BACKGROUND STUDY

PVWC REGIONAL WATER SYSTEM

MASTER PLAN FINAL REPORT

Submitted to:
Pembina Valley Water Cooperative

Project No: WE 02 121 00 WE

December, 2003

PEMBINA VALLEY
WATER COOPERATIVE INC.

COCHRANE ENGINEERING LTD.

600 – 5 DONALD STREET
WINNIPEG, MB R3L 2T4

ENGINEERS, SCIENTISTS & PROJECT MANAGERS

COCHRANE
ENGINEERING

TABLE OF CONTENTS

0.0 EXECUTIVE SUMMARY

Cochrane Engineering Ltd. was retained by the Pembina Valley Water Cooperative (PVWC) to undertake a study of their regional water system in order to get a clear understanding of its capacities and upgrade requirements over the short and long term. The work was divided into a number of major components including; a review of economic, population and water demand projections; a water distribution network analysis; a facilities condition and capacity assessment; development of upgrading alternatives; a recommended strategy and implementation program.

0.1 GROWTH AND DEMAND PROJECTIONS

In 1990, a report on community growth and water needs was prepared by the Department of Rural Development (now the Department of Intergovernmental Affairs), with the assistance of the Departments of Agriculture and Natural Resources. Four separate population growth scenarios were set forth, predicting population growth rates between 0% to 20% by the year 2001. The most accurate of these growth scenarios at the regional level and the majority of municipalities was the Historic Growth Scenario, which predicted growth rates would continue at historic rates. Actual regional population growth by 2001 was 9.8%.

A new set of growth scenarios was prepared, projecting regional and municipal population growth to the year 2021. Two Historic Growth Scenarios were projections of population growth based on historic growth rates, while an Optimistic Growth Scenario assumed that future growth rates would equal the strongest recent rates achieved by each municipality in the past 20 years. The Optimistic Scenario projected regional population growth of 37.4% by 2021, while the Historic Growth Scenarios projected increases of 17.7% and 26.0%. The projections for individual municipalities vary from the regional rates. Metering data for the year 2002 allowed actual water demands to be modelled and analysed. The growth rate scenario that predicted the highest positive growth for each respective metered location was selected and used along with the metering for future demand predictions. The domestic water demand for the PVWC, currently estimated at 114 L/sec, was estimated to grow to approximately 158 L/sec by the year 2021.

Agricultural water demand was estimated by comparing census livestock populations with accepted standard livestock water requirements. This demand is currently estimated to be approximately 41 L/sec. Future livestock populations are difficult to predict, due to the unpredictable influence of market trends and changing agricultural practices. Future water demands were instead estimated by assuming that the all of the existing livestock in the serviceable areas would be on-line in the near future, yielding a demand of approximately 129 L/sec. Furthermore, it was assumed that the Manitoba pork industry would increase by 50% by 2021. Each municipality was evaluated based on existing concentrations and expected growth between 0 and 50%. The estimated total agricultural demand for the year 2021 is approximately 149 L/sec.

0.2 DISTRIBUTION SYSTEM MODELING

A hydraulic model of the PVWC distribution system was developed in order to assess the performance of the existing water distribution system and to provide insight into system capacities and future demands within the region. Known components and characteristics of the system were included in the model to simulate and analyse the operating conditions of the existing distribution network. Only the major pipelines, those providing regional delivery of water, were included in this model as smaller scale distribution is beyond the scope of this planning study. The existing system was analysed using peak hour demands for current and future (20-year) conditions and specific shortcomings were identified.

0.3 WATER TREATMENT

The PVWC operates three water treatment plants; Red River Regional Water Treatment Plant; Morris Regional Water Treatment Plant; and the Stephenfield Regional Water Treatment Plant.

These water plants were assessed to review condition and current operating capacity. Based upon this evaluation, expected future quality objectives and capacity limitations were determined for each facility. These were used in preparing upgrading scenarios.

0.4 SYSTEM UPGRADES

Using the water distribution model, four upgrade scenarios were developed to provide adequate flows to meet the demands for future development, population growth and population re-distribution. These scenarios each involved a combination of pipe, pumping and water treatment plant upgrades and installations. Each of these scenarios is described below along with probable costs. All of the options include water plant upgrades and the installation of a 200mm pipeline from the Stephenfield WTP north to a location mid-way between Haywood and St. Claude where it branches through lateral pipelines to each. Upgrades will generally require revisions to the existing Water Rights Licenses.

Upgrade Scenario 1

With a probable cost of **$17,520,000**, this scenario generally involves the installation of a 250mm pipeline between Lowe Farm and the Altona area as well as a 250mm interconnection between Morris and St. Jean. The first of these exploits the additional capacity of the 300mm pipeline between Morris and Lowe Farm while bypassing the heavily loaded pipes between Letellier and Altona. The Morris – St. Jean interconnection allows for significant expansion of the Morris WTP and provides backup water supply options if either of the Red River water plants experience failures. The scenario also involves miscellaneous booster station upgrades and installations and a short pipeline to provide capacity to the Plum Coulee area. This upgrade scenario would require water treatment plant capacity upgrades as follows:

Water Plant Upgrades – Scenario 1			
WTP	Current Capacity (L/s)	Upgrade (L/s)	Upgraded Capacity (L/s)
Morris Regional	32	106	138
Red River Regional	96	0	96
Stephenfield Regional	20	53	73
Total	148	159	307

Upgrade Scenario 2

The second scenario, with a probable cost of **$21,539,00**, involves pipeline twinning between Lowe Farm and Roland (200mm) as well as a high pressure pipeline twin between Roland and Winkler (150mm). It also includes a 250mm interconnection between Morris and St. Jean, a 150mm pipeline from Roseau River to Dominion City, a 150mm pipeline to provide capacity to the Plum Coulee area and miscellaneous booster station upgrades and installations. This upgrade scenario would require water treatment plant capacity upgrades as follows:

Water Plant Upgrades – Scenario 2			
WTP	Current Capacity (L/s)	Upgrade (L/s)	Upgraded Capacity (L/s)
Morris Regional	32	85	117
Red River Regional	96	36	132
Stephenfield Regional	20	37	57
Total	148	159	307

Upgrade Scenario 3

The main components of upgrade scenario 3 are a 300mm Morris – St. Jean interconnect and a 250mm St. Jean – Altona pipeline that bypasses Letellier. The scenario also includes a 150mm twin from Roseau River to Dominion City and a number of pumping upgrades and installations. The distribution of water supply among the three treatment plants is shown in the following table. The probable cost of this upgrade scenario is **$19,140,000**.

Water Plant Upgrades – Scenario 3			
WTP	Current Capacity (L/s)	Upgrade (L/s)	Upgraded Capacity (L/s)
Morris Regional	32	101	133
Red River Regional	96	0	96
Stephenfield Regional	20	58	78
Total	148	159	307

Upgrade Scenario 4

The last scenario modelled is very similar to scenario 2 except it does not include a Morris – St. Jean interconnect. Note that the added interconnect in scenario 2 does not result in any decreased upgrade requirements elsewhere, and is subsequently higher priced. The reason for this is that instead of the Red River Regional WTP producing the water, the Morris plant produces it and sends it to Letellier for distribution. All of the pipeline upgrades between Letellier and Winkler / Morden are therefore the same. The disadvantage of this scenario is that the system is not looped as it is in all of the other scenarios, resulting in much less system flexibility and redundancy. The probable cost of scenario 4 is **$20,742,000**. The distribution of water supply for this scenario is shown in the following table.

Water Plant Upgrades – Scenario 4			
WTP	Current Capacity (L/s)	Upgrade (L/s)	Upgraded Capacity (L/s)
Morris Regional	32	57	89
Red River Regional	96	65	161
Stephenfield Regional	20	37	57
Total	148	159	307

0.5 RECOMMENDATIONS

All of the upgrade scenarios developed satisfy the projected demands through to 2021. **Scenario 1** is the recommended strategy based on technical and economic considerations. This scenario has the lowest probable cost at **$17,520,000**. Scenario 3 has the second lowest probable cost at $19,140,000, which is approximately 10% higher than the recommended scenario.

Scenario 1 is also the most desirable upgrade scenario from a technical perspective because of the system redundancy and flexibility that it provides. Scenarios 2 and 3 also provide looping and the ability to provide backup flexibility between the two Red River water plants. Scenarios 1 and 3 have the added advantage in that they provide water through an area that is currently not serviced. Scenario 1 does not have as much dependence on the Morris – St. Jean interconnect for its ability to accommodate transfer of water between the two plants.

1.0 INTRODUCTION

1.1 BACKGROUND

Over a decade ago, a number of municipalities in south central Manitoba joined to form the Pembina Valley Water Cooperative Inc. (PVWC). The purpose was to develop a regional approach to supplying potable water in an area which lacked wide distribution of good, plentiful water resources, but which also exhibited the highest rate of economic growth of any region in Manitoba. Municipalities that are currently members of the cooperative include:

Town of Altona	R.M. of Dufferin
Town of Carman	R.M. of Franklin
Town of Emerson	R.M. of Grey
Town of Gretna	R.M. of Montcalm
Town of Morden	R.M. of Morris
Town of Morris	R.M. of Rhineland
Town of Plum Coulee	R.M. of Roland
Village of St. Claude	R.M. of Stanley
City of Winkler	R.M. of Thompson

Today, the PVWC owns three modern water treatment plants and hundreds of kilometres of transmission pipeline. While these facilities are serving the public well, they are challenged by the continuing rapid growth of the economy and the population. Some facilities - especially many pipelines - were undersized in part due to senior government funding constraints, and in part because growth in water demand has outstripped expectations.

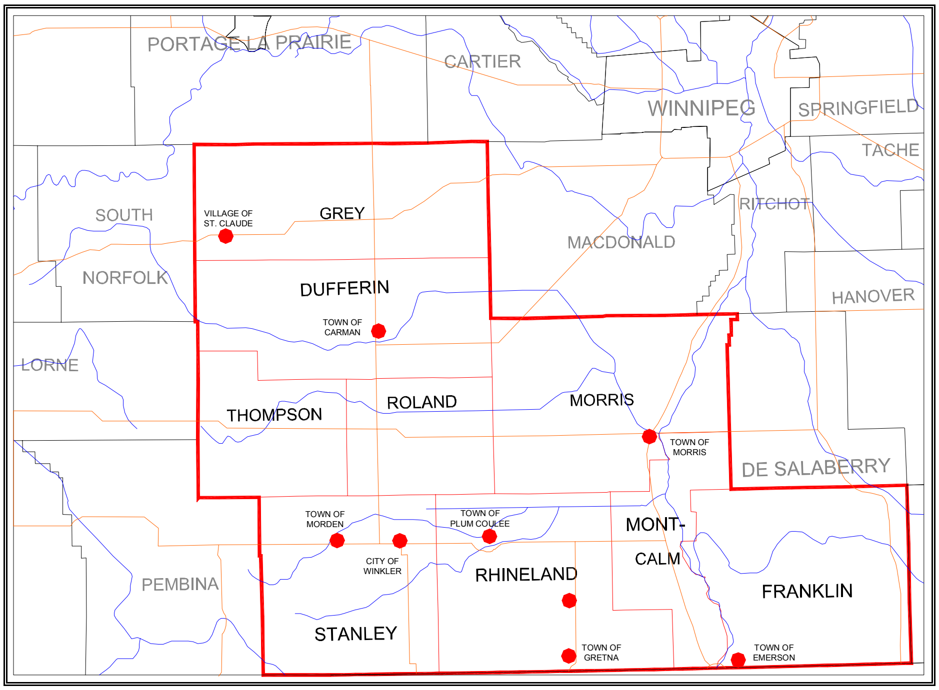


Figure 1.1: Regional Map

1.2 THE PROJECT

PVWC must begin to increase the capacity of many components of its infrastructure. Not all components need attention immediately. More to the point, it is not certain which need immediate attention, and which can be deferred to the medium and longer term. Feasible scenarios had to be developed to provide tools to manage the growth in the system.

In order to get a clear understanding of system capacities, and community needs over the short and longer term, a Master Plan background study was commissioned. Cochrane Engineering was retained to assess these challenges and develop alternative upgrading scenarios.

1.3 PROJECT SCOPE

The work completed was divided into a number of major components, further broken down into various tasks. The major items are:

- Review Economic / Population / Water Demand Projections
- Water Distribution Network Analysis
- Facilities Condition / Capacity Assessment
- Conceptualization of Upgrading / Expansion Alternatives
- Development and Evaluation of Alternative Strategies
- Recommend Strategy and Implementation Program
- Preparation of Report

2.0 GROWTH AND DEMAND PROJECTIONS

Economic studies were completed over a decade ago when the PVWC concept first became a reality. These studies led to projections of water demand over the short and long term. While generally successful, these projections must be revisited and extended into the future.

The following section will analyze growth and demand on both local and regional levels. This will lay the groundwork for estimation of overall treatment capacity needs, as well as pipeline requirements to meet individual district and community needs for the short and long term.

2.1 REVIEW OF PAST STUDIES

In 1990, a series of studies were undertaken through the leadership of the Pembina Valley Water Task Force in anticipation of the development of a regional water supply for the Pembina Triangle. These studies were published in a report entitled; *A Water Supply Strategy for the Pembina Valley.* This initiative led to the creation of what is now the Pembina Valley Water Co-operative and a regional water system that supplies water to all or parts of 18 municipalities with a combined population of approximately 42,000 residents. The original series of studies included a report on community growth and water needs which was prepared by the Department of Rural Development (now the Department of Intergovernmental Affairs) with the assistance of the Departments of Agriculture and Natural Resources.

In the aforementioned report, four scenarios were used to project population growth and water demand. The four scenarios were proposed as follows:

'No Growth' Scenario - populations and livestock water demand were assumed to remain the same while domestic water demand continued to increased.

'Historic Growth' Scenario - a linear projection of past population trends was extended into the future. Projections for increasing domestic water demand were the same as those used in the 'no growth' scenario. Livestock consumption rates remained the same, but projections allowed for a 2% annual increase in livestock numbers.

'Optimistic Growth' Scenario – similar to 'historic growth' scenario, but assumed that aggressive approach to economic development could accelerate, resulting in increased numbers of dry industries and corresponding increases in population. An exponential growth rate was used for the domestic and livestock growth, with an additional 25% increase in livestock by 2000 as a result of "Crow Rate" changes.

'Enhanced Growth' Scenario – this scenario was the most optimistic in terms of growth for the Pembina Triangle. The projected water demand is based on the highest population growth potential, an increase in livestock production, the introduction of wet industries and demand for irrigation.

The projected populations and water demands for each of the communities studied, under each of the scenarios above, are detailed in Tables 2.1a and 2.1b. Not all of the current member communities of the Pembina Valley Water Co-operative are represented, as these projections were only prepared for those communities that were participating in the Pembina Valley Water Task Force at the time the report was written.

Shaded cells in Table 2.1a indicate the population projections that were closest to the 2001 actual population. For many of the communities, more than one cell has been shaded as these population projections were equally accurate. It can be seen that the historic growth scenarios, in general, tended to be the most accurate in projecting community and total populations.

Table 2.1a: Previous Population Growth Scenarios

	No Growth Scenario	Historic Growth Scenario	Optimistic Growth Scenario	Enhanced Growth Scenario	2001 Actual
Altona	2,958	3,375	3,417	3,417	3,434
Carman	2,500	2,758	2,776	2,776	2,831
Emerson	725	725	725	725	655
Gretna	503	503	503	503	563
Morden	5,005	6,195	6,409	6,409	6,142
Morris	1,613	1,733	1,740	1,740	1,673
Plum Coulee	677	915	1,286	1,286	725
Winkler	5,926	8,390	9,264	9,264	7,943
Urban Total	19,907	24,594	26,120	26,120	23,966
Rural Total	18,516	19,653	19,833	19,833	18,218
Total	38,423	44,247	45,953	45,953	42,184

Table 2.1b: Water Demand Scenarios

	No Growth Scenario	Historic Growth Scenario	Optimistic Growth Scenario	Enhanced Growth Scenario
Altona	393.0	460.9	466.3	466.3
Carman	490.9	541.4	545.1	545.1
Emerson	66.7	69.3	69.3	69.3
Gretna	50.7	51.8	52.1	52.1
Morden	895.1	1,107.8	1,146.2	1,146.2
Morris	307.3	330.4	331.5	331.5
Plum Coulee	47.2	70.5	75.8	75.8
Winkler	679.2	1,022.8	1,130.6	1,130.6
Urban Total	2,930.1	3,654.9	3,816.9	3,816.9
Rural Total	1,419.3	1,506.3	1,520.9	1,520.9
Domestic Total	4,349.4	5,161.2	5,337.8	5,337.8
Livestock	1,613.5	2,088.3	2,690.8	2,690.8
Irrigation	-	-	-	43,200.0
Industrial	-	-	-	550.0
Total	5,980.9	7,249.5	8,028.6	51,778.6
Note: Water demand is in millions of litres per year.				

2.2 REVISED GROWTH SCENARIOS

Informed by a review of the above growth scenarios, a new set of scenarios was developed, based on a comparison of information obtained from the 1981, 1986, 1991, 1996 and 2001 censuses. These scenarios include all of the municipalities currently supplied with water by the PVWC.

As with the original study, these projections are intended to project the future water needs within the study area. In these projections, the years 2011 and 2021 are used as benchmarks, being 10- and 20-year projections from the most recently published populations numbers of the 2001 census.

The growth scenarios address domestic consumption only. Agricultural water use is covered under a separate section. This has been done because planning for domestic and agricultural use involves separate but parallel planning processes.

2.2.1 Historic Growth Scenario A

This historic growth scenario is based on a linear projection of past population trends. This trend analysis assumes a continuity between the present and the future. The water demands for domestic use have been included for this scenario, as they will be in subsequent scenarios.

To ascertain a trend for domestic use, growth patterns for the period 1981-2001 were examined. The average growth rate for each municipality during this period was then used to project growth rates to the year 2021. For example, if a municipality experienced growth rates of 6%, 3%, 5%, and 6% over the past four 5-year periods, the average growth of (6+3+5+6)/4 = 5% would be applied to each of the next four 5-year periods that we are projecting for. The projected population for the study area and the growth rate used to calculate it are shown on Table 2.2.

Some projected R.M. populations may seem unreasonably low given recent or planned rural residential developments and growth in some of the smaller, unincorporated communities of the region. However, population increases in these areas will be at the expense of residential development in the neighbouring urban municipalities, which may not realise their projected growth due to the emigration of residents to these rural areas.

Table 2.2: Historic Growth Scenario A

Municipality	Population 2001	Projected 5-Year Growth Rate	Projected Population 2006	Projected Population 2011	Projected Population 2016	Projected Population 2021
Altona	3,434	5.2%	3,611	3,797	3,993	4,199
Carman	2,831	4.1%	2,948	3,070	3,196	3,328
Emerson	655	-3.6%	632	609	587	566
Gretna	563	1.7%	573	583	593	603
Morden	6,142	7.6%	6,610	7,115	7,657	8,241
Morris	1,673	1.6%	1,700	1,727	1,755	1,783
Plum Coulee	725	5.4%	764	805	848	894
St. Claude	558	-1.4%	550	543	535	528
Winkler	7,943	12.1%	8,902	9,976	11,180	12,529
Dufferin	2,405	0.0%	2,405	2,405	2,405	2,406
Franklin	1,781	-3.1%	1,725	1,671	1,619	1,568
Grey	2,147	-0.4%	2,139	2,130	2,122	2,113
Montcalm	1,400	-5.6%	1,321	1,247	1,177	1,110
Morris (RM)	2,723	-2.2%	2,664	2,607	2,551	2,496
Rhineland	4,183	-1.6%	4,114	4,047	3,981	3,916
Roland	1,035	1.6%	1,052	1,068	1,086	1,103
Stanley	5,139	4.9%	5,393	5,660	5,940	6,234
Thompson	1,333	-0.5%	1,326	1,320	1,313	1,306
Total	46,670		48,430	50,380	52,538	54,925

2.2.2 Historic Growth Scenario B

This growth scenario is similar to the Historic Growth Scenario A, except that projections were adjusted to account for current trends toward positive or negative growth.

Growth patterns for the period 1981-2001 were again examined. Growth rates for the period 2001-2021 were projected based not on the average growth rate, but on the average growth rate adjusted by the average change in the growth rate 1981-2001. Using this formula, a community that has experienced greater and greater growth rates since 1981 is projected to continue experiencing greater and greater growth rates into the future. For example, if a community experienced 1%, 3%, 5%, and 7% growth over the past four 5-year periods, the growth rate would be projected to continue to increase by 2% for each of the next four 5-year periods, to 9%, 11%, 13%, and eventually 15% by the period 2016-2021. Likewise, communities that have experienced greater and greater population decline are projected to experience even greater rates of decline into the future. The projected population for the study area and adjusted growth rates are shown on Table 2.3.

Utilising this method of population projection produces a total 2021 regional population approximately 7% greater than that produced by Historic Growth Scenario A. Individual municipal populations for 2021 vary by as much as 39% from the estimates for 2021 under Historic Growth Scenario A.

Even more so than in the previous scenario, some projected R.M. populations may seem unreasonably low given recent or planned rural residential developments and growth in some of the smaller, unincorporated communities of the region. However, as with Scenario A, population increases in these areas will be at the expense of residential development in neighbouring urban municipalities, which may not realize their projected growth due to the emigration of residents to these rural areas.

