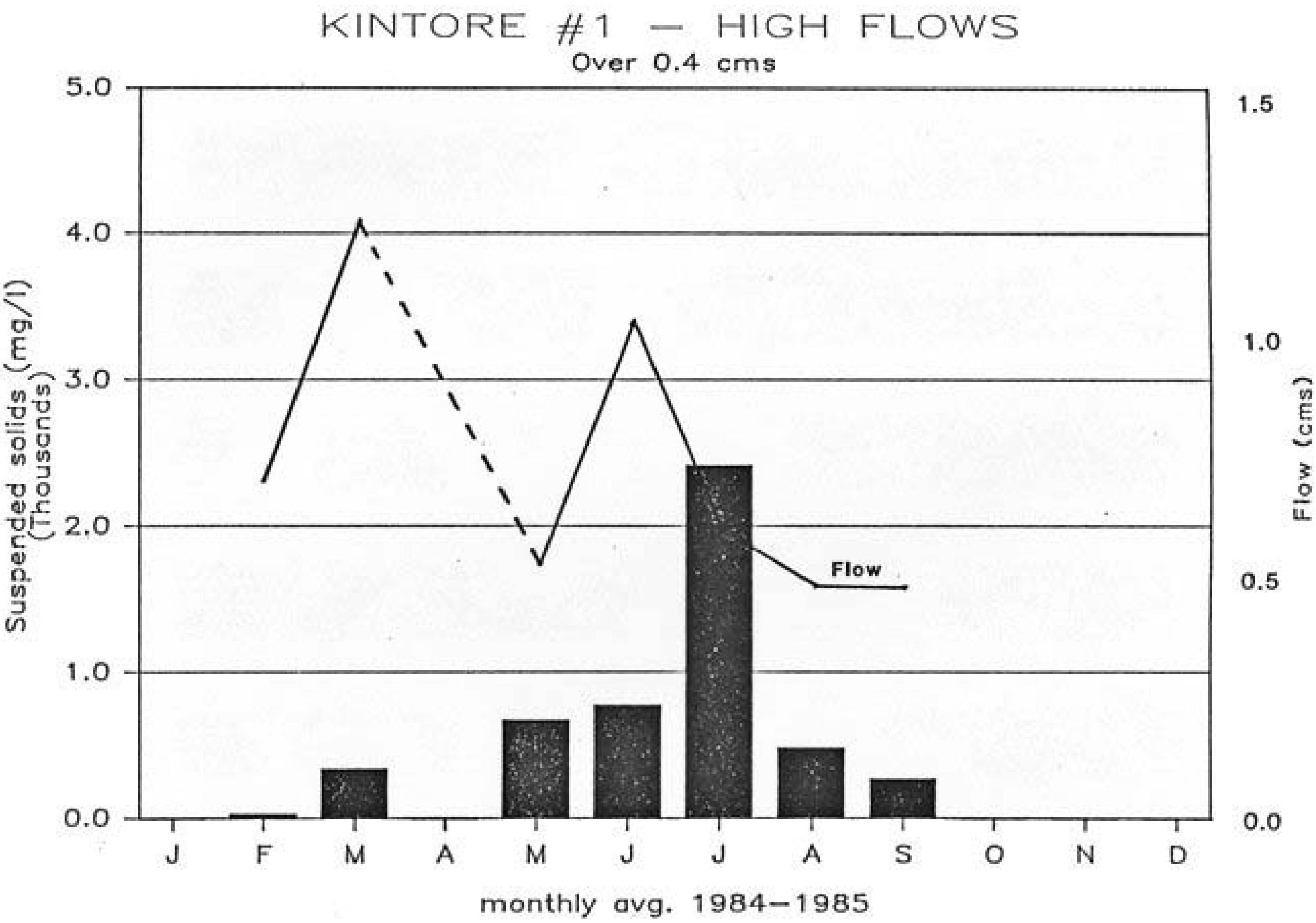
For/Pas/Hay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Over 0.4 cms
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Flow (cms)
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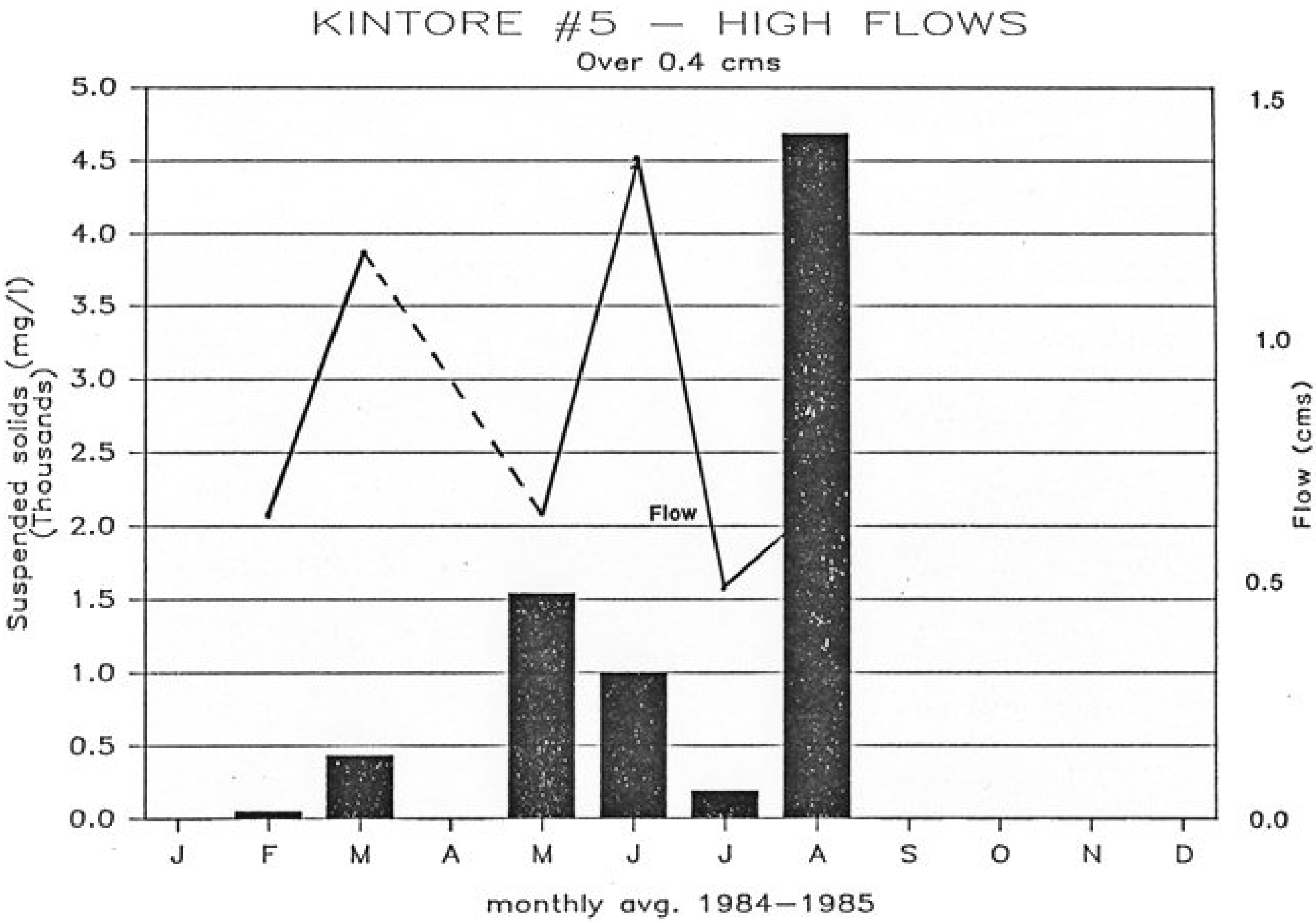
monthly avg. 1984—1985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0.5
