Winnipeg

Water and Waste Department

REPORT ON THE SHUTDOWN OF THE NORTH END WATER POLLUTION CONTROL CENTRE ON SEPTEMBER 16, 2002

December 19, 2002

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Water and Waste Department

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Foreword

This report documents the event that occurred on September 16, 2002, and is based on interviews of the staff involved. Also included is an analysis of the impact of the event on the river. In preparing this report, previous reports and related documents were reviewed, including:

- Unit MP5 Design Reports, Supply and Installation Tender, and file, 1978-1981
- Main Building Operating Manual, 1991
- Unit MP1 Valve Replacement Engineering reports & tender, 1993-1994
- Risk Control Report (Draft) – Aon Risk Control Services, 2002
- Plant Log, July – September 2002

As a result of the event, the following assignments are complete or in progress:

- Design of Temporary Bulkhead – Wardrop Engineering Inc.
- Design of Permanent Works To Separate The Pump Wells – Wardrop Engineering Inc.
- Valve Removal Sequence – Wardrop Engineering Inc.
- Main Street North Basement Flooding Investigation – UMA Engineering Ltd. – See Appendix J.
- Analysis of Valve Failure – Wardrop Engineering Inc.
- River Water Quality – Computer Modeling and Analysis – TetrES Consultants Inc.

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December 19, 2002

Summary

What happened?

At about 1:15 p.m. on Monday, September 16, 2002, mechanical failure shut down the North End Water Pollution Control Centre (NEWPCC). Raw sewage could not be pumped through the regular wastewater treatment processes. At about 5:00 p.m., sewage began draining into the Red River at a rate of about 185,000 cubic metres per day, or approximately 1% – 1.5% of the river flow. Manitoba Conservation, Manitoba Health, Environment Canada, Winnipeg Regional Health Authority were notified promptly.

Section 4 of the report provides a chronology of the events of September 16, 2002.

What caused the shutdown?

The following sequence of events resulted in the shutdown.

- A guide inside the 36-inch diameter valve was broken and missing and caused the valve to be lodged open by approximately 13.5 inches.
- A staff team concluded incorrectly that the valve was closed but not "seated."[1]. The staff team included the plant supervisor, senior operator, operator, and lead mechanic at the plant.
- Staff believed their plan to "seal" the valve with debris was working when it was not – rather the sewage debris was sealing the pump inspection plate passages.
- Staff loosened the 12-inch diameter inspection plate to the point that it blew off the pump, allowing sewage to flow into the pump well.
- The interconnecting tunnels between the pump wells allowed all three pump wells to flood, submersing the motors and other equipment, and shutting down the facility.

Further discussion on the cause of the shutdown is in Section 10 - Conclusions and Recommendations.

What was done to get the plant running again?

Working around the clock, the department had three motors removed on the 17th, and sent them to be cleaned, dried, and serviced. By 1:30 a.m. on the 19th, two pumps were working. Starting at 12:01 a.m. on the 19th, there was a gradual reduction in the amount of sewage discharged to the river, and by about 2:00 a.m., all discharges to the river had ceased. Two additional pumps were ready if needed by the 21st.

Section 6 and Appendix C describe the recovery process.

The effort to get the plant running again was exemplary. Emergency preparedness training was invaluable to the response. Many department staff worked long hours to deal with the emergency. We acknowledge those efforts with gratitude.

[1] "Seating" refers to the last one-half inch movement of the valve that in effect creates a seal by having the wedge seating faces contact the body seating faces.

What was the impact of the spill on the Red River?

The normal river water quality testing program was expanded to closely monitor the impact of the spill on the Red River, particularly dissolved oxygen levels. A major purpose of sewage treatment is to prevent low dissolved oxygen levels in receiving streams, because low oxygen levels would kill fish. Test results showed that the oxygen levels were always above the acceptable range to support aquatic life in the Winnipeg area as well as downstream of Winnipeg.

Details of the river impact analysis are in Section 8 and Appendix K.

Who conducted reviews of the incident?

- The Federal Government instituted an investigation with respect to the Fisheries Act.
- The Province of Manitoba asked the Clean Environment Commission to review the City's wastewater system (hearings scheduled for January 2003).
- City Council instructed the Chief Administrative Officer to hire an independent engineering firm to conduct a review of the incident. Associated Engineering (B.C.) Ltd. is the firm selected.
- The Water and Waste Department investigated the incident, including interviewing staff, and reviewing operating conditions and previous reports.

Have there been other similar incidents?

There has been one other incident at the NEWPCC - in 1965, the suction valve for main pump #1 (MP1) opened during construction, flooding all three pump wells. This incident is described in Appendix B. No action was taken to separate the pump wells after the 1965 occurrence, based on the belief that a similar incident would not occur.

Could this happen at the other two treatment plants?

A similar event could not happen at the other plants because the pumping arrangements are different. The Department is committed to a formal risk management process to cover all three plants. An amount of $750,000 has been included in the 2003 capital to conduct this risk assessment. The major output of the assessment will be a formal list of risks that are significant in terms of either likelihood or consequences and mitigation measures. Decisions will be made on addressing each of the identified risks.

Who is responsible for the incident?

The Water and Waste Department operates and manages the plant, and is therefore responsible for this event. Management has reviewed the incident in detail.

This was a preventable accident. There was no wrongdoing or negligence on the part of the staff. They had the best of intentions and thought carefully about what they were doing. They believed the valve was closed. In hindsight:

- it was clear to the staff that there were things that could have been done to better determine the position of the valve and to prevent the inspection plate from coming off.
- it is clear to management that had the pump wells been separated, this accident would not have shut down the whole facility.

Documented procedures and training on the details of the equipment and/or markings on the equipment may have prevented the accident. Management will be instituting changes to prevent this from happening.

How much did the plant flooding cost?

The total cost of the work to get the plant operating and to replace damaged equipment including the faulty valve is estimated to cost $540,000. Details are in Section 9 and Appendix I.

What steps is the Department taking to prevent similar incidents from occurring?

The Water and Waste Department will implement the following recommendations as soon as possible to prevent similar incidents from occurring. Section 10 of the report also provides the conclusions that led to these recommendations.

1. **Prepare written procedures for isolating the main building pumps.**

2. **Alter the main building pumps, including:**

    a. **Devise a way to clean and back flush drains.**
    b. **Outfit inspection hatches with a number of strategically placed longer studs to assist in reassembly if needed in an emergency.**
    c. **Add a 4 or 6-inch gate valve to the top of each pump, possibly connected to a clear plastic cylinder to provide an additional tool for operators to confirm the safety of the operation.**

3. **Prepare written procedures for other key activities where safety or plant integrity is at issue. The procedures should include reference to and location of operating manuals and equipment layout and shop drawings.**

4. **Place external markings (or their equivalent) on all valve stems to clearly indicate when the valve is in the closed position.**

5. **Review training for all procedures and implement a requirement and schedule for refresher training.**

6. **Take action to separate the pump wells to prevent another catastrophic failure of the main pumping facilities at the North End Water Pollution Control Centre.**

7. **Examine the installation of gates on the main interceptor to isolate the plant.**

8. **Review all three wastewater plants and the collection system to identify and mitigate any risks that could result in discharges to the rivers.**

The Department will also review recommendations that arise out of the investigation by the independent engineers engaged by the CAO and others as they become available.

1. Introduction

On Monday, September 16, 2002, at approximately 1:15 p.m., a problem occurred at the North End Water Pollution Control Centre that shut down the City's largest sewage treatment plant for 57 hours. Approximately 427 million litres of raw sewage was discharged into the Red River until the plant was back in service at 12:01 a.m., Thursday, September 19, 2002.

This event caused considerable concern in the community. People wanted to know what happened, why it happened, and why there weren't any backup systems in place to prevent such an event. Investigations were started by several external agencies including Environment Canada, the Province of Manitoba, and an independent engineering firm at the request of City Council.

The Wastewater Services Division of the Water and Waste Department is responsible for operating the plant. This Division coordinated the efforts to repair the plant and get it back in service as quickly as possible.

Subsequently, the Manager of Wastewater Services and the Director of the Water and Waste Department led an internal review of the event. The scope of the review included interviewing staff, reviewing maintenance and operating records, reviewing design reports and analyzing the event.

The purpose of this report is to document the internal review and to identify steps the Department will take to minimize the possibility of such an event reoccurring.

2. Treatment Plant Description

The North End Sewage Treatment Plant opened in 1937. Since then, the plant has been upgraded and expanded to become the North End Water Pollution Control Centre (NEWPCC). NEWPCC, located at 2230 Main Street, treats sewage or wastewater generated from the north and central parts of the city, representing about 70% of Winnipeg, or approximately 370,000 residents. Treated wastewater from NEWPCC is discharged to the Red River, which flows north to Lake Winnipeg. The NEWPCC is the largest of three wastewater treatment facilities serving the City of Winnipeg, and provides primary and secondary activated sludge treatment, and sludge processing.

The purpose of the water pollution control centres is to treat wastewater so that it is in an acceptable condition to release to the rivers. The treatment processes remove inorganic solids such as sand and gravel, and reduces the amount of organic material in the wastewater. Treated wastewater is 90-95 percent free of organic material present in sewers (as measured by the standard 5-day carbonaceous Biochemical Oxygen Demand (CBOD5) analysis).

The process used to treat wastewater is very similar to the natural decomposition that would occur if wastewater were released directly into the rivers. Bacteria would feed on the organic materials and break them down, using up the oxygen in the water. This would decrease the oxygen in the river, so that healthy populations of fish and aquatic life could not live there. As these organic materials decomposed and caused septic conditions, they would also give off unpleasant odours and create a public health concern. In the plant, the wastewater treatment process occurs in a controlled environment at an accelerated rate.

a. Pump Station Design

Sewage enters the treatment plant by flowing through the main interceptor into a surge well, 54 feet (16 metres) below ground level.

From the surge well, the sewage flows into either the east or west suction header or conduit to the three pump wells, each having two pumps. The number of pumps in use at one time depends on the amount of wastewater flowing into the plant. The amount of wastewater depends on rainfall, run-off from spring thaw, and the time of day.

The pumps lift the sewage above ground level into a discharge chamber. The sewage then flows through the rest of the treatment plant by gravity. From the discharge chamber, it flows to the first stage of treatment, known as pre-aeration and grit removal.

Table 2.1 lists the six pumps, and Figures 2.1 to 2.3 show the layout of the pump wells.

Table 2.1 - Main Building Pumps

Pump	Installed	Capacity MLD	Horsepower	Speed
MP1	1994	114	400	Constant
MP2	1965	188	700	Variable
MP3	1965	188	700	Constant
MP4	1965	188	700	Variable
MP5	1981	195	600	Two
MP6	1965	188	700	Constant
Total		1061	3800	

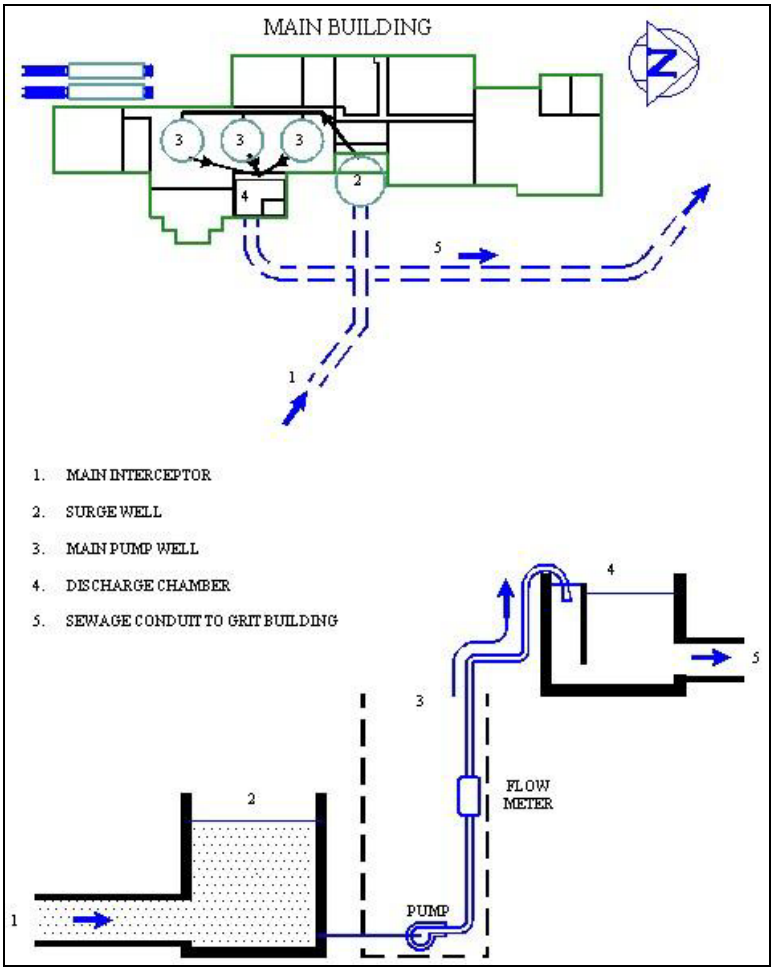


Figure 2.1 - Main Building Pump Schematic

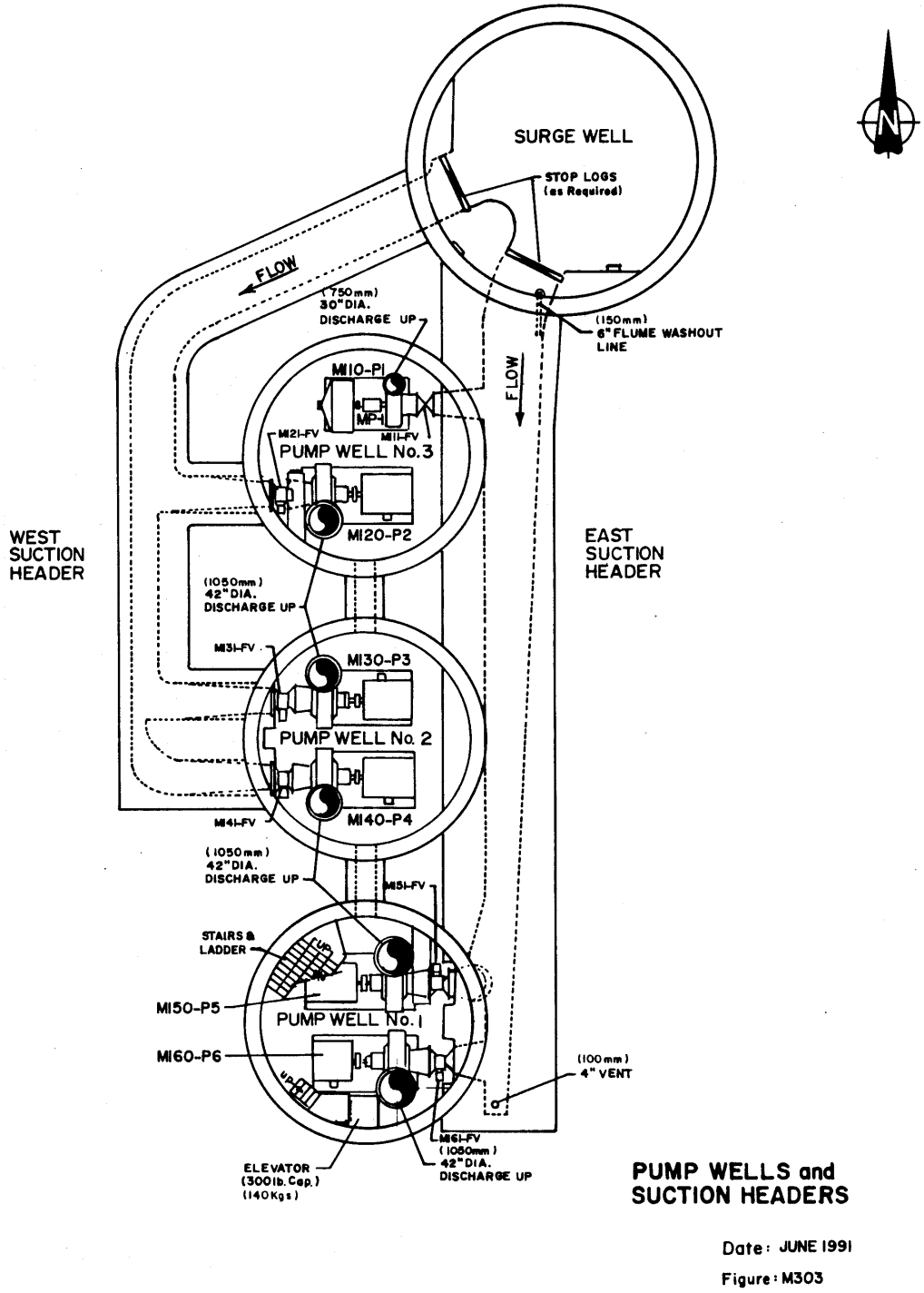


Figure 2.2 – Drawing of Pump Wells[2]

[2] Source: North End Water Pollution Control Centre Main Building Operating Manual

Figure 2.3 -Main Building Looking South – View of 3 Pump Wells

b. 36-Inch Suction Valve

This suction (or gate) valve, which connects the east suction conduit to main pump #5 (MP5):

- is 36 inches in diameter, and weighs approximately 8000 pounds (3,500 kg)
- is "Jenkins" (brand), Figure 454 (model)
- is iron body flanged gate valve, bronze trim, solid wedge, outside screw and yoke, rising stem valve (see Figure 2.4)
- was purchased with a "Rotork" brand electric operator
- was manufactured by Jenkins Bros. Limited of Montreal; the Shop Order Number which appears cast into the valve is 4564.
- was ordered and manufactured in 1979 (the date 1979 is also cast into the valve).
- is approximately 30 inches thick (flange face to flange face), 50 inches wide and 145 inches high (closed) – according to shop drawings
- was installed during a 40 hour shutdown of the plant on November 7-9, 1980, by Kamtar Construction Limited. The operation consisted of removing a blind flange (a blank piece of metal covering an opening) and installing the valve in its place. With the valve closed and locked, the plant could safely be put back in service. The pump (MP5) could then be installed.

