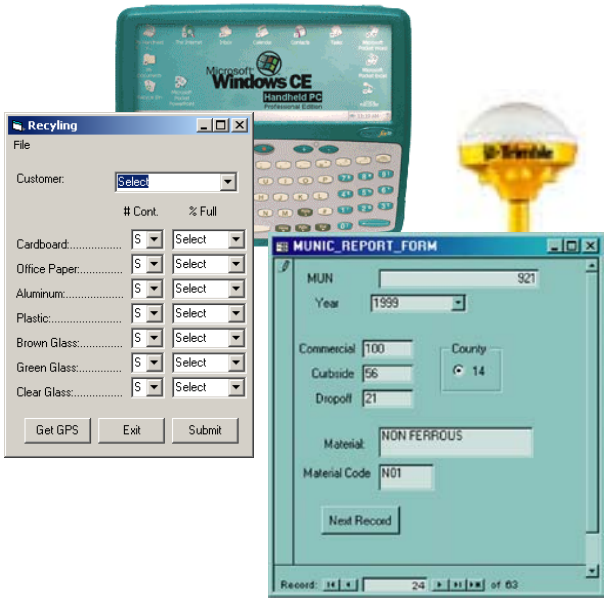
Recycling Feasibility Report – The Integration of Digital Data Capture and Use into Traditional Recycling Collection Programs

Prepared for
Centre County, Pennsylvania
And the
Pennsylvania Department of Environmental Protection



Gannett Fleming

GeoDecisions
A Division of Gannett Fleming

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Recycling Feasibility Report –
The Integration of Digital Data Capture and Use into Traditional Recycling Collection Programs

I. Study Purpose

The opportunity to collect in-field data without adding time or burden to the collection crew exists with the use of current technology. This critical data, which once seemed impossible to ascertain such as exact weights of recycled materials, is possible to acquire with today's technology and will be described in this report in a series of integration scenarios.

These scenarios are differentiated primarily on up-front capital costs for equipment and training but all are designed to achieve or move in the direction of the project goals. The goals were established through a series of interviews with Centre County recycling staff. The staff members described their current collection techniques and operational needs. They provided Gannett Fleming personnel with their 'wish list' for data attributes and management opportunities. From this, a succinct set of goals were established:

II. Needs as Identified by Centre County Recycling

- **Standardization of data entry and reporting:** Currently, the method used to determine the total weight of recycled materials by type in Centre County is to estimate the 'percentage full' estimate of containers and calculate the approximate total weight.

Although this report is intended to describe conditions and opportunities in Centre County, it is recognized that collection techniques vary greatly across the state. This variability ultimately leads to inaccurate estimates of recycled materials and inefficient time spent in possessing the results.

The differences in collection technique are often a result of fiscal limitations of various operations but in many cases the differences can be overcome with a set of guidelines and assistance from more advanced recycling organizations. These guidelines would take the variable Borough, County, State and Federal reporting needs into account and would be designed to be Web based and available to private haulers and commercial reporting centers alike.

The 'standardized' data entry forms and connected report forms and functions could eventually become part of local ordinances where zoning exists. Web based

programs for assistance in standard and easy-to-use commercial forms could make the response rate increase and the quality improve for commercial contributions.

The easier it is for commercial and private haulers to record data, the more accurate this data will be and the more likely they will make their reports. This will also result in less time spent 'chasing' these numbers by reporting organizations. The identification of violations of education needs will be enhanced through reporting techniques that use current data and web based technology.

Needs and Goals:

- **Provide the opportunity to make the field data more accurate**: Similar to standardization, accuracy in field data collection is often limited to fiscal ability to purchase equipment necessary to provide accurate results. Whether measurements are made at the curb-side or drop-off site, the total reported tonnage by recycled type needs more accurately established. Having the ability to measure the accurate weight at the collection would provide more opportunity for identifying regional trends and educational opportunities.

