CANADIAN CONSULTING ENGINEERING AWARDS 2012

WINDSOR RIVERFRONT RETENTION TREATMENT BASIN

CATEGORY: WATER RESOURCES
PROJECT OWNER: CITY OF WINDSOR
SUBMITTED BY: STANTEC CONSULTING LTD.

Stantec

Executive Summary

Combined sewer overflows (CSOs) are recognized as a serious environmental issue facing many major cities and communities in North America. CSOs are a significant source of pollution that contributes to environmental degradation of our lakes and rivers. Reducing and eliminating CSOs presents an enormous challenge in terms of complexity and cost.

The Detroit River is identified by the Canada and United States International Joint Commission on Great Lakes Water Quality (IJC) as an area of concern (AOC) in the Great Lakes basin. To address this concern, the City of Windsor developed and implemented a long-term pollution control strategy with the specific objective of reducing CSOs and total pollutant loadings into the Detroit River. The strategy included the implementation of a high-rate retention treatment basin (RTB) to collect and treat CSOs generated along the old riverfront and downtown district.

Stantec was retained by the City of Windsor to prepare and guide the proponents through a very long, challenging, and extensive planning and environmental assessment process, followed by the development of a practical and cost effective solution; and once funding became available from both levels of Provincial and Federal Governments via the Infrastructure Stimulus Funding program, commissioned to prepare the detailed design for tendering and oversee the construction to completion.

The implementation of the high-rate RTB project has fulfilled a key recommendation of the City of Windsor's Pollution Control Plan in a practical and cost-effective manner. Considering the high risks associated with designing and constructing the world's largest high-rate RTB (and believed to be the first of its kind) in an area having an inordinate number of site constraints with extremely tight time lines; the project can be considered a "screaming" success having been completed on time, on budget, and without litigation.

Extensive Cooperation Promoted Innovative Solutions

Development of the Windsor high-rate RTB project was a large, complex, highly innovative project that required many years of preliminary work and an unusually high level of cooperation between the City, Stantec, various Provincial and Federal government agencies and Academia.

In cooperation with the University of Windsor, local CSO discharges were analyzed and an effective treatment process developed. This process entailed characterizing CSOs, determining optimum chemical treatment levels, and then developing a dosing strategy to meet real world requirements. At each stage of the process, the University provided the scientific input to support Stantec's engineering.

This cooperation led to a significant technological advancement with the establishment of innovative and unique design criteria for designing and constructing high-rate RTB facilities that require only 15% of the footprint of a conventional RTB facility thus offering substantial cost savings to the City of Windsor.

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Complexities Resolved

The Windsor Riverfront RTB project presented many of the challenges and complexities associated with developing, designing, and constructing a very large treatment facility in a very tight, highly visible, and publicly sensitive area within a relatively short period of time.

Faced with a huge amount of issues and obstacles during all facets of the project stemming from complexities and challenges with regulatory requirements, treatment processes, site constraints, detailed design, and finally construction, the project team of the City of Windsor, Stantec with their subconsultants and the University of Windsor, and many Contractors, was highly successful in resolving these challenges despite many serious and formidable problems that arose from unanticipated encounters during construction.

Positive Impacts

The Windsor Riverfront RTB project has been instrumental in improving the water quality of the Detroit River and Great Lakes by eliminating a significant portion of Windsor's untreated sewage discharges into the river while complying with Ministry of Environment Guidelines Procedure F-5-5 and addressing the Canadian component of this AOC. Water quality and ecosystems have also been greatly improved along the riverfront with major shoreline improvements and creation of fish habitat.

The smaller footprint of the high-rate RTB facility also eliminated community concerns regarding the visual impact on the riverfront lands while the higher quality discharge satisfies the concerns of downstream stakeholders.

The project has enhanced the City's riverfront amenities to the public and provided the community with an inviting, environmentally-friendly area consistent with the strategies and design guidelines set out in the City's Central Riverfront Implementation Plan.

The project was also instrumental in providing an immediate stimulus to the local economy through job creation as a result of the large-scale, intensive construction activities, and implementation of a government infrastructure stimulus program.

Extensibility

The Windsor Riverfront RTB project is recognized as a showcase to other Great Lakes communities on how to address environmental impairment and degradation stemming from CSOs in a feasible and economical manner and what can be accomplished through the combined efforts of all levels of government, educational institutions, and private consultants.