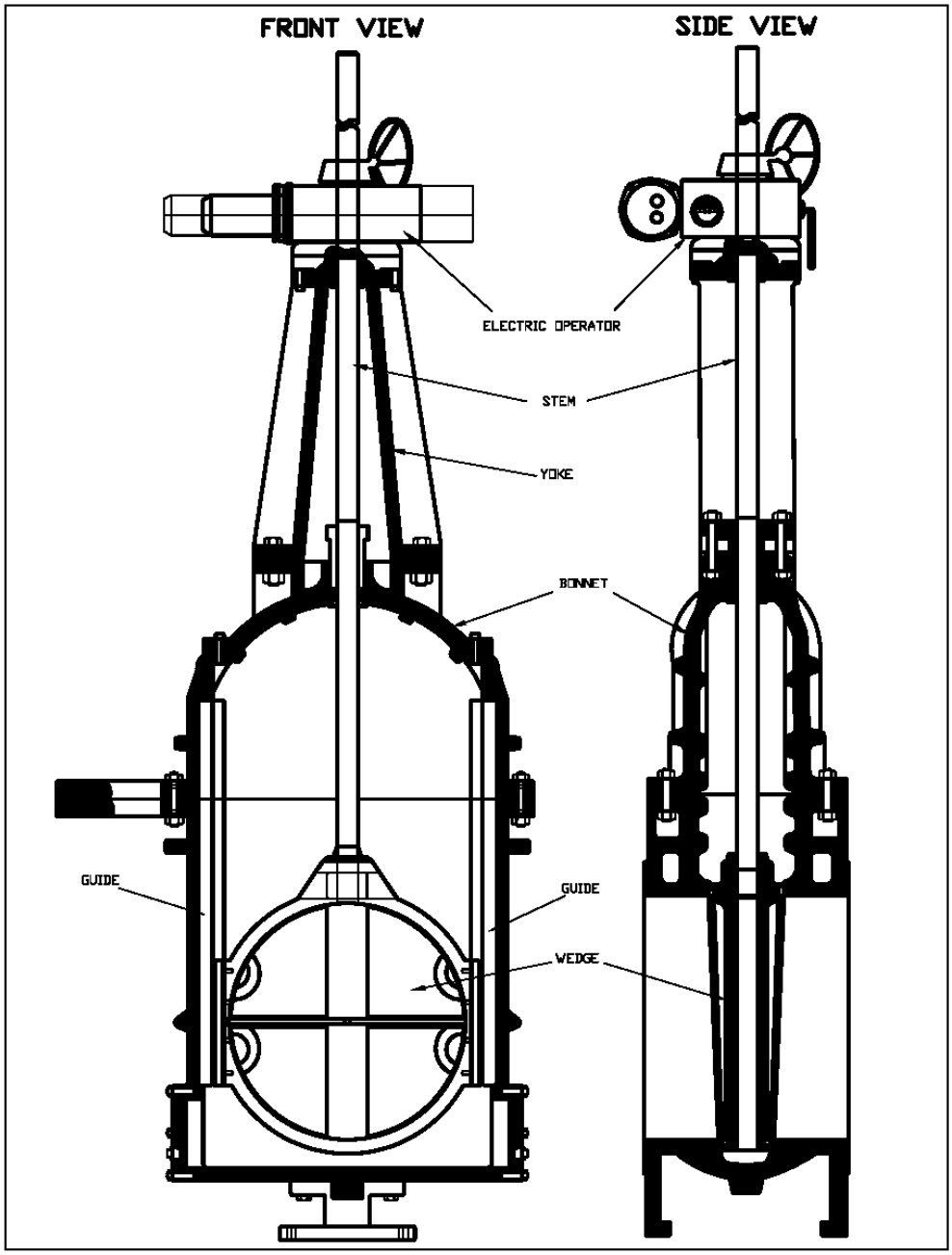


Figure 2.4 - Portion of Suction Valve Shop Drawing

c. Main Pump # 5 (MP5)

MP5 was installed in late 1980 to early 1981. It is a horizontal mixed flow pump model "MF150", manufactured by Morris Pumps of Baldwinsville, N.Y.

Figure 2.5 - Pump Well Number 1 - Looking Down at MP5. The suction valve is on the far right. The pump (MP5) is next to it. The motor is on the left (red).

d. Pump Well Interconnections

The three pump wells are interconnected with a walkway at the floor level. The interconnections are openings about three feet wide by six feet high. These openings were part of the original construction in 1937. In addition to access, the openings provide for utilities and drainage between the three pump wells. A single stairway was built in pump well number 1. In 1965, an elevator was added in pump well number 1 and an emergency egress ladder was added in pump well number 3. There is no separate egress from pump well number 2.

e. Staffing and Training

The plant is staffed by operators, mechanical maintenance, and electrical, instrumentation and control staff. During evenings and weekends, two staff members are present. During regular working hours, about 20 operators and 8 specialist staff are on site. Appendix F describes the organization of the plant staff.

Operators undergo training as an Assistant Operator before becoming an Operator or Senior Operator. A description of the staff training is included as Appendix H.

3. Relevant History of Work on MP5 – 1993 to September 16, 2002

This section is a summary of the relevant maintenance work on MP5 and the valve. It is based on interviews with NEWPCC staff and maintenance records.

a. 1993 – Valve Stem Comes Off Wedge

Records show that in 1993 the valve stem became detached from the wedge. This event was reviewed to determine if it might shed light on the valve failure.

A key component of the valve is a stem. As the stem rises and lowers, it is supposed to pull the wedge up and to push it down to open or close the 36-inch opening to allow or stop the flow of sewage. In 1993, the operators noticed that the pump was running hot and speculated the valve must be closed even though the stem was in the open position.

The only way for the staff to confirm the suspicion that the valve was closed was to drain the pump. If they were wrong, they would flood the pump well. Accordingly, great care was taken to ensure the valve was closed. The pump was successfully drained, and the inspection plate was very carefully removed.

To repair the valve, first the electric operator, the yoke and the bonnet was removed as one unit. The valve stem was reattached to the wedge using the stem nut, and a new locking pin was installed. This was done at 2:00 a.m., when flows were low and the surge well was pumped down to under 16 feet. The pump packing was replaced because it had been damaged by heat.

Subsequent to the recent finding that the valve guide was broken and missing, staff involved in the 1993 event confirmed that all guides were in place in 1993.

b. September 1997 – MP5 Was Successfully Isolated

1997 was the last time the valve was documented as closed.

Work order number 5072 was issued on August 28, 1997 to "Please check packing." It was completed on August 28, 1997. A note was placed on the work order "Add one ring of 7/8" packing." This was also recorded on the "Mechanical Month End Report – September 1997", by the Mechanical Maintenance Supervisor dated December 12, 1997. An entry of the report indicates, "NEWPCC Main Building – MP#5 added one ring of 7/8" packing." This procedure requires isolating the pump – so the valve was successfully closed.

While staff indicate that the pump was isolated annually to check and repack the pump, there is no record of this for the period 1998 – 2002.

c. Attempts to Isolate the Pump – December 2001 – January 2002

The staff involved in the incident of September 16, 2002 were aware that there were failed attempts to close the valve for MP5. Interviews were undertaken to document these attempts.

For purposes of this report, the names of staff have been omitted. Staff are referred to by their position, such as Operator, Senior Operator, or Supervisor, followed by a number (e.g. Operator 1 or Operator 2) to show which Operator, Senior Operator or Supervisor is being referred to.

Operator 1 and Supervisor 1 worked on isolating this pump in December 2001 and January of 2002. Operator 1 has 24 years experience in wastewater treatment, and Supervisor 1 has 30 years experience. Supervisor 1 retired in May 2002. Operator 1 and Supervisor 1 worked together on a project to examine sporadic problems with pumps not reaching rated capacity. Supervisor 1 remembers this occurring on both the east and west suction headers and the theory was that it had something to do with debris in the headers. It was known that pieces of grating were missing from the surge well. The Supervisor indicated that they were "back flushing" all the pumps during this period, including closing the anti-siphon valves to get better back flushing.

As part of this project, they also discovered and attempted to address the inability to isolate pump MP5 by closing the suction valve.

Operator 1 recalls that he worked with Supervisor 1 to isolate MP5. They followed the usual process to close the valve and open the drains. Operator 1 recalls that they did not get a closed signal from the computer until they closed the valve manually. He recalls that the drains kept running, indicating the valve was not seated.

They worked on this for about a week. Every day they would open and close the valve a couple of times hoping to get it to "seat", or fully close. (With sewage, it is common for a valve to leak due to debris lodging between the wedge and the seat.) Each time they opened the drains on the pump and header, the drains would run, indicating the valve was not closed. The Senior Operator 1 at the time was aware of the valve being exercised by Operator 1, but did not operate the valve himself.

After a few weeks, they tried closing the valve slowly with the pump running. This procedure creates increased velocity across the seat to remove any debris. Operator 1 recalls that the valve was closed to within 6 inches to 8 inches – in other words, with as little as 5 inches showing on the stem. He indicates that they were almost getting full flow through the pump as indicated by the magnetic flow meter.

Supervisor 1 also remembers running MP5 and closing the valve to increase velocities as discussed above. He indicates that this was suggested by the Supervisor of Mechanical Maintenance, who is now retired. Supervisor 1 indicated that they closed the valve to within 12 inches to 6 inches of closed. At that point, the supervisor recalls that cavitation[3] was occurring and the pump was rumbling. On being asked about the magnetic flow meter indicating flow, he thought that the flow meter would not be accurate during this cavitation.

[3] Cavitation refers to a collapse of gas bubbles in a pump, which can damage a pump. The gas bubbles arise because of a lack of suction pressure.

Operator 1 indicates that he would normally have changed work area on January 1, but that he stayed over an additional week to continue working on the project with Supervisor 1. Following that, Operator 1 transferred his role to Operator 2. Operator 2 indicated that he did not pursue the valve while working in that area from January to June.

The Supervisor and the Wastewater Engineer met with Dominion Divers on January 10, 2002 to discuss inspecting, locating and removing debris from the headers, and inspecting MP5 suction valve. As stated above, there was a concern that the pumps were not reaching capacity. At the meeting, it was concluded that the City would develop a tender to drain the headers for inspection during the winter of 2002-2003, using the stop log procedure that was used in 1994 when the valve on MP1 was replaced.

In the meantime, the flow meters were recalibrated and the capacity problem did not reoccur.

The work orders referring to MP5 were reviewed to see if there was other documented work. Senior Operator 2 issued a work order June 6, 2002, titled "MP5 Suction Valve not close." The work order was still open at the time of the incident on September 16, 2002.

d. Attempt to Isolate MP5 – July 1 - September 16, 2002

This describes the work done to isolate the pump leading up to the plant shutdown on September 16, 2002.

Operator 3 was assigned to the primary area that includes the main building pumping systems on July 1, 2002. Senior Operator 2 was the Senior Operator for the "wet side", having moved there in March of 2002. Senior Operators rotate from the "wet side" to the "solids side" approximately every year. Operators rotate through four areas approximately every six months.

Operator 3 and Senior Operator 2 were aware of previous attempts to isolate MP5. They decided to see if they could isolate the pump so that they could perform the following work:

- Repack the pump as there was a significant loss of seal water with the pump in operation;
- Replace/repair the drain piping as it was severely corroded; and
- Inspect the wear rings and impeller.

On July 5, 2002, Operator 3 closed the seal water to MP5 and put this note on the control room white board.

> *"July 5/02 – If you need MP5, you have to go into pump well and open seal water valve (valve has a red tag) before starting. After #5 shuts down, please close this same valve. (Suction Valve Closed)"*

The plan was to encourage clogging of the suction valve by drawing sewage flow through the closed valve. This procedure normally causes the opening between the wedge and the seat to plug with debris. Their experience with other sewage valves in the collection system and in other areas of the plant was that small openings would plug with debris and tallow and create a seal that otherwise would not be there.

At first Operator 3 opened up the drain valves that plugged quickly, which is normal and the reason why they are not used to drain these pumps.

Upon returning from holidays in August, Operator 3 began to use the 12-inch diameter "hand hole" or inspection plate (Figure 3.1) to encourage clogging of MP5 suction valve, closing the plate up each night so that the night shift staff did not have to worry about it.

After some time, he noted the flow was lessening and decided to leave the pump draining overnight. The Senior Operator 2 and the supervisor (Supervisor 2) agreed with this plan.

The following log entries are recorded in the "log" which is used as an additional means of communications between day and night staff.

> Tuesday, Sept 3, 2002: *"MP5 O/S (Draining)"*
>
> Thursday, Sept 5, 2002: *"MP5 O/S (Draining – Keep an eye on sump pump.)"*
>
> Monday, Sept 9, 2002: *"MP5 O/S – draining onto floor, please keep an eye on sump pump"*
>
> Tuesday, Sept 10, 2002: *"MP5 O/S –Draining Pump, keep an eye on sump pump"*
>
> Wednesday, Sept 11, 2002: *"MP5 O/S – Pump Draining, keep an eye on sump pump"*
>
> Thursday, Sept 12, 2002: *"MP5O/S – still draining onto floor, please keep an eye on sump."*
>
> Friday, Sept 13, 2002: "*MP5 O/S (Draining – Please keep an eye on sump)"*

Operator 3 indicated that on Friday, September 13, 2002, only a trickle was coming out, and a decision was made to leave the inspection plate loose for the weekend as per the log entry above.

Fig. 3.1 - Views of the Inspection Plate after the event. The plate weights about 90 pounds.

4. Chronology of Events – September 16, 2002, 7:30 a.m. to 5:00 p.m.

a. Inspection Plate Removed - MP5

i) Operator 3 came to work and looked over the rail at 7:30 a.m. The draining had stopped. Mechanical maintenance staff wanted MP1 drained so that they could service the packing. Operator 3 isolated MP1 in the morning. On walking back from MP1 to the elevator near MP5, the mechanical staff noticed that MP5 had stopped draining and reported that to other staff over the lunch hour.

ii) After lunch, at about 1:10 p.m., Operator 3 went down the elevator first. The Lead Mechanic at the plant and the Apprentice Plumber were to follow. Operator 3 removed all but two side bolts in the inspection plate and moved it by hand. Then a little sewage flow came out. At that point, he decided that the flow had not stopped and that they would not be servicing MP5 on that day. He decided that the plate should be loosened a bit more to improve drainage and backed off the two bolts ½ turn. While he did this, the plate suddenly gave way.

iii) The operator was thrown down the man way, or opening, from pump well 1 to pump well 2 by the force of the sewage pouring through the opening where the inspection plate was. He thought that the flow would slow down, as the head in the discharge header would reduce. He attempted to reinstall the plate but could not. The inspection plate weighs approximately 90 pounds. In addition, based on the surge well level, the static force against the plate would be about 2.5 pounds per square inch, or about 280 pounds of force on the 12-inch diameter opening.

iv) The Lead Mechanic confirms that he came down the elevator after the Operator. He came around the motor, saw that the sewage was still leaking and then saw the plate come off and the sewage flow start. He ran to the valve and turned the handle with all his strength. Under these conditions, he managed to get another 7 or 8 turns (the equivalent of a wedge movement of 1/16th of an inch). The mechanic also thought that the flow would slow down, but it did not. Both men indicated that the sewage flow was a full 12-inch diameter horizontal jet that hit the wall of the pump well.

v) They called to the Apprentice Plumber, who was about to go down the elevator to begin plumbing work on MP5. The plumber heard the noise of the sewage and looked down into the pump well. He described the noise as a "roar", which could be easily heard over the pumps running in the building. They asked him to shut off the power to MP4, which was running at the time. The plumber indicates that he did that within a minute of the event. (Digital records are available at 6-minute intervals for key points, including the flow meters. The records show that both MP1 and MP4 were running at 1:12 p.m. and the flow of sewage was at zero at 1:18 p.m.)

vi) The sewage level in the pump wells rose rapidly - it was ankle deep within seconds. When they left in 4 to 5 minutes, the sewage was to the level of the elevator ramp, or approximately 3 feet. The operator left using the elevator. Calculations based on a free 12 inch diameter orifice, using K=0.62, indicate that a level of 3 feet could be expected in about 6 to 7 minutes.

vii) The Lead Mechanic climbed the ladder and stairs and immediately switched off the 4160-volt breakers to MP1 thru MP6.

b. Flooding of Pump Wells

i) The time of the incident has been estimated at 1:15 p.m. The event log kept by the computer control system confirms this. The system indicates MP4 was switched off between 1:12 p.m. and 1:18 p.m. The system indicates that total plant flow was 204 MLD at 1:12 p.m., and zero at 1:18 p.m.

ii) The level of the surge well was approximately -13 feet[4] about this time, varying by less than 0.1 feet each six minutes. Between 1:12 p.m. and 1:18 p.m., the level in the surge well rose 0.9 feet from -12.95 to -12.05 feet.

iii) From both visual observations and calculations from flow through the 12-inch diameter hole, it is expected that the level in the pump wells would quickly reach the level of the hole (-18.7 feet) or 4.3 feet above the floor elevation of -23 feet. The level in the pump wells would continue to rise until it matched the levels in the surge well.

iv) The level in the surge well rose steadily from -12 feet to +6 feet over the next three hours and twelve minutes (from 1:18 p.m. to 4:30 p.m.), or at a rate of about 5.6 feet per hour. It then rose from +6 feet to a maximum of about +10 feet by 6:30 p.m. or at a rate of 3 feet per hour. Overflow to the river began at about 5:00 p.m., when the level in the surge well exceeded weir elevations and river levels.

v) Overflow alarms were received as shown in Table 4.1. Overflow alarms indicate an impending overflow condition. These are discussed in Section 8 on river impacts.

[4] City datum 0=727.57 feet geodetic, historical average normal winter ice level for the Red River at James Avenue. Surge well levels are with respect to that datum. For example –13.0 represents a level of 13.0 feet below normal winter ice level at James Avenue.

