

Task 8 Technical Memorandum

Future Opportunities and Recommendations

Prepared For

New York Metropolitan Transportation Council

Prepared By

Rutgers University, Center for Advanced Infrastructure and Transportation

100 Brett Road

Piscataway, NJ 08854-3925

with

Econsult Solutions Inc.

Ramboll Americas Engineering Solutions, Inc.

University at Albany, State University of New York

Date

June 4th, 2025



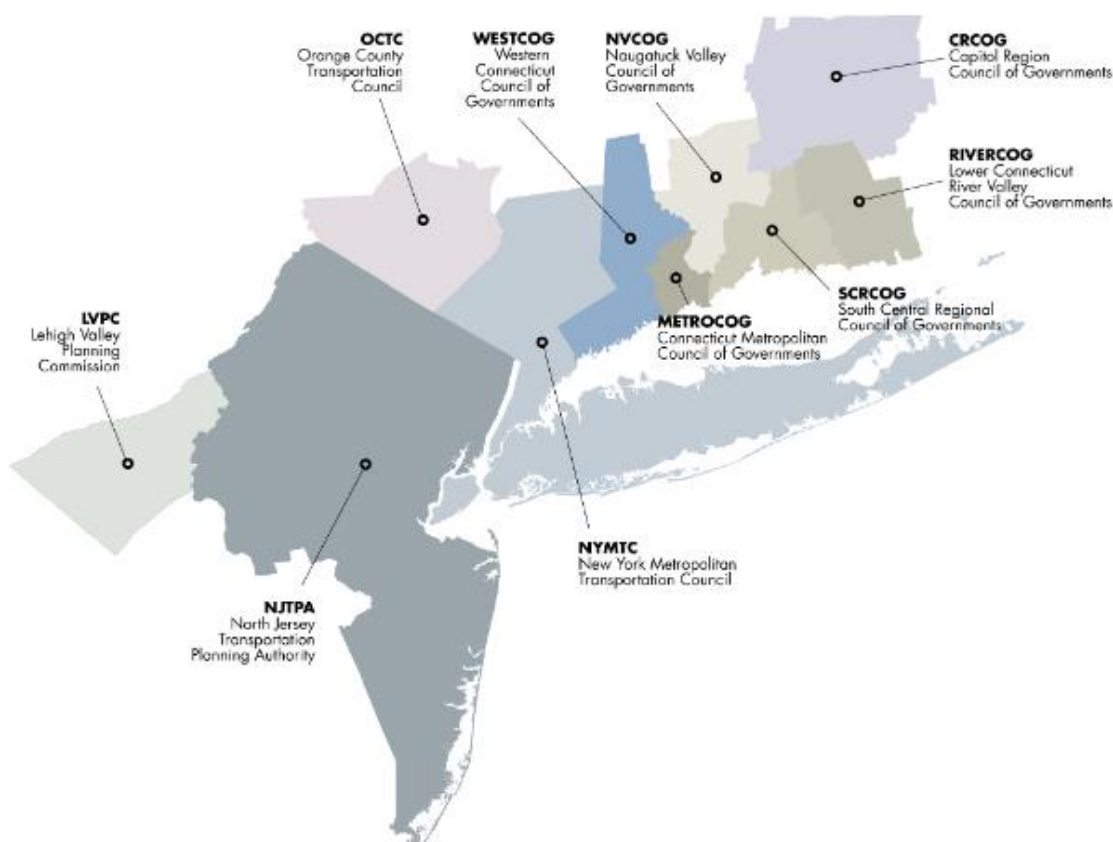
Contents

1. Introduction	2
2. Recommendations to Address Existing Challenges and Limitations	3
2.1. Planning	3
2.2. Analytics	5
2.3. Infrastructure	7
3. Opportunities	10
4. Conclusions	12
5. References	13

1. Introduction

The Regional Waste Movement Study is focused on identifying the “needs and opportunities associated with the movement of municipal solid waste (MSW) and construction and demolition (C&D) debris” or waste in the Metropolitan Area Planning (MAP) Forum area, which encompasses 10 Councils of Governments (COGs)¹ and Metropolitan Planning Organizations (MPOs) in Connecticut, New Jersey, New York, and Pennsylvania (refer to **Figure 1**) [1].

