10.0 Benchmark Information

The following section provides an overview of benchmark communities' use of offsite levies in the financing of water and wastewater infrastructure. Benchmark communities include:

Lakeland County	Leduc County
Parkland County	Red Deer County
Yellowhead County	Municipality of Wood Buffalo

All benchmark communities contacted have used or continue to use offsite levies to finance water and/or wastewater infrastructure requirements. Of the communities contacted, two were using levies that had not been updated since levy inception in 1979 or prior; two had recently created or updated offsite levy bylaws and two were establishing or updating an offsite levy bylaw.

The methodology each municipality uses to calculate offsite levies varies. Of the five communities that have active offsite levy bylaws, four calculate rates on a modified net area basis while the remaining community calculates rates on a per lot basis. Of those communities using the modified net area calculation basis, it was most usual that area calculations included allowances for environmental reserves, municipal reserves and road right of way.

In many of the contacted communities, the development area targeted by the offsite levy contained only a single land use type which resulted in development of a single uniform offsite levy rate. In other communities where multiple land uses existed within the targeted development area, offsite levy rates were created for each land use type or equivalency factors (e.g. 1,500 sq. ft. of commercial development is equal to single family residence) are used to account for differences of cost impact between different land uses.

While many contacted communities summarized all development area improvements into a single offsite levy rate, other communities had a specific rate for each service element. This granular rate schedule allows these municipalities to choose between services where multiple service options might exist.

For those communities that recently updated offsite levy bylaws, it was evident that the municipality clearly understood the infrastructure costs that were being recovered through the offsite levy rate. Furthermore, offsite levy rates most often recovered the full cost of providing water and sewer infrastructure to the development area. For one community however, their existing offsite levy bylaw provided a rate exemption for schools and the community was considering a further rate exemption to non-for-profit organizations like churches.

The types of infrastructure recovered through offsite levies also varied. In most instances local servicing and trunk requirements below specified diameters were held outside of offsite levy rate calculations. In these instances this infrastructure cost was to be borne directly by the developer of the area. With regard to recovery of water and wastewater treatment costs one community's offsite levies were specifically created to recovery a portion of treatment plant infrastructure costs. In a further case water and wastewater treatment costs were excluded from offsite levy rate calculations because

both the water and wastewater treatment functions were performed outside of the municipality.

The following are details related each benchmarked communities' offsite levies.

10.1 Municipality of Wood Buffalo

Question	Wood Buffalo Response
Contact Information	Wayne MacIntosh, Engineering Technologist
Does your municipality use offsite levies to support the construction of water and wastewater services?	Yes, offsite levies have been used to recover infrastructure costs related to water and sewer treatment.
In what areas within you municipality do you collect offsite levies for water and sewer infrastructure?	Wood Buffalo currently has four offsite levy bylaws, all of which relate to water and sewer treatment in Fort McMurray. Three of the bylaws relate to new subdivision developments and the fourth bylaw relates to redevelopment of an area. The municipality is in the process of developing a new offsite levy that would be aimed at development elsewhere in the municipality (rural areas).
In calculating offsite levy fees do you base fees on gross or net development areas?	Existing levies are based upon net development area. Net development area is based upon deductions from gross area for environmental reserves and municipal reserves. The new offsite levy being developed will make deductions for public utility lands and for road right of way in addition to environmental and municipal reserves.
Is land use considered in your offsite levy calculations? What land use categories are considered?	The existing levies are aimed at servicing primarily residential areas within the community however single family, multi-family and commercial land uses exist within development areas. Existing levies also consider school and municipal lands. Both of these land uses are currently exempt from offsite levies. The new offsite levy bylaw is further considering additional rates that would relate to industrial and institutional land uses. In this later regard an exemption from levies is also being considered for all not-for-profit organizations (e. g. such as churches).
Are development densities used in development of offsite levy rates?	The existing bylaws charge fees to single and multi-family land uses on a residential unit basis. Both single and multi-family units are considered equivalent and have occupant densities of three persons per unit.

Question	Wood Buffalo Response
	Commercial land uses are equated to single family units by using a conversion factor of 1,500 sq. ft. of commercial development being equal to a single family unit. In the new bylaw floor area ratio equivalencies will be created for industrial and institutional land uses. This will permit a single rate structure to be applied across land uses.
Are demand factors considered in offsite levy calculations?	All land uses are equated back to a single family equivalent.
When are offsite levies charged? (subdivision or development permit)	Water and sewer offsite levies are collected at the time of development permit application. However it should be noted that Wood Buffalo has offsite levies for roads and stormwater facilities that it collects at the time of subdivision.
What are the current rates for water and sewer offsite levies?	Water offsite levies are $956.49 per single-family unit or equivalent. Sewer offsite levies are $126.94 per single-family unit or equivalent.
When were offsite levy rates last updated?	There is a new offsite levy bylaw that is currently under development that is aimed at development outside of Fort McMurray. The existing bylaw was last reviewed in 2000 when major upgrades of water and sewer plant infrastructure was being considered.
What is the value of water and sewer infrastructure being recovered through offsite levies?	The existing bylaws recover water, sewer, stormwater and road infrastructure costs. The water and sewer levies relate to water and sewer treatment facilities only but exclude upgrades of the sewer treatment plant for tertiary treatment. The total dollar value of infrastructure recovery anticipated from the offsite levies is approximately $20M however there is no breakdown on how much of the $20M relates only to water and sewer infrastructure costs as opposed to stormwater and road costs. The new offsite levy bylaw is intended to recover approximately $100M in infrastructure costs.
Do offsite levies recover the full cost of infrastructure or only part of infrastructure costs?	Existing bylaws are intended to recover all infrastructure costs however in the new bylaw some infrastructure costs will be recovered from conditional grants.

Question	Wood Buffalo Response
Does the municipality offset or subsidize the cost of levies to developers or any land use type?	Yes, the existing bylaw exempts schools for offsite levy charges. The new bylaw will also consider exemptions for not-for-profit land uses (e. g. churches).
What water infrastructure is included in the development of offsite levy rates?	The existing bylaw only considers water treatment infrastructure. The new bylaw will consider all types of water infrastructure including treatment, transmission, reservoirs, pumping stations etc.
What sewer infrastructure is included in the development of offsite levy rates?	The existing bylaw only considers sanitary treatment infrastructure (excluding tertiary treatment). The new bylaw will consider all types of sewer infrastructure including treatment, transmission, lift stations, storage etc.

10.2 Lakeland County

Question	Lakeland Response
Contact Information	Terry Colosimo, Manager of Public Works
Does your municipality use offsite levies to support the construction of water and wastewater services?	Not presently.
In what areas within you municipality do you collect offsite levies for water and sewer infrastructure?	Offsite levies were used to collect water and wastewater infrastructure costs in the village of Plamondon. The levy was $1,500 per lot which did not recover the full cost of providing water and sewer servicing. In 2002, Plamondon reverted to a Hamlet and a connection fee through development agreement was introduced to replace the offsite levy. In the Beaver Lake area, just outside of the Town of Lac La Biche, water and sewer extensions are provided for new residential development also through a service connection fee of $2,600. Lakeland is presently developing an offsite levy bylaw to deal with requests from developers who wish to tie into the new water supply line to Plamondon.

10.3 Yellowhead County

Question	Yellowhead Response
Contact Information	Brent Shepherd
Does your municipality use offsite levies to support the construction of water and wastewater services?	Yes. Offsite levy bylaws were first adopted in 1979. The intent of the bylaw was to receive development contributions toward water supply, treatment and storage facilities, sewage treatment and disposal facilities. The offsite levies were developed when Yellowhead County was an improvement district of the Province and have not been changed or updated since inception.
In what areas within you municipality do you collect offsite levies for water and sewer infrastructure?	The offsite levy is collected on new residential subdivisions within the County. Collected funds are pooled to assist servicing requirements in Hamlets. There currently are no industrial subdivisions within Yellowhead County.
In calculating offsite levy fees do you base fees on gross or net development areas?	Offsite levy fees are charged on a lot basis.
Is land use considered in your offsite levy calculations? What land use categories are considered?	Development in hamlets is primarily residential in nature and as such no land use categories are considered in the development of offsite levy charges.
Are development densities used in development of offsite levy rates?	No. Offsite levies are charged on a lot basis.
Are demand factors considered in offsite levy calculations?	No. Development is primarily residential in nature and so a uniform rate per lot is established.
When are offsite levies charged? (subdivision or development permit)	Offsite levies are charged at the time of subdivision.
What are the current rates for water and sewer offsite levies?	Rates were established in 1979 when Yellowhead County was an improvement district of the Province. Charges are follows: Water systems per lot - $300.00 Water and sewer systems per lot - $500.00 Adjacent to subdivision without sewage disposal - $200.00 Adjacent to subdivision with sewage disposal - $100.00

Question	Yellowhead Response
When were offsite levy rates last updated?	The rates have not been updated since they were created in 1979.
What is the value of water and sewer infrastructure being recovered through offsite levies?	Unknown as the funding is for anticipated infrastructure development.
Do offsite levies recover the full cost of infrastructure or only part of infrastructure costs?	No.
Does the municipality offset or subsidize the cost of levies to developers or any land use type?	Yes, the general tax levy of the municipality is used to pay for infrastructure costs that are in excess of offsite levies contributions.
What water infrastructure is included in the development of offsite levy rates?	The offsite levy in intended to pay for water supply, treatment and storage facilities.
What sewer infrastructure is included in the development of offsite levy rates?	The offsite levy in intended to pay for sewage treatment and disposal facilities.

