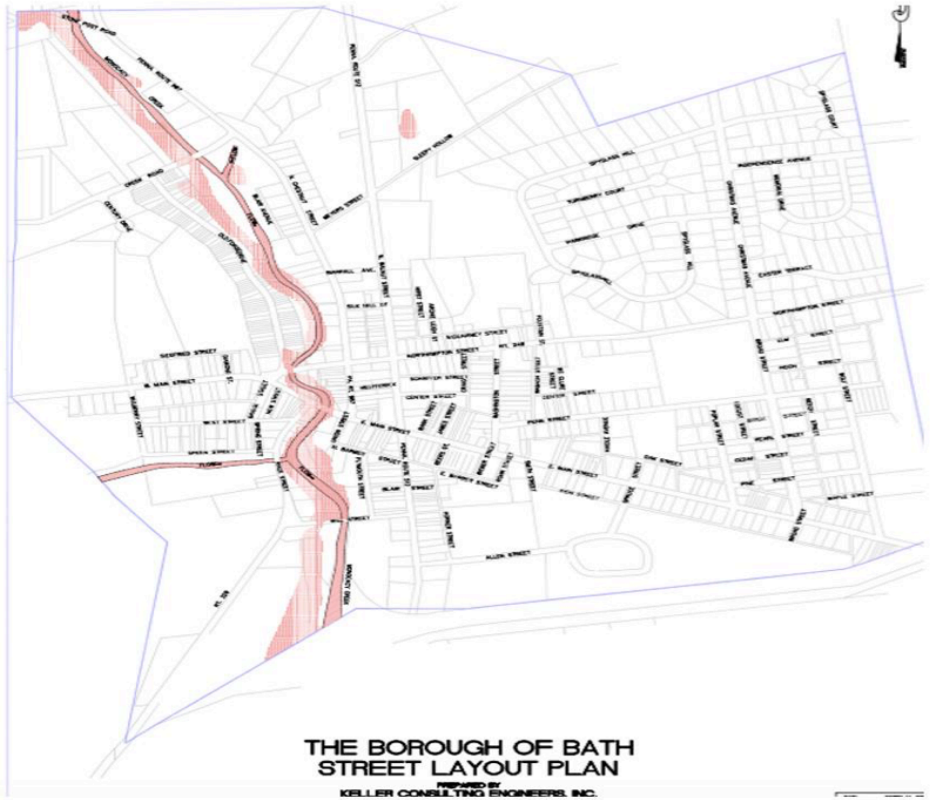


Reduce, Reuse, Recycle: Bath's Mission to Clean the Streets

Final Report: December 2016

Technology Clinic: Meet the Team

Technology Clinic is a two-semester program at Lafayette College where an interdisciplinary team of students works with advising faculty members to address a real world client. Each team works with one client on a problem for the duration of the Technology Clinic. Since its founding 1986, teams have worked on projects for private clients, NGOs and municipalities on a wide range of topics. The 2016 Technology Clinic team is consulting for the Borough of Bath to investigate options and suggest plans for handling waste collected by its newly acquired street sweeper as well as suggesting ways to most effectively use the street sweeper.

Team Members:
Stephanie McCartney ‘17
Kaelin King ‘17
Dana Smith ‘18
Kenzie Corbin ‘18
Michelle Foley ‘19

Faculty Facilitators:
Prof. Dan Bauer
Prof. Chris Ruebeck
Prof. Lawrence Malinconico

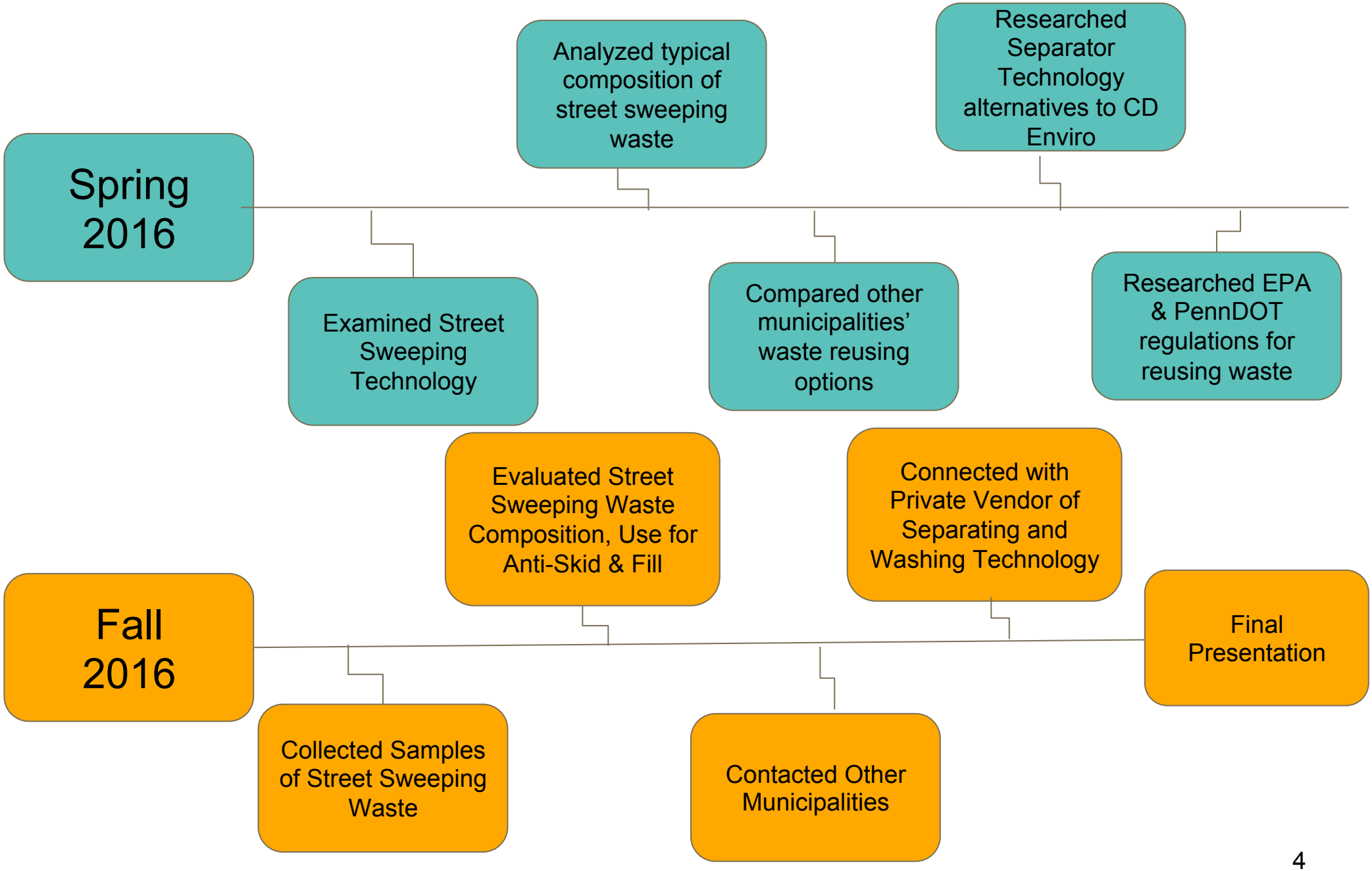
Problem Statement

- **Current Situation:** Bath is using a street sweeper that arrived in late Spring 2016 and facing high dumping costs for their street sweeping waste.

- **Goal:** To explore potential options to reuse street-sweeping waste in more economically beneficial way, including consideration of inter-municipality involvement.

- **Topics considered:**
  - Separating the usable waste from the non-usable waste
  - Uses for street-sweeping waste
  - Environmental regulations for re-use
  - Inter-municipality coordination
  - Community support

Summary of Progress



This Report Will:

- Review work accomplished this semester.
- Examine the implications associated with 3 options for handling street sweepings.
- Investigate the potential for inter-municipality involvement in street cleaning/waste recycling.
- Highlight additional ideas that could intersect with the street-sweeping program.

Outline

- Testing and Regulations
- Option 1: Continue Dumping
- Option 2: Anti-Skid & Fill
- Option 3: Fill Only
- Inter-Municipality Options
- Total Summary Analysis
- Further Potential
- Conclusion & Next Steps
- Special Thanks

This section outlines the regulations for using materials as anti-skid and fill. It also discusses Pennsylvania's regulations for testing materials. We detail our team's separating and testing of a sample of Bath's street sweeping waste and highlight the findings of this process.

Anti-Skid Regulations

The table below presents the size classifications of the different types of anti-skid approved for use in Pennsylvania. Type AS1 anti-skid is composed of natural sand, manufactured sand, or a combination of the two. Types AS2 and AS3 are composed of crushed stone, gravel or slag. Type AS4 is composed of crushed stone or gravel only.

These size classifications are important in considering how street sweepings can be separated into different reusable materials. In order to be reused as anti-skid, these different sizes will be an important part of the separation process; it will be necessary to purchase a separator with different grade sizes that will qualify the material as these different levels of anti-skid. In testing the street waste samples from Bath, we used these appropriate mesh sizes in order to gauge the prominence of each type in the samples and content of the different size levels.

Anti-Skid Type	Maximum Percent Passing Sieve								
	31.5 mm (1 1/4")	19.0 mm (3/4")	12.5 mm (1/2")	9.5 mm (3/8")	4.75 mm (No. 4)	2.36 mm (No. 8)	300 µm (No. 50)	150 µm (No. 100)	75 µm (No. 200)*
Type AS1				100	60-100	0-80		0-8	0-5
Type AS2				100	35-80	0-45		0-6	0-3**
Type AS3			100	90-100		0-30		0-8	
Type AS4				100	35-80	0-45		0-6	0-3**

* Determined by PTM No. 100.

** If the total percent passing the 2.36 mm (No.8) sieve is less than 25%, then the total percent passing the 75 µm (N0. 200) sieve is allowed to be 0-5.

Fill Regulations

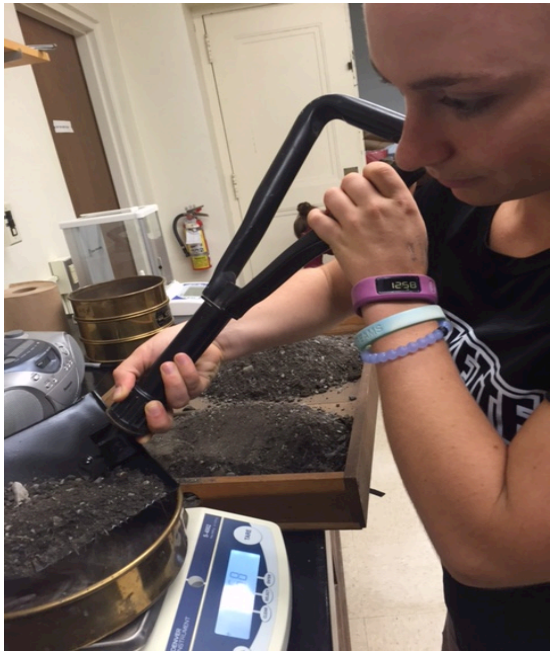
Fill material must be analyzed in order to determine if it qualifies as clean fill or as regulated fill. If a visual contamination does not reveal **staining, odors, or other signs of contamination**, the material can be considered clean fill and used for road repair as needed. If visual contamination is apparent, testing for contaminants must be done in accordance to PA regulations in order to determine if the fill is classified as clean or regulated fill. Regulated fill is fill that contains levels of contaminants defined by the PA regulations and can only be used after obtaining a permit. The testing and regulation procedures for classifying fill and using regulated fill are further outlined in Appendix G.

