2021 Evapotranspiration-based (ET-based) Irrigation Pilot – Results

Introduction

An evapotranspiration-based (ET-based) irrigation pilot project was conducted during the 2021 season. It builds on an initial pilot conducted in 2020. The goals of the 2021 project were to:

- Learn if ET-based watering can save water while maintaining high standards for turf condition based on comparisons with a control group of parks.
- Develop the skills of staff in working with ET software and refine the system's programming.
- Address the challenges identified in the 2020 pilot project and correct adverse effects.

What is ET-based Watering?

As it metabolizes and grows, grass loses water through transpiration and soil loses water through evaporation. The two together are called "evapotranspiration," or ET. Using weather data and software to control irrigation systems to replace only the amount of water lost to evapotranspiration can help maintain healthy turf, prevent overwatering, and minimize water use.

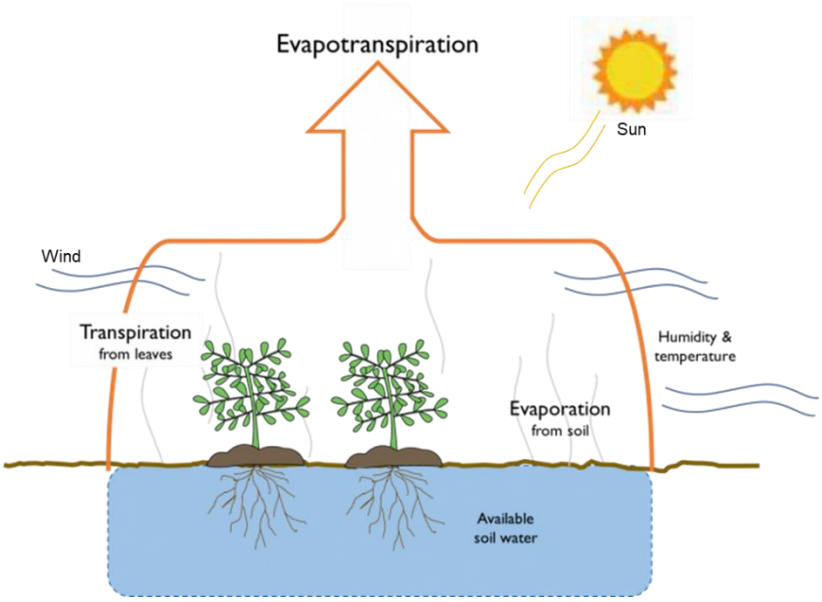

Figure 3. Evapotranspiration diagram. Source:
https://serc.carleton.edu/integrate/teaching_materials/food_supply/student_materials/1091

Pilot Design

The Pilot included five east side and five west side pilot parks with comparable control parks. Details of the pilot and control parks are provided in Tables 1 and 2.

The Pilot involved:

- Programing irrigation equipment to optimize ET-based watering;
- Conducting turf assessments at beginning, mid-way, and end of season to ensure turf quality was being maintained;
- Tracking field activity such as irrigation maintenance and testing and filling watering trucks to correlate water meter irregularities with field activities;
- Documenting program settings (water limit cap, watering time window) to correlate with any water meter irregularities or turf quality issues;
- Compiling and analysing field and smart meter data;
- Assessing results and making recommendations for next steps; and
- Preparation of a business case to accelerate asset management plans and upgrade all irrigation systems.

Table 1. East Side Parks

	ET Pilot	**Comparable Parks / Control Group**		
Item	Christine Morris	Don Ross	Jill Postlethwaite	Korpan
Park Code	4210	4400	4680	4740
Size	0.15	0.15	0.19	0.21
Item	Kopko	Becket Green	Forest Grove Linkage	
Park Code	4760	4480	4010	
Size	0.49	0.58	0.6	
Item	Herbert Stewart	Balsam		
Park Code	4150	4030		
Size	1.51	1.45		
Item	Herzberg	Brevoort North		
Park Code	4160	3080		
Size	5.34	5.51		
Item	Willowgrove Square	Becket Green	Forest Grove Linkage	
Park Code	4590	4480	4010	
Size	0.56	0.58	0.6	

