E

Activity Levels

This appendix provides detailed tables in support of Chapter 2, *Activity Levels*:

- Table E-1 Logan Airport Historical Air Passenger and Operations Data
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Table E-1 Logan Airport Historical Air Passenger and Operations Data

Year	Operations	Air Passengers	Year	Operations	Air Passengers
1980	258,167	14,722,363	1999	494,816	27,052,078
1981	251,961	14,827,684	2000	487,996	27,726,833
1982	244,468	15,867,722	2001	463,125	24,474,930
1983	288,956	17,848,797	2002	392,079	22,696,141
1984	318,959	19,417,971	2003	373,304	22,791,169
1985	349,518	20,448,424	2004	405,258	26,142,516
1986	363,995	21,862,718	2005	409,066	27,087,905
1987	414,968	23,369,002	2006	406,119	27,725,443
1988	407,479	23,732,959	2007	399,537	28,102,455
1989	388,797	22,272,860	2008	371,604	26,102,651
1990	424,568	22,878,191	2009	345,306	25,512,086
1991	430,403	21,450,143	2010	352,643	27,428,962
1992	474,378	22,723,138	2011	368,987	28,909,267
1993	493,093	23,579,726	2012	354,869	29,236,087
1994	458,623	24,468,178	2013	361,339	30,218,970
1995	466,327	24,192,095	2014	363,797	31,634,445
1996	456,226	25,134,826	2015	372,930	33,449,580
1997	482,542	25,567,888	2016	391,222	36,288,042
1998	507,449	26,526,708			

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Table E-2 Logan Airport Changes in Domestic Passenger Operations by Carrier

Airline	2000	2005	2010	2011	2012	2013	2014	2015	2016	2015-2016 Change	2015-2016 Percent Change
Scheduled Jet Carriers	**233,993**	**190,991**	**203,052**	**207,369**	**203,376**	**211,176**	**214,854**	**225,629**	**235,381**	**9,752**	**4.3%**
AirTran Airlines	3,090	14,580	13,672	12,869							
Alaska Airlines		1,088	1,733	1,757	1,873	2,661	3,090	3,027	3,256	**229**	**7.6%**
America West Airlines	5,116	4,467									
American Airlines[1]	30,821	27,712	21,313	18,943	20,962	22,535	58,222	56,623	55,249	**-1,374**	**-2.4%**
American Trans Air	1,448	2,294									
Continental Airlines	16,894	13,546	10,869								
Delta Air Lines[2]	52,954	36,388	28,980	25,429	23,270	21,139	23,614	30,705	30,476	**-229**	**-0.7%**
Frontier Airlines	1,052		1,094		275						
Independence Air		4,676									
JetBlue		15,069	49,981	58,737	63,210	73,374	76,247	79,364	84,590	**5,226**	**6.6%**
Midway Airlines	4,096										
Midwest Airlines	3,726	3,570	1,961	2,786							
Northwest Airlines	13,147	9,685									
People Express							170				
Southwest Airlines[3]			13,727	17,413	23,667	23,701	21,967	21,542	24,436	**2,894**	**13.4%**
Spirit Airlines			3,023	3,054	3,365	2,721	2,945	4,896	7,245	**2,349**	**48.0%**
Sun Country Airlines	723		313	509	596	926	1,027	1,414	1,374	**-40**	**-2.8%**
Trans World Airlines	6,280										
United Airlines[4]	28,092	18,304	16,314	26,425	25,636	25,214	24,374	24,632	25,031	**399**	**1.6%**
US Airways[5]	66,554	39,612	36,678	36,421	36,633	35,613					
Virgin America			3,394	3,026	3,889	3,292	3,198	3,426	3,724	**298**	**8.7%**
Regional/Commuter Carriers	**160,041**	**137,203**	**94,535**	**89,586**	**79,790**	**79,922**	**76,682**	**70,274**	**68,204**	**-2,070**	**-2.9%**
America West Express	1,267										
American Eagle	62,140	37,394	15,291	6,669	4	4	5	52	6,418	**6,366**	**12242.3%**
Cape Air	31,026	25,018	35,899	35,940	37,184	37,194	35,080	35,994	35,993	**-1**	**0.0%**
Continental Connection			1,809	1,199	131						
Continental Express		12,544	529	902	385						
Delta Connection	15,438	26,557	18,445	23,243	20,925	20,848	20,265	15,466	18,586	**3,120**	**20.2%**
MidAtlantic Express											
Midwest/Republic			258								
Northwest Airlink		5,034									
PenAir					2,268	4,384	4,382	3,747	3,662	**-85**	**-2.3%**
Republic Airlines						58	53	34		**-34**	**-100.0%**
United Express		3,178	2,802	2,763	4,342	5,829	5,628	4,699	3,545	**-1,154**	**-24.6%**
US Airways Express	50,170	27,478	19,502	18,870	14,551	11,605	11,269	10,282		**-10,282**	**-100.0%**
Non-Scheduled Operations (Incl. Charter)	**1,008**	**325**	**501**	**106**	**181**	**200**	**164**	**176**	**158**	**-18**	**-10.2%**
Total Domestic Operations	**395,042**	**328,519**	**298,117**	**297,061**	**283,347**	**291,298**	**291,700**	**296,079**	**303,743**	**7,664**	**2.6%**

Source: Massport

Notes: Excludes general aviation and all-cargo operations.

Table E-3 Logan Airport Changes in International Passenger Operations by Carrier

Airline	2000	2005	2010	2011	2012	2013	2014	2015	2016	2015-2016 Change	2015-2016 Percent Change
Scheduled Jet Carriers	**27,427**	**24,550**	**20,771**	**24,973**	**25,633**	**23,301**	**25,065**	**28,225**	**34,752**	**6,527**	**23.1%**
Aer Lingus	1,160	1,016	1,097	1,130	1,273	1,513	1,933	1,973	2,066	**93**	**4.7%**
Aeromexico		534						345	580	**235**	**68.1%**
Air Berlin									192	**192**	**100.0%**
Air Canada	10,047	5,782	3,895	4,125	4,517	1,747	1,084	1,686	2,729	**1,043**	**61.9%**
Air France	1,046	1,334	995	1,013	974	955	899	910	900	**-10**	**-1.1%**
Air Jamaica		349									
Air One											
Alitalia	729	986	624	604	530	542	550	562	558	**-4**	**-0.7%**
American Airlines[1]	4,657	4,672	2,422	2,149	1,901	447	344	571	533	**-38**	**-6.7%**
Astraeus				100							
British Airways	2,159	2,151	2,082	2,161	2,149	2,573	2,678	2,575	2,702	**127**	**4.9%**
Canadian Airlines	417										
Cathay Pacific								279	454	**175**	**62.7%**
Copa Airlines						347	730	646	638	**-8**	**-1.2%**
Delta Air Lines[2]	733	749	1,675	3,280	2,531	2,851	3,008	3,122	3,459	**337**	**10.8%**
El Al								152	296	**144**	**94.7%**
Emirates							600	914	1,382	**468**	**51.2%**
Eurowings									72	**72**	**100.0%**
Finnair		44									
FlyGlobespan											
Hainan Airlines							280	744	961	**217**	**29.2%**
Iberia Airlines			435	445	441	404	332	336	412	**76**	**22.6%**
Icelandair	726	811	816	928	938	1,120	1,227	1,287	1,338	**51**	**4.0%**
Japan Airlines					474	646	731	728	736	**8**	**1.1%**
JetBlue			2,262	5,173	5,902	6,138	6,348	6,488	7,146	**658**	**10.1%**
Korean Air Lines	314										
LACSA Airlines											
Lufthansa	1,140	1,564	1,657	1,734	1,784	1,723	1,712	1,687	1,728	**41**	**2.4%**
Northwest Airlines	744	727									
Norwegian Air Shuttle								34	656	**622**	**1829.4%**
Olympic Airways	256										
Qatar Airways									552	**552**	**100.0%**
Sabena	724										
SATA International Airlines		315	403	400	412	466	533	542	630	**88**	**16.2%**
Scandinavian Airlines									500	**500**	**100.0%**
SWISS International	926	704	720	725	716	720	722	711	1,020	**309**	**43.5%**

Table E-3 Logan Airport Changes in International Passenger Operations by Carrier

TACA		327									
TACV - Cabo Verde		154	240	236	234	214	186	60		**-60**	**-100.0%**
TAP - Air Portugal	200								378	**378**	**100.0%**
Thomas Cook Airlines									62	**62**	**100.0%**
Trans World Airlines											
Turkish Airlines							452	726	658	**-68**	**-9.4%**
United Airlines	728								21	**21**	**100.0%**
US Airways		1,607	667	49	146	186					
VG Airlines											
Virgin Atlantic Airways	721	724	707	721	711	709	716	702	715	**13**	**1.9%**
Wow Air								445	678	**233**	**52.4%**
Regional/Commuter Carriers	**15,594**	**13,112**	**12,494**	**12,153**	**12,270**	**14,378**	**14,720**	**14,153**	**15,204**	**1,051**	**7.4%**
Air Canada Regional	4,088	5,120	7,065	6,803	7,058	9,563	10,364	10,024	9,051	**-973**	**-9.7%**
American Eagle Airlines	8,975	4,637	2,480	2,206							
Delta Connection	2,531	3,355	81	1	1,489	1,082	56	38	32	**-6**	**-15.8%**
Porter Airlines			2,868	3,143	3,723	3,733	4,300	4,091	3,869	**-222**	**-5.4%**
Westjet Encore									2,252	**2,252**	**100.0%**
Non-Scheduled Operations	**2,141**	**1,068**	**305**	**300**	**268**	**277**	**185**	**248**	**63**	**-185**	**-74.6%**
Total International Operations	**45,162**	**38,643**	**33,570**	**37,426**	**38,171**	**37,956**	**39,970**	**42,626**	**50,019**	**7,393**	**17.3%**

Source: Massport

Notes: Excludes general aviation and all-cargo operations.

1 - American Airlines includes US Airways beginning in 2014 (following 2013 merger)

2 - Delta Air Lines totals include Northwest Airlines beginning in 2009 (following merger)

Table E-4 Logan Airport Scheduled Passenger Departures by Destination

Destination Airport	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	2015-2016 Change	2015-2016 Percent Change
Domestic		**210,068**	**163,684**	**149,962**	**152,303**	**143,871**	**147,078**	**149,208**	**152,210**	**155,485**	**3,275**	**2.2%**
New York La Guardia	LGA	11,872	13,350	11,705	11,489	9,564	9,255	9,056	9,352	9,365	**13**	**0.1%**
Washington National	DCA	8,474	10,680	9,419	9,793	8,543	8,360	8,645	8,678	8,629	**-48**	**-0.6%**
Chicago O'Hare	ORD	10,063	7,412	7,403	7,635	7,461	7,733	7,822	7,401	7,139	**-261**	**-3.5%**
New York J F Kennedy	JFK	9,899	4,985	7,054	5,969	5,428	5,919	6,139	6,745	6,971	**227**	**3.4%**
Philadelphia	PHL	11,785	7,014	6,548	7,985	6,301	7,305	8,092	7,971	5,786	**-2,185**	**-27.4%**
Baltimore	BWI	1,773	5,029	7,053	6,755	5,910	5,737	5,060	4,897	5,731	**834**	**17.0%**
Atlanta	ATL	7,110	6,003	5,548	5,569	5,574	5,501	5,454	5,192	5,386	**194**	**3.7%**
New York Newark	EWR	5,206	5,626	3,666	4,608	5,228	5,702	5,532	5,366	5,239	**-127**	**-2.4%**
Los Angeles	LAX	3,647	2,655	3,382	3,164	3,544	3,603	4,080	4,456	4,650	**194**	**4.4%**
Nantucket	ACK	5,022	3,452	3,884	3,382	3,469	3,601	3,567	4,311	4,605	**293**	**6.8%**
San Francisco	SFO	3,526	2,591	3,711	3,884	4,198	4,038	4,305	4,272	4,551	**279**	**6.5%**
Detroit	DTW	2,937	2,827	2,353	2,437	2,314	2,340	3,354	3,875	3,932	**57**	**1.5%**
Charlotte	CLT	2,758	3,288	4,180	3,976	3,991	3,911	3,916	3,920	3,878	**-42**	**-1.1%**
Raleigh/Durham	RDU	3,775	4,110	3,259	2,867	3,059	3,313	3,634	3,598	3,718	**121**	**3.4%**
Dallas/Fort Worth	DFW	5,002	3,544	2,938	2,781	3,790	4,147	3,705	3,406	3,418	**12**	**0.4%**
Orlando	MCO	4,914	3,517	3,179	3,580	3,496	3,399	2,883	3,057	3,323	**266**	**8.7%**
Martha's Vineyard	MVY	3,863	2,231	3,218	2,829	2,774	2,740	2,793	2,731	2,929	**198**	**7.2%**
Minneapolis	MSP	3,078	1,791	1,927	2,031	2,062	2,200	2,322	2,737	2,865	**128**	**4.7%**
Denver	DEN	2,628	1,990	2,812	2,640	2,518	2,433	2,446	2,611	2,839	**228**	**8.7%**
Fort Lauderdale/Hollywood	FLL	3,327	3,065	2,370	2,517	2,371	2,379	2,173	2,258	2,634	**376**	**16.6%**
Miami	MIA	2,068	2,072	2,238	2,555	2,610	2,555	2,551	2,520	2,523	**3**	**0.1%**
Washington Dulles	IAD	8,625	6,139	4,625	3,910	3,014	2,974	2,714	2,505	2,485	**-20**	**-0.8%**
Richmond	RIC	1,537	1,404	1,431	1,525	1,481	1,723	2,450	2,603	2,338	**-265**	**-10.2%**
Pittsburgh	PIT	3,086	2,021	2,312	3,179	2,498	2,641	2,678	2,457	2,210	**-247**	**-10.0%**
Buffalo	BUF	950	1,226	2,181	2,183	2,264	2,468	2,433	2,203	2,120	**-83**	**-3.8%**
Cleveland	CLE	2,797	1,260	1,369	1,326	1,455	1,501	1,260	2,070	2,098	**28**	**1.3%**
Fort Myers	RSW	949	1,525	1,587	1,620	1,738	1,806	1,734	1,742	1,938	**195**	**11.2%**
Provincetown	PVC	2,023	1,659	2,410	2,086	2,054	1,982	1,929	1,957	1,912	**-45**	**-2.3%**
Seattle/Tacoma	SEA	458	610	1,001	993	1,051	1,378	1,607	1,625	1,907	**282**	**17.3%**
West Palm Beach	PBI	1,674	1,126	1,450	1,380	1,161	1,235	1,389	1,650	1,652	**3**	**0.2%**
Houston Intercontinental	IAH	1,995	1,752	1,717	1,697	1,704	1,789	1,822	1,831	1,618	**-213**	**-11.6%**
Chicago Midway	MDW	868	1,339	1,756	1,751	1,690	1,617	1,542	1,531	1,604	**73**	**4.8%**
Indianapolis	IND	765	2,076	1,121	977	936	895	844	1,181	1,595	**414**	**35.0%**
Columbus	CMH	2,708	2,114	972	1,048	972	871	844	1,081	1,591	**510**	**47.2%**
Phoenix	PHX	1,386	944	1,348	1,895	1,773	1,413	1,557	1,569	1,552	**-17**	**-1.1%**
Nashville	BNA	642				153	588	628	688	1,467	**779**	**113.2%**
Lebanon	LEB			1,734	1,460	1,464	1,460	1,460	1,460	1,464	**4**	**0.3%**
Tampa	TPA	2,502	1,946	1,246	1,255	1,266	1,195	1,182	1,177	1,429	**252**	**21.4%**
Rockland	RKD	1,152	1,374	1,301	1,279	1,282	1,279	1,279	1,372	1,348	**-24**	**-1.7%**
Augusta	AUG	584	621	1,000	1,187	1,091	1,248	1,248	1,248	1,220	**-28**	**-2.2%**
Las Vegas	LAS	1,098	1,679	756	904	737	813	819	1,162	1,216	**55**	**4.7%**
Cincinnati	CVG	2,235	2,637	1,364	1,308	1,272	1,269	1,239	1,218	1,204	**-14**	**-1.1%**
Bar Harbor	BHB	1,196	1,154	815	1,030	1,213	1,283	1,156	1,095	1,098	**3**	**0.3%**
Albany	ALB	3,433	1,073	647	2,180	1,523	1,183	1,095	1,095	1,098	**3**	**0.3%**
Saranac Lake	SLK		800	1,174	1,157	1,222	1,157	1,095	1,095	1,098	**3**	**0.3%**
Rutland	RUT	1,259	643	1,095	1,148	1,160	1,095	1,095	1,095	1,098	**3**	**0.3%**
San Diego	SAN	366	365	571	535	476	859	1,030	1,052	1,042	**-10**	**-1.0%**
Houston Hobby	HOU						664	1,325	978	1,032	**55**	**5.6%**
Salt Lake City	SLC	1,094	730	669	438	370	584	597	617	1,009	**392**	**63.5%**

Table E-4 Logan Airport Scheduled Passenger Departures by Destination

Destination Airport	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	2015-2016 Change	2015-2016 Percent Change
Presque Isle	PQI	1,835	1,017	991	991	993	991	991	991	993	**3**	**0.3%**
Milwaukee	MKE	1,189	2,182	2,213	1,941	1,069	880	674	854	990	**136**	**15.9%**
Hyannis	HYA	2,274	1,059	1,165	1,047	1,028	705	731	787	775	**-11**	**-1.4%**
Rochester	ROC	3,644	1,181	908	886	889	878	882	886	767	**-119**	**-13.5%**
Austin	AUS			365	365	366	352	352	444	754	**311**	**70.0%**
St. Louis	STL	2,187	1,461	934	713	815	748	722	722	745	**24**	**3.3%**
Jacksonville	JAX		428	365	544	619	593	984	767	701	**-66**	**-8.6%**
Plattsburgh International	PBG			1,025	899	623	639	787	756	697	**-59**	**-7.8%**
Kansas City	MCI	597	241	313	536	571	515	669	661	631	**-30**	**-4.5%**
Portland	PDX			352	440	528	615	494	519	555	**35**	**6.8%**
Charleston	CHS		61				398	474	365	545	**180**	**49.2%**
New Orleans	MSY		191	348	304	335	339	344	365	527	**162**	**44.5%**
Westchester County	HPN	6,065	2,256						263	502	**239**	**91.1%**
Myrtle Beach	MYR	105	265	365	365	366	378	383	383	379	**-3**	**-0.9%**
Savannah	SAV		78					306	365	370	**5**	**1.5%**
Atlantic City Pomona Field	ACY			536	326	355	123	153	166	366	**200**	**120.1%**
Syracuse	SYR	3,876	1,762	991	964	784	626	617	578	314	**-264**	**-45.7%**
Harrisburg	MDT	1,307	886	551	574	540	469	434	325	300	**-25**	**-7.7%**
Long Beach	LGB		853	459	296	292	274	270	292	297	**5**	**1.7%**
San Jose	SJC	842	245	232	292	227	205	214	223	236	**13**	**5.9%**
Sarasota/Bradenton	SRQ		30	82	242	248	348	181	212	186	**-26**	**-12.1%**
Dallas Love Field	DAL								153	153	**0**	**0.0%**
Oakland	OAK		853	195	105	83	83	83	88	79	**-9**	**-9.8%**
Sacramento	SMF								48	57	**9**	**17.8%**
Madison	MSN									9	**9**	**100.0%**
Akron/Canton	CAK		730	475	488	497	557	457	287		**-287**	**-100.0%**
Islip	ISP	4,222	1,581				293	324				
Norfolk	ORF	838	1,032		511	667	613	71				
Newport News	PHF		671	549	549	60		31				
Memphis	MEM	972	1,034	1,048	1,029	688	313					
Bangor	BGR	6,644	2,946									
Greensboro	GSO	415	1,120									
Trenton	TTN											
Watertown	ART											
Burlington	BTV	5,913	1,632									
Allentown/Bethlehem	ABE	780	626									
Louisville	SDF											
Manchester	MHT											
Massena	MSS											
Dayton	DAY											
Plattsburgh	PLB											
Portland (ME)	PWM	6,267	1,394									
Wilkes-Barre Scranton	AVP	584	420									
Columbia	CAE											
Ithaca	ITH	872										
Elmira/Corning	ELM	441										
Hartford	BDL											
Binghamton	BGM											
Providence	PVD	91										

Table E-4 Logan Airport Scheduled Passenger Departures by Destination

Destination Airport	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	2015-2016 Change	2015-2016 Percent Change
International		**23,711**	**19,837**	**18,764**	**19,641**	**19,540**	**19,093**	**20,372**	**21,765**	**25,353**	**3,588**	**16.5%**
Toronto Pearson	YYZ	3,691	3,876	3,603	3,737	3,529	3,306	2,715	2,799	3,702	**903**	**32.3%**
Montreal-Trudeau	YUL	3,401	2,578	2,008	2,021	2,009	1,833	1,948	2,047	2,092	**45**	**2.2%**
London Heathrow	LHR	2,187	2,133	2,331	2,833	2,642	2,134	2,069	2,026	2,058	**31**	**1.5%**
Toronto Island Apt	YTZ			1,535	1,687	2,009	2,009	2,310	2,236	2,018	**-218**	**-9.7%**
San Juan	SJU	1,750	1,237	1,294	1,130	1,031	1,038	1,018	1,068	1,141	**73**	**6.8%**
Reykjavik Keflavik Apt	KEF	393	361	404	531	467	561	614	854	968	**114**	**13.4%**
Halifax	YHZ	3,210	1,891	852	744	745	704	704	700	955	**255**	**36.4%**
Paris De Gaulle	CDG	898	853	710	946	619	784	780	916	938	**22**	**2.4%**
Dublin	DUB	223		348	457	480	605	653	653	694	**41**	**6.2%**
Dubai	DXB							306	457	692	**235**	**51.5%**
Ottawa	YOW	2,575	864	744	696	623	652	635	630	649	**19**	**3.0%**
Amsterdam	AMS	366	365	457	553	558	575	536	579	580	**1**	**0.2%**
Santo Domingo	SDQ		174	305	275	358	339	401	365	519	**154**	**42.1%**
Frankfurt	FRA	580	575	548	544	572	545	532	536	515	**-21**	**-4.0%**
Bermuda	BDA	550	518	532	540	511	501	523	536	510	**-26**	**-4.8%**
Aruba	AUA	9	338	407	426	405	408	417	417	471	**54**	**12.9%**
Zurich	ZRH	523	356	365	365	366	365	365	365	366	**1**	**0.3%**
Tokyo Narita	NRT					236	352	365	365	357	**-8**	**-2.1%**
Munich	MUC		210	313	335	357	348	357	357	357	**1**	**0.2%**
Shannon	SNN	366	737	213	118	144	166	348	352	349	**-3**	**-0.9%**
Istanbul	IST							236	365	340	**-25**	**-6.9%**
Cancun	CUN		207	307	270	217	225	273	264	326	**62**	**23.5%**
Beijing	PEK							136	287	323	**35**	**12.3%**
Panama City	PTY							365	334	318	**-16**	**-4.9%**
Copenhagen	CPH									293	**293**	**100.0%**
Mexico City	MEX		234						166	292	**126**	**76.0%**
Doha	DOH									284	**284**	**100.0%**
Santiago	STI				92	201	214	248	206	275	**70**	**34.0%**
Rome Leonardo Da Vinci-Fiumicino	FCO		135	313	314	266	271	258	271	271	**0**	**0.0%**
Hong Kong	HKG								140	227	**87**	**61.9%**
Lisbon	LIS	44		26	26	48	39	39	44	223	**179**	**410.5%**
Punta Cana	PUJ			95	92	139	134	160	174	214	**40**	**22.9%**
Madrid	MAD			218	231	222	209	166	166	205	**39**	**23.8%**
Ponta Delgada	PDL	30	39	165	170	148	179	209	196	196	**0**	**0.1%**
Saint Thomas	STT	78	108	125	117	156	173	176	184	186	**1**	**0.8%**
London Gatwick	LGW	362								161	**161**	**100.0%**
Shanghai Pudong	PVG								83	157	**74**	**88.7%**
Tel Aviv	TLV								75	148	**74**	**98.7%**
Nassau	NAS		100	180	134	142	108	139	136	133	**-3**	**-2.0%**
Providenciales	PLS	4	43	39	26	69	52	82	86	104	**18**	**20.6%**
Dusseldorf	DUS									101	**101**	**100.0%**
Saint Maarten	SXM			39	43	61	61	52	56	91	**35**	**61.9%**
Terceira	TER	44		17	17	17	17	17	31	70	**39**	**127.0%**
Oslo	OSL									57	**57**	**100.0%**
Port Au Prince	PAP								26	53	**26**	**100.0%**
Cologne/Bonn	CGN									52	**52**	**100.0%**
Montego Bay	MBJ		238	126	52	69	56	73	56	52	**-4**	**-7.1%**
Barbados	BGI								9	43	**35**	**398.4%**
Fort-de-France	FDF								9	43	**35**	**390.3%**

Table E-4 Logan Airport Scheduled Passenger Departures by Destination

Destination Airport	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	2015-2016 Change	2015-2016 Percent Change
Grand Cayman	GCM		31	17		9	26	26	26	43	**17**	**67.4%**
Manchester	MAN	26	241							31	**31**	**100.0%**
Pointe-a-Pitre	PTP								9	30	**22**	**243.5%**
St. Lucia Hewanorra	UVF							9	26	26	**0**	**0.6%**
Liberia	LIR							9	26	26	**0**	**0.6%**
Puerto Plata	POP	4						9	26	26	**0**	**0.6%**
Praia	RAI		9	121	122	109	104	92	30		**-30**	**-100.0%**
Sao Vicente	VXE			4		4						
Charlottetown	YYG											
Helsinki	HEL											
Milan Malpensa	MXP	366	343									
Fredericton	YFC		686									
Quebec	YQB	1,229	30									
Glasgow	GLA											
Connaught	NOC											
Stockholm Arlanda	ARN											
Las Palmas	LPA											
San Salvador	SAL		178									
Vancouver	YVR	366	62									
Ilha Do Sal	SID		56									
Nykoping	NYO		31									
Lerwick Sumburgh Apt	LSI											
Freeport	FPO											
Brussels	BRU	362										
Gander	YQX											
Athens	ATH	74										
Total Scheduled Carrier Operations		**233,779**	**183,520**	**168,726**	**171,945**	**163,411**	**166,171**	**169,579**	**173,974**	**180,838**	**6,864**	**3.9%**

Source: OAG Schedules.

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F

Regional Transportation

This appendix provides detailed tables in support of Chapter 4, *Regional Transportation*:

- Table F-1 Aircraft Operations by Classification for New England's Airports, 2000 to 2016
- Table F-2 Percentage Change in Aircraft Operations by Classification for New England's Airports, 2000 to 2016

Scheduled Passenger Operations by Market and Carrier for New England's Regional Airports

- Table F-3 Bradley International Airport, Connecticut
- Table F-4 T.F. Green Airport, Rhode Island
- Table F-5 Manchester-Boston Regional Airport, New Hampshire
- Table F-6 Portland International Jetport, Maine
- Table F-7 Burlington International Airport, Vermont
- Table F-8 Bangor International Airport, Maine
- Table F-9 Tweed-New Haven Airport, Connecticut
- Table F-10 Worcester Regional Airport, Massachusetts
- Table F-11 Hanscom Field, Massachusetts
- Table F-12 Portsmouth International Airport, New Hampshire

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Table F-1 Aircraft Operations by Classification for New England's Airports, 2000 to 2016

Airport	Bradley International	T.F. Green	Manchester-Boston Regional	Portland International Jetport	Burlington	Bangor	Tweed-New Haven	Worcester Regional	Portsmouth International	Hanscom Field[2]	Subtotal	Logan Airport[3]	Total
2000													
Commercial	132,062	103,750	61,506	47,609	45,745	21,446	5,260	4,029	6,104	6,572	434,083	452,763	886,846
General Aviation[1]	31,863	52,184	45,740	56,571	59,377	34,831	56,200	46,518	31,601	204,512	619,397	35,233	654,630
Military & Other	5,811	2,764	586	2,072	10,241	26,507	328	495	9,973	1,287	60,064	0	60,064
Total	169,736	158,698	107,832	106,252	115,363	82,784	61,788	51,042	47,678	212,371	1,113,544	487,996	1,601,540
2001													
Commercial	128,638	100,606	61,669	47,770	47,261	18,286	4,581	5,631	4,485	6,414	425,341	434,386	859,727
General Aviation[1]	30,478	45,095	44,358	62,014	61,986	35,230	56,092	45,464	30,148	197,770	608,635	28,739	637,374
Military & Other	5,913	2,635	607	2,259	11,821	26,623	437	917	8,221	1,252	60,685	0	60,685
Total	165,029	148,336	106,634	112,043	121,068	80,139	61,110	52,012	42,854	205,436	1,094,661	463,125	1,557,786
2002													
Commercial	113,194	96,595	62,346	45,899	38,929	24,412	3,827	4,062	5,059	6,603	400,926	366,476	767,402
General Aviation[1]	27,838	45,473	29,549	57,720	59,679	35,711	62,163	52,277	28,333	210,221	608,964	25,596	634,560
Military & Other	6,085	2,587	376	2,162	12,167	27,297	593	418	8,220	1,424	61,329	0	61,329
Total	147,117	144,655	92,271	105,781	110,775	87,420	66,583	56,757	41,612	218,248	1,071,219	392,072	1,463,291
2003													
Commercial	103,917	84,301	68,184	42,658	38,293	25,626	3,705	868	4,552	2,956	375,060	344,644	719,704
General Aviation[1]	27,115	42,878	29,552	44,036	50,461	36,706	54,224	55,972	24,866	190,789	556,599	28,660	585,259
Military & Other	4,214	2,496	324	1,449	11,466	32,938	776	378	7,720	1,142	62,903	0	62,903
Total	135,246	129,675	98,060	88,143	100,220	95,270	58,705	57,218	37,138	194,887	994,562	373,304	1,367,866
2004													
Commercial	108,823	83,496	75,360	46,474	41,719	24,970	4,501	0	3,981	4,308	393,632	374,022	767,654
General Aviation[1]	32,269	34,878	27,438	41,547	54,709	29,884	58,881	61,343	25,962	175,301	542,212	31,236	573,448
Military & Other	4,100	346	749	1,338	12,404	29,676	1,010	530	7,797	1,195	59,145	0	59,145
Total	145,192	118,720	103,547	89,359	108,832	84,530	64,392	61,873	37,740	180,804	994,989	405,258	1,400,247
2005													
Commercial	119,048	88,374	76,342	42,661	43,987	25,976	6,137	2,727	3,197	3,627	412,076	377,830	789,906
General Aviation[1]	33,341	28,138	26,369	36,191	49,888	30,016	60,893	62,743	25,446	165,424	518,449	31,236	549,685
Military & Other	3,701	241	479	1,405	11,468	24,154	1,063	519	7,669	904	51,603	0	51,603
Total	156,090	116,753	103,190	80,257	105,343	80,146	68,093	65,989	36,312	169,955	982,128	409,066	1,391,194

Table F-1 Aircraft Operations by Classification for New England's Airports, 2000 to 2016

Airport	Bradley International	T.F. Green	Manchester-Boston Regional	Portland International Jetport	Burlington	Bangor	Tweed-New Haven	Worcester Regional	Portsmouth International	Hanscom Field[2]	Subtotal	Logan Airport[3]	Total
2006													
Commercial	111,341	81,282	67,326	38,663	41,342	23,466	5,177	3,793	3,981	3,057	379,428	374,675	754,103
General Aviation[1]	34,548	25,510	25,074	35,572	44,471	29,848	51,702	56,770	25,962	167,560	497,017	31,444	528,461
Military & Other	4,348	229	738	1,536	9,299	22,359	1,157	609	7,797	1,433	49,505	0	49,505
Total	150,237	107,021	93,138	75,771	95,112	75,673	58,036	61,172	37,740	172,050	925,950	406,119	1,332,069
2007													
Commercial	107,097	80,525	69,134	41,450	39,928	22,571	4,594	3,162	4,270	3,477	376,208	370,905	747,113
General Aviation[1]	29,308	22,984	23,959	31,724	47,521	25,542	51,200	61,296	27,000	160,992	481,526	28,632	510,158
Military & Other	5,097	242	644	1,384	9,528	20,949	944	879	8,017	1,438	49,122	0	49,122
Total	141,502	103,751	93,737	74,558	96,977	69,062	56,738	65,337	39,287	165,907	906,856	399,537	1,306,393
2008													
Commercial	98,194	73,096	63,505	40,834	37,832	19,282	4,013	2,553	1,347	104	340,760	347,784	688,544
General Aviation[1]	22,908	19,470	16,198	31,869	46,391	27,143	44,642	43,763	31,051	164,195	447,630	23,820	471,450
Military & Other	3,637	187	840	974	9,688	20,449	243	886	7,993	1,590	46,487	0	46,487
Total	124,739	92,753	80,543	73,677	93,911	66,874	48,898	47,202	40,391	165,889	834,877	371,604	1,206,481
2009													
Commercial	82,021	62,233	54,336	35,909	31,153	16,485	3,096	2,527	422	0	288,182	333,064	621,246
General Aviation[1]	19,586	19,438	14,354	25,473	32,872	19,558	37,722	41,700	25,161	148,696	384,560	12,242	396,802
Military & Other	2,726	260	1,163	778	8,628	16,267	486	17	6,851	1,215	38,391	0	38,391
Total	104,333	81,931	69,853	62,160	72,653	52,310	41,304	44,244	32,434	149,911	711,133	345,306	1,056,439
2010													
Commercial	80,418	60,128	53,971	35,035	29,538	16,190	3,201	1,629	1,516	0	281,626	337,961	619,587
General Aviation[1]	18,759	21,096	13,636	24,776	36,106	20,142	31,884	41,843	25,674	161,942	395,858	14,682	410,540
Military & Other	3,028	347	933	446	4,776	15,525	381	572	7,707	1,795	35,510	0	35,510
Total	102,205	81,571	68,540	60,257	70,420	51,857	35,466	44,044	34,897	163,737	712,994	352,643	1,065,637
2011													
Commercial	86,838	57,194	51,379	35,157	29,166	16,177	3,367	2,017	1,717	750	283,762	340,757	624,519
General Aviation[1]	16,483	21,774	12,497	21,453	42,562	19,503	33,919	44,050	27,056	160,840	400,137	28,230	428,367
Military & Other	3,630	369	874	533	5,890	13,220	310	634	8,158	1,409	35,027	0	35,027
Total	106,951	79,337	64,750	57,143	77,618	48,900	37,596	46,701	36,931	162,999	718,926	368,987	1,087,913

Table F-1 Aircraft Operations by Classification for New England's Airports, 2000 to 2016

Airport	Bradley International	T.F. Green	Manchester-Boston Regional	Portland International Jetport	Burlington	Bangor	Tweed-New Haven	Worcester Regional	Portsmouth International	Hanscom Field[2]	Subtotal	Logan Airport[3]	Total
2012													
Commercial	79,704	50,301	45,379	33,118	27,067	14,826	3,936	1,639	502	635	257,107	326,755	583,862
General Aviation[1]	15,589	24,781	12,504	20,864	42,352	18,069	34,775	42,655	30,186	164,841	406,616	28,114	434,730
Military & Other	3,726	434	1,073	584	7,079	11,503	416	740	7,917	738	34,210	0	34,210
Total	99,019	75,516	58,956	54,566	76,498	44,398	39,127	45,034	38,605	166,214	697,933	354,869	1,052,802
2013													
Commercial	78,213	48,340	43,572	31,076	26,814	14,707	4,094	1,586	560	253	249,215	334,657	583,872
General Aviation[1]	15,192	24,729	11,432	20,021	40,413	15,535	28,794	32,888	28,951	153,706	371,661	26,682	398,343
Military & Other	2,558	435	1,224	471	6,972	11,045	423	593	7,573	529	31,823	0	31,823
Total	95,963	73,504	56,228	51,568	74,199	41,287	33,311	35,067	37,084	154,488	652,699	361,339	1,014,038
2014													
Commercial	79,060	44,351	38,674	29,538	26,057	14,428	4,795	2,368	8,278	256	247,805	337,381	585,186
General Aviation[1]	14,752	29,490	12,293	16,535	40,858	15,548	26,273	29,138	24,440	133,437	342,764	26,416	369,180
Military & Other	2,665	1,036	908	560	6,842	11,567	529	956	7,621	602	33,286	0	33,286
Total	96,477	74,877	51,875	46,633	73,757	41,543	31,597	32,462	40,339	134,295	623,855	363,797	987,652
2015													
Commercial	76,425	42,417	38,060	30,415	25,178	13,618	6,316	2,414	8,547	220	243,610	344,764	588,374
General Aviation[1]	14,402	22,700	12,934	17,916	41,576	16,487	27,711	35,711	26,848	127,467	343,752	28,166	371,918
Military & Other	2,680	430	811	567	5,912	10,684	685	889	7,499	592	30,749	0	30,749
Total	93,507	65,547	51,805	48,898	72,666	40,789	34,712	39,014	42,894	128,279	618,111	372,930	991,041
2016													
Commercial	77,174	43,659	40,589	32,171	26,405	14,603	7,195	2,616	9,512	266	254,190	360,442	614,632
General Aviation[1]	14,460	26,032	14,447	18,334	38,614	16,965	28,811	31,858	28,341	120,891	338,753	30,780	369,533
Military & Other	3,178	397	501	488	6,114	11,337	683	780	8,191	632	32,301	0	32,301
Total	94,812	70,088	55,537	50,993	71,133	42,905	36,689	35,254	46,044	121,789	625,244	391,222	1,016,466

Source: Massport, Federal Aviation Administration (FAA) Tower Counts, and individual airport records.

1 Includes itinerant and local general aviation (GA) operations at the regional airports. There are no local (touch-and-go training) operations at Logan Airport.

2 Commercial operations at Hanscom Field include scheduled commercial operations only; other air taxi operations counted as GA.

3 Operations at Logan Airport include international operations.

Table F-2 Percentage Change in Aircraft Operations by Classification for New England's Airports, 2000 to 2016

Airport	Bradley International	T.F. Green	Manchester-Boston Regional	Portland International Jetport	Burlington	Bangor	Tweed-New Haven	Worcester Regional	Portsmouth International	Hanscom Field[2]	Subtotal	Logan Airport[3]	Total
2000 to 2001													
Commercial	(2.59%)	(3.03%)	0.27%	0.34%	3.31%	(14.73%)	(12.91%)	39.76%	(26.52%)	(2.40%)	(2.01%)	(4.06%)	(3.06%)
General Aviation[1]	(4.35%)	(13.58%)	(3.02%)	9.62%	4.39%	1.15%	(0.19%)	(2.27%)	(4.60%)	(3.30%)	(1.74%)	(18.43%)	(2.64%)
Military & Other	1.76%	(4.67%)	3.58%	9.03%	15.43%	0.44%	33.23%	85.25%	(17.57%)	(2.72%)	1.03%	-	1.03%
Total	(2.77%)	(6.53%)	(1.11%)	5.45%	4.95%	(3.20%)	(1.10%)	1.90%	(10.12%)	(3.27%)	(1.70%)	(5.10%)	(2.73%)
2001 Percent of Total	10.59%	9.52%	6.85%	7.19%	7.77%	5.14%	3.92%	3.34%	2.75%	13.19%	70.27%	29.73%	100.00%
2001 to 2002													
Commercial	(12.01%)	(3.99%)	1.10%	(3.92%)	(17.63%)	33.50%	(16.46%)	(27.86%)	12.80%	2.95%	(5.74%)	(15.63%)	(10.74%)
General Aviation[1]	(8.66%)	0.84%	(33.39%)	(6.92%)	(3.72%)	1.37%	10.82%	14.99%	(6.02%)	6.30%	0.05%	(10.94%)	(0.44%)
Military & Other	2.91%	(1.82%)	(38.06%)	(4.29%)	2.93%	2.53%	35.70%	(54.42%)	(0.01%)	13.74%	1.06%	-	1.06%
Total	(10.85%)	(2.48%)	(13.47%)	(5.59%)	(8.50%)	9.09%	8.96%	9.12%	(2.90%)	6.24%	(2.14%)	(15.34%)	(6.07%)
2002 Percent of Total	10.05%	9.89%	6.31%	7.23%	7.57%	5.97%	4.55%	3.88%	2.84%	14.91%	73.21%	26.79%	100.00%
2002 to 2003													
Commercial	(8.20%)	(12.73%)	9.36%	(7.06%)	(1.63%)	4.97%	(3.19%)	(78.63%)	(10.02%)	(55.23%)	(6.45%)	(5.96%)	(6.22%)
General Aviation[1]	(2.60%)	(5.71%)	0.01%	(23.71%)	(15.45%)	2.79%	(12.77%)	7.07%	(12.24%)	(9.24%)	(8.60%)	11.97%	(7.77%)
Military & Other	(30.75%)	(3.52%)	(13.83%)	(32.98%)	(5.76%)	20.67%	30.86%	(9.57%)	(6.08%)	(19.80%)	2.57%	-	2.57%
Total	(8.07%)	(10.36%)	6.27%	(16.67%)	(9.53%)	8.98%	(11.83%)	0.81%	(10.75%)	(10.70%)	(7.16%)	(4.79%)	(6.52%)
2003 Percent of Total	9.89%	9.48%	7.17%	6.44%	7.33%	6.96%	4.29%	4.18%	2.72%	14.25%	72.71%	27.29%	100.00%
2003 to 2004													
Commercial	4.72%	(0.95%)	10.52%	8.95%	8.95%	(2.56%)	21.48%	(100.00%)	(12.54%)	45.74%	4.95%	8.52%	6.66%
General Aviation[1]	19.01%	(18.66%)	(7.15%)	(5.65%)	8.42%	(18.59%)	8.59%	9.60%	4.41%	(8.12%)	(2.58%)	8.99%	(2.02%)
Military & Other	(2.71%)	(86.14%)	131.17%	(7.66%)	8.18%	(9.90%)	30.15%	40.21%	1.00%	4.64%	(5.97%)	-	(5.97%)
Total	7.35%	(8.45%)	5.60%	1.38%	8.59%	(11.27%)	9.69%	8.14%	1.62%	(7.23%)	0.04%	8.56%	2.37%
2004 Percent of Total	10.37%	8.48%	7.39%	6.38%	7.77%	6.04%	4.60%	4.42%	2.70%	12.91%	71.06%	28.94%	100.00%
2004 to 2005													
Commercial	9.40%	5.84%	1.30%	(8.20%)	5.44%	4.03%	36.35%	-	(19.69%)	(15.81%)	4.69%	1.02%	2.90%
General Aviation[1]	3.32%	(19.32%)	(3.90%)	(12.89%)	(8.81%)	0.44%	3.42%	2.28%	(1.99%)	(5.63%)	(4.38%)	0.00%	(4.14%)
Military & Other	(9.73%)	(30.35%)	(36.05%)	5.01%	(7.55%)	(18.61%)	5.25%	(2.08%)	(1.64%)	(24.35%)	(12.75%)	-	(12.75%)
Total	7.51%	(1.66%)	(0.34%)	(10.19%)	(3.21%)	(5.19%)	5.75%	6.65%	(3.78%)	(6.00%)	(1.29%)	0.94%	(0.65%)
2005 Percent of Total	11.22%	8.39%	7.42%	5.77%	7.57%	5.76%	4.89%	4.74%	2.61%	12.22%	70.60%	29.40%	100.00%

Table F-2 Percentage Change in Aircraft Operations by Classification for New England's Airports, 2000 to 2016

Airport	Bradley International	T.F. Green	Manchester-Boston Regional	Portland International Jetport	Burlington	Bangor	Tweed-New Haven	Worcester Regional	Portsmouth International	Hanscom Field[2]	Subtotal	Logan Airport[3]	Total
2005 to 2006													
Commercial	(6.47%)	(8.02%)	(11.81%)	(9.37%)	(6.01%)	(9.66%)	(15.64%)	39.09%	24.52%	(15.72%)	(7.92%)	(0.84%)	(4.53%)
General Aviation[1]	3.62%	(9.34%)	(4.91%)	(1.71%)	(10.86%)	(0.56%)	(15.09%)	(9.52%)	2.03%	1.29%	(4.13%)	0.67%	(3.86%)
Military & Other	17.48%	(4.98%)	54.07%	9.32%	(18.91%)	(7.43%)	8.84%	17.34%	1.67%	58.52%	(4.07%)	-	(4.07%)
Total	(3.75%)	(8.34%)	(9.74%)	(5.59%)	(9.71%)	(5.58%)	(14.77%)	(7.30%)	3.93%	1.23%	(5.72%)	(0.72%)	(4.25%)
2006 Percent of Total	11.28%	8.03%	6.99%	5.69%	7.14%	5.68%	4.36%	4.59%	2.83%	12.92%	69.51%	30.49%	100.00%
2006 to 2007													
Commercial	(3.81%)	(0.93%)	2.69%	7.21%	(3.42%)	(3.81%)	(11.26%)	(16.64%)	7.26%	13.74%	(0.85%)	(1.01%)	(0.93%)
General Aviation[1]	(15.17%)	(9.90%)	(4.45%)	(10.82%)	6.86%	(14.43%)	(0.97%)	7.97%	4.00%	(3.92%)	(3.12%)	(8.94%)	(3.46%)
Military & Other	17.23%	5.68%	(12.74%)	(9.90%)	2.46%	(6.31%)	(18.41%)	44.33%	2.82%	0.35%	(0.77%)	-	(0.77%)
Total	(5.81%)	(3.06%)	0.64%	(1.60%)	1.96%	(8.74%)	(2.24%)	6.81%	4.10%	(3.57%)	(2.06%)	(1.62%)	(1.93%)
2007 Percent of Total	10.83%	7.94%	7.18%	5.71%	7.42%	5.29%	4.34%	5.00%	3.01%	12.70%	69.42%	30.58%	100.00%
2007 to 2008													
Commercial	(8.31%)	(9.23%)	(8.14%)	(1.49%)	(5.25%)	(14.57%)	(12.65%)	(19.26%)	(68.45%)	(97.01%)	(9.42%)	(6.23%)	(7.84%)
General Aviation[1]	(21.84%)	(15.29%)	(32.39%)	0.46%	(2.38%)	6.27%	(12.81%)	(28.60%)	15.00%	1.99%	(7.04%)	(16.81%)	(7.59%)
Military & Other	(28.64%)	(22.73%)	30.43%	(29.62%)	1.68%	(2.39%)	(74.26%)	0.80%	(0.30%)	10.57%	(5.36%)	-	(5.36%)
Total	(11.85%)	(10.60%)	(14.08%)	(1.18%)	(3.16%)	(3.17%)	(13.82%)	(27.76%)	2.81%	(0.01%)	(7.94%)	(6.99%)	(7.65%)
2008 Percent of Total	10.34%	7.69%	6.68%	6.11%	7.78%	5.54%	4.05%	3.91%	3.35%	13.75%	69.20%	30.80%	100.00%
2008 to 2009													
Commercial	(16.47%)	(14.86%)	(14.44%)	(12.06%)	(17.65%)	(14.51%)	(22.85%)	(1.02%)	(68.67%)	(100.00%)	(15.43%)	(4.23%)	(9.77%)
General Aviation[1]	(14.50%)	(0.16%)	(11.38%)	(20.07%)	(29.14%)	(27.94%)	(15.50%)	(4.71%)	(18.97%)	(9.44%)	(14.09%)	(48.61%)	(15.83%)
Military & Other	(25.05%)	39.04%	38.45%	(20.12%)	(10.94%)	(20.45%)	100.00%	(98.08%)	(14.29%)	(23.58%)	(17.42%)	-	(17.42%)
Total	(16.36%)	(11.67%)	(13.27%)	(15.63%)	(22.64%)	(21.78%)	(15.53%)	(6.27%)	(19.70%)	(9.63%)	(14.82%)	(7.08%)	(12.44%)
2009 Percent of Total	9.88%	7.76%	6.61%	5.88%	6.88%	4.95%	3.91%	4.19%	3.07%	14.19%	67.31%	32.69%	100.00%
2009 to 2010													
Commercial	(1.95%)	(3.38%)	(0.67%)	(2.43%)	(5.18%)	(1.79%)	3.39%	(35.54%)	259.24%	-	(2.27%)	1.47%	(0.27%)
General Aviation[1]	(4.22%)	8.53%	(5.00%)	(2.74%)	9.84%	2.99%	(15.48%)	0.34%	2.04%	8.91%	2.94%	19.93%	3.46%
Military & Other	11.08%	33.46%	(19.78%)	(42.67%)	(44.65%)	(4.56%)	(21.60%)	3264.71%	12.49%	47.74%	(7.50%)	-	(7.50%)
Total	(2.04%)	(0.44%)	(1.88%)	(3.06%)	(3.07%)	(0.87%)	(14.13%)	(0.45%)	7.59%	9.22%	0.26%	2.12%	0.87%
2010 Percent of Total	9.59%	7.65%	6.43%	5.65%	6.61%	4.87%	3.33%	4.13%	3.27%	15.37%	66.91%	33.09%	100.00%
2010 to 2011													
Commercial	7.98%	(4.88%)	(4.80%)	0.35%	(1.26%)	(0.08%)	5.19%	23.82%	13.26%	-	0.76%	0.83%	0.80%
General Aviation[1]	(12.13%)	3.21%	(8.35%)	(13.41%)	17.88%	(3.17%)	6.38%	5.27%	5.38%	(0.68%)	1.08%	92.28%	4.34%
Military & Other	19.88%	6.34%	(6.32%)	19.51%	23.32%	(14.85%)	(18.64%)	10.84%	5.85%	(21.50%)	(1.36%)	-	(1.36%)
Total	4.64%	(2.74%)	(5.53%)	(5.17%)	10.22%	(5.70%)	6.01%	6.03%	5.83%	(0.45%)	0.83%	4.63%	2.09%
2011 Percent of Total	9.83%	7.29%	5.95%	5.25%	7.13%	4.49%	3.46%	4.29%	3.39%	14.98%	66.08%	33.92%	100.00%

Table F-2 Percentage Change in Aircraft Operations by Classification for New England's Airports, 2000 to 2016

Airport	Bradley International	T.F. Green	Manchester-Boston Regional	Portland International Jetport	Burlington	Bangor	Tweed-New Haven	Worcester Regional	Portsmouth International	Hanscom Field[2]	Subtotal	Logan Airport[3]	Total
2011 to 2012													
Commercial	(8.22%)	(12.05%)	(11.68%)	(5.80%)	(7.20%)	(8.35%)	16.90%	(18.74%)	(70.76%)	-	(9.39%)	(4.11%)	(6.51%)
General Aviation[1]	(5.42%)	13.81%	0.06%	(2.75%)	(0.49%)	(7.35%)	2.52%	(3.17%)	11.57%	2.49%	1.62%	(0.41%)	1.49%
Military & Other	2.64%	17.62%	22.77%	9.57%	20.19%	(12.99%)	34.19%	16.72%	(2.95%)	(47.62%)	(2.33%)	-	(2.33%)
Total	(7.42%)	(4.82%)	(8.95%)	(4.51%)	(1.44%)	(9.21%)	4.07%	(3.57%)	4.53%	1.97%	(2.92%)	(3.83%)	(3.23%)
2012 Percent of Total	9.41%	7.17%	5.60%	5.18%	7.27%	4.22%	3.72%	4.28%	3.67%	15.79%	66.29%	33.71%	100.00%
2012 to 2013													
Commercial	(1.87%)	(3.90%)	(3.98%)	(6.17%)	(0.93%)	(0.80%)	4.01%	(3.23%)	11.55%	(60.16%)	(3.07%)	2.42%	0.00%
General Aviation[1]	(2.55%)	(0.21%)	(8.57%)	(4.04%)	(4.58%)	(14.02%)	(17.20%)	(22.90%)	(4.09%)	(6.75%)	(8.60%)	(5.09%)	(8.37%)
Military & Other	(31.35%)	0.23%	14.07%	(19.35%)	(1.51%)	(3.98%)	1.68%	(19.86%)	(4.35%)	(28.32%)	(6.98%)	-	(6.98%)
Total	(3.09%)	(2.66%)	(4.63%)	(5.49%)	(3.01%)	(7.01%)	(14.86%)	(22.13%)	(3.94%)	(7.05%)	(6.48%)	1.82%	(3.68%)
2013 Percent of Total	9.46%	7.25%	5.54%	5.09%	7.32%	4.07%	3.28%	3.46%	3.66%	15.23%	64.37%	35.63%	100.00%
2013 to 2014													
Commercial	1.08%	(8.25%)	(11.24%)	(4.95%)	(2.82%)	(1.90%)	17.12%	49.31%	1378.21%	1.19%	(0.57%)	0.81%	0.23%
General Aviation[1]	(2.90%)	19.25%	7.53%	(17.41%)	1.10%	0.08%	(8.76%)	(11.40%)	(15.58%)	(13.19%)	(7.78%)	(1.00%)	(7.32%)
Military & Other	4.18%	138.16%	(25.82%)	18.90%	(1.86%)	4.73%	25.06%	61.21%	0.63%	13.80%	4.60%	-	4.60%
Total	0.54%	1.87%	(7.74%)	(9.57%)	(0.60%)	0.62%	(5.15%)	(7.43%)	8.78%	(13.07%)	(4.42%)	0.68%	(2.60%)
2014 Percent of Total	9.77%	7.58%	5.25%	4.72%	7.47%	4.21%	3.20%	3.29%	4.08%	13.60%	63.17%	36.83%	100.00%
2014 to 2015													
Commercial	(3.33%)	(4.36%)	(1.59%)	2.97%	(3.37%)	(5.61%)	31.72%	1.94%	3.25%	(14.06%)	(1.69%)	2.19%	0.54%
General Aviation[1]	(2.37%)	(23.02%)	5.21%	8.35%	1.76%	6.04%	5.47%	22.56%	9.85%	(4.47%)	0.29%	6.62%	0.74%
Military & Other	0.56%	(58.49%)	(10.68%)	1.25%	(13.59%)	(7.63%)	29.49%	(7.01%)	(1.60%)	(1.66%)	(7.62%)	-	(7.62%)
Total	(3.08%)	(12.46%)	(0.13%)	4.86%	(1.48%)	(1.81%)	9.86%	20.18%	6.33%	(4.48%)	(0.92%)	2.51%	0.34%
2015 Percent of Total	9.44%	6.61%	5.23%	4.93%	7.33%	4.12%	3.50%	3.94%	4.33%	12.94%	62.37%	37.63%	100.00%
2015 to 2016													
Commercial	0.98%	2.93%	6.64%	5.77%	4.87%	7.23%	13.92%	8.37%	11.29%	20.91%	4.34%	4.55%	4.46%
General Aviation[1]	0.40%	14.68%	11.70%	2.33%	(7.12%)	2.90%	3.97%	(10.79%)	5.56%	(5.16%)	(1.45%)	9.28%	(0.64%)
Military & Other	18.58%	(7.67%)	(38.22%)	(13.93%)	3.42%	6.11%	(0.29%)	(12.26%)	9.23%	6.76%	5.05%	-	5.05%
Total	1.40%	6.93%	7.20%	4.28%	(2.11%)	5.19%	5.70%	(9.64%)	7.34%	(5.06%)	1.15%	4.90%	2.57%
2016 Percent of Total	9.33%	6.90%	5.46%	5.02%	7.00%	4.22%	3.61%	3.47%	4.53%	11.98%	61.51%	38.49%	100.00%

Source: Massport, Federal Aviation Administration (FAA) Tower Counts, and individual airport records.

1 Includes itinerant and local general aviation (GA) operations at the regional airports. There are no local (touch-and-go training) operations at Logan Airport.

2 Commercial operations at Hanscom Field include scheduled commercial operations only; other air taxi operations counted as GA.

3 Operations at Logan Airport include international operations.

Table F-3 Scheduled Passenger Operations by Market and Carrier for Bradley International Airport

				Departures											Departing Seats												
Carrier	Code	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	2000	2004	2005	2009	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Jet Carriers																											
Aer Lingus		Dublin	DUB									66	66	-											11,657	11,657	-
Alaska	AS	Chicago O'Hare	ORD	30									-	-	4,050											-	-
America West	HP	Columbus	CMH	149									-	-	18,441											-	-
America West	HP	Las Vegas	LAS	210									-	-	27,469											-	-
America West	HP	Phoenix	PHX	275	365								-	-	37,772	51,960	54,570									-	-
American	AA	Charlotte	CLT							1,763	1,775	1,918	143	8.1%									257,645	244,756	278,511	33,755	13.8%
American	AA	Chicago O'Hare	ORD	2,139	1,570							240	240	-	304,855	265,113	203,929								35,717	35,717	-
American	AA	Dallas/Fort Worth	DFW	1,343	1,052	1,052	1,078	1,068	1,069	1,008	695	678	-17	-2.4%	185,922	180,987	136,897	154,343	160,983	172,457	170,811	171,017	157,952	103,576	101,001	-2,575	-2.5%
American	AA	Los Angeles	LAX	214					122	243		205	205	-	31,244							19,520	38,880		30,588	30,588	-
American	AA	Miami	MIA	366	365	413	516	366	396	476	400	365	-35	-8.8%	51,427	71,102	49,990	54,020	63,559	82,560	58,560	63,360	74,981	59,600	54,342	-5,258	-8.8%
American	AA	Philadelphia	PHL							265	31	271	240	774.2%									29,004	3,069	28,245	25,176	820.3%
American	AA	New York J F Kennedy	JFK										-	-												-	-
American	AA	San Juan	SJU	366	365	365	365	91					-	-	69,348	92,171	84,425	56,900	55,856	58,400	14,560					-	-
American	AA	St. Louis	STL										-	-												-	-
American	AA	Washington National	DCA							103	18	17	-1	-5.6%									12,536	2,196	1,680	-516	-23.5%
Boston-Maine Airways	E9	Fort Lauderdale/Hollywood	FLL		13								-	-			1,993									-	-
Continental	CO	Cleveland	CLE	582	131								-	-	68,974	15,985	16,262	9,203								-	-
Continental	CO	Houston Intercontinental	IAH	366	313								-	-	45,790	25,341	34,072									-	-
Continental	CO	New York Newark	EWR	331									-	-	38,916											-	-
Delta	DL	Atlanta	ATL	2,192	3,098	2,099	2,094	2,105	2,109	2,391	2,374	2,360	-14	-0.6%	392,835	450,671	479,098	300,052	300,185	310,149	317,331	319,290	355,968	354,751	354,943	192	0.1%
Delta	DL	Boston	BOS	4									-	-	634											-	-
Delta	DL	Cancun	CUN			35	35	17	13	17	35	39	4	11.4%				4,543	5,470	5,397	2,735	1,973	2,571	5,207	5,956	749	14.4%
Delta	DL	Cincinnati	CVG	1,464	1,373						4		-4	-100.0%	244,837	257,177	196,741	37,709						471		-471	-100.0%
Delta	DL	Detroit	DTW			1,003	658	506	753	1,053	1,375	1,366	-9	-0.7%				113,746	129,228	91,657	73,117	110,361	145,867	187,833	184,729	-3,104	-1.7%
Delta	DL	Fort Lauderdale/Hollywood	FLL	732	673	237	210						-	-	87,108	139,613	133,927	39,902	33,674	29,280						-	-
Delta	DL	Fort Myers	RSW			99	90						-	-				17,369	13,104	12,780						-	-
Delta	DL	Las Vegas	LAS			9							-	-					1,394							-	-
Delta	DL	Los Angeles	LAX		100	83							-	-			19,928		13,257							-	-
Delta	DL	Minneapolis	MSP			758	576	511	549	605	858	662	-196	-22.8%				84,739	99,431	79,418	75,291	82,545	87,377	114,722	96,039	-18,683	-16.3%
Delta	DL	New York J F Kennedy	JFK	183									-	-	39,894											-	-
Delta	DL	Orlando	MCO	1,838	1,095	261	608		57			4	4	-	218,705	203,634	217,905	93,534	99,129	88,041		8,514			471	471	-
Delta	DL	Salt Lake City	SLC		27								-	-			3,986									-	-
Delta	DL	Tampa	TPA		678	813	120						-	-		131,795	134,894	58,210	33,625	15,420						-	-
Delta	DL	West Palm Beach	PBI	732	516	205	120						-	-	87,108	106,806	102,684	48,132	37,536	16,500						-	-
Frontier Airlines	F9	Denver	DEN										-	-												-	-
jetBlue	B6	Washington National	DCA							402	730	714	-16	-2.2%									40,229	85,300	77,600	-7,700	-9.0%
jetBlue	B6	Fort Lauderdale/Hollywood	FLL			101	599	627	612	590	590	568	-22	-3.7%					15,086	90,231	94,029	91,800	87,836	88,479	85,264	-3,215	-3.6%
jetBlue	B6	Fort Myers	RSW						61	181	212	242	30	14.2%								9,150	27,150	31,800	36,300	4,500	14.2%
jetBlue	B6	Orlando	MCO			101	730	723	730	747	730	746	16	2.2%					15,086	109,860	108,300	109,500	112,071	109,500	111,100	1,600	1.5%
jetBlue	B6	San Juan	SJU					366	365	405	465	561	96	20.6%							54,900	54,793	60,729	69,686	84,150	14,464	20.8%
jetBlue	B6	Tampa	TPA						61	365	365	365	-	0.0%								9,150	44,693	48,750	54,750	6,000	12.3%
jetBlue	B6	West Palm Beach	PBI					366	365	365	365	387	22	6.0%							45,700	54,750	44,907	45,550	51,929	6,379	14.0%
Laker Airways (Bahamas)	7Z	Freeport	FPO	39									-	-	5,850	3,900										-	-
Midway Airlines	JI	Raleigh/Durham	RDU	683									-	-	69,213											-	-
Midwest/Republic	YX	Milwaukee	MKE	619									-	-	44,455											-	-
Northwest	NW	Amsterdam	AMS										-	-												-	-
Northwest	NW	Detroit	DTW	1,699	1,451								-	-	215,750	204,604	192,679									-	-
Northwest	NW	Fort Myers	RSW										-	-												-	-
Northwest	NW	Minneapolis	MSP	1,177	1,042								-	-	135,570	149,646	140,194									-	-
Northwest	NW	Orlando	MCO										-	-												-	-
Northwest	NW	Tampa	TPA										-	-												-	-
Northwest	NW	West Palm Beach	PBI										-	-												-	-
Southwest	WN	Atlanta	ATL						174	1,086	172		-172	-100.0%								20,391	131,627	24,482		-24,482	-100.0%
Southwest	WN	Baltimore	BWI	2,841	3,094	2,700	2,708	2,658	2,610	2,448	2,435	2,514	79	3.2%	389,158	419,083	423,878	371,357	367,534	367,414	362,995	372,650	353,791	353,038	372,278	19,240	5.4%
Southwest	WN	Chicago Midway	MDW	723	953	923	979	964	967	961	974	966	-8	-0.9%	99,090	97,309	130,541	128,780	126,412	133,267	133,533	146,270	142,513	147,672	148,701	1,029	0.7%
Southwest	WN	Denver	DEN			306	365	366	365	374	374	374	0	0.1%					41,922	50,005	50,982	54,860	58,570	61,917	60,234	-1,683	-2.7%
Southwest	WN	Fort Lauderdale/Hollywood	FLL			70	365	366	348	369	387	387	0	0.1%					9,551	50,005	50,272	49,521	53,381	57,309	56,240	-1,069	-1.9%
Southwest	WN	Fort Myers	RSW					147	203	216	212	212	-	0.0%							20,413	28,917	30,949	30,586	30,586	0	0.0%
Southwest	WN	Las Vegas	LAS	52	365	361	365	270	245	245	306	306	-	0.0%	7,163	51,336	50,005	50,005	49,398	50,005	40,466	34,876	35,035	44,037	46,551	2,514	5.7%
Southwest	WN	Nashville	BNA	672	365	361	304						-	-	92,064	50,142	50,005	50,005	49,398	41,648						-	-
Southwest	WN	Orlando	MCO	375	1,108	1,016	1,003	997	944	975	1,003	999	-4	-0.4%	51,336	114,082	151,816	143,459	139,212	137,411	137,843	136,115	140,866	151,806	156,562	4,756	3.1%
Southwest	WN	Philadelphia	PHL		1,590								-	-		40,591	217,850									-	-

Table F-3 Scheduled Passenger Operations by Market and Carrier for Bradley International Airport

				Departures											Departing Seats												
Carrier	Code	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	2000	2004	2005	2009	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Southwest	WN	Tampa	TPA		695	570	656	623	629	656	651	642	-9	-1.4%		52,530	95,156	58,362	78,129	89,852	85,873	90,219	93,662	93,905	93,646	-259	-0.3%
Southwest	WN	West Palm Beach	PBI				61				4	4	-	0.0%						8,357				633	633	-	0.0%
Sunworld International	SM	Philadelphia	PHL										-	-												-	-
Trans World Airlines	TW	Portland (ME)	PWM	305									-	-	43,310											-	-
Trans World Airlines	TW	St. Louis	STL	1,460									-	-	206,109											-	-
United	UA	Chicago O'Hare	ORD	2,034	1,812	1,296	1,077	697	593	800	554	605	51	9.2%	299,522	317,682	259,437	200,920	198,709	159,738	104,725	86,911	112,864	72,529	84,972	12,443	17.2%
United	UA	Denver	DEN	366								275	275	-	46,901										36,838	36,838	-
United	UA	New York Newark	EWR						18				-	-								2,126				-	-
United	UA	San Francisco	SFO	366									-	-	45,384											-	-
United	UA	Washington Dulles	IAD	1,455	726	1,192	812	514	180	222	82	472	390	475.6%	173,869	63,854	81,631	131,883	155,750	108,500	66,780	25,418	32,132	11,182	73,998	62,816	561.8%
US Airways	US	Baltimore	BWI	488									-	-	41,760											-	-
US Airways	US	Charlotte	CLT	1,464	2,188	1,588	1,664	1,665	1,734				-	-	214,719	229,826	350,776	146,512	228,119	238,508	241,320	255,885				-	-
US Airways	US	Fort Lauderdale/Hollywood	FLL	366	123								-	-	39,232	1,272	15,161									-	-
US Airways	US	Orlando	MCO	1,098	30								-	-	117,696	5,986	3,842									-	-
US Airways	US	Philadelphia	PHL	2,148	2,102	361	317	340	365				-	-	310,118	267,741	301,242	58,153	49,914	44,595	46,989	49,083				-	-
US Airways	US	Phoenix	PHX										-	-												-	-
US Airways	US	Pittsburgh	PIT	1,800	27								-	-	278,575	157,633	3,189									-	-
US Airways	US	Washington Dulles	IAD	732									-	-	86,376											-	-
US Airways	US	Washington National	DCA	1,329	1,064	361	365	335	208				-	-	171,891	141,901	141,068	84,917	51,434	52,210	46,511	25,610				-	-
US Airways	US	West Palm Beach	PBI	366									-	-	39,232											-	-
USA 3000 Airlines	U5	Cancun	CUN		26								-	-			4,336									-	-
USA 3000 Airlines	U5	Punta Cana	PUJ		13								-	-			2,128									-	-
Subtotal				38,171	30,507	18,695	18,841	16,686	16,845	19,331	18,175	19,530	1,354	7.5%	5,179,671	4,361,471	4,486,236	2,496,754	2,622,086	2,693,666	2,404,036	2,484,577	2,765,786	2,604,342	2,846,211	241,870	9.3%
Regional/Commuter Carriers																											
Air Canada Express	AC	Montreal Dorval	YUL	1,385	1,038	1,021	986	976	952	996	1,008	1,038	30	3.0%	19,392	21,557	19,475	19,157	19,399	18,739	18,549	17,144	17,925	18,141	18,692	551	3.0%
Air Canada Express	AC	Toronto	YYZ	1,589	1,342	1,287	1,308	1,294	1,295	1,313	1,395	1,399	4	0.3%	61,991	35,666	38,242	38,410	36,960	38,342	33,044	28,103	25,102	25,118	35,328	10,210	40.6%
America West Express	HP	Columbus	CMH	450									-	-	22,493											-	-
American Connection	AA	St. Louis	STL		947								-	-		32,571	44,356	9,240								-	-
American Eagle	AA	Charlotte	CLT							366	290	156	-134	-46.1%									28,940	22,265	11,774	-10,491	-47.1%
American Eagle	AA	Chicago O'Hare	ORD			1,501	1,630	1,613	1,630	1,622	1,604	1,421	-183	-11.4%		416		50,374	79,594	95,985	80,413	90,663	115,856	115,366	93,468	-21,898	-19.0%
American Eagle	AA	New York J F Kennedy	JFK	1,460									-	-	48,166											-	-
American Eagle	AA	Philadelphia	PHL							2,234	2,502	2,133	-369	-14.8%									136,683	146,222	123,285	-22,937	-15.7%
American Eagle	AA	Pittsburgh	PIT							939	782		-782	-100.0%									67,549	39,086		-39,086	-100.0%
American Eagle	AA	Raleigh/Durham	RDU		1,364	257							-	-		46,535	54,521	45,154	10,774							-	-
American Eagle	AA	St. Louis	STL										-	-				4,600								-	-
American Eagle	AA	Washington National	DCA							2,119	2,125	2,251	126	5.9%									141,783	130,975	142,309	11,334	8.7%
Continental Connection	CO	Albany	ALB		51								-	-		16,337	961									-	-
Continental Connection	CO	Binghamton	BGM										-	-												-	-
Continental Connection	CO	Boston	BOS										-	-												-	-
Continental Connection	CO	Buffalo	BUF	89									-	-	1,683											-	-
Continental Connection	CO	Burlington	BTV	4									-	-	84											-	-
Continental Connection	CO	New York J F Kennedy	JFK										-	-												-	-
Continental Connection	CO	New York Newark	EWR			608							-	-				13,859	22,485							-	-
Continental Connection	CO	Philadelphia	PHL										-	-												-	-
Continental Connection	CO	Rochester	ROC	93									-	-	1,767											-	-
Continental Connection	CO	Syracuse	SYR	97									-	-	1,851											-	-
Continental Express	CO	Cleveland	CLE	803	1,102	1,208							-	-	39,357	56,179	54,951	58,179	60,400							-	-
Continental Express	CO	New York Newark	EWR	1,747	1,351	465							-	-	82,365	68,285	67,455	42,029	23,264							-	-
Delta Connection	DL	Atlanta	ATL				48	9	4	4	4		-4	-100.0%						3,396	647	279	288	326		-326	-100.0%
Delta Connection	DL	Cincinnati	CVG			1,218	1,251	902	895	839	475	300	-175	-36.8%				60,954	61,642	66,559	45,181	44,757	43,557	25,537	22,800	-2,737	-10.7%
Delta Connection	DL	Cleveland	CLE							170	243	266	23	9.5%									11,898	15,450	19,798	4,348	28.1%
Delta Connection	DL	Columbus	CMH		994								-	-		4,650	49,196									-	-
Delta Connection	DL	Detroit	DTW			1,004	1,323	1,429	1,195	659	313	264	-49	-15.7%				53,556	54,265	82,915	100,525	80,351	45,421	20,860	18,905	-1,955	-9.4%
Delta Connection	DL	Fort Lauderdale/Hollywood	FLL										-	-												-	-
Delta Connection	DL	Fort Myers	RSW		612								-	-			42,840									-	-
Delta Connection	DL	Indianapolis	IND										-	-				3,857								-	-
Delta Connection	DL	Minneapolis	MSP			481	814	858	812	738	342	539	197	57.6%				34,895	36,567	61,731	64,643	61,035	55,233	25,556	40,845	15,289	59.8%
Delta Connection	DL	Myrtle Beach	MYR	61									-	-	3,057											-	-
Delta Connection	DL	New York J F Kennedy	JFK			365	304	183					-	-				39,736	18,250	15,200	9,216					-	-
Delta Connection	DL	Orlando	MCO							43	35	8	-27	-77.1%									3,156	2,354	641	-1,713	-72.8%
Delta Connection	DL	Raleigh/Durham	RDU			100	569	454	270	257	261	253	-8	-3.1%					6,136	28,436	22,686	13,500	12,850	17,611	18,054	443	2.5%
Delta Connection	DL	Tampa	TPA										-	-												-	-
Delta Connection	DL	Washington National	DCA			166	929	360					-	-					11,324	51,524	18,074					-	-
Delta Connection	DL	West Palm Beach	PBI										-	-												-	-
Frontier Express	F9	Milwaukee	MKE			140	417						-	-					6,313	18,746						-	-
Independence Air	DH	Washington Dulles	IAD		1,966								-	-		57,714	98,307									-	-
Midway Airlines	JI	Raleigh/Durham	RDU	1,348									-	-	67,393											-	-
Midwest Connect	YX	Milwaukee	MKE	4	965								-	-	142	30,117	30,871									-	-

Table F-3 Scheduled Passenger Operations by Market and Carrier for Bradley International Airport

				Departures											Departing Seats												
Carrier	Code	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	2000	2004	2005	2009	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Northwest Airlink	NW	Detroit	DTW										-	-												-	-
Northwest Airlink	NW	Indianapolis	IND		638								-	-		5,664	31,907									-	-
Northwest Airlink	NW	Memphis	MEM										-	-												-	-
Northwest Airlink	NW	Minneapolis	MSP		31								-	-			1,550									-	-
OneJet		Pittsburgh	PIT									289	289	-											2,597	2,597	-
Shuttle America	S5	Albany	ALB	66									-	-	3,286											-	-
Shuttle America	S5	Bedford	BED	233									-	-	11,671											-	-
Shuttle America	S5	Buffalo	BUF	337									-	-	16,857											-	-
Shuttle America	S5	Islip	ISP	27									-	-	1,329											-	-
Shuttle America	S5	Wilmington	ILG	159									-	-	7,936											-	-
Swissair	SR	New York J F Kennedy	JFK	31									-	-	1,023											-	-
Trans World Airlines	TW	New York J F Kennedy	JFK	1,098									-	-	31,842											-	-
United Express	UA	Chicago O'Hare	ORD		691	548	685	1,038	1,045	877	904	696	-208	-23.0%		24,456	48,370	26,387	36,797	43,701	63,807	59,896	47,419	60,980	45,255	-15,725	-25.8%
United Express	UA	Cleveland	CLE				1,200	1,125	1,127	235			-	-						59,979	55,744	56,436	11,750			-	-
United Express	UA	Houston	IAH							96	365	361	-4	-1.1%									7,521	26,998	25,240	-1,758	-6.5%
United Express	UA	New York Newark	EWR				1,159	1,347	1,269	853	1,335	1,357	22	1.6%						46,231	56,787	61,339	38,317	65,086	69,442	4,356	6.7%
United Express	UA	Washington Dulles	IAD		1,519	494	889	928	1,280	1,224	1,243	870	-373	-30.0%		84,513	84,484	46,746	30,270	54,707	59,507	72,861	68,684	77,783	56,035	-21,748	-28.0%
US Airways Express	US	Baltimore	BWI	1,185									-	-	43,850											-	-
US Airways Express	US	Buffalo	BUF	1,032	839								-	-	38,200	32,121	28,607									-	-
US Airways Express	US	Charlotte	CLT		4	537	452	462	364				-	-		650	221	86,653	45,043	37,510	39,235	28,392				-	-
US Airways Express	US	New York La Guardia	LGA			139	1,057	364					-	-					5,159	39,098	13,468					-	-
US Airways Express	US	New York Newark	EWR										-	-												-	-
US Airways Express	US	Philadelphia	PHL		439	2,404	2,430	2,356	2,260				-	-		9,500	27,685	148,400	183,838	163,675	151,526	133,663				-	-
US Airways Express	US	Pittsburgh	PIT		1,646	939	939	941	939				-	-		9,247	84,598	46,929	46,929	46,929	47,057	77,901				-	-
US Airways Express	US	Rochester	ROC	937	574	478							-	-	34,658	21,280	19,555	19,501	16,242							-	-
US Airways Express	US	Syracuse	SYR	732	478								-	-	27,084	11,093	9,077									-	-
US Airways Express	US	Washington National	DCA		551	1,334	1,411	1,574	1,825				-	-		19,813	34,454	60,107	89,629	89,940	109,321	115,989				-	-
Subtotal				14,968	19,143	16,694	19,799	18,212	17,164	15,584	15,226	13,601	-1,625	-10.7%	567,477	588,364	871,682	908,722	901,282	1,063,342	989,430	942,310	879,932	835,714	744,468	-91,246	-10.9%
													-	-												-	-
Total				53,139	49,651	35,389	38,640	34,898	34,009	34,915	33,402	33,131	-271	-0.8%	5,747,148	4,949,835	5,357,918	3,405,476	3,523,368	3,757,008	3,393,466	3,426,886	3,645,718	3,440,056	3,590,679	150,624	4.4%

Source: OAG Schedules.

Notes:

All Northwest Airlines operations included in Delta Air Lines from 2009 onwars (following 2008 merger)

All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)

All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)

All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

Table F-4 Scheduled Passenger Operations by Market and Carrier for T.F. Green Airport

			Departures														Departing Seats											
Carrier	**Market**	**Code**	**2000**	**2001**	**2003**	**2004**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**'15-'16 Change**	**'15-'16 Pct. Change**	**2000**	**2004**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**'15-'16 Change**	**'15-'16 Pct. Change**
Jet Carriers																												
American	Charlotte	CLT										1,275	1,176	1,274	98	8.3%								196,644	170,310	189,856	19,546	11.5%
American	Chicago O'Hare	ORD	1,464	1,460	1,421	1,609	1,113								-	-	203,104	207,543	143,522								-	-
American	Dallas/Fort Worth	DFW			61	366	365								-	-		47,214	47,085								-	-
American	Philadelphia	PHL										347	366	520	154	42.1%								34,381	36,514	50,988	14,474	39.6%
American	Washington National	DCA										77	52		-52	-100.0%								9,566	6,483		-6,483	-100.0%
Continental	Cleveland	CLE	569	167	13	131	13								-	-	69,771	15,622	1,630								-	-
Continental	Houston Intercontinental	IAH	366	243											-	-	45,946										-	-
Continental	New York Newark	EWR	738	1,170	450	331	282								-	-	96,448	38,535	34,808								-	-
Condor	Frankfurt	FRA											22	18	-4	-18.2%									5,940	4,783	-1,157	-19.5%
Delta	Atlanta	ATL	1,464	1,460	1,825	1,830	1,976	510	1,043	990	978	993	997	1,060	63	6.3%	207,888	289,611	290,915	72,461	150,526	147,729	145,241	148,012	148,078	156,507	8,429	5.7%
Delta	Cincinnati	CVG	732	730	730	732	695								-	-	103,944	103,944	89,235								-	-
Delta	Detroit	DTW						414	58		218	476	707	719	12	1.7%				50,065	7,139		30,414	62,046	87,078	91,281	4,203	4.8%
Delta	Fort Lauderdale/Hollywood	FLL		306											-	-											-	-
Delta	Minneapolis	MSP						74							-	-				9,211							-	-
Delta	Orlando	MCO	732	730	424										-	-	87,108										-	-
jetBlue	Fort Lauderdale/Hollywood	FLL								31	365	365	365	365	-	0.0%						4,650	54,750	54,750	54,750	54,750	-	0.0%
jetBlue	Orlando	MCO								62	713	713	713	713	0	0.1%						9,300	103,786	106,886	106,886	106,886	0	0.0%
Laker Airways (Bahamas)	Freeport	FPO				9									-	-		1,329									-	-
Northwest	Detroit	DTW	1,682	1,631	1,513	1,512	1,550								-	-	200,509	203,837	202,255								-	-
Northwest	Minneapolis	MSP			726	641	539								-	-		85,995	68,977								-	-
Sata Internacional	Ponta Delgada	PDL				17								9	9	-		3,486								1,966	1,966	-
Southwest	Baltimore	BWI	3,913	3,877	4,043	4,222	4,180	3,260	3,043	3,128	3,004	2,820	2,793	2,793	0	0.0%	535,911	578,063	572,699	442,637	415,554	433,081	429,658	411,154	407,651	414,057	6,406	1.6%
Southwest	Chicago Midway	MDW	1,072	1,022	1,056	1,089	1,349	1,135	1,095	1,094	992	975	988	996	8	0.9%	146,844	149,232	184,813	153,121	149,877	150,303	154,633	156,543	158,640	153,783	-4,857	-3.1%
Southwest	Denver	DEN								366	304	9			-	-						51,110	44,281	1,246			-	-
Southwest	Fort Lauderdale/Hollywood	FLL	9	30		26		594	590	500	479	474	477	485	8	1.7%	1,194	3,562		81,378	80,791	68,347	70,413	68,401	70,778	74,477	3,699	5.2%
Southwest	Fort Myers	RSW								86	40	44	48	52	4	8.0%						11,743	5,520	6,292	7,305	7,918	613	8.4%
Southwest	Houston	HOU	152												-	-	20,824										-	-
Southwest	Islip	ISP	608	1,369											-	-	83,237										-	-
Southwest	Kansas City	MCI	366	365	365	366	365								-	-	50,142	50,142	50,005								-	-
Southwest	Las Vegas	LAS				9	31	365	365	362					-	-		1,194	4,247	50,005	50,005	49,932					-	-
Southwest	Nashville	BNA	706	700	708	706	721	296	123						-	-	96,702	96,722	98,816	39,578	16,067						-	-
Southwest	Orlando	MCO	955	1,095	1,460	1,586	1,821	1,799	1,659	1,585	1,423	1,419	1,464	1,469	5	0.3%	130,855	217,302	249,418	245,156	225,244	216,998	210,082	204,947	215,253	219,994	4,741	2.2%
Southwest	Philadelphia	PHL				1,199	1,773	1,402	1,298						-	-		164,224	238,366	192,054	177,001						-	-
Southwest	Phoenix	PHX	366	703	730	732	726	361	365						-	-	50,142	100,284	99,403	49,398	50,005						-	-
Southwest	Tampa	TPA	745	730	1,095	1,085	1,086	813	808	763	753	748	735	713	-22	-3.0%	102,065	148,625	148,821	111,231	109,572	104,140	107,959	107,481	108,451	107,723	-728	-0.7%
Southwest	West Palm Beach	PBI									31	35	31	31	-	0.0%							4,433	5,046	4,433	4,433	-	0.0%
Southwest	Washington National	DCA												122	122	-										19,119	19,119	-
Spirit Airlines	Detroit	DTW				61	120								-	-		9,150	18,000								-	-
Spirit Airlines	Fort Lauderdale/Hollywood	FLL				131	568								-	-		19,586	84,117								-	-
Spirit Airlines	Fort Myers	RSW				70	365								-	-		10,436	54,750								-	-
TACV	Praia	RAI											39	74	35	89.7%									7,739	14,578	6,839	88.4%
United	Chicago O'Hare	ORD	1,477	1,491	1,666	1,555	1,460	644	626	388	334	320	144	236	92	63.9%	239,076	234,843	200,677	82,802	78,487	48,697	46,258	42,658	17,570	31,940	14,370	81.8%
US Airways	Baltimore	BWI	2,462	2,101											-	-	263,921										-	-
US Airways	Charlotte	CLT	977	1,309	1,513	1,582	1,858	1,643	1,599	1,726	1,608				-	-	128,984	223,314	274,039	233,886	226,854	238,503	225,454				-	-
US Airways	Fort Lauderdale/Hollywood	FLL				31	17								-	-		3,941	2,186								-	-
US Airways	Orlando	MCO	52	48		48	43								-	-	5,605	6,126	5,831								-	-
US Airways	Philadelphia	PHL	1,830	1,794	1,738	2,416	2,182	1,299	1,012	399	313				-	-	253,015	345,461	312,890	130,008	101,987	39,529	30,973				-	-
US Airways	Pittsburgh	PIT	1,339	1,460	1,165	1,290	31								-	-	185,109	174,598	4,446								-	-
US Airways	Washington National	DCA	1,333	1,147	1,390	1,107	1,270	365	313	182	124				-	-	167,278	149,503	170,009	49,501	44,006	24,350	14,997				-	-
Subtotal			26,108	27,136	24,093	26,488	26,499	14,974	13,998	11,661	11,677	11,090	11,116	11,649	533	4.8%	3,475,622	3,683,422	3,651,961	1,992,492	1,883,114	1,598,412	1,678,851	1,616,053	1,613,859	1,705,039	91,180	5.6%

Table F-4 Scheduled Passenger Operations by Market and Carrier for T.F. Green Airport

			Departures														Departing Seats											
Carrier	Market	Code	2000	2001	2003	2004	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	2000	2004	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Regional/Commuter Carriers																												
Air Canada Express	Toronto	YYZ	989	991	906	798	734	625	591	593	84				-	-	37,482	14,364	13,783	11,880	11,232	11,262	1,517				-	-
American Eagle	Charlotte	CLT										175	341	301	-40	-11.7%								13,971	26,810	25,452	-1,358	-5.1%
American Eagle	Chicago O'Hare	ORD												550	550	-										34,650	34,650	-
American Eagle	Detroit	DTW								12					-	-						808					-	-
American Eagle	New York J F Kennedy	JFK	1,291	1,404	330										-	-	42,589										-	-
American Eagle	New York La Guardia	LGA	2,756	1,788											-	-	90,957										-	-
American Eagle	Raleigh/Durham	RDU				643	343								-	-		25,643	13,081								-	-
American Eagle	Philadelphia	PHL										2,213	2,163	1,982	-181	-8.4%								150,139	142,721	127,895	-14,826	-10.4%
American Eagle	Washington National	DCA										1,609	1,755	2,112	357	20.3%								111,183	111,865	138,655	26,790	23.9%
Cape Air	Block Island	BID										538	418		-418	-100.0%								4,846	3,765		-3,765	-100.0%
Cape Air	Hyannis	HYA													-	-											-	-
Cape Air	Martha's Vineyard	MVY	1,762	1,871	1,502	1,960	1,015	747	672	659	501	285	192		-192	-100.0%	15,861	17,640	9,132	6,722	6,048	5,930	4,513	2,561	1,725		-1,725	-100.0%
Cape Air	Nantucket	ACK	2,453	2,653	1,975	2,765	1,199	681	668	576	501	271	244		-244	-100.0%	22,073	24,885	10,787	6,128	6,012	5,181	4,510	2,438	2,196		-2,196	-100.0%
Continental Connection	Albany	ALB		944	863	702	51								-	-		13,335	961								-	-
Continental Connection	Boston	BOS		51											-	-											-	-
Continental Connection	New York Newark	EWR						427							-	-				31,630							-	-
Continental Connection	Plattsburgh	PLB		22											-	-											-	-
Continental Connection	Washington Dulles	IAD													-	-											-	-
Continental Express	Cleveland	CLE	699	1,190	1,200	1,119	1,238	1,217							-	-	34,936	55,900	61,900	60,836							-	-
Continental Express	New York Newark	EWR	1,482	465	1,019	1,395	1,455	1,028							-	-	86,552	67,702	71,185	51,407							-	-
Delta Connection	Atlanta	ATL					31	724	9	43	70	51	43		-43	-100.0%			1,550	52,959	662	3,279	4,522	3,380	3,001		-3,001	-100.0%
Delta Connection	Cincinnati	CVG		275	334	335	373	43							-	-		16,750	19,109	2,150							-	-
Delta Connection	Detroit	DTW						1,324	1,995	2,054	1,748	871	289	324	35	12.1%				78,701	111,901	113,630	90,191	45,809	18,671	22,103	3,432	18.4%
Delta Connection	Minneapolis	MSP						347	392	266	240	170			-	-				26,192	29,553	20,189	17,380	12,878			-	-
Delta Connection	New York J F Kennedy	JFK													-	-											-	-
Delta Connection	New York La Guardia	LGA	610	155											-	-	19,520										-	-
Delta Connection	Raleigh/Durham	RDU							131						-	-					6,557						-	-
Delta Connection	Washington National	DCA							685	225					-	-					34,243	11,271					-	-
Independence Air	Washington Dulles	IAD				875	1,509								-	-		43,764	75,429								-	-
Midway Airlines	Raleigh/Durham	RDU		510											-	-											-	-
Northwest Airlink	Detroit	DTW													-	-											-	-
Northwest Airlink	Minneapolis	MSP		302	40	79	31								-	-		3,943	1,550								-	-
United Express	Chicago O'Hare	ORD				214	262	455	375	309	306	325	605	464	-141	-23.3%		10,700	18,330	29,820	24,079	19,900	19,896	19,443	34,473	24,750	-9,723	-28.2%
United Express	Cleveland	CLE							1,079	886	875	102			-	-					53,943	42,991	43,757	5,100			-	-
United Express	New York Newark	EWR							1,439	1,346	1,213	994	1,356	1,355	-1	-0.1%					69,724	61,168	65,636	57,558	73,682	64,804	-8,878	-12.0%
United Express	Washington Dulles	IAD	1,468	1,507	1,460	1,876	1,716	1,569	1,421	1,157	1,035	1,031	837	886	49	5.9%	52,832	93,779	85,821	99,719	89,593	73,470	65,632	67,077	52,139	55,328	3,189	6.1%
US Airways Express	Albany	ALB	679												-	-	12,898										-	-
US Airways Express	Boston	BOS	48												-	-	909										-	-
US Airways Express	Charlotte	CLT				13	18	126	147	65	166				-	-		657	879	10,047	12,035	5,423	12,857				-	-
US Airways Express	Hyannis	HYA			17										-	-											-	-
US Airways Express	Nantucket	ACK			9										-	-											-	-
US Airways Express	New York La Guardia	LGA	2,298	2,233	1,876	1,808	1,669	1,222	957	286					-	-	84,116	50,163	55,077	45,225	33,141	10,582					-	-
US Airways Express	New York Newark	EWR	1,569	1,507											-	-	31,176										-	-
US Airways Express	Philadelphia	PHL	366	365	9	22	716	1,526	1,713	2,206	2,347				-	-	13,542	1,324	45,199	107,790	122,386	152,816	154,401				-	-
US Airways Express	Pittsburgh	PIT				183	1,360								-	-		9,157	72,808								-	-
US Airways Express	Plattsburgh	PLB	26												-	-	497										-	-
US Airways Express	Washington National	DCA				143	482	1,373	1,304	1,479	1,492				-	-		7,171	30,996	92,151	95,527	110,451	107,775				-	-
Subtotal			18,527	18,233	11,538	14,930	14,200	13,436	13,577	12,161	10,577	8,635	8,243	7,974	-269	-3.3%	546,963	456,879	587,576	713,356	706,634	648,351	592,587	496,383	471,048	493,637	22,589	4.8%
															-	-											-	-
Total			44,635	45,369	35,631	41,419	40,699	28,409	27,575	23,822	22,255	19,725	19,359	19,623	264	1.4%	4,022,585	4,140,301	4,239,537	2,705,848	2,589,748	2,246,763	2,271,438	2,112,436	2,084,907	2,198,676	113,769	5.5%

Source: OAG Schedules.

Notes:

All Northwest Airlines operations included in Delta Air Lines from 2009 onwards (following 2008 merger)

All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)

All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)

All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

Table F-5 Scheduled Passenger Operations by Market and Carrier for Manchester-Boston Regional Airport

			Departures													Departing Seats												
Carrier	Market	Code	2000	2004	2005	2009	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	2000	2004	2005	2009	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Jet Carriers																												
Boston-Maine Airways	Myrtle Beach	MYR		83										-	-		12,429										-	-
Boston-Maine Airways	Portsmouth	PSM		183										-	-		27,471										-	-
Boston-Maine Airways	Sanford	SFB		87										-	-		13,114										-	-
Continental	Cleveland	CLE	130			9								-	-	16,151			1,038								-	-
Continental	New York Newark	EWR	462	314	286									-	-	62,358	36,123	30,953									-	-
Delta	Atlanta	ATL	244	732	668		275	565	514	463	459	365	365	-	0.0%	34,648	103,944	94,856		39,050	81,600	76,629	69,307	68,468	53,545	54,212	667	1.2%
Delta	Cincinnati	CVG		710	664									-	-		100,840	86,583									-	-
Delta	Detroit	DTW				778	796					122	87	-35	-28.8%				93,450	89,289					14,414	9,881	-4,533	-31.4%
Delta	New York - LGA	LGA										4		-4	-100.0%										596		-596	-100.0%
Northwest	Detroit	DTW	1,609	1,460	1,399									-	-	194,058	202,623	180,879									-	-
Northwest	Minneapolis	MSP		362	365									-	-		44,835	46,933									-	-
Southwest	Baltimore	BWI	2,828	3,874	3,850	3,312	2,891	2,761	2,775	2,726	2,494	2,476	2,576	100	4.1%	387,397	530,588	527,405	450,616	393,093	376,945	385,044	387,879	364,979	363,524	383,914	20,390	5.6%
Southwest	Chicago Midway	MDW	706	693	1,355	1,253	1,144	1,244	1,168	1,010	984	948	996	48	5.0%	96,702	94,744	185,481	169,754	155,466	169,440	161,822	158,820	157,501	148,825	153,459	4,634	3.1%
Southwest	Denver	DEN						92	366	304				-	-						12,604	50,379	43,211				-	-
Southwest	Fort Lauderdale/Hollywood	FLL		9		120	9	9	152	90		4		-4	-100.0%		1,194		16,440	1,194	1,194	21,190	12,793		633		-633	-100.0%
Southwest	Kansas City	MCI	366	305										-	-	50,142	41,785										-	-
Southwest	Las Vegas	LAS		375	365	365	365	365	122	61	9	9		-9	-100.0%		51,336	50,005	50,005	50,005	50,005	16,766	8,723	1,246	1,246		-1,246	-100.0%
Southwest	Nashville	BNA	397	715	730									-	-	54,389	97,896	99,879									-	-
Southwest	Orlando	MCO	410	1,129	1,468	1,201	1,125	977	906	831	752	743	765	22	3.0%	56,111	154,673	201,175	164,332	154,145	133,829	125,620	123,873	109,202	113,888	118,422	4,534	4.0%
Southwest	Philadelphia	PHL		788	1,786	1,894	1,411	1,325						-	-		107,995	244,356	259,275	192,456	180,871						-	-
Southwest	Phoenix	PHX				365	322	273						-	-				50,005	44,114	37,401						-	-
Southwest	Tampa	TPA		845	1,099	673	782	629	579	466	470	479	487	8	1.7%		115,693	150,165	92,240	107,173	86,212	79,639	68,120	67,509	70,529	71,922	1,393	2.0%
United	Chicago O'Hare	ORD	1,403	1,464	1,339	608								-	-	221,523	209,179	179,151	85,929								-	-
United	Portland (ME)	PWM	57											-	-	7,241											-	-
US Airways	Baltimore	BWI	1,782											-	-	191,078											-	-
US Airways	Charlotte	CLT		1,276	1,308	378	365	51						-	-		167,699	178,836	53,676	52,560	7,406						-	-
US Airways	Orlando	MCO	52											-	-	5,605											-	-
US Airways	Philadelphia	PHL	1,821	1,806	2,021	395	365	313	187	351				-	-	222,331	244,129	274,215	56,219	33,132	30,973	18,499	34,791				-	-
US Airways	Pittsburgh	PIT	1,085	553										-	-	139,837	77,259										-	-
US Airways	Washington National	DCA	675	113	575									-	-	82,085	14,323	77,461									-	-
Subtotal			14,026	17,876	19,279	11,352	9,850	8,604	6,769	6,302	5,168	5,150	5,276	126	2.4%	1,821,657	2,449,873	2,608,335	1,542,979	1,311,677	1,168,481	935,588	907,518	768,905	767,200	791,810	24,610	3.2%
Regional/Commuter Carriers																												
Air Canada Express	Montreal Dorval	YUL												-	-												-	-
Air Canada Express	Toronto	YYZ	339	1,024	930	908	707	403						-	-	5,616	18,758	17,439	17,252	13,441	7,652						-	-
American Eagle	Charlotte	CLT									496	730	734	4	0.5%									37,761	54,688	60,890	6,202	11.3%
American Eagle	New York La Guardia	LGA	1,833											-	-	60,480											-	-
American Eagle	Philadelphia	PHL									2,295	2,237	2,090	-147	-6.6%									149,598	152,206	136,795	-15,411	-10.1%
American Eagle	Washington National	DCA									1,198	1,152	1,304	152	13.2%									77,065	74,008	85,620	11,612	15.7%
Boston-Maine Airways	Bangor	BGR		4										-	-		80										-	-
Boston-Maine Airways	Martha's Vineyard	MVY												-	-												-	-
Boston-Maine Airways	Nantucket	ACK												-	-												-	-
Boston-Maine Airways	New London/Groton	GON		22										-	-		399										-	-
Boston-Maine Airways	Portsmouth	PSM		4										-	-		80										-	-
Boston-Maine Airways	Saint John	YSJ												-	-												-	-
Continental Connection	Albany	ALB	80	1,007	313									-	-	1,515	19,130	5,944									-	-
Continental Connection	New York J F Kennedy	JFK												-	-												-	-
Continental Connection	New York Newark	EWR				337	141							-	-				24,906	9,483							-	-
Continental Connection	Plattsburgh	PLB												-	-												-	-
Continental Connection	Rochester	ROC	44											-	-	841											-	-
Continental Connection	Syracuse	SYR	22											-	-	421											-	-
Continental Connection	Westchester County	HPN												-	-												-	-
Continental Express	Cleveland	CLE	593	1,198	1,186	1,178	1,178							-	-	29,614	59,729	58,991	58,893	58,921							-	-
Continental Express	New York Newark	EWR	1,028	1,150	1,165	1,072	1,267							-	-	64,944	57,169	58,140	53,579	63,336							-	-
Delta Connection	Atlanta	ATL	488	366	485	365	90			51	59			-	-	24,400	18,300	26,620	25,550	6,300			3,843	4,484			-	-
Delta Connection	Bangor	BGR	244											-	-	12,200											-	-
Delta Connection	Cincinnati	CVG	1,673	750	735									-	-	83,657	39,299	38,426									-	-
Delta Connection	Detroit	DTW				359	499	1,858	1,609	1,510	1,296	912	935	23	2.5%				25,524	32,795	95,802	80,786	75,507	69,261	51,960	60,782	8,822	17.0%
Delta Connection	New York J F Kennedy	JFK												-	-												-	-
Delta Connection	New York La Guardia	LGA	727	1,067	486				586	1,165	1,140	970	804	-166	-17.1%	36,357	53,350	24,300				31,216	66,132	63,202	55,968	49,250	-6,718	-12.0%
Delta Connection	Minneapolis	MSP				92								-	-				6,992								-	-
Independence Air	Washington Dulles	IAD		1,439	1,568									-	-		71,971	78,379									-	-
Northwest Airlink	Detroit	DTW		13										-	-		664										-	-
Northwest Airlink	Minneapolis	MSP		324	233									-	-		16,179	11,664									-	-
United Express	Chicago O'Hare	ORD		213	31	388	1,040	983	867	695	857	779	718	-61	-7.8%		10,650	2,170	25,402	67,675	62,096	45,929	39,114	49,854	42,976	39,887	-3,089	-7.2%
United Express	Cleveland	CLE						935	759	740	111			-	-						46,736	36,046	36,986	5,564			-	-
United Express	New York Newark	EWR						1,391	1,298	1,120	965	1,304	1,284	-20	-1.5%						67,250	60,049	54,604	44,824	60,052	59,682	-370	-0.6%
United Express	Washington Dulles	IAD		1,678	1,760	1,161	1,104	658	427	90				-	-		83,900	90,419	62,534	55,951	33,514	20,788	5,444				-	-
US Airways Express	Boston	BOS												-	-												-	-
US Airways Express	Charlotte	CLT			307	227	153	318	366	417				-	-			21,863	19,547	13,146	27,181	31,476	32,885				-	-

Table F-5 Scheduled Passenger Operations by Market and Carrier for Manchester-Boston Regional Airport

Departures

Carrier	Market	Code	2000	2004	2005	2009	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
US Airways Express	New York La Guardia	LGA	2,583	2,632	2,499	1,464	1,381	1,269	594					-	-
US Airways Express	Philadelphia	PHL		370	562	1,929	2,116	2,068	2,092	2,004				-	-
US Airways Express	Pittsburgh	PIT		567	1,022									-	-
US Airways Express	Washington National	DCA		976	508	1,008	1,039	1,043	1,002	1,252				-	-
Subtotal			9,655	14,804	13,788	10,486	10,716	10,925	9,600	9,045	8,417	8,084	7,869	-215	-2.7%
														-	-
Total			23,681	32,680	33,067	21,839	20,566	19,529	16,369	15,347	13,585	13,234	13,145	-89	-0.7%

Departing Seats

Carrier	Market	Code	2000	2004	2005	2009	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
US Airways Express	New York La Guardia	LGA	96,936	90,511	86,492	49,761	49,420	43,737	21,962					-	-
US Airways Express	Philadelphia	PHL		19,654	30,239	118,750	140,277	135,156	134,567	126,552				-	-
US Airways Express	Pittsburgh	PIT		28,935	51,107									-	-
US Airways Express	Washington National	DCA		48,684	25,379	76,259	81,095	81,683	78,512	84,499				-	-
Subtotal			416,980	637,439	627,572	564,949	591,840	600,808	541,331	525,567	501,613	491,858	492,906	1,048	0.2%
														-	-
Total			2,238,636	3,087,313	3,235,907	2,107,928	1,903,517	1,769,288	1,476,919	1,433,085	1,270,518	1,259,058	1,284,716	25,658	2.0%

Source: OAG Schedules.

