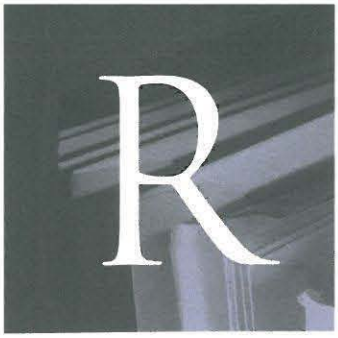

RESEARCH REPORT

WATER QUALITY GUIDELINE AND WATER MONITORING TOOLS FOR RESIDENTIAL WATER REUSE SYSTEMS

HEALTHY HOUSING AND COMMUNITIES SERIES

CMHC SCHL

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WATER QUALITY GUIDELINE AND WATER MONITORING TOOLS FOR RESIDENTIAL WATER REUSE SYSTEMS

Prepared by:

J. Stidwill and R. Dunn
totten sims hubicki associates

July, 1999

CMHC Project Officers:
Cate Soroczan and Stéphanie McFadyen

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ABSTRACT

A recurring obstacle to the acceptance of water recycling technologies for residential use is the lack of a consistent and reliable monitoring strategy to ensure long-term water quality.
To fulfill this need, CMHC has conducted a significant amount of research in the area of water conservation and reuse for residential applications over the last ten (10) years. The results of this work has led to funding for a number of water reuse demonstration projects. These, and other initiatives have helped to support and promote a better understanding of good planning and design practices associated with water reuse systems.

This research paper discusses the requirements for a monitoring and control protocol for small residential water reuse systems. It reports the findings of a workshop held with key personnel from health and environmental agencies: *On-Site Water Reuse in Canada - Ottawa '99 Protocol*. Key agency discussions and findings concerning the requirements of a monitoring and control protocol for on-site water reuse systems are presented.

The contents of this paper will be of particular interest to homeowners, property managers, consulting engineers and regulatory agencies wishing to assess available monitoring and control technologies and review the elements of a long-term monitoring and water quality control protocol.

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1.0 INTRODUCTION

1.1 Background

Water management programs to encourage and improve water use efficiency are slowly being considered and incorporated into policies by all levels of government: federal, provincial and municipal. The concept of performing the same activities with less water is being undertaken by many of these agencies and is supported by recent changes in toilet, faucet and shower head designs. Using water more efficiently through demand management, repair of leaking distribution systems and other innovative approaches such as water reuse systems are examples of techniques that are being incorporated into the planning and design of residential and commercial buildings. These initiatives can help preserve the natural environment and reduce the stress on our fresh water resource.

Canada Mortgage and Housing Corporation (CMHC) has been most supportive of these new initiatives. It has recently undertaken a number of important studies on water reuse systems including:

- Regulatory Barriers To On-Site Reuse;
- Conservation Co-op Residential Water Reclamation;
- An Application Guide For Water Reuse Systems; and
- Innovative Residential Water And Wastewater Management.

These and other research projects complement pilot water reuse systems such as CMHC's award winning Toronto Healthy Homes and the Ottawa Conservation Co-operative's demonstration water reuse system. All of these initiatives have helped to support and promote a better understanding of good planning and design practices associated with water reuse systems. The projects have stimulated an interest from regulatory agencies, municipalities and the public about how such systems could be applied and has also raised important questions about residential water reuse systems.

Across Canada, many municipalities have aging and undersized infrastructure (water and sewer). The ability of such municipalities to expand infrastructure services for housing development projects is hampered by the need to conserve water resources and costs. A dual water system (reuse system and potable system) has excellent potential to conserve water resources and reduce high costs associated with municipal infrastructure expansion. There are only a few isolated examples of Canadian housing complexes which use water reuse technologies.

1.2 Purpose of the Study

CMHC has commissioned this research paper in view of the need to develop realistic and practical water quality monitoring requirements for residential water reuse to satisfy health and safety concerns. The purpose of this paper is to help establish a long-term monitoring and control system protocol which is applicable to residential water reuse, meets the needs of homeowners, property managers and regulators, and is cost effective.

Key components of the study are to examine regulatory, health and safety concerns; identify concerns of the various responsible authorities and develop a consensus/protocol for water reuse system monitoring and control. The guideline identifies and describes various monitoring parameters and control system components which are available and reviews their application in a residential water reuse system.

2.0 MONITORING PROTOCOL

2.1 Introduction

Over the years, regulatory authorities have expressed concerns about health and safety issues in water reuse systems. Although their interest may be driven by public attitudes and perceptions, there have been very few instances where the regulatory authorities have participated in the decision-making process on the application of such systems. Additionally, when dealing with public health and safety, regulatory authorities cannot make changes to current procedures and policies on water reuse without providing extensive background data to support their decisions. Until recently, data available on the efficiency of water reuse systems has been scarce.

CMHC has dedicated a substantial amount of resources and effort towards research in water reuse. Such efforts include identifying the need, designing system guidelines, protocol testing programs and identifying regions or situations in Canada which may benefit from reuse applications. To continue with this research and practical safe application of water reuse systems, the development of a monitoring control program was deemed appropriate.

To develop this monitoring program the following activities were conducted:

- Identify monitoring program appropriate for an indirect water reuse classification (toilets);
- Review existing monitoring water reuse programs in Canada and other jurisdictions;
- Examine water quality parameters;
- Conduct a one-day round table discussion with key environmental and health decision makers; *(On-Site Reuse in Canada-Ottawa '99 Protocol)*; and
- Survey water monitoring and control equipment.

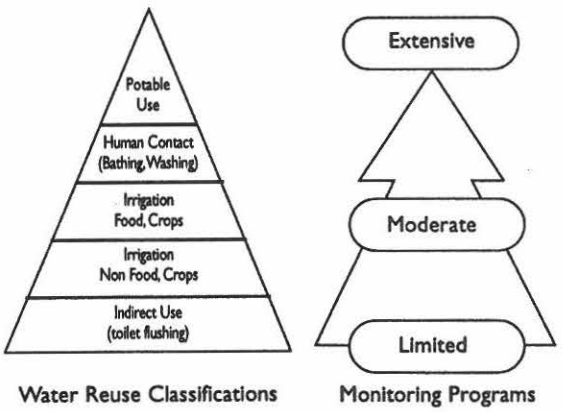
2.2 Water Reuse Classifications Requiring a Monitoring Program

Currently there are several water reuse classifications requiring monitoring programs. They are outlined in the CMHC document entitled "An Application Guide For Water Reuse Systems" (see Appendix A). The "Guidelines for Canadian Drinking Water Quality" is generally applicable for a direct potable use classification. There can be a variety of monitoring programs for the water reuse classifications: human contact (bathing, washing) irrigation (food crops) and lawn irrigation, and these should be developed in the future. This research paper concentrates on the establishment of a monitoring program for the indirect use classification (toilet use, clothes washing) because this use has lower public exposure than direct consumption. For indirect use classification, the monitoring program does not require an extensive drinking water treatment system.

Figure 1 illustrates a hierarchy of monitoring programs for water reuse. For instance, treated reused water intended for drinking purposes should be monitored to ensure that all the Canadian Drinking Water Quality parameters are adhered to and the established criteria are met. On the other hand, treated water reused for toilet use need not meet such restricted criteria since the standing water in most toilet bowls is exposed to residual contaminants.

