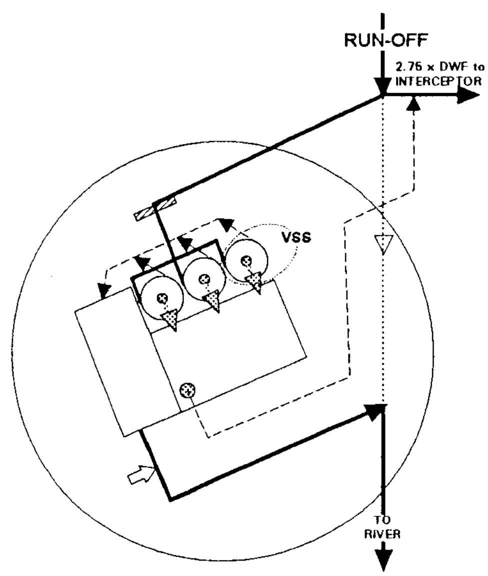
City of Winnipeg
Waterwork, Waste
and Disposal Department

Phase 1 Technical Memorandum for

Combined Sewer Overflow Management Study

CONTROL ALTERNATIVES

Technical Memorandum No. 5



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1.0 INTRODUCTION

1.1 BACKGROUND

Technical Memorandum 4 (Receiving Stream) reviewed the water quality of the Red and Assiniboine River, the manner in which discharges from Winnipeg affect that quality, the Manitoba Surface Water Quality Objectives (MSWQO) and the manner in which the Clean Environment Commission (CEC) considered that the effects of Winnipeg discharges should be studied. The conclusion of this review was that Winnipeg CSOs are particularly relevant to the following water quality issues:

- *Aesthetics* - the river should be free from constituents attributable to sewage (e.g., floatables, scum, grease). The numerous outfalls in Winnipeg (both CSO, LDS and sanitary sewerage) represent a pollution control issue in this regard;

- *Microbiological quality* - the microbiological quality of the Red and Assiniboine river, as measured by fecal coliforms, exceeds the MSWQO, chiefly because of discharges from the City's Water Pollution Control Centre (WPCC) effluents during dry weather and CSOs during wet weather.

- *Dissolved oxygen (DO)* - CSOs are a potential concern with regard to the oxygen resources in the rivers, as they represent a Biochemical Oxygen Demand (BOD) load on the rivers. However, actual monitoring of DO in the rivers, both prior to the CEC river hearings and after, have indicated that CSOs are not an apparent issue with regard to DO. It has been recommended that more monitoring data be obtained on this issue.

In keeping with the foregoing, and previous discussions in other technical memoranda, the water quality issues associated with CSOs in Winnipeg relate to aesthetic considerations and microbiological quality. Accordingly, the main focus of the review of CSO control options, as discussed below, relates to these water quality issues.

2.0 COMBINED SEWER OVERFLOW CONTROL OPTIONS

In developing conceptual control options for the City of Winnipeg, the range of techniques used in other North American cities (U.S.A. and Canada) was investigated. Representatives of the study team have attended all of the Water Environment Federation (WEF) CSO specialty conferences to date, where numerous case histories have been presented. In addition, the Water Pollution Control Federation (WPCF) published the Manual of Practice entitled "Combined Sewer Overflow Pollution Assessment" (WPCF 1989[1]). All of the above experience, as well as information developed in the course of members of the study team undertaking investigations for others, were used to outline potential control options.

2.1 AVAILABLE OPTIONS FOR CSO CONTROL

There are a multiplicity of options available for CSO control:

- no action;
- non-structural/best management technologies;
- minimal structural alternatives;
- structurally intensive alternatives.

In applying any of the options to a CSO control strategy, it would be expected that a number of them would be used together. In addition, it is likely that they would be implemented in a progressive manner, rather than all options being applied at once.

The following is a more or less comprehensive list of available options.

2.1.1 <u>No Action</u>

No action effectively means continuation of the status quo. In the case of Winnipeg, this does not necessarily mean *no action* with regard to CSO control but rather would include the following:

- *Roof leader disconnection* - The City of Winnipeg have been undertaking a program to encourage the disconnection of roof leaders across the combined sewer districts. The impact of this option is to increase the overland flow time and therefore decrease the peak combined sewer discharge.

- *Sub-district sewer separation* - During the course of basement flood relief program, wherever economically advantageous, small areas within the CSO districts have been separated. The effect of this is to reduce the quantity of sanitary sewage in the CSO, and hence reduce fecal coliform discharges to the rivers. Floatables would not be affected to the same degree, although floatables associated with sanitary sewage would be reduced.

- *Catch basin inlet restrictions* - As a part of the basement flood relief program, the basic design of the relief system has been to protect against flooding caused by storms with a five year return period. In order to increase this to a 10 year return storm, catch basin inlet restrictions have been used. Accordingly, the road surface has been used to store the excess rainfall and therefore to dampen the peak flow through the relief sewers. This would not likely affect the load of floatables on the rivers but would affect the rate of discharge of fecal coliforms to the rivers.