Notes:

All Northwest Airlines operations included in Delta Air Lines from 2009 onwards (following 2008 merger)

All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)

All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)

All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

Table F-6 Scheduled Passenger Operations by Market and Carrier for Portland International Jetport

			Departures											Departing Seats										
Carrier	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Jet Carriers																								
American	Charlotte	CLT							374	365	487	122	33.4%							46,341	45,504	62,336	16,832	37.0%
American	Philadelphia	PHL							92			-	-							9,108			-	-
American	Washington National	DCA								30	4	-26	-86.7%								3,720	567	-3,153	-84.8%
AirTran	Atlanta	ATL			92	167						-	-			10,764	19,522						-	-
AirTran	Baltimore	BWI			944	927						-	-			112,951	109,024						-	-
AirTran	Orlando	MCO			52	52						-	-			6,503	6,355						-	-
Continental	Cleveland	CLE										-	-										-	-
Continental	New York Newark	EWR										-	-										-	-
Delta	Atlanta	ATL	732	486	424	793	751	737	693	714	710	-4	-0.6%	103,944	61,229	60,167	114,597	110,397	109,750	103,571	107,000	106,660	-340	-0.3%
Delta	Cincinnati	CVG	1,089	486								-	-	154,658	69,012								-	-
Delta	Detroit	DTW									74	74	-									8,124	8,124	-
Delta	New York La Guardia	LGA					184	239	79	30		-30	-100.0%					24,256	35,374	11,750	3,300		-3,300	-100.0%
Independence Air	Washington Dulles	IAD		307								-	-		40,524								-	-
jetBlue	New York J F Kennedy	JFK			1,201	1,323	1,239	1,307	1,332	1,295	1,198	-97	-7.5%			128,936	135,379	124,571	130,671	133,200	130,314	119,800	-10,514	-8.1%
jetBlue	Orlando	MCO			212	181						-	-			21,214	21,344						-	-
Northwest	Detroit	DTW	523	427								-	-	52,105	42,700								-	-
Southwest	Baltimore	BWI					1,016	1,005	1,084	1,106	1,175	69	6.2%					119,112	136,588	152,939	158,358	168,423	10,065	6.4%
Southwest	Orlando	MCO					13		4	4	4	-	0.0%					1,521		633	633	633	-	0.0%
Southwest	Chicago Midway	MDW							9	9	9	-	0.0%							1,246	1,246	1,246	-	0.0%
Trans World Airlines	Hartford	BDL	305									-	-	43,310									-	-
United	Chicago O'Hare	ORD	728								66	66	-	88,996								8,066	8,066	-
United	Manchester	MHT	366									-	-	53,802									-	-
United	New York Newark	EWR									9	9	-									1,196	1,196	-
United	Washington Dulles	IAD									18	18	-									2,657	2,657	-
US Airways	Charlotte	CLT			395	352	366	365				-	-			48,688	47,130	49,044	45,260				-	-
US Airways	Philadelphia	PHL	1,312	154		217	18					-	-	163,051	19,404		21,525	1,895					-	-
US Airways	Pittsburgh	PIT	1,081									-	-	137,472									-	-
US Airways	Washington National	DCA		52								-	-		6,668								-	-
Subtotal			6,135	1,912	3,320	4,013	3,587	3,653	3,667	3,553	3,754	201	5.7%	797,338	239,537	389,224	474,876	430,796	457,644	458,788	450,075	479,708	29,633	6.6%
Regional/Commuter Carriers																								
Air Canada Express	Montreal Dorval	YUL	344									-	-	4,734									-	-
Air Canada Express	Toronto	YYZ			481	783	671	97				-	-			9,142	14,872	12,749	1,741				-	-
America West	New York Newark	EWR	52									-	-	2,457									-	-
American Eagle	Boston	BOS	3,804									-	-	125,518									-	-
American Eagle	Charlotte	CLT							26	143	243	100	69.9%							2,065	11,666	20,898	9,232	79.1%
American Eagle	Chicago O'Hare	ORD										-	-										-	-
American Eagle	New York La Guardia	LGA	2,033									-	-	67,084									-	-
American Eagle	Philadelphia	PHL							1,986	2,148	2,066	-82	-3.8%							125,325	141,789	120,072	-21,717	-15.3%
American Eagle	Washington National	DCA							1,426	1,613	1,707	94	5.8%							99,757	107,469	113,463	5,994	5.6%
Continental Conencion	Albany	ALB		291								-	-		5,537								-	-
Continental Conencion	Boston	BOS	204	241								-	-	3,871	4,576								-	-
Continental Conencion	New York Newark	EWR			1,426							-	-			105,503							-	-
Continental Conencion	Presque Isle	PQI										-	-										-	-
Continental Express	Cleveland	CLE	425	223	188							-	-	20,378	11,021	9,400							-	-
Continental Express	New York Newark	EWR	1,429	1,394	4							-	-	70,393	69,605	200							-	-
Delta Connection	Atlanta	ATL		700	350							-	-		48,440	25,532							-	-
Delta Connection	Boston	BOS		1,153								-	-		57,650								-	-
Delta Connection	Cincinnati	CVG		600								-	-		31,166								-	-
Delta Connection	Detroit	DTW			1,217	1,314	1,264	1,249	1,061	896	840	-56	-6.3%			62,320	65,686	64,758	62,436	60,448	59,315	60,354	1,039	1.8%
Delta Connection	New York J F Kennedy	JFK			270							-	-			13,500							-	-
Delta Connection	New York La Guardia	LGA	475	1,095	786	1,034	1,050	1,202	1,231	1,284	1,332	48	3.7%	15,191	54,750	41,440	57,437	67,453	80,898	80,103	76,325	80,582	4,257	5.6%
Delta Connection	Minneapolis	MSP										-	-										-	-
Independence Air	Washington Dulles	IAD		1,384								-	-		69,186								-	-
Lufthansa German Airlines	Washington Dulles	IAD	31									-	-	1,550									-	-
Northwest Airlink	Detroit	DTW	484	915								-	-	33,366	53,132								-	-
Northwest Airlink	Minneapolis	MSP		404								-	-		20,186								-	-
Starlink Aviation	Yarmouth	YQI			521	521	217					-	-			9,386	9,386	3,909					-	-
Swissair	Boston	BOS	31									-	-	1,023									-	-
Ulendo Airlink	Bar Harbor	BHB									18	18	-									886	886	-
Ulendo Airlink	Islip	ISP									18	18	-									886	886	-
Ulendo Airlink	Melbourne	MLB									91	91	-									5,573	5,573	-

Table F-6 Scheduled Passenger Operations by Market and Carrier for Portland International Jetport

Ulendo Airlink	Sarasota/Bradenton	SRQ									17	17	-									906	906	-
United Express	Chicago O'Hare	ORD		1,095	1,249	1,176	1,125	1,045	1,038	1,029	964	-65	-6.3%		67,590	82,273	72,457	59,896	65,872	63,099	64,054	53,558	-10,496	-16.4%
United Express	Cleveland	CLE				188	249	298				-	-				9,400	11,906	14,886				-	-
United Express	New York Newark	EWR				1,426	1,596	1,630	1,470	1,779	2,035	256	14.4%				103,511	81,454	102,156	92,953	108,900	113,044	4,144	3.8%
United Express	Washington Dulles	IAD	996	1,456	1,078	1,066	885	750	689	560	572	12	2.1%	49,779	83,730	64,767	62,493	43,839	39,624	37,949	35,213	35,764	551	1.6%
US Airways Express	Bangor	BGR	231									-	-	8,558									-	-
US Airways Express	Boston	BOS	2,229									-	-	42,359									-	-
US Airways Express	Charlotte	CLT		365	88	18	31	35				-	-		23,710	5,323	1,364	2,542	2,777				-	-
US Airways Express	New York La Guardia	LGA	1,218	1,665	1,647	1,526	598					-	-	43,901	77,909	78,477	68,755	26,013					-	-
US Airways Express	Philadelphia	PHL		1,913	1,947	1,987	2,153	2,131				-	-		100,307	133,521	129,133	139,908	137,137				-	-
US Airways Express	Pittsburgh	PIT		219								-	-		10,971								-	-
US Airways Express	Plattsburgh	PLB	48									-	-	909									-	-
US Airways Express	Presque Isle	PQI										-	-										-	-
US Airways Express	Washington National	DCA	1,089	1,149	1,043	1,043	1,260	1,408				-	-	33,976	75,568	83,302	87,190	102,160	100,248				-	-
US Airways Express	Westchester County	HPN	65									-	-	1,235									-	-
Subtotal			15,187	16,261	12,296	12,081	11,098	9,843	8,927	9,452	9,903	451	4.8%	526,282	865,033	724,086	681,682	616,586	607,775	561,699	604,731	605,986	1,255	0.2%
												-	-										-	-
Total			21,322	18,174	15,615	16,094	14,684	13,496	12,594	13,005	13,657	652	5.0%	1,323,619	1,104,570	1,113,310	1,156,558	1,047,382	1,065,419	1,020,487	1,054,806	1,085,694	30,888	2.9%

Source: OAG Schedules.

Notes:

All Northwest Airlines operations included in Delta Air Lines from 2009 onwards (following 2008 merger)

All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)

All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)

All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

Table F-7 Scheduled Passenger Operations by Market and Carrier for Burlington International Airport

			Departures											Departing Seats										
Carrier	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Jet Carriers																								
AirTran	Baltimore	BWI										-	-										-	-
Allegiant Air	Orlando/Sanford	SFB							94	104	95	-9	-8.7%							15,873	17,880	16,452	-1,428	-8.0%
American	Philadelphia	PHL							116			-	-							11,470			-	-
Continental	New York Newark	EWR										-	-										-	-
Delta	Atlanta	ATL						153	92	92	110	18	19.6%						21,394	13,708	13,708	15,202	1,494	10.9%
jetBlue	New York J F Kennedy	JFK	244	1,126	1,434	1,405	1,363	1,365	1,244	1,156	1,182	26	2.2%	39,528	173,920	180,286	163,839	163,821	143,907	124,357	115,600	118,157	2,557	2.2%
jetBlue	Orlando	MCO			330	339	326					-	-			33,014	33,871	32,643					-	-
Northwest	Detroit	DTW		174								-	-		17,429								-	-
United	Chicago O'Hare	ORD	815	365						113	345	232	205.3%	105,509	42,379						13,777	45,877	32,100	233.0%
United	Portland (ME)	PWM										-	-										-	-
US Airways	Philadelphia	PHL	1,098	365				26				-	-	150,338	46,170				2,546				-	-
US Airways	Pittsburgh	PIT	732									-	-	103,568									-	-
US Airways	Washington National	DCA		4								-	-		558								-	-
Subtotal			2,889	2,035	1,764	1,744	1,690	1,543	1,546	1,465	1,732	267	18.2%	398,943	280,456	213,300	197,710	196,464	167,847	165,408	160,965	195,688	34,723	21.6%
Regional/Commuter Carriers																								
America West	New York Newark	EWR	166									-	-	7,889									-	-
American Eagle	Boston	BOS	3,094									-	-	102,111									-	-
American Eagle	Charlotte	CLT								122	378	256	209.8%								9,516	29,858	20,342	213.8%
American Eagle	Chicago O'Hare	ORD										-	-										-	-
American Eagle	New York La Guardia	LGA									18	18	-									886	886	-
American Eagle	Philadelphia	PHL							1,823	1,921	1,933	12	0.6%							110,129	126,772	103,725	-23,047	-18.2%
American Eagle	Washington National	DCA							1,276	1,339	1,394	55	4.1%							89,462	86,015	96,228	10,213	11.9%
Continental Connecti	Albany	ALB										-	-										-	-
Continental Connecti	Boston	BOS	244	634								-	-	4,628	12,054								-	-
Continental Connecti	Buffalo	BUF	4									-	-	84									-	-
Continental Connecti	Hartford	BDL										-	-										-	-
Continental Connecti	New York Newark	EWR			405							-	-			30,002							-	-
Continental Connecti	Plattsburgh	PLB	213	367								-	-	4,039	6,970								-	-
Continental Connecti	Plattsburgh International	PBG										-	-										-	-
Continental Connecti	Poughkeepsie	POU	66									-	-	1,262									-	-
Continental Connecti	Washington Dulles	IAD										-	-										-	-
Continental Connecti	Westchester County	HPN										-	-										-	-
Continental Express	Cleveland	CLE	322	509	366							-	-	16,064	25,351	18,286							-	-
Continental Express	New York Newark	EWR	1,458	1,455	1,020							-	-	70,203	72,707	51,000							-	-
Continental Express	Westchester County	HPN										-	-										-	-
Delta Connection	Atlanta	ATL		62				61	273	273	255	-18	-6.6%		3,100				4,636	20,701	20,748	19,369	-1,379	-6.6%
Delta Connection	Boston	BOS		1,002								-	-		50,100								-	-
Delta Connection	Cincinnati	CVG		1,060								-	-		52,979								-	-
Delta Connection	Detroit	DTW			1,227	1,309	1,282	1,223	1,201	1,004	1,005	1	0.1%			61,417	65,443	64,114	61,224	60,043	57,053	55,842	-1,211	-2.1%
Delta Connection	New York J F Kennedy	JFK			1,336	1,338	221					-	-			67,071	81,259	14,884					-	-
Delta Connection	New York La Guardia	LGA	355				781	1,279	1,248	1,257	1,151	-106	-8.4%	11,351				50,144	83,899	82,592	76,339	69,396	-6,943	-9.1%
Independence Air	Washington Dulles	IAD		1,903								-	-		95,136								-	-
Lufthansa German Ai	Washington Dulles	IAD	31									-	-	1,550									-	-
Northwest Airlink	Detroit	DTW		1,159								-	-		61,983								-	-
Northwest Airlink	Minneapolis	MSP		61								-	-		3,050								-	-
Porter Airlines	Toronto Island Apt	YTZ				9	31	56	47	39	22	-17	-43.6%				620	2,150	3,910	3,308	2,886	1,607	-1,279	-44.3%
Swissair	Boston	BOS	31									-	-	1,023									-	-
United Express	Chicago O'Hare	ORD		1,003	1,353	1,565	1,391	1,396	1,402	1,144	794	-350	-30.6%		59,930	84,431	88,435	81,204	84,669	85,350	63,845	42,348	-21,497	-33.7%
United Express	Cleveland	CLE				348	331	409	73			-	-				17,421	15,376	20,464	3,636			-	-
United Express	New York Newark	EWR				1,425	1,425	1,456	1,281	1,569	1,705	136	8.7%				94,675	80,261	85,373	82,670	96,340	94,246	-2,094	-2.2%
United Express	Washington Dulles	IAD	1,477	1,456	1,130	1,112	1,000	910	892	738	795	57	7.7%	73,843	72,786	61,988	69,793	58,665	48,930	50,633	41,127	48,150	7,023	17.1%

Table F-7 Scheduled Passenger Operations by Market and Carrier for Burlington International Airport

			Departures											Departing Seats										
Carrier	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
US Airways Express	Boston	BOS	2,404									-	-	48,139									-	-
US Airways Express	Charlotte	CLT										-	-										-	-
US Airways Express	New York La Guardia	LGA	2,074	2,175	1,680	1,487	650					-	-	76,749	80,491	62,144	55,008	24,050					-	-
US Airways Express	Philadelphia	PHL		1,980	1,903	1,956	1,873	1,803				-	-		97,288	128,140	131,727	121,653	111,615				-	-
US Airways Express	Pittsburgh	PIT										-	-										-	-
US Airways Express	Plattsburgh	PLB	2,427									-	-	46,116									-	-
US Airways Express	Poughkeepsie	POU	718									-	-	13,639									-	-
US Airways Express	Saranac Lake	SLK	44									-	-	841									-	-
US Airways Express	Washington National	DCA	988	990	1,043	1,043	1,072	1,347				-	-	31,574	61,458	77,625	82,974	85,623	100,348				-	-
US Airways Express	Wilkes-Barre Scranton	AVP	22									-	-	415									-	-
Subtotal			16,138	15,816	11,461	11,593	10,058	9,941	9,516	9,405	9,450	45	0.5%	511,521	755,382	642,104	687,357	598,123	605,069	588,524	580,640	561,655	-18,985	-3.3%
												-	-										-	-
Total			19,028	17,851	13,225	13,336	11,748	11,484	11,062	10,870	11,182	312	2.9%	910,464	1,035,838	855,404	885,067	794,588	772,916	753,932	741,605	757,343	15,738	2.1%

Source: OAG Schedules.

Notes:

Allegiant stopped reporting to the OAG in 2009, so Allegiant 2009-2015 statistics from the T100 database.

All Northwest Airlines operations included in Delta Air Lines from 2009 onwars (following 2008 merger)

All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)

All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)

All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

Table F-8 Scheduled Passenger Operations by Market and Carrier for Bangor International Airport

Carrier	Market	Code	Departures 2000	Departures 2005	Departures 2010	Departures 2011	Departures 2012	Departures 2013	Departures 2014	Departures 2015	Departures 2016	Departures '15-'16 Change	Departures '15-'16 Pct. Change	Departing Seats 2000	Departing Seats 2005	Departing Seats 2010	Departing Seats 2011	Departing Seats 2012	Departing Seats 2013	Departing Seats 2014	Departing Seats 2015	Departing Seats 2016	Departing Seats '15-'16 Change	Departing Seats '15-'16 Pct. Change
Jet Carriers																								
Allegiant Air	Orlando/Sanford	SFB			181	150	156	165	153	180	182	2	1.1%			27,150	22,500	23,912	27,335	26,536	31,156	31,730	574	1.8%
Allegiant Air	Punta Gorda	PGD							33	0		-	-							5,478	0		-	-
Allegiant Air	St. Petersburg/Clearwater	PIE			107	93	112	115	119	134	143	9	6.7%			16,050	13,950	16,944	19,090	20,501	23,531	25,201	1,670	7.1%
Delta	Detroit	DTW								175	180	5	2.9%								19,334	19,769	435	2.2%
Pan American Airways	Allentown/Bethlehem	ABE										-	-										-	-
Pan American Airways	Baltimore	BWI										-	-										-	-
Pan American Airways	Pittsburgh	PIT	285									-	-	42,729									-	-
Pan American Airways	Portsmouth	PSM	389									-	-	58,414									-	-
Pan American Airways	Sanford	SFB										-	-										-	-
Subtotal			674	0	288	243	268	280	305	489	505	16	3.3%	101,143	0	43,200	36,450	40,856	46,425	52,515	74,021	76,700	2,679	3.6%
Regional/Commuter Carriers																								
American Eagle	Boston	BOS	4,670	1,530								-	-	154,115	56,594								-	-
American Eagle	New York La Guardia	LGA	382	518							35	35	-	12,606	19,166							1,757	1,757	-
American Eagle	Philadelphia	PHL							1,496	1,452	1,447	-5	-0.3%							94,849	91,163	85,549	-5,614	-6.2%
American Eagle	Washington National	DCA							791	771	900	129	16.7%							41,033	40,260	47,737	7,477	18.6%
Boston-Maine Airways	Halifax	YHZ										-	-										-	-
Boston-Maine Airways	Manchester	MHT										-	-										-	-
Boston-Maine Airways	Portsmouth	PSM										-	-										-	-
Boston-Maine Airways	Saint John	YSJ										-	-										-	-
Continental Connection	Albany	ALB		189								-	-		3,583								-	-
Continental Express	New York Newark	EWR		481								-	-		22,698								-	-
Delta Connection	Atlanta	ATL										-	-										-	-
Delta Connection	Boston	BOS		1,416								-	-		70,800								-	-
Delta Connection	Cincinnati	CVG	1,342	1,394								-	-	67,100	82,439								-	-
Delta Connection	Detroit	DTW			975	871	703	706	711	279	204	-75	-26.9%			50,540	54,640	46,260	46,371	47,269	19,614	14,863	-4,751	-24.2%
Delta Connection	New York J F Kennedy	JFK			180							-	-			9,000							-	-
Delta Connection	New York La Guardia	LGA			537	844	1,043	1,153	975	976	1,007	31	3.2%			26,958	49,368	62,868	71,955	59,239	57,025	58,761	1,736	3.0%
Delta Connection	Minneapolis	MSP										-	-										-	-
Northwest Airlink	Boston	BOS	27									-	-	797									-	-
Northwest Airlink	Detroit	DTW		1,012								-	-		55,222								-	-
Northwest Airlink	Minneapolis	MSP		61								-	-		3,050								-	-
Pan American Airways	Portsmouth	PSM										-	-										-	-
Pan American Airways	Saint John	YSJ										-	-										-	-
United Express	Chicago O'Hare	ORD							245	215	206	-9	-4.2%							16,170	14,190	13,624	-566	-4.0%
United Express	New York Newark										123	123	-									6,150	6,150	-
US Airways Express	Boston	BOS	1,942									-	-	36,906									-	-
US Airways Express	New York La Guardia	LGA	35	158	1,017	1,230	299					-	-	1,295	7,914	44,051	53,371	14,950					-	-
US Airways Express	Philadelphia	PHL	428	1,179	1,156	1,405	1,543	1,564				-	-	15,836	58,943	68,510	89,548	99,457	101,167				-	-
US Airways Express	Pittsburgh	PIT										-	-										-	-
US Airways Express	Portland (ME)	PWM	231									-	-	8,558									-	-
US Airways Express	Presque Isle	PQI	299									-	-	6,224									-	-
US Airways Express	Washington National	DCA			31	52	589	883				-	-			1,529	2,607	29,464	47,981				-	-
Subtotal			9,357	7,937	3,896	4,402	4,178	4,307	4,218	3,693	3,922	229	6.2%	303,436	380,408	200,587	249,535	253,000	267,474	258,560	222,252	228,441	6,189	2.8%
												-	-										-	-
Total			10,031	7,937	4,184	4,645	4,446	4,587	4,523	4,182	4,427	245	5.9%	404,579	380,408	243,787	285,985	293,856	313,899	311,075	296,273	305,141	8,868	3.0%

Source: OAG Schedules.

Notes:

Allegiant stopped reporting to the OAG in 2009, so Allegiant 2009-2015 statistics from the T100 database.
All Northwest Airlines operations included in Delta Air Lines from 2009 onwars (following 2008 merger)
All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)
All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)
All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

Table F-9 Scheduled Passenger Operations by Market and Carrier for Tweed-New Haven Airport

			Departures											Departing Seats										
Carrier	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Regional/Commuter Carriers																								
American Eagle	Philadelphia	PHL							1,356	1,222	1,121	-101	-8.3%							50,161	49,657	63,913	14,256	28.7%
Delta Connection	Cincinnati	CVG		1,025								-	-		51,236								-	-
Boston-Maine Airways	Baltimore	BWI										-	-										-	-
Boston-Maine Airways	Bedford	BED										-	-										-	-
Boston-Maine Airways	Elmira/Corning	ELM										-	-										-	-
Boston-Maine Airways	Portsmouth	PSM										-	-										-	-
US Airways Express	Philadelphia	PHL	1,773	1,904	1,608	1,535	1,381	1,399				-	-	65,612	76,208	59,491	56,806	52,972	51,768				-	-
US Airways Express	Washington National	DCA	937									-	-	34,658									-	-
												-	-										-	-
Total			2,710	2,929	1,608	1,535	1,381	1,399	1,356	1,222	1,121	-101	-8.3%	100,270	127,444	59,491	56,806	52,972	51,768	50,161	49,657	63,913	14,256	28.7%

Source: OAG Schedules.

Notes:

All Northwest Airlines operations included in Delta Air Lines from 2009 onwars (following 2008 merger)

All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)

All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)

All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

Table F-10 Scheduled Passenger Operations by Market and Carrier for Worcester Regional Airport

Carrier	Market	Code	Departures 2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change	Departing Seats 2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Jet Carriers																								
Allegiant Air	Sanford	SFB										-	-										-	-
Boston-Maine Airways	Allentown/Bethlehem	ABE										-	-										-	-
Boston-Maine Airways	Portsmouth	PSM										-	-										-	-
Boston-Maine Airways	Sanford	SFB										-	-										-	-
Direct Air	Myrtle Beach	MYR			73	96						-	-			9,782	14,120						-	-
Direct Air	Orlando/Sanford	SFB			144	148						-	-			21,937	24,339						-	-
Direct Air	Punta Gorda	PGD			94	105						-	-			14,541	17,287						-	-
Direct Air	West Palm Beach	PBI			13	51						-	-			1,872	7,444						-	-
jetBlue	Fort Lauderdale/Hollywood	FLL						61	365	365	365	-	0.0%						6,100	36,500	36,500	36,500	-	0.0%
jetBlue	Orlando	MCO						61	365	365	365	-	0.0%						6,100	36,500	36,500	36,500	-	0.0%
Subtotal			0	0	324	400	0	122	730	730	730	-	0.0%	0	0	48,132	63,190	0	12,200	73,000	73,000	73,000	-	0.0%
Regional/Commuter Carriers																								
American Eagle	Chicago O'Hare	ORD										-	-										-	-
American Eagle	New York J F Kennedy	JFK	552									-	-	18,216									-	-
Delta Connection	Atlanta	ATL	670									-	-	33,500									-	-
US Airways Express	Philadelphia	PHL	1,464									-	-	54,168									-	-
Subtotal			2,686	0	0	0	0	0	0	0		-	-	105,884	0	0	0	0	0	0			-	-
												-	-										-	-
Total			2,686	0	324	400	0	122	730	730	730	-	0.0%	105,884	0	48,132	63,190	0	12,200	73,000	73,000	73,000	-	0.0%

Source: OAG Schedules.

Notes:

All Northwest Airlines operations included in Delta Air Lines from 2009 onwars (following 2008 merger)

All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)

All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)

All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

Table F-11 Scheduled Passenger Operations by Market and Carrier for Hanscom Field

Departures

Carrier	Market	Code	2000	2004	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Regional/Commuter Carriers														
Boston-Maine Airways	Elmira/Corning	ELM											-	-
Boston-Maine Airways	Hyannis	HYA											-	-
Boston-Maine Airways	Manchester	MHT											-	-
Boston-Maine Airways	Martha's Vineyard	MVY											-	-
Boston-Maine Airways	Nantucket	ACK											-	-
Boston-Maine Airways	New Haven	HVN											-	-
Boston-Maine Airways	New London/Groton	GON		61	9								-	-
Boston-Maine Airways	Portsmouth	PSM		336	193								-	-
Boston-Maine Airways	Trenton	TTN		987	867								-	-
Pan American Airways	Atlantic City Pomona Field	ACY											-	-
Pan American Airways	Martha's Vineyard	MVY											-	-
Pan American Airways	New York Newark	EWR											-	-
Pan American Airways	Portsmouth	PSM											-	-
Pan American Airways	Westchester County	HPN											-	-
Shuttle America	Buffalo	BUF	1,119										-	-
Shuttle America	Hartford	BDL	173										-	-
Shuttle America	New York La Guardia	LGA	523										-	-
Shuttle America	Trenton	TTN	2,062	43									-	-
Streamline	Trenton	TTN					155						-	-
US Airways	Martha's Vineyard	MVY											-	-
US Airways	Nantucket	ACK											-	-
US Airways	New York La Guardia	LGA											-	-
US Airways	Philadelphia	PHL											-	-
US Airways	Trenton	TTN		734									-	-
US Airways	Westchester County	HPN											-	-
													-	-
Total			3,876	2,161	1,069	0	155	0	0	0	0	0	-	-

Departing Seats

Carrier	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	'15-'16 Change	'15-'16 Pct. Change
Regional/Commuter Carriers												
Boston-Maine Airways	Elmira/Corning	ELM									-	-
Boston-Maine Airways	Hyannis	HYA									-	-
Boston-Maine Airways	Manchester	MHT									-	-
Boston-Maine Airways	Martha's Vineyard	MVY									-	-
Boston-Maine Airways	Nantucket	ACK									-	-
Boston-Maine Airways	New Haven	HVN									-	-
Boston-Maine Airways	New London/Groton	GON		159							-	-
Boston-Maine Airways	Portsmouth	PSM		3,482							-	-
Boston-Maine Airways	Trenton	TTN		15,606							-	-
Pan American Airways	Atlantic City Pomona Field	ACY									-	-
Pan American Airways	Martha's Vineyard	MVY									-	-
Pan American Airways	New York Newark	EWR									-	-
Pan American Airways	Portsmouth	PSM									-	-
Pan American Airways	Westchester County	HPN									-	-
Shuttle America	Buffalo	BUF	55,950								-	-
Shuttle America	Hartford	BDL	8,636								-	-
Shuttle America	New York La Guardia	LGA	26,143								-	-
Shuttle America	Trenton	TTN	103,093								-	-
Streamline	Trenton	TTN				4,650					-	-
US Airways	Martha's Vineyard	MVY									-	-
US Airways	Nantucket	ACK									-	-
US Airways	New York La Guardia	LGA									-	-
US Airways	Philadelphia	PHL									-	-
US Airways	Trenton	TTN									-	-
US Airways	Westchester County	HPN									-	-
											-	-
Total			193,821	19,247	0	4,650	0	0	0	0	-	-

Source: OAG Schedules.

Notes:

All Northwest Airlines operations included in Delta Air Lines from 2009 onwars (following 2008 merger)

All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)

All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)

All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

Table F-12 Scheduled Passenger Operations by Market and Carrier for Portsmouth International Airport

Departures

Carrier	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Jet Carriers													
Allegiant Airways	Orlando/Sanford	SFB		35				16	83	95	100	5	5.3%
Allegiant Airways	Punta Gorda	PGD							22	35	48	13	37.1%
Allegiant Airways	Fort Lauderdale/Hollywood	FLL								27	43	16	59.3%
Allegiant Airways	St. Petersburg/Clearwater	PIE									13	13	-
Boston-Maine Airways	Fort Lauderdale/Hollywood	FLL		13								-	-
Boston-Maine Airways	Hartford	BDL		13								-	-
Boston-Maine Airways	Newburgh	SWF		48								-	-
Boston-Maine Airways	Sanford	SFB		57								-	-
Pan American Airways	Allentown/Bethlehem	ABE	93									-	-
Pan American Airways	Bangor	BGR	389									-	-
Pan American Airways	Gary	GYY	51									-	-
Pan American Airways	Manchester	MHT										-	-
Pan American Airways	New York Newark	EWR										-	-
Pan American Airways	Pittsburgh	PIT	261									-	-
Pan American Airways	Sanford	SFB	296									-	-
Pan American Airways	Santo Domingo	SDQ										-	-
Pan American Airways	St. Petersburg/Clearwater	PIE										-	-
Pan American Airways	Worcester	ORH										-	-
Skybus	Columbus	CMH										-	-
Skybus	Greensboro	GSO										-	-
Skybus	Punta Gorda	PGD										-	-
Skybus	Saint Augustine	UST										-	-
Subtotal			1,091	167	0	0	0	16	105	157	204	47	29.9%
Regional/Commuter Carriers													
Boston-Maine Airways	Baltimore	BWI										-	-
Boston-Maine Airways	Bangor	BGR										-	-
Boston-Maine Airways	Bedford	BED		171								-	-
Boston-Maine Airways	Hyannis	HYA										-	-
Boston-Maine Airways	Manchester	MHT										-	-
Boston-Maine Airways	Martha's Vineyard	MVY										-	-
Boston-Maine Airways	Nantucket	ACK										-	-
Boston-Maine Airways	New Haven	HVN										-	-
Boston-Maine Airways	New London/Groton	GON										-	-
Boston-Maine Airways	Saint John	YSJ										-	-
Boston-Maine Airways	Trenton	TTN		22								-	-
Boston-Maine Airways	Westchester County	HPN										-	-
Pan American Airways	Atlantic City Pomona Field	ACY										-	-
Pan American Airways	Baltimore	BWI										-	-
Pan American Airways	Bangor	BGR										-	-
Pan American Airways	Bedford	BED										-	-
Pan American Airways	Martha's Vineyard	MVY										-	-
Pan American Airways	Saint John	YSJ										-	-
Subtotal			0	193	0	0	0	0	0	0	0	-	-
												-	-
Total			1,091	360	0	0	0	16	105	157	204	47	29.9%

Departing Seats

Carrier	Market	Code	2000	2005	2010	2011	2012	2013	2014	2015	2016	'15-'16 Change	'15-'16 Pct. Change
Jet Carriers													
Allegiant Airways	Orlando/Sanford	SFB		5,229				2,656	14,242	16,111	17,062	951	5.9%
Allegiant Airways	Punta Gorda	PGD							3,652	5,909	8,496	2,587	43.8%
Allegiant Airways	Fort Lauderdale/Hollywood	FLL								4,779	7,611	2,832	59.3%
Allegiant Airways	St. Petersburg/Clearwater	PIE									2,158	2,158	-
Boston-Maine Airways	Fort Lauderdale/Hollywood	FLL		1,993								-	-
Boston-Maine Airways	Hartford	BDL		1,993								-	-
Boston-Maine Airways	Newburgh	SWF		7,179								-	-
Boston-Maine Airways	Sanford	SFB		8,593								-	-
Pan American Airways	Allentown/Bethlehem	ABE	13,950									-	-
Pan American Airways	Bangor	BGR	58,414									-	-
Pan American Airways	Gary	GYY	7,714									-	-
Pan American Airways	Manchester	MHT										-	-
Pan American Airways	New York Newark	EWR										-	-
Pan American Airways	Pittsburgh	PIT	39,171									-	-
Pan American Airways	Sanford	SFB	44,400									-	-
Pan American Airways	Santo Domingo	SDQ										-	-
Pan American Airways	St. Petersburg/Clearwater	PIE										-	-
Pan American Airways	Worcester	ORH										-	-
Skybus	Columbus	CMH										-	-
Skybus	Greensboro	GSO										-	-
Skybus	Punta Gorda	PGD										-	-
Skybus	Saint Augustine	UST										-	-
Subtotal			163,650	24,986	0	0	0	2,656	17,894	26,799	35,327	8,528	31.8%
Regional/Commuter Carriers													
Boston-Maine Airways	Baltimore	BWI										-	-
Boston-Maine Airways	Bangor	BGR										-	-
Boston-Maine Airways	Bedford	BED		3,083								-	-
Boston-Maine Airways	Hyannis	HYA										-	-
Boston-Maine Airways	Manchester	MHT										-	-
Boston-Maine Airways	Martha's Vineyard	MVY										-	-
Boston-Maine Airways	Nantucket	ACK										-	-
Boston-Maine Airways	New Haven	HVN										-	-
Boston-Maine Airways	New London/Groton	GON										-	-
Boston-Maine Airways	Saint John	YSJ										-	-
Boston-Maine Airways	Trenton	TTN		399								-	-
Boston-Maine Airways	Westchester County	HPN										-	-
Pan American Airways	Atlantic City Pomona Field	ACY										-	-
Pan American Airways	Baltimore	BWI										-	-
Pan American Airways	Bangor	BGR										-	-
Pan American Airways	Bedford	BED										-	-
Pan American Airways	Martha's Vineyard	MVY										-	-
Pan American Airways	Saint John	YSJ										-	-
Subtotal			0	3,482	0	0	0	0	0	0		-	-
												-	-
Total			163,650	28,467	0	0	0	2,656	17,894	26,799	35,327	8,528	31.8%

Source: OAG Schedules.

Notes:

Allegiant stopped reporting to the OAG in 2009, so Allegiant 2009-2015 statistics from the T100 database.
All Northwest Airlines operations included in Delta Air Lines from 2009 onwars (following 2008 merger)
All Continental Airlines operations included in United Airlines from 2011 onwards (following 2010 merger)
All AirTran Airways operations included in Southwest Airlines from 2012 onwards (following 2011 merger)
All US Airways operations included in American Airlines from 2014 onwards (following 2013 merger)

G

Ground Access

This appendix provides information in support of Chapter 5, *Ground Access to and from Logan Airport*:

- Table G-1A Logan Express Bus Service Ridership (Annual)
- Table G-1B Logan Express Back Bay Service Ridership (Annual)
- Table G-2 Water Transportation Services Ridership (Annual)
- Table G-3 Massachusetts Bay Transportation Authority (MBTA) Airport Station Passengers
- Table G-4 Annual Taxi Dispatches (Tickets Sold)
- Table G-5 Logan Airport Employee Parking Supply
- Table G-6 Logan Airport Commercial Parking Supply
- Table G-7 2016 Existing Conditions – Airport-Related Traffic, On-Airport Link Attributes, Traffic Assignment, and Vehicle Miles Traveled (VMT) Summary
- VISSIM Traffic Roadway Network
- April 2016 Logan Airport Parking Space Inventory, submitted to Massachusetts Department of Environmental Protection (also known as the *Parking Freeze Report*)
- September 2016 Logan Airport Parking Space Inventory, submitted to Massachusetts Department of Environmental Protection (also known as the *Parking Freeze Report*)
- Massport Sustainable Transportation Options Newsletter, February 2018

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Table G-1A Logan Express Bus Service Ridership

	Ridership			Percent Change		
Service Year	**Air Passengers**	**Employees**	**Total**	**Air Passengers**	**Employees**	**Total**
Framingham						
1992	207,847	7,573	215,420	4.3%	21.3%	4.8%
1993	229,064	12,307	241,371	10.2%	62.5%	12.0%
1994	250,342	17,352	267,694	9.3%	41.0%	10.9%
1995	274,754	21,129	295,883	9.8%	21.8%	10.5%
1996	325,665	22,932	348,597	18.5%	8.5%	17.8%
1997	316,306	29,871	346,175	(2.9%)	30.3%	(0.7%)
1998	337,007	33,971	370,978	6.5%	13.7%	7.2%
1999	345,715	31,946	380,661	3.5%	(6.0%)	2.6%
2000	371,560	34,508	406,068	6.6%	8.0%	6.7%
2001	354,521	38,740	393,261	(4.6%)	12.3%	(3.2%)
2002	342,746	42,441	385,187	(3.3%)	8.7%	(2.1%)
2003	310,024	55,979	366,003	(9.5%)	31.9%	(5.0%)
2004	323,931	54,763	378,694	4.5%	(2.2%)	3.5%
2005	318,125	57,569	375,694	(1.8%)	5.1%	(0.8%)
2006	349,022	60,764	409,789	9.7%	5.5%	9.1%
2007	311,299	57,252	368,551	(2.1%)[5]	(0.6%)[5]	(1.9%)[5]
2008	276,112	57,797	333,909	(11.3%)	1.0%	(9.4%)
2009	264,233	59,840	324,073	(4.3%)	3.5%	(2.9%)
2010	272,190	62,226	334,416	3.0%	4.0%	3.2%
2011[1]	272,301	68,228	340,529	0.0%	9.6%	1.8%
2012	279,603	82,951	362,554	2.7%	21.6%	6.5%
2013	295,654	84,008	379,662	5.7%	1.3%	4.7%
2014	303,646	87,488	391,134	2.7%	4.1%	3.0%
2015	345,680	82,943	428,623	13.8%	(5.2%)	9.6%
2016	**406,253**	**92,642**	**498,895**	**17.5%**	**11.7%**	**16.4%**

Table G-1A	Logan Express Bus Service Ridership (Continued)					
		Ridership			**Percent Change**	
Service Year	**Air Passengers**	**Employees**	**Total**	**Air Passengers**	**Employees**	**Total**
Braintree						
1992	186,217	9,694	195,911	10.6%	16.6%	10.8%
1993	205,209	22,768	227,977	10.2%	134.9%	16.4%
1994	247,636	37,489	285,125	20.7%	64.7%	25.1%
1995	264,579	70,723	335,302	6.8%	88.7%	17.6%
1996	335,232	103,519	438,751	26.7%	46.4%	30.1%
1997	300,006	135,340	435,346	(10.5%)	30.7%	(0.8%)
1998	300,005	156,105	456,110	0.0%	15.3%	4.8%
1999	328,818	125,286	454,105	9.6%	(19.7%)	(0.5%)
2000	355,932	149,687	505,619	8.2%	19.5%	11.3%
2001	345,249	156,240	501,489	(3.0%)	4.4%	(0.8%)
2002	323,115	190,360	513,475	(6.4%)	21.8%	2.4%
2003	301,013	216,765	517,778	(6.8%)	13.9%	0.8%
2004	318,100	208,566	526,666	5.7%	(3.8%)	1.7%
2005	307,659	189,531	497,190	(3.2%)	(9.1%)	(5.5%)
2006	333,413	202,983	536,396	8.4%	7.1%	7.9%
2007	300,715	196,955	497,670	(2.3%)5	3.9%[5]	0.1%[5]
2008	252,289	221,591	473,880	(16.1%)	12.5%	(4.8%)
2009	231,151	234,908	466,059	(8.4%)	6.0%	(1.7%)
2010	231,422	251,443	482,865	0.1%	7.0%	3.6%
2011[1]	233,521	285,515	519,036	0.9%	13.6%	7.5%
2012	247,346	314,542	561,888	5.9%	10.2%	8.3%
2013	268,154	320,329	588,483	8.4%	1.8%	4.7%
2014	296,975	313,334	610,309	10.7%	(2.2%)	3.7%
2015	313,576	311,695	625,271	5.6%	(0.5%)	2.5%
2016	**329,043**	**326,115**	**655,158**	**4.9%**	**4.6%**	**4.8%**

Table G-1A	Logan Express Bus Service Ridership (Continued)					
		Ridership			**Percent Change**	
Service Year	**Air Passengers**	**Employees**	**Total**	**Air Passengers**	**Employees**	**Total**
Woburn[2]						
1992[3]	3,052	91	3,143	NA	NA	-
1993	59,635	5,027	64,662	NA	NA	-
1994	119,567	9,082	128,649	100.5%	80.7%	99.0%
1995	150,147	13,376	163,523	25.6%	47.3%	27.1%
1996	190,566	17,322	207,888	26.9%	29.5%	27.1%
1997	199,715	20,018	219,733	4.8%	15.6%	5.7%
1998	208,286	22,876	231,162	4.3%	14.3%	5.2%
1999	191,454	23,495	214,949	(8.1%)	2.7%	(7.0%)
2000	195,744	27,522	223,266	2.2%	17.1%	3.9%
2001	177,375	38,318	215,530	(9.4%)	39.2%	(3.4%)
2002	161,145	73,277	234,422	(9.2%)	91.0%	8.7%
2003	164,980	103,963	268,943	(2.4%)	41.9%	14.7%
2004	172,110	111,326	283,436	4.3%	7.1%	5.4%
2005	163,227	110,961	274,188	(5.1%)	(0.3%)	(3.2%)
2006	167,341	121,672	289,013	2.5%	9.7%	5.4%
2007	149,149	123,066	272,215	(8.6%)[5]	10.9%[5]	(0.7%)[5]
2008	129,385	122,777	252,162	(13.3%)	(0.2%)	(7.4%)
2009	113,607	121,633	235,240	(12.2%)	(0.9%)	(6.7%)
2010	115,257	127,120	242,377	1.5%	4.5%	3.0%
2011[1]	118,232	151,029	269,261	2.6%	18.8%	11.1%
2012	126,549	188,747	315,296	7.0%	25.0%	17.1%
2013	140,407	192,289	332,696	11.0%	1.9%	5.5%
2014	156,045	194,341	350,386	11.1%	1.1%	5.3%
2015	163,469	191,242	354,711	4.8%	(1.6%)	1.2%
2016	**170,704**	**197,568**	**368,272**	**4.4%**	**3.3%**	**3.8%**

Table G-1A Logan Express Bus Service Ridership (Continued)

	Ridership			Percent Change		
Service Year	**Air Passengers**	**Employees**	**Total**	**Air Passengers**	**Employees**	**Total**
Peabody						
2001[4]	8,151	3,097	11,248	NA	NA	NA
2002	28,626	20,629	49,255	NA	NA	NA
2003	32,318	23,425	55,743	21.4%	13.6%	13.2%
2004	43,389	33,642	77,031	34.3%	43.6%	38.2%
2005	51,023	39,599	87,622	17.6%	17.7%	13.7%
2006	42,142	32,632	74,774	(17.4%)	(17.6%)	(14.7%)
2007	36,367	26,949	63,316	(28.7%)[5]	(31.9%)[5]	(27.7%)[5]
2008	30,887	30,596	61,483	(15.1%)	13.5%	(2.9%)
2009	27,856	32,220	60,076	(9.8%)	5.3%	(2.3%)
2010	25,543	26,231	51,744	(8.3%)	(18.6%)	(13.8%)
2011[1]	25,555	31,741	57,296	0.0%	21.0%	10.7%
2012	27,542	37,909	65,451	7.8%	19.4%	14.2%
2013	28,790	38,067	66,857	4.5%	0.4%	2.1%
2014	31,485	36,848	68,333	9.4%	(3.2%)	2.2%
2015	37,478	36,125	73,603	19.0%	(2.0%)	7.7%
2016	**40,872**	**36,143**	**77,015**	**9.1%**	**0.0%**	**4.6%**

Table G-1A Logan Express Bus Service Ridership (Continued)

	Ridership			Percent Change		
Service Year	**Air Passengers**	**Employees**	**Total**	**Air Passengers**	**Employees**	**Total**
Total System Ridership						
1992	397,116	17,358	414,474	8.0%	19.2%	8.5%
1993	493,908	39,832	533,740	24.4%	129.5%	28.8%
1994	617,545	63,923	681,468	25.0%	60.5%	27.7%
1995	689,480	105,228	794,708	11.6%	64.6%	16.6%
1996	851,463	143,773	995,236	23.4%	36.6%	25.2%
1997	816,015	185,229	1,001,254	(4.2%)	28.8%	0.6%
1998	845,598	212,952	1,058,550	3.6%	15.0%	5.7%
1999	868,987	180,727	1,049,714	2.7%	(15.2%)	(0.8%)
2000	923,236	211,717	1,134,953	6.2%	17.1%	8.1%
2001	885,296	236,395	1,121,691	(4.1%)	11.7%	(1.2%)
2002	855,632	326,707	1,182,339	(3.4%)	38.2%	5.4%
2003	808,335	400,132	1,208,467	(5.5%)	22.5%	2.2%
2004	857,530	408,297	1,265,827	6.1%	2.0%	2.2%
2005	837,034	397,660	1,234,694	(2.4%)	(2.6%)	(2.4%)
2006	891,918	418,051	1,309,969	6.6%	5.1%	6.1%
2007	797,530	404,222	1,201,752	(4.7%)[5]	1.7%[5]	(2.7%)[5]
2008	688,673	432,761	1,121,434	(13.6%)	7.1%	(6.7%)
2009	636,847	448,601	1,085,448	(7.5%)	3.7%	(3.2%)
2010	644,412	467,020	1,111,432	1.2%	4.1%	2.4%
2011[1]	649,609	536,513	1,186,122	0.8%	14.9%	6.7%
2012	681,040	624,149	1,305,189	4.8%	16.3%	10.0%
2013	733,005	634,693	1,367,698	8.0%	2.0%	5.0%
2014	788,151	632,011	1,420,162	7.5%	(0.4%)	3.8%
2015	860,203	622,005	1,482,208	9.1%	-1.6%	4.4%
2016	**946,872**	**652,468**	**1,599,340**	**10.1%**	**4.9%**	**7.9%**

Source: Massport.

Notes: January 23, 2008: I-90/Ted Williams Tunnel opens to all traffic. The last toll pricing change for Ted Williams Tunnel and Sumner/Callahan Tunnels was October 2016.

NA Not applicable.

1 Changes to employee parking and bus fares were implemented in October 2011.

2 Woburn Express moved from Mishawum Station to the Anderson Regional Transportation Center (ARTC) in Woburn in May 2001.

3 Reflects a partial year of operation. Woburn Logan Express service was implemented in November 1992.

4 Reflects a partial year of operation. The Peabody Logan Express service commenced in September 2001.

5 Percent comparison between 2007 and 2005. The I-90 Ted Williams Tunnel closures in 2006 resulted in atypical ridership.

Table G-1B	Logan Express Back Bay Service Ridership[1]	
	Ridership	**Percent Change**
Service Year		
2014	152,892	NA
2015	290,796	NA
2016	**216,329**	**(25.6%)**

Source: Massport.

Notes:

1 Back Bay Logan Express service commenced in April 2014. Only total ridership available.

Table G-2 Water Transportation Services Ridership to and from Logan Airport

	Rowes Wharf/Fan Pier Water Shuttle	Private Water Taxi (on-demand)	Harbor Express (Long Wharf/Quincy/Hull)[1]	Boston-Logan Water Shuttle (Long Wharf)	Total
1990	181,530	NS	NS	NS	181,530
1991	142,500	NS	NS	NS	142,500
1992	133,297	NS	NS	NS	133,297
1993	159,525	NS	NS	NS	159,525
1994	209,057	NS	NS	NS	209,057
1995	203,829	NS	NS	NS	203,829
1996	159,992	3,364	11,781	NS	175,137
1997	132,542	6,299	71,309	NS	210,150
1998	124,836	9,243	101,174	NS	235,253
1999	122,211	17,252	98,539	NS	238,002
2000	128,097	26,335	83,243	NS	237,675
2001	107,400	29,642	82,704	NS	219,746
2002	75,304	36,736	66,471	NS	178,511
2003	26,480[2]	35,724[3]	61,849	5,722[4]	129,775
2004	NS	54,540	58,788	3,202[5]	116,530
2005	NS	44,975	51,960	NS	96,935
2006	NS	63,639	70,998	NS	134,637
2007	NS	50,737	59,460	NS	110,197
2008	NS	48,630	48,003	NS	96,633
2009	NS	50,734	37,861	NS	88,595
2010	NS	54,382	34,794	NS	89,176
2011	NS	58,879	33,403	NS	92,282
2012	NS	60,840	30,337	NS	91,177
2013	NS	70,378	21,925	NS	92,303
2014	NS	67,479	19,340	NS	86,819
2015	NS	70,798	7,748	NS	78,546
2016	**NS**	**74,788**	**7,757**	**NS**	**82,545**

Source: Massport.
Notes: Figures from 2003 – 2007 have been revised from previous documents.
NS Operation not in service.
1 Service to Quincy was discontinued in 2013 and now operates between Long Wharf/Hingham/Hull.
2 Rowes Wharf Water Shuttle operated from January to June only in 2003.
3 Operated from May to October only in 2003.
4 Long Wharf Boston-Logan Water Shuttle operated from August to December in 2003.
5 Joint operation with City Water Taxi began on August 16, 2003.

Table G-3 Massachusetts Bay Transportation Authority (MBTA) Airport Station Passengers

Year	Entrances	Exits	Total Turnstile Count[1]	Percent Change
1990	NA	NA	2,854,317	-
1991	NA	NA	2,515,293	(11.9%)
1992	NA	NA	2,626,572	4.2%
1993	NA	NA	2,604,980	(0.8%)
1994	NA	NA	3,108,734	19.3%
1995	NA	NA	3,040,868	(2.2%)
1996	NA	NA	2,974,850	(2.2%)
1997[2]	NA	NA	2,774,268	(6.7%)
1998	NA	NA	2,850,367	2.7%
1999	NA	NA	2,974,045	4.3%
2000	NA	NA	3,019,086	1.5%
2001	NA	NA	2,896,638	(4.1%)
2002	NA	NA	2,670,594	(7.8%)
2003[3]	1,300,272	1,275,627	2,575,899	(3.6%)
2004	1,373,861	1,366,511	2,740,372	6.4%
2005	NA	NA	NA	NA
2006	NA	NA	NA	NA
2007[4]	1,412,055	--	2,524,079	--
2008[5]	2,212,111	--	3,647,394	56.7%
2009[5]	2,329,370	--	3,750,549	5.3%
2010[5]	2,270,241	--	3,629,193	(2.5%)
2011	2,277,311	NA	NA	0.3%
2012	2,442,085	NA	NA	7.2%
2013	2,597,306	NA	NA	6.3%
2014	2,378,965	NA	NA	(8.4%)[6]
2015	2,122,597	NA	NA	(10.8%)[6]
2016	**2,240,744**	**NA**	**NA**	**5.6%**

Source: MBTA.
Note: Total Turnstile count figures include both Logan Airport bound (turnstile exits) and non-Logan Airport bound (turnstile entrances) passengers.
NA Data not available
1 As stated in the *Logan Airport 1999 ESPR*, Massport believes that ridership estimates through 2005 from the old Airport Station were understated because many travelers that were destined for the Airport with baggage had been observed to avoid the turnstiles and exit the old Airport Station via the wide gate (designed for handicapped access) that did not have the capability to count passengers.
2 Airport Station was closed on six weekends during September and October 1997 due to construction.
3 Airport Station was closed on eight weekend days during 2003.
4 Automated fare collection and new fare gates implemented beginning January 2007. Station access to Bremen Street Park opened June 2007. Exits are undercounted.
5 Exits are undercounted, as some exits occur through exit doors rather than turnstiles.
6 Due to the closure of Government Center Station in 2014, it is possible that passengers who would normally take the Blue Line to the Green Line switched to alternate modes for their trips.

Table G-4 Annual Taxi Dispatches (Tickets Sold)		
Year	**Total (yearly tickets sold)**	**Percent Change**
1990	1,330,418	-
1991	1,208,611	(9.2%)
1992	1,266,033	4.8%
1993	1,336,603	5.6%
1994	1,409,505	5.5%
1995	1,499,869	6.4%
1996	1,721,093	14.7%
1997	1,827,244	6.2%
1998	1,888,281	3.3%
1999	1,955,895	3.6%
2000	2,140,724	9.4%
2001	1,789,736	(16.4%)
2002	1,679,508	(6.2%)
2003	1,562,076	(7.0%)
2004	1,713,696	9.7%
2005	1,769,876	3.3%
2006	1,857,609	5.0%
2007	1,925,817	3.7%
2008	1,749,730	(9.1%)
2009	1,630,333	(6.8%)
2010	1,829,961	12.1%
2011	1,937,743	6.0%
2012	2,022,239	4.4%
2013	2,131,371	5.0%
2014	2,237,793	5.0%
2015	2,302,059	2.9%
2016	**2,420,391**	**5.1%**

Source: Massport.

Table G-5 Logan Airport Employee Parking Supply

	Number of Spaces					
Location	**March 2014**	**September 2014**	**March 2015**	**September 2015**	**March 2016**	**September 2016**
Terminal Area	857	868	868	865	**865**	**865**
North Service Area	883	883	881	876	**876**	**876**
Southwest Service Area	4	4	14	16	**16**	**16**
South Service Area	681	681	674	665	**665**	**665**
Airside (Fire/Rescue)	0	0	0	0	**0**	**0**
Total spaces in service	2,425	2,436	2,437	2,422	**2,422**	**2,422**
Total spaces out of service	248	237	236	251	**26**	**26**
Total employee spaces	2,673	2,673	2,673	2,673	**2,448**	**2,448**

Source: Logan Airport Parking Space Inventory submitted to Massachusetts Department of Environmental Protection (MassDEP), March and September 2014, 2015, and 2016.

Note: As of June 2013, the Logan Airport Parking Freeze sets a limit of 18,415 commercial spaces and 2,673 employee spaces at the Airport.

Table G-6 Logan Airport Commercial Parking Supply

	Number of Spaces					
Location	**March 2014**	**September 2014**	**March 2015**	**September 2015**	**March 2016**	**September 2016**
Terminal Area						
Central Garage and West Garage	10,267	10,267	10,267	10,340	**11,954**	**11,954**
Terminal B Garage	2,254	2,254	2,254	2,201	**2,212**	**2,212**
Terminal E Lot 1	275	275	243	237	**237**	**237**
Terminal E Lot 2	248	248	248	249	**249**	**249**
Terminal E Lot 3 (Gulf Lot)	219	219	219	217	**217**	**217**
Signature (General Aviation)	35	35	35	35	**35**	**35**
Logan Airport Hilton	235	235	35	35	**235**	**235**
North Service Area					**2,864**	**2,864**
Economy Garage	2,809	2,809	2,809	2,864	**2,864**	**2,864**
Overflow Green Lot (Wood Island)	0	0	235	242	**0**	**0**
South Service Area						
Harborside Hyatt Conference Center and Hotel	270	270	270	270	**270**	**270**
Overflow Blue Lot (Harborside Dr.)	0	0	315	339	**367**	**367**
Southwest Service Area						
Overflow Red Lot (Tomahawk Dr.)	0	0	282	282	**0**	**0**
Total spaces in service	16,612	16,612	17,212	17,311	**18,640**	**18,640**
Total spaces out of service	1,803	1,803	1,203	1,104	**-**	**-**
Total commercial spaces	18,415	18,415	18,415	18,415	**18,640**	**18,640**

Source: Logan Airport Parking Space Inventory submitted to MassDEP, March and September 2014, 2015, and 2016.
Note: Logan Airport Parking Freeze sets a limit of 21,088 spaces on Airport. As of June 2013, the allocation is 18,640 commercial and 2,448 employee spaces.

Table G-7 2016 Existing Conditions – Airport-Related Traffic, On-Airport Link Attributes, Traffic Assignment and Vehicle Miles Traveled (VMT) Summary

Link Name	Link Distance (ft)	Link Speed (mph)	VOLUME				VMT			
			AM Peak	PM Peak	High 8-Hour	AWDT	AM Peak	PM Peak	High 8-Hour	AWDT
1	344	23	1105	1362	9722	21698	72.00	88.75	633.51	1413.89
2	496	27	569	701	5004	11167	53.45	65.85	470.04	1048.95
3	1347	20	510	628	4483	10005	130.11	160.22	1143.73	2552.53
4	1166	28	1054	1298	9265	20678	232.74	286.62	2045.88	4566.08
5	378	25	1563	1926	13747	30683	111.97	137.97	984.81	2198.07
6	441	30	462	569	4061	9065	38.60	47.54	339.29	757.36
7	896	24	1097	1352	9650	21538	186.24	229.53	1638.31	3656.58
8	644	26	1087	1339	9557	21331	132.68	163.44	1166.54	2603.68
9	1214	21	528	650	4640	10355	121.37	149.42	1066.61	2380.34
10	1303	19	634	781	5575	12442	156.50	192.78	1376.13	3071.19
11	421	20	592	730	5211	11629	47.21	58.21	415.55	927.34
12	236	25	42	52	371	828	1.87	2.32	16.56	36.96
13	1311	26	64	79	564	1259	15.89	19.61	140.00	312.52
14	750	23	1674	2063	14725	32865	237.79	293.05	2091.67	4668.43
15	441	25	1457	1795	12812	28596	121.66	149.88	1069.77	2387.70
16	1724	23	22	27	193	430	7.18	8.82	63.02	140.40
17	644	15	636	783	5589	12474	77.52	95.43	681.20	1520.36
18	354	23	558	687	4904	10944	37.42	46.07	328.87	733.92
19	687	17	84	104	742	1657	10.92	13.52	96.48	215.44
20	94	14	638	786	5610	12522	11.38	14.02	100.04	223.29
21	877	6	28	35	250	558	4.65	5.82	41.54	92.72
22	79	28	28	35	250	558	0.42	0.52	3.72	8.31
23	81	29	22	27	193	430	0.34	0.41	2.94	6.56
24	79	5	24	30	214	478	0.36	0.45	3.22	7.19
25	87	9	32	40	286	637	0.53	0.66	4.70	10.46
26	209	5	32	40	286	637	1.27	1.59	11.34	25.27
27	187	5	24	30	214	478	0.85	1.06	7.58	16.93
28	124	5	57	70	500	1115	1.34	1.65	11.77	26.25
29	226	30	241	297	2120	4731	10.32	12.71	90.75	202.52
30	1070	5	494	609	4347	9702	100.07	123.36	880.54	1965.27
31	385	32	172	212	1513	3377	12.53	15.44	110.23	246.03
32	516	18	68	84	600	1338	6.65	8.21	58.64	130.78
34	181	17	382	471	3362	7503	13.07	16.12	115.03	256.72
35	248	18	450	555	3961	8842	21.12	26.05	185.93	415.04
36	89	16	390	481	3433	7663	6.57	8.10	57.79	129.00
37	102	18	61	75	535	1195	1.18	1.46	10.38	23.19
38	110	28	106	131	935	2087	2.21	2.73	19.46	43.45
39	219	32	25	31	221	494	1.04	1.28	9.16	20.47
40	232	9	33	41	293	653	1.45	1.80	12.87	28.69
41	177	22	6	8	57	127	0.20	0.27	1.91	4.26
42	205	30	9	11	79	175	0.35	0.43	3.06	6.78
43	597	18	27	33	236	526	3.06	3.73	26.71	59.52
44	587	28	67	82	585	1306	7.45	9.12	65.03	145.18
45	96	32	59	73	521	1163	1.07	1.33	9.48	21.16
46	112	14	5	6	43	96	0.11	0.13	0.92	2.04
47	859	28	12	15	107	239	1.95	2.44	17.40	38.86
48	94	15	422	520	3712	8284	7.49	9.23	65.86	146.97
49	420	25	433	534	3812	8507	34.48	42.52	303.55	677.42
50	353	33	25	31	221	494	1.67	2.07	14.76	32.99
51	717	25	458	564	4026	8985	62.18	76.57	546.56	1219.78
52	403	33	258	318	2270	5066	19.70	24.28	173.31	386.79
53	321	33	5	6	43	96	0.30	0.36	2.61	5.83

Table G-7 2016 Existing Conditions – Airport-Related Traffic, On-Airport Link Attributes, Traffic Assignment and Vehicle Miles Traveled (VMT) Summary (Continued)

Link Name	Link Distance (ft)	Link Speed (mph)	VOLUME				VMT			
			AM Peak	PM Peak	High 8-Hour	AWDT	AM Peak	PM Peak	High 8-Hour	AWDT
54	612	25	263	324	2313	5162	30.48	37.54	268.03	598.17
55	194	25	603	743	5303	11837	22.12	27.26	194.54	434.23
56	101	5	0	0	0	0	0.00	0.00	0.00	0.00
57	97	32	123	152	1085	2421	2.27	2.80	20.00	44.63
58	103	5	0	0	0	0	0.00	0.00	0.00	0.00
59	105	5	0	0	0	0	0.00	0.00	0.00	0.00
60	331	25	726	895	6388	14258	45.44	56.02	399.86	892.48
61	224	5	151	186	1328	2963	6.39	7.87	56.21	125.42
62	218	23	287	353	2520	5624	11.88	14.61	104.27	232.71
63	242	5	0	0	0	0	0.00	0.00	0.00	0.00
64	232	5	34	42	300	669	1.50	1.85	13.21	29.45
65	593	25	863	1063	7587	16934	96.97	119.45	852.53	1902.84
66	465	25	17	21	150	335	1.50	1.85	13.20	29.48
67	483	21	10	12	86	191	0.92	1.10	7.87	17.49
68	487	5	0	0	0	0	0.00	0.00	0.00	0.00
69	361	14	28	34	243	542	1.91	2.32	16.61	37.05
90	582	5	400	493	3519	7854	44.10	54.35	387.96	865.89
103	85	33	13	16	114	255	0.21	0.26	1.83	4.09
104	85	5	0	0	0	0	0.00	0.00	0.00	0.00
105	95	5	0	0	0	0	0.00	0.00	0.00	0.00
106	95	5	0	0	0	0	0.00	0.00	0.00	0.00
107	260	20	123	152	1085	2421	6.06	7.49	53.48	119.33
108	389	19	81	100	714	1593	5.97	7.37	52.59	117.33
109	114	12	27	33	236	526	0.58	0.71	5.10	11.36
110	169	17	27	33	236	526	0.86	1.05	7.54	16.81
111	261	5	0	0	0	0	0.00	0.00	0.00	0.00
112	237	26	16	20	143	319	0.72	0.90	6.43	14.34
113	565	17	29	36	257	574	3.11	3.86	27.52	61.47
114	609	32	20	25	178	398	2.31	2.88	20.52	45.89
115	451	29	265	326	2327	5193	22.64	27.85	198.76	443.57
116	399	21	28	35	250	558	2.12	2.64	18.89	42.16
117	283	21	43	53	378	844	2.31	2.84	20.27	45.26
118	295	29	276	340	2427	5416	15.41	18.99	135.53	302.44
119	240	12	196	242	1727	3855	8.91	11.00	78.52	175.26
120	365	28	52	64	457	1020	3.60	4.43	31.61	70.54
121	356	17	87	107	764	1705	5.87	7.22	51.54	115.01
122	486	19	78	96	685	1529	7.18	8.83	63.03	140.70
123	486	18	88	108	771	1721	8.09	9.93	70.90	158.27
124	280	20	50	62	443	988	2.65	3.29	23.48	52.36
125	280	19	70	86	614	1370	3.71	4.56	32.54	72.60
126	631	20	124	153	1092	2437	14.82	18.29	130.52	291.29
127	652	19	80	99	707	1577	9.88	12.23	87.32	194.77
128	257	32	18	22	157	350	0.88	1.07	7.64	17.03
129	257	18	27	33	236	526	1.31	1.61	11.48	25.59
130	422	5	0	0	0	0	0.00	0.00	0.00	0.00
131	493	30	4	5	36	80	0.37	0.47	3.36	7.46
132	361	23	140	173	1235	2756	9.57	11.83	84.42	188.38
133	236	24	72	89	635	1418	3.22	3.98	28.37	63.35
134	1521	27	192	236	1685	3760	55.29	67.96	485.26	1082.82
135	1542	24	67	83	592	1322	19.57	24.24	172.93	386.17
136	384	5	14	17	121	271	1.02	1.24	8.80	19.72
137	354	16	10	12	86	191	0.67	0.80	5.77	12.81

Table G-7 2016 Existing Conditions – Airport-Related Traffic, On-Airport Link Attributes, Traffic Assignment and Vehicle Miles Traveled (VMT) Summary (Continued)

Link Name	Link Distance (ft)	Link Speed (mph)	VOLUME AM Peak	VOLUME PM Peak	VOLUME High 8-Hour	VOLUME AWDT	VMT AM Peak	VMT PM Peak	VMT High 8-Hour	VMT AWDT
138	225	22	37	46	328	733	1.57	1.96	13.95	31.17
139	96	13	37	46	328	733	0.67	0.84	5.98	13.36
140	295	24	68	84	600	1338	3.80	4.69	33.51	74.74
142	257	17	154	190	1356	3027	7.48	9.23	65.91	147.12
144	518	8	129	159	1135	2533	12.64	15.58	111.25	248.28
145	195	17	58	71	507	1131	2.15	2.63	18.76	41.85
146	463	17	54	67	478	1067	4.73	5.87	41.90	93.52
147	230	17	167	206	1470	3282	7.28	8.98	64.11	143.13
148	794	17	38	47	335	749	5.71	7.06	50.35	112.58
149	661	20	88	109	778	1736	11.02	13.65	97.39	217.32
150	281	20	90	111	792	1768	4.79	5.91	42.15	94.10
151	360	20	56	69	493	1099	3.82	4.70	33.59	74.87
152	88	32	3	4	29	64	0.05	0.07	0.49	1.07
153	66	30	34	42	300	669	0.42	0.52	3.75	8.35
154	173	33	37	46	328	733	1.21	1.51	10.76	24.04
155	258	30	147	181	1292	2883	7.20	8.86	63.24	141.13
156	645	23	58	71	507	1131	7.08	8.67	61.89	138.07
157	218	22	89	110	785	1752	3.67	4.54	32.39	72.30
158	185	24	265	326	2327	5193	9.30	11.44	81.63	182.17
159	354	19	353	435	3105	6930	23.68	29.18	208.30	464.91
160	470	28	57	70	500	1115	5.07	6.23	44.46	99.16
161	94	13	115	142	1014	2262	2.06	2.54	18.12	40.42
162	50	13	1	1	7	16	0.01	0.01	0.07	0.15
163	66	13	114	140	999	2230	1.43	1.76	12.57	28.05
164	367	33	50	62	443	988	3.48	4.31	30.81	68.72
165	124	29	119	147	1049	2342	2.79	3.44	24.57	54.85
166	84	29	103	127	906	2023	1.65	2.03	14.48	32.34
167	956	29	103	127	906	2023	18.65	22.99	164.04	366.28
168	380	15	52	64	457	1020	3.74	4.60	32.87	73.35
169	293	13	155	191	1363	3043	8.61	10.61	75.71	169.03
170	205	33	16	20	143	319	0.62	0.78	5.54	12.37
171	158	5	0	0	0	0	0.00	0.00	0.00	0.00
172	180	5	0	0	0	0	0.00	0.00	0.00	0.00
173	48	5	0	0	0	0	0.00	0.00	0.00	0.00
174	502	14	226	279	1991	4445	21.47	26.51	189.18	422.35
175	640	17	198	244	1742	3887	24.00	29.58	211.16	471.17
176	319	23	1364	1681	11999	26780	82.29	101.42	723.93	1615.71
177	286	30	1364	1681	11999	26780	73.91	91.08	650.15	1451.04
178	353	23	1139	1403	10014	22351	76.25	93.92	670.35	1496.21
179	348	31	720	887	6331	14131	47.41	58.41	416.87	930.47
180	366	29	945	1164	8308	18543	65.50	80.68	575.87	1285.31
181	453	14	74	91	650	1450	6.35	7.81	55.75	124.37
182	119	14	74	91	650	1450	1.66	2.04	14.59	32.55
183	50	14	62	76	542	1211	0.59	0.72	5.13	11.46
184	54	14	47	58	414	924	0.48	0.59	4.20	9.37
185	62	14	50	61	435	972	0.59	0.71	5.09	11.38
186	39	14	117	144	1028	2294	0.87	1.07	7.63	17.03
187	208	5	0	0	0	0	0.00	0.00	0.00	0.00
188	212	5	0	0	0	0	0.00	0.00	0.00	0.00
189	218	5	0	0	0	0	0.00	0.00	0.00	0.00
190	193	32	12	15	107	239	0.44	0.55	3.91	8.73

Table G-7 2016 Existing Conditions – Airport-Related Traffic, On-Airport Link Attributes, Traffic Assignment and Vehicle Miles Traveled (VMT) Summary (Continued)

Link Name	Link Distance (ft)	Link Speed (mph)	VOLUME				VMT			
			AM Peak	PM Peak	High 8-Hour	AWDT	AM Peak	PM Peak	High 8-Hour	AWDT
191	169	5	0	0	0	0	0.00	0.00	0.00	0.00
192	540	5	67	83	592	1322	6.86	8.50	60.59	135.31
193	138	17	199	245	1749	3903	5.19	6.39	45.65	101.87
194	932	16	196	242	1727	3855	34.59	42.70	304.74	680.24
195	79	16	15	18	128	287	0.23	0.27	1.92	4.31
196	49	16	277	341	2434	5432	2.55	3.14	22.43	50.05
197	83	18	277	341	2434	5432	4.38	5.39	38.49	85.90
198	692	18	324	399	2848	6356	42.47	52.30	373.28	833.06
199	70	28	299	368	2627	5863	3.98	4.90	34.97	78.04
200	158	5	0	0	0	0	0.00	0.00	0.00	0.00
201	160	9	44	54	385	860	1.33	1.63	11.64	26.01
202	335	22	45	55	393	876	2.85	3.49	24.92	55.56
203	30	5	0	0	0	0	0.00	0.00	0.00	0.00
204	2022	9	111	137	978	2183	42.50	52.46	374.48	835.88
205	71	25	378	466	3326	7424	5.11	6.29	44.92	100.27
206	142	25	264	325	2320	5178	7.11	8.76	62.52	139.53
207	859	33	247	304	2170	4843	40.17	49.44	352.92	787.65
208	284	33	215	265	1892	4222	11.56	14.25	101.76	227.09
209	80	29	787	970	6924	15453	11.98	14.76	105.39	235.21
210	71	29	946	1165	8316	18559	12.79	15.75	112.45	250.95
211	390	29	1002	1235	8815	19675	73.98	91.18	650.83	1452.66
212	117	29	583	718	5125	11438	12.94	15.94	113.80	253.97
213	1344	24	1458	1796	12819	28612	371.25	457.32	3264.13	7285.54
214	449	31	967	1191	8501	18974	82.19	101.23	722.53	1612.66
215	1110	30	50	61	435	972	10.51	12.82	91.41	204.26
216	905	31	410	505	3605	8045	70.31	86.60	618.21	1379.61
217	1050	30	211	260	1856	4142	41.96	51.70	369.06	823.62
218	581	28	713	879	6274	14003	78.42	96.68	690.04	1540.12
219	1063	32	347	427	3048	6802	69.89	86.00	613.88	1369.94
220	415	32	347	427	3048	6802	27.27	33.55	239.51	534.49
221	698	5	0	0	0	0	0.00	0.00	0.00	0.00
222	1920	22	17	21	150	335	6.18	7.64	54.56	121.85
223	1564	29	1060	1306	9322	20806	313.95	386.81	2761.00	6162.34
224	377	28	629	775	5532	12346	44.96	55.39	395.39	882.40
225	551	28	125	154	1099	2453	13.04	16.07	114.68	255.96
226	788	32	161	198	1413	3154	24.03	29.55	210.88	470.71
227	1303	32	458	564	4026	8985	112.99	139.14	993.22	2216.62
228	580	29	1029	1268	9051	20200	113.09	139.36	994.77	2220.13
229	1653	30	342	421	3005	6707	107.06	131.79	940.69	2099.58
230	2058	28	687	847	6046	13493	267.78	330.14	2356.61	5259.31
231	1300	10	681	839	5989	13366	167.62	206.51	1474.14	3289.91
232	736	13	803	989	7059	15756	111.89	137.81	983.64	2195.52
233	488	23	687	846	6039	13477	63.50	78.20	558.18	1245.67
234	449	11	472	581	4147	9256	40.13	49.40	352.59	786.97
235	310	26	379	467	3333	7440	22.25	27.41	195.66	436.75
236	310	5	92	113	807	1800	5.41	6.64	47.46	105.85
237	105	5	206	254	1813	4046	4.11	5.06	36.13	80.63
238	697	31	81	100	714	1593	10.69	13.19	94.20	210.16
239	186	25	56	69	493	1099	1.97	2.43	17.33	38.63
240	145	29	177	218	1556	3473	4.87	6.00	42.83	95.60
241	578	29	233	287	2049	4572	25.53	31.44	224.49	500.90

Table G-7 2016 Existing Conditions – Airport-Related Traffic, On-Airport Link Attributes, Traffic Assignment and Vehicle Miles Traveled (VMT) Summary (Continued)

Link Name	Link Distance (ft)	Link Speed (mph)	VOLUME				VMT			
			AM Peak	PM Peak	High 8-Hour	AWDT	AM Peak	PM Peak	High 8-Hour	AWDT
242	125	32	81	100	714	1593	1.91	2.36	16.88	37.66
243	564	32	81	100	714	1593	8.65	10.68	76.25	170.13
244	88	32	81	100	714	1593	1.34	1.66	11.83	26.40
245	48	5	0	0	0	0	0.00	0.00	0.00	0.00
246	175	12	227	280	1999	4461	7.52	9.28	66.24	147.83
247	65	22	3	4	29	64	0.04	0.05	0.36	0.79
248	39	12	311	383	2734	6101	2.28	2.81	20.08	44.80
249	128	12	230	283	2020	4508	5.57	6.85	48.88	109.09
250	484	12	239	295	2106	4700	21.93	27.07	193.24	431.25
251	388	5	0	0	0	0	0.00	0.00	0.00	0.00
252	308	14	321	395	2819	6293	18.75	23.08	164.69	367.65
253	54	12	10	12	86	191	0.10	0.12	0.88	1.95
254	51	5	0	0	0	0	0.00	0.00	0.00	0.00
255	290	31	3	4	29	64	0.17	0.22	1.60	3.52
256	377	31	38	47	335	749	2.71	3.36	23.93	53.51
257	215	31	24	29	207	462	0.98	1.18	8.44	18.83
258	321	29	6	7	50	112	0.36	0.43	3.04	6.81
259	203	29	2	3	21	48	0.08	0.12	0.81	1.84
260	362	29	2	3	21	48	0.14	0.21	1.44	3.29
261	219	31	20	25	178	398	0.83	1.04	7.39	16.53
262	218	11	6	7	50	112	0.25	0.29	2.06	4.62
263	177	33	24	29	207	462	0.80	0.97	6.93	15.46
264	157	5	0	0	0	0	0.00	0.00	0.00	0.00
265	2458	26	104	128	914	2039	48.41	59.58	425.47	949.17
266	752	26	149	184	1313	2931	21.22	26.20	186.99	417.42
267	1323	26	218	268	1913	4269	54.61	67.13	479.20	1069.37
268	1252	29	288	355	2534	5655	68.27	84.15	600.67	1340.49
269	302	30	17	21	150	335	0.97	1.20	8.59	19.19
270	1005	11	550	678	4839	10801	104.68	129.05	921.02	2055.78
271	954	14	638	786	5610	12522	115.24	141.98	1013.35	2261.88
272	656	8	593	731	5218	11645	73.68	90.83	648.37	1446.97
273	485	5	620	764	5453	12171	56.96	70.19	500.99	1118.19
274	1244	26	160	197	1406	3138	37.70	46.41	331.26	739.33
275	419	5	0	0	0	0	0.00	0.00	0.00	0.00
276	649	26	147	181	1292	2883	18.06	22.24	158.75	354.25
277	2473	24	101	125	892	1991	47.31	58.56	417.86	932.69
278	573	31	218	269	1920	4285	23.67	29.20	208.43	465.17
279	458	18	256	316	2256	5034	22.19	27.40	195.58	436.42
280	295	24	157	194	1385	3091	8.78	10.85	77.43	172.81
281	440	14	153	188	1342	2995	12.74	15.65	111.72	249.34
282	76	14	97	120	857	1912	1.40	1.74	12.41	27.68
283	697	14	275	339	2420	5401	36.28	44.72	319.24	712.48
284	690	21	446	549	3919	8746	58.25	71.70	511.81	1142.21
285	91	21	389	479	3419	7631	6.70	8.25	58.90	131.46
286	464	21	766	944	6738	15039	67.33	82.97	592.23	1321.84
287	229	27	736	907	6474	14449	31.95	39.37	281.00	627.14
288	500	9	733	903	6445	14386	69.35	85.43	609.74	1361.02
289	738	12	2022	2491	17780	39684	282.64	348.20	2485.31	5547.09
290	190	14	1734	2137	15253	34044	62.32	76.80	548.15	1223.45
291	494	31	420	518	3697	8252	39.32	48.49	346.08	772.47
292	689	10	1313	1618	11549	25776	171.23	211.01	1506.13	3361.50

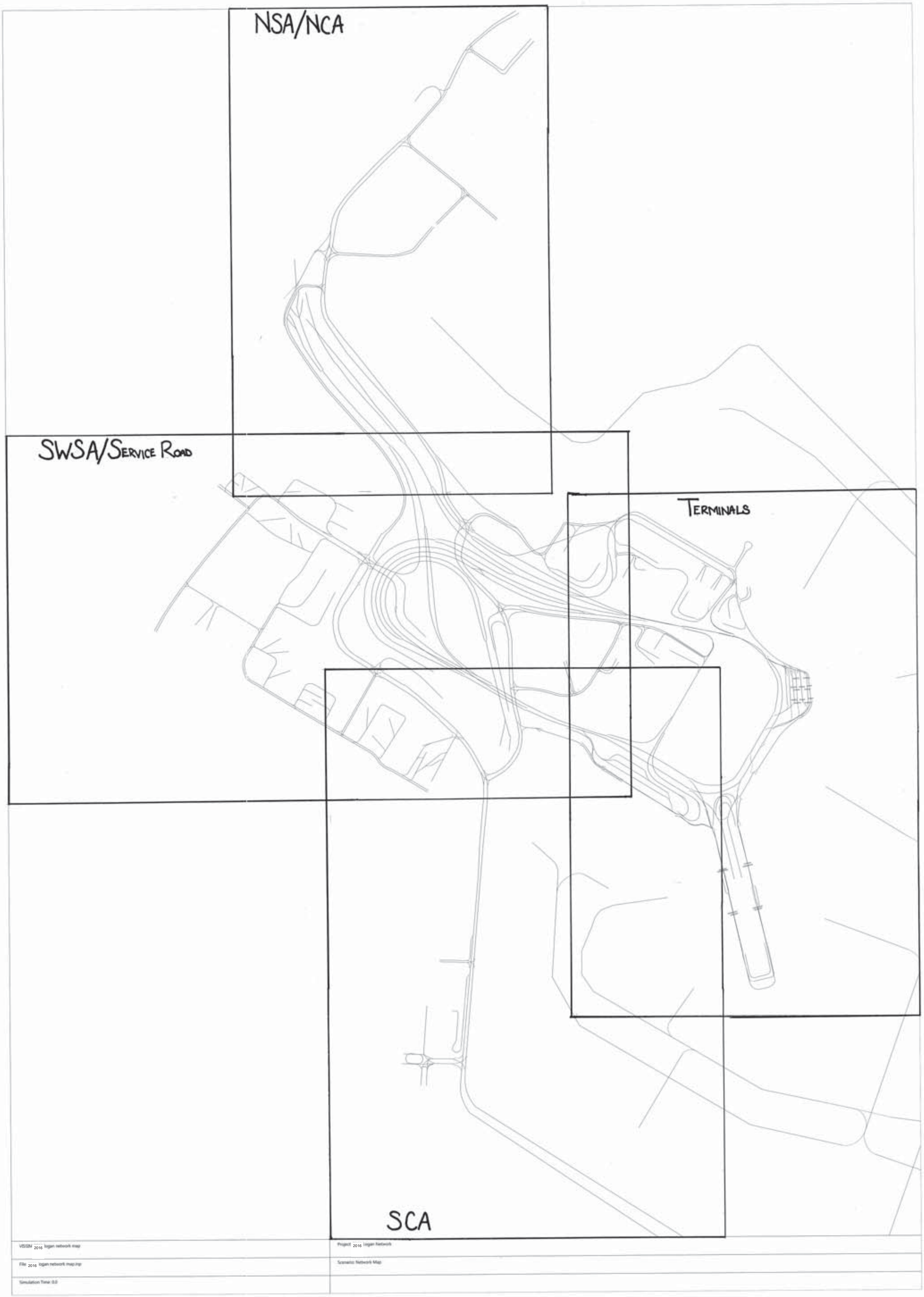
Table G-7 2016 Existing Conditions – Airport-Related Traffic, On-Airport Link Attributes, Traffic Assignment and Vehicle Miles Traveled (VMT) Summary (Continued)

Link Name	Link Distance (ft)	Link Speed (mph)	VOLUME				VMT			
			AM Peak	PM Peak	High 8-Hour	AWDT	AM Peak	PM Peak	High 8-Hour	AWDT
293	325	16	1291	1591	11356	25346	79.48	97.95	699.14	1560.45
294	396	5	365	450	3212	7169	27.40	33.78	241.10	538.13
295	1017	27	917	1130	8066	18002	176.65	217.68	1553.84	3467.92
296	162	16	287	354	2527	5640	8.81	10.87	77.60	173.20
297	140	16	287	354	2527	5640	7.60	9.38	66.94	149.41
298	951	7	278	343	2448	5464	50.09	61.80	441.07	984.47
299	805	17	305	376	2684	5990	46.51	57.33	409.25	913.35
300	518	11	99	122	871	1944	9.72	11.98	85.49	190.82
301	749	7	127	156	1113	2485	18.02	22.13	157.92	352.59
302	652	5	340	419	2991	6675	41.98	51.74	369.33	824.24
303	547	5	196	242	1727	3855	20.29	25.05	178.79	399.10
304	406	10	34	42	300	669	2.61	3.23	23.06	51.43
305	442	5	31	38	271	605	2.60	3.18	22.70	50.67
306	207	5	65	80	571	1274	2.55	3.14	22.40	49.97
307	70	5	261	322	2298	5130	3.46	4.27	30.47	68.02
308	319	8	58	71	507	1131	3.50	4.29	30.64	68.35
309	281	6	84	104	742	1657	4.47	5.53	39.47	88.15
310	555	30	554	682	4868	10865	58.19	71.63	511.28	1141.13
311	208	26	554	682	4868	10865	21.82	26.87	191.77	428.02
312	125	26	1295	1596	11392	25426	30.66	37.78	269.70	601.94
313	332	10	610	751	5360	11964	38.39	47.27	337.35	753.00
314	440	10	924	1139	8130	18145	77.03	94.96	677.81	1512.77
315	215	17	886	1092	7794	17396	36.08	44.47	317.43	708.49
316	543	11	125	154	1099	2453	12.86	15.84	113.06	252.36
317	180	8	381	470	3355	7487	12.99	16.02	114.38	255.25
318	221	9	381	470	3355	7487	15.93	19.65	140.25	312.98
319	2544	11	472	581	4147	9256	227.40	279.92	1997.97	4459.42
320	552	12	43	53	378	844	4.49	5.54	39.50	88.19
321	628	11	310	382	2727	6086	36.89	45.46	324.51	724.24
322	181	9	377	465	3319	7408	12.93	15.94	113.80	253.99
323	58	9	310	382	2727	6086	3.42	4.22	30.10	67.18
324	387	9	4	5	36	80	0.29	0.37	2.64	5.87
325	406	9	314	387	2762	6165	24.13	29.73	212.21	473.68
326	89	5	88	109	778	1736	1.48	1.83	13.07	29.16
327	463	12	331	408	2912	6500	29.03	35.78	255.36	570.00
328	79	19	418	515	3676	8204	6.26	7.71	55.05	122.85
329	103	19	418	515	3676	8204	8.12	10.01	71.43	159.42
330	323	12	22	27	193	430	1.34	1.65	11.80	26.29
331	179	10	469	578	4126	9208	15.89	19.59	139.83	312.05
332	993	7	347	427	3048	6802	65.25	80.29	573.12	1278.98
333	384	5	0	0	0	0	0.00	0.00	0.00	0.00
334	366	23	297	366	2612	5831	20.57	25.35	180.89	403.82
335	583	31	427	526	3754	8380	47.15	58.08	414.49	925.26
336	428	27	935	1152	8223	18352	75.84	93.44	666.97	1488.54
337	94	23	360	444	3169	7073	6.42	7.92	56.55	126.23
338	366	5	200	247	1763	3935	13.86	17.11	122.14	272.62
339	311	5	161	198	1413	3154	9.47	11.65	83.11	185.51
340	273	18	20	25	178	398	1.03	1.29	9.20	20.56
341	66	16	20	25	178	398	0.25	0.31	2.22	4.96
342	48	5	0	0	0	0	0.00	0.00	0.00	0.00
343	52	22	45	55	393	876	0.44	0.54	3.87	8.63

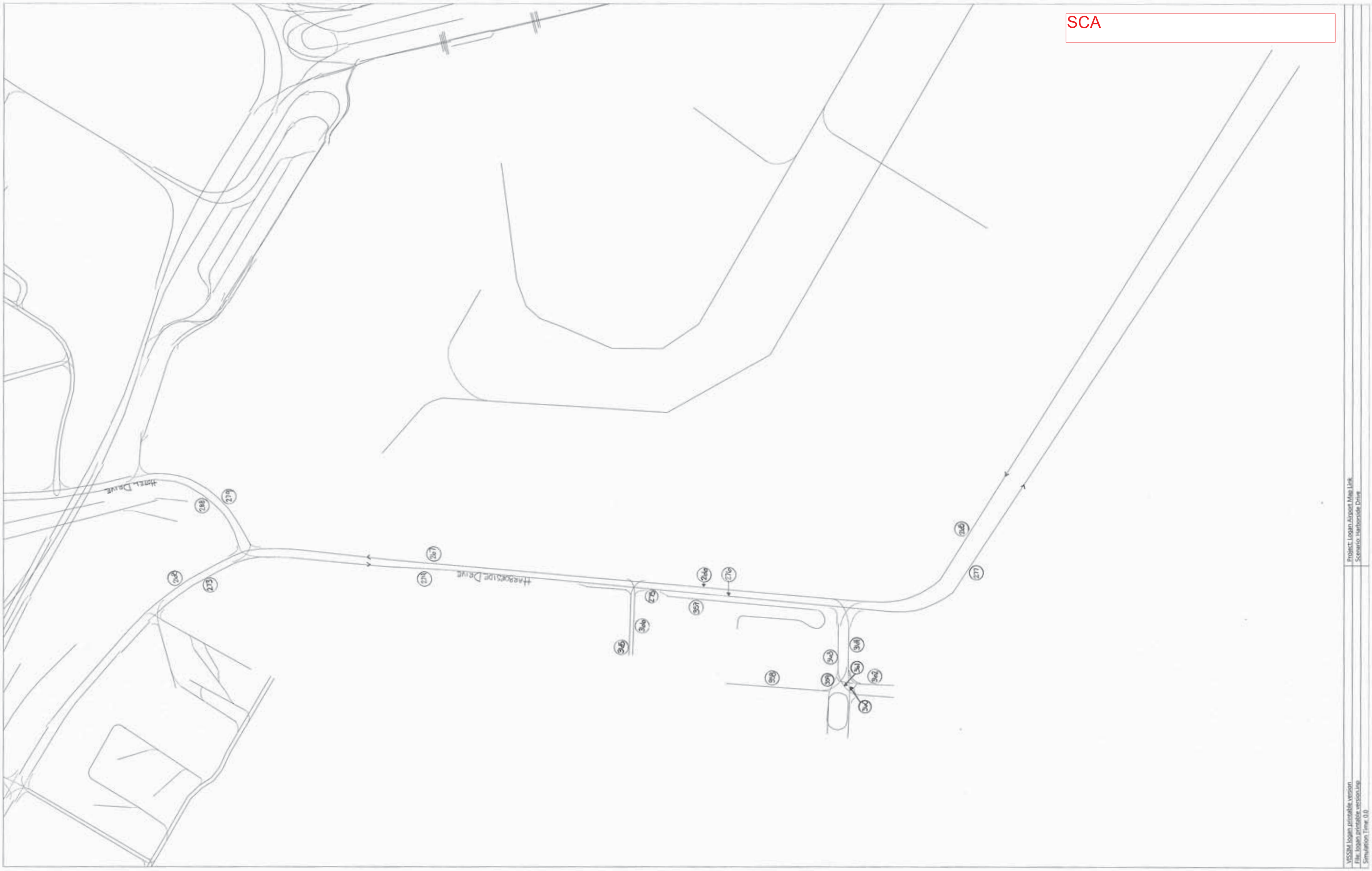
Table G-7 2016 Existing Conditions – Airport-Related Traffic, On-Airport Link Attributes, Traffic Assignment and Vehicle Miles Traveled (VMT) Summary (Continued)

Link Name	Link Distance (ft)	Link Speed (mph)	VOLUME				VMT			
			AM Peak	PM Peak	High 8-Hour	AWDT	AM Peak	PM Peak	High 8-Hour	AWDT
344	82	12	34	42	300	669	0.53	0.65	4.67	10.41
345	25	5	76	94	671	1497	0.36	0.45	3.18	7.09
346	121	5	75	92	657	1466	1.71	2.10	15.00	33.48
347	303	10	108	133	949	2119	6.20	7.63	54.44	121.56
348	146	6	496	611	4361	9734	13.73	16.91	120.72	269.45
349	67	6	237	292	2084	4652	3.00	3.69	26.34	58.81
350	446	5	234	288	2056	4588	19.75	24.31	173.57	387.33
351	335	5	31	38	271	605	1.97	2.41	17.22	38.44
352	430	5	218	268	1913	4269	17.74	21.81	155.66	347.38
353	360	5	43	53	378	844	2.93	3.61	25.74	57.47
354	50	14	108	133	949	2119	1.02	1.26	8.99	20.07
355	88	5	232	286	2041	4556	3.87	4.78	34.08	76.08
356	113	5	493	607	4333	9670	10.55	12.99	92.76	207.02
358	463	5	0	0	0	0	0.00	0.00	0.00	0.00
359	229	12	4	5	36	80	0.17	0.22	1.56	3.47
360	245	13	4	5	36	80	0.19	0.23	1.67	3.72
361	248	17	45	56	400	892	2.11	2.63	18.77	41.86
362	199	8	45	55	393	876	1.70	2.07	14.82	33.04
363	230	22	50	61	435	972	2.18	2.65	18.93	42.30
364	256	19	49	60	428	956	2.38	2.91	20.76	46.38
365	201	23	15	19	136	303	0.57	0.72	5.17	11.53
366	201	10	71	88	628	1402	2.71	3.35	23.93	53.43
367	337	31	620	764	5453	12171	39.58	48.77	348.11	776.97
368	868	11	353	435	3105	6930	58.06	71.55	510.69	1139.81
369	167	5	323	398	2841	6340	10.24	12.62	90.06	200.98
370	96	10	429	528	3769	8411	7.77	9.57	68.28	152.39
371	141	25	761	937	6688	14927	20.31	25.01	178.49	398.38
372	283	17	249	307	2191	4891	13.34	16.45	117.37	262.01
373	283	24	168	207	1478	3298	9.00	11.09	79.18	176.67
			Logan Airport VMT				**9,009**	**11,101**	**79,234**	**176,841**

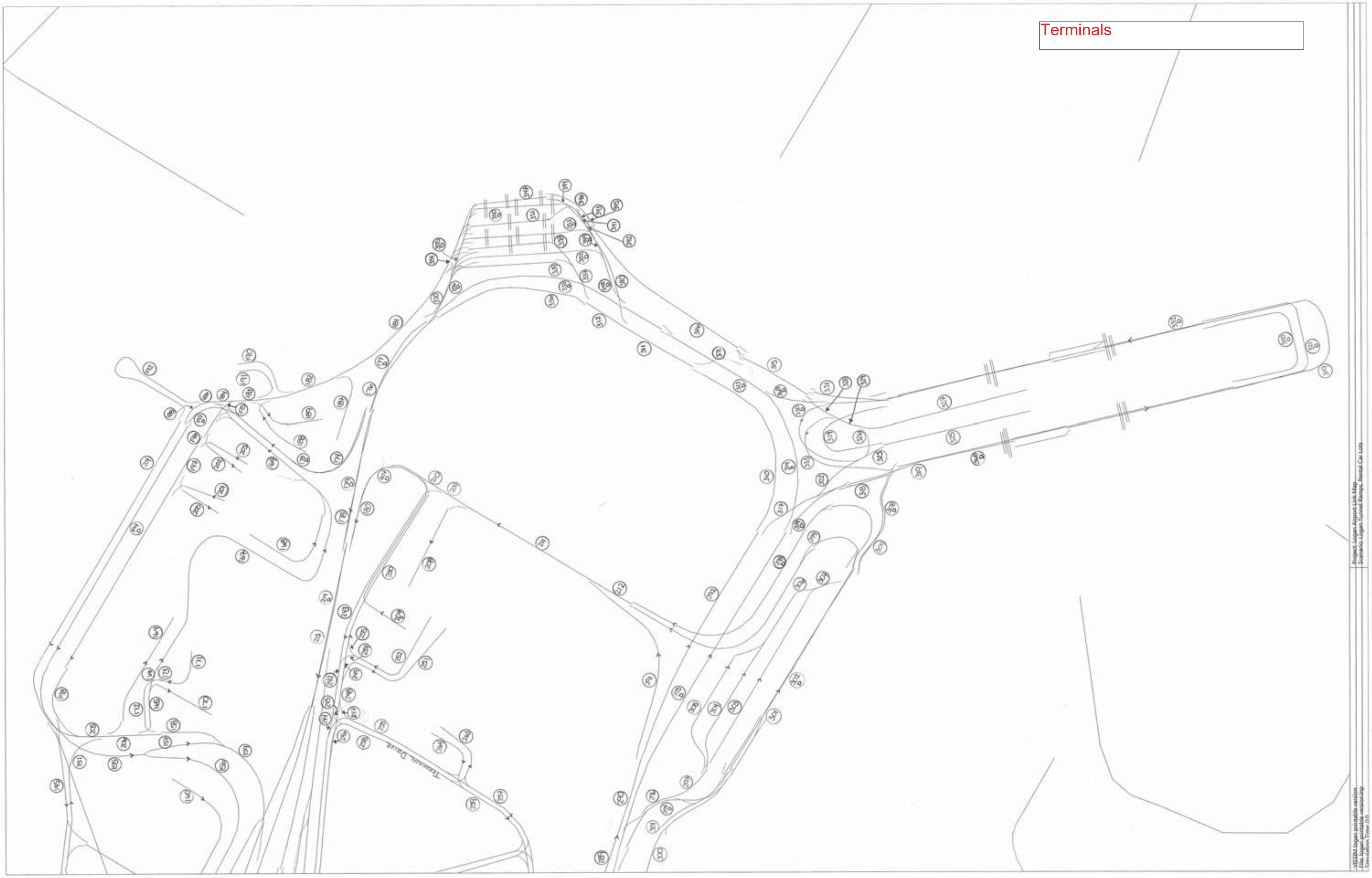
Source: VHB.
Notes:
AWDT = Average annual weekday daily traffic


NSA/NCA
SWSA/Service Road
Terminals
SCA


NSA/NCA
Cottage Street
Economy Bus Driveway
Service Road
Economy Parking Drive
Prescott Street
Frankfort Street
Lovell
Ramp 1A-SB
SCT 1B
RT 1A-1B
RT 1A-OB
SCT OB


SCA
Hotel Drive
Harborside Drive
Project: Logan Airport Map Link
Scenario: Harborside Drive
VISSIM logan printable version
File: logan printable version.inp
Simulation Time: 0.0

SWSA/Service Roadways


Terminals

Massachusetts Port Authority
One Harborside Drive, Suite 200-S
East Boston, MA 02128-2909
Telephone: 617-568-5000
www.massport.com

April 15, 2016

Christine Kirby, Director, Air & Climate Division
Massachusetts Department of Environmental Protection
Bureau of Air & Waste
One Winter Street
Boston, MA 02108

Re: Logan Airport Parking Space Inventory

Dear Ms. Kirby:

In compliance with the reporting requirements of 310 CMR 7.30 (3)(d), enclosed are the following Massachusetts Port Authority (Massport) submissions for Logan Airport:

- Commercial Parking Space Inventory
- Employee Parking Space Inventory
- Location Map

The attachments provide the quantity, physical distribution, and allocation of commercial and employee parking spaces on the airport, as defined by 310 CMR 7.30, as amended. These inventory tables represent information provided by the Aviation Department and are supported by comprehensive field checks and counts conducted in late February and March 2016.

The Commercial Parking Space Inventory totals 18,640 spaces; the Employee Parking Space Inventory totals 2,448 parking spaces; the total inventory of spaces at Logan Airport is 21,088. For your information, we continue to provide information on rental car spaces.

As noted in our September letter, Massport consolidated all remaining (i.e., designated) parking spaces allowed under the freeze into the central terminal area's West Garage. The garage expansion is currently operating and the revised capacity is presented in the attached tables.

Page 2

The attached Logan Airport Parking Space Inventory reflects Massport's successful management of its parking program, within the requirements of 310 CMR 7.30, as amended. If you have any questions, please call me at 617-568-3689.

Sincerely,

Hayes Morrison
Deputy Director - Maritime, Land Use, and Transportation Planning
Strategic & Business Planning Department

cc: D. Conroy, EPA
S. Dalzell, MPA
B. Desrosiers, MPA
H. Morrison, MPA
I. Wallach, MPA

Employee Parking Space Inventory
Logan International Airport
April 15, 2016 Submission

As of 2014: space count excludes spaces designate

Employee Parking Spaces

Area		Map ID#	Location of Employee Parking Areas	Jan-16 Number of Spaces	Aug-15 Number of Spaces
Terminal	Terminal Area	E81	West Garage	98	98
Terminal		E26	Airport Tower/Administration (parking in Central Garage)	521	521
Terminal		E20	Terminal C Pier A (Old Terminal D) (two lots)	122	122
Terminal		E18	Massport Facilities 1 (Heating Plant)	92	92
Terminal		E34	Hilton Hotel employee lot	28	28
Terminal		E86	Gulf Gas Station	4	4
North	North Service Area	E68a	LSG Sky Chefs (Bldg. 68), main lot	25	25
North		E68b	LSG Sky Chefs (Bldg. 68), overflow lot	126	126
North		E1	Flight Kitchen Building 1 (and nearby lot)	80	80
North		E40	Lovell Street Lot (contractor trailer)	25	25
North		E53	Green Bus Depot (Bus Maintenance Facility)	12	12
North		E11a	North Cargo Building 11, TSA lot	93	93
North		E11b	North Cargo Building 11, State Police lot	136	136
North		E43	North Gate & EMS Trailer (EMS Station A7)	21	21
North		E8	North Cargo Building 8	114	114
North		E5	US Airways Administration/Hangar (Bldg. 5)	75	75
airside		*N/A*	Massport Facilities 2 (airside, Bldg. 3)	0	0
North		E4	Massport Facilities 3 (landside, Bldg. 4)	69	69
North		E13	UPS (Cargo Building 13)	44	44
North		E94	United Aircraft Maintenance (Buildings 93 & 94)	56	56
SW	SWSA	E59	Bus/Limo Pool Lot	4	4
SW		E60	Rental Car Center (Customer Service Center)	4	4
SW		E72	Taxi Pool Lot	8	8
South	South Service Area	E84	Bird Island Flats / Logan Office Center (LOC) Garage	416	416
South		E63	South Cargo Building 63	16	16
South		E62	South Cargo Building 62	43	43
South		E58	South Cargo Building 58	23	23
South		E57	South Cargo Building 57	44	44
South		E56	South Cargo Building 56	39	39
South		E78	Fire-Rescue HQ & Amelia Earhart Terminal/Hangar	84	84
airside		*N/A*	*ARFF Satellite Station* [1]	0	0

[1] This facility is located on the airfield and is not shown in the map. No employee parking spaces are provided.

	Jan-16	Aug-15
Total In-Service Employee Parking Spaces	**2,422**	**2,422**
Total Designated Employee Parking Spaces	**26** *	**251**
Total Employee Parking Spaces	**2,448**	**2,673**
Total Commercial Parking Spaces *(see table on previous page)*	**18,640**	**18,415**
TOTAL PARKING SPACES	**21,088**	**21,088**
TOTAL PARKING FREEZE SPACES	[redacted]	[redacted]

SUMMARY

TOTAL COMMERCIAL PARKING SPACES	**18,415**
TOTAL EMPLOYEE PARKING SPACES	**2,673**
TOTAL PARKING FREEZE SPACES	**21,088**

* Total Designated Employee Parking Space Calculation	Total Parking Freeze Spaces - Total Commercial	
Total Designated Employee Parking Space	26	251

Commercial Parking Space Inventory
Logan International Airport
April 15, 2016 Submission

Commercial Parking Spaces

Old Map ID#	Map ID#	Location of Commercial Parking Areas	Jan-16 Number of Spaces	Difference	Aug-15 Number of Spaces
	Terminal Area and Economy Spaces				
C1a	C1	Central Garage	7179	(34)	7,213
C1b	C2	West Garage	3076	(51)	3,127
		West Garage Expansion	1699	1,699	
C2	C3	Terminal B Garage	2212	11	2,201
C8a	C5	Terminal E Lot 1	237	0	237
C8b	C6	Terminal E Lot 2	249	0	249
C9	C7	Terminal E Lot 3 (fka "Gulf Station" Lot)	217	0	217
		Blue Lot	367	367	
C6	C8	Economy Garage	2864	0	2,864
		subtotal	18100	1,992	*16,108*
	Overflow Commercial Spaces				
	C11	Red Lot (Tomahawk Dr.)		(282)	282
	C12	Blue Lot (Harborside Dr.)		(339)	339
	C13	Green Lot (Wood Island)		(242)	242
		subtotal	0	(863)	*863*
	Hotel Spaces				
C4	C4a & ~~C4b~~	Logan Airport Hilton Hotel (one lot)	235	200	35
C7a	C10	Harborside Hyatt Conference Center	270	0	270
		subtotal	505	200	*305*
	General Aviation Spaces				
C5	C9	Signature (General Aviation Terminal)	35		35
		subtotal	35		*35*
	Total In-Service Commercial Parking Spaces		**18,640**	**1,329**	**17,311**
	Total Designated Commercial Parking Spaces		**0**	**(1,104)**	**1,104**
	Total Commercial Parking Spaces		**18,640**	**225**	**18,415**
	Total Employee Parking Spaces *(see table on next page)*		**2,448**	**(225)**	**2,673**
	TOTAL PARKING FREEZE SPACES		**21,088**	**-**	**21,088**
			18,100		*18,075*

For Information Only:
Rental Car Spaces Inventory
Logan International Airport
April 15, 2016 Submission

Rental Car Company Parking Spaces

Map ID#		Number of Spaces
R1	Rental Car Center (RCC)	5,020
Total Rental Car Spaces		**5,020**

Massachusetts Port Authority
One Harborside Drive, Suite 200-S
East Boston, MA 02128-2909
Telephone: 617-568-5000
www.massport.com

September 29, 2016

Christine Kirby, Director, Air & Climate Division
Massachusetts Department of Environmental Protection
Bureau of Air & Waste
One Winter Street
Boston, MA 02108

Re: Logan Airport Parking Space Inventory

Dear Ms. Kirby:

In compliance with the reporting requirements of 310 CMR 7.30 (3)(d), enclosed are the following Massachusetts Port Authority (Massport) submissions for Logan Airport:

- Commercial Parking Space Inventory
- Employee Parking Space Inventory
- Location Map

The attachments provide the quantity, physical distribution, and allocation of commercial and employee parking spaces on the airport, as defined by 310 CMR 7.30, as amended. These inventory tables represent information provided by the Aviation Department and are supported by comprehensive field checks and counts conducted in late September 2016.

The Commercial Parking Space Inventory totals 18,640 spaces; the Employee Parking Space Inventory totals 2,448 parking spaces; the total inventory of spaces at Logan Airport is 21,088. For your information, we continue to provide information on rental car spaces.

The attached Logan Airport Parking Space Inventory reflects Massport's successful management of its parking program, within the requirements of 310 CMR 7.30, as amended. If you have any questions, please call me at 617-568-3689.

