Water Quality Performance Review of Boston Logan International Airport

By

Romeo Evasco Capuno, Jr.
BS Chemical Engineering
University of the Philippines Los Baños, 1995

Submitted to the Department of Civil and Environmental Engineering
In Partial Fulfillment of the Requirements for the Degree of

MASTER OF ENGINEERING in Civil and Environmental Engineering
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
JUNE 2001

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ABSTRACT

The increasing demand for air transportation has become one of the major issues in attaining sustainable development in airports. With the annual growth rate in demand of 5% to 6.5%, the volume is expected to double every 12 years. Government and airport group are exerting efforts on how to meet this demand but at the same time minimize impacts in the environment.

To insure that the airports do not create impacts that will degrade the environment, the government enacts regulations. The Federal Aviation Administration is a regulatory board, which sets standards and guidelines for airport groups to follow. Regulations in water pollution, though, are not extensive and overly rigid which give the airport group leeway especially in choosing to implement. Water pollution regulations focuses on sources of fuel contamination and ground anti-icing and deicing specifically on effects of ice, troubleshooting and guidelines that airport groups should consider.

Boston Logan International Airport has three areas of focus, which focus on water quality monitoring, fuel use and spills and water quality management program. These three areas support the Massachusetts Port Authority's environmental policy.

With the increasing demand for air transportation, airport groups must carefully plan for and consider factors that will help avoid problems in the future. This thesis identifies considerations in terms of water pollution for expansion or construction of airports. These considerations include clear policies, regulations, well running systems and programs, precise targets and goals, strict monitoring and control, stringent preventive measures and continuous development through new technologies and research.

Focusing on continuous planning, development and research should help airport groups to attain sustainability whilst focusing on increasing demand for air transport.

Thesis Supervisor: Professor David H. Marks
Title: Professor of Environmental Systems and Civil and Environmental Engineering

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Biographical sketch

The author was born to Colonel Romeo Aquino Capuno (PA, ret.) and Doctor Marcosa Evasco Capuno. His siblings are Rose Nonette and Maria Sheila. Rose Nonette works at the University of the Philippines as researcher and at the same time pursuing her Master of Public Administration program in the same school. Maria Sheila works as Project Manager at Fujitsu Philippines.

The author

- graduated with a Bachelor of Science in Chemical Engineering (magna cum laude and class valedictorian) at the University of the Philippines Los Banos. Among his awards are: 4th place Chemical Engineering Licensure Exam, International Honor Society of Phi Kappa Phi Outstanding Student for Overall Academic Excellence, Bank of the Philippine Islands Science Award, Department of Science and Technology Award for Academic Excellence in Science, 1996 The Outstanding Young Science-Researcher, Ten Outstanding Students of the Philippines finalist and Student Leadership Award.

- served as Eucharistic Minister and Lector at the MIT Catholic Community. In the Philippines, he served as lector at Holy Trinity Parish and reviewer at University of the Philippines Los Banos Chemical Engineering.

- spends his free time at the gym lifting weights and doing cardiovascular exercise. Among his hobbies are playing the piano, table tennis and chess.

- worked in Coca Cola Manila Plant as Production, Quality Assurance and Process Supervisor. Prior to his graduate study in MIT, he worked in the operations of Sucere Foods Corporation.

Acknowledgments

This manuscript will not be complete without the help, in one way or another, of the following:

Professor David Marks, thesis advisor, for his encouragement, guidance and for making the trip to the Netherlands possible

Professor Eric Adams, for his support

All my Professors, who shared their knowledge

Messrs. Eduardo S. Yu and Clarence C. Yu, for sponsoring me in my graduate study

Keith Beasley, Pollution Prevention Officer of Massachusetts Port Authority, for his help in gathering data and information at Boston Logan International airport

Ralph Hall, for all the help he has extended.

Adonis Boutatis, Nisrine Al-kadi, Jui Shan Yong: Project team members for all the fun and hardships we had in accomplishing our project

Environmental Engineering track batch mates

M Eng, batchmates from the three other tracks

Filipino Students Association members: Joe, Phillip, RJ, John, Mark, Marissa, Tiffany, Stephanie, Jeremy, Christian, for teaching me how to dance "tinikling" but most of all for the good and fun times

407ers, Pia, Prerna, Karen, Lily, for their kindness

Woody, Ashdown roommate, Joe and Dan, Ashdown suitemates

The Navato family, my host family, for their warmth and hospitality

Uncle Mike, Aunt Zita, Carl, Nina, CB, Gina, Vinny, Theo, Cole, Miguel, Hem. Thanks to all of you for making my stay in Massachusetts a memorable one

Sisters, Rose and Sheila, for always being there to support and encourage me

Parents, Dad and Mom, for never ending help and guidance

And Above all, GOD, who is the source of strength, energy and wisdom. For without Him, the author cannot even lift a pen.

" I am not on this earth by chance. I am here for a purpose, and that purpose is to grow into a mountain and not to shrink into a grain of sand. Henceforth will I apply all my efforts to become the highest mountain of all. And I will strain my potentials until it cries for mercy. My skills, my mind, my body shall rot stagnate and die lest I put them to good use. I have an unlimited potential. Only a portion of my brain do I implore, a portion of my muscle do I flex. A hundred fold or more shall I improve my accomplishments of yesterday and this will I do beginning today."

Og Mandino, The Greatest Salesman in the World

1 INTRODUCTION

The air transportation demand has been increasing constantly and is predicted to increase further in the future. With the increasing demand for air transportation, the government and the airport group must find ways and means to meet the demand's growing needs.

Growth rate for aviation is rated at an annual average of 5% to 6.5% and is expected to double every 12 years (Al-Kadi, Boutatis, Capuno, Yong, 2001). An increase in air transportation denotes growth of the economy in terms of increase in income and infrastructures in particular. On the other hand, increasing air transportation will increase environmental impacts such as noise, air and water in outlying communities.

1.1 Sustainable Development

The World Commission on Environment and Development defines sustainable development as any development that meets the needs of the present generations without compromising the ability of the future generations to meet their own needs. This is a simple definition, which implies that in order for the future generation to meet their own needs the present generation must not use up all natural resources and must preserve the environment. Use of renewable resources must not exceed the rate at which it is produced. Otherwise there will be a decrease of the resources. Preservation of the environment takes into account the effects of the chemicals and other materials that are used in the operation. Furthermore, it also takes into account the proper disposal and handling of the chemicals and materials.

Sustainability (Heathrow, 2000) can be viewed as the intersection between environment, social welfare and economy as shown in Figure 1. The three circles represent the different areas of concerns such as the environment, social welfare and economy. The intersection of the circles signifies the area of sustainable development.

Sustainability is a balance between all of the areas. In England, the government's key aims for sustainable development are:

1. Maintenance of high and stable levels of economic growth and employment.
2. Social progress, which recognizes the needs for everyone.
3. Effective protection of the environment.
4. Prudent use of natural resources.