The successful development and implementation of an innovative space-saving and cost-effective high-rate RTB solution has not only fulfilled a major objective of Windsor's Pollution Control Plan but also instrumental in advancing the art of designing and constructing small footprint high-rate RTB facilities that can be deployed throughout the world.

Project Background

Faced with aging infrastructure and limited funds, many cities in North America are not able to adequately address environmental impacts created from the use of combination sewer systems typically found in the older areas of these cities.

A combination sewer system is a wastewater collection system that conveys a mixture of municipal wastewater and storm water runoff through a single pipe system to a wastewater treatment plant. During wet weather events, there may be insufficient capacity to convey all of the flow to the wastewater treatment plant (WWTP) and/or insufficient treatment capacity at the wastewater treatment (WWTP) resulting in the excess flow to be discharged directly into our waterways, rivers, and Lakes untreated. These discharge events are referred to as Combined Sewer Overflows (CSOs) and are recognized as significant sources of pollution that contribute to environmental degradation.

The Detroit River separates the border cities of Windsor, Ontario and Detroit, Michigan and has been identified by the Canada & United States International Joint Commission on Great Lakes Water Quality (IJC) as an Area of Concern (AOC). An AOC is a location where there are specific beneficial use impairments due to environmental degradation. Windsor has many older areas that are still serviced by combined sewer systems which frequently overflow into the Detroit River thus contributing to the impairment of the Detroit River and Great Lakes. Although these CSOs represent less than 5% of the total annual volume discharged into the Detroit River, they do, however, contribute to over 27% of the total annual solids load.

In 1992, the City of Windsor initiated a Pollution Control Plan (PCP) study along the old riverfront district with participation and funding assistance from provincial and federal governments via the Great Lakes Sustainability Fund. The district comprises a land area of approximately 8,200 acres serving a population equivalent to 100,000 persons including residential, commercial, and industrial development.

Source: Environment Canada

WINDSOR RIVERFRONT RETENTION TREATMENT BASIN

CATEGORY: WATER RESOURCES PROJECT DESCRIPTION

Stantec Consulting Ltd. (Stantec) was retained to develop an overall pollution control strategy with the specific objective of reducing CSOs and total pollutant loadings into the Detroit River while complying with Ministry of Environment Guidelines Procedure F-5-5. Completed in 1999, the PCP Study identified CSOs to the Detroit River as being a significant source of pollution and presented alternative CSO control strategies while establishing the preferred pollution control plan with the following four recommendations:

1. Increase pumping capacity at the Caron Avenue Pumping Station (CAPS).
2. Provide additional primary treatment capacity at the Lou Romano Water Reclamation Plant (LRWRP) to treat wet weather flows.
3. Provide three satellite treatment facilities known as retention treatment basins (RTBs) along the Windsor riverfront east of CAPS.
4. Provide tunnel storage or possibly RTBs west of CAPS.

In 2001, Stantec commenced the detailed design of CAPS and LRWRP Upgrades. Following construction, pumping capacity at CAPS was increased in 2003 from 265 MLD to 322 MLD at a capital cost of $4.5 million so that spare capacity in the downstream sewer collection system could be fully utilized. Construction of the LRWRP Upgrades took place during the period 2003 to 2011 and resulted in a primary treatment facility having a capacity of 189 MLD being converted into a secondary treatment process having an increased capacity of 265 MLD at a capital cost of $115 million.

As part of implementing the RTB treatment facility recommendation along the riverfront east of CAPS, Stantec carried out a CSO Treatability Study in partnership with the University of Windsor to help characterize CSO pollutants along the riverfront while assessing RTB treatment options to meet OMOE F-5-5.

At the same time, Stantec carried out a Class Environmental Assessment to establish the preferred means of implementing CSO control. The resulting Environmental Study Report and functional design was completed in 2008 establishing the preferred solution as the construction of a series of new CSO Interceptor Chambers, CSO Collector Sewer, and one High-Rate RTB Treatment Facility along the old riverfront east of CAPS.