Toxic Material/Need for Testing?

- PA's regulations for utilizing street waste state that visual examination is sufficient.
- Additional concerns for safety/environmental hazards could be addressed by **examination for toxins**.
- In terms of streets, coal ash is one of the most prominent culprits of toxins.
  - PA waste management regulations state that coal ash could be utilized as structural fill, anti-skid material, and road-surface preparation material.
  - Coal ash has high **mercury** levels.
- Coal ash is more commonly utilized in the Midwest and is not widely utilized in PA.
- PA regulations do not require inspection for mercury; however, Appendix C explains the procedure if it is of interest.

How we Tested "Waste" Material

1. We looked up PennDOT regulations for anti-skid/fill size.
2. We matched these regulation sizes to the sizes of available meshes in the geology department. Meshes were either from the Tyler Standard Screen Scale or U.S Standard Testing Sieve
   a. Penndot approves: 12.5 mm, 9.74 mm, 4.75 mm, 2.36 mm, 150 um, 75 um
   b. We used: 13.33 mm, 9.5 mm, 4.75 mm, 2.36 mm, .15mm, .074 mm
3. To get a random sample from the buckets, we used a device to separate our samples into two random piles and then used those as our samples.
4. We then took part of the random sample and weighed it.
   a. We tried to get all of our samples in the range of 1200-1600g.
5. Placed our sample in the Ro Tap Testing Sieve Shaker and ran it for 5 minutes
6. After 5 minutes, we took apart each layer of waste, weighed it, and bagged it.
7. We used this method to conduct three tests from the dry bucket and three tests from the wet bucket.



Dana obtaining our randomized samples

Testing “Waste” Material

Ro Tap Testing Sieve

Mesh Screens used to separate components

Testing “Waste” Material

Bucket full of sample of “dry” waste collected from Bath

Dana and Michelle separate out layers of waste based on screen size

Data from Sample Analysis: Dry

		Dry 1		Dry 2		Dry 3	
Type	**mm**	**Weight (g)**	**wt%**	**Weight (g)**	**wt%**	**Weight (g)**	**wt%**
Pebble	**13.33**	48.1	3.1	36.4	2.2	14.6	0.9
	9.5	41.3	2.7	62.3	3.8	56.9	3.7
	4.75	229.3	14.9	318.8	19.3	291.3	18.9
Granule	**2.36**	387.0	25.1	453.7	27.4	425.2	27.6
Fine Sand	**0.15**	711.5	**46.2**	677.4	**41.0**	680.1	**44.2**
Very Fine Sand	**0.074**	104.2	6.8	85.4	5.2	65.8	4.3
Silt & Clay		10.8	0.7	14.0	0.8	6.3	0.4
Total		1532.2	99.5	1648.0	99.7	1540.2	100.0

This table shows the composition of the street waste in the various sizes ranging from pebbles to silt and clay. For each test, fine sand makes up the majority of the street waste composition, followed by granules, then small pebbles.

Data from Sample Analysis: Wet

		Wet 1		Wet 2		Wet 3	
Type	**mm**	**Weight (g)**	**wt%**	**Weight (g)**	**wt%**	**Weight (g)**	**wt%**
Pebble	**13.33**	33.0	2.7	28.4	2.2	16.7	1.2
	9.5	21.4	1.7	29.3	2.2	27.3	2.0
	4.75	181.8	14.7	224.7	17.2	210.6	15.3
Granule	**2.36**	417.7	**33.8**	477.0	**36.5**	452.5	**32.9**
Fine Sand	**0.15**	567.8	**46.0**	530.3	**40.6**	649.9	**47.2**
Very Fine Sand	**0.074**	0.2	0.01	0	0	0	0
Silt & Clay		0.2	0.02	0	0	0	0
Total		1222.1	98.9	1289.7	98.7	1357	98.6

This table shows the composition of the street waste in the various sizes ranging from pebbles to silt and clay. For each test, fine sand makes up the majority of the street waste composition, followed by granules, then small pebbles.

What Sample Analysis Tells Us

These samples were obtained from a **spring** and **summer** waste collection and give us a good idea of what will be regularly collected. Ideally, we would have also tested a sample from the fall months to get an even better idea of what the composition of waste looks like every season.

One thing that surprised us during this testing is how there was a very **small amount of pedestrian trash**. This could be the result of how the Bath public works staff chose what waste they put in the bucket. If this minimal amount of pedestrian trash is, however, typical of what kind of waste the street sweeper picks up, there will be no issue separating it from the re-usable material.

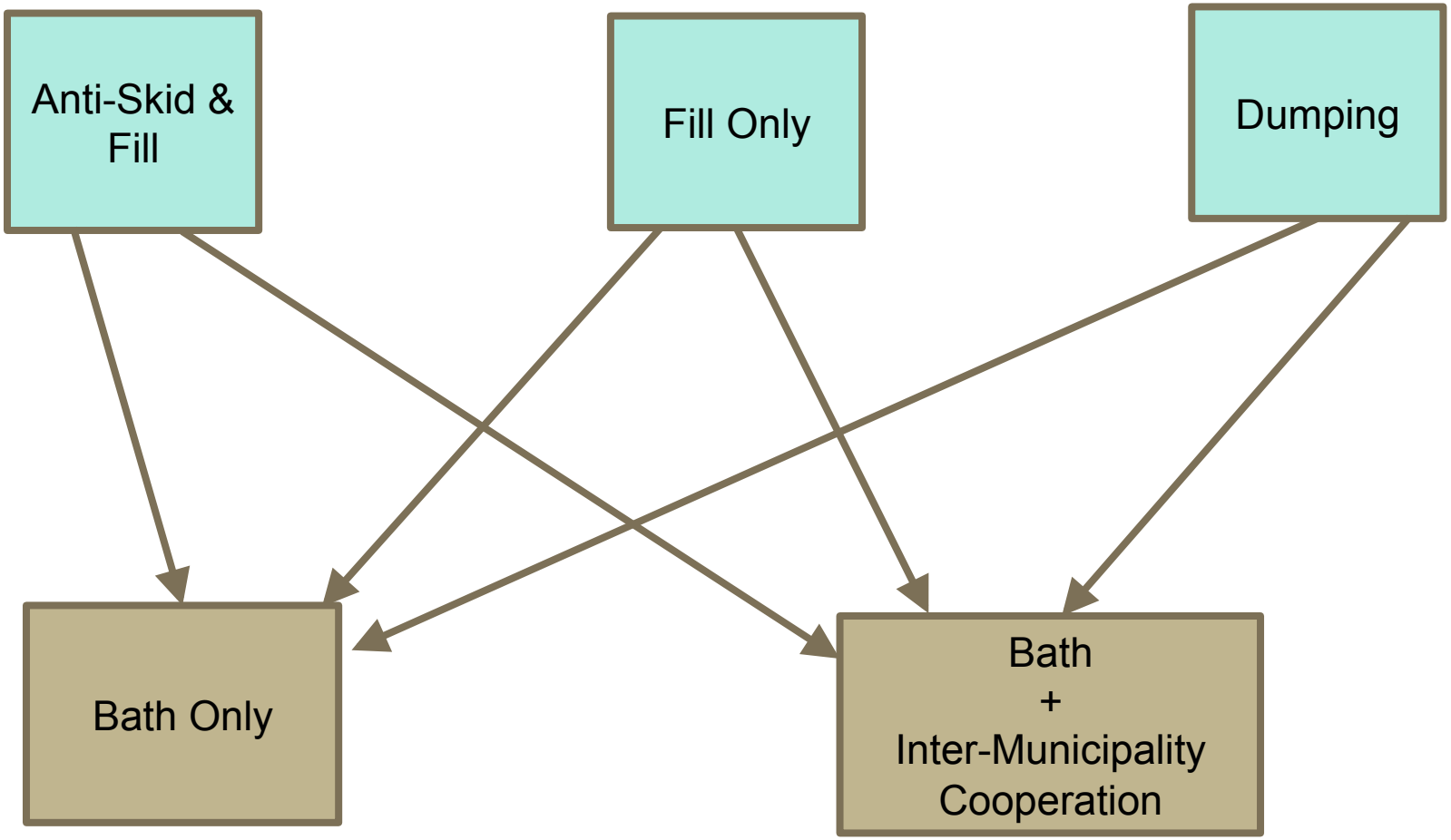
What our samples also show is that most of the re-usable waste ranges from pebble size (4.75mm) to fine sand (0.15 mm) which will qualify it to be used as **Type 1 or Type 2 anti-skid**. We have some waste that could be used at Type 3, but a much smaller percentage as compared to what can be used in Type 1 or Type 2. In addition, we could use the fine sands as well as whatever is left from this separating process as fill.

Future Testing Ideas

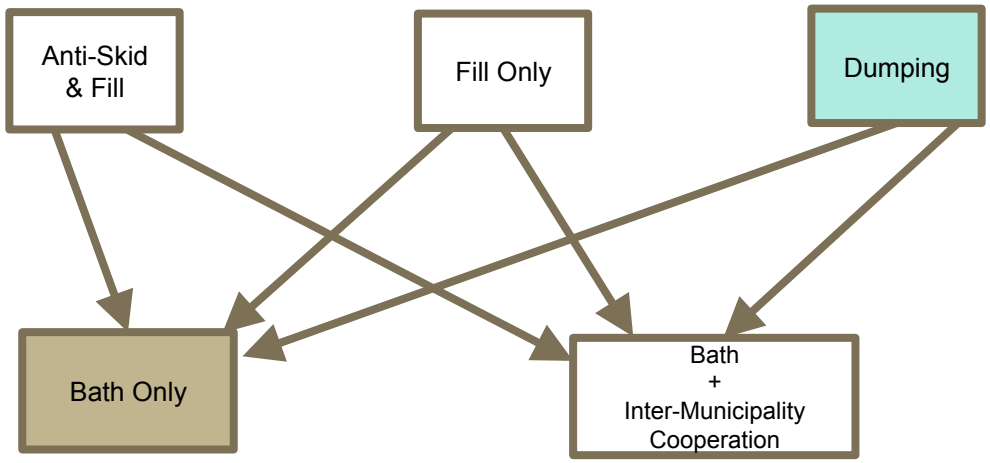
To improve testing of the waste samples we could employ several different techniques. First, we could acquire a more accurate sample to test in the sieve by making sure that the sample is representative of the majority of the waste and not just of the material that, for example, has accumulated at the top of the pile in Bath. In addition, we could test a sample from November-December street waste to see if any different materials are found. The exact moisture content of the waste could also be analyzed to determine how much potential product could be lost or separated inaccurately due to clumping. Lastly, a chemical analysis could be conducted and used to find possible contaminants we expect to see on roads because of cars, such as oil, as well as specific pollutants that regulatory agencies such as the DEP care about. (See pg. 9 and 10 for more information).