Table 2.3: Historic Growth Scenario B									
Municipality	Population 2001	Growth Rate 2001-2006	Projected Population 2006	Growth Rate 2006-2011	Projected Population 2011	Growth Rate 2011-2016	Projected Population 2016	Growth Rate 2016-2021	Projected Population 2021
Altona	3,434	6.2%	3,649	7.3%	3,916	8.4%	4,246	9.5%	4,651
Carman	2,831	5.4%	2,983	6.6%	3,181	7.9%	3,432	9.1%	3,745
Emerson	655	-6.0%	615	-8.5%	563	-11.0%	501	-13.4%	434
Gretna	563	5.3%	593	8.8%	645	12.3%	724	15.8%	839
Morden	6,142	9.2%	6,707	10.8%	7,429	12.3%	8,346	13.9%	9,508
Morris (Town)	1,673	1.7%	1,702	1.9%	1,734	2.0%	1,770	2.2%	1,808
Plum Coulee	725	3.0%	747	0.6%	751	-1.8%	738	-4.2%	707
St. Claude	558	-4.4%	533	-7.5%	493	-10.5%	441	-13.6%	382
Winkler	7,943	13.2%	8,988	14.2%	10,267	15.3%	11,839	16.4%	13,779
Dufferin	2,405	-1.0%	2,381	-2.0%	2,335	-2.9%	2,266	-3.9%	2,177
Franklin	1,781	-1.6%	1,753	-0.1%	1,752	1.5%	1,778	3.0%	1,831
Grey	2,147	-2.2%	2,100	-4.0%	2,016	-5.8%	1,900	-7.6%	1,756
Montcalm	1,400	-8.8%	1,277	-12.0%	1,124	-15.2%	953	-18.4%	778
Morris (RM)	2,723	-3.2%	2,635	-4.3%	2,522	-5.4%	2,386	-6.5%	2,232
Rhineland	4,183	-1.3%	4,128	-1.0%	4,086	-0.7%	4,058	-0.4%	4,042
Roland	1,035	2.3%	1,059	2.9%	1,090	3.6%	1,129	4.3%	1,177
Stanley	5,139	6.9%	5,492	8.8%	5,975	10.7%	6,615	12.6%	7,450
Thompson	1,333	0.9%	1,345	2.3%	1,376	3.7%	1,427	5.1%	1,500
Total	46,670		48,687		51,254		54,548		58,796

2.2.3 Optimistic Growth Scenario

This growth scenario assumes that the region will experience strong and continued economic growth as a result of the current aggressive approach to industrial development, spurring all communities to develop at a rapid rate. In general, this gives us the highest consumption rates, though the Historic Growth Scenario B projected larger populations for some individual municipalities.

Growth pattern for the period 1981-2001 were again examined. Growth rates for the period 2001-2021 were projected based on the greatest single 5-year growth rate of the past 20 years. This growth rate was applied to each of the next four 5-year periods. For example, if a municipality experienced 2%, 4%, 9%, and 3% growth over the past four 5-year periods, the highest rate of 9% was used to project each of the next four 5-year periods. For those municipalities that experienced negative population growth over each of the past four 5-year periods, the lowest rate of negative growth was used. The projected population for the study area is shown on Table 2.4.

Utilising this method of population projection produces a total regional population approximately 9% greater than that produced by Historic Growth Scenario B. Individual municipal populations for 2021 vary by as much as 75% from the estimates for 2021 under Historic Growth Scenario A.

Table 2.4: Optimistic Growth Scenario						
Municipality	Population 2001	Projected 5-Year Growth Rate	Projected Population 2006	Projected Population 2011	Projected Population 2016	Projected Population 2021
Altona	3,434	7.2%	3,682	3,947	4,232	4,537
Carman	2,831	4.7%	2,964	3,103	3,249	3,402
Emerson	655	2.2%	670	684	700	715
Gretna	563	23.3%	694	855	1,054	1,300
Morden	6,142	9.3%	6,713	7,338	8,021	8,767
Morris (Town)	1,673	2.7%	1,719	1,766	1,814	1,864
Plum Coulee	725	14.4%	829	948	1,084	1,240
St. Claude	558	3.0%	575	592	610	629
Winkler	7,943	17.4%	9,328	10,955	12,866	15,109
Dufferin	2,405	3.8%	2,497	2,592	2,691	2,794
Franklin	1,781	4.5%	1,862	1,947	2,035	2,128
Grey	2,147	5.0%	2,254	2,367	2,485	2,610
Montcalm	1,400	-2.4%	1,366	1,333	1,300	1,269
Morris (RM)	2,723	-1.1%	2,692	2,661	2,631	2,600
Rhineland	4,183	1.3%	4,237	4,293	4,348	4,405
Roland	1,035	5.2%	1,089	1,145	1,204	1,267
Stanley	5,139	11.3%	5,721	6,369	7,091	7,895
Thompson	1,333	4.7%	1,395	1,461	1,529	1,600
Total	51,990		50,287	54,356	58,945	64,131

2.3 DOMESTIC WATER CONSUMPTION RATES

Natural Resources Canada estimates that the average Canadian uses between 160 and 320 litres/person/day. Specific water usage figures were available for 1999 for 5 of the urban municipalities, and are as follows:

- Altona – 295 l/p/d
- Carman – 225 l/p/d
- Morden – 291 l/p/d
- Morris – 277 l/p/d
- Winkler – 224 l/p/d

Note that the "Domestic" water demand discussed throughout this report includes all human usage, including commercial and institutional in addition to household demands. For discussion purposes, a figure of 295 l/p/d is used for all communities, as this represents the highest known rate of water usage in the study area, yet is still well within the consumption range published by Natural Resources Canada. Table 2.5 shows the projected 2011 and 2021 daily water consumption rates under each of the above scenarios.

In these scenarios, the entire population of each municipality was included, including those rural municipalities that are only partially serviced by the system. This must be considered when viewing the projected water consumption figures. Smaller communities were not included separately in the study because of the lack of recent, accurate population numbers. Since the 1980's, the Census of Canada has not recorded population numbers at the sub-municipal level.

Table 2.5: Water Usage at 295 Litres/person/day						
Municipality	Consumption – Litres/day					
	Historic Growth Scenario A		Historic Growth Scenario B		Optimistic Growth Scenario	
	2011	2021	2011	2021	2011	2021
Altona	1,120,115	1,238,705	1,155,220	1,372,045	1,164,365	1,338,415
Carman	905,650	981,760	938,395	1,104,775	915,385	1,003,590
Emerson	179,655	166,970	166,085	128,030	201,780	210,925
Gretna	171,985	177,885	190,275	247,505	252,225	383,500
Morden	2,098,925	2,431,095	2,191,555	2,804,860	2,164,710	2,586,265
Morris	509,465	525,985	511,530	533,360	520,970	549,880
Plum	237,475	263,730	221,545	208,565	279,660	365,800
St. Claude	160,185	155,760	145,435	112,690	174,640	185,555
Winkler	2,942,920	3,696,055	3,028,765	4,064,805	3,231,725	4,457,155
Dufferin	709,475	709,770	688,825	642,215	764,640	824,230
Franklin	492,945	462,560	516,840	540,145	574,365	627,760
Grey	628,350	623,335	594,720	518,020	698,265	769,950
Montcalm	367,865	327,450	331,580	229,510	393,235	374,355
Morris	769,065	736,320	743,990	658,440	784,995	767,000
Rhineland	1,193,865	1,155,220	1,205,370	1,192,390	1,266,435	1,299,475
Roland	315,060	325,385	321,550	347,215	337,775	373,765
Stanley	1,669,700	1,839,030	1,762,625	2,197,750	1,878,855	2,329,025
Thompson	389,400	385,270	405,920	442,500	430,995	472,000
Total	14,862,100	16,202,875	15,119,930	17,344,820	16,035,020	18,918,645

If an optimistic projection were to be made of attaining an average consumption rate of 225 l/p/d across the district by 2011 (a rate of use that has already been achieved in the communities of Carman and Winkler), the results of the above three scenarios would be as follows in Table 2.6.

Table 2.6: Water Usage at 225 Litres/person/day						
Municipality	Consumption – Litres/person/day					
	Historic Growth Scenario A		Historic Growth Scenario B		Optimistic Growth Scenario	
	2011	2021	2011	2021	2011	2021
Altona	854,325	944,775	881,100	1,046,475	888,075	1,020,825
Carman	690,750	748,800	715,725	842,625	698,175	765,450
Emerson	137,025	127,350	126,675	97,650	153,900	160,875
Gretna	131,175	135,675	145,125	188,775	192,375	292,500
Morden	1,600,875	1,854,225	1,671,525	2,139,300	1,651,050	1,972,575
Morris	388,575	401,175	390,150	406,800	397,350	419,400
Plum	181,125	201,150	168,975	159,075	213,300	279,000
St. Claude	122,175	118,800	110,925	85,950	133,200	141,525
Winkler	2,244,600	2,819,025	2,310,075	3,100,275	2,464,875	3,399,525
Dufferin	541,125	541,350	525,375	489,825	583,200	628,650
Franklin	375,975	352,800	394,200	411,975	438,075	478,800
Grey	479,250	475,425	453,600	395,100	532,575	587,250
Montcalm	280,575	249,750	252,900	175,050	299,925	285,525
Morris	586,575	561,600	567,450	502,200	598,725	585,000
Rhineland	910,575	881,100	919,350	909,450	965,925	991,125
Roland	240,300	248,175	245,250	264,825	257,625	285,075
Stanley	1,273,500	1,402,650	1,344,375	1,676,250	1,433,025	1,776,375
Thompson	297,000	293,850	309,600	337,500	328,725	360,000
Total	11,335,500	12,358,125	11,532,375	13,229,100	12,230,325	14,429,025

2.4 AGRICULTURAL WATER DEMAND

Agricultural water demand may be divided into two areas; livestock water demand and irrigation water demand. The water supply system has not been designed for supply of water for irrigation, it is not feasible to utilise treated water in large quantities for the irrigation of the region's fields. However, many farms are already utilising the system to provide water for the use of their livestock.

Planning to provide for agricultural water demand is a separate exercise from planning to provide for domestic water requirements in rural municipalities. Municipalities are expected to supply domestic water, and thus must plan to have enough capacity to meet the demands of increasing populations. Nonetheless, the supply of water for livestock consumption, is a mandated function of the Cooperative and is therefore considered equally important.

Livestock populations are difficult to project. They may change dramatically in response to market conditions and other, more local factors such as climate or disease. If accurate population projections were possible, they still would be of questionable use for projecting water demand. At present, a good number of livestock operations are connected to the regional water supply, and it is difficult to determine at what rate the number of connections will increase. The number of future connections will be largely reliant on upgrades to the PVWC water system and the subsequent capacity of the regional water supply. The following information on water demand details typical requirements of livestock to help illuminate the impact of significant increases in livestock populations.

Table 2.7 indicates commonly accepted consumption rates for the most common livestock.

Table 2.7: Livestock Daily Water Consumption				
Livestock		Consumption (Litres/day)		
		Single Animal	100 Animals	1000 Animals
Cattle	Beef	22 - 75	2,200 - 7,500	22,000 – 75,000
	Dairy	38 - 100	3,800 - 10,000	38,000 – 100,000
Horses		30 - 45	3,000 - 4,500	30,000 – 45,000
Swine		9 - 23	900 - 2,300	9,000 - 23,000
Sheep & Goats		5 - 18	500 - 1,800	5,000 – 18,000
Chickens	Broilers	.02 - .24	2 – 24	20 – 240
	Layers	.2 - .3	20 - 30	200 - 300
Turkeys		.4 - .6	40 - 60	400 - 600

It has been assumed that livestock water consumption per animal has been and will remain constant, as consumption rates are not likely to be affected in the same way as human consumption has been by water conservation initiatives. In reality, each farm utilises a different quantity of water per animal, dependant on current management and conservation procedures. Consumption rates will vary depending on such factors as the size as:

- kind and size of animal
- physiological state (lactating, pregnant, growing, etc)
- activity level
- type of diet and amount consumed
- climatic conditions
- water quality

The maximum and minimum accepted standard consumption rates per animal from Table 2.7 have been utilised in calculating the potential livestock water demand in Table 2.8. This was done to anticipate the total potential water demand of the region's existing livestock population. The high (maximum) consumption level represent an extreme level of demand that could potentially (though not likely) be reached on a peak demand day (typically a hot summer day) when consumption rates are at their greatest.

It should be noted that a large portion of this demand will be met by local water sources. It is unlikely that the total livestock population of a municipality would be connected to the regional water supply. However, increasing numbers of farms are anticipated to hook up to the regional water system as it continues to expand. Furthermore, the portion of livestock operations that are connected will vary from municipality to municipality, depending on the extent and affordability of the rural piped water supply, and the quality and availability of local groundwater supplies.

For reference, Table 2.8 lists 2001 livestock populations for the rural municipalities of the PVWC. Livestock populations are those from the *2001 Census of Agriculture*, provided by Manitoba Agriculture and Food. Projections of livestock populations are not feasible, as numbers can fluctuate significantly in response to market demand. For example, slightly fewer than 6000 swine were reported for the RM of Roland in the 2001 Census, but 8 operations containing nearly 13000 swine are presently hooked up to the water system.

Table 2.8: Livestock Populations (2001)									
Rural Municipality & Water Demand		Beef	Dairy	Horses & Ponies	Swine	Sheep & Goats	Chickens	Turkeys	Total Water Demand (L/day)
Dufferin		4,972	499	377	32,157	1,364	98,000*	105	
	High	931,950	49,900	16,965	739,611	24,552	26,424	63	1,789,465
	Median	602,661	34,431	14,138	514,512	15,686	18,594	53	1,182,866
	Low	273,372	18,962	11,310	289,413	6,820	10,765	42	598,039
Franklin		5,771	763	166	26,411	1,005*	55,000*	0	
	High	951,150	76,300	7,470	607,453	18,090	14,935	0	1,675,398
	Median	615,077	52,647	6,225	422,576	11,558	10,510	0	1,111,850
	Low	273,372	28,994	4,980	237,699	5,025	6,085	0	556,582
Grey		6,084	3,436	1,998	28,375	2,173	42,005	0	
	High	95,1150	343,600	89,910	652,625	39,114	11,341	0	2,464,915
	Median	615,077	237,084	74,925	454,000	24,990	7,981	0	1,582,865
	Low	279,004	130,568	59,940	255,375	10,865	4,621	0	790,996
Montcalm		512	104	31	14,578	300	8,500*	0	
	High	103,500	10,400	1,395	335,294	5,400	2,298	0	458,287
	Median	66,930	7,176	1,163	233,248	3,450	1,617	0	312,421
	Low	30,360	3,952	930	131,202	1,500	936	0	167,950
Morris		594	4	118	50,769	83	253,869	0	
	High	105,750	400	5,310	1,167,687	1,494	68,545	0	1,349,186
	Median	68,385	276	4,425	812,304	955	48,235	0	929,568
	Low	31,020	152	3,540	456,921	415	27,926	0	516,179
Rhineland		1,381	397	84	65,641	947	164,853	0	
	High	300,600	39,700	3,780	1,509,743	17,046	44,510	0	1,915,379
	Median	194,388	27,393	3,150	1,050,256	10,891	31,322	0	1,312,283
	Low	88,176	15,086	2,520	590,769	4,735	18,134	0	716,045
Roland		659	0	12	5,895	215*	13,000*	0	
	High	99,000	0	540	135,585	3,870	3,447	0	242,442
	Median	64,020	0	450	94,320	2,473	2,425	0	163,065
	Low	29,040	0	360	53,055	1,075	1,404	0	84,499
Stanley		5,314	1,360	682	26,702	938	92,849	0	
	High	1,687,425	136,000	30,690	614,146	16,884	25,069	0	2,510,214
	Median	1091202	93840	25575	427232	10787	17641	0	1,639,908
	Low	494,978	51,680	20,460	240,318	4,690	10,213	0	801,534

Table 2.8: Livestock Populations (2001)									
Rural Municipality & Water Demand		Beef	Dairy	Horses & Ponies	Swine	Sheep & Goats	Chickens	Turkeys	Total Water Demand (L/day)
Thompson		2,249	76	378	27,521	1,067*	50,460	0	
	High	475,950	7,600	17,010	632,983	19,206	13,624	0	1,166373
	Median	307,781	5,244	14,175	440,336	12,271	9,587	0	774,701
	Low	139,612	2,888	11,340	247,689	5,335	5,551	0	400,850
Total		27,536	6,649	3,846	278,049	8,092	778,536	105	
	High	5,983,650	663,900	173,070	6,395,127	145,656	210,193	63	13,571,659
	Median	3,869,427	458,091	144,225	4,448,784	93,058	147,913	53	9,161,551
	Low	1,755,204	252,282	115,380	2,502,411	40,460	85,634	42	4,751,413
Note: Figures marked with a * are estimates, as statistics were incomplete									

The following Table 2.9 indicates the combined domestic and agricultural water demand rates for the PVWC, including the domestic projections. While the total water demand is shown here, individual municipal totals can be arrived at by consulting Tables 2.5 and 2.8. For the purposes of this study, it has been decided to anticipate meeting 50% of agricultural demand for 2011 and 100% for 2021.

Table 2.9: Combined Domestic and Agricultural Projections							
Municipality		Historic Scenario A		Historic Scenario B		Optimistic Scenario	
		2011	2021	2011	2021	2011	2021
Dufferin	High Ag. Demand	1,604,208	2,499,235	1,583,558	2,431,680	1,659,373	2,613,695
	Median Ag. Demand	1,300,908	1,892,636	1,280,258	1,825,081	1,356,073	2,007,096
Franklin	High Ag. Demand	1,330,644	2,137,958	1,354,539	2,215,543	1,412,064	2,303,158
	Median Ag. Demand	1,048,870	1,574,410	1,072,765	1,651,995	1,130,290	1,739,610
Grey	High Ag. Demand	1,860,808	3,088,250	1,827,178	2,982,935	1,930,723	3,234,865
	Median Ag. Demand	1,419,783	2,206,200	1,386,153	2,100,885	1,489,698	2,352,815

Table 2.9: Combined Domestic and Agricultural Projections							
Municipality		Historic Scenario A		Historic Scenario B		Optimistic Scenario	
		2011	2021	2011	2021	2011	2021
Montcalm	High Ag. Demand	597,009	785,737	560,724	687,797	622,379	832,642
	Median Ag. Demand	524,076	639,871	487,791	541,931	549,446	686,776
Morris (RM)	High Ag. Demand	1,443,658	2,085,506	1,418,583	2,007,626	1,459,588	2,116,186
	Median Ag. Demand	1,233,849	1,665,888	1,208,774	1,588,008	1,249,779	1,696,568
Rhineland	High Ag. Demand	2,151,555	3,070,599	2,163,060	3,107,769	2,224,125	3,214,854
	Median Ag. Demand	1,850,007	2,467,503	1,861,512	2,504,673	1,922,577	2,611,758
Roland	High Ag. Demand	436,281	567,827	442,771	589,657	458,996	616,207
	Median Ag. Demand	396,593	488,450	403,083	510,280	419,308	536,830
Stanley	High Ag. Demand	2,924,807	4,349,244	3,017,732	4,707,964	3,133,962	4,839,239
	Median Ag. Demand	2,489,654	3,478,938	2,582,579	3,837,658	2,698,809	3,968,933
Thompson	High Ag. Demand	972,587	1,551,643	989,107	1,608,873	1,014,182	1,638,373
	Median Ag. Demand	776,751	1,159,971	793,271	1,217,201	818,346	1,246,701
Altona		854,325	944,775	881,100	1,046,475	888,075	1,020,825
Carman		690,750	748,800	715,725	842,625	698,175	765,450
Emerson		137,025	127,350	126,675	97,650	153,900	160,875
Gretna		131,175	135,675	145,125	188,775	192,375	292,500
Morden		1,600,875	1,854,225	1,671,525	2,139,300	1,651,050	1,972,575
Morris (Town)		388,575	401,175	390,150	406,800	397,350	419,400
Plum Coulee		181,125	201,150	168,975	159,075	213,300	279,000
St. Claude		122,175	118,800	110,925	85,950	133,200	141,525

Table 2.9: Combined Domestic and Agricultural Projections							
Municipality		Historic Scenario A		Historic Scenario B		Optimistic Scenario	
		2011	2021	2011	2021	2011	2021
Winkler		2,244,600	2,819,025	2,310,075	3,100,275	2,464,875	3,399,525
Total	High Ag. Demand	19,672,180	27,486,974	19,877,525	28,406,769	20,707,690	29,860,894
	Median Ag. Demand	17,391,114	22,924,842	17,596,459	23,844,637	18,426,624	25,298,762
Note: 2011 totals anticipate meeting 50% of agricultural demand, while 2021 totals anticipate meeting 100% of agricultural demand.							

2.5 WET INDUSTRIES

In none of the current scenarios was it proposed that one or more wet industries might locate within the region. It appears to be generally accepted in the region that there are not enough water resources available to support the establishment of any new industries that might demand high volumes of water. The establishment of a wet industry within a municipality serviced by the PVWC would necessitate an assessment of available water resources.

2.6 GROWTH AND DEMAND PROJECTIONS FOR NETWORK MODELING

To be able to plan for future expansion of the water system, it is first necessary to anticipate future water demand. Municipal domestic and livestock populations were examined to develop projections of future water needs in the PVWC.