WINDSOR RIVERFRONT RETENTION TREATMENT BASIN

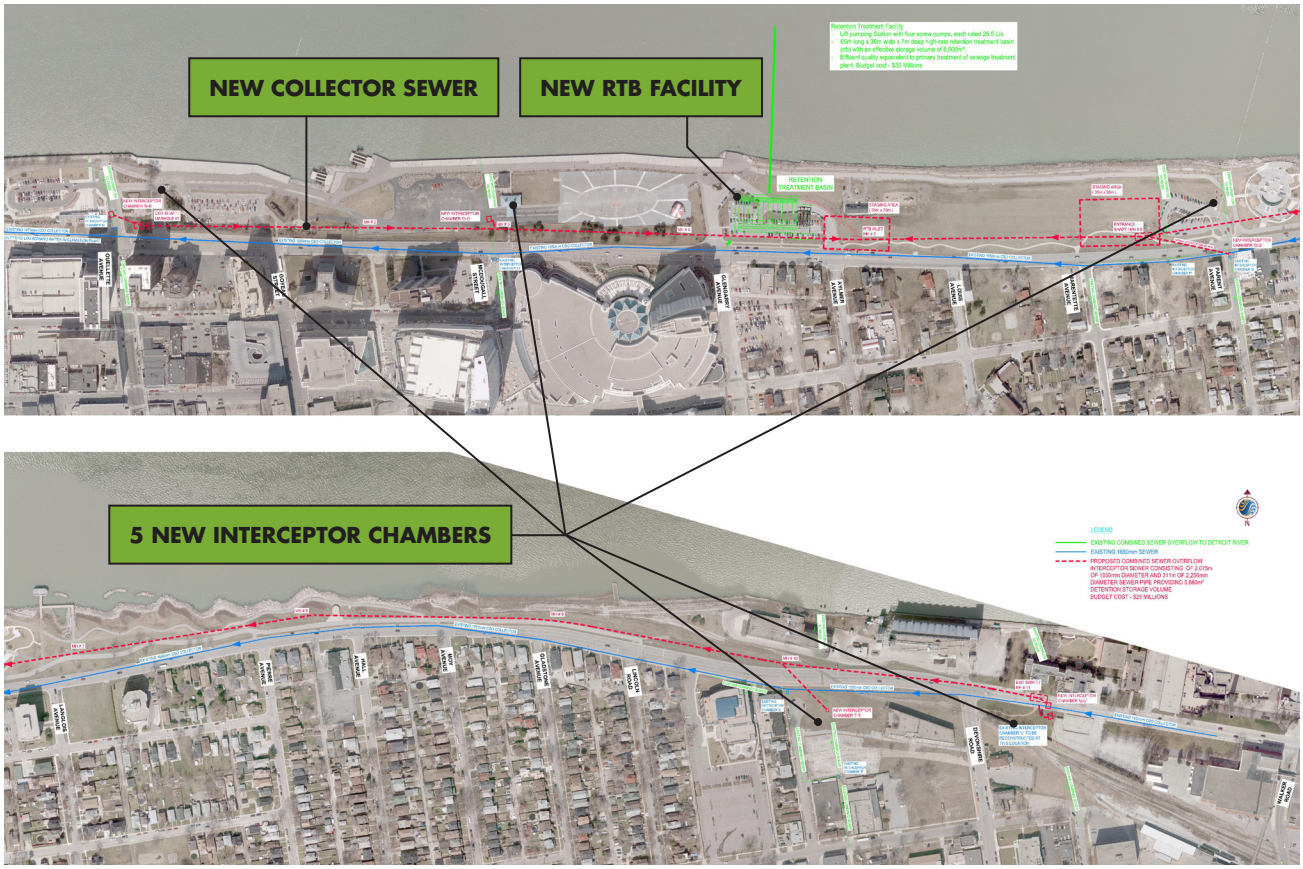
CATEGORY: WATER RESOURCES

PROJECT DESCRIPTION

Stantec commenced detailed design of the high rate RTB facility, CSO Collector Sewer, and CSO Interceptor Chambers in mid-2009 with construction starting in late 2009 and finishing in late-2011 at a capital cost of $66 million with two-thirds funding coming from Federal and Provincial governments through Infrastructure Stimulus funding programs.

To date, three of the four recommendations of the CSO Pollution Control Plan have been implemented and in operation with the exception of the last remaining recommendation being tunnel storage or RTBs west of CAPS. Total capital costs to date stand at approximately $186 million.

This award submission focuses on the third recommendation of the CSO pollution control plan; the provision of RTB facilities and associated collector sewer and interceptor chambers to capture and treat CSOs prior to discharge to the Detroit River.



