Attachment A: 2015 Severe Winter Weather Pattern Impacts - Supplemental Information

March 27, 2015

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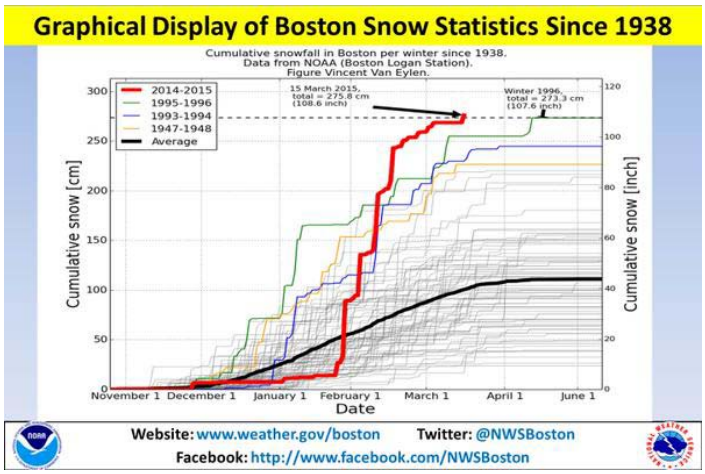
1. WEATHER/METEOROLOGICAL BACKGROUND

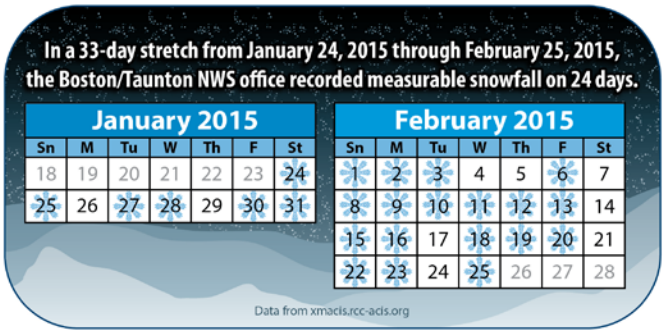
The winter of 2015 was unprecedented, unrelenting, and devastating. The large-scale weather pattern that set up across the U.S. and remained constant for weeks on end resulted in persistent, extreme cold temperatures and unending snowfall. The condensed timeframe in which this historic and devastating snow fell created a public safety crisis, resulted in dozens of deaths and hundreds of injuries and caused tens of millions of dollars in destruction.

Anomalous Winter Weather Pattern

It is hard to put into perspective an anomalous winter weather pattern such as this, when it is so far beyond any winter event in the recorded history of Massachusetts. Similar to previous stretches of winter weather, this year we observed in the jetstream a pronounced ridge over the west coast and a trough downstream. During the early part of this winter, the typical flow pattern over the U.S. resulted in the jetstream being zonal over the Pacific Ocean but split between two branches near the west coast of the U.S. due to a blocking dipole. As a result, the jetstream formed an ideal configuration to bring persistent warm air north over the west and cold arctic air south over the eastern continental U.S.



The blocking dipole formed in the middle of January as the result of a very active Pacific storm track. A sequence of low-pressure systems moved along the Pacific jet, advecting warm moist air and maturing near the west coast. This coincided with the establishment of a blocking upper atmospheric high-pressure system. This year however, the ridge was particularly pronounced and was positioned further downstream of the Rockies than normal. This led to extremely persistent warm weather out west and cold bitter temperatures out east. This continual pattern was also an ideal configuration to favor winter storms over the East Coast.



Once the blocking pattern was established downstream of the Rockies, storms moving in from the west, were forced to move north around the high and then south along the jet which oriented itself north-south, encouraging steady storm development over the eastern U.S. Disturbances developing downstream of the blocking dipole were forced to move south and then east toward the Gulf region where they interacted with the warm ocean and developed into strong surface lows over the East Coast, causing the record snow falls over Massachusetts.

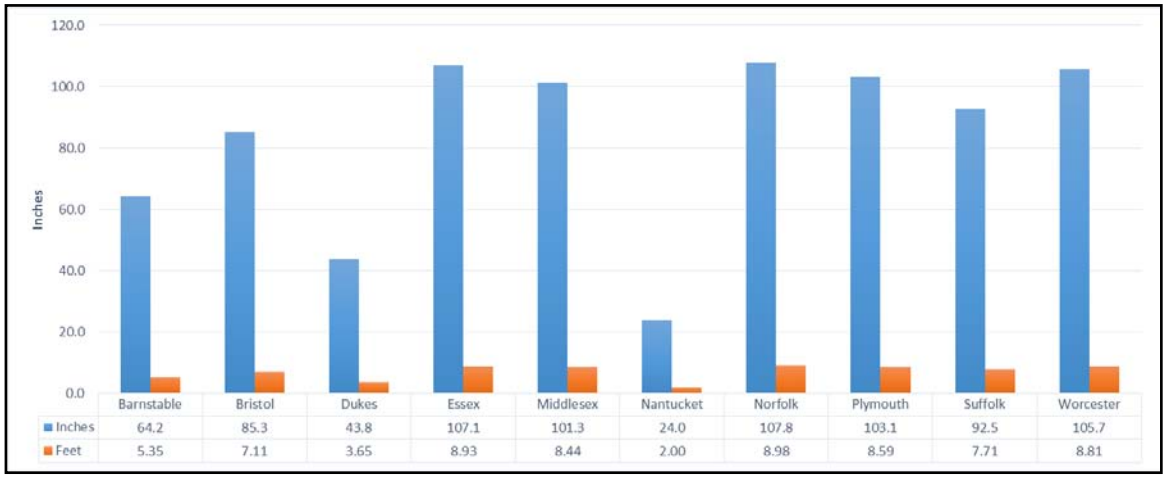
In addition to the unusual positioning of the jetstream, the numbers of high-end snowstorms observed in such rapid succession are near the limits of what the atmosphere can produce locally. Following the passage of a significant coastal storm, there is a surge of arctic air that pushes the coastal baroclinic zone southeastward and temporarily decreases the amplitude of the temperature gradient over the open ocean. As a result, a disturbance that follows two to three day later (average synoptic timescale) often features a much weaker low pressure system tracking south of the previous storm track. The atmosphere essentially has to “reload” before the next

significant storm. To overcome this limitation, disturbances tracking toward the East Coast must be ideally spaced apart, with sufficient amplitude to trigger surface cyclogenesis and restore the baroclinic zone. This is effectively what happened during late January to late February in 2015.

As this large-scale weather pattern persisted from mid-January through February, the Commonwealth of Massachusetts experienced extraordinary and unprecedented weather events in rapid succession. In these first two months of 2015, a continuous series of events created challenges across the entire state and buried the eastern regions under almost nine feet of snow. In a 33-day stretch from January 24, 2015 through February 25, 2015, the Boston/Taunton NWS office recorded measurable snowfall on 24 days. The snowfall experienced in eastern areas of the Commonwealth during the 2015 winter season was nothing less than astounding. In the 30-day period from late January to late February, Boston received an incredible 94.4 inches of snow, which eclipsed the prior 30-day record of 58.8 inches by almost 3 feet. Since 1937, the date of the earliest data from the National Climatic Data Center (NCDC), only two winters have recorded over 90 inches in a season. During those two seasons, it took a 78-day span and an 85-day span to achieve 90.3 inches of snowfall.

In the 20-day period from January 27 to February 15, four significant bursts of snow from this series of extraordinary events assaulted Boston: 22.1 inches on January 26-27th, 16.2 inches on February 2-3, 23.1 inches on February 9-10th, and 16.2 inches on February 14-15th. For the month of February 2015, Boston received 64.8 inches of snow, far beyond the prior monthly record of 43.3 inches set in January 2005. Similarly, Worcester received 94.6 inches of snow during the 30-day period, a value that far surpassed the prior monthly record of 66.2 inches. Furthermore, records for the number of days receiving measurable snow were shattered for the month of February in Boston, with 16 days (more than half the month) receiving snow, and more than 12 inches falling on 3 days (the past record was 1 day). The accretion of this series of events delivered in such rapid succession was unprecedented, shattering nearly every winter weather record. The unfathomable snowfall subtotals from January 26 through February 23 for the counties of Massachusetts are provided below.

Figure 1.1: Cumulative Snowfall in Massachusetts Counties (1/26/2015 to 2/23/2015)



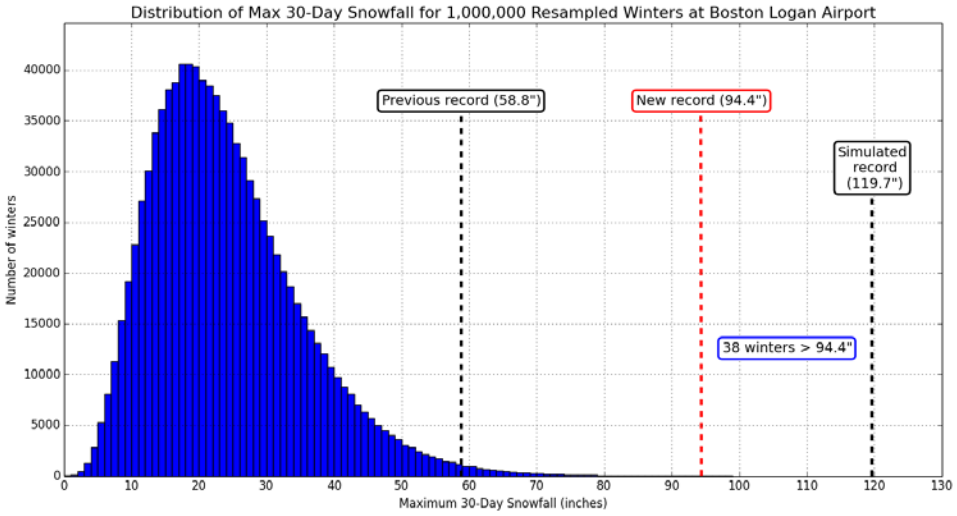
	Barnstable	Bristol	Dukes	Essex	Middlesex	Nantucket	Norfolk	Plymouth	Suffolk	Worcester
Inches	64.2	85.3	43.8	107.1	101.3	24.0	107.8	103.1	92.5	105.7
Feet	5.35	7.11	3.65	8.93	8.44	2.00	8.98	8.59	7.71	8.81

Statistical Analysis

In an attempt to quantify the rarity of this extraordinary weather series, University of Oklahoma meteorologist, Sam Lillo, conducted a statistical study, where climate is static, comparing one million resampled winters. Mr. Lillo's study determined that the 2015 winter season has a return period of just over 26,000 years. In other words, Boston can expect a series of winter weather events with a 30-day stretch like the one experienced from late January to late February 2015 approximately once every 26,315 years (38 out of a million). For comparison purposes, Mr. Lillo ran the same study for the District of Columbia's "Snowmaggeddon" winter of 2009-2010. He

concluded the 2009-2010 winter for D.C. was only a 1 in 238 year occurrence, 110 times more likely than Boston's stretch of winter weather.

Figure 1.2: Statistical Frequency of Winter Weather Events Experienced by Boston from late January to Late February 2015



Temperatures[1]

As witnessed during late January into late February, snowfall was accompanied by sustained cold temperatures. As a result, a record 22 days experienced maximum temperatures below 32 degrees, with 15 consecutive days not getting above freezing. Boston recorded its second coldest February on record with an average high of 27.8 degrees. The average mean temperature for Boston during this time was 19.0 degrees, resulting in the second coldest month ever, after the February 1934 record of 17.5 degrees.

Figure 1.3: Temperature Data from Boston Logan (1/26/2015 to 2/28/2015)

[1] All temperatures are being reported in Fahrenheit.

Wind was also a factor this winter season. Blizzard-like conditions were recorded on January 27 and February 15. Extreme blowing and drifting snow resulted from gusts between 65 and 75 mph along the Massachusetts' coastline on January 27. Similar cascading effects were experienced on February 15, as wind gusted between 55 and 65 mph across the southeastern portion of the state. The above numbers validate the fact that the series of winter weather events sustained from late January through February 2015 brought unprecedented snowfall to the Commonwealth of Massachusetts accompanied by one of the coldest periods on record.

The above written weather summary was a joint effort between personnel at the National Weather Service (NWS) Office of Taunton and Ms. Caitlin Kelly, B.S. Meteorology. All record, snowfall, wind, and temperature data was derived from NWS sources. Both NWS Taunton and Ms. Kelly concur on the meteorological position taken in this summary regarding the month-long winter weather pattern from late January 2015 into late February 2015. Ms. Kelly received her Bachelor of Science degree in meteorology in 2007 from Millersville University of Pennsylvania. From 2007-2010, Ms. Kelly worked at NBC – Lancaster (WGAL-TV Channel 8), as a meteorologist and weather forecaster. During her tenure, Ms. Kelly was responsible for synthesizing complex technical data from surface and upper air stations, satellites and radar into cogent daily forecasts.

2. EMERGENCY PROTECTIVE MEASURES

In response to the extreme threat posed by the pattern of severe winter weather, the Massachusetts State Emergency Operations Center (SEOC) was activated to Level 3 (Full Activation) and remained operational for 28 consecutive days. The Governor directed the implementation of the state emergency operations plan and executed a number of emergency protective measures to ensure the health and safety of the residents of the Commonwealth.

At the local level, 122 cities and towns declared a local State of Emergency. Local Emergency Operations Centers (EOCs) were activated in 87 cities and towns, with many local jurisdictions closing government offices and schools, and implementing parking bans. Thirty-six local shelters were opened, many of which were supported by the American Red Cross.

Timeline

The following timeline chronicles State activities throughout the unprecedented pattern of severe winter weather.

EOC Activations

- SEOC open for 28 consecutive days
- 87 Local EOCs open

State of Emergency Declarations

- 01/26/15 1130: Gov. Baker issued State of Emergency Declaration
- 01/28/15 1730: Gov. Baker lifted the State of Emergency
- 02/09/15 1720: Gov. Baker issued State of Emergency Declaration
- 02/25/15 2000: Gov. Baker lifted the State of Emergency

Travel Bans

- 01/27/15 0000: Statewide travel ban went into effect.
- 01/27/15 1200: Travel ban lifted for the following counties: Berkshire, Franklin, Hampden and Hampshire; with the exception of the I-90 Turnpike.
- 01/28/15 0000: Statewide travel ban lifted.

High Water Rescue Asset Staging

- 01/26/15 2100: Massachusetts State Police (MSP) and Massachusetts Army National Guard (MANG) assets pre-staged in the following locations to assist communities with evacuations: Plum Island, Nahant, Quincy, Hingham, Plymouth and OTIS Air National Guard Base / Camp Edwards.
- 01/27/15 1900: MSP and MANG assets released from evacuation mission.
- 02/14/15 1700: MSP and MANG assets pre-staged in the following locations to assist communities with evacuations: Newburyport, Ipswich, Gloucester, Hull, Scituate and Sandwich.
- 02/15/15 2200: MSP and MANG assets released from evacuation mission.

Stranded Motorist Asset Staging

- 01/26/15: MSP, Massachusetts Environmental Police (MEP), and MANG assets pre-staged in the following locations to assist with stranded motorists: Andover, Bourne, Charlton, Concord, Danvers, Foxboro, Framingham, Holden, Leominster, Middleborough, Milton, Newbury, Northampton, Norwell, S. Boston, Springfield, Sturbridge, Weston, and Westover.
- 01/27/15 2300: MSP, MEP, and MANG assets released from stranded motorists mission.
- 02/14/15 2000: MSP, MEP, and MANG assets pre-staged in the following locations to assist with stranded motorists: Andover, Bourne, Concord, Danvers, Foxboro, Middleborough, Milton, Norwell, S. Boston, Springfield, and Weston.
- 02/15/15 1345: MSP, MEP, and MANG assets released from stranded motorists mission.