Sincerely,

Hayes Morrison
Deputy Director - Maritime, Land Use, and
Transportation Planning
Strategic & Business Planning Department

cc:

D. Conroy, EPA
L.O'Connor, MPA
S. Dalzell, MPA
B. Desrosiers, MPA
M. Kalowski, MPA

Commercial Parking Spaces

Old Map ID#	Map ID#	Location of Commercial Parking Areas	Number of Spaces Sep-16
	Terminal Area and Economy Spaces		
C1a	C1	Central Garage	7179
C1b	C2	West Garage	3076
		West Garage Expansion	1699
C2	C3	Terminal B Garage	2212
C8a	C5	Terminal E Lot 1	237
C8b	C6	Terminal E Lot 2	249
C9	C7	Terminal E Lot 3 (fka "Gulf Station" Lot)	217
		Blue Lot	367
C6	C8	Economy Garage	2864
		subtotal	18100
	Overflow Commercial Spaces		
	C11	Red Lot (Tomahawk Dr.)	
	C12	Blue Lot (Harborside Dr.)	
	C13	Green Lot (Wood Island)	
		subtotal	0
	Hotel Spaces		
C4	C4a ~~& C4b~~	Logan Airport Hilton Hotel (one lot)	235
C7a	C10	Harborside Hyatt Conference Center	270
		subtotal	505
	General Aviation Spaces		
C5	C9	Signature (General Aviation Terminal)	35
		subtotal	35

Total In-Service Commercial Parking Spaces	**18,640**
Total Designated Commercial Parking Spaces	**0**
Total Commercial Parking Spaces	**18,640**
Total Employee Parking Spaces *(see table on next page)*	**2,448**
TOTAL PARKING FREEZE SPACES	**21,088**

As of 2014: space count excludes

Employee Parking Spaces

Area		Map ID#	Location of Employee Parking Areas	Number of Spaces Sep-16
Terminal	Terminal Area	E81	West Garage	98
Terminal	Terminal Area	E26	Airport Tower/Administration (parking in Central Garage)	521
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Terminal	Terminal Area	E18	Massport Facilities 1 (Heating Plant)	92
Terminal	Terminal Area	E34	Hilton Hotel employee lot	28
Terminal	Terminal Area	E86	Gulf Gas Station	4
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North	North Service Area	E8	North Cargo Building 8	114
North	North Service Area	E5	US Airways Administration/Hangar (Bldg. 5)	75
airside	North Service Area	*N/A*	Massport Facilities 2 (airside, Bldg. 3)	0
North	North Service Area	E4	Massport Facilities 3 (landside, Bldg. 4)	69
North	North Service Area	E13	UPS (Cargo Building 13)	44
North	North Service Area	E94	United Aircraft Maintenance (Buildings 93 & 94)	56
SW	SWSA	E59	Bus/Limo Pool Lot	4
SW	SWSA	E60	Rental Car Center (Customer Service Center)	4
SW	SWSA	E72	Taxi Pool Lot	8
South	South Service Area	E84	Bird Island Flats / Logan Office Center (LOC) Garage	416
South	South Service Area	E63	South Cargo Building 63	16
South	South Service Area	E62	South Cargo Building 62	43
South	South Service Area	E58	South Cargo Building 58	23
South	South Service Area	E57	South Cargo Building 57	44
South	South Service Area	E56	South Cargo Building 56	39
South	South Service Area	E78	Fire-Rescue HQ & Amelia Earhart Terminal/Hangar	84
airside		*N/A*	*ARFF Satellite Station* [1]	0

[1] This facility is located on the airfield and is not shown in the map. No employee parking spaces are provided

Total In-Service Employee Parking Spaces	**2,422**
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TOTAL PARKING SPACES	**21,088**
TOTAL PARKING FREEZE SPACES	21,088

SUMMARY

TOTAL COMMERCIAL PARKING SPACES	***18,640***
TOTAL EMPLOYEE PARKING SPACES	***2,448***
TOTAL PARKING FREEZE SPACES	***21,088***

Rental Car Company Parking Spaces

Map ID#		Number of Spaces
R1	Rental Car Center (RCC)	5,020
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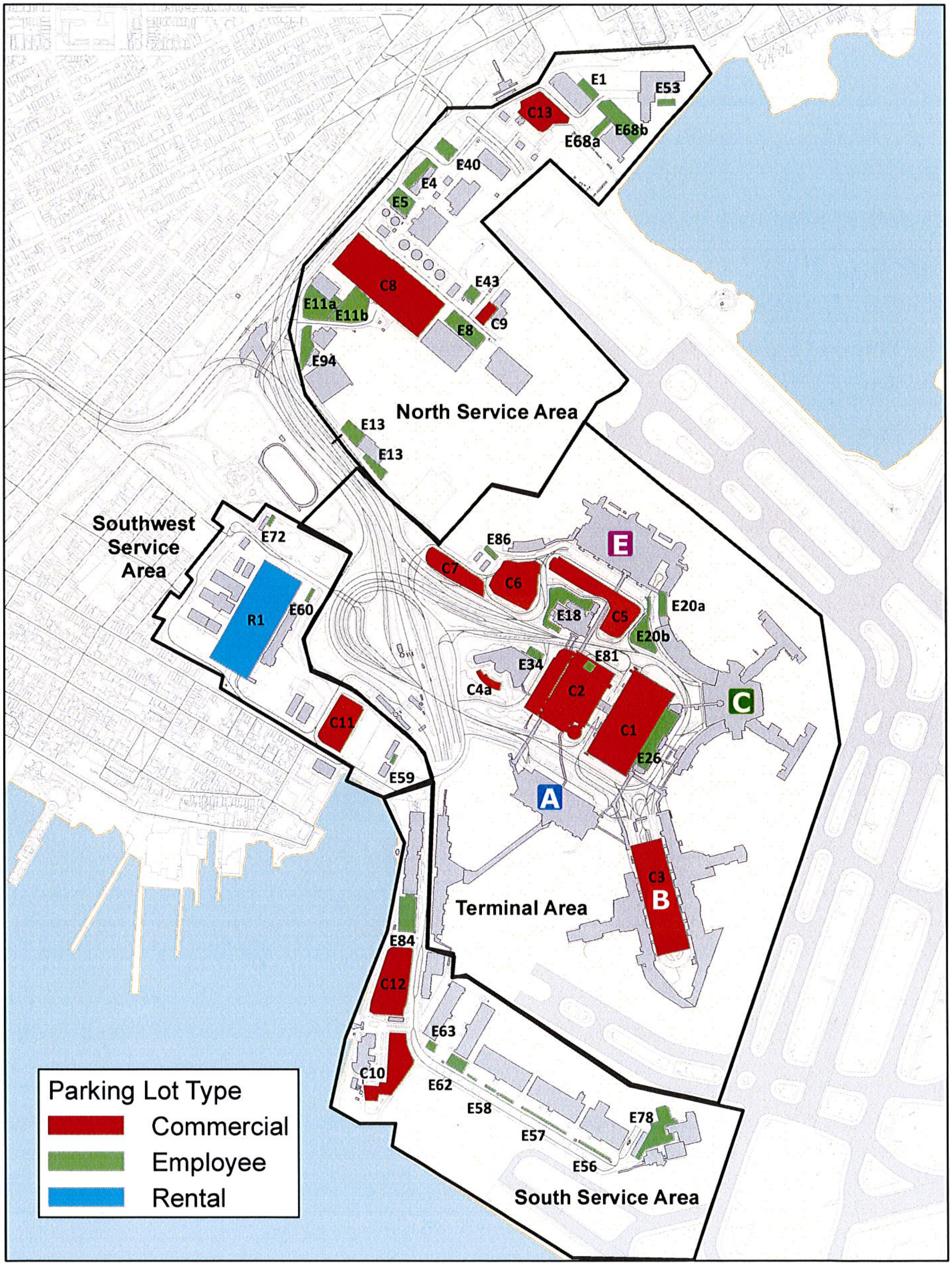
Logan Airport Parking Space Inventory



Date: September 27, 2016
Projection: Lambert Conformal Conic
Coordinate System: NAD 1983 State Plane Massachusetts Mainland FIPS 2001 (Meter)

H

Noise Abatement

This appendix provides detailed information, tables, and figures in support of Chapter 6, *Noise Abatement*. The contents of this appendix are summarized below.

- Massport and FAA correspondence letters regarding AEDT modeling adjustments
  - Massport AEDT Non-Standard Modeling Request dated July 12, 2017
  - FAA Response to AEDT Non-Standard Modeling Request dated August 18, 2017
  - Massport Letter and memorandum to FAA Regarding AEDT Model Results dated November 16, 2016
  - FAA Response Letter Responding dated November 28, 2016
- Massport and FAA correspondence letter regarding RNAV Pilot Test: Request that FAA adopt the JetBlue Airways RNAV Visual Approach Procedure to Runway 33L
- Massport and FAA correspondence letter regarding Massport recommended procedural changes to RNAV
- Fundamentals of Acoustics and Environmental Noise

- Regulatory Framework
- Logan Airport RealContours™ and RC for AEDT™ Data Inputs

- Table H-22b Runways 22R and 22L Shoreline Crossings Above 6,000 Feet for 2016
- Table H-23a Runway 27 Corridor Percent of Tracks Through Each Gate for 2015
- Table H-23b Runway 27 Corridor Percent of Tracks Through Each Gate for 2016
- Table H-24a Runway 33L Gates – Passages Below 3,000 Feet for 2015
- Table H-24b Runway 33L Gates – Passages Below 3,000 Feet for 2016
- Table H-25 Runway Usage by Runway End

- Logan Airport Census Block Group Noise Levels
  - Table H-26 Logan Census Block Group Noise Levels
- Dourado, E. and Russell, R. October 2016. "Airport Noise NIMBYism: An Empirical Investigation." *Mercatus on Policy: Mercatus Center at George Mason University*.

Massport AEDT Non-Standard Modeling Request dated July 12, 2017

HMMH
77 South Bedford Street
Burlington, Massachusetts 01803
781.229.0707
www.hmmh.com

TECHNICAL MEMORANDUM

To:	Flavio Leo Massport One Harborside Drive, Suite 2005 East Boston, MA 02128
From:	Robert Mentzer Jr., HMMH
Date:	July 12, 2017
Subject:	BOS AEDT Non-Standard Modeling Request
Reference:	HMMH Project Number 307500.003.004

1. INTRODUCTION

HMMH and Massport met with the Federal Aviation Administration (FAA) New England region on October 17, 2016 to review the Aviation Environmental Design Tool (AEDT) and Integrated Noise Model (INM) results for Logan Airport. Massport had received approval from FAA for adjustments to the INM model for the Logan Airside EIS and has included those adjustments each year in their annual DNL contour submittal to the Massachusetts Environmental Policy Act (MEPA). It was decided at that meeting for Massport to submit a list of adjustments/modifications for the new AEDT model to the FAA Office of Environment & Energy (AEE) so that a discussion between the groups could begin.

HMMH and Massport submitted a request for non-standard modeling for AEDT to the FAA on November 17, 2016. The intent of this letter was to start the dialog with AEE on how to best use AEDT at Logan Airport with modifications that Massport has used in the past.

FAA AEE responded on 11/28/2016. AEE responded that they would need additional information including specific details on the proposed methodologies before any determination can be made. AEE suggests that a dialog between AEE, Massport and Massport consultants may be the most efficient way to address what if any of the methods will be appropriate for AEDT.

Massport and HMMH met with FAA NE and AEE on January 31, 2017 to review the non-standard request for AEDT and to discuss options for each proposal. AEE suggested Massport provide an outline of their revised approach to each proposal for AEE to review. This way AEE can assist Massport with developing non-standard proposals for AEDT that they can approve.

AEDT 2C Service Pack 2 (SP2) was released on March 13, 2017 and is the version expected to be used for the upcoming DNL contour development. HMMH completed a review of AEDT 2C SP2 and then provided the non-standard outline for AEE on April 5, 2017. Massport and HMMH met with FAA NE and AEE on May 5, 2017 to review and discuss the revised non-standard outline.

The following is the non-standard modeling request memorandum for AEE seeking formal concurrence for modifications to AEDT data to develop DNL contours to support the Residential Sound Insulation Program (RSIP). The current year that Massport has data for is 2015. This data was published as part of the 2015 Environmental Data Report (2015 EDR). Massport understands if it decides to use this modeling for a different project, it will have to resubmit the letter for individual project approval.

2. MASSPORT REQUESTED ADJUSTMENTS

2.1 Overwater Adjustment

Like INM, AEDT currently includes a lateral attenuation adjustment to account for the effects of lateral aircraft directivity and for acoustic propagation over soft ground. Both models do not account for mixed surfaces or hard surfaces such as water. This issue was identified at Logan Airport in the 1990's and to

Flavio Leo
July 11, 2017
Page 2

address it Massport conducted a noise measurement program and developed an adjustment for the INM model to account for the hard surface. At that time, the measurements indicated as much as a 6 dB difference between measured and modeled data. The adjustment was approved by FAA for use during the Logan Airside Improvements Project[1]. It has been in use for more than a decade with INM at Logan Airport and is designed to account for the water surface surrounding Logan Airport. The INM process involves adjusting the Start of Takeoff roll thrust values for all jet aircraft to achieve a 6 dB increase along the takeoff roll. This adjustment is ended when the aircraft reaches 100' and returns to standard INM profile data.

As part of this process, Massport evaluated other possible methods including other noise models. Other aircraft noise models such as the Department of Defense Noisemap model have the ability to incorporate a hard surface (such as water) but Noisemap lacks a current civil aircraft database and would not provide a suitable adjustment grid for the current fleet mix at Logan Airport.

The Airport Cooperative Research Project ACRP 02-52, *Improving AEDT Noise Modeling of Ground Surfaces* has been evaluating this issue and just released its final report. The study evaluated data for several airports including Logan Airport and methods employed in other noise models. The ACRP report proposes a method for FAA to incorporate into AEDT; however it is unknown when that will occur. Until such time that this option is available in AEDT, we request to use a method similar to the one previously developed for INM.

Requested Approach

Massport proposes to modify the Initial takeoff roll noise level to increase the noise level along the runways. Increasing the noise level while the aircraft is on the runway was the method approved previously by FAA for the INM model.

To accomplish this Massport proposes the following:

- For each INM type, the takeoff roll thrust will be determined.
- If the takeoff roll thrust is greater than the highest thrust available then add a new higher thrust departure Noise-Power-Distance (NPD) curve (10% higher) which will be 6 dB higher than the highest AEDT standard NPD curve for each aircraft. A new curve is necessary to allow for the NPD extrapolation limit to be increased at Start-of-Takeoff Roll (STR).
- If the takeoff roll thrust is less than the highest thrust available then adjust the highest thrust departure Noise-Power-Distance (NPD) curve by adding 6 dB to each distance provided in that curve. A new curve will be added with a thrust value 10% below the STR thrust and each noise value will be the interpolated value for that thrust level from the original NPD curves.
- In most cases, this upper NPD curve is only used by aircraft employing "Maxtakeoff" thrust on departure and would not be used in other phases of flight.

The following graphics display how the SEL contours are modified by this process. Figure 1 displays the Embraer 195 (EMB195) aircraft departing on Runway 4R. The increase due to the proposed adjustments is shown in the red SEL contour along Start-of-Takeoff roll. The black SEL contour line is the standard AEDT departure SEL. Figure 2 displays the Boeing 737-800 (737800) aircraft departing on Runway 4R. The increase due to the proposed adjustments is shown in the red SEL contour along Start-of-Takeoff roll. The black SEL contour line is the standard AEDT departure SEL.

[1] The approval was for the Logan Airport Improvement Program EIS, Massport has included the adjustment in annual contours submitted to the State of Massachusetts since then.

Flavio Leo
July 11, 2017
Page 3

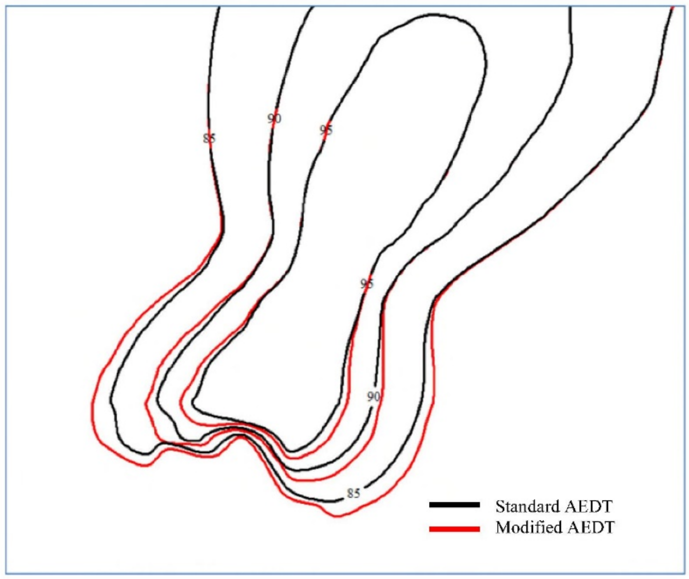


Figure 1 – Embraer 195 Departure SEL

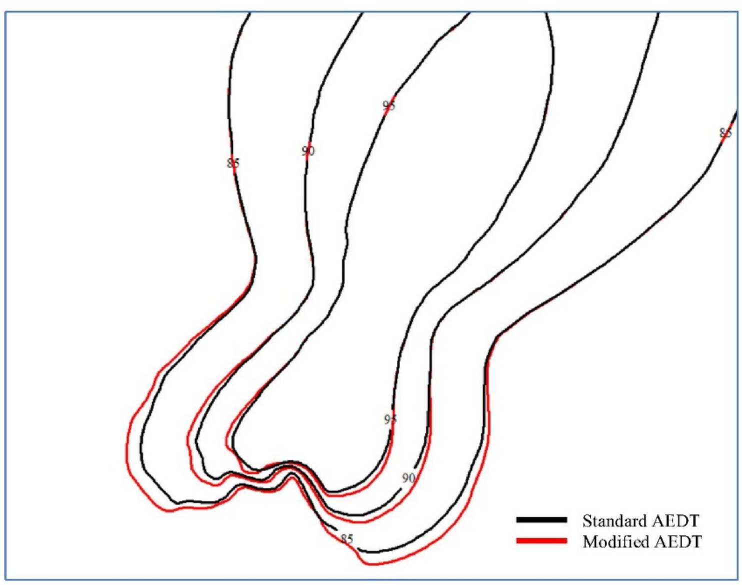


Figure 2 Boeing 737-800 Departure SEL

2.2 Hill Effects Adjustment

In response to community concerns regarding the possible influence of terrain elevation on Logan Airport's annual noise contours, Massport undertook a study of hill effects in the vicinity of the airport. In December of 1999, Massport requested approval for a Hill Effects Adjustment for Logan Airport. After completion of a measurement program, review by both FAA AEE and the Department of Transportation's Volpe Center, FAA approved the use of this adjustment for INM in June 2000[2].

Since then the INM model was updated to include refined terrain data and modifications were made to the terrain algorithms. However, the updates to INM and AEDT have not included adjustments to the ground-to-ground propagation algorithms for situations in which the terrain causes a direct line of sight between aircraft on runway and the noise-sensitive receiver located on a hill at higher elevation relative to the aircraft. Therefore, versions of the current models (both INM and AEDT) do not offer the capability that is addressed by the Hill Effects Adjustment. .

ACRP 02-79, *AEDT Noise Model Improvements to Account for Terrain and Man-made Structures* is anticipated to begin in 2017. It is expected that this project will evaluate this issue and Massport plans to cooperate with the study if possible. Until such time that this study is completed and an option is added to the AEDT to account for this condition, we request to use the existing Hill Effects adjustment grid.

Requested Approach

We propose to use the new grid combine tool in the AEDT model to incorporate the existing Hill Effects adjustment grid.

To include this in the modeling:

- The AEDT modeling grid will be exported to a grid file
- Using the data from the prior approved adjustment grid we will increase the DNL value at each location over Orient Heights
- Where there is no increase, the DNL at that point will be reduced by 30 dB (this is done to ensure that when the grid is combined with the original grid the AEDT value is not changed)
- Where there is an increase the DNL will be raised to result in the proper increase using decibel addition. For example: we want to add 4dB to a grid point that is at 60 dB, we would set the point in the grid to 61.79518 dB to get to 64 dB when they are combined.
- The modified grid will be imported into AEDT and combined using the AEDT grid combine tool

2.3 Stage length Selection

The city-pair method for stage length selection is standard industry practice and is the method required to use for AEDT. Members of the community have raised questions as to whether the city-pair selection is correct for the fleet operating at Logan Airport due to high load factors and lower flight profiles[3]. Massport undertook an evaluation of departure takeoff weights to determine if any of the city-pair stage lengths should be modified. Massport utilized U.S. Department of Transportation (US DOT) T100 Data to compare to the Aviation Environmental Design Tool (AEDT) data.

The purpose of this comparison is to advise if there was evidence to adjust the weights compared to the default profiles available in AEDT. In recent years, passenger load factors at BOS have been over 80%.[4]

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[2] The Hill Effects approval was for the development of DNL contours using INM for Logan Airport.
[3] The majority of the radar profile is lower than the AEDT standard profile
[4] US DOT Bureau of Transportation Statistics http://www.transtats.bts.gov/Data_Elements.aspx?Data=1

However, the AEDT weight assumptions, documented in the AEDT Technical Manual Version 2c Service Pack 1 states "Load Factor - 65% Total Payload", though a prior document, the Integrated Noise Model (INM) 6.2 release notes, were more specific and said based on "65% Total Payload of the Maximum Certificated weight sold to airlines".[5] The term "load factor" is based on the number of seats (passengers) whereas payload is based on weight. Specifically, the US DOT defines these terms as follows.

- Load Factor = "passenger-miles as a proportion of available seat-miles in percent (%)"[6]
- Payload = "Equal to the certificated takeoff weight of an aircraft, less the empty weight, less all justifiable aircraft equipment, and less the operating load (consisting of minimum fuel load, oil, flight crew, steward's supplies, etc)."[7]

Therefore average weight calculation *includes more than passenger load factor*. AEDT has a payload factors built into the model. It also includes passenger load and the weight of the aircraft, cargo, and fuel.

The analysis reviewed all of the available 2015 data and concluded that in general the AEDT standard weights are representative of the departures from BOS for 2015. However, the analysis has indicated about six percent of operations could be represented by profiles at higher weights within AEDT and that about four percent could be represented by profiles at lower weights within AEDT.

Even though an aircraft may have be carrying an operating revenue weight greater than the "65% of total payload" mentioned in AEDT, that incremental increase in weight needs to be sufficient to justify using the next available weight available in the included AEDT database. An analysis of the differences between the operating revenue weight, the 65% Total Payload, and the available profiles weights found in AEDT, yielded 31 airline/aircraft/stage length combination that could be represented by a higher weight profile in AEDT.

Combined, these 31 combinations represent 9,651 departures out of the total 171,660 departures reported in the US DOT data, or six percent. These operations also represent seven percent of the revenue operating weight for the year. Of these combinations, 29 would increment to the next highest available weight. Eight of these 29 are already at the maximum available profile weight. The remaining two combinations, both wide-body aircraft on relatively short trips, display differences in weight made up by freight and mail rather than passengers and would both increment two available profile weights.

The same analysis of the differences between the operating revenue weight, the 65% Total Payload, and the available profiles weights found in AEDT, yielded 21 airline/aircraft/stage length combination that could be potentially represented by a lower weight profile in AEDT. Combined, these 21 combinations represent 6,412 departures or about four percent of operations.

Of these combinations, 12 would increment to the next lowest available weight, four would increment two profiles down. The remaining five initially indicated that the aircraft could go down three more profiles. All five of these combinations were compared to manufactures data. In each of the five cases, the DOT T100 over reported the available payload by a significant margin compared to the variant in INM. In three cases, the recommendation is to leave the aircraft at its recommended stage length profile. In two cases, the recommendation is to decrease the weight, but not as much as suggested by the DOT T100 data.

Attachment A to this memorandum details the process to determine the airline, aircraft, stage-length combinations to be modified. Table 1 summarizes the operations to be increased.

[5] The Aviation Environmental Design Tool (AEDT), Technical Manual Version 2c Service Pack 1 December 2016 11.2.3.2.3 Guidance for Default Weights and Procedures" pp 318-321 is less specific and says "65% of payload". INM Version 6.2 Software Update, 05/19/2006, Appendix A. INM Version 6.2 also mentions an assumption of 200 lb per passenger.

[6] See footnote 4.

[7] http://www.transtats.bts.gov/databaseinfo.asp?DB_ID=111

Flavio Leo
July 11, 2017
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Table 1 – Airline, Aircraft Stage-length combinations to be modified

UNIQUE_CARRIER_NAME	Description	Stage Length	CY 2015 Departures	Proposed Stage Length	Note
a	b	c	d		
American Airlines Inc.	McDonnell Douglas DC9 Super 80/MI	4	3	4	MAX
American Airlines Inc.	Airbus Industrie A330-300	2	1	3	+1
Alaska Airlines Inc.	Boeing 737-800	5	563	5	MAX
Alaska Airlines Inc.	Boeing 737-900	5	60	5	MAX
Alaska Airlines Inc.	Boeing 737-900ER	5	74	5	MAX
British Airways Plc	Boeing 777-200ER/200LR/233LR	1	1	2	+1
British Airways Plc	Boeing 777-300/300ER/333ER	1	1	2	+1
Delta Air Lines Inc.	McDonnell Douglas MD-90	2	1,557	3	+1
Delta Air Lines Inc.	McDonnell Douglas MD-90	3	283	4	+1
ExpressJet Airlines Inc.	Embraer-145	1	165	2	+1
ExpressJet Airlines Inc.	Embraer-145	2	1,337	3	+1
Lan-Chile Airlines	B787-900 Dreamliner	1	1	**3**	+2
Lufthansa German Airlines	Boeing 777-200ER/200LR/233LR	2	1	**4**	+2
Lufthansa German Airlines	McDonnell Douglas MD-11	2	1	3	+1
Spirit Air Lines	Airbus Industrie A320-100/200	2	386	3	+1
Spirit Air Lines	Airbus Industrie A320-100/200	3	511	4	+1
Spirit Air Lines	Airbus Industrie A319	1	147	2	+1
SkyWest Airlines Inc.	Canadair CRJ 900	2	146	3	+1
SkyWest Airlines Inc.	Embraer ERJ-175	2	106	2	MAX
United Air Lines Inc.	Boeing 737-700/700LR/Max 7	3	1	4	+1
United Air Lines Inc.	Boeing 737-800	2	273	3	+1
United Air Lines Inc.	Boeing 737-800	3	5	4	+1
United Air Lines Inc.	Boeing 737-800	5	803	5	MAX
United Air Lines Inc.	Boeing 757-300	2	6	3	+1
United Air Lines Inc.	Boeing 757-300	5	807	5	MAX
United Air Lines Inc.	Boeing 767-400/ER	5	1	6	+1
United Air Lines Inc.	Boeing 737-900	5	679	5	MAX
United Air Lines Inc.	Airbus Industrie A320-100/200	2	490	3	+1
United Air Lines Inc.	Airbus Industrie A319	3	1	4	+1
Southwest Airlines Co.	Boeing 737-800	4	325	5	+1
Southwest Airlines Co.	Boeing 737-300	1	916	2	+1

Note: MAX – means that the Proposed stage-length profile is equivalent to the maximum weight profile available for that type

2.4 Non-standard weather data

The AEDT model contains historical average data for each airport and the data within the model is required for use unless approved by FAA AEE. Massport is requesting to use the weather data representing the actual year, in this case 2015.

The data was obtained from the National Climatic Data Center (NCDC). Integrated Surface data (TD 3505) was downloaded for Weather Bureau Army Navy (WBAN) location 14739, Logan Airport for 2015.

Annual Average Data was computed from the hourly data resulting in the following averages:

Temperature	51.5 degrees (F)
Pressure	30.04 inHG
Relative Humidity	65.7%

hmmh

FAA Response to AEDT Non-Standard Modeling Request dated August 18, 2017

U.S. Department of Transportation
Federal Aviation Administration

Office of Environment and Energy

800 Independence Ave., S.W.
Washington, D.C. 20591

8/18/2017

Richard Doucette
Airports Division
Federal Aviation Administration, New England Region
1200 District Avenue
Burlington, MA 01803

Dear Richard,

The Office of Environment and Energy (AEE) has received the memo dated July 12th 2017, requesting FAA-AEE concurrence on non-standard AEDT modeling adjustments and inputs for noise modeling at Boston Logan International Airport as submitted by HMMH on behalf of Massachusetts Port Authority (HMMH Project Number 307500.003.004).

As highlighted in the request and understood by FAA-AEE, this memo requests concurrence and not approval for the non-standard modeling elements presented. A specific project requiring FAA review and use of the proposed non-standard elements has not been identified; therefore any findings of concurrence detailed in this response are for reference only as they relate to a level of understanding and capability with AEDT 2c SP2 and at the time of this response.

Any findings of concurrence detailed here are therefore subject to change under future updates to AEDT or any relevant technical or policy updates. Formal approval of any proposed non-standard elements will require additional project specific approval by FAA-AEE.

Section 2.1 Overwater Adjustment: Adjustments to departure Noise-Power-Distance curves for Start-of-Takeoff Roll (STR) noise to emulate acoustic overwater propagation.

AEE **DOES NOT CONCUR** with the proposed process as it is not adequately supported through the presentation of a defensible technical analysis or current research findings and is therefore not suitable for use with AEDT.

Section 2.2 Hill Effects Adjustment: Contour grid adjustments to emulate ground propagation effects in the presence of terrain.

AEE **DOES NOT CONCUR** with the proposed process as it is not adequately supported through the presentation of a defensible technical analysis or current research findings and is therefore not suitable for use with AEDT.

Section 2.3 Stage Length Selection: Modified Stage Lengths Selection Based on US DOT BTS T100 Data

AEE **CONCURS IN PRINCIPAL** with the use of US DOT BTS T100 data as a method to evaluate stage length selections. However, due to the specific nature of matching annual flight operations to T100 data, any approval would still require evaluation on a case by cases basis. AEE agrees that the T100 data is a reasonable reference to complete this review, but cautions that since the data may only provide supporting information for existing conditions that there could be concerns when applying any proposed stage length modification assumptions to future year modeling cases. Further supporting information may therefore be required for proposed use with future case modeling conditions. In order to ensure consistent stage length considerations for all modeling cases, it remains AEEs recommendation to continue use of the industry standard city-pair method.

Section 2.4 Non-standard Weather Data: Average Calendar Year 2015 Weather Data Parameters for Temperature, Pressure and Relative Humidity from the National Climatic Data Center (NCDC) are requested for use with Calendar Year 2015 modeling inputs.

AEE **CONCURS IN PRINCIPAL** with the use of the NCDC data to determine appropriate annual average weather data parameters. Please note however that the format of weather parameter inputs for AEDT has been updated compared with INM. Each of the following parameters, in the units specified, must be provided when a formal review for approval is requested:

Temperature (°F)
Pressure (millibars)
Sea Level Pressure (millibars)
Relative humidity (%)
Dew Point (°F)
[Average] Wind Speed (knots)

As described above please understand that this memo provides a record of concurrence and not approval for the non-standard modeling elements presented; and that a specific project, AEDT model version and timeframe would need to be identified before formal approval could be granted. Findings of concurrence are therefore for reference only as they relate to a level of understanding and capability with AEDT 2c SP2 and at the time of this response.

Sincerely,

Rebecca S Cointin

Rebecca Cointin
Manager
AEE/Noise Division

cc: Jim Byers, Jean Wolfers-Lawrence (APP)

Massport Letter and Memorandum to FAA Regarding AEDT Model Results dated November 16, 2016

massport

Massachusetts Port Authority
One Harborside Drive, Suite 200S
East Boston, MA 02128-2090
Telephone (617) 568-1003
www.massport.com

November 16, 2016

Richard Doucette
Airports Division
Federal Aviation Administration, New England Region
1200 District Avenue
Burlington, MA 01803

Dear Mr. Doucette:

Following up to our October 17th meeting where we discussed the FAA's new AEDT model for noise and air emissions, I am writing to you to request that FAA review the AEDT model results as applied to Boston Logan International Airport (Boston Logan) both related to noise and air quality. We also request that the FAA work with Massport and our consultants to develop Logan specific modification to the AEDT so that the model more accurately reflects the local noise and air quality environment.

As you are aware, Massport produces and circulates an annual environmental and planning report for Boston Logan to state officials and the interested public. FAA noise and air quality models form the basis of much of these reports. Massport also seeks to maintain with the FAA an updated Noise Exposure Map that supports our soundproofing efforts of eligible homes. As a result, Massport publishes annually Boston Logan specific noise and air quality data based on the latest FAA approved models (previously the INM and EDMS models). Overtime, Massport has worked closely with the FAA, and USDOT Volpe Center, to enhance the INM including, for example, Logan-specific modifications for "hill effects" and "over water propagation".

For the 2015 calendar year EDR, Massport's noise and air quality consultants utilized the FAA's new AEDT model (Version 2B Service Pack 2). Based on preliminary results, we have strong concerns on the general applicability of the noise module to accurately reflect Boston Logan's noise environment. To assist with the development of a Boston Logan specific modeling process, we have asked our consultant to put together a request (attached) to be sent to FAA AEE for review and approval of AEDT Non-standard modeling and methods. Finally, we also have a narrower concern on the AEDT's estimate of Particulate Matter (PM) which we would also like to discuss.

We look forward to working with you on reviewing and modifying the AEDT to better reflect Boston Logan's noise and air quality footprint.

Very truly yours,

Flavio Leo
Director, Aviation Planning & Strategy

CC: Mary Walsh (FAA), Gail Latrell (FAA), Stewart Dalzell (Massport)

Operating | Boston Logan International Airport • Port of Boston general cargo and passenger terminals • Hanscom Field • Boston Fish Pier • Commonwealth Pier (site of World Trade Center Boston) • Worcester Regional Airport

HMMH
77 South Bedford Street
Burlington, Massachusetts 01803
781.229.0707
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TECHNICAL MEMORANDUM

To:	Flavio Leo Massport One Harborside Drive, Suite 2005 East Boston, MA 02128
From:	Robert Mentzer Jr., HMMH Bradley Dunkin, HMMH
Date:	November 16, 2016
Subject:	Logan International Airport Annual DNL Noise Contours - Requested Review and Approval of Aviation Environmental Design Tool Non-Standard Modeling
Reference:	HMMH Project Number 307260.002

hmmh

1. INTRODUCTION

Harris Miller Miller & Hanson Inc. (HMMH) is assisting the Massachusetts Port Authority (Massport) in the preparation of their annual DNL noise contours for the Massachusetts Environmental Policy Act (MEPA) review. Massport will also potentially use the updated DNL contour to submit to FAA for additional sound insulation funding. We plan to use the Aviation Environmental Design Tool (AEDT) Version 2c (released September 2016) for all future aircraft noise modeling. Consistent with Federal Aviation Administration (FAA) policies and procedures, any changes to the standard AEDT modeling procedures require prior written approval from the FAA Office of Environment and Energy Noise Division (AEE-100). This requirement applies to the use of custom adjustments to the model and use of non-standard data.

As part of the preparation of Massport's annual Environmental Data Review (EDR) for 2015, an AEDT study using the latest version available at the time (Version 2b, Service Pack 2) was conducted in order to assess consistency with an INM study of the same data, as well as INM results for previous years. The judgment was made that the results were not consistent, and that this was largely due to unique conditions at Logan Airport that have, in the past, been addressed by specific FAA-approved adjustments to the INM process. Massport seeks to work with the FAA to develop and implement approved methods to address these conditions in future AEDT studies.

Massport has historically strived to provide an accurate DNL contour to the public. This has resulted in several model methods and adjustments that are Logan-specific:

- 1996 – Overwater adjustment approved for INM model
- 1999 – Hill Effects adjustment approved for the INM model
- 2004 – All radar tracks used for modeling - RealContours & RealProfiles
    - o Stagelength selected by Profile match
    - o Custom Profile developed for each flight
- 2007 Incorporation of daily weather averages for modeling

Massport has consistently used the updated INM version in the year of or the year after its release. The Overwater and Hill Effects adjustments were also approved for use in the Logan Airside EIS (LAIP) completed in 2001.

On behalf of Massport, HMMH is evaluating the options and data available in AEDT and is in the process of developing recommended adjustments and non-standard data for AEDT. Massport is requesting AEE review and concurrence of this process to develop and implement adjustments and the use of non-standard data for AEDT for Logan International Airport.

Flavio Leo
November 16,2016
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2. OVERWATER ADJUSTMENT

2.1 Background

Logan Airport is surrounded on three sides by water. Massport has several permanent noise monitoring sites located near the edge of the Harbor that have consistently measured noise and reported levels higher than modeled with the standard INM. Massport commissioned additional noise measurement data and along with their consultants developed a method to increase the thrust of aircraft in the INM on takeoff roll to more accurately reflect the monitoring results.

2.2 Current Method

The current method involves the development of an adjustment grid to increase the noise levels from aircraft departing on the runways at Logan Airport. The adjustment generally results in a 6 dB increase from departing aircraft up to 100 feet above the runway. A point is inserted in the profile at 100 feet to return the aircraft to its normal model thrust and climb.

All jet departures for each year are run in the model with the adjustment and then without. The grid without the increase is subtracted from the grid with the increased thrust. This results in an adjustment grid which can be applied to the annual INM result. This results in increased noise levels on the west sides of Runway 15R-33L and portions of Runway 4L-22R that are not adjacent to water however most of this area is airport property.

2.3 Proposed Method

We are aware that ACRP 02-52, *Improving AEDT Noise Modeling of Ground Surfaces* is underway and is designed to provide a method for incorporating modeling of mixed surfaces within the AEDT. Until such time that this option is available in AEDT, we propose to use the GIS capabilities of the AEDT and modify noise levels over identified hard water surfaces. This method will also eliminate noise increases over areas of non-water surfaces as was done by the previous method. The existing Department of Defense NOISEMAP model has a method for modeling mixed surfaces once they have been identified using mapping however its civil aircraft database is very limited (Lear35, older 747, DC9 aircraft). The NOISEMAP model also uses the NMPLOT grid format which can easily be applied to the AEDT NMPLOT result grid.

HMMH has been evaluating this method and propose to incorporate a representative current fleet of aircraft into the Noisemap database to develop an adjustment grid for AEDT. Using the representative fleet, we will model a set of prototypical flight tracks for arrivals and departures in the model both with and without the mixed surfaces adjustment turned on. The grid without the adjustment will be subtracted from the grid with the adjustment and the result added to the AEDT NMPLOT result grid.

As this approach incorporates the effects of surface reflections directly rather than using increased thrust as a proxy, the results should have equal or better accuracy than the former method if implemented correctly.

Please let us know if you concur with this approach or suggest an alternate method.

3. HILL EFFECTS ADJUSTMENT

3.1 Background

This adjustment has been used since 1999 and was developed and approved by FAA for use in the INM (was used in LAIP EIS). Orient Heights just to the northwest of Runway 22R has a rapid increase in elevation and residents look down onto the runway and start of takeoffs from Runway 22R.

Massport conducted a measurement program for this area and an adjustment grid was developed. FAA and the Volpe Center reviewed and ultimately approved for INM at Logan Airport. This resulted in a grid adjustment that shifted the DNL contour up the hill and the adjustment area only applies to the area of the hill.

3.2 Current Method

After the annual DNL contour is completed, the Hill Effects grid is applied to the INM results. This grid increases the DNL values on the side of the hill facing the airport.

3.3 Proposed Method

ACRP 02-79, *AEDT Noise Model Improvements to Account for Terrain and Man-made Structures* is anticipated to begin in 2017. Massport plans to cooperate with the study if possible. Until such time that this study is completed and an option is added to the AEDT to account for this condition, we propose to use the existing Hill Effects adjustment grid. It is a NMPLOT adjustment grid and is easily applied to the AEDT NMplot result grid.

Since this adjustment is unchanged from the former approach, the results should be identical.

Please let us know if you concur with this approach or suggest an alternate method.

4. STAGELENGTH SELECTION

4.1 Background

Logan Airport has a diverse set of operations including domestic and international traffic. The INM modeling since 2004 has includes stagelength selection based on radar profile matching instead of city pair assignments.

4.2 Current Method

For INM, each radar ground track is imported into the study for modeling. The flight profile up to 3,000 feet is compared to the set of available standard profiles in the INM for that aircraft type. Using a least squares fit method; the best match stagelength is selected.

4.3 Proposed Method

For AEDT, following FAA guidance, each city pair would be used to select the stagelength. This generally results in a lower stagelength than the method historically used and does not take advantage of the available radar data. Since, for the Logan Airport modeling each radar ground track is imported into the AEDT database, we propose to use the data to select the stagelength. The flight profile up to 3,000 feet will be compared to the set of available standard profiles in the AEDT for that aircraft type. Using a least squares fit method the best match stagelength is selected. This results in a stagelength best match for each ground track.

This approach is a straightforward port of the former method, and thus should yield identical results.

Please let us know if you concur with this approach or suggest an alternate method.

5. CUSTOM PROFILES

5.1 Background

Since 2004, Logan Airport modeling has used a pre-processor to develop custom profiles for each track based on the radar data. This process uses the SAE 1845 equations and procedure step data available in the model. AEDT now provides a method for developing custom profiles without additional FAA approval.

5.2 Current Method

The current INM modeling for Logan Airport processes each radar track through a pre-processor. This pre-processor uses the radar data, procedure step data and the SAE 1845 equations to develop a custom profile to closely match the radar data profile. This allows the mode to account for ATC level segments and low departure climbs where necessary. If a custom profile cannot be constructed, the flight is modeled using the best match INM standard profile that is available.

5.3 Proposed Method

The AEDT model now has the ability to use altitude control codes (ACC) to allow the model to develop custom profiles. However, there is no guidance on how to use these options in the model. Massport would like to use this option to the extent possible especially since the local community is accustomed to this type of modeling and every radar track is being modeled. Does FAA have any guidance on how best to add the codes? Should they be added every x number of miles in distance or every 1000 feet in altitude? The ACC = 2 (Match) frequently results in errors which then discard the operation instead of defaulting to another method to allow the flight to continue. With hundreds or thousands of tracks, this results in an enormous amount of effort by the modeler to correct these errors in order to retain these tracks. Does the FAA have any suggestions to reduce this effort? We did encounter odd results with AEDT 2B Service Pack 2 but understand these have been corrected in AEDT 2C. Are there other known issues with the custom profile construction and use?

As there are currently many unknowns with this approach, the results are uncertain and Massport looks forward to collaboration with the FAA to ensure that a method can be developed that is robust, repeatable, and automated.

We will be using AEDT 2C to evaluate the application of this method to Logan Airport modeling and any assistance you can provide will be helpful.

6. NON-STANDARD WEATHER DATA

6.1 Background

Since 2007, the daily DNL modeling conducted for BOS has used daily weather averages. The current version of AEDT does not appear to have this capability except for when using High Fidelity weather. The FAA guidance also requires the use of the 30-year normal weather data built into the model or the modeler can request use of other data from the FAA.

6.2 Current Method

The prior INM modeling was run for each day and daily weather averages were used in the INM model to adjust aircraft performance and atmospheric absorption. These daily DNL results were then averaged to develop the annual average DNL.

6.3 Proposed Method

The AEDT only allows for one set of average weather data for the study. Even though, the model can be setup to use a detailed flight schedule which includes the date and time, the weather is fixed to this average unless detailed High Fidelity weather data is selected. We expect that the High Fidelity weather data will further reduce processing times and increase database size therefore we would prefer to just use the daily average.

FAA guidance requires the use of the 30 –year normal data built into the model. Since contours for BOS are developed for each specific year at a minimum we request the use of annual average weather data (acquired

Flavio Leo
November 16,2016
Page 5

from the National Climatic Data Center (NCDC)) for the year being modeled. We also would appreciate any suggestions for using daily average values without having to use the High Fidelity weather data.

Approval of the use of annual weather will improve accuracy for an annual study by removing the effects of long-term weather trends. If a method for using daily weather can be developed, this will allow for equal accuracy to the former approach by modeling performance using existing conditions.

hmmh

FAA Response Letter dated November 28, 2016

U.S. Department of Transportation
Federal Aviation Administration

Office of Environment and Energy

800 Independence Ave., S.W.
Washington, D.C. 20591

Date 11/28/2016

Richard Doucette
Airports Division
Federal Aviation Administration, New England Region
1200 District Avenue
Burlington, MA 01803

Dear Richard,

The Office of Environment and Energy (AEE) has received the memo dated November 16, 2016 forwarded from Flavio Leo, Director of Aviation Planning and Strategy, Massachusetts Port Authority requesting consideration of non-standard noise modeling adjustments in AEDT at Boston Logan International Airport.

After review of the methods outlined, AEE will require additional information including specific details on the proposed methodologies before any determinations or recommendations can be made. It should also be considered that due to the significant updates introduced with AEDT, to enhance modeling capability, any prior approvals for these methods under the legacy INM or EDMS tools are no longer valid.

Due to the complexity and history of these methods we recognize however, that a dialog between AEE and MassPort with their consultants may be the most efficient way to start a discussion on addressing what if any of these methods are still appropriate applications within AEDT.

To address each of the proposed methods in brief:

Overwater Adjustment:
AEDT currently only supports "soft" ground surfaces in the calculation of sound propagation, however ongoing development including AEE involvement in **ACRP 02-52: *Improving AEDT Noise Modeling of Hard, Soft, and Mixed Ground Surfaces*** is aimed at including additional functionality for variable surfaces within AEDT.

Hill Effects Adjustment:
Terrain data is supported within AEDT and can be used internally to adjust noise calculations in order to better model local elevation variation. Additionally AEE is supporting involvement in research to enhance modeling while considering terrain through **ACRP 02-79:** ***AEDT Noise Model Improvements to Account for Terrain and Man-made Structures***

Stagelength Selection:
Due to uncertainties in directly matching radar altitude profiles to AEDT flight profiles, only city-pair to stage length mapping is approved for use within AEDT. Variations due to aircraft weight and reduced thrust takeoffs therefore make a direct least squares fit to available profile stagelenghts unappropriated. Ongoing AEE supported research including **ASCENT 035**: ***Airline Flight Data Examination to Improve flight Performance Modeling*** and **ACRP 02-55:** ***Enhanced AEDT Modeling of Aircraft Arrival and Departure Profiles*** are exploring future enhancements to AEDT for custom profile selection.

Custom Profiles:
The use of custom profiles is allowed within AEDT, however only with prior AEE approval. Conversely the use of AEDT altitude control codes does not required AEE approval, however care must be taken by the modeler to ensure that control codes are being assigned appropriately and that any resulting errors generated are understood and addressed. Due to the myriad conditions which may be result it is not possible to create guidance to address the application of altitude control codes in all cases. Any specific concerns on the functionality of altitude control codes may be best addressed first by AEDT support, however we are open to having a larger "best practices" discussion as well.

Non-Standard Weather Data
Within AEDT only one set of weather data parameters, for noise modeling purposes, are currently allowed per airport definition. It may be feasible in the future however, to allow weather data parameters to be defined at the operations group level within AEDT; allowing the option for providing multiple weather data parameters within a single animalization. This concept would first have to be reviewed and considered for feasibility against existing AEDT development priorities.

Non-Volatile Particulate Matter (NVPM) modeling
A note on discussing estimates of Particulate Matter was made in the letter, however specifics were not provided. If you could please provide additional clarification on we can look to provide a better response to the concern.

3

Please let us know how you would like to discuss these options in more detail and where available if you could also please provide additional information supporting any of the proposed methodologies prior to any discussions.

Sincerely,

Rebecca Cointin
Manager
AEE/Noise Division

cc: Jim Byers

Massport and FAA correspondence letter regarding RNAV Pilot Test: Request that FAA adopt the JetBlue Airways RNAV Visual Approach Procedure to Runway 33L

Massachusetts Port Authority
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April 7, 2017

Todd Friedenberg
Deputy Regional Administrator
Federal Aviation Administration
New England Region
1200 District Avenue
Burlington, MA 01803-5299

Re: FAA\MPA RNAV Pilot Test: Request that FAA adopt the jetBlue RNAV Visual Approach Procedure to Boston Logan Runway 33L

Dear Mr. Friedenberg:

As a follow up to our ongoing work on the joint Massport and FAA RNAV Pilot Test, I'm writing to request that the FAA adopt and refine for public use the existing jetBlue Airways (jetBlue) RNAV Visual to Boston Logan's Runway R33L. We believe that by making this procedure more readily available to all national airspace users, there will be an increase in the utilization of the RNAV Visual to R33L during the late night period, providing greater noise abatement benefits to communities near Boston Logan.

Recall that one outcome of the Boston Logan Overflight Noise Study was the design of a noise abatement approach to R33L that avoids the Town of Hull and other South Shore communities by taking advantage of overflying Boston Harbor during the late night time period. Consistent with this goal, in November 2014, jetBlue published a RNAV Visual procedure and agreed to make this "public" and therefore available to the broader Boston Logan air carrier community.

Massport has been working with the FAA's NextGen Eastern Branch to advocate and encourage air carriers to adopt the JetBlue RNAV Visual procedure. However, the most recent data (March 2017) from Massport shows that only about 26% of R33L jet arrivals from midnight to 5AM took advantage of this noise reduction procedure. We believe that if the FAA adopts this procedure the utilization rate of the RNAV Visual to R33L will increased when demand and weather allow.

Please feel free to contact me with any further questions.

Sincerely,

Flavio Leo
Director, Aviation Planning and Strategy
Massachusetts Port Authority

Cc: Amy Corbett (FAA), Ed Freni (Massport)

Massport and FAA correspondence letter regarding Massport recommended procedural changes to RNAV

massport
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December 20, 2017

Ms. Amy Corbett
Regional Administrator
Federal Aviation Administration
New England Region
1200 District Avenue
Burlington, MA 01803-5299

RE: FAA\MPA RNAV MOU Block 1 Ideas: Request for FAA Review and Implementation for Boston Logan International Airport

Dear Ms. Corbett: Amy

I am writing to request that the Federal Aviation Administration (FAA) review and implement the Block 1 procedure recommendations by the Massachusetts Institute of Technology (MIT) study team as a result of the Memorandum of Understanding (MOU) between the FAA and the Massachusetts Port Authority (Massport). The MOU, executed in September 2016, commits the FAA and Massport to undertake a unique, pilot testing of ideas to reduce noise from the FAA's implementation of Precision Based Navigation (PBN) procedures including RNAV at Boston Logan International Airport (Boston Logan).

Consistent with the MOU, the testing of ideas has involved a technical team of FAA and Massport staff, supported by subject matter experts lead by MIT's International Center for Air Transportation. The work included extensive public outreach, feedback through public hearings, and briefings to and feedback from the Massport Community Advisory Committee (MCAC) and local, state and federal elected officials.

After an initial investigation, the MIT team proposed segregating ideas to be evaluated into two blocks. Block 1 ideas would provide noise benefits while not generating major equity issues (moving noise from one community to another) and would have minimal operational/ technical implementation barriers. Block 2 ideas would result in shifting of noise, or would have substantial technical hurdles and, therefore, require further analysis and review.

MIT has completed its work on Block 1 and issued its final report "Block 1 Procedure Recommendations for Logan Airport Community Noise Reduction" to Massport and the FAA. MIT's technical feasibility analysis of Block 1 includes an examination of flight safety, aircraft performance, navigation and flight management systems (FMS) limitations, pilot workload, Air Traffic Control workload, and procedure design criteria. Representatives from MIT, Massport and the FAA have briefed the public and the MCAC throughout the process, and feasible feedback from the public has been included into MIT's recommendations. On December 7, 2017, the MCAC voted to support and recommend implementation of the Block 1 procedures.

The table below from the MIT report summarizes MIT's recommendations and highlights the primary benefits.

Block 1 Procedure Recommendations

Proc. ID D = Dep. A = Arr.	Procedure	Primary Benefits
1-D1	Restrict target climb speed for jet departures from Runways 33L and 27 to 220 knots or minimum safe airspeed in clean configuration, whichever is higher.	Reduced airframe and total noise during climb below 10,000 ft (beyond immediate airport vicinity)
1-D2	Modify RNAV SID from Runway 15R to move tracks further to the north away from populated areas.	Departure flight paths moved north away from Hull
1-D3	Modify RNAV SID from Runway 22L and 22R to initiate turns sooner after takeoff and move tracks further to the north away from populated areas.	Departure flight paths moved north away from Hull and South Boston
1-D3a	*Option A*: Climb to intercept course (VI-CF) procedure	
1-D3b	*Option B*: Climb to altitude, then direct (VA-DF) procedure	
1-D3c	*Option C*: Heading-based procedure	
1-A1	Implement an overwater RNAV approach procedure with RNP overlay to Runway 33L that follows the ground track of the jetBlue RNAV Visual procedure as closely as possible.	Arrival flight paths moved overwater instead of over the Hull peninsula and points further south
1-A1a	*Option A*: Published instrument approach procedure	
1-A1b	*Option B*: Public distribution of RNAV Visual procedure	

Source: MIT

We understand that the FAA will also need to undertake its own internal review including safety, operational feasibility and environmental impacts. It is our hope that the FAA will be able to adopt these recommendations as expeditiously as possible.

On behalf of Massport, I want to thank the FAA for its commitment to this very important and unique initiative. Please feel free to contact me directly or Flavio Leo, Director of Aviation Planning and Strategy, with any further questions.

Sincerely,

Edward C. Freni
Director of Aviation

cc: Todd Friedenberg (FAA), David Carlon (MCAC), Tom Glynn (Massport), John Hansman (MIT), Liz Becker (Massport), Flavio Leo (Massport)

Fundamentals of Acoustics and Environmental Noise

This section introduces the fundamentals of acoustics and noise terminology as well as the effects of noise on human activity and community annoyance.

Introduction to Acoustics and Noise Terminology

Chapter 6, *Noise Abatement* of this *2016 Environmental Data Report (EDR)* relies largely on a measure of cumulative noise exposure over an entire calendar year, in terms of a metric called the Day-Night Average Sound Level (DNL). However, DNL does not always provide a sufficient description of noise for many purposes. Other measures are available to address essentially any issue of concern. This section introduces the following acoustic metrics, which are all related to DNL, but provide bases for evaluating a broad range of noise situations. These metrics include:

- Decibel (dB)
- A-Weighted Decibel (dBA)
- Sound Exposure Level (SEL)
- Equivalent Sound Level (Leq)
- Time Above (TA)
- Time Above, Night (TAN)
- DNL

The Decibel (dB)

All sounds come from a sound source – a musical instrument, a voice speaking, or an airplane that passes overhead. It takes energy to produce sound. The sound energy produced by any sound source is transmitted through the air in the form of sound waves – tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear.

Our ears are sensitive to a wide range of sound pressures. The loudest sounds that we hear without pain have about one million times more energy than the quietest sounds we hear. However, our ears are incapable of detecting small differences in these pressures. Thus, to match how we hear this sound energy, we compress the total range of sound pressures to a more meaningful range by introducing the concept of sound pressure level (SPL). SPL is a measure of the sound pressure of a given noise source relative to a standard reference value (typically the quietest sound that a young person with good hearing can detect). SPLs are measured in decibels (abbreviated dB). Decibels are logarithmic quantities – logarithms of the squared ratio of two pressures, the numerator being the pressure of the sound source of interest, and the denominator being the reference pressure (the quietest sound we can hear).

The logarithmic conversion of sound pressure to SPL means that the quietest sound we can hear (the reference pressure) has a SPL of about zero decibels, while the loudest sounds we hear without pain have SPLs of about 120 dB. Most sounds in our day-to-day environment have SPLs from 30 to 100 dB.

Because decibels are logarithmic quantities, they do not behave like regular numbers with which we are more familiar. For example, if two sound sources each produce 100 dB and they are operated together, they produce only 103 dB – not 200 dB as we might expect. Four equal sources operating simultaneously result in a total SPL of 106 dB. In fact, for every doubling of the number of equal sources, the SPL goes up another three decibels. A tenfold increase in the number of sources makes the SPL go up 10 dB. A hundredfold increase makes the level go up 20 dB, and it takes a thousand equal sources to increase the level 30 dB.

If one source is much louder than another source, the two sources together will produce the same SPL (and sound to our ears) as if the louder source were operating alone. For example, a 100-dB source plus an 80-dB source produces 100 dB when operating together. The louder source “masks” the quieter one, but if the quieter source gets louder, it will have an increasing effect on the total SPL. When the two sources are equal, as described above, they produce a level 3 dB above the sound of either one by itself.

From these basic concepts, note that one hundred 80 dB sources will produce a combined level of 100 dB; if a single 100-dB source is added, the group will produce a total SPL of 103 dB. Clearly, the loudest source has the greatest effect on the total decibel level.

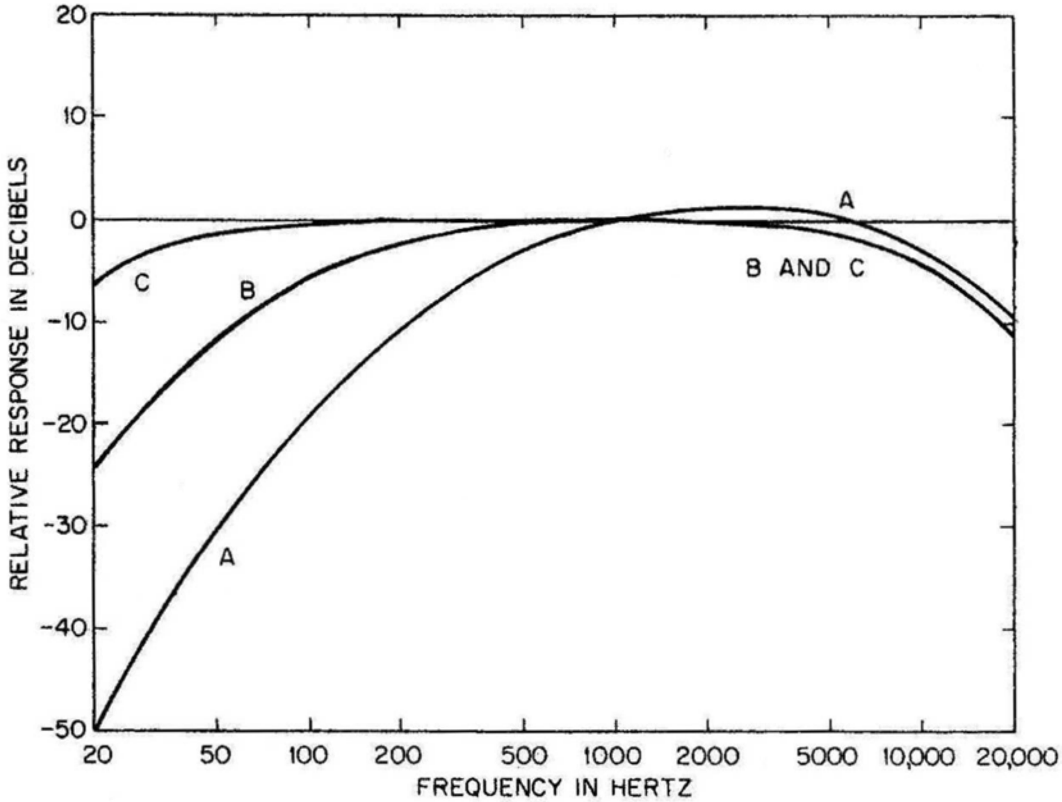
A-Weighted Decibel, dBA

Another important characteristic of sound is its frequency, or “pitch.” This is the rate of repetition of the sound pressure oscillations as they reach our ear. Formerly expressed in cycles per second, frequency is now expressed in units known as Hertz (Hz).

Most people hear from about 20 Hz to about 10,000 to 15,000 Hz. People respond to sound most readily when the predominant frequency is in the range of normal conversation, around 1,000 to 2,000 Hz. Acousticians have developed "filters" to match our ears' sensitivity and help us to judge the relative loudness of sounds made up of different frequencies. The so-called "A" filter does the best job of matching the sensitivity of our ears to most environmental noises. SPLs measured through this filter are referred to as A-weighted levels (dBA). A-weighting significantly de-emphasizes noise at low and very high frequencies (below about 500 Hz and above about 10,000 Hz) where we do not hear as well. Because this filter generally matches our ears' sensitivity, sounds having higher A-weighted sound levels are usually judged louder than those with lower A-weighted sound levels, a relationship which does not always hold true for unweighted levels. It is for these reasons that A-weighted sound levels are normally used to evaluate environmental noise.

Other weighting networks include the B and C filters. They correspond to different level ranges of the ear. The rarely used B-weighting attenuates low frequencies (those less than 500 Hz), but to a lesser degree than A-weighting. C weighting is nearly flat throughout the audible frequency range, hardly de-emphasizing low frequency noise. C-weighted levels can be preferable in evaluating sounds whose low-frequency components are responsible for secondary effects such as the shaking of a building, window rattle, or perceptible vibrations. Uses include the evaluation of blasting noise, artillery fire, and in some cases, aircraft noise inside buildings. **Figure H-1** compares these various weighting networks.

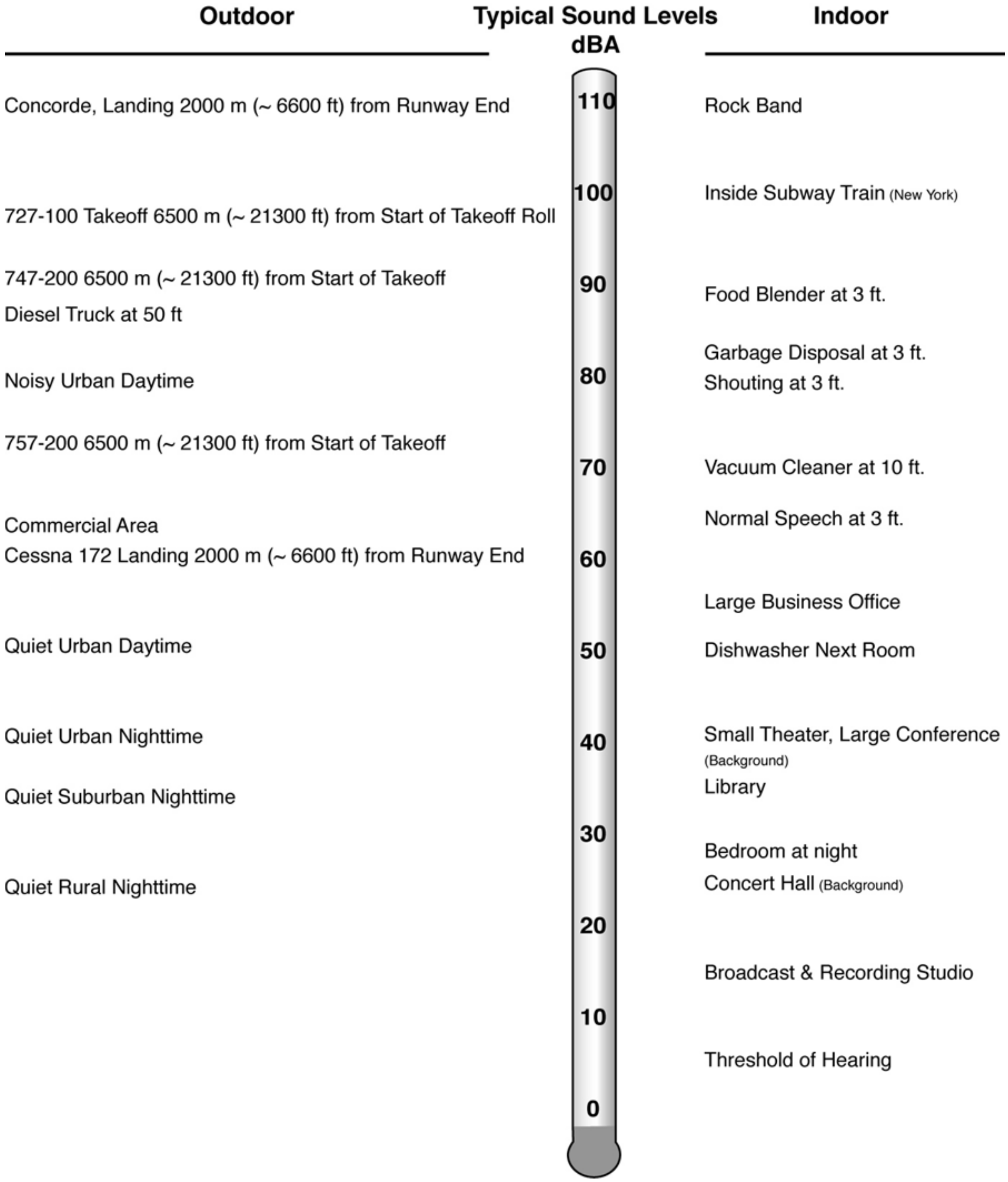
Figure H-1 Frequency-Response Characteristics of Various Weighting Networks



Source: Harris, Cyril M., editor; Handbook of Acoustical Measurements and Noise Control, (Chapter 5, "Acoustical Measurement Instruments"; Johnson, Daniel L.; Marsh, Alan H.; and Harris, Cyril M.); New York; McGraw-Hill, Inc.; 1991; p. 5.13.

Because of the correlation with our hearing, the A-weighted level has been adopted as the basic measure of environmental noise by the U.S. Environmental Protection Agency (EPA) and by nearly every other federal and state agency concerned with community noise. **Figure H-2** presents typical A-weighted sound levels of several common environmental sources.

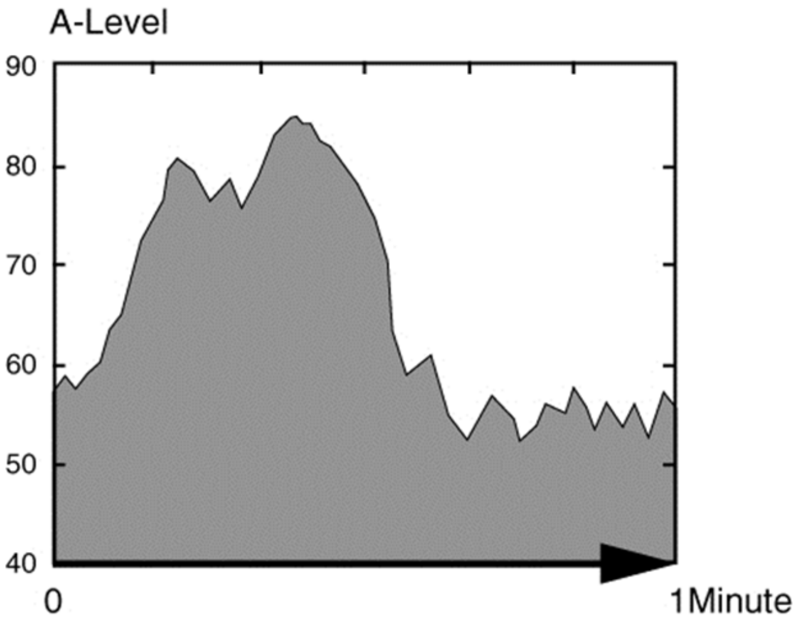
Figure H-2 Common Environmental Sound Levels, in dBA



Source: HMMH (Aircraft noise levels from FAA Advisory Circular 36-3H)

An additional dimension to environmental noise is that A-weighted levels vary with time. For example, the sound level increases as an aircraft approaches, then falls and blends into the background as the aircraft recedes into the distance (though even the background varies as birds chirp or the wind blows or a vehicle passes by). **Figure H-3** illustrates this concept.

Figure H-3 Variations in the A-Weighted Sound Level Over Time



Source: HMMH

Maximum A-Weighted Noise Level, L_{max}

The variation in noise level over time often makes it convenient to describe a particular noise "event" by its maximum sound level, abbreviated as L_{max}. In the figure above, it is approximately 85 dBA.

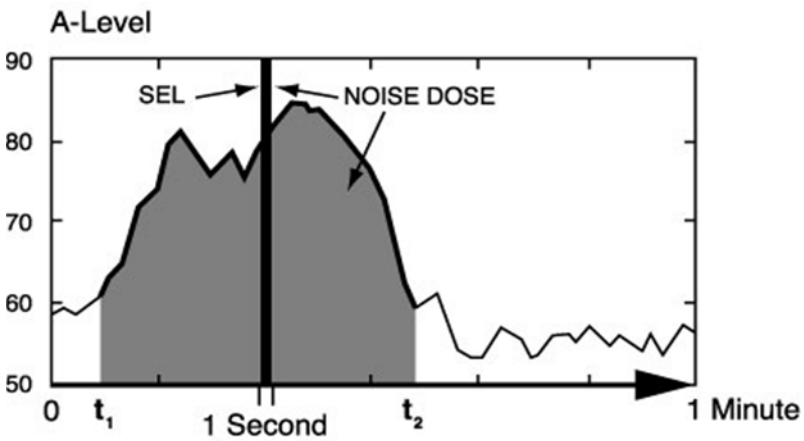
The maximum level describes only one dimension of an event; it provides no information on the cumulative noise exposure. In fact, two events with identical maxima may produce very different total exposures. One may be of very short duration, while the other may continue for an extended period and be judged much more annoying. The next measure corrects for this deficiency.

Sound Exposure Level (SEL)

The most frequently used measure of noise exposure for an individual aircraft noise event (and the measure that Part 150 specifies for this purpose) is the SEL. SEL is a measure of the total noise energy produced during an event, from the time when the A-weighted sound level first exceeds a threshold level (normally just above the background or ambient noise) to the time that the sound level drops back down below the threshold. To allow comparison of noise events with very different durations, SEL "normalizes" the duration in every case to one second; that is, it is expressed as the steady noise level with just a one-second duration that includes the same amount of noise energy as the actual longer duration, time-varying noise. In lay terms, SEL "squeezes" the entire noise event into one second.

Figure H-4 depicts this transformation. The shaded area represents the energy included in an SEL measurement for the noise event, where the threshold is set to 60 dBA. The dark shaded vertical bar, which is 90 dBA high and just one second long (wide), contains the same sound energy as the full event.

Figure H-4 Sound Exposure Level (SEL)



Source: HMMH

Because the SEL is normalized to one second, it will always be larger than the L_{max} for an event longer than one second. In this case, the SEL is 90 dB; the L_{max} is approximately 85 dBA. For most aircraft overflights, the SEL is normally on the order of 7 to 12 dB higher than L_{max}. Because SEL considers duration, longer exposure to relatively slow, quiet aircraft, such as propeller models, can have the same or higher SEL than shorter exposure to faster, louder planes, such as corporate jets.

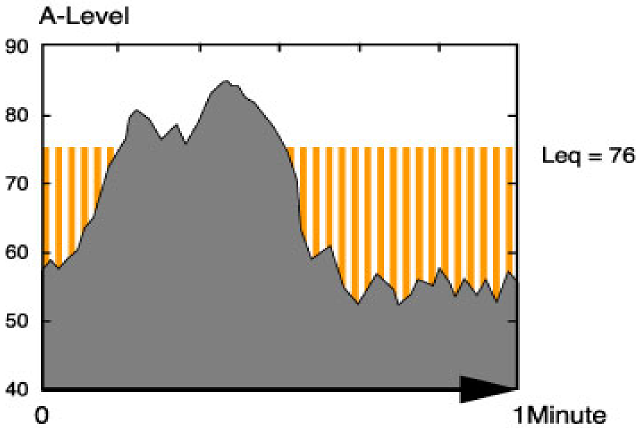
Equivalent Sound Level (L_{eq})

The L_{max} and SEL quantify the noise associated with individual events. The remaining metrics in this section describe longer-term cumulative noise exposure that can include many events.

The Equivalent Sound Level (L_{eq}) is a measure of exposure resulting from the accumulation of A-weighted sound levels over a particular period of interest (e.g., an hour, an eight-hour school day, nighttime, or a full 24-hour day). Because the length of the period can differ, the applicable period should always be identified or clearly understood when discussing the metric. Such durations are often identified through a subscript, for example $L_{eq(8)}$ or $L_{eq(24)}$.

L_{eq} is equivalent to the constant sound level over the period of interest that contains as much sound energy as the actual time-varying level. This is illustrated in **Figure H-5**. Both the solid and striped shaded areas have a one-minute L_{eq} value of 76 dB. It is important to recognize, however, that the two signals (the constant one and the time-varying one) would sound very different in real life. Also, be aware that the "average" sound level suggested by L_{eq} is not an arithmetic value, but a logarithmic, or "energy-averaged" sound level. Thus, loud events dominate L_{eq} measurements.

Figure H-5 Example of a One Minute Equivalent Sound Level (L_{eq})



Source: HMMH

In airport noise studies, L_{eq} is often presented for consecutive one-hour periods to illustrate how the exposure rises and falls throughout a 24-hour period, and how individual hours are affected by unusual activity, such as rush hour traffic or a few loud aircraft.

Time Above (TA)

TA is a metric that gives the duration, in minutes, for which aircraft-related noise exceeds a specified A-weighted sound level during a given period. The measure is referred to generally as TA. For this *2016 EDR*, three threshold sound levels are used in the analysis: 65, 75, and 85 dBA. These times are computed using the Federal Aviation Administration (FAA)-approved Integrated Noise Model (INM).

Time Above Night (TAN)

Identical to TA, except it is computed for only the 9-hour period between 10:00 PM and 7:00 AM. The TAN is also developed using three threshold sound levels 65, 75, and 85 dBA.

Day-Night Average Sound Level (DNL)

Virtually all studies of aircraft noise rely on a slightly more complicated measure of noise exposure that describes cumulative noise exposure during an average annual day: the DNL. The EPA identified DNL as the most appropriate means of evaluating airport noise based on the following considerations:[1]

1. The measure should be applicable to the evaluation of pervasive long-term noise in various defined areas and under various conditions over long periods.

2. The measure should correlate well with known effects of the noise environment and on individuals and the public.

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1 Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," U. S. EPA Report No. 550/9-74-004, March 1974

3. The measure should be simple, practical, and accurate. In principal, it should be useful for planning as well as for enforcement or monitoring purposes.

4. The required measurement equipment, with standard characteristics, should be commercially available.

5. The measure should be closely related to existing methods currently in use.

6. The single measure of noise at a given location should be predictable, within an acceptable tolerance, from knowledge of the physical events producing the noise.

7. The measure should lend itself to small, simple monitors, which can be left unattended in public areas for long periods.

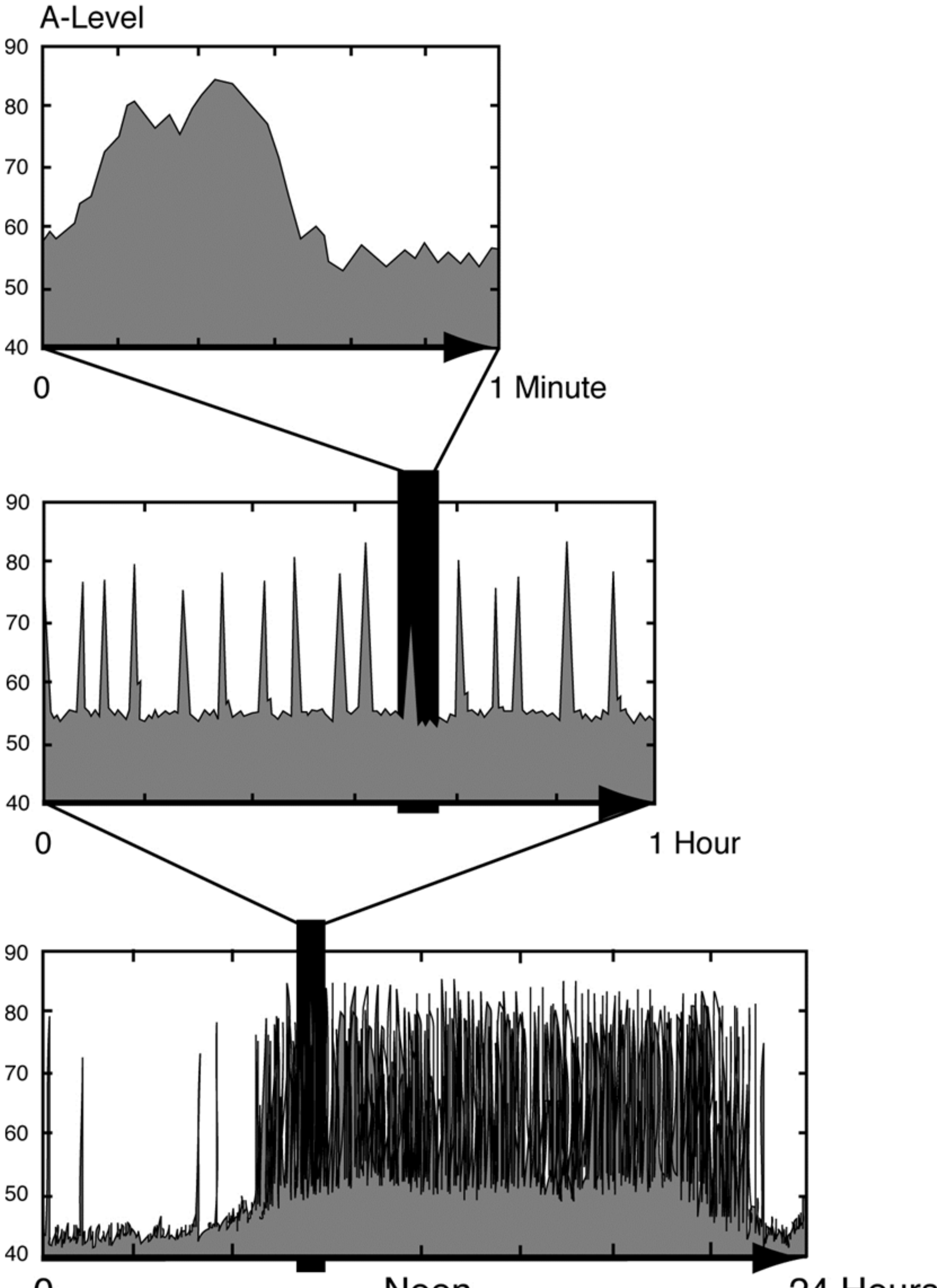
Most federal agencies dealing with noise have formally adopted DNL. The Federal Interagency Committee on Noise (FICON) reaffirmed the appropriateness of DNL in 1992. The FICON summary report stated; "There are no new descriptors or metrics of sufficient scientific standing to substitute for the present DNL cumulative noise exposure metric."

The DNL represents noise as it occurs over a 24-hour period, with one important exception: DNL treats nighttime noise differently from daytime noise. In determining DNL, it is assumed that the A-weighted levels occurring at night (defined as 10:00 PM to 7:00 AM) are 10 dB louder than they really are. This 10-dB penalty is applied to account for greater sensitivity to nighttime noise, and the fact that events at night are often perceived to be more intrusive because nighttime ambient noise is less than daytime ambient noise.

Figure H-4 illustrated the A-weighted sound level due to an aircraft fly-over as it changed with time. The top frame of **Figure H-6** repeats this figure. The shaded area reflects the noise dose that a listener receives during the one-minute period of the sample. The center frame of **Figure H-4** includes this one-minute sample within a full hour. The shaded area represents the noise during that hour with 16 noise events, each producing an SEL. Similarly, the bottom frame includes the one-hour interval within a full 24 hours. Here the shaded area represents the listener's noise dose over a complete day. Note that several overflights occur at a time when the background noise drops some 10 dB, to approximately 45 dBA.

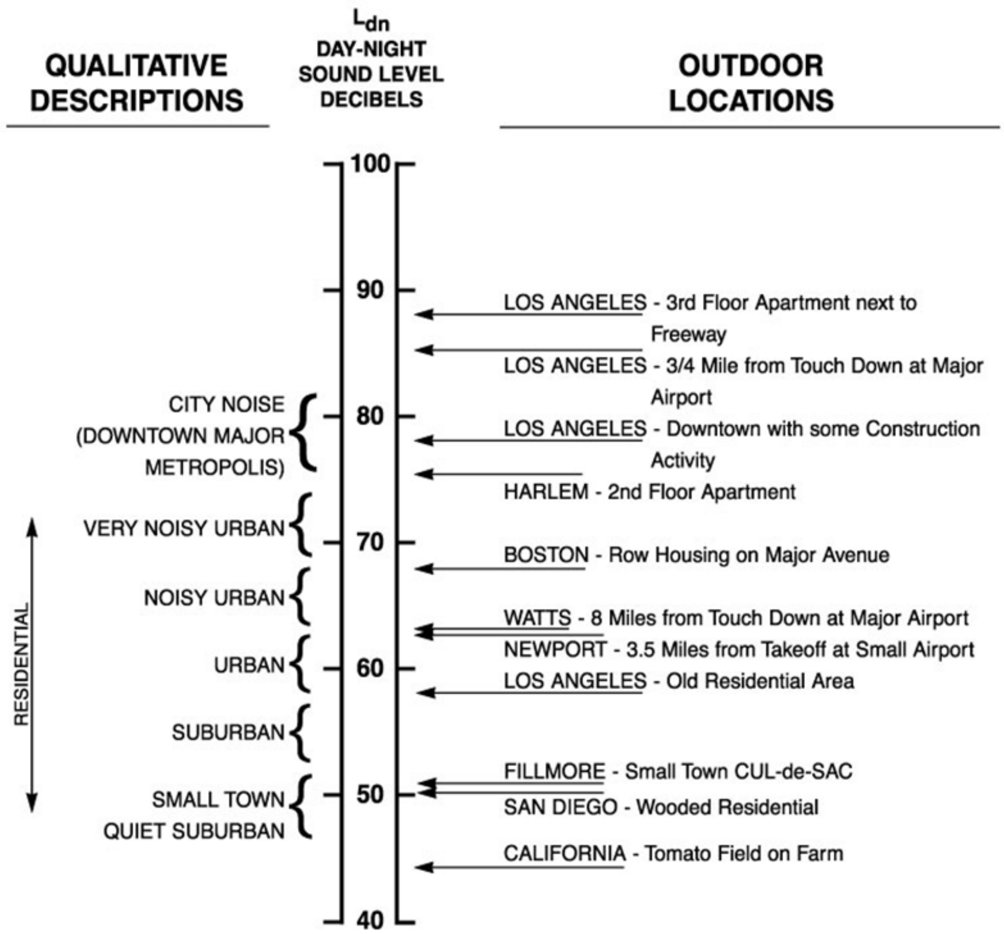
DNL can be measured or estimated. Measurements are practical only for obtaining DNL values for relatively limited numbers of points, and, in the absence of a permanently installed monitoring system, only for relatively short time periods. Most airport noise studies are based on computer-generated DNL estimates, determined by accounting for all the SELs from individual events, which comprise the total noise dose at a given location. Computed DNL values are often depicted in terms of equal-exposure noise contours (much as topographic maps have contours of equal elevation). **Figure H-7** depicts typical DNL values for a variety of noise environments.

Figure H-6 Daily Noise Dose



Source: HMMH

Figure H-7 Examples of Day-Night Average Sound Levels (DNL)



Source: EPA, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974, p. 14.

As of May 2015, FAA is beginning work on the next step in a multi-year Noise Research Program that will update the scientific evidence on the relationship between aircraft noise exposure and its effects on communities around airports. If changes are warranted, FAA will propose revised policy and related guidance and regulations, subject to interagency coordination, as well as public review and comment.

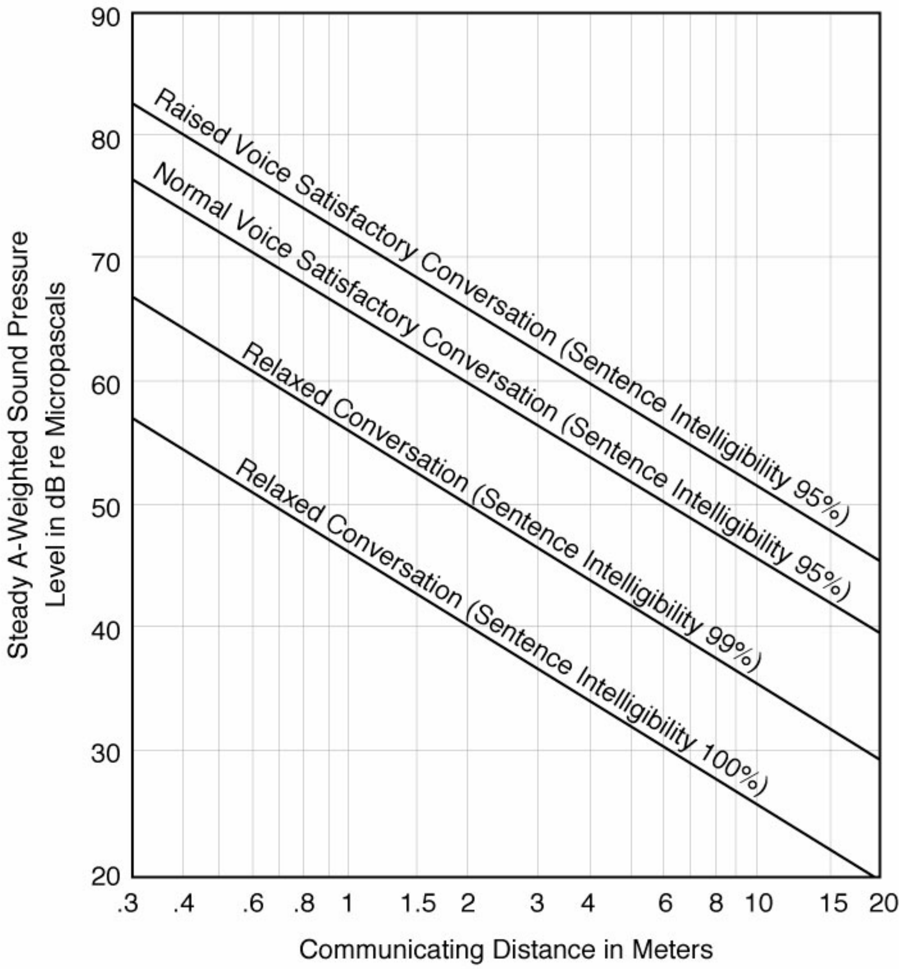
The Effects of Aircraft Noise on People

To residents around airports, aircraft noise can be an annoyance and a nuisance. It can interfere with conversation and listening to television, it can disrupt classroom activities in schools, and it can disrupt sleep. Relating these effects to specific noise metrics helps in the understanding of how and why people react to their environment.

Speech Interference

A primary effect of aircraft noise is its tendency to drown out or "mask" speech, making it difficult to carry on a normal conversation. The sound level of speech decreases as the distance between a talker and listener increases. As the background sound level increases, it becomes harder to hear speech. **Figure H-8** presents typical distances between talker and listener for satisfactory outdoor conversations, in the presence of different steady A-weighted background noise levels for raised, normal, and relaxed voice effort. As the background level increases, the talker must raise his/her voice, or the individuals must get closer together to continue talking.

Figure H-8 Outdoor Speech Intelligibility



Source: EPA, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974, p. D-5.

As indicated in the figure, "satisfactory conversation" does not always require hearing every word; 95 percent intelligibility is acceptable for many conversations. Listeners can infer a few unheard words when they occur in a familiar context. However, in relaxed conversation, we have higher expectations of hearing speech and generally require closer to 100 percent intelligibility. Any combination of talker-listener distances and background noise that falls below the bottom line in **Figure H-8** (thus assuring 100 percent intelligibility) represents an ideal environment for outdoor speech communication and is considered necessary for acceptable indoor conversation as well.

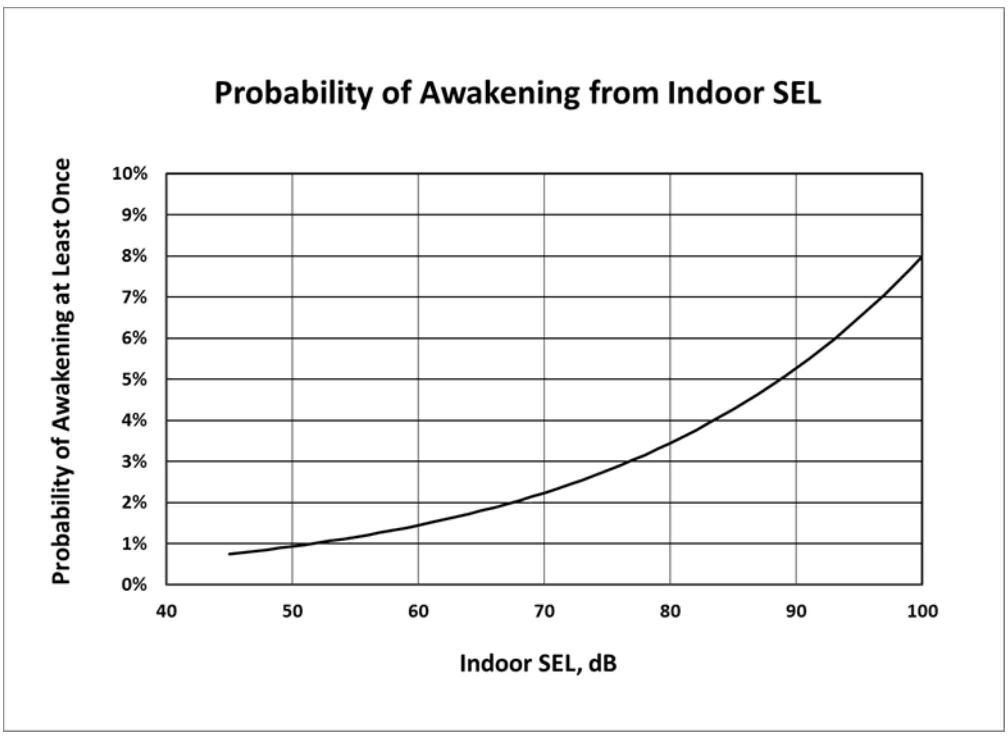
One implication of the relationships in **Figure H-8** is that for typical communication at distances of 3 or 4 feet (1 to 1.5 meters), acceptable outdoor conversations can be carried on in a normal voice as long as the background noise outdoors is less than about 65 dBA. If the noise exceeds this level, as might occur when an aircraft passes overhead, intelligibility would be lost unless vocal effort were increased or communication distance were decreased.

Indoors, typical distances, voice levels, and intelligibility expectations generally require a background level less than 45 dBA. With windows partly open, housing generally provides about 12 dBA of interior-to-exterior noise level reduction. Thus, if the outdoor sound level is 60 dBA or less, there is a reasonable chance that the resulting indoor sound level will afford acceptable conversation inside. With windows closed, 24 dB of attenuation is typical.

Sleep Interference

Research on sleep disruption from noise has led to widely varying observations. In part, this is because (1) sleep can be disturbed without awakening, (2) the deeper the sleep the more noise it takes to cause arousal, and (3) the tendency to awaken increases with age, and other factors. **Figure H-9** shows one such relationship from recent research conducted in the U.S. – the probability that a group of people will be awakened at least once when exposed to a given indoor SEL.

Figure H-9 Probability of Awakening at Least Once from Indoor Noise Event



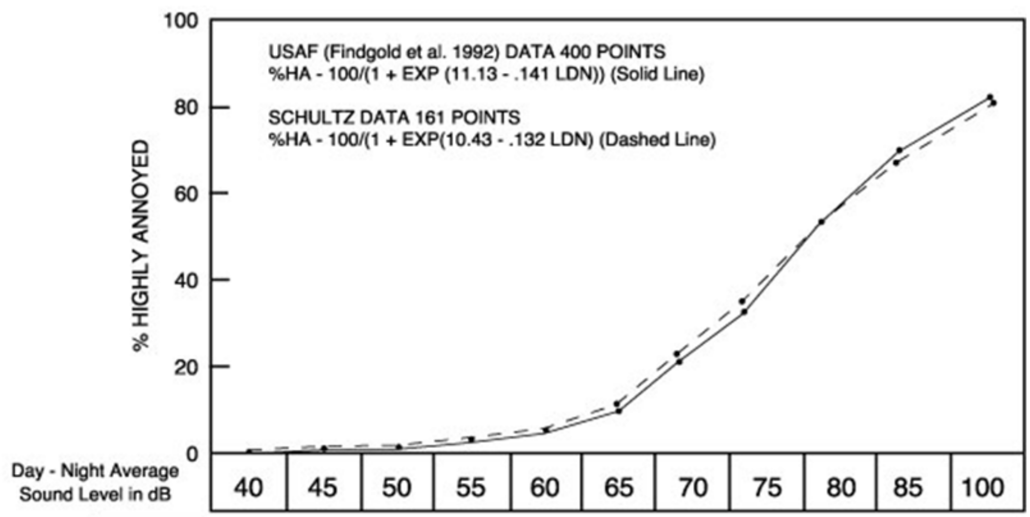
Source: ANSI S12.9-2008/Part 6, Quantities and Procedures for Description and Measurement of Environmental Sound — Part 6: Methods for Estimation of Awakenings Associated with Outdoor Noise Events Heard in Homes; Equation 1

For example, an indoor SEL of 80 dB results in approximately 3.5 percent of the exposed population being awakened. If windows are open in the bedroom on a warm evening and a house provides a typical outside-to-inside noise level reduction of around 15 dB, which suggests it takes an SEL of about 95 dB outdoors to awaken 3.5 percent of the population. The American National Standards Institute (ANSI) has extended this concept further and developed a standard (ANSI S12.9-2008/Part 6) for computing the percentage of the population that is likely to be awakened by multiple noise events occurring throughout the night. The Federal Interagency Committee on Aviation Noise (FICAN) subsequently endorsed the standard as the best available means of estimating behavioral awakenings from aircraft noise.

Community Annoyance

Social survey data make it clear that individual reactions to noise vary widely for a given noise level. Nevertheless, as a group, people's aggregate response is predictable and relates well to measures of cumulative noise exposure such as DNL. **Figure H-10** shows a widely recognized relationship between environmental noise and annoyance.

Figure H-10 Percentage of People Highly Annoyed



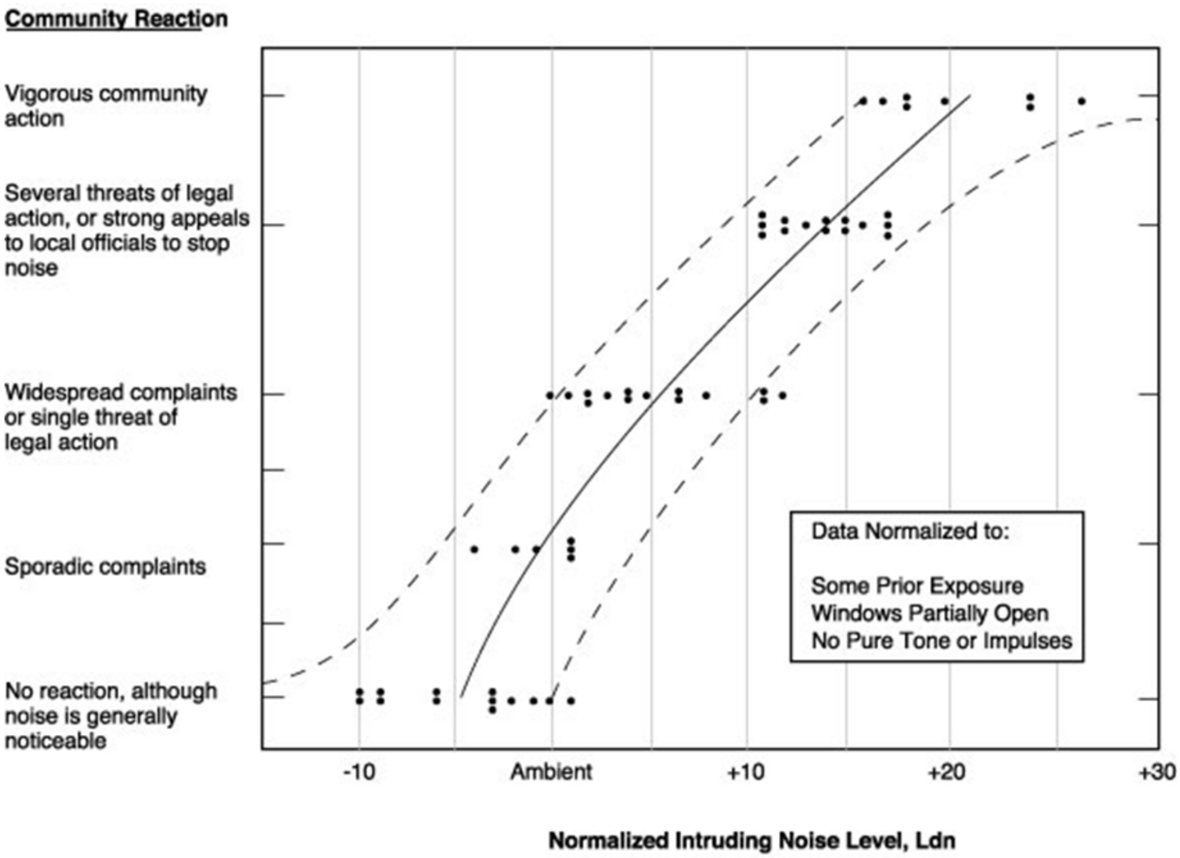
Calculated %HA Points											
USAF	0.41	0.831	1.66	3.31	6.48	12.29	22.1	36.47	53.74	70.16	82.64
SCHULTZ	0.576	1.11	2.12	4.03	7.52	13.59	23.32	37.05	53.25	68.78	81

Source: FICON. "Federal Agency Review of Selected Airport Noise Analysis Issues." August 1992. (From data provided by USAF Armstrong Laboratory). pp. 3-6.

Based on data from 18 surveys conducted worldwide, the curve indicates that at levels as low as DNL 55, approximately 5.0 percent of the people will still be highly annoyed, with the percentage increasing more rapidly as exposure increases above DNL 65.

Separate work by the EPA has shown that overall community reaction to a noise environment can also be related to DNL. This relationship is shown in **Figure H-11**. Levels have been normalized to the same set of exposure conditions to permit valid comparisons between ambient noise environments. Data summarized in **Figure H-11** suggest that little reaction would be expected for intrusive noise levels five decibels below the ambient, while widespread complaints can be expected as intruding noise exceeds background levels by about five decibels. Vigorous action is likely when the background is exceeded by 20 dB.

Figure H-11 Community Reaction as a Function of Outdoor DNL



Source: Wyle Laboratories, "Community Noise," prepared for the U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, D.C., December 1971, pg. 63

Regulatory Framework

Logan Airport Noise Abatement Rules and Regulations

Massport's primary mechanism for reducing noise impacts from Logan Airport's operations is the Noise Rules.[2] The Noise Rules were designed to reduce noise impacts by encouraging use of quieter aircraft by requiring decreased use of noisier aircraft and by limiting nighttime activity by louder Stage 2 types. Many secondary goals aimed at limiting noise in specific areas also were stated.

Specific provisions of the Noise Rules, which continue to serve these goals, include:

- Limiting cumulative noise exposure at Logan Airport (as measured by Massport's CNI) to a maximum of 156.5 Effective Perceived Noise Decibels (EPNdB);
- Maximizing use of Stage 3 aircraft;

2 The Logan International Airport Noise Abatement Rules and Regulations, effective July 1, 1986, are codified at 740 Code of Massachusetts Regulations (CMR) 24.01 et seq (also known as the Noise Rules).

- Restricting nighttime operations by Stage 2 aircraft;
- Placing limitations on times and locations of engine run-ups and use of auxiliary power units (APU); and
- Restricting use of certain runways by noisier aircraft and time of day.

These restrictions and limitations are subject to FAA implementation and safe operation of the airport and airspace.

Federal Aviation Regulation (FAR) Part 36

Logan Airport operates within a framework of federal aviation regulations that limits an airport operator's ability to control noise. For example, FAA's FAR Part 36[3] sets noise limits for aircraft certification and the procedures by which aircraft noise emission levels must be measured to determine compliance. The regulation defines noise emission limits for turbojets, turboprops, and helicopters, classifying turbojets into categories referred to as stages based on noise levels at each of three locations: takeoff, landing, and to the side of the runway during takeoff (sideline). The stages are:

- Stage 1 aircraft are the oldest and usually have the loudest operations, having preceded the existence of any noise emission regulation. Rare examples include old, restored civil or military aircraft. There are no Stage 1 aircraft operating at Logan Airport.
- Stage 2 aircraft are less old and less noisy than Stage 1; they were the first aircraft types required to meet a noise limit. A subsequent regulation, FAR Part 91 (described in the next section), prohibits the operation of a Stage 2 aircraft in the continental U.S. unless its takeoff weight is 75,000 pounds or less. FAA Reauthorization bill of 2012 also mandated the phase out of Stage 2 aircraft with a takeoff weight less than 75,000 pounds by the end of 2015. Thus, there were no Stage 2 operations at Logan Airport for all of 2016.
- Stage 3 aircraft were certified for service before 2006 and have relatively quiet jets, although some are Stage 2 aircraft that have been re-engined, or have been fitted with hushkits, enabling them to meet Stage 3 noise limits.
- Stage 4 aircraft are required to operate with a cumulative noise level at least 10 dB quieter than Stage 3 aircraft at three prescribed measurement points. Jet aircraft certificated after January 1, 2006 must meet the Stage 4 limits. Although not required, the majority of aircraft in the 2016 Logan Airport fleet would also meet the Stage 4 noise limits if they were recertificated.
- Stage 5 aircraft are the newest and quietest aircraft. Starting January 1, 2018, all aircraft certificated must meet Stage 5 limits which are a cumulative 7 dB below Stage 4 and 17 dB below Stage 3 aircraft. The Boeing 787, 747-8 and Airbus A350 and A380 are examples of aircraft that meet the new limits.

FAR Part 150

First implemented in February 1981, FAR Part 150[4] defines procedures that an airport operator must follow if it chooses to conduct and implement an airport noise and land use compatibility plan. Part 150 Noise Compatibility studies require the use of DNL to evaluate the airport noise environment. FAR Part 150 identifies noise compatibility guidelines for different land uses depending on their sensitivity. Key

3 14 CFR Part 36, "Noise Standards: Aircraft Type and Air Worthiness Certification."

4 14 CFR Part 150, "Airport Noise Compatibility Planning."

values include a DNL of 75 dB, above which no residences, schools, hospitals, or churches are considered compatible, and a DNL of 65 dB, above which those land uses are considered compatible only if they are sound insulated.

Noise abatement or mitigation measures that an airport operator must consider in a Part 150 study include acquisition of incompatible land, construction of noise barriers, sound insulation of buildings, implementation of a preferential runway program, use of noise abatement flight tracks, implementation of airport use restrictions, and any other actions that would have a beneficial effect on the public.

While Massport has implemented variations of these and additional measures at Logan Airport, Massport has not filed an official Part 150 noise compatibility study with FAA because all of Logan Airport's program elements, while regularly reviewed and updated, preceded the promulgation of Part 150 and are effectively grandfathered under the regulation.

FAR Parts 91 and 161

The Airport Noise and Capacity Act of 1990 (ANCA)[5] directed the U.S. Secretary of Transportation to undertake three key noise-related actions:

- Establish a schedule for a phase out of Part 36 Stage 2 aircraft by the year 2000;
- Establish a program for FAA review of all new airport noise and access restrictions limiting operations of Stage 2 aircraft; and
- Establish a program for FAA review and approval of any restriction that limits operations of Stage 3 aircraft, including public notice requirements.

FAA addressed these requirements through amendment of an existing federal regulation, "Part 91,"[6] and establishment of a new regulation, "Part 161."[7] ANCA effectively ended Massport's pursuit of any additional operational restrictions outside of this program.

Amendment to Part 91

FAA establishes and regulates operating noise limits for civil aircraft operation in Subpart I, "Operating Noise Limits," of 14 CFR Part 91, "General Operating and Flight Rules." The noise limits are based on aircraft noise certification criteria set forth in 14 CFR Part 36, "Noise Standards: Aircraft Type and Airworthiness Certification." For transport category "large" aircraft (with maximum takeoff weights of 12,500 pounds or more) and for all turbojet-powered aircraft, Part 36 identifies four "stages" of aircraft with respect to their relative noisiness:

- Stage 1 aircraft, which have never been shown to meet any noise standards, because they have never been tested, or because they have been tested and failed to meet any established standards;
- Stage 2 aircraft, which meet original noise limits, set in 1969;
- Stage 3 aircraft, which meet more stringent limits, established in 1977; and
- Stage 4 aircraft, which meet the most stringent limits, established in 2005.

5 Pub. L. No. 101-508, 104 Stat. 1388, as recodified at 49 United States Code 47521- 47533.
6 14 CFR Part 91, "General Operating and Flight Rules."
7 14 CFR Part 161, "Notice and Approval of Airport Noise and Access Restrictions."

In 1976, FAA ordered a phase out of all Stage 1 aircraft with a maximum gross takeoff weight (MGTOW) over 75,000 pounds, to be completed on January 1, 1985. After that date, Stage 1 civil aircraft over 75,000 pounds MGTOW were banned from operating in the U.S. (with limited exemptions related to commercial service at "small communities," which has since expired in 1988). ANCA required a similar phase out of Stage 2 aircraft over 75,000 pounds by December 31, 1999. The 75,000-pound weight limit exempted most "business" (or "corporate") jets and a very small number of the very smallest "air carrier" type jets until December 31, 2015 when a full ban took effect.[8] Aircraft operators responded to the Stage 1 and 2 phase-outs by retiring their non-compliant aircraft or modifying some of their aircraft to meet the more stringent standards. The modifications undertaken include installation of quieter engines, noise-reducing physical modifications to the airframe and/or existing engines, and limitation of operating weights and procedures to meet the applicable Part 36 limits. Some former Stage 2 airline aircraft that were "recertificated" as Stage 3 with these modifications still operate at Logan Airport, but are generally declining due to the aircrafts' age and high operating costs (in particular due to the generally low fuel efficiency of these older aircraft).