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Innovations, Originality and Design Excellence

The development of the Windsor high-rate Retention Treatment Basin (RTB) was a large, complex, highly innovative project that required many years of preliminary work and an unusually high level of cooperation between the City, Stantec, various Provincial and Federal government agencies, and Academia.

Typically, RTBs are satellite treatment facilities that can be used at local discharge points to treat CSOs. They are self-contained structures designed to provide equivalent to primary treatment through separation of solids at relatively high flow-through rates. During mild storm events, all flow is captured and retained within a basin and then drained back to the sanitary sewer system following the storm event. With more intense storms, basin storage capacity is typically exceeded, following which the RTB acts as a flow-through device providing primary treatment prior to discharging into the receiving water body. Level of treatment varies with flow rate and pollutant characteristics.

In Windsor's downtown riverfront area, space to accommodate the construction of conventional CSO storage and treatment facilities is extremely limited and therefore, a space-saving and effective solution needed to be developed. To accomplish this, Stantec undertook an extensive evaluation of alternative approaches and concepts that eventually led to the selection of high rate RTBs as the preferred design for controlling CSOs along the old riverfront drainage area.

However, in order to implement the high rate RTB concept, considerable knowledge and technological advancements needed to be achieved, particularly in the area of design and operation of retention treatment basins of significantly smaller size than proven conventional RTB designs while achieving equal performance.

A significant portion of the advancement involved the selection and practice of using flocculants to assist in improving the solid/liquid separation process within small-footprint basins. Achieving these objectives provided the ability for a complete CSO treatment facility to be located in urban areas where conventional approaches were impractical while significantly reducing the amount of untreated sewage entering and polluting the environment.

Major specific technological objectives achieved for this project included the following:

1. Determination of efficacy of up-scaled pilot designs of small footprint RTBs for use in design and construction of full-scale high-rate RTB facilities with peak design surface overflow rates (SOR) of 20 m^3/m^2h.
2. Development of polymer feed system that can be automatically controlled in response to a CSO event.

As part of the evaluation for developing CSO control, both pure storage and conventional RTB options were examined by Stantec. For the pure storage option (i.e., no allowance for treatment so 90% of wet-weather flow must be stored and returned to sewer system), it was determined that storage tank size requirements approached ~482 Mega Liters (ML). For the conventional RTB option, it was determined that three (3) RTB structures using conventional design criteria having a total surface area of ~11,600 m^2 would be needed.

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The CSO Characterization and Treatability Study showed that CSOs contain a relatively high concentration of suspended material with poor settle-ability. Results of long column settling tests revealed that coagulant aid was needed to significantly enhance CSO settle-ability and achieve the required degree of suspended solids removal in a high rate RTB. From this study, it was concluded that provisions for chemical addition were to be implemented in the high rate RTB facilities along the Windsor Riverfront.

In order to further establish design criteria for full-scale high rate RTBs, bench and pilot-scale tests as well as computational fluid dynamics (CFD) modeling were carried out to evaluate the effectiveness of CSO treatment with polymer coagulation at high hydraulic loading rates of up to 58 m^3/m^2h.

Bench and pilot-scale field tests confirmed polymer addition significantly improved the settling characteristics of suspended solids leading to good solids removal. The tests also showed that high rate RTB facilities can be operated effectively at significantly higher surface overflow rates with reduced footprints.

CFD modeling was used to scale-up bench and pilot-scale results to full-scale and then used to evaluate preliminary designs of full-scale RTBs. This led to optimization of design criteria for inlet and outlet arrangements within high-rate RTBs in order to rapidly dissipate the high energy created during high overflow rates that lead to fast-settling in a full-scale operational setting.

Results of field testing and CFD work proved very useful in developing the design criteria for design of full-scale high rate RTB facilities that would comply with OMOE F-5-5.

A major technological challenge in the scale-up of high-rate RTBs was how to manage hydraulic conditions in a full-scale RTB operating at higher SORs. The pilot-scale studies found that hydraulic loading had a significant effect on performance upon process scale-up for full-scale design. The solution was to minimize the effects of turbulent mixing in the settling zone and re-suspension of sediment deposited at the bottom of high-rate RTB. This development led to further enhancement of the design criteria for full-scale RTBs.