In summary, reuse water for flushing toilets does not require a standard as high as potable use since it is not ingested or used for body contact.

Figure 1
Hierarchy of Typical Water Reuse Classifications and Monitoring Program Requirements



2.3 Monitoring Program Objectives

The objectives of this monitoring research project were three fold:

- To establish an interim monitoring protocol for the indirect water reuse systems (toilet flushing);
- To identify parameters to be monitored; and
- To establish criteria, identify control equipment and determine sampling frequency for the monitoring program.

2.4 Water Quality Monitoring Parameters

Water quality sampling parameters are generally considered to be either physical, chemical or microbiological in nature. To evaluate sampling requirements, it is important to understand that the regulation of water quality levels is likely to become more rigorous both in concentration levels and number of contaminants with the advent of better detection technologies and detection equipment sensitivity. Small treatment system operators might be expected to face more stringent water quality challenges in the future.

A brief description of each of these general water quality parameters follows.

2.4.1 Physical Parameters

The physical properties of colour, turbidity, taste and odour have the greatest subjective impact on water consumers. Physical parameters of concern such as aesthetics account for certain substances or conditions in the water, the presence of which may render the water unpalatable or unacceptable to the consumer.

The key physical properties are described as follows:

Colour: Colour is an aesthetic objective under the water quality guidelines. The presence of colour in water is not directly linked to health concerns. The target colour level for reuse of light grey water (bath/shower water) in toilets—30 TCU (True colour units) —is considered aesthetically acceptable to most consumers.

Turbidity: Acceptable turbidity levels have been established on the basis of both health and aesthetic considerations. High levels of turbidity can protect micro-organisms from the effects of disinfection, stimulate the growth of bacteria and exert a higher chlorine demand for disinfection. It is advisable to monitor chlorine residuals (when used for disinfection) and coliform levels when the turbidity approaches 5 NTU (nephelometric turbidity units). Above 5 NTU, higher coliform levels in the water may be expected without a higher disinfection effort.

Taste: Taste will not be considered in reuse applications since potable water use for reuse systems is not included in this report. Nevertheless, taste in some instances may closely correlate to a subjective evaluation of odour.

Odour: Odour cannot be objectively measured. The treatment objective is to provide water that has no offensive

odour. Odours may be attributed to a specific chemical yet are rarely indicative of the presence of harmful chemical substances. Odours may indicate undesirable biological activity in the water.

2.4.2 Chemical Parameters

Chemical parameters which may be of concern for residential water reuse systems can be closely linked to physical properties such as odour or colour. Some chemicals may cause microbiological upsets in conjunction with their discharge in private sewage disposal systems or there may be other effluent discharge concern.

If there are local soil/groundwater concerns associated with an effluent discharge through a land application, then an impact assessment should be conducted. An external monitoring program may also be considered. Groundwater and surface water sampling will likely be required to validate conclusions regarding contamination pathways. External environmental monitoring programs such as groundwater and surface water sampling are not discussed in this paper.
It is important to identify and understand whether there are any water quality concerns with the source water. In the publication "An Application Guide for Water Reuse Systems", prepared by Canada Mortgage and Housing Corporation, it is recommended that all chemical constituents in the source water be investigated. A complete and comprehensive water analysis to determine a full spectrum of parameters is advisable.

In the chemical or biochemical category there are a number of parameters which may be of interest. These constituents include:

- biochemical or chemical oxygen demand (BOD/COD);
- oxidation—reduction potential (ORP);
- dissolved oxygen (DO);
- organic compounds; and
- volatile residues.

Volatile residues of interest can also include disinfectant residuals from a water reuse system.

2.4.3 Microbiological Characteristics

Consumer acceptance of water reuse applications is closely linked with public health concerns and safe water issues. Health and safety issues for example will include microbiological contamination and the physical appearance and palatability of the water. To minimize health hazards and risks associated with exposure, the treated water should be microbiologically safe. To confirm a safe water, bacteriological testing will be necessary.

Microbiological testing techniques continue to improve in the detection of pathogenic bacteria and viruses; yet it is still not practical to attempt to isolate and test for a wide range of pathogenic organisms. Testing still relies on the presence of specific organisms which best indicate the presence of pathogens. Indicator organisms when absent tend to suggest that there are probably no disease-producing organisms present.

Bacteriological indicators are commonly used to characterize the general microbiological condition of water. Fecal coliform bacteria which occur in warm blooded animal intestines and feces are generally considered. Not all strains in the total coliform group are exclusive to fecal coliform. Some coliform groups are also present in soil and as such the use of Escherichia-coli as a contamination indicator is preferred because it is specific for mammal fecal contamination.

A number of methods can be used to detect coliform organisms in water. The following popular methods are used extensively in Canada and other countries.

TYPE	TECHNIQUE	CHARACTERISTICS
MPN (most probable number)	Typically conducted in controlled settings such as a lab. Multiple tube fermentation technique. Tests the presence of gas fermentation by-products which corresponds to a statistical estimate of the number of bacteria that would probably give the observed result more than any other.	Takes longer than MF and has largely been replaced by the MF technique in laboratories except with contaminated water containing high levels of coliforms
MF (membrane filter)	Typically conducted in controlled settings such as a lab. Requires the water sample to pass through a filter that retains bacteria. The filter is placed on an appropriate medium and incubated for 24 hours. A count of the number of colonies observed on a standard plate count is made.	
P/A Testing (Presence/ Absence test)	It is a modification of the multiple tube fermentation technique (MPN) whereby only one sample is used to detect the presence of organisms. A water sample is added to media and incubated for a period. An indicator is used; in the presence of bacterial growth, the pH of the water changes causing the indicator to change colour.	This does not provide a quantitative result but rather a qualitative indication of the presence of bacteria in a water sample.

2.5 Existing Monitoring Guidelines for Treated Reused Water for Toilet Flushing

The United States Environmental Protection Agency (USEPA) has developed an unrestricted urban reuse category that includes:

- irrigation;
- toilet flushing;
- fire protection;
- construction;
- landscape impoundments; and
- street cleaning.

A review of existing regulations and criteria reveals a wide variation in quality requirements. There are, however, only two states with regulations and criteria for toilet flushing. Criteria in United States for the unrestricted urban reuse category is shown in Table 1.

Table 1
Unrestricted Urban Reuse Criteria (Toilet Flushing)

Parameter	Range Expected	Comments
BOD	5-30 mg/l	Normally monthly average.
Total Suspended Solids	5-30 mg/l	Lower limit for most states.
Coliform	0-200 per 100 ml	Most states require no single fecal coliform count to exceed 75/100 ml or 75% of samples over month must be below detectable limits.
Turbidity	2-5 NTU	

Table 2
CMHC Toilet Reuse Pilot Project Ottawa
Water Reuse Criteria

Parameter	Light Grey Water Criteria For Toilet Flushing
Total Suspended Solids	10 mg/l
Coliform	Conform to Drinking Water Standards
Turbidity	20 NTU
Colour	30 TCU
Iron	1.0 mg/l
Manganese	0.5 mg/l

The suggested guidelines for all of the USEPA water reuse categories are noted in the "Application Guide For Water Reuse Systems" prepared by CMHC (refer to Appendix A).