Emergency Medical Services Waivers

- 1/26/15 – 1/29/15: Staffing Waiver
- 1/26/15 – 1/29/15: Transport Waiver
- 2/8/15 – 2/10/15: Staffing Waiver
- 2/14/15 – 2/16/15: Staffing Waiver

108.6" of Snow
315,753 Miles Plowed
114,057 Tons of Salt Used
211,732 Hours Worked

Fuel Delivery Hours of Service Waiver

- 2/8/15 – 2/21/15: transport of gas, oil and natural gas
- 2/10/15 – 2/21/15: gasoline and diesel fuel
- 2/22/15 – 3/7/15: propane gas, heating oil, natural gas, diesel fuel and gasoline

Despite the deliberate and precise actions of the Commonwealth to prepare and position for a rapid recovery, unrelenting and continuous winter weather conditions overwhelmed the Commonwealth's capacity to respond requiring the support of both out-of-state and contracted resources.

Snow Removal Operations

Snow removal operations were a critical emergency protective measure that had to be continuously implemented throughout the duration of the severe winter weather pattern.

The unrelenting snow and nonexistent melting created dangerously high snowbanks along roadways and pedestrian routes that greatly inhibited line of sight and afforded little to no room for snow to be plowed from roadways. Each significant snow accumulation period further narrowed streets and roadways, rendering many of them impassable or nearly impassible for days at a time. Many urban areas were forced to convert streets narrowed by snow from two-way traffic to one-way travel.

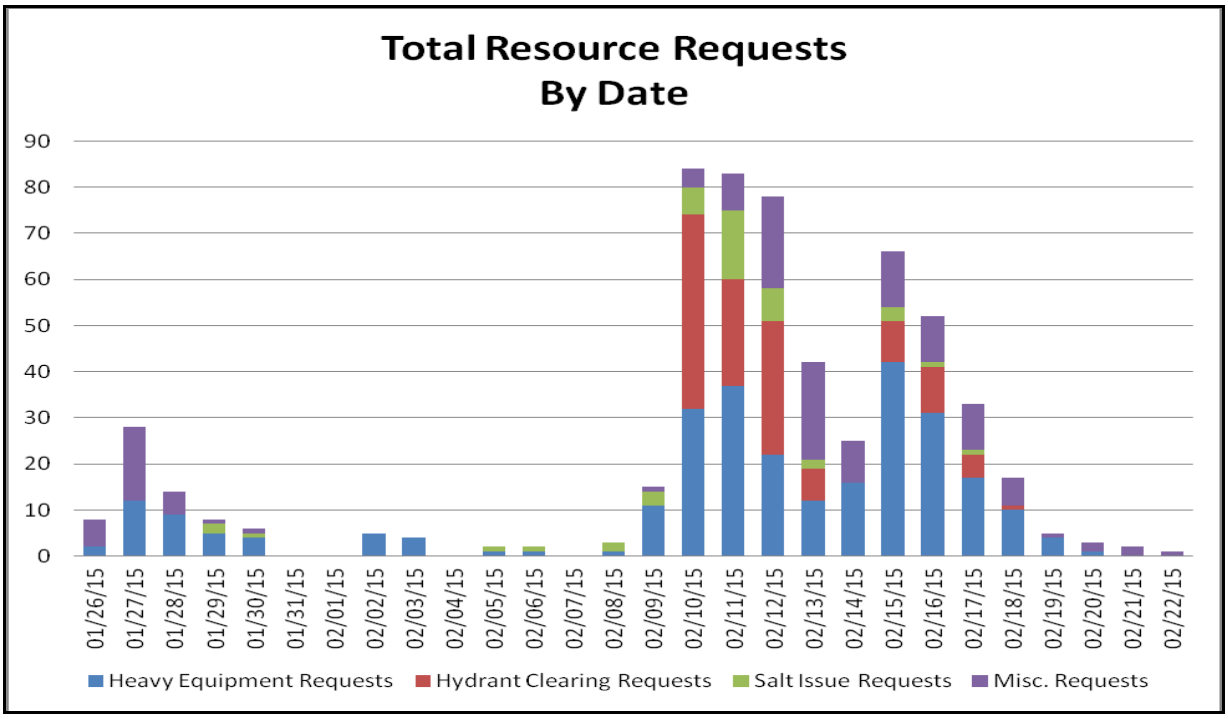
Sidewalks and pedestrian walkways remained unplowed for days and even weeks on end, creating significant life-safety issues by forcing pedestrians to walk the narrowed roadways, and requiring them to share this space with moving cars, plows and emergency response vehicles. In fact, six pedestrians were struck and killed by snow plows or moving vehicles during this time period.

The narrowed roadways also greatly impacted the flow of traffic; indeed, the narrowed streets in the City of Boston resulted in hours-long gridlock during morning and evening commutes in the days after each period of significant snowfall accumulation. These gridlock conditions created public safety issues as emergency vehicles were incapable of quickly navigating through traffic.

Requests for State Assistance

In all, the SEOC fielded and sourced a total of 586 resource requests received from 153 communities between January 26 and February 22. The nature of the resource requests are shown in the figure below.

Figure 2.1: Resource Requests for State Assistance



EMAC Support

Despite the deliberate and precise actions of the Commonwealth to prepare and position for a rapid recovery, unrelenting and continuous winter weather conditions overwhelmed the Commonwealth's capacity to respond requiring the support of both out-of-state and contracted resources. The SEOC was inundated with requests for resources to support clearing snow and opening roads and critical transportation routes. With essentially all in-state heavy equipment resources already engaged in snow removal operations, the Commonwealth was required to issue a request for resources through the Emergency Management Assistance Compact (EMAC).

As a result of this EMAC request, five states deployed a total of 151 pieces of heavy equipment from eight agencies to Massachusetts. Assistance was received from the following:

- Maine National Guard
- New Jersey Department of Transportation
- New York City Department of Sanitation

- New York State Department of Transportation
- New York Thruway
- Pennsylvania Department of Transportation
- Pennsylvania Turnpike
- Vermont National Guard

To manage the influx of heavy equipment resources into the Commonwealth, MEMA, in collaboration with the MANG, the Massachusetts Port Authority and the Massachusetts Department of Fire Services stood up a state staging area that operated on a 24/7 basis from February 11-22. This required a vast amount of support resources, including a Type III Incident Management Team, two mobile command posts, and numerous personnel to ensure the effective and timely deployment of equipment to the most heavily impacted areas of the Commonwealth.

Heavy Equipment from New York State Arriving at State Staging Area

Table 2.1 shows the support provided to the Commonwealth through the EMAC.

Table 2.1: EMAC Resource Support

EMAC STATE	Resource	Mobilization Date	Demobilization Date
NY Thruway	4 Dump Trucks, 3 Front End Loaders	02/11/2015	02/14/2015
NY State DOT	14 Dump Trucks, 15 Front End Loaders, 18 Skid Steers, 1 Large FEL w/blower	02/11/2015	02/23/2015
NY NYC	2 Snow Melters	02/11/2015	02/17/2015
NJ State DOT	10 Dump Trucks, 6 Front End Loaders, 12 Skid Steers	02/11/2015	02/23/2015
PA SEOC Support	10 personnel	02/13/2015	02/24/2015
PA State DOT	15 Dump Trucks, 3 Backhoes	02/12/2015	02/20/2015
PA Turnpike	5 Dump Trucks, 5 Backhoes	02/13/2015	02/20/2015
VT National Guard	12 Dump Trucks, 2 Front End Loaders, 2 Backhoes, 2 Skid Steers**,** 39 personnel	02/11/2015	02/23/2015
ME National Guard	10 Dump Trucks, 2 Front End Loaders, 4 Backhoes, 5 Skid Steers**,** 52 Personnel	02/12/2015	02/23/2015

Additionally, the Massachusetts Emergency Management Agency (MEMA) contracted with private vendors in two states to supply nearly 100 additional pieces of heavy equipment for emergency snow removal operations. The Massachusetts National Guard also deployed heavy equipment and soldiers to support snow removal operations.[2] The MANG was deployed in coordination with the SEOC, tasked with a total of 190 missions (183 Completed, 7 Cancelled) throughout the Commonwealth. MANG Mission highlights include: 7,382 fire hydrants cleared, over 120,564 yards of snow cleared, 2964 truckloads of snow removed, 52 bus stops shoveled, 174 miles of road cleared, and over 4 miles of MBTA track shoveled.

Snow being loaded into a National Guard Dump Truck
Deployed to Support a Massachusetts Community

MassDOT owns and operates approximately 2,150 miles of the 22,000 city/town owned roads in the most heavily impacted areas. At peak times throughout the severe weather pattern, MassDOT had 753 DOT personnel working, and continuously used over 3,000 pieces of contracted equipment. This level of engagement required MassDOT to spend 34% over their budget.

The MBTA was forced to suspend services system-wide on three occasions as a result of this persistent weather pattern and its record cold temperatures and repeated periods of significant snowfall. Even when some modes of transit were able to come back online, they ran far below normal service levels for weeks while the MBTA worked to recover from the impacts of the snow and cold. The resources of the MBTA for clearing snow and ice from tracks, railbeds, platforms, maintenance yards, bus stops, and commuter lots were significantly overwhelmed. The specialized equipment used for track clearing operations could not handle the large-scale, system-wide impacts, leaving the MBTA with the need to hand shovel accumulated snow, ice and snowdrifts from more than 15 miles of track. The SEOC supported MBTA by re-directing MANG crews, coordinating DOC crews on shoveling missions. Contracted support was also activated to support track clearing.

[2] By February 22, the MANG removed more than 120,000 yards and 3,000 truckloads of snow, clearing 52 Bus stops, 174 miles of road, and over 4 miles of MBTA track.

Personnel deployed to hand shovel 15 miles of MBTA rail track.

Snow Disposal Operations

Cold temperatures allowed for accumlating snowfall to quickly consume the landscape leaving no space to push and plow snow. It quickly became necessary to load and haul snow to dumping locations, or 'snow farms' to provide emergency access, open roads, and maintain public safety. As snow farms exceeded capacity, many communities were left with the last resort option of coordinating emergency requests with the Massachusetts Department of Environmental Protection (MassDEP) and the US Environmental Protection Agency for open water disposal of snow. The Commonwealth also coordinated the purchase of two snow melters to facilitate snow removal and disposal operations.

3. DAMAGE AND COST ESTIMATES

Initial Damage Assessment (IDAs) for January 26-28 Severe Winter Weather

In the days immediately following the emergency response to the severe winter storm of January 26-28, the Massachusetts Emergency Management Agency (MEMA) began to assess the impacts to help determine whether federal disaster assistance may be warranted. The Commonwealth's damage assessment efforts were focused on collection of emergency response costs and repair of physical damages to public infrastructure resulting from this incident to determine if the most heavily impacted areas of the State may qualify for FEMA's Public Assistance (PA) disaster assistance.

Immediately following the blizzard of January 26-28, MEMA sent IDA forms to all municipal emergency management directors and state agencies in the most heavily impacted areas (the ten counties included in this disaster declaration request). The IDA forms asked for initial estimates of storm related costs and damages in the following FEMA categories of work:

- Category A - Debris clearance and removal, including overtime and equipment costs associated with clearing downed trees, limbs and poles from roadways, sidewalks and public infrastructure;
- Category B - Emergency response and protective measures, including first responder overtime and equipment costs, fuel costs, shelter costs, etc.

  - Local communities and state agencies were asked to report snow removal costs separately for a continuous 48-hour period (including snow removal, de-icing, salting and sanding of roads, etc.) in accordance with the requirements of FEMA's Snow Assistance Policy (DAP 9523.1).

- Categories C thru G - Repair and replacement costs associated with storm damage to roads, bridges, seawalls, piers, culverts, government owned buildings, utilities and other public infrastructure.

As part of the IDA process for the January 26-28 blizzard, local communities and state agencies reported more than $87 million dollars in estimated costs for snow removal, permanent repair of physical damages and other potentially eligible PA costs. Based on MEMA's analysis of this IDA data, it appeared that the required PA damage cost thresholds in all ten counties were exceeded.

FEMA/State Joint Preliminary Damage Assessments (PDAs)

On February 9, MEMA initiated the second step in the damage assessment process and requested that FEMA conduct joint preliminary damage assessments (PDAs) to verify and validate reported costs. From February 17 and continuing through March 2, MEMA, in conjunction with FEMA, conducted more detailed PDAs to verify reported costs for January 26-28 and to confirm that the state will be eligible to request federal disaster assistance under the FEMA PA program.

The PDA process entailed sending damage assessment teams, comprised of state and federal technical experts, to those communities and state agencies that reported the most significant storm related costs and damages on their IDA forms. PDAs were not conducted in each and every community – generally assessments were completed for those areas that reported the most significant costs with the goal of exceeding federal damage dollar thresholds as quickly as possible in support of a request for federal disaster assistance. During these PDAs, the FEMA/State PDA teams viewed damages, as well as examined local and state financial records to verify and validate reported costs.

The results of the FEMA/State Joint PDAs conducted for the January 26-28 blizzard are presented in Table 3.1 below. More than $35 million in costs associated with damages and emergency protective measures (including snow removal costs) were verified and validated by FEMA as part of the FEMA/State Joint PDAs. It is important to note that once the FEMA/State Joint PDA teams verified that county and state costs exceeded the minimum per capita thresholds of each county as well as the $9,232,157 statewide threshold, the PDA process stopped; therefore not all $87 million of reported costs were reviewed. Accordingly, the PDA figures do not represent the total magnitude and economic impact of this disaster.

Table 3.1: Summary FEMA/State Joint PDA Total Estimates by PA Category of Work

JOINT PDA ESTIMATES FOR JANUARY 26-28 SNOWFALL									
County	**PA Threshold**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**TOTAL**
Barnstable	*$768,561.28*		$1,787,192						$1,787,192
Bristol	*$1,951,894.60*		$2,517,943						$2,517,943
Dukes	*$58,864.60*		$104,022						$104,022
Essex	*$2,645,646.04*		$4,149,796				$60,310		$4,210,106
Middlesex	*$5,350,982.60*		$6,916,469					$3,239	$6,919,708
Nantucket	*$36,212.32*						$144,166	$1,200,000	$1,344,166
Norfolk	*$2,388,226.00*		$3,370,742			$5,000			$3,375,742
Plymouth	*$1,761,911.64*		$2,905,082	$165,200		$65,355		$2,767,645	$5,903,282

JOINT PDA ESTIMATES FOR JANUARY 26-28 SNOWFALL									
County	**PA Threshold**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**TOTAL**
Suffolk	*$2,570,401.88*		$5,347,398						$5,347,398
Worcester	*$2,842,845.12*		$3,661,691						$3,661,691
Total Estimates		*$0*	*$30,760,335*	*$165,200*	*$0*	*$70,355*	*$204,476*	*$3,970,884*	*$35,171,250*
% of total		0%	87.46%	0.47%	0%	0.20%	0.58%	11.29%	

Total Estimated Costs Associated with the Severe Winter Weather Pattern (January 26 through February 22, 2015)

As a result of the continued snowfall throughout the month of February 2015, local communities and state agencies continued to incur significant costs associated with implementing emergency protective measures including snow removal operations and other actions to protect public health and safety. The tremendous snow accumulations also caused additional physical damages to public infrastructure such as building, equipment and utilities.