Figure 1: Metropolitan Area Planning (MAP) Forum Study Area [2]



This final memorandum presents a set of strategic recommendations to improve the coordination, planning, and implementation of waste movement across the study area. The recommendations are grounded in findings from the study and reflect persistent regional challenges related to infrastructure constraints, data fragmentation, and governance silos. They are intended to guide future planning efforts, strengthen inter-jurisdictional collaboration, and inform investment in waste-related transportation and processing infrastructure. The memorandum also identifies a set of forward-looking opportunities – emerging ideas, technologies, and practices – that could support a more sustainable, efficient, and resilient waste system for the region.

¹ While not part of the Study Area, the Southeastern Connecticut Council of Government (SECCOG) has been engaged and consulted with as part of this study,

2. Recommendations to Address Existing Challenges and Limitations

This section presents recommendations to address key challenges identified throughout the study related to the movement of municipal solid waste (MSW) and construction and demolition (C&D) debris in the study area. These recommendations reflect persistent and systemic issues across jurisdictions, including fragmented governance, inconsistent data systems, limited regional coordination, and underinvestment in infrastructure.

Planning for waste movement and infrastructure across the MAP Forum region is significantly constrained by inconsistencies in data quality, forecasting methodology, and the lack of a unified planning framework across jurisdictions. While scenario modeling and strategic forecasting tools have been developed, their effectiveness is limited by inconsistent inputs, differing assumptions, and missing information from multiple states. These gaps present significant challenges in preparing for future waste volumes projected for 2035 and 2050.

Specific limitations or challenges are organized into three interrelated categories:

1. **Planning** – focuses on improving regional coordination, leadership, and long-range decision-making.
2. **Analytics** – addresses foundational gaps in data, definitions, tracking systems, and forecasting tools.
3. **Infrastructure** – identifies investments and strategies needed to increase capacity and reduce the environmental and logistical burden of waste movement.

This sequence reflects the logic that effective infrastructure investment depends on good planning, and good planning depends on reliable and standardized analytics. Each section identifies the most significant challenges in that area, followed by a series of recommendations.

2.1. Planning

The study area spans hundreds of jurisdictions across four states, each with its own regulatory framework, infrastructure constraints, and planning practices. Despite this fragmentation, the study area faces common challenges: increasing waste generation, diminishing disposal capacity, volatile recycling markets, and increasing climate-related disruptions. Planning decisions often determine where waste moves, what infrastructure exists to manage it, and whether the system can respond to disruptions, such as disposal facility closures, natural disasters, or changes in the market.

Solid Waste Management Plans (SWMPs) are the primary planning tools jurisdictions use to document current waste practices and guide future investments. Required by state regulations, these plans are often developed with limited data, staff, and analytical tools. Many jurisdictions do not have current SWMPs and few, if any, are coordinated across jurisdictional boundaries. These plans rely on static, backward-looking approaches, using per-capita waste generation assumptions and shortest-distance routing, which fail to account for the contractual, economic, and logistical issues that shape how waste moves through and out of the study area. As a result, local plans often underestimate travel distances, misrepresent waste flows and facility use, and offer limited value for long-term planning.

To address these challenges, the region could adopt a more dynamic and coordinated approach to planning. Scenario modeling, common and consistent data standards, and regular updates to forecasting tools can help jurisdictions and the region make better-informed decisions.