- **Provide a simple data-capturing tool that does not add significant additional collection time**: Electronic data collection is nothing new to the recycling world. There are many devices currently being used that achieve some level of standardization and accuracy requirements but are found to be too cumbersome for the field crew to use either because (1) their high sophistication level needed to operate, or (2) because they add considerable time to each stop, or (3) the device is not robust enough for field conditions, or (4) some combination of the above. The data capture tools researched for this feasibility report should be ones that are both easy to use by operators and collection staff and add little to no additional time at each collection point.

- **Be scaleable to suit the financial capacity of a collector:** The scenarios described in this report are designed to be scaleable. The intent is that each will achieve some advance in standardization and accuracy and can be built upon one-another over time when the opportunity for advancement exists.

- **Capture data that can be used to more efficiently manage resources such as staff, routing, and educational opportunities.** The most important needs as identified in this study are standardization and accuracy but the opportunity also exists for management functions as well. The type of data that can be collected and the ability to analyze this information can allow managers to better analyze collection routes, track employees, and respond to educational needs.

If drop-off bins are consistently being misused or vandalized, the limited dollars available for education efforts can be better spent in directing the materials to those residents and businesses in that area. Centre County, like many counties in Pennsylvania, has extensive Geographic Information System databases including

digital tax parcels with associated assessment information. The x/y coordinates of recycling drop-off containers can be used as a 'buffer' point to develop mailing lists from tax parcels attributes.

The attributes that are associated with the advanced scenarios are geospatial in nature and can be mapped in the collection region for more sophisticated routing networks in GIS as well.

- **Provide the opportunity to make the associated database compatible with Excel and Microsoft Access.** Mainstream databases are essential. For any improvement in data collection to be successful, it needs to be recognized that current programs at the local and state level already use Microsoft Access and Excel spreadsheets and functions. Development of any unique program in non-standard software would only prohibit the potential use and deployment of standardization and accuracy tools.

Any potential program that is developed from this feasibility study must be done in a 'mainstream' programming language and it must be updateable. Any unique code that is written will be one in a mainstream language such as Visual Basic or other open formats.

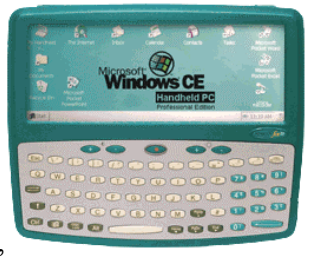
Other specific needs as identified during the interview process include the following:

1. There needs to be the ability to send a standardized report to a specific customer. (educational/ violation notices) .
2. The ability to maintain the number (count) of violations is needed by drop-off bin and/or container.
3. The ability to record the 'data collection area' is needed as well as the route number and recorder.
4. Trash collection in a Borough would have different parameter settings than recycling collection in the County, therefore default values for weight would be needed assist specific municipalities.
5. A standardized report for the Health Department must be made available.
6. If barcodes are to be used for collection, they must be categorized by (a) roll-offs, (2) 90 gallon containers, (3) 60 gallon containers (4) other.
7. Private haulers need to be encouraged to use the potential new data collection program by rebates or ordinances.
8. The violations reporting function must include at a minimum: (1) report by type, (2) municipality, (3) hauler, (4) occurrence, (5) frequency, and (6) total number of violations.
9. Enforcement Officers also need area in the program to add to record (with GPS) and retrieve data on illegal dumpsites.
10. Benefits for proper recording must be stressed to the haulers so that there is a win/ win situation with the recycling commission and the hauling outfits.

III. Scenarios for Implementation of Digital Data Collection and Management

Scenario One

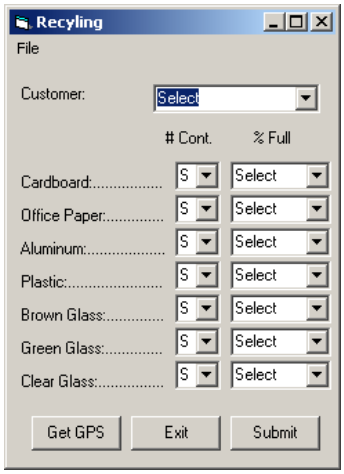
The most simple and potentially least expensive for implementation would have a data collection screen on a small and easy to operate computer. This scenario would not include measuring equipment such as truck scales, but rather would code the 'percentage full' entry by material type similar to the manual methods done currently. Through a pull down menu the field crew would be able to choose the current 'stop', and upon entering the 'percentage full' number, the internal computer clock would record the time, thus allowing the automatically managers to track location in conjunction with time of day.



