From: Raj, Phani (FRA)
To: Clay, Steve (FRA); Fairbanks, Gary (FRA); Holt, Christian (FRA); Kesler, Kevin (FRA); Masci, Michael (FRA); Rouse, Devin (FRA); Shurland, Melissa (FRA); (b) (6) (BWY)"; (b) (6) (FECR.BWY)"
Subject: Conference calls with FECR on LNG tender pilot project
Start: Tuesday, April 12, 2016 11:00:00 AM
End: Tuesday, April 12, 2016 12:00:00 PM
Location: FRA Conference Bridge HQ1; Call in # (b) (6) Pass Code (b) (6)

This conference call is the inaugural meeting with Florida East Coast Railway (FECR) to get bi-weekly updates on their LNG Tender pilot project. It is the intent to hold these bi-weekly meetings every Wednesday at 11 AM except the one on 4/12 (Tuesday) to accommodate Gay Fairbanks schedule.

In your reply please indicate whether 11 AM every other Wednesday is OK with your schedule for meetings with FECR.

Phani

From: Raj, Phani (FRA)
Cc: Gonzalez, Francisco (FRA); Clay, Steve (FRA); Holt, Christian (FRA); Masci, Michael (FRA); Rouse, Devin (FRA); Shurland, Melissa (FRA); (b) (6) (BWY)"; (b) (6) (BWY); (b) (6) "; Maday, Mark (FRA)
Subject: FW: Raj, Phani (FRA) FECR Presentatio fo Risk Analysis Report
Start: Friday, June 16, 2017 9:00:00 AM
End: Friday, June 16, 2017 11:30:00 AM
Location: ConfRm-HQ-W34-101 (FRA)

Florida East Coast Railway and its contractor, Exponent, will be presenting the final version of report on their analysis of risks in transporting LNG by rail in portable tanks.

Please confirm whether you will be able to attend this meeting.

-----Original Appointment-----
From: Raj, Phani (FRA)
Sent: Wednesday, May 17, 2017 10:01 AM
To: Raj, Phani (FRA)
Subject: Raj, Phani (FRA) FECR Presentatio fo Risk Analysis Report
When: Friday, June 16, 2017 9:00 AM-11:30 AM (UTC-05:00) Eastern Time (US & Canada).
Where: ConfRm-HQ-W34-101 (FRA)

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Photo Location Map

No Map Available

Locomotive Details

» Florida East Coast Railroad (FEC) (more..)
» GE ES44C4 (more..)

Location/Date of Photo

» FEC Railway--New Smyrna Beach Yard (more..)
» New Smyrna Beach, Florida, USA (more..)
» December, 2015

Locomotive No./Train ID

» FEC 816 (more..)
» NFX29 (more..)

Photographer

» Kevin Andrusia (more..)
» Contact Photographer

Remarks & Notes

If you've been watching FEC for any length of time, you'll note Dec-Jan are historically when "things happen" with the roster. Dec 2015 is no exception, here we see the "debut" of the FEC LNG program, which has been in the works for a few months now. Today is the first road test with FEC 801-FEC fuel tender 300-GE 3000-FEC 816. Set is pulling from the shop lead and will cross over into yard to get onto siding and head north.

Community Response

Photo Comments (2)

Views: 5,688* **Favorited:** 18
Since added on December 29, 2015

+ Add to Favorites

(b) (2) [redacted]

+ Nominate for People's Choice
+ Subscribe
+ Add to Photo Album
+ Post a Photo Comment

Tweet

* Views on this page updated in real-time.

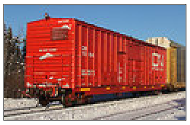
Posted by bradley on December 29, 2015
Hooray!! Bring on more LNG!

Posted by Steve Larson on December 30, 2015
Great shot, Kevin. Curious, what is the role of GE 3000? Is it on loan from GE or something else?

- Post a Comment -

User Photo Albums Containing this Photo (4)

+ Add to Album



Things that would be cool to model in HO scale.

Album Views: 24,717

Album created by member corvette

If you have an HO scale layout or any other scale and like to kit-bash this is this is the album for you!

Exotic

Album Views: 132,176

Album created by member Nathan Richters

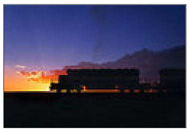
Looking for rare, obscure, or otherwise exotic locomotives? Look here!

Paint Schemes

Album Views: 102,231

Album created by member Nathan Richters

***Not** just heritage schemes, not just commemorative schemes - this album is devoted to some of the world's most interesting paint schemes, past or present.*



DreamTrains

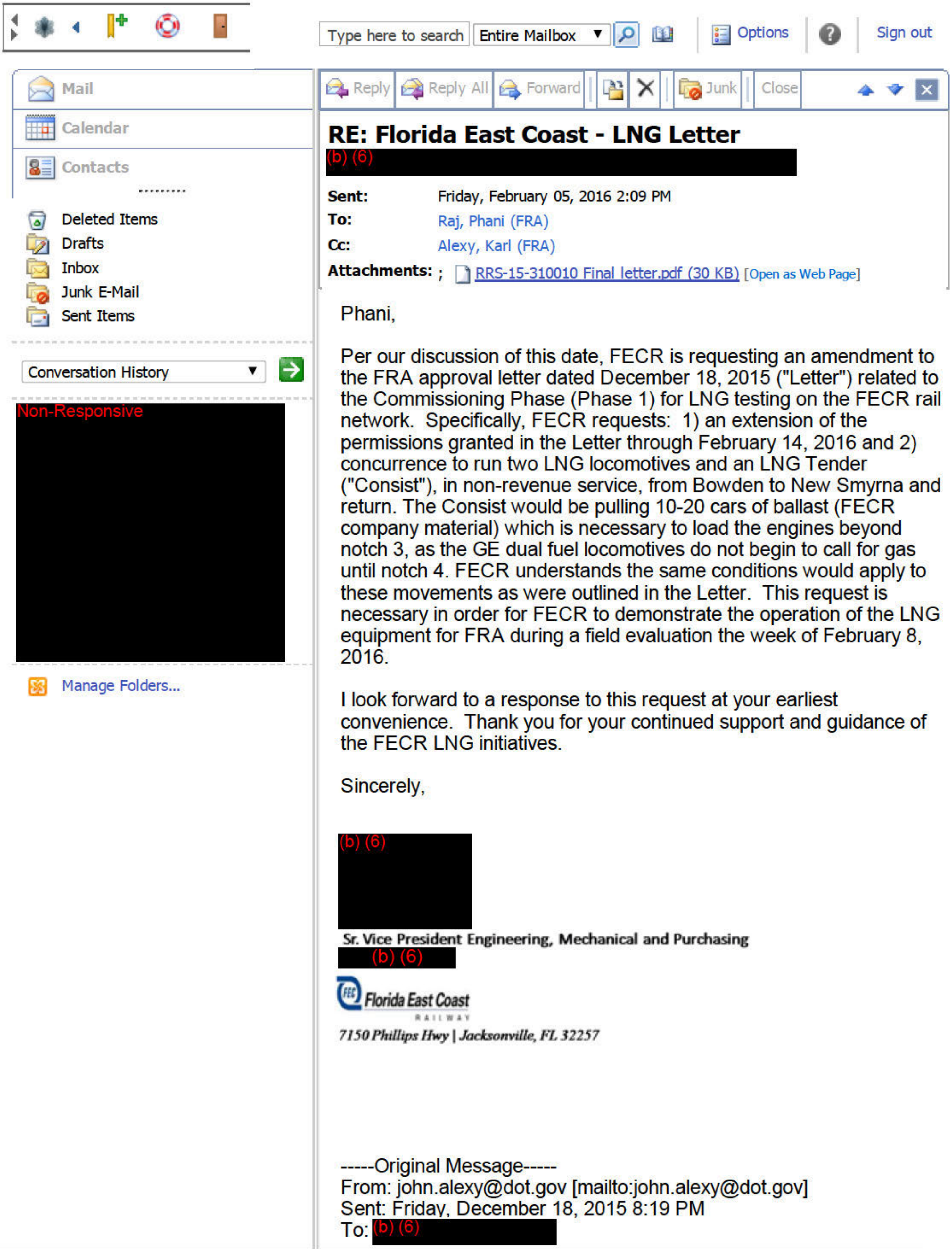
Album Views: 1,359,273

Album created by member coco13cos

Add to Photo Album or Get Your Own Photo Album

EXIF Data for this photo: [What's this?]

No header data found for this image.



RE: Florida East Coast - LNG Letter

(b) (6)

Sent: Friday, February 05, 2016 2:09 PM
To: Raj, Phani (FRA)
Cc: Alexy, Karl (FRA)
Attachments: ; RRS-15-310010 Final letter.pdf (30 KB) [Open as Web Page]

Phani,

Per our discussion of this date, FECR is requesting an amendment to the FRA approval letter dated December 18, 2015 ("Letter") related to the Commissioning Phase (Phase 1) for LNG testing on the FECR rail network. Specifically, FECR requests: 1) an extension of the permissions granted in the Letter through February 14, 2016 and 2) concurrence to run two LNG locomotives and an LNG Tender ("Consist"), in non-revenue service, from Bowden to New Smyrna and return. The Consist would be pulling 10-20 cars of ballast (FECR company material) which is necessary to load the engines beyond notch 3, as the GE dual fuel locomotives do not begin to call for gas until notch 4. FECR understands the same conditions would apply to these movements as were outlined in the Letter. This request is necessary in order for FECR to demonstrate the operation of the LNG equipment for FRA during a field evaluation the week of February 8, 2016.

I look forward to a response to this request at your earliest convenience. Thank you for your continued support and guidance of the FECR LNG initiatives.

Sincerely,

(b) (6)

Sr. Vice President Engineering, Mechanical and Purchasing
(b) (6)

Florida East Coast
RAILWAY
7150 Phillips Hwy | Jacksonville, FL 32257

-----Original Message-----
From: john.alexy@dot.gov [mailto:john.alexy@dot.gov]
Sent: Friday, December 18, 2015 8:19 PM
To: (b) (6)

(b) (2)

Cc: steve.clay@dot.gov; gary.fairbanks@dot.gov; thomas.herrmann@dot.gov; Christian.holt@dot.gov; michael.masci@dot.gov; phani.raj@dot.gov; devin.rouse@dot.gov; Melissa.Shurland@dot.gov
Subject: FW: Florida East Coast - LNG Letter

Fran - please let me know if you have any questions.

Karl

From: Lauby, Robert (FRA)
Sent: Friday, December 18, 2015 5:04:27 PM
To: Alexy, Karl (FRA)
Subject: FW: Florida East Coast - LNG Letter

Karl,

Please forward as appropriate to your contact in Florida.

Bob Lauby

From: Carney, Shari CTR (FRA)
Sent: Friday, December 18, 2015 5:03 PM
To: Alexy, Karl (FRA); Lauby, Robert (FRA)
Subject: Florida East Coast - LNG Letter

Greetings,
Attached you will find a signed copy of a letter mailed to (b) (6) .

Thanks
Shari

Connected to Microsoft Exchange

Raj, Phani (FRA)

From:	(b) (6)
Sent:	Saturday, July 16, 2016 11:27 AM
To:	Raj, Phani (FRA)
Cc:	Clay, Steve (FRA); Fairbanks, Gary (FRA); Shurland, Melissa (FRA); (b) (6)
Subject:	FECR Utilization of GE Resources on LNG
Attachments:	FRA Request for Concurrence - Phase 3 LNG Operations.pdf

Dr. Raj,

As discussed on our bi-weekly LNG conference call with the FRA LNG Team, FECR discussed changing the current practice of having a GE representative onboard each Phase 3 train movement between Bowden and Hialeah. GE representatives were originally included onboard to ensure that train crews gained experience with the equipment and seamless operation of the dual fuel locomotives. FECR crews have gained significant experience (with over 70 LNG train movements over the rail network) and both FECR and GE feel the crews are appropriately knowledgeable, supportive and comfortable with the seamless operation of the LNG consist. Therefore, FECR requests FRA concurrence to utilize the GE riders on LNG trains only as deemed necessary by either FECR or GE. These resources will be utilized elsewhere on the property to progress the conversion of additional FECR locomotives and provide necessary training to our Mechanical employees.

(b) (6)

Sr. Vice President Engineering, Mechanical and Purchasing
(b) (6)
Florida East Coast
RAILWAY
7150 Phillips Hwy | Jacksonville, FL 32257

a) What parts/functions of the tender and locomotive consist will be “inspected” and how, before the consist is placed on trains and at the New Smyrna Locomotive Shop?

LNG locomotives and Tenders will be inspected in accordance with 49 CFR 229 inspection requirements. In addition, the inspector will ensure that the Tender has no visible frost or condensation on ISO tank and no visible or audible leaks from any connections. Frost on the ambient coil or piping is normal as a result of the Tender building pressure prior to consist departure.

Hoses will be inspected to ensure that they are properly connected to the locomotive and are free from visible damage or pinch points. Inspector will also ensure that control panels are closed and latched. FECR will provide training and visual aids to all FECR Train Crews and related employees (e.g. - Mechanical) working on or around the LNG equipment.

b) Qualifications of the individuals who will be performing the inspections, including the level of competency to perform inspections of cryogenic equipment and associated appurtenances.

FECR will utilize Train Crews trained in the basics of LNG and cryogenic liquids in general to inspect the LNG consist. During the Phase 2 testing, FECR will also have GE and LNG experts onboard the locomotive consist. Additionally, a Chart Industries cryogenic expert will be present on initial trips. FECR personnel involved with the LNG initiative will also be onboard to gain knowledge from the Chart and GE experts, gain experience with the equipment and processes and to ingrain LNG into our safety culture at FECR.

c) Types of documents and oversight items that will be generated prior to, during and completion of a test run.

Documents will be required ensuring that each Train Crew operating an LNG consist has received orientation and basic training in LNG. This training is being rolled into FECR annual training programs. Other documents generated prior to a test run will include at minimum:

- Train consist
- Presence of any Hazmat in train (and positioning if present)
- Waybills
- Train dispatching bulletins
- Locomotive inspection report
- Brake test documentation.

d) Parameters that will be measured at the beginning of and during the test, in each run. What are the dependent and independent variable parameters that will be measured? For example, will the buff and draft forces on the tender car be measured and how this will be reported?

In 5 minute intervals, FECR will electronically measure:

- Tender volume
- Tender pressure
- Gas temperature
- Pump speed
- Gas discharge pressure
- Glycol supply/return temperature
- Gas flow rate

Additionally, the request for gas from the locomotive and the Tender acknowledgment of request (handshake) will be recorded for each instance during each test run. The substitution rate and volume of both diesel and natural gas will be monitored for each run.

Excessive buff and draft force alarms are currently being captured for all FECR locomotives through the WiTronix onboard remote monitoring system. The Tender is equipped with a similar WiTronix device which will record excessive forces in both longitudinal and vertical orientations.

e) Details of the appurtenances (valves, breakaway connections, pipes, safety systems) on the tender and how they are protected against impact forces.

FECR shall protect the LNG plumbing appurtenances with Klaw breakaway closure devices currently used in large volume marine transfer service. A mechanical impact to a Klaw breakaway results in LNG flow being terminated in both directions. Breakaway devices are located on all penetrations into and out of the ISO container, with the exception of the vent relief system.

f) In the LNG tender will the cryogenic pumps be operated exclusively to pump LNG through the heat exchanger/vaporizer? Will there be operations with both pumps and internal vapor pressure generated head for the flow? If so how will the performance of the cryogenic pump (at different loads) be tested? What situations would form the baseline of operation with pumps alone? What is the target operating pressure inside the tank?

It is FECR's desire to not saturate the LNG to a greater level than is necessary by a continuous pump operation, as this will add heat to the LNG and shorten the hold time in the Tender. The sole function of the single internal pump is to drive LNG to the two vaporizers. Further analysis during Phase 2 testing is required to fully understand the exact requirements of the pump and relationship with the locomotive(s). Ideally, the target pressure shall be to maintain and deliver an uninterrupted supply of gas volume to two locomotives in notch 8 at a nominal pressure of 120 psig. In order to maintain sub-cool to hold pump prime, “intermittent pressure building” may be required during pump operation.

The actual head and pump pressure to maintain this requirement may vary as the vessel moves down the track and LNG moves in the tank collapsing head pressure. Also it may be found that head pressure may vary based upon the volume of LNG remaining in the tank. Algorithms of pump operation may be altered with additional knowledge gained in Phase 2 testing.

g) What other parameters will be tested or measured to provide a basis for using cryogenic pumps in LNG tenders?

Recognizing that FECR has the first LNG ISO style Tender design with an internal pump, FECR is especially interested in how much heat is being imparted upon the LNG and what level of operation provides the highest reliability and availability of the tender to provide natural gas when locomotives are calling for gas. FECR will perform an operational study during Phase 2 testing to determine the time needed to fulfill locomotive demand for gas. Additionally, long term monitoring of tank pressure will be another parameter to be examined. Finally, the relationship of tank pressure, gas flow rate/notch setting and the resulting pump speed starting point will be evaluated.

h) Are there any way-side systems for data collection of locomotive-tender performance parameters? Also, will there be instrument car in the consist to measure and record various events?

The FECR property has several types of wayside equipment for equipment monitoring. Car performance can be observed from Wheel Impact Load Detection (WILD), hot bearing and dragging equipment and clearance detection systems. An instrumentation car shall not be used in the consist. FECR shall monitor the LNG Tender critical parameters such as pressure and volume of LNG as discussed above.

i) Will there be speed restrictions for the LNG consist train? What are the track speeds in different operating territories?

FECR will operate LNG consist train at track timetable (see attached) speed. This document was in an earlier submittal but shall be resent with current revision.

j) Nature of the train(s) (i.e., the loads on the train) in which LNG consist will be operating.

FECR will operate LNG consists as it would deploy conventional diesel locomotives. Trains are typically powered to approximately 1.10 horsepower per trailing ton (HPTT). Southbound trains often have greater tonnage than Northbound trains. At this time, trains would average between 7,500 and 9,000 tons and be operated by 2 LNG locomotives. FECR is absent of any severe gradient on its rail network resulting in very low gallons of fuel per gross ton mile.

k) Will the trains with LNG consist operate with an absolute block ahead, until PTC becomes active?

Yes, all LNG consist trains will operate under signal indication while on the main track controlled by a centralized traffic control system. In FECR Yards, signals on main track are automatic block signal system. FECR also operates a 40 Hz Automatic Train Control (ATC) signal system with “in-cab” signal aspects as well as wayside signals. Currently, this is the safest conventional signal system used by any railroad in North America. Crews must comply with signal indications or the ATC signal system will bring the train to stop. The company is also currently working on design and installation of an Enhanced ATC (EATC) Positive Train Control (PTC) system overlay that will be used where passenger and freight trains operate on common tracks.

l) What are the test “success” criteria? Also, what are the criteria for immediate stoppage of the test, or termination of the project?

Safety of LNG testing will be the first and foremost measure of success. In addition, FECR intends to monitor performance with several other areas critical for success:

- Crews must remain undistracted from normal duties while operating an LNG consist
- Employees demonstrate proficiency with coupling and uncoupling LNG equipment
- Locomotive transition from gas to diesel operation must be seamless
- Ability to manage pressure within the Tender during consumption cycle
- No difficulty in building or switching with LNG consist within Yards
- Proficiency in safe fueling of LNG equipment
- High availability and reliability of LNG equipment
- Achieve diesel substitution rate as expected
- No degradation of HP from operating with LNG
- Leadership in the rail industry supporting other companies transitioning to LNG

Safety issues that could endanger the Crew, the Public or train movement would result in an immediate stoppage of the test until permanently and effectively resolved. These may include:

- A safety issue that could result in a release of gas
- Mechanical failure of either the Locomotive, Tender or control systems
- Problem or non-compliance with the Tender rail platform as determined by FRA rules
- An unforeseen problem requiring engineering solution to resolve

There is no plan to terminate the LNG fueling initiative on FECR and we are committed to the continuation of the LNG fueling initiative. FECR has made a strategic choice to transition to LNG as have other forms of public transportation, utilities, and private industry. FECR will persevere to ensure safe and successful operation with LNG.

m) Will experts on instrumentation and cryogenics be riding the train or in a chase car? If not, how does FECR propose to handle leak emergencies (small, medium and large releases of LNG or its vapor) and instrument malfunctions during the test?

During the Phase 2 testing, FECR will have GE experts onboard the locomotive consist. Additionally, Chart Industries cryogenic experts will be present on the initial trips. FECR personnel involved with the LNG initiative will also be onboard to gain knowledge from the Chart and GE experts and gain experience with the equipment and processes.

FECR Police are always positioned strategically along the route and will be immediately available by radio in the event wayside support is needed and/or to coordinate with emergency responders. Additionally, the FECR dispatch control office has train position information and radio communications with all trains and will be engaged to make immediate contact with emergency responders as needed.

Leak emergencies are considered unacceptable and must be guarded against. Many of these risks are mitigated with the “fail-closed” design of the Tender. Other features such as breakaway closure devices ensure positive closure in event of mechanical damage to the Tender. Finally, the design incorporates no bottom penetrations for draining the Tender, and check valves incorporated into the design to limit flow to one direction.

In the event of a medium or large scale leak, the Crew will immediately stop the train movement and communicate the situation to the Dispatch Center who will summon the appropriate Emergency Responders to the exact location. Crew will depart the area and position themselves in an upwind position. Subsequent train movement will only be allowed once the situation has been resolved and confirmed by experts. FEC Connect has been made available to Emergency Responders detailing content on each FECR train. In the event of a small release of LNG or natural gas vapor, the train movement will be stopped as soon as practical, evaluated by experts onboard, and the leak shall be resolved by terminating the gas flow from the Tender using the emergency closure button on each end of the Tender. Once the situation has been satisfactorily mitigated the train movement will be allowed to resume. Reporting of such leak occurrences shall be made in accordance with earlier documentation provided to FECR by FRA. In addition, a thorough root cause analysis and corrective action shall be performed.

n) Are the tracks on which the LNG consist will be operating shared with passenger train services? What actions have been initiated by FECR to ensure that passenger trains and LNG consist trains do not interfere with each other’s schedules and operations?

FECR does not operate passenger service on the railroad at this time. And, there are currently no plans to operate passenger trains along the Phase 2 test route. FECR routes will host All Aboard Florida (AAF) passenger trains in the months/years ahead on its route south of Cocoa, FL. This plan includes having PTC implementation on those routes prior to starting this service. Beyond Phase 2, FECR expects to be operating LNG powered trains on these southernmost routes alongside passenger trains. Scheduling for both classes of traffic have not yet been defined, but FECR does not plan to segregate freight trains using LNG as fuel from passenger trains.

U.S. Department
of Transportation

**Federal Railroad
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

FEB 10 2016

(b) (6)
Senior Vice President, Engineering, Mechanical, and Purchasing
Florida East Coast Railway
7150 Philips Highway
Jacksonville, FL 32256

Dear (b) (6):

This reply is in response to Florida East Coast Railway's (FEC) February 5, 2016, email request to the Federal Railroad Administration (FRA) to amend certain provisions of FRA's December 18, 2015, letter of concurrence on the Commissioning Phase (Phase 1) of FEC's liquefied natural gas- (LNG) fueled locomotive project. FEC requested the following amendments to the conditions outlined by FRA:

1. Revision of Condition 1 to allow FEC to complete Phase 1 tests no later than February 14, 2016.
2. Concurrence to run two LNG locomotives and an LNG tender (together referred to as the "Consist"), in non-revenue service, from FEC's Bowden Yard in Jacksonville, FL, to FEC's yard in New Smyrna Beach, FL, and back.

FEC indicates that in order to evaluate the performance of the equipment under conditions similar to expected real-world operating conditions, the Consist will pull 10 to 20 cars of ballast (FEC company material). This load is necessary to ensure the engines are tested and operated using LNG as the sole fuel source, as well as using both LNG and diesel fuel.

FEC indicates this request is necessary to demonstrate the operation of LNG equipment to the FRA staff visiting FEC's Bowden facilities for field evaluations during the week of February 8, 2016.

After careful review, FRA concurs with FEC's request to amend Condition 1 of FRA's December 18, 2015, letter to allow the completion of Phase 1 testing no later than February 14, 2016. FRA also concurs with FEC's proposal to operate the Consist and cars of ballast from FEC's Bowden Yard to FEC's New Smyrna Beach Yard and back. Movement of the Consist from Bowden to New Smyrna Beach will provide an opportunity for FRA staff to ride the Consist and observe the equipment's performance under typical operating conditions.

Therefore, FRA amends Condition 1 of its December 18, 2015, letter to read as follows:

1. FEC must complete Phase 1 not later than February 14, 2016. Throughout Phase 1, FEC must comply with its planned actions outlined in its December 9, 2015, letter to FRA.

FRA concurs with FEC's proposal to operate the Consist in non-revenue service from Bowden to New Smyrna Beach and, no later than February 14, 2016, back to Bowden, under the conditions outlined in FEC's December 9, 2015, letter.

FEC must comply with all other conditions and requirements specified in FRA's December 18, 2015, letter.

FRA's point of contact for the pilot program is Mr. Karl Alexy, Staff Director, Hazardous Materials Division. Mr. Alexy may be reached at (b) (6) or at Karl.Alexy@dot.gov.

Sincerely,

Karl Alexy for

Robert C. Lauby
Associate Administrator for Railroad Safety
Chief Safety Officer

Enclosure

U.S. Department
of Transportation

**Federal Railroad
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

DEC 18 2015

(b) (6)
Senior Vice President—Engineering, Mechanical, and Purchasing
Florida East Coast Railway
7150 Philips Highway
Jacksonville, FL 32256

Dear (b) (6):

This reply is in response to Florida East Coast Railway's (FECR) December 9, 2015, letter requesting FRA's concurrence with the planned Commissioning Phase (Phase I) of FECR's liquefied natural gas (LNG)-fueled locomotive project. FRA understands that the objective of this project is for FECR to evaluate the feasibility of using LNG as a locomotive fuel in its operations.

Your letter outlined the components of Phase I of the FECR's LNG-fueled locomotive project, which includes static operational testing at FECR's New Smyrna Beach (NSB) locomotive shop and limited movement of two LNG-fueled locomotives and an LNG-tender within the confines of FECR's NSB Yard. After reviewing and evaluating FECR's plan for Phase I, as identified in FECR's December 9, 2015 letter, FRA conditionally concurs with all identified components of FECR's Phase I of the project. Upon successful completion of Phase I, FRA concurs with FECR's proposal to operate an LNG locomotive consist in a non-revenue train from NSB to Bowden Yard during the week of December 26, 2015, under the conditions outlined in FECR's letter. FRA understands that the movement of the equipment to Bowden Yard is necessary for FECR to provide training on its LNG project for local FECR employees and other stakeholders (including local emergency responders).

In sum, subject to FECR's compliance with the following conditions, FRA concurs with Phase I of FECR's LNG-fueled locomotive project, as described in its December 9, 2015, letter:

1. FECR must complete Phase I no later than January 31, 2016. Throughout Phase I, FECR must comply with its planned actions outlined in its December 9, 2015, letter.

2. Before any FECR employee operates or conducts any testing involving LNG equipment, FECR must provide that employee appropriate hazardous materials training for the LNG equipment.

3. FECR must ensure that local emergency responders responsible for responding to emergencies in the geographic vicinity of the NSB locomotive shop and yard, at the Bowden Yard, and along the route between NSB and the Bowden Yard, receive

appropriate hazardous materials training for LNG equipment prior to the first loading of LNG into the tender during implementation of Phase I.

4. FECR must inform FRA of any abnormal pressure rise in the tender tank, the occurrence of any equipment alarms, or venting events, any accident or incident, or other release of LNG within 24 hours of occurrence. Within 30 calendar days of any such event, FECR must provide FRA a detailed written report identifying the root cause(s) for the occurrence and measures taken to prevent future such events.

5. FECR must provide FRA a report of "out-of-service events" as defined by the original equipment manufacturers within 30 days of any such events.

If there are any additional questions regarding this letter, please contact Mr. Karl Alexy, Staff Director, Hazardous Materials Division, at (b) (6) or John.Alexy@dot.gov.

Sincerely,

Robert C Lauby

Robert C. Lauby
Associate Administrator for Railroad Safety
Chief Safety Officer

U.S. Department
of Transportation

Federal Railroad Administration

1200 New Jersey Avenue, SE
Washington, DC 20590

MAR 04 2016

(b) (6)
Senior Vice President–Engineering, Mechanical, and Purchasing
Florida East Coast Railway
7150 Philips Highway
Jacksonville, FL 32256

Dear (b) (6):

This letter is in response to Florida East Coast Railway's (FEC) request to the Federal Railroad Administration (FRA) for concurrence with proposed Phase 2 of FEC's liquefied natural gas (LNG)-fueled locomotive project. FEC submitted its initial request for FRA's concurrence on December 16, 2015, amended that request on January 8, 2016, and in response to FRA's request, submitted additional clarifying information on January 22, 2016.

Based on the information submitted, FRA understands that the objective of Phase 2 is to test in-revenue service, the technical performance of FEC's LNG-fueled locomotives and tenders, and the applicable operational procedures. FEC's letter outlined the components of its planned Phase 2 testing, including the operation of LNG consists (two dual-fuel locomotives, coupled to an LNG tender) in-revenue service trains on two to three round trips per week between FEC's Bowden Yard to its New Smyrna Beach (NSB) Yard, a round trip of approximately 230 miles.

FRA previously conditionally concurred with FEC's planned Phase 1 of this project (the Commissioning Phase) and based on FRA's review of the results of Phase 1 and the additional information FEC provided in support of its proposed Phase 2, FRA concurs with FEC's proposed Phase 2 testing, as described in its written communications to FRA dated December 16, 2015, January 8, 2016, and January 22, 2016, and subject to FEC's compliance with the following conditions:

1. FEC shall complete Phase 2 no later than May 31, 2016. Throughout Phase 2, FEC shall comply with its planned actions outlined in its written submissions to FRA.
2. Before any FEC employee operates or conducts any testing involving LNG equipment, FEC shall provide that employee appropriate hazardous materials training related to the equipment or LNG in general.
3. During on-the-road tests, to the extent possible, the tender shall be operated at the lowest possible tank operating pressure consistent with the locomotive demand for natural gas, using only the cryogenic pump and built up pressure head in the tender

tank for supplying gas to the locomotive.

4. During on-the-road tests, FEC shall monitor, measure, and evaluate the operating parameters of the cryogenic pump, the pressure in the tender tank, and the pump's heat input to the LNG. This data will provide baseline information on the efficacy and safety of operating LNG tenders with cryogenic pumps only. At the conclusion of Phase 2, FEC shall report to FRA the detailed data gathered.

5. FEC shall stop the train movement or other test immediately if any safety issues arise that could endanger the crew, the public, or the train movement itself. The test shall not resume until the problem is effectively resolved and the potential danger is abated. FEC shall inform FRA within 24 hours of any such occurrence.

6. FEC shall inform FRA of any abnormal pressure rise in the tender tank, the occurrence of any equipment alarms, or venting events, any accident or incident, or other release of LNG within 24 hours of occurrence.

7. FEC shall provide FRA a report of "out-of-service events" as defined by the original equipment manufacturers within 30 days of any such events. In addition, within 30 calendar days of any event subject to condition numbers 5 or 6 above, FEC must provide FRA a detailed written report identifying the root cause(s) for the occurrence and measures taken to prevent future such events.

8. Before the first loading of LNG into any tender during Phase 2, FEC must ensure that local emergency responders responsible for responding to emergencies in the geographic vicinity of the NSB Yard, the Bowden Yard, and along the route between NSB and the Bowden Yard receive appropriate hazardous materials training for LNG equipment.

If there are any additional questions regarding this letter, please contact me at (b) (6) (b) (6) or John.Alexy@dot.gov.

Sincerely,

Karl Alexy
Staff Director, Hazardous Materials Division

FEC Florida East Coast
RAILWAY, L.L.C.

7150 Philips Highway
Jacksonville, Florida 32256
(904) 279-3119

December 16, 2015

Dr. Phani Raj
General Engineer HazMat
Federal Railroad Administration
Hazardous Materials Division, West Building
1200 New Jersey, Avenue S. E.
Washington DC, 20590

Subject: Florida East Coast Railway (FECR) Phase 2 LNG Locomotive Test Plan

Dr. Raj,

Florida East Coast Railway (FECR) is pleased to provide FRA with this detailed overview for Phase 2 of the FECR LNG locomotive testing to begin in January 2016.

Phase 2 - Bowden Yard - New Smyrna – 116 miles
The initial FECR LNG consist will be comprised of a FEC 800 LNG dual fuel locomotive coupled to the FEC 300 LNG Tender, which will be coupled to GECX3000 LNG dual fuel locomotive ("LNG Consist").

FECR plans to operate the LNG Consist between Bowden Yard (Jacksonville, FL) to New Smyrna Beach, FL until such time as FECR is satisfied it can demonstrate consistent safe operations and has met the requirements and intent of the test plan. While FECR's test success is condition based as opposed to time based, FECR anticipates this phase of testing to last approximately 3 months.

FECR has completed training with First Responders along the entire mainline test route from Bowden Yard to New Smyrna Beach. FECR will continue to remain in close contact with First Responders throughout this phase of testing providing them information and updates as required.

FECR plans to run the LNG locomotive consist 2-3 round trips per week within the constraints of the current FECR Train Operating Plan. The schedule will be anchored on the operation of the Bowden to Ft. Pierce, FL FECR Train 111 and the Ft. Pierce, FL to Bowden FECR Train 212. The schedule will run in a repeating, two week cycle as outlined below:

Week 1	**Week 2**
Sunday 111	Sunday 212
Monday 212	Monday 111
Tuesday 111	Tuesday 212
Wednesday 212	Wednesday 111
Thursday 111	Thursday 212

On FECR Train 111, the LNG Consist will run on the head end of the train. Directly behind the LNG Consist will be one (1) or two (2) conventional FECR road locomotives (GE ES44C4 or EMD SD40-2) required to power the train once the LNG consist is cut off in New Smyrna Beach. FECR may also elect to have a conventional road locomotive (GE ES44C4 or EMD SD40-2) in the lead of the train.

Upon arrival in New Smyrna Beach, the LNG Consist will be cut away from Train 111 and yarded. FECR Train 111 will continue to Ft. Pierce, FL with non-LNG locomotives. The LNG Consist will be turned on the New Smyrna "wye" and prepared for use of the Northbound Train 212 from New Smyrna to Jacksonville.

During this time between Train 111 and Train 212, the LNG Consist will be inspected at New Smyrna Beach Locomotive Shop for basic functions, mechanical attributes and variables and for proper operation.

When northbound FECR Train 212 arrives in New Smyrna from Ft. Pierce, the original power will be cut away from the train and the LNG Consist will be coupled to the head prior to departure for Bowden Yard in Jacksonville.

Upon arrival in Bowden Yard, the LNG Consist will be uncoupled, turned on the wye track, inspected and serviced as to be prepared for the next southbound Train 111 trip. If the number of cars on the revenue train for this short move is light, FECR may utilize a conventional SD40-2 diesel locomotive(s) to provide resistive force through dynamic braking to simulate the load of a larger train.

The LNG Consist will be subjected to a pre-trip inspection in according with documented FECR procedures. FECR will utilize an experienced FECR crew, previously trained on the properties and operation of LNG as a locomotive fuel, to operate the LNG Consist. Additionally, FECR will have a GE LNG engineering representative onboard the LNG Consist at all times for each run.

FECR requests FRA support and concurrence with the steps listed above so that we can remain on schedule. In the next few weeks FECR will provide FRA with an outline of "Phase 3 LNG Testing" to be conducted on the general system in 2016-17 which will include additional LNG locomotive conversions and Tenders.

FECR continues to be appreciative of the guidance and support from FRA in regard to testing LNG in railroad operations on our network.

Sincerely,

(b) (6)

[redacted]

Senior Vice President
Engineering, Mechanical and Purchasing

U.S. Department
of Transportation

**Federal Railroad
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

JUN - 3 2016

(b) (6)
Senior Vice President-Engineering, Mechanical, and Purchasing
Florida East Coast Railway
7150 Philips Highway
Jacksonville, FL 32256

Dear (b) (6):

This letter is in response to Florida East Coast Railway's (FEC) March 31, 2016, letter requesting the Federal Railroad Administration's (FRA) concurrence with proposed Phase 3 of FEC's liquefied natural gas (LNG)-fueled locomotive project. Previously, FRA concurred with FEC's proposed Phase 2 of this project involving use of FEC's LNG consists in limited revenue service trains. FRA conditioned its concurrence with Phase 2 on FEC completing the phase by May 31, 2016. FEC's March 31, 2016, letter indicates that, although Phase 2 is not yet completed, to ensure continuity FEC is requesting FRA's concurrence with its proposed Phase 3 before FEC completes Phase 2.

In its March 31, 2016, letter, FEC indicates the objectives of its Phase 3 tests are consistent with those of Phase 2, with the addition of incremental incorporation of additional LNG equipment over an extended operational testing area. Specifically, in its March 31, 2016, letter, FEC lists the following principal components of its proposed Phase 3 testing and operations:

1. Extension of the geographic operational test area from Jacksonville, Florida, to FEC's Hialeah Yard near Miami, Florida. (This extends the Phase 2 operational test area about 250 miles, from Jacksonville to New Smyrna Beach, Florida);

2. Perform Phase 3 testing for 24 months (from June 1, 2016, through May 31, 2018);

3. Incrementally incorporate up to 23 additional LNG dual-fueled locomotives, 6 in the fourth quarter of 2016 and 17 in 2017. Convert FEC locomotives numbered FEC 803–808 beginning in the third quarter of 2016, and complete the conversions by the end of 2016. FEC will complete conversion of the remaining locomotives during 2017. FEC will convert the locomotives at its facilities and under the supervision of a representative of each locomotive's original equipment manufacturer (OEM). Each locomotive will be the same design as the current FEC 800 locomotive;

4. Incrementally bring 13 additional LNG fuel tenders online to support FEC's LNG dual-fueled locomotive fleet. Each tender will be the same design as the current FEC 300 tender;
5. Increase the number of revenue service trains in which the LNG consists will be tested, ensuring that each new LNG tender-locomotive combination is tested under the conditions outlined in FRA's March 4, 2016, letter before tested in revenue service in Phase 3;
6. Refuel the tenders at both Bowden Yard in Jacksonville and at Hialeah Yard near Miami; and
7. Operate the LNG consist in trains in and through rail facilities in Titusville, Fort Lauderdale, Fort Point, City Point, Medley, Jacksonville, and Hialeah, Florida.

Based on FRA's review of the information submitted in FEC's March 31, 2016, letter and FRA's understanding of the findings of Phase 2 to date, FRA concurs with FEC's proposed Phase 3 testing subject to FEC's compliance with the following requirements:

1. FEC must complete Phase 3 testing, as described in FEC's March 31, 2016, letter by May 31, 2017;
2. FEC must adhere to its planned actions outlined in its March 31, 2016 (Attachment 1);
3. FEC must comply with numbered conditions 2 through 7 of FRA's March 4, 2016, letter (Attachment 2);
4. FEC must adopt and comply with locomotive OEM-provided procedures for purging the locomotives of natural gas and other safety checks before moving the equipment indoors;
5. FEC must provide to FRA a document describing any OEM recommendations for shop upgrades and modifications related to the locomotive conversion operations. The document must list each OEM's recommendations and whether those recommendations are necessary to ensure the proper and safe conversion of the locomotives along with FEC's plan for implementing the identified modifications or upgrades;
6. FEC must identify the specific locations where the LNG equipment (locomotives and tenders) will be purged of LNG and natural gas and how FEC will protect (e.g., with Blue Flag) these areas while purging operations are underway;
7. FEC must provide employees working with the locomotive retrofit or modifications familiarity training on the use of hand-held methane detectors along with followup processes in the event of activation of the detectors;

8. FEC must notify FRA in writing if and when it introduces new LNG consists into revenue service trains as part of the test operations; and
9. Before the first loading of LNG into any tender during Phase 3, FEC must ensure that local emergency responders in the vicinity of Bowden Yard (near Jacksonville), the New Smyrna Beach Yard, Hialeah Yard (near Miami), and along the route between the Hialeah and Bowden Yards receive appropriate hazardous materials training on LNG properties, potential hazards, proper use of LNG compatible equipment, and correct procedures to handle an LNG release (or potential release) emergencies.

If you have any questions, FRA's point of contact for this issue is Mr. Kurt Eichenlaub, Acting Staff Director, Hazardous Materials Division. Mr. Eichenlaub may be reached at (b) (6) or Kurt.Eichenlaub@dot.gov.

Sincerely,

Robert C Lauby

Robert C. Lauby
Associate Administrator for Railroad Safety
Chief Safety Officer

Attachment 1: FEC letter dated March 31, 2016
Attachment 2: FRA letter of concurrence dated March 4, 2016, on Phase 2

Florida East Coast
RAILWAY, L.L.C.

7150 Philips Highway
Jacksonville, Florida 32256
(904) 279-3119

March 31, 2016

Dr. Phani Raj
HazMat Division
Federal Railroad Administration
Hazardous Materials Division, West Building
1200 New Jersey, Avenue S. E.
Washington, DC 20590

Subject: Florida East Coast Railway Request for Concurrence for Phase 3 LNG Operations

Dr. Raj,

Florida East Coast Railway (FECR) continues to safely and successfully operate the LNG Consist (FEC 800, FEC 300 Tender and GECX 3000) under the requirements of FRA Phase 2 concurrence letter dated March 4, 2016 and expiring May 31, 2016. During Phase 2 operations, FECR has complied with all regulations and requirements as well as the guidance and special instructions provided by FRA in previous correspondence for Phase 1.

LNG Phase 1 and Phase 2 operations have provided FECR with data, experience and knowledge for managers, craft employees and equipment suppliers through the operation of scheduled revenue Trains 111 and 212. Information continues to be collected and shall be provided to FRA as requested in the Phase 2 concurrence letter.

Key measures of success with regard to FECR LNG operation include:

1) **Safety Policy and Procedures**
Safety procedures with regard to LNG as a locomotive fuel have been demonstrated throughout Phase 1 and Phase 2 LNG operations and have become standard operating practices for FECR daily LNG operations. These practices have been demonstrated in daily routine events such as: preparing the LNG Consist for train operations, Yard operations, and in mainline revenue service between Jacksonville and New Smyrna Beach, FL. FECR LNG train runs have included craft employees, managers and representatives from GE and Chart onboard to gain experience with the equipment and seamlessness of the dual fuel locomotives and Tender. Further, FECR has selected specific employees for training on the LNG cryogenics and equipment at all three FECR shop locations (Bowden Yard, New Smyrna Beach Yard and Hialeah Yard).

2) **Employee Training and Orientation**

Training for FECR employees has been successfully developed and implemented for personnel engaged in LNG operations, including those craft employees in Train and Engine service, Dispatchers and Mechanical and Car personnel. All operating rules classes include LNG information and prior to any employee operating LNG equipment a thorough review of the Tender and locomotives are performed. This training will continue to be refined to ensure FECR has the most comprehensive program in the industry.

3) **Emergency Responder Training**
Training has been conducted for Emergency responders along the route through the support of FECR Police. Additional sponsorship was also provided to the Jacksonville Fire School for LNG training. Reviews of equipment have been provided to responders to allow familiarity with the LNG Tender and locomotives.

4) **LNG Fueling Operations**
Fueling of the Tender has been performed using the FECR purpose-built LNG Fuel Transfer Station at Bowden Yard. This state-of-the-art facility was designed specifically for the safe transfer of LNG from delivery vessel to the LNG Tender. Each of these fueling events has been performed successfully and as designed.

5) **LNG Train Operations**
Each FECR LNG Consist will be comprised of two (2) dual fuel GE ES44C4 locomotives and a Chart Industries 10K gallon (nominal) Tender coupled between the locomotives. Trains powered with an LNG Consist may also incorporate a third diesel powered locomotive in the trailing position as necessary to provide adequate horsepower for the train tonnage.

FECR plans to prepare and build the LNG Consist at both Bowden Yard and Hialeah Yard. Each LNG Consist will be subjected to a pre-trip inspection in accordance with documented FECR procedures and training with regard to the properties and operation of LNG as a locomotive fuel. FECR will use OEM reference materials as criteria for these inspections.

Prior to operation of the LNG Consist and before using in train service Mechanical forces will inspect the LNG dual fuel locomotives and Tender for all regulatory requirements as well as LNG specific requirements.

Upon arrival at each terminus point, the LNG Consist will be uncoupled from the train and delivered to Mechanical forces as a 3-piece Consist for post-trip inspection and routine servicing. Servicing will include normal activities such as diesel fueling, lubrication and sanding. The Consist will also be moved to an LNG fueling facility for filling the LNG Tender. At Hialeah, the Tender will be fueled by FECR affiliate, New Fortress Energy (NFE). At Bowden Yard, the Tender will be filled by a qualified 3rd party LNG operator. FECR will monitor the rollout of LNG trains carefully and will ensure crew members remain in compliance for training. FECR will perform pre-trip reviews of each new scheduled train prior to rollout and will seek crew feedback in post-trip analysis. The team will perform audits of the LNG process to ensure the Process Safety Management protocol is observed. Audits will be performed by LNG program and safety officers with oversight by FECR senior management.

Request for Concurrence for Phase 3 LNG Operations

As previously discussed with FRA in relation to Phase 3 LNG operations, FECR is requesting consideration for a longer term and FRA support to incorporate incremental LNG equipment as is brought online. To ensure continuity with personnel, supplier representatives and the supply chain related to LNG, FECR is requesting this in advance of the expiration of Phase 2 operational testing which is May 31, 2016.

FECR requests that Phase 3 LNG operations would provide the opportunity to run LNG powered trains, with normal 2-man crews, in routine scheduled revenue train service from Jacksonville to Hialeah, FL for a period of 24 months. This would include LNG service on any or all of the existing scheduled trains currently in operation.

Southbound Trains		**Northbound Trains**	
Train 101	Jacksonville to Miami	Train 202	Miami to Jacksonville
Train 107	Jacksonville to Miami	Train 210	Miami to Jacksonville
Train 109	Jacksonville to Miami	Train 212	Titusville to Jacksonville
Train 111	Jacksonville to Titusville	Train 218	Ft. Lauderdale to Jacksonville
Train 117	Jacksonville to Ft. Lauderdale	Train 222	Miami to Jacksonville
Train 121	Jacksonville to Miami	Train 224	Ft. Lauderdale to Jacksonville
Train 123	Jacksonville to Ft. Lauderdale	Train 226	Miami to Jacksonville
Train 141	Extra South	Train 240	Extra North
Train 191	Ft. Pierce to Hialeah	Train 290	Medley to Ft. Pierce
Train 335	City Point to Hialeah	Train 336	Medley to City Point

Prior to initiation of Phase 3 LNG operations, FECR would be required to:

1) Ensure LNG orientation and training for all employees engaged in LNG service. This would include all Train and Engine employees, Transportation Managers, Mechanical Manager and Mechanics, Contractors and Suppliers that would be involved in the LNG operations. This training would follow the FECR Process Safety Management Protocol provided to FRA previously prepared by safety specialist, Chilworth-Dekra, as a portion of materials in Phase 1. Further training materials are being prepared such as video components that incorporate specific FECR operations from orientation to specific operations.

2) Ensure LNG training of Emergency Responders along the route extending south of New Smyrna Beach to include Response Centers in each county. This training has been

coordinated by FECR Police and Property Protection in cooperation with protocol that exists between emergency response departments.

3) Continued revision and publication of all FECR operating practices and special instructions for LNG operations as a result of learning and experience gained from Phase 1 and Phase 2 of LNG operations. These instructions may be in the form of Train Messages, Bulletins, Operating Rules, or Timetable instructions.

4) Complete specific training of Mechanical forces to begin LNG locomotive conversions at the FECR New Smyrna Beach Locomotive Shop. This training will include engine removal conversion and reinstallation as well as LNG control systems installation. Locomotive training will be provided by General Electric and will serve to greatly enhance the knowledge and expertise of the Mechanical forces that will maintain LNG locomotives in the future.

Incremental LNG locomotives and Tenders will be added to the fleet to support the Phase 3 Operational testing. FECR expects to incorporate up to twenty-three (23) additional LNG dual fuel locomotives, six (6) in Q4 2016 and seventeen (17) in 2017. FECR locomotives FEC 803 - 808 will be converted at the FECR New Smyrna Beach Locomotive Shop beginning in Q3 2016 and will be completed by the end of 2016. Remaining locomotives of the mainline fleet will be converted during 2017 to complete the initial conversion process with minor modifications being added by the OEM, as available. FECR locomotives 801 and 802 are currently at the GE facility in Erie, PA and will return in Q1 2017 as fully validated units expected to burn LNG at a diesel substitution rate of 75%. Additionally, thirteen (13) Tenders are expected to come online to support the twenty-four (24) LNG locomotives in the FECR fleet. Each Tender and locomotive will be the same design as the current FEC 800 locomotive and FEC 300 Tender.

Prior to operating on any other part of the FECR network, each incremental LNG Consist (2 locomotives and a Tender), will be operated between Bowden Yard and New Smyrna Beach under the original guidelines required for Phase 2 LNG Operations until each Consist is validated with respect to proper LNG functionality.

FECR continues to be appreciative of the guidance and support from FRA in regard to LNG as a locomotive fuel in railroad operations. I look forward to continuing the positive relationship with FRA and receiving a timely response to the FECR request for Phase 3 LNG operations.

Sincerely,

(b) (6)

(b) (6)
Senior Vice President
Engineering, Mechanical and Purchasing

U.S. Department
of Transportation

**Federal Railroad
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

MAR 04 2016

(b) (6)

Senior Vice President–Engineering, Mechanical, and Purchasing
Florida East Coast Railway
7150 Philips Highway
Jacksonville, FL 32256

Dear (b) (6)

This letter is in response to Florida East Coast Railway's (FEC) request to the Federal Railroad Administration (FRA) for concurrence with proposed Phase 2 of FEC's liquefied natural gas (LNG)-fueled locomotive project. FEC submitted its initial request for FRA's concurrence on December 16, 2015, amended that request on January 8, 2016, and in response to FRA's request, submitted additional clarifying information on January 22, 2016.

Based on the information submitted, FRA understands that the objective of Phase 2 is to test in-revenue service, the technical performance of FEC's LNG-fueled locomotives and tenders, and the applicable operational procedures. FEC's letter outlined the components of its planned Phase 2 testing, including the operation of LNG consists (two dual-fuel locomotives, coupled to an LNG tender) in-revenue service trains on two to three round trips per week between FEC's Bowden Yard to its New Smyrna Beach (NSB) Yard, a round trip of approximately 230 miles.

FRA previously conditionally concurred with FEC's planned Phase 1 of this project (the Commissioning Phase) and based on FRA's review of the results of Phase 1 and the additional information FEC provided in support of its proposed Phase 2, FRA concurs with FEC's proposed Phase 2 testing, as described in its written communications to FRA dated December 16, 2015, January 8, 2016, and January 22, 2016, and subject to FEC's compliance with the following conditions:

1. FEC shall complete Phase 2 no later than May 31, 2016. Throughout Phase 2, FEC shall comply with its planned actions outlined in its written submissions to FRA.

2. Before any FEC employee operates or conducts any testing involving LNG equipment, FEC shall provide that employee appropriate hazardous materials training related to the equipment or LNG in general.

3. During on-the-road tests, to the extent possible, the tender shall be operated at the lowest possible tank operating pressure consistent with the locomotive demand for natural gas, using only the cryogenic pump and built up pressure head in the tender

tank for supplying gas to the locomotive.

4. During on-the-road tests, FEC shall monitor, measure, and evaluate the operating parameters of the cryogenic pump, the pressure in the tender tank, and the pump's heat input to the LNG. This data will provide baseline information on the efficacy and safety of operating LNG tenders with cryogenic pumps only. At the conclusion of Phase 2, FEC shall report to FRA the detailed data gathered.

5. FEC shall stop the train movement or other test immediately if any safety issues arise that could endanger the crew, the public, or the train movement itself. The test shall not resume until the problem is effectively resolved and the potential danger is abated. FEC shall inform FRA within 24 hours of any such occurrence.

6. FEC shall inform FRA of any abnormal pressure rise in the tender tank, the occurrence of any equipment alarms, or venting events, any accident or incident, or other release of LNG within 24 hours of occurrence.

7. FEC shall provide FRA a report of "out-of-service events" as defined by the original equipment manufacturers within 30 days of any such events. In addition, within 30 calendar days of any event subject to condition numbers 5 or 6 above, FEC must provide FRA a detailed written report identifying the root cause(s) for the occurrence and measures taken to prevent future such events.

8. Before the first loading of LNG into any tender during Phase 2, FEC must ensure that local emergency responders responsible for responding to emergencies in the geographic vicinity of the NSB Yard, the Bowden Yard, and along the route between NSB and the Bowden Yard receive appropriate hazardous materials training for LNG equipment.

If there are any additional questions regarding this letter, please contact me at (b) (6) (b) (6) or John.Alexy@dot.gov.

Sincerely,

Karl Alexy
Staff Director, Hazardous Materials Division

U.S. Department
of Transportation

**Federal Railroad
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

SEP 12 2016

(b) (6)
Senior VP-Engineering, Mechanical and Purchasing
Florida East Coast Railway
7150 Phillips Highway
Jacksonville, FL 32256

(b) (6):

This response is in reply to your letter dated June 14, 2016, to the Federal Railroad Administration (FRA) requesting concurrence for increasing the time period for Phase 3 testing of Liquefied Natural Gas locomotives on the Florida East Coast Railway. The reason for the longer time period, as stated in your letter, is due to the equipment's procurement schedule over the next 12–18 months.

FRA understands the challenges of procuring new equipment; therefore, FRA modifies the time period for Phase 3 Concurrence stated in requirement 1 of the June 3, 2016, letter to May 31, 2018. All other requirements remain the same.

FRA's point of contact for this issue is Mr. Gary G. Fairbanks, Staff Director, Motive Power and Equipment Division. Mr. Fairbanks may be reached at (b) (6) or Gary.Fairbanks@dot.gov.

Sincerely,

Robert C Lauby

Robert C. Lauby
Associate Administrator for Railroad Safety
Chief Safety Officer

U.S. Department
of Transportation

**Federal Railroad
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

NOV 04 2016

(b) (6)
Senior Vice President–Engineering, Mechanical, and Purchasing
Florida East Coast Railway
7150 Phillips Highway
Jacksonville, FL 32256

Dear (b) (6):

This reply is in response to Florida East Coast Railway's (FEC) July 16, 2016, email to the Federal Railroad Administration (FRA) requesting that FRA modify a letter of concurrence. FEC has been performing pilot program tests to evaluate the feasibility of and safety issues related to using liquefied natural gas (LNG) as a locomotive fuel. The current practice is to have a General Electric (GE) representative onboard each LNG consist train operating between Bowden and Hialeah, FL.

FEC requested FRA's concurrence to operate revenue service trains with an LNG tender and dual fuel locomotive as part of a series of pilot test operations. FEC indicated in its letter dated December 16, 2015, requesting a Phase 2 concurrence and its letter dated March 31, 2016, requesting a Phase 3 concurrence that FEC would have an LNG engineering representative from the locomotive manufacturer (GE) onboard the LNG consist at all times. This was to ensure that train crews gained experience with the equipment and a seamless operation of the dual fuel locomotives. FRA issued concurrence letters for Phases 2 and 3 on May 4, 2016, and June 3, 2016, respectively. Currently, FEC is conducting Phase 3 tests.

FRA acknowledges FEC's justification to discontinue the practice of a GE representative riding in each LNG consist because FEC crews have gained significant experience with over 70 LNG-fueled train movements over its rail network. Both FEC and GE feel the crews are appropriately knowledgeable, supportive, and comfortable with the seamless operation of the LNG consist. However, FEC may request the participation of a GE representative in the LNG consist if there is a benefit.

After a careful review of FEC's request by technical staff, FRA determined that having a GE representative in each of the LNG consist train is not necessary. The absence of a GE representative does not adversely impact the safety of operating an LNG consist train. FRA concurs with FEC in suspending the practice of having a GE representative in each of the LNG consists. Furthermore, FRA also concurs with FEC that if a situation arises when the presence of a GE representative in the LNG consist is beneficial, the practice may be reinstated on a case-by-case basis.

FRA's point of contact on this matter is Mr. Gary Fairbanks, Staff Director, Motive Power and Equipment Division. Mr. Fairbanks may be reached at (b) (6) or Gary.Fairbanks@dot.gov.

Sincerely,

Robert C Lauby

Robert C. Lauby
Associate Administrator for Railroad Safety
Chief Safety Officer

U.S. Department
of Transportation

**Federal Railroad
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

OCT 28 2016

(b) (6)
Senior Vice President–Engineering, Mechanical and Purchasing
Florida East Coast Railway
7150 Phillips Highway
Jacksonville, FL 32256

Dear (b) (6)

This reply is in response to your September 9, 2016, letter requesting a formal status update to the revision of Florida East Coast Railway's (FEC) original request for approval to begin shipping LNG in common carrier rail service. FEC had originally petitioned FRA in a September 3, 2014, letter for approval of LNG shipments on its network and subsequently revised the application in a June 7, 2016, letter to limit the LNG transportation to the rail corridors between the Hialeah yard (in Miami) to the Port of Miami, and Hialeah yard to Port Everglades.

The FEC application is currently under review by FRA. We will notify you as soon as the review is complete and a decision is made.

FRA thanks you for your understanding and patience. If you have any questions or concerns, FRA's point of contact is Mr. Kurt Eichenlaub, Acting Staff Director, Hazardous Materials Division, Office of Railroad Safety. Mr. Eichenlaub can be reached at (b) (6) or Kurt.Eichenlaub@dot.gov.

Sincerely,

Thomas J. Herrmann
Director, Office of Technical Oversight

FEC Florida East Coast
RAILWAY, L.L.C.

RECEIVED
SEP 21 2016

September 9, 2016

Mr. Karl Alexy
Federal Railroad Administration
Hazardous Materials Division, West Building
1200 New Jersey, Avenue S. E.
Washington, DC 20590

Subject: Inquiry to Florida East Coast Railway (FECR) Revised Request for Concurrence to Move LNG Revenue Loads by Rail

Karl,

Florida East Coast Railway (FECR) respectfully submits this inquiry for a formal status update to the revision of our original request for concurrence to begin shipping LNG in common carrier rail service.

It was our feeling that once the scope of the original request was narrowed to pertain only to the two (2) south Florida ports, that FECR would likely receive FRA concurrence to move LNG ISO containers on the specified routes as a "pilot" initiative. This initiative is important to gain experience with the rail moves, demonstrate to FRA that the moves could be performed safely, and enable FECR to service the current demand from its customers. At the same time, FECR would continue its commitment to work with both FRA and Volpe to continue the ongoing study necessary to receive concurrence for a broader portion of our rail network. On behalf of FECR, I would like to request an update on the status of this "pilot" request for concurrence.

Thank you for your support of FECR and our efforts to advance the utilization of LNG as a fuel and cargo. Please contact me if you have any questions or require additional information to support your evaluation of this specific request.

Sincerely,

(b) (6)

Senior Vice President - Engineering, Mechanical and Purchasing

Attached:

1. FECR Original Request for Concurrence to Move LNG Revenue Loads by Rail, dated Sept 3, 2014
2. FECR Revised Request for Concurrence to Move LNG Revenue Loads by Rail, dated June 7, 2016

FEC Florida East Coast
RAILWAY, L.L.C.

June 7, 2016

Mr. Karl Alexy
Federal Railroad Administration
Hazardous Materials Division, West Building
1200 New Jersey, Avenue S. E.
Washington, DC 20590

Subject: Florida East Coast Railway (FECR) Revised Request for Concurrence to Move LNG Revenue Loads by Rail (original request of September 3, 2014 attached)

Karl,

Florida East Coast Railway (FECR) respectfully submits this update and revision to its formal request for concurrence to begin shipping LNG in common carrier rail service. The scope of this request continues to be specific to rail shipments of LNG having both origination and destination points on the FECR network.

Origin/Destination

Initial proposed shipments of LNG on FECR will originate from a rail served liquefaction facility owned and operated by New Fortress Energy (NFE) in Miami, FL. Delivery points for shipments would be limited to Port Miami and Port Everglades. FECR understands that additional movements of LNG ISO containers on the network would require a separate and distinct request for concurrence to be submitted to FRA.

ISO Container and Loading

The specific LNG containers that will be utilized to ship LNG on the FECR rail network will be a standard UN T-75 ISO certified cryogenic container which is acceptable to be loaded upon railcars in Intermodal service. The specific UN T-75 ISO containers utilized by FECR will be 40 feet in nominal length, holding approximately 11,000 gallons of LNG. FECR will require that shippers of LNG monitor the tank pressure, volume and location of the ISO tank vessels while on FECR property. These devices include a transmitter that will send wireless signals indicating a concern with regard to critical attributes and variables (e.g. pressure and volume). Tracking will include any alarm that would be indicative of a concern with the LNG product or vessel

Summary

FECR respectfully requests that FRA consider this revised request, along with all previously submitted supporting documentation, in an effort to provide concurrence for the movement of LNG ISO containers on our railroad. With this limited "pilot" LNG process, gain valuable experience and begin to serve customers from Hialeah to the Port of Miami and/or Port Everglades.

Thank you for your continued support of FECR in its efforts to advance the utilization of LNG as a fuel and cargo. Please contact me if you have any questions or require additional information to support your evaluation of this specific request.

Sincerely,

(b) (6)

Senior Vice President - Engineering, Mechanical and Purchasing

Florida East Coast
RAILWAY, L.L.C.

7150 Phillips Highway
Jacksonville, Florida 32256
(904) 279-3119

September 3, 2014

Mr. Karl Alexy
Federal Railroad Administration
Hazardous Materials Division, West Building
1200 New Jersey, Avenue S. E.
Washington DC, 20590

Subject: Florida East Coast Railway Request for Concurrence to Move LNG Loads by Rail

Dear Mr. Alexy,

Florida East Coast Railway (FECR) is requesting concurrence from the FRA to begin shipping liquid natural gas (LNG) in common carrier rail service. The scope of this request is specific to rail shipments of LNG having both origination and destination points on the FEC network. However, final delivery of the LNG shipments may be performed by a certified highway common carrier to FECR customer facilities.

Origin/Destination

Initial proposed shipments of LNG on FECR will originate from a rail served liquefaction facility, currently being constructed by LNG Holdings, LLC, in Miami, FL, and the initial delivery point will be FECR Bowden Yard in Jacksonville, FL. Shipments would begin upon completion of the facility which could be as early as Q2 2015. Potential customers for these rail shipments will likely be Crowley Maritime Corporation and/or LNG Holdings, LLC. However, future rail deliveries may include destination points at other rail terminals on the FECR network.