10.4 Red Deer County

Question	Red Deer Response
Contact Information	Ken Enion, Assistant County Manager
Does your municipality use offsite levies to support the construction of water and wastewater services?	Yes, offsite levies are used to support the construction of water, wastewater services as well as transportation system development and upgrades.
In what areas within you municipality do you collect offsite levies for water and sewer infrastructure?	Offsite levies are used for land areas adjacent to the primary highway corridors and for growth hamlets. The **South Hills Area** is bounded on the east by Highway 2; on the south by Mackenzie Road; and on the north and west by Highway 2A and is adjacent to the southwest boundary of the City of Red Deer. Planning and development in this area is governed by The South Hills Area Structure Plan, dated June 1997. The planning area accommodates institutional, industrial/business, residential, highway commercial,

Question	Red Deer Response
	industrial uses and protects Waskasoo Creek. This area contains new development such as Costco and Staples as well as all of the gasoline service stations, restaurants and fast food outlets on the highway commercial strip known as "Gasoline Alley". Water and sanitary sewage services were handled on a piece-meal basis prior to the adoption of the area structure plan in 1997. **Springbrook** is a new hamlet community created on the decommissioned lands of the CFB Penhold Airbase. The Town of Penhold is located immediately to the south. In 1996, the County of Red Deer recognized the military housing portion of the Penhold base area as a hamlet. An area redevelopment plan was completed in April 1999 which includes the original hamlet and additional lands to provide for long range growth of the community. The Department of National Defense constructed a piped and treated water system for the base and residential area. In 1975, a new water main was constructed. This system was turned over to the County. A sewage collection system operated by the Waskasoo Regional Services Board collects sewage from the Town of Penhold, the Hamlet of Springbrook and a County commercial area known as Gasoline Alley and transfers it to the City of Red Deer sewage treatment facility. After the County completed an infrastructure study and regained control of the water source, the capital costs were clarified and modified. From these revised costs, off site levies were assessed on new development. Redevelopment off site levies for the Hamlet of Springbrook is based on a developable area of 654 acres out of a total area of 1218 acres. The levies are formalized in Schedule E of Bylaw No. 17/96 and were amended by resolution on February 1, 2000.
In calculating offsite levy fees do you base fees on gross or net development areas?	Calculations are based upon a net area basis with reductions from gross area for environmental reserves, municipal reserves and road right of way.
Is land use considered in your offsite levy calculations? What land use categories are considered?	Land use is considered in calculations. Land use categories include single family, multi-family, commercial, industrial and institutional land uses.
Are development densities used in development of offsite levy rates?	Yes

Question	Red Deer Response
Are demand factors considered in offsite levy calculations?	Yes water consumption per land use type.
When are offsite levies charged? (subdivision or development permit)	Levies are charged at the time of subdivision.
What are the current rates for water and sewer offsite levies?	Red Deer County current rates (per acre) South Hills: Water Supply Phase 1 $ 805 Water Supply Phase 2 $2,350 Trunk Water Main $1,120 Local Water Distribution $4,690 Trunk Sanitary $ 470 Local Sanitary Sewer System $3,520 Storm Water Management $ 950 Regional Sewer System $6,000 Springbrook: Water Storage Reservoirs (2) $1,380 Water Well and Pump House $ 225 Regional Sewer System $6,000
When were offsite levy rates last updated?	Offsite levy rates are currently under review. The last time that rates were revised was in 2001.
What is the value of water and sewer infrastructure being recovered through offsite levies?	The value of water and sewer infrastructure costs is approximately $20M.
Do offsite levies recover the full cost of infrastructure or only part of infrastructure costs?	Levies recover the full cost of infrastructure.
Does the municipality offset or subsidize the cost of levies to developers or any land use type?	No contributions or subsidies are provided by the municipality. Offsite levies recover the full cost of providing water and sewer infrastructure.

Question	Red Deer Response
What water infrastructure is included in the development of offsite levy rates?	Offsite levies recover the cost of all types of water infrastructure including treatment, transmission, reservoirs, pumping stations etc.
What sewer infrastructure is included in the development of offsite levy rates?	Offsite levies recover the cost of all types of sewer infrastructure including treatment, transmission, lift stations, storage etc.

10.5 Parkland County

Question	Parkland Response
Contact Information	Bill Sommer, Technical Services Supervisor
Does your municipality use offsite levies to support the construction of water and wastewater services?	Yes, in 1995 the County began to front end the construction of sewer and water trunk lines to accommodate demand for serviced industrial and industrial-commercial developments. The County uses offsite levies to reimburse construction front ending. Offsite levy information can be found in By-Law No. 52-2003 Imposition And Collection of Off-Site Levies.
In what areas within you municipality do you collect offsite levies for water and sewer infrastructure?	The original Acheson Industrial Area consisted of the Ellis and Sherwin Industrial parks with development commencing in 1975. The developers paid for and installed a water distribution line that connected to the regional water line from Edmonton. Parkland County purchased the water line from the developer in the 1990's. This initial phase of the Acheson Industrial Area consisted of portions of three quarter sections of land bounded by the old Hwy. 16 (16X) to the south, Hwy. 60 to the east, and the CN Rail line to the north. Acheson now consists of a number of new areas north of the CN Rail line up to Hwy. 16, east of Hwy. 60 and south of Hwy. 16X. The County, starting in 1995 began to fund and construct sewer and water trunk lines to accommodate increased demand for serviced industrial and industrial-commercial development using contingencies reserve funds. The trunk lines were built using cost-shared grants from the federal and provincial governments. The County used their contingency reserves to pay their 33% share. The front end funding by the County was to be paid back through the use of off site levies.

Question	Parkland Response
In calculating offsite levy fees do you base fees on gross or net development areas?	Calculations are based upon a modified net development area. This modified area calculation is based on the gross titled area of the subdivision or development including roads, easements, public utility lots, municipal reserve dedication and storm ponds but excluding Existing rights of way not included in the title of the developer. Environmental reserves. The county may also exclude treed areas, natural habitat or parks and natural areas (municipal reserves plus any areas above the MGA requirement). Land dedication for provincial highways.
Is land use considered in your offsite levy calculations? What land use categories are considered?	Yes, as the areas where offsite levies exist are industrial parks calculations consider commercial land use and industrial land use.
Are development densities used in development of offsite levy rates?	No.
Are demand factors considered in offsite levy calculations?	No.
When are offsite levies charged? (subdivision or development permit)	Levies may be charged at the time of subdivision or at time of development permit. The timing of these requirements is determined upon development application.
What are the current rates for water and sewer offsite levies?	Acheson Sewer Trunk System, 1995, base levy $358.21/ha, levy starts Jan. 1, 1996, interest rate: 2.5%, 10 increments. Hunters' Sewer Trunk System, 1997, base levy $1,995.27/ha, levy starts Jan. 1, 1998, interest rate: 3.0%, 10 increments. Acheson Sewer Collection System, 1995, base levy $2,800 to $4,700/ha, levy starts Jan. 1, 1996, interest rate: 2.5%, 10 increments. Acheson Water Connection, future, estimated cost after inflation $128,000, base levy $275.33/ha, levy starts January 1, 1998. Hunter' Water Main, 1997, base levy $4,561, levy starts Jan. 1, 1998, interest rate $2.5%, 10 increments. Acheson Reservoir/Pump House, future, estimated cost after inflation $3,578,812, base levy $2,344/ha, levy starts Jan. 1, 1998.

Question	Parkland Response
When were offsite levy rates last updated?	The present offsite levy bylaw was created in 2003.
What is the value of water and sewer infrastructure being recovered through offsite levies?	Acheson Sewer Trunk System $323K. Hunters' Sewer Trunk System $202K. Acheson Sewer Collection System $359K. Acheson Water Connection $128K. Hunter' Water Main $273K. Acheson Reservoir/Pump House $3,840K.
Do offsite levies recover the full cost of infrastructure or only part of infrastructure costs?	The offsite levies are slated to recover the County portion of front ended infrastructure costs.
Does the municipality offset or subsidize the cost of levies to developers or any land use type?	When an exceptional circumstance exists the municipality has deferred collection from some developers. This deferment however has not reduced or eliminated the developer's requirement to pay offsite levy amounts.
What water infrastructure is included in the development of offsite levy rates?	Treated water is supplied through a regional water line from Edmonton and is therefore not included in offsite levy calculations. New transmission lines up to 300mm are the direct responsibility of the developer. Larger trunks are the responsibility of the County with reimbursement of cost achieved through offsite levies. Reservoirs, pumping stations are also infrastructure that is considered in offsite levy calculations.
What sewer infrastructure is included in the development of offsite levy rates?	Sewage Treatment is provided through a regional sewage line to the Alberta Capital Region Wastewater Commission and is therefore not included in offsite levy calculations. New transmission lines up to 300 mm are the direct responsibility of the developer. Larger trunks are the responsibility of the County (Acheson trunk 1/3 county share) with reimbursement of cost achieved through offsite levies. There are no lift stations, storage or other facilities including within existing offsite levy rates.