Table 4.1 – Overflow Alarms – September 16, 2002

Station	Overflow Alarm	Surge Well Level (feet)
Polson	16:29	+5.5
Selkirk	17:18	+8.5
Newton	17:19	+8.5
Bannatyne	17:24	8.8
St. John's*	18:09	+9.8
Jefferson**	14:13 (Sept 17)	+9.9

*Fluctuating level caused alarm to go on and off.
**Alarm malfunction, overflow occurred earlier

5. Removal of MP5 Suction Valve – November 2002

Two months after the event, following weeks of planning, it took five days to remove the suction valve for MP5.

- At about 4:00 a.m. on Thursday, November 15, divers began installing a stop log wall to isolate the east suction header. A 15.5 foot wall was made using 25, 6-inch by 8-inch weighted logs. The wall was completed on Friday, November 16, 2002 at about 11:30 a.m.
- By about 6:30 p.m., the sewage had been pumped out of the east suction header to allow access.
- At about 6:30 p.m. on Friday, November 16, 2002, a diver made his way down to the end of the 75 foot long east suction header to examine the valve. He reported that the valve was open about 12 to 14 inches. Although there was no visible indication of any problem, one side of the valve felt different than the other. It was later determined that the guide on the north side was missing.
- On Monday, November 18, 2002, no work was done because many of the divers were ill.
- On Tuesday, November 19, 2002, the valve was removed at about 4:30 p.m.. Using wood braces, the divers secured the valve in the position it had been found. The operator, yoke and bonnet were removed first, followed by the stem and wedge as a unit, and finally the body. A blind flange was installed over the opening.

Examination of the valve revealed:

- The valve was open approximately 13.5 inches.
- On each side of the valve (north side and south side for reference) there is provision for a 42-inch guide dove-tailed and babitted into the valve body, and a 13.5-inch guide dove-tailed and babbitted into the valve bonnet.
- Only a 13.5-inch piece of the guide on the north side of the valve body was present; the other 42-inch guide was missing.
- The entire guide on the north side of the valve bonnet was missing.
- The 42-inch guide on the south side of the valve body was intact.
- The 13.5-inch guide on the south side of the valve bonnet was there, but was loose.
- The stem was pinned properly to the wedge.

Figure 5.1 shows the valve body and bonnet.

Based on this information, the following conclusions were drawn:

- The 42-inch guide on the north side of the valve body was missing. To date, it has not been found. An inspection of the MP5 pump impellor reveals a large gouge, presumably from hitting and passing a substantial piece of metal, possibly the missing guide.
- The 13.5-inch guide from the north side valve bonnet ended up at the bottom of the guide channel in the valve body. Presumably, it was moved to this position as a result of opening and closing the valve.

- The valve wedge had lodged 13.5 inches open because the guide was missing on the north side. The valve wedge had offset and the guide on the wedge had contacted the 13.5 inch piece of the guide in the body, which then prevented the wedge from closing.
- The valve stem was intact. This meant that the earlier conclusion that the stem was in a position that the valve was closed was in fact in error. The stem on this valve would recess about 13 inches into the operator had the valve been closed. This is different than the other valves. The operators had used their experience on the other valves when they had determined the valve was closed. This valve, manufactured in 1979, has a valve stem approximately 14 inches shorter than the other similar valves manufactured in the 1960s.

Fig. 5.1 View of Valve Body (top) and Bonnet (bottom). Note missing guide on North side.

6. Response and Recovery – September 16 to October 4, 2002

a. Overall Plan

A plan to re-establish the wastewater treatment processes was established in the hour after the event. The basic steps were:

i) Use a diver to find and reattach the inspection plate on MP5.

ii) Pump out the pump wells using portable submersible pumps.

iii) Remove the six 4160-volt motors in a logical sequence and send them for servicing locally.

iv) While the motors are out for servicing, service the pumps and ancillary equipment in order of priority so that when a motor was returned, the pump would be ready.

v) Reinstall, align the motor with the pump, check rotation, and install the coupling.

vi) Restart the pumps and the treatment process.

vii) Repair other equipment as time permits.

viii) Initiate a river water quality monitoring program.

ix) Initiate a public information plan.

x) Ongoing site management and communications meetings.

Appendix C is a chronology of the repairs.

b. Mechanical Systems

The following major mechanical systems had to be repaired:

i) Main building pumps

ii) Sump pump system

iii) Seal water system

c. Electrical Systems

The following major electrical systems had to be repaired:

i) 4160-volt main building pump motors

ii) 4160 volt cable to MP1 through 6 (less MP5)

iii) Motorized suction valve motors and electric operators

iv) All wiring, junction boxes, lighting and related equipment

v) Elevator

d. Instrumentation and Control Systems

The following major instrumentation and control systems had to be repaired:

i) Motor instrumentation for vibration, temperature, etc.

ii) Pump instrumentation

iii) Motorized suction valve electric operator controls

iv) Sump pump controls

v) Flow meters

e. Process Recovery

i) Surge Well Levels – September 19, 2002

The surge well level remained at approximately +10 feet from September 16 at 6:30 p.m. to September 19 at 12:01 a.m., when MP3 was turned on. When pump MP 1 was started at 1:30 a.m., the level dropped to +8.3 feet. By 2:00 a.m., the level dropped to +6 feet, and dropped continuously to -13 feet through the day. Overflow alarms cleared as shown in the Table 6.1. The actual overflows would have stopped earlier, by approximately 2.00 a.m.

Table 6.1 – Overflow Alarms Clear – September 19, 2002

Station	Overflow Clear	Surge Well Level (feet)
St. John's	01:46 a.m.	+6.4
Newton	01:54 a.m.	+6.2
Selkirk	02:10 a.m.	+5.7
Bannatyne	02:35 a.m.	+5.2
Jefferson	04:25 a.m.	+3.1
Polson	05:16 a.m.	+1.7

7. Communications

a. Notification of Authorities on September 16, 2002

2:00 p.m. Bill Borlase advised Barry MacBride of mechanical failure and shutdown of the NEWPCC.

2:00 p.m. Kelly Kjartanson, Research Engineer reported the incident to: Mr. Larry Strachan, Director, Environmental Approvals, Manitoba Conservation; Dr. Margaret Fast, Medical Officer of Health, Winnipeg Regional Health Authority; Dr. Jim Popplow, Manitoba Health; Randy Borsa, Director of Operations, City of Selkirk; and to Marilyn Regic, Chief Administrative Officer, Rural Municipality of St. Andrews.

2:20 p.m. Barry MacBride advised Mayor Murray, Councillor Angus, Gail Stephens and others by email that flooding in the main pump room had shut down NEWPCC.

3:14 p.m. To confirm his earlier phone calls regarding the shutdown of NEWPCC, Kelly Kjartanson, Research Engineer, sent an email to: Dr. Margaret Fast, Medical Officer of Health, Winnipeg Regional Health Authority; Dr. Jim Popplow, Manitoba Health; and Larry Strachan, Director Environmental Approvals, Manitoba Conservation.

5:00 p.m. Paul Lagassé, Wastewater Engineer, left a voice mail message for Barry Briscoe, Environment Canada, advising him of the plant shutdown.

Before 5:23 p.m. Manitoba Emergency Measures Organization (Jim Wainwright) advised RM of St. Andrews (CAO), RM of St. Clements (Clerk and Reeve), RM of West St. Paul (By-Law Enforcement Officer), RM of East St. Paul (CAO), by telephone or voice mail. Mr. Kjartanson also advised the City of Selkirk (Randy Borsa) at the time he contacted Provincial officials and the Winnipeg Regional Health Authority.

b. Public Information

September 16, 2002

2:30 p.m. Designated the Director, Barry MacBride, as spokesperson for all media interviews.

5:38 p.m. Issued first news release - "Mechanical Failure Shuts Down the North End Water Pollution Control Centre." The news releases are included in Appendix D.

Afternoon Customer Service Centre advised and provided with information to assist staff in responding to calls from residents. Daily briefings occurred over the next 3 days.

Evening Director interviewed by CJOB, Global TV, CBC Radio, Winnipeg Free Press

September 17, 2002

11:45 a.m. Issued news release – "Repairs Continue at North End Water Pollution Control Centre"

Afternoon Director interviewed by all local media. In addition to a one-on-one interview with the Director, the media were invited to see and film/photograph the pump room and were offered a guided tour to one of the outfalls where the sewage was flowing to the Red River.

September 18, 2002

1:34 p.m. Issued news release – "Repairs Ahead of Schedule at North End Water Pollution Control Centre"

3:00 p.m. Held a briefing session for the Mayor and Councillors at City Hall.

Afternoon In addition to interviews with national media, such as CBC Newsworld Today, the Globe and Mail, and CBC TV in Toronto, the Director continued to do interviews with local media.

September 19, 2002

10:02 a.m. Issued news release – "North End Water Pollution Control Centre Operating Again"

1:00 p.m. Held a second briefing session for the elected officials (at NEWPCC). Two councillors and two Free Press reporters attended.

3:14 p.m. Mayor's office issued a news release – "Mayor Calls for Independent Review of Treatment Plant Operations"

All day Interviews with local media.

September 20, 2002

11:00 a.m. Meeting held at North End Water Pollution Control Centre to brief Reeves/Mayors of downstream communities on the event and river water quality test results.

September 23, 2002

1:38 p.m. Issued news release – "North End Water Pollution Control Centre Continues to Perform Well"

September 24, 2002

Briefing note prepared for environmental activist Robert F. Kennedy, Jr. who was visiting Winnipeg.

November 20, 2002

11:00 a.m. Issued news release – "Faulty Valve Removed at the North End Water Pollution Control Centre"

c. Post Shutdown Communications

- Obtained a copy of all media coverage (electronic and print)
- Placed the following information on the Department's page of the City's internet site:
  - summary document of the shutdown, including pictures
  - river water quality test results
  - news releases
- Emailed the Mayor and Councillors advising them of the letter and the information on the web site.
- Sent a letter under the Director's signature to 24 concerned citizens who were interviewed by the media. The letter thanked them for their interest in the event and concern for the environment, and directed them to our web site for more information. The summary document was attached.
- Executive Policy Committee Secretariat – Intergovernmental Affairs Coordinator advised Reeves/Mayors in communities downstream that information has been posted on the City's website and provided them with copies of the summary document.

8. River Quality Impacts

a. Overflows to River

Under normal circumstances, all wastewater during dry weather conditions is fully treated before being discharged to the Red River.

At approximately 1:15 p.m. on September 16, 2002, pumping of all raw sewage at the North End Water Pollution Control Centre (NEWPCC) was disengaged due to a major malfunction associated with the inspection of pump #5. Wastewater continued to accumulate in the interceptor system, which normally conveys flow to the NEWPCC, until the available system storage was exhausted. Wastewater level alarm records indicate that the first indication of imminent overflow of untreated wastewater to the Red River was reported at approximately 4:29 p.m. of the same day. Flow records for the week prior to the incident indicate that the average flow to the NEWPCC was between 180 and 190 ML/d. An average value of 185 ML/d has therefore been used in subsequent river water quality impact assessments.

On September 19, 2002, at approximately 12:01 a.m., a first pump, pump #3, was put back into service. On September 19, 2002, at approximately 1:30 a.m., a second pump, pump #1, was put back into service. With both pumps operating at maximum capacity, treatment processes resumed and the interceptor system was dewatered. Wastewater level alarm records indicate that at approximately 5:16 a.m. on September 19, 2002, the last overflow alarm had been cleared.

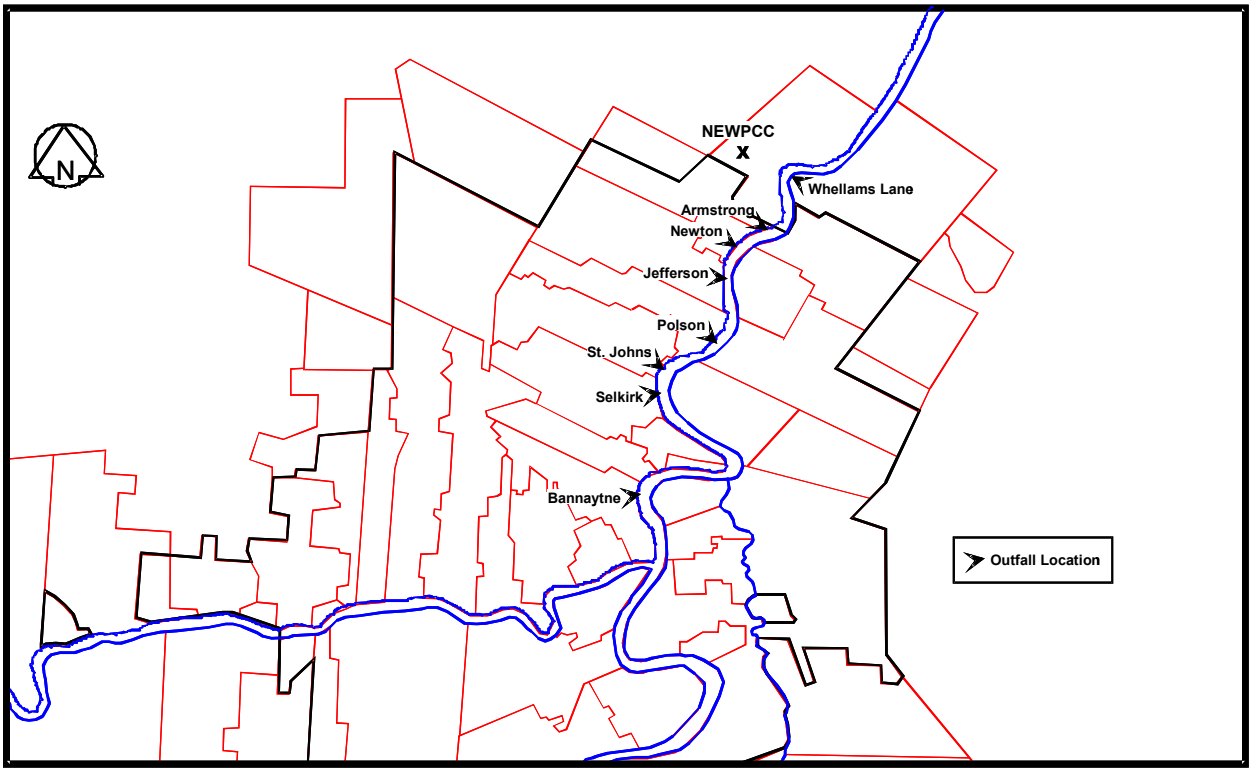
For operation and maintenance purposes, most of the combined sewer overflow locations are equipped with an alarm system that records location and start/stop times of combined sewer overflows. The alarm systems were designed to indicate that an overflow is imminent. As such, the alarms are an indication of the approximate time of an imminent overflow event, not the exact time of occurrence of an event. It is important to note that the time of actual overflow occurrence is dependent on weir elevations that divert flows into the interceptor system and river water level elevations. Table 8.1 summarizes the alarms that were triggered during the September 16 to 19, 2002 overflow events.

Table 8.1 Summary of Overflow Alarms

Station	Overflow Alarm ON at:	Overflow Alarm OFF at:	Comments
Polson	Sept 16, 2002 16:29	Sept 19, 2002 05:16	First alarm on and Last alarm off
Selkirk	Sept 16, 2002 17:18	Sept 19, 2002 02:10	
Newton	Sept 16, 2002 17:19	Sept 19, 2002 01:54	
Bannatyne	Sept 16, 2002 17:24	Sept 19, 2002 02:35	
St. John's	Sept 16, 2002 18:09	Sept 16, 2002 19:30	Fluctuating level in sewer causing alarm to be triggered
St. John's	Sept 16, 2002 20:21	Sept 17, 2002 00:44	Fluctuating level in sewer causing alarm to be triggered
St. John's	Sept 17, 2002 08:24	Sept 18, 2002 02:16	Fluctuating level in sewer causing alarm to be triggered
Jefferson/Main	Sept 17, 2002 14:13**	Sept 19, 2002 04:25	**Alarm relay faulty, overflow likely occurred at an earlier time
St. John's	Sept 18, 2002 08:01	Sept 19, 2002 01:46	

Based on containment efforts at outfalls and field observations noted by staff from the Laboratory Services Division, overflows also occurred at the Armstrong outfall and from the NE interceptor overflow at Whellams Lane. The interceptor system configuration, overflow weir elevations, the system alarms, and river levels, all verified that the Polson station was the first overflow location and the last to stop flowing. Figure 8.1 depicts the overflow locations.

Figure 8.1: Overflow Locations



A detailed review of the system was performed to more accurately assess when overflows to the Red River started and stopped. An important factor in the analysis was river water level during the entire event. Many of the sewer outfalls to the river contain flap gates that were designed to prevent river flows from entering the sewer system, which would cause flooding of the interceptor sewers and the treatment plant under higher river level conditions. As such, during the event, wastewater had to rise to and spill over the diversion weir and continue to rise until it reaches or exceeds the river level to open the flap gate before it could overflow to the river. An analysis of the surge well records revealed that wastewater levels in the sewer system would have reached river levels at about 5:00 p.m. on September 16, 2002, and signified the start of overflows to the Red River. The surge well level stabilized at approximately 6:30 p.m. of the same day indicating that the system had exhausted available system storage and was spilling at the same rate that wastewater was being generated, that is, at an average flow of 185 ML/d. After two pumps were put back into service, the water levels in the surge well dropped rapidly and the NEWPCC was actively processing wastewater. Levels in the surge well dropped below river water level at approximately 2:00 a.m. on September 19, 2002 signifying the stop of all overflows from the system. From this time on, all wastewater flows were conveyed to the NEWPCC for secondary treatment.

Based on a detailed review of system records and conditions, approximately 427 ML (427,000 m^3) of untreated wastewater was discharged to the Red River during the 57 hours the plant was shut down.

b. River Flow and Movement

Mr. Sam Ip and Mr. Rick Bowering of Manitoba Conservation's Water Branch were contacted daily during and following the overflow event to ascertain estimates of flow in the Red River. Estimated flows in the river were provided and based on the most current information available and model predictions by the Water Branch. Subsequent discussions with Mr. Alf Warkentin, Senior Hydrologic Forecaster of Manitoba Conservation's Water Branch revealed that the initial flow estimates weren't accurate due to a discrepancy between flows reported south of the border and flows monitored north of the border. Table 8.2 presents the corrected flow information that was provided on September 23, 2002. The flows are slightly lower than the daily values provided during the event and reported to the media.

