Baltimore Routine Services Operational Review

Route Optimization Solution for the City of Baltimore, Department of Public Works, Bureau of Solid Waste

City of Baltimore, MD

January 6, 2022

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Executive Summary

The recent pandemic continues to critically impact the Baltimore's Department of Public Works ("DPW") and the waste collection industry overall. DPW staff remain on the front lines ensuring trash and recycling are safely and correctly disposed of to protect the public health of the city.

In summer 2009, The One Plus One program started and the City implemented one trash day and one recycling day. When DPW first began its recycling program, we distributed 41,000 yellow bins to residents who purchased them. Residents either disposed of recycling in their own containers or they paid a small fee to purchase recycling carts to participate. Due to the pandemic, DPW suspended recycling in Spring 2020 to focus personnel and fleet resources on routine trash removal. DPW returned the program to full operations in January 2021, but service levels remained inconsistent.

In September 2021, DPW expanded recycling through a free, citywide recycling carts distribution. Now, for the first time, every resident in Baltimore has access to recycling at no additional cost. With more residents recycling now than ever before, recycling collections increased from September 2021 through August 2022. Increased participation has also increased constraints on limited resources. The increase in containers distributed and the increase in usage without any additional staff and equipment has caused routes to double in size. Against all odds, DPW has managed to meet the demand of increased recycling while still providing routine trash collection with temporarily moving to a biweekly schedule.

DPW's temporary decision to move to biweekly recycling maintains the department's commitment to equity in all we do. By doing so, DPW has maintained in Calendar Year 2022, a 99.99% route completion target. Biweekly recycling reduces the strain on our workforce while lowering the barriers to environmental stewardship and accommodating all city residents who want to participate in the program.

DPW is committed to returning to weekly recycling in a way that is effective and sustainable. This assessment provides a plan forward. To improve Baltimore's current trash and recycling practices, DPW began working with RUBICONSmartCity's™ in its Routine Services Division to implement an integrated solid waste routing software.

This technology has enabled DPW to digitize its operations, optimize existing routes, deploy in-truck-technology solutions, and monitor operations in real time to improve customer service. Although there is no firm timeline for the change back to weekly recycling, because of pending trucks being delivered and contractor availability, Rubicon's technology, combined with the department's internal changes, presents a path forward.

Rubicon's technology permits DPW to:

- **Digitize Solid Waste Collection:** Digitize routes for trash and recycling collection services so that routes are available to drivers in an electronic form and not dependent on each driver.
- **Deploy In-Truck Technology:** Install, train, and implement in-truck technology to provide frontline operators with navigation, issue tagging, and other support tools.

- **Optimize Bureau of Solid Waste (BSW) and Recycle Collection Routes:** Create more efficient and balanced routes that are accurate and consistent.
- **Enable Flexible, Responsive Operations:** Manage daily operations, with the ability to capture and analyze operational data for decisions, performance measurement, and enact improvements that will allow the City to operate the department in the most efficient manner possible.
- **Deliver Best-in-class Customer Service:** Provide consistent and proactive customer service.

Specifically, DPW has, or is committed to, implementing the following to improve waste collection and recycling:
- **Rightsizing Routes:** Based on Rubicon's recommendation, DPW will be working to right size its collection route. This means that currently, DPW's trash and recycling routes are simply too large. Rightsizing requires additional equipment and staffing to increase the number of trash and recycling routes.
- **New Waste Collection Trucks:** DPW has ordered new trucks, including 2 front end trucks, 15 small trucks, and 50 large trucks to increase its capacity for recycling. This equals 67 total new trucks ordered.
- **Increased Staffing Capacity:**
  - Expanding its Commercial Driver's License (CDL) driver training program
  - Collaborating with other City agencies in creating a substantial CDL hiring and retention bonus program
  - Conducting targeted recruitment events and creating partnerships with local trade schools; and
  - Comprehensive salary surveys to be competitive in the market.

This report provides an analysis of Routine Services' current operations and collection schedule and sets forth recommendations for an optimized trash and recycling collection route structure.

Our analysis shows that **Baltimore's current trash and recycling routes when evaluated against industry best practices[1] are too large for a rear load collection operation.** Current Baltimore trash routes are 20% larger on average than the industry standard of 950 stops per route. As a result of the oversized routes, the City's service expectations are practically impossible to achieve. The current collection structure creates customer service issues for both residents and elected officials as well as decreased morale for department management and employees.

For recycling, Baltimore's current routes are **101% larger** than the industry standard of 1,300 stops per route, with an average stop count of 2,608 per route.

Rightsizing the collection routes is clearly in order. Combined with optimization and on-board technology, rightsizing is foundational to a sustainable operation. However, rightsizing requires increasing daily route counts which impacts equipment and staffing requirements. We lay out a comprehensive, yet phased pathway, to achieve the City's preferred solid waste services operation as soon as possible.

Summary of Route Structure Change Recommendations for Routine Services

	Current State (2022)	Future (OPTIMAL) State (~2026)
Route Count	**Trash:** 45 Daily Routes **Recycling:** 10 Daily Routes (Bi-Weekly Collection)	**Trash:** 55 Daily Routes **Recycling:** 40 Daily Routes (Weekly Collection)
Fleet Size	101 Rear load packers	149* Rear load packers
Personnel	**CDL Drivers**: 66 **Laborers**: 132	**CDL Drivers**: 114 **Laborers**: 228

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[1] Solid Waste Association of North America (SWANA), Applied Research Foundation.

Budget Impact of Recommended Routine Services Changes

Item	Type	Current	Recommendation	+/-	Cost	Addnt'l Cost
Route Structure Change Recommendations for Routine Services (2022 v. 2026)						
Drivers	Recurring	66	114	48	$ 70,629	$ 3,390,192
Laborers	Recurring	132	228	96	$ 55,874	$ 5,363,904
Vehicles	Non-recurring	101	149	48	$ 250,000	$ 12,000,000
Vehicle Maint.	Recurring	101	149	48	$ 44,800	$ 2,150,400
Supplies	Recurring	198	342	144	$ 3,409	$ 490,909
					Total	$ 23,395,405
					Recurring	*$ 11,395,405*
					Non-recurring	*$ 12,000,000*

Our mission is to support the health, environment and economy of our City and the region by providing customers with safe drinking water and keeping neighborhoods and waterways clean. DPW is a strong proponent and protector of our environment and the health and vitality of our community. DPW takes its mission and vision seriously and is deeply committed to resolving issues that impact the department, so it can continue to provide best-in-class service to our valued customers and the region.