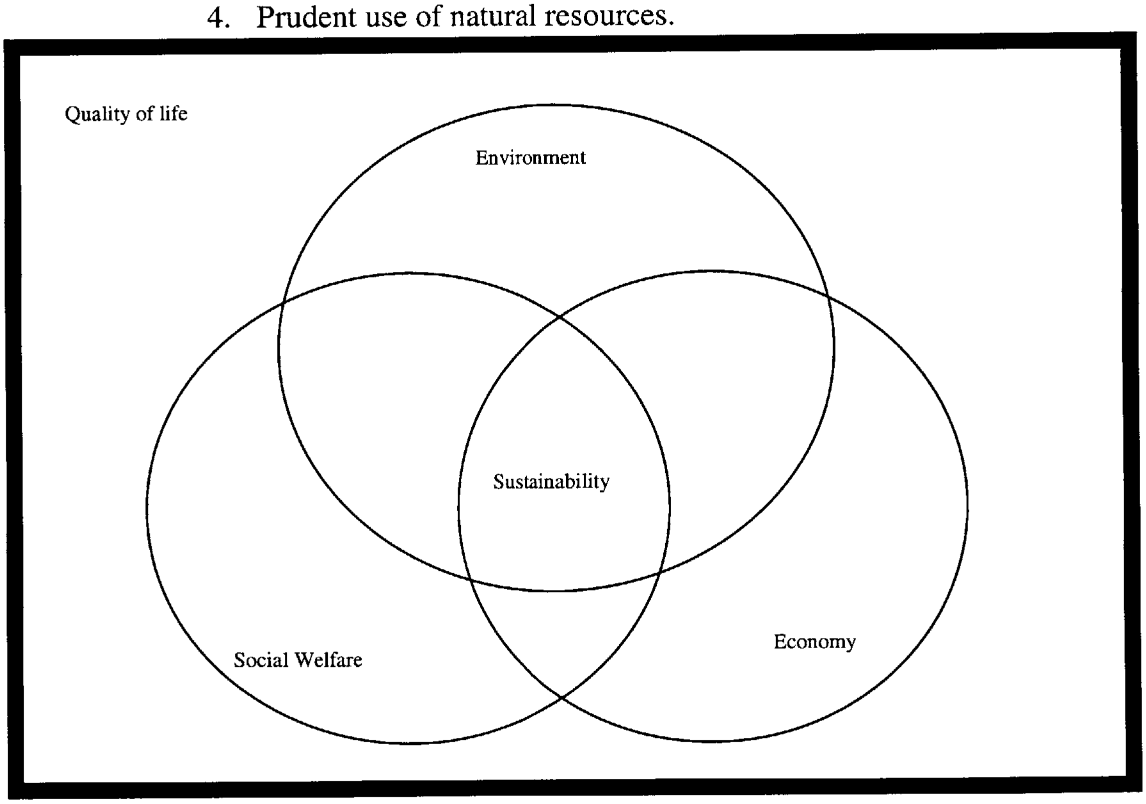


Figure 1.1. Sustainability Concept (Heathrow, 2000)

In airport operation, noise, air and water pollution, in order of importance, are the environmental concerns that constrict the expansion or increase in the airport's capacity.

1.2 Decision making in airports

Expansion and construction of airports take into consideration the impacts that it will create on its neighborhood and on the environment as a whole. Some methods of decision making for airport expansion are using negotiation, regulation, and technical approaches. Negotiation involves different stakeholders, individual or group of individuals who have concern over the issue under negotiation. Negotiation aims to arrive at a compromise that will satisfy all the stakeholders. Regulation, on the other hand, does not involve participation of the stakeholders. The governing body will be implementing the regulations, which could be the basis of the decision-making.

The technical approach uses linear programming as a means of resolving conflicts between objectives. The Open Design Methodology by Van Gunsteren and Van Loon uses a linear programming model as the basis in arriving at a certain value of the item of interest.

Linear programming is an optimization method, which uses mathematical equations to arrive at the optimized objective function. It has two parts: objective function and the constraints. The objective function is the item of interest. Constraints are the stakeholders' concerns, which limit the solution space of the function.

In airport expansion, an objective function may be to maximize the number of flight movements or passengers. Economic, social, environmental and other constraints shape the outcome of the decision space. An example of economic constraint is the target operating income. The constraint relating all the variables will state that the particular relationship of the variables should be above the particular target. Social constraints, on the other hand, are hard to establish since the degree of happiness and satisfaction is relative. However, once the mathematical equation for social issues is generated then this would serve as the social constraint. Environmental constraints include noise, water and air. Environmental constraints take into account the maximum emission or generation of a specific pollutant. Beyond this maximum emission or the generation, the airport will not meet the required standards. Other constraints may include safety factors at the airport, fuel consumption and so on.

Figure 1.2 should serve as sample worksheet of a linear programming model. This worksheet was developed in MS Excel and uses What's Best Problem Solver to optimize the functions. The variables presented are shown in the column. The objective function is the number of flights. The constraints include fuel consumption, environmental constraint and safety.

A combination of these methods with the inclusion of other methods will enhance the decision making process.

1.3 Airport pollution

1.3.1 Noise pollution

Noise, primarily from aircraft engine, is the major environmental problem in aviation. Airport groups have been addressing noise issues through several measures. In particular landing and takeoff procedures were designed to minimize noise annoyance to the neighboring communities and a reduction of aircraft operations at night was also

Figure 1.2 Sample of linear programming worksheet

	Flight Movement							
	Capacity class				Passenger class			
	no of flights	Class A	Class B	Class C	Class A	Class B	Class C	
Optimal solution	1600	889.6	531.2	179.2	80064	69056	30464	
Objective function	1							1600
Constraints								0
Flightmovements								0
Capacity runway 1								0
Capacity runway 2								0
Capacity runway 3								6.25E-13
Capacity runway 4								0
number of flights	1							0
class A	0.556	-1						1.14E-13
class B	0.332		-1					0
class C	0.112			-1				2.84E-14
Pollution								
Water Pollution	2							0
Total air pollution	5							0
Total noise pollutions								2471680
Noise polllution class A		1200						0
Noise polllution class B			1800					1.16E-10
Noise polllution class C				2500				0
Consumption								
class A		1000						0
class B			2000					0
class C				3000				0
Passengers								
class A		90			-1			0
class B			130			-1		0
class C				170			-1	-3.6E-12
Total					-1	-1	-1	0
Finance								
Operating income	862270							0

condensed version of the model by Capuno et.al.

implemented. Other measures include stricter noise monitoring system and continuous development of quieter aircraft engine.

1.3.2 Air pollution

Air pollution, next to noise in terms of airport impacts, is due to the emission of particulates and gases from the aircraft engines. The gaseous and particulate emission includes carbon dioxide, water vapor, nitrogen oxide, hydrocarbons, carbon monoxide, soot and sulfur dioxide. Among the steps that the airport groups are implementing are the use of low sulfur fuel, age limit for operating aircraft, stricter air quality monitoring and compliance to standards and development of cleaner exhaust aircraft.

1.3.3 Water pollution

Although water pollution has a minor environmental impact, it does have the same importance as other pollution types, since it comes indirectly from the aircraft. Two major contributors to water pollution are the use of anti-icers and deicers on aircraft and runways, and the leakage of fuel either in containers or while transferring.

1.4 Airport water pollution

1.4.1 Deicing and anti-icing

Anti-icing is defined as "practice of preventing the formation or development of bonded snow and ice by timely applications of a chemical freezing point depressant" (Ketcham et al. 1996). On the other hand, deicing is a method "necessary when ice or compacted snow is strongly bonded to the pavement and the bond has to be destroyed in order to remove the frozen layer" (Minsk, 1998).

Both anti-icing and deicing are practices that improve safety in aircraft and airport operation by removing or preventing snow and ice on runways and aircraft. Generally, the deicing and anti-icing process (as described by Al-Kadi, Boutatis, Capuno, Yong, 2001) starts by applying under pressure the hot mixture of anti-icing and de-icing fluids. Consequently, the pressure plus the temperature of the liquid melts the snow and ice present on the aircraft surface. Up to 80% of the deicers and anti-icers applied end up as runoff. With increasing aircraft use, there will be a corresponding increase in deicer and anti-icer runoff.

1.4.1.1 Characteristic of snow and ice

Ice and snow threatens safety of passengers if not properly removed from runways and aircrafts, since these reduce the friction on runways, which might cause aircraft tires to slip on the runways. Furthermore, ice adds weight, distorts airfoil shapes and may damage propellers and other parts during take off or in flight.

1.4.1.2 Deicing and anti-icing chemicals

Urea was originally the common deicing and anti-icing chemical, until its negative environmental impacts were discovered such as high biochemical oxygen demand in water and enhancement of algal bloom. Currently, the common deicing and anti-icing chemicals are either glycol or acetate based. Ethylene glycol, propylene glycol and diethylene glycol are examples of glycol-based chemicals. On the other hand, potassium, sodium and calcium magnesium acetate is an example of acetate-based chemicals.

1.4.2 Fuel spills

Fuel spills is another contributor to water pollution that occur during fueling or during transfer to storage tanks. Airport groups usually measure leakage on a yearly basis against the number of flights.

2 PURPOSE OF THE STUDY

This study is primarily aimed to review and assess the existing regulations to assure that water quality in the airport and its surrounding body of water is within standard parameters. It is specifically aimed to assess water quality and management programs of Boston Logan International Airport and to recommend water quality considerations for future airport expansion and construction.