From 2006 to 2017, as airlines add new aircraft, Stage 4 aircraft have been added to their fleets. The Stage 4 noise standard applies to any new jet aircraft type designs over 12,500 pounds requiring FAA approval after January 1, 2006. The International Civil Aviation Organization (ICAO) has also adopted the same regulation for international operators, but neither FAA nor ICAO have indicated there will be restrictions on the remaining recertificated Stage 3 aircraft from carrier fleets.

ICAO and FAA have adopted a higher standard of noise classification called Stage 5 (Chapter 14 for ICAO) which will be effective for new aircraft type certification after December 31, 2017 and December 31, 2020, depending on the weight of the aircraft.[9]

Part 161

FAA implemented the ANCA requirements related to notice, analysis, and approval of use restrictions affecting Stage 2 and 3 aircraft through the establishment of a new regulation, 14 CFR Part 161, "Notice and Approval of Airport Noise and Access Restrictions." In simple terms, Part 161 requires an airport operator that proposes to implement a restriction on Stage 2 or 3 aircraft operations to undertake, document, and publicize certain benefit-cost analyses, comparing the noise benefits of the restriction to its economic costs. Operators must obtain specific FAA approvals of the analysis, documentation, and notice processes, and – for Stage 3 restrictions – approval of the restriction itself.

Part 161 and ANCA define more demanding requirements and explicit guidance for Stage 3 restrictions. To implement a Stage 3 restriction, formal FAA approval is required. FAA's role for Stage 2 restrictions is limited to commenting on compliance with Part 161 notice and analysis procedural requirements. Part 161 provides guidance regarding appropriate information to provide in support of these findings. While Part 161 does not require this information for a Stage 2 restriction, Part 161 states that it would be "useful." Moreover, FAA has required airports to provide this same information for Stage 2 restrictions (and even for Stage 1 restrictions pursued under FAR Part 150), on the grounds that they are required for airports to comply with grant assurance 22(a), "Economic Nondiscrimination," which states that an airport

8 FAA Modernization and Reform Act of 2012 sets a January 1, 2016 ban of Stage 2 aircraft less than 75,000 lbs.

9 The Final Rule was published on October 4, 2017.

operator "will make its airport available as an airport for public use on reasonable terms and without unjust discrimination to all types, kinds, and classes of aeronautical activities, including commercial aeronautical activities offering services to the public at the Airport."[10]

Although several (on the order of a dozen) airports have embarked on efforts to adopt both Stage 2 and 3 restrictions in the past two decades, FAA has found that only one, Naples Municipal Airport, a GA airport in Naples, Florida, has fully complied with Part 161 analysis, notice, and documentation requirements for a ban on Stage 2 jet operations. FAA found the airport was in violation of prior to FAA grant assurances. The airport operator successfully sued FAA to overturn that ruling and has implemented the restriction.

ANCA and Part 161 specifically exempt Stage 3 use restrictions that were effective on or before October 1, 1990 and Stage 2 restrictions that were proposed before that date. The Logan Airport Noise Rules were promulgated in 1986; therefore, ANCA and Part 161 have no bearing on their continued implementation in their current form. Any future proposals to make the rules more stringent regarding Stage 2 operations or to restrict Stage 3 operations in any way would almost certainly trigger Part 161 notice, analysis, and approval processes for Stage 3 restrictions. In 2006, Massport requested an opinion from FAA regarding the pursuit of a Part 161 waiver or exemption to allow Massport to implement a curfew of nighttime operations of hush-kitted Stage 3 aircraft. FAA informed Massport that a waiver or exemption from the requirements of Part 161 is not authorized under, or consistent with, federal statutory and regulatory requirements. A copy of FAA's letter to Massport was provided in Appendix H, *Noise Abatement* in the *2005 EDR*.

Logan Airport RC for AEDT™ Data Inputs

To relate portions of the foregoing discussion to the specific noise environment around Logan Airport, for this *2016 EDR*, Massport has produced a set of DNL noise contours, TA noise metrics, and population counts for 2016 using the software pre-processor RC for AEDT™. This software takes radar data from individual flights occurring throughout the year, processes the information, and formats it into a form usable as input to the latest version of FAA's AEDT, which serves as the computational "engine" for calculating noise. Version 2c SP2 was used for 2016. The RC for AEDT™ system used the individual flight tracks taken directly from the Massport Noise and Operations Management System (NOMS) rather than relying on consolidated data summaries. Prior year INM studies used RealContours™ which operated in a similar manner. For 2015, the INM noise model used 370,014 flights from the NOMS that retained suitable data. For 2016, the AEDT noise model used 388,857 flights from the NOMS that retained suitable data.

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10 FAA Order 5190.6(b), "Airport Compliance Manual" Chapter 13, Section 14, paragraph (a). To be approved, restrictions must meet the following six statutory criteria: 1) The proposed restriction is reasonable, nonarbitrary, and nondiscriminatory. 2) The proposed restriction does not create an undue burden on interstate or foreign commerce. 3) The proposed restriction maintains safe and efficient use of the navigable airspace. 4) The proposed restriction does not conflict with any existing federal statute or regulation. 5) The applicant has provided adequate opportunity for public comment on the proposed restriction. 6) The proposed restriction does not create an undue burden on the national aviation system.

Overview

Standard AEDT input methodology involves development of operational inputs and calculation of the DNL for a prototypical average annual day.[11] This approach requires manually collecting, refining, and entering the enormous amount of data averaged over a full year of activity at an airport. Typically, the model inputs may include an aircraft fleet mix with several dozen representative aircraft types, on the order of 100 to 300 representative flight tracks (common for a facility the size of Logan Airport), and runway use and flight track use percentages for three or four categories of aircraft types with similar performance characteristics.

This normal approach to noise modeling meets accepted professional standards, and reduces the effort and cost that would be associated with manually entering the parameters for every actual operation. However, it represents a significant simplification of the extraordinary diversity of actual aircraft operations over a year. It also does not take full advantage of the investment that Massport has made in installing and maintaining a state-of-the-art radar system,[12] which automatically collects flight track data and flight identification data for all operations at the Airport and feeds the NOMS.

Instead, for this report, Massport has utilized an AEDT pre-processor, RC for AEDT™, which takes maximum possible advantage of both AEDT's capabilities and the investment that Massport has made in operations monitoring. RC for AEDT™ automates the process of preparing the AEDT inputs directly from the actual flight operations, and permits airports to model the full diversity of activity as precisely as possible, at a cost equivalent to the more simplified manual approach. RC for AEDT™ improves the precision of modeling by utilizing operations monitoring results in five key areas:

- Directly converts the flight track for every identified aircraft operation to an AEDT track, rather than assigning multiple operations to a limited number of prototypical tracks.
- Models each operation on the specific runway that it actually used, rather than applying a generalized distribution to broad ranges of aircraft types.
- Models each operation in the period that it occurred, which considers delays at the Airport during the year.
- Selects the specific airframe and engine combination to model, on an operation-by-operation basis, based on the registration data for each flight wherever possible; otherwise, the published compositions of the fleets of the specific airlines operating at Logan Airport are used.

Figure H-12 provides a schematic representation of the RC for AEDT™ noise modeling process compared to the standard AEDT process.

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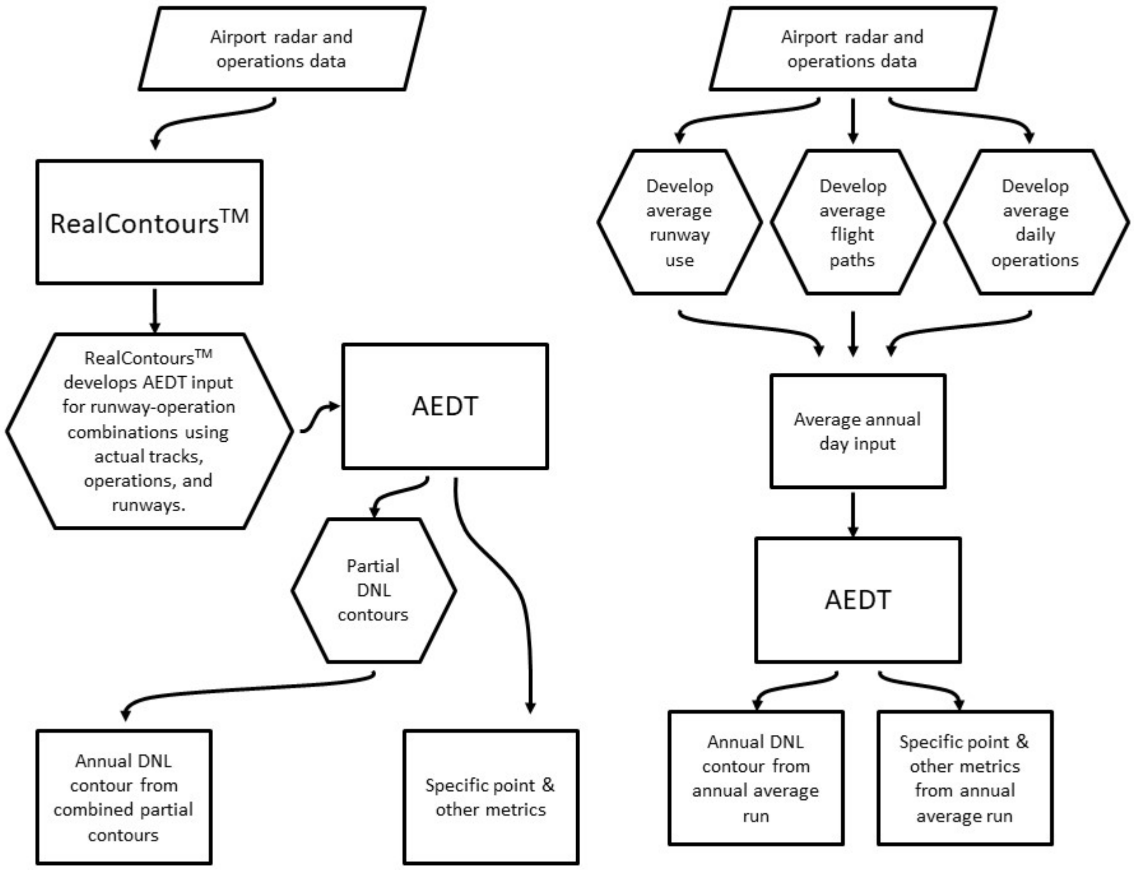
11 FAA INM Version 7.0 User's Guide, April 2007, p. 12.

12 Starting in 2010, the Massport system utilized the Airscene.com product of Era Corporation. The radar data source has been updated and the system is now provided by Harris.

Figure H-12 Schematic Noise Modeling Process (Standard AEDT vs. RC for AEDT™)



Source: FAA, HMMH

AEDT 2C SP2 Model

FAA's AEDT version 2c Service Pack 2 (AEDT 2cSP2) was released for general use on March 13, 2017. The latest version has been used for the 2016 DNL contour in this report as the primary analytical tool to assess the noise environment at Logan Airport. This version of the model includes data for the Boeing 787-8R, Embraer E170, and Embraer E190, all types in use at Logan Airport.

The remaining sections of this appendix provide several tables describing the data for 2016. Where possible, the data for 2015 are included for comparison and in general the tables listed as (a) are for 2015 and (b) for 2016.

2016 Radar Data

Logan Airport's radar data provide the key to the RC for AEDT™ system. Since February 2004, Massport has collected Passive Surveillance Radar System (PASSUR) radar data, which supplies information to the Airport's web-based Airport Monitor software. This dataset was used for the *2004 Environmental Status and Planning Report (2004 ESPR)* through the *2008 EDR*. Beginning with the *2009 EDR*, Massport began utilizing the radar data from its Harris NOMS system. These radar data are obtained from a multilateration system of eight sensors deployed around the Airport. The positioning data from these sensors are correlated to provide better, more accurate coverage of aircraft (in areas where the traditional FAA radar has limitations) and provide a more complete set of points to define each track. Traditional radar provides points every four to five seconds where the multilateration system provides data every second.

In 2015, the Massport system switched to FAA's Nextgen data feed, which integrates the Automatic Dependent Surveillance Broadcast (ADS-B) feed with multiple redundant real-time FAA surveillance sources into a single fused data feed. The NextGen data is a "multisensor based" subscription data source that aggregates all available surveillance sources, including:

- FAA En Route Radars;
- FAA Terminal Radars;
- FAA Airport Surface Detection Equipment X Band (ASDE-X) Systems;
- FAA Aircraft Situational Display to Industry (ASDI) Oceanic and Canadian Tracks only; and
- Harris ADS-B Data Feed.

Logan Airport is supported by an FAA ASDE-X system which provides highly accurate one-second data points for aircraft situational awareness on the Airport and within at least 5 miles of the Airport. These data are fused with the other sources and provided to the Massport NOMS system in a geo-referenced data format. The geo-referenced radar data are imported into the AEDT model, which is built on a geo-referenced platform to retain accuracy of the data for modeling.

The system was able to collect 366 complete days of data for 2016 with approximately 98 percent of these tracks usable for the development of the noise exposure contours.

Fleet Mix

The 2016 radar data was first processed to establish a baseline set of operations. After processing the 366 days of radar data (396,615 operations), flight tracks with sufficient operational information were identified to use as the baseline for the 2016 contours. The operations from these tracks were then scaled upwards by airline and aircraft type to match the reported totals provided by Massport for 2016. **Tables H-1a** (2015 for comparison) and **H-1b** (2016) provide the scaled annual operations, by INM aircraft type. Each INM type listed in **Tables H-1a** and **H-1b** is also mapped to a Runway Use group based on its weight and performance characteristics described in the Runway Use section below.

Regional jets (RJ) are defined as those aircraft with 90 or fewer seats, consistent with the categorization in Chapter 2, *Activity Levels*.[13] For years prior to 2010, the RJs in this report were classified as aircraft with less than 100 seats. When RJs first started gaining popularity, the aircraft types available were typically 50 seats or less with the traditional air carrier jet being 100 seats and higher. As newer aircraft types have become available, the smaller 35 to 50 seat types have been replaced by 70 to 99-seat types, with the 90 and above seat types flying many of the traditional air carrier routes. The majority of the newer types fall into two categories: the 70 to 75-seat category, which remain categorized as RJs, and the 91- to 99-seat category, which are categorized as air carrier jets. The Embraer 190 falls into this category and is now in the Light Jet B group.

AEDT Analysis

In 2015, FAA released its next-generation environmental analysis software, the Aviation Environmental Design Tool (AEDT) version 2B.[14] AEDT incorporates the computational engines of the legacy tools INM and the Emissions and Dispersion Modeling System (EDMS), and provides a unified database back end and graphical user interface. With a common set of aircraft and airport data that are updated regularly, AEDT ensures that noise and emissions analyses can be performed with up-to-date information.

Massport first explored the use of AEDT for the *2015 EDR*. Logan Airport presents a set of unique challenges to modeling software, and over the course of several years, Massport has addressed these challenges by developing a series of adjustments and customizations to better represent the operations, conditions, and terrain that affect noise at Logan Airport. These adjustments have historically been incorporated into INM analyses, and an AEDT analysis would need to incorporate equivalent features to continue the modeling accuracy of previous efforts. These unique analysis features include:

- ***Custom profiles***. The analysis has developed custom climbing and descent profiles based on radar altitude data, rather than using default profiles built into INM. This results in more accurate aircraft thrust calculations, which in turn affects an aircraft's noise emissions.
- ***Daily weather data***. Noise calculations have used average weather conditions for each day to determine aircraft performance and sound propagation.
- ***Hill effect adjustment***. Due to discrepancies between noise monitor data and INM calculations in the Orient Heights area close to the Airport, adjustments have been included to improve the accuracy of calculations in areas with direct line-of-sight exposure to the airfield.

13 U.S. Code, 2006 Edition, Supplement 3, Title 49 – Transportation Subtitle VII – Aviation Programs Part A – Air Commerce and Safety, Subpart II, Economic Regulation, Chapter 417 - Operations or Carriers, Subchapter III - Regional Air Service Incentive Program, Sec. 41762 – Definitions – defines RJ air carrier service to be aircraft with a maximum of 75 seats. Therefore, this report categorizes aircraft with 70-75 seats and below as RJ and aircraft with 90 seats and higher aircraft as air carrier (Note: there are no types with 75 to 90 seats).

14 AEDT 2A was released in 2013 and replaced the NIRS model for airspace analysis. AEDT 2B replaces, AEDT 2A, INM and EDMS.

- ***Over water adjustment***. The INM calculations assume that noise is absorbed as it propagates over ground. However, Logan Airport is mostly surrounded by water, which reflects rather than absorbs the sound. This results in higher noise levels in areas near the Airport. An adjustment has been used that allows the INM to assume higher aircraft noise emissions when they are close to the ground.

In transitioning from INM to AEDT, Massport has investigated how to implement these adjustments in the new software. At the same time, Massport has coordinated with FAA regarding approval of any adjustments proposed. While the Massachusetts state EDR/ESPR process does not require FAA approval, Massport wishes to perform analysis to FAA standards. Massport has held numerous meetings with FAA since the release of AEDT to get approval for adjustments to AEDT. The final set of formal request memoranda from Massport to FAA, and FAA's responses, are presented at the end of Chapter 6, *Noise Abatement* and the original request and response memoranda are presented at the beginning of this appendix. The following is a summary of the measures proposed to address the adjustments previously implemented in INM, and FAA's response.

- ***Altitude control codes***. This feature of AEDT performs a similar function to the custom profiles used previously, using altitude data to more accurately calculate aircraft thrust levels. Since this is a capability built into AEDT, **FAA approval is implicit** and was not requested.
- ***Aircraft weight adjustment***. It has been determined that aircraft takeoff weights, based on Department of Transportation T-100 data, do not always match the weight assumptions made by AEDT. Consequently, an adjustment has been made to more accurately represent takeoff weight, and therefore aircraft thrust during takeoff. **FAA concurs with this approach**.
- ***Annual weather***. AEDT by default uses 30-year average weather for the Airport. Massport has proposed using an annual average for the year under study to better capture year-to-year variations in weather.[15] **FAA concurs with this approach**.
- ***Hill effects***. Massport has proposed including the adjustments previously used in INM. **FAA does not concur with this approach**. There are ongoing research studies to develop modifications to the AEDT model and FAA recommends waiting until those methods are available.
- ***Over water adjustment***. Massport explored other options including the existing INM adjustment method. Massport proposed including the adjustments previously used in INM. **FAA does not concur with this approach**. There are ongoing research studies to develop modifications to the AEDT model and FAA recommends waiting until those methods are available.

Massport will continue to work with FAA to address these issues and to incorporate enhancements to AEDT as they become available.

At this time, FAA has approved adjustments for annual average weather and aircraft weight correction, but disapproved adjustments for over-water effects and elevated terrain line-of-sight exposure. Massport has performed an AEDT analysis for 2016 using only FAA-approved adjustments.

15 Daily weather is currently not an option in AEDT modeling inputs, however Massport will continue to request that FAA allow for such an option.

Table H-1a 2015 Annual Modeled Operations

		Arrivals		Departures		
INM Type	**Group**	**Day**	**Night**	**Day**	**Night**	**Total**
Commercial Jet Operations						
74720B	Heavy Jet A	1	0	0	1	2
747400	Heavy Jet A	1,260	33	862	431	2,586
7478	Heavy Jet A	156	0	150	5	311
A340-211	Heavy Jet A	564	6	191	379	1,139
A340-642	Heavy Jet A	350	0	230	120	701
767300	Heavy Jet B	976	489	824	641	2,931
767400	Heavy Jet B	282	3	252	33	570
767CF6	Heavy Jet B	69	7	49	27	151
767JT9	Heavy Jet B	95	28	19	104	245
777200	Heavy Jet B	583	110	578	116	1,387
7773ER	Heavy Jet B	581	66	129	518	1,293
7878R	Heavy Jet B	870	0	747	123	1,739
A300-622R	Heavy Jet B	182	448	314	316	1,259
A310-304	Heavy Jet B	240	18	58	200	517
A330-301	Heavy Jet B	1,399	9	1,050	359	2,817
A330-343	Heavy Jet B	553	7	395	165	1,119
DC1010	Heavy Jet B	217	186	218	185	806
DC1030	Heavy Jet B	64	50	53	60	227
MD11GE	Heavy Jet B	32	9	27	15	82
MD11PW	Heavy Jet B	12	12	9	15	48
717200	Light Jet A	3,814	656	3,892	579	8,942
727EM2	Light Jet A	0	2	2	0	4
MD9025	Light Jet A	1,129	114	1,172	72	2,487
MD9028	Light Jet A	554	44	569	30	1,197
737300	Light Jet B	1,963	353	1,939	377	4,633
7373B2	Light Jet B	127	27	128	26	308
737400	Light Jet B	27	14	26	15	82
737500	Light Jet B	0	0	0	0	0
737700	Light Jet B	6,690	2,432	7,468	1,657	18,247
737800	Light Jet B	13,986	5,609	16,305	3,289	39,188
757300	Light Jet B	558	290	615	233	1,696
757PW	Light Jet B	2,193	550	2,392	352	5,487
757RR	Light Jet B	2,677	473	2,670	480	6,300
A319-131	Light Jet B	9,100	2,030	9,717	1,413	22,260
A320-211	Light Jet B	3,809	1,085	4,255	639	9,788
A320-232	Light Jet B	16,664	5,833	19,778	2,719	44,994
A321-232	Light Jet B	2,704	877	2,975	607	7,163
EMB190	Light Jet B	27,031	3,582	26,711	3,908	61,232
EMB195	Light Jet B	1,720	198	1,732	186	3,836
MD82	Light Jet B	15	0	15	0	30

Table H-1a	2015 Annual Modeled Operations (Continued)					
		Arrivals		**Departures**		
INM Type	**Group**	**Day**	**Night**	**Day**	**Night**	**Total**
Commercial Jet Operations						
MD83	Light Jet B	992	33	974	51	2,049
CL600	Light Jet B	2	0	2	0	4
CL601	RJ	4,713	266	4,805	176	9,960
CNA680	RJ	1	3	4	0	9
CRJ9-ER	RJ	3,650	192	3,510	331	7,683
CRJ9-LR	RJ	1,610	75	1,509	176	3,369
EMB145	RJ	114	1	114	1	229
EMB14L	RJ	2,124	14	2,088	49	4,275
EMB170	RJ	2,458	111	2,445	124	5,138
EMB175	RJ	3,744	54	3,695	103	7,595
F10062	RJ	9	0	9	0	17
GV	RJ	1	0	1	0	1
LEAR35	RJ	14	1	13	2	30
Commercial Jets Subtotal		**122,677**	**26,398**	**127,682**	**21,403**	**298,160**
Commercial Non-Jet Operations						
BEC58P	Non-jet	17,650	308	17,864	172	35,994
CNA208	Non-jet	227	0	222	5	454
DHC8	Non-jet	970	2	960	13	1,944
DHC830	Non-jet	2,081	150	2,002	229	4,463
DO228	Non-jet	1	0	1	0	2
SF340	Non-jet	1,873	0	1,875	0	3,747
Commercial Non-Jet Operations Subtotal		**22,801**	**461**	**22,923**	**419**	**46,604**
Commercial Aircraft Total		**145,479**	**26,858**	**150,605**	**21,822**	**344,764**
General Aviation Operations						
74720B	Heavy Jet A	2	2	2	2	8
777200	Heavy Jet B	1	0	1	0	2
A330-301	Heavy Jet B	3	0	2	1	6
DC93LW	Light Jet A	0	1	1	0	2
737700	Light Jet B	12	2	12	1	27
757PW	Light Jet B	10	0	6	4	21
757RR	Light Jet B	3	3	4	1	10
A319-131	Light Jet B	3	2	5	0	10
EMB195	Light Jet B	0	2	1	1	4
MD81	Light Jet B	4	3	4	3	14
MD83	Light Jet B	6	2	7	1	17
1900D	Non-jet	2	0	2	0	4

Table H-1a 2015 Annual Modeled Operations (Continued)

		Arrivals		Departures		
INM Type	**Group**	**Day**	**Night**	**Day**	**Night**	**Total**
General Aviation Operations						
BEC58P	Non-jet	480	22	476	26	1,004
CNA172	Non-jet	84	0	83	1	168
CNA182	Non-jet	59	0	59	0	117
CNA206	Non-jet	97	0	95	2	193
CNA208	Non-jet	1,140	109	1,172	82	2,503
CNA20T	Non-jet	3	1	4	0	8
CNA441	Non-jet	566	76	563	80	1,285
DHC8	Non-jet	7	0	7	0	14
DHC830	Non-jet	12	1	12	1	27
DO228	Non-jet	430	38	442	29	938
DO328	Non-jet	8	0	8	0	16
GASEPF	Non-jet	8	0	8	0	16
GASEPV	Non-jet	512	36	526	23	1,096
PA28	Non-jet	20	2	23	0	45
PA30	Non-jet	1	0	1	0	2
PA31	Non-jet	54	3	54	2	113
SF340	Non-jet	14	0	14	0	29
CIT3	RJ	48	4	50	2	105
CL600	RJ	1,079	83	1,079	85	2,326
CL601	RJ	1,067	84	1,092	61	2,304
CNA500	RJ	72	6	70	8	156
CNA510	RJ	53	7	50	10	121
CNA525C	RJ	346	36	340	42	764
CNA55B	RJ	212	22	215	19	466
CNA560E	RJ	526	44	539	31	1,140
CNA560U	RJ	137	8	129	15	289
GV	RJ	737	68	748	57	1,610
IA1125	RJ	91	2	90	3	187
LEAR25	RJ	6	0	5	1	12
LEAR35	RJ	1,349	127	1,355	120	2,950
MU3001	RJ	553	42	554	41	1,191
General Aviation Total		**12,951**	**1,122**	**13,110**	**983**	**28,166**
Grand Total		**158,430**	**27,980**	**163,715**	**22,805**	**372,930**

Source: HMMH, 2016.
Notes: BEC58P is the AEDT substitution for the Cessna 402.
The CRJ9-ER in the RJ category is the CRJ700 aircraft
Annual operations modeled in the 2015 Annual contour.
Some totals may not match due to rounding.

Table H-1b	2016 Annual Modeled Operations					
		Arrivals		**Departures**		
INM Type	**Group**	**Day**	**Night**	**Day**	**Night**	**Total**
Commercial Jet Operations						
747400	HJA	877	19	491	405	1,792
7478	HJA	274	1	260	15	549
A340-211	HJA	125	0	51	75	250
A340-642	HJA	502	1	400	103	1,006
A380-841	HJA	1	1	2	0	4
A380-861	HJA	1	0	1	0	2
767300	HJB	1,051	582	979	653	3,264
767400	HJB	484	2	480	6	972
767CF6	HJB	70	1	67	3	141
767JT9	HJB	27	0	19	8	54
777200	HJB	775	123	789	109	1,797
777300	HJB	1	0	1	0	2
7773ER	HJB	962	102	452	611	2,127
7878R	HJB	1,224	33	1,141	117	2,515
A300-622R	HJB	188	478	328	338	1,331
A310-304	HJB	190	36	91	135	451
A330-301	HJB	2,354	27	1,654	728	4,764
A330-343	HJB	1,062	7	549	520	2,138
DC1010	HJB	256	188	268	175	886
DC1030	HJB	74	48	74	47	242
MD11GE	HJB	37	20	27	29	113
MD11PW	HJB	22	12	18	16	68
717200	LJA	2,798	413	2,866	345	6,421
727EM2	LJA	1	0	1	0	1
MD9025	LJA	1,064	161	1,064	161	2,450
MD9028	LJA	538	72	536	74	1,220
737300	LJB	1,792	324	1,829	287	4,234
7373B2	LJB	112	25	120	18	274
737400	LJB	11	5	8	8	32
737500	LJB	1	0	1	0	2
737700	LJB	7,262	2,260	7,908	1,613	19,042
737800	LJB	16,665	6,965	19,675	3,954	47,259
737N17	LJB	1	0	1	0	2
757300	LJB	815	436	1,008	242	2,501
757PW	LJB	1,516	547	1,583	480	4,125
757RR	LJB	2,353	481	2,411	423	5,668
A319-131	LJB	9,753	1,822	10,077	1,499	23,151
A320-211	LJB	3,879	900	4,417	362	9,557
A320-232	LJB	17,885	6,357	20,796	3,446	48,484
A321-232	LJB	5,299	1,552	5,750	1,101	13,702
EMB190	LJB	26,332	2,907	25,460	3,779	58,477

Table H-1b 2016 Annual Modeled Operations (Continued)

		Arrivals		Departures		
INM Type	**Group**	**Day**	**Night**	**Day**	**Night**	**Total**
Commercial Jet Operations						
EMB195	LJB	1,608	124	1,549	183	3,464
MD82	LJB	6	0	6	0	12
MD83	LJB	827	135	810	152	1,924
CL601	RJ	5,418	167	5,153	432	11,170
CRJ9-ER	RJ	4,442	282	4,243	481	9,448
CRJ9-LR	RJ	1,446	61	1,390	118	3,014
EMB145	RJ	80	1	81	0	162
EMB14L	RJ	1,516	16	1,514	18	3,064
EMB170	RJ	1,691	218	1,750	159	3,818
EMB175	RJ	2,654	330	2,641	342	5,966
GV	RJ	13	1	12	1	27
LEAR35	RJ	34	11	36	9	89
Commercial Jets Subtotal		**128,363**	**28,250**	**132,832**	**23,782**	**313,227**
Commercial Non-Jet Operations						
BEC58P	Non-Jet	17,559	438	17,787	210	35,994
CNA208	Non-Jet	198	0	198	0	396
CNA441	Non-Jet	4	0	2	2	8
DHC8	Non-Jet	427	4	415	16	861
DHC830	Non-Jet	2,980	146	2,850	275	6,251
SF340	Non-Jet	1,827	4	1,826	5	3,662
Commercial Non-Jet Operations Subtotal		**22,995**	**592**	**23,078**	**509**	**47,173**
Commercial Aircraft Total		**151,358**	**28,842**	**155,911**	**24,290**	**360,401**
General Aviation Operations						
A109	Helicopter	29	1	28	2	59
B206B3	Helicopter	35	5	29	11	80
B206L	Helicopter	23	3	20	7	53
B212	Helicopter	14	0	11	3	29
B222	Helicopter	2	1	1	2	6
B407	Helicopter	25	2	24	4	55
B427	Helicopter	2	0	2	0	4
B429	Helicopter	9	0	7	2	18
BO105	Helicopter	7	0	7	0	14
EC130	Helicopter	14	0	13	1	29
H500D	Helicopter	6	1	6	1	14
R44	Helicopter	13	2	15	0	31
S61	Helicopter	6	0	6	0	12
S70	Helicopter	16	3	17	2	39
S76	Helicopter	61	9	59	10	139

Table H-1b 2016 Annual Modeled Operations (Continued)

		Arrivals		Departures		
INM Type	**Group**	**Day**	**Night**	**Day**	**Night**	**Total**
General Aviation Operations						
SA330J	Helicopter	108	4	105	7	223
SA350D	Helicopter	6	1	5	2	14
SA355F	Helicopter	26	0	21	4	51
SC300C	Helicopter	4	1	5	0	10
A340-211	HJA	2	0	1	1	4
A340-642	HJA	2	1	1	2	6
777200	HJB	0	2	0	2	4
DC93LW	LJA	2	0	0	2	4
737400	LJB	13	7	12	7	39
737700	LJB	16	3	16	3	39
737800	LJB	1	1	2	0	4
737N17	LJB	1	0	1	0	2
757PW	LJB	3	2	3	2	10
757RR	LJB	9	0	7	2	18
A319-131	LJB	2	7	8	1	18
A320-211	LJB	0	2	0	2	4
A320-232	LJB	1	1	2	0	4
EMB190	LJB	2	0	1	1	4
MD81	LJB	2	2	1	2	6
MD83	LJB	5	6	8	2	21
1900D	Non-Jet	2	0	2	0	4
BEC58P	Non-Jet	512	28	511	29	1,079
CNA172	Non-Jet	90	2	89	2	182
CNA182	Non-Jet	68	0	66	1	135
CNA206	Non-Jet	82	0	81	1	164
CNA208	Non-Jet	1,952	205	2,076	81	4,313
CNA20T	Non-Jet	9	0	9	0	18
CNA441	Non-Jet	409	56	398	67	930
DHC6	Non-Jet	1	0	1	0	2
DO228	Non-Jet	618	41	621	38	1,317
DO328	Non-Jet	3	0	3	0	6
GASEPF	Non-Jet	5	0	5	0	10
GASEPV	Non-Jet	406	18	406	18	848
PA28	Non-Jet	50	0	50	0	100
PA31	Non-Jet	72	1	71	2	145
PA42	Non-Jet	0	2	2	0	4
SD330	Non-Jet	15	0	15	0	31
CIT3	RJ	40	2	39	3	84
CL600	RJ	1,219	93	1,224	88	2,624
CL601	RJ	1,094	106	1,140	59	2,398
CNA500	RJ	44	5	46	3	98

Table H-1b 2016 Annual Modeled Operations (Continued)

		Arrivals		Departures		
INM Type	**Group**	**Day**	**Night**	**Day**	**Night**	**Total**
General Aviation Operations						
CNA510	RJ	39	11	39	11	100
CNA525C	RJ	360	43	351	51	805
CNA55B	RJ	159	15	152	22	348
CNA560E	RJ	605	67	628	45	1,346
CNA560U	RJ	118	9	116	11	254
CNA560XL	RJ	890	74	914	49	1,927
CNA680	RJ	441	22	430	33	926
CNA750	RJ	497	54	523	28	1,102
ECLIPSE500	RJ	16	0	16	0	33
EMB145	RJ	37	4	39	2	82
EMB14L	RJ	1	0	0	1	2
F10062	RJ	489	48	490	46	1,073
GIV	RJ	605	50	584	71	1,309
GV	RJ	884	98	904	78	1,964
IA1125	RJ	101	5	103	3	213
LEAR35	RJ	1,197	135	1,221	110	2,662
MU3001	RJ	522	32	523	31	1,108
General Aviation Total		**14,118**	**1,292**	**14,337**	**1,074**	**30,821**
Grand Total		**165,477**	**30,133**	**170,248**	**25,364**	**391,222**

Source: HMMH, 2017.
Notes: BEC58P is the AEDT substitution for the Cessna 402.
The CRJ9-ER in the RJ category is the CRJ700 aircraft
Annual operations modeled in the 2016 Annual contour.
Some totals may not match due to rounding.

Runway Use

RC for AEDT™ determines which runway was used by each aircraft type and whether it was a daytime or nighttime operation directly from the radar data. The summary of daytime and nighttime runway usages presented here is broken into six representative aircraft groups listed below with example aircraft types from each group, grouped in this format to allow comparison with prior years (see **Tables H-2a** and **H-2b**):

- Heavy Jet A – B747s, A340s, DC-8s;
- Heavy Jet B – B767s, B777s, A300s, A310s, A330s, DC-10s, L1011s, MD-11s;
- Light Jet A – B717s, B727s, DC-9s, F100s, MD-90s;
- Light Jet B – B737s, B757s, A319s, A320s, B-146s, MD-80s, E190;
- Regional Jet (RJ) – E135, E145, E170, CRJ2, CRJ7, CRJ9, J328 and Corporate Jets; and
- Turboprops and Piston Aircraft (non-jets).

Table H-2a shows the runway use that was used to model the 2015 noise conditions. **Table H-2b** shows the runway used to model the 2016 noise conditions. As described above, turbojet aircraft in the table were grouped into different categories for reporting purposes. Because the 2015 contours developed using RealContours™ and 2016 contours developed using RC for AEDT™ reflect the individual use of the runways by each INM aircraft type, they accurately represent Logan Airport's noisiest aircraft by modeling them on the actual runways that they used during the year. The modeled runway use for each particular aircraft type may be different from the overall group runway use presented in **Table H-2a** for 2015 and **Table H-2b** for 2016.

Comparing **Table H-2b** (2016) with the similar **Table H-2a** (2015) in this *2016 EDR*, the largest change was a 20 percent decrease in the share of nighttime arrivals of the Heavy Jet B group on Runway 33L. These operations shifted to Runway 22L and Runway 27, with increases of 14 percent and 9 percent, respectively.

Departures on Runway 33L showed the broadest increases. Heavy Jet departures from Runway 33L had increased shares for both nighttime and daytime operations. The share of operations on Runway 22R fell broadly across all aircraft groups, with the largest decrease among Heavy Jet A aircraft.

Table H-2a 2015 Modeled Runway Use Percentages by Aircraft Group

	Heavy Jet A		Heavy Jet B		Light Jet A		Light Jet B		Regional Jets		Turboprops	
ARRIVALS												
Runway	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**
04L	0.12	0.00	0.37	0.14	4.38	0.48	4.01	0.24	12.19	0.88	26.03	6.79
04R	38.22	30.12	37.97	20.64	30.88	21.47	32.03	19.12	24.13	22.54	10.80	18.79
09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
15L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00
15R	2.02	2.12	1.61	0.76	1.51	2.29	1.39	2.27	1.22	2.11	0.77	1.21
22L	31.61	29.97	26.64	30.61	17.68	37.07	21.87	35.96	22.52	35.94	29.28	38.31
22R	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.00	3.65	0.97
27	9.80	0.00	17.55	3.06	30.12	19.26	26.60	12.85	22.50	12.41	7.66	7.61
32	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00	3.95	0.13	8.19	0.27
33L	18.23	37.80	15.85	44.79	15.40	19.43	13.22	29.57	13.43	25.99	8.43	21.20
33R	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	4.68	4.85
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
DEPARTURES												
Runway	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**
04L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	19.75	12.19
04R	9.75	7.64	12.31	4.25	1.15	1.25	5.14	3.99	0.94	1.47	4.29	3.61
09	9.02	4.93	15.79	12.78	34.53	25.65	29.41	18.12	36.19	22.01	16.78	11.35
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00
15L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
15R	26.50	34.25	11.91	23.69	1.64	8.72	3.02	18.45	1.05	15.88	2.29	10.86
22L	11.42	4.33	9.34	3.09	0.32	0.15	2.61	1.66	0.06	0.50	0.81	0.32
22R	22.96	23.00	24.48	26.77	33.76	31.56	32.52	25.63	35.84	30.20	35.20	33.48
27	1.09	0.22	6.46	1.59	16.00	27.38	11.55	19.68	11.79	17.18	5.12	7.31
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
33L	19.27	25.63	19.71	27.83	12.59	5.28	15.76	12.45	14.12	12.76	15.53	20.88
33R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Total	100.0	100.0	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Massport, HMMH, 2016.
Notes: Night for noise modeling is defined as 10:00 PM to 7:00 AM.
Nighttime runway restrictions are from 11:00 PM to 6:00 AM.
Values may not add to 100 percent due to rounding.

Table H-2b 2016 Modeled Runway Use by Aircraft Group

	Heavy Jet A		Heavy Jet B		Light Jet A		Light Jet B		Regional Jets		Turboprops	
ARRIVALS												
Runway	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**
04L	0.06	0.00	0.09	0.00	3.31	0.15	3.15	0.15	10.31	0.67	21.94	1.16
04R	42.33	30.39	39.39	22.67	34.49	19.77	34.35	20.51	27.01	23.83	16.74	21.14
09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00
15R	0.95	0.00	0.89	0.96	0.62	1.10	0.80	0.55	0.59	0.74	0.50	0.18
22L	31.07	43.55	25.75	27.69	20.99	30.81	22.67	30.33	23.51	32.15	26.39	37.01
22R	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.02	0.00	3.03	3.12
27	5.46	8.68	18.07	3.97	27.61	28.16	25.91	19.35	19.68	20.03	5.14	10.61
32	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00	5.25	0.00	11.97	0.00
33L	20.13	17.37	15.80	44.70	12.96	20.00	11.99	29.11	13.63	22.58	7.77	20.63
33R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.32	6.15
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
DEPARTURES												
Runway	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**	**Day (%)**	**Night (%)**
04L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.85	11.48
04R	9.16	6.87	10.78	4.05	0.65	1.92	4.94	3.61	0.58	0.71	4.60	4.85
09	8.67	6.70	16.72	11.23	37.90	25.24	31.28	20.45	37.50	25.94	19.94	8.58
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
15L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15R	31.30	33.68	15.41	25.89	2.30	8.66	3.99	15.82	2.25	14.83	2.28	12.62
22L	7.82	3.02	6.57	2.53	0.29	1.04	2.48	2.42	0.17	0.55	0.35	0.54
22R	17.75	18.08	21.50	19.38	29.18	29.58	27.25	22.31	29.80	26.17	29.67	34.91
27	0.58	0.33	6.21	0.94	14.94	29.55	11.73	22.52	12.60	20.82	5.32	7.32
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.14
33L	24.72	31.32	22.80	35.99	14.75	4.01	18.33	12.87	17.09	10.97	18.82	19.56
33R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00
Total	100.0	100.0	100.00	100.0	100.00	100.00	100.00	100.00	100.00	100.00	100.0	100.0

Source: Massport, HMMH, 2017.
Notes: Night for noise modeling is defined as 10:00 PM to 7:00 AM.
Nighttime runway restrictions are from 11:00 PM to 6:00 AM.
Values may not add to 100 percent due to rounding.

While **Tables H-2a** and **H-2b** present runway use by aircraft groups, **Tables H-3a** and **H-3b** present the total runway use (jets and non-jets) by runway and time of day. The first section of the table displays the operations by runway and time of day for an average day. The second section displays the same information for the year and the last section displays the percent that each runway is used by operation type and time of day. **Table H-3a** shows that on an average day in 2015 Runway 22R had the most departures (165.6 per day) and Runway 4R had the most arrivals (134.85 per day). At night, Runway 22R had the most departures (16.5 per night) but Runway 22L had the most arrivals (27.42 per night). **Table H-3b** shows that on an average day in 2016, Runway 9 had the most departures (151.7 per day) and Runway 4R had the most arrivals (155.2 per day). At night, Runway 22R had the most departures (15.7 per night) but Runway 22L had the most arrivals (25.1 per night).

Table H-3a Summary of Jet and Non-Jet Aircraft Runway Use: 2015

	Runway												
	4L	**4R**	**9**	**14[2]**	**15L**	**15R**	**22L**	**22R**	**27**	**32**	**33L**	**33R**	**Total**
2015 Daily Operations													
Dep Day	14.3	19.7	126.1	0.1	0.0	13.4	9.3	149.0	46.9	0.0	69.4	0.1	448.4
Dep Night	0.2	2.4	10.8	0.0	0.0	11.9	1.1	16.5	10.2	0.0	9.4	0.0	62.5
Arr Day	38.7	118.9	0.1	0.0	0.3	5.6	101.6	2.8	96.6	11.1	55.2	3.4	434.2
Arr Night	0.4	14.9	0.0	0.0	0.0	1.7	27.4	0.0	9.5	0.0	22.7	0.1	76.7
Total Daily Operations	53.6	156.0	137.0	0.1	0.3	32.5	139.4	168.4	163.2	11.1	156.7	3.5	1,021.7
2015 Annual Operations													
Dep Day	5,228	7,200	46,028	24	6	4,878	3,405	54,397	17,134	0	25,343	17	163,660
Dep Night	82	889	3,927	0	0	4,347	406	6,022	3,713	0	3,418	0	22,804
Arr Day	14,135	43,410	33	0	106	2,027	37,065	1,033	35,259	4,038	20,146	1,233	158,485
Arr Night	126	5,445	0	0	0	602	10,007	8	3456	4	8,295	36	27,979
Total Annual Operations	19,571	56,944	49,988	24	112	11,854	50,884	61,460	59,562	4,042	57,201	1,287	372,930
2015 Percentage Operations													
Dep Day	3%	4%	28%	<1%	<1%	3%	2%	33%	10%	<1%	15%	<1%	100%
Dep Night	<1%	4%	17%	<1%	<1%	19%	2%	26%	16%	<1%	15%	<1%	100%
Arr Day	9%	27%	<1%	<1%	<1%	1%	23%	1%	22%	3%	13%	1%	100%
Arr Night	<1%	19%	<1%	<1%	<1%	2%	36%	<1%	12%	<1%	30%	<1%	100%

Source: Massport Noise Office and HMMH 2017.

Notes: The data reflect actual percentages of aircraft operations on each runway end. They should not be confused with effective runway use, which is used by the Preferential Runway Advisory System (PRAS) to derive recommendations for use of a particular runway.

Runway 14-32 is unidirectional.

Values may not add to 100 percent due to rounding.

Table H-3b Summary of Jet and Non-Jet Aircraft Runway Use: 2016

	Runway												
	4L	**4R**	**9**	**142**	**15L**	**15R**	**22L**	**22R**	**27**	**32**	**33L**	**33R**	**Total**
2016 Daily Operations													
Dep Day	14.2	20.3	138.4	0.0	0.0	18.8	8.9	129.0	49.2	0.0	85.2	0.1	464.1
Dep Night	0.2	2.4	13.2	0.0	0.0	12.0	1.5	15.7	12.8	0.0	11.3	0.0	69.1
Arr Day	32.6	138.1	0.0	0.0	0.1	3.2	106.6	2.3	94.2	15.7	53.5	4.7	451.0
Arr Night	0.2	17.2	0.0	0.0	0.0	0.5	25.1	0.1	15.2	0.0	23.9	0.2	82.2
Total Daily Operations	47.1	177.9	151.7	0.0	0.1	34.5	142.1	147.0	171.4	15.8	173.9	4.9	1,066.5
2016 Annual Operations													
Dep Day	5,179	7,413	50,669	8	0	6,897	3,268	47,196	18,019	14	31,175	25	169,865
Dep Night	86	880	4,836	0	0	4,375	555	5,743	4,699	1	4,130	0	25,305
Arr Day	11,921	50,529	0	0	53	1,185	39,010	837	34,462	5,752	19,597	1,723	165,069
Arr Night	62	6,278	0	0	0	176	9,191	30	5,555	0	8,750	58	30100
Total Annual Operations	17,247	65,101	55,505	8	53	12,633	52,024	53,806	62,736	5,768	63,653	1,806	390,339
2016 Percentage Operations													
Dep Day	3%	4%	30%	<1%	<1%	4%	2%	28%	11%	<1%	18%	<1%	100%
Dep Night	<1%	3%	19%	<1%	<1%	17%	2%	23%	19%	<1%	16%	<1%	100%
Arr Day	7%	31%	<1%	<1%	<1%	1%	24%	1%	21%	3%	12%	1%	100%
Arr Night	<1%	21%	<1%	<1%	<1%	1%	31%	<1%	18%	<1%	29%	<1%	100%

Source: Massport Noise Office and HMMH 2017.
Notes: The data reflect actual percentages of aircraft operations on each runway end. They should not be confused with effective runway use, which is used by the Preferential Runway Advisory System (PRAS) to derive recommendations for use of a particular runway.
Runway 14-32 is unidirectional.
Values may not add to 100 percent due to rounding.

Runway use can also be presented in terms of percent of total operations as shown in **Table H-4** for 2015 and 2016. **Tables H-2a** and **H-2b** total the runway use by aircraft group and time of day. **Tables H-3a** and **H-3b** total the runway use by operation type and time of day. **Table H-4** presents the 2015 and 2016 runway use for all operations which use Logan Airport.

In 2015, Runway 22R was the runway with the highest activity (primarily jet departures) with Runway 27 a very close second (primarily by jet arrivals). For 2016, Runway 04R was the most active, with primarily jet arrivals, followed by Runway 33L, with a mix of arrivals and departures

Each year, non-jet activity makes up approximately 7 percent of the arrivals and 7 percent of the departures at Logan Airport.

Table H-4 Total 2015 and 2016 Modeled Runway Use by All Operations

	Jet Arrivals		Non-Jet Arrivals		Jet Departures		Non-Jet Departures		All Operations
	Day	**Night**	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**	
Runway				**2015 Operations**					
4L	2.0%	<0.1%	1.8%	<0.1%	<0.1%	<0.1%	1.4%	<0.1%	5.2%
4R	10.9%	1.4%	0.8%	<0.1%	1.6%	<0.1%	<0.1%	<0.1%	15.3%
9	0.0%	0.0%	<0.1%	0.0%	11.2%	1.0%	1.2%	<0.1%	13.4%
14	0.0%	0.0%	<0.1%	0.0%	<0.1%	0.0%	<0.1%	0.0%	<0.1%
15L	0.0%	0.0%	<0.1%	0.0%	0.0%	0.0%	<0.1%	0.0%	<0.1%
15R	<0.1%	<0.1%	<0.1%	<0.1%	1.1%	1.1%	<0.1%	<0.1%	3.2%
22L	7.9%	2.6%	2.1%	<0.1%	0.9%	<0.1%	<0.1%	<0.1%	13.6%
22R	<0.1%	<0.1%	<0.1%	<0.1%	12.1%	1.6%	2.5%	<0.1%	16.5%
27	8.9%	0.9%	0.5%	<0.1%	4.2%	1.0%	<0.1%	<0.1%	16.0%
32	0.5%	<0.1%	0.6%	<0.1%	0.0%	0.0%	<0.1%	0.0%	1.1%
33L	4.8%	2.2%	0.6%	<0.1%	5.7%	0.9%	1.1%	<0.1%	15.3%
33R	<0.1%	0.0%	<0.1%	<0.1%	0.0%	0.0%	<0.1%	0.0%	<0.1%
Total	35.4%	7.3%	7.1%	<0.1%	36.8%	5.9%	7.1%	<0.1%	100.0%
Runway				**2016 Operations**					
4L	1.5%	<0.1%	1.5%	<0.1%	0.0%	0.0%	1.3%	<0.1%	4.4%
4R	11.8%	1.6%	1.2%	<0.1%	1.6%	<0.1%	<0.1%	<0.1%	16.7%
9	0.0%	0.0%	0.0%	0.0%	11.6%	1.2%	1.4%	<0.1%	14.2%
14	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	<0.1%	0.0%	<0.1%
15L	0.0%	0.0%	<0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	<0.1%
15R	<0.1%	<0.1%	<0.1%	<0.1%	1.6%	1.1%	<0.1%	<0.1%	3.2%
22L	8.1%	2.3%	1.8%	<0.1%	0.8%	<0.1%	<0.1%	<0.1%	13.3%
22R	<0.1%	0.0%	<0.1%	<0.1%	10.0%	1.4%	2.1%	<0.1%	13.8%
27	8.5%	1.4%	<0.1%	<0.1%	4.2%	1.2%	<0.1%	<0.1%	16.1%
32	0.6%	0.0%	0.8%	0.0%	0.0%	0.0%	<0.1%	<0.1%	1.5%
33L	4.5%	2.2%	0.5%	<0.1%	6.7%	1.0%	1.3%	<0.1%	16.3%
33R	0.0%	0.0%	<0.1%	<0.1%	0.0%	0.0%	<0.1%	0.0%	<0.1%
Total	35.3%	7.5%	7.0%	<0.1%	36.5%	6.3%	7.0%	<0.1%	100.0%

Flight Tracks

RC for AEDT™ converts each radar track to an AEDT model track and then models the scaled aircraft operation on that track. This method keeps the lateral and vertical dispersion of the aircraft types consistent with the radar data, and ensures that anomalies in the departure paths are captured in the RC for AEDT™ system. **Table H-5** lists the number of flight tracks used in the RealContours™ modeling system for 2015 and the RC for AEDT™ modeling system for 2016. A sample of flight tracks from 2016 are displayed in **Figures 6-3** through **6-9** in Chapter 6, *Noise Abatement*.

Table H-5 Total Count of Flight Tracks Modeled in RealContours™ (2015) and RC for AEDT™ (2016)

	Runway											
	4L	**4R**	**9**	**14**	**15L**	**15R**	**22L**	**22R**	**27**	**32**	**33L**	**33R**
2015												
Departures	5,310	8,089	49,955	24	6	9,225	3,811	60,419	20,847	0	28,761	17
Arrivals	14,261	48,855	33	0	106	2,629	47,073	1,041	38,715	4,042	28,440	1,269
2016												
Departures	5,265	8,294	55,505	8	0	11,272	3,823	52,939	22,719	15	35,305	25
Arrivals	11,982	56,807	0	0	53	1,362	48,201	867	40,017	5,752	28,347	1,782

Source: HMMH, 2016/2017; Harris NOMS data.

Fleet Mix

Table H-6 summarizes the numbers of operations by categories of aircraft operating at Logan Airport from 1990 through 2016. Operations are summarized by operator category (commercial/GA), aircraft category, and day or night operation (night defined as 10:00 PM to 7:00 AM, consistent with the definition of DNL). General aviation (GA) operations were not included in the noise modeling prior to 1998 and commercial jet operations were not separated until 1999.

Table H-6 Modeled Daily Operations by Commercial and General Aviation (GA) Aircraft – 1990 to 2016

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Commercial Aircraft											
Stage 2 Jets[2]	Day	312.4		228.89	203.34	189.4	156.9	132.4	108.46	84.93	83.3
	Night	19.99		13.13	7.44	10.1	5.5	4.79	7.75	5.92	6.66
	Total	**332.39**		**242.02**	**210.78**	**199.5**	**162.4**	**137.19**	**116.21**	**90.85**	**89.96**
Stage 3 Jets	Day	288.89		384.49	418.99	425.7	429.4	439.81	505.08	541.43	597.28
	Night	57.25		58.29	65.47	62.8	69	80.16	85.06	95.54	98.59
	Total	**346.14**		**442.78**	**484.46**	**488.5**	**498.4**	**519.97**	**590.14**	**636.97**	**695.87**
Air Carrier Jets	Day	N/A[3]		N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	569.18
	Night	N/A[3]		N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	96.21
	Total	**N/A[3]**		**N/A[3]**	**N/A[3]**	**N/A[3]**	**N/A[3]**	**N/A[3]**	**N/A[3]**	**N/A[3]**	**665.39**
Regional Jets	Day	N/A[3]		N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	28.1
	Night	N/A[3]		NA[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	N/A[3]	2.38
	Total	**N/A[3]**		**N/A[3]**	**N/A[3]**	**N/A[3]**	**N/A[3]**	**N/A[3]**	**N/A[3]**	**N/A[3]**	**30.48**
Non-jets	Day	444.41		411.84	598.16	541.97	526.85	505.31	514.7	552.56	448.82
	Night	11.72		69.32	46.84	13.59	11.14	13.73	27.27	21.86	16.63
	Total	**456.13**		**481.16**	**645**	**555.56**	**537.99**	**519.04**	**541.97**	**574.42**	**465.45**
Total Commercial Operations											
Operations	Day	1045.7		1025.22	1220.49	1157.07	1113.15	1077.52	1128.24	1178.92	1129.9
	Night	88.96		140.74	119.75	86.49	85.64	98.68	120.08	123.32	121.88
	Total	**1134.7**		**1,166**	**1340.2**	**1243.6**	**1198.79**	**1176.2**	**1248.3**	**1302.2**	**1251.8**
GA Aircraft											
Stage 2 Jets[2]	Day	N/A[4]		N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	5.25	9.89
	Night	N/A[4]		N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	0.4	0.74
	Total	**N/A[4]**		**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**5.65**	**10.63**
Stage 3 Jets	Day	N/A[4]		N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	30.54	48.46
	Night	N/A[4]		N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	4.21	6.55
	Total	**N/A[4]**		**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**34.75**	**55.01**
Non-jets	Day	N/A[4]		N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	37.29	19.36
	Night	N/A[4]		N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	16.28	18.89
	Total	**N/A[4]**		**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**53.57**	**38.25**
Total GA Operations											
Operations	Day	N/A[4]		N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	73.08	77.71
	Night	N/A[4]		N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	20.89	26.17
	Total	**NA[4]**		**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**N/A[4]**	**93.97**	**103.88**
Overall totals											
Total	Day	1045.7		1025.22	1220.49	1157.07	1113.15	1077.52	1128.24	1252	1207.61
	Night	88.96		140.74	119.75	86.49	85.64	98.68	120.08	144.21	148.05
	Total[3]	**1134.66**		**1165.96**	**1340.24**	**1243.56**	**1198.79**	**1176.2**	**1248.32**	**1396.21**	**1355.66**

Table H-6 Modeled Daily Operations by Commercial and General Aviation (GA) Aircraft – 1990 to 2016 (Continued)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Commercial Aircraft											
Stage 2 Jets[2]	Day	5.13	1.18	0.05	0.08	0.03	0.05	0.03	0.03	0.01	0
	Night	0.26	0.05	0	0	0.01	0.01	0	0.01	0.01	0
	Total	**5.39**	**1.23**	**0.05**	**0.08**	**0.05**	**0.06**	**0.03**	**0.04**	**0.02**	**0**
Stage 3 Jets	Day	727.09	756.24	740.75	717.85	772.39	765.76	767.55	748.13	699.39	668..32
	Night	103.66	109.77	97.04	92.69	113.24	113.66	114.81	118.29	114.3	103.11
	Total	**830.75**	**866.01**	**837.79**	**810.54**	**885.63**	**879.42**	**882.36**	**866.42**	**813.69**	**771.43**
Air Carrier Jets	Day	648.95	569.99	500.7	461.06	518.96	505.48	490.63	472.39	443.15	421.51
	Night	99.79	101.3	83.52	72.69	89.24	91.99	92.71	96.28	89.89	82.19
	Total	**748.74**	**671.29**	**584.22**	**533.75**	**608.2**	**597.47**	**583.34**	**568.66**	**533.04**	**503.7**
Regional Jets	Day	78.14	186.25	240.05	256.8	253.43	260.34	276.95	275.77	256.24	246.81
	Night	3.87	8.47	13.52	19.99	24	21.68	22.11	22.03	24.4	20.93
	Total	82.01	194.72	253.57	276.79	277.43	282.01	299.06	297.8	280.64	267.73
Non-jets	Day	409.62	317.62	165.45	135.18	133.24	148.77	140.81	145.27	132.52	136.45
	Night	21.58	10.97	3.45	2.41	3.03	3.02	3.26	3.47	4	5.54
	Total	**431.2**	**328.58**	**168.89**	**137.59**	**136.28**	**151.79**	**144.07**	**148.73**	**136.52**	**141.99**
Total Commercial Operations											
Operations	Day	1141.84	1075.04	906.25	853.1	905.66	914.59	908.41	893.43	831.92	804.77
	Night	125.51	120.79	100.49	95.1	116.29	116.68	118.09	121.77	118.31	108.65
	Total	**1267.4**	**1195.82**	**1006.7**	**948.2**	**1022**	**1031.27**	**1026.51**	**1015.2**	**950.23**	**913.42**
GA Aircraft											
Stage 2 Jets[2]	Day	7.29	5.15	3.65	2.84	0.94	2.29	1.9	1.24	0.36	0.09
	Night	0.64	0.5	0.41	0.26	0.14	0.25	0.17	0.19	0.03	0.01
	Total	**7.93**	**5.65**	**4.08**	**3.1**	**1.08**	**2.54**	**2.07**	**1.43**	**0.38**	**0.1**
Stage 3 Jets	Day	40.08	34.23	37.83	46.21	53.72	58.84	61.08	54.82	43.98	22.31
	Night	3.21	3.28	6.42	6.98	8.37	9.33	6.57	6.39	4.52	2.28
	Total	**43.29**	**37.51**	**44.25**	**53.19**	**62.09**	**68.16**	**67.65**	**61.21**	**48.49**	**23.59**
Non-jets	Day	34.57	37.31	17.36	17.81	16.95	14	15.05	11.98	15.13	8.19
	Night	1.83	1.92	4.45	4.4	5.2	4.75	1.39	3.61	1.08	0.74
	Total	**36.4**	**39.23**	**21.81**	**22.21**	**22.14**	**18.75**	**16.44**	**15.58**	**16.2**	**8.93**
Total GA Operations											
Operations	Day	81.94	76.68	58.84	66.88	71.6	75.12	78.03	68.04	59.46	30.46
	Night	5.68	5.71	11.29	11.64	13.71	14.33	8.13	10.19	5.62	3.08
	Total	87.62	82.39	70.13	78.52	85.31	89.46	86.15	78.22	65.05	33.54
Overall totals											
Total	Day	1223.78	1151.72	965.09	919.98	977.27	989.71	986.43	961.46	891.39	834.33
	Night	131.19	126.5	111.78	106.74	130	131.02	126.22	131.96	123.93	111.7
	Total[3]	**1354.9**	**1278.2**	**1076.8**	**1026.7**	**1107.2**	**1120.7**	**1112.6**	**1093.4**	**1015.3**	**946.03**

Table H-6 Modeled Daily Operations by Commercial and General Aviation (GA) Aircraft – 1990 to 2016 (Continued)

		2010	2011	2012	2013	2014	2015	2016	Change 2015 to 2016
Commercial Aircraft									
Stage 2 Jets[2]	Day	0.01	0.01	0.01	0.01	0	0	0.00	0.00
	Night	0.01	0	0	0	0	0	0.00	0.00
	Total	**0.02**	**0.01**	**0.01**	**0.01**	**0**	**0**	**0.00**	**0.00**
Stage 3 Jets	Day	674.25	684.19	649.22	667.65	670	685.92	715.35	29.43
	Night	107.92	109.38	106.55	115.91	123.6	130.96	142.53	11.57
	Total	**782.17**	**793.57**	**755.77**	**783.56**	**793.61**	**816.88**	**857.88**	**41.01**
Air Carrier Jets	Day	521.64	571.03	530.76	546.27	556.59	585.55	622.15	36.59
	Night	93.98	99.17	98.68	107.17	115.84	126.36	135.30	8.94
	Totals	**615.62**	**670.2**	**629.44**	**653.44**	**672.43**	**711.92**	**757.45**	**45.53**
Regional Jets	Day	152.61	113.16	118.46	121.38	113.41	100.36	93.20	-7.16
	Night	13.94	10.21	7.87	8.74	7.77	4.6	7.23	2.63
	Total	**166.55**	**123.37**	**126.33**	**130.12**	**121.18**	**104.96**	**100.43**	**-4.53**
Non-jets	Day	138.53	135.18	133.92	132.33	128.45	125.27	125.88	0.61
	Night	5.21	4.73	3.06	3.21	2.28	2.41	3.01	0.60
	Total	**143.74**	**139.91**	**136.98**	**135.54**	**130.73**	**127.68**	**128.89**	**1.21**
Total Commercial Operations									
Operations	Day	812.78	819.39	783.14	799.99	798.45	811.19	841.23	30.04
	Night	113.13	114.11	109.62	119.12	125.88	133.37	145.54	12.17
	Total	**925.91**	**933.5**	**892.76**	**919.12**	**924.33**	**944.56**	**986.77**	**42.21**
GA Aircraft									
Stage 2 Jets[2]	Day	0.27	0.08	0.25	0.31	0	0.28	0.01	-0.27
	Night	0.04	0	0.04	0.02	0	0.02	0.00	-0.02
	Total	**0.3**	**0.08**	**0.29**	**0.33**	**0**	**0.3**	**0.01**	**-0.29**
State 3 Jets	Day	27.8	52.51	52.93	51.21	52.64	51.82	53.97	2.16
	Night	3.21	5.35	7.2	5.1	4.65	4.28	4.85	0.56
	Total	**31.01**	**57.87**	**60.13**	**56.31**	**57.29**	**56.1**	**58.82**	**2.72**
Non-jets	Day	8.19	18.18	15.16	13.06	13.95	19.31	23.77	4.46
	Night	0.72	1.29	1.29	1.15	1.13	1.46	1.62	0.16
	Total	**8.92**	**19.48**	**16.45**	**14.22**	**15.08**	**20.77**	**25.38**	**4.62**
Total GA Operations									
Operations	Day	36.26	70.78	68.35	64.58	66.59	71.4	77.75	6.34
	Night	3.97	6.65	8.52	6.28	5.78	5.77	6.47	0.70
	Total	**40.22**	**77.43**	**76.86**	**70.85**	**72.37**	**77.17**	**84.21**	**7.05**
Overall Totals									
Total	Day	849.03	890.16	851.49	864.57	865.05	882.59	918.98	36.39
	Night	117.1	120.76	118.13	125.4	131.66	139.14	152.00	12.87
	Total[3]	**966.13**	**1,010.92**	**969.61**	**989.97**	**996.7**	**1,021.73**	**1,070.98**	**49.26**

Source: Massport's Noise Monitoring System and Revenue Office numbers, HMMH 2017.
Notes: Data from 1991 not available.
1 Includes scheduled and unscheduled operations.
2 Stage 2 aircraft have not been permitted to operate effective December 31, 2015.
3 RJ operations were not tracked separately prior to 1999.
4 Totals prior to 1998 do not include GA operations.
5 The definition of RJ for the EDR changed between 2009 and 2010. A RJ in 2010 is a jet in commercial service with less than 80 seats. Prior to 2010, a RJ was a jet in commercial service with 100 seats or less.

Commercial Jet Aircraft by Part 36 Stage Category

FAA categorizes jet aircraft currently operating at Logan Airport into three groups: Stage 2, Stage 3, and Stage 4. As described in Chapter 6, *Noise Abatement*, the designation refers to a noise classification specified in Federal Aviation Regulation Part 36 that sets noise emission standards at three measurement locations – takeoff, landing, and sideline – based on an aircraft's maximum certificated weight. The heavier the aircraft, the more noise it is permitted to make within limits. Aircraft are allowed to be recertificated to the higher standard when modifications are made to the aircraft engine or design. Because of the substantial differences in noise between Stage 2, recertificated Stage 3, Stage 3, and Stage 4 aircraft, Massport tracks operations by these separate categories to follow their trends. **Table H-7** shows the percentage of commercial jet operations by stage category from 1999 through 2016. One of the most significant changes occurring after the economic downturn in 2001 was the almost immediate retirement of the re-certificated aircraft from airlines' fleets due to their high operating costs. This type of accelerated retirement is not as prevalent during the 2008 to 2009 economic downturn since it is no longer the major airlines operating these aircraft. However, these aircraft still have high operating costs and are being replaced wherever possible.

Table H-7 Percentage of Commercial Jet Operations by Part 36 Stage Category – 1999 to 2016

	Stage 4 Requirements[3]	Certificated Stage 3[1]	Recertificated Stage 3[2]	Stage 2	Total
1999	N/A	70.0%	21.0%	9.0%	100%
2000	N/A	75.0%	24.0%	1.0%	100%
2001	N/A	86.3%	13.6%	0.1%	100%
2002	N/A	92.8%	7.2%	0.0%	100%
2003	N/A	95.8%	4.1%	0.0%	100%
2004	N/A	97.8%	2.2%	0.0%	100%
2005	N/A	98.0%	2.0%	0.0%	100%
2006	N/A	98.6%	1.4%	0.0%	100%
2007	N/A	98.9%	1.1%	0.0%	100%
2008	N/A	99.1%	0.9%	0.0%	100%
2009	N/A	99.1%	0.9%	0.0%	100%
2010	93.2%[4]	98.9%	1.1%	0.0%	100%
2011	95.5%[4]	99.5%	0.5%	0.0%	100%
2012	95.8%[4]	99.9%	0.1%	0.0%	100%
2013	97.4%[4]	100.0%	<0.1%	<0.1%	100%
2014	97.4%[4]	100.0%	<0.1%	0.0%	100%
2015	96.7%[4]	100.0%	<0.1%	<0.1%	100%
2016	97.0%	100.0%	<0.1%	0.0%	100%

Source: Massport and FAA radar data.

Notes:

1 New Stage 3 aircraft are aircraft originally manufactured as a certified Stage 3 aircraft under Federal Regulation Part 36.

2 Recertificated Stage 3 aircraft are aircraft originally manufactured as a certified Stage 1 or 2 aircraft under Federal Regulation Part 36, which either have been treated with hushkits or have been re-engineered to meet Stage 3 requirements.

3 Aircraft that meet Stage 4 requirements are aircraft that are certificated Stage 4 or would qualify if recertificated. Certificated Stage 4 aircraft were not available until 2006 and the level of aircraft that meet Stage 4 requirements has not been determined prior to 2010.

4 All aircraft listed as meeting Stage 4 requirements are also listed as Stage 3 aircraft.

Nighttime Operations

Massport tracks flights that operate between the broader DNL nighttime periods of 10:00 PM to 7:00 AM, when each flight is penalized 10 dB in calculations of noise exposure. **Table H-8** shows this nighttime activity by different groups of aircraft. Nighttime flights by commercial jet operators increased by 8.9 percent in 2016, following increases of 6.6 percent in 2014 and 5.7 percent in 2015. Commercial non-jet operations increased by 24.9 percent following increases of 29 percent in 2014 and 5.7 percent in 2015. GA traffic increased by 12.3 percent in 2016, following decreases of 8 percent in 2014 and 0.2 percent in 2015. Overall, nighttime operations at Logan Airport increased by 9.3 percent in 2016, after increasing 5.0 percent in 2014 and 5.7 percent in 2015. The majority of nighttime operations (between 10:00 PM and 7:00 AM) occurred either before midnight or after 5:00 AM.

Table H-8 Modeled Nighttime Operations at Logan Airport – 1990 to 2016

	Commercial Jets	Commercial Non-Jets	General Aviation	Total
1990	77.24	11.72	N/A	88.96
1991	NA	NA	N/A	N/A
1992	71.42	69.32	N/A	140.74
1993	72.91	46.84	N/A	119.75
1994	72.90	13.59	N/A	86.49
1995	74.50	11.14	N/A	85.64
1996	84.95	13.73	N/A	98.68
1997	92.81	27.27	N/A	120.08
1998	101.46	21.86	20.89[1]	144.21
1999	105.25	16.63	26.17	148.05
2000	103.92	21.58	5.68	131.19
2001	109.82	10.97	5.71	126.50
2002	97.04	3.45	11.29	111.78
2003	92.69	2.41	11.64	106.74
2004	113.26	3.03	13.71	130.00
2005	113.67	3.02	14.33	131.02
2006	114.81	3.26	8.13	126.22
2007	118.30	3.47	10.19	131.96
2008	114.31	4.00	5.62	123.93
2009	103.05	5.56	3.08	111.70
2010	107.93	5.21	3.97	117.10
2011	109.38	4.73	6.65	120.76
2012	106.55	3.06	8.52	118.13
2013	115.91	3.21	6.28	125.40
2014	123.60	2.28	5.78	131.66
2015	130.96	2.41	5.77	139.14
2016	142.55	3.01	6.48	152.05
Change (2015 to 2016)	**11.59**	**0.6**	**0.71**	**12.91**
Percent Change	**8.85%**	**25.10%**	**12.38%**	**9.28%**

Source: Massport, HMMH, 2017.
Note: N/A = Not available.
1 Previously reported as N/A. 1998 was the first year GA operations were reported and included in the total nighttime operations.

Jet Runway Use

Table H-9 presents a summary of runway use by jets. Since 2009, the radar data have been analyzed with Massport's Harris Noise and Operational Monitoring System (NOMS), data from 2001 through 2008 was compiled with Massport's PreFlight™ software. PreFlight™ was an analysis package used to compile fleet, day/night splits, and runway use information from radar data. Data prior to 2001 were derived from Massport's original noise monitoring system, supplemented with field records. Note that Logan Airport Noise Rules prevent arrivals to Runway 22R and departures from Runway 4L by jet aircraft.

Table H-9 Summary of Jet Aircraft Runway Use – 1990 to 2016

Runway	4L	4R	9	14[1]	15R	22L	22R	27	32[1]	33L
1990										
Departures	0%[2]	3%	21%	N/A	10%	2%	36%	20%	N/A	7%
Arrivals	1%	25%	0%	N/A	2%	14%	0%	28%	N/A	29%
1992[2]										
Departures	0%	6%	31%	N/A	7%	2%	38%	10%	N/A	6%
Arrivals	1%	37%	0%	N/A	3%	12%	0%	30%	N/A	17%
1993										
Departures	0%	9%	33%	N/A	7%	3%	40%	4%	N/A	4%
Arrivals	2%	44%	0%	N/A	1%	11%	0%	28%	N/A	15%
1994										
Departures	0%	9%	33%	N/A	4%	3%	32%	12%	N/A	5%
Arrivals	3%	42%	0%	N/A	1%	8%	0%	27%	N/A	19%
1995										
Departures	0%	8%	36%	N/A	5%	5%	29%	11%	N/A	5%
Arrivals	3%	41%	0%	N/A	2%	8%	0%	27%	N/A	17%
1996										
Departures	0%	8%	32%	N/A	5%	6%	33%	12%	N/A	5%
Arrivals	2%	38%	0%	N/A	2%	11%	0%	29%	N/A	18%
1997										
Departures	0%	8%	30%	N/A	5%	6%	31%	15%	N/A	5%
Arrivals	2%	36%	0%	N/A	2%	9%	0%	30%	N/A	20%
1998										
Departures	0%	8%	35%	N/A	6%	5%	28%	14%	N/A	5%
Arrivals	2%	41%	0%	N/A	2%	7%	0%	28%	N/A	19%
1999										
Departures	0%	8%	31%	N/A	5%	4%	30%	15%	N/A	6%
Arrivals	3%	37%	0%	N/A	2%	10%	0%	28%	N/A	21%
2000										
Departures	0%	8%	35%	N/A	4%	3%	30%	15%	N/A	6%
Arrivals	4%	40%	0%	N/A	1%	7%	0%	28%	N/A	20%

Table H-9 Summary of Jet Aircraft Runway Use – 1990 to 2016 (Continued)

Runway	4L	4R	9	14[1]	15R	22L	22R	27	32[1]	33L
2001										
Departures	0%	7%	34%	N/A	4%	3%	35%	12%	N/A	5%
Arrivals	5%	36%	0%	N/A	1%	8%	0%	32%	N/A	18%
2002										
Departures	0%	4%	31%	N/A	6%	3%	35%	16%	N/A	6%
Arrivals	6%	31%	0%	N/A	1%	12%	0%	30%	N/A	21%
2003										
Departures	0%	4%	33%	N/A	7%	2%	34%	14%	N/A	6%
Arrivals	7%	33%	0%	N/A	1%	14%	0%	28%	N/A	18%
2004										
Departures	0%	5%	34%	N/A	10%	4%	24%	18%	N/A	6%
Arrivals	6%	34%	0%	N/A	1%	12%	0%	24%	N/A	23%
2005										
Departures	0%	5%	36%	N/A	7%	1%	31%	13%	N/A	7%
Arrivals	8%	33%	0%	N/A	1%	11%	0%	29%	N/A	17%
2006										
Departures	0%	4%	33%	0%	3%	1%	40%	13%	-	6%
Arrivals	7%	29%	0%	-	1%	14%	0%	33%	0.2%	16%
2007										
Departures	0%	5%	31%	0%	4%	1%	33%	7%	-	19%
Arrivals	5%	31%	0%	-	1%	15%	0%	36%	2%	11%
2008										
Departures	0%	6%	33%	<1%	3%	<1%	36%	6%	-	16%
Arrivals	6%	30%	-	-	2%	17%	-	33%	2%	11%
2009										
Departures	0%	7%	32%[3]	0%	3%	2%	34%	6%[3]	-	16%
Arrivals	7%	31%	-	-	3%	17%	0%	30%[3]	1%	11%
2010										
Departures	0%	4%	28%	<1%	8%	2%	31%	10%	-	17%
Arrivals	5%	28%	-	-	1%	15%	0%	32%	1%	16%
2011										
Departures	0%	6%	36%	<1%	5%[4]	2%	36%	7%	-	7%[4]
Arrivals	7%	37%	-	-	<1%[4]	16%	0%	28%	1%	11%[4]
2012										
Departures	0%	6%	33%	<1%	5%[4]	3%	38%	6%	-	9%[4]
Arrivals	6%	34%	-	-	1%[4]	16%	0%	33%	<1%	9%[4]
2013										
Departures	<1%	5%	30%	<1%	5%	2%	35%	12%	-	12%
Arrivals	6%	29%	-	-	1%	16%	<1%	32%	1%	15%

Table H-9 Summary of Jet Aircraft Runway Use – 1990 to 2016 (Continued)

Runway	4L	4R	9	14[1]	15R	22L	22R	27	32[1]	33L
2014										
Departures	0%	5%	31%	<1%	5%	2%	28%	13%	-	17%
Arrivals	5%	30%	0%	-	2%	25%	<1%	21%	1%	16%
2015										
Departures	<1%	4%	29%	<1%	5%	2%	32%	12%	-	15%
Arrivals	5%	29%	0%	-	2%	25%	<1%	23%	1%	16%
2016										
Departures	0%	4%	30%	0%	6%	2%	27%	13%	-	18%
Arrivals	4%	31%	0%	-	1%	24%	<1%	23%	1%	16%

Source: HMMH 2017, Massport Noise Office.

Notes: The data reflect actual percentages of jet aircraft operations on each runway end. They should not be confused with effective runway use, which is used by the PRAS to derive recommendations for use of a particular runway. Effective runway percentages include a factor of 10 applied to nighttime operations so that use of a runway at night more closely reflects its effect on total noise exposure.

Jet aircraft are not able to use Runway 15L or 33R due to its length of only 2,557 feet.

Values may not add to 100 percent due to rounding.

N/A = Not available.

1 Runway 14-32 opened in late November 2006. (Runway 14-32 is unidirectional with no arrivals to Runway 14 and no departures from Runway 32).

2 The *1990 Final Generic Environmental Impact Report* was published and submitted to the Secretary of Environmental Affairs in July 1993. It included modeled operations and resulting noise contours for 1987, 1990, and a 1996-forecast year. The *1993 Annual Update* published in July 1994 included operations and contours for 1992 and 1993. 1991 data are not available.

3 Runway 9-27 had extended weekend closings for resurfacing during 2009.

4 Runway 15R-33L was closed for 3 months in 2011 and in 2012.

Annual Model Results and Status of Mitigation Programs

Noise Exposed Population

Table H-10 presents the noise-exposed population by community through 2016. This table includes population within the DNL 60 to 65 dB contours, although a DNL of 65 dB is the federally-defined noise criterion used as a guideline to identify when residential land use is considered incompatible with aircraft noise.

Table H-10 Noise-Exposed Population by Community

Year	Census Data	80+ dB DNL	75+ dB DNL	70-75 dB DNL	65-70 dB DNL[1]	Total (65+)	60-65 dB DNL
BOSTON[2]							
1990	1980	0	0	1,778	28,970	30,748	N/A
1992	1980	0	0	800	4,316	5,116	N/A
1993	1980	0	0	264	2,820	3,084	N/A
1994	1990	0	106	265	7,698	8,069	30,895
1995	1990	0	106	851	8,815	9,772	33,765
1996	1990	0	106	374	8,775	9,255	40,992
1997	1990	0	106	719	13,857	14,682	54,804
1998	1990	0	58	580	10,877	11,515	52,201
1999[3]	1990	0	58	364	11,632	12,054	45,948
2000[3]	1990	0	58	183	7,880	8,121	32,474
2000[3]	2000	0	0	234	9,014	9,248	35,785
2001[3]	2000	0	0	315	6,515	6,700	27,778
2002[3]	2000	0	0	132	2,625	2,757	23,225
2003[3]	2000	0	0	164	1,730	1,894	21,763
2004[3,4]	2000	0	65	192	4,142	4,399	24,473
2005[3,4]	2000	0	65	104	2,020	2,189	17,661
2006[4]	2000	0	65	99	1,054	1,218	14,866
2007	2000	0	0	169	4,094	4,263	21,446
2008	2000	0	5	0	3,487	3,492	18,890
2009	2000	0	5	67	937	1,009	12,284
2010	2000	0	0	67	644	711	14,900
2010	2010	0	0	0	689	689	17,646
2011	2010	0	0	0	331	331	11,600
2012	2010	0	0	0	439	439	12,076
2012	2010	0	0	0	421	421	11,037
2013	2010	0	0	0	612	612	14,835
2014	2010	0	0	34	4,151	4,185	23,343
2015	2010	0	0	110	7,225	7,365	32,309
2016[5]	2010	0	0	0	4,031	4,031	20,806
CHELSEA							
1990	1980	0	0	0	4,813	4,813	N/A
1992	1980	0	0	0	3,952	3,952	N/A
1993	1980	0	0	0	0	0	N/A
1994	1990	0	0	0	0	0	8,510
1995	1990	0	0	0	95	95	9,750
1996	1990	0	0	0	0	0	8,744
1997	1990	0	0	0	0	0	10,001
1998	1990	0	0	0	0	0	9,222

Table H-10 Noise-Exposed Population by Community (Continued)

Year	Census Data	80+ dB DNL	75+ dB DNL	70-75 dB DNL	65-70 dB DNL[1]	Total (65+)	60-65 dB DNL
CHELSEA							
1999	1990	0	0	0	95	95	9,249
2000	1990	0	0	0	0	0	5,622
2000	2000	0	0	0	0	0	7,361
2001	2000	0	0	0	0	0	4,508
2002	2000	0	0	0	0	0	3,995
2003	2000	0	0	0	0	0	3,591
2004[4]	2000	0	0	0	0	0	7,756
2005[4]	2000	0	0	0	0	0	5,772
2006[4]	2000	0	0	0	0	0	2,477
2007	2000	0	0	0	0	0	9,774
2008	2000	0	0	0	0	0	7,793
2009	2000	0	0	0	0	0	5,462
2010	2000	0	0	0	0	0	4,880
2010	2010	0	0	0	0	0	4,897
2011	2010	0	0	0	0	0	0
2012	2010	0	0	0	0	0	0
2012	2010	0	0	0	0	0	0
2013	2010	0	0	0	0	0	3,485
2014	2010	0	0	0	0	0	9,236
2015	2010	0	0	0	0	0	0
2016[5]	2010	0	0	0	0	0	12,110
EVERETT							
1990	1980	0	0	0	0	0	N/A
1992	1980	0	0	0	0	0	N/A
1993	1980	0	0	0	0	0	N/A
1994	1990	0	0	0	0	0	0
1995	1990	0	0	0	0	0	0
1996	1990	0	0	0	0	0	0
1997	1990	0	0	0	0	0	0
1998	1990	0	0	0	0	0	0
1999[3]	1990	0	0	0	0	0	0
2000[3]	1990	0	0	0	0	0	0
2000[3]	2000	0	0	0	0	0	0
2001[3]	2000	0	0	0	0	0	0
2002[3]	2000	0	0	0	0	0	0
2003[3]	2000	0	0	0	0	0	0
2004[3,4]	2000	0	0	0	0	0	0
2005[3,4]	2000	0	0	0	0	0	0
2006[4]	2000	0	0	0	0	0	0
2007	2000	0	0	0	0	0	0
2008	2000	0	0	0	0	0	0
2009	2000	0	0	0	0	0	0
2010	2000	0	0	0	0	0	0
2010	2010	0	0	0	0	0	0
2011	2010	0	0	0	0	0	0
2012	2010	0	0	0	0	0	0
2012	2010	0	0	0	0	0	0
2013	2010	0	0	0	0	0	0

Table H-10 Noise-Exposed Population by Community (Continued)

Year	Census Data	80+ dB DNL	75+ dB DNL	70-75 dB DNL	65-70 dB DNL[1]	Total (65+)	60-65 dB DNL
EVERETT							
2014	2010	0	0	0	0	0	0
2015	2010	0	0	0	0	0	0
2016[5]	2010	0	0	0	0	0	0
MEDFORD							
1990	1980	0	0	0	0	0	N/A
1992	1980	0	0	0	0	0	N/A
1993	1980	0	0	0	0	0	N/A
1994	1990	0	0	0	0	0	0
1995	1990	0	0	0	0	0	0
1996	1990	0	0	0	0	0	0
1997	1990	0	0	0	0	0	0
1998	1990	0	0	0	0	0	0
1999	1990	0	0	0	0	0	0
2000	1990	0	0	0	0	0	0
2000	2000	0	0	0	0	0	0
2001	2000	0	0	0	0	0	0
2002	2000	0	0	0	0	0	0
2003	2000	0	0	0	0	0	0
2004[4]	2000	0	0	0	0	0	0
2005[4]	2000	0	0	0	0	0	0
2006[4]	2000	0	0	0	0	0	0
2007	2000	0	0	0	0	0	0
2008	2000	0	0	0	0	0	0
2009	2000	0	0	0	0	0	0
2010	2000	0	0	0	0	0	0
2010	2010	0	0	0	0	0	0
2011	2010	0	0	0	0	0	0
2012	2010	0	0	0	0	0	0
2012	2010	0	0	0	0	0	0
2013	2010	0	0	0	0	0	0
2014	2010	0	0	0	0	0	0
2015	2010	0	0	0	0	0	0
2016[5]	2010	0	0	0	0	0	0
QUINCY							
1990	1980	0	0	0	0	0	N/A
1992	1980	0	0	0	0	0	N/A
1993	1980	0	0	0	0	0	N/A
1994	1990	0	0	0	0	0	0
1995	1990	0	0	0	0	0	0
1996	1990	0	0	0	0	0	0
1997	1990	0	0	0	0	0	0
1998	1990	0	0	0	0	0	0
1999	1990	0	0	0	0	0	0
2000	1990	0	0	0	0	0	0
2000	2000	0	0	0	0	0	636
2001	2000	0	0	0	0	0	610
2002	2000	0	0	0	0	0	610
2003	2000	0	0	0	0	0	610

Table H-10 Noise-Exposed Population by Community (Continued)

Year	Census Data	80+ dB DNL	75+ dB DNL	70-75 dB DNL	65-70 dB DNL[1]	Total (65+)	60-65 dB DNL
QUINCY							
2004[4]	2000	0	0	0	0	0	610
2005[4]	2000	0	0	0	0	0	610
2006[4]	2000	0	0	0	0	0	610
2007	2000	0	0	0	0	0	0
2008	2000	0	0	0	0	0	0
2009	2000	0	0	0	0	0	0
2010	2000	0	0	0	0	0	0
2010	2010	0	0	0	0	0	0
2011	2010	0	0	0	0	0	0
2012	2010	0	0	0	0	0	0
2012	2010	0	0	0	0	0	0
2013	2010	0	0	0	0	0	0
2014	2010	0	0	0	0	0	0
2015	2010	0	0	0	0	0	0
2016[5]	2010	0	0	0	0	0	0
REVERE							
1990	1980	0	0	0	4,274	4,274	N/A
1992	1980	0	0	0	3,848	3,848	N/A
1993	1980	0	0	0	4,617	4,617	N/A
1994	1990	0	0	0	3,569	3,569	2,099
1995	1990	0	0	0	3,364	3,364	2,304
1996	1990	0	0	172	3,292	3,464	2,505
1997	1990	0	0	0	3,293	3,293	2,047
1998	1990	0	0	0	3,168	3,168	2,132
1999	1990	0	0	128	3,165	3,293	2,047
2000	1990	0	0	0	2,552	2,552	2,386
2000	2000	0	0	0	2,496	2,496	3,100
2001	2000	0	0	0	2,496	2,496	3,100
2002	2000	0	0	0	2,822	2,822	2,399
2003	2000	0	0	0	2,994	2,994	2,227
2004[4]	2000	0	0	82	2,969	3,051	2,678
2005[4]	2000	0	0	82	2,540	2,622	2,731
2006[4]	2000	0	0	82	2,540	2,622	2,698
2007	2000	0	0	0	2,450	2,450	2,853
2008	2000	0	0	0	2,434	2,434	1,802
2009	2000	0	0	0	2,512	2,512	1,452
2010	2000	0	0	0	2,505	2,505	1,385
2010	2010	0	0	0	2,413	2,413	2,473
2011	2010	0	0	0	2,547	2,547	3,123
2012	2010	0	0	0	2,772	2,772	3,236
2012	2010	0	0	0	2,762	2,762	3,191
2013	2010	0	0	0	2,505	2,505	2,791
2014	2010	0	0	0	2,832	2,832	3,829
2015	2010	0	0	0	3,789	3,789	3,385
2016[5]	2010	0	0	0	2,376	2,376	3,508
WINTHROP							
1990	1980	0	676	1,211	2,420	4,307	N/A
1992	1980	0	626	1,146	2,488	4,262	N/A

Table H-10 Noise-Exposed Population by Community (Continued)							
Year	**Census Data**	**80+ dB DNL**	**75+ dB DNL**	**70-75 dB DNL**	**65-70 dB DNL[1]**	**Total (65+)**	**60-65 dB DNL**
WINTHROP							
1993	1980	0	648	1,211	1,773	3,632	N/A
1994	1990	0	417	1,343	5,154	6,914	7,512
1995	1990	0	482	1,611	5,757	7,850	7,077
1996	1990	0	417	1,376	5,930	7,723	7,333
1997	1990	0	417	1,659	6,386	8,462	6,839
1998	1990	0	519	1,522	6,572	8,613	6,507
1999	1990	0	353	1,408	5,946	7,707	7,135
2000	1990	0	277	991	5,240	6,508	7,296
2000	2000	0	247	1,070	4,684	6,001	7,776
2001	2000	0	244	683	4,123	5,050	8,104
2002	2000	0	2	481	2,247	2,730	7,921
2003	2000	0	0	339	1,956	2,295	7,386
2004[4]	2000	0	2	337	1,649	1,988	6,508
2005[4]	2000	0	39	347	1,280	1,666	6,353
2006[4]	2000	0	39	416	1,288	1,743	6,845
2007	2000	0	0	247	1,139	1,386	6,749
2008	2000	0	0	244	1,409	1,653	6,547
2009	2000	0	0	171	643	814	4,221
2010	2000	0	0	131	523	654	3,960
2010	2010	0	0	130	598	728	3,720
2011	2010	0	0	130	939	1069	4,303
2012	2010	0	0	200	1,325	1,525	5,564
2012	2010	0	0	200	1,186	1,386	5,305
2013	2010	0	0	130	1,060	1,190	5,466
2014	2010	0	0	130	1,775	1,905	6,456
2015	2010	0	0	320	2,623	2,943	6,375
2016[5]	2010	0	0	130	913	1,403	5,062
All Communities							
1990	1980	0	676	2,989	40,477	44,142	NA
1992	1980	0	628	2,352	14,604	17,584	NA
1993	1980	0	648	1,475	9,210	11,333	NA
1994	1990	0	523	1,608	16,421	18,552	49,016
1995	1990	0	588	2,462	18,031	21,081	52,896
1996	1990	0	523	1,922	17,997	20,442	59,574
1997	1990	0	523	2,378	23,536	26,437	73,691
1998	1990	0	577	2,102	20,617	23,296	70,062
1999	1990	0	411	1,900	20,838	23,149	64,379
2000	1990	0	335	1,174	15,672	17,181	47,778
2000	2000	0	247	1,304	16,194	17,745	54,190
2001	2000	0	244	998	13,004	14,246	43,616
2002	2000	0	2	613	7,694	8,309	38,150
2003	2000	0	0	503	6,680	7,183	35,577
2004[4]	2000	0	67	611	8,760	9,438	41,975
2005[4]	2000	0	104	533	5,840	6,477	33,127
2006[4]	2000	0	104	597	4,882	5,583	27,496
2007(7.01)[4, 5]	2000	0	0	416	7,683	8,099	40,822
2008(7.0b)[4, 5]	2000	0	5	244	7,330	7,579	35,122

Table H-10 Noise-Exposed Population by Community (Continued)

Year	Census Data	80+ dB DNL	75+ dB DNL	70-75 dB DNL	65-70 dB DNL[1]	Total (65+)	60-65 dB DNL
All Communities							
2009	2000	0	5	238	4,092	4,335	23,419
2010	2000	0	0	198	3,672	3,870	25,125
2010	2010	0	0	130	3,700	3,830	28,736
2011	2010	0	0	130	3,817	3,947	19,026
2012	2010	0	0	200	4,536	4,736	20,876
2012(7.0d)[4, 5]	2010	0	0	200	4,369	4,569	19,533
2013(7.0d)[4, 5]	2010	0	0	130	4,177	4,307	26,577
2014(7.0d)[4, 5]	2010	0	0	164	8,758	8,922	42,864
2015	2010	0	0	430	13,667	14,097	52,748
2016[6]	2010	0	0	130	7,320	7,450	41,486

Source: Data prepared for Massport by HMMH 2017.
Notes: South End is included in Boston totals.
N/A Not available.
1 65 dB DNL is the federally-defined noise criterion.
2 Portions of Dorchester, East Boston, Roxbury, South Boston
3 Boston population by community changed in 1999 due to employment of more accurate hill effects methodology and reporting change.
4 All results from 2004 to 2015 are from the RealContours™ modeling system.
5 7.01, 7.0b, 7.0c, and 7.0d refer to INMv7.01, INMv7.0b, INMv7.0c, and INMv7.0d respectively. AEDT version 2cSP2 was used for 2016.
6 All results from 2016 are from AEDT using the RC for AEDT™ pre-processor

Residential Sound Insulation Program (RSIP)

In 2016, no new dwelling units received sound insulation from Massport, leaving totals of 5,467 residential buildings and 11,515 dwelling units that have been sound insulated since 1986 when the program was first implemented. **Table H-11** lists the yearly progress of this mitigation effort.

Following FAA's approval of model adjustments based on the effects of terrain (discussed in the *1999 ESPR*), Massport submitted, and the New England Region of FAA approved, a new sound insulation program. The revised contour, approved for a two-year period beginning in 1999, included dwelling units in East Boston, South Boston, and Winthrop that previously had not been eligible for insulation. Massport received notice of FAA funding for $5 million. Subsequently, Massport updated its program contour, first with the *2001 EDR* contour and more recently with the Logan Airside Improvements Project approved contour. These updates have allowed Massport to continue the program with additional funds every year since 1999. This latest update takes into account runway use changes due to the new Runway 14-32 which opened in late November 2006. This update expands the focus of the sound insulation program into Chelsea to satisfy the mitigation commitments made in the Airside Improvements Program Record of Decision (ROD). Massport has also utilized a program where they have contacted properties that are still eligible within the RSIP boundaries that had previously declined to participate. They have been offered a second chance to participate in the program.

Table H-11 Residential Sound Insulation Program (RSIP) Status (1986-2016)

Construction Year	Residential Buildings[1]	Dwelling Units[2]
1986	4	8
1987	43	51
1988	102	159
1989	94	133
1990	121	200
1991	175	360
1992	197	354
1993	318	654
1994	310	542
1995	372	753
1996	323	577
1997	364	808
1998	328	806
1999	330	718
2000	195	601
2001	260	278
2002	205	354
2003	230	468
2004	320	791
2005	314	471
2006	286	827
2007	160	548
2008	94	388
2009	111	287
2010	56	83
2011	62	114
2012[3]	0	0
2013	45	76
2014	48	106
2015	0	0
2016	0	0
Total	**5,467**	**11,515**

Source: Massport, 2017.
Notes:
1 Includes multiple units.
2 Individual units.
3 Federal funding was delayed in 2012

Table H-12 provides a list of all schools that have been treated under Massport's sound insulation program. To date, Massport has provided sound insulation to 36 schools at a cost of over $8 million.

Table H-12 Schools Treated Under Massport Sound Insulation Program

Boston:	
East Boston	**Winthrop**
East Boston High	Winthrop Jr. High School
St. Mary's Star of the Sea	E. B. Newton
St. Dominic Savio High	A. T. Cummings (Ctr.) School
St. Lazarus	3 Total Winthrop Schools
James Otis	
Samuel Adams	
Curtis Guild	**Revere**
Dante Alighieri	Beachmont School
P.J. Kennedy	1 Total Revere School
Donald McKay	
Hugh Roe O'Donnell	
E Boston Central Catholic	**Chelsea**
Manassah Bradley	Shurtleff School
13 East Boston Schools	Williams School
	St. Rose Elementary
South Boston	St. Stanislaus
St. Augustine	Chelsea High School
Cardinal Cushing	5 Total Chelsea Schools
Patrick Gavin	
St. Bridgid's	**36 Total Schools**
Oliver Hazard Perry	
Condon School	
6 South Boston Schools	
Roxbury and Dorchester	
Samuel Mason	
Dearborn Middle	
Ralph Waldo Emerson	
Lewis Middle	
Nathan Hale Elem.	
Phillis Wheatley Elem.	
Davis Ellis Elem.	
Henry L. Higginson	
8 Roxbury and Dorchester Schools	
27 Total Boston Schools	

Source: Massport, 2015.

Noise Complaints

Table H-13 presents a detailed list by community of the total complaints made in 2015 and 2016, which can be filed either on Massport's Noise Complaint Line, through a form on Massport's website or through the PublicVue flight track portal. The Noise Complaint Line provides individuals the ability to express their concerns about aviation noise (activities) or to ask questions regarding noise at Logan Airport. Callers ask a range of questions such as "Why is this runway in use?"; "What times do the planes stop flying?" and "Was that aircraft off-course?"

The Noise Abatement Office (NAO) staff documents noise line complaints by obtaining information from the caller about the nature of the complaint, time of the occurrence, location of caller's residence, and the activity that was disturbed. The NAO uses the collected information to determine the probable activity responsible for the complaint and writes a letter report to the complainant. The letter includes the original complaint, a response that identifies the activity responsible for the call (arrivals, departures, run-up, etc.), meteorological information at the time of the call (a major factor in aviation activities), runways in use at the time of the call, and a notice that FAA will receive a copy of the report.

In 2016, Massport received 38,053 noise complaints from 82 communities (**Figure H-13)**, an increase from 17,369 in 2015. The number of individual complainants increased at a much smaller rate, by 1,903 individuals in 2015 to 2,255 individuals in 2016, indicating that noise annoyance is growing among a concentrated population rather than spreading to a larger population. This is consistent with a recent survey of U.S. airports that finds noise complaints concentrated among relatively small numbers of complainants.[16] This research, completed by George Mason University, shows that a small number of people account for a disproportionately high share of the total number of noise complaints (the full article is included at the end of this appendix). Massport's website, http://www.massport.com/logan-airport/about-logan/noise-abatement/complaints/), provides for additional general questions and answers regarding the Noise Complaint Line.

16 Dourado, E. and Russell, R. October 2016. *Airport Noise NIMBYism: An Empirical Investigation.* Mercatus Center at George Mason University. https://www.mercatus.org/system/files/dourado-airport-noise-mop-v1.pdf. Accessed September 27 ,2017.

Figure H-13 Complaint line calls and callers by year

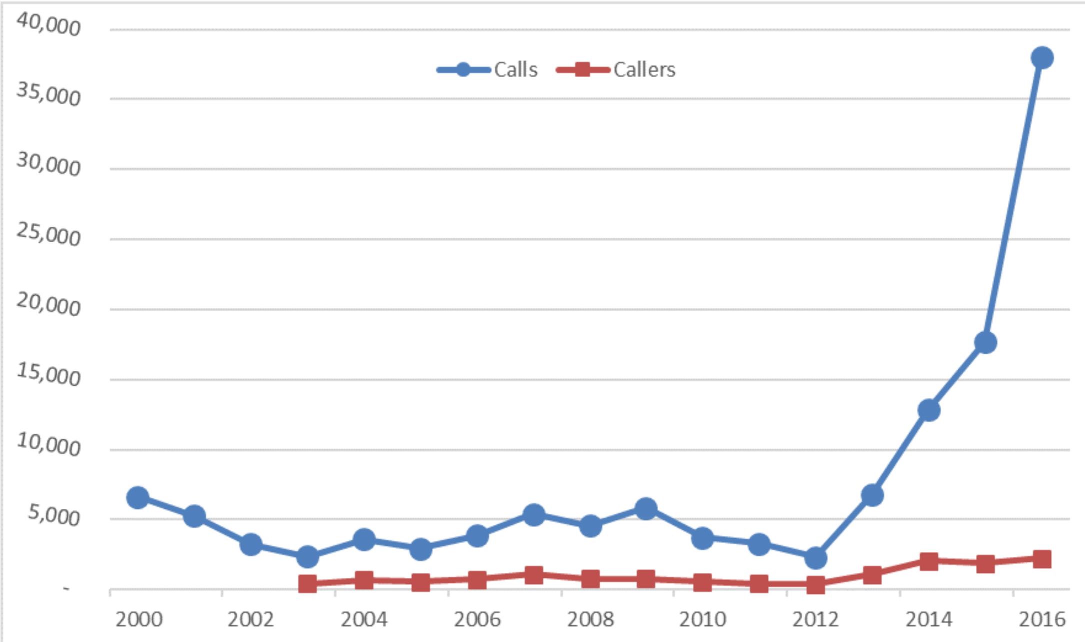


Table H-13 Noise Complaint Line Summary

	2015		2016		
Town Name	**Calls**	**Callers**	**Calls**	**Callers**	**Change (calls)**
Allston	0	0	1	1	1
Arlington	1,851	92	1,968	87	117
Belmont	715	95	501	63	(214)
Beverly	1	1	4	4	3
Billerica	0	0	1	1	1
Boston	120	10	78	24	(42)
Braintree	2	2	12	5	10
Brookline	5	3	5	4	0
Cambridge	1,697	136	2,154	128	457
Canton	10	2	20	6	10
Charlestown	6	3	25	13	19
Chelmsford	0	0	1	1	1
Chelsea	116	37	146	39	30
Cohasset	110	12	125	8	15
Danvers	8	2	9	4	1
Dedham	10	5	6	4	(4)
Dorchester	115	20	326	36	211
Duxbury	1	1	1	1	0
East Boston	250	69	203	61	(47)

Table H-13 Noise Complaint Line Summary (Continued)

	2015		2016		
Town Name	**Calls**	**Callers**	**Calls**	**Callers**	**Change (calls)**
Essex	0	0	1	1	1
Everett	114	30	84	25	(30)
Framingham	19	2	6	2	(13)
Groveland	0	0	1	1	1
Hamilton	2	1	42	15	40
Hingham	55	16	68	18	13
Holbrook	19	4	11	2	(8)
Hull	1,136	152	1,266	220	130
Hyde Park	28	7	190	8	162
Ipswich	0	0	10	5	10
Jamaica Plain	288	60	434	76	146
Littleton	6	1	11	1	5
Lynn	424	13	323	15	(101)
Lynnfield	4	3	2	2	(2)
Malden	36	6	10	7	(26)
Manchester	0	0	6	2	6
Marblehead	10	5	14	4	4
Marshfield	2	1	3	3	1
Mattapan	6	1	2	2	(4)
Medfield	0	0	1	1	1
Medford	508	116	1,784	177	1,276
Melrose	8	4	9	4	1
Middleton	1	1	3	2	2
Millis	1	1	113	2	112
Milton	4,991	343	21,796	466	16,805
Nahant	50	19	339	12	289
Natick	7	1	10	1	3
Needham	7	2	51	5	44
Newton	19	6	44	19	25
North End	0	0	1	1	1
Norwell	4	3	13	1	9
Peabody	64	12	72	6	8
Pembroke	1	1	4	2	3
Quincy	89	11	28	16	(61)
Randolph	1	1	7	3	6
Rehoboth	0	0	1	1	1
Revere	57	25	87	33	30
Roslindale	285	55	588	103	303

Table H-13 Noise Complaint Line Summary (Continued)

	2015		2016		
Town Name	**Calls**	**Callers**	**Calls**	**Callers**	**Change (calls)**
Rowley	0	0	1	1	1
Roxbury	129	11	286	40	157
Salem	7	6	26	8	19
Saugus	1	1	4	1	3
Scituate	3	3	37	10	34
Sharon	9	2	2	1	(7)
Shrewsbury	0	0	1	1	1
Somerville	1,910	191	1,804	153	(106)
South Boston	263	48	577	42	314
South End	216	38	294	40	78
Stoneham	7	2	24	6	17
Stoughton	2	2	21	2	19
Sudbury	0	0	116	1	116
Wakefield	0	0	25	2	25
Waltham	1	1	1	1	0
Watertown	298	34	265	38	(33)
Wellesley	0	0	1	1	1
Wenham	285	2	416	9	131
West Roxbury	205	28	170	21	(35)
Weston	0	0	1	1	1
Westwood	0	0	56	4	56
Weymouth	41	6	125	5	84
Wilmington	0	0	1	1	1
Winchester	733	24	489	16	(244)
Winthrop	0	0	271	96	271
Woburn	0	0	0	0	0
Grand Total	**17,369**	**1,792**	**38,035**	**2,255**	**20,666**

Source: Massport, HMMH 2017
Note: Negative numbers are shown in ( )

Cumulative Noise Index (CNI)

Massport reports total annual fleet noise at Logan Airport, defined in the Logan Airport Noise Rules by a metric referred to as the CNI. The CNI is a single number representing the sum of the entire set of single-event noise levels experienced at the Airport over a full year of operation, weighted similarly to DNL so that activity occurring at night is penalized by adding an extra 10 dB to each event. This penalty is mathematically equivalent to multiplying the number of nighttime events by each aircraft by a factor of 10. The Logan Airport Noise Rules define CNI in terms of Effective Perceived Noise Level (EPNL) and require that the index be computed for the fleet of commercial aircraft operating at Logan Airport throughout the year. In addition, in EDRs and ESPRs, Massport reports partial CNI values of noise at Logan Airport, so that various subsets of the fleet (cargo, night operations, passenger jets, etc.) are identified (see **Table H-14**). The Noise Rules, adopted by Massport following public hearings held in February 1986, established a CNI limit of 156.5 Effective Perceived Noise Decibels (EPNdB). The CNI generally has decreased since 1990, remaining below that cap, with changes from year to year on the order of a few tenths of a decibel. The 2016 CNI remains well below the cap of 156.5 EPNL.