Project Overview

Route Digitization. Rubicon modernized Baltimore's existing paper route maps and GIS parcel data into 282 digitized trash and recycling routes. This was a critical task to ready Baltimore's operation for optimal performance, operational accountability and customer service.

In-Truck Technology. Rubicon has outfitted 159 trucks with telematics pods and four trucks have front facing cameras for additional operational confirmation.

Route Optimization. In 2021, Rubicon conducted a route optimization exercise for trash collection routes with the intention of holding current equipment and personnel resources constant. The resulting routes, while more balanced and equitable, were still maxed out and overtime, employee injuries and fatigue issues are likely to persist. Our goal is to bring Baltimore's Routine Services in line with industry standard route sizing and performance standards to stabilize the operation in order to provide weekly trash service and restore recycling collection citywide.

Given the budgetary planning and external supply-chain delays in load packer acquisition, we propose a 2-phase approach to help Baltimore achieve this route rightsizing as soon as possible.

Flexible Operation. With digitized routes and real-time data feeds from the field, the RUBICONSmartCity™ platform allows BSW leadership to manage operations on the fly, adjusting to changing conditions.

Customer Service. Visibility into truck locations, driver-tagged issues in the field, and automatic service verification allows Routine Services supervisors and administrative staff to respond to citizen concerns and service requests in a more timely and thorough manner.

Evaluation

Routine Services Current Operations Overview

Within the Bureau of Solid Waste, the Routine Services division handles the collection of trash and single stream recycling for the City's 208,000 residential locations. Collections occur on a 4-day schedule of Tuesday – Friday weekly. This summary shows the existing trash and recycling collection route breakdown.

Current State: Trash			
	# of Routes	# of Stops	Average # of Stops/Route
Tuesday	45	50,097	1,113
Wednesday	45	56,375	1,253
Thursday	45	50,230	1,116
Friday	44	51,945	1,181
Weekly	**179**	**208,647**	**1,166**

The review of the current operations demonstrates 20% larger routes than recommended industry standards of 950 stops per route. Forty percent (40%) of routes are even larger than Baltimore's average route size of 1,173. Seventeen percent (17%) of Baltimore's routes are below the industry standard of 950 stops per route.

Baltimore's recycling collection has experienced significant changes in the past year:

(1) From October 2021 to March 2022 the City distributed 170,000, 65-Gallon recycling carts to all residential households. As part of the July 28, 2020, *Less Waste, Better Baltimore* plan, this cart distribution is a key component of the City's strategy to increase recycling participation and divert as much material as possible from the landfill.

Original Recycling Collection (Weekly)			
	# of Routes	# of Stops	Average # Stops/Route
Tuesday	20	49,736	2,486
Wednesday	18	51,880	2,882
Thursday	22	50,164	2,252
Friday	20	56,372	2,810
Weekly	**80**	**208,152**	**2,608**

(2) In January 2022, the City temporarily transitioned from weekly recycling collection to bi-weekly collection. This is intended as a temporary operational change necessitated by resource and staffing challenges, as the new cart rollout did not include additional operational staff and equipment.
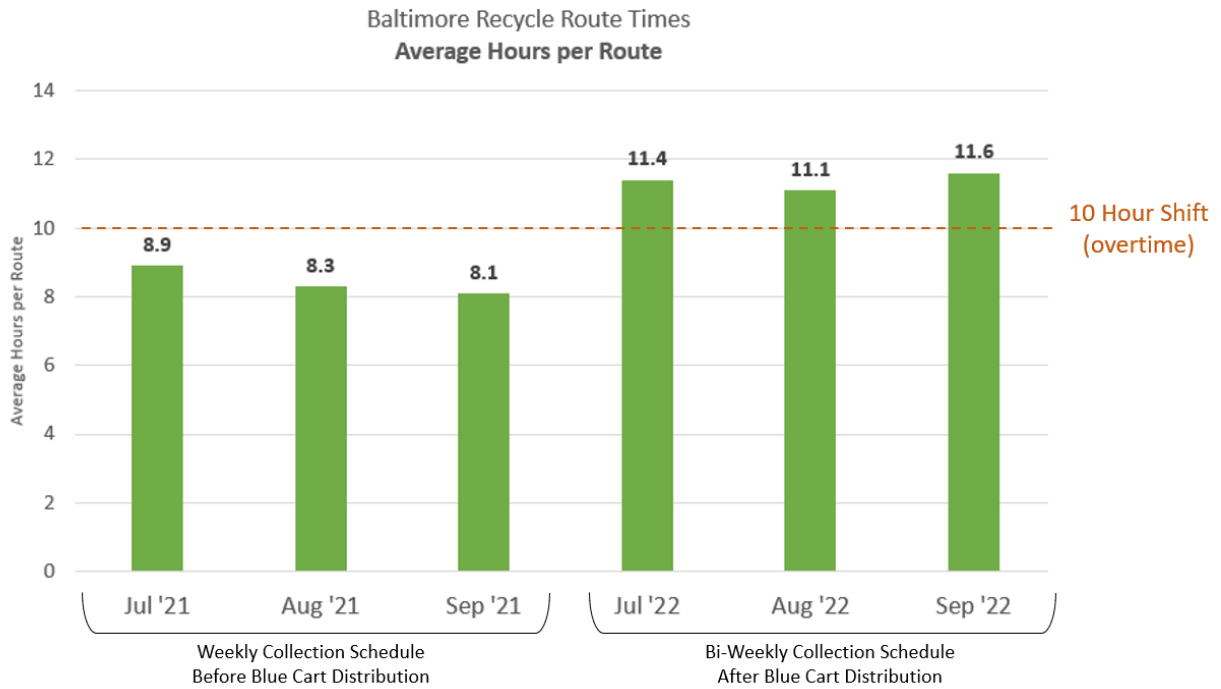
Moving to a temporary schedule where the Northern half of the city is collected on A Weeks, and the Southern half is collected on B Weeks allows the Department to ensure full coverage for recycling collection, reduces route completion delays, and takes pressure off of remaining collections crews.