FECR understands that such concurrence, if granted, would be for shipments confined to its rail network and that interchange of these shipments with another railroad would need to be handled under a separate request for concurrence.

Containment and Loading

The specific LNG container that will be utilized to ship LNG on the FECR rail network will be a standard UN T-75 ISO certified cryogenic container which is acceptable to be loaded upon railcars in Intermodal service. The specific UN T-75 ISO containers utilized by FECR will be 20 feet or 40 feet in nominal length, and not exceeding 11,000 gallons of LNG per container.

LNG containers will be loaded in a single stack configuration, which shall be adhered to regardless if loaded or considered empty. Initially, the total number of loaded containers to be shipped will be approximately 10-20 containers per day depending on the container size, production at facility, switching frequency, etc. This volume would be gradually ramped up based on demand, new customers coming online and/or new LNG production facilities coming online. Additionally, ISO T75 containers considered empty will be included in train service as they return to the plant for refilling.

Railroad Equipment

The specific types of railroad equipment proposed by FECR to be used as the loading platform shall be either Trailer-On-Freight-Car (TOFC) or Container-On-Freight-Car (COFC). The Association of American Railroads (AAR) Loading Capabilities Guide shall be used to select appropriate equipment. Equipment proposed for accepting a T75 ISO LNG vessel may be:

- IBC Type 100 or 125 Ton cars (3 unit articulated)
- IBC Type 70 Ton (3 unit drawbar connected cars)
- IBC Type 70 Ton (4 unit connected cars)
- IBC Type 70 Ton single car
- Spine Car (2, 3 and 5 units)

Under no circumstances will FECR utilize a fully enclosed railcar for the transportation of LNG shipments in T-75 ISO containers.

Rules and Regulations

FECR will comply with Hazardous Material Regulations set forth in 49 Congressional Federal Register (CFR), Chapter 1, Subchapters A and C, with specific focus on Parts 171-174, "Carriage by Rail", and as appropriate Part 177, "Carriage by Public Highway". As such, all documentation, packing, shipping papers and placards shall be in accordance with these CFR requirements.

Other, potential FECR customers have expressed a desire to receive LNG via FECR rail lines in the very near future. Therefore, FECR requests that the FRA grant concurrence for this request as practical so that FECR can take the next steps to carefully plan out and initiate these LNG customer shipments.

Thank you for your consideration of this request. Please contact me if you have any questions or require additional information to support your evaluation of this specific request.

Sincerely,

(b) (6)

Senior Vice President - Engineering, Mechanical and Purchasing

U.S. Department
of Transportation

**Federal Railroad
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

MAR 13 2017

(b) (6)
Senior Vice President–Engineering, Mechanical and Purchasing
Florida East Coast Railway
7150 Phillips Highway
Jacksonville, FL 32256

Dear (b) (6)

This reply is in response to the Florida East Coast Railway's (FECR) September 3, 2014, petition, subsequently amended in letters dated July 16, 2015, June 7, 2016, and October 25, 2016, to the Federal Railroad Administration (FRA) requesting approval for FECR to carry, in common carrier rail service, Methane, refrigerated liquid *or* Natural gas, refrigerated liquid, UN1972, Div. 2.1 (commonly known as liquefied natural gas or LNG), in cryogenic portable tanks (T75, UN portable cryogenic tanks or cryogenic ISO tanks) secured within intermodal well cars.

FECR had originally petitioned FRA, in a letter dated September 3, 2014, for approval of LNG shipments on its network between Hialeah Yard (Miami, FL) and Bowden Yard (Jacksonville, FL). The amended requests of June 7, 2016, and October 25, 2016, modified the destination points to the Port of Miami (POM) and Port Everglades (POE). The rail distances from the Hialeah Yard to these locations are approximately 15 miles and 23 miles respectively. The origin and destination points for LNG shipments will be entirely within the operating network of FECR. FECR has also submitted a number of technical support documents (listed in Appendix A) with this petition, including a detailed risk assessment for the shipments of LNG on these routes. FECR understands that additional shipments of LNG in ISO containers elsewhere on its network would require a separate and distinct request for approval to be submitted to FRA.

Based on the review of the request and supporting documents, FRA is granting approval under Title 49 Code of Federal Regulations (CFR) Section 174.63(a) to FECR for transporting LNG in portable cryogenic tanks secured within intermodal well cars, subject to the following conditions.

1. This approval is valid for shipments between the origin point of FECR Hialeah Yard, and the destination points of POM and POE beginning March 9, 2017, through June 30, 2019. A maximum of 10 loaded portable tanks of LNG per day is approved for shipment in one or more manifest trains. Each portable tank must not exceed a water capacity of 11,000 gallons.

2. Shipments must be transported only in intermodal well cars with only one portable tank

per car, and in compliance with the requirements of 49 CFR § 174.63, *Portable tanks, IM portable tanks, IBCs, Large Packagings, cargo tanks, and multi-unit tank car tanks*, for the movement of portable tanks containing hazardous materials in well cars.

3. Portable tanks must comply with all requirements for the shipments of cryogenic liquids in 49 CFR Subchapter C, Hazardous Material Regulations, and specifically with the following sections: special provisions for T75 and TP5, as detailed in 49 CFR §§ 172.102(7)(iv) and (8)(ii); 174.63; 178.274, *Specifications for UN portable tanks*; and 178.277, *Requirements for the design, construction, inspection and testing of portable tanks intended for the transportation of refrigerated liquefied gases.*

4. Train placement of cars transporting LNG must be consistent with the results of the safety and risk assessment performed by FECR and indicated in the report "FECR Movement of LNG in UN-T75 ISO Containers by Rail." The location of residue shipments within a train must conform to the requirements in 49 CFR § 174.85, *Position in train of placarded cars, transport vehicles, freight containers, and bulk packagings*. The maximum authorized speed of trains with loaded LNG portable tanks in the consist is 40 mph over the authorized routes.

5. FECR must perform a minimum of one track geometry car inspection annually (at least every 365 calendar days) of the LNG shipment routes. FECR must report the results of this inspection to FRA within 30 days of completing the inspection.

6. FECR must perform, at least, four internal rail flaw inspections annually of the LNG shipment route, with no more than 95 calendar days between each inspection. FECR must report the results of these inspections to FRA within 30 days of completing each inspection.

7. Before commencing operations under this approval, FECR must ensure that training in accordance with the requirements of 49 CFR § 172.704, *Training requirements*, is provided to the railroad employees whose job involves any activity connected with the transportation of LNG by rail.

8. FECR must ensure that proper emergency response planning and preparedness, to include emergency response drills and exercises, on LNG is provided to emergency responders along the approved shipment routes. Thirty days before the commencement of operations approved in this letter, FECR must submit to FRA for review their outreach plan to the first responders and local authorities along the approved routes.

9. If FECR is notified or otherwise becomes aware of any changes in the conditions assumed in the risk analysis report, or of an accident or incident involving a shipment of LNG, FECR must notify FRA's Hazardous Materials Division (at HMASSIST@dot.gov) within 24 hours of obtaining such knowledge and seek FRA advice.

10. FECR must provide a quarterly report to FRA containing, at a minimum: a summary of the operations, the number of portable tank loads and residues transported, number of

trains in which the LNG tanks were transported, and any specific problems related to the transportation of the portable tanks (i.e., non-accident releases, handling or securement issues, etc.). This quarterly report must be received by FRA by the 15th day following the end of each calendar quarter.

Nothing in this approval relieves FECR from its responsibility to comply with all applicable regulations governing the transport of hazardous materials by rail, including 49 CFR Parts 200-299, and 100-199. FRA's approval of FECR's request for rail transportation of these LNG shipments should not be construed by other rail carriers as a requirement that these shipments must be accepted for transportation.

FRA reserves the right to amend or revoke this approval based on noncompliance with any condition of this approval or applicable Federal regulations, or based on information pertaining to the safety of the operation. Further, FRA reserves the right to take enforcement action under 49 U.S.C. § 20111 for FECR's noncompliance with any condition of this approval or applicable Federal regulations.

If you have any questions, please contact Mr. Mark Maday, Staff Director, Hazardous Materials Division, Office of Railroad Safety, at (b) (6) or Mark.Maday@dot.gov.

Sincerely,

Robert C Lauby

Robert C. Lauby
Associate Administrator of Railroad Safety
Chief Safety Officer

Enclosure

Enclosure

Appendix A

1. NFE LNG ISO Container Specification–18 Aug. 2015
2. FECR LNG–New Fortress Energy (NFE) Overview
3. FECR–LNG ISO Route Analysis Document–8 Oct. 2015
4. FECR–Quantitative Risk Analysis (QRA)–8 Dec. 2016
5. Well Car Capability Analysis by Sims Professional Engineers
6. List of Incidents
7. FECR Accident Incidents 2011 to 2016

New Fortress
ENERGY

40’ UN-T75
LNG ISO Container

Specification: NFE-S001
Date of Issue: 02/09/15
Rev: August 18, 2015

1.0 Specification Overview

New Fortress Energy is providing specifications for 40 foot UN-T75 Liquid Natural Gas (LNG) Intermodal Containers (ISO). The containers will be transported by railroad, tractor-trailer and marine vessel. The containers also may be maintained in a storage environment and subject to outside conditions including: inclement weather, sea salt spray, humidity and varying temperatures. The design of the container must allow for handling and transporting by normal means for this type of equipment. The containers will be constructed in accordance with all container regulations found in this document with the goal to achieve the greatest product payload complemented with construction that shall provide service robustness and protection from mechanical damage. (b) (4)

(b) (4)

The specifications for these are listed appropriately within this document.(b) (4)

(b) (4)

(b) (4) The documentation detailing the applicable transfer processes and procedures is required by the manufacturer. Design, manufacturing, shipping and delivery shall be conducted in a safe manner as to avoid injury to personnel or equipment in this process. Precaution shall be taken to ensure proper safety training of all personnel has been conducted and completed prior to beginning any phase of LNG transfer operation.

The supplier shall provide all drawings including a General arrangement drawing showing (b) (4) [redacted]

(b) (4) [redacted]

Supplier shall provide purchaser:

1)Delivery schedule for the manufacture of the ISO tanks

2) Primary manufacturing location, and any other ancillary manufacturing sites. The purchaser shall retain the right to reject any site

Reference Standards:

The following technical specifications describe the (b) (4) [redacted] (b) (4) [redacted] ISO container. All dimensions shall be in US standard.

2.0 [redacted] ISO Tank Specifications

2.1 Exterior Tank:

A.) (b) (4) [redacted]

(b) (4) [redacted]

C (b) (4) [redacted]

D

E.

F.

2.2 Inner Vessel

A.) (b) (4) [redacted]

1

2

3

3.0 Frame

3.1 The (b)(4) [redacted] LNG ISO container frame must (b) (4) [redacted]

(b) (4) [redacted]

Additionally, the frame and structure must support/have:

(b) (4) [redacted]

A.)

B.)

C.)

D.)

E.)

F.)

G.)

H. (b) (4)

3.2 Piping

A.) All piping will be (b) (4)

1.) Manufacturer shall provide thread pitch and standard of any thread component

2.) Piping shall be sized to accommodate (b) (4)

(b) (4)

B.) Stainless steel ball valves shall be (b) (4)

(b) (4)

C.) Piping Control Panel with schematic delineating safe valve positions

D.) All piping shall be designed to ensure weld integrity in all modes of transportation.

E.) Any piping requiring dampening shall be described in detail by the manufacturer.

F.) Piping valve controls shall be oriented at ISO End location

3.3 Insulation

A.) Vacuum with multi-layered insulation

B.) Manufacturer shall describe the quality of the vacuum between tanks.

C.) Rugged Thermocouple Tube

4.0 Relief valves

4.1 Safety Relief Valves: (b) (4)

A.) Safety Valve shall be utilized such as (b) (4)

B.) Two safety relief Valve, Primary and Secondary

4.2Cabinet – Manufacturer shall describe dimensions and location of external cabinet.

A (b) (4)

B.

C.

D.

E.

F.) Manufacture lists and describes any other or additional component.

G.) Manufacturer shall provide air lines and the appropriate air connection within the control cabinet to allow the fail closed valves to be opened

H.) (b) (4)

4.3 Maximum Allowable Working Pressure (MAWP)

A.) (b) (4)

B.) Emergency Shutdown System (ESD)

C.) Pneumatic emergency shutdown valve shall be in the closed position should an air failure occur.A manual valve backup shall be installed

D.) Manufacturer shall describe type of valves such as Tri-cock, liquid level gauge and blow-down.

5.0 Telemetric Devices

Manufacturer shall install and provide power source for telemetric tracking device (b) (4) (b) (4) (b) (4) The device shall use manufacturers suggested mounting instructions and sensor devices and shall use power source and battery supplied by (b) (4) o ensure operational integrity.

5.1 Attribute and variables to be monitored are as follows:

a. (b) (4)
b.
c.
d.
e.
f.

6.0 Paint and Decals(outer tank and frame)

a. Zinc rich Epoxy Primer three coats arerequired.An option for the supplier to recommend an alternative finish which shall carry an extended warranty against corrosion if this supplier's offered finish is considered to be a superior product.

b. White (to withstand environmental elements) Manufacturer shall describe primer, paint, and top coat(s) products and application method

c. Identification label and placard frames in accordance with all regulatory requirements.

d. Tank numbering sequence, font and size shall be approved and provided by New Fortress Energy. A New Fortress Energy Logo(s) shall be supplied.

    1. Logo or commercial identification
    2. UN classification number for LNG
    3. Flammability nomenclature
    4. Emergency Contact Information and Stewardship
    5. Placard signs for LNG Refrigerated Liquid Methane
    6. Independent and unique identification number

6.1 Fittings and Accessories shall ensure (b) (4) [redacted]
(b) (4) [redacted]

A.) Main Fill and Decant Line: (b) (4) [redacted]
(b) (4) [redacted]

B.) Top Fill Line: (b) (4) [redacted]
(b) (4) [redacted]

C.) Second Fill Line: (b) (4)
(b) (4)

D.) Vent Line: (b) (4)
(b) (4)

E.) Pressure Build Coil Line (PBC): (b) (4)
(b) (4)

F.) (b) (4)
(b) (4)

7.0 Standard Documentation

Data package will include the following for each ISO Container:

- A.) Operational Manual - 2 paper copies and 1 electronic schematics
- B.) U1A Manufacturers Data Report
- C.) Radiography X-ray Report – inner tank
    - 1.) Hydraulic Helium Mass-Spectrometer
    - 2.) Nitrogen thermal
    - 3.) Black Light
- D.) Radiography X-ray Report (b) (4)
  (b) (4)
- E.) Helium Mass-Spectrometer
- F.) MTR Material Traceability Matrix
- G.) Oxygen Clean Certificate
- H.) Inner Tank (Vessel) Pressure Test Report

I.) External Piping Pressure Test Report

J.) ASME Original Data Plate (copy), UN Identity Plate (copy)

K.) Cold Shock Certificate

L.) Cold and Warm Retention Certificate

M.)Mass Spectrometer Leak Detection

N.) Vacuum Report; including report of any failure of the vacuum test and location of failure described accurately pictorially following repair and retesting to ensure the location is known.

O.) Final Inspection Report provided both electronically to FECR and a photocopy affixed the ISO container in the valve control cabinet.

8.0 Submittals

Within 30 days of Notice to Proceed, prior to ISO containers qualification testing:

1.) A letter stating that the Quick Connects, gauges, and Emergency Shutdown System are compatible with all FECR requirements.

2.) Submit method of shipment; submit method of handling, loading, shipping, unloading and stacking of ISO containers, including working drawings showing the ISO containers stacking arrangements and options.

8.1 Deliverables

Letter with supporting documentation stating that the ISO containers meet the required specifications as appended to the purchasing agreement.

8.2 Manufacturer's Qualification

A minimum of (b) [redacted] years experience manufacturing ISO containers.

8.3 Warranty

Manufacturer shall guarantee all items against defective materials, construction, or workmanship for a period of [redacted] years from the date of the ISO containers has been receipted.

8.4 Spare Parts

1.) Drawings and schematics of ISO containers are developed that indicate parts, tolerances, and material specifications.

2.) A listing of maintenance components or consumables shall be provided.

9.0 Quality Control

1.) The ISO containers shall be provided in a "fit for use" condition.

2.) Perform the testing required in this section for the ISO containers. Submit test and results to NFE for review and approval.

3.) Do not proceed with the production of the ISO containers until the shop drawings, ISO containers design, and qualification have been reviewed and approved by the NFE.

9.1 Shop Inspection by NFE

1.) NFE reserves the right of onsite inspection prior to, during and after production.

2.) Provide the NFE written notice of inspection availability at least [redacted] days in advance of the initial in-shop inspection and [redacted] days in advance for subsequent in-shop inspections. Do not prepare ISO containers for shipment before the

NFE or representative has either inspected ISO container(s) or has waived inspection requirements.

10.0 Regulations

All Regulations superseded by: Title 49 CFR 172.101, UN T75, 178.274, 178.277

ANSI (America National Standards Institute)

ANSI NGV1, ANSI NGV2, ANSI NGV3.1, ANSI NGV4.2, ANSI NGV4.6, ANSI NGV4.8

ASME (American Society of Mechanical Engineers)

BPVC Sections II, Parts A, B, C, D, Section V, Section VII, Section VIII, Section IX, B31.3

ASTM (American Society for Testing and Materials)

ASTM A553 (Class 1, 2), ASTM A353, ASTM D4784-93(2010), ASTM STP 579

EPA (Environmental Protection Agency)

40 CFR 86.098-8

DOT (Department of Transportation)

49 CFR 193, 49 CFR 393.68, 49, DOT-FTA-MA-90-7007-95-3, DOT49 CFR UN75

AAR

EN (European Standard)

EN12079

FMCSA (Federal Motor Carrier Safety Administration)

73 FR 76825.396.1, 73 FR 76825.396.3, 73 FR 76825.396.5, 73 FR 76825.396.7, 73 FR 76825.396.9, 73 FR 76825.396.11, 73 FR 76825.396.12, 73 FR 76825.396.13, 73 FR

76825.396.15, 73 FR 76825.396.17, 73 FR 76825.396.19, 73 FR 76825.396.21, 73 FR 76825.396.23, 73 FR 76825.396.25

FRA (Federal Railroad Association)

49 CFR 571.301, 49 CFR 571.303, 49 CFR 229.93, 49 CFR 229.95, 49 CFR 229.97, 49 CFR 230.67

ISO (International Standards Organization)

ISO1496-1:2013 refers to 49 CFR 173.411(b)(6)(iii), ISO668:2013, ISO830:1981, Vocabulary 2013, ISO1161:2000, ISO6346:1984, 2013, ISO42U6, ISO12115, ISO/DIS12614(1-18), ISO 1496, ISO/DIS16924, ISO20421-1, ISO20421-2, ISO21009-1, ISO21009-2, ISO21012, ISO21013(1-4), ISO21014, ISO21028-1, ISO21028-2, ISO21029-1, ISO21029-2, ISO23208, ISO9001.2008

NFPA (National Fire Protection Agency)

NFPA52, 2013, NFPA59A, 2013

American Bureau of Shipping (ABS)

Approved by:

(b) (6)

[redacted]

New Fortress Energy

Fortress Energy Partners

July 2015

Introduction to Fortress Energy Partners

Fortress Energy Partners ("FEP") was established in 2014 to build a small scale LNG production and distribution platform

LNG production

- FEP will own and operate a network of small scale liquefaction production facilities across the US
  - Target plant size of (b) (4)
  - Typical plant will be located near a transportation hub and accessible by rail
  - (b) (4)

LNG distribution

- FEP affiliate will distribute LNG from FEP's network of production plants and provide customers all necessary logistical support to deliver LNG to its final destination, typically by (b) (4)
  - Target customers include (b) (4) (b) (4)

Sponsor

- FEP is sponsored by Fortress Investment Group LLC
  - NYSE: FIG
  - AUM: (b) as of 9/30/14
- Long history of investing in transportation and infrastructure assets

RailAmerica
Florida East Coast Industries
Flagler Global Logistics
All Aboard Florida
Aircastle
SeaCube Container Leasing
Seacastle
TRAC Intermodal

What We Offer

Firm and Reliable LNG Supply

- **Only LNG liquefaction plant in Florida to have broken ground**
  - Our Miami LNG plant is currently under construction, and is expected to be operational by Q3 2015
  - The project is fully funded, and completion is not contingent upon financing
  - We have executed an (b) (4) [redacted]
- **Firm supply**
  - We are a privately-owned and non-utility-owned LNG producer
  - We have no obligation to provide peak-shaving assistance to the local utility
  - As a result, we are able to offer <u>a firm, uninterruptible supply contract</u> to our customers who will rely on the LNG to fuel their fleet

- **Orlando:** 235 miles
- **Tampa:** 271 miles
- **Jacksonville:** 351 miles
- **Tallahassee:** 480 miles

What We Offer

Partnership

- **Development of custom-tailored LNG distribution and logistics channel**
    - A reliable and sizable merchant LNG distribution channel does not currently exist
    - It is not enough to say "we will deliver LNG to your vessel."
    - Users and providers of LNG must collaborate closely to develop a custom-tailored LNG distribution and logistics channel – taking into consideration:
        - ✓ Volume: minimum and backup volume
        - ✓ Voyage: schedule and duration
        - ✓ Fueling: fixed facility or mobile (tanker truck, barge, etc…)
        - ✓ Infrastructure: receiving, storage, transfer and fueling infrastructure
    - First movers will have the advantage of getting the channel as closely tailored as possible to their needs
- **Florida East Coast Railway (FECR)**
    - FECR runs along the eastern coastline of Florida and is best positioned to serve all major ports in the state
    - Our unique relationship with FECR will enhance our ability to transport and supply LNG to our customers at the lowest cost and highest reliability possible
- **Financing capabilities**
    - We welcome any opportunity to provide capital towards any conversion or related infrastructure developments

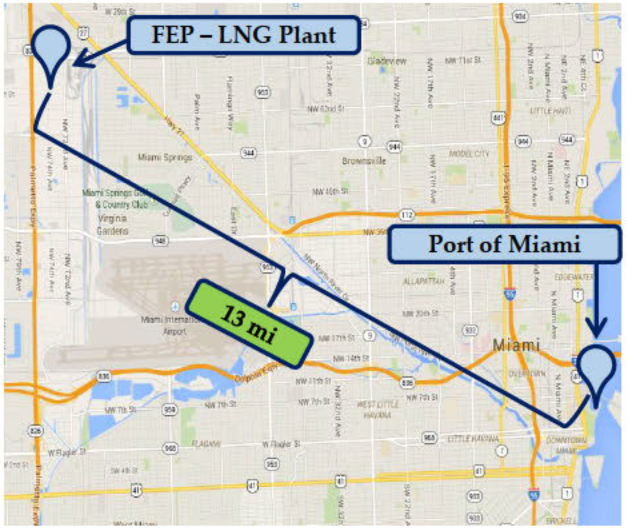
Miami-Dade County LNG Plant

- **FEP's 1st LNG liquefaction plant is under development in Miami-Dade County, FL**
  - (b) (4)
  - Located in FECR's Hialeah Railyard
- **Construction currently ongoing and expected completion in September 2015**
  - Facility will have truck and rail loading capability, so LNG can be transported by (b) (4) on (b) (4)
- **Anchor customer is Florida East Coast Railway**
  - (b) (4) to provide LNG to fuel recently converted dual-fuel GE locomotives
- **Other potential target customers (both merchant and contracted volume)**

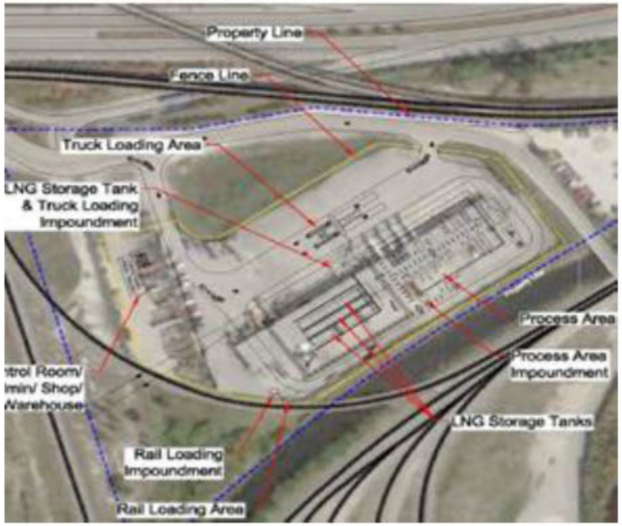
[redacted]

- **Proposed points of export**
  - ✓ 13 mi – Port of Miami
  - ✓ 24 mi – Port Everglades
  - ✓ 74 mi – Port of Palm Beach
  - ✓ 209 mi – Port Canaveral
  - ✓ 271 mi – Port of Tampa
  - ✓ 351 mi – JAX Port

Map of Miami Facility



Map of Plant Site



Titusville LNG Plant

- **FEP's 2nd LNG liquefaction plant is under development in Titusville, FL**
  - [redacted]
  - Located on land controlled by FEP
- **Pre-development activities in progress with a projected in-service date of** [redacted]
  - Facility will be capable of loading LNG into [redacted]
- **Potential target customers include:**

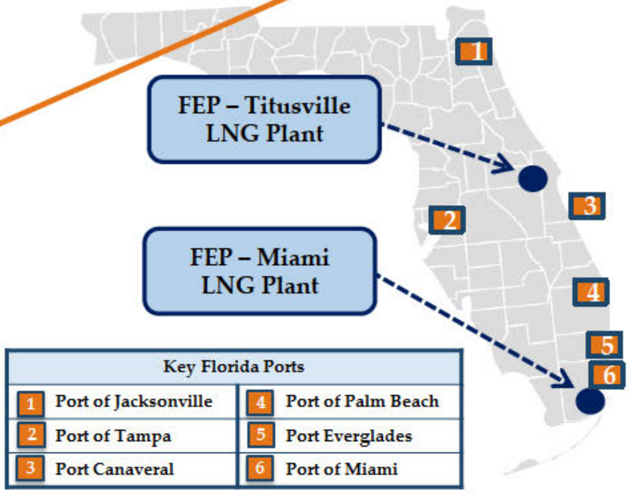
(b) (4)

[redacted]

- **Proposed points of export**
  - ✓ 25 mi – Port Canaveral
  - ✓ 124 mi – Port of Tampa
  - ✓ 134 mi – JAX Port
  - ✓ 147 mi – Port of Palm Beach
  - ✓ 196 mi – Port Everglades
  - ✓ 215 mi – Port of Miami

Map of Titusville Site

Distance from FL Ports



Key Florida Ports	
1 Port of Jacksonville	4 Port of Palm Beach
2 Port of Tampa	5 Port Everglades
3 Port Canaveral	6 Port of Miami

FORTRESS

Potential Near-Term Shipping Service Needs

(b) (4) [redacted]

A. Customer with a need of (b) (4) [redacted]

B. Estimate of (b) (4) [redacted]

C. (b) (4) [redacted]

  - Logistics design to reduce time in port (b) (4) [redacted]
  - Will unload (b) (4) [redacted] for return to Florida

(b) (4) [redacted]

A. Potential customer with a need of (b) (4) [redacted]

B. Estimate of (b) (4) [redacted]

C. (b) (4) [redacted]

FEC Florida East Coast
RAILWAY

Movement of LNG ISO Containers

Prepared for:

U.S. Department of Transportation
Federal Railroad Administration

Karl Alexy - Staff Director Hazardous Materials Division
Ron Hynes - Director of Technical Oversight
Richard Rusnak - Railroad Safety Specialist

October 8, 2015

THE MOST RELIABLE CONNECTION
BETWEEN FLORIDA AND THE WORLD

fecrwy.com

Florida East Coast Railway

Overview

Florida East Coast Railway (FECR) and New Fortress Energy (NFE) are affiliate companies owned by funds managed by Fortress Investment Group (FIG).

FECR is engaged with FRA on two (2) initiatives related to LNG. First, we are actively engaged with FRA to begin the safe operation of LNG as a locomotive fuel with initial testing to begin in Q4 2015. Secondly, FECR desires to move LNG ISO containers by rail on its rail network. These movements would serve FECR for its own locomotive fuel needs at Bowden (Jacksonville) vs. moving by truck, and serve customers on FECR's network, such as NFE.

FECR has submitted a "Request for Concurrence to Move LNG Loads by Rail" to FRA on September 3, 2014. A subsequent communication, "Addendum to Florida East Coast Railway Request for Concurrence to Move LNG by Rail" was submitted on July 16, 2015 (Appendix A).

In January of this year, (b) (6) of Fortress, attended a summit with Vice President Biden and several (b) (4) leaders. The (b) (4) (b) (4) informed us that (b) (4) had decided to convert an existing power plant so it could operate on natural gas. (b) (4) issued an RFP and New Fortress Energy won the bid, after competing with global competitors. NFE will serve the (b) (4) contract by exporting LNG from liquefaction plants in Florida.

FECR has a request from NFE to transport LNG by rail from their facility in Miami adjacent to our Hialeah Rail Yard to various ports in Florida. The first NFE liquefaction plant opens November 2015.

Service will incorporate new, purpose built, double lined ISO tanks. The design of the pressure vessel on these particular LNG ISO containers is over 50% stronger than those utilized in LNG highway transportation service today.
"Fully loaded" LNG ISO containers are too heavy to move over the highways. Containers would have to be short-filled, which is inefficient and a major factor in tractor trailer over-turns due to "sloshing". So, FECR and NFE feel the safest option is to move this commodity by rail.

FECR needs LNG at its Bowden Yard facility in Jacksonville for its LNG locomotive fuel initiative. Ideally, the LNG ISO's would be shipped by rail to Bowden. Otherwise, they would need to be shipped over the highways from Georgia or Alabama.

As part of a public-private partnership, FECR and its funding partners, including USDOT, FECR has invested (b) (4) [redacted] to provide on-dock rail service at Port Miami and Port Everglades.

Safety

Safety is critical at FECR and paramount in this LNG initiative. We have existing safety programs in place that we incorporate with all freight movements, including the current movement ethanol tank cars.

FECR's rail network is robust with 100% premium, head-hardened rail and concrete crossties. The network is also relatively flat, straight and is not susceptible to major temperature fluctuations.

All public crossings on the FECR network all equipped with active crossing lights and gates. Additionally, the FECR Signal System utilizes state of the art Automatic Train Control (ATC). This is the forerunner of the planned PTC system which will be implemented before the end of 2017 for passenger service. No passenger train will operate without PTC in place, even if an extension is granted by Congress.

FECR maintains a comprehensive Equipment Defect Detectors system along the main line from Jacksonville to Hialeah. These devices include Dragging Detectors that sense materials dragging such as chains or banding. Additionally, hot bearing detectors monitor the temperature of each axle bearing on the FECR trains at a distance of approximately every 12 miles.

Clearance detectors are located to detect rolling stock that may have a shifted load or out of normal clearance. Furthermore, Wheel Impact Load Detectors (WILD) are positioned at strategic locations to sense wheels that have imperfections causing them to impact the rail as they roll. These WILD detectors can also detect a shifted load or abnormal weigh distribution. The combination of these detectors creates a comprehensive safety review of each train as it traverses the railway. All systems have radio connections with train crews and dispatchers to inform the crew immediately in the event of an unsafe condition. The train receiving this alarm will stop and inspect the rolling stock identified and remove it from the train if the conditions warrants.

Risk Analysis

FECR has conducted a formal risk analysis as required by 49 CFR part 172.820 for the mainline track between Jacksonville and Miami. Additionally, FECR has engaged the globally recognized firms of Exponent Engineering and Scientific, a firm specializing in hazardous materials and safety in industrial operations, and

Chilworth-Dekra that specializes in "process safety management". These firms operate in many hazardous industries to assess, mitigate and teach companies how to manage conditions; and then help them prepare operating practices where hazardous or flammable materials are involved. The two firms have supported FECR in conducting initial hazards identification and mitigation strategies, as well as, safety processes related to using LNG as a locomotive fuel.

Exponent Engineering has also been used to site and assess risks relative to a locomotive LNG transfer facility constructed at Bowden Yard at Jacksonville. This facility is purpose built for transferring LNG to and from rail bound and highway equipment. In parallel, much of this learning and understanding already gained by FECR is relative and directly transferable to the movement of LNG as a revenue commodity.

FECR has used Exponent Engineering to assess the entire mainline route to examine and provide population density relative to moving LNG as a revenue commodity. In early work, Exponent also engaged railroad crafts personnel, contractors, managers to dig deep into railroad operations to identify hazards that may exist with regard to LNG. It is expected that FECR will continue to use both Exponent Engineering and Scientific and Chilworth as we further develop and review FECR's operating rules and special instructions with regard to LNG.

Training

FECR has incorporated a general orientation and discussion concerning the use of LNG into annual employee Operating Rules classes beginning in 2015. These meetings have included General Managers of Transportation, FECR Police, Environmental, Asset Management, and Customer Service. The feedback from these meeting provided additional information to enhance handling process and procedures. Many union craft employees were used in combination with contractors, suppliers and FECR managers to assess and identify risks of LNG as a locomotive fuel. Physical material properties and behaviors of LNG were discussed in these meeting with employees.

These FECR cross-functional teams have helped to identify real world railroad operating scenarios that may represent a risk to LNG operations. Risks were then followed by mitigation efforts that could be employed to eliminate or reduce the hazard in these scenarios. FECR will continue to provide LNG training in our Operating Rules materials. These will be rolled into training on hazardous materials which are presently a portion of the FECR operating rules. Existing rules and those which will be developed shall focus on all hazardous, including LNG, and other commodities that the railway is currently moving in revenue service.

FECR is also planning a LNG Drayage training class that will be provided to encompass the entire ISO handling process- ISO lifting and un-lifting activity to and from freight car as well as placement upon the trailer chassis.

We will provide initial training to employees, contractors and First Responders, and will follow-up with quarterly training for employees, contractors and suppliers with respect to LNG properties, safe-handling and PPE. ISO lifting, rail transportation, and rolling stock repair for the first year of LNG ISO movements on the railroad. After first year of operations, training will be incorporated into annual training program. In addition, it will be included as part of the FECR new employee on-boarding training.

FECR will maintain records and a database of the training events and employees trained and certified for specific tasks.

First Responders

FECR is also working with Emergency responders along the route and has performed training meetings with Duval, St. Johns, Flagler and Volusia Counties. Miami Dade County and Titusville will receive Fire School Training in mid October. Other meetings and opportunities are being planned for remaining responders along the route. Many of the county level responders have been trained to date with additional classes to be provided in the near future. At these meetings FECR describes LNG, its properties and provides insight with regard the way FECR will move LNG on the railroad. Information includes the ability for emergency responders to access the FECR Connect system to view data on trains in a real time fashion. Meetings are to be coordinated with the FECR Railroad Police Department that has an excellent relationship with these communities.

The railway has also engaged and funded the local community in Jacksonville support LNG specific training at Jacksonville Fire Academy for emergency responders along our route. The training was offered to emergency responders was provided and delivered by the Gas Technology Institute. Jacksonville has become a center of excellence for LNG, and local officials are discussing the establishing a sustained LNG Training program which FECR would certainly support. The railway has also provided emergency responders with resource materials and locations where additional training can be provided such as Texas A&M University. This specialty school is being used to train key FECR and NFE employees engaged in LNG activities.

Communications Plan

FECR presently provides open access to real time data for each of its train consists to First Responders along its rail network through FECR Connect. We are also cultivating relationships with First Responders responsible for territories along FECR tracks or within rail yards. FECR will coordinate with these First Responders to jointly communicate and address concerns from a public outreach perspective.

Additionally, the (b) (4) [redacted] (b) (4) [redacted] FECR shall monitor all LNG movements and provide an electronically generated communication to all key employees on the FECR rail network.

Governing Laws and Regulations

FECR shall ensure LNG is handled and transported in accordance with existing and emerging governing laws and regulations for hazardous materials; in particular, those outlined in 49 CFR 172.532, 174.63, 174.85 and 174 subpart G. These regulations describe the types of vessels authorized to transport cryogenic fluids, required markings, and the requirements for properly securing loads onto railcars.

FECR shall perform self audits on a monthly basis for 6 months from the commencement of operations to ensure compliance with regulations and procedures. Subsequent audits shall be performed on a quarterly basis.

Operating Rules

FECR shall ensure LNG is handled and transported in accordance with FECR Operating Rules, Florida East Coast Railway Hazardous Material Incident & Emergency Response Plan, and The General Regulations and Safety Rules for

FECR's Intermodal Contractor (s).

Emergency Response

Southwest Environmental Services (SWS), FECR's contracted environmental response team, shall be prepared to manage LNG when FECR commences operations. FECR shall utilize processes currently in place through the FECR Train Dispatching Operations to notify and coordinate with First Responders in the event of an emergency.

As an additional level of redundancy, ISO containers shall also be marked with contact information for "CHEMTREC," a hazardous materials response company.

Remote Monitoring of LNG ISO Containers

Electronic monitoring of the LNG on FECR property is important to the railway. Although ISO containers of LNG have a very long hold time, FECR will insist that shippers of LNG (NFE and others) monitor the tank pressure, volume and location of the ISO tank vessels while on FECR property. The hold times of ISO containers en route shall be carefully monitored through remote telemetric devices. These devices include a transmitter that will send wireless signals concerning a state of concern with regard to critical attributes and variables (e.g. pressure, and volume). Tracking will include any alarm that would be indicative of a concern with the LNG product or vessel such as a severe shock that may have occurred with ISO container. FECR will require that the shipper provide these telemetric devices and data with an assured monitoring system. Any alarms shall be directed to the FECR customer service representative and to the FECR Train Dispatching Office for appropriate handling. Actions may include cutting ISO cars out of train and placing in a pre-determined location for safe handling and disposition by shipper.

Compliance and Audits

FECR AVP Safety and AVP Operating Policies & Procedures shall conduct formal quarterly, documented audits of all critical functional activities.

- To provide necessary redundancy to the internal audit process, FECR shall contract with outside third party contractors to audit processes and procedures for transporting LNG on an annual basis.

- Additionally, each department shall be required to document behavioral observations with regard to the proper handling and transportation of rolling stock.

Continuous Improvement Process

FECR shall seek continuous improvement by monitoring and benchmarking the "best practices" employed by other shippers presently moving LNG by rail (e.g. - Japan railways, Japex).

- FECR shall perform reviews to refresh, update and re-distribute documents specific to LNG transportation to key stakeholders on a quarterly basis.

- FECR shall also work to educate industry peers with LNG transportation and handling knowledge that has been acquired. FECR shall further take an active role in LNG industry recommended practices development through Association of American Railroads (AAR) and other organizations.

Equipment

As outlined in detail the initial request for concurrence, FECR will utilize only (b) (4) (b) (4) ISO certified cryogenic containers. Containers will be with pressure relief safety valves shall be accepted for shipment on FECR. Additionally, FECR has listed the specific types of railroad equipment in its request for concurrence as to ensure that only suitable equipment will be utilized. The specific types of railroad equipment proposed by FECR to be used as the loading platform shall be either Trailer-On-Freight-Car (TOFC) or Container-On-Freight-Car (COFC). The

Association of American Railroads (AAR) Loading Capabilities Guide shall be used to select appropriate equipment.

Equipment proposed by FECR for accepting a (b) (4) ISO LNG vessel may be:

- (b) (4)
-
-
-

Under no circumstances will FECR utilize a fully enclosed railcar for the transportation of LNG shipments in (b) (4) ISO containers. Additionally:

- FECR shall require the shipper shall maintain equipment records for the ISO containers detailing maintenance and certification history. Shipper shall also inspect all containers prior to loading.
- Containers shall be inspected in accordance with FECR standard operating practices for Intermodal gates and for hazardous materials upon arrival on FECR property.
- FECR shall ensure the equipment used in the transportation and handling of LNG (e.g., chassis, railcars, and cranes) is in good mechanical order and is inspected prior to operations.

Operating Procedures

1. Communication and training of employees, contractors and First Responders.
    a. LNG orientation
    b. Safety rules
    c. Operating rules
    d. Hazmat handling rules
    e. Timetable

2. Require shipper to install and utilize GPS based, telemetric communication devices on each ISO container to monitor and remotely report the location, pressure and volume within the LNG ISO container .
    a. Receive telemetric alarms from shipper in the event of an issue with LNG ISO containers on FECR network.

3. Utilization of the proper car types for LNG lading.
    a. Specific car types were identified in the FECR "Request for Concurrence to Move LNG Loads by Rail" dated Sept 13, 2014.

4. Proper placement of loaded LNG cars within train.

5. Automatic, electronic communication of LNG car movements pushed to key employees with train id, car numbers and origin/destination.

6. Track cars with LNG ISO's on FECR network with centralized Dispatching System.

7. Monitor trains and cars en route using dynamic defect detector systems located approximately every (b)(4) miles.

    a. Hot bearing, dragging equipment, wide load and wheel impact load detectors.

Proposed Routes

Initial proposed shipments of LNG will originate from a rail served liquefaction facility, currently being constructed by New Fortress Energy (NFE), in Miami, FL, adjacent to the FECR Hialeah Rail Yard. The plant will have a total capacity of (b) (4).

The aggregate volume of "loaded" LNG ISO containers being shipped to these locations from the Hialeah liquefaction plant are projected to be (b) (4) per day beginning in September 2015. Additionally, the empty LNG ISO containers are also planned to be returned to the liquefaction plant in Hialeah via rail. The initial routes proposed by FECR for LNG ISO container movements via rail are:

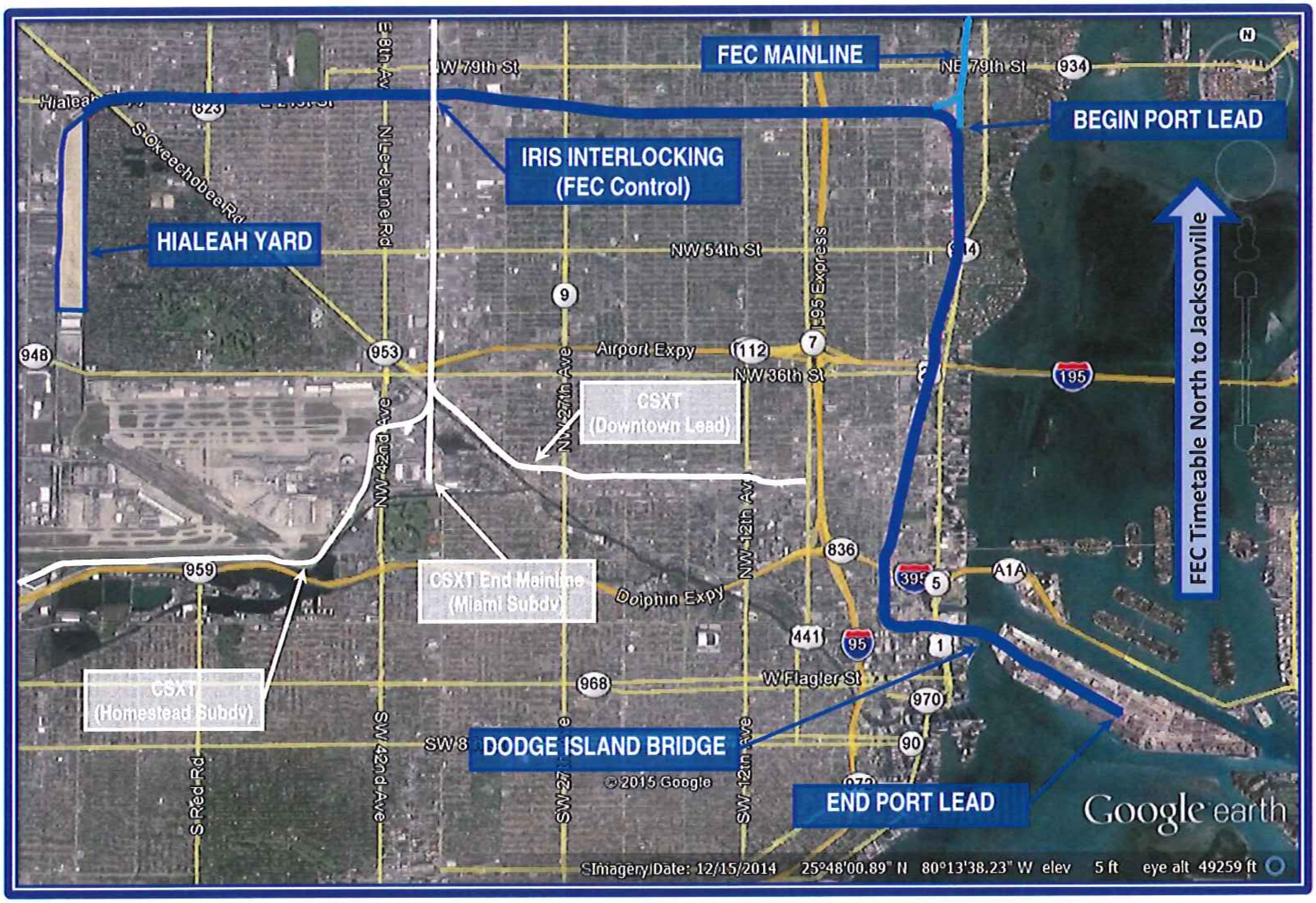
1. Hialeah to Bowden Yard
2. Hialeah to Port Everglades (PEV)
3. Hialeah to Port Miami (POM)

The routes have been mapped and further defined on the following pages.

Proposed Route1

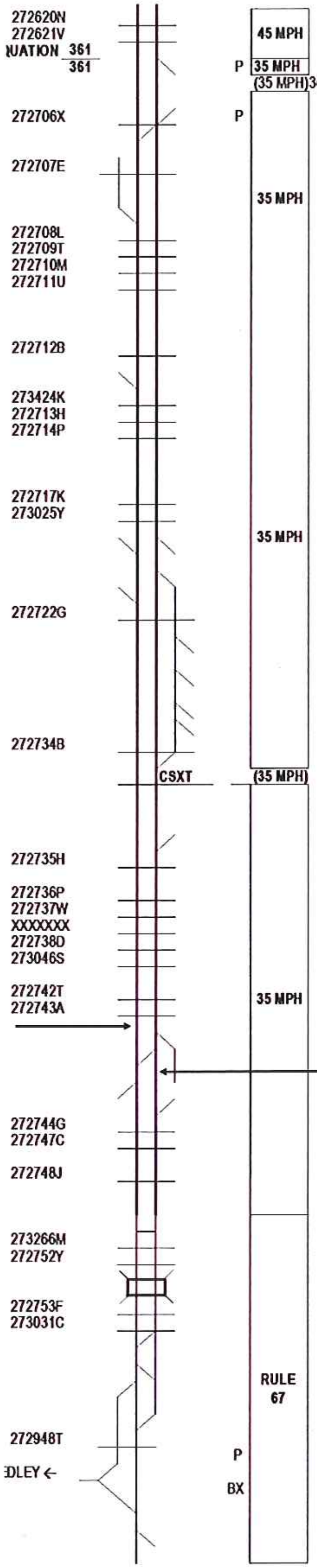
Hialeah Yard to Port of Miami

(Mainline MP. 369.20 to 360.90)
(Port Lead MP. PL 0.00 to PL 6.73)



ROUTE	Total Mileage	At-Grade Rail Crossings	At Grade Road Crossings	Above Grade Road Crossings	Under-Grade Road Crossings	Rail Weight	Switches	X-Overs	Type Signal System	Track Speed	Defect Detectors	Bridges	Population Average (/mile²)
HIALEAH YARD To PORT OF MIAMI	15 (8.2 – Hialeah Yard to Port Lead) (6.73 – Port Lead)	1	48	10	1	136#	18	4	CTC/ ATC CAB	25-35 Rule 67	0	3	9500

MAINLINE TRACK (Little River – MP 360.90 to Hialeah Yard – MP 369.20)



		STATION: LITTLE RIVER
360.90		NORTH LITTLE RIVER
361.10-361.37		CURVE-BOTH TRACKS
361.43		SOUTH LITTLE RIVER
361.50		CROSSOVER
		END CTC-ATC SB/BEGIN CTC-ATC NB
		BEGIN ABS SB/END ABS NB
		BEGIN SBM SB/ END NBM NB
361.67		MARYLAND CUP
362.90		PETROLIANCE
364.74		CARIBE FOODS
364.75		Industry Switch
364.90		N/E CIS LEAD (3,533')
364.91		SEGAL OIL
365.19		CIS1
365.29		CIS2
365.36		CIS3
365.39		INDUSTRY TRACK
365.57		S/E CIS LEAD
365.62	X	IRIS
365.70		FREIGHT HOUSE
367.16		N/E G-6
367.37		NB-SB CROSSOVER
		NORTHBOUND MAIN
367.18		NACHON LUMBER
367.45		WATER PLANT MAIN LEAD
		SOUTH RIVER
368.20		END ABS SB / BEGIN ABS NB
		END SBM SB / BEGIN NBM NB
368.40		BRIDGE NO. 368.40
368.46		NB-SB CROSSOVER
368.50		TOFC CROSSOVER
368.52		MEDLEY MAIN
368.55		SOUTH RIVER SWITCH
		BEGIN NB, NB / END SB,SB
368.58		TOFC SWITCH
368.60		GATOR SWITCH
369.00		OLD MAIN
369.20		STATION: HIALEAH YARD

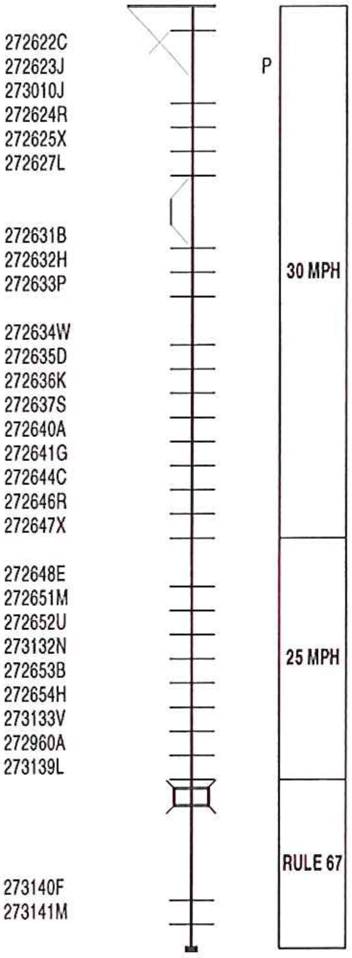
PORT LEAD
FEC MP. 360.90 = PL 0.00

(See Next sheet for Continuation)

IRIS INTERLOCKING
FEC MP. 365.62

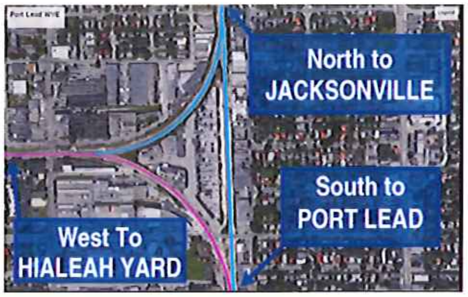
HIALEAH YARD
MP. 369.20

PORT LEAD TRACK (See Mainline Connection at MP 360.90)



PL 0.00	= MAINLINE MP. 360.90
PL 0.60	PORT LEAD (SOUTH WYE)
PL 1.27	Port Lead Setout N
PL 1.93	Port Lead Setout S
PL 2.20	STATION: BUENA VISTA
PL 4.20	STATION: MIAMI
PL 5.25	END ATC/CTC SB PORT MIAMI BRIDGE BEGIN ATC/CTC NB
PL 6.73	END OF TRACK

PORT LEAD
FEC MP. PL 0.00



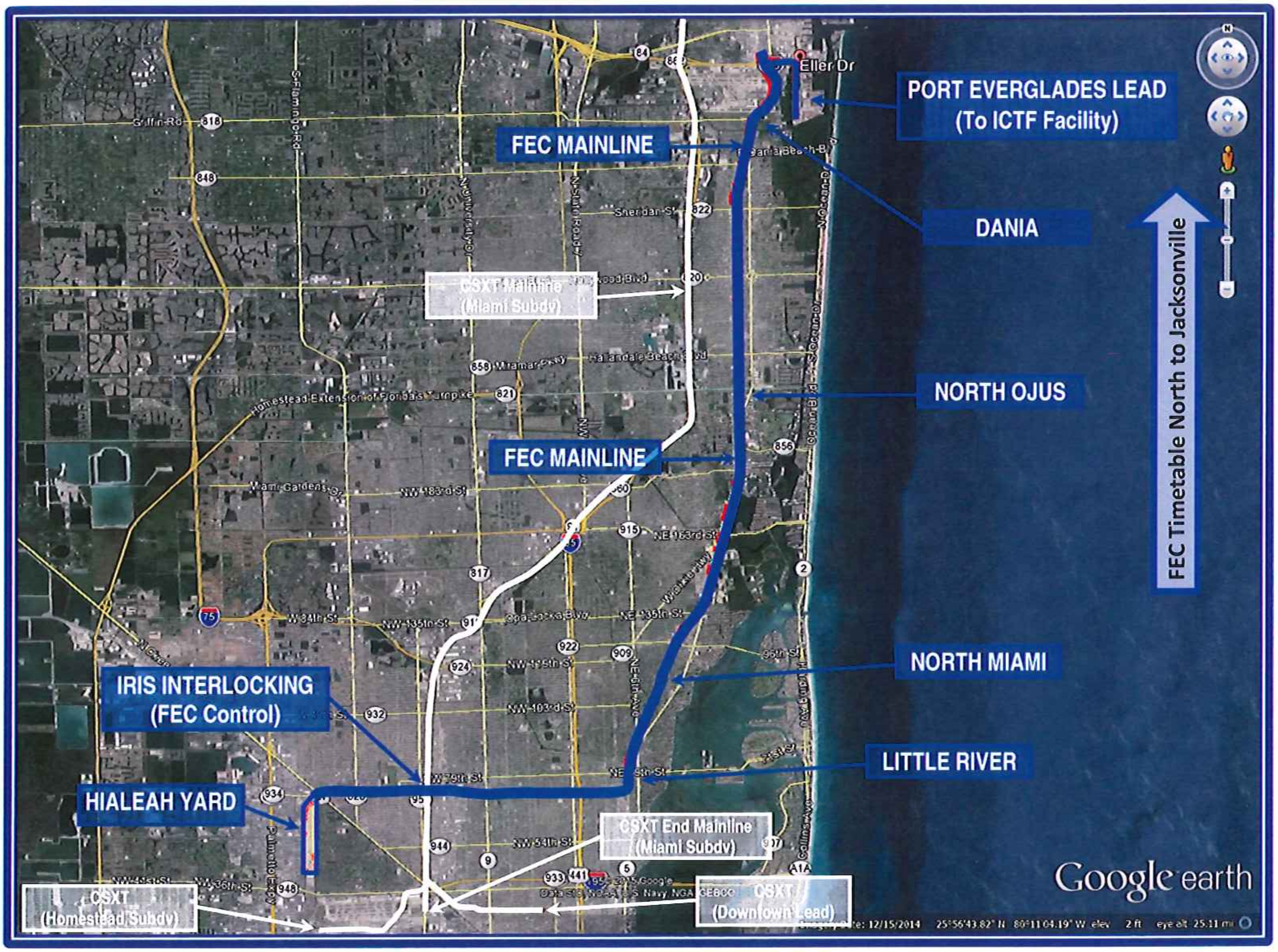
DODGE ISLAND BRIDGE
FEC MP. PL 5.25

PORT OF MIAMI
MP. PL 6.73

Proposed Route 2

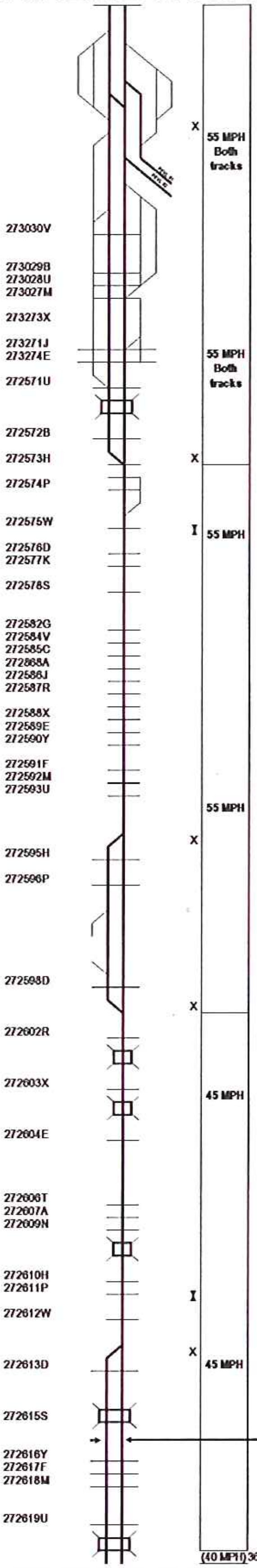
Hialeah Yard to Port Everglades

(Mainline MP. 369.20 to 343.60)
(Port Everglades Lead MP. PEVL 0.00 to PEVL2.26)



ROUTE	Total Mileage	At-Grade Rail Crossings	At Grade Road Crossings	Above Grade Road Crossings	Under-Grade Road Crossings	Rail Weight	Switches	X-Overs	Type Signal System	Track Speed	Defect Detectors	Bridges	Population Average (/mile^2)
HIALEAH YARD To PORT EVERGLADES	27.86 (25.6 – Hialeah Yard to Port Everglades) (2.26 – Port Everglades)	1	61	13	2	136#	30	5	CTC/ ATC CAB	35-55 Rule 67	2 346.30 – DE,HB 356.90 – HB,ID,WD	8	9150

MAINLINE TRACK (Port Everglades – MP 343.60 to Hialeah Yard – MP 369.20)



343.07	
343.21	WEST #1 and #2
343.24	N/E ANDREWS YARD
343.60	= 0.00 PEVL #1 (Port Everglades Lead)
343.61	NE CROSSOVER
343.68	WEST #1 and #2
343.68	**STATION: PORT EVERGLADES**
343.69	WEST MAKE-UP TRACK
343.70	S/E CROSSOVER
343.71	S/E ANDREWS YARD
343.71	= PEVL 0.11 #2 (Port Everglades Lead) PEVL TRACKS 1 & 2 TO ICTF
343.87	NE CROSSOVER TO WEST MAKEUP
343.92	SE CROSSOVER TO WEST MAKE-UP
343.97	EAST MAKEUP TRACK
344.75	EAST MAKEUP TRACK
344.98	SE EAST MAKE-UP TRACK
345.20	AIRPORT SPUR
345.22	WEST STORAGE TRACK
345.41	BRIDGE NO. 345.41
345.70	**STATION: DANIA**
346.14	DANIA DRAY TRACK
346.30	DE, HB
348.60	**STATION: HOLLYWOOD**
350.60	**STATION: HALLANDALE**
351.10	**NORTH OJUS (10,451')**
352.60	MIRON LUMBER
352.85	CONCREFORM
353.30	**SOUTH OJUS**
353.40	**STATION: OJUS**
353.74	BRIDGE NO. 353.74
354.51	BRIDGE NO. 354.51
354.70	**STATION: NORTH MIAMI BEACH**
356.53	BRIDGE NO. 356.53
356.90	HB, WILD
357.60	**NORTH MIAMI**
358.78	BRIDGE NO. 358.78
	NORTHBOUND MAIN (EAST)
360.27	BRIDGE NO. 360.27
(40 MPH) 360.30-360.50	CURVE-BOTH TRACKS

(Continued on Next Page)

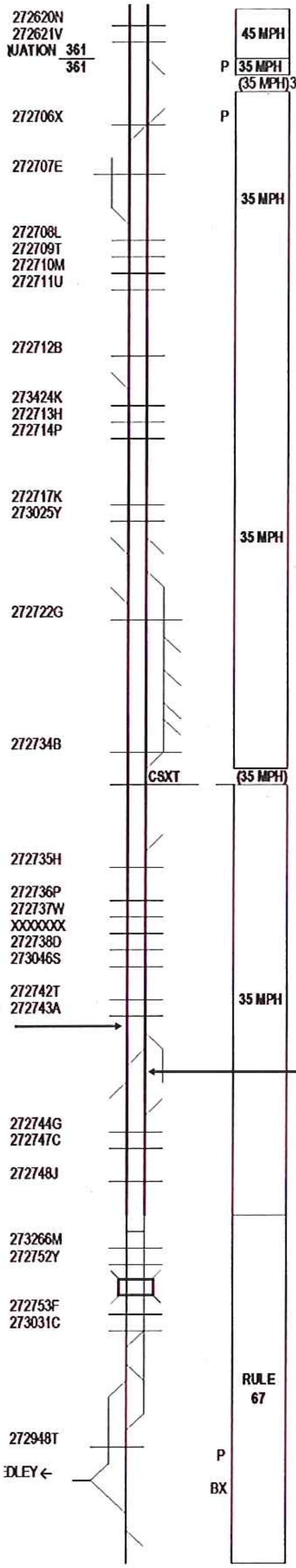
PORT EVERGLADES
(Mainline Connection)
MP. 343.60

(See Port Everglades Lead Track)

NORTH OJUS
MP. 351.10

NORTH MIAMI
MP. 357.60

MAINLINE TRACK (Little River – MP 360.90 to Hialeah Yard – MP 369.20)