A secondary challenge was automating the polymer dosing system as polymer dosage was manually controlled during pilot-scale study. For full-scale application, a unique polymer dosing process control system was developed that automatically responds to CSO events caused by both quick and intense storms as well as long and mild storms.

Technological advancements developed on this project have led to the establishment of an innovative and unique design criteria for designing and constructing high-rate RTB facilities that require only 15% of the space normally occupied by conventional RTB facilities sized using conventional design criteria developed for primary settling facilities. With the addition of polymer flocculation, the net surface area of the high-rate RTB facility constructed for this project was established at 1,400 m^2 based on a design SOR of 20 m^3/m^2h and peak flow rate of 680 ML. This advancement enabled Windsor to implement one high-rate RTB in place of three conventional RTBs on a very restrictive site and at considerable cost savings.

In conclusion, the successful development of an innovative space-saving and cost-effective high-rate RTB solution has not only fulfilled one of the objectives of Windsor's Pollution Control Plan but was also instrumental in advancing the art of designing and constructing small footprint RTB facilities that can be deployed throughout the world.

Project Complexity

The Windsor Riverfront RTB project presented many of the complexities and challenges associated with designing and constructing a very large treatment process facility in a very tight, highly visible, and publicly sensitive area within a relatively short period of time.

Site Complexities

The Windsor Riverfront is a narrow band of partially reclaimed land sandwiched between a major road and the Detroit River. The area is largely open green space and gardens with walking and cycling paths, but contains a myriad of challenges for siting an RTB facility.

The road is considered a scenic route as it parallels the river with an unobstructed view. On account of its location along an international border, these lands have served as a hub for transporting freight to and from the United States for over a century using an extensive network of railways. As the result, the lands are full of environmental issues and fish habitat restrictions that were addressed through extensive biological, geotechnical, and environmental testing and monitoring programs.

Source: Dan Reaume Photography

The Windsor Riverfront was also home to Native Indian settlements therefore having a high probability of discovering extensive artifacts or human remains, and contains documented registered archaeological sites and heritage resources. This presented considerable risk to the project requiring the undertaking of extensive archeological investigations, preservations, and public consultation in accordance with Canadian law to mitigate risk as much as possible.

The area is also extensively used by both Windsorites and visitors for recreational purposes including walkways and entertainment venues, such as a large, open-area theatres and the International Freedom Festival along with other summer events.

A major challenge was finding a suitable plot of land to contain the RTB facility with minimal archeological impact since the uncovering of a significant artifact could have the potential to cancel the project until another plot of land could be found. As a result, the RTB facility had to be constructed within a very tight location while maintaining the surrounding park-like amenities and unimpeded view of the river.

This was accomplished by designing the RTB structure below grade and covered with a parking lot while being accessible for operation and maintenance through dedicated sealed access hatches and removable concrete planking. This configuration enabled all site objectives to be realized while isolating the facility from public interaction.

Process Complexities

The development of a high-rate treatment process had to be specific to the CSO characteristics found locally. In concert with Stantec, the University of Windsor was able to contribute research facilities to test methodologies and develop models to meet treatment objectives and provide data to enable scaling up to a full-size facility.

Specific complexities included:

- Development of complex details of inlets and outlets for a full-scale RTB facility while keeping in line with concepts established during pilot-scale testing and CFD modeling. Prior to this project, it was unknown how to design inlets and outlets that would achieve fluid flow objectives identified in the CFD analyses and would be manufacturable and constructible in a short time period at reasonable cost.

  Through numerical simulation, the effects of various inlet arrangements on hydraulic performance were tested. The analysis indicated that double tapered influent channel with a series of weir-orifice combinations could achieve ideal hydraulic conditions for flow distribution, polymer flocculation, and liquid/solid separation. The full-scale RTB facility inlet design was finalized based on hydraulic analysis and constructability while maintaining even flow distribution under higher SORs up to the design objective of 20 m^3/m^2h.

  Pilot-scale and CFD model studies showed that an outlet system comprising a scum baffle, effluent weir, and effluent collection channel would provide superior hydraulic conditions and pollutant removal. The effluent weir with a serpentine, v-notch arrangement was evaluated and adopted to reduce weir overflow velocities and enhance solids retention in the basin to allow for more uniform distribution of effluent flow as compared to a rectangular weir found in conventional designs. A net settling area was evaluated for the full-scale RTB test facility by applying the design SOR of 20 m^3/m^2h which is approximately 10-25% of the size of RTB facilities sized using conventional design criteria for primary settling facilities with typical design SORs of 2-5 m^3/m^2h. This work has shown that the length of effluent weirs can't be reduced as much as the settling area. Since the test facility had limited space available for effluent weirs in the outlet area, various outlet arrangements were tested for full-scale based on CFD modeling results and cost-benefit analyses to ensure effluent weirs were constructible within the design objective footprint.