Amended Recycling Collection (Bi-Weekly)			
A Week (North)			
	# of Routes	# of Stops	Average # Stops/Route
Tuesday	10	21,666	2,167
Wednesday	9	23,681	2,631
Thursday	11	24,005	2,182
Friday	11	24,581	2,235
Weekly	**41**	**93,933**	**2,304**

Amended Recycling Collection (Bi-Weekly)			
B Week (South)			
	# of Routes	# of Stops	Average # Stops/Route
Tuesday	10	28,057	2,806
Wednesday	9	28,199	3,133
Thursday	11	25,540	2,322
Friday	9	31,613	3,513
Weekly	**39**	**113,409**	**2,944**

Rubicon conducted an analysis of recycling data from the 41,000 yellow recycling bins in Summer/Fall 2021 in comparison to the same period after the rollout of 170,000 blue recycling carts city-wide – Summer/Fall 2022. The results showed the average route completion time for recycling has increased by 2.9 hours in 2022. This route completion data compares pre-recycling cart (**weekly**) versus post-recycling cart rollout (**biweekly**). Per the data, if DPW was to move to weekly recycling service with their current resources, crews would need to work on average 23-24 hour shifts to provide weekly services. To meet current demands, the BSW deploys "help trucks" to assist crews to compete with current oversized bi-weekly routes. Simultaneously, recycling tonnage increased by 12%.

	Total Sum of Route Hours	Average Hours per Route	% of Routes over 10 hours
Jul '21	2,775	8.9	32%
Aug '21	2,513	8.3	27%
Sep '21	2,355	8.1	26%
Jul '22	1,899	11.4	71%
Aug '22	1,957	11.1	72%
Sep '22	2,083	11.6	74%

RUBICON

Baltimore Recycle Route Times
Average Hours per Route

Weekly Collection Schedule
Before Blue Cart Distribution

Bi-Weekly Collection Schedule
After Blue Cart Distribution

10 Hour Shift (overtime)

2021 Recycling Tonnage (pre carts)				
Region	**Jul-21**	**Aug-21**	**Sep-21**	**Total Tonnage**
Eastern District	773.42	729.04	539.64	**2,042.10**
Western District	804.73	893.42	1,079.18	**2,777.33**
Total	**1,578.15**	**1,622.46**	**1,618.82**	**4,819.43**

2022 Recycling Tonnage (post carts)				
Region	**Jul-22**	**Aug-22**	**Sep-22**	**Total Tonnage**
Eastern District	836.58	891.05	1,074.60	**2,802.23**
Western District	830.08	911.55	867.56	**2,609.19**
	1,666.66	**1,802.60**	**1,942.16**	**5,411.42**

The increase in recycling tonnage occurred with no increase in collection staffing -- necessitating the shift from weekly to bi-weekly service.

Recommendations

Upon review of Mayor Scott's 2021 Action Plan, Routine Services can address Pillar Three: Clean and Healthy Communities, by implementing the recommendations below.
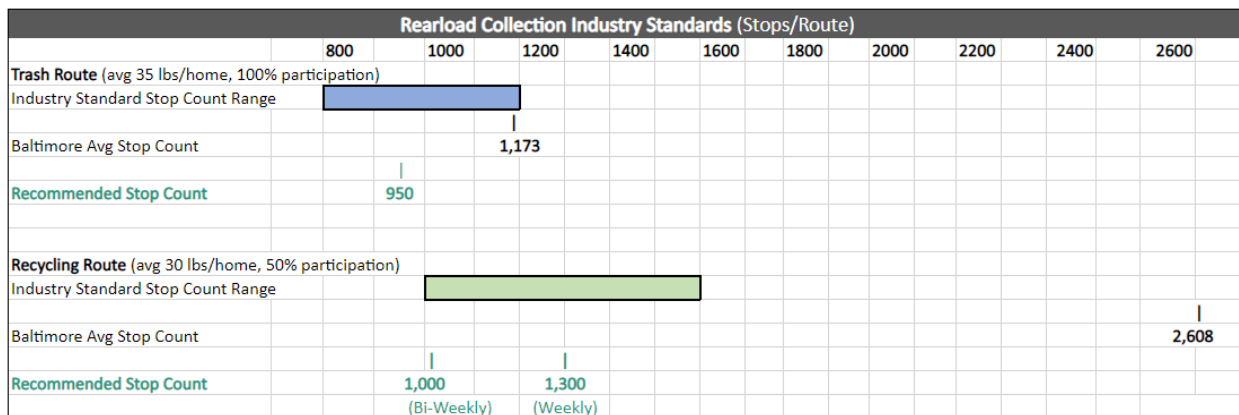
(1) Rightsize the routes for customer and employee success;
(2) Increase collection equipment and crews (drivers and laborers) to properly meet customer, elected officials and administration expectations. This is presented in a 2-phase approach to accommodate budget concerns;
(3) Increase and modernize the fleet for solid waste services with properly maintained funding levels;
(4) Maintain on-board technology for customer and employee success;
(5) Implement a collection performance standard

Recommendation 1: Rightsizing of Routes

Our goal is for Baltimore to exceed industry best practices. This will stabilize operations, restore customer confidence, and increase employee morale. Increasing the number of routes and crews will reduce open daily routes and the need for excessive overtime limiting employee injuries and fatigue.

Given the time required to adjust departmental budgets, along with anticipated supply-chain delays for new loadpackers, we have laid out a two-phase process to help Baltimore achieve route rightsizing with adequate resources and/or necessary staff augmentation. **Ultimately, the recommendation is for Baltimore to have trash collection routes near 950 homes per route, and recycling collection routes near 1,300 homes per route,** *assuming* **weekly collection citywide.**

Note: For a number of reasons such as lower recycling set out rate, and lower compaction of materials, recycling stops per route can be higher than that of trash routes.

Rearload Collection Industry Standards (Stops/Route)										
800	1000	1200	1400	1600	1800	2000	2200	2400	2600	
Trash Route (avg 35 lbs/home, 100% participation)										
Industry Standard Stop Count Range										
Baltimore Avg Stop Count		1,173								
Recommended Stop Count	950									
Recycling Route (avg 30 lbs/home, 50% participation)										
Industry Standard Stop Count Range										
Baltimore Avg Stop Count										2,608
Recommended Stop Count	1,000	1,300								
	(Bi-Weekly)	(Weekly)								

Recommendation 2: Short-Term Rightsizing of Routes, Equipment and Personnel

Our assessment of Baltimore's current trash route structure shows the City is on the upper end of industry standard route sizes. At current vehicle and staffing levels, maintaining the current number of routes will continue to push crews close, if not over, the 10-hour workday with limited room for disruptions from vehicle break downs, crew injury/illness, traffic, or weather challenges.