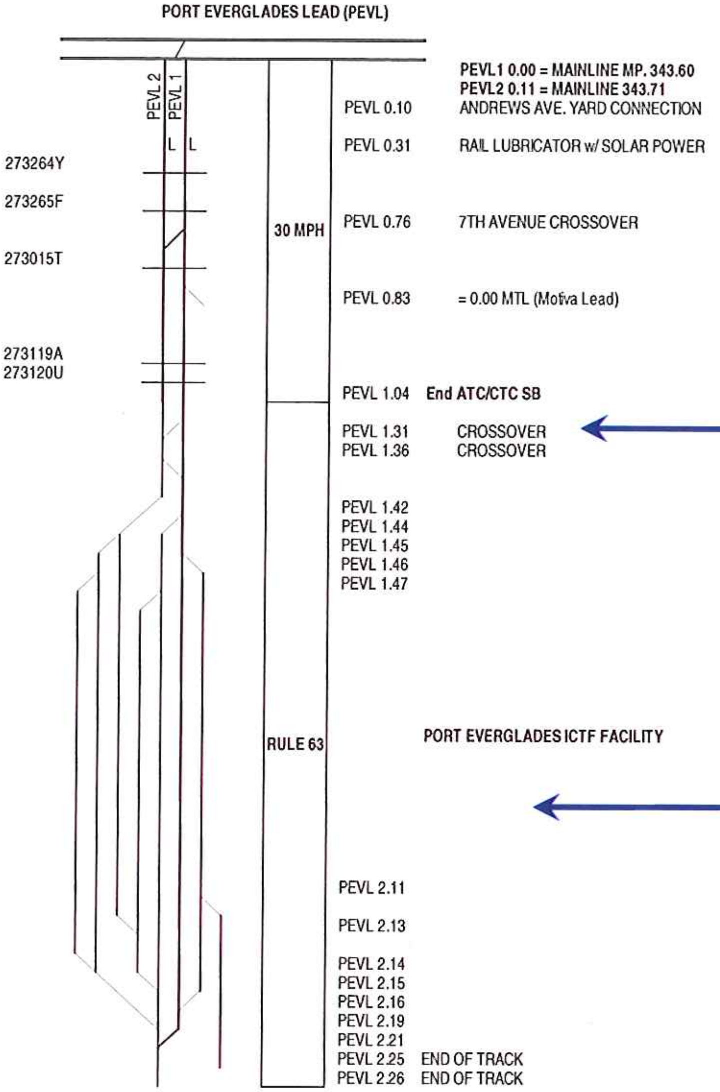
		STATION: LITTLE RIVER
360.90		NORTH LITTLE RIVER
361.10-361.37		CURVE-BOTH TRACKS
361.43		SOUTH LITTLE RIVER
361.50		CROSSOVER
		END CTC-ATC SB/BEGIN CTC-ATC NB
		BEGIN ABS SB/END ABS NB
		BEGIN SBM SB/ END NBM NB
361.67		MARYLAND CUP
362.90		PETROLIANCE
364.74		CARIBE FOODS
364.75		Industry Switch
364.90		N/E CIS LEAD (3,533')
364.91		SIEGAL OIL
365.19		CIS1
365.29		CIS2
365.36		CIS3
365.39		INDUSTRY TRACK
365.57		S/E CIS LEAD
365.62	X	IRIS
365.70		FREIGHT HOUSE
367.16		N/E G-6
367.37		NB-SB CROSSOVER
		NORTHBOUND MAIN
367.18		NACHON LUMBER
367.45		WATER PLANT MAIN LEAD
		SOUTH RIVER
368.20		END ABS SB / BEGIN ABS NB
		END SBM SB / BEGIN NBM NB
368.40		BRIDGE NO. 368.40
368.46		NB-SB CROSSOVER
368.50		TOFC CROSSOVER
368.52		MEDLEY MAIN
368.55		SOUTH RIVER SWITCH BEGIN NB, NB / END SB,SB
368.58		TOFC SWITCH
368.60		GATOR SWITCH
369.00		OLD MAIN
369.20		STATION: HIALEAH YARD

LITTLE RIVER
FEC MP. 360.90

IRIS INTERLOCKING
FEC MP. 365.62

HIALEAH YARD
MP. 369.20

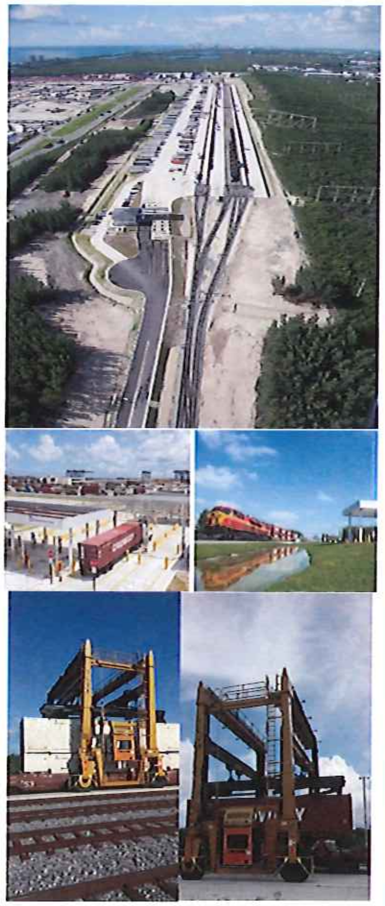
PORT EVERGLADES LEAD TRACK (See Mainline Connection at MP 343.60)



PORT EVERGLADES
(Mainline Connection)
MP. 343.60 = PEVL 0.00

I-595 Overpass Highway
MP. PEVL 1.01

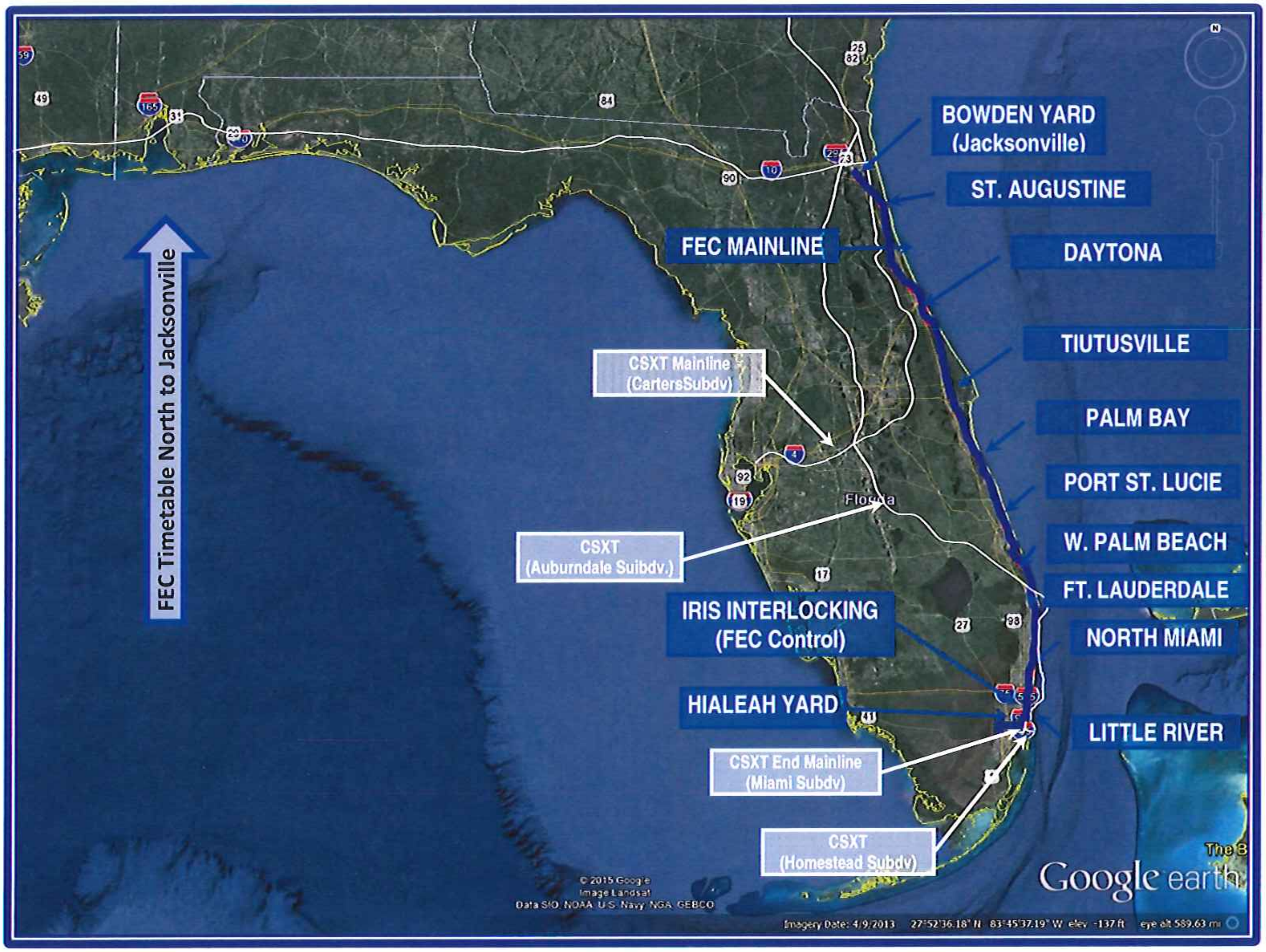
ICTF Facility
MP. PEVL 1.80



Proposed Route 3

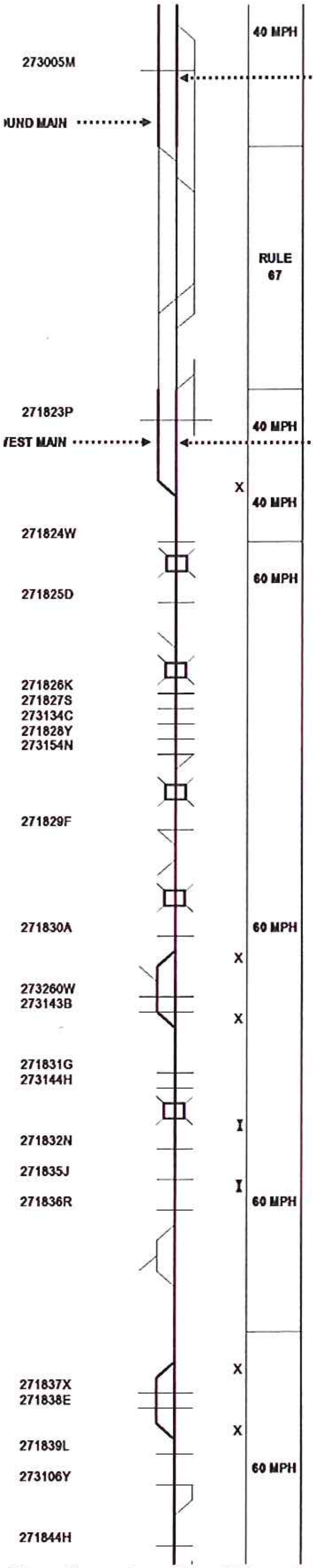
Hialeah Yard to Bowden Yard (Jacksonville)

(Mainline MP. 369.20 to 5.40)



ROUTE	Total Mileage	At-Grade Rail Crossings	At Grade Road Crossings	Above Grade Road Crossings	Under-Grade Road Crossings	Rail Weight	Switches	X-Overs	Type Signal System	Track Speed	Defect Detectors	Bridges	Population Average (/mile^2)
HIALEAH YARD To BOWDEN YARD	363.80	1	509	60	6	136#	186	22	CTC/ ATC CAB	25-60 Rule 67 Rule 55	2 WL=2 HB=28 DE=27 WD=2 ID=2	59	2900 To 9500

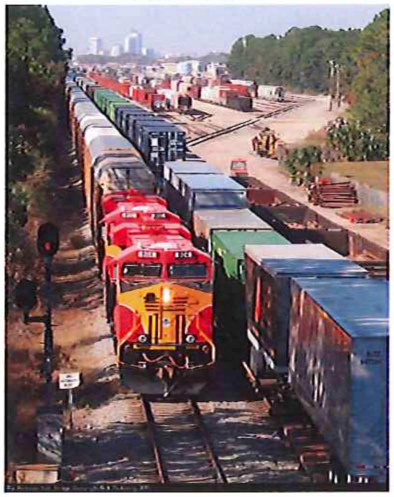
MAINLINE TRACK (Bowden Yard (Jax) – MP 7.00 to St. Augustine – MP 34.50)



4.78	N/E FLORIDA ROCK LEAD
	NORTHBOUND MAIN
5.40	BEGIN ABS NBM NB/END ABS NBM SB BEGIN ABS SBM NB/END ABS SBM SB BEGIN YL NB / END YL SOUTHBOUND
5.45	C1 LEAD CROSSOVER MB MAIN TO FLORIDA F
7.28	X - OVER NBM - C1 PKT
7.29	MIDDLE BOWDEN X-OVER
8.00	8 MILEPOST SWITCH
8.29	CROSSOVER
8.30	END ABS EAST & WEST NB BEGIN ABS EAST & WEST SB
8.39	SOUTH BOWDEN CROSSOVER
	EAST MAIN
9.70	SUNBEAM END ABS EAST & WEST SB BEGIN CTC-ATC SB / END CTC-ATC NB BEGIN ABS EAST & WEST NB
10.36	BRIDGE NO. 10.36
11.31	SOUTH INDUSTRIAL LEAD
11.43	BRIDGE NO. 11.43
12.96	MANNING BUILD. SUPPLY
12.99	BRIDGE NO. 12.99
13.49	TITAN CONCRETE
13.70	J.B. COXWELL
14.64	BRIDGE NO. 14.64
15.40	NORTH BAYARD (14,975')
15.83	BAYARD INDSTRL. LEAD
18.50	SOUTH BAYARD
19.50	BRIDGE NO. 19.50
21.10	WL, DE, HB
26.00	ID
27.11	N/E CEMEX RUNAROUND
27.20	CEMEX MATERIALS
27.30	STATION: SAMPSON
27.31	S/E CEMEX RUNAROUND
30.00	NORTH MAGNOLIA (15,527')
33.10	SOUTH MAGNOLIA
34.50	STATION: ST. AUGUSTINE
34.66	WERNINCK LUMBER
34.70	INDUSTRIAL LEAD

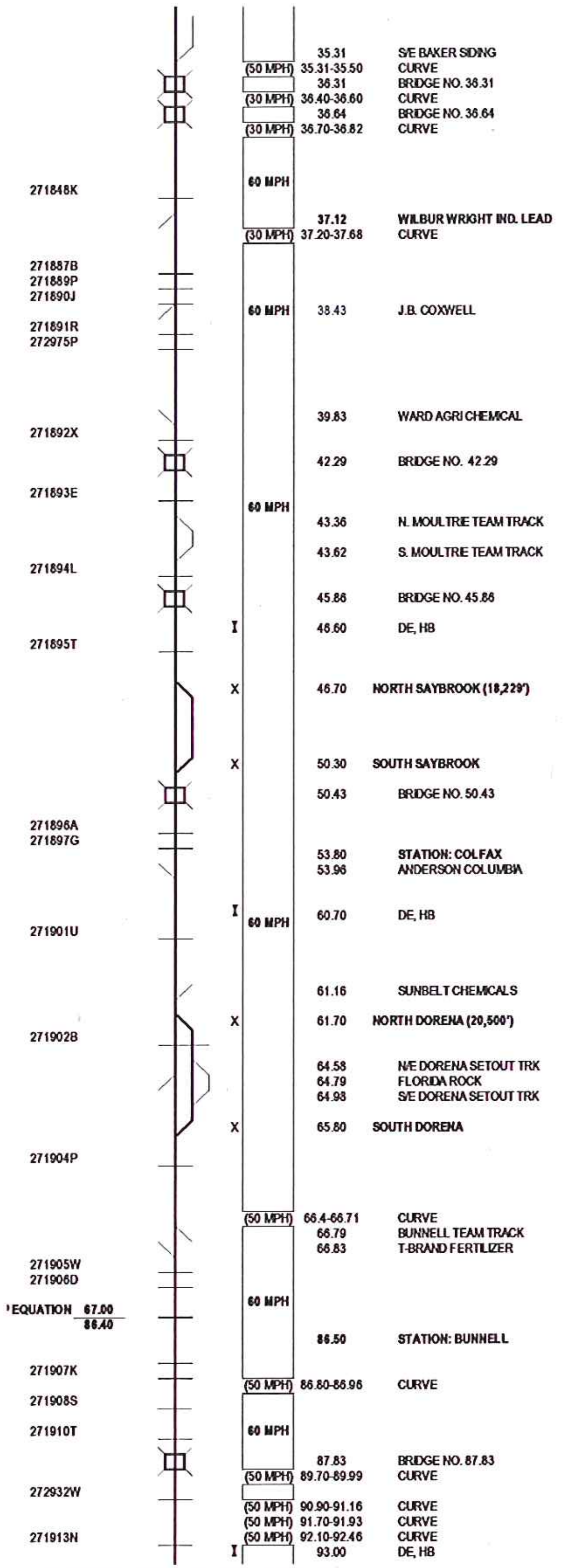
(Continued on Next Page)

BOWDEN YARD
MP. 7.00



ST. AUGUSTINE
MP. 34.50

MAINLINE TRACK (St. Augustine – MP 34.50 toBunnell – MP. 86.50)



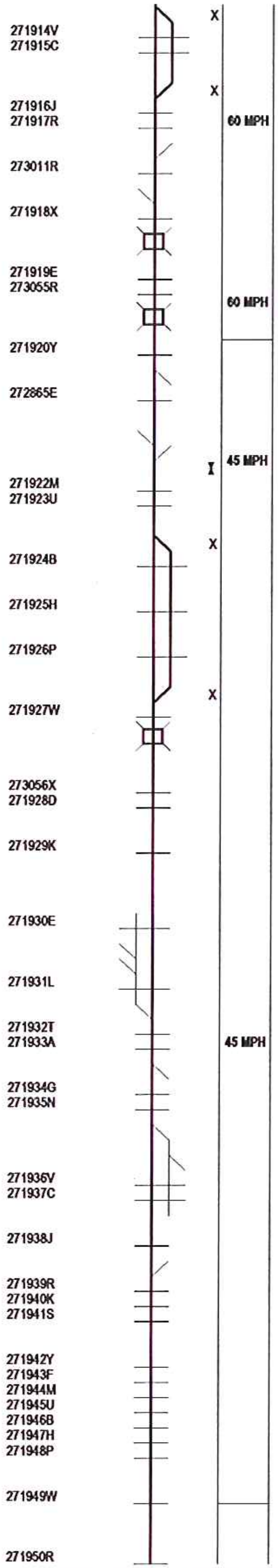
			35.31	S/E BAKER SIDING
		(50 MPH)	35.31-35.50	CURVE
			36.31	BRIDGE NO. 36.31
		(30 MPH)	36.40-36.60	CURVE
			36.64	BRIDGE NO. 36.64
		(30 MPH)	36.70-36.82	CURVE
		60 MPH		
271848K				
			37.12	WILBUR WRIGHT IND. LEAD
		(30 MPH)	37.20-37.68	CURVE
271887B				
271889P				
271890J				
		60 MPH	38.43	J.B. COXWELL
271891R				
272975P				
			39.83	WARD AGRI CHEMICAL
271892X				
			42.29	BRIDGE NO. 42.29
271893E				
		60 MPH		
			43.36	N. MOULTRIE TEAM TRACK
			43.62	S. MOULTRIE TEAM TRACK
271894L				
			45.86	BRIDGE NO. 45.86
	I		46.60	DE, HB
271895T				
	X		46.70	NORTH SAYBROOK (18,229')
	X		50.30	SOUTH SAYBROOK
			50.43	BRIDGE NO. 50.43
271896A				
271897G				
			53.80	STATION: COLFAX
			53.96	ANDERSON COLUMBIA
	I	60 MPH	60.70	DE, HB
271901U				
			61.16	SUNBELT CHEMICALS
	X		61.70	NORTH DORENA (20,500')
271902B				
			64.58	N/E DORENA SETOUT TRK
			64.79	FLORIDA ROCK
			64.98	S/E DORENA SETOUT TRK
	X		65.80	SOUTH DORENA
271904P				
		(50 MPH)	66.4-66.71	CURVE
			66.79	BUNNELL TEAM TRACK
			66.83	T-BRAND FERTILIZER
271905W				
271906D				
EQUATION 67.00 / 86.40		60 MPH		
			86.50	STATION: BUNNELL
271907K				
		(50 MPH)	86.80-86.96	CURVE
271908S				
271910T		60 MPH		
			87.83	BRIDGE NO. 87.83
		(50 MPH)	89.70-89.99	CURVE
272932W				
		(50 MPH)	90.90-91.16	CURVE
		(50 MPH)	91.70-91.93	CURVE
271913N		(50 MPH)	92.10-92.46	CURVE
	I		93.00	DE, HB

(Continued on Next Page)

WILBUR WRIGHT IND. LEAD
MP. 37.12

BUNNELL
MP. 86.50

MAINLINE TRACK (Bunnell – MP. 86.50 to Daytona Beach – MP 109.80)



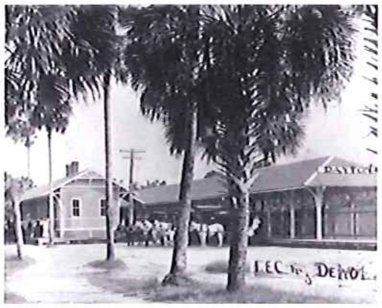
94.90	**NORTH HARWOOD (15,565')**
98.00	**SOUTH HARWOOD**
99.20	**STATION: NATIONAL GARDENS**
99.55	NATIONAL GDNS. TM. TRK.
100.43	HALIFAX PAVING
101.60	BRIDGE NO. 101.60
103.56	BRIDGE NO. 103.56
104.00	
104.08	PERROTT DISTRIBUTERS
104.40	**STATION: ORMOND BEACH**
104.42	CEMEX MATERIALS
104.55	ORMOND BCH TEAM TRK
104.70	HB
105.10	**NORTH HOLLY HILL (9,482')**
107.10	**SOUTH HOLLY HILL**
107.04	BRIDGE NO. 107.04
108.16	D&W PAVING/TRADEMARK
108.24	CEMEX
108.33	SETOUT TRACK
108.64	TITAN
109.08	SWITCHING LEAD N. END
109.13	CONRAD YELVINGTON
109.80	**STATION: DAYTONA BEACH**
109.98	Dunn Lumber
111.80	

(Continued on Next Page)

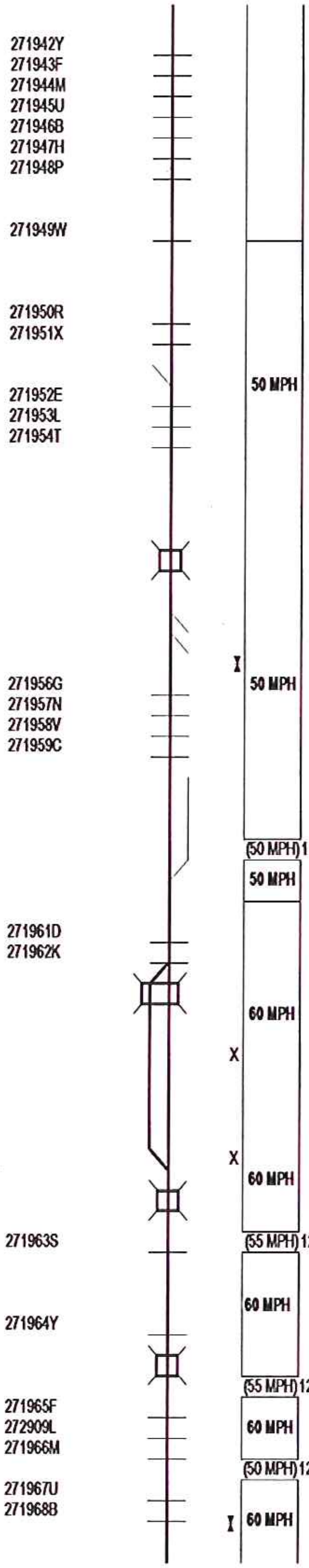
SOUTH HARWOOD
MP. 98.00

SOUTH HOLLY HILL
MP. 107.10

Daytona Beach
MP. 109.80



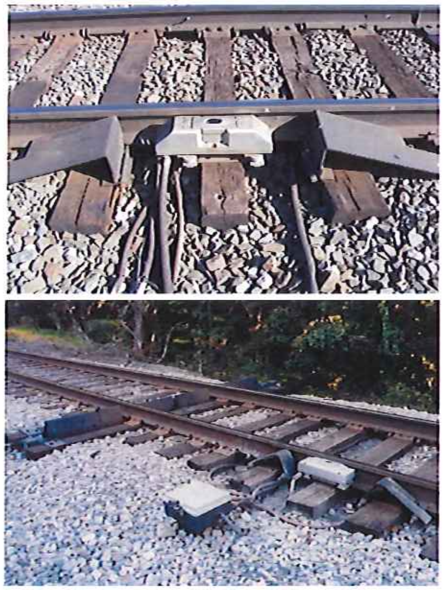
MAINLINE TRACK (Daytona Beach – MP 109.80to S. Spruce Creek – MP 119.00)



111.80	
112.63	BLAKE TEAM TRACK
113.55	BRIDGE NO. 113.55
113.60	CEMEX MATERIALS
113.88	SE PANEL & LUMBER
114.00	DE, HB
115.50	STATION: PORT ORANGE
(50 MPH) 115.50-115.74	CURVE
115.80	PORT ORANGE TEAM TRK
115.87	
116.70	NORTH SPRUCE CREEK (11,244')
117.23	BRIDGE NO. 117.23
119.00	SOUTH SPRUCE CREEK
119.05	BRIDGE NO. 119.05
(55 MPH) 120.40-120.66	CURVE
121.71	BRIDGE NO. 121.71
(55 MPH) 122.10-122.35	CURVE
(50 MPH) 123.70-123.92	CURVE
124.30	HB

PORT ORANGE
MP. 115.50

DEFECT DETECTOR
MP. 124.30



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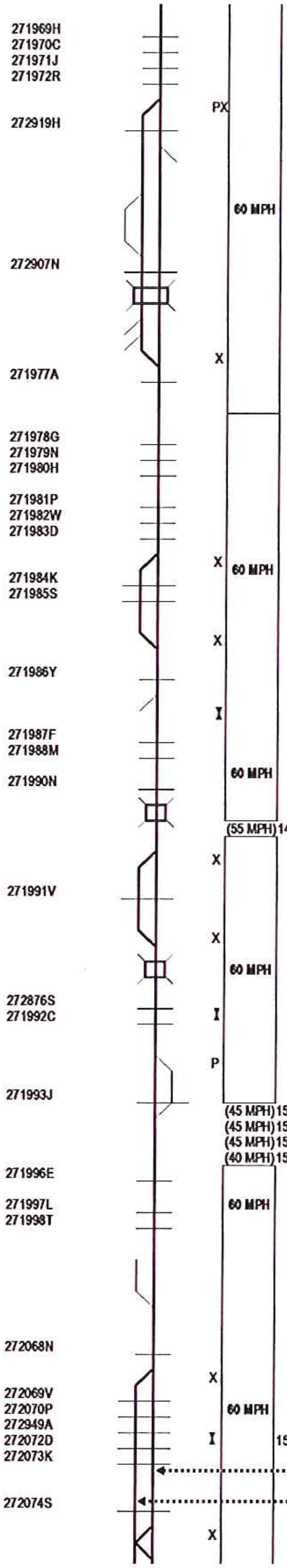
MAINLINE TRACK (S. Spruce Creek – MP 119.00to Tico – MP 158.50)



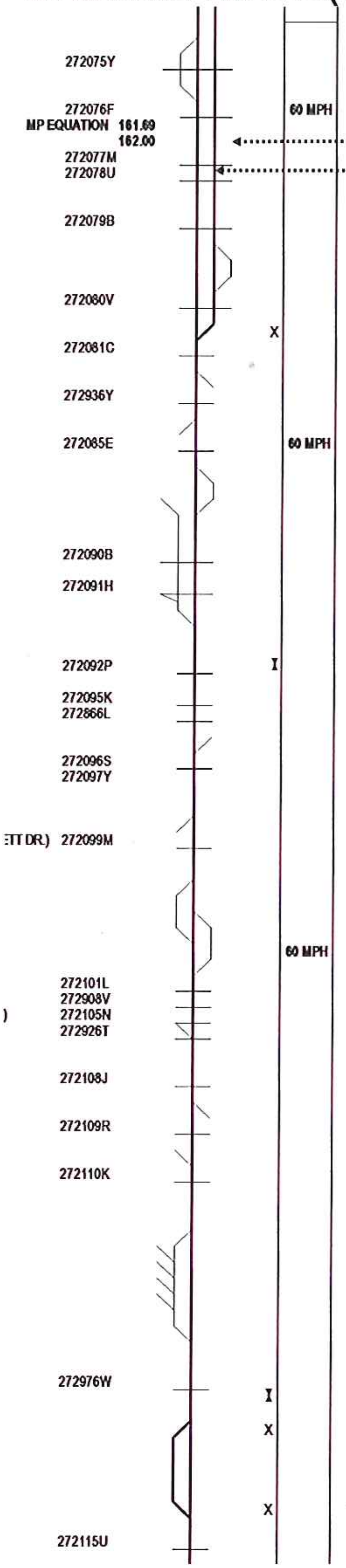
	124.60	N. NEW SMYRNA BEACH (10,900')
	124.85	CEMEX
	125.04	N. NEW SMYRNA BEACH
	126.03	S. NEW SMYRNA BEACH
	126.06	BRIDGE NO. 126.06
	126.66	TITAN
	126.73	EDGEWATER IND. LEAD
	126.80	S. NEW SMYRNA BEACH
	126.80	STATION: EDGEWATER
	133.60	NORTH OAK HILL (13,472')
	136.30	SOUTH OAK HILL
	136.41	OAK HILL TEAM TRACK
	137.00	DE, HW, HB
	140.53	BRIDGE NO. 140.53
(55 MPH)	140.60-140.84	CURVE
	142.10	NORTH SCOTTSMOOR (9,808')
	144.10	SOUTH SCOTTSMOOR
	144.14	BRIDGE NO. 144.14
	149.50	HB
	151.25	STATION: JAY JAY
	151.50	N/E JAY JAY SETOUT
	151.64	JAY JAY YARD (NASA)
	151.62	S/E JAY JAY SETOUT
(45 MPH)	152.90-153.10	CURVE
(45 MPH)	153.30-153.44	CURVE
(45 MPH)	153.50-153.64	CURVE
(40 MPH)	153.70-153.91	CURVE
	154.00	STATION: TITUSVILLE
	154.38	TEAM TRACK
	154.60	INDIAN RIVER CITY
	157.6	Both Tracks DE,HB
	158.50	TICO

S. NEW SMYRNA BEACH
MP. 126.80

TITUSVILLE
MP. 154:00

(Continued on Next Page)

MAINLINE TRACK (Tico – MP 158.50to S. Pineda - MP 182.60)

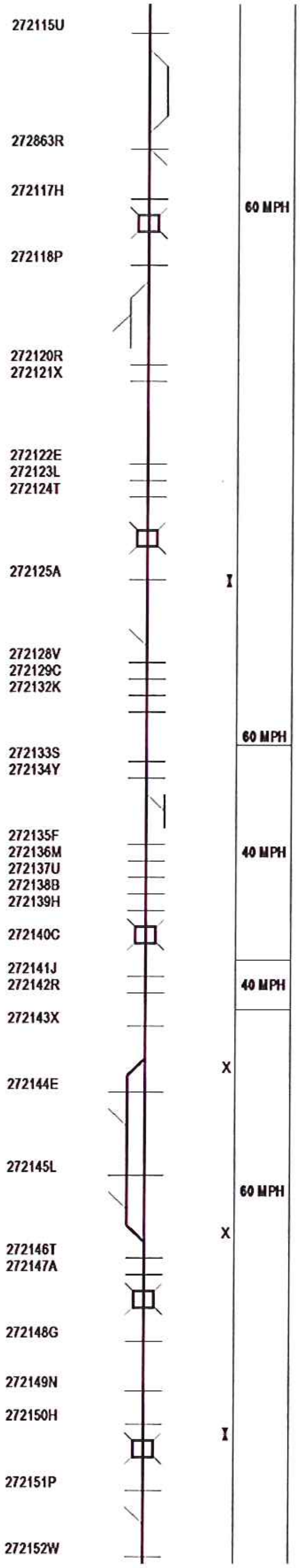


160.20	N/E TITUSVILLE AUTO RAMP
161.51	S/E TITUSVILLE AUTO RAMP
165.52	FRONTENAC TEAM TRK. N.
166.14	FRONTENAC TEAM TRK. S.
166.90	**FRONTENAC**
167.40	**STATION: SHARPES**
167.43	DOMINION
168.86	CIDCO LEAD
168.98	CITY POINT TEAM TRACK N.
169.30	**STATION: CITY POINT**
169.34	CITY POINT TEAM TRACK S.
170.08	MID-FLORIDA FREEZER
170.00	**CP 170**
170.20	**CITY POINT**
170.30	HB
172.60	INLAND PLYWOOD
173.19	MORTON SALT
173.54	RUNAROUND TRACK N.
173.58	**STATION: COCOA-ROCKLEDGE**
173.60	COCOA TEAM TRACK N.
173.88	RUNAROUND TRACK S.
173.92	COCOA TEAM TRACK S.
176.30	CEMEX
178.27	AMERIGAS
179.31	SOUTHEAST WOOD
179.41	SWITCHING LEAD N.
179.49	WWG / TRADEMARK
179.62	STARK TRUSS
179.77	WWG ASPHALT LEAD
179.84	SCHENCK CO. OF COCOA
180.03	SWITCHING LEAD S.
180.30	DE, HW, HB
180.50	**NORTH PINEDA (10,410')**
182.60	**SOUTH PINEDA**

FRONTENAC
MP. 166.90

(Continued on Next Page)

MAINLINE TRACK (S. Pineda – MP182.60 to Grant – MP 205.60)



183.50	PINEDA TEAM TRACK N.
183.70	**STATION: PINEDA**
184.23	PINEDA TEAM TRACK S.
184.52	84 LUMBER
187.37	BRIDGE NO. 187.37
188.17	CEMEX
188.40	TITAN
189.50	**STATION: EAU GALLIE**
190.47	BRIDGE NO. 190.47
190.90	HB
192.34	HALL SETOUT TRACK
193.80	
193.92	MELBOURNE TEAM TRACK
193.93	FPL
194.34	BRIDGE NO. 194.34
194.80	
195.00	**NORTH PALM BAY (11,356')**
195.00	**STATION: MELBOURNE**
195.39	HOPKINS TEAM TRACK
196.60	TIBBETS LUMBER
197.30	**SOUTH PALM BAY**
197.70	BRIDGE NO. 197.70
200.00	**STATION: MALABAR**
201.70	WL, DE, HB
202.59	BRIDGE NO. 202.59
203.85	RANGER
205.60	**STATION: GRANT**

MELBOURNE
MP. 195.00

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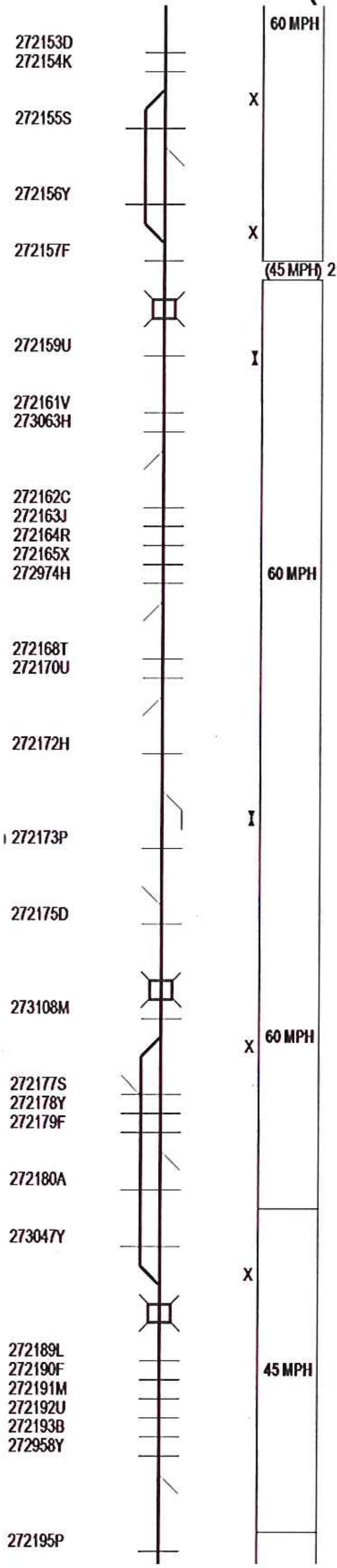
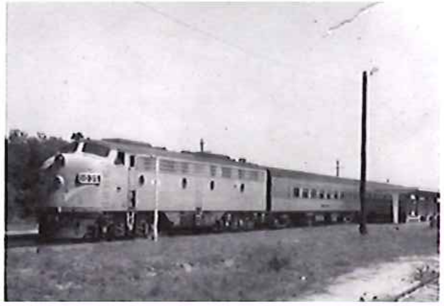
MAINLINE TRACK (South Palm Bay – MP197.30 to Vero Beach – MP 227.70)



208.40	NORTH MICCO (15,243')
209.10	MICCO TEAM TRACK
211.40	SOUTH MICCO
211.7-212.10	CURVE
212.07	BRIDGE NO. 212.07
212.80	HB
214.86	SEBASTIAN TEAM TRACK N.
214.90	STATION: SEBASTIAN
219.10	WABASSO TEAM TRACK
219.20	STATION: WABASSO
220.98	RUSSELL CONCRETE
221.90	STATION: WINTER BEACH
221.90	WINTER BEACH TEAM TRK.
222.10	HB
222.48	AIRLITE PROCESSING
223.70	BRIDGE NO. 223.70
223.90	GIFFORD (14,036')
224.24	COMMUNITY ASPHALT
225.23	GIFFORD TEAM TRACK
226.60	
226.80	BOUGARD
226.87	BRIDGE NO. 226.87
227.63	VERO BEACH HOUSE TK
227.70	STATION: VERO BEACH
227.80	

SOUTH MICCO
MP. 211.40

WINTER BEACH
MP. 221.90



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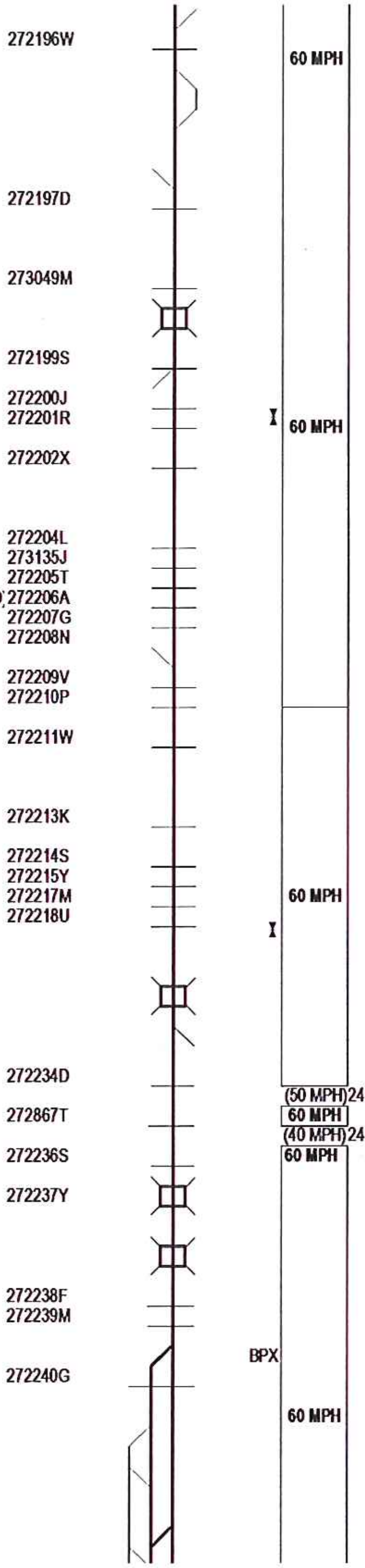
MAINLINE TRACK (Vero Beach – MP 227.70to Savannah – MP 243.60)



228.41	RUSSELL BRO. CONC.
228.70	12TH STREET RUNAROUND
228.93	12TH STREET RUNAROUND
228.96	CEMEX
229.80	**STATION: OSLO**
230.03	BRIDGE NO. 230.03
230.10	DICKERSON OSLO
232.90	DE, HB
236.20	**STATION: INDRIO**
236.27	INDRIO TEAM TRACK
238.30	**STATION: ST. LUCIE**
239.90	DE, HB
240.10	BRIDGE NO. 240.10
240.35	MARCONA & SWITCH LEAD
(50 MPH)240.90-241.07	CURVE
(40 MPH)241.10-241.21	CURVE
241.22	BRIDGE NO. 241.22
241.27	BRIDGE NO. 241.27
241.50	**FORT PIERCE (20,000')**
242.16	FORT PIERCE YARD N.
243.07	FORT PIERCE YARD S.
243.60	**SAVANNAH**
243.66	**NUMBER 5 POWER SWITCH**

ST. LUCIE
MP. 238.30

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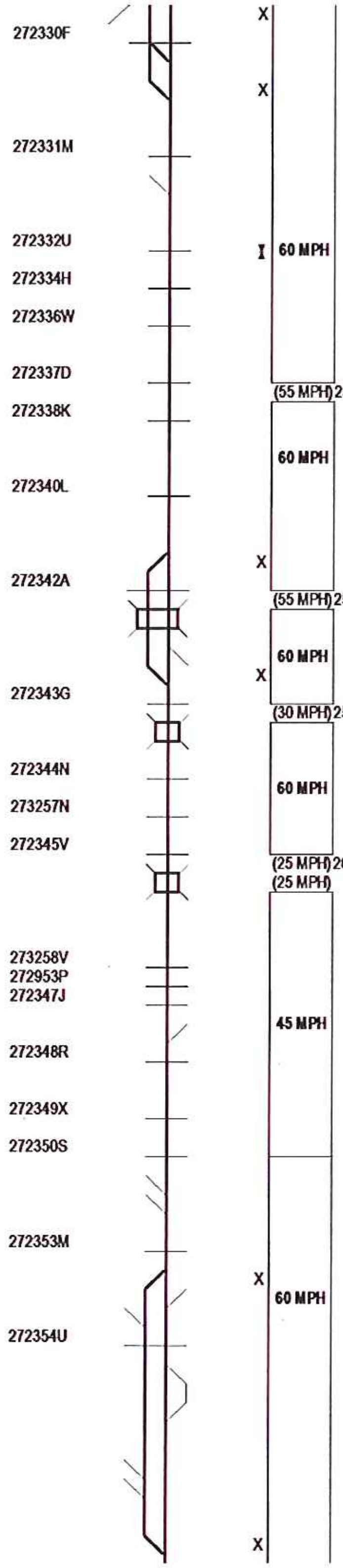
MAINLINE TRACK (Savannah – MP 243.60to South Port Sewell– MP266.20)



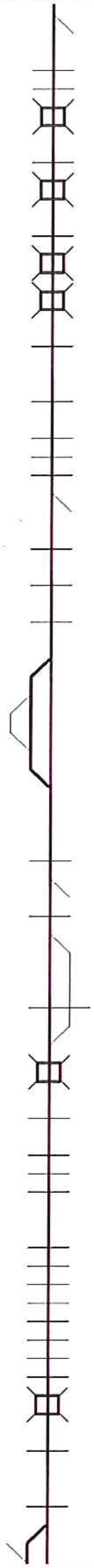
X		243.66	CROSSOVER
			K BRANCH
		243.79	CROSSOVER
X		246.30	WHITE CITY
		246.62	WHITE CITY TEAM TRACK
I	60 MPH	252.60	DE, HW, HB
	(55 MPH)	255.90-256.09	CURVE
	60 MPH	256.60	STATION: JENSEN BEACH
X		257.10	NORTH RIO (10,900')
	(55 MPH)	257.40-257.93	CURVE
		258.45	BRIDGE NO. 258.45
		259.00	84 LUMBER
	60 MPH	259.07	STUART PAINT & SUPPLY
X		259.30	SOUTH RIO
	(30 MPH)	259.90-260.43	CURVE
		259.95	BRIDGE NO. 259.95
	60 MPH		
	(25 MPH)	260.80-260.93	CURVE
	(25 MPH)	260.93	BRIDGE NO. 260.93
		261.10	STATION: STUART
	45 MPH	261.79	EAST COAST & CASA LUMBER
		262.50	
		262.64	CEMEX MATERIALS
		263.00	STUART CONTRACTING
X		263.20	NORTH PORT SEWALL (14,717')
	60 MPH	263.61	VOUGHT
		263.68	TITAN
		264.45	PORT SEWALL TEAM TRK.
		264.88	PORT SEWALL TEAM TRK.
		264.90	JJ TAYLOR DIST
		265.50	FLORIDA GUNITE
X		266.20	SOUTH PORT SEWALL

JENSEN BEACH
MP. 256.60

STUART DRAWBRIDGE
MP. 260.93

(Continued on Next Page)

MAINLINE TRACK (South Port Sewell – MP266.20 to Lake Park – MP292.60)



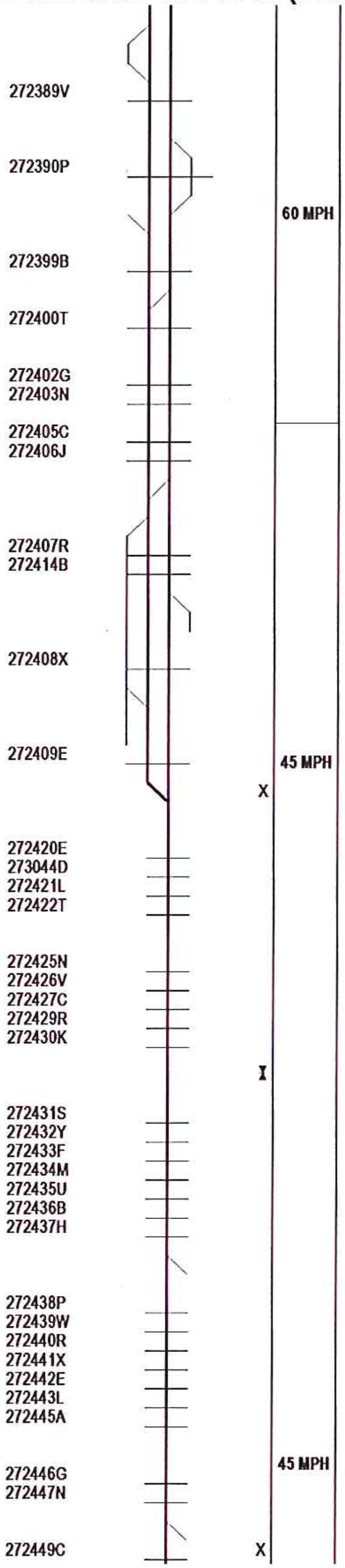
		266.31	SALERNO TEAM TRACK
	60 MPH	266.40	**STATION: SALERNO**
		266.58	BRIDGE NO. 266.58
		266.86	BRIDGE NO. 266.86
	(55 MPH)	267.30-267.48	CURVE
	60 MPH	267.34	BRIDGE NO. 267.34
		267.70	BRIDGE NO. 267.70
	(55 MPH)	268.30-268.62	CURVE
	60 MPH		
I	60 MPH	270.90	DE, HB
		274.38	HOBE SOUND TEAM TRK.
		274.40	**STATION: HOBE SOUND**
	(50 MPH)	275.30-275.50	CURVE
	60 MPH		
	(55 MPH)	276.90-277.10	CURVE
X		277.80	**NORTH CAMP MURPHY (15,135')**
	60 MPH	279.88	CAMP MURPHY RUNAROUND
		280.45	CAMP MURPHY RUNAROUND
X		280.90	**SOUTH CAMP MURPHY**
		280.90	**STATION: MARS**
I	60 MPH	280.91	MARS TEAM TRACK
		281.10	DE, HB
		281.80	CEMEX MATERIALS
	(30 MPH)	281.90-282.33	CURVE
	60 MPH	282.48	CEMEX MATERIALS
	(30 MPH)	282.58	X BRIDGE NO. 282.58
	(30 MPH)	282.80-283.04	CURVE
		283.30	**STATION: JUPITER**
	60 MPH		
I		290.10	DE, HB
		291.86	BRIDGE NO. 291.86
	(55 MPH)	291.90-292.08	CURVE
X	60 MPH	292.60	**LAKE PARK**
		293.22	CEMEX MATERIALS

HOBE SOUND
MP. 274.40

JUPITER DRAWBRIDGE
MP. 383.30

(Continued on Next Page)

MAINLINE TRACK (Lake Park – MP292.60 to Bunker Road – MP302.70)



293.39	LAKE PARK RUNAROUND
293.63	LAKE PARK RUNAROUND
294.42	N/E RIVIERA BCH TEAM TRK.
295.05	PORT OF PALM BEACH
295.05	S/E RIVIERA BCH TEAM TRK
295.07	LEWIS TERMINALS
295.30	CROSSOVER
296.60	
297.59	CROSSOVER
297.63	N/E W. GULF SWITCH LEAD
297.97	MAXWELL TRACK
298.45	CROSSOVER-W. GULF SDGN.
299.00	**WEST PALM BEACH**
300.1	DE, HB
300.96	PALM BEACH PAPERS
302.54	BUNKER SIDING
302.70	**BUNKER ROAD**

WEST PALM BEACH
MP. 299.00

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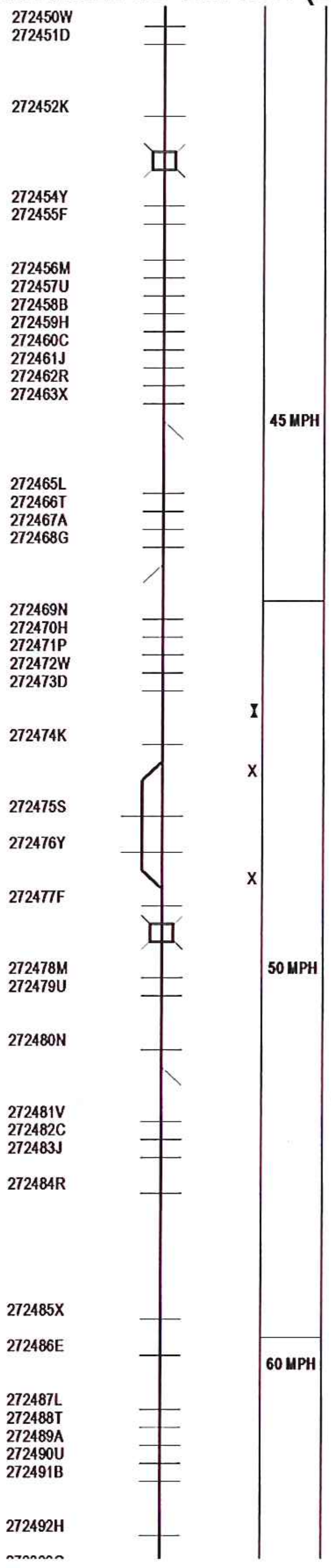
MAINLINE TRACK (Bunker Road – MP302.70 to Delray Beach– MP316.90)



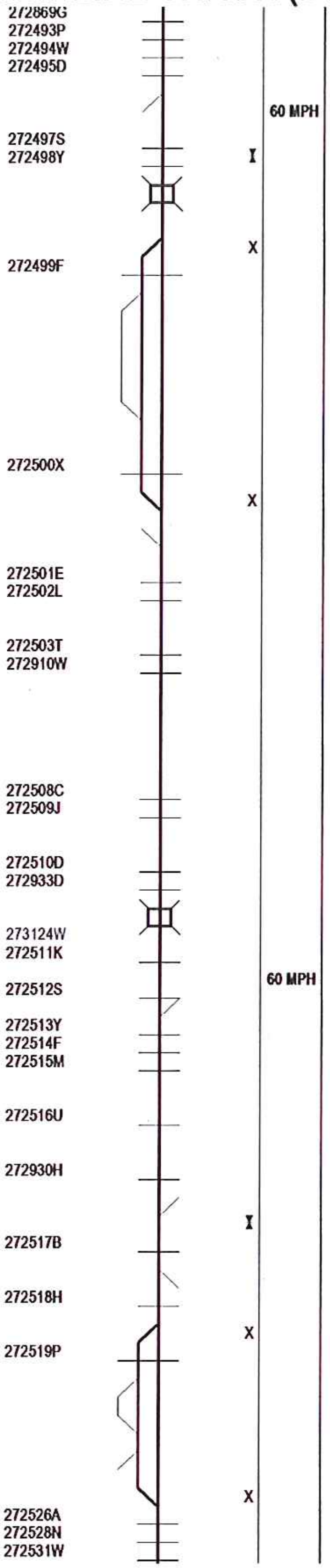
304.05	BRIDGE NO. 304.05
306.17	GOLD COAST DIST
306.20	STATION: LAKE WORTH
307.53	FLA PUBLIC UTILITIES
307.60	
309.00	DE, HB
309.20	NORTH HYPOLUXO (9,853')
311.30	SOUTH HYPOLUXO
311.45	BRIDGE NO. 311.45
312.18	BOYNTON BCH TEAM TRK.
312.20	STATION: BOYNTON BEACH
313.70	
316.90	STATION: DELRAY BEACH

LAKE WORTH
MP. 306.20

BOYNTON BEACH
MP. 312.20

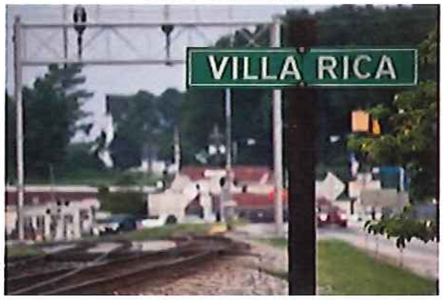
(Continued on Next Page)

MAINLINE TRACK (Delray Beach – MP316.90 to S. Pompano Beach – MP332.40)

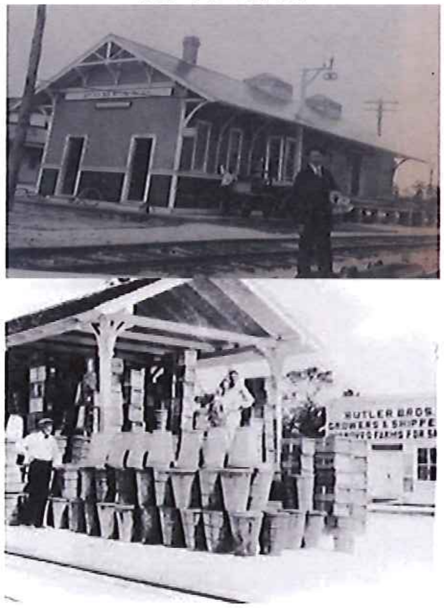


318.03	TITAN
319.10	DE, HB
319.55	BRIDGE NO. 319.55
319.60	**NORTH VILLA RICA (9,670')**
320.07	N/W VILLA RICA SETOUT TK
321.08	S/W VILLA RICA SET OUT TK
321.60	**SOUTH VILLA RICA**
321.97	JONES LUMBER
325.10	**STATION: BOCA RATON**
326.58	BRIDGE NO. 326.58
327.00	**STATION: DEERFIELD BEACH**
327.15	DEERFIELD BLDRS. SUPLY
329.91	AMER. CAST IRON PIPE
330.00	WL ,DE, HW, HB
330.14	VIDA APPLIANCE
330.40	**N. POMPANO BEACH (10,179')**
331.23	POMPANO SETOUT TRACK
331.92	POMPANO SETOUT TRACK
332.15	**POMP BCH. FARMERS MKT. LEAD**
332.40	**S. POMPANO BEACH**

NORTH VILLA RICA
MP. 321.60



N. POMPANO BEACH
MP. 330.40



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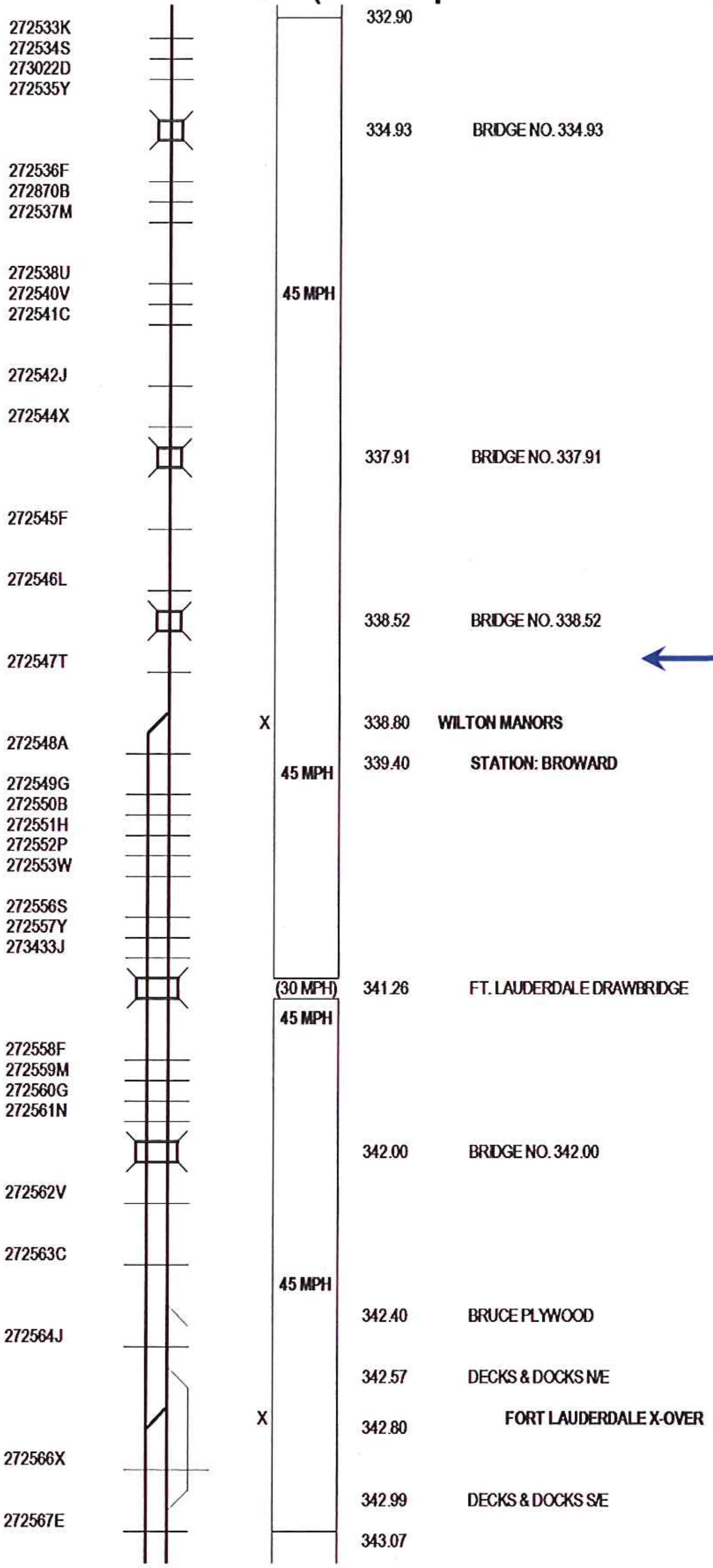
MAINLINE TRACK (S. Pompano Beach – MP332.40 to Port Everglades – MP 343.60)

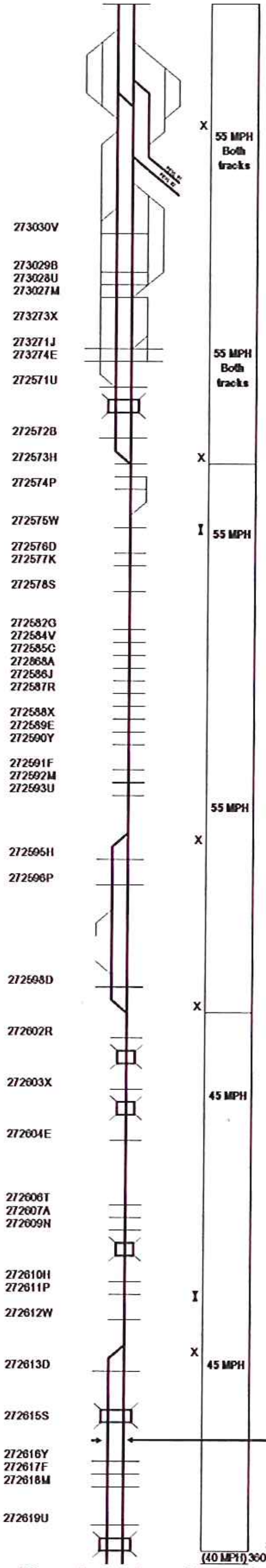


WILTON MANORS
MP. 338.80

FT. LAUDERDALE DRAWBRIDGE
MP. 341.26

(Continued on Next Page)

MAINLINE TRACK (Port Everglades – MP 343.60 to Hialeah Yard – MP 369.20)



343.07	
343.21	WEST #1 and #2
343.24	N/E ANDREWS YARD
343.60	= 0.00 PEVL #1 (Port Everglades Lead)
343.61	NE CROSSOVER
343.68	WEST #1 and #2
343.68	**STATION: PORT EVERGLADES**
343.69	WEST MAKE-UP TRACK
343.70	S/E CROSSOVER
343.71	S/E ANDREWS YARD
343.71	= PEVL 0.11 #2 (Port Everglades Lead) PEVL TRACKS 1 & 2 TO ICTF
343.87	NE CROSSOVER TO WEST MAKEUP
343.92	SE CROSSOVER TO WEST MAKE-UP
343.97	EAST MAKEUP TRACK
344.75	EAST MAKEUP TRACK
344.98	SE EAST MAKE-UP TRACK
345.20	AIRPORT SPUR
345.22	WEST STORAGE TRACK
345.41	BRIDGE NO. 345.41
345.70	**STATION: DANIA**
346.14	DANIA DRAY TRACK
346.30	DE, HB
348.60	**STATION: HOLLYWOOD**
350.60	**STATION: HALLANDALE**
351.10	**NORTH OJUS (10,451')**
352.60	MIRON LUMBER
352.85	CONCREFORM
353.30	**SOUTH OJUS**
353.40	**STATION: OJUS**
353.74	BRIDGE NO. 353.74
354.51	BRIDGE NO. 354.51
354.70	**STATION: NORTH MIAMI BEACH**
356.53	BRIDGE NO. 356.53
356.90	HB, WLD
357.60	**NORTH MIAMI**
358.78	BRIDGE NO. 358.78
	NORTHBOUND MAIN (EAST)
360.27	BRIDGE NO. 360.27
360.30 360.50	CURVE-BOTH TRACKS

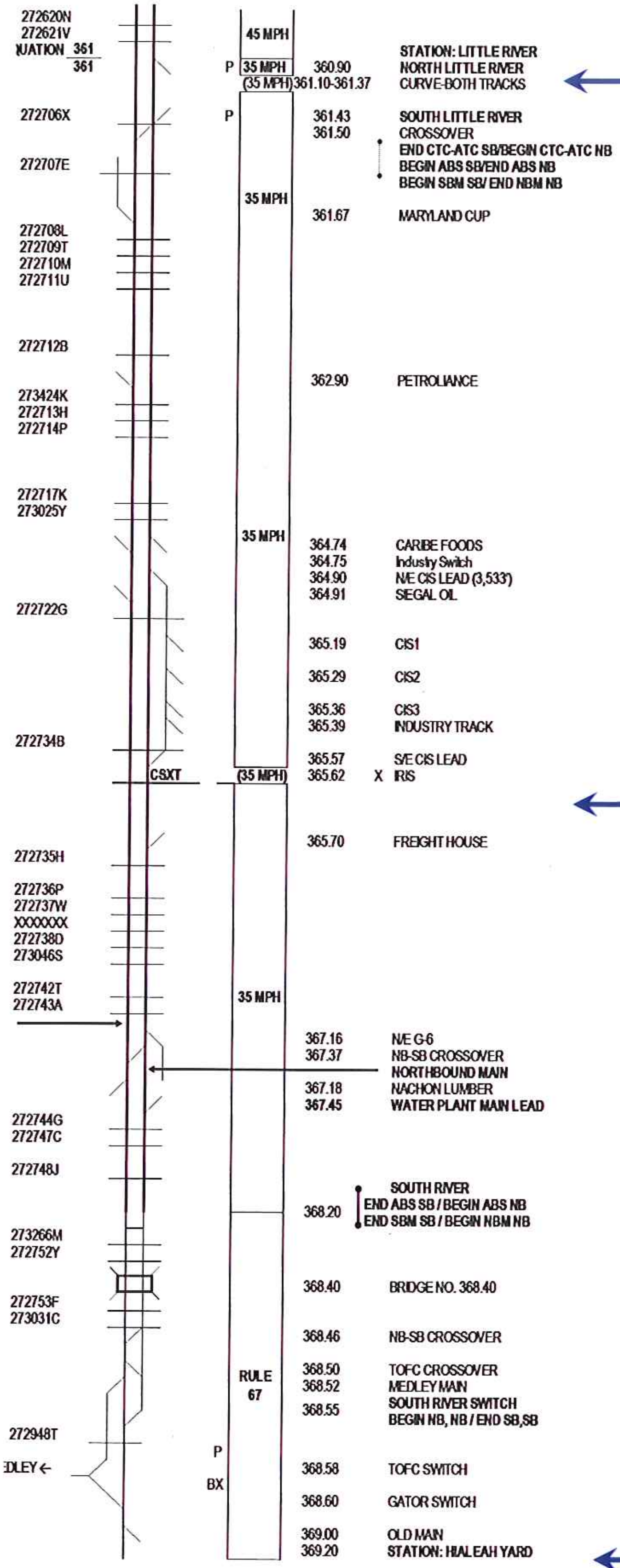
(Continued on Next Page)

PORT EVERGLADES
MP. 343.60

NORTH OJUS
MP. 351.10

NORTH MIAMI
MP. 357.60

MAINLINE TRACK (Little River – MP 360.90 to Hialeah Yard – MP 369.20)

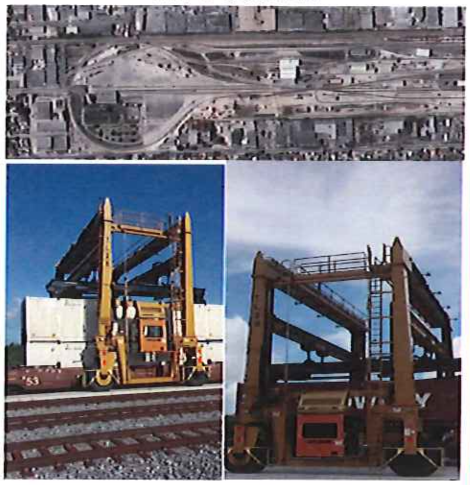


		STATION: LITTLE RIVER
360.90		NORTH LITTLE RIVER
361.10-361.37		CURVE-BOTH TRACKS
361.43		SOUTH LITTLE RIVER
361.50		CROSSOVER
		END CTC-ATC SB/BEGIN CTC-ATC NB
		BEGIN ABS SB/END ABS NB
		BEGIN SBM SB/ END NBM NB
361.67		MARYLAND CUP
362.90		PETROLIANCE
364.74		CARIBE FOODS
364.75		Industry Switch
364.90		N/E CIS LEAD (3,533')
364.91		SIEGAL OIL
365.19		CIS1
365.29		CIS2
365.36		CIS3
365.39		INDUSTRY TRACK
365.57		S/E CIS LEAD
365.62	X	IRIS
365.70		FREIGHT HOUSE
367.16		N/E G-6
367.37		NB-SB CROSSOVER
		NORTHBOUND MAIN
367.18		NACHON LUMBER
367.45		WATER PLANT MAIN LEAD
		SOUTH RIVER
368.20		END ABS SB / BEGIN ABS NB
		END SBM SB / BEGIN NBM NB
368.40		BRIDGE NO. 368.40
368.46		NB-SB CROSSOVER
368.50		TOFC CROSSOVER
368.52		MEDLEY MAIN
368.55		SOUTH RIVER SWITCH
		BEGIN NB, NB / END SB,SB
368.58		TOFC SWITCH
368.60		GATOR SWITCH
369.00		OLD MAIN
369.20		STATION: HIALEAH YARD

LITTLE RIVER
FEC MP. 360.90

IRIS INTERLOCKING
FEC MP. 365.62

HIALEAH YARD
MP. 369.20



Notes:

Thermal Sciences

Florida East Coast Railway

FECR Movement of LNG (b) (4) [redacted] (b) (4) [redacted] ISO Containers by Rail

Quantitative Risk Analysis (QRA) Considering LNG Position in Train and Train Speed

Exponent Project No. 1308194.001

Exponent®
Failure Analysis Associates®

Florida East Coast Railway

FECR Movement of LNG (b) (4) [redacted] (b) (4) [redacted] ISO Containers by Rail

Quantitative Risk Analysis (QRA) Considering LNG Position in Train and Train Speed

Exponent Project No. 1308194.001

Prepared for

Florida East Coast Railway, LLC
7150 Phillips Highway
Jacksonville, Florida 32256

Prepared by

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December 8, 2016

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Acronyms and Abbreviations

ALARP	As Low as Reasonably Practicable
ASME	American Society of Mechanical Engineers
ATC	Automatic Train Control
BLEVE	Boiling Liquid Expanding Vapor Explosion
°C	Degrees Celsius
DNV	Det Norske Veritas
DOT	U.S. Department of Transportation
ESD	Emergency Shutdown Device
°F	Degrees Fahrenheit
FECR	Florida East Coast Railway
FN	Frequency and Severity of Outcome
FRA	Federal Railroad Administration
ft	Feet
gpm	Gallons Per Minute
gal	Gallon
GPS	Global Positioning System
GSM	Gas Supply Module
HAZID	Hazard Identification
HAZMAT	Hazardous material
HSE	UK Health & Safety Executive
IR	Individual Risk
ISO	International Standards Organization
LEL	Lower Explosive Limit
LFL	Lower Flammable Limit
LIS	Locomotive Interface System
LNG	Liquefied Natural Gas
LOC	Loss of Containment
LPG	Liquefied Petroleum Gas
MAWP	Maximum Allowable Working Pressure
MU	Multiple Unit
NFPA	National Fire Protection Association
PHMSA	Piping and Hazardous Materials Safety Administration
P&ID	Piping and Instrumentation Diagram
psig	Pounds per square inch gauge
QRA	Quantitative Risk Assessment/Analysis
RTG	Rubber Tire Gantry
SOP	Standard Operating Procedure
SR	Societal Risk
Train Mile	Mile traveled by a train
UDM	Unified Dispersion Model
UFL	Upper Flammable Limit
yr	Year

Executive Summary

This report summarizes the Quantitative Risk Assessment (QRA) study conducted on the Florida East Coast Railway (FECR) movement of liquefied natural gas (LNG) (b) (4) [redacted] ISO tank containers by rail in freight trains. In order to assist the process safety management of the overall design, testing, and implementation project, the focus of the study was to evaluate the risk for movement of the (b) (4) [redacted] ISO tank containers by intermodal rail transportation. This Executive Summary highlights Exponent's findings in the QRA. Note that this Executive Summary does not contain all of Exponent's technical evaluations, analyses, conclusions, and recommendations. Hence, the main body of this report is at all times the controlling document.

