IPLC Performance Validity Test: Summary of Results

September 2011
Department of Energy Mines and Resources
Energy Solutions Centre

The IPLC M200 dual parking stall controller.

Energy, Mines and Resources

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Background

From November to March the average temperature in the Yukon's capital, Whitehorse, is below freezing. In January that average temperature is -17.7°C. These cold temperatures can damage vehicle engines and increase fuel consumption and exhaust emissions, so many people install engine block heaters, battery blankets and oil pan heaters on their vehicles. All of these heaters require electrical power. In the Yukon, this extra power consumption occurs when the grid has the least amount of renewable hydro energy available for generating electricity. However, with a minor regulation of the amount of power given to vehicle heating devices a significant amount of electrical energy can be saved, which results in reduced electrical consumption.

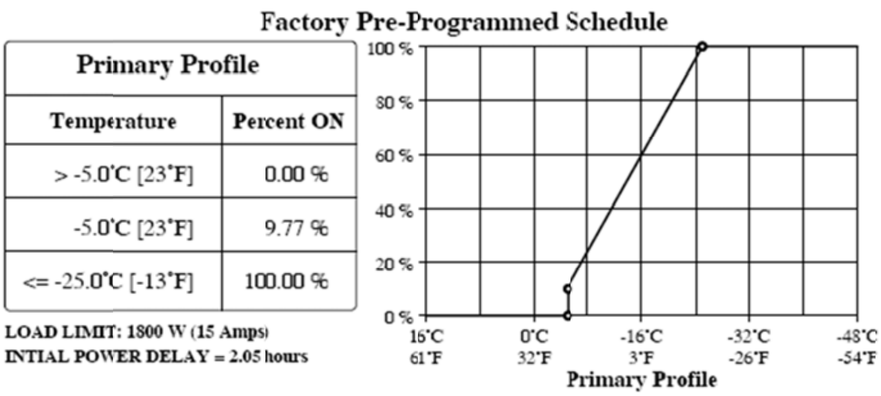
The Intelligent Parking Lot Controller (IPLC) is a 'smart receptacle' that regulates power to a vehicle based on user-defined settings. These settings may depend on ambient temperature, plug-in times, and known plug-in habits of IPLC users. For example, power may not be supplied to a vehicle if the outside temperature is greater than -5°C; this and other features of the IPLCs provide power to the vehicle when needed, rather than for the entire time it is plugged in, reducing the amount of wasted energy. The IPLCs also have the ability to log the amount of energy saved throughout the course of their operation.

In 2001/2002 the Yukon government's Energy Solutions Centre (ESC) piloted IPLC testing in Whitehorse. The report based on this testing was published in 2003 and titled, "*Six Pack* Parking Lot Controller Pilot Project". In this pilot project many IPLC settings were changed to maximize energy savings, achieving on average a 78% reduction in electrical consumption. The report's final conclusions were that IPLC units offered significant savings in employee parking lots for larger businesses and institutions (City of Whitehorse and Yukon government), where stalls were in constant use; yet, businesses with few employees would generally not find IPLC installations cost effective, where stalls were less often used. Based on these results, over 230 IPLC units were installed by the Yukon Government in its employee parking lots.

In 2010 ESC initiated an IPLC pilot follow-up to determine the effectiveness of installed IPLC units and their potential for growth. This follow-up test was begun due to faulty reporting on plug-in counts in the IPLC data logs, and to determine the potential for further IPLC usage in the Yukon. To facilitate this, in the summer of 2010 a survey of Whitehorse plug-ins and IPLCs was conducted by a Yukon 'Green Team'. 224 IPLC units were identified within Whitehorse in four different parking lots. In the winter of 2011 this data was used to begin the monitoring of 57 IPLC units within the City.

Methodology

The Yukon 'Green Team' found 224 IPLC units in these four parking lots: Copper Ridge Place, Selkirk Elementary, Yukon Territorial Government Main Administration, and 1215 Highway and Public Works (H&PW). Fifteen units were randomly chosen in each parking lot[1] using a random number generator (http://www.random.org/integers/). All units were then programmed to a default profile (Std IPLC M200:A) with a 2.05 hour delay added by Energy Solutions Centre staff to offer a reduction in energy consumption while ensuring vehicle heating requirements were met. This profile provides no power to receptacles until the outside temperature is at or below -5°C. At this point, after an initial 2.05 hour delay, power is delivered to the vehicle in increasing amounts as the temperature drops. At an outside temperature equal to -5°C the maximum load (1800 W) is delivered to the vehicle 9.77% of each five minute cycle. At a temperature less than or equal to -25°C the maximum load is delivered 100% of each five minute cycle. Once this profile was loaded, data on power consumption was then collected from randomly chosen IPLCs every 2 weeks from December 1, 2011 to March 30, 2011.



To validate the IPLCs' internal data logging results two IPLCs with Magnelab AC current transformers connected to the load wire of the IPLC units were installed at the ESC staff building. These transformers were then connected to Hobo Energy Logger Pro (a data logger) and data on kWh usage was continuously collected by a computer. These monitored IPLCs were used by staff member vehicles during the regular work week and the data collected by the independent data logger was then compared to that of the IPLCs' internal data logger.

[1] There are only 12 IPLC units in Selkirk Elementary schools parking lot. All 12 were monitored for this pilot project.

Results

The primary energy measurement of interest (kWh used) collected on the Hobo Energy Logger Pro was found to be consistent with the IPLC data for three, out of the four, receptacles on the two IPLC units that were monitored by the data logger. The fourth receptacle logged 9.04 kWh less usage than the IPLC unit data logger.

All other data collected by the IPLCs, such as plug-in counts and plug-in times, were found to be faulty and were not included in the following analysis.

The average savings in kWh for the four parking lots was found to be 32.39%, representing a savings of 2,852 kWh. These savings ranged from 25% to 37.3% overall. The most energy saved was at the 1215 Highway and Public Works parking lot at 1,047 kWh saved; however, this was also the lowest percent of kWh saved at 25.28%. The highest percent of kWh saved was found at Copper ridge Place at 37.31%.

Figure two shows the average percent of kWh saved by all monitored IPLCs over each sampling period in relation to the average temperature in each sampling period. Figure three shows the average kWh saved versus the average temperature during the sample period.