Historically, the municipalities of the PVWC have met moderate to optimistic population growth projections. Analysis of recent growth patterns gathered from Statistics Canada Census profiles allowed three growth scenarios to be developed, projecting municipal populations to 2021. The following projections in Table 2.10 were made for the years 2011 and 2021, under each of the scenarios. Projections were made from 2001, as this was the most recent year for which Census population statistics were available.

By multiplying the population by an average consumption rate, we can anticipate the required demand under each scenario. For example, if the current water consumption rates of 295L/person/day (the approximate current consumption rate of Altona and Morden) were used, the results would be as presented in Table 2.4. For the present study, however, metering information was available allowing for more "real" estimates of the current demand. This is presented in further sections of the report.

Table 2.10: Summary of Projected Municipal Populations

Municipality	Projected Population					
	Historic Growth Scenario A		Historic Growth Scenario B		Optimistic Growth Scenario	
	2011	2021	2011	2021	2011	2021
Altona	3,797	4,199	3,916	4,651	3,947	4,537
Carman	3,070	3,328	3,181	3,745	3,103	3,402
Emerson	609	566	563	434	684	715
Gretna	583	603	645	839	855	1,300
Morden	7,115	8,241	7,429	9,508	7,338	8,767
Morris (Town)	1,727	1,783	1,734	1,808	1,766	1,864
Plum Coulee	805	894	751	707	948	1,240
St. Claude	543	528	493	382	592	629
Winkler	9,976	12,529	10,267	13,779	10,955	15,109
Dufferin	2,405	2,406	2,335	2,177	2,592	2,794
Franklin	1,671	1,568	1,752	1,831	1,947	2,128
Grey	2,130	2,113	2,016	1,756	2,367	2,610
Montcalm	1,247	1,110	1,124	778	1,333	1,269
Morris (RM)	2,607	2,496	2,522	2,232	2,661	2,600
Rhineland	4,047	3,916	4,086	4,042	4,293	4,405
Roland	1,068	1,103	1,090	1,177	1,145	1,267
Stanley	5,660	6,234	5,975	7,450	6,369	7,895
Thompson	1,320	1,306	1,376	1,500	1,461	1,600
Total	50,380	54,925	51,255	58,796	54,357	64,129

Actual water demands were compiled for the year 2002 using monthly metering records provided by PVWC. Although metering was also available for years prior to 2002, it was felt that with the highly dynamic nature of the system it would be more prudent to look only at the most recent year. Figure 2.1 illustrates the water demand "nodes" that have been chosen for the hydraulic model. These nodes generally reflect metered locations (customers). In some cases, however, several smaller customer meterings have been combined to simplify the system and allow more efficient analysis of the regional system(s).

In order to project the future demands for these nodal locations, the growth rates listed earlier were used. In some cases where it was possible to estimate growth rate for a particular metered location, such as for the Town of Altona, this was a simple process. In other locations, where statistical population data was not available (e.g. Dominion City), the estimated growth rate for the respective Rural Municipality was used. The 2002 demands and the estimated 2012 and 2022 demands are listed in Table 2.11 for each of the model demand nodes. When compared to Figure 2.1, it is seen that some of the model nodes have actually been spread over a number of locations (i.e. R.M. of Dufferin and R.M. of Morris). This was done because these meters were located near the water treatment plants and would not otherwise accurately reflect the hydraulic piping requirements.

Table 2.11: Current and Future Demands

Model Node	Description	2002 (L/s)	2011 (L/s)	2021 (L/s)
1	Dominion City	1.76	4.69	7.62
2	Letellier	0.77	0.74	0.70
3	Morris East	0.17	0.63	1.08
4	St. Jean	4.45	4.70	4.95
5	Altona Rural	6.80	6.00	5.11
6	Horndean Reservoir	0.47	1.96	3.44
7	Altona	30.51	37.58	44.64
8	Morris	10.68	11.29	11.90
9	Altona Booster	11.13	10.16	9.18
10	Emerson	5.36	5.57	5.77
11	Morden	5.77	12.59	19.40
12	St. Joseph	0.36	0.71	1.05
13	Halbstadt Marais Water Coop	1.26	2.94	4.61
14	Roseau River	3.79	5.89	7.99
15	Plum Coulee	5.30	6.40	7.50
16	R.M. of Roland	1.28	4.51	7.74

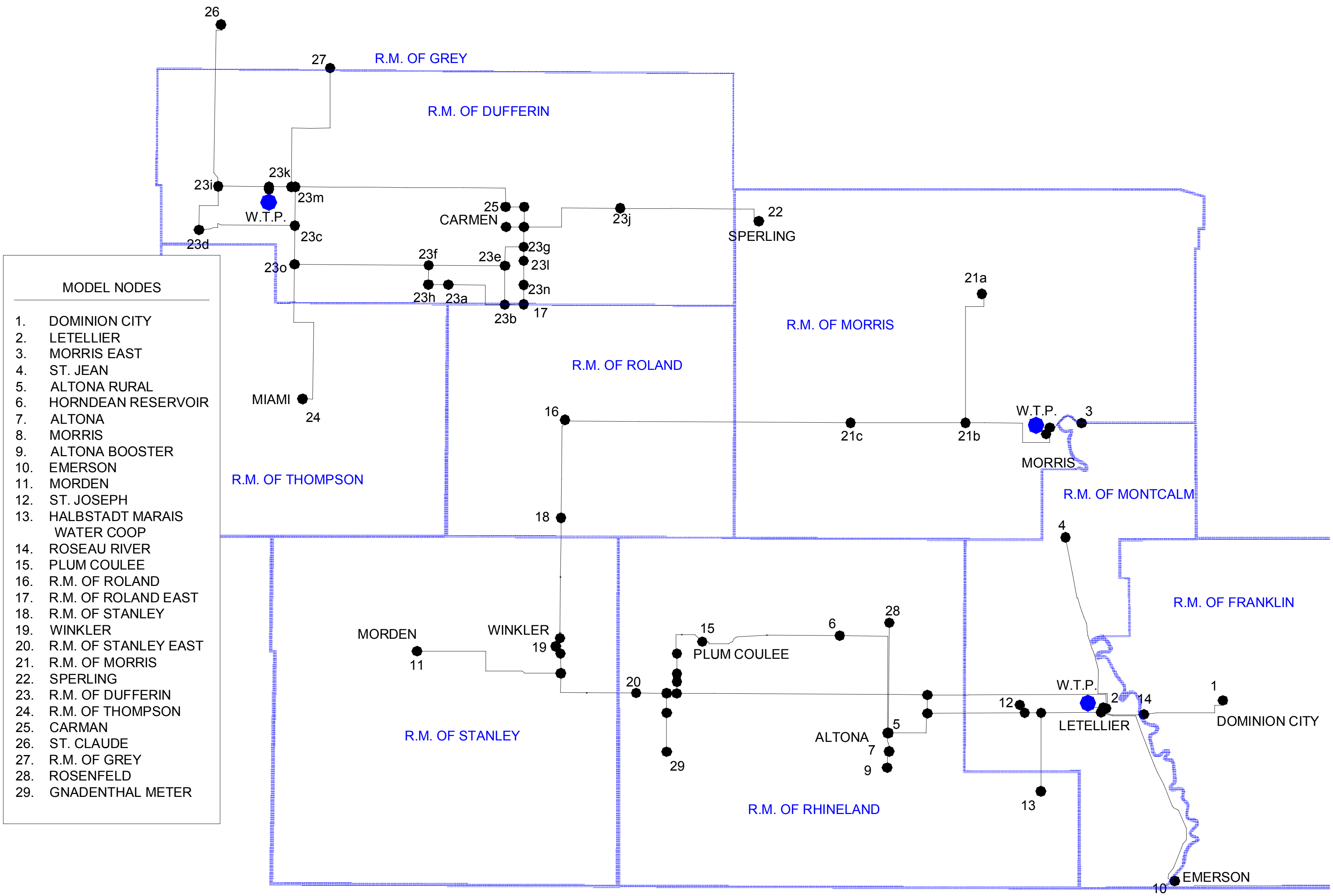


Figure 2.1: Network Model with Demand Nodes

Table 2.11: Current and Future Demands				
Model Node	Description	2002 (L/s)	2011 (L/s)	2021 (L/s)
17	R.M. of Roland East	0.23	1.51	2.79
18	R.M. of Stanley	0.18	0.98	1.77
19	Winkler	22.23	36.94	51.64
20	R.M. of Stanley East	9.35	6.47	3.59
21	R.M. of Morris	7.45	14.27	21.09
22	Sperling	0.30	1.66	3.01
23	R.M. of Dufferin	9.58	9.97	10.35
24	R.M. of Thompson	2.41	6.36	10.30
25	Carman	5.33	7.55	9.77
26	St.Claude	3.63	12.79	21.94
27	R.M. of Grey	0.82	10.23	19.63
28	Rosenfeld	2.26	3.38	4.50
29	Gnadenthal Meter	1.43	2.56	3.69
	Total	155.05	230.91	306.80

Agricultural water demand in the municipalities of the PVWC was estimated by comparing current livestock populations (from the 2001 Census of Agriculture) with accepted standard livestock water requirements.

High, median, and low per-animal water demands were compiled from various sources, to show the range of demand. The upper end values for each animal were used for developing alternatives. These demand ranges are intended to reflect conditions that may be seasonal, such as humidity and temperature that could cause all agricultural demands throughout the region to rise simultaneously.

The current agricultural demand is estimated to be approximately 41 L/s. Future livestock water demands were estimated by assuming that all of the existing livestock in the serviceable areas would be on-line in the near future, yielding a demand of approximately 129 L/s. Furthermore, it was assumed that the Manitoba pork industry would increase by 50% by 2021. Each municipality was evaluated based on existing concentrations and expected growth between 0 and 50%. The estimated total agricultural demand for the year 2021 is therefore approximately 149 L/s. The agricultural demands used in the hydraulic model are included in the Table 2.12. These demands were spread appropriately over the demand nodes within each rural municipality to better model the likely distribution.

Table 2.12: Projected Agricultural Water Demand (L/day)

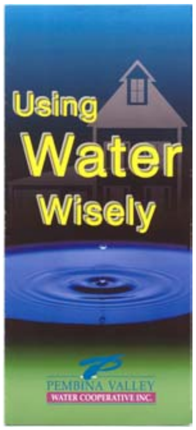
R.M.	2021
Dufferin	1,881,913
Franklin	989,547
Grey	2,791,075
Montcalm	500,191
Morris	1,816,092
Rhineland	2,292,731
Roland	293,310
Stanley	1,616,703
Thompson	701,933
Total (L/day)	12,883,494
Total (L/s)	149

2.7 SUMMARY OF GROWTH AND DEMAND PROJECTIONS

This examination of domestic and agricultural water demands identifies potential and future water requirements of the study area. The projected water demand varies greatly depending on methods of projecting population and agricultural growth and associated consumption rates.

Domestic projections represent a potential need that must be satisfied. If the PVWC is to ensure that future domestic needs are met, the largest population estimates of the Historic Growth Scenario B and the Optimistic Growth Scenario should be used.

Livestock consumption rates provide context for decisions regarding future agricultural connections and use of the system's excess (to domestic use) capacity.



The implementation of a regional domestic and livestock water supply strategy would ensure that the number of connections is increased at a sustainable rate, and that the infrastructure is in place for future connections. Additionally, education regarding water conservation techniques should result in noticeable reductions in rates of water consumption. The PVWC has recently instituted such a program utilizing mail-out brochures and a radio information campaign.

3.0 WATER DISTRIBUTION SYSTEM MODELING

3.1 INTRODUCTION

The Pembina Valley Water Coop water distribution system consists of several pipelines for regional delivery of water and many comparatively smaller local systems and branch lines. Analysis of the system is complicated by the involvement of three water plants and looped piping. The relative supply and distribution of water from each of the two plants in the Morris / Letellier system, and the distribution of water through the looped Stephenfield system cannot be manually computed without many iterations. Modern computer modeling systems do these iterations very rapidly and allow for quick and efficient system analysis. The model can be used to determine the relative supply and distribution from each plant and through any looping in the pipe system for existing systems and to help determine system improvements that would result from upgrade alternatives.

For the present study, a water distribution model has been developed using WaterCAD v. 6.0 to provide a good analytical tool to assess the performance of the existing water distribution system and provide insight into system capacities for future demands within the region. WaterCAD software is one of the most widely used water distribution modeling software packages.

Using demand data and system inventory (i.e. pumps, pipes, etc.), a computerised schematic has been created for the main components of the existing water distribution system. The known pipe and pump characteristics as well as nodal data have been inserted into the model to simulate the existing distribution network and analysis has been performed to simulate real world operating conditions. Smaller branch pipes and isolated systems have been excluded from the model to allow for analysis of regional supply and delivery only. In future studies, the model can be expanded to include smaller sub-systems and branch lines.

The existing system is analysed using peak hour demands, determined by applying a peaking factor to the average day demand. The projected 10- and 20-year peak hour demands, estimated using the growth scenarios described in Section 1.0 are analysed to identify system bottlenecks and inadequacies and to assist with identification of upgrade alternatives. These simulations provide corresponding system pressures to verify that adequate service is being provided during periods of extreme demand from the end users.

The distribution modelling study conclusions will identify specific system shortcomings. Upgrade alternatives, developed to ensure adequate flows are available to meet the demands for future development, population growth and population re-distribution, are presented in later sections of this report.

3.2 WATER DISTRIBUTION MODEL – SYSTEM INVENTORY

An inventory of piping, pumps, pressure regulating valves and water meters was provided by PVWC. The pipe inventory, comprised of vector data provided in an AutoCAD drawing, formed the basis for the distribution model. As mentioned, only the main pipelines and significant looping is considered in this study. Figure 3.1 illustrates the baseline model of the existing system.

To determine the frictional headloss in the pipes, the model uses the Hazen Williams formula, (Equation 3.1). This equation relates the pipeline discharge (Q) to the friction slope (S), flow area (A), hydraulic radius (R), and the Hazen-Williams roughness coefficient (C). The friction slope indicates the headloss (m) per meter of pipe, the flow area and hydraulic radius are functions of the pipe inside diameter and the roughness coefficient indicates the expected friction between the water and the pipe wall. For this study, the roughness coefficient has been estimated at 140 for all modelled pipelines. This is considered appropriate because they are all plastic (PVC and HDPE), are conveying treated water and will presumably be appropriately maintained through the timeframe of this study. This parameter has not been calibrated at the time of this writing. Minor losses due to pipe bends, meter chambers, etc. are assumed negligible for pipelines with lengths of the magnitude common to this system and the relatively low velocities that will be maintained.

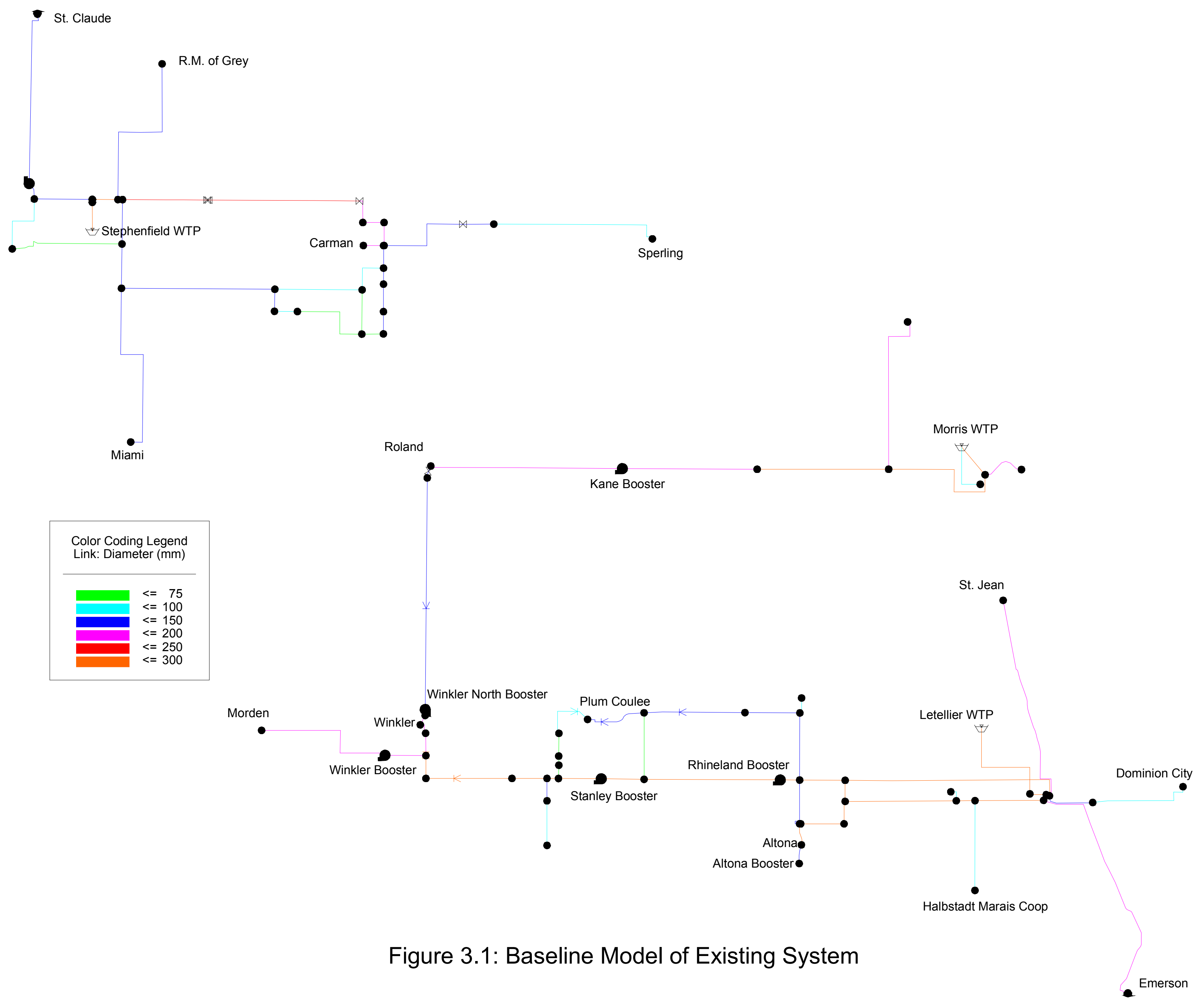


Figure 3.1: Baseline Model of Existing System

COCHRANE ENGINEERING

PEMBINA VALLEY WATER COOPERATIVE INC.

$$Q = kCAR^{0.63}S^{0.54} \quad (3.1)$$

Where: Q = Discharge in the section (m^3/s, cfs)
k = Constant (0.85 for SI units, 1.32 for US units)
C = Hazen-Williams roughness coefficient (unitless)
A = Flow Area (m^2, ft^2)
R = Hydraulic Radius (m, ft)
S = Friction slope (m/m, ft/ft)

The system incorporates distribution pumping at each plant as well as booster pumping at strategic locations along main pipelines. Pump curves for each pump are included in the Appendix A of this report.

Because the purpose of this portion of the study is to analyse the distribution system, the existing water treatment plant pumps have been replaced with “reservoirs”, WaterCAD objects that simulate an endless supply of water at a constant head. This allows testing of various upgrade scenarios for the piping system and booster pumping stations to be completed without the complication of changing pumps. Once a given system upgrade scenario is developed, the required pumping at the water plants is simple to determine. These reservoirs have been given an elevation that corresponds to a head of 552 kPa (80 psi) at their respective location and elevation, the highest pressure that should be realised within the system to prevent possible damage.

In some cases the booster stations provide additional pressure to account for headloss resulting from the long pipe lengths (i.e. Morris – Winkler, Letellier – Winkler). In other cases, (i.e. Winkler – Morden), the boosters are largely used to overcome static head losses due to the significant elevation differences across the escarpment. All appropriate pump curves have been incorporated into the model in a manner that will simulate the expected operational strategies.

Pressure regulating valves are incorporated in the existing system and are included in the model. In most cases these are used to ensure pumping pressures do not exceed pipe ratings and that unreasonably high system pressures are not subsequently experienced by those consumers closer to the plants and pumping stations. In other cases, such as the Stephenfield – Carman pipeline, pressure regulating valves are used to prevent pipe over-pressurization due to the static head gained descending the escarpment.

3.3 EXISTING SYSTEM RESULTS ANALYSIS

The existing system was modeled using the 2002 water demands and water distribution system described previously. It should first be noted that the demands described for 2002 indicate a design condition that may or may not have been experienced during the year 2002. These demand values assume a peak day peaking factor of 2.0 for all nodes which reflects the large populations and dispersed geography of the system. The peaking factor of 2.0 means that the design condition assumes all nodes are using twice their average yearly demand concurrently. This should reflect a condition similar to the worst case in terms of the system hydraulics. Furthermore, an event similar to this condition may have occurred for only several seconds, or minutes, and the consumers would have realised only a temporary period of low pressure. Peaking factors greater than 2.0 could be realised at specific locations, but would not likely occur over the entire system concurrently.

The model results, shown in Figure 3.2 as Scenario 1, indicate that the system is marginally inadequate for the existing demands. This is indicated by the low pressures (i.e. < 20 psi) found to occur in the Winkler area. When run for the existing distribution system and the 2021 demand, the model indicates a severely undersized system incapable of meeting required pressures. This scenario (Scenario 2) is shown in Figure 3.3 and points to a theoretical deficit of water in the areas between Morden and Altona. This is to be expected as this is the region expected to experience the greatest population growth. Aside from a requirement for expanded capacity of the Stephenfield WTP, the Stephenfield distribution system appears to be adequate for the projected demands.