10.6 Leduc County

Question	Leduc Response
Contact Information	D'Anne O'Keefe, Development Officer
Does your municipality use offsite levies to support the construction of water and wastewater services?	Yes, offsite levies are applied to developments to support water supply infrastructure in the Nisku Industrial Business Park and North Vistas Country Residential Area.
In what areas within you municipality do you collect offsite levies for water and sewer infrastructure?	See Above.
In calculating offsite levy fees do you base fees on gross or net development areas?	A modified net development area is used which considers deductions from gross area for municipal reserves and road rights of way.
Is land use considered in your offsite levy calculations? What land use categories are considered?	The Nisku Industrial Park is zoned as light industrial and therefore there is no need to differentiate between land uses. Likewise the North Vistas Area is country residential development and therefore there is no need to differentiate between land uses.
Are development densities used in development of offsite levy rates?	No, levies are charged on an area basis.
Are demand factors considered in offsite levy calculations?	No.
When are offsite levies charged? (subdivision or development permit)	While offsite levies may be collected at either the time of subdivision or develop permit the County prefers to apply levies at the time of subdivision.
What are the current rates for water and sewer offsite levies?	Nisku Industrial Park - $3,000 per gross acre. North Vista Country Residential Area - $800 per gross acre
When were offsite levy rates last updated?	The Nisku Industrial Park offsite levy was established in 1979. The North Vista Country Residential Area offsite levy was established prior to 1979.
What is the value of water and sewer infrastructure being recovered through offsite levies?	Answer declined

Question	Leduc Response
Do offsite levies recover the full cost of infrastructure or only part of infrastructure costs?	Answer declined
Does the municipality offset or subsidize the cost of levies to developers or any land use type?	Answer declined
What water infrastructure is included in the development of offsite levy rates?	Offsite levy rates include provisions for all water infrastructure including treatment, transmission, reservoirs, pumping stations and distribution network.
What sewer infrastructure is included in the development of offsite levy rates?	Some wastewater collection is being provided in the Nisku Industrial Park however these infrastructure requirements are being funded through local improvement charges.

11.0 Wastewater System Best Practice

11.1 Introduction

Most efficient, effective organizations have adopted a continuous improvement strategy around their operations. A critical element of this improvement strategy is to gain traction from the experiences of other industry partners to identify and adopt leading industry practices.

Aquatera wants to ensure at the outset of its operation that the leading practices of other wastewater utilities have been considered. This section outlines several leading practices of various Canadian and U.S. utilities, as well as management studies of utilities and similar industries. Topics include:

- Good Governance in Water Utilities
- Reducing the Impact of Variations in Financial Plans
- Adoption of s Strategic Planning Framework
- Strategies for competitive advantage
- Best Practices for Maintenance Work Orders
- Wastewater Environmental Objectives
- Total Productive Organization
- Program Driven Maintenance
- Treatment Plant Performance Dashboard
- Selecting Wastewater System Rehabilitation Technologies

Each topic area is discussed more fully below.

11.2 Good Governance in Wastewater Utilities

Good governance is achieving the desired results in the right way. The importance of good governance is recognized, yet in many utilities the principles of governance are not articulated and the relationship between utility stakeholders is unclear. Good governance is characterized by a set of ranked principles that guide decision-making processes and management practices. Principles of good governance and the prioritization of principles vary between organizations and jurisdictions. The governance principles are as follows:

- Public safety is paramount
- Public accountability for decisions related to the wastewater system
- Effective exercise of owner's oversight responsibilities
- Competent and effective management and operation of the system
- Full transparency in decision-making.

Typical good governance principles in wastewater management include:

- Protection of public health and safety
- Environmental protection
- Accountability for stewardship and performance
- Transparency
- User participation
- Balancing equity, efficiency and effectiveness in performance
- Financial sustainability.

11.3 Reducing the Impact of Variations in Financial Plans

The financial planning process for wastewater utilities can vary significantly from the actual results:

- Extremes in wet or dry weather can dramatically impact residential and some commercial customers water consumption habits and utility revenues and hence the amount of wastewater flow.
- Over heated development growth can expedite capital infrastructure plans.
- Regulatory changes can result in new infrastructure, rehabilitation or operational requirements.
- Capital project variances can result in unforeseen of wastewater flow.

The development and maintenance of various reserve funds can provide continuity during these unpredicted events. Several reserve funds a utility should consider include:

- Rate Stabilization Fund – The rate stabilization fund minimizes the rate impact of extraordinary cost increases such as large increases in debt borrowings or related interest rates. Normally the rate stabilization fund is drawn upon when rate increase requirements exceed defined hurdle rate percentage. Typically rate stabilization funds are replenished, up to a defined limit, through an allocation of a part of any annual operating surpluses. Aggressive management and utilization of the fund permits development and adoption of long-range rate strategies and avoids the political tension associated with short range rate planning.

- Operating Reserve Fund – The operating reserve fund is a fall back for any years when operating losses may occur due to temporary customer consumption drops and the like. The fund is established and replenished when operating surpluses arise. The fund typically is set marginally greater than the largest history loss position providing support for a single catastrophic operating year and multiple years where operations are marginally below predictions.

- Insurance Reserve Fund – Most utilities are self-insured. This fund pays for ordinary losses incurred through operations etc. that result from accident, theft and usual liability claims (Note extra-ordinary claims are usually covered through insurance held with private insurance companies). This fund is created and replenished though self applied insurance premiums levied annually as part of operating budgets. The fund is typically set according to long term claims history with reserve adjustments made through periodic review of the asset base being insured.

- Renewal and Replacement Reserve – This fund helps replace and rehabilitate existing infrastructure when the asset has reached the end of its useful life. The reserve is established and replenished through depreciation charges in the annual operating budget and through special requisitions to budget that recognize that replacement assets may have escalated from the time they were originally booked. Reserve funds are usually earmarked for use through the annual capital budget process. The creation and use of these funds are also important to the development and adoption of long range financial plans and rate strategies.

11.4 Adoption of a Strategic Planning Framework

A strategic planning framework involves establishing a set of linked cyclical management processes, which together form a planning, implementing and measurement tool set to satisfy both long term as well as short term needs. The following illustration shows typical strategic plan elements.

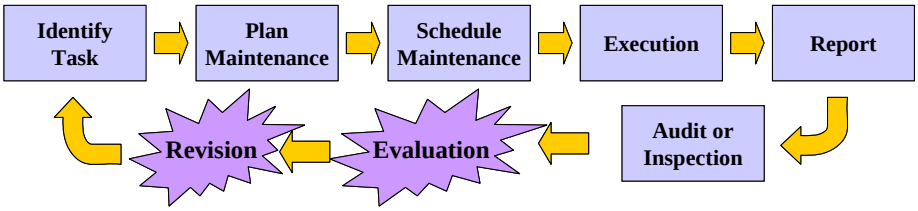
11.5 Strategies for Competitive Advantage

Deregulation of the wastewater environment and the added pressures of opened market competition places greater and greater emphasis on those actions that can have immediate positive impact on the bottom line. The maintenance and reliability of wastewater operations is coming under minute scrutiny. Modern tools and systems have created maintenance and operational opportunities that were not possible in the past. The following lists and explains some of the identified maintenance "best practices" being used in the utility industry:

- Benchmarking – One tool used effectively today by many utilities is that of benchmarking. The process of benchmarking can take many forms. On method of benchmarking is to compare oneself to a single leading wastewater system. Using indicative data from operations and maintenance differences are highlighted for potential opportunity. This approach also has the appeal of allowing key management and staff to visit the maintenance and operations of the benchmark wastewater system to understand first hand cultural and environmental factors that play a vital role in achieving a highly efficient operation. Another approach is to use an outside firm to provide comparison data across many wastewater system operations so that standards can be developed and anomalies from these standards highlight. This approach has the advantage of quickly highlighting potential target areas.

- Work Flow Control – Workflow control involves flow-charting, measurement, analysis and assessment and standardization of the steps involved in typical maintenance and operational activities. These activities might include what transpires in maintenance callouts for emergency items or routine maintenance activities like sewer flushing or hydrant testing.

A controlled maintenance work stream should involve the following steps:



- Preventive Maintenance – Everyone has a preventative maintenance program however most programs are over burdened with wants versus needs. The result is that the preventative program may not be applied to the "right" facilities and infrastructure, preventative maintenance routines are not being fulfilled because of "higher priority" needs, preventative strategies have not be kept current and scheduled down time is viewed as intrusive rather than a planned outage. In most instances preventive maintenance routines have to be pared and non-effective tasks removed and other tasks added.

- Operations Responsibilities – Maintenance of operating equipment in a treatment plant etc. is an operating responsibility. The degree to which equipment or a facility is maintained is determined and approved by operations. The expertise and capabilities of the maintenance force and its management determine the quality and quantity of work performed. In many cases in today's competitive market operators are used to perform basic maintenance tasks where skill is not a factor.

- Materials Management – The most efficient plants recognize that management of the materials used in the performance of maintenance is a definite best practice. Practice considerations include locating maintenance inventory relative to the work areas, spare part delivery schemes, vendor managed inventories etc.

- Diagnostics – Establish the use of diagnostics with follow-up corrective actions associated with prior notification of failure leads to improved reliability and bottom line performance.

- Training – Aging workforces, unaccustomed to change are finding their skills are deficient in providing the level of repair and diagnostics needed for today's plant equipment.

11.6 Best Practices for Maintenance Work Orders

There is an aversion to developing and using standard procedures for maintenance tasks. Arguments are presented that the workforce is mature, performing the same tasks for an number of years "successfully" and as such there is no compelling reason to have detailed procedures. However the inefficiencies that existing within and

surrounding the every day maintenance work order offer many improvement opportunities. The following are some best practices surrounding maintenance work orders:

- The Risks and Benefits of an Aging Workforce – Most utility organizations have a very experienced maintenance workforce. This experienced workforce does not require maintenance procedures or protocols to handle many of the utilities critical infrastructure, plant systems and equipment maintenance requirements. Because of this ready availability of experience and knowledge it is important that maintenance procedures and protocols be documented and preserved now. Human resource studies have shown that a large knowledge drain will occur in the work place as baby boomers exit the workforce. Utilities are not immune from the experience drain and as such establishing robust maintenance procedures and methods now will lessen the impact of the loss of knowledge and experience that is occurring.