- Development of a complex polymer dosing control philosophy that would be compatible with commercially available polymer solution and handling equipment having a long reaction period and slow response but, at the same time, would be able to start up quickly in response to a CSO event. The equipment would also need to endure long periods of inactivity between CSO events and be able to deliver a diluted polymer solution with a low tolerance of equal or less than 0.2%. It was learned through this work that a solids analyzer would need to be employed in conjunction with the polymer equipment in order to pace polymer dosage to the pumping rate and actual influent TSS loading rate.

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Construction Complexities

The Windsor Riverfront RTB Project was implemented using a multiple contract approach to address requirements of the Infrastructure Stimulus Funding (ISF) program. This approach required Stantec to develop and implement complex staging and sequencing procedures to ensure all new works under separate contracts would connect and coincide with each other at the proper time. Special construction sequencing with temporary measures was required to redirect existing sewage flows during construction of the Interceptor Sewer and Interceptor Chambers. This sequencing required complex tie-ins to redirect flows during extended periods without interfering with the continued operation of the existing sewers.

The project was tendered in four contracts as follows:

1. Contract No.1A for Excavation of RTB Facilities undertaken in October 2009 and completed in February 2010
2. Contract No.1B for Construction of RTB Facilities undertaken in March 2010 and completed in October 2011
3. Contract No.2 for Construction of CSO Collector Sewer undertaken in February 2010 and completed in May 2011
4. Contract No.3 for Construction of CSO Interceptor Chambers undertaken in May 2010 and completed in October 2011

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Complex Monitoring Requirements

Managing and monitoring the construction of such a large complex undertaking spread over multiple contracts over a sensitive 4 kilometer area having a large number of restrictions and limitations imposed by biological, archeological, geotechnical, environmental, and public access conditions presented considerable and formidable challenges to the project team.

The use of innovative and complex construction technology such as special shoring systems, micro pile foundation systems, and tunnel boring machines required the development of complex monitoring programs in order to ensure compliance with specifications. All project team members conducted daily meetings to resolve construction issues and conflicts quickly in order to maintain project schedule.

Under normal conditions, this project would typically require 4 to 5 years to complete. To meet the very tight 24-month deadline imposed by ISF, Stantec developed a multi-contract approach to carry out the detailed design and administer the construction using a full complement of engineers, biologists, archeologists, inspectors, subconsultants, contractors, and suppliers while meeting all ISF and regulatory conditions.

All of the construction challenges were successfully met by the Stantec/City/Contractor(s) team despite many problems arising from unanticipated encounters during construction.

Complex Automation Requirements

The high-rate RTB is highly automated and essentially operates unmanned. The facility consists of 12 retention cells which are filled from an inlet channel via overflow weirs and evenly distributing the influent into the cells. The facility has a total storage capacity of approximately 11.8 ML including 5.9 ML in the new CSO Interceptor Sewer and will contain influent flows for small CSO events without discharging to the river. For larger CSO events, the facility provides equivalent to primary treatment prior to discharge into the Detroit River. Draining and flushing of the Interceptor Sewer and RTB facility are accomplished through flow control gates and interconnections to the existing trunk sanitary sewer and controlled via Caron Avenue Pumping Station.

Draining and flushing of the Interceptor Sewer and RTB automatically starts after a CSO event has ended. Flow in the existing trunk sanitary sewer and CAPS are monitored so that draining will automatically start and continue provided there is adequate capacity in the upstream and downstream trunk sanitary sewer to and from CAPS. Flow control gates are automatically controlled to regulate the drain rate into the existing sewers to match available capacity and prevent flooding of downstream facilities.

Environmental Impact

The Windsor Riverfront RTB project has been instrumental in improving the water quality of the Detroit River and Great Lakes by eliminating a significant portion of Windsor's untreated sewage discharges into the river while complying with Ministry of Environment Guidelines Procedure F-5-5 and addressing the Canadian component of this AOC. Water quality and ecosystems were also greatly improved along the riverfront as a result of major shoreline improvements and the creation of fish habitat.

