Proposed Improvements of Plastic Waste Processes at Utrecht University

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Abstract

Recycling programs are one of the most popular initiatives for universities to improve their sustainability. Using literature reviews, case studies, interviews with stakeholders, and data collection, solutions to improve plastic waste recycling at the UU Uithof are proposed. Potential areas of improvement are policy, infrastructure and behaviour modifications. On the policy and procedures level the inclusion of sustainability and social responsibility in the Code of Conduct for students and staff, and future or renewed contracts for vendors on campus incorporating sustainable practices is suggested. In addition, an improvement in communication of policies and practices to the public (in particular students and staff) should be achieved. This can be done by hosting a sustainability-oriented week and by regularly training staff and students about sustainability efforts. Infrastructure improvements can be achieved, through an intervention on the spatial arrangement of bins working towards centralised waste management. If carried out these proposed solutions could also improve the current STARS ranking of the UU.

Summary

In order to improve the UU plastic recycling program and achieve a higher level of sustainability, the sustainability goals outlined by university policy and practises need to be achieved. To achieve this, important areas of approach were highlighted and the extent of investment and the effective output of these proposed recommendations were weighed. The solutions are weighed against each other to then determine which require the highest effort, financial investment and then potential return. The areas highlighted are: policies and procedures, behavioural change, infrastructure and economic factors. Currently, the University of Utrecht (UU) is striving towards a more sustainable future; evidenced by the UU strategic plan 2012-16 and existing policies effective since 2012. Appointing a sustainability coordinator in 2012 also shows that the UU understands that a holistic approach encompassing all levels of the organisation and covering the complexity of inter-institutional communication is important. The Milieujaarverslag (2012) highlights that the UU is also taking the environment as a corporate social responsibility (UU - Milieujaarverslag, 2012). The Milieujaarverslag expands on the possibility of altering contractual agreements for the next renewal of on-campus vendor contracts to more clearly include sustainability and social responsibility. This report also highlights that communication of policies and practices to staff and students is of vital importance to achieve sustainability goals. The following recommendations are made to further improve the plastic waste management at the UU Uithof.

- Behavioural change is necessary due to the high staff and student turnover typical of a university. Behavioural changes arise as a complex result that starts with an example being set by the institution before the effects can filter down through the entire system of staff/ faculty and students. To tackle this, it is recommended to use events highlighting sustainability. On-campus training sessions geared towards cleaning staff and waste management, incentives and competitions can also be employed to positively influence behaviour. Flyers and posters can be used to support these measures.
- Major improvement opportunities can arise from upgrading and changing the existing infrastructure. Direct observations made in various on-campus buildings highlight that rethinking the spatial arrangement of bins more logically as well as clustering different types of waste bins together can have a very significant positive impact. Implementing centralised waste systems and alterations to waste bin distribution have also been shown to have significant effects on improvement. This is supported very well by a number of different case studies.
- The report aims to make all the above function in an economically sustainable way as well as being environmentally sustainable. Expected payback periods and investment in implementing the improvements proposed by our areas of approach are outlined with available means. If applied correctly, the recommendations have the potential to improve plastic waste diversion by up to 33%, or minimally by 5%; which will still improve overall sustainability in a way that can be quantified and ranked using STARS. The recommendations presented have a large potential effect on plastic waste, but this will only be achieved with consistency and participation from all levels within the university.

1 Introduction

1.1 Background

It is often asserted that universities have a moral and ethical obligation to act responsibly towards the environment and lead the movement of environmental protection, thereby adopting responsible waste management (Armijo de Vega *et al.*, 2008; Zhang *et al.*, 2011). Through both declarations and actions, Utrecht University (UU) has consistently placed a priority on sustainability through infrastructure, curricula, and operations. In line with this commitment, the UU has listed sustainability as one of its "four strategic themes" (UU - Sustainability). The Secretary General of UU's executive board, Joop M. M. Kessels, has furthermore stated that the UU is focused on improving their policies regarding sustainability (Kessels J. M. M., 2013). In addition, the UU has reached out to its student body to highlight areas that are in need of improvement and has looked to them to develop innovative approaches and solutions to these problems.

Of the requested improvements, recycling programs are one of the most popular environmental initiatives (Armijo de Vega *et al.*, 2008). In response to this request, the UU in partnership with Nedvang, have provided plastic waste bins on the UU campus from the Plastic Hero campaign. UU waste management and collection have both included recycling into their services. Recycling does not currently have priority in the UU waste management program, even though improvement of plastic waste management is requested. The current recycling program has not achieved its expected potential. Improper plastic waste disposal has also resulted in contaminated plastic waste collection. The UU and its facilities managers are now seeking assistance both internally and externally to improve the proper use of plastic waste bins and to improve overall recycling processes on campus. The question to investigate the improvement opportunities of plastic recycling was proposed by the Green Office of the UU.

1.2 Study objective

This report will document current practices, evaluate areas of improvement and develop possible solutions that can be implemented to improve plastic waste management on the UU Uithof campus. This investigation will provide practical plastic waste management solutions on policy, infrastructure and behaviour. Improvements made on the plastic/sustainability policy will allow for a strong foundation for all other proposed solutions. Solutions proposed on the infrastructure and behaviour level will explore how best to operationalize plastic waste management at the UU Uithof campus. The Association for the Advancement of Sustainability in Higher Education (AASHE) Sustainability Tracking, Assessment & Rating System (STARS) will be used to quantify the success of current procedures as well as the potential effect and input level of recommended solutions. The following questions will be explored:

- **Policy & Procedures regarding plastic waste management**
    - What current procedures have the most potential for improvement?
    - What are the best practices found to be effective for other universities?
    - What are the cost implications/savings as a result of the proposed solutions?
- **Infrastructure**
    - What infrastructure changes can be implemented to assist in improving recycling behaviour?
    - What can be done to improve plastic recycling through use of existing infrastructure?
    - What are the cost implications/savings as a result of the proposed solutions?

- **Behaviour**
  - How can behaviour be improved on campus with regards to recycling?

The provided solutions will be grouped based on the monetary investment needed, effort required by students/staff/faculty/management and expected return on the plastic waste recycling at the Uithof. This range of solutions allows the UU to choose the level of investment they wish to pursue, while balancing the needs for improvement of plastic waste collection at the Uithof.

1.3 Boundaries of the study
There are two approaches to limiting waste on UU's campus; limiting input of disposable plastic on campus and managing the output of plastic waste. As the primary sources of disposable plastic are from non-university owned or monitored companies, it was determined that evaluation of the input of plastic waste is outside the scope of this study. That being said, for the purposes of policy and procedure the input of plastic waste will be included in the discussion. As such, this report will be primarily focused on management of plastic waste and recycling. When referring to the UU and its campus, this report will only focus on waste associated with the buildings under university care located at the Uithof. A full list of the buildings included in this study can be found in Appendix A. It is important to note that student housing buildings located near to the campus are excluded, as they currently do not fall under maintenance of the UU. Further boundaries have been established concerning the kinds of plastic waste considered in this study. This study will focus on consumer generated plastic waste (identification code 1, 2, 4, 5, 6). All of these plastics can currently be processed within the Plastic Hero's campaign (Subramanian, 2000; Plastics Europe - Types and categories of plastics).

2 Methods

2.1 Engagement of stakeholders

In every aspect of this study the stakeholders play an important role. The main stakeholders in plastic waste recycling are the student population and the faculty, where some parties within the faculty have a larger stake than others. As all these parties have important stakes in the waste recycling program the UU offers at present, various stakeholders of waste management and sustainability have been interviewed to provide first hand insight into the current state of plastic management at the UU on both policy and procedures as well as infrastructure and implementation. As of 2012, the UU had 29,755 Full Time Equivalent (FTE) students and 5,106 UU faculty members (UU - Facts and figures). UU Waste management has stated student behaviour as a major hurdle towards achieving an effective recycling program. It is important to understand what students see as being the major deterrent of recycling and what would make a recycling program more student-friendly. An informal poll of students/staff concerning their on campus waste management was carried out to determine where plastic waste originates from, where it is being disposed, and what the general attitude towards recycling is.

2.2 Evaluation of current procedures and policies at the UU Uithof

Current procedures and policies will be mapped. This will provide a greater understanding of the current measures in place concerning plastic waste management. A clear understanding of who is tasked with what aspects of the waste management at the UU Uithof will also be obtained.

2.3 AASHE STARS

To evaluate the general improvement options for the University of Utrecht on plastic recycling the STARS benchmarking system was used to determine the position of the UU compared to other universities. STARS, a volunteer based university benchmarking system created by the AASHE, gives awareness to universities of their current standing concerning sustainability, to inspire action and provide best practices to help improve conditions on campuses. Initially a US based system, UU was one of the few universities to be invited to participate in the international pilot and submitted their report in 2013 (STARS - STARS Participants & Reports). The data used in this report is thus readily available. For the purposes of this report, STARS is used to quantify the effectiveness of UU's current procedures to that of the recommended solutions. The STARS benchmarking tool covers a broad range of sustainable aspects as displayed in Appendix B, but for the purposes of this study, only topics related to plastics and waste, OP 22 - Waste Minimization and OP 23 - Waste Diversion, were considered.

2.4 Literature studies

Literature focused on recycling programs and influencing waste management behaviour at universities was evaluated. Improvement options for the University of Utrecht were gathered. Information that was found to be relevant was used to determine what effects proper recycling could have on the share of waste diversion, what type of behavioural issues are related to facilitate waste collection, and what could be learned from the best practices of other universities. To collectively come to a package of solutions the literature studies will form the theoretical basis from which both the options within policy and procedures as well as in behaviour and infrastructure can be evaluated.

2.5 Case studies
Universities around the world have been testing and implementing waste recycling programs resulting in an array of outcomes. Where the literature provides the theoretical background, evaluation of case studies provides the practical interpretation that could be translated to the UU. Where the literature is mostly focused on behaviour and infrastructure, policy and procedures from other universities provide a useful insight in the possibilities for the UU. The evaluation of case studies focussed mainly on universities similar in structure and size to that of the UU, but innovative ideas from other universities that have shown promise were also considered.

2.6 Framework
The proposed solutions will be presented using a framework. This framework will present the expected monetary investment (including staff hours), expected return with regards to plastic waste recycled and the needed effort from university staff, students, faculty and management to achieve return. This framework will allow for a representation of the required investment on these various levels.
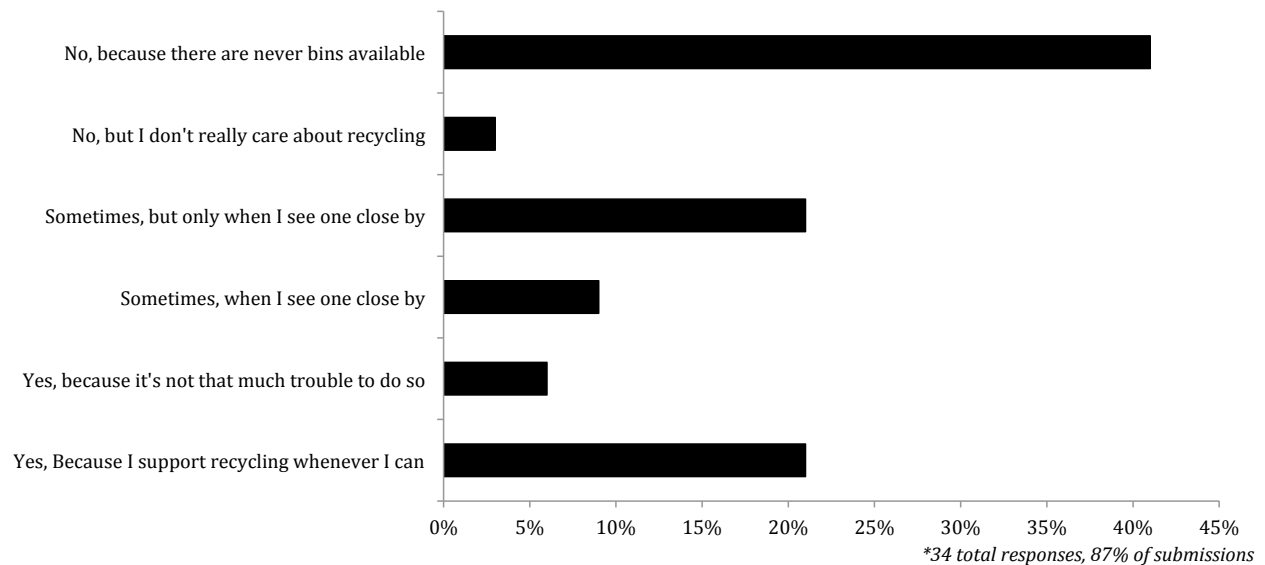
3 Results

3.1 Engagement of stakeholders

Plastic enters the Uithof campus via many avenues. Along with the large number of students and faculty members there are numerous commercial businesses located that serve as a source of plastic on campus (see Appendix C). Other routes include: plastic that is brought along by persons from outside the Uithof, the various canteens located at the Uithof and myriad miscellaneous sources. Plastics are consumed by students, faculty members, staff and employees of the commercial enterprises at the Uithof. This plastic is then either separated in appropriate plastic waste bins or mixed in the general waste.