E.1 QRA Overview

Movements were evaluated along three proposed routes: (1) from Hialeah Yard to Port of Miami, (2) from Hialeah Yard to Port Everglades, and (3) from Hialeah Yard to Bowden Yard in Jacksonville. ISO Lift On/Lift Off activities and train movements were evaluated in four yards/intermodal facilities: (1) Hialeah Yard, (2) Bowden Yard, (3) Port Everglades, and (4) Port of Miami.

The QRA relied upon a series of concept-phase Hazard Identification (HAZID) studies performed in FECR's LNG fuel tender project[1] along with a review of intermodal Lift On/Lift Off hazards to identify potential accident scenarios. A list of potential accident scenarios was developed from the HAZID studies, literature review, and review of FECR intermodal facilities and was used to define a reduced list of representative accidental release scenarios for the QRA.

The (b) (4) [redacted] ISO tank container movements were grouped into three distinct activities, distinguished by the type of operations and the risks present:

1. Lift On and yard movement at the Hialeah Rail Yard.
2. Mainline train movement.
3. Lift Off and yard movement at the receiving yard/intermodal facility.

The hazard scenarios corresponded to accidents involving the ISO tank, which is a (b) (4) [redacted]. Accident event

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[1] Exponent Project No. 1308194.000 report titled: "HAZID Study Report, Florida East Coast Railway Dual-Fuel Locomotive LNG Tender Project," issued January 2, 2015. Exponent Project No. 1308194.000 report titled: "HAZID Study Report, Florida East Coast Railway Dual-Fuel Locomotive LNG Tender Project, Updated to Reflect Chart LNG Tender," issued October 24, 2014. Exponent Project No. 1308194.000 report titled: "Integration HAZID Study Report, Florida East Coast Railway Dual-Fuel Locomotive and LNG Tender Project," issued December 12, 2014.

trees were constructed describing the necessary events and the frequency or probability of each step occurring to lead to a loss of containment (LOC) and ultimately a fire and/or explosion. Representative accident/failure frequency and probability values were developed from industry-available databases and FRA rail accident statistics. Several conservative assumptions were applied during the analysis to estimate failure probabilities for the LNG ISOs since no specific historical data exists for this operation. The assumptions may be evaluated and changed based upon new information, and this may lead to different and likely lower (i.e., less conservative) failure probabilities (e.g., lower risk). It was assumed that each train includes (b)(4) LNG ISO containers single-stacked in well cars, and (b)(4) cars were shipped every day of the year. Further, each of the three routes was evaluated independently to bound the maximum potential risk by assuming shipment via only one route. If the (b)(4) LNG ISOs are split among multiple routes, then the risk calculated for each route would decrease.

U.S. Census population data and Port passenger statistics were used to represent the populations surrounding the mainline rail routes, rail yards, and intermodal facilities. The populations along the proposed mainline routes were evaluated as aggregated population groupings within 1.6 miles from the rail yards and either side of the rail mainline. Along the mainline, the population was evaluated within approximately one-mile increments along the route. The maximum one-mile population density was 11,800 people per square mile, which occurred in the Miami area. This population value was used to conservatively bound the risk for mainline movement of LNG ISOs.

E.1.1 Evaluating the Risk

A commercially available software tool (PHAST Risk v6.7) was used to model the consequences of potential releases resulting in pool fires, flash fires, pressurized jet fires, and explosions, and to calculate the resulting Individual Risk (IR) and Societal Risk (SR) for the mainline and yard/intermodal facilities. Typically, stakeholders (e.g., government agencies, investors, communities) set a threshold risk level that is deemed acceptable. This is called quantitative risk criteria and may vary from region to region and depends upon the type of facility or transportation activity. Currently, the U.S. Department of Transportation (DOT) Federal Railroad Administration (FRA) has not codified quantitative risk criteria for LNG hazardous materials transportation scenarios. Additionally, QRA analyses are not common regulatory requirements in the U.S. and no broadly-accepted risk criteria are employed by domestic communities or industries.

In this report, the calculated risk was benchmarked against a similar hazardous commodity—liquefied petroleum gas (i.e., propane or LPG). The quantitative risk criteria for evaluating the IR and SR used in this report were developed from those presented for stationary LNG plants in NFPA 59A *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG), 2016 edition*. The stationary LNG plant risk criteria are not directly applicable to rail movement of LNG, but these criteria are used as a reference point for evaluating the risk in this report. The risk criteria as applied in this report are summarized in the following table.

Summary of IR and SR quantitative risk criteria developed from NFPA 59A (2016) and used in this report.

IR Criteria (yr^{-1})	SR Criteria (evaluated per mile for Mainline)
Zone 1: IR ≥ 10^{-5}	Unacceptable Above: F = 10^{-4}, N = 10 Slope = −1
Zone 2: 10^{-6} ≤ IR < 10^{-5}	ALARP: Region between curves
Zone 3: 3 × 10^{-7} ≤ IR < 10^{-6}	Broadly Acceptable Below: F = 10^{-6}, N = 10 Slope = −1

E.2 Findings

The QRA generated several findings regarding shipping LNG ISOs on the FECR routes. The analysis required development of an accident model to calculate the release scenarios, which was then used to calculate the risk for various LNG ISO movement options along the routes. The risk was calculated for the rail yards and intermodal facilities by treating them as fixed facilities while the mainline risk was evaluated on a transportation route basis. Since transportation quantitative risk criteria are not typically applied in the U.S., the risk was benchmarked against a similar hazardous commodity—liquefied petroleum gas (i.e., propane or LPG) and similar risk criteria proposed for stationary LNG plants in the U.S. Finally, the Individual Risk for the intermodal facilities and mainline transportation routes was mapped to compare against potentially sensitive targets along the routes.

E.2.1 Accident Model

An accident model was developed as part of the QRA to address yard movements and mainline movements of LNG ISOs in freight trains. The intermodal facility risk also included considerations for lifting ISOs onto and off of trains. For train movements, loss of containment of LNG from an ISO was assumed to occur as the result of a derailment accident. LNG was assumed to be the only hazardous material involved in any incident. FRA data and Pipelines and Hazardous Material Administration (PHMSA) data were used to build the accident model. A flowchart depicting the sequential steps of the accident model is provided in Figure E-1. The sections of the report where each analysis block is described are listed in Figure E-1.

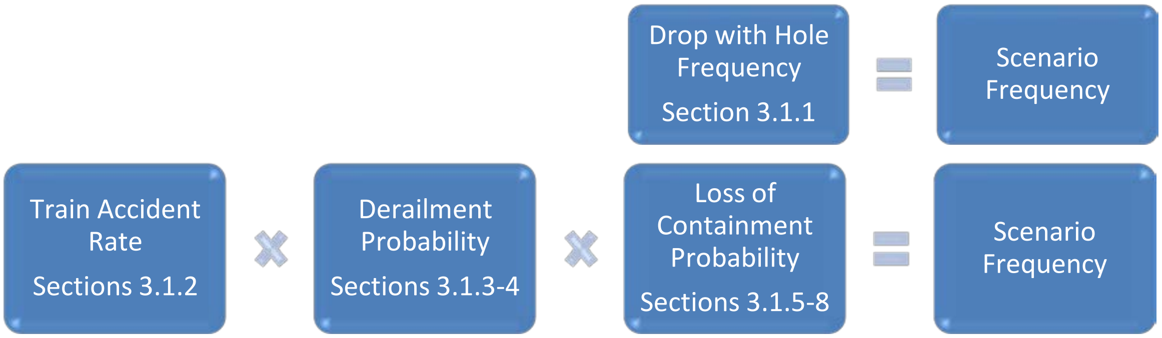

Figure E-1. LNG ISO train accident model overview.

Based on the assumed daily movement of (b)(4) ISO containers, the analysis accounted for (b)(4) lifts per day at Hialeah Yard, and another (b)(4) lifts per day at the receiving intermodal facility. The frequency for dropping an ISO that results in a 50 mm hole was found in the literature to be 6.7×10^{-7} per lift. For (b)(4) lifts per day, this resulted in the following release frequency for each intermodal facility.

LOC frequency for dropping an LNG ISO container.

Event	Release Frequency
Dropped ISO, large leak (50 mm hole)	2.2×10^{-3} yr^{-1}

FRA accident data from 1995 through 2015 were analyzed to develop train accident rates. Based on the available data, the train accident rate was calculated as accidents per train mile as shown in the table below. The accident rates for the last five years is provided for comparison and are approximately 20-25% lower than the historical average. However, the QRA conservatively applied the higher accident rate in order to provide an upper bound for the risk.

Train accident rates from FRA data.

	Statistic	2011-2015	1995-2015
Yard	Total Yard Train Miles	0.446×10^{9}	1.853×10^{9}
	Yard Accident Rate (/train mile)	1.55×10^{-5}	1.98×10^{-5}
Mainline	Total Non-Yard (Mainline) Train Miles	3.254×10^{9}	13.48×10^{9}
	Non-Yard Accident Rate (/train mile)	1.81×10^{-6}	2.47×10^{-6}

The position in train derailment probability was evaluated as a function of train configuration for LNG ISOs as part of the QRA. A derailment model was employed where the probability that LNG ISOs would be derailed in an accident was related to the probability of the first car derailed and average number of cars derailed. It was assumed that a derailment would involve sequential cars starting with the first car derailed. The following two tables provide the probability of being the first car derailed versus position in the train and the average number of cars derailed in an accident.

Representative probability of first car derailed for Class 1 and 2 Railroads (1995-2015).

Statistic	Car Position in Train			
	1	11	21	31
Yard Derailment Accident	24.8%	1.60%	1.20%	0.82%
Mainline Derailment Accident, Speed < 25 mph	17.3%	1.80%	1.13%	0.97%
Mainline Derailment Accident, Speed ≥ 25 to ≤ 60 mph	15.8%	1.07%	1.02%	0.80%

Average number of cars derailed (1995-2015).

Statistic	No. of Cars
Yard Derailment Accident	4
Mainline Derailment Accident, Speed < 25 mph	5
Mainline Derailment Accident, Speed ≥ 25 to ≤ 60 mph	11

Seven different train configurations were evaluated to demonstrate the effects of blocking LNG ISOs into sequential car groupings on the calculated risk. The baseline configuration (C-1) placed [redacted] LNG ISOs in sequence from train position [redacted] to [redacted] If a train accident leads to a derailment, then each configuration and speed/yard case will represent a distinct probability array for multiple cars being derailed. The probability relationship for multiple cars being derailed from the baseline train configuration C-1 at high speed (≥ 25 to ≤ 60 mph) is shown in the table below. Similar relationships were developed for each train configuration, yard accidents, low speed accidents, and high speed accidents.

Probability of having X number of LNG ISO cars derail in the event of a train accident, where X is the number of LNG ISOs involved, for the baseline train configuration and mainline train movements at high speed.

Number of LNG ISOs Derailed (X)	0	1	2	3	4	5	6	7	8	9	10
Probability	59%	17%	3.7%	3.7%	3.0%	2.1%	2.7%	2.5%	2.3%	2.4%	2.4%

Finally, the loss of containment (LOC) was modeled using a probability versus quantity released relationship developed from analysis of historical PHMSA data. Since data are sparse for [redacted] [redacted] ISO containers in rail accidents, pressure tank car data was used as an analog to represent pressurized ISO container failure probability. The probabilities are shown in the table below.

The release scenario probabilities were combined with the probabilities of derailment for multiple cars in an event tree model to estimate the quantity released for each distinct outcome in the accident model.

LOC probability from PHMSA pressure tank car incident data and equivalent release scenario for LNG ISOs.

Quantity Released in gallons	Probability	Release Scenario
=< 100	0.958	No Release
100 < x =< 1,000	0.014	½-inch Leak
1,000 < x =< 30,000	0.025	2-inch Leak
> 30,000	0.003	Catastrophic

E.2.2 Mainline Risk

The risk posed by the LNG ISOs along the mainline was evaluated by making conservative assumptions in order to bound the maximum risk of all route options. The results are reported for the highest mainline population density value of 11,800 people per square mile. For regions of the mainline with lower population, the calculated risk will be less than that presented. Two speed ranges, low speed <25 mph and high speed ≥25 mph to ≤60 mph, were applied in the model to demonstrate the effects of train speed restrictions. Seven different train configurations were evaluated to demonstrate the effects of blocking LNG ISOs into sequential car groupings. For example, the baseline case (C-1) placed (b)(4) LNG ISOs in sequence from train position (b)(4) to (b)(4) This configuration poses the highest risk since all LNG ISOs are in sequence, all may be involved in an individual derailment (high speed only), and the highest probability of derailment is at the front of the train. As a comparison, train configuration C-2 places the (b)(4) LNG ISOs in sequence from train position (b)(4) to (b)(4) The table below compares the calculated risk metrics for low speed and high speed movement of these train configurations along the mainline when assuming the highest population density. For slow speed train movements, the Zone 3 risk level is never reached in the analysis, and for high speed train movements, the Zone 2 risk level is never reached.

Summary of the risk metrics for mainline LNG ISO car train movements.

Risk Metric	Train Speed < 25 mph		Train Speed 25 – 60 mph	
	(b)	(b)	(b)	(b)
SR Integral (total risk, yr^{-1})	[redacted]	(b) (4)	[redacted]	[redacted]
Maximum IR (yr^{-1})	[redacted]	(b) (4)	[redacted]	[redacted]
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	(b)	[redacted]	[redacted]	[redacted]
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	(b)	[redacted]	[redacted]	[redacted]
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	(b)	[redacted]	[redacted]	[redacted]

E.2.3 Intermodal Facility Risk

The overall risk of LNG ISO lifting and train movement within the intermodal facilities and train yards is influenced by the contribution from lifting risk. The analysis was conducted by assuming that all lifts occurred at a single point on the intermodal ramp track, which had the effect of maximizing the Individual Risk for the facility. When the lifting is distributed along the intermodal track, the Individual Risk profile will decrease for the facility. The Individual Risk posed by train movement within the facilities yielded an Individual Risk profile that was a combination of yard track movement overlapped with lifting risk where applicable. For the facilities, the Individual Risk thresholds typically crossed the property boundaries when lifting was assumed to occur at a point, but only the Zone 3 risk threshold appeared to overlap offsite populations when lifting was modeled along the intermodal ramp track.

A summary of the risk results for the facilities is provided in the table below. For the facilities, the actual surrounding population densities were applied, and these results represent train configuration C-1. Since Individual Risk is dominated by lifting, which is independent of train configuration, other train configurations are not included. Note that the distances are from the track or point of lifting—not from the property boundary.

Summary of the risk metrics for LNG ISO train movement and ISO lifting.

Risk Metric	Hialeah	Port of Miami	Port Everglades	Bowden Yard
SR Integral (total risk, yr^{-1})	(b) (4)	[redacted]	[redacted]	[redacted]
Maximum IR (yr^{-1})	(b) (4)	[redacted]	[redacted]	[redacted]
Train Movement (from Track):				
Max Distance to Zone 1 - 1×10^{-5} IR (ft)	(b) (4)	[redacted]	[redacted]	[redacted]
Max Distance to Zone 2 - 1×10^{-6} IR (ft)	(b) (4)	[redacted]	[redacted]	[redacted]
Max Distance to Zone 3 - 3×10^{-7} IR (ft)	(b) (4)	[redacted]	[redacted]	[redacted]
ISO Lifting (from Point):				
Max Distance to Zone 1 - 1×10^{-5} IR (ft)	(b) (4)	[redacted]	[redacted]	[redacted]
Max Distance to Zone 2 - 1×10^{-6} IR (ft)	(b) (4)	[redacted]	[redacted]	[redacted]
Max Distance to Zone 3 - 3×10^{-7} IR (ft)	(b) (4)	[redacted]	[redacted]	[redacted]

E.2.4 Benchmarking LNG against LPG

There is no current regulatory quantitative risk criteria for Individual Risk or Societal Risk of LNG transportation by rail, and the criteria used here were developed from those applicable to stationary LNG plants. Acceptable quantitative risk criteria for transportation of hazardous materials typically represent higher risk levels than stationary facilities. To benchmark the risk posed by LNG ISO train movements, the risk of movements of liquefied petroleum gas (propane or LPG) in the rail yards and along the mainline were analyzed. On an energy equivalence basis, (b) (4) 10,000 gallon ISO containers of LNG were compared to (b) (4) 34,000 gallon DOT-112 tank cars of LPG.

As a result of the QRA, the transportation and handling of (b) (4) LNG ISO containers was found to present similar or less risk than the movement of (b) (4) tank cars containing LPG. Accidents involving LPG cars were only considered during train movements in the rail yards since no lifting occurs with this car type. Overall, risk of transporting LPG was found to be comparable to LNG within the rail yards and intermodal facilities and was found to be slightly higher than LNG on the proposed routes. The overall risk for LNG ISOs in the Hialeah yard is significantly influenced by the contribution from lifting risk, which is not present for LPG. The risks between LNG and LPG are summarized in the tables below for mainline movements and for the Hialeah facility.

Comparison of risk metrics for LNG ISOs and LPG rail car mainline train movements.

Risk Metric	Train Speed < 25 mph		Train Speed from 25 – 60 mph	
	LNG	LPG	LNG	LPG
SR Integral (total risk, yr^{-1})	(b) (4)	[redacted]	[redacted]	[redacted]
Maximum IR (yr^{-1})	(b) (4)	[redacted]	[redacted]	[redacted]
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	(b)	[redacted]	[redacted]	[redacted]
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	(b)	[redacted]	[redacted]	[redacted]
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	(b)	[redacted]	[redacted]	[redacted]

Comparison of risk metrics for LNG ISOs and LPG rail car movements and LNG ISO lifting in the Hialeah Yard.

Risk Metric	LNG	LPG
SR Integral (total risk, yr^{-1})	(b) (4)	[redacted]
Maximum IR (yr^{-1})	(b) (4)	[redacted]
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	(b)	[redacted]
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	(b)	[redacted]
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	(b)	[redacted]

E.2.5 Sensitive Targets for Routes 1 and 2

The FRA requested that FECR perform an analysis of potentially sensitive establishments along the proposed railway routes. There is no current regulatory quantitative risk criteria for Individual Risk or Societal Risk of LNG transportation by rail, and the criteria used here were developed from those applicable to stationary LNG plants. For stationary LNG plants, NFPA 59A does not permit sensitive establishments, such as churches, schools, hospitals, and major public assembly areas, to be located within an Individual Risk contour greater than 3×10^{-7} per year (called Zone 3).[2] There are many differences in the hazards and risk profile between a stationary facility and a transportation activity. Acceptable quantitative risk criteria for transportation of hazardous materials typically represent higher risk levels than stationary facilities. However, the Zone 3 risk from NFPA 59A was used as the benchmark for evaluation of risk to offsite populations.

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[2] NFPA 59A (2016) *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* §15.10.1

The distance to the Zone 3 contour is approximately [redacted] feet for high speed train movement, with high population density, and train configuration C-1 with LNG ISOs from train position [redacted]. By changing the train configuration, the distance to the Zone 3 contour will be decreased or eliminated entirely. For example, the C-2 configuration with [redacted] LNG ISOs in sequence from train position [redacted] yields a distance of [redacted] feet to the Zone 3 contour. At low speed, the Zone 3 contour is eliminated entirely. Only one section of the two mainline routes had listed speed restriction of 25 mph or less, and this was in downtown Miami near the American Airlines Center. No Zone 3 contour was present in this area since the train was restricted to low speed. Potentially sensitive targets along Route 1 and Route 2 were identified from Google Maps, and their distance was determined from the approximate center of the track or approximate facility boundary. The following potentially sensitive targets were identified given these assumptions.

Potentially sensitive establishments along Route 1 – Hialeah to Port of Miami.

Establishment Name	Category	Sub-Category	Distance to Railway
iMater Academy Charter School	School	Public Charter School	[redacted]
New Vision Emmanuel Baptist Church	Church	Self-standing church	[redacted]
ASPIRA of Florida	School	Charter School	[redacted]

*Notes: 1) Distance measurements taken from center of track to closest portion of building. 2) Identified only schools that were elementary and above

Potentially sensitive establishments along Route 2 – Hialeah to Port Everglades.

Establishment Name	Category	Sub-Category	Distance to Railway
iMater Academy Charter School	School	Public Charter School	[redacted]
New Vision Emmanuel Baptist Church	Church	Self-standing church	[redacted]
Aventura Waterways K-8 School	School	Public School	[redacted]
Victory Christian Center	Church	Self-standing church	[redacted]
Hallandale Church of Christ	Church	Self-standing church	[redacted]
Ebenezer Baptist Church	Church	Self-standing church	[redacted]

*Notes: 1) Distance measurements taken from center of track to closest portion of building. 2) Identified only schools that were elementary and above

E.3 Limitations of the Study

As requested by Florida East Coast Railway, LLC, Exponent conducted a Quantitative Risk Assessment (QRA) study addressing FECR movement of LNG (b) (4) ISO containers by rail. The scope of services performed during this review may not adequately address the needs of other users of this report, and any use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the study. The representation of NFPA 59A risk criteria in this report has been done for the purposes of comparing the transportation risk to a set of existing stationary facility quantitative risk criteria available in the U.S. and may not necessarily be appropriate or applicable for directly assessing acceptability of transportation risk. The assumptions adopted in this study do not constitute an exclusive set of reasonable assumptions, and use of a different set of assumptions or methodology might produce materially different results. Therefore, these results should not be interpreted as predictions of a loss that may occur as a result of any specific future event. Accordingly, no guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

The findings and recommendations presented herein are made to a reasonable degree of engineering certainty. The methodology that was used in this report is based on mathematical modeling of physical systems and processes as well as data from third parties in accordance with the regulatory requirements. Uncertainties are inherent to the methodology and these may subsequently influence the results generated.

1 Introduction

Exponent conducted a Quantitative Risk Assessment (QRA) for movement of liquefied natural gas (LNG) in (b) (4) [redacted] ISO tank containers by rail on the Florida East Coast Railway (FECR). The objective of the study was to determine the level of risk associated with the shipping of the LNG ISO containers along three potential routes in Florida. The analysis incorporated aspects of prior LNG-related rail transportation risk analyses and hazard identification studies by FECR. The QRA included typical accidental release scenarios that may lead to a loss of containment from LNG ISO containers including consideration of ISO container Lift On/Lift Off (i.e. lifting) at intermodal facilities.

The Federal Rail Administration (FRA) provided the following requirements for risk analysis of LNG shipping by rail, which were addressed through this study:[3]

> A detailed risk analysis of the proposed operation along with appropriate mitigating measures. At a minimum, this risk analysis must include:
>
> a. Risks to the public and railroad workers from the proposed transportation of LNG, considering volumes transported, routes, operations on main lines, passenger rail operations on the proposed transportation lines, yards, Lift On and Lift Off areas, types of trains used, and any other relevant risk factors.
> b. Analysis of the specific structural characteristics (e.g., susceptibility, strength, ability to withstand exposure to heat) of the portable tanks proposed to be used, the number of tanks in a train, train speed, and position in train.
> c. Analysis of the thermophysical properties of LNG and its vapor, and expected multifaceted behavior of released LNG (fires, confinement-caused explosions, vapor fires, unconfined vapor cloud explosions, etc.) and the magnitudes of the different types of hazards presented by these properties.
> d. Considerations of the population density, critical infrastructures, and sensitive assets (e.g., schools, churches, playgrounds, sports arenas, elderly care/nursing homes, Emergency Medical Services, police stations, hospitals, power stations) along the routes proposed.
> e. Assessment of both societal risks and individual risk to persons in the vicinity of the transportation routes and who may be adversely affected by an accident or incident involving a train transporting LNG.

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[3] Guidance for Preparing an Application under Title 49 Code of Federal Regulations Section 174.63 for Approval by the Federal Railroad Administration to Transport Liquefied Natural Gas by Rail in Portable Tanks.

f. A quantitative comparison of the risks of LNG transportation in portable tanks to the risks from other flammable hazardous materials shipped on rail in portable tanks (using the volume of shipments and routes proposed for LNG shipments).

To address the FRA request, the risk of potential major incidents posed to surrounding populations was calculated during the QRA. The risk results have been presented in this report as Individual Risk (IR) contours around the rail yard intermodal facilities and graphically as Societal Risk (SR) through an incident frequency and severity of outcome (FN) curve on a per mile basis.

1.1 Understanding Risk

Risk, simply defined, is the potential to lose something of value. Risk is evaluated by taking the product of event likelihood with the event outcome severity, and then comparing the product to some benchmark risk which is considered by the stakeholders as being acceptable.

The likelihood of an event can be estimated using experience relating to given equipment in similar service, industry data, or engineering approximations. A challenge of quantifying risk, or affixing a number to a particular risk level, is determining how to quantify the event outcome portion of the equation. For quantifying risk at industrial facilities and operations, the outcome of an event is typically evaluated as the potential for a fatality or multiple fatalities.

In evaluating the potential for fatality, two metrics are utilized to yield the risk: (1) Individual Risk (IR) and (2) Societal Risk (SR). Individual Risk is the frequency (yr^{-1}) where an individual with continuous potential exposure may be expected to sustain a serious or fatal injury.

In this QRA report, the IR is presented in two different manners. For the intermodal facilities and rail yards at the Bowden Yard, the Hialeah Yard, Port of Miami, and Port Everglades, which are treated as fixed facilities, the IR is provided as frequency contours on aerial maps that illustrate the risk to individuals positioned within those contours. Because the LNG ISO containers will be shipped along fixed routes, release scenarios were modeled along the rail lines. There are approximately (b)(4) miles of rail along the line of road between Bowden and Hialeah. IR contours cannot be succinctly represented for long routes such as this, but they are related to the population level along the line.[4] Thus, the highest risk along the mainline will occur at the portion of the track exposed to the highest populations.

Societal Risk (SR) is another method for evaluating the risk of a given process or operation. Unlike IR, the SR calculation considers the relationship between the number of potential fatalities versus likelihood from a series of potential events. The outcome of a SR analysis is a

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[4] IR is a weak function of population due to the population density effect on the likelihood of ignition.

graph depicting annual frequency on the y-axis and N fatalities on the x-axis, where N is the cumulative number of potential fatalities for all scenarios represented by the corresponding cumulative frequency of events. Whereas the IR calculation gives insight into the probability of having a fatality, the SR calculation gives the likelihood of a number of potential fatalities. This is especially important for evaluating scenarios with a large potential impact for loss of life, such as train derailments of flammable materials.

1.1.1 Developing Quantitative Risk Criteria

After quantifying risk and presenting the calculations as IR and SR for a given operation or process, the results are evaluated for tolerability (or acceptability). Typically, stakeholders (e.g., government agencies, investors, communities) have a threshold risk level that is deemed acceptable—known as quantitative risk criteria. Currently, the U.S. Department of Transportation (DOT) Federal Railroad Administration (FRA) has not codified quantitative risk criteria for LNG hazardous materials transportation scenarios.[5] Additionally, QRA analyses are not common regulatory requirements in the U.S. and no broadly-accepted risk criteria are employed by domestic communities or industries. The Dutch government and their respective regulatory agencies have been international leaders in utilizing QRA techniques for determining acceptability of fixed facilities and transportation routes. The approach for evaluating the risk results presented here is consistent with the Dutch guidance.

There are several foreign and several domestic examples of quantitative risk criteria.[6,7,8] Within these, there is a wide disparity in risk criteria for public exposure, with acceptable IR fatality probabilities ranging from 10^{-4} yr^{-1} (or a fatality per 10,000 years) to 10^{-8} yr^{-1} (or a fatality per 100,000,000 years). Recommendations for QRA of LNG plants were issued in the National Fire Protection Association (NFPA) standard, NFPA 59A *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*.[9,10] In addition to including QRA as a risk assessment

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[5] Strang J, "Federal Railroad Administration Risk Reduction Programs," United States Army Corps of Engineers Workshop on Tolerable Risk, March 18-19, 2008, Alexandria, Virginia.

[6] Appendix B: Survey of Worldwide Risk Criteria Applications, *Guidelines for Developing Quantitative Safety Risk Criteria*. Center for Chemical Process Safety, AIChE (2009).

[7] Cornwell JB and MM Meyer, "Risk Acceptance Criteria or 'How Safe is Safe Enough?'" presented at II Risk Control Seminar in Puerto La Cruz, Venezuela, October 13, 1997.

[8] Ham JM, M Struckl, AM Heikkila, E Krausmann, C DiMauro, M Christou, JP Nordvik, "Comparison of Risk Analysis Methods and Development of a Template for Risk Characterisation," Institute for the Protection and Security of the Citizen, European Commission, Directorate-General Joint Research Center (2006).

[9] NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, 2016 edition, National Fire Protection Association.

[10] It should be noted that an older version – the 2001 edition of NFPA 59A – is one of the primary references for the requirements found in 49 CFR § 193, which provides the regulatory requirement for fixed LNG facilities operating in the U.S., and many of the 49 CFR § 193 codes reference NFPA 59A requirements directly. The 2001 edition of NFPA59A does not include requirements or suggestions for QRA.

tool in the latest edition of NFPA 59A, the standard also includes quantitative risk criteria for fixed LNG facilities. NFPA 59A explicitly applies to LNG plants and stationary facilities; it does not apply to LNG transportation or portable LNG containers. Thus, the quantitative risk criteria proposed in the standard are not directly applicable to rail shipping of LNG. However, these risk criteria were used as one basis for quantitative risk criteria for rail shipping of LNG that were used in this analysis.

1.1.2 Individual Risk Criteria

NFPA 59A identifies three "Zones" representing ranges of quantitative risk criteria for evaluating IR. Each risk zone reflects general types of public occupancies recommended to be permitted. As the magnitude of the calculated risk increases, the type of occupancy becomes more restrictive. The quantitative risk criteria for IR of LNG plants are reproduced in Table 1. The occupancies not permitted in Zone 3, as described in Table 1, are referred to as "sensitive targets," consistent with the FRA guidance document.[11] The FRA has requested that FECR identify Zone 3 occupancies that are located within 500 feet of the proposed rail shipping routes. These are provided in tabular form and identified on aerial images in Appendix G.

For LNG release scenarios, the magnitude of the risk generally increases as the observation point is moved closer to the railroad. The distance to each risk level identified in the table is a result of the compilation of the outcomes calculated from an event tree of many potential fire and explosion events.

Based on Zone 3 being the most restrictive zone, any IR values less than (b) (4) [redacted] [redacted] are not of concern for the analysis in this report and these contours are not reported. The IR ranges and associated criteria appear to be based on guidance provided by the Health and Safety Executive in the UK for QRA[12] and do not account for the factors typically considered in a transportation risk analysis. However, the commonly acceptable level of IR for transportation risks on sensitive populations is 10^{-6}, which is the upper threshold for Zone 3.[13]

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[11] Guidance for Preparing an Application under Title 49 Code of Federal Regulations Section 174.63 for Approval by the Federal Railroad Administration to Transport Liquefied Natural Gas by Rail in Portable Tanks.

[12] "B.1 Evolution of Land Use Planning Criteria in the UK," in Guidelines for Developing Quantitative Safety Risk Criteria, American Institute of Chemical Engineers, Center for Chemical Process Safety (2009).

[13] See Section 5.4 in reference: Ham JM, M Struckl, AM Heikkila, E Krausmann, C DiMauro, M Christou, JP Nordvik, "Comparison of Risk Analysis Methods and Development of a Template for Risk Characterisation," Institute for the Protection and Security of the Citizen, European Commission, Directorate-General Joint Research Center (2006).

Table 1. Quantitative risk criteria for IR contours as provided by NFPA 59A (2016).

Criterion Annual Frequency (yr^{-1})	Remarks
Zone 1 $IR > 10^{-5}$	Not permitted: Residential, office, and retail Permitted: Occasionally occupied developments (e.g., pump houses, transformer stations)
Zone 2 $10^{-6} \leq IR < 10^{-5}$	Not permitted: Shopping centers, large-scale retail outlets, restaurants, etc. Permitted: Work places, retail and ancillary services, residences in areas of 7,250 to 23,300 persons/mile^2 density
Zone 3 $3 \times 10^{-7} \leq IR < 10^{-6}$	Not permitted: Churches, schools, hospitals, major public assembly areas, and other sensitive establishments Permitted: All other structures and activities

1.1.3 Societal Risk Criteria

Based on a review of the literature and an understanding of the risk analysis framework, it is apparent that stationary facility SR criteria are not appropriate for transportation or shipping of hazardous materials. For the risk of a stationary facility, all consequences (e.g., toxic release, fires, and explosions) are limited to the region surrounding the facility, which may have a characteristic dimension on the order of 1 km with a fixed surrounding population. If the same consequences are applied to a tanker truck or rail car transportation route, then the geographic region where those consequences may be manifest can be much larger and the surrounding population may vary. Additionally, for stationary facilities there may be green space (i.e., no permanent population) around the site and/or a considerable amount of property under their control; however, concerning transport applications, this standoff distance is greatly reduced or may not exist.

The aggregate societal risk for a transportation route is directly proportional to the length of the route. For example, a 10 km route would have 10 times the risk of a stationary facility all else being equal, a 100 km route would have 100 times the risk, and so on. Using a quantitative risk criterion that is based on a stationary facility will inherently limit the consideration of routes to those that are similar in dimension to a stationary facility. In fact, to address this limitation, the international regulations and guidance documents employ a scaled approach where the SR criteria are evaluated on a per unit length of route (i.e., per route kilometer) basis. Authors and regulators have concluded that in order to directly compare the analysis of transportation or pipeline risk to stationary facilities, these scenarios should consider FN curves normalized per representative unit length (which is typically on a per route kilometer basis).[14,15,16] Although many international groups and agencies also increase the stationary facility quantitative risk criteria by an order-of-magnitude when applied to transportation routes, this approach was not taken here in order to use conservative risk criteria (although increasing the thresholds by an order of magnitude may ultimately be decided as being appropriate by the stakeholders for this project). Thus, the NFPA 59A stationary facility quantitative risk criteria were used as a basis for evaluating the transportation risk results on a per track mile basis. The SR has also been calculated on a per mile basis using customary measure of distance in the U.S. for the rail routes, which is also more conservative than using a per kilometer basis (i.e., the per mile risk is approximately twice the value as a per kilometer basis). Thus, Exponent's approach was to analyze the SR for shipping LNG on a per track mile basis and use the NFPA 59A stationary facility quantitative risk criteria in order to provide conservative risk results relative to the recommended approaches relied upon by international governments and agencies.

The SR quantitative risk criteria lines, as depicted in Figure 1, will be used in this report on a per track mile basis[17] for line of road operations. The FN curves for the yards and intermodal facilities will not be normalized per mile of track length since these operations more closely resemble stationary facilities and, therefore, will include the switching areas of the yards and the intermodal loading facilities.

The SR for alternative train configurations was also evaluated by examining the SR integral, or the area under the FN curve. This allows for the FN curves between multiple scenarios to be easily compared to one another by representing the FN curves as a single number. To compare against the values reported for the specific scenarios, the SR integral for the upper risk criterion (labeled "unacceptable" in NFPA 59A) is 6.91×10^{-3} when integrated from 1 to 1,000 (or $4.61\text{x}10^{-3}$ when integrated from 1 to 100).

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[14] Chapter 3.3.5 Detailed QRA, Railways, Calculation and presentation of results, p. 3.15 in *Guideline for Quantitative Risk Assessment, Part Two: Transport* (Dutch Purple Book), Publication Series on Dangerous Substances, Ministerie van Verkeer en Waterstaat (2005).

[15] Section 5.4, p. 23 in Ham JM, M Struckl, AM Heikkila, E Krausmann, C DiMauro, M Christou, JP Nordvik, "Comparison of Risk Analysis Methods and Development of a Template for Risk Characterisation," Institute for the Protection and Security of the Citizen, European Commission, Directorate-General Joint Research Center (2006).

[16] Schork JM, EM Lutostansky, and SR Auvil, "Societal Risk Criteria and Pipelines," Pipeline & Gas Journal, 239(10), October 2012.

[17] Two types of mile units are used in this report: train miles and track miles. Train miles represent the distance traveled by a train, typically as an average value of miles traveled per year. Track miles represent the length or position along a fixed route along the rail line.

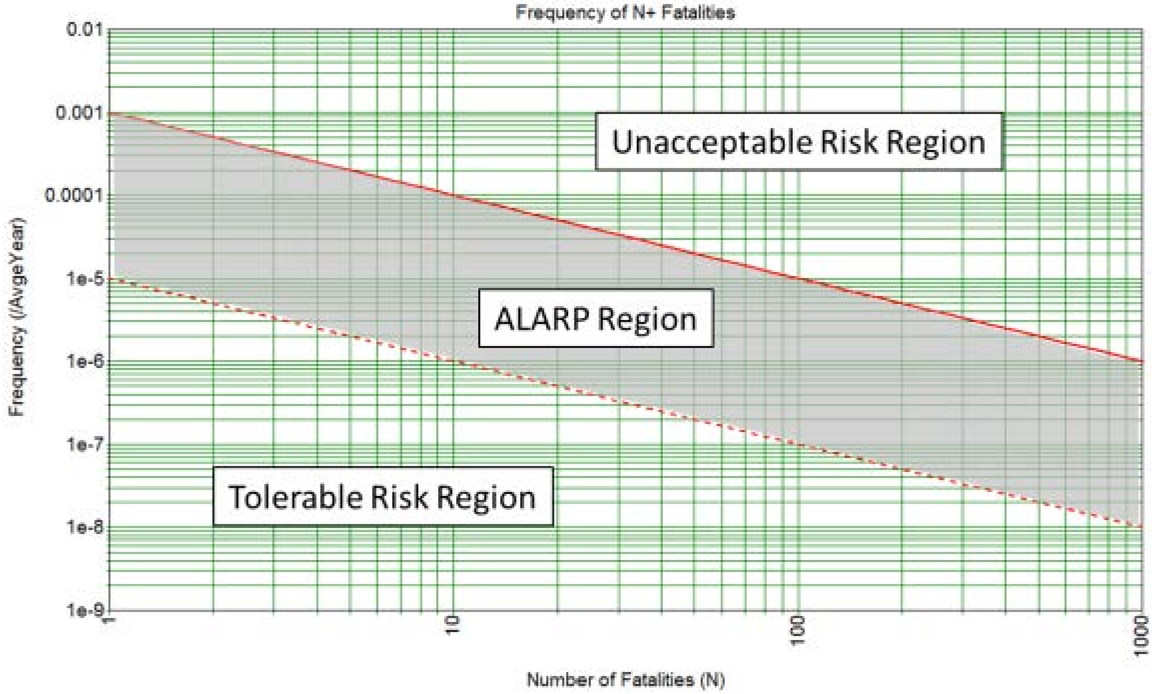


Figure 1. SR quantitative risk criteria presented on an example FN graph, as provided in NFPA 59A for fixed (stationary) LNG facilities. The definitions of the tolerable risk region, ALARP (As Low as Reasonably Practicable), and unacceptable risk region are provided by NFPA 59A, and do not necessarily reflect the tolerability criteria for transportation risk. The representation of NFPA 59A risk criteria in this report has been done for the purposes of comparing the transportation risk to a set of existing criteria used in the U.S. and may not necessarily be appropriate or applicable for assessing acceptability of transportation risk.

1.2 LNG Hazards

LNG poses unique hazards relative to other non-pressurized liquid fuels. LNG has a shipping identification number of UN1972 for refrigerated cryogenic methane. LNG, comprised primarily of methane, has a flammable range when mixed with air in concentrations of approximately 5% to 15%; outside of this range, the fuel will not burn. The liquefaction of natural gas is achieved by cooling the material to its normal boiling point, - 260°F. This is unlike other low molecular weight hydrocarbon fuels, like propane, which can be liquefied by pressurization. At the boiling point temperature, LNG does not need to be stored under pressure but it must be insulated to avoid excessive boiling due to heat transfer. As the liquid boils, it does so at its constant, low boiling point temperature. To avoid excessive pressure buildup under extended duration (e.g., on the order of 50 days) storage conditions, LNG ISO containers will vent low volumes of natural gas to the atmosphere via a pressure relief valve.

The cryogenic temperatures of LNG pose unique hazards to rail and intermodal personnel. Due to a large difference in temperature, the rapid transfer of heat from an object into the cryogenic liquid can cause burns if direct contact with skin occurs or if PPE is inadequate to prevent cold-temperature injury due to an exposure. Additionally, large spills of the liquid onto metal structures can cause embrittlement and fracturing. Methane is odorless and LNG contains no odorant (unlike residential natural gas supplies), making detection difficult without a flammable gas detector device.

The behavior of a spill of LNG is unique due to the cryogenic temperature of the liquid. For example, a spill of LNG will vaporize rapidly when it contacts ambient air and even faster when in contact with warm solids such as the ground. The cold vapors may condense humid air, causing fog formation and decreased visibility. After vaporization, the cold vapors are denser than ambient air, will tend to stay close to the ground as they disperse, and will get pushed by prevailing winds. The dense vapors can travel great distances without significant dilution, as the mixing with ambient air is limited near the ground, and the vapor will tend to accumulate in low spots or trenches along the ground.

The operational hazards of handling LNG were not considered in this study; only large scale releases and ignition that could cause fire and explosion events were explored. The specific fire and explosion scenarios, as well as release, ignition, and consequence probabilities will be discussed in more detail later in this report.

1.3 Robustness of FECR Engineering and Administrative Safeguards

The Florida East Coast Railway (FECR) system includes several aspects of engineering and administrative safeguards that are consistent with FRA best practices and are anticipated to minimize the risk of train accidents such as derailments and collisions. These are discussed in detail in Appendix B. In summary, the FECR system has the following features to complement the overall safety of rail operations:

1. Automatic Train Control
2. Low elevation changes
3. Concrete ties
4. Active crossing lights and gates
5. Equipment Defect Detector system along mainline route

For example, FECR uses Automatic Train Control (ATC) on all locomotives, which is integrated into the existing full aspect cab signal system (Engineer has an illuminated color coded signal in the locomotive cab as well as a similar corresponding signal on the wayside), that mitigates the following accident risks:

1. Main-line train to train collision.
2. Engineer disregard of a red signal as a result of an unsafe track condition or switch position.
3. Automatic application of the train brakes to a train when the engineer or conductor has not complied with a red signal indication.

The rules for ATC are provided in 49 CFR Part 236 Subpart E–Automatic Train Stop, Train Control and Cab Signal Systems.

2 Systems Description

LNG ISO tank container movements were evaluated along three proposed routes: (1) from Hialeah Yard to Port of Miami, (2) from Hialeah Yard to Port Everglades, and (3) from Hialeah Yard to Bowden Yard (Jacksonville). The LNG will be provided by the nearby LNG facility in Hialeah, Florida. This facility has a liquefaction capacity of (b) (4) gallons per day; thus, the QRA assumed an average daily movement rate of (b) (4) 10,000 gallon ISO containers. As will be discussed below, although more containers may theoretically be shipped intermittently, the overall risk is adequately represented by modeling this annual average movement capacity.

The (b) (4) ISO tank container movements were grouped into three distinct activities, distinguished by the type of operations and the unique risks present:

1. Lift On at Intermodal Facility in Hialeah Rail Yard
2. Mainline train movement
3. Lift Off at Intermodal Facility

The following sections will provide more details on the ISO tank containers, intermodal operations, and the proposed train routes.

2.1 (b) (4) ISO Tank Containers

The LNG will be transported in (b) (4) ISO cryogenic portable tank containers (ISOs). The ISOs are certified against the International Maritime Organization – International Maritime Dangerous Goods Code, Volume 1, which is incorporated into the specific federal code – Title 49 Code of Federal Regulations (CFR) Part 172.519(f). The ISOs are designed to be transported as intermodal freight by railroad, tractor-trailer, and marine vessel, in order to reduce the need for transfer between containers during transport from the liquefaction facility and the end customer. (b) (4)

The (b) (4) ISO is comprised of an (b) (4)

The ISO containers are designed for LNG service. Some design parameters are listed in Table 2, and Figure 2 is a copy of the general assembly drawing. The ISOs will operate at (b) (4) psig and will be fitted with pressure relief safety valves set at the Maximum Allowable Working Pressure (MAWP) of (b) (4) psig. The saturation temperature (i.e., boiling point) for LNG at the operating pressure of (b) (4)

Table 2. (b) [redacted] ISO tank container design parameters.

Parameter	Value
Operating Pressure (psig)	(b) [redacted]
Design Pressure (psig)	(b) [redacted]
MAWP (psig)	(b) [redacted]
Design Temperature (°C)	(b) [redacted]
Operating Temperature (°C)	(b) [redacted]
Net Volume (gal)	(b) (4) [redacted]

(b) (4) [redacted]

Figure 2. General assembly drawing for LNG (b) [redacted] ISO portable tank containers to be used by FECR.

Figure 3 is a copy of the piping and instrumentation diagram (P&ID) for the (b) (4) ISO tank container, which depicts the piping connections to the inner tank. The piping connections to the inner tank are the following:

- (b) (4)

Images of a representative ISO container are provided in Figure 4, Figure 5, and Figure 6. Figure 4 is a photograph of one of the LNG (b) (4) ISO portable tank containers mounted on an intermodal truck chassis at the offsite LNG loading station. Figure 5 is a picture of the rear of the chassis depicting the closed valve cabinet. Figure 6 is a photograph of the valves and outer tank penetrations inside the valve cabinet. The pressure relief valve array is located above the cabinet inside the frame. (b) (4)

(b) (4)

Figure 3. Piping and instrumentation diagram for (b) (4) ISO portable tank container.

D15997 - 0051

Figure 4. (b) (4) [redacted] ISO tank container mounted on a truck chassis.

D15997 - 0045

Figure 5. Rear view of (b) (4) [redacted] ISO portable tank container on a truck chassis depicting the valve cabinet.

Figure 6. View of valves and outer tank penetrations inside valve cabinet.

2.2 Intermodal Facility Operations

The filled LNG ISOs will be transferred onto well cars at the Hialeah Yard intermodal facility. The operation of transferring the LNG ISOs from the truck chassis to the well cars is termed "Lift On," and transferring from well cars back to truck chassis is termed "Lift Off." After movement on a train along a given route, the ISOs will be lifted off the well cars and attached to truck chassis at the receiving intermodal yard. This risk analysis does not address over the road transport or storage of LNG ISOs; only the train movement and Lift On/Lift Off activities are considered. Additionally, empty ISOs pose minimal hazardous material risks; thus, the return of empty ISOs was not analyzed.

FECR contracts (b) (4) to operate and maintain lifting equipment for transferring ISO containers from truck chassis onto well cars. Truck chassis are driven within the intermodal yard by local drivers who may be either FECR contractors or Port contractors. The truck chassis are positioned near the trains on the intermodal facility ramp area. Figure 7 and Figure 8 show the two types of container lifting equipment used in the intermodal facilities. Trained (b) (4) operators control (b) (4) cranes or (b) (4) depending upon the logistics for each train. The ISOs will be lifted onto or off of single well cars in the FECR intermodal facilities. ISOs will not be double-stacked in the well cars; only one ISO will be stacked in each well car. A representative image of a well car loaded with two 20-ft ISO portable tank containers at an FECR intermodal facility is provided in Figure 9. The [redacted] LNG ISO container would occupy the equivalent space to these two smaller ISOs.


D15997 - 0088

Figure 7. [redacted] crane used for Lift On/Lift Off of intermodal containers.

D15997 - 0101

Figure 8. (b) (4) used for Lift On/Lift Off of intermodal containers.

D15997 - 0132

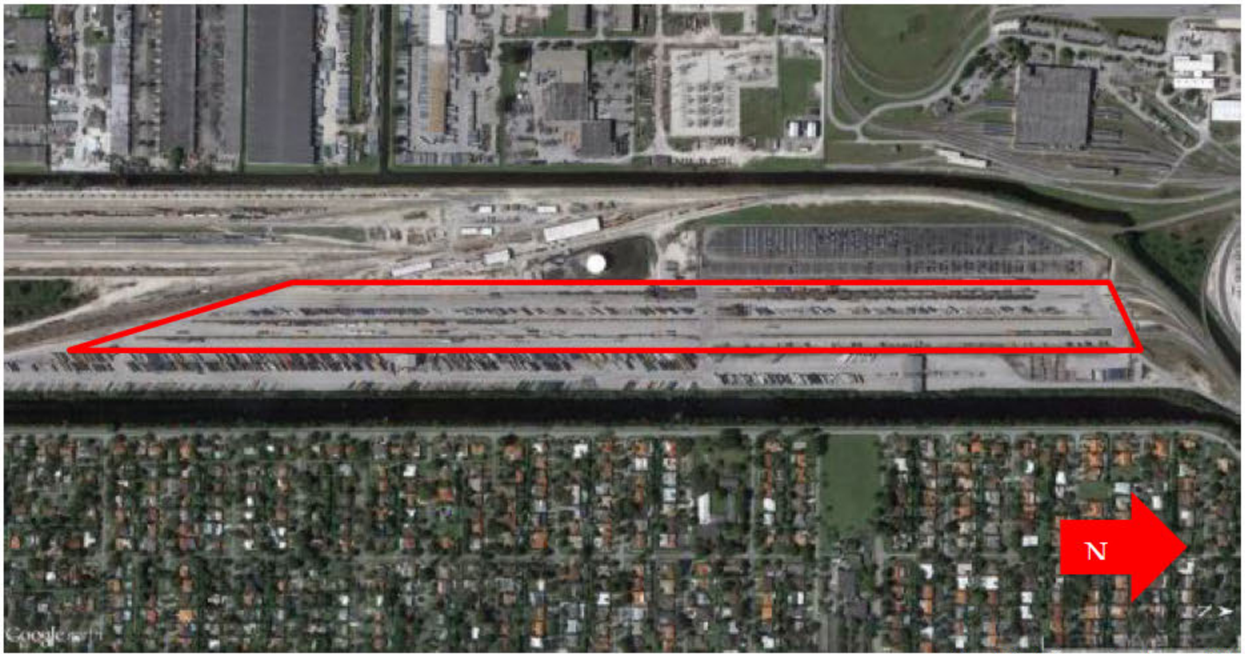
Figure 9. Representative well car in FECR intermodal yard containing two 20-ft ISO portable tank containers. One LNG ISO would replace these two containers in the proposed service.

2.2.1 Aerial Views of Intermodal Facilities

The equipment, procedures, and operating practices were reported to be equivalent for all four intermodal facilities. Aerial images of the rail yards and intermodal facilities are provided in the following figures.

Google Earth image, circa January 2016

Figure 10. Aerial image of the FECR **Hialeah Rail Yard** (enclosed in red outline). Trains enter and leave the Hialeah Yard at the right side of the image. North is to the right in the image. The rail yard is surrounded on three sides by a canal. Industrial occupancies are located to the north, west and south. Residential areas are located to the east.



Google Earth image, circa January 2016

Figure 11. Close-up view of the FECR **Hialeah Intermodal Facility** intermodal ramps (area outlined in red) where containers are lifted on and off of rail cars.

Google Earth image, circa January 2016

Figure 12. Dodge Island, which contains the **Port of Miami** (enclosed in red outline). The Port includes container ship docks (yellow hashed lines) and cruise ship docks (white hashed lines).

Google Earth image, circa January 2016

Figure 13. FECR **Port of Miami Intermodal Facility** (enclosed in red outline) intermodal ramps.

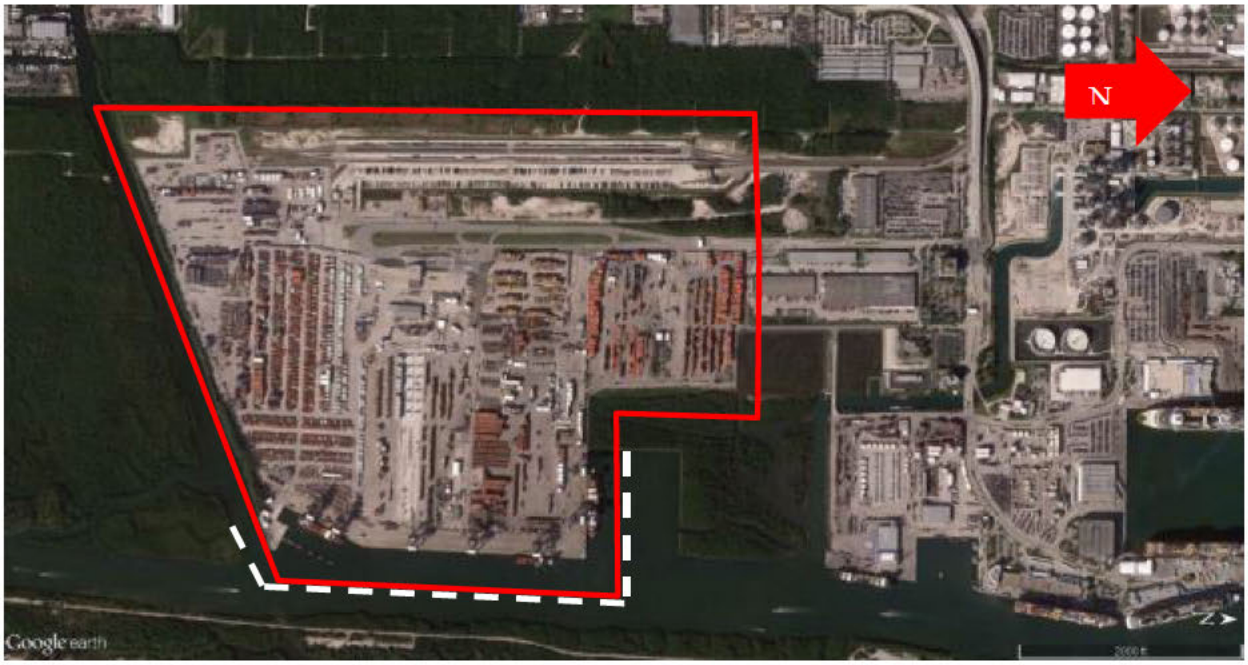


Figure 14. Aerial image of the **Port Everglades Intermodal Area** (enclosed in red outline). North is to the right in the image. The FECR intermodal facility is located to the west (top) of the intermodal container storage area. The Port includes container ship docks (white hashed lines) and cruise ship docks located farther to the north (right side of image).

Figure 15. FECR **Port Everglades Intermodal Facility** (enclosed in red outline) intermodal ramps and container staging area.

Figure 16. Aerial image of the **FECR Bowden Rail Yard** (enclosed in red outline). North is to the lower right in the image. The FECR intermodal facility is located to the north (right) of the yard.