With more than 60% of Baltimore residents receiving trash collection in a rear alley, service time is increased due to slow speeds at which vehicles are forced to maneuver in tight alleys, or crews collecting trash on foot and bringing it to the vehicle.

Once DPW achieves adequate staff augmentation and/or fleet resources, we recommend adjusting trash routes from an average of 1,173 stops per route down to 1,050 stops per route. This would increase the number of daily trash routes from 45 to 50.

These additional routes, plus building in the recommended 20% reserve, would mean:
- Maintaining a fleet of at least 60 load packers with <20% breakdown factor
- Increase trash CDL drivers from 40 to 60
- Increase trash laborers from 115 to 120

Baltimore Trash Collection Structure (Interim)

Vehicle Needs	
Frontline Trucks	50
Backup Trucks	10
Total Daily Truck Requirements	60

Daily Personnel	
Drivers	50
Backup drivers	10
Helper/Laborers	100
Backup Laborers	20
Total Daily Personnel	180

Weekly MSW	Household Customers Weekly	Days Serviced	Net Workday Hours	Daily Routes
Total Customer Base	208,000	4	6	50
Average Daily Units	52,000			

Daily Route Hours	297		Average Daily Units	52,000
Average Stop Count Per Route	1,050		Tip Time/Second	23
Require Lifts Per Hour	171		Tips/Hour	2.6
Actual Hourly Performance	171		Minutes Needed per Day	19,933.33
Hours to Complete Based On			Crew Hours per Day	332.22
Actual Performance	6.1		Work Hours per Day	6
Potential Overtime (If negative, Indicates potential for overtime)	-0.1			
Percent Efficiency. Actual Hourly Performance vs Required Lifts	100%			
Maximum Route Size (# of Stops)	1,053			
Current Tonnage Collection	18.38			
Maximum Tonnage Collection/Route	18.42			

Recommendations based on industry standards for rear load operations: 800 – 1,200 stops per route. 35 pounds per stop (MSW) and 20% personnel and vehicle spare factor.

Budget Impact of Short-term Rightsizing Recommendation (Trash)

Route Structure Change Recommendations for Routine Services (2022 v. 2026)						
Item	Type	Current	Recommendation	+/-	Cost	Addnt'l Cost
Drivers	Recurring	45	60	12	$ 70,629	$ 847,548
Laborers	Recurring	90	120	24	$ 55,874	$ 1,340,976
Vehicles	Non-recurring	45	60	15	$ 250,000	$ 3,750,000
Vehicle Maint.	Recurring	45	60	15	$ 44,800	$ 672,000
Supplies	Recurring	135	180	45	$ 3,409	$ 153,409
					Total	$ 6,763,933
					Recurring	$ 3,013,933
					Non-recurring	$ 3,750,000

Once DPW achieves adequate staff augmentation and/or fleet resources, we recommend adjusting bi-weekly recycling routes from an average of 2,608 stops per route down to 2,200 stops per route. This would increase the number of daily recycling routes from 20 to 24, maintaining a bi-weekly schedule.

These additional routes, plus building in the recommended 20% reserve, would mean:
- Maintaining a fleet of at least 29 load packers with <20% breakdown factor
- Increase recycle CDL drivers from 22 to 29
- Increase recycling laborers from 46 to 58

Baltimore Bi-Weekly Recycle Collection Structure (Interim)

Vehicle Needs	
Frontline Trucks	24
Backup Trucks	5
Total Daily Truck Requirements	29

Daily Personnel	
Drivers	24
Backup drivers	5
Helper/Laborers	48
Backup Laborers	10
Total Daily Personnel	87

Weekly MSW	Household Customers Weekly	Days Serviced	Net Workday Hours	Daily Routes
Total Customer Base	104,000	4	6	24
Average Daily Units	26,000			

Daily Route Hours	240	Average Daily Units	26,000	
Average Stop Count Per Route	1,100	Tip Time/Second	23	
Require Lifts Per Hour	171	Tips/Hour	2.6	
Actual Hourly Performance	171	Minutes Needed per Day	9,966.67	
Recycling Participation Rate	0.5	Crew Hours per Day	166.11	
Hours to Complete Based On Actual Performance	3.2	Work Hours per Day	6	
Potential Overtime (If negative, Indicates potential for overtime)	2.8			
Percent Efficiency. Actual Hourly Performance vs Required Lifts	100%			
Maximum Route Size (# of Stops)	1,103			
Current Tonnage Collection	16.5			
Maximum Tonnage Collection/Route	16.54			

Recommendations based on industry standards for rear load operations: 1,000 – 1,500 stops per route. 60 pounds per stop per 2 weeks (recycling) and 20% personnel and vehicle spare factor.

Budget Impact of Short-term Rightsizing Recommendation (Bi-weekly Recycling)

Route Structure Change Recommendations for Routine Services (2022 v. 2026)						
Item	Type	Current	Recommendation	+/-	Cost	Addnt'l Cost
Drivers	Recurring	20	29	5	$ 70,629	$ 353,145
Laborers	Recurring	40	58	18	$ 55,874	$ 1,005,732
Vehicles	Non-recurring	20	29	9	$ 250,000	$ 2,250,000
Vehicle Maint.	Recurring	20	29	9	$ 44,800	$ 403,200
Supplies	Recurring	60	87	27	$ 3,409	$ 92,045
					Total	$ 4,104,122
					Recurring	$ 1,854,122
					Non-recurring	$ 2,250,000

Recommendation 2a: Final Rightsizing of Routes, Equipment and Personnel

Once DPW achieves adequate staff augmentation and/or fleet resources, we recommend the final adjustment to trash routes to 950 stops per route. This would increase the number of daily trash routes from 50 to 55. These additional routes plus building in the recommended 20% reserve, would mean:

- Maintaining a fleet of at least 66 load packers with <20% breakdown factor
- Increase trash CDL drivers from 60 to 66
- Increase trash laborers from 120 to 132