- *Public education* - The City of Winnipeg has endeavoured to reduce the amount of debris discharged to the river through a pamphlet encouraging the public to be more conscious and conscientious in litter control.

2.1.2 <u>Non-structural/Best Management Technologies</u>

Non-structural/best management technologies involve relatively low cost optional or functional modifications to existing facilities. Any construction associated with these technologies is generally very small. The options include the following:

- *Sewer Flushing* - Sewer flushing restores the capacity of sewers by removing settled sediments. Quality improvements are also realized by the removal of settled material from the system. Sewer flushing is indicated for flat sewers where the operating velocity is not sufficient to keep sediments in suspension and therefore convey them with each runoff event.

- *Catch Basin Cleaning* - Catch basin cleaning serves to remove pollutants from the watershed rather than allowing them to overflow to the receiving water with CSO during a runoff event.

- *Street Sweeping* - Street sweeping removes from the catchment surface debris and pollutants which would normally wash off the streets into combined or storm sewers and possibly overflow to receiving waters.

The above three activities comprise housekeeping on the part of the municipality and represent good practice. They are generally labour intensive and, unless practiced frequently and routinely, may not necessarily have a high return on the investment of time.

In the case of Winnipeg, street sweeping is generally done once or twice a season. However, in the downtown areas this is probably undertaken once or twice a week. The latter could make a significant contribution to the removal of debris and sediment from CSOs.

- *Overland flow attenuation* - Stormwater runoff can be controlled on the surface by the use of ditches and swales. Under this category this application would generally be through the use of existing features.

- *Roof Leader Disconnection* - In the older portion of many cities, roof leaders are connected to the municipal sewer system. These areas contribute significant runoff directly to the system. Disconnection of the roof leaders is a very effective means of reducing this runoff where site conditions and grading allow roof runoff to be directed to sufficiently sized, vegetated areas. The City of Winnipeg has made concerted efforts to encourage residents to disconnect roof leaders. This program has been about 95% successful. They continue to encourage residents in this regard.

- *Chemical addition* - Chemical addition of ferric chloride or other coagulant can increase the removal efficiency of a treatment process. Issues such as handling and storage safety, cost and efficiency should be considered if chemical addition is contemplated. This option is only used in conjunction with other (more capital intensive) technology.

- *Control of De-icers* - Control of deicers removes pollutants such as chlorides at source to reduce pollutants discharged to the receiving water. Alternate deicers with fewer environmental impacts are being developed, but currently are not economically comparable to chlorides.

- *Control pesticides and fertilizers* - Control of fertilizers and pesticides removes these pollutants at source to prevent them from entering receiving waters. The majority of fertilizers and pesticides, if properly applied, are reasonable innocuous to the environment, but should regardless be applied as a last resort and sparingly.

The latter two options comprise quality control. They would have little or no impact on fecal coliform. Fertilizers are more likely to cause an aesthetic problem in Lake Winnipeg than in the Red and Assiniboine rivers, given the natural turbidity of these rivers.

- *Erosion/sediment control* - Erosion/sediment control measures reduce the potential for eroded materials to enter the sewer system and thence to receiving waters. Erosion/sediment control measures can be required at construction sites and storage areas for salt, sand and other pollutants.

- *Discharge by-law review/implementation process* - Discharge By-Laws stipulate that undesirable industrial and residential flows cannot be discharged to the sewer system. By-Law review, implementation and enforcement ensures that By-Laws are equitable, effective and being adhered to. Winnipeg has such a By-law.

- *Industrial runoff control* - Runoff from industrial areas may contain the residue from chemicals that are spilled during handling and storage. Gasoline and oil spills are typical pollutants often found in service areas. Industrial runoff control requires that the runoff from these areas be intercepted and the pollutants separated from the runoff and disposed of elsewhere.

- *Enforcement of Anti-litter by-laws* - A number of localized sources may contribute to water pollution, including animal, pet and bird faeces, boats, people, refreshment stands, etc. The enforcement of anti-litter laws can assist in reducing these non-point sources of pollution.

The latter four options comprise good practice. They improve the quality of the stormwater discharges through a reduction of litter and sediments.

- *Water conservation* - Water conservation, whether residential, commercial or industrial, reduces the amount of dry weather flow in the sewer system thereby theoretically providing more capacity for stormwater and reducing the volume of CSO. Most municipalities will be practising water conservation for its own sake, so any benefits to CSO control will be realized. Winnipeg has initiated a water conservation program with a target of reducing consumption by 10%.

- *Public Education* - Public education with respect to the uses and impacts of discharges to storm, sanitary and combined sewers, as well as the issues and constraints associated with available alternatives, can greatly assist a government endeavouring to implement pollution control. As indicated above, the City of Winnipeg have initiated a program of public education to encourage a reduction of litter on land and the disposal of unnecessary materials in sanitary wastewaters. Public education is always an important factor for a municipality. Not only does it promote good practice but it keeps the City's efforts to control pollution in the public's mind on a continuous basis.

2.1.3 Minimal Structural Alternatives

Minimal structural technologies would involve significant, but not substantial, structural modification or rehabilitation of existing facilities. The options included are as follows.

