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Solid Waste Indicators at the University of Waterloo

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Acknowledgments

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Abstract

The objective of this paper is to contribute to a campus-wide sustainability indicators project adapted for the University of Waterloo by Crystal Legacy. Solid Waste issues and progress were studied at both a macro (national) and a micro (university) level to give a complete understanding of these issues and their impact. The four indicators for waste management were calculated to measure the university's waste reduction rate and diversion efforts. Also, an assessment of the availability of current information was made and recommendations concerning the feasibility of the indicators and data collections are provided as reference for improvement plans. Examples of good practices in waste reduction from other universities were also presented to serve as references for what we can do in the university to achieve sustainability.

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1 Introduction

Like all other institution in North America, University of Waterloo has a high resource consumption rate. We are aware that this consumption pattern is driving us away from environmental sustainability and that improvements must be made. A campus-wide indicator project was adopted by a student, Crystal Legacy, as a standard to evaluate sustainability at the University of Waterloo. It is the goal of this report to help evaluate those indicators – specifically indicators M9 through M12 which relate directly to solid waste. Throughout the process of preparing and calculating these indicators, however, we have been able to develop an understanding of the university's waste management practices, policies, and reduction rates. Consequently, we have been able to provide several recommendations, not only on how to improve our ability, as a university community, to calculate the indicators, but also how to incorporated these indicators into the existing waste management strategy so that they can be used to provide valuable information on how to meet our goals of sustainability. As well, we have prepared a number of examples and best practices, taken from other universities as references for what we can do to improve.

Before discussing the indicators and our recommendations, however, it is important to consider the scope of the waste problem - this crisis exists at all levels of the Canadian landscape.

2 Context: from Canada to the Campus

The amount of waste a society generates reflects on its production and consumption patterns, and has a potential impact on human health and the environment. An indicator on the amount of waste generated is, therefore, a first approximation of environmental pressure on air, water, and land resources[1].

Waste is something we have used or consumed and consider no longer useful. According to the American's Resource Conservation and Recovery Act, solid waste is "any garbage, refuse, sludge and any other discarded material, including: solid, liquid, semisolid or contained gaseous material, resulting from industrial, commercial, mining, and agricultural operations and from community activities."[2] Solid waste is generally produced in three ways: through the production and consumption of goods and services; through the processing of wastes from these services; and through end-of-pipe control or treatment of emissions.[1]

Urbanization and the increase in population have resulted in a rapid rise of waste generation. Natural resources are consumed faster than they recover, landfills are filling up faster than we can find new sites, and pollution is damaging the environment faster than what nature or human can handle. Hence, reducing the rate of waste generation should be our first priority out of all the waste management methods.

Today, reuse, recycling, composting, landfilling, and incineration are among the most common types of waste management methods. Reuse, recycling and composting are new waste management methods to reduce waste and stresses to our environment. To be really effective, we have to incorporate the 4Rs Reduce, Reuse, Recycle and Recover into our daily routine.

2.1 Solid Waste in Canada

Nationally

Canadians are proud to have a high standard of living that allows us to enjoy nature and have the luxury of technology at the same time. However, the high consumption subsequently high rate of waste generating that result from such a high quality of life has been stressing our once-healthy environment. In return, money, resources, and efforts are paid for waste management and the minimization of impacts that waste generates.

Canadians generate 22 million tones of municipal and industrial waste a year[3]. All three levels of governments are pressed to deal with environmental risks, costs and liabilities arising form contaminated sties. In order to maintain both economical and environmental sustainability, the Canadian Council of Ministers of the Environment set a targets of fifty percent solid waste reduction in 1989 that was scheduled to be met by the year 2000[4].

Since this target was set, Canadians have invested an increased effort into recycling and composting in attempt to meet the goal. In 1990, about 459,000 tonnes of materials were recycled in Canada. And now, about 2/3 of our population (17 million) have access to recycling[5]. In addition to our recycling effort, the number of centralized composting facilities throughout Canada has more than tripled from 30 to over 120 since 1989. Despite this effort, an estimated 1/3 of solid waste going to landfill is recyclable, and 1/3 could be composted[3].

Provincially

To align with the national waste reduction target, in 2002 the Ontario provincial government established "The Waste Diversion Act" which created Waste Diversion Ontario (WDO). WDO is mandated to implement waste reduction programs provincially. Programs such as the blue box program, used tires programs, and used oil program have begun, but are still gaining speed[6].

Municipally

Waste management has been a challenge to most municipalities in Canada. Municipalities spend millions of dollars searching for landfills[5] and many millions more managing the landfills they have. Land degradation, contaminated water, and greenhouse gas emission are among the major impacts a landfill has on its immediate, regional, and global ecology.

The region of Waterloo landfill site, which is the primary waste disposal facility serving the Region, has been in operation since 1972 and is expected to continue to receive wastes until 2026[7]. The capacity of the site is provided in Table 1.