Baltimore Trash Collection Structure (Final Version)

Vehicle Needs	
Frontline Trucks	55
Backup Trucks	11
Total Daily Truck Requirements	66

Daily Personnel	
Drivers	55
Backup drivers	11
Helper/Laborers	110
Backup Laborers	22
Total Daily Personnel	198

Weekly MSW	Household Customers Weekly	Days Serviced	Net Workday Hours	Daily Routes
Total Customer Base	208,000	4	6	55
Average Daily Units	52,000			

Daily Route Hours	328	Average Daily Units	52,000
Average Stop Count Per Route	950	Tip Time/Second	23
Require Lifts Per Hour	171	Tips/Hour	2.6
Actual Hourly Performance	171	Minutes Needed per Day	19,933.33
Hours to Complete Based On		Crew Hours per Day	332.22
Actual Performance	5.5	Work Hours per Day	6
Potential Overtime (If negative, Indicates potential for overtime)	0.5		
Percent Efficiency. Actual Hourly Performance vs Required Lifts	100%		
Maximum Route Size (# of Stops)	952		
Current Tonnage Collection	16.63		
Maximum Tonnage Collection/Route	16.67		

Recommendations based on industry standards for rear load operations: 800 – 1,200 stops per route. 35 pounds per stop (MSW) and 20% personnel and vehicle spare factor.

Budget Impact of Final Rightsizing Recommendation (Trash)

Route Structure Change Recommendations for Routine Services (2022 v. 2026)						
Item	Type	Current	Recommendation	+/-	Cost	Addnt'l Cost
Drivers	Recurring	55	66	11	$ 70,629	$ 776,919
Laborers	Recurring	110	132	22	$ 55,874	$ 1,229,228
Vehicles	Non-recurring	55	66	11	$ 250,000	$ 2,750,000
Vehicle Maint.	Recurring	55	66	11	$ 44,800	$ 492,800
Supplies	Recurring	165	198	33	$ 3,409	$ 112,500
					Total	$ 5,361,447
					Recurring	$ 2,611,447
					Non-recurring	$ 2,750,000

Once adequate staff and resources expand current capacity, we recommend returning to weekly city-wide recycling collection, and *increasing* the stop count from 1,100 to 1,300 stops per route. This would increase the number of daily recycle routes from 24 to 40. These additional routes plus building in the recommended 20% reserve, would require DPW to:

- Maintaining a fleet of at least 48 load packers with <20% breakdown factor
- Increase recycle CDL drivers from 29 to 48
- Increase recycling laborers from 58 to 196

Baltimore Weekly Recycle Collection Structure (Final)

Vehicle Needs	
Frontline Trucks	40
Backup Trucks	8
Total Daily Truck Requirements	48

Daily Personnel	
Drivers	40
Backup drivers	8
Helper/Laborers	80
Backup Laborers	16
Total Daily Personnel	144

Weekly MSW	Household Customers Weekly	Days Serviced	Net Workday Hours	Daily Routes
Total Customer Base	208,000	4	6	40
Average Daily Units	52,000			

Daily Route Hours	240		Average Daily Units	52,000
Average Stop Count Per Route	1,300		Tip Time/Second	23
Require Lifts Per Hour	171		Tips/Hour	2.6
Actual Hourly Performance	171		Minutes Needed per Day	19,933.33
Recycling Participation Rate	0.5		Crew Hours per Day	332.22
Hours to Complete Based On Actual Performance	3.8		Work Hours per Day	6
Potential Overtime (If negative, Indicates potential for overtime)	2.2			
Percent Efficiency. Actual Hourly Performance vs Required Lifts	100%			
Maximum Route Size (# of Stops)	1,303			
Current Tonnage Collection	9.75			
Maximum Tonnage Collection/Route	9.77			

Recommendations based on industry standards for rear load operations: 1,000 – 1,500 stops per route. 30 pounds per stop each week (recycling) and 20% personnel and vehicle spare factor.

Budget Impact of Final Rightsizing Recommendation (Weekly Recycling)

Route Structure Change Recommendations for Routine Services (2022 vs 2026)						
Item	Type	Current	Recommendation	+/-	Cost	Addnt'l Cost
Drivers	Recurring	40	48	5	$ 70,629	$ 353,145
Laborers	Recurring	80	96	10	$ 55,874	$ 558,740
Vehicles	Non-recurring	40	48	8	$ 250,000	$ 2,000,000
Vehicle Maint.	Recurring	40	48	8	$ 44,800	$ 358,400
Supplies	Recurring	120	144	24	$ 3,409	$ 81,818
					Total	$ 3,352,103
					Recurring	$ 1,352,103
					Non-recurring	$ 2,000,000

Recommendation 3: Maintain funding levels to sustain the fleet and staffing

Routine Services currently has a combined 101 load packers for trash and recycling collection. Sixty-six (66) of these load packers are allocated for trash collection, while thirty-five (35) are allocated for recycling collection.

The median age of the fleet is 4 years old (2018 model year). The typical useful lifespan of a rear load packer is 6-8 years. Eighteen load packers are more than 7 years old and should be considered for immediate replacement. There are 22 vehicles from model year 2016, that more than likely will need to be replaced in the next 1-2 years. Routine Services has 50 load packers approved and on order that will serve as replacements for the aging portion of the fleet. DPW began procuring these vehicles November 2021, but the build-time for these types of vehicles under current economic conditions is typically 2.5-3 years.

Model Year	Count of Loadpackers	Comment
2006	3	
2007	3	
2008	2	18 Vehicles Past Replacement Age
2011	1	
2015	9	
2016	22	22 Vehicles due for Replacement in 2023
2017	4	
2018	30	
2019	9	
2020	18	
Grand Total	**101**	

It is industry standard to maintain a 20% spare vehicle and reserve personnel rate. This 20% reserve is critical to maintaining on-time collections, and serves as a buffer to accommodate vehicle maintenance, breakdowns, and planned/unplanned staff absenteeism.

Baltimore's Routine Services team reported a vehicle breakdown factor of 30-40% for load packers, meaning on any given day 30-40% of load packers are unavailable due to breakdowns or planned maintenance. The 50 additional loadpackers will help reduce this breakdown rate.

Similarly, Routine Services noted crew absenteeism rates (planned and unplanned leave) for CDL Drivers and Helpers ranging from 20% - 30% daily.