MEMA recognized that these additional costs and damage estimates would not be captured in the ongoing FEMA/State Joint PDAs; therefore on February 26, MEMA engaged in an effort to gather all costs associated with the entire severe weather pattern of January 26 through February 22. MEMA conducted a second IDA process to collect cumulative cost data related to the severe weather pattern. As part of this cumulative IDA process, MEMA again requested that cities, towns and state agencies in the most heavily impacted area (the same 10 counties included in this disaster declaration request) report their costs for snow removal and other FEMA PA categories of work. The cumulative IDA forms asked for initial estimates of storm related costs and damages in the following FEMA categories of work:

- Category A - Debris clearance and removal, including overtime and equipment costs associated with clearing downed trees, limbs and poles from roadways, sidewalks and public infrastructure;
- Category B - Emergency response and protective measures, including first responder overtime and equipment costs, fuel costs, shelter costs, etc.
    - To understand the true scope and magnitude of the impacts of this severe winter weather pattern, local communities and state agencies were asked to report 100 percent of their eligible snow removal costs in approximately one week increments that coincided with the most significant snowfall accumulations occurring between January 26 and February 22.
- Categories C thru G - Repair and replacement costs associated with storm damage to roads, bridges, seawalls, piers, culverts, government owned buildings, utilities and other public infrastructure.

As detailed in Table 3.2 below, the overwhelming majority of cumulative costs reported for January 26 to February 22 were directly related to implementing emergency protective measures in the form of snow removal operations. This included emergency protective measures costs in the form of snow removal (by both force account overtime as well as hired equipment), plowing, sanding and salting of roads, and establishment and operation of 'snow farms'. Of the total $393 million in estimated PA costs reported by cities, towns and state agencies for January 26 through February 22, more than $343 million of this (or 87%) was related to emergency protective measures associated with snow removal.

Table 3.2: Total Estimated Cumulative Costs/Losses (Jan. 26th to February 22nd 2015)

County	FEMA Categories of Work (A-G)	Additional Emergency Snow Removal Costs	Total
Barnstable	$1,906,496	$7,082,417	$8,988,914
Bristol	$1,295,296	$13,266,559	$14,561,854
Dukes	$63,545	$366,809	$430,354
Essex	$5,370,566	$30,630,184	$36,000,750
Middlesex	$8,439,215	$63,596,775	$72,035,991
Nantucket	$4,346	$330,454	$334,800
Norfolk	$6,315,240	$38,475,007	$44,790,247
Plymouth	$3,814,758	$16,785,375	$20,600,134
Suffolk	$1,483,217	$29,328,898	$30,812,115
Worcester	$1,263,437	$19,159,354	$20,422,791
State Agencies	$19,985,717	$124,580,130	$144,565,847
TOTAL	**$49,941,834**	**$343,601,963**	**$393,543,796**

When compared against damages verified as part of the previous FEMA/State Joint PDA, this cumulative IDA damage cost data revealed substantially more in snow removal costs and estimated damages reported for other FEMA PA categories of work. More specifically, the cumulative IDA data shows significant damages reported and cost estimates for permanent repair work reported in Category D (Water Control Facilities), Category E (Buildings, Contents and Equipment), Category F (Utilities) and Category G (Parks , Recreation and Other). Additional information regarding reported damage estimates for these categories of permanent repair work can be found below.

Anticipated Permanent Repairs (FEMA Category C through G) for January 26 through February 22

Based on the damage cost data collected during the IDA for January 26 through February 22, the Commonwealth estimates that there is $28,723,779 in anticipated permanent work.

Table 3.3: IDA Cost Estimate Data (Categories C-G)

	CATEGORY C (Road Systems and Bridges)	CATEGORY D (Water Control Facilities)	CATEGORY E (Buildings, Contents and Equipment)	CATEGORY F (Utilities)	CATEGORY G (Parks, Recreation and Other)	Total
Joint FEMA/State PDA Estimates	$165,200	$0	$70,355	$204,476	$3,970,884	$4,410,095
Jan. 26-Feb. 22 IDA Reported Estimates	$1,938,994	$651,571	$17,806,859	$1,090,352	$2,825,088	$ 24,313,684
Totals	$2,104,194	$651,571	$17,877,214	$1,294,828	$6,795,972	$28,723,779

Collapsed buildings and structures contributed to a 25,310% increase in Category E (Buildings, Contents and Equipment) costs when compared to the costs captures in the FEMA/State Joint PDA process.

Cumulative State Agency and Authority Cost Estimate Data

During the IDA data collection process, 21 state agencies and authorities reported costs associated with responding to the incident and estimates for future repairs. The Massachusetts Department of Transportation Highway Division (MassDOT), Massachusetts Bay Transit Authority and the Massachusetts Port Authority (MassPort) represent 86% of the total state agency expenditures from January 26 through February 22 and comprise approximately 94% of the emergency road and rail clearing activities.

Table 3.4: State Agency Cumulative Cost Data

	Emergency Snow Removal (Additional Cat B)	Traditional A-G	Total
MassDOT	$87,292,544	$2,089,915	$89,382,459
MBTA	$16,914,220	$5,500,024	$22,414,245
MassPort	$12,839,652	$ 515,882	$13,355,534
All Other	$ 7,533,712	$11,879,894	$19,413,607
Total	**$124,580,130**	**$19,985,717**	**$144,565,847**

It is important to note that these figures are only estimates and will be refined by local governments and state agencies over the next several months. An example of this is the MBTA, which reported nearly double the damage costs in their second IDA report.

> *"To date, we have identified approximately $40 million in projected storm costs that include labor, equipment, materials, police, and supplemental bus services. Of this amount, approximately $4.7 million is attributed to revenue loss. The full cost of the storm impacts and recovery are likely to exceed these amounts."*

Annual Snow Removal Budget Comparison – Cities and Towns

As described in Section 1 – Weather/Meteorology, the Commonwealth receives snowfall each winter season, and state agencies along with cities and towns establish annual budgets for snow removal activities. The Massachusetts Department of Revenue, Division of Local Services estimates that "over the previous three years, snow and ice budgets for Massachusetts cities and towns have averaged about $90 million."

In an effort to demonstrate the uniqueness of this severe winter weather pattern, the Massachusetts Municipal Association (MMA) issued a statewide survey on February 25, 2015 asking all 351 Massachusetts communities how much they budgeted for snow removal activities versus how much they had expended (as of March 1, 2015). This statewide snow and ice budget and expenditure data from MMA was 'filtered' to only examine the survey responses from the 249 cities and towns located in the counties eligible for FEMA snow assistance. Of the 249 communities in these counties, 142 responded to the MMA survey – a 57 percent response rate. The purpose of obtaining this data was to compare snow and ice budgets against estimated expenditures for snow removal activities for the winter of 2014/2015.

Table 3.5 illustrates that the cumulative budgets for the 142 cities and towns for the current season is $68,690,551 whereas expenditures totaled $164,861,781 - an overage of $96,171,230 or approximately 1.4 times what was budgeted.

Table 3.5: Snow Removal Costs for Cities and Towns: Budgeted versus Actual

FY15 Budget	Actual Expenditures	Overage ($)	Overage (%)
$ 68,690,551	$ 164,861,781	$96,171,230	140%

As stated by the Department of Revenue – Division of Local Services, the impacts on overspending on snow and ice removal have deep impacts within the community.

> *"Although snow and ice accounts may be legally overspent under Massachusetts municipal finance laws, communities must either appropriate from limited reserves to cover the shortfall or provide for the deficit in the tax rate of the following year. In either case, expenditures of this magnitude will cause communities to deplete precious, one-time reserves, or reduce spending on local priorities such as education and public safety to finance these deficits. Drawing down limited reserves to cover the overspending will not be viewed favorably by the municipal bond rating agencies, potentially increasing the cost of borrowing for communities going forward. In instances where communities reduce other local budgets to finance the deficit, there is added risk that the community will not be able to meet minimum state spending requirements on education."*

Annual Snow Removal Budget Comparison – State Agencies and Authorities

As described in the preceding section on cities and towns, state agencies and authorities also budget for snow and ice removal annually. Between January 26 and February 22, the state agencies and authorities exceeded their budgeted amount by an average of 208% as illustrated in Table 3.6.

Table 3.6: Snow Removal Costs State Agencies: Budgeted versus Actual

	14/15 Snow and Ice Budget	Actual Snow Removal Costs	Overage ($)	Overage (%)
MassDOT	$57,355,389[3]	$143,017,305[4]	$85,661,916	149%
MBTA	$3,400,000	$16,914,220	$13,514,220	397%
Massport	$7,240,271	$12,839,652	$5,599,381	77%

4. FATALITIES, INJURIES AND HEALTHCARE IMPACTS

The severe winter weather pattern created significant public health and safety threats. Based on data provided by the Massachusetts Office of Chief Medical Examiner (OCME) and the Massachusetts Department of Public Health (MDPH), the severe weather resulted in loss of life, injuries, and impacted

Public Health Impacts
25 Fatalities
1,320 Falls
181 Cold Exposure

[3] MassDOT statewide budget figure includes $8.7M from toll funded roads and $48.6M in State funds.
[4] Statewide snow & ice expenditures as of 3/18/2015.

emergency medical services and healthcare facilities.

Fatalities

The extreme cold temperatures and record breaking snow accumulation created hazardous conditions that contributed to the weather related deaths of 25 people between January 26 and March 12, 2015.

Based on data provided by the OCME for the Commonwealth, 17 fatalities resulted from blunt trauma injuries sustained in relationship to emergency road clearing activities, clearing of private property to prevent roof collapses or icy conditions. The exact numbers of fatalities resulted from weather-related blunt force trauma incidents are as follows:

- 4 pedestrians struck by snow plows
- 2 pedestrians struck by motor vehicles
- 2 while setting up towing of motor vehicles
- 2 fell off roof while clearing snow
- 1 fell on ice while clearing snow
- 1 fell down steps while clearing snow
- 1 driver of car struck front-end loader clearing snow
- 1 fell through skylight while assessing snow removal
- 3 slipped on ice

An additional eight (8) fatalities were attributed to cardiac episodes during snow removal activities.

Injuries

Hospitals and urgent care centers around the Commonwealth treated numerous injuries to individuals throughout the severe weather pattern that were directly attributable to the hazardous conditions during and created by the severe winter weather pattern.

Based on data collected by the Massachusetts Ambulance Trip Recovery Information System (MATRIS), there were a total of 1,320 individuals transported to area hospitals with blunt force trauma injuries related to the impacts of the weather pattern, and an additional 181 individuals transported with symptoms of exposure related to the cold temperatures.

Healthcare Impacts

Impacts to Emergency Medical Services

Further exacerbating the issues associated with the injuries sustained by the public and caused by the hazardous conditions were the impacts to the Emergency Medical Services (EMS) vehicles transporting those in need of urgent care.

Delays: Based on data collected by the Massachusetts Ambulance Trip Recovery Information System (MATRIS), which collects EMS trip data, during the most heavily impacted days throughout the severe weather pattern, there were 964 ambulance runs with weather-related delays on one or more legs of each run. These included 574 response delays, 214 on-scene delays, and 425 transport delays.

Emergency Medical Services Waivers: Under M.G.L. c. 111C Section 22, the Commissioner of the Department of Public Health acted on her authority to issue waivers of certain regulatory requirements for ambulance services. These waivers loosened ambulance staffing requirements to allow an increased number of ambulances to operate at the paramedic level, and authorized transport to alternate care facilities such as shelters. The transport waiver was issued for the period from January 26 through January 29. The staffing requirement waiver was issued February 8 through February 10, and again on February 14 through February 16.

Impacts to Healthcare Facilities

Healthcare facilities throughout the region were tremendously impacted by this winter weather pattern. Staffing – both direct clinical care givers and support staff - was especially challenging given the major service disruptions to the MBTA system. Hospitals, nursing homes and long-term care facilities had to take extraordinary steps to accommodate staff and meet clinical care responsibilities. This included multiple clinical care shifts with associated overtime costs, providing taxi vouchers, and in some cases providing hotel rooms for staff. In the most extreme cases police officers were required to transport doctors and nurses to their medical care facilities.

These facilities also incurred substantial snow removal costs associated with maintain system availability, and suffered damages associated with roof collapses and frozen pipes. For example, Brigham and Women's Hospital, which is a major teaching hospital in Boston, expended $400,000 clearing snow and ice, and saw overtime increases of $700,000 due to the inability to bring in personnel for regular shifts while suffering $10M in lost revenue for factors such as cancelled elective surgery as well as reduced general admissions, outpatient services and visitors. Another Boston hospital, Faulkner Hospital, spent approximately $560,000 clearing snow and ice between January 26 and February 22.

Table 4.1: Estimated Costs from Several Boston Area Hospitals

Institution	Category	Direct Costs	Other
Brigham and Women's Hospital	Overtime	$ 700,000	
	Snow removal (main campus)	$ 400,000	
	Lost revenue		$ 10,000,000
	Excess utilities		$ 300,000
	Subtotal	**$ 1,100,000**	**$ 10,300,000**
Faulkner Hospital	Snow Removal (Jan/Feb)	$ 561,000	
	Snow Removal (Ongoing/March)		$ 84,000
	Overtime (TBD)		
	Subtotal	**$ 561,000**	**$ 84,000**
Massachusetts General Hospital	Overtime	$ 1,329,023	
	Snow Removal (Purchased)	$ 670,000	
	Taxi and hotel fees	$ 14,800	
	Subtotal	**$ 2,013,823**	**$ -**
Partners IS	Overtime	$ 23,500	
	Building/Roof Damage	$ 17,500	
	Subtotal	**$ 41,000**	**$ -**
	Totals	**$ 3,715,823**	**$ 10,384,000**

5. PROPERTY AND INFRASTRUCTURE DAMAGE

A significant amount of infrastructure was damaged as a result of the persistent severe weather pattern. Extreme snowfall accumulations and bitterly cold temperatures contributed to hundreds of roof and building collapses as well as the failure of a city's sewer system. In addition, wind and storm surge contributed to the destruction of piers and seawalls.

Building Collapses

The impacts to private property can be most notably illustrated by the 270 reported incidents of collapsed structures and significant damage. Residential homes, outbuildings (barns, garages) and commercial/industrial structures (grocery stores, churches, ice skating rinks, and warehouses) caved under the weight of high accumulations of snow and ice. Table 5.1 describes in greater detail the number of collapsed structures by category.