Table 2. West Side Parks

		ET Pilot	Comparable Parks / Control Group		
Item		Cahill	City Hall	Hampton	Peter Currie
Park Code		206	1010	2610	6090
Size		0.58	0.41	0.44	0.5
Item		Ed Jordan	City Hall	Hampton	Peter Currie
Park Code		610	1010	2610	6090
Size		0.51	0.41	0.44	0.5
Item		Rik Steernberg	Lt. Simonds	St. Andrews	Peter Currie
Park Code		265	2250	2370	6090
Size		0.6	0.77	0.84	0.5
Item		Lt. Walker	Gougeon	St. Andrews	Lt. Simonds
Park Code		2240	2150	2370	2250
Size		0.77	0.72	0.84	0.77
Item		CJ Mackenzie	Gougeon	Lt. Simonds	Friendship Park
Park Code		600	2150	2250	1030
Size		0.75	0.72	0.77	0.73

The 2020 pilot was unable to provide clear results due to challenges in the study design. The 2021 pilot considered these challenges in its design, including:

- Since irrigation practices varied quite a bit from year to year, it was hard to compare water consumption with past years' water consumption;
- There were no control parks identified to compare 2020 water consumption with similar parks without ET-based programing;
- Field activity data, to correlate water use irregularities, was not collected; and
- Turf quality was not tracked and monitored.

Figure 4. Irrigation sensor at Korpan Park

Pilot Results Summary

The goals of the Irrigation Pilot Project were met. The pilot demonstrated that ET-based watering can save water while maintaining turf quality based on comparisons with a control group of parks. Staff developed skills to work with and refine ET software programing and will continue to improve in this area. The challenges identified in the 2020 pilot and other risks to the pilot were mitigated and an analysis was successfully completed.

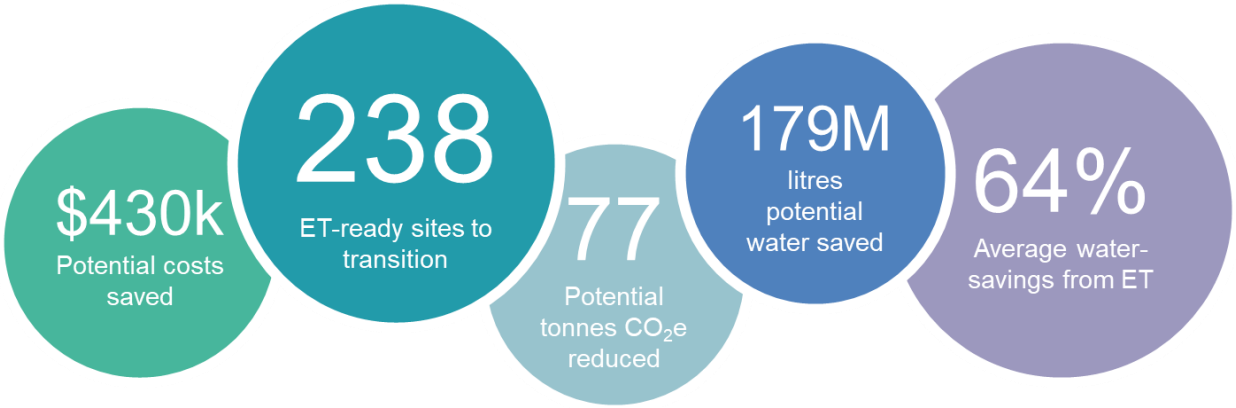

Figure 5. Summary of potential savings from ET based watering

- Overall water use in parks was almost 60% higher in 2021 than historical average due to hot and dry conditions.
- 6 ET parks could be analyzed and showed positive results from ET programing.
- Compared to the historical water consumption (prior to switching to an ET schedule), ET-based watering has shown an average 5% decrease in water use this year (average from the 6 parks with positive results range from a 29% decrease to a 13% increase in water use).
- Compared to the historical water consumption, control parks showed an average 59% increase in water use this year (average from the analyzed control parks results range from 9% decrease to 103% increase).
- ET Parks used 64% less water than the control parks this year.
- There are 283 ET-ready sites that could be transitioned to ET-based watering. In 2021, if those sites had been programed for ET 179 million litres water, $430,000, and 77 tonnes CO_2e would potentially have been saved.
- In 2021, if the whole network was on ET watering, 247 million litres water, $600,000 and 106 tonnes CO_2e could have been saved.

