Jack Johnson
UW Garbology Project
The Denny Project Phase 1: Waste Analysis
Final Report
6/30/2013

The Denny Project was graciously supported by a grant awarded by the UW Campus Sustainability Fund.

**Abstract**
This document discusses results of the waste-analysis phase of the Denny Project, a collaboration between the UW Garbology Project (UWGP) and UW Recycling which was funded by a grant from the UW Campus Sustainability Fund (UW CSF). Project background and goals are discussed first, followed by an outline of methods used to examine and document the waste-diversion benefits of implementation of two UW Recycling programs – MiniMax and paper towel composting – in Denny Hall. Resultant data and interpretations are then discussed, wherein it is argued that implementation of these programs confers an improvement in waste diversion rates of around 10% and a reduction in waste-disposal costs of around 3.5%.

**Background**
Reasons for undertaking this project and larger project objectives are detailed at length elsewhere[1], but for this document a few key points are worth reviewing. First, UW Recycling and UWGP are working towards increasing waste diversion rates on the UW campus, and there are significant environmental and fiscal incentives for doing so. Second, UW Recycling has developed programs designed to increase waste diversion by encouraging composting and recycling in UW buildings and is currently working to implement these systems across campus. These programs include the MiniMax program[2] (which includes compost) as well as restroom paper towel composting. Third, it is not currently mandated that campus buildings adopt these programs. Instead, administrative staff within each building must choose to implement these programs on their own initiative. To encourage such implementation, empirical documentation of the efficacy of these programs is needed as a means of incentivizing participation.

The Denny Project, created by UWGP and UW Recycling and funded by UW CSF, seeks to meet this need through a two-phase approach. The first phase, discussed below in detail, aims to document the waste-diversion benefits of the MiniMax and restroom paper towel composting systems by conducting a before/after analysis of diversion rates exhibited by Denny Hall's waste stream. The second phase aims to strategically disseminate the results and conclusions from the first phase to UW administrators and students through dedicated outreach programs; this phase is ongoing and will not be discussed further in this report.

**Methods**
Quantification of the benefits of MiniMax and restroom paper towel composting was achieved by means of a before/after comparison of Denny Hall's waste stream. The "before" period involved a characterization of the building's waste load prior to implementation of these programs. MiniMax and restroom paper towel composting were then implemented in Denny

1 http://f2.washington.edu/oess/csf/node/2991

2 http://www.washington.edu/facilities/building/recyclingandsolidwaste/minimax

Hall, and waste characterization was then repeated during the "after" period to allow direct comparison between the two periods, and therefore direct quantification of the impacts of these programs in Denny Hall.

This building itself was chosen for several reasons. First, neither tested program had yet been implemented in Denny Hall prior to project inception, meaning the building's waste load provided a pristine basis of comparison. Second, the building is arguably a good cross-section of the waste load of the UW campus as a whole, because 1) it employed waste infrastructure in common use across campus (like many campus buildings, Denny Hall held trash bins and bins for paper recycling and bottle/can recycling, but no compost bins), and 2) it is heavily-used and houses numerous multi-use classrooms, offices, and academic departments. Results from Denny Hall should therefore be broadly representative of other buildings on campus. Third, the building was logistically accessible, as it is the home base of UWGP, enabling easy sampling and analysis.

Waste from Denny Hall was sampled, sorted, and measured each Monday and Wednesday afternoon for 4 weeks to facilitate the "before" period of waste characterization and analysis. Each day's sample of waste represented all waste accumulated within the building over an interval of about 24 hours (Wednesday's sample) or about 72 hours (Monday's sample; waste bins are not emptied over the weekends even though the building is open to the public on Saturdays and Sundays). As such, each sample represents a snapshot of Denny Hall's entire waste stream, and between these two sampled days approximately 4/7 of the building's total weekly waste load was analyzed, allowing for confident characterization of Denny Hall's waste stream as a whole. Sampling from waste bins was conducted by building custodians, who were very gracious in their cooperation, and samples were then collected by UWGP volunteers for sorting and analysis.

