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When can rail evacuation of containers relieve yard congestion and protect throughput at Port Houston's Barbours Cut Container Terminal?

ABSTRACT

As container volumes increase, marine terminals face growing pressure to manage yard occupancy and container dwell time while maintaining efficient throughput. At Port Houston's Barbours Cut Container Terminal, intermodal rail can evacuate containers and free up yard capacity; however, the operational conditions under which rail service meaningfully reduces congestion remain insufficiently defined. This study examines how yard occupancy, container dwell time, rail evacuation capacity, and train frequency interact to determine when rail evacuation becomes operationally effective without reducing terminal throughput. Using scenario-based quantitative analysis, EagleView aerial imagery, Port Houston operating data, and literature-supported parameter ranges, the study develops four operating scenarios: Normal, Elevated, Critical, and Critical with Weak Rail Service. These scenarios will help identify the decision threshold at which rail evacuation releases enough yard capacity to protect terminal throughput. The findings can support rail and intermodal capacity planning at Barbours Cut and contribute to Port Houston's long-term infrastructure and operational planning toward 2040.

INTRODUCTION

Container terminals are a key component in the movement of goods by connecting maritime transportation with inland freight networks. Containers continue to increase; terminals can experience operational challenges when containers accumulate in storage yards faster than they can be removed. High yard utilization and longer container dwell times can limit available storage space, increase handling requirements, and interfere with terminals' ability to efficiently process incoming and outgoing containers. These obstacles are important at high volume facilities like Port Houston's Barbours Cut Container terminals, where keeping a constant movement of containers through the terminals is essential. One potential strategy for reducing pressure on the container yard is increasing the use of rail to evacuate containers from the terminal rather than relying primarily on truck movements. Rail may provide additional capacity for moving large numbers of containers inland; however, its effectiveness depends on terminal demand, yard condition, container dwell time, and available rail capacity. Therefore, this study will look at the conditions under which rail evacuation of containers can reduce yard congestion while preserving terminal throughput at the Barbours Cut Container terminal.

METHODOLOGY

This study uses scenario-based quantitative analysis to determine the conditions under which rail evacuation can reduce yard congestion while maintaining terminal operations at Port Houston's Barbours Cut container terminal. Operating conditions are verified using data on container throughput, yard utilization, dwell time, and evacuation; alternative scenarios then vary container demand and rail evacuation to compare changes in yard utilization and throughput. Rail evacuation is considered effective when it reduces congestion without decreasing throughput relative to baseline conditions—identifying the operating conditions and rail evacuation levels that provide the greatest congestion relief.

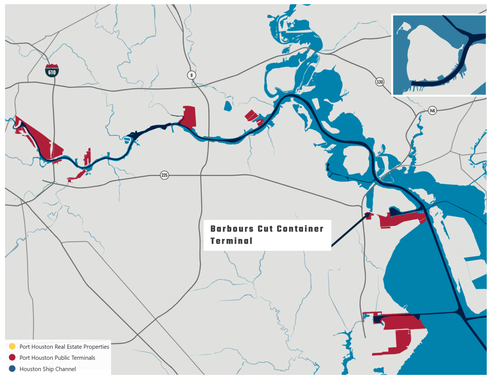
WHY BARBOURS CUT?

- More than 8,000 ft of working track; dedicated near-dock rail ramp with four ~2,700-ft working tracks and five ~2,250-ft storage tracks (Port Houston).
- BNSF and Union Pacific have expanded intermodal service at the terminal.
- Port Houston 2040 Plan prioritizes container capacity, terminal optimization, and rail/intermodal corridors.
- Houston-specific research base enables calibration with local data.

Photorealistic image of Barbours Cut Container Terminal

Eagleview image of Barbours Cut Container Terminal

A MAP OF THE PORT OF HOUSTON



Overview map of the Port of Houston

WHAT LITERATURE SHOWS

- Rail relieves marine-terminal congestion when available train capacity is well utilized (Ng & Talley 2020; Ng et al. 2025; Rathi & Upadhyay 2022).
- Yard congestion is multi-factor: utilization, dwell time, truck activity, storage allocation, and handling capacity (Zhen 2016; Feng et al. 2022; Martin Alcalde et al. 2015; Wang et al. 2025).
- Rail-based hinterland strategies shift flows off the road network (Roso et al. 2009; Hu et al. 2019). Houston evidence: drayage operations (Harrison et al. 2007); AIS-measured vessel congestion (Kang et al. 2022).

RESEARCH GAP

The **operational threshold has not been clearly defined**: the point at which yard occupancy, dwell time, rail capacity, and train frequency allow rail evacuation to reduce congestion enough to protect terminal throughput.

THE VALUE OF ONE TRAIN

1 Train Departure ≈ 240 to 280 TEUs evacuated.

≈ 140 to 160 equivalent truck moves avoided per train departure.