Table H-14 Cumulative Noise Index (EPNL) – 1990 to 2015 (limit 156.5)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Full CNI (Entire Commercial Jet Fleet)	**156.4**	**155.8**	**155.5**	**155.3**	**155.4**	**155.3**	**155.1**	**154.8**	**154.7**	**154.9**
Total Passenger Jets	155.2	154.8	154.6	154.4	154.4	154.2	154.1	153.9	153.7	153.9
Total Cargo Jets	150.1	148.9	148.0	147.9	148.3	148.8	148.6	147.5	147.9	148.0
Total Daytime	152.5	152.1	152.4	152.1	152.1	151.6	151.2	150.8	150.4	150.4
Total Nighttime	154.4	153.4	152.6	152.4	152.6	152.9	152.9	152.5	152.7	153.1
Total Stage 2 Jets	N/A	N/A	N/A	N/A	151.0	150.2	149.4	149.2	147.7	147.1
Total Stage 3 Jets	N/A	N/A	N/A	N/A	153.4	153.8	153.8	153.4	153.8	154.2
Daytime Stage 2	N/A	N/A	N/A	N/A	149.0	148.5	147.6	146.5	145.2	144.1
Nighttime Stage 2	N/A	N/A	N/A	N/A	146.7	145.1	144.8	145.8	144.1	144.0
Daytime Stage 3	N/A	N/A	N/A	N/A	149.1	148.8	148.7	148.8	148.9	149.2
Nighttime Stage 3	N/A	N/A	N/A	N/A	151.4	152.1	152.2	151.5	152.1	152.5
Passenger Jet Stage 2	N/A	N/A	N/A	N/A	150.5	149.9	149.2	148.9	147.5	146.8
Passenger Jet Stage 3	N/A	N/A	N/A	N/A	152.2	152.3	152.3	152.2	152.6	153.0
Cargo Jet Stage 2	N/A	N/A	N/A	N/A	141.5	137.4	136.8	137.4	139.0	134.5
Cargo Jet Stage 3	N/A	N/A	N/A	N/A	147.3	148.5	148.3	147.0	147.3	147.9
Daytime Passenger	N/A	152.0	152.2	152.0	152.0	151.5	151.1	150.6	150.1	150.1
Nighttime Passenger	N/A	151.6	150.9	150.6	150.8	151.0	151.0	151.1	151.2	151.6
Daytime Cargo	137.1	137.1	137.6	135.2	136.1	138.0	136.7	136.2	138.0	138.2
Nighttime Cargo	149.9	148.6	147.6	147.6	148.0	148.4	148.3	147.1	147.5	147.6
Daytime Passenger Stage 2	N/A	N/A	N/A	N/A	148.9	148.4	147.6	146.5	145.0	143.9
Daytime Passenger Stage 3	N/A	N/A	N/A	N/A	149.0	148.5	148.4	148.5	148.6	149.0
Nighttime Passenger Stage 2	N/A	N/A	N/A	N/A	149.0	148.5	148.4	148.5	142.8	143.7
Nighttime Passenger Stage 3	N/A	N/A	N/A	N/A	149.4	149.9	150.1	149.8	150.5	150.8
Daytime Cargo Stage 2	N/A	N/A	N/A	N/A	128.3	126.7	124.6	126.4	131.6	131.5
Daytime Cargo Stage 3	N/A	N/A	N/A	N/A	135.3	137.7	136.4	135.7	136.9	137.1
Nighttime Cargo Stage 2	N/A	N/A	N/A	N/A	141.3	137.0	136.5	137.0	138.2	131.5
Nighttime Cargo Stage 3	N/A	N/A	N/A	N/A	147.0	148.1	148.0	146.6	146.9	147.5

Table H-14 Cumulative Noise Index (EPNL) – 1990 to 2015 (limit 156.5) (Continued)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Full CNI (Entire Commercial Jet	**155**	**154**	**153**	**153**	**153**	**153**	**152.6**	**153**	**153**	**152**
Total Passenger Jets	153.6	152.9	151.8	151.3	152.2	152.1	151.4	151.5	151.9	151.1
Total Cargo Jets	148.2	147.8	147.4	147.1	147	146.6	146.5	146.4	146.1	145.9
Total Daytime	149.5	149	148.5	148	148.5	148.2	147.5	147.2	147.6	147.1
Total Nighttime	153.1	152.4	151.3	150.9	151.7	151.6	151	151.2	151.4	150.7
Total Stage 2 Jets	124.7	121.5	114.3	114.1	118.1	N/A	N/A	N/A	N/A	N/A
Total Stage 3 Jets	154.7	154.1	153.2	152.7	153.4	153.2	152	152.7	152.9	152.3
Daytime Stage 2	122.6	119.3	111.2	113.7	109.4	N/A	N/A	N/A	N/A	N/A
Nighttime Stage 2	120.5	117.3	111.4	103.2	117.5	N/A	N/A	N/A	N/A	N/A
Daytime Stage 3	149.5	149	148.5	148	148.5	148.2	147.5	147.2	147.6	147.1
Nighttime Stage 3	153.1	152.4	151.3	150.9	151.7	151.6	151	151.2	151.4	150.7
Passenger Jet Stage 2	124.2	116.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Passenger Jet Stage 3	153.6	152.9	151.8	151.3	152.2	152.1	151.4	151.5	151.9	151.1
Cargo Jet Stage 2	114.8	119.9	114.3	114.1	118.1	NA	NA	NA	NA	NA
Cargo Jet Stage 3	148.2	147.8	147.4	147.1	147	146.6	146.5	146.4	146.1	145.9
Daytime Passenger	149.3	148.7	148.2	147.7	148.2	147.9	147.2	146.9	147.3	146.8
Nighttime Passenger	151.6	150.8	149.4	148.8	150	150.1	149.3	149.7	150	149.1
Daytime Cargo	137.5	137.1	137	136.2	135.7	135.8	135.5	135.8	135.8	135.2
Nighttime Cargo	147.8	147.4	147	146.8	146.7	146.2	146.1	146	145.6	145.5
Daytime Passenger Stage 2	122.3	115	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Daytime Passenger Stage 3	149.2	148.7	148.2	147.7	148.2	147.9	147.2	146.9	147.3	146.8
Nighttime Passenger Stage	119.8	110.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nighttime Passenger Stage	151.6	150.8	149.4	148.8	150	150.1	149.3	149.7	150	149.1
Daytime Cargo Stage 2	111.1	117.3	111.2	113.7	109.4	N/A	N/A	N/A	N/A	N/A
Daytime Cargo Stage 3	137.5	137	137	136.1	135.7	135.8	135.5	135.8	135.8	135.2
Nighttime Cargo Stage 2	112.3	116.4	111.4	103.2	117.5	N/A	N/A	N/A	N/A	N/A
Nighttime Cargo Stage 3	147.8	147.4	147	146.8	146.7	146.2	146.1	146	145.6	145.5

Table H-14 Cumulative Noise Index (EPNL) – 1990 to 2016 (limit 156.5) (Continued)

	2010	2011	2012	2013	2014[1]	2015	2016	Change 2015 to 2016
Full CNI (Entire Commercial Jet Fleet)	**152**	**152**	**152**	**152**	**153**	**153**	**152.6**	**(0.1)**
Total Passenger Jets	150.9	150.6	151.3	151.4	151.7	152	152.0	0.0
Total Cargo Jets	145.1	146.7	144.9	145.1	144.5	144.2	143.8	(0.4)
Total Daytime	146.8	146.9	147	147	147.1	147.2	147.0	(0.2)
Total Nighttime	150.3	150.6	150.6	150.8	151.0	151.2	151.2	0.0
Total Stage 2 Jets	113.6	110.8	104.9	111.3	N/A	N/A	N/A	N/A
Total Stage 3 Jets	151.9	152.1	152.2	152.3	152.5	152.7	152.6	(0.1)
Daytime Stage 2	103.6	N/A	104.9	101.4	N/A	N/A	N/A	N/A
Nighttime Stage 2	113.1	110.8	N/A	110.8	N/A	N/A	N/A	N/A
Daytime Stage 3	146.8	146.9	147	147	147.1	147.2	147.0	(0.2)
Nighttime Stage 3	150.3	150.6	150.6	150.8	151.0	151.2	151.2	0.0
Passenger Jet Stage 2	N/A	N/A	104.9	101.4	N/A	N/A	N/A	N/A
Passenger Jet Stage 3	150.9	150.6	151.3	151.4	151.7	152	152.0	0.0
Cargo Jet Stage 2	113.6	110.8	N/A	110.8	N/A	N/A	N/A	N/A
Cargo Jet Stage 3	145.1	146.7	144.9	145.1	144.5	144.2	143.8	(0.4)
Daytime Passenger	146.6	146.5	146.8	146.8	146.9	147	146.8	(0.2)
Nighttime Passenger	149	148.5	149.4	149.6	150.0	150.3	150.4	0.1
Daytime Cargo	134.5	136.6	134	133.6	134.9	134.4	133.8	(0.6)
Nighttime Cargo	144.7	146.3	144.5	144.8	144.0	143.7	143.4	(0.3)
Daytime Passenger Stage	N/A	N/A	104.9	101.4	N/A	N/A	N/A	N/A
Daytime Passenger Stage	146.6	146.5	146.8	146.8	146.9	147	146.8	(0.2)
Nighttime Passenger	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nighttime Passenger	149	148.5	149.4	149.6	150.0	150.3	150.4	0.1
Daytime Cargo Stage 2	103.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Daytime Cargo Stage 3	134.4	136.6	134	133.6	134.9	134.4	133.8	(0.6)
Nighttime Cargo Stage 2	113.1	110.8	N/A	110.8	N/A	N/A	N/A	N/A
Nighttime Cargo Stage 3	144.7	146.3	144.5	144.8	144.0	143.7	143.4	(0.3)

Source: HMMH, 2017.
Notes: GA and non-jet aircraft are not included in the calculation.
N/A = Not available.
1 The 2014 CNI analysis contained errors which appeared in the *2014 EDR* and *2015 EDR*. The analysis has been corrected and the numbers presented in this table are correct.

Flight Track Monitoring Report

As part of its ongoing commitment to mitigate noise at Logan Airport, Massport has undertaken evaluating the flight tracks of turbojet aircraft engaged in the implementation of established FAA noise abatement procedures. As is true for any airport operator, however, Massport has no authority to control where individual aircraft fly. That remains the responsibility of FAA, while the individual pilots are responsible for safely executing FAA's instructions. The flight procedures, which are used by the Air Traffic Control (ATC) staff at Boston Tower to achieve desired noise abatement tracks, are contained in FAA's Tower Order (BOS TWR 7040.1).

This is the fifteenth annual report for flight track monitoring. Prior to 2002, Massport had issued semi-annual reports, an outgrowth of the Flight Track Monitoring Program study. That study was contained in the *Generic Environmental Impact Report* filed with Massachusetts Environmental Policy Act (MEPA) in July 1996, and was the subject of two Community Working Group workshops in September and October 1996. The fourteenth annual report was published in Appendix H, *Noise Abatement* in the *2015 EDR*. The information for 2015 is repeated in this report for reference. The period covered by this *2016 EDR* is January 1, 2016 through December 31, 2016.

The purpose of the ongoing monitoring program is to identify any systematic changes in flight tracks that may occur and to reduce flight track dispersion, where appropriate. The next report will cover the period January 1, 2017 through December 31, 2017, and will be included in the *2017 ESPR*.

FAA Air Traffic Control (ATC) Procedures

FAA Tower Order BOS TWR 7040.1 entitled "Noise Abatement" describes the series of noise abatement policies, rules, regulations, and the procedures to be followed by FAA air traffic controllers in meeting their designated responsibilities to be "a good neighbor, while meeting our operational objectives/ responsibilities to the National Airspace System." Section 7.a.3 of the Order, subtitled "Turbojet Departure Noise Abatement Procedures," states that all turbojet departures shall be issued the Standard Instrument Departure (SID) procedure appropriate for the departure runway. They are paraphrased from the LOGAN NINE SID[17] below.

Note in the descriptions that follow that terms such as "BOS 2 DME" are used frequently. Here, BOS refers to an aid to navigation known as the BOSTON VORTAC, a radio beacon physically located on Logan Airport near the eastern shoreline between the ends of Runways 27 and 33L (see **Figure H-14**). DME refers to "Distance Measuring Equipment," a co-located aid to navigation that provides pilots with a cockpit display of the number of nautical miles that the aircraft is from the designated radio beacon. Thus, BOS 2 DME means an aircraft should be two nautical miles away from the BOS. The term "vectored" means the pilot is assigned to fly a magnetic heading given by and at the discretion of FAA air traffic controller to maintain the safe separation of aircraft. "MSL" is defined as feet above mean sea level and is the indicator of aircraft altitude used both by the pilot in the cockpit and the air traffic controller on the ground.

During 2010, several of the conventional-only (or radar vector) and RNAV procedures from the Boston Logan Airport Noise Study Categorical Exclusion (CATEX)[18] were implemented. There are eight new RNAV procedures for departures from Logan Airport. These eight procedures are used by aircraft departing Runways 4R, 9, 15R, 22L, 22R, 27, and 33L (Runways 27 and 33L were added in 2014). These procedures primarily affected departures flying over the North and South shores and were designed to increase the amount of jet traffic crossing back over land above 6,000 feet to minimize noise impacts to communities.

17 Accessed 04/07/2016

18 Federal Aviation Administration (FAA) Boston Logan Airport Noise Study Categorical Exclusion Record of Decision (CATEX ROD), Issued October 16, 2007

A ninth RNAV procedure, which is used by Runway 27, has been in use at the Airport and has been modified several times. For departures, the conventional procedures (flown by non-RNAV equipped aircraft) from the LOGAN NINE SID are:

- For Runway 4R, climb heading 036 degrees to BOS 4 DME, then turn right to a heading of 090 degrees, and then expect radar vectors to assigned route/navaid/fix. Aircraft that are initially vectored over water can expect to cross the coastline above 6,000 MSL before proceeding on course.
- For Runway 9, climb heading 093 degrees, and then expect radar vectors to assigned route/navaid/fix. Aircraft that are initially vectored over water can expect to cross the coastline above 6,000 MSL before proceeding on course.
- For Runway 14, climb heading 142 degrees to BOS 1 DME, then turn left to heading 120 degrees, then expect radar vectors to assigned route/navaid/fix. Aircraft that are initially vectored over water can expect to cross the coastline above 6,000 MSL before proceeding on course.
- For Runway 15R, climb heading 151 degrees to BOS 1 DME then turn left to 120 degrees, then expect radar vectors to assigned route/navaid/fix. Aircraft that are initially vectored over water can expect to cross the coastline above 6,000 MSL before proceeding on course.
- For Runways 22R and 22L, climbing left turn to a heading of 140 degrees, then expect radar vectors to assigned route/navaid/fix. Aircraft that are initially vectored over water can expect to cross the coastline above 6,000 MSL before proceeding on course.
- For Runway 33L, climb heading 331 degrees to BOS 2 DME then turn left to 316 degrees, then expect radar vectors to assigned route/navaid/fix.
- For Runway 27, climb heading 273 to BOS 2.2 DME, then turn left heading 235 degrees, then expect radar vectors to assigned route/navaid/fix.

The RNAV procedures (used only by Turbojets)[19] and the runways they serve:

- BLZZR THREE – Runways 4L, 9, 15R, 22L, 22R, 27, and 33L: This procedure directs most jet traffic in a well-defined flight corridor over the ocean and crossing back over the South Shore near Cohasset and Scituate.
- BRUWN FOUR – Runways 4L, 9, 15R, 22L, 22R, 27, and 33L: This procedure directs most jet traffic in a well-defined flight corridor over the ocean towards Cape Cod.
- CELTK FOUR – Runways 4L, 9, 15R, 22L, 22R, 27, and 33L: This procedure directs most jet traffic in a well-defined flight corridor over the ocean.
- HYLND FOUR – 4L, 9, 15R, 22L, 22R, 27, and 33L: This procedure directs most jet traffic in a well-defined flight corridor over the ocean and crossing back over the North Shore near Beverly.
- LBSTA FOUR – 4L, 9, 15R, 22L, 22R, 27, 33L: This procedure directs most jet traffic in a well-defined flight corridor over the ocean and crossing back over the North Shore near Manchester and Gloucester.
- PATSS FOUR – 4L, 9, 15R, 22L, 22R, 27, 33L: This procedure directs most jet traffic in a well-defined flight corridor over the ocean and crossing back over the South Shore near Cohasset and Scituate.
- REVSS THREE – 4L, 9, 15R, 22L, 22R, 27, 33L: This procedure directs most jet traffic in a well-defined flight corridor over the ocean and crossing back over the South Shore near Cohasset and Scituate.

19 These are the procedures as defined on April 7, 2016. Procedures may be adjusted at points throughout the year.

- SSOXS FOUR – 4L, 9, 15R, 22L, 22R, 27, 33L: This procedure directs most jet traffic in a well-defined flight corridor over the ocean and crossing back over the South Shore over Marshfield.
- WYLYY TWO – 27: This procedure directs most jet traffic in a well-defined flight corridor on a heading of 273 degrees then a turn to 235 degrees over South Boston.

These brief procedural statements form the basis of the verbal instructions and flight clearances that are passed from controller to pilot to achieve reduced noise in the communities surrounding Logan Airport while also maintaining the safe and efficient flow of aircraft in and out of the Airport. However, consistency with which these procedures are used varies due to air traffic demands, controller workloads, weather conditions, and other operational factors, as noted in the Flight Track Monitoring Program Study.

Figure H-14 presents the gates used in the analysis for the Flight Track Monitoring Report. These gates are virtual vertical planes, which are used in the analysis to capture the aircraft flight paths. The gates are defined using a geographic coordinate for each end of the gate along with a floor and a ceiling altitude. The gates also capture direction of flights (in or out). The edges of each gate in **Figure H-14** point in the direction that the aircraft is coming from. This information is used to evaluate the performance of the flight procedures off each runway end and is presented below. **Figure H-14** also displays the BOS location, which is used for the distance measurements for the conventional procedures.

The RNAV procedures are still captured by the original flight track monitoring gates. Traffic crossing over the North Shore passes through the Marblehead Gate and traffic passing over the South Shore passes through the Hull 2, Hull 3, and Cohasset Gates. Turbojets departing Runway 27 on the RNAV pass through the Runway 27 gates and the new Runway 33L RNAV flight tracks still pass between the Somerville and Everett gates as expected.

Figure H-14 Logan Airport Flight Track Monitor Gates

Source: HMMH, MassGIS, USDA NAIP 2010

Logan Airport Flight Track Monitor Gates

Logan Flight Gates

Boston VOR/DME

Figure H-14

Statistical Analyses of Flight Tracks - Runway 4R

The Nahant Gate (**Figure H-14**) monitors aircraft after the first turn at 4 DME. The Swampscott and Marblehead Gates monitor northbound shoreline crossings, while the Hull 2, Hull 3, and Cohasset Gates monitor southbound shoreline crossings.

Tables H-15a and **H-15b** show that Runway 4R departures for 2016 were concentrated, with 99.5 percent "over the Causeway," and about 0.1 percent over the south end of the gate compared to 99.2 percent over the Causeway in 2015 and 0.3 percent over the south end of the gate. Departures through the north end of the gate remained the same at 0.5 percent in 2015 and 2016.

Table H-15a Runway 4R Nahant Gate Summary for 2015

	Number of Tracks Through Gate Segment	Total Number of Tracks Through Gate	Percentage of Tracks Through Gate Segment
North End of Gate	35	6,851	0.5%
Over Causeway	6,797	6,851	99.2%
South End of Gate	19	6,851	0.3%
Total	**6,851**	**6,851**	**100.0%**

Source: Massport, HMMH 2016.

Table H-15b Runway 4R Nahant Gate Summary for 2016

	Number of Tracks Through Gate Segment	Total Number of Tracks Through Gate	Percentage of Tracks Through Gate Segment
North End of Gate	31	6,850	0.5%
Over Causeway	6,814	6,850	99.5%
South End of Gate	5	6,850	0.1%
Total	**6,850**	**6,850**	**100.0%**

Source: Massport, HMMH 2017.

Table H-16a and **H-16b** show how many of the shoreline crossings from Runway 4R were above 6,000 feet. For 2016, 98.3 percent of the flights were above 6,000 feet compared to 97.2 percent in 2015. The Swampscott gate had 97.9 percent of flights above 6,000 feet in 2016 compared to 23.3 percent in 2015. The number of flights through the Swampscott gate increased in 2015 (116 in 2015, up to 234 in 2016). The crossing percentage for this gate is historically lower than most gates due to its proximity to the Nahant gate itself. As seen in **Figure H-14**, the Swampscott gate is adjacent to the Nahant gate and aircraft would have to climb very quickly to be above 6,000 feet when crossing the Swampscott gate.

Table H-16a Runway 4R Shoreline Crossings Above 6,000 Feet for 2015

	Number of Tracks Through Gate	Number Above 6,000 ft	Percentage Above 6,000 ft
Swampscott Gate	116	27	23.3%
Marblehead Gate	2,770	2,735	98.7%
Hull 2 Gate	345	345	100.0%
Hull 3 Gate	1,034	1,033	99.9%
Cohasset Gate	196	196	100.0%
Total	**4,461**	**4,336**	**97.2%**

Source: Massport, HMMH 2016.

Table H-16b Runway 4R Shoreline Crossings Above 6,000 Feet for 2016

	Number of Tracks Through Gate	Number Above 6,000 ft	Percentage Above 6,000 ft
Swampscott Gate	234	229	97.9%
Marblehead Gate	2,532	2,531	100.0%
Hull 2 Gate	82	18	22.0%
Hull 3 Gate	386	354	91.7%
Cohasset Gate	3032	3030	99.9%
Total	**6,266**	**6,162**	**98.3%**

Source: Massport, HMMH 2017.

Statistical Analyses of Flight Tracks - Runway 9

The Winthrop 1 and Winthrop 2 gates (**Figure H-14**) monitor early turns for departures off Runway 9. The Revere, Swampscott, or Marblehead gates monitor northbound shoreline crossings, while the Hull 2, Hull 3, or Cohasset gates monitor southbound shoreline crossings.

Tables H-17a and **H-17b** show how many tracks turned prior to the BOS 2 DME. Northbound turns before BOS 2 DME pass through the Winthrop 1 Gate. Southbound traffic would pass through the Winthrop 2 Gate. In 2016, between both gates there were a total of 52 such turns, 0.1 percent. In 2015, 44 tracks or 0.1 percent of the total also crossed these gates.

Table H-17a Runway 9 Gate Summary — Winthrop Gates 1 and 2 for 2015

	Number of Departure Tracks	Number of Tracks Through Gate	Percent Turning Before BOS 2 DME
Winthrop 1 Gate	45,371	20	<0.1%
Winthrop 2 Gate	45,371	24	0.1%
Total	**45,371**	**44**	**0.1%**

Source: Massport, HMMH 2016.

Table H-17b Runway 9 Gate Summary — Winthrop Gates 1 and 2 for 2016

	Number of Departure Tracks	Number of Tracks Through Gate	Percent Turning Before BOS 2 DME
Winthrop 1 Gate	55,882	18	<0.1%
Winthrop 2 Gate	55,882	34	0.1%
Total	**45,371**	**52**	**0.1%**

Source: Massport, HMMH 2017.

Table H-18a and **H-18b** indicate that 99.4 percent of Runway 9 departures were above 6,000 feet when crossing the shoreline in 2016, compared with 99.3 percent in 2015. The number of Runway 9 departures crossing back over the South Shore increased from 33,807 in 2015 to 36,811 in 2016.

A decrease in the percentage above 6,000 feet occurred at the Revere gate (60.6 percent in 2015 to 36.5 percent in 2016) and a slight increase at the Hull 2 gate (99.4 percent in 2015 to 99.5 percent in 2016).

The number of crossings decreased for the Revere gate (66 in 2015 to 63 in 2016) and increased at the Swampscott gate (435 in 2015 to 537 in 2016). The Marblehead gate had an increase in crossings (from 11,333 in 2015 to 12,489 in 2016), and an increase in the percent above 6,000 feet (from 99.7 percent in 2015 to 99.9 percent in 2016). Both the Hull 2 and Hull 3 gates had an increase in crossings compared to 2015. Hull 2 increased from 2,120 in 2015 to 2,379 in 2016, and Hull 3 increased from 4,834 in 2015 to 6,052 in 2016. The Hull 2 crossing percentage increased slightly from 99.4 percent in 2015 to 99.5 percent in 2016, and the Hull 3 gate crossings increased from 98.1 percent to 98.7 percent. The crossings through the Cohasset gate increased (from 15,019 in 2015 to 15,497 in 2016) and the percent above 6,000 feet increased slightly from 99.8 percent in 2015 to 99.9 percent in 2016.

Table H-18a Runway 9 Shoreline Crossings Above 6,000 Feet for 2015

	Number of Tracks Through Gate	Number Above 6,000 ft	Percentage Above 6,000 ft
Revere Gate	66	40	60.6%
Swampscott Gate	435	398	91.5%
Marblehead Gate	11,333	11,298	99.7%
Hull 2 Gate	2,120	2,108	99.4%
Hull 3 Gate	4,834	4,742	98.1%
Cohasset Gate	15,019	14,993	99.8%
Total	**33,807**	**33,579**	**99.3%**

Source: Massport, HMMH 2016

Table H-18b Runway 9 Shoreline Crossings Above 6,000 Feet for 2016

	Number of Tracks Through Gate	Number Above 6,000 ft	Percentage Above 6,000 ft
Revere Gate	63	23	36.5%
Swampscott Gate	537	495	92.2%
Marblehead Gate	12,489	12,471	99.9%
Hull 2 Gate	2,379	2,367	99.5%
Hull 3 Gate	6,052	5,971	98.7%
Cohasset Gate	15,497	15,484	99.9%
Total	**37,017**	**36,811**	**99.4%**

Source: Massport, HMMH 2017.

Statistical Analyses of Flight Tracks - Runway 15R

After takeoff, Runway 15R departures turn left approximately 30 degrees to avoid Hull, head out over Boston Harbor, and return over the shore through the Swampscott and Marblehead Gates (**Figure H-14**) to the north, or through the Hull 2, Hull 3, and Cohasset Gates to the south. **Tables H-19a** and **H-19b** indicate that 98.3 percent of Runway 15R departures were above 6,000 feet when crossing the shoreline in 2016, compared with 99.4 percent in 2015. While compliance at the Swampscott, Marblehead, and Cohassett gates remained at 98 percent or better for both 2015 and 2016, the proportion of flights over 6,000 feet at the Hull 2 gate fell from 94.3 percent in 2015 to 91.7 percent in 2016, and only 22 percent of flights crossed the Hull 1 gate over 6,000 feet in 26, compared to perfect compliance for 2015.

Table H-19a Runway 15R Shoreline Crossings Above 6,000 Feet for 2015

	Number of Tracks Through Gate	Number Above 6,000 ft	Percentage Above 6,000 ft
Swampscott Gate	179	176	98.3%
Marblehead Gate	2,025	2,025	100.0%
Hull 2 Gate	14	14	100.0%
Hull 3 Gate	282	266	94.3%
Cohasset Gate	2,554	2,544	99.6%
Total	**5,054**	**5,025**	**99.4%**

Source: Massport, HMMH 2016.

Table H-19b Runway 15R Shoreline Crossings Above 6,000 Feet for 2016

	Number of Tracks Through Gate	Number Above 6,000 ft	Percentage Above 6,000 ft
Swampscott Gate	234	229	97.9%
Marblehead Gate	2,532	2,531	100.0%
Hull 2 Gate	82	18	22.0%
Hull 3 Gate	386	354	91.7%
Cohasset Gate	3,032	3,030	99.9%
Total	**6,266**	**6,162**	**98.3%**

Source: Massport, HMMH 2017.

Statistical Analyses of Flight Tracks - Runways 22R and 22L

The Squantum 2 and Hull 1 Gates (**Figure H-14**) are used to monitor the turn to 140 degrees over Boston Harbor and north of Hull. The shoreline gates are used to monitor shoreline crossings, as for Runways 4R, 9, and 15R above. **Tables H-20a** and **H-20b** show the dispersion of the jet departures from Runways 22R and 22L as they pass through the Squantum 2 Gate. The first segment of the gate is the northernmost segment and is primarily over Boston Harbor. The other segments extend southward toward Quincy. The percentage of tracks passing through the first two segments of this gate decreased from 89.2 percent in 2015 to 88.8 percent in 2016.

Table H-20a Runways 22R and 22L Squantum 2 Gate Summary for 2015

	Number of Tracks Through Gate Segment	Total Number of Tracks Through All Gate Segments	Percentage of Tracks Through Gate Segment
0 - 12,000 ft	3,183	53,958	5.9%
12,000 - 14,000 ft	44,923	53,958	83.3%
14,000 - 21,000 ft	5,806	53,958	10.8%
21,000 - 27,000 ft	46	53,958	0.1%
Total	**53,958**	**53,958**	**100.0%**

Source: Massport, HMMH 2016.
Note: Percentages sum to more than 100 percent due to rounding.

Table H-20b Runways 22R and 22L Squantum 2 Gate Summary for 2016

	Number of Tracks Through Gate Segment	Total Number of Tracks Through All Gate Segments	Percentage of Tracks Through Gate Segment
0 - 12,000 ft	870	47,371	1.8%
12,000 - 14,000 ft	41,218	47,371	87.0%
14,000 - 21,000 ft	5,247	47,371	11.1%
21,000 - 27,000 ft	36	47,371	0.1%
Total	**47,371**	**47,371**	**100.0%**

Source: Massport, HMMH 2017.
Note: Percentages sum to more than 100 percent due to rounding.

Tables H-21a and **H-21b** show that the percent of tracks crossing north of the Hull peninsula as they passed through the Hull 1 Gate was 98.8 percent in 2015 and 98.7 percent in 2016.

Table H-21a Runways 15R, 22R, and 22L Hull 1 Gate Summary – North of Hull Peninsula for 2015

	Number of Tracks Through Gate Segment	Total Number of Tracks Through Gate	Percentage of Tracks Through Gate Segment
North of Hull Peninsula	61,537	62,259	98.8%
Over Hull	722	62,259	1.2%
Total	**62,259**	**62,259**	**100.0%**

Source: Massport, HMMH 2016

Table H-21b Runways 15R, 22R, and 22L Hull 1 Gate Summary – North of Hull Peninsula for 2016

	Number of Tracks Through Gate Segment	Total Number of Tracks Through Gate	Percentage of Tracks Through Gate Segment
North of Hull Peninsula	57,059	57,834	98.7%
Over Hull	775	57,834	1.3%
Total	**57,834**	**57,834**	**100.0%**

Source: Massport, HMMH 2017.

Tables H-22a and **H-22b** indicate that 99.0 percent of Runway 22R/22L departures were above 6,000 feet when crossing the shoreline in 2016, compared with 99.7 percent in 2015. Compliance was above 97.0 percent for the Swampscott, Marblehead, Hull 3, and Cohasset gates for both years. While 87.5 percent of flights through the Hull 2 gate were above the altitude threshold in 2015, this fell to 40.9 percent in 2016.

Table H-22a Runways 22R and 22L Shoreline Crossings Above 6,000 Feet for 2015

	Number of Tracks Through Gate	Number Above 6,000 ft	Percentage Above 6,000 ft
Revere Gate	127	124	97.6%
Swampscott Gate	1114	1114	100.0%
Marblehead Gate	13,932	13,929	100.0%
Hull 2 Gate	32	28	87.5%
Hull 3 Gate	2,119	2057	97.1%
Cohasset Gate	20,704	20,651	99.7%
Total	**38,028**	**37,903**	**99.7%**

Source: Massport, HMMH 2016.

Table H-22b Runways 22R and 22L Shoreline Crossings Above 6,000 Feet for 2016

	Number of Tracks Through Gate	Number Above 6,000 ft	Percentage Above 6,000 ft
Revere Gate	106	95	89.6%
Swampscott Gate	951	951	100.0%
Marblehead Gate	12,250	12,245	100.0%
Hull 2 Gate	452	185	40.9%
Hull 3 Gate	2,082	2035	97.7%
Cohasset Gate	18,017	18,006	99.9%
Total	**33,858**	**33,517**	**99.0%**

Source: Massport, HMMH 2017.

Runway 27

On September 15, 1996, FAA implemented a new departure procedure for Runway 27 called the WYLYY RNAV procedure. In accordance with the provisions of the ROD issued for the Runway 27 Environmental Impact Statement, Massport has been providing on-going radar flight track data and analysis to FAA with respect to the procedure.

In 2012, for the first time since 1997 when flight track monitoring began, each gate (Gates A through E) averaged over 68 percent for every month the Airport had all runways open and for the annual average. The percent of flight tracks through all gates (a number tracked but not required per the 1996 ROD) rounded up to 68 percent for the last two months of 2011 and continued for all of 2012. FAA had discussed these data internally and concluded that acceptable flight track dispersion had been achieved and that no subsequent action by FAA is required per the 1996 ROD requirements.[20]

Massport will continue to provide **Tables H-23a** and **H-23b** in the subsequent annual reports. **Table H-23a** presents the conformance results for the Runway 27 corridor for 2015 and **Table H-23b** for 2016. The average percentage of tracks through the corridor was 83.7 percent for 2015 and 80.6 percent for 2016.

Each gate is further from the runway and falls along the procedure. The gates also increase in width as the distance is increased along the flight path and they form a noise abatement corridor. A consistent percentage of traffic through each gate means that flights are not entering the corridor late or exiting the corridor too early. The average percent through each gate was 95.1 percent in 2015 and 95.0 percent for 2016.

Table H-23a Runway 27 Corridor Percent of Tracks Through Each Gate for 2015

Month	Total # of Tracks	Total # of Tracks Through All Gates	Percent of Tracks Through All Gates	Gate A	Gate B	Gate C	Gate D	Gate E	Average Percent Through Each Gate
				1,400[1]	2,200[1]	2,900[1]	4,700[1]	6,300[1]	
January	2,586	2,118	81.9%	2,212	2,435	2,524	2,560	2,538	94.9%
February	3,142	2604	82.9%	2,725	2,944	3,059	3,111	3,076	94.9%
March	2,706	2,207	81.6%	2,314	2,547	2,633	2,675	2,642	94.7%
April	1,245	1,059	85.1%	1,100	1,189	1,222	1,235	1,224	95.9%
May	685	539	78.7%	581	647	649	657	640	92.7%
June	772	642	83.2%	681	727	747	760	753	95.0%
July	1005	837	83.3%	868	954	975	995	989	95.1%
August	996	861	86.4%	891	940	968	984	980	95.6%
September	855	721	84.3%	742	809	834	846	840	95.2%
October	1,821	1569	86.2%	1,604	1,736	1,794	1,806	1,793	95.9%
November	1,868	1,612	86.3%	1,650	1,789	1,826	1,848	1,831	95.8%
December	1,634	1,379	84.4%	1,410	1,563	1,603	1,611	1,592	95.2%
Average	**1,610**	**1,346**	**83.7%**	**1,398**	**1,523**	**1,570**	**1,591**	**1,575**	**95.1%**

Source: Massport, HMMH 2016.
Notes: Gray shading indicates the percentage rounds up to 68 percent or greater.
1 Width of each gate in feet.

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Table H-23b Runway 27 Corridor Percent of Tracks Through Each Gate for 2016

Month	Total # of Tracks	Total # of Tracks Through All Gates	Percent of Tracks Through All Gates	Gate A	Gate B	Gate C	Gate D	Gate E	Average Percent Through Each Gate
				1,400[1]	2,200[1]	2,900[1]	4,700[1]	6,300[1]	
January	2,345	1,790	76.3%	1,849	2,256	2,297	2,313	2,299	93.9%
February	1,968	1560	79.3%	1,618	1,908	1,930	1,950	1,930	94.9%
March	1,895	1,509	79.6%	1,569	1,821	1,851	1,856	1,857	94.5%
April	1,148	936	81.5%	972	1,115	1,130	1,127	1,106	94.9%
May	988	809	81.9%	828	944	959	968	969	94.5%
June	1358	1048	77.2%	1,085	1,311	1,332	1,370	1,378	95.4%
July	1823	1510	82.8%	1,565	1,746	1,782	1,795	1,793	95.2%
August	837	703	84.0%	721	810	825	829	840	96.2%
September	737	614	83.3%	630	708	720	733	742	95.9%
October	2,285	1808	79.1%	1,860	2,204	2,239	2,246	2,252	94.5%
November	2,703	2,169	80.2%	2,226	2,609	2,645	2,674	2,670	94.9%
December	2,926	2,380	81.3%	2,448	2,808	2,862	2,897	2,886	95.0%
Average	**1,751**	**1,403**	**80.6%**	**1,448**	**1,687**	**1,714**	**1,730**	**1,727**	**95.0%**

Source: Massport, HMMH 2017.
Notes: Gray shading indicates the percentage rounds up to 68 percent or greater.
1 Width of each gate in feet.

Statistical Analyses of Flight Tracks — Runway 33L

The Somerville and Everett Gates (**Figure H-14**) extend from BOS 2 DME to BOS 5 DME and are used to monitor the departure procedure for Runway 33L. Turns to the left prior to the BOS 5 DME would pass through the Somerville Gate. Turns to the right prior to the BOS 5 DME would pass through the Everett Gate.

Tables H-24a and **H-24b** indicate the percentage of tracks turning before BOS 5 DME decreases from 1.7 percent in 2015 to 1.5 percent in 2016. The total number of tracks increased from 24,203 in 2015 to 29,854 in 2016.

Table H-24a Runway 33L Gates — Passages Below 3,000 Feet for 2015

	Number of Departure Tracks	Number of Tracks Turning Before BOS 5 DME	Percentage of Tracks Turning Before BOS 5 DME
Everett Gate	24,203	205	0.8%
Somerville Gate	24,203	197	0.8%
Total	**24,203**	**402**	**1.7%**

Source: Massport, HMMH 2016.

Table H-24b Runway 33L Gates — Passages Below 3,000 Feet for 2016

	Number of Departure Tracks	Number of Tracks Turning Before BOS 5 DME	Percentage of Tracks Turning Before BOS 5 DME
Everett Gate	29,854	222	0.7%
Somerville Gate	29,854	230	0.8%
Total	**29,854**	**452**	**1.5%**

Source: Massport, HMMH 2017.

Table H-25 provides the level of traffic off each runway end in 2015 and 2016. These percentages represent the amount of activity experienced off each runway end for a given year.

Table H-25 Runway Usage by Runway End

		2015		2016	
By Runway End	**Operations(s)**	**Total Flights**	**% of Total**	**Total Flights**	**% of Total**
04L	R4L A + R22R D	74,695	20.0%	64,921	16.6%
04R	R4R A + R22L D	52,664	14.1%	60,630	15.5%
09	R9 A + R27 D	20,892	5.6%	22,719	5.8%
14	N/A	0	0.0%	15	0.0%
15L	R15L A + R33R D	123	0.0%	78	0.0%
15R	R15R A + R33L D	31,388	8.4%	36,667	9.4%
22L	R22L A + R4R D	55,164	14.8%	56,495	14.5%
22R	R22R A + R4L D	6,312	1.7%	6,132	1.6%
27	R27 A + R9 D	88,683	23.8%	95,522	24.5%
32	R32 A + R14 D	4,066	1.1%	5,760	1.5%
33L	R33L A + R15R D	37,667	10.1%	39,619	10.1%
33R	R33R A + R15L D	1,275	0.3%	1,782	0.5%
All		**372,930**	**100.0%**	**390,339**	**100.0%**

Notes: A=Arrivals
1 D=Departures

2016 DNL Levels for Census Block Group Locations

Table H-26 reports the DNL value for each Census block group down to the DNL 50 dB computed with AEDT.

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250250203021	Back Bay	1,181	721	50.5	50.5
250250202001	Back Bay	1,266	897	49.9	49.9
250250703001	Back Bay	1,065	804	51.4	51.5
250173521012	Cambridge	1,473	1,187	48.7	48.8
250250408012	Charlestown	828	263	55.4	55.6
250250408013	Charlestown	2,011	1,296	53.5	53.5
250250402001	Charlestown	775	304	53.4	53.3
250250408011	Charlestown	1,061	530	52.7	52.7
250250402002	Charlestown	831	423	52.1	52.1
250250403001	Charlestown	739	334	52.2	52.3
250250403004	Charlestown	617	320	51.8	51.8
250250403003	Charlestown	657	366	51.4	51.3
250250401001	Charlestown	958	555	51.0	51.2
250250403002	Charlestown	1,247	662	51.1	51.3
250250406001	Charlestown	863	491	51.5	50.9
250250406002	Charlestown	1,581	843	51.2	51.2
250250401002	Charlestown	1,210	684	50.6	50.6
250250403005	Charlestown	622	355	50.7	50.8
250250404011	Charlestown	1,689	766	50.1	50.2
250250404012	Charlestown	750	456	49.7	49.9
250251602003	Chelsea	1,497	494	64.0	63.8
250251601015	Chelsea	1,025	261	64.2	64.1
250251602002	Chelsea	1,210	374	62.9	62.9
250251601013	Chelsea	1,730	568	62.2	62.2
250251601011	Chelsea	1,332	353	61.9	62.0
250251603002	Chelsea	596	366	61.5	63.4
250251604002	Chelsea	1,783	683	61.2	61.3
250251602001	Chelsea	1,336	357	61.2	61.0
250251603001	Chelsea	1,469	913	60.5	61.0
250251604001	Chelsea	933	345	59.9	59.6
250251601012	Chelsea	1,372	438	59.5	59.4
250251605022	Chelsea	1,359	477	54.3	54.0

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250251601014	Chelsea	2,092	539	58.2	58.3
250251605021	Chelsea	1,703	624	55.2	54.1
250251605013	Chelsea	774	233	56.8	56.8
250251605023	Chelsea	1,398	488	54.8	54.9
250251605012	Chelsea	1,231	396	55.5	55.3
250251605014	Chelsea	754	392	55.6	55.7
250251605015	Chelsea	748	304	54.5	54.4
250251605011	Chelsea	2,097	646	54.7	54.9
250251606011	Chelsea	2,158	1,005	51.5	51.7
250251606012	Chelsea	1,905	565	53.0	52.9
250251606024	Chelsea	780	271	50.1	50.4
250251606025	Chelsea	985	409	50.8	50.9
250251606021	Chelsea	1,290	470	52.1	52.3
250251606022	Chelsea	795	304	49.9	50.0
250251606023	Chelsea	825	346	48.7	48.6
250251006032	Dorchester	598	284	59.3	58.2
250251007002	Dorchester	1,027	527	58.1	57.6
250251006031	Dorchester	1,306	556	56.2	55.9
250251007003	Dorchester	672	290	56.1	56.2
250250907004	Dorchester	651	302	55.2	55.3
250250909012	Dorchester	2,103	1,034	55.2	53.6
250250913002	Dorchester	1,131	388	54.4	54.3
250251007001	Dorchester	1,050	484	54.3	54.4
250250913001	Dorchester	1,368	480	53.3	53.2
250250907002	Dorchester	1,253	644	53.4	53.4
250250914001	Dorchester	1,672	584	52.6	52.4
250251008004	Dorchester	1,117	666	53.1	51.8
250251007004	Dorchester	856	371	53.0	52.9
250250907003	Dorchester	1,153	526	52.5	52.4
250250912003	Dorchester	742	296	52.1	52.2
250250921013	Dorchester	729	321	52.0	51.3
250251006011	Dorchester	1,094	488	52.2	52.2
250251007005	Dorchester	717	303	52.2	52.3
250250912001	Dorchester	1,081	451	52.2	52.2
250250907001	Dorchester	1,218	518	52.3	52.3
250250921011	Dorchester	1,113	467	51.1	50.9

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250250910013	Dorchester	682	335	51.0	50.6
250250912002	Dorchester	1,411	492	51.1	51.1
250250915002	Dorchester	1,494	547	50.8	50.7
250250911005	Dorchester	817	297	51.2	51.3
250250909011	Dorchester	1,627	606	51.6	51.9
250250915001	Dorchester	1,978	744	50.7	50.9
250251006012	Dorchester	898	382	50.5	50.7
250251008003	Dorchester	899	412	50.4	50.4
250250918003	Dorchester	933	357	50.5	50.4
250250918001	Dorchester	1,517	517	50.6	50.6
250250919001	Dorchester	1,042	329	50.2	50.2
250250918002	Dorchester	1,002	340	50.4	50.6
250250911001	Dorchester	1,395	625	51.0	51.1
250250203031	Downtown Boston	878	693	49.9	49.9
250250203033	Downtown Boston	1,179	789	49.6	49.6
250250701011	Downtown Boston	850	529	56.9	56.1
250250702002	Downtown Boston	1,133	444	54.9	54.8
250250303001	Downtown Boston	1,757	1,283	53.9	54.1
250250305001	Downtown Boston	704	442	52.8	52.8
250250305002	Downtown Boston	1,025	687	52.8	52.8
250250305003	Downtown Boston	809	527	52.5	52.5
250250701018	Downtown Boston	449	246	54.4	54.5
250250702001	Downtown Boston	1,460	599	54.4	54.4
250250304001	Downtown Boston	1,519	994	52.3	52.5
250250303002	Downtown Boston	1,262	709	53.0	53.1
250250301001	Downtown Boston	1,053	790	51.8	51.8
250250304002	Downtown Boston	932	665	52.2	52.2
250250701017	Downtown Boston	1,102	701	53.9	54.2
250250301002	Downtown Boston	901	587	51.4	51.4
250250302001	Downtown Boston	1,665	1,103	51.5	51.6
250250303004	Downtown Boston	548	465	52.8	52.9
250250701012	Downtown Boston	303	90	53.0	53.0
250250702003	Downtown Boston	2,625	647	53.0	53.3
250250303003	Downtown Boston	1,305	503	51.5	51.7
250250701016	Downtown Boston	366	325	52.9	52.8
250250701015	Downtown Boston	451	161	52.6	52.6

Table H-26	2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)				
U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250250701013	Downtown Boston	494	390	52.0	52.1
250250203032	Downtown Boston	1,343	365	50.1	50.3
250250701014	Downtown Boston	1,887	941	52.3	52.2
250250703002	Downtown Boston	733	449	52.4	52.4
250250203012	Downtown Boston	1,673	1,209	49.4	49.2
250250203011	Downtown Boston	350	205	49.2	49.2
250250509011	Eagle Hill East Boston	1,283	420	68.0	67.2
250250509013	Eagle Hill East Boston	918	309	65.9	65.1
250250509012	Eagle Hill East Boston	1,964	717	65.7	65.7
250250507003	Eagle Hill East Boston	1,476	505	62.9	63.4
250250502004	Eagle Hill East Boston	1,055	349	64.0	64.1
250250502003	Eagle Hill East Boston	836	283	63.9	63.9
250250507002	Eagle Hill East Boston	1,344	484	61.6	61.8
250250501011	Eagle Hill East Boston	1,713	534	63.1	62.6
250250507001	Eagle Hill East Boston	1,684	617	59.8	59.5
250250501013	Eagle Hill East Boston	1,930	684	62.0	61.9
250250502001	Eagle Hill East Boston	2,189	757	60.4	60.4
250250502002	Eagle Hill East Boston	1,151	445	59.5	58.9
250250501012	Eagle Hill East Boston	1,472	632	60.2	60.4
250173424004	Everett	1,348	517	58.7	57.5
250173424002	Everett	1,132	480	57.0	57.3
250173424003	Everett	905	346	55.9	57.3
250173424001	Everett	1,878	847	55.8	55.8
250173425003	Everett	2,200	970	55.4	55.6
250173423003	Everett	2,137	858	53.8	53.8
250173426002	Everett	904	347	54.1	54.1
250173423004	Everett	1,807	805	52.7	52.5
250173424005	Everett	792	363	53.0	53.1
250173426003	Everett	2,336	941	53.0	53.1
250173425002	Everett	2,169	870	52.8	53.0
250173426001	Everett	1,125	395	52.1	52.1
250173423002	Everett	1,555	596	52.1	52.2
250173421014	Everett	943	362	49.7	49.8
250173423001	Everett	1,327	495	51.1	51.3
250235001012	Hull	819	452	51.5	52.4
250235001011	Hull	1,502	836	50.6	54.7

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250251202013	Jamaica Plain	451	221	51.8	51.7
250251202012	Jamaica Plain	1,841	894	51.9	51.8
250251202011	Jamaica Plain	1,147	611	50.8	50.9
250251204002	Jamaica Plain	676	363	50.5	50.6
250251201041	Jamaica Plain	516	252	50.1	49.6
250250512002	Jefferies Point	1,548	692	59.4	59.6
250250512001	Jefferies Point	32	19	59.4	58.3
250250512003	Jefferies Point	799	449	58.7	58.5
250092072001	Lynn	1,212	391	58.2	56.0
250092070002	Lynn	1,235	456	56.7	56.4
250092072002	Lynn	1,727	789	56.7	56.5
250092071002	Lynn	992	307	56.7	56.5
250092061002	Lynn	2,051	665	56.4	56.3
250092055002	Lynn	2,552	961	55.9	55.8
250092060001	Lynn	1,443	478	55.8	55.7
250092071001	Lynn	1,446	444	55.7	55.3
250092062002	Lynn	2,267	786	55.5	55.0
250092061001	Lynn	1,793	797	55.3	54.8
250092052004	Lynn	1,435	511	55.1	55.0
250092060002	Lynn	1,916	642	54.8	54.5
250092052002	Lynn	714	277	54.6	54.4
250092052005	Lynn	854	385	54.7	52.5
250092051005	Lynn	637	264	54.3	54.1
250092071003	Lynn	1,075	342	54.4	54.3
250092052003	Lynn	1,510	564	53.9	54.0
250092051004	Lynn	1,527	556	53.7	53.2
250092052001	Lynn	806	410	53.6	52.7
250092062003	Lynn	1,859	573	53.3	53.6
250092062001	Lynn	1,128	327	53.3	53.2
250092051003	Lynn	919	361	53.1	53.0
250092070001	Lynn	963	585	52.7	53.6
250092058002	Lynn	1,089	342	52.4	52.3
250092063004	Lynn	1,040	367	52.4	52.3
250092058001	Lynn	1,044	362	52.1	52.0
250092059001	Lynn	1,743	598	52.2	52.1
250092068002	Lynn	1,792	915	51.7	51.7

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250092063001	Lynn	712	250	51.4	51.3
250092055001	Lynn	2,054	736	51.3	51.6
250092059002	Lynn	1,262	443	51.2	51.3
250092051002	Lynn	1,077	413	51.1	51.0
250092051001	Lynn	1,192	534	51.1	50.6
250092058003	Lynn	1,179	435	50.7	50.6
250092063003	Lynn	1,030	379	50.3	50.4
250173412003	Malden	1,070	451	53.1	52.8
250173412004	Malden	978	383	52.8	52.7
250173414005	Malden	769	389	52.1	52.1
250173412005	Malden	1,693	713	51.4	51.3
250173412006	Malden	976	362	50.4	50.7
250173412002	Malden	976	386	50.5	50.4
250259811004	Mattapan	400	128	50.9	50.6
250250924004	Mattapan	1,142	413	50.9	50.8
250251001001	Mattapan	167	61	50.4	50.2
250173398012	Medford	617	263	56.3	56.3
250173398011	Medford	2,101	1,369	56.3	56.6
250173398021	Medford	1,308	586	55.9	55.7
250173398013	Medford	808	375	56.2	56.2
250173397001	Medford	552	280	54.4	54.1
250173398022	Medford	2,498	1,096	54.5	54.9
250173398014	Medford	884	363	55.3	55.4
250173397003	Medford	785	357	53.8	53.8
250173397002	Medford	1,678	670	53.9	53.7
250173398023	Medford	751	294	53.8	53.7
250173396002	Medford	813	371	53.1	53.1
250173396003	Medford	757	369	53.0	52.9
250173399001	Medford	1,651	719	54.0	53.9
250173396004	Medford	827	363	53.1	53.0
250173396001	Medford	797	392	52.8	52.9
250173397004	Medford	863	377	53.3	53.3
250173399002	Medford	950	380	53.6	53.7
250173396005	Medford	885	377	52.8	52.8
250173399004	Medford	759	346	53.2	53.1
250173395002	Medford	1,312	547	52.5	52.4

Table H-26	2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)				
U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250173396006	Medford	945	443	52.7	52.6
250173395004	Medford	736	307	51.2	51.2
250173399003	Medford	939	425	52.5	52.5
250173399005	Medford	872	342	52.9	52.8
250173400003	Medford	713	303	52.7	52.6
250173391003	Medford	1,169	691	52.2	52.2
250173400001	Medford	1,033	435	52.0	52.0
250173401004	Medford	1,483	609	51.5	51.4
250173395001	Medford	2,710	553	51.8	51.6
250173400002	Medford	848	377	52.2	52.1
250173391002	Medford	1,460	603	51.7	51.7
250173391004	Medford	1,797	1,041	51.3	51.3
250173395003	Medford	641	283	50.9	51.1
250173401006	Medford	826	310	50.5	50.5
250173391001	Medford	617	243	50.3	49.2
250173391005	Medford	1,399	446	50.4	50.4
250214164007	Milton	1,002	386	56.6	53.7
250214164001	Milton	789	302	55.5	54.8
250214164005	Milton	1,028	348	55.6	54.9
250214164006	Milton	978	357	55.4	53.0
250214161012	Milton	1,969	732	54.7	53.9
250214164004	Milton	797	281	51.1	50.0
250214164002	Milton	664	267	50.6	49.4
250092011001	Nahant	629	319	50.0	47.7
250250511013	Orient Heights	1,537	621	63.3	62.6
250250511011	Orient Heights	1,602	598	58.5	59.2
250250511012	Orient Heights	1,949	741	57.0	57.1
250250511014	Orient Heights	1,005	385	57.7	60.9
250259813002	Other East Boston	389	245	79.3	66.0
250250510001	Other East Boston	2,039	855	63.9	64.1
250250510003	Other East Boston	1,088	467	62.7	63.8
250250510002	Other East Boston	962	462	57.5	58.6
250250505001	Other East Boston	1,857	702	59.2	59.4
250250506001	Other East Boston	1,248	494	58.5	58.7
250250506002	Other East Boston	815	312	57.9	57.7
250250504002	Other East Boston	1,735	797	57.5	57.4

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250250504001	Other East Boston	637	238	56.8	56.8
250250503001	Other East Boston	727	282	56.4	56.5
250250503002	Other East Boston	1,524	759	55.7	55.8
250251805002	Point Shirley Winthrop	572	271	67.1	65.1
250251805004	Point Shirley Winthrop	882	459	67.6	67.1
250251805003	Point Shirley Winthrop	1,156	671	58.6	60.0
250251805001	Point Shirley Winthrop	1,273	613	56.8	55.9
250214173001	Quincy	1,781	1,180	57.9	53.8
250214174001	Quincy	1,125	485	54.7	48.2
250214173002	Quincy	900	630	56.9	53.1
250214172001	Quincy	2,743	1,256	52.1	52.8
250214175023	Quincy	887	337	50.7	51.0
250214176021	Quincy	1,328	585	48.4	41.5
250251708002	Revere	1,359	577	64.3	62.6
250251708003	Revere	967	419	63.2	62.6
250251708001	Revere	1,815	797	62.6	62.9
250251707012	Revere	1,311	622	61.1	60.8
250251708004	Revere	977	424	60.6	62.9
250251705022	Revere	1,684	998	58.6	58.3
250251705021	Revere	1,134	550	58.3	58.0
250259815021	Revere	9	3	54.8	55.7
250251705012	Revere	1,501	814	56.5	54.9
250251705011	Revere	1,934	1,113	55.9	54.9
250251707025	Revere	1,391	553	55.4	55.8
250251707011	Revere	788	431	55.0	57.0
250251707022	Revere	1,474	509	55.2	55.3
250251706012	Revere	1,413	573	51.3	51.1
250251707021	Revere	1,146	352	53.5	53.9
250251707024	Revere	959	358	53.4	53.1
250251707023	Revere	1,658	547	52.3	52.1
250251706014	Revere	954	380	50.5	50.8
250251706013	Revere	1,387	497	49.4	49.5
250251701003	Revere	773	320	49.9	50.0
250251701007	Revere	1,335	498	48.5	48.5
250251701002	Revere	1,012	384	49.2	49.2
250251701001	Revere	1,671	769	48.7	48.4

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250251706011	Revere	1,351	557	48.9	48.9
250251704002	Revere	1,151	506	50.3	50.0
250251702002	Revere	1,395	499	47.6	47.6
250251702001	Revere	1,228	542	47.1	47.1
250251703007	Revere	729	300	46.4	46.4
250251701004	Revere	727	290	47.9	47.9
250251704003	Revere	1,101	431	48.2	48.4
250251701005	Revere	1,320	514	47.4	47.4
250251703006	Revere	1,209	517	46.7	46.9
250251704004	Revere	2,025	910	46.7	47.1
250251703005	Revere	1,692	659	45.2	45.2
250251704001	Revere	1,102	485	48.5	50.4
250251702004	Revere	1,335	533	46.1	46.1
250251703004	Revere	1,609	637	45.3	45.1
250251702003	Revere	606	240	46.5	46.5
250251703002	Revere	899	344	44.3	44.5
250251701006	Revere	722	289	47.2	47.3
250251703003	Revere	946	338	44.2	44.3
250259811003	Roslindale	6	6	52.1	51.9
250251101031	Roslindale	568	325	52.0	52.1
250251103012	Roslindale	1,271	552	51.3	51.2
250251101036	Roslindale	583	271	51.4	51.4
250251101035	Roslindale	1,440	666	51.5	51.5
250251103011	Roslindale	1,134	403	50.8	50.8
250251101034	Roslindale	620	289	51.2	51.2
250251101033	Roslindale	653	241	51.0	51.0
250251102011	Roslindale	2,051	874	50.2	50.1
250251104011	Roslindale	2,011	733	50.8	50.8
250250801001	Roxbury	2,612	450	56.4	56.1
250250906001	Roxbury	1,094	351	55.3	55.3
250250801002	Roxbury	738	294	55.6	55.6
250250906002	Roxbury	1,254	442	55.5	55.4
250250818002	Roxbury	921	442	55.1	55.1
250250904004	Roxbury	870	294	55.0	55.0
250250818003	Roxbury	820	369	54.7	54.7
250250818001	Roxbury	1,157	577	55.1	55.1

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250250820003	Roxbury	841	414	54.5	54.4
250250904003	Roxbury	763	254	54.6	54.6
250250817002	Roxbury	893	430	54.7	54.7
250250820002	Roxbury	682	298	54.2	54.1
250250820001	Roxbury	1,292	566	54.1	54.1
250250803001	Roxbury	1,769	791	55.2	55.1
250250821003	Roxbury	2,244	1,012	54.0	54.0
250250819001	Roxbury	906	453	54.4	54.4
250250904001	Roxbury	871	311	54.2	54.2
250250817001	Roxbury	619	225	54.7	54.7
250250821001	Roxbury	1,228	526	53.7	53.7
250250904002	Roxbury	1,155	435	53.9	53.9
250250819002	Roxbury	617	259	54.1	54.0
250250819004	Roxbury	992	428	53.8	53.7
250250819003	Roxbury	600	257	53.9	53.9
250250821002	Roxbury	1,553	579	53.4	53.3
250250903003	Roxbury	978	422	53.6	53.5
250250817003	Roxbury	780	291	53.8	53.8
250250914002	Roxbury	1,069	355	53.3	53.4
250259803001	Roxbury	338	2	52.6	52.8
250250817004	Roxbury	887	355	53.9	54.0
250250804011	Roxbury	1,265	526	54.3	54.2
250250903002	Roxbury	1,310	513	52.8	52.4
250250901001	Roxbury	1,631	660	52.5	52.6
250250902003	Roxbury	934	308	52.6	52.7
250250817005	Roxbury	641	298	53.7	53.9
250250813001	Roxbury	1,661	806	52.9	52.9
250250815002	Roxbury	1,346	554	53.1	53.1
250250902002	Roxbury	626	278	52.3	52.1
250251203013	Roxbury	1,543	554	52.6	52.5
250250903001	Roxbury	891	333	52.5	52.5
250251203012	Roxbury	855	331	52.6	52.6
250250901003	Roxbury	693	303	51.7	51.8
250250901002	Roxbury	531	237	51.5	51.6
250250902001	Roxbury	673	244	51.4	51.5
250250815001	Roxbury	788	351	52.3	52.4

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250250806013	Roxbury	459	242	52.5	52.6
250250804012	Roxbury	1,445	723	52.5	52.4
250250814001	Roxbury	1,067	558	52.1	52.1
250250924005	Roxbury	721	276	50.7	50.7
250250901004	Roxbury	1,099	414	50.6	50.7
250251203014	Roxbury	1,231	567	51.3	51.4
250250924003	Roxbury	1,688	711	50.5	50.8
250251203011	Roxbury	1,166	443	51.3	51.5
250250813002	Roxbury	1,749	690	51.5	51.4
250250901005	Roxbury	617	249	50.2	50.1
250250813003	Roxbury	1,350	615	50.9	51.0
250092081021	Saugus	752	301	55.6	48.5
250173501032	Somerville	1,210	520	54.6	54.2
250173504001	Somerville	1,006	368	52.6	52.5
250173501042	Somerville	2,584	947	53.2	53.4
250173504005	Somerville	849	392	52.3	52.3
250173504002	Somerville	1,232	565	52.1	52.1
250173503003	Somerville	849	390	52.0	52.0
250173501041	Somerville	2,119	793	52.3	52.6
250173504003	Somerville	1,017	462	51.5	51.4
250173501044	Somerville	1,384	673	52.1	52.0
250173509001	Somerville	803	398	51.1	51.0
250173501043	Somerville	1,188	485	51.7	51.4
250173503002	Somerville	627	304	51.0	51.0
250173502001	Somerville	1,376	586	51.2	51.1
250173503001	Somerville	965	454	51.1	51.7
250173502006	Somerville	1,044	502	51.2	51.2
250173510005	Somerville	1,056	484	50.5	50.5
250173514031	Somerville	763	309	50.8	50.9
250173502005	Somerville	749	315	50.7	50.8
250173510001	Somerville	1,236	595	50.0	49.9
250173514033	Somerville	587	321	50.1	50.1
250173502004	Somerville	1,410	594	50.1	50.1
250173514035	Somerville	619	288	49.9	49.9
250173514032	Somerville	1,017	391	50.0	50.1
250173514034	Somerville	1,042	369	50.0	50.2

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250173502003	Somerville	1,385	533	50.0	49.9
250173511002	Somerville	912	465	49.8	49.7
250173502002	Somerville	603	233	49.8	49.8
250173514041	Somerville	1,147	448	49.0	49.0
250173504004	Somerville	1,464	721	51.7	51.7
250173506001	Somerville	1,656	2	52.2	52.2
250173506004	Somerville	1,164	487	52.1	52.0
250173510004	Somerville	1,813	870	49.2	49.2
250173510006	Somerville	1,018	523	49.2	49.3
250173506002	Somerville	939	371	51.7	51.6
250173511005	Somerville	1,146	540	49.0	49.0
250173505002	Somerville	811	382	51.8	51.8
250173505001	Somerville	818	390	51.9	51.9
250173511001	Somerville	1,601	747	49.0	49.0
250173506003	Somerville	813	231	51.3	51.2
250173514042	Somerville	1,335	527	49.0	49.0
250173514043	Somerville	1,026	396	48.8	48.8
250250606001	South Boston	2,357	1,530	62.7	61.0
250250612001	South Boston	1,702	1,188	59.0	59.0
250250601011	South Boston	881	441	60.5	60.5
250250607001	South Boston	741	253	58.8	58.9
250250601013	South Boston	981	496	59.7	59.8
250250601012	South Boston	633	350	59.3	59.5
250250607002	South Boston	1,152	383	58.3	58.3
250250601014	South Boston	721	397	58.7	59.3
250250612002	South Boston	627	383	57.1	56.8
250250608003	South Boston	886	470	57.9	57.9
250250608004	South Boston	1,666	943	57.4	57.1
250250605014	South Boston	631	295	58.1	58.4
250250608002	South Boston	757	396	56.8	56.9
250250605015	South Boston	656	333	57.2	57.3
250250602001	South Boston	821	419	57.3	57.3
250250608001	South Boston	655	333	56.6	56.6
250250605013	South Boston	717	431	56.8	56.8
250250605011	South Boston	699	375	57.0	57.0
250250605012	South Boston	868	508	56.5	56.5

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250250612003	South Boston	911	470	55.3	55.3
250250602002	South Boston	1,095	580	56.1	56.3
250250610001	South Boston	1,033	544	55.5	55.6
250250604005	South Boston	960	336	55.6	55.8
250250610002	South Boston	1,164	471	55.1	55.1
250250610003	South Boston	901	393	55.0	55.0
250250603013	South Boston	1,092	561	56.0	56.1
250250604001	South Boston	1,021	542	55.4	55.2
250250611011	South Boston	617	278	54.4	54.5
250250603011	South Boston	1,285	741	55.6	55.7
250250603012	South Boston	699	345	55.1	55.1
250250604002	South Boston	988	530	54.9	54.8
250250604004	South Boston	1,093	669	54.5	54.5
250250604003	South Boston	842	466	54.4	54.4
250250611012	South Boston	1,615	766	53.5	53.7
250250712011	South End	1,899	819	56.5	56.2
250250711012	South End	1,424	750	55.6	54.9
250250712012	South End	1,232	580	55.6	55.5
250250711011	South End	1,498	928	55.4	55.6
250250704021	South End	1,723	680	55.4	55.2
250250711013	South End	831	507	54.9	54.6
250250705001	South End	1,700	1,018	54.3	54.3
250250705003	South End	1,393	803	53.9	53.8
250250705002	South End	999	524	53.4	53.4
250250705004	South End	1,368	721	53.4	53.4
250250709001	South End	2,166	1,231	52.9	53.0
250250703004	South End	1,119	746	52.7	52.6
250250805002	South End	2,020	863	52.5	52.4
250250709002	South End	1,163	567	52.5	52.5
250250706001	South End	1,127	667	52.3	52.5
250250703003	South End	992	707	51.8	52.0
250250706002	South End	1,113	642	51.8	51.8
250251802004	Winthrop	1,343	549	62.1	61.1
250251802001	Winthrop	1,471	610	59.3	59.9
250251802003	Winthrop	648	336	58.8	58.9
250251804002	Winthrop	839	347	58.8	58.9

Table H-26 2016 DNL Levels for Census Block Group Locations within the DNL 50 dB (Continued)

U.S. Census 2010 Block Group					
Block Group ID	**Name**	**Population**	**Housing units**	**Average Block DNL**	**DNL at centroid**
250251802002	Winthrop	647	299	57.2	57.3
250251804001	Winthrop	876	435	58.1	58.1
250251801013	Winthrop	2,344	1,194	55.8	55.0
250251801011	Winthrop	1,207	584	53.9	53.7
250251801012	Winthrop	1,215	724	51.5	52.2
250251803014	Winthrop Court Rd	760	297	63.8	64.0
250251803012	Winthrop Court Rd	778	322	61.7	61.8
250251803011	Winthrop Court Rd	652	258	60.3	60.4
250251803013	Winthrop Court Rd	834	351	61.1	61.3

MERCATUS ON POLICY

Airport Noise NIMBYism: An Empirical Investigation

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MERCATUS CENTER
George Mason University

Every growing city encounters criticism from residents who will settle for little else but the status quo. Local governments intent on building or expanding infrastructure must contend with citizens opposed to the inconvenience and nuisance of increased construction, more neighbors, and heavier traffic. This hostility to expansion, called "NIMBYism" (not in my backyard), can be a barrier to denser development, lower housing prices, and ultimately economic growth.

But NIMBYism extends beyond opposition to urban development, and its consequences can hinder economic growth in nonobvious ways. In this policy brief, we explore a particular category of NIMBY complaints surrounding airport noise. Airport noise can be a nuisance, but it is also necessary for economic activity in the modern world. We evaluate noise complaint data from a selection of US airports to quantify opposition to airport noise. We find that the source of airport noise complaints is highly concentrated in a few dedicated complainers.

Airport noise policy must strike a reasonable balance between noise abatement and the economic benefits associated with noisy airplane takeoffs and landings. However, because the majority of noise complaints come from a small number of loud objectors, there is a danger that this balance has been tilted too far in the direction of noise abatement.[1] We hope that increasing awareness of the lopsided distribution of noise complaints can help promote noise standards that strike an appropriate balance and facilitate the advancement of faster and cheaper commercial flight.

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MANY COMPLAINTS COME FROM A SMALL NUMBER OF CALLERS

Most airports in the United States allow the public to submit noise complaints through dedicated hotlines and online portals. Nearly all of the country's largest airports publish data on the calls they receive, but this information varies in thoroughness. Some airport authorities, such as the Port of Seattle, allow public access to each complainant's name, their personal information, and a summary of the call. Others, like Boston's Massport, only publish the number of complaints received and the number of unique callers. But even this summary information is useful; data from Massport on Boston Logan International Airport still illustrate the distribution and origin of complaints.

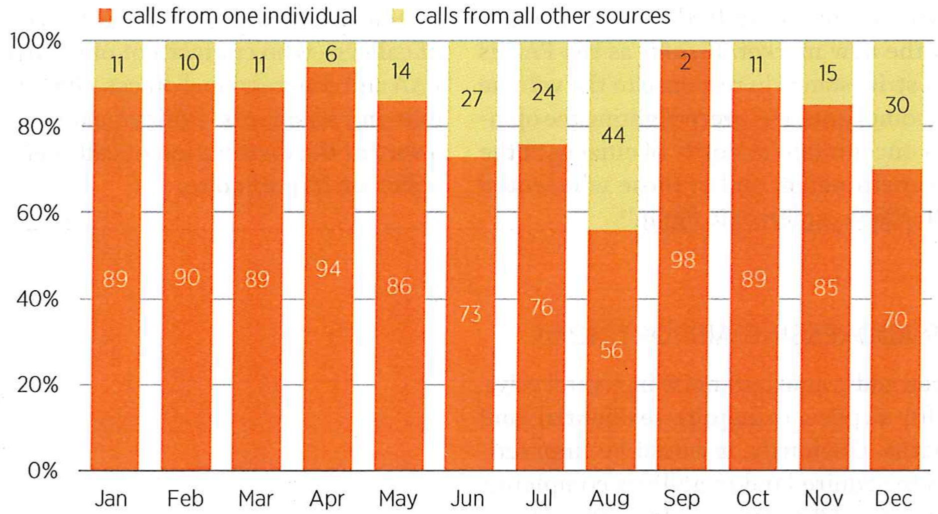
Generally, a very small number of people account for a disproportionately high share of the total number of noise complaints. In 2015, for example, 6,852 of the 8,760 complaints submitted to Ronald Reagan Washington National Airport originated from one residence in the affluent Foxhall neighborhood of northwest Washington, DC.[2] The residents of that particular house called Reagan National to express irritation about aircraft noise an average of almost 19 times per day during 2015. Other major airports report similar trends. In Seattle's detailed call-by-call lists, one individual complains so frequently that her grievances are not transcribed in full but simply tallied at the end of the month. While airport employees provide summaries of other calls, the description of this particular individual's calls is, "Same complaint over and over. Records a/c flying over."[3]

Relative to other large US airports, San Francisco International Airport receives an enormous number of complaints each year. In 2015, it registered 890,376 complaints. Predictably, we find that these complaints were not lodged by a correspondingly large number of people; rather, hundreds of thousands of calls came from just 9,561 callers. Even if calls were uniformly distributed among these callers, each would still have had to place 93 calls. But as with other US airports, San Francisco's complaint records show a high degree of concentration among a very small subset of total callers. In October 2015, 53 Portola Valley, CA, residents placed 25,259 calls to the airport—nearly 477 per person. Similarly, three residents of Daly City placed 1,034 calls in December 2015, and six Woodside callers complained 2,432 times in November.

TABLE 1. SUMMARY OF AIRPORT NOISE COMPLAINTS

Airport	Time period covered	Total number of complaints	Evidence of concentration
Ronald Reagan Washington National Airport (DCA)	2015	8,760	2 individuals at 1 residence in NW DC accounted for 6,852 complaints (78 percent).[4]
Denver International Airport (DEN)	2015	4,870	1 individual in Strasburg, CO, 30 miles from the airport, accounted for 3,555 complaints (73 percent). 4 callers accounted for 4,653 complaints (96 percent). A total of 42 households complained.[5]
Washington Dulles International Airport (IAD)	2015	1,223	1 individual in Poolesville, MD, 13 miles away from the airport, accounted for 1,024 complaints (84 percent).[6]
Las Vegas McCarran International Airport (LAS)	2015	3,963	1 individual accounted for 450 calls in September 2015 (98 percent of monthly total).[7]
Los Angeles International Airport (LAX)	2015	8,862	1 individual in Monterey Park, CA, accounted for 489 complaints during June 2015 (50 percent of monthly total). The top 3 callers accounted for 88 percent of June complaints.[8]
Portland International Airport (PDX)	2015	688	5 individuals accounted for 420 complaints (61 percent).[9]
Phoenix Sky Harbor International Airport (PHX)	2015	24,247	1,338 households in total lodged complaints. While data is not available by household, the airport received 3,814 complaints from 13 households in zip code 85258, for an average of 293 calls per household.[10]
Seattle-Tacoma International Airport (SEA)	2014	1,006	3 individuals accounted for 648 complaints (64 percent). Top caller accounted for 42 percent of total.[11]
San Francisco International Airport (SFO)	2015	890,376	53 Portola Valley, CA, individuals accounted for 25,259 complaints during the month of October 2015, for an average of 477 calls per person in that month.[12]

FIGURE 1. CONCENTRATION OF NOISE COMPLAINTS AT LAS VEGAS MCCARRAN INTERNATIONAL AIRPORT (LAS), 2015



Source: McCarran International Airport, "Noise Complaint Reports."

Table 1 summarizes the concentration of noise complaints registered at several large US airports. Figure 1 shows the monthly concentration of noise complaints over the course of 2015 at McCarran International Airport in Las Vegas.

SMALL NUMBER OF CALLERS HAVE DISPROPORTIONATE IMPACT

Airport noise complaint data paints a startling picture. A handful of individuals are responsible for most of the noise complaints at most airports we examine. Some of these individuals do not appear to live particularly close to the airports to which they are complaining. For example, one individual in Strasburg, CO, 30 miles from Denver International Airport, complained 3,555 times in 2015, an average of 9.7 times per day. One individual in La Selva Beach, CA, about *55 miles* from San Francisco International Airport, complained about airport noise 186 times during October 2015.

There are worrisome signs that this small, frustrated minority of citizens is affecting aviation policy. In recent decades, the Federal Aviation Administration (FAA) has imposed progressively more stringent noise standards on aircraft operating in US airspace.[13] While noise abatement is desirable, it can have significant costs—particularly on the fuel efficiency of aircraft—resulting not only in higher carbon emissions but also in higher ticket prices. It is troubling that a tiny but vocal group is potentially driving policy. While we do not have data on grievances lodged directly to the FAA or to members of Congress, it is probable that those airport noise complaints follow a similar pattern.

AIRPORT NOISE AND FUEL EFFICIENCY

Airport noise is entangled with fuel efficiency in at least two ways. First, the FAA's NextGen airspace modernization program will enable aircraft to travel along denser and more direct routes, particularly on approach for landing. NextGen will remove much of the need for circling above the airport in holding patterns, and it allows aircraft to descend more gradually, saving valuable fuel. However, denser and more gradual approaches also correspond to more noise on the ground under approach paths to the airport. Airports undergoing NextGen implementation have experienced a significant uptick in noise complaints.[14]

Second, airport noise standards are very important for fuel efficiency gains on potential new supersonic aircraft. Aircraft are more fuel efficient when they can take off at full throttle, and these gains in efficiency are of particular importance when aircraft are climbing to the high cruise speeds and altitudes of supersonic planes. Yet in the FAA's most recent policy statement on supersonics, the agency said it "would propose that any future supersonic airplane produce no greater noise impact on a community than a subsonic airplane."[15] Subsonic noise type certification requirements are quite strict, and they will become stricter still in 2018. Holding supersonic aircraft to subsonic noise standards would hamper the viability of the new market. Insofar as the FAA is adopting such a strict stance in response to the volume of airport noise complaints, it is overweighting the opinions of a small, concentrated minority of citizens at the expense of the environment and of those who would benefit from affordable supersonic flight.[16]

OPTIONS FOR ADDRESSING AIRPORT NOISE

Policymakers can address airport noise in several ways. One option is for airports to acquire residential land below flight paths. Obviously, it would be impractical for airports to acquire land to address complaints originating from up to 50 miles away from the airport. Nevertheless, numerous airports have bought up nearby land to reduce the effect of noise on people nearby. A second approach is to make noise standards more severe, creating mandatory retirement of the existing fleet of airplanes. This was done in the 1990s as the Stage 2 noise standard was replaced with Stage 3. Economist Stephen A. Morrison and his coauthors estimate that the benefits of the phaseout, in terms of property values for homeowners, were $5 billion less than the costs to airlines, in terms of the reduced life of their capital.[17]

A third approach is to subsidize and otherwise support the installation of more and better insulation in homes affected by airport noise. Aerospace engineer Philip J. Wolfe and his coauthors estimate that this is more cost-effective than land acquisition or mandatory retirement.[18] There are a number of insulation programs run by airports around the country.[19]

Finally, a noise tax could help to efficiently discourage the production of noise without outright banning it, and revenues could be used to fund insulation programs. This is a better strategy than existing FAA policy of continuing to increase noise standards, perhaps in response to a high volume of complaints.

CONCLUSION

It would be a mistake to allow the preferences of a vocal but minuscule minority of citizens, however sympathetic their circumstances, to impede much-needed improvements in aviation. Airport noise standards are already quite strict, and they create real economic and environmental costs associated with lower aircraft fuel efficiency. While our analysis cannot recommend a precise noise standard, we are concerned that a handful of callers—who contact not only airports but also the FAA and congressional offices—have unduly influenced existing standards. Policymakers should be acutely aware of the distribution of calls before taking further action on airport noise.

NOTES

1. In other words, airport noise complaints could be a classic case of concentrated benefits and diffused costs. Mancur Olson, *The Logic of Collective Action: Public Goods and the Theory of Groups*, 2nd ed. (Cambridge, MA: Harvard University Press, 1971).
2. Metropolitan Washington Airports Authority, "2015 Annual Aircraft Noise Report," accessed August 18, 2016.
3. Port of Seattle, "Public Records Request: Request #16-34," January 27, 2016.
4. Ibid.
5. Denver International Airport, "DEN Noise Report: January 1, 2015–December 31, 2015," accessed August 19, 2016.
6. Metropolitan Washington Airports Authority, "2015 Annual Aircraft Noise Report."
7. McCarran International Airport, "Noise Complaint Reports," July through September 2015 Noise Complaint Reports, October 22, 2015.
8. Los Angeles World Airports, "June 2015 ANCR Report," July 31, 2015.
9. Port of Portland, "2015 Year in Review," accessed August 19, 2016.
10. City of Phoenix Aviation Department, "Annual Noise Report 2015," accessed August 18, 2016.
11. Port of Seattle, "Public Records Request: Request #16-122," April 6, 2016.
12. San Francisco International Airport, "Noise Abatement Data," accessed August 19, 2016.
13. Federal Aviation Administration, "Details on FAA Noise Levels, Stages, and Phaseouts," June 10, 2016.
14. Pia Bergqvist, "NextGen Flight Paths Give Rise to Noise Complaints," *Flying Magazine*, June 23, 2016. Entire websites also exist to coordinate noise complaints against NextGen. See NextGenNoise, accessed September 26, 2016, http://nextgennoise.org/.
15. Federal Aviation Administration, Civil Supersonic Airplane Noise Type Certification Standards and Operating Rules, 73 Fed. Reg. 205 (October 22, 2008).
16. For subsonic aircraft, noise standards have in fact become stricter over time. In 2000, so-called Stage 3 noise requirements became mandatory. In 2006, the FAA stopped certifying aircraft under Stage 3 in favor of the more restrictive Stage 4 standards. In 2018, new Stage 5 standards will be required for certification. This continuous one-way ratchet in noise standards is at least circumstantial evidence that noise complaints are effective.
17. Steven A. Morrison, Clifford Winston, and Tara Watson, "Fundamental Flaws of Social Regulation: The Case of Airplane Noise," *Journal of Law and Economics* 42, no. 2 (1999): 723–44.
18. Philip J. Wolfe et al., "Costs and Benefits of US Aviation Noise Land-Use Policies," *Transportation Research Part D: Transport and Environment* 44 (2016): 147–56.
19. Jon Hilkevitch, "Midway-Area Homes to Get $10 Million More for Soundproofing," *Chicago Tribune*, August 5, 2015; Massachusetts Port Authority, "Sound Insulation Program," accessed August 19, 2016; Community Development Commission of the County of Los Angeles, "Residential Sound Insulation Program (RSIP)," accessed August 19, 2016.

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I

Air Quality/Emissions Reduction

This appendix provides the following detailed information and data tables in support of Chapter 7, *Air Quality/Emissions Reduction*:

- Fundamentals of Air Quality
  - Table I-1 National Ambient Air Quality Standards
  - Table I-2 Airport-Related Sources of Air Emissions
  - Table I-3 Attainment, Nonattainment, and Maintenance Areas
- Aircraft Fleet and Operational Data Used in AEDT 2c SP2
  - Table I-4 2016 Fleet Mix, Annual Landing-and-Takeoff Cycles (LTOs), and Taxi/Delay Time-in-Mode by Aircraft Type
- Ground Service Equipment Time-in-Mode Survey
  - Table I-5 GSE Time-in-Mode (minutes)
- Ground Service Equipment/Alternative Fuels Conversion
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- Motor Vehicle Emissions
  - Table I-7 MOVES2014a Sample Input File for 2016
  - Table I-8 MOVES2014a Sample Output File for 2016
- Fuel Storage and Handling
  - Table I-9 Fuel Throughput by Fuel Category (gallons)
- Stationary Sources
  - Table I-10 Stationary Source Fuel Throughput by Fuel Category (gallons)
- 1993 – 2009 Emissions Inventories
  - Table I-11 Estimated VOC Emissions (in kg/day) at Logan Airport 1993-2001
  - Table I-12 Estimated VOC Emissions (in kg/day) at Logan Airport 2002-2009

Fundamentals of Air Quality

This section contains a general summary of air quality and air emissions with a particular emphasis on airport-related emissions where appropriate. This material is intended to supplement and provide background information for the materials contained in Chapter 7, *Air Quality/Emissions Reduction*.

Pollutant Types and Standards

The U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for a select group of "criteria air pollutants" designed to protect public health, the environment, and the quality of life from the detrimental effects of air pollution. Listed alphabetically, these pollutants are briefly described below:

- **Carbon monoxide (CO)** is a colorless, odorless, tasteless gas. It may temporarily accumulate, especially in cool, calm weather conditions, when fuel use reaches a peak and CO is chemically most stable due to the low temperatures. CO from natural sources usually dissipates quickly, posing no threat to human health. Transportation sources (e.g., motor vehicles), energy generation, and open burning are among the predominant anthropogenic (i.e., man-made) sources of CO.

- **Lead (Pb)** in the atmosphere is generated from industrial sources including waste oil and solid waste incineration, iron and steel production, lead smelting, and battery and lead manufacturing. The lead content of motor vehicle emissions, which was the major source of lead in the past, has significantly declined with the widespread use of unleaded fuel. Low-lead fuel used in some general aviation (GA) aircraft is still a source of airport-related lead.

- **Nitrogen dioxide (NO_2)**, nitric oxide (NO), and the nitrate radical (NO_3) are collectively called oxides of nitrogen (NO_x). These three compounds are interrelated, often changing from one form to another in chemical reactions, and NO_2 is the compound commonly measured for comparison to the NAAQS. NO_x is generally emitted in the form of NO, which is oxidized to NO_2. The principal man-made source of NO_x is fuel combustion in motor vehicles and power plants – aircraft engines are also a source. Reactions of NO_x with other atmospheric chemicals can lead to formation of ozone (O_3) and acidic precipitation.

- **Ozone (O_3)** is a secondary pollutant, formed from daytime reactions of NO_x and volatile organic compounds (VOCs) in the presence of sunlight. VOCs, which are a subset of hydrocarbons (HC) and have no NAAQS, are released in industrial processes and from evaporation of gasoline and solvents. Sources of NO_x are discussed above.

- **Particulate matter (PM)** comprises very small particles of dirt, dust, soot, or liquid droplets called aerosols. The NAAQS for PM is segregated by sizes (i.e., less than 10 and less than 2.5 microns as PM_{10} and $PM_{2.5}$, respectively). PM is formed as an exhaust product in the internal combustion engine or can be generated from the breakdown and dispersion of other solid materials (e.g., fugitive dust).

- **Sulfur oxides (SO_x)** are primarily composed of sulfur dioxide (SO_2) which is emitted in natural processes and by man-made sources such as combustion of sulfur-containing fuels and sulfuric acid manufacturing.

The NAAQS for these criteria pollutants are subdivided into the Primary Standards (designed to protect human health) and the Secondary Standards (designed to protect the environment and human welfare) and are listed below in **Table I-1**. Exceedances of these values constitute violations of the NAAQS.

Table I-1 National Ambient Air Quality Standards

Pollutants	Averaging Time	Concentration	Condition of Violation
Ozone (O_3)	8-hour	0.070 ppm	3-year average of the fourth-highest daily maximum 8-hour average.
Carbon Monoxide (CO)	8-hour	9 ppm	No more than once per year.
	1-hour	35 ppm	
Nitrogen Dioxide (NO_2)	Annual Average	53 ppb	Annual mean.
	1-hour	100 ppb	3-year average of the 98th percentile of the daily maximum 1-hour average.
Sulfur Dioxide (SO_2)	3-hour	0.5 ppm	No more than once per year.
	1-hour	75 ppb	Three-year average of the 99th percentile of 1-hour daily maximum concentrations.
Particulate Matter (PM_{10})	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years.
Particulate Matter ($PM_{2.5}$)	Annual (primary)	12 $\mu g/m^3$	Annual mean, averaged over 3 years.
	Annual (secondary)	15 $\mu g/m^3$	Annual mean, averaged over 3 years.
	24-hour	35 $\mu g/m^3$	3-year average of the 98th percentile.
Lead (Pb)	Rolling 3-month average	0.15 $\mu g/m^3$	Not to be exceeded.

Source: EPA, 2017, https://www.epa.gov/criteria-air-pollutants.
Note: ppm - parts per million; ppb – parts per billion; µg/m3 - micrograms per cubic meter

Sources of Airport Air Emissions

Almost all large metropolitan airports generate air emissions from the following general source categories: aircraft, ground service equipment (GSE), and motor vehicles traveling to, from, and moving about the airport; fuel storage and transfer facilities; a variety of stationary sources (e.g., steam boilers, back-up generators, snow melters, etc.); an assortment of aircraft maintenance activities (e.g., painting, cleaning, repair, etc.); routine airfield, roadway, and building maintenance activities (e.g., painting, cleaning, repair, etc.); and periodic construction activities for new projects or improvements to existing facilities. **Table I-2** provides a summary listing of these sources of air emissions, the pollutants, and their characteristics.

Table I-2 Airport-related Sources of Air Emissions

Sources	Emissions	Characteristics
Aircraft	CO NO_2 PM SO_2 VOCs	Exhaust products of fuel combustion that vary depending on aircraft engine type, number of engines, power setting, and period of operation. Emissions are also emitted by an aircraft's auxiliary power unit (APU).
Motor vehicles	CO NO_2 PM SO_2 VOCs	Exhaust products of fuel combustion from patron and employee traffic approaching, departing, and moving about the airport site. Emissions vary depending on vehicle type, distance traveled, operating speed, and ambient conditions.
Ground service equipment	CO NO_2 PM SO_2 VOCs	Exhaust products of fuel combustion from service trucks, tow tugs, belt loaders, and other portable equipment.
Fuel storage and transfer	VOCs	Formed from the evaporation and vapor displacement of fuel from storage tanks and fuel transfer facilities. Emissions vary with fuel usage, type of storage tank, refueling method, fuel type, vapor recovery, climate, and ambient temperature.
Stationary sources	CO NO_2 PM SO_2 VOCs	Exhaust products of fossil fuel combustion from boilers dedicated to indoor heating requirements and emissions from incinerators used for waste reduction. Emissions are generally well controlled with operational techniques and post-burn collection methods. Sources include boilers and hot water generators, emergency generators, incinerators, paint booth and surface coating operations, welding operations, and firefighting facilities.
Construction Activities	CO NO_2 PM SO_2 VOCs	Construction projects may have associated emissions from dust generated during excavation and land clearing, exhaust emissions from construction equipment and motor vehicles, and evaporative emissions from asphalt paving and painting. The amount of particulate emissions varies with the material type, the amount of area exposed, and meteorology. The construction of airport and airfield improvement projects at airports represents temporary sources of emissions.

Source: KBE 2013.

Notes: CO - Carbon monoxide; VOC - Volatile organic compounds; PM - Particulate matter; NO_2 - Nitrogen dioxide; SO_2 - Sulfur dioxide.

EPA, state, and local air quality agencies maintain outdoor air monitoring networks to measure air quality conditions and gauge compliance with the NAAQS. Based upon the data collected by these agencies, all areas throughout the country are designated by EPA with respect to their compliance with the NAAQS. **Table I-3** provides the definitions of each of these designations.

Table I-3 Attainment, Nonattainment, and Maintenance Areas

Attainment/Nonattainment Designations			
Attainment	**Attainment/Maintenance**	**Nonattainment Area**	**Unclassifiable**
Any area that meets the NAAQS established for all of the criteria air pollutants.	Any area that is in transition from formerly being a nonattainment area to an attainment area (also called Maintenance).	Any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) one or more of the NAAQS.	Any area that cannot be classified on the basis of available information as meeting or not meeting the NAAQS.

Source: EPA

For O_3, CO, PM_{10}, and $PM_{2.5}$, the nonattainment designations are further classified by the severity, or degree, of the violation of the NAAQS. For example, in the case of O_3, these classifications range from highest to lowest as extreme, severe, serious, marginal, and moderate.

The nonattainment designation of an area has a bearing on the emission control measures required and the time periods allotted by which a State Implementation Plan (SIP) must demonstrate attainment of the NAAQS. It is also important to note that the degree of nonattainment determines the thresholds of emissions that are considered to be "*de minimis*," or levels below (i.e., within) which a formal General Conformity determination is not required.

Finally, the boundaries of nonattainment areas are generally determined based on Core Based Statistical Areas (CBSA) as defined by U.S. census data (air monitoring station locations and contributing emission sources also play a role). However, nonattainment areas for localized pollutants such as lead and CO typically only comprise a partial CBSA or a local "hot-spot." By comparison, regional pollutants such as O_3 can encompass multiple CBSAs and can extend across state lines.

State Implementation Plans (SIP)

For the purposes of this summary explanation of SIPs, it is sufficient to characterize SIPs as the principal instrument by which a state formulates and implements its strategies for bringing nonattainment or maintenance areas into compliance with the NAAQS. In equally broad terms, the SIP contains the necessary emission limitations, control measures and timetables for achieving this objective. Therefore, the SIP development process is delegated to state air quality agencies that may in turn rely on regional, county, and local agencies to help prepare emission inventories that include airport-related emissions.

Aircraft Fleet and Operational Data used in AEDT 2c SP2

The Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT), Version 2c Service Pack 2 (AEDT 2c SP2) was used in support of the 2016 air quality analysis.

Table I-4 contains the data that were used in AEDT 2c SP2 to represent actual conditions at Logan Airport in 2016. These data include aircraft type, engine, landing takeoff cycles (LTOs), and taxi times. The aircraft are divided into four categories: air carrier (AC), cargo (CA), commuter (CO), and GA.

Table I-4 2016 Fleet Mix, Annual Landing-and-Takeoff Cycles (LTOs), and Taxi/Delay Time-in-Mode by Aircraft Type

Aircraft Type	Engine	LTOs	Description (Airline)	Taxi Times
Air Carrier Aircraft				
Boeing 767-300 Series	CF6-80C2B6 1862M39	2	AC (CHARTER)	25.34
Boeing 737-200 Series	JT8D-15A	1	AC (CHARTER) AJI	25.34
Boeing 737-400 Series	CFM56-3B-2	7	AC (CHARTER) BSK	25.34
Boeing 777-200 Series	GE90-90B DAC I	1	AC (CHARTER) CSN	25.34
Boeing 737-800 Series	CFM56-7B26 (8CM051)	9	AC (CHARTER) EAL	25.34
Boeing 767-300 Series	CF6-80C2B6 1862M39	1	AC (CHARTER) ISS	25.34
Boeing 737-200 Series	JT8D-15A	1	AC (CHARTER) KFS	25.34
Bombardier Learjet 35	TFE731-2-2B	35	AC (CHARTER) KFS	25.34
Bombardier CRJ-200	CF34-3B	1	AC (CHARTER) MNU	25.34
Boeing 787-8 Dreamliner	GEnx-1B64 TAPS (11GE136)	1	AC (CHARTER) RAM	25.34
Bombardier Learjet 35	TFE731-2-2B	8	AC (CHARTER) RAX	25.34
Boeing 777-200 Series	GE90-90B DAC II (6GE090)	3	AC (CHARTER) SVA	25.34
Boeing 737-800 Series	CFM56-7B26 (8CM051)	2	AC (CHARTER) SWG	25.34
Boeing 737-400 Series	CFM56-3B-2	11	AC (CHARTER) SWQ	25.34
Raytheon Beech Baron 58	TIO-540-J2B2	1	AC (CHARTER) USC	25.34
Bombardier Learjet 35	TFE731-2-2B	1	AC (CHARTER) USC	25.34
Bombardier Global Express	BR700-710A2-20	13	AC (CHARTER) VJT	25.34
Airbus A319-100 Series	CFM56-5B6/P	5,705	AC AAL	25.34
Airbus A320-200 Series	V2527-A5	1,574	AC AAL	25.34
Airbus A321-100 Series	V2533-A5	5,360	AC AAL	25.34
Airbus A330-200 Series	PW4168 Talon II	155	AC AAL	25.34
Boeing 737-800 Series	CFM56-7B26 (8CM051)	8,457	AC AAL	25.34
Boeing 757-200 Series	RB211-535E4B Phase 5	1,641	AC AAL	25.34

Table I-4 2016 Fleet Mix, Annual Landing-and-Takeoff Cycles (LTOs), and Taxi/Delay Time-in-Mode by Aircraft Type (Continued)

Aircraft Type	Engine	LTOs	Description (Airline)	Taxi Times
Air Carrier Aircraft (Cont'd.)				
Embraer ERJ190	CF34-10E6 SAC	4,990	AC AAL	25.34
Boeing MD-88	JT8D-219 Environmental Kit (E_Kit)	8	AC AAL	25.34
Airbus A319-100 Series	CFM56-5A5	35	AC ACA	25.34
Boeing 787-8 Dreamliner	GEnx-1B64 TAPS (11GE136)	1	AC ACA	25.34
Embraer ERJ190	CF34-10E5A1 SAC	1,321	AC ACA	25.34
Airbus A330-200 Series	CF6-80E1A3	85	AC AFR	25.34
Airbus A340-300 Series	CFM56-5C2	8	AC AFR	25.34
Airbus A380-800 Series	Trent 9XX	1	AC AFR	25.34
Boeing 777-200 Series	GE90-90B DAC I	356	AC AFR	25.34
Boeing 737-700 Series	CFM56-7B22	136	AC AMX	25.34
Boeing 737-800 Series	CFM56-7B26 (8CM051)	154	AC AMX	25.34
Boeing 737-800 Series	CFM56-7B24	598	AC ASA	25.34
Boeing 737-900 Series	CFM56-7B27	1,030	AC ASA	25.34
Airbus A330-200 Series	CF6-80E1A4 Low emissions	279	AC AZA	25.34
Airbus A318-100 Series	CFM56-5B8/P	1	AC BAW	25.34
Airbus A380-800 Series	Trent 9XX	2	AC BAW	25.34
Boeing 747-400 Series	RB211-524H	657	AC BAW	25.34
Boeing 777-200 Series	GE90-90B DAC I	595	AC BAW	25.34
Boeing 787-9 Dreamliner	Trent 1000-J2	95	AC BAW	25.34
Airbus A330-200 Series	JT9D-70	96	AC BER	25.34
Boeing 787-8 Dreamliner	GEnx-1B64 TAPS (11GE136)	326	AC CHH	25.34
Boeing 787-9 Dreamliner	Trent 1000-J2	154	AC CHH	25.34
Boeing 737-300 Series	CFM56-3-B1	189	AC CMP	25.34
Boeing 737-800 Series	CFM56-7B26 (8CM051)	130	AC CMP	25.34
Boeing 777-300 ER	GE90-115B	227	AC CPA	25.34
Airbus A319-100 Series	CFM56-5A5	3,174	AC DAL	25.34
Airbus A320-200 Series	CFM56-5A3	2,146	AC DAL	25.34
Airbus A321-100 Series	V2533-A5	265	AC DAL	25.34
Airbus A330-300 Series	PW4168A Talon II	377	AC DAL	25.34

Table I-4 2016 Fleet Mix, Annual Landing-and-Takeoff Cycles (LTOs), and Taxi/Delay Time-in-Mode by Aircraft Type (Continued)

Aircraft Type	Engine	LTOs	Description (Airline)	Taxi Times
Air Carrier Aircraft (Cont'd.)				
Boeing 717-200 Series	BR700-715A1-30	3,211	AC DAL	25.34
Boeing 737-800 Series	CFM56-7B26 (8CM051)	1,990	AC DAL	25.34
Boeing 737-900 Series	CFM56-7B26 (8CM051)	513	AC DAL	25.34
Boeing 757-200 Series	PW2037 (4PW072)	1,634	AC DAL	25.34
Boeing 767-300 Series	CF6-80A2	385	AC DAL	25.34
Boeing 767-400 ER	CF6-80C2B7F 1862M39	480	AC DAL	25.34
Boeing MD-88	JT8D-219 Environmental Kit (E_Kit)	960	AC DAL	25.34
Boeing MD-90	V2525-D5	1,835	AC DAL	25.34
Airbus A330-300 Series	PW4168A Talon II	72	AC DLH	25.34
Airbus A340-600 Series	Trent 556-61 Phase5 Tiled (6RR041)	282	AC DLH	25.34
Boeing 747-400 Series	CF6-80C2B1F 1862M39	235	AC DLH	25.34
Boeing 747-8	GEnx-2B67 TAPS (8GENX1)	275	AC DLH	25.34
Bombardier CRJ-900	CF34-8C5 LEC (8GE110)	688	AC EDV	25.34
Airbus A330-200 Series	CF6-80E1A2 1862M39	208	AC EIN	25.34
Airbus A330-300 Series	CF6-80E1A4 Standard	459	AC EIN	25.34
Boeing 757-200 Series	PW2040 (4PW073)	275	AC EIN	25.34
Boeing 767-200 Series	CF6-80A	92	AC EIN	25.34
Boeing 767-300 Series	PW4060 Reduced smoke	148	AC ELY	25.34
Airbus A330-200 Series	PW4168A Talon II	36	AC EWG	25.34
Bombardier CRJ-200	CF34-3B	159	AC FLG	25.34
Bombardier CRJ-900	CF34-8C5 LEC (8GE110)	2,971	AC FLG	25.34
Airbus A330-300 Series	CF6-80E1A4 Standard	206	AC IBE	25.34
Boeing 757-200 Series	RB211-535E4 (3RR028)	603	AC ICE	25.34
Boeing 767-300 Series	CF6-80C2B6 1862M39	76	AC ICE	25.34
Boeing 787-8 Dreamliner	GEnx-1B64 TAPS (11GE136)	164	AC JAL	25.34
Boeing 787-9 Dreamliner	Trent 1000-J2	204	AC JAL	25.34
Airbus A320-200 Series	V2527-A5	20,397	AC JBU	25.34
Airbus A321-100 Series	V2533-A5	811	AC JBU	25.34

Table I-4 2016 Fleet Mix, Annual Landing-and-Takeoff Cycles (LTOs), and Taxi/Delay Time-in-Mode by Aircraft Type (Continued)

Aircraft Type	Engine	LTOs	Description (Airline)	Taxi Times
Air Carrier Aircraft (Cont'd.)				
Embraer ERJ190	CF34-10E6 SAC	24,659	AC JBU	25.34
Boeing 737-800 Series	CFM56-7B26 (8CM051)	80	AC NAX	25.34
Boeing 787-8 Dreamliner	GEnx-1B64 TAPS (11GE136)	179	AC NAX	25.34
Boeing 787-9 Dreamliner	Trent 1000-J2	69	AC NAX	25.34
Airbus A319-100 Series	V2522-A5	2,039	AC NKS	25.34
Airbus A320-200 Series	V2527-A5	1,584	AC NKS	25.34
Embraer ERJ145	AE3007A1E	2	AC PDT	25.34
Airbus A350-900 series	Trent XWB	275	AC QTR	25.34
Boeing 777-300 ER	GE90-115B	1	AC QTR	25.34
Airbus A310-200 Series	CF6-80C2A2 1862M39	145	AC RZO	25.34
Airbus A330-200 Series	PW4168A Talon II	169	AC RZO	25.34
Boeing 767-300 Series	CF6-80C2B6 1862M39	1	AC RZO	25.34
Boeing 737-300 Series	CFM56-3-B1	250	AC SAS	25.34
Boeing 737-700 Series	CFM56-7B22	274	AC SCX	25.34
Boeing 737-800 Series	CFM56-7B27	413	AC SCX	25.34
Bombardier CRJ-900	CF34-8C5 LEC (8GE110)	12	AC SKW	25.34
Boeing 737-300 Series	CFM56-3-B1	2,255	AC SWA	25.34
Boeing 737-700 Series	CFM56-7B24	7,937	AC SWA	25.34
Boeing 737-800 Series	CFM56-7B26 (8CM051)	2,026	AC SWA	25.34
Airbus A330-300 Series	Trent 772 Improved traverse	401	AC SWR	25.34
Airbus A340-300 Series	CFM56-5C4	109	AC SWR	25.34
Airbus A330-200 Series	PW4168A Talon II	189	AC TAP	25.34
Airbus A330-200 Series	PW4168A Talon II	31	AC TCX	25.34
Airbus A330-300 Series	Trent 772 Improved traverse	329	AC THY	25.34
Boeing 777-300 ER	GE90-115B	691	AC UAE	25.34
Airbus A319-100 Series	V2522-A5	545	AC UAL	25.34
Airbus A320-200 Series	V2527-A5	1,630	AC UAL	25.34
Boeing 737-700 Series	CFM56-7B24	747	AC UAL	25.34
Boeing 737-800 Series	CFM56-7B26 (8CM051)	2,808	AC UAL	25.34
Boeing 737-900 Series	CFM56-7B26 (8CM051)	5,406	AC UAL	25.34

Table I-4 2016 Fleet Mix, Annual Landing-and-Takeoff Cycles (LTOs), and Taxi/Delay Time-in-Mode by Aircraft Type (Continued)

Aircraft Type	Engine	LTOs	Description (Airline)	Taxi Times
Air Carrier Aircraft (Cont'd.)				
Boeing 757-200 Series	PW2037 (4PW072)	173	AC UAL	25.34
Boeing 757-300 Series	RB211-535E4B Phase 5	1,122	AC UAL	25.34
Boeing 777-200 Series	PW4077	95	AC UAL	25.34
Airbus A330-200 Series	PW4168A Talon II	80	AC VIR	25.34
Airbus A340-600 Series	Trent 556-61 Phase5 Tiled (6RR041)	213	AC VIR	25.34
Boeing 787-9 Dreamliner	Trent 1000-A Phase5 Tiled (11RR049)	64	AC VIR	25.34
Airbus A320-200 Series	V2527-A5	1,862	AC VRD	25.34
Bombardier de Havilland Dash 8 Q400	PW150A	1,126	AC WEN	25.34
Airbus A321-100 Series	V2533-A5	339	AC WOW	25.34
Total Air Carrier Aircraft LTOs		**140,126**		
Cargo Aircraft				
Boeing 767-200 Series	CF6-80A	4	CA ABX	25.34
Boeing 757-200 Series	PW2040 (4PW073)	251	CA FDX	25.34
Airbus A300F4-600 Series	CF6-80C2A5F	308	CA FDX	25.34
Boeing 757-200 Series	RB211-535E4 (3RR028)	302	CA FDX	25.34
Boeing 767-300 Series	CF6-80C2B6 1862M39	683	CA FDX	25.34
Boeing DC-10-10 Series	CF6-6D	655	CA FDX	25.34
Boeing 767-200 Series	JT9D-7R4D, -7R4D1	8	CA GTI	25.34
Cessna 208 Caravan	PT6A-114	3	CA MTN	25.34
Airbus A300F4-600 Series	PW4158	438	CA UPS	25.34
Boeing 757-200 Series	PW2040 (4PW073)	162	CA UPS	25.34
Boeing 767-300 ER	CF6-80C2B6F	317	CA UPS	25.34
Raytheon Beech 99	PT6A-36	4	CA WIG	25.34
Cessna 208 Caravan	PT6A-114	195	CA WIG	25.34
Total Cargo Aircraft LTOs		**3,330**		

Table I-4 2016 Fleet Mix, Annual Landing-and-Takeoff Cycles (LTOs), and Taxi/Delay Time-in-Mode by Aircraft Type (Continued)

Aircraft Type	Engine	LTOs	Description (Airlines)	Taxi Times
Commuter Aircraft				
Bombardier CRJ-700	CF34-8C1	223	CO ASH	25.34
Embraer ERJ170	CF34-8E5 LEC (8GE108)	20	CO ASH	25.34
Bombardier CRJ-700	CF34-8C1	946	CO ASQ	25.34
Embraer ERJ145	AE3007A1 Type 2	1,070	CO ASQ	25.34
Bombardier CRJ-200	CF34-3B	2,505	CO AWI	25.34
Bombardier CRJ-700	CF34-8C5 LEC (8GE110)	346	CO GJS	25.34
Bombardier CRJ-900	CF34-8C5 LEC (8GE110)	1,045	CO GJS	25.34
Bombardier CRJ-700	CF34-8C1	3	CO JIA	25.34
Bombardier CRJ-200	CF34-3B	2,916	CO JZA	25.34
Bombardier de Havilland Dash 8 Q100	PW120A	175	CO JZA	25.34
Bombardier de Havilland Dash 8 Q400	PW150A	65	CO JZA	25.34
Cessna 402	TIO-540-J2B2	17,997	CO KAP	25.34
Bombardier de Havilland Dash 8 Q100	PW120A	256	CO PDT	25.34
Saab 340-B-Plus	CT7-9B	1,831	CO PEN	25.34
Bombardier de Havilland Dash 8 Q400	PW150A	1,935	CO POE	25.34
Embraer ERJ170	CF34-8E5 LEC (8GE108)	729	CO RPA	25.34
Embraer ERJ170	CF34-8E5 LEC (8GE108)	1,369	CO SKV	25.34
Embraer ERJ170	CF34-8E5 LEC (8GE108)	42	CO SKW	25.34
Embraer ERJ145	AE3007A1E	541	CO TCF	25.34
Embraer ERJ170	CF34-8E5 LEC (8GE108)	1,948	CO TCF	25.34
Embraer ERJ175	CF34-8E5A1 LEC (8GE105)	784	CO TCF	25.34
Total Commuter LTO		**36,746**		
General Aviation Aircraft				
Pilatus PC-12	PT6A-67B	981	GA CNS	25.34
Raytheon Beechjet 400	JT15D-5, -5A, -5B	41	GA CNS	25.34
Cessna 560 Citation Excel	JT15D-5, -5A, -5B	944	GA EJA	25.34

Table I-4 2016 Fleet Mix, Annual Landing-and-Takeoff Cycles (LTOs), and Taxi/Delay Time-in-Mode by Aircraft Type (Continued)

Aircraft Type	Engine	LTOs	Description (Airline)	Taxi Times
General Aviation Aircraft (Cont'd.)				
Cessna 680 Citation Sovereign	PW308C	407	GA EJA	25.34
Cessna 750 Citation X	AE3007C Type 2	392	GA EJA	25.34
Bombardier Learjet 45	TFE731-2-2B	380	GA EJA	25.34
Dassault Falcon 2000	PW308C	322	GA EJA	25.34
Gulfstream G400	TAY Mk611-8	77	GA EJM	25.34
Gulfstream G500	BR700-710A1-10 (4BR008)	71	GA EJM	25.34
Bombardier Challenger 300	AE3007A1 Type 2	53	GA EJM	25.34
Bombardier Learjet 45	TFE731-2-2B	41	GA EJM	25.34
Raytheon Hawker 800	TFE731-3	32	GA EJM	25.34
Raytheon Super King Air 300	PT6A-60A	358	GA GAJ	25.34
Raytheon Super King Air 300	PT6A-60A	121	GA GAJ	25.34
Cessna 560 Citation XLS	JT15D-5, -5A, -5B	96	GA GAJ	25.34
Cessna 560 Citation V	JT15D-5, -5A, -5B	5	GA GAJ	25.34
Bombardier Learjet 60	TFE731-2/2A	4	GA GAJ	25.34
Pilatus PC-12	PT6A-67B	891	GA GPD	25.34
Cessna 525 CitationJet	JT15D-1 series	5	GA GPD	25.34
Bombardier Challenger 300	AE3007A1 Type 2	271	GA LXJ	25.34
Bombardier Learjet 60	TFE731-2/2A	46	GA LXJ	25.34
Gulfstream G400	TAY Mk611-8	43	GA LXJ	25.34
Bombardier Challenger 600	CF34-3B	24	GA LXJ	25.34
Bombardier Learjet 45	TFE731-2-2B	22	GA LXJ	25.34
Cessna 172 Skyhawk	TSIO-360C	67	GA NGF	25.34
Raytheon Beech Bonanza 36	TIO-540-J2B2	57	GA NGF	25.34
Cessna 182	IO-360-B	56	GA NGF	25.34
Raytheon Beech Bonanza 36	TIO-540-J2B2	46	GA NGF	25.34
Raytheon Beech Baron 58	TIO-540-J2B2	42	GA NGF	25.34
Bombardier Learjet 45	TFE731-2-2B	97	GA OPT	25.34
Cessna 750 Citation X	AE3007C Type 2	29	GA OPT	25.34
Raytheon Beechjet 400	JT15D-5, -5A, -5B	29	GA OPT	25.34

Table I-4 2016 Fleet Mix, Annual Landing-and-Takeoff Cycles (LTOs), and Taxi/Delay Time-in-Mode by Aircraft Type (Continued)

Aircraft Type	Engine	LTOs	Description (Airline)	Taxi Times
General Aviation Aircraft (Cont'd.)				
Embraer ERJ135	AE3007A1/3 Type 3 (reduced emissions)	18	GA OPT	25.34
Raytheon Beechjet 400	JT15D-5, -5A, -5B	349	GA TMC	25.34
Raytheon Hawker 800	TFE731-3	194	GA TMC	25.34
Bombardier Challenger 600	CF34-3B	17	GA TMC	25.34
Gulfstream G400	TAY Mk611-8	1,336	GA	25.34
Bombardier Challenger 600	CF34-3B	1,249	GA	25.34
Gulfstream G500	BR700-710A1-10 (4BR008)	1,161	GA	25.34
Dassault Falcon 2000	PW308C	953	GA	25.34
Raytheon Hawker 800	TFE731-3	908	GA	25.34
Raytheon Super King Air 200	PT6A-42	736	GA	25.34
Bombardier Challenger 300	AE3007A1 Type 2	643	GA	25.34
Raytheon Hawker 800	TFE731-3	194	GA TMC	25.34
Bombardier Challenger 600	CF34-3B	17	GA TMC	25.34
Gulfstream G400	TAY Mk611-8	1,336	GA	25.34
Bombardier Challenger 600	CF34-3B	1,249	GA	25.34
Gulfstream G500	BR700-710A1-10 (4BR008)	1,161	GA	25.34
Dassault Falcon 2000	PW308C	953	GA	25.34
Raytheon Hawker 800	TFE731-3	908	GA	25.34
Raytheon Super King Air 200	PT6A-42	736	GA	25.34
Bombardier Challenger 300	AE3007A1 Type 2	643	GA	25.34
Dassault Falcon 900	TFE731-3	552	GA	25.34
Cessna 525 CitationJet	JT15D-1 series	544	GA	25.34
Bombardier Global Express	BR700-710A2-20	483	GA	25.34
Cessna 750 Citation X	AE3007C Type 2	123	GA XOJ	25.34
Bombardier Challenger 300	AE3007A1 Type 2	95	GA XOJ	25.34
Total General Aviation Aircraft LTOs		**15,411**		
Total Fleet LTOs		**195,613**		

Source: KBE, HMMH, and FAA ASPM 2017.