Water Use Analysis

The following tables show how each ET park performed in 2021 compared to its own historical water use over the past 10 years with its control parks' comparisons listed below each. ET parks that achieved favorable results are highlighted in green, whereas the other ET Parks that did not see savings or were removed from the pilot are highlighted in grey. Favorable results are those that showed less water use than the control parks, less water use than historical average, or both.

Location	Park	% Increase (Decrease) Compared to Historical	2021 Results
west side	**[ET] Cahill Park**	**13%**	***Favorable***
	Peter Pond	103%	
	DL Hamilton	66%	
	Marlborough	73%	
	[ET] Rik Steernberg	**-9%**	***Favorable***
	St Andrews	63%	
	Lt Simonds	21%	
	[ET] CJ Mackenzie	**-10%**	***Favorable***
	Lt Simonds	21%	
	Gougeon	-9%	
	Friendship Park	100%	
	[ET] Lt. Walker	**79%**	***Unfavorable***
	GD Archibald West	28%	
	St Andrews	63%	
	Dr. J Valens	16%	
	Friendship Park	100%	
	[ET] Ed Jordan	**1%**	***Cannot be determined***
	Hampton Village Square	35%	
	City Hall Square	29%	

Location	Park	% Increase (Decrease) Compared to Historical	2021 Results
east side	**[ET] Kopko**	**5%**	***Favourable***
	Becket Green	81%	
	Forest Grove Linkage	83%	
	[ET] Herbert Stewart	**1%**	***Favourable***
	Balsam	1%	
	[ET] Willowgrove Square	**-29%**	***Favourable***
	Becket Green	81%	
	Forest Grove Linkage	83%	
	[ET] Christine Morris	**151%**	***Unfavorable***
	Don Ross	101%	
	Jill Postlethwaite	69%	
	Korpan	2%	
	[ET] Herzberg	**-15%**	***Cannot be determined***
	Breevort North	12%	

Four parks did not show favorable results or could not be analyzed as follows:

- Ed Jordan Park showed turf stress mid-season and was removed from ET pilot, it was later discovered that a programing error caused the problem. Documenting correct settings and monitoring the programing for errors and glitches will be important to successfully implement ET-watering more broadly. There were also problems with City Hall, one of its control parks. City Hall Park had extensive leaks and couldn't be used for comparison;
- Herzberg Park has 2 meters and a community garden using water during the daytime so analysis could not correlate smart meter data with field activities; and
- Christine Morris and Lt. Walker Parks did not show reduction, but this is likely due to communication hub problems and programing errors.

To summarize, results for the ET Parks ranged from a 29% decrease up to a 13% increase in water consumption compared to their historical water use. On average, the ET Parks used 5% less water than historical average. The control parks saw a wider range in water consumption which ranged from a 9% decrease up to a 103% increase. On average, control parks used 59% more water than historical average.

This means the ET parks used 64% less water than the control parks in 2021.

Cost Analysis

As shown in the water use analysis, ET Parks used 64% less water than the controlled parks in 2021. The % savings was then factored in to determine the water consumption, cost savings and emissions reduction as shown in the following table.