The major planning limitations identified through this study are:

- **Lack of regional leadership on waste movements by mode.** No regional entity currently sets a direction or coordinates planning efforts around how waste is moved – by truck, rail, or barge – despite shared dependencies and infrastructure constraints across jurisdiction. Currently, waste planning and coordination efforts are coordinated at the state or more local levels.
- **Solid Waste Management Plans are geographically constrained and lack regional alignment.** While SWMPs are often coordinated with state requirements and reflect local conditions, they are typically developed at the municipal or county level without integration across jurisdictional boundaries. This geographic constraint limits their ability to account for cross-border and through waste flows, shared infrastructure, and the regional dynamics of waste movement. In addition, many jurisdictions either lack a SWMP or rely on plans that are outdated or incomplete.
- **Planning tools are not current, may be inconsistent, and are disconnected from waste movement dynamics.** Many local and regional planning efforts – including SWMPs – rely on static models built around per-capita waste generation and shortest-distance routing. These tools do not reflect how waste actually moves through the region and often exclude key operational and economic factors such as tipping fees, hauling contracts, modal constraints, and facility access. As a result, projections can misrepresent waste flows and facility use, leading to poorly aligned investments. Most planning frameworks also lack the ability to simulate future disruptions or policy changes, such as facility closures, shifts in export markets, or new diversion mandates.
- **Policy, funding, and regulatory separation between waste planning and related systems limits coordinated decision-making.** Waste management planning (e.g., policy, funding, regulations) is almost always undertaken independent of land use, transportation, and climate resilience planning, each of which is typically governed by different levels of government or agencies. This separation makes it difficult to align facility siting with transportation capacity, avoid climate-vulnerable locations, mitigate community impacts, or integrate waste flows into broader freight or infrastructure strategies.
- **Regulatory differences impact cross-border waste movements.** Regulations such as differing vehicle weight limits, varying state-specific rules on waste transport by rail (e.g., New York's mandate on covered railcars), and inconsistent permitting processes significantly complicate interstate waste transport and logistics planning (highlighted in the Task 3 Memorandum).

The following are recommendations related to waste planning:

- **Recommendation P-1: Establish an overarching regional framework.** Use the MAP Forum as a platform for greater regional and policy coordination of waste movement planning by mode across the region. A data architecture should be an initial objective (see data recommendations in Section **Error! Reference source not found.**) and propose a schedule for producing and sharing key data products (e.g., databases, GIS layers). The group should report progress at regional meetings and integrate waste movement considerations into the next regional freight plan update.

- **Recommendation P-2: Develop and incorporate scenario-based regional planning methods.** Develop and incorporate scenario modeling to simulate different policy, technology, and infrastructure shifts (e.g., high-diversion future versus business-as-usual). This will allow proactive investment and regulatory planning. For example, the region can mirror Metro Vancouver’s Integrated Solid Waste and Resource Management Plan modeling approach. [3]
- **Recommendation P-3: Develop a regional strategy for waste planning.** Develop a regional strategy to significantly improve waste planning. A coordinated approach to regional waste planning could help streamline data collection, mitigate challenges for private haulers working across multiple jurisdictions, and reduce vehicle miles traveled (VMT). Part of this strategy is the increase in waste diversion, including organics, as researchers found significant challenges and opportunities with diverting organic materials and improving the quality of recycling, throughout the study.
- **Recommendation P-4: Promote greater consistency in regional waste transport regulations.** Work toward increased consistency in waste transport regulations across Connecticut, New Jersey, New York, and Pennsylvania. Differences in vehicle weight limits, railcar coverage requirements, and permitting processes create friction in planning and executing cross-border waste movement. A regional regulatory framework – or at minimum, a set of mutually recognized guidelines – would reduce barriers to coordinated infrastructure planning, simplify logistics for haulers, and enable more efficient use of shared transportation networks.

2.2. Analytics

Reliable, standardized, and accessible analytics is the foundation of effective waste movement planning. Across the MAP Forum region, data inconsistencies and system fragmentation make it difficult to understand how waste moves, how much is being generated, and where infrastructure bottlenecks or gaps exist. While each state has its own reporting and permitting requirements, these systems are not coordinated across borders, and definitions often vary for major waste categories, including C&D debris and other non-MSW streams. These inconsistencies reduce the fidelity of modeling, impede cross-jurisdictional planning, and hinder enforcement and forecasting.