2.1.3.1 Storage Options

- *In-line storage* - In-line storage under this option, would comprise simple and more or less fail-safe means of optimizing the use of available storage in the combined sewer trunks and relief systems, where practicable. Such storage would be effected by weirs or by level controlled gates with some means of ensuring that the gates open if the systems fail.

- *Flow balancing* (between districts) - In undertaking the basement flood relief programs, the City of Winnipeg has been able to combine the relief systems of more than one district. Apart from optimizing in-line storage, however, it is unlikely that the current arrangement of districts and the interceptor will lend itself to flow balancing between districts.

- *Open space and grassed area detention* - Naturally available park land and the like can be artificially contoured so as to provide overland flow attenuation during storms. Such facilities are not as costly nor are they dedicated to storage, such as stormwater management ponds.

- *Catch basin inlet control* - Inlet control, sometimes referred to as source control, is achieved by restricting the inlets to the conveyance system at the source of the runoff. Typical locations for inlet control include rooftops, parking lots, industrial yards, or city streets (catchbasin restrictors). In Winnipeg, inlet control for catch basin restrictions has been implemented in some of the CSO districts. As noted above, the use of storage on streets through inlet control in Winnipeg has been designated for upgrading the basement flooding protection.

- *Porous pavement and porous gutter* - Porous pavements and gutters are constructed from a special asphaltic mix which contains a lower proportion of fines, thereby leaving void spaces and allowing runoff to filtrate to the ground. Porous gutters may consist of perforated pre-cast gutters permitting infiltration into local soils. Since paved surfaces contribute significant amounts of runoff to the system, porous pavements and gutters have potential as a stormwater control alternative. Constraints similar to those described for infiltration apply to porous pavement, and as porous pavement does not have all of the same structural qualities as standard pavement, it is not suitable in all applications. Given the generally heavy, dense clay soils of Winnipeg, these options are unlikely to become major forms of runoff attenuation.

- *Infiltration trenches and basins* - Infiltration trenches are long, narrow facilities, while basins can take any other shape. For *in situ* infiltration to be effective, the ground water table must be sufficiently low and soil infiltration rates must be sufficiently high. This method encourages recharge of the groundwater table, removes a significant number of pollutants from stormwater, and can also assist in reducing peak flows in the system by acting as a source control. Again, because of the extremely heavy, dense clay soils, this option would be completely impracticable in the Winnipeg area.

- *Increase pervious areas* - An increase in pervious areas in a watershed can help to reduce the amount of runoff which that area produces. Control of lot densities is a specific means of increasing pervious areas. Increases in pervious areas can only be achieved in re- or new development areas.

- *Dunker's flow balancing method* - A Dunker's flow balancing system consists of series of heavy, hanging screens which provide a storage area within an existing waterbody. The incoming CSO or stormwater displaces the lake water and is then retained for *in situ* treatment or pumping to treatment. A flow balancing method can be considered where an appropriate offshore site exists.

- *Interception Optimization* - Interception optimization involves the deterministic adjustment of interceptor levels and controls to optimize the storage within the sewer system and reduce CSO. Interception optimization is an inexpensive means of reducing volume of CSO.

2.1.3.2 Maximize Treatment Plant Capacity

- *Maximize wet weather flow treatment at the water pollution control centres* - In Ohio, the regulators allow the municipal treatment facility effluents to exceed normal dry weather limits for Total Suspended Solids (TSS) and BOD. They encourage the passage, through the secondary system of as much flow as the treatment system can sustain without being washed-out. This reduces the quantity of flow that receives only primary treatment and improves the overall effluent quality.

2.1.3.3 Flow control

- *Inflow/Infiltration (I/I) control* - I/I control reduces the amount of inflow and infiltration into combined sewers, thus reducing the volume of CSO during a runoff event, and also reduces the volume of flow to the plant for treatment. Sources of removable infiltration include leaking sewers, services and manholes. Inflow sources include foundation drains connected to the combined/sanitary sewer system and illegal connections of catch basins to sanitary sewers. Connection of foundation drains to sanitary sewers is, however, acceptable in order to provide a high level of protection from the fluctuation of the hydraulic grade line of storm sewers which can lead to structural damage to buildings. (As of 1991, the Ontario Building Code will not permit foundation drains from new developments to be connected to sanitary sewers).

- *Sewer system rehabilitation* - Sewer system rehabilitation is generally carried out to enhance structural capability, restore flow carrying capacity and to reduce extraneous flows entering the sewer. Rehabilitation methods include spot repairs, cutting of roots and protruding connections, and various insertion lining methods.

- *Hydraulic control devices (regulators)* - Regulators are key components of an in-line storage system and may consist of weirs, gates, vortex valves, inflatable dams, control of pumping, etc., to regulate the effluent rate from the sewer system to treatment facilities and also to regulate overflows. Regulators are used to optimize the sewer system operation.