Table 1 - Landfill Capacity for Region of Waterloo (2001)

Landfill Summary	
Waste in place	6,000,000 Tonnes
Waste disposed	200,000 Tonnes
Landfill capacity	12,000,000 Tonnes

The site may still have a long lifetime, but the reduction of waste would greatly reduce the burden of both the site and the surrounding area. In the Region of Waterloo, organic material such as paper, kitchen and yard waste, makes up 2/3 of the waste stream. Most of this material can be recycled or composted thus reducing occupying landfills space[8].

2.2 Solid Waste at the University of Waterloo

In 1993 the Ministry of the Environment introduced the 3R's Regulations to reduce waste in Ontario. All institutions in the province, including universities, were to adopt the 3Rs programs in order to achieve the national waste reduction goal. The regulations requires all Universities to perform waste audits, complete a waste audit workplan, and introduce a recycling program. But even before the introduction of the regulation, the University of Waterloo had created WATgreen, an organization to involve the staff, faculty and students in waste reduction programs, waste auditing, and other related activities. Though the university has no official policy on environmental preservations, the WATgreen advisory Committee, along with the newly instituted UW Sustainability Project (UWSP) serve the responsibility of promoting and implementing environmental programs. A list of programs and initiatives are available at http://www.watgreen.uwaterloo.ca/.

From 1987 to the end of 1998, the university had reduced its solid waste to landfill by 48%, which exceeded the national target[9]. The next objective was to exceed the provincial goal of 50% reduction in solid waste by the year 2000. Unfortunately, the 48% reduction has actually declined to approximately 44% in 2002.

In order to achieve the goal, it is important to understand our pattern of waste generation (i.e. the breakdown of the waste stream) and find out how we can improve in different functional areas on campus. The current waste audit work plan has provided some useful targets for improvement. These audits are conducted on a yearly basis, on behalf of WATgreen, by students in Environmental Resource Studies who take the course ERS 317 – Waste Management. These reports are available in printed form from the university's waste management coordinator Patti Cook.

Waste to Landfill

In 2002 (the most recent year of data available), the university generated 1,648 tonnes of landfill waste[10]. All solid waste goes to the Region of Waterloo landfill mentioned above. There are 74 waste containers campus-wide, representing a total capacity of 355 cubic yards.[11] This waste is collect daily by Waste Services, a devision of Capital Environmental Inc.[12] Larger amount of waste requires larger custodial work force and more trash removal services. Excluding these costs, and only considering transportation and tipping fees, the cost for waste disposal is approximately $225,000 a year. This cost amounts to approximately 0.2% of the 2001/2002 budget[13].

Recycling & Composting

There were 848 tonnes of recycled material produced at the University of Waterloo in 2002[10]. Currently, there are 231 large recycling carts from all 50 buildings on campus, as well as several large bins for cardboard. These large carts & bins are collected once a week by Waste Services. A breakdown of net costs and revenues from various recycled materials on campus is provided in Table 2.

Table 2 - Cost/Revenue of Recyled Materials at U of W

Category	*(Cost)* or **Revenue** ($/yr)
Fine Paper	**7000**
Cardboard	*(35,000)*
Blue-box (PET, Plastic, Glass)	*(25,000)*

Since 1987, UW saved approximately $100,000 from recycling and reducing the burden of our landfill, and paid 30% less for resource consumption[9].

In addition to recycling, a minimal amount of composting and vermi-composting occurs at the University of Waterloo. In 2002 approximately 120 tonnes of material was composted – most of that plant and yard waste. However, unlike recycling, we do not get rebates for composted materials, reducing the incentive to increase composting practices. If centralized composting such as the system in Guelph were brought to the Waterloo Region, composting would certainly increase.

3 Solid Waste Indicators

With a clear understanding of how waste is dealt with on campus, we can now calculate the four solid waste indicators as outlined by Lindsay Cole in her original report[14]. These indicators have were calculated, for the very first time, by Concordia University in Montreal[15]. Since this is the first time these indicators have been calculated at U of W, a more thorough explanation of each calculation is provided. In the following four sections, each indicator is defined, the results are given, the source of the data is provided, and the validity of that data is discussed. The source data for all charts is provided in Appendix A.