A total of 39 persons participated in an informal poll of students concerning their on campus plastic waste management. Responses indicate that a majority of their generated plastic waste is not ending up in the plastic bins located around the campus (see figure 3.1).
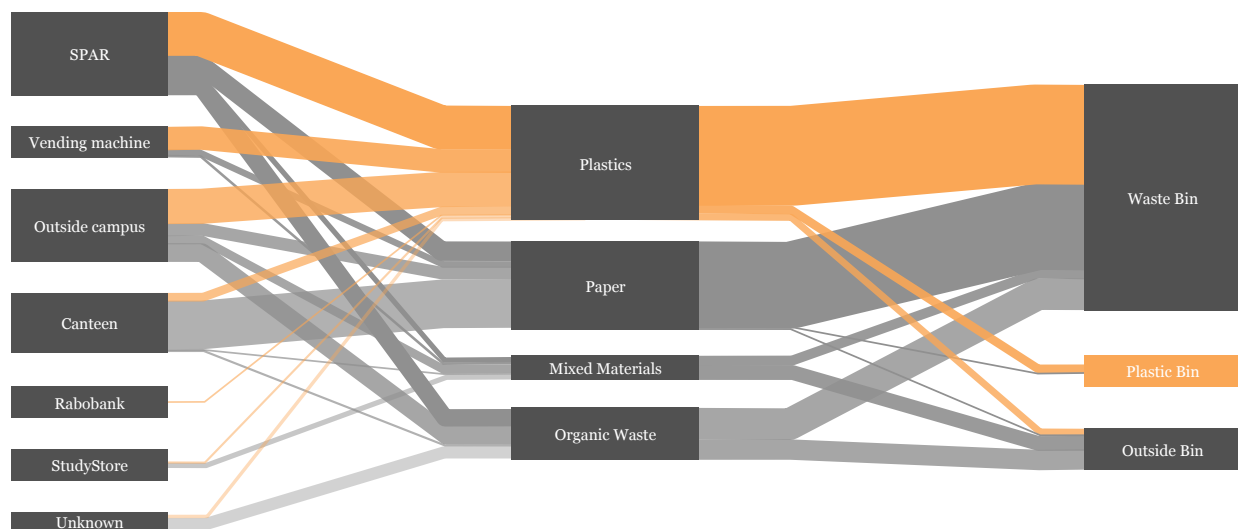
Figure 3.1*: Sankey diagram depicting the flow of waste generated by survey participants. A large portion of the generated plastic waste is not being recycled in the plastic recycling bins*

When asked if respondents sort plastic waste into recycle bins, low proximity and absence of plastic recycle bins were indicated as reasons not to recycle (see figure 3.2). Indicating that access and ease of recycling are currently hindering the participants of the survey in their wish to recycle (see figure 3.3). These factors may also influence the behavior of other members of the Uithof community in their plastic waste recycling.

No, because there are never bins available

No, but I don't really care about recycling

Sometimes, but only when I see one close by

Sometimes, when I see one close by

Yes, because it's not that much trouble to do so

Yes, Because I support recycling whenever I can

0% 5% 10% 15% 20% 25% 30% 35% 40% 45%

*34 total responses, 87% of submissions

Figure 3.2: *Response to why or why not respondents sort plastic waste into recycle bins. Many respondents indicate not having bins close-by or available as reasons not to recycle*

No

Only when one is close by

Yes

0% 10% 20% 30% 40% 50% 60% 70% 80% 90%

*35 total responses, 90% of submissions
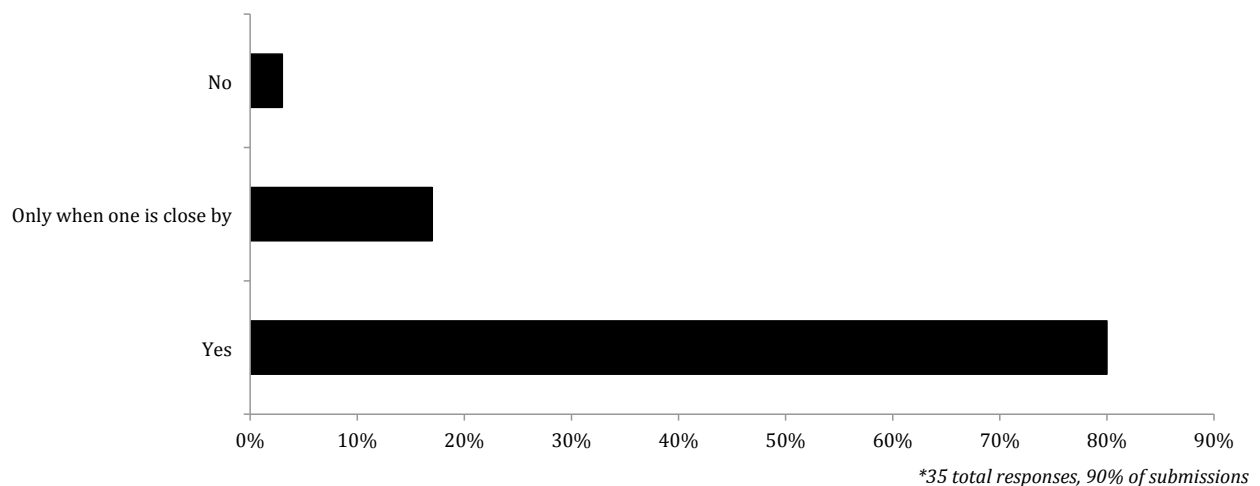
Figure 3.3: *Participant response to question if they would recycle plastic if appropriate bins were provided*

3.2 Current UU policies and practices

Waste management at the Uithof is carried out by FSC *Operationele Services Reststoffenbeheer* (RSB - rest-waste management), which is directed by Frank Kooiman. RSB mainly focuses on the collection of waste outside of buildings. *Lokaal Facilitair Management* (LFM - local facility management) is tasked with the coordination of the different regions that make up the university campus. LFM focusses on the internal collection of waste within the buildings. Utrecht University is primarily split into two locations: the Uithof and the Utrecht city center. As of 2010 the city centre location began collecting plastics separately due to the municipality of Utrecht starting recycling services. In response to requests, the UU began their own pilot to separately collect plastic waste at the Uithof as well. This was done in partnership with the Plastic Hero campaign. 150 plastic waste bins were provided by Nedvang that were distributed

across the Uithof campus. Communication on plastic waste disposal was also increased at this time. After a successful trial, the project was continued by placing 130L and 240L Plastic Hero waste bins throughout the campus. The placement of the bins was found to be successful at the Olympos Sport Center, but results were variable in all other locations. This was mainly due to contamination of the plastic waste bins with non-plastic waste or plastic being improperly disposed of with general waste (UU- Regelgeving afvalverwijdering).

To improve plastic waste collection Reststoffen Beheer (RSB) and Local Facility Management (LFM) developed a list of priorities in the Fall of 2013. Their recommendations included the following:

- Placement of a press container at the Uithof for the purpose of plastic waste.
- Increasing clarity of collection points outside of buildings.
- Including more locations for internal plastic collection.
- Setup of a communications campaign on how and where to recycle and clarification of what qualifies to be recycled.
- Production of stickers in order to clarify the purpose of the bins.
- Reconsideration of the locations of the plastic bins with focus mainly on the pairing of regular and plastic waste bins together.
- A contract with SITA waste management for plastic processing.
- Separate collection and pick-up of plastic foils.

A press container was placed in October 2013, resulting in a plastic yield of 740 kg in the period of October 2013 to December 2013. Furthermore a contract was signed with SITA for the processing of the collected plastic waste, the separate collection and pick-up of plastic foils has been arranged and the clarification of collection points outside the buildings has been achieved.

Logistically there has been some resistance to the inclusion of more locations for internal plastic collection, the re-evaluation of the placement of the plastic bins and the pairing of waste and plastic bins, mainly coming from the LFM of the UU buildings in the inner city. The main arguments here are that the orange plastic bins don't fit in with the decor of the buildings in the city centre or that there is too little space for internal plastic collection in the buildings. To do this pushback the recycling campaign and production of stickers have been halted until further steps are taken towards the introduction of three-compartment separate waste collection bins. Apart from these points, a new initiative was started recently involving a pilot with the van Vlietgroep, a waste management company, to separate, collect, and process clean plastic waste from the labs. The pilot will be applied for the TNO-GML building, the Kruyt building and the Adroclus building. On the waste management level the environmental care system ISO 14001 (2004) and the quality system ISO 9001 (2008) are used to measure and improve the performances of the department. Furthermore associated waste processing and removal companies such as the van Vlietgroep are contracted by standard regulation and the UU waste disposal scheme (Regeling Afval Verwijdering Universiteit Utrecht). This regulation includes the requirement that the contractors must practice sustainable procedures within their own companies. According to the 2012 annual environmental report, the UU has seen positive effects of its recycling policies and operations. In 2012 it was reported that 40% of the university's waste was diverted through either recycling or reuse. With these results, the near future goal for diverted waste was set to 45% (UU - Milieujaarverslag, 2012). According to recent updates from

the unpublished annual report of 2013 this goal was not met as only 43% of waste was recycled or otherwise diverted.

3.3 Current STARS ranking

The first step in determining what the UU can do to improve its sustainability success is to create a quantifiable baseline and determine where there is room for improvement. This was achieved by using the STARS ranking system. The ranking of a university is based on the percentage of points received out 199. The ranking is as follows:

- o   Bronze   0 - 25%
- o   Silver   26 - 45%
- o   Gold   46 - 65%
- o   Platinum   65 - 85%

As the UU would like to be ranked as high as possible, it is desirable to receive as many points per section as possible. For the purposes of this study, OP 22 and OP 23 are evaluated as they pertain to waste diversion and reduction. Calculated in Appendix D, it is determined that the UU is currently only capturing 1.91 points out of a possible 8 available from OP 22 and OP 23.