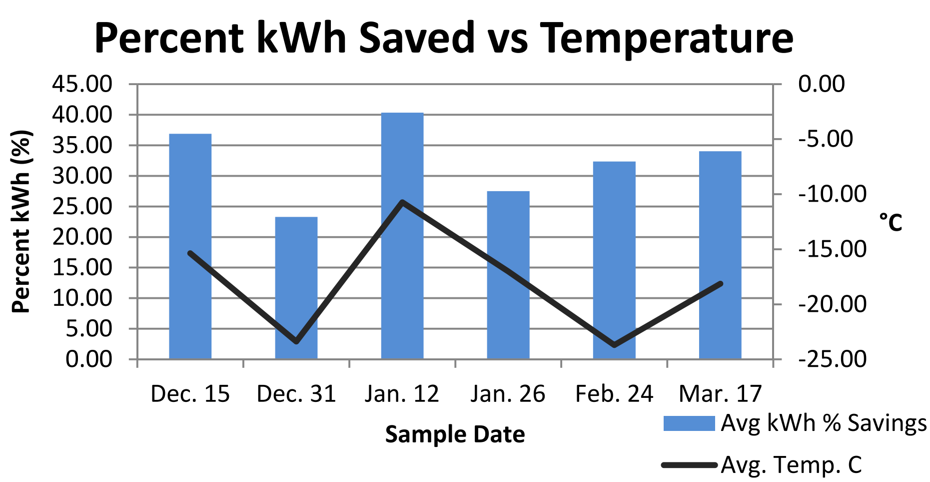


Figure 2. Percent kWh Saved vs Temperature: A correlation between lowering temperatures and reduced percent kWh saved is shown.

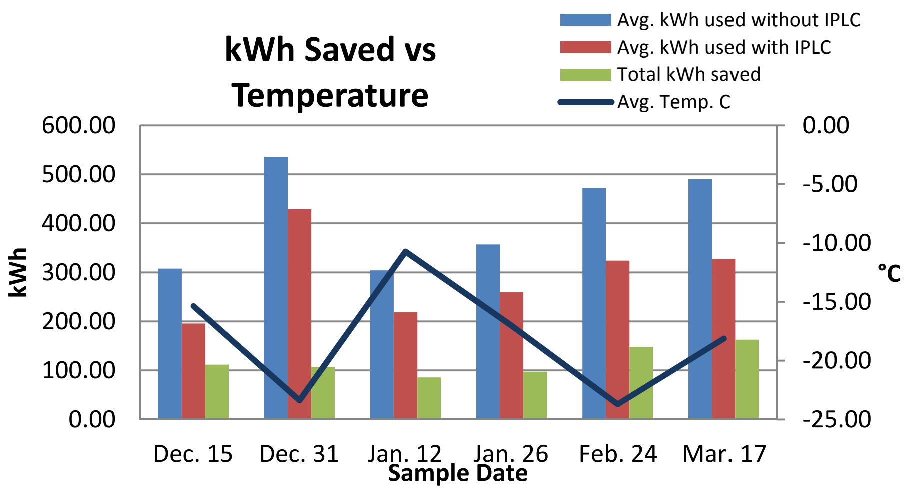


Figure 3. kWh Saved versus Temperature: As temperatures rise, the IPLC provides power less often so the amount of energy used drops and the *relative* amount of energy saved increases.

From these figures we can see a correlation between the drop in temperature and amount of energy saved and used. The December 31st sampling period was one of the coldest at -23.3°C while it was also a period with the highest kWh usage with lower savings. It was when the temperature rose in warmer periods such as the Janurary 12th sampling period with an average temperature of -10.7°C that we saw the highest average percent of energy savings at 40.3%.

Analysis

The findings from the Hobo data logger gave good reason for ESC staff to trust the IPLCs' reported kWh usage. All readings from the data logger except one were similar to the IPLCs' reports. The differing reading is addressed in the 'Error analysis' section.

Fron Figures Two and Three we can see that as the temperature drops the relative amount of energy saved decreases while as the temperture rises the relative amount of energy saved increases. The Feburary 24th sampling period goes againest this trend. This could be because of an especially warm 2 week period before this sampling date

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which decreased the amount of people plugging in, as noted in the 'Error analysis' section.

As noted in the 'Results' section, the total saved energy of all sampled IPLC's was 2,852 kWh. If this number is extrapulated to the 224 IPLC units in the City of Whitehorse we can estimate a total energy savings of 11,207 kWh. There are 1,603 outlets without IPLC units. If these were converted, a further 80,206 kWh of savings could have been achieved over this study period.

All these energy savings are based on the profile "Std IPLC M200:A" with a 2.05 hour delay. This is a conservative profile which could be modified for greater savings. In the 2003 Energy Solutions Centre pilot project a more stringent IPLC profile was programmed which achieved on average 78% kWh savings. Pages 4 and 5 of the "Six Pack" 2003 summary report detail the profiles used.

Error analysis

One reading from the data logger was 9.04 kWh less than the IPLC's data, making the IPLC overestimate the energy used. The added energy could be accountable to the program used to analyze IPLC data. This program at times has kWh readings and increasing plug-in counts when there is infact, no new inputted data or IPLCs are known not to have been used.

Approximinatly 14% of the data is missing, as the Janurary 27th to Feburary 10th 2011 data were a repitition of the previous period's readings. It was therefore discounted in the analysis and all kWh savings from that period were unrecorded. The data repeated due to a complication that arose when new computers were installed at ESC, but enough data were collected for this report's purpose. However, because this data is missing it may be assumed that the kWh savings presented here are an underestimate. This sampling period was also a warm one from a temperature standpoint. Six out of the fifteen days had maximum temperatures greater than 0°C. These especially warm days could have accounted for the increased savings seen from Feburary 11th to March 30th 2011, despite a drop in temperature.

Conclusions

The 57 IPLCs sampled from December to March used, on average 32.39% less than a regular receptacle which amounted to 2,852 kWh of electricity saved. Currently there are 1,603 parking lot outlets in Whitehorse that do not use IPLC units and 224 that do. Based on savings from this study, if all these outlets were converted the Yukon could see a reduction of 80,206 kWh from December to March. Based on the 2003 pilot study which included more aggressive IPLC programming, these extra savings could be upwards of 190,000 kWh. If this is extrapolated to include October and November the annual savings could range from 100,000 kWh to 250,000 kWh.