Table 8.2: Flow in the Red River

	James Ave (cfs)		Lockport		
Date	**ft³/s**	**m³/s**	**ft³/s**	**m³/s**	**Comments**
September 15, 2002	7250	205.3	7900	223.7	
September 16, 2002	**6530**	**184.9**	**7250**	**205.3**	**Start of overflow**
September 17, 2002	**5830**	**165.1**	**6530**	**184.9**	**Overflow**
September 18, 2002	**5490**	**155.5**	**5830**	**165.1**	**Overflow**
September 19, 2002	**5440**	**154.0**	**5490**	**155.5**	**End of overflow**
September 20, 2002	5290	149.8	5440	154.0	
September 21, 2002	5150	145.8	5290	149.8	
September 22, 2002	5000	141.6	5150	145.8	
September 23, 2002	4900	138.8	5000	141.6	
September 24, 2002	4750	134.5	4900	138.8	
September 25, 2002	4650	131.7	4750	134.5	

The river flow in the Red River at James Avenue for this time of the year are typically 3000 ft³/s (85 m³/s). Based on the information provided by Manitoba Conservation's Water Branch, the flows were approximately double the seasonal norm, and provided a higher dilution and therefore the capacity to assimilate more sewage flow without impacts.

The estimated river flows at Lockport appear to be one day behind the estimated flows for the James Avenue location. The flows reported at Lockport by the Province appear not to include any additional inflows downstream of the James Avenue location, including discharges from the NEWPCC plant. As a result, impacts on the river water quality may be lesser downstream of Winnipeg due to dilution from other downstream inflow sources. For calculation purposes, the flows estimated at the James Avenue location and an average flow from the NEWPCC of 185 ML/d (equivalent to 2.14 m³/s or 75.6 ft³/s) were used in water quality assessments.

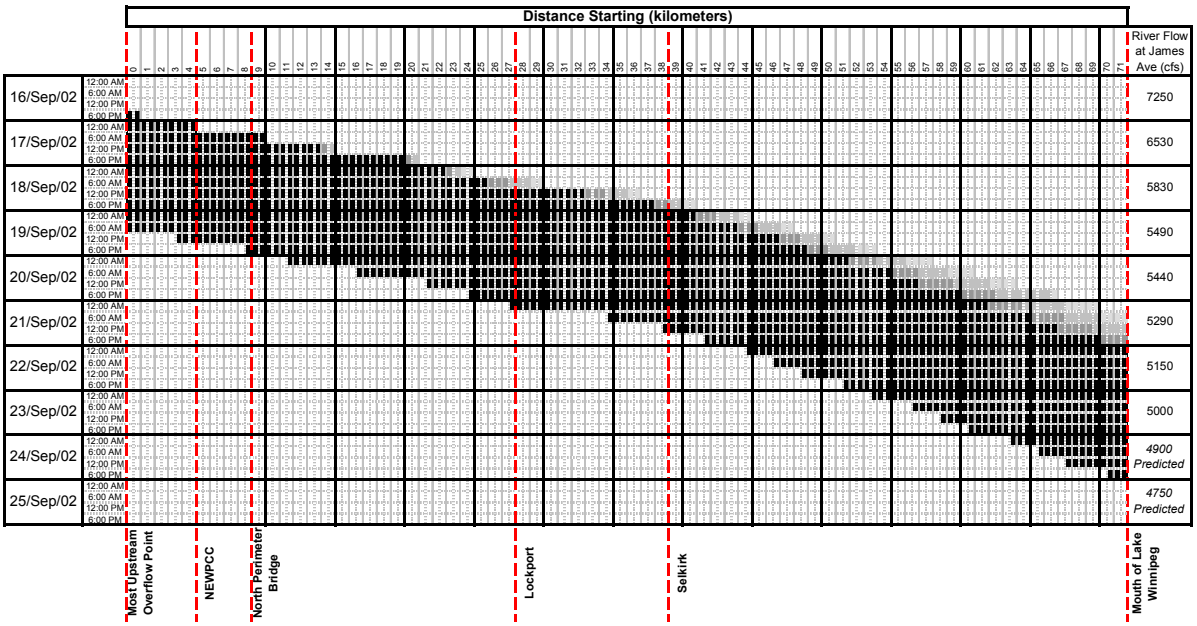
Based on the reported river flows at the James Avenue location, untreated wastewater was approximately 1.1% of the Red River flows on Monday, September 16, 2002, and increased to about 1.4% by Thursday, September 19, 2002.

Travel time and movement of the untreated wastewater discharge along the Red River from just downstream of the junction of the Red and Assiniboine Rivers to Lake Winnipeg (approximately 72 km), was estimated based on segmented volume of the Red River determined from previous river modeling work by the Department and flows at James Avenue provided by Manitoba Conservation's Water Branch.

Figure 8.2 graphically depicts the estimated movement of the untreated wastewater as it travelled down the Red River. The following assumptions and conditions were used to determine the path of the flow:

- The length of river from the first overflow point to the Lake Winnipeg is 72 km.
- The volume of the river remained constant over the range of flows during the event.
- The river was segmented in 36 representative elements, each having similar hydraulic characteristics.
- The lead edge of the discharge, noted by the grey shading, was assumed to move as a wave and travel at a constant velocity based on the September 16, 2002 estimated flow of 6530 ft^3/s. This flow was held constant for the leading edge and represents the fastest the discharge could travel down river. It depicts the earliest that a river reach could have been affected by the overflow.
- The trailing edge discharge, noted by the solid black colouring, was assumed to travel down the river based on a displacement principle, similar to that of flow in a pipe. Each river segment was assumed to have a unique volume that was held constant. Flows provided by the Province for each day were used to displace the volume in each river segment. This assumption would result in the longest period that the trailing edge would remain in the river system.

Figure 8-2: Estimated Travel of Untreated Discharge Down the Red River



Based on a detailed estimate of river flows, the untreated wastewater would have:

- Reached Lockport at about 6 a.m. on September 18, 2002
- Reached Selkirk about 6 p.m. on September 18, 2002
- Reached Lake Winnipeg about 6 a.m. on September 21, 2002
- Cleared Lockport by 6 a.m. on September 21, 2002
- Cleared Selkirk by 6 p.m. on September 21, 2002
- Cleared the complete river system by midnight September 24, 2002

Based on actual field-monitored fecal coliform levels by the City and Province, the actual travel of the untreated wastewater discharge agrees and correlates well with numerical estimates of movement down the Red River, as depicted in figure 8.2.

c. Booms Erected at Outfalls

On Tuesday, September 17, 2002, Euroway Industrial Service Co. Ltd. set up booms at the Bannatyne, Selkirk, St. John's, Polson, Jefferson, and Newton outfalls, and on Wednesday, September 18/02, installed booms at the Armstrong and Whellams Lane outfalls.

Staff of the Department's Laboratory Services Division monitored the booms daily until September 23 for debris and floatable material. The booms and outfalls were tended as required:

- On September 18, the boom located at St. John's was vandalized. Euroway repaired the boom the same day. Staff monitoring the outfalls reported that only the Jefferson location showed a significant amount of debris, such as condoms, rags and other floatables. Euroway promptly removed the debris with a vacuum. That same day, a rainstorm occurred and a large quantity of grease was washed from the outfall into the boom area. A1 Sewage, already on site, removed the grease before it could escape from the boom.
- On September 19, Laboratory Services Division staff noticed debris on the Jefferson outfall bar screen. Euroway hosed off the bar screen using a high-pressure wash system, and then removed the debris with a nylon pool net.

d. River Monitoring Program

The normal river water quality testing program was expanded to closely monitor the impact of the spill on the Red River, particularly dissolved oxygen levels. River water was sampled and tested from September 17 to 25, 2002 inclusive. Normal biweekly sampling of the Red River resumed after that time. Detailed information on water quality monitoring and laboratory results is in Appendix K.

- Samples were taken from locations upstream and downstream of the wastewater release. Up to 13 locations were tested, ranging from Dunkirk Bridge upstream of the discharges to Netley Creek downstream of Selkirk.

- Field-testing consisted of pH, in-situ dissolved oxygen, and temperature at three stations across the river at each sampling location south of Selkirk Park in Selkirk, MB.
- Samples were taken from a depth of one metre using a submersible sampling device.
- Separate samples were taken for laboratory analysis at each of three stations across the river at the Chief Peguis Bridge location, due to the proximity of the wastewater outfall from the North End Water Pollution Control Centre.
- Samples for all other locations south of Selkirk Park consisted of composites of three separate one-litre samples taken at each of the stations across the river.
- Parameters analysed included: total and fecal coliform, Enterococcus, ammonia nitrogen, unionized ammonia, oxygen percent saturation, nitrite-nitrate nitrogen, total organic carbon, and biochemical oxygen demand.
- During the period of the wastewater release, staff monitored conditions at the outfalls and checked the condition of the booms installed to capture any floating debris.
- Staff documented weather conditions, river conditions and any odours.

e. Dissolved Oxygen

- The lowest dissolved oxygen reading determined in the field along the Red River was observed just upstream of Lockport at a concentration of 5.4 mg/L, which is within the Manitoba Water Quality Standards, Objectives, and Guideline requirements.
- All other monitored values were well above this concentration and in the 6.0 to 9.2 mg/L range.

f. Ammonia

Since the NEWPCC is a conventional secondary treatment plant, the ammonia concentration of the effluent is reduced only slightly from the influent concentration before it is discharged to the river. As such, it was expected that the monitored values would not be significantly different than normal effluent discharges and would therefore not result in any increased stress on the aquatic environment. In addition, since ammonia is non-persistent, that is, it will decompose in the river environment, the observed concentration will diminish as it travels down the river.

The highest calculated un-ionized ammonia concentration based on field-monitored temperature and pH, along with laboratory analyzed ammonia between September 16 and 19 was 0.0156 mg/L-N on September 19, 2002 in the Red River as observed at the Chief Peguis Bridge. It is noteworthy that the maximum un-ionized ammonia concentration observed was 0.0213 mg/L, which occurred on September 23, 2002 at the same location. It is likely that both of these values were monitored after the NEWPCC returned to normal operations and discharges were concentrated at the NEWPCC outfall. All other monitored values were well below these concentrations. All monitored ammonia and un-ionized ammonia values were within the Manitoba Water Quality Standards, Objectives, and Guideline requirements.

g. Nutrients (Nitrogen and Phosphorus)

The conventional secondary treatment processes at the NEWPCC remove a small fraction of the nutrients, that is, nitrogen and phosphorus, in the wastewater. Based on long-term monitoring and analysis of raw influent and fully treated effluent, typical concentration for wastewater nitrogen and phosphorus are:

- Total Phosphorus
  - Influent, about 4.9 mg/L
  - Effluent, about 3.1 mg/L

- Total Nitrogen
  - Influent, about 36 mg/L
  - Effluent, about 29 mg/L

The estimated loading from the NEWPCC and incremental increase in nutrients to the Red River attributable to the overflow event are summarized below. Total annual loading of nitrogen and phosphorous were calculated using a NEWPCC average annual flow of 230 MLD.

- Total Nitrogen load from NEWPCC, approximately 12.7 tonnes over a typical 57 hour period
  - Incremental nitrogen load from 57 hour overflow event, 3.0 tonnes or 24.1% increase

- Total Annual Nitrogen load from NEWPCC, approximately 2430 tonnes/yr
  - Incremental nitrogen load from 57 hour overflow event, 3.0 tonnes or 0.12% increase on annual basis

- Total Phosphorus load from NEWPCC, approximately 1.32 tonnes over a typical 57 hour period
  - Incremental phosphorus load from 57 hour overflow event, 0.77 tonnes or 58.0 % increase

- Total Annual Phosphorus load from NEWPCC, approximately 260 tonnes/yr
  - Incremental phosphorus load from 57 hour overflow event, 0.77 tonnes or 0.30% increase on annual basis

h. Pathogens

Fecal coliform (number/100mL) are a standard indicator organism used to assess pathogenic contamination of a water body. Additional sampling locations were added downstream of Selkirk between September 21 to 25, 2002. This was done explicitly to collect samples more specific to the river reach potentially affected by the overflow as it travelled northward along the river to Lake Winnipeg. Due to laboratory processing errors, samples collected on September 17, 2002 were improperly prepared and could not be enumerated. All remaining samples were properly prepared and processed.

Disinfection of final effluent is currently not in place at the NEWPCC. Raw wastewater contains fecal coliform in the order of 10 to $100x10^6$ /100mL. Although the NEWPCC is a conventional secondary treatment plant, the environment and processes used to treat the wastewater are hostile to pathogens and their concentrations are significantly reduced in the final effluent discharged to the Red River. Final effluent from the NEWPCC typically contains less than $0.10x10^6$ /100mL. As such, it was expected that the monitored values would be significantly higher in the river during and immediately after the overflow event. It is important to note that these organisms do die off rapidly in the river environment as a function of several factors (namely time, temperature and sunlight) and will be at or below background levels normally found in the river 4 to 5 days after the event. Accordingly, fecal coliform concentrations are expected to be highest in Winnipeg and of decreasing concentrations as sampled along the Red River to Lake Winnipeg.

A cursory review of the data finds that that there is a general temporal and spatial trend of decreasing fecal coliform concentrations as monitored downstream of Winnipeg. Due to the variability associated with microorganisms at its source, collection of field samples, and laboratory testing procedures, it is not possible to delineate an exact relationship with the fecal coliform indicator organism as the overflow travelled down river. A maximum concentration of 82,000 /100mL was recorded on September 18, 2002 as sampled at the Chief Peguis Bridge near the west bank. Maximum values of 65,000 /100mL were reported for September 19 and 20, 2002 at Lockport.

Fecal coliform counts in samples taken by the City tend to be higher in general than those monitored by Manitoba Conservation, but are in the same order of magnitude. On September 18, fecal coliform levels of 13,000 /100ml at Lockport confirm that the plume had travelled this far, which is consistent with the Provincial interpretation. On September 19, fecal coliform of 23,400 was measured at Selkirk confirming that the plume had reached there which again was consistent with the Province. Upstream values ranged from 23,000 to 82,000 /100ml. A rainfall event occurred on September 22, which caused an elevation in coliform levels within Winnipeg likely caused by combined sewer overflows. By September 23, coliform counts were returning to normal background levels.

i. Other Contaminants and Visual Observations

As wastewater began overflowing from outfall locations along the Red River south of the NEWPCC outfall, distinct outfall plumes, approximately 1- 4 metres from shore, were evident and characterized by a dark colouration.

Department personnel inspecting the booms at the discharge locations reported visible signs of household generated waste. Portions were captured after containment booms were installed. Amounts of floatable material captured at the various outfall locations varied from minimal to none except at the Jefferson outfall, which according to Department crews inspecting the booms, and at the Kildonan Park (Armstrong) outfall, which according to river monitoring crews, yielded a larger amount of floatable material.

Film and grease were noted within the booms at the St. John's and Jefferson outfalls on September 18, and at the St. John's and Kildonan Park (Armstrong) outfalls on September 19.

j. Odour

As survey crews travelled the river to extract samples for analysis, the presence of odour and corresponding location were noted.

- On the first day of sampling, September 17, sewage related odour was detected in the vicinity of the Chief Peguis Bridge.
- On September 18, the sewage related odour was evident downstream at Lister Rapids as the sampling crew travelled northward. On the return trip to Winnipeg, sewage related odour was detected on the River at the Larter's Golf Course, and persisted southerly to the Redboine Yacht Club dock.
- On September 19, sewage related odour was detected in the vicinity of the NEWPCC outfall, as the plant had begun discharging again that morning. A strong sewage odour was also still detectable at the Kildonan Park (Armstrong) outfall.
- On September 20, a sewage odour was noted from the picnic grounds north of Lister Rapids up to and just below the Lockport dam.
- After September 20, no further odour was reported along the downstream sampling route.

9. Costs

The cost of the accident and associated work is estimated to be $540,000 (see Appendix I). Approximately $335,000 of this relates to actual damages. The remaining $205,000 is associated with the removal and replacement of the faulty valve.

The costs to put the NEWPCC back into service and other costs resulting from the flooding of the main pump building were tracked in a separate cost centre in the general ledger. This gives the Department the ability to report on the costs to the regulators, elected officials, other stakeholders, and insurance providers.

Included in the total are:

Costs for Damages

- Overtime for City staff involved in cleaning up and removing and reinstalling the pump motors and sundry equipment.
- Cleaning, drying and repairing the pump motors.
- Repairing or replacing flow meters, sump pumps and other equipment.
- Placing, servicing and removal of the river booms.
- Consultant assignments directly related to the event, such as:
  - Shooters Family Golf Centre, 2731 Main Street, claimed the NEWPCC flooding caused sewage backup to flood their premises. The City retained a consultant to determine the cause of this backup.
  - Modeling of river quality impacts.

Costs to remove and replace the valve

- Services of Wardrop Engineering Inc. as project managers.
- Services of Dominion Divers as contractors for the work.
- Purchase of the valve.

Plant improvements or risk mitigation strategies are not included in the costs.

10. Conclusions and Recommendations

A sequence of events resulted in the shutdown.

- A guide inside the 36-inch diameter valve was broken and missing and caused the valve to be lodged open by approximately 13.5 inches.
- A staff team concluded incorrectly that the valve was closed but not "seated" 5. The staff team included the plant supervisor, senior operator, operator, and lead mechanic at the plant.
- Staff believed their plan to "seal" the valve with debris was working when it was not – rather the sewage debris was sealing the pump inspection plate passages.
- Staff loosened the 12-inch diameter inspection plate to the point that it blew off the pump allowing sewage to flow into the pump well.
- The interconnecting tunnels between the pump wells allowed all three pump wells to flood, submersing the motors and other equipment shutting down the facility.

In terms of conclusions and recommendations it is useful to discuss what happened in terms of:

- The procedures that led to the incident;
- The design of the facility; and
- The recovery.

a. The Procedures

Conclusions

The incident was an accident. It was preventable. The staff were not negligent in their duties.