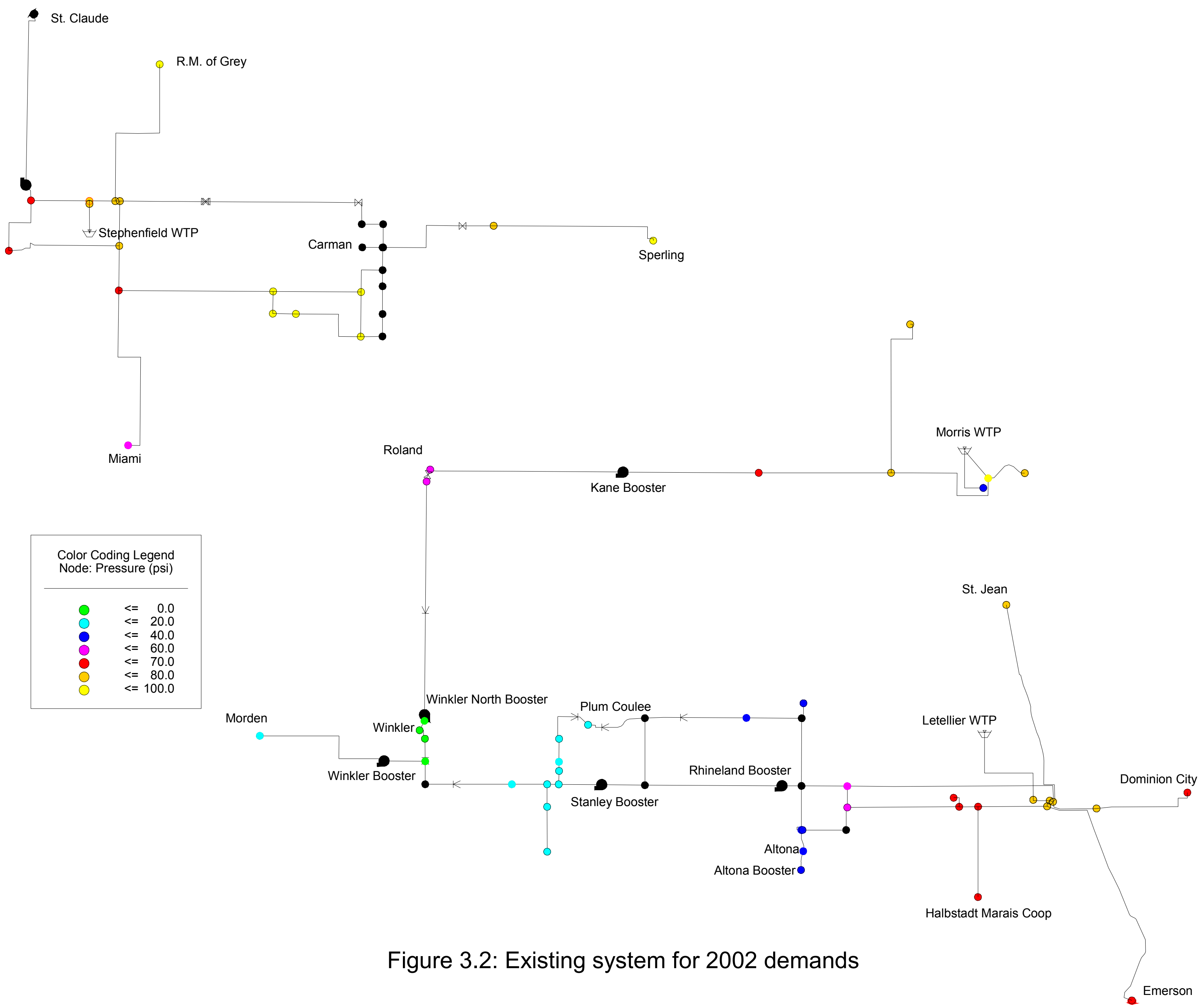


Figure 3.2: Existing system for 2002 demands

COCHRANE ENGINEERING

PEMBINA VALLEY WATER COOPERATIVE INC.

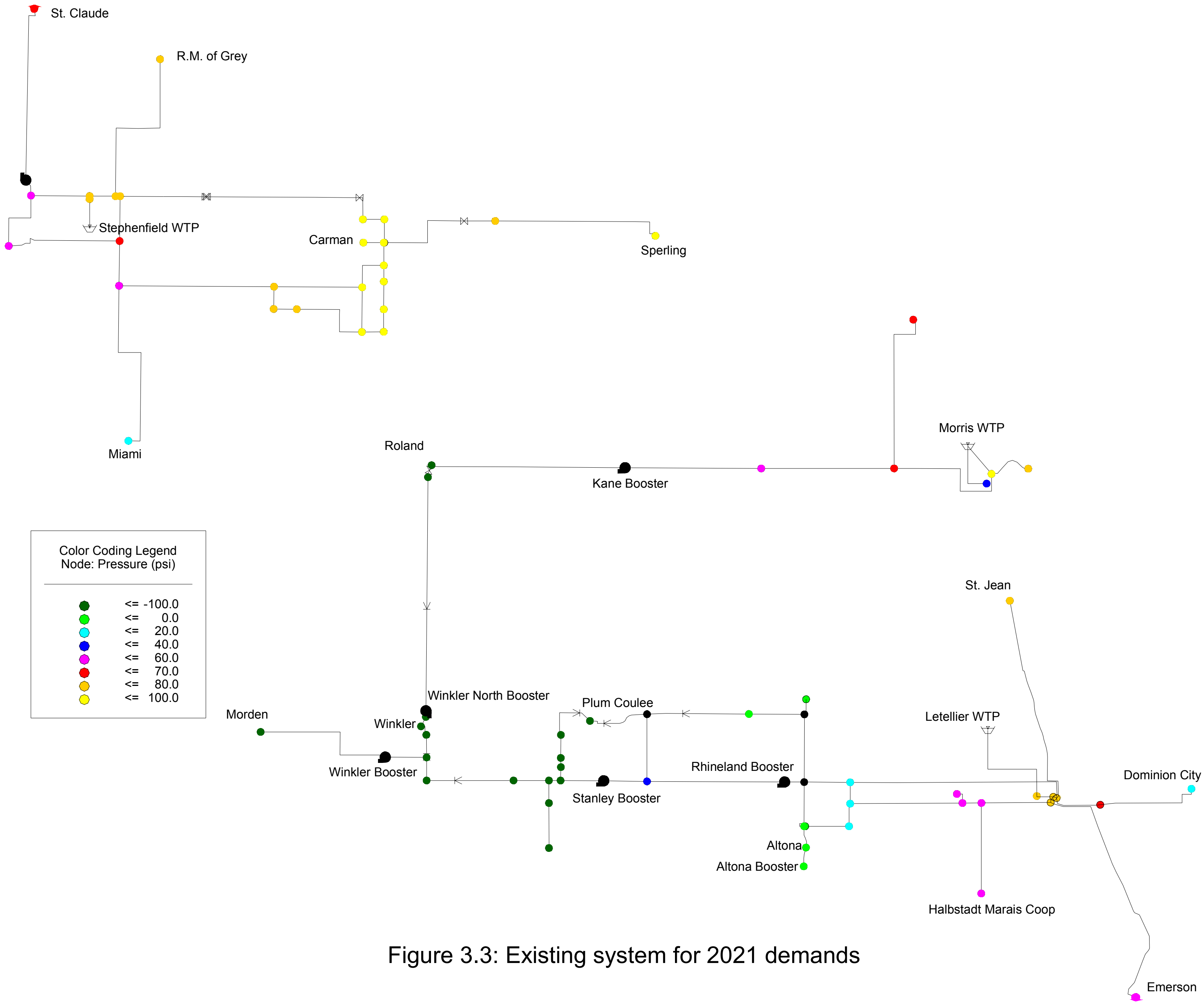


Figure 3.3: Existing system for 2021 demands

To avoid confusion, the reader should be aware that the WaterCAD modeling software operates procedurally by satisfying all demands within the modeled system and then determines the resulting pressures. Any time the model returns negative pressures, the model results are illogical. In reality the demands would simply not be satisfied and consumers would experience very low flows at low pressure. Results such as these nonetheless indicate system weaknesses and allow the user to conceptualize augmentative solutions.

The proposed Roland Reservoir, under construction in late 2003, has thus been conceptualized as a means of contributing water to the Stephenfield system in the short-term to allow for expansion of the service area into further reaches of the R.M. of Grey. The reservoir piping has been designed to allow additional flexibility. It will allow the reservoir to be replenished by either the Morris or Stephenfield plants and supply water to either the Stephenfield system or to the Winkler area, or both. In the long-term, the reservoir has been conceptualized to provide equalization storage and re-pumping for the Winkler area.

While equalization is an advantage in that it reduces the requirement of the upstream system to supply and convey high short-term peaks, it has a disadvantage for current conditions in that the reservoir breaks the pressures that currently exist in the pipe at that location. Figure 3.4 illustrates the immediate effect that the Roland Reservoir will have on the system. These conditions do not include additional servicing to the R.M. of Grey.

From the demand forecasts and model results, the existing Stephenfield system is expected to be generally adequate for the forecasted period with the exception of the imminent demands from the R.M. of Grey. Expansion of the Stephenfield plant from a capacity of 20 L/s to as much as 80 L/s, along with appropriate boosting and additional pipelines, would provide system capacity to supply larger amounts of water (exceeding 40 L/s) to the expanded areas in the further reaches of the R.M. of Grey under peak day conditions.

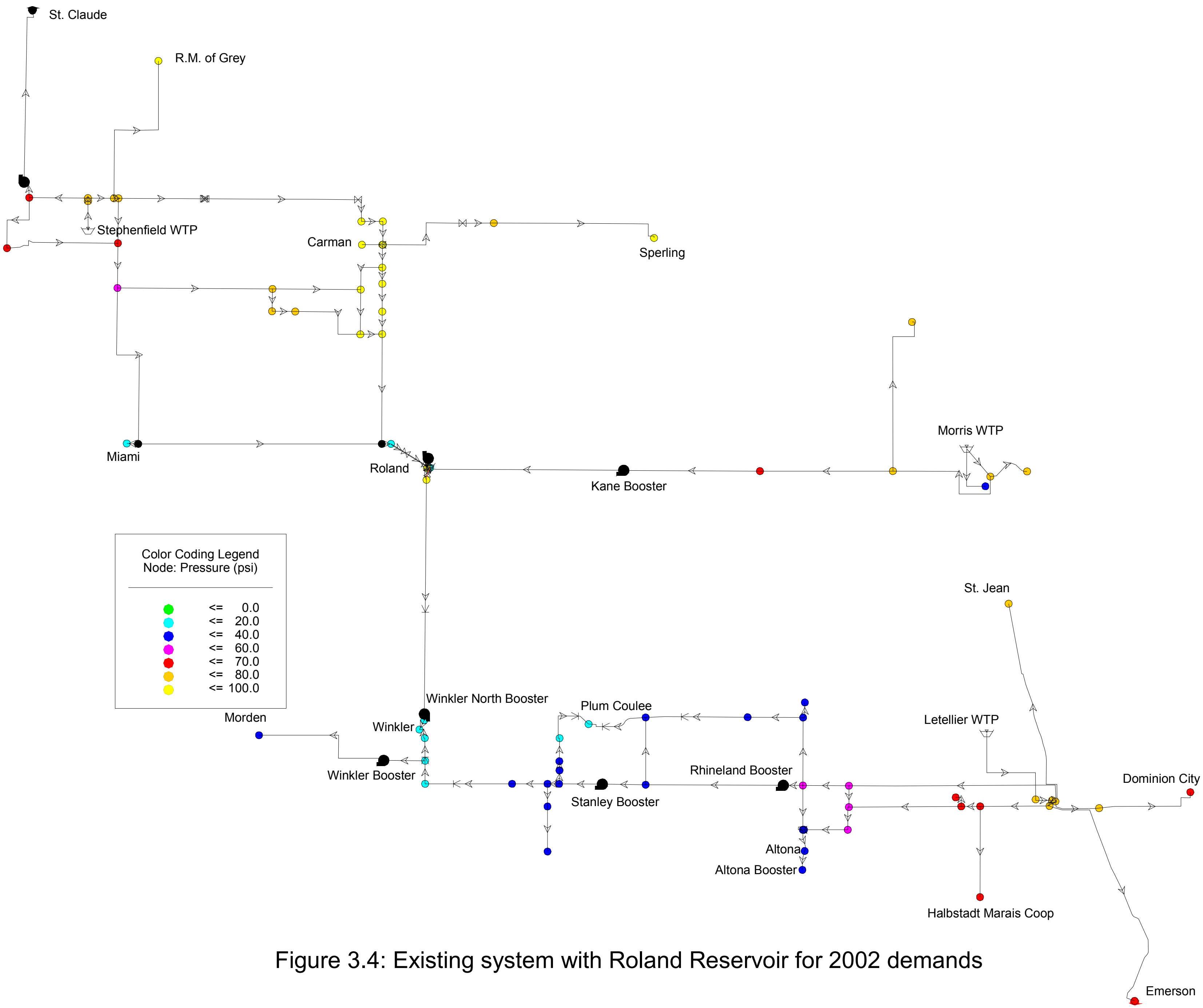


Figure 3.4: Existing system with Roland Reservoir for 2002 demands

COCHRANE ENGINEERING

PEMBINA VALLEY WATER COOPERATIVE INC.

Table 3.1 summarizes the total system demand projections used in the model based on the growth and assumptions described previously.

Table 3.1: Projected System Demands (L/s)			
	2002	2011	2021
Domestic	114	136	158
Agricultural	41	95	149
Total	155	231	307
Increase	-	76	76

In order to accommodate the projected system demands, the water treatment plants will require expansion. The relative partitioning of these expansions was determined based on the network upgrades and is described for each upgrade scenario.

Note that these water treatment plant expansions may require revisions to the existing water rights licensing, which may or may not be granted. The Boyne River, the source of water for the Stephenfield water treatment plant, for example, is approaching its capacity and further withdrawal applications will likely face challenges. It is noted, however, that the existing license permits a rather generous maximum withdrawal rate of 76 L/s. For these reasons, upgrade scenarios are presented that involve Stephenfield treatment capacity upgrades within the range of 40 L/s (average allowable withdrawal multiplied by peaking factor) and 76 L/s. The reader is reminded that the modeled upgrade scenarios correspond to the peak day demand, one that is not sustained throughout the year. It is valid, therefore, to design for treatment capacities up to 76 L/s, provided that the Morris and Red River Regional Water plants supplement the Stephenfield system at other times of the year in that the average supply from Stephenfield does not exceed the licensed amount.

4.0 FACILITIES ASSESSMENT

The PVWC operates three water treatment plants supplying treated water to the distribution network;

- 96 L/s - Red River Regional WTP, Letellier
- 32 L/s - Morris Regional WTP, Morris
- 20 L/s - Stephenfield Regional WTP, Stephenfield

Other facilities in the system include booster pumping and meter chambers and a 1.1 million litre reservoir/ pumping station (under construction late 2003) located near Roland.

The three water treatment plants were assessed to review condition and current operating capacity. This included:

- a review of record drawings
- on-site reviews
- interviews with operating staff
- analysis of water quality and meter reading data
- review of residuals (sludge and backwash water) disposal, in terms of quality, environment and pond capacity
- discussions with the Office of Drinking Water as to plant operations and the implementation of more stringent quality standards

Based upon evaluation of this information, future quality objectives have been established, and capacity limitations for each facility will be confirmed.

4.1 PROCESS DESCRIPTIONS AND PLANT DETAILS

The following is a description of the major treatment processes for the Red River Regional and Morris Regional Water Treatment Plants:

- Pre-Oxidant (Potassium Permanganate)
- Adsorbents (Activated Carbon)
- Cold Lime Softening-Clarification
- Quicklime (CaO)
- Calcium Hydroxide ($Ca(OH)_2$)
- Soda Ash
- Aluminum Sulphate (Alum)
- Coagulant Aide (Polymer)
- Recarbonation (CO_2)
- Chlorine Disinfection
- Fluoridation (Hydrofluosilicic Acid)
- Storage

Figures 4.1 and 4.2 show floor plans the facilities.

The following is a description of the major treatment processes for the Stephenfield Regional Water Treatment Plant:

- Pre-Oxidant (Potassium Permanganate)
- Adsorbents (Activated Carbon)
- Cold Lime Softening-Clarification
- Hydrated Lime (Calcium Hydroxide ($Ca(OH)_2$))
- Caustic Soda (Sodium Hydroxide)
- Aluminum Sulphate (Alum)
- Coagulant Aide (Polymer)
- Recarbonation (CO_2)
- Chlorine Disinfection
- Fluoridation (Hydrofluosilicic Acid)
- Storage

Figures 4.3 shows the floor plan for the facility.

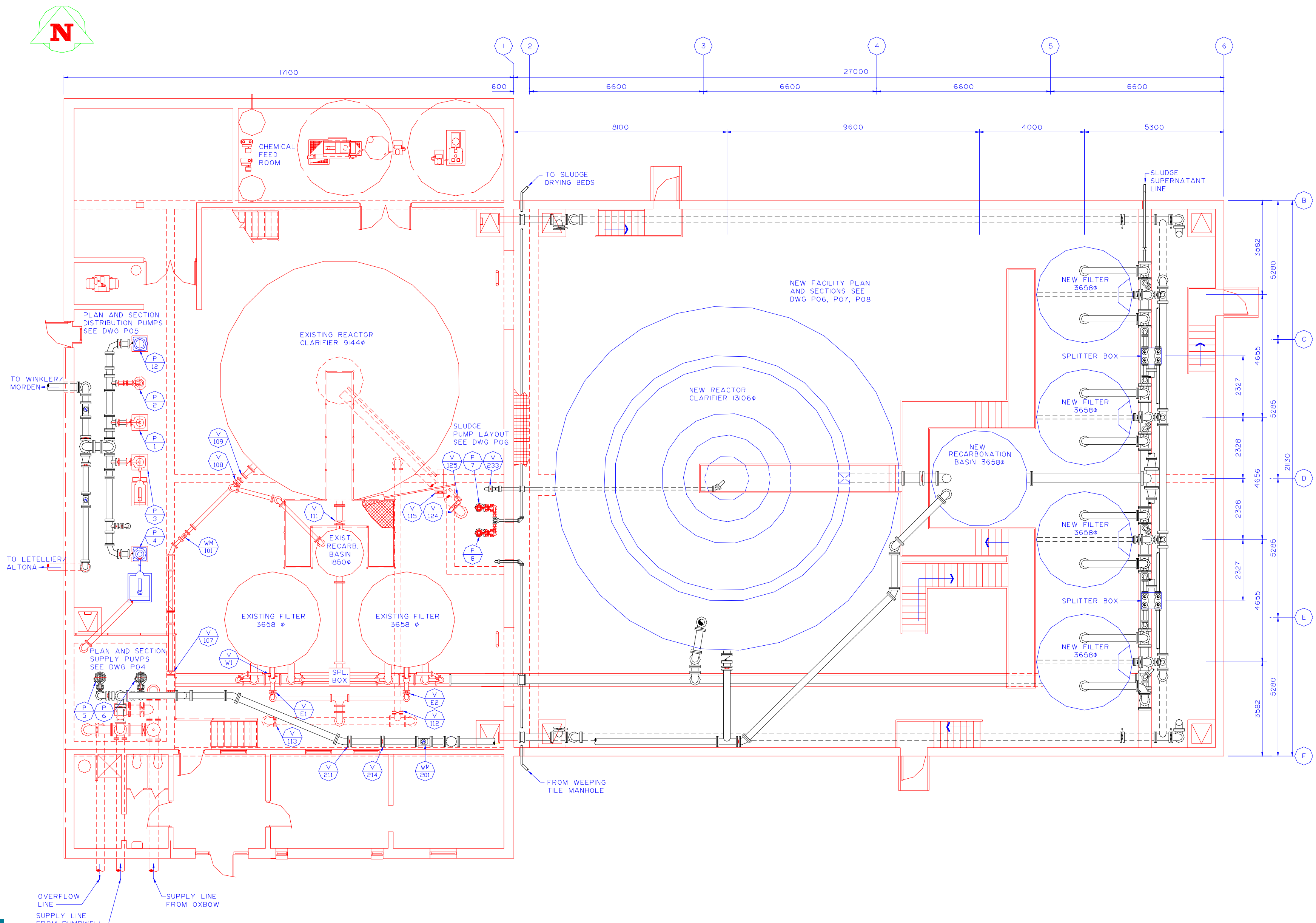


Figure 4.1: Red River Regional WTP Floor Plan (Previous Upgrade Plan, 1998)

COCHRANE ENGINEERING

PEMBINA VALLEY WATER COOPERATIVE INC.