STARS is a benchmarking system, therefore it is possible to evaluate how the UU compares to universities of similar size and see if there are effective strategies that could be used. Unfortunately, at the time of this report, no other Dutch universities were participating in the STARS benchmarking program and other European universities were not considered comparable to the UU. Therefore it was important to find universities that were similar in size and operation to that of the UU with which the UU could be compared. The first filter applied to all participating universities was the number of Full Time Equivalent (FTE) students.   At the time of the STARS submission (2012), UU was reported to have 29,755 FTE students. It was decided that universities could only be deemed "similar" if they had within 5,000 FTE students of the UU (Forbes - America's Top Colleges, 2013). After removing all universities reporting to STARS that did not fall within 24,755 and 34,755 FTE students, sites were then filtered out based on their participation in waste reduction and waste diversion. Those institutions that did not include any data for these sections were removed. The final list of universities that were used to evaluate the success of UU's plastic waste procedures are listed in Appendix E. The results of the comparison were not surprising, considering the UU has already invested in policies and procedures to reduce and divert their waste. Figure 3.4 depicts the total amount of waste broken down into composted, recycled, and general waste. In comparison to the other universities, UU is shown to have the least amount of waste of all 24 universities. This result, however, could be attributed to the fact that the comparable universities are all from the United States which typically have large campuses and almost all included on-campus student housing within their waste disposal rates.
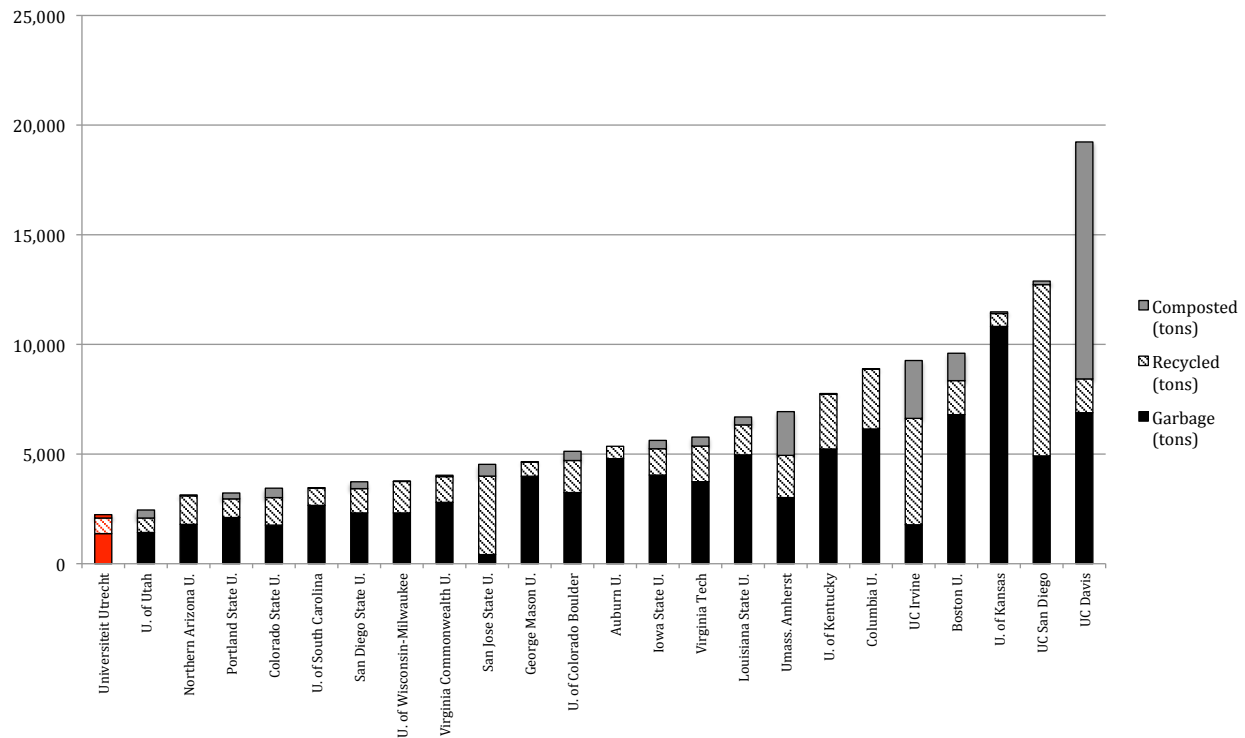
Figure 3.4*: Breakdown of total waste of the 23 other universities in the STARS program that are comparable with the UU. Compared with the other 23 universities the UU has the smallest amount of total waste.*

Though this figure depicts UU as doing very well in its waste reduction, it is important to normalise the results. Figure 3.5 gives a more comparable view of the universities, showing that the university is 9th out of the 24 universities with regards to diverting its waste. According to the information provided to STARS, UU is only diverting 39% of its waste, 32% being recycled and 7% being composted (STARS - Utrecht University).
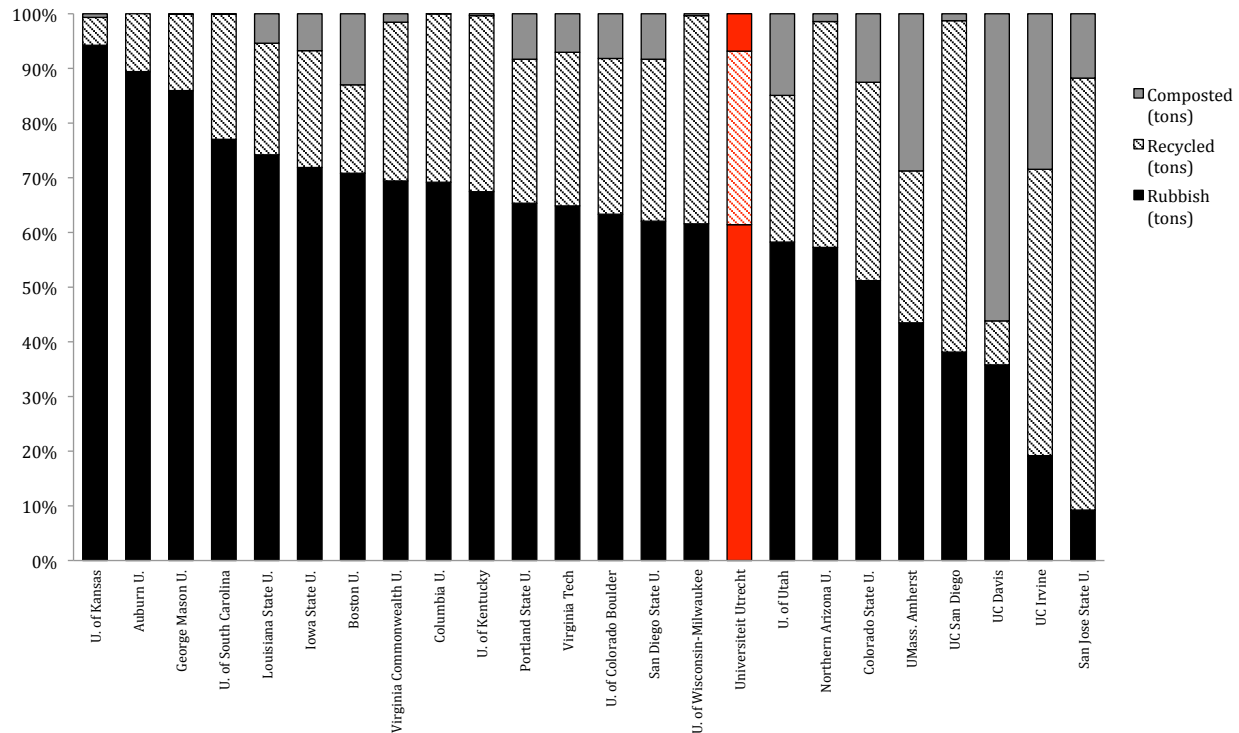
Figure 3.5: *Breakdown of waste of university by percentage. While the UU may produce the least amount of waste among the comparable universities in the STARS program, it does not among them divert the most of its produced waste to recycle streams*
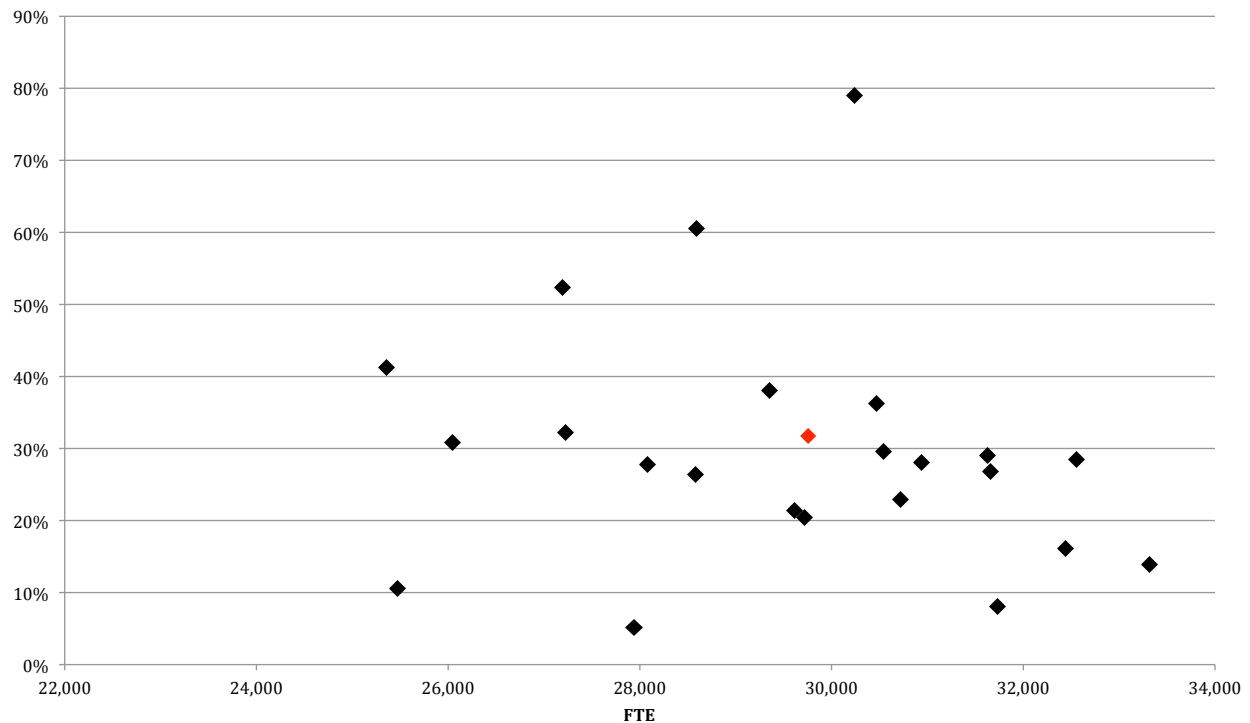
Figure 3.6: *Percent recycled waste vs. FTE. The red dot indicates the UU. The UU is currently achieving average results when compared to comparable universities in the STARS program.*

The final evaluation in Figure 3.6 depicts the percentage of waste that is recycled vs. the number of FTE students at the university. UU is again sitting at about average with regards to its recycling. It can also be seen that the smaller population of a university, generally the higher its percentage of recycling. This can be explained by ease of communication and less waste to manage. In addition, it can also be assumed that with small universities comes a decrease in faculty size which may explain why larger institutions, with more people and bureaucracy involved in implementing procedures, could have slower adaptations of sustainable practices. An outlier of this data, however, is San Jose University (SJU) which has a larger FTE student population, but their percent of waste recycled is over double that of UU. This university should be seen as an example of where the UU could be with proper procedures in place. Overall, the results of the benchmarking process have shown that the UU's current practices are about average, but with great opportunity for improvement. It is important to remember that this is only with respect to general waste diversion and not plastics specifically. As it will be seen further in this report, the UU is not capturing its full potential of plastic waste diversion, the hope will be that by improving this aspect, the UU could be seen as a leader in waste diversion in comparison to similar universities.

3.4 Current recycle rates
According to the UU's annual report, the amount of plastic recycled in 2012 was 0.01% of total waste collected by the university (Figure 3.7). In October of 2013, a new collection method was established for plastic at the UU. Individual buildings were given the opportunity to separate their plastic waste in special bags that were collected once a week along with current trash pick-up service. This new procedure was designed to facilitate the collection and delivery of all collected plastic waste to a trash compressor that is located on site at the UU. Once the compactor is full, the contracted waste management company replaces the compactor with an empty compactor and then takes the full compactor to a sorting facility. At the time of this report, the new collection system had only been in place for 6 months and had only been emptied once. The single time the compactor was emptied was three months after installation (January 2014) for the purpose of starting a baseline year in 2014. At the time of emptying the container, 740 kg of plastic had been collected which, when averaged over the three months and compared to the previous year's total waste collection, would amount to less than 0.1% of all waste collected (Kooiman, 2014). Though this is a large improvement compared to previous years, there is still much room for improvement when compared to plastic recycling rates of similar institutions.
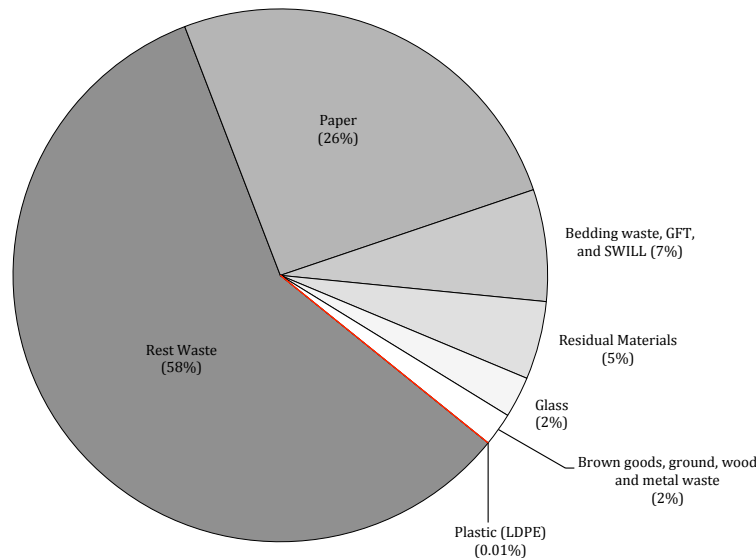
Figure 3.7: *Breakout of waste collected at the UU for 2012. Collected plastic waste makes up a very small portion of the total waste collected at the UU. Plastic not collected via the plastic collection route is part of the rest waste stream (UU - Milieujaarverslag, 2012).*

According to findings at other universities, it has been determined that plastic waste can account for anywhere between 5 and 33% of total waste in university common areas. The most common finding is that 18% of total waste in university common areas is plastic (Mason, *et al.*, 2004). With this in mind, the expected plastic to be collected has been broken down into the following:

- **Current Case**: Using the data of collected plastic between October 2013 and January 2014, an estimated average collection rate has been determined to be less than 0.1%
- **Conservative Potential Case**: The lowest expected amount of plastic to be found on campus is 5% of total waste.
- **Average Potential Case**: The average amount of plastic found on university campuses has been found to be 18% of total waste.
- **Extreme Potential Case**: Some universities have found plastic waste to be as high as 33% of their total collected waste.