- Safety Considered On Every Work Order – Primary information required for every maintenance task or work order is the safety issues associated with completion of the task. Safety worksheets should be provided and linked to every work order to ensure that maintenance staff, regardless of experience level, fully understands how to accomplish the maintenance task in a safe manner.

- Linkage of Tools, Materials and Equipment on Every Work Order – Studies have shown that a typical maintenance worker only spends 24% of their workday performing maintenance work. A good portion of residual time is spent waiting for or lost as tools, materials and equipment is not readily available for the task at hand. Discussions with maintenance workers will highlight simple tasks that can be undertaken to dramatically improve productivity.

- Acceptance Criteria – Many work order procedures already define how inspection should be performed as well as how to perform it safely the most commonly missing information however is an acceptable range of results that advises a maintenance worker when a task may not be required or when the job is functionally complete.

- Mean-time-to-repair – Maintenance work order descriptions should also include the standard hours the task typically requires to complete. This information is not only essential for effective task planning and scheduling but can assist workers to maintain pace or to document situations where abnormal maintenance efforts may be required.

11.7 Wastewater Environmental Goals and Objectives

Goals and objectives provide the organization with a “north star” or point to focus organizational energies. The following are leading environmental goals and objectives of wastewater systems:

- No overflows or diversions
- No permit or regulatory violations
- Protection of the environment by identifying and meeting sewage system needs with due consideration of system impacts on air, land and water
- Maximize reuse and conservation of resources generated from waste water treatment including biosolids, digester gas and water.

11.8 Total Productive Organization

Total Productive Organization refers to the concept of integrating operation and maintenance functions. Historically, large public wastewater utilities have not integrated the operation and maintenance functions. When the functions are segregated, operators of process equipment are often unfamiliar with the maintenance of that equipment. Further maintenance personnel, who are responsible for repairing process equipment, are usually unfamiliar with its operation. With the utilization of the Total Productive Organization concept, wastewater utilities pursue an integrated approach that results in reduced staffing and increased efficiency.

Critical factors that can limit management from achieving the desired level of operations and maintenance integration include collective agreement limitations and reluctant staff attitudes. Overcoming these limitations requires direct discussions with unions and workers on the productivity gains that may be achieved and their overall importance to the utilities operation. Union and staff may be enticed to adopt this concept by offering them economic incentives such as a share of productivity gains realized from employing the concept.

A vital step in establishing the Total Productive Organization concept is the development of formalized operations and maintenance cross training programs. Cross-training is an effective technique that can be used by wastewater utilities to enhance productivity and optimize plant performance. As wastewater plants downsize, it is even more important to a have a versatile staff that has a thorough understanding of all plant processes and the ability to perform many tasks. Cross training also promotes a better work environment as staff learns to appreciate the importance of each other's jobs. Cross training is also a useful technique in fostering a team approach and eliminating "it's not my job" mentality.

11.9 Program Driven Maintenance Programs

Emergency repairs are costly to wastewater utilities as they are disruptive, impacting customer services as critical infrastructure is taken out of service at inopportune times, and costly as resources are drawn away from other tasks to enact corrective or emergent repairs, resulting in greater maintenance set up costs and repairs being often undertaken at a premium cost (overtime).

Program driven maintenance programs use predictive and preventative maintenance management approaches to reduce/eliminate these more costly, emergent and corrective maintenance activities. Preventive maintenance programs establishes scheduled inspections and maintenance over the life cycle of utility infrastructure while predictive maintenance establishes sensors, such as oil and vibration testing on system pumps and large motors, and other monitoring mechanisms that test and interpret changes in processes and equipment performance.

Review of maintenance programs of various wastewater treatment plants, by Black and Veatch Corporation has resulted in maintenance efficiency benchmarks for planned versus reactive maintenance efforts. Black and Veatch found that high performance wastewater plants were found to have less than 25% of total generated work orders to be corrective in nature (emergent or unplanned repairs) and in excess of 75% of total wastewater plant maintenance work orders resulting from planned or driven maintenance programs.

With regard to wastewater collection systems the Water Environment Research Federation, American Society of Civil Engineers, and the Environmental Protection Agency provide measures on the effectiveness of wastewater collective system maintenance. The following is a summary of some of the benchmarks:

Description	Benchmark
Percentage of sewers rehabilitated per year.	0.5%
Percentage of sewers inspected per year.	6.5%
Percentage of sewers cleaned per year.	20.5%
Crew size for repairs	3.2
Percentage of work orders completed in 1 day.	62%
Percentage of work orders completed in 2 days.	84%
Flow evaluation (percentage of system)	53%
Manhole inspection (percentage of system)	37%
Flow monitoring (percentage of system)	20.5%

11.10 Treatment Plant Performance Dashboard

A system to measure and manage the performance of a wastewater system is integral to the systems long-term success. Most wastewater utilities have been largely driven by government regulations and plant reliability considerations. With the watchwords of “no violations” and “no plant failures” little attention was given to cost efficiency or service effectiveness. Today’s forces still include increasing government regulations, but O&M costs are usually the major consideration due to competition from private contract operators. “Getting competitive” means reducing these O&M costs while maintaining or even improving effluent quality and service reliability. Tools are needed to analyze performance over time to achieve greater O&M efficiencies, and to predict when action or intervention is necessary to maintain service reliability or quality. A performance measurement system must be carefully designed and built to present the right information to aid in achieving O&M efficiencies.

Well-designed and properly implemented performance measurement systems can enable utilities to achieve these new levels of performance. These information systems are typically enterprise-wide, meaning they must integrate measures from several “front-end” information and control systems. Performance measures are many times consolidated, aggregate measures, which combine costs and production information to enable near real-time adjustments in utility business processes.

The “balanced scorecard” approach to performance measurement is an approach currently used in many organizations to monitor efficiency and effectiveness. The approach may be applied with success in a wastewater treatment plant setting. This approach allows for measures at various levels of the plant in order to provide different views of information from various performance centers.

The balanced scorecard is based on measures of efficiency, quality, and effectiveness at each level of the performance framework. The types of measures for each level include:

Efficiency - measure of ratio of production (output) to the resources required (input), typically cost or time of input resources per unit of output (e.g. $/Ml treated).

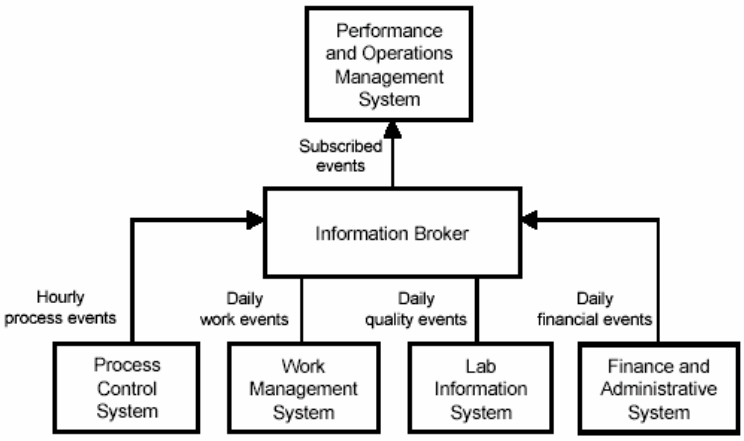
Quality - measure of the characteristics of the output that adds value to a customer or stakeholder, often measured against a target value or compliance standard (e.g. effluent suspended solids, mg/l).

Effectiveness - measure of a process or service to meet demand or achieve outcomes, typically expressed as capacity effectiveness (relationship between demand and input, i.e. capacity available) or production effectiveness (relationship between demand and output, i.e. production results available.) Effectiveness is usually measured at a level above the process or service where related efficiency or quality is measured.

Each type of measure must be defined for each service or process at a given level, in order to have a "balanced scorecard". The challenge is to be selective in defining these measures to establish the smallest number of most relevant measures. An example of a scorecard is provided below:

Service or Process	Efficiency Measure	Quality Measure	Effectiveness Measure
Plant Facility	Cost to Treat ($/Ml)	Effluent BOD, Total Suspended Solids etc. (mg/l)	Treatment Capacity Available
Solids Handling	Cost to Treat / Dispose ($ per dry tonne)	Aggregate Concentration (% solids)	Process Unit Availability (% available)
Sludge Dewatering	Polymer Dosage (kg/dry tonne)	Aggregate Concentration (% solids)	Dosage Control Accuracy ("+ or –" target dosage)

Performance Measurement Systems gather information from key performance centers on a hourly, daily, weekly or monthly basis. An example of a collection network is outlined below.



11.11 Selecting Wastewater System Rehabilitation Technologies

Sewer rehabilitation or replacement needs are often not known to a municipality as this infrastructure is underground. It takes a regular program of inspection, usually through closed-circuit television (CCTV), to maintain awareness of the physical condition of the sewers. Operational issues (e.g., sewer backup, basement flooding, overflows, and odour complaints) are often indicators of rehabilitation needs in the system. A municipality can choose a balance between reactive rehabilitation (responding to pipe collapses that cause backups and/or road surface failures) and proactive rehabilitation (investing in lower cost rehabilitation when internal inspection shows early signs of physical distress but the pipe has not yet failed). Choosing to preserve the physical condition of sewers ahead of time is cost-effective since reactive repairs are several times the cost of proactive rehabilitation. Therefore, an annual inspection and flushing program should be established.

Critical items that should be considered before selecting an appropriate rehabilitation or replacement technology include impact on users, (user disruption, user inconvenience etc.), local availability of the types of technologies, surface conditions, the density of sewer laterals, and the depth of the sewers and laterals being considered for remedial action. The options available to a municipality focus on two possible alternatives: replacement/structural rehabilitation, or non-structural and semistructural rehabilitation. Within both of these rehabilitation alternatives trenchless and open cut methods exist. The following is an overview of methods and their relative advantages and disadvantages.