Waste sorting and data collection was conducted in a custom facility in nearby Raitt Hall. During the "before" period of analysis, all landfill-bound waste from Denny Hall was sorted by composition into compost, recyclables, or trash following protocols detailed elsewhere[3], with the exception that waste for this study was weighed to 1-gram precision. This process allowed characterization of the composition of landfill-bound waste, as well as the quantification of the percentage of this trash which *should be* landfilled, recycled, or composted, and by extension estimation of the *potential* diversion rate exhibited by Denny Hall's waste stream. Given time and facilities constraints, waste collected from recycling bins was not fully sorted[4], but was instead weighed in bulk to enable calculation of diversion rates by comparison with landfill-bound waste totals. As Denny Hall contained no compost bins prior to this project, there was no waste from compost bins to sample or sort at this stage, and waste diversion rates were entirely driven by the ratio of waste deposited in recycling bins versus landfill-bound waste bins. Weights of sorted samples were recorded and are presented as percentages of total daily samples in Table 1.

---

[3] http://uwgarbology.weebly.com/uploads/1/3/0/1/13017489/summer_2012_garbology_report.pdf

[4] Previous UWGP work has documented significant contamination in outdoor campus recycling bins – usually by compostable liquids – but this contamination was less evident here (as most of Denny Hall's recyclable mass was clean paper) and was not investigated, as it was peripheral to the calculation of overall diversion rates and therefore secondary to project objectives.

Upon completion of the initial 4 weeks of sorting and analysis, sampling was suspended for 1 week and MiniMax and restroom paper towel composting infrastructure and signage were implemented throughout Denny Hall. Sampling and analysis was then repeated to generate an identical number of sampled days representing the "after" characterization of Denny Hall's waste. During this stage, waste drawn from newly-implemented compost bins was separated into two categories – paper towels and "other" – to allow direct estimation of the impacts of restroom paper towel composting as distinct from composting due to implementation of MiniMax. Importantly, the entire 9-week span of the project was contained within the spring academic quarter to ensure that no vacations, breaks, or schedule changes impeded our ability to compare Denny Hall's waste stream from before and after implementation of these programs.

**Results and Discussion**

Tables 1 and 2 (appended below) display results of sorting and analysis. Table 1 shows total weights of each day's sample, percentages of each sorted category as a function of the total waste load, summary statistics for these categories, total landfilled and diversion rates, and statistical differences between "before" and "after" phases of analysis. Table 2 shows the bottom line in terms of changes in landfilled waste, fiscal benefits of program implementation, and potential fiscal benefits if users were to sort their waste 100% correctly.

Results displayed in Table 1 make it clear that Denny Hall's total waste load was unchanged between the first and second halves of this study. This is a positive outcome, as it ensures that any other observed differences between "before" and "after" results are due to changes *within* this waste stream and that these changes are largely encompassed by the scope of the data collected. In other words, it ensures that before/after comparisons are apples-to-apples in nature, as no additional waste appears to be systematically entering/leaving observation over the course of the study.

With this in mind, results displayed in Table 1 also make it clear that waste diversion rates are significantly increased as a result of implementation of these programs, as waste diversion jumped from about 42.6% before implementation to about 52.5% after implementation, an improvement of almost exactly 10%. This improvement was due to a reduced amount of contamination in landfill-bound trash, as landfill-bound recyclables decreased by about 4.4% (a change which was statistically significant at the 95% level of confidence) and landfill-bound compostables decreased by about 7% (this result was not statistically significant, but would likely be if additional samples were analyzed and overall variance reduced). Much of the material diverted from landfill-bound trash bins was accumulated within compost bins, as accumulations in these bins accounted for about 21% of the overall waste stream after program implementation. As such, the presence of compost bins was primarily responsible for observed improvements in diversion rates. Within the overall budget of composted materials (in the "after" stage), composted paper towels made up a little over half of the waste discarded as compost (10.8% of the total waste load) and other types of compost made up the rest (about 10.1% of the total waste load). Taken together, these data therefore clearly demonstrate that 1) these programs make a significant improvement in terms of overall waste diversion rates, 2) each of these programs is likely a roughly equal contributor to this improvement, and 3) this improvement stems largely from reduced contamination in landfill-bound waste in favor of increased composting.