It was an accident in the sense that there was no intent of wrongdoing. In fact, the staff initiated the project in order to solve the problem – to isolate MP5 for needed maintenance. The staff knew that it had been tried before. The staff could have left the situation for management and engineering to solve. It was dedication to duty that resulted in staff taking on this project.

The staff had a plan. The Supervisor, Senior Operator, and Operator had discussed and agreed to the plan. The mechanical staff were aware of the plan and were supportive. The plan was based on their experience that leaks due to poor "seating" of a valve can "seal itself" providing the material is sewage and you let the sewage drain. This assumption was incorrect in this case. It would be impossible to "seal" a 13.5 inch opening. What did happen, was that the passages around the inspection plate "sealed" resulting in the flow ceasing to drain from the loose inspection plate.

At the time, the staff believed their plan to seal the valve was working. The staff were aware of the need to be very careful in executing the plan. At every step of the way, precautions were taken. As the plan was executed, the staff had evidence that to them indicated that their plan was working and on Monday, September 16, 2002, they concluded that the plan had worked.

[5] "Seating" refers to the last one-half inch movement of the valve that in effect creates a seal by having the wedge seating faces contact the body seating faces.

Like any accident, this incident was preventable. The staff themselves knew immediately how the procedure could have been modified to prevent catastrophic failure. For example, they could have installed longer bolts or studs on the inspection plate so that it could have been held in place and reinstalled. The operator called for longer bolts when it did happen. Staff have since installed longer bolts (studs) on two of the bolt holes on this inspection plate and plan to install similar studs on all of the inspection plates in this area.

The underlying problem was that the suction valve was not fully closed. When the valve was removed for examination on November 19, 2002, it was discovered that a guide was missing inside the valve, causing the valve to be lodged open about 13.5 inches. An investigation is underway to find out why the guide is missing.

The operators' conclusion that the valve was closed based on the position of the stem was not correct. It became clear when the valve was removed that the valve stem location was not an indication that the valve was closed. While the valve stem at the top of the electric operator would normally indicate a closed valve, for this particular valve, the stem would be recessed 13 inches into the operator when closed. This valve is different than the other 4 Jenkins valves that have 14-inch longer stems so the stem is near the top of the operator when closed.

The observation of the stem position was so powerful that it blocked staff and management from believing the position indicator which showed that the valve was not closed. External markings or other means of noting this at the valve would have alerted operators to the fact that the stem was 13 inches from the closed position.

The operators did not review the shop drawings for the valve to determine if there was supplementary information that could have assisted in determining the position of the valve. For example, it would have been possible to use the measurement of the stem length on the shop drawing to conclude that the valve was not closed. However, the staff may not have come to that conclusion even with the shop drawing. For example, in the intervening period since the accident, management and investigators had access to the shop drawing but did not come to that conclusion until the valve was actually removed. This further demonstrates human nature to make a conclusion (the valve appears closed) and not to accept information to the contrary.

There is the need to be more prescriptive about procedures. There is a need for formal written procedures for critical operations. Written procedures and checklists that list the steps and explicitly state the hazards and responsibilities for isolating equipment are required for critical equipment anywhere in the plant.

In addition the Department is proposing some alterations to the main building pumps to further minimize the chance of a recurrence.

Recommendations

1. Prepare written procedures for isolating the main building pumps.

2. Alter the main building pumps, including:

- **a. Devise a way to clean and back flush drains.**
- **b. Outfit inspection hatches with a number of strategically placed longer studs to assist in reassembly if needed in an emergency.**
- **c. Add a 4 or 6 inch gate valve to the top of each pump, possibly connected to a clear plastic cylinder to provide an additional tool for operators to confirm the safety of the operation.**

3. Prepare written procedures for other key activities where safety or plant integrity is at issue. The procedures should include reference to and location of operating manuals and equipment layout and shop drawings.

4. Place external markings (or their equivalent) on all valve stems to clearly indicate when the valve is in the closed position.

5. Review training for all procedures and implement a requirement and schedule for refresher training.

b. The Design of the Facility

Conclusions

In 1965, the suction valve for MP1 in pump well number 3 inadvertently opened during construction, flooding all three pump wells as described in Appendix B. The Department was aware of the potential for flooding the motors, but based on the low probability of re-occurrence, did not take any action.

For example, this risk appears in a list of potential projects maintained by staff, and is also noted in the minutes dated January 16, 2001 of a meeting to discuss NEWPCC raw sewage pump vibration lockouts. Staff from the Wastewater Operations and Engineering Divisions attended, and discussed cleaning the surge well and suction conduits. The following notes appear in these minutes.[6]

> *The 3 dry wells that contain the 6 pumps are interconnected by doorways. There is a concern that in the event of a major leak in one of the dry wells, all 3 could flood and result in a complete shutdown of the NEWPCC. This problem is believed to be more likely to occur during a flood period. Adding waterproof doors in the openings was suggested as one potential way to mitigate this concern.*

[6] File 020-17-06-01-00, January 19, 2001, Minutes of Meeting #1

However, staff did not think it significant enough to recommend that an item be included in the capital budget to separate the dry wells. It was never a priority because staff indicated that the separation would be complex, and there was a low probability of an incident.

The judgement not to build walls should be evaluated against what a reasonable engineer would do faced with the possibility and consequences of flooding and with options to separate the wells.

Engineers designed the facility in 1937. Since then, many engineers and consultants have worked on changes to the original design. In 1950, a consultant engineering review was carried out for an expansion completed in 1954. Clearly, in 1965 when the first flooding occurred, consulting engineers were on site. As described Appendix B, the engineers knew that this could happen again. While there are no records on what factors they considered, it is assumed that they believed that the risk of such an event ever happening again was very low.

In 1978, the City engaged Wardrop – MacLaren Engineers to provide engineering services to add MP5 to the treatment plant. The report does not reference a concern over possible flooding.

In 1993, the City engaged Wardrop Engineering in association with Gore & Storrie Engineers, to provide engineering services to replace MP1. Again, the functional design report and file does not show any concern over a risk of flooding of the pump wells. In fact, the low bidder for the project offered an alternative submersible pump to the pump specified. Wardrop recommended against accepting this alternative as it would be incompatible with the pumps that were already there.

In hindsight, it is clear that the facility must be protected against this ever happening again. It is also apparent that the Department should review all of the critical treatment facilities for significant failures and review the possible risks and mitigation measures that may be applied.

The time taken to inspect the valve using the stoplog procedure described in Section 5 is very time consuming and does not allow plant staff to deal with problems in a timely manner. Many plants have positive gates on the interceptors to facilitate this work at the head end of the plant. This should be investigated for the North End Water Pollution Control Centre.

Recommendations

6. Take action to separate the pump wells to prevent another catastrophic failure of the main pumping facilities at the North End Water Pollution Control Centre.

This project was assigned to Wardrop Engineering Inc. on September 25, 2002 and is well underway. Possible isolation options include watertight doors and structural blockage.

7. Examine the installation of gates on the main interceptor to isolate the plant.

The Department has engaged Wardrop Engineering Inc. to study and report on options to isolate the plant.

8. Review all three wastewater plants and the collection system to identify and mitigate any risks that could result in discharges to the rivers.

The 2003 capital budget contains an amount of $750,000 for this review.

c. Emergency Response

Conclusions

The emergency response operation to put the plant back in service was excellent. The total time from failure to start up of the first pump was 59 hours.

A key factor in this success was that many department staff are trained in emergency response, including emergency operations management and incident commander roles, through the Canadian Emergency Preparedness College. A plan was developed early and followed, and decisions were made on a timely basis. Daily briefings took place at 9:00 a.m. with key staff, including department public information staff and representatives from Manitoba Conservation.

Public information staff provided access for the media and prepared daily news releases on the event. Briefings were held with other City staff, Councillors, and with representatives from downstream municipalities.

Staff across the department worked together in a coordinated way. Staff and other resources were made available so that the number of staff available was never a limitation. In addition, engineering consultants and contractors offered priority service to deal with the emergency.

Appendix A – Plant History

Early sewers were built to carry storm runoff only. Discharge of domestic waste was first prohibited as pit privies were used. Eventually pit privies were not allowed and discharge into the sewers was mandated.

The history of sewerage in Winnipeg began with the construction of these combined sewers in the late 1800s. The discharge of waste to the rivers resulted in objectionable conditions in the rivers and in the early 1930s pressure to solve the problem became significant. As a result, the Greater Winnipeg Sanitary District was formed. A system of intercepting sewers and a primary type sewage treatment plant was put into service on October 25, 1937. Winnipeg became the first city of over 100,000 people in Canada to install sewage treatment. The plant serviced six municipalities namely Winnipeg, St. Boniface, East Kildonan, Transcona West Kildonan and St. Vital. The plant was expanded in 1953-1955 to serve Tuxedo, St. James and Fort Garry.

Eventually, it became obvious that primary treatment was not sufficient to protect the rivers. When the Metropolitan Corporation of Greater Winnipeg was established in 1961, it was given the mandate to provide sewage treatment taking over from the Greater Winnipeg Sanitary District.

Metro undertook a major expansion of the facility in 1963-65 to provide secondary sewage treatment. This provided a major improvement in the quality of the effluent from the plant. At about the same time, the Charleswood lagoons were developed and later the South End Water Pollution Control Centre was put in service in 1974.

The North End Water Pollution Control Centre underwent another major expansion in the late 70s and early 80s. Additional primary clarifiers were added. The secondary treatment process was changed from step feed air-activated sludge to a pure oxygen process. Additional sludge digestion was added as well as a distributed computer control system. The capacity of the secondary is currently 598 MLD.

The latest addition to the plant was the sludge dewatering facility that was commissioned in 1990. This facility allowed the City to stop using sludge drying beds located in West St. Paul. Overall, the cost of the expansions since 1978 has exceeded $110 million.

Appendix B – Flooding of Pump Wells - 1965 Event

This report summarizes the following documents on the event:

1 - Report: Gordon Freeman, Operator, Area A, December 20, 1965
2 - Report: George Regier, Electrical Technician, Wardrop Engineering, December 20, 1965
3 - Report: Dirk Van Es, Engineer of Sewage Disposal, December 20, 1965
4 - Letter: G. C. Koopmans, James F. MacLaren Ltd., December 29, 1965
5 - Attached Report: G. C. Koopmans, James F. MacLaren Ltd., December 23, 1965
6 - Letter: G. C. Koopmans, James F. MacLaren Ltd., July 13, 1966

Summary of Flood Event:

On December 16, 1965, early in the morning, the MP1 suction gate valve was closed and the pump dewatered by the night shift operators, as mechanical staff had planned maintenance on the pump scheduled for that morning. A hold card was placed on the starter button for MP1, but no hold card was placed on the contactor. This provides warning that the pump must not be started while the card is in place.

On the morning of Thursday, December 16, 1965, major plant improvements and repairs were in progress, and consultant engineers were on site administering various contractors. Plant maintenance activities were also in progress. A mechanic and his helper were in the drywell performing maintenance on MP1 as planned, and had removed the 24 inch spool piece between the valve and pump.

At 11:25 am, December 16, the main pumps were shut down (MP4 and MP6 were running) for an inspection of the influent sample pump. During the shutdown, a consultant engineer, technician and the electrical contractor decided to remove the electrical contactor for MP1 in order to plan work on the pump starter.

At approximately 11:30 pm, December 16, when the contactor was removed, the MP1 suction gate valve opened, flooding the pump well with sewage within 5 minutes. This resulted in plant shutdown. The mechanic and his helper evacuated the area.

Document 2 indicates that the electrical contractor replaced the contactor for MP1 immediately after realizing that the wells were filling up, hoping this would close the valve, but this did not happen (explained later).

Probable Cause of the Incident:

The MP1 suction gate valve was operated by a hydraulic cylinder, with water pressure fed to either the top (to close) or the bottom (to open) of the cylinder by a solenoid valve, as shown in Figure B1.

An emergency stop button is used to close the MP1 gate valve. This button energizes a relay, which seals itself in, and closes a contact in the solenoid valve circuit, energizing it. When the solenoid valve is energized, it allows water to flow to the top of the hydraulic cylinder, driving the cylinder's piston down to close the valve, while draining water from the bottom of the cylinder. When the contactor was removed, this released the emergency stop relay, which de-energized the solenoid valve. The valve shuttled to it's de-energized position, feeding water to the bottom of the hydraulic cylinder, pushing the piston up and opening the valve while releasing water from the top of the cylinder.

According to Document 5, the controls for the MP1 suction valve had been altered to suit the automatic pump control system proposed for the new pumping arrangements. The solenoid valve was designed to "fail" in the MP1 suction valve opening position to prevent the valve from closing while the pump was operating in the event of a solenoid valve/circuit malfunction. The document states that after the suction valve is closed, 2 manual valves should be closed to "lock" the valve in its closed position. This was not done.

Document 2 indicates that any momentary power interruption will cause the solenoid valve to open the MP1 suction valve. While not documented, this may be because on loss of power, the relay in the emergency stop circuit would immediately release and de-energize the solenoid circuit. Resuming power would not re-energize the solenoid circuit and close the suction valve, unless the emergency stop button was pushed. Document 2 indicates that the electrical contractor tried to energize the solenoid valve by replacing the contactor, but does not indicate that the emergency stop button was pressed, which would have been required. In any case, it is likely that before the suction gate could close completely, the solenoid valve would have become immersed and shorted, which would have opened the suction valve again.

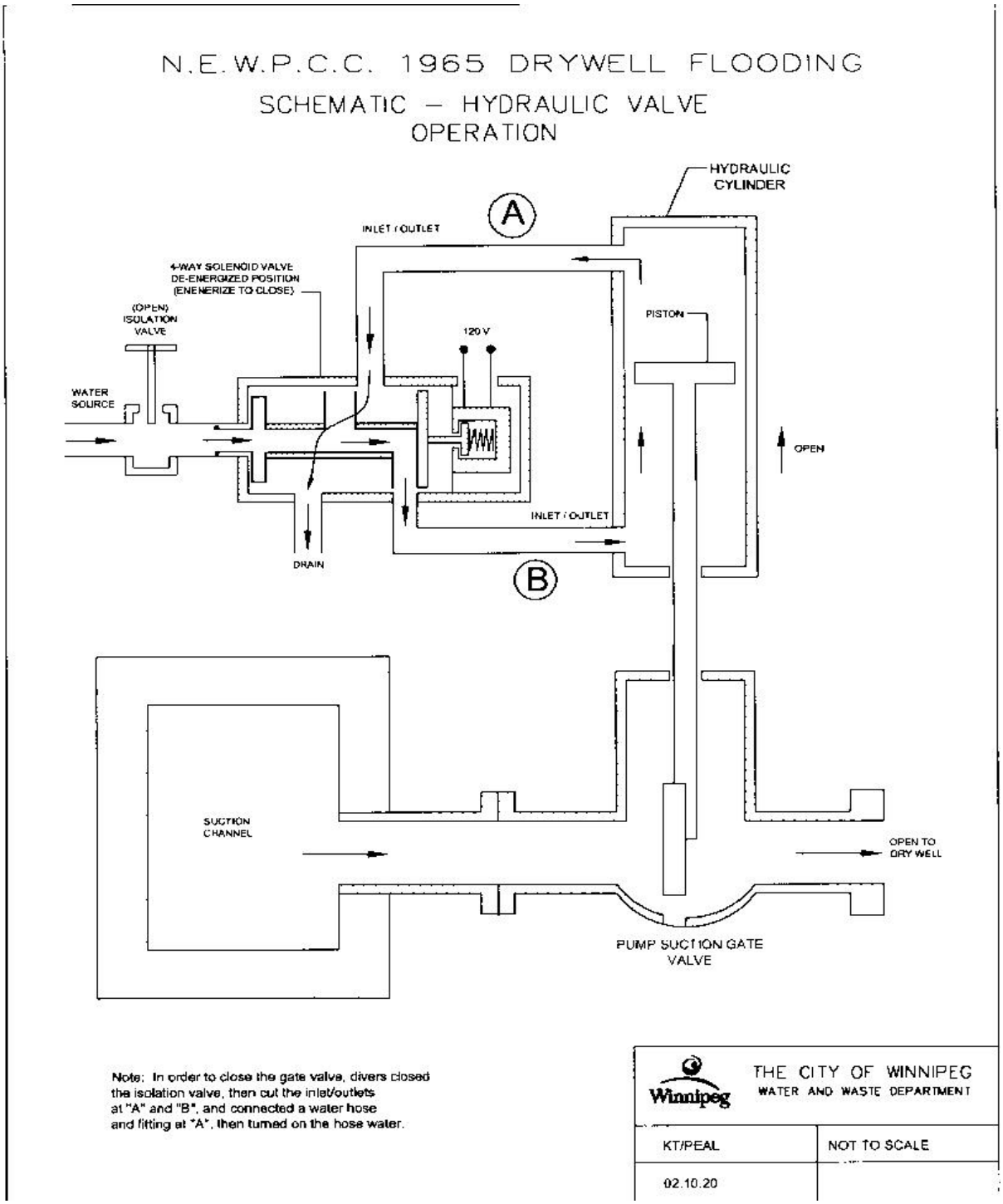

N.E.W.P.C.C. 1965 DRYWELL FLOODING
SCHEMATIC – HYDRAULIC VALVE OPERATION
HYDRAULIC CYLINDER
A
INLET / OUTLET
4-WAY SOLENOID VALVE DE-ENERGIZED POSITION (ENERGIZE TO CLOSE)
(OPEN) ISOLATION VALVE
120 V
PISTON
WATER SOURCE
OPEN
INLET / OUTLET
DRAIN
B
SUCTION CHANNEL
OPEN TO DRY WELL
PUMP SUCTION GATE VALVE
Note: In order to close the gate valve, divers closed the isolation valve, then cut the inlet/outlets at "A" and "B", and connected a water hose and fitting at "A", then turned on the hose water.
Winnipeg
THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT
KT/PEAL
NOT TO SCALE
02.10.20

Figure B1

Post Pump Well Flooding Activities:

With no pumping capability at the NEWPCC, Wastewater Collection System pumping stations were taken out of operation by 1:00 p.m., December 16, 1965 resulting in raw sewage spilling into the Red and Assiniboine Rivers.