0.0
Suspended solids (mg/l)
(Thousands)
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1.0
0.5
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Flow (cms)
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N
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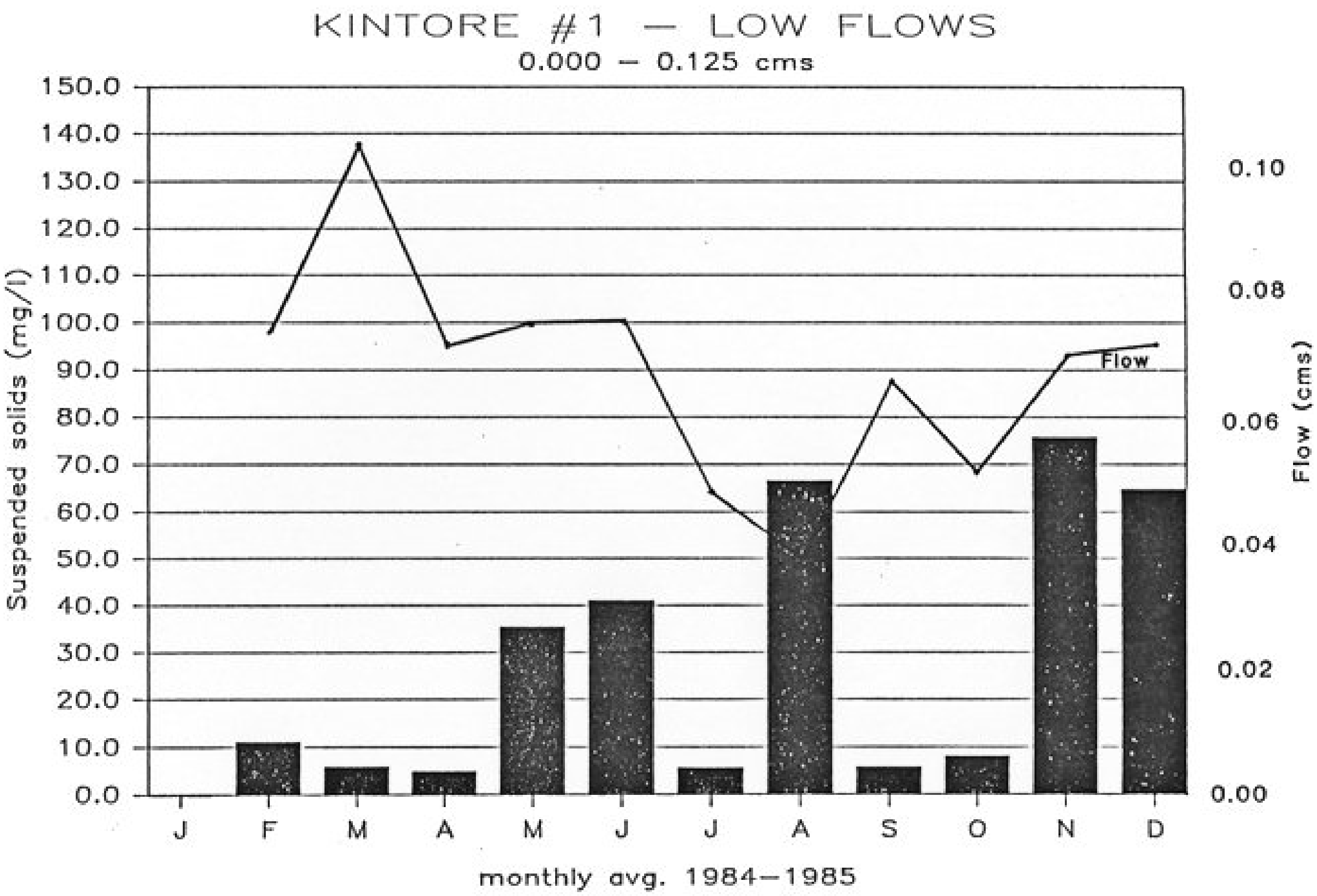