3 *REGULATORY BOARD REVIEW*

3.1 Background

Economic growth and industrialization often pose a great threat to the environment. With the ever-increasing demand for services and products, organizations tend to focus more in meeting this demand leaving less attention to the treating of wastes. As a consequence, there are more polluted rivers, lower air quality and more polluted ground water. Given this context, for the environment to be sustainable, stricter regulations must therefore be imposed. As a preventive action, the government has been regulating the emission of this pollution by setting standards that the companies must not exceed and by giving preventive measures to avoid occurrence of pollution.

The Federal Aviation Administration is a government organization in the United States of America, which sets standards and gives advise in terms of aviation operation.

The Federal Aviation Administration mission includes the provisions for the protection of the U.S. traveling public in air transportation throughout the world and providing for the integrity of the civil aviation system. It also includes developing and implementing regulatory policies, programs, and procedures to; prevent criminal and other disruptive acts against civil aviation; protect FAA employees, facilities, and equipment, assist in the interdiction of dangerous drugs and narcotics into the United States; and support the national security.[1]

3.2 Environmental Concerns

The Federal Aviation Administration identifies different kinds of airport water pollution. These are non-storm water discharges, storm water run-off, surface run-off and unintentional releases.

Non-storm water discharges include sanitary sewage, cooling water and industrial waste, discharges from terminal, office and concession buildings, aircraft and vehicle maintenance, washing facilities and flight kitchens.

Storm water run-off includes transport fuels, deicers, pesticides and spilled chemicals from paved and unpaved airport surfaces.

Surface run-off involves water directly going into body of water without passing through collection system.

Unintentional releases usually come from storage tanks and pipes.

Knowing the sources of this water pollution will be beneficial in preventing occurrence of water pollution. The following section reviews the existing regulations, policies and programs related in airport operation and water pollution.

3.3 Discussion

The following discussion enumerates regulations, advice and recommendations made by the Federal Aviation Administration and policies and programs implemented by the Massachusetts Port Authority in connection with water pollution.

3.3.1 Federal Aviation Administration

The Federal Aviation Administration issued summary of sources of pollution and corresponding preventive measures from petroleum bulk stations and terminals. Sources of fuel and oil pollution in airport come from the charging of fuel and maintenance of the airplane.

Table 3.1 summarizes the activities associated with the pollutant of storm water discharges by petroleum bulk stations and terminals and pollutant source as identified by FAA. The pollutants identified come specifically from vehicle and equipment maintenance and cleaning operations.

FAA also requires airports to have a stormwater pollution prevention plan to monitor and report water quality parameters and a Federal National Pollutant Discharge Elimination System (NPDES) Permit required for storm water which includes: general permits, individual permits, group application, storm water discharges from airports

On deicing or anti-icing, particularly, there are six Advisory Circulars (AC) that the FAA listed. These are: AC 20-29B, 91-51A, 120-60, 135-16, 135-17 and 150/5300-14.

AC 20-29B is about the use of aircraft fuel anti-icing additives. Please refer to appendix 1 for the complete content of this advisory circular. The advisory circular indicates the approved FAA concentration of additives, acceptable means of compliance, etc.

TABLE 3.1 Bulk stations and terminals activities associated with the pollutants

Activity	Pollutant source	Pollutant
Fueling	Spills and leaks during delivery, spills caused by topping off fuel tanks, Rain falling on the fuel area or storm water running onto the fuel area, Hosing or washing down fuel area, Leaking storage tanks	Fuel, oil and heavy metals
Vehicle and equipment maintenance	Parts cleaning, waste disposal of greasy rags, oil filters, air filters, batteries, hydraulic fluids, transmission fluids, radiator fluids, degreaser, Spills of oil and other fluids, Fluid replacement including oil	Chlorinated solvents, oil, heavy metals, acid / alkaline wastes, ethylene glycol
Outdoor vehicle and equipment storage and parking	Leaking vehicle fluids including hydraulic lines and radiators, leaking or improperly maintained on-board drip collection systems, brake dust	Oil, hydraulic fluids, arsenic, heavy metals, organics, fuel
Painting areas	Paint and thinner spills, spray painting, sanding or paint stripping, paint clean-up	Paint, spent chlorinated solvent, dust, heavy metals
Vehicles or equipment washing areas	Washing or other cleaning	Oil, detergents, heavy metals phosphorus, salts and suspended solids
Liquid storage in above ground storage	External corrosion and structural failure, installation problems, spills and overfills due to operator error, failure of piping systems (pipes, pumps, flanges, coupling, hoses and valves	Fuel, oil, heavy metals, materials being stored
Cold weather activities	Salt application, dirt/ash application	Suspended solids, heavy metals
Improper connection to storm sewer	Process wastewater, sanitary water, floor drains, vehicle wash waters, radiator flushing wastewater, leaky underground storage tanks	Bacteria, BOD, suspended solids, oil, heavy metals, chlorinated solvents, fuel, deicers
Other activities such as sanding	Loading traction sand	Sediment

AC 91-51A discusses the effect of icing on aircraft control and airplane deice and anti-ice systems. This circular gives information for pilots on hazards of aircraft icing. It is necessary for pilots to know types of weather conducive to icing and how to respond on accidental icing conditions. Table 3.2 gives icing intensity and the corresponding pilot action.

Table 3.2 Icing intensity and corresponding pilot action (FAA AC 91-51A)

Intensity	Airframe Accumulation	Pilot Action
Trace	Ice becomes perceptible. Rate of accumulation of ice is slightly greater than the rate of loss due to sublimation	Unless encountered for one hour or more, deicing / anti-icing equipment and / or heading or altitude change not required.
Light	The rate of accumulation may create a problem if flight in this environment for one hour.	Deicing / anti-icing required occasionally to remove / prevent accumulation or heading or altitude change required.
Moderate	The rate of accumulation is such that even short encounters become potentially hazardous.	Deicing / anti-icing required or heading or altitude change required.
Severe	The rate of accumulation is such that deicing / anti-icing equipment fails to reduce or control the hazard.	Immediate heading or altitude change required.

AC 120-60 is about ground deicing and anti-icing program. Each airport shall design its deicing and anti-icing program. An inspector from Federal Aviation Administration shall check on holdover time, deicer fluid type, outsourcing and deicing and anti-icing equipments. Holdover time is defined as the period between aircraft deicing fluid application and takeoff. An example of the inspection checklist is shown in Figure 3.1. The checklist establishes whether the program of a certain airport is already in place and is functioning properly.

AC 135-16 is about training and checking of ground deicing and anti-icing. Deicing is defined as "procedure by which frost, ice or snow is removed from the aircraft in order to provide clean surfaces" while anti-icing is defined as "precautionary procedure that provides protection against the formation of frost and ice and accumulation of snow on treated surfaces of the aircraft for a limited period of time". Deicing and anti-icing are achieved by application of certain fluids. Types and characteristics of anti-icing and deicing fluids, unapproved fluids and anti-freeze and fluid handling are included in this circular.

AC 135-17 is on aircraft ground deicing guide. This circular is a corollary of the AC 135-16. The circular contains frozen contaminants and their causes and effects, cold weather preflight procedures, post-deicing/anti-icing and pre takeoff contamination checks and deicing and anti-icing fluids and procedures.

AC 150/5300-14 deals with the design of deicing facilities including the appropriate standards and specifications. Included in this advisory circular are sizing and siting deicing facilities, design of aircraft deicing pads, aircraft access and vehicle service roads, water quality mitigation and design of infra-red aircraft deicing facilities.

The infrared technology was described in the circular as an alternative method for deicing aside from the mechanical removal of certain types of contamination from the airplane surfaces. This technology will reduce the amount of deicers that will be disposed off as runoff. However, anti-icers will still be required. Design guidance for entrance taxiway, modular truss design, modular truss construction and framing materials, fabric cover, lightning protection, roof size, height of structure, width of structure, floor design, drainage design etc. is provided in the circular.