The lack of a shared data infrastructure also prevents the region from efficiently tracking movements by mode (truck, rail, barge), type, origin, and destination. This makes it difficult to anticipate shifts in flow patterns, identify inefficiencies in routing, or respond to emergencies such as facility closures or natural disasters. In addition, models used in this study – including the one described in the Task 7 Memorandum – relied on incomplete datasets and assumptions that do not reflect real-world logistics, such as contractual hauling arrangements and tipping fees. As a result, regional planning suffers from a poor understanding of the actual scale, direction, and impact of waste flows.

To address these challenges, the region would benefit from building a shared data architecture for waste movement – one that includes common definitions, standardized reporting formats, and digital tracking tools. These improvements are essential not only for effective planning, but also for investment prioritization, environmental monitoring, and policy enforcement.

Specific limitations or challenges identified in the study include:

- **Inconsistent waste classifications.** Each state within the region uses its own definitions for various categories of waste particularly for non-MSW materials, including C&D debris, which

makes up a significant portion of the region's waste. This incompatibility significantly restricts the comparability of waste metrics, including waste production rates and volume of movements, and reduces the fidelity of regional waste modeling for long-term planning.

- **Fragmented or incomplete data collection.** Despite strong regulations and permitting requirements within each state in the study area, the region lacks an integrated system capable of tracking waste movements by mode, type, origin, and destination. This gap undermines forecasting and enforcement efforts and requires the use of proxy data from other jurisdictions, further reducing accuracy and realism in modeling waste flows. In addition, information on facility availability, operational constraints, and expected end-of-life is tracked in localized or state-specific systems only. This lack of a region-wide facility registry hinders load balancing, contingency planning, and investment decision-making.
- **Modeling limitations due to incomplete and poor data inputs.** The model developed for this study (refer to the Task 7 Memorandum) was constrained by incomplete data and the lack of a traffic model. This led to unrealistic assumptions and the use of a shortest trip distribution methodology. The methodology could not account for operational realities such as tipping fees, contract obligations, and access to specific transport modes. This resulted in the underestimation of actual travel distances and unreliability of network usage patterns.

Considering the identified limitations, the following recommendations were developed:

- ***Recommendation A-1: Move towards adopting a regional “Definition of Waste”.*** Move towards adopting a standardized, region-wide waste classification system across Connecticut, New Jersey, New York, and Pennsylvania. This harmonization effort should focus on aligning categories such as MSW, C&D, and non-MSW to enable consistent data collection, improve modeling, and facilitate cross-jurisdictional planning. A common set of definitions will enhance policy alignment, ease compliance, and support long-term regional investment planning. A harmonized classification system would also create the foundation for optimizing system-wide routing—such as prioritizing high-calorific, non-recyclable waste for nearby Waste-to-Energy (WTE) facilities [4]—reducing transportation distances, emissions, and operational inefficiencies.
- ***Recommendation A-2: Work toward a cross-state registration platform for waste transport.*** A unified cross-state registration platform for all waste moved by truck, train, or barge from their origins to destinations would greatly improve waste movement planning and tracking efforts in the region. The registration platform would include a centralized regional database of waste facility locations, capacities, and operational statuses. This platform would enable real-time data collection and routing, better forecasting, and regulatory enforcement. Additionally, the centralized dashboard would provide system-wide visibility, enhancing day-to-day operations, long-term contingency planning, and emergency response strategies during natural disasters. Such a system would align with recommendations from the Tasks 5 and 7 Memoranda for digital modernization. Sweden's e-Avfall portal [5] allows registered carriers and facilities to log waste movements nationwide, improving transparency and optimizing transport routes. This type of platform could also identify unauthorized or inefficient routing. Another example is Austria's Electronic Data Management (EDM) Portal (Elektronisches Abfallnachweisverfahren) [6], which provides centralized tracking of treatment facilities and waste flows for regulatory and commercial users.

- **Recommendation A-3: Institutionalize a regional waste forecast.** Establish a regular forecast of waste generation and movement, grounded in shared data definitions and regional infrastructure capacity. This effort should build on improved modeling methods (see Recommendation D-3) and move beyond one-time or per-capita approaches. Regularly updated forecasts would enable jurisdictions to monitor trends, support planning and permitting decisions, and evaluate future infrastructure needs. Institutionalizing this function will provide a consistent foundation for coordinated regional planning.