2.1.4 Structurally Intensive Alternatives

2.1.4.1 Storage Options

- *Surface Stormwater Control* - Stormwater runoff can be controlled on the surface by the use of ditches, swales, open channels and stormwater management ponds. These methods generally intercept runoff from a sizeable area and help to reduce the peak flows that would result from releasing these flows uncontrolled. For numerous ponds, care must be taken to avoid attenuating downstream peaks that would consequently coincide with upstream peaks, thereby increasing the total peak flow.

- *Surface Storage* - Surface storage is used primarily for stormwater detention. Stormwater is discharged into the storage facility and then released back into the system when capacity becomes available (generally after a runoff event).

- *Subsurface Tank Storage* - Subsurface storage involves an underground storage system using advanced tankage concepts and equipment. It is most appropriate for storage of CSO due to potential health hazards of combined sewage. Subsurface storage is most readily provided at the downstream end of a catchment with facilities for draining by gravity or pumping to treatment.

- *Tunnel Storage* - Deep underground tunnels can be used for storage and conveyance of CSO where near surface space is unavailable due to existing services. Inflow to a tunnel is usually by deep shafts (vortex chambers) and outflow to the interceptor sewers/treatment facilities is by pumping.

- *Additional Conveyance/Storage* - Additional conveyance systems such as oversized interceptor sewers and/or storage elements and tanks can be used to provide in-line storage to attenuate peak flows.

2.1.4.2 Real-time Control

Real time control is an operational system whereby field data consisting of rainfall, sewer flows and regulator settings are regularly monitored and transferred to a cental computer on a real time basis. The data measured is then analyzed and this information is used to operate regulators within the system to achieve better performance of the system, particularly during wet weather events, resulting in more efficient system usage and reduced overflows to receiving waters. The function of real-time control differs from in-line storage in that the intent is to make use of all available information and to optimize the in-line storage, system wide where practicable.

2.1.4.3 Sewer Separation

Sewer separation is a viable alternative for areas which are serviced by combined sewers. Separation isolates the sewage flows from the generally less polluted stormwater flows so that each can be dealt with appropriately. Research indicates that sewer separation alone does not significantly reduce pollutant loadings to receiving waters. This particularly applies to BOD and TSS. Sewer separation does, however, significantly lower the level of fecal coliform discharges as compared to CSO. Sewer separation is highly effective for areas experiencing flooding problems.

2.1.4.4 Partial Separation (roads only)

Partial (road) separation involves only separating the road drainage (catchbasins) into new storm sewers. Separation traditionally is difficult and very disruptive in a city because of narrow and over-utilized utility corridors.

2.1.4.5 Full separation (roads and houses)

Full separation consists of separating both the road drainage and the private side connections into separate sewers. Full separation can be very difficult due to the legal implications of requiring a homeowner to change the private side connection if required.

2.1.5 <u>Treatment Alternatives</u>

2.1.5.1 Central Treatment

- *Primary, Secondary or Tertiary* - The level of treatment will be dictated by the sensitivity of the receiving waters. Treatment may consist of primary (sedimentation), secondary or tertiary. The CSO collection system may also dictate the level of treatment to be applied. As already noted, the main concerns insofar as river quality is concerned are aesthetics and fecal coliform. This being the case it is unlikely that treatment in excess of primary will be required, since, in combination with disinfection, it will address both of these concerns.

- *Increase Existing Treatment Capacity* - Treatment of CSO and/or stormwater could be undertaken at the existing sewage treatment facility by increasing its capacity (assuming capacity is not currently available).

2.1.5.2 Satellite Treatment

In order to address concerns with regard to microbiological contamination of the rivers, disinfection of CSOs will be required. In order to disinfect CSOs some form of upstream solids removal will be required in order to render disinfection cost-effective. These will be end-of-pipe facilities and have been designated as satellite treatment devices.

- *Screening Devices* - Screening can provide high rate separation of gross solids from CSO and stormwater. Types frequently used include mechanically cleaned permanent screens, travelling screens and drum screens. Screens are designed to remove a given particle size and are very effective in removing solids of the design size and larger. It should be noted, that fine screens suffer from relatively high cost of maintenance and are susceptible to clogging and mechanical difficulties, particularly as the solids removal size is decreased. A courser screening device would likely be needed upstream of other downstream treatment devices, primarily for the removal of larger suspended solids and protection of the downstream equipment.

- *Vortex Solids Separators* - Primary treatment by vortex solids separators can be undertaken for individual outfalls or by the combination of two or more outfalls where feasible.

- *Sedimentation Basins* - Sedimentation basins are designed to remove sediments from CSO or stormwater through the process of settling. The supernatant, or treated water can be discharged to receiving waters (after disinfection, if required) while the underflow, or settled material, can be sent in suspension for treatment elsewhere. Sedimentation basins are a well known and frequently used technology. As a result of the low hydraulic loading used to promote settling, sedimentation basins may require large tracts of land. They also require operator attention, and handling and disposal of settled solids. Some installations use flushing techniques to gather the solids for conveyance to the interceptor and the wastewater treatment plant.