monthly avg. 1984—1985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70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Suspended solids (mg/l)
0.10
0.08
0.06
0.04
0.02
0.00
Flow (cms)
Flow
J
F
M
A
M
J
J
A
S
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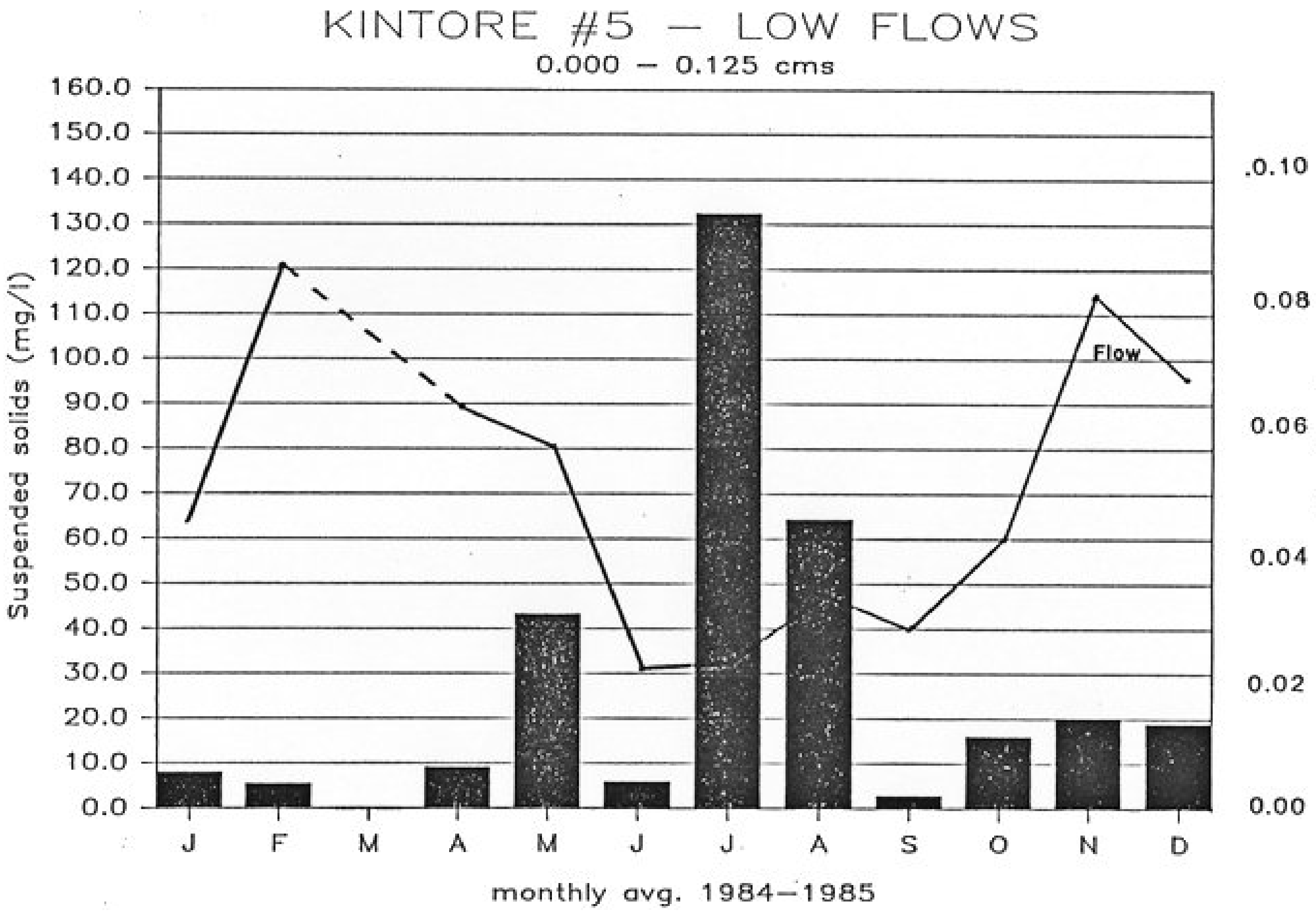