ET Park	Irrigated Area [ha]	Historical Water Usage [ft3/ha]	Water Usage With ET [ft3/ha]	Estimated Water Usage Without ET [ft3/ha]	Water Savings Per Area [ft3/ha]	Water Savings [ft3]	Water Savings [litres]	Cost Savings [2021 Rates]	Emissions Reduction [kg CO2e]
Rik Steernberg	0.60	103,723	94,173	164,950	70,777	42,466	1,202,515	$ 2,906	517.08
CJ Mackenzie	0.13	305,141	275,017	485,264	210,247	27,332	773,963	$ 1,870	332.80
Kopko	0.65	52,434	55,473	83,386	27,912	18,143	513,755	$ 1,242	220.91
Herbert Stewart	0.45	70,865	71,886	112,697	40,811	18,365	520,044	$ 1,257	223.62
Willowgrove Square	0.28	82,486	58,648	131,177	72,529	20,308	575,061	$ 1,390	247.28
Cahill	0.69	25,759	30,504	40,965	10,461	7,218	204,399	$ 494	87.89
				Total Savings		133,833	3,789,737	$ 9,158	1,629.59
				Average Savings Per Park		22,305	631,623	$ 1,526	271.60
				ET-Ready Parks (283)		6,312,437	178,749,282	$ 431,960	76,862.19
				Entire Irrigation System (391)		8,721,424	246,964,555	$ 596,807	106,194.76

The analysis estimates that the six ET Parks saved a total of 3.8 million litres of water, which is equivalent to $9,160 in cost savings and 1,630 kg CO2e in 2021. This averages to 22,300 ft^3 630,000 litres of water, $1,530 in costs and 270 kg CO2e per park.

There are 283 of 391 irrigated sites that can already be managed by ET-based programing. Based on 2021 average water savings from ET, 179 million litres of water, $430,000 and 77 tonnes CO2e could have been saved if these 283 sites had been transitioned to ET-based watering. If all 391 irrigated sites were upgraded to ET-based watering, savings could be 247 million litres of water, almost $600,000 and 106 tonnes CO_2e.

Transitioning the 283 sites to ET-based watering would mainly involve adding additional communication hubs to the irrigation network, moderate equipment upgrades, and reprograming and monitoring each system to optimize water use. The remaining 108 sites would require irrigation system replacements and significant equipment upgrades to be optimized.

2021 Weather

The 2021 summer operating condition was prolonged by hot weather and drought. This was identified as a risk to the pilot – that, in extreme conditions, signs of turf stress might be seen regardless of watering practices. Temperatures as well as rain days were considered in the analysis and have not impacted the results of the pilot.

Saskatoon Water monitors the rainfall in Saskatoon and creates a monthly rainfall report. Figures 6, 7 and 8 show rainfall conditions throughout the summer.

Cooling Degree Day (CDD) is a measure that is typically used to quantify the cooling demand for buildings, but CDD also correlates very well with water production and usage. The severe heatwave in June and July increased the CDD in Saskatoon this summer. More cooling demand means more water demand.