11.11.1 Open Cut Construction

The installation of new or replacement sewers by trenching is frequently referred to as the open cut method. The installation of new pipe should be undertaken when the review of all potential technologies has been completed and the open cut method is ranked as the best alternative.

Advantages:

- A new sewer is installed, complete with all new appurtenances. This provides a longer expected life than obtainable through most trenchless methods.
- The alignment of the sewer can be set to meet the needs of the local area.
- Sewer connections can be replaced to meet current standards.
- The sewer sizing and/or grade can be changed to meet current and future hydraulic requirements.
- Other infrastructure can be rehabilitated or replaced at the same time, allowing for coordination of work and sharing of costs.
- Combined sewers can be separated.
- Storm sewer laterals currently connected to the sanitary system can be disconnected.

Disadvantages:

- The cost of the open cut method can be substantial compared to some newer technologies.
- Construction is usually longer than with most trenchless technologies due to the quantity of disturbance to other infrastructure and traffic, and the amount of reinstatement work required following the installation of the sewer.

- There are more safety concerns due to traffic issues on road rights-of-way, the number of excavations required, and the large equipment needed to perform the work.
- There can be disturbances to other surface and buried infrastructure.
- The social and economic costs of major open cut projects can be substantial during construction.

11.11.2 Sliplining

Sliplining is the insertion of flexible liners directly into the sewer. Either continuous or jointed discrete lengths of pipe are pulled or pushed through the existing pipe. Sliplining creates a new pipe inside the old sewer without a complete excavation. The sliplined pipe is then reconnected to the existing sewer at both ends.

PVC and HDPE (high density polyethylene) pipe is primarily used in sewer sliplining applications. With PVC pipes, joints are traditional push-on joints. HDPE pipe are either butt fused (thermal process), or joined together by electrofusion in various possible lengths above ground, then inserted into the host sewer at entry points.

Once the new sliplined pipe has been inserted into the host pipe, grouting is generally required to fill the void between the new and old pipes. Grouting is an important step in the sliplining process to maintain the structural stability of the new pipe. A sliplined pipe substantially reduces the cross-sectional area of the pipe. However, the reduction in friction with the lined pipe compared to the previous, old unlined pipe can partially compensate for the reduced internal diameter. Hydraulic requirements must be considered carefully before selecting sliplining as a preferred alternative.

Advantages:

- Sliplining can be applied to most types of pipe.
- Rapid and causes little disturbance to other utilities.
- Most successful with few connections.
- Provides an improved friction coefficient for improved hydraulic performance.
- Depending on flows, installations can be done in live lines without bypass pumping.

Disadvantages:

- The sliplined pipe is usually sized so its outside diameter is at least 10 percent smaller than the inside diameter to allow for smooth insertion. This reduction, in association with the wall thickness of the pipe, leads to the loss of cross-sectional capacity.
- Sliplining requires a long assembly/lay down area.
- When short pipe sections are used, there is an increased cost in the jointing techniques.
- Poorly controlled grouting to the annular space can lead to buckling of the liner pipe.
- Many excavations may be required if many service and branch reconnections are involved.
- Because the liners used for sliplining do not turn through elbows, the alignment of the unlined pipe must be considered before selecting this technique.

11.11.3 Diameter Reduction Sliplining

Close fit sliplining involves inserting a thermoplastic tube that has been temporarily deformed to allow sufficient clearance for insertion into the host pipe. The tube is subsequently returned to its original shape and diameter, providing a close fit in the host pipe. The outside diameter of the tube is the same or slightly larger than the inside diameter of the host pipe. The tube is passed through a set of dies (referred to as "swageing") or through an array of compression rollers, to reduce the tube diameter to allow for insertion by winching. The tube then reverts to its original dimensions once the winch tension is released, and in most cases, with the help of internal pressure.

Advantages:

- Close fit diameter reduction sliplining can be applied to most types of pipe.
- Rapid and causes little disturbance to other utilities.
- Most successful when there are long runs with few connections.
- Provides an improved friction coefficient for improved hydraulic performance.
- Minimal loss of pipe diameter and no grouting requirement when compared to the traditional sliplining technique.
- Liner can be selected to provide either full structural integrity or semi-structural integrity, depending on the condition of the host pipe.

Disadvantages:

- Energy required to reduce the pipe diameter increases dramatically with larger pipe sizes and greater wall thicknesses.
- Installation of the tube may get hung up during the installation of pipes that are deformed, have dimensional irregularities or displaced joints.
- Manufactured pipe for insertion usually requires special extrusion dies due to non-standard pipe diameters.
- Host pipe needs surveying, cleaning, and preparation.
- Sufficient site space is required to accommodate butt-fusion welding of pipes before the diameter reduction and during insertion.
- As with standard sliplining, the alignment of the host pipe must be considered before selecting the diameter reduction technique, as the winched pipe does not turn well through elbows.

11.11.4 Fold and Form Sliplining

This technique is based on the liner being heated and folded at the manufacturer's factory, and then transported to the installation site. The folded liner is then inched into the host pipe and re-rounded using a combination of heat and pressure and, at times, a device propelled through the liner. PE liners are preferred for pressure applications while PVC systems are mainly used for gravity sewers.

Advantages:

- Fold and form sliplining can be applied to most types of pipe.
- Rapid and causes little disturbance to other utilities.
- Most successful with few connections.
- Provides an improved friction coefficient for improved hydraulic performance.
- Minimal loss of pipe diameter and no grouting requirement when compared to traditional sliplining techniques.
- Liner can be selected to provide either full structural integrity or semi-structural stability depending on the condition of the host pipe.
- Cutting and reinstatement of service connections can be done remotely with robotic equipment reducing surface excavations.

- Some liners can be used in host pipes with bends up to 45°, with some internal wrinkling.
- Site-folded technique is less sensitive to the variations in diameter or pipe with dimensional irregularities, when compared to the diameter reduction technique.

Disadvantages:

- Folding and re-rounding process of the liner may affect the long-term pressure capability of the liner.
- Sometimes, the reversion process may not be completed fully.
- The liner may move in relation to the host pipe due to stresses that may be developed in the liner (e.g., due to thermal expansion or contraction).
- Liner cannot be used in bends of more than 45°.
- Host pipe needs surveying, cleaning, and preparation.
- For full structural applications, the folding and re-rounding process of the installed liner must be carefully monitored to avoid long-term liner problems.
- Pre-grouting may be necessary in damaged areas or where there are voids.

11.11.5 Cured in Place Pipe (CIPP)

CIPP is frequently referred to as in situ relining. A fabric tube is impregnated with a thermosetting or ambient-cured polyester or epoxy resin before being inserted into the host pipe. The resin is then cured to produce a rigid pipe within the host pipe. The combination of the fabric material, with or without fibres, and the resin can be designed to produce a new pipe that has full structural capabilities or semi-structural capabilities. The fabric material to be used can be tailored in the factory to suit the diameter of the host pipe. Non-circular sections can also be lined if required. CIPP liners can also negotiate 90° bends within the host pipe.

There are three main groups of CIPP systems. These are available independently or in combination: felt-based, woven hose, and membrane systems. All three are usually installed by inversion, in which the liner is fed through the host pipe and turned inside out by water or air pressure. Some CIPP liners can also be installed by winching the liner through the host pipe and then inflating it.

Advantages:

- Installation is relatively fast with minimal excavation required.
- Access to the sewer is normally gained from an existing access hole.
- Variety of different resins to suit the application.
- The system can accommodate very long lengths as well as a variety of diameters and can negotiate bends.
- Service connections can be reinstated by robotic cutters, reducing excavation requirements.
- It fits in very tightly to the host pipe, and resists thermal expansions or contractions.
- An improved interior friction coefficient usually increases hydraulic capabilities.
- It can be used in structural, semi-structural, and non-structural applications.
- CIPP is widely available.

Disadvantages:

- The host pipe needs extensive surveying, cleaning, and preparation.
- Sizes smaller than 100mm or larger than 600mm have greater difficulty of installation.
- Partial buckling and/or ovality may occur during installation.

- For full structural applications, liner preparation and installation processes must be carefully monitored to avoid long-term liner problems.
- Pre-grouting may be necessary in damaged areas or where there are voids.

11.11.6 Pipe-bursting

Pipe bursting is a trenchless technology that replaces a sewer by breaking and displacing the existing pipe and installing a replacement pipe in the void created. The system uses a pneumatic, hydraulic, or static bursting unit to split and break up the existing pipe, compressing the materials into the surrounding soil as it progresses. The new replacement pipe is simultaneously pulled or pushed with the bursting head to fill the void created. It is possible to upsize to about 30 percent greater than the diameter of the existing pipe, but this depends on soil conditions, the proximity of other existing structures, and the depth of cover. The replacement pipe must be installed in one continuous length and, as such, butt-fused PE pipe is used in most cases. Service connections and other appurtenances connected to the sewer to be rehabilitated must be excavated and exposed before starting the pipe bursting. As well, all pipes and underground structures within one metre of the sewer to be rehabilitated by bursting must be excavated and exposed to avoid damage due to the forces transmitted through the soil during the pipe-bursting process.

Advantages:

- Cleaning of the existing pipe is not necessary.
- A larger diameter pipe can be inserted. This, in conjunction with the improved interior friction coefficient, can substantially increase the hydraulic capabilities of the new sewer.
- Provides for full structural rehabilitation.
- Most successful when there are long runs with few connections.
- Continuous pipe (HDPE) or discrete, joined pipe, such as PVC or DI can be used.