By 4:45 p.m., a diver had succeeded in severing the hydraulic connections to the hydraulic cylinder, which operates the suction valve, and in attaching a water line to the top inlet of the hydraulic cylinder. Although not mentioned in the documents, the diver must have also closed the water hand valve to the solenoid valve to do this. At approximately 5:00pm, December 16, water pressure was applied to the new water line, closing the suction valve.

Submersible pumps were used to pump down the pump wells and dismantling of the motors commenced at 8:00am, December 17. The motors were removed and sent out for drying and servicing, while staff worked around the clock to repair pumps and equipment in the pump wells. By 9:00 pm, Saturday, December 18, 1965, the motor for MP6 had been returned, installed and operated. Approximately 58 hours had elapsed between flooding of the pump wells and resuming operation with one pump.

Mitigation:

As a result of the incident, James F. MacLaren Limited, consulting engineers, recommended 22 modifications (Document 6), some of which would improve response/safety in the event of a reoccurrence of the incident, and others which improved overall plant safety and performance.

According to a retired mechanic (not documented in the six documents), in order to ensure that this incident would not re-occur, the plant superintendent instituted the following operations, to be followed whenever work was performed on a pump with a hydraulically operated suction valve (applicable to two suction valves):

1 Push the emergency stop button. This shuts down the motor and closes the suction valve.
2 Close all 3 solenoid hand valves to isolate the solenoid valve and lock the hydraulic cylinder in the closed position.
3 De-energize the 4160-volt circuit at the control panel.
4 De-energize the 600-volt circuit at the control panel.
5 Remove the fuses from the 110-volt control circuit in the control panel.
6 Tag and lock out the control panel.
7 Secure the pump suction valve in the closed position with chains.

The last of the hydraulically operated suction valves was removed in 1994.

Appendix C – Chronology of Response to Re-Establish Pumping

An overall plan of attack to re-establish pumping at the NEWPCC was established in the hour after the event. The basic steps were:

i) Use a diver to locate and reattach the inspection plate on MP5. Dominion Divers was contacted and confirmed.

ii) Pump out the pump wells using portable submersible pumps. Arrangements were made for portable pumps.

iii) Remove the 4160-volt motors in a logical sequence and send them for servicing locally. Local repair shops were contacted and confirmed availability on a 24/7 basis. The logical sequence was MP3, MP2, MP1, MP4, and MP6. MP5 motor would be removed last and not reinstalled pending replacement of the suction valve.

iv) While the motors were out for servicing, by priority service the pump and ancillary equipment so that when a motor was returned, the pump would be ready. New feeder cable was located and ordered.

v) Reinstall, check rotation, and align the motor with the pump.

vi) Restart the pumps and the treatment process.

vii) Repair other equipment as time permits.

Other plans in terms of public information, notification of authorities along with ongoing reporting, and engineering studies were made and executed as discussed elsewhere in this report.

September 16, 2002

- Several commercial diving firms were contacted. Dominion Divers was the only firm willing and able to do this type of job due to the hazardous nature. No team was available. After several calls explaining the urgency of the situation, a dive team was pulled from a floodway project.
- Portable pumps were located, installed and tested.
- Dominion Divers attended the site at approximately 5:30 p.m.
- Power to the entire building was turned off as a safety precaution to protect the dive team.
- The diver was able to locate and reinstall the inspection plate by 7:00 p.m. and were clear by 7:30 p.m. Power was then turned on.
- Three portable pumps were started at about 7:30 p.m. with an estimated pumping time of 20 hours and completion time of September 17, at 3:30 p.m. The wet well level at the start of pumping was approximately +10 feet, which would equate to 33 feet of sewage in the wells.

September 17, 2002

- Pumping continued in the morning according to schedule. At 9:00 a.m., 7 to 8 feet remained in the pump wells. Pumping continued throughout the day.
- In the early afternoon when sewage levels were such that the bolts on the motors were showing and the staff could work with hip waders, staff began removing motors on MP 2, 3 and 1.
- By 7:00 p.m., the motor from MP2 was shipped to King's Electric.
- Later that evening MP1 and MP3 were shipped to G.E.
- During the day, booms were installed at 6 river outfalls to catch any floating material being discharged.

September 18, 2002

- During the day, work continued in preparing pumps MP2, MP3 and MP1 for return of the motors, including the installation of new 4160-volt cables.
- During the day, work continued on removing motor MP4.
- At about 6:30 p.m. motors for MP3 and MP1 arrived on site from GE. The motor for MP4 was shipped to GE by return load.
- Crews stayed and worked through the evening on installing MP3 and MP1 motors. By midnight MP3 motor was installed, aligned, bumped and close coupled to pump MP3.

September 19, 2002

- At 12:01 a.m., pump MP3 was started and ran successfully. Flow was established at 185 MLD.
- At 1:30 a.m., pump MP1 was started. This increased the flow through the plant to about 280 MLD.
- The motor for MP6 was removed and sent to G.E.
- MP5 valve was chained and double locked to ensure no tampering.

September 20, 2002

- Staff continued to work on repairing damage concentrating on controls for the main pumps that have been reinstalled and on re-establishing sump pumps.
- Number 5 motor was disconnected from the pump.
- The motors for MP4, MP2 and MP6 were received late in the day.
- Staff proceeded to install motors on MP2 and MP4.
- The motor for MP2 was reconnected and MP2 was started at approximately 11:00 p.m.
- Staff then turned their attention to installing the motor for MP4.

September 21, 2002

- The motor for MP4 was connected and pump MP4 was tested and started at 2:00 a.m.
- The motor for MP6 was not installed at this time because it had to be out of the way in order to remove the motor from MP5. MP5 motor was not to be removed until a bulkhead was designed and installed to isolate this pump well from the other two.
- Electrical and instrumentation staff worked to refurbish control equipment.

September 22, 2002

- Electrical and instrumentation staff worked to refurbish control equipment.

Week of September 23 - 27, 2002

- Consultant engaged to design bulkhead.
- Overhead crane inspected and repaired to lift motor for MP5
- Electrical/instrumentation and mechanical staff worked to refurbish submerged equipment.
- Booms were removed from outfalls.

Week of September 30 – October 4, 2002

- An engineered temporary bulkhead was installed between drywell #1 and #2 to minimize the risk of flooding all 3 drywells in the event of an accident (e.g., dropping the motor onto MP5 in the process of removal.
- Due to access challenges, the MP6 motor could not be installed until the MP5 motor was removed, which was completed Wednesday afternoon, October 2nd.
- MP6 motor was then installed October 3rd and in service October 4th.
- MP5 motor was repaired and will be set aside until its suction valve is repaired or replaced.

Appendix D – News Releases

September 16, 2002 – For Immediate Release

MECHANICAL FAILURE SHUTS DOWN THE NORTH END WATER POLLUTION CONTROL CENTRE

Due to mechanical failure, the North End Water Pollution Control Centre is temporarily out of service. At approximately 1:15 pm today, staff were repairing one of the six pumps in the main pump room. Because of a faulty valve, raw sewage flowed into the pump room immersing equipment. As a result, raw sewage cannot be pumped through the regular wastewater treatment processes and began draining into the Red River at approximately 5:00 pm. One operator sustained minor injuries and is seeking medical treatment.

Staff are working around the clock and could have the facility back in operation within a week. Until repairs are complete, approximately 230,000 cubic metres of raw (untreated sewage) will drain to the Red River per day. Barry MacBride, Director of the City's Water and Waste Department says, "Because of high river flows from upstream of Winnipeg, the sewage will be diluted and we don't expect a major impact on river water quality. We will start monitoring river water quality tomorrow and should have results within a couple of days."

The North End Water Pollution Control Centre, located at 2230 Main Street, processes raw sewage from the north and central areas of the city, including about 370,000 residents. There is no impact to residents in the city of Winnipeg - they can continue to use the water and sewer services as usual.

MacBride says, "We advised Manitoba Conservation and Winnipeg Regional Health Authority immediately, and we will give them regular updates on our progress. Municipalities downstream of the Red River are being notified. There aren't any communities downstream of Winnipeg on the Red River that use river water as a source of drinking water."

- 30 -

Media inquiries may be directed to:

Kathy Taylor
Public Information Officer
Water and Waste Department
794-4529 (cell)
986-4478

September 17, 2002 – For Immediate Release

REPAIRS CONTINUE AT NORTH END WATER POLLUTION CONTROL CENTRE

Repairs are progressing well at the North End Water Pollution Control Centre. A mechanical failure temporarily shut down the centre yesterday at approximately 1:15 pm. Because of a faulty valve, raw sewage flowed into the pump room immersing equipment. The raw sewage cannot be pumped through the wastewater treatment processes, and as of 5:00 pm yesterday, was draining into the Red River.

Until repairs are complete, approximately 230,000 cubic metres of raw (untreated) sewage will drain into the river per day. Barry MacBride, Director of the City's Water and Waste Department says, "Our staff were on the Red River early this morning taking water samples, and initial test results show that there is no noticeable impact on aquatic life. High river flows and cooler river water temperatures are helping to reduce the impact on water quality. We will continue to test and monitor river water quality on a daily basis."

"We expect the repairs to be complete and the facility operating again by Monday or perhaps earlier. The sewage has been drained from the pump room. Staff have been hosing down the pump wells and cleaning the debris off the equipment. The first two of six electric motors were removed late this afternoon and were sent to be cleaned and dried," says MacBride. The approximate size of each motor is 2 metres by 2 metres by 2 metres.

Winnipeg residents can continue to use their water and sewer services as usual. There aren't any communities downstream of Winnipeg on the Red River that use river water as a source of drinking water. Depending on wind and weather conditions, residents may notice an unpleasant odour on the river from downtown to the North Perimeter bridge and beyond. MacBride says, "Although we are not seeing increased floating debris from the sewer system, we are installing booms at all six outfalls to collect as much as we can. Three of the booms were in place by 4:00 this afternoon, and the remaining three will be installed this evening."

"We are continuing to work with our regulatory agencies, both for monitoring river water quality and investigating the failure, including Manitoba Conservation and Health, Winnipeg Regional Health Authority and Environment Canada", says MacBride.

The North End Water Pollution Control Centre, located at 2230 Main Street, processes raw sewage from the north and central areas of the city, including about 370,000 residents.

- 30 -

Media inquiries may be directed to:

Kathy Taylor, Public Information Officer
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794-4529 (cell)
986-4478 (office)

September 18, 2002 – For Immediate Release

REPAIRS AHEAD OF SCHEDULE
AT NORTH END WATER POLLUTION CONTROL CENTRE

Repairs are ahead of schedule at the North End Water Pollution Control Centre. Three motors were removed late in the day yesterday and sent to be cleaned and dried. Two of the motors are expected back late this afternoon and crews will be working late into the evening to install them. Barry MacBride, Director of the City's Water and Waste Department says, "We are optimistic that we will be able to get part of the facility operating by late Friday so that we can stop discharging sewage directly to the river."

Approximately 230,000 cubic metres of raw (untreated) sewage is draining into the river each day. This is about 1.5% of the river's flow. MacBride says, "Our staff were out on the Red River again early this morning taking water samples, and test results continue to show that the oxygen levels in the river water remain adequate to support healthy aquatic life. River flows remain above average, and together with cooler river water temperatures, helps to reduce the impact on water quality. We will continue to test and monitor river water quality on a daily basis."

Winnipeg residents can continue to use their water and sewer services as usual. Residents can help reduce the amount of debris going into the river by not using plumbing systems as a litter basket. MacBride says, "This is a message we promote all the time, but it is particularly important right now." The most common litter is cigarette butts, dental floss, feminine hygiene products, disposable diapers, rags, and household hazardous waste products. Many of the household hazardous waste products can't be removed in our wastewater treatment processes. They can be harmful to fish and other aquatic life, and can also damage your household sewer system and the city's sewer system.

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Public Information Officer
Water and Waste Department
794-4529 (cell)
986-4478

September 19, 2002 – For Immediate Release

NORTH END WATER POLLUTION CONTROL OPERATING AGAIN

The North End Water Pollution Control Centre is back in service. The first of six pumps was running at midnight, and the second pump was working by 1:30 am. Barry MacBride, Director of the City's Water and Waste Department says, "Starting at 1:46 am, we started to see a gradual reduction in the amount of sewage discharged to the river, and by approximately 5:00 this morning, all discharges to the river had ceased."

Repairs efforts are continuing on the remaining four motors and instrumentation. Test results on the Red River continue to show that the oxygen levels in the river water remain adequate to support healthy aquatic life. MacBride says, "We will continue to test and monitor river water quality on a daily basis."

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Media inquiries may be directed to:

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986-4478

September 23, 2002 – For Immediate Release

NORTH END WATER POLLUTION CONTROL CENTRE CONTINUES TO PERFORM WELL

All plant processes are running well on two pumps at the North End Water Pollution Control Centre, and as of early Saturday morning, two additional pumps are ready if needed. In dry weather conditions, the plant normally runs on two pumps, and in wet weather, runs on two to five pumps, depending on the severity of the rainstorms. The sixth pump is used as a backup.

Since the plant failure, oxygen levels were always within the acceptable range to support aquatic life, in the Winnipeg area as well as in other communities downstream of Winnipeg. Test results showed that the lowest oxygen level in the river was 5.4 mg/L, reported immediately upstream of Lockport on Friday. Below the locks, the oxygen levels never fell below 8.0 mg/L. This level is better than Provincial water quality objectives to support aquatic life. As of Saturday, oxygen levels at Lockport were back up to 8.4 mg/L, which is well within the normal range.

Barry MacBride, Director of the City's Water and Waste Department says, "Starting tomorrow we will begin reducing the number of locations where we are drawing river samples. By Thursday, we will return to our normal river water quality testing schedule, which is monthly samples taken on a year round basis."

Work continues this week on inspecting, servicing, and repairing/replacing support equipment. The sixth and last motor will be removed and sent out for reconditioning, which will make room to install the fifth motor later this week. The booms that were installed at eight outfalls last week to collect floating sewage debris will be removed starting today.

- 30 -

Media inquiries may be directed to:

Kathy Taylor
Public Information Officer
Water and Waste Department
794-4529 (cell)
986-4478

November 20, 2002 – For Immediate Release

Faulty Valve Removed at the North End Water Pollution Control Centre

Winnipeg – It has been determined that the mechanical failure at the North End Water Pollution Control Centre in September that resulted in raw sewage flowing directly to the river was caused by a broken guide inside a large suction valve.

The valve weighs approximately 8,000 pounds, and is about 12 feet high, 30 inches thick and 50 inches wide. Inside the valve, a cast iron disk, which is 36 inches in diameter, moves up and down along guides as the valve opens and closes. One of the guides was broken, causing the disk to twist and be lodged open by about 12 inches. Barry MacBride, Director of the City's Water and Waste Department, says, "There is no indication at this time as to why the guide broke. We have hired a consultant to study and report on the valve failure. In the meantime, the plant continues to perform well."

A decision will be made next week on whether to have the valve repaired or purchase a new valve.

When the valve was removed on Tuesday, November 19, 2002, representatives of Manitoba Conservation, Environment Canada and the City's independent engineering firm were present.

At about 1:15 pm on Monday, September 16, 2002, the failure shut down the wastewater treatment processes at the North End Water Pollution Control Centre. At about 5:00 pm, sewage began flowing directly into the Red River at a rate of about 185,000 cubic metres per day, or approximately 1% – 1.5% of the river flow. Repairs to the plant progressed quickly, and 57 hours later at approximately 2:00 am on September 19, full wastewater treatment resumed and all flows to the river had ceased.

-30-

Members of the media are invited to view and photograph/film the valve today at 1:00 pm at the North End Water Pollution Control Centre, 2230 Main Street. Barry MacBride, Director of the City's Water and Waste Department, will be available to describe the valve failure.

Media inquiries should be directed to:
Kathy Taylor
Public Information Officer, Water and Waste Department
986-4478 or 794-4529

Appendix E – Summary Document for the Web

Summary
North End Water Pollution Control Centre Shutdown
September 16 – 19, 2002

The North End Water Pollution Control Centre (NEWPCC), located at 2230 Main Street, treats sewage generated from the north and central parts of the city, representing about 70% of Winnipeg, or approximately 370,000 residents. Treated wastewater from NEWPCC is discharged to the Red River, which flows north to Lake Winnipeg.

What happened?

- At about 1:15 pm on Monday, September 16, 2002, a mechanical failure shut down the plant.
- Raw sewage flowed into all three 54-foot deep pump wells, which contain two motorized pumps each. The wells are connected, and sewage immersed all six pumps. The sewage could no longer be pumped through the regular wastewater treatment processes.
- At about 5:00 pm, sewage began to overflow through a number of combined sewer outfalls directly into the Red River at a rate of about 185,000 cubic metres per day, or approximately 1% – 1.5% of the river flow.
- Manitoba Conservation, Manitoba Health, Environment Canada, and Winnipeg Regional Health Authority were notified promptly.
- The first in a series of daily press releases advising the community of the plant shutdown and its effect was issued on September 16 at approximately 5:38 pm.

What caused the mechanical failure?

A broken guide inside a large suction valve caused the mechanical failure. The valve weighs approximately 8,000 pounds, and is about 12 feet high, 30 inches thick and 50 inches wide. Inside the valve, a cast iron disk, which is 36 inches in diameter, moves up and down along guides as the valve opens and closes. One of the guides was broken, causing the disk to twist and be lodged open by about 12 inches. As there is no obvious reason why the guide broke, we have hired a consultant to study and report on the failure.

When did the raw sewage stop flowing to the river?

Repairs to the plant progressed quickly, and 57 hours later at approximately 2:00 am on September 19, full wastewater treatment resumed and all flows to the river had ceased.

- Working around the clock, staff had three motors removed on September 17, and sent them to be cleaned, dried, and serviced.
- By 12:01 am on September 19, one pump was working, and there was a gradual reduction in the amount of sewage flowing to the river. Two hours later, at approximately 2:00 am, a second pump was working and all flows to the river had ceased. Only two of the six main pumps are required to pump normal plant flows.
- Two additional pumps were ready if needed by September 21.
- A fifth pump was operational by October 4.
- The sixth pump will remain out of service until the investigation into the cause of the mechanical failure is complete.
- The plant has performed well since it was placed back into service.