When CMHC undertook a Light Grey Water Reuse Pilot Plant Project in Ottawa, an interim water quality program was developed in consultation with the Ontario Ministry of Environment and the Regional Municipality of Ottawa-Carleton Health Department. Criteria developed for the project are shown in Table 2.

The Ottawa criteria were developed with iron and manganese considerations to prevent staining of fixtures which could lead to complaints from the users of the reused water.

In the CMHC report "Advancing the Light Grey Option", Townshend suggested toilet flushing water standards shown in Table 3.

Table 3
Toilet Flushing Water Standards - Townshend

Parameters	Criteria
Turbidity	20 NTU
Colour	30 TCU
Odour	6 units
Manganese	0.5 mg/l
Copper	1.0 mg/l
Iron	1.0 mg/l

3.0 ON-SITE WATER REUSE IN CANADA - OTTAWA '99 PROTOCOL

3.1 Background

In order to move residential water reuse from an experimental stage to the mainstream and protect public health, it will be necessary to establish the elements of a monitoring program which address the needs of the regulatory agencies, homeowners and occupants. In mid April 1999, CMHC invited key personnel from health and environmental agencies to discuss requirements of a water reuse monitoring and control protocol. The goal of the round table discussion titled "On-Site Water Reuse in Canada - Ottawa '99 Protocol" was to establish mutual understanding and consensus about an appropriate monitoring program.

3.2 Participants

The key agencies who participated in the Ottawa '99 Protocol are listed in Table 4 as well as specific mandates and knowledge/involvement in water quality issues.

Table 4
Ottawa '99 Protocol Participant Agencies

Health/Environmental Agency	Reasons For Agency Consultation
Environment Canada	Involved in national standards on water quality objectives
Ontario Ministry of the Environment	Establishes water quality criteria and ensures compliance with regulations in Ontario. MOE has supported water reuse projects in the past. Positions and policies taken by the province of Ontario have assisted other provinces and territories.
Regional Municipality of Ottawa-Carleton (RMOC) Health Department	Health Department extremely influential in the protection of health of residents in the Regional Municipality of Ottawa-Carleton. RMOC Director of the Health Department is Past-President of the Canadian Public Health Association.
Regional Municipality of Ottawa-Carleton Water Division	The RMOC has closely followed CMHC research projects and has participated in the studies. Water conservation and reuse is of interest to the RMOC which includes a large urban community and rural component. It has implemented a wide range of water conservation measures and demands management initiatives.
Canadian Water and Wastewater Association (CWWA)	CWWA represents the interests of municipalities in water and wastewater issues across Canada. In recent years CWWA has been actively interested in water reuse, and through their newsletter has reported on the development of water reuse projects.
Canada Mortgage and Housing Corporation	CMHC has shown leadership in the research field of water conservation and water reuse.
totten sims hubicki (TSH)	TSH is one of the eminent firms in the design of water facilities and has a wide range of experience with water reuse systems.

Individuals representing the various agencies (please refer to Appendix B) were selected because of their expertise and knowledge of water quality issues.

3.3 Round Table Format

In the early stages of the round table discussion it was decided that the participants would focus on a particular level of water reuse, because different end uses required different standards. For this reason, the Ottawa '99 Protocol group focused on one of the most common applications, toilet water reuse. The reused water would be light grey water treated prior to being distributed to the toilets. In the development of a monitoring program it was recommended that the treatment of reused water be of the highest practical degree.

A list of the main parameters for any monitoring program was reviewed by the group. These parameters consisted of the following categories:

- **Bacteriological**
  - Fecal Coliforms
- **Physical/Chemical**
  - Turbidity
  - Colour
  - Total Suspended Solids
  - Total Dissolved Solids
  - Conductivity
  - pH
  - Inorganic Chemicals
  - Organic Chemicals
- **Biochemical Oxygen Demand (BOD)**
- **Others**
  - Odours
  - Viruses and Parasites

The discussions centred on:

- the reasons to include anyone parameter in a monitoring program;
- problems with the parameter;
- frequency of monitoring in the short term (normally determined to be the period after treatment facility has been commissioned and treatment uniform performance has been achieved);
- long-term monitoring; and
- the eventual selection of a criteria for the selected parameter.

Summary sheets were prepared for the key parameters (refer to Appendix B).

3.4 Conclusions

The basic conclusions which resulted from the Ottawa '99 Protocol are presented in the following sections:

3.4.1 Bacteriological Parameters

Monitoring for fecal coliforms in particular was concluded to be important as this parameter is associated with health risks, is well identified and can be measured readily. Although residual contamination in toilet bowls was recognized, it was concluded that a strong disinfectant, preferably chlorination, should be included in the designed system. Chlorination was the disinfectant suggested because testing is easy to perform, practical and more easily monitored than bacteria culture testing.

A limit range of 0-200 counts per 100 ml for fecal coliform, similar to body contact criteria for swimming and bathing use of water, was deemed to be acceptable from a health or public acceptability perspective. Advising the public that the water in the toilet bowl meets a body contact criteria would make water reuse more acceptable to most people.

A general conclusion included the observation that all disinfection agents may create their own specific health risks. As an example, ozonation affects air quality and would require venting around the treatment process.

3.4.2 Turbidity

Since turbidity is a key health parameter, relatively easy to check and can be monitored on-line, it was concluded that turbidity should be included in any monitoring program. A limit range of 5 to 20 NTU was deemed reasonable.

Monitoring turbidity can also indicate the efficiency of the treatment process. Elevated turbidity levels would signal a problem with the filtration process and to a lesser degree the effectiveness of the disinfection process.

3.4.3 Colour

Although colour is an aesthetic parameter, it is an important one for assessing the efficiency of the unit treatment processes. More significantly, it provides a visual indication to the users as to whether the reused treated water appears acceptable. Some discolouring of water in toilet bowl may raise complaints. A limit range of 5 to 20 TCU was selected. Since the raw water in a community may already have high colour, the range should be established based on local conditions.

It was suggested that adding a colour artificially to reuse water might be an excellent strategy. For instance, if colour was used to indicate the presence of residual disinfectant, homeowners could instantly tell if their system was working properly. The absence of colour could reveal a malfunction or stoppage in disinfection treatment similar to "blue flushes" for retail toilet pucks. A deliberately coloured reuse water can also serve as a visual indication that this is not potable water.

3.4.4 Total Suspended Solids, Total Dissolved Solids, Conductivity

Analysis of solids was considered important in the short term while the treatment facility is being commissioned. However, in the long term, testing for these parameters was considered unnecessary or less important provided the treatment facility is being monitored for other key parameters.

3.4.5 Inorganic Chemicals

Although elements such as copper, iron, manganese may be found in soap and shampoos, it was concluded that it was unnecessary to establish a monitoring program for these parameters. Again it was recommended that the main parameters of turbidity and chlorine residual be monitored. This will indicate if the treatment facility is operating in a satisfactory manner and will lead to acceptable reused water for the toilets.

3.4.6 Biochemical Oxygen Demand (BOD)

BOD was considered a possible indicator of potential problems but because of the difficulties and length of time required to conduct the analysis, it was concluded that a monitoring program need not include BOD. In the early stages of the pilot plant investigation, it may be necessary to establish the overall strength of the grey water as this will have a bearing on the unit treatment design process.

3.4.7 Other Parameters

The group discussed the need for including other parameters in the monitoring program such as odours, organic chemicals, but concluded it was not required.