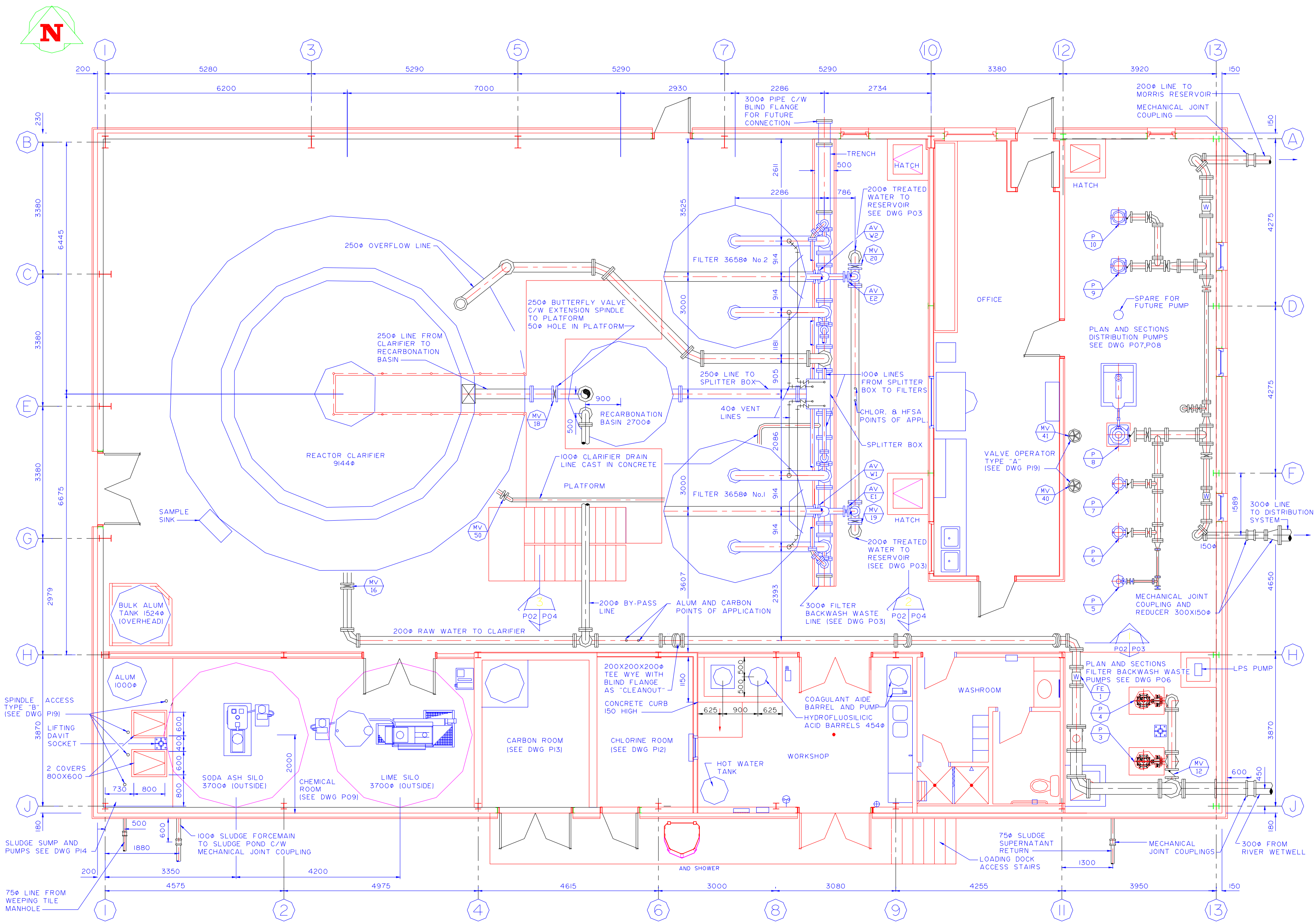


Figure 4.2: Morris Regional WTP Floor Plan (Previous Upgrade Plan, 1998)

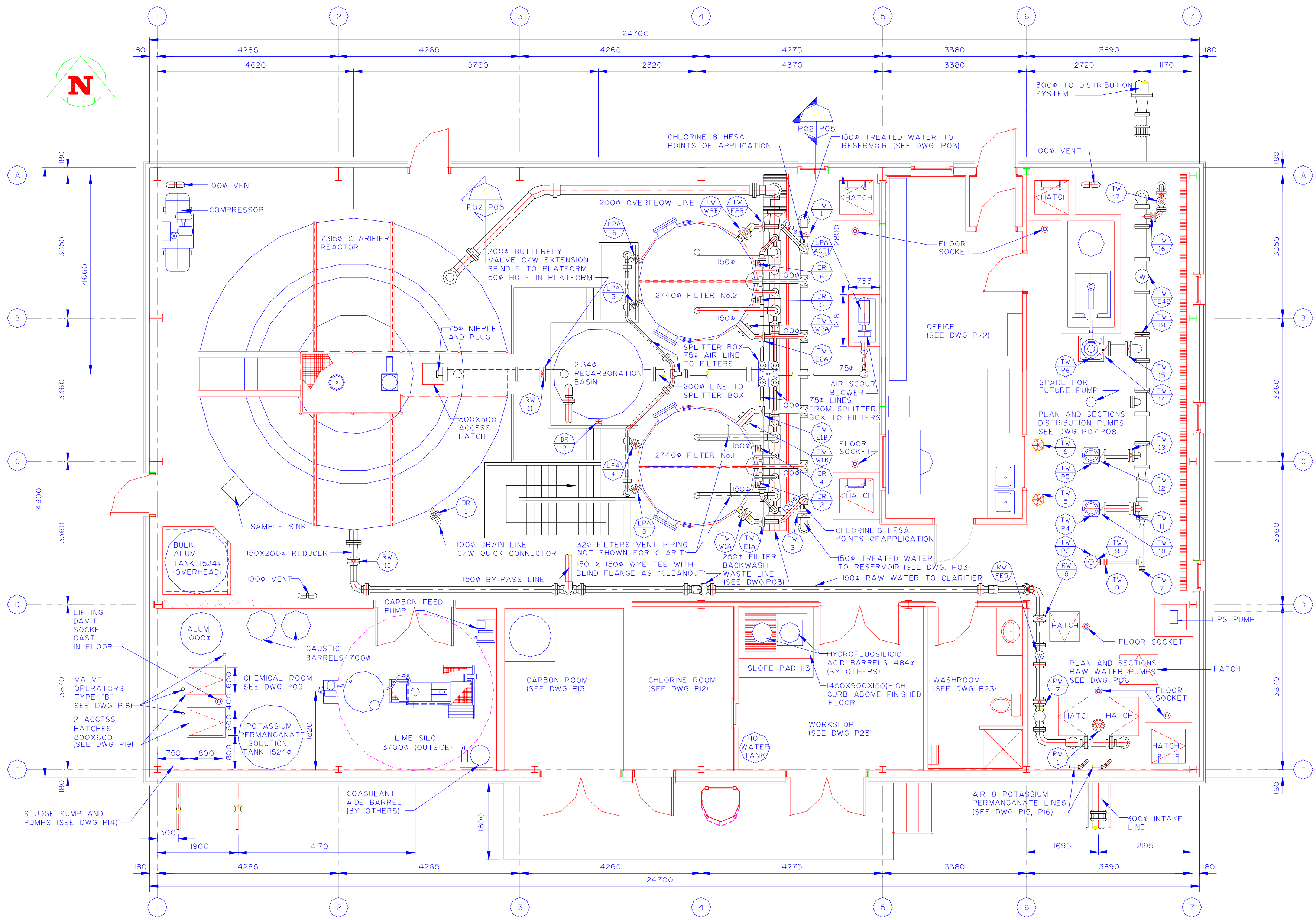


Figure 4.3: Stephenfield Regional WTP Floor Plan (Previous Upgrade Plan, 1999)

4.2 PLANT ASSESSMENTS

Each water treatment plant was visited to confirm equipment capacity and obtain operator comments. Tables 4.1, 4.2 and 4.3 summarize this investigation.

Table 4.1: Red River Regional WTP Major Equipment Review

Description	Units	Rated QTY	Max. QTY	Year in Service	Comments
Rated Plant Capacity	L/s	96	108		
Water Rights License					Max Rate: 0.1 m^3/sec or (100 L/s) Total QTY/year: 3157.72 dam^3 or (100 L/s- average)
DFO Intake Screen/ Structure	L/s	106	106	1998	Condition good, no concerns noted.
Intake Pipe (2002): Summer Winter Upgraded Twinned Piping (2003)	 L/s L/s L/s	 106 106 106	 100 70 106	 1986 2003	A second intake pipe was installed in summer 2003 to add capacity for low river level conditions. No other concerns noted.
Raw Water Pumps – River Well (LP-1, 2): Two KSB Model KRTK100-400 49 Hp, 50 L/s at 42.6m	L/s	100	110	1998	Condition fair. Well depth and diameter do not permit future upgrades to the pumping for increased capacity..
WTP Wet Well (LP-5, 6) Two Flygt CP3152 20Hp 52 L/s at 19 m head	L/s	104	110	1998	Concerns noted on base elbow deterioration and poor and costly service by pump supplier. (typical concerns with all Flygt submersible pumps)
Existing Clarifiers: No1: diameter 9.1 m - (Ecodyne Graver) No.2: diameter 13.1 m – (Ecodyne Graver)	 L/s	 32 64	 38 70	 1986 1998	No concerns noted.
Recarbonation Basins: No1 - 1.8 m Retention Time - No 2 - 3,8 m Retention Time -	 Min	 5 12		 1986 1998	Condition good. Effectiveness of gas transfer is reduced at higher flow rates.
Existing Filters: Backwash Self Storage From Clarifier No.1 2 x 3,658 Area 20.34 m Filter Flow Rate From Clarifier No.2 4 x 3,658 Area 40.68 m Filter Flow Rate	 L/s/m	 1.86 1.72		 1986 1998	No1: Condition fair. No2: Condition good. Underdrain strainers have been problematic and required replacement. Filter loading rate adequate. Backwash control is moderate. Upgrades should include, air scour, filter rinse cycle after backwash.

Table 4.1: Red River Regional WTP Major Equipment Review					
Description	Units	Rated QTY	Max. QTY	Year in Service	Comments
Treated Water Reservoirs: No. 1 No. 2	m	850 1,600		1986 1998	Condition Good. Each reservoir has two cells with interconnection piping and shut-off valves. Upgrades should include baffling for improved CT.
Chemical Feed Systems: Lime Silo Lime Slaker (BIF/Omega slurry slaker) Soda Ash Silo	Tons Tons/ hr Tons	30 0.5 30		1986 1986 1986	Condition poor Lime and soda ash silos will be replaced in late 2003. Lime slaker is in poor condition with recent major equipment failure.
Coagulant Aide				1986/ 1998	Condition fair. Bulk storage depot installed early 2003.
Alum, Carbon, Chlorine and Fluoride				1986/ 1998	Condition good. All four systems are in good shape and have adequate chemical feed capacity. A back-up chlorination system should be considered. Containment should be considered for all chemicals.
Sludge Handling and Storage: Transfer Pumps (LP-7, 8): Two Flygt SP3127 HT, 10 Hp Sludge Pond	L/s	25 2 cell		1998 1986	Condition fair. Sludge ponds are cleaned every ten months. Additional drainage piping installed in pond cells have improved serviceability. Additional ponds are proposed.
Distribution Pumps: Jockey Berkley (P2) 20 Hp @ 43m Duty Pumps (P4, P12) 50 Hp @ 43m Duty Pumps Peerless (P1, P3) 25Hp @ 43m	L/s	25 50 35		1990 1986/ 1998 1986	Condition good. Pumping capacity is adequate to 145 L/s with one stand-by pump 50 L/s. Maximum pumping capacity 195 L/s. Distribution services piping - 250 to Winkler / Morden line - 300 to Altona line
Comments	In summer 2003 the plant utilized the oxbow lake for raw supply and pretreatment. Turbidities and sludge quantities were reduced. Chemical feed systems (lime and soda ash) are problematic related to slaker and silo. Sludge pond storage is not adequate and expansion is proposed. In addition, subnatant return from the pond will be directed to waste. Plant is in fair to good condition.				

Table 4.2: Morris Regional WTP Major Equipment Review

Description	Units	Rated QTY	Max. QTY	Year in Service	Comments
Rated Plant Capacity	L/s	32	40		
Water Rights License					Max Rate: 0.04 m^3/sec or (40 L/s) Total QTY/year: 3157.72 dam^3 or (100 L/s- average)
Intake Pipe	L/s	32	40		No concerns noted.
Raw Water Pumps at River Well (MP-1, 2): Two Flygt CP3170 MT, 30 Hp at 25.8 Head	L/s	38	40	1998	Well diameter will limit the installation of pumps with greater capacity. Well is often flooded restricting access.
Filter Backwash Waste Pumps (MP-3, 4): Two Flygt 3140 MT 15 Hp at 12 m Head	L/s	43		1998	Condition good, no concerns noted.
Existing Clarifier 9.1 m	L/s	32	40	1998	Condition good, no concerns noted.
Recarbonation Basin 2.7 m - Retention Time	Min	15	13	1998	Condition good, no concerns noted.
Existing Filters: 2 x 3,658 Area 20.34 m Filter Flow Rate	L/s/m	1.86	2.21	1998	Condition good. Filter loading rate adequate. Backwash control is moderate. Upgrades should include, air scour, filter rinse cycle after backwash.
Treated Water Reservoir	m	1,400		1998	Condition Good. Reservoir has two cells with interconnection piping and shut-off valves. Upgrades should include baffling for improved CT.
Chemical Feed Systems: Lime Silo Lime Slaker Soda Ash Silo Alum Bulk Tank Alum, Carbon, Chlorine and Fluoride	 m kg/hr m m	 45 227 45 2.5		 1998	Condition good. Systems have adequate chemical feed capacity. A back-up chlorination system should be considered. Containment should be considered for all chemicals.
Sludge Transfer and Storage: Transfer Pumps (MP-11, 12): Two Flygt SP3127 HT, 10 Hp Sludge Pond	L/s m	25 9,500 2 cell		1998	Condition good. Storage adequate. Subnatant return piping has been routed to waste due to poor quality as raw water source.

Table 4.2: Morris Regional WTP Major Equipment Review					
Description	Units	Rated QTY	Max. QTY	Year in Service	Comments
Distribution Pumps Jockey (MP-5) 7.5 Hp Two Duty Pumps (MP-6, 7) Peerless 10 Hp at 43 m head Dual Drive Stand-by Pump (MP-8) Peerless 60 Hp Low Pressure Duty Pumps (MP-9,10) Peerless 5 Hp @ 8m	L/s	5 8 50 24		1986 1998	Condition good. Jockey pump was transferred from Letellier WTP. Duty pumps deliver water to distribution system with typical flow of 21 L/s. Transfer pump delivers water to Morris reservoir with maximum flow 40 L/s. Stand-by pump is available for both systems
Comments	River wetwell is difficult to maintain and prone to flooding. River pumping capacity is limited during low river levels. Plant is in good condition.				

Table 4.3: Stephenfield WTP Major Equipment Review					
Description	Units	Rated QTY	Max. QTY	Year in Service	Comments
Rated Plant Capacity	L/s	20	23		
Water Rights License					Max Rate: 0.076 m^3/sec or (76 L/s) Total QTY/year: 616.74 dam^3 or (20 L/s- average)
DFO Intake Screen/ Structure	L/s	75		1999	The existing intake structure and intake pipe are rated for a capacity up to 75 L/s.
Intake Pipe	L/s	75		1999	
Raw Water Pumps at WTP Well (P-1, 2): Two Flygt CP3140 HT, 15 Hp at 23.0 Head	L/s	23	30	1999	Condition good. Space is available for an additional raw water pump.
Raw Water Mixer	Hp	2.5		1999	Condition good, no concerns noted.
Existing Clarifier 7.3 m	L/s	20	23		Condition good, no concerns noted.
Recarbonation Basin 2.1 m Retention Time	Min	15		1999	Condition good, no concerns noted
Existing Filters: 2 x 2.74 Area 11.78 m Filter Flow Rate	L/s/m	1.7		1999	Condition good. Filter loading rate adequate. Backwash control is moderate. Upgrades should include filter rinse cycle after backwash.
Air Scour Blower	Hp	5.0		1999	Condition good.
Treated Water Reservoir	m	950		1999	Condition Good. Reservoir has two cells with interconnection piping and shut-off valves. Upgrades should include baffling for improved CT.

Table 4.3: Stephenfield WTP Major Equipment Review					
Description	Units	Rated QTY	Max. QTY	Year in Service	Comments
Chemical Feed Systems: Lime Silo Lime Slaker Alum Bulk Tank Alum, Caustic, Carbon, Chlorine and Fluoride	 m m /hr	 45 0.12		 1999	Condition good. Systems have adequate chemical feed capacity. A back-up chlorination system should be considered. Containment should be considered for all chemicals. Caustic feed system requires excess storage. Bulk storage or conversion to soda ash c/w silo should be considered.
Sludge Transfer and Storage: Transfer Pumps (MP-11, 12): Two Flygt SP3127 HT, 10 Hp Sludge Pond	 L/s m	 25 4,000 2 cell		 1999	Condition good. Storage adequate.
Distribution Pumps Jockey (P3) Grundfos 5 Hp Two Duty Pumps (P4, 5) Peerless 15 Hp at 43 m head Dual Drive Stand-by Pump (P6) Peerless 40 Hp	 L/s	 4.1 21 60		 1999	Condition good. Distribution pumping capacity is adequate to 46 L/s with one stand-by pump to 60 L/s. Peak flows are just met with pumping. VFD controls have been installed to improve distribution pumping stability.
Comments	Problems have been resolved with the addition of VFD drives on the distribution pumps. Poor raw water quality was experienced related to high sulfides in the raw water. The intake screen was raised off the lake bottom to remedy the problem.				

4.3 WATER QUALITY

4.3.1 Water Quality Data

Water quality data for the Red River at Letellier and Morris, and Lake Stephenfield are shown in the following Tables 4.4, 4.5 and 4.6. The data presented in the tables represents a summary of recent water quality analysis. Due to a limited amount of data, values do not necessarily represent statistical or seasonal values. However, for the purposes of this report, these values are sufficiently representative for review and discussion. Detailed water quality data is available in Appendix B.

Table 4.4: Water Quality Data – Red River Regional WTP (Red River)

		RAW WATER		TREATED WATER			
Parameter	Unit	Average Value	Maximum Value	Average Value	Maximum Value	Current Objective (CDWQG)	Probable Future Objective
Alkalinity as $CaCO_3$	mg/L	219.2	273	60.2	98.8		
Aluminum	mg/L	0.045	0.045	0.018	0.018	0.05-0.2 (SMCL)	0.05
Colour	TCU	46.2	150	6.7*	10*	15 (TCU)	5
Conductivity	uS/cm	668	830	462	598		
Fluoride	mg/L	0.172	0.2	1.0	1.0	1.5 (MAC)	
Hardness ($CaCO_3$)	mg/L	284	353	116	155	200 (PO)	
Iron	mg/L	0.45	1.24	0.02	0.05	0.3 (AO)	
Lead	mg/L			<	<	0.01 (MAC)	0
Manganese	mg/L	0.186	0.387	0.001	0.001	0.05 (AO)	
pH		8.04	8.28	7.5	8.0	6.5-8.05 (AO)	
Phosphorus	mg/L	0.19	0.19	0.0	0.022		
Sodium	mg/L	35.0	53.2	40.7	67.4	200 (AO)	
Sulphate	mg/L	107.6	147	100.8	136	500 (AO)	
TDS	mg/L	454	454	293.0	293	500 (AO)	
Total Organic Carbon (TOC)	mg/L	14	14	6.3*	6.3*	10 (PO)	2
TTHMs	µg/L			56*	56*	100 (IMAC)	40
Turbidity	NTU	78.15	240	0.40*	0.86*	0.3 / 1 (MAC)	0.1
Abbreviations/ Notes	AO = aesthetic objective, MAC = maximum acceptable concentration , SMCL = secondary maximum contaminant level, IMAC = interim maximum acceptable concentration, PO = practical objective * Exceeds probable future objectives						

Data presented in Table 4.4 shows that for the Red River Regional WTP raw water, colour, hardness, iron, manganese, total organic carbon (TOC), total trihalomethanes (TTHMs) and turbidity exceed CDWQG objectives. Hardness at 353 mg/L is high. Treated water meets current guidelines but exceeds probable future objectives for colour, TOC, TTHM and turbidity.

Table 4.5: Water Quality Data – Morris Regional WTP (Red River)

		RAW WATER		TREATED WATER			
Parameter	Unit	Average Value	Maximum Value	Average Value	Maximum Value	Current Objective (CDWQG)	Probable Future Objective
Alkalinity as $CaCO_3$	mg/L	206.33	248	53.9	72.4		
Aluminum	mg/L	0.116	0.180	0.026	0.040	0.05-0.2 (SMCL)	0.05
Colour	TCU	20.33	40	5	5	15 (TCU)	5
Conductivity	uS/cm	627	700	443	516		
Fluoride	mg/L	0.20	0.3	0.86	0.96	1.5 (MAC)	
Hardness ($CaCO_3$)	mg/L	245	293	91.6	99.7	200 (PO)	
Iron	mg/L	0.90	2.37	0.1	0.21	0.3 (AO)	
Lead	mg/L	0.06	0.06	0.005*	0.005*	0.01 (MAC)	0
Manganese	mg/L	0.16	0.32	0.007	0.02	0.05 (AO)	
pH		7.89	8.03	7.46	7.77	6.5-8.05 (AO)	
Phosphorus	mg/L	0.16	0.16	0.018	0.018		
Sodium	mg/L	31.4	37.8	45.2	61.1	200 (AO)	
Sulphate	mg/L	94.6	131	103.8	137	500 (AO)	
TDS	mg/L	433	440	289	320	500 (AO)	
Total Organic Carbon (TOC)	mg/L	13.5	15	5.2*	5.4*	10 (PO)	2
TTHMs	μg/L			50*	84*	100 (IMAC)	40
Turbidity	NTU	15.43	37	0.44*	0.82*	0.3 / 1 (MAC)	0.1
Abbreviations/ Notes	AO = aesthetic objective, MAC = maximum acceptable concentration , SMCL = secondary maximum contaminant level, IMAC = interim maximum acceptable concentration, PO = practical objective * Exceeds probable future objectives						

Table 4.5 shows that for the Morris Regional WTP raw water, colour, iron, lead, manganese, total organic carbon (TOC), total trihalomethanes (TTHMs) and turbidity exceed CDWQG objectives. Hardness at 293 mg/L is high. Treated water meets current guidelines but exceeds probable future objectives for colour, TOC, TTHM and turbidity.

