Water Environment Association of Ontario
Young Professionals Committee and Student Design Competition Sub-Committee

and the

Ontario Ministry of the Environment and Climate Change

In Collaboration with

The Regional Municipality of Durham

WEAO STUDENT DESIGN COMPETITION 2016

PROJECT STATEMENT

Resource Recovery at the York-Durham Duffin Creek Water Pollution Control Plant

SEPTEMBER 2015

WEAO Student Design Competition 2016

Resource Recovery and Process Improvements at the Duffin Creek WPCP

Background – The Plant

Figure 1: Aerial photo of the Duffin Creek WPCP

The Duffin Creek Water Pollution Control Plant (WPCP) is jointly owned by the Regional Municipality of Durham and the Regional Municipality of York and operated in accordance with the terms and conditions of the Duffin Creek WPCP's Sewage Works Environmental Compliance Approval (ECA) 5531-9FJJT5 March 3, 2014 and Air ECA 1110-9AJP5C dated September 13, 2013.

The Duffin Creek WPCP is located at the south end of Squires Beach Road at the intersection of McKay Road on the north shore of Lake Ontario in the City of Pickering.

Address: Duffin Creek WPCP
901 McKay Road
Pickering, Ontario
L1W 3A3

The Duffin Creek WPCP treats wastewater from the Ajax/Pickering service area in the Regional Municipality of Durham as well as the following service areas in the Regional Municipality of York: Vaughan, King, Newmarket, Whitchurch-Stouffville, Aurora, East Gwillimbury, Richmond Hill, and Markham.

Wastewater collected through approximately 650 km of sewers in Ajax and Pickering is conveyed to the treatment plant by gravity and by forcemains from the following pumping stations located within the collection system: Bayly St., Jodrel Rd., Toy Ave., Liverpool/Finch and Liverpool. Wastewater collected from the Regional Municipality of York is conveyed to the treatment plant via the primary trunk sewer, and the new south east collector trunk sewer, accounting for approximately 81% of the wastewater treated at this facility in 2014.

The Duffin Creek WPCP is operated by Durham Region. It is ISO 14001 Certified and a regulated Class IV wastewater treatment facility that utilizes a conventional activated sludge process to treat the wastewater including:

- mechanical screening
- grit removal
- primary sedimentation
- aerated bioreactor
- secondary clarification
- enhanced phosphorus removal, with dual point chemical addition
- disinfection (chlorination)
- dechlorination

The treated effluent is discharged through a 3 meter diameter outfall extending 1,100 meters into Lake Ontario.

The plant was first built in 1979 and it continues to be expanded and upgraded. The following table summarizes the plant's capacity.

Table 1: Plant Capacity

Rated Capacity of the Treatment Train	630,000 m^3/day
Hydraulic Capacity of the Outfall	520,000 m^3/day

The influent wastewater is treated in several stages for removal of total suspended solids, organics, nitrogen and phosphorus and receives year-round disinfection before being discharged into Lake Ontario. Influent characteristics and ECA effluent discharge criteria are listed in Table 2 and Table 4, respectively.

Sludge management at Duffin Creek WPCP utilizes anaerobic digestion, sludge blending, dewatering by centrifuges, and incineration by a fluidized bed process. Waste activated sludge is co-thickened in the primary clarifiers. The raw and digested sludge are blended to create a homogenous sludge. The homogenous sludge is dewatered and incinerated. Imported sludge (both undigested and digested) from satellite plants within both the Regional Municipality of Durham and the Regional Municipality of York, is transported to this plant for further treatment and disposal. All sludge is dewatered and incinerated at this facility. In 2014, 29,304 dry tonnes of dewatered biosolids were generated at the plant, resulting in 10,783 dry tonnes of ash. The incineration ash is sent to St. Mary's

Cement (Bowmanville, ON) for reuse. No land application or landfill occurred in 2014.

It should be noted that the plant's digester complex currently receives only approximately 20% of the total co-thickened primary sludge produced by the plant. The remaining 80% of the primary sludge is sent directly to dewatering and incineration.