3.4.8 Additional Issues

There was concern that an owner/occupant could disrupt the treatment facility by using a strong cleaner or solution such as concentrated ammonia or bleach, or common commercial type products such as "Liquid Plumber" or "Drano". This led to a general consensus that occupants' education will be particularly important for a residential reuse system. Education could include an owner's manual, tips on bathroom/shower room cleaning and possibly labels on pipes and system components.

3.5 Summary

Three key elements to a monitoring program for toilet reused water were identified:

- Disinfection - to protect health and meet health agency criteria;
- Aesthetics - turbidity (related to health as well) colour, staining; and
- Operational - adequate operation of treatment facility will generally ensure water quality parameters are being met.

The round table participants concluded there are two monitoring program objectives associated with water reuse for toilets: an operation process monitoring program and a treatment quality monitoring program. The operation process monitoring program would comprise alarms and control functions to continuously operate/monitor the treatment system. This would ensure unit treatment processes are performing within their operating parameters such as initiating filter backwash when pressure losses over the unit treatment process become high. If the facility is operating properly then an acceptable quality of water would normally be produced.

4.0 CONTROL EQUIPMENT

Monitoring of the water reuse system and treated water quality represent an integral part of all system operation and maintenance functions. Monitoring criteria and parameter requirements should not be expected to remain uniform over the treatment facility's life cycle. Interim start-up concerns may be different than long-term system treatment performance considerations. The water quality design criteria should depend on the intended purpose or application of the water reuse scenario. Water quality monitoring requirements should be in proportion with the potential risk to public safety and health.

This section will describe some of the water quality parameters and their importance in water reuse applications. It will focus on available monitoring and control equipment, assessment of water quality parameters and a discussion on their suitability in residential sites.

A detailed review of basic laboratory and handling procedures is beyond the scope of this assignment. For specific information, readers should refer to: *Standard Methods for the Examination of Water and Wastewater*, published by the American Public Health Association, American Water Works Association and the Water Environment Federation.

4.1 Location of Sampling Points and Handling

Samples should be collected where the water enters the system and from representative points in the process train or distribution system. The following should be noted:

a) The sample must be truly representative of the whole.

b) All possible sources of sample contamination (sampling devices, motor exhausts, disturbing bottom sediments and the use of inappropriate containers) should be eliminated or reduced to a minimum level.

c) Because sample composition will change with time, continuous real time sampling and analysis equipment is preferred. When samples are delivered to a laboratory, rapid transportation is imperative especially for bacteriological analyses.

d) With sampling equipment and monitors, equipment calibration and quality control and assurance checks are important.

Standard protocols exist for routine sampling. Proper procedures for collecting samples should be followed to ensure that sample is representative of the water being sampled. Detailed instructions are provided in "Standard Methods for the Examination of Water and Wastewater" and government publications such as the Ontario Ministry of Environment publication "A Guide to the Collection and Submission of Samples for Laboratory Analysis, sixth edition, 1989".

It is further noted that in the case of laboratory samples, the laboratory conducting the test should be consulted for their particular sample handling requirements such as preservation techniques. For bacterial flora, the testing should start as soon as possible after collection and generally should not exceed 24 hours. Refrigerated storage of samples is recommended.

4.2 Monitoring and Testing Considerations

Monitoring of a water reuse system is an integral part of system operation and maintenance. The requirements for monitoring and associated reporting should depend on the purpose of the water reuse application and be proportionate to

the potential for public safety and health risks. Monitoring requirements for a small system sized for a single residential dwelling may have to be established on a case-by-case basis.

In locations where there are no structured municipalities, there may be some difficulty in ensuring compliance and adherence with regulatory requirements. To ensure a degree of success in such localities, the following guidance is provided for the system proponent.

1. Consider one of the following approaches concerning water quality/performance monitoring and sampling:

   a) Outside laboratory analysis;
   b) In-house laboratory analysis (test kits); and
   c) On-line analysis.

2. Consider the type of parameters to be monitored, number, frequency and handling requirements when deciding on the best and most economical approach to follow.

3. Consider the ease of operation, maintenance and calibration requirements associated with any continuous on-line monitoring equipment.

4. Consider whether there are any additional advantages to incorporating monitoring equipment into the process which can help to produce good quality water and maintain a smooth treatment process.

The United States Environment Protection Agency (USEPA) has proposed guidelines based on water reclamation and reuse practices in the United States, directed at states that have not developed their own regulations or guidelines. The guidelines for a toilet flushing urban reuse classification (including landscape irrigation) are as follows:

- pH - weekly;
- BOD - weekly;
- Turbidity - continuous;
- Coliform - daily; and
- Cl_2 residual - continuous.

The USEPA guidelines state: "While the guideline should be useful in many areas outside the US, local conditions may limit the applicability of the guidelines in some countries".

The NSF in their Basic Criteria C-9 indicate similar monitoring frequency requirements for reclaimed water with one notable change in the coliform sampling, namely, weekly testing where flows are less than 5,000 m^3/d. In a restricted public access category, TSS daily sampling is recommended. It would appear the USEPA and NSF guidelines are applicable for small to large municipal systems.

In single residential applications monitoring frequencies should take into account the system design, and operational environment. The following monitoring frequency are suggested for consideration in a residential toilet reuse application:

- Cl_2 residual - daily;
- turbidity - daily;
- coliform - weekly; and
- other parameters - occasionally as required to ensure proper operation.

The remaining sections of this chapter evaluate testing and monitoring equipment in the context of grey water treatment, specifically as it relates to the parameters being measured. Recommendations for acceptance of testing equipment, devices or approaches are provided based on the adaptability to housing conditions, degree of equipment sophistication and costs. These are some of the key issues which may complicate the use and operation of the equipment and subsequent acceptance by the residential owners.

4.3 Monitoring and Control Equipment

This section discusses the various key parameters, test procedures, equipment and instruments, in the following order:

- Microbiological testing;
- Chlorination/disinfection measurements;
- Conductivity;
- Colorimeters;
- pH meters;

- Spectrophotometers;
- Turbidity meters;
- Particle counters;
- Gene probe technology; and
- Automation.

4.4 Microbiological Testing

Description

There are a number of methods and tests used to measure microbiological populations. Methods such as Membrane Filtration, heterotrophic plate count and Most Probable Number methods involve a list of equipment such as: ampule beakers, autoclave, tubes, filter funnel manifold, incubators, microscopes, and other apparatus and reagents. These methods require adherence to standard procedures, assay preparations and examinations all which may require some degree of training and microbiological understanding. If there is no prior knowledge, these microbiological tests, with the possible exception of Presence/ Absence and other similar biological activity reaction tests, should be performed in a laboratory setting.

Some microbiological test kits using fermentation tubes or luminescence methods are suitable for rapid field testing applications. These test kits include the Presence/Absence (P/A) test for bacteriological analysis. P/A tests can be effective screening devices and typically require a pre-measured medium to be added to a sample. The sample is then incubated at 35 degrees C in an autoclave for 24 hours. Colour or luminescence changes indicate the presence of test organisms.

A bioluminescence P/A method requires a sensor to detect emitted light when the sample is combined with the reagent. The reagent, commonly ATP (adenosine triphosphate), reacts with organic chemicals (luciferin) produced by the micro-organism. The reaction process emits light which can be detected to confirm the presence of micro-organisms. There are other P/A detection methods being developed such as emerging gene probe technology.