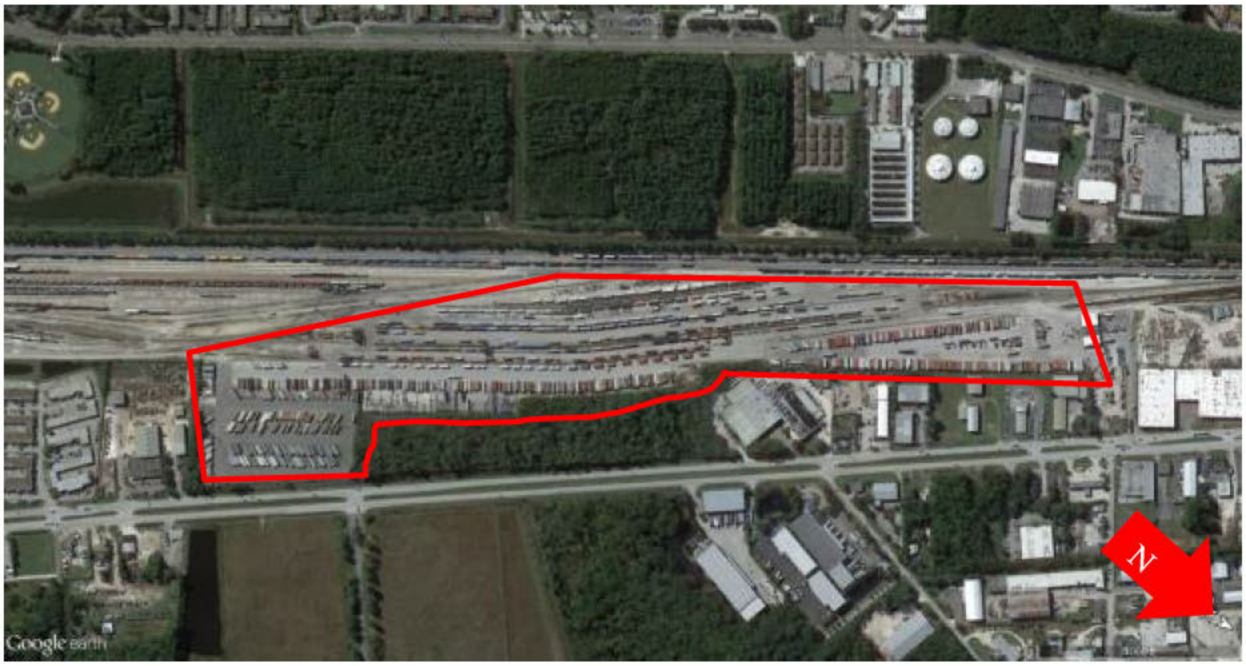


Figure 17. FECR **Bowden Intermodal Facility** (enclosed in red outline) intermodal ramps and container staging area.

2.3 LNG ISO Movement Routes

Movements were evaluated along three proposed routes: (1) From Hialeah Yard to Port of Miami, (2) From Hialeah Yard to Port Everglades, and (3) Hialeah Yard to Bowden Yard (Jacksonville). Train movements were evaluated within the respective train yards and along the mainline track to these destinations. The maps for the routes and the mainline in the following figures were provided by FECR (additional information is provided in Appendix C). These maps were used as the basis for the train routes in the QRA. The total estimated track mileage and train mileage for each route are supplied in Table 3.

As a conservative assumption, each route was analyzed independently by assuming that each route handled (b) (4). This conservative approach may overestimate the risk for each route depending upon the actual annual average of ISOs shipped per route since an average of (b) ISOs per day may be split between the three routes.

Table 3. Routes and estimated mileage.

Route	Route Length (track miles)	Estimated Total Annual Route Length (train miles)
Route 1	15	(b)
Route 2	28	(b) (4)
Route 3	364	(b) (4)

Figure 18. Route 1 - Hialeah Yard to Port of Miami. FECR route is traced in blue. North is up.

Figure 19. Route 2 - Hialeah Yard to Port Everglades. FECR route is traced in blue. North is up.

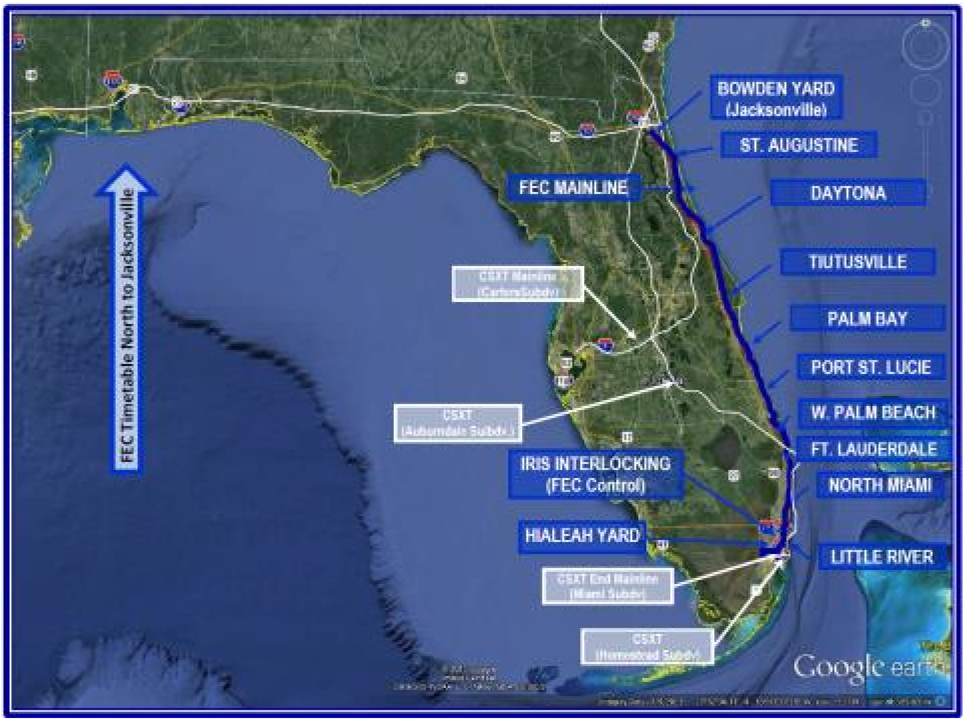


Figure 20. Route 3 - Hialeah Yard to Bowden Yard along the FECR mainline. FECR route is traced in blue. North is up.

3 Methodology

The QRA was conducted by applying PHAST Risk software to evaluate a series of accident scenarios involving the transportation of LNG along the three proposed routes and at the intermodal facilities. The objective of the analysis was to quantify the Individual Risk (IR) and Societal Risk (SR) for populations surrounding the Hialeah Yard, Port Everglades, Port of Miami, the Bowden Yard, and the rail lines along the three routes.

The design of the UN (b)(4) [redacted] ISO portable tank is final, and several ISOs have been made available for use in LNG service along FECR's routes. Engineering and administrative systems that may be employed to reduce the likelihood or the severity of releases in the intermodal facilities and along the routes were not considered in this analysis (unless otherwise stated). The objective of this QRA study is to provide the conservative maximum baseline risk levels for transporting LNG ISO containers along three proposed routes and movements within the intermodal facilities.

In consultation with FECR, a list of representative transportation scenarios was developed for analysis in the QRA. Three unique LNG handling and ISO movement scenarios are considered:

1. Lift On of LNG ISO containers onto rail cars at Hialeah Rail Yard Intermodal Facility.
2. LNG movement on rail, either in the yard or on the mainline.
3. Lift Off of LNG ISO containers from rail cars at the destination intermodal facility.

A potential incident resulting from a loss of containment of LNG would require a sequence of events to occur. QRA takes this sequence of events and assigns a frequency to the initiating event and conditional probabilities of occurrence for subsequent events. One initiating event may lead to several potential outcomes, not all of which create a potential hazard. QRA models the sequence of events through event trees with appropriate complexity to describe the most likely event outcomes. Each outcome, e.g., the consequence of a release of LNG, is then modeled to determine the impact of the flammable release event. For releases from a fixed location, the source for the release is modeled as a pseudo point source. For releases that may occur along a route, e.g., line of road for rail, the source for the release is modeled at periodic intervals along the route. In terms of a QRA for LNG transportation, only the potential flammable release hazards were evaluated for LNG. The outcome, which may be injury or fatality of onsite personnel or the public, is related not only to the physical event consequences (e.g., size of a flash fire), but also to the potentially impacted population. The PHAST Risk software incorporates the surrounding population, the phenomenological release and consequence models, event tree-derived frequencies for each outcome, and industry-accepted population impact models to calculate the IR and SR for facilities and transportation operations.

The key parameters that must be evaluated to perform the QRA, from beginning (accident occurs) to end (a potential fatality is realized), include:

1. Accident—in order for the identified consequence to occur, a vessel containing LNG must first be involved in an accident. The likelihood of an accident involving the LNG ISO is estimated.
2. Loss of Containment—the hazards evaluated here concern the flammable nature of the LNG fuel vapors. In order for a fire or explosion to occur, there must be a loss of containment (LOC) event involving the LNG vessel. The LOC probabilities and leak size distributions are estimated.
3. Formation of flammable atmosphere—following an LOC, the LNG must vaporize and the flammable vapors must mix with air in the appropriate concentrations. The size and downwind distance of the flammable clouds are calculated in PHAST Risk.
4. Ignition of flammable atmosphere—the flammable atmosphere must be ignited in order for a fire or explosion to occur. The ignition probabilities, as a function of time, distance, and population as the flammable cloud is formed and dispersed, are calculated in PHAST Risk.
5. Exposure to a population—the populations that may be affected by an incident involving LNG are estimated using U.S. Census data, and the population data is input into PHAST Risk for calculation of the IR[18] and SR. The potential for a fatality, given a specific thermal event (i.e. flash fire, pool fire, jet fire, or explosion), is calculated in PHAST Risk.

Figure 21 provides a flow chart identifying each step of the risk assessment process. A further discussion of these key QRA parameters, as considered and evaluated for the proposed FECR shipping of (b) (4) ISO containers project, is provided in subsequent sections.

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[18] Note that IR assumes continuous potential exposure of personnel or the public; thus, it is not directly related to population like SR. However, population density is an input to the probability of the ignition model employed in the software; hence, IR is a function of population.

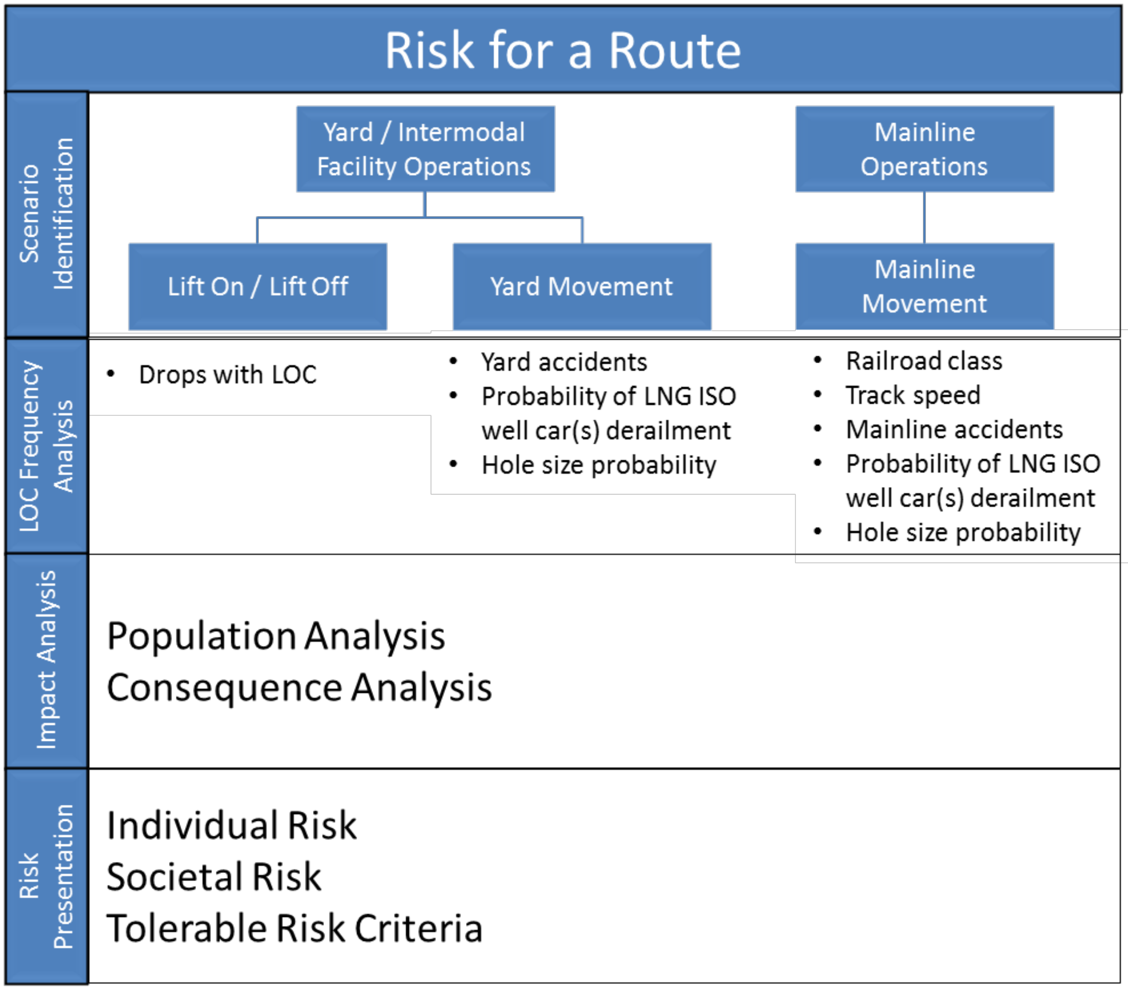

Figure 21. General approach for risk analysis in the QRA.

Given the nature of the project, several variables were approximated or estimated to provide this QRA. For example, accident rates involving [redacted] ISO containers in intermodal shipping via rail in the US are not available. Currently, the Federal Railroad Administration (FRA) has not codified guidelines for acceptable risk to individuals or society. Thus, the risk values are compared to quantitative risk criteria for stationary LNG facilities provided by NFPA 59A as recommended by the FRA team. The representation of NFPA 59A risk criteria for IR and SR in this report has been done for the purposes of comparing the transportation risk to a set of related criteria and may not be appropriate or directly applicable for assessing acceptability of transportation risk. Additionally, the risk profiles for LNG shipping are compared to another hazardous material (HAZMAT) as requested by the FRA; FECR, along with many other railroads, currently ships propane by rail so this was used as a benchmark comparison for the risk of shipping LNG in ISO containers.

3.1 Estimating Accident Rates and LOC Probabilities

The sequence of events leading to a loss of containment (LOC) of LNG in the analysis starts with an accident involving one or more ISOs. The rate of mainline train accidents was applied to shipping along the routes. The rate of yard train accidents and dropping of ISO containers during lifts was applied to the rail yards and intermodal facilities. No QRA-ready databases of train accidents and LOC probabilities existed for LNG ISOs. Thus, representative accident/failure frequency and probability values were developed from industry-available databases and FRA rail accident statistics. An accident model was developed to calculate the LOC frequency for rail movements in the QRA. As shown in Figure 22, the train accident rate was first calculated. Then, given an accident, the probability of derailment for various considerations was calculated. Ultimately, the probability of LOC was calculated. Multiplying these three values together yielded the LOC rate for a given scenario. The bases, assumptions, and results are discussed in the following sections.

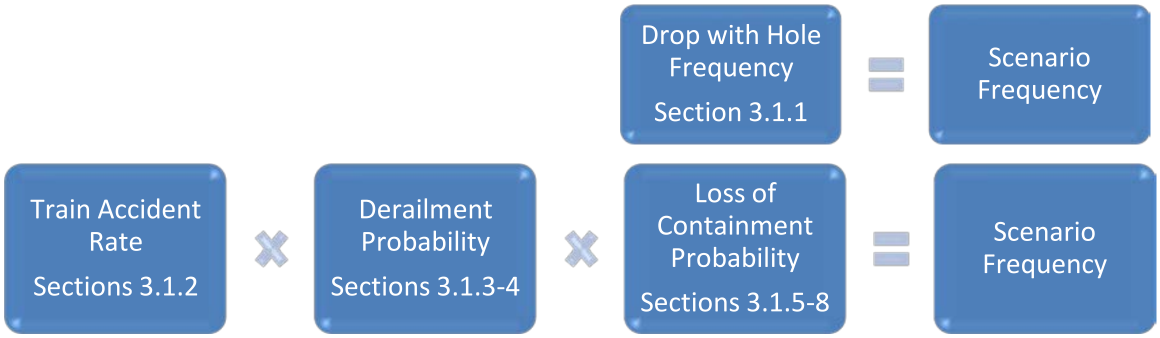

Figure 22. LNG ISO train accident model overview.

3.1.1 Lifting Accident Rates and LOC Probabilities

Lifting of the ISO containers onto rail cars occurs at the Hialeah Yard Intermodal Facility; they are then lifted off at the destination intermodal facility. Given the safety management systems (e.g., training, independent verification of twist-lock engagement, equipment maintenance, etc.) at FECR’s intermodal facilities, the predominant hazard considered during this operation was a dropped ISO container during Lift On/Lift Off operations. No FECR or general U.S. drop rates were available for intermodal operations at rail yards, but international failure rates were available. It is reasonable to assume that an international failure rate would apply to this operation since intermodal freight is shipped internationally. The UK Health and Safety Executive (HSE)[19] estimates a rate of 6×10^{-7} drops per lift will result in a 50 mm (2-inch) diameter hole for ISO tank containers (Table 4), for lifts at a height of less than 5 meters (16.4

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[19] *Failure Rate and Event Data for use within Risk Assessments*, UK Health and Safety Executive (June 28, 2012).

feet). These conditions apply to Lift On/Lift Off of ISOs into well cars since they will be single-stacked.

Table 4. Lifting operation LOC rate due to drops.

Description	Frequency ($lift^{-1}$)
50 mm (2-inch) hole	6.7×10^{-7}

3.1.2 Train Accident Rates

LNG shipping by rail is historically uncommon in recent U.S. rail industry history; thus, accident data that are directly comparable to movement of LNG ISO containers do not exist. Thus, Exponent analyzed publicly-available data from the FRA to estimate train accident rates for the QRA. Potential train accidents may occur in a yard when trains are assembled, during switching activities, and when trains travel in the yard and along the line of road. Due to the frequency of simultaneous operations and other factors, accident rates are typically higher in a rail switching yard than on the line of road. However, the speed of trains in yards is significantly slower on average than on mainline track. Thus, at lower speeds, the accident outcomes (e.g., derailment or LOC) are also anticipated to be less likely in rail yards than on mainline track. The following discussion will provide an overview of application of the available data to estimating potential LNG ISO train accident rates.

The FRA Office of Safety Analysis maintains an online database that provides historical accident and failure rate data for the rail industry.[20] Accidents in the database include broken equipment, highway grade crossing collisions, train collisions, and derailments. FECR operates a relatively small line with fewer trains, fewer train miles traveled, and fewer potential hazardous materials incidents than Class 1 railroads and many other short-line railroads. In order to provide a larger basis of operation for conservatively estimating accident rates on FECR’s line, the industry data was used and applied to FECR’s train miles.

The FRA industry-wide database for train accidents with reportable damage data[21] was first queried and downloaded for all accident reports during the twenty-one year period from 1995-2015, yielding a total count of 70,072 accidents. The accidents are identified in the database by category and include multiple types of collisions, explosions, fires, other impacts, and other events. These types of accidents are consistent with the events necessary to lead to an LOC of LNG from an ISO. There were, on average, 3,337 total accidents reported per year for the overall rail industry. The FRA data was filtered for all accidents from 1995-2015 (all railroad

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[20] Accessible via safetydata.fra.dot.gov.

[21] FRA Office of Safety Analysis, Report 3.16 – Summary of Train Accidents with Reportable Damage, Casualties, and Major Causes.

classes), and the results were analyzed to determine accident frequency for one of two cases: (1) yard accidents and (2) mainline accidents. The values are summarized in Table 5 for accidents and derailments from this data.

Table 5. Analysis of train accidents from FRA data.

	Statistic	2011-2015	1995-2015
Yard Accidents	Total Accidents	6,907	36,742
	Total Derailments	4,812	26,204
	% of All Accidents	54.0%	52.4%
	Probability that Derailment Occurs	69.7%	71.3%
Mainline, Speed < 25mph	Total Accidents	4,007	22,817
	Total Derailments	2,527	15,709
	% of All Accidents	31.3%	32.6%
	Probability that Derailment Occurs	63.1%	68.8%
Mainline, Speed = 25mph	Total Accidents	128	899
	Total Derailments	79	652
	% of All Accidents	1.0%	1.3%
	Probability that Derailment Occurs	61.7%	72.5%
Mainline, Speed from ≥ 25 to ≤ 60 mph	Total Accidents	1,640	9,189
	Total Derailments	712	5,149
	% of All Accidents	12.8%	13.1%
	Probability that Derailment Occurs	43.4%	56.0%

The raw accident numbers were then divided by train mileage to develop accident frequency estimates for the QRA. Operational data tables provided by the FRA were used to determine the total number of yard and mainline[22] train miles for the period from 1995-2015 for all classes of railroad represented in the data.[23] The operational data tables did not subdivide the mainline train miles according to track speed; thus, a single train accident frequency value was applied to all mainline train movements regardless of train speed. Using the total accident and total mileage values, the accident frequency (on a per train mile basis) were then calculated. The average accident frequencies were found to be 1.98×10^{-5} and 2.47×10^{-6} (accidents/train mile) for

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[22] All "Non-yard" miles were assumed to be mainline miles for the purpose of this analysis.

[23] FRA Office of Safety Analysis, Report 1.02 – Operational Data Tables.

the yard travel and mainline travel, respectively. These were compared against the accident frequencies for the 5-year period from 2011-2015 which were found to be 1.55×10^{-5} and 1.81×10^{-6} (accidents/train mile) for the yard travel and mainline travel, respectively. Although the 5-year data demonstrates a reduction in accident rate versus the 21-year data, the 21-year data was used throughout the analysis due to the relatively large number of data points that provide a larger confidence in the position-in-train derailment probabilities (discussed in Section 3.1.3). The results are summarized in Table 6.

Table 6. Train accident rates from FRA data.

	Statistic	2011-2015	1995-2015
Yard	Total Yard Train Miles	0.446×10^{9}	1.85×10^{9}
	Yard Accident Rate (/train mile)	1.55×10^{-5}	1.98×10^{-5}
Mainline	Total Non-Yard (Mainline) Train Miles	3.25×10^{9}	13.5×10^{9}
	Non-Yard Accident Rate (/train mile)	1.81×10^{-6}	2.47×10^{-6}

The mainline accident frequencies[24] from Table 6 were then multiplied by the total number of annual train miles estimated for each route (Table 3) to arrive at the yearly accident frequency (accidents per year). A summary of the calculated annual accident rates for each route is provided in Table 7. Again, this analysis conservatively assumes that the planned travel of ten LNG ISO's per day arrive at a single destination (in reality, the destination may change from day-to-day or the ISOs may be split and sent along more than one of the routes). Thus, the accident rate for each route is anticipated to be smaller than that assumed here leading to a conservatively high accident rate for each route. The yard accident rates were applied to the intermodal facilities assuming travel across the facility once per day.

Table 7. Calculated annual accident frequencies for the mainline portion of the 3 FECR routes.

Route	Estimated Total Annual Route Length (train miles/yr)	Accident Frequency (accident/train mile)	Calculated Annual Accident Frequency (accident/yr)
Route 1	5,475	2.47×10^{-6}	1.35×10^{-2}
Route 2	10,220	2.47×10^{-6}	2.52×10^{-2}
Route 3	132,860	2.47×10^{-6}	3.28×10^{-1}

The train accident values shown above estimate the frequency that a train accident will occur somewhere along FECR's rail line. However, a train accident doesn't necessarily lead to a

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[24] Note that the terms frequency and rate are used interchangeably.

condition where an LOC of an LNG ISO may occur. Therefore, it was assumed that only train accidents leading to the derailment of cars could potentially result in an LOC (as discussed in more detail in Section 3.1.3). The 21-year accident data was analyzed to determine the probability that a train accident will lead to a derailment of any of the rail cars for one of three cases: (1) yard movement, (2) mainline movement with train speeds from 25 mph and 60 mph, and (3) mainline movement with train speeds less than 25 mph.[25] As listed in Table 5, the calculated results indicate that in 71.3% of yard train accidents, the accident will lead to derailment of at least one rail car. The other accident-leading-to-derailment probabilities were found to be 68.8% for mainline movement with train speeds less than 25 mph and 56.0% for mainline movement with train speeds between 25 mph and 60 mph. These are the probabilities of at least one car being derailed in a train accident; however, there is a different probability that the derailment will involve LNG ISOs. The calculation of the probability that an accident-leading-to-derailment involves LNG ISOs is addressed in the next section.

3.1.3 Derailment Probability for LNG ISO-Containing Well Cars

Not all accidents-leading-to-derailment will involve an LNG ISO car, as most of the cars in an FECR train are expected to contain freight other than an LNG ISO. Several factors are expected to affect the likelihood than an LNG ISO car is derailed including: (1) the position of the LNG ISO car(s) within the train and (2) the number of LNG ISOs grouped together. These two factors were explored in estimating the derailment probability for LNG ISO cars. First, the historical FRA accident data was analyzed to develop a model for estimating the probability of derailment of an individual car versus its position in the train. This model was then applied to trains containing LNG ISOs in a parametric study to evaluate various train configurations.

3.1.3.1 Probability of Derailment and Number of Cars Derailed

The probability of derailment for one or more LNG ISO cars is dependent on the position of the first car derailed in the train, the average number of cars derailed during an accident, and the location of LNG ISOs in the train. These parameters are expected to be affected by both the type of train movement (yard versus mainline) and the train speed, which were explored here using the FRA 21-year accident data.

The FRA 21-year accident data from 1995-2015 was first filtered to include only those accidents for Class 1 and Class 2 railroads. The resulting Class 1 and 2 railroad accidents were then subdivided into either yard accidents or mainline accidents. The mainline accidents were then further split into either low speed mainline accidents with train speeds less than 25 mph or high speed mainline accidents with train speeds inclusive between 25 mph and 60 mph. Next,

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[25] Note that 25 mph data was included in the high speed mainline accident rates, however the 25 mph data is shown separately in Table 5 to illustrate that including the 25 mph data in the low speed (i.e. < 25 mph) derailment probabilities would be expected to result in a negligible change to the resulting risk profiles.

the accidents for the three cases were filtered in the database by including only accidents resulting in derailment. The average number of cars derailed for each of the three cases was then calculated (rounded up to whole numbers):

Case 1. Yard derailments, average number of cars derailed = 4

Case 2. Mainline derailments, speed < 25 mph, average number of cars derailed = 5

Case 3. Mainline derailments, speed 25-60 mph, average number of cars derailed = 11

Based upon the dynamics of a derailment, it was assumed that in an average derailment, the first car derailed plus the immediately following sequence of n-1 cars would derail, where n is the average number of cars derailed. The derailment statistics indicate that although the accident frequency is higher in yards relative to mainline movements, there are fewer cars derailed on average in yard derailments compared to mainline derailments. Regarding mainline movements, lower speed derailment accidents involve fewer cars on average than higher speed derailment accidents.

The filtered data for each of the three cases was then placed into a histogram based on the position of the first car derailed. An example plot for the mainline derailments with train speeds between 25 mph and 60 mph is provided in Figure 23. The first car derailed plots for mainline derailments for train speeds less than 25 mph (Figure 24) and yard derailments (Figure 25) are similar.

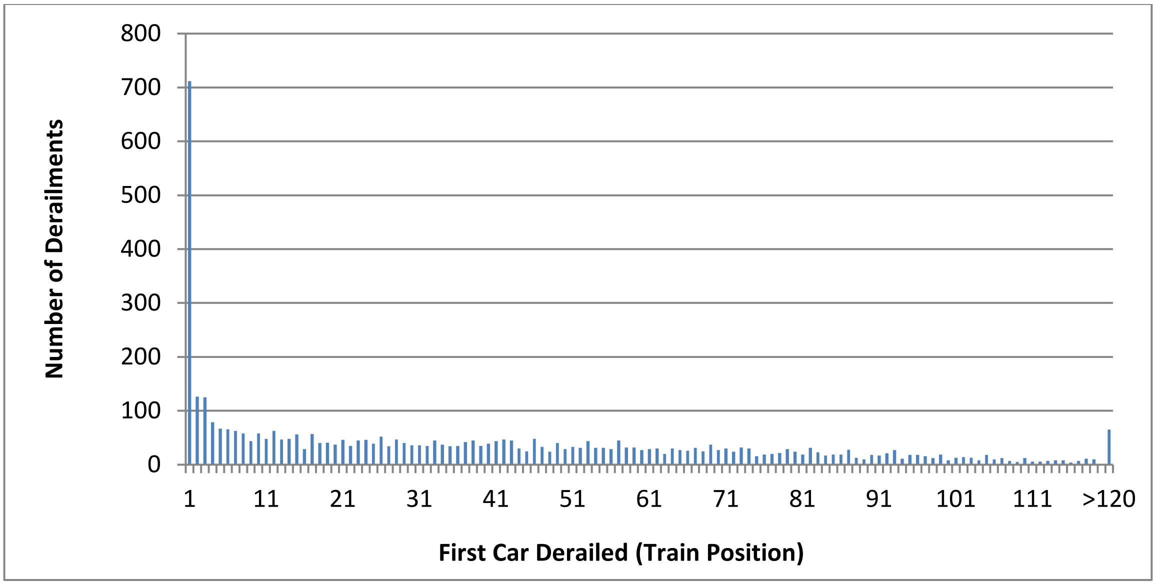

Figure 23. Frequency (count) of the first car position-in-train for mainline derailments with train speeds between 25 mph and 60 mph (total count equals 5,149 derailments).[26]

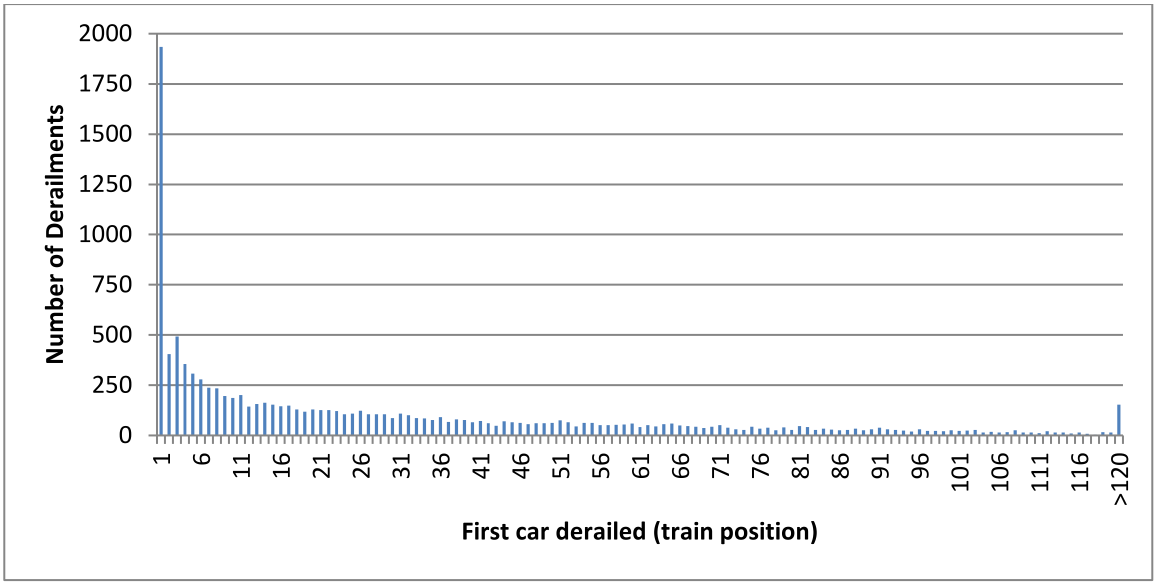

Figure 24. Frequency (count) of the first car position-in-train for mainline derailments with train speeds less than 25 mph (total count equals 15,709 derailments).

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[26] Note that the value of approximately 80 at the 120 car position in the histogram represents the sum of all cars from 120 up to 200 listed in the database.

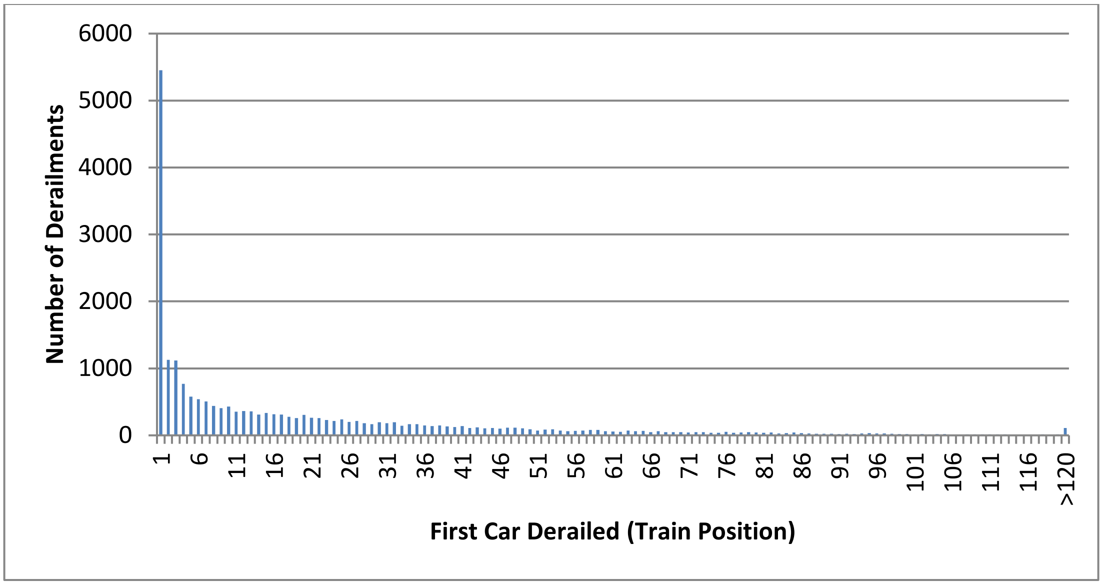

Figure 25. Frequency (count) of the first car position-in-train for yard derailments (total count equals 26,204 derailments).

The data reveal that when a train accident results in a derailment, the first car derailed is usually the head car (position 1). In fact, for the data provided in Figure 23, the first car derailed is one of the first ten cars in nearly a third (31%) of all mainline derailments where train speeds are between 25 mph and 60 mph. Similar results are found for the percentage of derailments starting with a car in position 1-10 for the other two cases: 52% for yard derailments and 41% for mainline derailments where train speeds are less than 25 mph. Representative probability of first car derailed versus position are provided in Table 8. The probability of the first car derailed and the average number of cars derailed were then used to undertake a parametric sensitivity analysis for the probability of LNG ISO car derailment for various LNG ISO train configurations.

Table 8. Representative probability of first car derailed for Class 1 and 2 Railroads (1995-2015).

Statistic	Car Position in Train			
	1	11	21	31
Yard Derailment Accident	24.8%	1.60%	1.20%	0.82%
Mainline Derailment Accident, Speed < 25 mph	17.3%	1.80%	1.13%	0.97%
Mainline Derailment Accident, Speed ≥ 25 to ≤ 60 mph	15.8%	1.07%	1.02%	0.80%

3.1.3.2 Parametric Analysis of Train Configurations

Using the assumption that a train would contain (b) (4) LNG ISO's, multiple train configurations were explored for the purpose of calculating the probability that multiple LNG ISO cars are derailed in a train accident. For example, (b) (4) sequential LNG ISO cars will have a different probability distribution for number of cars derailed and release quantities than other LNG ISO car groupings (e.g., groups of (b) (4) groups of (b) (4) etc.). However, there are some constraints on placement of LNG ISOs in a train. For example, there must be at least (b) (4) buffer cars between the first HAZMAT car and the front of the train. Also, trains will have a finite length depending upon the route and schedule. Thus, our analysis conservatively started with the first LNG ISOs no closer than car position (b) (4) and no further back in a train than car (b) (4) The resulting sensitivity analysis of multiple train configurations was used to identify optimum LNG ISO placement in a train. The following train configurations in Table 9 were considered in order to represent the effects of LNG ISO position and grouping within trains, and the configurations are illustrated schematically in Figure 26.

Table 9. Train configurations evaluated in the analysis.

Train Configuration ID	Description
C-1	• (b) (4) LNG ISO cars in sequence • Train positions: (b) (4)
C-2	• (b) (4) LNG ISO cars in sequence • Train positions: (b) (4)
C-3	• Two groups of (b) (4) LNG ISO cars • Separated by 5 buffer cars • Train positions: (b) (4)
C-4	• Two groups of (b) (4) LNG ISO cars • Separated by 10 buffer cars • Train positions: (b) (4)
C-5	• (b) (4) groups of (b) (4) LNG ISO cars and (b) (4) single car • Separated by 10 buffer cars • Train positions: (b) (4)
C-6	• (b) (4) groups of (b) (4) LNG ISO cars • Separated by 10 buffer cars • Train positions: (b) (4) (b) (4)
C-7	• (b) (4) groups of (b) (4) LNG ISO cars • Separated by 5 buffer cars • Train positions: (b) (4) (b) (4)

(b) (4)

[redacted]

Figure 26. Schematic representation of the blocking of LNG ISOs into consist configurations C-1 to C-7.

The probability of first car derailed as a function of position-in-train was calculated for the three cases (yard, low speed, and high speed). This data was then analyzed using the average number of cars derailed for each case to calculate the probability of having from one to ten LNG ISOs derail for the seven configurations described above.[27] A summary of the calculated probabilities is provided in Table 10 for mainline derailments with speeds between 25 mph and 60 mph.

(b) (4) [redacted]

[redacted]	[redacted]						
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

The data for Case 3 demonstrate a significant reduction in the probability of having any LNG ISOs involved in a derailment ("Total" row from table) when moving from train configuration 1 (C-1) to train configuration 2 (C-2). However, the total probability of any number of cars derailing is not the only parameter to consider when minimizing the risk. The total probability increases from C-2 to C-3, but the number of LNG ISOs involved decreases from (b) (4) [redacted] Thus, the total magnitude of the potential outcomes of C-3 will be less than C-2. As the configurations move from C-3 to C-7, the total probability increases but the maximum number of LNG ISOs involved in the derailment decreases. Using this approach allowed the

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[27] Only Configurations 1-4 were considered for the yard derailment and mainline derailments with speeds less than 25 mph cases.

permutations of LNG ISO car groupings in the train to be optimized for the QRA to reduce the risk.

The probabilities for the other two cases are provided in Table 11 for mainline derailments with speeds less than 25 mph and Table 12 for yard derailments. Only Configurations 1-4 were evaluated for these two cases. Although the total probability of having an LNG ISO involved in a derailment decreases from C-1 to C-2 for both cases, the maximum number of cars involved doesn't change for any of the configurations considered for either case. This is because the average number of cars derailed is only five cars for mainline derailments with speeds less than 25 mph and only four cars for yard derailments, compared to eleven cars for mainline derailments with speeds between 25 mph and 60 mph.

Table 11. Case 2 - Mainline train accident with derailment for train speeds less than 25 mph. Probability of having X number of LNG ISOs derailing in the event of a train accident with derailment, where X is the number of LNG ISOs involved. On average, 5 cars are involved in a derailment for this scenario.

(b) (4)

[redacted]

Table 12. Case 1 - Yard train accident with derailment. Probability of having X number of LNG ISOs derailing in the event of a train accident with derailment, where X is the number of LNG ISOs involved. On average, 4 cars are involved in a derailment for this scenario.

(b) (4)

[redacted]

Although the derailment data for train speeds exactly 25 mph was included in the high speed (i.e. 25 – 60 mph) case, Table 13 depicts what the derailment probabilities would look like had the 25 mph data been included in the low speed (i.e. < 25 mph) case. By comparison to Table 11, it is expected that including the 25 mph data in the low speed risk analysis would have a negligible effect on the resulting risk profiles.

Table 13. Mainline train accident with derailment for train speeds less than and equal to 25 mph. On average, 5 cars are involved in a derailment for this scenario. These derailment probabilities were not used in the analysis but are shown here to illustrate the minimal effect of including the 25 mph data in the low

(b) (4) [redacted]

3.1.4 Derailment of LPG Rail Cars

LPG (UN1075) was identified as a reasonable comparison HAZMAT commodity to compare against LNG. The risks associated with the shipping of LNG ISO cars were compared to the transportation risks associated with LPG cars. The LPG rail cars were assumed to be DOT-112 pressurized rail cars (nominal volume of 34,000 gallons). The LPG transportation analysis did not include Lift On/Lift On risks since they were inapplicable, but yard movement and mainline movement were applicable. When LNG ISOs were compared to LPG rail cars on an energy-equivalent basis, it was found that approximately (b)(4) [redacted] 34,000 gallon LPG rail cars have the same energy content as (b)(4) [redacted] 10,000 gallon LNG ISOs.[28] Thus, (b)(4) [redacted] LPG cars were used in the derailment probability calculations.

The same base train accident and derailment statistics described in Section 3.1.2 were applied to the LPG cars since the type of rail car was independent of the accident and derailment statistics. The derailment probability for LPG car involvement was calculated similar to the LNG ISO cars

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[28] (b) (4) [redacted]

using only one baseline train configuration: all three LPG cars are assumed to be in series starting at train position 11. This configuration is consistent with the LNG train configuration 1 (C-1). As with the LNG ISO cars, three cases (yard, low speed, and high speed) were considered for determining the probability of LPG car involvement in the event of a train accident with derailment.

The probability of first car derailed as a function of position-in-train was then calculated for the three cases using the 21-year FRA data. This data was then analyzed using the average number of cars derailed for each case to calculate the probability of having from one to three LPG rail cars derail. A summary of the calculated probabilities is provided in Table 14.

Table 14. Probability of having X number of LPG rail cars derailing in the event of a train accident with derailment, where X is the number of LPG rail cars involved.

# of LPG Rail Cars Derailed	Probability of X Number of LPG Rail Cars Derailing		
	Mainline ≥ 25 & ≤ 60 mph	Mainline < 25 mph	Yard
[redacted] (b)(4)	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

3.1.5 ISO LOC Probabilities

The prior sections detailed the development of accident rate and derailment probability estimates for LNG ISO cars. Not every accident will lead to an LOC of LNG. The specific dynamics of an individual accident will dictate whether and to what extent an LOC may occur. This section discusses the development of LOC and release size probability estimates for the QRA model based on industry data and guidelines.

LOC probability data for LNG ISO containers does not exist, so general rail industry data was used, and reasonable engineering assumptions were made as necessary. Pressure tank cars and cryogenic tank cars have an extensive history of operation with corresponding accident data, and with some engineering judgement, this type of accident data was applied to shipping LNG ISOs. A flow chart supplementing the following discussion is provided in Figure 27 at the end of this section. The Pipeline and Hazardous Materials Safety Administration (PHMSA) maintains an online database that provides historical LOC data for rail tank cars, among other transportation vessels.[29] The database complements the FRA database in that the PHMSA

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[29] Accessible via hazmatonline.phmsa.dot.gov/IncidentReportsSearch/search.aspx.

database records the inventory of HAZMAT cargo released for each accident; whereas, the FRA database only identifies that an LOC has occurred. The PHMSA database was analyzed in order to estimate the LOC probabilities for the LNG ISO containers. The analysis assumed that LOC could only occur if the LNG ISO well car was derailed. The PHMSA database did not readily provide accident data for [redacted] ISO portable tank containers, but it did list pressure tank car LOC accidents. Although there are differences between the [redacted] ISO construction and a DOT-112 pressure tank car, the dynamics and consequences of LOC are reasonably similar. Thus, pressure tank cars were used as an analog to estimate the probability of an LOC if a car was derailed.

The PHMSA database listed accident data from 1971 to the present. All rail car data was queried from 1971 to 2014, for incidents including spillage, vapor (gas) dispersion, and no release. The resulting data was then filtered for pressure tank cars only, and incidents where no tank car specification was available were excluded from the analysis. The resulting 5,152 pressure tank car incidents[30] were then sorted by amount released (units are either cubic feet (ft^3) or gallons).

The PHMSA data was grouped into four release volume ranges in order to estimate the probability of a certain leak size. The categories were no release (less than 100 gallons), small release (100 to 1,000 gallons), large release (1,000-30,000 gallons), and catastrophic release (30,000+ gallons).[31,32] These volumes were chosen as the PHMSA data appeared to reflect mostly 30,000+ gallon tank cars in contrast to the 10,000 gallon ISO container used for LNG transportation.

Representative hole sizes were chosen for each release category, in line with a previous quantitative risk assessment completed for FECR.[32] Small releases were modeled using a ½-inch hole while a 2-inch hole was used for large releases. These hole sizes are consistent with appurtenance sizes on the ISO container. A catastrophic release assumes that the tank shell has been ruptured, leading to an instantaneous spill of the entire tank contents. Catastrophic releases were thus assumed to represent the PHMSA database cases where 30,000 gallons or more of contents were spilled. The resulting release probabilities are provided in Table 15.

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[30] As of November 14, 2014.

[31] Section 3.3.3.3, Railways, page 3.13 in *Guideline for Quantitative Risk Assessment, Part Two: Transport* (Dutch Purple Book), Publication Series on Dangerous Substances, Ministerie van Verkeer en Waterstaat (2005).

[32] Exponent report titled: “Florida East Coast Railway Dual-Fuel Locomotive and LNG Tender Project Quantitative Risk Assessment Report,” issued January 2, 2015.

Table 15. PHMSA pressure tank car incident data from 1971-2014 and equivalent release scenarios based on a sensitivity analysis of spill diameters.

Quantity Released in gallons	Incident Count	Probability	Release Scenario
=< 100	4,937	0.958	No Release
100 < x =< 1,000	73	0.014	½-inch Leak
1,000 < x =< 30,000	127	0.025	2-inch Leak
> 30,000	15	0.003	Catastrophic

The LOC probabilities estimated here are based on data for all pressurized tank car accidents, and it was not possible to differentiate between yard and mainline accidents. It is anticipated that yard accidents will result in a decreased probability of LOC relative to mainline accidents due to lower travel speeds (and, therefore, less kinetic energy and smaller net forces generated during accidents). Based on the rail tank car QRA analysis guidelines published in the Dutch Purple Book, it is expected that the probability of outflow for low speed (i.e., yard) accidents is a factor of 10 less than that for high speed (i.e., mainline) accidents.[33] However, it was conservatively assumed that the LOC probabilities for yard accidents involving ISOs are the same as those on the mainline in the QRA.

As a comparison, Jeong et al. developed a probabilistic puncture model for head impact to general tank cars as a function of wall thickness.[34] The authors analyzed proprietary accident data collected since 1960 by the Railway Supply Institute and the Association of American Railroads (AAR). They found that their probabilistic model closely matched historical data reflecting a historical probability of approximately 1-3% for head puncture due to derailment or collision for jacketed vessels and 3-8% for non-jacketed vessels. These statistics are consistent with our analysis of the publicly available HAZMAT data from DOT as listed in Table 15 above.

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[33] Table 3.7, Probability of outflow (> 100 kg) given an accident, page 3.13 in *Guideline for Quantitative Risk Assessment, Part Two: Transport* (Dutch Purple Book), Publication Series on Dangerous Substances, Ministerie van Verkeer en Waterstaat (2005).

[34] Jeong DY. Probabilistic Approach to Conditional Probability of Release of Hazardous Materials from Railroad Tank Cars During Accidents, Proceedings of IMECE2009, ASME International Mechanical Engineering Congress and Exposition, Lake Buena Vista, Florida, USA (November 13-19, 2009).

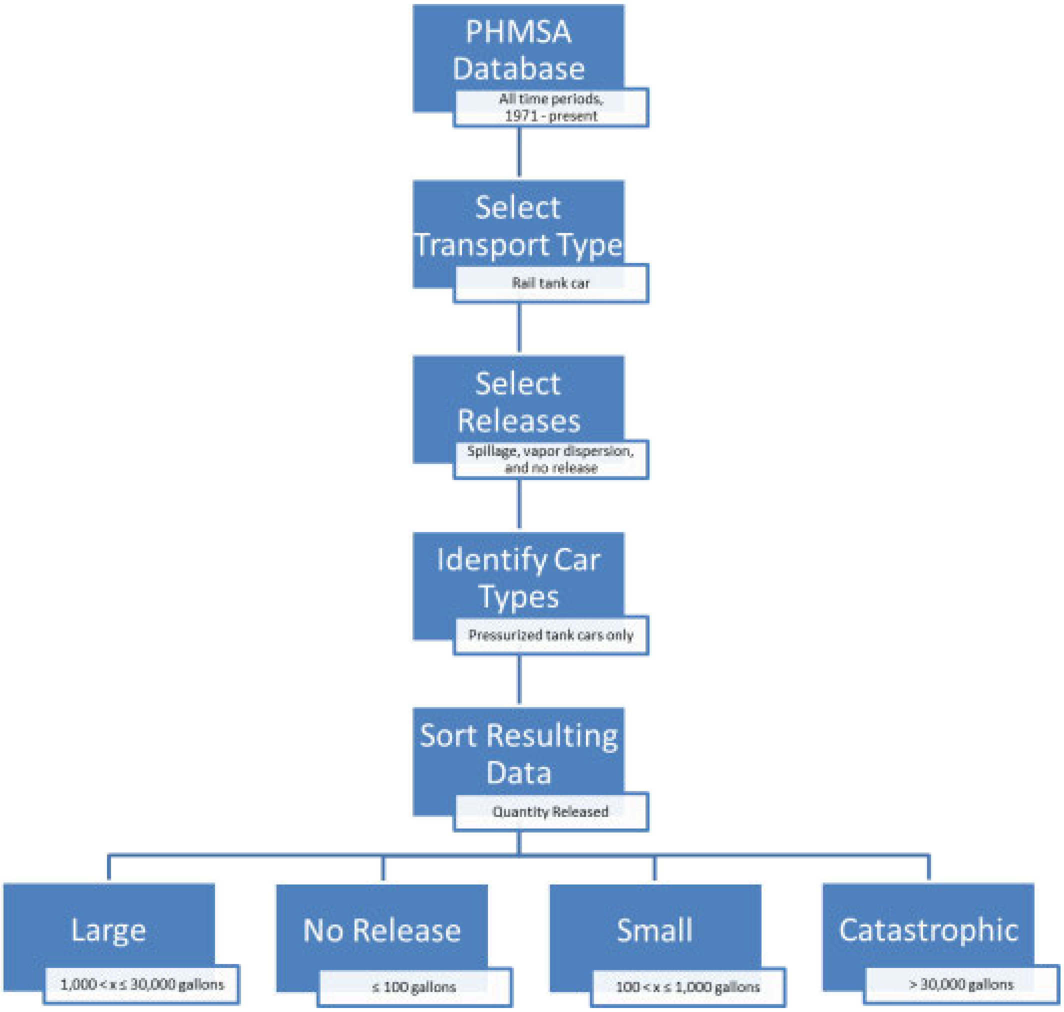

Figure 27. Flow chart describing the LNG ISO LOC probability estimation approach.

3.1.6 LPG Rail Car LOC Frequency

The risks associated with the transportation of LNG ISO cars was compared to the transportation risks associated with LPG cars. The LPG rail cars were assumed to be transported in DOT-112 pressurized rail cars (nominal volume of 34,000 gallons). The LNG ISOs were compared to LPG rail cars on an energy-equivalent basis; it was estimated that approximately (b) (4)

The PHMSA database included data for propane DOT-112 cars involved in accidents. Estimated outflow frequency and corresponding effective hole sizes were developed by analyzing this data from 1971 to 2014.[35] The data set was filtered to include only UN1075 commodity accidents for the LPG tank car outflow frequencies. The data were then sorted and filtered by quantity released in order to estimate outflow frequencies. A histogram approach was taken, and spill volumes were ordered into logical groupings consistent with the intent of the QRA and the approach for LNG. Any spill less than 100 gallons was assumed as no release, spills between 100 and 1,000 gallons were a small spill (0.5-inch hole), spills between 1,000 and 30,000 gallons were a large spill (2-inch hole), and spills greater than 30,000 gallons were considered as a catastrophic release. A summary of the rail transport outflow frequency estimates versus spill size used in this study are provided in Table 16. The LOC probabilities for each spill volume range were remarkably similar to the statistics for all pressure cars.

Table 16. Rail transport outflow frequencies for LPG rail car accidents.

Quantity Released in gallons	Incident Count	Probability	Release Scenario
=< 100	2,293	0.945	No Release
100 < x =< 1,000	32	0.013	½-inch Leak
1,000 < x =< 30,000	84	0.035	2-inch Leak
> 30,000	17	0.007	Catastrophic

3.1.7 Multiple LNG ISO LOC Events

As the number of cars involved in an accident increases, the number of possible release scenarios grows exponentially. For example, an accident involving five cars, each with four possible outcomes, results in 4^5 (i.e. 1,024) possible combinations. PHAST Risk requires that each outcome be modeled as a single release; for example, a small release from one car combined with a large release from a second car would need to be combined into an equivalent release scenario. Within all of these combinations, several distinct outcomes are represented. As such, the combinatorial releases were grouped by discharge rates with aggregate probabilities of LOC. The outcomes were then refined by eliminating all potential LOC events with probabilities less than 1×10^{-7}; below this probability value, the risk was assumed to be insignificant.

None of the permutations were limited to only one ISO for all leak scenarios. Consolidated release rates ranged from 0 to approximately 100 kg/s depending upon the case. None of the permutations led to a catastrophic release of more than three LNG ISOs. The consolidated releases for accidents involving two through ten LNG ISOs are shown in Table 17 through Table 25.

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[35] Accessible via hazmatonline.phmsa.dot.gov/IncidentReportsSearch/search.aspx.

Table 17. Consolidated release scenarios for two LNG ISOs.

Equivalent release rate (kg/s)	Probability
0	9.18×10^{-1}
1.57	2.70×10^{-2}
19.4	4.86×10^{-2}
37.6	6.25×10^{-4}
Catastrophic Rupture (1 ISO)	5.98×10^{-3}
Catastrophic Rupture (2 ISOs)	9.00×10^{-6}

Table 18. Consolidated release scenarios for three LNG ISOs.

Equivalent release rate (kg/s)	Probability
0	8.79×10^{-1}
2.01	3.91×10^{-2}
20.0	7.09×10^{-2}
40.8	1.84×10^{-3}
Catastrophic Rupture (1 ISO)	8.95×10^{-3}
Catastrophic Rupture (2 ISOs)	2.69×10^{-5}

Table 19. Consolidated release scenarios for four LNG ISOs.

Equivalent release rate (kg/s)	Probability
0	8.42×10^{-1}
2.51	5.03×10^{-2}
20.6	9.18×10^{-2}
38.8	3.54×10^{-3}
59.0	6.11×10^{-5}
Catastrophic Rupture (1 ISO)	1.19×10^{-2}
Catastrophic Rupture (2 ISOs)	5.37×10^{-5}
Catastrophic Rupture (3 ISOs)	1.08×10^{-7}

Table 20. Consolidated release scenarios for five LNG ISOs.

Equivalent release rate (kg/s)	Probability
0	8.07×10^{-1}
3.03	6.07×10^{-2}
21.1	1.12×10^{-1}
39.4	5.74×10^{-3}
57.6	1.48×10^{-4}
77.4	1.91×10^{-6}
Catastrophic Rupture (1 ISO)	1.48×10^{-2}
Catastrophic Rupture (2 ISOs)	8.92×10^{-5}
Catastrophic Rupture (3 ISOs)	2.68×10^{-7}

Table 21. Consolidated release scenarios for six LNG ISOs.

Equivalent release rate (kg/s)	Probability
0	7.73×10^{-1}
3.58	7.03×10^{-2}
21.7	1.30×10^{-1}
39.9	8.37×10^{-3}
58.1	2.87×10^{-4}
76.4	5.54×10^{-6}
Catastrophic Rupture (1 ISO)	1.77×10^{-2}
Catastrophic Rupture (2 ISOs)	1.33×10^{-4}
Catastrophic Rupture (3 ISOs)	5.35×10^{-7}

Table 22. Consolidated release scenarios for seven LNG ISOs.

Equivalent release rate (kg/s)	Probability
0	7.41×10^{-1}
4.14	7.92×10^{-2}
22.3	1.48×10^{-1}
40.5	1.14×10^{-2}
58.7	4.88×10^{-4}
76.9	1.26×10^{-5}
95.1	1.94×10^{-7}
Catastrophic Rupture (1 ISO)	2.06×10^{-2}
Catastrophic Rupture (2 ISOs)	1.86×10^{-4}
Catastrophic Rupture (3 ISOs)	9.34×10^{-7}

Table 23. Consolidated release scenarios for eight LNG ISOs.

Equivalent release rate (kg/s)	Probability
0	7.09×10^{-1}
4.77	1.06×10^{-1}
22.9	1.64×10^{-1}
41.1	1.48×10^{-2}
59.3	7.59×10^{-4}
77.5	2.44×10^{-5}
95.7	5.02×10^{-7}
Catastrophic Rupture (1 ISO)	2.35×10^{-2}
Catastrophic Rupture (2 ISOs)	2.47×10^{-4}
Catastrophic Rupture (3 ISOs)	1.49×10^{-6}

Table 24. Consolidated release scenarios for nine LNG ISOs.

Equivalent release rate (kg/s)	Probability
0	6.80×10^{-1}
5.30	9.48×10^{-2}
23.5	1.79×10^{-1}
41.7	1.84×10^{-2}
59.9	1.11×10^{-3}
78.1	4.27×10^{-5}
96.3	1.10×10^{-6}
Catastrophic Rupture (1 ISO)	2.64×10^{-2}
Catastrophic Rupture (2 ISOs)	3.17×10^{-4}
Catastrophic Rupture (3 ISOs)	2.23×10^{-6}

Table 25. Consolidated release scenarios for ten LNG ISOs.

Equivalent release rate (kg/s)	Probability
0	6.51×10^{-1}
5.88	1.02×10^{-1}
24.1	1.94×10^{-1}
42.3	2.24×10^{-2}
60.5	1.54×10^{-3}
78.7	6.92×10^{-5}
96.9	2.14×10^{-6}
Catastrophic Rupture (1 ISO)	2.92×10^{-2}
Catastrophic Rupture (2 ISOs)	3.95×10^{-4}
Catastrophic Rupture (3 ISOs)	3.17×10^{-6}

3.1.8 Multiple LPG Rail Car LOC Frequency

The same strategy utilized for consolidating the LNG ISO car LOC frequencies was used for the LPG cars. As with the LNG ISO cars, the outcomes were also refined by eliminating all potential LOC events with probabilities less than 1×10^{-7} as this is expected to result in an outcome with negligible risk (regardless of outcome). The consolidated release scenarios for involvement of two and three LPG rail cars are provided in Table 26 and Table 27.

Table 26. Consolidated release scenarios for two LPG rail cars.

Equivalent release rate (kg/s)	Probability
0	8.93×10^{-1}
2.87	2.47×10^{-2}
35.5	6.71×10^{-2}
68.9	1.23×10^{-3}
Catastrophic Rupture (1 LPG car)	1.39×10^{-2}
Catastrophic Rupture (2 LPG cars)	4.90×10^{-5}

Table 27. Consolidated release scenarios for three LPG rail cars.

Equivalent release rate (kg/s)	Probability
0	8.44×10^{-1}
3.69	3.53×10^{-2}
36.6	9.64×10^{-2}
69.9	3.52×10^{-3}
103.3	4.29×10^{-5}
Catastrophic Rupture (1 LPG car)	2.07×10^{-2}
Catastrophic Rupture (2 LPG cars)	1.46×10^{-4}
Catastrophic Rupture (3 LPG cars)	3.43×10^{-7}

3.2 Flammable Cloud Formation

The release conditions, LNG vaporization, cloud formation and dispersion, and flammable cloud envelope as a function of time were calculated in PHAST Risk v6.7. PHAST Risk is a commercial software package developed and distributed by Det Norske Veritas (DNV). PHAST Risk combines a phenomenological release and consequence analysis model with a risk analysis sub-model to evaluate spills, sprays, and gas dispersions and the resulting toxic, fire, and explosion consequences on populations.

PHAST is widely used for the calculation of hazard distances from the release of several hazardous substances, including LNG. PHAST is approved by the U.S. Pipeline and Hazardous Materials Safety Administration (PHMSA) for evaluating LNG release exclusion zones. The

PHAST code uses the Unified Dispersion Model (UDM) as an integral calculation model to estimate the dispersion following a pressurized release or an unpressurised release. It consists of the following linked modules (as shown in Figure 28):

- Near-field jet dispersion
- Non-equilibrium droplet evaporation and rainout, touchdown
- Pool spread and vaporization
- Heavy gas dispersion
- Far field passive dispersion

The UDM allows for continuous, instantaneous, constant finite-duration and general time-varying releases. The UDM also allows for possible plume lift-off if a grounded plume becomes buoyant. The UDM has been validated extensively with experimental data and is the subject of several peer-reviewed scientific papers.[36] The PHAST-UDM has also been approved by PHMSA for analyzing LNG vapor dispersion exclusion zones.[37]

PHAST model calculations assume that the terrain is completely flat and do not account for any obstructions (either natural or nearby equipment) on the dispersion distance of flammable clouds. In many cases, this assumption produces a conservative overestimate of the distance to hazardous outcomes.

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[36] Witlox, H.W.M. and Holt, A., 1999, A unified model for jet, heavy and passive dispersion including droplet rainout and re-evaporation, International Conference and Workshop on Modeling the Consequences of Accidental Releases of Hazardous Materials, CCPS, San Francisco, California, September 28-October 1, pages 315–344.

[37] PHMSA Docket No. 2011-0075, October 11, 2011.

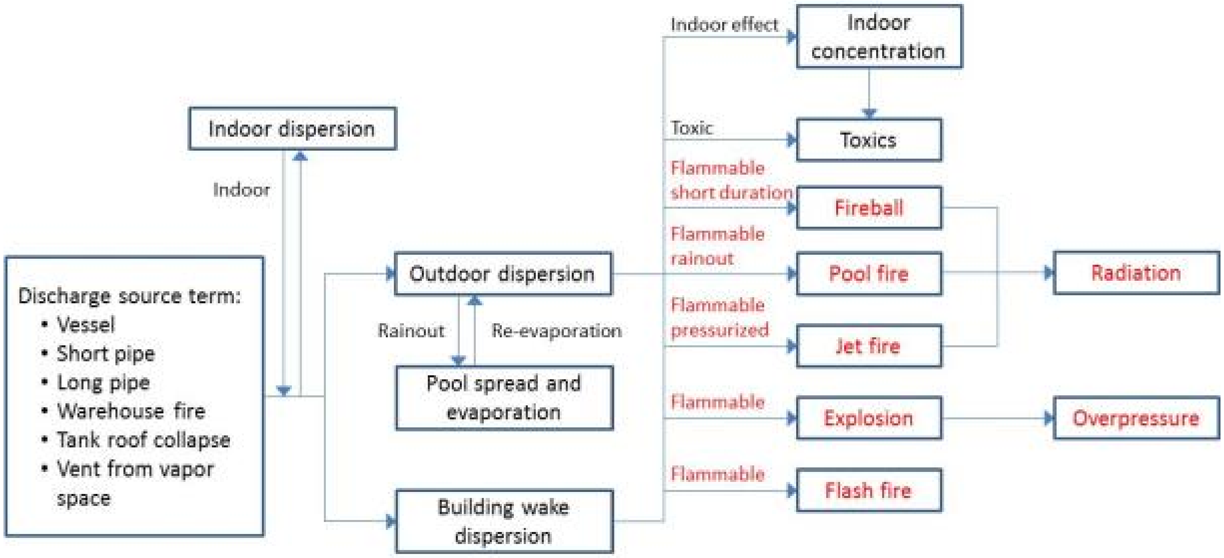

Figure 28. Block diagram for PHAST.