Table 4.6: Water Quality Data – Stephenfield Regional WTP (Lake Stephenfield)							
		RAW WATER		TREATED WATER			
Parameter	Unit	Average Value	Maximum Value	Average Value	Maximum Value	Current Objective (CDWQG)	Probable Future Objective
Alkalinity as $CaCO_3$	mg/L	304.7	649	47.4	77.0		
Aluminum	mg/L	0.097	0.71	0.008	0.008	0.05-0.2 (SMCL)	0.05
Colour	TCU	60	130	5	5	15 (TCU)	5
Conductivity	uS/cm	757	1150	440.6	487.0		
Fluoride	mg/L	0.25	0.3	0.90	0.90	1.5 (MAC)	
Hardness ($CaCO_3$)	mg/L	349	568	105	139	200 (PO)	
Iron	mg/L	0.33	2.9	0.07	0.14	0.3 (AO)	
Lead	mg/L	0.005	0.02	0.0003	0.0003	0.01 (MAC)	0
Manganese	mg/L	1.46	2.5	0.0015	0.004	0.05 (AO)	
pH		7.57	8.5	7.05	7.81	6.5-8.05 (AO)	
Phosphorus	mg/L	0.23	0.38	0.021	0.021		
Sodium	mg/L	27.2	46	42.7	54.4	200 (AO)	
Sulphate	mg/L	122.7	239	120.8	131.0	500 (AO)	
TDS	mg/L	648	648	296.0	296.0	500 (AO)	
Total Organic Carbon (TOC)	mg/L	15.5	27.5	6.84*	8.00*	10 (PO)	2
TTHMs	µg/L			77*	100*	100 (IMAC)	40
Turbidity	NTU	11.2	20	0.1	0.2*	0.3 / 1 (MAC)	0.1
Abbreviations/ Notes	AO = aesthetic objective, MAC = maximum acceptable concentration , SMCL = secondary maximum contaminant level, IMAC = interim maximum acceptable concentration, PO = practical objective * Exceeds probable future objectives						

Table 4.6 shows that for the Stephenfield Regional WTP raw water, colour, iron, lead, manganese, total dissolved solids (TDS), total organic carbon (TOC), total trihalomethanes (TTHMs) and turbidity exceed CDWQG objectives. Hardness at 568 mg/L is high. Treated water meets current guidelines but exceeds probable future objectives for colour, TOC, TTHM and turbidity.

As indicated in the above tables, the Red River and Lake Stephenfield waters exhibit a number of common characteristics. The traditional characteristics of concern to water supply professionals include relatively high hardness, moderate colour and turbidity. These three parameters will vary with the seasons, over a fairly wide range of values. In addition, relatively low levels of pesticides and herbicides are usually detectable. Finally, the natural levels of nutrients, supplemented by fertilizer dissolved in run-off waters, can support significant algal blooms. The decomposition of dead algae releases substances such as geosmin and methylisoborneol, which are implicated in taste and odour problems.

Hardness is caused by a number of minerals, mainly calcium and magnesium, which precipitate as scale in boilers and kettles, scum in baths and sinks, and white sediment where water evaporates. These minerals have no particular significance with respect to human health. Some small degree of “hardness” does improve the taste of water, compared to totally demineralized or distilled water. The hardness of water can be generally classified as follows:

Soft	< 50 mg/L
Moderately hard	50 – 150 mg/L
Hard	150 – 300 mg/L
Very hard	> 300 mg/L

Colour in water is imparted by either dissolved substances or very fine colloidal (clay sized) particles. The dissolved substances and fine particulate matter may be organic or inorganic. Generally, colour is of little concern except that if water appears aesthetically displeasing, it may result in the loss of consumer confidence. Colour can be an indicator of other problems. Notably, organic-based colour can be an indicator of high concentrations of substances which may react with disinfectants to form potentially carcinogenic substances (see disinfection by products below).

Turbidity is a measure of particulate matter in water, and generally consists of settleable solids. Again, turbidity-causing particles may be organic or inorganic in nature. Some of these particles may be intrinsically inert and may pose no direct threat to health. However, such particulate matter may harbour bacteria and viruses, and may shield them from the effects of disinfection. Some particulate matter may also pose a direct threat to health. Aesthetically, high turbidity will discourage people from consuming the water.

Pesticides and herbicides are generally organic-based synthetic compounds used in our western agricultural industry. These can have a wide variety of effects on human health, some of which are based on long-term cumulative impact.

Nutrients such as nitrogen and phosphorus-containing compounds, are essential for the growth of algae. The source of these nutrients in river water is both natural and agricultural. The results of algae blooms are far ranging. Aesthetics are compromised due to tastes and odour, particularly as a result of decomposition of dead algae. Certain species of algae (notably blue-green) are toxic, and have been implicated in sickness and deaths among cattle.

Aside from these "traditional" issues which have been a primary focus of prairie water supply professionals, new water quality issues have emerged in recent years, including disinfection byproducts (DBPs), parasitic protozoa and zebra mussels. While the primary focus of DBP concerns in Manitoba have been related to trihalomethanes (formed by the reaction between chlorine and certain organics in water), there are many other DBP issues emerging, including reaction byproducts of ozone used in plants as a preoxidant or post-treatment disinfectant.

Reduction of DBPs may be done by optimizing the basic treatment process, and often by increasing dosages of non-chlorine-based preoxidants and powdered activated carbon. Post-filtration chlorine should be optimized to the minimum compatible with maintaining the microbiological safety of the water throughout the distribution system. Additionally, the process of granular activated carbon adsorption may be considered.

Parasites such as giardia lamblia and cryptosporidium have created serious health threats, such as in 1993, when 400,000 people in Milwaukee were affected. The basic cold lime softening-clarification-filtration-disinfection process, when properly operated, may provide an adequate barrier. Vigilance is required and some optimization of process may be needed in the longer term, as standards become more stringent. Supplemental disinfection (i.e. Ultraviolet light) is desirable.

Zebra mussels have in the past decade infected many watersheds in eastern and southern parts of North America. There is no evidence that these prolific creatures have reached the Red River basin but it seems inevitable that they will. While they pose no threat to health, they can affect water utilities by plugging intake lines.

4.3.2 Long Term Treatment Objectives and CT Requirements

Table 4.7 summarizes drinking water guidelines for constituents of interest. These include the Canadian and American (USEPA) guidelines. The table also includes other constituents that have become concerns in public (i.e. THM, aluminum, haloacetic acids and bromates).

Table 4.7: Water Quality Guidelines

	Canadian (1996)	USEPA (1998)	Probable Future Limits
Colour (TCU)	15 (AO)	15 (SMCL)	5
Organic Carbon (mg/L)	---	---	2 - 5
Turbidity (NTU)	1 (MAC)	TT (MCL)	0.1 - 0.3
Total THM	100 (IMAC)	40 – 80 (MCL)	40
Aluminum	100	5 – 20 (SMCL)	5
Haloacetic Acids	Under review	30 - 60 (MCL)	50
Bromates	Under review	10 (MCL)	0
Abbreviations	All above units in μg/L unless otherwise indicated. AO = aesthetic objective, MAC = maximum acceptable concentration , SMCL = secondary maximum contaminant level, IMAC = interim maximum acceptable concentration, MCL = maximum contaminant level TT = Tabulated Total		

In addition to the above objectives, consideration should be given to satisfying guidelines for control of giardia.

The guidelines for GCDWQ giardia and cryptosporidium are currently being reviewed. Although it is difficult to predict the future regulations, professionals in the water treatment industry generally accept that guidelines are becoming “more stringent” and following US trends. To satisfy USEPA requirements, all surface waters must be treated to achieve certain levels of inactivation, expressed as the natural logarithm of the residual component or “log removal”. Table 4.8 summarizes common log removal ranges.

Table 4.8: Log Removal	
Log Removal	% Removed
1.0	90.0%
2.0	99.0%
3.0	99.9%
4.0	99.99%

USEPA SWTR (surface water treatment rule) guidelines removal requirements are:

- Giardia 3 log 99.9%
- Enteric Viruses 4 log 99.99%

The USEPA regulations provide “credits” for conventional plants such as the three plants listed in this report. The “credits” reduce the level of inactivation needed through disinfection.

Table 4.9 summarizes the plant credits and level of disinfection required to achieve the required log removal for the inactivation of giardia cysts and viruses.

Table 4.9: Process Treatment Log Credits						
	Expected Log Removals Through Process		Disinfection Requirements		Total Removal	
	Giardia	Viruses	Giardia	Viruses	Giardia	Viruses
Conventional Plant	2.5	2.0	0.5	2.0	3.0	4.0

Each plant was assessed in regards to their effectiveness in log removal for giardia and viruses, specifically their disinfection efficiency.

Disinfection efficiency is based on being able to provide an appropriate CT to achieve the required disinfection level. CT is a measure of the concentration "C" (in mg/L) of the disinfection residual multiplied by the effective contact time "T" in minutes. The required CT values are a function of water temperature and pH.

The three plants in this report must each achieve a 0.5 log removal of giardia. Providing CT values for inactivation of giardia will provide the required 2.0 log removal necessary for inactivation of viruses.

For all three plants, contact time is achieved through the clearwell reservoirs below the plants. Ideally, the contact time for disinfection calculations should be obtained through tracer studies. However, for preliminary calculations of contact time, an effective volume of 30% of reservoir capacity can be considered appropriate.

The following are the CT checks for each plant. Treated water conditions were obtained through daily plant operation records.

Red River Regional WTP

Volume of Reservoirs	=	2,370 m^3
Peak Hour Flow Rate	=	13 m^3 / minute (220 litres per second)
Theoretical Detention Time (TDT)	=	2,370 m^3 / 13 m^3/minute
	=	180 minutes
Baffling Condition (Poor Baffling)	=	0.3 = T_{10}/T
Effective Detention Time	=	(0.3) 180 minutes
	=	54 minutes

From plant records; pH = 7.5-7.7, water temperature 0.5° C, and free chlorine residual of 1.5 mg/L. From Tables C-1 and C-7, found in Appendix C, CT = 50 mg/L. min. for inactivation of giardia, and CT = 6.0 for inactivation of viruses.

Calculated CT = (1.5 mg/L)(54 min.) = 81 mg/L. min which is ≥ 50 mg/L/ min.

Therefore, the Red River Regional plant meets CT requirements for giardia and virus removal.

Morris Regional WTP

Volume of Reservoirs	=	1,100 m^3
Peak Hour Flow Rate	=	5 m^3 / minute (80 litres per second)
Theoretical Detention Time (TDT)	=	1,100 m^3 / 5 m^3/minute
	=	229 minutes
Baffling Condition (Poor Baffling)	=	0.3 = T_{10}/T
Effective Detention Time	=	(0.3)229 minutes
	=	69 minutes

From plant records; pH = 7.5-7.7, water temperature 0.5° C, and free chlorine residual of 1.8 mg/L. From Tables C-1 and C-7, found in Appendix C, CT = 52 mg/L. min. for inactivation of giardia, and CT = 6.0 for inactivation of viruses.

Calculated CT = (1.8 mg/L)(69 min.) = 124 mg/L. min which is ≥ 52 mg/L/ min.

Therefore, the Morris Regional plant meets CT requirements for giardia and virus removal.

Stephenfield Regional WTP

Volume of Reservoirs	=	820 m^3
Peak Hour Flow Rate	=	3 m^3 / minute (46 litres per second)
Theoretical Detention Time (TDT)	=	820 m^3 / 3 m^3/minute
	=	297 minutes
Baffling Condition (Poor Baffling)	=	0.3 = T_{10}/T
Effective Detention Time	=	(0.3)297 minutes
	=	89 minutes

From plant records; pH = 7.5-7.7, water temperature 0.5° C, and free chlorine residual of 1.5 mg/L. From Tables C-1 and C-7, found in Appendix C, CT = 50 mg/L. min. for inactivation of giardia, and CT = 6.0 for inactivation of viruses.

Calculated CT = (1.5 mg/L)(89 min.) = 124 mg/L. min which is ≥ 50 mg/L/ min.

Therefore, the Stephenfield Regional plant meets CT requirements for giardia and virus removal.

4.3.3 Cold Lime Process

In the context of the foregoing, cold lime softening-clarification remains the process of choice to treat such prairie waters to potable standards. The process can handle wide variations in turbidity. A long clarifier retention time helps overcome the negative effect of cold winter time water temperatures. The use of relatively high dosages of lime affects the chemical nature of the water. Application of lime raises the pH of the water, resulting in the precipitation of many substances, including hardness-causing minerals (compounds of calcium and magnesium), iron, manganese, and a wide range of agrichemicals. Soda ash (sodium carbonate) is usually used in addition to lime, to assist in removal of non-carbonate hardness. Alternatively caustic soda (sodium hydroxide) may replace soda ash, or even lime.

Applying a preoxidant such as potassium permanganate at the headworks of the plant, breaks down organics. The supplemental use of adsorbents (activated carbon) also assists in removing organics. A number of these organics cause tastes and odours, and others include many agrichemicals.

In summary, despite advances made in development of "high tech" processes such as membrane technologies, the cold lime process remains the most suitable to deal with the wide range of issues raised by variable prairie surface water conditions. It is typically followed by recarbonation, to neutralize the high pH maintained in the reactor-clarifier, and then by granular filtration, to remove residual particulate matter which eludes the solids-capturing ability of the reactor-clarifier sludge blanket. The final step consists of chlorine disinfection and fluoridation.

4.4 METER READING DATA

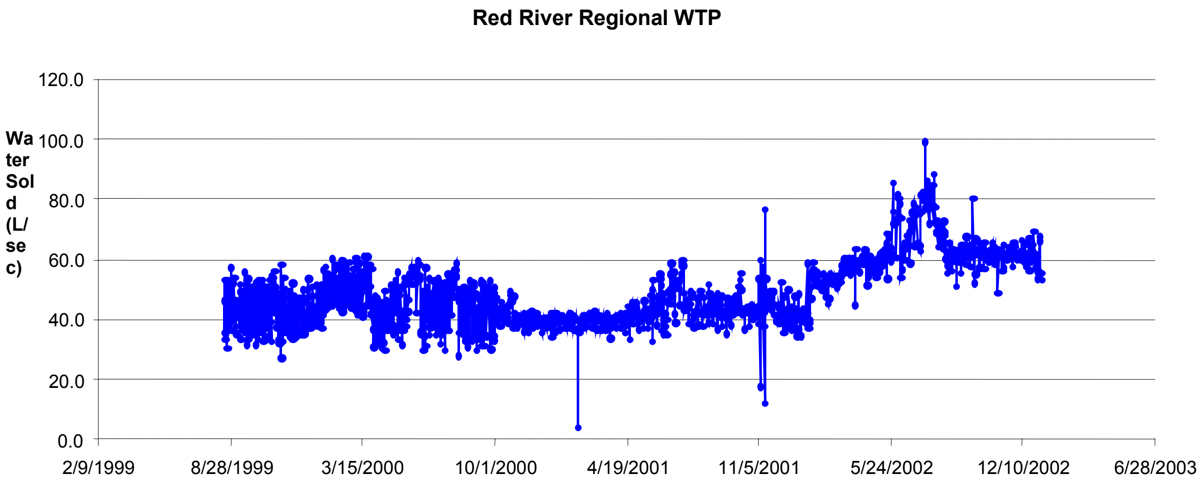
Water meter reading data was obtained for each facility. Table 4.10 summarizes the results of meter logs for the years 1999 to 2002.

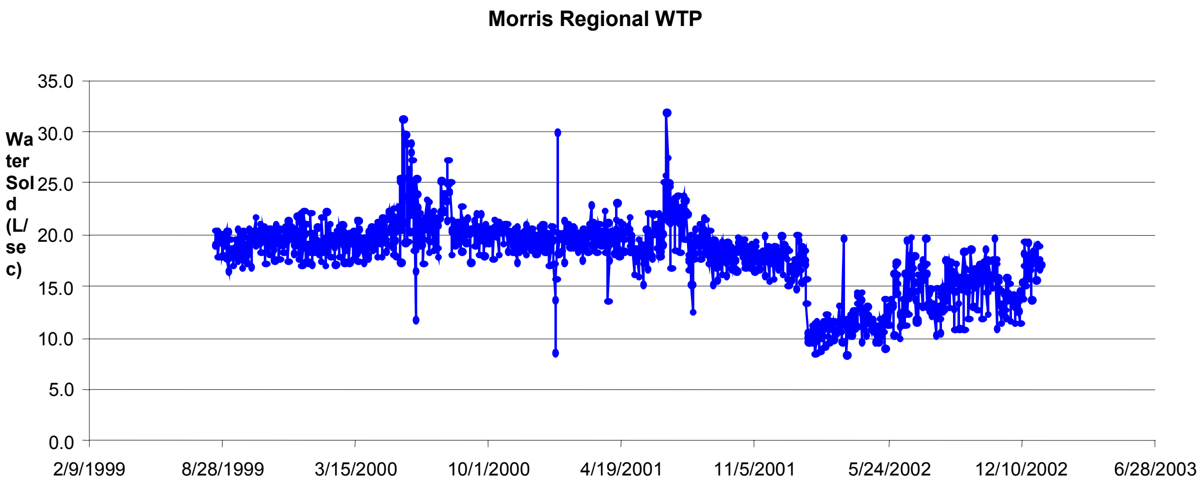
Table 4.10: Meter Readings

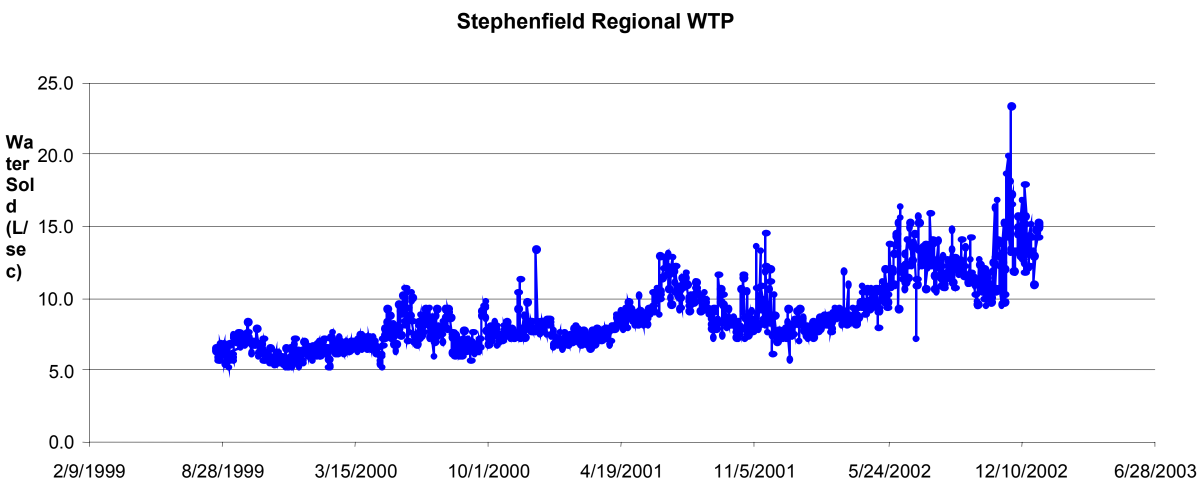
Treatment Plant	Rated Treatment Capacity	Average Day Demand		Peak Day Demand		Peak Day Peaking Factor
	L/s	m^3	L/s*	M^3	L/s*	
Red River Regional	96	4,209	48.7	8,507	99.7	2.05
Morris Regional	32	1,552	18.0	2,764	31.9	1.77
Stephenfield	20	764	8.8	2,020	23.4	2.66
Notes	* 24 hour period					

The above table demonstrates that the Red River Regional WTP is operating near capacity and the Morris and Stephenfield Regional WTPs are working above capacity on peak day. Upgrades are required in the immediate future to satisfy these system demands. Actual peak-day peaking factors, determined using the plant metering for the years 1999 through 2002, are also included in Table 4.11. These were computed by dividing the peak day demand by the corresponding average day demand. Figure 4.4 illustrates these three meter logs. From these plots, we see that this method for computing peaking factors is relatively conservative as we would be dividing peak day quantities by the average demand over a four year period. Any given yearly peak should be divided by the average for that year. For example, the peak day demand for the Stephenfield WTP occurred during the year 2002 which experienced an average flow of approximately 13.0, not 8.8 L/s. Using this approach, peak day peaking factors are actually in the range of 1.5 – 1.8.

The peak hour demands were also estimated for the system. The Harmon formula, which relates the peak hour peaking factor to the relevant population, was used for this purpose. Using the current and future populations described in section 2.0, these peaking were estimated at 2.25 and 2.17, respectively. Because the actual system includes storage and re-pumping that is not included in the present model, a peaking factor of 2.0, which represents a blend of these estimates, was used for modeling purposes.