3.1 Total waste generated (M-9)

This indicator is designed to provide information about the total waste generated by the University for the given year. The indicator actually calls for the "total weight of solid waste and recycling"[14] for the year, but it is assumed that composted waste is also included in that total, since generated waste fits into one of those three categories. This breakdown leads to the simple equation:

$$\textit{Total Waste} = \textit{Waste Landfilled} + \textit{Recycling} + \textit{Composting} \quad (1)$$

The value for M-9 also depends on the number of Campus Community Members (CCM). This value is calculated using the Full-Time Equivalent (FTE) values for students, staff, and faculty[14]:

$$\textit{CCM} = \textit{FTE Students} + \textit{FTE Staff} + \textit{FTE Faculty} \quad (2)$$

Now, using two equations above, we can calculate the indicator value:

$$M9 = \frac{\textit{Total Waste}}{\textit{CCM}} \quad (3)$$

Results

Since data is available as far back as 1990 and since this indicator has never been calculated, a chart of results from 1990-2002 are provided for comparison (see Figure 1).

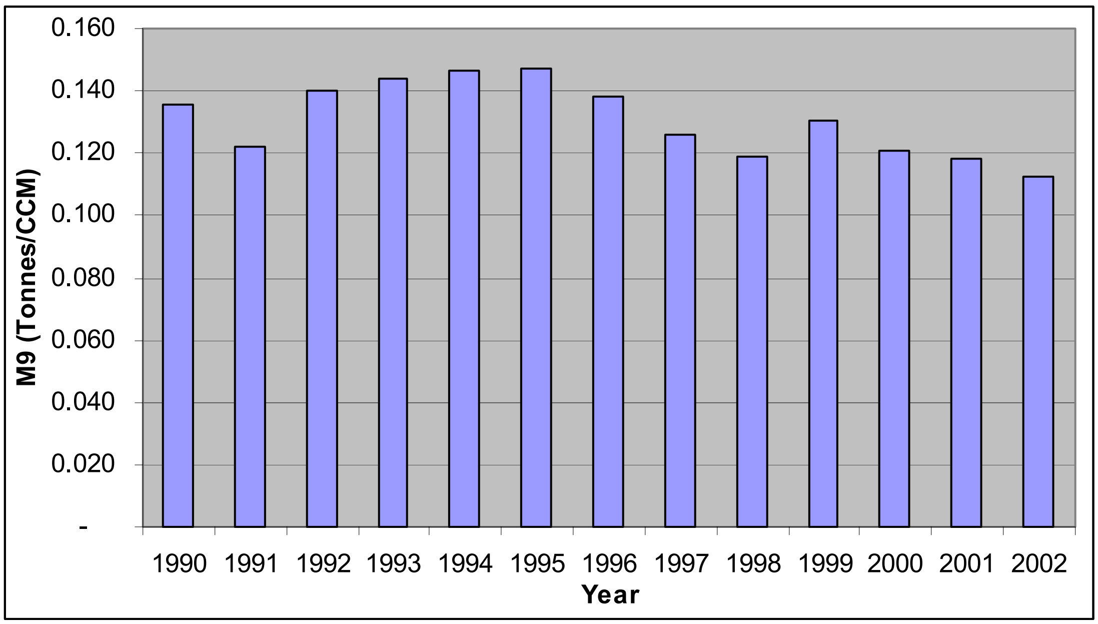

Figure 1 - M9 - Waste Generated per CCM: 1990 – 2002

The peak value for M9 occurred in 1995 when it reached 147 kg/CCM. For 2002, however, the value has decreased significantly to 112 kg/CCM.

Source & Validity

The FTE values used in the CCM calculation are prepared by the Office of Institutional Analysis & Planning each fiscal year[13]. This information is well known by the university, and is therefore considered to be the most accurate information provided in this report. Unfortunately, the student FTE values for the 1995/1996 and 1999/2000 fiscal years were not directly available before this project was completed. The number used were taken directly from a graph, which reduces their accuracy somewhat.

The waste data used is collected and tabulated by the campus waste coordinator Patti Cook. The values for landfill and recycling are taken from documentation provided by Waste Services and are considered to be significantly accurate. The compost data is, however, less valid. Since the actual tonnage of compost was first measured during 2002, the retro-active calculation of tonnage for the years 1990-2001 is not necessarily accurate. The per-year increase of 1 is simply an estimate from operations staff[16].

When compared to Concordia's results, the U of W numbers seem quite high. Concordia's M-9 was calculated at 20.9 kg/CCM – a difference of more than 125 kg/CCM. This substantial difference is because of a large difference in both Concordia's reported waste generation and CCM values. According to the endnotes of the published report {REF – Concordia report}, Concordia produced only a little more than 613 tonnes of waste from April 2002 to March 2003. This number is more than half of the reported U of W generation. In contrast, Concordia reports exactly 40,000 CCM over the same time period, while the Waterloo numbers are around 23,000 CCM. Under the assumption that the CCM numbers presented by both schools are trustworthy, it is startling to think that Concordia, with more than twice the population, is able to produce less than half the waste. The only logical motivation for this difference is that either Concordia or U of W are incorrectly reporting their tonnage of waste. The problem that arises from this observation is discussed further in Section 4.1 below.