Figure 3.1 Sample Checklist for Deicing/Anti-icing Program

Element Performance Inspection (EPI) Job Aid
Element 1.3.18: De-icing Program
1.3.18 De-icing Program

To meet this objective, the inspector will accomplish the following tasks (at the inspection location(s) where applicable):

1.Review the FAA guidance and Specific Regulatory Requirements (SRR) included in the supplemental information section of this EPI.		
2.Review the associated SAI, with emphasis on the Controls Attribute section.		
3.Review the Deicing / Anti-icing Program policies and procedures.		
4.Discuss the Deicing/Anti-icing Program with the appropriate personnel.		
5.Observe and assess the results of the De-icing/ Anti-icing Program.		
6. Review and asses the records of the Deicing/Anti-icing Program.		
To meet this objective, the inspector will determine and record answers to the following questions:		
1. Was the following performance measure met:		
1.1 The air carrier and/or its vendors properly deiced/anti-iced the aircraft prior to takeoff?	☐ YES ☐ NO	If no, explain:
2. Were the Air Carrier's the Deicing/ Anti-icing Program policies and procedures followed?	☐ YES ☐ NO	If no, explain:
3. Were the Air Carrier's the Deicing/ Anti-icing Program controls followed?	☐ YES ☐ NO	If no, explain:
4. Did the Air Carrier's records comply with the Deicing/Anti-icing Program policies and procedures?	☐ YES ☐ NO	If no, explain:
5. Were all observations unrelated to the Deicing/Anti-icing Program satisfactory?	☐ YES ☐ NO	If no, explain:
6. Other comment, use space below:		

The main contributors to water pollution in airports are fuel and oil spills and deicing and anti-icing chemical spills. FAA was able to identify the sources and prevention of fuel and oil spills. However, from the materials gathered, no information on corrective action during fuel and oil spills was mentioned.

One good thing about the circular is the freedom of the airport group to choose their own deicing and anti-icing program. However, the circulars focused on the fluids and effects on airplane operation without identifying the type of acceptable deicers and anti-icers. There are no quality standards on the water generated from deicing. Moreover, the circulars focus less on the impact on water pollution. Instead, it focuses more on the operational side of the airport.

In terms of water monitoring requirements, FAA only requires pH, settleable solids and oil and grease (please refer to the next section for the monitoring undertaken by Massachusetts Port Authority). There was no requirement for Chemical Oxygen Demand, COD, or Biological Oxygen Demand, BOD. These parameters are quite important to measure especially wastewater from airport after some filtration is directly dumped into a body of water. BOD and COD are measures of the amount of oxygen needed to oxidize the organic load to carbon dioxide and water in order that the body of water will sustain aquatic life. Settleable solids, oil and grease and pH are not enough to tell whether the quality of water can sustain aquatic life.

3.3.2 Massachusetts Port Authority

Aside from the policies given by the Federal Aviation Administration, Massachusetts Port Authority uses an Environmental Management Policy to contribute to the achievement of sustainable development.

The policy is summarized below and was taken from the 1999 Environmental Status and Planning Report:

"Massachusetts Port Authority (Massport) is committed to operate all of its facilities in an environmentally sound and responsible manner.

Massport will strive to minimize the impact of its operations on the environment through the continuous improvement of its environmental performance and the implementation of pollution prevention measures, both to the extent feasible and practicable in a manner that is consistent with Massport's overall mission and goals. To successfully implement this policy Massport will develop and maintain management systems that will:

- Ensure that the environmental management policy is available to staff, tenants, customers and the general public.
- Ensure compliance with all applicable environmental laws and regulations.
- Ensure that environmental considerations are included in business, financial, operational and programmatic decisions, including feasible and practicable options for potentially exceeding compliance with applicable regulatory requirements.
- Define and apply sustainable design principles in the planning, design, operation and decommissioning of its facilities.
- Define and establish environmental objectives, targets and best management practices and monitor performance.

- Provide training to and communication with staff and affected tenants regarding environmental goals, objectives, targets and their respective roles and responsibilities in fulfilling them.
- Incorporate monitoring of Massport and Massport tenants' environmental activities.
- Include the preparation of an annual environmental performance report which will be made available to staff, tenants, customers and the general public."

Massachusetts Port Authority has a substantial environmental policy. The policy includes a commitment to run the business in a way that will protect the environment and this policy is applied to all employees of Mass port. For managers, environmental concerns shall be included in the decision-making process while for associates, environmental awareness is linked directly to environmental processes and proper environmental performance monitoring and reporting for process owners.

4 *BOSTON LOGAN INTERNATIONAL AIRPORT*

4.1 Background information

Boston Logan International Airport (according to www.massport.com), is the seventeenth busiest airport in the United States and twenty-sixth busiest airport in the world in terms of passenger served. It is located in East Boston, Massachusetts and occupies approximately 2,400 acres of land. Refer to Figure 4.1 for the aerial view of the airport. Logan airport is New England's largest transportation center serving more than 26 million passengers.

4.2 Water Quality Improvement and other Highlights

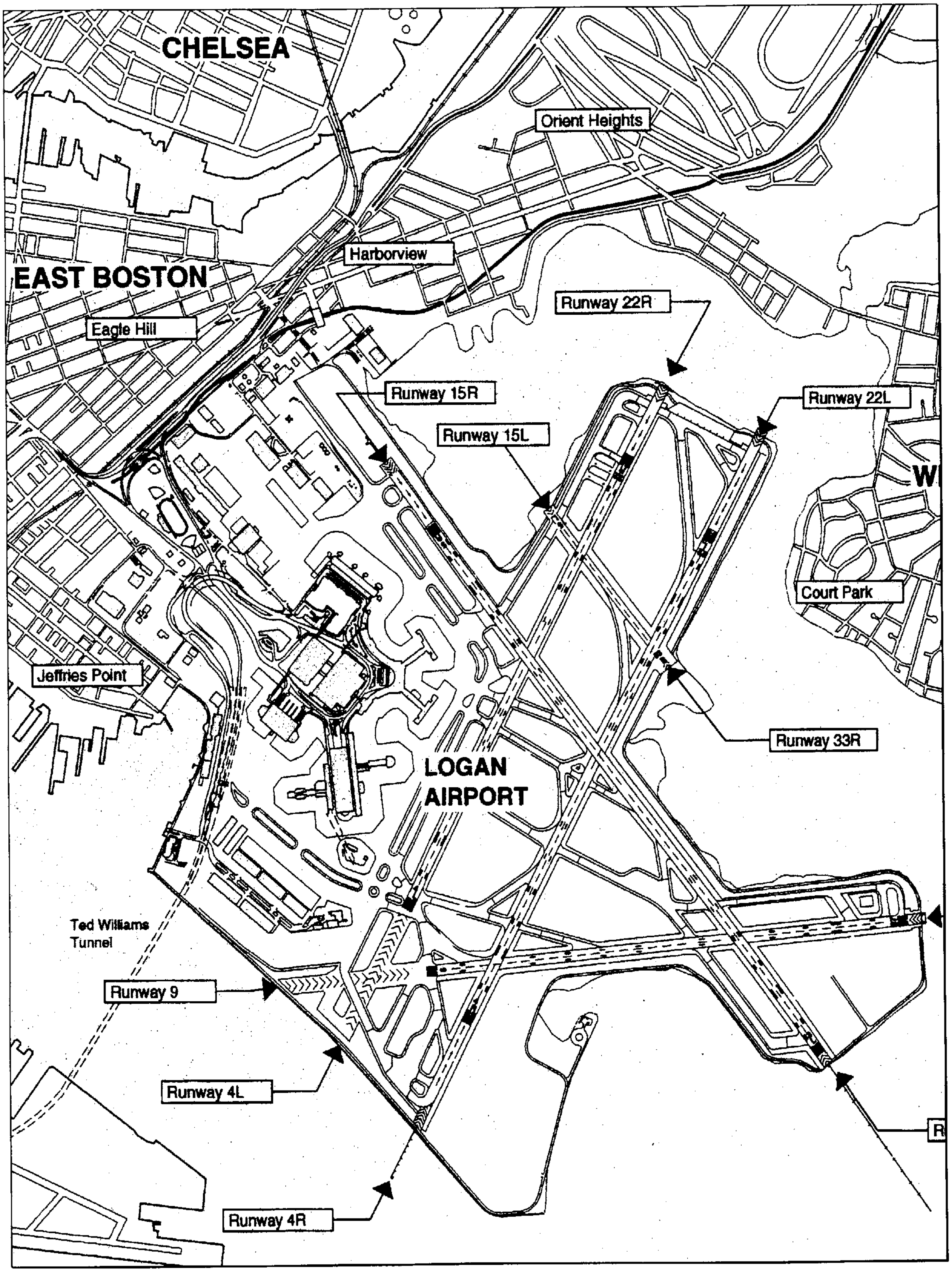
4.2.1 Introduction

As described from the previous section, pollutants come from different sources. It may come from spills and leaks during transfer, cleaning of machine parts, leaking collection systems, installation problem and leaky storage tanks.