Once all routes are covered, when there are additional crews available, they are assigned to a help truck. Help trucks are used on larger routes to decrease the route completion time. If no additional crews are available, employees are pulled from another operation to create help trucks. This reduces the impact of employees working long hours and into the night.

These factors point to the need for sustained investments to maintain both equipment and personnel. The charts below show Baltimore is operating at a deficit for both vehicles and staff for trash collection, much less maintaining a 20% reserve.

Trash: Current State Vehicles & Staffing							
# of Vehicles	Breakdown Factor	Down Vehicles	Available Vehicles	Daily Routes	Spare Vehicles	Suggested Spares	Delta
66	40%	26	40	45	-5	9	-14
Total # of CDL	Absenteeism Rate	Daily Callouts	Daily CDLs	Daily Routes	Extra CDLs (actual)	Suggested Spare CDLs	
44	20%	7	37	45	-8	9	-17
Total Helpers	Absenteeism Rate	Daily Callouts	Daily Helpers	Daily Routes	Extra Helpers (actual)	Suggested Spare Helpers	
115	30%	30	85	45	-5	18	-23

BI-WEEKLY Recycling: Current State Vehicles & Staffing							
# of Vehicles	Breakdown Factor	Down Vehicles	Available Vehicles	Daily Routes	Spare Vehicles	Suggested Spares	Delta
35	30%	11	25	10	15	2	13
Total # of CDL	Absenteeism Rate	Daily Callouts	Daily CDLs	Daily Routes	Extra CDLs (actual)	Suggested CDLs	
22	20%	7	15	10	5	2	3
Total Helpers	Absenteeism Rate	Daily Callouts	Daily Helpers	Daily Routes	Extra Helpers (actual)	Suggested Spare Helpers	
46	30%	20	26	10	6	4	2

WEEKLY Recycling: Current State Vehicles & Staffing							
# of Vehicles	Breakdown Factor	Down Vehicles	Available Vehicles	Daily Routes	Spare Vehicles	Suggested Spares	Delta
24	30%	7	17	20	-3	4	-7
Total # of CDL	Absenteeism Rate	Daily Callouts	Daily CDLs	Daily Routes	Extra CDLs (actual)	Suggested CDLs	
22	20%	4	18	20	-2	4	-6
Total Helpers	Absenteeism Rate	Daily Callouts	Daily Helpers	Daily Routes	Extra Helpers (actual)	Suggested Spare Helpers	
46	30%	13.8	32.2	20	-8	4	-12

Recommendation 4: Maintain on-board technology for employee and departmental success

RUBICONSmartCity™ drives innovation in residential and community waste collection, bringing the next generation of technology to solid waste and other heavy-duty fleet operations.

RUBICION X, also referred to as the in-cab interface (ICI), is a customized smartphone or tablet loaded with Rubicon's proprietary application. The ICI verifies the collection service of an area, in near real-time and provides drivers with intuitive tools to enhance their workflow.

THE PORTAL. The Portal is a password protected browser-based dashboard that helps centralize decision making, provide operational oversight, and view all data related to a solid waste operation.

FEATURES

Work order management	Asset management
Weight ticket reporting	AVL/GPS
Real-time issues reporting	Route completion data
Vehicle diagnostic	Daily route management
Identify neighborhood insights	Web-based portal
Driver performance	Customized reports
Turn-by-turn navigation	iOS or Android-based App
Breadcrumb trails & route layback	Pre/Post trip inspection reporting
Complete telematics	Portal monitoring

In short, Rubicon's technology does exactly what the administration and leadership are looking for in the delivery of best-in-class and equitable city services.

Recommendation 5: Implement a Collection Performance Standard

We recommend that DPW, BSW Routine Services Division adopts an appropriate performance management system for the trash and recycling collection program that tracks route completion time and customer complaints. They should also design key performance indicators when they have reached appropriate staffing levels and resources to be successful. Key performance indicators of a performance system should include homes serviced

per hour, route time, and customer defects such as missed collection, spills, and property damage. Adopting a performance system will ensure operator, supervisory and managerial accountability to best-in-class service.

Conclusion

With the digitization of more than 208,000 collection locations throughout the City and visibility into fleet operations, Rubicon has successfully established the foundation for Baltimore's ongoing success. We look forward to working with the Bureau of Solid Waste to determine the appropriate path forward and implementation of the recommendations set forth.

Appendix 1: Routine Services Vehicle Inventory (October 2022)

NORTHWEST		NORTHEAST		SOUTHWEST		SOUTHEAST		Prefix # denotes Year	
Malcolm Denton		Doreen Moore		Malcolm Denton		Doreen Moore		VEHICLE KEY	
(410) 396-1418		(410) 396-9950		(410) 396-3367		(410) 396-9952			
3193	20K	3163	18P	3132	19K	3190	19K	K	Kenilworth
3133	19K	3170	17A	3188	19K	3199	19K	P	Peterbuilt
3299	19K	3182	17A	3140	20K	3194	19K	A	Autocar
3185	20K	3823	16A	3184	20K	3154	19K	M	Mitsubishi
3197	20K	3820	16A	3186	20K	3131	20K	N	Nissan
3168	19K	3802	16A	3198	20K	3130	20K		
3143	18P	3818	16A	3189	20K	3195	20K		
3867	18P	3551	16A	3127	20K	3129	20K		
3872	18P	3545	16A	3196	20K	3187	20K		
3876	18P	3547	16A	3866	18P	3128	20K		
3181	17A	3817	16A	3171	18P	3191	20K		
3149	17A	3804	16A	3174	18P	3192	20K		
3553	16A	3800	16A	3175	18P	3327	18P		
3559	16A	3548	16A	3150	18P	3884	18P		
3569	16A	3851	16A	3176	18P	3166	18P		
3811	16A	3853	16A	3880	18P	3173	18P		
3815	16A	3527	15A	3180	18P	3142	18P		
3850	16A	3500	15A	3885	18P	3144	18P		
3852	16A	3324	15A	3167	18P	3177	18P		
3909	16A	3522	15A	3172	18P	3145	18P		
3540	15A	3166	07M	3819	16A	3147	18P		
3821	15A			3173	07M	3183	18P		
3503	15A			3157	06M	3893	18P		
3505	15A					3179	18P		
3909	15A					3869	18P		
3876	08M					3815	18P		

3191	11N					3181	08M		
3174	07M					3169	06M		
3157	06M								
29		**21**		**23**		**28**			

Appendix 2: About Fleet Optimization

Fleet optimization is a complex process that encompasses more than simply identifying the shortest route between points on a map. In addition to distance, specific constraints are taken into consideration ranging from the number and location of required segments to turns and intersections along a route, among others identified by the City. Fleet optimization, when based on comprehensive data about your operations, can save the City significant time and money.