Our Report's Structure: Street Sweep Waste Options

This is a visual overview of the options that Bath can consider for re-using their street sweeping waste. In the following sections, we will first report each of these three options for Bath only, listed as Options 1, 2 and 3 on the next page. We will then look at the potential for Bath to engage in these options with inter-municipality cooperation.



Outline



The following section presents the details of Bath's first option for its street waste: continuing to dump the waste. We discuss what this option entails, its costs, its environmental impact, and compare the overall pros and cons of continuing to send the waste to a landfill.

Option 1: Continue Dumping

- Send all street waste material to landfill
  - No sorting or cleaning process will be required.
  - Incur landfill fee and dumpster fee.

Example landfill in the Lehigh Valley:
Chrin Brothers Sanitary Landfill

http://media.lehighvalleylive.com/easton_impact/photo/chrin-landfill-6565fef5ae6d26f5.jpg

Costs of Dumping Per Year

	Cost Per Unit	Units	Total Cost
Landfill Tipping Fee	$89/ton	120 tons	$10,680
Dumpster Fee	$125/dumpster	4 dumpsters	$500
Total			**$11,180 per year**

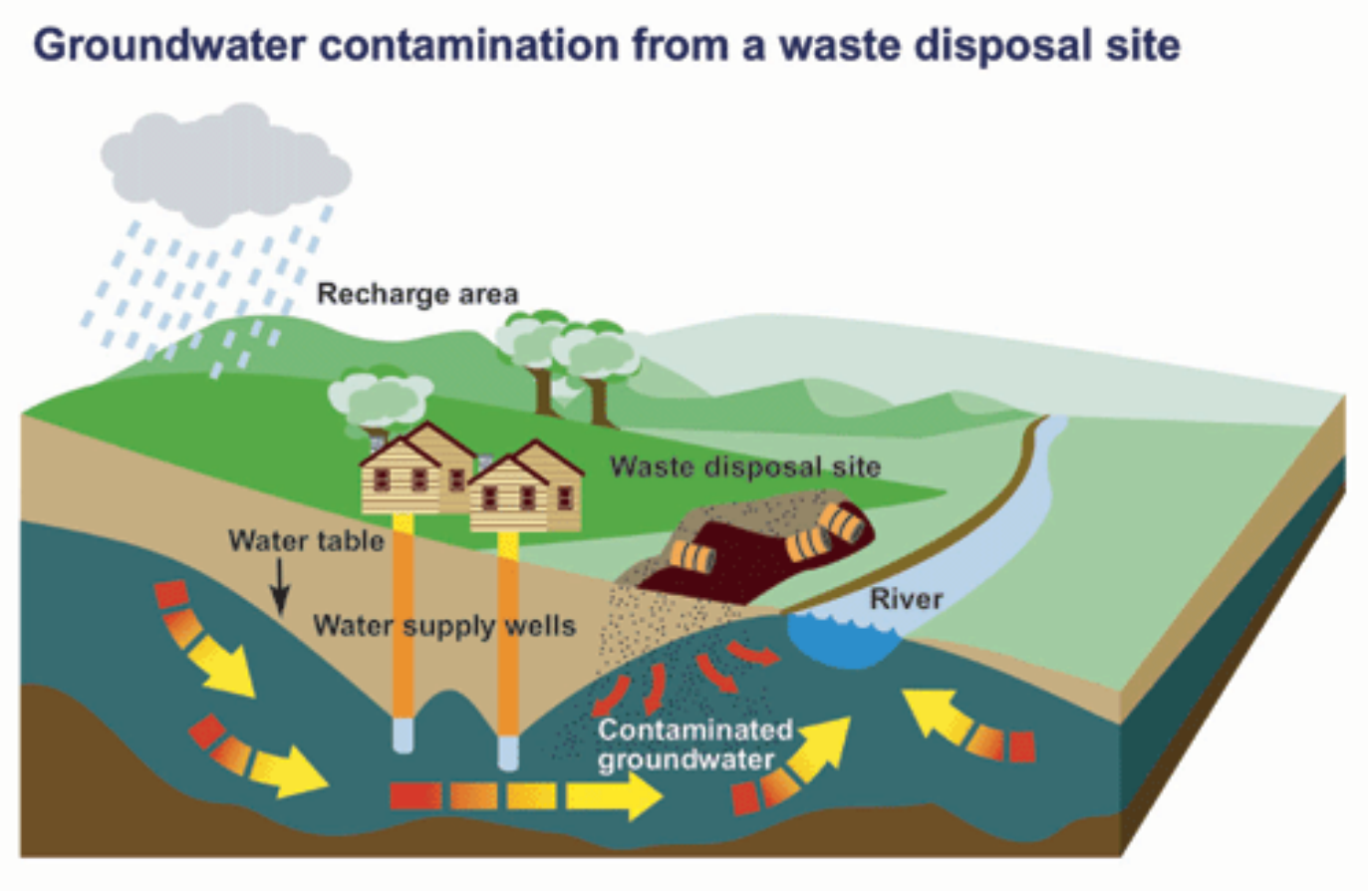
The cost of dumping street sweeping waste consists of the cost per ton to send waste to a landfill and the rental cost of the dumpster required for storage and transportation of waste. The estimated annual cost for Bath is $11,180 based off of a presumed 120 tons of street sweeping waste collected and filling four dumpsters per year (Appendix F).

Environmental Implications of Dumping

Landfills have a negative impact on the environment. They **contaminate** groundwaters, aquifers and soil, polluting and damaging the local environment. Even more drastically, landfills produce methane, a greenhouse gas more powerful than carbon dioxide that is considered one of the leading causes of **global warming**. Methane is released as organic substances, such a food waste, paper and yard scraps, decompose. Although these substances may not be particularly prominent in street waste, adding to the quantity of waste dumped at landfills will contribute to the negative environmental impacts of landfills.

Howard, 2009
Source:
http://livelifegreen.com/landfills-and-th-environmental-effects/

Contamination for Dumping



https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=6A7FB7B2-1

Above is a diagram depicting the effects of a waste disposal site. It can be seen that contamination has spread to many water bodies including groundwater, river, well supplies, etc.

Summary of Dumping

Pros

Since waste will not be separated there are no upfront capital costs

It is unlikely street waste in Bath would ever be classified as hazardous so no washing or cleaning would be required to dump it

There is little need for further planning and organization

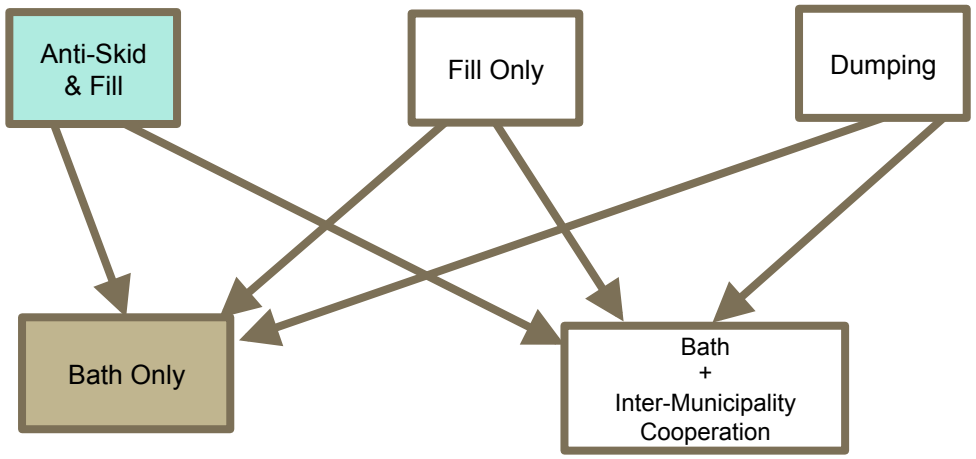
Cons

Annual costs are high and likely to rise as the trend in tipping fees is increasing

Adding more waste to landfills has negative environmental consequences (i.e. high methane emissions)

No opportunity to generate revenue for the Borough of Bath

Outline



The following section presents the details of Bath's second option for its street sweeping waste: reusing the waste as anti-skid and fill. As mentioned previously, in this section we discuss this possibility within Bath itself. We will later discuss the connections to inter-municipality coordination. This section introduces the concept and costs of a separation technology that Bath could use to separate its street sweeping waste into the proper sized materials to be reused as anti-skid. It also delves deeper into the savings that Bath would find from reusing the materials instead of dumping them. We consider the environmental impact of using anti-skid and road fill and discuss PennDOT's recommendations for road treatment with anti-skid.

Anti-Skid & Fill

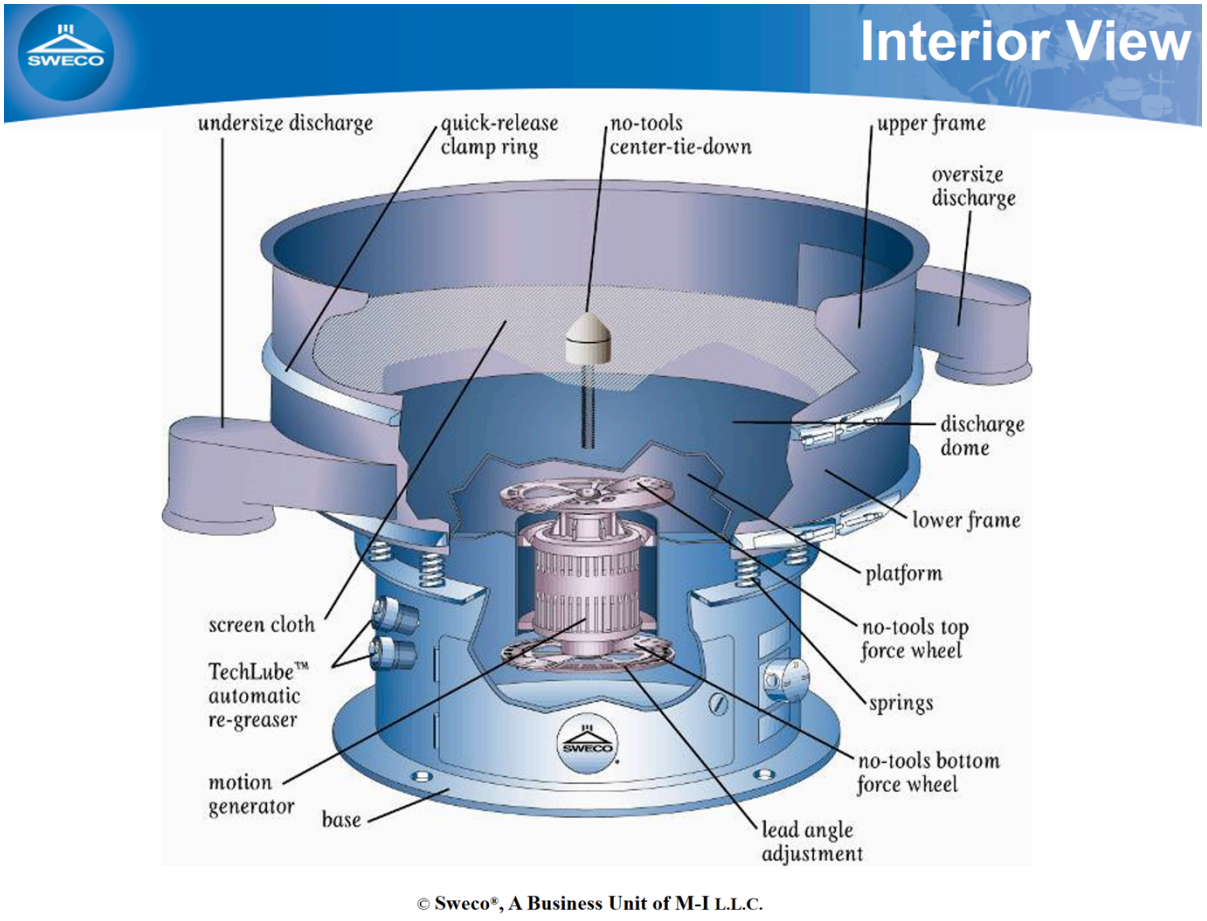
The material found in street waste has the potential to be reused as both anti-skid and fill material. In order for the waste to be reused as anti-skid, it must first be **separated by size** with a separation technology, the details of which are discussed on the next page. Material that is intended for use as fill does not have to be separated for size; only large pieces of trash must be removed from the material. The borough can designate some of the material to be used as anti-skid and the rest as fill. The borough can also plan to separate all the material for use as anti-skid and decide to use any excess of this material as fill.