≈ 1.5% to 2.2% of absolute yard capacity released per train block, lowering yard occupancy metrics toward the target safety zones.

≈ 12 to 18 hours gained before hitting critical yard occupancy (85%+) during a dual-vessel unloading cycle.

The throughput is protected with each train departure

KEY VARIABLES

Condition	Measure	Why it matters
Yard occupancy	% of usable yard area occupied	When congestion pressure begins
Container dwell time	Avg. days containers remain	Longer dwell consumes finite capacity
Rail evacuation capacity	TEU/containers per train	How much inventory rail can remove
Train frequency	Trains per day / week	How quickly capacity is released

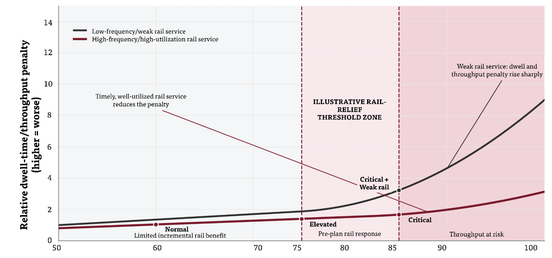
SCENARIO FRAMEWORK

Scenario	Yard occupancy	Rail frequency	Train load	Expected effect
Normal	60%	Low	Moderate	Minimal benefit
Elevated	75%	Moderate	High	Congestion relief
Critical	85%	High	High	Throughput protection
Critical + weak rail	85%	Low	Low	Congestion persists

FINDINGS

Rail evacuation is most effective when yard occupancy approaches critical levels and rail service removes containers faster than new inventory accumulates. Under normal conditions, additional rail departures offer limited benefit; under elevated or critical conditions, frequent, highly utilized departures can release yard capacity and help protect terminal throughput. The benefit depends on more than rail infrastructure. Containers must be released, rail-booked, and ready to move; trains must have sufficient capacity and depart often enough to prevent rail-bound containers from remaining in the yard through later vessel calls. Predictive data can strengthen this response by forecasting yard pressure 48–72 hours ahead using vessel discharge, container dwell risk, release status, truck appointments, rail bookings, and train capacity. This allows the terminal to prioritize rail-ready containers and activate rail service before projected congestion disrupts operations**.**
Key takeaway: Predictive rail evacuation can protect Barbours Cut throughput when timely, well-utilized trains remove rail-ready containers before yard occupancy reaches a critical threshold. Digital tools should support human decision-making through worker training, secure data governance, and operational oversight.

THE RAIL RELIEF THRESHOLD



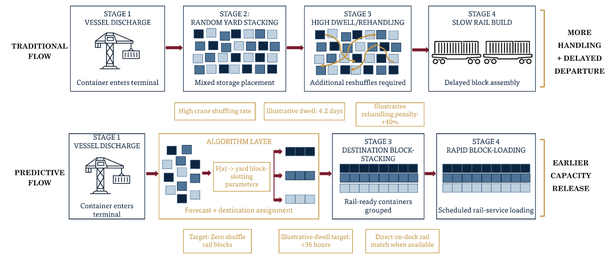
Interpretation: As occupancy enters the threshold zone, frequent, well-utilized rail departures can release capacity before congestion constrains terminal throughput

SUPPORTING EVIDENCE

Rail evacuation is most effective when high-utilization train departures remove rail-ready containers before yard occupancy reaches critical levels. Supporting research identifies dwell time, yard utilization, truck activity, storage allocation, and handling capacity as key congestion drivers. At Barbours Cut, near-dock rail infrastructure and UP/BNSF intermodal connections provide a practical setting to test how predictive visibility and timely rail activation can protect throughput.

PREDICTIVE SORTING & RAIL EVACUATION

Conceptual comparison of conventional and predictive terminal workflows



Research concept: predictive data supports rail-ready block formation; outcomes require validation with Barbours Cut operating data.

PATH FORWARD/CONCLUSION

Calibrate the Rail Relief Threshold using Barbours Cut data on yard occupancy, container dwell, truck gate-outs, rail lift-outs, and train utilization. This will identify when additional or better-utilized rail service provides meaningful congestion relief.
Pilot a 48–72-hour forecast combining vessel discharge, container release status, truck appointments, rail bookings, and train capacity. When projected occupancy approaches the threshold, partners can prioritize rail-ready containers and coordinate timely switching and rail departures.

Planning value

- Shorter dwell time and more reliable container flow
- Better use of near-dock rail capacity
- Fewer rehandles and avoidable truck drayage moves
- Stronger terminal–rail–truck coordination
- Human-centered implementation with secure data governance and worker engagement

REFERENCES & GRAPHICS

References

Graphics and Images

The Rail Relief Threshold

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