Disadvantages:

- Pit excavations are normally required to accommodate the replacement of pipe sections.
- All sewer appurtenances must be excavated before bursting, and reconnected to the new sewer afterward.
- All underground structures within one metre of the existing sewer to be rehabilitated must be excavated to avoid damage that may occur due to the force being transmitted, and the displacement of soil, by the bursting technique.
- Any rigid obstructions in the host pipe bedding will deflect the new pipe.
- This method is not recommended where grade is critical.
- Ground surface heaving can occur if the depth of cover is too little.

11.11.7 Horizontal Drilling

Horizontal drilling, frequently referred to as HDD (horizontal directional drilling), consists of several stages for installation. First, a pilot bore is made with a suitably sized drilling rig. The bore is steered to create an initial hole at the required line and grade. Successive reamers are then pulled back to enlarge the hole diameter to the desired size. During the last stage of the reaming, the service pipe is pulled back into the bore. This method is primarily employed when an open cut excavation is completely unsuitable (e.g., at a railway crossing) and a new sewer alignment is desired. Most sewer force mains installed by this method are continuously welded PE pipe, although

steel, ductile iron and PVC have also been used. Gravity sewer installations are also possible.

Advantages:

- Reduced disruption to surface operations, such as major thoroughfares, railway tracks, rivers, buildings, and trees.
- Less disruption to buried infrastructure compared to the open cut method.
- Allows for a new sewer alignment.
- Usually has lower restoration costs compared to the open cut method.

Disadvantages:

- Exact pipe alignment can be difficult to attain, although still fairly accurate.
- Cobble and gravel seams might cause difficulties during the pilot bore and pullback stages.
- On large installations, large quantities of drilling mud are used creating the potential risk of frac-out and costly slurry management actions (i.e., recycling, containment, and disposal).
- HDD requires consistent and good soil conditions (e.g., firm clay, boulderless cohesive tills) for good performance.

11.11.8 Internal Joint Seals

Internal joint seal make the inside surfaces of leaking concrete pipe joints watertight. This technique is primarily used in pressure applications, such as force mains or water mains. The seal's flexibility ensures a bottle-tight seal around the entire pipe joint, while its low profile and graded edge allows water to flow without creating turbulence. Internal joint seals are made of EPDM a synthetic rubber. This technique requires people to access the sewer to perform the work and, as such, pipe diameters of sufficiently large size are good candidates for this technology. Internal preparation of the pipe is really critical for internal joint seals to perform to specifications. Complete pipe preparation is appropriate for the working environment of the workers. The pipe joints must be completely cleared of debris and dust. Complete preparation of the area on either side of the joint is also required to accommodate the lip of the seal. Once the cleaning is completed, a cement grout is used to fill the joint gap completely and made flush with the internal surface of the sewer. Next, the area must be cleaned with a dry brush and coated with a lubricant soap compatible with the type of seal being used. The lubricant soap is only an aid for installing the seal. The seal is then placed in position, spanning the gap. Stainless steel retaining bands are then installed in the grooves of each seal. A hydraulic expanding device is used to apply the correct pressure to the retaining bands, thereby keeping the seal in place.

Advantages:

- Technology is specific to pipe joint issues only.
- Minimal working space is required at the surface.
- A low-cost alternative.

Disadvantages:

- Can only be used in pipe sizes suitable for human access.
- Does not address other possible pipeline deficiencies.
- Bypass pumping is required.

11.11.9 Panel or Section Insert Liners

Panel or section insert liners are used only where person entry to the sewer is available. Various materials can be used, but GRP (glass reinforced plastic), GRC (glass reinforced concrete) and Ferro-cement are primarily designed for this type of application. When panels are used, they are designed to form a close fit, with fixed spacers, then grouted in place. The panels are relatively light and are designed to pass through access holes. Larger diameter sewers can be lined with sections rather than panels. These would be carried into the pipe and joined in situ. The sections should also be grouted in place.

Advantages:

- Technologies can be applied for structural or non-structural purposes.
- Liner can be designed to match the original host pipe diameter, thereby minimizing the loss in capacity.
- Liner can be effectively laid to a required grade as individual pipes can be fixed within the host pipe by spacers.
- Reduced infiltration.
- Minimal disruption at the surface as access can take place from existing access holes (manholes).

Disadvantages:

- Bypass pumping is required.
- Labour-intensive technology.
- A loss of cross-sectional diameter in the existing pipe due to the installation of the panels or sections and the grouting space required.

11.11.10 Chemical Grouting

Chemical grouting is a technology primarily used for spot repairs to seal joints and non-structural cracks. Chemical grouting reduces or stops water infiltration and exfiltration. The chemical grout builds up an external, flexible, and impermeable mass in the soil surrounding the spot repair location. Chemical grouting is used primarily for cracks in pipes, at leaky joints, and in access holes. One of the main benefits of grouting includes the fact that sections of sewer can remain in service during the rehabilitation process.

Advantages:

- Cost-effective method to stop water infiltration by filling voids and sealing fissures in fractured soil.
- Can prevent future structural damage.
- Chemical grouting is effective when used with other technologies.

Disadvantages:

- Application is restricted due to potential harmful effects.
- Potential of ground water pollution (selection of grout type is a major consideration).
- Does not provide structural repair.

11.11.11 Full Tunnelling and Micro-Tunnelling

Full tunnelling and micro-tunnelling are techniques normally used for very deep installations. Although primarily used for new installations, applications have been included for rerouting existing sewers. Experts in this field should be engaged for application of this technology. Full tunnelling is a construction method of excavating an opening beneath the ground without continuous disturbance of the ground surface and of sufficient diameter to allow individuals to access and erect a ground support system

at the location of the material excavation. Micro-tunnelling is different than full tunnelling in that the process uses a remotely controlled boring machine combined with the pipe jacking technique to install pipelines directly.

Advantages:

- High level of accuracy due to the laser-guided installation.
- Non-human entry reduces safety considerations (micro-tunnelling).
- Continuous tunnel support. Micro-tunnelling is suitable in unstable ground conditions.
- Method is applicable in deep sewer installations.

Disadvantages:

- Tunnelling needs a minimum depth of cover.
- A tail tunnel is required for effective spoil removal (full tunnelling).
- Expensive for short stretches.
- Extensive geotechnical information is required.
- Potential exists for ground settlement.
- High-level operator experience is needed.

11.11.12 Auger Boring

Auger boring is the process of simultaneously jacking casing through the earth between two pre-sunk shafts while removing the spoil inside the encasement with a rotating flight auger. The casing supports the surrounding soil as spoil is systematically removed. As a general rule, auger boring has poor steering capabilities. There are two types of auger boring: track type and cradle type. The track type method consists of a track system, machine, casing pipe, cutting head, and augers. The boring operation is cyclic, as pipe segments and auger flights are added after a prescribed auger flight length is installed. No rotation is applied to the casing as it is jacked through the soil by hydraulic thrust rams located at the rear of the machine. Lubrication is used to reduce skin friction and to aid with soil cutting and transport. An additional common measure to reduce skin friction includes an over excavation in the order of 25mm to 50mm. Pipe diameters range from 200mm to 1200mm, and overall installation lengths are typically limited to 100 m.

Advantages:

- Technology is well established and widely available.
- Minimum surface disruption. Boring is suitable for road and railway crossings.
- Steel casing remains in the bore after the drilling operation is complete; it can be used as a conduit or as the host pipe.

Disadvantages:

- Steering capability is limited after installation is initiated.
- Cannot be used in loose sand and very soft clay/organic soils.

11.11.13 Pipe Eating

Pipe Eating is a technique based on micro-tunnelling, in which a defective pipe is excavated together with the surrounding soil. The micro-tunnelling shield machine will usually need some crushing capability to perform effectively. The replacement pipes are connected to the back of the tunnelling shield. The defective pipe may initially be filled with grout to improve steering performance of the shield machine. The pipe fragments can be removed by either vacuum excavation or by slurry pumping.

Advantages:

- This method permits in-line replacement and upsizing of sewers with reduced potential for disturbing paved surfaces or adjacent utilities.
- No fragments from the old pipe are left in the ground.
- Enables sagging sewers to be realigned.
- Some systems allow the wastewater to be pumped through the shield during installation, thus eliminating the need for a bypass.
- Steering is possible within limits, and can follow the alignment of existing pipe.

Disadvantages:

- Method is not suitable for the replacement of metallic or thermoplastic pipes.
- Can be costly in comparison with pipe bursting.
- Working space is needed above ground for ancillary construction equipment

12.0 Funding Mechanism

12.1 Government Grants

The following section provides an overview of grant programs that maybe used to finance water and sewer servicing of the Clairmont Corridor.

There are three funding programs that provide assistance to rural municipal water and wastewater infrastructure. These include: New Deal for Cities and Communities (NDCC), Alberta Municipal Infrastructure Program (AMIP), and the Alberta Municipal Water/Wastewater Partnership. Each program is discussed more fully below.

12.1.1 New Deal for Cities and Communities (NDCC)

The New Deal for Cities and Communities is a federal initiative introduced as acknowledgement of the increasing infrastructure pressures facing municipalities and in particular their current infrastructure debt (the backlog of capital infrastructure projects that are integral to a sustainable community plan) and longer term infrastructure requirements. It is anticipated that the program will provide municipalities with approximately $477 million over the five-year period of the program. The program will ramp up over the five-year period with $57 million allocated in the first year of the program while $191 million will be provided in the final year of the program. Distribution of funding is based upon the population of each municipality with the first three years of the program allocated based upon the population estimate for 2006. Distribution of the last two years of the program will be based upon census numbers that will be available in 2007.