A durable device such as the Husky, for example would allow the field crew to enter site-specific data quickly and assist with standardization across the collection area. This device itself would not necessarily improve the accuracy of weight determination of recycled materials itself but sets the format with simple data entry screens and attribute field identification needed to move to more advanced levels of data collection of the opportunity presented itself in the future.

All scenarios described in this feasibility report involve the use of barcodes and scanners. Initially, these codes can be attached to drop-off and commercial bins only. These barcodes would be associated with each business or collection region and would be scanned at the time of collection to populate an individual customer database.

This Graphical User Interface(GUI) is designed to allow truck drivers to input the information for location and materials for every stop they make.
A small handheld unit will be used for the data entry.



This table represents an example of the daily downloaded summary report available for each driver.

Driver 103 - 1/2/2001

Date	News	Mixed Office	Clear Glass	Green Glass	Brown Glass	Metal Can
5:34:12 PM	0	0	100	150	100	
5:37:52 PM	0	0	0	0	50	
5:38:01 PM	50	0	0	0	0	
5:39:01 PM	0	0	100	100	100	
5:41:01 PM	0	0	0	0	0	
5:46:01 PM	0	0	0	0	50	
5:50:01 PM	100	100	50	0	0	
5:52:01 PM	0	350	0	0	0	
5:59:01 PM	0	75	0	0	0	
6:06:01 PM	0	0	0	0	0	
6:09:01 PM	0	0	200	300	400	
6:18:01 PM	0	100	50	0	0	
6:22:01 PM	0	50	0	0	0	
6:28:01 PM	0	0	0	0	0	
6:38:01 PM	0	50	0	0	0	
6:45:01 PM	0	0	0	0	50	
6:52:01 PM	0	0	0	50	0	
6:59:01 PM	0	0	100	0	0	
7:22:01 PM	50	0	0	0	0	
7:29:01 PM	0	0	0	0	0	

Number of Stops: 11 **Average Length per Stop:** 3.4 min.

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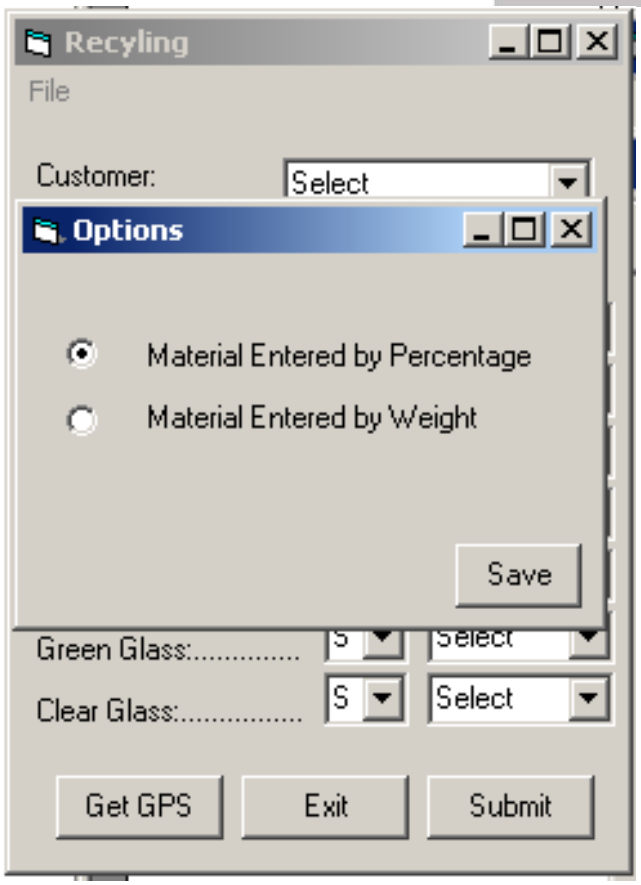
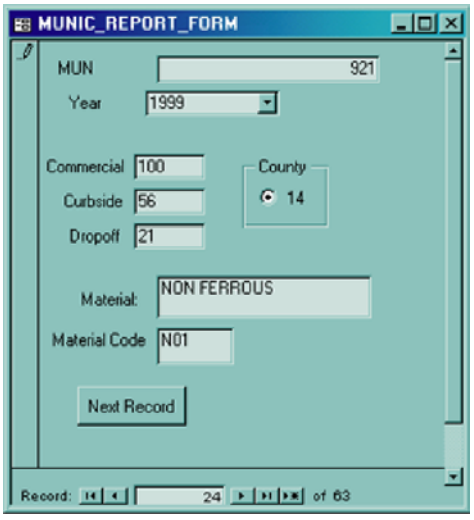