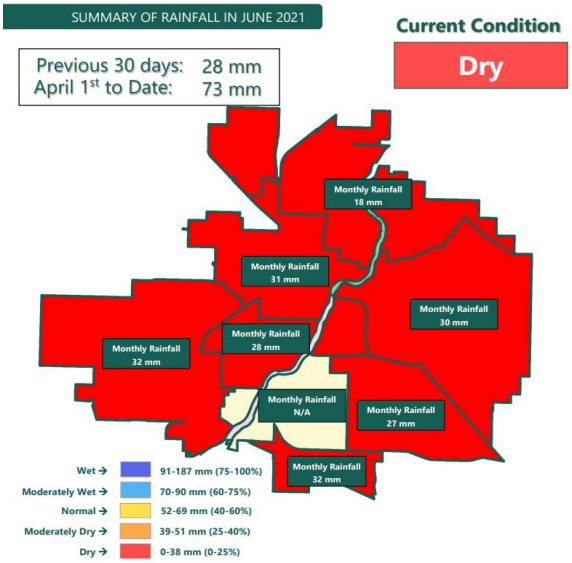

Figure 6. Rainfall in June 2021

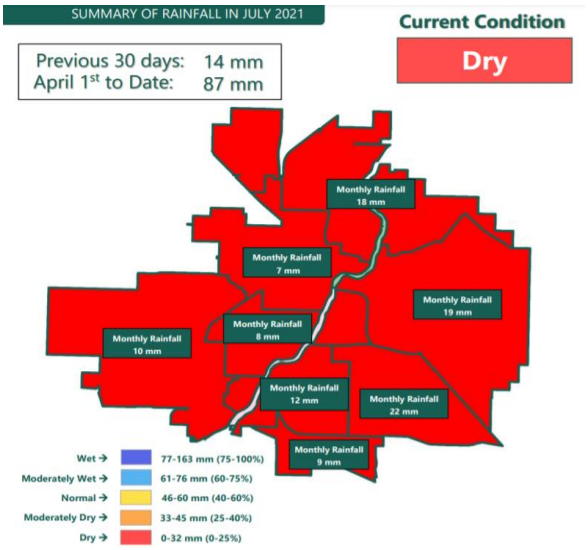

Figure 7. Rainfall in July 2021

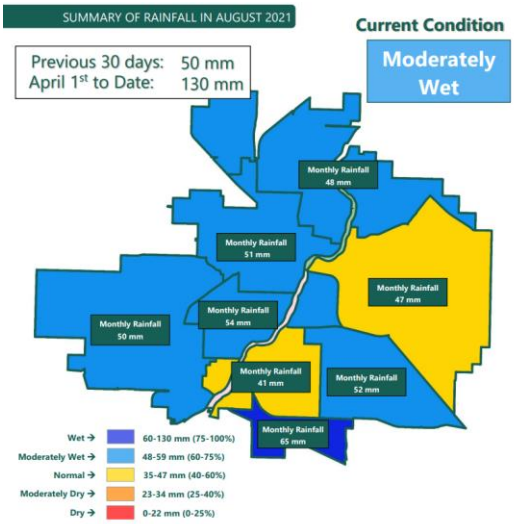

Figure 8. Rainfall in August 2021

Turf Quality

One of the goals was to maintain turf quality with less water. One pilot park, Ed Jordan, showed signs of stress mid-season and was removed from the pilot. All other parks' turf quality was maintained, six of the ET parks with much less water than their control parks.

Figure 9. Example of turf quality assessments – colour and weed count

Figure 10. Example of turf quality assessment - root growth sample

Challenges and Lessons Learned

Extreme Hot Dry Season

- Overall water-use for park irrigation in 2021 was above average due to hot, dry summer conditions.
- Controlled parks used 59% more water compared to their historical average, whereas the pilot parks used 5% less.

Programing Quality and Leaks

- Having ten pilot parks with comparable controls mitigated the problems with having to remove two pilot parks (Ed Jordan and Herzberg) and one control park (City Hall) from the analysis.
- The programing issues at Ed Jordan resulted in turf stress and required that the ET-based programing be turned off. The issue was investigated, and the programing was adjusted to correct the issue. Developing a step-by-step flow chart for how to implement the programing for both Toro Sentinel and Rainbird IQ should be completed so that multiple staff are able to do the programing.
- Christine Morris was not getting weather data and had communication issues, it also had program setting errors. Documenting program settings and implementing standard operating procedures will minimize the programing issues in the future.
- Lt. Walker had communication issues. Adequate communication hubs are critical to optimize watering.

Variable Results

- Water use fluctuates from park to park and from year to year based on temperatures, precipitation timing and intensity, but the pilot demonstrates that even in an extreme condition ET-based watering performed better than the control parks and even used less than historical average. The range of savings in the pilot parks compared to the controls and compared to historical average, is shown in the table below.

Park	Range	Average	Comments
ET Parks	-29% (decrease) to 13% (increase)	-5%	On average, ET Parks used 5% less water than historical.
Controlled Parks	-9% (decrease) to 103% (increase)	59%	On average, controlled parks used 59% more water than historical.