The data gathered and analysed in this report continues to support the recommendations and conclusions of the 2003 pilot study, which include:

- IPLCs offer significant energy savings in employee parking lots in larger businesses and institutions.
- Colder winters reduce IPLC savings while warmer winters increase savings.
- Employee education and awareness are important to IPLC success.

A detailed accounting of these recommendations can be found on pages 10 and 11 of the "Six Pack" 2003 summary report.

The energy saved by further IPLC installations would be during peak energy usage winter hours. This is when hydro production is at its lowest and diesel fuel is used to make up any shortcomings.

Appendix 1: IPLC Performance Validity Test Data

Date Sampled	Total kWh w/o IPLC	Total kWh w IPLC	Total kWh Saved	kWh % Saved
Dec. 15	480.68	325.17	155.51	32.35
Dec. 31	1174.93	1019.11	155.82	13.26
Jan. 12	1009.83	765.87	243.96	24.16
Jan. 26	323.40	237.68	85.72	26.51
Feb. 24	747.12	546.21	200.91	26.89
Mar. 17	721.65	515.94	205.71	28.51

Table 1. ***12 15 H&PW IPLC Readings***

Date Sampled	Total kWh w/o IPLC	Total kWh w IPLC	Total kWh Saved	kWh % Saved
Dec. 15	264.09	163.87	100.22	37.95
Dec. 31	106.92	81.79	25.13	23.50
Jan. 12	21.23	12.82	8.41	39.61
Jan. 26	283.19	199.25	83.94	29.64
Feb. 24	352.07	240.57	111.50	31.67
Mar. 17	321.77	210.52	111.25	34.57

Table 2. ***Selkirk School IPLC Readings***

Date Sampled	Total kWh w/o IPLC	Total kWh w IPLC	Total kWh Saved	kWh % Saved
Dec. 15	321.82	188.24	133.58	41.51
Dec. 31	583.63	410.3	173.33	29.70
Jan. 12	96.54	55.21	41.33	42.81
Jan. 26	481.12	353	128.12	26.63
Feb. 24	404.94	251.36	153.58	37.93
Mar. 17	450.93	246.77	204.16	45.28

Table 3. ***Copper Ridge Place IPLC Readings***

Date Sampled	Total kWh w/o IPLC	Total kWh w IPLC	Total kWh Saved	kWh % Saved
Dec. 15	164.22	105.65	58.57	35.67
Dec. 31	278.12	203.8	74.32	26.72
Jan. 12	88.82	40.18	48.64	54.76
Jan. 26	340.00	247.32	92.68	27.26
Feb. 24	385.36	258.75	126.61	32.85
Mar. 17	466.87	337.44	129.43	27.72

Table 4. ***YG Main Admin IPLC Readings***

Date Sampled	Avg. kWh used without IPLC	Avg. kWh used with IPLC	Total kWh saved	Avg. kWh % Savings
Dec. 15	307.70	195.73	111.97	36.87
Dec. 31	535.90	428.75	107.15	23.30
Jan. 12	304.11	218.52	85.59	40.34
Jan. 26	356.93	259.31	97.62	27.51
Feb. 24	472.37	324.22	148.15	32.34
Mar. 17	490.31	327.67	162.64	34.02

Table 5. ***Averages and Totals Across Each Sampling Period***

Total kWh Saved from all sampled	Total kWh Saved from all IPLCs	Potential kWh savings
2852.43	11209.55	80218.34

Table 6. ***kWh Saved, and Potential***

Sample Date	Avg. Temp. C	Deg. Days
Dec. 15	-15.37	500.5
Dec. 31	-23.38	662
Jan. 12	-10.73	344.8
Jan. 26	-17.02	513.5
Feb. 24	-23.70	510
Mar. 17	-18.13	686.5

Table 7. ***Whitehorse Weather and Degree Day Data***

2010 Green Team Survey Results

Neighbourhood/Area	Street Name & Number	Location Name	IPLC Count
Riverdale	5 Selkirk	Selkirk Elementary School	12
Industrial	9010 Quartz Road	1215 Highways and Public Works	70
Downtown	2071 Second Ave.	Main Government Administration + Library Parking	97
Copper Ridge	60 Lazulite Rd.	Copper Ridge Place	45
		Total	**224**

Table 8. ***IPLC Count by Neighbourhood/Area***

Neighbourhood/Area	Regular Outlet Count
Copper Ridge	68
Downtown	671
Hillcrest	244
Industrial	266
Porter Creek	72
Riverdale	157
Takhini	125
Total	**1603**

Table 9. ***Regular Non-Residential Outlet Count by Neighbourhood/Area***

IPLC Count	Regular Outlet Count	Total Plug-in Count
224	**1603**	**1827**
% IPLC in Whitehorse	**% Regular Outlet in Whitehorse**	
12.26	**87.73**	

Table 10. ***Total IPLC and Regular Outlet Counts***

Appendix 2: "Six Pack Parking Lot Controller Summary Report"

"Six Pack" Parking Lot Controller Pilot Project

A study of
Intelligent Parking
Lot Controllers
in six Whitehorse locations

Summary report

Prepared

for Yukon Development Corporation
and the Energy Solutions Centre Inc.

by Hicklin Consulting Service

December 2003

Yukon Development Corporation

energy solutions centre

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Recognition and appreciation is extended to the following individuals who contributed time, interest and expertise to this pilot project:

- Glenn Rosendahl, P.Eng., Vantera Incorporated, Elie Manitoba
- David Buckler, owner, The Electrical Shop
- Craig Olsen, Yukon Conservation Society
- Doug MacLean, Property Management, Government of Yukon
- Bob Sharp (teacher) and students of the Experiential Science Class, Wood Street School

Cover photo by Cathie Archbould.

The title of this report came out of conversations about the IPLCs in which the six units installed at each pilot project location were referred to as a "six-pack" (e.g., "Have we programmed that six-pack for the city yet?").

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PILOT PROJECT DESCRIPTION

The purpose of this pilot project was to test and compare energy consumption, savings and potential applicability of pre-programmed Intelligent Parking Lot Controllers (IPLC) in employee parking lots. To accomplish this, timers were installed in a variety of commercial and institutional parking lots in Whitehorse, and monitored from the fall of 2000 until the winter of 2001.

BACKGROUND

The Parking Lot Controller Pilot Project was one of several recommendations included in a discussion paper completed under the Energy Efficiency Initiative for the Yukon, completed for Yukon Development Corporation in June 2000. The recommendations addressed a number of residential and commercial electrical uses that contribute to peak winter loads on the Whitehorse area hydro-electric system.