Based on 2014 plant information, the following data is noted:

Table 2: 2014 Annual Average Raw Wastewater Characteristics

Parameter	**Concentration (mg/L)**	**Loading (kg/d)**
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	183	62,679
Total Suspended Solids (TSS)	296	101,579
Total Phosphorus (TP)	5.6	1,904
Total Kjeldahl Nitrogen (TKN)	45.6	15,640

Table 3: 2014 Hydraulic Load

	Plant Load (m^3/day)	**Flow limit (m^3/day)**
Annual Average Daily Flow	342,979	520,000
Maximum Daily Flow	626,492	--

The plant is currently operated at 66% of its approved rated capacity. The plant flow is limited by hydraulic capacity of the outfall diffuser pipe, which is subject to a decision related to the outfall EA filed by the Regions.

Table 4: Duffin Creek WPCP ECA Effluent Discharge Criteria

Parameter	Concentration (mg/L)		Loading (kg/d)
	Limit	Objective	Limit
$CBOD_5$ (1)	25.0	15.0	--
Total Suspended Solids(1)	25.0	15.0	--
Total Phosphorus	0.8(1)	0.6(1)	311(2)
Total Ammonia Nitrogen May 1 – Oct 31(1)	6.0	5.0	--
Nov 1 – Apr 30(1)	10.0	5.0	--
Un-ionized Ammonia Nitrogen(1)	0.2	0.1	--
Total Residual Chlorine(1)	0.02	ND	--
E. coli (counts/100 mL)(3)	200	100	--
pH	6.0 - 9.5	6.5 - 8.5	--

Notes:
ND – Non-detectable
1. Based on the monthly average
2. Based on the annual average
3. Based on the monthly geometric mean

More information about the performance of the treatment plant, chemical and utility consumption, operating costs and other issues may be found in subsequent sections, and in the 2014 Annual Report included in the supplemental information. A simplified schematic of the plant is included in Appendix A.

Background - Challenges

Biogas is produced during the anaerobic digestion process at the plant. This digester gas by-product contains methane as its main constituent. While a portion of the gas produced is used for process and building heating loads within the plant, a considerable volume of biogas is flared on an annual basis. Various technologies now exist to help optimize the production and beneficial use of biogas systems at facilities like the Duffin Creek WPCP. Below is a table outlining historical digester gas production.

Table 5: Historical Digester Gas Production at the Duffin Creek WPCP

	Digester Gas to Boilers	Digester Gas to Waste Gas Burners	Total Digester Gas
	m^3	m^3	m^3
2012	118,583	1,885,653	2,004,236
2013	939,014	1,543,504	2,482,518
2014	987,333	1,624,830	2,612,163

In addition to the biogas recovery potential, the incineration process at the facility also produces a large amount of recoverable energy in the form of excess steam as well as lower grade heat sources. While the facility does incorporate steam driven turbines to help offset electrical load within the incineration process, further evaluation and optimization of these energy sources should be completed.

A summary of resources consumed over the course of 2014 is provided in the table below.

Table 6: 2014 Energy and Chemical Use

Month	Plant Flow [m^3]	Ferrous Chloride [L]	Chlorine [kg as Cl_2]	Sodium Bisulphite [L]	Hydro [kWh]	Natural Gas [m^3]	Polymer Usage [kg]
January	10,475,165	1,590,140	21,254	80,385	5,536,677	587,785	39,309
February	9,321,444	845,794	19,162	70,785	5,075,299	487,306	57,031
March	10,633,129	980,338	21,976	80,803	5,048,280	424,143	58,785
April	12,720,290	961,434	27,172	51,578	5,186,069	371,162	58,468
May	11,373,625	1,029,124	25,300	55,955	5,972,923	221,995	78,078
June	9,888,900	922,361	20,767	50,922	5,091,191	66,344	39,299
July	9,895,109	858,227	30,469	53,161	5,744,921	91,810	58,143
August	10,268,491	680,927	26,684	48,724	6,230,746	0	39,717
September	10,137,357	957,580	20,061	38,429	5,031,591	88,061	58,949
October	10,095,134	1,147,311	21,201	36,762	5,356,214	128,069	38,098
November	9,797,971	1,002,220	20,676	43,303	5,178,559	385,637	38,937
December	10,580,778	953,213	22,554	38,219	5,978,311	319,267	57,168
Total	125,187,393	11,928,669	277,276	649,026	65,430,781	3,171,579	621,982

Background – Resource Recovery

Durham Region acts as the Operator of the Duffin Creek WPCP. Consistent with the theme of the Durham Region Strategic Plan 2009-2014, the Region has a goal to "protect and enhance our environment for today and tomorrow through stewardship of our natural resources"

In addition, as noted in the Region's Conservation and Demand Management Plan 2014-2019, the Region's key goals include "*reductions in energy waste and Green House Gas (GHG) emissions and cost avoidance, particularly given rising* *energy costs. Further, investigation and implementation of renewable energy generation and energy harvesting opportunities are considered where feasible*."