Separator Information

- Contact: Dave Bizal from EPI Sales, Flexion Corporation
- Separators use vibratory technology to separate waste into Anti-Skid and Fill Components at a rate of 2000* lbs/hour
- Round Separator
  - 48'', 60'', 72'' diameter sizes
  - $25,000-$40,000 range
  - Rental option to test the system before investing in purchasing the equipment
- Customizable parts
  - Interchangeable standard screen sizes to adapt to different types of materials in different seasons
  - Add a washing device that will clean the waste
- Conveyor Belt

*assuming 50% recovery of "good material", 500-1000+ lbs can be recovered per hour

Round Separator



Photos and Information Provided by Dave Bizal, EPI Sales.

Flexible Screw Conveyor

3-A Compliant Units

-Fast, thorough cleaning

-No cracks, crevices, filters or bearings

-Quick disconnect features available

Photos and Information Provided by Dave Bizal, EPI Sales.

Capital Costs of Separating Anti-Skid and Fill

	Cost per Unit	Units	Total
Separator	$25,000	1 separator	$25,000
Conveyor	$16,000*	1 conveyor	$16,000
Storage facility	$5,000	1 storage structure	$5,000
Total			**$46,000**

There are three main capital costs associated with this option: the separation equipment, conveyor equipment and a storage facility for the anti-skid, waste and pre-separation waste. Assuming the least expensive technologies are used the total capital cost would be about $46,000 significantly lower than the two million dollar CDEnviro technology (*see Ap. H for stainless steel technology cost breakdown).

If this capital cost is paid by monthly installments over seven years at a conservative assumed interest rate of 3.25% then the monthly payment will be $613.01, leading to an annual cost of $7,356.12.

EPI offers a rental option that the borough may consider. Bath could initially rent the technology to verify the feasibility of the project and try different sized machines before investing $46,000 in separation technology. Approximate prices are used throughout the report, no purchase order with final prices has been placed.

Ongoing Annual Costs: Separating Anti-Skid and Fill

	Cost Per Unit	Units	Total
Maintenance costs of separation technology (screen replacement)	$400 per screen	6 replacements per year	$2,400 annually
Annual Payments for Capital	$613.01 per month	12 months	$7,356.12, annually
Total			**$9,756.12**

The ongoing cost specifically associated with this option is **$9,756.12** for the first seven years while payments are being made for separation capital. After seven years, the ongoing cost is **$2,400** annually to replace the three screens in the separation unit twice per year. This annual cost may be lower depending on the usage of the separator.

Replacing each screen every six months is likely the maximum amount of replacements required. The more material separated each year, the more wear there will be on the screens. The wear may be less significant if only Bath's street waste is separated. Wider intermunicipal use will put more wear on the screens and lead to this higher annual cost.

Savings from Capturing Anti-Skid and Fill

	Savings per Unit, annual	Units	Total, annual
Reducing Anti-skid costs	$15.00-$21.95	60 tons	$900-$1,317
Reducing Fill costs	$9.70-$15.50	60 tons	$582-$930
Reducing Road Salt costs by half	$59	15 tons	$885
Alternative to Dumping: No Tipping Fee	$89	120 tons	$10,680
Alternative to Dumping: No Dumpster Fee	$125	4 dumpsters	$500
Total			**$13,547-$14,312**

There are many potential opportunities to save money with this option. First there is the money saved by not incurring the costs to dump. The Borough can also save money on anti-skid and fill by reusing the materials collected and can cut salt costs in half if a **50/50 mixture of anti-skid and salt** is used on the roads. Excess anti-skid might also be sold to other boroughs at a competitive price. The table shows ranges because costs of these materials vary (details in Ap. E) and we expect that Bath will face prices in this range. Actual savings will depend on how much the materials will cost Bath each year based on bid prices the borough receives. Bath may have forty-five extra tons of anti-skid, which if sold at $20 would make $900 in profit. There may be a similar option for selling excess fill. (Source for the anti-skid and fill prices found in Appendix E.)

Environmental Implications of Road Salt

Road salt can have many **negative environmental effects**. Road salt is a compound of sodium and chloride, both of which cause damage when they come in contact with natural organisms. Both sodium and chloride easily mix with rain, melting snow, and ice and are transported to meet soil, vegetation, groundwater, stormwater, and surface waters.

Chloride is especially dangerous because it is very soluble and mobile, and toxic to aquatic life, vegetation, and wildlife. There is no natural process by which chloride can be metabolized or removed from the environment once it is present. It is estimated that 40% of urban streams have chloride levels that exceed the acceptable standard. This can very negatively impact the survival rate of crustaceans, amphibians, fish, plants and other organisms. It could also allow for an increase in salt-tolerant invasive species. While sodium is not as harmful to organisms as chloride, increased levels of sodium alters the soil chemistry, increasing the amount of sodium in groundwater and affecting the aquatic environment. In addition, highly concentrated salt can dehydrate and kill trees and plants growing next to roadways.

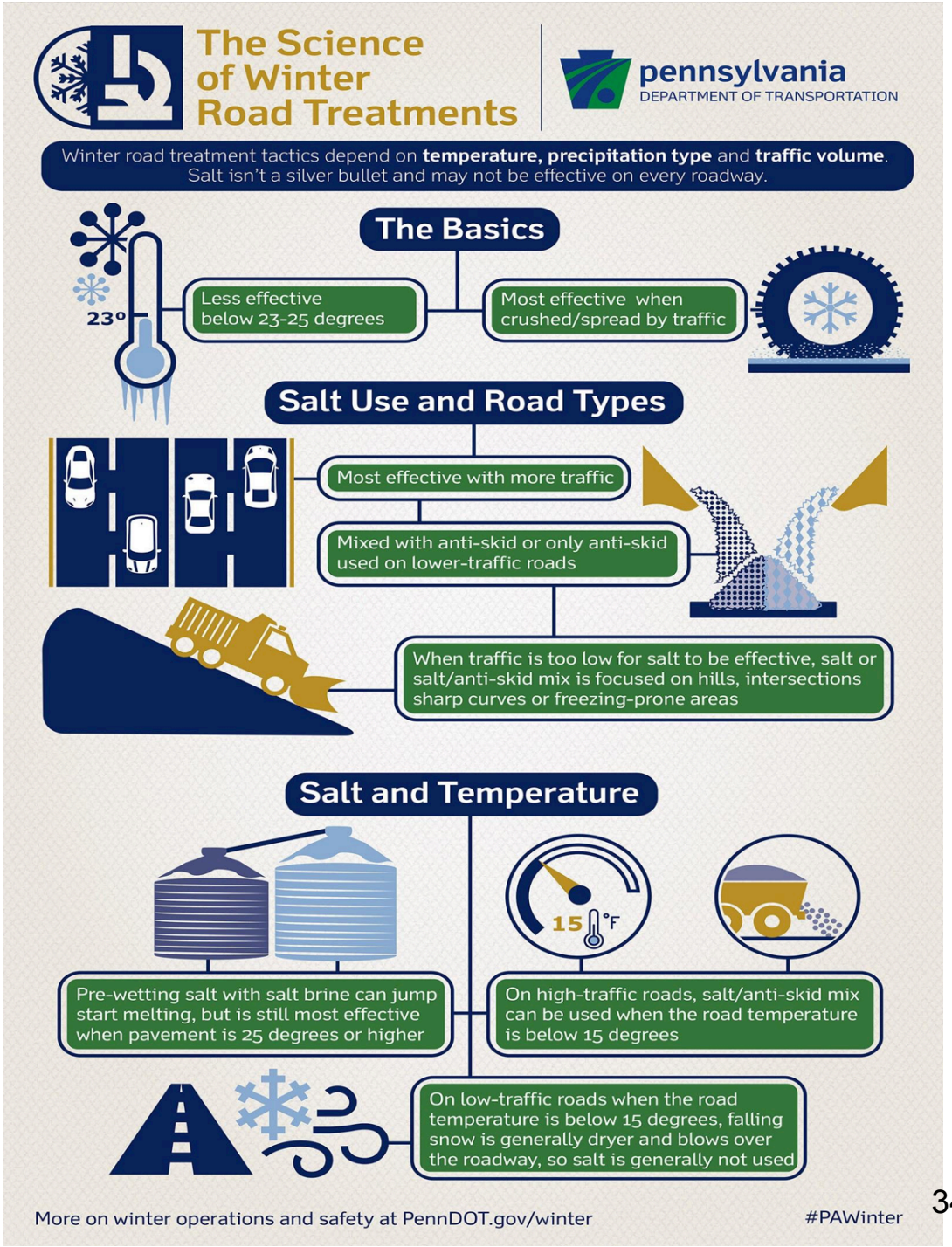
These situations can also increase the amount of chloride and sodium that is present in drinking water, which could potentially impact human health if the concentrated amounts become too high. Water containing high levels of sodium is especially concerning for individuals who need to maintain low-sodium intake.

Benefits of Using Anti-Skid over Salt

As discussed, road salt has many negative environmental effects. Sodium and chloride have the potential to pollute neighboring water bodies and vegetation. Salt is especially a concern in Bath due to its close proximity to Monocacy Creek. Anti-skid, however, could be used in combination with road salt to mitigate some environmental impacts. A **50/50 ratio of anti-skid to salt** could be used; salt, although potentially harmful to the environment, does play a significant role as antifreeze during the winter. Studies have shown the using salt in combination with anti-skid has no decreased effectiveness in protecting roads from winter weather. PennDot promotes using the combination. Furthermore, Bath can protect its surrounding environment while reusing street sweeping waste as antiskid.