2.3. Infrastructure

The MAP Forum region must contend with rising waste volumes and increasingly complex logistics against a backdrop of aging infrastructure and political constraints. Shifts in policy, capacity, and environmental requirements are placing new demands on the region's ability to move waste efficiently and reliably.

The greatest pressure falls on disposal facilities – particularly landfills and Waste-to-Energy (WTE) facilities – which face growing public and political resistance, environmental scrutiny, and, in many cases, limited remaining capacity. Expanding or siting new disposal facilities has become increasingly difficult, leaving many communities reliant upon long-haul transport to out-of-state destinations (refer to Task 3 Memorandum).

Specific limitations or challenges include:

- **The regional freight rail network has limited available capacity and infrastructure for waste movement.** While rail offers emissions and congestion benefits for long-distance waste transport, the region's rail network is tightly constrained (see Task 3 Memorandum). Sidings, transload facilities, and intermodal terminals capable of handling waste are limited in number and often shared with higher-value freight or passenger service. Without dedicated investment and coordination, waste is unlikely to increase its share of regional rail use significantly despite the desire of jurisdictions in the region to do so.
- **Disposal capacity is declining, and expansions face political resistance.** Many landfills are nearing capacity, and Waste-to-Energy (WTE) facilities face political opposition despite their role in absorbing in-region waste. Without new capacity or modernization of existing facilities, the region will become increasingly dependent on exporting waste.
- **Rail access and intermodal capacity are insufficient.** While most waste in the region is transported by truck, many jurisdictions are interested in shifts to rail or, in fewer instances, barge. However, stakeholders noted that access to rail and intermodal facilities in the region is insufficient to enable this kind of shift, particularly in Long Island and high-density areas. Critical infrastructure, such as Fresh Pond Yard in NYC [7], is under threat due to growing passenger rail needs and lack of policy protections for freight corridors. The reduction of freight-only rail routes reduces the region's ability to shift away from the use of trucks, contributing to congestion, higher emissions, and increased wear on roads.
- **The region lacks sufficient processing and recycling capacity.** Outdated or undersized processing facilities for recyclables, particularly near high-generation nodes such as New York City, result in excessive travel distances, higher transportation costs, and increased environmental

impacts. In addition, the siting of new facilities is constrained due to community resistance and permitting hurdles.

- **Waterfront access for barge transport is limited.** Most disposal facilities are not located directly on the waterfront, requiring inefficient intermodal transfers. Natural competition for land, and logistical constraints make marine transport challenging despite its potential benefits.

Considering these limitations, the following recommendations related to the waste infrastructure regionally were developed:

- **Recommendation I-1: Increase recycling capacities to reduce travel distances.** Increase investment in regional recycling infrastructure, specifically Material Recovery Facilities (MRFs), near high waste generation centers as these are the regions with the most significant waste generation due to its high population. Limited local processing capacity results in recyclables being transported over long distances, unnecessarily increasing costs and emissions. Enhanced processing facilities in the region would reduce transportation impacts, stabilize local recycling markets, and support increased diversion rates, an objective identified in the Tasks 3 and 5 Memoranda.
- **Recommendation I-2: Explore available capacity for waste movement by rail and water.** Invest in preserving and improving strategic rail infrastructure that supports long-haul waste movement, particularly for areas with limited disposal options, and which mitigates community impacts. Priority investments may include maintaining rail access at Fresh Pond Yard in Queens, upgrading transload facilities, and evaluating opportunities for reactivating underutilized corridors. These targeted enhancements can reduce reliance on long-distance trucking and increase system flexibility, especially in dense urban areas like New York City and Long Island. Infrastructure upgrades modeled on Chicago's CREATE program [8] would significantly reduce truck dependency, alleviate roadway congestion, and reduce environmental impacts. Additionally, a comprehensive study of the regional rail capacity and use can elucidate current rail infrastructure challenges and opportunities.
- **Recommendation I-3: Increase intermodal transfer capacity across modes.** Expand and enhance intermodal infrastructure to improve the transfer of waste between truck, rail and barge. The region's infrastructure limits the potential of modal shifts in waste movement at a significant scale, especially for marine transport, as highlighted in the Task 5 Memorandum. Establishing modern intermodal hubs near urban centers, particularly New York City, similar to the Port of Los Angeles's Waste Transfer Hub [9], can reduce congestion on regional arterials, lower greenhouse gas (GHG) emissions, and improve logistics for waste movement.
- **Recommendation I-4: Modal balance and strategies to address traffic impacts near high-volume waste corridors and facilities.** Waste is primarily transported by truck across the region. Certain areas, particularly urban corridors leading to landfills, transfer stations, and processing facilities, experience high volumes of truck traffic that contributes to congestion, road wear, and environmental burdens. These high-impact nodes should be identified for targeted improvements and assessment for improving movement modal balance. Potential strategies include shifting to alternative modes, upgrading intersections and curb access, reviewing signal timing near facilities, coordinating truck route designations, and evaluating emission mitigation or community buffering investments in overburdened areas.