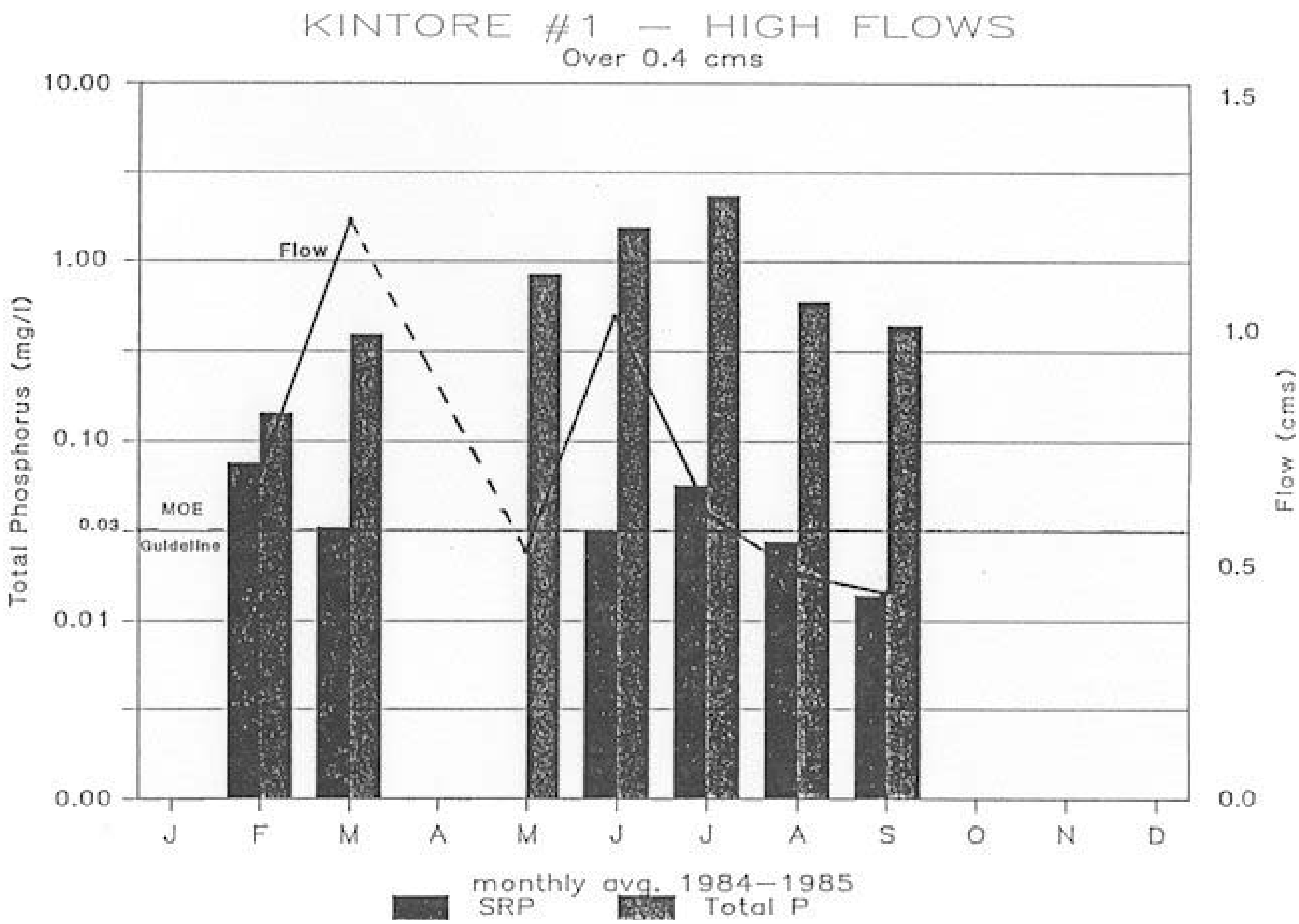
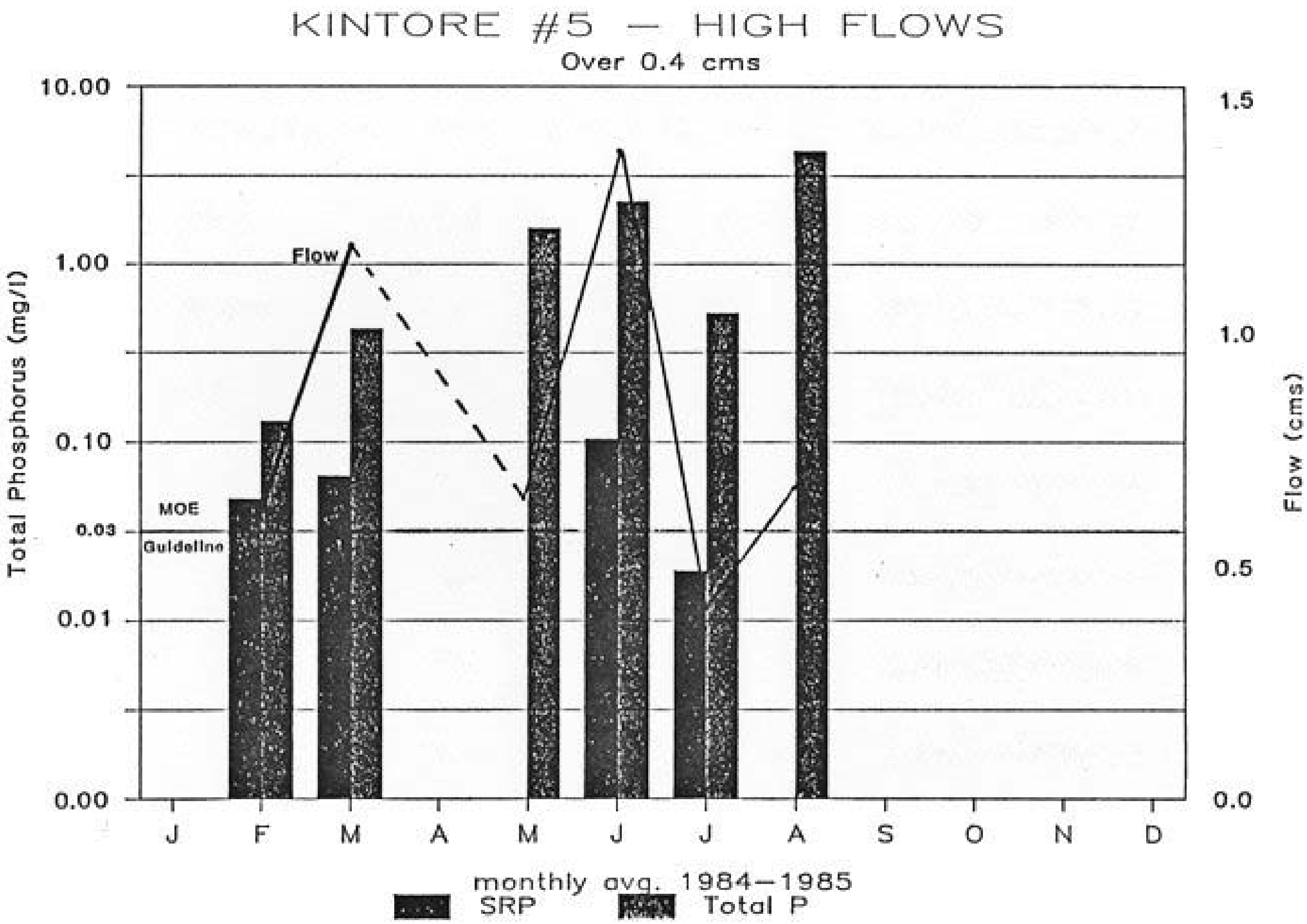
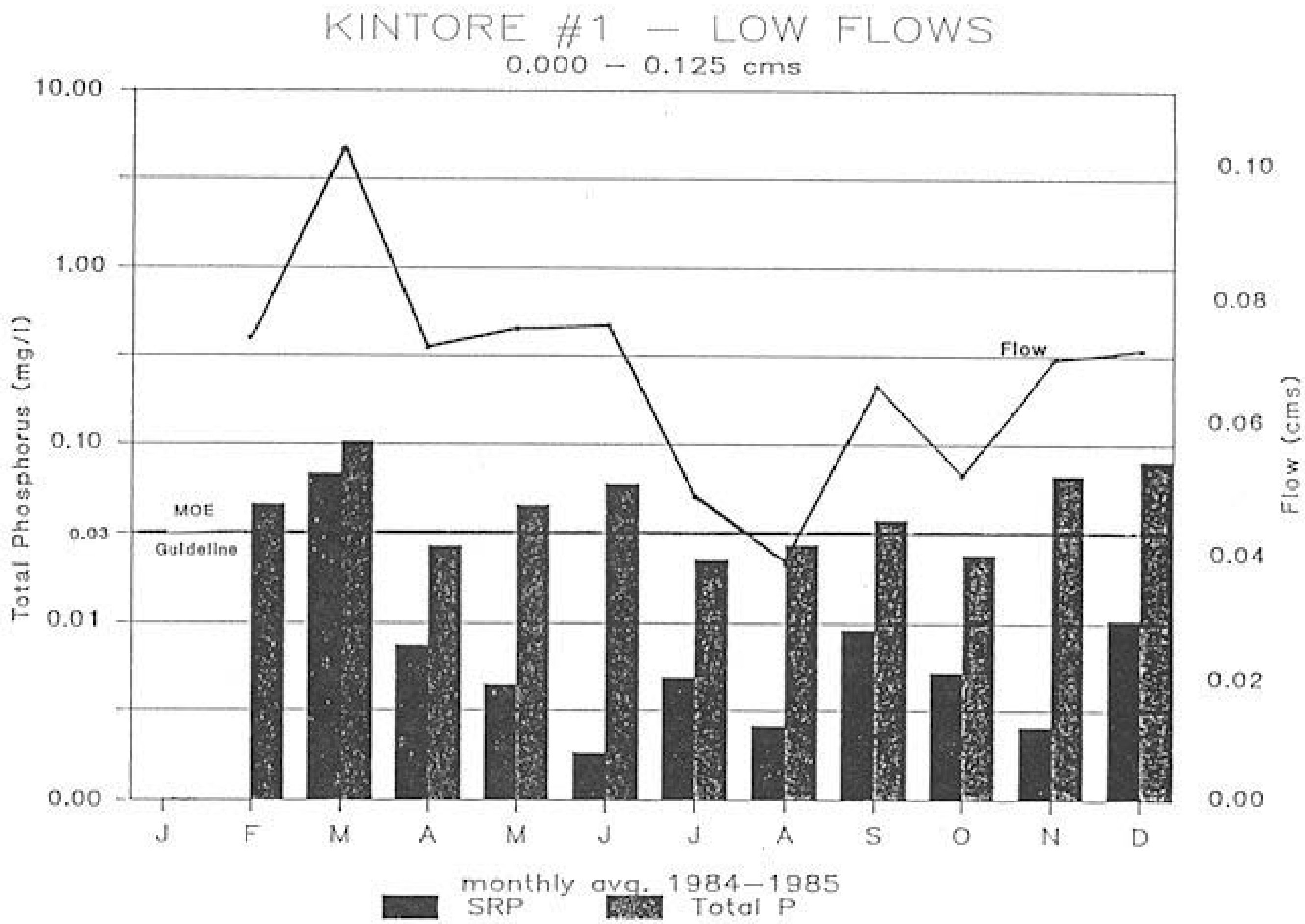
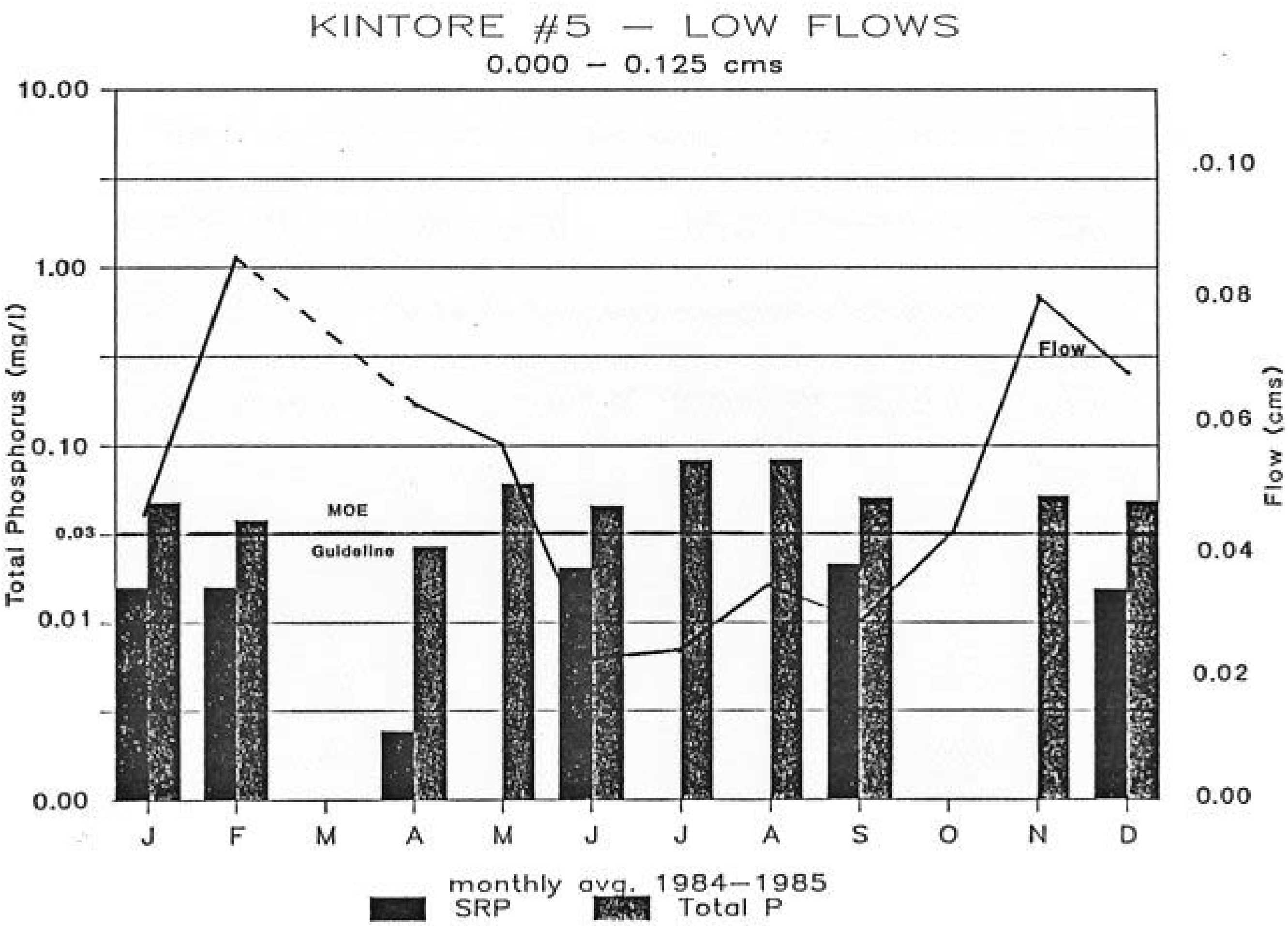
N
D
monthly avg. 1984—1985

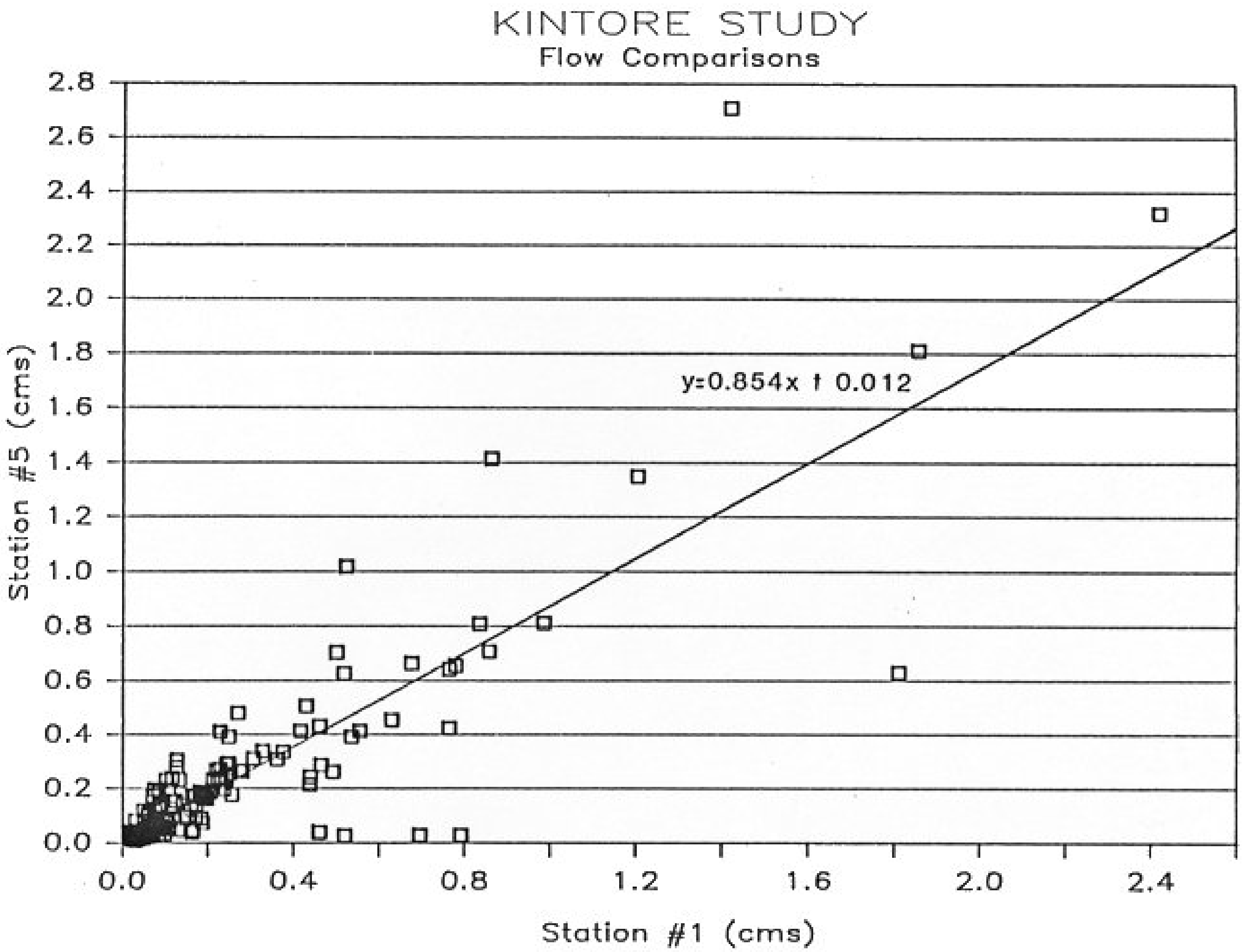

KINTORE #5 – LOW FLOWS
0.000 – 0.125 cms
