INNOVATIVE FEATURES OF JERSEY AIRPORT'S NEW FIRE TRAINING GROUND

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SUMMARY

This Paper describes an innovative development at Jersey Airport in which a new Fire Training Ground (FTG) has been constructed in such a way that all of the natural precipitation and fluids introduced during fire training exercises are dealt with at the FTG so that no fluid exfiltrates into the ground and nothing enters the local public foul drain unless it is clean and the drain has sufficient capacity at the time of discharge. The major innovative feature comprises the integration of several technologies to ensure that water is stored beneath the FTG during winter and is then sprayed over the FTG during summer to achieve evaporation. This Paper describes all of the innovative elements embodied within the development. These include water handling systems, lining systems, control systems and construction materials as well as full scale proof testing. Under normal operational parameters, the new FTG is water neutral, i.e. it neither discharges into nor abstracts from the public water supply. Rainwater is harvested for fire training and this same water can then be either evaporated away or alternatively cleaned and discharged into the public sewer when this is considered to be beneficial.

Key facts:

<u>The FTG Project:</u>
Design life: 25 years from 2004 to 2029
Surface area: 5321m^2
Water holding capability: 2200m^3
Fire tender weight: 32t on three axles
Annual rainfall used in design: 843mm (April 2000 to March 2001 - highest figure recorded)
Maximum output to public sewer: 0.5litres/second
Maximum groundwater abstraction rate: 10m^3/6hr (in case of shortfall)
Total weight of construction: 27,600t
Weight of water falling on FTG per year: 4,500t (April 2000 to March 2001)

<u>States of Jersey</u>
Location: Jersey, English Channel. Co-ordinates: 49 15 N, 2 10 W
Area of Jersey: 116 sq. km

Annual weight of rainfall on Jersey: 9.8 million tons (April 2000 to March 2001)
Population: 88,915
Capital: Saint Helier
GDP per capita: $US24,800
Climate: temperate; mild winters and cool summers
Terrain: gently rolling plain with low, rugged hills along north coast

1. INTRODUCTION

Jersey is the largest of the Channel Islands in the English Channel. It is a British Crown Dependency and is part of neither the UK nor the European Community. Jersey Airport serves several market sectors including short flights to the other Channel Islands, tourist and business scheduled and charter flights to the UK, France and other European countries and general aviation. It is used by a wide range of aircraft types up to Boeing 757s. Jersey Airport is licensed in accordance with the International Civil Aviation Convention and the Island's Harbours and Airport Committee (IHAC) also acts as a self-regulating authority. Under these obligations the Airport has a duty to meet expected standards for airfield safety and to have due regard for the health, safety and welfare of its employees and users of or visitors to the Airport.

The airport is required to maintain a well-trained fire fighting resource whose training needs to be to a very high standard. This training involves regular exercises at the FTG as detailed in Section 2. Figure 1 shows the FTG prior to reconstruction.

Precipitation and fire fighting fluids could drain through the fragmented shale rock over which the training took place. Oil, foam and dirty water contaminated aquifers and became a nuisance to the local community. The Airport's difficulties were exacerbated by the unavailability of additional capacity in the local public foul sewer and the reluctance of Jersey's Public Works Department to allow oil and foaming agents into the sewerage system. Also, large quantities of water used in fire training were obtained from Jersey's already stretched water distribution system.

This led the Airport to develop a design for the new FTG which embodies several innovative concepts which work together to eliminate pollution entirely. They severely curtail the volume of water entering the public sewer, they ensure that the water which does enter the public sewer is clean and they use either rainwater or groundwater for fire training exercises.

The innovations can be summarised as follows:

1. Development of an evaporative storage cell concept which stores water during winter and evaporates it during summer.
2. Development of control systems which ensure that the water demand is as close as possible to neutral, i.e. water inputs and outputs balance over a wide range of fire training scenarios and during extremes of climate.
3. The development of liner systems which eliminate the ingress of fluids into fissured rocks
4. The development of water spray control systems which optimise the rate of evaporation for all temperature, humidity and wind directions.
5. The development and proving of pavement construction materials which can withstand trafficking by heavy fire tenders whilst at the same time holding up to 2200m^3 of water throughout a design life of 25 years.