- ***Recommendation I-5: Modernize and expand Waste-to-Energy Facilities.*** Include Waste-to-Energy (WTE) facilities as part of a long-term regional disposal strategy. Properly designed and regulated, modern WTE facilities can provide in-region capacity for waste disposal, reduce dependence on long-distance landfills, produce energy, and safely handle byproducts such as ash. The recent closure of Hartford, CT's facility demonstrates the political opposition these sites face, but abandoning this infrastructure altogether will constrain the region's options. The CopenHill WTE facility in Copenhagen demonstrates how a modern facility can be safely integrated into urban life and public perception. The facility is located in an industrial area close to the city center and designed as an architectural landmark including public areas, in the form of an artificial ski slope or hiking trails on the rooftop. Apart from the visual advantages and the public participation and engagement, in 2013 the facility was known to be the cleanest WTE plant in the world, emitting CO₂ emissions in sudden, bursting smoke rings, instead of a continuous stream of smoke [10].

3. Opportunities

Interactions and research throughout the execution of this study has identified several emerging ideas, technologies and practices that could potentially improve waste management across the MAP Forum region. While not all these opportunities are currently in place or viable locally, they offer a forward-thinking perspective on implementation to enhance sustainability, efficiency, and resilience in the regional waste system. These opportunities could serve as a foundation for future planning and investment.

3.1. Expansion of Geotab Trial Run

The Geotab pilot project in New York City [11], which is referenced in the Global Positioning Systems (GPS) and truck movement tracking discussions, has demonstrated the potential for real-time telematics to improve the understanding of different waste flows in the region. Though software integration challenges were observed during the trial, Geotab's tracking capabilities, if applied properly, can capture driver behavior, vehicle movement, and cargo characteristics. This data can be analyzed through the Geotab Data Connector to enable powerful visualizations in platforms like Power BI or Tableau.

Expanding such trials across other high-traffic corridors or municipalities in the study area would support optimization of the collection routes. It would also help identify bottlenecks and enforce overweight vehicle restrictions. Broader adoption could also enhance compliance and improve planning accuracy for the modal shift and infrastructure development.

3.2. Expansion of Clean Trucks Program

Electrifying the regional waste truck fleet represents a significant opportunity to lower emissions, reduce fuel costs, and improve air quality in communities disproportionately affected by waste traffic. As indicated during the interviews (refer to the Task 3 Memorandum), waste movement is truck-dominated in the region, and electric vehicle (EV) technology is viable for medium size and even heavy-duty urban freight use. The transition to electric trucks in dense urban environments like New York City, Newark, and Stamford would significantly contribute to GHG reduction targets and reduce local noise and air pollution.

Municipalities such as Los Angeles have begun replacing their diesel waste fleets with electric alternatives, which are supported by public incentives and zero-emission zones. The introduction of a similar initiative, combined with fleet management software like Geotab, could position the MAP region as a national leader in sustainable waste transport.