The smaller footprint of the high rate RTB facility also eliminated community concerns regarding the visual impact of the riverfront lands while the higher quality discharge satisfies the concerns of downstream stakeholders.

The Windsor Riverfront RTB project is recognized as a showcase to other Great Lakes communities on how to address environmental impairment and degradation stemming from CSOs in a feasible and economical manner and what can be accomplished through the efforts of all levels of government, educational institutions, and private consultants.

Social and Economic Benefits

Social Benefits

By improving water quality and natural habitat in the Detroit River and Great Lakes; Windsor, Detroit, and downstream communities are further protected from the potential consequences of under-treated water for an improved quality of life.

Economic Benefits

The implementation of a high-rate RTB facility with its significantly smaller footprint compared to conventional RTBs resulted in an estimated $40 - $50 million savings to the City of Windsor in implementing CSO control east of Caron Avenue Pumping Station.

The project was also instrumental in providing an immediate stimulus to the local economy with job creation as a result of large-scale and intensive construction activities, and the implementation of a government infrastructure stimulus program.

Source: Dan Reaume Photography

Owner's Needs

The implementation of the high-rate RTB project has fulfilled a key recommendation of the City's Pollution Control Plan in an economical and cost effective manner. Considering the high risks associated with site constraints, construction difficulty, unknowns and time, the project was a screaming success having been completed on time, on budget, and without litigation.

The project has also enhanced the City's riverfront amenities to the public and provides an inviting, environmentally-friendly area consistent with the strategies and design guidelines set out in the City's Central Riverfront Implementation Plan.

Source: Dan Reaume Photography

Conclusion

Construction of the Windsor Riverfront RTB project was successfully commissioned in November 2011.

To date, the RTB facility has been performing to expectations and has been the subject of many published papers and conferences as follows:

i. "Characterization and Treatability Study on Windsor CSO". Thirty-seventh Central Canadian Symposium on Water Pollution Research, 2002.

ii. "Windsor Combined Sewer Overflow Treatability Study with Chemical Coagulation". Water Quality Research Journal of Canada, 2003.

iii. "High-Rate Retention Treatment Basins for CSO Control in Windsor, Ontario". Water Quality Research Journal of Canada, 2004.

iv. Windsor CSO Treatability Study Using Pilot-Scale Retention Treatment Basins – Presented at the Water Environment Association of Ontario (WEAO) Conference in Toronto in 2004.

i. Retention Treatment Basins – Presented at the CSO Workshop in Milton, Ontario in 2007.

i. "Treatment of Combined Sewer Overflow (CSO) Using Retention Treatment Basin (RTB) assisted with Polymer Chemical Coagulation". Water Environment Research, 2007.

ii. "Modeling a Retention Treatment Basin for CSO". Journal of Environmental Engineering, 2007.

iii. Preferred Alternative to Control CSOs in the Riverfront Drainage Area East of Caron Avenue in the City of Windsor - Presented at the Water Environment Association of Ontario (WEAO) Conference in April 2007.

iv. High Rate CSO Treatment – Presented at the Water Environment Federation Technical Exhibition and Conference (WEFTEC) in Orlando, Florida in October 2009.

v. City of Windsor Riverfront Retention Treatment Basin Project – Presented at the American Public Works Association (APWA) (Detroit Chapter) in Windsor in April 2011.

vi. High Rate Retention Treatment Basins as a Preferred Solution for CSO Control in the City of Windsor, Ontario, Canada – Presented at the New England Water Environment Association (NEWEA) Conference in New England in May 2011.

vii. City of Windsor Riverfront Retention Treatment Basin Project – Presented at the Regional Public Works Commissioners of Ontario (RPWCO) Conference in Windsor in September 2011

viii. City of Windsor Riverfront High-Rate Retention Treatment Facility Planning to Implementation – Presented at the Water Environment Association of Ontario (WEAO) Conference in Ottawa in April 2012.

ix. City of Windsor Riverfront High-Rate Retention Treatment Facility Planning to Implementation – To be presented at the Michigan Water Environment Association (MWEA) Conference in Boyne Falls, Michigan in June 2012.

The learning arising from this project has significantly advanced the general state of knowledge for RTB technology and paved the way for adoptions by others in similar situations.