PennDOT's Road Treatment Recommendations

This graphic summarizes some of PennDOT's recommendations for road treatment in the winter. Note that a mixture of salt and anti-skid is most effective on low traffic roads and at temperatures below 15 degrees.



http://www.penndot.gov/TravelInPA/

PennDOT's Road Treatment Recommendations

Salt is most effective on high-traffic roads when there are many cars to crush and spread it. It is also most effective when temperatures are above 25 degrees. On lower traffic rural roads, it is more effective to use a combination of salt and anti-skid in order to help treat the roads. Salt is useful in helping melt the ice while anti-skid is useful for adding traction to the roads. Even on high traffic roads, in very cold conditions, salt becomes less effective when used alone, so it is used in combination with anti-skid to create the safest conditions. PennDOT recommends a **75/25 anti-skid/salt ratio when applied at 270 pounds per snow lane mile** and a **50/50 ratio when applied at 200 pounds per snow lane mile.** Thus, Bath can increase its overall effectiveness of road treatment by using salt in combination with anti-skid.

Summary of Anti-Skid & Fill

Pros

Reduce yearly costs by purchasing less salt

Protect the environment by putting less salt down on the roads

Increase the effectiveness of winter road maintenance by using salt in combination with anti-skid

Potential to generate revenue by selling anti-skid or promoting other boroughs to separate their materials in Bath

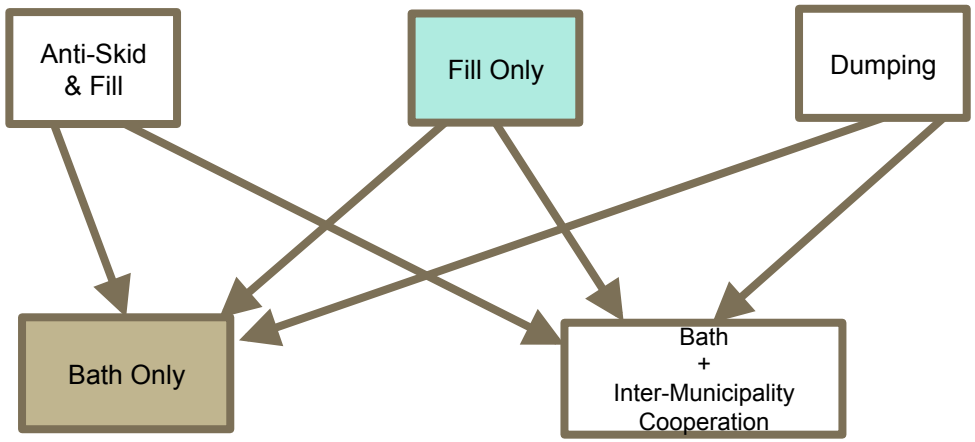
Cons

Cost of purchasing and maintaining a separator to obtain anti-skid

Required purchase of a new salt storage facility

Required designated area to store anti-skid before use

Outline



The following section discusses the final options for Bath working on its own: reusing the street sweeping waste as fill only. We highlight what using the material as road fill entails, including how PA regulates this process. We also analyze the costs and savings that would accompany this option.

Fill Only

- Street waste material can be used as fill in places of erosion, gravel paths and driveways and potholes.
- Fill material does not need to be separated by particle size.
  - Large pieces of trash can be manually removed.
- Fill material can be stored in piles on the public works lot.
  - No covered or cement-based storage unit necessary.
- Environmental regulation is only “visible contamination” which is not expected in street

Description of road material and how recycled fill can be utilized as supplementary material

PA Fill Regulations

Pennsylvania recognizes two types of fill: clean and regulated. **Clean fill** is classified as non-contaminated fill material (soil, rock, stone, degraded material, used asphalt, etc.). **Regulated fill** is fill material that is determined to be contaminated. The initial classification of fill as clean or regulated is determined by environmental due diligence—investigation techniques that include a visual property inspection, review of ownership and use of property, environmental assessments, and analytical testing. If there is no evidence of the release of a hazardous substance, the material is determined to be clean fill and may be used without a permit. If the fill material appears to be contaminated and is tested according to PA standards and found to be non-contaminated clean fill, it may be used as clean fill with a permit certifying that is had passed these tests. If the fill material is tested and found to be contaminated, it is classified as regulated fill and must be managed as waste material. The details of the testing and potentially hazardous substances found are outlined further in Appendix G.

Savings of Using as Fill Only

	Savings per Unit	Units	Total, annual
Alternative to Dumping: No Tipping Fee	$89	120 tons	$10,680
Alternative to Dumping: No Dumpster Fee	$125	4 dumpsters	$500
Reducing Fill Purchases	$9.70-$15.50	120 tons	$1,164-$1,860
Total			**$12,344-$13,040**

As compared to data presented in previous tables, there are no specific costs associated with using street waste for fill only, thus this section has only one table. Potential savings include the savings from not dumping material and savings on the Borough's annual fill costs. A range is presented because costs of fill vary (details in Appendix E) and we expect that Bath can face prices in this range. There may be a market for Bath to sell its excess fill, or an informal agreement between municipalities may be of interest. We expect that the Borough will accumulate 120 tons of street sweepings (Appendix F), all of which may not be needed as fill within the Borough.

Environmental Implications of Fill Only

As discussed, PA regulations required that fill be classified as clean, or non-contaminated, before it can be used. Thus, the environmental impacts of fill will be minimal, as we can be assured that the material being used does not contain a harmful level of contaminants. Once the material has been compacted and added to the roads, its potential to contaminate the environment is further diminished. Using fill is an environmentally friendly option for street waste re-use.

Summary: Fill Only

Pros

No separation technology required

- No initial capital costs
- No covered storage facility needed

Over $12,000 in annual savings predicted

- Eliminate costs to dump
- Cut Borough's spending on fill

There may be demand for excess fill if Bath does not use 120 tons per year

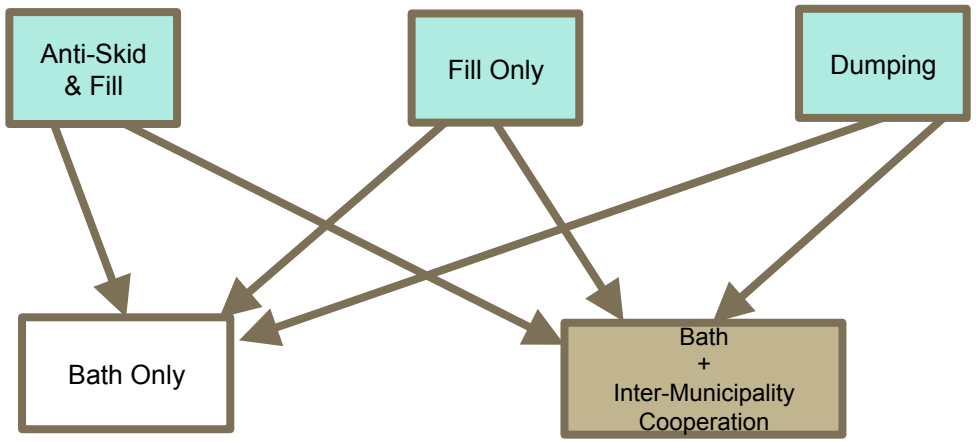
- Potential revenue

Cons

Fill is already relatively inexpensive so neighboring Boroughs may not be interested in reducing their existing contracts for fill material and entering a deal with Bath.

Unused fill may need to be sent to landfill, incurring dumping costs and adding to the environmental costs of overflowing landfills.

Outline



Now that we have outlined all of the options Bath may choose to pursue on its own, we turn to discussing the possibilities that exist for Bath in pursuing inter-municipality cooperation and programs. After highlighting the current practices of other local municipalities, we explain the ways in which Bath could further benefit from using its street sweeper and street waste by involving other municipalities. These potentials include renting out the street sweeper, creating a symbiotic street sweeping relationship, making Bath a waste-separator hub for the area with a new technology, and selling repurposed anti-skid and fill to others.

Inter-Municipality Involvement: Overview

One potential way to make this project **more economically feasible**, either through creating a market for the recycled anti-skid or by obtaining enough material to make it worth recycling, would be to work with other municipalities. Throughout this semester we reached out to 24 municipalities in Northampton County and Lehigh County to see what they were already doing (i.e if they had a street sweeper, what the put down on their roads), as well as to gage their level of interest in this new opportunity.

We also considered using the FRCA (First Regional Compost Authority) to help start this idea because several boroughs and townships already work with this group. However, we found that some boroughs that might be interested in recycling anti-skid were not a part of the FRCA. It thus may be best to start independent of the FRCA and maybe one day work together.

The next page provides a spreadsheet detailing the kind of feedback we received from local municipalities. Five out of the eleven boroughs we contacted use anti-skid which provides us with a solid number of municipalities to reach out to about this new program.

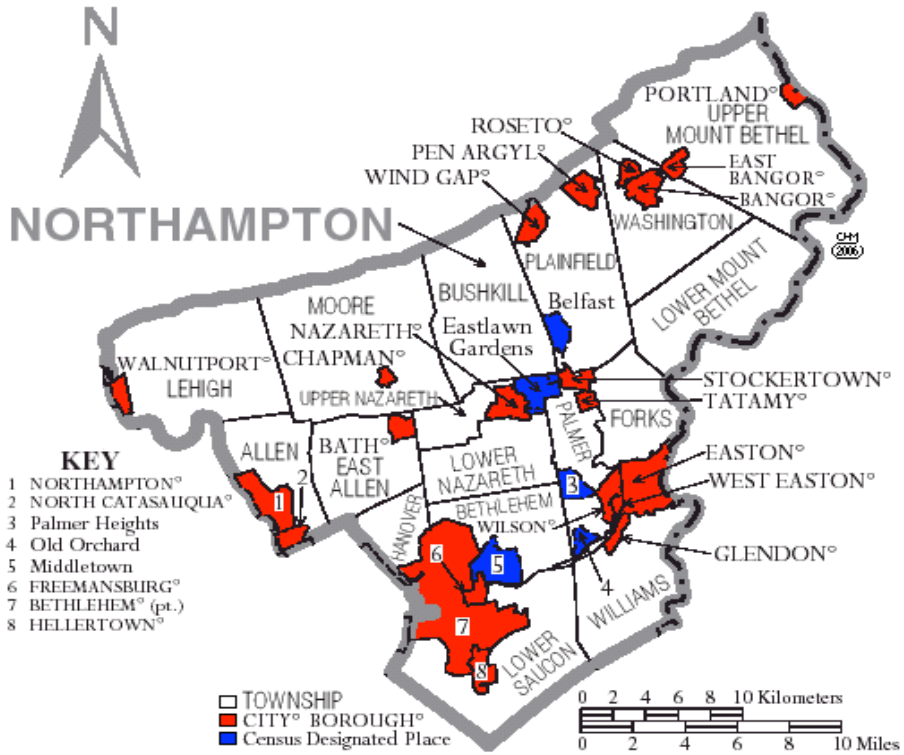
As we discuss inter-municipality cooperation, it is important to keep in mind that as the scale of the operation increases there is a potential for more production (and potential savings) but also an increase in labor costs for operating and overseeing the separation center.