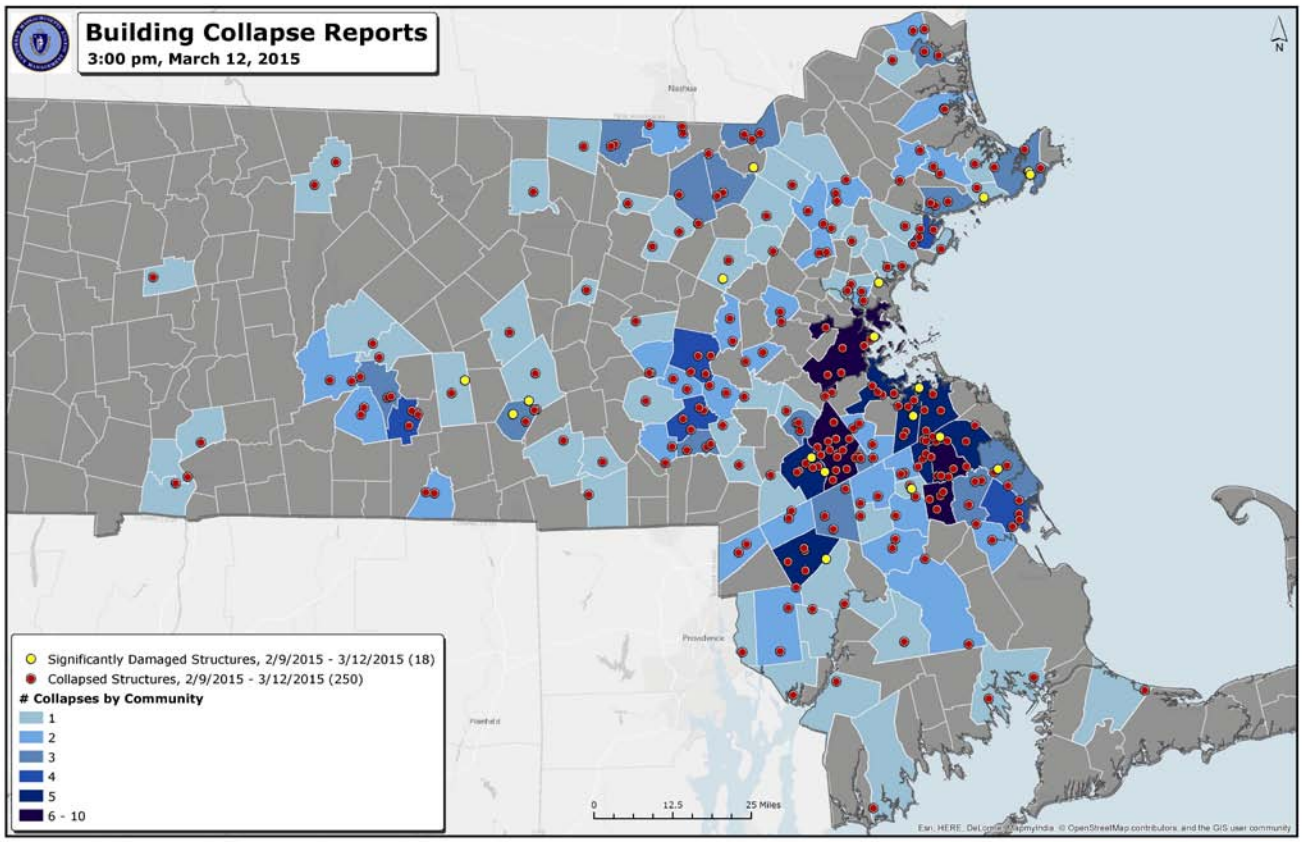
Table 5.1: Collapsed Structures

Classification	Collapsed Structures
Residential Home or Outbuilding	132
Commercial/Industrial	89
Private Non-Profit/School	6
Local/State	5
Federal	1
Unspecified	37
Total	**270**

The snow load and roof collapse issues were so unusual and extreme that on Thursday February 26, 2015 the FEMA Building Science Branch of the Flood Insurance and Mitigation Administration (FIMA) sent a team of engineers and architects to several Massachusetts communities to investigate roof damage and partial collapses of public school buildings. This team conducted a focused forensic investigation on the roof failures that occurred due to the excessive snow accumulation for the severe winter that impacted Massachusetts. The team was comprised of FEMA Building Sciences Branch subject matter experts, an architect, and structural engineers with specific expertise in roof snow loading - these teams were also accompanied by local officials and State building inspectors from the Massachusetts Department of Public Safety. These investigations by the FEMA Building Sciences Branch highlight the truly historic nature and cumulative impacts of these weather events on structures in Massachusetts.

Figure 5.1 illustrates the widespread nature of the collapses throughout eastern Massachusetts. Throughout the Commonwealth, numerous communities experienced building collapses and responded with emergency medical and law enforcement services to examine the structure, secure the area, and conduct searches of the area.

Figure 5.1: Structures Collapses throughout the Commonwealth



In addition to the safety concerns for those in and around those structures at the time of collapse and beyond, some collapsed structures presented additional public health and safety threats due to the use of the facility or in some cases the sheer size of the facility. Table 5.2 provides examples of collapsed structures that posed on-going threats to the public:

Table 5.2: Examples of Collapsed Structures that Pose Ongoing Threats to the Public

Category	Name	Description
Commercial/Industrial	Former chemical processing facility	Approximately 50x300 FT. with complete roof / building collapse and numerous drums inside of unknown material.
State	Hopkinton Mass DOT Salt Shed	One of the two salt barns at the MassDOT Hopkinton Depot collapsed.
School	Mitchell Elementary School	Approximately 40,000 Ft^2 school home to 1,200 students partially collapsed.
Local	Manchester-By-The-Sea Water Filtration Plant	Snow load on the roof has caused damage to the water filtration plant, resulting in the plant needing to be shut down.

Plum Island Sewer System

The combination of extreme cold and deep snowpack also contributed to the failure of the City of Newburyport's sewer system on Plum Island. The City's air-vacuum sewer system serves hundreds of local residents. This system experienced frozen valve pits and feet of accumulated snow blocked air vents which are required to keep

the pressurized system operational. The failure of the system resulted in sewer back-ups into dozens of homes, and a prohibition on the use of water for basic household needs. Residents were urged to refrain from using water, including flushing toilets, doing laundry and taking showers until the system function was restored. The system was impacted for approximately 4-weeks and resulted in the City placing approximately 60 households into local hotels for approximately 2-weeks. To assist impacted residents, an information center was established and staffed by City officials as well as representatives from the American Red Cross, Massachusetts Division of Insurance, State and local public health officials, Massachusetts Department of Housing and Community Development and the Massachusetts Emergency Management Agency.

Nantucket Industrial and Recreational Pier

On Nantucket, a town-owned pier with more than 100 boat slips was severely damaged. This pier is one of the busiest on the east coast of the United States during the summer and serves both commercial and recreational users. Preliminary damage estimates collected during FEMA's Preliminary Damage Assessment (PDA) process indicate that the cost of repair to the pier and associated pump-out facilities is approximately $1.2 million dollars.

6. TRANSPORTATION IMPACTS

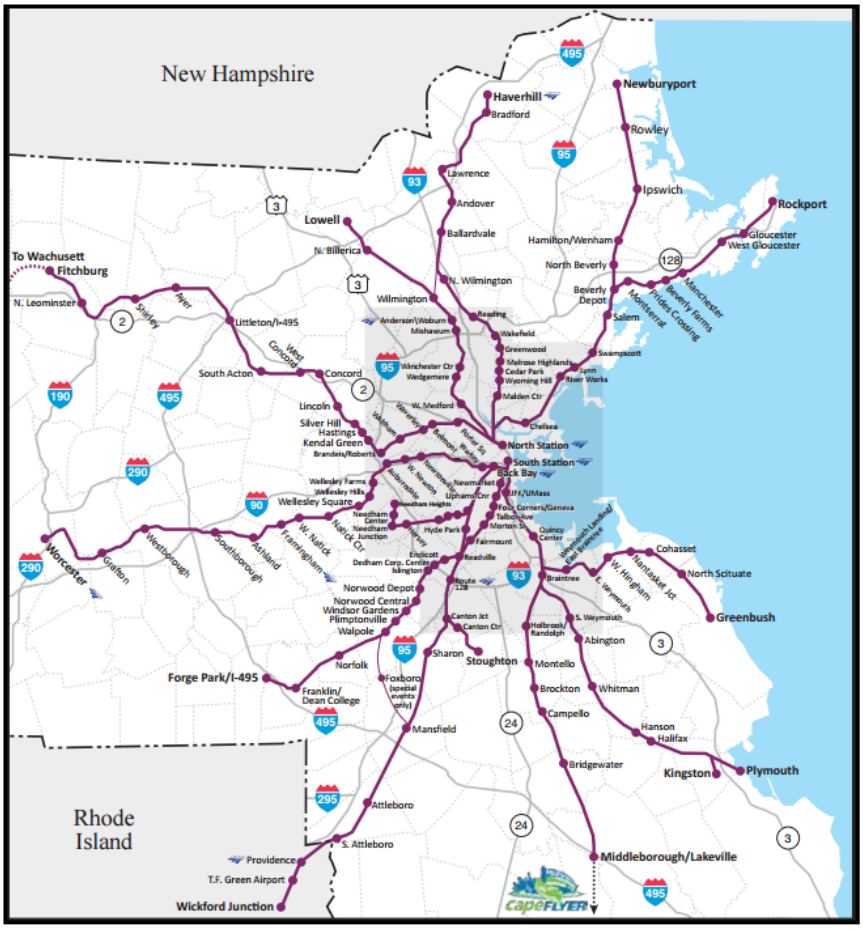
Massachusetts Bay Transportation Authority (MBTA)

The Massachusetts Bay Transportation Authority (MBTA), the country's fifth largest mass transit system, provides public transit service to 176 cities and towns with an area of 3,249 square miles and a total population of nearly 5 million. The MBTA system includes a number of transit modes, including three rapid transit lines and five light rail lines, four trackless trolley lines, 13 commuter rail lines, 183 bus routes, paratransit service, and ferry service. The MBTA has a large ridership that relies on its services to get to and from work each day, including healthcare professionals. Average weekday ridership for the entire MBTA system is approximately 1.3 million passengers. The following tables and figures describe the MBTA service area and ridership statistics.

Table 6.1: MBTA Service Area

MBTA Service Area Statistics	
Cities and Towns	176
Size in Square Miles	3,249
Population (2010)	4,812,658

Figure 6.1: MBTA Ridership Area



The MBTA, more commonly known as “The T”, is woven into the fabric of the community it services much like “The Metro” is to Washington, D.C. or the “The L” is to Chicago. For the residents of eastern Massachusetts, the transportation services provided by the MBTA are akin to other essential public utility services like water, sewer or electric power. In addition, a large percentage of the workforce who are employed by organizations located in Boston use public transit to commute to work. As such, disruptions to the MBTA for extended periods of time bring social, economic and public safety impacts to the region.

Table 6.2: MBTA Profile

MBTA Service Area Profile Statistics	
1.297M riders per weekday (FY2013)	**25%** of riders do not have access to a vehicle
23% of riders on the commuter rail system utilize multiple public transportation systems on trip	**30%** of riders use MBTA to get to work or school

MBTA Service Area Profile Statistics	
40% of riders have a household income of less than $40,000; and **17%** with a household income less than 20,000	Population proximity within ½ mile of MBTA stations: **2M** – Bus **665K** – subway/light rail **700K** – commuter rail

Extensive Service Disruptions as A Result of Severe Weather Pattern Impacts

Record breaking snow accumulations, wind, and brutally low temperatures not only buried MBTA stations, tracks, switches, equipment, bus yards and shops, but also resulted in significant freezing throughout the system. Snow and ice covered the subway system's third rail – the rail that provides power to the train cars on the tracks – and caused traction motor failures, resulting in power losses to trains. In addition, switches failed throughout the heavy rail and commuter rail networks, and ice encased vehicle doors, freezing them shut. Ice and snow on the brakes of commuter rail trains delayed the necessary inspections needed to operate trains. While, these challenges are not new to the MBTA, they are normally addressed on a much smaller scale and cause only minor and intermittent service disruptions; record snowfall and cold temperatures in a condensed period of time, created system-wide interruptions and failures from which the MBTA is still actively working to recover.

The impacts from the severe winter weather pattern crippled the infrastructure and the vehicle fleet forcing an unprecedented complete shutdown of the transit system. **The MBTA completely shut down revenue service on three separate occasions** to clear tracks, switches and rights of way, shovel out maintenance and storage facilities, and repair/replace critical component parts that were damaged, some beyond repair.

The closures coupled with lingering, widespread, system-wide interruptions compromised the ability of the public to resume daily activities and impacted employers across the Commonwealth. Based on an interview with MBTA staff, the system is still not operating at 100 percent as of the publication of this document; however they anticipate a full recovery by April 30, 2015, more than 3 months after the initial impacts to the system in late January.

People were both inconvenienced and placed at great risk trying to access a transit system that was crippled for weeks on end. Service disruptions resulted in long waits for commuters in adverse weather conditions, pushing them into the roadways in the countless locations where bus stops and sidewalks were buried in snow. The disastrous impacts to the subway and light rail systems forced riders onto alternate shuttle buses, which further congested highways and local roads. Even when some modes of transit were able to come back online, service was severely impacted as they ran far well below normal service levels for weeks while the MBTA worked to recover from the impacts of the snow and cold.

Rail Performance – Heavy Rail

Both heavy and light rail operations were grossly impacted as a result of the serve winter weather pattern. The compounding effects of snow and cold temperatures crippled the outdoor portions of the rail system, forcing long-term service suspensions and significant delays.

The graphs below provide a snapshot of the percentage of train cars in operation between January 15 and March 10, 2015. A rate of 100% means that the MBTA was able to run a full complement of trains during peak-hour service. A rate over 100% indicates additional service was added. The black bars indicate a system-wide suspension of service.