Commercial and institutional parking lots, where company and/or employee vehicles are often plugged in from the beginning to the end of a daytime shift, was one target identified in the discussion paper. This continuous load contributes to morning and afternoon peak periods, specifically during the winter months. This has energy production and capacity implications for the utility. This load also translates into energy costs for the company or institution, when vehicles draw power at warmer temperatures and for longer than necessary, contributing to both energy use and demand charges.

Additionally, during cold winter months, this heavy peak demand results in the use of diesel generators to produce electricity when hydro turbines are unable to keep up. Since the use of commercial and institutional parking lot plug-ins coincide with peak winter use, this pilot project was one of the first recommendations implemented.

OPTIONS FOR CONTROLLING PARKING ELECTRICITY SUPPLY

Central controller systems

Prior to this pilot project, the only type of parking lot controller used in institutional parking lots in the Yukon was a central controller system. A central system involves a single control unit, typically installed adjacent to the parking lot electrical panel, connected to parking receptacles. It is programmed to turn power supply on and off to all "controlled" receptacles at pre-set hours of the day, corresponding to use by employees.

There are problems associated with these central, or flip-flop, systems. They include lack of flexibility, increased system maintenance and dramatic load swings when the power turns on or off. Parts of these systems are not completely reliable and a component failure can cut off power to the entire parking lot. Obviously this will present complications for users, who have no way of knowing whether or not there is power to their vehicle.

An additional reliability issue in a northern climate, such as the Yukon's, is that these systems are typically programmed for an eight-hour working day schedule, after which they are often deactivated, mainly to avoid unauthorized (overnight) use of power. This could cause serious public safety consequences in cold temperatures.

The following anecdote is one reason for this lack of popularity: A central system in one Yukon government building was programmed to turn power off to the entire parking lot between 6 p.m. and 6 a.m. Unfortunately, a government employee, working late on a very cold (-35°C) winter evening, discovered that the block heater in their vehicle had not received power for several hours and the car would not start. This did not bode well for the reputation of the central controller system.

Intelligent Parking Lot Controller

The Intelligent Parking Lot Controller was the product chosen for testing in the pilot project. IPLC won Natural Resources Canada's 2000 Energy Management Technology Award for its ability to control the flow of electricity delivered to vehicle engine block heaters.

The IPLC M-200, designed in Elie, Manitoba, consists of a programmable electronic receptacle installed in a standard electrical box. The cover plate features red and green indicator LEDs for each side of the receptacle and a connector port for a hand held data logger.

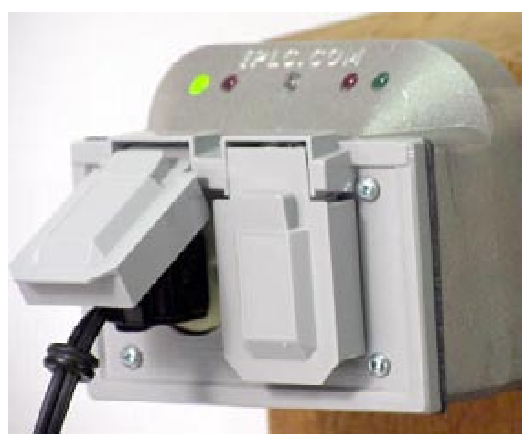
To install the IPLC, the circuit to the receptacle is deactivated and the old receptacle is removed and replaced with the IPLC. When the circuit is reactivated, the IPLC commences operation according to the programmed settings. Settings can be modified at any time using the hand-held data logger.

The user friendly IPLC

A flashing green light on the receptacle indicates that power is flowing to the IPLC.

The flashing green light changes to solid green when something is plugged in. This tells the user that power is available and that the IPLC schedule is activated.

If a red light appears, the circuit is overloaded. The user must unplug one of the heating devices installed on the vehicle.



The IPLC won out over other options because of numerous, flexible features, including the ability to specify:

- temperature sensitive "power-on" periods: The micro-processor runs on a five-minute cycle, during which it checks outside temperature against the program set-points. The colder it gets, the more time during each five-minute cycle that the power is allowed to flow into the vehicle.
- an initial "engine cool-down" period: After a vehicle is plugged in, the IPLC is programmed to allow an initial delay period, during which an engine retains an adequate amount of heat to start without needing to be plugged in.
- a limit on individual vehicle plug-in loads: Employers may wish to limit the wattage of individual vehicles to a maximum level to help reduce energy and demand costs for the employer.
- individually programming each of the two outlets on the IPLC.

Another feature of the IPLC is that each unit responds individually. Because the cycle for each car starts at the time it is plugged in, the entire parking lot is not turning on at the same time, which would cause "spiking" and significantly affect the demand charge.

Choosing suitable technology for the project

After comparing the features of the two types of parking lot control systems, the IPLC was selected over the central controller system for this pilot project for the following reasons:

- The internal IPLC timer responds to individual vehicles, as users arrive at work and plug in, which reduces energy demand by giving the IPLC system softer "on-off" characteristics than a central controller.
- The LED indicator lights alert the user if there is a problem supplying power to the vehicle, such as too many heating appliances or a faulty power cord. The central controller does not flag these conditions, which can result in damage to vehicles.
- The IPLC offers flexible programming abilities to meet (or limit) the power requirements of individual vehicles for a wide range of circumstances.
- Under real conditions in Manitoba parking lots, the IPLC demonstrated reductions in electricity consumption between 50 and 70 percent over a four-year period (PowerSmart Profiles, April 1997).

PARTICIPANTS

Pilot project participants were selected to represent a variety of large and small commercial and institutional employers in the greater Whitehorse area. In keeping with the pilot project design, six units (programmed with specified parameters for temperature, delay and load) were installed in each of the six selected locations. One of these (Whitehorse Elementary) was a "control," programmed to deliver power 100% of the time like a normal receptacle.

At each location, a contact person was chosen to identify any problems experienced by those using the parking stalls with IPLCs.

Pilot project locations and user characteristics are as follows:

- Whitehorse Elementary School: teacher and staff parking lot and assigned staff parking (control lot, "on" 100% of the time).
- Air North: small local airline, 15 employees; employee and public parking lot; parking stalls are not assigned.
- City of Whitehorse, Municipal Services Building: combination of fleet and personal vehicles; employee parking only; assigned parking.
- Dana Naye Ventures: small private venture company (less than 20 employees); employee parking only; non-assigned stalls.
- NorthwesTel: primary communications company for the Yukon; specialized program for diesel engines; assigned fleet truck parking.
- Yukon government, Main Administration Building: many employees; non-assigned parking.