- *Retention/Treatment Basins* - One variation of the use of sedimentation on CSOs is a device termed "Retention/Treatment Basins" (RTB). These devices are sized so as to store the discharge from a "design" storm. Storms in excess of the design return frequency continue to pass through the tank up to the design sedimentation capacity and then discharge to the river with the equivalent of primary sedimentation. In the case of the design of the sedimentation aspect, higher rates of flow would be used than would normally be used in the sewage treatment plant. Flows in excess of the design sedimentation capacity bypass the device and discharge directly to the river.

- *Disinfection* - Disinfection is used to reduce the concentration of pathogens in wastewater prior to discharge to receiving waters. When used in conjunction with upstream solids removal, such as vortex solids separators, disinfection can remove in excess of 99.99% of total coliforms. Disinfection alternatives include chlorination, ultraviolet light, ozone and bromium chloride. The manual of practice on combined sewer overflow pollution abatement (WPCF 1989) notes that disinfection can only be used in conjunction with some form of upstream solids removal in order to be cost-effective.

3.0 REVIEW OF LOCAL STUDIES

The City has, since 1976, commissioned a number of studies of the overall combined sewer system and of individual combined sewer districts. These studies were primarily directed at relief of basement flooding but many have also investigated pollution control aspects of CSOs. The basement flooding aspects of these studies are discussed in the Technical Memorandum No. 2 - Infrastructure. The studies which dealt with pollution control are:

- An overview study was undertaken in 1977, which reviewed the quantity and quality of CSOs on a regional basis and estimated the discharges from each of the combined sewer districts within the City (MacLaren 1977).

The district studies which also evaluated quality aspects of CSO included the following:

- Clifton district (MacLaren 1978/79);
- St. John's/Polson/Jefferson (IDE 1980);
- Ash (Dillon 1981);
- Mager (IDE 1992);
- Tylehurst (UMA 1993);
- Linden-Hawthorne (Wardrop/Tetr*ES* 1993/94);
- Selkirk (IDE Selkirk 1993);
- Armstrong (IDE Armstrong 1993);
- Baltimore (IDE Baltimore 1993).

These studies investigated ways to improve the quality of discharge and the means of reducing the volume and frequency of CSOs.

A summary of the pollution control options considered in the Winnipeg basement flooding relief studies is given on Table 4-1. The studies are generally listed in order of occurrence,

Table 4-1

SUMMARY OF WINNIPEG STUDIES FOR BASEMENT FLOODING RELIEF - POLLUTION CONTROL OPTIONS

DISTRICT	OPTIONS CONSIDERED: NO ACTION	SURFACE TREATMENT	ON-SITE RUNOFF CONTROL	STREET CLEANING	SEWER FLUSHING	SEWER SEPARATION	OVERFLOW REGULATION	IN-LINE STORAGE	OFF-LINE STORAGE	VORTEX SOLIDS SEPARATION (VSS)	SCREENING	RETENTION / TREATMENT	WASTEWATER TREATMENT FACILITY	DISINFECTION	OPTION RECOMMENDED *(IN PLACE *)*	REASON *(IN ADDITION TO HYDRAULIC RELIEF)*
CLIFTON			●	●	●			●		●			○		IN-LINE STORAGE WITH LEVEL CONTROL	
ST. JOHNS/POLSON/ JEFFERSON			●	●				●		●		●	○		IN-LINE STORAGE WITH REAL TIME CONTROL	
ASH				●	●	●		●	●			●	○		SHORT TERM - IN-LINE STORAGE; LONG TERM - SEPARATION	
MUNROE/ROLAND/ HART				●	●	●		●		●	●	●	○		IN-LINE STORAGE/ REAL TIME CONTROL	
TYLEHURST				●	●	●		●	●	●			○		IN-LINE STORAGE/ 14 % SEWER SEPARATION	
MAGER	●					●		●	●	●	●		○	●	FURTHER STUDY IN-LINE 50% SEWER SEPARATION	LIMITED AREA FOR OFF-LINE
SELKIRK DISTRICT	●					●		●	●	●	●		○	●	IN-LINE (REAL TIME CONTROL) 12 % SEWER SEPARATION	IN-LINE ADEQUATE
LINDEN/HAWTHORNE			●	●	●	●		●	●	●	●	●	○	●	IN-LINE STORAGE/ PARTIAL SEPARATION & STUDIES (END-OF-PIPE OPTIONS)	
ARMSTRONG	●					●		●	●	●	●		○	●	NONE FOR POLL. CONTROL SEWER SEPARATION FOR B.F.	
BALTIMORE	●					●		●	●	●	●		○	●	IN-LINE STORAGE THROUGH LARGER COLLECTORS	

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with the studies from Tylehurst on having been undertaken in the 1990s. Of the earlier studies, Clifton and the St. John's/Polson undertook a fuller investigation of pollution control options than did Ash and Munroe/Roland/Hart. In both cases, the technology of choice was in-line storage. In the case of Clifton, a level actuated control gate was proposed with the level of the gate opening being dictated by the level of storage behind the gate. This alternative was designed and would have been tendered, had it not been decided that the basement flooding relief program excluded pollution control. In the case of St. John's/Polson the proposal was for a more complex control system which would have included a forecast of storm events and thence optimizing storage. Some aspects of the Selkirk, Armstrong, Baltimore and Mager studies and the Linden/Hawthorne study are discussed below.