3.3. Improvement of the Recycling Process

Despite the rebound of recycling markets noted in the Task 3 Memorandum, inefficiencies remain in sorting, contamination management, and localized processing. Many municipalities struggle with outdated infrastructure and limited capacity to handle diverse recyclable streams of waste. Improving recycling processes through better collection systems (e.g., dual-stream separation), investment in advanced MRFs, and public education could significantly increase diversion rates.

The adoption of artificial intelligence (AI)-assisted robotic sorters that are already in use in San Francisco and Toronto have improved recovery of valuable materials while also reducing labor costs and

contamination. In the study area, diversion rates vary dramatically, and such improvements would enhance the systems performance and reduce reliance on landfills or long-haul waste transportation.

3.4. Development of Public-Private Partnerships

As described in the Task 3 Memorandum, participants emphasized the potential of Public-Private Partnerships (PPPs) to foster innovation in zero waste and circular economy strategies. Such partnerships can drive the development of technologies such as anaerobic digesters, advanced composting systems, and material reprocessing hubs that can transform waste into usable products or energy. For example, New Jersey's recent support for a public-private organics recycling plant showcases how government backed schemes can catalyze sustainable infrastructure development in waste movement and generation. Implementing such partnerships in the study area, particularly in under-resourced municipalities, could address infrastructure gaps, promote local economic development, and move the region closer to zero waste goals that are the eventual aim.

3.5. Managing Vehicle Weight Enforcement

Enforcing a strict 80,000-pound weight limit on trucks can inadvertently increase the number of vehicles required to move the same volume of waste and potentially triple truck trips in some places, as stated during the public online workshop on November 10th, 2023 (refer to Task 3 Memorandum). While weight enforcement can enhance road safety and infrastructure longevity, its implications on emissions, traffic, and costs must also be considered. One solution is to combine enforcement with investments in alternative modes such as rail and barge, which are better able to handle bulk loads. Alternatively, policy reform should include variable permit structures or incentives for clean fuel vehicles that offset the externalities of higher truck volumes. This issue spans beyond waste movement which is being addressed in New York City for trucks using weigh-in-motion.

In cities like Portland, Oregon, they have experimented with congestion pricing and emissions-linked permits to balance efficiency and sustainability. This approach could be tailored for the waste sector in the MAP Forum region and aims to balance efficiency and sustainability, making it applicable to other sectors, including waste management.

3.6. Create Awareness for Reduction, Reuse, and Real Recycling

The Task 3 interviews underscored the importance of moving beyond disposal and diversion toward waste reduction and circular economic principles (refer to the Task 3 Memorandum). Local initiatives, such as New York City's "Zero Waste" schools or food rescue programs [12] can significantly cut MSW volumes and transport needs. Also, policy tools like Extended Producer Responsibility (EPR) and deposit-refund schemes would further support upstream reduction and real recycling, not just downstream sorting.

3.7. Climate- and Community-Responsive Infrastructure Siting

Future siting decisions should consider climate risk (e.g., flood zones, heat islands) and community concerns. Coastal waste infrastructure should be climate-resilient, similar to New York City's Lower Manhattan Coastal Resilience plans [4], adapted for waste facilities.

4. Conclusions

The Regional Waste Movement Study has highlighted the complex and multifaceted nature of solid waste generation and movement across a multi-state metropolitan region comprising New York, New Jersey, Connecticut, and Pennsylvania. The study reveals that, while the region generates significant volumes of MSW and C&D debris, which is estimated at over 47 million tons annually and which is expected to grow by approximately 13% by 2050, it currently lacks the in-region infrastructure, governance and long-term strategic planning required to sustain and manage this waste within the region. As a result of limited disposal capacity and local opposition to new facilities, as well as cost considerations, the region relies heavily on exporting its waste to out-of-state facilities, particularly landfills and WTE facilities.

Findings from agency interviews and literature reviews have underscored the fragmented nature of waste governance in the region. Regulatory inconsistencies and limited public data on waste transport routes to facility operations as well as outdated or incomplete SWMPs have hampered efforts to coordinate waste strategies across jurisdictions in the region. The data used in the waste forecasting and infrastructure analysis has gaps, inconsistencies, and incompatible formats, which undermine confidence in future planning efforts.