IPLC SCHEDULE DESIGN AND INSTALLATION

The test design was based on the experience of Manitoba Hydro, with a slightly more severe pre-set program for the pilot project. Temperature set-points were lowered slightly; initial delays were lengthened; and load limits were decreased to reflect adequate levels of car-warming according to local research.

Pilot project receptacles in the Yukon government location were replaced with IPLCs in 1999. In the spring of 2000, pilot project IPLC units were installed and commissioned in all other locations (except NorthwesTel which was installed and commissioned in the spring of 2001).

Pre-programming options included meetings with representatives for each participating location to explain temperature setpoints, initial delay and load limits.

Temperature setpoints

- For the pilot project, no power was delivered to the vehicles until the outside temperature reached -15°C.
- From -15°C to -25°C, the program specified that power would be delivered to the receptacle for 20% of each five-minute cycle.
- From -25°C to -30°C, power was on for 50% of each cycle.
- From -30°C to -40°C, power was on for 75% of each cycle.
- Below -40°C, power was on 100% of the time.

The exception to this was NorthwesTel where, to accommodate the requirements of diesel engines in their fleet vehicles, IPLCs were programmed to turn on for 10% of the time at -5°C, and gradually increase to 100% by -25°C.

Initial delay

The pilot project specified an initial "engine cool-down" period of 2.5 hours following plug-in, down to a temperature of -40°C. Below -40°C, the initial delay was reduced to two hours. For the NorthwesTel location, the initial delay was set at two hours.

Load limits

A survey of local service stations indicated that any two of the three commonly used vehicle heaters (block heater, oil pan heater, battery blanket) would be more than adequate to keep most engines at an acceptable temperature for starting, even in very cold weather in the Yukon.

The service station representatives agreed unanimously that any combination of two of these three heaters would seldom exceed 1,000 watts. Based on this information, the pilot project limited the load on each side of the IPLC plug-in to 1,000 watts. A red warning light on the IPLC indicated an overload. At that point, the user would have to unplug something to get a green light.

For the NorthwesTel location, load limits were increased to 1,800 watts to accommodate the extra heating requirements for fleet diesel trucks.

FACTORS AFFECTING RESULTS

The two main factors that affected the results of this pilot project were outside temperature and user choices.

Outside temperature

Outside temperature is the one external factor affecting IPLC performance. If the temperature is above the programmed set-point, no power will flow through the IPLC to the vehicle when it is plugged in. If the outside temperature has reached (or dropped below) the start-up set-point, the IPLC program is activated. When a vehicle is plugged in, the IPLC first confirms that the load is within the set limits. This is followed by an initial delay period, which is followed by the regular primary program.

Inside the IPLC, power flows to the vehicle for a percentage of each five-minute cycle, according to pre-determined temperature set-points. In the case of the pilot project, the amount of "on" time increased as the temperature dropped, to a minimum of -40°C, below which the IPLC delivered power 100% of the time.

User choices

While a significant part of the IPLC performance is due to the programmed response of technology to outside temperature, the decisions and choices of the user still play a role.

One user choice is the combination of heaters installed on the vehicle. Some vehicles have a block heater only, while others may also include an oil pan heater, a battery blanket or an interior car warmer.

Some users may plug in on a cool day (-5 to –15°C), just to be on the safe side while others may not feel that it is cold enough to warrant plugging in. On a very cold day, one individual might choose to plug in for a couple of hours prior to using their vehicle, whereas another person might plug in upon arrival at the workplace.

The final user factor is the length of time that the person plugs in. Individual parking group reports (Appendix B) provide details on the average number of hours that a vehicle is parked at each stall.

PILOT PROJECT COSTS

All costs associated with the purchase and installation of the IPLCs were covered by the pilot project. The installed cost of each IPLC is approximately $200. IPLCs were installed at each pilot project location by staff electricians, with the exception of Dana Naye Ventures, where an electrician was contracted to install the units.

Data collection

A compact hand-held unit allows for easy downloading of data stored in an IPLC through a port on the back of each unit.

The information is then transferred to a computer where IPLC software prepares a detailed report for each receptacle.

Data from all pilot project locations were downloaded at the end of December 2001.

ANALYSIS

Data was downloaded from the IPLC to the hand-held unit and transferred to a computer for analysis by the IPLC software.

Appendix A provides a definition of terms used in the data tables in Appendix B, which is a detailed report for each IPLC at individual pilot project locations. A review of climate data for this period shows that the average winter temperature during the pilot project was approximately 7% warmer than the 30-year average. See Appendix C for more weather information.

The summary table below enables a quick comparison of the results. Explanatory notes on each column follow and results are discussed in the next section.

Summary table

Participant location	Number of days in operation	Possible kWh (without IPLC)	Actual kWh (with IPLC)	kWh saved	Savings	Number of units working	Average saved per unit ($0.148/kWh)	Payback in years
Whitehorse Elementary (control)	328	650	643	7	0%	6	$0.17	1,039
Air North	570	405	66	339	84%	5	$10.05	31
City of Whitehorse, Municipal Services Building	222	3,592	801	2,791	78%	6	$68.94	2
Dana Naye Ventures	440	191	40	151	79%	5.5	$4.07	59
Yukon government, Main Administration Building	634	1,918	554	1,364	71%	5	$40.43	9
NorthwesTel	248	3,563	1,789	1,774	50%	6	$43.82	3

All columns to the left of the *kWh saved* were transferred directly from the individual pilot project reports.

Savings: percentage savings from installing IPLCs compared to supplying full power to the receptacles while they were in use.

Number of days in operation: number of days since the IPLC was installed.

Possible kWh: potential energy consumption of vehicles using the IPLC units over the test period (calculated by multiplying the number of times the IPLC was used by the average vehicle load by the average parking duration).

Actual kWh: recorded energy use during the test period.

kWh saved: possible kWh minus actual kWh.

Average saved per unit: Possible kWh less the *Actual kWh* times the commercial energy cost per kWh ($0.148/kWh), divided by the number of units in use at each location.

Payback: installed unit cost divided by the average annual dollars saved per unit divided by the number of days the unit was in operation.