Table 5
Microbiological Test Methods

Equipment Process	Product Availability	Cost per unit or test	Comments
Continuous on-line monitoring equipment	No		There are some promising technologies such as particle counters which help to establish particle size baseline measurements.
Portable lab	Yes	$250 to $1,000	Portable lab accessory kits are available. Include medium and apparatus. Also biotrace luminometers for rapid microbial testing of water are available.
Laboratory services	Yes	$4-5 per test sample	Cost may depend on the batch number of samples. All test methods (P/A, MPN, MF) are available in laboratories.
Test kits, test strips or Ampule tube tester	Yes	$5 per test unit	Pre-prepared Presence /Absence tube testers or paddle testers are available.

Recommended Test Method For Residential Water Reuse System:

Utilize laboratory services or Presence /Absence tube testers for water quality verification purposes on an as required basis.

Note: Costs are approximate only. Laboratory costs may vary from region to region.

Cost

The cost for disposable and presterilized systems for the detection of coliforms in water range between $4 to $6 per Presence/Absence test, exclusive of any laboratory equipment such as a small autoclave. The cost for a laboratory coliform test is approximately $5 per sample.

Microbiological test methods and costs are summarized in Table 5 on page 13.

4.5 Chlorination/Disinfection Measurements

Description

Chlorination has been the predominant microbiological sterilization method used in the last several decades. The success in achieving a sterile product can be measured using a microbiological test or can be implied through surrogate testing of disinfectant levels or residuals as in the case of chlorination.

The objective in using chlorine is to achieve a chlorine contact time and to maintain a chlorine residual in the water treatment/distribution system to help control the general bacterial population. Disinfection results can be disrupted by levels of high particulate matter in the water.

To understand the effectiveness of chlorination, pH levels in the water are important. This is because chlorine is present in the water as either an hypochlorite ion above a pH of 9 and predominates as hypochlorous acid below a pH of 6.5. The germicidal efficiency of hypochlorous acid is approximately two orders of magnitude greater (100 times) than the hypochlorite ion formation. Therefore for chlorination systems, a measure of residual chlorine and the efficacy of the disinfection process is related to water pH levels.

The results of all disinfection processes, whether chlorination, ozone or UV disinfection systems, can be affected by high turbidity levels in the water. Particles in the water can shelter micro-organisms or shield organisms against direct effects of the disinfection process. Similarly high levels of organic compounds in the water such as ammonia can bond most of the chlorine chemical thereby lowering residual concentrations.

Disinfection using ozone, a powerful disinfectant, is not affected by the pH or ammonia content of the water. Ozone can also eliminate taste and odours in the water, aid in the removal of trace metals which may cause colour problems, and destroy viruses and cysts which are not as susceptible to chlorine disinfection. To ensure an effective disinfection process, instruments or tools to measure water conductivity and ozone levels are helpful. Ozone can be measured using an ozone reagent kit and a colour chart or colorimeter.

The ultraviolet (UV) disinfection process can also represent an effective means to disinfect water. As with other disinfection unit treatment processes, it is important to know the quality of the water you are working with in order to obtain the desired sterilization results. Some water parameters which can inhibit the effectiveness of UV include total dissolved solids, turbidity, suspended solids, iron and manganese, therefore knowledge of the source water levels is helpful. Ultraviolet wavelengths can also be directly measured using specific wave length light meters.

Chlorine residuals can be measured using the following equipment:

- Automatic chlorine residual analyser;
- Chlorine reagent test kits (colorimeters); and
- Thiosulphate Titrimetric Method (drop count test kit).

Automatic chlorine residual analysers need to be checked regularly generally using an amperometric titrator. The pH of the samples should also be checked so that the major chlorine constituents in the water can be determined. The disadvantage of an automatic analyser is its high cost. Microprocessor technology is used in some water monitoring equipment to test for ozone and other ions such as residual chlorine based on a specific amperometric sensor and probe. Such systems are extremely accurate, are reliable, incorporate alarm status functions and can be readily incorporated into a fully automated system.

Table 6
Chlorine Residual Test Equipment

Equipment Process	Product Availability	Cost per unit or test	Comments
Continuous on-line monitoring equipment	Yes	Varies ($1 to $5,000+)	Cost can vary depending on the number of features, auxiliary and interface requirements. Chlorine analyser based on DPD colorimetric method. Method requires total chlorine indicator and buffer solutions.
Portable hand-held instrument	Yes	Available up to $1,000	Portable spectrophotometers, colorimeter and chlorine meters are available.
Laboratory services	Yes	$5 per test sample	Subject to batch quantity pricing.
Test kits	Yes	$1 to $2 per test unit	Pre-prepared reagents with colour tubes or colour discs.

Recommended Test Method For Residential Water Reuse System:

Chlorination is the recommended disinfectant for residential water reuse systems. The use of test kits for chlorine and pH, as required to verify the process residual level, are recommended. Disinfectant levels can be treated as a surrogate bacteria test. If other disinfectants, such as ozone, are used in the treatment process, particulars such as ventilation must be taken into account. Considerations for other chemicals should also be provided to maintain safe residual levels in the distribution system.

Note: Costs are approximate only. Laboratory costs may vary from region to region.

A widely accepted method of testing chlorine residuals are the DPD (diethyl-p-phenylene diamine) comparator kit. With the comparator or DPD colorimetric test, pre-packaged tablets are dissolved in a water sample in a test cell. The chlorine residual is determined usually within 30 seconds by comparing the sample to a test colour chart. This method is familiar to homeowners who routinely test residuals in outdoor swimming pools.

Disinfection test equipment findings and recommendations are summarized in Table 6.

4.6 Conductivity

Conductivity is the ability of a solution to conduct electric current. The total quantity of free ions in the solution determines the magnitude of conductivity. Conductivity is measured in micromhos/cm. The reciprocal of conductivity is resistance. A one micromho solution is one megohm in resistivity. Typical conductivity values which may be expected from various source waters are:

Distilled water:	0.5 - 2 micromhos
Tap water:	50 - 1,500 micromhos
Wastewater:	10,000 micromhos
Ocean water:	40,000 - 50,000 micromhos

Conductivity meter readings are sensitive to water temperature. Water has a conductivity change of +/- 2% per 1 degree C. The level of total dissolved solids in a sample, measured in parts per million is equivalent to the microhm range. The concentration of dissolved ionic matter in parts per million (PPM) often may be estimated by multiplying conductivity values by an empirical factor. The factor typically varies between 0.55 and 0.9 depending on various factors such as the solution type and temperature.

Electrodes in conductivity meters may require replacement annually. Different electrodes can be

used to monitor different measurements for instance oxidation - reduction potential and pH. Small pocket size conductivity meters are available for approximately $150. Portable and benchtop units are available between $1,000 and $2,000+. Costs will vary depending on the type of optional features requested. Electrode replacements can cost from $100 to $1,000.

Electrical electrodes can be used to monitor the oxidation-reduction potential of a sample stream. For pH measurements, a reference electrolyte is used to provide a current reference potential to measure pH. Different electrolyte filling solutions, and ion selective sensing elements can be used to measure orp, ammonia, chloride, and other elements.