Reaching targets

- Parks has set a target to reduce irrigation water use by 15%. ET-based watering is key to achieving that goal and in average summer conditions may be enough. But climate change projections anticipate more hot, dry summers so other ways to reduce water use should continue to be explored as well. Other ways to reduce water include leak detection, alternate sources (raw water, spray pad water re-use), reviewing standard water application rates, auditing systems to see if they

exceed design standards, and transitioning more irrigated area to naturalized area within parks. A high-level irrigation strategy would further help set targets about what is irrigated and how irrigation service is delivered.

Equipment

- 283 of 391 (72%) of existing irrigation systems can be managed by ET programing. Transitioning the 283 sites to ET-based watering involves adding additional communication hubs to the irrigation network, upgrading some equipment, and reprograming and monitoring each system to optimize water use.
- The remaining 108 sites would require irrigation system replacements and significant equipment upgrades to be optimized. These include manual and semi-automated systems that are very labour intensive to operate and typically run during the day which is the least water efficient time and systems with aging equipment that cannot make use of ET programing.
- DC controllers tend to lose programing more often and have other issues and specifying their use in irrigation designs should be reviewed.
- Weak communication in some areas of the City mean some parks do not receive the communications they need from the control centre to operate optimally.
- Most water meters have been downsized which saved money. 16 more 4-inch meters have been identified that could probably be downsized as well.

Monitoring and Analysis

- Data analysis takes a lot of time to do manually. Software to automate analysis is needed for program monitoring and leak detection for a large number of parks.
- Field checking during the first year to make sure programing is correct also takes time, additional staff capacity is needed to set up ET programing.
- Appropriate resources need to be allocated to implement, maintain, and verify savings to ensure persistence of the desired outcomes.
- More utility account monitoring is also needed. While conducting the water use analysis for the pilot project, it was discovered that many park irrigation accounts got billed for sewer in 2021 totalling ~$300,000.

Recommendations

Scale Up ET-Based Watering

- Conduct a radio survey to identify where communications need to be improved and add communication hubs to address any gaps.
- Find software to automate water use monitoring and leak detection.
- Monitor programing and turf quality in the first year to ensure program settings are correct.
- Conduct an irrigation audit to:
  - determine if service levels and design standards are exceeded;
  - find areas of over-spray;
  - find areas to transition from irrigated and naturalized; and
  - identify other opportunities.

Staff Capacity and Training

- Train multiple staff about system control settings and document the settings in a step-by step flow chart for both Toro Sentinel and Rainbird IQ systems.

Asset Management

- Upgrade manual and semi-automated irrigation systems and aging equipment so that as many systems as possible can be managed by ET.
- Check if Saskatoon Water's rain collectors can be used by Parks to supplement weather data that triggers rain delays.
- Look for meters that have not been downsized yet and downsize them if possible.
- Review utility accounts to ensure sewer charges are not being applied.
- Switching DC controllers to AC to reduce system errors where possible.
- Create an irrigation strategy to set targets about what is irrigated and how irrigation service is delivered by determining different approaches to irrigation (mechanical or natural; potable, storm, grey, or raw water opportunities), looking for more efficiency and reductions, and completing cost and environmental impact analyses.

Pilots

- Conduct a leak detection pilot to more quickly find and fix leaks. Leak issues were a problem at City Hall and other older systems likely have leak issues as well which, if left unrepaired, can lose a lot of water.
- Pilot new watering rate standards to determine if turf quality can be maintained with a lower watering standard (current standard is 1 inch per week, 0.8 inch per week has been tested in some places, sports field standard is 1.2 inch per week).

Conclusion

Moving toward full implementation evapotranspiration (ET)-based water control could cut water use at City parks by 10% – 20% while maintaining turf quality. Full implementation would include reprograming control settings, upgrading communications hardware, installing additional rain monitors, installing Advanced Metering Infrastructure (AMI) meters and sub-meters and other improvements. These efficiencies could save approximately 179 million litres of water and about $430,000 per year, based on the current parks land base and average summer temperatures and precipitation.