6. The development of detailed design and engineering specifications which integrates all of the innovative systems into a buildable project.

Figure 1. The original Fire Training Ground at Jersey Airport. Water, foam and other contaminants can permeate into the ground and pollute watercourses and the aquifer below.

2. LEVELS OF USEAGE OF THE FIRE TRAINING GROUND

This section sets out in detail Jersey Airport's use of its FTG. It is included to allow other airport operators to check whether their procedures are similar in scale. The Airport maintains the following fire fighting resources:

- 4 Tenders – minimum 3 operational per shift
- 33 fire fighting personnel (3 crews – 11 personnel each) & additional support staff

Fire training includes the following activities which require the use of the FTG.

- Each fire fighter to carry out 1 hot rig exercise (water only) per month
- Fire Service to carry out 6 Monex foam exercises per year or 1 every 2 months
- Each fire fighter to carry out 1 hot rig exercise using foam media per quarter
- Each Tender to be checked to ensure that its Foam Production System is operational every month

The level of usage of the FTG can be gauged by reference to the following tables which detail the activities requiring the use of the FTG.

Table 1. Seven Categories of Training Exercise

Item	Training Activity	Media used	Frequency
1	Hot training (Aircraft Rig)	Water only	3-6 / month
2	Hot training (Aircraft Rig)	Monex / Water	6 / year
3	Hot training (Aircraft Rig)	Foam	1 / month
4	Tender-Foam Production Test	Foam	1/ week
5	Confined Spaces training (Aircraft Rig)	Water only	1/ month
6	Third Party training (Mobil Gas Rig)	Foam/water	4 / month
7	Hot training (Car)	Water only	1 / month

3. WATER CONTAMINATION

The Fire Training Ground (FTG) at Jersey Airport has been used for approximately forty years for the purposes of fire training of the airport fire crews. Previously, waste oil products were collected from local businesses and were used as fuel for a number of fires set in a tray on the site. Extinguishing these fires with water has resulted in the dispersion of oil over the site surface.

During the 1980's the use of foam was introduced for fire fighting training and in 1991 a training rig fuelled by oil replaced the former tray. Monitoring of boreholes and surface water bodies downstream of the FTG has identified the presence of foam constituents in the groundwater. It appears that the foams are not totally biodegradable and have persistent residues which have been identified as fluorosurfactants. Some of these fluorosurfactants are environmentally persistent and potentially harmful.

Prior to the redevelopment of the FTG, the groundwater beneath the FTG was polluted and moreover the groundwater downstream of the Airport is used for public and private water supply. There was an obligation on the Airport to take action to correct the pollution caused under the Water Pollution (Jersey) Law, 2000. Therefore to prevent further movement of fluorosurfactants and hydrocarbons to groundwater, remediation of the FTG was carried out by removal of the most contaminated materials prior to reconstruction of the FTG.

4. OBJECTIVES OF THE PROJECT

The overall project objectives were defined as:
a) To develop a scheme which will remediate the existing site leading to the minimisation of the risk of further pollution through isolation and the restoration of the full fire training ability of the site.
b) By using the best techniques and best environmental practices that are available and, as far as is reasonably practical, meet the requirements of the Water Resources Regulator acting under the Water Pollution (Jersey) Law 2000. The requirements of the regulator are as follows:-

- Remediate to make safe any earth and other materials from the Airport Fire Training Ground that has been contaminated with constituents of fire fighting foam and hydrocarbon fuels and their residues.
- Carry out appropriate works to contain any pollutants remaining after Stage 1 above at the Airport Fire Training Ground and its environs.

- Restore the groundwater as far as is reasonably practical under the Airport Fire Training Ground and its environs to an agreed concentration based on current limits of detection.

5. ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURE

Under Article 6 of the Island Planning (Jersey) Law 1964 (as amended) any development proposal (for example the FTG remediation) that may threaten or cause damage to the environment is subject to a full Environmental Impact Assessment (EIA) in accordance with current UK best practice.

Environmental Impact Assessment (also referred to as Environmental Assessment), is a procedure that is designed to aid the decision making process. It ensures that the likely effects of new development on the environment are fully appraised and taken into account before the development is allowed to go ahead. The assessment process usually provides for some level of consultation. It is now good practice in the UK and a requirement of the recent European Union directive on Environmental Assessment to consider alternatives to the proposed scheme.

An Environmental Assessment is delivered in material form as an Environmental Statement. This is a report that contains the following information:

- Consideration of alternatives to the proposed development
- A description of the proposed development comprising information about the site, design and size or scale
- Data necessary to identify and assess the main environmental effects of the development
- A description of the likely significant effects, both direct and indirect, of the proposed development on the environment by reference to its impact on a number of environmental receptors
- A description of any measures proposed to mitigate significant adverse effects
- A summary of the statement and proposals written in non-technical format

The issues identified are shown in Table 2.

Table 2. Environmental Issues from Consultation

Environmental Parameter	Potential Impact	Reason
Water Quality	*Construction:* Further pollution of ground and surface waters.	Chosen method of remediation fails to be effective or causes enhanced release of contaminants to groundwater through disturbance or displacement.
	Operation: Further pollution of ground and surface waters	Design of new fire ground fails to contain potentially polluting chemicals used during fire training.

Environmental Parameter	**Potential Impact**	**Reason**
Waste Disposal	*Construction:* Contamination/ pollution from relocation/ storage/ treatment/ disposal of contaminated soil, rock and any "purged" groundwater. *Operation:* Pollution from disposal of liquid effluents from operational re-developed fire ground	Dependent on chosen method of treatment/ stabilisation /disposal. Dependent on chosen method of treatment and location for disposal
Air Quality	*Operation:* Air Quality impacts during use of fire training rig	Open air combustion of fuel oil – some potentially sensitive properties nearby.
Landscape and Visual Amenity	*Construction:* Visual Impacts of construction materials and plant. *Operation:* Visual impact of new fire training facility infrastructure and associated landscaping. *Operation:* Visual impact of emissions from fire training rig	Very prominent location on skyline of Les Mielles. Very prominent location on skyline of Les Mielles. Regular combustion of fuel oil for training purposes and smoke emissions in prominent location.
Flora and Fauna	*Construction:* Disturbance of protected species on and near site. *Construction:* Damage to habitat adjacent to site	Large area of site likely to be disturbed – also close proximity to existing semi-natural habitat (Current status of any protected wild animal species associated with the site and its environs unknown). Important semi-natural habitat immediately adjacent to site. Risk of encroachment and damage during construction and operation.
Contamination	*Construction:* Exposure of construction personnel and public to chemicals hazardous to health *Operation:* Further contamination of ground on site.	Dependent on chosen solution for ground remediation. Especially of concern if contaminated materials will need to be handled, transported and disposed of away from site. Design of new fire ground fails to contain chemicals used during fire training.
Archaeology	Impact on structures and features of archaeological interest.	Groundworks could damage or destroy any previously undiscovered archaeology

The principle conclusion of the Environmental Statement was that the project as described in this Report had the least negative environmental impact, both during construction and during its operation and was likely to eliminate the possibility of the future pollution of downstream watercourses and local groundwater.

6. CONCEPTUAL DESIGN

The Environmental Impact Analysis and the analysis of future training requirements led to the development of a conceptual design for the new FTG which would achieve the aims of eliminating further pollution and ensuring that sufficient water could be stored to avoid overloading downstream drainage. Indeed, it was decided to enhance the required performance by designing to entirely eliminate downstream drainage except in exceptional circumstances. This led the designers to develop an Evaporative Storage Cell which would store water during the period October to March and evaporate it during the summer months. Furthermore, it was decided to design the system to allow stored water to be used as the drench water during training exercises. This brought the scheme close to the water-neutral zero-pollution ideal. Any water discharged from the FTG must go via an already overloaded public foul sewer. Precipitation, water and foam resulting from fire training and groundwater extracted from two boreholes (drilled as a source of fire training water during times of drought) is constrained at the FTG both in terms of volume and pollution as follows. The new FTG is capped to protect an underlying aquifer from pollution and to form a detention volume for the water. It is divided into an inner zone and an outer zone. Fire training takes place in the inner zone and the outer zone acts principally as the evaporative cell.