3.2 Waste reduction (M-10)

This second indicator measures the reduction in waste with respect to the previous year. The calculation is quite simple:

$$M10 = \left(\frac{M9_{2001} - M9_{2002}}{M9_{2001}} \right) \times 100\% \quad (4)$$

Results

Just as for the M9 data, a chart of results for M10 across multiple years (1991-2002) is provided (Figure 2). There is a great deal of variability in the values across the 11 years. Two notable peaks are the best year for reduction (1991) and the worst year (1992) which occurred back to back. In the past three years, however, an average 5% reduction has occurred. In 2002 specifically, the M10 value was almost exactly 5%.

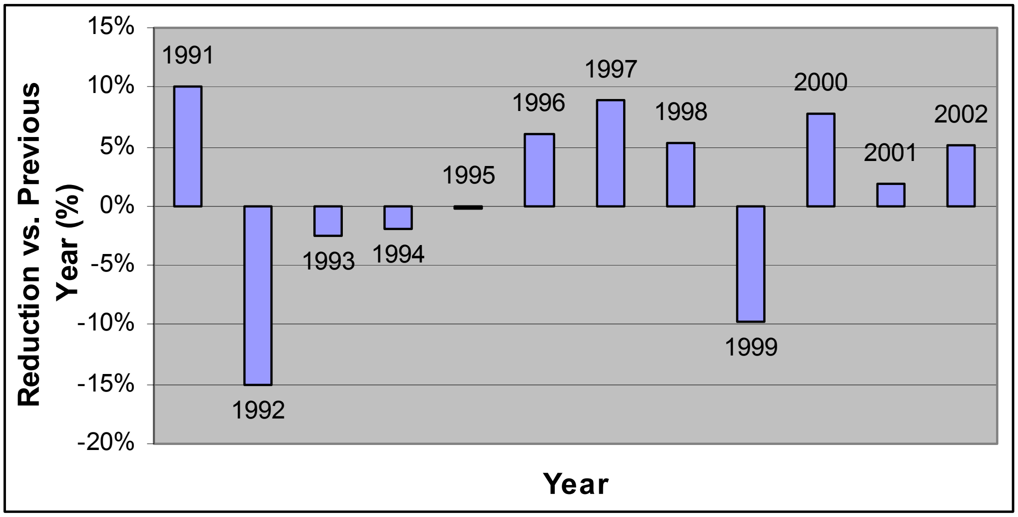

Figure 2 - Waste Reduction per CCM - Year over Year

It is also important, in order to comply with provincial legislation, to calculate the reduction in waste since 1987. This data is provided for 1991 to 2002 in Figure 3.

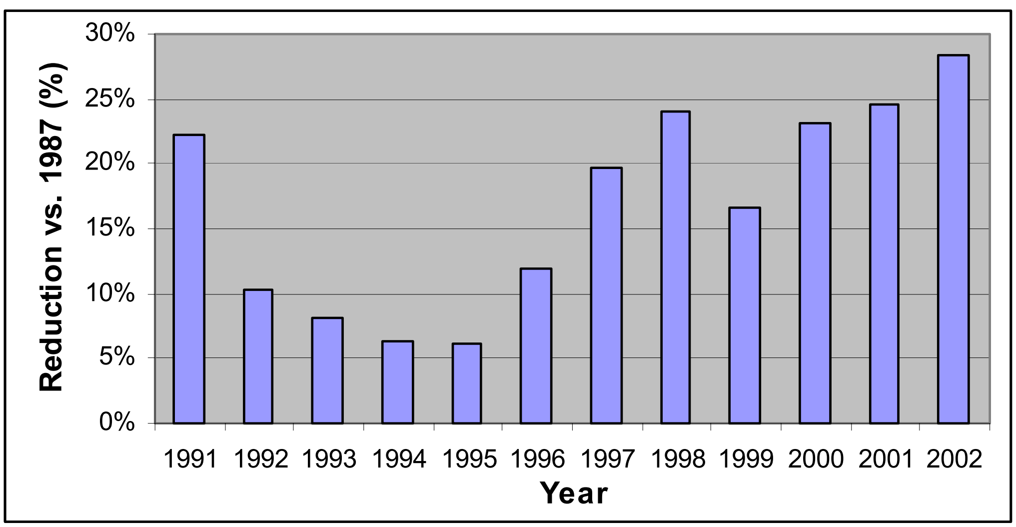

Figure 3 - Waste Reduction per CCM - vs. 1987

The results vs. 1987 are somewhat more impressive than the year-over-year numbers. In fact, the chart indicates that in 2002 the university finally reached a 25% per capita reduction. This number is not exactly comparable to requirement for 50% overall reduction in waste mandated by the Provincial Government. However, the per CCM value is more telling of how the university has succeeded in reducing waste than the raw reduction numbers presented by WATGreen in their "State of the Environment" report[9].