Interestingly, however, the amount of waste discarded in recycling bins diminished by about 11% (significant at 99% confidence), apparently being siphoned off by the newly-added compost bins. This result was somewhat unexpected, although it is probably due to the fact that, prior to the availability of compost bins, conscientious users were more likely to place materials which resemble recyclables more closely than landfill waste (e.g., items like food-soiled paper items, compostable coffee cups, or compostable plastics) into recycling bins. This reduction in recycling in favor of an increase composting is therefore likely to be reflective of a modest overall reduction in contamination in recycling bins, a supposition which generally fits with previous UWGP results. Still, a portion of this diversion from recycling bins to compost bins may be sub-optimal – consisting of materials which should indeed have been recycled – although full documentation of this phenomenon and its potential negative effects on the overall waste streams will require additional sorting and analysis. Given the obvious overall benefits of these programs, however, such investigation should remain a low-priority endeavor for the near term.

On the other hand, it is clear that – even with implementation of these programs – there remains substantial room for overall improvement in waste diversion within Denny Hall, as these programs yielded a waste diversion rate which still sits about 4% *below* the campus-wide average. Perhaps Denny Hall's waste diversion rate will improve once building denizens are more accustomed to the new systems in place, but moving forward it will nonetheless be important to continue to encourage such improvements, as nearly 40% of Denny Hall's waste stream is still composed of landfilled compost or recyclables. In sum, then, these programs work, but they don't fully resolve Denny Hall's waste issues on their own.

Still, for the present it is clear that implementation of these programs will represent a major step forward for many campus buildings, and particularly for those which currently employ older waste systems and/or those which lack compost bins. In Denny Hall alone, implementation of these programs will result in around .83 fewer landfilled tons over the 2013-2014 regular academic year alone and around 3.5% lower waste-disposal costs (see Table 2). If summer quarter, breaks, and holidays are considered, these programs will easily reduce Denny Hall's landfilled waste production by well over a ton over the course of the coming year, as well as each year thereafter. If implemented campus-wide, these programs will therefore have an immense impact on UW's sustainability, as well as its fiscal bottom line. If, beyond this, we can also push for more efficient use of these systems by the UW community, this infrastructure will provide a baseline for truly astounding improvement, and could even help push our waste diversion rates to well over 92%.

**Acknowledgements**
Thanks are due to everyone at UW CSF, Emily Newcomer and UW Recycling, UW Custodial Services staff members Jesus, Pheng, Sattia, Andre, and Shelley, Denny Hall building coordinator Douglas Machle, all Denny Hall administrators and denizens, John Cady for his administrative support, and UWGP volunteers Amy, Megan, Beth, Sharon, Johnny, Katie, Alex, Erin, Ellie, Julia, Alexey, Mara, Hana, Epiphany, and Sara.