3.3 Ignition of a Flammable Cloud

Given a release of LNG and the formation of a flammable cloud, the hazardous outcomes analyzed in the QRA only occur if there is ignition of the flammable mixture. The timing of the ignition affects the consequence outcome because the flammable cloud stops growing after ignition since the flammable vapor will be burned. For example, immediate ignition of the release may result in a pool fire or jet fire (or both); delayed ignition may result in a pool fire, flash fire, or explosion. For each scenario modeled, PHAST Risk calculates the outcome due to both immediate ignition and delayed ignition. The immediate and delayed ignition probabilities in PHAST Risk are consistent with the guidelines published in the Dutch Purple Book.[38,39]

Exponent applied the default PHAST Risk ignition probability values for two release types:

- “Stationary” facility ignition probabilities were assigned for lifting operation incidents.
- “Tank wagon” (i.e., rail tank car) ignition probabilities were assigned for the train movement incidents.

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[38] PHAST Risk Technical Documentation, “MPACT Theory,” DNV Software, page 103 (2010).

[39] Chapter 4.7, Ignition, in *Guideline for Quantitative Risk Assessment* (Dutch Purple Book), Publication Series on Dangerous Substances, Ministerie van Verkeer en Waterstaat (2005).

3.3.1 Probability of Immediate Ignition

The "stationary" immediate ignition probability is dependent on the specific release characteristics for the scenario including the leak rate for a continuous release, the storage volume for an instantaneous/catastrophic release, and the material released. Methane is defined as a low reactivity material in the software, and the probability of immediate ignition has fixed value depending upon the hole size. PHAST Risk also considers a catastrophic instantaneous release of the entire contents of the vessel and calls this an "instantaneous" release. The term "tank wagon" refers to rail tank cars and was used to represent ISOs during train movement here. The "tank wagon" immediate ignition probability only depends on whether the release is continuous or instantaneous; the rate of release is not considered. Table 28 lists the probability of immediate ignition for the scenarios identified in the QRA.

Table 28. Probability of immediate ignition for methane in PHAST Risk

Hole Size	Stationary	Rail Tank Car
0.5-inch	0.02	0.1
2-inch	0.04	0.1
Instantaneous	0.09	0.8

3.3.2 Probability of Delayed Ignition

The probability of delayed ignition is dependent upon many characteristics of the release scenario, including the growth of an un-ignited vapor cloud with time and the presence of potential ignition sources at some distance from the point of release. Thus, the probability of delayed ignition is not a fixed value; it is calculated as a function of space and time for "stationary" and "tank wagon." The model domain space is split into grid cells, and the size of the cells is an integer value dependent on the size of the model domain. PHAST Risk performs calculations for each grid cell and sums the probability of ignition for all cells at a given time step. The domain is the maximum spatial extent of the consequence (e.g., maximum flammable cloud size), and PHAST Risk uses up to 40,000 grid cells for analyzing the domain.

The delayed ignition probability for a given grid cell is then calculated from the equation,

$$P_{x,y,t} = f_{x,y}(1 - e^{-\omega_{x,t} t})$$

where $P_{x,y,t}$ is the probability of delayed ignition in the grid cell located at (x,y). The variable $f_{x,y}$ is the proportion of time that the flammable cloud is present in the grid cell located at (x,y), $\omega_{x,y}$ is the ignition effectiveness factor for that grid cell, and t is the time step. No fixed location ignition sources were defined in the QRA analysis presented here (e.g., a stationary flare), thus the PHAST Risk delayed ignition probability model considers only the potential for ignition due to the surrounding population. The default PHAST Risk ω for ignition due to population used in this analysis was 1.68×10^{-4}/person (for outdoor populations only). Thus, the ignition effectiveness factor, ω, in the QRA is dependent on the population specified in the domain. The probability of delayed ignition increases with increasing population which then increases the overall risk as population increases.

3.4 Flammable Effects on a Population

The flammable effects resulting from a release of LNG include pool fires, jet fires, flash fires, and BLEVEs. The probability that an exposed population will suffer a fatality due to exposure to a flammable effect depends on the extent of exposure and protection of the population (indoor versus outdoor). For the IR calculations, PHAST Risk assumes that the entire population is outdoors. For the SR calculations, the standard model assumes that 90% of the population is indoors and 10% is outdoors. All calculations assume that people are at ground level, so the ground level effect zones are used in calculating consequence outcomes.

The flammable effects and fatality consequences are calculated in PHAST Risk utilizing a grid cell system to calculate fatalities in effect zones, and the probability of fatality as a function of distance is calculated. As previously described, the model domain is split into grid cells, and the size of the cells is an integer value dependent on the size of the model domain. The effect zones for fireballs, jet fires, and pool fires are modeled as ellipses. The shape of the vapor cloud determined from the dispersion calculations defines the shape of the flash fire. For grid cells where the flammable effect only overlaps a portion of the cell, the fraction of overlap is considered in calculating the fatality probability.

The flammable effect in a grid is then compared to the populations in that grid to determine the probability and number of expected fatalities. For the IR calculations, the model only considers whether a person is located in a grid cell, which is always assumed to be yes. To obtain the SR outputs, the flammable effect consequences are integrated by the number of people present in the grid cell (defined by the population density and size of the grid cell) to obtain the number of expected fatalities.

The flammable effect consequence methods used in PHAST Risk are consistent with the guidelines published in the Dutch Green Book[40] (and applied to QRA in the Dutch Purple Book[41]).[42] The Probit Method, which is dependent on radiation level and exposure time, is used

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[40] Chapter 1, Damage Caused by Heat Radiation, in *Methods for the Determination of Possible Damage* (Dutch Green Book), Publication Series on Dangerous Substances, Ministerie van Verkeer en Waterstaat (1992).

[41] Chapter 5, Modeling Exposure and Damage, in *Guideline for Quantitative Risk Assessment* (Dutch Purple Book), Publication Series on Dangerous Substances, Ministerie van Verkeer en Waterstaat (2005).

[42] PHAST Risk Technical Documentation, “MPACT Theory,” DNV Software, pages 66-94 (2010).

to calculate the probability of fatality for flammable effects on exposed populations for BLEVE, pool fire, and jet fire effects. This method is applied to each grid cell independently and then the cumulative consequence outcome for a specific flammable effect is obtained by summing all the grid cells.

The consequence outcomes for the classes of flammable effects are summarized (the flame envelope is defined as the area between the lower flammable limit, LFL, and upper flammable limit, UFL):

- <u>BLEVE, pool fire, jet fire</u>—all persons, indoor and outdoor, within the flame envelope are considered fatalities. All persons, indoor and outdoor, exposed to radiation levels exceeding 11,000 BTU/hr/ft^2 (35 kW/m^2) are considered fatalities. For smaller radiation levels, the Probit method is utilized to calculate the probability of fatality.
- <u>Flash fire</u>—all persons, indoor and outdoor, within the flame envelope are considered fatalities. All persons, indoor and outdoor, outside of the flame envelope are not considered fatalities.
- <u>Explosion</u>—all persons, indoor and outdoor, exposed to overpressures exceeding 4.35 psig (0.3 barg) are considered fatalities. All indoors persons exposed to pressures exceeding 1.45 psig (0.1 barg) are considered have a probability of fatality 2.5% of the time. All other exposures are not considered fatalities. The Baker-Strehlow-Tang (BST) explosion method is used to calculate the overpressure profile for explosion. The BST model inputs are provided in Table 29. The clouds were conservatively assumed to entirely occupy congested regions.

Table 29. Model inputs for the Baker-Strehlow-Tang (BST) modeling of explosions in PHAST Risk.

Parameter	Value
Material Reactivity	Low
Flame Expansion Factor	3
Obstacle Density	Low
Ground Reflection Factor	2
Congested Fraction	100%

3.4.1 Flammable Effects Event Trees

The flammable effects resulting from a release of LNG include pool fires, jet fires, flash fires, and BLEVE. The likelihood of each effect and the consequence outcome are affected by many parameters in the model. The probability of any of these outcomes occurring (or no ignition at all) is complex and is dealt with in PHAST by use of event trees. The probabilities of an individual consequence for a given release depends on whether the release is instantaneous (e.g., catastrophic scenarios) or continuous (e.g., the other scenarios considered), the presence of liquid rainout, subsequent pool vaporization, the presence of a persistent liquid pool, and the dispersion behavior of the flammable vapors.

A majority of the LNG releases considered here are continuous and will have some fraction of LNG that flashes immediately upon release with the remainder raining out on the ground, forming a pool, subsequently vaporizing, and/or leaving a persistent pool. The event tree used in PHAST to represent the probabilistic outcomes for these continuous releases with rainout is provided in Figure 29.

Similar event trees exist for a continuous release with no rainout and an instantaneous release with rainout, all scenarios examined in this study. The structure of the event trees is consistent with guidance in the Dutch Purple Book.[43] Each branch of these event trees corresponds to a probability of occurrence for that branch, and the sum of all branches for a given step (i.e., branches aligned vertically) sums to unity. The probabilities used in PHAST Risk are consistent with the values provided in the Dutch Purple Book.[44] For the example event tree provided in Figure 29, the delayed ignition branch has a 60% probability of resulting in a flash fire and a 40% probability of resulting in an explosion (there is zero probability for no effect); the residual pool fire has a probability of 15% and “no effect” is 85% for that branch.

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[43] *Guideline for Quantitative Risk Assessment* (Dutch Purple Book), Publication Series on Dangerous Substances, Ministerie van Verkeer en Waterstaat (2005).

[44] PHAST Risk Technical Documentation, “MPACT Theory,” DNV Software, page 128 (2010).

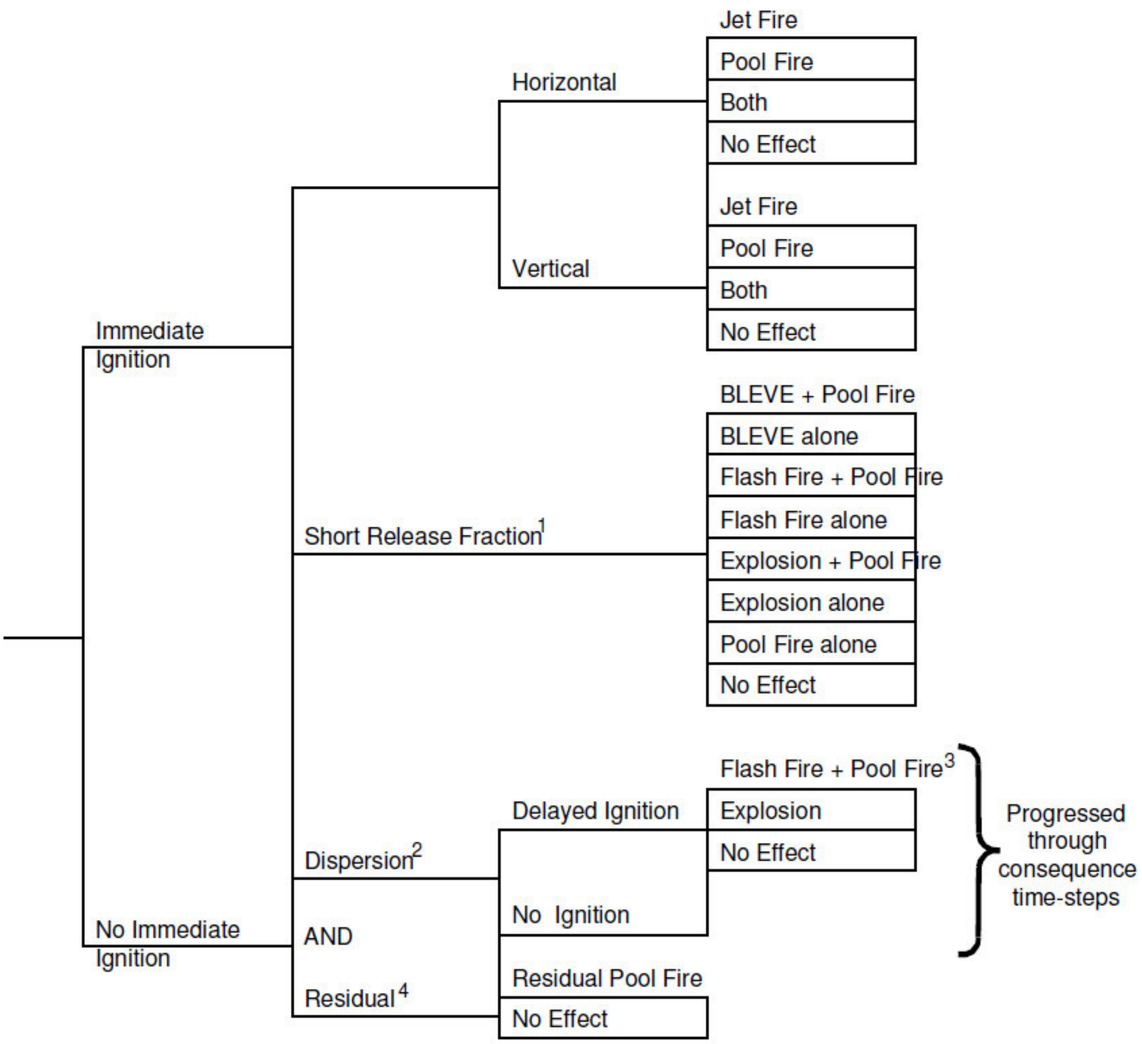

Figure 29. PHAST Risk consequence event trees for a continuous release with liquid rainout.[45]

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[45] PHAST Risk Technical Documentation, “MPACT Theory,” DNV Software, page 52 (2010).

4 Release Scenario Frequencies

Several accidental release scenarios were analyzed using the PHAST Risk software for each phase of LNG ISO tank container operations. The PHAST Risk software requires definition of the release sizes (e.g., no release, small, large, and catastrophic as defined earlier), release conditions, and the LOC frequency for each size of hole for each release scenario. The following section will provide the model conditions for each scenario and discuss the event trees used to estimate the release frequencies.

The LNG ISO tank container operations were grouped into three separate categories, distinguished by the type of operations and the unique risks present:

1. Lift On at intermodal facility in Hialeah Yard and yard movement.
2. Main line movement (Route 1, 2, or 3).
3. Yard movement and Lift Off at destination intermodal facility.

For all three operations categories, the ISOs are assumed to have an LNG capacity of [redacted] gallons, and it is expected to be handled at its boiling point temperature (-223°F/-142°C) at the design pressure of [redacted] psig pressure. The ½-inch and 2-inch hole size scenarios conservatively assumed a constant leak source pressure of [redacted] psig at the saturation temperature of methane; it was assumed that the LNG was released at this same pressure and temperature for the catastrophic release scenario. For calculation of vaporization rates due to the evaporation of spilled LNG, it was assumed that the LNG was spilled on dry soil. The release elevation used in the analysis was six feet, and all releases were assumed to be directed horizontally to conservatively maximize the flammable vapor dispersion distance.

4.1 LNG ISO Container Lifting Accidents

The LNG ISOs will be lifted onto well cars at Hialeah Yard intermodal facility and lifted off at the destination facility. The ISOs will be lifted by rubber tire gantry cranes or a container handler depending on the facility and the logistics for each train.

Based on the assumed daily movement of [redacted] ISO containers, the analysis accounted for [redacted] lifts per day at Hialeah Yard, and another [redacted] lifts per day at the receiving intermodal facility. The frequency for dropping an ISO that results in a 50 mm hole is 6.7×10^{-7} per lift (see Section 3.1). For [redacted] lifts per day, this results in an LOC frequency of [redacted] [redacted]^{1} for Hialeah and for each destination intermodal facility. The event frequency is provided in Table 30.

Table 30. LOC frequency for dropping an LNG ISO container at an intermodal facility.

Event	Release Frequency
Large leak (50 mm)	(b) (4)

4.2 Train Movement Accidents in Intermodal Facilities and Rail Yards

ISOs in well cars will be moved along intermodal ramps and within rail yards during train assembly and movement. Because the speed limits, rail quality, and adjacent activities differ between the yard line and the mainline, the yards and intermodal facilities were considered separately from the mainline in this QRA.

Given the fact that intermodal cars are intended to be moved as freight out of the yards, each ISO-containing train was assumed to travel the entire length of the intermodal facility/yard once each day. Using this uniform basis, a general event tree represents the frequency for all releases involving from one to four cars in any yard.[46]

The event frequencies for each release source size in a yard are summarized from the event tree as shown in Table 31, and the full event tree demonstrating the calculation of individual event frequencies is shown in Figure 30. Note that the event frequencies and event tree correspond to train Configuration 1 (C-1) only. Event trees representing the yard movements for the remaining train configurations are provided in Appendix D.

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[46] The derailment probability analysis described in Section 3.1.3 determined that, on average, 4 rail cars derail in the event of an accident with derailment in yards.

Table 31. Event frequencies for LNG ISO yard movement release scenarios at yards and intermodal facilities, presented here for Configuration 1 (C-1).[47]

	Release rate (kg/s)	Release Frequency (/year)
1 of [redacted] ISOs Involved	0	1.68×10^{-4}
	1.17	2.46×10^{-6}
	18.8	4.40×10^{-6}
	Catastrophic Rupture (1 ISO)	5.28×10^{-7}
2 of [redacted] ISOs Involved	0	1.44×10^{-4}
	1.57	4.23×10^{-6}
	19.4	7.61×10^{-6}
	37.6	9.78×10^{-8}
	Catastrophic Rupture (1 ISO)	9.36×10^{-7}
	Catastrophic Rupture (2 ISOs)	1.41×10^{-9}
3 of [redacted] ISOs Involved	0	1.47×10^{-4}
	2.01	6.53×10^{-6}
	20.0	1.18×10^{-5}
	40.8	3.07×10^{-7}
	Catastrophic Rupture (1 ISO)	1.49×10^{-6}
	Catastrophic Rupture (2 ISOs)	4.49×10^{-9}
4 of [redacted] ISOs Involved	0	4.66×10^{-4}
	2.51	2.78×10^{-5}
	20.6	5.08×10^{-5}
	38.8	1.96×10^{-6}
	59.0	3.38×10^{-8}
	Catastrophic Rupture (1 ISO)	6.58×10^{-6}
	Catastrophic Rupture (2 ISOs)	2.97×10^{-8}
	Catastrophic Rupture (3 ISOs)	5.96×10^{-11}

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[47] C-1 references the train configuration where all [redacted] LNG ISO cars are in a row, starting at train position [redacted] See Section 3.1.3 for a detailed explanation of all configurations explored.

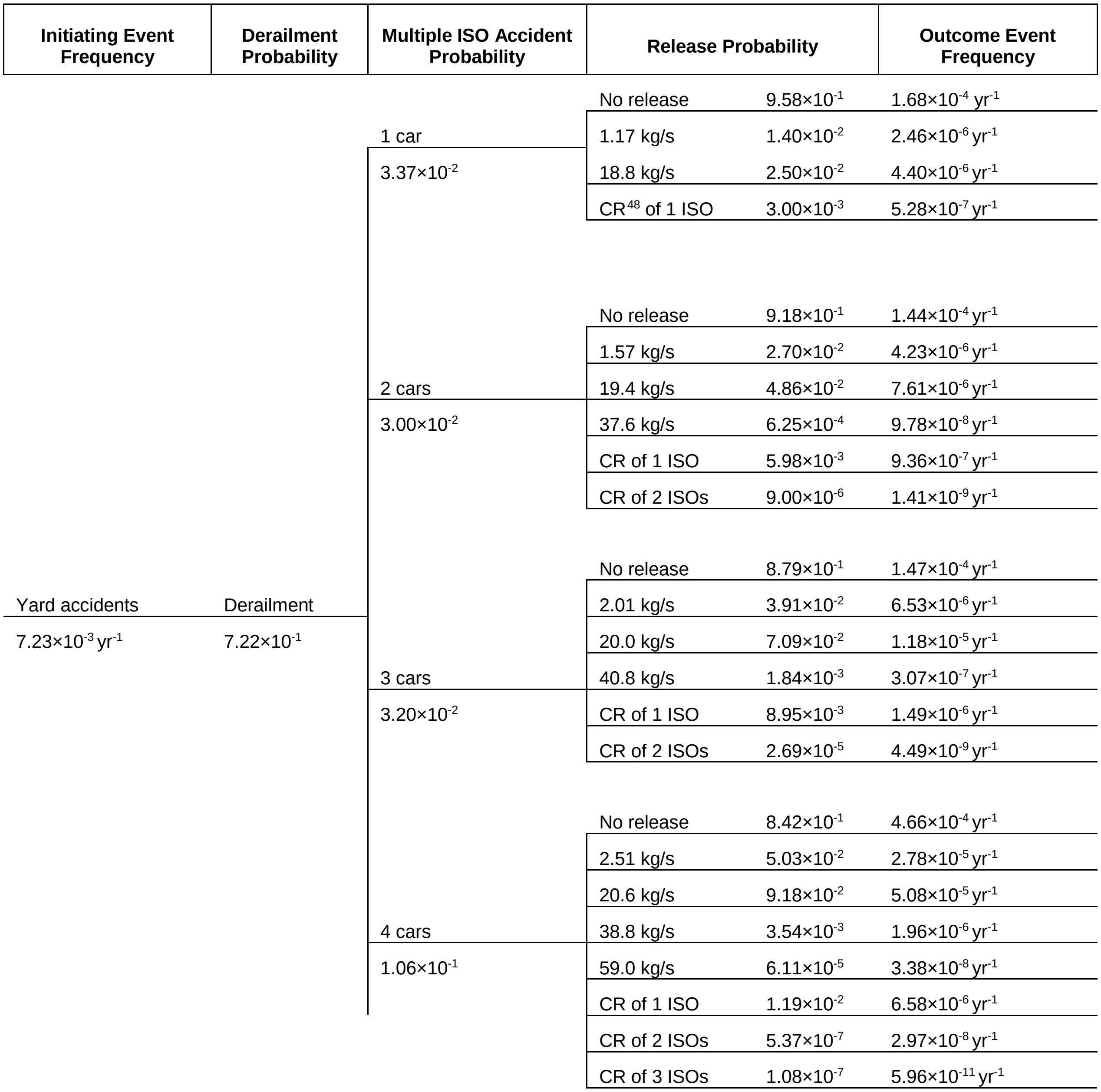

Figure 30. Event tree for yard movement for train Configuration 1 (C-1). “Outcome Event Frequency” is the product of the “Initiating Event Frequency,” “Derailment Probability,” “Multiple ISO Accident Probability,” and “Release Probability.”

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[48] The abbreviation “CR” represents a catastrophic rupture where the entire (b) (4) gallons contained in the ISO is released instantaneously.

4.3 Train Accidents on the Mainline and Port Lead Tracks

ISOs in well cars will be moved on mainline track from Hialeah Yard to either port lead tracks or to Bowden Yard in Jacksonville. The port lead tracks are treated here equivalently to mainline tracks. The QRA assumes that each route is independent and handles [redacted] ISOs per day of LNG.

Event trees representing the three separate routes, multiple mainline train speeds, and multiple train configurations are provided in Appendix D. The following tables summarize the release rates and associated release frequencies for combinations of one to ten ISOs along each route for train Configuration 1 (C-1) and mainline train movement at train speeds between 25 mph and 60 mph.[49] The release frequencies are a function of the length of the route; therefore, each route has a distinct table of release frequencies. "Release Frequency" is the product of the "Initiating Event Frequency," "Derailment Probability," "Multiple ISO Accident Probability," and "Release Probability."

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[49] C-1 references the train configuration where all [redacted] LNG ISO cars are in a row, starting at train position [redacted] See Section 3.1.3 for a detailed explanation of all configurations explored.

Table 32. Event frequencies for LNG ISO mainline movement release scenarios along Route 1 (Hialeah to Port of Miami), presented here for Configuration 1 (C-1) and train speeds between 25 mph and 60 mph.

Release rate (kg/s)	Release Frequency (/year)
1 of (b ISOs Involved	
0	1.28×10^{-3}
1.17	1.87×10^{-5}
18.8	3.34×10^{-5}
CR[50] 1 ISO	4.01×10^{-6}
2 of (b ISOs Involved	
0	2.74×10^{-4}
1.57	8.07×10^{-6}
19.4	1.45×10^{-5}
37.6	1.87×10^{-7}
CR 1 ISO	1.79×10^{-6}
CR 2 ISOs	2.69×10^{-9}
3 of (b ISOs Involved	
0	2.59×10^{-4}
2.01	1.15×10^{-5}
20.0	2.09×10^{-5}
40.8	5.41×10^{-7}
CR 1 ISO	2.63×10^{-6}
CR 2 ISOs	7.93×10^{-9}
4 of (b ISOs Involved	
0	2.05×10^{-4}
2.51	1.22×10^{-5}
20.6	2.23×10^{-5}
38.8	8.61×10^{-7}
59.0	1.49×10^{-8}
CR 1 ISO	2.89×10^{-6}
CR 2 ISOs	1.30×10^{-8}
CR 3 ISOs	2.62×10^{-11}
5 of (b ISOs Involved	
0	1.38×10^{-4}
3.03	1.04×10^{-5}
21.1	1.91×10^{-5}
39.4	9.84×10^{-7}
57.6	2.53×10^{-8}
77.4	3.27×10^{-10}
CR 1 ISO	2.54×10^{-6}
CR 2 ISOs	1.53×10^{-8}
CR 3 ISOs	4.60×10^{-11}
6 of (b ISOs Involved	
0	1.69×10^{-4}
3.58	1.53×10^{-5}
21.7	2.84×10^{-5}
39.9	1.82×10^{-6}
58.1	6.26×10^{-8}
76.4	1.21×10^{-9}
CR 1 ISO	3.87×10^{-6}
CR 2 ISOs	2.91×10^{-8}
CR 3 ISOs	1.17×10^{-10}
7 of (b ISOs Involved	
0	1.47×10^{-4}
4.14	1.57×10^{-5}
22.3	2.93×10^{-5}
40.5	2.26×10^{-6}
58.7	9.70×10^{-8}
76.9	2.50×10^{-9}
95.1	3.85×10^{-11}
CR 1 ISO	4.10×10^{-6}
CR 2 ISOs	3.70×10^{-8}
CR 3 ISOs	1.86×10^{-10}
8 of (b ISOs Involved	
0	1.33×10^{-4}
4.77	1.98×10^{-5}
22.9	3.07×10^{-5}
41.1	2.77×10^{-6}
59.3	1.42×10^{-7}
77.5	4.58×10^{-9}
95.7	9.42×10^{-11}
CR 1 ISO	4.41×10^{-6}
CR 2 ISOs	4.64×10^{-8}
CR 3 ISOs	2.79×10^{-10}
9 of (b ISOs Involved	
0	1.30×10^{-4}
5.30	1.82×10^{-5}
23.5	3.43×10^{-5}
41.7	3.53×10^{-6}
59.9	2.12×10^{-7}
78.1	8.18×10^{-9}
96.3	2.10×10^{-10}
CR 1 ISO	5.05×10^{-6}
CR 2 ISOs	6.08×10^{-8}
CR 3 ISOs	4.27×10^{-10}
10 of (b ISOs Involved	
0	1.23×10^{-4}
5.88	1.92×10^{-5}
24.1	3.66×10^{-5}
42.3	4.24×10^{-6}
60.5	2.91×10^{-7}
78.7	1.31×10^{-8}
96.9	4.04×10^{-10}
CR 1 ISO	5.52×10^{-6}
CR 2 ISOs	7.48×10^{-8}
CR 3 ISOs	6.00×10^{-10}

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[50] The abbreviation "CR" represents a catastrophic rupture where the entire (b) (4) gallons contained in the ISO is released instantaneously.

Table 33. Event frequencies for LNG ISO mainline movement release scenarios along Route 2 (Hialeah to Port Everglades), presented here for Configuration 1 (C-1) and train speeds between 25 mph and 60 mph.

Release rate (kg/s)	Release Frequency (/year)	Release rate (kg/s)	Release Frequency (/year)	Release rate (kg/s)	Release Frequency (/year)
1 of (b ISOs Involved		6 of (b ISOs Involved		9 of (b ISOs Involved	
0	2.93×10^{-3}	0	3.15×10^{-4}	0	2.34×10^{-4}
1.17	3.49×10^{-5}	3.58	2.86×10^{-5}	5.30	3.39×10^{-5}
18.8	6.23×10^{-5}	21.7	5.30×10^{-5}	23.5	6.41×10^{-5}
CR[51] 1 ISO	7.48×10^{-6}	39.9	3.41×10^{-6}	41.7	6.59×10^{-6}
2 of (b ISOs Involved		58.1	1.17×10^{-7}	59.9	3.96×10^{-7}
0	5.11×10^{-4}	76.4	2.25×10^{-9}	78.1	1.53×10^{-8}
1.57	1.51×10^{-5}	CR 1 ISO	7.22×10^{-6}	96.3	3.93×10^{-10}
19.4	2.71×10^{-5}	CR 2 ISOs	5.43×10^{-8}	CR 1 ISO	9.42×10^{-6}
37.6	3.48×10^{-7}	CR 3 ISOs	2.18×10^{-10}	CR 2 ISOs	1.13×10^{-7}
CR 1 ISO	3.33×10^{-6}	7 of (b ISOs Involved		CR 3 ISOs	7.96×10^{-10}
CR 2 ISOs	5.02×10^{-9}	0	2.75×10^{-4}	10 of (b ISOs Involved	
3 of (b ISOs Involved		4.14	2.94×10^{-5}	0	2.30×10^{-4}
0	4.83×10^{-4}	22.3	5.48×10^{-5}	5.88	3.59×10^{-5}
2.01	2.15×10^{-5}	40.5	4.22×10^{-6}	24.1	6.83×10^{-5}
20.0	3.90×10^{-5}	58.7	1.81×10^{-7}	42.3	7.91×10^{-6}
40.8	1.01×10^{-6}	76.9	4.66×10^{-9}	60.5	5.42×10^{-7}
CR 1 ISO	4.92×10^{-6}	95.1	7.19×10^{-11}	78.7	2.44×10^{-8}
CR 2 ISOs	1.48×10^{-8}	CR 1 ISO	7.65×10^{-6}	96.9	7.54×10^{-10}
4 of (b ISOs Involved		CR 2 ISOs	6.9170×10^{-8}	CR 1 ISO	1.03×10^{-5}
0	3.82×10^{-4}	CR 3 ISOs	3.46×10^{-10}	CR 2 ISOs	1.40×10^{-7}
2.51	2.28×10^{-5}	8 of (b ISOs Involved		CR 3 ISOs	1.12×10^{-9}
20.6	4.17×10^{-5}	0	2.48×10^{-4}		
38.8	1.61×10^{-6}	4.77	3.70×10^{-5}		
59.0	2.77×10^{-8}	22.9	5.74×10^{-5}		
CR 1 ISO	5.39×10^{-6}	41.1	5.16×10^{-6}		
CR 2 ISOs	2.43×10^{-8}	59.3	2.66×10^{-7}		
CR 3 ISOs	4.88×10^{-11}	77.5	8.54×10^{-9}		
5 of (b ISOs Involved		95.7	1.76×10^{-10}		
0	2.58×10^{-4}	CR 1 ISO	8.22×10^{-6}		
3.03	1.94×10^{-5}	CR 2 ISOs	8.66×10^{-8}		
21.1	3.57×10^{-5}	CR 3 ISOs	5.21×10^{-10}		
39.4	1.84×10^{-6}				
57.6	4.72×10^{-8}				
77.4	6.10×10^{-10}				
CR 1 ISO	4.74×10^{-6}				
CR 2 ISOs	2.85×10^{-8}				
CR 3 ISOs	8.59×10^{-11}				

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[51] The abbreviation "CR" represents a catastrophic rupture where the entire (b) (4) gallons contained in the ISO is released instantaneously.

Table 34. Event frequencies for LNG ISO mainline movement release scenarios along Route 3 (Hialeah to Bowden Yard), presented here for Configuration 1 (C-1) and train speeds between 25 mph and 60 mph.

Release rate (kg/s)	Release Frequency (/year)
1 of (b ISOs Involved	
0	3.11×10^{-2}
1.17	4.54×10^{-4}
18.8	8.10×10^{-4}
CR[52] 1 ISO	9.72×10^{-5}
2 of (b ISOs Involved	
0	6.65×10^{-3}
1.57	1.96×10^{-4}
19.4	3.52×10^{-4}
37.6	4.53×10^{-6}
CR 1 ISO	4.33×10^{-5}
CR 2 ISOs	6.52×10^{-8}
3 of (b ISOs Involved	
0	6.28×10^{-3}
2.01	2.80×10^{-4}
20.0	5.06×10^{-4}
40.8	1.31×10^{-5}
CR 1 ISO	6.39×10^{-5}
CR 2 ISOs	1.92×10^{-7}
4 of (b ISOs Involved	
0	4.97×10^{-3}
2.51	2.97×10^{-4}
20.6	5.42×10^{-4}
38.8	2.09×10^{-5}
59.0	3.61×10^{-7}
CR 1 ISO	7.01×10^{-5}
CR 2 ISOs	3.17×10^{-7}
CR 3 ISOs	6.35×10^{-10}
5 of (b ISOs Involved	
0	3.36×10^{-3}
3.03	2.52×10^{-4}
21.1	4.64×10^{-4}
39.4	2.39×10^{-5}
57.6	6.14×10^{-7}
77.4	7.94×10^{-9}
CR 1 ISO	6.16×10^{-5}
CR 2 ISOs	3.71×10^{-7}
CR 3 ISOs	1.12×10^{-9}
6 of (b ISOs Involved	
0	4.09×10^{-3}
3.58	3.72×10^{-4}
21.7	6.89×10^{-4}
39.9	4.43×10^{-5}
58.1	1.52×10^{-6}
76.4	2.93×10^{-8}
CR 1 ISO	9.38×10^{-5}
CR 2 ISOs	7.06×10^{-7}
CR 3 ISOs	2.83×10^{-9}
7 of (b ISOs Involved	
0	3.57×10^{-3}
4.14	3.82×10^{-4}
22.3	7.12×10^{-4}
40.5	5.49×10^{-5}
58.7	2.35×10^{-6}
76.9	6.06×10^{-8}
95.1	9.34×10^{-10}
CR 1 ISO	9.95×10^{-5}
CR 2 ISOs	8.98×10^{-7}
CR 3 ISOs	4.50×10^{-9}
8 of (b ISOs Involved	
0	3.23×10^{-3}
4.77	4.81×10^{-4}
22.9	7.46×10^{-4}
41.1	6.71×10^{-5}
59.3	3.45×10^{-6}
77.5	1.11×10^{-7}
95.7	2.28×10^{-9}
CR 1 ISO	1.07×10^{-4}
CR 2 ISOs	1.13×10^{-6}
CR 3 ISOs	6.78×10^{-9}
9 of (b ISOs Involved	
0	3.16×10^{-3}
5.30	4.41×10^{-4}
23.5	8.33×10^{-4}
41.7	8.57×10^{-5}
59.9	5.14×10^{-6}
78.1	1.98×10^{-7}
96.3	5.10×10^{-9}
CR 1 ISO	1.22×10^{-4}
CR 2 ISOs	1.47×10^{-6}
CR 3 ISOs	1.04×10^{-8}
10 of (b ISOs Involved	
0	2.99×10^{-3}
5.88	4.66×10^{-4}
24.1	8.88×10^{-4}
42.3	1.03×10^{-4}
60.5	7.05×10^{-6}
78.7	3.17×10^{-7}
96.9	9.80×10^{-9}
CR 1 ISO	1.34×10^{-4}
CR 2 ISOs	1.81×10^{-6}
CR 3 ISOs	1.46×10^{-8}

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[52] The abbreviation "CR" represents a catastrophic rupture where the entire (b) (4) gallons contained in the ISO is released instantaneously.

5 Release Location Assumptions

The release scenarios can occur in one of the four yard locations, (1) Hialeah Yard, (2) Bowden Yard, (3) Port Everglades or (4) Port of Miami, or along any of the three proposed routes between these yards. This section provides descriptions of the assumptions for the release locations applied to each route.

5.1 Hialeah Yard Releases

The Hialeah Yard is located in Hialeah, Florida, approximately ten miles northwest of Miami. The Hialeah Yard represents the starting point for all three proposed routes and is the location where all LNG ISO containers will be loaded into the well cars. The Hialeah Yard contains two release scenario classifications: (1) ISO container lifting, and (2) yard movement. The lifting operations have been modeled as a fixed location release and as a release anywhere along the intermodal ramp track, while the yard movement scenario follows a path which terminates at the approximate FECR yard boundaries. The spur track connecting to the neighboring LNG facility to the north was also considered. The QRA transitioned to mainline accident analysis outside of these boundaries. Further, the layout of the Hialeah yard, which is enclosed on the east side by an approximately 10 ft high wall, will reduce the likelihood that flammable vapor clouds will expand beyond the property in that direction.[53] Thus, the route of the train was modeled for the primary north-south track on the west side of the property. PHAST Risk modeled the release sources for the route at 75-feet intervals along the path.

Two route representations were applied for the Hialeah Yard to demonstrate the range of risk results applicable to lifting and train movement for the intermodal facilities and rail yards. The first route assumption is depicted in the aerial image of the Hialeah Yard in Figure 31. This model represents all lifting activities as occurring at a single point on the intermodal ramp and train movement located only on the western-most track in the yard. As will be shown in the results section, these assumptions lead to the maximum calculated distance to IR risk thresholds for lifting operations but only negligibly affect the distance to the thresholds for train movement. The second route assumption is depicted in the aerial image in Figure 32. This second model represents lifting along the entire eastern intermodal ramp track and train movements down the eastern track, the circular turnaround at the south end of the facility, and the western-most track. The effects of these assumed routes on the calculated risk will be discussed in the Results section.

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[53] Note that the integral equation-based models in PHAST Risk are not suitable for modeling the barrier effects of walls on flammable vapor cloud dispersion; thus, the north-south track was used as the primary rail yard route.

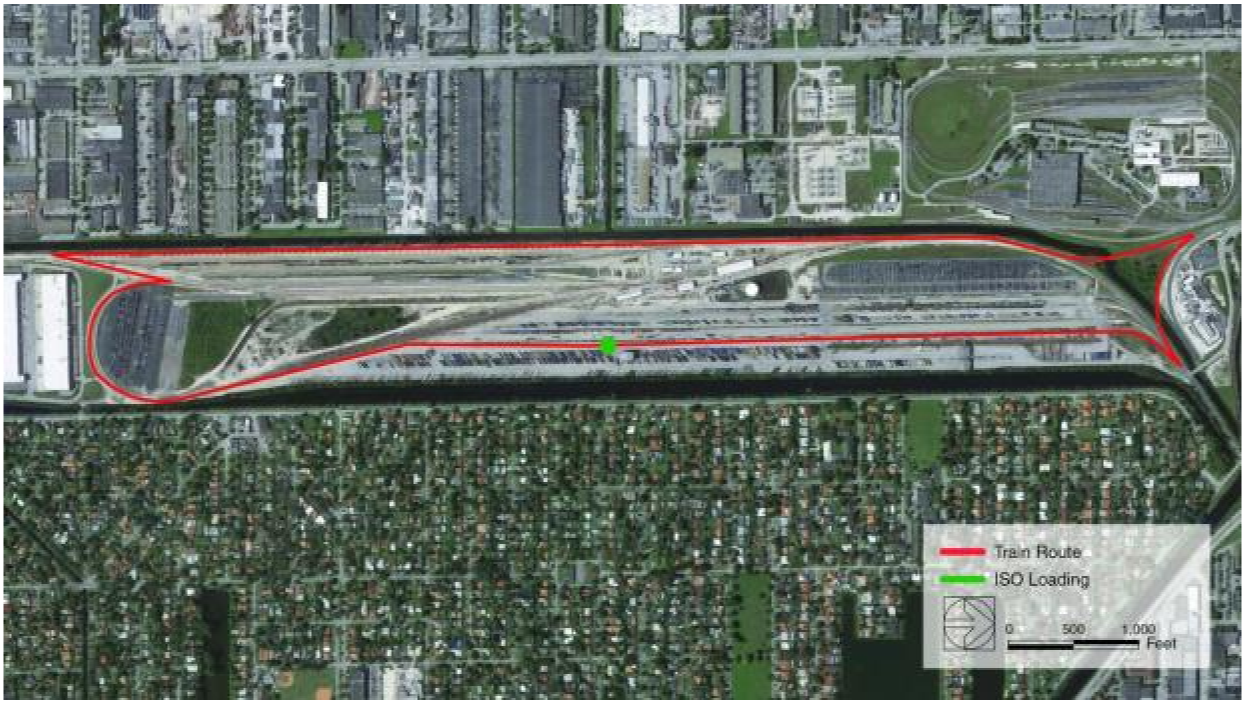

Figure 31. Aerial view of the Hialeah Yard. The train route along the outside yard rail lines is red and a representative location of lifting operations is shown as a green dot.

Figure 32. Aerial view of the Hialeah Yard. The train route through the yard is red and the range of lifting operations along the intermodal ramp is shown as a green line.

5.2 Port of Miami Intermodal Facility Releases

The Port of Miami intermodal facility is located on Dodge Island in Biscayne Bay, and is the destination yard for all LNG ISO containers on Route 1. The Port of Miami intermodal facility contains two release scenario classifications: (1) ISO container lifting, and (2) yard movement.

Figure 33 shows an aerial image of the Port of Miami intermodal facility depicting the location of the lifting activities as a point and the yard rail line. The QRA transitioned to mainline accident analysis outside of these boundaries. PHAST Risk modeled the release sources for the yard track route at 75-feet intervals along the path.

Figure 33. Aerial view of Port of Miami. The yard rail line is red and the approximate location of lifting operations is represented as a green dot.

5.3 Port Everglades Intermodal Facility Releases

The FECR Port Everglades intermodal facility is located directly to the east of Fort Lauderdale airport in Port Everglades, Florida. The Port Everglades intermodal facility is the destination point for Route 2, and as such, all LNG ISOs on this route will be lifted off the well cars here. Therefore, the Port Everglades intermodal facility contains two release scenario classifications: (1) ISO container lifting, and (2) yard movement.

An aerial image of the Port Everglades intermodal facility, depicting the route for the release scenario, is provided in Figure 34. The train yard movement scenario follows a path which terminates at the approximate FECR property boundaries. The QRA transitioned to mainline accident analysis outside of these boundaries. PHAST Risk modeled the release sources for the route at 75-feet intervals along the path.

Figure 34. Aerial view of the Port Everglades intermodal facility. The yard rail line is red and the approximate location of lifting operations is represented as a green dot.

5.4 Bowden Yard Releases

The Bowden Yard is located on the south side of Jacksonville, Florida, and represents the northern terminus of the FECR mainline track considered in this QRA. The Bowden Yard contains two release scenario classifications: (1) ISO container lifting, and (2) yard movement. An aerial image of the Bowden Yard, depicting the location/routes for the two release scenarios, is provided in Figure 35. The lifting operations have been modeled as a fixed location release while the yard movement scenario follows a path which terminates at the approximate FECR property boundaries. PHAST Risk modeled the release sources for the route at 75-feet intervals along the path.

Figure 35. Aerial view of the Bowden Yard. The yard rail line is red and the approximate location of the lifting operations is represented as a green dot.

5.5 Route 1 – Hialeah to Port of Miami

Route 1 begins at Hialeah Yard and ends at the Port of Miami intermodal facility, as shown earlier in Figure 18. The majority of the route is covered by the FECR mainline. This population density is bounded by the mainline risk analysis. Mainline movement is the only release scenario classification considered along this 15-mile route. PHAST Risk modeled the release sources for the route at 75-feet intervals along the path.

5.6 Route 2 – Hialeah to Port Everglades

The second route begins at Hialeah Yard and ends at Port Everglades intermodal facility, as shown earlier in Figure 19. Nearly the entirety of the route is covered by the FECR mainline. Mainline movement is the only release scenario classification considered along this 28-mile route. PHAST Risk modeled the release sources for the route at 75-feet intervals along the path.

5.7 Route 3 – Hialeah to Bowden Yard

Route 3 is the longest of the three routes, starting at Hialeah Yard and terminating at the Bowden Yard, as shown earlier in Figure 20. Mainline movement is the only release scenario classification considered along this 364-mile route. PHAST Risk modeled the release sources for the route at 75-feet intervals along the path.

6 Potentially Affected Populations

The population along the rail routes and around the rail yards and intermodal facilities directly affect the risk; thus, the population was evaluated as part of the QRA. A commercially available mapping tool, ArcGIS (ArcMap v10.2.1), along with commercially available census and rail databases, were used to estimate the nearby populations for the Hialeah Yard, Port Everglades, Port of Miami, Bowden Yard, and the FECR mainline rail and lead tracks to both Port Everglades and Port of Miami. By using ArcGIS, 2010 U.S. census data,[54] 2012 railroads geographic data,[55] and satellite imagery for the state of Florida, a multilayered GIS map was generated. The rail map layer was then filtered to exclude all non-FECR[56] railroads and census data was filtered to exclude all census blocks that did not intersect an area of 1.6 miles (2500 m) on either side of the FECR rail line.

6.1 Hialeah Yard Populations

Analysis of the Hialeah Yard's surrounding population was accomplished by defining the Hialeah Yard track in GIS rail map layer and excluding all other rail lines. Subsequently, a query of the census layer data was run to identify only the relevant census blocks that were within 1.6 miles (2500 m) of the specified yard track. The results of this map query identified 1,105 census blocks that were within 1.6 miles (2500 m) to either side of the approximate location of the yard line track. Finally, using geographical markers, such as highways and major roads, the resulting census map was grouped into four consolidated census blocks.

The population densities of the four larger consolidated census blocks represent an average population density for all of the census blocks contained within each. The consolidated census block population densities were directly used in the QRA analysis. An aerial view of the Hialeah Yard and four consolidated census blocks is depicted in Figure 36. A table of the population densities of the four consolidated census block is provided in Table 35.

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[54] Florida Geographic Data Library (FGDL) http://www.fgdl.org, March 11, 2010.

[55] Florida Geographic Data Library (FGDL) http://www.fgdl.org, 2012.

[56] As labeled in the FGDL 2012 railroad shapefile.

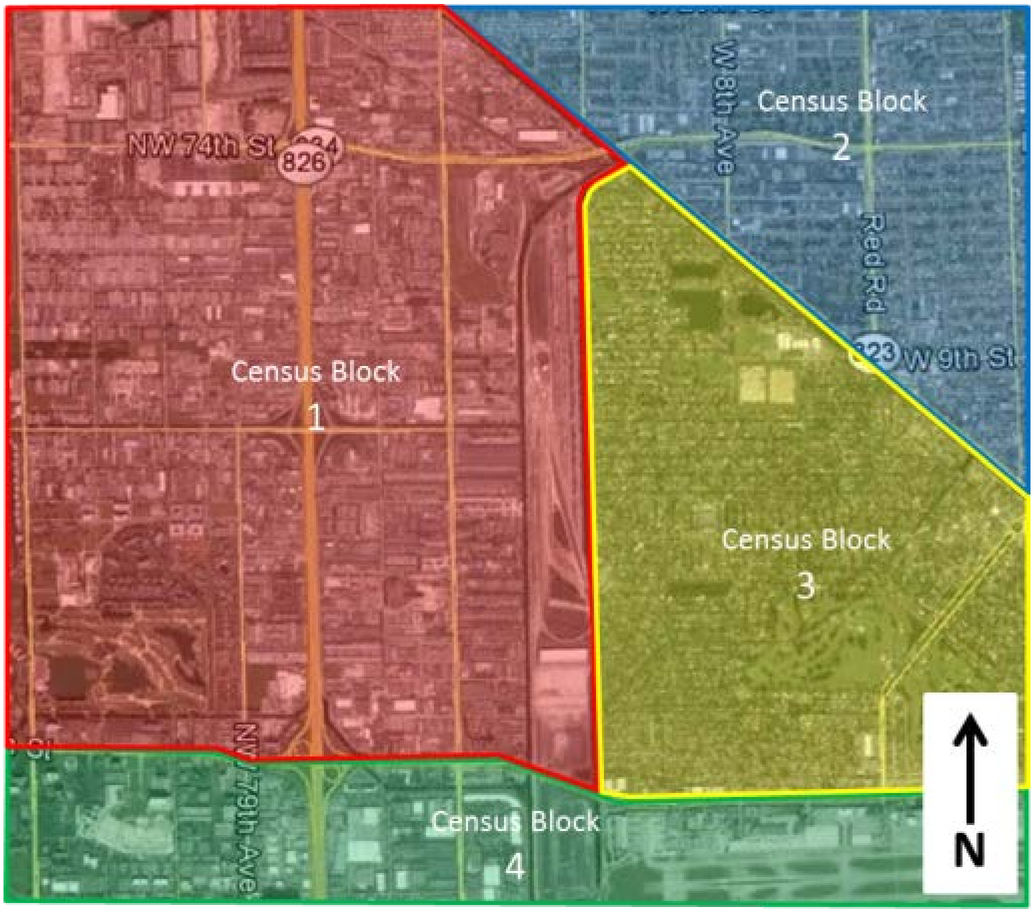

Figure 36. Aerial view of the Hialeah Yard depicting the four consolidated census blocks used to represent nearby populations.

Table 35. Population densities of the consolidated census blocks in the Hialeah Yard area.

Census Block	Population Description	Population Density (People per square mile)
1	Commercial / Industrial	1,276
2	Residential	12,860
3	Residential	5,471
4	Commercial / Industrial	447

6.2 Port of Miami Populations

The census data used to determine population density is based on residential populations. As Port of Miami is located on an island dedicated to the port operations, the census data was not applicable. In addition to general port operations, the Port of Miami contains seven cruise terminals, each of which processes thousands of passengers and crew members per year. As such, the population analysis also considered cruise ship passengers and crew, port operations personnel, and surrounding residential islands.

In 2015, the Port of Miami processed nearly 4.9 million cruise passengers,[57] equating to approximately 13,500 passengers per day. Based on Carnival cruise ship capacity information, crew numbers are on average 40% of the number of passengers,[58] therefore, it was assumed that there are approximately 19,000 passengers and crew present at the cruise terminals each day. The 19,000 people were conservatively assumed to be present for 24 hours, even though embarkation and disembarkation would not take an entire day. For example, the cruise operations may only lead to high population for a few hours a day. Thus, by assuming the maximum population is present for 24 hours per day, the potentially affected population is conservatively maximized to conservatively upper bound the risk. This population was allocated to the region labelled Area A in Figure 37.

During 2013 and 2014, Port of Miami had 349 full time employees;[59] this population was assigned to Area B as shown in Figure 37 in the QRA model. The population density for the residential areas, labelled Area C in Figure 37, was calculated from the census data as per the Port of Miami Lead Track section. The populations for the three areas are summarized in Table 36.

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[57] Port of Miami, *Cruise Facts*, http://www.miamidade.gov/portmiami/cruise-facts.asp.

[58] Carnival, *Cruise Ships*, http://www.carnival.com/cruise-ships.aspx.

[59] Miami-Dade Seaport Department, *Comprehensive Annual Financial Reports for the fiscal years ended September 30, 2014 and 2013*, http://www miamidade.gov/portmiami/library/reports/comprehensive-annual-financial-report-2014.pdf.

Figure 37. Aerial view of the Port of Miami depicting the three distinct population densities.

Table 36. Population of the consolidated census blocks in the Port of Miami area.

Area	Population Description	Population (People per Block)	Population Density (People per square mile)
A	Cruise Ship	19,000	191,800
B	Industrial	350	488
C	Residential	--	10,252

6.3 Port Everglades Populations

Analysis of the Port Everglades intermodal facility was accomplished by defining the yard track in the GIS rail map layer and filtering all other track segments. Subsequently, a query of the census layer data was run to identify only the relevant census blocks that were within 1.6 miles (2500 m) of either side of the yard track. Finally, using geographical markers, such as a waterfront and highways, the resulting census map was grouped into four consolidated census blocks.

The population densities of the four larger consolidated census blocks represent an average population density for all of the census blocks contained within each. The consolidated census block population densities were directly used in the QRA analysis. An aerial view of the Port Everglades intermodal facility and four consolidated census blocks is depicted in Figure 38 and the corresponding population densities of the four blocks are provided in Table 37.

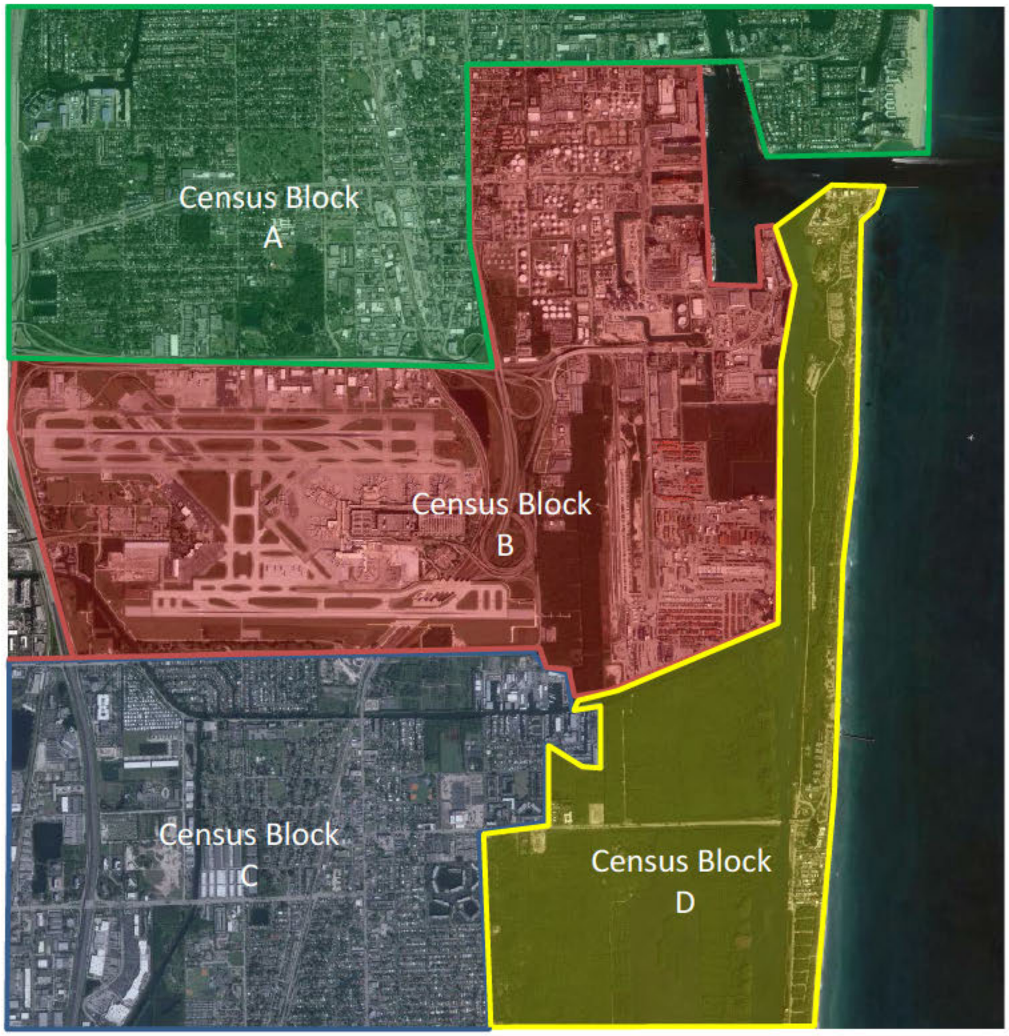

Figure 38. Aerial view of the Port Everglades intermodal facility depicting the four distinct population densities.

Table 37. Population densities of the consolidated census blocks in the Port Everglades intermodal facility area.

Census Block	Population Description	Population Density (People per square mile)
A	Residential / Commercial	4,680
B	Commercial / Industrial	707
C	Residential / Commercial	6,965
D	Sparse	250[60]

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[60] Based on the census data the population density for this area is zero, therefore 250 was chosen as a conservative assumption to account for recreational users of the parklands and waterways.

6.4 Bowden Yard Populations

Analysis of the Bowden Yard was accomplished by applying the census layer data for the relevant census blocks that were within 1.6 miles (2500 m) of either side of the locomotive turn-around track. The results of this map query identified 257 census blocks that were within 1.6 miles (2500 m) of either side of the yard track. Finally, using geographical markers, such as a waterfront and highways, the resulting census map was grouped into five consolidated census blocks.

The population densities of the four larger consolidated census blocks represent an average population density for all of the census blocks contained within each. The consolidated census block population densities were directly used in the QRA analysis. An aerial view of the Bowden Yard and five consolidated census blocks is depicted in Figure 39. A table of the population densities of the five consolidated census block is provided in Table 38.

Figure 39. Aerial view of the Bowden Yard depicting the five consolidated census blocks used to represent nearby populations.

Table 38. Population densities of the consolidated census blocks for the Bowden Yard.

Census Block	Population Description	Population Density (People per square mile)
A	Residential	2,847
B	Residential / Commercial	5,720
C	Residential	5,098
D	Commercial / Industrial	478
E	Residential / Commercial	687

6.5 Main Line Track Populations

Analysis of the longest section of mainline route from the Bowden rail yard to the Hialeah Yard was accomplished by filtering all sections of the FECR rail line (from the GIS rail map layer) to include only the rail sections from the approximate southern boundary of the Bowden Yard to the approximate northern boundary of the Hialeah Yard. A query of the census layer data was run to identify only the relevant census blocks that were within 1.6 miles (2500 m) of either side of the rail line. The results of this map query identified 37,837 census blocks that met the criterion. The routes to the Port of Miami and Port Everglades intermodal facilities are largely covered by this analysis, except for the individual port lead tracks.

The mainline census blocks were then grouped into one latitudinal-mile sections (north to south) along the rail line resulting in 314 consolidated census blocks. These consolidated census blocks, referred to here as "mile markers," represent the population per mile along the FECR mainline. The FECR mainline runs approximately north and south, but these mile markers are not the same as their rail mile markers.[61] The population densities of these 314 larger consolidated census blocks were directly used in the QRA analysis to represent the population along the rail line.

A plot showing the population density from the Bowden Yard (Mile Marker 1) to the Hialeah Yard (Mile Marker 314) is provided in Figure 40. The highest population densities are near the Hialeah Yard, which lies approximately ten miles northwest of Miami. The maximum population density was found at Mile Marker 308, with a population density of approximately 11,800 people/mile^2.

The population density profile is overlaid on an aerial image of the FECR rail line map, provided in Appendix E.

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[61] The mainline from Hialeah Yard to Bowden Yard is actually 364 miles long; however, by using latitude to estimate mile marker, the analysis resulted in 314 latitudinal miles which do not correspond to the FECR mile markers.

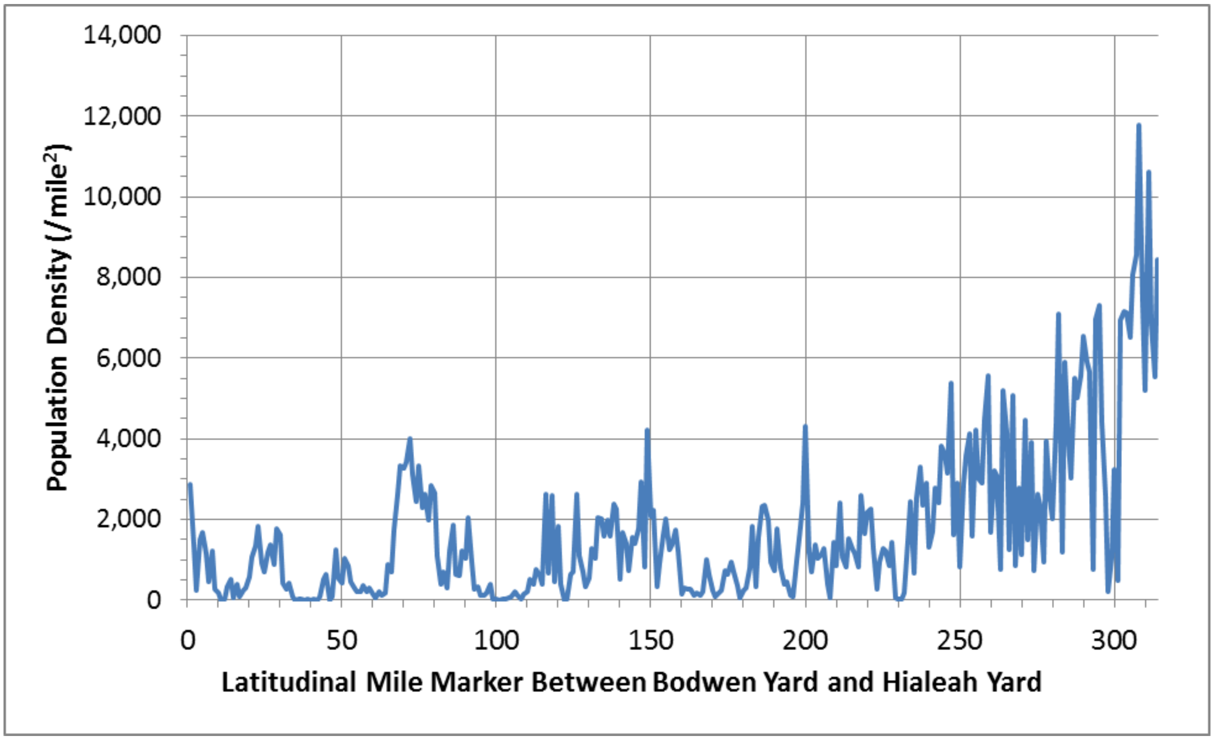

Figure 40. Average population density per latitudinal mile from the Bowden Yard to the Hialeah Yard.