RESULTS

LOCATIONS WITH STANDARD PILOT PROJECT SCHEDULE

Savings for the four locations with IPLCs programmed specifically for this pilot project (Air North, City of Whitehorse, Dana Naye Ventures and Yukon government) averaged 78%.

Actual cost savings may be greater (and payback periods shorter) than shown, as the only factor used for the calculations was the kilowatt hours consumed. Demand charges, which refer to the second portion of a commercial or institutional electrical bill based on the highest power demand over the previous 12-month period, were not factored into the cost savings calculations.

There were not enough units installed during the pilot project to affect demand charges and therefore demand charges were not used.

In terms of actual savings and payback, however, the combined effect of a relatively warm test period and the way people used their plug-ins contributed to the wildly varying results, showing payback ranging from two to 59 years.

For example, two of the larger institutions (City of Whitehorse and Yukon government) showed significant savings and short payback periods based on their energy savings through the pilot project test period. For these participants, this translated into two-year and nine-year paybacks on the cost of the IPLCs.

Although the two smaller companies (Air North and Dana Naye Ventures) showed similarly high percentage savings, the actual amount of energy they used was so small that the payback period is very lengthy (31 and 59 years).

IPLCs installed at the NorthwesTel fleet vehicle parking lot had less severe programming (shorter delays, a warmer start-up set-point, and a higher load limit). This schedule, which better accommodated the needs of their diesel fleet trucks, still achieved 50% energy savings and a three-year payback period.

Given the small sample size of the pilot project, it was not possible to assess the load reduction impact on daily energy profiles generated by Yukon Energy.

PILOT PROJECT CONTROL LOCATION

The original purpose of including a control location at Whitehorse Elementary School was to compare the results of two school staff parking areas, one with power to the IPLC receptacles 100% of the time and the other with the pre-programmed pilot project schedule.

Unfortunately, the wiring for the parking lot at the Wood Street school (which has since been upgraded) was not adequate for installing the IPLCs. Dana

Naye Ventures was invited to make up the full compliment of six pilot project locations.

Similar to the other pilot project locations, the original data reports for Whitehorse Elementary indicated the number of plug-in times, individual vehicle loads and average duration of each plug-in. These three figures are multiplied together to calculate the power consumption without IPLC. As expected for the control, this figure is almost the same as the power consumption with IPLC.

For extrapolation purposes shown in the table below, the average percent savings from all other pilot project locations (except NorthwesTel) was entered for Whitehorse Elementary and a new power consumption with IPLC was re-calculated (called *Actual kWh* on the summary report). Assuming all other conditions remained the same, these control units, if programmed with the same schedule as other pilot project locations would have a payback period of 14 years.

Extrapolated energy savings for Whitehorse Elementary School

Participant location	Number of days in operation	Possible kWh	Actual kWh	Percentage difference	Actual savings kWh	Annual savings kWh	Savings per unit ($0.148/kWh)	Payback in years
Whitehorse Elementary	328	650	138	78	512	570	$12.64	14
Air North	570	405	66	84	339	217	$10.05	31
City of Whitehorse, Municipal Services Building	222	3,592	801	78	2,791	4,589	$68.94	2
Dana Naye Ventures	440	191	40	79	151	125	$4.07	59
Yukon government, Main Administration Building	634	1,918	554	71	1,364	784	$40.43	9
Note: IPLC diesel schedule for NorthwesTel location was not used for purpose of these calculations)								

CONCLUSIONS AND RECOMMENDATIONS

Given a similar program schedule and load limits, outdoor temperature is the main external factor contributing to IPLC savings and payback periods. With a comparatively mild test period, the results of this pilot project offer a very strong case for several pilot locations to invest in an IPLC system.

While a colder winter would have reduced the savings and lengthened the payback period for the IPLCs in all pilot project locations, a permanent IPLC installation would result in a balancing of the savings and payback over colder and milder winters.

In all pilot project locations, three user factors also contributed significantly to the payback period: the load of individual vehicles, the length of time that plug-ins were used per day, and the total number of days that the plug-ins were activated.

For employee parking in larger businesses and institutions (City of Whitehorse and Yukon government), or for fleet vehicles that must be kept in a ready-to-go condition at all times (NorthwesTel), the IPLC offered significant savings and short payback periods. This can be attributed to the fact that the average loads are higher, the average duration of parking (both daily and seasonally) is longer, and the frequency of plug-ins is greater.

For small businesses with few employees (Dana Naye and Air North) the savings were lower and the payback period was much longer. Based on the preliminary results of this pilot project, it would generally not be cost-effective for these businesses to invest in parking lot controls.

Employers considering investing in IPLCs for existing employee parking should conduct a staff survey and/or random inspections of the parking lot at various temperatures to record plug-in habits for staff vehicles, estimate duration of daily plug-ins, and estimate or measure actual vehicle loads. If it is determined that a timer program will result in reasonable savings, then it will be helpful to have this information to help with designing an appropriate schedule.

IPLCs should be specified for installation into employee parking lots of all new institutional and appropriate commercial buildings.

In all cases, employee education and awareness play an important role in the success of a parking lot controller program. This reduces the risk of a program backfiring due to lack of information, such as the case of a well-meaning energyconscious employee who plugs in their vehicle two hours before the end of a cold working day. The IPLC, programmed for a 2.5 hour "initial delay" (cool-down) period would not allow power to the car at all during that time. Obviously, on a very cold day this could have unfortunate consequences.

A very concise (quick to read at -35°C) weatherproof summary of operating instructions should be mounted in a visible location on each post, so that new users can easily understand that they want to see a steady green light to have confidence that the unit is operating correctly as programmed.

APPENDIX A
Definition of terms

Serial Number:	The unique number assigned to each IPLC for identification and performance tracking.
Power On Time:	Total number of days the main power has been applied to an IPLC.
'Plug-in' Time (A):	This value gives the total number of hours that customer loads' were "plugged-in" to the IPLC.
Power Consumption, Without IPLC (B):	This indicates how much power (in Kwhrs) would have been delivered to attached loads if the IPLC was not present.
Power Consumption, With IPLC (C):	Indicates how much power (in KWhrs) was actually delivered to attached loads using the IPLC.
'Plug-in' Count (D):	This count identifies the total number of times a load was "plugged-in" into the IPLC.
Park Time (hours):	Is the average number of hours a vehicle parks at this stall.
Load Size (Watts):	Is the average load size in Watts this stall has seen.
Stall Savings (%):	Is the total percent energy reduction (savings) for this stall.
Overload Count:	Indicates the number of loads which have exceeded the preset load limits.
Requalify Count:	This count gives the number of times that the IPLC attempted to requalify loads marked as an overload.
Short Circuit Count:	Indicates the number of loads asserted which were determined to be short circuits.
Power Up Count:	This value indicates the number of times the onboard computer was reset due to either power failures or excessive power line "noise".