Rainfall is stored within the construction materials forming the outer cell. In an average year, all of the precipitation is pumped over the surface of the FTG and is thereby evaporated into the atmosphere. The only water which possibly enters the public sewer is the water used in fire training and groundwater abstracted by scavenge pumps in the two boreholes.

During the winter months, the water level in the storage cell rises because the evaporation has less power than the rainfall. In the summer months, the spray can evaporate the previous winter's rainfall plus the summer rainfall. When rainwater is available it is used to supply the drench demand on the fire training rig (this is known as rainwater harvesting). If stored rainwater is not available then the scavenged groundwater is used via the evaporative cell. If the water in the cell is high in winter, then fire training also uses evaporative storage cell water.

When the FTG is used for training, drainage for the inner zone is to the public sewer. The discharge from fire training can be high in BOD (Biological Oxygen Demand), owing to fire fighting foam and to reduce this BOD load and also the potential for foaming the discharge is attenuated in a tank. Here the foam is diluted with water from the drench, with water from water-only fire fighting and with scavenged groundwater. Discharge from the attenuation tank passes through an oil separator before being pumped at a flow rate of 0.5litre/second to the public sewer.

7. PHYSICAL DESIGN

The first stage of transforming the conceptual design to a physical one was to study rainfall data to determine the level of water storage required. A mathematical model has been developed which allows patterns of rainfall recorded at Jersey Airport to be considered. The model has been used to assess the performance of the evaporative cell in both very wet and very dry years. The model simulates the performance of the system by balancing water sources against water sinks.

Water sources comprise:

Water from precipitation
Abstracted groundwater
Water introduced during fire training exercises

Water sinks comprise:

Water evaporated to the atmosphere
Water (+foam) pumped to the public foul sewer

Precipitation has been recorded at Jersey Airport since 1953. An annual rainfall of 843mm is based on monthly 30-year averages from 1971 to 2000. Rainfall is applied to the mathematical cell model on a daily basis. Daily rainfall records for 2000 and 2001 were used. Evaporation has been calculated using the Penman-Monteith formula which is used commonly to estimate evaporation from open water surfaces. The model was run for a catchment area of 5321m^2 since this is the area available for the evaporative cell of which 3943m^2 was assumed to be available for evaporation. Other physical parameters used in the mathematical model were:

Capacity of storage cell = 2200m^3
Pump rate to supply drench demand = 1000 litres/minute
Groundwater abstraction rate = 10m^3/6hr
Capacity of attenuation tank = 80m^3
Pump rate from attenuation tank = 0.5 litres/second

The following switch level settings were used in the mathematical model:

Upper level switch setting that starts pumping from the attenuation tank set to 45% of tank volume
Lower level switch setting that stops pumping from the attenuation tank set to 10% of tank volume.
Operation times for the groundwater scavenge pumps: ON 21.00hrs/OFF 03:00hrs
Operation times for the pump to foul: ON 05.00hrs/OFF 21:00hrs

Excessive rainfall is the significant factor in the design of the storage cell. The rainfall for the period April 2000 to March 2001 is the highest recorded of any in the period 1953 to 2001. The storage cell has been designed to accommodate this volume of rainfall. In dry periods, when water in the storage cell has been evaporated ground water will be pumped into to the cell to supply the drench demand. An intense level of fire training activity is the significant factor in the design of the attenuation tank because of the increase in water discharge and BOD load. The most intense training period has been assumed to be one hot rig and three foam tests within 7 days. This could occur during the second week in January. The mathematical model showed that a storage capacity of 2200m^3 is required for the high level of rainfall which occurred during the period April 2000 to March 2001 and this formed the starting parameter for the detailed design of the FTG

Figure 2. The contaminated material has been excavated and the lining to the evaporative cell is being installed.