3.1 SELKIRK, ARMSTRONG, BALTIMORE, MAGER STUDIES

Of the later studies, the Selkirk, Armstrong, Baltimore and Mager all used a similar approach to evaluate pollution control options. This comprised the development of a complete duration series of rainfall events over the 29 years of rainfall data available. Hyetographs were then developed for a one week, two week, one month, three month and six month recurrence interval storm. The return period represented the average interval of time within which the magnitude of the event would be equalled or exceeded. Having established these rainfall intensity data, the year 1971 was selected as representative of a typical year, because the total rainfall was 14.9 inches and the distribution recurrence interval of storm events appeared reasonable (IDE 1993). In analyzing the effectiveness of pollution control options, the results of their application to the 1971 rainfall period was determined.

As indicated in Table 4-1, no pollution control option was recommended for Armstrong, since the basement flooding option involved completion of sewer separation in the Armstrong district. Accordingly, fecal coliform was already substantially reduced and sewage attributable to floatables would also be substantially reduced. The other three districts recommended in-line storage, with real-time control similar to the St. John's/Polson proposal, i.e., more sophisticated development of an in-line storage control system than was proposed for Clifton.

The Selkirk district is of particular interest since there is a potential storage volume of approximately 20,000 m^3 of in-line storage. Even discounting this to 75%, because of the difficulty in controlling the storage level precisely, would still allow some 15,000 m^3 of available storage (IDE Selkirk 1993). There may be other factors which mitigate for or against Selkirk or other districts in considering the use of an in-line storage pilot plant, but Selkirk should certainly be included in the evaluation. Of interest in the Selkirk analysis was the assessment of the time it would take to drain the stored wastewater in order to provide adequate pipe capacity. The analysis indicated that 30 minutes would be sufficient to provide adequate pipe capacity. The implication of this was that it appeared that a 30 minute warning of impending additional rainfall or increase in severity of rainfall would be adequate to ensure that the gates were opened in time to regain the full sewer capacity.

Selkirk also analyzed an interim in-line storage option which would use a similar approach to that proposed earlier for Clifton, that is the use of float controls in the gate chambers and electric motors to raise and lower the existing slide gates and hence achieve the design in-line storage.

These studies did review the cost and effectiveness of offline storage and end of pipe treatment, but did not recommend one or the other because of the lack of defined water quality objectives for the rivers.

3.2 LINDEN/HAWTHORNE STUDY

In the Linden/Hawthorne study, the 29 years of rainfall records were analyzed. The 1980s were selected as being representative of this time period and the data for rainfall and long-term monthly evaporation were used in calibrating the storm model to estimate runoff and overflow under current conditions.

The Linden/Hawthorne study reviews street sweeping and sewer flushing. It notes that the manual MOP FD-17 (WPCF 1989) indicates that street sweeping, if done frequently enough (once or twice a day) could result in solids and heavy metals removal as high as 50%. Typical street sweeping programs (once or twice a month), however remove less than 5%. Street sweeping would have little impact on fecal coliform and would not likely affect the objectionable aspects of floatables significantly. The report also notes that flushing of sewers has a great potential to reduce the load imposed by all pollutants associated with settleable solids. Such pollutants do not include fecal coliform, considered the most important pollutant in the City's rivers. Similarly, oils, greases and floatables, the major contributors to aesthetics, would remain a CSO concern.

The pollution control options reviewed in the Linden/Hawthorne study were storage, in-line and off-line, and treatment which comprised:

- screening (for removal of some floatable debris);
- vortex solid separators (including in-line storage, bar screens, housing, underflow storage, chlorination and dechlorination);
- retention treatment basins (comprising in-line storage, bar screens, housing, chlorination and dechlorination).

Separation was also evaluated since partial separation was one of the options considered for basement flooding relief.

The performance of the selected pollution control devices was assessed on the basis of the reduction in the number of overflows, the number of untreated overflows which occurred and the volume of untreated overflows which occurred.

The results of the comparison of the three treatment options of pollution treatment options is of interest. The VSS was the most cost-effective method for all levels of service. Off-line storage was about the same as the RTB to reduce the number of overflows per year by one half. However, to obtain a higher level of service of only three to four overflows per year the RTB options were more cost-effective than off-line storage. The difference between the off-line and the RTB costs results from the fact that the RTB only stores quantities up to a certain defined amount (i.e., the RTB then acts a sedimentation basin) or are bypassed. The off-line storage volume would continue to be increased and therefore costs would also increase.

The conclusion of the Linden/Hawthorne study noted that in-line storage was the most cost-effective and lowest cost of the pollution abatement. The recommended procedure was to install in-line storage through the use of an overflow weir chamber. The VSS system was identified as the most cost-effective in reducing the number of microbially contaminated overflows per year. RTBs and off-line storage may be more effective in reducing BOD and other pollutants since they store the overflow and send it to the treatment plant. However, there could be an increased cost at the treatment plant which must be accounted for. It was recommended that the VSS system be studied further to determine its effectiveness for pollution control, and to determine the underflow rate and hence the size of the sludge storage tank which might be needed for Winnipeg conditions.