What steps were taken to minimize the impact on the river water quality?

Booms were installed on September 17 at eight outfall locations to trap any floating sewage debris. The booms were checked daily and any debris that had accumulated was removed.

What steps were taken to monitor river water quality?

We routinely sample and test river water quality along the Red River throughout the year on a biweekly basis at six locations. In response to the plant shutdown, we expanded our normal testing program as follows:

- Staff began daily tests of the river water beginning the morning of September 17.
- The testing program was expanded to include up to 14 locations, beginning upstream in Winnipeg at the Provencher Bridge, and continuing downstream past Selkirk.

The number of sampling locations was reduced starting September 24, and after September 25, the normal river water quality testing schedule resumed.

We shared our test results with Manitoba Conservation, who also conducted river water quality tests as a result of the shutdown. For information on their test results, visit www.gov.mb.ca/conservation/watres/red_river_water_quality_sampling_sept_30-02.pdf

What was the impact on river water quality?

The following is a summary of the dissolved oxygen and fecal coliform test results at the sampling locations:

Dissolved Oxygen

- River dissolved oxygen levels in the Winnipeg area as well as downstream of Winnipeg, met provincial water quality objectives and were within the acceptable range to support healthy aquatic life at all times.
- Test results showed that the lowest dissolved oxygen level in the river was 5.4 mg/L, reported immediately upstream of Lockport on September 20. Downstream of the locks, dissolved oxygen levels never fell below 8.0 mg/L. As of September 21, oxygen levels at Lockport were back up 8.4 mg/L, which is well within the normal range.

Fecal Coliform

- The highest recorded value for fecal coliform in the Red River, during the period of untreated discharge, was on September 18 at one location at the Chief Peguis Bridge.
- By September 24 (5 days after the uncontrolled discharge was stopped), fecal coliform levels in the Red River had returned to earlier levels.

No communities downstream of Winnipeg on the Red River use the river as a source of drinking water.

The Province maintained two of their ongoing recommendations:

- River water should not be used at any time for recreation purposes such as swimming, or for personal use such as drinking and irrigating ready-to-eat produce.
- Proper handling procedures for fishing and processing fish from the river should always be followed.

What are the next steps?

In addition to conducting a review of the event, we are also:

- Conducting a study to find a way to isolate each of the three wells.
- Analyzing all three wastewater treatment plants to determine if improvements can be made to prevent future unplanned shutdowns.

There are also three other reviews:

City of Winnipeg
An independent engineering firm, Associated Engineering (B.C. Ltd.) is conducting an impartial review to identify the root cause(s) of the event and recommend measures to reduce the chances of future events. Their report is expected to be completed in December 2002.

Province of Manitoba
On October 3, 2003, the Minister of Conservation has requested that the Clean Environment Commission hold public hearings regarding the City of Winnipeg's wastewater collection and treatment systems. The Commission is to forward a report to the Minister within six months, and is to include recommendations on:

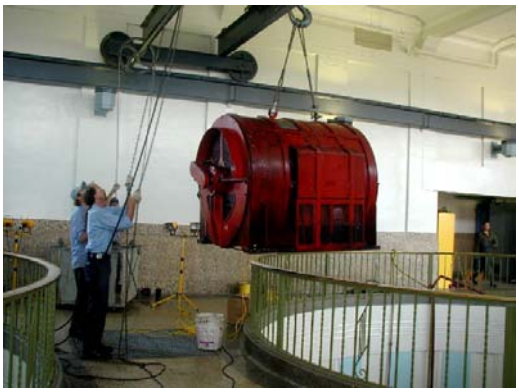
- The reliability of the City's systems, especially the backup capability of the systems to prevent a discharge of inadequately treated sewage to the rivers during malfunctions.
- The appropriate ammonia, nutrient, combined sewer overflow and microbiological limits on effluent from the City's systems necessary to protect the aquatic environment and recreational activities, including in Lake Winnipeg.
- The current and planned effectiveness of the City's systems in treating wastewater to achieve the discharge limits.
- The adequacy of the City's plans and schedule for upgrading its systems
- The adequacy of processes being followed in reviewing those plans and schedules.

For more information on the hearings, visit
www.cecmanitoba.ca/start.cfm?SC=1&PT=7&EV=18

Environment Canada, Environmental Protection Branch
Environment Canada is investigating the incident under the authority of the Fisheries Act.

November 22, 2002

Dry Well #2 before Flood



Motor Hoisted to Top of Dry Well

Motor Being Removed from Main Building

Boom Placed in the Red River to Catch Floating Debris at the Jefferson Outfall

Collecting River Water Samples for Testing

Testing River Water Samples for Levels of Dissolved Oxygen

Appendix F – Management and Staffing

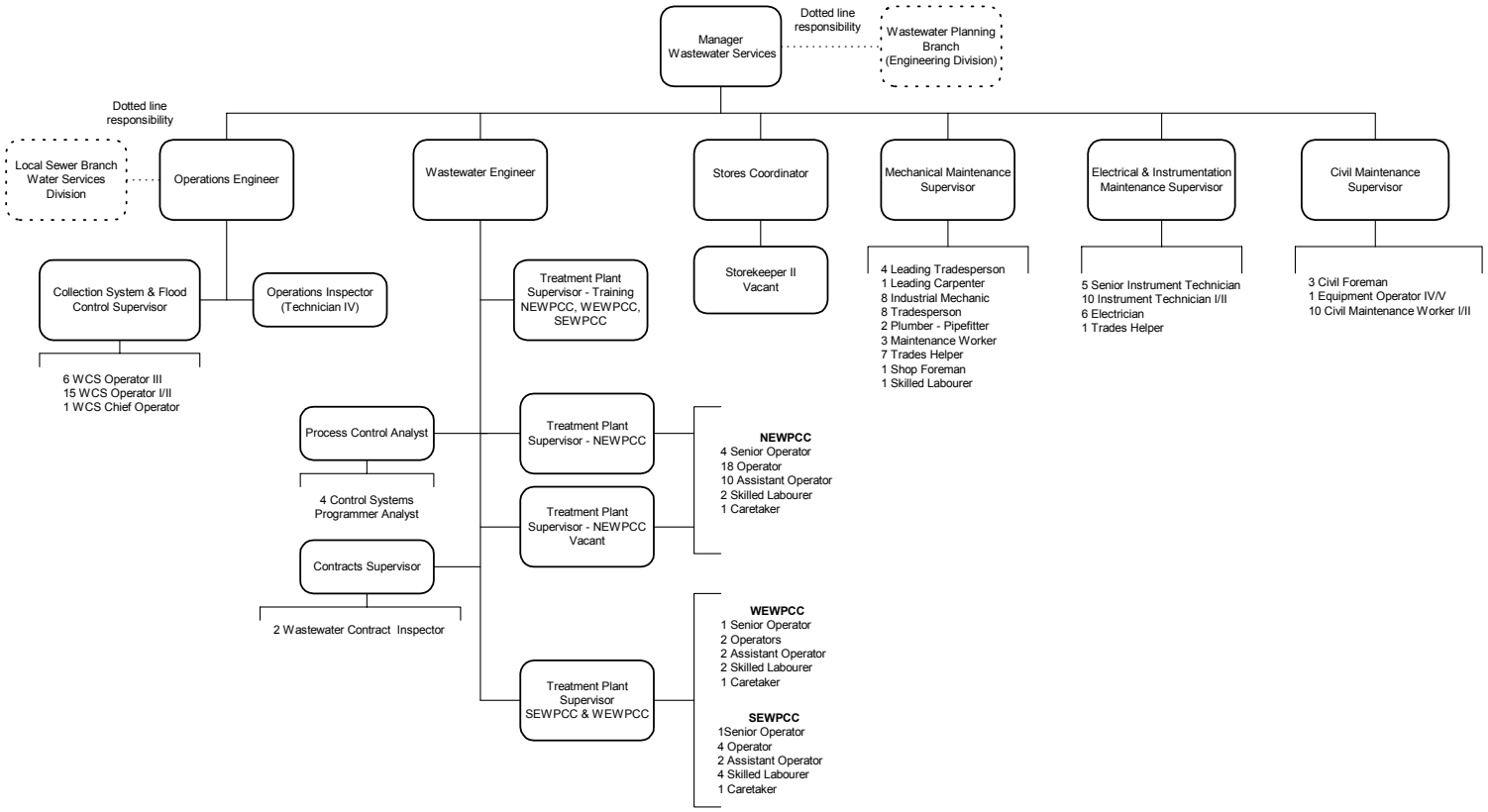
The Wastewater Services Division, as outlined on the organization chart on the next page, reports to the Director of the Water and Waste Department. This Division is responsible for operating and maintaining all wastewater functions within the City of Winnipeg. This is accomplished with staff and resources within the Division as well as staff and resources available to the Division in a "dotted line relationship". For example, the Water Services Division operates and maintains the local sewer system, and the Engineering Division provides professional engineering support, engineering technical support and infrastructure management.

With specific reference to the NEWPCC, day-to-day operation and maintenance staff report to on-site treatment plant supervisors, who in turn report to the Wastewater Engineer, who reports to the Division Manager.

In addition to the operating staff on site, there are a number of trades staff assigned to the NEWPCC. At the time of the September 16 incident, there were four mechanical maintenance staff and four electrical/instrumentation staff assigned to the plant. These trades staff report to and receive direction from the Treatment Plant Supervisor on a day-to-day basis.

Water and Waste Department

Wastewater Services Division



Appendix G – Letter to Citizens

Winnipeg

Water and Waste Department • Service des eaux et des déchets

Our File No: 010-17-06-01-00

November 22, 2002

Thank you for your interest and concern with the North End Water Pollution Control Centre shutdown on September 16, 2002. We appreciate the comments you and many others expressed in the media relating to the shutdown and its effects on the Red River.

A broken guide inside a large 8,000-pound suction valve caused the mechanical failure. As there is no obvious reason why the guide broke, we have hired a consultant to study and report on the failure. We will decide within the next week whether we should repair the valve or buy a new one. In the meantime, the plant continues to perform well.

We take the plant shutdown very seriously, and we are doing everything we can to ensure that this doesn't happen again – at this facility, or at our other two wastewater treatment facilities. In addition to investigating the cause of the valve failure, we are conducting a detailed analysis of all three facilities to see if any improvements can be made.

The Province of Manitoba, Environment Canada, and, at the request of City Council, an independent engineering firm are investigating the shutdown.

The North End Water Pollution Control Centre (NEWPCC) opened in 1937. Over the past 65 years, the plant has been upgraded and expanded and is now the largest of three wastewater treatment facilities serving the city. In the last 25 years, we have spent approximately $110 million on NEWPCC to improve the treatment processes and on odour control. We are committed to continuing to improve the system so that we can meet all of the provincial river water quality objectives.

Enclosed is a summary of the events that occurred during the shutdown and more details on the reviews. Copies of the news releases, as well as the test results of our river water quality samples are posted on our website at www.city.winnipeg.mb.ca/waterandwaste/newpcc.stm. We will update our website as information becomes available.

Again, thank you for your interest.

Sincerely,

Barry D. MacBride, P. Eng.
Director
Water and Waste Department

Encl.

Appendix H – Staff Training

The following is a summary of the training provided to and required of staff employed in operating positions at the Department's Wastewater Treatment Plants.

Assistant Operator is an entry-level position, with minimum qualifications as described below.

- Grade 12 education.
- Successful completion of Sacramento State College Field Study training program for operation of Wastewater Treatment Plants (Volumes 1 and 2) within 24 months of the appointment.
- Must be willing to enrol and successfully complete MWWA wastewater treatment 3-week program as provided by Red River Community College.
- Demonstrated ability to establish and maintain an effective working relationship with others.
- Demonstrated ability to operate various hand and power tools.
- Knowledge of safety regulations, procedures and practises.
- Physically capable of performing the duties of this position.
- Willingness and ability to undertake training related to the duties of this position.
- Must be willing to perform standby duty on weekends and evenings on a rotation basis.

Following employment there is an initial plant orientation, emphasis on safety and safety procedures. Assistant Operator is then assigned various tasks of increasing complexity, initially partnering with senior personnel and later at times working along. Further training is provided in these areas:

- Lift truck operations.
- Transportation of Dangerous Goods
- Applied knowledge of safety equipment (first aid courses, CPR, etc.)
- Applied knowledge of confined space techniques and procedures.
- Applied knowledge of sample collection techniques and procedures
- Applied knowledge of the Workplace Safety and Health Act
- Applied knowledge of Bailey Distributed Control System
- Basic computer skills (MS software, email, spreadsheet, word processing, etc.)
- Computerized work Management System (Synergen Series) training.
- Basic knowledge of Self Contained Breathing Apparatus
- Basic knowledge of security procedures
- Basic knowledge of storeroom and tool organization
- Ability to read and interpret basic information from drawings, plans
- Ability to use housekeeping tools, techniques and procedures

- Advanced Wastewater Treatment Sacramento State College
- Fifth Class Power Engineering (highly recommended)

As an employee becomes more familiar with the Treatment Plants, further technical training is provided. Through the use of a Training Officer, extensive hands-on training is provided. This includes but is not limited to exhaustive review of operating manuals with supervised practical operating experience, extensive use of plant blueprints and process and instrumentation drawings (P&ID). Trouble shooting techniques are taught and various projects of increasing complexity are completed. In total, this one-on-one training may take in excess of six consecutive months. Providing assistance to Mechanical and Electrical/Instrumentation staff experiences reactive and preventative maintenance. Further extensive practical experience is gained by working with experienced operators similar to an apprenticeship. This may include shift work. Training is also provided as a primer for future Operator Certification through review of Sacramento Courses and ABC sample questions and/or various levels 1 to 4 training as provided by Red River Community College.

As an Assistant Operator gains insight through study and experience, he/she will progress to the position of Operator. Here his/her continued familiarity and experience will improve upon the required skills necessary for efficient Plant Operation. Training continues with the addition of any new equipment and any changes to the process techniques.

Assistant Operators are rotated through the Department's three wastewater treatment plants.

Generally, assistant operators may be considered for promotion to an operator position after a minimum of four (4) years satisfactory performance as an assistant operator.

The Operator involved has had all of the above training (with the exception of CWMS, Synergen training). He has just recently completed the Advanced Wastewater Treatment Course as offered by the University of California, Sacramento. He is also scheduled to start intensive in-house training with the Training Supervisor with the goal of challenging the level 2 ABC Certification and is scheduled for the CWMY Synergen training. At the time of the drywell flood incident, he was working with an inter-provincially certified Industrial Mechanic.

Appendix I – Costs

NEWPCC Flooding of Main Pump Building
Costs as at December 11, 2002

	Total cost	Damages	Valve Replacement
Salaries & Benefits			
Overtime	10,000	7,000	3,000
Meal Expense	400	300	100
	$ 10,400	$ 7,300	$ 3,100
Services			
Diving services	40,000	1,500	38,500
Rentals	25,000	2,000	23,000
Water Quality Testing	10,000	10,000	-
Media Relations	3,667	3,667	-
Real Property & Construction (Euroway)	20,000	20,000	-
Consultant assignments	115,000	-	-
Shooters (UMA)		25,000	-
Modeling (Tetres)		10,000	-
Main Building (Wardrop)	-	10,000	60,000
Valve Analysis (Tennessy)	-	-	10,000
	$ 213,667	$ 82,167	$ 131,500
Materials & Supplies			
Rebuild motors	75,000	75,000	-
Other Equipment Repairs	30,000	30,000	-
Replacement Valve	50,000	-	50,000
	$ 155,000	$ 105,000	$ 50,000
2003 Business			
Replacement Actuator	20,000	-	20,000
Refurbish/Replace 4 Mag Flow Meters	130,000	130,000	-
Miscellaneous Drywell Repairs	10,000	10,000	
	$ 160,000	$ 140,000	$ 20,000
TOTAL	**$ 539,067**	**$ 334,467**	**$ 204,600**

Note 1: Manitoba Conservation will bill the City of Winnipeg for the costs they incurrred in relation to the flooding event. These costs are unknown and not included in the above analysis.

Appendix J – Basement Flooding - Main Street North

As a result of the flooding of the main pump building at the NEWPCC, sewage was stored in the NW Stage II Interceptor, and the upstream 600 mm diameter wastewater sewer (WWS), which services Main Street from Fernbank Avenue to the north City limit. Water levels in the sewers reached about 224.81 and remained there from evening of September 16 to the morning of September 19, 2002.

During this time, problems with the plumbing systems were experienced both at Shooters Family Golf Centre (2731 Main Street) and the residence at 2772 Main Street. Both addresses have long sewer service connections (81 and 64 metres respectively) to the 600 WWS on Main Street. Basement elevations at Shooters and 2772 Main St. are 228.29 and 229.22 respectively. The invert of the 600 WWS at the service connection locations is about 218.6 and 219.2 respectively.

Shooters discovered 25-50 mm of sewage on their basement floor on the morning of September 17. Shooters estimates resultant damages at about $25,000.00. A high water level in the sewer service, at about basement floor level, was noted in the service at 2772 Main Street, but no damages occurred. On September 17, 2002, Shooters and 2772 Main Street attempted to clear their sewer connections, but no blockages were found, and both contacted the Water & Waste Department Customer Services Branch. Shooters and 2772 Main Street observed that the water level in their plumbing returned to normal on September 19, and both resumed using their plumbing facilities.

UMA Engineering Inc. was engaged by the Water & Waste Department to determine the cause of the basement flooding and high water level at Shooters and the high water level at 2772 Main Street during the period of September 16-19, 2002. Based on the use of a remote camera in the sewer connection, they determined that the plumbing on the two properties was not usable during this period because of a lack of venting in the service connections. This was caused by significant dips in the service connections of both properties. Rather than a continuous slope to the sewer, the connections had dips and rises, providing a location for an air lock.

During this period, the WWS was surcharged and sewage entered the vertical riser portion of the service connections. Sewage levels rose to about 3 - 4 metres below the basement elevations, and maintained that level for about 2 - 3 days. With the dips in the two sewer connections, non-venting air locks in the sewer service connections were created, which prevented the services for both Shooters and 2772 Main Street from functioning properly.