Other Municipalities' Current Practices

Borough	Size of Borough	Street Sweep?	Antiskid?	Tons used per year	Participate in FRCA?	Interest in program?
East Allen	14.4 sq miles	Rent one for special projects	No		Founding Member	No-not a large enough need
City of Bethlehem	19.38 sq miles	4 sweepers for 750 road miles at least 3x/year and some daily	when low on salt/icy conditions			have a compost/ recycling program
Allen Township	11.2 sqmile	Yes-self-share with N. Catasauqua	Yes-salt/fine aggregate		Founding Member	depends on criteria/cost effectiveness
Nazareth	1.7 sq miles	Yes-self	anti skid down with a salt mix approx 2 to 1 type 2 anti skid		No	
Pen Argyl	1.4 miles	yes- contract out	no		no	yes
Plainfield	24.7	yes- contract out, once a year looking to increase	anti skid down, PennDOT type one and two in a 50/50 mix with road salt		no	yes
palmer	10.7 miles	yes- own their own	don't use		no but "mutual aid agreements" with other boroughs	no
Moore	38 sq miles	yes-rent once a year for spring cleanup	50/50 type AS3 and salt	800 tons	Yes	
Upper Nazareth	7.99 sq miles	yes-contract out	2Antiskid:1 Salt 1/4inch antiskid clean stone	100 tons		
Upper Mount Bethel		"Brush" it off to side of road				
Bangor		Contracts out to Martin				

Option 1: Charge Municipalities to use Bath's street sweeper

- Municipalities such as East Allen, Pen Argyl, Upper Nazareth, Moore, and Plainfield all contract out to a private street sweeping company.
- Increase Bath's revenue by promoting municipalities to rent out Bath's street sweeper instead of a private company.
- Would need to invest in a way to transport street sweeper across municipal lines, or could drive it over.



https://upload.wikimedia.org/wikipedia/commons/thumb/c/ca/Map_of_Northampton_County_Pennsylvania_With_Municipal_and_Township_Labels.png/275px-Map_of_Northampton_County_Pennsylvania_With_Municipal_and_Township_Labels.png

Option 2: Street Sweeping Symbiotic Relationship

- Similar to the “Good Neighbor” relationship already established with Upper Nazareth, allow neighboring partners to use street sweeper in return for another needed service.
  - Example: Contracting out leaf pickup
- This would save money from having to contract out one-time services from private companies and encourage inter-municipality cooperation.

Option 3: Make Bath a Separator Hub

- Separating can save money by providing the means to create recycled and reusable products such as anti-skid or multi-purpose fill.

- The recyclable street sweeping waste industry is new and innovative, and this could be an exciting opportunity for Bath.

- Bath's separating technology would be available for other municipalities in the Lehigh Valley and could provide revenue for Bath. Charging a fee would also help allocate the use of this scarce resource.

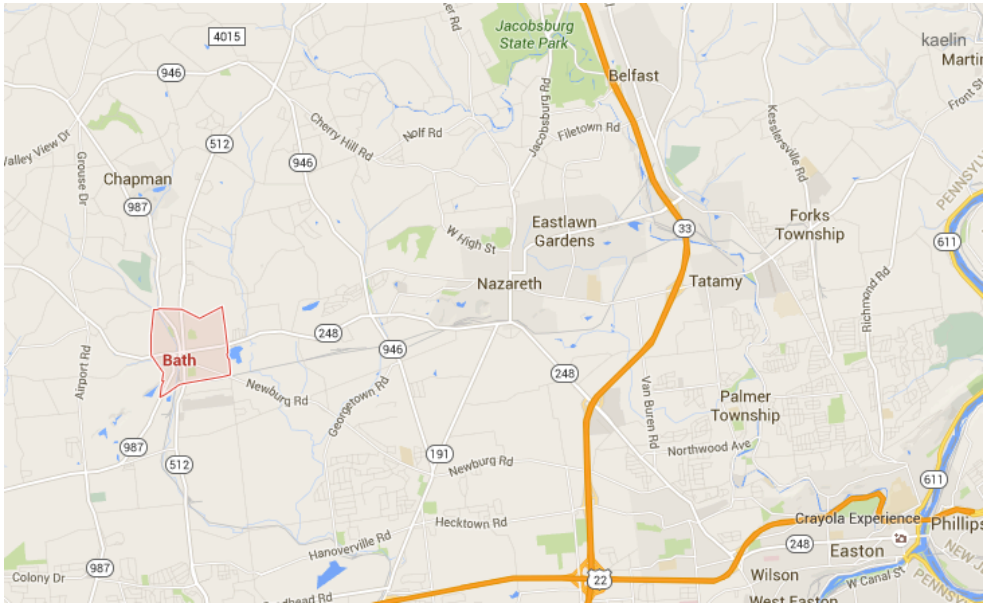
Why would Bath be a good Separator Hub?

- Bath's **central location** puts it in a good position to be an established destination for other boroughs and municipalities to bring their waste.

- Bath is also located **close to several major roads** in PA, which would allow those bringing materials to have easy access to Bath's facilities.

- Bath already has a **good relationship** with several surrounding boroughs who may take interest in this opportunity to reuse their street waste and be willing to support Bath's new project.

- Given Bath's **insights** into the benefits of reusing street waste, Bath can promote this to other municipalities and encourage this separation as being both more economically and environmentally beneficial to others. This will further encourage other municipalities to bring their waste to Bath, even if there is a separation fee, they can still reduce their overall costs.



Option 4: Sell anti-skid or fill to others

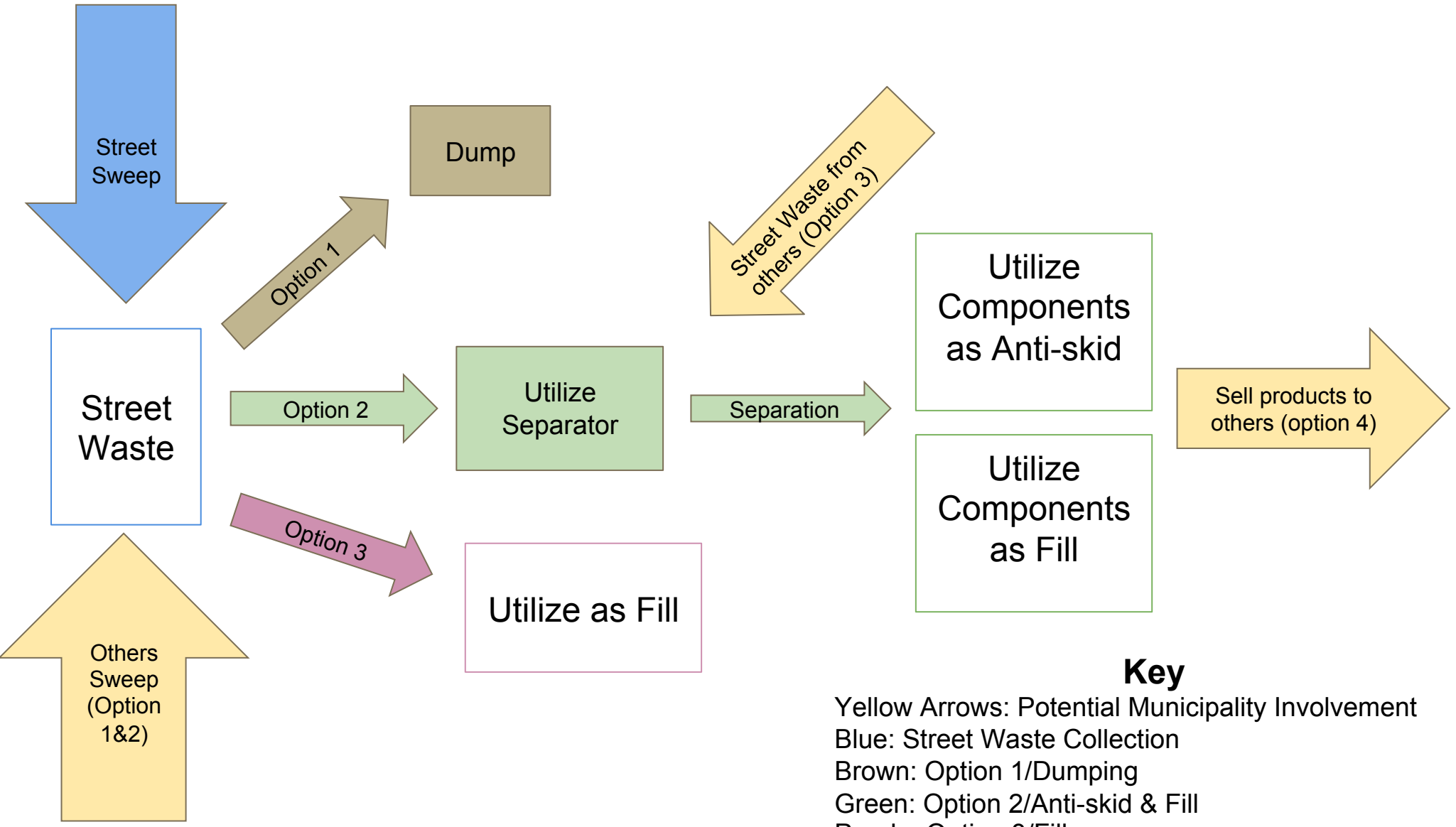
- Instead of encouraging other municipalities to recycle and separate their own waste, Bath could separate its waste and then sell the refined anti-skid and fill product.
  - Better for the environment and there is the opportunity to save money by not having to purchase as much salt!

- Currently we have tested for anti-skid and fill capabilities, but depending on future tests, there could be a potential for repurposed mulch from organic matter.

Outline

This section of the report summarizes the different possibilities for Bath, as well as the costs and benefits of each option using on the cost/savings data presented in previous sections of the report. We also discuss the environmental impact of each of these options.

End summary flow sheet of ALL options



Key

Yellow Arrows: Potential Municipality Involvement
Blue: Street Waste Collection
Brown: Option 1/Dumping
Green: Option 2/Anti-skid & Fill
Purple: Option 3/Fill

Capital Cost and Conversion to Annual Cost

Costs	Price per unit	Units	Total
Separator	$25,000	1 separator	$25,000, once
Conveyor	$16,000	1 systems	$16,000
Storage Unit	$5,000	1 storage structure	$5,000, once
Total			**$46,000**

Assuming that this $46,000 cost can be paid over seven years at an interest rate of 3.25%, monthly payments would be $613.01. This leads to an annual cost of $7,356.12 for seven years.

(The time period and interest rate were chosen based on the last three loans taken by the Borough.)

Annual Cost

Costs	Price per unit	Units	Total
Annual Installments for Separation Technology	$613.01 per month	12 months	$7,356.12, annually
Annual Costs of Self-Sweeping (From worksheet Appendix D)	Various, in worksheet	Various, in worksheet	$5,943.24, annually
Separator Maintenance	$400 per screen	6 replacement screens per year	$2,400 annually

The annual costs of sweeping the streets (calculated in Appendix D) includes the costs of maintenance, fuel, labor, and additional benefits required for any workers. This is the cost Bath will incur from sweeping regardless of which disposal option is chosen. If the option requiring a separator is used, Bath would incur an additional annual cost of approximately $2,400 from replacing the screens each year and pay $7,356.12 annually for the first seven years if paying off a loan for separation technology.