Doing preventive and corrective action plans however can prevent pollution occurring at the sources identified. Preventive action plans involve steps or measures to be undertaken by the organization in order to prevent the occurrence of the identified mechanism of pollution. Corrective actions include all measures to be carried out in case of an unexpected occurrence of pollution. Preventive and corrective action planning is a common practice for most companies.

In the Boston Logan airport, a comprehensive water quality management program is already in place to promote sound environmental practices.

Figure 4.1 Aerial view of Boston Logan International Airport



4.2.2 Environmental Concern

The water quality management program in Boston Logan airport, as stated in its 1999 Environmental Status and Planning Report, aims to protect water quality airport-wide during construction, to reduce occurrences of leaks and spills, to preserve coastal resources adjacent to the airport, to promote good practices for handling of fuel and hazardous materials, prevention and control of spills and maintenance of pollution control facilities.

A detailed description of the airport's effort to properly implement the water quality management program is discussed in succeeding section. The highlight of these efforts are summarized below:

1. Continuous compliance to National Pollutant Discharge Elimination System (NPDES) permit for the four storm water outfalls.
2. Meetings with Environmental Protection Agency and the Department of Environmental Protection to discuss water quality issues.
3. Majority of treated water on site is reused to conserve water instead of discharging into the harbor.
4. Completed design for upgrade of its pollution control equipment at North and West outfalls. Construction will begin in 2001.
5. Continuous collaboration with Boston Natural Areas Fund (BNAF) to preserve and enhance resources.
6. Created salt marsh through salt marsh replication project.

4.2.3 Discussion

This discussion highlights the environmental issues at the Logan Airport, as described in Massachusetts Port Authority Annual Report, and have been divided into three areas entitled water quality reporting, fuel use and spills and water quality management program.

4.2.3.1 Water Quality Monitoring

Water quality is monitored three times a month at each outfall by collecting samples and checking for parameter compliance. The sampling is done in dry weather conditions, during a rainfall event, and within 24 hours after the rainfall event.

Measurement of oil and grease, total settleable solids and pH are taken at each outfall. The four outfalls are identified as North, West, Porter Street and Maverick Street.

North outfall discharge is located at Wood Island Bay with a drainage area of 145 acres. Discharge water from terminal E, apron, taxiway, cargo areas and fuel farms goes to the north outfall.

West outfall, on the other hand discharges to Bird Island Flats with a drainage area of 557 acres. Water from taxiways, terminal areas, aprons and cargo areas goes to this outfall. Both north and west outfalls have pollution control pipe equipment for removal of debris and floating oils.

Porter Street outfall discharge is also located at the Bird Island Flats with drainage area of less than 4 times as that of the West outfall at 130 acres. Water from Hangars, vehicle maintenance facilities, cargo areas, car rental facilities and roadways goes to this outfall.

Maverick Street outfall is located at the Jeffries Cove. The drainage area is the smallest among the four at 34 acres. Water from the car rental facilities, parking areas and flight kitchen goes to this outfall.

NPDES permit limits are as follows:

Oil and grease	15 mg/L	
Total settleable solids	0.3 mg/L	maximum
	0.1 mg/L	average
pH	6.0-8.5	

From the result presented by the Environmental Status and Planning Report, all parameters during the 1999 outfall-sampling summary fall within the range except for the west outfall during the rainfall at March 22, when total settleable solids exceeded standard by 0.1 mg/L.

Currently the airport holds a NPDES permit for storm water discharges from the four outfalls. Aside from the storm water discharge permit, the airport holds a permit for treated water discharges from fire-fighting operations located at the Fire Training Facility on Governors Island.

Treated water, used in fire training exercises to reduce smoke, from the Fire Training facility is stored, tested and discharged. It is discharged monthly with the permission from the NPDES permit. The airport is currently reusing water from the facility to mainly conserve water.

4.2.3.2 Fuel Use and Spills

The airport monitors fuel usage and spills on a yearly basis. This is summarized on the table below:

Table 4.1 Estimated fuel use and spill at Logan International period from 1991-1999

Year	Estimated Fuel Use (Gal)	Estimated Fuel Spilled (Gal)
1999	425,973,051	7,289
1998	387,224,004	10,047
1997	377,488161	2,029
1996	346,700,000	1,321
1995	309,200,000	21,412
1994	476,700,000	4,046
1993	451,900,000	3,131
1992	-	-
1991	-	-
1990	438,000,000	3,745

The largest spill occurred in 1995 from a tenant spill, which totaled 18,000 gallons. In 1998, two separate spills occurred. A 7,200-gallon spill happened on September 2nd and a 1,300-gallon spill occurred on June 3rd. In 1999, a 5,000-gallon spill occurred.

4.2.3.3 Water Quality Management Program

The airport water quality management program can be divided into six categories as discussed below containing highlights of the airport's actions.

1 Protect water quality, airport wide

- Continuous implementation of an Environmental Audit program that provides with site-specific recommendations for improving the storage and handling of the potentially hazardous materials.

The airport in 1999 performed on the different tenant facilities within the airport. The tenants include:

  - Delta Shuttle
  - American Airlines Hangar and GSE Maintenance Facility
  - BOSFUEL Fuel Farm
  - Delta Airlines Hangar and GSE Maintenance Facility
  - Delta Cargo
  - United Airlines Hangar and GSE Maintenance Facility
  - Trans World Airlines Freight Facility

- Tenant forums on regulatory responsibility

In 1999, two environmental forums for Logan airport tenants were conducted. Topics that were covered include storm water management, regulatory updates, air quality permitting, alternative fuel vehicles, and spill policy and procedures.

- Continuous participation in Clean State meetings and quarterly update of Clean State database.

The airport conducted audits on all facilities as part of the Clean State Initiative. Furthermore, the airport is in the process of establishing the environmental management system in preparation for certification to the International Standards Organization (ISO) 14000.

2 Protect groundwater resources

- Continuous assessment, remediation and regulatory closure of areas of subsurface contamination.

The Massachusetts Contingency Plan (MCP) contains suggestion for site clean-up depending on the extent and nature of contamination. This defines specific actions to be undertaken by responsible individuals including release reporting program and submission deadlines for tracking events.

In line with this plan, the airport continuously assesses and remediates subsurface conditions. The area that is tracked by Logan airport includes Fuel Distribution System, Citgo Service Station, Terminal A, Eastern Fuel Farm, Pan Am Fuel Farm, North Outfall, North Outfall Drainage Area, American/Exxon/United, Redundant Water Supply, United Airlines GSE Facility, Centerfield Taxiway and a New AVGAS Facility.

3 Protect surface water resources (Boston harbor)

- Continuous monitoring and sampling at four outfalls in accordance with NPDES requirements.

Water quality is monitored three times a month at each of the four outfalls through sample collection and parameter compliance.

- Equipment evaluation on outfall pollution and design of Porter Street drainage area low flow diversion.

Upgrade of pollution control equipment in the outfall was done.

- Storm water Discharge Pollution Prevention and Drainage System Improvements

The airport drafted a Storm Water Pollution Prevention Plan (SWPPP) for the use of tenants and airport operations.

4 Enhance fuel storage and handling

- Jet fuel storage and distribution system – project completed and operated in July 1999

This system is an underground pipe system using controls. The system includes a leak detection system. The principle behind detection of leaks evolves in the volumetric changes of the product at operating and zero pressures. In conjunction with this system, manual and plans were developed. These are on Operation and Maintenance Manual, Spill Prevention, Control and Countermeasure Plan, and a Facility Response Plan.

- Operation of Alternative Fuels program

The airport invested in vehicles powered by alternative fuels through the Alternative Fuel Vehicle Program. This fleet of vehicles includes shuttle buses, airport tenants operating at the airport roadway and ground service equipment on the airside and rental car tenants.