In addition, the use of the main floor plumbing on the evening of September 16, 2002 and an improperly functioning backwater valve resulted in Shooters flooding their own basement. No other properties in this area experienced problems during the period of September 16-19, but several complaints of “sewer gas” were noted.

UMA recommends that Shooters and 2772 Main Street repair or replace the sewer connections to remove existing dips as well as repair and maintain their plumbing systems to ensure continuous and proper operation. If this is not done, similar problems could occur under normal WWS operating conditions. Additionally, UMA recommends that the 600 WWS on Main Street should be cleaned and maintained.

Appendix K – River Quality Data

Table 1. Total organic carbon (mg/L) results at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	13	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	**	14	14
6	**Red River @ Provencher Bridge**	12	15	15	12	12	13	14	12	14
7	**Red River @ Redwood Bridge**	14	14	14	13	11	14	15	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	12	14	14	13	13	14	15	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	13	15	15	14	14	14	14	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	14	14	14	13	12	13	14	**	**
9	**Red River @ North Perimeter**	12	15	14	14	12	13	13	14	14
10	**Red River @ Lister Rapids**	**	13	15	14	12	13	12	**	**
11	**Red River @ Captain Kennedy's**	12	14	13	13	13	13	12	**	**
12	**Red River @ Lockport Bridge**	12	14	13	12	14	14	13	14	14
13	**Red River upstream Selkirk, MB**	**	15	12	12	15	13	12	13	14
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	**	**	**	**	**
15	**Red River @ Highway 4**	**	**	**	**	**	**	**	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	**	**	**	**	**
17	**Red River @ Netley Creek**	**	**	**	**	**	**	**	14	13

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 2. Nitrate (mg/L N) at 16 stations on the red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	0.40	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	**	0.50	0.53
6	**Red River @ Provencher Bridge**	0.40	0.38	0.38	0.40	0.39	0.38	0.34	0.35	0.53
7	**Red River @ Redwood Bridge**	0.37	0.35	0.34	0.37	0.37	0.36	0.37	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	0.39	0.36	0.32	0.38	0.36	0.35	0.37	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	0.39	0.37	0.72	0.39	0.42	0.43	0.51	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	0.39	0.37	0.32	0.39	0.35	0.35	0.37	**	**
9	**Red River @ North Perimeter**	0.39	0.37	0.56	0.34	0.37	0.37	0.39	0.36	0.42
10	**Red River @ Lister Rapids**	**	0.39	0.37	0.35	0.38	0.39	0.40	**	**
11	**Red River @ Captain Kennedy's**	0.47	0.43	0.39	0.51	0.39	0.40	0.41	**	**
12	**Red River @ Lockport Bridge**	0.50	0.44	0.41	0.54	0.39	0.40	0.45	0.42	0.47
13	**Red River upstream Selkirk, MB**	**	0.43	0.43	0.41	0.49	0.45	0.50	0.43	0.45
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	**	**	**	**	**
15	**Red River @ Highway 4**	**	**	**	**	**	**	**	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	**	**	**	**	**
17	**Red River @ Netley Creek**	**	**	**	**	**	**	**	0.46	0.48

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 3. Ammonia (mg/L N) at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	0.06	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	**	0.12	0.10
6	**Red River @ Provencher Bridge**	<0.05	<0.05	<0.05	<0.05	0.06	0.08	<0.05	0.07	0.10
7	**Red River @ Redwood Bridge**	<0.05	<0.05	0.09	0.08	0.08	0.10	0.12	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	0.13	0.10	0.09	0.05	0.07	0.10	0.12	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	0.17	0.28	2.30	0.13	0.49	0.72	1.70	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	0.10	0.09	0.10	<0.05	0.08	0.10	0.11	**	**
9	**Red River @ North Perimeter**	0.13	0.20	0.74	0.24	0.21	0.29	0.22	0.31	0.53
10	**Red River @ Lister Rapids**	**	0.29	0.43	0.29	0.31	0.44	0.32	**	**
11	**Red River @ Captain Kennedy's**	0.10	0.12	0.23	0.55	0.15	0.22	0.20	**	**
12	**Red River @ Lockport Bridge**	0.14	0.09	0.27	0.51	0.16	0.25	0.35	0.27	0.42
13	**Red River upstream Selkirk, MB**	**	<0.05	0.18	0.23	0.32	0.28	0.29	0.19	0.22
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	**	**	**	**	**
15	**Red River @ Highway 4**	**	**	**	**	**	**	**	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	**	**	**	**	**
17	**Red River @ Netley Creek**	**	**	**	**	**	**	**	0.21	0.20

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 4. Un-ionized ammonia (mg/L N) at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	0.0014	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	**	0.0019	0.0018
6	**Red River @ Provencher Bridge**	<0.0009	<0.0011	<0.0022	<0.0017	0.0015	0.0011	<0.0008	0.0009	0.0011
7	**Red River @ Redwood Bridge**	<0.0012	<0.0011	0.005	0.0033	0.0025	0.0017	0.0025	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	0.0024	0.0023	0.0032	0.0013	0.0017	0.0021	0.0024	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	0.0024	0.0064	0.0156	0.0043	0.0089	0.0077	0.0213	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	0.0024	0.0020	0.0051	<0.0021	0.0020	0.0021	0.0029	**	**
9	**Red River @ North Perimeter**	0.0022	0.0045	0.0099	0.0063	0.0065	0.0062	0.0058	0.0039	0.0057
10	**Red River @ Lister Rapids**	**	0.0066	0.0114	0.0077	0.0076	0.0075	0.0085	**	**
11	**Red River @ Captain Kennedy's**	0.0023	0.0027	0.0061	0.0116	0.0046	0.0063	0.0053	**	**
12	**Red River @ Lockport Bridge**	0.0025	0.0020	0.0061	0.0068	0.0049	0.0066	0.0074	0.0053	0.0057
13	**Red River upstream Selkirk, MB**	**	<0.0019	0.0038	0.0049	0.0079	0.0080	0.0072	0.0037	0.0039
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	**	**	**	**	**
15	**Red River @ Highway 4**	**	**	**	**	**	**	**	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	**	**	**	**	**
17	**Red River @ Netley Creek**	**	**	**	**	**	**	**	0.0041	0.0043

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 5. Enterococcus bacteria (colony forming units/ 100 mL) at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	80	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	210	120	200
6	**Red River @ Provencher Bridge**	100	50	650	140	130	330	370	180	240
7	**Red River @ Redwood Bridge**	180	90	1,070	380	160	520	370	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	3840	830	330	370	200	200	590	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	3840	1,580	1,170	450	70	500	550	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	3960	910	230	370	<100	300	390	**	**
9	**Red River @ North Perimeter**	190	1,370	1,210	540	300	400	420	220	170
10	**Red River @ Lister Rapids**	**	2,200	1,370	550	200	1,300	580	**	**
11	**Red River @ Captain Kennedy's**	180	800	940	680	420	190	400	**	**
12	**Red River @ Lockport Bridge**	4800	740	220	800	330	120	430	240	150
13	**Red River upstream Selkirk, MB**	**	100	710	470	200	140	350	260	130
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	280	230	120	**	**
15	**Red River @ Highway 4**	**	**	**	**	40	30	140	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	30	30	80	**	**
17	**Red River @ Netley Creek**	**	**	**	**	230	20	270	50	150

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 6. Fecal coliform bactieria (colony forming units/100mL) at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	30	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	120	800	240
6	**Red River @ Provencher Bridge**	60	180	3,840	550	200	350	220	100	150
7	**Red River @ Redwood Bridge**	200	350	10,600	202,000	400	1,520	420	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	* No Result	43,000	16,000	<1000	700	950	510	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	* No Result	82,000	69,000	3,000	1,200	1,020	760	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	* No Result	19,000	17,000	4,000	600	860	330	**	**
9	**Red River @ North Perimeter**	250	31,700	5,760	15,000	1,600	2,200	570	440	1050
10	**Red River @ Lister Rapids**	**	8,640	24,000	14,000	28,000	5,400	1900	**	**
11	**Red River @ Captain Kennedy's**	200	22,000	57,600	28,000	7,000	2,400	1500	**	**
12	**Red River @ Lockport Bridge**	* No Result	13,000	65,000	65,000	2,500	870	980	760	740
13	**Red River upstream Selkirk, MB**	**	200	23,400	1,700	3,000	1,100	660	800	590
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	1,180	1,000	590	**	**
15	**Red River @ Highway 4**	**	**	**	**	200	1,100	680	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	330	320	490	**	**
17	**Red River @ Netley Creek**	**	**	**	**	1,700	2,300	210	320	330

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 7. Total coliform bacteria (colony forming units/100mL) at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	190	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	1400	1100	2300
6	**Red River @ Provencher Bridge**	1600	1400	6720	700	3300	4600	3200	1100	2700
7	**Red River @ Redwood Bridge**	2000	2200	106000	200000	9000	8700	3900	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	* No Result	480000	151000	22000	14000	9200	2600	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	* No Result	280000	298000	18000	22000	12500	8400	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	* No Result	220000	192000	13000	10000	8700	5400	**	**
9	**Red River @ North Perimeter**	2800	202000	96000	81000	15000	13100	7100	5900	5900
10	**Red River @ Lister Rapids**	**	96800	154000	22000	29000	13400	7900	**	**
11	**Red River @ Captain Kennedy's**	1600	240000	96000	138000	33000	18200	10200	**	**
12	**Red River @ Lockport Bridge**	* No Result	224000	76000	282000	12900	24000	11700	9200	6600
13	**Red River upstream Selkirk, MB**	**	1000	96000	15000	11300	26000	9200	10200	6200
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	14800	26000	11000	**	**
15	**Red River @ Highway 4**	**	**	**	**	4200	12600	11800	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	6800	7000	7800	**	**
17	**Red River @ Netley Creek**	**	**	**	**	14400	5500	6900	8000	3600

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 8. Biochemical oxygen demand (mg/L) at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	<20	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	**	<2.5	<2.5
6	**Red River @ Provencher Bridge**	<20	<10	<10	<20	<10	<10	<4	<2.5	<2.5
7	**Red River @ Redwood Bridge**	<20	<10	<10	<20	<10	<10	<2.5	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	<125	<20	<20	<20	<10	<10	<4	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	<125	<20	<20	<20	<10	<10	<4	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	<125	<20	<20	<20	<10	<10	<4	**	**
9	**Red River @ North Perimeter**	<125	<20	<20	<20	<10	<10	<4	<4	<4
10	**Red River @ Lister Rapids**	**	<10	<20	<20	<10	<10	<2.5	**	**
11	**Red River @ Captain Kennedy's**	<20	<10	<10	<20	<10	<10	<2.5	**	**
12	**Red River @ Lockport Bridge**	<20	<10	<10	<20	<10	<10	<4	<4	<4
13	**Red River upstream Selkirk, MB**	**	<10	<10	<20	<10	<10	<2.5	<4	<4
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	**	**	**	**	**
15	**Red River @ Highway 4**	**	**	**	**	**	**	**	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	**	**	**	**	**
17	**Red River @ Netley Creek**	**	**	**	**	**	**	**	<4	<4

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 9. pH (units) at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	7.8	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	8.0*	7.9	7.8
6	**Red River @ Provencher Bridge**	7.8	7.8	8.1	8.1	7.9	7.7	7.8	7.7	7.7
7	**Red River @ Redwood Bridge**	7.9	7.8	8.2	8.1	7.9	7.8	7.9	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	7.7	7.9	8.0	7.9	7.9	7.9	7.9	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	7.7	7.8	8.2	8.0	7.8	7.6	7.7	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	7.7	7.9	7.3	8.1	7.9	7.9	8.0	**	**
9	**Red River @ North Perimeter**	7.7	7.9	7.6	7.9	8.0	7.8	8.0	7.7	7.8
10	**Red River @ Lister Rapids**	**	7.8	7.9	7.9	7.9	7.8	8.0	**	**
11	**Red River @ Captain Kennedy's**	7.8	7.9	7.9	7.8	8.0	8.0	8.0	**	**
12	**Red River @ Lockport Bridge**	7.7	7.9	7.8	7.6	8.0	8.0	7.9	7.9	7.8
13	**Red River upstream Selkirk, MB**	**	8.0	7.8	7.9	7.9	7.7	8.0	7.9	7.9
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	7.8*	8.0*	8.1*	**	**
15	**Red River @ Highway 4**	**	**	**	**	7.9*	7.9*	8.0*	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	8.0*	7.8*	8.0*	**	**
17	**Red River @ Netley Creek**	**	**	**	**	7.9*	7.9*	7.9*	7.9*	8.0*

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 10. Dissolved oxygen (mg/L) at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	7.8	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	9.4*	8.9	8.2
6	**Red River @ Provencher Bridge**	7.9	7.9	7.8	8.1	8.6	9.2	9.5	9.9	8.3
7	**Red River @ Redwood Bridge**	8.2	7.9	7.2	8.0	8.7	9.2	9.4	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	7.6	7.3	7.1	7.8	8.6	9.1	9.2	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	7.4	6.8	7.1	7.8	8.5	8.9	9.9	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	7.6	7.4	7.2	7.8	8.7	9.2	9.2	**	**
9	**Red River @ North Perimeter**	7.5	6.7	6.5	7.6	8.3	8.8	8.9	9.5	8.4
10	**Red River @ Lister Rapids**	**	6.4	6.0	7.4	8.3	8.6	8.7	**	**
11	**Red River @ Captain Kennedy's**	8.1	7.0	6.8	6.7	8.3	9.0	8.9	**	**
12	**Red River @ Lockport Bridge**	8.0	7.4	6.6	5.5	8.4	8.9	8.8	9.4	8.6
13	**Red River upstream Selkirk, MB**	**	9.1	8.7	8.8	9.4	10.4	10.5	10.9	9.9
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	9.1*	10.3*	10.6*	**	**
15	**Red River @ Highway 4**	**	**	**	**	8.9*	10.1*	10.7*	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	9.0*	9.2*	10.1*	**	**
17	**Red River @ Netley Creek**	**	**	**	**	8.9*	9.4*	9.5*	10.4*	9.2*

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 11. Oxygen saturation (%) at 16 locations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	85.9	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	91.2*	86.3	77.5
6	**Red River @ Provencher Bridge**	85.8	86.4	84.1	86.4	88.7	92.4	94.4	96.2	78.3
7	**Red River @ Redwood Bridge**	90.0	85.6	78.1	85.4	89.5	91.5	92.6	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	82.5	78.9	76.3	82.8	89.0	91.3	90.3	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	80.2	73.4	75.8	82.8	86.8	97.9	97.1	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	82.5	79.7	77.1	82.8	90.2	92.7	90.9	**	**
9	**Red River @ North Perimeter**	80.1	72.5	69.3	80.8	85.5	88.4	88.3	92.4	78.6
10	**Red River @ Lister Rapids**	**	69.3	64.5	78.1	85.7	86.3	86.3	**	**
11	**Red River @ Captain Kennedy's**	87.8	76.2	72.5	71.7	85.9	90.3	88.6	**	**
12	**Red River @ Lockport Bridge**	86.7	80.5	71.1	58.5	86.9	89.4	87.5	91.1	80.3
13	**Red River upstream Selkirk, MB**	**	100.8	93.0	93.5	97.6	104.5	103.0	105.2	92.6
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	93.5*	104.0*	103.5*	**	**
15	**Red River @ Highway 4**	**	**	**	**	91.3*	102.0*	104.7*	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	92.3*	91.1*	98.4*	**	**
17	**Red River @ Netley Creek**	**	**	**	**	91.5*	93.5*	92.8*	101.8*	85.8*

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations

Table 12. Temperature (^{O}C) at 16 stations on the Red River.

Station #	Station Description	17-Sep-02	18-Sep-02	19-Sep-02	20-Sep-02	21-Sep-02	22-Sep-02	23-Sep-02	24-Sep-02	25-Sep-02
3	**Red River @ Dunkirk Bridge**	19.7	**	**	**	**	**	**	**	**
4	**Red River @ Redboine Boat Club**	**	**	**	**	**	**	13.8*	13.9	12.5
6	**Red River @ Provencher Bridge**	19.0	19.4	18.4	18.2	16.7	15.4	14.7	13.9	12.4
7	**Red River @ Redwood Bridge**	19.5	19.1	18.7	18.0	16.7	15.1	14.5	**	**
8a	**Red River @ Chief Peguis Br. - river CENTER**	19.0	18.8	18.5	17.9	16.7	15.3	14.3	**	**
8b	**Red River @ Chief Peguis Br. - nr. West bank**	18.9	18.7	18.2	17.9	16.1	14.6	14.3	**	**
8c	**Red River @ Chief Peguis Br. - nr. East bank**	19.0	18.6	18.3	17.9	16.8	15.5	14.6	**	**
9	**Red River @ North Perimeter**	18.2	18.8	18.4	18.0	16.7	15.2	14.6	13.8	12.2
10	**Red River @ Lister Rapids**	**	18.8	18.2	17.9	16.6	15.3	14.6	**	**
11	**Red River @ Captain Kennedy's**	18.9	18.9	18.3	18.0	16.7	15.5	14.8	**	**
12	**Red River @ Lockport Bridge**	18.9	19.3	18.6	18.0	16.7	15.3	14.7	13.9	12.1
13	**Red River upstream Selkirk, MB**	**	19.8	18.4	18.1	16.9	15.5	14.3	13.6	12.4
14	**Red River @ Selkirk Boat Launch / Picnic Area**	**	**	**	**	16.4*	15.6*	14.1*	**	**
15	**Red River @ Highway 4**	**	**	**	**	16.3*	15.6*	14.2*	**	**
16	**Red River @ Boat Launch N of Hwy #4**	**	**	**	**	16.3*	14.7*	14.0*	**	**
17	**Red River @ Netley Creek**	**	**	**	**	16.4*	14.9*	14.1*	14.2*	12.1*

Remark 1: pH, Temperature and Dissolved Oxygen done on site
Remark 2: all samples collected from boat at 1 meter depth
Remark 3: values are averages of river center, west bank and east bank excluding Chief Peguis Bridge locations
***:** sampling conducted in main channel only
****:** analysis not conducted at these locations