One of the general recommendations of the study was that alternatives such as off-line storage may be more cost-effective on a multi-district basis. It recommended that this be included in the city-wide study (that is, the current study). It also recommended that an accurate measurement of sewer flows from small rainfall events is required to provide confidence in the calibration of the quality model. Future monitoring programs should be carried out in accordance with the procedures outlined in the Technical Memorandum on Infrastructure.

4.0 THE RANGE OF APPROPRIATE TECHNOLOGY FOR THE CITY OF WINNIPEG

In selecting the most appropriate CSO control technologies for the City of Winnipeg, it is necessary to consider those water quality issues in the Red and Assiniboine river that are most relevant to CSO characteristics. These were established early in this series of Technical Memoranda, and earlier still by the CEC hearings, to be bacterial contamination and aesthetics. The latter have been interpreted as being chiefly the floatables and constituents of sewage. Accordingly, the selection of appropriate CSO technology for Winnipeg focussed on these water quality issues. The attached Table 4-2, entitled "Water Quality Issues Most Relevant to Winnipeg", has been reproduced from the Red and Assiniboine Surface Water Quality Objectives Technical Report as prepared for the CEC hearings (Wardrop/Tetr*ES* 1991). The columns containing the water quality parameters of greatest relevance to Winnipeg, i.e., floatables and coliforms, are highlighted. The information indicates that sewer separation, storage, and a treatment system which culminates in disinfection are the potential CSO technology for the Winnipeg system.

TABLE 4-2

WATER QUALITY ISSUES MOST RELEVANT TO WINNIPEG

TECHNIQUE	SOLIDS	BOD	COLIFORMS	FLOATABLES	REDUCED OVERFLOWS
	PARAMETER AFFECTED				
1.1 Source Control					
A. Surface Treatment					✓
B. On-Site Run-Off Control	●	●	●	●	✓
C. Street Cleaning	✓				
D. Sewer Flushing	✓	(✓)			
E. Sewer Separation	✓	✓	✓	✓	✓
1.2 Sewer System Control					
A. Overflow Regulation	●	●	●	●	✓
B. In-Line Storage	●	●	●	●	✓
C. Off-Line Storage	●	●	●	●	✓
1.3 Treatment Strategy					
A. Swirl Concentrator	✓	(?)		✓	
B. Screening	✓			✓	
C. Sedimentation	✓	✓		✓	
D. Wastewater Treatment Facility	✓	✓	(✓)	✓	
E. Disinfection			✓		

LEGEND	
✓	EFFECTIVE
(✓)	PARTIALLY EFFECTIVE
●	INDIRECTLY EFFECTIVE *(by reducing volume of overflow)*
(?)	UNPROVEN PERFORMANCE

Good Housekeeping

Quality control of runoff should be actively pursued. This would include control of de-icers, control of pesticides and fertilizers, control of industrial runoff, and enforcement of anti-litter by-laws. Sewer flushing, catchbasin cleaning, and street sweeping will improve the quality aspects of all storm runoff (LDS and CSO) as they relate to suspended solids. All of the above activities are good practice in themselves but do not address the two main quality concerns of CSO. Inflow/infiltration control and sewer rehabilitation fall into the same category and should be pursued on a continuing basis.

Flow Attenuation

Insofar as flow attenuation is concerned any technique that reduces the quantity of runoff through some means of surface storage will reduce the quantity of CSO, and also will reduce the cost of treating CSOs. In addition, such techniques will reduce the cost of relieving basement flooding.

Flow Diversion

Alternative means of regulating the 2.75 times DWF to the interceptor, such as vortex valves, should be reviewed as part of the ongoing study.

Storage

The reduction of CSO events is an objective that addresses both bacterial contamination and aesthetics. Such a reduction can be effected by in-line storage or off-line storage. Available in-line storage for the CSO districts in Winnipeg, is district specific. Some have considerable in-line storage, some have limited in-line storage. In any case, development of this in-line storage will probably be the most cost-effective means of reducing CSO quantity, and will likely form a part of any program designed to improve CSO impacts on the rivers. Alternative means of effecting in-line storage, such as inflatable dams, should be reviewed as part of the ongoing study.

Real-time Control

Real-time control should be maintained as a possible means of reducing CSOs. Given the preliminary review undertaken to date, it would appear that the existing interceptor to the North End Plant is not a particularly good candidate for such a real-time control. CSO reduction could be effected, however, through construction of oversized sewers, new interceptors or oversized CSO trunks, on which real-time control could be practiced. Investigations should continue into the "real-time" control of in-line storage on those areas, such as Selkirk district, which have significant quantities of in-line storage potential. Whether or not rainfall forecasts are sufficiently precise to be able to safely predict storm intensity on small areas would have to be assessed as part of this study.

Treatment

The Linden/Hawthorne investigation indicated that a combination of in-line storage, vortex solids separators and the ancillaries associated with sludge storage and disinfection were the most cost-effective means of addressing bacterial contamination. It recommended therefore that the technology be tested in Winnipeg. Another possibility which came out of the same study was in-line storage in combination with retention treatment basins, as well as associated disinfection, were somewhat more expensive but were still worthy of being considered as options.