Ground Service Equipment Time-in-Mode Survey

A GSE time-in-mode (TIM) survey was conducted at Logan Airport on June 27-28, 2017. The purpose of the GSE TIM survey was to provide up-to-date GSE operating times, which directly affects GSE emissions. The last GSE TIM survey was conducted in 2012 in support of the *2011 ESPR*. The TIM is the average time that GSE and aircraft auxiliary power units (APUs) operate during a single aircraft LTO cycle. The surveyed TIM is used in place of the default TIM values in AEDT, thus yielding GSE emissions that best reflect the conditions at Logan Airport. The TIM survey focused on the most prevalent airlines (e.g., Southwest, JetBlue, American, Delta, and United) and the most common aircraft types, such as narrow body air carriers (e.g., A320, A321, B737, B757, etc.) and large commuter aircraft (e.g., ERJ170, ERJ190, CRJ700, CRJ900, etc.). The TIMs are provided in **Table I-5**.

Table I-5 GSE Time-in-Mode (minutes)

GSE Type	Narrow-Body Air Carriers	Large Commuter Aircraft
Aircraft Tractor	6.37	7.13
Baggage Tractor	27.23	17.43
Belt Loader	26.85	14.88
Cabin Service Truck	2.07	0.53
Catering Truck	11.30	13.28
Hydrant Truck	3.73	2.53
Lavatory Truck	4.82	2.45
Service Truck	0.12	0.57
Water Service Truck	1.65	0.75
Auxiliary Power Unit (APU)	16.63	14.70

Source: KBE 2017.
Notes: GSE TIM survey conducted by KBE with assistance from Massport (security escorts) on June 27-28, 2017.

Ground Service Equipment/Alternative Fuels Conversion

For the 2016 analyses, GSE emissions were calculated using AEDT emission factors which are based on EPA NONROAD2005 model in combination with the recently updated GSE time-in-mode survey and the GSE fuel types obtained from the Logan Airport Vehicle Aerodrome Permit Application. In this way, the most up-to-date GSE fleet operational, conversion, and emissions characteristics are used (**Table I-6**).

Table I-6 Ground Service Equipment Alternative Fuel Conversion Summary (kg/day)

Year	Pollutant	Percent Reduction	Calculated Emissions without Reduction	Reduction from AFVs	Calculated Emissions with Reduction
2000	Volatile Organic Compounds (VOCs)	13.72%	178	24	154
	Oxides of Nitrogen (NO_x)	9.87%	369	36	333
	Carbon Monoxide (CO)	12.88%	6,124	789	5,335
2001	VOCs	13.72%	166	23	143
	NO_x	9.87%	338	33	305
	CO	12.88%	5,960	768	5,193
2002	VOCs	13.6%	286	39	247
	NO_x	8.0%	350	28	322
	CO	16.3%	6,174	1,004	5,170
2003	VOCs	13.8%	263	36	227
	NO_x	8.0%	316	25	291
	CO	16.4%	5,692	934	4,758
2004	VOCs	11.9%	212	25	187
	NO_x	6.6%	357	24	333
	CO	15.4%	4,236	650	3,586
2005	VOCs	12.2%	203	25	178
	NO_x	6.9%	335	23	312
	CO	15.4%	4,175	643	3,531
	$PM_{10}/PM_{2.5}$	9.9%	11	1	10
2006	VOCs	10.7%	86	9	77

Table I-6 Ground Service Equipment Alternative Fuel Conversion Summary (kg/day) (Continued)

Year	Pollutant	Percent Reduction	Calculated Emissions without Reduction	Reduction from AVFs	Calculated Emission with Reduction
	NO_x	7.5%	324	24	300
	CO	13.8%	1,841	255	1,586
	$PM_{10}/PM_{2.5}$	10.8%	10	1	9
2007	VOCs	8.2%	85	7	78
	NO_x	5.1%	315	16	299
	CO	10.4%	2,124	220	1,904
	$PM_{10}/PM_{2.5}$	5.9%	10	<1	10
2008	VOCs	8.3%	72	6	66
	NO_x	4.8%	270	13	257
	CO	10.2%	1,792	183	1,609
	$PM_{10}/PM_{2.5}$	5.6%	16	<1	15
2009	VOCs	8.2%	61	5	56
	NO_x	4.8%	230	11	219
	CO	10.0%	1,516	152	1,364
	$PM_{10}/PM_{2.5}$	3.5%	14	<1	14
2010	VOCs	7.5%	53	4	49
	NO_x	3.9%	206	8	198
	CO	8.5%	1,335	113	1,222
	$PM_{10}/PM_{2.5}$	2.5%	13	<1	13
2011	VOCs	13.2%	38	5	33
	NO_x	7.5%	188	14	173
	CO	16.7%	834	139	694
	$PM_{10}/PM_{2.5}$	5.5%	14	1	13
2012	VOCs	11.8%	34	4	30
	NO_x	6.8%	176	12	164

Table I-6 Ground Service Equipment Alternative Fuel Conversion Summary (kg/day) (Continued)

Year	Pollutant	Percent Reduction	Calculated Emissions without Reduction	Reduction from AVFs	Calculated Emission with Reduction
	CO	16.3%	738	120	618
	$PM_{10}/PM_{2.5}$	4.9%	13	<1	13
2013	VOCs	10.3%	29	3	26
	NO_x	6.5%	155	10	145
	CO	15.9%	634	101	533
	$PM_{10}/PM_{2.5}$	5.0%	12	<1	12
2014	VOCs	11.5%	26	3	23
	NO_x	5.6%	142	8	134
	CO	15.4%	572	88	484
	$PM_{10}/PM_{2.5}$	4.8%	12	<1	12
2015	VOCs	4.5%	22	1	21
	NO_x	5.2%	135	7	128
	CO	15.2%	521	79	442
	$PM_{10}/PM_{2.5}$	14.3%	14	2	12
2016	VOCs	9.0%	26	2	24
	NO_x	3.8%	173	6	167
	CO	13.5%	560	67	493
	$PM_{10}/PM_{2.5}$	2.6%	15	<1	15

Source: KBE and Massport.

Notes: 2000 and 2001 analyses used EDMS v4.03. 2002 and 2003 analyses used EDMS v4.11, which used updated emission factors from the NONROAD2002 Model. 2004 analyses used EDMS v4.21, which again used emission factors from EPA NONROAD2002 Model. 2005 analysis used EDMS v4.5, which used emission factors from EPA NONROAD2002 Model. 2006 analysis used EDMS v5.0.1, which used emission factors from EPA NONROAD2005 Model. 2007 analysis used EDMS v5.0.2, which used emission factors from EPA NONROAD2005 Model. 2008 analysis used EDMS v5.1, which used emission factors from EPA NONROAD2005 Model. 2009 analysis used EDMS v5.1.2, which used emission factors from EPA NONROAD2005 Model. 2010, 2011, and 2012 analysis used EDMS v5.1.3, which used emission factors from EPA NONROAD2005 Model. 2013, 2014, 2015, and 2016 used AEDT2c SP2, which used emission factors from EPA NONROAD2005 Model.

Motor Vehicle Emissions

For the 2016 analysis, the motor vehicle emission factor model MOVES2014a was used. The resultant emission factors were multiplied by average daily vehicle miles to calculate daily emissions. The on-Airport traffic data are summarized in the vehicle miles traveled (VMT) analyses of Appendix G, *Ground Access*. Due to the new roadway configuration of the Ted Williams Tunnel, through-traffic no longer traverses Airport property. Therefore, as of 2003, emissions from these vehicles are no longer included as part of the Logan Airport emissions inventory. Further, MOVES2014a was used to obtain vehicle emissions at idle to estimate parking and curbside motor vehicle emissions. Idling emissions are determined for a unit of time and multiplied by total idling time to reach the associated emissions. The input and output files of MOVES2014a are included as **Tables I-7** and **I-8.**

Table I-7 MOVES2014a Sample Input File for 2016


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Source: KBE and Massport.

Table I-8 MOVES2014a Sample Output File for 2016

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1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 117 NULL 31 0 0 0 0 0 0 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 116 NULL 31 0 0 0 0 0 0 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 115 NULL 31 0 0 0 0 0 0.00303332 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 112 NULL 31 0 0 0 0 0 0.0135009 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 111 NULL 31 0 0 0 0 0 0.021888399 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 110 NULL 31 0 0 0 0 0 0.0471095 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 107 NULL 31 0 0 0 0 0 0 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 106 NULL 31 0 0 0 0 0 0 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 100 NULL 31 0 0 0 0 0 0.052074101 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 98 NULL 31 0 0 0 0 0 4689.25 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 91 NULL 31 0 0 0 0 0 0.061799474 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 90 NULL 31 0 0 0 0 0 4688.810059 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 87 NULL 31 0 0 0 0 0 0.752602875 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 79 NULL 31 0 0 0 0 0 0.70127213 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 66 NULL 31 0 0 0 0 0 0.000818762 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 59 NULL 31 0 0 0 0 0 0.000481374 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 58 NULL 31 0 0 0 0 0 0.000109358 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 57 NULL 31 0 0 0 0 0 0.000216864 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 56 NULL 31 0 0 0 0 0 1.33E-05 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 55 NULL 31 0 0 0 0 0 0.000545211 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 54 NULL 31 0 0 0 0 0 4.09E-05 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 53 NULL 31 0 0 0 0 0 3.19E-05 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 52 NULL 31 0 0 0 0 0 5.29E-05 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 22 51 NULL 31 0 0 0 0 0 0.000108801 1 0 NULL g mi

1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	22	36	NULL	31	0	0	0	0	0	0.000821018	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	22	35	NULL	31	0	0	0	0	0	0.000181631	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	22	31	NULL	31	0	0	0	0	0	0.0918229	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	22	5	NULL	31	0	0	0	0	0	0.017741052	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	22	3	NULL	31	0	0	0	0	0	1.661653042	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	22	2	NULL	31	0	0	0	0	0	13.89191437	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,22,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	22	1	NULL	31	0	0	0	0	0	0.718864202	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	122	NULL	21	0	0	0	0	0	0.0045505	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	121	NULL	21	0	0	0	0	0	0.00186946	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	119	NULL	21	0	0	0	0	0	0	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	118	NULL	21	0	0	0	0	0	0.033500101	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	117	NULL	21	0	0	0	0	0	0	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	116	NULL	21	0	0	0	0	0	0	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	115	NULL	21	0	0	0	0	0	0.00130928	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	112	NULL	21	0	0	0	0	0	0.00571219	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	111	NULL	21	0	0	0	0	0	0.022752499	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	110	NULL	21	0	0	0	0	0	0.039212301	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	107	NULL	21	0	0	0	0	0	0	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	106	NULL	21	0	0	0	0	0	0	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	100	NULL	21	0	0	0	0	0	0.044315699	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	98	NULL	21	0	0	0	0	0	3604.77002	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	91	NULL	21	0	0	0	0	0	0.047527436	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	90	NULL	21	0	0	0	0	0	3604.280029	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	87	NULL	21	0	0	0	0	0	0.955521941	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	79	NULL	21	0	0	0	0	0	0.89418292	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	66	NULL	21	0	0	0	0	0	0.000803656	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	59	NULL	21	0	0	0	0	0	0.000745486	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	58	NULL	21	0	0	0	0	0	0.000132223	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	57	NULL	21	0	0	0	0	0	0.000132695	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	56	NULL	21	0	0	0	0	0	1.39E-05	1	0	NULL	g	mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	55	NULL	21	0	0	0	0	0	0.000589248	1	0	NULL	g	mi

1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	54	NULL	21	0	0	0	0	0		5.91E-051 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	53	NULL	21	0	0	0	0	0		3.48E-051 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	52	NULL	21	0	0	0	0	0		1.72E-051 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	51	NULL	21	0	0	0	0	0		4.30E-051 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	36	NULL	21	0	0	0	0	0		0.00113269 1 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	35	NULL	21	0	0	0	0	0		0.0001181131 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	31	NULL	21	0	0	0	0	0		0.0715200011 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	5	NULL	21	0	0	0	0	0		0.0200134571 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	3	NULL	21	0	0	0	0	0		1.2766045331 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	2	NULL	21	0	0	0	0	0		5.0523424151 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,21,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	21	1	NULL	21	0	0	0	0	0		0.9139379261 0 NULL g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	122	NULL	31	0	0	0	0	0		0.0004391671 1 0.000439167g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	121	NULL	31	0	0	0	0	0		0.0001791871 1 0.000179187g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	119	NULL	31	0	0	0	0	0	0	1 1 0 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	118	NULL	31	0	0	0	0	0		0.00327079 1 1 0.00327079 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	117	NULL	31	0	0	0	0	0		0.0012442 1 1 0.0012442 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	116	NULL	31	0	0	0	0	0		0.0014 1 1 0.0014 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	115	NULL	31	0	0	0	0	0		0.0001686011 1 0.000168601g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	112	NULL	31	0	0	0	0	0		0.00121482 1 1 0.00121482 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	111	NULL	31	0	0	0	0	0		0.00219583 1 1 0.00219583 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	110	NULL	31	0	0	0	0	0		0.00448561 1 1 0.00448561 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	107	NULL	31	0	0	0	0	0		0.00829473 1 1 0.00829473 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	106	NULL	31	0	0	0	0	0		0.0112 1 1 0.0112 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	100	NULL	31	0	0	0	0	0		0.00503061 1 1 0.00503061 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	98	NULL	31	0	0	0	0	0		418.3670044 1 1 418.3670044g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	91	NULL	31	0	0	0	0	0		0.0055128741 1 0.005512874g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	90	NULL	31	0	0	0	0	0		418.27801511 1 418.2780151g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	87	NULL	31	0	0	0	0	0		0.1064201971 1 0.106420197g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	79	NULL	31	0	0	0	0	0		0.0990578981 1 0.099057898g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	66	NULL	31	0	0	0	0	0		1.64E-051 1 1.64E-05g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	20	59	NULL	31	0	0	0	0	0		6.94E-051 1 6.94E-05g mi

1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 58 NULL 31 0 0 0 0 0
1.26E-051 1 1.26E-05g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 57 NULL 31 0 0 0 0 0
1.37E-051 1 1.37E-05g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 56 NULL 31 0 0 0 0 0
1.34E-061 1 1.34E-06g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 55 NULL 31 0 0 0 0 0
5.66E-051 1 5.66E-05g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 54 NULL 31 0 0 0 0 0
5.55E-061 1 5.55E-06g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 53 NULL 31 0 0 0 0 0
3.34E-061 1 3.34E-06g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 52 NULL 31 0 0 0 0 0
2.28E-061 1 2.28E-06g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 51 NULL 31 0 0 0 0 0
4.86E-061 1 4.86E-06g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 36 NULL 31 0 0 0 0 0
0.0001061921 1 0.000106192g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 35 NULL 31 0 0 0 0 0
1.21E-051 1 1.21E-05g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 31 NULL 31 0 0 0 0 0
0.00818743 1 1 0.00818743 g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 5 NULL 31 0 0 0 0 0
0.0035963581 1 0.003596358g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 3 NULL 31 0 0 0 0 0
0.2608312961 1 0.260831296g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 2 NULL 31 0 0 0 0 0
2.5339233881 1 2.533923388g mi
1,1,2016,7,5,15,25,25025,250250,20,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 20 1 NULL 31 0 0 0 0 0
0.1026116981 1 0.102611698g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 122 NULL 31 0 0 0 0 0
0.0004450661 1 0.000445066g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 121 NULL 31 0 0 0 0 0
0.0001814321 1 0.000181432g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 119 NULL 31 0 0 0 0 0 0
1 1 0 g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 118 NULL 31 0 0 0 0 0
0.00331308 1 1 0.00331308 g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 117 NULL 31 0 0 0 0 0
0.0013404 1 1 0.0013404 g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 116 NULL 31 0 0 0 0 0
0.00219603 1 1 0.00219603 g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 115 NULL 31 0 0 0 0 0
0.0001700621 1 0.000170062g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 112 NULL 31 0 0 0 0 0
0.00119351 1 1 0.00119351 g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 111 NULL 31 0 0 0 0 0
0.00222533 1 1 0.00222533 g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 110 NULL 31 0 0 0 0 0
0.00450659 1 1 0.00450659 g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 107 NULL 31 0 0 0 0 0
0.00893608 1 1 0.00893608 g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 106 NULL 31 0 0 0 0 0
0.0175682011 1 0.017568201g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 100 NULL 31 0 0 0 0 0
0.00505381 1 1 0.00505381 g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 98 NULL 31 0 0 0 0 0
427.23300171 1 427.2330017g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 91 NULL 31 0 0 0 0 0
0.0056296921 1 0.005629692g mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 19 90 NULL 31 0 0 0 0 0
427.14099121 1 427.1409912g mi

1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	87	NULL	31	0	0	0	0	0	0.108525284	1	1	0.108525284	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	79	NULL	31	0	0	0	0	0	0.101111598	1	1	0.101111598	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	66	NULL	31	0	0	0	0	0	1.82E-05	1	1	1.82E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	59	NULL	31	0	0	0	0	0	6.98E-05	1	1	6.98E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	58	NULL	31	0	0	0	0	0	1.27E-05	1	1	1.27E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	57	NULL	31	0	0	0	0	0	1.41E-05	1	1	1.41E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	56	NULL	31	0	0	0	0	0	1.36E-06	1	1	1.36E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	55	NULL	31	0	0	0	0	0	5.73E-05	1	1	5.73E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	54	NULL	31	0	0	0	0	0	5.58E-06	1	1	5.58E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	53	NULL	31	0	0	0	0	0	3.38E-06	1	1	3.38E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	52	NULL	31	0	0	0	0	0	2.35E-06	1	1	2.35E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	51	NULL	31	0	0	0	0	0	5.09E-06	1	1	5.09E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	36	NULL	31	0	0	0	0	0	0.00010705	1	1	0.00010705	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	35	NULL	31	0	0	0	0	0	1.24E-05	1	1	1.24E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	31	NULL	31	0	0	0	0	0	0.00836078	1	1	0.00836078	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	5	NULL	31	0	0	0	0	0	0.003693645	1	1	0.003693645	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	3	NULL	31	0	0	0	0	0	0.25458011	1	1	0.25458011	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	2	NULL	31	0	0	0	0	0	2.517087221	1	1	2.517087221	g	mi
1,1,2016,7,5,15,25,25025,250250,19,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	19	1	NULL	31	0	0	0	0	0	0.1047616	1	1	0.1047616	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	122	NULL	31	0	0	0	0	0	0.00046558	1	1	0.00046558	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	121	NULL	31	0	0	0	0	0	0.000189645	1	1	0.000189645	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	119	NULL	31	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	118	NULL	31	0	0	0	0	0	0.00346393	1	1	0.00346393	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	117	NULL	31	0	0	0	0	0	0.00144464	1	1	0.00144464	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	116	NULL	31	0	0	0	0	0	0.00307423	1	1	0.00307423	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	115	NULL	31	0	0	0	0	0	0.000176824	1	1	0.000176824	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	112	NULL	31	0	0	0	0	0	0.00119599	1	1	0.00119599	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	111	NULL	31	0	0	0	0	0	0.0023279	1	1	0.0023279	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	110	NULL	31	0	0	0	0	0	0.00465992	1	1	0.00465992	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	107	NULL	31	0	0	0	0	0	0.00963098	1	1	0.00963098	g	mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	18	106	NULL	31	0	0	0	0	0	0.0245938	1	1	0.0245938	g	mi

1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 100 NULL 31 0 0 0 0 0
0.00522606 1 1 0.00522606 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 98 NULL 31 0 0 0 0 0
438.7279968 1 1 438.7279968 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 91 NULL 31 0 0 0 0 0
0.005781106 1 1 0.005781106 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 90 NULL 31 0 0 0 0 0
438.631012 1 1 438.631012 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 87 NULL 31 0 0 0 0 0
0.11164511 1 1 0.11164511 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 79 NULL 31 0 0 0 0 0
0.104209997 1 1 0.104209997 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 66 NULL 31 0 0 0 0 0
2.05E-051 1 2.05E-05g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 59 NULL 31 0 0 0 0 0
7.25E-051 1 7.25E-05g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 58 NULL 31 0 0 0 0 0
1.32E-051 1 1.32E-05g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 57 NULL 31 0 0 0 0 0
1.50E-051 1 1.50E-05g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 56 NULL 31 0 0 0 0 0
1.42E-061 1 1.42E-06g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 55 NULL 31 0 0 0 0 0
5.99E-051 1 5.99E-05g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 54 NULL 31 0 0 0 0 0
5.80E-061 1 5.80E-06g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 53 NULL 31 0 0 0 0 0
3.54E-061 1 3.54E-06g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 52 NULL 31 0 0 0 0 0
2.48E-061 1 2.48E-06g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 51 NULL 31 0 0 0 0 0
5.47E-061 1 5.47E-06g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 36 NULL 31 0 0 0 0 0
0.000111454 1 1 0.000111454 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 35 NULL 31 0 0 0 0 0
1.31E-051 1 1.31E-05g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 31 NULL 31 0 0 0 0 0
0.00858492 1 1 0.00858492 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 5 NULL 31 0 0 0 0 0
0.003913358 1 1 0.003913358 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 3 NULL 31 0 0 0 0 0
0.249039963 1 1 0.249039963 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 2 NULL 31 0 0 0 0 0
2.586617231 1 1 2.586617231 g mi
1,1,2016,7,5,15,25,25025,250250,18,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 18 1 NULL 31 0 0 0 0 0
0.108077303 1 1 0.108077303 g mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 17 122 NULL 31 0 0 0 0 0
0.000499927 1 1 0.000499927 g mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 17 121 NULL 31 0 0 0 0 0
0.000203487 1 1 0.000203487 g mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 17 119 NULL 31 0 0 0 0 0 0
1 1 0 g mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 17 118 NULL 31 0 0 0 0 0
0.00371732 1 1 0.00371732 g mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 17 117 NULL 31 0 0 0 0 0
0.001556 1 1 0.001556 g mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 17 116 NULL 31 0 0 0 0 0
0.00413246 1 1 0.00413246 g mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 17 115 NULL 31 0 0 0 0 0
0.000188512 1 1 0.000188512 g mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 17 112 NULL 31 0 0 0 0 0
0.00121684 1 1 0.00121684 g mi

1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	111	NULL	31	0	0	0	0	0	0.00249963	1	1	0.00249963	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	110	NULL	31	0	0	0	0	0	0.00493416	1	1	0.00493416	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	107	NULL	31	0	0	0	0	0	0.0103734	1	1	0.0103734	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	106	NULL	31	0	0	0	0	0	0.033059601	1	1	0.033059601	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	100	NULL	31	0	0	0	0	0	0.00553441	1	1	0.00553441	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	98	NULL	31	0	0	0	0	0	453.7569885	1	1	453.7569885	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	91	NULL	31	0	0	0	0	0	0.005979039	1	1	0.005979039	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	90	NULL	31	0	0	0	0	0	453.651001	1	1	453.651001	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	87	NULL	31	0	0	0	0	0	0.115952313	1	1	0.115952313	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	79	NULL	31	0	0	0	0	0	0.108516097	1	1	0.108516097	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	66	NULL	31	0	0	0	0	0	2.34E-05	1	1	2.34E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	59	NULL	31	0	0	0	0	0	7.73E-05	1	1	7.73E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	58	NULL	31	0	0	0	0	0	1.42E-05	1	1	1.42E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	57	NULL	31	0	0	0	0	0	1.63E-05	1	1	1.63E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	56	NULL	31	0	0	0	0	0	1.53E-06	1	1	1.53E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	55	NULL	31	0	0	0	0	0	6.43E-05	1	1	6.43E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	54	NULL	31	0	0	0	0	0	6.19E-06	1	1	6.19E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	53	NULL	31	0	0	0	0	0	3.79E-06	1	1	3.79E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	52	NULL	31	0	0	0	0	0	2.70E-06	1	1	2.70E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	51	NULL	31	0	0	0	0	0	6.02E-06	1	1	6.02E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	36	NULL	31	0	0	0	0	0	0.000119138	1	1	0.000119138	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	35	NULL	31	0	0	0	0	0	1.43E-05	1	1	1.43E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	31	NULL	31	0	0	0	0	0	0.00887758	1	1	0.00887758	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	5	NULL	31	0	0	0	0	0	0.004255366	1	1	0.004255366	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	3	NULL	31	0	0	0	0	0	0.243295908	1	1	0.243295908	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	2	NULL	31	0	0	0	0	0	2.730957508	1	1	2.730957508	g	mi
1,1,2016,7,5,15,25,25025,250250,17,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	17	1	NULL	31	0	0	0	0	0	0.1127211	1	1	0.1127211	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	122	NULL	31	0	0	0	0	0	0.000545325	1	1	0.000545325	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	121	NULL	31	0	0	0	0	0	0.000221774	1	1	0.000221774	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	119	NULL	31	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	118	NULL	31	0	0	0	0	0	0.0040537	1	1	0.0040537	g	mi

1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	117	NULL	31	0	0	0	0	0	0.0016765	1	1	0.0016765	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	116	NULL	31	0	0	0	0	0	0.00553236	1	1	0.00553236	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	115	NULL	31	0	0	0	0	0	0.0002054	1	1	0.0002054	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	112	NULL	31	0	0	0	0	0	0.00126867	1	1	0.00126867	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	111	NULL	31	0	0	0	0	0	0.00272662	1	1	0.00272662	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	110	NULL	31	0	0	0	0	0	0.00532236	1	1	0.00532236	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	107	NULL	31	0	0	0	0	0	0.0111767	1	1	0.0111767	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	106	NULL	31	0	0	0	0	0	0.0442589	1	1	0.0442589	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	100	NULL	31	0	0	0	0	0	0.00597	1	1	0.00597	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	98	NULL	31	0	0	0	0	0	479.0830078	1	1	479.0830078	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	91	NULL	31	0	0	0	0	0	0.006312671	1	1	0.006312671	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	90	NULL	31	0	0	0	0	0	478.9689941	1	1	478.9689941	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	87	NULL	31	0	0	0	0	0	0.121400006	1	1	0.121400006	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	79	NULL	31	0	0	0	0	0	0.113921002	1	1	0.113921002	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	66	NULL	31	0	0	0	0	0	2.73E-05	1	1	2.73E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	59	NULL	31	0	0	0	0	0	8.37E-05	1	1	8.37E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	58	NULL	31	0	0	0	0	0	1.54E-05	1	1	1.54E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	57	NULL	31	0	0	0	0	0	1.80E-05	1	1	1.80E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	56	NULL	31	0	0	0	0	0	1.67E-06	1	1	1.67E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	55	NULL	31	0	0	0	0	0	7.01E-05	1	1	7.01E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	54	NULL	31	0	0	0	0	0	6.71E-06	1	1	6.71E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	53	NULL	31	0	0	0	0	0	4.13E-06	1	1	4.13E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	52	NULL	31	0	0	0	0	0	2.99E-06	1	1	2.99E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	51	NULL	31	0	0	0	0	0	6.75E-06	1	1	6.75E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	36	NULL	31	0	0	0	0	0	0.000129304	1	1	0.000129304	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	35	NULL	31	0	0	0	0	0	1.58E-05	1	1	1.58E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	31	NULL	31	0	0	0	0	0	0.00937161	1	1	0.00937161	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	5	NULL	31	0	0	0	0	0	0.004640481	1	1	0.004640481	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	3	NULL	31	0	0	0	0	0	0.240565047	1	1	0.240565047	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	2	NULL	31	0	0	0	0	0	2.887135744	1	1	2.887135744	g	mi
1,1,2016,7,5,15,25,25025,250250,16,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	16	1	NULL	31	0	0	0	0	0	0.118506595	1	1	0.118506595	g	mi

1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	122	NULL	31	0	0	0	0	0	0.000610181	1	1	0.000610181	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	121	NULL	31	0	0	0	0	0	0.00024788	1	1	0.00024788	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	119	NULL	31	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	118	NULL	31	0	0	0	0	0	0.00454062	1	1	0.00454062	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	117	NULL	31	0	0	0	0	0	0.00180606	1	1	0.00180606	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	116	NULL	31	0	0	0	0	0	0.00732576	1	1	0.00732576	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	115	NULL	31	0	0	0	0	0	0.00023576	1	1	0.00023576	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	112	NULL	31	0	0	0	0	0	0.00145322	1	1	0.00145322	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	111	NULL	31	0	0	0	0	0	0.0030509	1	1	0.0030509	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	110	NULL	31	0	0	0	0	0	0.00599383	1	1	0.00599383	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	107	NULL	31	0	0	0	0	0	0.0120404	1	1	0.0120404	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	106	NULL	31	0	0	0	0	0	0.058606099	1	1	0.058606099	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	100	NULL	31	0	0	0	0	0	0.00671969	1	1	0.00671969	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	98	NULL	31	0	0	0	0	0	537.6270142	1	1	537.6270142	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	91	NULL	31	0	0	0	0	0	0.007084184	1	1	0.007084184	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	90	NULL	31	0	0	0	0	0	537.507019	1	1	537.507019	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	87	NULL	31	0	0	0	0	0	0.127673104	1	1	0.127673104	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	79	NULL	31	0	0	0	0	0	0.119943202	1	1	0.119943202	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	66	NULL	31	0	0	0	0	0	3.28E-05	1	1	3.28E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	59	NULL	31	0	0	0	0	0	9.30E-05	1	1	9.30E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	58	NULL	31	0	0	0	0	0	1.72E-05	1	1	1.72E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	57	NULL	31	0	0	0	0	0	2.04E-05	1	1	2.04E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	56	NULL	31	0	0	0	0	0	1.86E-06	1	1	1.86E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	55	NULL	31	0	0	0	0	0	7.84E-05	1	1	7.84E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	54	NULL	31	0	0	0	0	0	7.46E-06	1	1	7.46E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	53	NULL	31	0	0	0	0	0	4.62E-06	1	1	4.62E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	52	NULL	31	0	0	0	0	0	3.46E-06	1	1	3.46E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	51	NULL	31	0	0	0	0	0	7.74E-06	1	1	7.74E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	36	NULL	31	0	0	0	0	0	0.000143917	1	1	0.000143917	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	35	NULL	31	0	0	0	0	0	1.78E-05	1	1	1.78E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	31	NULL	31	0	0	0	0	0	0.0105167	1	1	0.0105167	g	mi

1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	5	NULL	31	0	0	0	0	0	0.00485863	1	1	0.00485863	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	3	NULL	31	0	0	0	0	0	0.258709222	1	1	0.258709222	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	2	NULL	31	0	0	0	0	0	2.965916395	1	1	2.965916395	g	mi
1,1,2016,7,5,15,25,25025,250250,15,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	15	1	NULL	31	0	0	0	0	0	0.124744698	1	1	0.124744698	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	122	NULL	31	0	0	0	0	0	0.000755474	1	1	0.000755474	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	121	NULL	31	0	0	0	0	0	0.000306653	1	1	0.000306653	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	119	NULL	31	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	118	NULL	31	0	0	0	0	0	0.00561965	1	1	0.00561965	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	117	NULL	31	0	0	0	0	0	0.00194578	1	1	0.00194578	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	116	NULL	31	0	0	0	0	0	0.00826578	1	1	0.00826578	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	115	NULL	31	0	0	0	0	0	0.000291024	1	1	0.000291024	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	112	NULL	31	0	0	0	0	0	0.00172933	1	1	0.00172933	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	111	NULL	31	0	0	0	0	0	0.00377736	1	1	0.00377736	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	110	NULL	31	0	0	0	0	0	0.00734897	1	1	0.00734897	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	107	NULL	31	0	0	0	0	0	0.0129719	1	1	0.0129719	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	106	NULL	31	0	0	0	0	0	0.066126198	1	1	0.066126198	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	100	NULL	31	0	0	0	0	0	0.00823882	1	1	0.00823882	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	98	NULL	31	0	0	0	0	0	601.4290161	1	1	601.4290161	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	91	NULL	31	0	0	0	0	0	0.007924982	1	1	0.007924982	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	90	NULL	31	0	0	0	0	0	601.2979736	1	1	601.2979736	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	87	NULL	31	0	0	0	0	0	0.137463138	1	1	0.137463138	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	79	NULL	31	0	0	0	0	0	0.129362106	1	1	0.129362106	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	66	NULL	31	0	0	0	0	0	4.09E-05	1	1	4.09E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	59	NULL	31	0	0	0	0	0	0.00011437	1	1	0.00011437	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	58	NULL	31	0	0	0	0	0	2.12E-05	1	1	2.12E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	57	NULL	31	0	0	0	0	0	2.56E-05	1	1	2.56E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	56	NULL	31	0	0	0	0	0	2.31E-06	1	1	2.31E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	55	NULL	31	0	0	0	0	0	9.70E-05	1	1	9.70E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	54	NULL	31	0	0	0	0	0	9.17E-06	1	1	9.17E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	53	NULL	31	0	0	0	0	0	5.71E-06	1	1	5.71E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	14	52	NULL	31	0	0	0	0	0	4.34E-06	1	1	4.34E-06	g	mi

1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 14 51 NULL 31 0 0 0 0 0
9.82E-061 1 9.82E-06g mi

1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 14 36 NULL 31 0 0 0 0 0
0.0001773141 1 0.000177314 g mi

1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 14 35 NULL 31 0 0 0 0 0
2.23E-051 1 2.23E-05g mi

1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 14 31 NULL 31 0 0 0 0 0
0.0117668 1 1 0.0117668 g mi

1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 14 5 NULL 31 0 0 0 0 0
0.00533265 1 1 0.00533265 g mi

1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 14 3 NULL 31 0 0 0 0 0
0.27053839 1 1 0.27053839 g mi

1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 14 2 NULL 31 0 0 0 0 0
3.5305728911 1 3.530572891 g mi

1,1,2016,7,5,15,25,25025,250250,14,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 14 1 NULL 31 0 0 0 0 0
0.1346327071 1 0.134632707 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 122 NULL 31 0 0 0 0 0
0.0008525881 1 0.000852588 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 121 NULL 31 0 0 0 0 0
0.0003451021 1 0.000345102 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 119 NULL 31 0 0 0 0 0 0
1 1 0 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 118 NULL 31 0 0 0 0 0
0.00634918 1 1 0.00634918 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 117 NULL 31 0 0 0 0 0
0.0020966 1 1 0.0020966 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 116 NULL 31 0 0 0 0 0
0.00985681 1 1 0.00985681 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 115 NULL 31 0 0 0 0 0
0.0003399741 1 0.000339974 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 112 NULL 31 0 0 0 0 0
0.0019461 1 1 0.0019461 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 111 NULL 31 0 0 0 0 0
0.00426293 1 1 0.00426293 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 110 NULL 31 0 0 0 0 0
0.00829528 1 1 0.00829528 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 107 NULL 31 0 0 0 0 0
0.0139774 1 1 0.0139774 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 106 NULL 31 0 0 0 0 0
0.0788545011 1 0.078854501 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 100 NULL 31 0 0 0 0 0
0.00929102 1 1 0.00929102 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 98 NULL 31 0 0 0 0 0
699.65802 1 1 699.65802 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 91 NULL 31 0 0 0 0 0
0.0092195781 1 0.009219578 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 90 NULL 31 0 0 0 0 0
699.51599121 1 699.5159912 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 87 NULL 31 0 0 0 0 0
0.1508546171 1 0.150854617 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 79 NULL 31 0 0 0 0 0
0.1420160981 1 0.142016098 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 66 NULL 31 0 0 0 0 0
5.46E-051 1 5.46E-05g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 59 NULL 31 0 0 0 0 0
0.0001263621 1 0.000126362 g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 58 NULL 31 0 0 0 0 0
2.38E-051 1 2.38E-05g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 57 NULL 31 0 0 0 0 0
2.99E-051 1 2.99E-05g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001 1 2016 7 5 15 25 25025 250250 13 56 NULL 31 0 0 0 0 0
2.60E-061 1 2.60E-06g mi

1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	55	NULL	31	0	0	0	0	0	0.000109185	1	1	0.000109185	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	54	NULL	31	0	0	0	0	0	1.02E-05	1	1	1.02E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	53	NULL	31	0	0	0	0	0	6.43E-06	1	1	6.43E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	52	NULL	31	0	0	0	0	0	5.22E-06	1	1	5.22E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	51	NULL	31	0	0	0	0	0	1.19E-05	1	1	1.19E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	36	NULL	31	0	0	0	0	0	0.00019711	1	1	0.00019711	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	35	NULL	31	0	0	0	0	0	2.60E-05	1	1	2.60E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	31	NULL	31	0	0	0	0	0	0.0136925	1	1	0.0136925	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	5	NULL	31	0	0	0	0	0	0.005771743	1	1	0.005771743	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	3	NULL	31	0	0	0	0	0	0.290587336	1	1	0.290587336	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	2	NULL	31	0	0	0	0	0	3.886432409	1	1	3.886432409	g	mi
1,1,2016,7,5,15,25,25025,250250,13,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	13	1	NULL	31	0	0	0	0	0	0.147721902	1	1	0.147721902	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	122	NULL	31	0	0	0	0	0	0.000960362	1	1	0.000960362	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	121	NULL	31	0	0	0	0	0	0.00038653	1	1	0.00038653	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	119	NULL	31	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	118	NULL	31	0	0	0	0	0	0.00717113	1	1	0.00717113	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	117	NULL	31	0	0	0	0	0	0.00225858	1	1	0.00225858	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	116	NULL	31	0	0	0	0	0	0.0130533	1	1	0.0130533	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	115	NULL	31	0	0	0	0	0	0.000412149	1	1	0.000412149	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	112	NULL	31	0	0	0	0	0	0.00223454	1	1	0.00223454	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	111	NULL	31	0	0	0	0	0	0.0048018	1	1	0.0048018	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	110	NULL	31	0	0	0	0	0	0.00940568	1	1	0.00940568	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	107	NULL	31	0	0	0	0	0	0.0150573	1	1	0.0150573	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	106	NULL	31	0	0	0	0	0	0.104427002	1	1	0.104427002	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	100	NULL	31	0	0	0	0	0	0.0105134	1	1	0.0105134	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	98	NULL	31	0	0	0	0	0	891.2810059	1	1	891.2810059	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	91	NULL	31	0	0	0	0	0	0.01174516	1	1	0.01174516	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	90	NULL	31	0	0	0	0	0	891.1220093	1	1	891.1220093	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	87	NULL	31	0	0	0	0	0	0.175893709	1	1	0.175893709	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	79	NULL	31	0	0	0	0	0	0.165509611	1	1	0.165509611	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	66	NULL	31	0	0	0	0	0	8.19E-05	1	1	8.19E-05	g	mi

1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	59	NULL	31	0	0	0	0	0	0.000136307	1	1	0.000136307	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	58	NULL	31	0	0	0	0	0	2.63E-05	1	1	2.63E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	57	NULL	31	0	0	0	0	0	3.60E-05	1	1	3.60E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	56	NULL	31	0	0	0	0	0	2.93E-06	1	1	2.93E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	55	NULL	31	0	0	0	0	0	0.00012245	1	1	0.00012245	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	54	NULL	31	0	0	0	0	0	1.10E-05	1	1	1.10E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	53	NULL	31	0	0	0	0	0	7.20E-06	1	1	7.20E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	52	NULL	31	0	0	0	0	0	6.66E-06	1	1	6.66E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	51	NULL	31	0	0	0	0	0	1.51E-05	1	1	1.51E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	36	NULL	31	0	0	0	0	0	0.000215323	1	1	0.000215323	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	35	NULL	31	0	0	0	0	0	3.10E-05	1	1	3.10E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	31	NULL	31	0	0	0	0	0	0.017449699	1	1	0.017449699	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	5	NULL	31	0	0	0	0	0	0.006440759	1	1	0.006440759	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	3	NULL	31	0	0	0	0	0	0.330884218	1	1	0.330884218	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	2	NULL	31	0	0	0	0	0	4.24930191	1	1	4.24930191	g	mi
1,1,2016,7,5,15,25,25025,250250,12,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	12	1	NULL	31	0	0	0	0	0	0.171878904	1	1	0.171878904	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	122	NULL	31	0	0	0	0	0	0.00128368	1	1	0.00128368	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	121	NULL	31	0	0	0	0	0	0.000510813	1	1	0.000510813	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	119	NULL	31	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	118	NULL	31	0	0	0	0	0	0.00963698	1	1	0.00963698	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	117	NULL	31	0	0	0	0	0	0.00243372	1	1	0.00243372	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	116	NULL	31	0	0	0	0	0	0.022643	1	1	0.022643	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	115	NULL	31	0	0	0	0	0	0.000628671	1	1	0.000628671	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	112	NULL	31	0	0	0	0	0	0.00309987	1	1	0.00309987	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	111	NULL	31	0	0	0	0	0	0.00641839	1	1	0.00641839	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	110	NULL	31	0	0	0	0	0	0.0127369	1	1	0.0127369	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	107	NULL	31	0	0	0	0	0	0.0162249	1	1	0.0162249	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	106	NULL	31	0	0	0	0	0	0.181143999	1	1	0.181143999	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	100	NULL	31	0	0	0	0	0	0.0141806	1	1	0.0141806	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	98	NULL	31	0	0	0	0	0	1466.150024	1	1	1466.150024	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	91	NULL	31	0	0	0	0	0	0.01932182	1	1	0.01932182	g	mi

1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	90	NULL	31	0	0	0	0	0	1465.939941	1	1	1465.939941	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	87	NULL	31	0	0	0	0	0	0.251010656	1	1	0.251010656	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	79	NULL	31	0	0	0	0	0	0.235990405	1	1	0.235990405	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	66	NULL	31	0	0	0	0	0	0.000163752	1	1	0.000163752	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	59	NULL	31	0	0	0	0	0	0.000166143	1	1	0.000166143	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	58	NULL	31	0	0	0	0	0	3.40E-05	1	1	3.40E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	57	NULL	31	0	0	0	0	0	5.42E-05	1	1	5.42E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	56	NULL	31	0	0	0	0	0	3.91E-06	1	1	3.91E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	55	NULL	31	0	0	0	0	0	0.000162243	1	1	0.000162243	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	54	NULL	31	0	0	0	0	0	1.36E-05	1	1	1.36E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	53	NULL	31	0	0	0	0	0	9.51E-06	1	1	9.51E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	52	NULL	31	0	0	0	0	0	1.10E-05	1	1	1.10E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	51	NULL	31	0	0	0	0	0	2.48E-05	1	1	2.48E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	36	NULL	31	0	0	0	0	0	0.000269963	1	1	0.000269963	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	35	NULL	31	0	0	0	0	0	4.62E-05	1	1	4.62E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	31	NULL	31	0	0	0	0	0	0.028721301	1	1	0.028721301	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	5	NULL	31	0	0	0	0	0	0.008447787	1	1	0.008447787	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	3	NULL	31	0	0	0	0	0	0.451777756	1	1	0.451777756	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	2	NULL	31	0	0	0	0	0	5.337890148	1	1	5.337890148	g	mi
1,1,2016,7,5,15,25,25025,250250,11,31,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	11	1	NULL	31	0	0	0	0	0	0.244350404	1	1	0.244350404	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	122	NULL	21	0	0	0	0	0	0.000385359	1	1	0.000385359	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	121	NULL	21	0	0	0	0	0	0.000158324	1	1	0.000158324	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	118	NULL	21	0	0	0	0	0	0.00283591	1	1	0.00283591	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	117	NULL	21	0	0	0	0	0	0.001229	1	1	0.001229	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	116	NULL	21	0	0	0	0	0	0.00128294	1	1	0.00128294	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	115	NULL	21	0	0	0	0	0	0.000109844	1	1	0.000109844	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	112	NULL	21	0	0	0	0	0	0.000483508	1	1	0.000483508	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	111	NULL	21	0	0	0	0	0	0.00192679	1	1	0.00192679	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	110	NULL	21	0	0	0	0	0	0.00331942	1	1	0.00331942	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	107	NULL	21	0	0	0	0	0	0.00819337	1	1	0.00819337	g	mi

1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	106	NULL	21	0	0	0	0	0	0.0102635	1	1	0.0102635	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	100	NULL	21	0	0	0	0	0	0.00375146	1	1	0.00375146	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	98	NULL	21	0	0	0	0	0	309.4840088	1	1	309.4840088	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	91	NULL	21	0	0	0	0	0	0.004079897	1	1	0.004079897	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	90	NULL	21	0	0	0	0	0	309.4060059	1	1	309.4060059	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	87	NULL	21	0	0	0	0	0	0.125556514	1	1	0.125556514	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	79	NULL	21	0	0	0	0	0	0.115660302	1	1	0.115660302	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	66	NULL	21	0	0	0	0	0	1.61E-05	1	1	1.61E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	59	NULL	21	0	0	0	0	0	6.31E-05	1	1	6.31E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	58	NULL	21	0	0	0	0	0	1.12E-05	1	1	1.12E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	57	NULL	21	0	0	0	0	0	1.12E-05	1	1	1.12E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	56	NULL	21	0	0	0	0	0	1.18E-06	1	1	1.18E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	55	NULL	21	0	0	0	0	0	4.99E-05	1	1	4.99E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	54	NULL	21	0	0	0	0	0	5.00E-06	1	1	5.00E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	53	NULL	21	0	0	0	0	0	2.95E-06	1	1	2.95E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	52	NULL	21	0	0	0	0	0	1.45E-06	1	1	1.45E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	51	NULL	21	0	0	0	0	0	3.65E-06	1	1	3.65E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	36	NULL	21	0	0	0	0	0	9.59E-05	1	1	9.59E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	35	NULL	21	0	0	0	0	0	1.00E-05	1	1	1.00E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	31	NULL	21	0	0	0	0	0	0.00613782	1	1	0.00613782	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	5	NULL	21	0	0	0	0	0	0.00319101	1	1	0.00319101	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	3	NULL	21	0	0	0	0	0	0.197913229	1	1	0.197913229	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	2	NULL	21	0	0	0	0	0	2.003333807	1	1	2.003333807	g	mi
1,1,2016,7,5,15,25,25025,250250,10,21,0,0,0,0,001	1	2016	7	5	15	25	25025	250250	10	1	NULL	21	0	0	0	0	0	0.118810304	1	1	0.118810304	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00 1	1	2016	7	5	15	25	25025	250250	9	122	NULL	21	0	0	0	0	0	0.000383303	1	1	0.000383303	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00 1	1	2016	7	5	15	25	25025	250250	9	121	NULL	21	0	0	0	0	0	0.000157479	1	1	0.000157479	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00 1	1	2016	7	5	15	25	25025	250250	9	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00 1	1	2016	7	5	15	25	25025	250250	9	118	NULL	21	0	0	0	0	0	0.0028208	1	1	0.0028208	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00 1	1	2016	7	5	15	25	25025	250250	9	117	NULL	21	0	0	0	0	0	0.001324	1	1	0.001324	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00 1	1	2016	7	5	15	25	25025	250250	9	116	NULL	21	0	0	0	0	0	0.00198081	1	1	0.00198081	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00 1	1	2016	7	5	15	25	25025	250250	9	115	NULL	21	0	0	0	0	0	0.000109279	1	1	0.000109279	g	mi

1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	112	NULL	21	0	0	0	0	0	0.000480934	1	1	0.000480934	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	111	NULL	21	0	0	0	0	0	0.00191651	1	1	0.00191651	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	110	NULL	21	0	0	0	0	0	0.00330173	1	1	0.00330173	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	107	NULL	21	0	0	0	0	0	0.00882671	1	1	0.00882671	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	106	NULL	21	0	0	0	0	0	0.0158465	1	1	0.0158465	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	100	NULL	21	0	0	0	0	0	0.00373148	1	1	0.00373148	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	98	NULL	21	0	0	0	0	0	317.0320129	1	1	317.0320129	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	91	NULL	21	0	0	0	0	0	0.004179437	1	1	0.004179437	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	90	NULL	21	0	0	0	0	0	316.9549866	1	1	316.9549866	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	87	NULL	21	0	0	0	0	0	0.12703304	1	1	0.12703304	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	79	NULL	21	0	0	0	0	0	0.117001198	1	1	0.117001198	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	66	NULL	21	0	0	0	0	0	1.79E-05	1	1	1.79E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	59	NULL	21	0	0	0	0	0	6.28E-05	1	1	6.28E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	58	NULL	21	0	0	0	0	0	1.11E-05	1	1	1.11E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	57	NULL	21	0	0	0	0	0	1.12E-05	1	1	1.12E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	56	NULL	21	0	0	0	0	0	1.17E-06	1	1	1.17E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	55	NULL	21	0	0	0	0	0	4.96E-05	1	1	4.96E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	54	NULL	21	0	0	0	0	0	4.97E-06	1	1	4.97E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	53	NULL	21	0	0	0	0	0	2.93E-06	1	1	2.93E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	52	NULL	21	0	0	0	0	0	1.44E-06	1	1	1.44E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	51	NULL	21	0	0	0	0	0	3.63E-06	1	1	3.63E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	36	NULL	21	0	0	0	0	0	9.54E-05	1	1	9.54E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	35	NULL	21	0	0	0	0	0	9.96E-06	1	1	9.96E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	31	NULL	21	0	0	0	0	0	0.00628758	1	1	0.00628758	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	5	NULL	21	0	0	0	0	0	0.003139933	1	1	0.003139933	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	3	NULL	21	0	0	0	0	0	0.192997023	1	1	0.192997023	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	2	NULL	21	0	0	0	0	0	2.018112183	1	1	2.018112183	g	mi
1,1,2016,7,5,15,25,25025,250250,9,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	9	1	NULL	21	0	0	0	0	0	0.120100796	1	1	0.120100796	g	mi
1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	8	122	NULL	21	0	0	0	0	0	0.000394183	1	1	0.000394183	g	mi
1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	8	121	NULL	21	0	0	0	0	0	0.00016195	1	1	0.00016195	g	mi
1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	8	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 118 NULL 21 0 0 0 0 0
0.00290085 1 1 0.00290085 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 117 NULL 21 0 0 0 0 0
0.001427 1 1 0.001427 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 116 NULL 21 0 0 0 0 0
0.00275537 1 1 0.00275537 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 115 NULL 21 0 0 0 0 0
0.00011236 1 1 0.00011236 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 112 NULL 21 0 0 0 0 0
0.000494587 1 1 0.000494587 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 111 NULL 21 0 0 0 0 0
0.00197091 1 1 0.00197091 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 110 NULL 21 0 0 0 0 0
0.00339544 1 1 0.00339544 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 107 NULL 21 0 0 0 0 0
0.00951338 1 1 0.00951338 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 106 NULL 21 0 0 0 0 0
0.022043001 1 1 0.022043001 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 100 NULL 21 0 0 0 0 0
0.00383739 1 1 0.00383739 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 98 NULL 21 0 0 0 0 0
327.5499878 1 1 327.5499878 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 91 NULL 21 0 0 0 0 0
0.004318093 1 1 0.004318093 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 90 NULL 21 0 0 0 0 0
327.4700012 1 1 327.4700012 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 87 NULL 21 0 0 0 0 0
0.129978836 1 1 0.129978836 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 79 NULL 21 0 0 0 0 0
0.119802296 1 1 0.119802296 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 66 NULL 21 0 0 0 0 0
2.01E-05 1 1 2.01E-05 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 59 NULL 21 0 0 0 0 0
6.46E-05 1 1 6.46E-05 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 58 NULL 21 0 0 0 0 0
1.15E-05 1 1 1.15E-05 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 57 NULL 21 0 0 0 0 0
1.15E-05 1 1 1.15E-05 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 56 NULL 21 0 0 0 0 0
1.21E-06 1 1 1.21E-06 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 55 NULL 21 0 0 0 0 0
5.10E-05 1 1 5.10E-05 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 54 NULL 21 0 0 0 0 0
5.11E-06 1 1 5.11E-06 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 53 NULL 21 0 0 0 0 0
3.01E-06 1 1 3.01E-06 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 52 NULL 21 0 0 0 0 0
1.48E-06 1 1 1.48E-06 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 51 NULL 21 0 0 0 0 0
3.73E-06 1 1 3.73E-06 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 36 NULL 21 0 0 0 0 0
9.81E-05 1 1 9.81E-05 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 35 NULL 21 0 0 0 0 0
1.02E-05 1 1 1.02E-05 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 31 NULL 21 0 0 0 0 0
0.00649621 1 1 0.00649621 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 5 NULL 21 0 0 0 0 0
0.003245141 1 1 0.003245141 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 3 NULL 21 0 0 0 0 0
0.192626998 1 1 0.192626998 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00 1 1 2016 7 5 15 25 25025 250250 8 2 NULL 21 0 0 0 0 0
2.134444714 1 1 2.134444714 g mi

1,1,2016,7,5,15,25,25025,250250,8,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	8	1	NULL	21	0	0	0	0	0	0.123005599	1	1	0.123005599	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	122	NULL	21	0	0	0	0	0	0.000416333	1	1	0.000416333	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	121	NULL	21	0	0	0	0	0	0.000171052	1	1	0.000171052	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	118	NULL	21	0	0	0	0	0	0.00306381	1	1	0.00306381	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	117	NULL	21	0	0	0	0	0	0.001537	1	1	0.001537	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	116	NULL	21	0	0	0	0	0	0.00369191	1	1	0.00369191	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	115	NULL	21	0	0	0	0	0	0.00011862	1	1	0.00011862	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	112	NULL	21	0	0	0	0	0	0.000522374	1	1	0.000522374	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	111	NULL	21	0	0	0	0	0	0.00208166	1	1	0.00208166	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	110	NULL	21	0	0	0	0	0	0.00358618	1	1	0.00358618	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	107	NULL	21	0	0	0	0	0	0.0102467	1	1	0.0102467	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	106	NULL	21	0	0	0	0	0	0.029535299	1	1	0.029535299	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	100	NULL	21	0	0	0	0	0	0.00405297	1	1	0.00405297	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	98	NULL	21	0	0	0	0	0	341.7309875	1	1	341.7309875	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	91	NULL	21	0	0	0	0	0	0.004505022	1	1	0.004505022	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	90	NULL	21	0	0	0	0	0	341.644989	1	1	341.644989	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	87	NULL	21	0	0	0	0	0	0.134433419	1	1	0.134433419	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	79	NULL	21	0	0	0	0	0	0.124085799	1	1	0.124085799	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	66	NULL	21	0	0	0	0	0	2.30E-05	1	1	2.30E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	59	NULL	21	0	0	0	0	0	6.82E-05	1	1	6.82E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	58	NULL	21	0	0	0	0	0	1.21E-05	1	1	1.21E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	57	NULL	21	0	0	0	0	0	1.21E-05	1	1	1.21E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	56	NULL	21	0	0	0	0	0	1.27E-06	1	1	1.27E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	55	NULL	21	0	0	0	0	0	5.39E-05	1	1	5.39E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	54	NULL	21	0	0	0	0	0	5.40E-06	1	1	5.40E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	53	NULL	21	0	0	0	0	0	3.18E-06	1	1	3.18E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	52	NULL	21	0	0	0	0	0	1.56E-06	1	1	1.56E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	51	NULL	21	0	0	0	0	0	3.94E-06	1	1	3.94E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	36	NULL	21	0	0	0	0	0	0.00010363	1	1	0.00010363	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	35	NULL	21	0	0	0	0	0	1.08E-05	1	1	1.08E-05	g	mi

1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	31	NULL	21	0	0	0	0	0	0.00677748	1	1	0.00677748	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	5	NULL	21	0	0	0	0	0	0.003482968	1	1	0.003482968	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	3	NULL	21	0	0	0	0	0	0.195656136	1	1	0.195656136	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	2	NULL	21	0	0	0	0	0	2.343386173	1	1	2.343386173	g	mi
1,1,2016,7,5,15,25,25025,250250,7,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	7	1	NULL	21	0	0	0	0	0	0.127523899	1	1	0.127523899	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	122	NULL	21	0	0	0	0	0	0.00044439	1	1	0.00044439	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	121	NULL	21	0	0	0	0	0	0.000182581	1	1	0.000182581	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	118	NULL	21	0	0	0	0	0	0.00327026	1	1	0.00327026	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	117	NULL	21	0	0	0	0	0	0.001656	1	1	0.001656	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	116	NULL	21	0	0	0	0	0	0.00493551	1	1	0.00493551	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	115	NULL	21	0	0	0	0	0	0.000126585	1	1	0.000126585	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	112	NULL	21	0	0	0	0	0	0.000557579	1	1	0.000557579	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	111	NULL	21	0	0	0	0	0	0.00222195	1	1	0.00222195	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	110	NULL	21	0	0	0	0	0	0.00382784	1	1	0.00382784	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	107	NULL	21	0	0	0	0	0	0.0110401	1	1	0.0110401	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	106	NULL	21	0	0	0	0	0	0.039484099	1	1	0.039484099	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	100	NULL	21	0	0	0	0	0	0.0043261	1	1	0.0043261	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	98	NULL	21	0	0	0	0	0	363.631012	1	1	363.631012	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	91	NULL	21	0	0	0	0	0	0.004793718	1	1	0.004793718	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	90	NULL	21	0	0	0	0	0	363.5390015	1	1	363.5390015	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	87	NULL	21	0	0	0	0	0	0.140103295	1	1	0.140103295	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	79	NULL	21	0	0	0	0	0	0.129515499	1	1	0.129515499	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	66	NULL	21	0	0	0	0	0	2.68E-05	1	1	2.68E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	59	NULL	21	0	0	0	0	0	7.28E-05	1	1	7.28E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	58	NULL	21	0	0	0	0	0	1.29E-05	1	1	1.29E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	57	NULL	21	0	0	0	0	0	1.30E-05	1	1	1.30E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	56	NULL	21	0	0	0	0	0	1.36E-06	1	1	1.36E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	55	NULL	21	0	0	0	0	0	5.75E-05	1	1	5.75E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	54	NULL	21	0	0	0	0	0	5.77E-06	1	1	5.77E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	53	NULL	21	0	0	0	0	0	3.40E-06	1	1	3.40E-06	g	mi

1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	52	NULL	21	0	0	0	0	0	1.67E-06	1	1	1.67E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	51	NULL	21	0	0	0	0	0	4.20E-06	1	1	4.20E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	36	NULL	21	0	0	0	0	0	0.000110619	1	1	0.000110619	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	35	NULL	21	0	0	0	0	0	1.15E-05	1	1	1.15E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	31	NULL	21	0	0	0	0	0	0.00721187	1	1	0.00721187	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	5	NULL	21	0	0	0	0	0	0.003747167	1	1	0.003747167	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	3	NULL	21	0	0	0	0	0	0.202133402	1	1	0.202133402	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	2	NULL	21	0	0	0	0	0	2.564254761	1	1	2.564254761	g	mi
1,1,2016,7,5,15,25,25025,250250,6,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	6	1	NULL	21	0	0	0	0	0	0.133214399	1	1	0.133214399	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	122	NULL	21	0	0	0	0	0	0.000481429	1	1	0.000481429	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	121	NULL	21	0	0	0	0	0	0.000197798	1	1	0.000197798	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	118	NULL	21	0	0	0	0	0	0.00354292	1	1	0.00354292	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	117	NULL	21	0	0	0	0	0	0.001784	1	1	0.001784	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	116	NULL	21	0	0	0	0	0	0.00655266	1	1	0.00655266	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	115	NULL	21	0	0	0	0	0	0.000137223	1	1	0.000137223	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	112	NULL	21	0	0	0	0	0	0.000604072	1	1	0.000604072	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	111	NULL	21	0	0	0	0	0	0.00240714	1	1	0.00240714	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	110	NULL	21	0	0	0	0	0	0.00414699	1	1	0.00414699	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	107	NULL	21	0	0	0	0	0	0.0118934	1	1	0.0118934	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	106	NULL	21	0	0	0	0	0	0.052421201	1	1	0.052421201	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	100	NULL	21	0	0	0	0	0	0.0046868	1	1	0.0046868	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	98	NULL	21	0	0	0	0	0	407.3989868	1	1	407.3989868	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	91	NULL	21	0	0	0	0	0	0.005370806	1	1	0.005370806	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	90	NULL	21	0	0	0	0	0	407.303009	1	1	407.303009	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	87	NULL	21	0	0	0	0	0	0.146872103	1	1	0.146872103	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	79	NULL	21	0	0	0	0	0	0.135898501	1	1	0.135898501	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	66	NULL	21	0	0	0	0	0	3.21E-05	1	1	3.21E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	59	NULL	21	0	0	0	0	0	7.89E-05	1	1	7.89E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	58	NULL	21	0	0	0	0	0	1.40E-05	1	1	1.40E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	57	NULL	21	0	0	0	0	0	1.40E-05	1	1	1.40E-05	g	mi

1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	56	NULL	21	0	0	0	0	0	1.47E-06	1	1	1.47E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	55	NULL	21	0	0	0	0	0	6.23E-05	1	1	6.23E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	54	NULL	21	0	0	0	0	0	6.25E-06	1	1	6.25E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	53	NULL	21	0	0	0	0	0	3.68E-06	1	1	3.68E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	52	NULL	21	0	0	0	0	0	1.81E-06	1	1	1.81E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	51	NULL	21	0	0	0	0	0	4.55E-06	1	1	4.55E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	36	NULL	21	0	0	0	0	0	0.000119841	1	1	0.000119841	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	35	NULL	21	0	0	0	0	0	1.25E-05	1	1	1.25E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	31	NULL	21	0	0	0	0	0	0.00808013	1	1	0.00808013	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	5	NULL	21	0	0	0	0	0	0.003894251	1	1	0.003894251	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	3	NULL	21	0	0	0	0	0	0.221521229	1	1	0.221521229	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	2	NULL	21	0	0	0	0	0	2.637727022	1	1	2.637727022	g	mi
1,1,2016,7,5,15,25,25025,250250,5,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	5	1	NULL	21	0	0	0	0	0	0.139742494	1	1	0.139742494	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	122	NULL	21	0	0	0	0	0	0.000607645	1	1	0.000607645	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	121	NULL	21	0	0	0	0	0	0.000249663	1	1	0.000249663	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	118	NULL	21	0	0	0	0	0	0.0044711	1	1	0.0044711	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	117	NULL	21	0	0	0	0	0	0.001922	1	1	0.001922	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	116	NULL	21	0	0	0	0	0	0.00745541	1	1	0.00745541	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	115	NULL	21	0	0	0	0	0	0.000172525	1	1	0.000172525	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	112	NULL	21	0	0	0	0	0	0.000762326	1	1	0.000762326	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	111	NULL	21	0	0	0	0	0	0.00303822	1	1	0.00303822	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	110	NULL	21	0	0	0	0	0	0.00523342	1	1	0.00523342	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	107	NULL	21	0	0	0	0	0	0.0128134	1	1	0.0128134	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	106	NULL	21	0	0	0	0	0	0.059643298	1	1	0.059643298	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	100	NULL	21	0	0	0	0	0	0.00591469	1	1	0.00591469	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	98	NULL	21	0	0	0	0	0	460.1749878	1	1	460.1749878	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	91	NULL	21	0	0	0	0	0	0.006066531	1	1	0.006066531	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	90	NULL	21	0	0	0	0	0	460.0639954	1	1	460.0639954	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	87	NULL	21	0	0	0	0	0	0.158370227	1	1	0.158370227	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	79	NULL	21	0	0	0	0	0	0.146915898	1	1	0.146915898	g	mi

1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	66	NULL	21	0	0	0	0	0	4.02E-05	1	1	4.02E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	59	NULL	21	0	0	0	0	0	9.95E-05	1	1	9.95E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	58	NULL	21	0	0	0	0	0	1.77E-05	1	1	1.77E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	57	NULL	21	0	0	0	0	0	1.77E-05	1	1	1.77E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	56	NULL	21	0	0	0	0	0	1.86E-06	1	1	1.86E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	55	NULL	21	0	0	0	0	0	7.87E-05	1	1	7.87E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	54	NULL	21	0	0	0	0	0	7.88E-06	1	1	7.88E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	53	NULL	21	0	0	0	0	0	4.64E-06	1	1	4.64E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	52	NULL	21	0	0	0	0	0	2.27E-06	1	1	2.27E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	51	NULL	21	0	0	0	0	0	5.74E-06	1	1	5.74E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	36	NULL	21	0	0	0	0	0	0.000151264	1	1	0.000151264	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	35	NULL	21	0	0	0	0	0	1.58E-05	1	1	1.58E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	31	NULL	21	0	0	0	0	0	0.00912692	1	1	0.00912692	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	5	NULL	21	0	0	0	0	0	0.004480024	1	1	0.004480024	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	3	NULL	21	0	0	0	0	0	0.234676778	1	1	0.234676778	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	2	NULL	21	0	0	0	0	0	3.257755756	1	1	3.257755756	g	mi
1,1,2016,7,5,15,25,25025,250250,4,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	4	1	NULL	21	0	0	0	0	0	0.151338309	1	1	0.151338309	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	122	NULL	21	0	0	0	0	0	0.000702602	1	1	0.000702602	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	121	NULL	21	0	0	0	0	0	0.000288677	1	1	0.000288677	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	118	NULL	21	0	0	0	0	0	0.00516983	1	1	0.00516983	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	117	NULL	21	0	0	0	0	0	0.002071	1	1	0.002071	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	116	NULL	21	0	0	0	0	0	0.00888722	1	1	0.00888722	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	115	NULL	21	0	0	0	0	0	0.000199518	1	1	0.000199518	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	112	NULL	21	0	0	0	0	0	0.000881464	1	1	0.000881464	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	111	NULL	21	0	0	0	0	0	0.003513	1	1	0.003513	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	110	NULL	21	0	0	0	0	0	0.00605129	1	1	0.00605129	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	107	NULL	21	0	0	0	0	0	0.0138067	1	1	0.0138067	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	106	NULL	21	0	0	0	0	0	0.071097799	1	1	0.071097799	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	100	NULL	21	0	0	0	0	0	0.00683902	1	1	0.00683902	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	98	NULL	21	0	0	0	0	0	539.059021	1	1	539.059021	g	mi

1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	91	NULL	21	0	0	0	0	0	0.007106571	1	1	0.007106571	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	90	NULL	21	0	0	0	0	0	538.9370117	1	1	538.9370117	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	87	NULL	21	0	0	0	0	0	0.174041167	1	1	0.174041167	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	79	NULL	21	0	0	0	0	0	0.161721706	1	1	0.161721706	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	66	NULL	21	0	0	0	0	0	5.36E-05	1	1	5.36E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	59	NULL	21	0	0	0	0	0	0.000115081	1	1	0.000115081	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	58	NULL	21	0	0	0	0	0	2.04E-05	1	1	2.04E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	57	NULL	21	0	0	0	0	0	2.05E-05	1	1	2.05E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	56	NULL	21	0	0	0	0	0	2.15E-06	1	1	2.15E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	55	NULL	21	0	0	0	0	0	9.10E-05	1	1	9.10E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	54	NULL	21	0	0	0	0	0	9.12E-06	1	1	9.12E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	53	NULL	21	0	0	0	0	0	5.37E-06	1	1	5.37E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	52	NULL	21	0	0	0	0	0	2.63E-06	1	1	2.63E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	51	NULL	21	0	0	0	0	0	6.64E-06	1	1	6.64E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	36	NULL	21	0	0	0	0	0	0.000174903	1	1	0.000174903	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	35	NULL	21	0	0	0	0	0	1.82E-05	1	1	1.82E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	31	NULL	21	0	0	0	0	0	0.0106918	1	1	0.0106918	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	5	NULL	21	0	0	0	0	0	0.004948465	1	1	0.004948465	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	3	NULL	21	0	0	0	0	0	0.249984428	1	1	0.249984428	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	2	NULL	21	0	0	0	0	0	3.673358202	1	1	3.673358202	g	mi
1,1,2016,7,5,15,25,25025,250250,3,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	3	1	NULL	21	0	0	0	0	0	0.166606307	1	1	0.166606307	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	122	NULL	21	0	0	0	0	0	0.000823725	1	1	0.000823725	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	121	NULL	21	0	0	0	0	0	0.000338436	1	1	0.000338436	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	118	NULL	21	0	0	0	0	0	0.00606167	1	1	0.00606167	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	117	NULL	21	0	0	0	0	0	0.002231	1	1	0.002231	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	116	NULL	21	0	0	0	0	0	0.0117074	1	1	0.0117074	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	115	NULL	21	0	0	0	0	0	0.000234523	1	1	0.000234523	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	112	NULL	21	0	0	0	0	0	0.00103354	1	1	0.00103354	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	111	NULL	21	0	0	0	0	0	0.00411862	1	1	0.00411862	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	110	NULL	21	0	0	0	0	0	0.00709521	1	1	0.00709521	g	mi

1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	107	NULL	21	0	0	0	0	0	0.0148734	1	1	0.0148734	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	106	NULL	21	0	0	0	0	0	0.093659602	1	1	0.093659602	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	100	NULL	21	0	0	0	0	0	0.0080188	1	1	0.0080188	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	98	NULL	21	0	0	0	0	0	691.4180298	1	1	691.4180298	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	91	NULL	21	0	0	0	0	0	0.009115422	1	1	0.009115422	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	90	NULL	21	0	0	0	0	0	691.2800293	1	1	691.2800293	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	87	NULL	21	0	0	0	0	0	0.203301311	1	1	0.203301311	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	79	NULL	21	0	0	0	0	0	0.189212799	1	1	0.189212799	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	66	NULL	21	0	0	0	0	0	8.04E-05	1	1	8.04E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	59	NULL	21	0	0	0	0	0	0.000134926	1	1	0.000134926	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	58	NULL	21	0	0	0	0	0	2.39E-05	1	1	2.39E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	57	NULL	21	0	0	0	0	0	2.40E-05	1	1	2.40E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	56	NULL	21	0	0	0	0	0	2.52E-06	1	1	2.52E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	55	NULL	21	0	0	0	0	0	0.000106667	1	1	0.000106667	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	54	NULL	21	0	0	0	0	0	1.07E-05	1	1	1.07E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	53	NULL	21	0	0	0	0	0	6.30E-06	1	1	6.30E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	52	NULL	21	0	0	0	0	0	3.09E-06	1	1	3.09E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	51	NULL	21	0	0	0	0	0	7.78E-06	1	1	7.78E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	36	NULL	21	0	0	0	0	0	0.000205052	1	1	0.000205052	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	35	NULL	21	0	0	0	0	0	2.14E-05	1	1	2.14E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	31	NULL	21	0	0	0	0	0	0.0137142	1	1	0.0137142	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	5	NULL	21	0	0	0	0	0	0.005582626	1	1	0.005582626	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	3	NULL	21	0	0	0	0	0	0.276655585	1	1	0.276655585	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	2	NULL	21	0	0	0	0	0	4.136309624	1	1	4.136309624	g	mi
1,1,2016,7,5,15,25,25025,250250,2,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	2	1	NULL	21	0	0	0	0	0	0.194723397	1	1	0.194723397	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	122	NULL	21	0	0	0	0	0	0.00118709	1	1	0.00118709	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	121	NULL	21	0	0	0	0	0	0.000487712	1	1	0.000487712	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	119	NULL	21	0	0	0	0	0	0	1	1	0	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	118	NULL	21	0	0	0	0	0	0.0087372	1	1	0.0087372	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	117	NULL	21	0	0	0	0	0	0.002404	1	1	0.002404	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	116	NULL	21	0	0	0	0	0	0.0201681	1	1	0.0201681	g	mi

1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	115	NULL	21	0	0	0	0	0	0.000339537	1	1	0.000339537	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	112	NULL	21	0	0	0	0	0	0.00148975	1	1	0.00148975	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	111	NULL	21	0	0	0	0	0	0.00593545	1	1	0.00593545	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	110	NULL	21	0	0	0	0	0	0.010227	1	1	0.010227	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	107	NULL	21	0	0	0	0	0	0.0160267	1	1	0.0160267	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	106	NULL	21	0	0	0	0	0	0.161345005	1	1	0.161345005	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	100	NULL	21	0	0	0	0	0	0.0115581	1	1	0.0115581	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	98	NULL	21	0	0	0	0	0	1148.48999	1	1	1148.48999	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	91	NULL	21	0	0	0	0	0	0.015141946	1	1	0.015141946	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	90	NULL	21	0	0	0	0	0	1148.310059	1	1	1148.310059	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	87	NULL	21	0	0	0	0	0	0.291081756	1	1	0.291081756	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	79	NULL	21	0	0	0	0	0	0.27168569	1	1	0.27168569	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	66	NULL	21	0	0	0	0	0	0.000160731	1	1	0.000160731	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	59	NULL	21	0	0	0	0	0	0.000194461	1	1	0.000194461	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	58	NULL	21	0	0	0	0	0	3.45E-05	1	1	3.45E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	57	NULL	21	0	0	0	0	0	3.46E-05	1	1	3.46E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	56	NULL	21	0	0	0	0	0	3.63E-06	1	1	3.63E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	55	NULL	21	0	0	0	0	0	0.000153719	1	1	0.000153719	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	54	NULL	21	0	0	0	0	0	1.54E-05	1	1	1.54E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	53	NULL	21	0	0	0	0	0	9.07E-06	1	1	9.07E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	52	NULL	21	0	0	0	0	0	4.47E-06	1	1	4.47E-06	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	51	NULL	21	0	0	0	0	0	1.12E-05	1	1	1.12E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	36	NULL	21	0	0	0	0	0	0.000295501	1	1	0.000295501	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	35	NULL	21	0	0	0	0	0	3.08E-05	1	1	3.08E-05	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	31	NULL	21	0	0	0	0	0	0.0227817	1	1	0.0227817	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	5	NULL	21	0	0	0	0	0	0.007485085	1	1	0.007485085	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	3	NULL	21	0	0	0	0	0	0.356667012	1	1	0.356667012	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	2	NULL	21	0	0	0	0	0	5.52515316	1	1	5.52515316	g	mi
1,1,2016,7,5,15,25,25025,250250,1,21,0,0,0,0,00	1	1	2016	7	5	15	25	25025	250250	1	1	NULL	21	0	0	0	0	0	0.279074788	1	1	0.279074788	g	mi

Source: KBE and Massport.

Fuel Storage and Handling

As in previous years, VOC emissions from fuel storage and handling were calculated using methods based on EPA's AP-42[1] document. Calculations account for evaporative emissions from breathing losses, working losses, and spillage from aboveground storage tanks, underground storage tanks, and aircraft refueling. In 2003, additional information became available on the fire training fuel, Tek-Flame®. Emissions of VOCs from this fuel were estimated by AEDT. **Table I-9** presents Logan Airport's fuel throughput by category.

Stationary Sources

Stationary sources include the Central Heating and Cooling Plant, emergency generators, snow melters, space heaters, and boilers. Emission factors from EPA's AP-42 or NO_x Reasonably Available Control Technology (RACT) compliance testing were combined with the actual 2016 fuel throughput of the stationary sources to obtain emissions of VOCs, NO_X, CO, and PM with a diameter of less than or equal to 10 micrograms or 2.5 micrograms (PM_{10}/$PM_{2.5}$).

Title V of the 1990 Clean Air Act (CAA) Amendments requires facilities with air emissions to document their emissions and obtain a single permit combining all sources. The permitting program ensures that all emission sources are accounted for, the proper permits have been received, and permit conditions are being followed. A Title V Air Operating Permit covers all of the stationary sources at Logan Airport including boilers, emergency generators, snow melters, fire training, cooling towers, paint booths, deicing facilities, and storage tanks. **Table I-10** presents Logan Airport's stationary source fuel throughput by fuel category.

1 Compilation of Air Pollutant Emission Factors, AP-42, Office of Air Quality Planning and Standards, EPA, Fifth Edition, 1995.

Table I-9 Fuel Throughput by Fuel Category (gallons)

Fuel Category	1999	2000	2001	2002	2003	2004	2005	2006	2007
Jet Fuel	354,095,516	441,901,932	416,748,819	358,190,362	319,439,910	373,996,141	368,645,392	364,450,864	367,585,187
Fire Training Fuel[1]	N/A	N/A	N/A	N/A	13,719	12,227	8,105	5,000	8,631
Aviation Gas	99,726	90,922	60,691	35,111	32,515	34,717	52,487	35,098	29,067
Auto Gas	7,200,000	7,569,206	6,181,472	5,754,740	5,436,322	5,803,442	5,903,424	6,028,931	6,022,237
Diesel	768,106	839,751	1,239,904	1,067,847	1,030,185	1,078,665	1,567,688	1,164,493	1,141,335
Heating Oil No.2	480,733	494,500	582,283	340,492	370,903	381,852	367,899	259,768	423,181
Heating Oil No.62	1,600,893	1,555,527	1,641,693	1,079,283	1,122,975	2,940,752	3,098,126	1,396,529	1,073,260

Fuel Category	2008	2009	2010	2011	2012	2013	2014	2015	2016
Jet Fuel	345,631,788	327,358,619	335,693,997	340,421,373	343,731,127	349,397,940	370,222,342	374,985,216	456,003,328
Fire Training Fuel[1]	5,971	3,510	800	3,810	2,587	5,400	3,753	7,619	6,153
Aviation Gas	25,037	18,238	15,268	14,064	12,306	14,422	12,514	10,225	10,654
Auto Gas	5,693,178	5,736,724	5,696,505	5,487,952	6,694,626	6,800,936	7,007,591	7,432,165	7,794,957
Diesel	1,071,707	1,121,241	1,168,761	1,099,720	878,499	1,094,714	1,178,805	1,473,720	1,233,200
Heating Oil No.2	303,143	409,049	319,727	384,906	210,794	289,665	289,956	294,704	520,977
Heating Oil No.6[2]	16,385	368,690	9,010	11,285	6,786	17,721	77,146	0	0

Source: Massport, 2017.
N/A Not available.
1 Fire Training Fuel used in 1999-2002 was Jet A Fuel while in 2003 through 2014 it was Tek-Flame®. 2012 includes 100 gallons of avgas, 2013 includes 400 gallons of avgas, 2014 includes 338 gallons of avgas, 2015 includes 742 gallons of avgas, and 2016 includes 494 gallons of avgas.
2 Effective November 2014, Massport no longer uses No. 6 heating oil at the CHP and was replaced with No. 2 heating oil.

Table I-10 Stationary Source Fuel Throughput by Fuel Category (gallons)

Fuel Category	1999	2000	2001	2002	2003	2004	2005	2006	2007
Natural Gas (ft^3)	183,943,000	283,720,049	199,500,000	268,359,282	201,714,114	62,610,000	92,460,000	112,390,000	338,430,000
Heating Oil No. 2	480,733	494,500	582,283	340,492	370,903	381,852	367,899	259,768	423,181
Heating Oil No. 6[1]	1,600,893	1,555,527	1,641,693	1,079,283	1,122,975	2,940,752	3,098,126	1,396,529	1,073,260
Diesel Fuel[2]	57,441	N/A	N/A	N/A	N/A	67,198	77,848	77,848	258,606
Fire Training Fuel[3]	23,000	N/A	N/A	N/A	13,719	12,227	8,105	5,000	8,631

Fuel Category	2008	2009	2010	2011	2012	2013	2014	2015	2016
Natural Gas (ft^3)	458,680,000	430,810,000	449,640,000	479,830,000	360,523,000	402,496,000	418,805,000	463,170,000	429,502,000
Heating Oil No. 2	303,143	409,050	319,727	384,906	210,794	289,665	289,956	294,704	520,977
Heating Oil No. 6[1]	16,385	368,690	9,010	11,285	6,786	17,721	77,146	0	0
Diesel Fuel[2]	146,718	145,778	116,511	218,081	42,109	231,130	124,480	381,581	90,850
Fire Training Fuel[3]	5,971	3,510	800	3,810	2,587	5,400	3,753	7,619	6,153

Source: Massport, 2017.
N/A Not available.
1 Effective November 2014, Massport no longer uses No. 6 heating oil at the CHP and was replaced with No. 2 heating oil.
2 Diesel fuel was from the stationary snow melter usage. Starting in 2007, portable snow melter usage was also included.
3 Fire Training Fuel used in 1999-2002 was Jet A Fuel while in 2003 through 2015 it was Tek-Flame®. 2012 includes 100 gallons of avgas, 2013 includes 400 gallons of avgas, 2014 includes 338 gallons of avgas, 2015 includes 742 gallons of avgas, and 2016 includes 494 gallons of avgas.

Tables I-11 through **I-17** contain the 1993 through 2009 Emissions Inventory summary tables for Logan Airport.

Table I-11 Estimated VOC Emissions (in kg/day) at Logan Airport 1993-2001[1]

Aircraft/GSE Model:	**Logan Dispersion Modeling System (LDMS)**					**EDMS v3.22**	**EDMS v4.21**	**EDMS v4.03**	
Motor Vehicle Model:	**MOBILE5a**					**MOB 5a_h**	**MOB 6.2.03**	**MOBILE 6.0**	
Year:	1993	1994	1995	1996	1997	1998	1999[2]	2000	2001
Aircraft Sources									
Air carriers	1,958	1,554	1,407	1,390	1,227	736	653	514	374
Commuter aircraft	943	543	531	622	498	154	196	140	113
Cargo aircraft	89	244	236	214	207	43	318	207	149
General aviation	51	48	36	24	27	13	141	42	43
Total aircraft sources	3,041	2,389	2,210	2,250	1,959	946	1,308	903	679
Ground Service Equipment[3]	636	533	521	497	530	145	243	153	143
Motor Vehicles									
Ted Williams Tunnel through-traffic	N/A	N/A	N/A	N/A	N/A	N/A	15	12	10
Parking/curbside	173	148	127	102	102	118	101	89	77
On-airport vehicles[4]	238	215	179	223	205	258	256	206	170
Total motor vehicle sources	411	363	306	325	307	376	372	307	257
Other Sources									
Fuel storage/handling	408	434	318	356	381	372	352	412	372
Miscellaneous sources[5]	5	5	5	6	6	2	16	2	2
Total other sources	413	439	323	362	387	374	368	414	374
Total Airport Sources	4,501	3,724	3,360	3,434	3,183	1,841	2,291	1,777	1,453

Source: KBE and Massport.
Notes:
N/A Not available.
kg/day Kilograms per day. One kg/day is approximately equivalent to 0.40234 tons per year (tpy).
MOB MOBILE model for motor vehicle emissions (MOB5a_h=MOBILE5a_h, MOB6.2.03=MOBILE6.2 version .03)
1 The emissions inventory for 1990 is shown in Chapter 7. Emission inventories for 1991 and 1992 were not prepared.
2 Year 1999 emissions were last re-calculated using EDMS v4.21 in the 2004 ESPR Air Quality Analysis.
3 Beginning in 1996 and later, emissions include vehicles and equipment converted to alternative fuels. APU emissions are also included.
4 1999 emissions inventory include reductions attributable to CNG shuttle buses.
5 Includes the Central Heating and Cooling Plant, emergency electricity generation, and other stationary sources. Fire Training emissions were included in 1999. Diesel snow melter usage was added in 1999.

Table I-12 Estimated VOC Emissions (in kg/day) at Logan Airport 2002-2009

Aircraft/GSE Model:	**EDMS v4.11**		**EDMS v4.21**	**EDMS v4.5**		**EDMS v5.0.1**		**EDMS v5.0.2**		**EDMS v5.1**		**EDMS v5.1.2**
Motor Vehicle Model:	**MOBILE 6.0**	**MOB 6.2.01**	**MOBILE 6.2.03**									
Year:	**2002**	**2003**	**2004**	**2005**	**2006**		**2007**		**2008**		**2009**	
Aircraft Sources												
Air carriers	248	208	292	271	227	511	435	381	324	286	237	235
Commuter aircraft	75	95	127	140	125	371	479	409	253	176	131	133
Cargo aircraft	127	94	110	41	19	46	129	112	107	70	71	71
General aviation	52	61	127	147	147	236	226	206	201	171	78	78
Total aircraft sources	502	458	656	599	518	1,164[1]	1,269	1,108	885	703	517	517
Ground Service Equipment[2]	247	227	187	178	167	77	78	78	66	66	56	56
Motor Vehicles												
Ted Williams Tunnel through-traffic	9	0[3]	0[3]	0[3]	0[3]	0[3]	0[3]	0[3]	0[3]	0[3]	0[3]	0[3]
Parking/curbside[4]	51	45	38	37	33	33	31	31	25	25	22	22
On-airport vehicles	152	135	129	118	106	106	104	104	82	82	71	71
Total motor vehicle sources	212	180	167	155	139	139	135	135	107	107	93	93
Other Sources												
Fuel storage/handling	329	297	341	340	336	336	338	338	320	320	307	307
Miscellaneous sources[5]	2	3	9	13	8	8	14	14	13	12	7	7
Total other sources	331	300	350	353	344	344	352	352	333	332	314	314
Total Airport Sources	1,292	1,165	1,360	1,285	1,168	1,724	1,834	1,673	1,391	1,208	980	980

Source: KBE and Massport

Notes: Years 2006 to 2009 were computed with previous years EDMS version to provide for a common basis of comparison.

Kg/day Kilograms per day. One kg/day is equivalent to approximately 0.40234 tons per year (tpy).

1 The 2006 increase in aircraft VOC emissions is largely attributable to the addition of aircraft main engine startup emissions.

2 GSE emissions include aircraft APUs as well as vehicles and equipment converted to alternative fuels.

3 Due to the new roadway configuration and opening of the Ted Williams Tunnel there was no Ted Williams Tunnel through- traffic at Logan Airport beginning in 2003.

4 Parking/curbside is based on VMT analysis.

5 Includes the Central Heating and Cooling Plant, emergency electricity generation, snow melter usage, and other stationary sources.

Table I-13	Estimated NO_X Emissions (in kg/day) at Logan Airport 1993-2001[1]								
Aircraft/GSE Model:	**Logan Dispersion Modeling System (LDMS)**					**EDMS v3.22**	**EDMS v4.21**	**EDMS v4.03**	
Motor Vehicle Model:	**MOBILE5a**					**MOB 5a_h**	**MOB 6.2.03**	**MOBILE 6.0**	
Year:	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999[2]**	**2000**	**2001**
Aircraft Sources									
Air carriers	4,271	4,317	3,861	3,781	4,150	4,471	4,183	4,202	3,707
Commuter aircraft	202	158	192	137	159	203	166	125	233
Cargo aircraft	213	257	332	363	262	254	286	284	267
General aviation	13	13	17	18	21	5	12	49	34
Total aircraft sources	4,699	4,745	4,402	4,299	4,592	4,933	4,647	4,660	4,241
Ground Service Equipment[3]	722	617	607	588	622	317	444	333	305
Motor Vehicles									
Ted Williams Tunnel through-traffic	N/A	N/A	N/A	N/A	N/A	N/A	28	26	22
Parking/curbside	25	24	24	24	24	37	39	52	46
On-airport vehicles[4]	240	239	229	257	244	372	449	425	369
Total motor vehicle sources	265	263	253	281	268	409	516	503	437
Other Sources									
Fuel storage/handling[5]	0	0	0	0	0	0	0	0	0
Miscellaneous sources[6]	278	330	320	275	244	284	165	211	185
Total other sources	278	330	320	275	244	284	165	211	185
Total Airport Sources	5,964	5,955	5,582	5,443	5,726	5,943	5,772	5,707	5,168

Source: KBE and Massport.
N/A Not available.
Kg/day Kilograms per day. One kg/day is approximately equivalent to 0.40234 tons per year (tpy).
MOB MOBILE model for motor vehicle emissions (MOB5a_h=MOBILE5a_h, MOB6.2.03=MOBILE6.2 version .03)
1 The emissions inventory for 1990 is shown in Chapter 7. Emission inventories for 1991 and 1992 were not prepared.
2 Year 1999 emissions were last re-calculated using EDMS v4.21 in the 2004 ESPR Air Quality Analysis.
3 Beginning in 1996 and later, emissions include vehicles and equipment converted to alternative fuels. APU emissions are also included.
4 1999 emissions inventory include reductions attributable to CNG shuttle buses.
5 Fuel storage and handling facilities are not sources of NOx emissions.
6 Includes the Central Heating and Cooling Plant, emergency electricity generation, and other stationary sources. Fire Training emissions were included in 1999. Diesel snow melter usage was added in 1999.

Table I-14 Estimated NO_X Emissions (in kg/day) at Logan Airport 2002-2009

Aircraft/GSE Model:	**EDMS v4.11**		**EDMS v4.21**	**EDMS v4.5**		**EDMS v5.0.1**		**EDMS v5.0.2**		**EDMS v5.1**		**EDMS v5.1.2**
Motor Vehicle Model:	**MOBILE 6.0**	**MOB 6.2.01**	**MOBILE 6.2.03**									
Year:	**2002**	**2003**	**2004**	**2005**	**2006**		**2007**		**2008**		**2009**	
Aircraft Sources												
Air carriers	2,721	2,479	2,949	2,880	2,849	3,044	3,120	3,121	3,031	3,031	2,944	2,952
Commuter aircraft	208	185	245	225	195	256	353	354	319	319	309	234
Cargo aircraft	246	213	215	211	192	125	248	248	233	233	215	204
General aviation	38	45	49	50	49	60	56	56	43	43	27	23
Total aircraft sources	3,213	2,922	3,458	3,366	3,285	3,485	3,777	3,779	3,626	3,626	3,495	3,413
Ground Service Equipment[1]	322	291	333	312	280	300	299	299	257	257	219	219
Motor Vehicles												
Ted Williams Tunnel through-traffic	20	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]
Parking/curbside[3]	32	28	21	22	19	19	18	18	15	15	13	13
On-airport vehicles	341	302	267	269	238	238	233	233	182	182	153	153
Total motor vehicle sources	393	330	288	291	257	257	251	251	197	197	166	166
Other Sources												
Fuel storage/handling[4]	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous sources[5]	175	151	211	218	109	109	128	128	124	124	181	181
Total other sources	175	151	211	218	109	109	128	128	124	124	181	181
Total Airport Sources	4,103	3,694	4,290	4,187	3,931	4,151	4,455	4,457	4,204	4,204	4,061	3,979

Source: KBE and Massport
Notes: Years 2006 to 2009 were computed with previous years EDMS version to provide for a common basis of comparison.
Kg/day Kilograms per day. One kg/day is approximately equivalent to 0.40234 tons per year (tpy).
1 GSE emissions include APUs as well as vehicles and equipment converted to alternative fuels.
2 Due to the new roadway configuration and opening of the Ted Williams Tunnel there was no Ted Williams Tunnel through-traffic at Logan Airport beginning in 2003.
3 Parking/curbside data is based on VMT analysis.
4 Fuel storage/handling facilities are not a source of NOx emissions.
5 Includes the Central Heating and Cooling Plant, emergency electricity generation, snow melter usage, and other stationary sources.

Table I-15 Estimated CO Emissions (in kg/day) at Logan Airport 1993-2001[1]

Aircraft/GSE Model:	**Logan Dispersion Modeling System (LDMS)**					**EDMS v3.22**	**EDMS v4.21**	**EDMS v4.03**	
Motor Vehicle Model:	**MOBILE5a**					**MOB5a_h**	**MOB 6.2.03**	**MOBILE 6.0**	
Year:	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999[2]**	**2000**	**2001**
Aircraft Sources									
Air carriers	5,663	4,660	4,691	4,812	4,698	3,079	3,754	2,994	2,475
Commuter aircraft	1,309	927	934	859	770	482	1,404	1,188	1,072
Cargo aircraft	344	572	598	580	514	218	503	400	323
General aviation	353	356	339	549	654	269	940	295	407
Total aircraft sources	7,669	6,515	6,562	6,800	6,636	4,048	6,601	4,877	4,277
Ground Service Equipment[3]	7,482	6,187	6,029	5,740	6,098	5,113	4,532	5,335	5,193
Motor Vehicles									
Ted Williams Tunnel through-traffic	N/A	N/A	N/A	N/A	N/A	N/A	151	133	121
Parking/curbside	952	820	650	644	586	772	437	495	440
On-airport vehicles[4]	1,575	1,451	1,087	1,514	1,283	1,883	2,547	2,245	2,001
Total motor vehicle sources	2,527	2,271	1,737	2,158	1,869	2,655	3,135	2,873	2,562
Other Sources									
Fuel storage/handling[5]	0	0	0	0	0	0	0	0	0
Miscellaneous sources[6]	26	30	29	39	37	37	168	27	24
Total other sources	26	30	29	39	37	37	168	27	24
Total Airport Sources	17,704	15,003	14,357	14,737	14,640	11,853	14,436	13,112	12,056

Source: KBE and Massport.
Kg/day Kilograms per day. One kg/day is approximately equivalent to 0.40234 tons per year (tpy).
N/A Not available.
MOB MOBILE model for motor vehicle emissions (MOB5a_h=MOBILE5a_h, MOB6.2.03=MOBILE6.2 version .03)
1 The emissions inventory for 1990 is shown in Chapter 7. Emission inventories for 1991 and 1992 were not prepared.
2 Year 1999 emissions were last re-calculated using EDMS v4.21 in the 2004 ESPR Air Quality Analysis.
3 Beginning in 1996 and later, emissions include vehicles and equipment converted to alternative fuels. APU emissions are also included.
4 1999 emission inventory include reductions attributable to CNG shuttle buses.
5 Fuel storage and handling facilities are not sources of CO emissions.
6 Includes the Central Heating and Cooling Plant, emergency electricity generation, and other stationary sources. Fire Training emissions were included in 1999. Diesel snow melter usage was added in 1999.