Annual Savings

Savings (annual)	Savings per unit	Units	Total
Alternative to Dumping: Tipping Fee	$89 per ton	120 tons	$10,680
Alternative to Dumping: Dumpster	$125	4 dumpsters	$500
Self-Produced Anti-skid	$15.00-$21.95 per ton	60 tons	$900-$1,317
Salt savings	$59 per ton	15 tons	$885
Fill if separate and use half as Anti-Skid	$9.70-$15.50 per ton	60 tons	$582-$930
Fill if only produce fill	$9.70-$15.50 per ton	120 tons	$1,164-$1,860
Total		**Fill only: $12,344-$13,040**	**Anti-skid and Fill: $13,547-$14,312**

If Bath reuses its street sweeping waste either just as fill or for anti-skid and fill it will save over $11,000 a year just by avoiding landfill and dumpsters fees. The additional savings listed above will come from cutting back on fill costs, salt costs and anti-skid costs. This table is built from information presented in the previous pages describing the fill-only and anti-skid and fill options in detail.

Cost-Benefit Overall Analysis Con't.

Option	Continue Dumping	Anti-skid and Fill	Fill Only
Installment Payments for capital	$0	$7,356.12 Annually for seven years	$0
Other Annual Costs	$17,123.24	$8,343.24	$5,943.24
Annual Savings	$0	$13,547-$14,312	$12,344-$13,040
Annual Net Savings in First Seven Years	-$17,123.24	**-$2,152.36- -$1,387.36**	$6,400.76 - $7,096.76
Annual Net Savings after Seven Years	-$17,123.24	$5,203.76- $5,968.76	$6,400.76 - $7,096.76

If a loan is used to purchase the capital, the borough will spend between $1,387.36 and $2,152.36 additionally year for the first seven years. Given the potential range for savings after the first seven years, it would take Bath another 2 to 3 years to recover this spending and realize the full savings from the Anti-skid and Fill option. If the borough can purchase all the equipment upfront or receive a grant, then the savings (the final cell in the middle column) will be realized immediately. The fill-only option results in the highest annual savings but that is only if Bath would actually use 120 tons of fill in town each year.

Environmental Overall Analysis of Options

	Dumping	Anti-skid & salt	Fill only
Analysis	Landfills cause a lot of damage to the environment through contamination and omitting greenhouse gases.	Road salt negatively impacts the local environment. Using a combination of salt and anti-skid will reduce the amount of salt used and help the environment.	In order for material to be used as fill it must qualify as being “clean” and containing no contaminants, therefore the potential for environmental harm is very slight.
Rating			

Outline

This section of the report present ways in which Bath can further embrace its street sweeper and emphasize its importance to the community.

Further Potential

- In an effort to increase community pride and draw further positive attention to the street sweeper's use and benefits, a slogan for the street sweeper contest could be held at local schools.

- In an effort to further educate the borough about the new processes occurring in Bath, science classes in the local schools could integrate a lesson about sifting and testing street waste for contaminants into their curriculum.

Slogan Contest

- Elementary schools in Bath have environmental clubs, which could spearhead this event.
- Students could learn about recycling and separating technologies on Earth Day and then end the event with coming up with a slogan about street sweeping.
- The winning slogan would be painted on the Street Sweeper.
- This would encourage civic engagement among residents, especially the youth, and offer Borough Pride!

Photo from: http://www.city-data.com/picfilesc/picc51493.php

Outline

We now present the conclusions we have drawn from our research and analysis over the past year. We also explain the next steps for Bath in the process towards successfully pursuing one of these options.

Conclusion

- Throughout the semester, Technology Clinic has worked to analyze potential avenues for waste management.
- 3 options were explored for handling the street waste:
  - Option 1: Continue dumping street waste
  - Option 2: Separating street waste to produce both anti-skid and fill
  - Option 3: Utilize street waste as fill only
- Pros/cons for each option were explained on the basis of financial and environmental implications.
- Possibility for inter-municipality involvement in the collection/ recycling of street waste was investigated.
- Brainstormed additional ideas to continue with the improvement of the Bath community and the street sweeping program.

Next Steps for Brad

- Examine the benefits and implications involved with each option listed and decide which will fit Bath's needs the best.
  - Note that members of Tech Clinic will always be available for future discussion in regards to this issue.
- Examine potential avenues for inter-municipality involvement.
  - Go to Nazcog meeting and pitch the idea for a street waste recycling program.
  - Contact municipalities who may be interested in utilizing the street sweeper.
- Contact teachers/leaders in the Bath community who may be interested in involving the street sweeping/recycling program in education.

Outline

Our team would like to take the time to thank all of the people who helped us throughout our time working on this project. We are grateful for their help and support.

Special Thanks

- Brad Flynn, Borough Manager of Bath, PA
- Dave Bizal, EPI Sales
- John Wilson, Geology Dept.
- Lafayette Geology Dept. Custodians
- Bob Reimer, Nazareth Borough
- Dave Tashner, Moore Township
- Shawn Shupe, Upper Nazareth Township
- Frank Russo, CEO, Tellus Underground Technologies
- Deborah Seiple, East Allen Township
- Robert Kirtzhoffer, City of Bethlehem
- Ilene Eckhart, Allen Township
- Professor James Schaffer, Chemical Eng. Dept.
- Herb Johns, Retired LaFarge Cement Scientist
- Harold Pudliner, Borough Manager of Weatherly, PA
- David Due, Upper Mount Bethel Supervisor

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Appendix A: Questions We Asked Municipalities

Do you street sweep? Yourself or do you contract it out?

Do you put down anti-skid? What do you use?

Do you participate in any inter-municipality programs such as the first regional compost authority?

How are these programs set up, what is the degree of borough cooperation?

Would you be interested in a street waste recycling program?

Appendix B: Interview with Dave Tashner about Moore Township's Street Sweeping, Anti-Skid Use, and Street Waste Re-Use

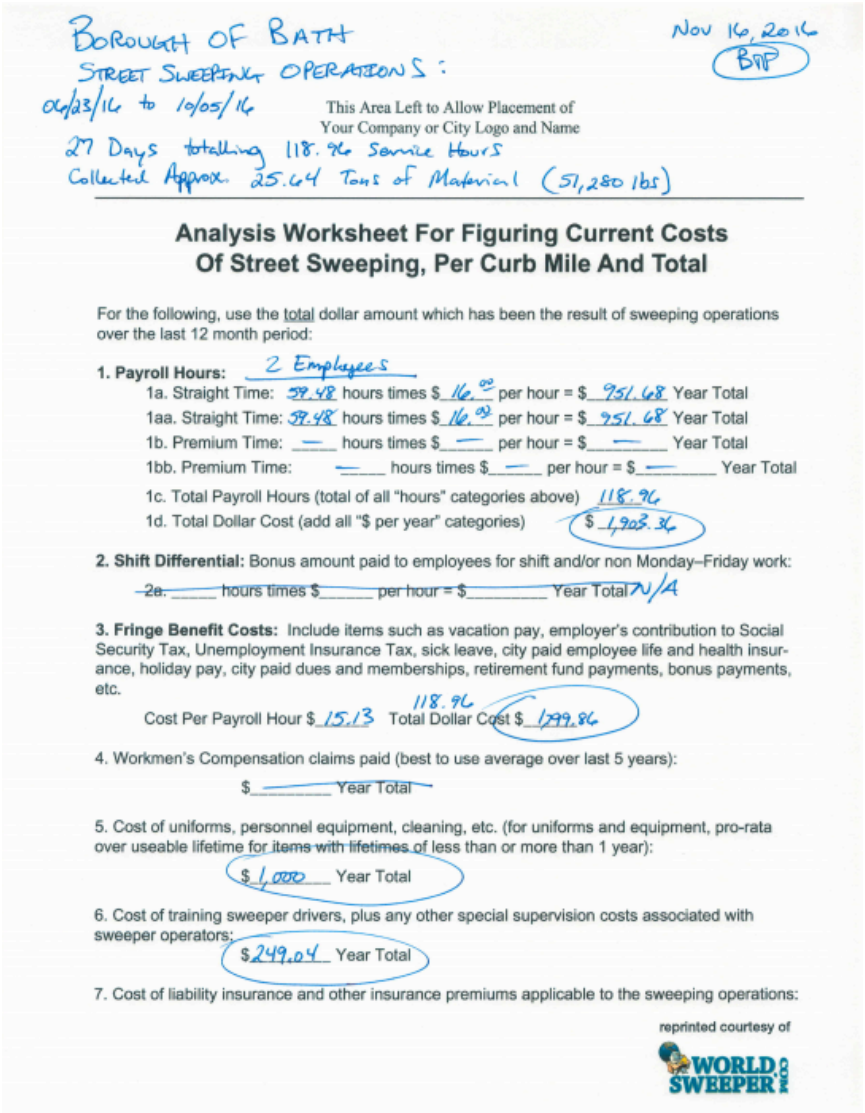
- Do you street sweep?-1 spring cleanup based on how many winter events there are-street sweeping is contracted out
  - If less than 4 winter events they let the cars move the material to the shoulder
- Do you use antiskid?-50/50 mix between type AS3 (from eastern industries) and salt
- Inter-municipality cooperation?-organization of public works directors-Bob Reimer of Nazareth heads it-use this forum to share assets.
- Member of the FRCA-a branch of it is located in Moore Township
- **They use their left over street-waste to build a perimeter trail around their recreation park** and give some to the fire company for their parking lot
  - 1 bucket of the anti-skid they pick up from the street
  - 1 bucket of 1b size tar/chip (street millings he called it)
  - 2 buckets of fines (crusher sand)
  - mix this to blend for trails
  - it comes out looking like 1b modified
  - it is an ADA (American disabilities act) compliant trail
    - can use wheel chairs on it
  - received a county grant to help with it

Appendix C: Mercury Testing

- Testing for toxic mercury requires atomic absorption spectrophotometer.
- This method uses cold-vapor atomic absorption and is based on the absorption of radiation at the 253.7-nm wavelength by mercury vapor.
- The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) is measured as a function of mercury concentration.
- It is not financially viable to test on-site in Bath, thus samples must be sent to a lab for mercury testing.

https://www.epa.gov/sites/production/files/2015-12/documents/7471b.pdf

Appendix D1: Street Sweeping Costs Worksheet



BOROUGH OF BATH
STREET SWEEPING OPERATIONS:
06/23/16 to 10/05/16
27 Days totalling 118.96 Service Hours
Collected Approx. 25.64 Tons of Material (51,280 lbs)

Nov 16, 2016
BPP

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Your Company or City Logo and Name

Analysis Worksheet For Figuring Current Costs Of Street Sweeping, Per Curb Mile And Total

For the following, use the total dollar amount which has been the result of sweeping operations over the last 12 month period:

1. Payroll Hours: 2 Employees

1a. Straight Time: 59.48 hours times $ 16.00 per hour = $ 951.68 Year Total
1aa. Straight Time: 59.48 hours times $ 16.03 per hour = $ 951.68 Year Total
1b. Premium Time: — hours times $ — per hour = $ — Year Total
1bb. Premium Time: — hours times $ — per hour = $ — Year Total
1c. Total Payroll Hours (total of all "hours" categories above) 118.96
1d. Total Dollar Cost (add all "$ per year" categories) $ 1,903.36

2. Shift Differential: Bonus amount paid to employees for shift and/or non Monday–Friday work:

~~2a. _____ hours times $_____ per hour = $_____ Year Total~~ N/A

3. Fringe Benefit Costs: Include items such as vacation pay, employer's contribution to Social Security Tax, Unemployment Insurance Tax, sick leave, city paid employee life and health insurance, holiday pay, city paid dues and memberships, retirement fund payments, bonus payments, etc.