An important means of achieving these goals is approaching wastewater treatment from the energy and resource recovery point of view. Resources that can be recovered from the process include:

- Nutrients (e.g. phosphorus and nitrogen);
- Energy in the form of heat, kinetic, methane gas or other fuels; and
- Reusable water.

Initiatives that have already been undertaken at the Duffin Creek WPCP include:

- Recycling of effluent water for non-potable use;
- Recovery of ash product for cement production
- Use of recoverable energy from digester gas for process and building heating; and
- Energy recovery turbines within the incineration process.

Objectives

The Design Team will provide the following:

- Preliminary design for optimization of digester gas production and energy recovery
- Preliminary design for additional energy recovery from the existing incineration process
- Conceptual design for two additional areas in which the Duffin Creek WPCP may benefit from resource recovery opportunities

Design Criteria

Proposed designs must take into consideration the rated capacity of the WPCP, limitations of the footprint of the existing plant and the importation of digested sludge from other facilities. The best designs will reduce operating costs and energy use over the existing methods used at the plant, and not increase the loading of other portions of the plant.

Scope of Work

The project documents should address the following elements:

Phase I

Provide a proposal to optimize digester gas production and beneficial use as well as identify opportunities for additional energy recovery from the existing incineration process. The proposed methods must take into consideration the limitations of the footprint of the existing plant and the importation of digested solids from other facilities.

The proposal should include a review and comparison of various methods and the engineering feasibility of implementing them.

Phase II

Propose two other areas in which the Duffin Creek WPCP could adopt a resource recovery approach to benefit the operations, lessen the environmental impact and/or reduce the cost of treatment. A conceptual design must be provided including comparisons of technologies, energy demands, preliminary economics and if relevant, effluent characteristics.

DESIGN REPORT REQUIREMENTS

The design should address the following points:

Background

- Analysis of the existing sludge digestion, biogas collection and handling, and incineration processes at the facility; and
- Identification of challenges of the existing plant design with regard to energy recovery.

Phase I

- Comparative discussion of alternative energy recovery processes and techniques;
- An economic cost-benefit analysis should be conducted for the preferred and alternative methods with specific energy balances;
- Selection of the preferred process (decision matrix);
- Expected energy requirements and recovered resource yield;
- Identify limitations of the preferred approaches and how they may be minimized through addressing other plant processes/design in order to increase energy recovery, decrease energy requirements, etc.;
- Preliminary sizing of major equipment or installations, including an outline of process control systems;
- Methods used to minimize environmental impact during construction;
- Preliminary capital cost estimate;
- Operating and Maintenance cost estimates; and
- Implementation schedule and the need for pilot work to verify the preferred alternatives for scale up application.

Phase II

- Identification of two other areas with resource recovery potential;
- Conceptual design of the process or processes; and

- Estimates of the quantity of resources that could be recovered, the associated cost, income or cost avoidance, and if relevant, effluent characteristics.