8. DETAILED DESIGN

Detailed design of the FTG had to account for the movement of the Airport's fire tenders over an area in which up to 2200m^3 of water was contained. Normally, trafficked areas are specifically designed to eliminate the ingress of moisture since conventional road construction materials lose much, sometimes all, of their strength when saturated. The challenge was to find materials which would hold 2200m^3 of water yet permit the use of the surface by 32t three-axle fire tenders with little or no maintenance over a 25 years design life. Fortunately, there has been a growing interest in the use of permeable pavements in the UK during the last 10 years and this allowed material specifications to be drawn up.

The design section selected comprised the following components:

65mm thickness of permeable clay pavers
50mm thickness of 6mm single size grit laying course material
150mm thickness of 20mm to 10mm Coarse Graded Aggregate to BS 882
1300mm thickness of 125-50mm graded stone
Woven Geotextile HPS 5
2 No. layers of 150mm deep ‘Permavoid’ Storage Cells
100mm thickness of 6mm single size grit bedding course
Woven Geotextile HPS 5
1.9mm thickness HDPE FML
300mm thickness of recycled material used as Type 2 bedding stone

1.9mm thickness HDPE FML
6mm thickness GCL
Total thickness = 2275mm

Essentially, this consists of permeable clay pavers installed over successive layers of no-fines crushed rock becoming progressively coarser with depth down to a layer of proprietary material "Permavoid " which is both strong and hollow (90% void). The materials beneath the Permavoid are part of the waterproof lining and are selected to ensure that the storage cell does not leak during its 25 years design life. Also, geotextile layers are introduced to prevent materials from one layer intruding into another.

Because the construction materials had not been used in the same arrangement before, full scale testing was undertaken to verify their hydraulic and structural adequacy. Initially, a small test was carried out at a local quarry in which one of the quarry's own dump trucks and also one of the Airport's fire tenders were driven over a full-scale test area constructed from the materials which were being proposed for the FTG. Because the results from that test were inconclusive, a larger test was carried out at the Airport. In that test, one of the Airport's fire tenders and then a truck of similar weight and wheel arrangement were driven over a larger test panel. The results of that test confirmed that the design will withstand the loadings expected to be applied to the new FTG over a life of 25 years with little or no maintenance.

One of the components being proposed for the FTG is a proprietary plastic moulding called Permavoid whose purpose is to hold a maximum amount of water in a minimum volume. Because Permavoid was entirely unproven structurally, a test was undertaken in which an Airport fire tender was driven onto a single unit - see Figure 3. This test demonstrated the structural adequacy of Permavoid.

Figure 3. In order to check that Permavoid units can withstand the weight of a fire tender, a simple test was conducted to check that a unit can accept the weight of a fire tender wheel directly. This is a more onerous situation that the one which will apply in service since the load will have been dissipated by the upper pavement courses. Also, the clipping together of Permavoid units enhances their strength. The fire tender was able to remain on a single Permavoid unit for as long as required. There was minor damage to some of the Permavoid elements but the unit remained stable.

9. THE PROJECT AS CONSTRUCTED

Jersey's Public Services Department produced drawings, specifications and contract documents on behalf of Jersey Airport. These formed the basis of the tender exercise and of the construction phase of the project. The following pictures illustrate the FTG on opening day.

Figure 4. The inner zone pavers drain to a holding tank where dirty water is managed. The outer pavers are permeable allowing all the winter's rain to be stored in readiness for summer evaporation.

Figure 5. The fire chief controls training events from the control centre located on the perimeter of the new fire training ground.

Figure 6. When environmental and operational conditions are suitable, water is sprayed over the pavers from where it evaporates.