Cost Per Payroll Hour $ 15.13 Total Dollar Cost ($ 118.96) $ 1799.86

4. Workmen's Compensation claims paid (best to use average over last 5 years):

~~$_____ Year Total~~

5. Cost of uniforms, personnel equipment, cleaning, etc. (for uniforms and equipment, pro-rata over useable lifetime for items with lifetimes of less than or more than 1 year):

$ 1,000 Year Total

6. Cost of training sweeper drivers, plus any other special supervision costs associated with sweeper operators:

$ 249.04 Year Total

7. Cost of liability insurance and other insurance premiums applicable to the sweeping operations:

$ 1,291.26 Year Total
- Sweeper Insurance
- 6% Workers Comp Insurance

8. Pro-rata or amortized costs, fuel, maintenance, repairs and parts for the sweeper unit and other related equipment:

$ 689.84 Year Total
- Maintenance
- Fuel
- Inspection Services

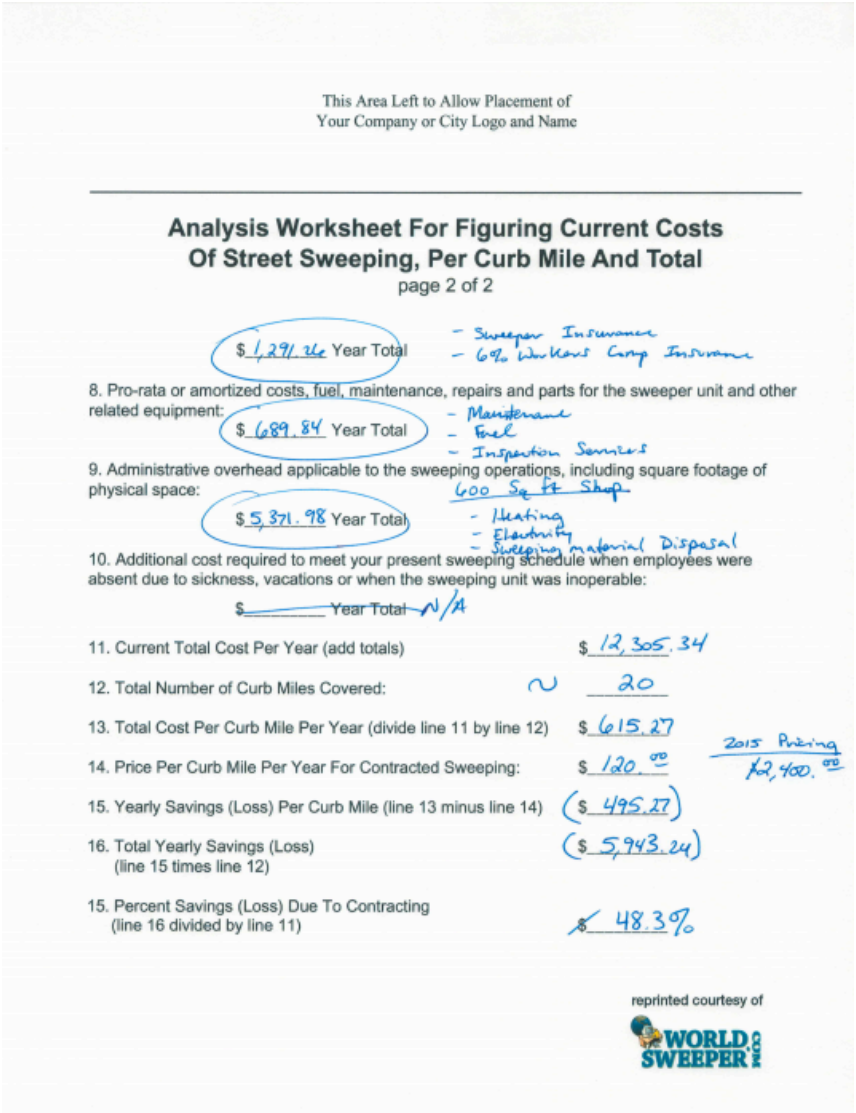
9. Administrative overhead applicable to the sweeping operations, including square footage of physical space:

600 Sq ft Shop
$ 5,371.98 Year Total
- Heating
- Electricity
- Sweeping material Disposal

10. Additional cost required to meet your present sweeping schedule when employees were absent due to sickness, vacations or when the sweeping unit was inoperable:

~~$_____ Year Total~~ N/A

reprinted courtesy of
WORLD SWEEPER INC



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Your Company or City Logo and Name

Analysis Worksheet For Figuring Current Costs Of Street Sweeping, Per Curb Mile And Total

page 2 of 2

11. Current Total Cost Per Year (add totals) $ 12,305.34

12. Total Number of Curb Miles Covered: ~ 20

13. Total Cost Per Curb Mile Per Year (divide line 11 by line 12) $ 615.27

14. Price Per Curb Mile Per Year For Contracted Sweeping: $ 120.00

2015 Pricing ~~$2,400.00~~

15. Yearly Savings (Loss) Per Curb Mile (line 13 minus line 14) ($ 495.27)

16. Total Yearly Savings (Loss) (line 15 times line 12) ($ 5,943.24)

15. Percent Savings (Loss) Due To Contracting (line 16 divided by line 11) ~~$~~ 48.3%

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Appendix D2: Additional Labor Costs

The previous worksheet considers the labor costs Bath faces for street sweeping. The report has assumed that Bath will not incur additional labor costs for also separating the waste as Brad Flynn has observed that sweeping does not take up a significant portion of time for the public works department. It has been assumed that separating the waste would be done during current hours. It is possible that if the separation operation grew to include waste from other boroughs then additional labor hours may be needed to oversee and manage this facility. In that case, it is possible that there will be additional labor costs to consider.

Appendix E: Salt, Anti-Skid and Fill Prices

2015 Aggregate Products Bid Tabulation

Schedule A: Base Pricing for Limestone or Shale Aggregate

		Glenn O. Hawbaker, Inc. - delivery to landfill - Pricing for Limestone only		Glenn O. Hawbaker, Inc. - delivery to transfer station - Pricing for Limestone only		Hanson Aggregates PA LLC		Eastern Industries, Inc. - West (delivery to landfill)		Eastern Industries, Inc. - West (delivery to transfer station)		Pikes Creek Asphalt & Crushed Stone	
Material Name	AASHTO Number	Quarry Price/Ton	Delivered Price	Quarry Price/Ton	Delivered Price	Quarry Price/Ton	Delivered Price	Quarry Price/Ton	Delivered Price	Quarry Price/Ton	Delivered Price	Quarry Price/Ton	Delivered Price
Screenings	#10	-	-	-	-	$7.25	$11.75	$7.95	$12.75	$7.95	$15.35	$8.80	$22.05
2RC Modified		$6.00	$18.37	$6.00	$16.33	$5.40	$9.90	$6.80	$11.60	$6.80	$14.20	$5.25	$18.35
2A Subbase		$6.80	$19.17	$6.80	$17.13	$7.65	$12.15	$7.85	$12.65	$7.85	$15.25	$5.25	$18.35
Anti-Skid (Graduation Size - 6S)		$9.00	$21.37	$9.00	$19.33	$10.50	$15.00	-	-	-	-	$8.75	$21.95
1B Stone	#8	$10.00	$22.37	$10.00	$20.33	$16.00	$20.50	$11.55	$16.35	$11.55	$18.85	$9.15	$22.35
2B Stone*	#57	$9.00	$21.37	$9.00	$19.33	$9.75	$14.25	$9.85	$14.65	$9.85	$17.25	$7.60	$20.85
3A Stone	#3	$8.50	$20.87	$8.50	$18.83	$9.75	$14.25	$9.85	$14.65	$9.85	$17.25	$7.50	$20.85
#2 Stone	#67	$10.00	$22.37	$10.00	$20.33	$10.15	$14.65	$10.90	$15.70	$10.90	$18.30	$8.95	$21.95
#4 Stone	#1	$9.00	$21.37	$9.00	$19.33	$9.75	$14.25	$9.85	$14.65	$9.85	$17.25	$7.95	$21.25
Gabion Stone (Section 625 - Gabions, 7" Max)		$10.00	$22.37	$10.00	$20.33	$12.25	$16.75	$11.25	$16.05	$11.25	$18.65	$10.25	$23.95
Structural Backfill (Clean Dirt)		-	-	-	-	$9.75	$14.25	$6.25	$11.05	$6.25	$13.65	$4.75	$17.60
Quarry Fill (Dirt & Limestone or Shale Mix)		-	-	-	-	$5.75	$10.25	$4.90	$9.70	$4.90	$12.30	$4.50	$17.35
Minimum Load Charge Loads Less Than 20 Tons	Per Ton		$225.00 flat fee				$120.00		$10.00		$10.00		$60.00

*2B Stone = 100% < 1-1/2", 90-100% < 1", 25-60% < 1/2", 0-10% < 4, and 0-5%<#8

NOTICE: Quotes for delivery required before ordering for delivery to sites other than the two primary locations listed in bid document.

http://www.lyco.org/Portals/1/ResourceManagementServices/Documents/WS%202015%20Aggregates%20Products%20Bid%20Tab%202_5_15.pdf

Appendix F: Calculating Tons of Waste Accumulated in Bath

25 tons of waste were collected over the 27 days Bath used its street sweeper this year. That comes to 0.93 tons per day of swept material collected. That number multiplied by 132 actual working days in that six month period Bath plans to sweep their streets, equals an estimated 122.76 tons Bath would have accumulated on the season. From these calculations, the round figure of 120 tons of street waste per year was used for calculations throughout the report.

Calculations and information from Brad Flynn

Appendix G: Testing Fill

- Testing for potentially contaminated fill varies depending on the volume of material
  - Larger volumes of materials require more samples tested
  - Ex: less than 125 cubic yards of material requires ten samples, more than 125 cubic yards of material requires fifteen samples
- PA provides a list of all possible contaminants and the concentration limits for each of these chemicals
  - Available at: http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-103747/258-2182-773.pdf
- Once fill is characterized as regulated fill a General Permit must be obtained before it can be used

Appendix H: Alternative Sweco Technology

	Cost per Unit	Units	Total
Separator	$25,000	1 separator	$25,000
Conveyor technology	*$21,000*	1 conveyor	*$21,000*
Storage facility	$5,000	1 storage structure	$5,000
Total			**$51,000**

If the more expensive stainless-steel conveyor is purchased then the total capital cost increases to $51,000 which could be paid off in seven years with monthly payments of **$679.64** at the assumed 3.25% interest rate (bankrate.com). Annual costs for this capital would then be **$8,155.68** for seven years. At the given savings potential, **it would take an additional 3 to 4 years (after the first seven years) for the borough to realize the same savings as the less expensive option**. Recall that using the less expensive option presented in the report would lead to realizing savings in an additional 2 to 3 years. Acquiring a grant or using funds available in the existing budget to purchase the technology upfront would lead to realizing the savings immediately.