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Suspended solids (mg/l)
.0.10
0.08
0.06
0.04
0.02
0.00
Flow (cms)
Flow
J F M A M J J A S O N D
monthly avg. 1984–1985

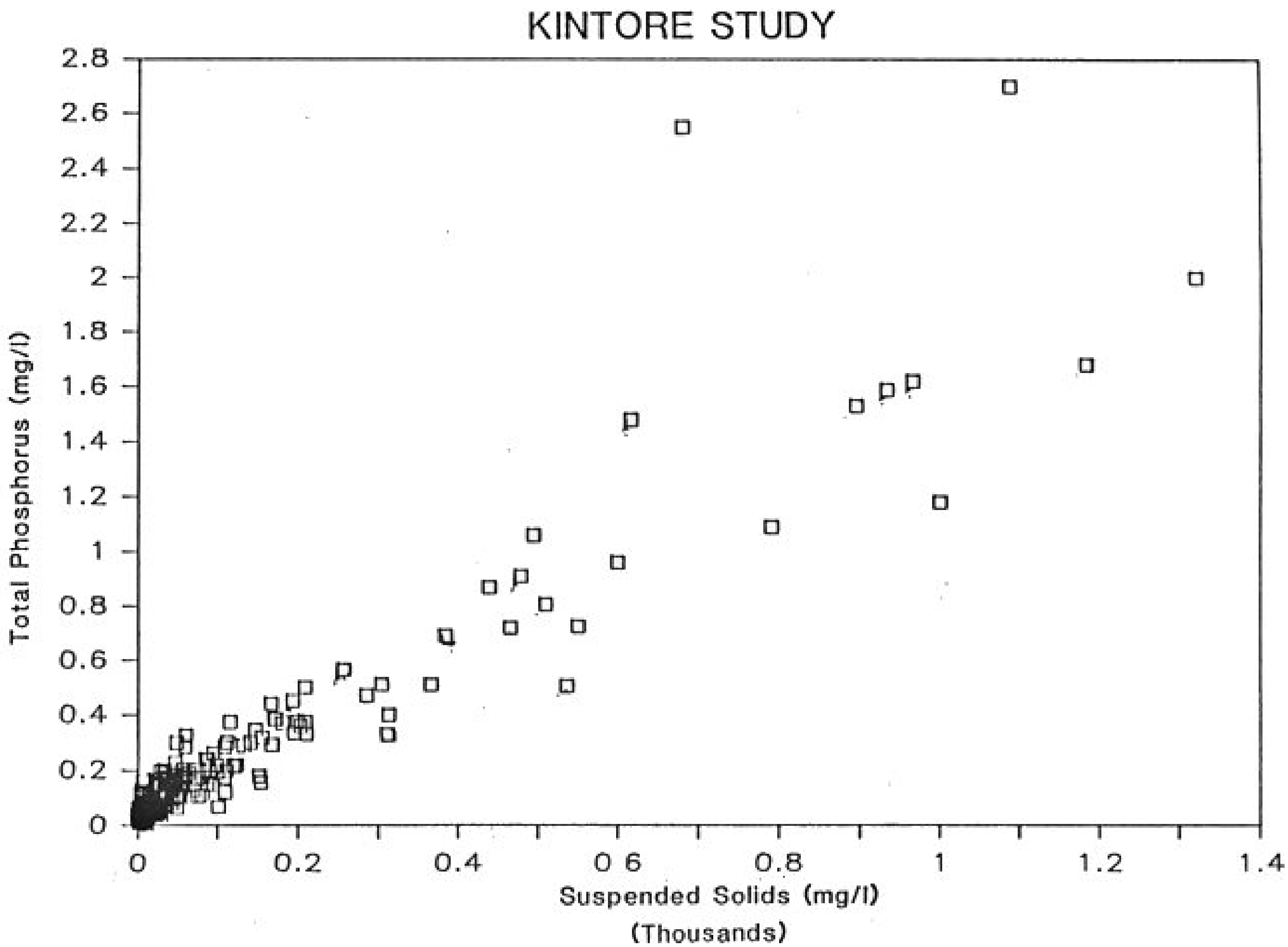

KINTORE #1 — HIGH FLOWS
Over 0.4 cms
Total Phosphorus (mg/l)
10.00
1.00
0.10
0.03
0.01
0.00
MOE
Guideline
Flow
Flow (cms)
1.5
1.0
0.5
0.0
J
F
M
A
M