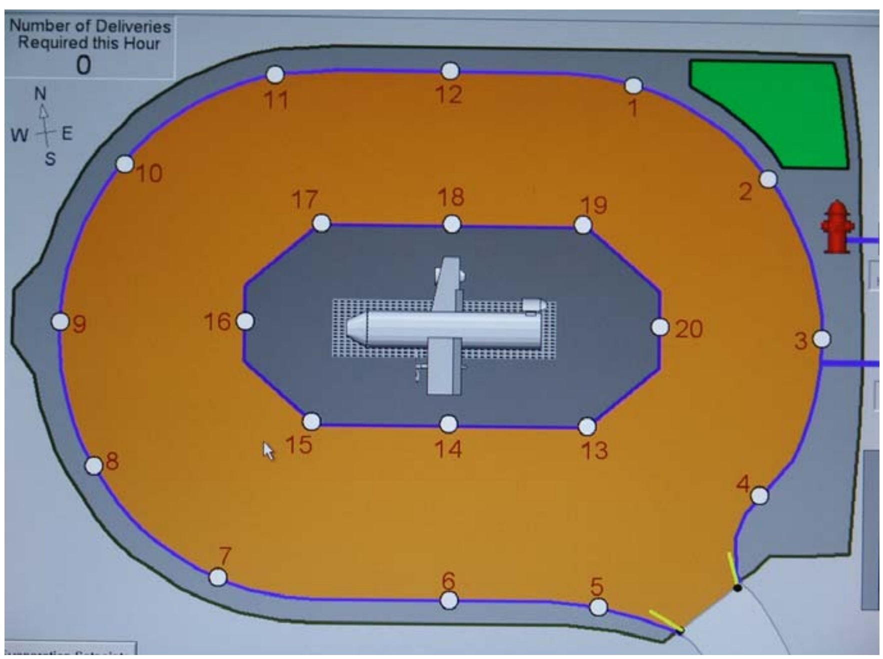

Figure 7. New software was commissioned to monitor and manage the evaporation system.

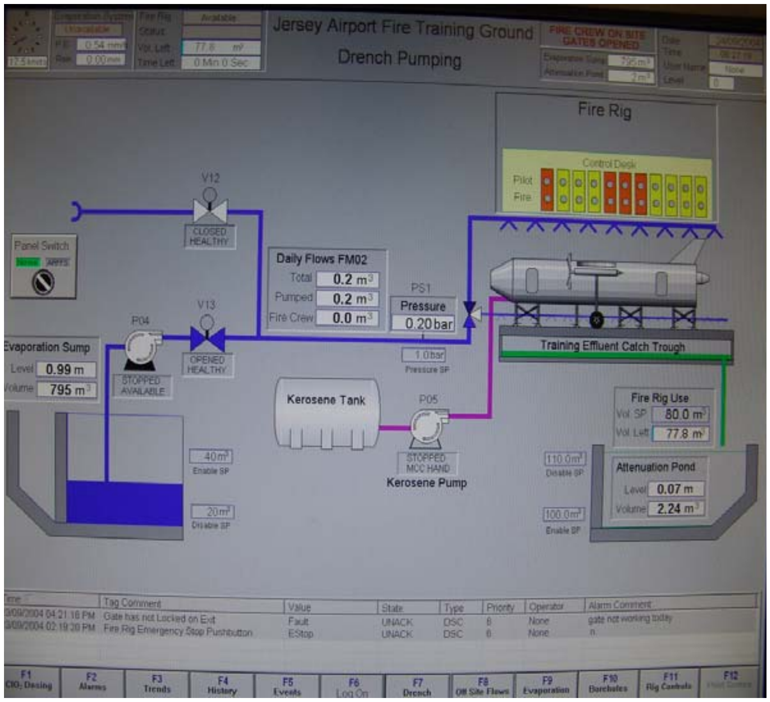

Figure 8. The state of all of the control systems are summarised on the computer screen both at the Fire Training Ground and at the airport's engineering centre.