Off-line Storage

The Linden/Hawthorne investigation also indicated, on a preliminary basis that, up to a point, off-line storage might prove to be a feasible and cost-effective means of reducing CSOs. Investigations for the current study should include this option.

Sewer Separation

Sewer separation is certainly an effective means of reducing microbial contamination and sewage related floatables being discharged into the river. However, it is a very expensive means of so doing and does not reduce the quantities of other pollutants being discharged. However, selective sewer separation, such as that which is being currently practiced in the review of the basement flooding relief program should continue to be evaluated and, where practicable, effected.

Public Education

Public education is a part of the CSO study program. Public education should continue after the completion of this program. It promotes good practice and also keeps the City's efforts at maintaining the quality of the City's rivers before the public.

5.0 POTENTIAL WET WEATHER FLOW MANAGEMENT STRATEGIES

In order to proceed with a study and evaluation of a program involving alternative means of controlling CSOs, it is necessary to identify the objectives, priorities and constraints associated with the implementation of such a program.

5.1 COST (AVAILABILITY OF FUNDS)

The overall program will be very costly. The City has just completed major WPCC upgrades and is still spending large amounts for flood relief. The CSO program will presumably be financed from sewer rates, which are currently increasing at 11% per year. Accordingly, the magnitude of the cost involved in a full CSO control program implies that the program will need to be a long-term, staged program, this emphasizing the need for priorization of the program elements. This will likely result in a program with early emphasis on non-structurally-intensive actions, working progressively to more capital intensive options.

Political Support

A program involving millions of dollars will need strong political support in a climate of limited funds. Accordingly, ongoing communication with the political bodies will be of great importance.

Public Opinion

Public value judgements will be an important factor in the evaluation of the benefits of CSO control. Much of the water quality improvements relate to perception, philosophy and willingness to pay for improvements. Accordingly, ongoing public input and communication will be important in the development of the CSO control program and in establishing its priorities.

5.2 FULL RANGE OF ALTERNATIVES

The ongoing study will need to evaluate the full range of alternatives, from the "do-nothing" options through non-structural/best management alternatives, minimal structural alternatives, structurally intensive alternatives and finally treatment alternatives (Section 2 of this Technical Memorandum). A preliminary assessment of appropriate technology for Winnipeg has been made in Section 4. This assessment will be revisited and elaborated on in Phase 2.

5.3 CSO CONTROL BENEFITS

The benefits of CSO control will be difficult to quantify but should relate to enhanced river use, which will include aesthetic enjoyment and recreation. This applies to areas such as the Forks, the river walk areas, and the reach of the Red River, south of the junction with the Assiniboine River (recreation).

The Forks

Through redevelopment of the Forks area and the construction of the associated river walks, the Forks has become a major attraction to tourists and to Winnipegers. There is every reason to believe that this popularity will continue. Since the focus of the Forks is on the City's rivers, their condition (particularly aesthetic) must be a prime focus of any CSO control program. Accordingly, the Forks has first priority for improved river quality, from all causes, but particularly from CSOs. This fact places an emphasis on the Assiniboine River, since, because of its relatively fast-flowing characteristics, does not have sufficient time for coliform die-off, even from the WEWPCC.

5.4 ENVIRONMENTAL CONSIDERATIONS

CSO Control Actions

The environmental implications of the control actions will play a key role in the evaluation and acceptability of the program. For example, "end-of-pipe" treatment may be a prime feature of a long-term strategy. If this were the case, the location and installation of such facilities will have their own problems and environmental advantages/disadvantages.

Disinfection of WPCC Effluents

The treated (but non-disinfected) effluent from the three WPCCs are a dominant influence on the microbiological quality of the rivers during DWF. CSO for microbiological control must assume the implementation of WPCC effluent disinfection. The timing on the sequence of implementation of WPCC effluent disinfection will have an influence on priorities for the CSO control. For example, there would be little benefit in targeting CSO control for Districts discharging to the Assiniboine River (for microbiological control) without WEWPCC effluent disinfection.

Basement Flooding

The CSO control program should be integrated into the flood relief program. Substantial money has been and will continue to be spent on piping relief in the combined sewer districts. These hydraulic improvements increase the number of overflow pipes. The potential pollution control features that could be incorporated into flood relief need serious consideration, as pilot programs and/or as a beginning of an overall CSO program.

Sewer Relief/Replacement

Similar to the above, CSO control should be considered when sewers are rehabilitated or pumping stations are replaced. An example of this situation is currently taking place with regard to the River Combined Sewer District. The diversion and flood pumping stations are in process of being relocated because of road and bridge realignments. The City are currently reviewing the implications of this situation and are studying the manner in which future CSO control aspects could be accommodated.

Regulatory Compliance

Compliance with the MSWQO will be a major regulatory consideration. This will require consideration of frequency and location of exceedances during WWF and DWF.

Ongoing dialogue with the regulatory bodies will be vital. The beginnings of this strategy are inherent in the establishment of the Advisory Committee.