In Figure 3.8 these potential cases are stacked to show how much of the UU's general waste in 2012 could potentially have been plastic if sorted correctly.
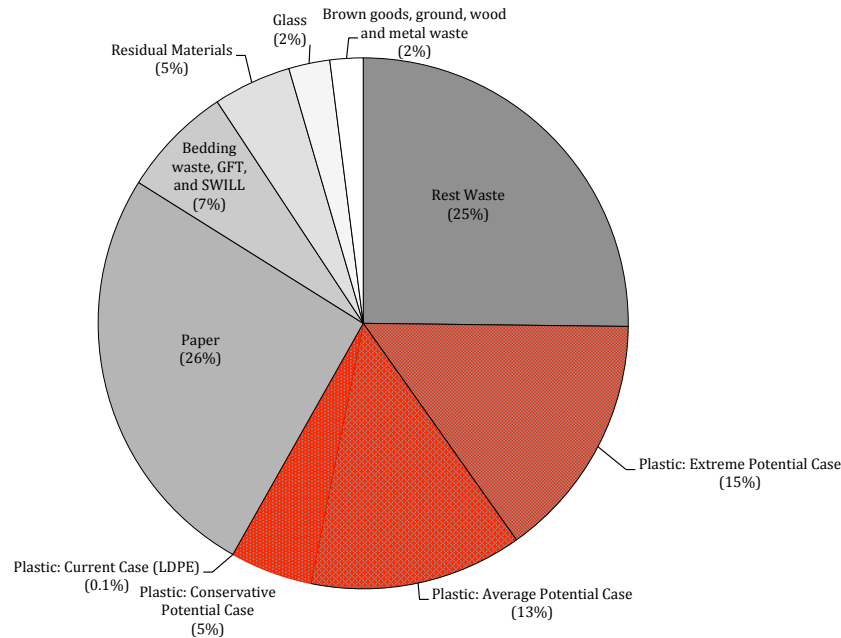
Figure 3.8: *Breakout of potential UU waste for 2012 including potential plastic waste as based on other university findings. (UU - Milieujaarverslag, 2012; Mason et al., 2004)*

From this information it is clear that the UU has worked hard to improve its plastic recycling rates and succeeded in improving this rate from 0.01% to 0.1%. With that said, however, other universities have proven that the amount of plastic present on campuses is much higher, thus the UU could potentially increase its total plastic waste recycling to 18%. To get a more exact picture of the maximum potential of plastic waste recycling waste audits should be performed regularly, as is done at Portland State University (PSU - Waste audit reports, 2013). A similar waste audit was performed at the Buys Ballot Laboratory here at Utrecht University in 2006 (Rapportage bedrijfsafvalonderzoek 2006). This audit didn't specify on the share or nature of plastic waste, while this could provide useful information to estimate the maximum potential of plastic waste recycling.

3.5 Behaviour

Fostering desired waste management practices at institutions of higher learning can be achieved by understanding the drivers that affect this behaviour. Internal attitudinal support for sustainability improvements on all organisation levels is essential for such measures to be effective. Practices and principles of sustainability need to be understood and practised by all levels of the university from students to staff to cleaning personnel. This can be supported by employing a holistic approach to sustainability by a university. A holistic approach, integrating sustainability in education, policy and execution, supports increased adoption of sustainability values by students (Nejati & Nejati, 2013).

Various barriers to the implementation of sustainability at institutions of higher learning practices have been identified. Among them: 1) a culture of freedom among staff members, this freedom may hinder the proposal of change by an administrator; 2) the lack of an incentive structure that rewards the sustainability efforts of the students and staff; 3) lack of external pressure to transform. Common drivers of sustainable waste management at institutions: 1) visionary leadership, 2) individual champions of sustainability, 3) the presence of a coordinating force behind the sustainability efforts, 4) smaller

university size (Ferrer-Balas *et al.*, 2008). Progress on sustainability has been shown to be promoted by having: 1) a written sustainability plan; 2) a group of skilled leaders that implement these plans; 3) a large base of support through the institution in support of the progress on sustainability (McNamara, 2010).

Continuously providing feedback on the results that have been achieved also support the cause, especially if performance is lacking behind the wanted improvement. Extrinsic rewards can also motivate recycling linked to the action one wishes to stimulate - handing out reusable water bottles to decrease the use of plastic bottles - and in this way making the action of recycling more appealing, especially among those currently not actively recycling. Any reward given should not be too large or valuable. If a valuable reward is chosen the lack of the reward may decrease the intrinsic motivation (Recyclemania - Guide to a More Effective RecycleMania). Offering of an extrinsic reward must be done in conjunction with other activities to have effect. Extrinsic Rewards are merely a way to remove a barrier, not a stand-alone motivational tool.

Key to changing behaviour is knowledge on how to execute an activity. Perceived difficulty of an activity may prevent recycling. "Knowing why one should do a behaviour does not mean that one knows how to do the behaviour" (Kelly *et al.*, 2012). Negative reinforcement such as fines or punishments should be avoided. Flyers and posters and other forms of prompts to enhance awareness will not be effective on their own, they can be very effective if combined with change strategies. Any prompts to recycle should not be obtrusive, located close to where the behaviour should take place, short, relevant to audience, aware of the motivations of the audience and as straight forward as possible (what can and cannot be recycled visually communicated) (Recyclemania - Guide to a More Effective RecycleMania). Such a strategy has been employed by University of Reading and University of Victoria (University of Reading - Clean & Green; University of Victoria - Sustainability). Finally the focus should not be on the lack of current recycling but on the desire to do so. This can be done by demonstrating/facilitating the positive behaviour at major events/gatherings (Recyclemania - Guide to a More Effective RecycleMania). See Appendix G.

Annual events that promote on campus sustainability have also been shown to improve the recycling behaviour of students and staff. These events also act towards educating on campus sustainability practices (University of Reading - Clean & Green; University of Reading - Environmental report; University of Victoria - STARS). Though training and clearly marked recycling bins can have a positive impact on behaviour, it is important to note that there will always be those that choose not to change. An example of this was shown during a study at Massey University (MU). Though training was provided to kitchen staff regarding disposal processes, there were a few staff members who chose not to participate in the program. This led to decreased diversion rates and increased contamination of diverted waste (Mason *et al.*, 2004). This can also be seen at the UU where an infrastructure change; the removal of Desk-side bins in the David de Wied building, led to some people bringing in their own bins, and the ultimate failure of the pilot.

Changing behaviour related to waste management is a complex task. Combinations of measures work best to achieve support on all levels of the university. Any undertaken measures (poster, incentives, events, competitions) should be targeted to the intended audience. Demonstrating the institution's commitment to any measures also supports adoption.

3.5 Policies and procedures best practices

On the internal organisation level the UU holds the aspiration to make the UU more sustainable, with a focus on energy, new construction/renovation, mobility and purchasing. They place emphasis within these themes on sustainable facilities processes and effective communication of the university's efforts. It is stated in the Milieujaarverslag 2012 that the UU is ambitious and regards the care for the environment as a social responsibility that goes a step beyond satisfying the demands of law and regulation. Herein the university formulates its own demands and agreements to achieve this goal (UU - Milieujaarverslag, 2012). While the UU is very consistent in this message, no mention of sustainability is made within the code of conduct for students and staff or the scientific practices (UU - Code of conduct; The Netherlands Code of Conduct for Scientific Practise). As the UU strives to incorporate sustainability into all practices performed at the university, it is important to include sustainability holistically into all types of policy and especially those related to behavioural aspects. The study of Nejati & Nejati (2013) supports this by showing that a fully holistic approach on sustainability is the only way to achieve general awareness and to set a common goal.

A holistic view of waste management can also be applied as a contractual condition for the sales of items as done by the University of Washington & Seattle (Chan, 2008). Inclusion of mandatory waste recycling in the contracts with vendors on campus have been shown to allow more control on the produced, amounts and types of waste. This may not be applicable for the whole of the UU, but may be possible for the stores on the Uithof.

The often complex communication structure of institutions of higher learning along with high turnover of staff and students can make the coordination of sustainable waste management practices difficult. Having an institution wide coordinator who ensures that the vision is shared by all levels of the organisation along with support from knowledgeable persons in each department who also commit to the implementation of sustainable waste management can combat institutional complexity (Zhang *et al.*, 2011). To provide a structural change an institution wide coordinator was installed by the UU in 2012, to map and monitor all sustainability initiatives already implemented in the university's structure. While large steps have been made, the UU is still working towards achieving a shared sustainability vision on all organisation levels. Other institutions such as the University of Berkeley and the University of Queensland Australia have made progress on these fronts by providing trainings for their staff. The University of Berkeley provides this type of training under the name of WORKbright green. The focus lies within the development of several competences among them: generating less waste, reuse, recycling and composting, green purchasing, student-led sustainability initiatives and applying to the grants and funding available to staff for green campus initiatives (University of Berkeley - Staff Sustainability Training). The University of Queensland also has a training program, the University Staff Development Program. This program consists of a free one-day training in two sessions. The aim of these sessions is to introducing the staff to campus sustainability and simple and feasible ways to reduce the environmental impact of their job (University of Queensland - University Staff Development Program). A personal anecdote from one of this report's authors illustrates the need for a training day a little further:

"I was waiting for class to start near the vending machines at the Van Unnik-building and was working on my laptop when the cleaning lady asked me, 'Do you want any of these?' while holding up some flyers. I thanked her, and continued working on this report. Three seconds later when I looked up I saw her put all the collected flyers in the plastic bin. I was a little shocked."

Whether or not such trainings are also recommendable for the University of Utrecht depends on whether there is an intrinsic interest among staff-members for them.

The key point of improvement for plastic recycling within waste policy and procedures however seems to be in communication. If students and staff do not feel they are in a sustainable institution, they will also not behave in such a manner. American universities have demonstrated the value in sparking enthusiasm for sustainable practices. The organisation of events such as Earth Day (Oregon State University), Recyclemania (Cornell University, Oregon State University, Florida International University and many others), America Recycles Day (Cornell University, North Carolina State University) and Green week (University of Reading) have been shown to stimulate responsibility for sustainable practises as well as communicate to students and staff that the university takes sustainability seriously (University of Reading - Green Week). Where events like Earth Day, Recyclemania and America Recycles Day are nationwide initiatives, most universities decide to organise a week of sustainability related activities. These weeks give a strong signal and could serve multiple purposes, such as:

- Communication to students and staff on new initiatives or measures that increase the sustainability on campus;
- Provide a podium for events and actions such as:
  - plenary student-staff discussions on sustainable initiatives,
  - lectures on outstanding sustainability research,
  - present an award for best sustainability research/best sustainable practice by staff/best sustainable initiative by students, etc.
  - informing/incentivising actions such as providing free coffee from vending machines if you bring your own cup, the distribution of free KeepCups for example when returning five empty water bottles, etc;
- Provide an annual deadline for internal sustainability-related initiatives;
- Remind students and staff of the sustainability of their behaviour.

All together there are many possibilities to improve the policy and procedural practices at the UU concerning plastic waste management.