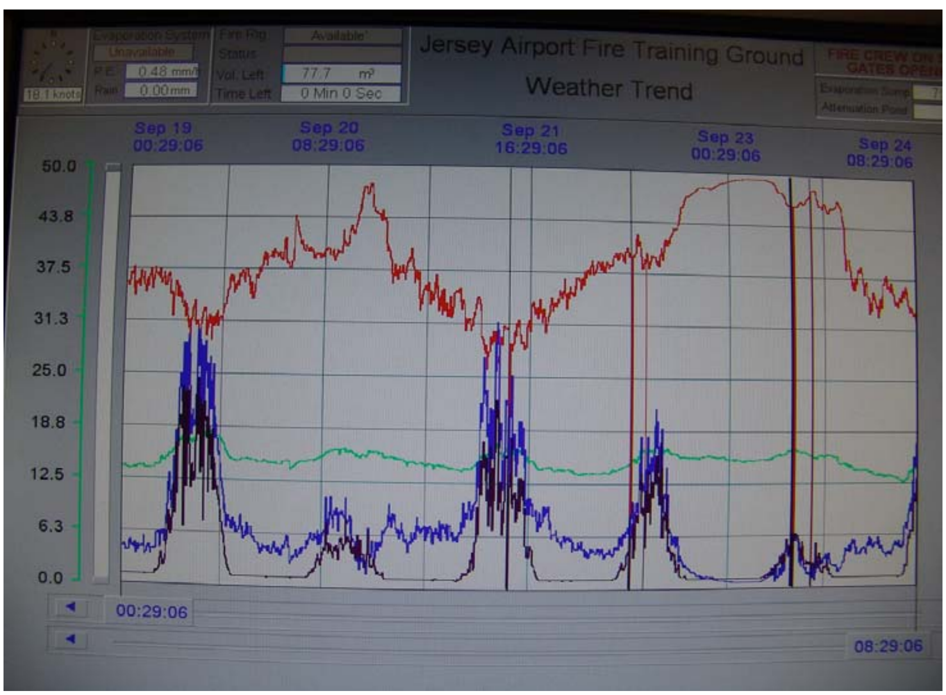

Figure 9. The facility includes a new weather station which records relevant meteorological data. The chart shows the variation of temperature, wind speed, rainfall, sunshine and humidity. It also provides an indication of total water stored.

Figure 10. Fire training in operation. The brick pavers can accept the heat generated without suffering in the long or short term.

Figure 11. The pre-construction trials confirmed the suitability of the paving system for 12t axle fire trucks.

Figure 12. The entire paved area has been designed to withstand the weight of the fire trucks over a 25 years design life.

10. CONCLUSIONS

The new Fire Training Ground at Jersey is the first in the world to be constructed on the basis of water neutral features with a minimum of pollution. It is based upon the concept of an evaporative cell which eliminates ground water ingress and downstream discharge. It also provides the water needed for fire training.

Key to the success of the project is the use of permeable clay pavers for the 5,000m^2 training ground. The conflicting requirements of clean and dirty water storage and structural performance were addressed by the use of Coarse Graded Aggregates of progressively increasing size with depth and with the provision of plastic storage units as the lowest layer of the pavement.

The facility has been in successful use for over two years and is attracting a significant level of interest from airports worldwide, many of whom are struggling to satisfy their conflicting obligations with regard to safety training and environmental protection.

Jersey Airport has developed a body of information which has given it the confidence to proceed with a major construction project which embodies several important innovative features. The information has been developed by considering historic records, by mathematical modelling, by full-scale trials and by ensuring that all interested parties maintained a constructive dialogue throughout a two years research period. The outcome of the investigation comprises reports, specifications, drawings, contract documents and progress records which are transferable to other sites where a FTG needs to be upgraded in terms of its functionality with an emphasis on zero pollution, water demand neutrality and low maintenance.

Jersey Airport understands the importance of technology transfer and recognises the importance of disseminating new information especially when that information can have a positive impact on airfield safety and on the airfield's environment. The Airport considers that these impacts have been demonstrated in this report and hopes that airport regulatory bodies will take the trouble to evaluate the findings summarised in this Report and will encourage their international dissemination.