Table I-16 Estimated CO Emissions (in kg/day) at Logan Airport 2002-2009

Aircraft/GSE Model:	EDMS v4.11		EDMS v4.21	EDMS v4.5		EDMS v5.0.1		EDMS v5.0.2		EDMS v5.1		EDMS v5.1.2
Motor Vehicle Model:	**MOBILE 6.0**	**MOB 6.2.01**	**MOBILE 6.2.03**									
Year:	**2002**	**2003**	**2004**	**2005**	**2006**		**2007**		**2008**		**2009**	
Aircraft Sources												
Air carriers	2,156	2,128	2,985	2,895	2,828	3,167	2,973	2,973	2,710	2,710	2,460	2,448
Commuter aircraft	783	846	1,010	1,010	950	1,587	2,484	2,484	2,436	2,436	2,364	2,795
Cargo aircraft	285	209	229	174	138	158	241	241	255	255	256	266
General aviation	256	276	416	437	398	442	401	403	345	345	145	150
Total aircraft sources	3,480	3,459	4,640	4,516	4,314	5,354	6,099	6,101	5,746	5,746	5,225	5,659
Ground Service Equipment[1]	5,170	4,758	3,586	3,531	3,409	1,586	1,904	1,904	1,609	1,609	1,364	1,364
Motor Vehicles												
Ted Williams Tunnel through-traffic	112	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]
Parking/curbside[3]	295	253	180	179	144	144	139	139	117	117	107	107
On-airport vehicles	1,872	1,685	1,412	1,290	1,036	1,036	1,038	1,038	834	834	740	740
Total motor vehicle sources	2,279	1,938	1,592	1,469	1,180	1,180	1,177	1,177	951	951	847	847
Other Sources												
Fuel storage/handling[4]	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous sources[5]	23	22	33	40	24	24	51	51	55	55	55	55
Total other sources	23	22	33	40	24	24	51	51	55	55	55	55
Total Airport Sources	10,952	10,177	9,851	9,556	8,927	8,144	9,231	9,233	8,361	8,361	7,491	7,925

Source: KBE and Massport
Notes: Years 2006 to 2009 were computed with previous years EDMS version to provide for a common basis of comparison.
Kg/day Kilograms per day. One kg/day is approximately equivalent to 0.40234 tons per year (tpy).
1 GSE emissions include APUs as well as vehicles and equipment converted to alternative fuels.
2 Due to the new roadway configuration and opening of the Ted Williams Tunnel there was no Ted Williams Tunnel through-traffic at Logan Airport beginning in 2003.
3 Parking/curbside information is based on VMT analysis.
4 Fuel storage/handling facilities are not a source of CO emissions.
5 Includes the Central Heating and Cooling Plant, emergency electricity generation, snow melter usage, and other stationary sources.

Table I-17 Estimated $PM_{10}/PM_{2.5}$ Emissions (in kg/day) at Logan Airport, 2005-2009[1,2]

Aircraft/GSE Model:	**EDMS v4.5**		**EDMS v5.0.1**		**EDMS v5.0.2**		**EDMS v5.1**		**EDMS v5.1.2**
Motor Vehicle Model:	**MOBILE 6.2.03**								
Year:	**2005**	**2006**		**2007**		**2008**		**2009**	
Aircraft Sources									
Air carriers	25	25	38	35	67	63	42	43	36
Commuter aircraft	1	1	2	6	14	11	6	5	5
Cargo aircraft	2	3	2	3	6	5	4	4	3
General aviation	2	2	2	2	5	5	4	2	2
Total aircraft sources	30	31	44	46	92	84	56	54	46
Ground Service Equipment[3]	11	9	9	10	10	8	15	14	14
Motor Vehicles									
Parking/curbside[4]	1	1	1	<1	<1	<1	<1	<1	<1
On-airport vehicles	8	8	8	9	9	7	7	6	6
Total motor vehicle sources	9	9	9	9	9	7	7	6	6
Other Sources									
Fuel storage/handling[5]	0	0	0	0	0	0	0	0	0
Miscellaneous sources[6]	34	16	16	17	17	3	3	5	5
Total other sources	34	16	16	17	17	3	3	5	5
Total Airport Sources	84	65	78	82	128	102	81	79	71

Source: KBE and Massport
Notes: Years 2006 to 2009 were computed with previous years EDMS version to provide for a common basis of comparison.
Kg/day Kilograms per day. One kg/day is approximately equivalent to 0.40234 tons per year (tpy); PM – particulate matter
1 It is assumed that all PM are less than 2.5 microns in diameter (PM2.5).
2 2005 is the first year that PM10/PM2.5 emissions were included in the Logan Airport ESPR/EDR emission inventories.
3 GSE emissions include APUs as well as vehicles and equipment converted to alternative fuels.
4 Parking/curbside is based on VTM analysis.
5 Fuel storage and handling facilities are not sources of PM emissions.
6 Includes the Central Heating and Cooling Plant, emergency electricity generation, fire training, snow melters, and other stationary sources.

Greenhouse Gas Emissions Inventory for 2016

The Massachusetts Executive Office of Energy and Environmental Affairs (EEA) has published the *MEPA Greenhouse Gas Emissions Policy and Protocol*.[2] These guidelines require that certain projects undergoing review under the Massachusetts Environmental Policy Act (MEPA) quantify the greenhouse gas (GHG) emissions generated by proposed projects, and identify measures to avoid, minimize, or mitigate such emissions.[3] Even though the *2016 EDR* does not assess any proposed projects and is therefore not subject to the GHG policy, Massport has voluntarily prepared an emission inventory of GHG emissions directly and indirectly associated with Logan Airport.

In April 2009, the Transportation Research Board Airport Cooperative Research Program (ACRP); published the *Guidebook on Preparing Airport Greenhouse Gas Emission Inventories (ACRP Report 11)*, which provides recommended instructions to airport operators on how to prepare an airport-specific GHG emissions inventory.[4] The 2016 GHG emissions estimates include aircraft (within the ground taxi/delay and up to 3,000 feet), GSE, APU, motor vehicles, a variety of stationary sources, and electricity usage. Aircraft cruise emissions over the 3,000-foot level were not included. This work was accomplished following the EEA guidelines and uses widely-accepted emission factors that are considered appropriate for this application, including International Organization for Standardization New England electricity-based values.

Methodology

Airport GHG emissions are calculated in much the same way as criteria pollutants,[5] through the use of input data such as activity levels or material throughput rates (i.e., fuel usage, VMT, electrical consumption) that are applied to appropriate emission factors (i.e., in units of GHG emissions per gallon of fuel).

In this case, the input data were either based on Massport records, or data and information derived from the latest version of the FAA AEDT (AEDT 2c SP2). **Table I-18** summarizes the data and information used in the 2016 GHG inventory.

Massport will update the GHG Emissions Inventory for Logan Airport annually.

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2 Revised MEPA Greenhouse Gas Emissions Policy and Protocol, Massachusetts Executive Office of Energy and Environmental Affairs, effective May 10, 2010.

3 These GHGs are comprised primarily of carbon dioxide (CO2), methane (CH4), nitrous oxides (N2O), and three groups of fluorinated gases (i.e., sulfur hexafluoride [SF6], hydrofluorocarbons [HFCs], and perfluorocarbons [PFCs]). GHG emission sources associated with airports are generally limited to CO2, CH4, and N2O.

4 Transportation Research Board, Airport Cooperative Research Panel, ACRP Report 11, Project 02-06, Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories (in production). See http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf for the full report.

5 Criteria pollutants are pollutants for which there are National Ambient Air Quality Standards (i.e., carbon monoxide, sulfur dioxide, nitrogen dioxide, etc.).

Table I-18 Logan Airport Greenhouse Gas (GHG) Inventory Input Data and Information for 2016

Activity	Fuel Type	Usage	Units	Source
Aircraft				
Aircraft Taxi	Jet A[1]	19,455,006	gallons	AEDT 2c SP2
	AvGas[2]	455	gallons	AEDT 2c SP2
Engine Startup[6]	Jet A	104,490	gallons	EDMS v5.1.4
Aircraft Ground up to 3,000 feet	Jet A[1]	17,812,612	gallons	AEDT 2c SP2
	AvGas[2]	513	gallons	AEDT 2c SP2
Aircraft Support Equipment				
GSE	Diesel	638,425	gallons	Massport
	Gasoline	548,115	gallons	Massport
	Propane	798	gallons	AEDT 2c SP2
	CNG	0	ft^3	AEDT 2c SP2
APU	Jet A	934,480	gallons	AEDT 2c SP2
Motor Vehicles				
On-airport Vehicles	Composite[3]	64,546,848	VMT	Massport
On-airport Parking/Curbsides	Composite[3]	1,427,467	Idle hours	Massport
Massport Shuttle Bus	CNG	269,135	GEG	Massport
	Diesel	Defleeted 2014	gallons	Massport
Massport Express Bus	Diesel	211,799	gallons	Massport
Massport Fire Rescue	Diesel	20,000	gallons	Massport
Agricultural Equipment	Diesel	83,600	gallons	Massport
Massport Fleet Vehicles (Honda Civic)	CNG	2,752	GEG	Massport
Massport Fleet Vehicles (Fueled Onsite)	Gasoline	202,104	gallons	Massport
Massport Fleet Vehicles (Fueled Offsite)	Gasoline	83,500	gallons	Massport
Massport Fleet Vehicles (Fueled Onsite)	Diesel	83,643	gallons	Massport
Off-airport Vehicles (Public)	Composite[3]	187,616,704	VMT	Massport
Off-airport Vehicles (Airport Employees)	Composite[3]	4,122,697	VMT	Massport
Off-airport Vehicles (Tenant Employees)	Composite[3]	55,684,012	VMT	Massport
Stationary and Portable Sources				
Boilers and Space Heaters	No 2 Oil	537,884	gallons	Massport
	No 6 Oil	0	gallons	Massport

6 The EDMS fuel usage for Aircraft Engine Startup was reported as a surrogate because AEDT does not calculate this fuel usage.

Table I-18 Logan Airport Greenhouse Gas (GHG) Inventory Input Data and Information for 2016 (Continued)

Activity	Fuel Type	Usage	Units	Source
Aircraft Support Equipment (Cont'd.)				
	Natural Gas	438	million ft^3	Massport
Generators	Diesel	36,791	gallons	Massport
Snow melters	ULSD	90,850	gallons	Massport
	CNG	1.54	million ft^3	Massport
Fire Training Facility	Tekflame	5,659	gallons	Massport
	AvGas	494	gallons	Massport
Electrical Consumption – Massport	-	16,337,490	kWh	Massport
Electrical Consumption – Tenant/Common Area	-	168,885,976	kWh	Massport

Sources: Massport and KBE.
Notes: APU – Auxiliary power units; CNG – compressed natural gas; GEG – gasoline equivalent gallons; GSE – ground support equipment; kWh – kilowatt hours; VMT – vehicle miles traveled; ULSD – ultra low sulfur diesel.
1 Jet A density of 6.84 pounds per gallon.
2 AvGas density of 6.0 pounds per gallon.
3 Composite means gasoline, diesel, CNG, and liquefied petroleum gas (LPG) fueled motor vehicles.

Emission factors were obtained from the U.S. Energy Information Administration, the Intergovernmental Panel on Climate Change (IPCC), EPA's MOVES, and the most recent version of EPA's GHG Emission Factors Hub (November 2015).[7,8,9,10] **Table I-19** presents emission factors for carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) for 2016.

7 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, 2006, www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

8 U.S. Energy Information Administration, Voluntary Reporting of Greenhouse Gases Program. Fuel and Energy Source Codes and Emission Coefficients, www.eia.doe.gov/oiaf/1605/coefficients.html.

9 EPA, GHG Emissions Factors Hub (November 2015) https://www.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub. The most recent version of the Emission Factors Hub includes updates to emission factors for stationary and mobile combustion sources, new electricity emission factors from EPA's Emissions & Generation Resource Integrated Database (eGRID) and the IPCC Fifth Assessment Report (AR4/AR5).

10 U.S. Environmental Protection Agency, MOVES Emissions Model, http://www.epa.gov/otaq/models/moves/.

Table I-19 Greenhouse Gas (GHG) Emission Factors for 2016

Sources	Fuel	CO_2	N_2O	CH_4	Units
Aircraft[1]	Jet A	21.5	0.00066	-[5]	lb/gallon
	AvGas	18.3	0.00024	0.01556	lb/gallon
Ground Support Equipment/ Auxiliary Power Units[1]	Diesel	22.5	0.00057	0.00126	lb/gallon
	Gasoline	19.4	0.00049	0.00110	lb/gallon
	CNG	120.0	0.00023	0.00226	lb/1000 ft^3
	Propane	12.6	0.00011	0.00060	lb/gallon
	Jet A	21.5	0.00066	-[5]	lb/gallon
Motor Vehicles[1,2]	Composite	472	0.00005	0.0044	g/mile
	Composite	4,147	0.00022	0.01888	g/hour
	CNG	120.0	0.00023	0.00226	lb/1000 ft^3
	Diesel	22.5	0.00057	0.00126	lb/gallon
	Gasoline	19.4	0.00018	0.0008	lb/gallon
Stationary and Portable[1]	No. 2 Oil	22.5	0.00018	0.00090	lb/gallon
	No. 6 Oil	24.8	0.00020	0.00099	lb/gallon
	Natural Gas	120.0	0.00023	0.00226	lb/1000 ft^3
	ULSD	22.5	0.00018	0.00090	lb/gallon
Fire Training Facility[1]	Tekflame[3]	12.6	0.00011	0.00060	lb/gallon
	AvGas	18.3	0.00024	0.01556	lb/gallon
Electrical Consumption[4]	-	0.86	0.000026	0.000011	lb/kW-hr

Sources: Massport and KBE.

Notes: CH_4 – methane; CNG – compressed natural gas; CO_2 – carbon dioxide; g- grams; kWh – kilowatt hour; lb – pound; N_2O – nitrous oxides; ULSD – Ultra Low Sulfur Diesel.

1 Environmental Protection Agency, GHG Emissions Factors Hub (November 2015), https://www.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub.

2 EPA, MOVES2014a, http://www.epa.gov/otaq/models/moves/.

3 As propane.

4 Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID2012), October 2015, http://www.epa.gov/climateleadership/documents/emission-factors.pdf.

5 Contributions of CH_4 emissions from commercial aircraft are reported as zero. Years of scientific measurement campaigns conducted at the exhaust exit plane of commercial aircraft gas turbine engines have repeatedly indicated that CH_4 emissions are consumed over the full emission flight envelope [Reference: Aircraft Emissions of Methane and Nitrous Oxide during the Alternative Aviation Fuel Experiment, Santoni et al., Environ. Sci. Technol., July 2011, Volume 45, pp. 7075-7082]. As a result, EPA published that: "…methane is no longer considered to be an emission from aircraft gas turbine engines burning Jet A at higher power settings and is, in fact, consumed in net at these higher powers." [Reference: EPA, Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines, May 27, 2009 [EPA-420-R-09-901], http://www.epa.gov/otaq/aviation.htm]. In accordance with the following statements in the 2006 IPCC Guidelines (IPCC 2006), FAA does not calculate CH_4 emissions for either the domestic or international bunker commercial aircraft jet fuel emissions inventories. "Methane (CH_4) may be emitted by gas turbines during idle and by older technology engines, but recent data suggest that little or no CH_4 is emitted by modern engines." "Current scientific understanding does not allow other gases (e.g., N_2O and CH_4) to be included in calculation of cruise emissions." (IPCC 1999).

Results

Table I-20 presents the results of the 2016 GHG emissions inventory for Logan Airport by emission source (i.e., aircraft, GSE, motor vehicles, and stationary sources) and compound (i.e., CO_2, N_2O, and CH_4), respectively.

Table I-20 Greenhouse Gas (GHG) Emissions (MMT CO2 Eq)[1] for 2016

Activity	CO_2	N_2O	CH_4	Total
Aircraft Sources				
Aircraft Taxi	0.22	<0.01	-[2]	0.19
Engine Startup	<0.01	<0.01	<0.01	<0.01
Aircraft AGL to 3,000 feet	0.17	<0.01	<0.01	0.22
Aircraft Support Equipment				
GSE	0.01	<0.01	<0.01	0.01
APU	0.01	<0.01	-[2]	0.01
Motor Vehicles				
On-airport Vehicles	0.03	<0.01	<0.01	0.03
On-airport Parking/Curbsides	0.01	<0.01	<0.01	0.01
Massport Shuttle Buses	<0.01	<0.01	<0.01	<0.01
Massport Fleet Vehicles	0.01	<0.01	<0.01	0.01
Off-airport Vehicles (Public)	0.05	<0.01	<0.01	0.06
Off-airport Vehicles (Airport Employees)	<0.01	<0.01	<0.01	<0.01
Off-airport Vehicles (Tenant Employees)	0.03	<0.01	<0.01	0.03
Stationary Sources				
Boilers	0.03	<0.01	<0.01	0.03
Generators, Snow melters, etc.	<0.01	<0.01	<0.01	<0.01
Fire Training Facility	<0.01	<0.01	<0.01	<0.01
Electrical Consumption	0.06	<0.01	<0.01	0.05

Sources: Massport and KBE.

1 Units expressed as million metric tons of CO_2 equivalent (MMT CO2 Eq): 1 metric ton = 1.1 short tons.

2 Contributions of CH_4 emissions from commercial aircraft are reported as zero. Years of scientific measurement campaigns conducted at the exhaust exit plane of commercial aircraft gas turbine engines have repeatedly indicated that CH_4 emissions are consumed over the full emission flight envelope [Reference: Aircraft Emissions of Methane and Nitrous Oxide during the Alternative Aviation Fuel Experiment, Santoni et al., Environ. Sci. Technol., July 2011, Volume 45, pp. 7075-7082]. As a result, EPA published that: "…methane is no longer considered to be an emission from aircraft gas turbine engines burning Jet A at higher power settings and is, in fact, consumed in net at these higher powers." [Reference: EPA, Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines, May 27, 2009 [EPA-420-R-09-901], http://www.epa.gov/otaq/aviation.htm]. In accordance with the following statements in the 2006 IPCC Guidelines (IPCC 2006), FAA does not calculate CH_4 emissions for either the domestic or international bunker commercial aircraft jet fuel emissions inventories. "Methane (CH_4) may be emitted by gas turbines during idle and by older technology engines, but recent data suggest that little or no CH_4 is emitted by modern engines." "Current scientific understanding does not allow other gases (e.g., N_2O and CH_4) to be included in calculation of cruise emissions." (IPCC 1999).

Table I-21 compares the total GHG emission from Logan Airport in 2016 to the total GHG emissions for Massachusetts.

Table I-21 Logan Airport Greenhouse Gas (GHG) Emissions Compared to Massachusetts Totals[1]

	CO_2	N_2O	CH_4	Totals
Logan Airport Emissions (2016)[2]	0.64	<0.01	<0.01	0.65
Massachusetts[3]	68.7	0.8	1.1	70.6
Percent of Logan Airport to Massachusetts[4]	<1%	<1%	<1%	<1%

Sources: Massport and KBE.
1 Units expressed as million metric tons of CO_2 equivalents (MMT CO_2 Eq): 1 metric ton = 1.1 short tons.
2 Total from Massport, tenants, and public categories.
3 Climate Analysis Indicators Tool (CAIT US) Version 4.0. (Washington, DC: World Resources Institute, 2012)
4 Percentages represent the relative amount Logan Airport-related emissions compared to the state totals.

Table I-22 provides a comparison between Airport-related GHG emissions from 2007 through 2016. Total GHG emissions in 2016 were slightly higher (2 percent) than 2015 levels. To equally compare to previous years, the 2016 emissions are summarized in a manner similar to previous years.

Table I-22 Comparison of Estimated Total Greenhouse Gas (GHG) Emissions (MMT of CO_2eq) at Logan Airport – 2007 through 2016

Source	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Direct Emissions[2]										
Aircraft[3]	0.22	0.21	0.19	0.18	0.19	0.19	0.19	0.20	0.21	0.19
GSE/APUs	0.08	0.08	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Motor vehicles[4]	0.03	0.03	0.03	0.03	0.04	0.03	0.05	0.05	0.05	0.05
Other sources[5]	0.04	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03
Total Direct Emissions	0.37	0.35	0.27	0.27	0.28	0.26	0.29	0.29	0.32	0.29
Indirect Emissions[6]										
Aircraft[7]	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.22
Motor vehicles[8]	0.05	0.05	0.05	0.05	0.06	0.05	0.08	0.07	0.08	0.09
Electrical consumption[9]	0.09	0.08	0.07	0.07	0.08	0.08	0.06	0.06	0.06	0.06
Total Indirect Emissions	0.32	0.30	0.29	0.29	0.30	0.30	0.31	0.30	0.32	0.36
Total Emissions[10]	0.69	0.65	0.56	0.56	0.58	0.57	0.60	0.60	0.63	0.65
Percent of State Totals[11]	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Sources: Massport and KBE.

1 MMT – million metric tons of CO_2 equivalents (1 MMT = 1.1M Short Tons). CO_2 equivalents (CO_2eq) are bases for reporting the three primary GHGs (e.g., CO_2, N_2O and CH_4) in common units. Quantities are reported as "rounded" and truncated values for ease of addition.

2 Direct emissions are those that occur in areas located within the Airport's geographic boundaries.

3 Direct aircraft emissions based engine start-up, taxi-in, taxi-out and ground-based delay emissions.

4 Direct motor vehicle emissions based on on-site vehicle miles traveled (VMT).

5 Other sources include Central Heating and Cooling Plant, emergency generators, snow melters and live fire training facility.

6 Indirect emissions are those that occur off the Airport site.

7 Indirect aircraft emissions are based on take-off, climb-out and landing emissions which occur up to an altitude of 3,000 ft., the limits of the landing/take-off (LTO) cycle

8 Indirect motor vehicle emissions based on off-site Airport-related VMT and an average round trip distance of approximately 60 miles.

9 Electrical consumption emissions occur off-airport at power generating plants.

10 Total Emissions = Direct + Indirect.

11 Percentage based on relative amount of Airport total of direct emissions to statewide total from World Resources Institute (cait.wri.org).

Measured NO_2 Concentrations

This section presents the results of Massport's long-term ambient (i.e., outdoor) air quality monitoring program for NO_2 – a pollutant associated with aircraft activity and other fuel combustion sources. Between 1982 and 2011, Massport collected NO_2 concentration data at numerous locations both on the Airport and in neighboring residential communities. The purpose of this monitoring program was to track long-term trends in NO_2 levels and to compare the results to the NAAQS for this pollutant. In 2011, Massport determined that the Logan NO_2 Monitoring Program had achieved its objectives with the significant and stable decrease in NO_2 emissions since 1999 and thus discontinued the program in 2011.

When it was operational, this monitoring program used passive diffusion tube technology for a period of one week each month for 12 months of the year at each of the monitoring stations. The samples of NO_2, along with Quality Assurance/Quality Control (QA/QC) samples, were then analyzed in a laboratory.

Table I-23 presents the final year NO_2 monitoring data (i.e., 2011). For comparative purposes, historical data from 1999 are similarly shown in **Table I-23**. The table also includes NO_2 data collected under a separate effort by MassDEP using continuous monitors at four Boston-area locations.

As shown on **Table I-23**, the 2011 NO_2 levels were somewhat higher than in 2010. However, this occurrence is consistent with the cyclical trend of the average levels over the past several years[11]. Importantly, there remains a long-term trend of decreasing NO_2 concentrations at both the Massport and MassDEP monitoring sites since 1999. Other notable observations of the 2011 data reveal the following:

- Annual NO_2 concentrations at all Massport and MassDEP monitoring locations were below the annual NO_2 NAAQS of 100 micrograms per cubic meter (μg/m^3) in 2011.
- The Massport-collected data compare relatively closely with data collected by the MassDEP. The average of all Massport monitoring sites was 29.8 μg/m^3 compared to 32.3 μg/m^3 for the four MassDEP Boston-area monitors.
- The highest NO_2 concentrations in 2011 from the Massport program occurred in areas characterized by high levels of motor vehicle traffic (i.e., Main Terminal Area [Site 8] and Maverick Square [Site 12]).

11 Spatial and temporal changes in measured NO_2 levels from year to year are typical and should not be used to define short-term results. Rather, NO_2 levels are better assessed by looking at the trends over several years.

Table I-23 Massport and MassDEP Annual NO_2 Concentration Monitoring Results ($\mu g/m^3$)

Monitoring Site	Site No.	1999	2000	2001	2002	2003	2004	Year 2005	2006	2007	2008	2009	2010	2011
Massport Monitoring Sites														
Runway 9	1	61.0	58.2	41.6	45.8	33.9	30.1	35.0	31.9	17.3	31.3	32.2	32.3	38.7
Runway 4R	2	55.6	44.6	41.4	36.9	32.5	30.9	30.7	29.0	17.2	20.2	19.2	21.9	25.7
Runway 33L	3	47.7	42.6	39.4	33.3	30.8	25.4	24.5	26.3	24.2	21.6	16.9	25.0	29.8
Runway 27	4	42.9	37.8	35.8	30.3	25.5	24.1	22.7	22.3	16.9	18.3	17.6	19.4	23.3
Runaway 22L	5	47.5	39.8	38.2	33.8	27.8	23.7	22.1	24.9	17.1	21.3	20.1	21.9	29.0
Runway 22R	6	60.6	59.2	51.6	45.0	32.3	29.7	32.9	25.1	24.8	29.7	27.8	33.1	30.6
Runway 15R	7	47.0	43.4	44.3	42.6	40.8	28.7	27.7	28.7	20.5	24.2	23.9	26.7	29.7
Main Terminal Area	8	70.8	87.0	80.7	69.3	44.3	44.7	46.2	43.5	29.5	41.7	37.7	43.9	49.0
Webster St., Jeffries Point	11	52.4	45.5	43.4	39.1	32.5	28.3	31.3	31.3	22.7	25.2	23.9	27.0	30.1
Maverick Square, E. Bos	12	81.2	72.2	68.5	61.3	47.9	46.5	41.4	45.6	36.0	41.3	38.2	42.5	43.5
Bremen St., E. Boston	13	59.1	52.6	52.0	46.2	39.1	35.7	37.6	37.1	27.8	30.1	28.6	31.9	35.3
Shore St. E. Boston	14	45.7	38.5	38.8	35.0	27.2	24.0	24.9	22.4	18.1	19.7	18.3	20.7	26.7
Orient Heights Yacht Club	15	45.1	46.9	47.7	43.1	29.4	25.2	25.5	25.1	19.6	21.1	18.3	22.5	26.7
Bayswater St. E. Boston	16	45.2	45.5	48.3	41.2	28.4	22.8	30.4	23.1	18.4	20.2	17.8	21.0	25.9
Annavoy St. E. Boston	17	40.8	39.2	44.4	33.7	24.7	21.4	23.3	21.0	18.2	19.6	17.3	20.9	25.8
Pleasant St. Winthrop	18	42.0	39.3	37.8	32.3	27.9	22.6	23.4	21.4	17.8	20.2	17.7	20.1	24.4
Court Road, Winthrop	19	40.0	36.1	33.8	27.4	24.0	19.2	22.3	21.0	16.3	17.1	16.7	18.4	22.7
Cottage Park Yacht Club	20	37.1	50.9	45.9	36.7	22.5	19.1	27.7	21.4	16.3	18.4	17.8	17.8	22.5
Point Shirley, Winthrop	21	33.1	37.7	38.6	24.4	22.7	17.4	17.2	20.2	15.7	15.6	14.9	17.5	21.6
Deer Island	22	36.3	31.9	33.8	33.1	21.3	17.8	16.9	17.8	13.0	17.0	14.7	16.7	20.7
Runway 4R–9	23	42.2	66.0	42.3	33.4	28.6	24.1	27.1	26.3	19.2	22.4	21.2	21.6	26.5
Runway 33L–4R	24	44.3	41.7	41.8	33.5	28.1	24.3	22.3	25.7	20.9	25.2	20.0	23.6	26.2

Table I-23 Massport and MassDEP Annual NO2 Concentration Monitoring Results (μg/m^3) (Continued)

Monitoring Site	Site No.	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Massport Monitoring Sites (continued)														
Runway 22R–33L	25	62.4	50.3	49.4	42.2	33.8	31.7	29.4	34.5	22.9	25.1	25.3	29.5	34.9
Jeffries Point Park/Marginal St.	26	68.6	49.8	45.0	42.0	35.2	30.5	32.5	31.7	24.4	27.0	25.6	28.6	33.1
Harborwalk	27	54.3	48.5	47.4	43.5	35.6	35.5	29.3	34.2	24.2	26.1	24.5	28.3	34.9
Logan Athletic Fields	29	NA	69.1	67.6	54.9	41.9	40.2	37.5	37.0	24.6	28.8	26.8	30.8	37.8
Brophy Park, Jeffries Point	30	NA	48.0	45.2	41.0	36.5	31.2	32.9	31.3	24.8	26.6	24.6	26.8	30.8
Average of all Monitoring Sites		**50.5**	**50.5**	**47.5**	**40.0**	**31.7**	**28.0**	**28.7**	**28.7**	**21.0**	**24.3**	**22.5**	**25.6**	**29.8**
MassDEP Monitoring Sites[1]														
Long Island Road	A	20.7	24.4	22.6	22.6	16.9	12.6	13.2	13.2	13.2	13.2	11.3	13.6	13.4
Harrison Avenue	B	NA	45.1	47.0	45.1	43.2	37.4	35.8	35.8	37.7	37.7	33.9	32.1	33.1
Kenmore Square	C	56.4	54.5	56.8	47.0	47.0	51.7	43.3	43.3	39.6	41.5	37.7	36.0	38.4
East First Street	D	39.5	37.6	43.2	39.5	39.5	36.8	33.9	39.6	37.7	30.2	28.3	24.0	25.4

Notes: The NAAQS is 100 μg/m^3.
Massport determined that the Logan NO_2 Monitoring Program had achieved its objectives with the significant and stable decrease in NO_2 emissions since 1999 and thus discontinued the program in 2011.
N/A Not available.
μg/m^3 micrograms/cubic meter.
1 NO_2 monitoring sites operated by the MassDEP.

Air Quality Initiative (AQI)

Massport developed the AQI as a 15-year voluntary program with the overall goal to maintain NO_X emissions associated with Logan Airport at, or below, 1999 levels. The *2015 EDR* presented the results of the final year of this program, and the final year of data are shown below. The AQI had four primary commitments, shown below, along with Massport's progress in meeting the AQI commitments.

- **Expand on the air quality initiatives already in-place at Logan Airport.** See **Table 7-12** for the initiatives in place at the time the AQI was developed.
- **As necessary to maintain NO_X emissions at or below 1999 levels, retire emissions credits, giving priority to mobile sources.** Massport updated the AQI inventory of NO_X emissions annually to reflect

new information and changing conditions associated with the Airport's operations. **Table I-24** presents the updated NO_x emissions inventory and shows that, in 2015, again it was not necessary to purchase and retire mobile source emission credits to maintain NO_X emissions at, or below, 1999 levels.

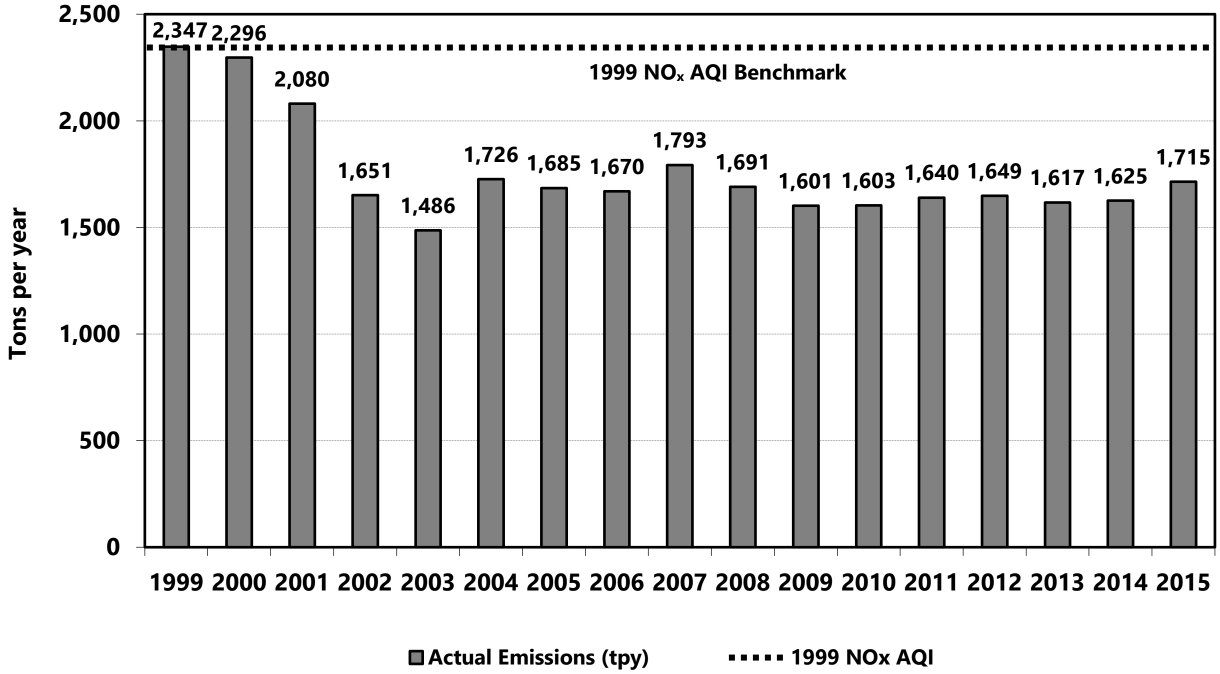
- **Report the status and progress of the AQI in the ESPR or EDR.** Massport reported on the status of the AQI in the Logan Airport EDRs and ESPRs since 2001 (**Table I-24**).
- **Continue to work at international and national levels to decrease air emissions from aviation sources.** Massport maintains memberships and active participation in a number of organizations involved in addressing aviation-related environmental issues, including air quality. These include serving on Environmental Committees of the American Association of Airport Executives (AAAE) and Airports Council International–North America (ACI-NA).

As shown in **Table I-24**, NO_X emissions at Logan Airport in 2015 (net total with reductions) were approximately 632 tpy lower than the 1999 AQI benchmark. Since 1999, this trend represents a 27 percent decrease by 2015. Between 1999 and 2015, the greatest reductions of NO_X emissions were associated with aircraft, GSE, and on-Airport motor vehicles at 17 percent, 71 percent, and 87 percent reductions, respectively.

For ease of review, **Figure I-1** also compares the 1999 AQI threshold level of 2,347 tpy of NO_X emissions to NO_X emissions for 2001 through 2015. Cumulatively, and as of December 31, 2015, NO_X emissions at Logan Airport were approximately 10,049 tons below the benchmark set by the AQI.

Based upon these results, the 1999 threshold of NO_x emissions at Logan Airport was never surpassed and thus full compliance with the AQI was achieved. However, NO_x will continue to be reported in future EDRs/ESPRs as part of the Logan Airport emissions inventory.

Figure I-1 Modeled NOx Emissions Compared to AQI[1]



Source: Massport

1 Includes emission reductions from the use of alternative fuel vehicles, shuttle buses, and ground service equipment. See **Table I-24**.

As part of the reporting process, the AQI also called for an itemization of NO_x emissions generated by activities at Logan Airport according to the individual airline operator. **Table I-25** shows the estimated amounts of NO_x air emissions in 2015 generated by each airline in units of tpy and tons per LTO.

Based on **Table I-25**, international carriers are the higher NO_x emitters per LTO because their longer stage lengths require aircraft equipped with larger and/or additional engines and heavier takeoff weights. Overall, international carriers emitted 20 percent of the total aircraft NO_x emissions at Logan Airport in 2015. Other notable findings included:

- Carriers with the greatest number of flights tended to generate the highest percentage of total NO_X emissions;
- Combined, the four largest air carriers (by LTO), emitted 49 percent of the total aircraft NO_X emissions in 2015;
- Commercial airlines (excludes cargo and GA) accounted for 93 percent of total aircraft NO_X emissions in 2015;
- Cargo aircraft operators accounted for 5 percent of total aircraft NO_X emissions in 2015; and
- GA aircraft accounted for 1 percent of total aircraft NO_X emissions in 2015.

Table I-24 AQI Inventory Tracking of Modeled NOx Emissions (in tpy)[1] for Logan Airport

	Actual Conditions[2]								
Year	**1999[3]**	**2000**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Total Annual Emissions	2,347	2,315	1,609	1,608	1,647	1,654	1,627	1,628	1,605
Above (Below) 1999 Levels Before Reductions	N/A	(32)	(738)	(739)	(700)	(693)	(720)	(719)	(628)
Potential Reductions/ Increases[4]									
Alternative Fuel Vehicles/Shuttle Bus	(11)	(4)	(4)	(2)	(1)	0	(6)	0	0
Alternate Fuel Ground Service Equipment[5]	(14)	(14)	(4)	(3)	(6)	(5)	(4)	(3)	(4)
Total Potential Reductions	(25)	(19)	(8)	(5)	(7)	(5)	(10)	(3)	(4)
Above (Below) 1999 Levels After Reduction	(25)	(51)	(746)	(744)	(707)	(698)	(730)	(722)	(632)
Credit Trading[6]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Net Total w/Reductions and Credits	2,322	2,296	1,601	1,603	1,640	1,649	1,617	1,625	1,715

Source: Massport

Notes: Values in parentheses, such as "(250)" are negative values. Values without parentheses are positive values.

N/A Not available.

1 For consistency with the AQI, the NO_x emission values in this table are reported in tpy. The EDR/ESPR Emissions Inventory values are reported in kg/day. A conversion factor of 0.40234 is used to convert kg/day to tpy.

2 The 2009 analysis was completed using EDMS v5.1.2 and MOBILE6.2.03. The 2010 through 2012 analysis was completed using EDMS v5.1.3 and MOBILE6.2.03. The 2013 analysis was completed using EDMS v5.1.4.1 and MOVES2010b. The 2014 analysis was completed using EDMS v5.1.4.1 and MOVES2014. The 2015 analysis was completed using EDMS v5.1.4.1 and MOVES2014a.

3 The year 1999 is the "baseline" year for the AQI. Thus, 2,347 tpy is considered the AQI threshold for NO_x emissions.

4 Other initiatives that Massport and Logan Airport tenants may use for possible emission reductions include: Central Heating and Cooling Plant boilers, 400-Hz power at gates, and low NO_x fuels in Logan Express buses.

5 Massport's current plan for the conversion of GSE to alternative fuels is being re-evaluated based on the new diesel rule (2007). GSE AFV credits were based on fuel type data obtained from the aerodrome vehicle permit applications beginning in 2007.

6 Since the AQI threshold is not exceeded in 2015, nor are the emissions expected to exceed the threshold in the near future, no credits will need to be purchased.

Table I-25 Contribution of NO_x Air Emissions by Airline in 2015 (Estimated)

	Total Emissions (tons/year)		Normalized Emissions (tons/lto)		Total Emissions (tons/year)		Normalized Emissions (tons/lto)
Air Carrier, by Airline	**NO_x**	**LTOs**	**NO_x per LTO**	**Air Carrier, by Airline**	**NO_x**	**LTOs**	**NO_x per LTO**
ABX Air	0.07	3	0.023	Miami Air International	0.27	25	0.011
Aer Lingus	27.32	987	0.028	Mountain Air Cargo	0	5	<0.001
Aeromexico	1.71	172	0.01	Netjets	3.62	2,349	0.002
Air Canada[1]	7.29	3,978	0.003	No Airline	16.75	8,693	0.002
Air France	23.71	455	0.052	Norwegian	0.22	18	0.012
Air Transport International	2.88	151	0.019	PenAir	0.97	1,874	0.001
Air Wisconsin / US Airways Express	4.38	2,499	0.002	Piedmont Airlines	0.33	390	0.001
AirTran Airways	0.1	14	0.007	Pinnacle Airlines	16.73	3,642	0.005
Alaska Airlines	18.44	1,514	0.012	Porter Airlines	1.77	2,046	0.001
Alitalia	7.44	281	0.026	PSA Airlines	0.01	3	0.003
American Airlines	261.57	24,177	0.011	Republic Airlines	6.35	2,502	0.003
Angel Flight America	0.01	275	<0.001	Royal Air	0.01	14	0.001
Atlantic Southeast Airlines	7.63	2,461	0.003	SATA International	4.67	271	0.017
Atlas Air	3.03	109	0.028	Shuttle America	7.24	2,645	0.003
Bombardier Business Jet Solutions	0.5	340	0.001	Sky Regional / Air Canada Express	4.99	1,892	0.003
British Airways	93.46	1,289	0.073	SkyWest Airlines	0.74	274	0.003
Cape Air	0.48	17,997	<0.001	Southwest Airlines	101.82	10,757	0.009
Cathay Pacific	5.55	139	0.04	Spirit Airlines	24.87	2,448	0.01
Cobalt Air	0.21	876	<0.001	Sun Country Airlines	8.15	707	0.012
Copa Airlines	3.53	323	0.011	Swift Air	0.19	23	0.008
Delta Air Lines	190.7	16,956	0.011	Swiss International Air Lines	11.28	355	0.032
El Al	2.25	76	0.03	TACV - Cabo Verde Airlines	0.53	30	0.018
Emirates Airline	18.56	458	0.041	Talon Air	0.4	191	0.002
Executive Jet Mgmt	0.64	242	0.003	Tradewind Aviation	0.04	173	<0.001

Table I-25 Contribution of NOx Air Emissions by Airline in 2015 (Estimated) (Continued)

	Total Emissions (tons/year)		Normalized Emissions (tons/lto)		Total Emissions (tons/year)		Normalized Emissions (tons/lto)
Air Carrier, by Airline	**NO_x**	**LTOs**	**NOx per LTO**	**Air Carrier, by Airline**	**NO_x**	**LTOs**	**NO_x per LTO**
FedEx Express	60.41	1,762	0.034	Travel Management Company	0.66	533	0.001
Flight Options	0.32	256	0.001	Turkish Airlines	12.18	364	0.033
Go! Hawaii	0.73	219	0.003	United Airlines	151.93	12,322	0.012
GoJet Airlines	2.61	655	0.004	UPS Airlines	19.55	769	0.025
Hainan Airlines	9.94	372	0.027	US Airways	38.43	4,422	0.009
Iberia	5.79	168	0.034	Virgin America	17.5	1,713	0.01
Icelandair	14.5	683	0.021	Virgin Atlantic Airways	15.24	351	0.043
Japan Airlines	9.72	364	0.027	Wiggins Airways	0.03	222	<0.001
JetBlue Airways	311.73	42,918	0.007	WOW Air	3.8	223	0.017
Lufthansa	36.32	844	0.043	Xojet	0.47	209	0.002
				Total	**1,605.29**	**186,468**	**0.00914**

Source: Massport and KBE.

Notes: Other International may include: AeroMexico, Saudi Arabian Airlines, etc.
The "Other" Categories may include airlines with less than 10 operations.
Normalized emissions are based on a Landing and Takeoff Cycle (LTO).
This list combines the major airlines with their commuters (i.e., Jazz with Air Canada).
Cargo carriers include: ABX, Atlas, FedEx, Mountain Air Cargo, UPS, and Wiggins.
GA – General Aviation

1 Includes Jazz.

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J

Water Quality/Environmental Compliance and Management

This appendix provides detailed information in support of Chapter 8, *Water Quality/Environmental Compliance and Management*:

Table J-1 Logan Airport NPDES Permit (No. MA0000787) Stormwater Outfall Monitoring Requirements (2007)

Monitoring Event	North Outfall 001		West Outfall 002		Maverick Outfall 003	
	Field Measurement	Laboratory Analysis	Field Measurement	Laboratory Analysis	Field Measurement	Laboratory Analysis
Monthly Dry Weather	Not Required	Oil and Grease TSS[1] Benzene Surfactant Fecal Coliform *Enterococcus*	Not Required	Oil and Grease TSS[1] Benzene Surfactant Fecal Coliform *Enterococcus*	Not Required	Oil and Grease TSS[1] Benzene Surfactant Fecal Coliform *Enterococcus*
Monthly Wet Weather	pH Flow Rate[6]	Oil and Grease TSS[1] Benzene[2] Surfactant Fecal Coliform *Enterococcus*	pH Flow Rate[6]	Oil and Grease TSS[1] Benzene[2] Surfactant Fecal Coliform *Enterococcus*	pH Flow Rate[6]	Oil and Grease TSS[1] Benzene[2] Surfactant Fecal Coliform *Enterococcus*
Quarterly Wet Weather	pH Flow Rate[6]	PAHs[3]: - Benzo(a)anthracene - Benzo(a)pyrene - Benzo(b)fluoranthene - Benzo(k)fluoranthene - Chrysene -Dibenzo(a,h)anthracene - Indeno(1,2,3-cd)pyrene - Naphthalene	pH Flow Rate[6]	PAHs[3]: - Benzo(a)anthracene - Benzo(a)pyrene - Benzo(b)fluoranthene - Benzo(k)fluoranthene - Chrysene -Dibenzo(a,h)anthracene - Indeno(1,2,3-cd)pyrene - Naphthalene	pH Flow Rate[6]	PAHs[3]: - Benzo(a)anthracene - Benzo(a)pyrene - Benzo(b)fluoranthene - Benzo(k)fluoranthene - Chrysene -Dibenzo(a,h)anthracene - Indeno(1,2,3-cd)pyrene - Naphthalene
Deicing Episode (2/Deicing Season)	Not Required	Ethylene Glycol Propylene Glycol BOD5[4] COD[5] Total Ammonia Nitrogen Nonylphenol Tolyltriazole	Not Required	Ethylene Glycol Propylene Glycol BOD5[4] COD[5] Total Ammonia Nitrogen Nonylphenol Tolyltriazole	Not Required	Not Required
Whole Effluent Toxicity (1st and 3rd Year Deicing Season)	Not Required	Menidia beryllina Arbacia punctulata	Not Required	Menidia beryllina Arbacia punctulata	Not Required	Not Required
Treatment System Sampling (Internal Outfalls)[7]	pH Quantity, Gallons	Oil and Grease TSS[1] Benzene[2]	Not Required	Not Required	Not Required	Not Required

Table J-1 Logan Airport NPDES Permit (No. MA0000787) Stormwater Outfall Monitoring Requirements (2007) (Continued)

Monitoring Event	**Northwest Outfall 005**		**Porter Outfall 003 (3 upstream locations)**		**Select Runway/Perimeter Outfalls**	
	Field Measurement	**Laboratory Analysis**	**Field Measurement**	**Laboratory Analysis**	**Field Measurement**	**Laboratory Analysis**
Monthly Dry Weather	Not Required	Not Required	Not Required	Oil and Grease TSS[1] Benzene Surfactant Fecal Coliform *Enterococcus*	Not Required	Not Required
Monthly Wet Weather	Not Required	Not Required	pH Flow Rate	Oil and Grease TSS[1] Benzene[2] Surfactant Fecal Coliform *Enterococcus*	Not Required	Not Required
Quarterly Wet Weather	pH Flow Rate[6]	Oil and Grease TSS[1] Benzene[2]	pH Flow Rate[6]	PAHs[3]: - Benzo(a)anthracene - Benzo(a)pyrene - Benzo(b)fluoranthene - Benzo(k)fluoranthene - Chrysene -Dibenzo(a,h)anthracene - Indeno(1,2,3-cd)pyrene - Naphthalene	pH	Oil and Grease TSS[1] Benzene[2]
Deicing Episode (2/Deicing Season)	Not Required	Not Required	Not Required	Ethylene Glycol Propylene Glycol BOD5[4] COD[5] Total Ammonia Nitrogen Nonylphenol Tolytriazole	Not Required	Ethylene Glycol Propylene Glycol BOD5[4] COD[5] Total Ammonia Nitrogen Nonylphenol Tolytriazole
Whole Effluent Toxicity (1st and 3rd Year Deicing Season)	Not Required	Not Required	Not Required	Menidia beryllina Arbacia punctulata	Not Required	Not Required
Treatment System Sampling (Internal Outfalls)[7]	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required

Source: Massport
Notes: Requirements are from NPDES Permit MA0000787, issued July 31, 2007.
1 TSS - Total Suspended Solids
2 Benzene must be collected with HDPE bailer.
3 PAH - Polycyclic Aromatic Hydrocarbons
4 BOD - Biological Oxygen Demand
5 COD - Chemical Oxygen Demand
6 Flow Rate will be estimated based on measured precipitation and the hydraulic model developed for the Logan Airport drainage system.
7 Outfalls 001D and 001E samples collected by Swissport.

Table J-2 Fire Training Facility NPDES Permit (No. MA0032751) Stormwater Outfall Monitoring Requirements (2014)

Monitoring Event	Outfall Serial Number 001	
	Field Measurement	**Laboratory Analysis**
Each Discharge Event[1]	Flow Rate[2] pH	TSS[3] Oil and Grease[4] Total BTEX[5] Toluene Benzene Ethylbenzene Xylene PAHs[5,6]
Whole Effluent Toxicity (once per year during discharge event)	Not Required	Acute Toxicity[7]

Source: Massport

Notes: Requirements are from NPDES Permit MA0032751, issued November 1, 2006.

All samples, except for wet testing, shall be collected after treatment and prior to discharge from above ground holding tank.

1 Flows from more than one training session may be held in treatment train for several weeks. Treatment and subsequent discharge through Outfall 001 is usually triggered by tank levels. Sampling will be conducted during each discharge event with the sampling point after the GAC unit and prior to discharge from the above ground holding tank. Each sample shall be a composite of three equally weighted (same volume) grab samples taken at the bottom, middle, and top of the above ground tank.

2 Total flow volume shall be reported monthly in gallons and the maximum flow rate in gallons per minute shall be reported for each month.

3 TSS - Total Suspended Solids

4 Oil and grease is measured using EPA Method 1664.

5 BTEX and PAH compounds shall be analyzed using EPA approved methods. Testing method used and method detection level for each parameter will be included in each DMR submittal.

6 PAH - Polycyclic Aromatic Hydrocarbons

7 The permittee shall conduct one acute toxicity test per year. The test results shall be submitted by the last day of the full month following completion of the test in accordance with protocols defined in the permit.

Table J-3 Logan Airport 2016 Monthly Monitoring Results for First Quarter — North, West, and Maverick Street Stormwater Outfalls

	Date	Event	Maximum Daily Flow (MGD)	Average Monthly Flow (MGD)	pH (S.U.)	Oil and Grease (mg/L)	TSS (mg/L)	Benzene (µg/L)	Surfactant (mg/L)	Fecal Coliform (cfu/100mL)	*Enterococcus* (cfu/100mL)	*Klebsiella* (cfu/100mL)
001A – North Outfall	---	Wet Weather	5.2	0.7	NS	NS	NS	NS	NS	NS	NS	NS
002A – West Outfall	---	Wet Weather	17.34	1.51	NS	NS	NS	NS	NS	NS	NS	NS
004A – Maverick Street Outfall	---	Wet Weather	1.19	0.08	NS	NS	NS	NS	NS	NS	NS	NS
001C – North Outfall	1/6/2016	Dry Weather				<4.0	15	<1.0	0.120	20	440	NA
002C – West Outfall	1/6/2016	Dry Weather				<4.0	18	<1.0	0.230	140	20	NA
004C – Maverick Street Outfall	1/6/2016	Dry Weather				<4.0	9.9	<1.0	0.230	260	50	NA
001A – North Outfall	2/3/2016	Wet Weather	3.3	0.9	6.71	<4.0	9.0	<1.0	0.110	3,200	480	NA
002A – West Outfall	2/3/2016	Wet Weather	12.4	1.9	6.71	<4.0	5.0	<1.0	0.150	400	20	NA
004A – Maverick Street Outfall	2/3/2016	Wet Weather	0.8	0.1	6.21	<4.0	5.7	<1.0	0.120	55	60	NA
001C – North Outfall	2/15/2016	Dry Weather				<4.0	16	<1.0	0.080	2.0	1,100	NA
002C – West Outfall	2/15/2016	Dry Weather				<4.0	5.6	<1.0	0.050	3.0	<2.0	NA
004C – Maverick Street Outfall	2/15/2016	Dry Weather				<4.0	<5.0	<1.0	<0.050	140	150	NA
001A – North Outfall	3/2/2016	Wet Weather	4.1	0.4	6.04	<4.0	10	<1.0	0.050	160	390	NA
002A – West Outfall	3/2/2016	Wet Weather	15.1	1.1	6.52	<4.0	15	<1.0	0.200	100	200	NA
004A – Maverick Street Outfall	3/2/2016	Wet Weather	1.0	0.1	**5.59**	<4.0	5.2	<1.0	0.180	790	220	NA
001C – North Outfall	3/8/2016	Dry Weather				<4.0	11	<1.0	0.130	140	460	NA
002C – West Outfall	3/8/2016	Dry Weather				<4.0	5.3	<1.0	0.070	180	10	NA
004C – Maverick Street Outfall	3/8/2016	Dry Weather				<4.0	<5.0	<1.0	0.050	4,500	260	NA
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.												
Discharge Limitations												
Maximum Daily			Report	Report	6.0 to 8.5	15 mg/L	100 mg/L	Report	Report	Report	Report	
Average Monthly			Report	Report	6.0 to 8.5	—	Report	Report	Report	Report	Report	

Source: Massport.
Notes: Bold values exceed maximum daily discharge limitation.
Flow rates were estimated for outfalls 001, 002, and 004 by using the SWMM model developed for Logan Airport.
For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit. For geometric mean calculations (fecal coliform and *Enterococcus*) a value of 1 was employed for those results measured below the laboratory detection limit.
1 *Klebsiella* is an indication of non-fecal coliform bacteria and is tested for at the North Outfall when fecal coliform concentration exceeds 5,000 cfu/100ml.
NA Not Analyzed.
TSS Total Suspended Solids.
NS Not Sampled. A wet weather sampling event was not conducted during the month of January 2016 due to lack of precipitation.

Table J-4 Logan Airport 2016 Monthly Monitoring Results for First Quarter — Porter Street Stormwater Outfall

	Date	Event	Maximum Daily Flow (MGD)	Average Monthly Flow (MGD)	pH (S.U.)	Oil and Grease (mg/L)	TSS (mg/L)	Benzene (µg/L)	Surfactant (mg/L)	Fecal Coliform (cfu/100mL)	*Enterococcus* (cfu/100mL)
003 - Porter Street Outfall 1	---	Wet Weather	-	-	NS	NS	NS	NS	NS	NS	NS
003 - Porter Street Outfall 2	---	Wet Weather	-	-	NS	NS	NS	NS	NS	NS	NS
003 - Porter Street Outfall 3	---	Wet Weather	-	-	NS	NS	NS	NS	NS	NS	NS
003 - Porter Street Outfall Average		Wet Weather	3.57	0.30	NS	NS	NS	NS	NS	NS	NS
003 - Porter Street Outfall 1	1/6/2016	Dry Weather				<4.0	39	<1.0	0.270	1,000	240
003 - Porter Street Outfall 2	1/6/2016	Dry Weather				<4.0	5.0	<1.0	0.090	30	30
003 - Porter Street Outfall 3	1/6/2016	Dry Weather				<4.0	<5.0	<1.0	0.220	<10	<10
003 - Porter Street Outfall Average		Dry Weather				0.0	15	0.0	0.193	31.1	19.3
003 - Porter Street Outfall 1	2/3/2016	Wet Weather	-	-	6.61	<4.0	14	<1.0	0.190	<10	10
003 - Porter Street Outfall 2	2/3/2016	Wet Weather	-	-	6.90	8.0	48	<1.0	0.700	10	30
003 - Porter Street Outfall 3	2/3/2016	Wet Weather	-	-	6.67	<4.0	31	<1.0	0.330	70	160
003 - Porter Street Outfall Average		Wet Weather	2.56	0.33	6.73	2.7	31	0.0	0.407	9.0	36
003 - Porter Street Outfall 1	2/15/2016	Dry Weather				<4.0	170	<1.0	0.160	2.0	12
003 - Porter Street Outfall 2	2/15/2016	Dry Weather				<4.0	49	<1.0	0.120	2.0	<2.0
003 - Porter Street Outfall 3	2/15/2016	Dry Weather				<4.0	17.0	<1.0	0.070	<2.0	<2.0
003 - Porter Street Outfall Average		Dry Weather				0.0	79	0.0	0.117	1.6	2.3
003 - Porter Street Outfall 1	3/2/2016	Wet Weather	-	-	6.56	<4.0	8.0	<1.0	0.130	50	290
003 - Porter Street Outfall 2	3/2/2016	Wet Weather	-	-	6.11	<4.0	<5.0	<1.0	0.160	<10	<10
003 - Porter Street Outfall 3	3/2/2016	Wet Weather	-	-	6.46	<4.0	<5.0	<1.0	0.150	<10	<10
003 - Porter Street Outfall Average		Wet Weather	2.10	0.20	6.38	0.0	3.0	0.0	0.147	4.0	7.0
003 - Porter Street Outfall 1	3/8/2016	Dry Weather				<4.0	41	<1.0	0.170	<10	<10
003 - Porter Street Outfall 2	3/8/2016	Dry Weather				<4.0	28	<1.0	0.250	<10	<10
003 - Porter Street Outfall 3	3/8/2016	Dry Weather				<4.0	12	<1.0	0.120	<10	50
003 - Porter Street Outfall Average		Dry Weather				0.0	27	0.0	0.180	0.0	3.7
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.											
Discharge Limitations											
Maximum Daily			Report	Report	6.0 to 8.5	Report	Report	Report	Report	Report	Report
Average Monthly			Report	Report	6.0 to 8.5	—	Report	Report	Report	Report	Report

Source: Massport.

Notes: Flow rates were estimated for outfalls 001, 002, 003 and 004 by using the SWMM model developed for Logan Airport.
For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit. For geometric mean calculations (fecal coliform and Enterococcus) a value of 1 was employed for those results measured below the laboratory detection limit.

TSS Total Suspended Solids.

NA Not Analyzed.

NS Not Sampled. A wet weather sampling event was not conducted during the month of January 2016 due to lack of precipitation.

Table J-5 Logan Airport 2016 Monthly Monitoring Results for Second Quarter — North, West, and Maverick Street Stormwater Outfalls

	Date	Event	Maximum Daily Flow (MGD)	Average Monthly Flow (MGD)	pH (S.U.)	Oil and Grease (mg/L)	TSS (mg/L)	Benzene (µg/L)	Surfactant (mg/L)	Fecal Coliform (cfu/100mL)	*Enterococcus* (cfu/100mL)	*Klebsiella*[1] (cfu/100mL)
001A – North Outfall	4/12/2016	Wet Weather	5.5	0.5	**5.50**	<4.0	17	<1.0	0.130	210	80	NA
002A – West Outfall	4/12/2016	Wet Weather	10.3	1.1	6.55	<4.0	35	<1.0	0.170	160	80	NA
004A – Maverick Street Outfall	4/12/2016	Wet Weather	0.8	0.05	7.42	4.0	35	<1.0	0.230	66,000	600	NA
001C – North Outfall	4/11/2016	Dry Weather				<4.0	19	<1.0	0.090	450	420	NA
002C – West Outfall	4/11/2016	Dry Weather				<4.0	18	<1.0	0.060	130	10	NA
004C – Maverick Street Outfall	4/11/2016	Dry Weather				<4.0	6.4	<1.0	0.050	3,400	360	NA
001A – North Outfall	5/24/2016	Wet Weather	3.6	0.3	6.94	<4.0	9.0	<1.0	0.250	40	450	NA
002A – West Outfall	5/24/2016	Wet Weather	12.85	0.90	7.48	<4.0	39	<1.0	0.240	2,800	1,800	NA
004A – Maverick Street Outfall	5/24/2016	Wet Weather	0.88	0.04	7.08	<4.0	9.3	<1.0	0.140	1,000	500	NA
001C – North Outfall	5/12/2016	Dry Weather				<4.0	<5.0	<1.0	0.130	2,900	230	NA
002C – West Outfall	5/12/2016	Dry Weather				<4.0	11	<1.0	0.520	910	<10	NA
004C – Maverick Street Outfall	5/12/2016	Dry Weather				<4.0	16	<1.0	<0.050	3,800	480	NA
001A – North Outfall	6/28/2016	Wet Weather	1.9	0.1	7.13	<4.0	22	<1.0	1.430	3,600	1,400	NA
002A – West Outfall	6/28/2016	Wet Weather	6.9	0.46	7.33	<4.0	16	<1.0	0.790	16,000	2,100	NA
004A – Maverick Street Outfall	6/28/2016	Wet Weather	0.64	0.013	7.85	<4.0	8.9	<1.0	0.460	5,500	90	NA
001C – North Outfall	6/13/2016	Dry Weather				<4.0	16	<1.0	0.350	>80,000	1,300	8,000
002C – West Outfall	6/13/2016	Dry Weather				<4.0	7.2	<1.0	0.180	41,000	46,000	NA
004C – Maverick Street Outfall	6/13/2016	Dry Weather				<4.0	5.8	<1.0	0.050	6,800	1,700	NA
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.												
Discharge Limitations												
Maximum Daily			Report	Report	6.0 to 8.5	15 mg/L	100 mg/L	Report	Report	Report	Report	
Average Monthly			Report	Report	6.0 to 8.5	—	Report	Report	Report	Report	Report	

Source: Massport.

Notes: Flow rates were estimated for outfalls 001, 002, 003 and 004 by using the SWMM model developed for Logan Airport.
For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit. For geometric mean calculations (fecal coliform and Enterococcus) a value of 1 was employed for those results measured below the laboratory detection limit.

1 *Klebsiella* is an indication of non-fecal coliform bacteria and is tested for at the North Outfall when fecal coliform concentration exceeds 5,000 cfu/100ml.

TSS Total Suspended Solids.

NA Not Analyzed.

Table J-6 Logan Airport 2016 Monthly Monitoring Results for Second Quarter — Porter Street Stormwater Outfall

	Date	Event	Maximum Daily Flow (MGD)	Average Monthly Flow (MGD)	pH (S.U.)	Oil and Grease (mg/L)	TSS (mg/L)	Benzene (µg/L)	Surfactant (mg/L)	Fecal Coliform (cfu/100mL)	*Enterococcus* (cfu/100mL)
003 - Porter Street Outfall 1	4/12/2016	Wet Weather	-	-	7.00	<4.0	22	<1.0	0.190	610	800
003 - Porter Street Outfall 2	4/12/2016	Wet Weather	-	-	7.62	11.0	14	<1.0	0.090	<10	<10
003 - Porter Street Outfall 3	4/12/2016	Wet Weather	-	-	7.62	<4.0	<5.0	<1.0	0.080	30	50
003 - Porter Street Outfall Average		Wet Weather	1.40	0.20	7.41	3.7	12	0.0	0.120	26	34
003 - Porter Street Outfall 1	4/11/2016	Dry Weather				<4.0	11	<1.0	0.150	<10	<10
003 - Porter Street Outfall 2	4/11/2016	Dry Weather				5.6	<5.0	<1.0	0.240	<10	20
003 - Porter Street Outfall 3	4/11/2016	Dry Weather				<4.0	15.0	<1.0	0.110	<10	120
003 - Porter Street Outfall Average		Dry Weather				1.9	9.0	0.0	0.167	1.0	13.4
003 - Porter Street Outfall 1	5/24/2016	Wet Weather	-	-	7.82	4.7	25	<1.0	0.090	130	390
003 - Porter Street Outfall 2	5/24/2016	Wet Weather	-	-	7.94	<4.0	5.0	<1.0	0.130	150	1,400
003 - Porter Street Outfall 3	5/24/2016	Wet Weather	-	-	7.70	<4.0	<5.0	<1.0	0.230	680	3,800
003 - Porter Street Outfall Average		Wet Weather	2.60	0.20	7.82	1.6	10	0.0	0.150	237	1,275
003 - Porter Street Outfall 1	5/12/2016	Dry Weather				<4.0	92	<1.0	0.070	<10	40
003 - Porter Street Outfall 2	5/12/2016	Dry Weather				<4.0	8.0	<1.0	0.190	10.0	130
003 - Porter Street Outfall 3	5/12/2016	Dry Weather				<4.4	11	<1.0	0.130	<10	30
003 - Porter Street Outfall Average		Dry Weather				0.0	37	0.0	0.130	2.2	53.8
003 - Porter Street Outfall 1	6/28/2016	Wet Weather	-	-	6.92	<4.0	40	<1.0	0.880	13,000	800
003 - Porter Street Outfall 2	6/28/2016	Wet Weather	-	-	7.50	<4.0	<5.0	<1.0	0.130	<10	510
003 - Porter Street Outfall 3	6/28/2016	Wet Weather	-	-	8.01	<4.0	6.0	<1.0	0.700	1,300	2,100
003 - Porter Street Outfall Average		Wet Weather	1.94	0.09	7.48	0.0	15	0.00	0.570	257	950
003 - Porter Street Outfall 1	6/13/2016	Dry Weather				<4.0	27	<1.0	0.140	30	90
003 - Porter Street Outfall 2	6/13/2016	Dry Weather				<4.0	49	<1.0	0.330	10	20
003 - Porter Street Outfall 3	6/13/2016	Dry Weather				<4.0	<5.0	<1.0	0.130	110	10
003 - Porter Street Outfall Average		Dry Weather				0.0	25	0.0	0.200	32.1	26.2
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.											
Discharge Limitations											
Maximum Daily			Report	Report	6.0 to 8.5	Report	Report	Report	Report	Report	Report
Average Monthly			Report	Report	6.0 to 8.5	—	Report	Report	Report	Report	Report

Source: Massport.

Notes: Flow rates were estimated for outfalls 001, 002, 003, and 0034 by using the SWMM model developed for Logan Airport.
For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit. For geometric mean calculations (fecal coliform and Enterococcus) a value of 1 was employed for those results measured below the laboratory detection limit.

TSS Total Suspended Solids.

Table J-7	Logan Airport 2016 Monthly Monitoring Results for Third Quarter — North, West, and Maverick Street Stormwater Outfalls

	Date	Event	Maximum Daily Flow (MGD)	Average Monthly Flow (MGD)	pH (S.U.)	Oil and Grease (mg/L)	TSS (mg/L)	Benzene (µg/L)	Surfactant (mg/L)	Fecal Coliform (cfu/100mL)	*Enterococcus* (cfu/100mL)	*Klebsiella*[1] (cfu/100mL)
001A – North Outfall	7/29/2016	Wet Weather	0.4	0.1	7.30	<4.0	26	<1.0	1.540	33,000	10,000	600
002A – West Outfall	7/29/2016	Wet Weather	1.40	0.19	7.36	<4.0	16	<1.0	1.10	48,000	3,800	NA
004A – Maverick Street Outfall	7/29/2016	Wet Weather	0.12	0.0092	7.42	<4.0	6.4	<1.0	0.400	4,600	1,200	NA
001C – North Outfall	7/13/2016	Dry Weather				<4.0	24	<1.0	0.290	1,600	1,200	NA
002C – West Outfall	7/13/2016	Dry Weather				<4.0	8.1	<1.0	0.290	16,000	180	NA
004C – Maverick Street Outfall	7/13/2016	Dry Weather				<4.0	9.2	<1.0	0.370	5,100	450	NA
001A – North Outfall	8/22/2016	Wet Weather	2.9	0.2	7.41	<4.0	6.0	<1.0	0.130	14,000	7,300	6,000
002A – West Outfall	8/22/2016	Wet Weather	10.09	0.58	7.35	<4.0	67	<1.0	0.140	25,000	6,300	NA
004A – Maverick Street Outfall	8/22/2016	Wet Weather	0.83	0.02	7.15	<4.0	19	<1.0	0.110	42,000	1,700	NA
001C – North Outfall	8/19/2016	Dry Weather				<4.0	6.9	<1.0	0.210	38,000	2,200	13,000
002C – West Outfall	8/19/2016	Dry Weather				<4.0	13	<1.0	0.210	49,000	420	NA
004C – Maverick Street Outfall	8/19/2016	Dry Weather				<4.0	7.6	<1.0	0.410	260	40	NA
001A – North Outfall	9/19/2016	Wet Weather	0.76	0.098	7.30	11	100	<1.0	1.38	29,000	11,000	<10
002A – West Outfall	9/19/2016	Wet Weather	2.876	0.338	7.08	<4.0	12	<1.0	1.07	32,000	5,600	NA
004A – Maverick Street Outfall	9/19/2016	Wet Weather	0.211	0.002	7.13	<4.0	12	<1.0	0.600	>80,000	1,700	NA
001C – North Outfall	9/9/2016	Dry Weather				<4.0	5.3	<1.0	0.410	64,000	11,000	<10
002C – West Outfall	9/9/2016	Dry Weather				<4.0	14	<1.0	0.530	33,000	320	NA
004C – Maverick Street Outfall	9/9/2016	Dry Weather				<4.0	8.5	<1.0	0.410	13,000	1,000	NA
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.												
Discharge Limitations												
Maximum Daily			Report	Report	6.0 to 8.5	15 mg/L	100 mg/L	Report	Report	Report	Report	Report
Average Monthly			Report	Report	6.0 to 8.5	----	Report	Report	Report	Report	Report	Report

Source: Massport

Notes: Bold values exceed maximum daily discharge limitation.
Flow rates were estimated for outfalls 001, 002, and 004 by using the SWMM model developed for Logan Airport.
For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit. For geometric mean calculations (fecal coliform and *Enterococcus*) a value of 1 was employed for those results measured below the laboratory detection limit.

1 *Klebsiella* is an indication of non-fecal coliform bacteria and is tested for at the North Outfall when fecal coliform concentration exceeds 5,000 cfu/100ml.

TSS Total Suspended Solids.

NA Not Analyzed.

Table J-8 Logan Airport 2016 Monthly Monitoring Results for Third Quarter — Porter Street Stormwater Outfall

	Date	Event	Maximum Daily Flow (MGD)	Average Monthly Flow (MGD)	pH (S.U.)	Oil and Grease (mg/L)	TSS (mg/L)	Benzene (µg/L)	Surfactant (mg/L)	Fecal Coliform (cfu/100mL)	*Enterococcus* (cfu/100mL)
003 - Porter Street Outfall 1	7/29/2016	Wet Weather	-	-	7.62	<4.0	74	<1.0	0.510	820	1,300
003 - Porter Street Outfall 2	7/29/2016	Wet Weather	-	-	8.03	<4.0	38	<1.0	0.310	80	770
003 - Porter Street Outfall 3	7/29/2016	Wet Weather	-	-	7.81	<4.0	29	<1.0	0.750	1,100	2,600
003 - Porter Street Outfall Average		Wet Weather	0.38	0.05	7.82	0.0	35	0.0	0.523	416	1,376
003 - Porter Street Outfall 1	7/13/2016	Dry Weather				<4.0	18	<1.0	0.240	110	30
003 - Porter Street Outfall 2	7/13/2016	Dry Weather				<4.0	14	<1.0	0.090	<10	45
003 - Porter Street Outfall 3	7/13/2016	Dry Weather				<4.0	<10	<1.0	0.170	220	10
003 - Porter Street Outfall Average		Dry Weather				0.0	11	0.0	0.167	28.9	23.8
003 - Porter Street Outfall 1	8/22/2016	Wet Weather	-	-	7.10	<4.0	<5.0	<1.0	0.110	15,000	3,700
003 - Porter Street Outfall 2	8/22/2016	Wet Weather	-	-	7.81	<4.0	<5.0	<1.0	0.070	<10	80
003 - Porter Street Outfall 3	8/22/2016	Wet Weather	-	-	6.70	<4.0	<5.0	<1.0	0.110	80	1,200
003 - Porter Street Outfall Average		Wet Weather	2.22	0.14	7.20	0.0	0.0	0.00	0.097	106	708
003 - Porter Street Outfall 1	8/19/2016	Dry Weather				<4.0	65	<1.0	0.160	2,400	1,500
003 - Porter Street Outfall 2	8/19/2016	Dry Weather				<4.0	10	<1.0	0.150	<10	<10
003 - Porter Street Outfall 3	8/19/2016	Dry Weather				<4.0	290	<1.0	0.170	20	330
003 - Porter Street Outfall Average		Dry Weather				0.0	122	0.0	0.160	36.3	79.1
003 - Porter Street Outfall 1	9/19/2016	Wet Weather	-	-	7.31	5.2	110	<1.0	0.750	5,100	5,300
003 - Porter Street Outfall 2	9/19/2016	Wet Weather	-	-	8.11	<4.0	27	<1.0	0.150	120	3,200
003 - Porter Street Outfall 3	9/19/2016	Wet Weather	-	-	7.49	<4.0	<5.0	<1.0	0.420	2,700	4,000
003 - Porter Street Outfall Average		Wet Weather	0.66	0.07	7.64	1.7	46	0.00	0.440	1,182	4,078
003 - Porter Street Outfall 1	9/9/2016	Dry Weather				<4.0	57	<1.0	0.210	3,000	3,100
003 - Porter Street Outfall 2	9/9/2016	Dry Weather				<4.0	6.0	<1.0	0.110	20.0	10
003 - Porter Street Outfall 3	9/9/2016	Dry Weather				<4.0	22	<1.0	0.150	140	5,100
003 - Porter Street Outfall Average		Dry Weather				0.0	28	0.0	0.157	203.3	540.7
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.											
Discharge Limitations											
Maximum Daily			Report	Report	6.0 to 8.5	Report	Report	Report	Report	Report	Report
Average Monthly			Report	Report	6.0 to 8.5	–	Report	Report	Report	Report	Report

Source: Massport.
Notes: Bold values exceed maximum daily discharge limitation.
Flow rates were estimated for outfall 003 by using the SWMM model developed for Logan Airport.
For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit. For geometric mean calculations (fecal coliform and Enterococcus) a value of 1 was employed for those results measured below the laboratory detection limit.
TSS Total Suspended Solids.

Table J-9 Logan Airport 2016 Monthly Monitoring Results for Fourth Quarter — North, West, and Maverick Street Stormwater Outfalls

	Date	Event	Maximum Daily Flow (MGD)	Average Monthly Flow (MGD)	pH (S.U.)	Oil and Grease (mg/L)	TSS (mg/L)	Benzene (µg/L)	Surfactant (mg/L)	Fecal Coliform (cfu/100mL)	*Enterococcus* (cfu/100mL)	*Klebsiella*[1] (cfu/100mL)
001A – North Outfall	10/21/2016	Wet Weather	6.36	0.550	6.85	<4.0	12	<1.0	0.530	48,000	3,600	<10
002A – West Outfall	10/21/2016	Wet Weather	22.05	1.99	6.96	<4.0	11	<1.0	0.330	53,000	420	NA
004A – Maverick Street Outfall	10/21/2016	Wet Weather	1.58	0.12	7.35	<4.0	<5.0	<1.0	0.210	4,500	290	NA
001C – North Outfall	10/7/2016	Dry Weather				<4.0	7.6	<1.0	0.120	23,000	1,600	<10
002C – West Outfall	10/7/2016	Dry Weather				<4.0	11	<10	0.100	400	20	NA
004C – Maverick Street Outfall	10/7/2016	Dry Weather				<4.0	10	<1.0	0.070	2,700	200	NA
001A – North Outfall	11/15/2016	Wet Weather	3.28	0.24	6.90	<4.0	7.8	<1.0	0.280	67,000	2,300	17,000
002A – West Outfall	11/15/2016	Wet Weather	8.17	0.72	7.35	<4.0	38	<1.0	0.400	3,900	750	NA
004A – Maverick Street Outfall	11/15/2016	Wet Weather	0.80	0.05	7.38	<4.0	**260**	<1.0	0.300	3,500	3,000	NA
001C – North Outfall	11/9/2016	Dry Weather				<4.0	9.2	<1.0	0.210	52,000	1,100	17,000
002C – West Outfall	11/9/2016	Dry Weather				<4.0	7.4	<1.0	0.090	250	50	NA
004C – Maverick Street Outfall	11/9/2016	Dry Weather				<4.0	13	<1.0	0.140	1,200	40	NA
001A – North Outfall	12/12/2016	Wet Weather	2.730	0.546	6.80	<4.0	8.6	<1.0	0.130	3,400	770	NA
002A – West Outfall	12/12/2016	Wet Weather	11.192	1.327	7.45	<4.0	25	<1.0	0.210	2,700	400	NA
004A – Maverick Street Outfall	12/12/2016	Wet Weather	0.794	0.058	6.44	<4.0	<5.0	<1.0	0.360	240	130	NA
001C – North Outfall	12/21/2016	Dry Weather				<4.0	11	<1.0	0.230	28,000	480	<10
002C – West Outfall	12/21/2016	Dry Weather				<4.0	12	<1.0	0.330	150	80	NA
004C – Maverick Street Outfall	12/21/2016	Dry Weather				<4.0	12	<1.0	0.360	150	<10	NA
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.												
Discharge Limitations												
Maximum Daily			Report	Report	6.0 to 8.5	15 mg/L	100 mg/L	Report	Report	Report	Report	Report
Average Monthly			Report	Report	6.0 to 8.5	–	Report	Report	Report	Report	Report	Report

Source: Massport.

Notes: Bold values exceed maximum daily discharge limitation.

Flow rates were estimated for outfalls 001, 002, and 004 by using the SWMM model developed for Logan Airport.

For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit. For geometric mean calculations (fecal coliform and Enterococcus) a value of 1 was employed for those results measured below the laboratory detection limit.

1 *Klebsiella* is an indication of non-fecal coliform bacteria and is tested for at the North Outfall when fecal coliform concentration exceeds 5,000 cfu/100ml.

TSS Total Suspended Solids.

NA Not Analyzed.

Table J-10 Logan Airport 2016 Monthly Monitoring Results for Fourth Quarter — Porter Street Stormwater Outfall

	Date	Event	Maximum Daily Flow (MGD)	Average Monthly Flow (MGD)	pH (S.U.)	Oil and Grease (mg/L)	TSS (mg/L)	Benzene (µg/L)	Surfactant (mg/L)	Fecal Coliform (cfu/100mL)	*Enterococcus* (cfu/100mL)
003 - Porter Street Outfall 1	10/21/2016	Wet Weather	-	-	7.78	<4.0	55	<1.0	0.270	250	210
003 - Porter Street Outfall 2	10/21/2016	Wet Weather	-	-	7.87	<4.0	<5.0	<1.0	0.160	100	80
003 - Porter Street Outfall 3	10/21/2016	Wet Weather	-	-	6.92	<4.0	<5.0	<1.0	0.130	500	3,500
003 - Porter Street Outfall Average		Wet Weather	4.26	0.42	7.52	0.0	18	0.0	0.187	232	389
003 - Porter Street Outfall 1	10/7/2016	Dry Weather				< 4.0	92	< 1.0	0.140	130	80
003 - Porter Street Outfall 2	10/7/2016	Dry Weather				< 4.0	15	< 1.0	0.100	<10	10
003 - Porter Street Outfall 3	10/7/2016	Dry Weather				< 4.0	7.3	< 1.0	0.060	<10	<10
003 - Porter Street Outfall Average		Dry Weather				0.0	38	0.0	0.100	5.1	9.3
003 - Porter Street Outfall 1	11/15/2016	Wet Weather	-	-	7.14	<4.0	110	<1.0	0.230	40	70
003 - Porter Street Outfall 2	11/15/2016	Wet Weather	-	-	7.75	<4.0	15	<1.0	0.310	<10	300
003 - Porter Street Outfall 3	11/15/2016	Wet Weather	-	-	6.81	<4.0	6.2	<1.0	0.240	<10	460
003 - Porter Street Outfall Average		Wet Weather	1.39	0.16	7.23	0.0	44	0.0	0.260	3.4	213
003 - Porter Street Outfall 1	11/9/2016	Dry Weather				29	6.7	<1.0	0.160	<10	10
003 - Porter Street Outfall 2	11/9/2016	Dry Weather				<4.0	16	<1.0	0.120	<10	<10
003 - Porter Street Outfall 3	11/9/2016	Dry Weather				<4.0	<5.0	<1.0	0.160	10	170
003 - Porter Street Outfall Average		Dry Weather				9.7	7.6	0.0	0.147	2.2	12
003 - Porter Street Outfall 1	12/12/2016	Wet Weather	-	-	6.83	<4.0	31	<1.0	0.210	110	460
003 - Porter Street Outfall 2	12/12/2016	Wet Weather	-	-	6.41	4.6	22	<1.0	0.090	<10	90
003 - Porter Street Outfall 3	12/12/2016	Wet Weather	-	-	6.37	<4.0	<5.0	<1.0	0.100	230	530
003 - Porter Street Outfall Average		Wet Weather	2.847	0.261	6.54	1.5	18	0.0	0.133	29	280
003 - Porter Street Outfall 1	12/21/2016	Dry Weather				<4.0	490	<1.0	0.270	<10	<10
003 - Porter Street Outfall 2	12/21/2016	Dry Weather				11	120	<1.0	0.170	<10	50
003 - Porter Street Outfall 3	12/21/2016	Dry Weather				4.0	9.0	<1.0	0.290	<10	<10
003 - Porter Street Outfall Average		Dry Weather				3.7	206	0.0	0.243	1.0	3.7
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.											
Discharge Limitations											
Maximum Daily			Report	Report	6.0 to 8.5	Report	Report	Report	Report	Report	Report
Average Monthly			Report	Report	6.0 to 8.5	–	Report	Report	Report	Report	Report

Source: Massport.

Notes: Bold values exceed maximum daily discharge limitation.

Flow rates were estimated for outfall 003 using the SWMM model developed for Logan Airport.

For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit. For geometric mean calculations (fecal coliform and Enterococcus) a value of 1 was employed for those results measured below the laboratory detection limit.

The modeled Maverick Street Outfall on average ended up being negative because of tidal effects.

Table J-11 Logan Airport 2016 Quarterly Wet Weather Monitoring Results – North, West, Maverick Street, and Porter Street Stormwater Outfalls

	Date	pH (S.U.)	Benzo(a)-anthracene (µg/L)	Benzo(a)-pyrene (µg/L)	Benzo(b)-fluoranthene (µg/L)	Benzo(k)-fluoranthene (µg/L)	Chrysene (µg/L)	Dibenzo(a,h,)-anthracene (µg/L)	Indeno(1,2,3-cd)-pyrene (µg/L)	Naphthalene (µg/L)	Total PAHs (µg/L)
001 - North Outfall	3/2/2016	6.04	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
002 - West Outfall	3/2/2016	6.52	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
004 - Maverick Street Outfall	3/2/2016	5.59	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 1	3/2/2016	6.56	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 2	3/2/2016	6.11	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 3	3/2/2016	6.46	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall Average		6.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
001 - North Outfall	6/28/2016	7.13	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
002 - West Outfall	6/28/2016	7.33	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
004 - Maverick Street Outfall	6/28/2016	7.85	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 1	6/28/2016	6.92	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 2	6/28/2016	7.50	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 3	6/28/2016	8.01	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall Average	6/28/2016	7.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
001 - North Outfall	9/19/2016	7.30	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
002 - West Outfall	9/19/2016	7.08	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
004 - Maverick Street Outfall	9/19/2016	7.13	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 1	9/19/2016	7.31	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 2	9/19/2016	8.11	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 3	9/19/2016	7.49	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall Average	9/19/2016	7.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
001 - North Outfall	12/12/2016	6.80	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
002 - West Outfall	12/12/2016	7.45	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
004 - Maverick Street Outfall	12/12/2016	6.44	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 1	12/12/2016	6.83	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 2	12/12/2016	6.41	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall 3	12/12/2016	6.37	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND
003 - Porter Street Outfall Average		6.54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.											
Discharge Limitations											
Maximum Daily		6.0 to 8.5	Report	Report	Report	Report	Report	Report	Report	Report	Total

Source: Massport

Notes: Quarterly Samples were unable to be collected during the first and second quarters. During the first quarter, the perimeter road was mostly inaccessible because of the historic snowfall events, as were many of the sampling locations. There were few rain opportunities late in the season which were not timed well with the tides. During the second quarter, sampling could not be conducted due to thunderstorms and timing of precipitation versus the low tide.
Bold values exceed maximum daily discharge limitation.
For averaging calculations, a value of zero was employed for those results measures below the laboratory detection limit.

PAHs Polynuclear Aromatic Hydrocarbons
ND Not Detected
TSS Total Suspended Solids.

Table J-12 Logan Airport 2016 Quarterly Wet Weather Monitoring Results – Northwest and Runway/Perimeter Stormwater Outfalls

	Date	Maximum Daily Flow (MGD)	Average Monthly Flow (MGD)	pH (SU)	Oil and Grease (mg/L)	TSS (mg/L)	Benzene (µg/L)
005 - Northwest Outfall	3/2/2016	0.5	0.04	5.68	<4.0	11	<1.0
006Q- Runway/ Perimeter Outfall (A9)	3/2/2016	0.32	0.02	6.14	<4.0	7.0	<1.0
006Q- Runway/ Perimeter Outfall (A15)	3/2/2016	0.11	0.01	6.21	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A19)	3/2/2016	0.05	0.003	6.86	<4.4	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A21)	3/2/2016	2.73	0.18	6.28	<4.0	9.0	<1.0
006Q- Runway/ Perimeter Outfall (A23)	3/2/2016	0.27	0.02	6.47	<4.0	7.2	<1.0
006Q- Runway/ Perimeter Outfall (A33)	3/2/2016	0.23	0.02	6.99	<4.0	6.0	<1.0
006Q- Runway/ Perimeter Outfall (A38)	3/2/2016	0.34	0.02	6.61	<4.0	<5.0	<1.0
006- Runway/Perimeter Outfall Average		0.58	0.04	6.51	0.0	4.0	0.0
005 - Northwest Outfall	6/28/2016	0.3	0.02	6.95	<4.0	8.0	<1.0
006Q- Runway/ Perimeter Outfall (A9)	6/28/2016	0.17	0.02	7.38	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A15)	6/28/2016	0.06	0.005	7.73	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A19)	6/28/2016	0.03	0.002	7.58	<4.0	8.5	<1.0
006Q- Runway/ Perimeter Outfall (A21)	6/28/2016	1.25	0.10	7.39	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A23)	6/28/2016	0.15	0.01	7.21	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A33)	6/28/2016	0.13	0.01	7.35	<4.0	9.0	<1.0
006Q- Runway/ Perimeter Outfall (A38)	6/28/2016	0.16	0.01	6.99	<4.0	<5.0	<1.0
006- Runway/Perimeter Outfall Average	6/28/2016	0.28	0.02	7.38	0.0	2.4	0.0
005 - Northwest Outfall	9/19/2016	0.1	0.01	7.29	4.6	220	<1.0
006Q- Runway/ Perimeter Outfall (A9)	9/19/2016	0.01	0.003	6.68	9.1	8.0	<1.0
006Q- Runway/ Perimeter Outfall (A15)	9/19/2016	0.01	0.001	7.83	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A18)	9/27/2016	0.00	0.001	6.64	<4.0	22.0	<1.0
006Q- Runway/ Perimeter Outfall (A21)	9/19/2016	0.08	0.02	7.69	4.3	19	<1.0
006Q- Runway/ Perimeter Outfall (A23)	9/19/2016	0.01	0.003	7.29	<4.0	23.0	<1.0
006Q- Runway/ Perimeter Outfall (A33)	9/19/2016	0.01	0.003	7.35	<4.0	14	<1.0

Table J-12 Logan Airport 2016 Quarterly Wet Weather Monitoring Results – Northwest and Runway/Perimeter Stormwater Outfalls (Continued)

006Q- Runway/ Perimeter Outfall (A38)	9/19/2016	0.01	0.002	6.81	<4.0	13	<1.0
006- Runway/Perimeter Outfall Average	9/19/2016	0.02	0.01	7.18	1.9	14.2	0.0
005 - Northwest Outfall	12/12/2016	0.416	0.036	6.15	<4.0	9.0	<1.0
006Q- Runway/ Perimeter Outfall (A9)	12/12/2016	0.218	0.023	6.68	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A15)	12/12/2016	0.080	0.008	6.87	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A20)	12/12/2016	0.102	0.011	6.95	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A21)	12/12/2016	1.433	0.151	6.77	<4.0	12	<1.0
006Q- Runway/ Perimeter Outfall (A23)	12/12/2016	0.174	0.018	6.79	<4.0	<5.0	<1.0
006Q- Runway/ Perimeter Outfall (A33)	12/12/2016	0.123	0.016	7.39	<4.0	5.3	<1.0
006Q- Runway/ Perimeter Outfall (A38)	12/12/2016	0.188	0.017	6.67	<4.0	11	<1.0
006- Runway/Perimeter Outfall Average		0.331	0.035	6.87	0.0	4.0	0.0
Discharge Limitations		Report	Report	Report	Report	Report	Report

Source: Massport

Notes: Bold values exceed maximum daily discharge limitation.
For averaging calculations, a value of zero was employed for those results measures below the laboratory detection limit.
Requirements are from NPDES Permit MA 0000787, issued July 31, 2007.

TSS Total Suspended Solids

ND Not Detected

Table J-13 Logan Airport February 2016 Wet Weather Deicing Monitoring Results – North, West, Porter Street, and Runway/Perimeter Stormwater Outfalls

	Date	Ethylene Glycol, Total (mg/L)	Propylene Glycol, Total (mg/L)	BOD5 (mg/L)	COD (mg/L)	Ammonia Nitrogen (mg/L)	Nonylphenol (µg/L)	4-Methyl-1-H-benzotriazole (µg/L)	5-Methyl-1-H-benzotriazole (µg/L)	Tolytriazole (µg/L)
001B - North Outfall	2/8/2016	<7.0	14	3,500	4,700	0.870	<0.020	33.56	20.02	53.58
002B - West Outfall	2/8/2016	<350	4,400	5,600	8,700	0.889	<0.020	14.64	9.33	23.97
003B - Porter Street Outfall 1	2/8/2016	<7.0	13	220	480	1.33	0.612	2.19	2.10	4.29
003B - Porter Street Outfall 2	2/8/2016	<70	370	580	760	<0.075	<0.020	11.82	13.73	25.55
003B - Porter Street Outfall 3	2/8/2016	<7.0	<7.0	24	96	1.47	<0.020	<0.25	<0.25	ND
003B - Porter Street Outfall Average		0.0	128	275	445	0.93	0.204	4.67	5.28	9.95
006B- Runway/ Perimeter (A9)	2/8/2016	<7.0	<7.0	25	140	0.524	<0.020	5.90	2.28	8.180
006B- Runway/ Perimeter (A15)	2/8/2016	<7.0	<7.0	15	34	0.773	<0.020	3.08	1.03	4.110
006B- Runway/ Perimeter (A19)	2/8/2016	<7.0	8.5	100	160	1.69	<0.020	12.97	5.75	18.72
006B- Runway/ Perimeter (A21)	2/8/2016	<7.0	<7.0	46	48	0.554	<0.020	3.47	0.94 J	4.41 J
006B- Runway/ Perimeter (A23)	2/8/2016	<7.0	40	77	27	0.68	<0.020	5.51	1.54 J	7.05 J
006B- Runway/ Perimeter (A34)	2/8/2016	<140	2,300	70	350	0.822	<0.020	5.690	1.56	7.250
006B- Runway/ Perimeter (A38)	2/8/2016	<7.0	<7.0	88	960	0.108	<0.020	<0.25	<0.25	ND
006B- Runway/Perimeter Outfall Average		0.0	336	60	246	0.736	0.00	5.23	1.87	7.10
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.										
Discharge Limitations										
Average Monthly		Report	Report	Report	Report	Report	Report	Report	Report	Report
Maximum Daily		Report	Report	Report	Report	Report	Report	Report	Report	Report

S

Source: Massport

Notes: For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit.
J = value is an estimate calculated by the lab from the response factors of the other two triazole compounds.
Tolytriazole concentrations calculated as sum of 4-Methly-1-H-benzotriazole and 5-Methyl-1-H-benzotriazole.

BOD5 Five-day Biochemical Oxygen Demand
COD Chemical Oxygen Demand
ND Not Detected

Table J-14 Logan Airport March 2016 Wet Weather Deicing Monitoring Results – North, West, Porter Street, and Runway/Perimeter Stormwater Outfalls

	Date	Ethylene Glycol, Total (mg/L)	Propylene Glycol, Total (mg/L)	BOD5 (mg/L)	COD (mg/L)	Ammonia Nitrogen (mg/L)	Nonylphenol (µg/L)	4-Methyl-1-H-benzotriazole (µg/L)	5-Methyl-1-H-benzotriazole (µg/L)	Tolytriazole (µg/L)
001B - North Outfall	3/21/2016	<70	1,100	1,400	3,300	1.37	<0.020	0.036	0.047	0.083
002B - West Outfall	3/21/2016	<1,400	11,000	14,000	23,000	1.41	<0.020	0.030	0.031	0.061
003B - Porter Street Outfall 1	3/21/2016	<7.0	<7.0	54	210	1.88	1.557	0.003 J	0.004 J	0.007 J
003B - Porter Street Outfall 2	3/21/2016	<35	430	930	2,700	0.159	<0.020	0.03	0.031	0.06
003B - Porter Street Outfall 3	3/21/2016	<7.0	<7.0	23	180	0.80	0.908	<0.001	<0.001	ND
003B - Porter Street Outfall Average	3/21/2016	0.0	143	336	1,030	0.95	0.822	0.010	0.012	0.021
006B- Runway/ Perimeter (A9)	3/21/2016	<7.0	<7.0	3.1	<20	0.832	1.118	0.008	0.002 J	0.01 J
006B- Runway/ Perimeter (A15)	3/21/2016	<7.0	<7.0	2.7	<20	2.49	1.47	0.017	0.004 J	0.021 J
006B- Runway/ Perimeter (A19)	3/21/2016	<7.0	<7.0	5.8	<20	6.68	0.7	0.026	0.009	0.04
006B- Runway/ Perimeter (A21)	3/21/2016	<7.0	<7.0	6.8	280	1.080	0.835	0.01	0.002 J	0.012 J
006B- Runway/ Perimeter (A23)	3/21/2016	<7.0	<7.0	20	60	1.94	1.34	0.017	0.003 J	0.02 J
006B- Runway/ Perimeter (A32)	3/21/2016	<7.0	<7.0	69	89	3.16	1.63	0.023	0.007	0.030
006B- Runway/ Perimeter (A38)	3/21/2016	<7.0	<7.0	8.3	63	0.308	1.28	<0.001	<0.001	ND
006B- Runway/Perimeter Outfall Average		0.0	0.0	17	70	2.36	1.20	0.014	0.004	0.018
Requirements are from NPDES Permit MA0000787, issued July 31, 2007.										
Discharge Limitations										
Average Monthly		Report	Report	Report	Report	Report	Report	Report	Report	Report
Maximum Daily		Report	Report	Report	Report	Report	Report	Report	Report	Report

Source: Massport.

Notes: For averaging calculations, a value of zero was employed for those results measured below the laboratory detection limit.

J = value is an estimate calculated by the lab from the response factors of the other two triazole compounds.

Tolytriazole concentrations calculated as sum of 4-Methly-1-H-benzotriazole and 5-Methyl-1-H-benzotriazole.

BOD5 Five-day Biochemical Oxygen Demand

COD Chemical Oxygen Demand

ND Not Detected

Table J-15 Logan Airport Stormwater Outfall NPDES Water Quality Monitoring Results – 1993 to 2016

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
# / # = Number of samples at or below NPDES limits / Total number of samples taken[1]																								
Oil and Grease (mg/L)																								
North Outfall	30/31	35/36	33/35	29/35	30/35	35/36	29/30	34/36	28/28	36/36	30/32	32/34	33/35	33/33	29/29	23/23	24/24	24/24	24/24	21/21	20/20	21/21	19/20	23/23
West Outfall	29/30	36/36	34/34	36/36	34/35	36/36	30/30	35/35	27/28	36/36	31/32	33/34	35/35	32/33	28/28	22/23	24/24	24/24	22/24	21/21	21/21	21/21	19/19	23/23
Maverick Street Outfall	29/29	36/36	35/35	36/36	35/35	35/36	30/30	34/34	26/28	35/36	32/32	34/34	35/35	32/33	29/29	22/23	20/21	19/19	23/23	15/15	4/4	20/20	18/18	23/23
Settable Solids[2] (mg/L)																								
North Outfall	19/19	34/35	34/35	32/35	31/34	34/36	30/30	34/36	29/29	32/36	32/32	34/34	33/35	32/34	22/22	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
West Outfall	19/19	32/36	34/34	35/36	34/34	35/36	29/30	36/36	27/28	36/36	31/32	34/34	32/35	33/33	22/22	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TSS (mg/L)																								
North Outfall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6/6	24/24	24/24	22/23	24/24	21/21	20/21	21/21	20/20	23/23
West Outfall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5/6	24/24	24/24	23/23	22/24	20/22	21/21	20/21	18/19	23/23
Maverick Street Outfall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4/6	22/24	20/21	18/19	20/23	14/15	4/4	19/20	18/18	22/23
pH																								
North Outfall	34/35	33/36	35/35	35/35	35/35	36/36	30/30	36/36	29/29	36/36	32/32	34/34	35/35	34/34	26/26	12/12	16/16	11/11	12/12	9/9	8/8	8/8	8/8	10/11
West Outfall	34/34	28/36	33/34	35/36	35/35	36/36	30/30	36/36	29/29	36/36	32/32	34/34	35/35	33/33	26/26	12/12	16/16	11/11	12/12	9/9	9/9	8/8	8/8	11/11
Porter Street Outfall	35/35	30/36	34/34	36/36	35/35	36/36	30/30	36/36	28/28	36/36	32/32	34/34	35/35	33/33	22/22	21/21	48/48	24/24	23/23	26/27	24/27	24/24	19/23	33/33
Maverick Street Outfall	35/35	35/36	35/35	36/36	34/35	36/36	30/30	35/35	28/28	36/36	32/32	34/34	35/35	33/33	26/26	10/10	16/16	10/10	11/11	6/6	2/2	7/7	7/7	10/11

Source: Massport

Notes: Sampling requirements changed in 2007 with the issuance of a new NPDES permit. Results through 2007 are based on NPDES Permit MA0000787, issued March 1, 1978. Stormwater outfall water quality monitoring results collected in accordance with the requirements of former NPDES permit. A portion of the Porter Street Drainage Area was incorporated into the West Drainage Area as part of roadway construction projects at Logan Airport.

N/A Not available.

1 The total number of samples at each outfall varies year to year. In some years, fewer samples are taken due to factors such as construction, weather, and/or tidal conditions.

2 Settleable solids analyses were replaced with TSS in 2008.

Table J-16 Logan Airport Oil and Hazardous Material Spills[1] and Jet Fuel Handling – 1990 to 2016

Year	Total Number of all Spills	Total Number of all Spills >10 gallons	Total Volume of all Spills (Gallons)	Estimated Volume of Jet Fuel Handled (Gallons)	Total Volume of Jet Fuel Spilled (Gallons)
1990	173	N/A	N/A	438,100,000	3,745
1991	186	N/A	N/A	N/A	2,471
1992	195	N/A	N/A	N/A	4,355
1993	188	N/A	N/A	451,900,000	3,131
1994	217	N/A	N/A	476,700,000	4,046
1995	161	N/A	N/A	309,200,000	21,412[2]
1996	159	N/A	N/A	346,700,000	1,321
1997	147	N/A	N/A	377,488,161	2,029[3]
1998	191	N/A	N/A	387,224,004	10,047[4]
1999	196	43	7,151	425,937,051	7,012[5]
2000	136	20	1,318	441,901,932	1,227
2001	139	37	1,924	416,748,819	1,771
2002	101	16	653	358,190,362	559
2003	128	19	10,364	319,439,910	10,188[6]
2004	126	18	894	373,996,141	574
2005	97	15	2,319	368,645,932	585
2006	92	11	752	364,450,864	644
2007	108	7	604	367,585,187	361
2008	99	20	944	345,631,788	662
2009	95	6	1004	327,358,619	915
2010	87	15	476	335,693,997	360
2011	108	12	572	340,421,373	337
2012	132	5	593	343,731,127	439
2013	94	6	452	349,397,940	351
2014	129	17	2,785	370,222,342	785
2015	196	16	1,278	374,985,216	885
2016	231	14	1,158	456,003,328	558

Source: Massport Fire-Rescue Department.
Notes:
N/A Not available.
1 Materials include: jet fuel, hydraulic oil, diesel fuel, gasoline, and other materials such as glycol and paint.
2 One tenant spill, which occurred on October 15, 1995, totaled 18,000 gallons (84 percent of the annual spill total). The spill did not enter the Airport's storm drain system.
3 On October 23, 1997, a fuel line on an aircraft failed, resulting in the release of approximately 2,500 gallons, all but 60 gallons of which were recovered in drums before reaching the ground. Only the 60 gallons is included in the 1997 total.
4 Includes a 7,200-gallon spill that was discovered on September 2, 1998, and a 1,300-gallon spill that occurred on June 3, 1998. Neither spill entered the Airport's storm drain system.
5 Includes a 5,000-gallon spill, none of which entered the Airport's storm drainage system.
6 In 2003, one fuel spill comprised 9,460 gallons or 94 percent of the total volume of the MassDEP/MCP reportable spills that year. The fuel spill was contained and did not enter the drainage system.

Table J-17 Type and Quantity of Oil and Hazardous Material Spills at Logan Airport – 1999 to 2016

	Jet Fuel			Hydraulic Oil			Diesel Fuel			Gasoline			Other		
Year	No. of Spills	Quantity (Gallons)	No. of Spills ≥ 10 Gallons	No. of Spills	Quantity (Gallons)	No. of Spills ≥ 10 Gallons	No. of Spills	Quantity (Gallons)	No. of Spills ≥ 10 Gallons	No. of Spills	Quantity (Gallons)	No. of Spills ≥ 10 Gallons	No. of Spills	Quantity (Gallons)	No. of Spills ≥ 10 Gallons
1999	151	7,012	40	24	67	1	13	49	2	5	7	0	3	16	0
2000	115	1,227	18	8	59	2	3	11	0	8	16	0	2	5	0
2001	104	1,771	32	21	92	3	5	30	1	6	26	1	3	5	0
2002	79	559	15	7	38	0	8	37	18	4	8	0	3	11	0
2003	89	10,188	15	15	91	3	15	30	0	7	24	0	2	31	1
2004	82	574	12	17	189	4	14	52	0	7	26	0	6[1]	53[2]	2[3]
2005	66	585	12	14	78	1	7	1,610	2	7	45	0	3[4]	1	0
2006	65	644	9	10	25	0	6	57	1	4	9	0	7	17	1
2007	66	361	4	16	37	0	16	57	1	3	8	0	7	141[5]	2
2008	74	662	19	15	56	2	5	14	0	1	7	0	4	205[6]	1
2009	95	915	6	21	51	0	9	20	0	3	3	0	11	15	0
2010	54	360	12	17	50	1	5	56	2	2	3	0	7	7	0
2011	69	337	10	21	149	1	7	55	1	4	16	0	7	15	0
2012	80	439	4	25	79	1	17	38	0	2	12	0	8	25	0
2013	56	351	5	15	51	0	13	32	0	2	<2	0	7	10	0
2014	81	785	13	24	98	1	17	1,810	2	4	9	0	3	83	1
2015	110	885	10	43	149	3	16	151	2	7	46	1	20	47	0
2016	94	558	8	73	224	4	30	300	2	6	12	0	28	64	0

Source: Massport

Notes:

1 Includes two Unknown spills (14 gallons), plus one spill of each of the following: Ethylene Glycol, Propylene Glycol, AVGAS, and Paint.

2 Ethylene Glycol (25 gallons), Propylene Glycol (10 gallons), AVGAS (1 gallon) and Paint (3 gallons).

3 One spill of Ethylene Glycol; one spill of Propylene Glycol.

4 Includes two spills of an unknown substance and volume.

5 Includes one spill of motor oil (4 gallons); one spill of kerosene (5 gallons); one spill of cooking oil (120 gallons); one spill of fuel oil (10 gallons); one spill from a battery (1 gallon); two spills of an unknown substance (1 gallon).