The program is supported through the allocation of the federal gasoline tax. The funding will be provided over a five-year period beginning in federal/provincial fiscal 2005/2006. Funding will be provided in annual or semi-annual increments and can be spent over the life of the program according to local planning needs and priorities. While it is intended that all projects should be completed within the five-year period, allowances for completion of projects in progress at the end of the period will be considered. Funding under this program is intended to support the development of public transit systems, road rehabilitation, water and wastewater systems, storm drainage, solid waste management, community energy systems and community capacity building. There is no municipal cost sharing required on this program; however municipalities are expected to maintain their current level of spending on infrastructure before accessing NDCC funding. Further NDCC funding may not be used as the municipal share of funding projects on any other grant program. In special cases, NDCC funds may be used to top-up the funding source of a project when all other funding sources have been exhausted.

There are both Federal and Provincial reporting requirements associated with the NDCC program. Federal reporting requirements include submissions by the municipality of an “Integrated Community Sustainability Plan”, a detailed multi-year capital plan, project applications as well as descriptions and details regarding the outcomes achieved under the program. Provincial reporting requirements are similar to those being introduced for the new Alberta Municipal Infrastructure Program (AMIP), see below.

12.1.2 Alberta Municipal Infrastructure Program (AMIP)

Like NDCC the Alberta Municipal Infrastructure Program (AMIP) was introduced to as acknowledgement of the increasing infrastructure pressures facing municipalities. This program will provide a total of three billion dollars over a five-year period and is supported by Alberta's current level of prosperity. Grants totalling $600 million have been allocated to municipalities as of April 2005.

Funding will be advanced to municipalities following the signing of trust agreements and can be spent by municipality over the next ten years according to local planning needs and priorities. Distribution of funding is essentially on a per capita basis again with funding in the first three years of the program based upon 2006 population estimates and funding in the last two years of the program based upon census information available in 2007.

Funding will be provided over a five-year period beginning in the provincial 2005/2006 fiscal year. The program provides funding for "core infrastructure" and "other infrastructure" projects. Core infrastructure projects include roadways, bridges, public transit, water supply and treatment systems, wastewater treatment and collection systems, storm sewer drainage systems and facilities, emergency service facilities and vehicles etc. Other infrastructure projects include environmental energy improvements, solid waste management, other municipal buildings, other municipal infrastructure. The funding program permits projects already in progress to be eligible for AMIP funding. Funding can also be used as the municipal share of new projects under other Alberta Infrastructure and Transportation municipal support programs with the exception of ICAP program funding. Funding also does not require any cost sharing on the part of municipalities however municipalities are expected to maintain their current level of spending on infrastructure. Projects should be carried out by the private sector and furthermore justification must be provided and approval received to use funds on project awards that are other than lowest price. Where municipalities wish to undertake a project using their own forces a economic analysis is to be provided that substantiates a lower more cost effect project.

There are unique provincial reporting requirements associated with AMIP funding that include: the development of an infrastructure management plan that provides an assessment of all municipally owned infrastructure, submission of a project profile containing general project information, submission of an application for program acceptance, provision of a multi-year capital infrastructure plan, a statement of funding and actual grant expenditures each year.

12.1.3 Alberta Municipal Water / Wastewater Partnership

This continuing program ensures that Albertans have access to safe water supplies and adequate wastewater treatment. Funding is provided to cities under 45,000 population, towns, villages, summer villages, regional commissions and eligible hamlets within rural municipalities.

Project eligibility includes construction of high-priority water supply and treatment and wastewater treatment and disposal facilities. Water projects may include planning and/or design studies, general municipal infrastructure planning studies, raw-water intakes and wells, raw-water supply lines to storage facilities, raw-water storage facilities, raw-water supply lines to treatment facilities, water treatment facilities, treated-water supply lines to the distribution system and treated-water storage facilities. Wastewater

project may include planning and/or design studies, general municipal infrastructure planning studies, sewer outfalls and, wastewater treatment facilities.

Projects not eligible for assistance include water distribution and/or sewage collection systems. All services, material and equipment engaged on projects must be from the private sector. Projects must also be assigned on the basis of lowest tender price. Project costs not eligible for funding include municipal labour, equipment and administrative costs.

Funding is allocated as a percentage of eligible approved project costs. For those municipalities under 1,000 population, projects are cost shared on a 75% Government/25% municipality basis. For communities over 1,000 population (to a maximum of 45,000 population), grant percentage ratios are calculated by a formula. The percentage ratio declines as the population increases.

Municipalities apply for funding on a project-by-project basis. In some cases, funding can be provided for regional facilities (serving more than one municipality) where a regional concept is more cost-effective and environmentally sound than a stand-alone system. Regional water systems receive 10 percent more funding. Funding approval may also be allocated on a priority basis. Priorities ranked from highest to lowest include: health related improvements involving water treatment or water supply; environmental protection improvements related to wastewater treatment; system improvements related to safety, fire protection and operational improvements.

After approval of projects municipalities may be provided with an advance payment representing a portion of the estimated grant. The final payment on grants will be provided upon completion and verification of final project costs. Transportation and Infrastructure must be kept informed of project progress and must receive written notification by the municipality when the project is nearing approximately 80% of completion.

Regional water projects approved for funding in 2004, as of December 31, 2004, include the Clairmont Regional Water Line-Preliminary Engineering and Location Study and the Clairmont Regional Water Line.

12.2 Infrastructure Charge Fees

12.2.1 Introduction

Aquatera and the County of Grande Prairie County No. 1 is considering charging a development levy to fund growth related water and sewer infrastructure for the development area surrounding Clairmont. The development infrastructure charges would be charged to all developments that require new or expanded water or sewer services. The development levy would be charged to the developer at the time that the development connects to an Aquatera water or sewer service. As a result Aquatera/ County of Grande Prairie No. 1 would be required to front-end construction of water and sewer infrastructure facilities in the new growth area in anticipation of future development.

This section of the report considers the development of development infrastructure charge used to recover water and sewer infrastructure constructed by Aquatera/County of Grande Prairie No. 1 to support service growth. This report describes future growth areas, the infrastructure required to service these areas, the development levy required

to recover infrastructure investments as well as the impact of infrastructure front-ending on Aquatera/County of Grande Prairie No. 1.

12.2.2 New Growth Service Area

The development areas that benefit from new water and sewer infrastructure are 3,460 net ha. for the water development area and 3,351.78 net ha. for sewer development area.

Water infrastructure (distribution system and reservoir) will serve the water development area equally - all water infrastructure costs will be applied in equal fashion over entire water development area. Though we have identified 18 sub-areas all water development charges will be the same for each area. Sewer infrastructure (sanitary trunks, forcemains, and lift stations) provides differential benefit to various sub areas within the sewer development area - some sewer infrastructure will be applied to some development areas and not to others. For purpose of identifying this differential benefit we have divided the sewer development area into 24 sub-areas.

12.2.3 New Growth Service Area Land Use

Development within the new grow service areas can take various forms which will directly impact the demand for water and sewer services. The estimated future development will categorize all new grow service areas into residential, general industrial/commercial, heavy industrial highway industrial/commercial and school site land use classifications. The following summarizes the land use classification for the sewer development areas. Land use classification of the sewer development area is summarized in Table D-1 in Appendix D attached.

Classification	**Sewer Development Area (ha.)**
Residential	1,318.98
School	5.11
General Industrial / Commercial	1,462.22
Heavy Industrial	138.99
Highway Industrial / Commercial	426.48
Total	**3,351.78**

12.2.4 Sewer Demand Factors

As previously stated differences in land use will results in variations in demand for sewer services. That is, a hectare of residential development will require different sewer service support than a hectare of highway industrial/commercial development. The following table outlines sewer demand factors for each land use classification defined earlier. The table considers sewer service demand based upon developments relationship to residential development sewer service demands. For example a hectare of residential development is provided with a sewer demand factor of 1, while a hector of general industrial/commercial land development is considered equivalent residential development demand and a hectare of highway industrial/commercial development is considered to have 2.6 times the sewer service as a hectare of residential development.

Classification	Sewer Demand Factor
Residential	1.0
School	1.0
General Industrial / Commercial	1.0
Heavy Industrial	2.0
Highway Industrial / Commercial	2.6

12.2.5 New Growth Area Sewer Infrastructure

Table D-2 in Appendix D outlines sewer related infrastructure required to support growth in the new growth service area. Sewer infrastructure totalling $58.9 M includes trunk sewers, forcemains, lift stations and lagoon. Trunk sewers, forcemains and lift stations provide benefit to designated areas whereas the lagoon like water infrastructure provides benefit on a area wide basis. Individual sewer projects have been earmarked specifically to support development sub-areas as previously described.

12.2.6 New Growth Area Sewer Service Development Infrastructure Charges

Based upon the growth service areas as defined, projected land uses, related service demand factors for sewer we have developed sewer development levy rates to recover growth area sewer infrastructure costs. The infrastructure charge rates have been developed assuming that sewer infrastructure may benefit development sub-areas differently—multiple basins are used to calculate development infrastructure charges. Table D-3 in Appendix D outlines the sewer connection rates that are applicable for each development area. The average rates for each land use are outlined as follows:

Classification	Average Sewer Development Infrastructure Charges
Residential	$13,753.81
School	$12,183.90
General Industrial / Commercial	$14,128.04
Heavy Industrial	$38,260.10
Highway Industrial / Commercial	$34,448.29

Table D-4 provides a listing of infrastructure that benefits each sewer sub-area. Each sub-area benefiting from an infrastructure component is highlighted with a “1”.

Again it should be noted that the above rates are based upon immediate construction and full development of the area. If construction or development is staged over a number of years front ending carrying costs will further add to the rates. In order to deal with front ending impacts we believe that sewer developments infrastructure charges should be increased as follows.