3.6 Infrastructure

A convenient infrastructure for waste management coupled with informed behaviour of students/staff support the realisation of effective sustainable waste management solutions. One approach to achieve a convenient infrastructure is centralised waste collection. Several implementations of centralised waste have been implemented at institutions of higher learning. At the University of Reading desk-side bins in office spaces that only take general waste were removed; these were then replaced with bins at fixed, centralized locations accessible to more people (University of Reading - Policy, 2013). University of Victoria uses 3-bin recycling stations in most buildings on its campus as a centralised waste strategy (University of Victoria - Waste reduction). Portland State University implemented an "It's All in the Hall: The Bin Consolidation Project". This project intends to pair trash and recycling bins together: something that would be unfeasible for every single room of the university. In order to implement this centralised waste system they removed bins from classrooms to central locations, such as hallways (Portland State University - Programs & Services). For centralised waste to be effective it must be enforced as a rule. If not

individuals could potentially bring their own desk-side bins from home. As a prime example of the effects of centralised waste and clustering bins, a study was conducted at Massey University (MU) which focused on waste separation in the kitchen/cafeteria and concourse areas. It is important to note that though MU only has 9,000 FTE students and is located in New Zealand, the results of the study provide an understanding of potential diversion rates for a given university. In the experiment waste bins were clustered together while providing minimal training and recycling prompts. Disposed waste was monitored for five weeks prior to clustering the bins and then was monitored for 5 weeks after the bins were clustered and positioned. Before the clustering of the bins, diverted plastic waste amounted to 18% in student areas. After the clustering of bins, however, diverted plastic waste increased to 31% of total waste, with an additional 2% of plastic waste being disposed of in the wrong containers. This study shows that in the best case scenario, 33% of plastic waste can potentially be diverted (Mason *et al.*, 2003). This percentage was also supported by previous evaluations found in other papers (Keniry, 1995), and is propagated in the proposed recycling potential (Figure 3.5).

While both suggestions above can be considered changes that require a fairly large amount of organisation, there are also smaller improvements with regards to policy and procedures that can be found at other universities. One of the most interesting ones comes from the University of Boston, where the territory of the university is divided into sections that are managing waste collection and cleaning individually, as is also the case at the UU. The idea of centralised waste is used at the University of Boston to optimise the placement of recycling bins. By assessing a new area each week with a team from Facilities Management and Planning, a representative of their internal furniture recycling program and the university's recycling vendor optimal placement of the bins could be assigned. The team walked through each floor in every building to design integrated recycling and waste stream systems that would increase the convenience of recycling, clearly communicate what can be recycled, and reduce the volume of the University's waste (Boston University - Recycle). Since the structural outline of the waste management in Boston is organised much like the University of Utrecht's, this could provide a simple method to increase recycling rates.

Direct observations in the UU Ruppert building and around campus highlight that rethinking the spatial arrangement of bins more logically is entirely necessary. Bins targeting different waste types should be clustered together to maximise separation and ensure maximum student/ staff participation. LFM and RSB will receive a spatial plan informing them of the most effective bin placement. Studies at the MU prove the effectiveness of centralised waste and dustbin clustering, which is further supported by Reading, UVic, and Portland State universities as mentioned.

3.7 Economics

Currently, rest waste is delivered to sorting facilities which charge €60/tonnes of material. By diverting plastic waste from this material, a decrease in waste costs would be realised. Currently the sorting facility does not charge for the intake of plastic material, therefore the only cost associated with recycling plastic is the replacement of the compactor and travel costs. It has been determined that the total cost to recycle 1 compactors worth of plastic is €87.50 per container including transport costs (Kooiman, 2014). Determining the amount of plastic in the compactor is less straight forward. Since the compactor has not yet reached its full capacity while in use of the UU, the total weight in kilograms that the compactor can hold is unknown. Adding to this problem is the fact that plastic has various densities based on its type and

form, therefore it is not easy to calculate the potential weight of a completely full compactor, but a rough estimate can be determined using conservative assumptions.

It is assumed that the majority of the plastic on campus comes from plastic bottles (polyethylene terephthalate), and so the average density of the material would be close to that composition. Polyethylene terephthalate has a density of 1.38 g/cm³ at 20ºC (GESTIS - Substance database). Since the size of the compactor is 15m³ (Kooiman, 2014), it is calculated that the compactor could theoretically hold around 20.7 tonnes. For the purposes of this evaluation, a more conservative assumption of 20 tonnes will be used. The conclusion of these calculations is that for every 20 tonnes of plastic waste collected, €87.50 of cost will be incurred by the university. A summary of the potential costs and savings based on expected plastic waste scenarios can be found in Table 3.1.

Table 3.1: Expected plastic collect and cost savings for three plastic waste collection scenarios at the UU. With increasing plastic collection savings can be made on the rest waste stream costs.

	Extreme (33%)	Average (18%)	Conservative (5%)	Current
Plastic Waste (kg)	591,184	322,464	89,573	2,973
No. of Recycling Trips	30	17	5	1
Recycling (Costs)	(€ 2,625)	(€ 1,488)	(€ 438)	(€ 88)
Diversion Savings	€ 35,471	€ 19,348	€ 5,374	€ 178
Total Savings/(Costs)	**€ 32,846**	**€ 17,860**	**€ 4,937**	**€ 91**

To simplify this table it can be stated that for every compactor of plastic that is recycled (20 tonnes), the university would be saving €1,112.50. It is important to note that what is not included in these costs are the increased cost of maintenance for picking up separated waste, trash liners or any other costs that may arise from increasing this service. As an example, it is possible that with large influxes in plastic being delivered to the sorting facility, they may no longer offer this service for free. The main take away of these calculations is that it is important to implement waste diversion methods that effectively optimise recycling rates. The better separation and collection of plastic waste, the better savings expected.

4 Discussion

The following solutions are recommended for the purposes of improving plastic waste management at the UU based on the research carried out. Alterations to the UU's current policy & procedures and infrastructure are detailed. These will all stimulate better recycling behaviour on campus. The range of solutions are organised with regards to financial investment, effort required, and expected return. A scale of low, medium, or high will be used to express these values.

4.1 Policy and procedures

On both the policy and procedure level of the UU, there are significant steps that if taken could result in a more efficient and effective plastic recycling system. These recommendations stem from the best practices of similar institutions, as discussed in the "Results" section.

4.1.1 Changes to Code of Conduct

The Code of Conduct for students and staff are meant to be the underpinning of the behaviour of students and staff at the UU. In addition, considering the UUs place in the Association of Universities (Vereniging van Universiteiten [VSNU]) and the overall increasing importance of sustainability implementation in practice, a step towards more sustainable practice in research might be one to consider.

As such, it is recommended that the Code of Conduct (CoC) be updated to include the topic of sustainability. Recommended additions to the CoC are the following

- Under 'CORE VALUES', add 'Sustainability', and specify that staff and students strive to be as sustainable in their practices as can be considered reasonable. They pursue this goal by minimising water; electricity and material use, and make environmental considerations in the purchase of new goods.

To assure that these values are understood by new and continuing students, it is recommended that a review of the UU's sustainability efforts is included in all orientations. The following topics should be covered during this instruction:

- Review of the Code of Conduct, specifically adding sustainability as one of the 'CORE VALUES' for staff and students of the UU, and requesting this addition in The Netherlands Code of Conduct for Scientific Practices;
- Review of current recycling procedures including separate plastic, glass, paper and rest-waste collection.

Repeated support and coverage of this topic will make it more present in the minds of those whose behaviour dictates the outcome of the other recommended improvements. The expected effect of these revisions and reminders would be similar to the "branding" side of marketing. The needed effort to achieve this would be minimal, requiring that a review of the code of conduct be done and accepted. The financial investment would be for the hours needed for the review. The expected results would be minimal at first but would increase as the new sustainable codes of conduct become institutionalised.

4.1.2 Training for staff and faculty

To integrate the visions of all organisational layers involved with the sustainable practices, training for students, faculty, and staff is recommended. Training for faculty and students may be in the form of

lectures or workshops, while staff training should take the shape of biannual reviews and meetings. The recommendation for faculty and student training is to hold an annual lecture series on the topic of sustainability. Suggested workshop topics are outlined below:

Lecture/workshop #1
- General background on sustainability, the purpose of recycling and why it is important;
- Explanation of material pathways from production through sales to trash and recycling;
- Methods to reduce, reuse and recycle - Ladder van Lansink;
- Specific attention in a workshop to material selection and material separation, with special attention to plastic waste.

Lecture/workshop #2
- Focus on reducing waste production, brainstorm on possibilities;
- Reducing material, electricity and water use in own practices, show best practices;
- Reuse of materials as a way to save waste.

Lecture/workshop #3
- Promote sustainability initiatives from students and staff
- Grants and funding that are available for green campus initiatives
- Sustainable procurement guidelines and assessment forms for staff

This lecture series will provide an opportunity for the university to communicate its best practices as well as host a forum to generate new ideas and understand where current procedures are in need of improvement. This feedback system will assist in the effectiveness of any recycling procedures and engage both faculty and students on the subject.

Regarding staff and maintenance trainings, instructional meetings should occur at least twice per year. The reason for this frequency is due to staff turnover as well as the importance that proper procedures are implemented. It is recommended that one of these trainings should occur concurrently with the lecture series, so as to drive the point home that all levels are included in this focus. The second meeting should also be used as a milestone to audit performance and verify that all staff correctly understand and are actively involved in the recycling procedures. A sample agenda for each meeting is below:

Meeting 1 (During sustainability lectures)
- Explanation of why recycling is important
- Breakdown of what can/cannot be recycled
- Detail of best practices
- Review of past questions/issues
- Request for feedback

Audit (preferably these meetings should be held twice a year to provide continuity
- Dependant on what procedures are in place. Could include:
  - Random checks of location of waste bin receptacles
  - Monitoring of waste

Meeting 2 (1 week after Audit)
- Explanation of why recycling is important
- Breakdown of what can/cannot be recycled

- Detail of best practices
- Review of past questions/issues
- Review of audit that occurred the week prior to the meeting
- Request for feedback

It is recommended that these training opportunities be coordinated and managed by the Sustainability Manager (Projectmedewerker Duurzaamheid) with assistance from the Green office in order to guarantee consistency, constituting the financial investment. The expected effect of these trainings is again to keep recycling and sustainable practices current while enforcing proper implementation of these procedures, as without proper support, any recommended procedures would be ineffective.

4.1.3 Sustainability week

It is recommended that the UU hold an annual event surrounding the topic of sustainability. Such a week could provide a means for communication on environmental topics, hosting events and lectures on sustainability research and promoting internal sustainability initiatives. This event could occur near the date of the international Earth Day (April 22th), as there is already much momentum towards the environment and sustainability at this time. A possible week program is provided below.

Monday
Meatless Monday: No meat in the canteen and a vegan option available
Evening program: Showing of the documentary Meat Inc. or similar.

Tuesday
Free coffee if you use your own cup
Competition to win Green Office KeepCups
Evening program: Lectures/workshops on sustainable coffee

Wednesday
Sustainability Awards: Award given for most sustainable practices on campus
Evening program: Bring-your-own-cup-borrel

Thursday
Tap water promotion day: No sale of bottled water/distribution or reusable water bottles
Evening program: Lectures on social enterprises that work on water, such as Join the Pipe and Water Footprint

Friday
Recyclemania: Placement of stickers on every available bin to remind students and staff of recycling options, contest on lowest waste production per department of the university. Presentation of initiatives to decrease waste, such a biodegradable utensils in the cafeteria
Evening program: Brainstorm on options for improvement of recycling, exhibit of waste collected in the past week and share of recyclables within that waste.

It is important to stress the communication aspects of this week; the week offers a podium for all sustainability-related issues and initiatives the university is dealing with. The needed financial investment

would be the costs associated with organising and coordinating this week. The overall effect of this recommendation is not only reinforcing procedures, but to engage students and faculty who may otherwise not typically participate in sustainable practices. This also provides a chance for the university to publicise its efforts.