NOTE: *Table entries marked with dashes ("----!----") indicate that the IPLC in question was either inaccessible or the collected data values in question were too small to provide a reasonable value.*

***IPLC** is short for "Intelligent Parking Lot Controller".*

APPENDIX B
Individual reports for six pilot project

Thursday, January 24, 2002
Present Data Report

Report for Parking Group: YTG..main

Average parking duration (A/D): 11.92 Hours
Average vehicle load (B/A): 547.34 Watts
Average power consumption savings ((B-C)/B): 71.13 %

Serial Number	Stall Name	Power On Time (days)	'Plug-in' (A) Time (hrs)	Power Consumption Without (B) IPLC (Kwh)	Power Consumption With (C) IPLC (Kwh)	'Plug-in' Count (D)	Park Time (hrs)	Load Size (W)	Stall Save (%)	Overload Count	Requalify Count	Short Cct. Count	Power-Up Count
1497A	001497A	206.07	68.11	37.84	21.12	0	----!----	555.53	44.18	0	0	0	3
1497B	001497B	206.07	158.15	131.53	58.72	0	----!----	831.65	55.36	0	0	0	3
1498A	001498A	639.01	199.49	108.61	48.30	20	9.97	544.43	55.53	0	0	0	7
1498B	001498B	639.01	238.63	132.31	54.03	22	10.85	554.46	59.16	1	0	0	7
1499A	001499A	639.03	299.69	145.87	54.25	32	9.37	486.72	62.81	8	162	1	7
1499B	001499B	639.03	250.39	120.55	45.74	32	7.82	481.44	62.06	12	55	0	7
1500A	001500A	614.14	450.41	312.42	82.59	45	10.01	693.65	73.56	4	171	0	7
1500B	001500B	614.14	544.31	267.02	58.60	31	17.56	490.56	78.06	1	0	0	7
1501A	001501A	642.47	316.07	192.61	30.70	29	10.90	609.39	84.06	16	153	7	22
1501B	001501B	642.47	412.86	166.28	9.54	26	15.88	402.74	94.26	29	3	15	22
1502A	001502A	638.96	336.02	189.83	50.50	36	9.33	564.93	73.40	8	202	0	7
1502B	001502B	638.96	229.53	112.83	39.59	21	10.93	491.57	64.91	1	0	0	7
Totals			**3503.67**	**1917.68**	**553.67**	**294**				**80**	**746**	**23**	

Thursday, January 24, 2002
Present Data Report

Report for Parking Group: SCHOOLS..whse elem

Average parking duration (A/D): 3.81 Hours
Average vehicle load (B/A): 648.65 Watts
Average power consumption savings ((B-C)/B): 1.10 %

Serial Number	Stall Name	Power On Time (days)	'Plug-in' (A) Time (hrs)	Power Consumption Without (B) IPLC (Kwh)	Power Consumption With (C) IPLC (Kwh)	'Plug-in' Count (D)	Park Time (hrs)	Load Size (W)	Stall Save (%)	Overload Count	Requalify Count	Short Cct. Count	Power-Up Count
1516A	001516A	327.82	169.30	134.18	132.56	39	4.34	792.53	1.20	0	1	0	9
1516B	001516B	327.82	16.16	9.85	9.70	4	4.04	609.86	1.55	0	1	0	9
1518A	001518A	328.31	189.10	108.78	108.15	43	4.40	575.25	0.58	0	0	0	10
1518B	001518B	328.31	61.36	50.73	50.23	17	3.61	826.72	1.00	0	0	0	10
1519A	001519A	328.36	58.71	67.24	66.32	18	3.26	1145.23	1.36	0	0	0	6
1519B	001519B	328.36	6.83	2.14	2.14	3	2.28	313.00	0.00	0	0	0	6
1522A	001522A	328.36	108.62	61.47	60.94	25	4.34	565.87	0.86	0	0	0	7
1522B	001522B	328.36	30.95	14.02	13.93	10	3.09	452.87	0.60	0	0	0	7
1532A	001532A	328.04	57.27	38.65	38.02	26	2.20	674.98	1.63	0	0	0	9
1532B	001532B	328.04	31.18	20.93	20.78	11	2.83	671.24	0.71	1	28	0	9
1533A	001533A	327.22	122.35	68.05	66.85	33	3.71	556.18	1.77	0	0	0	8
1533B	001533B	327.22	150.11	73.88	73.16	34	4.42	492.17	0.97	0	0	0	8
Totals			**1001.93**	**649.90**	**642.78**	**263**				**1**	**30**	**0**	

Report for Parking Group: CITY WHSE..MSB

Thursday, January 24, 2002
Present Data Report

Average parking duration (A/D): 18.89 Hours
Average vehicle load (B/A): 537.15 Watts
Average power consumption savings ((B-C)/B): 77.71 %

Serial Number	Stall Name	Power On Time (days)	'Plug-in' (A) Time (hrs)	Power Consumption Without (B) IPLC (Kwh)	Power Consumption With (C) IPLC (Kwh)	'Plug-in' Count (D)	Park Time (hrs)	Load Size (W)	Stall Save (%)	Overload Count	Requalify Count	Short Cct. Count	Power-Up Count
1513A	001513A	222.08	1472.66	856.50	170.41	15	98.18	581.60	80.10	0	0	0	6
1513B	001513B	222.08	502.90	231.24	89.42	34	14.79	459.82	61.33	1	0	0	6
1517A	001517A	222.08	93.30	49.06	10.58	19	4.91	525.85	78.44	0	0	0	6
1517B	001517B	222.08	158.08	65.26	9.92	33	4.79	412.85	84.80	1	0	0	6
1523A	001523A	222.08	110.90	55.29	15.16	22	5.04	498.55	72.58	0	0	0	6
1523B	001523B	222.08	1605.78	862.27	128.55	30	53.53	536.98	85.09	0	0	0	6
1528A	001528A	222.08	797.20	645.42	170.25	35	22.78	809.60	73.62	0	0	0	6
1528B	001528B	222.08	526.94	203.21	38.41	42	12.55	385.63	81.10	1	0	0	6
1530A	001530A	222.06	280.05	148.15	30.31	45	6.22	529.01	79.54	0	0	0	6
1530B	001530B	222.06	184.78	55.99	13.59	37	4.99	303.03	75.73	0	0	0	6
1531A	001531A	222.07	872.22	387.22	115.33	32	27.26	443.94	70.22	3	13	0	6
1531B	001531B	222.07	83.89	33.20	9.02	10	8.39	395.80	72.85	3	32	0	6
Totals			**6688.69**	**3592.80**	**800.93**	**354**				**9**	**45**	**0**	