Rubicon's optimization process differs from its competitors in the market in several ways. First, Rubicon manages most fleet optimization tasks and responsibilities and requests City input and collaboration when needed, removing the burden of significant time commitments from City personnel. Our process is designed to keep optimizations as simple as possible for the City, as we guide our City partners through the process with collaboration in multiple iterations. We optimize all routes offline and then provide City back-office staff with the tools necessary to keep them up to date and balanced within our Portal.
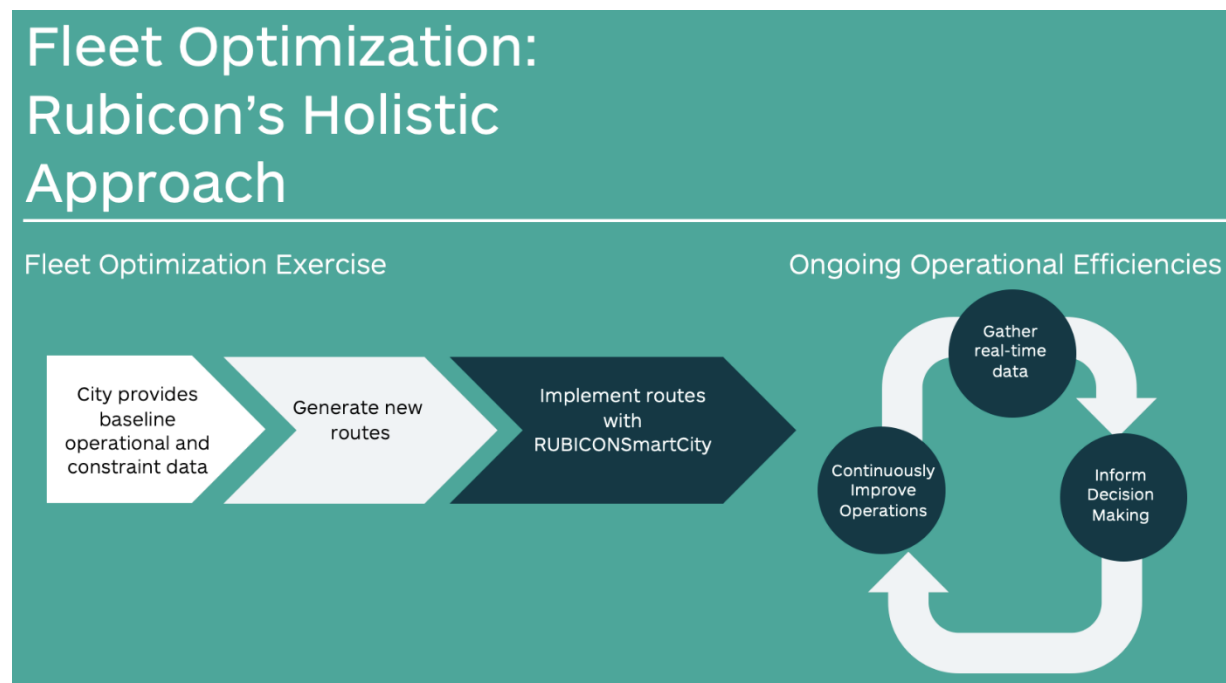
Finally, Rubicon's in-truck technology also offers unique capabilities that assist the City in implementing the new, optimized routes. For example, changes to recurring routes after optimization can be immediately pushed to drivers through the ICI and assist them via turn-by-turn navigation as they learn their new routes. And the ICI collects additional data that can be used to optimize routes over time.

TOOLS In order to successfully complete a comprehensive optimization of the City's current routes, Rubicon will employ tools including mapping software such as ArcGIS, ESRI, and Mapbox, a variety of route optimization tools, as well as our own proprietary software and hands-on expertise to achieve the City's goals.

PHASE 1: ESTABLISH PROJECT GOALS If selected for this contract, Rubicon will work with Baltimore's Division of Street's to outline key deliverables, discuss objectives, and identify the pain points within the existing operation. Our team of routing specialists will meet with the City's team to establish project goals, scope, timeline, and key requirements. Sample project goals include the following:

- o Optimize Number of Trucks
- o Optimize Number of Collection Stops per Route
- o Balance Route Hours
- o Reduce Overtime Hours
- o Improve Customer Service
- o Optimize Miles Driven
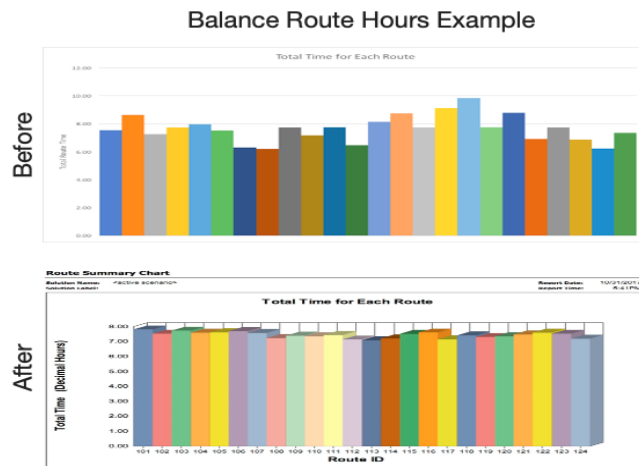
EXAMPLE OF ROUTE HOURS BEFORE AND AFTER BALANCING

PHASE 2: COLLECT BASELINE DATA After agreeing on goals, KPIs, and project scope with the City, Rubicon's team will begin collecting baseline data derived from the City's historical data. These data points will include:

- o Route Start/End Times
- o Route Hours
- o Street Data
- o Disposal Sites
- o Number of Routes
- o Number of Personnel
- o Number of Trucks Utilized
- o Special Service Requirements