Source & Validity

The sources for calculating M10 are the same as those of M9, with the exception of the 1987 CCM data used for comparison. The 1987/1988 FTE student data was not available at the time of this project. Like the 1995 and 1999 data, it was estimated from a yearly chart.

3.3 Recyclables sent to landfill (M-11)

In order to assess the amount of waste that could potentially be recycled, M-11 is based on the following calculation:

$$M11 = \left(\frac{Total\ \ Mass\ \ \mathrm{Re}cycleables\ \ Landfilled}{Total\ \ Mass\ \ Landfilled} \right) \times 100\% \qquad (3)$$

The value for M11 can be calculated, not only for recyclable materials (**M11R**), but for compostable ones as well (**M11C**). Both numbers are provided in the results.

Results

Over the past eleven years, waste audits have been conducted which provide the waste breakdown of different locations and functional areas on campus. Two data points have been chosen for comparison in this report: the original 1992 audit data, and an average of the 2003 audit data (Table 3).

Table 3 - M11 Calculations for 1992 and 2003

	Recycleables Landfilled (M11R)	Compostables Landfilled (M11C)	Space Type Coverage (% of Total)
1992	37%	18%	76%
2003	24%	18%	39%

Measuring the change in M11 values is an indication of how effective waste diversion efforts have been over the past eleven years. It would seem as though diversion of recyclable materials has been quite successful, since this value decreased by 13%. On the other hand, composting appears not to have improved at all since 1992.

We have used tentative language such as "seems as though" and "appears not to" to describe this data because its accuracy is questionable. The third column in Table 3 is an attempt to estimate how accurately this data represents the average yearly landfilled waste breakdown for the entire university. Though the 1992 audit was much more inclusive (i.e. a wide variety of space types were considered) neither confidence value is within 20% of a full census. The reason for this inaccuracy is discussed in the next section.

Source & Validity

Both the 1992 and 2003 data were collected during waste audits. Since the results of these audits only exist in their respective reports, the raw data from those reports was transferred to a spreadsheet and the percentages were calculated. Summaries of this aggregation are available in Appendix A.

The 1992 data corresponds to the largest waste audit conducted on campus to date[17]. This audit included waste from several key buildings on campus and included functional areas which account for 76% of the university by area. Unfortunately, the actual area audited was only 10% of the 1997 total of 4.8 Million square feet[18].

The 2003 audit data, taken from 9 different audit reports, is considerably less inclusive than the 1992 sample[19]. These audits concentrated on only 5 different functional areas on campus, accounting for a potential 39% of the university by area. Though the actual area audited was not available, it is estimated at less than 1%, given the huge difference in daily tones compared to the 1992 data.

Not only do both sets of data exclude a large part of the university's area, but they also exclude variation in waste across the entire year. For the 1992 data, waste was audited in each building for only a single day's sample. The 2003 data is more representative, however, since most of the 10 audits were conducted over an entire week.

The efficacy of the current waste audit practices is discussed further in Section 4.2.

3.4 Organic Materials Composted (M-12)

Though there is a great deal of overlap with M11C, this indicator calculates a ratio between the amount of composted organic waste and the total amount of organic waste produced:

$$M12 = \left(\frac{Mass\ \ Organics\ \ Composted}{Total\ \ \ Mass\ \ Organic\ \ Waste} \right) \times 100\% \qquad (4)$$

Unfortunately, the total mass of organic waste was not directly available. It could be calculated from the results of a typical waste audit, and using the formula:

$$Total\ Organics = Organics\ Composted + Organics\ in\ Waste\ Stream \qquad (5)$$

For this equation, the organics in the waste stream is based on the percentage of organics found in the audit multiplied by the total waste sent to landfill in the given year. The organics composted was one of the components in M9.

Results

During the tabulation of the 2003 waste audits, the percentage organic waste in the waste stream was not calculated, only the percentage *compostable* organics. It would be simple to re-evaluate the audit data to calculate M12.
For the 1992 data, however, the percentage of organics in the waste stream was estimated in the report as 27%. This leads to an M12 value of 16%.

Source & Validity

The percentage of organics used for the 1992 results comes directly from the audit report[17]. Because of the uncertainty associated with the 1990 to 2001 compost results discussed in the M9 section, the accuracy of this indicator value is considered to be quite low.

4 Recommendations

4.1 Critique of Indicators

The purpose of the solid waste indicators is straight-forward: to describe the level of waste reduction and diversion that the university has achieved. In addition, as exemplified by Concordia University's report[15], the indicators also allow for waste management operations and policy across the university to be described. This description is necessary and useful, but so are the values of the indicators themselves. After having calculated the indicators for the 2002-2003 fiscal year (and earlier periods) some criticism of their usefulness and validity can be made.