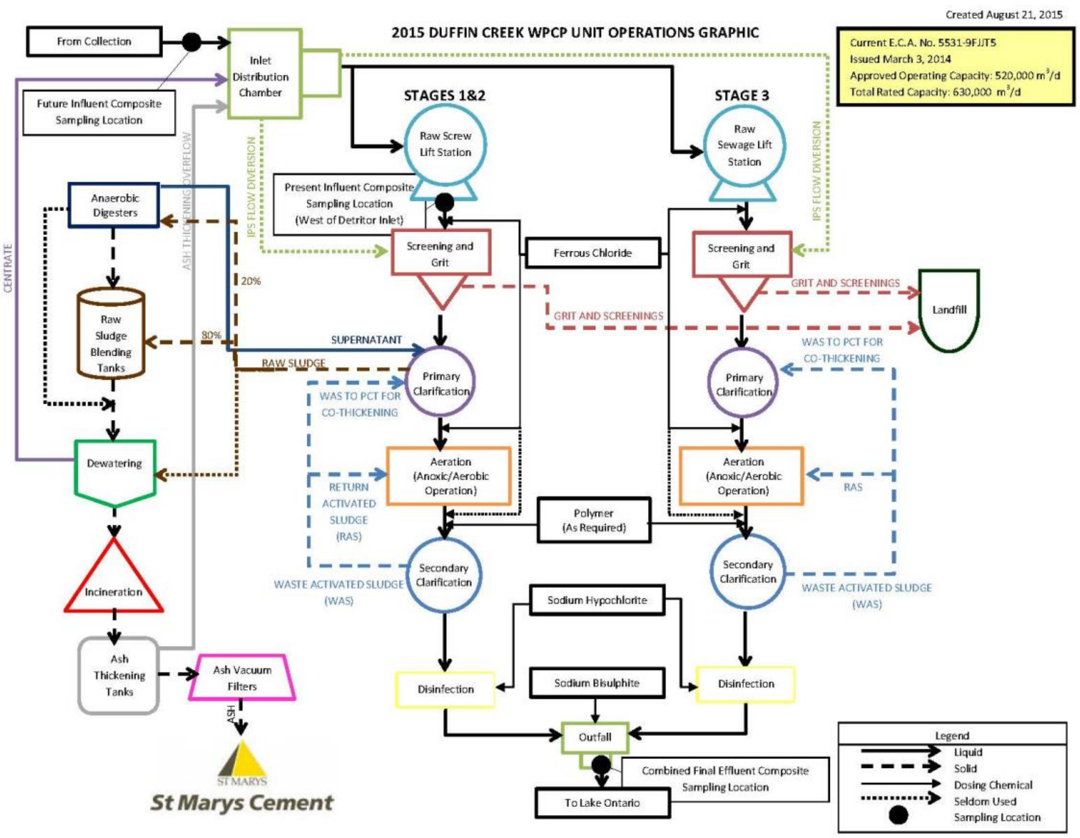
Appendices must include:

- Calculations indicating the expected energy recovery and any effects on the treatment process (either to the liquid or solid streams) of the proposed design. Include all calculation spreadsheets;
- Manufacturer data sheets and catalogues of all major equipment; and
- Design drawings (see below for details).

Design drawings must be provided that clearly show the layout of the proposed WPCP retrofit(s). As a minimum, the following three drawings must be included:

1. Site plan for the Phase I retrofit including value added component;
2. Process schematic for Phase I retrofit; and
3. A drawing identifying Phase II sites and preliminary layouts.

Appendix A – Plant Process Flow Diagram


Created August 21, 2015
2015 DUFFIN CREEK WPCP UNIT OPERATIONS GRAPHIC
Current E.C.A. No. 5531-9FJJT5
Issued March 3, 2014
Approved Operating Capacity: 520,000 m³/d
Total Rated Capacity: 630,000 m³/d
From Collection
Inlet Distribution Chamber
Future Influent Composite Sampling Location
STAGES 1&2
STAGE 3
Raw Screw Lift Station
Raw Sewage Lift Station
Present Influent Composite Sampling Location (West of Detritor Inlet)
IPS FLOW DIVERSION
ASH THICKENING OVERFLOW
CENTRATE
Anaerobic Digesters
Raw Sludge Blending Tanks
20%
80%
SUPERNATANT
RAW SLUDGE
Screening and Grit
Ferrous Chloride
GRIT AND SCREENINGS
Landfill
WAS TO PCT FOR CO-THICKENING
Primary Clarification
Aeration (Anoxic/Aerobic Operation)
RETURN ACTIVATED SLUDGE (RAS)
RAS
Polymer (As Required)
Secondary Clarification
WASTE ACTIVATED SLUDGE (WAS)
Dewatering
Incineration
Ash Thickening Tanks
Ash Vacuum Filters
ASH
St Marys Cement
Sodium Hypochlorite
Sodium Bisulphite
Disinfection
Outfall
Combined Final Effluent Composite Sampling Location
To Lake Ontario
Legend
Liquid
Solid
Dosing Chemical
Seldom Used
Sampling Location