Figure 6.2: Weekday Morning Peak Service for MBTA Subway System

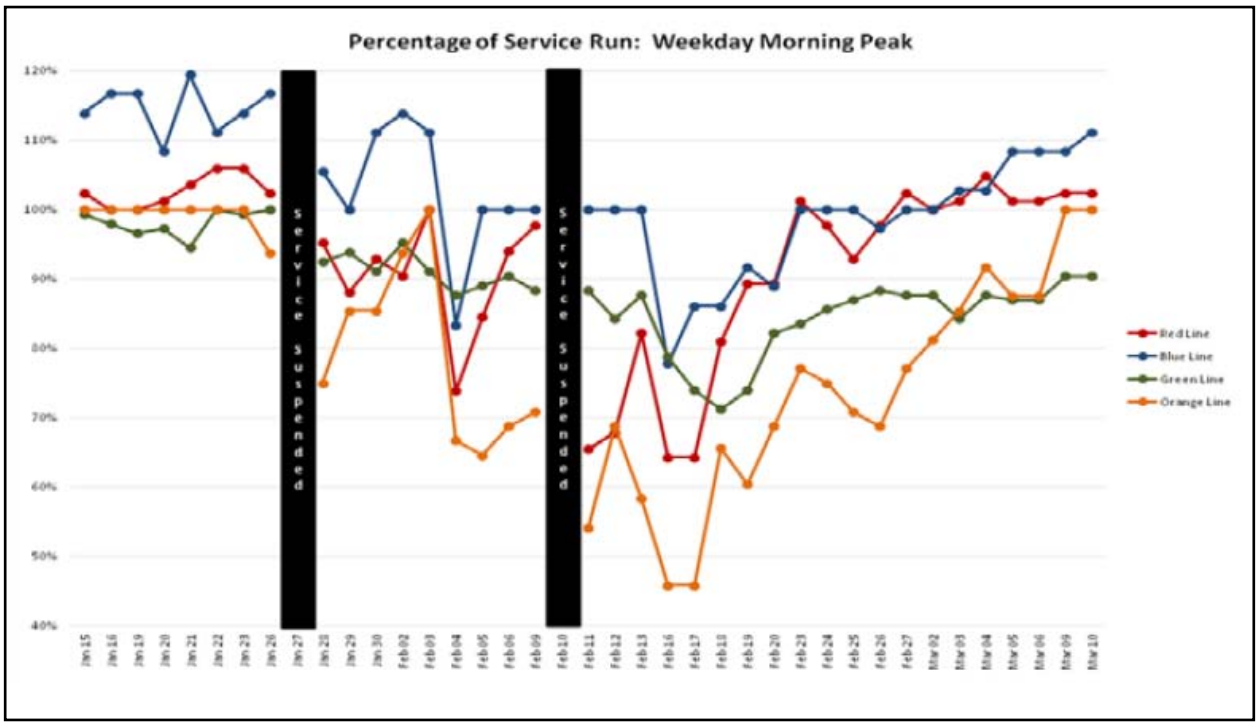
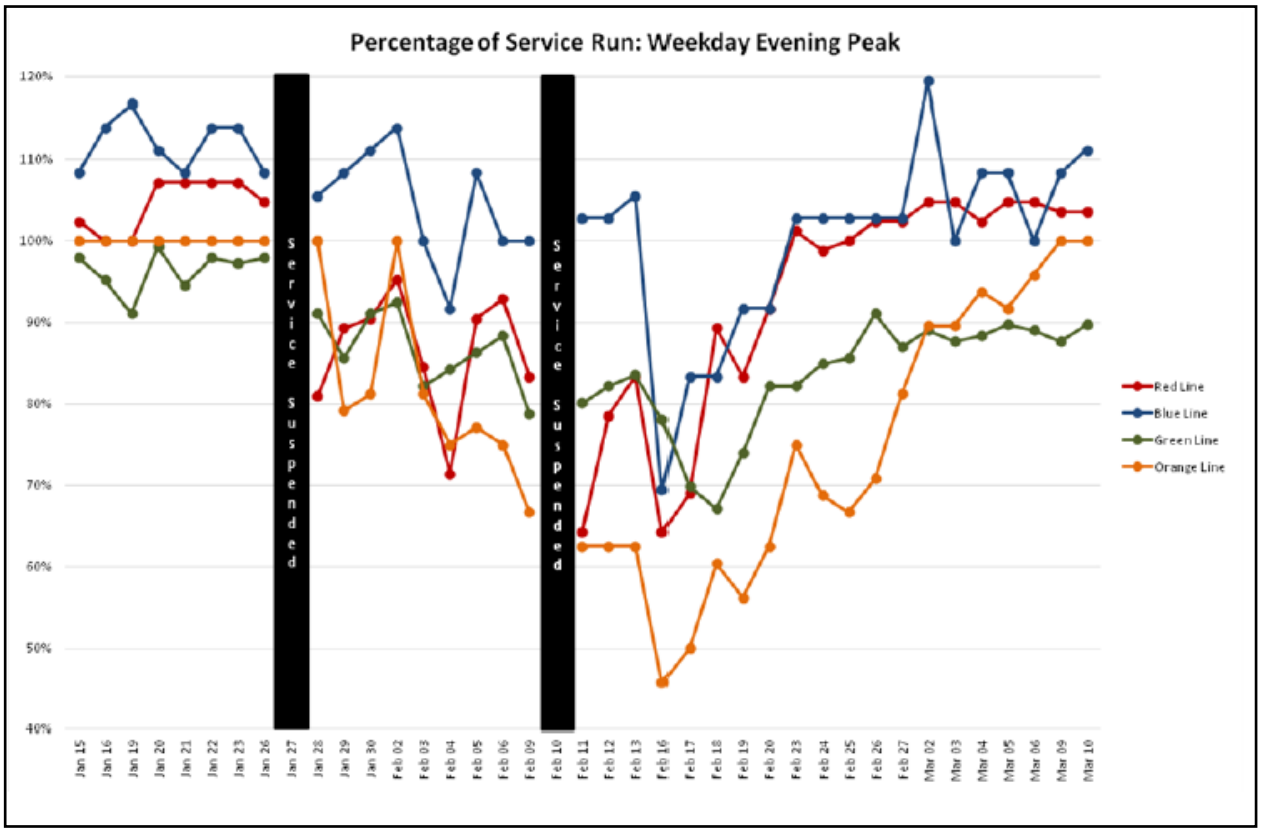
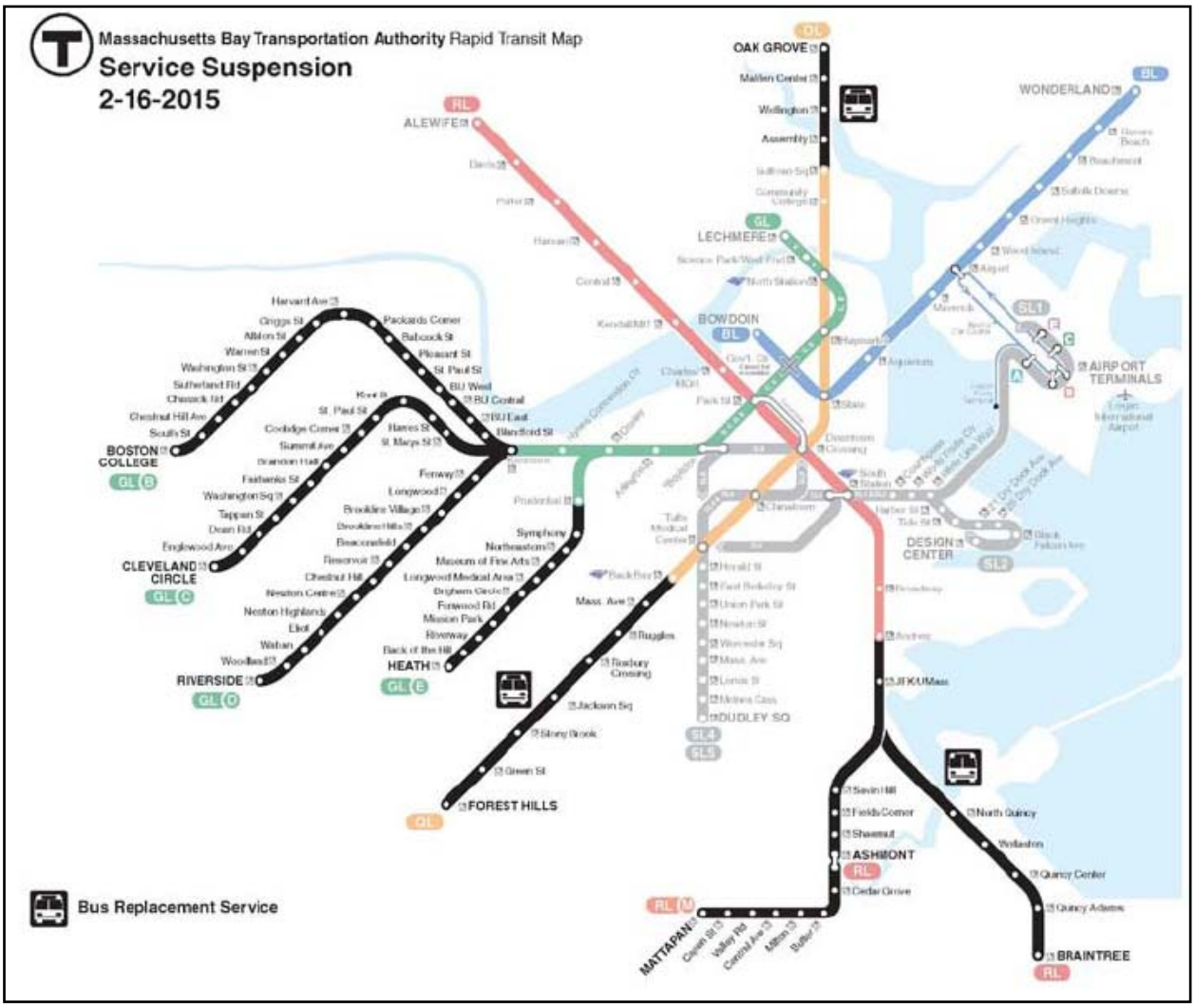


Figure 6.3: Weekday Evening Peak Service for MBTA Subway System



The graphic below of the MBTA subway system on February 16, 2015 depicts the peak of ongoing service disruptions for the subway and light rail systems: lines colored in black show the areas and subway lines that suffered complete service suspensions. This extent of disruption continued for two days before small portions of service began to be recovered.

Figure 6.4: Peak Service Disruption on MBTA Subway System



During the period from January 27, 2015 through February 28, 2015, buses provided alternate service on many rail lines that were unable to operate. In addition to the MBTA buses that provided alternate service throughout this period, private carriers also assisted from February 12 through February 21.

Red Line

The Red Line runs through Boston from north to south, beginning at Alewife Station in Cambridge and then splitting into two southern branches ending at Ashmont Station in the Dorchester neighborhood of Boston, and Braintree Station in the City of Braintree. Trains run above ground along the two southern branches, with the Ashmont Branch running 2.9 miles in length and the Braintree Branch running 8.8 miles.

The Red Line provides more than 270,000 unlinked trips on a typical weekday, with 30,161 riders entering the system along the Braintree Branch, and 19,441 riders entering the system along the Ashmont Branch.

Service Impacts: The Red Line experienced severe service disruptions in the four weeks between January 26, 2015 and February 22, 2015 as a result of snow and ice accumulation on the tracks. In addition, cold temperatures, and snow and ice caused numerous equipment failures, particularly with traction power motor units (67 units) and propulsion line choke failures (13 units). The Red Line operated at reduced peak service levels on most weekdays in the four weeks following the initial snowfall associated with the severe weather pattern. The impact on service to above-ground stations on the Ashmont and Braintree lines were particularly severe. In addition to the three dates when all MBTA rail service was suspended (January 27, February 10, and February 15), train service along the Ashmont Branch was suspended and replaced by limited shuttle bus service on February 7, 9, and 16. Train service on the Braintree Branch was suspended and replaced by limited shuttle bus service from February 9 - February 21.

In addition, Red Line trains experienced several significant safety incidents during this period. On January 29, a Red Line train at Quincy Center Station experienced a mechanical failure that led to smoke and emergency evacuation. On February 9, a train became disabled between Quincy Center and Quincy Adams centered and had to be evacuated.

Orange Line

The Orange Line runs through Boston from north to south, beginning at Oak Grove Station in Malden and running south to Forest Hills Station in the Jamaica Plain neighborhood of Boston. The Orange Line runs 11.1 miles, with approximately three miles of track above ground, servicing the five northern-most stations, and the six southern-most stations along the line. The Orange Line provides more than 200,000 unlinked trips on a typical weekday.

Service Impacts: The Orange Line experienced severe service disruptions in the four weeks between January 26, 2015 and February 22, 2015 as a result of the severe winter weather pattern. Cold temperatures, and snow and ice caused numerous equipment failures, including traction power motor units (currently 125 units with an anticipated total of nearly 160) and propulsion line choke failures (13 units). Service on portions of the aboveground sections of the Orange Line was suspended and replaced by bus service on February 7, 9, 11, 12, 16, 17, and 18. Weekday peak service levels on operational portions of the Orange Line were reduced by 20 to 55 percent from normal levels each day from February 4 through February 27th.

Rail Performance – Light Rail

MBTA light rail services include trolley service along the 23-mile Green Line, which includes the “core” line as well as four branch lines. The “core” of Green Line service runs from Lechmere Station in Somerville through downtown Boston, and includes 13 underground subway stations. There are four branches that are serviced on the Green Line: the B, C, D and E Branches. The E Line branches off from Copley Station in Boston, and in total runs 5.3 miles through Boston between Lechmere Station and Heath Street Station along Huntington Avenue. The remaining branches split off from Kenmore Station in Boston. The B Line runs 6.4 miles in total through Boston along Commonwealth Avenue between Government Center Station and Boston College Station. The C line runs 5.6 miles in total, traversing from North Station in Boston and Cleveland Circle in the town of Brookline. The D line runs 11.9 miles in total, operating through Brookline and Newton between Government Center Station and Highland Station in Newton.

The Green Line vehicle fleet includes 205 Light Rail vehicles. In 2013, the Green Line provided 227,645 unlinked trips on a typical weekday.

Service Impacts: The Green Line experienced severe service disruptions in the four weeks between January 26, 2015 and February 22, 2015 as a result of snow and ice accumulation on the tracks. In addition, cold temperatures, and snow and ice caused numerous equipment failures and mechanical issues, compounding the service disruptions, including but not limited to the necessary replacement of sixty (60) “Gate Pulse Amplifier” Circuit Boards and damage to traction power motors. All equipment damage was directly attributed to snow ingestion.

Service was intermittently terminated on the E Line at Brigham Circle on the following dates: January 26 - February 6, February 8, February 11-13, and February 20-26. On February 2, a Green Line train became disabled with a power problem, requiring shuttle buses to operate from Packard's Corner to Boston College. On February 3, a cracked rail at Copley Station required alternate service shuttle buses between Arlington Station and Kenmore and Prudential Stations. Additionally, services on the B, C, and E Branch Lines were suspended on February 6. On February 8, 9, 11 and 12, Green Line D Line service was terminated at Park Street due to intermittent switch failures at North Station. On February 16 and 17, service was suspended on the B, C and D Lines from Kenmore Station to the end of the respective lines, and on the E line between Prudential Station and Heath Street Station. On February 19, service was suspended on the B Line between Kenmore Station and Boston College Station, and on the E Line between Prudential and Heath Street Station.

Rail Performance - Commuter Rail

The MBTA's Commuter Rail system is the sixth-busiest commuter rail in the U.S., behind New York, Chicago, and Philadelphia area systems, and is tied for fifth-busiest with Philadelphia's SEPTA Regional Rail in terms of weekday ridership. Trains originate at two major terminals in Boston — South Station and North Station — both transportation hubs offering connections to Amtrak, and local bus and subway lines. Through a third party contractor, Keolis, the MBTA provides Commuter Rail service along 14 active trunkline routes essentially split into two districts.

The MBTA owns over 500 pieces of commuter rail rolling stock, including passenger locomotives, utility locomotives, work train equipment (e.g., flat cars, hopper cars, etc.), snow plows, midtrain coaches, and cab cars. Keolis is responsible for the operation, staffing, and maintenance of this equipment. Heavy maintenance on trains is performed at the Commuter Rail Maintenance Facility in Somerville while running maintenance and special work are performed at the Southside Service and Inspection Facility near South Station and at the Readville Interim Repair facility in the Hyde Park neighborhood of Boston.

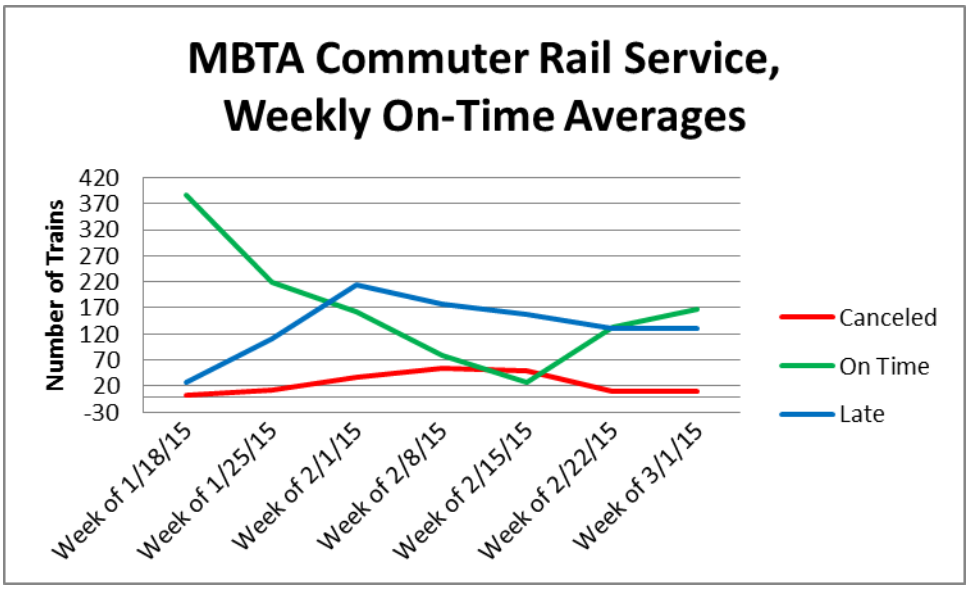
Service Impacts: During this historic winter weather pattern, commuter rail related equipment suffered heavily from the lengthy sub-freezing temperatures. Because of the sustained below freezing temperatures, the accumulated snow never melted or packed, resulting in fine dusty snow constantly being kicked up by trains. This fine snow-dust got stuck inside traction motors, causing failures. Packed ice and snow along brake rigging, underframes, electrical connections and MU cables made connecting trains in the field extremely difficult and caused failures during service.