This graphic represents the ability to upgrade to higher accuracy use of on-board scales through the same on-board program simply by changing the collection option .



This graphic demonstrates an example of the municipal data entry screen for use by the recycling center staff for summary report generation.

Scenario Two

A second alternative with a higher implementation cost would include all features described in Scenario 1 plus the capture of weight per container with on-board scales. The total trip weight would be verified with weigh-ins at the trip's conclusion. Scenario two could also include other fields for data entry such as the condition of the material (i.e. wet cardboard, contaminated material, vandalism).

Scales may be cost prohibitive for some municipalities and especially private haulers. There is however, no better way to manage information about a customer's recycled goods than to have accurate weight information that would be provided by on-board scales. The scales would be integrated electronically with the program so that readings would be inputted based on location with very minimal driver downtime. Providing incentives and funding support for the purchase of scales should be encouraged at the state and local levels.

Information on the quantity of recycled materials is almost as important as the materials themselves. Without the details that scale provide on the true measurement of recycled goods, the action of recycling itself will remain an 'optional' activity by many commercial business and residents alike.

Scenario Three

The third option is similar to the second scenario but would also include the use of a GPS receiver, mounted in the truck, which could provide pick up point locations, time, and other data such as collection speed. The data could be transmitted to the office via a real time wireless connection or through an upload with the other collection data at the end of the route. Using real time information, office personnel can monitor progress, reroute collection trucks, and collect additional field data.

Certainly the use of GPS (Global Positioning Systems) can add benefit without the use of a wireless, real time connection. Affordable GPS receivers can be mounted on each collection truck for acquiring the exact coordinate of recycling containers. This information is important for local use, but also can be forwarded to national organizations that post data on web sites designed to permit citizens to access the location of drop-off containers in their area. Any time a recycling bin is moved, the location and time of removal would be updated.

Better management opportunities increase with the use of GPS. Enforcement officers would gain the ability to precisely identify locations of illegal dumps with mobile GPS units. The recycling center can redirect trucks if necessary and/or determine the efficiency of collection routes and staff.

The collection routes themselves can be better assessed with GIS/GPS tools and maps can be generated to assist new drivers. GIS also provides the collection center a better tool for assessing collection rates by geographic area. Rapidly developing communities can be added to the collection system easily. A cooperative agreement between the recycling center and the county level GIS department would permit these determinations to be made without incurring the additional expense of maintaining the tax parcel database themselves.

An example of one GPS receiver that offers the collection parameters and accuracy requirements describe above is the Trimble CrossCheck AMPS. This unit can log up to 4000 records and provides 5-8 meter non-differential correction accuracy.

IV. Databases: Attributes currently collected vs. ones needed to support each scenario.

In order to fully explain the integration of existing and 'potential' data attributes and information available through the use of today's technology, Gannett Fleming has prepared mock tables in Microsoft Access. These tables not only list the additional data fields available with the use of advanced technology collection tools but also display the

interrelationship of this information. This interrelationship will result in more efficient management of data.