First, there appears to be no rigorous procedure in place for calculating the indicators. For example, the massive difference between the Waterloo and Concordia calculation of M9 is almost certainly not caused by intense waste reduction on behalf of Concordia, since Waterloo has had comparable reductions in waste over the same time period. Ruling out waste reduction efforts, the only two conclusions that can be made to explain the difference is either that a) one of the universities is incorrectly reporting the amount of waste they have generated, or b) the portion of the campus (and CCM) included in M9 is not equal across the two universities. Regardless of whether the problem is bad accounting, or un-equal inclusion, the solution is to structure the indicator so that it specifies exactly which parts of the university are included and how accurate the values must be for them to be useful. Moreover, if the indicators are not accurate (or not available in the case of M10-M12 for Concordia), the university should be obligated to improve efforts to calculate them to the best accuracy possible. The value of the indicators exercise requires that the data be standardized and comparably accurate.

Second, indicators are not useful if they cannot be broken down into solutions. Currently the only breakdowns explicitly included are between compostable, recyclable and landfill waste. In order to make decisions about how to reduce and divert waste, a more thorough breakdown of information is required. For example, Waterloo still has 24% of its landfilled waste in recyclable materials (M11R). In order to reduce this number, we need to know exactly what could be recycled, and how to get that material out of the waste stream. The first part of this solution suggests that the indicators should require some information about the breakdown of recyclables and compostables in the waste stream, not just the total for each. Thankfully, waste audits at the University of Waterloo include this finer breakdown.

The final critique of the indicators is that M12 is perhaps an unnecessary calculation, especially if M11C is calculated. In fact, by capturing the two M11 values, combined with M9, a complete picture of the waste distribution can be calculated. The following four equations provide that distribution:

Total Waste (M9) = *Waste Landfilled* ***(M9L)*** + *Recycling* ***(M9R)*** + *Composting* ***(M9C)*** (*1)

Compostable Waste = ***M9C*** + *Compostables Landfilled* ***(M9L × M11C)*** (6)

Recyclable Waste = ***M9R*** + *Recyclables Landfilled* ***(M9L × M11R)*** (7)

Landfillable Waste = ***M9L*** × *(1 -* ***M11R*** *-* ***M11C****)* (8)

(* - This is the same as equation 1, only variables are included this time)

Using these equations, the university can understand exactly how much of their waste can be diverted, and how much should be reduced. Combining these numbers with a more thorough breakdown of information by building, space type, CCM traffic, and type of waste generated, would create a useful measurement system for university waste management.

4.2 Improvements for Data Collection

The only truly effective way of measuring the breakdown of landfilled wasteis through waste audits. There are, however, quite a few problems with waste audits, and specifically audits at U of W, that need to be fixed in order to improve the quality of data.

First, while reading the audit reports provided, we noticed that audits can be difficult because they are both time-consuming, and messy. Both of these issues are difficult to address. Reducing the time required to conduct an audit may also reduce the quality of the results. The speed of an audit could be increased by convincing more people to perform audits, however that is where the messiness or "yuck-factor" comes into play. People in ERS 317 do audits because they are required to complete the course, not because they are particularly inspired to assist with university-wide waste management efforts.

There are also several issues with data collection for current audits. Though there is a guide for performing audits[18], that guide is not always stringently followed. Even when the data is collected in the appropriate way (i.e. with the right waste categories and using the correct tools and measurement units) there is still the issue of presenting those results only in a report. Since there is no central store of audit data, there is no standardized way of collecting and saving information so that it can be easily extracted and calculated on.

The final issue with waste audits on campus is that they cannot be said to fully represent, with any reasonable degree of certainty, the entire waste breakdown of the university. Nothing nearing a census has been conducted at the university since 1992. Many audits have been conducted since then, but they focused on specific functional areas[20] rather than systematically considering the entire school. To truly capture and compare the waste breakdown at the university from year to year, a useful understanding of the entire school's waste is required. Moreover, that census cannot simply be conducted in a single day, since waste generation patterns shift throughout the entire year. Capturing this yearly variation is also very valuable.

Though the problems of participation, collection, and quality are challenging, we would like to suggest a few actions that could be taken to improve the audit process and the accuracy of data.

One very important step towards reducing audit time and coverage is the creation of a waste audit management system. Essentially a large database, with a web-based or easily accessible interface, this management system would be the centre of all waste-stream information on campus. Briefly, the system would perform the following functions:

- Assist students in ERS317 and other classes with choosing the location for, conducting, and recording the data from all their waste audits

- Storing all pertinent information about the location of a specific audit (e.g. building, space type, usage, area covered, etc.)
- Assist the waste management coordinator by providing indicator-like charts and graphs as frequently as new data is entered
- Collect all waste-related information into one central store so that any reporting or data analysis that the waste management coordinator would like to prepare can be done with relative ease.