## Appendix: Tables

| | Day | Total Daily Waste (kg) | % Landfilled | % of Total Daily Waste Landfilled | | | % Diverted | % of Total Daily Waste Diverted | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Compostable | Recyclable | Trash | | Composted | | |
| | | | | | | | | Other | Paper Towels | Recycled |
| Before | 1 | 48.472 | 55.1 | 29.2 | 18.7 | 7.2 | 44.9 | 0.0 | 0.0 | 44.9 |
| | 2 | 67.094 | 39.4 | 28.2 | 5.7 | 5.5 | 60.6 | 0.0 | 0.0 | 60.6 |
| | 3 | 29.37 | 50.6 | 26.9 | 18.9 | 4.8 | 49.4 | 0.0 | 0.0 | 49.4 |
| | 4 | 37.836 | 73.4 | 54.6 | 12.2 | 6.6 | 26.6 | 0.0 | 0.0 | 26.6 |
| | 5 | 59.028 | 56.9 | 41.5 | 9.9 | 5.4 | 43.1 | 0.0 | 0.0 | 43.1 |
| | 6 | 48.338 | 56.7 | 36.1 | 12.4 | 8.2 | 43.3 | 0.0 | 0.0 | 43.3 |
| | 7 | 37.297 | 67.8 | 45.7 | 17.7 | 4.4 | 32.2 | 0.0 | 0.0 | 32.2 |
| | 8 | 42.962 | 59.2 | 43.2 | 8.6 | 7.4 | 40.8 | 0.0 | 0.0 | 40.8 |
| | **Mean** | **46.300** | **57.4** | **38.2** | **13.0** | **6.2** | **42.6** | **0.0** | **0.0** | **42.6** |
| | **SD** | **12.269** | **10.3** | **9.8** | **5.0** | **1.3** | **10.3** | **0.0** | **0.0** | **10.3** |
| After | 1 | 60.061 | 57.1 | 36.2 | 9.5 | 11.4 | 42.9 | 9.3 | 5.5 | 28.1 |
| | 2 | 33.006 | 38.0 | 27.7 | 6.7 | 3.6 | 62.0 | 6.3 | 14.5 | 41.3 |
| | 3 | 52.812 | 39.6 | 25.2 | 5.4 | 9.1 | 60.4 | 9.6 | 15.3 | 35.4 |
| | 4 | 48.578 | 48.8 | 34.1 | 9.2 | 5.6 | 51.2 | 9.0 | 11.5 | 30.6 |
| | 5 | 24.664 | 53.1 | 39.0 | 9.2 | 4.9 | 46.9 | 5.6 | 9.5 | 31.8 |
| | 6 | 35.628 | 47.9 | 33.0 | 10.0 | 4.8 | 52.1 | 20.1 | 14.2 | 17.8 |
| | 7 | 28.318 | 44.8 | 25.2 | 6.7 | 13.0 | 55.2 | 7.0 | 7.8 | 40.3 |
| | 8 | 84.206 | 50.4 | 29.3 | 12.1 | 9.0 | 49.6 | 13.8 | 7.9 | 27.8 |
| | **Mean** | **45.909** | **47.5** | **31.2** | **8.6** | **7.7** | **52.5** | **10.1** | **10.8** | **31.6** |
| | **SD** | **19.838** | **6.5** | **5.2** | **2.2** | **3.4** | **6.5** | **4.8** | **3.7** | **7.6** |
| **Signficant Difference?** | | **No** | **99%** | **No (almost 90%)** | **95%** | **No** | **99%** | **Yes** | **Yes** | **99%** |

Table 1: Results of waste sorting and analysis. Segmented into “before” and “after” results, this table shows daily waste totals, diversion rates, a percentage breakdown of the entire Denny Hall waste stream, and the statistical confidence level with which differences between before and after results are distinct using formal t-testing. “No” results represent instances in which no statistical change has taken place; “Yes” results are instances where change is an absolute certainty.

| | | |
|---|---|---|
| **Before** | **42.6** | Waste diversion (%) |
| | **83.22** | Cost per ton ($)* |
| | **4.81** | Tons landfilled per academic year** |
| | | |
| **After** | **52.5** | Waste diversion (%) |
| | **80.3** | Cost per ton ($)* |
| | **2.90** | Savings per ton ($)* |
| | **3.5** | Savings (%)* |
| | **3.98** | Tons landfilled per academic year** |
| | **0.83** | Reduction in tons landfilled per academic year** |
| | | |
| **Potential** | **92.3** | Waste diversion ($) |
| | **61.89** | Cost per ton ($)* |
| | **21.33** | Savings per ton ($)* |
| | **25.6** | Savings (%)* |
| | **0.64** | Tons landfilled per academic year** |
| | **4.17** | Reduction in tons landfilled per academic year** |

Table 2: Key metrics of waste diversion performance in Denny Hall before implementation of MiniMax and restroom paper towel composting (top), after implementation of these programs (mid), and if waste were correctly sorted by users (bottom). Potential savings and waste reduction estimates were derived by comparison with the waste stream before implementation of MiniMax and restroom paper towel composting. *Costs were estimated using the current rate of $145 per landfilled ton, $55 per composted ton, and $0 per recycled ton. **Limited to the inclusion of workdays during the 3 quarters of the regular adacemic year, or a total of 165 days per year; this number is certainly a minimum estimate of total waste produced, and therefore also of waste reduction.