4.1.4 Vendor contract alterations
The most effective way to reduce plastic waste is to reduce its creation. As such, it is recommended that the source of plastic waste, typically vendors, have plastic waste reduction included in their contracts and their own policy and procedures. This could range from a limit on the sale of bottled beverages to a ban on non-recyclable plastic packaging. The following is a sample list of items that are recommended to be included in future contracts with vendors:

- Overall waste management contract should be awarded to a company with a commitment to assist with the Environmental Policies and Procedures and recycling targets of the UU. If this cannot be done; the waste management companies currently used should have their contracts updated to be in line with UU sustainability goals.
- Contracts to waste management companies should include the necessity for data on the weight of each bin lifted on campus on a monthly basis, giving a more accurate account of recycling rates which could help to identify problem areas and populate a league table aiming to tap into the competitive side of departments and buildings (as in Recyclemania).
- Contract alterations to waste management companies could also help to find recycling routes for waste items that could not be recycled previously i.e. paper cups.
- Before a waste management contract is issued or renewed, the company in consideration should fulfil the above prerequisites.
- In terms of contracts towards on-campus shops and vendors such as the SPAR supermarket: A description of the sustainability practices carried out by said company, complete with a recent external waste audit of the company, proof of efforts to collect, dispose of and minimise plastic waste streams, an evaluation of plastic packaging used for the products of on-campus vendors, attempts to replace plastic packaging with more environmentally friendly material in an effort to reduce overall plastic waste inputs, removal of the distribution of thin plastic bags by on-campus vendors should all be considered in contract agreements.
- On-campus vendors should also be able to report on their waste streams by providing data on the weight of each sorted bin being used before it is picked up by waste management services.

Effectiveness of this directive on plastic waste is directly related to the extensiveness of these contract changes. Theoretically, if the UU were to modify their vendor contracts so that no plastic packaging was allowed on campus, there would be virtually no plastic waste and thus solve the issue of plastic recycling. It is foreseen, however, that this level of commitment is not necessarily feasible, and so effectiveness of this recommendation will vary with the commitment given. For these reasons the required effort to achieve this solution are high involving higher level management. The financial investment needed would once again be the man hours spent in preparing these contract negotiations.

Table 4.1: Framework showing the results and investments associated with different proposed methods to policy and procedure to achieve successful plastic waste management.

Solution	Financial investment	Effort management	Effort student and staff	Return
Changes to Code of Conduct	●	●	Not applicable	Necessary to support future changes
Training for staff and faculty	● ●	●	Not applicable	● ●
Sustainability week	● ● ●	● ●	● ●	● ●
Vendor contract alterations	● ●	● ● ●	Not applicable	● ● ●

4.2 Infrastructure

As infrastructure can affect behaviour, it is important first and foremost that whatever decision is made, consistency must be maintained. That being said, the following are several infrastructure related recommendations, which have the ability to result in varied outcomes tied almost directly to their implementation.

4.2.1 Pairing of waste and plastic collection bins

It is recommended that all general waste bins will be accompanied by a plastic waste receptacle. By pairing plastic and general waste bins, a large improvement in effectiveness can be seen in case studies and literature without requiring a large upfront investment. This recommendation also does not require much effort, other than initial coupling of these bins and periodic audits of their locations. As plans for new buildings include the placement of connected general waste/plastic/paper bins, this recommendation is primarily for all existing buildings and outdoor locations. The implementation of this recommendation should follow these steps:

Step 1: Divide campus buildings and areas into several audit sections.

Step 2: Audit 1 section per week. During this audit, determine the number of general waste and plastic collection bins.

Step 3: After all sections have been completed and the number of necessary general waste bins have been confirmed, determine the number of additional plastic waste bins required to assure that all general waste bins will be accompanied by a plastic collection bin.

**Step 4:** Order or relocate all needed extra plastic waste bins.

Step 5: Complete pairing of recycling and regular waste bins. This can be achieved in stages, following the previous sections, or can be done in a large rollout.

In addition to the proper placement of the waste and recycle bins, placement of prompts (posters, stickers) by all waste bins is crucial for effectiveness. The purpose of these signs should be to inform users of proper recycling procedures with the goal of increasing recycling while limiting contamination. Posters and stickers should follow the below best practices:

- Be positively worded, not chastise unwanted behaviour
- Be located near bins for recycling
- Be concise in their message
- Speak to the target audience
- Not be considered as a stand-alone solution but as axillary support to other solutions
- Negative reinforcement such as fines or punishments should be avoided.

Information about how recycling functions at the institution should also be placed on the website of an institution to support the objective. As referenced in Policy and Procedures, it is also important that orientations for staff and students include information on this topic.

To provide a financial evaluation of this recommendation, several factors would need to be determined that were not covered in this study. The first and most costly is the number of needed recycling bins. As determining the amount of recycle bins needed was not possible during this evaluation, it is not possible to give a correct rate of return. It can be assumed, however, that with proper implementation of this recommendation, an annual savings of anywhere between €4,937 and €17,860, as detailed in the Results section, would be expected. A financial evaluation and rate of return would need to be completed at the time of ordering. If it is only possible to purchase a limited amount of these bins, it is recommended that areas of heavy traffic and locations near to sources of plastic waste, such as cafeterias and markets get priority. Figures 4.1 and 4.3 show the current placement of bins and the recommended measures in order to increase the efficiency of recycling and waste characterisation.
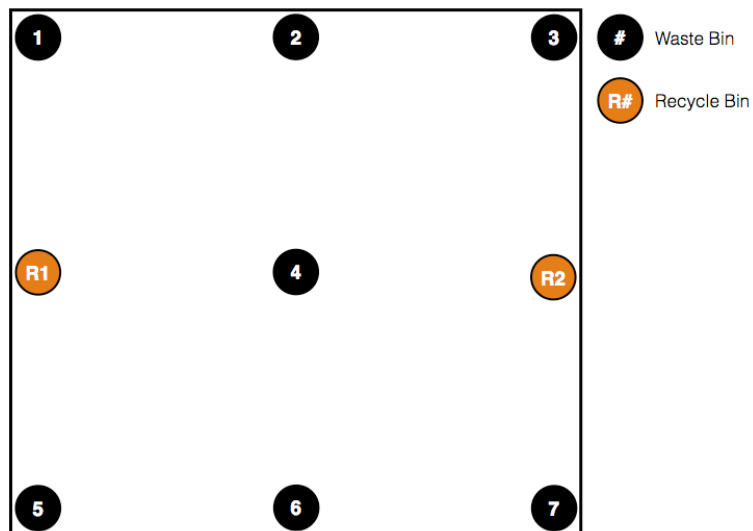
Figure 4.1: *Current waste and recycling bin location at the UU. Various waste bins are available on the campus. These bins are not coupled with recycle bins.*
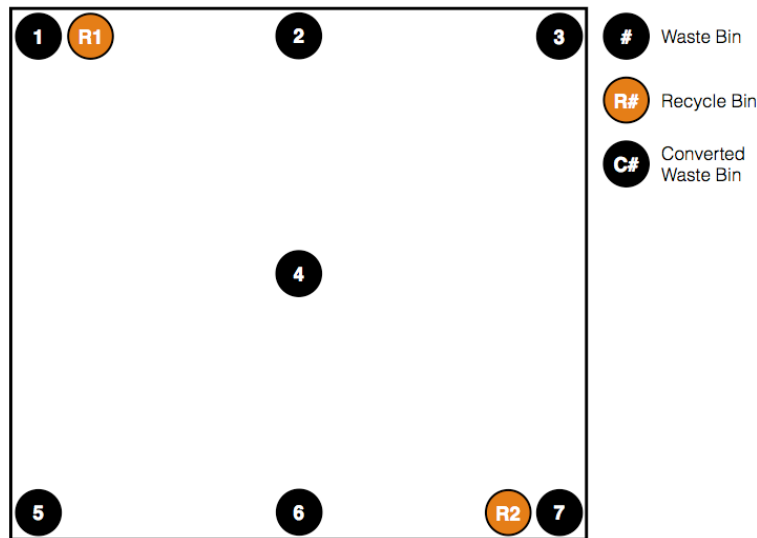
Figure 4.2: *Proposed change waste and recycling bin placement. Pairing of Recycle bins with waste bins. If funds for new recycle bins are limited, pairing of bins in areas of high traffic should be paramount.*

4.2.2 Reduce number of waste bins

The next level of commitment to plastic recycling would be the overall reduction of waste bins. This recommendation would be in addition to the previous proposition (4.2.1). Removal of bins would not only include reducing the number of common area waste bins, but also the complete removal of all small personal bins found in offices and classrooms. Placement of waste bins would mimic the idea of centralised waste. This solution could be implemented during or after the pairing of waste and plastic collection bins, though it is recommended that it be done concurrently to better utilise staff resources and prevent the purchase of unnecessary recycle bins. The method of this recommendation is to organise the placement of bins around the idea of centralised waste, by going through every floor and department with a waste management team, LFM, Green Office and students. This involves some extra effort on the management side, but creates opportunity to create a solution that works for everyone and pushes students and staff to think about their waste behaviour. This measure will have a larger effect than the previously mentioned, although the steps to follow for this proposition are additional to the previous recommendation:

> **Step 1:** Divide campus buildings and areas into several audit sections. Make sure to create a floor diagram for each area so that it will be easier to note the locations of waste bins.

> **Step 2:** Audit 1 section per week. During this audit, determine the number of general waste and plastic collection bins and their locations. During this evaluation, come to a consensus about how many trash bins are actually required and note the optimal location for waste bins to be located. As a rule of thumb, only one waste bin should be seen from any point.

> **Step 3:** After all sections have been completed and the number of necessary general waste bins have been confirmed, determine the number of additional plastic waste bins required to

assure that all general waste bins will be accompanied by a plastic collection bin. In addition, diagrams should be developed that state the exact location of the waste bins per area.

Step 4: It is recommended that within 1 month of the completion of the audits, all needed recycle bins need to be ordered.

Step 5: Complete pairing of recycling and regular waste bins and removal of unnecessary bins. This can be achieved in stages, following the previous sections, or can be done in a large rollout. For maximum effectiveness, it is advised, that the implementation of this step happen as quickly as possible.

It is expected that by increasing the awareness of the number of trash cans and their location, many receptacles will be found to be redundant. In addition, by decreasing the number of waste locations, savings can also be seen in maintenance. In reducing the number of disposal locations, increased separation of plastics is expected and the cost savings is expected to be closer to €17,860, see result section. Small bins could be sold or donated, and though this would be a loss of profit, it would result in higher recycle rates and would have the potential for costs savings in waste diversion. As mentioned previously, it was not possible to determine this exact number in the limited time of this evaluation. It was noted that a similar approach to reduce the number of waste bins was attempted by the UU previously. This attempt was ineffective, as loopholes were found by the users. It is recommended for this solution to be effective that buy-in occurs on every level. It is recommended that users be informed of where waste is to be disposed of and that maintenance staff are reminded to only empty the specific waste bins and not desk-side or personal waste bins. This is once instance were staff freedom may actually hinder an effort. A clear message from all levels of management would combat this. Figure 4.3 shows the optimal placement of bins, as a next step after pairing. This is expected to maximise correct use of bins by limiting the choice of waste disposal locations, effectively simplifying waste disposal.
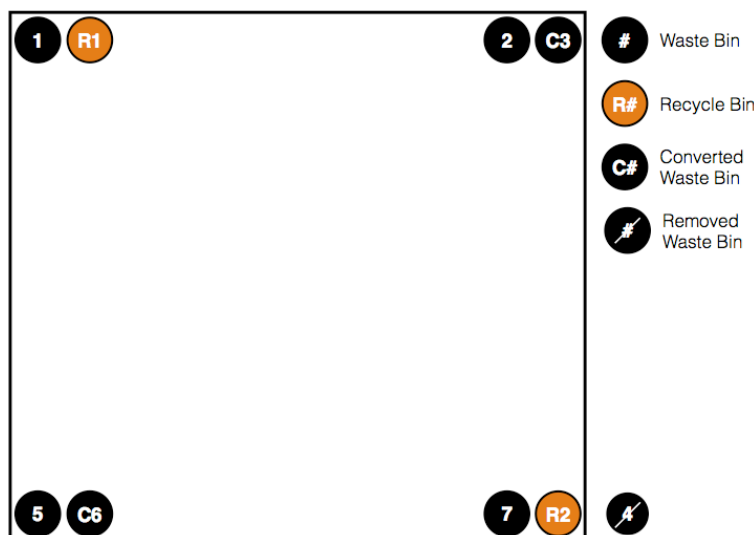
Figure 4.3: Proposed waste bin solution in which each waste bin is paired with a recycle bin and unpaired bins are removed from the facility. As in all infrastructure solutions only one pairing should be in line of sight at any point.