Such a system would be both valuable and easily developed. It is likely that a single student with sufficient experience in database design and web development could prepare the database in one or two work terms (depending on the degree of complexity). Once the system was in place, training for ERS317 students could be done for all at the beginning of each term that the course is taught.

Our second suggestion is to increase repetition, and improve distribution of waste audits across the entire university. Instead of allowing students to audit whichever building and functional area they prefer, auditors should be required to focus on a specific area of the university – an area that has not yet been audited. Following this regime, the forty or so space types that exist on campus can be covered thoroughly by an entire class of ERS 317 students (approximately ten groups a term) in four years. These yearly audits can still be used to focus on problem areas, but their primary purpose should be to consider the whole campus.

In addition to the four year interval for the yearly audits, we suggest that a census-like audit be conducted every five or six years. This school-wide effort should be an initiative of WATGreen above and beyond the usual ERS317 audits. For this university-wide event, only the major waste bins on campus need to be studied (similarly to the 1992 audit). However, in order to make the census truly representative, several samples of each bin should be audited at random dates throughout the year. A suitable sample, given the size of the project, would likely involve one week of auditing the entire school once each term. This set of data would lead to three data points roughly evenly spaced throughout the entire year. Such an initiative will be difficult to implement, given the time commitment and yuck-factor as discussed above. However, if the University of Waterloo Sustainability Project, WATGreen, and all other environmentally conscious groups on campus worked together under the banner of the sustainability indicators, it is more likely that enough students could be inspired to help.

4.3 Best Practice

Case Study: Kennesaw State University[21]

An aggressive recycling campaign in Kennesaw State University has cut down on the amount of waste being sent to landfills by recycling 15 separate product materials. The program engages the participation of university faculty, staff, and students throughout all phases of the process, including design, construction, and implementation. A university-wide survey by an accounting class two years ago revealed that the campus community would more likely recycle if doing so were made convenient. With plans calling for 40 recycling stations across campus at an estimated cost of $1,100 per unit, purchasing bins proved cost prohibitive. As an alternative, the university's Plant Operations Carpenter Shop was tapped to build containers for recycling that would feature four separate receptacles, one each for aluminum, plastic, mixes paper, and trash. Campus-wide announcements and educational efforts followed. Buy-in from faculty and staff was essential as the university was experiencing budgetary reductions that resulted in restrictions in office cleaning, trash pickup, and night custodial staff positions. The Building Services Department reduced office cleanings to one night a week and encouraged occupants to take their own recyclables and trash to the new recycling centers, resulting in participants' increased interest in sorting the recyclables from the trash at the source. Today, Kennesaw State University recycles approximately 11 ½ - 12 tons of material per month, double the amount it recycled before the program.

Recommendations Based on Article

One of the conclusions to the 24% of landfilled waste that is recyleable is that bin accessibility is low in University of Waterloo. We could reduce our recyclables going to landfill by increasing the number of bins and improve level of convenience to recycle.

Students from Architecture could practice their woodshop skill by making recycling center like Kennesaw State University's carpenter shop did. Or we can simply add more bins around campus to improve the accessibility.

Other Recommendations

The University of Waterloo has taken many approaches to reducing waste, as discussed on the Waste Management website[22]. However, there is still a long way to our goal and more can be done. By looking at alternative practices other universities have taken, we can develop a more complete waste reduction program that suits our university. The followings are what other universities have done to achieve their waste reduction goals.

Packaging

- Sending a message to suppliers letting them know that university buyers are committed to waste reduction. Specifically, buyers are looking for products with the following attributes: packaging that will be taken back by the supplier upon delivery, reduced packaging by volume and weight, reusable and refillable packaging, increased amounts of recycled materials in packaging and packaging which is recyclable in the majority of today's recycling systems[23]. Reducing the number of days of office and room clean ups and garbage pick up would require the users to reduce amount waste and recycles that get piled up.
- When suppliers fill vending machines on campus, they must transport their goods in large containers. Ask suppliers to take their cardboard boxes and other packaging containers with them when they leave campus. This eliminates a portion of the campus waste stream while providing incentives to the companies to use sturdy, reusable containers[23].
- Rather than placing shredded documents in the recycling bin, keep bags of old paper for use in packing fragile items.

Paper

- Promote two-sided copies by introducing two-sided copiers; encourage professors and students to produce double-sided copies for assignments and notes would greatly reduce the paper used[24]. Photo copying center could charge double sided copies less to encourage the practice.

- Large envelopes can be reused by simply placing labels over the old address[23]. By charging the department or office unit for extra orders of office supplies they consume instead of having unlimited supply we can discourage wasteful uses. Let them know that the cost for extra orders is to cover the cost for waste management. This way, they would know they have the responsibility to help the university in reducing waste.
- Having students handing in their homework electronically by copying their work into a directory[23].