Report for Parking Group: DANA NAYE..Dana Naye

Thursday, January 24, 2002
Present Data Report

Average parking duration (A/D): 3.83 Hours
Average vehicle load (B/A): 434.50 Watts
Average power consumption savings ((B-C)/B): 79.05 %

Serial Number	Stall Name	Power On Time (days)	'Plug-in' (A) Time (hrs)	Power Consumption Without (B) IPLC (Kwh)	Power Consumption With (C) IPLC (Kwh)	'Plug-in' Count (D)	Park Time (hrs)	Load Size (W)	Stall Save (%)	Overload Count	Requalify Count	Short Cct. Count	Power-Up Count
1511A	001511A	440.49	65.01	11.54	1.40	19	3.42	177.48	87.85	0	0	0	9
1511B	001511B	440.49	114.84	54.88	12.06	20	5.74	477.90	78.03	0	0	0	9
1520A	001520A	440.55	38.15	19.24	3.30	13	2.93	504.27	82.87	1	0	0	9
1520B	001520B	440.55	27.00	13.78	3.31	7	3.86	510.42	75.96	0	0	0	9
1521A	001521A	440.62	64.55	28.57	6.95	16	4.03	442.63	75.68	0	0	0	9
1521B	001521B	440.62	72.89	35.39	8.57	16	4.56	485.56	75.77	1	0	0	9
1524A	001524A	440.58	10.16	4.91	0.76	3	3.39	482.69	84.55	0	0	0	9
1524B	001524B	440.58	4.40	1.48	0.25	2	2.20	336.21	82.92	0	0	0	9
1525A	001525A	440.42	0.00	0.00	0.00	0	----!----	----!----	----!----	0	0	0	9
1525B	001525B	440.42	15.25	8.29	1.15	8	1.91	544.03	86.12	0	0	0	9
1526A	001526A	440.55	22.76	10.62	1.81	9	2.53	466.50	82.94	0	0	0	10
1526B	001526B	440.55	5.46	2.68	0.52	2	2.73	491.25	80.49	0	0	0	10
Totals			**440.47**	**191.39**	**40.09**	**115**				**2**	**0**	**0**	

Thursday, January 24, 2002
Present Data Report

Report for Parking Group: NWTel..diesel

Average parking duration (A/D):	16.17	Hours
Average vehicle load (B/A):	847.54	Watts
Average power consumption savings ((B-C)/B):	49.79	%

Serial Number	Stall Name	Power On Time (days)	'Plug-in' (A) Time (hrs)	Power Consumption Without (B) IPLC (Kwh)	Power Consumption With (C) IPLC (Kwh)	'Plug-in' Count (D)	Park Time (hrs)	Load Size (W)	Stall Save (%)	Overload Count	Requalify Count	Short Cct. Count	Power-Up Count
2090A	002090A	247.91	960.21	813.27	486.97	33	29.10	846.98	40.12	1	89	0	11
2090B	002090B	247.91	156.25	118.90	89.59	6	26.04	760.97	24.66	1	2	0	11
2091A	002091A	247.91	8.04	0.86	0.00	1	8.04	107.55	100.00	0	0	0	11
2091B	002091B	247.91	194.10	16.41	7.39	12	16.18	84.56	54.97	0	0	0	11
2092A	002092A	247.91	111.88	90.69	36.25	6	18.65	810.59	60.02	1	0	0	11
2092B	002092B	247.91	305.99	243.11	87.50	13	23.54	794.50	64.01	0	0	0	11
2093A	002093A	247.86	298.55	201.92	148.68	17	17.56	676.33	26.37	0	0	0	11
2093B	002093B	247.86	792.27	574.85	308.15	21	37.73	725.57	46.40	0	0	0	11
2095A	002095A	247.90	842.79	856.88	471.92	25	33.71	1016.72	44.93	11	1	0	11
2095B	002095B	247.90	534.22	646.39	152.85	126	4.24	1209.97	76.35	3	0	0	11
Totals			**4204.32**	**3563.31**	**1789.31**	**260**				**17**	**92**	**0**	

APPENDIX C

Whitehorse weather data, degree-day data

	Actual	Average Year		
1999				
Jan	1,183.1	1,141.8		
Feb	976.2	880.0		
Mar	738.0	784.2		
April	508.8	531.5		
May	388.8	353.9		
June	153.9	193.3		
July	109.9	127.9		
August	150.7	177.7		
September	311.3	322.4		
October	499.8	538.3		
November	792.4	841.5		
December	844.4	1,054.2	Change	
Totals:	6,657.3	6,946.7	289.4	Degree Days (warmer)
			4.3	% - adjustment from a normal (30 year average) year
2000				
January	1,082.9	1,141.8		
February	735.2	880.0		
March	659.6	784.2		
April	516.1	531.5		
May	379.1	353.9		
June	172.2	193.3		
July	139.3	127.9		
August	219.3	177.7		
September	353.8	322.4		
October	539.3	538.3		
November	694.1	841.5		
December	972.4	1054.2	Change	
Totals:	6,463.3	6,946.7	483.4	Degree Days (warmer)
			7.5	% - adjustment from a normal (30 year average) year
2001				
January	724.8	1141.8		
February	864.1	880.0		
March	771.9	784.2		
April	505.7	531.5		
May	390.4	353.9		
June	167.3	193.3		
July	139.7	127.9		
August	139.7	177.7		
September	309.0	322.4		
October	573.4	538.3		
November	818.0	841.5		
December	1094.6	1054.2	Change	
Totals:	6498.6	6946.7	448.1	Degree Days (warmer)
			6.9	% - adjustment from a normal (30 year average) year