4.2.3 Standardisation of waste bins and commitment to centralised waste

Plastic waste collection is best served, based on the experience of other universities by replacement of all separate waste bin with three-prong bins that collect general waste, plastic and for example organic or paper waste. There are currently plans to have such bins installed in all new building projects of the UU. Implementation across all UU Uithof buildings will create a uniform recycle system across the campus. The replacement of all bins and purchase constitutes a large financial investment, including the storage/sale of the currently used bins. Office work spaces that cannot receive three-prong bins must receive alternative bins for the collection of plastic, such as is currently being done with paper for this system to be effective. Standardisation of all waste bins constitutes a long term investment on the part of UU. While the monetary investment to replace all the current bins may be too large at this time all future bin purchases should be geared towards three-prong standardised waste bins. Figure 4.4 shows the ideal scenario after the introduction of 3-prong waste bins, since they are highly effective fewer bins need to be present in total.
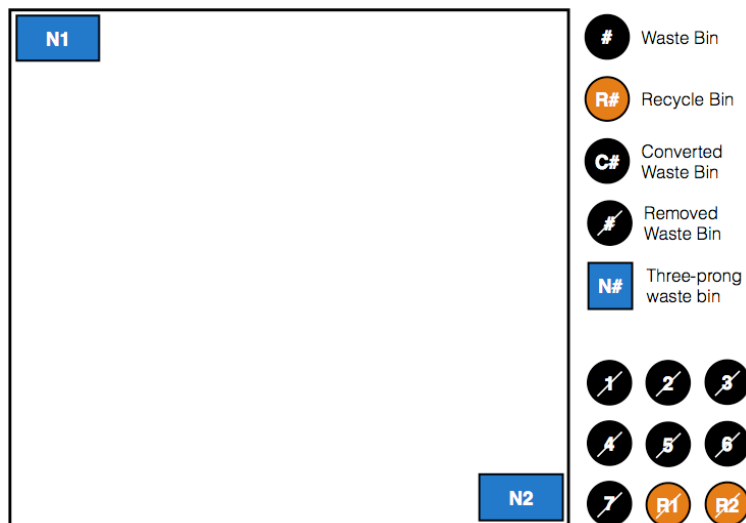
Figure 4.4: *Ideal scenario after the introduction of 3-prong bins. All other forms of bins have been removed from the system, stimulating that waste be only centrally collected in the three-prong waste bins.*

Table 4.2: Framework showing the results and investments associated with different proposed methods to the infrastructure of the university to achieve successful plastic waste management

Solution	Financial investment	Effort management	Effort student and staff	Potential return in % of plastic collected
Pairing of waste and plastic collection bins	●	Not applicable	Not applicable	5%
Reduce number of waste bins	● ●	● ●	●	18%
Standardisation of waste bins	● ● ●	● ●	Not applicable	33%

4.3 Behaviour

There are no specific recommendations for this section as it is anticipated that behavioural change will result from implementation of the above directives. Effectiveness of these procedures on behaviour depends on the following:

- Educating incoming students and faculty of proper procedures to maintain campus wide awareness.
- Consistent campus wide roll-out of the preferred system.
- Role modelling of wanted behavior to students by staff.
- Informative posters in near vicinity to clustered bins that clearly state how waste should be handled.

It has been found that the creation of the opportunity to recycle accounts for 50% of behavioral change, while specific communication improves behaviour by another 20%. In addition, events related to recycling and sustainability have the ability to change the mind-set of students and staff and make them more aware of their own sustainable behaviour.

5. Conclusion

The University of Utrecht places serious emphasis on sustainability stating that the subject is "one of four strategic themes in which Utrecht University will further define its profile over the coming years."(UU - Sustainability). At present day the UU's sustainability policies are still under great development and herein the university refers to STARS as an inspiration, by providing areas of potential to achieve a more sustainable campus (Kessels J. M. M., 2013). However, the report that was submitted to STARS showed that although intentions towards a more sustainable campus are present, specific waste-reduction plans or goals such as zero waste are not yet in place.

A focus on waste management is one of the most visible sustainability initiatives for a university, and can do a lot for the image to the outside, the atmosphere amongst students and staff and the impact the university has on the environment. As was expressed throughout this report, the recommendations presented have a large potential effect on reduction and recycling of plastic waste, but this can only be achieved with consistency and buy in from all levels within the university. The importance of setting goals and actively promoting plastic waste diversion cannot be underestimated in this task, as it provides the stimulation waste management is currently lacking on the subject of plastic waste recycling.

Acknowledgements

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Appendices

Appendix A - UU Uithof included buildings

Building	Address
A.A. Hijmans van den Berghbuilding	Universiteitsweg 98
Administration Building	Heidelberglaan 8
Alexander Numanbuilding	Yalelaan 40
Androclusbuilding	Yalelaan 1
Botanic Gardens	Budapestlaan 17
Buys Ballot building	Princetonplein 5
Caroline Bleekerbuilding	Sorbonnelaan 4
Centrumgebouw Noord	Padualaan 14
David de Wied building	Universiteitsweg 99
De Tolakker	Jenalaan 19
Educatorium	Leuvenlaan 19
F.A.F.C. Went building	Sorbonnelaan 16
Fort Hoofddijk	Budapestlaan 17
Geosciences building	Budapestlaan 4
H.R. Kruyt building	Padualaan 8
Hans Freudenthal building	Budapestlaan 6
ICT Service Centre	Jenalaan 18 A
IRAS	Jenalaan 18 D
Jeanette Donker-Voet building	Yalelaan 104-106
Marinus Ruppert building	Leuvenlaan 21
Martinus G. de Bruin building	Yalelaan 7
Martinus J. Langeveld building	Heidelberglaan 1
Matthias van Geuns building	Bolognalaan 40
Minnaert building	Leuvenlaan 4
Nicolaas Bloembergenbuilding	Padualaan 12
Nieuw Gildestein	Yalelaan 2
Ornstein Laboratory	Princetonplein 1
Prof. dr. H. Jakob building	Yalelaan 108
Robert J. van de Graafflaboratory	Princetonlaan 4
Stratenum	Universiteitsweg 100
University Library Uithof	Heidelberglaan 3
Willem C. Schimmel building	Yalelaan 114
Willem C. van Unnik building	Heidelberglaan 2

Appendix B - STARS reporting process,

STARS 2.0 Credit Checklist

1. ACADEMICS

Curriculum *40 points available*	AC 1	Academic Courses	14
	AC 2	Learning Outcomes*	8
	AC 3	Undergraduate Program*	3
	AC 4	Graduate Program*	3
	AC 5	Immersive Experience*	2
	AC 6	Sustainability Literacy Assessment	4
	AC 7	Incentives for Developing Courses	2
	AC 8	Campus as a Living Laboratory*	4
Research *18 points available*	AC 9	Academic Research*	12
	AC 10	Support for Research*	4
	AC 11	Access to Research*	2

2. ENGAGEMENT

Campus Engagement *20 points available*	EN 1	Student Educators Program	4
	EN 2	Student Orientation	2
	EN 3	Student Life	2
	EN 4	Outreach Materials and Publications	2
	EN 5	Outreach Campaign	4
	EN 6	Employee Educators Program	3
	EN 7	Employee Orientation	1
	EN 8	Staff Professional Development	2
Public Engagement *22 points available*	EN 9	Community Partnerships	3
	EN 10	Inter-Campus Collaboration	2
	EN 11	Continuing Education*	5
	EN 12	Community Service	5
	EN 13	Community Stakeholder Engagement	2
	EN 14	Participation in Public Policy	2
	EN 15	Trademark Licensing*	2
	EN 16	Hospital Network*	1

3. OPERATIONS

Air and Climate *11 points available*	OP 1	Greenhouse Gas Emissions	10
	OP 2	Outdoor Air Quality	1
Buildings *8 points available*	OP 3	Building Operations and Maintenance	4
	OP 4	Building Design and Construction*	3
	OP 5	Indoor Air Quality	1
Dining Services *7 points available*	OP 6	Food and Beverage Purchasing*	4
	OP 7	Low Impact Dining*	3
Energy *10 points available*	OP 8	Building Energy Consumption	6
	OP 9	Clean and Renewable Energy	4
Grounds *3-4 points available*	OP 10	Landscape Management*	2
	OP 11	Biodiversity*	1-2

	OP 12	Electronics Purchasing	1
Purchasing *6 points available*	OP 13	Cleaning Product Purchasing	1
	OP 14	Office Paper Purchasing	1
	OP 15	Inclusive and Local Purchasing	1
	OP 16	Life Cycle Cost Analysis	1
	OP 17	Guidelines for Business Partners	1
Transportation *7 points available*	OP 18	Campus Fleet*	1
	OP 19	Student Commute Modal Split*	2
	OP 20	Employee Commute Modal Split	2
	OP 21	Support for Sustainable Transportation	2
Waste *10 points available*	OP 22	Waste Minimization	5
	OP 23	Waste Diversion	3
	OP 24	Construction and Demolition Waste Diversion*	1
	OP 25	Hazardous Waste Management	1
Water *5-9 points available*	OP 26	Water Use	2-6
	OP 27	Rainwater Management	2
	OP 28	Wastewater Management	1

4. PLANNING & ADMINISTRATION

	PA 1	Sustainability Coordination	1
Coordination, Planning and Governance *8 points available*	PA 2	Sustainability Planning	4
	PA 3	Governance	3
Diversity and Affordability *10 points available*	PA 4	Diversity and Equity Coordination	2
	PA 5	Assessing Diversity and Equity	1
	PA 6	Support for Underrepresented Groups	2
	PA 7	Support for Future Faculty Diversity	1
	PA 8	Affordability and Access	4
Health, Well-Being and Work *7 points available*	PA 9	Employee Compensation	3
	PA 10	Assessing Employee Satisfaction	1
	PA 11	Wellness Program	1
	PA 12	Workplace Health and Safety	2
Investment *7 points available*	PA 13	Committee on Investor Responsibility*	2
	PA 14	Sustainable Investment*	4
	PA 15	Investment Disclosure*	1

Total Points Available: 199-204

5. INNOVATION

	IN 1	Innovation Credit 1	1
Innovation *4 points available*	IN 2	Innovation Credit 2	1
	IN 3	Innovation Credit 3	1
	IN 4	Innovation Credit 4	1

* credit does not apply to all institutions

Appendix C - Commercial businesses in De Uithof campus

Spar
Hema
Studystore
Primera
Pizzeria Tricolore
Gutenberg Coffee UB
Espressobar Goliath/David de Wiedgebouw
Restaurants (Sodexo)
Grand café The Basket
Tuincafé Botanische Tuinen
Cambridgebar
Rabobank

Appendix D - Calculation of UU STARS scores

OP 22 - Waste Minimization (5 pts)

This action is focused on reducing waste, specifically between the "base year" (2005) to the "performance year". Waste minimization is worth 5 of the total 199 points which equates to 2.5% of the total score. This deliverable is tracked by comparing the total tons of all waste, including plastic, disposed of in 2005 to that of the performance year. The point determination method is broken into two parts (AASHE - STARS technical manual, 2014):

Part 1: Reduce waste by 50% from base year to performance year. (2.5 pts)

A - Total waste generated (diverted + disposed), baseline year (short tons/tonnes)
B - Weighted campus users, baseline year
C - Total waste generated (diverted + disposed), performance year (short tons/tonnes)
D - Weighted campus users, performance year

UU's Evaluation:

A - Total waste generated, baseline year (2005)

Recycled	1,097	Tons
Composted	153	Tons
Garbage	1,226	Tons
Total	2,476	Tons

B - Weighted campus users, baseline year (2005)

Total	34,005	FTE

C - Total waste generated, performance year (2012)

Recycled	710	Tons
Composted	7	Tons
Garbage	1,374	Tons
Total	2,091	Tons

D - Weighted campus users, performance year (2012)

Total	34,861	FTE

= **0.88**

Part 2: Reduce waste from base year to performance year beyond Part 1. (2.5 pts)

A - Total waste generated (diverted + disposed), performance year (short tons/tonnes)
B - Weighted campus users, performance year
C - Minimum performance threshold (0.45 short tons or 0.41 tonnes)

UU's Evaluation:
Since UU did not meet the minimum for Part 1, it is not eligible for points in Part 2.

OP 23 - Waste Diversion (3 pts)

This action is focused on redirecting waste from general "rubbish" to reusable and recyclable tracks. This includes composting, reuse of materials, recycling of paper and plastics as well as any other actions that reduce the amount of waste being discarded. OP 23 is worth 3 points, which equates to 1.5% of the total score. The points for this action are calculated as follows:

These two actions together account for 8 points which equates to 4% of the total score and would get a university 1/10 of the way to bronze status.