Red River Regional WTP
Water Sold (L/sec)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
2/9/1999
8/28/1999
3/15/2000
10/1/2000
4/19/2001
11/5/2001
5/24/2002
12/10/2002
6/28/2003


Morris Regional WTP
Water Sold (L/sec)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2/9/1999
8/28/1999
3/15/2000
10/1/2000
4/19/2001
11/5/2001
5/24/2002
12/10/2002
6/28/2003


Stephenfield Regional WTP
Water Sold (L/sec)
25.0
20.0
15.0
10.0
5.0
0.0
2/9/1999
8/28/1999
3/15/2000
10/1/2000
4/19/2001
11/5/2001
5/24/2002
12/10/2002
6/28/2003

5.0 DEVELOPMENT OF UPGRADE ALTERNATIVES

5.1 DISTRIBUTION SYSTEM UPGRADE SCENARIOS

In order to examine various ways of accommodating future growth within the region, the model simulating the existing system with the addition of the Roland Reservoir and associated piping has been used as a baseline. After setting all nodal demands to those corresponding to the year 2021, including agricultural demand, system weaknesses have been determined and various upgrades, including booster pumping, new pipelines, pipeline twinning, reservoirs have been identified. Four additional upgrade scenarios, each involving several upgrade components, are presented in the following section. These scenarios involve a combination of pipe, pumping and water treatment plant upgrades and installations. Each of these scenarios is described below along with probable costs (Class D estimate). All of the options include water plant upgrades and the installation of a 200 mm pipeline from the Stephenfield plant north to a location mid-way between Haywood and St. Claude where it branches through lateral pipelines to each.

Upgrade Scenario 1

Figure 5.1 illustrates a potential upgrade scenario to accommodate demand growth through the next 20 years. The plan generally comprises a 250 mm pipeline between Lowe Farm and the Altona area as well as a 250 mm interconnection between St. Jean and Morris.

Several new booster stations and booster station pump upgrades are required for this plan as well as another short pipeline twin near Plum Coulee. The components associated with all upgrade scenarios are listed in Table 5.1 along with respective cost estimates. Figure 5.1 illustrates the system pressures during the 2021 peak day demand.

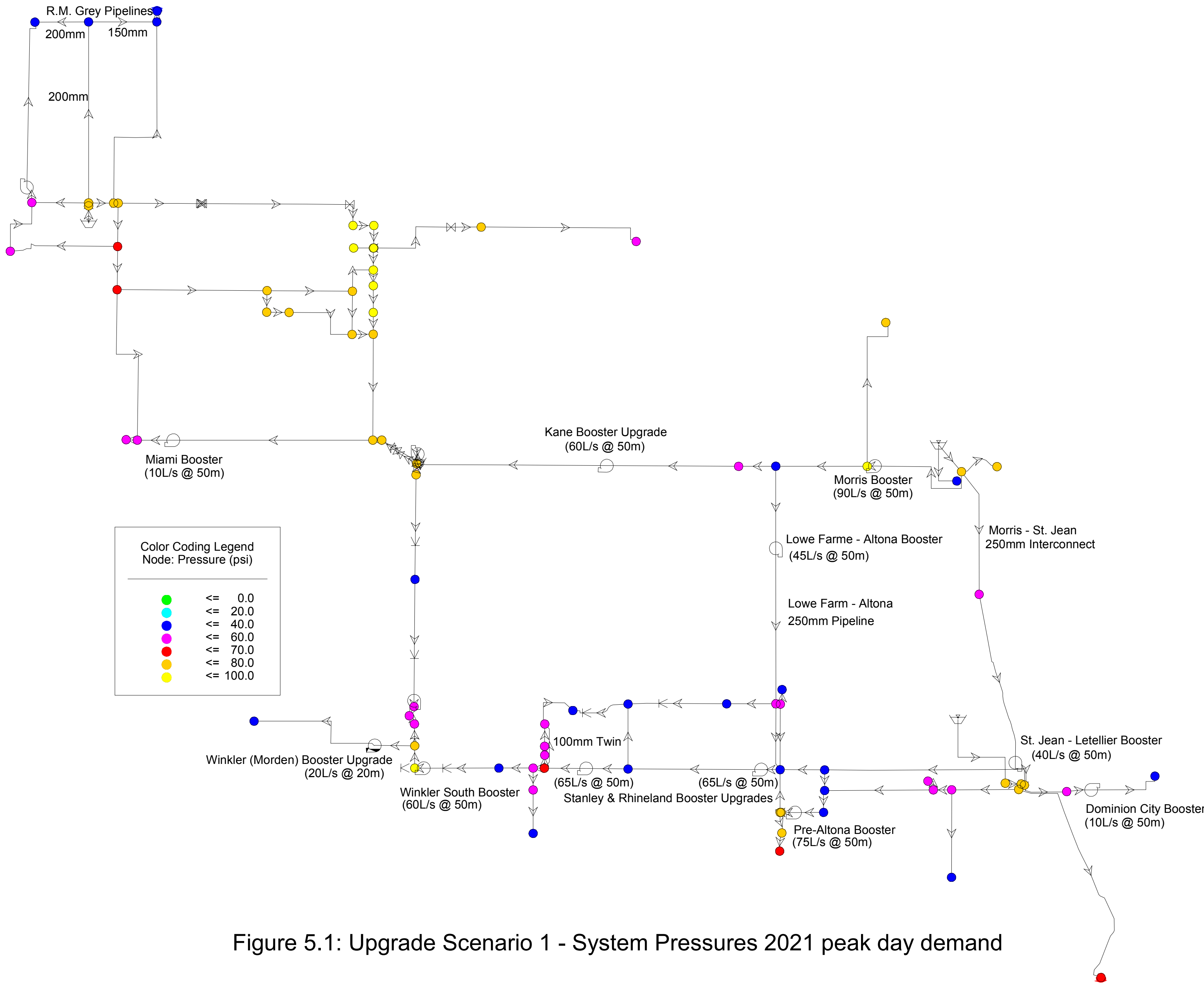


Figure 5.1: Upgrade Scenario 1 - System Pressures 2021 peak day demand

COCHRANE ENGINEERING

PEMBINA VALLEY WATER COOPERATIVE INC.

Table 5.1: Upgrade Scenario Costs		
Upgrade Item	Description	Estimated Price ($)
Scenario 1		
R.M. of Grey 200mm Pipelines	17.50 km	1,530,813
R.M. of Grey 150mm Pipelines	5.02 km	376,500
Morris - St.Jean 250mm Interconnect	9.56 km	956,000
Lowe Farm - Altona 250mm Pipeline	22.45 km	2,245,000
Miami Booster	10L/s @ 50m head	25,000
Morris Booster	90L/s @ 50m head	62,500
Lowe Farm - Altona Booster	45L/s @ 50m head	50,000
St.Jean - Letellier Booster	40L/s @ 50m head	50,000
Dominion City Booster	10L/s @ 50m head	25,000
Pre-Altona Booster	75L/s @ 50m head	56,250
Winkler South Booster	60L/s @ 50m head	56,250
Winkler (Morden) Booster Upgrade	20L/s @ 20m head	25,000
Kane Booster Upgrade	60L/s @ 50m head	56,250
Stanley Booster Upgrade	65L/s @ 50m head	56,250
Rhineland Booster Upgrade	65L/s @ 50m head	56,250
Stephenfield WTP Upgrades	53 L/s Upgrade	2,550,000
Morris WTP Upgrades	106 L/s Upgrade	5,300,000
	Subtotal	13,477,063
	Eng. / Cont. (30%)	4,043,119
	Total	$ 17,520,181
		Use $17,520,000
Scenario 2		
R.M. of Grey 200mm Pipelines	17.50 km	1,530,813
R.M. of Grey 150mm Pipelines	5.02 km	376,500
Morris - St.Jean 250mm Interconnect	9.56 km	956,000
Morris - Roland 200mm Twin	23.48 km	2,054,500
Roland - Winkler 150mm Twin	17.57 km	1,317,750
Plum Coulee 100mm Twin	5.00 km	250,000
Dominion City 150mm Twin	7.62 km	571,500
Miami Booster	6L/s @ 50m	25,000
Morris Booster	45L/s @ 50m	62,500
Morris - Roland Twin Booster	25L/s @ 50m	37,500
Roland - Winkler Twin High Pressure Booster	35L/s @ 70m	50,000
St.Jean - Letellier Booster	25L/s @ 50m	37,500
Pre-Altona Booster	60L/s @ 20m	43,750
Winkler South Booster	45L/s @ 40m	50,000
Relocate and Upgrade Stanley Booster	60L/s @ 50m	56,250
Relocate and Upgrade Rhineland Booster	70L/s @ 40m	50,000
Roland Pumping Upgrade	50L/s @ 50m	50,000
Kane Booster Upgrade	25L/s @ 50m	37,500
Winkler (Morden) Booster Upgrade	20L/s @ 40m	31,250

Table 5.1: Upgrade Scenario Costs		
Upgrade Item	Description	Estimated Price ($)
Stephenfield WTP Upgrades	37 L/sec Upgrade	2,390,000
Morris WTP Upgrades	80 L/sec Upgrade	3,700,000
Red River Regional WTP Upgrades	36 L/sec Upgrade	2,890,000
	Subtotal	16,568,313
	Eng. / Cont. (30%)	4,970,494
	Total	$ 21,538,806
		Use $21,539,000
Scenario 3		
R.M. of Grey 200mm Pipelines	17.50 km	1,530,813
R.M. of Grey 150mm Pipelines	5.02 km	376,500
Morris - St.Jean 300mm Interconnect	9.56 km	1,195,000
St. Jean - Altona 250mm Bypass	27.86 km	2,786,300
Dominion City 150mm Twin	7.62 km	571,500
Miami Booster	10L/s @ 50m	25,000
St.Jean - Altona Bypass Boosters	45L/s @ 50m	100,000
St.Jean - Letellier Booster	20L/s @ 50m	37,500
Winkler South Booster	50L/s @ 20m	37,500
Stanley Booster Upgrade	60L/s @ 50m	56,250
Rhineland Booster Upgrade	70L/s @ 50m	56,250
Roland Pumping Upgrade	50L/s @ 50m	50,000
Kane Booster Upgrade	30L/s @ 50m	43,750
Winkler (Morden) Booster Upgrade	20L/s @ 35m	31,250
Stephenfield WTP Upgrades	58 L/sec Upgrade	2,575,000
Morris WTP Upgrades	102 L/sec Upgrade	5,250,000
	Subtotal	14,722,613
	Eng. / Cont. (30%)	4,416,784
	Total	$ 19,139,396
		Use $19,140,000
Scenario 4		
R.M. of Grey 200mm Pipelines	17.50 km	1,530,813
R.M. of Grey 150mm Pipelines	5.02 km	376,500
Lowe Farm - Roland 200mm Twin	23.48 km	2,054,500
Roland Winkler 150mm Twin	17.57 km	1,757,000
Plum Coulee 100mm Twin	5.00 km	250,000
Dominion City 150mm Twin	7.62 km	571,500
Miami Booster	6L/s @ 50m	25,000
Roland - Carman Booster	20L/s @ 50m	75,000
Lowe Farm - Roland Twin Booster	25L/s @ 50m	37,500
Roland - Winkler Twin High Pressure Booster	35L/s @ 70m	50,000
Winkler South Booster	45L/s @ 40m	50,000
Pre-Altona Booster	60L/s @ 20m	43,750
Stanley Booster Re-locate and Upgrade	60L/s @ 50m	56,250
Rhineland Booster Re-locate and Upgrade	70L/s @ 50m	56,250
Winkler (Morden) Booster Upgrade	20L/s @ 40m	31,250

Table 5.1: Upgrade Scenario Costs		
Upgrade Item	Description	Estimated Price ($)
Stephenfield WTP Upgrades	37 L/sec Upgrade	2,390,000
Morris WTP Upgrades	51 L/sec Upgrade	3,050,000
Red River Regional WTP Upgrades	65 L/sec Upgrade	3,550,000
	Subtotal	15,955,313
	Eng. / Cont. (30%)	4,786,594
	Total	$ 20,741,906
		Use $20,742,000

In this Scenario, the Roland Reservoir would supply 12 L/s of the peak day water demand for Winkler (i.e. 52 L/s), and would supply only 13 L/s to the Stephenfield system. During this time, the Roland reservoir would be replenished at a rate of approximately 25 L/s, leaving approximately no net outflow.

It is evident in this scenario, that very little water is being supplied to the Stephenfield system from the Morris WTP. Subsequently, this plan involves a significant WTP upgrade at Stephenfield in order to accommodate demand growth within the area and expected expansions into the R.M. of Grey. As discussed in Section 3.3, an expansion of this magnitude may be difficult due to licensing issues. Because the existing license does allow for a maximum withdrawal rate 76 L/s, however, the plant could be expanded to provide this capacity during peak times provided a significant percentage of the annual withdrawal is removed and provided, instead, by the Morris WTP.

The Lowe Farm – Altona Pipeline is intended to exploit the additional capacity of the 300 mm pipeline between Morris and Lowe Farm while bypassing the heavily load pipes between Letellier and Altona. For this reason, as well as the presence of the Roland Reservoir, the Morris WTP would require expansion to approximately 138 L/s.

Another feature of this plan is a connection between the Morris and Letellier water treatment plants. Not only would this connection allow Morris to take some of the demand off the Letellier plant, it would provide system redundancy that would allow transmission of water to either community (and their surrounding areas), albeit at reduced amounts, in the event of partial system failure.

The relative distribution of water supply from each of the three water plants is shown in Table 5.2. For this scenario, the Stephenfield and Morris plants require capacities upgraded to 73 and 138 L/s, respectively.

Table 5.2: Relative Distribution of Water Supply from PVWC WTP's				
Upgrade Scenario	Required Water Treatment Plant Capacity (L/s)			
	Red River Regional WTP	Morris Regional WTP	Stephenfield Regional WTP	Total WTP Capacity
1	96	138	73	307
2	132	117	57	307
3	96	133	78	307
4	161	89	57	307

Upgrade Scenario 2

This plan, described in Figure 5.2, is generally comprised of a 200 mm twin between Lowe Farm and Roland as well as a high pressure pipeline between Roland and Winkler (150 mm). It also includes a 250 mm interconnection between Morris and St. Jean, a 150 mm pipeline from Roseau River to Dominion City, a 150 mm pipeline to provide capacity to the Plum Coulee area and miscellaneous booster station upgrades and installations.

In this scenario, the Roland Reservoir supplies approximately 27 L/s to Winkler and 28 L/s to Roland and the Stephenfield system. The reservoir is replenished at approximately 49 L/s leaving the reservoir in a state of net-outflow. This is thought to be adequate by observing peaking trends in the plant meter data. If necessary, this gap could be narrowed by additional booster stations on the feeder lines.

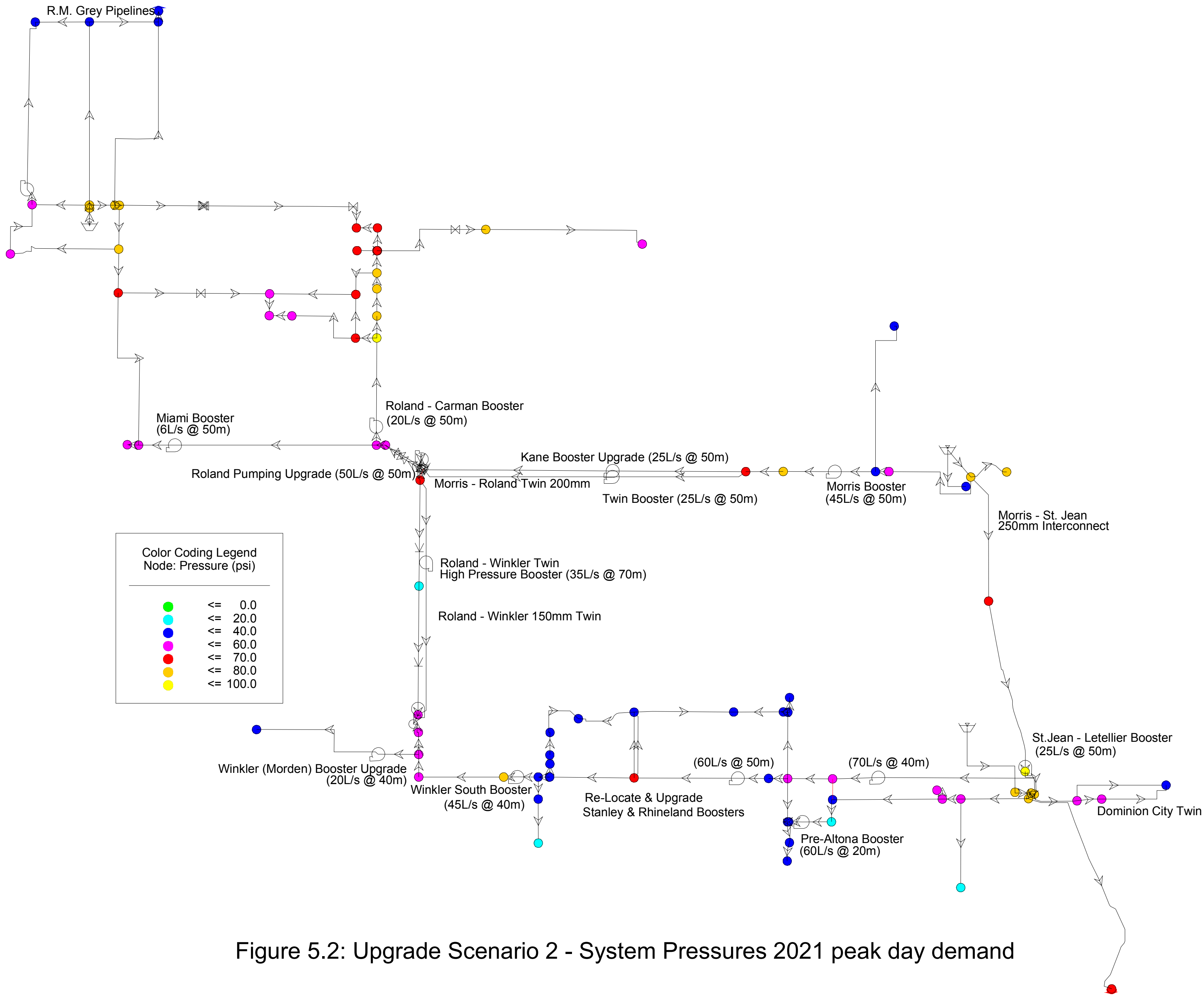


Figure 5.2: Upgrade Scenario 2 - System Pressures 2021 peak day demand

COCHRANE ENGINEERING

PEMBINA VALLEY WATER COOPERATIVE INC.

The relative partitioning of the water treatment and supply is listed in Table 5.2. For this scenario, the Stephenfield, Morris and Red River Regional water plants require capacities upgraded to 57, 117 L/s and 132, respectively. This expansion at Stephenfield would require a license revision to allow an average annual withdrawal rate of approximately 29 L/s and the elaborate supply management scheme presented earlier would not be as necessary, if at all.

Upgrade Scenario 3

This plan, shown in Figure 5.3, involves a 300 mm interconnection between Morris and St. Jean as well as a 250 mm bypass pipeline between St. Jean and the Altona area. A 150 mm twin from Roseau River to Dominion City and a number of pumping upgrades are also required for this plan.

In this plan, the Morris-St. Jean line is expected to provide significant improvements through system "looping" with only a relatively short length of pipe. Closing the loop between Morris and Letellier allows for system flexibility and redundancy and the ability to provide backup supply in the event of plant shutdowns. The additional bypass will provide a means for supplying water to the Winkler area while bypassing Altona.

In this scenario, the Roland Reservoir provides approximately 15 L/s to Winkler and none to the Stephenfield system, thereby requiring significant upgrades of the Stephenfield plant. The pipelines between the reservoir and the Stephenfield system would only be required to allow supplemental water into the Stephenfield system, from the Red River plants, during low demand times in order to help reduce the average yearly withdrawal from Lake Stephenfield.

For this scenario, the Stephenfield and Morris plants require capacities upgraded to 78 and 134 L/s, respectively. The components associated with this plan are listed in Table 5.1 along with relative cost estimates.