6 Includes one spill of transformer oil (200 gallons).

Table J-18 MCP Activities Status of Massport Sites at Logan Airport

Location (Release Tracking Number) and MassDEP Reporting Status	Action/Status
1. Fuel Distribution System (3-1287)	
2007	Inspection and Monitoring Status Reports were submitted to the Massachusetts Department of Environmental Protection (MassDEP) detailing monitoring and product recovery efforts along the FDS between September 2006 and September 2007. A Periodic Evaluation Report was submitted in January 2008 which indicated that a Condition of No Substantial Hazard existed at the FDS and a permanent solution was not currently feasible. Massport coordinated with BOSFUEL who prepared construction documents for replacing a portion of the FDS. Construction was conducted under a RAM Plan.
2008	Inspection and monitoring reports were submitted to the MassDEP detailing monitoring and product recovery efforts along the FDS between September 2007 and September 2008. Massport coordinated with BOSFUEL during construction to replace a portion of the FDS. The work was conducted under a RAM Plan that was submitted to the MassDEP in May 2008. A RAM Status Report was submitted in September 2008. Construction of the pipeline replacement was approximately 90 percent complete.
2009	Inspection and monitoring reports were submitted to the MassDEP detailing monitoring and product recovery efforts along the FDS between September 2008 and December 2009. The BOSFUEL project to replace a portion of the FDS continued, with work being completed on pipeline connections, testing of the new fuel line, and abandonment of the old fuel line. RAM Status Reports for the BOSFUEL Project were submitted in February and September 2009.
2010	Inspection and monitoring reports were submitted to the MassDEP detailing monitoring and product recovery efforts along the FDS between September 2009 and September 2010. A RAM Completion Report for the BOSFUEL Project was submitted in February, and the report was revised in March 2010.
2011	A Periodic Review of the Temporary Solution for the FDS was submitted in April 2011. Additionally, three Post-Class C RAO Status Reports were submitted for the FDS in February, June, and December 2011, summarizing the routine inspection and monitoring activities.
2012	Post-Class C RAO Status Reports were submitted in May and November 2012, summarizing the routine inspection and monitoring activities.
2013	Post-Class C RAO Status Reports were submitted in May and November 2013, summarizing the routine inspection and monitoring activities.
2014	Post-Class C RAO Status Reports were submitted in May and November 2014, summarizing the routine inspection and monitoring activities. In addition, a RAM Plan was submitted in April 2014 to address construction in the area of the FDS followed by a RAM Completion Report submitted in August 2014.
2015	Post-Temporary Solution Status Reports were submitted in May and November 2015, summarizing the routine inspection and monitoring activities.
2016	RAO-C 5-year periodic review submitted in July 2016. Two Post-Temporary Solution Status Reports were submitted in 2016 summarizing the routine inspection, monitoring and product recovery activities.
2. North Outfall (3-4837) - CLOSED	
Phase II and Phase III Reports filed in March 1997	Indicated petroleum contamination present at the site was likely the result of decades of airport operation; risk assessment reported no significant risk to human health, or to the aquatic and avian community.
RAO submitted in March 1998	Class C RAO using a Temporary Solution (periodic site monitoring and assessment); remediation steps included (not limited to) installation of a new fuel distribution system and decommissioning of certain fuel lines, and natural biodegradation processes; goal is to have petroleum contamination reduced to an area less than 1,000 square feet. Installation of the new fuel distribution system and decommissioning of sections of the old system were completed. Massport initiated site evaluation to document the reduction of petroleum contamination following the decommissioning of the North Fuel Farm and fuel distribution system.
Post Class C RAO evaluation report submitted in December 2002	Massport has eliminated substantial hazards at this site and submitted a Class C RAO statement. In accordance with applicable regulations, Massport will conduct a periodic evaluation at five-year intervals until a Permanent Solution has been achieved. The next periodic evaluation was scheduled for 2007.
2004	Evaluation report indicated that a "Condition of No Significant Risk" has not been achieved at this site. Massport scheduled another assessment in 2007.
2005	No change in status for 2005.
2006	Massport prepared the five-year review of the Class C RAO for this site, which was due in December 2007.
2007	Massport completed its five-year review of the Class C RAO and transmitted it to MassDEP in December 2007. It was determined that a "Condition of No Significant Risk" has not been achieved at this site at this time. The next five-year re-evaluation will be conducted in 2012.
2008	No change in status.

Table J-18 MCP Activities Status of Massport Sites at Logan Airport (Continued)

Location (Release Tracking Number) and MassDEP Reporting Status	Action/Status
2. North Outfall (3-4837) - CLOSED (Continued)	
2009	No change in status.
2010	No change in status.
2011	No change in status. Massport provided updated data for the MassDEP website.
2012	Response Action Outcome submitted to MassDEP on December 27, 2012. No further MCP response action is required.
3. Former Robie Park (3-10027) - CLOSED	
2005	A Phase I was completed in 2005 with an RAO retraction. The RAO had been completed by the former property owner.
2006	No change in status for 2006.
2007	No change in status for 2007.
2008	A Phase II Scope of Work was prepared on May 9, 2008. A RAM Plan was submitted to MassDEP on September 16, 2008.
2009	A Phase V Remedy Operation Status Plan was submitted on March 31, 2010.
2010	Two Remedy Operation Status Reports were submitted on September 29, 2010 and March 28, 2011. The next status report was scheduled for September 30, 2011.
2011	Phase IV Project Status Reports 2 and 3 were submitted in March and September 2011, respectively.
2012	Phase V Status Reports 4 and 5 were submitted in March and September 2012, respectively.
2013	Phase V Status Reports 6 and 7 were submitted in March and September 2013, respectively.
2014	Phase V Status Reports 8 and 9 were submitted in March and September 2014, respectively.
2015	Phase V Reports 10 and 11 were submitted in March and September 2015, respectively.
2016	A Permanent Solution Statement was submitted in 2016.
4. Former Robie Property (3-23493) - CLOSED	
2005	A Phase I was completed in 2005.
2006	No change in status for 2006.
2007	No change in status for 2007.
2008	A Phase II was submitted to MassDEP on October 21, 2008.
2009	An Activity and Use Limitation (AUL) was recorded with the Suffolk County Registry of Deeds for the site on December 16, 2009.
2010	A Class A-3 RAO was submitted on January 4, 2010, corresponding with the recording of an AUL. On May 21, 2010, a RAM Plan for the Economy Parking Structure was submitted. The first RAM Status Report was submitted on September 21, 2010. An AUL Amendment was recorded on December 9, 2010.
2011	A RAM Completion Statement was submitted on March 15, 2011. Regulatory closure has been achieved. No further response actions are required.
5. Tomahawk Drive (3-27068) - CLOSED	
2007	Release notification form submitted in August 2007.
2008	A Class B-1 RAO was submitted to MassDEP on January 9, 2009. No further response actions were required.
2009	No further response actions were required.
2011	No further response actions required
6. Fire Training Facility (3-28199)	
2008	Oral notification of release was provided to MassDEP/BWSC on December 10, 2008.
2009	A Phase I/Tier classification was submitted on December 17, 2009.
2010	A RAM Plan was submitted to MassDEP on August 6, 2010. A RAM Status Report was submitted to MassDEP on December 3, 2010.

Table J-18 MCP Activities Status of Massport Sites at Logan Airport (Continued)

Location (Release Tracking Number) and MassDEP Reporting Status	Action/Status
6. Fire Training Facility (3-28199) (Continued)	
2011	A RAM Completion Statement was submitted on April 25, 2011. A Phase II Scope of Work was prepared and submitted to MassDEP on January 18, 2011. Phase II and Phase III Reports were submitted on December 8, 2011. A RAM Completion Statement was submitted on April 25, 2011.
2012	Phase 4 Status Report transmitted in June 2012; the Phase IV Remedy Implementation Plan was submitted in December 2012.
2013	Phase 4 Status Report transmitted in June 2013, the Phase IV Completion Report was transmitted in December 2013.
2014	Phase 5 Remedy Operation Status Reports submitted in June and December 2014.
2015	Phase 5 Remedy Operation Status Reports submitted in June and December 2015.
2016	Phase 5 Remedy Operation Status Reports submitted in June and December 2016.
7. Southwest Service Area (3-28792) - CLOSED	
2009	Release notification form was submitted to MassDEP/BWSC on October 8, 2009.
2010	A Class B-1 RAO was submitted to MassDEP on October 18, 2010. No further response actions required.
2011	No further response actions required.
8. Airfield Duct Bank Site (3-29716) - CLOSED	
2010	Release notification form was submitted on December 22, 2010.
2011	A Class A-1 RAO was submitted on December 23, 2011. No further response actions required.
9. West Outfall Release (3-29792) - CLOSED	
2011	Release notification form was submitted on April 8, 2011. Two IRA Status Reports were submitted to MassDEP on June 9 and December 5, 2011. An RAO was submitted on February 13, 2012. No further response actions required.
10. Hertz Parking Lot Site (3-30260) - CLOSED	
2011	Release notification form was submitted on August 29, 2011. A RAM Plan was submitted to MassDEP on September 1, 2011.
2012	A Class A-2 RAO was submitted on September 10, 2012. No Further response actions required.
11. Former Butler Aviation Hangar (3-30654) - CLOSED	
2012	Verbal notification of a release was provided to MassDEP on February 14, 2012, when Rental Car Center construction encountered an unidentified underground storage, and a Release Notification Form was submitted on April 23, 2012. An IRA Plan was submitted May 21, 2012 and IRA Status Reports were submitted on June 18 and December 26, 2012.
2013	Phase I Report and Tier Classification submitted February 21, 2013 and IRA Completion Report submitted on July 11, 2013.
2014	A Permanent Solution Statement was submitted in October 2014. No further response actions required.
12. Taxi Pool Site (3-32022)	
2014	MassDEP notified of 72-hour Reportable Condition on March 10, 2014
2015	Phase I Report and Tier Classification submitted March 9, 2015.
2016	Permanent Solution Statement scheduled to be submitted in 2017
13. Hangar 16 (3-32351) - CLOSED	
2014	Release Notification Form Submitted August 4, 2014.
2015	A RAM Plan was submitted on January 29, 2015; a Phase I Report and Tier Classification were submitted on August 3, 2015; a RAM Completion Report was submitted November 16, 2015; and a Permanent Solution Statement was submitted on January 21, 2016. No further response actions are required.

Source: Massport
Notes: This list includes Massport MCP sites only. Additional sites are the responsibility of Logan Airport tenants. Refer to Figure 8-2 in Chapter 8, *Water Quality/Environmental Compliance and Management,* for location of MCP sites.

AUL	Activity and Use Limitation	Phase I	Initial Site Investigation
MCP	Massachusetts Contingency Plan	Phase II	Comprehensive Site Assessment
RAM	Release Abatement Measure	Phase III	Identification, Evaluation, and Selection of Comprehensive Remedial Actions
RAO	Response Action Outcome	Phase IV	Implementation of Selected Remediation Action
FDS	Fuel Distribution System	Phase V	Operation, Maintenance and/or Monitoring
IRA	Immediate Response Action		

Capital Programs and Environmental Affairs

EnviroNews

A Massport Newsletter

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INSIDE THIS ISSUE:

EnviroNews is a newsletter published quarterly for Massport and its tenants. Your comments and suggestions are welcome. Please contact Brenda Enos (benos@massport.com) at 617-568-5963.

2016 Sustainable Massport Calendar

The 2016 Sustainable Massport Calendar is now available for all Massport employees and tenants. The 2016 calendar expanded to showcase sustainability efforts across all Massport facilities, including: Hanscom Field, Worcester Regional Airport, Parks, Real Estate Holdings, and the Port of Boston.

The annual Sustainable Massport Calendar is part of the engagement strategies laid out in the first ever Logan Airport Sustainable Management Plan (SMP), published in 2015. The Logan SMP serves as a roadmap to advance Massport's leadership and commitment to sustainability, by prioritizing and implementing initiatives that emphasize economic viability, operational efficiency, natural resource conservation, and social responsibility. The Sustainable Massport Calendar is one tool to share Massport's sustainability successes, and raise awareness about the organization's commitment to sustainability. Each month within the calendar will highlight a different sustainability-related topic, associated activities which Massport has undertaken and its progress, as well as ideas of programs and actions which individuals can participate in to improve personal sustainability at work and home.

Topics for the year are as follows:

January 2016	Sustainability Awareness
February 2016	Buildings and Facilities
March 2016	Air Quality
April 2016	Parks and Open Space
May 2016	Sustainable Transportation
June 2016	Natural Resources
July 2016	Community-Schools
August 2016	Climate Change Adaptation and Resiliency
September 2016	Energy Efficiency and Greenhouse Gas (GHG) Reduction
October 2016	Community - Health and Wellness
November 2016	Waste Management and Recycling
December 2016	Tenants

If you haven't received a 2016 Calendar or would like additional copies to distribute, please contact Jacob Glickel at jglickel@massport.com.

Recycling Empty Barrels of Firefighting Foam

Massport Facilities and Fire Rescue have given a second life to empty barrels of firefighting foam. Ten barrels are being repurpose at the Mass Audubon's Blue Hills Trailside Museum Center in Milton. The barrels are now being used to hold sand to keep the trails open during the winter months.

Great Job to all involved!

Safe Winter Driving

The three P's of Safe Winter Driving:

PREPARE for the trip; PROTECT yourself; and PREVENT crashes on the road

PREPARE

- Check tire tread, headlights, brake lights, windshield wipers and windshield washer fluid prior to driving.
- Completely clear snow and ice off your car – including windows, mirrors, lights, reflectors, hood, roof and trunk.
- Have a snow brush and ice scraper in your vehicle.

PROTECT YOURSELF

- Always use your seat belt while driving or when you are a passenger in a moving vehicle.
- Watch for ice when stepping in and out of the vehicle. Most falls happen when getting in and out of vehicles during the winter months. Use three points of contact while getting in and out and use caution.
- Always wear high visibility clothing when working around vehicles at roadways, garages, container yards and ramp areas.
- Make sure your exhaust pipe is clear of snow. There is danger of carbon monoxide poisoning if snow blocks the pipe while idling. Remember- do not idle more than 5 minutes per MassDEP regulation.

PREVENT CRASHES

- Stopping distances are longer on snow and ice. Slow down and increase distances between vehicles.
- Keep your eyes open for pedestrians walking in the road. Visibility can be low during snow storms. Use caution around terminal and ramp areas where pedestrians could be in or near the road.
- Drive with your headlights on and be sure to keep them clean to improve visibility.
- Use caution when snow banks limit your view of oncoming traffic.
- Be cautious on bridges and overpasses as they are commonly the first areas to become icy.
- Remember that speed limits are meant for dry roads, not roads covered in snow and ice. You should reduce your speed and increase your following distance as road conditions and visibility worsen.

2015 DERA Grant Award, Conley Terminal

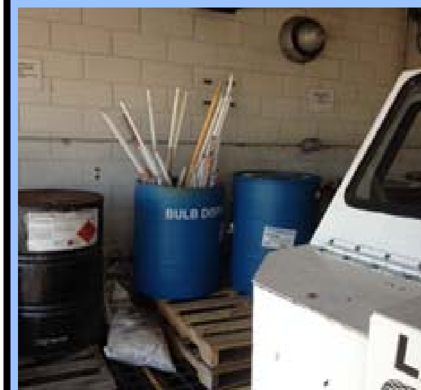
The Massport Maritime Department and the Environmental Management Unit worked collaboratively to secure an EPA grant that will allow for the replacement of diesel generators in five (5) Rubber Tire Gantry Cranes (RTGs) at Conley Terminal in South Boston. This grant was made possible under the Diesel Emissions Reduction Act (DERA) and will contribute $333,185 toward the cost of the project. This was the only project in New England to be selected for FY2015 DERA funding.

This grant will allow Massport to replace five older, Tier III diesel powered generators with current EPA Tier-4F certified units. Along with extending the service life of this critical equipment, Conley Terminal and surrounding communities in South Boston will benefit from reduced air emissions. The new generators represent a significant improvement over the existing units because they emit less emissions while operating and will be equipped with a fuel saver system which will reduce fuel use during standby time. Annually, the new Tier-4F engines are expected to conserve approximately 2,800 gallons of diesel fuel and reduce emissions of nitrogen oxides, particulate matter and carbon dioxide by an estimated 8 tons, 0.5 tons and 155 tons, respectively. The grant funding was formally presented to Massport by the U.S. EPA during a press conference on Friday, December 4th, 2015 at Conley Terminal.

The retrofit of RTGs at Conley Terminal follows on the success of the Massport Clean Truck program. In 2007, Massport and the EPA established a "Clean Truck" program giving owners of older trucks servicing Conley Terminal an incentive to replace the vehicles with ones that are 2007 emission compliant or newer. A total of $1.5 million, including a $500,000 EPA DERA grant provides truck owners with 50 percent of the replacement cost up to $25,000 of older trucks. So far 55 trucks, some up to 25 years old, have been replaced with new models that dra-

Compliance Corner

Universal Waste Compliance



Do you know the difference between Hazardous Waste and Universal Waste?

Many Massport tenants generate regulated universal waste and don't even realize it! Generation of universal waste can come from businesses that utilize administrative office space, storage, restaurants and retail stores. In fact, it is called universal waste because it is generated by nearly every type of business entity and many homeowners as well.

Universal waste is a type of hazardous waste and its storage, handling, transportation and disposal are regulated. However, because of the relatively low hazard associated with these wastes and the large number of entities generating this material, universal waste is regulated differently with reduced compliance requirements compared to those for hazardous waste.

Examples of Universal Waste are:

Used light bulbs (fluorescent tubes, compact fluorescent, halogen, metal halide, high/low pressure sodium and mercury vapor)

Used Batteries (most rechargeable batteries and lead acid batteries)

Mercury Containing Equipment (thermostats, thermometers, barometers, mercury switches, etc.)

Pesticides (unused or recalled pesticides which are collected as waste)

Much like hazardous waste, the level of regulation is defined by the volume generated. Entities storing in excess of 11,000 lbs at any one time are considered Large Quantity Handlers, while those storing less are considered Small Quantity Handlers. In both cases universal waste can only be stored on site for one year or less and must be collected, labeled and disposed of through a licensed handler or disposal facility. Records should be kept to document proper disposal. **Regulated universal wastes should NEVER be disposed of in trash cans, solid waste dumpsters or single stream recycling containers.**

More information is available at the MassDEP web site at:

http://www.mass.gov/eea/docs/dep/recycle/hazardous/univrule.pdf

If you have any questions or concerns about hazardous waste compliance, contact the Massport Environmental Department.

Questions about Environmental/Safety Issues

Who should you contact?

Contact	Phone Number	Email Address
 **Auditing/General**		
Brenda Enos	(617) 568-5963	benos@massport.com
Universal Waste		
Glenn Adams	(617) 568-3542	gadams@massport.com
Safety		
Brian Dinneen	(617) 568-7427	bdinneen@massport.com
Michael McAveeney	(617) 561-3390	mmcaveeney@massport.com
Karisa Hanson	(617) 568-7434	khanson@massport.com
Spill Follow-Up		
James Stolecki	(617) 568-3552	jstolecki@massport.com
NPDES Permitting		
Rosanne Joyce	(617) 568-3516	rjoyce@massport.com
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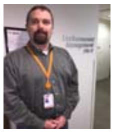 **Air Quality/Hazardous Waste**		
Ian Campbell	(617) 568-3508	icampbell@massport.com
 **EMS/Sustainability/Recycling**		
Jacob Glickel	(617) 568-3558	jglickel@massport.com

Capital Programs and Environmental Affairs

EnviroNews

A Massport Newsletter

Volume 42, Issue 2
May 2016

INSIDE THIS ISSUE:

Logan Annual Sustainability Report

The 2016 Logan Airport Annual Sustainability Report was released on Earth Day, April 22. This report provides a progress summary of sustainability efforts at Boston-Logan International Airport. It highlights notable actions and achievements since the 2015 Sustainability Management Plan was published and characterizes Massport's plans for a Sustainable Massport. As we celebrate our successes this year, we hope that the excitement for sustainability efforts continues to grow throughout the year. Massport strives to be a good neighbor and environmental steward in everything that we do.

The report focuses on progress towards each of Massport's sustainability goals in the following ten resource areas:

- Energy and Greenhouse Gas Emissions
- Water Conservation
- Community, Employee, and Passenger Well-being
- Materials, Waste Management, and Recycling
- Resiliency
- Noise Abatement
- Air Quality Improvement
- Ground Access and Connectivity
- Water Quality/Stormwater
- Natural Resources

Visit www.massport.com/environment to download a copy of the Logan Annual Sustainability Report. If you would like a hard copy please contact Jacob Glickel at jglickel@massport.com.

EnviroNews is a newsletter published quarterly for Massport and its tenants. Your comments and suggestions are welcome. Please contact Brenda Enos (benos@massport.com) at 617-568-5963.

Compliance Corner

Spills of Hazardous Waste and Hazardous Materials

Despite extensive planning, preventive measures and implementation of Best Management Practices (BMPs), spills of hazardous substances sometimes occur at active commercial and industrial facilities. All Massport owned properties have plans in place to respond to and address these incidents. When in doubt over whether or not to clean up a spill, you can ask yourself the following questions:

- *Is this spill inside of a building and on an impervious surface?*
- *Do I know the cause of this spill?*
- *Am I familiar with the material that was spilled and hazards associated with it?*
- *Is the spill below reportable spill quantities (RQ)?*
- *Am I equipped with proper spill supplies , Personal Protective Equipment (PPE) and training to clean up this spill (only if below RQ)*

If you answered no to any of these questions, you must report this spill to Massport. Notification should be made as soon as possible after discovery of the spill.

Any spill entering the storm drainage system or a surface water body must be promptly reported to Massport to ensure that cleanup is completed and any required regulatory reporting is made.

Spills at Massport owned facilities should be called in to the following numbers:

- *Logan Airport:* *Logan Fire Alarm 617-567-2020*
- *Worcester Airport:* *Worcester ARFF, 508-849-5519*
- *Hanscom Field:* *Hanscom Emergency, 781-869-8080*
- *Maritime Properties*: *Massport Port Office, 617-464-8250*

In most cases, spent cleanup supplies, contaminated packaging and recovered spilled material(s) will become regulated hazardous waste at the conclusion of the cleanup activities. Proper handling and disposal of this waste is always the responsibility of the company responsible for the spill. Massport and their spill response contractors can assist with coordination of proper or ownership transportation and disposal of regulated hazardous waste(s) but Massport cannot take responsibility for this waste. It is up to the company responsible for the spill to make proper arrangements for storage, transportation and disposal of spill related waste(s).

More information is available at the MassDEP web site at http://www.mass.gov/eea/agencies/massdep/about/programs/emergency-response-program.html

If you have any questions or concerns about hazardous waste compliance, contact the Massport Environmental Department.

Massport Safety Manual Revised

Safety and Security at all facilities is one of the Massport Top 10 Goals. Massport's Safety and Health Manual supports this goal to eliminate unsafe conditions and minimize the impact of hazardous situations. This Manual can benefit Massport by reducing illness and injury to personnel, preventing property damage, and preserving the environment.

Over the past several months, the Safety Unit has been working with many Departmental Units to update the policies and procedures that comprise the Massport Safety and Health Manual. Since the last version of the Manual was distributed, Massport has grown, some regulations have changed, and new technologies have emerged to minimize incidents.

The latest version of the Safety and Health Manual was distributed this April. In order to minimize paper waste, the manual is available to everyone on the Safety Department's tab of the Massport Portal (http://sharepoint/CapitalPrograms/Safety/default.aspx). A limited number of paper manuals will be made available at select locations for those who do not have access to the Massport Portal.

To support the Manual roll out, we will be covering a topic each month for the next year to review the Policy and Procedure Section. It will be supported with Safety Focus (Tool Box) flyers, training and inspections of Safety Equipment related to the subject.

The manual is a living and fluid document. As we review and implement each Policy and Procedure Section, we encourage comments and suggestions to continually improve the Manual for the entire Massport Community.

Questions about Environmental/Safety Issues

Who should you contact?

Contact	Phone Number	Email Address
 **Auditing/General**		
Brenda Enos	(617) 568-5963	benos@massport.com
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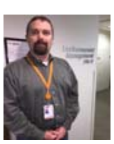 Ian Campbell	(617) 568-3508	icampbell@massport.com
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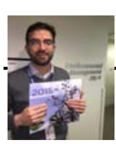
 Jacob Glickel	(617) 568-3558	jglickel@massport.com

Capital Programs and Environmental Affairs

EnviroNews

A Massport Newsletter

Volume 42, Issue 3
August 2016

INSIDE THIS ISSUE:

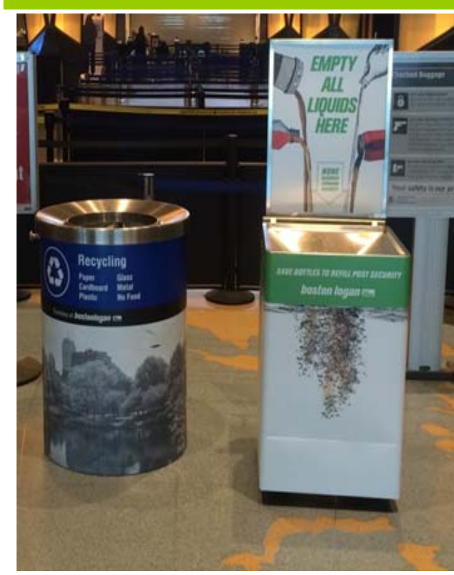
EnviroNews is a newsletter published quarterly for Massport and its tenants. Your comments and suggestions are welcome. Please contact Brenda Enos (benos@massport.com) at 617-568-5963.

Using Soy to Help Keep the Streets Clean

Massport's Fleet Maintenance has been using a bio-based hydraulic fluid in street sweepers serving Logan Airport. Three Elgin Pelican Street Sweepers have been piloting a program on the effectiveness of using a bio-based hydraulic fluid.

Street sweepers are a work horse of the Logan fleet, keeping all the roads and parking lots clean. Bill Crowley, Supervisor for Fleet Maintenance, was looking for a natural alternative that didn't hinder performance. Beginning in July 2015, Bill began the pilot program with one street sweeper and expanded to all three in early 2016. The soy-based hydraulic fluid is more environmentally friendly and, in the event of a release to the environment, easier to clean up. Bill is looking into expanding the use of bio-based hydraulic fluids in other vehicles.

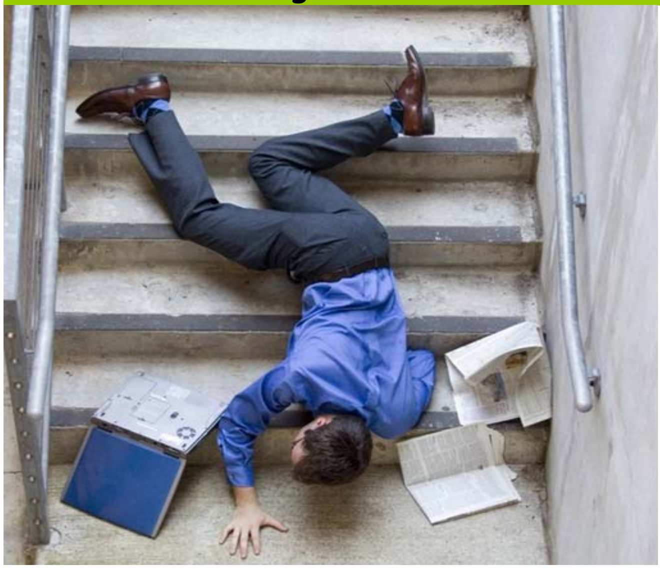
Pour Your Liquid Here



To improve recycling and reduce waste, Massport has installed collection stations at select security checkpoints in Terminals A, C and E. The first two stations in Terminal C were installed in April 2016, and have already collected over 3,000 gallons of liquid that would have normally gone in the trash. Massport expanded to two new locations in Terminal A and E in July.

With the increase in security precautions over the past decade, water and other drinks are not allowed through security checkpoints. Some passengers drink the remaining drops of their drink, but most throw bottle and the remaining liquid in the trash. With the liquid collection stations, passengers are now able to empty their bottles and refill them on the secure side for the remainder of their journey. Operationally, Massport will save on trash hauling costs, increase the recycling rate and reduce the weight of the trash bags for the cleaners, thereby preventing any potential back injuries.

Distracted Walking



A quick internet search of "Distracted Walking" brings up a number of example videos of people falling and potentially being injured. These videos range from the humorous (people walking into mall water fountains) to disturbing (people falling onto train tracks). It has become such a big problem in recent years the National Safety Council, for the first time, has included statistics on cell phone distracted walking.

According to the National Safety Council's *Injury Facts*, distracted walking incidents involving cell phones accounted for more than 11,100 injuries between 2000 and 2011.

- 52% of cell phone distracted walking injuries happen at home
- 68% of those injured are women
- 54% are age 40 or younger
- Nearly 80% of the injuries were due to a fall

This trend will surely continue as more and more of the population begins to use hand held devices and games like *Pokémon GO* become more popular. All of us have seen people using their hand-held devise while walking down the sidewalk, on stairs, and on escalators. Most of us have probably done this as well. It is important to realize that just because we did something yesterday and didn't get hurt, doesn't mean we will have the same outcome today. Hand-held devices are preventing people from seeing potential hazards in front of them. The National Safety Council recommends:

- Never use your hand-held device on stairs and escalators
- Never use a cell phone or other electronic device while walking indoors or outside
- Only cross at designated crosswalks
- Look left, right and left again before crossing the street
- Make eye contact with drivers of oncoming vehicles to make sure they see you
- Never rely on a car to stop
- Don't wear headphones while walking
- Wear bright and/or reflective clothing
- Walk in groups

Walking is a great way to stay healthy, but only if we are smart about it.

Compliance Corner

Refrigerant Management

With typical summertime weather here, we all appreciate having air conditioned spaces where we can escape the heat and humidity. Historically, air conditioning systems have relied on chemicals such as ammonia, carbon dioxide, and others to create a cooling effect. However, modern air conditioning systems rely almost entirely on less toxic synthetic gases called refrigerants. Environmental compliance issues surrounding air conditioning systems have been around since the early 20th Century, originally related to the toxic nature of gases like ammonia when they escaped from their closed-loop systems. With the advent of Freon (chlorofluorocarbons) in the early 20th Century, it was thought that a safe alternative had been found. Unfortunately, even though chlorofluorocarbons do not have immediate toxic effects on people or animals, they do contribute to the depletion of stratospheric ozone. Newer refrigerants have proven to be safer to the ozone layer but have been found more recently to be powerful contributors to global warming.

The important takeaway from all this is although refrigerants do a great job when contained properly, they cause a lot of harm when released to the environment. Since 1990, the Clean Air Act has been used to phase out more harmful refrigerants while encouraging the development and use of newer, less harmful alternatives. Technicians handling refrigerants and servicing refrigerant containing equipment must be certified and use approved equipment for containing refrigerant gas. Intentional venting of refrigerant gas to the atmosphere is illegal!

Even though some refrigerants are available for purchase at retail locations, they are still regulated by the EPA and are harmful to the environment if released. It is the responsibility of the equipment owner to make sure that refrigerant and refrigerant-containing equipment is properly handled to avoid releases to the environment. Prior to disposal of refrigerant-containing equipment, all refrigerant must be properly removed by a licensed technician. Once refrigerant is removed, the piece of equipment is tagged indicating that it no longer contains refrigerant and can be recycled, generally as scrap metal.

Business owners need to ensure that, prior to being placed into dumpsters or recycling containers, refrigerant is removed and the equipment is clearly labeled indicating this. Homeowners can utilize community hazardous waste collection days, hire a licensed contractor or drop off their equipment at a designated drop off location such as a solid waste transfer station.

More information is available at the U.S. EPA website at:

https://www.epa.gov/section608/managing-refrigerant-stationary-refrigeration-and-air-conditioning-equipment

If you have any questions or concerns about refrigerant compliance, contact the Massport Environmental Department at (617) 568-3525.

2016 Safety Fair

SEPTEMBER 21, 2016
10:30 TO 14:30
JetBlue Hangar (Hangar 8)*

***Directly across from the North Gate.**
Accessible from Airside and Landside.
Badged and unbadged employees are welcome!
Parking is limited. Accessible using Massport Economy Parking or Employee Shuttle Buses.

The 2016 SAFETY FAIR is sponsored by the Logan Airport Safety Alliance and JetBlue.

Questions: Contact Brian Dinneen, Massport Safety Manager at 617-568-7427 or bdinneen@massport.com.

SEE A SAFETY PROBLEM? REPORT IT ANONYMOUSLY. RAMP SAFETY HOTLINE

617-568-3600

Questions about Environmental/Safety Issues

Who should you contact?

Contact	Phone Number	Email Address
 **Auditing/General**		
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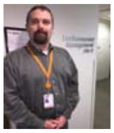 **Air Quality/Hazardous Waste**		
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 **EMS/Sustainability/Recycling**		
Jacob Glickel	(617) 568-3558	jglickel@massport.com

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2016 and 2017 Peak Period Pricing Monitoring Report

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BOSTON-LOGAN INTERNATIONAL AIRPORT MONITORING REPORT ON SCHEDULED AND NON-SCHEDULED FLIGHT ACTIVITY

Peak Period Surcharge Regulation 740 CMR 27:00: Massachusetts Port Authority

Report Number:	**013**
Monitoring Period:	**Through Sept. 2016**
Report Issue Date:	**May 2016**

Note: This report reflects the Boston-Logan Airport flight activity monitoring under 740 CMR 27.03 Peak Period Surcharge Regulation on Aircraft Operations at Boston-Logan International Airport.

Findings: This report includes actual and projected activity data **through September 2016**. Current and projected near-term flight levels at Boston Logan are well below Logan's good weather (VFR) throughput of approximately 120 flights per hour. **As a result, average VFR delays are projected to be minimal and well below the 15 minutes threshold through the analysis period.**

In the event demand conditions at the airport change significantly from the current projection, Massport will issue updates to this report.

Attachments

Table 1: Summary Overview of Peak Period Surcharge Program

Table 2: Summary Overview of Forecast Methodology

Table 3: Projected Aircraft Operations at Logan Airport Projected

Table 4: Projected Hourly Operations, Average Weekday

Table 5: Forecast Logan Average Weekday Operations

Massport Contact:

Mr. Flavio Leo
Director, Aviation Planning and Strategy
617-568-3528
fleo@massport.com

Table 1: Summary Overview of Peak Period Surcharge Program

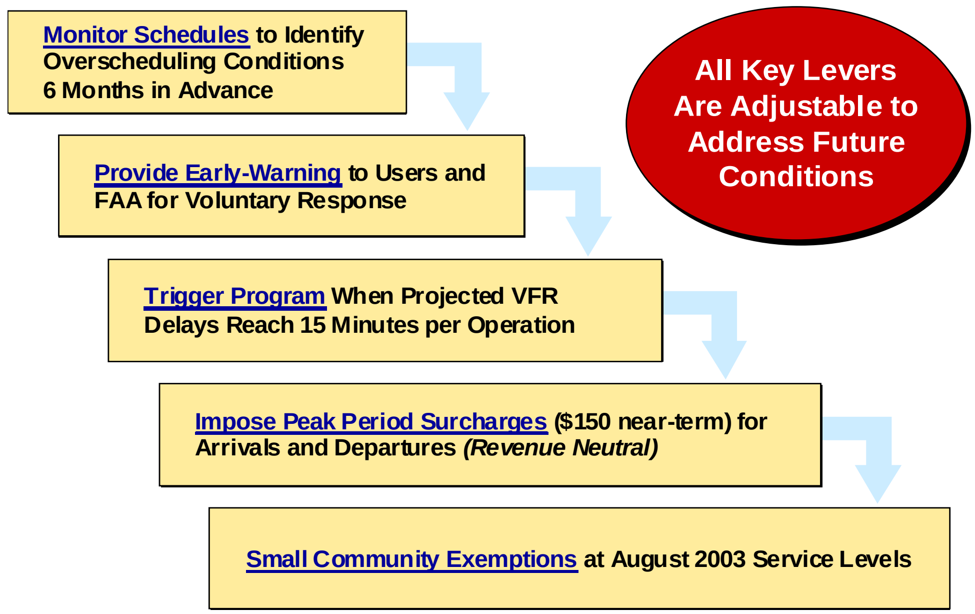
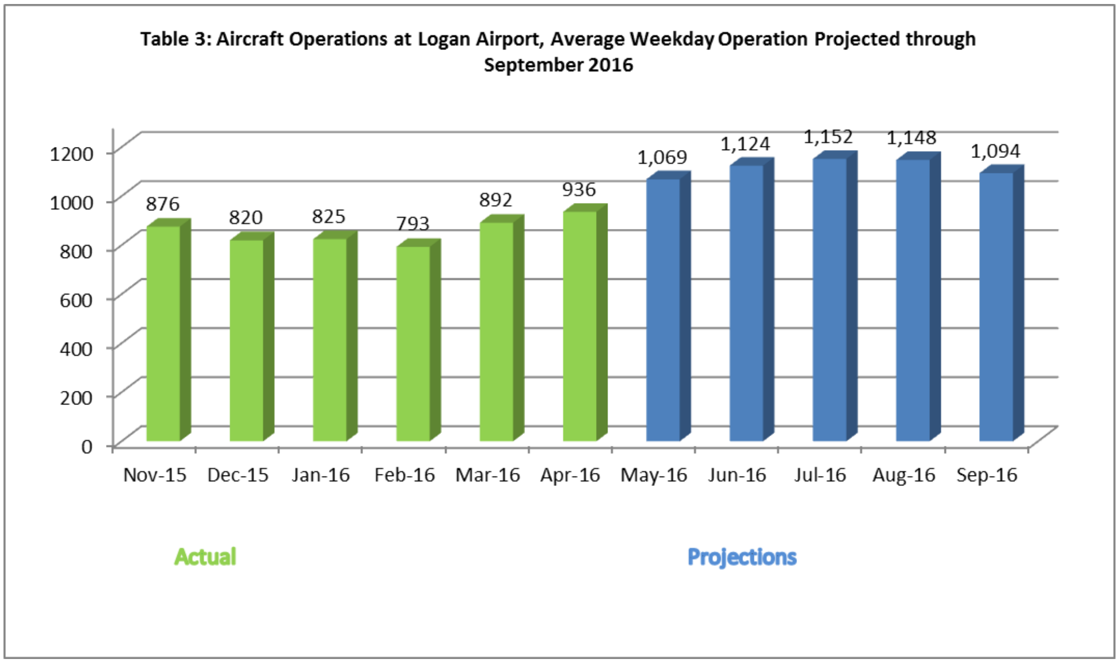


Table 2: Summary Overview of Forecast Methodology

- Scheduled passenger airline flights represent more than 93 percent of total aircraft operations. Passenger airline activity for the Spring and Summer periods were projected based on published advance airline schedules
- Forecasts of monthly activity for other segments (GA, Cargo, Charter) are based on the past three months of actual flight volume and historic patterns of monthly seasonality
- Day-of-week and time of day distributions for non-scheduled segments are based on analysis of Logan radar data
- Projections for each segment were combined to produce the forecast pattern of hourly flight activity for an average weekday, Saturday, and Sunday for the period from February through September

Table 3: Aircraft Operations at Logan Airport



Note: Actual Operations are based on Massport data/air carrier reports and reflect flight cancellations due to weather and other operational impacts.

Table 4: Projected Hourly Operations

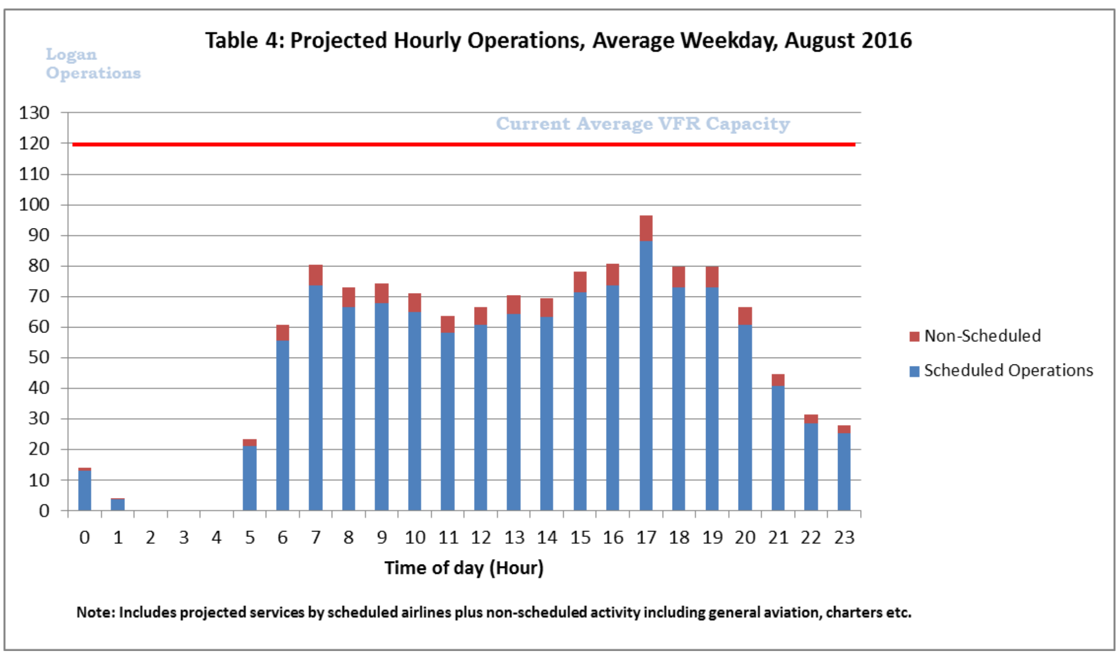


Table 5: Forecast Logan Average Weekday Operations, *Feb. – Sep.*

Forecast Daily Operations								
Hour Range	**Feb-16**	**Mar-16**	**Apr-16**	**May-16**	**Jun-16**	**Jul-16**	**Aug-16**	**Sep-16**
0	14	14	12	16	16	16	13	11
1	3	4	3	2	3	4	4	3
2	2	1	0	1	0	0	0	0
3	1	0	0	0	0	0	0	0
4	1	1	0	0	0	0	0	0
5	14	19	17	18	23	26	21	16
6	38	45	51	54	54	58	56	53
7	45	50	58	68	71	66	73	69
8	49	54	76	65	63	66	67	65
9	48	56	63	68	68	71	68	67
10	43	45	45	58	63	66	65	57
11	42	49	50	48	55	57	58	57
12	39	45	52	50	57	61	61	57
13	41	47	53	60	63	61	64	62
14	37	42	55	58	63	66	63	65
15	42	51	59	61	68	70	71	66
16	50	55	66	73	80	81	74	70
17	54	61	79	82	84	87	88	85
18	50	57	75	70	70	71	73	73
19	47	54	64	74	73	75	73	70
20	46	49	52	49	55	58	61	58
21	36	38	35	39	40	38	41	36
22	27	31	25	28	28	31	29	30
23	25	24	30	25	27	24	25	23
Total	**793**	**892**	**1,020**	**1,069**	**1,124**	**1,152**	**1,148**	**1,094**

February – April, actual data

May – September, forecast data

BOSTON-LOGAN INTERNATIONAL AIRPORT MONITORING REPORT ON SCHEDULED AND NON-SCHEDULED FLIGHT ACTIVITY

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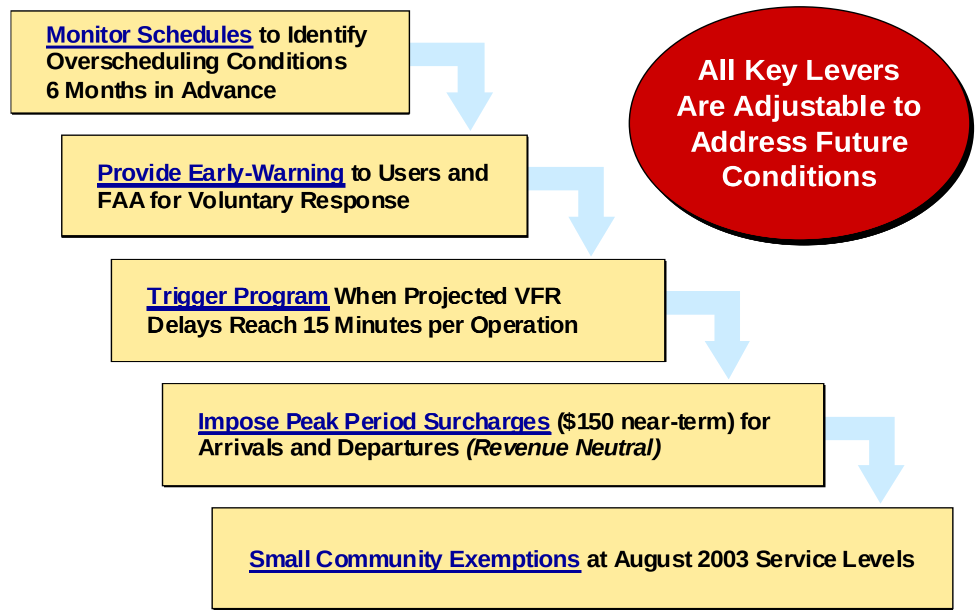

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Table 3: Aircraft Operations at Logan Airport

Note: Actual Operations are based on Massport data/air carrier reports and reflect flight cancellations due to weather and other operational impacts.

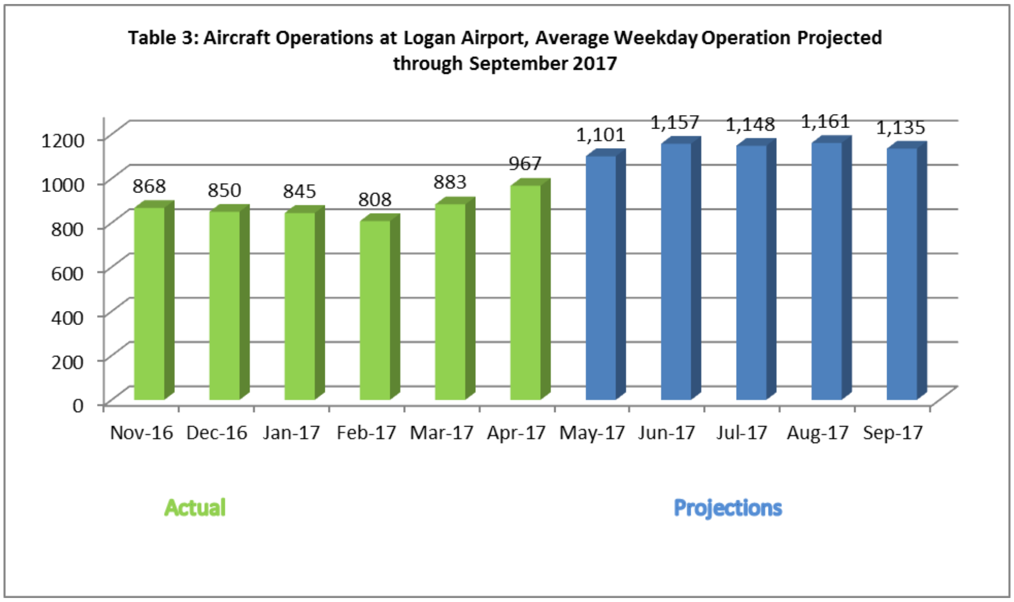

Table 4: Projected Hourly Operations

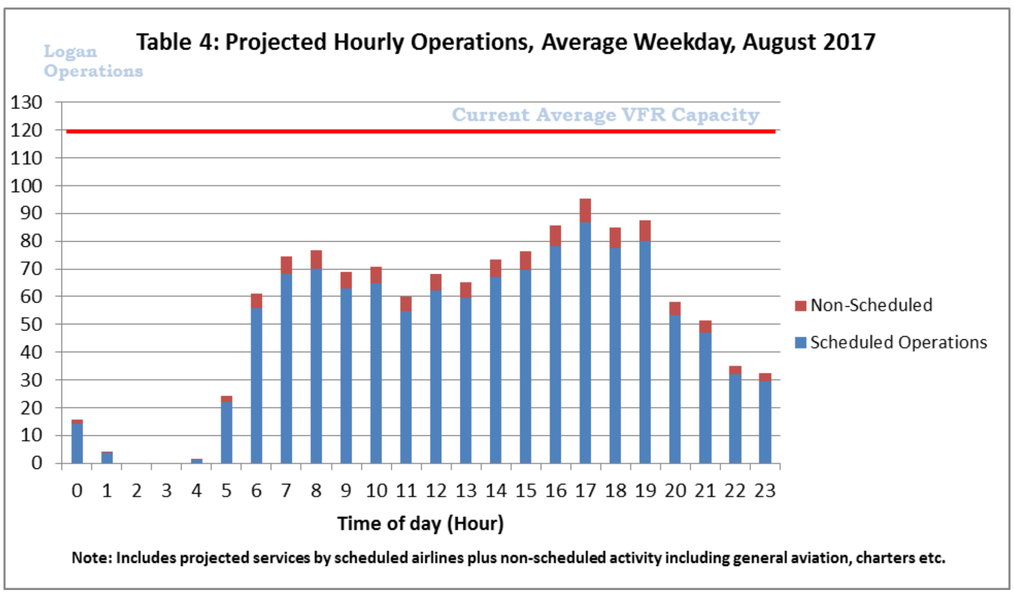

Table 5: Forecast Logan Average Weekday Operations, *Feb. – Sep.*

Forecast Daily Operations								
Hour Range	**Feb-17**	**Mar-17**	**Apr-17**	**May-17**	**Jun-17**	**Jul-17**	**Aug-17**	**Sep-17**
0	9	14	12	11	15	16	14	12
1	3	4	3	5	5	5	4	3
2	0	1	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	2	2	0	0	0	0	1	1
5	12	17	18	21	27	30	22	18
6	39	47	54	53	55	52	56	52
7	46	49	61	64	66	66	68	76
8	44	47	80	67	67	64	70	66
9	45	52	66	64	65	63	63	65
10	43	47	48	62	68	66	65	58
11	44	43	53	50	52	53	55	56
12	37	39	55	60	62	62	62	62
13	41	45	56	63	61	57	59	65
14	42	45	57	63	68	68	67	63
15	48	50	62	66	70	67	70	62
16	57	55	70	78	77	82	78	79
17	57	58	83	77	87	86	87	87
18	52	59	79	74	75	69	78	78
19	51	56	67	77	82	81	80	75
20	48	52	55	43	48	52	53	48
21	40	41	36	44	47	46	47	45
22	27	34	26	34	35	33	32	33
23	20	25	31	25	28	28	30	29
Total	**808**	**883**	**1,071**	**1,101**	**1,157**	**1,148**	**1,161**	**1,135**
	February - Apr are actual data							
	May - September is forecast data							

L

Reduced/Single Engine Taxiing at Logan Airport Memoranda

This Appendix provides detailed information in support of Chapter 7, *Air Quality/ Emissions Reduction:*

- Memorandum from Edward C. Freni, Massport Director of Aviation, to the Boston Logan Airline Committee, Regarding Single/Reduced-Engine Taxiing and the Use of Idle Reverse Thrust as Strategies to Reduce Aircraft-Generated Emissions and Noise at Boston Logan, Dated May 18, 2016
- Memorandum from Edward C. Freni, Director of Aviation, To Boston Logan Air Carriers and Chief Pilots, Single/Reduced-Engine Taxiing and Other Strategies to Reduce Aircraft-Generated Emissions and Noise at Boston Logan, Dated May 30, 2017
- Simaiakis, I, Khadilkar, H., Balakrishnan, H., Reynolds, T.G., Hansman, R.J., Reilly, B., and Urlass, S. "Demonstration of Reduced Airport Congestion Through Pushback Rate Control." *Ninth USA/Europe Air Traffic Management Research and Development Seminar (ATM2011)*.

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Massachusetts Port Authority
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East Boston, MA 02128-2909
Telephone (617) 568-5000
www.massport.com

To: Boston Airline Committee

From: Edward C. Freni
Director of Aviation

Date: May 18, 2016

RE: Single/Reduced-Engine Taxiing and Other Strategies to Reduce Aircraft- Generated Emissions and Noise at Boston Logan

As an important user of Boston-Logan International Airport ("Boston Logan"), you are an essential partner in our efforts to ensure that Boston Logan operates in the safest, most dependable and environmentally responsible manner feasible. Our success in implementing physical and technological improvements and piloting cutting-edge safety enhancements at Boston Logan is based, in part, on continuing to evaluate and promote operational measures with the potential to reduce environmental impacts from various landside and airside operations.

Important measures that have been identified are:

1.) Single/reduced-engine taxiing,
2.) Use of idle-reverse thrust, and
3.) Retrofitting older A320 aircraft with "vortex generators" to reduce aircraft noise.

Based on outreach to the Logan air carrier community, it is clear that single- or reduced-engine taxiing is being voluntarily implemented by the vast majority of air carriers at Boston Logan. I write to you again to encourage your continued use of this fuel-saving emissions reduction strategy, subject to pilot discretion and to the extent consistent with your established operating safety procedures.

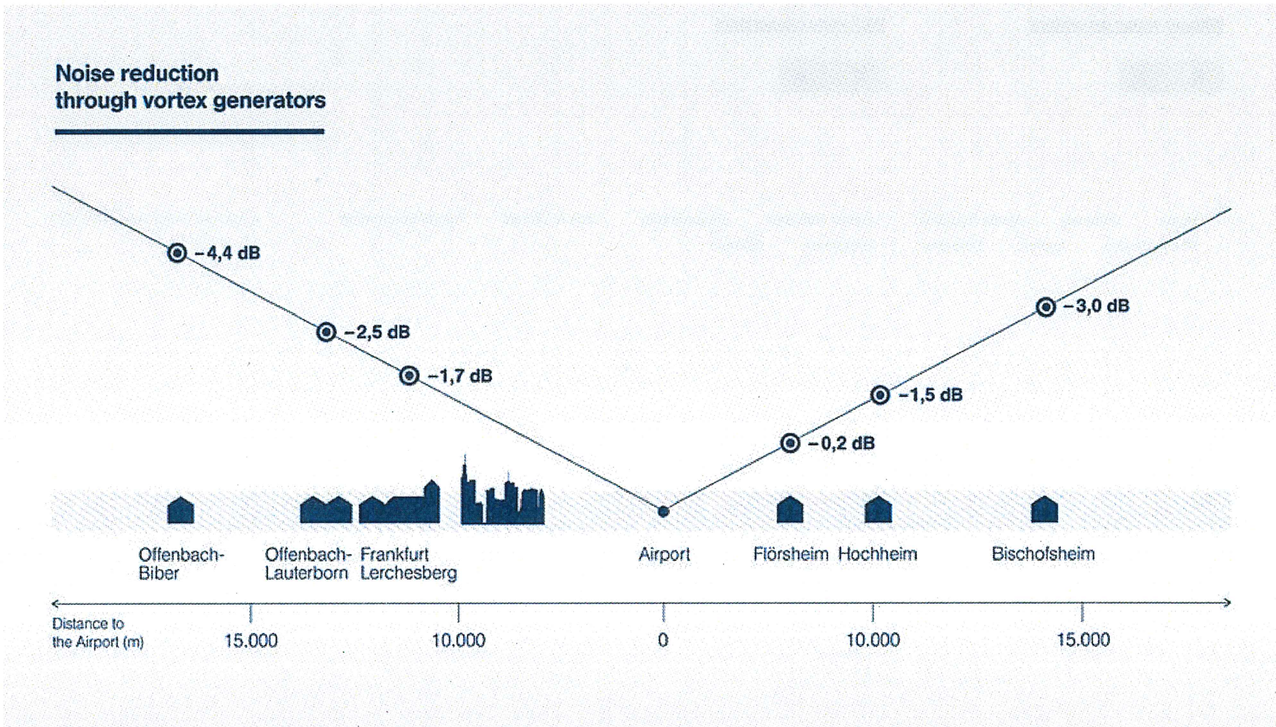
I also encourage your use of idle reverse thrust (or minimize the use of reverse thrust) on landing, as a second operational measure, again, only at the discretion of the pilot and only to the extent consistent with your established operational safety procedures. This measure provides noise relief to our nearest neighbors and, at the same time, provides companion benefits to you, such as reducing fuel burn and engine wear. Clearly, the use of this procedure must be consistent with operational conditions at Boston Logan, including runway surface conditions and whether LAHSO is in use.

Finally, I again want to share with you information regarding recent industry efforts to retrofit A320 aircraft with "vortex generators" to reduce airframe noise. Although the A320 is a fully noise-compliant/modern aircraft, this is an excellent example of additional, incremental actions we can take as an industry to reduce operational impacts on the environment. Attached please find more information related to this technology.

Thank you for your continued work to enhance Boston Logan's operational safety and efficiency, while improving its environmental footprint. If you have any questions or would like to discuss any aspect of this letter, please feel free to contact me or Mr. Flavio Leo, Director of Planning and Strategy, at 617-568-3528.

Edward C. Freni
Director of Aviation

Attachments



Retrofitting the existing fleet

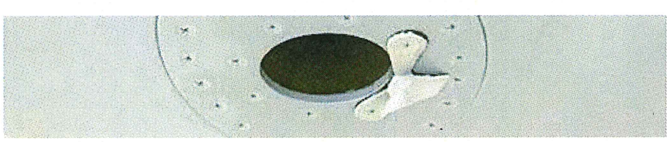
The Lufthansa Group is also retrofitting older aircraft in its fleet with noise-reducing technologies. In this connection the Group is working closely with the German Aerospace Center (DLR) and the various aircraft manufacturers.

Lufthansa is retrofitting more than 200 aircraft with vortex generators so that they will fly more quietly in the future.

In February 2014 Lufthansa became the first airline in the world to take delivery of an Airbus A320 equipped with vortex generators. A total of 157 aircraft in the existing fleet will be equipped with the new noise-reducing component, so that, when the expected new deliveries are added in, more than 200 A320 aircraft in total will be flying more quietly. As result, every second Lufthansa landing in Frankfurt and one in three in Munich will become audibly quieter. Overfly measurements revealed that the vortex generators are able to eliminate two unpleasant tones and thereby lower the aircraft's total noise level on approach by up to four decibels at distances between 17 and 10 kilometers from the runway. Thus the Lufthansa Group has realized a key objective of the "Alliance for More Noise Protection", a joint initiative of the Lufthansa Group, Fraport, the airline association BARIG, DFS, the Airport and Region Forum (FFR), and the government of the State of Hesse.

A320 audio tests

A320 audio tests with and without vortex generators on the **final approach at Frankfurt Airport** from the Offenbach-Lauterborn monitoring point



Press Releases

25.06.2015
Lufthansa now flying much quieter

12.02.14
Lufthansa takes delivery of world's first aircraft with vortex generators

29.10.13
Lufthansa to make majority of short-haul aircraft quieter

Sustainability Report

To find out more about responsibility within the Lufthansa Group, read the latest sustainability report Balance (E-Paper).

Order or download the report.

Weitersagen

More Themes

Overview

Without vortex generators **With vortex generators**

A320 audio tests with and without vortex generators on the **final approach at Munich Airport** from the Massenhausen monitoring point

Without vortex generators **With vortex generators**

Massachusetts Port Authority
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Telephone (617) 568-5000
www.massport.com

TO: Boston Logan Air Carriers, Chief Pilots

FROM: Edward C. Freni
Director of Aviation

DATE: May 30, 2017

RE: Single/Reduced-Engine Taxiing and Other Strategies to Reduce Aircraft-Generated Emissions and Noise at Boston Logan

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I encourage you to share this letter with your flight crews and thank you for your continued work to enhance Boston Logan's operational safety and efficiency, while improving its environmental footprint. If you have any questions or would like to discuss any aspect of this letter, please feel free to contact me or Mr. Flavio Leo, Director of Planning and Strategy, at 617-568-3528.

Edward C. Freni
Director of Aviation

Attachment

An even quieter approach: Airbus introduces air flow deflectors on the A320 Family

10 JULY 2014 NEWS IN BRIEF

Building on the A320 Family's established reputation for quiet operations, Airbus is reducing noise levels even further for its popular single-aisle product line with the introduction of small underwing air flow deflectors. Positioned just ahead of underwing cavities for the fuel over-pressure protection system, these devices prevent the cavities from generating a "whistling" sound which can sometimes be heard on the ground when the engines are at idle during final approach. Air flow deflectors were implemented in production A320 jetliners this spring and are also available as a retrofit modification.

Tags : INNOVATION A320 FAMILY NOISE

Demonstration of Reduced Airport Congestion Through Pushback Rate Control

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***Abstract*—Airport surface congestion results in significant increases in taxi times, fuel burn and emissions at major airports. This paper describes the field tests of a congestion control strategy at Boston Logan International Airport. The approach determines a suggested rate to meter pushbacks from the gate, in order to prevent the airport surface from entering congested states and to reduce the time that flights spend with engines on while taxiing to the runway. The field trials demonstrated that significant benefits were achievable through such a strategy: during eight four-hour tests conducted during August and September 2010, fuel use was reduced by an estimated 12,000-15,000 kg (3,900-4,900 US gallons), while aircraft gate pushback times were increased by an average of only 4.3 minutes for the 247 flights that were held at the gate.**

Keywords- departure management, pushback rate control, airport congestion control, field tests

I. Introduction

Aircraft taxiing on the surface contribute significantly to the fuel burn and emissions at airports. The quantities of fuel burned, as well as different pollutants such as Carbon Dioxide, Hydrocarbons, Nitrogen Oxides, Sulfur Oxides and Particulate Matter, are proportional to the taxi times of aircraft, as well as other factors such as the throttle settings, number of engines that are powered, and pilot and airline decisions regarding engine shutdowns during delays.

Airport surface congestion at major airports in the United States is responsible for increased taxi-out times, fuel burn and emissions [1]. Similar trends have been noted in Europe, where it is estimated that aircraft spend 10-30% of their flight time taxiing, and that a short/medium range A320 expends as much as 5-10% of its fuel on the ground [2]. Domestic flights in the United States emit about 6 million metric tonnes of CO_2, 45,000 tonnes of CO, 8,000 tonnes of NOx, and 4,000 tonnes of HC taxiing out for takeoff; almost half of these emissions are at the 20 most congested airports in the country. The purpose of the Pushback Rate Control Demonstration at Boston Logan International Airport (BOS) was to show that a significant portion of these impacts could be reduced through measures to limit surface congestion.

This work was supported by the Federal Aviation Administration's Office of Environment and Energy through MIT Lincoln Laboratory and the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER).

A simple airport congestion control strategy would be a state-dependent pushback policy aimed at reducing congestion on the ground. The *N-control* strategy is one such approach, and was first considered in the Departure Planner project [3]. Several variants of this policy have been studied in prior literature [4, 5, 6, 7]. The policy, as studied in these papers, is effectively a simple threshold heuristic: if the total number of departing aircraft on the ground exceeds a certain threshold, further pushbacks are stopped until the number of aircraft on the ground drops below the threshold. By contrast, the *pushback rate control* strategy presented in this paper does not stop pushbacks once the surface is in a congested state; instead it regulates the rate at which aircraft pushback from their gates during high departure demand periods so that the airport does not reach undesirable highly congested states.

A. Motivation: Departure throughput analysis

The main motivation for our proposed approach to reduce taxi times is an observation of the performance of the departure throughput of airports. As more aircraft pushback from their gates onto the taxiway system, the throughput of the departure runway initially increases because more aircraft are available in the departure queue. However, as this number, denoted N, exceeds a threshold, the departure runway capacity becomes the limiting factor, and there is no additional increase in throughput. We denote this threshold as N^*. This behavior can be further parameterized by the number of arrivals. The dependence of the departure throughput on the number of aircraft taxiing out and the arrival rate is illustrated for one runway configuration in Figure 1 using 2007 data from FAA's Aviation System Performance Metrics (ASPM) database. Beyond the threshold N^*, any additional aircraft that pushback simply increase their taxi-out times [8]. The value of N^* depends on the airport, arrival demand, runway configuration, and meteorological conditions. During periods of high demand, the pushback rate control protocol regulates pushbacks from the gates so that the number of aircraft taxiing out stays close to a specified value, N_{ctrl}, where $N_{\text{ctrl}} > N^*$, thereby ensuring that the airport does not reach highly-congested states. While the choice of N_{ctrl} must be large enough to maintain runway utilization, too large a value will be overly conservative, and result in a loss of benefit from the control strategy.

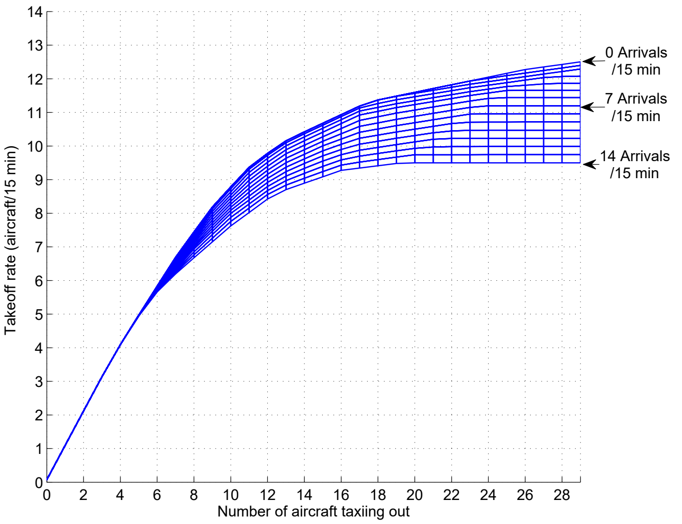

Fig. 1: Regression of the departure throughput as a function of the number of aircraft taxiing out, parameterized by the arrival rate for 22L, 27 | 22L, 22R configuration, under VMC [9].

II. Design of the pushback rate control protocol

The main design consideration in developing the pushback rate control protocol was to incorporate effective control techniques into current operational procedures with minimal additional controller workload and procedural modifications. After discussions with the BOS facility, it was decided that suggesting a rate of pushbacks (to the BOS Gate controller) for each 15-min period was an effective strategy that was amenable to current procedures.

The two important parameters that need to be estimated in order to determine a robust control strategy are the N^* threshold and the departure throughput of the airport for different values of N. These parameters can potentially vary depending on meteorological conditions, runway configuration and arrival demand (as seen in Figure 1), but also on the fleet mix and the data sources we use.

A. Runway configurations

BOS experiences Visual Meteorological Conditions (VMC) most of the time (over 83% of the time in 2007). It has a complicated runway layout consisting of six runways, five of which intersect with at least one other runway, as shown in Figure 2. As a result, there are numerous possible runway configurations: in 2007, 61 different configurations were reported. The most frequently-used configurations under VMC are 22L, 27 | 22L, 22R; 4L, 4R | 4L, 4R, 9; and 27, 32 | 33L, where the notation 'R1, R2 | R3, R4' denotes arrivals on runways R1 and R2, and departures on R3 and R4. The above configurations accounted for about 70% of times under VMC.

We note that, of these frequently used configurations, 27, 32 | 33L involves taxiing out aircraft across active runways. Due to construction on taxiway "November" between runways 15L and 22R throughout the duration of the demo, departures headed to 22R used 15L to cross runway 22R onto taxiway

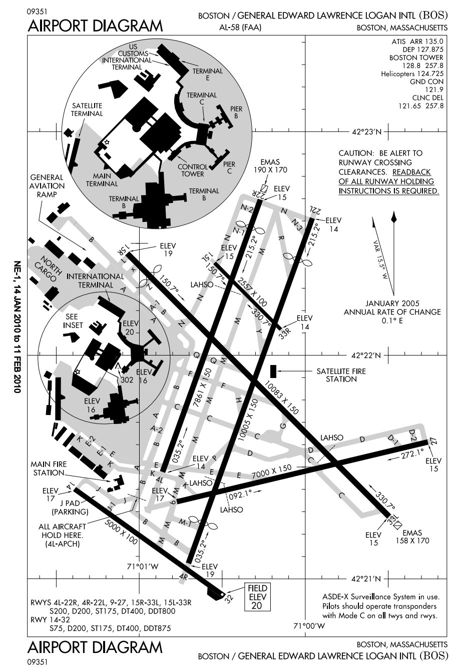

Fig. 2: BOS airport diagram, showing alignment of runways.

"Mike". This resulted in departing aircraft crossing active runways in the 27, 22L | 22L, 22R configuration as well.

During our observations prior to the field tests as well as during the demo periods, we found that under Instrument Meteorological Conditions (IMC), arrivals into BOS are typically metered at the rate of 8 aircraft per 15 minutes by the TRACON. This results in a rather small departure demand, and there was rarely congestion under IMC at Boston during the evening departure push. For this reason, we focus on configurations most frequently used during VMC operations for the control policy design.

B. Fleet mix

Qualitative observations at BOS suggest that the departure throughput is significantly affected by the number of propeller-powered aircraft (props) in the departure fleet mix. In order to determine the effect of props, we analyze the tradeoff between takeoff and landing rates at BOS, parameterized by the number of props during periods of high departure demand.

Figure 3 shows that under Visual Meteorological Conditions (VMC), the number of props has a significant impact on the departure throughput, resulting in an increase at a rate of nearly one per 15 minutes for each additional prop departure. This observation is consistent with procedures at BOS, since air traffic controllers fan out props in between jet departures, and therefore the departure of a prop does not significantly interfere with jet departures. The main implication of this observation for the control strategy design at BOS was that props could be exempt from both the pushback control as well as the counts of aircraft taxiing out (N). Similar analysis also shows that heavy departures at BOS do not have a significant

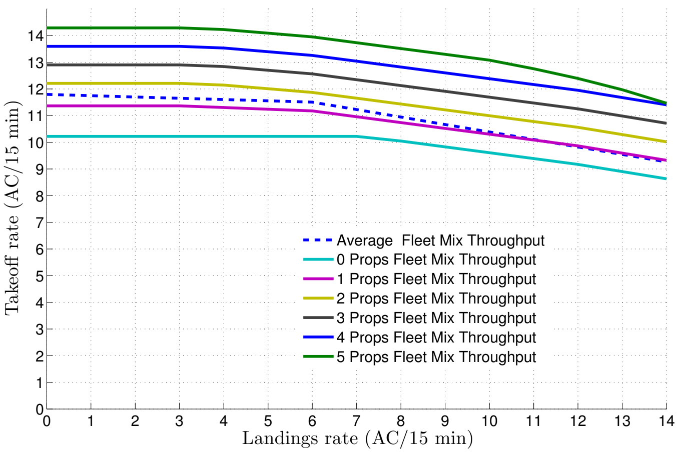

Fig. 3: Regression of the takeoff rate as a function of the landing rate, parameterized by the number of props in a 15-minute interval for 22L, 27 | 22L, 22R configuration, under VMC [9].

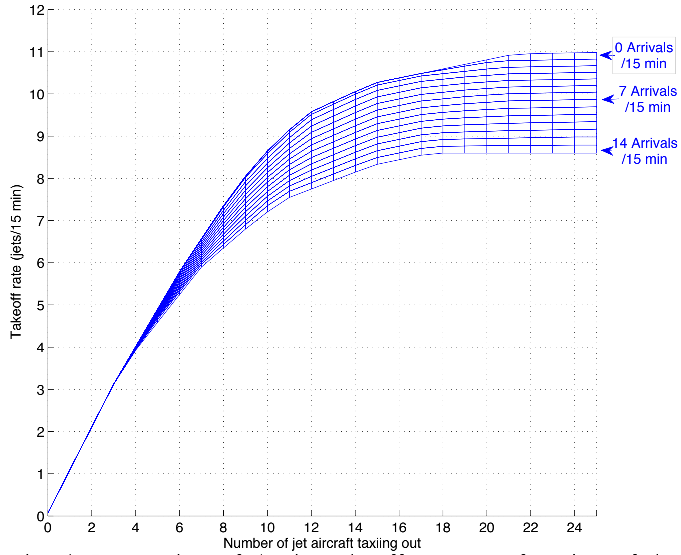

Fig. 4: Regression of the jet takeoff rate as a function of the number of departing jets on the ground, parameterized by the number of arrivals for 22L, 27 | 22L, 22R configuration, under VMC [9].

impact on departure throughput, in spite of the increased wake-vortex separation that is required behind heavy weight category aircraft. This can be explained by the observation that air traffic controllers at BOS use the high wake vortex separation requirement between a heavy and a subsequent departure to conduct runway crossings, thereby mitigating the adverse impact of heavy weight category departures [9].

Motivated by this finding, we can determine the dependence of the jet (i.e., non-prop) departure throughput as a function of the number of jet aircraft taxiing out, parameterized by the number of arrivals, as illustrated in Figure 4. This figure illustrates that during periods in which arrival demand is high, the jet departure throughput saturates when the number of jets taxiing out exceeds 17 (based on ASPM data).

C. *Data sources*

It is important to note that Figure 1, Figure 3 and Figure 4 are determined using ASPM data. Pushback times in ASPM are determined from the brake release times reported through the ACARS system, and are prone to error because about 40% of the flights departing from BOS do not automatically report these times [10]. Another potential source of pushback and takeoff times is the Airport Surface Detection Equipment Model X (or ASDE-X) system, which combines data from airport surface radars, multilateration sensors, ADS-B, and aircraft transponders [11]. While the ASDE-X data is likely to be more accurate than the ASPM data, it is still noisy, due to factors such as late transponder capture (the ASDE-X tracks only begin after the pilot has turned on the transponder, which may be before or after the actual pushback time), aborted takeoffs (which have multiple departure times detected), flights cancelled after pushback, etc. A comparison of both ASDE-X and ASPM records with live observations made in the tower on August 26, 2010 revealed that the average difference between the number of pushbacks per 15-minutes as recorded by ASDE-X and by visual means is 0.42, while it is -3.25 for ASPM and visual observations, showing that the ASPM records differ considerably from ASDE-X and live observations. The above comparison motivates the recalibration of airport performance curves and parameters using ASDE-X data in addition to ASPM data. This is because ASPM data is not available in real-time and will therefore not be available for use in real-time deployments, and the ASDE-X data is in much closer agreement to the visual observations than ASPM.

We therefore conduct similar analysis to that shown in Figure 4, using ASDE-X data. The results are shown in Figure 5. We note that the qualitative behavior of the system is similar to what was seen with ASPM data, namely, the jet throughput of the departure runway initially increases because more jet aircraft are available in the departure queue, but as this number exceeds a threshold, the departure runway capacity becomes the limiting factor, and there is no additional increase in throughput. By statistically analyzing three months of ASDE-X data from Boston Logan airport using the methodology outlined in [9], we determine that the average number of active jet departures on the ground at which the surface saturates is 12 jet aircraft for the 22L, 27 | 22L, 22R configuration, during periods of moderate arrival demand. This value is close to that deduced from Figure 5, using visual means.

D. *Estimates of N^**

Table I shows the values of N^* for the three main runway configurations under VMC, that were used during the field tests based on the ASDE-X data analysis. For each runway configuration, we use plots similar to Figure 5 to determine the expected throughput. For example, if the runway configuration is 22L, 27 | 22L, 22R, 11 jets are taxiing out, and the expected arrival rate is 9 aircraft in the next 15 minutes, the expected departure throughput is 10 aircraft in the next 15 minutes.

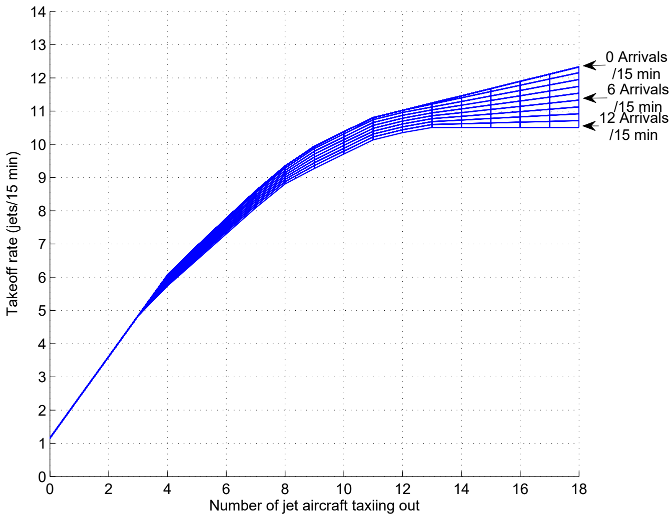

Fig. 5: Regression of the takeoff rate as a function of the number of jets taxiing out, parameterized by the number of arrivals, using ASDE-X data, for the 22L, 27 | 22L, 22R configuration.

III. Implementation of Pushback Rate Control

The pushback rate was determined so as to keep the number of jets taxiing out near a suitable value (N_{ctrl}), where N_{ctrl} is greater than N^*, in order to mitigate risks such as under-utilizing the runway, facing many gate conflicts, or being unable to meet target departure times. Off-nominal events such as gate-use conflicts and target departure times were carefully monitored and addressed. Figure 6 shows a schematic of the decision process to determine the suggested pushback rate.

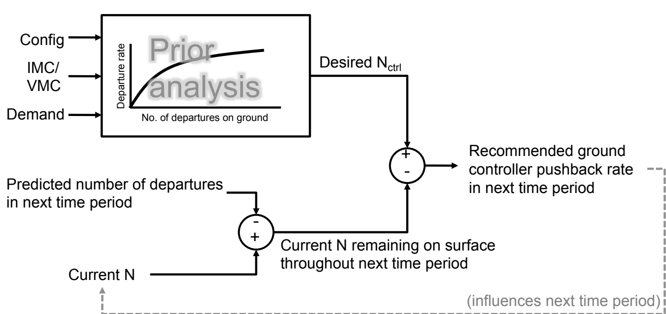

Fig. 6: A schematic of the pushback rate calculation.

The determination of the pushback rate is conducted as follows. Prior to the start of each 15-minute period, we:

1) Observe the operating configuration, VMC/IMC, and the predicted number of arrivals in the next 15 minutes (from ETMS) and using these as inputs into the appropriate departure throughput saturation curves (such as Figure 5), determine the expected jet departure throughput.
2) Using visual observations, count the number of departing jets currently active on the surface. We counted a departure as active once the pushback tug was attached to the aircraft and it was in the process of pushing back.
3) Calculate the difference between the current number of active jet departures and the expected jet departure throughput. This difference is the number of currently active jets that are expected to remain on the ground through the next 15 min.
4) The difference between N_{ctrl} and the result of the previous step provides us with the additional number of pushbacks to recommend in next 15 minutes.
5) Translate the suggested number of pushbacks in the next 15 minutes to an approximate pushback rate in a shorter time interval more appropriate for operational implementation (for example, 10 aircraft in the next 15 minutes would translate to a rate of “2 per 3 minutes.”).

TABLE I
Values of N^* estimated from the analysis of ASDE-X data.

Configuration	N^*
22L, 27 | 22L, 22R	12
27, 32 | 33L	12
4L, 4R | 4L, 4R, 9	15

A. Communication of recommended pushback rates and gate-hold times

During the demo, we used color-coded cards to communicate suggested pushback rates to the air traffic controllers, thereby eliminating the need for verbal communications. We used one of eight 5 in × 7.5 in cards, with pushback rate suggestions that ranged from “1 per 3 minutes” (5 in 15 minutes) to “1 aircraft per minute” (15 in 15 minutes), in addition to “Stop” (zero rate) and “No restriction” cards, as shown in Figure 7 (left). The setup of the suggested rate card in the Boston Gate controllers position is shown in Figure 7 (right).

Fig. 7: (Left) Color-coded cards that were used to communicate the suggested pushback rates. (Right) Display of the color-coded card in the Boston Gate controller’s position.

The standard format of the gate-hold instruction communicated by the Boston Gate controller to the pilots included both the current time, the length of the gate-hold, and the time at which the pilot could expect to be cleared. For example:
Boston Gate: “AAL123, please hold push for 3 min. Time is now 2332, expect clearance at 2335. Remain on my frequency, I will contact you.”

In this manner, pilots were made aware of the expected gate-holds, and could inform the controller of constraints such as gate conflicts due to incoming aircraft. In addition, ground crews could be informed of the expected gate-hold time, so that they could be ready when push clearance was given. The post-analysis of the tapes of controller-pilot communications showed that the controllers cleared aircraft for push at the times they had initially stated (i.e., an aircraft told to expect to push at 2335 would indeed be cleared to push at 2335), and that they also accurately implemented the push rates suggested by the cards.

B. Handling of off-nominal events

The implementation plan also called for careful monitoring of off-nominal events and system constraints. Of particular concern were gate conflicts (for example, an arriving aircraft is assigned a gate at which a departure is being held), and the ability to meet controlled departure times (Expected Departure Clearance Times or EDCTs) and other constraints from Traffic Management Initiatives. After discussions with the Tower and airlines prior to the field tests, the following decisions were made:

1) Flights with EDCTs would be handled as usual and released First-Come-First-Served. Long delays would continue to be absorbed in the standard holding areas. Flights with EDCTs did not count toward the count of active jets when they pushed back; they counted toward the 15-minute interval in which their departure time fell. An analysis of EDCTs from flight strips showed that the ability to meet the EDCTs was not impacted during the field tests.
2) Pushbacks would be expedited to allow arrivals to use the gate if needed. Simulations conducted prior to the field tests predicted that gate-conflicts would be relatively infrequent at BOS; there were only two reported cases of potential gate-conflicts during the field tests, and in both cases, the departures were immediately released from the gate-hold and allowed to pushback.

C. Determination of the time period for the field trials

The pushback rate control protocol was tested in select evening departure push periods (4-8PM) at BOS between August 23 and September 24, 2010. Figure 8 shows the average number of departures on the ground in each 15-minute interval using ASPM data. There are two main departure pushes each day. The evening departure push differs from the morning one because of the larger arrival demand in the evenings. The morning departure push presents different challenges, such as a large number of flights with controlled departure times, and a large number of tow-ins for the first flights of the day.

IV. Results of field tests

Although the pushback rate control strategy was tested at BOS during 16 demo periods, there was very little need to control pushbacks when the airport operated in its most

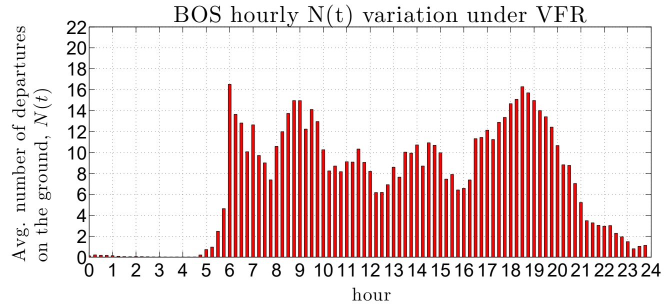

Fig. 8: Variation of departure demand (average number of active departures on the ground) as a function of the time of day.

efficient configuration (4L, 4R | 4L, 4R, 9), and in only eight of the demo periods was there enough congestion for gate-holds to be experienced. There was insufficient congestion for recommending restricted pushback rates on August 23, September 16, 19, 23, and 24. In addition, on September 3 and 12, there were no gate-holds (although departure demand was high, traffic did not build up, and no aircraft needed to be held at the gate). For the same reason, only one aircraft received a gate-hold of 2 min on September 17. The airport operated in the 4L, 4R | 4L, 4R, 9 configuration on all three of these days. In total, pushback rate control was in effect during the field tests for over 37 hours, with about 24 hours of test periods with significant gate-holds.

A. Data analysis examples

In this section, we examine three days with significant gate-holds (August 26, September 2 and 10) in order to describe the basic features of the pushback rate control strategy.

Figure 9 shows taxi-out times from one of the test periods, September 2. Each green bar in Figure 9 represents the actual taxi-out time of a flight (measured using ASDE-X as the duration between the time when the transponder was turned on and the wheels-off time). The red bar represents the gate-hold time of the flight (shown as a negative number). In practice, there is a delay between the time the tug pushes them from the gate and the time their transponder is turned on, but statistical analysis showed that this delay was random, similarly distributed for flights with and without gate-holds, and typically about 4 minutes. We note in Figure 9 that as flights start incurring gate-holds (corresponding to flights departing at around 1900 hours), there is a corresponding decrease in the active taxi-out times, i.e., the green lines. Visually, we notice that as the length of the gate-hold (red bar) increases, the length of the taxi-out time (green bar) proportionately decreases. There are still a few flights with large taxi-out times, but these typically correspond to flights with EDCTs. These delays were handled as in normal operations (i.e., their gate-hold times were not increased), as was agreed with the tower and airlines. Finally, there are also a few flights with no gate-holds and very short taxi-out times, typically corresponding to props.

The impact of the pushback rate control strategy can be further visualized by using ASDE-X data, as can be seen in

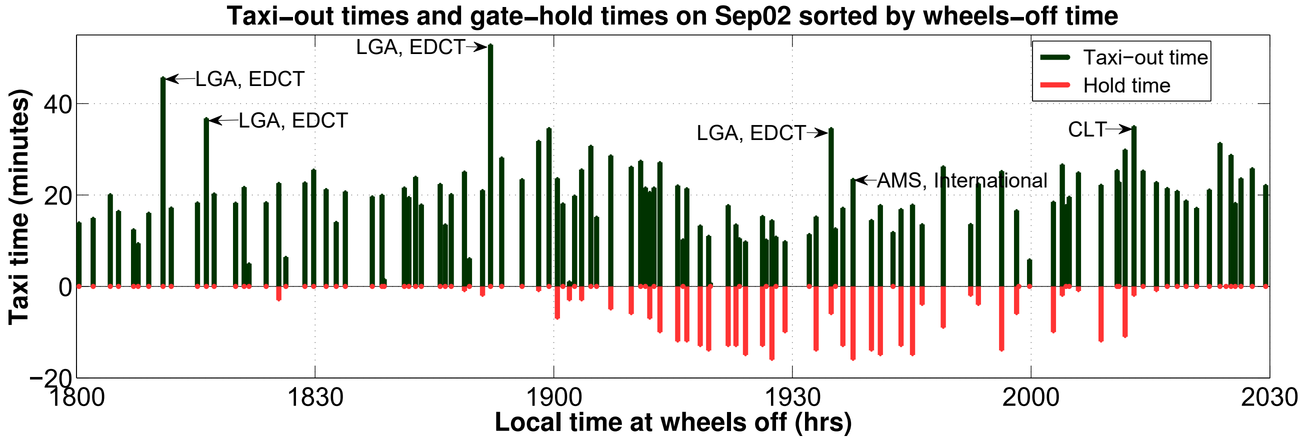

Fig. 9: Taxi-out and gate-hold times from the field test on September 2, 2010.

Fig. 10: Snapshots of the airport surface, (left) before gate-holds started, and (right) during gate-holding. Departing aircraft are shown in green, and arrivals in red. We note that the line of 15 departures between the ramp area and the departure runway prior to commencement of pushback rate control reduces to 8 departures with gate-holds. The white area on the taxiway near the top of the images indicates the closed portion of taxiway "November".

the Figure 10, which shows snapshots of the airport surface at two instants of time, the first before the gate-holds started, and the second during the gate-holds. We notice the significant decrease in taxiway congestion, in particular the long line of aircraft between the ramp area and the departure runway, due to the activation of the pushback rate control strategy.

Looking at another day of trials with a different runway configuration, Figure 11 shows taxi-out times from the test period of September 10. In this plot, the flights are sorted by pushback time. We note that as flights start incurring gate-holds, their taxi time stabilizes at around 20 minutes. This is especially evident during the primary departure push between 1830 and 1930 hours. The gate-hold times fluctuate from 1-2 minutes up to 9 minutes, but the taxi-times stabilize as the number of aircraft on the ground stabilizes to the specified N_{ctrl} value. Finally, the flights that pushback between 1930 and 2000 hours are at the end of the departure push and derive the most benefit from the pushback rate control strategy: they have longer gate holds, waiting for the queue to drain and then taxi to the runway facing a gradually diminishing queue.

Figure 12 further illustrates the benefits of the pushback rate control protocol, by comparing operations from a day with pushback rate control (shown in blue) and a day without it (shown in red), under similar demand and configuration. The upper plot shows the average number of jets taxiing-out, and the lower plot the corresponding average taxi-out time, per 15-minute interval. We note that after 1815 hours on September 10, the number of jets taxiing out stabilized at around 15. As a result, the taxi-out times stabilized at about 16 minutes. Pushback rate control smooths the rate of the pushbacks so as to bring the airport state to the specified state, N_{ctrl}, in a controlled manner. Both features of pushback rate control, namely, smoothing of demand and prevention of congestion can be observed by comparing the evenings of September 10 and September 15. We see that on September 15, in the absence of pushback rate control, as traffic started accumulating at 1745 hours, the average taxi-out time grew to over 20 minutes. During the main departure push (1830 to

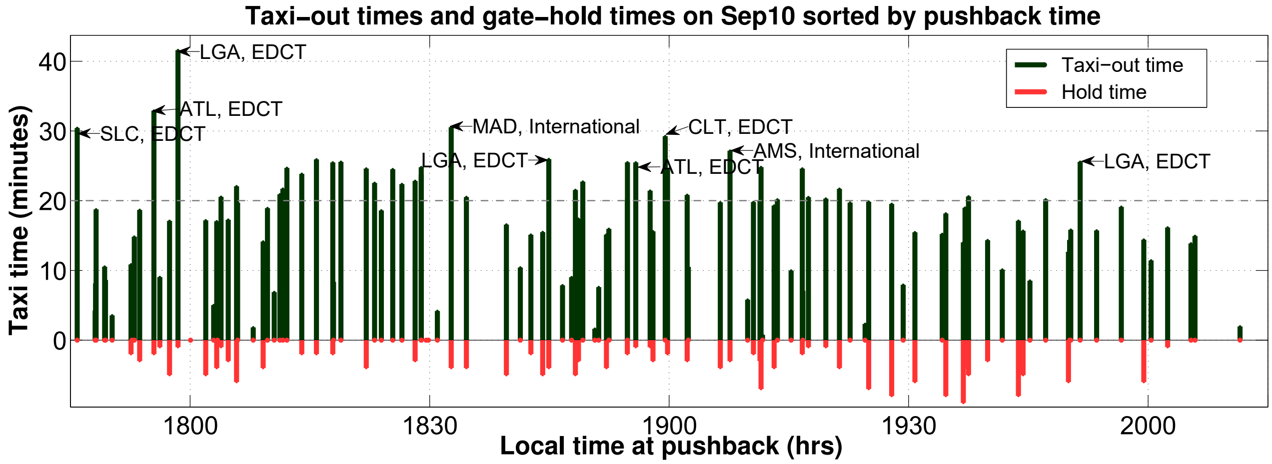

Fig. 11: Taxi-out and gate-hold times from the field test on September 10, 2010.

1930), the average number of jets taxiing out stayed close to 20 and the average taxi-out time was about 25 minutes.

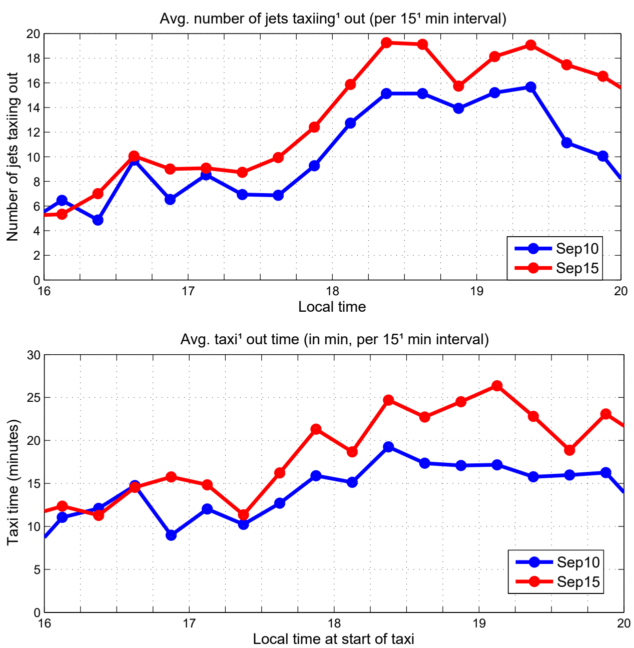

Fig. 12: Surface congestion (top) and average taxi-out times (bottom) per 15-minutes, for (blue) a day with pushback rate control, and (red) a day with similar demand, same runway configuration and visual weather conditions, but without pushback rate control. Delay attributed to EDCTs has been removed from the taxi-out time averages.

Similarly, Figure 13 compares the results of a characteristic pushback rate control day in runway configuration 27, 22L | 22L, 22R, August 26, to a similar day without pushback rate control. We observe that for on August 26, the number of jets taxiing out during the departure push between 1830 and 1930 hours stabilized at 15 with an average taxi-out time of about 20 minutes. On August 17, when pushback rate control was not in effect, the number of aircraft reached 20 at the peak of the push and the average taxi-out times were higher than those of August 26.

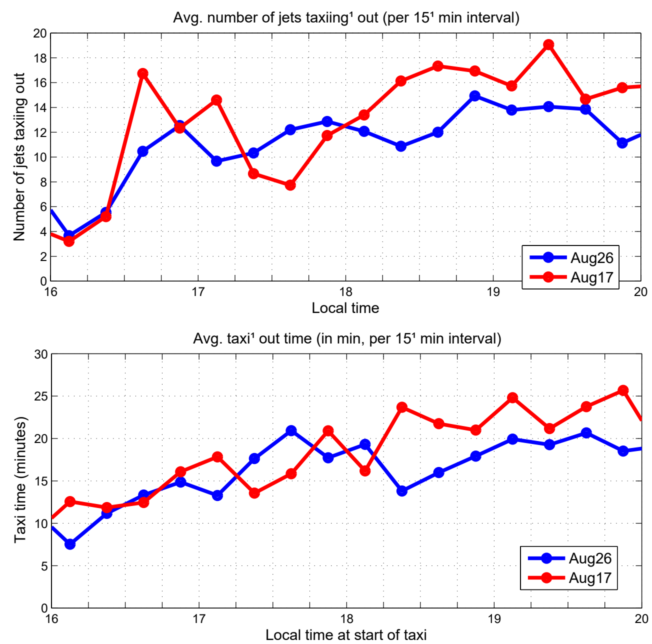

Fig. 13: Ground congestion (top) and average taxi-out times (bottom) per 15-minutes, for (blue) a day with pushback rate control, and (red) a day with similar demand, same runway configuration and weather conditions, but without pushback rate control. Delay attributed to EDCTs has been removed from the taxi-out time averages.

B. Runway utilization

The overall objective of the field test was to maintain pressure on the departure runways, while limiting surface congestion. By maintaining runway utilization, it is reasonable to expect that gate-hold times translate to taxi-out time reduction, as suggested by Figure 9. We therefore also carefully analyze runway utilization (top) and departure queue sizes (bottom) during periods of pushback rate control, as illustrated in Figure 14.

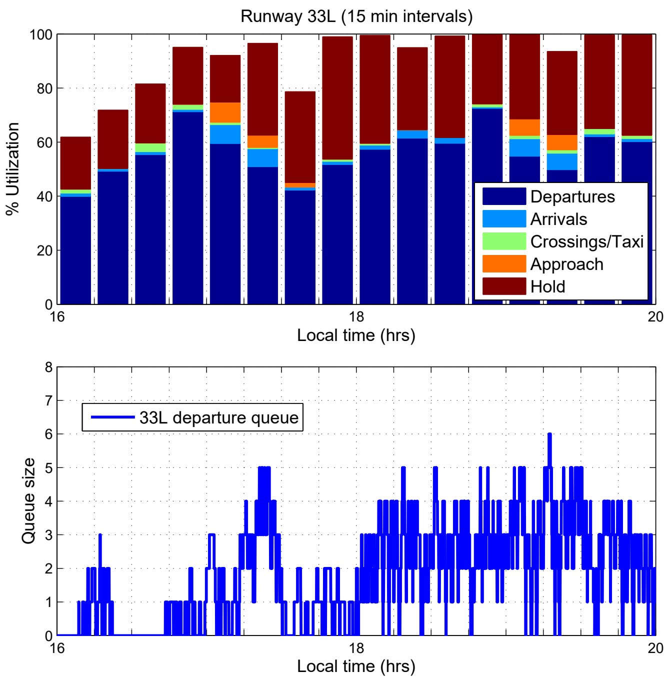

Fig. 14: Runway utilization plots (top) and queue sizes (bottom) for the primary departure runway (33L) during the field test on September 10, 2010. These metrics are evaluated through the analysis of ASDE-X data.

In estimating the runway utilization, we determine (using ASDE-X data) what percentage of each 15-min interval corresponded to a departure on takeoff roll, to aircraft crossing the runway, arrivals (that requested landing on the departure runway) on final approach, departures holding for takeoff clearance, etc. We note that between 1745 and 2000 hours, when gate-holds were experienced, the runway utilization was kept at or close to 100%, with a persistent departure queue as well.

Runway utilization was maintained consistently during the demo periods, with the exception of a three-minute interval on the third day of pushback rate control. On this instance, three flights were expected to be at the departure runway, ready for takeoff. Two of these flights received EDCTs as they taxied (and so were not able to takeoff at the originally predicted time), and the third flight was an international departure that had longer than expected pre-taxi procedures. Learning from this experience, we were diligent in ensuring that EDCTs were gathered as soon as they were available, preferably while the aircraft were still at the gate. In addition, we incorporated the longer taxi-out times of international departures into our predictions. As a result of these measures, we ensured that runway utilization was maintained over the remaining duration of the trial. It is worth noting that the runway was "starved" in this manner for only 3 minutes in over 37 hours of pushback rate control, demonstrating the ability of the approach to adapt to the uncertainties in the system.

V. Benefits analysis

Table II presents a summary of the gate-holds on the eight demo periods with sufficient congestion for controlling pushback rates. As mentioned earlier, we had no significant congestion when the airport was operating in its most efficient configuration (4L, 4R | 4L, 4R, 9).

TABLE II
Summary of gate-hold times for the eight demo periods with significant gate-holds.

	Date	Period	Configuration	No. of gate-holds	Average gate-hold (min)	Total gate-hold (min)
1	8/26	4.45-8PM	27,22L | 22L,22R	63	4.06	256
2	8/29	4.45-8PM	27,32 | 33L	34	3.24	110
3	8/30	5-8PM	27,32 | 33L	8	4.75	38
4	9/02	4.45-8PM	27,22L | 22L,22R	45	8.33	375
5	9/06	5-8PM	27,22L | 22L,22R	19	2.21	42
6	9/07	5-7.45PM	27,22L | 22L,22R	11	2.09	23
7	9/09	5-8PM	27,32 | 33L	11	2.18	24
8	9/10	5-8PM	27,32 | 33L	56	3.7	207
Total				247	4.35	1075

A total of 247 flights were held, with an average gate-hold of 4.3 min. During the most congested periods, up to 44% of flights experienced gate-holds. By maintaining runway utilization, we traded taxi-out time for time spent at the gate with engines off, as illustrated in Figures 9 and 11.

A. Translating gate-hold times to taxi-out time reduction

Intuitively, it is reasonable to use the gate-hold times as a surrogate for the taxi-out time reduction, since runway utilization was maintained during the demonstration of the control strategy. We confirm this hypothesis through a simple "what-if" simulation of operations with and without pushback rate control. The simulation shows that the total taxi-out time savings equaled the total gate-hold time, and that the taxi time saving of each flight was equal, in expectation, to its gate holding time. The total taxi-out time reduction can therefore be approximated by the total gate-hold time, or 1077 minutes (18 hours).

In reality, there are also second-order benefits due to the faster travel times to the runway due to reduced congestion, but these effects are neglected in the preliminary analysis.

B. Fuel burn savings

Supported by the analysis presented in Section V-A, we conduct a preliminary benefits analysis of the field tests by using the gate-hold times as a first-order estimate of taxi-out time savings. This assumption is also supported by the taxi-out time data from the tests, such as the plot shown in Figure 9. Using the tail number of the gate-held flights, we determine the aircraft and engine type and hence its ICAO taxi fuel burn index [12]. The product of the fuel burn rate index, the number of engines, and the gate-hold time gives us an estimate of the fuel burn savings from the pushback rate control strategy. We can also account for the use of Auxiliary Power Units (APUs) at the gate by using the appropriate fuel burn rates

[13]. This analysis (not accounting for benefits from reduced congestion) indicates that the total taxi-time savings were about 17.9 hours, which resulted in fuel savings of 12,000-15,000 kg, or 3,900-4,900 US gallons (depending on whether APUs were on or off at the gate). This translates to average fuel savings per gate-held flight of between 50-60 kg or 16-20 US gallons, which suggests that there are significant benefits to be gained from implementing control strategies during periods of congestion. It is worth noting that the per-flight benefits of the pushback rate control strategy are of the same order-of-magnitude as those of Continuous Descent Approaches in the presence of congestion [14], but do not require the same degree of automation, or modifications to arrival procedures.

C. Fairness of the pushback rate control strategy

Equity is an important factor in evaluating potential congestion management or metering strategies. The pushback rate control approach, as implemented in these field tests, invoked a First-Come-First-Serve policy in clearing flights for pushback. As such, we would expect that there would be no bias toward any airline with regard to gate-holds incurred, and that the number of flights of a particular airline that were held would be commensurate with the contribution of that airline to the total departure traffic during demo periods. We confirm this hypothesis through a comparison of gate-hold share and total departure traffic share for different airlines, as shown in Figure 15. Each data-point in the figure corresponds to one airline, and we note that all the points lie close to the 45-degree line, thereby showing no bias toward any particular airline.

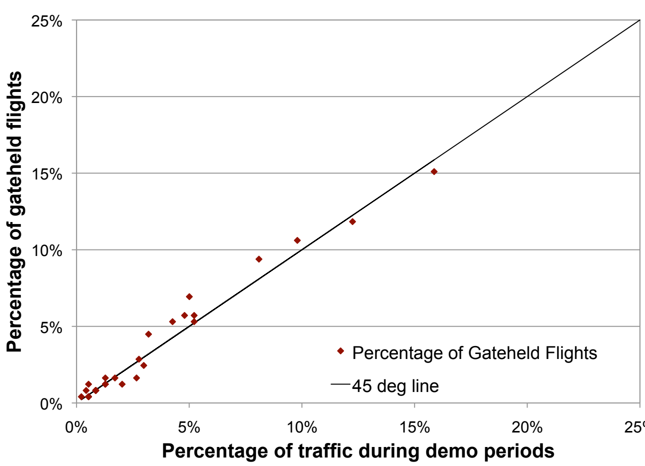

Fig. 15: Comparison of gate-hold share and total departure traffic share for different airlines.

We note, however, that while the number of gate-holds that an airline receives is proportional to the number of its flights, the actual fuel burn benefit also depends on its fleet mix. Figure 16 shows that while the taxi-out time reductions are similar to the gate-holds, some airlines (for example, Airlines 3, 4, 5, 19 and 20) benefit from a greater proportion of fuel savings. These airlines are typically ones with several heavy jet departures during the evening push.

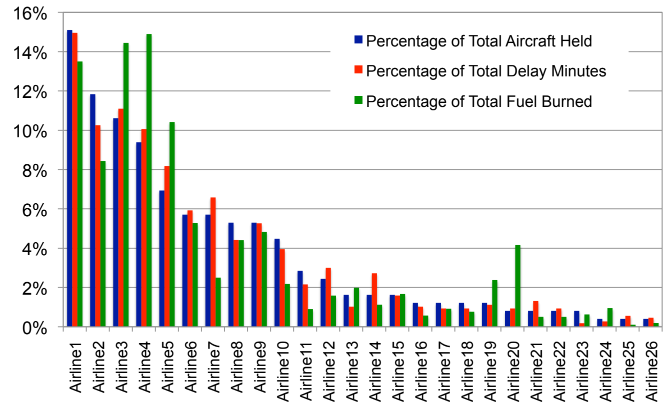

Fig. 16: Percentage of gate-held flights, taxi-out time reduction and fuel burn savings incurred by each airline.

VI. Observations and Lessons Learned

We learned many important lessons from the field tests of the pushback rate control strategy at BOS, and also confirmed several hypotheses through the analysis of surveillance data and qualitative observations. Firstly, as one would expect, the proposed control approach is an aggregate one, and requires a minimum level of traffic to be effective. This hypothesis is further borne by the observation that there was very little control of pushback rates in the most efficient configuration (4L, 4R | 4L, 4R, 9). The field tests also showed that the proposed technique is capable of handling target departure times (e.g., EDCTs), but that it is preferable to get EDCTs while still at gate. While many factors drive airport throughput, the field tests showed that the pushback rate control approach could adapt to variability. In particular, the approach was robust to several perturbations to runway throughput, caused by heavy weight category landings on departure runway, controllers' choice of runway crossing strategies, birds on runway, etc. We also observed that when presented with a suggested pushback rate, controllers had different strategies to implement the suggested rate. For example, for a suggested rate of 2 aircraft per 3 minutes, some controllers would release a flight every 1.5 minutes, while others would release two flights in quick succession every three minutes. We also noted the need to consider factors such as ground crew constraints, gate-use conflicts, and different taxi procedures for international flights. By accounting for these factors, the pushback rate control approach was shown to have significant benefits in terms of taxi-out times and fuel burn.

VII. Summary

This paper presented the results of the demonstration of a pushback rate control strategy at Boston Logan International Airport. Sixteen demonstration periods between August 23 and September 24, 2010 were conducted in the initial field trial phase, resulting in over 37 hours of research time in the BOS tower. Results show that during eight demonstration periods