Conductivity measurements represent an additional cost for residential water reuse systems and the use of conductivity meters is not considered necessary provided other parameters are being monitored. It is unlikely that conductivity meters will be installed in small residential water reuse system.

4.7 Colorimeters

Description

Colorimeters can be used to test a large number of chemical parameters. Such tests are based on the colours produced when reagent indicating solutions are added to a water sample. The colour intensity of the samples are compared to known colour standards. Light absorbency or percent transmittance results in comparison to programmed calibration tests are suggested to determine chemical concentrations.

Colorimeters come in a variety of sizes ranging from table top units, small pocket portable units, to simple reagent colour matching discs kits, colour cube kits, and drop count titration indicator solutions. Colour filter photometers which can selectively measure narrow wavelength bands from the broad spectrum of light wavelengths are available. The addition of photometric or galvanometer cells can also be used to improve the accuracy and consistency of the instruments and measurement results.

Colorimeters are used to test for over 100 different parameters. Parameters range from aluminum, chlorine, iron, manganese, nitrogen, oxygen demand (chemical), ozone, phosphorus, turbidity, volatile acids, zinc and many other substances.

The accuracy of visual colorimetric tests can depend on the individuals' eye colour sensitivity. As mentioned, accuracy can be improved through the use of photocell or galvanometer cell measurements. Such instruments measure the light transmission on a galvanometer and can incorporate calibration curve adjustments. Further accuracy refinements include multiple electro photometer cell measurements which split the light to minimize errors caused by light intensity variations.

Costs

There are a large number and type of colorimeters available ranging from portable units to desk top units. Instruments typically cost $750 and higher. Costs for colorimeter reagents may typically be expected to range between $20 to $60 per packages of 50 test units.

The decision to purchase a colorimeter for a residential water reuse facility depends on the number of parameters and sampling frequency required. The cost of a colorimeter can only be economically justified in comparison to laboratory test sample costs. It is unlikely this equipment can be economically justified for use in a single residential system unless other service providers such as a laboratory are not readily available or the number and cost of testing is high.

Colorimeter test equipment findings and recommendations are summarized in Table 7.

Table 7
Colorimeters

Equipment Process	Product Availability	Cost per unit or test	Comments
Portable hand-held instrument	Yes	$700	Can be used to test for a wide range of chemicals.
Laboratory services	Yes	$3 + per parameter	Cost depends on parameter sample
Test kits	Yes	Typically less than $1 to $5 per test, depends on parameter to be tested	A wide variety of reagents, tablets and colour tubes, colour discs and test kits are available.

Recommended Test Method For Residential Water Reuse System:

The use of colorimeters for a residential water reuse system does not seem economical. Laboratory services for small sample quantities are recommended.

4.8 pH Meters

pH measurements are a unit of measure describing the degree of acidity or alkalinity of a solution. pH is measured on a log scale of 0 - 14 with pH 7 neutral, below 7 acidic and above 7 basic.

There are a wide number of different pH measurement instruments, devices and test kits available. Electrical instruments involve a potentiometer measuring the voltage change over two purpose specific electrodes. Standard titration methods which are based on the colour change in a reagent buffer solution are available including standard colorimetric tests.

Determining the concentration of specific ion species involves measuring the flow of ions across a membrane or electrode. The pH meter is generally quite reliable and can remain calibrated for a long period of time. The probe electrode will age which can cause changes and necessitate periodic adjustments. Typical meter accuracy ranges between 0.01 pH to 0.1 pH.

pH measurements can be conducted using hand-held battery operated pH testers or buffers in a liquid or tablet form. pH testers can range from as little as $40 for a battery-operated hand-held unit to $2,000 for a deluxe pH meter. Litmus paper treated with a buffer can be used for individual test results which can cost less than $1 per test unit. Reagents and tablets are typically purchased in batch sample quantities. Laboratory testing can be approximately $3 per sample.

pH readings should be conducted in conjunction with chlorine residual testing if required. With a chlorination process, the use of a hand-held battery operated tester is recommended. pH test equipment findings and recommendations are summarized in Table 8.

Table 8
pH Test Equipment

Equipment Process	Product Availability	Cost per unit or test	Comments
Continuous on-line monitoring equipment	Yes	Varies ($1 to $5,000+)	Cost can vary depending on the number of features, auxiliary and interface requirements.
Portable hand-held instrument	Yes	$40 to $1,000	Small battery-operated units are available for approximately $40. Portable units can accommodate a number of different measurement functions such as temperature, ORP, conductivity, TDS, resistivity.
Laboratory services	Yes	$3 per test sample	
Test kits	Yes	$1 to $2 per test unit	Pre-prepared reagents with colour tubes or colour discs.

Recommended Test Method For Residential Water Reuse System:

If pH measurements are required, the use of a battery-operated portable unit is recommended.

Note: Costs are approximate only. Laboratory costs may vary from region to region.

4.9 Spectrophotometers

Spectrophotometers are used for wide spectrum white light, ultraviolet or infrared range sources. Typically a monochromator such as a prism is used to separate the white light source. The isolation of wavelengths depends on the parameter test to be performed. Spectrophotometers measure the radiant energy which passes through the sample with a photoelectric device.

Sophisticated types of spectrophotometers include atomic absorption spectrophotometry. Atomic absorption units use a light beam shone through a sample aspirated in a flame and atomized. The amount of light absorbed by the atomized element in the flame can be measured in the visible and/or UV spectrum. Each element has its own characteristic absorption wavelength. Comparison of resultant wavelength to a test element source lamp allows an analysis of the various elements and their concentrations to be determined.

Spectrophotometers can measure a wide range of chemical elements in the water. Some manufactures have portable kits which can convert a battery-operated hand-held spectrophotometer to a nephelometer for turbidity measurements and a DPD chlorine residual analyser.

Spectrophotometer equipment can be expensive and as such is expected to have limited application potential in a residential water reuse system. This equipment is typically used in a laboratory setting. Desktop spectrophotometer instruments costs may be expected to range between $3,000 and $4,000 for visible light range units and up to $6,000 for UV/visual range units. Equipment recommendations are summarized in Table 9.

Table 9
Spectrophotometer Equipment

Recommendations For Residential Water Reuse System:
The use of spectrophotometers in residential water reuse systems is expected to be limited due to high equipment cost and level of operating understanding required. It is recommended that laboratory services be used for various chemical test elements, if required.

4.10 Turbidity Meters

Turbidity is a measure of the inability of light to travel through water or the lack of clarity of a liquid. Turbidity makes water cloudy and aesthetically unpleasant. The cloudy appearance is caused by suspended particles such as clay, silt, bacteria or organic matter.

Turbidity meters shine light though a liquid. The amount of light scattered is proportional to the concentration of the suspended matter in the sample. The standard method to determine turbidity is based on a visual method, Jackson turbidity units (JTU). A measurement of light scattered at right angles to the incident light can be expressed as nephelometric turbidity units (NTU).

There is no direct relationship between the intensity of light scattered at 90 degrees and the Jackson candle turbidity. Using a formalin polymer reference, a concentration of formalin suspension defined as 40 nephelometric units has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, using a formalin preparation, NTU and JTU values are similar although not identical. The nephelometric method tends to be more applicable over a wide turbidity range and particularly with low turbidities in treated water (0 to 5 units). The Jackson candle turbidimeter is reported not to directly measure turbidity below 25 units.