Below is a summary list of data already being collected by Centre County Recycling in Microsoft Access format and attribute information added to the collection database (marked in Italic) from the use of digital technology:

Data Collection Tables :

Commercial – Daily updated table of Commercial site collection. Includes the date, location code, ID, and each total for recycled materials
Commercial Route – Names of pickup locations with Code #s, address, and day of pickup.
Comm99 – Totals for the year (i.e. 1999) from the Commercial table.
MUNIC_REPORT_FORM – Yearly updated form to report totals of different types of material
tbl_103_1-2-01 – Example of a daily table that each driver would have automatically filled out during the day. Information includes date (with time of day), location code, driver ID, and each material entered by % full or scaled weight.
tbl_dvr_103 – A cumulative table for individual drivers that is updated daily for each driver. This table is fed into the cumulative Collection table that is currently used. The driver ID is sent to the Collection table.
tbl_drivers – A table of all currently working drivers including driver ID, name, address, telephone, etc…
tbl_errors – A coded list of possible collection problems such as mixed recyclables, trash in recyclable bins, etc…

Queries:

Muni Query – Selection of codes from location that are located in by municipality.
Daily Commercial Totals – Query for selecting out daily records from Commercial table.
Drop Off – Not Functional
qry_Penn_State – Selects out Penn State coded locations based on time periods
qry_Driver_Time – Linked to a report to show the time that a driver spent in the field.
qry_Weight_Calcs – A query that determines the actual weight from percentage weight based on a constant for each particular recycled material. (Not used if scale option is selected.)

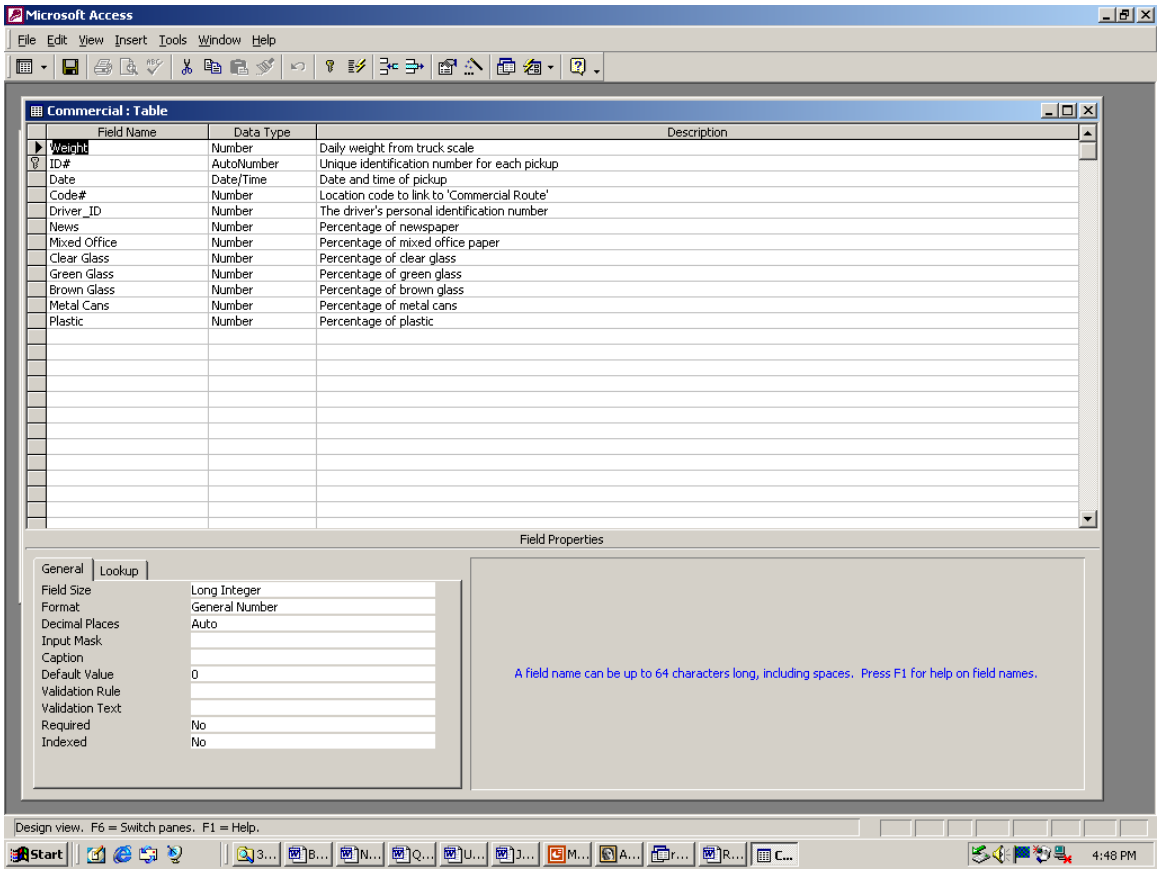
Reports:

Bellefonte – Results of Bellefonte query in report format based on date
Commercial – Selects Commercial table data based on date
Construction – construction activities

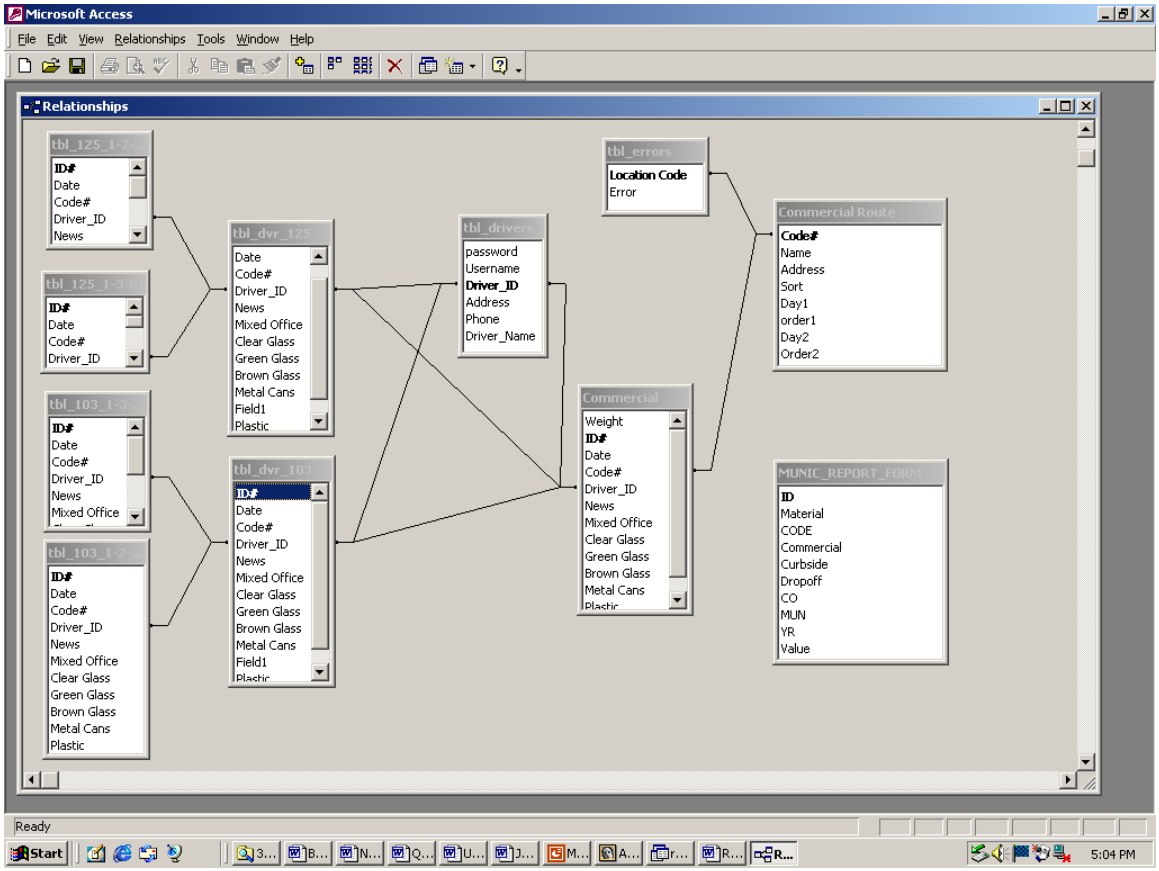
Forms:

Commercial – Form used by Dawn to enter the daily totals brought in by the drivers. Includes each item from the Commercial table (Date, location code, ID, and each of the totals for recycled material.)
Curbside – Not Functional
Recycling – Not Functional

The example Microsoft Access database below shows some of the attribute fields and definitions used in the program written to display the data entry screens in the collection trucks.



The relationship between various proposed tables in Microsoft Access is displayed below:



Each municipality that is required to submit data on recycled materials would do so through standardized data forms. Each form would be electronically captured where possible through a database similar to the one shown below already in use :

ID	Material	CODE	Commercial	Curbside	Dropoff	CO	MUN
1	ANTIFREEZE	O02	254	20	36	14	920
2	AUTO PARTS: CATALYTIC CONVERTERS, RADIATORS	V01				14	
3	BATTERY: LEAD-ACID	B01				14	
4	BATTERY: NICKEL & CADMIUM	B02				14	
5	CLOTHING/TEXTILES	M03				14	
6	CONSTRUCTION: CONCRETE, WOOD, CINDER BLOCKS, ASPHALT	M02				14	
7	FOOD WASTE	FW1				14	

ID	Material	CODE	Commercial	Curbside	Dropoff	CO	MUN
8	FURNITURE & FURNISHINGS	M04				14	
9	GLASS: CLEAR	GL1				14	
10	GLASS: GREEN	GL3				14	
11	GLASS: BROWN	GL4				14	
12	GLASS: PLATE	GL5				14	
13	GLASS: MIXED	GL2				14	
14	GLASS: OTHER	GL6				14	
15	ALUMINUM CANS	AA1				14	
16	ALUMINUM SCRAP	AA2				14	
17	BRASS	N03				14	
18	COPPER	N02				14	
19	DRUM FIBER	DR3				14	
20	DRUM STEEL	DR2				14	
21	FERROUS	F01				14	
22	LEAD	N04				14	
23	NICKEL	N10				14	
24	NON FERROUS	N01	100	56	21	14	921
25	STAINLESS STEEL	N05				14	
26	STEEL & BIMETALLIC (TIN) CANS	F02				14	
27	WHITE GOODS	F03				14	
28	MIXED METALS	MM1				14	
29	PAPER: BROWN BAGS & SACKS	C02				14	
30	PAPER: CARDBOARD	C01				14	
31	PAPER: COMPUTER	PA5				14	
32	PAPER: MAGAZINE	PA1				14	
33	PAPER: NEWSPRINT	PA2				14	

ID	Material	CODE	Commercial	Curbside	Dropoff	CO	MUN
34	PAPER: OFFICE PAPER	PA4				14	
35	PAPER: PHONE BOOKS	PA6				14	
36	PAPER: MIX	PA3				14	
37	DRUM PLASTIC	DR1				14	
38	PLASTIC: FILM	PL8				14	
39	PLASTIC: HDPE	PL2				14	
40	PLASTIC: LPDE (LOW DENSITY POLYETHYLENE)	PL4				14	
41	PLASTIC: PET	PL1				14	
42	PLASTIC: PP (POLYPROPLENE)	PL5				14	
43	PLASTIC: PS (POLYSTYRENE)	PL6				14	
44	PLASTIC: PVC (POLYVINYL/CHLORIDE)	PL3				14	
45	PLASTIC: MIXED	PL7				14	
46	PLASTIC: OTHER	PL9				14	
47	RUBBER TIRES	M01				14	
48	USED OIL	OL2				14	
49	WIRE/CABLE	W01				14	
50	WOOD WASTE	WW1				14	
51	YARD WASTE	Y03				14	
52	HOUSEHOLD HAZARDOUS WASTE	HHW				14	
53	OIL FILTERS	OL3				14	
54	FLUORESCENT TUBES	FL1				14	
55	MATTRESSES	MT1				14	
56	CONSUMER ELECTRONICS	CRT				14	
57	CIRCUIT BOARDS	CB1				14	
58	COMMINGLED MATERIALS	XXX				14	
59		MIS				14	