PHASE 3: ESTABLISH PARAMETERS & CONSTRAINTS Typical parameters and constraints include the following:

- o Route Start/End Times
- o Number of Service Days
- o Number of Trucks/Routes
- o Service Side

- o Restricted U-Turns, Left Turns, etc.
- o Driver Breaks
- o Pre/Post Trip Time
- o Workable Hours
- o Distance to Disposal Facilities Such as Landfills, Incinerators, MRFs, Transfer Stations or Other Relevant Facilities

Turn Analysis				
(count)	(count)	(count)	(count)	(count)
465	151	189	20	16
344	116	147	19	36
618	115	161	30	20
409	122	183	17	34
739	93	128	13	24

SAMPLE ROUTE TURN ANALYSIS

PHASE 4: FLEET OPTIMIZATION During Phase 4, our fleet optimization experts run scenarios and establish optimal routes based upon the first four phases:

- o Establish baseline historical data
- o Factor in optimizing constraints
- o Create optimized routes
- o Implement and test optimized routes

Rubicon and the City will work collaboratively to review each step, make iterative adjustments, and, if needed, rerun scenarios.

PHASE 5: TEST NEW ROUTES, FINALIZE, & GO-LIVE After the route optimization process has been completed, Rubicon will work with the City to test and finalize the new routes. Small adjustments and tweaks can be made during this phase. Once both sides are satisfied with the results, the new routes will be pushed out to drivers via the ICI. Additionally, the ICI will help drivers learn their routes after the optimization. The ICI provides turn-by-turn navigation to guide drivers directly to their routes and back and forth to facilities. The ICI will also assist drivers in ensuring service locations are not missed by verifying when service has been completed on a particular street.

Appendix 3:
Rubicon Background Information

Rubicon is a digital marketplace for waste and recycling, and provider of innovative software-based solutions to businesses and governments worldwide. Creating a new industry standard by using technology to drive environmental innovation, the company helps turn businesses into more sustainable enterprises, and neighborhoods into greener and smarter places to live and work. Rubicon's mission is to end waste. It helps its partners find economic value in their waste streams and confidently execute on their sustainability goals.

Founded in 2008, Rubicon has been utilizing technology to create smart, sustainable businesses and cities for 14 years. Today, Rubicon is the worldwide leader in providing cloud-based waste and recycling solutions. The company focuses on developing cutting-edge software that brings transparency to the waste and recycling industry, encouraging customers to make data-driven decisions that lead to more efficient and effective operations that drive more sustainable outcomes. With more than 8 million service locations worldwide, Rubicon is headquartered in Lexington, KY, and deploys a remote workforce with core teams in Atlanta, GA; Lexington KY; New York, NY; and San Francisco, CA.

In January 2022, Rubicon announced it acquired CIVIX LLC, a routing software and solutions company based out of Freiburg, Germany. Founded in 1999, CIVIX is the developer of the market-leading FleetRoute route optimization and strategic planning software and associated technologies for data collection, in-cab navigation, dispatching, tracking, performance monitoring, and messaging. FleetRoute's geographic information system (GIS) and cloud-based route optimization software is used to solve the most complex high-density routing problems through advanced network algorithms developed specifically for the municipal services, utility, and street surveying industries. With customers in North America, Europe, and the Middle East, FleetRoute's book of business includes local governments, councils and municipalities; private companies and corporations; public utilities; and federal and regional government agencies. In addition to CIVIX's full suite of route optimization services, it also provides operational consulting services as part of its offering.

A Certified B Corporation, affirming that the company meets the highest standards of verified social and environmental performance, Rubicon is transforming the traditional waste and recycling industry business model. Certified since 2012, Rubicon is one of the largest B Corporations in the world joining the ranks of Patagonia and Ben & Jerry's. Rubicon's B Corp status is representative of how we leverage our business as a catalyst for environmental stewardship.

In 2019, B Corp awarded Rubicon "Best for the World" recognitions for "Environment" as well as "Corporate Governance."

Rubicon has also been awarded a Great Place to Work in 2018, 2019, 2020, 2021, and 2022 as well as recognized as one of Glassdoor's "Eleven Companies with Seriously Impressive Benefits" in 2018.

Rubicon uses technology to transform businesses into more sustainable enterprises and neighborhoods into greener and smarter places to live and work. Rubicon is helping small businesses, multi-site locations, cities, and municipalities find economic value in their waste streams and confidently execute on their sustainability goals.

Rubicon's team of route optimization experts coupled with Rubicon's powerful, in-house routing software will deliver on all of the City's goals. In parallel, Rubicon will install RUBICONSmartCity's in-truck technology in the City's fleet of solid waste vehicles.

RUBICONSmartCity's full suite of technology is comprised of two main hardware components and powerful, cloud-based software platform. The first hardware component is a telematics device (which we commonly refer to as the Pod) that plugs into the diagnostic port within the vehicle. In this proposal, Rubicon will provide the City of Baltimore with our proprietary software, our In Cab Interface, and Geotab telematics device.

We believe this will best meet the City's goals for several reasons. First and foremost, the Geotab telematics device is widely considered to be the industry leader in highly accurate GPS vehicle tracking, engine and vehicle health assessment, and advanced vehicle capture metrics.

The second component of Rubicon's technology is a smartphone or tablet preloaded with our customized application (which we refer to as the in-cab interface, or ICI). The telematics device and Driver Application devices collect data that is then transmitted in near real-time back to a web-based Manager Portal (the Portal).

Together the components of our technology—the In Cab Interface, Pod, and Portal—provide the following capabilities:

- **Route generation & optimization services** to implement right sized and balanced operations where vehicles are consistently following the most efficient and cost-effective routes leading to safer streets and a more

streamlined operation. Our technology empowers the City with the capabilities necessary to implement and sustain the optimized level of service.

- An end-to-end **route and service management solution** for solid waste operations, including paperless routes and ability to provide real-time communication of all information between the vehicles and the back office.
- A **driver application** that provides drivers with relevant route and street information, turn-by-turn navigation, pre-and post-trip inspections with a customizable list of items for inspection, ability to assist on additional routes, note issues in the field, and two-way messaging.
- **Service verification** by location based on a combined algorithm of proximity and speed
- A complete **telematics solution** for collection vehicles, including the ability to provide real-time and historical truck location and data related to routes and driving metrics for all vehicles.