Meter calibration is required to ensure turbidity readings are accurate. Calibration results are sensitive to the turbidity value, and various parameters in the water which affect light scatter such as air content, temperature, light source, distance traversed, and particle light scattering properties.

Turbidity meters are available in portable hand-held models, laboratory meters with a number of complementary display and operational features and process on-line turbidimeters. All meters need to be calibrated to ensure accuracy and correct adjustment. As with any optical measuring equipment, keeping the sensors and windows clean are vital.

Turbidity test equipment findings and recommendations are summarized in Table 10.

Table 10
Turbidity Meter Equipment

Equipment Process	Product Availability	Cost per unit or test	Comments
Continuous on-line monitoring equipment	Yes	Varies, up to $5,000	Cost can vary depending on the number of features, auxiliary and interface requirements.
Portable hand-held instrument	Yes	$700	Portable spectrophotometers, colorimeters, nephelometric meters and pocket turbidimeter.
Laboratory services	Yes	$5 per test sample	Subject to batch quantity pricing.
Test kits			Pre-prepared reagents available for use with portable instruments.

Recommended Test Method For Residential Water Reuse System:

Depending on the number of test samples required and timing for process status information, the total expenditure should determine the preferred method. Consider utilizing a pocket turbidimeter where the sample number warrant it, otherwise the use of laboratory services is recommended.

Note: Costs are approximate only. Laboratory costs may vary from region to region.

4.11 Particle Counters

Particle counter systems are used to track and monitor the number and size of particles in a sample. The advantage of particle counting is that it can be used in a continuous mode to monitor process results and track particular particle sizes such as those associated with parasitic cysts, and more. A basic counting system includes a number of photodiode sensors which detect various laser or light source wavelengths.

Particle counters represent a relatively new technology which can be useful in optimizing or monitoring treatment processes. Particle counters can detect sizes and numbers of particles in a process stream. There are no recognized calibration standards available to accommodate counters so individual process results can show variations between instruments.

The advantages of particle counting technology is that it allows water quality data by particle size percentile statistic to be compiled. This information can be used as a water quality reference index, indicator of treatment performance, water quality trends monitor, assistance in identifying maintenance operational needs and optimizing treatment performance. Investigation can be initiated when differences or fluctuations are observed.

Particle counts can be set or defined based on known operation limits such as treated water turbidity level. This might require defining the number of partial counts in the 3 to 15 micron (10 counts) and in the less than 2 micro range (30 counts). Based on the established operational limit, a sudden increase in the number of counts within this limit could indicate something has happened in the process.

The cost of particle counting technology is high, approximately $5,000 plus an additional $4,500 for analysis and evaluation software. This is beyond the affordability limit for small treatment process units at this time. The technology is expected to find an increasing use in the future as the need for quality assurance/quality control procedures increase. This technology is expected to fill a void in the complete particle counting technology and may even in the future allow the detection of submicron size particles such as viruses and perhaps the ability to identify some of the particle composition (organic or inorganic, viable or nonviable).

The current high cost of particle counters prohibits this technology from being considered in residential water reuse systems.

4.12 Gene Probe Technology

With the understanding of genetic DNA codes, the ability to detect complex groups of microbes will expand. Gene probe testing in the past was previously limited to conventional assays for a small group of indicator organisms. New approaches which are based on identifying nucleic acid sequences from a microbe genetic code are emerging and being developed.

This technology is expected to provide a valuable alternative to the more traditional microbial analyses currently used by the water industry (bacterial culturing on selective media). The application of gene probe assays for the detection of microbes in water indicate that gene probe technology may soon provide the water industry with simple, reliable and inexpensive methods for evaluating the microbial quality of water. Research efforts in this area are continuing.

4.13 Automation

The United States General Accounting Office cited in a review of States' water regulation compliance, deficiencies in operator skill as a major factor in water treatment quality problems. Similar findings have been noted in Canadian regulatory/optimization studies. It is expected that operators of residential systems will likely have little or no formal training, and as such, maintaining a consistent and acceptable water quality performance level will represent a paramount concern for private reuse systems.

With the advent of electronic control systems and microprocessors such as remote terminal units, programmable logic controllers (PLC) and other components of a supervisory control system, full or semi automation of treatment processes are possible. Advantages of an automated process are consistent and reliable water quality results. A number of computer expert systems are available or computer logic steps can be programmed to control, analyse and monitor the process.

For a small water reuse system comprising electronic valves, pumps, monitoring equipment and disinfection units, a small programmable controller can be used. A 20 or 30 point input/output programmable controller should be adequate for a small system. The cost of a PLC can range between $500 to $1,000 per unit. Units can be programmed either through a manufacture representative for logic function array inputs or by the operator directly with user-defined functions and entry keys. An alternative to programmable controllers is to consider using electronic relays which can provide control rudimentary functions based on a simple ON/OFF logic event sequencing.

Incorporation of controllers into small water reuse systems are recommended. Operation and maintenance control requirements should be considered at the facility planning stage.

5.0 DISCUSSION

This research paper discusses the requirements for a monitoring and control protocol for small residential water reuse systems. It reports the findings of a workshop held with key personnel from health and environmental agencies: On-Site Water Reuse in Canada - Ottawa '99 Protocol. Key agency discussions and findings concerning the requirements of a monitoring and control protocol for on-site water reuse systems are summarized as presented below.

Water Quality Parameters - Ottawa '99 Protocol

1. Microbiological parameters for reuse water in toilet applications should conform to a swimming and bathing body contact criteria. A range of 0 to 200 counts per 100 mg for fecal coliforms was deemed to be reasonable from a health or public acceptability perspective. Frequent testing for residual disinfectant levels, a parameter more readily tested for than a bacteria culture, can be used to confirm proper conditions are being maintained.

2. Turbidity should be considered in any monitored program. A maximum limit of 20 NTU was deemed to be a reasonable criteria.

3. Colour as an aesthetic parameter should be established based on local conditions since raw water in a community may already have high colour.

4. Testing for solids and conductivity, while helpful in the short term for commissioning the treatment system operation, was not considered necessary for a long-term monitoring program, providing the facility is being monitored for other key parameters.

5. It was concluded that establishing monitoring criteria for other parameters such as: organic chemicals; inorganic chemicals; and biological oxygen demand, while they may be necessary in the unit treatment design process, are not deemed necessary for water reuse in toilets.

6. It was determined that a residual disinfectant level should be maintained in the distribution system. Participants at the Ottawa '99 Protocol preferred chlorination to provide residual levels in the piping system.

7. If the facility is operating properly, then an aesthetically acceptable water (colour and odour) would normally be expected.

Monitoring Control Equipment

A number of monitoring instruments and test procedures are reported. Equipment findings and strategies for incorporation into monitoring programs in residential water reuse systems are presented below.

8. For microbiological testing and/or verification purposes, the use of a private laboratory or a simple Presence/Absence tube tester is recommended.

9. In chlorine residuals testing, the use of test kits is recommended, which can be cost effective.

10. The use of specific testing equipment such as conductivity meters, colorimeters and spectrophotometers for continuous monitoring or in-house testing purposes, is considered to be too costly for a residential application. When specific organic or inorganic chemical tests are required, the use of a laboratory to perform such testing should be considered.