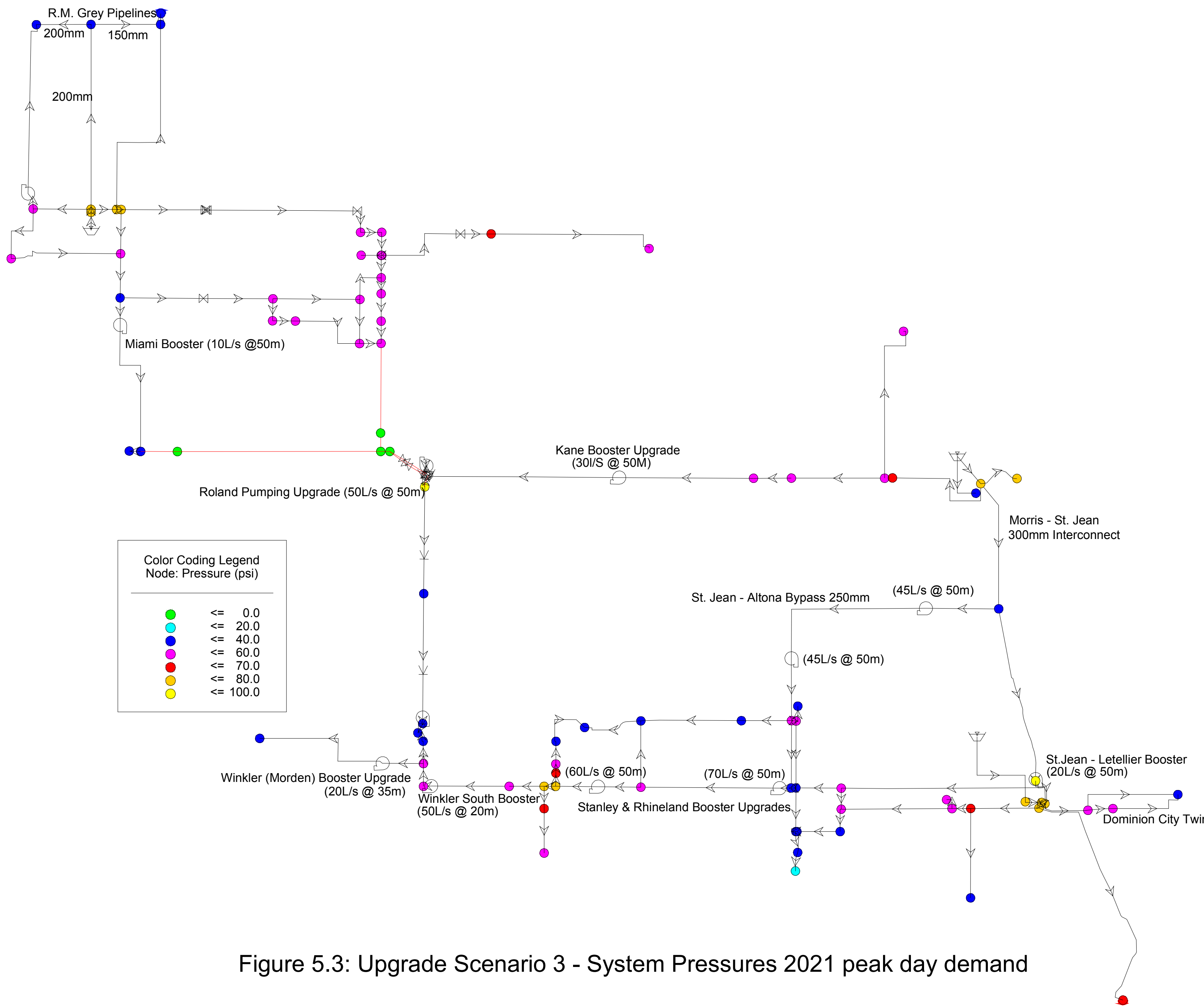


Figure 5.3: Upgrade Scenario 3 - System Pressures 2021 peak day demand

COCHRANE ENGINEERING

PEMBINA VALLEY WATER COOPERATIVE INC.

Upgrade Scenario 4

This plan, shown in Figure 5.4, is very similar to Scenario 2, except it does not include a Morris – St. Jean interconnect. Note that the interconnect in Scenario 2 does not result in any decreased upgrade requirements elsewhere, and is subsequently higher priced. The reason for this is that instead of the Red River Regional WTP producing the water, the Morris plant produces it and sends it to Letellier for distribution. All of the pipeline upgrades between Letellier and Winkler / Morden are therefore the same.

The disadvantage of this upgrade scenario is that the system is not looped as it is in all of the other scenarios, resulting in much less system flexibility and redundancy. In other words, there is no means of re-routing water from each region in the event of water plant interruptions.

For this scenario, the Stephenfield, Morris and Red River Regional plants require capacities upgraded to 57, 83 and 161 L/s, respectively.

The components associated with this plan are listed in Table 5.1 along with relative cost estimates.

5.2 WATER TREATMENT PLANT UPGRADE SCENARIOS

To meet the projected demands in the above scenarios, additional treatment capacity must be developed in the system. This will require upgrades to the existing water treatment plants. Table 5.2 details these upgrades. In addition, upgrades will be required to meet the more stringent water quality guidelines discussed Section 4. The following sections list the recommended upgrades.

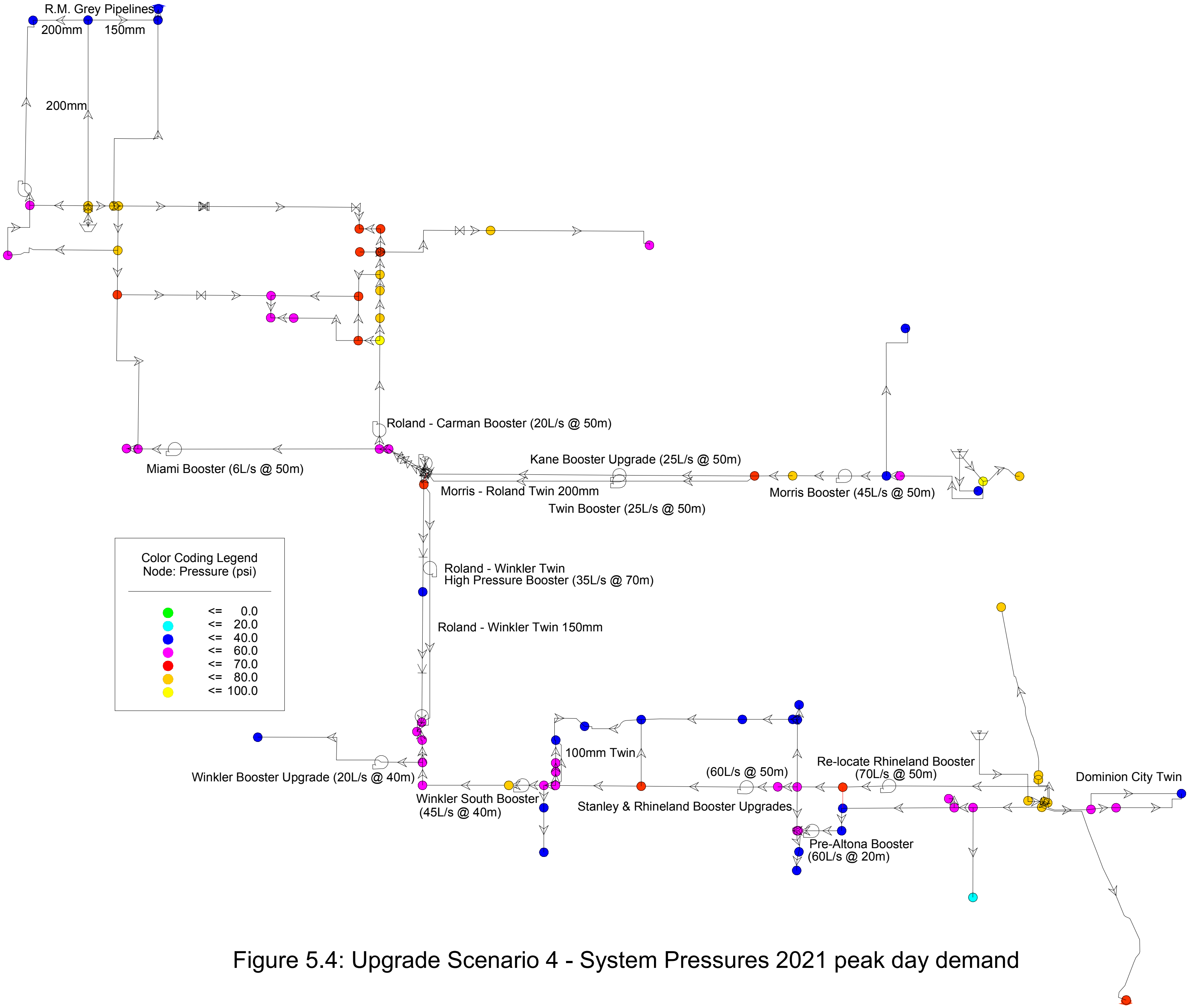


Figure 5.4: Upgrade Scenario 4 - System Pressures 2021 peak day demand

COCHRANE ENGINEERING

PEMBINA VALLEY WATER COOPERATIVE INC.

5.2.1 Red River Regional Water Treatment Plant Upgrades

The recommended upgrades to the Red River Regional WTP include:

- New wetwell, intake, pumping and raw water piping
- New softening clarifier – Recarbonation basin and dual media filters
- New and upgraded chemical feed systems
- New lime slaker
- Upgraded lime and soda ash silos
- Upgraded distribution pumping
- Upgraded sludge pumping and ponds
- Upgraded electrical and controls

In order to meet anticipated future guidelines, the following upgrades should be considered for improved water quality.

- Backwash piping revisions, backwash storage pond
- Reservoir baffling
- Clarifier tube settlers
- UV disinfection
- New filter underdrain and the addition of air scour
- Filter rinse piping and controls
- Oxbow lake aeration
- Redundant chemical feed equipment including back-up chlorine system
- Overflow piping
- Chemical containment

5.2.2 Morris Regional Water Treatment Plant Upgrades

The recommended upgrades to the Morris Regional WTP include:

- New wetwell, intake, pumping and raw water piping
- New softening clarifier – Recarbonation basin and dual media filters
- New and upgraded chemical feed systems
- New lime slaker (depending on capacity)
- Upgraded lime and soda ash silos (depending on capacity)
- Upgraded distribution pumping
- Upgraded sludge pumping and ponds
- Upgraded electrical and controls

In order to meet anticipated future guidelines, the following upgrades should be considered for improved water quality.

- Backwash piping revisions, backwash storage pond
- Reservoir baffling
- Clarifier tube settlers
- GAC Filters
- UV disinfection
- New filter underdrain and the addition of air scour
- Filter rinse piping and controls
- New raw water storage pond with aeration
- Redundant chemical feed equipment including back-up chlorine system
- Chemical containment

5.2.3 Stephenfield Regional Water Treatment Plant Upgrades

The recommended upgrades to the Stephenfield Regional WTP include:

- Upgraded water pumping
- New softening claifier – Reacbonation basin and dual media filters
- New and upgraded chemical feed systems
- New lime slaker (depending on capacity)
- New soda ash silos and feed system (depending on capacity), caustic as back-up
- Upgraded distribution pumping
- Upgraded sludge pumping and ponds
- Upgraded electrical and controls

In order to meet anticipated future guidelines, the following uprades should be considered for improved water quality.

- Backwash piping revisions, backwash storage pond
- Reservoir baffling
- Claifier tube settlers
- GAC Filters
- UV disinfection
- Filter rinse piping and controls
- Lake aeration near intake
- Redundant chemical feed equipment including back-up chlorine system
- Chemical containment

6.0 RECOMMENDATIONS

Following an analysis of projected growth and demand for the PVWC regional water system, a distribution model was developed in order to examine system bottlenecks and to conceptualize upgrade scenarios. From this review, preliminary recommendations were formulated and are detailed below.

The alternatives examined include a number of specific upgrades developed to satisfy the projected 2021 demands in the system. These scenarios represent feasible strategies providing a cross section of ideas for use as a planning tool, but do not encompass all potential solutions.

Based on technical merit and cost, upgrade Scenario 1 appears the most feasible. The stated opinion of probable cost for this plan is approximately $17,520,000. The major features of this scenario include a 106 L/s upgrade to the Morris Regional WTP, a 53 L/s upgrade to the Stephenfield Regional WTP, a 250mm pipeline between Lowe Farm and the Altona area and a 250 mm interconnection between Morris and St. Jean.

In terms of technical merit, this scenario provides:

- System flexibility in terms of spreading capacity throughout the region
- Network redundancy though looping providing back-up in case of system failures
- A reasonable balance between pipelines and booster stations
- Feasible WTP upgrades
- Full utilization of the peak flow component of the Stephenfield Water Rights License. This is particularly appealing in the context that increases to the license limit for yearly average will likely prove challenging.

A preliminary implementation strategy is as follows:

Short Term Upgrades

- 20 L/s expansion of Stephenfield WTP (Total 40 L/s peak capacity – existing water rights license limit), (Figure 6.1)
- R.M. of Grey pipelines
- Morris - St. Jean interconnect pipeline (and associated booster pumping)
- Miscellaneous boosters and pipe twinning

Medium Term Upgrades

- 50 L/s expansion of Morris WTP (Total 82 L/s peak capacity – existing water rights license limit), (Figure 6.2)
- Miscellaneous boosters and pipe twinning

Long Term Upgrades

- 33 L/s expansion of Stephenfield WTP (revised license required), (Figure 6.1)
- 56 L/s expansion of Morris WTP (revised license required), (Figure 6.2)
- Lowe Farm – Altona pipeline (and associated booster pumping)
- Miscellaneous boosters and pipe twinning

It is important to note that scenario 1 could be accomplished in one of several ways with respect to water rights licensing. The first, and most preferable, would be to increase the average yearly limit to a minimum of 40 L/s, thereby allowing the peak day requirement of

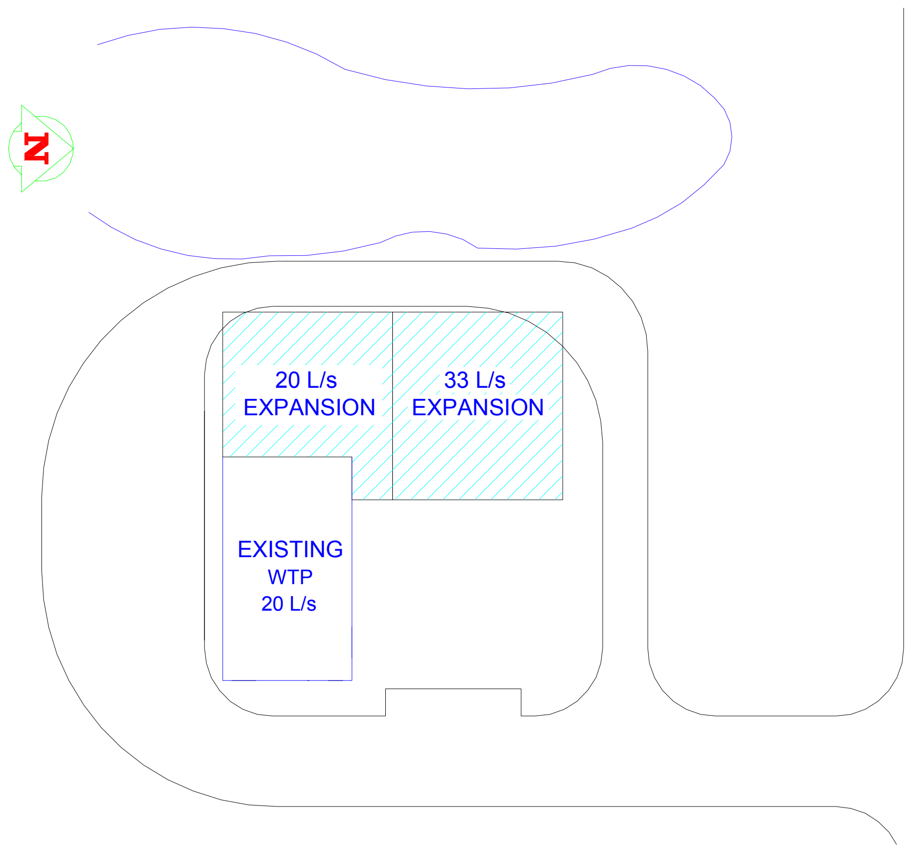


Figure 6.1: Recommended Stephenfield WTP Staged Expansions

COCHRANE
ENGINEERING

PEMBINA VALLEY
WATER COOPERATIVE INC.

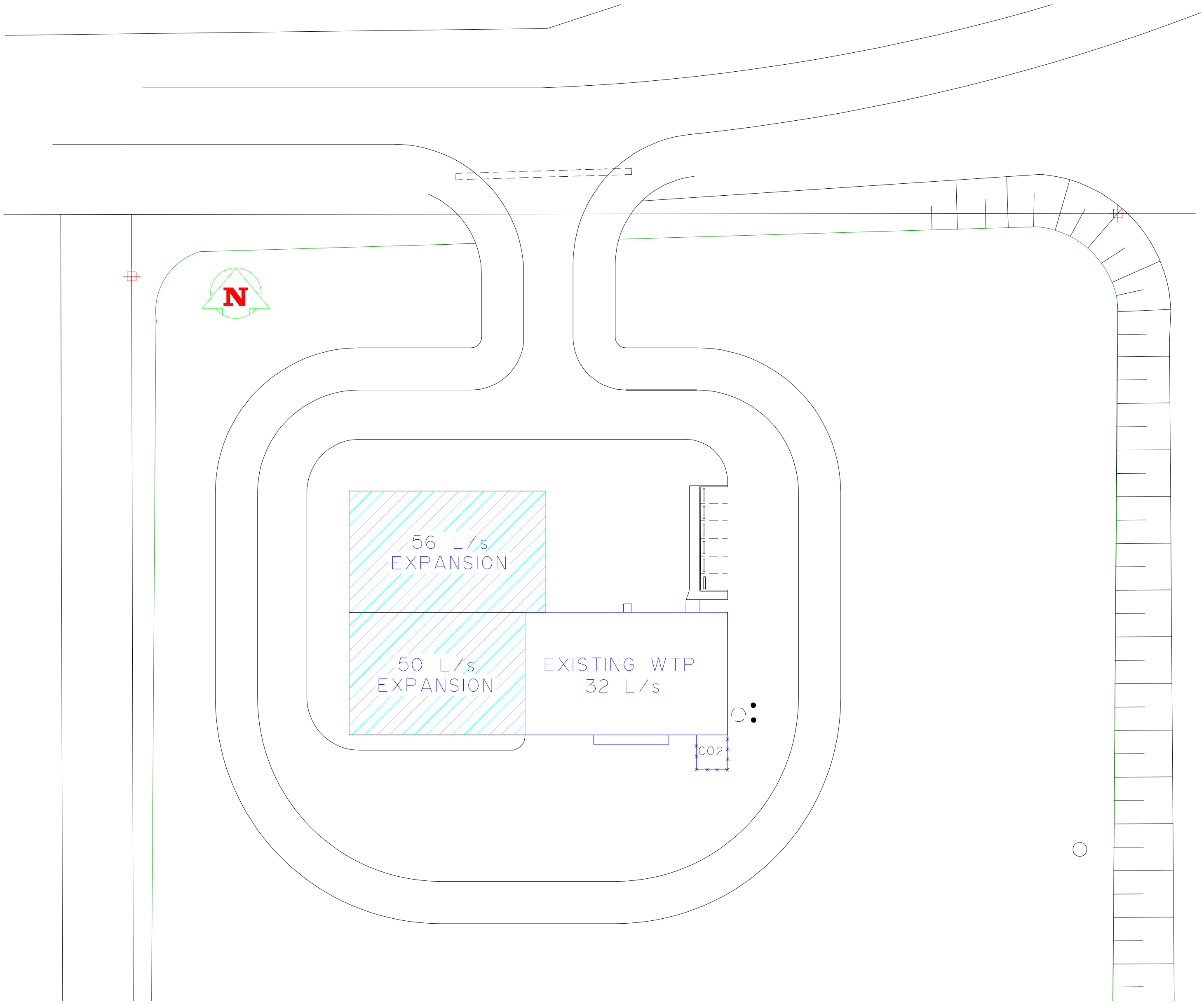


Figure 6.2: Recommended Morris WTP Staged Expansions

COCHRANE ENGINEERING

PEMBINA VALLEY WATER COOPERATIVE INC.

73 L/s (peaking factor of 2.0). In the event that this limit is unachievable, then the second objective would be to increase the limit to the highest value possible. In this case, the overall PVWC system would need to be operated in such a way that the Morris WTP would supplement the Stephenfield system, via the Roland Reservoir and pumping station, during low demand periods, allowing the yearly average allotment of the Stephenfield WTP to be "saved" for higher demand periods. This could be extended to the extreme case; that no license limit increases are granted. Since the existing license allows for a maximum withdrawal from the Lake of 76 L/s, the Stephenfield plant could be used during peak demand periods, and maintained at much lower production rates during the remainder of the calendar year.

In the event that this operation scheme is not appealing, a secondary recommendation would be scenario 2, at a cost of approximately $21,539,000. This scenario was chosen over scenario 3 because, like scenario 1, it involves a large expansion of the Stephenfield WTP and the subsequent system management scheme. It was chosen over scenario 4 because it provides system redundancy, flexibility and reliability through looping via the Morris – St. Jean interconnect line at an additional cost of only $800,000.

These study recommendations should provide a valuable planning tool for the Pembina Valley Water Coop to use for implementing cost effective upgrades that will meet long term requirements, while preserving the health, welfare and economic growth of the region.

7.0 ACKNOWLEDGEMENTS

The Cochrane Engineering team has appreciated the opportunity to work with the Pembina Valley Water Coop in undertaking this study.

We thank the management, staff and operators of the Pembina Valley Water Coop for their participation on this project. Most notably Sam Schellenberg and Gordon Martel who contributed significantly to this study. In addition, planning could not have been completed without assistance from the PVWC members.

Respectfully submitted:
Cochrane Engineering Ltd.

J.P. O'Driscoll, P.Eng.
Manager, Water Technology Group

W.H. Brant, P.Eng.
Vice President, Manitoba Division

Report Prepared with the assistance of:
D. Danielson, P.Eng. - Hydraulic Modelling
K. Sumner – Planning
K. Anderson, P.Eng. - Process & Water Quality
B. Kirshner, C.E.T. - Process Mechanical