6.6 Port of Miami Lead Track Populations

The route between Hialeah Yard and Port of Miami was divided into three sections as shown in Figure 41. The population densities for Census Blocks 1 and 2 correspond to the population densities for mile markers 304-314 in Figure 40. For the Port of Miami lead track (census block 3), the census data for all census blocks within 1.6 miles (2500 m) of either side of the rail line were consolidated to calculate the population density for that portion of the track. The population densities for these Census Blocks are provided in Table 39. Therefore, the risk of transport along the Port of Miami lead track is bounded by the mainline track risk analysis with an average population density of 11,800 people/mile^2 at Mile Marker 308.

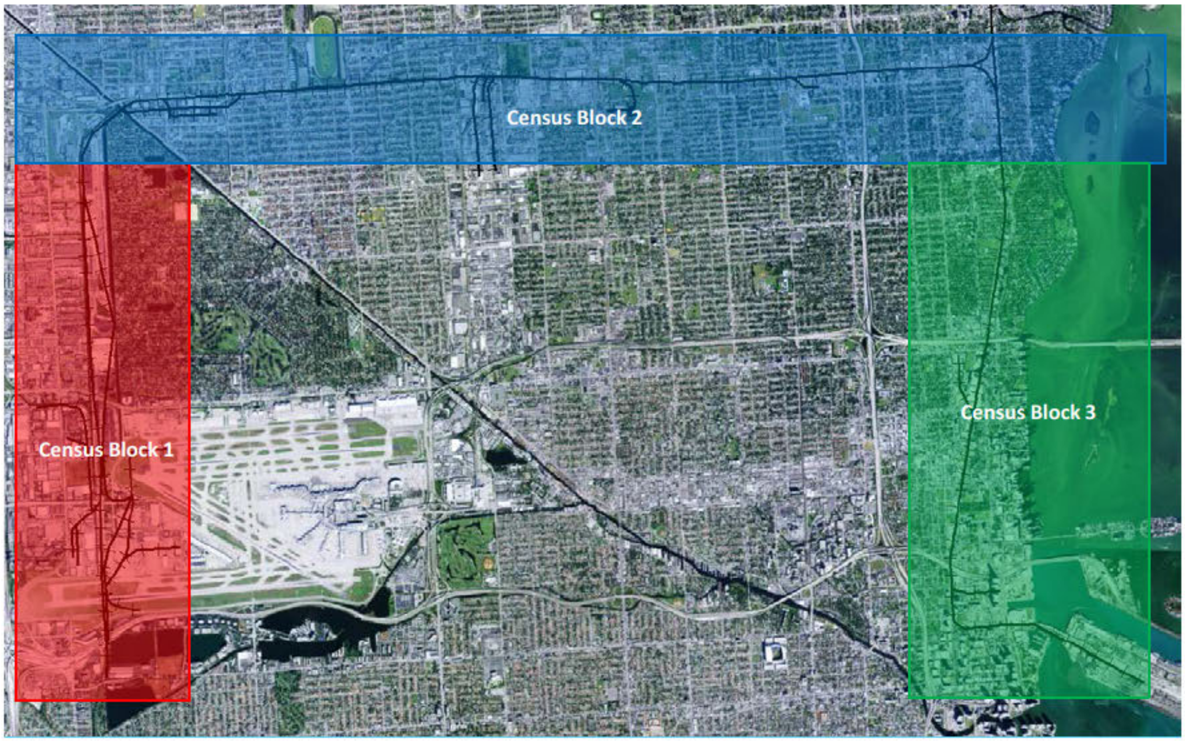

Figure 41. Aerial image of the route between Hialeah Yard and the Port of Miami.

Table 39. Population densities of the consolidated census blocks for Route 1.

Census Block	Population Description	Population Density (People per square mile)
1	Residential / Commercial	10,879
2	Residential / Commercial	11,069
3	Residential / Commercial	10,252

6.7 Port Everglades Lead Track Populations

The route from Hialeah Yard to Port Everglades initially follows the same track as the route to Bowden Yard, before turning onto the Port Everglades lead track, approximately 25 miles north on the mainline.

The population density along the route to Port Everglades corresponds to mile markers 282 to 314 in Figure 40 (mile marker 314 is located at Hialeah Yard). The risk of transport along the Port Everglades Lead Track is bounded by the mainline track risk analysis with an average population density of 11,800 people/mile^2 at Mile Marker 308.

7 Weather and Terrain

The ambient air temperature and ground temperature of the Hialeah Yard, the Ports, the Bowden Yard, and the routes were conservatively assumed to be the annual average temperature for the Jacksonville area, 68°F (20°C). This temperature was used for all calculations. Higher or lower temperatures are expected to impact the release consequence calculations slightly. The selection of a single temperature equal to the average annual temperature for the region is consistent with 49 CFR § 193 guidance for conducting vapor dispersion analyses of LNG releases at LNG terminal facilities.[62]

The wind speed was assumed to be constant at 4.5 mph (2 m/s) and was assumed to occur with equal likelihood in any direction. Based on experience with dense cloud dispersion, lower wind speeds typically result in the largest impact areas. A Pasquill-Gifford stability class of F was assigned for all calculations, and this value is expected to provide conservative (i.e. larger) hazard impact areas. Additionally, a wind speed of 4.5 mph (2 m/s) and Pasquill-Gifford stability class F are consistent with 49 CFR § 193 guidance for conducting vapor dispersion analyses of LNG releases.

The terrain was assumed to have a surface roughness factor consistent with suburbs and forests (1 m high). This selection was based on inspection of the test track environment during an Exponent inspection of the FECR track and via satellite imagery.

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[62] 49 CFR § 193.2059 – Flammable vapor-gas dispersion protection.

8 Results

Based on the forgoing discussion of the QRA assumptions, inputs, and calculations, the risk was calculated for a range of LNG ISO train consist configurations for each of the three routes and the rail yards and intermodal facilities. The risk results are presented in the form of Individual Risk contours, distance to Individual Risk thresholds, the Societal Risk integral, and Societal Risk as F-N curves for the fixed facilities and along the rail routes. For the proposed mainline routes, the risk results varied with demographics along the railroad. The underlying accident likelihoods and release scenarios are independent of the route demographics; thus, local population around the facilities and along the rail routes directly influences the calculated shipping risk. The risk was benchmarked against another flammable commodity, LPG, which has an established history of rail shipment. The LNG ISO risk results were then compared to quantitative risk criteria developed from those provided in NFPA 59A for stationary LNG plants.

The risk is first presented for a baseline case of a [redacted]-LNG ISO car consist shipped along the mainline at low speed, at high speed, and for movements in the rail yards and intermodal facilities. This baseline case is then benchmarked against an equivalent energy content of LPG moved along the same routes and in the same rail yards to show that the risks of LNG shipping are comparable yet less than the risks of shipping LPG. Next, the effect of train configuration on the risk profiles for transporting and handling LNG is examined. Finally, the risk to sensitive targets is presented along Route 1 – Hialeah to Port of Miami and Route 2 – Hialeah to Port Everglades.

8.1 LNG ISO Shipping Baseline Risk

The LNG ISO shipping risk was first analyzed for the baseline train configuration since this configuration represents the highest risk. Configuring a train to contain [redacted] LNG ISO cars in sequence will lead to a probability of multiple car derailment that maximizes the chances of up to [redacted] cars being involved in a LOC event. The probability of derailment is also highest when the LNG ISO cars are located near the front of the train. Thus, this configuration provides a conservative baseline case for risk comparison.

Baseline Train Configuration:

Configuration 1 (C-1)	[redacted] LNG ISO cars in sequence LNG ISO car positions: [redacted]

The IR transects and FN curves were calculated as a function of population density for one mile long sections of track. The maximum IR and SR are also influenced by the magnitude of the potentially affected population within each one mile section. The maximum population density along any route was 11,800 people per square mile. This population density will therefore correlate to the highest risk for train movement anywhere along the mainline. As a conservative approach, using this population density will bound the risk for all sections of mainline track.

8.1.1 Train Speeds Less Than 25 mph

A summary of the baseline risk metrics for the LNG mainline movement at train speeds less than 25 mph case is provided in Table 40. The SR integral is the area under the FN curve presented in Figure 43. For comparison, the SR integral for the upper risk criterion is 6.91×10^{-3} when integrated from 1 to 1,000 (or $4.61\text{x}10^{-3}$ when integrated from 1 to 100). The maximum IR is always less than the Zone 3 3×10^{-7} yr^{-1} threshold; thus, no sensitive targets will be affected in the applicable sections of the routes for any population density less than or equal to 11,800 people per square mile.

Table 40. Mainline train speeds less than 25 mph - summary of the risk metrics for LNG ISO car train movements.

Risk Metric	Mainline Train Speeds < 25 mph
	C-1 (Baseline)
SR Integral (total risk, yr^{-1})	3.63×10^{-4}
Maximum IR (yr^{-1})	2.70×10^{-7}
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	N/A
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	N/A
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	N/A

The maximum Individual Risk value of 2.70×10^{-7} yr^{-1} is located on the route. A representative graph of the IR value versus distance from the PHAST Risk software is provided in Figure 42. The IR never reaches the Zone 3 threshold value of 3×10^{-7} yr^{-1} for train configuration C-1 for the highest population density at low speed.

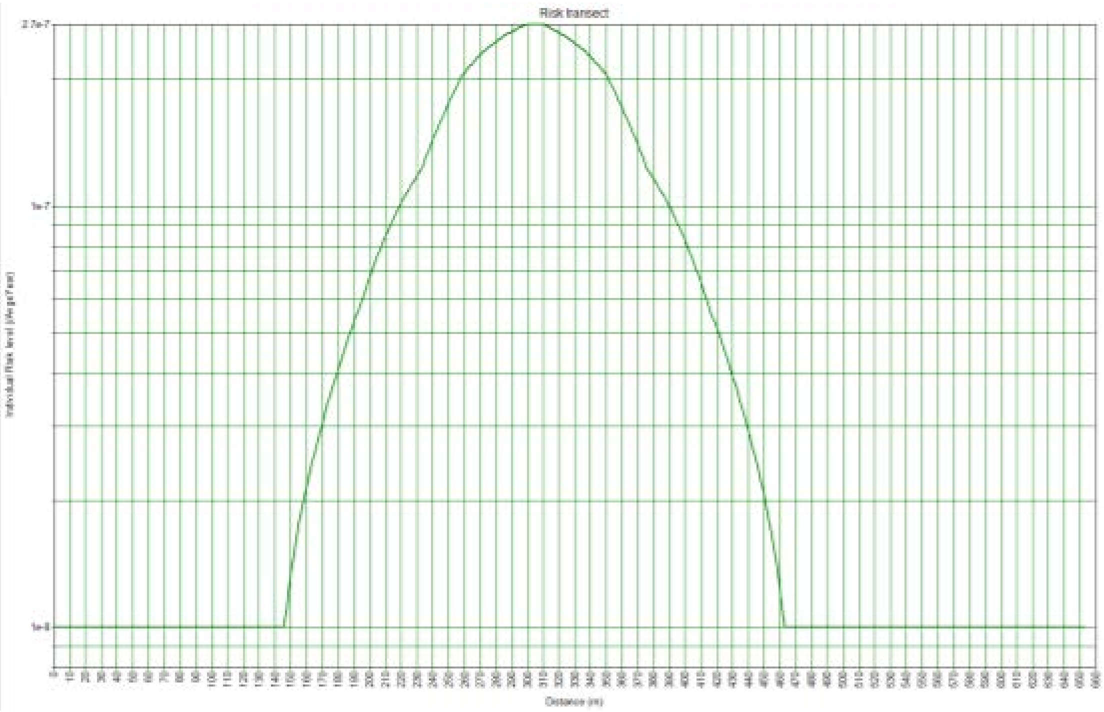

Figure 42. Representative graphical output of IR versus distance from PHAST Risk for slow train speed, train configuration C-1, and the highest population density of 11,800 people per square mile. The peak value is located at the route. The IR drops in a parabolic fashion moving perpendicularly away from the route.

The corresponding FN curve for the mainline track movement at train speeds less than 25 mph is provided in Figure 43 for train configuration C-1. The results indicate that the SR for the mainline movement at train speeds less than 25 mph falls within the “ALARP” region of acceptability.

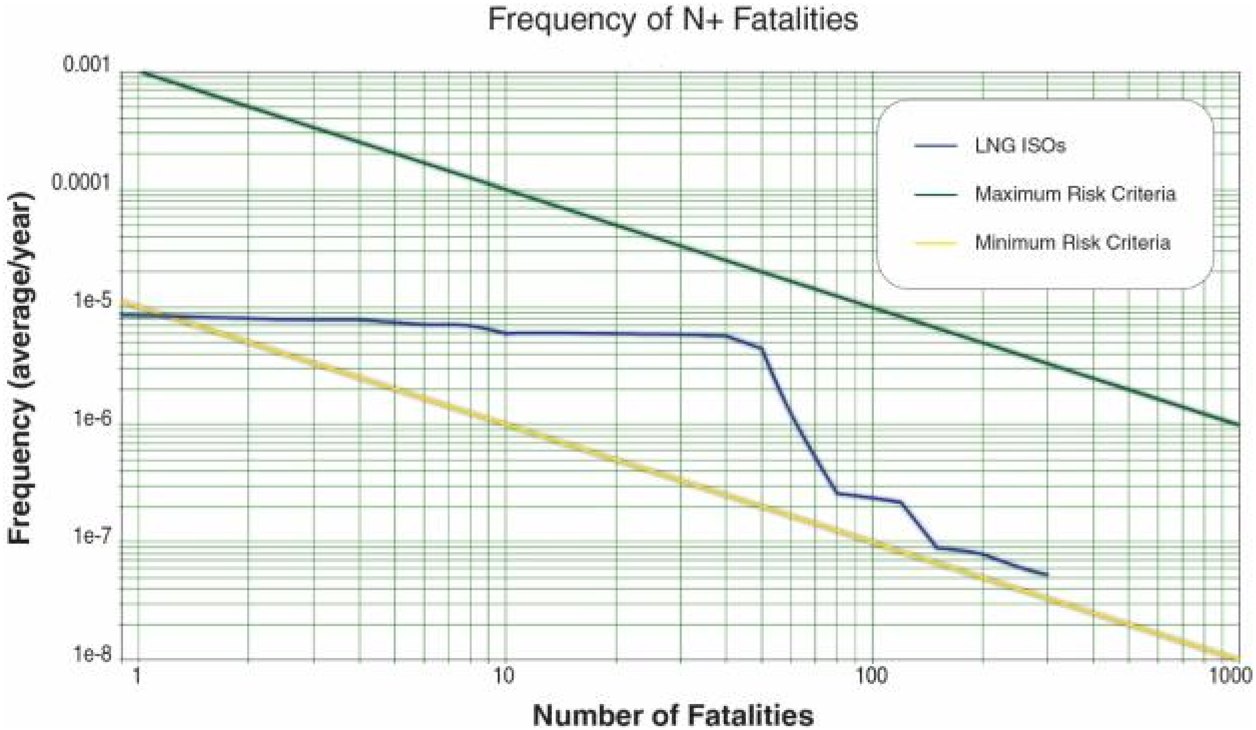

Figure 43. FN curve for the baseline train configuration C-1 mainline train movement for train speeds less than 25 mph along the highest population density portion of the mainline (at 11,800 people/mile^2).

8.1.2 Train Speeds between 25 mph and 60 mph

A summary of the baseline risk metrics for the LNG mainline movement at train speeds between 25 mph and 60 mph cases is provided in Table 41. The maximum IR (5.12×10^{-7} yr^{-1}) is less than the Zone 2 threshold criterion (1×10^{-6} yr^{-1}) for the highest population density (11,800 people per square mile); thus, IR for any lower population density will have a lower maximum IR. Sensitive targets falling within the Zone 3 (IR between 3×10^{-7} yr^{-1} and 1×10^{-6} yr^{-1}) range can be identified along the individual routes as necessary when accounting for the actual population density. The sensitive targets along the route are discussed in Section 8.4.

Table 41. Mainline train speeds between 25 mph and 60 mph - summary of the risk metrics for LNG ISO car train movements.

Risk Metric	Mainline Train Speeds 25 – 60 mph
	C-1 (Baseline)
SR Integral (total risk, yr^{-1})	7.14×10^{-4}
Maximum IR (yr^{-1})	5.12×10^{-7}
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	N/A
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	N/A
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	200[63]

The maximum Individual Risk value is located on the route, and the IR drops moving away from the route. A representative graph of the IR value versus distance from the PHAST Risk software is provided in Figure 44. The maximum IR value of 5.12×10^{-7} yr^{-1} is located at the route, and the value drops in a parabolic fashion to the Zone 3 threshold value of 3×10^{-7} yr^{-1} by approximately 60 meters (200 feet) to either side of the route.

The corresponding FN curve for the mainline track movement at train speeds between 25 mph and 60 mph is provided in Figure 45 for C-1. The results indicate that the SR for the mainline movement at train speeds between 25 mph and 60 mph falls within the "ALARP" region.

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[63] Note that the distance to the IR thresholds is reported as rounded to the nearest 5 feet increments.

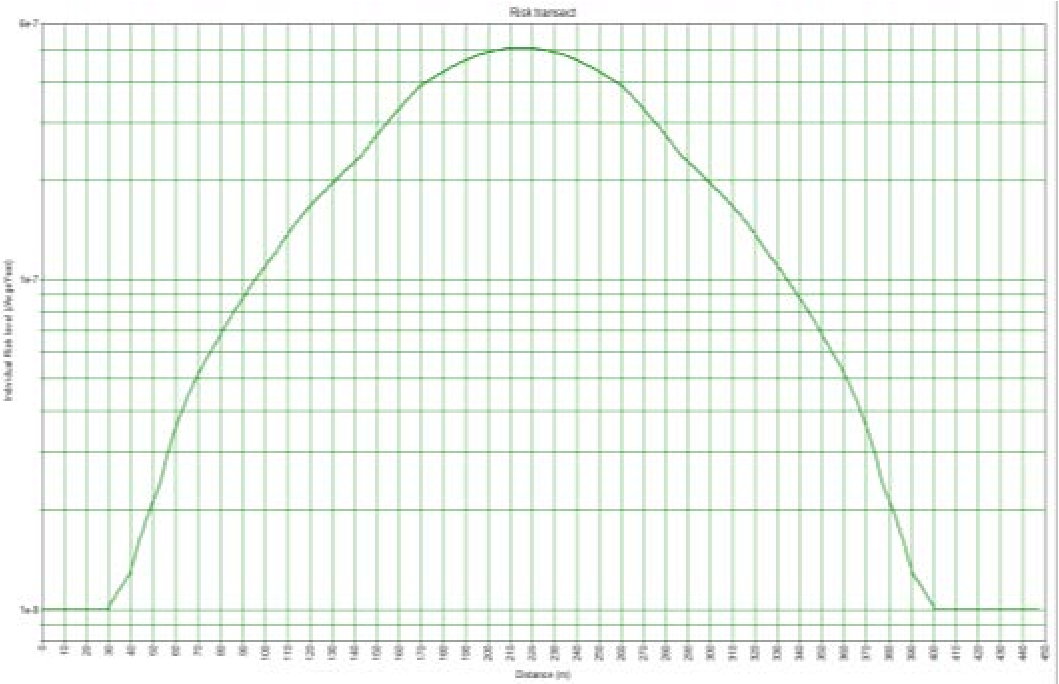

Figure 44. Representative graph of IR versus distance for high speed train, train configuration C-1, and a population density of 11,800 people per square mile. The peak value is located at the route. The IR drops in a parabolic fashion moving perpendicularly away from the route.

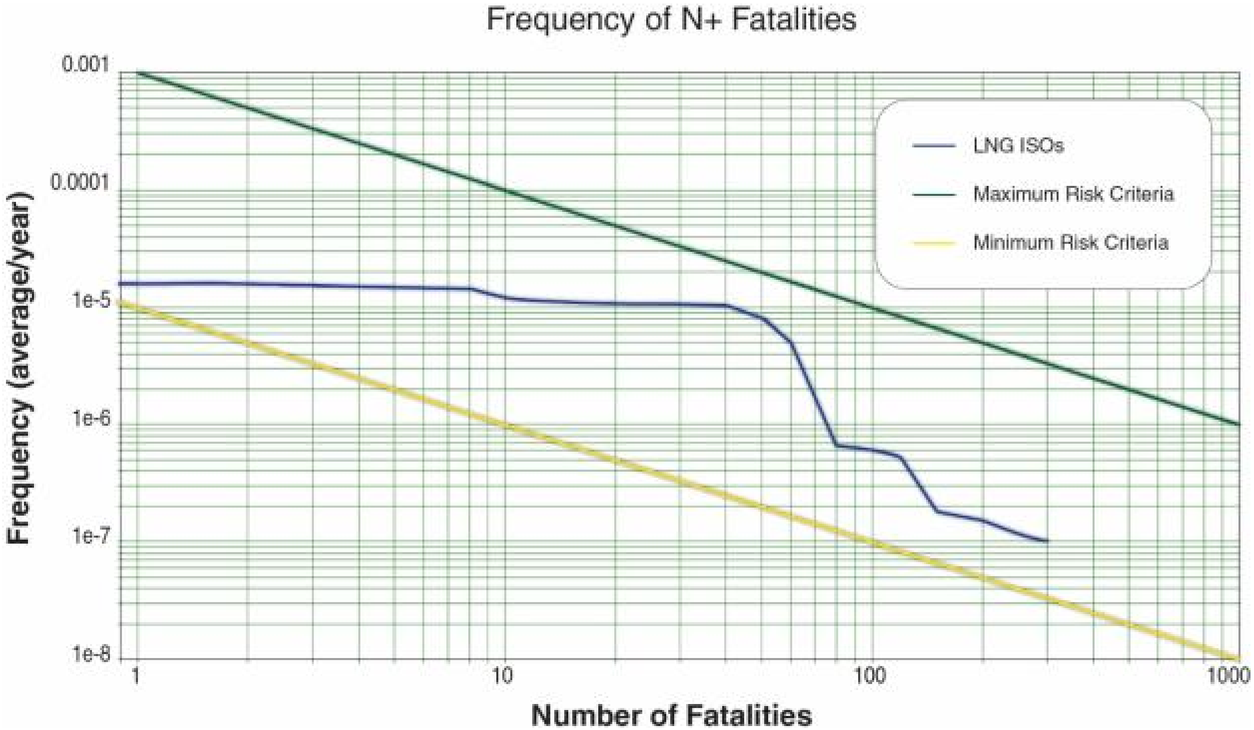

Figure 45. FN curve for the baseline train configuration C-1 mainline train movement for train speeds between 25 mph and 60 mph along the highest population density portion of the mainline (at 11,800 people/mile^2).

8.1.3 Rail Yards and Intermodal Facilities

The risk of LNG ISO handling and train movement within the rail yards and intermodal facilities was calculated for four scenarios: (1) Hialeah Yard, (2) Port of Miami, (3) Port Everglades, and (4) Bowden Yard. The risk represents the contribution from Lift On/Lift Off and train movement in the facilities for train configuration C-1.

Note that the locations of the lifting activities and the routes for train movements for each facility were applied as single points and fixed routes, respectively. In practice, lifting activities may occur along the tracks on the intermodal ramps at the facilities. By assuming that lifting only occurs at a single point, the total risk of the activity has been concentrated around this point. The actual risk for each facility posed by lifting will likely be less than represented by this conservative assumption since the risk would be distributed along each intermodal ramp's multiple tracks. Thus, this assumption conservatively bounds the anticipated risk for lifting activities at each facility.

The routes within each facility for LNG ISO train movements have been represented only along the main track to conservatively maximize the risk from train movements. In practice, the LNG ISOs are anticipated to move along many tracks within each yard; however, exact routes were unavailable for this analysis. By concentrating all accidents along the mainline, the distance to the risk thresholds is maximized. If all potential routes within the yard were modeled, then the distance to offsite risk levels would likely be reduced below the single main track route assumption.

The assumptions of using fixed points for lifting and fixed main track routes are anticipated to represent the maximum potential risk for each facility; therefore, these are the results provided below.

8.1.3.1 Hialeah Yard

The Hialeah Yard is the origin of LNG ISOs, and Lift On of the containers occurs there along the intermodal ramp. Two sets of assumptions were modeled for Hialeah in order to demonstrate the effects of route assumptions and the location of lifting on the risk outcomes. The first model (Route A) assumed that lifting occurred at a single point on the intermodal ramp and that train movement only occurred on the western-most yard track (see Figure 31). This simplified route was found to adequately represent the distance to the offsite Zone 3 IR threshold for train movement inside the facility regardless of the location of the track. By modeling lifting at a single point, the distance to the offsite IR thresholds was also conservatively calculated. The second model (Route B) calculated the risk for train movement along the western-most route, around the south loop track, and along the eastern-most track (see Figure 32). The movement along the easternmost track overlapped the intermodal ramp track, which was also used to represent lifting. The Route B model assumes that lifting activities could occur anywhere along the eastern intermodal ramp track. A further discussion of the model results is provided below, and serves as a basis for applying only the simplified route assumptions to the other facilities to represent the maximum potential distance to the offsite IR thresholds.

A summary of the baseline risk metrics for the LNG ISO car Hialeah Yard handling and movement cases is provided in Table 42. The maximum contributions to the IR and SR are from the Lift On activities. The SR Integral representing the total Societal Risk with the surrounding population (approximately 1,276 to 5,471 people per square mile) is approximately an order of magnitude larger than that for the mainline routes with assumed high population density as shown earlier in Table 40 and Table 41. The effects of localizing the lifting to a single point versus applying the activity along the intermodal ramp track are apparent in the table. The distance to each risk threshold is decreased when the lifting operation is distributed, and the Zone 1 - 1×10^{-5} yr^{-1} threshold onsite disappears when lifting is distributed. There is an insignificant difference between IR profiles for the train movement cases.

Table 42. Hialeah Yard - summary of the risk metrics for LNG ISO train movement and ISO lifting for two sets of route and lifting assumptions.

Risk Metric	Route A	Route B
	C-1 (Baseline)	**C-1 (Baseline)**
SR Integral (total risk, yr^{-1})	1.10×10^{-3}	1.51×10^{-3}
Maximum IR (yr^{-1})	6.39×10^{-5}	7.16×10^{-6}
Train Movement (from Track):		
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	N/A	N/A
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	N/A	N/A
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	205[64]	205
ISO Lifting (from Point):		
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	410	N/A
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	515	455
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	540	510

IR contour plots for Route A and Route B are overlaid on aerial images of the Hialeah Yard in Figure 46 and Figure 47 for train configuration C-1. The highest IR is observed onsite and is centered around the point of the Lift On activities assumed in the calculations. The Zone 3

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[64] Note that the distance to the IR thresholds is reported as rounded up to the nearest 5 feet increments.

boundary (IR isopleth of 3×10^{-7} yr^{-1}) is shown overlapping the nearby surrounding areas as represented by the yellow contours in the figures. Note that the layout of the Hialeah Yard, which is enclosed on the east side by an approximately 10 feet high wall, will also reduce the likelihood that flammable vapor clouds could expand beyond the property in that direction.[65] The offsite areas where IR is between 3×10^{-7} yr^{-1} and 1×10^{-6} yr^{-1} contain only commercial /industrial structures. The Zone 2 risk boundary crosses the property line at the north and south ends of the yard in an area of industrial activity, but the population densities in these areas are less than the Zone 2 threshold criterion of 7,250 to 23,300 persons per square mile. No Zone 3 sensitive targets were identified within regions of IR values greater than 3×10^{-7} yr^{-1} for either model. Given this analysis, the Individual Risk profiles for the Hialeah Yard are calculated to align with the fixed facility IR acceptability criteria stated in NFPA 59A (see Table 1).

The FN curves for the two routes, which represent the SR as the cumulative frequency versus severity, are provided in Figure 48 for train configuration C-1. The results indicate that the SR for the Hialeah Yard falls within the “ALARP” or tolerable region of acceptability according to the fixed facility SR criteria in NFPA 59A (see Figure 1).

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[65] Note that the integral equation-based models in PHAST Risk are not suitable for modeling the barrier effects of walls on flammable vapor cloud dispersion; thus, the north-south track was used as the primary rail yard route.

Figure 46. The IR contours for the Hialeah Yard and baseline train configuration C-1 using Route A.

Figure 47. The IR contours for the Hialeah Yard and baseline train configuration C-1 using Route B.

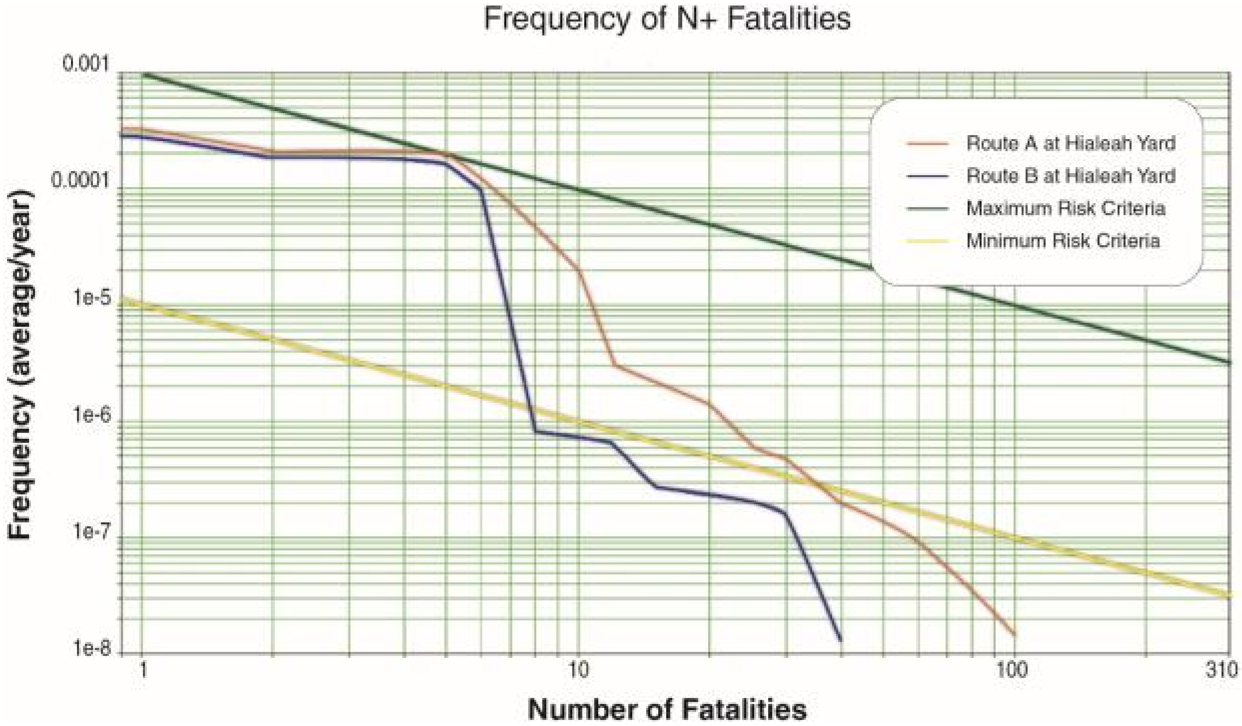

Figure 48. FN curve for Route A at the Hialeah Yard and baseline train configuration C-1.

8.1.3.2 Port of Miami Intermodal Facility

A summary of the baseline risk metrics for the LNG ISO car lifting and movement cases at the Port of Miami intermodal facility is provided in Table 43. The maximum contribution to the IR and SR is from the Lift Off activities. The SR Integral representing the total Societal Risk with the surrounding population is the same order of magnitude as the mainline route segments with high population. The surrounding population immediately around the intermodal facility was represented as 488 people per square mile whereas the cruise ship terminal had an assumed population of 19,000 people (with an equivalent density of 191,800 people per square mile).

Table 43. Port of Miami - summary of the risk metrics for LNG ISO train movement and ISO lifting.

Risk Metric	Port of Miami
	C-1 (Baseline)
SR Integral (total risk, yr^{-1})	$1.69×10^{-4}$
Maximum IR (yr^{-1})	$4.45×10^{-5}$
Train Movement (from Track):	
Maximum Distance to Zone 1 - $1×10^{-5}$ IR (ft)	N/A
Maximum Distance to Zone 2 - $1×10^{-6}$ IR (ft)	N/A
Maximum Distance to Zone 3 - $3×10^{-7}$ IR (ft)	175
ISO Lifting (from Point):	
Maximum Distance to Zone 1 - $1×10^{-5}$ IR (ft)	290
Maximum Distance to Zone 2 - $1×10^{-6}$ IR (ft)	525
Maximum Distance to Zone 3 - $3×10^{-7}$ IR (ft)	545

An IR contour plot for the Port of Miami intermodal facility is provided in Figure 49 for train configuration C-1. The frequency contours correspond to the summed individual risks for release scenarios occurring from the Lift Off operations and intermodal facility train movements. The highest IR is centered around the location of the Lift Off operations. This contour is maintained within industrial low population areas of the Port.

The areas outside the intermodal facility where IR is greater than $3×10^{-7}$ yr^{-1} contain only commercial/industrial structures, including a parking garage and shed to the north of the Lift Off operations. No Zone 3 sensitive targets were identified at IR values greater than $3×10^{-7}$ yr^{-1}. Given this analysis, the Individual Risk profiles for the Port of Miami intermodal facility are calculated to align with the fixed facility IR acceptability criteria stated in NFPA 59A (see Table 1).

Figure 49. The IR contours for the Port of Miami intermodal facility and baseline train configuration C-1. North is up.

The FN curve for the Port of Miami intermodal facility, which represents the SR as the cumulative frequency versus severity, is provided in Figure 50 for train configuration C-1. The results indicate that the SR for the Port of Miami intermodal facility falls within the "ALARP" or tolerable region of acceptability according to the fixed facility SR criteria in NFPA 59A (see Figure 1).

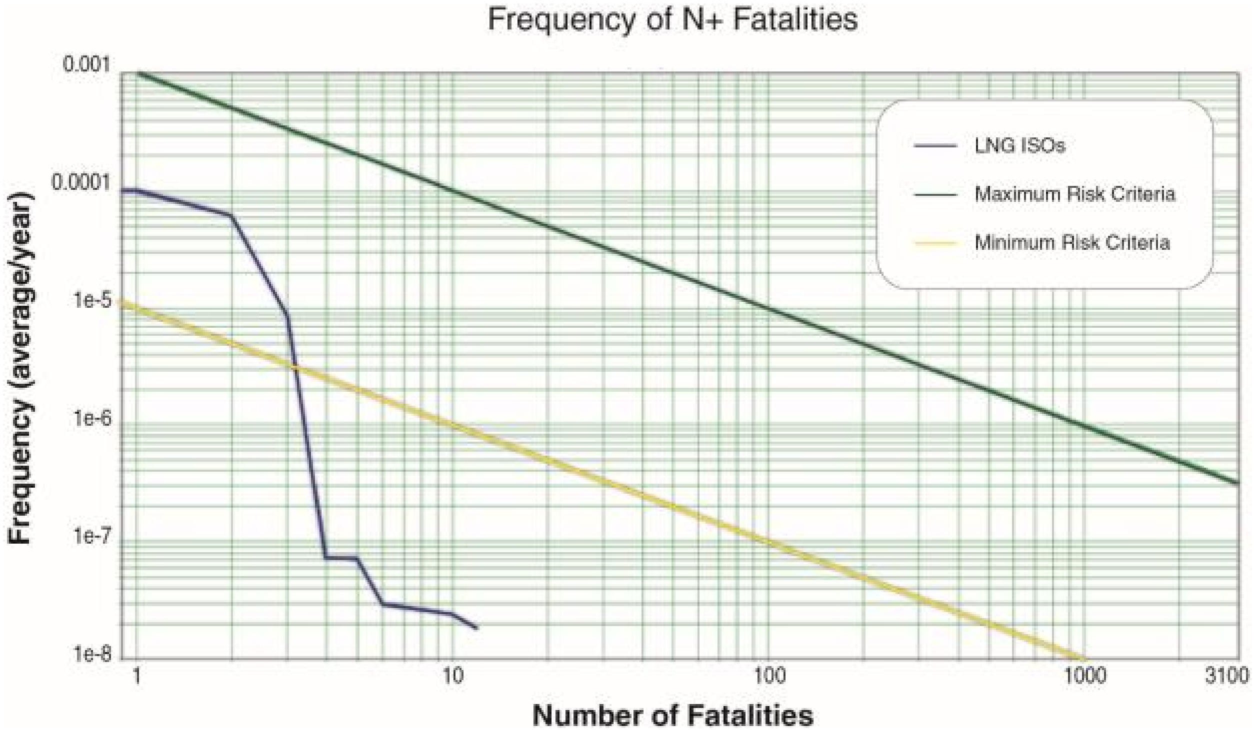

Figure 50. FN curve for the Port of Miami intermodal facility and baseline train configuration C-1.

8.1.3.3 Port Everglades Intermodal Facility

A summary of the baseline risk metrics for the LNG ISO car Port Everglades intermodal facility lifting and movement cases is provided in Table 44. The maximum contribution to the IR and SR is from the Lift Off activities. The SR Integral representing the total Societal Risk with the surrounding population (approximately 707 people per square mile) is the same order of magnitude as the mainline route segments with high population.

Table 44. Port Everglades - summary of the risk metrics for LNG ISO car movement and ISO lifting.

Risk Metric	Port Everglades
	C-1 (Baseline)
SR Integral (total risk, yr^{-1})	3.40×10^{-4}
Maximum IR (yr^{-1})	4.98×10^{-5}
Train Movement (from Track):	
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	N/A
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	N/A
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	190
ISO Lifting (from Point):	
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	330
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	535
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	550

An IR contour plot for the Port Everglades is provided in Figure 51 for train configuration C-1. The frequency contours correspond to the summed individual risks for release scenarios occurring from the Lift Off operations and intermodal facility train movements. The highest IR centers around the assumed location of the Lift Off operations.

On the northern boundary of the intermodal facility, the Zone 3 (3×10^{-7} yr^{-1}) frequency contour reaches Eller Drive; while on the other boundaries it overlaps only commercial/industrial structures and the undeveloped area. No Zone 3 sensitive targets were identified at IR values greater than 3×10^{-7} yr^{-1}. Given this analysis, the Individual Risk profiles for the Port Everglades intermodal facility are calculated to align with the fixed facility IR acceptability criteria stated in NFPA 59A (see Table 1).

Figure 51. The IR contours for Port Everglades intermodal facility and baseline train configuration C-1. North is up.

The FN curve for the Port Everglades intermodal facility, which represents the SR as cumulative frequency versus severity, is provided in Figure 52 for train configuration C-1. The results indicate that the SR for the Port Everglades intermodal facility falls within the “ALARP” or tolerable region of acceptability according to the fixed facility SR criteria in NFPA 59A (see Figure 1).

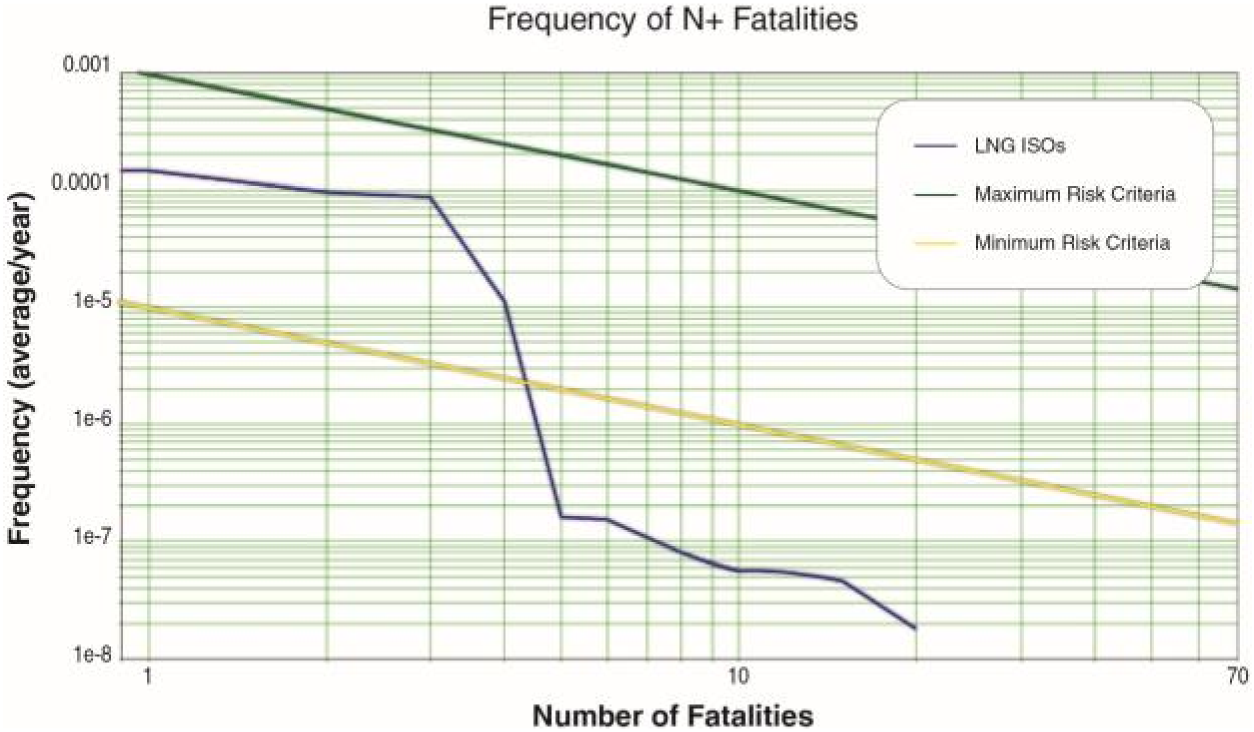

Figure 52. FN curve for the Port Everglades intermodal facility and baseline train configuration C-1.

8.1.3.4 Bowden Yard

A summary of the baseline risk metrics for the LNG ISO car Bowden Yard lifting and movement cases is provided in Table 45. The maximum contribution to the IR and SR is from the Lift Off activities. The SR Integral representing the total Societal Risk with the surrounding population (from approximately 478 to 5,720 people per square mile) is the same order of magnitude as the mainline route segments with high population.

Table 45. Bowden Yard - summary of the risk metrics for LNG ISO car movement and ISO lifting.

Risk Metric	Bowden Yard
	C-1
SR Integral (total risk, yr^{-1})	2.27×10^{-4}
Maximum IR (yr^{-1})	4.20×10^{-5}
Train Movement (from Track):	
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	N/A
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	N/A
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	185
ISO Lifting (from Point):	
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	290
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	530
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	560

An IR contour plot for the Bowden Yard is provided in Figure 53 for train configuration C-1. The frequency contours correspond to the summed individual risks for release scenarios occurring from the Lift Off operations and yard train movements. The highest IR is centered around the assumed point of Lift Off operations.

Moving away from the lifting operations, the IR decreases rapidly with distance. Zone 1 IR values higher than 1×10^{-5} yr^{-1} are maintained onsite, with the edge of the Zone 3 IR contour (3×10^{-7} yr^{-1}) traveling at most 100 feet from the FECR property line around the point of lifting. Areas offsite where IR falls within Zone 2 and Zone 3 (IR between 1×10^{-5} and 3×10^{-7} yr^{-1}) contain residential structures and commercial/industrial structures. The population density in this area is less than the Zone 2 threshold criterion of 7,250 to 23,300 persons/mile^2 for permitted populations. Given this analysis, the Individual Risk profiles for the Bowden Yard are calculated to align with the fixed facility IR acceptability criteria stated in NFPA 59A (see Table 1).

Figure 53. The cumulative IR contours for the Bowden Yard for baseline train configuration C-1. North is up.

The FN curve for the Bowden Yard, which represents the SR as the cumulative frequency versus severity, is provided in Figure 54 for train configuration C-1. The results indicate that the SR for Bowden Yard falls within the "ALARP" region of acceptability according to the fixed facility risk acceptability criteria in NFPA 59A (see Figure 1).

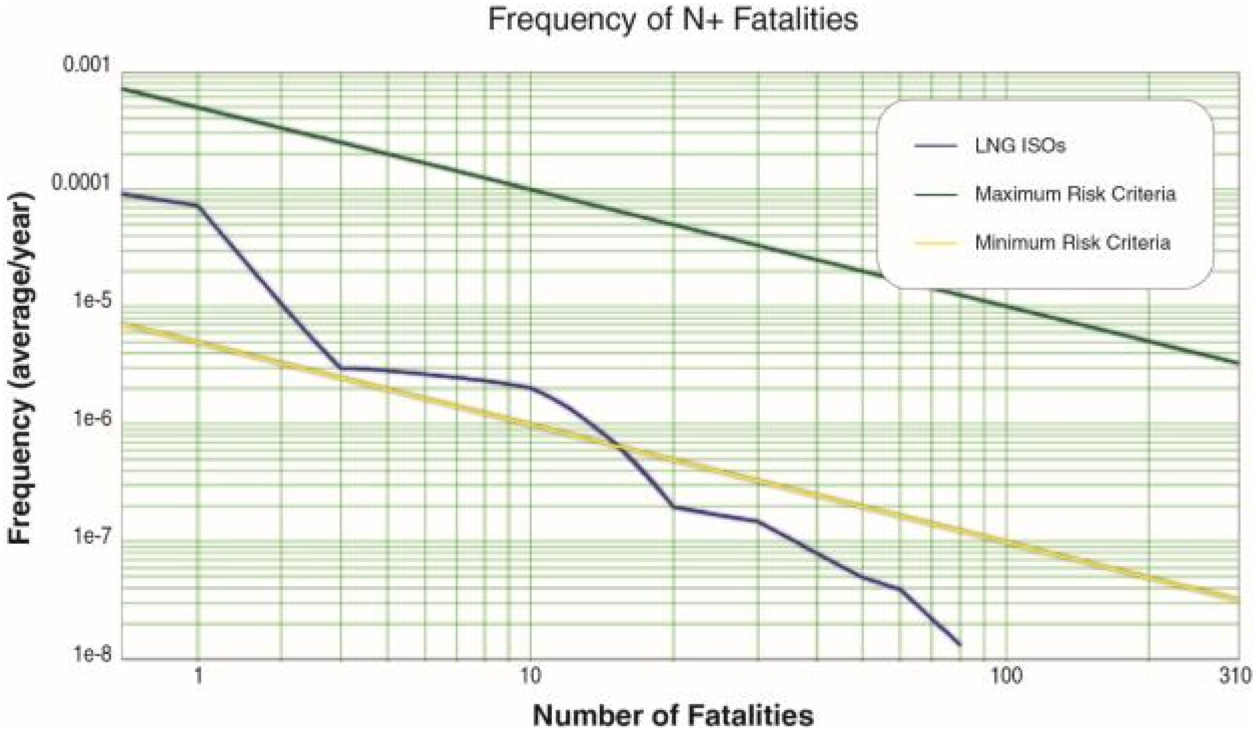

Figure 54. FN Curve for the Bowden Yard for baseline train configuration C-1.

8.2 Comparison with LPG Transportation

The risks associated with handling and transporting LNG ISOs were benchmarked against the risks associated with transporting liquefied petroleum gas (also known as propane or LPG under the UN1075 designation) rail cars. LPG was chosen as a comparison flammable hazardous material due to its shipping history in the general rail industry and at FECR and because it is similar to LNG. LPG does not behave identically to LNG since LPG is a pressurized liquefied gas whereas LNG is a refrigerated liquefied gas, but it provides a useful HAZMAT commodity comparison. In 2015, (b) (4). For the analysis here, the highest risk section of mainline transport (corresponding to a population density of 11,800 people/mile^2) and highest risk yard/intermodal facility (Hialeah Yard) were used to provide a consistent basis for comparison. The risk posed by an energy-equivalent quantity of LPG was analyzed for these cases.

The LPG rail cars were assumed to be transported in DOT-112 pressurized rail cars (nominal volume of 34,000 gallons); hence, the Lift On/Lift Off activities associated with LNG ISOs were not applicable to the LPG rail cars. To compare the LNG ISOs to LPG rail cars on an energy-equivalent basis, it was estimated that approximately (b) 34,000 gallon LPG rail cars have the same energy content as (b) 10,000 gallon LNG ISOs.[66] The accident rate methodologies developed in Section 3.1 were applied here to estimate the LPG car derailment rates and the LOC probabilities. The LPG event accident, derailment, and release event trees can be found in Appendix D.

8.2.1 LNG versus LPG Mainline Risks

The baseline train configuration C-1 was considered for the LNG ISOs along with a similar configuration for the LPG rail cars ((b) cars blocked in a sequence starting at train position (b) A summary of the risk metrics for the LNG and LPG mainline movement cases is provided in Table 46. Overall, the analysis indicates that the risks for shipping an energy-equivalent quantity of LNG on the mainline are similar to those posed by LPG. The SR Integral for LPG is approximately twice the value of that for LNG for both low speed and high speed cases. There is no Zone 3 - 3×10^{-7} yr^{-1} IR contour for the LNG ISO mainline movement at train speeds less than 25 mph (whereas for LPG, a Zone 3 contour exists and the distance is 323-feet) and the distance to the 3×10^{-7} yr^{-1} IR contour is 612-feet for LPG compared to just 243-feet for LNG for train speeds between 25 mph and 60 mph.

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[66] The energy-equivalent amount of LPG relative to (b) 10,000 gallon LNG ISOs was estimated to be (b) (4) gallons of LPG. Assumptions: density of LNG = 440 kg/m^3, density of LPG = 500 kg/m^3, specific energy of LNG = 55.5 MJ/kg, and specific energy of LPG = 46.4 MJ/kg.

Table 46. Comparison of risk metrics for LNG ISO car and LPG rail car mainline train movements.

Risk Metric	Speeds < 25 mph		Speeds Between 25 – 60 mph	
	LNG	**LPG**	**LNG**	**LPG**
SR Integral (total risk, yr^{-1})	3.63×10^{-4}	6.44×10^{-4}	7.14×10^{-4}	1.44×10^{-3}
Maximum IR (yr^{-1})	2.70×10^{-7}	3.95×10^{-7}	5.12×10^{-7}	8.85×10^{-7}
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	N/A	N/A	N/A	N/A
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	N/A	N/A	N/A	N/A
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	N/A	323	200	623

The FN curves for the LNG ISO train configuration C-1 and LPG mainline movement, for train speeds less than 25 mph, along a one mile mainline track surrounded by a population of 11,800 people/mile^2 are provided in Figure 55. The complementary FN curves for train speeds between 25 mph to 60 mph, along a one mile mainline track surrounded by a population of 11,800 people/mile^2 are depicted in Figure 56. The FN curves for the LPG cases are similar to LNG, but both remain in the ALARP region.

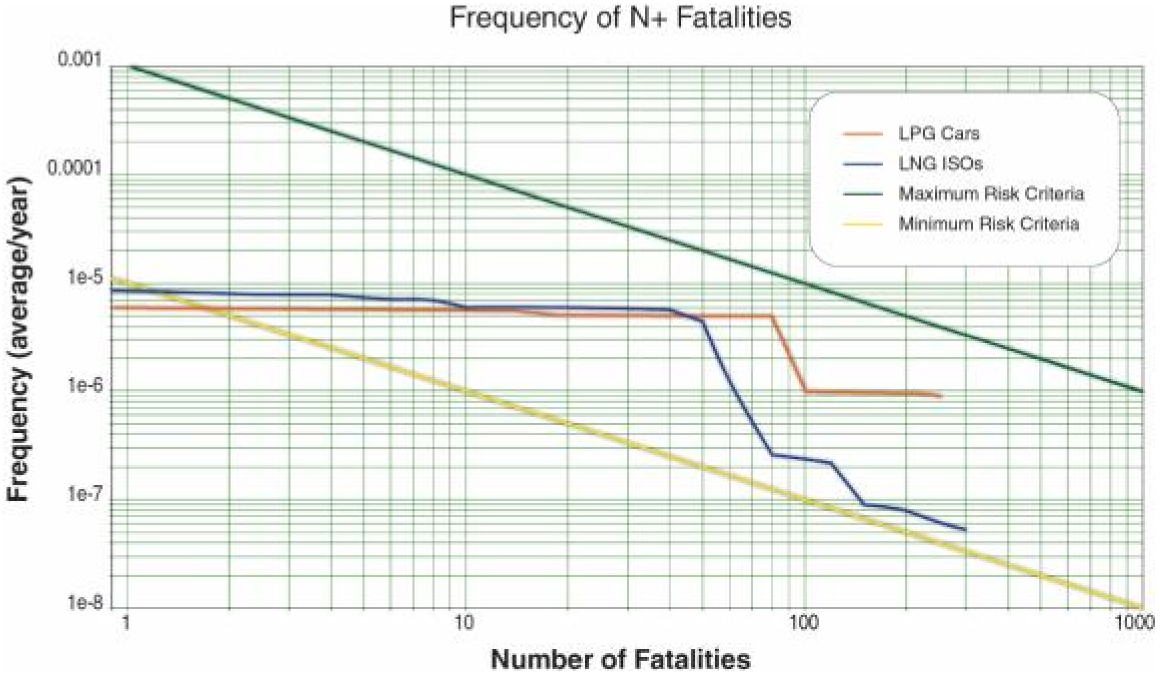

Figure 55. FN curve comparison for LNG ISOs and LPG rail car movement, for speeds less than 25 mph for the anticipated highest population density along FECR's rail.

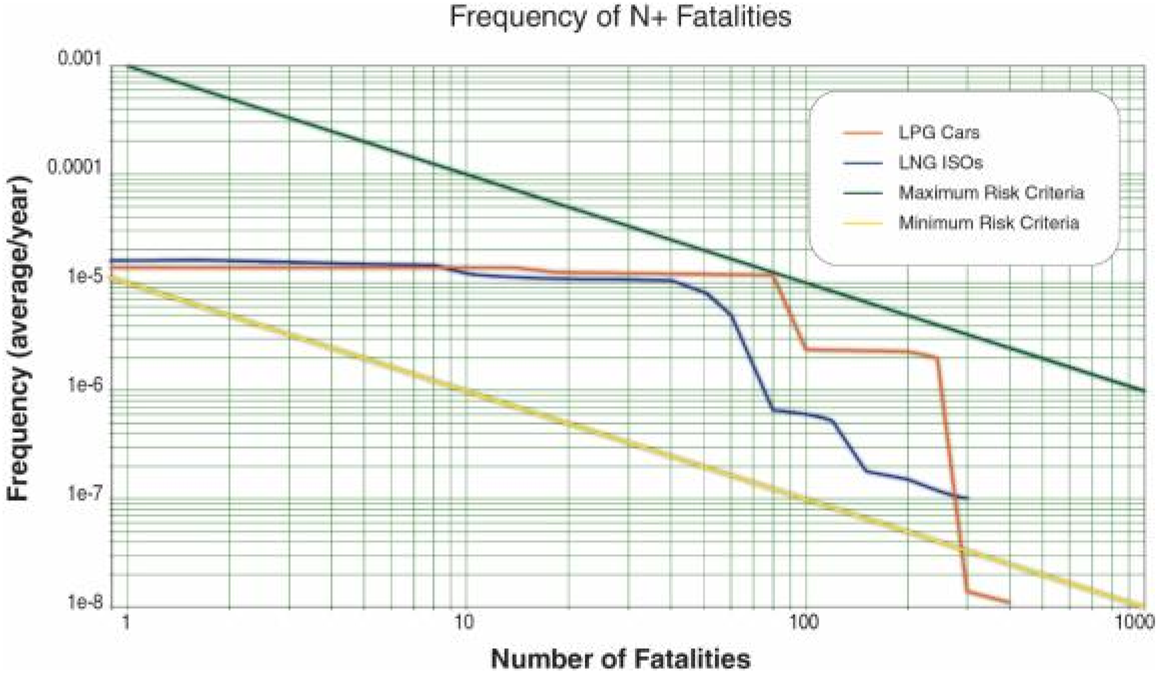

Figure 56. FN curve comparison for LNG ISOs and LPG rail car movement, for speeds between 25 mph and 60 mph for the anticipated highest population density along FECR's rail.

8.2.2 LNG versus LPG Yard/Intermodal Facility Risks

The baseline train configuration C-1 was considered for LNG ISOs along with a similar configuration for the LPG rail cars (three cars blocked in a sequence starting at train position 11). Only the Hialeah Yard was considered for this comparison, as this is the highest risk yard of the four considered (Bowden, Port of Miami, and Port Everglades being the other yards). A summary of the risk metrics for the LNG and LPG Hialeah Yard movement and handling cases are provided in Table 47. The SR Integrals are approximately the same order of magnitude for LNG and LPG.

Table 47. Comparison of risk metrics for LNG ISO car and LPG rail car movement and LNG ISO lifting in the Hialeah Yard. Note that there are no Lift On/Lift Off activities associated with the LPG cars.

Risk Metric	Hialeah Yard	
	LNG	LPG
SR Integral (total risk, yr^{-1})	1.10×10^{-3}	7.18×10^{-4}
Maximum IR (yr^{-1})	6.39×10^{-5}	4.74×10^{-6}
Maximum Distance to Zone 1 - 1×10^{-5} IR (ft)	410[67]	N/A
Maximum Distance to Zone 2 - 1×10^{-6} IR (ft)	515	560
Maximum Distance to Zone 3 - 3×10^{-7} IR (ft)	540	815

The IR contours for the LPG yard movements are overlaid on a satellite image of the Hialeah Yard with the corresponding contours for LNG ISO train configuration C-1 in Figure 57. Comparison of the Hialeah Yard IR contours for LPG and LNG indicates that the distances to the Zone 2 - 1×10^{-6} $yr^{-1}$and Zone 3 - 3×10^{-7} yr^{-1} contours are larger for LPG than for LNG (consistent with the findings from the mainline analysis) for train movement within the yard. The absence of a Zone 1 - 1×10^{-5} yr^{-1} contour for the LPG scenario is due to the lack of Lift On/Lift Off activities and a corresponding risk component for LPG rail cars. Thus, the risks associated with yard movements and activities of LNG ISOs are similar to yard movement of LPG rail cars on an energy-equivalent basis.

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[67] The distance to these contours for LNG are associated with the lifting-related risk since that is the maximum contribution to the risk.

Figure 57. Comparison of IR contours for the movement of LNG ISOs and LPG in the Hialeah Yard.

The FN curve for the LPG Hialeah Yard movements is presented in Figure 58and compared against the FN curve for LNG ISO train handling and ISO lifting. The SR profiles of moving an energy-equivalent amount of LNG and LPG are similar, even in this instance where Lift On/Lift Off is included for the LNG ISOs but not applicable for LPG.

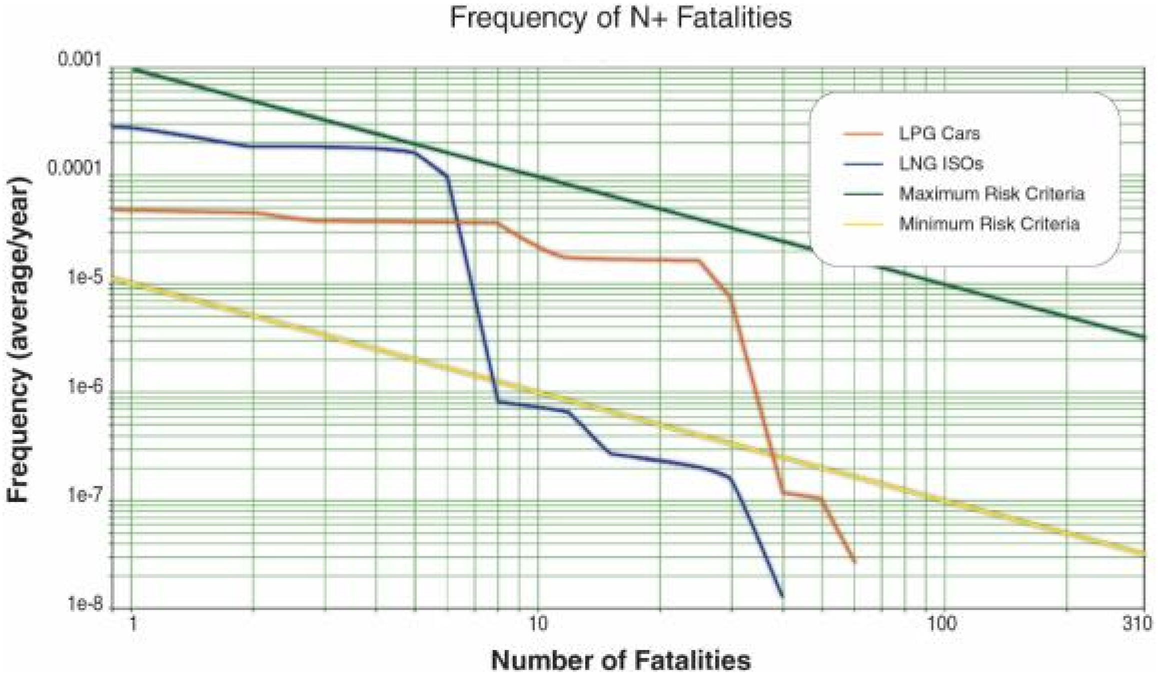

Figure 58. FN curve comparison for LNG ISOs and LPG train movements in the Hialeah Yard. Note that Lift On/Lift Off was not considered for LPG; the risk corresponds to only train movements in the yard.

8.3 Train Configuration and Risk Reduction for LNG ISO Transportation

The influence of train configuration on the calculated risk for transporting ten (10) LNG ISOs was calculated for the mainline train movement and rail yard and intermodal facility operations. Seven potential train configurations were considered in the analysis:

Train Configuration ID	Description
C-1	• (b) (4) [redacted] [redacted]
C-2	• (b) (4) [redacted] [redacted]
C-3	• (b) (4) [redacted] [redacted]
C-4	• (b) (4) [redacted] [redacted]
C-5	• (b) (4) [redacted] [redacted]
C-6	• (b) (4) [redacted] [redacted]
C-7	• (b) (4) [redacted] [redacted]

8.3.1 Mainline LNG ISO Risk – Influence of Train Configuration

The different train configurations were evaluated for the mainline train movement scenarios at (1) train speeds less than 25 mph and (2) train speeds between 25 mph and 60 mph. The SR and IR were calculated as a function of population density for a one mile long section of track with a surrounding population density of 11,800 people/mile^2. This mile segment is the highest population density mile track along the entire main line route and will, therefore, bound the highest risk for train movement along the entire mainline.

8.3.1.1 Train Speeds Less Than 25 mph

From the seven train configurations, it was found that there was little change in the risk from configurations C-4 to C-7 for the mainline train movement scenarios at train speeds less than 25 mph. Thus, the first four train configurations (C-1 through C-4) are discussed here. A summary of the risk metrics for the LNG mainline movement at train speeds less than 25 mph cases is provided in Table 48. The baseline train configuration C-1 bounds the highest risk and is used as the basis for comparison purposes. The reduction in the SR Integral for each configuration is compared against C-1 in the table. The maximum IR is always less than the Zone 3 - 3×10^{-7} yr^{-1} threshold for these train configurations. Based on comparison of the SR Integral for the four configurations, a risk reduction of 38.8% may be realized by using C-4 instead of C-1 for the mainline movement at train speeds between 25 mph and 60 mph.