11. Measurements for turbidity are recommended as part of any monitoring program. Should the number of samples be sufficient to warrant the purchase of an instrument, then a portable turbidimeter should be considered, otherwise, it is recommended that laboratory services be used to conduct turbidity tests.

12. There are a number of new emerging instruments and techniques such as particle counters and gene probe technologies which hold considerable promise as monitoring tools. These technologies might provide the water industry with reliable and inexpensive methods to conduct parameter testing. Future research and/or lower instrument costs will be required before such technologies become widely available.

13. The use and incorporation of automation controllers into small water reuse systems are recommended.

The findings in this water quality guideline provide the basis for an interim monitoring tool protocol for indirect water reuse systems (toilet flushing). Key parameters to be monitored are identified along with suggestions on the use of control equipment and test procedures for a residential water reuse monitoring program.

It is important to emphasize that the findings and recommendations in this report do not constitute a definitive criterion or risk assessment but rather provide guidelines for consideration in a monitoring program. Each regulatory agency is expected to have their own specific concerns which may have to be addressed separately on a case-by-case basis. The information in this paper is expected to provide a good reference and starting point which can be cited by regulatory agencies, designers and homeowners in deciding the various monitoring parameters and control system components for a residential water reuse monitoring program.

APPENDIX A
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APPENDIX B
ON-SITE WATER REUSE IN CANADA - OTTAWA '99 PROTOCOL

AGENDA

- Introduction
- Protocol Objectives
- Background
  - Water Reuse Systems
  - Barriers to the Application of Reuse Systems
- Interaction
  - Parameters to be Monitored
  - Type of Monitoring
- Where to Go From Here

INTRODUCTION

- Welcome/Thanks
- CMHC's Role/Activity in Water Reuse
- Describe Proposal
- Participants at Round Table
- Participants' Experience
- Introduce Consultant Team
- Where to Go From Here/What to Do With Information Received at Round Table

REQUIREMENTS

- Notes/Pencils
- Coffee/Donuts
- Overhead
- Clip Board/Stand
- Scotch Tape/Appendix
- Identification of Players/Seating Arrangements/Name Plates
- Resumés
- Note Taker
- Copy of MOE Drinking Water Objective Handout
- Other Handouts?

BARRIERS TO WATER REUSE

- Regulatory
  - plumbing/building codes/municipal by-laws
- Absence of controls/guidelines/ directions in Canada
- Absence of firm data on performance of reuse systems
- Abundance of water in Canada

PROTOCOL OBJECTIVES

- To Establish an Interim Monitoring Protocol for Non-Potable/Non Body Contact Reuse Systems.
- To Identify Parameters to be Monitored.
- To Establish Type of Monitoring Program to be Conducted.

WATER REUSE SYSTEMS

- Black Water/Grey Water/Light Grey Water
- Research Examples CMHC
- Reuse
  - Drinking
  - Body Contact
  - Non-Potable/Non Body Contact
    - Washing
    - Irrigation
    - Toilets

WATER REUSE PARAMETERS

- Treat to The Highest Degree/Practical/ Reasonable

A. Drinking Water Parameters
B. Body Contact Parameters
C. Non-Potable/Non Body Contact Parameters
   - Washing
   - Irrigation
   - Toilets

PARAMETER

REASONS TO INCLUDE	PROBLEMS/DIFFICULTIES
GENERAL FREQUENCY	
Short Term	
Long Term	
Limits Range:	
General Conclusion:	

PARAMETERS

TOILET REUSE

A. Bacteriological
   - Coliform

B. Physical/Chemical
   - Turbidity
   - Colour
   - Total Suspended Solids
   - Total Dissolved Solids
   - Conductivity
   - pH
   - Inorganic Chemicals
   - Organic Chemicals

C. Biochemical Oxygen Demand (BOD)

D. Others

MONITORING PROTOCOL

Monitoring Required

- On-Line Automatic Monitoring
- Field Kits
- Grad Samples - Commercial Laboratory
- Composite Samples - Commercial Laboratory

Frequency - Standards

TOILET REUSE PARAMETERS

AWWA Report

Restricted Urban Reuse category which includes irrigation, toilet, flooding, fire, street cleaning.

Turbidity.....2 - 5 NTU
Suspended Solids ..5 - 30 mg/L
Coliform.....75% of FC samples over 30 period below detectable. No sample above 200/100 ml
BOD .....5 - 30 mg/L

CMHC Conservation Co-op

Parameter	Concentration of Treated Light-Greywater
Total Suspended Solids	10 mg/L
Turbidity	20 ntu
Colour	30 tcu
Bacteriological	Conform to Drinking Water Standards
Iron	1.0 mg/L
Manganese	0.5 mg/L

CMHC Light Grey Option - Townshend

Turbidity .....20 ntu
Colour .....30 tcu
Manganese .....0.5 mg/L
Iron .....1.0 mg/L
Copper .....1.0 mg/L

On-Site Water Reuse in Canada Ottawa '99 Protocol Participants

Goff Jenkins
Drinking Water Specialist
Drinking Water, Wastewater and Watershed Standards Section
Standards Development Branch
Ontario Ministry of the Environment and Energy
2 St. Clair Avenue West
12th Floor
Toronto, ON M4V 1L5

Michèle Giddings
Senior Evaluator
Drinking Water Section
Product Safety Bureau, Environmental Health Directorate
Health Protection Branch, Health Canada
Jeanne Mance Building
Tunney's Pasture, Address Locator 1912A
Ottawa, ON K1A 0K9

Steve Burns
District Manager, Ottawa District
Eastern Region, Ontario Ministry of the Environment and Energy
2435 Holly Lane
Ottawa, ON K1V 7P2

T. Duncan Ellison
Executive Director
45 Rideau Street, Suite 402
Ottawa, ON K1N 5W8

Gillian Huntley
Water Management Analyst
Water Issues Branch
Ecosystems and Environmental Resources Directorate
Environment Canada
351 St. Joseph Blvd
Hull, Québec K1A 0H3

Al Raven
Director, Environmental Health, Communicable Disease Control Division
Region of Ottawa Carleton Health Department
495 Richmond Road
Ottawa, ON K2A 4A4

Trish Johnson-Cover
Manager, Waste Diversion Branch and Water Efficiency Strategy
Regional Municipality of Ottawa-Carleton
Cartier Square, 111 Lisgar Street
Ottawa, ON K2P 2L7

Christopher Ives
Senior Researcher
Canada Mortgage and Housing Corporation
National Office, 700 Montreal Road
Ottawa, ON K1A 0P7

Stéphanie McFadyen
Researcher
Canada Mortgage and Housing Corporation
National Office, 700 Montreal Road
Ottawa, ON K1A 0P7

Cate Soroczan
Researcher
Canada Mortgage and Housing Corporation
National Office, 700 Montreal Road
Ottawa, ON K1A 0P7

Robert Dunn
totten sims hubicki Associates
240 Terence Matthews Crescent
Kanata, ON K2M 2C4

John Stidwill
totten sims hubicki Associates
240 Terence Matthews Crescent
Kanata, ON K2M 2C4

Jason Schaefer
totten sims hubicki Associates
240 Terence Matthews Crescent
Kanata, ON K2M 2C4

Visit our Web site at: www.cmhc-schl.gc.ca