Salt spread on the roadways caused grade crossings to fail, resulting in delays. Dwarf signals were buried by snow and were unable to be seen by trains. There were innumerable switch failures, because trains passing by constantly reburied switches that had been dug out. Due to the temperatures and quantity of snow, the switch heaters could not keep up with the heavy volume of snow. Terminals also took a long period of time to dig out after heavy snow. Switching at the engine house took two to three times longer than normal. Fortunately, there were very few major track issues, such as broken rails and joints.

As a direct result of the continued impacts brought on by the persistent weather pattern, the MBTA's commuter rail system became extremely fatigued. Limited train schedules had to be created and implemented on very short notice. The limited schedule could not allow extra run time for slower boardings, poor braking, and other weather-related conditions. Additionally, the limited schedule could not accommodate full and excess passenger loads. Extra trains ran when available to cover excess passenger volumes, but the number of extra trains was limited by equipment availability. By February 16, over 50% of scheduled service was cancelled.

Figure 6.5 below provides information on the numbers of commuter trains that ran on time or late, or were cancelled between mid-January and early March. Notably, the number of on-time trains dropped dramatically during this time period.

Figure 6.5: MBTA Commuter Rail Service, Weekly On-Time Averages



Bus Shuttle Service

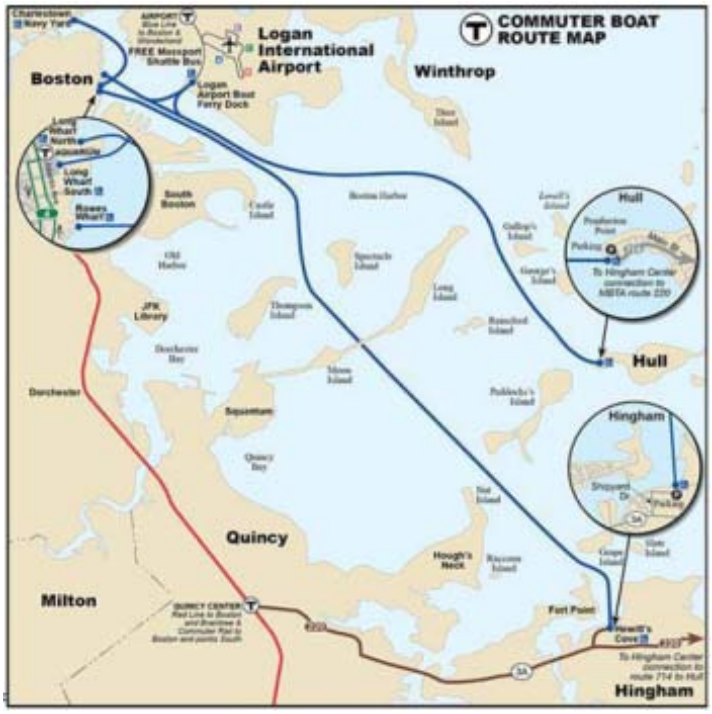
MBTA bus routes were severely impacted during the severe winter weather pattern and some routes, due to snow induced lane restrictions, are continuing to operate with reduced on time performance levels as compared to pre-storm conditions. The roads traveled by the buses were severely compromised by the continuous snowfall. Many of the bus routes were forced to institute travel restrictions taking traditionally 2 lane roads and making them one lane. The traveling public was forced into the streets, in the pathway of oncoming traffic to wait for buses. The frigid temperatures and long wait times put the traveling public at risk. Normal travel times for commuters were tripled given the virtual gridlock that existed across eastern Massachusetts.

Many bus routes had to be diverted during snow removal. In addition, on February 14, the City of Boston modified several streets to one-way traffic routes because of narrowed roadways. As of that date, several bus routes (5, 7, 9, 10 and 11) were modified and will remain rerouted until April 1st.

Ferry Service

The MBTA provides ferry service to downtown Boston from two South Shore communities (Hingham and Hull) and the Boston neighborhood of Charlestown.

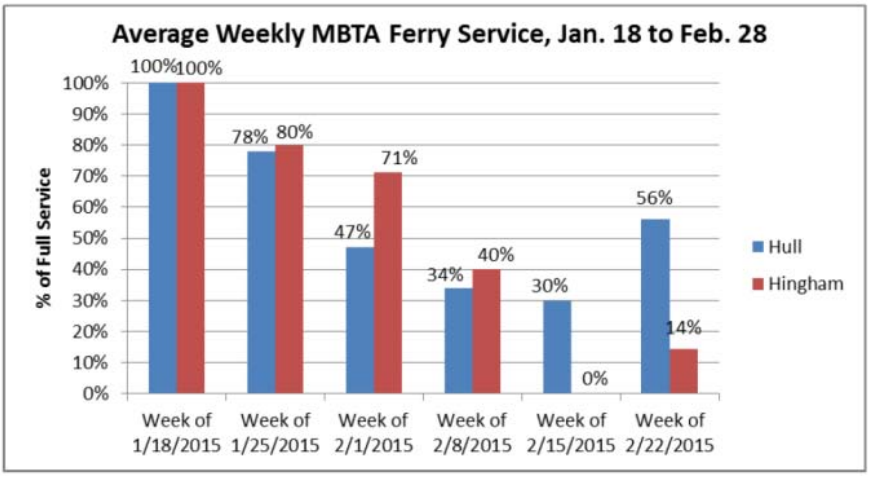
Figure 6.6: Ferry Service Route Map



Service impacts: The severe winter weather pattern impacted MBTA ferry service between January 25 and February 27. The Back River (fresh water) flowed into the Hingham Harbor, which is protected from the tidal and ocean currents, a phenomenon that allowed the brackish waters in the area to freeze. While ice-breaking efforts were intermittently efficient during ebbing tides, ice continually returned to Hingham Harbor causing disruption to the Hingham Service. In addition, the ice in Hingham damaged the Shuggart floats. After evaluating the floats, it has been determined that three of the spuds will need replacement once the ice has cleared. Because of the ice in Hingham Harbor and the limited parking at the Hull Ferry terminal, buses were operated from Nantasket Beach to the Ferry Terminal between February 25, 2015 and March 6, 2015 during weekdays.

Figure 6.7 below illustrates the average weekly MBTA Ferry Service, and demonstrates recovery was slow in terms of restoration of service due to the historic winter weather pattern.

Figure 6.7: Average Weekly MBTA Ferry Service



Response

The MBTA required a significant amount of support to implement measures to recover the transit system. In addition to the MBTA's internal labor force, the MBTA received mutual aid and outside assistance from state partners, outside contractors, and other non-profit organizations. Due to the magnitude of this historic weather pattern, an "all-hands on deck" approach was taken to ensure that the MBTA could properly clear all snow from various right-of-ways. A detailed breakdown of this contracted/outside snow removal is provided in Figure 6.8.

Figure 6.8: Contracted/Outside Snow Removal Support

Organization	2/16	2/17	2/18	2/19	2/20	2/21	2/22
MBTA/MassDOT	✓	✓	✓	✓	✓	✓	✓
MEMA	✓	✓	✓	✓	✓	✓	✓
MA National Guard	✓	✓		✓	✓		
VT National Guard	✓	✓					
MA DOC	✓	✓	✓	✓	✓	✓	
SEIU	✓	✓	✓	✓	✓	✓	
LM Heavy	✓	✓	✓	✓	✓	✓	
McCourt	✓	✓	✓	✓	✓	✓	
Barletta	✓	✓	✓	✓	✓	✓	
JF White	✓	✓	✓	✓	✓	✓	
Reliable						✓	
New Jersey DOT	✓	✓					
Pennsylvania DOT	✓	✓					
Pennsylvania Turnpike	✓	✓					
Northern Tree	✓	✓	✓	✓	✓	✓	
Don Cariati			✓	✓	✓	✓	✓
Butler Company					✓	✓	✓
Salvation Army	✓						
American Red Cross	✓						
UMass Boston	✓						

Economic Impacts

The MBTA continues to recover from the system-wide interruptions and failures it experienced. To date, MBTA estimates total storm costs at approximately $40 million (including labor, equipment, materials, police, and supplemental bus services). Of this, approximately $4.7 million is attributed to revenue loss due to service disruptions and cancellations.

To gather a better understanding of these impacts, A Better City, conducted a survey of its membership, which includes a cross section of the region's largest employers, building owners, and institutions and received detailed feedback from 40 members. While there were many impediments to getting employees to work during and after this winter's storms, each of the following were identified by over 85% of respondents as the most challenging: MBTA Subway Service Disruptions (96%), Poor Roadway Conditions (92%), Disruptions to MBTA/Keolis Commuter Rail Service (88%), and Disruptions to MBTA Bus Service (85%). Sidewalk conditions and parking availability were also identified by 38% of participants each. However, when asked to select the TOP TWO impediments to getting employees to work during and after this winter's storms, MBTA Subway Service (88%) and MBTA/Keolis Commuter Rail Service (56%) were far and away the leading impediments.

These impacts on the workforce have direct impacts to the economy. In addition, the delays and suspension of MBTA service also greatly impacted retail and restaurant businesses throughout the winter weather pattern.

Safety Impacts

The disruptions, delays and shut downs experienced within the MBTA system during the pattern of severe winter weather posed dangers to riders across the service area. These dangers included:

- Prolonged periods of exposure sub-freezing temperatures while waiting at stations
- Stranded MBTA vehicles in between stations for multiple hours requiring evacuations and placing riders directly on the right of way to walk to emergency bus service
- Increased traffic volume on roadways as individuals were forced to take their own vehicles and drive to work, and as alternate service shuttle buses were placed on already congested highways and local roadways. This congestion had direct impacts on the ability of emergency response vehicles to quickly traverse through standstill traffic enroute to emergency response calls.

Massachusetts Port Authority

Boston Logan International Airport

4,576 flight cancellations
230,000 passengers impacted

The severe winter weather pattern had a tremendous impact on all Massachusetts Port Authority (Massport) operations – most notably Boston Logan International Airport (Logan). Logan experienced 4,576 flight cancellations that impacted approximately 230,000 passengers. On January 28, the weather was so severe that Logan Airport, in an extremely rare instance, closed all operations between 1:00 am and 7:50 am. Logan estimates that its direct costs due to the severe winter weather pattern approximate $13 million.

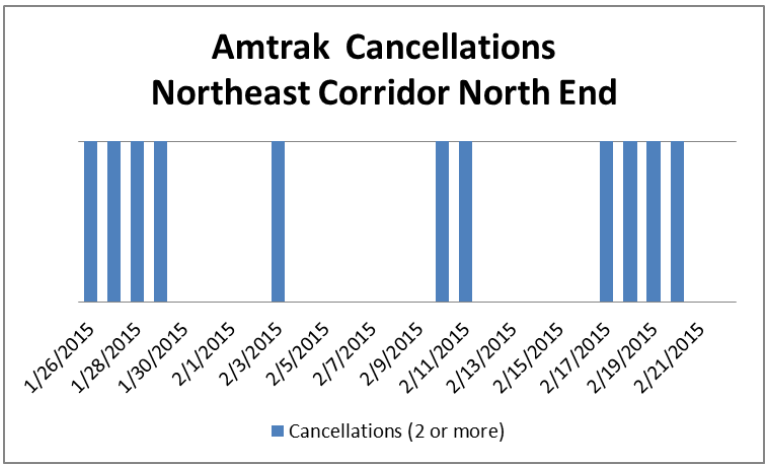
Steamship Authority

The Steamship Authority, which provides ferry services to the islands of Martha's Vineyard and Nantucket, was forced to cancel nearly 50% of all scheduled routes between January 26 and February 22 (142 route cancellations of 291 scheduled routes) because of severe weather conditions.

Amtrak

Severe winter weather considerations lead to the complete cancellation of all Amtrak service between New York Penn Station (NYP) and Boston (BOS) on January 27. Additional weather related cancellations in which two or more trains were cancelled on the northeast corridor north end (NYP-BOS) occurred on 10 additional dates throughout the severe winter weather pattern (January 26, 28 and 29 as well as February 2, 10, 11, 17, 18, 19 and 20).

Figure 6.9: Amtrak Cancellations



MassDOT

MassDOT owns and operates approximately 2,150 miles of the 22,000 city/town owned roads in the most heavily impacted areas. Hundreds of lane and road closures had to be implemented throughout the severe weather pattern. Lane and road closures throughout the severe winter weather pattern are summarized in the table below.

Table 6.3: MassDOT Lane and Road Closures

MassDOT Closures	Number
Lane/Road Closures of Significant Duration	171
Road Closures	66
Lane Closures	105

7. ECONOMIC IMPACTS

The severe winter weather pattern brought significant economic losses associated with the service disruptions to industry, retail, and commercial businesses. According to a survey completed by A Better City (ABC)[5] of its membership, which includes a cross section of the region's largest employers, building owners, and institutions, the severe winter weather pattern had the following impacts:

- The closure of the MBTA on Sunday, February 15th, resulted in the cancellation of the second day of the Boston Wine Expo, as the Seaport Hotel and World Trade Center determined that it would be in the best public interest to close and refund tickets versus encouraging people to try and find other ways to get to the event without the MBTA in service. The direct financial impact of this was more than $200,000 loss in revenues.
- Financial impacts came through a multitude of areas including: lost productivity, canceled appointments, canceled visits, increased costs for maintenance/operations, and increased transportation costs. Respondents reported a drop in overall morale as employees had to utilize sick/personal time because

[5] A Better City is a nonprofit membership organization that provides the business and institutional leadership essential for ensuring progress and tangible results on transportation, land development, and public realm infrastructure investments that are vital to sustaining and improving the Boston area's economy and quality of life.

they were unable to get into work or because they had school-aged children at home due to school closings that necessitated their absence even if they could have traveled into work.

- Due to the impacts of the weather and MBTA service failures, 42% or respondents stated that they allowed employees to work from home during and after the storms. This compares to only 4% of employers that stated that they normally allowed employees to work from home. A significant increase, which aligns with the general feeling that there was a loss in employee productivity as the employees that were being asked to work from home may not have been fully prepared to do so; lacking access to files and other information as well as the inability to meet with colleagues and clients.
- Respondents reported that the median number of days that this winter's weather reduced their business's on-site staff levels or required all employees to stay home was 4 days. In some cases, these closures had a further negative impact on the individual employee as almost half of respondents reported that they continued to pay salaried and contract employees only during the closures and just less than half reported paying all employees including hourly employees for the time lost.

Economic Cost of Disruption Resulting from Severe Winter Weather Pattern

While it is impossible to calculate in real-time the true economic cost of a disruption of this magnitude, the Commonwealth has collected data from economic analysts' forecasts, post incident surveys by the Retailers Association of Massachusetts, as well as general studies by academic institutions on the economic impact of the severe winter weather pattern.

Economic Analyst Forecast Data

In contrast to the hard costs illustrating governments unbudgeted, additional expenditures described in the previous section, the "higher level" economic costs of the 2015 winter weather presented are often difficult to immediately quantify. This "higher level" or macro-economic costs, defined in terms of lost revenue or taxes can be difficult to immediately quantify or measure. The following section describes several data points that illustrate losses due to the pattern of severe winter weather.

Lost Revenue for MBTA: The MBTA identifies the loss of revenue by comparing subway Automated Fare Collection (AFC) fare-gate transactions with the prior two years' seasonal average (January -March). As a result of closures and limited services caused by impacts from the severe weather pattern, the MBTA experienced nearly $4.7 million in revenue loss within the period of January 26–February 22.