J
J
A
S
O
N
D
monthly avg. 1984—1985
SRP
Total P


KINTORE #5 — HIGH FLOWS
Over 0.4 cms
10.00
1.00
0.10
0.03
0.01
0.00
Total Phosphorus (mg/l)
MOE
Guideline
Flow
1.5
1.0
0.5
0.0
Flow (cms)
J
F
M
A
M
J
J
A
S
O
N
D
monthly avg. 1984—1985
SRP
Total P


KINTORE #1 — LOW FLOWS
0.000 — 0.125 cms
10.00
1.00
0.10
0.03
0.01
0.00
Total Phosphorus (mg/l)
MOE
Guideline
Flow
0.10
0.08
0.06
0.04
0.02
0.00
Flow (cms)
J
F
M
A
M
J
J
A
S
O
N
D
monthly avg. 1984—1985
SRP
Total P


KINTORE #5 — LOW FLOWS
0.000 — 0.125 cms
10.00
1.00
0.10
0.03
0.01
0.00
Total Phosphorus (mg/l)
.0.10
0.08
0.06
0.04
0.02
0.00
Flow (cms)
MOE
Guideline
Flow
J
F
M
A
M
J
J
A
S
O
N
D
monthly avg. 1984—1985
SRP
Total P


KINTORE STUDY
Flow Comparisons
y=0.854x + 0.012
Station #5 (cms)
Station #1 (cms)
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.4
0.8
1.2
1.6
2.0
2.4


KINTORE STUDY
Total Phosphorus (mg/l)
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Suspended Solids (mg/l)
(Thousands)