Table 48. Summary of the risk metrics for slow speed LNG ISO car train movements.

Risk Metric	**Mainline Train Speeds < 25 mph**			
	C-1	C-2	C-3	C-4
SR Integral (total risk, yr^{-1})	3.63×10^{-4}	2.60×10^{-4}	2.40×10^{-4}	2.22×10^{-4}
Maximum IR	2.70×10^{-7}	1.93×10^{-7}	1.79×10^{-7}	1.66×10^{-7}
Distance to 3×10^{-7} yr^{-1}IR (ft)	N/A	N/A	N/A	N/A
Risk Reduction	--	28.4%	33.9%	38.8%

The FN curves for these four train configurations are depicted in Figure 59. The results indicate that the SR for the mainline movement at train speeds less than 25 mph falls within the “ALARP” or tolerable region of acceptability, regardless of train configuration.

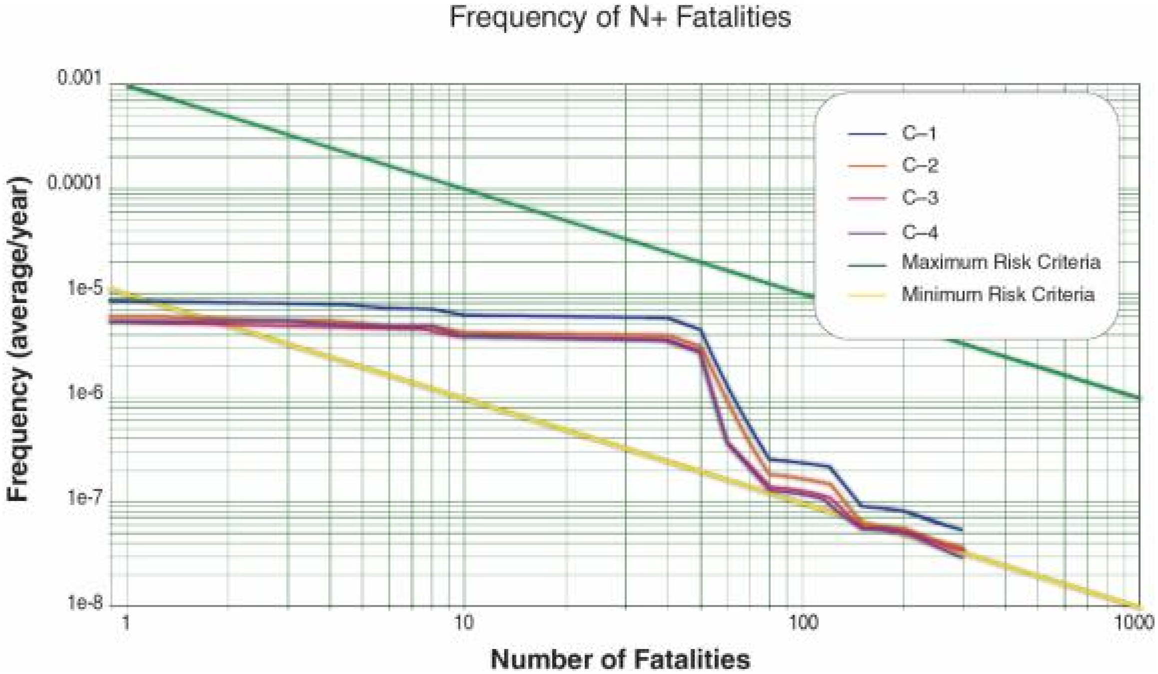

Figure 59. Comparison of FN curves for mainline train speeds less than 25 mph for four train configurations.

8.3.1.2 Train Speeds Between 25 mph and 60 mph

All seven train configurations were evaluated for the mainline train movement scenarios for train speeds from 25 mph to 60 mph, inclusive. A summary of the risk metrics for the LNG mainline movement at train speeds from 25 mph to 60 mph cases is provided in Table 49. The baseline train configuration C-1 bounds the highest risk and is used for comparison purposes. The reduction in the SR Integral for each configuration is compared against C-1. The maximum IR observed is always less than Zone 2 - 1×10^{-6} yr^{-1} for all configurations, and it is less than the Zone 3 - 3×10^{-7} yr^{-1} threshold for train configurations C-6 and C-7. Based on comparison of the SR Integral for the seven configurations, a risk reduction of 38.0% may be realized by using C-4 instead of C-1 for the mainline movement at train speeds between 25 mph and 60 mph. Further, a risk reduction of 49.0% may be realized by using C-7 instead of C-1.

Table 49. Summary of the risk metrics for high speed LNG ISO car train movements.

Risk Metric	Mainline Train Speeds ≥25 to ≤60 mph						
	C-1	C-2	C-3	C-4	C-5	C-6	C-7
SR Integral (total risk)	7.14×10^{-4}	4.92×10^{-4}	4.63×10^{-4}	4.43×10^{-4}	4.14×10^{-4}	3.75×10^{-4}	3.64×10^{-4}
Maximum IR	5.12×10^{-7}	3.54×10^{-7}	3.42×10^{-7}	3.29×10^{-7}	3.14×10^{-7}	2.76×10^{-7}	2.68×10^{-7}
Distance to 3×10^{-7} IR (ft)	200	120	110	80	60	N/A	N/A
Risk Reduction	--	31.1%	35.2%	38.0%	42.0%	47.5%	49.0%

The FN curves for the seven train configurations are compared in Figure 60. The results indicate that the SR for the mainline movement at train speeds between 25 mph and 60 mph falls within the “ALARP” or tolerable region, regardless of train configuration.

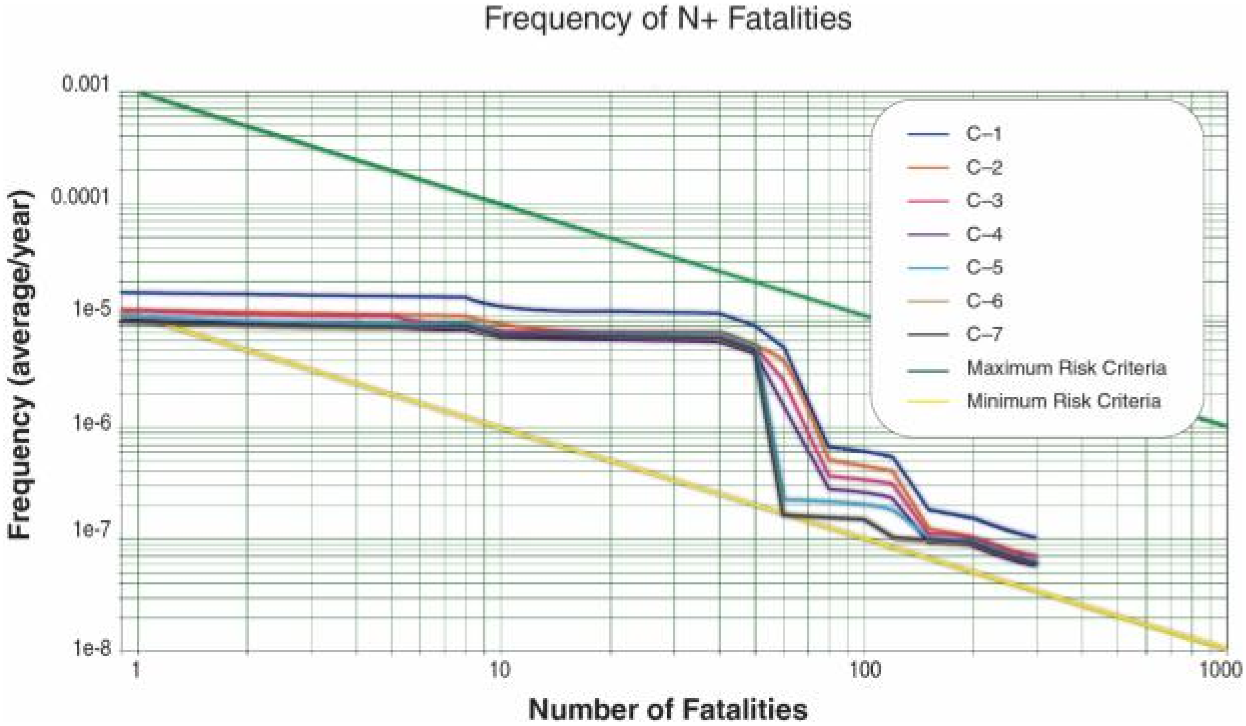

Figure 60. Comparison of FN curves for mainline train speeds between 25 mph and 60 mph for seven train configurations.

8.3.2 Rail Yards and Intermodal Facilities LNG ISO Transportation – Influence of Train Configuration

The different train configurations were evaluated for LNG ISO movement and handling within the rail yards and intermodal facilities: (1) Hialeah Yard, (2) Port of Miami, (3) Port Everglades, and (4) Bowden Yard.

8.3.2.1 Hialeah Yard

The first four train configurations (C-1 through C-4) are discussed for the train movement and lifting of LNG ISOs in the Hialeah Yard.[68] A summary of the risk metrics for the LNG ISO car Hialeah Yard handling and movement cases is provided in Table 50. The risk reduction presents the percent reduction in the SR Integral based on the C-1 (baseline) train configuration case. The maximum IR observed is the same for all cases, as it is driven by the Lift On activities which are not influenced by the train configuration. Based on comparison of the SR Integral for the four configurations, a risk reduction of 7.27% may be realized by using C-4 instead of C-1 for the Hialeah Yard movement and handling operations. The risk results for C-1, which are the basis for comparison, are discussed above in Section 8.1.3.

Table 50. Hialeah Yard - summary of the risk metrics for LNG ISO car movements and LNG ISO lifting for multiple train configurations.

Risk Metric	Hialeah Yard			
	C-1	C-2	C-3	C-4
SR Integral (total risk)	1.10×10^{-3}	1.04×10^{-3}	1.03×10^{-3}	1.02×10^{-3}
Maximum IR	6.39×10^{-5}	6.39×10^{-5}	6.39×10^{-5}	6.39×10^{-5}
Risk Reduction	--	5.45%	6.36%	7.27%

The Zone 3 isopleth of 3×10^{-7} yr^{-1} travels at most 200 feet from the train route for C-1. The distance to this isopleth did not vary significantly compared to the other three train configurations. The primary difference was represented in the shape of the 1×10^{-6} yr^{-1} contour at the north end of the facility. This contour's area decreased with each successive train configuration from C-2 to C-4. The offsite areas where IR is greater than 3×10^{-7} yr^{-1} contain only commercial/industrial structures. The population densities in these areas are less than the Zone 2 threshold criterion of 7,250 to 23,300 persons/mile^2 for permitted populations. No Zone 3 sensitive targets were identified within the contours having IR values greater than 3×10^{-7} yr^{-1}. The maximum IR observed at the Hialeah Yard was centered around the assumed point of Lift

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[68] The IR contours are overlaid on an aerial image of the facility for these four train configurations in Appendix F, and the FN curves for the four train configurations can be found in Appendix G.

On activities for all cases. Given this analysis, the IR for the Hialeah Yard aligns with the fixed facility IR acceptability criteria stated in NFPA 59A (see Table 1) for all train configurations C-1 to C-4.

The comparison of FN curves for the facility shows that the risk profile drops similar to that presented in Figure 59 for the mainline; however, the decrease in risk from C-1 to C-4 is only slight since the lifting activities dominate. The results indicate that the SR for the Hialeah Yard falls within the "ALARP" or tolerable region of acceptability according to the fixed facility SR criteria in NFPA 59A (see Figure 1), regardless of train configuration.

8.3.2.2 Port of Miami Intermodal Facility

Based on the results for Hialeah, train configurations C-1 and C-4 are reported for the movement and handling of LNG ISOs in the Port of Miami intermodal facility.[69] A summary of the risk metrics for the LNG ISO car Port of Miami lifting and movement cases is provided in Table 51. The risk reduction presents the percent reduction in the SR Integral based on the C-1 (baseline) train configuration case. Based on comparison of the SR Integral for the two configurations, a risk reduction of 4.14% may be realized by using C-4 instead of C-1 for the Port of Miami intermodal operations. The maximum IR observed and the FN curve are virtually unchanged for C-4, as the risk is driven by the Lift Off activities which are not influenced by the train configuration. The risk results for C-1 are discussed above in Section 8.1.3. Given this analysis, the IR and the SR for the Port of Miami intermodal facility align with the fixed facility IR and SR acceptability criteria stated in NFPA 59A (see Table 1 and Figure 1) for both train configurations C-1 and C-4. Since train configuration C-1 represents the most significant risk of all configurations considered, it is anticipated that the other train configurations will have similar or less risk.

Table 51. Port of Miami - summary of the risk metrics for LNG ISO car movement and lifting for multiple train configurations.

Risk Metric	Port of Miami	
	C-1	C-4
SR Integral (total risk)	1.69×10^{-4}	1.62×10^{-4}
Maximum IR	4.45×10^{-5}	4.41×10^{-5}
Risk Reduction	--	4.14%

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[69] The IR contours are overlaid on an aerial image of the facility for these four train configurations in Appendix F, and the FN curves for the four train configurations can be found in Appendix G.

8.3.2.3 Port Everglades Intermodal Facility

Based on the results for Hialeah, train configurations C-1 and C-4 are reported for the movement and handling of LNG ISOs in the Port Everglades intermodal facility.[70] A summary of the risk metrics for the LNG ISO car Port Everglades lifting and movement cases is provided in Table 52. The risk reduction presents the percent reduction in the SR Integral based on the C-1 (baseline) train configuration case. Based on comparison of the SR Integral for the two configurations, a risk reduction of 5.00% may be realized by using C-4 instead of C-1 for the Port Everglades intermodal operations. The risk results for C-1 are discussed above in Section 8.1.3. Given this analysis, the IR and the SR for the Port Everglades intermodal facility align with the fixed facility IR and SR acceptability criteria stated in NFPA 59A (see Table 1 and Figure 1) for both train configurations C-1 and C-4. Since train configuration C-1 represents the most significant risk of all configurations considered, it is anticipated that the other train configurations will have similar or less risk.

Table 52. Port Everglades - summary of the risk metrics for LNG ISO car movement and lifting for multiple train configurations.

Risk Metric	Port Everglades	
	C-1	C-4
SR Integral (total risk)	3.40×10^{-4}	3.23×10^{-4}
Maximum IR	4.98×10^{-5}	4.95×10^{-5}
Risk Reduction	--	5.00%

8.3.2.4 Train Configuration Risk Comparison – Bowden Yard

Based on the results for Hialeah, train configurations C-1 and C-4 are reported for the movement and lifting of LNG ISOs in the Bowden Yard.[71] A summary of the risk metrics for the LNG ISO car Bowden Yard lifting and movement cases is provided in Table 53. The risk reduction presents the percent reduction in the SR Integral based on the C-1 (baseline) train configuration case. The maximum IR observed is virtually unchanged for both cases, as it is driven by the Lift Off activities which are not influenced by the train configuration. Based on comparison of the SR Integral for the two configurations, a risk reduction of 14.1% may be realized by using C-4 instead of C-1 for the Bowden Yard movement and handling operations.

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[70] The IR contours are overlaid on an aerial image of the facility for these four train configurations in Appendix F, and the FN curves for the four train configurations can be found in Appendix G.

[71] The IR contours are overlaid on an aerial image of the facility for these four train configurations in Appendix F, and the FN curves for the four train configurations can be found in Appendix G.

The risk results for C-1 are discussed above in Section 8.1.3. Given this analysis, the IR and the SR for the Bowden Yard align with the fixed facility IR and SR acceptability criteria stated in NFPA 59A (see Table 1 and Figure 1) for both train configurations C-1 and C-4. Since train configuration C-1 represents the most significant risk of all configurations considered, it is anticipated that the other train configurations will have similar or less risk.

Table 53. Bowden Yard - summary of the risk metrics for LNG ISO car movement and lifting for multiple train configurations.

Risk Metric	**Bowden Yard**	
	C-1	C-4
SR Integral (total risk)	2.27×10^{-4}	1.95×10^{-4}
Maximum IR	4.20×10^{-5}	4.17×10^{-5}
Risk Reduction	--	14.1%

8.4 Sensitive Target Analysis

The FRA requested that FECR perform an analysis of potentially sensitive establishments along the proposed railway routes. There is no current regulatory quantitative risk criteria for Individual Risk or Societal Risk of LNG transportation by rail, and the criteria used here were developed from those applicable to stationary LNG plants. For stationary LNG plants, NFPA 59A does not permit sensitive establishments, such as churches, schools, hospitals, and major public assembly areas, to be located within an Individual Risk (IR) greater than 3×10^{-7} per year.[72] There are many differences in the hazards and risk profile between a stationary facility and a transportation activity. Acceptable quantitative risk criteria for transportation of hazardous materials typically represent higher risk levels than stationary facilities. However, the Zone 3 risk from NFPA 59A was used as the benchmark for evaluation of risk to offsite populations.

The full list of potentially sensitive establishments and satellite maps depicting the Zone 3 (3×10^{-7} yr^{-1}) IR contours along the routes are provided in Appendix G. In the appendix, Tables G-1 and G-2 list potentially sensitive establishments along Routes 1 and 2, respectively. The satellite maps are provided as collages for each route and individual maps covering approximately one-mile sections of the routes.

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[72] Chapter 15.10.1 of NFPA 59A (2016) *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG).*

Google Earth Pro was used to identify potentially sensitive establishments near the proposed railway routes. In this analysis, the following categories of establishments were considered to be potentially sensitive:

- Schools, grades elementary and above
- Churches, synagogues, mosques, and other houses of worship
- Senior care facilities
- Hospitals
- Sports arenas

By using Google Earth Pro's built-in layers database that categorizes different types of establishments ("Banks/ATMS", "Pharmacy", etc.) and by validating their location and existence through internet searches, a list of potentially sensitive establishments was developed for the routes. Establishments where the nearest edge of the building was less than approximately (b)(4) [redacted] feet from the centerline of the railroad track were included in the analysis. The establishments and the approximate distance to the railway are listed in the following tables. The establishments are then identified on aerial maps of the routes with the maximum distance to the Zone 3 (3×10^{-3} yr^{-1}) Individual Risk contour overlaid along the route.

The maximum distance to the contour along the routes is (b)(4) [redacted] feet assuming the train is traveling at high speed (from 25 and 60 mph) for train configuration C-1 (i.e., (b)(4) [redacted] LNG ISOs in sequence from train position (b) (4) [redacted]). For any sections of the routes where the speed is maintained at less than or equal to 25 mph, there will be no Zone 3 Individual Risk contour. Note that the last one-mile section of Route 1 before the drawbridge to the Port of Miami has a maximum speed of 25 mph; thus, no Zone 3 risk contour is present on the figures. For the fixed railyard facilities, the distance to the contour is shown based on the fixed facility analyses for the Hialeah Yard, Port of Miami intermodal facility, and the Port Everglades intermodal facility. The contours as shown in the figures are representative of the distance to the contour, and the actual calculated distance should be relied upon in all cases. An example of the last two one-mile maps for Route 1, including downtown Miami and the Port of Miami, are provided in Figure 61. The maps illustrate a section of the route where the speed restriction to 25 mph eliminates the potential Zone 3 IR contour.

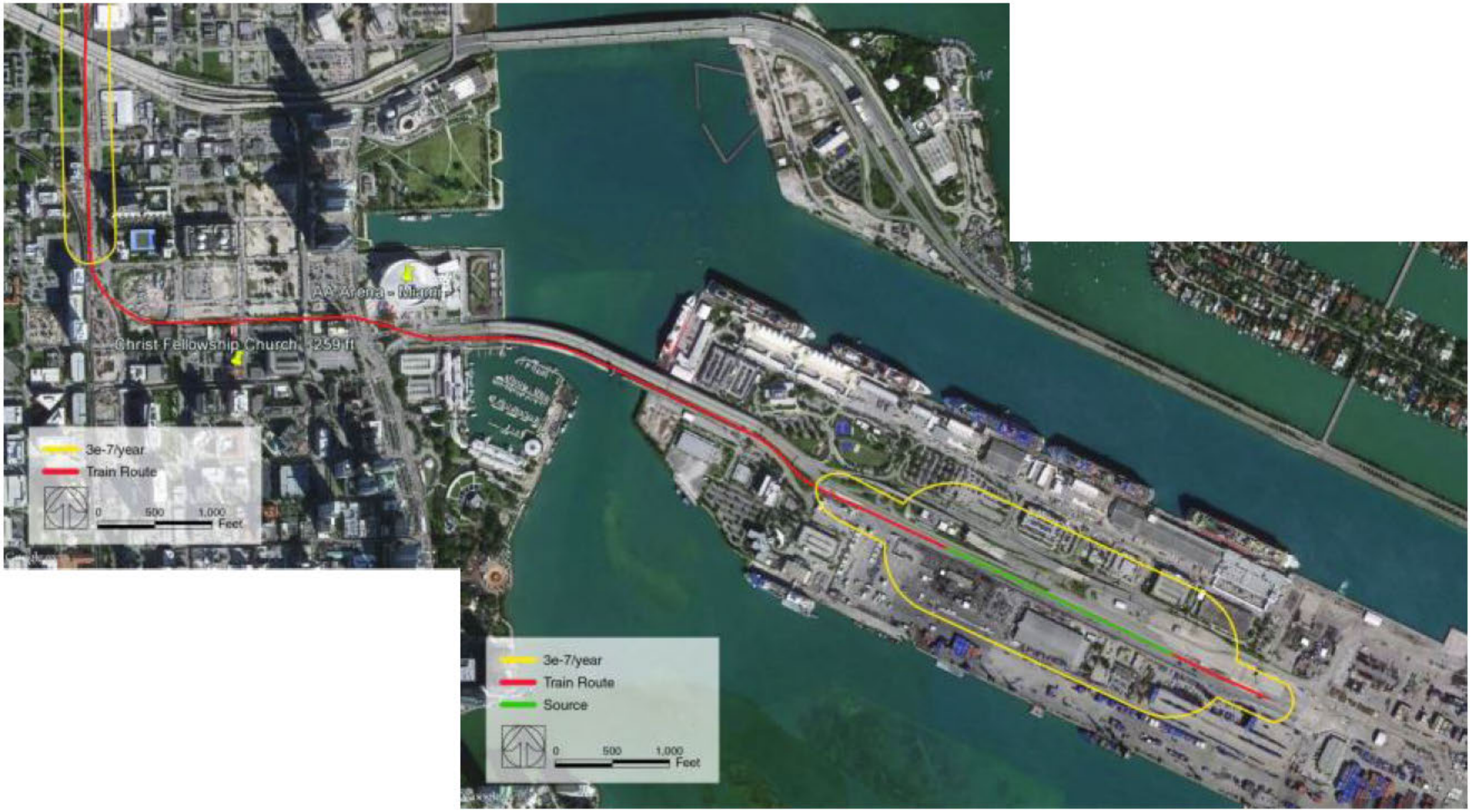

Figure 61. Composite aerial maps with Zone 3 contour depicted for Route 1 for the last two maps including the Port of Miami.

9 Limitations

As requested by Florida East Coast Railway, LLC, Exponent conducted a Quantitative Risk Assessment (QRA) study addressing FECR movement of LNG (b) (4) [redacted] ISO containers by rail. The scope of services performed during this review may not adequately address the needs of other users of this report, and any use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the study. The representation of NFPA 59A risk criteria in this report has been done for the purposes of comparing the transportation risk to a set of existing stationary facility quantitative risk criteria used in the U.S. and may not necessarily be appropriate or applicable for directly assessing acceptability of transportation risk. The assumptions adopted in this study do not constitute an exclusive set of reasonable assumptions, and use of a different set of assumptions or methodology might produce materially different results. Therefore, these results should not be interpreted as predictions of a loss that may occur as a result of any specific future event. Accordingly, no guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

The findings and recommendations presented herein are made to a reasonable degree of engineering certainty. The methodology that was used in this report is based on mathematical modeling of physical systems and processes as well as data from third parties in accordance with the regulatory requirements. Uncertainties are inherent to the methodology and these may subsequently influence the results generated.

Appendix A

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Appendix B

FECR “Movement of LNG Containers” Document, 10/8/2015

Appendix C

FECR “LNG ISO Container Proposed Routes” Document, 10/6/2015

Appendix D

LNG ISO and LPG Rail Car Derailment and Loss of Containment Event Trees

Appendix E

FECR Mainline Map with Population Densities

Appendix F

Societal Risk (SR) FN Curves

Appendix G

Potentially Sensitive Targets Results for Zone 3 Individual Risk

Well Car Capability Analysis

for

Florida East Coast Railway

Report No. FECR-20160426

(Project No. 9850)

Prepared by: Gretchen VanHeeren
Approved by: Keith A. Miller, P.E.
Date: April 26, 2016

SIMS PROFESSIONAL ENGINEERS

Table of Contents

1.0 Introduction

Sims Professional Engineers was contracted by Florida East Coast Rail to perform an analysis of two well car designs to carry cryogenic containers in revenue service. A loaded cryogenic container is only carried in a single-stack configuration, and has a maximum weight of 67,200 lb. The well cars were designed for current AAR loading, which includes double-stacking containers up to the load limit. As such the loading conditions for the AAR loads will tend to produce harsher loads at the container restraints. To quantify this a comparative analysis was performed between the cryogenic container and standard container loads.

The containers sit in the well of the railcars, with the sides extending above and with a floor structure below. A brief analysis describing the coverage of the container from the car body is discussed.

2.0 Model Description and Procedure

2.1 Model Description

The load considered for the model was a 40’ ISO cryogenic container, in a single-stack configuration. The container measured 8’ wide x 8’ 6” high x 40’ long, and had a maximum weight of 67,200 lb.

Two well car designs were analyzed. One was a Greenbrier car built in 2005 with a load limit of 166,900 lb., and the other was a Thrall car built in 1995 with a load limit of 163,000 lb. Both designs were stand-alone cars.

2.2 Analysis Method

To determine the capability of the well cars to safely carry the cryogenic container, a comparative loading analysis was performed. The live loads for the cryogenic container were compared to the standard AAR loading of double stacked 40’ containers, loaded to the maximum car capacity. Load cases are taken from AAR C-II, M-1001 Chapters 4 and 8 and included the following: 1.0 g vertical live load (Paragraphs 4.1.3, 4.2.2.5) a 1.8 g vertical load combined with .45 g lateral load (Paragraphs 4.1.3, 4.2.2.4, 4.2.2.7), and a 2.0 g longitudinal impact load (8.2.4.4.2.2). For all load cases, the maximum vertical, lateral, and longitudinal reaction loads were determined for one connector. The improvement in loading condition for each of the three directions was then calculated.

3.0 Data and Results

The cryogenic container was significantly lighter than the load limit of each of the well cars, and as such the resulting loads for the cryogenic container were signficantly lower than those induced by standard AAR double stack load conditions. Figure 1 below shows a bar graph which compares the loads from the fully loaded Thrall design, fully loaded Greenbrier design, and the cryogenic container. Each load indicated is the force reacted at one restraining lug for any given load case. The reaction loads for the lateral and longitudinal loads are also assumed to react at one set (two) restraints on one end or side in relation to the direction of load application.

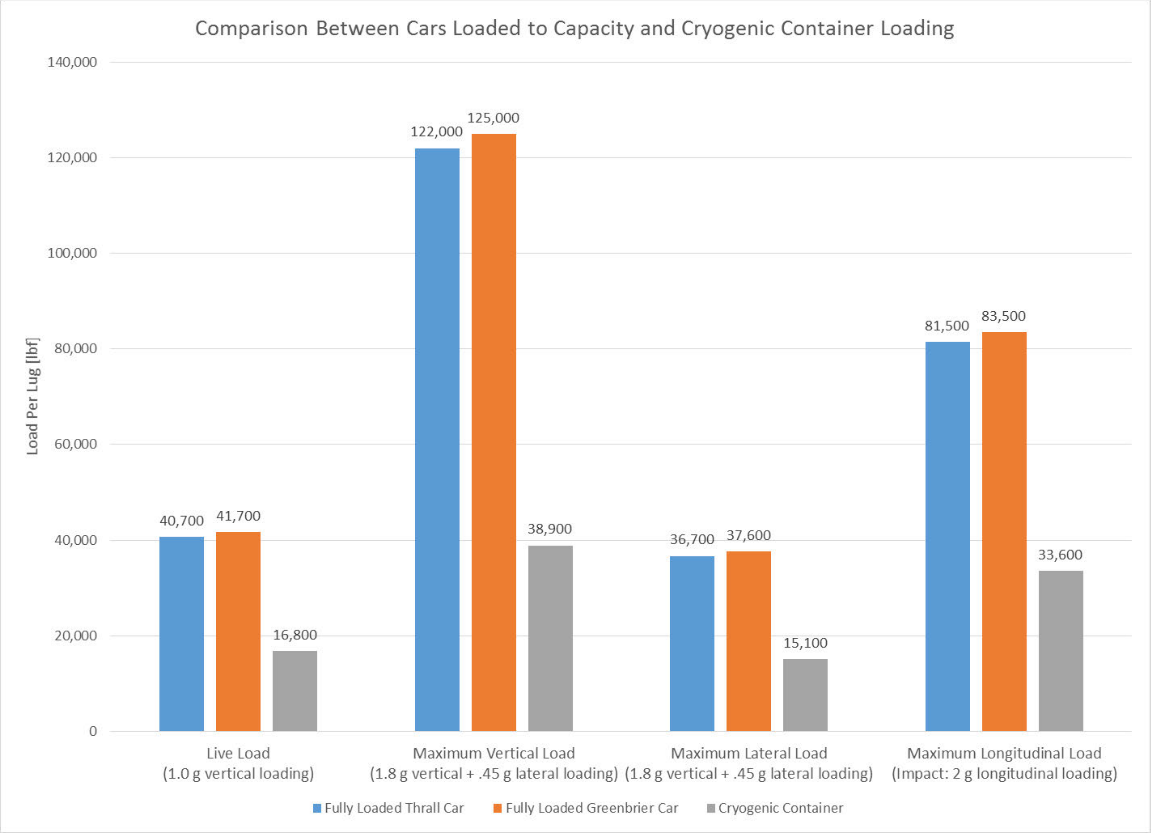

Figure 1: Load Comparisons between Fully Loaded Cars and Cryogenic Container

For all of these load cases, the cryogenic container reaction forces were significantly lower than that of the rated loading conditions for both cars. Another means of comparison is to show a relative factor resulting from the reduction in reaction forces. Figure 2 shows an improvement factor in regards to the reaction load for each well car carrying the cryogenic container vs their rated loads. The improvement factor represents the additional load factor that would need to be applied to the cryogenic container to obtain the same reaction load as the Greenbrier and Thrall cars carrying their load limit.

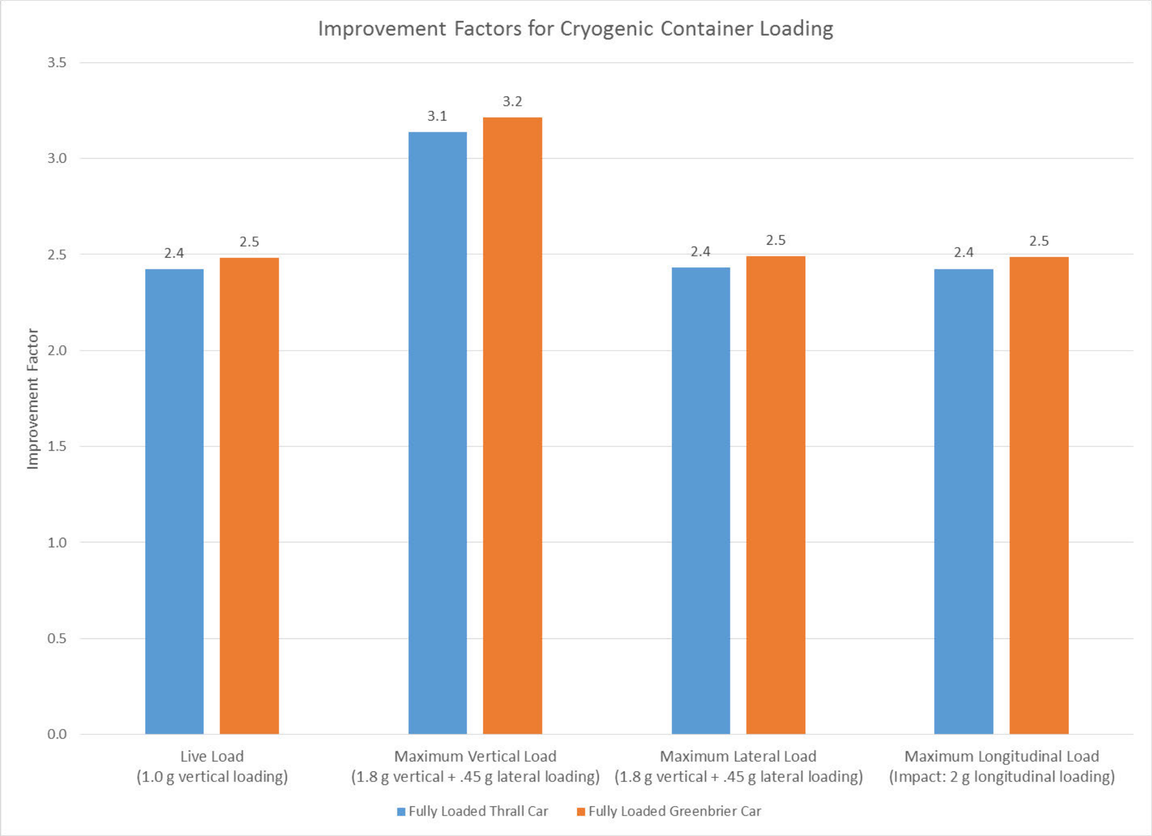

Figure 2: Improvement Factors for Thrall and Greenbrier Car Designs

The figures show that the cryogenic container loading was significantly less than the rated loads for either car, which would result in reduced stress significantly below the design limits.

The container cones on the well cars are standard intermodal types that do not have locking features. Both the standard containers and the cryogenic container are held in position by gravity. An acceleration equal to 1.0g vertically upward would be required to lift the container from the cones, which is the same regardless of the type of container loaded into the well car.

4.0 Structural Protection

The cryogenic tank container is carried in the well cars, which have sides and floors that has a significant amount of structure shielding the tank from any external object from the bottom and side.

The container extends 4’ 11” above the side of the Greenbrier well car which has a side sheet thickness of .25” and provides 61% coverage of the cryogenic container side area.

The container extends 5’ 10” above the side of the Thrall well car which has a side sheet thickness of .172” and provides 29% coverage of the cryogenic container side area.

The floors cover a significant amount of the area below the container compared to other designs with a lighter truss or cross beam floor construction. The Greenbrier car floor structure covers 74% of the total floor area, and 70% of the total area on the Thrall car.

These structural features will provide additional protection against the ability of an object which could puncture the cryogenic tank container, beyond the inherent resistance of the tank structure itself.

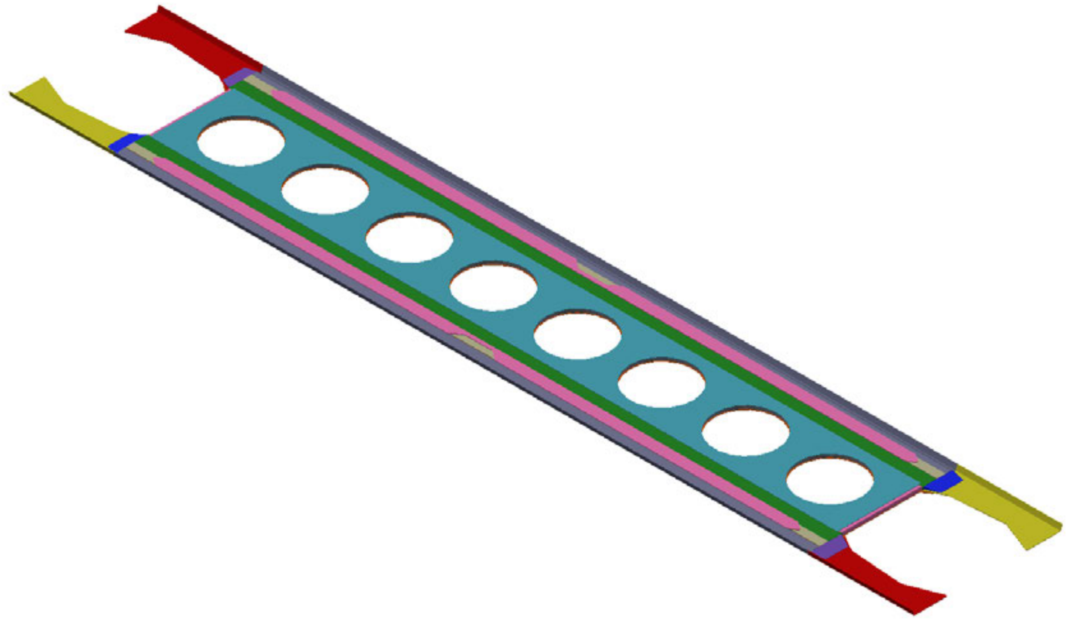

Figure 7: Greenbrier Car Floor Construction

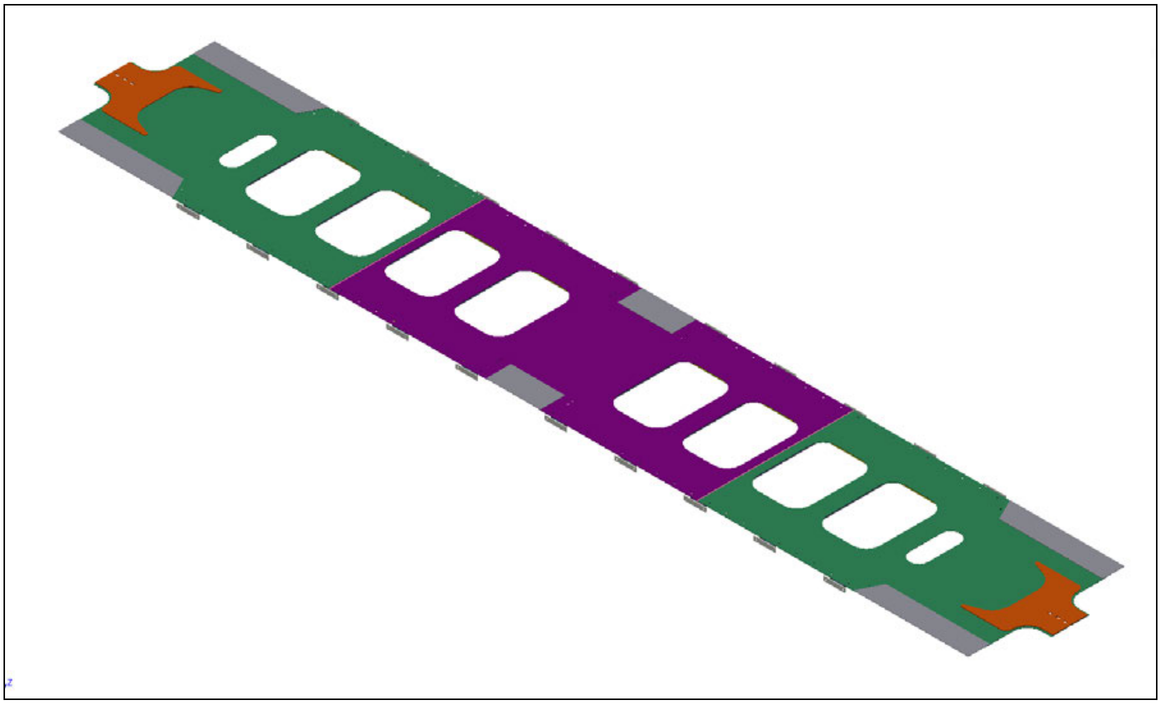

Figure 8: Thrall Car Floor Construction

5.0 Discussion and Conclusions

The well cars which were both built after 1990 are modern designs meeting all current AAR structural requirements under loading conditions up to their load limit. This includes standard AAR load factors. In all cases, the loads induced by the ISO cryogenic container are significantly lower than the AAR requirements. This is due to the lower overall weight of the cryogenic container as well as the single-stack configuration. Therefore, the cars loaded with the cryogenic container will be subjected to 58% - 69% less stress at the container cones than what is induced by the live load in normal service.

The position of the single cryogenic container results in significant coverage of the container area by the car body structure. The car body is expected to provide significant resistance to objects which may potentially strike the tank of the cryogenic container.

(b) (4)

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(b) (4)

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(b) (4)

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1.11 - One Year Accident/Incident Overview - Combined

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ONE YEAR ACCIDENT/INCIDENT OVERVIEW BY REGION/STATE/COUNTY
Report Type - ' CALENDAR YEAR '
SELECTION: Railroad - Florida East Coast Railway, LLC . [FEC ]
All Regions
State - All States  County - All
January To December, 2011
Reporting Level:...  INDIVIDUAL
***IMPORTANT: Rates calculated on National Level do not display for Region or State Geography***
------------------------------------------------------------------------------------------------

' CALENDAR YEAR '

         TOTAL ACCIDENTS/INCIDENTS:       44  Number of fatal accidents/incidents 18  40.9%
            Overall frequency rate:    24.25  Total train miles:        1,814,114
                  Total fatalities:       18    Switching miles:          500,557
         Total nonfatal conditions:       14     Employee hours:        1,067,225

Total accidents/incidents is the sum of train accidents, highway-rail incidents, and other incidents.
Total accident/incident rate is the number of events times 1,000,000 divided by total train miles.
------------------------------------------------------------------------------------------------

             TOTAL TRAIN ACCIDENTS:        5     Number of fatal train accidents 0      0  %
   Number per million train miles:      2.76           Collisions:           0      0  %
                  Total fatalities:        0          Derailments:           4    80.00%
         Total nonfatal conditions:        0      Other accidents:           1    20.00%

             --------------------------Primary causes---------------------------
                   Human factors:   40.00%      2       Track defects:        2    40.00%
               Equipment defects:     0  %      0      Signal defects:        0      0  %
            Miscellaneous causes:   20.00%      1

 Number of accidents on yard track:        4   80.00% of all train accidents.
  Nbr per million yard train miles:     7.99   For other tracks:     0.76

Train accidents represent 11.36% of all reported events.

Number of train accidents involving passenger trains   0    0  %

Number of train accidents that resulted in a release of hazardous material 0    0.00% of total
Number of persons evacuated      0  Number of rail cars releasing hazmat      0

A train accident is an event involving ontrack rail equipment that results in monetary damage to the equipment
and track above a certain threshold.  Lading, clearing costs, environmental damage is not included.
------------------------------------------------------------------------------------------------

                      HIGHWAY-RAIL              TRESPASSING INCIDENTS(not at crossings)
Crossings:      693       Incidents:         15
    Number per million train miles:      8.27    Frequency per million train miles:    11.02
                  Total fatalities:         4                     Total fatalities:       14
         Total nonfatal conditions:         4            Total nonfatal conditions:        6
      Number of fatal crossing incidents 4      26.67%

Public Crossings      597  With gates     537 Other activated crossings     13 Number with passive warnings      47
Private crossings     96     ***** THE COUNT OF CROSSINGS IS THE COUNT IN THE CURRENT INVENTORY *****

Highway-rail and trespassing incidents account for 100.0% of all fatalities.
Highway-rail incidents represent 34.09% of all reported events.

A highway-rail incident is any impact between a rail and a highway user at a crossing site, regardless of severity.
Includes motor vehicles and other highway/roadway/sidewalk users at both public and private crossings.
------------------------------------------------------------------------------------------------

                   OTHER INCIDENTS:        24  Number of fatal other incidents 14  58.33% of other incidents
       Other incidents account for:     54.55% of all accidents/incidents
                  Total fatalities:        14    0 Number to employees on duty.  Trespassers  14
         Total nonfatal conditions:        10       3 Number to employees on duty

Other incidents include any event where that caused a death, an injury, or an occupational illness
to a railroad employee.  Most fatalities in this category are to trespassers.
------------------------------------------------------------------------------------------------

           EMPLOYEES ON DUTY CASES:         3   Frequency per 200,000 hours worked:      0.56
                  Total fatalities:         0
         Total nonfatal conditions:         3   21.43% of all nonfatal cases
```

1.11 - One Year Accident/Incident Overview - Combined

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ONE YEAR ACCIDENT/INCIDENT OVERVIEW BY REGION/STATE/COUNTY
Report Type - ' CALENDAR YEAR '
SELECTION: Railroad - Florida East Coast Railway, LLC . [FEC ]
All Regions
State - All States  County - All
January To December, 2012
Reporting Level:...  INDIVIDUAL
***IMPORTANT: Rates calculated on National Level do not display for Region or State Geography***
```

```
' CALENDAR YEAR '

         TOTAL ACCIDENTS/INCIDENTS:       44   Number of fatal accidents/incidents 12  27.3%
            Overall frequency rate:    24.08   Total train miles:        1,826,899
                  Total fatalities:       12     Switching miles:          507,343
         Total nonfatal conditions:       25      Employee hours:        1,060,101

Total accidents/incidents is the sum of train accidents, highway-rail incidents, and other incidents.
Total accident/incident rate is the number of events times 1,000,000 divided by total train miles.
```

```
             TOTAL TRAIN ACCIDENTS:        2      Number of fatal train accidents 0       0  %
    Number per million train miles:     1.09          Collisions:          0       0  %
                  Total fatalities:        0         Derailments:          2  100.00%
         Total nonfatal conditions:        0     Other accidents:          0       0  %

              ---------------------------Primary causes---------------------------
              Human factors:   50.00%      1      Track defects:          1   50.00%
          Equipment defects:     0  %      0     Signal defects:          0       0  %
       Miscellaneous causes:     0  %      0

 Number of accidents on yard track:        1    50.00% of all train accidents.
  Nbr per million yard train miles:     1.97    For other tracks:     0.76

Train accidents represent  4.55% of all reported events.

Number of train accidents involving passenger trains   0    0  %

Number of train accidents that resulted in a release of hazardous material 0     0  % of total
Number of persons evacuated      0  Number of rail cars releasing hazmat      0

A train accident is an event involving ontrack rail equipment that results in monetary damage to the equipment
and track above a certain threshold.  Lading, clearing costs, environmental damage is not included.
```

```
                    HIGHWAY-RAIL                TRESPASSING INCIDENTS(not at crossings)
Crossings:     693      Incidents:            15
    Number per million train miles:     8.21     Frequency per million train miles:      6.02
                  Total fatalities:        4                    Total fatalities:          7
         Total nonfatal conditions:        6            Total nonfatal conditions:          4
      Number of fatal crossing incidents 4     26.67%

Public Crossings       597  With gates      537 Other activated crossings      13 Number with passive warnings      47
Private crossings      96      ***** THE COUNT OF CROSSINGS IS THE COUNT IN THE CURRENT INVENTORY *****

Highway-rail and trespassing incidents account for 91.67% of all fatalities.
Highway-rail incidents represent 34.09% of all reported events.

A highway-rail incident is any impact between a rail and a highway user at a crossing site, regardless of severity.
Includes motor vehicles and other highway/roadway/sidewalk users at both public and private crossings.
```

```
                   OTHER INCIDENTS:       27  Number of fatal other incidents 8  29.63% of other incidents
       Other incidents account for:   61.36% of all accidents/incidents
                  Total fatalities:        8    0 Number to employees on duty.  Trespassers     7
         Total nonfatal conditions:       19      12 Number to employees on duty

Other incidents include any event where that caused a death, an injury, or an occupational illness
to a railroad employee.  Most fatalities in this category are to trespassers.
```

```
          EMPLOYEES ON DUTY CASES:       12   Frequency per 200,000 hours worked:      2.26
                  Total fatalities:        0
         Total nonfatal conditions:       12   48.00% of all nonfatal cases
```

1.11 - One Year Accident/Incident Overview - Combined

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```
ONE YEAR ACCIDENT/INCIDENT OVERVIEW BY REGION/STATE/COUNTY
Report Type - ' CALENDAR YEAR '
SELECTION: Railroad - Florida East Coast Railway, LLC . [FEC ]
All Regions
State - All States  County - All
January To December, 2013
Reporting Level:...  INDIVIDUAL
***IMPORTANT: Rates calculated on National Level do not display for Region or State Geography***
--------------------------------------------------------------------------------------------------

' CALENDAR YEAR '

        TOTAL ACCIDENTS/INCIDENTS:      55   Number of fatal accidents/incidents 12  21.8%
           Overall frequency rate:   28.41   Total train miles:        1,936,055
                 Total fatalities:      12     Switching miles:          543,132
         Total nonfatal conditions:     25      Employee hours:        1,195,559

Total accidents/incidents is the sum of train accidents, highway-rail incidents, and other incidents.
Total accident/incident rate is the number of events times 1,000,000 divided by total train miles.
--------------------------------------------------------------------------------------------------

            TOTAL TRAIN ACCIDENTS:      10      Number of fatal train accidents 0      0  %
    Number per million train miles:   5.17          Collisions:          0      0  %
                 Total fatalities:       0         Derailments:          9   90.00%
         Total nonfatal conditions:      0     Other accidents:          1   10.00%

           ---------------------------Primary causes---------------------------
             Human factors:  30.00%      3        Track defects:         4   40.00%
         Equipment defects:    0  %      0       Signal defects:         0      0  %
      Miscellaneous causes:  30.00%      3

 Number of accidents on yard track:      9    90.00% of all train accidents.
  Nbr per million yard train miles:  16.57    For other tracks:      0.72

Train accidents represent 18.18% of all reported events.

Number of train accidents involving passenger trains   0    0  %

Number of train accidents that resulted in a release of hazardous material 0    0.00% of total
Number of persons evacuated       0  Number of rail cars releasing hazmat      0

A train accident is an event involving ontrack rail equipment that results in monetary damage to the equipment
and track above a certain threshold.  Lading, clearing costs, environmental damage is not included.
--------------------------------------------------------------------------------------------------

                    HIGHWAY-RAIL               TRESPASSING INCIDENTS(not at crossings)
Crossings:     693      Incidents:      18
    Number per million train miles:   9.30     Frequency per million train miles:      7.23
                 Total fatalities:       4                      Total fatalities:         7
         Total nonfatal conditions:      6              Total nonfatal conditions:        7
      Number of fatal crossing incidents 4     22.22%

Public Crossings       597  With gates     537 Other activated crossings      13 Number with passive warnings      47
Private crossings      96      ***** THE COUNT OF CROSSINGS IS THE COUNT IN THE CURRENT INVENTORY *****

Highway-rail and trespassing incidents account for 91.67% of all fatalities.
Highway-rail incidents represent 32.73% of all reported events.

A highway-rail incident is any impact between a rail and a highway user at a crossing site, regardless of severity.
Includes motor vehicles and other highway/roadway/sidewalk users at both public and private crossings.
--------------------------------------------------------------------------------------------------

                 OTHER INCIDENTS:       27  Number of fatal other incidents 8  29.63% of other incidents
       Other incidents account for:  49.09% of all accidents/incidents
                 Total fatalities:       8    0 Number to employees on duty.  Trespassers    7
         Total nonfatal conditions:     19      11 Number to employees on duty

Other incidents include any event where that caused a death, an injury, or an occupational illness
to a railroad employee.  Most fatalities in this category are to trespassers.
--------------------------------------------------------------------------------------------------

           EMPLOYEES ON DUTY CASES:     11    Frequency per 200,000 hours worked:     1.84
                 Total fatalities:       0
         Total nonfatal conditions:     11    44.00% of all nonfatal cases
```

1.11 - One Year Accident/Incident Overview - Combined

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```
ONE YEAR ACCIDENT/INCIDENT OVERVIEW BY REGION/STATE/COUNTY
Report Type - ' CALENDAR YEAR '
SELECTION: Railroad - Florida East Coast Railway, LLC . [FEC ]
All Regions
State - All States  County - All
January To December, 2014
Reporting Level:...  INDIVIDUAL
***IMPORTANT: Rates calculated on National Level do not display for Region or State Geography***
----------------------------------------------------------------------------------------------------

' CALENDAR YEAR '

         TOTAL ACCIDENTS/INCIDENTS:       71   Number of fatal accidents/incidents 13  18.3%
            Overall frequency rate:    35.79   Total train miles:         1,983,866
                  Total fatalities:       13     Switching miles:           588,627
          Total nonfatal conditions:       31     Employee hours:         1,354,870

Total accidents/incidents is the sum of train accidents, highway-rail incidents, and other incidents.
Total accident/incident rate is the number of events times 1,000,000 divided by total train miles.
----------------------------------------------------------------------------------------------------

             TOTAL TRAIN ACCIDENTS:       13      Number of fatal train accidents 0       0  %
     Number per million train miles:     6.55          Collisions:           2    15.38%
                  Total fatalities:        0         Derailments:          10    76.92%
          Total nonfatal conditions:        0     Other accidents:           1     7.69%

              ---------------------------Primary causes---------------------------
              Human factors:   38.46%      5       Track defects:           8    61.54%
          Equipment defects:    0  %       0      Signal defects:           0     0  %
       Miscellaneous causes:    0  %       0

 Number of accidents on yard track:        9    69.23% of all train accidents.
  Nbr per million yard train miles:    15.29    For other tracks:      2.87

Train accidents represent 18.31% of all reported events.

Number of train accidents involving passenger trains   0    0  %

Number of train accidents that resulted in a release of hazardous material 0    0.00% of total
Number of persons evacuated       0  Number of rail cars releasing hazmat      0

A train accident is an event involving ontrack rail equipment that results in monetary damage to the equipment
and track above a certain threshold.  Lading, clearing costs, environmental damage is not included.
----------------------------------------------------------------------------------------------------

                     HIGHWAY-RAIL                 TRESPASSING INCIDENTS(not at crossings)
Crossings:     693       Incidents:          19
    Number per million train miles:     9.58     Frequency per million train miles:     10.08
                  Total fatalities:        1                   Total fatalities:        12
         Total nonfatal conditions:        4           Total nonfatal conditions:         8
      Number of fatal crossing incidents 1      5.26%

Public Crossings      597  With gates      537 Other activated crossings      13 Number with passive warnings      47
Private crossings     96      ***** THE COUNT OF CROSSINGS IS THE COUNT IN THE CURRENT INVENTORY *****

Highway-rail and trespassing incidents account for 100.0% of all fatalities.
Highway-rail incidents represent 26.76% of all reported events.

A highway-rail incident is any impact between a rail and a highway user at a crossing site, regardless of severity.
Includes motor vehicles and other highway/roadway/sidewalk users at both public and private crossings.
----------------------------------------------------------------------------------------------------

                  OTHER INCIDENTS:       39  Number of fatal other incidents 12  30.77% of other incidents
        Other incidents account for:    54.93% of all accidents/incidents
                  Total fatalities:       12    0 Number to employees on duty.  Trespassers  12
          Total nonfatal conditions:       27      16 Number to employees on duty

Other incidents include any event where that caused a death, an injury, or an occupational illness
to a railroad employee.  Most fatalities in this category are to trespassers.
----------------------------------------------------------------------------------------------------

           EMPLOYEES ON DUTY CASES:       16    Frequency per 200,000 hours worked:      2.36
                  Total fatalities:        0
          Total nonfatal conditions:       16    51.61% of all nonfatal cases
```

1.11 - One Year Accident/Incident Overview - Combined

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ONE YEAR ACCIDENT/INCIDENT OVERVIEW BY REGION/STATE/COUNTY
Report Type - ' CALENDAR YEAR '
SELECTION: Railroad - Florida East Coast Railway, LLC . [FEC ]
All Regions
State - All States  County - All
January To December, 2015
Reporting Level:...  INDIVIDUAL
***IMPORTANT: Rates calculated on National Level do not display for Region or State Geography***
------------------------------------------------------------------------------------------------------
' CALENDAR YEAR '

         TOTAL ACCIDENTS/INCIDENTS:      63  Number of fatal accidents/incidents 16  25.4%
            Overall frequency rate:   30.34  Total train miles:         2,076,602
                  Total fatalities:      16   Switching miles:            622,588
         Total nonfatal conditions:      30    Employee hours:          1,464,709

Total accidents/incidents is the sum of train accidents, highway-rail incidents, and other incidents.
Total accident/incident rate is the number of events times 1,000,000 divided by total train miles.
------------------------------------------------------------------------------------------------------

             TOTAL TRAIN ACCIDENTS:      12     Number of fatal train accidents 0      0 %
    Number per million train miles:    5.78         Collisions:          1     8.33%
                  Total fatalities:       0        Derailments:         11    91.67%
         Total nonfatal conditions:       0    Other accidents:          0      0 %

              ---------------------------Primary causes---------------------------
              Human factors:  33.33%      4      Track defects:          6    50.00%
          Equipment defects:   8.33%      1     Signal defects:          0      0 %
       Miscellaneous causes:   8.33%      1

 Number of accidents on yard track:      10   83.33% of all train accidents.
  Nbr per million yard train miles:   16.06   For other tracks:     1.38

Train accidents represent 19.05% of all reported events.

Number of train accidents involving passenger trains   0    0 %

Number of train accidents that resulted in a release of hazardous material 0    0.00% of total
Number of persons evacuated      0  Number of rail cars releasing hazmat      0

A train accident is an event involving ontrack rail equipment that results in monetary damage to the equipment
and track above a certain threshold.  Lading, clearing costs, environmental damage is not included.
------------------------------------------------------------------------------------------------------

                      HIGHWAY-RAIL             TRESPASSING INCIDENTS(not at crossings)
Crossings:     693       Incidents:      12
    Number per million train miles:    5.78    Frequency per million train miles:     9.63
                  Total fatalities:       3                     Total fatalities:       12
         Total nonfatal conditions:       4            Total nonfatal conditions:        8
      Number of fatal crossing incidents 3     25.00%

Public Crossings      597  With gates    537 Other activated crossings     13 Number with passive warnings      47
Private crossings     96      ***** THE COUNT OF CROSSINGS IS THE COUNT IN THE CURRENT INVENTORY *****

Highway-rail and trespassing incidents account for 93.75% of all fatalities.
Highway-rail incidents represent 19.05% of all reported events.

A highway-rail incident is any impact between a rail and a highway user at a crossing site, regardless of severity.
Includes motor vehicles and other highway/roadway/sidewalk users at both public and private crossings.
------------------------------------------------------------------------------------------------------

                   OTHER INCIDENTS:      39  Number of fatal other incidents 13  33.33% of other incidents
       Other incidents account for:   61.90% of all accidents/incidents
                  Total fatalities:      13    0 Number to employees on duty.  Trespassers  12
         Total nonfatal conditions:      26       9 Number to employees on duty

Other incidents include any event where that caused a death, an injury, or an occupational illness
to a railroad employee.  Most fatalities in this category are to trespassers.
------------------------------------------------------------------------------------------------------

           EMPLOYEES ON DUTY CASES:       9   Frequency per 200,000 hours worked:     1.23
                  Total fatalities:       0
         Total nonfatal conditions:       9   30.00% of all nonfatal cases
```

1.11 - One Year Accident/Incident Overview - Combined

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```
ONE YEAR ACCIDENT/INCIDENT OVERVIEW BY REGION/STATE/COUNTY
Report Type - ' CALENDAR YEAR '
SELECTION: Railroad - Florida East Coast Railway, LLC . [FEC ]
All Regions
State - All States  County - All
January To December, 2016
Reporting Level:...  INDIVIDUAL
***IMPORTANT: Rates calculated on National Level do not display for Region or State Geography***
```

```
' CALENDAR YEAR '

         TOTAL ACCIDENTS/INCIDENTS:        6   Number of fatal accidents/incidents 0    0  %
            Overall frequency rate:    34.22   Total train miles:            175,354
                  Total fatalities:        0     Switching miles:             51,943
         Total nonfatal conditions:        4      Employee hours:            120,781

Total accidents/incidents is the sum of train accidents, highway-rail incidents, and other incidents.
Total accident/incident rate is the number of events times 1,000,000 divided by total train miles.
```

```
             TOTAL TRAIN ACCIDENTS:        1      Number of fatal train accidents 0      0  %
     Number per million train miles:    5.70          Collisions:            0      0  %
                  Total fatalities:        0         Derailments:            1   100.00%
         Total nonfatal conditions:        0     Other accidents:            0      0  %

              ---------------------------Primary causes---------------------------
              Human factors:     0  %      0        Track defects:           1   100.00%
          Equipment defects:     0  %      0       Signal defects:           0      0  %
       Miscellaneous causes:     0  %      0

 Number of accidents on yard track:        0
  Nbr per million yard train miles:      0      For other tracks:     8.10

Train accidents represent 16.67% of all reported events.

Number of train accidents involving passenger trains   0     0  %

Number of train accidents that resulted in a release of hazardous material 0    0.00% of total
Number of persons evacuated      0  Number of rail cars releasing hazmat      0

A train accident is an event involving ontrack rail equipment that results in monetary damage to the equipment
and track above a certain threshold.  Lading, clearing costs, environmental damage is not included.
```

```
                     HIGHWAY-RAIL                TRESPASSING INCIDENTS(not at crossings)
Crossings:     693       Incidents:        1
    Number per million train miles:     5.70      Frequency per million train miles:      5.70
                  Total fatalities:        0                      Total fatalities:          0
         Total nonfatal conditions:        0              Total nonfatal conditions:          1
      Number of fatal crossing incidents 0       0  %

Public Crossings       597  With gates    537 Other activated crossings     13 Number with passive warnings      47
Private crossings      96      ***** THE COUNT OF CROSSINGS IS THE COUNT IN THE CURRENT INVENTORY *****

Highway-rail and trespassing incidents account for  0.00% of all fatalities.
Highway-rail incidents represent 16.67% of all reported events.

A highway-rail incident is any impact between a rail and a highway user at a crossing site, regardless of severity.
Includes motor vehicles and other highway/roadway/sidewalk users at both public and private crossings.
```

```
                   OTHER INCIDENTS:        4  Number of fatal other incidents 0     0  % of other incidents
       Other incidents account for:    66.67% of all accidents/incidents
                  Total fatalities:        0    0 Number to employees on duty.  Trespassers    0
         Total nonfatal conditions:        4       1 Number to employees on duty

Other incidents include any event where that caused a death, an injury, or an occupational illness
to a railroad employee.  Most fatalities in this category are to trespassers.
```

```
          EMPLOYEES ON DUTY CASES:        1   Frequency per 200,000 hours worked:      1.66
                  Total fatalities:        0
         Total nonfatal conditions:        1   25.00% of all nonfatal cases
```