Lost Revenue for MassDOT: MassDOT Highway Division compared toll revenues from the period of January 26, 2014 through February 22, 2014 against the same period in 2015. This comparison included toll revenue generated on the Massachusetts Turnpike, the Sumner/Callahan and O'Neill Tunnels, the Tobin Bridge, and the Turnpike Extension. The comparison indicate a difference of $2,681,872.10 (unaudited) between the revenue received between January 26, 2014 and February 22, 2014 and the revenue received between January 26, 2015 and February 22, 2015.

Table 7.1: Estimated Revenue Loss – Tolls

Time Period	Toll Revenue
2014 Toll Revenue (1/26-2/22)	$22,903,085.25
2015 Toll Revenue(1/26-2/22)	$20,221,213.15
Estimated Revenue Loss	**$2,681,872.10**

Lost Revenue for the Steamship Authority: The Steamship Authority, which provides ferry services to the islands of Martha's Vineyard and Nantucket, was forced to cancel nearly 50% of all scheduled routes between January 26 and February 22 (142 route cancellations of 291 scheduled routes) because of severe weather conditions. The estimated Steamship Authority revenue loss due weather cancellations is shown in Table 7.2 below.

Table 7.2: Estimated Steamship Authority Revenue Loss Due to Weather Cancellations

Steamship Authority Route	Revenue Loss
Martha's Vineyard	$174,064
Nantucket	$213,832
TOTAL	**$387,896**

Impact on Taxes: Per the Department of Revenue March 5, 2015 Tax Impact Update report, the Commonwealth suffered a loss of meals and motor fuel tax revenue as a result of the severe winter weather pattern.

Table 7.3: Combined Impact of Severe Winter Weather Pattern on State/Local Tax Revenue

Sates/Local Tax	State	Local Option
Meals Tax*	$21,300,000	$800,000
Motor Fuels Excise	$15,500,000	
Total	$36,900,000	$ 800,000

**State meals include both budgeted meals tax and tax transferred to convention center fund. Local meals tax is also called local option meals tax.*

Impact to Massachusetts Businesses

The Massachusetts Retailers Association polled more than 1,600 companies to gain insight into the impact of the severe winter weather on their businesses. The study found that sales fell an average of 22% between January 26, 2015 and February 22, 2015 as compared to the same time in 2014. The study specifically reported that retailers and restaurants that were hardest hit during the period showing decreases in sales of nearly 50 percent.

Impact on Small Businesses
(1/26/2015 to 2/22/2015)
7% Average Drop in Payroll
22% Average Drop in Sales

The survey also reveals that small businesses were hit particularly hard as the majority of the businesses that responded to this survey (76%) have less than 50 employees and annual sales under $5 million, thereby classified as small businesses.

Macroeconomic Impact of Snowstorms

Several studies over the last several years have been published by academic and private sector institutions that focus on the potential impact of snowstorms to the economy at a macroeconomic level. These studies emphasize that reduction in mobility (especially for public transportation) and store closures can lead to severe economic damage. As reported by IHS Global Insight, each day of snow-related shut down can cost $250 million in lost revenue.

Economic Costs of a Disruption from a Snowstorm
$250 Million per Day

IHS Global Insight Study. IHS Global Study conducted a study on behalf of the American Highway Users Alliance to analyze the Economic Costs of Disruption from a Snowstorm. This study concluded that:

1. Among all economic classes, snow-related shutdowns harm hourly workers the worst, accounting for almost two thirds of direct economic losses.
2. The indirect economic impacts of snow-related shutdowns, including loss of retail sales and income and sales tax revenues, roughly double the initial economic impact.
3. The economic impact of snow-related closures far exceeds the cost of timely snow removal. Although states and localities may be hesitant to expend significant upfront resources in the short-term, the long-term payoff more than justifies the expense.

Attachment A: Severe Winter Weather Pattern Impacts - Supplemental Information

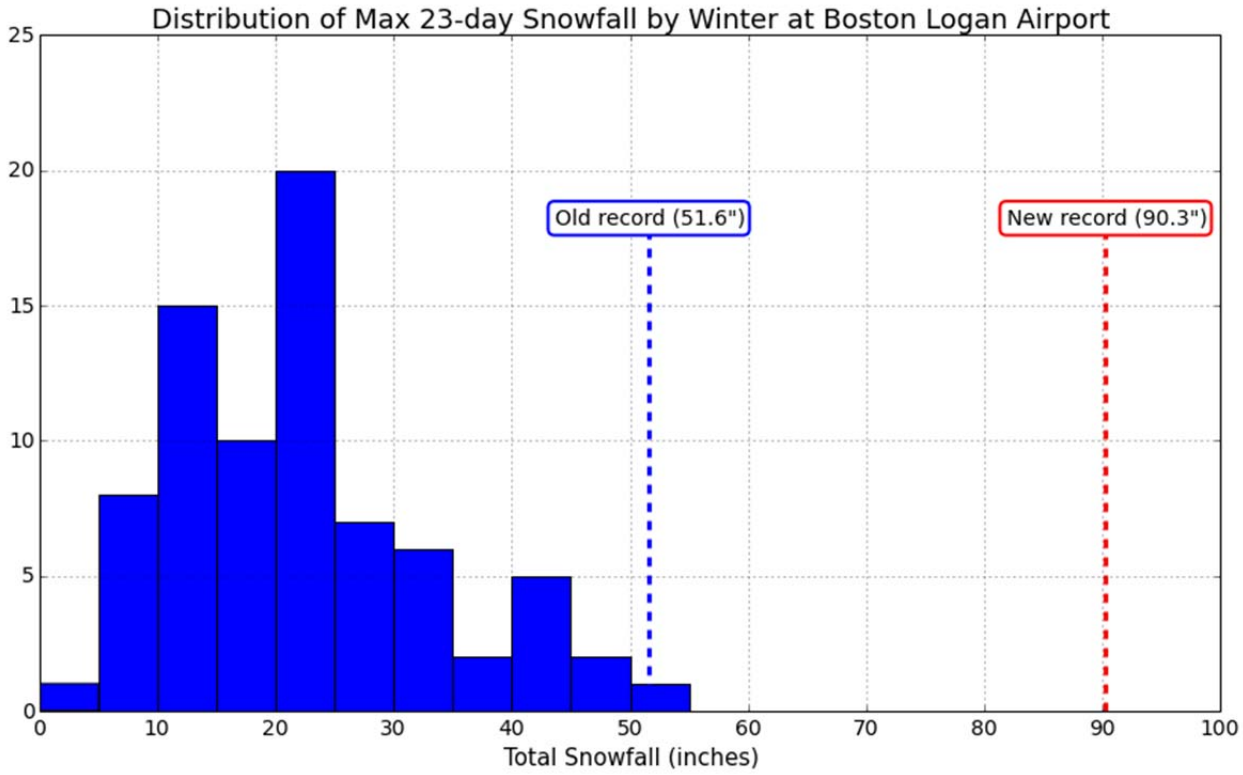
Appendix 1 –

Statistics on an Extremely Anomalous Period of Snowfall in Boston, MA

Statistics of an Extremely Anomalous Period of Snowfall in Boston, MA

Prepared by Sam Lillo, Graduate Research Fellow, University of Oklahoma School of Meteorology

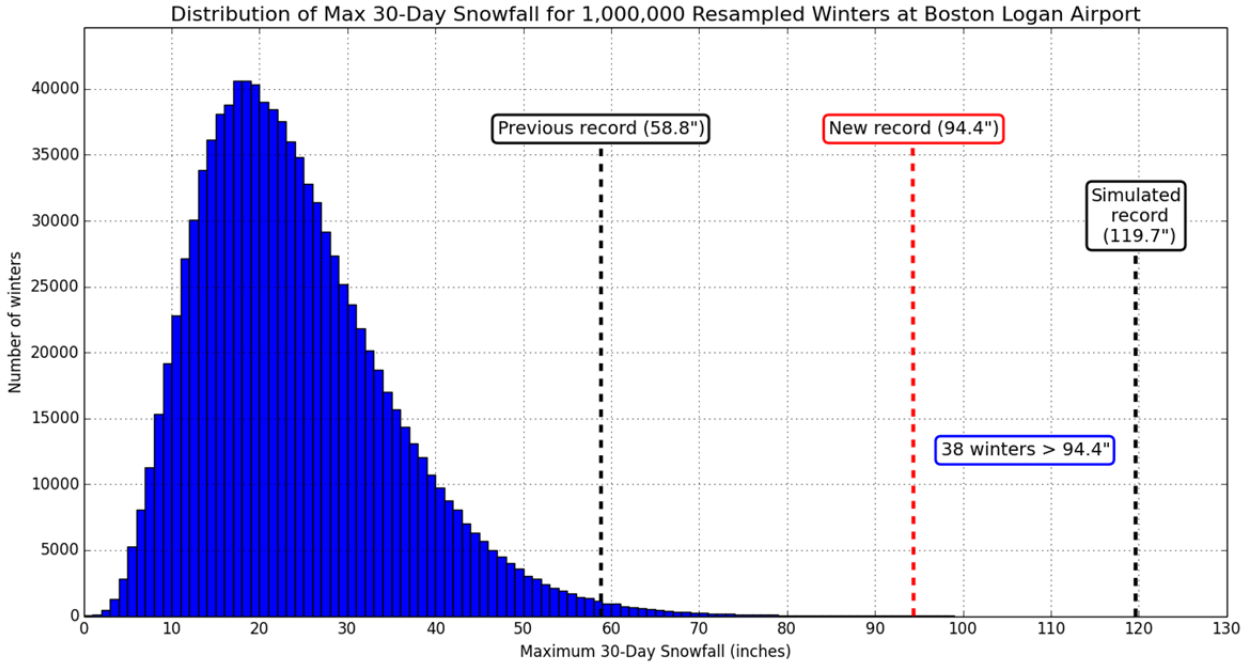
Over the course of 23 days, from 24 January 2015 through 15 February 2015, Boston Logan Airport (BOS) recorded 90.3 inches of snow. This came as a result of four major snowstorms that impacted New England, all of which had snowfall maxima in eastern Massachusetts. It is hard to put into perspective an extraordinary series of events like this, when it so far beyond any other stretch of winter weather in recorded history in Boston. From the National Climatic Data Center (NCDC), 78 winters (starting in 1937) at BOS were analyzed. The average seasonal snowfall for those winters is 44.0". The maximum is 107.6". The previous maximum 23-day snowfall was 51.6" in 1978, and the total seasonal snowfall that winter was 85.2". Since 1937, only two winters have recorded over 90" in a season. During those two seasons, it took a 78-day span and a 85-day span to achieve the 90.3" that fell in 23 days this year. Measurable snow was reported at BOS on 16 of the 23 days, which is also a record.



Similar to previous stretches of anomalous wintry weather, there was a persistent atmospheric pattern conducive to higher than normal snowstorm potential in the northeast US. Typically, these patterns might feature one high-end snowstorm, or two at best, because the atmosphere needs time to "reload" following a significant event. The four consecutive major snowstorms observed in the 23-day period is near the limits of what the atmosphere can produce locally. In addition, the repeated precise placement of the snowfall maxima is extraordinary.

In order to provide some context for comparison, simulated winters were generated by stitching together days sampled from past winters. A three-day period was chosen, to represent the typical timescale of synoptic weather systems. In addition, to account for the effect of long-term pattern forcing, the random selection of 3-day periods was weighted by the correlation between consecutive periods. Anomalies tended to persist across multiple periods, such that there's a better chance that a snowier than normal three days would follow a similarly snowy three days. This is well observed (and in extreme cases, like this year), so it's important to include in the simulation.

This method was applied to generate one million resampled winters. The snowiest 10-period (30-day) stretch was taken from each winter. As a check to the veracity of the resampled distribution, the percentile ranges were compared to the distribution of observed winters. The result is 38 winters with greater 30-day snowfall than this year. That puts this new record at a percentile range of 99.996%, with a return period of just over 25,000 years.



Despite the relatively complex logic utilized in this model, it is still simplistic. The idea is to try to quantify the rarity of this series of events. In comparison to the previous record, which had a calculated return period of about 100 years, the new record is 250 times more rare, or unlikely to be repeated.

Attachment A: Severe Winter Weather Pattern Impacts - Supplemental Information

Appendix 2 –

The Impacts of this Winter's Weather on ABC Members

The Impacts of this Winter's Weather on ABC Members

March 2015

Greater Boston experienced a series of winter storms that produced record snow fall throughout the region. The unprecedented amounts of snow caught the region's transportation agencies unprepared to manage the impacts before, during, and after the storms. Now still, a month after the last significant storm, the MBTA's Commuter Rail system, operated by Keolis is still operating on a reduced schedule. The failures of our transportation system had real economic impacts on businesses and commuters from lost productivity, lost business, and lost wages. To gather a better understanding of these impacts, A Better City, conducted a survey of its membership, which includes a cross section of the region's largest employers, building owners, and institutions and received detailed feedback from 40 members.

The following provides a summary and highlights of the responses we received.

- The effects of the MBTA shutting down were significant; 48% of respondents reported that business revenues and net profits decreased in January and February (compared to the year before) because of the impacts of the winter weather events. Another 38% reported that it was too early to know what the impacts might be. Only 14% reported that revenues and net profits remained the same. No respondent reported an increase in revenues or profits. In one instance, the closure of the MBTA on Sunday, February 15th, resulted in the cancellation of the second day of the Boston Wine Expo, as the Seaport Hotel & World Trade Center determined that it would be in the best public interest to close and refund tickets versus encouraging people to try and find other ways to get to the event without the MBTA in service. The direct financial impact of this was more than $200,000 loss in revenues and hopefully no lingering negative sentiment amongst vendors when it comes time to book booths for next year's event.

- Financial impacts came through a multitude of areas including: lost productivity, canceled appointments, canceled visits, increased costs for maintenance/operations, and increased transportation costs. Respondents reported a drop in overall morale as employees had to utilize sick/personal time because they were unable to get into work or because they had school-aged children at home due to school closings that necessitated their absence even if they could have traveled into work.

- Eighteen percent of respondents reported a decrease in the number of transit passes being sold through their corporate pass programs. While not significant, around 1% on average, it is not yet known whether these losses will be long-term or if these riders will return to public transit once the system is up and operating at its full capacity. Based on feedback from individual commuters and our own observations, it appears that monthly pass holders have determined that the likelihood of passes being checked (especially on the commuter rail) is low right now and that the odds are in their favor to simply purchase a pass and pay the additional fee on board the train versus paying up front for the entire month.

- Respondents reported that the median number of days that this winter's weather reduced their business's on-site staff levels or required all employees to stay home was 4 days. In some cases, these closures had a further negative impact on the individual employee as almost half of respondents reported that they continued to pay salaried and contract employees only during the closures and just less than half reported paying all employees including hourly employees for the time lost.

- While there were many impediments to getting employees to work during and after this winter's storms, each of the following were identified by over 85% of respondents as the most challenging: MBTA Subway Service (96%), Roadway Conditions (92%), MBTA/Keolis Commuter Rail Service (88%), and MBTA Bus Service (85%). Sidewalk conditions and parking availability were also identified by 38% of participants each. However, when asked to select the TOP TWO impediments to getting employees to work during and after this winter's storms, MBTA Subway Service (88%) and MBTA/Keolis Commuter Rail Service (56%) were far and away the leading impediments. As is well known, both of these services had a multitude of incidents that greatly impacted normal service operations. In fact, Commuter Rail is still operating on a limited service schedule, which continues to impact commuters who now have fewer and more crowded trains and when engines breakdown or other equipment fails, there are no longer immediately available back-ups to ensure reliability.