ID	Material	CODE	Commercial	Curbside	Dropoff	CO	MUN
60		MIS				14	
61	*NON-INDUSTRIAL COMMERCIAL (ONLY)					14	
62							
63							102

IV. Hardware and Software Requirements:

In order to make data collection easy to do and cost effective, simple and easy to use hardware and software are essential. All 3 scenarios take into account both a field data collection part and an office maintenance part.

Field data collection hardware varies in all almost all aspects or size, durability and cost. For our examples we used the Husky Ruggedized Handheld PC. This unit operates on Microsoft Windows CE and has 64MB of flash memory, which can be increased to 256MB of memory. Being a ruggedized unit, it is both water and shock resistant, making it perfect for data collection. Attached to the unit via a COM port is a digital bar code scanner. This scanner has a 4-foot cord attached making it easy for users to scan containers for input. This unit is an overall good middle ground for cost, durability and ease of use.

The data collection software used on the unit was custom written using Microsoft Visual Basic. This software requires Microsoft Windows, Windows CE, or Pocket PC to operate. This limitation shouldn't limit the choice of hardware on which it will reside, since most hand held hardware runs on one of the Microsoft Operating Systems. User interaction can be through a mouse, keyboard, stylus, or peripheral device.

For Scenario 2, other than purchasing on board scales, and making minor adjustments to the software application, no new hardware or software would be needed.

For Scenario 3, a GPS unit would be required. Two options are available for this scenario. A vehicle-mounted device would be more costly, but would provide better coordinates in urban areas, allow for the use of Automated Vehicle Location and in transit visibility, and would be more secure. The second option would be to use a hand-held GPS unit that could be attached to the hand-held collection unit, integrating on the fly the GPS coordinates with the data behind the application. Either option is viable, depending on the cost benefit solution of the agency.

The in office application will be centered on Microsoft Access. The County currently uses Access to store their data and to produce reports, so transition to

another application won't be necessary. An interface will be developed that will allow drivers to attach there hand held units to a desktop machine and synchronize there data on a daily basis. A Pentium II 233 PC running Windows 98 or better will be required to run Microsoft Access 2000.

V. Costs for Implementation:

Generalized costs for equipment by scenario are as follows: (Costs described below are for comparison purposes only. Total costs for implementation may vary).

All Scenarios:

Hardware
(1) Husky Ruggedized Hand-Held PC - $800 each
(1) Bar Code Scanner - $75 each

Software
Customized data collection application - $10,000

Scenario 2 specific items:

Hardware
On-board Scales – total costs are variable depending on the existing vehicle equipment.

Scenario 3 specific items:

Hardware
(1) Vehicle mounted GPS unit - $1500 each
(2) Hand-held GPS unit - $500

VI. Final Assessment – where to we go from here?

The benefits from utilizing technology in the collection of recycled materials are many. Above all, the standardization opportunities of collected data at the local, county and state level is paramount for the state's program for continued public and governmental support.

Implementation of any scenario described above will require capital and multi-organizational cooperation. Capital for initial purchases may come from Section 901, 902 and 904 state level grants. A more complete needs assessment of local, state and

national reporting requirements and limitations would be necessary for a state-wide adoption of standardized recycling techniques using advanced technology.

The data collection attributes described in this report however, are essential to any and all programs that may be adopted in the future. All attempts to initiate collection of materials by more accurate and efficient techniques is recommended for immediate funding and support at all levels of government.

The final recommendation as determined through this feasibility document is to move forward with acquisition of the hardware and software that will support standardization and accurate information on recycled materials. It is also recommend that round-table discussions for state-wide standardization continue and establishment of strategic goals that can be implemented for all recycled materials in Pennsylvania.