Classification	Sewer Development Infrastructure Charges per Net ha.
Residential	$22,000.00
School	$19,488.85
General Industrial / Commercial	$22,598.61
Heavy Industrial	$61,199.22
Highway Industrial / Commercial	$55,102.02

We will discuss the impact of variations in construction and development timing further in our report.

12.2.7 Impact of Service Connection Rates on Aquatera

We have considered the impact of front-ending construction and subsequently collecting service connection fees on Aquatera/County of Grande Prairie No. 1 finances. Front-ending growth related infrastructure can be onerous to a utility/municipality particularly when significant infrastructure must be front-ended and when related development recovery is slated to occur over a lengthy period. These circumstances appear to exist for the development areas in our study. In order to permit area growth significant infrastructure investment is required near immediately. Over a 5-year period, from 2006 to 2011, Aquatera/County of Grande Prairie No. 1 will make over $16.6 M in water related infrastructure disbursements and $35.5 M in sewer infrastructure disbursements (total $52.1 M in water and sewer investments) to serve development in the new growth area.

In our analysis we have assumed that growth in the service area will be accomplished over a 30 - year period or approximately 115 ha. of development each year. Our analysis assumes that both water and sewer development infrastructure charges will be increased (inflated) by 5% per annum in order to keep pace with inflation on construction costs which are also projected to increase by 5% per annum.

Table D-5 in Appendix D provides a cash flow analysis of sanitary related development charge receipts and infrastructure disbursements. The cash flow model also considers interest on cash/debt balances over the review period. Interest on fund balances is earned at 5% whereas interest on debt balances is paid at 7%.

As indicated in Table D-5, the early need to construction infrastructure results in an immediate fund deficit that must be front ended by Aquatera/County of Grande Prairie No. 1. The period between 2006 - 2030 requires major disbursements for sewer infrastructure resulting in a deficit of $26.4 M in 2010. This deficit decreases through recovering development infrastructure charges resulting in a year 2019 breakeven situation. The graph below further illustrates that in 2025 a forcemain from existing Clairmont lagoon to the City treatment plant will be required which decreases the wastewater infrastructure balance to a near breakeven situation. As shown in the table, given assumed development rates this deficit should be recovered by 2019. At the conclusion of sanitary infrastructure full buildout in 2030 a positive fund balance of $57.9M will result.

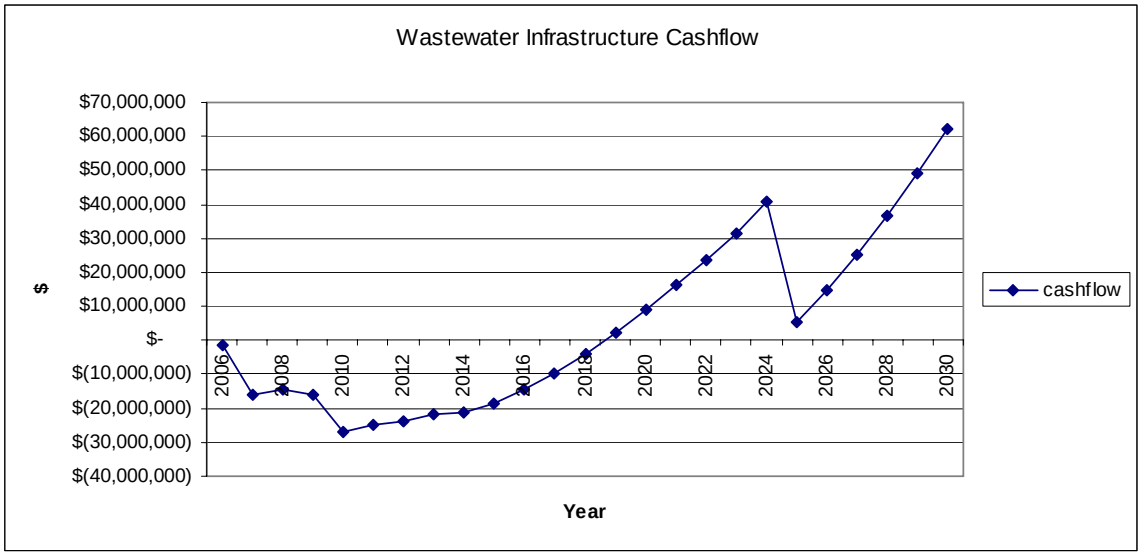
We have also considered the financial impact of water and sewer proceeds and disbursements jointly. The timing of expenditures of the two funds are at times complementary and reduce front ending impacts. Table D-6 shows the financial impacts of receipts and disbursements on a combined water/sewer basis. As shown in the graph below, the largest magnitude of the overall front ending deficit occurs in 2010 at $38.8 M deficit. By the time development of sanitary and water full buildout has concluded in 2030, the fund will have amassed a surplus of $59.1 M.

12.2.8 Sensitivity Analysis of Development Infrastructure Charges

During the course of our review we considered changes to various factors which might influence financial impacts on Aquatera/County of Grande Prairie #1. In this regard considered the impact of maintaining the timing of infrastructure construction and residential development but lengthening the time to fully development industrial sites from year 2035 to 2045. The impact on sewer development charges is outlined in the table below:

Classification	**Sewer Development Infrastructure Charges per Net ha.**
Residential	$27,000.00
School	$23,918.13
General Industrial / Commercial	$27,734.65
Heavy Industrial	$75,108.13
Highway Industrial / Commercial	$67,625.20

The following graph outlines the resulting front ending impact on Aquatera/County of Grande Prairie No. 1.



On a combined water and sewer basis the impact is very similar to that presented for a 30 - year ultimate development.

The year of breakeven was also further investigated for sensitivity. As illustrated in Table D-7, varying the breakeven year from 2015 - 2035 results in residential sewer infrastructure charges from $32,000/ha to $15,700/ha respectively. Choosing a breakeven year requires balancing financial impacts by Aquatera/County of Grande Prairie No. 1 while providing affordable rates to accelerate future development.

12.2.9 Development Infrastructure Charges Rate Conclusion

As indicated earlier, front-ending development infrastructure can be onerous to a utility particularly where front-end investments are large and when infrastructure recovery is slated to occur over an extended period. It is our opinion that given regular rate increase to offset rising construction costs, the respective infrastructure charges presented in the below table will fully recover sewer infrastructure investments, within the year 2019. Breakeven in 2019 is based on sewer infrastructure buildout completion in 2030 and full residential and industrial development by 2035.

Classification	**Sewer Development Infrastructure Charges per Net ha.**
Residential	$22,000.00
School	$19,488.85
General Industrial / Commercial	$22,598.61
Heavy Industrial	$61,199.22
Highway Industrial / Commercial	$55,102.02

It should be noted that the most significant infrastructure investments will occur in the 2025 time frame. This timing provides an opportunity to review development needs and the strength of development and determined whether these major investments should be incurred or deferred.

13.0 Conclusions

In order to calibrate the wastewater model, flow monitoring data will be required at the following locations. These flow monitoring sites are shown on Figure A in Appendix C.

The report has the following conclusions:

- Design criteria for three new types of land use including heavy industrial, general commercial and school were proposed. These new design criteria will enhance the design of the wastewater collection and disposal systems.

- The per capita wastewater flow was determined from three months of water billing records in the spring. Although the wastewater flow is generally lower than the water demand, it was proposed that the per capita wastewater flow to be 275 L/s which happen to be identical to the per capita water demand for the following reasons:
    - The water records in the spring which used in the determination of the per capita flow do not include water used for miscellaneous purposes like watering lawns, cleaning streets or flushing fire hydrants etc. On the basis of the available data, the estimated per capita flow is approximately 266 L/s. Generally, the wastewater flow in summer will be slightly higher that the wastewater flow in the spring. Since there is no flow monitoring data available for the assessment and the current design standards per capital wastewater flow of 275 L/s appears to be working very well for the design of the wastewater system, the current per capita wastewater flow which equivalent to the current per capita water demand was adopted. The design criteria for the per capita wastewater flow can be re-assessed and adjusted when flow monitoring data is available.
    - The higher per capita wastewater flow can be considered to provide the wastewater system with a higher factor of safety. Also, if the actual flow is less than the design flow, the wastewater system will provide a longer service life.

- Among all options for the disposal of the wastewater from the lagoon, discharging the effluent into the future 116 Street sanitary trunk sewer would be the preferred option. This option will require that the existing Aquatera Wastewater Treatment Plant be upgraded to accept the flow from the study area. A feasibility study to determine the upgrading requirements and the associated upgrading costs should be carried out prior to the implementation of this option.

- The servicing options for the study areas are discussed in Section 8.0 and was developed taking due consideration of the constraints in topography and the layout of developments and the servicing concept as shown in the proposed Area Structure Plans. The design of the upgrading of the Crossroads North trunk, Lakeside Trunk and the North regional Lift Station and the Regional Forcemain should be evaluated prior to finalizing the ultimate servicing options for the drainage areas.

- Since the commercial and industrial developments in the study area have large size of lots and the use of some of the lots may have a very small flow, a flow monitoring program should be implemented to assess the upgrading

requirements of the trunk sewers and update the proposed staging and interim servicing plan.

- The Master Plan is conceptual in nature and based on the best information available at the time of the study in 2005. As a result, a more detailed study may be required prior to the implementation of the recommendations.

- This Master Plan should be updated every 5 years in accordance with the new information and growth potential.

14.0 Recommendations

The study has the following recommendations:

- Adopt the proposed design criteria as the County of Grande Prairie design standards.
- Upgrade the existing lagoon immediately and carry out an investigation to select the most favourable disposal option.
- The design of the Regional Lift Station (#8) and forcemain should be carried out as soon as possible.
- Implement a flow monitoring program to continuously assess and update the upgrading requirements.