The life cycle assessment of landfills points to an urgency to find solutions as regional disposal capacity will fall short of demand within the next decade if the current trends continue and if the proposed expansions do not proceed. Jurisdictions within the study area in states like Connecticut and New York face more immediate threats to capacity than those in New Jersey and Pennsylvania, which may intensify regional differences and logistical pressures. While rail and barge transport offer some promise as alternatives to trucking, the infrastructure needed to support these modes being integrated (e.g., intermodal transfer facilities and protected freight corridors) are lacking or under pressure from competing land uses, especially in densely populated areas.

Despite these challenges, the study also identifies promising pathways for improving waste movement in the region, which include: (a) the expansion of rail infrastructure, (b) electrification of truck fleets, (c) improvement of recycling systems and (d) the development of intermodal transport facilities. Public-private partnerships must play a transformative role in advancing circular economy technologies and infrastructure such as anaerobic digesters and advanced MRFs. Importantly, any successful strategy will need to incorporate scenario-based planning to accommodate uncertainties in waste generation, recycling market fluctuations, and climate related disruptions.

Improving the precision of waste movement models should be a priority in the future. This includes enhanced data collection practices and the integration of contractual and fee structures into modeling logic to better be able to track modal choices. These improvements, with continued investment in multimodal infrastructure and zero-waste strategies, will provide the region with the tools necessary to plan proactively for a more resilient waste movement and generation future.

The region stands at a critical juncture as continuing with business-as-usual practices will exacerbate environmental, economic, and equity concerns, while a coordinated, data-driven, and multimodal waste movement strategy presents a viable pathway to improvement. By shifting the focus from mere disposal toward reduction, reuse, and real recycling that is then backed by supportive infrastructure and policy reform, the MAP Forum region can become a national leader in sustainable and adaptive waste movement and generation.

5. References

1. New York Metropolitan Transportation Council. *News and Events*. <https://www.nymtc.org/en-us/News-and-Events#rwms> (last accessed February 14, 2025).
2. New York Metropolitan Transportation Council. *Metropolitan Area Planning (MAP) Forum*. <https://www.nymtc.org/en-us/ABOUT-US/procedures-and-agreements/other-mous/MAP-forum> (last accessed February 15, 2025).
3. Metro Vancouver. *Solid Waste Management Plan*. <https://metrovancover.org/services/solid-waste/solid-waste-management-plan> (last accessed April 4, 2025)
4. City of New York. *Lower Manhattan Coastal Resiliency*. <https://www.nyc.gov/site/lmcr/index.page> (last accessed February 6, 2025)
5. Sopor.nu. *Sweden's e-Avfall Portal*. <https://www.sopor.nu/en/> (last accessed March 12, 2025)
6. EDM Portal. *Elektronisches Datenmanagement (Austria)*. <https://edm.gv.at> (last accessed April 1, 2025)
7. TrainsAreFun. *NY&A Freight Operations – Fresh Pond Yard*. <http://www.trainsarefun.com/lirr/fresh%20pond/freshpond.htm> (last accessed April 1, 2025)
8. CREATE Program. *Chicago Region Environmental and Transportation Efficiency Program*. <https://www.createprogram.org> (last accessed April 1, 2025)
9. Port of Los Angeles. *Environmental Initiatives: Waste Transfer*. <https://www.portoflosangeles.org> (last accessed April 1, 2025)
10. Eric Baldwin (2019). *CopenHill: The Story of BIG's Iconic Waste-to-Energy Plant*. ArchDaily. <https://www.archdaily.com/925966/copenhill-the-story-of-bigs-iconic-waste-to-energy-plant> (last accessed April 16, 2025)
11. GEOTAB *With Vision Zero, NYC takes aim at becoming the world's safest city*. <https://www.geotab.com/blog/vision-zero-nyc/> (last accessed April 4, 2025)
12. GrowNYC. *Zero Waste Schools Program*. <https://www.grownyc.org/zerowasteschools> (last accessed April 4, 2025)