- Creation of Tank Management Program and Spill Prevention Program.

The airport continues to monitor tank conditions and upgrades tanks that need upgrading. Some activities that fall into the tank management program include storage tank modifications by removal, installation and replacements, tenant underground storage tank assistance.

5 Protect coastal resources adjacent to the airport

- Continuous support to Boston Natural Areas Fund (BNAF) snowy owl tour and other activities.

The airport worked hand in hand with BNAF, a non-profit environmental organization, in sponsoring environmental tours. On the other hand, the airport also worked with Audubon Society to conduct salt marsh education tour.

- Filed a 5-year salt marsh monitoring program.

The airport is taking steps to replace the salt marsh displaced by runway improvement.

- Soft-shell clam planting and monitoring program

This program is in accordance with FAA requirement for airport operators to minimize hazardous wildlife attractants near the airport, which harvests shellfish from impact area and transfers them to the tidal flats of Governor Island.

6 Protect resources during construction

- Developed Soils Management Plan for Construction Activities, and Construction Storm water Pollution Prevention Plan (SWPPP)

The airport has developed practices that responsible individuals will undertake during construction activities to protect water resources. This includes control of sedimentation and release of pollutants from the construction project.

As a whole, Boston Logan International Airport is focused on water quality monitoring program, fuel use and spills and water quality management program in order to meet their environmental policy. Water quality monitoring program focuses mainly on the quality of water at the four outfalls. Fuel monitoring focuses on the spillage of fuel per year. Water quality management program, which is divided in to six areas, are programs and systems that are geared towards the protection surface waters, ground waters through continuous audit, assessment, evaluation and improvements.

In terms of the two major causes of water pollution in airports, deicing and anti-icing activities were not given priority or focus. Currently, the airport is using ethylene glycol as the chemical deicers and anti-icers. Glycol mixture includes water, wetting agents, corrosion inhibitors, surfactants and dyes. Glycol therefore has also potential for water pollution due to the presence of chemicals such as surfactants, wettings agents, etc. Alternative method for deicing and anti-icing should be explored. Alternative methods are infrared deicing, forced air blast deicing, clean wing detection system and upper wing heater system.

The infrared deicing method uses infrared energy to melt the ice without heating the aircraft. This system reduced glycol use at Rhinelander-Oneida County Municipal Airport in Wisconsin by approximately two-thirds.

Forced air blast deicing uses compressed air combined with a fine spray of glycol deicing fluid to remove ice and snow off aircraft wings. This system deices aircraft half the time as compared to the conventional method while using 70 percent less glycol.

The clean wing detection system utilizes sensors to detect and measure thickness of ice on surfaces of wings. Upper wing heater system uses thin pads that encapsulates heater to avoid heat loss to the wing. This system was designed to prevent condensation and icing problems in aircraft.

Fuel use and spills have been one of the three foci of the airport. Programs such as mentioned in this section prove that the airport has been giving emphasis on this type of water pollution contributor. The yearly fuel spills report shows that the airport have been exerting effort in preventing occurrence of fuel spills and leaks.

5 *RECOMMENDATIONS*

Planning for airport expansion or construction plays a very important role in making such undertaking a success. Careful investigation and consideration of concerns help in setting up the system.

The following are recommendations that should be considered in terms of water concerns when planning for expansion or construction of an airport.

The considerations in this paper can be divided into the following:

1. Policies
2. Regulations
3. Systems / Programs
4. Targets / Goals
5. Monitoring and Control
6. Preventive measures
7. New technologies

5.1 Policies

Policies such as those found in Environmental Policy of Boston Logan International Airport give definite directions to the whole airport group (from previous chapter). Such policies will help the management in shaping up programs and systems that will be implemented. They will also create a sense of environmental responsibility among the associates of the airport group.

5.2 Regulations

Regulations are statements from the airport group or governing body that controls its operations, functions and other related activities in the pursuit of its mission.

In Hong Kong airport, there were two regulations that enabled the water surrounding the airport sustain life. The two regulations are dumping at sea ordinance and water pollution control regulation.

The April 1995 Dumping at Sea Ordinance regulation sets the framework for controlling dumping and incineration of substances at sea. The ordinance defines "dumping" as any deliberate disposal of materials, including any discharge, from any aircraft or vessel, regardless of the country of origin or marine structure.

The 1994 Water Pollution Control (Sewerage) Regulation (Airport Authority Hong Kong) provides government with the authority to take over a treatment facility (including airport wastewater treatment facilities) if it fails to comply with government requirements such as license, emission standards and hazards.

5.3 Systems / Programs

Programs and systems help the airport group meet the environmental policy. The following are systems and programs from different airports that perceived as innovative, relevant and beneficial and, therefore, should merit careful consideration.

Schiphol airport has been implementing the Environmental Care System. This states, "the responsibility for water pollution should be placed with the polluters themselves", (Annual Environmental Report 1999). Knowing that urea is a source of nitrogen and phosphorus, the airport group, as a responsible organization, prohibits the use of urea in deicing and anti-icing operations.

Reduction of water consumption and inefficiency is another program by the Schiphol airport. Reduction of water consumption, without jeopardizing nonetheless the water requirements of the airport, will definitely reduce volume of wastewater. This will likely result in lesser cost in wastewater treatment and better water quality. In line with reduction of water consumption, another thrust of Schiphol is less drinking water consumption. Although, drinking water consumption is small compared to total airport water consumption, this small step will definitely have an impact on the total volume of water used. The reduction in drinking water consumption is accomplished with the commitment of Amsterdam Airport Schiphol, KLM and other tenants. A decreased consumption of drinking water per unit transport was reflected on Schiphol's 1999 annual report from 1990's 42 liters to 1999's 23 liters. It should be noted though that this drive should not prohibit customers to meet their water requirements while in the aircraft.

Another system that supports environmental policies is the reliever airport system. Minneapolis St. Paul International Airport uses six reliever airports to ease air traffic congestion. This is one of the busiest reliever systems with 800,000 operations per year (Metropolitan Airports Commission, Annual Report to the Community). Reliever airports maximize the capacity of the airport. On the other hand, the Metropolitan Airports Commission requires each reliever airports to each install water and sewer lines.

In Heathrow airport, systems and programs include general awareness raising and training activities, contingency plans and procedures for reporting and clean-up of spillages and inclusion of water quality concerns in drafting and re-tendering of the airport cleaning contracts.

Water quality mitigation may be considered under the systems and programs considerations. Some of the water quality mitigation was identified at the advisory circular 150-5300-14. This includes run-off mitigating structures, mitigation alternatives, underground storage tanks, publicly owned treatment works, recycling glycol fluids, anaerobic bioremediation systems.

Run-off mitigating structures and mitigation alternatives depend on the airport group but should be reviewed and approved first by Federal, state or local environmental authority. Underground storage tanks collect spent glycol deicer fluids. The collected fluid with concentration 5 percent and lower may be recycled be selling to vendors. Recycling reduces disposal cost for airport group.

Anaerobic bioremediation system converts collected spent glycol deicers to methane, which may be source of energy. Basic components of these systems include glycol contaminated storm water storage system, bioreactor treatment system and gas recovery system.

Allocating areas for specific activities will be a good way to prevent unexpected contamination. At the Phoenix airport, areas such as aircraft and vehicle fueling, aircraft, vehicle and equipment maintenance, aircraft and vehicle washing, chemical and fuel storage, fuel farms, floor wash down and pesticide and herbicide application are clearly identified. Aircraft and vehicle fueling are done only on paved surfaces. Aircraft and vehicle washing is only conducted on areas approved by the airport group. The airport group requires each tenant to identify washing area, storm drains, water recovery system, and waste disposal process. Washing cannot be performed in areas without a wash rack or oil/water separator. Chemicals and fuels are stored on different containers. Chemicals are stored in small containers while fuels and deicing fluids are stored in underground or aboveground storage tanks. Secondary containment, which is a precautionary measure, is observed in most storage containers.

Construction of an effective system requires planning, close monitoring and continuous improvement. In Phoenix airport, in order to comply with the policy, the airport group formed the Best Management Practices Implementation Program. The Best Management Practices Implementation Program includes formation of pollution prevention team, training of employees, inspection of Comprehensive Facility Compliance Evaluation Protocol, review of SWPPP content, monitoring progress of program and periodic evaluation.