A - Materials reused, recycled, or otherwise diverted
B - Total amount of waste generated (diverted + disposed)

UU's Evaluation:

A - Materials reused, recycled, or otherwise diverted
Total   863 tons

B - Total amount of waste generated (diverted + disposed)
Total   2,091 tons

    = **1.03**

OP 22 - Waste Minimization - Part 1	*0.88 / 2.5 pts*
OP 22 - Waste Minimization - Part 2	*0.00 / 2.5 pts*
OP 23 - Waste Diversion	*1.03 / 3.0 pts*
Total	*1.91 / 8.0 pts*

Appendix E - List of universities comparable to the UU participating in STARS

Matching Institutions	Ver.	No. of FTE	Rating	Total Score (~199 pts)	Waste Reduction (5pts)	Waste Diverted (3pts)	Recycl (2005) (tons)	Comp. (2005) (tons)	Rubbish (2005) (tons)	Recycle (tons)	Comp. (tons)	Rubbish (tons)
Auburn U.	1.2	25,469	Silver	49.13	0.00	0.32	296.00	0.00	4,479.00	567.00	0.00	4,790.00
Boston U.	1.2	32,439	Silver	49.85	1.60	0.95	361.00	0.00	10,600.00	1,553.00	1,247.00	6,798.00
Colorado State U.	1.0	30,467	Gold	77.54	1.08	2.15	1,210.10	842.00	1,609.20	1,250.00	432.00	1,763.55
Columbia U.	1.1	26,050	Gold	74.18	0.18	1.05	1,903.90	0.00	5,997.85	2,736.58	0.50	6,143.70
George Mason U.	1.0	33,320	Silver	51.98	0.00	0.42	849.00	0.00	2,537.00	647.00	5.00	3,990.00
Iowa State U.	1.2	29,611	Gold	75.93	0.98	2.22	837.71	0.00	4,646.48	1,200.65	380.58	4,043.42
Louisiana State U.	1.1	29,718	Silver	49.83	0.56	1.03	323.65	198.00	7,518.00	1,365.83	361.00	4,966.00
Northern Arizona U.	1.2	25,359	Gold	66.39	1.07	1.46	800.00	0.00	1,700.00	1,296.00	45.00	1,796.60
Portland State U.	1.0	28,584	Gold	68.55	0.00	0.86	873.00	0.00	1,662.00	849.20	267.93	2,107.36
San Diego State U.	1.2	30,541	Silver	51.1	0.32	1.16	950.00	160.00	2,506.00	1,106.00	311.00	2,318.00
San Jose State U.	1.0	30,236	Silver	50.55	0.00	2.72	1,431.00	456.00	2,027.00	3,578.00	533.00	418.00
Universiteit Utrecht	2.0	29,755	Reporting		0.88	1.88	1,097.00	153.00	1,226.00	710.00	7.00	1,374.00
UC Davis	1.2	31,732	Gold	71.18	1.35	1.92	1,699.00	8,222.00	9,425.00	1,543.00	10,803.00	6,884.00
UC Irvine	1.2	27,189	Gold	66	0.02	2.42	961.00	0.00	7,217.00	4,851.80	2,636.10	1,778.00
UC San Diego	1.2	28,593	Gold	68.32	0.00	1.63	2,918.00	0.00	6,264.00	7,809.45	165.00	4,915.46
U. of Colorado Boulder	1.0	32,558	Gold	68.77	0.95	1.11	1,515.50	234.20	3,709.00	1,460.20	419.60	3,246.00
U. of Kansas	1.1	27,939	Bronze	37.98	1.25	0.20	441.00	74.00	13,064.00	586.00	76.00	10,819.78
U. of Kentucky	1.0	27,226	Silver	48.03	3.67	0.98	2,636.00	126.00	8,540.00	2,498.00	27.00	5,233.00
UMass Amherst	1.2	28,084	Gold	70.93	1.64	1.70	2,120.00	1,931.00	3,508.00	1,926.00	1,994.00	3,015.00
U. of South Carolina	1.0	30,721	Gold	66.33	3.74	0.73	529.86	0.00	4,221.87	791.15	2.00	2,660.56
U. of Utah	1.0	31,660	Bronze	35.74	1.25	0.95	0.00	233.00	2,370.00	658.00	366.00	1,428.00
U. of Wisconsin-Milwaukee	1.2	29,350	Silver	55.33	1.68	1.19	1,263.18	0.00	2,784.97	1,433.15	13.65	2,318.92
Virginia Commonwealth U.	1.2	31,627	Silver	51.13	1.49	1.23	793.25	0.00	3,418.29	1,170.46	62.78	2,798.84
Virginia Tech	1.2	30,936	Silver	63.3	1.61	2.52	1,326.86	0.00	5,012.71	1,621.84	406.51	3,744.01

Appendix F - List of stakeholders

The following stakeholders were approached and interviewed to determine what they saw as the origin of the problem as well as possible solutions, while also gathering information regarding current practices, proposed actions and recurring issues.

- *UU Reststoffen beheer (RSB - restwaste management):* this department is in charge of budget for waste and would be directly involved in the implementation of proposed solutions.

- *UU Lokaal Facilitair Management (LFM - local facility management):* works together with the RSB and is in charge of the local management of facilities. As the scope of this project was concentrating on the Centrum area of the Uithof, the Regio Centrum - Uithof is the main stakeholder in this group. All not dangerous waste is managed by the LFM.

- *UU Gebouwzorg (building maintenance):* the building maintenance is contracted by the local facility management and operates under their conditions.

- *UU Green Office:* this office acts as the representative from the customer and will also play a part in the presentation, implementation and dissemination of proposed solutions.

- *UU Sustainability Office:* this office submitted data to STARS so it helped us understand what the motivation was behind the participation in the program.

- *UU Students and Employees:* this group of people have a direct interest in the proposed solutions as solutions may affect their campus and work environment.

Appendix G - Example poster from the University of Reading and University of Victoria

Recycling point
clean&green

Mixed recycling

✓ Plastic bottles
✓ Paper cups
✓ Food/drinks cans
✓ Plastic containers
✓ Food/drinks cartons (Tetra packs)
✓ Food tins and foil
✓ Paper
✓ Cardboard
✓ Newspapers
✓ Magazines
✓ Envelopes
✓ Catalogues
✓ Books

Please empty and rinse items before recycling

Non-recyclables

✓ General waste
✓ Other plastics
✓ Food waste
✓ Plastic bags
✓ Crisp and sweet wrappers
✓ Expanded polystyrene

Please help keep the campus clean and recycle your rubbish responsibly. Glass can by recycled at bottle banks across campus, check the website for the nearest location www.reading.ac.uk/cleanandgreen
For more information please contact waste@reading.ac.uk

Source: http://www.reading.ac.uk/cleanandgreen/Resources/cag2-resources-recyclingguidesandposters.aspx - Retrieved 12th March 2014

Recycling point
clean&green

Mixed recycling
- ✓ Plastic bottles ♳ ♴ ♵
- ✓ Paper cups
- ✓ Food/drinks cans
- ✓ Plastic containers ♷ ♺
- ✓ Food/drinks Cartons (Tetra paks)
- ✓ Food tins and foil

Please empty and rinse items before recycling

Paper recycling
- ✓ Cardboard
- ✓ Newspapers
- ✓ Magazines
- ✓ Envelopes
- ✓ Catalogues
- ✓ Books

Non-recyclables
- ✓ General waste
- ✓ Other plastics ♶ ♹
- ✓ Food waste
- ✓ Plastic bags
- ✓ Crisp and sweet wrappers
- ✓ Expanded polystyrene

Please help keep the campus clean and recycle your rubbish responsibly.
Glass can be recycled at bottle banks across campus, check the web site for the nearest location www.reading.ac.uk/cleanandgreen
For more information please contact waste@reading.ac.uk

Source: http://www.reading.ac.uk/cleanandgreen/Resources/cag2-resources-recyclingguidesandposters.aspx - Retrieved 12th March 2014
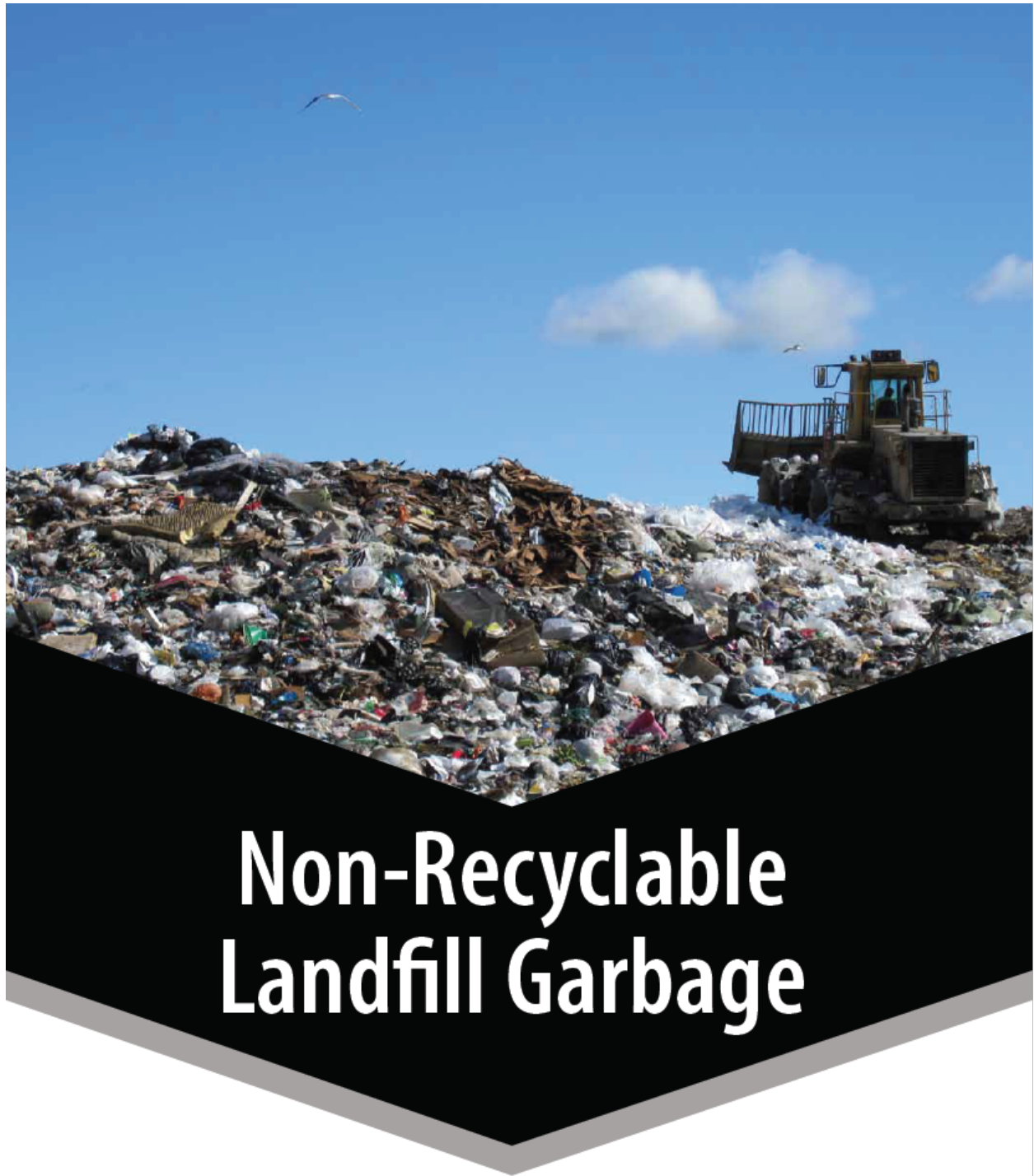
Bottles, Cans and Mixed Containers

Please compost!

SORT IT OUT
UVIC RECYCLING

Source: http://www.uvic.ca/sustainability/operations/waste/recycling/index.php -Retrieved: 12th March 2014

Non-Recyclable Landfill Garbage

Source: http://www.uvic.ca/sustainability/operations/waste/recycling/index.php -Retrieved: 12th March 2014

Mixed Paper

Source: http://www.uvic.ca/sustainability/operations/waste/recycling/index.php -Retrieved: 12th March 2014