- Due to the impacts of the weather and MBTA service failures, 42% or respondents stated that they allowed employees to work from home during and after the storms. This compares to only 4% of employers that stated that they normally allowed employees to work from home. A significant increase, which aligns with the general feeling that there was a loss in employee productivity as the employees that were being asked to work from home may not have been fully prepared to do so; lacking access to files and other information as well as the inability to meet with colleagues and clients. 23% of respondents reported that working from home was not an option for employees as the nature of their job would not allow for it, especially for employees within the healthcare and hospitality sectors.

- When asked if they provided assistance to employees with commuting options to get into work during this winter's storms, above and beyond, their normal commuter services, 42% of

respondents reported in the affirmative. These organizations represented some of the city's largest employers within the healthcare and financial sectors; organizations that could not close or have large numbers of employees working from home. These efforts included providing/reimbursing employee transportation expenses for the use of taxis/Uber/Lyft; asking employees to sleep/stay on site; paying for parking; and providing employees with places to stay (hotels) closer to work. While most reported that the costs associated with these efforts were not yet known, responses that we received ranged from a few hundred dollars to more than $100,000.

While the impacts of this winter's storms on our transportation systems were unprecedented we must accept the fact that severe weather events, whether they be record breaking snow storms, rain induced flooding, tropical storm surges, or high heat will continue to increase in strength and regularity as our world's climate changes. We must learn from these events and develop new plans for action that increase or ability to respond and recover our transportation services so that we minimize the economic impacts.

To be prepared for the next storm, businesses should consider beginning or expanding efforts to increase their resilience. This could include:

- Investing in technology upgrades to provide remote access and facilitate telecommuting during storms and other weather related events.
- Engaging vendors to ensure adequate supplies in advance of storms.
- Establishing written plans and procedures for severe weather procedures.
- Establishing or reviewing staffing requirements.
- Developing written resiliency plans for severe weather and other risks that include transportation and mobility for employees, customers, clients, and patients.

ABC, through its sustainability and climate change initiatives will continue to explore and bring to its members new research and best practices aimed at increasing your organizations preparedness and resilience. We encourage you to view our recently released report and online toolkit for "Enhancing Building Resilience Measures". The toolkit provides members with useful information on over 30 technologies and services that can be implemented to strengthen your building to severe weather events. You may view the toolkit online at: http://challengeforsustainability.org/resiliency-toolkit/.

Attachment A: Severe Winter Weather Pattern Impacts - Supplemental Information

Appendix 3 –

IHS Global Impact Study

GLOBAL INSIGHT

The Source for Critical Information and Insight™

The Economic Costs of Disruption from a Snowstorm

Study Prepared for the American Highway Users Alliance by IHS Global Insight

Executive Summary

This study, commissioned by the American Highway Users Alliance and carried out by renowned global consulting firm IHS Global Insight, quantifies the economic impact of a one-day snow-related shutdown in sixteen states and two Canadian provinces. As winter comes to a close after an abnormally heavy snow season, the study shows the significant expense, both directly and indirectly, a major storm has on businesses and government because of impassable roads, as much as $300-700 million in some states for just a one-day shutdown.

As a result of the study, we have reached three broad conclusions:

1. Among all economic classes, snow-related shutdowns harm hourly workers the worst, accounting for almost two thirds of direct economic losses.

2. The indirect economic impacts of snow-related shutdowns, including loss of retail sales and income and sales tax revenues, roughly double the initial economic impact.

3. The economic impact of snow-related closures far exceeds the cost of timely snow removal. Although states and localities may be hesitant to expend significant upfront resources in the short-term, the long-term payoff more than justifies the expense.

It is hoped that this data will highlight to state and local authorities, as well as the federal government, the immense costs incurred during these storms, and spur them to plan more aggressively for periods of heavy snow.

The report is organized below into two distinct sections, an explanation of the study's methodology, followed by the data, organized by state and province. States and provinces selected represent areas of higher than average snowfall, and include each of the major snow-bearing metropolitan areas in the United States.

--The American Highway Users Alliance

###

The Economic Costs of Disruption from a Widespread Snowstorm: Methodology for States

[Canadian equivalents in brackets]

The economic losses that would result from a widespread snowstorm include lost earnings of hourly workers who are paid only for time actually worked and lost revenue of certain types of retail businesses where spending would not subsequently be recouped. Both of these types of losses would result in lost tax revenue at the federal and local levels. Moreover, there are indirect effects that must be taken into account since the ripple effects through the economy of the earnings and revenue that are lost would also not occur. IHS Global Insight's methods of estimating all aspects of the economic impact of a widespread snowstorm are summarized here.

Direct Economic Losses

Lost Wages by Industry

In the event of a temporary shutdown of the majority of industry, the loss of employee income would be limited to workers paid by the hour. We assume that salaried workers would still collect their annual wage, and the work would be made-up at a later date. The Bureau of Economic Analysis (BEA) [SEPH] publishes data on wage and salary disbursements by industry for all employees by state. However, these data do not separate the incomes of salaried from hourly paid employees. The proportion of workers who are paid by the hour can vary considerably from industry to industry. It is very low in educational services and the finance and insurance industries but is very high in construction and manufacturing industries. To make these estimates for states, we assumed proportions would be similar to those in the Canadian provinces for which such data are published.

Essential Services

We assume that even in a widespread snowstorm not all essential services will be closed. To account for the operation of essential services under a skeleton staff, we constructed scaling factors for the proportion of employees that would work. The following service industries were classified as essential services: local and interurban passenger transit and health services. We assumed that 25 percent of the hourly paid staff in these industries would work through the shutdown.

Income Regained

Although hourly employees will lose income during the days in which the area is shut down, a portion of this income will be regained from overtime. Income is not assumed to be regained uniformly across industries. In manufacturing and construction the regain factor is high, while in public administration it is very low. Regain factors were constructed for each industry to account for income made up due to overtime. In addition, it was assumed that a portion of this overtime work was paid at time and a half.

Lost Tax Revenue

There would be lost tax revenues for state and local [provincial] governments

as well as the federal government. Both lost income and retail sales would give rise to lost direct and indirect tax revenues. We calculated an average effective (or implicit) personal tax rate by taking the ratio of taxes paid to state and local governments relative to personal income. The same calculation was made for each state's average effective federal income tax rate. These effective tax rates were applied to the lost income – both direct and indirect.

Statutory tax rates that apply to retail sales in each state [province] were employed to calculate lost tax revenues for state governments arising from lost retail sales. The statutory rate was applied to lost retail sales after the scaling adjustment was made.

Retail Trade

We assume that sales lost due to a widespread snowstorm that would not be recouped subsequently would be limited to gasoline stations, department stores and other general merchandise stores. As with the estimates of lost earnings, scaling factors were developed to implement assumptions about the proportion of each store type's sales that would be recovered in the days following a statewide shutdown.

The starting point for calculating retail sales losses was IHS Global Insight's [Statistics Canada] estimates of retail sales by store type by state for 2009. These estimates were developed from the relationship of retail sales by store type to personal income in each state as reported in the Census of Retail Trade, applied to personal income by state in 2009.

Indirect Impacts

In addition to the direct loss of income and sales, there is an indirect component associated with the rippling effect through the economy that would have been stimulated by the wages and sales that are lost. This is the "Derived" effect that is reported in the economic impact tables. We assume that all of the people who lost income as a result of the shutdown would have spent the majority of that income in the local economy. Lost sales in the local economy will amount to a potential loss of income by most retailers and their employees. The impact ripples further as retailers and employees curtail their purchasing activity.

Multipliers used to estimate these indirect effects were derived from the widely-used IMPLAN economic impact software package. This methodology calculates the changes in output, employment, and value added as the result of changes in final demand for one or more industries. The software calculates two impacts – indirect and induced. Indirect impacts are the changes in interindustry purchases that result from the direct impact. Induced impacts represent the changes in household spending due to changes in production. For the purposes of the study, we are combining the indirect and induced impact into what we call a "derived" impact. [Canada's multiplier on lost earnings was 1.34. Source: IHS Global Insight's macroeconomic model].

Other Economic Effects

IHS Global Insight recognizes that there are additional effects of dangers associated with untreated snow-covered roads. The health, insurance and repair expenses from increased accidents could, in fact, be quite large. However, they are beyond the scope of this report.

Illinois

Total Economic Impact	$ Millions
Direct	182.27
Derived	218.47
Total	400.73
Wages & Salaries	
Direct	114.72
Derived	153.72
Total	268.44
State & Local Taxes	
Direct	3.56
Derived	4.78
Total	8.34
Federal Taxes	
Direct	10.64
Derived	14.25
Total	24.89
Retail Sales	
Direct	53.35
Derived	45.72
Total	99.07

Iowa

Total Economic Impact	$ Millions
Direct	33.40
Derived	36.89
Total	70.28
Wages & Salaries	
Direct	20.14
Derived	26.98
Total	47.12
State & Local Taxes	
Direct	0.95
Derived	1.28
Total	2.23
Federal Taxes	
Direct	1.35
Derived	1.81
Total	3.16
Retail Sales	
Direct	10.96
Derived	6.82
Total	17.78

Indiana

Total Economic Impact	$ Millions
Direct	73.12
Derived	83.52
Total	156.64
Wages & Salaries	
Direct	45.11
Derived	60.44
Total	105.55
State & Local Taxes	
Direct	1.99
Derived	2.66
Total	4.65
Federal Taxes	
Direct	3.32
Derived	4.45
Total	7.76
Retail Sales	
Direct	22.71
Derived	15.97
Total	38.68

Kentucky

Total Economic Impact	$ Millions
Direct	46.58
Derived	49.45
Total	96.03
Wages & Salaries	
Direct	25.61
Derived	34.31
Total	59.92
State & Local Taxes	
Direct	1.41
Derived	1.89
Total	3.30
Federal Taxes	
Direct	1.78
Derived	2.38
Total	4.16
Retail Sales	
Direct	17.79
Derived	10.87
Total	28.66

Maryland Total Economic Impact	$ Millions
Direct	84.16
Derived	99.35
Total	183.51
Wages & Salaries	
Direct	53.82
Derived	72.12
Total	125.94
State & Local Taxes	
Direct	4.17
Derived	5.59
Total	9.76
Federal Taxes	
Direct	4.88
Derived	6.54
Total	11.43
Retail Sales	
Direct	21.28
Derived	15.10
Total	36.38

Michigan Total Economic Impact	$ Millions
Direct	116.92
Derived	134.15
Total	251.07
Wages & Salaries	
Direct	72.73
Derived	97.45
Total	170.18
State & Local Taxes	
Direct	2.72
Derived	3.64
Total	6.35
Federal Taxes	
Direct	5.36
Derived	7.18
Total	12.53
Retail Sales	
Direct	36.12
Derived	25.88
Total	62.00

Massachusetts Total Economic Impact	$ Millions
Direct	119.42
Derived	145.69
Total	265.12
Wages & Salaries	
Direct	82.95
Derived	111.16
Total	194.11
State & Local Taxes	
Direct	4.62
Derived	6.19
Total	10.82
Federal Taxes	
Direct	8.44
Derived	11.31
Total	19.74
Retail Sales	
Direct	23.41
Derived	17.04
Total	40.45

Minnesota Total Economic Impact	$ Millions
Direct	76.27
Derived	91.19
Total	167.46
Wages & Salaries	
Direct	48.14
Derived	64.51
Total	112.65
State & Local Taxes	
Direct	2.69
Derived	3.60
Total	6.29
Federal Taxes	
Direct	4.09
Derived	5.48
Total	9.57
Retail Sales	
Direct	21.35
Derived	17.60
Total	38.95

Missouri

Total Economic Impact	$ Millions
Direct	74.06
Derived	87.57
Total	161.63
Wages & Salaries	
Direct	46.10
Derived	61.78
Total	107.88
State & Local Taxes	
Direct	2.03
Derived	2.72
Total	4.76
Federal Taxes	
Direct	3.44
Derived	4.61
Total	8.05
Retail Sales	
Direct	22.48
Derived	18.46
Total	40.94

New York

Total Economic Impact	$ Millions
Direct	322.40
Derived	377.78
Total	700.17
Wages & Salaries	
Direct	198.92
Derived	266.55
Total	465.47
State & Local Taxes	
Direct	15.00
Derived	20.10
Total	35.10
Federal Taxes	
Direct	20.44
Derived	27.39
Total	47.83
Retail Sales	
Direct	88.04
Derived	63.74
Total	151.78

New Jersey

Total Economic Impact	$ Millions
Direct	132.58
Derived	156.77
Total	289.35
Wages & Salaries	
Direct	85.97
Derived	115.19
Total	201.16
State & Local Taxes	
Direct	4.15
Derived	5.56
Total	9.72
Federal Taxes	
Direct	8.49
Derived	11.38
Total	19.86
Retail Sales	
Direct	33.97
Derived	24.64
Total	58.61

Ohio

Total Economic Impact	$ Millions
Direct	139.54
Derived	160.89
Total	300.43
Wages & Salaries	
Direct	87.96
Derived	117.87
Total	205.84
State & Local Taxes	
Direct	4.87
Derived	6.53
Total	11.40
Federal Taxes	
Direct	6.47
Derived	8.67
Total	15.15
Retail Sales	
Direct	40.23
Derived	27.82
Total	68.05

Pennsylvania

Total Economic Impact	$ Millions
Direct	167.43
Derived	202.13
Total	369.56
Wages & Salaries	
Direct	107.88
Derived	144.56
Total	252.44
State & Local Taxes	
Direct	5.28
Derived	7.07
Total	12.35
Federal Taxes	
Direct	9.04
Derived	12.12
Total	21.16
Retail Sales	
Direct	45.22
Derived	38.37
Total	83.59

Virginia

Total Economic Impact	$ Millions
Direct	120.30
Derived	139.56
Total	259.86
Wages & Salaries	
Direct	76.36
Derived	102.32
Total	178.68
State & Local Taxes	
Direct	3.78
Derived	5.07
Total	8.85
Federal Taxes	
Direct	6.95
Derived	9.31
Total	16.26
Retail Sales	
Direct	33.21
Derived	22.86
Total	56.07

Utah

Total Economic Impact	$ Millions
Direct	30.68
Derived	35.68
Total	66.36
Wages & Salaries	
Direct	18.29
Derived	24.51
Total	42.81
State & Local Taxes	
Direct	0.85
Derived	1.13
Total	1.98
Federal Taxes	
Direct	1.42
Derived	1.90
Total	3.32
Retail Sales	
Direct	10.12
Derived	8.14
Total	18.26

Wisconsin

Total Economic Impact	$ Millions
Direct	69.35
Derived	79.33
Total	148.68
Wages & Salaries	
Direct	44.00
Derived	58.96
Total	102.97
State & Local Taxes	
Direct	2.23
Derived	2.99
Total	5.22
Federal Taxes	
Direct	3.59
Derived	4.81
Total	8.41
Retail Sales	
Direct	19.52
Derived	12.57
Total	32.09

Ontario Total Economic Impact	$ Millions
Direct	205.30
Derived	268.28
Total	473.59
Wages & Salaries	
Direct	152.74
Derived	204.68
Total	357.42
State & Local Taxes	
Direct	9.93
Derived	12.87
Total	22.79
Federal Taxes	
Direct	19.55
Derived	25.81
Total	45.37
Retail Sales	
Direct	23.08
Derived	24.93
Total	48.01

Quebec Total Economic Impact	$ Millions
Direct	108.52
Derived	141.56
Total	250.08
Wages & Salaries	
Direct	79.47
Derived	106.49
Total	185.96
State & Local Taxes	
Direct	8.11
Derived	10.61
Total	18.72
Federal Taxes	
Direct	7.95
Derived	10.42
Total	18.37
Retail Sales	
Direct	13.00
Derived	14.04
Total	27.04