5.4 Targets / goals

Being able to know the target will help in assessing the performance of the airport. Fuel leak target is one of the useful goals to have. In Schiphol airport, the targeted fuel leak should be no more than 50 leaks per 100,00 aircraft movements. With this target, Schiphol group knows their performance in terms of fuel leak performance. From their performance report in 1999, they are within their target at 36 leaks per 100,000 aircraft movements.

Another good goal is to have deicing and anti-icing chemical utilization. The target utilization per aircraft launch will instill the operators optimize the use of chemicals whilst effectively deicing and anti-icing the aircraft and runways. With this, the airport group can save from excessive use of deicing and anti-icing chemicals and at the same time reduce environmental impacts.

5.5 Monitoring and Control

Setting a target on a parameter, if not monitored, is deemed to be useless. Monitoring by sampling and testing in a regular frequency will help and ensure that the operation is running within the acceptable range of the parameter. It is important to set the parameter within the standards set by the governing body.

The Phoenix airport defines quality control as controls that are designed to limit the type and concentration of pollutants found in storm water runoff. This is subdivided into source control and treatment control. Source controls are practices that prevent pollutants in entering surface waters. Treatment controls are practices that remove the pollutants that are actually present in storm water.

In Phoenix airport, source controls include moving outdoor operation indoors, placing storage containers for recyclable oil in sheds or under cover, storing hazardous materials in covered contained areas, aircraft vehicle and equipment maintenance, and lavatory service operations. On the other hand, treatment control includes retention ponds, oil and water separators, grass swales and spill response program.

5.6 Preventive measures

Preventive measures are steps that make sure that the quality of water discharged is within the set standards. The Schiphol group established excavation pits that can be used for construction activities. Water from this pit is analyzed before releasing it into the

Ringvaart waterway or passing through preliminary purification depending on the result of the analysis.

Using excavation pits during construction is a measure used by Schiphol airport during construction activities. Water from the pit is analyzed first before releasing to a waterway or passing through preliminary purification depending on the result of the analysis.

In Advisory Circular 150-5300-14, detention basins were identified as preventive facility to avoid spent-up deicing chemicals reaching the groundwater and monitoring wells. This basin uses liners to totally avoid flow through the liner or to treat the water passing through the liner.

5.7 New Technologies

New technologies have been introduced to maximize operations and, likewise, help preserve the environment.

The Federal Aviation Administration Advisory Circular 150/5300-14 identified new technologies to deicing.

Using infrared for aircraft deicing is a new technology that minimizes the impact of the deicing chemicals. However, this method is limited only to deicing and does not include anti-icing activities.

New technologies for monitoring and control are now adapted at the Heathrow airport. These are as follows:

- Conducting research studies by identifying ecological indicators to ascertain whether heavy periods of deicing are likely to cause damage to the river ecosystem.
- Constructing test bed simulating aircraft pavement and modeled de-icer run off characteristics in different rainfall conditions. This will allow understanding the type of weather conditions, which give rise to greatest pollution risk and design treatment systems to cope.
- Building computer model of the airport surface water systems, which established pollution movement and dilution patterns. The model allows prediction of possible problem occurrence and design effective solutions.

6 *SUMMARY AND CONCLUSION*

In this paper, regulations made by the Federal Aviation Administration were identified. The regulations focused on source of fuel spills and guidelines and troubleshooting on deicing and anti-icing activities. The FAA empowers the airport group to implement programs. However, the airport group must apply for FAA's approval.

A particular airport, Boston Logan International Airport, was reviewed in terms of water quality performance. The airport focuses on monitoring programs, fuel and oil spills and water quality management programs to achieve the objective of the Massachusetts Port Authority's Environmental policy.

Recommendations for expansion and construction of airports in terms of water aspects were also identified. The following aspects were discussed: policies, regulations, systems and programs, targets and goals, monitoring and control, preventive measures and new technology. These considerations should help airport group attain sustainability.

Sustainability requires continuous planning, development and research. The ability to forecast and predict the future is beneficial in minimizing the potential effects of such expansion and construction. Perfectly planned designated areas for doing activities such as aircraft cleaning, and fueling will build confidence in preventing occurrence of water pollution. Knowing the designated areas will help in constructing preventive measures to avoid water deterioration of the surface and ground waters.

Appendix 1. Advisory Circular 20-29B

U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: USE OF AIRCRAFT FUEL ANTI-ICING ADDITIVES

Date: 18 Jan 72

AC No. 20-29B

Initiated by: FS-140

Change:

1. PURPOSE. This circular provides information on the use of anti-icing additives PFA-55MB and MIL-I-27686 as an acceptable means of compliance with the Federal Aviation Regulations that require assurance of continuous fuel flow under conditions where ice may occur in turbine aircraft fuel system.

2. CANCELLATION. AC 20-29A, effective June 19, 1967, is cancelled.

3. REFERENCE REGULATIONS. Part 25, Section 25.997(b), of the Federal Aviation Regulations.

4. BACKGROUND.

   a. FAA - The Southern Region approved the use of a 0.10 percent concentration (by volume) of PFA-55MB in all turbine aircraft fuels in December 1962. This approval was based upon compatibility tests of the additive in certificated aircraft and engines at a concentration of 0.15 percent of the fuel by volume and did not include approval for the use of the additive in lieu of fuel heaters. FAA may approve the 0.15 percent concentration where compatibility with the aircraft and engine fuel systems has been demonstrated (see Advisory Circular AC 20-24A).

   b. Air Force - The United States Air Force, after extensive tests with PFA-55B in JP-4 fuel, concluded that the additive satisfactorily prevents the formation of ice in the fuel. Starting in April 1, 1962, this additive, under its Military Specification No. MIL-I-27686A to D was used in all JP-4 fuel produced in the United States. Since January 1971, anti-icing additive to Military Specification MIL-I-27686E has been used. The main change involved in this revision to the specification is deletion of the glycerin. Because of the possible effect on fuel tank coatings and seals, the use of the new MIL-I-27686E additive should be cleared for each aircraft as being compatible with the fuel system of the aircraft. This is discussed in paragraph 8 below. At the present time, with the exception of a few areas, the use of the additive in JP-4 fuel is worldwide.

5. USE OF ADDITIVE IN KEROSENE. The characteristics of these additives, PFA-55MB and MIL-I-27686, in kerosene type fuel are similar to those in JP-4 fuel. Commercial aircraft kerosene, however, does not contain the additive and provisions for blending it into this type of fuel present a complication to its use. The additive is readily soluble in water but its solubility in the fuel is relatively low. It is, therefore, essential that the additive be uniformly blended into the fuel with proper equipment and procedures. Blending facilities and the additive are available at some airports, but cases will arise where it will be necessary blend at the aircraft to assure icing protection. To provide for these cases, it may be necessary for the aircraft to carry both the additive and blending equipment.

6. WATER IN FUEL.

a. Presence of Water in Fuel - Although rigorous precautions are taken to ensure that fuel being pumped into an aircraft contains as little water as possible, an aircraft fuel containing no water is an impossibility. This is due primarily to the affinity that hydrocarbon fuels have for water. Even if fuels are prepared, handled, and used without even contacting liquid water, the fuels will contain water picked up from the air. The extent of such pickup is largely a function of the humidity of the air drawn into the fuel tank to equalize the pressure resulting from changes in tank temperature and pressure.

b. Affinity of Fuel for Water - The affinity that fuel has for water varies with its composition and temperature. The saturation level for a jet fuel in parts per million by volume is approximately equivalent to the temperature in degrees F.; that is, a jet fuel at 50 degrees F. may contain approximately 50 parts per million of dissolved water. When the fuel is cooled, that water which is above the saturation level is rejected as discrete water in minute particles. Until this water can coalesce and migrate to the bottom of the tank, it will be carried in the fuel. At temperatures below the freezing point, these minute particles may be super cooled and will be deposited out only when they strike a solid obstruction and freeze.

c. Effect of Gravity - The small differences in the specific gravity of water and jet fuel (1.0, 0.77, and 0.83, respectively, for water, JP-4 and kerosene) complicate the task of removing the discrete water dispersed in the fuel. While this water will in time settle out of the fuel, the particle size is so small that filters and water separators cannot be depended upon for its complete removal. Experience has shown that jet fuels may contain up to 70 parts per million of dispersed water.

d. Condensation of Water in Flight - An aircraft after a long flight at high altitudes will have tank surfaces and fuel that are colder that the air that is drawn into the tank during descent. When moisture-laden air enters the tank space, condensation may occur in the tank. Due to the higher viscosity of cold fuel, this water will not settle out as readily and will be carried as dispersed water for a longer period of time. Under these conditions, the dispersed water in the fuel may reach 100 parts per million.

e. Microbial Control - Fuel tank corrosion has been a problem in jet aircraft due to the presence and growth of microbial at the water and fuel interface. Elimination of water and contaminants from the fuel and water reduces this corrosion, but complete elimination of water is not possible. Experience with fuel containing PFA-55MB and MIL-I-27686 has shown that when the concentration in the fuel is maintained above .05 percent by volume it is effective in eliminating many type of microbial growth and thus reduces tank corrosion.