Resource Sharing

- Setting up a reusable office supply exchange room. Set up a small office with shelf and let people put and get things there. This strategy works well unattended. Departments and school can drop off material they no longer need and have people organize and check once or twice a week[25]. Departments that bring in reusable supplies could be granted credits. Credits could be used to cut down the cost for extra supplies.
- Posting signs asking people to place electronic and machine parts in the hallway leading to the dumpster instead of placing them in the dumpster. This allow people to reuse the machine parts that are no longer useful to the original owner[23].

5 Conclusions

Calculating the waste indicators has provided a new perspective on our path towards sustainability. For example, with some improvements in calculations standards, we will now be able to compare our progress with other similar institutions such as Concorida University.

Unfortunately, such comparisons are not yet available, suggesting that the indicators could be improved. A more rigorous standard for calculation procedures would make data more comparable, and more emphasis on understanding the finer breakdown of the indicators would help target solutions. As well, indicator M12 may not be necessary if such a breakdown is suggested. These improvements could provide a better understanding of our waste generation pattern leading to better plans of action.

Also, our ability to calculate the indicators is not ideal. During the data gathering and calculation process, difficulties were experienced. The lack of sufficient data suggested that waste audits need to be further standardized and repeated. To improve data collection, we suggest that a waste information system be developed for faster, more organized data collected. To improve audit accuracy, we suggest increasing audit distribution across the entire university through the ERS 317 audits, and we also suggest that a census audit be conducted every 5 to 6 years as a benchmark.

A case study from the Kennesaw State University was provided as an innovation to what we can do to reduce waste through improving recycling. Other examples of how to reduce packaging, paper, and reuse resources have also been provided.

We realize that all of these suggestions are just a start towards sustainability – any improvement process requires implementation and follow-up as well as analysis and recommendation. We hope these indicators will be calculated again next year, and more useful suggestions can be made as to how the university can improve it’s solid waste management.

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Appendix A – Data Tables

Year	CCMs	Landfill	Recycle	Compost	Total Waste Gen.	Landfilled Waste Reduction vs. 1987	Waste Per CCM	Per Cap. Waste Reduction Yr-over-Yr	Per Cap. Waste Reduction vs. 1987	Recycleables in Waste	Compostables In Waste
1987	19626*	2970	0	105	3,075		0.157				
1990	20823	2714	0	108	2,822	8.6%	0.136	13.5%	13%		
1991	21702	2537	0	109	2,646	14.6%	0.122	10.0%	22%		
1992	21606	2203	720	110	3,033	25.8%	0.140	-15.1%	10%	37%	18%
1993	21283	2166	783	111	3,060	27.0%	0.144	-2.4%	8%		
1994	20555	2008	895	112	3,014	32.4%	0.147	-2.0%	6%		
1995	19816*	1917	885	113	2,914	35.5%	0.147	-0.3%	6%		
1996	19172	1526	1007	114	2,647	48.6%	0.138	6.1%	12%		
1997	19189	1526	771	115	2,412	48.6%	0.126	9.0%	20%		
1998	19600	1547	672	116	2,335	47.9%	0.119	5.2%	24%		
1999	19565*	1679	760	117	2,556	43.5%	0.131	-9.7%	17%		
2000	21122	1598	830	118	2,546	46.2%	0.121	7.7%	23%		
2001	21952	1673	803	119	2,595	43.7%	0.118	1.9%	25%		
2002	23307	1648	848	120	2,616	44.5%	0.112	5.0%	28%	24%	18%

* - Approximated by picking points off a graph

1992 RESULTS:	**Percentage of Total 1997 Area**	**Compostable**	**%Compost**	**Recyclable**	**%Recycle**	**Total**
Dana Porter Library	2.7%	39.335	11%	169.774	47%	363.145
ES1 ES2 AL	2.9%	73.82	15%	195.025	40%	482.205
Modern Languages	0.9%	77.34	20%	149.328	39%	380.036
Notre Dame College	1.1%	125.6	31%	46.237	11%	402.811
Physics	2.0%	23.56	11%	98.34	48%	206.614
Percentages	**10%**		*18%*		*37%*	
Estimate of Space Coverage:	**76.3%**					
M12 Calculation:	**15.6%**					

2002 RESULTS:	**Percent Coverage of 1997 Space Types**	**Compostable**	**%Compost**	**Recyclable**	**%Recycle**	**Total**
Tiered Class	2.0%	27.23	19%	33.471	24%	139.7
Non-Tiered Class	3.5%	7.25	19%	13.725	36%	38.475
Scheduled Class Lab	5.4%	0.42	2%	2.11	8%	27.495
Food Services	1.7%	75.745	25%	78.952	26%	306.075
Residential Living Space	25.9%	30.7245	27%	31.8898	28%	112.066
TOTALS/*AVERAGE*	**38.5%**		*18%*		*24%*	