7. ADDITIVE CONCENTRATION. Data indicate that a .015 percent by volume concentration of the additive would prevent ice formation in fuel containing 100 parts of water per million down to fuel temperature of -40 degrees F. Additive concentrations exceeding .015 percent by volume are necessary, however, for the following reasons:

   a. The additive tends to separate out of the fuel during its transportation (often via long pipe lines) from refinery to aircraft, and during long-time storage in refueling tanks. A drop in additive concentration to one-third the original refinery value has been reported.

   b. Free water may have accumulated in the aircraft tank in sufficient quantity to leach further additive from the fuel.

   c. Techniques for measuring the additive concentration of fuels necessarily involve some accuracy tolerance.

   d. The FAA therefore considers that, to ensure continuous fuel flow under conditions where ice may occur in the fuel system, the minimum additive concentration for a loaded aircraft tank should be .035 percent by volume. Moreover, to ensure that this concentration is maintained in the loaded aircraft tank, it should be refueled with fuel containing an additive concentration of at least .06 percent by volume.

8. ACCEPTABLE MEANS OF COMPLIANCE. Fuel containing anti-icing additives PFA-55MB and MIL-I-27686 may be approved as an acceptable means of complying with Section 25.997(b), if such fuel has been demonstrated to be compatible with the engine and aircraft fuel system at an additive concentration of 0.15 percent by volume using the procedures set forth in Advisory Circular AC 20-24A. Requests for such approval are considered by the Chief, Engineering and Manufacturing Branch, for the region in which the applicant is located. The approval, in each case, is subject to the following conditions:

   a. Placarding - The aircraft should be placarded near the fuel filler cover to show that fuel to be used must contain anti-icing additive PFA-55MB or MIL-I-27686 within the minimum and maximum allowed concentration.

b. Manuals - Federal Aviation Administration approved flight manuals should contain the following:

(1) The minimum concentration of the additive in a loaded fuel tank should be at least .035 percent by volume.

(2) The minimum concentration of the additive in the fuel with which the aircraft is to be refueled should be at least .06 percent by volume.

(3) The maximum concentration of the additive that may be used in fuel is 0.15 percent by volume

(4) The procedures that are to be used in blending the additive into the fuel.

(5) A list of approved types of equipment that may be used for blending the additive into the fuel.

(6) The procedures and approved equipment that may be used to determine the concentration of the additive in the fuel.

(7) A list of trade names under which the additive may be obtained.

(8) The minimum equipment that is required and approved for operations.

c. Tests - The applicant should show by tests that his additive sampling and blending procedures are feasible.

9. OTHER ADDITIVES. Fuel containing other anti-icing additives may be given similar approval after it has been conclusively demonstrated by test and service experience that:

a. The additives have no adverse effect on the engine and aircraft.

b. The additives provide satisfactory protection against the accumulation of ice that may clog fuel filters as required by Section 25.997(b).

/s/ WILLIAM G. SHREVE, JR.

REFERENCES:

Annual Environmental Report 1999. Schiphol Group

BAA Heathrow. Towards Sustainability, Heathrow's Environmental, Social and Economic Performance Report 1998/99.

BAA Heathrow. Towards Sustainability, Heathrow's Environmental, Social and Economic Performance Report 1999/2000.

Capuno, R.E., Holvoet, M., Rubenstein, E. and Williamson, J. Schiphol: A Sustainable Airport?, a paper submitted at the MIT-TUD open Design Methodology Workshop, January 8-19, 2001.

Department of Transportation Federal Aviation Administration Southern Region Atlanta, Georgia. Record of Decision for Proposed new Parallel runway and associated work at Miami International Airport Miami-Dade County, Florida. December 1998.

Department of Transportation Federal Aviation Administration. Cleveland Hopkins International Airport Environmental Impact Statement. November 2000.

De Neufville, Richard, 1990. APPLIED SYSTEMS ANALYSIS Engineering Planning and Technology Management. McGraw-Hill, Inc, USA.

Environmental Status & Planning Report (ESPR) 1999 Boston Logan International Airport prepared by Vanasse Hangen Brustlin, Inc. for Massachusetts Port Authority, Aviation Planning and Development.

[1] http://cas.faa.gov/ane/Mission1.html

http://www.faa.gov/arp/app600/5054a/searod.html#seaVI

http://www.faa.gov/arp/app600/505a/RODogg.html#VI

http://www.faa.gov/arp/app600/5054a/RODclt.htm#VIII

http://www.faa.gov/arp/app600/5054a/chap5.htm

http://www.faa.gov/arp/app600/5054a/chap8.htm

http://www.faa.gov/arp/app600/5054a/RODhou.htm#sec6watermit

http://www.faa.gov/arp/rpthome.htm

http://www.massport.com/logan/about.asp

http://www.massport.com/logan/about_histo.html

http://www.sydneyairportmedia.com/facts/environment.htm

http://www.hkairport.com/eng/corporate/corp_authority04.htm

http://news.airwise.com/airports/traffic/99top50.html

Krietor, David (Aviation Director). City of Phoenix Aviation Department Rules and Regulations. March 1, 1999.

Metropolitan Airports Commission. 1999 Annual Report to the Community. Minneapolis-St. Paul International Airport

Minsk, L. David. Snow and Ice Control Manual for Transportation Facilities, McGraw-Hill Companies, Inc. 1988.

New Airport Master Plan. Environmental Impact Assessment Update. Airport Authority Hongkong, February 1998

Newsletter of Southern Region Airports division. FAA Environmental Newsline. Issue Number 14, February 1999.

P:\PHOENIX\151577\SWPPP REVISION\SKY HARBOR\ SH SWPPP.DOC

Transportation Research Board, Highway Deicing Comparing Salt and Calcium Magnesium Acetate, Washington, D.C. 1991.

Transportation Research Board, Snow Removal and Ice Control Technology. National Academy Press, Washington, D.C. 1997.

Tufts University (September 1999), Evaluation of the Environmental Impacts, Regulatory Trends, and Technological Alternatives of Deicing Operations at Airports.

US Department of Transportation. Federal Aviation Administration. Advisory Circular number150/5300-14 change 2. August 31, 2000.

US Department of Transportation. Federal Aviation Administration. Advisory Circular number 91-51A. Effect of icing on Aircraft Control and Airplane Deice and Anti-ice Systems. July 17, 1996.

US Department of Transportation. Federal Aviation Administration. Advisory Circular number 135-16. Ground Deicing and Anti-Icing Training and Checking. December 12, 1994.

US Department of Transportation. Federal Aviation Administration. Advisory Circular number 135-17. Small aircraft ground Deicing- Pilot Guide. December 14, 1994.

US Department of Transportation. Federal Aviation Administration. Advisory Circular number 00-2.13 June 15, 2000.

US Department of Transportation. Federal Aviation Administration. Advisory Circular number 20-29B, January 18, 1972.

US Environmental Protection Agency. EPA Office of Compliance Sector Notebook Project, Air Transportation Industry. October 1998.

Vanesse Hangen Brustlin, Inc. 1999 Boston Logan International Airport Environmental Status and Planning Report.

Van Gunsteren, L.A. and Van Loon Peter-Paul. 2000. OPEN DESIGN: a Collaborative Approach to Architecture. Eburon Publishers, Delft.